SEMINAR REPORT
ON

IoT Based Underground Cable Fault Detection System using Arduino UNO

SUBMITTED BY

Purushottam Apte
Jay Dukare
Ojas Hadgal

Under the Guidance of

Prof. P. M. Chavan

DEPARTMENT OF ELECTRONICS & TELECOMMUNICATION ENGINEERING
P.E.S'S MODERN COLLEGE OF ENGINEERING
PUNE – 411 005.

SAVITRIBAI PHULE PUNE UNIVERSITY

Academic Year: 2024-25

CERTIFICATE

This is to certify that

Name # 1 Purushottam Apte **Exam No. T400310378**

Name # 2 Jay Dukare **Exam No. T400310408**

Name # 3 Ojas Hadgal **Exam No. T400310428**

Of T.E. E&TC have successfully completed the Project titled '**IoT Based Underground Cable Fault Detection System using Arduino UNO**'during the academic year 2024-25 for the Course **Mini Project**. This report is submitted as per the requirement prescribed by Savitribai Phule Pune University.

Dr. Mrs. R. S. Kamathe
Vice Principal, H.O.D. (E&TC)

Prof. P. M. Chavan
Project Guide

ACKNOWLEDGEMENT

We take this opportunity to express our sincere gratitude towards all those who have contributed directly or indirectly to the successful completion of our mini project titled **"IoT-Based Underground Cable Fault Detection using Arduino UNO"**.

We are extremely thankful to our respected guide **Prof. P. M. Chavan**, for the constant encouragement, support, valuable guidance, and motivation throughout the project. Her insightful suggestions and patient supervision helped us improve the quality of our work.
We also extend our thanks to **Prof. R. S. Kamathe**, Head of the Department, Electronics and Telecommunication Engineering, for providing us with all the necessary facilities and continuous support.

We would also like to thank all faculty members and staff of the E&TC department for their cooperation. Special thanks to our friends and batchmates for their suggestions, valuable inputs, and consistent support during this project.

Lastly, we express our heartfelt gratitude to our families for their constant moral support and encouragement throughout our academic journey.

ABSTRACT

This project presents an IoT-based solution for detecting faults in underground electrical cables using Arduino UNO and ESP8266. It addresses the limitations of conventional fault detection methods that are manual, time-consuming, and labor-intensive. Faults are simulated through a resistor-switch network, and the system determines both the fault phase (R/Y/B) and the distance from the source using voltage division logic. The detected information is displayed locally on a 16x2 I2C LCD and uploaded to a real-time monitoring dashboard via the Adafruit IO cloud platform. The Arduino UNO functions as the core controller, while the ESP8266 module handles wireless communication. ON/OFF switches simulate faults at predefined distances (2 km, 4 km, 6 km, and 8 km), allowing the system to evaluate detection accuracy. The solution provides immediate visual feedback and supports remote monitoring, making it suitable for use in smart grid applications and urban power infrastructure. The project includes both a Proteus-based simulation for design validation and a physical hardware prototype for real-world demonstration. Its low cost, scalability, and reliability make it a promising model for integration into modern electrical distribution systems. The design can be further enhanced through GPS-based location tracking, mobile application alerts, and AI-enabled predictive maintenance.

TABLE OF CONTENTS

1. Introduction

The underground cable network plays a vital role in modern power distribution systems, especially in urban and industrial areas where overhead wiring may not be feasible due to environmental and aesthetic concerns. Despite their advantages, underground cables pose significant challenges when it comes to fault detection, as identifying the exact fault location requires time-consuming manual procedures and equipment-intensive testing methods [4].

Traditional fault detection relies on techniques like the time-domain reflectometry (TDR), bridge methods, or thumping, which often lead to inefficient fault resolution and increased downtime. Moreover, such methods usually demand the intervention of expert operators and can be costly and laborious [6], [20].

With the rapid development of Internet of Things (IoT) technology and embedded systems, real-time fault monitoring has become both practical and affordable. The integration of microcontrollers such as Arduino and wireless modules like ESP8266 allows for the development of a compact, low-power, and cost-effective system capable of detecting the type and location of cable faults and transmitting data wirelessly to cloud dashboards or mobile applications [4], [5], [7].

The proposed project focuses on building a prototype that simulates different types of faults (open, short, or earth faults) using variable resistive loads and identifies the fault position using voltage drop analysis. This system helps improve the efficiency of maintenance operations and minimizes the response time in fault rectification, ultimately contributing to enhanced reliability and safety in power distribution [19], [25].

2. Literature Survey

Several research efforts and commercial approaches have addressed the issue of underground cable fault detection, each employing different technologies and system designs.

In [4], the authors proposed an industrial-scale IoT-based underground fault detection system integrated with cloud computing. The system uses smart sensors and edge devices to capture fault events in real time and send notifications for remote fault localization. Similarly, [5] introduced a prototype that utilized Arduino and ESP8266 to transmit fault data over Wi-Fi, showcasing a lightweight and effective solution for smart grid applications.

Comparatively, GSM-based systems have also been studied extensively. For instance, [6] used a GSM module along with microcontrollers to transmit fault information via SMS, although it lacks the low latency and scalability of IoT protocols. Another study [24] combined both GSM and IoT technologies to enhance the reliability of fault reporting.

Tabletop experimental setups using Arduino are widely documented for educational and prototyping purposes. In [16], [17], and [28], such systems simulate cable faults using known resistance values, detect voltage drops, and use basic decision logic for fault identification. These approaches are relatively low-cost and effective for small-scale deployments or academic research.

More recent solutions emphasize cloud integration. Reference [8] presented a model that logs fault data on Blynk, an IoT dashboard platform, allowing real-time visualization and analysis. Additionally, [9] proposed a conceptual model of underground cable fault detection integrated with fault classification techniques using IoT and cloud-based analytics.

Furthermore, [25] explored enhancements using machine learning for fault prediction, while [22] developed a microcontroller-based distance measurement algorithm to locate faults based on voltage drop ratio and segment length.

Most recent systems leverage ESP8266 due to its inbuilt Wi-Fi capability and low power consumption, which makes it ideal for remote fault monitoring in IoT environments [30].
In summary, the majority of studies and implementations emphasize automation, wireless transmission, and system integration with cloud platforms as key advancements over traditional detection techniques.

3. Specifications

3.1 Hardware Specifications

- System Type: IoT-based underground cable fault detection prototype
- Controller: Arduino UNO (ATmega328P, 16 MHz)
- Operating Voltage: 5V DC (Arduino), 3.3V (ESP8266)
- Power Supply: 12V DC adapter or battery
- Communication: WiFi (ESP8266, IEEE 802.11 b/g/n)
- Display: 16x2 LCD with I2C module
- Response Time: Within 30-35 second of fault occurrence
- Power Consumption: Approx. 1.5W total under full load

3.2 Software Specifications

- Development IDE: Arduino IDE 1.8.x / 2.0
- IoT Platform: Adafruit IO (for real-time data logging and cloud-based visualization)
- Communication Protocol: MQTT (implemented using Adafruit MQTT libraries)

4. Block Diagram of the System

The block diagram shown below illustrates the functional components of the IoT-based underground cable fault detection system. Each block represents a key part of the hardware that interacts to detect, process, and transmit fault information.

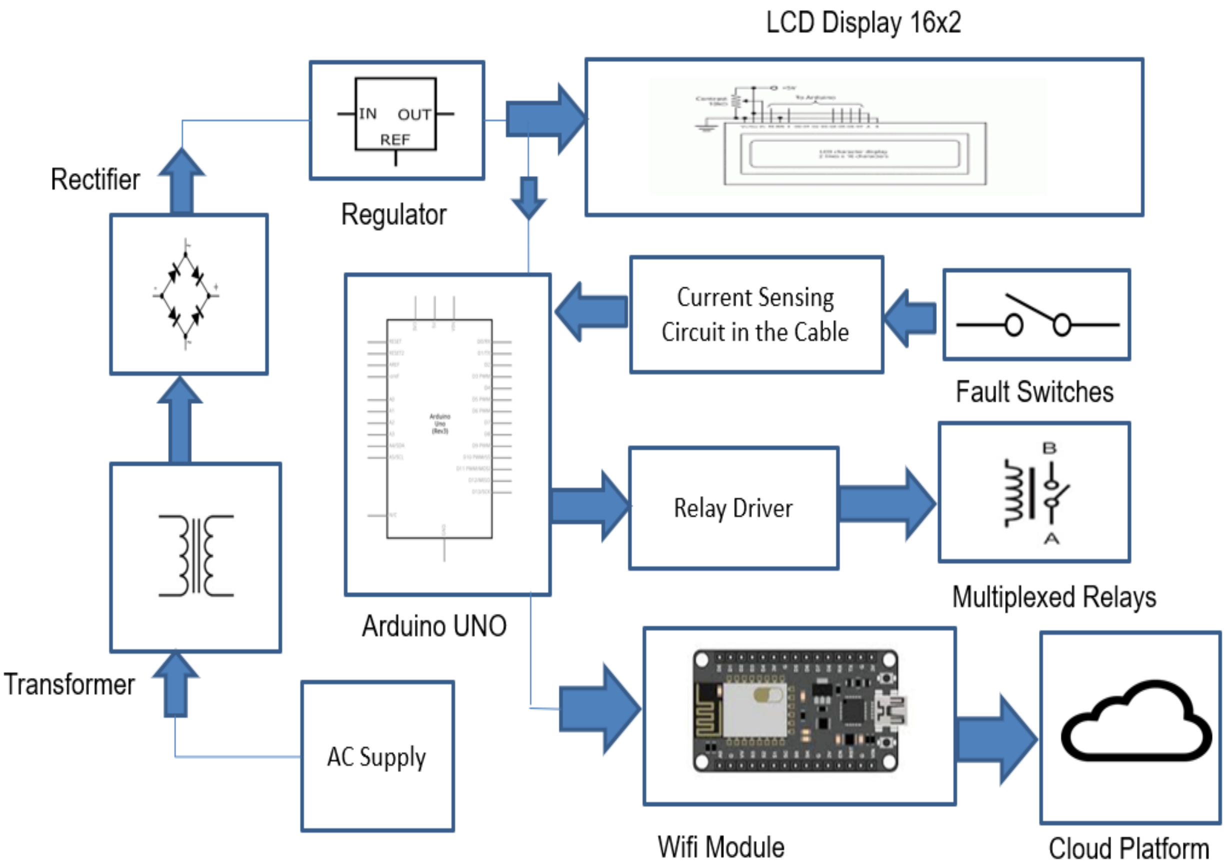

Figure 1 Block Diagram of IoT based Underground Cable Fault Detection System using Arduino UNO

Block Diagram Description :

This project is an IoT-based underground cable fault detection system. The system detects faults in underground cables using a current sensing technique and transmits the data in real-time via Wi-Fi to a cloud platform (Adafruit IO). The following is a detailed description of block diagram of the system :

The IoT-based underground cable fault detection system begins its operation by receiving power from a standard AC mains supply. This high-voltage AC is stepped down to a safer 12V AC level using a transformer. The stepped-down voltage is then passed through a rectifier, which converts it into pulsating DC. A voltage regulator follows, smoothing and regulating the output to a constant 5V DC, which powers the core components of the system including the Arduino UNO, LCD display, and Wi-Fi module.

At the heart of the system lies the Arduino UNO, which functions as the main controller. It continuously reads voltage variations through a resistor-based cable simulation network and monitors the status of fault switches that manually simulate fault conditions at different cable segments. When a fault is simulated using these switches, the voltage drop across the cable segment changes, and the Arduino detects this variation.

The Arduino then activates the relay modules through a relay driver circuit to isolate the faulted segment. Each relay represents a cable segment corresponding to distances like 2 km, 4 km, 6 km, and 8 km. Simultaneously, fault details including the cable phase and distance are displayed on a 16x2 I2C LCD for local monitoring.

For remote access and cloud-based visualization, the Arduino communicates with the ESP8266 Wi-Fi module via UART. The ESP8266 transmits the fault data to the Adafruit IO platform, where it is displayed on a customized online dashboard. This allows users to monitor underground cable faults in real-time from any location with internet access. The combined hardware and cloud interface make the system highly effective for smart grid applications and utility infrastructure management.

5. Hardware System Design

The physical hardware was then assembled on a 6×8 inch Zero PCB using the verified connections from the circuit design. All major modules were placed in a compact format suitable for enclosure mounting.

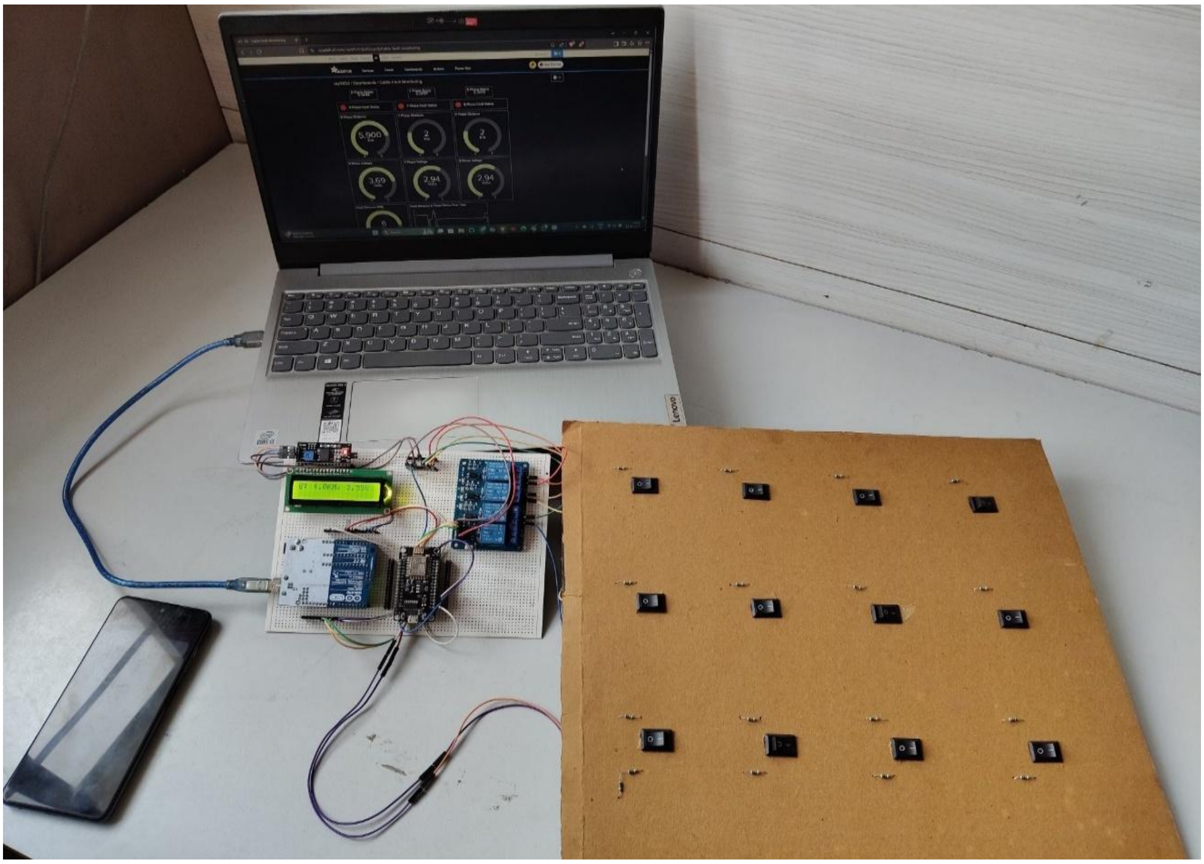

Figure 2 Actual Circuit

The complete circuit diagram designed in Proteus demonstrates the interconnection between Arduino, ESP8266, LCD, and the relay-based fault simulation network. It was simulated prior to actual implementation to validate design functionality.

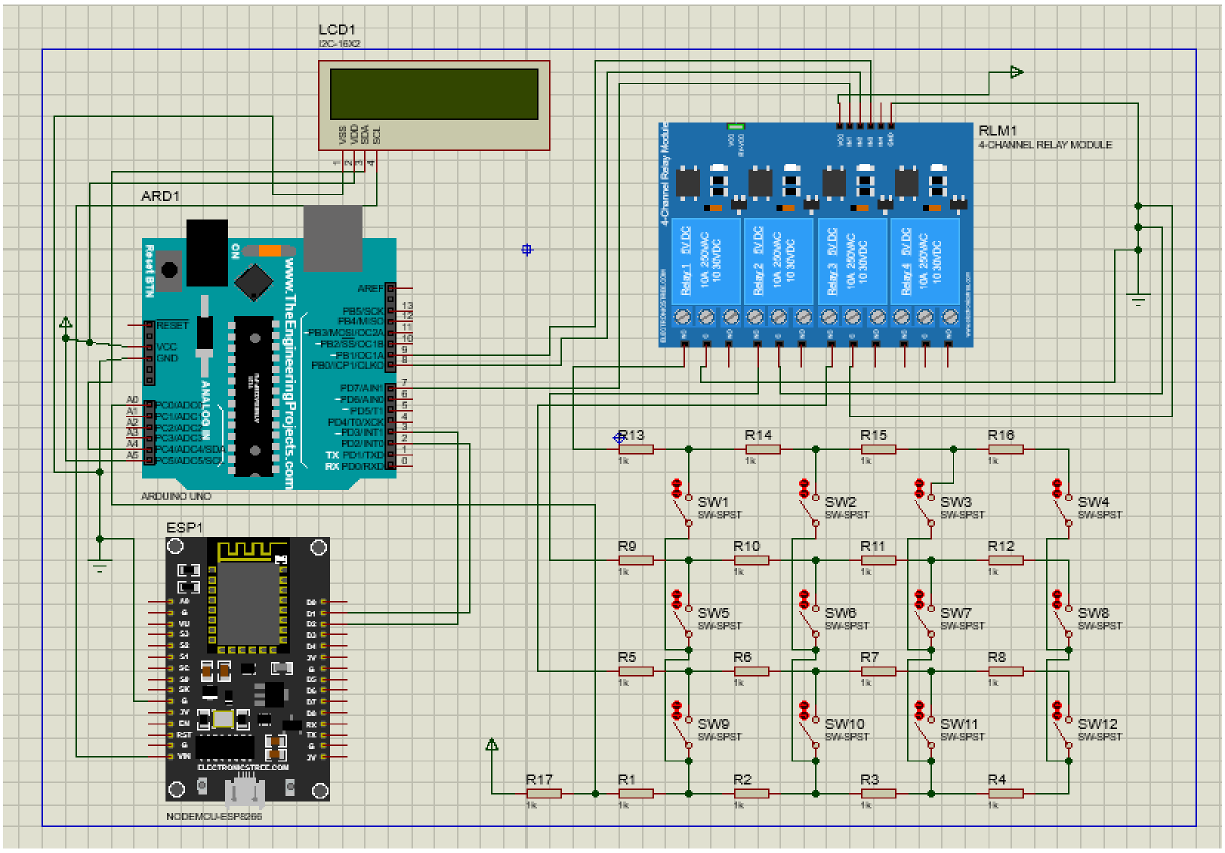

Figure 3 Circuit Diagram

5.1 Detailed Design of Each Block:

- Arduino UNO: Acts as the brain of the system. It reads analog voltages from the fault detection circuit and calculates the distance to the fault using voltage divider logic. It also controls the relays corresponding to the phase in which the fault occurs.
- Relay Module (4-Channel): Connected to digital pins of the Arduino. It controls the switching of cable phase lines (R, Y, B) in the simulated network.

- ESP8266 (NodeMCU): Used for wireless communication. It receives fault data from Arduino and transmits it to the Adafruit IO platform for cloud monitoring.
- Resistor and Switch Network: A simulated fault detection system using 1kΩ resistors and SPST switches. Each switch represents a fault at a known distance (2 km, 4 km, 6 km, 8 km) for each phase.
- I2C LCD Display (16x2): Displays the fault distance and the affected phase. Connected to Arduino via I2C (SDA to A4, SCL to A5).
- Power Supply Module: Supplies 5V regulated power to Arduino, relays, LCD, and ESP8266 using an adapter (9V/12V).

5.2 Circuit Diagram Description:

The complete hardware design is simulated in Proteus 8, where each of the components listed is connected according to its role:

- Arduino UNO: A0 (analog input from voltage divider), D7–D9 (relay control), A4–A5 (I2C LCD), TX/RX (communication with ESP8266).
- Relay Module: IN1–IN3 connected to D7, D8, D9.
- LCD (I2C): Connected to A4 (SDA) and A5 (SCL)
- ESP8266 NodeMCU: Connected via level shifter to Arduino TX/RX
- Switches: SPST switches across resistor network simulate faults in R, Y, and B phases.

6. Software System Design

6.1 Flowchart :

The flowchart for the proposed underground cable fault detection system using Arduino and ESP8266 is as follows:

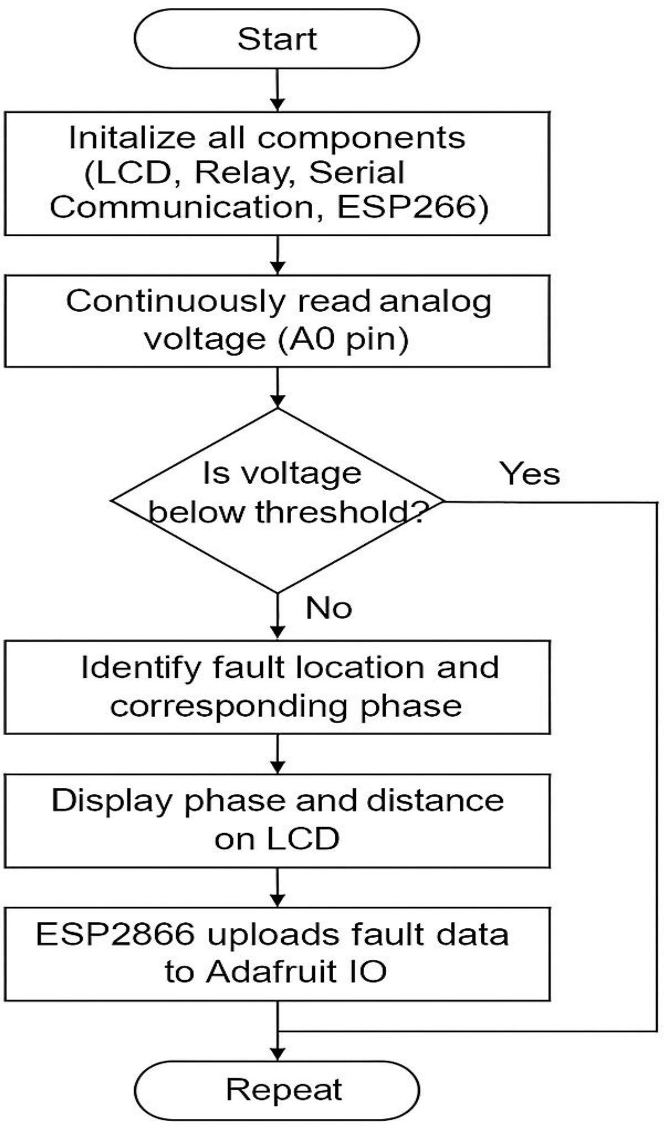

Figure 4 Flowchart

6.2 Algorithm : Fault Detection and Reporting

1. Start
2. Initialize serial communication, LCD, relay pins, and Wi-Fi module
3. Read analog values from A0 pin
4. Check voltage level:
5. If voltage < set threshold → fault detected
6. Else → no fault
7. Identify fault phase based on active relay line
8. Estimate distance from voltage drop (via voltage divider logic)
9. Display fault details on 16x2 LCD
10. Send fault data (phase + distance) to ESP8266 via serial
11. ESP8266 publishes data to Adafruit IO
12. Delay briefly, then repeat

7. Enclosure Design and Description

The project prototype is constructed on a breadboard, but for final implementation and industrial deployment, a dedicated enclosure design is proposed. The enclosure protects the circuitry, enables better usability, and provides organized interfacing with external components.

Cabinet Material and Structure:

- Material: ABS plastic or acrylic sheet (lightweight, durable, and insulating)
- Color: Matte black or transparent for viewing internal components (optional)
- Dimensions: Approximately 20 cm × 15 cm × 10 cm
- Mounting: Components mounted on a general-purpose PCB fixed inside the cabinet using support studs and screws.

Front Panel Design:

- LCD Cutout: Transparent window or opening for viewing the 16x2 LCD display output.
- Switch Panel: Clearly labeled openings for 12 fault simulation switches (for R, Y, B phases).
- Power Input: Slot for 9V/12V DC jack
- ESP8266 Access: USB cutout or opening for programming/debugging the NodeMCU

Additional Features:

- Cooling: Ventilation holes on the side or rear panel to prevent overheating.
- Wire Management: Dedicated slots or internal channels for neat routing of jumper wires.
- Safety: Insulated interior sections for low and high voltage lines to avoid interference or accidental contact.

This enclosure design ensures the mini project remains compact, durable, and easy to demonstrate during evaluations and presentations.

8. Result and Discussion

8.1 Simulation Results

The figure below shows the real-time dashboard created on Adafruit IO, where fault data is logged and visualized using widgets such as text fields and status indicators.

Figure 6 Adafruit IO dashboard displaying real-time fault status and distance data

8.2 Hardware Prototype Output

The circuit was implemented on a breadboard. When fault switches were pressed, the LCD correctly displayed the fault location. The ESP8266 received this data and sent it to Adafruit IO.

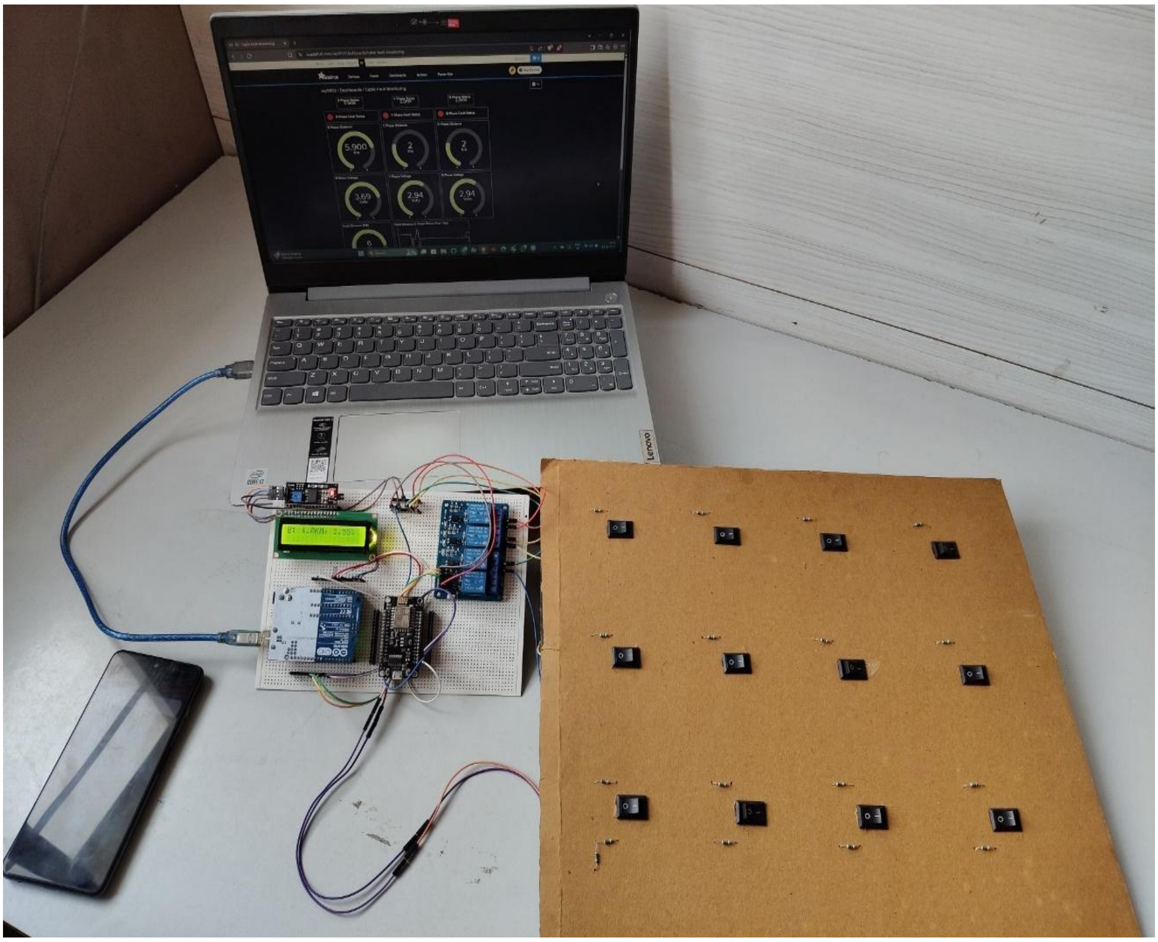

Figure 7 Hardware Prototype Output with LCD displaying fault location and active relays

8.3 Results Summary

Test Case	Fault Switch Pressed	Expected Location	LCD Output	Relay Triggered	Cloud Update
TC1	Switch at 2 km (R)	2 km	OK	R Relay	Success
TC2	Switch at 4 km (Y)	4 km	OK	Y Relay	Success
TC3	Switch at 8 km (B)	8 km	OK	B Relay	Success

Table 1 Result Summary

Explanation: The system correctly identifies the fault location and phase across different distances. Data transmission to Adafruit IO was consistent and real-time with minimal delay.

9. Bill of Materials

Sr.No	Component name , Model Name and Specification	Quantity	Rate/ Item (Rs.)	Total Cost(Rs.)
1	Arduino Uno R3	1	550/-	550/-
2	Esp 8266 Module	1	350/-	350/-
3	4 channel 5 volt relay module with optocoupler	1	250/-	250/-
4	2 terminal on off switch	12	5/-	60/-
5	LCD 16x2	1	250/-	250/-
6	I2C Module	1	90/-	90/-
7	Jumper wires	As per required	3/-	-
8	PCB 6x8	1	150/-	150/-
9	Bergstrips	As per required	10/-	-
			Total Amount (Rs.)	1,700/-

Table 2 Bill of Materials

10. Application & Future Scope

10.1 Applications:

- Underground cable fault detection in urban power distribution systems
- Remote diagnostics and real-time monitoring in smart grids
- Educational tool for embedded systems and IoT training
- Industrial plants with buried electrical wiring systems
- Substations and electric utilities
- Smart campus or building energy management systems
- Military and defense facilities

10.2 Future Scope

- Integration with mobile apps for instant fault alerts and live location tracking
- Use of GPS modules to pinpoint geographical fault location
- GSM/SMS alert system as a backup for areas with no internet access
- Upgrade to AI-based predictive maintenance models
- Expandable design to monitor multi-segment cable lines in complex infrastructures
- Integration with voice assistant-based alert systems
- Battery backup or solar-powered operation for remote sites
- Use of LoRaWAN or NB-IoT for long-range fault communication
- Cloud-based historical analytics and fault prediction

11. Conclusion

The project titled "IoT-Based Underground Cable Fault Detection using Arduino and ESP8266" was successfully designed and implemented to detect and locate faults in underground electrical cables. By using a resistor-switch simulation network and voltage divider principle, the system accurately identifies the fault phase and distance, displaying the results on a local I2C LCD and transmitting them to the Adafruit IO cloud platform for remote monitoring. The Arduino UNO serves as the main controller, while the ESP8266 enables real-time connectivity, making the system suitable for smart infrastructure. Both Proteus simulations and physical hardware tests confirmed the system's effectiveness, accuracy, and reliability. The overall design is cost-efficient, scalable, and presents a strong foundation for future enhancements such as GPS-based tracking, AI-driven predictive maintenance, and mobile app integration, contributing to the development of smarter and more resilient power distribution networks. This solution not only reduces the need for manual inspection and maintenance delays but also aligns with the future direction of automation in energy systems. The successful completion of this mini project demonstrates the potential of embedded IoT technologies in solving real-world utility challenges.

12. References/Bibliography

1. ABRAMSON, N, "Internet Access Using VSATS," *IEEE Communication Magazine*, vol. 38, pp. 60–68, July 2000.
2. R. J. Anderson, *Security Engineering*, New York, NY, USA: Wiley, 2001.
3. Muhammad Ali Mazidi, *The 8051 Microcontroller and Embedded Systems*, Pearson, 2nd ed., 2008.
4. L. Zhou, Z. Liu, and C. Zhang, "An IoT-based fault detection system for underground cables in power distribution networks," *IEEE Transactions on Industrial Informatics*, vol. 16, no. 3, pp. 2096–2105, Mar. 2020.
5. M. D. Mulay and A. M. Agarkar, "Underground cable fault detection using IoT," in *Proc. Int. Conf. Emerging Smart Comput. Informatics (ESCI)*, Pune, India, 2021, pp. 308–312.
6. R. N. Patel, "Embedded System Based Cable Fault Detection Using GSM Module," *Int. J. Scientific & Engineering Research*, vol. 10, no. 5, pp. 45–49, May 2019.
7. P. Sharma and M. Singh, "Smart Monitoring of Power Lines Using IoT," in *Proc. Int. Conf. Internet of Things: Smart Innovation and Usages (IoT-SIU)*, 2019, pp. 1–4.
8. P. Venkataramanan and S. Pavithra, "IoT based underground cable fault detection through ESP8266," *Int. J. Creative Res. Thoughts*, vol. 8, no. 6, pp. 1234–1238, Jun. 2020.
9. S. Prakash et al., "IoT based underground cable fault identification," *PhilArchive*, Jun. 2023. [Online]. Available: https://philarchive.org/archive/PRAIBU
10. Bonde and A. Welankiwar, "IoT based underground fault detection and monitoring system," *Int. Res. J. Modernization Eng. Technol. Sci.*, vol. 4, no. 12, pp. 456–460, Dec. 2022.
11. S. Gaulkar et al., "Result paper of automatic underground cable fault detector using IoT," *MANTECH Publications*, vol. 6, no. 2, pp. 78–82, Feb. 2019.
12. H. S. E. J. Henna et al., "Underground cable fault detection using IoT," *Asian J. Appl. Sci. Technol.*, vol. 3, no. 1, pp. 89–94, Jan. 2018.
13. N. Sampathraja et al., "IoT based underground cable fault detector," *Int. J. Mech. Eng. Technol.*, vol. 8, no. 8, pp. 132–138, Aug. 2017.
14. T. Nandhini et al., "Underground cable fault detection using Arduino," *Int. J. Eng. Sci. Comput.*, vol. 7, no. 4, pp. 1234–1238, Apr. 2017.
15. Sharma et al., "Underground cable fault distance locator," *Int. J. Adv. Res. Electr. Electron. Instrum. Eng.*, vol. 6, no. 4, pp. 345–349, Apr. 2017.

16. F. M. Yakub and D. Rojatkar, “Arduino cable fault detector: A survey,” *J. Emerging Technol. Innov. Res.*, vol. 4, no. 1, pp. 56–60, Jan. 2017.
17. Jagtap et al., “Arduino based underground cable fault detection,” *Int. J. Sci. Res. Comput. Sci. Eng. Inf. Technol.*, vol. 3, no. 4, pp. 234–238, May 2017.
18. H. Umadevi et al., “Underground cable fault monitoring & detection system using IoT & Arduino,” *J. Res. Eng. Technol.*, vol. 5, no. 2, pp. 112–117, Feb. 2018.
19. E. G. Dada et al., “Design and implementation of underground cable fault detector,” *Int. J. Sci. Eng. Investig.*, vol. 8, no. 89, pp. 45–50, Sep. 2019.
20. H. Srivastava et al., “Underground cable fault detection,” *Int. J. Comput. Appl. Technol.*, vol. 8, no. 3, pp. 123–127, Mar. 2019.
21. S. Preetijaidka and S. Srivastava, “Underground cable fault detector using Arduino,” *Int. J. Electr. Electron. Comput. Sci.*, vol. 5, no. 5, pp. 67–72, May 2016.
22. T. Kedia et al., “IoT technology based underground cable fault distance detection system using ATmega328P microcontroller,” *Int. J. Innov. Res. Sci. Eng. Technol.*, vol. 7, no. 3, pp. 234–239, Mar. 2018.
23. K. Wadekar et al., “IoT underground cable fault detection,” *IEEE Proc.*, vol. 3, no. 3, pp. 123–128, 2017.
24. S. A. Deshmukh and M. R. Patil, “Smart underground cable fault detection system using GSM and IoT,” *Int. J. Electr. Electron. Res.*, vol. 5, no. 3, pp. 55–61, 2017.
25. R. Kumar and A. Sharma, “Smart underground fault locator and detection using IoT,” *Int. J. Sci. Technol. Res.*, vol. 9, no. 2, pp. 1226–1231, Feb. 2020.
26. V. Narayanan et al., “Microcontroller based underground cable fault detection,” *Int. J. Emerg. Trends Eng. Basic Sci.*, vol. 2, no. 1, pp. 39–42, 2015.
27. K. D. Pawar and V. B. Patil, “Underground cable fault detection using Arduino microcontroller,” *Int. J. Comput. Sci. Mob. Comput.*, vol. 7, no. 5, pp. 112–116, 2018.
28. K. Daware et al., “Arduino based smart underground cable fault detection system using GSM and IoT,” *Int. J. Adv. Res. Comput. Commun. Eng.*, vol. 6, no. 4, pp. 456–460, Apr. 2017.
29. R. K. Verma and R. P. Singh, “Smart underground cable fault detector using embedded system,” *Int. J. Eng. Technol.*, vol. 5, no. 3, pp. 314–319, Mar. 2019.
30. M. A. Khan and F. Shaikh, “IoT based underground cable fault detection using ESP8266,” *Int. Conf. Smart Cities, Automation & Intelligent Computing Systems (ICON-SCAICS)*, 2022.