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Enhanced Power Distribution Through IOT Based Under Ground Cabel Fault Detection

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Abstract- Accurately locating faults in subterranean cable connections is a prevalent challenge, particularly in cities, and the suggested approach aims to tackle this problem. A power supply and an Arduino microcontroller kit form the basis of the system, which measures the wire length in kilometers using current measurement circuits linked to the microcontroller's Analog to Digital Convertors (ADC) device. A relay circuit is used to regulate the relays, and switches are employed to simulate faults. You can see the specifics of the issue as they happen on a 16x2 LCD screen. Short circuit problems in the underground cable may be caused by environmental factors such as rain, subterranean pollution, drain leakage, and so on. Among the many possible problems with subterranean cable, the identification of short circuit faults is the primary emphasis of this work. By monitoring voltage variations across the resistor and calculating the distance from the source feed point, the ADC digitizes the data and displays it on the LCD, pinpointing the exact position of the short circuit defect. The Wi-Fi module 8266 helps to save the specifics of the defect location in the cloud, allowing for subsequent investigation. Because of this, the suggested design for the Arduino microcontroller can pinpoint the precise location of the problem in terms of kilometers from the base station. Additionally, in the event of a malfunction, a buzzer alerts field personnel to the urgency of the situation. This innovative approach provides a dependable and efficient means of locating and identifying issues with underground cable cables. This reduces downtime and facilitates service.

Keywords- Internet of Things, Cable, Fault Detection, LCD, Arduino.

I. INTRODUCTION

Because they provide essential services like distribution, internet access, and phone service, subterranean cable connections must be reliable for municipal amenities to work well. Conversely, it is rather difficult to locate and identify issues with these underground cables, particularly in densely populated areas where such infrastructure is prevalent. Timely repair, less downtime, and improved overall efficiency depend on this issue being addressed. The adaptability of embedded systems has made them valuable resources for tackling challenging engineering challenges in a variety of domains [1]. This project seeks to improve the accuracy and efficiency of issue discovery and localization in subterranean cable cables by harnessing the power of embedded systems. The proposed setup is based on an Arduino microcontroller board. This platform is well-known for its adaptability and user-friendliness, making it ideal for creating integrated solutions [2].

The Arduino microcontroller plans the process of issue detection when linked to a recovered power supply and functions as the primary processor. The system can accurately determine the length of the buried cable in kilometers by attaching circuits that detect current to the microcontroller's built-in ADC unit [3]. Overall, fault finding methods benefit greatly from this feature's ability to restrict the region where defects may be discovered. Reproducing issues with the subterranean cable lines is an important component of the proposed system's value. Incorporating problem-causing switches allows the system to detect and localize issues immediately, allowing for the achievement of this aim [4]. The fault detection procedure may proceed without hiccups thanks to the relay driver, which simplifies the handling of relays. Problems are exhibited on a 16x2 LCD screen in real time so that individuals may see them and fix them immediately [5]. To detect a short circuit, the power voltage is monitored and investigated as it varies across the series resistors. These changes are detected by an ADC, which then converts them into precise digital data. In order to pinpoint the source of the problem, this is an essential step [6]. With this data, the specially built Arduino microcontroller can display, in kilometers from the base station, the precise position of the defect, which is helpful for repair personnel [7].

The system also includes safeguards to ensure it reacts and resolves issues promptly in the event that they arise. Field workers will know they need to take immediate action when a buzzer alert goes out. This careful approach decreases downtime, lessens potential dangers, and improves safety overall [8]. When it comes to finding and fixing defects in subterranean cable cables, the proposed technology represents a huge step forward. Incorporating cutting-edge technology such as ADC devices and Arduino microprocessor kits, the system offers a trustworthy, efficient, and cost-effective approach to managing urban infrastructure. In order to make cities more resilient, the proposed system can accurately detect and identify issues, which will revolutionize maintenance practices, guarantee the continuous operation of critical services, and transform the way cities are maintained in general. This section laid out the different essential pieces of hardware that would be required to construct the suggested fault finding circuit. In Section II, we provide a literature review on several issues with buried cables, along with suggested methods for detecting them. Section III shows the experimental setup and technique that was used to identify the subterranean cable problem. The findings are shown in section IV, which shows the fault position at different distances. These data are saved and sent to the cloud. The work is completed and its potential future extensions are detailed.

II. LITERATURE SURVEY

A growing number of applications are making use of embedded systems to address various issues, such as defect detection and localization in subterranean cable systems. The goal of improving the speed and accuracy of defect finding procedures has been the focus of much research into various approaches and technology. A method for locating problems with subterranean power lines was developed by Yang et al. [1] using a distributed parameter approach. Using mathematical models, this approach increases accuracy and reduces downtime by guessing where faults exist along the line. Similarly, by including wavelet analysis into their GPS moving wave fault detector for power lines, Zhao et al. [3] improved the accuracy of defect discovery. One helpful approach for locating defects in subterranean cable networks was developed by Westrom and Larsen [2], who are mentioned in the patent literature. For underground cable systems with many ends, Gilany et al. [4] demonstrated a technique for fault identification based on traveling waves. Because of this, we now know how to locate problems in intricate cable networks. Improvements to fault detection technologies have been the subject of research by groups such as Zhang et al. [9].

Using currents in the single-end sheath of subterranean cables, they devised a live, immature fault detection system. with order to identify problems with asymmetrical transmission lines, Schulze and Schegner [10] investigated several approaches. This furthered our understanding of how to identify problems in power systems. A ground-level magnetic field sensor device for inspecting cables underground was developed by Sun et al. [11]. A non-destructive method of inspecting the cables' condition is therefore made possible. Beyond that, Paul and Kakoti [12] developed a defect detector for subterranean cables that facilitates the detection and repair of such networks.

The potential of emerging technologies, such as the Internet of Things (IoT), to enhance defect detection has also been the subject of research. In their study, Islam et al. [13] examined several methods for locating problems in subterranean cables and proposed future directions for the field's development. Similarly, Teresa et al. [14] discussed the potential of Internet of Things (IoT) technology to enhance fault monitoring. This highlights the need of fresh perspectives in addressing the evolving challenges associated with handling subsurface wires. As this literature study has shown, there is a plethora of methods and tools available to help locate and repair issues with subterranean cable systems. Improving the speed, accuracy, and reliability of problem detection procedures is an ongoing goal of researchers. Among these novel approaches are mathematical models, wavelet analysis, tracking of magnetic fields, and integration with the internet of things. With these upgrades, city infrastructure may become more robust, preventing disruptions to critical services like electricity transmission and communications.

III. METHODOLOGY

A issue monitoring system for subterranean cable lines will be constructed using an Arduino microcontroller kit and current measurement circuitry. By carefully monitoring power fluctuations in real time and taking exact measurements of the cable lengths, problems may be discovered with pinpoint accuracy. A 16x2 LCD screen, a buzzer for rapid warning, and a switch driver for issue modeling are all components of the system. By using these components, the system strives to provide a trustworthy and efficient method for locating and repairing issues with underground cable lines, thereby decreasing maintenance downtime and making it simpler to arrange in advance. B. An Ideal Design Core, An approach to locating issues with subterranean electricity lines is shown via the proposed block model.

The heart of the gadget is an ESP8266 transmission module and an LCD screen, both linked to an Arduino UNO CPU. A regulated power supply powers the Arduino UNO. To locate problems, an Arduino UNO may be connected to a fault switch, which functions similarly to an underground wire line. The data is processed and displayed on the LCD screen in real time whenever the Arduino UNO detects a defect. The ESP8266 module also lets you communicate wirelessly so you can watch and handle things from afar. By streamlining the process, this all-in-one solution improves the likelihood of timely repairs and speeds up the process of locating issues with underground cable lines.

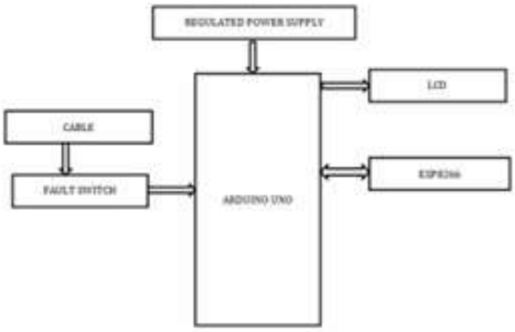
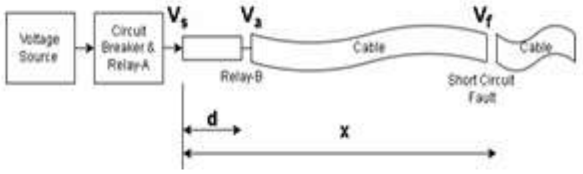


Fig. 1 Block Schematic of Proposed system.

Materials Employed: One option is the Arduino UNO, which may mimic an underground cable line by interacting with an LCD display, an ESP8266 module, and an issue switch. Its regulated power supply facilitates fault detection and real-time issue data visualization. In order to locate faults with subterranean electrical lines and fix them promptly, this compact device works well. 2) ESP8266: This little device allows the issue monitoring system to wirelessly communicate with other equipment. It facilitates remote monitoring and repair of subterranean wires when coupled with Arduino UNO. Thanks to its compact design and practical characteristics, ESP8266 enhances the system's data transmission capabilities, facilitating the prompt resolution of issues. Thirdly, the defect monitoring equipment receives real-time data from the LCD panel. When coupled with the Arduino UNO, it displays issue data in a clear and understandable manner, making it simpler for users to use and comprehend. Fixing problems with subterranean cables is a breeze with the LCD's 16x2 display design, which makes issue information simple to read and comprehend. 4) FAULT SWITCH: The fault monitoring system's fault switch pretends that the subterranean cable line is malfunctioning. When paired with an Arduino UNO, it triggers test and confirmation scenarios. By just toggling a switch, users may simulate various error scenarios. In this way, issues with the subterranean cable network may be accurately located and addressed by the system [15].

Fifthly, the issue monitoring system is powered by a portable battery, which allows it to function consistently even in remote areas that are not linked to the power grid. It provides continuous power to the system's components, including the LCD display, ESP8266 module, and Arduino UNO, after it is attached. Problem spotting may be done in different environments without the need for additional power sources because to the system's portability and rechargeable battery. 6) ADAPTOR: The defect detection system is powered by the ADOPTOR, which connects to power supply and powers components such as the ESP8266 module, LCD display, and Arduino UNO. All devices need an adapter to convert the alternating current (AC) electricity from wall outlets to direct current (DC). This guarantees the system's proper operation at all times. Because of its standard plug-and-play architecture, which facilitates setup and enhances interoperability, it is an integral component of the fault monitoring system. D. Methods of Work: In cities, where underground drains leak and digging is common, the cables running under the earth are vulnerable to environmental factors such moisture, temperature changes, and physical damage [16]. Even little rips or tears in the cable, as well as an increase in temperature from high current flow, might cause problems to be detected [17].



$$Vs = Vf + xr(Is) + xl\frac{dIs}{dt} \quad (1)$$

There is a relationship between the voltage at the site of the short circuit defect (Vf) and the current flowing through the circuit (Is). It is assumed that the dispersed network has a long run cable with an impedance ratio equal to the distance ratio, as stated by (2)".

$$\frac{Zx}{Zd} = \frac{Rx}{Rd} = \frac{x}{d} \quad (2)$$

When you express resistances as voltages and currents, you get "(3)".

$$\frac{x}{d} = \frac{Is(Vs-Vf)}{Is(Vs-Va)} \quad (3)$$

When there is a cable short circuit and the impedance changes to resistance, the Vf equals zero.

$$x = \left[\frac{Vs}{Vs-Va}\right]d \quad (4)$$

In "(4)," we use the known distance 'd' to determine the unknown distance 'x'. A number of components must be connected to the Arduino UNO before the proposed fault detection system for subterranean wires can function. An analog-to-digital converter (ADC) and current-sensing circuit allow the Arduino to accurately measure the wire's length and detect any issues. The relay motor controls the relays that are activated when the fault switch detects an issue. The ESP8266 module enables wireless communication, allowing for remote control and monitoring of the device. In the event of a short circuit, the ADC is able to detect voltage fluctuations and convert them into digital information. Using this data, the Arduino pinpoints the exact location of the problem from the base station, providing precise instructions to the field personnel.

In addition, a buzzer alert notifies staff of any problems with the system, allowing them to address them promptly. Because it runs on batteries or a regulated power source, the system is dependable in urban and rural settings alike. This reduces downtime in subterranean cable networks and makes maintenance simpler. In fig.3, we can see the algorithm's flowchart, which describes how it starts up the modules attached to the Arduino board, detects short circuit problems and their locations, shows them on an LCD, notifies the appropriate authorities, and then uploads the data to the cloud.

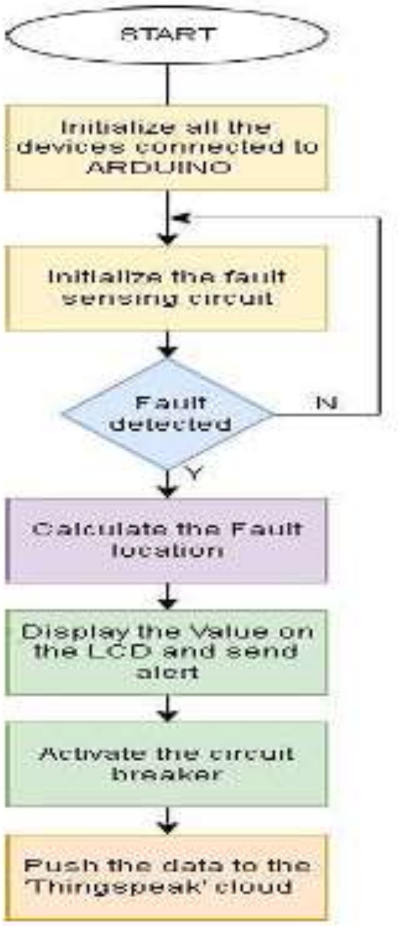


Fig. 3 Operational Flow chart

To accommodate the requirements of the dense population, big cities have vast underground cable networks built. At that point, it is necessary to disperse the Internet of Things technology in order to conduct edge computing by identifying the cables that have failed. Large edge computing devices are therefore necessary in these kinds of situations. In order to have a complete inventory of city-wide problems, cable integration also necessitates the integration of edge computing devices. It is advised to integrate computer devices at the edge with a central controller or cloud-based computing device. In fig. 4, you can see the whole integration configuration.

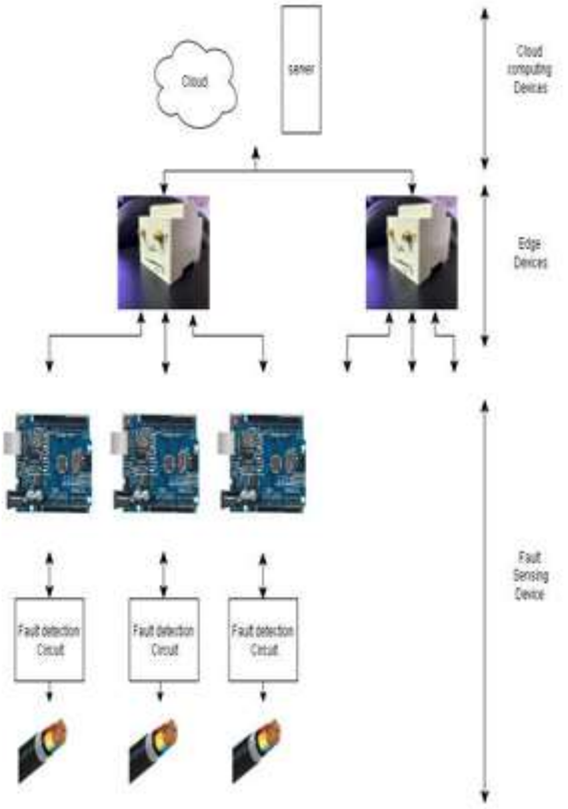


Fig. 4 Integrating cable Fault boards together.

IV. EXPERIMENTAL RESULTS

The experimental setup shown in Figure 5 is used for the purpose of evaluating the virtual defects. The "Welcome note" depicted in Fig.6 appears on the LCD screen after powering up the setup. A separate resistive network is used to induce the fault. The status bar will read NF (No Fault) if no faults are detected.

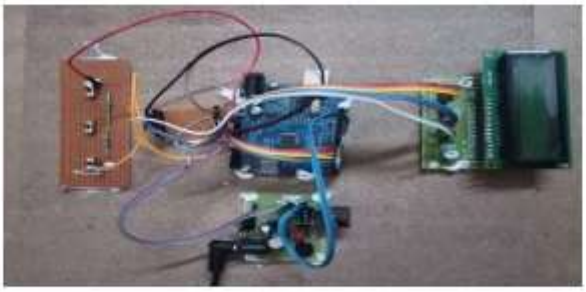


Fig. 5 Equipments & Wire Connection

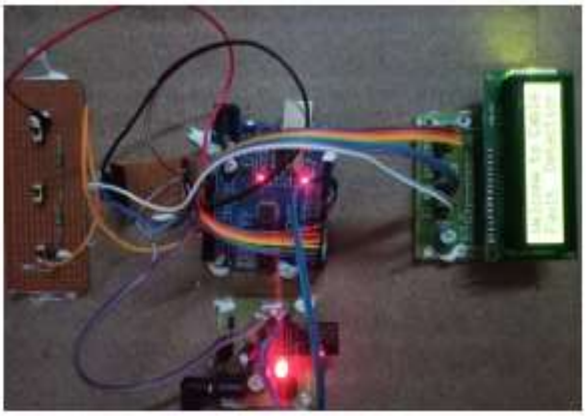


Fig. 6 Equipments & Wire Connection with Welcome Note on LCD

Fig. 7 No Fault Indication

Fig. 8 Fault Indication at 9Km distance

Figure 6 shows the resistive fault reading at 9 km distance from the test setup, whereas Figure 7 shows the reading at 6 km distance.

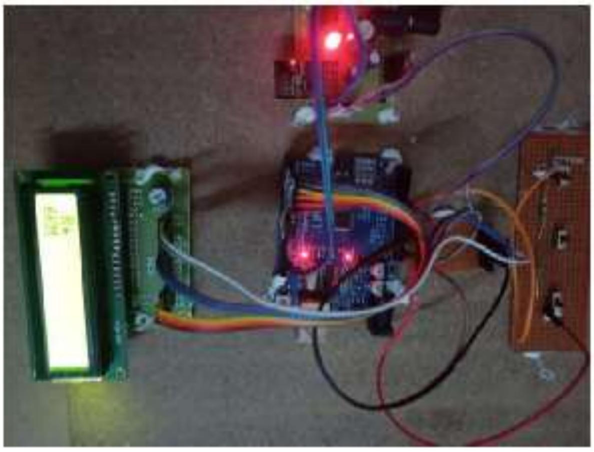


Fig. 9 Fault Indication at 6Km distance

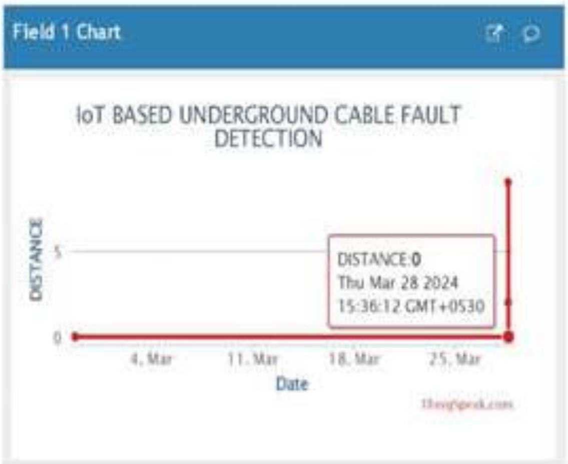


Fig. 10 No Fault.

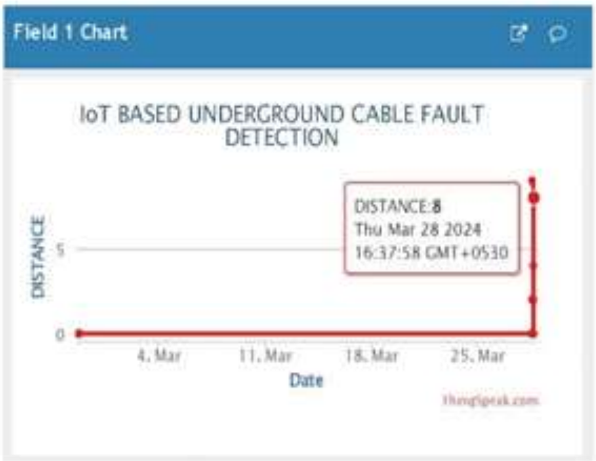


Fig. 11 Fault at distance of 8Kms.

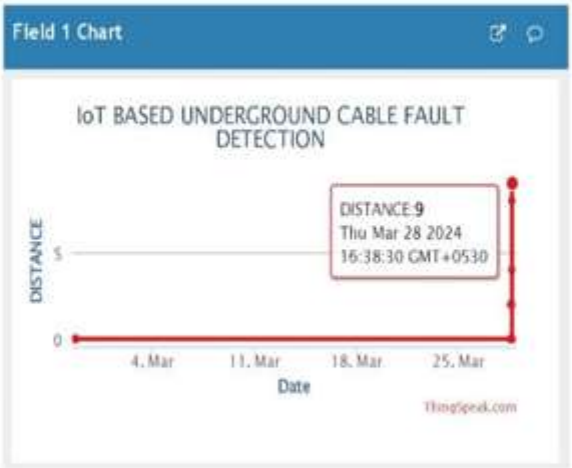


Fig. 12 Fault at distance of 9Kms.

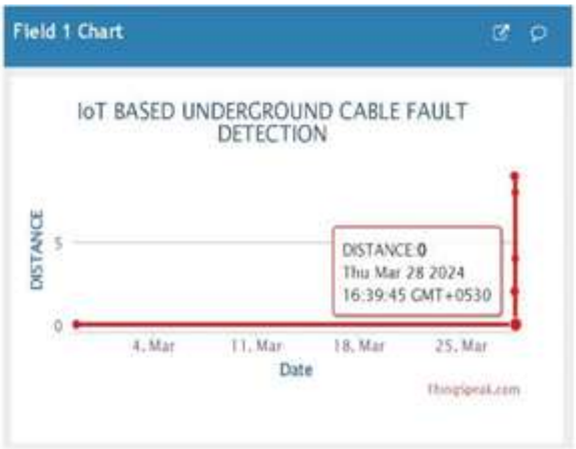


Fig. 13 No Fault.

Data submitted by end devices may be stored, visualized, and analyzed on the Thingspeak.com platform. Figures 10–13 show the data visualization of the Thingspeak.com platform's short circuit failures at different distances and times. The experimental configuration sends the distance to the fault's location to the cloud platform ThingSpeak.com. The LCD panel shows 0Kms as no fault, and the same is shown at cloud in Figures 10 and 13. Displayed in Figures 11 and 12, respectively, are the recorded and visible faults on the cloud at 8 and 9 kilometers distances. Figure 11: Fault at 8 kilometers away. By linking many of these devices together, the relevant authorities can guarantee that the end consumers of the subterranean cable would get better service. The data becomes accessible to the subscribing clients when the publisher-subscriber model is developed.

V. CONCLUSION

An effective method for detecting and localizing issues with subterranean cable systems is the underground fault monitoring device that is based on the Internet of Things. Embedded electronics, such as the ESP32 microcontroller with Wi-Fi connectivity, provide real-time tracking and online sharing of issue data, and the system use a voltage divider network to determine the unknown distance using the known distance. This streamlines the process of identifying problems and carrying out maintenance. In the event that an issue arises, the system can pinpoint its exact location and relay this data to the appropriate parties for resolution or cable replacement. Fixes may be expedited and debugging becomes simpler with this. Not only can date and time tracking capabilities aid in capturing and assessing issues, but they also make the repair process more responsible and traceable. Since the system uploads the whole data of the cable to the cloud, it makes it simple to analyze, and it also retains data relating to the cable's quality. Protecting and studying the cable's statistical behavior over time is possible using switch gears. Underwater defect detection using an IoT-based system is, all things considered, a major improvement over previous methods. An integral aspect of contemporary infrastructure management, it may increase overall stability, shorten maintenance times, and decrease downtime.

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