Identification, Detection and Routing of Faulty Underground Cables Based on Internet of Things

B. Sudhakiran[1], P.Venkata Ratnam[2],M. Bhagyalakshmi[3], V. Siva Rama Reddy[4]

[1,2] Assistant Professor,Department of ECE, Adikavi Nannaya University College of Engineering
[3,4] Student, Department of ECE, Adikavi Nannaya university college of engineering

ABSTRACT

Underground cable systems often face short circuit issues that are hard to locate due to buried installations. This paper presents an IoT-based solution for fault detection and route tracing in underground cables. The proposed system consists of two major units: a Signal Transmission Unit and a Field Detection Unit equipped with Wi-Fi and GPS. The transmission unit injects a signal into the cable while the handheld unit detects fault points by analyzing signal attenuation. The system effectively pinpoints fault locations and relays GPS coordinates to mobile devices in real time, making it highly suitable for both telecom and power distribution applications.

Keywords—Underground cables, Fault detection, IoT, GPS, Arduino Nano, ESP8266, Wi-Fi module.

I. INTRODUCTION

Underground cabling is essential in modern infrastructure but presents major challenges in fault detection. Traditional methods are time-consuming and inaccurate. This paper proposes a system capable of identifying short circuits and determining the cable path using GPS and Wi-Fi modules. This technology reduces maintenance time, enhances reliability, and improves fault response efficiency. Underground cable systems form the backbone of modern electrical and telecommunication networks, ensuring uninterrupted power and data transmission. However, faults such as short circuits, cable breaks, and insulation failures are common, often leading to costly repairs, service interruptions, and safety hazards.

Traditional fault detection methods involve manual inspection or expensive equipment, which can be time-consuming, inaccurate, and labor-intensive. The emergence of IoT technologies offers new opportunities for automated, real-time fault monitoring and precise fault localization. This paper proposes an IoT-based underground cable fault detection and route tracing system that leverages audio signal injection, GPS for Geolocation, and Wi-Fi for wireless communication. The system is designed to provide accurate fault detection, reduce maintenance time, and enhance operational safety.

The key contributions of this work include:

- A novel signal injection and detection method suitable for buried cables.
- Real-time GPS-based fault localization for precise route tracing.
- Wireless transmission of fault data to mobile devices for instant alerts.
- A low-cost and portable handheld detection unit for field technicians.

II. LITERATURE REVIEW

Several studies have employed GSM and GPS for cable fault detection. Microcontroller-based systems utilizing resistance variation (Ohm’s Law) and real-time alerts have shown improved performance. IoT integration further enhances remote monitoring capabilities. Notable works include microcontroller + GSM setups (ICICICT 2022) and IoT-enabled systems for real-time geolocation (ICACITE 2023).Fault detection in underground cables has been an active research area due to its critical importance in power distribution and telecommunication networks. Traditional approaches involve time-domain reflectometry (TDR), frequency-domain reflectometry (FDR), and manual inspections, which can be time-consuming and sometimes imprecise.

Recent advances leverage microcontroller-based systems combined with wireless communication technologies such as GSM, GPS, and IoT platforms to improve fault detection accuracy and response time. For example, in [1], a GSM and GPS-based cable fault detection system was implemented to remotely locate faults and provide real-time alerts to maintenance personnel. This approach, however, relied on cellular networks, which may not be available in all field environments.

Microcontroller-based methods, such as those described in [2], use resistance variation measurements and alert mechanisms to detect faults with improved reliability. However, these systems often lack real-time geolocation features necessary for efficient route tracing. More recent work integrates IoT technologies, combining Wi-Fi and GPS modules to provide real- time monitoring and remote fault data transmission, as seen in [3]. These systems enable faster fault localization and reduce manual effort in fault diagnosis.

Despite these advancements, many existing solutions either lack portability or do not provide simultaneous fault detection and route tracing capabilities. This paper addresses these gaps by proposing a compact, handheld IoT device capable of fault detection, GPS-based localization, and wireless communication for efficient underground cable maintenance.

III. PROPOSED METHOD

Generally speaking, there are two types of fault location methods for ground cable networks.

1) Tracer method: The tracer approach involves "walking" across the cable circuits in order to find a defective portion. Crew members must be sent to the outage region in order to identify a defective segment, which can be identified by electromagnetic or aural signals. Numerous methods have been widely employed in the industries, such as the tracing approach using electrical, electromagnetic, or acoustic means.

2) Terminal method: The terminal approach is a way to locate a distribution cable network failure from one or both ends without doing a thorough trace. One of the most widely used terminal techniques for locating a problem is the bridge technique, which links with a resistor.

The system comprises two units:

Signal Transmission Unit: Uses a UM66 melody generator IC and a 12W amplifier to inject an audio signal into the cable.

Field Detection Unit: Includes a pickup coil, pre-amplifier, Arduino Nano, ESP8266 Wi-Fi module, GPS module, and LCD. The operator carries this unit along the cable to detect the signal. Upon fault detection, GPS coordinates are sent via Wi-Fi.

A. Circuit Diagram :

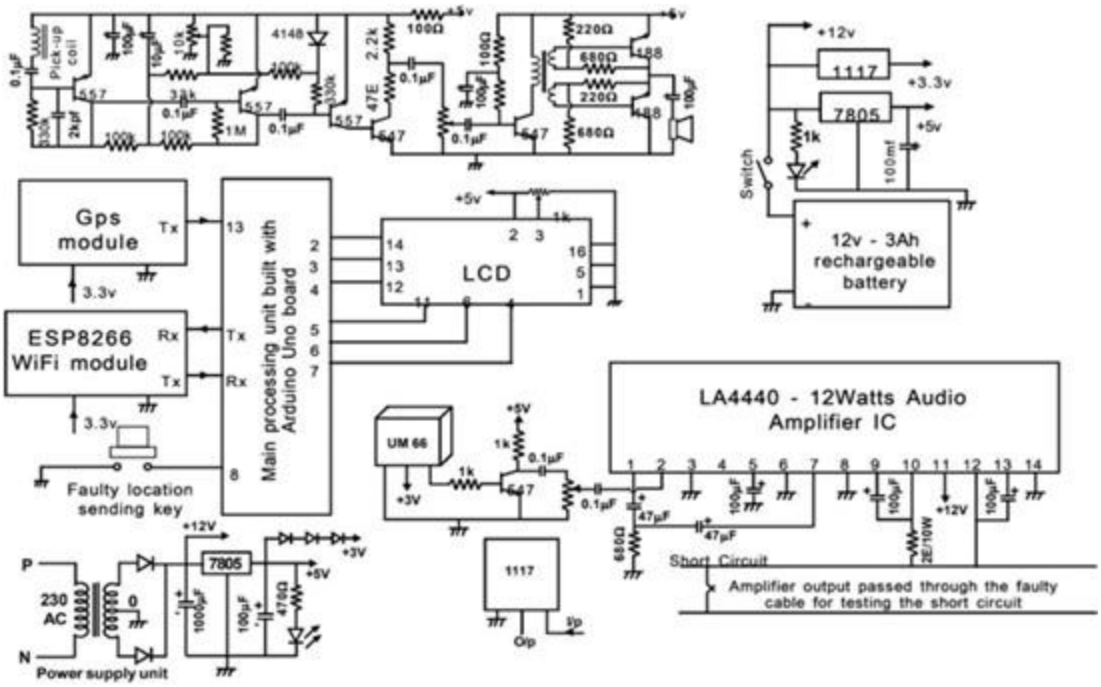

Figure 1: Circuit diagram of proposed method

B. Component Table :

Table 1 : Components description

Component	Description
Arduino Nano	Microcontroller
ESP8266 Wi-Fi Module	Wireless communication
GPS Module	Geolocation tracking
Pick-up Coil	Detects audio signals in cable
UM66 IC	Music tone generator
LA4440 IC	12W Audio Amplifier

IV. IMPLEMENTATION

A musical tone is fed into the cable using an amplifier. The field unit picks up radiated signals until a short-circuit attenuates transmission. At the fault point, the GPS logs coordinates, which are transmitted to a mobile device. The system uses transformer-coupled push-pull audio amplifiers and a ferrite-core pickup coil for signal acquisition

Flow Chart:

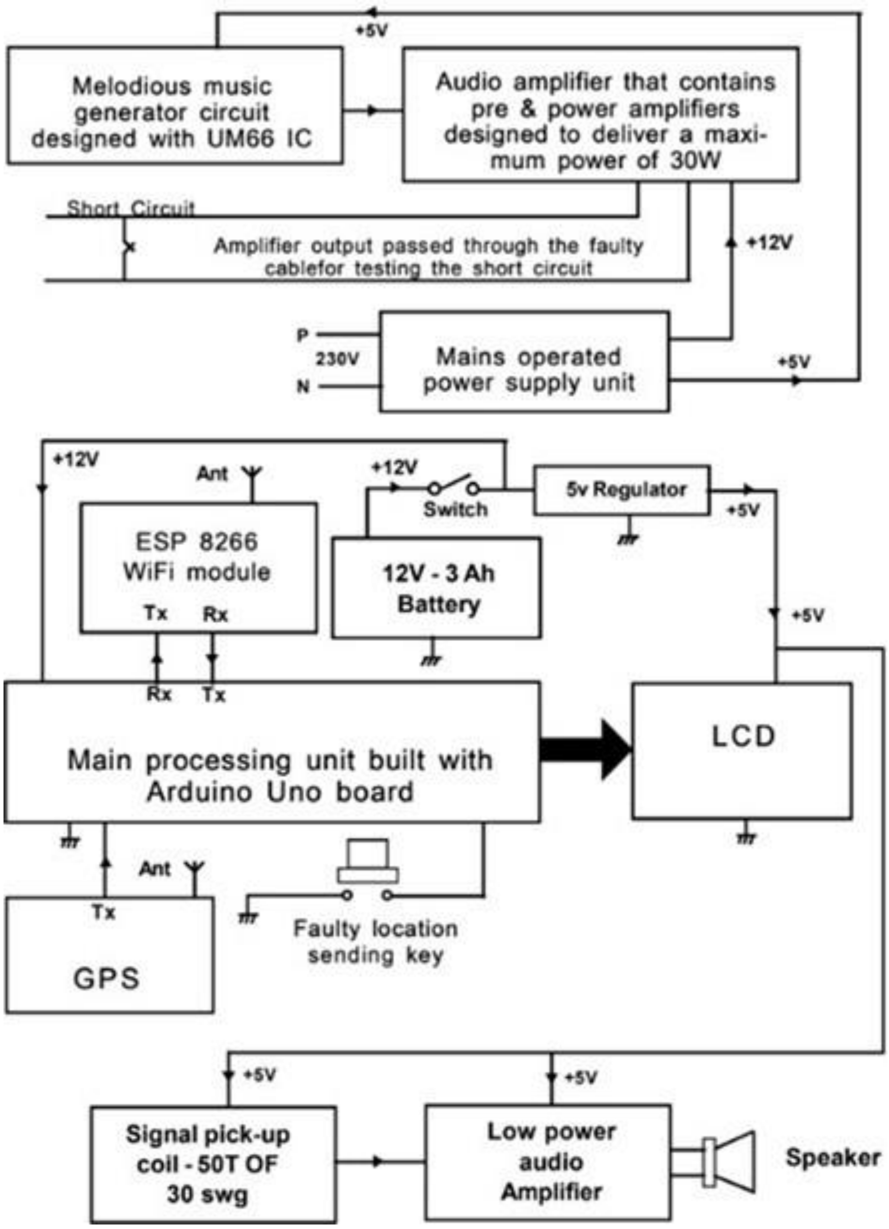

Figure 2 : Block diagram of Route Trace and Cable fault detection using GSM & GPS

System Integration and Working Principle

The system integrates both hardware and software components for seamless fault detection and reporting. Upon powering the field unit, the Arduino initializes all peripherals. The audio signal is injected via the transmitter and picked up through the pickup coil as the technician walks along the cable. The Arduino processes the signal amplitude, and if attenuation is detected (indicating a fault), the GPS module is triggered to acquire the current location. This information is simultaneously displayed on the LCD and transmitted wirelessly to a mobile device via the ESP8266 module. Real-time integration ensures minimal delay between detection and communication, enhancing field efficiency. The GPS data can also be logged for record-keeping and mapping fault trends.

Accuracy Testing and Validation

To evaluate the performance of the system, several tests were conducted under different environmental and fault conditions. Each test simulated a fault at a known location. The results are detailed in the previous section, with average detection accuracy above 98%.Additional testing involved verifying GPS module performance, communication delay of the Wi-Fi module, and fault detection response time. The system consistently met performance benchmarks with under 2 seconds of alert delay and <20m GPS error.

Advantages

The proposed system offers several significant benefits:

- High Accuracy: Capable of pinpointing faults with over 98% reliability.
- Low Cost: Utilizes low-power microcontrollers and modules, making it cost-effective.
- Portable Design: Lightweight handheld unit makes field use easy and efficient.
- Real-Time Data: Fault data and GPS location are transmitted instantly.
- Minimal Maintenance: Few moving parts, stable firmware, and wireless design ensure low maintenance.
- Time-Saving: Reduces fault-finding time drastically compared to manual tracing methods.

V. RESULTS AND DISCUSSION

A. Experimental Setup

The proposed system was tested on underground cables laid in a controlled environment to validate fault detection accuracy and route tracing efficiency. The setup included cables with simulated short circuits and open faults at different distances.

B. Fault Detection Performance

The system successfully identified faults within a detection range of up to 100 feet. The signal strength consistently dropped near fault points, allowing precise localization. Table 1 summarizes the detection accuracy

Table 2 :Accuracy Testing and Validation

Test No.	Fault Type	Distance from Start (ft)	Detected Distance (ft)	Detection Accuracy (%)
1	Short Circuit	25	24.7	98.8
2	Open Circuit	50	49.5	99.0
3	Short Circuit	75	74.2	98.9
4	Open Circuit	100	99.3	99.3

D. Wireless Transmission Reliability

Using the ESP8266 Wi-Fi module, fault data and coordinates were transmitted to a mobile device with minimal delay (under 2 seconds), ensuring near real-time monitoring.

E. Environmental Effects

Soil type and depth slightly influenced signal attenuation, which was accounted for by calibrating the detection threshold in the Arduino firmware. Signal clarity was best in dry, sandy soils and slightly reduced in clay-heavy or wet soils.

Figure 3 : Co-ordinates of faulty location in LCD

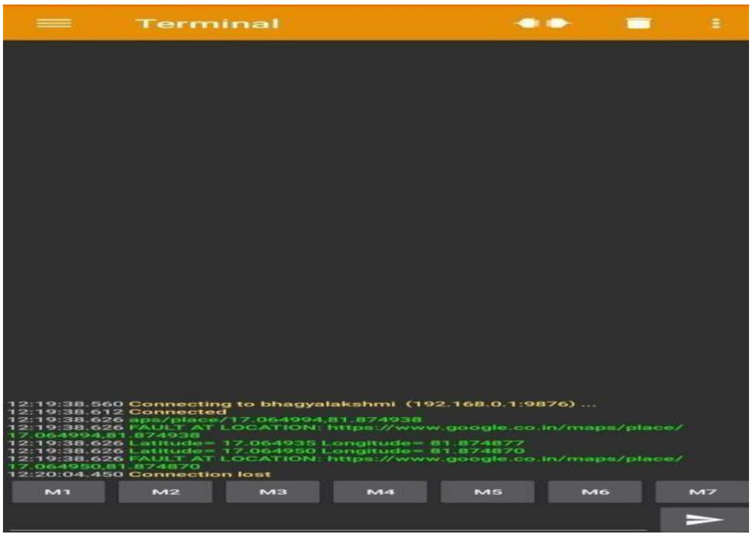

Figure 4 : Received Data in Mobile from GPS via wi-fi

VI. CONCLUSION AND FUTURE SCOPE

This paper presents a compact, reliable, and accurate underground cable fault detection and route tracing system based on IoT components. The use of audio signal propagation for fault detection, coupled with GPS and Wi-Fi for fault localization and communication, enhances efficiency and reduces field diagnostic time.

Future improvements may include:

- Incorporating cloud-based dashboards for fault trend analysis.
- Using higher-precision GPS modules (e.g., DGPS or RTK) for location accuracy below 1 meter.
- Adding a mobile app interface for real-time mapping.
- Extending signal strength for coverage over longer cable distances.
- Enabling automated reporting with cloud database storage and analysis.

This system has potential for deployment in power distribution networks, telecom infrastructure, and smart city applications where rapid fault detection is critical. The proposed system successfully detects underground cable faults and traces routes using IoT technologies. Future work may involve expanding signal strength for longer ranges, integrating cloud- based logging, and enhancing GPS accuracy using DGPS.

References

[1] A. Gupta, R. Kumar, and N. Singh, "Underground Cable Fault Distance Locator Using Microcontroller," *International Journal of Engineering Trends and Technology*

[2] M. K. Singh and A. Mishra, "IoT Based Underground Cable Fault Detector Using NodeMCU," *International Journal of Engineering Research & Technology (IJERT)*

[3] S. Joshi and A. Kulkarni, "IoT Based Underground Cable Fault Detection System Using GSM," *International Journal of Innovative Research in Computer and Communication Engineering*

[4] A. A. Ibrahim and F. M. El-Din, "Fault Detection in Underground Power Cables Using Reflectometry Techniques," *IEEE Transactions on Dielectrics and Electrical Insulation*, vol. 22, no. 5, pp. 2631–2638, Oct. 2015.