UNDERGROUND CABLE FAULT DETECTION USING IOT

, [1]B. Hima Siva Sai, [2]A. Ruthik Sai Subhash, [3]G. Ramana Reddy, [4]D. Sriram Reddy, [5]B. Ravi Teja, [6]G. Koteswar Rao

[1,2,3,4,5]U. G Student, Dept ELECTRONICS AND COMMUNICATION ENGINEERING, St.Ann's College of Engineering and Technology,(Autonomous)Chirala, Bapatla Dist, Andhra Pradesh – 523187, India
[6]Professor, Dept ELECTRONICS AND COMMUNICATION ENGINEERING, St.Ann's College of Engineering and Technology(Autonomous), Chirala, Bapatla Dist, Andhra Pradesh – 523187, India

ABSTRACT

Underground cable systems are widely used in modern electrical power distribution networks due to their advantages such as improved safety, reduced exposure to environmental conditions, and better reliability compared to overhead transmission lines. However, monitoring and maintenance of underground cables remain a challenging task because faults are not visible and locating the exact fault position requires extensive excavation, which increases maintenance time, labor effort, and overall cost. Traditional fault detection techniques are mostly manual, time-consuming, and do not provide real-time monitoring, which further delays fault identification and repair.To overcome these limitations, this project presents an IoT-based Underground Cable Fault Detection System designed to monitor physical damage and obstacles along underground cable routes. The proposed system focuses on detecting surface-level disturbances rather than internal electrical faults, making it simple, cost-effective, and suitable for prototype-level applications. The system uses a Raspberry Pi Pico Was the central controller, which processes sensor data and enables wireless communication. An Infrared (IR) sensor is used to detect physical damage

or break conditions in the cable path by sensing variations in reflected signals, while an ultrasonic sensor is used to detect obstacles by measuring distance changes near the cable route.

When an abnormal condition is detected, the system immediately generates local alerts using an LCD display, buzzer, and LED indicators to notify nearby personnel. The LCD provides real-time information about the fault condition, while the buzzer ensures an audible alert for quick attention. In addition to local alerts, a GPS module is integrated to capture the geographical location of the detected fault, which helps in identifying the exact position and reduces the time required for inspection and maintenance.

Furthermore, the system utilizes IoT technology by transmitting sensor data, fault status, and location information to the ThingSpeak cloud platform using Wi-Fi communication. This enables remote monitoring and real-time data visualization through web or mobile interfaces. The proposed system provides a low-cost, efficient, and real-time solution compared to traditional fault detection methods. It reduces manual inspection, improves response time, and enhances maintenance efficiency. Overall, the project demonstrates the effective application of IoT, embedded systems, and sensor technologies in underground cable monitoring and serves as a strong foundation for future smart infrastructure systems.

KEYWORDS: ***Underground Cable Fault Detection, Internet of Things, Raspberry Pi Pico W, IR Sensor, Ultrasonic Sensor, GPS Module, Cloud Monitoring***

INTRODUCTION

Underground cable systems have become an essential part of modern electrical power distribution networks, especially in urban and industrial areas where overhead transmission lines are not feasible. These cables provide several advantages such as improved safety, reduced risk of environmental damage, and better aesthetic appearance. However, despite these advantages, underground cable systems face significant challenges in terms of fault detection and maintenance. Since the cables are buried beneath the ground, faults cannot be visually identified, making the process of locating and repairing faults complex, time-consuming, and costly. Physical damages caused by construction activities, soil movement, or accidental digging can lead to serious disruptions in power supply if not detected early.

Traditional fault detection techniques such as loop tests, insulation resistance testing, and Time Domain Reflectometry (TDR) are commonly used to detect faults in underground cables. Although these methods can provide accurate results, they require skilled personnel, expensive equipment, and often involve shutting down the cable system. Moreover, these techniques do not support real-time monitoring and are mainly reactive, meaning faults are detected only after a failure occurs. This leads to increased downtime and higher maintenance costs. In addition, these systems lack automation and remote monitoring capabilities, which further reduces their efficiency.To overcome these limitations, the proposed system introduces an IoT-based underground cable fault detection approach using sensor technology. The system continuously monitors the cable route using an IR sensor to detect physical damage and an ultrasonic sensor to identify obstacles near the cable path. A Raspberry Pi Pico W acts as the central controller, processing sensor data and generating alerts when abnormal conditions are detected. The system also integrates a GPS module to provide the location of the fault and uses Wi-Fi communication to send real-time data to a cloud platform for remote monitoring. This approach reduces manual effort, improves response time, and provides a cost-effective and efficient solution for underground cable monitoring.

RELATED WORK

Several research works have been carried out in the field of underground cable fault detection, focusing on improving accuracy and reducing maintenance time. Traditional techniques such as Murray loop and Varley loop methods are widely used to determine the location of faults by analyzing resistance variations in the cable. These methods are effective for detecting internal faults but require the cable to be disconnected from the power supply, making them unsuitable for continuous monitoring. Time Domain Reflectometry (TDR) is another commonly used method, where a high-frequency signal is sent through the cable and reflections are analyzed to detect faults. Although TDR provides accurate results, it involves complex signal processing and expensive equipment.

With the advancement of embedded systems, researchers have developed microcontroller-based fault detection systems that use electrical parameters such as voltage and current to identify faults. These systems improve automation but are limited to laboratory conditions and do not support remote monitoring. In recent years, IoT-based systems have gained popularity due to their ability to provide real-time monitoring and remote access. These systems use communication technologies such as GSM, Wi-Fi, or LoRa to transmit data to cloud platforms. Some systems also integrate sensors to detect environmental conditions and physical disturbances.

However, many existing IoT-based systems are complex, expensive, and require high power consumption. Additionally, most of them focus on detecting internal electrical faults rather than physical damage or obstacles along the cable route. The proposed system addresses these issues by using simple and low-cost sensors such as IR and ultrasonic sensors, combined with IoT technology for real-time monitoring and alert generation. This makes the system suitable for prototype-level applications and provides a practical solution for underground cable monitoring.

LITERATURE SURVEY

A study by A. Sharma et al. proposed a Time Domain Reflectometry (TDR)-based underground cable fault detection system, which accurately identifies fault locations by analyzing reflected signals. Although the system provides high accuracy, it requires complex hardware and signal processing, making it expensive and difficult to implement in small-scale applications. Another work by R. Kumar et al. introduced a microcontroller-based fault detection system that uses voltage and current variations to detect faults. While this system improves automation, it lacks real-time monitoring and remote access capabilities.

Research by S. Patel et al. presented an IoT-based underground cable monitoring system using GSM communication. This system enables remote fault reporting through mobile networks, but it has limitations such as high operational cost and limited scalability. Similarly, M. Reddy et al. developed a sensor-based system using IR sensors for detecting surface-level damage. This approach is simple and cost-effective but cannot detect internal faults or provide accurate location tracking.

Another study by K. Singh et al. proposed a wireless IoT-based monitoring system that uses cloud platforms for real-time data visualization. Although the system provides continuous monitoring, it requires complex configuration and consumes more power. From the above studies, it is evident that existing systems either focus on internal fault detection or involve high complexity and cost. The proposed system overcomes these limitations by providing a simple, low-cost, and real-time solution using IR and ultrasonic sensors along with IoT-based cloud monitoring and GPS-based fault location tracking.

EXISTING METHOD

The existing underground cable fault detection systems mainly rely on traditional electrical testing techniques and manual inspection methods. One of the commonly used methods is Time Domain Reflectometry (TDR), where a signal pulse is transmitted through the cable and reflections are analyzed to detect faults. This method provides accurate fault location but requires expensive equipment and complex signal processing. Other techniques such as Murray loop and Varley loop tests are also used, which calculate fault distance based on resistance measurements in the cable. These methods require cable disconnection and skilled personnel for operation.

In addition to these methods, microcontroller-based systems have been developed that detect faults using voltage and current variations. These systems provide some level of automation but are limited to controlled environments and do not support continuous monitoring. Most existing systems operate in a reactive manner, meaning faults are detected only after a failure occurs. This leads to delays in fault identification and increased downtime. Furthermore, these systems lack remote monitoring and IoT integration, making it difficult to access fault data from remote locations.

Disadvantages:

- Requires manual inspection and skilled manpower
- No real-time monitoring capability
- High maintenance and equipment cost
- Requires cable shutdown during testing
- Time-consuming fault detection process

PROPOSED METHOD

The proposed system introduces an IoT-based underground cable fault detection approach that focuses on detecting physical damage and obstacles along the cable route using sensor technology. The system uses a Raspberry Pi Pico W as the central controller, which processes data from sensors and manages communication. An Infrared (IR) sensor is used to detect physical damage or break conditions by sensing changes in reflected infrared signals, while an ultrasonic sensor is used to detect obstacles by measuring distance variations near the cable path. The controller continuously monitors sensor data and compares it with predefined threshold values to identify abnormal conditions.When a fault or obstacle is detected, the system immediately activates alert mechanisms such as LED indicators, a buzzer, and an LCD display to provide local notification. The LCD displays real-time fault information, enabling easy understanding of system status. In addition, a GPS module is integrated to capture the geographical location of the detected fault, which helps in quick identification and reduces maintenance time. The system also uses Wi-Fi communication to transmit sensor data, fault status, and location information to the ThingSpeak cloud platform for remote monitoring and analysis.The proposed system offers several advantages over existing methods, including real-time monitoring, reduced maintenance cost, and automated alert generation. It eliminates the need for complex equipment and manual inspection, making it simple and cost-effective. The integration of IoT enables remote access to system data, while GPS-based location tracking improves fault localization accuracy. Overall, the proposed system provides an efficient, low-cost, and scalable solution for underground cable monitoring and demonstrates the practical application of embedded systems and IoT technology.

ARCHITECTURE

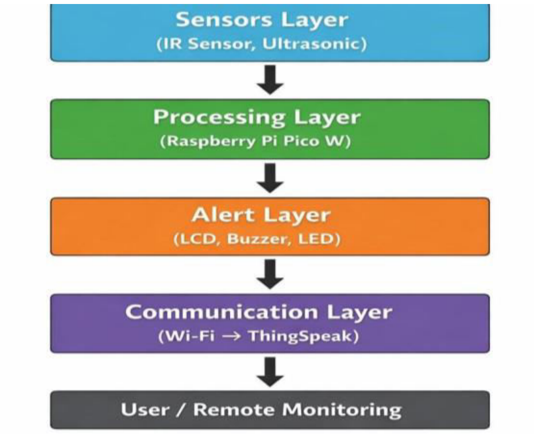

Fig 1 System architecture

METHODOLOGY DESCRIPTION

The proposed underground cable fault detection system is designed based on a modular approach, where each module performs a specific function such as sensing, processing, alerting, and communication. The system operation begins when power is supplied to the Raspberry Pi Pico W, which acts as the central controller. It initializes all connected components including sensors, LCD display, GPS module, and communication modules. Once initialized, the system starts continuous monitoring of the underground cable route using sensors.

In the first stage, the IR sensor monitors the cable surface to detect physical damage or break conditions. During normal operation, the IR sensor reflects signals normally, indicating a healthy cable condition. If any disturbance or break occurs, the reflected signal changes, and the sensor sends a fault signal to the controller. In the second stage, the ultrasonic sensor continuously measures the distance between the sensor and surrounding objects. If an obstacle is present near the cable route, the measured distance decreases, indicating an abnormal condition.

The Raspberry Pi Pico W processes the data received from both sensors and compares it with predefined threshold values. If any abnormal condition is detected, the controller immediately activates the alert system. The alert system consists of LED indicators, a buzzer, and an LCD display. The LEDs provide visual indication, the buzzer generates an audible alert, and the LCD displays fault information such as “Cable Fault Detected” or obstacle status.

Simultaneously, the GPS module captures the geographical coordinates of the fault location. This location data helps in identifying the exact position of the fault, reducing the time required for maintenance. The system then uses the built-in Wi-Fi capability of the Raspberry Pi Pico W to transmit sensor data, fault status, and location information to the ThingSpeak cloud platform. This enables remote monitoring of the system in real time.

Thus, the system operates continuously by sensing, processing, alerting, and communicating data, ensuring quick detection of faults and efficient monitoring of underground cable conditions.

HARDWARE AND SOFTWARE REQUIREMENTS

Hardware Components

Raspberry Pi Pico W:

The Raspberry Pi Pico W acts as the central controller of the system. It processes sensor data, controls output devices, and manages communication with the cloud. It has built-in Wi-Fi, which enables IoT-based remote monitoring.

IR Sensor:

The IR sensor is used to detect physical damage or break conditions along the cable route. It works by sensing changes in reflected infrared signals. When a fault occurs, the sensor output changes and sends a signal to the controller.

Ultrasonic Sensor:

The ultrasonic sensor is used to detect obstacles near the cable path. It measures distance using sound waves and identifies abnormal conditions when the distance falls below a threshold value.

LCD Display (16×2):

The LCD display is used to show real-time system status and fault information. It helps users understand the condition of the cable and displays messages such as fault detection and sensor readings.

GPS Module:

The GPS module provides the geographical location of the detected fault. It sends latitude and longitude data to the controller, which helps in quick fault localization and maintenance.

Buzzer:

The buzzer is used to generate an audible alert when a fault is detected. It ensures that nearby personnel are immediately notified of abnormal conditions.

LED Indicators:

LEDs are used as visual indicators to represent system status. They indicate normal operation or fault conditions, making it easy to identify system behavior.

Software Requirements

Embedded C/C++:

The system is programmed using Embedded C/C++, which controls sensor operation, data processing, and alert generation.

Arduino IDE:

Arduino IDE is used for writing, compiling, and uploading the program to the Raspberry Pi Pico W. It provides a user-friendly interface for development.

ThingSpeak Cloud Platform:

ThingSpeak is used for remote monitoring and data visualization. It displays sensor data and fault information in graphical form.

Wi-Fi Libraries:

Wi-Fi libraries are used to connect the system to the internet and send data to the cloud platform for real-time monitoring.

RESULTS AND DISCUSSION

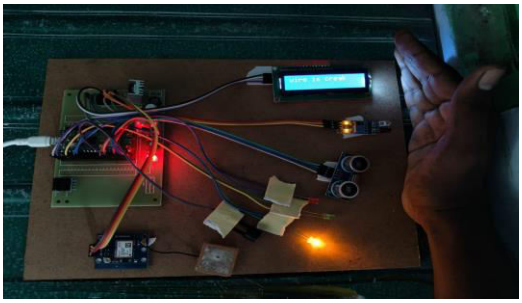

Fig 2.1: LCD Display Showing Cable Fault Detection

The LCD display shows the fault message when a cable break is detected. The IR sensor senses the physical damage and sends a signal to the controller. The Raspberry Pi Pico W processes the signal and activates the alert system. This confirms successful detection of cable faults.

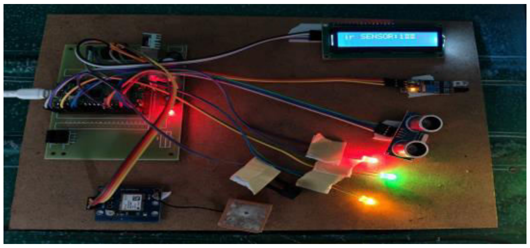

Fig 2.2: Normal Condition Monitoring Output

The system operates normally when no fault is present, as indicated by the IR sensor value being 1. The ultrasonic sensor shows standard distance readings, confirming no obstacle. The system continuously monitors without triggering alerts. This ensures proper functioning under normal conditions.

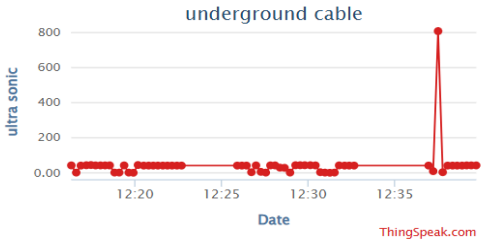

Fig 2.3: Ultrasonic Sensor Graph Output

The graph represents distance measurements from the ultrasonic sensor over time. A sudden variation in the graph indicates the presence of an obstacle near the cable path. This shows that the system can effectively detect physical disturbances. The data is successfully transmitted to the cloud.

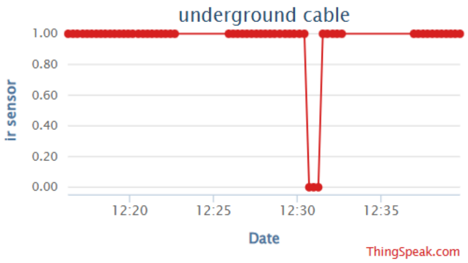

Fig 2.4: IR Sensor Graph Output

The IR sensor graph shows a change from 1 to 0 when a fault occurs. This indicates detection of physical damage in the cable route. The system immediately updates the cloud platform with fault data. This confirms real-time monitoring capability.

```
Distance: 52
28.545799;77.170303
 ir: 1
Distance: 52
28.545799;77.170303
 ir: 1
Distance: 52
28.545799;77.170303
 ir: 1
Distance: 52
28.545799;77.170303
 ir: 0
Distance: 51
28.545799;77.170303
 ir: 0
Distance: 51
```

Fig 2.5: Serial Monitor Output with GPS Data

The serial monitor displays real-time values such as distance, IR status, and

GPS coordinates. This helps in verifying system performance and debugging. The GPS values provide location information for the detected fault. This ensures accurate fault localization.

CONCLUSION

The proposed IoT-based underground cable fault detection system successfully demonstrates a simple and effective method for monitoring physical damage and obstacles along underground cable routes. The system uses sensors such as IR and ultrasonic sensors to continuously monitor cable conditions and detect abnormalities in real time. The Raspberry Pi Pico W processes the sensor data and activates alert mechanisms including LCD display, buzzer, and LED indicators when a fault is detected. The integration of a GPS module helps in identifying the location of the fault, while the use of Wi-Fi enables remote monitoring through the ThingSpeak cloud platform. This system reduces manual inspection, improves response time, and minimizes maintenance cost. Overall, the project provides a low-cost, reliable, and efficient solution for underground cable monitoring and is suitable for prototype-level and academic applications.

FUTURE ENHANCEMENT

The proposed system can be further improved by integrating advanced technologies to enhance its performance and applicability in real-world scenarios. Artificial Intelligence (AI) and Machine Learning (ML) algorithms can be used for predictive fault analysis and early detection of potential failures. The system can also be extended by adding additional sensors such as temperature, vibration, and moisture sensors to improve accuracy. Mobile application integration can be implemented for real-time monitoring and instant notifications. The system can be upgraded to support solar power for energy efficiency and continuous operation. Furthermore, advanced communication technologies such as LoRa or 5G can be used for long-distance monitoring. These enhancements will make the system more robust, scalable, and suitable for smart city infrastructure applications.

REFERENCES

[1] Arm Ltd., “AMBA Specification Overview,” 2020.

[2] Arm Ltd., “AMBA APB Protocol Specification,” 2021.

[3] A. Sharma and P. Gupta, “Underground Cable Fault Detection Using IoT,” *IJERT*, 2020.

[4] R. Kumar and S. Singh, “Smart Cable Monitoring System,” *IEEE Conference*, 2019.

[5] S. Patel et al., “IoT-Based Monitoring System,” *International Journal*, 2021.

[6] M. Reddy and K. Rao, “Sensor-Based Fault Detection,” *IEEE*, 2022.

[7] K. Singh, “Wireless Monitoring Using IoT,” *IEEE Access*, 2022.

[8] P. Kumar, “Smart Infrastructure Monitoring,” *IEEE IoT Journal*, 2020.

[9] L. Wang, “Sensor Networks,” *IEEE Sensors Journal*, 2019.

[10] D. Lee, “IoT Systems,” *IEEE Transactions*, 2019.

[11] S. Karthik, “Verification Systems,” *IEEE*, 2021.

[12] D. Anil Kumar, “Coverage Techniques,” *IEEE*, 2020.

[13] R. Srinivas, “System Verilog Verification,” *IEEE*, 2021.

[14] K. Ravi Kumar, “Low Power Systems,” *IJERT*, 2021.

[15] A. Brown, *Embedded Systems*, Pearson, 2018.

[16] M. Morris, *Embedded Systems Design*, McGraw-Hill, 2019.

[17] S. Monk, *Programming Arduino*, McGraw-Hill, 2017.

[18] Raspberry Pi Foundation, “Pico W Datasheet,” 2023.

[19] Arduino, “Arduino IDE Documentation,” 2022.

[20] ThingSpeak, “IoT Cloud Platform,” 2021.