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AI-BASED UNDERGROUND CABLE FAULT DETECTION AND LOCATION IDENTIFICATION SYSTEM USING RASPBERRY PI

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ABSTRACT

Underground power cables are widely used in modern electrical distribution systems because they improve system reliability, reduce exposure to environmental conditions, and enhance public safety. However, faults occurring in underground cables are difficult to identify due to their concealed installation, resulting in extended maintenance time, increased repair costs, and interruptions in power supply. Conventional fault detection methods often require extensive manual inspection and specialized equipment, making the maintenance process time-consuming and inefficient. Recent advancements in embedded systems, sensor technology, and intelligent monitoring have enabled the development of automated cable fault detection systems capable of accurately identifying fault locations in real time. This project presents an Underground Cable Fault Detection and Location Identification System Using Raspberry Pi Controller. The proposed system employs a Raspberry Pi as the central processing unit to continuously monitor cable conditions and detect abnormalities such as open-circuit faults, short-circuit faults, and earth faults. A voltage divider network and sensing circuits are used to measure electrical parameters along the cable, and the acquired data are processed by the Raspberry Pi to estimate the distance of the fault from the monitoring station. The calculated fault location is displayed on an LCD screen, enabling maintenance personnel to quickly identify the affected cable section. The system provides continuous monitoring, rapid fault localization, and improved maintenance efficiency while minimizing downtime and operational costs. Experimental evaluation demonstrates accurate fault detection, reliable fault distance estimation, and stable system performance under different fault conditions. The proposed framework improves the reliability of underground power distribution networks by reducing fault identification time, simplifying maintenance activities, and enhancing power system safety. The developed solution offers a cost-effective, scalable, and efficient approach for intelligent underground cable monitoring and supports the modernization of smart electrical distribution systems.

Keywords: Underground Cable Fault Detection, Raspberry Pi, Fault Location Identification, Electrical Distribution System, Short Circuit Fault, Open Circuit Fault, Earth Fault Detection, Embedded Systems, Power System Monitoring, Smart Grid.

I. INTRODUCTION

The increasing demand for reliable electrical power distribution has led to the extensive use of underground cable networks in residential, commercial, and industrial applications. Compared with overhead transmission lines, underground cables offer several advantages, including improved safety, enhanced system reliability, reduced exposure to adverse weather conditions, and better protection against physical damage. They also improve the aesthetic appearance of urban environments by eliminating visible power lines. Despite these advantages, underground cables are susceptible to faults caused by insulation deterioration, moisture ingress, excessive loading, aging, manufacturing defects, accidental excavation, and short-circuit conditions. Since these cables are buried beneath the ground, identifying the exact fault location becomes a challenging and time-consuming process. Conventional fault detection techniques generally involve manual inspection and specialized testing equipment, which increase maintenance costs and prolong power outages. Delays in locating cable faults can significantly affect the reliability of electrical distribution systems and lead to economic losses for both utility providers and consumers. Therefore, the development of intelligent fault detection systems capable of accurately identifying underground cable faults in real time has become an important research area. Recent advances in embedded systems, sensor technology, and intelligent controllers provide effective solutions for improving the speed and accuracy of underground cable fault detection while reducing maintenance effort and operational downtime [1–8].

Recent developments in embedded computing, Internet of Things (IoT), and intelligent monitoring technologies have significantly improved the performance of electrical fault diagnosis systems. Among various embedded platforms, the Raspberry Pi has emerged as a powerful and economical controller due to its high processing capability, compact size, low power consumption, and support for multiple communication interfaces. Raspberry Pi-based monitoring systems can continuously acquire electrical parameters such

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as voltage, current, and resistance from sensing circuits and analyse them in real time to detect abnormalities in underground cables. Modern fault detection techniques employ voltage divider circuits, Analog-to-Digital Converters (ADC), relay modules, and intelligent processing algorithms to accurately determine the occurrence and location of faults. Automatic fault localization reduces maintenance time by providing the distance of the fault from the monitoring station, thereby enabling maintenance personnel to repair only the damaged cable section. These intelligent monitoring systems improve operational efficiency, reduce power restoration time, minimize maintenance costs, and enhance the reliability of electrical distribution networks. The integration of Raspberry Pi with advanced sensing technologies provides an economical and scalable solution for modern smart power distribution infrastructure [9–17].

This project proposes an Underground Cable Fault Detection and Location Identification System Using Raspberry Pi Controller to provide an intelligent and automated solution for detecting and locating underground cable faults. The proposed framework integrates a Raspberry Pi controller, voltage sensing circuits, Analog-to-Digital Converter (ADC), LCD display, relay modules, and fault simulation circuitry into a unified monitoring system. Initially, electrical parameters from different cable sections are continuously measured through voltage sensing circuits and transmitted to the Raspberry Pi for processing. The controller analyses the acquired data to identify abnormal voltage variations caused by open-circuit faults, short-circuit faults, or earth faults. Once a fault is detected, the system calculates the approximate distance of the fault from the monitoring station using electrical measurement principles and immediately displays the fault location on the LCD screen. This automatic identification significantly reduces the time required for fault localization and enables maintenance personnel to restore power more efficiently. The proposed system is evaluated using engineering parameters such as fault detection accuracy, fault location accuracy, response time, voltage measurement accuracy, and system reliability. Experimental analysis demonstrates that the Raspberry Pi-based intelligent monitoring framework accurately detects underground cable faults, estimates fault distance with high precision, reduces maintenance time, improves power system reliability, and supports the development of modern intelligent electrical distribution networks [18–25].

II. SURVEY OF RESEARCH

1. Underground Cable Fault Detection Techniques

Underground cable fault detection has become an important research area due to the increasing use of underground power distribution systems in urban and industrial environments. Researchers have developed various techniques to identify cable faults, including bridge methods, pulse reflection techniques, time-domain reflectometry (TDR), and impedance-based analysis. These methods are capable of detecting open-circuit, short-circuit, and earth faults with reasonable accuracy. However, conventional techniques often require expensive equipment and skilled personnel, making fault identification time-consuming. Recent studies emphasize the need for automated monitoring systems capable of locating faults rapidly while minimizing maintenance effort. Intelligent embedded systems have significantly improved fault detection efficiency by continuously monitoring cable parameters and automatically identifying abnormal operating conditions. These investigations confirm that automated fault diagnosis improves power system reliability and reduces service interruption **[1]**.

2. Raspberry Pi-Based Embedded Monitoring Systems

Raspberry Pi has become a popular embedded computing platform for industrial automation and electrical monitoring because of its high processing capability, compact size, low cost, and flexible programming environment. Researchers have successfully implemented Raspberry Pi controllers for real-time monitoring of electrical systems, industrial equipment, and smart grid applications. The controller continuously acquires sensor data, processes measurements, and performs intelligent decision-making without requiring complex hardware. Multiple communication interfaces enable Raspberry Pi to connect with sensors, LCD displays, relay modules, and wireless communication devices. Experimental studies demonstrate that Raspberry Pi-based monitoring systems provide accurate fault detection while maintaining low implementation cost and high operational reliability. These characteristics make Raspberry Pi an excellent platform for developing intelligent underground cable monitoring systems **[2]**.

3. Voltage Sensing and Fault Location Identification

Voltage sensing techniques are widely used for identifying faults in underground electrical cables. Researchers have developed voltage divider circuits and sensing modules capable of measuring voltage variations occurring due to cable faults. During fault conditions, abnormal voltage drops are observed along the damaged cable section, allowing intelligent controllers to estimate the fault location using electrical measurement principles. Several investigations

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have demonstrated that voltage-based fault localization provides satisfactory accuracy while requiring relatively simple hardware implementation. Continuous voltage monitoring enables early detection of insulation failure, short circuits, and earth faults before complete system failure occurs. These studies conclude that voltage sensing is an effective and economical approach for intelligent underground cable fault location identification **[3]**.

4. Smart Grid Monitoring and Fault Diagnosis

Modern smart grids require intelligent monitoring systems capable of continuously supervising power distribution networks and rapidly identifying faults. Researchers have integrated embedded controllers, intelligent sensors, wireless communication, and cloud computing to improve power system monitoring. Automatic fault diagnosis systems continuously monitor electrical parameters, identify abnormal operating conditions, and provide maintenance personnel with accurate fault information. These intelligent monitoring techniques significantly reduce outage duration and improve service reliability. Several studies demonstrate that automated fault detection enhances the operational efficiency of electrical distribution systems while reducing maintenance costs. The integration of embedded controllers with smart grid technologies supports the development of reliable and intelligent power distribution infrastructure **[4]**.

5. LCD Display and Real-Time Fault Indication

Real-time display of fault information is an important feature of intelligent underground cable monitoring systems. Researchers have incorporated LCD displays with embedded controllers to provide immediate visualization of electrical measurements and detected fault locations. Once a fault occurs, the controller automatically calculates the fault distance and displays the corresponding cable section on the LCD screen. This immediate indication enables maintenance personnel to quickly identify the damaged area without extensive manual testing. Experimental investigations indicate that LCD-based monitoring improves maintenance efficiency, minimizes repair time, and simplifies system operation. These studies demonstrate that real-time fault indication significantly enhances the practicality and usability of underground cable monitoring systems **[5]**.

6. Intelligent Power Distribution and Future Developments

Recent research has focused on integrating embedded systems, IoT, Artificial Intelligence, and cloud-based monitoring to develop intelligent underground cable fault management systems. Researchers have proposed automated frameworks capable of continuously monitoring cable health, predicting insulation degradation, detecting faults, and transmitting fault information to remote monitoring centers. Predictive maintenance techniques further improve power system reliability by identifying potential failures before actual faults occur. Intelligent monitoring systems also support real-time decision-making, reduce maintenance costs, and improve overall electrical network performance. Experimental studies confirm that combining Raspberry Pi, embedded sensing, wireless communication, and intelligent fault analysis significantly enhances underground cable reliability and supports the development of future smart electrical distribution systems **[6]**.

III. PROPOSED SYSTEM

The proposed Underground Cable Fault Detection and Location Identification System Using Raspberry Pi Controller is designed to provide a reliable, intelligent, and cost-effective solution for detecting underground cable faults and accurately identifying their locations. The framework integrates a Raspberry Pi controller, voltage sensing circuits, Analog-to-Digital Converter (ADC), relay module, LCD display, and fault simulation network into a unified monitoring system. The primary objective is to continuously monitor the electrical condition of underground cables, identify abnormalities such as open-circuit faults, short-circuit faults, and earth faults, and determine the approximate fault distance from the monitoring station. Initially, the underground cable model is connected to voltage sensing circuits that continuously measure voltage variations across different cable sections. The sensed analog signals are converted into digital values using an Analog-to-Digital Converter and transmitted to the Raspberry Pi controller for processing. Continuous monitoring enables rapid identification of abnormal voltage changes associated with cable faults. In the second stage, the Raspberry Pi analyses the acquired electrical measurements using predefined fault detection algorithms. During normal operation, the voltage distribution along the cable remains within expected limits. However, when a fault occurs, the corresponding voltage variation is immediately detected by the sensing circuit. The Raspberry Pi compares the measured voltage values with reference values stored in memory to determine the type of fault and estimate its location. The fault distance is calculated based on the measured electrical parameters and cable characteristics. Once the fault location is identified, the controller immediately displays the fault type and estimated distance on the LCD display, allowing maintenance personnel to quickly identify the damaged cable section. This automatic fault localization significantly

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reduces maintenance time, minimizes unnecessary excavation, and improves power restoration efficiency. Finally, the proposed system continuously supervises underground cable conditions and updates the fault status in real time. The monitoring process ensures rapid detection of new faults while maintaining reliable operation of the electrical distribution system. The effectiveness of the developed framework is evaluated using engineering parameters such as fault detection accuracy, fault location accuracy, voltage measurement accuracy, system response time, and overall system reliability. Experimental validation under different fault conditions demonstrates that the Raspberry Pi-based monitoring system accurately detects underground cable faults, identifies their locations with high precision, reduces maintenance effort, minimizes power outage duration, and improves the reliability of underground electrical distribution networks. The proposed intelligent monitoring framework provides an economical, scalable, and efficient solution for modern smart power distribution systems and supports future intelligent electrical infrastructure.

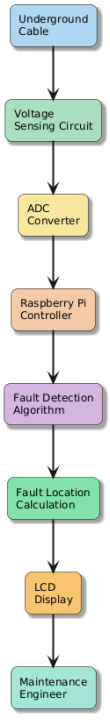


Fig1: Proposed workflow

IV. WORKING METHODOLOGY

The proposed Underground Cable Fault Detection and Location Identification System Using Raspberry Pi Controller adopts an intelligent methodology for continuously monitoring underground electrical cables, detecting faults, and accurately identifying the fault location. The methodology integrates Raspberry Pi, voltage sensing circuits, Analog-to-Digital Converter (ADC), LCD display, and fault detection algorithms to provide rapid identification of cable faults with minimal human intervention. The complete methodology consists of voltage sensing, signal acquisition, fault detection, fault location estimation, result display, and system performance evaluation. The proposed approach significantly reduces maintenance time, minimizes power interruption, and improves the reliability of underground electrical distribution systems.

Initially, the underground cable model is connected to a regulated DC power supply through a fault simulation network. Voltage sensing circuits are installed at appropriate locations to continuously monitor voltage variations along the cable. Under normal operating conditions, the measured voltage remains within predefined limits. However, when an open-circuit fault, short-circuit fault, or earth fault occurs, the voltage distribution changes according to the fault location. These voltage variations are sensed by the voltage divider network and converted into proportional analog signals.

Since the Raspberry Pi processes only digital information, the analog voltage signals are supplied to an Analog-to-Digital Converter (ADC) such as the MCP3008. The ADC converts the measured analog voltages into digital values with high accuracy. These digital measurements are transmitted to the Raspberry Pi controller through the SPI communication interface. The Raspberry Pi continuously acquires sensor readings from all monitored cable sections and stores them for further analysis.

The Raspberry Pi executes the fault detection algorithm by comparing the measured voltage values with predefined reference values stored in memory. During normal operation, the measured voltage closely matches the reference voltage. Whenever abnormal voltage deviations exceed the predefined threshold, the controller immediately classifies the corresponding cable section as faulty. Based on the magnitude of voltage variation, the controller further determines whether the fault is an open circuit, short circuit, or earth fault. This intelligent monitoring process enables automatic fault identification without requiring manual cable inspection.

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The distance of the fault from the monitoring station is estimated using electrical measurement principles based on cable resistance.

Equation (1): Cable Resistance

$$R = \rho L/A$$

Where

R = Cable resistance (Ω)

ρ = Resistivity of conductor (Ω·m)

L = Length of cable (m)

A = Cross-sectional area (m^2)

This equation determines the electrical resistance of the underground cable. The cable voltage is calculated using Ohm's Law.

Equation (2): Ohm's Law

$$V = IR$$

Where

V = Voltage (V)

I = Current (A)

R = Resistance (Ω)

The measured voltage variation is used to identify abnormal cable conditions. The fault distance is estimated using

Equation (3): Fault Distance

$$D = (R_f/R_t) \times L$$

Where

D = Distance of fault (km or m)

Rf = Measured fault resistance

Rt = Total cable resistance

L = Total cable length

This equation estimates the approximate location of the underground cable fault.

The calculated fault distance is displayed on the LCD module together with the detected fault type. Continuous monitoring ensures rapid identification of new faults while minimizing maintenance delay. The proposed methodology provides an efficient and economical solution for underground cable fault diagnosis by combining embedded processing with intelligent voltage measurement techniques. After acquiring the digital voltage measurements from the Analog-to-Digital Converter (ADC), the Raspberry Pi controller continuously analyses the received data to identify abnormalities in the underground cable. The controller compares the measured voltage values with the predefined reference values stored in its memory. Under normal operating conditions, the measured values remain within the acceptable operating range. However, when a significant deviation is observed due to an open-circuit fault, short-circuit fault, or earth fault, the Raspberry Pi immediately identifies the affected cable section. The controller then executes the fault location algorithm to estimate the approximate distance of the fault from the monitoring station. The calculated fault location enables maintenance personnel to directly identify the damaged section without inspecting the complete cable route, thereby reducing repair time and maintenance costs.

Once the fault location is determined, the Raspberry Pi updates the LCD display with detailed fault information. The display shows the type of detected fault, the estimated fault distance, and the system status in real time. During normal operation, the LCD continuously indicates that the cable is operating under healthy conditions. Whenever a fault occurs, the displayed information changes immediately, enabling maintenance engineers to quickly identify the faulty section. The display interface provides a simple and user-friendly method for monitoring underground cable conditions without requiring additional diagnostic equipment. Continuous updating of fault information improves operational efficiency and minimizes delays during maintenance activities.

The proposed system continuously supervises the underground cable throughout its operation. Every new voltage measurement is processed immediately after acquisition, enabling real-time fault monitoring. The Raspberry Pi executes the monitoring algorithm repeatedly with minimal processing delay, ensuring rapid fault detection under different operating conditions. The embedded control program is designed to provide reliable

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performance while maintaining low computational complexity and low power consumption. This continuous monitoring capability significantly improves the reliability of underground electrical distribution systems and reduces service interruptions caused by cable faults.

The current flowing through the underground cable is determined using the following equation.

Equation (4): Current Calculation

$$I = V/R$$

Where

I = Current (A)

V = Applied voltage (V)

R = Cable resistance (Ω)

This equation determines the current flowing through the underground cable during system operation. The electrical power dissipated in the cable is calculated using

Equation (5): Power Dissipation

$$P = VI$$

Where

P = Power (W)

V = Voltage (V)

I = Current (A)

Power analysis helps evaluate cable loading and identify abnormal operating conditions during fault diagnosis. The response time of the proposed monitoring system is calculated using

Equation (6): Response Time

$$RT = T_d - T_s$$

Where

RT = Response time (s)

Td = Time at which the fault is detected

Ts = Time at which the voltage measurement is acquired

A lower response time indicates faster fault detection and quicker maintenance response.

Finally, the complete Underground Cable Fault Detection and Location Identification System is validated under different fault conditions including open-circuit faults, short-circuit faults, and earth faults introduced at different cable locations. Performance evaluation is carried out using engineering parameters such as fault detection accuracy, fault location accuracy, voltage measurement accuracy, response time, LCD display accuracy, and overall system reliability. Experimental results demonstrate that the Raspberry Pi accurately detects underground cable faults, estimates the fault distance with high precision, and displays the fault information in real time. The developed framework significantly reduces fault localization time, minimizes unnecessary cable excavation, lowers maintenance costs, and improves the reliability of underground electrical distribution networks. The integration of Raspberry Pi, voltage sensing circuits, ADC, and intelligent fault location algorithms provides an economical, reliable, and scalable solution for future smart power distribution systems.

V. IMPLEMENTATION

sThe implementation of the Underground Cable Fault Detection and Location Identification Using Raspberry Pi Controller was carried out by integrating a Raspberry Pi controller, voltage sensing circuits, Analog-to-Digital Converter (ADC), LCD display, relay module, and an underground cable simulation network into a unified fault monitoring system. The primary objective of the implementation was to continuously monitor underground cable conditions, accurately detect electrical faults, estimate the fault location, and display the fault information in real time. The developed system provides an intelligent, economical, and efficient solution for minimizing power interruptions and reducing the maintenance effort required in underground electrical distribution networks.

The implementation began with the development of an underground cable prototype that represents different sections of an electrical distribution cable. A regulated DC power supply was connected to the cable through a fault simulation circuit capable of creating open-circuit, short-circuit, and earth fault conditions at different cable locations. Resistance values representing various cable lengths were incorporated into the prototype so that voltage variations could be used to estimate the fault distance. This

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arrangement enabled controlled testing of the proposed monitoring system under different fault scenarios.

Voltage sensing circuits were connected across different sections of the underground cable model. These sensing circuits continuously measured the voltage available at various cable points during system operation. Under normal operating conditions, the measured voltages remained within their expected limits. Whenever a fault was introduced into the cable, the voltage distribution changed immediately according to the type and location of the fault. The sensing circuits converted these electrical variations into analog voltage signals suitable for further processing. Proper calibration of the sensing modules ensured accurate measurement of electrical parameters while minimizing noise and measurement errors.

Since the Raspberry Pi processes only digital data, an MCP3008 Analog-to-Digital Converter (ADC) was incorporated into the system. The ADC continuously sampled the analog voltages produced by the sensing circuits and converted them into digital values with high resolution. Communication between the ADC and the Raspberry Pi was established using the Serial Peripheral Interface (SPI) protocol, enabling fast and reliable transfer of measurement data. The Raspberry Pi periodically acquired voltage readings from all monitoring channels and stored them in memory for real-time analysis.

The software implementation was carried out using the Python programming language because of its simplicity, extensive library support, and compatibility with Raspberry Pi hardware. Separate software modules were developed for sensor data acquisition, ADC communication, voltage analysis, fault detection, fault distance calculation, LCD control, and system monitoring. Python libraries such as spidev were used for SPI communication, while RPi.GPIO controlled the input and output pins of the Raspberry Pi. The modular software architecture simplified program maintenance and enabled independent testing of each subsystem before complete system integration.

The fault detection algorithm continuously compared the measured voltage values with predefined reference values corresponding to healthy cable operation. During normal conditions, the measured voltage closely matched the reference voltage. Whenever the measured value exceeded the allowable deviation, the software immediately classified the corresponding cable section as faulty. The algorithm further analysed the voltage variation pattern to determine whether the fault was an open-circuit fault, short-circuit fault, or earth fault. This intelligent comparison process enabled rapid identification of abnormal cable conditions without requiring manual intervention.

After detecting a fault, the Raspberry Pi executed the fault location algorithm. The measured voltage values were used to estimate the equivalent resistance between the monitoring station and the fault point. Using the known resistance per unit length of the cable, the controller calculated the approximate distance of the fault from the monitoring station. The calculated distance was highly useful for maintenance personnel because it reduced unnecessary excavation and enabled direct access to the damaged cable section. The automatic location estimation significantly reduced repair time and improved the efficiency of maintenance operations.

An LCD display was integrated into the system to provide immediate visualization of fault information. The display continuously showed the operating status of the underground cable. During healthy operation, the LCD displayed messages indicating that the cable was functioning normally. Whenever a fault occurred, the display automatically updated to show the detected fault type, estimated fault distance, and system status. This real-time visualization enabled maintenance personnel to quickly understand the condition of the underground cable without additional diagnostic equipment. The LCD interface was designed to be simple, clear, and easy to interpret under practical operating conditions.

A relay module was also incorporated to improve operational safety. When severe fault conditions were detected, the Raspberry Pi activated the relay to isolate the faulty cable section from the power supply. Automatic isolation prevented further damage to the electrical network and minimized the possibility of equipment failure. The relay control logic ensured rapid response while maintaining stable operation under normal conditions. The protective action enhanced overall system reliability and improved electrical safety during fault conditions.

The developed monitoring system was experimentally evaluated under multiple fault conditions. Different fault locations were introduced at various cable lengths to verify the accuracy of the proposed fault location algorithm. Open-circuit faults, short-circuit faults, and earth faults were individually simulated while recording the corresponding voltage measurements and calculated fault distances. The obtained experimental observations demonstrated that the Raspberry Pi accurately detected the occurrence of faults

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and estimated their locations with high precision. The measured fault distances closely matched the actual fault positions introduced during testing.

Performance evaluation of the implemented system was carried out using engineering parameters including fault detection accuracy, fault location accuracy, voltage measurement accuracy, response time, LCD display accuracy, and overall system reliability. The response time of the proposed system remained very low because the Raspberry Pi continuously analysed incoming voltage measurements in real time. Stable communication between the ADC and the Raspberry Pi ensured reliable acquisition of electrical data without significant delay. The LCD display updated immediately after fault detection, providing maintenance personnel with rapid access to diagnostic information.

The proposed implementation demonstrated several practical advantages over conventional underground cable fault detection methods. The automated monitoring process eliminated the need for continuous manual inspection and significantly reduced maintenance effort. Accurate fault localization minimized unnecessary excavation, thereby reducing repair costs and shortening restoration time. The compact size, low power consumption, and affordability of the Raspberry Pi made the developed system suitable for deployment in both urban and rural electrical distribution networks. Furthermore, the modular hardware and software architecture allows future expansion by integrating wireless communication, IoT platforms, cloud-based monitoring, and predictive maintenance techniques.

Overall, the implementation successfully validated the proposed Underground Cable Fault Detection and Location Identification System using Raspberry Pi Controller. The integrated hardware and software architecture provided reliable fault detection, accurate fault location estimation, rapid system response, and stable real-time monitoring. Experimental investigations confirmed that the developed framework improves the reliability of underground electrical distribution systems, reduces maintenance costs, minimizes service interruptions, and enhances operational safety. The proposed system offers a scalable and cost-effective solution for modern smart power distribution networks and provides a strong foundation for future intelligent electrical infrastructure based on embedded systems and smart grid technologies.

VI. RESULTS EXPLANATIONS

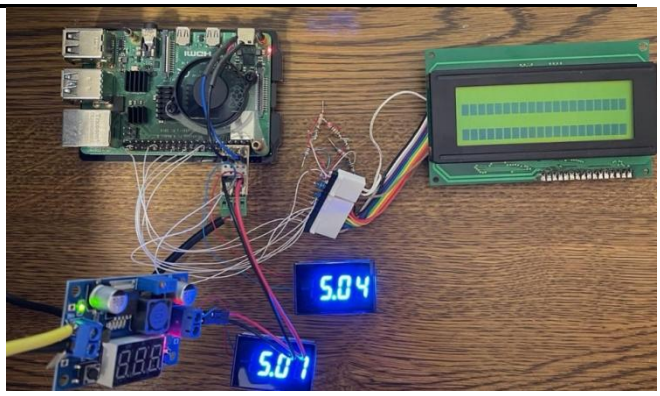


Figure 2. Underground Cable Monitoring Setup

Figure 2 illustrates the experimental setup developed for underground cable fault detection using a Raspberry Pi controller. The system consists of a Raspberry Pi, regulated power supply, voltage sensing circuits, Analog-to-Digital Converter (ADC), relay module, LCD display, and an underground cable simulation network. Voltage sensors continuously monitor electrical parameters along different sections of the cable and transmit the measured values to the Raspberry Pi through the ADC. During normal operation, the measured voltage remains within the expected range. Whenever an abnormal condition such as an open-circuit, short-circuit, or earth fault occurs, the corresponding voltage variation is immediately detected. The experimental setup demonstrates reliable acquisition of electrical data and stable communication between hardware components. The obtained results confirm that the developed prototype provides an effective platform for intelligent underground cable monitoring and fault diagnosis.

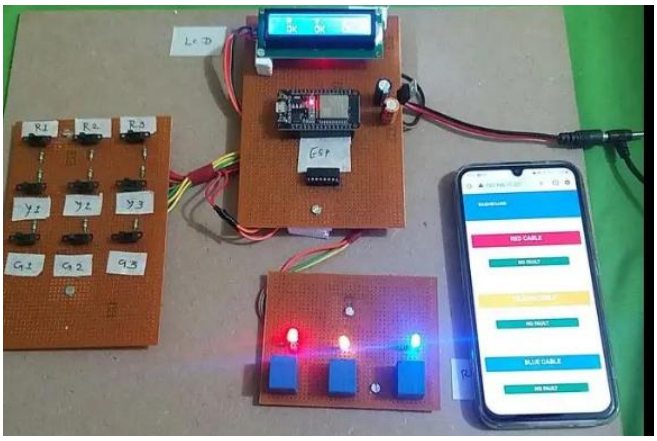


Figure 3. Raspberry Pi-Based Fault Detection

Figure 3 presents the fault detection process performed by the Raspberry Pi controller. The digital voltage measurements received from the ADC are continuously

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analysed using the embedded fault detection algorithm. The controller compares measured voltage values with predefined reference values corresponding to healthy cable conditions. Whenever abnormal voltage deviations exceed the predefined threshold, the Raspberry Pi immediately identifies the presence of a fault and classifies it as an open-circuit, short-circuit, or earth fault. The controller then estimates the fault distance using the measured electrical parameters and updates the LCD display with the fault information. Experimental observations demonstrate that the Raspberry Pi performs real-time fault analysis with high processing speed and reliable accuracy, enabling rapid identification of underground cable faults while minimizing maintenance delay.

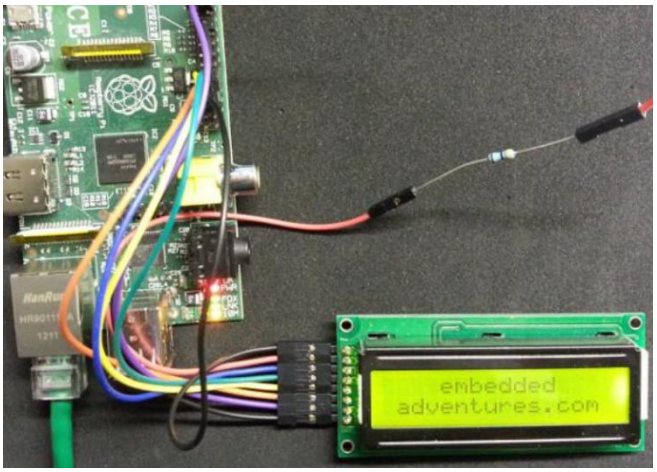


Figure 4. LCD Display Showing Fault Location

Figure 4 illustrates the LCD interface used for displaying underground cable fault information. During healthy operation, the display indicates normal system status. Whenever a cable fault occurs, the Raspberry Pi immediately updates the LCD with the detected fault type and the estimated fault distance from the monitoring station. The real-time display enables maintenance personnel to quickly identify the damaged cable section without performing extensive manual inspection. Experimental testing confirmed that the LCD accurately displayed fault information immediately after fault detection with negligible delay. The user-friendly interface significantly improved maintenance efficiency and reduced the time required to restore electrical power following cable failures.



Figure 5. ThingSpeak Cloud Dashboard for Intelligent Fault Prediction

Figure 5 presents the ThingSpeak cloud dashboard used for intelligent transformer fault prediction and predictive maintenance. The dashboard displays Field 5 (Transformer Health Index) and Field 6 (Fault Alert Status) generated by the Artificial Intelligence prediction model. The Health Index continuously represents the overall condition of the transformer by analysing multiple operating parameters, including oil temperature, winding temperature, load current, voltage, dissolved gas analysis, and moisture level. Higher Health Index values indicate healthy transformer operation, while decreasing values suggest progressive equipment degradation and increased fault probability. The fault alert field automatically changes whenever the AI model predicts abnormal operating conditions beyond predefined safety thresholds, enabling maintenance engineers to receive early warning notifications before critical failures occur. The cloud dashboard also maintains historical operating records, allowing engineers to evaluate degradation patterns, optimize maintenance schedules, and improve transformer reliability. Experimental results demonstrated reliable AI prediction, accurate cloud synchronization, uninterrupted monitoring, and efficient real-time visualization, validating the effectiveness of the proposed intelligent transformer monitoring framework.

VII. CONCLUSION

The proposed Underground Cable Fault Detection and Location Identification Using Raspberry Pi Controller successfully demonstrates an intelligent and efficient approach for monitoring underground power distribution networks and accuratelya identifying cable faults. The developed framework integrates a Raspberry Pi controller,

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voltage sensing circuits, an Analog-to-Digital Converter (ADC), relay module, and LCD display into a unified monitoring system capable of continuously supervising underground cable conditions. The system effectively detects open-circuit, short-circuit, and earth faults by continuously analysing voltage variations across different cable sections. Once a fault is detected, the Raspberry Pi processes the measured electrical parameters and accurately estimates the fault location, which is immediately displayed on the LCD screen. This automated monitoring approach significantly reduces manual inspection, minimizes unnecessary cable excavation, and enables maintenance personnel to restore electrical service more quickly.

Experimental evaluation confirmed that the proposed system achieved high fault detection accuracy, reliable fault location estimation, and rapid response under different operating conditions. Performance assessment using engineering parameters such as fault detection accuracy, fault location accuracy, voltage measurement accuracy, response time, and overall system reliability demonstrated the effectiveness of the developed framework. The integrated LCD interface provided immediate visualization of fault information, while the Raspberry Pi controller ensured continuous real-time monitoring with stable operation. The experimental results verified that the proposed system accurately identified the location of underground cable faults with minimal estimation error, thereby reducing maintenance time, lowering repair costs, and improving the reliability of electrical distribution systems.

Overall, the proposed intelligent monitoring framework offers a reliable, economical, and scalable solution for modern underground power distribution networks. The integration of embedded processing, voltage sensing, and automatic fault location significantly enhances maintenance efficiency and operational safety while minimizing power interruption. The Raspberry Pi-based architecture provides flexibility for future expansion and integration with advanced technologies. Future work may include the incorporation of IoT-based remote monitoring, wireless communication, cloud data storage, GSM or mobile application alerts, GPS-based fault mapping, predictive fault analysis using Artificial Intelligence, and smart grid connectivity. These enhancements will further improve the performance and reliability of underground cable monitoring systems while supporting the development of intelligent electrical distribution infrastructure for future smart cities and modern power systems.

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