IoT based Underground Cable Fault Locators using Raspberry PI

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ABSTRACT - Underground cable faults due to underground conditions, short circuit and tear, natural disaster, etc. It can be challenging to identify the cause of a failure; therefore, in order to inspect and repair the entire line, it must be lifted off the ground. a Raspberry Pi-based system designed to locate faults in subterranean cable lines from the Internet of Things base station. Repairing is made incredibly simple by the cable fault detection over IoT, which pinpoints the precise location of the defect. To identify the cause of the defect, only the specific portion that has the malfunction needs to be removed. This facilitates quicker maintenance of subterranean cables while also saving a great deal of time, money, and effort. The Internet of Things technology enables the authorities to track and examine issues over the internet. The technology uses the potential divider network that is positioned across the cable to identify faults. A particular voltage is produced according to the resistor network combination whenever a fault is established at a spot where two lines are shorted together. The voltage sensor detects this voltage and updates the user over the internet. The user is informed of the distance to which that voltage is corresponding. The Raspberry Pi receives the fault line data and sends it over the internet to be shown online as well as on a liquid crystal display (LCD).To create an online system that connects to the system to show cable issues online, use an IOT Blank server.

I.INTRODUCTION

A few transmission lines are essential to any power system of an electrical utility. In this context, the expense of power supply and precise fault location for the transmission of electric lines are critical to the restoration of power services and the minimization of outage duration. It is crucial for all utilities to have a reliable source for precisely identifying and pinpointing defects on high-voltage transmission networks in order to promptly notify the responsible authority of a repair crew or person. Three types of cable faults that can affect transmission lines are detectable underground: open conductor faults, short circuit faults, and high impedance faults. The Arduino microcontroller can be utilized for monitoring the cable underneath by loading a program into the microcontroller. The frame approach is a useful tool for locating short circuits to earth faults.

Power supply networks are expanding steadily, and it is becoming more crucial than ever for them to be reliable. The intricate network is made up of many parts that have the potential to malfunction and cut off the end user's electricity. Underground cables have been in use for many decades by the majority of low- and medium-voltage distribution lines that are in operation worldwide.

Due of their resistance to weather-related factors such severe rain, storms, snow, and pollution, underground high voltage cables are being used more and more. Despite the steady advancement of cable manufacturing technology, certain factors may still lead to cable failure in testing and operation. When placed appropriately and kept in good condition, a cable can have a 30-year lifespan. Nonetheless, cables are easily harmed by improper installation or shoddy jointing, which is then harmed by civil works like curb edging or trenching.

Make use of 85–87 percent of power system malfunctions are related to transmission lines. In order to enable prompt and dependable protection scheme functioning, this study proposes a method for identifying and categorizing the various shunt faults on a transmission line. Using evolutionary programming techniques, it is possible to distinguish between several kinds of transmission line defects. To simulate various operating and fault scenarios on high voltage transmission lines, such as single phase to ground fault, line to line fault, double line to ground, and three phase short circuit, installation software is utilized.

Because discrete wavelet transformations (DWT) may simultaneously extract information from the transient signal in both the time and frequency domains, they are used for the breakdown of fault transients. The architecture is trained and tested using the data sets that are retrieved from the DWT.

An proposed ground index is used to do the ground detection task. The Gaussian radial basis kernel function (RBF) was employed, and the classifiers' performances were assessed based on their ability to accurately classify faults, detect objects and barriers in real time, and navigate their environment.

II. LITERATURE SURVEY

For most traditional fault location methods, the fault type needs to be known in advance or there may be dead zones using the decoupled modulus. To solve the problems, an improved algorithm based on electromagnetic time reversal is proposed. The improved algorithm can realize fault location by using the coupling signal in the non-fault phase of the transmission line, so fault location can be realized effectively even when the fault phase is unknown.It is theoretically confirmed that non-fault phase linked signals can be used to locate faults. To acquire the failure signal at the observation location, a model of an overhead transmission line operating at 750kV is created. After being time-flipped, the fault signal is attached to the observation point as an injection source. The super-matrix equation is used to traverse each potential fault point and determine its current. The position with the largest norm is the fault location, and the 2-norm based on current energy is suggested as the criterion. The simulation results demonstrate the great accuracy of the algorithm and its independence from fault types, transition resistance, and initial phase angles of the power sources on both sides.Current sensor is developed for the detection of electric fields, and its sensitivity-adjustment curves are obtained by theoretical calculation and simulation.Based on feedback variational mode decomposition (FVMD) and the Wigner-Ville distribution (WVD), an improved method for the identification of fault-wave arrival time is devised, and its efficacy and accuracy are verified by simulations in Power Systems Computer-Aided Design/Electromagnetic Transients including software. Finally, the fault-wave arrival-time detection performance of the software is examined in a series of on-site DC(Direct Current) and experiments based on damped AC(Alternating Current) technology. The results show that exhibits feasible and effective performance, and that its response can be appropriately tuned based on its sensitivity-adjustment curves. This method is more accurate than several other current methods, as its error is only 0.48%, and thus this method enables the practical location of cable faults. In sum, the findings demonstrate the fault and this method comprise an improved system for the detection and location of cable faults, which will Worldwide, Nuclear Power Plants (NPP) must have higher security protection and precise fault detection systems, especially underground power cable faults, to avoid causing national disasters and keep on safe national ratios of electricity production. Hence, this paper proposes an automatic, effective, and accurate Deep Learning (DL)-based fault classification and location technique for these cables through a One-dimensional Convolutional Neural Network (1D-CNN) and a Binary Support Vector Machine (BSVM). The proposed approach includes four main steps are data collection, feature extraction and reduction, fault detection, and fault classification and location. Signal collection from the underground cable's sending end is performed via the Alternating Transient Program/Electromagnetic Transient Program. Feature extraction and reduction are performed via Fractional Discrete Cosine Transform and Singular Value Decomposition (SVD) methods. Fault detection is performed through the linear Kernel method in the third step. Finally, this permits Convolutional neural network to classify the fault type and locate it. Simulation results confirmed the efficiency of our proposed method, especially for 11kV underground cable faults, including different fault resistances and inception angles. Moreover, the proposed technique is applicable in real-time consideration. Although permanent faults on Vector distribution networks account for only 10 – 25 % of total faults to occur , many internet faults which don't get repaired will inevitably become permanent. Permanent faults are much more challenging because the faulted cable becomes un-operational and the delay in repair-work due to fault-finding complexities can bring greater expenses from longer loss of supply. Further, in contrary to fault-finding on the network, there is a very limited number of options available for fault-finding on the Local Vector distribution network because the majority of effective techniques are not applicable as they employ 'thumping' which utilizes current to break the fault. In order to prevent resistance from creating an error during a short circuit, thick cables are typically used by subterranean cable users. Though fuses can be removed and the cables grounded, access to every fuse service box is not always provided. This is especially true of the cables branching to homes. Nevertheless, the Wigner Ville distribution, which is used for error correction, is harmful to local vector domestic loads.Utilities can utilize three standard pinpointing techniques—the Twist method, the Voltage Gradient method, and the Sniffer—as well as one traditional pre-location technology to identify errors in this kind of network. If these approaches don't yield the desired results, the cut and test approach will be used.

III.EXISTING SYSTEM

Merits

The Alternating Transient Program/Electromagnetic Transient Program (ATP/EMTP) is used to gather signals from the transmitting end of the subterranean cable. Fractional Discrete Cosine Transform (FrDCT) and Singular Value Decomposition (SVD) techniques are used for feature extraction and reduction. In the third step, fault identification is carried out by using BSVM in conjunction with the linear Kernel approach. Eventually, this enables 1D-CNN to identify and detect the fault type. The effectiveness of our suggested approach was validated by simulation results, particularly for 11 kV subterranean cable faults with varying fault resistances and inception angles.

Demerits

High costs may limit adoption among individuals with limited financial resources or in developing regions, the limited availability of high- quality research studies. Devices with GPSand connectivity capabilities raise potential privacy concerns, as they may collect and transmit user data. Technical limitations, like signal interference or incorrect guidance. Situations where precise depth of perception is crucial.

Overall information about navigation systems, different hardware components used for obstacle avoidance, shortest path deciding, route finding and many others are explained in this section of the paper. The discussion section encapsulates all the relevant articles of the final cost, making it possible to be widely used in the consumer market.

IV.PROPOSED METHOD

- The proposed system will locate the errors automatically which is time saving process and also uses GPS to track the exact location of the error and uses GSM to send this information of the area of the fault and at what wire the fault has occurred.
- The fault at what distance is displayed on LCD that is interfaced with the microcontroller and further connected with the IoT which detect correct fault place with its longitude and latitude co-ordinates.

The Raspberry Pi and GSM need to be connected to the same device, which may be a battery bank or a laptop. Additionally, the microcontroller powers a relay driver, which manages the switching of a group of relays to ensure that the cable is connected correctly at each step.The display portion comprises of an LCD display interfaced with a microprocessor that indicates, in the event of a defect, the distance of the cable at that specific phase as well as the condition of each phase's cable. This component uses the voltage drop to detect changes in current. The controlling portion comes next. It consists of an analog to digital converter that takes input from the current detecting circuit, transforms the voltage into a digital signal, and then sends the signal to the microcontroller.

A. HARDWARE REQUIREMENTS

1. Raspberry Pi Pico
2. GSM, GPS
3. Voltage Sensor
4. Current Sensor
5. LCD Display
6. Power Supply

V. BLOCK DIAGRAM

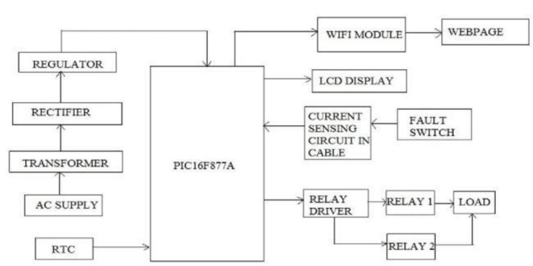

Fig 1.Proposed Block Diagram

WORKING PRINCIPLE

The Arduino Nano reads data from the voltage and current sensors. It continuously monitors the voltage and current levels in the underground cable. The collected data is processed by the Arduino Nano. Algorithms can be implemented to analyze the voltage and current waveforms and look for abnormalities that may indicate a fault, such as a short circuit or an open circuit. When the Arduino Nano detects an abnormality in the voltage and current data that matches the criteria for a cable fault, it triggers the fault detection mechanism. The Arduino Nano uses the GSM module to send an alert to the designated recipient (typically a maintenance team or a central monitoring system). The alert can include information about the fault location and type. For local monitoring and troubleshooting, real-time data—such as voltage, current, and fault status—is shown on the LCD. The Arduino Nano may occasionally cause the relay and driver to cut the cable's power. By doing this, you can increase safety and stop additional damage. The system can produce reports to support maintenance and repair activities and log fault data for subsequent investigation. In increasingly sophisticated systems, an operator can use a specific smartphone app or a web interface to remotely access data and control the device.Remember that the actual implementation may vary depending on the specific requirements of your underground cable system and the sensors and modules you are using. Calibration and fine-tuning of the system may also be necessary to ensure accurate fault detection and minimize false alarms.
communication ensures that the user remains informed and empowered to make informed decisions while navigating through various environments.

B. HARDWARE DESCRIPTIONS

POWER SUPPLY CIRCUIT:

The power supply unit is responsible for providing a stable source of electricity to the entire system. It typically connects to an external power source ora rechargeable battery, ensuring that the smart glass functions reliably without interruption. It has two pins they are positive pin and negative pin.

RASPBERRY PI PICO

- Raspberry Pi Pico is a low-cost, high-performance microcontroller board with flexible digital interfaces.
- RP2040 microcontroller chip designed by Raspberry Pi in the United Kingdom
- Dual-core Arm Cortex M0+ processor, flexible clock running up to 133 MHz
- 264kB of SRAM, and 2MB of on-board flash memory
- USB 1.1 with device and host support
- Low-power sleep and dormant modes
- Drag-and-drop programming using mass storage over USB

Fig 2. Raspberry Pi Pico

CURRENT SENSOR

- It works by measuring the electrical charge flowing through a conductor and producing a proportionate electrical signal or output based on this current.
- The ability of current sensors to deliver current levels in real time makes them indispensable for preserving the dependability and integrity of electrical systems.
- They can be in the shape of Rogowski coils, shunt resistors, or Hall effect sensors, among other variations.

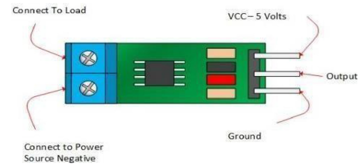

Fig 3.Current Sensor

VOLTAGE SENSOR

An electronic device or component used to measure and identify the voltage, or electrical potential difference, between two points in an electrical circuit is called a voltage sensor. It functions by transforming the voltage level into an electrical signal that is simple to understand and apply to a variety of scenarios. In electrical and electronic systems, voltage sensors are frequently used for safety, control, and monitoring. They are available in numerous configurations, such as digital and analog voltage sensors, and their voltage measurement ranges can be adjusted to accommodate certain uses. These sensors are essential for maintaining appropriate voltage levels, preventing overvoltage or undervoltage situations, and enabling precise measurements and control of electrical systems in a variety of industries, including power distribution, electronics, automation, and telecommunications.

Fig 4.Voltage Sensor

LCD DISPLAY

Liquid Crystal Displays, or LCDs for short, are a popular type of flat-panel technology used to present visual information. It consists of two glass or plastic substrates layered on top of a thin, transparent, flat panel filled with liquid crystal solution. The properties of liquid crystals, which may be adjusted to influence light flow through them, are the basis for LCD operation. Certain parts of the liquid crystal layer change optically when an electrical voltage is applied to them, permitting or preventing the passage of light. On the surface of the display, this well calibrated light modulation creates images, characters, or graphics. LCDs are a popular option for a variety of applications, including computer monitors, television screens, smartphones, digital watches, and various industrial and consumer electronics devices.

They are renowned for their thin profile, energy efficiency, and capacity to produce sharp and vibrant images. Because of their adaptability and versatility, they are widely used in contemporary display technology.

Global Positioning System(GPS)

The Global Positioning System, or GPS for short, is a satellite-based navigation system that gives users exact location and timing data anywhere they are on or close to the surface of the Earth. The GPS system, created and managed by the US Department of Defense, is made up of a group of satellites that circle the earth. Numerous outdoor activities, such as hiking and geocaching, as well as automobile, aircraft, and ship navigation, are made possible by this technology. In addition, it is essential for a number of economic, military, and scientific uses, including as disaster relief, agriculture, and surveying. Today's lifestyle would be impossible without GPS, which allows us to precisely locate ourselves and travel in a globally connected environment.

Fig 5.GPS

Global System for Mobile communication(GSM)

A digital cellular technology that is extensively used and powers most of the world's mobile phone networks is called GSM, or Global System for Mobile Communications. GSM, which replaced analog call encoding and encryption with digital speech encoding and encryption, transformed telecommunications. It was created as a standard for second-generation (2G) mobile networks. GSM allows several users to share the same radio channels at once by operating on different frequency bands and combining time division and frequency division techniques. It lays the groundwork for the mobile data services we use today by facilitating not just voice conversations but also text messaging (SMS) and data transmission. Even though newer generations like 3G, 4G, and 5G have arisen, GSM still plays a significant role in many regions due to its vast coverage and dependability. GSM's global compatibility and interoperability have made it a pivotal technology for linking people worldwide.

Fig 6.GSM

SOFTWARE REQUIREMENTS

PYTHON

Python is a general-purpose interpreted, interactive, object-oriented, and high-level programming language. It was created by Guido van Rossum during 1985- 1990. Like Perl, Python source code is also available under the GNU General Public License (GPL). This tutorial gives enough understanding on Python programming language.

Python is a high-level, interpreted, interactive and object-oriented scripting language. Python is designed to be highly readable. It uses English keywords frequently where as other languages use punctuation, and it has fewer syntactical constructions than other languages.

Python is a MUST for students and working professionals to become a great Software Engineer specially when they are working in Web Development Domain.

Python is currently the most widely used multi-purpose, high-level programming language. Python allows programming in Object-Oriented and Procedural paradigms. Python programs generally are smaller than other programming languages like Java.

Programmers have to type relatively less and indentation requirement of the language, makes them readable all the time. Python language is being used by almost all tech-giant companies like – Google, Amazon, Facebook, Instagram, Dropbox, Uber… etc. The biggest strength of Python is huge collection of standard libraries which can be used for the following:

- Machine Learning
- GUI Applications (like Kivy, Tkinter, PyQt etc)
- Web frameworks like Django (used by YouTube, Instagram, Dropbox)
- Image processing (like OpenCV, Pillow)
- Web scraping (like Scrapy, Beautiful Soup, Selenium)
- Test frameworks
- Multimedia
- Scientific computing
- Text processing and many more.

python
Programming

Fig.7.Python

PROTEUS 8 PROFESSIONAL

For developing, simulating, and testing electronic circuits and microcontroller-based systems, Proteus 8 Professional is a complex and adaptable software tool that is extensively used in the fields of electronics and electrical engineering. Proteus 8 Professional is a component of the Proteus Design Suite, created by Labcenter Electronics. Engineers and designers may design printed circuit boards (PCBs), generate and analyze electronic circuit schematics, and simulate the behavior of components and microcontrollers in real-world settings with its comprehensive environment.

Proteus 8 Professional's vast library of electronic components, which includes a variety of discrete components, integrated circuits, microcontrollers, sensors, and more, is one of its most notable features. With the help of this library, users may easily construct and simulate intricate circuits.
With the software's robust simulation engine, users may verify and test their plans before they are put into practice. This helps to save time and costs by detecting and fixing problems early in the design process. Proteus is a useful tool for microcontroller-based projects and the Internet of Things (IoT) since it also has a component that simulates microcontrollers, enabling the development and testing of embedded systems.

CIRCUIT DIAGRAM

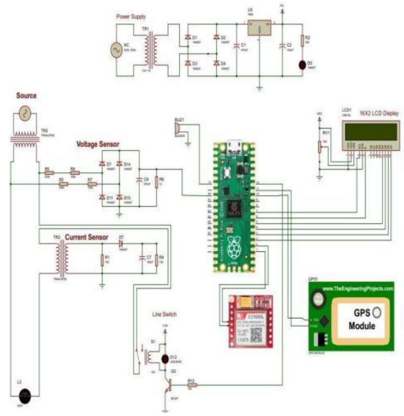

Fig.8.Circuit Diagram

RESULT

This system combines the capabilities of Raspberry Pi Pico as a microcontroller and the Python programming language for data processing and analysis. Here are some key expected results.

Real-time Fault Detection: The system would continuously monitor the underground cables and quickly detect any faults or abnormalities, such as water ingress, cable damage, or short circuits.

Precise Fault Localization: Upon detecting a fault, the system would accurately pinpoint the fault's location along the length of the cable. This information is crucial for maintenance crews to swiftly address the issue.

Alerts and Notifications: The system would be capable of sending real-time alerts and notifications to relevant personnel or a central monitoring station as soon as a fault is detected. This enables rapid response and minimizes downtime.

Cost Reduction: By enabling proactive maintenance and reducing the need for emergency repairs, the system helps reduce operational costs and extends the lifespan of underground cables.

Enhanced Safety: The quick detection and precise localization of faults contribute to the safety of maintenance personnel who can address issues efficiently and with reduced risk.

The expected result of an IoT-based underground cable fault detection system using Raspberry Pi Pico and Python is a robust and efficient solution that enhances the reliability and performance of underground cable networks while minimizing downtime and maintenance costs. It leverages the power of IoT and Python's flexibility for data analysis to create a smart and proactive approach to cable fault detection and management.

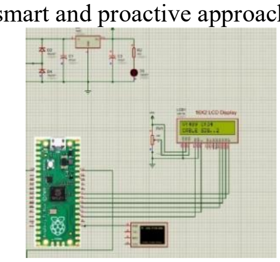

Fig.9.Simulation

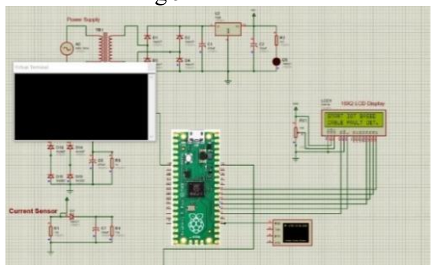

Fig.10.Simulation

CONCLUSION

The implementation of an IoT-based underground cable fault detection system using Raspberry Pi Pico and Python represents a significant step forward in improving the reliability and efficiency of underground cable networks. This technology offers real-time fault detection, precise localization, and proactive maintenance capabilities, which are paramount in ensuring uninterrupted power or communication services. By harnessing the capabilities of Raspberry Pi Pico as a versatile microcontroller and the flexibility of Python for data processing and analysis, this system empowers network operators and maintenance teams to respond swiftly to cable faults, reducing downtime and operational costs. The system's ability to log historical data, provide remote access, and integrate seamlessly with existing infrastructure further enhances its utility. As underground cable networks continue to play a critical role in our modern world, the adoption of IoT-based fault detection systems not only improves network reliability but also contributes to enhanced safety, reduced environmental impact, and overall operational excellence. Therefore, the integration of Raspberry Pi Pico and Python in underground cable fault detection holds great promise for the future of infrastructure management and service delivery. paramount in ensuring uninterrupted power or communication services. By harnessing the capabilities of Raspberry Pi Pico as a versatile microcontroller and the flexibility of Python for data processing and analysis, this system empowers network operators and maintenance teams to respond swiftly to cable faults, reducing downtime and operational costs. The system's ability to log historical data, provide remote access, and integrate seamlessly with existing infrastructure further enhances its utility. As underground cable networks continue to play a critical role in our modern world, the adoption of IoT-based fault detection systems not only improves network reliability but also contributes to enhanced safety, reduced environmental impact, and overall operational excellence. Therefore, the integration of Raspberry Pi Pico and Python in underground cable fault detection holds great promise for the future of infrastructure management and service delivery.

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