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Underground Cable Fault Locator Using Microcontroller

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Abstract: Underground cables are widely used in urban areas for power distribution due to their safety, aesthetic, and space-saving advantages. However, locating faults in these cables is challenging and time-consuming because the cables are not visible. This project proposes an Underground Cable Fault Locator System using a Microcontroller, which can detect the exact location of a fault in the underground cable. The system operates based on the Ohm's Law principle, where the cable's resistance is proportional to its length. A DC power supply is applied to the cable line, and in the event of a short circuit or open circuit, the voltage drop across the cable changes. The microcontroller measures this voltage drop and calculates the distance to the fault using pre-calibrated values. The core components of the system include a microcontroller, voltage sensing circuit, LCD display, and relay driver circuitry for safety control. The calculated fault distance is displayed on the LCD in real-time, helping maintenance teams quickly locate and fix the fault without unnecessary excavation

I. Introduction

Underground cable systems are increasingly adopted in modern cities for power distribution due to their enhanced safety, reduced visual impact, and resistance to environmental factors compared to overhead lines. However, one major challenge associated with underground cables is the difficulty in pinpointing the exact location of faults when failures occur. Locating a fault typically requires extensive manual testing, excavation, and can result in high repair costs and service disruptions. To address this issue, this paper presents a low-cost and efficient solution for fault detection and distance estimation in underground cables using an Arduino-based system. The methodology leverages Ohm's Law to monitor voltage variations across a series resistor connected along the cable. By detecting changes in voltage levels due to faults such as short circuits or ground faults, the system can accurately determine the location of the fault.

The proposed setup simulates the underground cable using resistive elements corresponding to specific lengths. Faults are introduced manually at predefined locations to validate the performance of the system. The Arduino microcontroller processes the analog voltage data through its built-in ADC and calculates the fault distance, which is then displayed on an LCD module. This project demonstrates a simple, scalable, and reliable method to identify and locate faults, potentially reducing the time and cost associated with underground cable maintenance and repair. The purpose of this paper is to determine the distance from the base station's underground cable fault in kilometers. In this project we used a simple concept of ohm's low .When a fault occurs in the system the distance located on liquid crystal display (LCD).. Until the last decade, cables were designed to be placed above the head and, at present, there is no underground cable that is higher than the previous method.

To address this challenge, this project focuses on the development of an Underground Cable Fault Locator Using Microcontroller. The proposed system is designed to detect the location of a fault in an underground cable using a simple and cost-effective approach.

The core concept of this system is based on the principle of Ohm's Law, where the voltage drop across a known resistance is used to estimate the distance to the fault. A microcontroller is used to process data from the cable, calculate the distance to the fault point, and display the results on an LCD screen. This not only reduces the time required for fault detection but also minimizes the labor and cost involved.

Adverse weather conditions such as storms, snow, torrential rains and pollution does not affect on underground lines But when a fault occurs in underground lines it is difficult to locate the fault in underground cable. We will find the exact location of the fault. Now the world has become digitized so, the project is to detect exact location of the fault in digital form. Underground cabling system is a more common practice in many urban areas. Although the fault occurs for some reason, at that time, the repair process for this particular cable is difficult because of not knowing the exact location of the cable breakdown. Fault in cable can be classified in two groups:

Open circuit fault :-In open circuit fault there is no current because there no conducting complete loop for current flowing that is I=0.in this fault supply voltage is equal to the output voltage. open circuit fault is better than short circuit fault..

- **Short circuit fault:-** In this fault output voltage is zero but current is same Further short circuit fault can be categorized in two types:
- **Symmetrical fault:-** In this fault :equal lead current and equal phase shift.
- **Unsymmetrical fault:-** In this fault magnitude of current is not equal & phase shifting is not equal by 120 degree.

Terminal method:- in this method used to detect the fault location in underground lines without any effort This method used to locate the type of circuit occurs; the voltage drop varies with the default length on the cable, as the current varies. A plurality of resistors is used to represent the cable and a DC voltage is supplied at one end and the defect is detected by detecting the voltage variation the defect area To accelerate the tracking of the buried cable. The objective of this project is to determine the distance of the failure of the underground cable ibase station using one kilometer of Arduino board. Underground cable system is a common practice in many urban areas. Even if a failure occurs for some reason, at that time the repair process related to this particular cable is difficult because of not knowing the exact location of cable failure. The project uses the classic concept of the Ohms law, when a low voltage at the end of the power supply device is applied across a series resistor the current varies depending on the location of the Fault the cable.

In the case of a short circuit (grounded line), the voltage across the series resistors changes accordingly, then input to the ADC constructs the Arduino board to develop accurate digital data for the in kilometer. The project is mounted with a resistance representing the length of the cable in KM and creating defects is executed by a set of switches in each known KM to check the accuracy of it. Failure occurs at a given distance and the respective phase is displayed on an LCD screen connected to the Arduino board.

Wheel-chair is still the most reliable transport means for them. This is the cause why wheelchairs are being produced with added latest improvements which leads its conversion to electric wheelchair. Shortly available manual wheelchairs need regular assistance of others for people having severe limitation and are at a high risk of damages to the upper part of the body due to mechanical inability of the wheelchair. Furthermore, standard wheelchairs possess problems while working up the hill or rough surface.

II. LITERATURE SURVEY

[1] Srilakshmi Inampudi, Rajitha T. B., Kavita Sawant, Lovely Gaur, Underground Cable Fault Detection Device Using Microcontroller. Successfully detects fault distance in kilometers 2022

[2] S. R. Purohit, Sunilkumar M. Hattaraki, Soumya P.Hampangoudra, Rashmi Nimbaragi, Savita Mattihal Shweta Bagali Arduino - Uno Based Underground Cable Fault Detection System (AUCFDS) Provides a cost-effective solution for fault detection 2023

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III. PROPOSED SYSTEM

3.1 Block Diagram

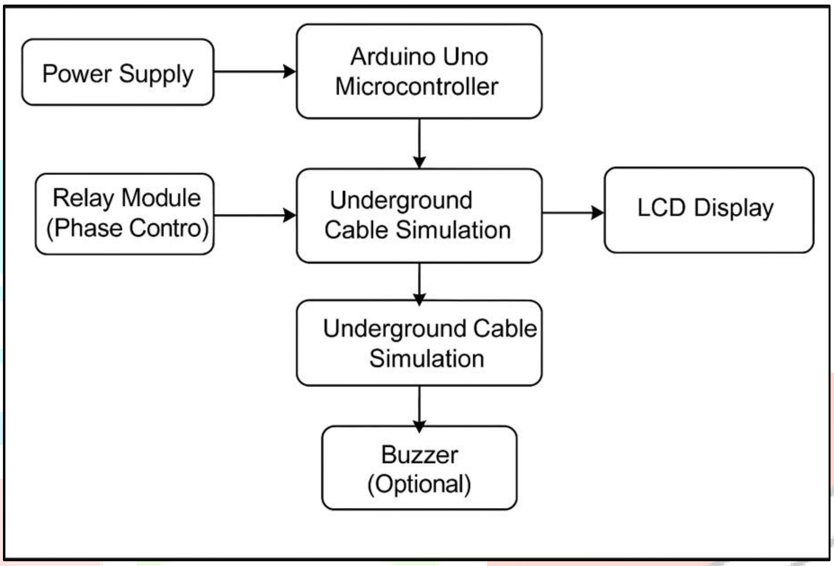


Fig.1 Block diagram of Underground Cable system

The block diagram represents the overall system architecture of the Underground Cable Fault Detection System using Arduino.

1. **Power Supply Unit**: Supplies regulated DC voltage to the Arduino, relay module, and other electronic components. Typically, 5V is used for Arduino and LCD, while 12V is used for the relay module.

2. **Relay Module:** Acts as a phase selector that connects one phase of the underground cable at a time to the Arduino for testing. It enables phase-wise fault detection (Phase A, B, and C).

3. **Underground Cable Simulation Block:** The cable is represented using resistors connected in series. Each resistor corresponds to a fixed length of cable (e.g., 1kΩ = 1 km). Faults are manually introduced using switches at known distances.

4. **Arduino Microcontroller:** The core controller of the system. It reads voltage changes from the cable using its analog inputs, detects the fault based on resistance, calculates the fault distance using Ohm's Law, and sends the result to the display.

5. **LCD Display (16x2):** Shows the output, which is the calculated distance to the cable fault in kilometers. It updates in real-time whenever a fault is detected.

6. **Buzzer (Optional Alert Unit):** Sounds an audible alert when a fault is detected to notify the user of the abnormal condition in the cable.

3.2 Description of each component

Arduino Micro-controller:

- Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. We can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so we use the Arduino programming language (based on wiring), and the Arduino Software(IDE), based on Processing.

- The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

- The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts

Pin Diagram:

FEATURE	SPECIFICATION
Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

Fig.2 Pin diagram

- Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF)
- The pins on your Arduino are the places where you connect wires to construct a circuit (probably in conjuction with a breadboard and some wire. They usually have black plastic „headers" that allow you to just plug a wire right into the board. The Arduino has several different kinds of pins, each of which is labeled on the board and used for different functions.
- GND (3): Short for „Ground". There are several GND pins on the Arduino, any of which can be used to ground your circuit.
- 5V (4) & 3.3V (5): As you might guess, the 5V pin supplies 5 volts of power, and the 3.3V pin supplies 3.3 volts of power. Most of the simple components used with the Arduino run happily off of 5 or 3.3 volts. Analog
- (6): The area of pins under the „Analog In" label (A0 through A5 on the UNO) are Analog In pins. These pins can read the signal from an analog sensor (like a temperature sensor) and convert it into a digital value that we can read.
- Digital (7): Across from the analog pins are the digital pins (0 through 13 on the UNO). These pins can be used for both digital input (like telling if a button is pushed) and digital output (like powering an LED).

- PWM (8): You may have noticed the tilde (~) next to some of the digital pins (3, 5, 6, 9, 10, and 11 on the UNO). These pins act as normal digital pins, but can also be used for something called Pulse-Width Modulation (PWM). We have a tutorial on PWM, but for now, think of these pins as being able to simulate analog output (like fading an LED in and out).
- AREF (9): Stands for Analog Reference. Most of the time you can leave this pin alone. It is sometimes used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

IV. Methodology

4.1 Circuit Diagram

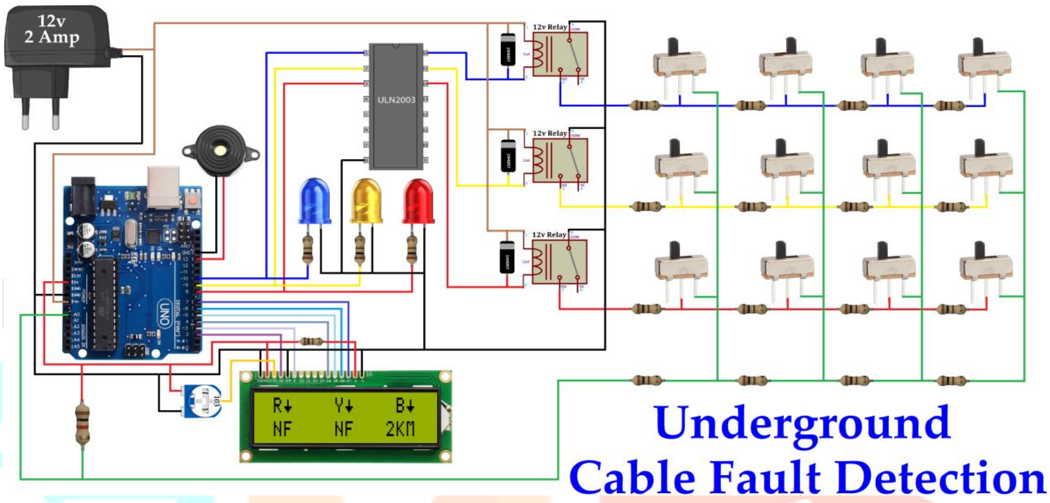
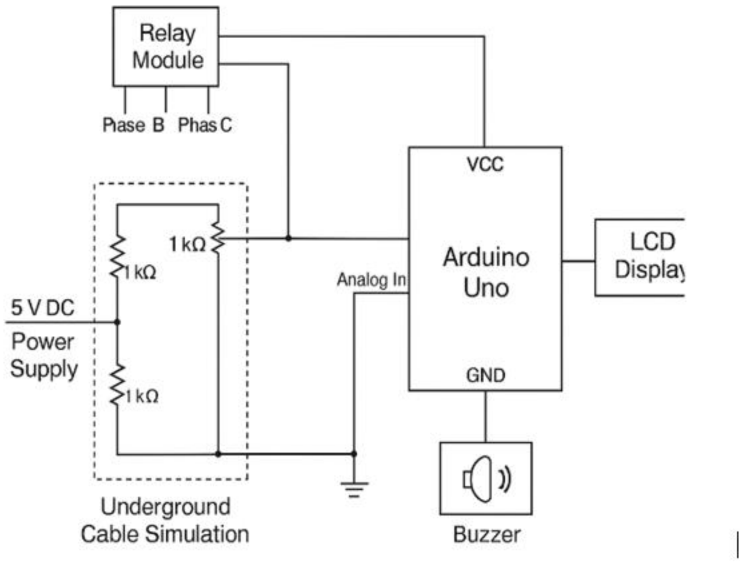


Fig.3 Circuit Diagram of System

In our paper we can detect the fault in three phases. In each phase of the system required large wire 3km,4km,5km. so this can't fit in this system.so used for this its internal resistance of cable. Because, as the length of the copper wire increase the resistance in the cable also increases. so we connect 1kΩ resistance for each 1 km distance 1km indicate 1km distance .In this project we connect 4 resistance of 1km in series so we cover 4km distance in each phase.

In this paper just connect switch to disconnect the wire in each km segment .with the three phage cable one reference cable are also present to compare with it .The arduino board required the reference resistance of cable with the fault cable resistance . consider, a single cable in which 4 resistance are connected with 4 switches and when fault occur the system at 2 km distance. The 2 kΩ resistance are given to the arduino .The arduino compare it with reference resistance.

The Arduino is program such that it contain the ohm lows V=IR as the resistance value decreases the voltage in the cable increases and it calculate the fault location. The arduino has only 1input port. so for 3 phages three relay are connected which gives data to the arduino one by one.



4.2 Working of Circuit Diagram

1. **Power Supply**
   - A 5V DC power source powers the Arduino and LCD.
   - A 12V DC source powers the relay module.
   - These regulated voltages ensure that all components operate within their required range.
2. **Relay Module (Phase Selection)**
   - The relay module is used to switch between different cable phases (Phase A, B, C).
   - Only one phase is tested at a time to avoid interference.
   - Arduino controls the relay through digital output pins to select which phase to monitor.
3. **Cable Simulation Using Resistors**
   - The underground cable is simulated using equal-value resistors, e.g., 1kΩ per kilometer.
   - Switches are connected between resistors to simulate faults at known distances.
   - When a switch is closed, it creates a short circuit or open circuit fault at that segment.
4. **Arduino Uno (Fault Sensing and Processing)**
   - The Arduino reads analog voltage from the cable via its analog input pin (A0).
   - Based on the voltage drop, it calculates the distance to the fault using Ohm's Law:
     V=IR⇒R=VIV = IR \Rightarrow R = \frac{V}{I}V=IR⇒R=IV
     where resistance corresponds to the cable length.
     The voltage value is mapped to kilometers using pre-defined resistor values (e.g., 1V = 1 km if 1kΩ per km).
     Arduino checks for significant changes in voltage to detect whether the fault is open or short circuit.

5. **LCD Display (Output Unit)**
   - A 16x2 LCD is connected to the Arduino via digital pins.
   - It displays:
   - Fault status (Open / Short circuit).
   - Distance to the fault (in km).
   - Affected phase (A/B/C), depending on relay selection.

6. **Buzzer (Optional Alert)**
   - A buzzer is connected to alert the user when a fault is detected.
   - It is activated through a digital output pin on the Arduino when a fault is identified.

Summary: This circuit helps maintenance teams quickly identify where a fault has occurred in an underground power line without digging or using expensive tools. The system is low-cost, easy to maintain, and ideal for academic or real-world power distribution monitoring

V. Conclusion & Future scope

5.1 Conclusion

Finally, we have done this project for location of fault in underground cable In the rural areas where underground transmission system is used. it is difficult to find the fault in the cable . So this project is beneficial to use to detect the fault location. So the fault can easily locate and extinguish. The Arduino has several advantages over the microcontroller so use of arduino is more useful arduino based underground fault detection is more advantageous than microcontroller based underground fault detection.

This project successfully demonstrates a simple and effective method to detect and locate faults in underground cables using Arduino technology. By using basic principles of electricity and modern microcontroller features, the system offers a low-cost and efficient solution suitable for urban and rural cable networks. This method helps reduce repair time, cost, and increases the reliability of power distribution systems.

5.2 Future Scope:

The development of an underground cable fault detection system using Arduino marks a significant step toward cost-effective and real-time monitoring solutions. However, there is considerable potential for enhancement and scalability. In the future, this system can be integrated with wireless communication technologies such as GSM, LoRa, or NB-IoT to transmit fault data remotely to control centers, allowing faster response times and predictive maintenance. By incorporating GPS modules, the system can provide precise geolocation of the fault, which would be invaluable for field technicians. Machine learning algorithms can also be embedded to analyze fault patterns and environmental conditions, enabling smarter decision-making and adaptive fault classification. Additionally, the current system can be upgraded to support longer cable lengths and higher voltage levels used in industrial applications. Integration with SCADA (Supervisory Control and Data Acquisition) systems would allow centralized control and monitoring across large utility networks. Furthermore, using more rugge

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