IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 12, Issue 3, March 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.379

International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 | Monthly Peer Reviewed & Referred Journal |

|| Volume 12, Issue 3, March 2024 ||

| DOI: 10.15680/IJIRCCE.2024.1203136 |

IoT-Enabled Underground Cable Fault Detection System with GSM Integration using Arduino

Mr . G . Sreenivasa Raju, Veempati Moksha , Bonagiri Venky Patel , Ma. Sumayya Tabassum

Assistant Professor, Anurag University, Telangana, India

Department of ECE, Anurag University, Telangana, India

ABSTRACT : The "IoT-enabled Underground Cable Fault Detection System with GSM Integration Using Arduino" represents a groundbreaking solution designed to address the critical Challenges associated with underground cable management. This innovative system not Only detects cable faults but also incorporates advanced capabilities to identify water Damage faults, thereby enhancing the overall reliability and efficiency of underground Cable infrastructure. Leveraging the power of Internet of Things (IoT) technology, the System integrates seamlessly with GSM communication, allowing for real-time Monitoring and remote notifications. Central to its functionality is the incorporation of Arduino-based hardware, which serves as the backbone for sensor interfacing and data Processing. The inclusion of a water level sensor enables the system to detect water Damage faults, complementing traditional fault detection mechanisms. Upon detecting A fault, whether it be a cable fault or water damage, the system automatically triggers a Call and SMS alert through the GSM module, ensuring prompt notification to relevant Stakeholders.

KEYWORDS: IoT , Underground cable fault detection ,GSM integration , Water damage detection , Cable infrastructure management , Real-time monitoring ,Remote notifications , Sensor interfacing , Data processing , Water level sensor , Fault detection mechanisms .

I. INTRODUCTION

The "IoT-enabled Underground Cable Fault Detection System with GSM Integration using Arduino" represents a groundbreaking solution designed to revolutionize the management of underground cable infrastructure. This innovative system not only addresses the critical challenge of detecting cable faults but also incorporates advanced capabilities to identify water damage, thereby enhancing the overall reliability and efficiency of underground cable networks. By leveraging the power of Internet of Things (IoT) technology, the system seamlessly integrates with GSM communication, allowing for real-time monitoring and remote notifications. At the heart of its functionality lies the incorporation of Arduino-based hardware, serving as the backbone for sensor interfacing and data processing [1] .

The [2] inclusion of a water level sensor further enhances the system's capabilities, enabling it to detect water damage faults alongside traditional fault detection mechanisms. Upon detecting a fault, whether it be a cable fault or water damage, the system automatically triggers SMS and call notifications through the GSM module, ensuring prompt alerting of relevant stakeholders. This comprehensive approach to underground cable management promises to revolutionize infrastructure monitoring, significantly reducing downtime and enhancing overall system reliability .

There are various cable fault types

1. **Open Circuit Fault:** This occurs when there is a break in the conductor, resulting in a discontinuity in the electrical circuit. It can be caused by physical damage to the cable, corrosion, or poor connections.
2. **Short Circuit Fault:** A short circuit fault occurs when two conductors come into contact with each other, bypassing the load and causing a high current flow. It can lead to overheating, arcing, and damage to equipment.
3. **Ground Fault:** A ground fault occurs when one of the conductors comes into contact with the ground or a grounded surface. This can result in a leakage of current to the ground, posing a safety hazard and potentially damaging equipment.

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4. **Water Damage:** Water damage occurs when water infiltrates the cable system, leading to insulation breakdown, corrosion, and increased leakage currents. It can result from factors such as flooding, underground water table fluctuations, or damaged cable insulation.

II. LITERATURE SURVEY

The integration of Internet of Things (IoT) technology with underground cable fault detection systems has emerged as a promising solution to address the challenges associated with the maintenance and management of underground infrastructure. In [3] recent literature, there has been a growing focus on developing advanced systems capable of not only detecting cable faults but also incorporating additional functionalities such as water damage detection and remote notifications. The [4] proposed "IoT-enabled Underground Cable Fault Detection System with GSM Integration using Arduino" represents a significant advancement in this field. By leveraging IoT technology, the system enables real-time monitoring and data collection from underground cable networks, enhancing the ability to detect faults and assess the condition of the infrastructure. The [5] integration of GSM communication allows for seamless remote notifications via SMS and call alerts, ensuring prompt responses to detected faults or water damage incidents. Additionally, the incorporation of Arduino-based hardware facilitates sensor interfacing and data processing, providing a robust and reliable platform for underground cable management. This literature review underscores the importance of integrating multiple functionalities into cable fault detection systems to improve reliability, efficiency, and maintenance practices in underground infrastructure networks.

A. *Existing Work*

The existing systems for underground cable fault detection typically rely on Conventional methods, often characterized by manual inspection and limited Automation. These systems lack the capability to provide real-time monitoring and immediate notification of faults, leading to delays in fault detection and response. Moreover, water damage faults are often overlooked, as existing systems primarily Focus on electrical parameters and do not incorporate dedicated sensors for water level Detection. Communication mechanisms in these systems are also rudimentary, with Limited capabilities for remote alerting and notification [6] .

As a [7] result, the reliability and Efficiency of underground cable management are compromised, leading to increased Downtime, safety risks, and maintenance costs. In contrast, the proposed IoT-enabled Underground Cable Fault Detection System with GSM Integration using Arduino offers A transformative solution by integrating advanced sensing technologies, IoT Connectivity, GSM communication, and Arduino-based hardware. This system not only Detects cable faults and water damage in real-time but also enables immediate alerts via SMS and calls, facilitating prompt response and remediation efforts.

B. *Proposed Work*

"In an era where road safety is paramount, our IoT-based Driver Drowsiness Detection And Smart Alerting System stands as a beacon of innovation. By seamlessly integrating Cutting-edge sensor technologies with intelligent algorithms, we have created a solution That not only monitors a driver's alertness but also takes proactive measures to ensure Their safety. Our [8] system's ability to analyze vital signs and vehicle data in real-time Allows it to detect even the slightest signs of drowsiness, ensuring that drivers are Promptly alerted and potentially dangerous situations are averted. [9] With this technology, We are not just transforming how we drive, but also saving lives on the road. "Our proposed system consists of two microcontrollers: Arduino UNO where the Ignition key, Ignition relay, buzzer, Eye-blink sensor, pulse sensor, ultrasonic sensor And alcohol sensor are connected to the Arduino board. The GSM is connected to the Arduino Uno board.

III. METHODOLOGY

These project involves a systematic approach to designing, Implementing, and deploying the system. The [10] first step in the methodology is to Strategically deploy sensors along the underground cable network, including water level Sensors to monitor for water damage. These sensors are carefully positioned at Vulnerable points such as manholes or junction boxes to detect any anomalies in water Levels. Next, Arduino microcontrollers are programmed to interface with the sensors, Acquire data, and process it for fault detection and water damage assessment [11] . Thresholds are set for fault detection algorithms, and GSM communication protocols Are implemented to enable communication with

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mobile networks. Once the system is Operational, it continuously monitors sensor data in real-time. When a fault or water Damage is detected, the system triggers alerts via GSM communication, sending SMS Notifications and making calls to designated recipients [12] . This methodology ensures Comprehensive monitoring, timely detection, and immediate response to cable faults And water damage, thereby enhancing the reliability and resilience of underground cable Networks.

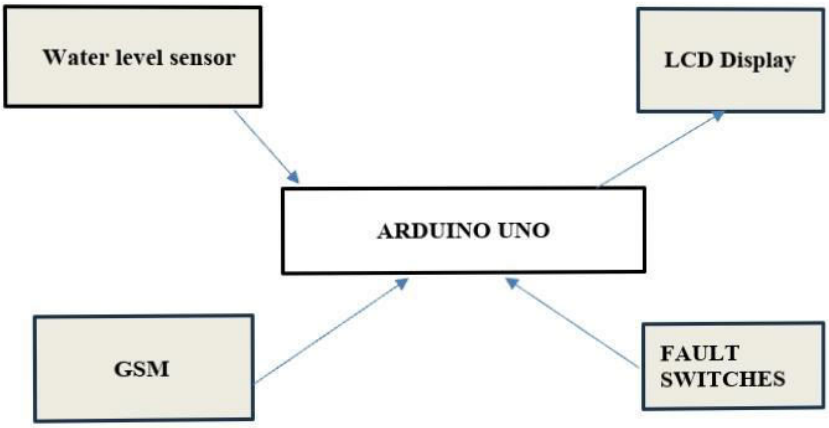

Fig.1. Block diagram of cable fault detection

A. Arduino UNO

The Arduino Uno, named for its debut as the first in the Series, is a microcontroller board centered around the ATmega328 chip. It boasts 14 digital input/output pins, 6 Analog input pins, and a 16 MHz ceramic resonator for Clocking. Equipped with a USB connection, power jack, And RST button, it supports seamless interfacing with Computers for programming and operation. Powering the Board can be achieved via AC to DC adapter, USB cable, or Battery. The ATmega328, part of Atmel's mega AVR Family, features a customized Harvard architecture with an 8-bit RISC processor core. Key features of the Arduino Uno Include an operating voltage of 5V, recommended input Voltage ranging from 7V to 12V, and 40 mA DC current for Each input/output pin. Additionally, it offers 50 mA for the 3.3V pin, 32 KB flash memory, 2 KB SRAM, 1 KB EEPROM, and a clock speed of 16MHz. Physical Components of the Arduino Uno board encompass power Pins, analog pins, ICSP header, reset button, power LED, Digital pins, test LED 13, TX/RX pins, USB interface, and Provision for external power supply.

B. Liquid Crystal Display

A liquid-crystal display (LCD) utilizes liquid crystals And polarizers to modulate light, enabling the display of Images in color or monochrome. LCDs can show arbitrary Or fixed images, such as digits and seven-segment displays. They are commonly found in LCD televisions, computer Monitors, and portable devices like smartphones and digital Cameras. Unlike bulky CRT displays, LCDs offer energy Efficiency and versatility. Each LCD pixel consists of liquid Crystal molecules aligned between transparent electrodes And polarizing filters. An electric field alters the orientation Of liquid crystals, controlling light transmission and creating Different shades of gray. Color LCDs employ color filters For red, green, and blue subpixels. A photolithography Process creates these color filters on glass sheets, later Assembled into LCD panels. Early color LCDs utilized Voltage variations to produce limited colors per pixel. Overall, LCD technology provides versatile and efficient Display solutions for various applications.

C. SIM900A GSM Module

The SIM900A GSM Module stands out as one of the most Compact and cost-effective solutions for GPRS/GSM Communication, frequently utilized in embedded Applications alongside Arduino and microcontrollers. This Module serves as a vital component for facilitating Communication through mobile SIM cards, operating Within the 900 and 1800MHz frequency bands. Capable of Handling both mobile calls and SMS, the SIM900A module Provides

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developers with a versatile platform for building Custom applications. One notable feature of the SIM900A Module is its keypad and display interface, allowing Developers to tailor applications to their specific Requirements. This interface empowers developers to create Customized functionalities, enhancing the module's Flexibility and usability. Moreover, the SIM900A module Offers two distinct modes: command mode and data mode. Command mode enables developers to modify default Settings according to their preferences, ensuring seamless Integration with diverse applications. Despite its compact Form factor, the SIM900A module boasts a robust pin Configuration, comprising a total of 68 pins. While this may Seem overwhelming, developers typically utilize only a Subset of these pins when interfacing with Arduino or other Microcontrollers. By leveraging the appropriate pins, Developers can harness the full potential of the SIM900A Module to build a wide range of commercial applications.

D. Water level Sensor

The water level sensor serves to measure liquid levels Within containers, categorized into contact and non-contact Types based on measurement methods. The SEN18 Water Level Depth Detection Sensor, a widely utilized component, Operates on capacitance measurement principles. It features A sensing probe immersed in the liquid and a ground probe Outside, detecting changes in capacitance as the water level Fluctuates. Renowned for its accuracy and sensitivity, this Sensor facilitates precise monitoring, particularly in Environments with harsh conditions or underwater Applications. Interfaceable with microcontrollers like Arduino, it processes analog signals for real-time Monitoring. Principally, it operates on hydrostatic pressure Measurement principles, where a pressure-sensitive element Within a waterproof casing detects water column pressure Proportional to the depth. Pascal's law governs this Relationship, enabling conversion of hydrostatic pressure Into an electrical signal proportional to water depth. This Mechanism ensures the SEN18 sensor's reliability and Accuracy, suitable for diverse applications requiring precise Water level measurements.

IV. RESULT AND DISCUSSION

By seamlessly integrating IoT technology with GSM communication and Arduino-based hardware, the system offers a comprehensive solution for detecting cable faults and water damage in underground cable networks. The inclusion of a water level sensor enhances its capabilities, enabling the system to detect water damage faults alongside traditional fault detection mechanisms. Furthermore, the system's ability to automatically trigger SMS and call notifications through the GSM module ensures prompt alerting of relevant stakeholders in the event of a fault. Overall, this innovative system promises to revolutionize underground cable management, significantly improving reliability, efficiency, and safety in infrastructure operations.

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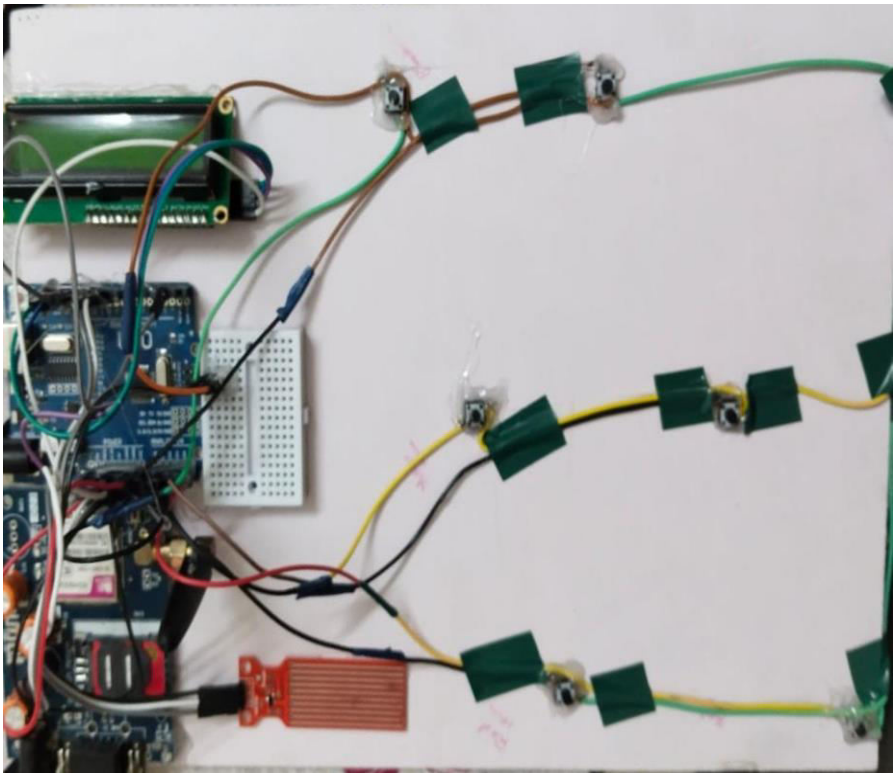

Fig.2. Hardware implementation

Fig.3. Screenshot of the SMS

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INNO SPACE
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Impact Factor: 8.379

doi cross ref

ISSN INTERNATIONAL STANDARD SERIAL NUMBER INDIA

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