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IOT BASED FAULT DETECTION OF UNDERGROUND CABLES USING NODE MCU

Aruna Kokkula, Department of ECE, Maturi Venkata Subba Rao Engineering College, Hyderabad
C Harika, Department of ECE, Stanley College of Engineering & Technology for Women, Hyderabad
Vishal Chandra Vuppula, Department of ECE, Matrusri Engineering College, Hyderabad
Venkataramana Battula, Department of CSE, Maturi Venkata Subba Rao Engineering College, Hyderabad

Abstract
The operations at underground cables, which are vulnerable to a wide range of faults due to underground conditions, wear and tear, rats, etc., are the main emphasis of this study. It is challenging to identify the source of a failure; instead, the entire cable needs to be removed from the ground to be examined and fixed. Using an ESP32, the system's work is to locate faults in subterranean cable cables from the base station in kilometers. Underground electrical cables are used in metropolitan areas rather than overhead power lines. It might be challenging to pinpoint the precise position of a defect in an underground cable while trying to repair that specific line. The suggested system locates the defect precisely. To cross-check the prototype's accuracy, a set of switches are placed at each known distance along with a set of resistors that represent the wire length in kilometers. A 2x16 LCD connected to the microcontroller displays the fault's distance, phase, and time. Information is displayed over the Internet using the Wi-Fi module ESP32 and the Internet of Things. Using HTML coding, webpage is generated and shown with information regarding fault occurrence.
Keywords: Underground Cable, IOT, LCD, ESP32, HTML.

I. INTRODUCTION
Power supply networks are constantly expanding, and their dependability is more crucial than ever. Numerous components that make up the complicated network might malfunction and stop providing electricity to end users. Underground cables have been utilized for many years on the majority of low voltage and medium-voltage distribution lines that are in operation globally. The usage of underground high-voltage cables is expanding as a result of their resistance to the effects of pollutants, severe weather, heavy rain, and storms. There are still factors that might lead to cable failure during testing and operation, despite the fact that cable production technology is always improving. A cable with proper installation and maintenance may survive for roughly 30 years.
While future third-party damage is caused by civil works like trenching or curb edging, cables can be quickly destroyed by faulty installation or badly executed jointing. The problem must be reduced as quickly as possible to maintain the stability of the power network. For this, exact (correct) techniques or procedures that operate quickly are required. This will enable the problem to be located and the power distribution to be shut off quickly. The main purpose of the electric transmission and distribution systems is to transfer electric energy from the age unit to the consumers.
Although the underground link system offers better dependability than the overhanging line system, it is still difficult to locate the problem area. When a flaw occurs during transmission, it is important to identify the problem while the machine is in transit in order to correct the problem before it causes more damage to the power device. The process of finding problems has improved as a result of the constant need for support. With initiatives of sign preparation techniques and outcome-based procedures, developments of the shortfall conclusion have been enhanced in recent years. It has been shown that the wavelet transformation is appropriate for studying the transient sign generated by a high-quality framework. Therefore, we have suggested a novel method to lessen the damage caused by faults in subterranean wires. And when compared to a variety of approaches, the accuracy of our suggested scheme is great. With the aid of the Node MCU WiFi Module, we have employed an IOT-based method in this work to expose faults using the Google database. It is entirely IOT-based. In

comparison to previous strategies, our suggested system has greater accuracy and efficiency.

II. LITERATURE SURVEY

The most common types of faults in power systems can be categorized into open circuit faults and short circuit faults. Open circuit faults, often referred to as series faults, encompass joint failures in cables and overhead lines, malfunction of one or more phases of a circuit breaker, and conductor or fuse melting in one or more phases. These faults, except for the three-phase open fault, result in asymmetrical or unbalanced conditions.

On the other hand, short circuit faults involve irregular connections between two sites with differing potentials, either formed intentionally or accidentally. Short circuits have extremely low impedance, leading to abnormally large currents flowing through machinery or transmission lines. Ignoring these defects, even for a short period, can cause significant harm to the equipment. Short circuit faults are also known as shunt faults [3].

Rats and mice pose additional threats to the integrity of electrical systems by chewing on cables, creating nests, and causing structural damage to homes, flats, workplaces, and other buildings. This destructive behaviour extends to the cable's additional conductors. Utilizing a digital system can help locate these defects, allowing for expedited repairs, increased system dependability, and reduced outage times. Megger readings of zero indicate a grounded conductor.

The table I outlines diverse fault types in power systems and their corresponding detection methods. For open circuit faults, techniques such as impedance-based methods using devices like Time Domain Reflectometers (TDR), visual inspections, and thermal imaging are employed, alongside the use of overcurrent protection devices like relays and circuit breakers. Short circuit faults are detected through a combination of overcurrent protection devices, current sensors, and digital fault recorders, along with communication systems for swift responses. Shunt faults involve protective devices like relays and circuit breakers, often integrated with digital systems for real-time monitoring. Rodent-induced faults are identified using digital systems equipped with sensors for abnormal activity, visual inspections for rodent damage signs, and protective measures like cable conduits or insulation barriers. Grounded conductor detection relies on periodic insulation resistance testing using Megger devices, where zero or very low insulation resistance readings indicate the presence of grounded conductors. These methods collectively provide a comprehensive approach to detecting and addressing various types of faults in power systems.

Table 1:FAULT TYPES AND DETECTION METHODS

Fault Type	Detection Method
Open Circuit Faults	Impedance-based techniques using devices like Time Domain Reflectometers (TDR). Visual inspections and thermal imaging to identify physical damage or joint failures. Overcurrent protection devices (relays, circuit breakers).
Short Circuit Faults	Overcurrent protection devices (relays, circuit breakers). Current sensors and digital fault recorders for pinpointing fault locations. Communication systems for faster responses.
Shunt Faults	Protective devices like relays and circuit breakers, similar to short circuit detection. Utilization of digital systems for realtime data and communication capabilities.
Rodent-Induced Faults	Digital systems with sensors (acoustic, vibration) for detecting abnormal activity or disturbances. Visual inspections for signs of rodent damage. Use of protective measures like cable conduits or insulation barriers.
Grounded Conductor Detection	Periodic insulation resistance testing using Megger devices. Megger readings indicating zero or very low insulation resistance for detecting grounded conductors.

III. PROPOSED WORK

As in power system generation, longer cables that are employed as subterranean cables must be implemented. When we use it to distribute in metropolitan areas, there is a potential that a defect can develop in the underground cable. At such a time, it might be challenging to locate the problem in the underground cable. So that we can quickly and precisely locate the problem, we're employing the Arduino microcontroller, GPS, and GSM modem. The purpose of this study is to locate the fault and calculate, in kilometers, the precise distance of the underground cable fault from a substation. A failure in an underground cable in a transmission line may be caused by a short circuit to another conductor in the cable, a short circuit to the earth, a high resistance to the earth, an open circuit, or even by a machine digger [1].

This project's main goal is to use an Arduino to find flaws and other irregularities in subterranean wires. Ohm's law is the fundamental principle that drives this project's operation. When a DC voltage is supplied at the feeder end, the value of the current also varies depending on where the cable fault is located. Therefore, the change in voltage value detected across the resistor in the event of a short circuit fault, such as an L-G or L-L fault, is then supplied to the Arduino's built-in ADC. The Arduino processes this value and determines the fault's location with relation to the base station. The precise position of the defect from the base station in kilometers for all three phases is displayed on the LCD connected to the Arduino board by this value, which is delivered to the LCD. A group of resistors are used in this project to represent the cable length. Fault switches are located every known km to manually cause problems. Finally, it is possible to calculate the fault distance. When a DC voltage is provided at the feeder end, the value of the current also varies depending on where the cable defect occurs [2]. Due to the subterranean environment, wear and tear, rats, etc., underground cables are vulnerable to a wide range of problems. It is challenging to identify the cause of a failure; instead, the entire cable needs to be removed from the ground to be examined and fixed. Using an MSP8266 WIFI MODULE, This prototype makes use of the straightforward OHMS LAW idea. Underground electrical cables are used in metropolitan areas rather than overhead power lines. It might be challenging to pinpoint the precise position of underground cable problems to repair that specific cable [3], [4].

A. Block Diagram

An underground cable failure detection system with IOT capabilities are the suggested system. Ohms law is the fundamental idea underlying the system. The voltage changes when a defect in the cable develops, and this variation is utilized to determine how far away the problem is. Wi-Fi module, Micro controller, four-channel relay module, LCD display, voltage regulator, and other components make up the system. The voltage regulator and battery are used to supply the electricity. The microcontroller receives information about the size of the voltage drop across the resistors from the current sensing circuit of the cable, and the defect is identified using the voltage. 1 displays the suggested system's block diagram

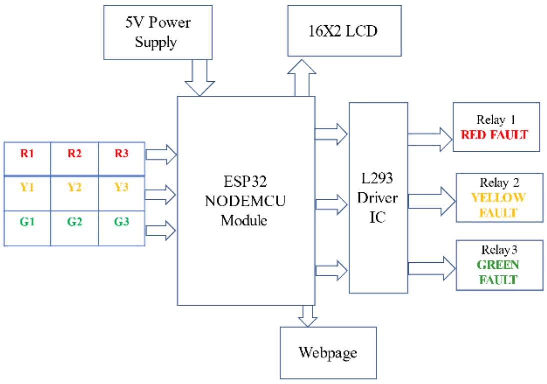

Figure 1:Block Diagram

B. Hardware Component Description

1) Node MCU (ESP32): The ESP32 System-on-a-Chip (SoC) is a low-cost System-ona- Chip (SoC) that is the foundation of the open-source NodeMCU (Node Microcontroller Unit). The Espressif Systems-designed and -produced ESP32 includes all of the essential components of a computer, including CPU, RAM,networking (Wi-Fi), and even a contemporary operating system and SDK. This makes it a fantastic option for all types of Internet of Things (IoT) projects. The NodeMCU Kit's board features analogue (A0) and digital (D0-D8) pins similar to those on an Arduino. A circuit board acting as a dual in line package (DIP) that incorporates a USB controller with a smaller surface-mounted board housing the MCU is the prototype hardware that is frequently utilised.

2) Pin Diagram of ESP32: The NodeMCU's pin diagram is shown in 2. The GPIO (General Purpose Input/Output) of the NodeMCU is accessible, and the API documentation includes a pin mapping table. This makes it a fantastic option for all types of Internet of Things (IoT) projects. The NodeMCU Kit's board features analogue (A0) and digital (D0-D8) pins similar to those on an Arduino.

Table 2:ESP32 Features

Category	Specification
Processors	CPU: Dual-core (or single-core) 32-bit Xtensa LX6 microprocessor with up to 600 DMIPS performance, running at 160 or 240 MHz, and an ultra-low power (ULP) coprocessor. Memory: 320 KiB RAM and 448 KiB ROM.
Bluetooth Connections	Wi-Fi: 802.11b/g/n Wi-Fi. Bluetooth: Bluetooth v4.2 BR/EDR and BLE; Wi-Fi and Bluetooth share the same radio.
Borderline Interfaces	Borderline Interfaces GPIOs: 34 programmable GPIOs. ADC: 12-bit SAR ADC with up to 18 channels. DAC: Two 8-bit DACs. Touch Sensors: Ten touch sensors (capacitive sensing GPIOs). Communication: SDIO/SPI slave controller; Ethernet MAC interface with dedicated DMA; CAN bus 2.0; Infrared remote controller (TX/RX, up to 8 channels); 4 SPI; 2 I2S interfaces; 2 I2C interfaces; 3 UART. Other Features: Pulse counter with complete quadrature decoding capabilities; PWM for motors; PWM for LEDs (up to 16 channels); Ultra-low-power analogue pre-amplifier; Hall effect sensor.
Security	Secure Boot: Supported. Encryption: Flash encryption. Security Standards: IEEE 802.11 standard security features, such as WLAN Authentication and Privacy Infrastructure (WAPI), WPA, WPA2, and WPA3 (depending on version). Cryptographic Hardware Acceleration: AES, SHA-2, RSA, elliptic curve cryptography (ECC), and random number generator (RNG).

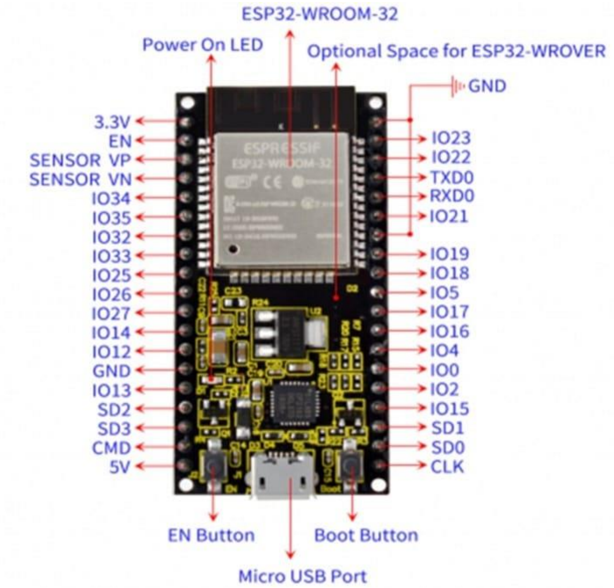

Figure 2:Pin Diagram of ESP32

C. Driver IC (L293D)

A dual H-bridge motor driver integrated circuit (IC) is called L293D. Motor drivers, like L293D, serve as current amplifiers by converting a low-current control signal into a higher-current signal. This higher-current signal is used to drive motors with a greater current level. L293D contains two integrated H-bridge driver circuits, allowing the simultaneous operation of two DC motors in both forward and backward directions. The motor operations for each motor can be controlled by the input logic at pins 2 7 and 10 15. If the input logic is 00 or 11, the associated motor will stop; it will rotate anticlockwise for logic 01 and clockwise for logic 10. To initiate the spinning of the two motors, the enable pins 1 and 9 need to be set to high. When an enable input is high, the linked driver becomes active, and its outputs operate in synchrony with their inputs. Conversely, when the enable input is low, the outputs are off and in a high-impedance condition, similar to that of the driver.

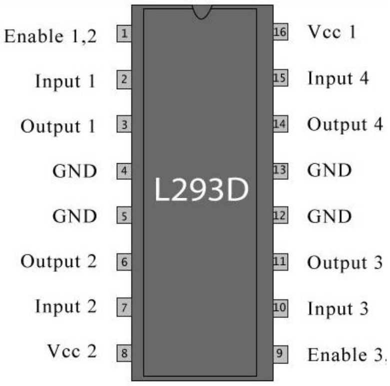

Figure 3:Driver IC (L293D)

1) Pin Diagram of L293D: The pin layout of the L293D driver IC is shown in Fig. 3.These quadruple high-current half-H drivers are the L293 and L293D. At voltages ranging from 4.5 V to 36 V, the L293 is intended to deliver bidirectional driving currents of up to 1 A. At voltages ranging from 4.5 V to 36 V, the L293D is intended to deliver bidirectional driving currents of up to 600 mA. Both devices are made to drive inductive loads in positive-supply applications, including relays, solenoids, dc and bipolar stepping motors, among others.

2) Relay: A relay's pins are shown in 4. Relays are straightforward electromechanical switches. Relays are switches that link or disconnect two circuits, similar to how regular switches are used to manually close or open circuits. However, a relay makes use of an electrical signal to operate an electromagnet, which in turn connects or disconnects another circuit, as opposed to a manual process. Relays might be electromechanical or another kind. stable condition. Relays with an electro-mechanical design are widely used. Before learning how this relay operates, let's examine its inside. Although there were many different types of relays, they all functioned the same.

Figure 4:Pin Connections of Relay.

The relay module consists of various pins serving distinct functions. The Normally Open (NO) pin remains open in the absence of a signal to the relay module's signal pin, connecting to the common contact pin by breaking its link through the Normally Closed (NC) pin. The common contact
pin is utilized to connect to the load intended for control by the module. When the relay is switched through an active high/low signal sent from a microcontroller to the signal pin, the NC connection to the COM pin dissipates, creating a closed circuit. The Signal Pin is pivotal for relay control, functioning in either an active low or active high scenario. In an active low situation, the relay activates with an applied active low signal, while in an active high scenario, a high signal to the signal pin triggers the relay. The relay coil must be strengthened for effective operation, often leading to modules operating on an active high signal. The 5V VCC pin requires a 5V DC power source for operation, and the Ground pin connects to the power supply's GND terminal.

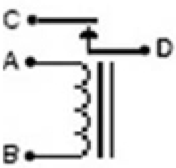

Figure 5:Single Pole Single Throw Relay

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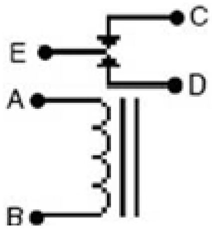

Figure 6:Single Pole Double Throw Relay

An SPST Relay, or Single Pole Single Throw Relay, is a device having only one input and one output. When it is operated, as shown in Fig. 5, just one contact is connected or disconnected. When the coil terminals are included, there are four total terminals. The SPST relay can only regulate one electrical or electronic circuit.

The" single pole double throw (SPDT) relay" design shown in Fig. 6 flips between two additional poles and one common pole. When the relay coil is at rest, that is, when no voltage is provided to it, as shown in the schematic picture, the common point E completes a circuit with C. This is comparable to a
wall switch for lights in your house. You may complete the circuit closure with a single" throw" of the switch. The circuit has been" closed." An" open" circuit is made when there is a space between the contacts at point E and D. A metal levels is drawn down when electricity is applied to the coil, which closes the circuit between points E and D and opens the circuit between E and C.

1) Liquid Crystal Display (LCD): A liquid-crystal display (LCD) is a flat-panel display or other electronically controlled optical device that uses polarizers and the light-modulating properties of liquid crystals. Liquid crystals don't generate light directly; instead, they need a backlight or reflector to produce colored or monochrome images. Some LCDs can display fixed displays with limited information that can be viewed or concealed or random graphics (as on a general-purpose computer display). Preset text, numbers, and seven segment displays, such as those seen in digital clocks, are a few examples of gadgets that use these displays.

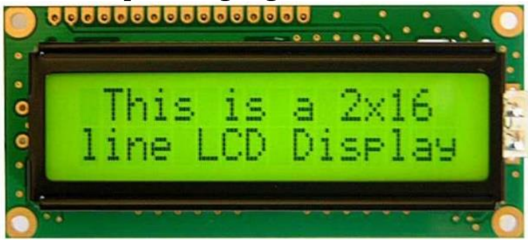

Figure 7:2x16 Line Alphanumeric LCD Display

Table 3:LCD PINS

Pin	Symbol	Function
1	Vss	Ground
2	Vdd	Supply Voltage
3	Vo	Contrast Setting
4	RS	Register Select
5	R/W	Read/Write Select
6	En	Chip Enable Signal
7-14	DB0-DB7	Data Lines
15	A/Vee	Gnd for the backlight
16	K	Vcc for backlight

2) Power Supply: Two coils, referred to as" WINDINGS" and referred to as the PRIMARY and secondary in a transformer, make up the device. Through electrical wires that connected. Alternating voltage is produced in the secondary coil as a result of a changing magnetic field in the core brought on by a changing main current. A load will experience an alternating current if it is connected to the secondary. In a perfect world, the magnetic field would allow for the complete passage of energy from the primary circuit to the secondary circuit. Transformer types are seen in 8.

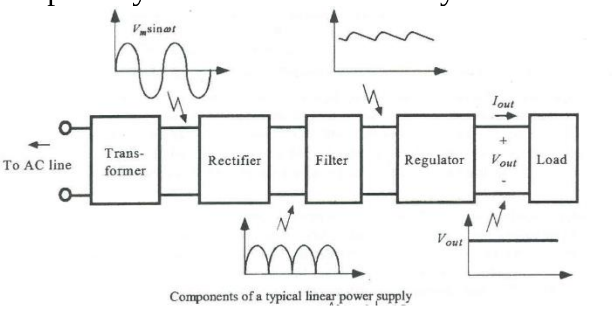

Figure 8:Power supply Block Diagram

D. Pin Connections of ESP32 For Proposed System

Complete pin connections of the ESP32 to relays, LCDs, power supplies, and cable lines are shown in 9. The ESP

32 board has 30 pins, of which GPIO pins 36, 39, and 34 are connected to red cable faults (R1, R2, and R3), while

GPIO pins 35, 32, and 33 are connected to green cable faults at distances of 1 km, 2 km, and 3 km, respectively. Yellow cable fault wires are connected to GPIO pins 25, 26, and 27. When it comes to the relays, the red relay is linked to GPIO pin 4, the yellow cable relay to GPIO pin 2, and the green cable relay to GPIO pin 15. Connected to GPIO pins 23, 22, 21, 19,18 and 5 is an LED display.

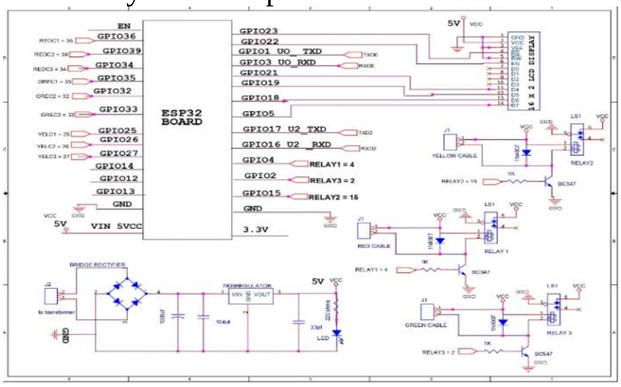

Figure 9:Pin Connections of ESP32 For Proposed System

The input for the ESP32 board is 5 volts, but the relay only requires 3.3 volts. The ESP board will convert 5 volts to 3.3 volts and supply it to the relays. The ground is attached to each color wire. When the R1 cable experiences a problem, the red cable relay will be notified and transmitted to the website and LCD display. Similarly, whenever a cable of any distance experiences a fault, the data will be shown on the LCD and sent to the website's server every five counts

IV. RESULTS

We utilized a website in this system to display the condition of the buried wires. To access the website, hotspot credentials and website credentials are required. The basic login page of the proposed system is depicted in Figure 10, showcasing the login fields where the appropriate information must be entered The login page can be accessed at the following URL:

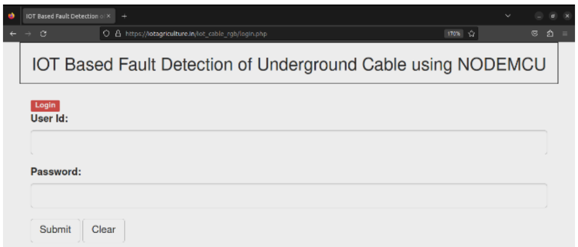

Figure 10:Login Page of the Proposed System

https://iotagriculture.in/iotcablergb/login.php
UserID : iotcable
Password : iotcable123

When utilizing the ESP32 hotspot credentials, a connection can be established by entering the password ”project1234” and the SSID ”project” when the system or device is turned on.Following the initialization of the ESP32 and LCD, the system will connect to an available hotspot if one is present.

Case 1: fig: No Cable Fault Occurred depicts the cables of Red, Yellow, and Green as being 1 km, 2 km, and 3 km long, respectively, with No Fault Occurring, All Ok Displays on LCD, and Updated on Website.

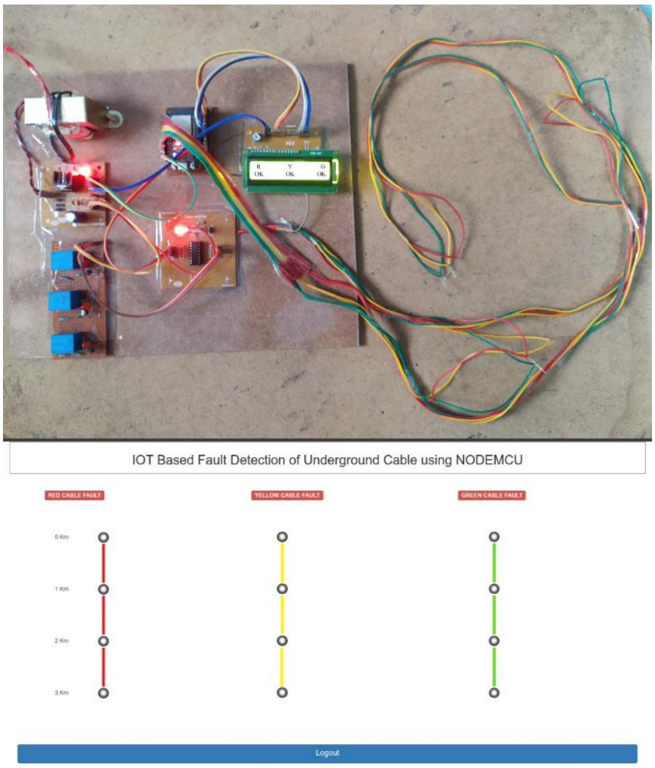

Figure 11:No Cable Fault Occurred

Case 2:12 demonstrates that the Yellow cable is fault-free over its entire length, but that the Red and Green cables have faults at 3 km and 2 km, respectively. R-3km, G-2km, and an updated website with dotted lines denoting errors were presented on the LCD as a result.

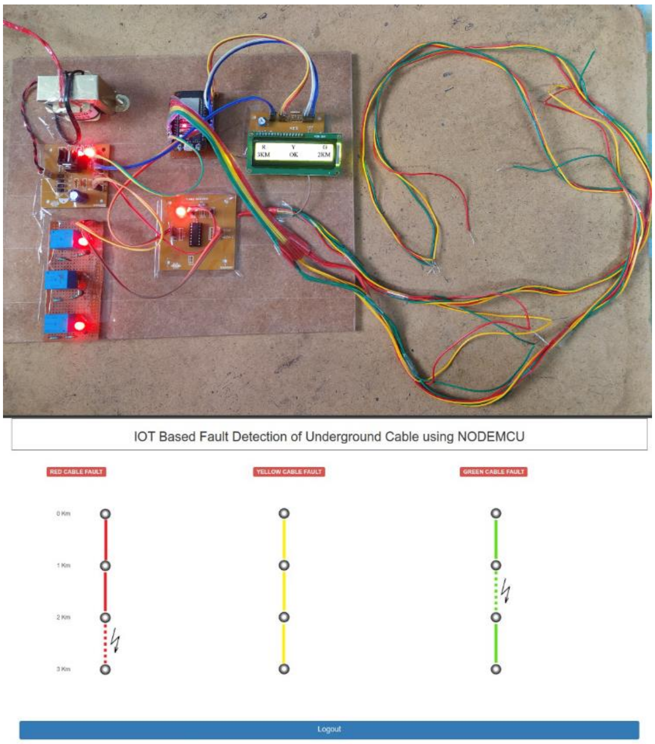

Figure 12:Red Cable Faults at 3km and Green Cable Faults at 2km

Case 3: 13 illustrates that all three cables fail at various locations, with the red cable failing at 2,3 km, the yellow cable failing at 1,3 km, and the green cable failing at 1,2 km.As a result, the LCD displayed R, Y, and G distances of 2, 3,and updated to a webpage with dotted lines to indicate errors.

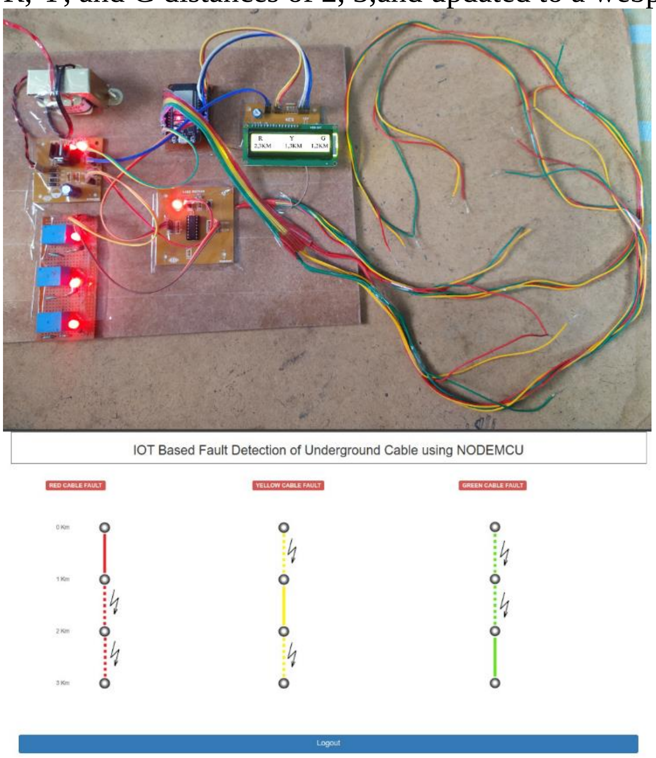

Figure 13:All Cables Fault Detected

V. CONCLUSION

The suggested work with Cases 1, 2, and 3 clearly demonstrates the challenge of locating the fault in subterranean cables using ESP32. We used an IOT-based model to display defects to help people more easily identify cable failures. Using the ESP32, we displayed faults in order to locate the subterranean cable fault. In comparison to other approaches now in use, our work provides the greatest results and the fastest operational speed. It can solve the issue of manpower and time requirements for locating underground cable problems. With the aid of the ESP32, the work shows the location of the issue in the LCD. Accurate fault finding has several advantages, including quick power system restoration, improved system performance, lower operating costs, and shorter field fault location times.

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