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System to Check the Healthiness of the Earthing System and Alert Staff in Case of Malfunction

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Abstract- This paper presents an IoT-based system for detecting faults in underground cable earthing using an ESP32 microcontroller unit and a soil moisture sensor. The system monitors soil moisture levels around the earthing rod to ensure proper conductivity. Variations in soil moisture can lead to earthing inefficiency, posing safety risks. Earth faults are not only by far the most frequent of all faults, but the fault currents may be limited in magnitude by the neutral earthing impedance, or by the earth contact resistance which makes detection challenging for conventional protection schemes. Currently, normal earth fault protection together with sensitive earth fault protection has been employed in both distribution networks to detect and clear earth faults. There have been incidences where earth fault detection has been extremely challenging as fault values drop significantly and the protective device does not have sensitivity to detect and isolate the faulty equipment. The earth resistance is detect by moisture of earth using moisture sensor Real-time data acquisition, wireless transmission, and alerts help in preventive maintenance of earthing systems, particularly in rural or inaccessible areas. Experimental results show that this system is reliable, low- cost, and scalable for smart grid applications.

Index Terms- - Soil Moisture Sensor, ESP32 MCU, Underground Earthing, LCD Display, IoT, Wireless Monitoring.

I. INTRODUCTION

Proper grounding is a fundamental requirement in electrical systems, playing a crucial role in ensuring user safety, protecting equipment, and maintaining system reliability. An effective earthing system relies heavily on the conductivity of the surrounding soil, which in turn is influenced by its moisture content. As soil conditions change due to environmental factors such as temperature, rainfall, or seasonal variation, the grounding resistance can increase, potentially leading to hazardous situations such as voltage instability, electrical shocks, or equipment malfunction. Traditionally, the condition of earthing systems has been evaluated through manual inspections and periodic testing, which are labor-intensive and may not provide timely insights into the system's health. With the advent of Internet of Things (IoT) technology, there is now a significant opportunity to automate and enhance the monitoring of critical infrastructure. This research introduces a Smart Underground Earthing System that employs a soil moisture sensor to continuously monitor the water content in the soil around an earthing installation. The data is processed by an ESP32 microcontroller and displayed in real-time on an LCD screen, while also being transmitted wirelessly to a mobile device for remote access. This approach provides a cost- effective, real-time, and scalable solution to maintain optimal earthing conditions and improve overall electrical safety.

System Design and Architecture
Components Used

- ESP32 Microcontroller
- Soil Moisture Sensor
- Wi-Fi Connectivity
- Power Source (Battery/USB)
- Mobile device (for notifications)
- Current Sensor (ACS712)
- Voltage Sensor (ZMPT101B)

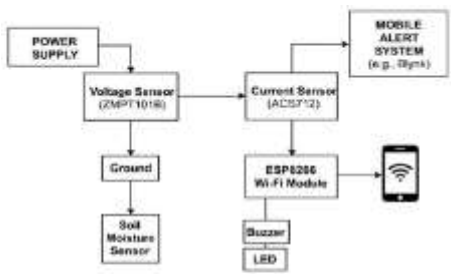

Figure 1: Block Diagram

Working Principle

- The soil moisture sensor is embedded underground near pipelines or electrical cables.
- When a leakage occurs, moisture levels in the soil change significantly.

- The ESP32 reads these values and compares them against a set threshold.
- If a leak is suspected, an alert is triggered and data is sent over Wi-Fi to a mobile device.

Soil Moisture Sensor
A soil moisture sensor can be used in an underground earthing monitoring system to detect changes in soil moisture, which can affect the effectiveness of the earthing system. By monitoring soil moisture levels, the system can help ensure proper grounding and prevent issues like corrosion or higher ground resistance.

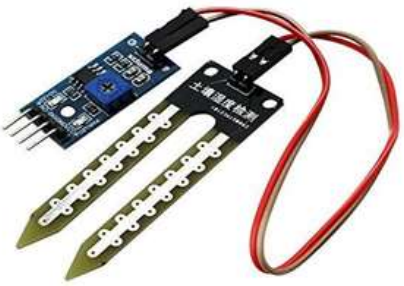

Figure 2: Soil Moisture Sensor

ESP32 MCU
In an underground earthing monitoring system, the ESP32 microcontroller unit (MCU) plays a vital role by collecting data from the soil moisture sensor and processing it to assess soil conditions around the earthing electrode. Since soil moisture directly affects conductivity, the ESP32 helps evaluate the effectiveness of the earthing system. With built-in Wi-Fi, it transmits real-time data to a remote device or server for continuous monitoring. The ESP32 can also be programmed to trigger alerts if moisture drops below a safe level. Its low power consumption, compact size, and reliable performance make it ideal for long-term underground monitoring applications.

Figure 3: ESP32 Microcontroller Unit

IOT (Internet of Things)
The Internet of Things (IoT) enables real-time monitoring and data communication to ensure the effectiveness of the earthing setup. IoT integrates sensors, such as a soil moisture sensor, with a microcontroller like the ESP32 that collects and processes data. Using Wi-Fi or other communication protocols, the ESP32 sends this data to cloud platforms or mobile devices for remote monitoring. This allows users to track soil conditions continuously and receive alerts if moisture levels fall below critical thresholds. IoT ensures timely maintenance, improves safety, and reduces manual inspections in electrical grounding systems.

Underground Earthing
Underground earthing is a method used to safely discharge excess electrical current into the ground through buried conductive elements like copper rods, plates, or strips. It provides a low-resistance path to the earth, protecting people, equipment, and structures from electric shock, equipment damage, or fire caused by fault currents or lightning.

Commonly used in residential, industrial, and power systems, underground earthing ensures electrical safety, system stability, and proper operation of protective devices by maintaining consistent ground potential.

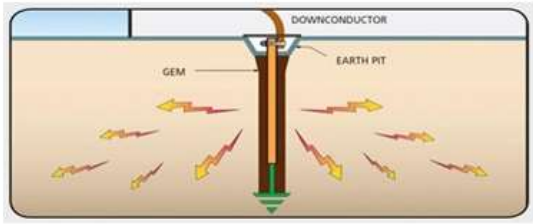

Figure 4: Underground Earthing

III. METHODOLOGY

Sensing-Phase:
Voltage and current sensors collect data from the earthing rod in real-time. The voltage sensor detects potential build-up, while the current sensor identifies unintended leakage current.

Processing-Phase:
Arduino UNO compares incoming sensor data against preset threshold values. If any reading exceeds the threshold, a fault condition is identified.

Alert-Phase:
Upon fault detection, the ESP8266 module sends an alert via Wi-Fi to the IoT platform. The alert is then pushed to the user’s mobile phone. Simultaneously, a buzzer and LED on-site provide a visual/audible warning.

Overall, this methodology ensured the development of a cost-effective, efficient, and practical solution for monitoring underground earthing systems, with the potential for further expansion and integration into broader electrical safety monitoring networks.

II. CONCLUSIONS

This research work presents the design and implementation of a smart underground earthing monitoring system using a soil

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moisture sensor and an ESP32 microcontroller. The system effectively detects changes in soil moisture and transmits real-time data to a mobile device using Wi-Fi. This enables users to monitor the condition of the earthing system remotely, ensuring safety and reliability in electrical installations.

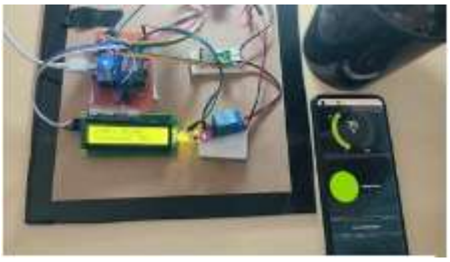

Figure 5: Experimental Setup

The integration of the ESP32 with a soil moisture sensor provides a compact and cost- effective solution for continuous monitoring. The system proved to be reliable in real-world testing, accurately identifying moisture variations and sending timely alerts. Overall, the proposed system enhances the safety of electrical systems and supports proactive maintenance, especially in areas where traditional monitoring is difficult or expensive

Future works

Figure 6: Normal Working(left), Earthing Malfunction(right)

While the current system offers an effective and low-cost solution for monitoring underground earthing through soil moisture detection, there is significant scope for improvement and expansion. One of the main limitations is the range of Wi-Fi communication. In future developments, long-range communication technologies such as GSM, LTE, or LoRa can be integrated to enable data transmission from remote or rural locations. To make the system energy-efficient and independent, a solar-powered power supply can be added. This would allow the device to operate in off-grid environments for long periods without manual intervention. Furthermore, cloud-based data storage and visualization platforms can be employed to store historical data, enabling trend analysis and long-term monitoring.

Incorporating Artificial Intelligence (AI) or Machine Learning (ML) algorithms could allow the system to predict when moisture levels are likely to fall below the critical threshold, improving preventive maintenance. The system can also be expanded by adding multiple sensors to monitor other important soil parameters such as temperature, pH, and soil resistance, creating a more comprehensive earthing health monitoring network.

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