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IOT Based Automatic Soil Moisture Control System & Earth Resistance Monitoring

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ABSTRACT—

The Earthing Fault Monitoring System is an automatic system developed to monitor and maintain suitable conditions around an electrical earthing arrangement. Effective earthing is important for providing a safe path for fault current and protecting electrical equipment and users from electrical hazards. In conventional earthing systems, materials such as coal and salt may be used to improve soil conductivity, but the surrounding soil can gradually lose moisture and its electrical properties can change over time. This may affect the effectiveness of the earthing system and can require regular manual inspection. The proposed system uses a two-probe soil sensor to monitor the electrical condition of the soil and sends the sensor output to an ESP32 microcontroller for processing. When the monitored soil condition indicates that additional moisture is required, the ESP32 activates a relay to turn ON a water pump. The pump supplies water to the earthing area, helping restore suitable soil conditions. An LCD provides system-status information, while a buzzer gives an alert when an abnormal condition is detected. The system therefore provides a simple and low-cost approach for continuous monitoring and automatic maintenance of the earthing environment, reducing manual intervention and improving the reliability of the earthing arrangement.

Keywords: Earthing Monitoring, Earthing Fault Detection, ESP32, Soil Sensor, Soil Resistance, Automatic Water Pump, Relay, Electrical Safety, LCD Display, Buzzer.

1. INTRODUCTION

Earthing is an essential part of any electrical installation because it provides a safe path for unwanted or fault current to flow into the ground. A properly maintained earthing system helps protect people, electrical equipment, and appliances from electric shock, leakage current, and damage during abnormal electrical conditions. The effectiveness of earthing depends not only on the grounding electrode but also on the condition of the soil surrounding it. Soil with suitable moisture and conductivity can provide a better path for current, whereas dry or unsuitable soil can increase electrical resistance and reduce the effectiveness of the earthing arrangement.

In many conventional earthing systems, materials such as coal and salt are added around the earthing electrode to improve the conductivity of the soil and help maintain a lower resistance path. However, these materials alone cannot prevent the soil from becoming dry over a long period. Changes in weather, temperature, and surrounding environmental conditions can reduce the moisture content of the soil. If this condition is not identified in time, the earthing performance may gradually deteriorate. Regular manual inspection and watering can help, but this approach requires human effort and may not provide continuous monitoring.

To overcome these limitations, the proposed Earthing Fault Monitoring System introduces an automatic method for observing the soil condition around the earthing arrangement. A two-probe soil sensor is used to sense the electrical condition of the soil. The sensor output is supplied to an ESP32 microcontroller, which processes the information and determines whether the soil condition is within the required operating range. This allows the system to continuously monitor changes instead of depending only on occasional manual inspection.

When the monitored soil condition indicates that additional moisture is required, the ESP32 activates a relay connected to a water pump. The pump supplies water to the earthing area and helps restore the required soil condition. Once the desired condition is reached, the controller can stop the pump, preventing unnecessary water usage. An LCD display is provided to show the system status, while a buzzer can generate an alert when an abnormal condition is detected.

Overall, the proposed system combines sensing, microcontroller-based decision-making, automatic pump control, and user indication into a single setup. It is intended to reduce manual monitoring, maintain more consistent soil conditions around the earthing electrode, and improve the reliability and safety of the earthing arrangement. The system also provides a practical foundation for developing more advanced earthing-monitoring solutions with remote monitoring and data logging capabilities in the future.

2. AIMS & OBJECTIVES

Aim:

The main aim of the Earthing Fault Monitoring System is to develop an automatic and reliable system for monitoring the soil condition around an earthing arrangement and maintaining suitable earthing conditions by controlling soil moisture. The system uses a soil sensor and an ESP32 microcontroller to identify unsuitable soil conditions and automatically operate a water pump when required. This reduces the need for frequent manual inspection and helps maintain the effectiveness and safety of the earthing system.

Objectives:

- To monitor the soil condition continuously around the earthing electrode using a two-probe soil sensor.
- To identify changes in soil resistance or conductivity that may indicate an unsuitable condition for effective earthing.
- To automatically maintain soil moisture by controlling a water pump through a relay whenever the soil becomes excessively dry.
- To display the operating condition of the system on an LCD and provide an audible warning through a buzzer during abnormal conditions.
- To reduce manual inspection and maintenance by providing an automatic method for monitoring and maintaining the earthing environment.
- To improve the reliability and safety of the earthing arrangement by helping maintain suitable soil conditions for an effective path to ground.

3. LITERATURE SURVEY

The development of earthing systems has progressed from simple grounding arrangements to more advanced monitoring and maintenance methods. Earlier systems mainly concentrated on providing a low-resistance path to the ground, while modern approaches increasingly focus on observing changes in soil and grounding conditions. Some important historical and existing approaches are discussed below:

1. **Traditional Earthing Systems:**

   Early earthing arrangements commonly used metal plates, pipes, or rods buried in the ground to provide a path for fault current. The effectiveness of these systems depended heavily on the surrounding soil properties, moisture level, and quality of the connection.

2. **Coal and Salt-Based Earthing:**

   A widely used traditional method involved placing materials such as charcoal or coal and salt around the earthing electrode. These materials were intended to improve the conductivity of the surrounding soil and help maintain a lower earth resistance. However, their effectiveness could reduce when the soil became dry or environmental conditions changed.

3. **Pipe and Rod Earthing Methods:**

   Later earthing practices increasingly used galvanized iron or copper pipes and rods because they provided a more practical and durable grounding arrangement. These systems offered improved mechanical strength and conductivity, but their performance still depended on soil characteristics and moisture.

4. **Chemical Earthing Systems:**

   More advanced earthing methods introduced conductive compounds or earthing enhancement materials around the electrode. These systems were developed to maintain better contact between the electrode and surrounding soil, particularly where natural soil conductivity was poor. However, periodic inspection is still required to ensure that the grounding arrangement remains effective.

5. **Digital Earth Resistance Measurement:**

   With the development of electronic measurement equipment, earth resistance could be checked more accurately using dedicated testing instruments. Such methods made it easier to identify changes in grounding performance, but conventional testing generally required an operator to perform measurements at intervals rather than continuously.

6. **Sensor-Based Soil Monitoring:**

   The introduction of microcontrollers and soil sensors created the possibility of continuously monitoring soil conditions. Sensor readings can be processed electronically to identify changes in moisture or electrical properties, reducing dependence on manual observation.

7. **Automatic Moisture-Control Systems:**

   Automated irrigation and soil-moisture control systems demonstrated that sensors, controllers, relays, and pumps could be combined to maintain a desired soil condition automatically. The same basic concept can be adapted to earthing applications, where maintaining suitable soil moisture can help support consistent grounding conditions.

8. **Proposed Earthing Fault Monitoring System:**

   Building on these earlier approaches, the proposed system combines soil-condition sensing with automatic control. A two-probe soil sensor provides information to an ESP32, which evaluates the soil condition and activates a relay-controlled water pump when moisture maintenance is required. An LCD and buzzer provide local status and fault indications. This combination aims to reduce manual inspection and provide a more responsive method of maintaining the earthing environment.

4. METHODOLOGY

The methodology of the Earthing Fault Monitoring System is based on continuous monitoring of the soil condition around the earthing electrode and automatic control of soil moisture whenever the condition becomes unsuitable. The complete system combines a soil sensor, ESP32 microcontroller, relay, water pump, LCD display, buzzer, power supply, and voltage regulator to provide automatic monitoring and maintenance.

1. **Earthing and Soil Preparation:**

   The earthing electrode is installed in the ground, and suitable earthing materials such as coal and salt can be placed around the electrode to improve the conductivity of the surrounding soil. The condition of this soil is important because its moisture and electrical properties directly influence the effectiveness of the earthing arrangement.

2. **Sensing of Soil Condition:**

   A two-probe soil sensor is positioned near the earthing area. The two probes make contact with the soil and provide a sensor output related to its electrical condition. As the soil condition changes, the sensor reading also changes. This reading is continuously supplied to the ESP32 for further processing.

3. **Data Processing Using ESP32:**

   The ESP32 acts as the main controller of the system. It receives the sensor signal and compares the measured value with the predefined operating condition. Based on this comparison, the controller determines whether the soil condition is suitable or whether additional moisture is required to support proper earthing.

4. **Automatic Pump Operation:**

   When the soil becomes excessively dry or the monitored condition moves outside the desired range, the ESP32 sends a control signal to the relay. The relay switches ON the water pump, which supplies water to the soil surrounding the earthing electrode. This helps restore the required moisture condition. After the desired condition is achieved, the controller switches the pump OFF.

5. **Display and Warning System:**

   The LCD is used to provide information about the current system condition, such as normal or abnormal soil status and pump operation. A buzzer is included to provide an audible warning when an undesirable earthing condition is detected. This allows the user to identify a problem quickly without continuously observing the system.

6. **Power Supply and Regulation:**

   A suitable power supply provides electrical energy to the complete system. A voltage regulator is used to provide a stable voltage to the ESP32 and other electronic components. The relay and pump are controlled according to the signals generated by the microcontroller, allowing the entire system to operate as an integrated automatic monitoring unit.

7. **Continuous Monitoring and Maintenance:**

   After the system is activated, the sensing and control process continues automatically. The soil condition is repeatedly monitored, and the pump is operated only when necessary. This reduces manual checking, helps maintain suitable soil conditions around the earthing electrode, and provides a practical approach for improving the reliability of the earthing arrangement.

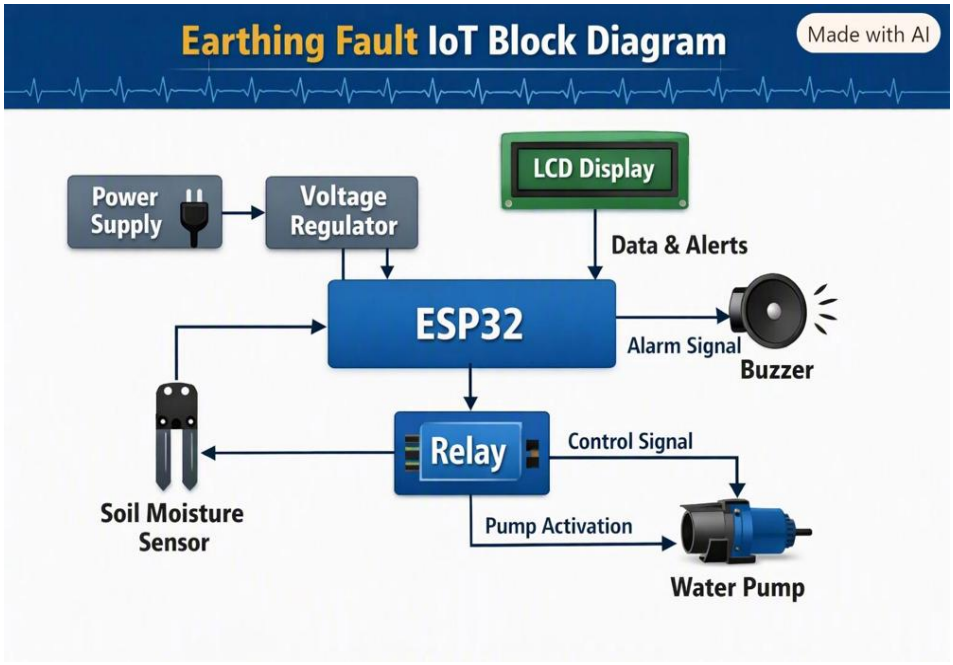


Figure 1: Block Diagram of the proposed system

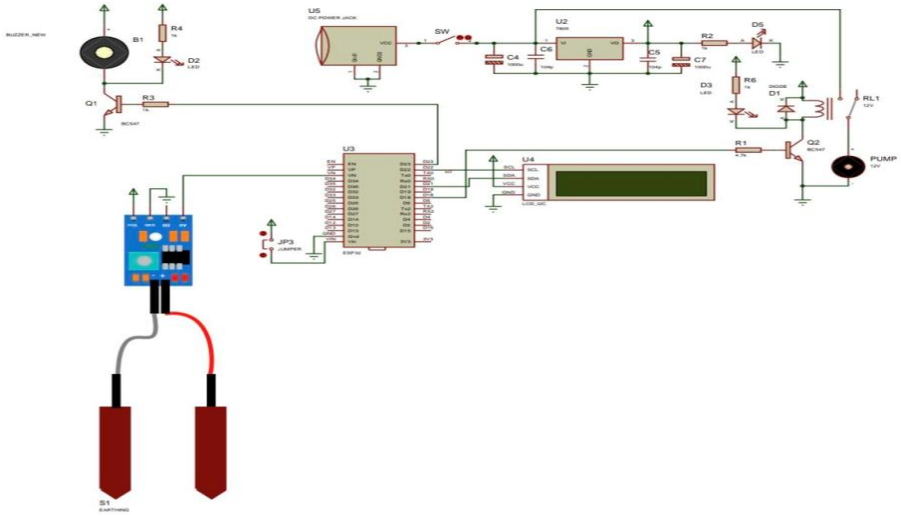


Figure 2: Circuit Design of the proposed system

5. RESULTS

The developed Earthing Fault Monitoring System successfully demonstrates automatic monitoring and maintenance of the soil condition around an earthing arrangement. The two-probe soil sensor continuously detects changes in the electrical condition of the soil and provides the corresponding signal to the ESP32 microcontroller. When the soil becomes excessively dry and the monitored value moves away from the required range, the ESP32 activates the relay, which turns ON the water pump. Water is then supplied to the earthing area to improve the soil condition. Once the required condition is restored, the pump can be switched OFF automatically. The LCD provides information about the operating status, while the buzzer gives an alert during an abnormal condition. The overall operation shows that the proposed system can reduce manual monitoring and provide a practical method for maintaining suitable conditions around the earthing electrode.

6. CONCLUSION

The Earthing Fault Monitoring System provides a simple and useful approach for continuously observing the condition of soil surrounding an earthing arrangement. Conventional earthing systems may gradually lose effectiveness when the surrounding soil becomes dry, making regular inspection and maintenance important. The proposed system addresses this issue by combining a soil sensor, ESP32 microcontroller, relay, and water pump to monitor

and automatically control the soil condition. The LCD and buzzer further improve the usability of the system by providing visual information and warning indications. By reducing dependence on manual checking and responding automatically when moisture maintenance is required, the system can help maintain more consistent earthing conditions and improve the reliability of the installation. Overall, the project demonstrates how low-cost embedded technology can be applied to electrical safety and earthing maintenance, while also providing a foundation for future improvements such as remote monitoring, data logging, and more accurate earth-resistance measurement.

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