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System to Monitor the Health of Earthing System and Alert Staff in Case of Malfunction

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Abstract: The safety and operational reliability of electrical systems are fundamentally dependent on an effective earthing (or grounding) mechanism, which ensures that fault currents are safely diverted to the ground, preventing electric shocks, protecting equipment, and mitigating fire risks. Traditional earthing systems, however, may degrade over time due to environmental factors, leading to unsafe conditions. This paper proposes a realtime monitoring system utilizing Arduino-based architecture to continuously assess the health of earthing systems. By integrating high-precision sensors for voltage and current measurements, the proposed system provides real-time diagnostics and early fault detection. It further supports automated alert mechanisms to notify maintenance personnel in case of abnormal readings, thus enhancing operational safety and reducing the potential for severe malfunctions. While the initial setup may involve higher costs, the long-term benefits in terms of reduced downtime, optimized maintenance, and enhanced safety make this system an indispensable tool for modern electrical infrastructure.
Index Terms: Arduino, Earthing System, Fault Detection, Monitoring System, Electrical Safety.

I. INTRODUCTION

In any electrical installation, earthing plays a critical role in maintaining safety by providing a low-resistance path for fault currents to flow into the ground, thereby preventing electrical hazards such as shocks and equipment damage. The reliability of the earthing system must be ensured through regular checks and real-time monitoring, especially in environments where manual inspection may be insufficient or too infrequent.

Traditional methods for monitoring earthing systems are often labor-intensive, time-consuming, and prone to errors. This research introduces an automated, Arduino-based monitoring system that integrates voltage and current sensors to assess the health of the earthing system in real-time. The system is capable of providing continuous diagnostic data, flagging abnormalities like excessive voltage or stray currents, which could indicate potential faults. The integrated alert system ensures prompt notification of maintenance personnel, helping to mitigate risks before they escalate. This solution contributes to enhancing the reliability of earthing systems, improving safety compliance, and optimizing maintenance workflows.

II. LITERATURE SURVEY

In recent years, various approaches have been proposed for monitoring electrical systems and improving safety through fault detection:

Jovin Chui, ”A Fault Detection and IoT Monitoring System for Single-Phase Wiring” [1]: This research highlights the integration of IoT for fault detection in singlephase electrical systems. By utilizing microcontroller- based systems for tracking electrical parameters (voltage, current), the system alerts users via mobile applications upon the detection of faults such as short circuits or voltage surges, thereby providing a more responsive approach to system health monitoring.

RR Sharma et al., ’’Design of a Talking Energy Meter Based on Microcontroller” [2]: This work explores the use of an ATMEGA328 microcontroller to track and announce electrical consumption. The system is designed to provide real-time data and voice alerts, which are particularly useful for users with hearing impairments. This design demonstrates how microcontroller-based systems can be employed to monitor energy consumption and offer more interactive user feedback.

Daoru Pan et al., ”Design and Implementation of IoT System and Equipment for Lightning Parameter Monitoring” [3]: This study investigates the use of IoT technologies for monitoring lightning parameters, such as grounding resistance and lightning strikes. The proposed system uses wireless sensor networks (WSN) to collect real-time data, which is processed and analyzed centrally, ensuring prompt action is taken in the event of a grounding fault. This IoT-based approach offers a cost- effective alternative to traditional methods of lightning protection.MD Joshi et al., ”Auto Watering System for Substation Earthing Using Soil Moisture Sensors” [4]: In this work, an automated watering system for substation earthing is proposed, where soil moisture levels are monitored to maintain optimal conditions for grounding effectiveness.

Using AVR microcontrollers and sensors, the system ensures that the grounding system remains effective even under varying environmental conditions.

Abdul Arif bin Arni, 'Development of Earthing Tester for Electrical Wiring in Residential Buildings" [5]: This research focuses on improving the reliability of earthing tests in residential buildings by replacing traditional methods with ultrasonic sensors. The system enhances the measurement accuracy of earth resistance by considering environmental factors such as soil conductivity, temperature, and humidity.

III. SYSTEM OVERVIEW

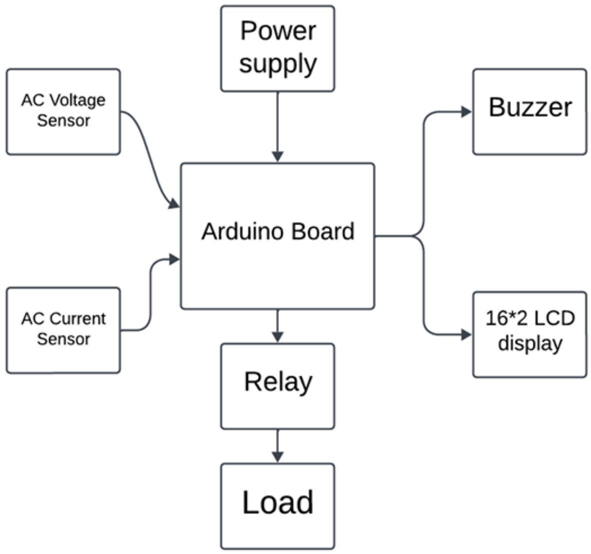

Fig. 1. BLOCK DIAGRAM

The proposed system architecture integrates sensors, a microcontroller, and alert mechanisms to monitor key parameters of an earthing system. The components include:

1) Arduino Board (Microcontroller): The central processing unit that reads data from sensors, applies logic to check for anomalies, and triggers alerts accordingly. The Arduino controls the entire system, including sensor interfacing and user notification mechanisms.
2) AC Voltage Sensor (ZMPT101B): Measures the AC voltage between ground and neutral. A significant deviation in this voltage could signal an improper earthing condition, such as a damaged earth electrode.
3) AC Current Sensor (ACS712): The system utilizes two ACS712 current sensors to monitor both the phase and neutral currents. If the current deviates from the normal range, it may signal an issue in the earthing system, such as a broken circuit or inadequate grounding.
4) Buzzer: An audible feedback mechanism that triggers when abnormal readings are detected. The buzzer serves as an immediate warning for maintenance personnel.
5) LCD Display (16x2): Displays real-time sensor readings (voltage and current) and provides feedback on the status of the earthing system.
6) Relay: The relay is used to disconnect the circuit in case an earth fault is detected. If the voltage or current sensors detect an earth fault (such as an imbalance or unsafe condition), the relay is activated to disconnect the electrical circuit, preventing further damage or potential hazards.
7) Reset: The reset functionality is built into the system to allow operators to reset the Arduino and sensor readings after a fault has been addressed or after the system has been disconnected. This could be a manual reset through a button or automatically triggered after a certain condition is met, ensuring that the system is back in a safe and functional state after any faults have been cleared.

IV. METHODOLOGY

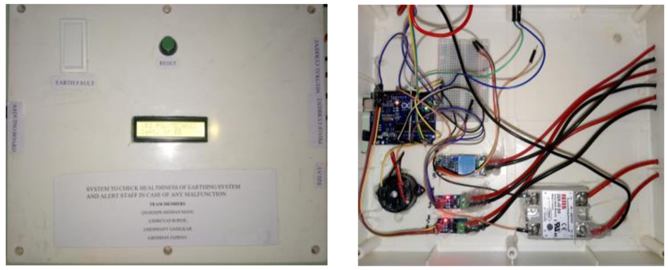

Fig. 2. KIT PHOTO

The system continuously monitors the health of the earthing system through a set of sensors that measure key parameters (voltage and current). The methodology is as follows:

1) Voltage Monitoring: The AC voltage sensor continuously measures the potential difference between the neutral and the earth. If the voltage deviates beyond a predefined threshold, the system flags an alert.
2) Current Monitoring: Two ACS712 current sensors are used to measure phase and neutral currents. A current reading outside the expected range indicates a potential fault in the earthing system, such as an open circuit or poor grounding.
3) Data Processing and Decision Making: The Arduino board processes the sensor data, comparing each reading with predefined threshold values. If any readings exceed the threshold, the system triggers an alert.
4) Alert Mechanism: When a fault condition is detected, the following alerts are activated:
5) Audible: The buzzer sounds an alarm to notify maintenance personnel.
6) Data Display: Real-time sensor data is shown on the LCD screen, offering an accessible interface for staff to assess the system's condition.
7) Relay: The relay serves to interrupt the circuit when an earth fault is detected. When the voltage or current sensors identify an imbalance or dangerous condition, the relay is triggered to cut off the electrical flow, preventing further harm or risks.
8) Reset: The reset function is integrated into the system to enable operators to restart the Arduino and refresh sensor readings once a fault is resolved or the system has been disconnected. This reset may be initiated manually via a button or automatically under certain conditions, ensuring the system is restored to a safe and operational state after addressing any issues.
9) Code Logic

The code is designed to monitor the current and voltage in an electrical system and detect earth faults. It uses an ACS current sensor (for both the positive and negative current inputs), a ZMPT voltage sensor, a relay for controlling the load, and a buzzer to alert users in case of a fault. The system is controlled and monitored through an LCD screen.

a) Key Components:

- ACS Current Sensors: The code uses two ACS current sensors to measure the current on the positive (PI) and negative (NI) sides of the system.
- ZMPT Voltage Sensor: This sensor measures the AC voltage of the system.
- Relay: The relay controls the connection/disconnection of the electrical load.
- Buzzer: It sounds an alarm in case of an earth fault (when the difference in current exceeds a threshold or the voltage exceeds a certain value).
- LCD Screen: The LCD displays various information, including the currents (PI, NI), their difference (DI), and the status of the system (e.g., whether an earth fault is detected).

b) Pin Definitions:

- ACS_Pin_A0 and ACS_Pin_A1: These pins (A0 and A1) are connected to the ACS current sensors to read the current values.
- RELAY_PIN: This pin is used to control the relay that connects or disconnects the load.
- RESET_PIN: The system can be reset by pressing a button connected to this pin.
- BUZZER_PIN: The buzzer is activated when an earth fault is detected.
- LCD_VCC_PIN: Controls the power to the LCD screen.

c) Constants:

- CURRENT_THRESHOLD: Defines the threshold value for detecting an overcurrent situation.

- WAIT_TIME: Defines the waiting time (10 seconds) before starting the voltage monitoring.

d) Setup:

- Pin Modes: The code sets up pin modes for various components like the ACS sensors, relay, buzzer, and LCD.
- LCD Initialization: Initializes the LCD screen and displays a welcome message followed by group members' names for a few seconds each.
- Running Statistics: Two RunningStatistics objects are used to store and calculate running statistics for current measurements on both sensors (A0 and A1). This helps in computing the RMS (Root Mean Square) values of the currents.

e) Main Loop:

- Reset Check: The code checks if the reset button is pressed (low signal). If so, it resets the system by calling the resetSystem() function.
- Read Sensor Values: The analog values from the ACS current sensors (A0 and A1) are read, and running statistics are updated for both sensors.
- RMS Current Calculation: Every second, the RMS values for both currents (PI and NI) are calculated using the RunningStatistics objects. These values are displayed on the LCD.
- Current Difference Calculation: The difference between the two currents (DI) is calculated. If this difference exceeds the defined threshold (CURRENT_THRESHOLD), it indicates an earth fault:
  - ➢ Earth Fault Handling: If an earth fault is detected, the relay is turned off (disconnecting the load), and the buzzer is activated. The LCD shows "Earth Fault" for 10 seconds.
- Voltage Monitoring: After a 10-second waiting period (controlled by the WAIT_TIME constant), the voltage sensor begins to monitor the voltage:
  - ➢ Voltage Calculation: The voltage is measured, calibrated, and displayed on the LCD.
  - ➢ Voltage Check: If the measured voltage exceeds 1.0V (indicating an earth fault in the system), the relay is turned off, and the buzzer sounds. The LCD shows "Earth Fault" with the voltage displayed.
  - ➢ If the voltage is below the threshold, the system is deemed safe, and the relay remains on while the buzzer is turned off. The LCD displays "NO Earth Fault."

f) Reset System:

- The resetSystem() function resets the relay, buzzer, and LCD screen, indicating that the system is resetting and then returns to its normal operation.

g) In Summary:

- Current Monitoring: Continuously monitors two currents (PI and NI) from the ACS sensors and calculates the difference (DI).
- Earth Fault Detection: If the current difference exceeds a threshold, it triggers an earth fault by turning off the relay and activating the buzzer.
- Voltage Monitoring: After a waiting period, it starts monitoring the voltage. If the voltage is above a threshold, it indicates an earth fault and activates the alarm.
- Display: Displays current, voltage, and system status on the LCD.

This system is useful for electrical fault detection and protection. It can be used to detect earth faults and alert the user while disconnecting the load to prevent further damage.

V. RESULTS AND DISCUSSION

The system has been successfully tested in simulated environments where voltage and current parameters were varied to simulate fault conditions. The system provided immediate feedback through visual and audible alerts, demonstrating its effectiveness in real-time fault detection.

Voltage and Current Monitoring: The system correctly identified voltage surges and abnormal currents, indicating faulty grounding conditions.

These results confirm that the proposed system is capable of effectively monitoring the earthing system and providing timely alerts for maintenance personnel.

VI. CONCLUSION

The Arduino-based real-time monitoring system for earthing systems offers a robust and efficient solution for ensuring electrical safety. The integration of voltage and current sensors allows for continuous monitoring, providing early detection of faults and timely alerts. This automated solution reduces the risk of electrical hazards, enhances maintenance efficiency, and improves the overall safety and reliability of electrical infrastructure.

VII. ACKNOWLEDGMENT

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