ISSN: 2582-7219

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Impact Factor: 8.206

Volume 8, Issue 6, June 2025

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ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Automated Earthing Health Monitoring and Alert System

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ABSTRACT: This is a concept design for an IoT-based earth pit health monitoring system intended to work towards the effective grounding of electrical safety. Grounding systems rely on the quality of earth pits, which undergo degradation with time due to soil conditions, corrosion, and other environmental conditions. The proposed system observes earth pit resistance and current levels using an ESP32 microcontroller, a current sensor, and an LCD display to provide direct on-site visualization of data. This setup captures data from a sensor using ESP32. That data is then reflected on an LCD screen for ready reference while also forwarded to the ThingSpeak cloud, where the data can then be stored and visualized for remote access, analysis, and tracking. Users can monitor earth pit health metrics from anywhere using the capability within the cloud that ThingSpeak provides to maintain it proactively. In the system, the alert functionality will be made use of inbuilt-this should then start visual and audible alarms using LEDs and a buzzer, respectively if the measured resistances or values of the current go beyond some predefined thresholds. The alerts provided by the system help in preventing electrical hazards due to timely intervention. The automated system, cost-effective and scalable, safely improves with simple monitoring of the earth pits through actionable insights generated through IoT technology

KEYWORDS: Iot- based earth pit, LCD display, ESP32 microcontroller , Buzzer, ThingsSpeak.

I. INTRODUCTION

Effective earthing is vital for ensuring electrical safety, as it provides a low-resistance path for fault currents and protects both equipment and human life. However, earthing systems degrade over time due to corrosion, soil conditions, moisture variation, and mechanical wear, leading to increased risk of electrical faults. Traditional manual inspections are infrequent, labor-intensive, and inadequate for early detection of such issues.

To overcome these limitations, **Automated Earthing Health Monitoring and Alert Systems** are gaining prominence. These systems utilize **IoT-based sensors**, wireless communication, and real-time data analytics to monitor critical parameters such as **earth resistance, leakage current, and soil moisture**. When abnormalities are detected, automated alerts are generated to prompt timely maintenance, thus reducing system failures and improving overall reliability.

This paper critically reviews current earthing monitoring practices and technologies. It contrasts manual and automated methods, highlighting the drawbacks of traditional approaches and the advantages of intelligent systems. Emerging trends show the integration of smart sensors, remote monitoring, and alert mechanisms in substations and industrial setups, enabling **predictive maintenance** and reducing dependence on periodic manual checks.

In conclusion, automated earthing health monitoring plays a significant role in modernizing electrical infrastructure. It enhances safety, minimizes operational downtime, and supports the development of a **smarter, more sustainable, and reliable power system**, especially in the context of growing urbanization and industrial expansion.

A. Proposed System

Monitoring the health of earth pits is crucial for the safety and reliability of electrical systems. Earth pits play a vital role in grounding, ensuring that electrical faults are safely discharged into the ground, preventing damage and injury. Traditional methods of checking earth pit resistance and current leakage involve periodic manual measurements, which are time-consuming and prone to human error. This project proposes an IoT-based solution that automates the process,

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using an ESP32 microcontroller, current sensor, and ThingSpeak platform to provide continuous, real-time monitoring and logging. The system also includes an LCD for local display and alert mechanisms for abnormal readings.

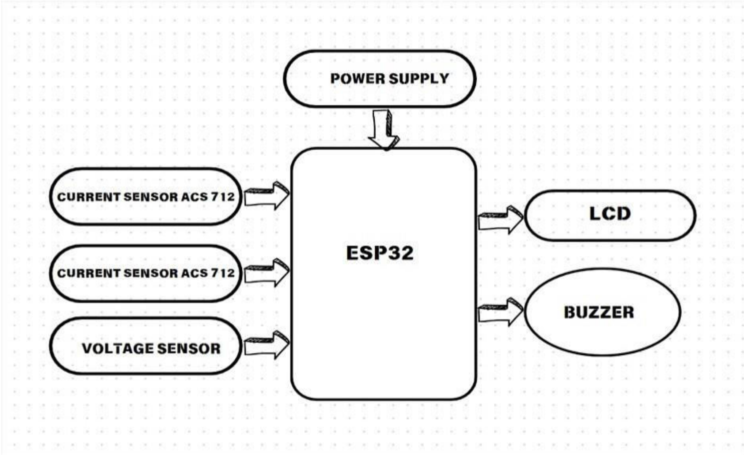

Fig1. Block Diagram of proposed system

B. Working

The intensity of the sun rays is greater in the east in the mornings. The holder on the east side contains a liquid refrigerant which gets heated by the sun rays. The expansion of the refrigerant is hence greater in the east side of the cylinder than the west side. The pressure in the bottom position of the double acting cylinder is greater and the piston connected to the cylinder tends to move upward, the eccentric arm tilts the panel along the east side. The intensity of the sun rays fall perpendicular to the solar panel The ESP-WROOM32 ESP32 ESP-32S Development Board 2.4GHz Dual-Mode WiFi + Bluetooth Dual Cores Microcontroller. The ESP32 is combined with Antenna switches, RF Balun, power amplifiers, low-noise amplifiers, filters, and management modules, and the whole solution takes up the smallest area of PCB. 2.4 GHz Wi-Fi plus Bluetooth dual-mode chip, with TSMC Ultralow power consumption 40nm technology, power dissipation performance, and RF performance is the best, safe and reliable, easy to extend to a variety of applications. ATTENUATOR CIRCUIT A full-wave rectifier converts the entire of the input waveform to one of constant polarity (positive or negative) at its output. It converts both polarities of the input waveform to pulsating DC (direct current). Two diodes and a filter capacitor are required for this purpose. The voltage derived from this is supplied to the potential divider, which is utilized to supply arduino compatible voltage. Resistors R1 and R2 constitute a voltage divider that reduces the AC voltage. Current measurement we are making use of a CT sensor. The current sensor module is an instrument for the measurement of electrical current. The ACS 712 is capable of the measurement of direct and alternating currents flowing through a conductor. The current to be measured induces a magnetic field, which is translated into an output voltage proportional by the Hall Effect. This voltage is then conditioned by a microcontroller system interfaced with an A/D converter, which enables the calculation of the peak value and the equivalent RMS value of the load current. A relay is an electrically controlled switch. Most relays employ an electromagnet to physically move a switch; however, other principles of operation are possible, including solid-state relays. Relays are utilized in applications where it is desired to control a circuit by an alternative low-power signal, or where multiple circuits are to be controlled by one signal. One of the first applications of relays was in long-distance telegraph circuits, where they were utilized as amplifiers: they replicated the received signal from one circuit and relayed it onto another circuit. Relays were utilized heavily in telephone exchanges and early computers to implement logical operations.

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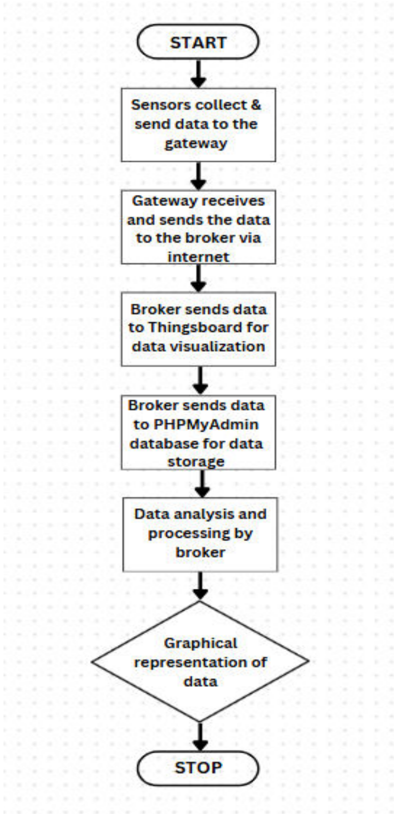

C. Mathematical Modelling
Transformer Design
Regulator Input Calculation
We require a +5V output. The drop-out voltage of the regulator is 2V (as per datasheet).
Therefore, the minimum voltage required at the regulator input (¡span class=”math-inline”V {dc}¡/span) is:
$Vdc = 5\ V + 2\ V = 7\ V$ (1)
According to the formula for the average DC voltage of a half-wave rectifier:
$Vdc = 2Vm/\ \pi$ (2)
Assuming there is no ripple capacitor, from Equation (1):
$Vm = Vdc \times \pi\ 2 = 7\ V \times \pi\ 2 = 10.99\ V$ (3)
During one cycle, two diodes conduct. Therefore, Voltage drop across two diodes = $2 \times 0.7\ V = 1.4\ V$ (4)
Thus, the peak input voltage (span class=”mathinline”V {im}¡/span) is:
$Vim = Vm + 1.4\ V = 10.99\ V + 1.4\ V = 12.39\ V$ (5)
The RMS input voltage (¡span class=”mathinline”V {rms}¡/span) is:
$Vrms = Vim\ \sqrt{}\ 2 = 12.39\ V\ \sqrt{}\ 2 = 8.76\ V$ (6)
So, we select a transformer with a secondary RMS voltage of approximately 9V.
Current Calculations:
Similarly,
$Im = Idc \times \pi\ 2 = 400\ mA \times \pi\ 2 = 628\ mA$ (7)
$Irms = Im\sqrt{}\ 2 = 628\ mA\ \sqrt{}\ 2 = 444.06\ mA$ (8)
So, we select a transformer with a secondary current rating of 500 mA.
Considering both voltage and current requirements, we choose a **0-9V / 500mA step-down transformer**.
Rectifier Design
$P\ IVdiode = Vm = 12.39\ V$ (9)
$Im = 628\ mA$ (10)
So, we select a bridge rectifier with a peak inverse voltage (PIV) rating greater than 12.39 V and a current rating of at

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least 1A.
Filter Design
R = Vdc Idc = 7 V 400 mA = 17.5 Ω (11)
Vr = 2(Vim − Vdc) = 2(12.39 V − 7 V) = 10.78 V (12)
C = Vdc f × R × Vr = 7 V (100 Hz) × (17.5 Ω) × (10.78 V)
= 371.05 μF (13)
For safe working, we select a capacitor of **1000 μF / 35V**

II. EXPECTED RESULT

The method concentrated on minimizing interference during earthing measurements using heavy-current injection methods. While effective in controlled environments, this method relies heavily on manual setups and specialized equipment, making it less adaptable to dynamic field conditions. In contrast, your system eliminates the need for such manual dependency by continuously monitoring using an IoT-based approach. It uses intelligent sensors that are able to capture real-time data, avoiding the risk of external disturbances without the need for complex manual calibration. This is a shift from manual to automated monitoring and ensures greater accuracy besides operational efficiency in large installations[1].

Feature	Traditional System	Existing IoT-based systems	Our Proposed system
Real-time Monitoring	No	Limited	Yes
Remote Access	No	Yes	Yes
Predictive Maintenance	No	Partial	Full
Alert System	Manual Checks	SMS-based	LED, Buzzer & Cloud Notifications
Scalability	Low	Medium	High
Cost-Effectiveness	Moderate	High	Optimized

The focus was on developing wireless systems capable of detecting leakage currents effectively in substations. This system improved data acquisition rates compared to wired systems but lacked comprehensive real-time analysis and proactive alerting mechanisms. These form the basis for your system, which integrates ThingSpeak cloud services that allow for real-time visualization and storage of data. The system also allows for immediate visual and audible alerts using LEDs and buzzers once the predefined thresholds are exceeded. This not only enhances the speed of fault detection but also increases the ability to proactively manage risks from remote locations, which is a feature not fully realized in earlier wireless systems[2].

The system proposed novel designs for high-voltage earthing systems concentrating on enhanced structural safety and efficiency. However, the study remained largely theoretical since there was an absence of practical implementations of real-time monitoring. Your system bridges this gap by introducing IoT technology for continuous data collection and automated monitoring. Unlike the conventional systems that are based on scheduled maintenance checks, your system continuously monitors earth resistance and leakage currents, automatically sending alerts in case of anomalies. This proactive approach significantly reduces the risk of system failures and enhances the overall reliability of electrical infrastructure[3].

The research introduced remote data access, it was limited in scope, focusing mainly on simple fault detection without advanced analytics or predictive capabilities. Your system, on the other hand, integrates a comprehensive data analytics framework using the ThingSpeak platform. This allows for real-time monitoring, historical data analysis, and predictive maintenance, which can detect potential issues before they become critical failures. Additionally, the alerts sent out through this system ensure prompt notification to the maintenance crew, hence it minimizes downtime and shortens the response time[4].

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A review of modern earthing practices provided a focus on design optimizations for safety and efficiency. The paper presented theoretical advance, but not on practical implementations of continuous monitoring systems. Furthermore, your research drives these theoretical suggestions forward by a real-world automated monitoring system underpinned in IoT. Shifting from idea to reality thereby demonstrates the transformational potential to be brought with real-time earthing system monitoring in terms of operational safety as well as operation reliability[5].

The modernized trends in terms of earthing systems, pointing out automation-oriented integration. However, the discussion was more conceptual than practical. Your system fills the gap by actually implementing an end-to-end fully automated solution based on ESP32 microcontrollers, current sensors, and cloud-based data visualization tools. This set-up not only demonstrates the possibility of modern earthing systems but also shows that they are scalable and cost-effective, making them suitable for extensive use in all industrial and commercial applications[6].

The data was very informative about the existing methodologies, it did not provide a practical framework for implementing these techniques in the field. Your system will fill this gap by providing a fully functional and field-tested solution that combines real-time monitoring, automated alert generation, and predictive analytics. With advanced sensors and cloud technologies, the system ensures continuous health assessment of the systems, reducing reliance on manual inspections and enabling proactive maintenance strategies[7].

Supply of good quality earthing is one of the most essential requirements to provide human safety and satisfactory operation of electrical/electronic devices. The earth resistance value is the most evident measure of the quality of earthing. Earth resistance measurement and monitoring is therefore an unavoidable task which every service provider must take seriously. Monitoring the earth resistance automatically and storing the values can thus prove to be a very useful. Initially, the investment involved in creating such systems might appear somewhat high but harm that it can prevent to the expensive electronic devices is indefinable. Although, such systems are commercially available, designing own solution can lead to significant cost savings for organisations provided that the testers can be produced in a lab environment[8].

This system is specifically designed to address leakage current. It gives the best results and also protects the devices from getting damaged. Intellectual earthing system minimized the equipment damage due to earth leakage current. It also assists in maintaining and controlling earth resistance. One can control leakage current beyond the limit of conventional earthing by using intellectual earthing kit. Intellectual earthing system minimized damage to the equipment due to earth leakage current. It also facilitates controlling and maintaining earth resistance. Control of leakage current beyond the ability of normal earthing can be achieved through intellectual earthing kit[9].

The result is obtained, measurement of resistance of soil, leakage current(mA), humidity/moisture of soil, display real time data and verify all the other component are in working condition i.e. Display, Buzzer, relay, pump, GSM module for message sending to observer[10].

In total 100% of respondents perform soil electrical resistivity testing, almost 100% also perform resistance tests, and 92% perform integrity tests. The authors view the survey findings as consistent with our experience in North America for utilities that operate in this field. For other utilities, the findings would be significantly lower everywhere except the Never column. The low usage of the more precise tests such as impedance, touch & step measurement, and the infrequent application of PEs in assessment or investigations, are a valuable opportunity for improved risk and cost management of earthing systems[11].

The timely publication of this journal article on emergency alert and real-time health monitoring systems is significantly owing to the invaluable support of several academics and researchers in healthcare technology. Their range of expertise and level of proficiency have greatly enhanced the depth of our research. We would like to extend our sincerest thanks to the authors of the sources under analysis for their efforts that have led to intelligent information, data, and methodology that have simplified the formulation and verification of our real-time health monitoring and emergency alerting system[12].

The expected outcome of the research is the creation of an all-encompassing health monitoring system that not only monitors vital signs in real-time but also facilitates immediate medical attention in cases of emergencies. By merging user information with local emergency services, the system hopes to offer timely response, thus bettering the health and well-being of aged individuals[13].

The real time monitoring system created by CCGE has the potential of being fully automated accurate monitoring in the distant locations. After installing the system, there will be no human intervention is necessary to achieve displacement results. The observation collection and processing can be scheduled to occur at predetermined intervals. Even in the event of power failures, the system will resume automatically right where it left off with no loss of any data cycles[14].

The programming is performed on Arduino platform with the help of C compiler. The outcomes are found on Web page or Smartphone App with the assistance of Bluetooth terminal software and are accessed on computer or laptop with serial port test software. The outcome includes number of droplets from saline bottle, solution administered to patient in ml, the rate of droplet and remaining solution in bottle[15].

III. CONCLUSION

This summary highlights advancements in earthing and monitoring systems across electrical and healthcare domains. A novel method [1] for earthing measurement using heavy-current injection enables accurate readings without disconnecting the transformer, even in fluctuating environments. A wireless condition monitoring system [2] measures leakage currents and voltages in high-voltage substations, offering reliable, interference-free data acquisition. Smart earthing systems [3][4] ensure cost-effective, safe infrastructure with automatic disconnection upon leakage detection. Detection of earth-return faults [5] is enhanced through a decentralized, low-voltage-side strategy unaffected by load imbalances. The Intellectual Earthing System [6][9] surpasses conventional systems in managing leakage current and maintaining resistance. Further insights [7] into grounding system design and monitoring trends provide useful references for researchers. An Arduino-based setup [8] accurately records and transmits earth resistance data online, with simulations supporting traditional and clamp-on testers. Healthcare innovations include the HealthGuard system [12][13], combining sensors and machine learning for real-time health tracking and emergency alerts via GPS. Reliable monitoring through geotechnical sensors [14] and automated saline level detection [15] further reduces human intervention and improves patient safety. These developments collectively enhance reliability, safety, and automation across sectors.

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