CHENNAI INSTITUTE OF TECHNOLOGY

Sarathy Nagar, Kundrathur, Chennai-600069

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ELECTRICAL AND ELECTRONICS ENGINEERING

AI-ENABLED SMART EARTH HEALTH MONITORING ANALYSIS SYSTEM

A Report on Core Course Project

ELECTRICAL AND ELECTRONICS ENGINEERING

By

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CHENNAI-69

Vision of the Institute:

To be an eminent centre for Academia, Industry and Research by imparting knowledge, relevant practices and inculcating human values to address global challenges through novelty and sustainability.

Mission of the Institute:

IM1.To creates next generation leaders by effective teaching learning methodologiesand in still scientific spark in them to meet the global challenges.

IM2.To transform lives through deployment of emerging technology, novelty, and sustainability.

IM3.To inculcate human values and ethical principles to cater the societal needs.

IM4.To contributes towards the research ecosystem by providing a suitable, effective platform for interaction between industry, academia, and R & D establishments.

Department of Electrical and Electronics Engineering

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(Autonomous)

Vision of the Department:

To Excel in the emerging areas of Electrical and Electronics Engineering by imparting knowledge, relevant practices and inculcating human values to transform the students as potential resources to meet the industrial and societal needs.

Mission of the Department:

DM1: To provide strong fundamentals and technical skills through effective teaching learning Methodologies

DM2: To transform lives of the students by fostering ethical values, creativity and novelty to become entrepreneurs and establish start-ups.

DM3: To habituate the students to focus on sustainable resources with optimal usage to ensure the welfare of the society.

DM4: To provide an ambience for research through collaborations with industry and academia

DM5: To inculcate learning of emerging technologies for pursuing higher studies Leading to life long learning.

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CERTIFICATE

This is to certify that the "**Core Course Project**" Submitted by **Saranya Shree R S, Sai Samicsha Shri D (Reg no: 23EE045, 23EE041)** is a work done by them and submitted during **2024-2025** academic year, in partial fulfilment of the requirements for the award of the degree of **BACHELOR OF ENGINEERING** in **DEPARTMENT OF ELECTRICAL and ELECTRONICS ENGINEERING**

Core Course Project Coordinator **Head of Department**

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We would like to extend our thanks to our **faculty coordinator, Dr.Sankar of the Department of Electrical and Electronics Engineering**, for their valuable suggestions throughout this project.

We wish to extend our sincere thanks to all **Faculty members of the Department of Electrical and Electronics Engineering** for their valuable suggestions and their kind cooperation for the successful completion of our project.

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Saranya Shree R S 23EE045

Sai Samicsha Shri D 23EE041

PREFACE

I, a student in the Department of Electrical and Electronics Engineering need to undertake a project to expand our knowledge. The main goal of our core project is to acquaint us with the practical application of the theoretical concepts I've learned during my course.

It was a valuable opportunity to closely compare theoretical concepts with real-world applications. This report may depict deficiencies on my part but still it is an account of our effort.

The results of our analysis are presented in the form of an industrial Project, and the report provides a detailed account of the sequence of these findings. This report is my Core Course Project, developed as part of our 1st project. As an engineer, it is our responsibility to contribute to society by applying my knowledge to create innovative solutions that address their changes.

ABSTRACT

This project presents a prototype simulation of a relay-based bypass mechanism integrated into an automated Earth Leakage Circuit Breaker (ELCB) monitoring system. The primary objective is to demonstrate the post-fault restoration process through a controlled relay operation that re-establishes normal circuit functionality within one to two seconds after tripping. The prototype employs an Arduino microcontroller to simulate real-time relay switching behavior. When a fault is detected and the ELCB trips, the system cuts off the main circuit and activates an indicator to signal the fault condition. After a short delay, the Arduino triggers an additional relay that acts as a bypass circuit, restoring power to the normal operation load while maintaining system safety. The relay's mechanical actuation produces an audible click, validating the switching action. This setup effectively illustrates how relay control logic can be used to achieve rapid fault recovery and system continuity in electrical safety systems. The project serves as a proof of concept for enhancing ELCB responsiveness and operational efficiency through intelligent relay automation.

INTRODUCTION

Electrical safety plays a vital role in both industrial and domestic environments, where unexpected leakage currents or faults can lead to equipment damage, electrical fires, and human hazards. The Earth Leakage Circuit Breaker (ELCB) is a protective device designed to detect such leakage currents and immediately disconnect the faulty circuit to ensure user safety. However, during real-world operation, after every tripping event, manual intervention is usually required to restore power once the fault is cleared. This delay in resuming normal operation can cause inconvenience and interrupt critical electrical functions.

To overcome this limitation, this project introduces a prototype of an Automated ELCB Monitoring System with Relay Bypass Mechanism. The system is designed to simulate the operation of an ELCB and demonstrate an automatic restoration process using an additional relay circuit controlled by an Arduino microcontroller. When a fault occurs, the ELCB trips and isolates the load. After a short delay of one to two seconds, a bypass relay activates automatically to restore the normal operation circuit, ensuring continuous power supply without manual reset. The use of LEDs provides visual indications of fault and normal conditions, while the relay’s clicking sound confirms the switching operation.

Problem Statement

Traditional Earth Leakage Circuit Breakers (ELCBs) are designed to trip and disconnect the power supply whenever a leakage current or fault is detected. However, these systems require manual intervention to restore the normal operation once the fault is cleared. This manual reset process leads to downtime, inconvenience, and potential safety risks in critical electrical systems where continuous operation is essential. Moreover, the lack of intelligent monitoring and prediction capabilities makes it difficult to anticipate faults or verify the health status of the ELCB in real time.

SOLUTION

The proposed project introduces an Automated ELCB Monitoring and Bypass System that enhances both safety and continuity of electrical operation. The system simulates a real ELCB setup using relays, sensors, and an Arduino microcontroller. When a fault occurs, the ELCB trips to isolate the circuit, indicated by the fault LED. After a delay of one to two seconds, a bypass relay is automatically triggered to restore the normal operation circuit, ensuring uninterrupted functionality while maintaining safety.

Additionally, an ML-based predictive model is integrated to analyze synthetic data representing current, voltage, and fault trends to forecast potential ELCB malfunctions before they occur. This predictive capability helps in preventive maintenance and improves overall system reliability.

Thus, the solution ensures:

- Automatic power restoration after fault clearance.
- Visual fault indication and relay feedback.
- Predictive fault analysis using machine learning.

METHODOLOGY

The proposed system is designed to simulate an Automated ELCB Monitoring System with a relay-based bypass operation for automatic power restoration after tripping. The methodology involves both hardware simulation and software-based control logic implemented using an Arduino microcontroller.

1. System Design Overview:

The system consists of:

- Arduino Uno microcontroller (for control and signal processing)
- Two primary relays (Relay A and Relay B)
- One bypass relay for post-fault recovery
- LEDs to indicate Normal Operation, Fault, and Bypass Active states
- A simulated Earth Leakage Current detection circuit (sensor module or analog input)
- Power supply (5V for prototype simulation)

2. Working Principle:

- **Normal Operation:**
  When the system is switched ON, Relay A is activated, representing the normal operation mode. The "Normal Operation" LED glows, indicating current flow through the main circuit.

- **Fault Simulation and ELCB Trip:**
  When the fault switch is turned ON, the Arduino simulates a leakage current detection. Relay A is turned OFF, and Relay B (fault relay) is triggered to show that the ELCB has

tripped. The “Fault” LED glows, and the circuit power is cut off.

- **Bypass Activation:**
After one to two seconds, the Arduino sends a HIGH signal to the **bypass relay** to restore power to the normal operation circuit. The “Normal Operation” LED glows again, representing that the system resumed normal function via the bypass path. The relay’s click sound provides real proof of switching action.

- **System Reset:**
Once the system stabilizes, it can be manually or automatically reset to normal conditions for the next test cycle.

3. ML Model Integration (Future Enhancement):

A separate Machine Learning model is developed using synthetic data representing current, voltage, and leakage trends.

- ✓ Input parameters: leakage current, relay response time, tripping frequency.
- ✓ Model output: predicts potential ELCB malfunction or degradation probability.
This predictive insight enables preventive maintenance and fault prediction.

LITERATURE REVIEW

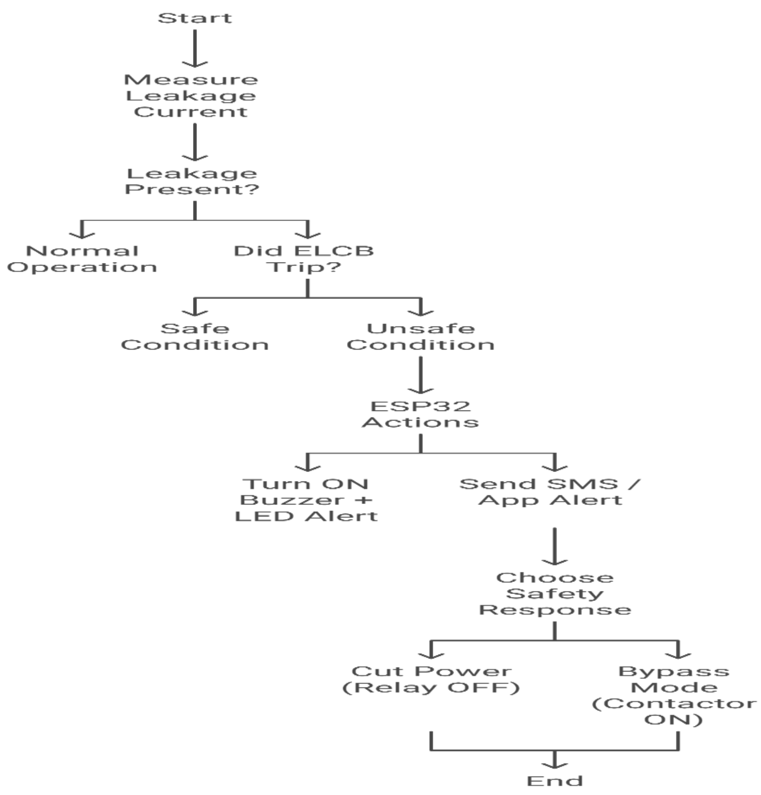
Protection systems such as Earth Leakage Circuit Breakers (ELCBs) and Residual Current Devices (RCDs) play a crucial role in safeguarding human life and electrical installations by detecting fault currents that leak to the ground. These devices disconnect the circuit whenever an imbalance is detected between the live and neutral conductors. The conventional ELCBs are electromechanical in nature and depend on magnetic or differential current sensing mechanisms to operate. However, despite their reliability, traditional ELCBs are prone to aging, mechanical wear, delayed response, and eventual failure due to environmental or electrical stress factors.

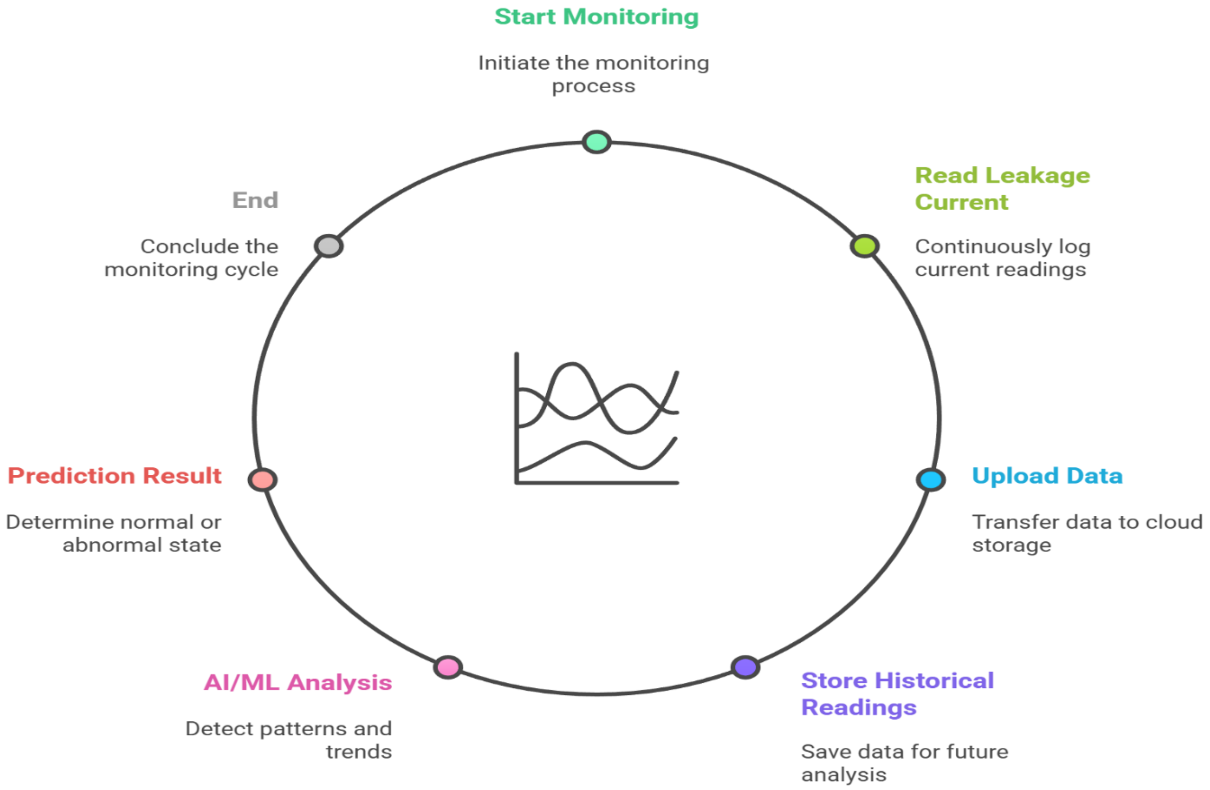
Over the years, several advancements have been made in the field of ELCB design and operation. Researchers have developed microcontroller-based smart ELCB systems to improve sensitivity, enable remote monitoring, and ensure faster tripping under unsafe conditions.

Links:

- The Smart IoT Earth Leakage Circuit Breaker with Transformerless and SMPS Auto Recloser (link)
- Development of Smart Earth Leakage Circuit Breaker Using IoT and Power Electronics (link)
- Development of Earth Leakage Circuit Breaker with an Auto Re-closer Unit(link)

WORKING FLOW OF THE SYSTEM





COMPONENTS

HARDWARE COMPONENTS:

- **Arduino Uno** – Controls relays and manages timing for bypass activation.
- **Relay A (Main/ELCB)** – Simulates normal operation and tripping.
- **Relay B (Fault/Backup)** – Activates during fault to indicate ELCB trip.
- **Relay C (Bypass)** – Restores normal operation after fault within 1–2 seconds.
- **LEDs** – Show Normal, Fault, and Bypass status visually.
- **Switches** – Simulate normal operation and fault conditions.
- **Resistors** – Limit current for LEDs and transistor bases.
- **Flyback Diodes** – Protect circuits from voltage spikes from relay coils.
- **DC Power Supply (5–12V)** – Powers relays and control circuit.
- **Current Sensor** – Simulates earth leakage detection for triggering faults.

SOFTWARE COMPONENT:

- **Arduino IDE** – To program and control the relay logic.
- **Fritzing / KiCad** – For creating circuit schematics and layouts (optional for documentation).
- **Proteus / Tinkercad Circuits** – For simulation of relay and LED operations (optional).
- **Python / MATLAB** – Optional, for generating synthetic data for ML model or testing logic.
- **Serial Monitor (Arduino IDE)** – To debug and monitor signals from switches and relays

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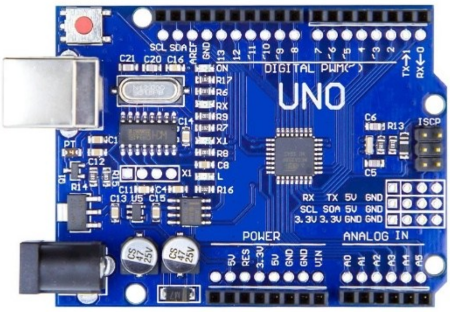
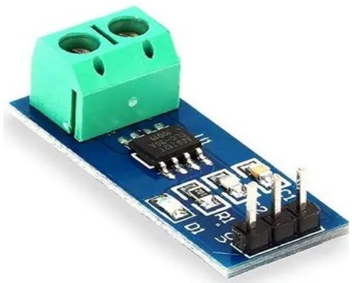
ARDUINO UNO



CURRENT SENSOR



RELAY

OLED DISPLAY

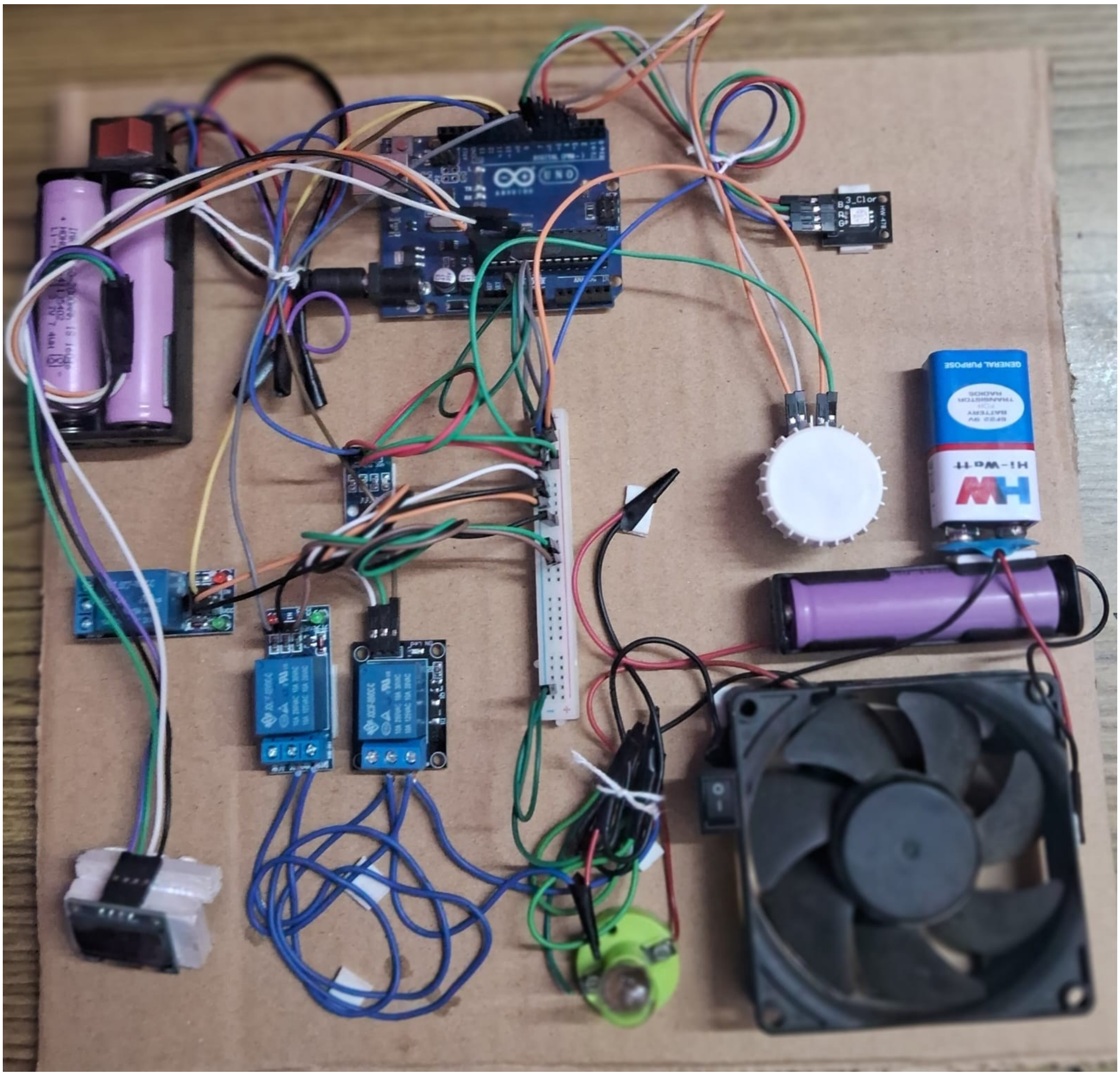
Google colab

CNN

TensorFlow

Firebase

PICTURES OF THE PROJECT



RESULT AND DISCUSSION

The prototype of the Automated ELCB Monitoring System with Relay Bypass successfully demonstrates a proof-of-concept for fault detection and automatic restoration of normal operation.

This prototype effectively demonstrates the operational flow of an automated ELCB system with a bypass mechanism. It highlights how relay logic, timed bypass activation, and visual indicators can improve safety and continuity in electrical systems. While this is a low-voltage demonstration, the concept can be scaled to actual ELCB systems with proper engineering safeguards.

Future scope:

The proposed prototype can be further enhanced by integrating Machine Learning models to predict potential ELCB faults and enable preventive maintenance. Additionally, connecting the system to an IoT platform would allow real-time monitoring, remote alerts, and control of the bypass operation from mobile or web interfaces. The concept can be scaled to full-scale ELCB systems in industrial or domestic settings, ensuring safe and continuous operation at standard voltages. Future improvements could also include adaptive bypass logic based on fault severity and load priority, energy consumption monitoring, and integration with other protective devices such as overcurrent or surge protection systems, creating a comprehensive smart electrical safety network.

CONCLUSION

The project successfully demonstrates a relay-based proof-of-concept for automated ELCB monitoring with bypass activation. Key achievements include:

- Simulated ELCB operation with fault detection using Relay B.
- Automatic restoration of normal operation within 1–2 seconds using a bypass relay (Relay C).
- Clear visual (LEDs) and auditory (relay click) feedback for normal, fault, and bypass conditions.
- Safe, low-voltage prototype suitable for demonstration and proof-of-concept purposes.

This system provides a foundation for future work, including integration with ML-based predictive health monitoring, full-scale ELCB applications, and IoT-enabled remote fault management. Overall, the project demonstrates an innovative, simple, and effective approach to improving operational continuity and safety in electrical circuits.

PO & PSO Attainment

PO.No	Graduate Attribute	Attained	Justification
PO 1	Engineering knowledge	Yes	The project was implemented with domain knowledge from Linear Integrated circuits.
PO 2	Problem analysis	Yes	The problem statement was analysed properly and best solution was given
PO 3	Design/Development of solutions	Yes	The RFID and access control was designed to get the best outcome
PO 4	Conduct investigations of complex problems	Yes	The awareness for RFID were addressed
PO 5	Modern Tool usage	Yes	Hands on experience with Arduino and other components have been gained
PO 6	The Engineer and society	Yes	The proposed solution provides Safety to the society
PO 7	Environment and Sustainability	No	No sustainable developments involved
PO 8	Ethics	Yes	Learnt Ethics of working on problems
PO 9	Individual and team work	Yes	Effective functioning together as a team

PO.No	Graduate Attribute	Attained	Justification
PO 10	**Communication**	Yes	**Developed communication skills to express point of views**
PO 11	**Project management and finance**	Yes	**Acquired money management and cost cutting skills**
PO 12	**Life-long learning**	Yes	**Ability to engage in independent and life-long learning has been attained**
PSO 1	To analyze, design and develop quality solutions in power electronics by applying core engineering knowledge for industrial and domestic applications	**Yes**	**The project was developed to the new emerging technology and make aware of RFID in humans day to day life.**
PSO 2	To provide solutions for generating clean, safe and sustainable power through multi disciplinary approaches.	**Yes**	**It replaces the traditional biometric system and make aware of these technologies.**