MULTIDISCIPLINARY APPLIED RESEARCH AND INNOVATION
e-ISSN: 2773-4773

MARI

Vol. 6 No. 3 (2025) 103-108
https://publisher.uthm.edu.my/periodicals/index.php/mari

Miniature Circuit Breaker Trip Detector

Dameer Aris Mokhzani Aris[1], Nabiah Zinal[1,2]

[1] *Department of Electrical Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600, Muar, Johor, MALAYSIA*
[2] *Microprocessors Based Technology for Internet of Things (MTIoT) Focus Group, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600, Muar, Johor, MALAYSIA*

*Corresponding Author: nabiah@uthm.edu.my
DOI: https://doi.org/10.30880/mari.2025.06.03.014

Article Info

Received: 1 Mac 2025
Accepted: 1 May 2025
Available online: 30 June 2025

Keywords

MCB, Trip, Relay AC Coil 240V

Abstract

This project presents a Miniature Circuit Breaker (MCB) Trip Detector system designed to monitor electrical circuits using a relay AC coil 240V integrated with an ESP32 microcontroller. The system aims to detect anomalies such as overloads and short circuits, providing real-time notifications via Telegram upon detecting an MCB trip. Performance evaluation revealed the system's high reliability in accurately identifying faults and its effectiveness in minimizing downtime through swift fault notification and detailed diagnostic information. Challenges included microcontroller processing capabilities for complex tasks, suggesting areas for future improvement. Research opportunities include enhancing alert technology, upgrading microcontroller capabilities, exploring IoT integration, and developing predictive maintenance algorithms for broader applications in residential and industrial settings.

1. Introduction

The significance of safeguarding residential and industrial environments from potential hazards in electrical safety cannot be overstated. MCB is the protection device that used to disconnect the circuit when a short circuit and overload fault occurred[1]. However, while existing MCBs effectively isolate faults, they fall short in offering post-trip diagnostic information. This leaves users struggling to identify the precise cause of the trip, leading to prolonged downtimes and potentially hazardous conditions. This project introduces a Miniature Circuit Breaker Trip Detector, leveraging a Relay AC Coil 240V and an ESP32 microcontroller to enable real-time monitoring and diagnostics, providing immediate notifications to users about MCB trips.

Electrical safety is paramount in both residential and industrial settings, where MCBs play a critical role in protecting circuits from overloads and short circuits. The short circuit is where the abnormal current flow causes the spark to occur. These can be observed when during thunder the MCB will kick off to prevent excess high voltage to enter the house circuit [2]. Despite their effectiveness in mitigating immediate threats, the aftermath of an MCB trip often leaves users without detailed information regarding the specific fault. This ambiguity hinders quick resolution of issues, leading to extended downtimes, increased operational inefficiencies, and heightened safety risks.

The current landscape of MCB technology showcases a significant gap in post-trip diagnostics. While existing MCBs excel in disconnecting circuits during faults, users are left without crucial details about the cause of the trip. This lack of information can be particularly challenging in industrial settings where electrical systems are complex and critical to operations. The inability to quickly diagnose and address the root cause of a trip can result in significant downtime, affecting productivity and potentially leading to substantial financial losses. Furthermore, the absence of real-time monitoring limits the ability to address potential electrical faults before they escalate proactively.

The Miniature Circuit Breaker Trip Detector aims to bridge this gap by providing real-time monitoring and diagnostic capabilities. The system continuously monitors the electrical circuit for anomalies by utilizing a Relay AC Coil 240V and an ESP32 microcontroller. In the event of a trip, the system not only disconnects the circuit to prevent damage but also logs detailed information about the nature of the fault. This information is then relayed to users promptly, enabling informed action to resolve the issue. Implementing this technology can significantly reduce downtime, enhance operational efficiency, and improve overall electrical safety, ultimately safeguarding both residential and industrial environments from potential hazards.

2. Material and Methodology

Materials and methodology are essential components in executing this project. It is important to consider the materials and equipment, project design, and project testing, as each of these elements is critical for achieving the project's goals and objectives.

2.1 Material

The main component for this project is a ESP32. The ESP32 is a low-cost, low-power system on a chip series of microcontrollers with Wi-Fi and Bluetooth capabilities and a highly integrated structure powered by a dual-core Tensilica Xtensa LX6 microprocessor [4]. Other than that, this project also used a Relay AC Coil 240V. A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered, in a broad sense, to be a form of an electrical amplifier. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts [6]. A Relay AC Coil 240V monitors the MCB's status, and upon detecting a trip, signals the ESP32 microcontroller.

2.2 Methodology

Fig. 1 shows the block diagram for Miniature Circuit Breaker Trip Detector. This block diagram illustrates a system designed to detect and notify users of a Miniature Circuit Breaker (MCB) trip. The Power Supply provides electricity to the MCB, which safeguards the Load by interrupting the power during fault conditions. A Relay AC Coil 240V monitors the MCB's status, and upon detecting a trip, signals the ESP32 microcontroller. The ESP32, equipped with Wi-Fi capabilities, processes the relay's status and sends an immediate notification to the user via Telegram, ensuring prompt awareness and response to the tripped MCB.

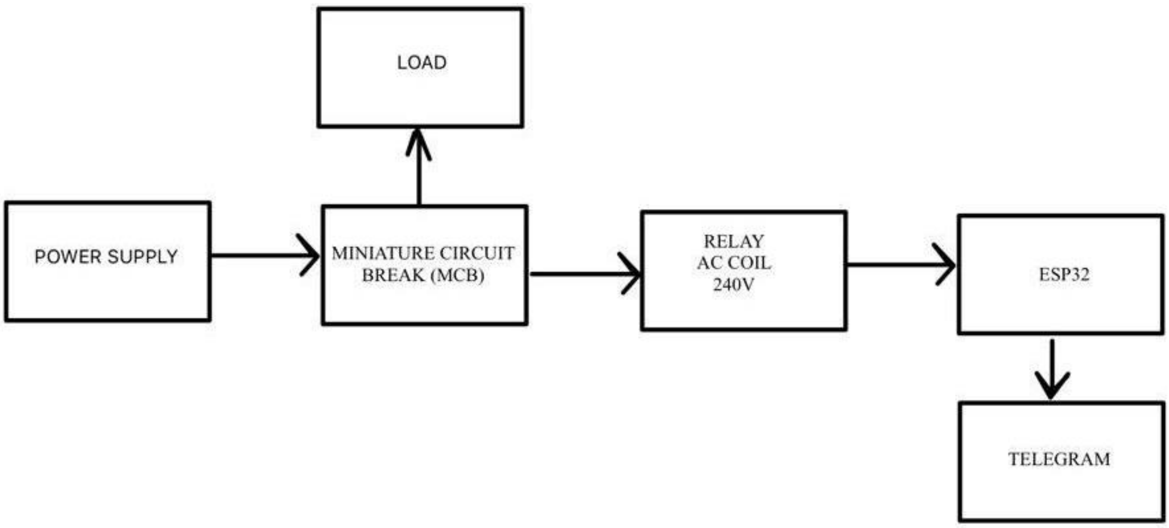

Fig. 1 *Block Diagram of Miniature Circuit Breaker Trip Detector*

Fig. 2 shows the flowchart for Miniature Circuit Breaker Trip Detector. This flowchart outlines the process of monitoring the status of a Miniature Circuit Breaker (MCB) and sending a notification if it trips. The flowchart begins with the initialization of the serial monitor and relay pin as an input to monitor the status of the Miniature Circuit Breaker (MCB). It then checks for a Wi-Fi connection, attempting to reconnect if not connected. Once connected, the system reads the relay state and checks for any changes. If a change is detected, it further checks if

Multidisciplinary Applied Research and Innovation Vol. 6 No. 3 (2025) p. 103-108

the relay state is LOW, indicating that the MCB has tripped. Upon detecting a LOW state, the system sends a notification about the tripped MCB, ensuring continuous monitoring and immediate alerts, before ending the process.

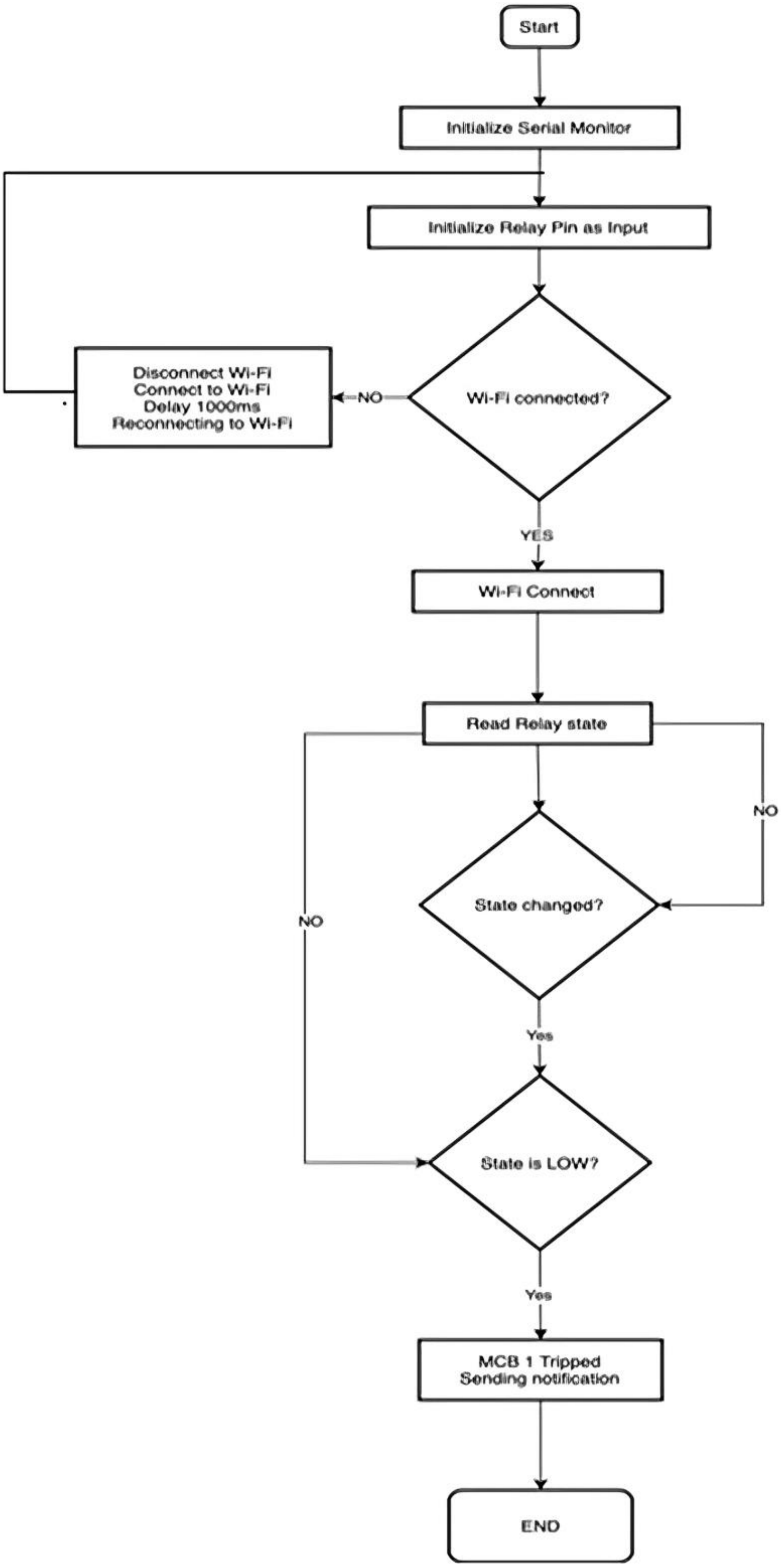

Fig. 2 *Flow Chart of Miniature Circuit Breaker Trip Detector*

3. Results and Discussion

This section will discuss the findings from the study of the Miniature Circuit Breaker Trip Detector project after its completion. The data and analysis obtained are the research results and discussion based on this project. Fig. 3(a) shows the prototype of the Miniature Circuit Breaker Trip Detector for the hardware and Fig. 3(b) shows that a notification promptly appears on Telegram when the system detects an MCB trip in Telegram Bot.

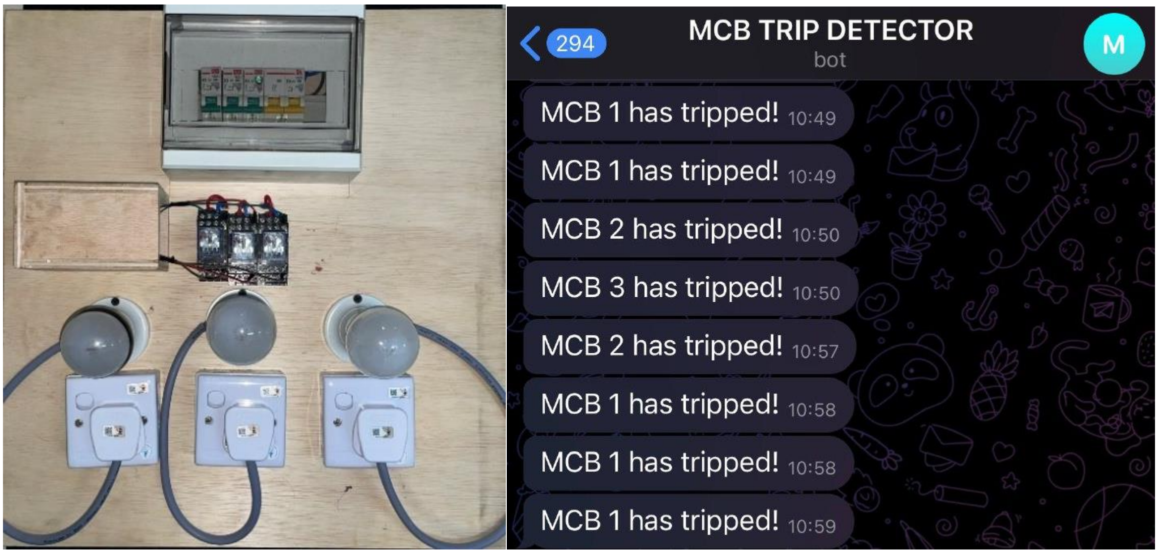

Fig. 3 *(a) Prototype of the Miniature Circuit Breaker Trip Detector, (b)Notification from Telegram Bot*

The Miniature Circuit Breaker (MCB) trip tracking system's Arduino IDE code includes MQTT and Wi-Fi connectivity, as shown in Figure 4. It connects to a wireless network using the ESP8266WiFi library and delivers trip status updates to an MQTT broker using the PubSubClient library. Two input digital pins that represent the states of two MCBs are initialised by the code, which also continuously checks the values of the pins and notifies the user when a trip situation is detected. In order to provide real-time fault detection and reporting for improved safety and system management, the system is configured to publish individual alerts identifying which MCB has triggered.

Based on Table 1, the performance evaluation of the Miniature Circuit Breaker Trip Detector demonstrated its ability to accurately detect MCB trips caused by overloads or short circuits, providing precise diagnostic information promptly. Integrated with Telegram for real-time alerts, the system notifies users immediately upon detecting an MCB trip, ensuring swift intervention and minimizing downtime. Benefits of the detector include enhanced electrical safety through proactive monitoring, quick response to faults, and minimized operational disruptions in industrial settings. Real-time notifications via Telegram enable rapid issue resolution, improving overall system efficiency and productivity. Challenges include the microcontroller capabilities of the ESP32 for more complex applications. Future iterations could enhance detection accuracy with advanced sensors, upgrade microcontrollers, and expand notification methods beyond Telegram. Future research could focus on integrating sophisticated sensors and higher-powered microcontrollers, exploring IoT integration for remote monitoring, developing predictive maintenance algorithms, and scaling for broader commercial and industrial applications.

Table 1 *Operational Results of the Miniature Circuit Breaker Trip Detector*

MCB STATE	RELAY STATE	TELEGRAM
Trip	Normally Open (NO)	Yes
No Trip	Normally Closed (NC)	No

Multidisciplinary Applied Research and Innovation Vol. 6 No. 3 (2025) p. 103-108

```
#include <WiFi.h>
#include <WiFiClientSecure.h>
#include <UniversalTelegramBot.h>

// WiFi credentials
const char* ssid = "Arizz";
const char* password = "adik291201";

// Telegram BOT details
#define BOTtoken "7211458209:AAH051g9R7Hj9teEhNv2wqT_U-Pdu5hEMmg"
#define CHAT_ID "979773239"

// Initialize Telegram BOT
WiFiClientSecure client;
UniversalTelegramBot bot(BOTtoken, client);

// Relay pins
const int relayPin1 = 15;
const int relayPin2 = 4;
const int relayPin3 = 13;

// Variables
bool relayState1 = HIGH;
bool relayState2 = HIGH;
bool relayState3 = HIGH;
void setup() {
  // Initialize Serial Monitor
  Serial.begin(115200);

  // Initialize Relay Pins
  pinMode(relayPin1, INPUT);
  pinMode(relayPin2, INPUT);
  pinMode(relayPin3, INPUT);

  // Connect to Wi-Fi
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi...");
  }
  Serial.println("Connected to WiFi");

  // Set up secure connection
  client.setCACert(TELEGRAM_CERTIFICATE_ROOT); // Add root certificate for api.telegram.org
}

void loop() {
  // Reconnect WiFi if it has been disconnected
  if (WiFi.status() != WL_CONNECTED) {
    WiFi.disconnect();
    WiFi.begin(ssid, password);
    while (WiFi.status() != WL_CONNECTED) {
      delay(1000);
      Serial.println("Reconnecting to WiFi...");
    }
    Serial.println("Reconnected to WiFi");
  }

  // Check the state of Relay 1
  int currentState1 = digitalRead(relayPin1);
  if (currentState1 != relayState1) {
    relayState1 = currentState1;
    if (relayState1 == LOW) { // Relay 1 triggered (MCB 1 tripped)
      Serial.println("MCB 1 Tripped! Sending notification...");
      bot.sendMessage(CHAT_ID, "MCB 1 has tripped!", "");
    }
  }

  // Check the state of Relay 2
  int currentState2 = digitalRead(relayPin2);
  if (currentState2 != relayState2) {
    relayState2 = currentState2;
    if (relayState2 == LOW) { // Relay 2 triggered (MCB 2 tripped)

      Serial.println("MCB 2 Tripped! Sending notification...");
      bot.sendMessage(CHAT_ID, "MCB 2 has tripped!", "");
    }
  }

  // Check the state of Relay 3
  int currentState3 = digitalRead(relayPin3);
  if (currentState3 != relayState3) {
    relayState3 = currentState3;
    if (relayState3 == LOW) { // Relay 3 triggered (MCB 3 tripped)
      Serial.println("MCB 3 Tripped! Sending notification...");
      bot.sendMessage(CHAT_ID, "MCB 3 has tripped!", "");
    }
  }

  delay(100); // Check every second
}
```

Fig. 4 *Coding for Miniature Circuit Breaker Trip Detector*

4. Conclusion

In essence, the Miniature Circuit Breaker Trip Detector project is crucial in enhancing electrical safety and operational efficiency in residential and industrial settings. By leveraging a Relay AC Coil 240V and ESP32 microcontroller, the system offers real-time monitoring and diagnostic capabilities that traditional MCBs lack. This innovation not only detects and notifies users promptly of circuit trips but also provides detailed post-trip diagnostic information crucial for quick fault resolution. Proactively managing electrical faults helps minimize downtime, reduce safety risks, and optimize system reliability. Continuing advancements in sensor technology, microcontroller capabilities, and integration with predictive maintenance algorithms hold promise for further improving the effectiveness and applicability of such systems across diverse electrical infrastructure. Ultimately, the Miniature Circuit Breaker Trip Detector stands poised to significantly enhance electrical safety practices significantly, ensuring safer environments and smoother operations in both residential and industrial contexts.

Acknowledgement

The author extends heartfelt thanks to the Department of Electrical Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia for the facilities provided and their support.

Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Dameer Aris Mokhzani Aris;* ***data collection:*** *Dameer Aris Mokhzani Aris;* ***analysis and interpretation of results:*** *Dameer Aris Mokhzani Aris;* ***draft manuscript preparation:*** *Dameer Aris Mokhzani Aris. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] A. A. Ashari, N. Z. Mohamad, and N. H. M. Radzi, "*MCB earth leakage fault detection scheme based on global system for mobile communication using Arduino Uno*," 2020, pp. 89–97.
[2] A. H. B. Hamee, S. S. Sarnin, W. N. W. Mohamad, M. N. M. Tan, R. S. S. Abdul Kadir, and N. F. Naim, "*Smart Monitoring Fault Detector Using IoT*," in Proc. 2021 IEEE 15th Malaysia Int. Conf. Commun. (MICC), Malaysia, pp. 65–70, 2021,
[3] A. Azzis and A. Z. H. Bin, "Automated Electrical Protection System (Auto-EProS)," 2012.
[4] A. Maier, A. Sharp, and Y. Vagapov, "*Comparative analysis and practical implementation of the ESP32 microcontroller module for the internet of things*," in Proc. 2017 Internet Technol. Appl. (ITA), Wrexham, UK, pp. 143–148, 2017.
[5] H. B. Rozani, "*Automated Electrical Protection Systems – Applied for Three-Phase System*," 2012.
[6] M. A. B. Suarin, "Automatic Tester Device for Earth Leakage Circuit Breaker," Univ. Malaysia Pahang, Pahang, 2007.