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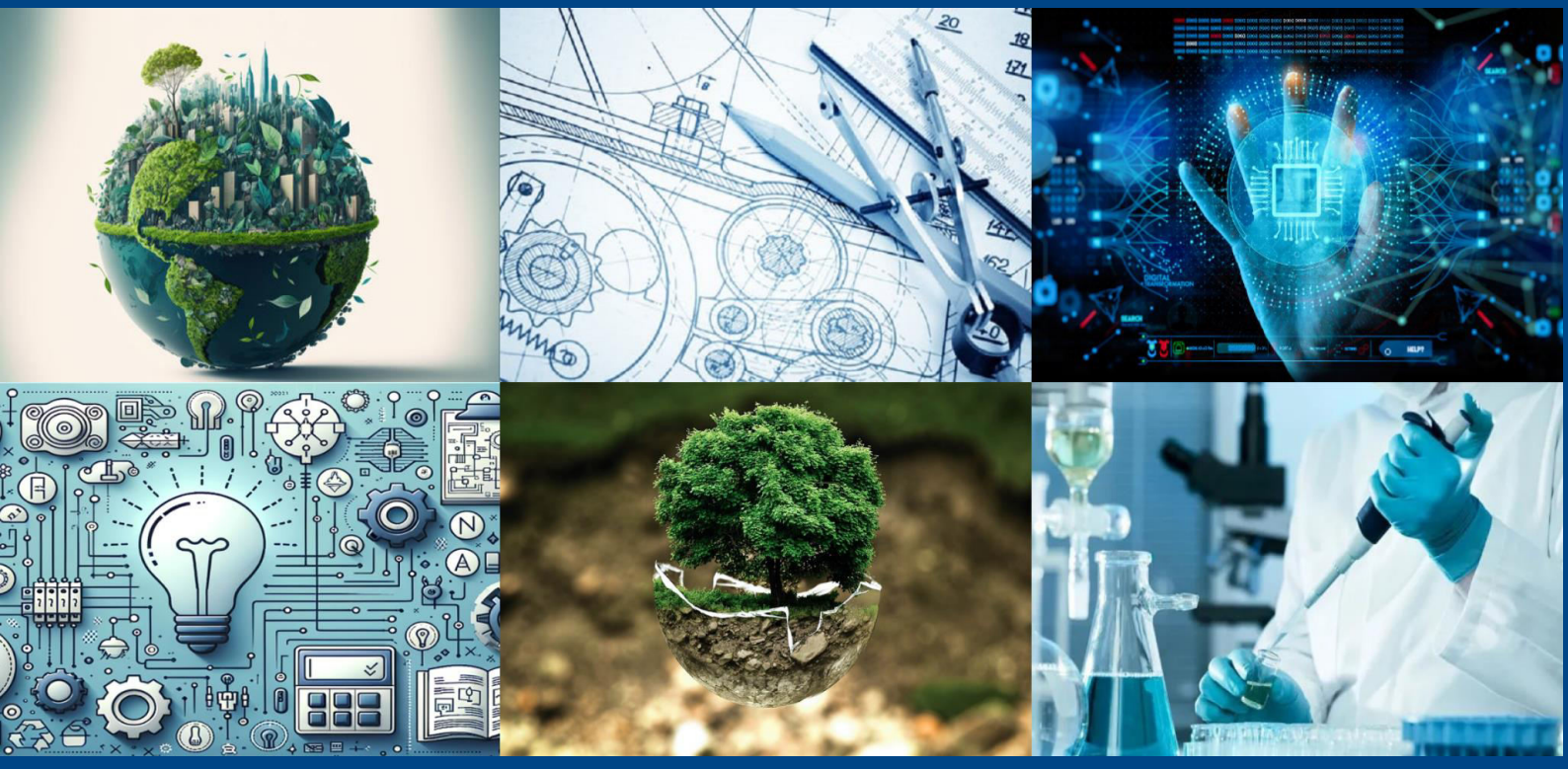

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IoT-Enabled Smart Circuit Breaker with Password-Protected Remote Control

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ABSTRACT: The IoT-Enabled Smart Circuit Breaker system is designed to enhance safety and reduce electrical hazards, particularly for linemen performing maintenance work. Miscommunication between substations and workers often leads to fatal accidents. This project addresses the issue by integrating IoT technology for remote circuit control via a password-protected interface using Firebase. The system is powered by an ESP32 microcontroller with built-in WiFi and Bluetooth, ensuring reliable connectivity. A relay module enables fast load switching, while a Hall Effect sensor (ACS712) monitors current flow. An OLED display provides real-time system status, and a solid-state relay (SSR) ensures noise-free operation. The circuit is powered by a 12V adapter, regulated by an LM7805 voltage regulator. Users can control the system remotely via a mobile app, developed using MIT App Inventor, ensuring secure access with password authentication. This innovative approach significantly enhances industrial safety, prevents electric shocks, and enables efficient remote monitoring of electrical loads.

KEYWORDS: IoT-Enabled, Smart Circuit Breaker, Safety, ESP32, Firebase, Relay Module, Hall Effect Sensor (ACS712), OLED Display, MIT App Inventor, Remote Monitoring.

I. INTRODUCTION

The rapid advancement of the Internet of Things (IoT) has transformed traditional electrical systems, enabling smarter and more efficient solutions. Circuit breakers, which play a crucial role in electrical safety, can be significantly improved by integrating IoT technology. By enabling remote monitoring, real-time control, and enhanced security, IoT-based circuit breakers can mitigate electrical hazards and improve overall system reliability.

This project introduces an IoT-enabled smart circuit breaker designed to enhance safety, particularly for linemen performing maintenance work. One of the major causes of electrical accidents is miscommunication between substations and workers, leading to unintended power restoration. To address this issue, the proposed system allows remote circuit control through a password-protected interface, ensuring that only authorized personnel can operate it.

At the core of this system is the ESP32 microcontroller, which offers built-in WiFi and Bluetooth capabilities for seamless connectivity. The system incorporates a relay module for fast load switching and a Hall Effect sensor (ACS712) for real-time current monitoring. Additionally, an OLED display provides live system status, while a solid-state relay (SSR) ensures noise-free operation. A 12V adapter powers the circuit, with an LM7805 voltage regulator maintaining stable voltage levels.

Users can control and monitor the circuit breaker remotely via a mobile application developed using MIT App Inventor. The app integrates Firebase for secure password authentication, ensuring that only authorized users can access the system. This innovative approach not only enhances industrial safety and prevents electric shocks but also enables efficient remote monitoring of electrical loads, making power management more reliable and secure.

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II. OVERVIEW

The IoT-Enabled Smart Circuit Breaker is designed to improve electrical safety by allowing remote monitoring and control of circuits, especially for linemen during maintenance work. It uses an ESP32 microcontroller with WiFi and Bluetooth for connectivity, along with a relay module and Hall Effect sensor (ACS712) to monitor and manage current flow. A mobile app, developed using MIT App Inventor, provides secure access with password protection. The system ensures quick response, real-time status updates via an OLED display, and efficient energy management using components like MOSFETs and solid-state relays. By integrating IoT technology with traditional circuit breakers, this project enhances safety, prevents electrical hazards, and allows for easy remote operation.

III. COMPONENTS

HARDWARE SPECIFICATION:

1. Microcontroller
2. Wireless Module
3. Display
4. Oscillator
5. Resistors
6. Capacitors
7. MOSFETs
8. Diodes
9. Relay Module
10. PCB & Breadboard
11. LEDs
12. Power Supply
13. Push Buttons
14. Hall Effect Sensor
15. Voltage Regulator
16. IoT Cloud Platform
17. Solid-State Relay (SSR)

1. **ESP32 microcontroller** – Controls the system with built-in wifi & bluetooth.
2. **ESP8266 wireless module** – Alternative wifi module for iot connectivity.
3. **OLED display** – Shows real-time system status and current flow.
4. **16 mhz crystal oscillator** – Provides accurate clock pulses for the microcontroller.
5. **Resistors (1kΩ, 10kΩ, 100Ω) –** Limit current and set voltage levels.
6. **Capacitors (ceramic & electrolytic)** – Store and regulate electrical energy.
7. **Mosfet (irf540n) –** Controls high-power switching efficiently.
8. **Diode (1n4007)** – Protects circuits from voltage spikes.
9. **Relay module (5v/12v)** – Switches electrical loads on and off.
10. **Pcb & breadboard –** Used for circuit prototyping and permanent assembly.
11. **Leds (red & green)** – Indicate system operation and status.
12. **Power supply (12v adapter/smps)** – Provides necessary voltage for components.
13. **Push buttons (tactile switches)** – Used for manual control and reset.
14. **Hall effect sensor (acs712)** – Measures current flow in the circuit.
15. **Voltage regulator (lm7805)** – Ensures a stable 5v power supply.
16. **Iot cloud platform (blynk/thingspeak)** – Enables remote monitoring and control.
17. **Solid-state relay (ssr)** – Provides noise-free and fast switching.
18. **Fuse & circuit protection** – Prevents short circuits and overloads.

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IV. SOFTWARE SPECIFICATION

1.Arduino IDE (For programming ESP32)
2.Embedded C / MicroPython (For firmware development)
3.Firebase (For cloud-based IoT integration)
4.MIT App Inventor (For mobile-based password control)

1. **Arduino IDE –** A platform used to write and upload code to the ESP32 microcontroller.
2. **Embedded C / MicroPython**– Programming languages used for developing firmware for ESP32.
3. **Firebase –** A cloud service enabling real-time IoT data storage and remote access.
4. **MIT App Inventor–** A tool for creating a mobile app to control the circuit breaker with a password.

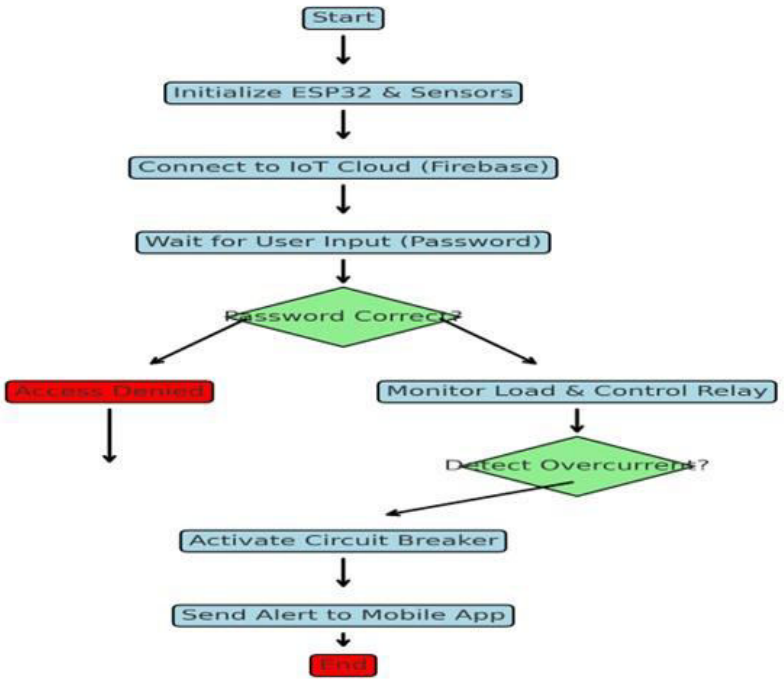

Fig 1: Flowchart

V. EXISTING SYSTEM

Mechanical relays in traditional electrical load control systems are slow and unreliable due to wear and tear over time. Lack of secure remote access makes these systems vulnerable to miscoordination and miscommunication, especially during critical maintenance operations. No real-time monitoring or long-distance operation, limiting overall efficiency and responsiveness in industrial applications. Delays in detecting and responding to faults increase the risk of electrical accidents, including electric shocks for maintenance workers.

A. ABBREVIATIONS

IoT – Internet of Things
ESP32 – Espressif Systems 32-bit Microcontroller
WiFi – Wireless Fidelity
SSR – Solid-State Relay
OLED – Organic Light-Emitting Diode

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MIT – Massachusetts Institute of Technology
ACS712 – Allegro Current Sensor 712 (Hall Effect Sensor)
LM7805 – Linear Monolithic 7805 Voltage Regulator
blynk– A Platform for IoT App Development
MOSFET – Metal-Oxide-Semiconductor Field-Effect Transistor
IRF540N – A Specific Model of N-Channel MOSFET

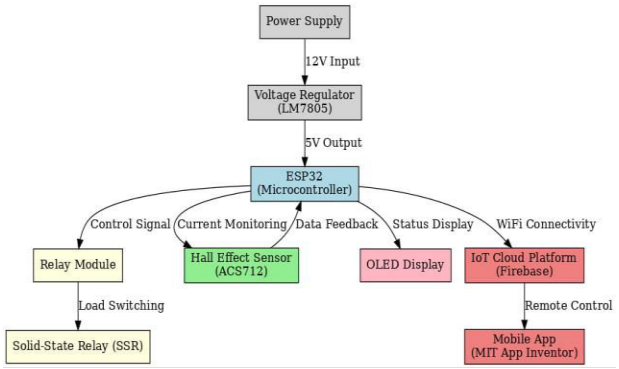

Fig 2: Block Diagram

B. METHODOLOG

The Iot-enabled smart circuit breaker system is implemented using an esp32 microcontroller, which connects to a firebase database for secure remote control. A relay module and a solid-state relay (ssr) facilitate efficient load switching, while a hall effect sensor (acs712) monitors current flow. The system is powered by a 12v adapter, regulated by an lm78005 voltage regulator. An oled display provides real-time system updates, and users can control the circuit breaker through a mobile app developed using mit app inventor, ensuring password-protected access. The system integrates iot platforms like blynk or thingspeak for remote monitoring, enabling real-time power usage insights and fault detection, enhancing safety and efficiency.

VI. IMPLEMENTATION OF PROJECT

The IOT-Enabled smart circuit breaker enhances safety by preventing miscommunication-related electrical hazards. It integrates an ESP32 microcontroller with Wifi and Bluetooth for remote control via a password-protected firebase interface. A relay module ensures fast load switching, while an ACS712 hall effect sensor monitors current flow. An OLED display provides real-time status, and an SSR enables noise-free operation. Powered by a 12V adapter with an LM7805 regulator, the system is controlled via an MIT app inventor-based mobile app. This innovation enhances industrial safety, prevents electric shocks, and enables secure, efficient remote monitoring of electrical loads.

VII. PROPOSED SOLUTION

The proposed IoT-Enabled Smart Circuit Breaker enhances safety by preventing electrical hazards caused by miscommunication. It leverages an ESP32 microcontroller with WiFi and Bluetooth for remote circuit control via a password-protected Firebase interface. A relay module enables fast switching, while an ACS712 Hall Effect sensor monitors current flow. An OLED display provides real-time system status, and an SSR ensures noise-free operation. Powered by a 12V adapter with an LM7805 regulator, the system is controlled via a secure MIT App Inventor-based mobile app. This solution improves industrial safety, prevents electric shocks, and enables efficient remote monitoring of electrical loads.

VIII. SCOPE OF THE PROJECT

The IoT-Enabled Smart Circuit Breaker has broad applications in industrial, commercial, and residential sectors, enhancing electrical safety and remote monitoring. It prevents accidents caused by miscommunication between substations and maintenance workers. The system enables remote circuit control via a password-protected mobile app,

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integrating ESP32, Firebase, and a relay module for efficient load management. Real-time current monitoring using an ACS712 sensor and OLED display improves operational transparency. Its secure, IoT-based architecture ensures reliable connectivity, preventing electric shocks and hazards. This project can be extended for smart grid applications, automated power management, and large-scale industrial safety systems.

IX. ADVANTAGES

- It reduces the risk of electrical accidents for line workers by allowing remote operation and ensuring controlled access with password protection via mit app inventor.
- It uses iot connectivity through firebase for quick communication, while mosfets (irf540n) and solid-state relays (ssr) enable faster circuit breaking compared to traditional relays.
- Operators can control electrical loads remotely from anywhere using an esp32 microcontroller, enhancing convenience and flexibility.
- It includes an oled display to show the real-time status (on/off) of connected loads, ensuring better system visibility.
- It provides a robust industrial safety solution by integrating hall effect sensors (acs712) to monitor current flow, reducing miscoordination and preventing fatal accidents.

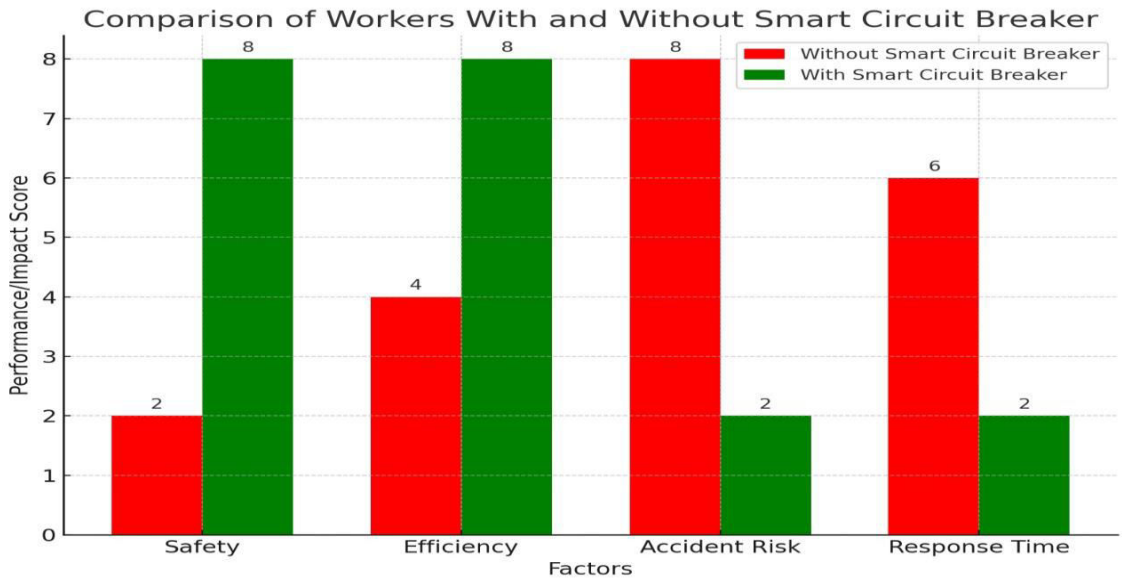

Fig 3: Comparison of workers with and without Smart Circuit Breaker

X. FUTURE WORK

- Add voice control through smart assistants like Alexa or Google Assistant.
- Implement real-time power usage monitoring to track energy consumption.
- Enable remote control via a mobile app for easy access anywhere.
- Integrate with home automation systems for automated on/off scheduling.
- Add notifications for unusual power consumption or circuit malfunctions.
- Implement multi-user access with different permission levels.
- Add integration with solar power systems to optimize energy use.
- Enable remote firmware updates to improve security and functionality.
- Integrate with home security systems to automatically turn off circuits during emergencies.

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XI. CONCLUSION

An IoT-enabled smart circuit breaker with password-protected remote control offers improved home safety, security, and convenience. This innovative device allows users to monitor and control their electrical circuits remotely through a secure, password-protected interface, ensuring that only authorized individuals can access and manage the system. This feature is particularly useful for homeowners who travel frequently or manage multiple properties, as it allows them to turn circuits on or off from anywhere, ensuring better control over their home's power system. The ability to monitor circuit status in real-time adds an extra layer of security, enabling users to respond quickly to unexpected electrical issues or power demands. Additionally, the password protection feature prevents unauthorized access, reducing the risk of tampering or accidental circuit control.

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