Smart Power Cut Fault Protection System Using ESP32 and IoT

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***Abstract*—This paper presents the design and implementation of a Smart Power Cut Fault Protection System using ESP32 and IoT technology for real-time monitoring and protection of electrical systems. The system utilizes the ESP32 microcontroller along with ACS712 current sensor and ZMPT101B voltage sensor to continuously measure electrical parameters such as current and voltage with high accuracy. The proposed system detects abnormal conditions including overload, short circuit, voltage fluctuation, and line faults, and automatically disconnects the power supply using a relay module to prevent equipment damage and improve electrical safety. Leveraging Wi-Fi connectivity and IoT cloud platforms, the system supports real-time data transmission, remote monitoring, and instant fault alerts through a mobile dashboard. Additional components such as a 16×2 I2C LCD display, buzzer, and LED indicators provide local monitoring and fault indication. Security, reliability, and low power consumption are considered in the system architecture. Experimental testing demonstrated stable operation, fast fault response, and reliable communication suitable for smart homes, industries, and electrical safety applications.**

***Index Terms*—IoT, ESP32, Electrical fault detection, ACS712, ZMPT101B, Relay protection, Smart power system, Remote monitoring, Real-time data, Electrical safety.**

I. Introduction

Electrical faults such as overload, short circuit, voltage fluctuation, and power interruptions can cause serious damage to electrical appliances and industrial equipment. Traditional protection systems mainly depend on manual monitoring and conventional circuit breakers, which may not provide real-time monitoring or instant fault alerts. With the advancement of the Internet of Things (IoT), smart monitoring and automated protection systems have become more efficient, reliable, and accessible for modern electrical applications.

The Smart Power Cut Fault Protection System using ESP32 and IoT is designed to provide continuous monitoring and automatic protection of electrical systems. The system uses an ESP32 microcontroller along with ACS712 current sensor and ZMPT101B voltage sensor to detect abnormal electrical conditions in real time. When a fault occurs, the relay module automatically disconnects the power supply to ensure safety and prevent equipment damage. In addition, IoT connectivity enables remote monitoring, real-time data transmission, and instant fault notifications through a mobile dashboard, making the system suitable for smart homes, industries, and electrical safety applications.

II. LITERATURE SURVEY

Several researchers have contributed to the development of IoT-based electrical monitoring and protection systems. Sharma and Gupta [3] presented an IoT-enabled electrical monitoring system that focuses on continuous tracking of voltage and current parameters using smart sensors. Kumar and Yadav [5] analyzed various electrical sensing devices and discussed their performance, accuracy, and suitability for smart power protection applications.

Alam and Rehman [4] explored the role of ESP32 in IoT-based electrical systems, highlighting its Wi-Fi capability, low power consumption, and efficiency in real-time data processing. Singh and Kaur [6] examined smart fault monitoring systems and demonstrated their importance in early fault detection and remote supervision for improving electrical safety.

Bharathi and Nandhini [7] conducted an in-depth analysis of ACS712 and ZMPT101B sensors, describing their effectiveness in measuring current and voltage accurately. Johnson [8] discussed the adoption of IoT technologies in modern electrical safety systems, emphasizing their benefits in remote monitoring and automated fault management.

Recent technology reports [1] highlighted the increasing use of IoT-enabled smart protection devices in homes and industries for improving electrical safety and energy efficiency. Additionally, recent studies [2] emphasized the practical use of ESP32 for smart power monitoring systems due to its reliable communication capability and easy integration with cloud platforms.

III. WORKING OF THE SYSTEM

The proposed Smart Power Cut Fault Protection System is designed to monitor and protect electrical systems in real time using an ESP32-based architecture. The system consists of three major modules: the sensing layer, the processing and communication layer, and the monitoring layer.

1. Sensing Layer

This layer uses ACS712 current sensor and ZMPT101B voltage sensor to continuously measure current and voltage parameters. The sensors generate signals representing the electrical condition of the system.

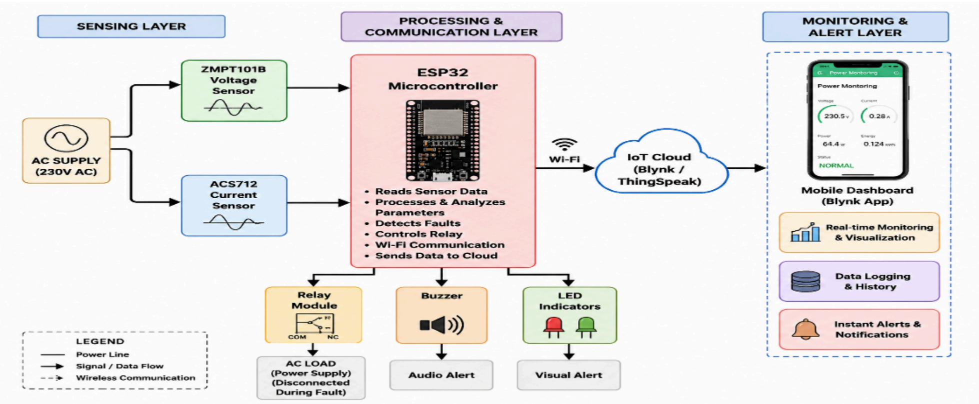
2. Processing and Communication Layer (ESP32)

The ESP32 microcontroller processes the sensor data, detects faults such as overload, short circuit, and voltage fluctuation, and controls the relay module to disconnect the power supply during faults. It also provides Wi-Fi connectivity for transmitting real-time data to the IoT platform.

3. Monitoring and Alert Layer

The IoT platform such as Blynk or ThingSpeak enables real-time monitoring, data logging, and remote access through a mobile dashboard. Instant fault notifications and alerts are also provided to improve electrical safety and system reliability.

Fig. 1 System Diagram



IV. IMPLEMENTATION DETAILS

1. Hardware Implementation

The system is implemented using ESP32, ACS712 current sensor, ZMPT101B voltage sensor, relay module, buzzer, LEDs, and a 16×2 I2C LCD display. The sensors measure voltage and current, while the relay disconnects the power supply during fault conditions. The buzzer and LEDs provide fault indication, and the LCD displays system status in real time.

2. Software Implementation

The ESP32 is programmed using Arduino IDE to read sensor data, detect faults such as overload and short circuit, and control the relay module. The software also manages LCD updates, alert indications, and Wi-Fi communication for IoT connectivity.

3. Cloud Integration

The system uses IoT platforms such as Blynk or ThingSpeak for remote monitoring. ESP32 sends real-time electrical data to the cloud, allowing users to monitor voltage, current, and fault status through a mobile dashboard.

4. Security Features

The system uses secured Wi-Fi communication and authentication tokens for safe cloud access. Proper data validation improves system reliability and prevents incorrect readings.

5. System Reliability and Testing

The system was tested under different fault conditions and showed stable operation, accurate sensor readings, reliable Wi-Fi communication, and fast fault response.

V. RESULTS AND EVALUATION

The Smart Power Cut Fault Protection System was tested to evaluate its accuracy, response time, and reliability under different electrical conditions. The performance of the sensors, relay operation, Wi-Fi communication, and IoT dashboard was observed during continuous monitoring**.**

1. Sensor Performance

The ACS712 and ZMPT101B sensors provided stable and accurate current and voltage readings throughout the testing process. The system successfully detected overload, short circuit, and voltage fluctuation conditions with reliable performance**.**

2. Cloud and Communication Performance

The ESP32 maintained stable Wi-Fi communication during testing. Real-time electrical data was transmitted to the IoT dashboard with very low delay, and the system showed reliable operation with minimal communication loss**.**

3. Monitoring and Alert Results

The IoT dashboard displayed voltage, current, and fault status clearly through graphs and numerical values. The buzzer, LED indicators, and relay module responded immediately during abnormal conditions, providing instant fault indication and automatic power cutoff.

VI. DISCUSSION

The developed Smart Power Cut Fault Protection System showed reliable performance in monitoring voltage and current parameters and detecting electrical faults in real time. The ESP32 provided fast processing and stable Wi-Fi communication, enabling continuous data updates on the IoT dashboard. The ACS712 and ZMPT101B sensors produced accurate readings during testing, while the relay module responded quickly to overload, short circuit, and voltage fluctuation conditions.

The system is easy to expand, allowing additional sensors and advanced monitoring features to be integrated in the future. Overall, the proposed solution is effective for smart electrical protection and remote monitoring applications. Future improvements may include AI-based fault prediction, enhanced security features, and advanced energy management capabilities.

VII. CONCLUSION

The Smart Power Cut Fault Protection System using ESP32 and IoT was successfully designed and implemented for real-time electrical monitoring and protection. The integration of ACS712 current sensor and ZMPT101B voltage sensor enabled accurate measurement of voltage and current parameters. Using Wi-Fi connectivity, the ESP32 efficiently transmitted data to the IoT dashboard for continuous remote monitoring and instant fault alerts. The system successfully detected overload, short circuit, and voltage fluctuation conditions and automatically disconnected the power supply using a relay module. Experimental results confirmed that the system is reliable, cost-effective, and suitable for smart homes, industries, and electrical safety applications. Future improvements may include advanced fault prediction, enhanced security features, and integration of additional smart energy management functions.

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