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IOT BASED SMART DISTRIBUTION BOX

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Abstract: The Smart Socket Monitoring and Protection System is an ESP32-based electrical safety and energy monitoring solution. It uses an AC voltage sensor and two ACS712 current sensors to measure real-time voltage, current, and power for the system loads. The system displays these parameters and also energy consumption on an LCD and continuously checks for faults such as overload, short circuit, high voltage, and low voltage, fire detection. When a fault is detected, a buzzer alert is triggered and the load is automatically disconnected using a relay to protects the loads. The relays are open up to the reset button press. The system also includes Io T functionality using the Blank cloud platform, which sends real-time electrical data for remote monitoring. This platform allows users to view live energy parameters, receive fault alerts, and monitor load status from anywhere. This system improves electrical safety, prevents equipment damage, and supports efficient smart industrial and commercials energy management.

I. INTRODUCTION

Traditional household and industrial electrical sockets are often "passive" components that lack the intelligence to monitor real-time energy consumption or detect internal faults. This leads to several critical issues:

- Fire Hazards and Electrical Faults: Conventional circuit breakers often react too slowly to minor overloads or localized overheating. Without inbuilt fire detection, a faulty appliance can cause a fire at the socket interface before a main breaker ever trips.
- Lack of Real-Time Visibility: Users generally have no way of knowing the exact power consumption of specific appliances, leading to energy wastage and unexpected utility costs.
- Physical Distance and Response Time: Standard safety features require a person to be physically present to hear an alarm or reset a switch. In a smart home or industrial setting, a fault occurring while the user is away can lead to catastrophic equipment failure or property damage.
- Voltage Instability: Sensitive electronic devices are frequently exposed to high and low voltage fluctuations that degrade their lifespan over time, as standard sockets do not provide automated disconnection during these events.

II. STATEMENT OF THE PROBLEM

Traditional electrical distribution boxes are used to distribute power to different circuits in homes, industries, and commercial buildings. However, these systems are mostly manual and do not provide real-time information about electrical parameters such as voltage, current, and energy usage. This makes it difficult for users to monitor power consumption and ensure efficient operation.One of the main problems with conventional systems is the lack of automatic fault detection. Issues like overload, short circuits, and voltage fluctuations are often detected only after they cause damage to electrical appliances or wiring. This delay can lead to increased repair costs and serious safety risks, including electrical accidents and fire hazards.

Another limitation is the dependence on manual control and monitoring. Users must physically check the system and operate switches, which is time-consuming and can lead to human errors. In larger systems, continuous monitoring becomes difficult, reducing overall reliability and efficiency.Therefore, there is a need for an IOT-based smart distribution box that can provide real-time monitoring, remote control, and automatic fault detection. Such a system can improve safety, reduce energy wastage, and ensure efficient and reliable power distribution in modern electrical systems.

III. METHODOLOGY

The development of the smart distribution box system follows a structured methodology divided into the following stages:

1. Hardware Integration

    Connect AC voltage sensor to measure supply voltage.

    Connect two ACS712 current sensors in series with two load lines.

    Interface sensors with ESP32 analog input pins.

    Connect relay modules for load control.

    Interface 16x2 LCD for local display.

    Connect buzzer for fault alerts.

    Integrate Wi-Fi module (ESP32) for Io communication.

2. Data Acquisition

    Continuously read analog voltage and current values from voltage and current sensors.

    Convert analog readings to actual RMS voltage and current values using calibration formulas.

3. Parameter Calculation

    Calculate power using:

    Power(W)=Voltage(V)×Current1(A) ×Current2(A) × . .. . . .

    Calculate Energy using:

    Energy(KWH)=(Power(W)/1000) ×(1/3600)

4. Fault Detection Algorithm

    Compare measured voltage with preset high and low voltage thresholds.

    Compare measured current with maximum safe current limit.

    Detect sudden excessive current rise indicating short circuit.

    Detects Fire or Smoke faults using predefind threshold values.

5. Protection and Alert Mechanism

    If abnormal condition detected:

Activate buzzer.

Display fault message on LCD.

Turn OFF corresponding relay to disconnect load.

If low or high or fire/smoke detected then entire system is isolated.

6. IoT Data Transmission

Send voltage, current, power, energy and fault status data to Blynk cloud via Wi-Fi.

Update cloud channel fields periodically.

This blynk cloud enables the user alerts while faults is detected.

IV. BLOCK DIAGRAM

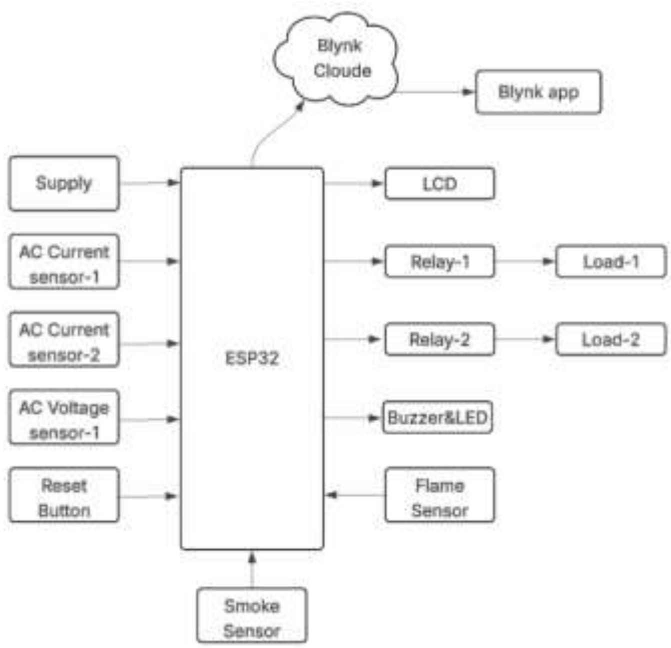

Fig Block Diagram

V. WORKING PRINCIPLE

1. The system is powered ON and initializes ESP32, LCD, sensors.
2. The voltage sensor measures AC supply voltage continuously.
3. Each ACS712 sensor measures current for its respective loads.
4. ESP32 processes analog readings and converts them into actual voltage and current values.
5. Power and energy consumption for entire system is calculated.
6. LCD displays:

Voltage value

Current for load 1

Current for load 2

Power consumption

Energy consumption

7. ESP32 checks for fault conditions:

If voltage > upper limit → High voltage fault.

If voltage < lower limit → Low voltage fault.

If current > set limit → Overload fault.

If sudden high spike → Short circuit detection.

If fire/smoke detected → Fire hazard detection.

8. If fault detected:

Buzzer activates.

LCD displays fault message.

Relay disconnects affected load automatically, For Fire Hazard entire system is isolated

9. Simultaneously, measured values and fault status are uploaded to Blynk cloud.

10. The mobile application displays live readings and alerts to the user.

11..The system continues monitoring in real time until manually reset or power is turned off.

VI. RESULTS

The IOT based Smart distribution System was successfully implemented and tested under various operating conditions. The ESP32-based system continuously measured AC voltage using the voltage sensor module and current for independent loads using ACS712 current sensors. The measured analog signals were accurately converted into RMS voltage and current values through proper calibration. Real-time voltage, current, and calculated power and energy values were displayed clearly on the 16x2 LCD screen. The system demonstrated stable performance during normal load conditions, providing continuous monitoring without interruption.

Fault detection features were tested by intentionally creating abnormal conditions such as overload, high voltage and low voltage simulation, and sudden current spikes representing short circuits and also we included the fire smoke protection for the system. The system successfully detected these conditions when the predefined threshold values were exceeded. Upon fault detection, the buzzer activated immediately, and the corresponding relay module disconnected the affected load automatically. If fire or smoke is detected then the hole system is isolated from the fault to decrease the seviour damage of the electrical system. This ensured protection of connected appliances and prevented further damage. The fault message was also displayed on the LCD for user awareness.

The IOT functionality was verified by transmitting real-time electrical data to the Blynk cloud platform through the ESP32 module. Voltage, current, power and energy values were updated on the Blynk dashboard in real time. The Blynk application is enables users to retrieved and displayed live data and fault alerts. Overall, the system operated reliably in both monitoring and protection modes, fulfilling all intended objectives.

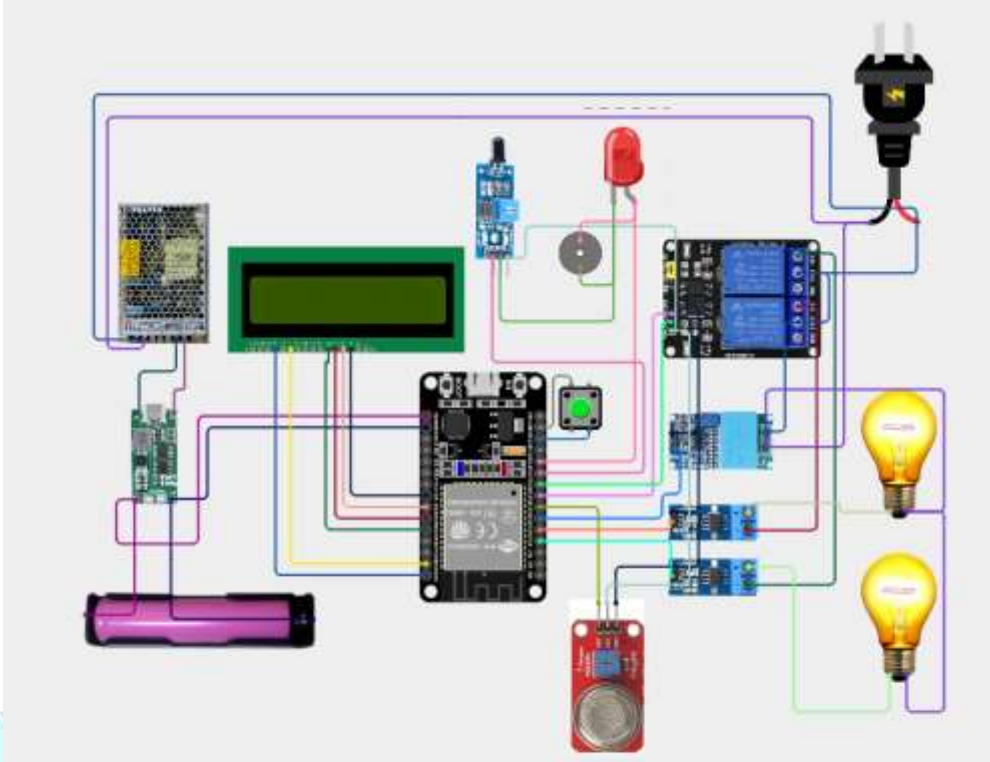

Fig Circuit Diagram

Fig Final Prototype Image

ADVANTAGES

- Provides real-time monitoring of voltage and current for individual loads.
- Calculates and displays power and energy consumption continuously.
- Detects overload, short circuit, high voltage, and low voltage conditions and also fire and smoke hazards.
- Automatically disconnects faulty loads using relay protection.
- Generates buzzer alerts during abnormal conditions.
- Enables remote monitoring through Io T cloud integration.

- Mobile app access for real-time data viewing.
- Enhances electrical safety and prevents appliance damage.
- Promotes energy awareness and efficient electricity usage.
- Low-cost and suitable for industries and commercial buildings and house hold applications.

APPLICATIONS

- Smart homes for appliance monitoring and protection.
- Offices and commercial buildings for energy management.
- Easy detection of fault lines for industrial applications.
- Laboratories and workshops for electrical safety monitoring.
- Hostels and apartments to monitor multiple loads.
- Small industries for equipment protection.
- Educational institutions for IOT and energy monitoring projects.
- Renewable energy systems for load supervision.

VII. FUTURE SCOPE

Feature	Current System	Future Scope
Detection	Threshold-based (High/Low)	Pattern-based (AI/ML)
Connectivity	Blynk Cloud	Matter / Home Assistant / Voice
Accuracy	Standard Analog Sensing	Dedicated Metering IC (PZEM)
Protection	Relays & Buzzer	Arc Fault (AFCI) & Surge (SPD)

VIII. CONCLUSION

The IOT based Smart distribution System provides an efficient, cost-effective, and reliable solution for real-time electrical monitoring and safety. By integrating an ESP32 microcontroller with AC voltage and current sensors, the system continuously measures voltage, current, and power consumption for independent loads. The implementation of overload, short circuit, high voltage, and low voltage ,fire and smoke fault detection enhances electrical safety and prevents appliance damage through automatic shutdown using relay modules.

The addition of IOT functionality through Blynk app enables remote monitoring and real-time alerts, improving user convenience and awareness. The system not only enhances safety but also promotes energy management and efficient power usage. Due to its affordability, scalability, and practical design, the smart socket system is suitable for industries, residential, commercial, and educational applications. Future improvements may include energy billing calculation, integration with smart home ecosystems, and advanced Analytics for power consumption trends.

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