IOT - Based Load Management System – An Effective Measure To Save Energy

Jyotishmoy Hazarika

Department of Power Electronics and Instrumentation Engineering,

Jorhat Institute of Science and Technology, Assam Science and Technology University Sotai, Chenijaan, Jorhat-785010, Assam, INDIA.

E-mail: jyotishmoyhazarika72@gmail.com

Chandana Dev

Department of Power Electronics and Instrumentation Engineering,

Jorhat Institute of Science and Technology, Assam Science and Technology University Sotai, Chenijaan, Jorhat-785010, Assam, INDIA.

E-mail: chandanajist@gmail.com

With the increasing demand for electrical power, preventing overload conditions is critical to ensuring safety and efficiency. This paper presents an IoT-based mains power cut system that monitors power consumption using an ACS712- 30A current sensor and automatically disconnects loads when a predefined threshold (135W) is exceeded. The system employs an ESP32 microcontroller, a 4-channel relay, and a WebSocket server for real-time control and monitoring. Users can manually or automatically manage loads through a web-based user interface, integrated with ThingSpeak for data visualization. Experimental results demonstrate the effectiveness of the system in preventing overload situations.

KEYWORDS — IoT, Power Monitoring, Overload Protection, ACS712, ESP32, WebSocket, ThingSpeak.

I. Introduction

Power consumption monitoring and control play a crucial role in energy management. Overloading can lead to equipment failure, safety hazards, and inefficiencies in power systems. Traditional circuit breakers lack real-time monitoring and remote control features.

This paper introduces an IoT- based solution that provides real-time monitoring and automation for preventing overloads.

II. LITERATURE REVIEW

Several studies have explored different methods for power monitoring, emphasizing IoT integration for enhanced control and automation. Smart meters, IoT-based monitoring systems, and automated cutoff mechanisms have been extensively re- searched.

Chu et al. [1] introduced an IoT-based power monitoring system with remote access capabilities but lacked an automatic load disconnection feature. Saleem et al. [2] designed a smart energymanagement system leveraging IoT and cloud

comput- ing for improved energy efficiency. Uzma et al. [3] developed an automatic electricity cutoff system to mitigate excessive power consumption. Kaur et al. [4] provided a comprehensive review of IoT-based smart grid applications, focusing on real-time data acquisition and intelligent control mechanisms.

Other research, such as that by Ke et al. [5] and Arun et al. [6], explored GSM-based automatic meter reading systems, enabling remote power consumption tracking. Widen et al. [7] analyzed household energy consumption patterns, while Tan et al. [8] implemented an automated power meter reading approach for more accurate usage assessment. While these studies highlight the role of IoT in power management they often lack real-time automation features necessary for proactive overload prevention.

III. SYSTEM DESIGN

The proposed system consists of the following key components:

- ACS712-30A Current Sensor: Measures real-time current flow.
- ESP32 Microcontroller: Processes data and controls relays.
- 4-Channel Relay Module: Switches loads based on power calculations.
- WebSocket Server: Facilitates real-time communication.
- ThingSpeak API: Logs and visualizes power data.
- Electrical Loads: The system is designed to control multiple loads, including a 9W LED bulb, a 33W fan, and a 100W incandescent bulb. These loads are independently monitored, and their combined power consumption determines whether the threshold is exceeded.

The system operates in two modes: manual and automatic. In manual mode, users receive alerts and take necessary actions. In automatic mode, the system proactively disconnects loads exceeding the
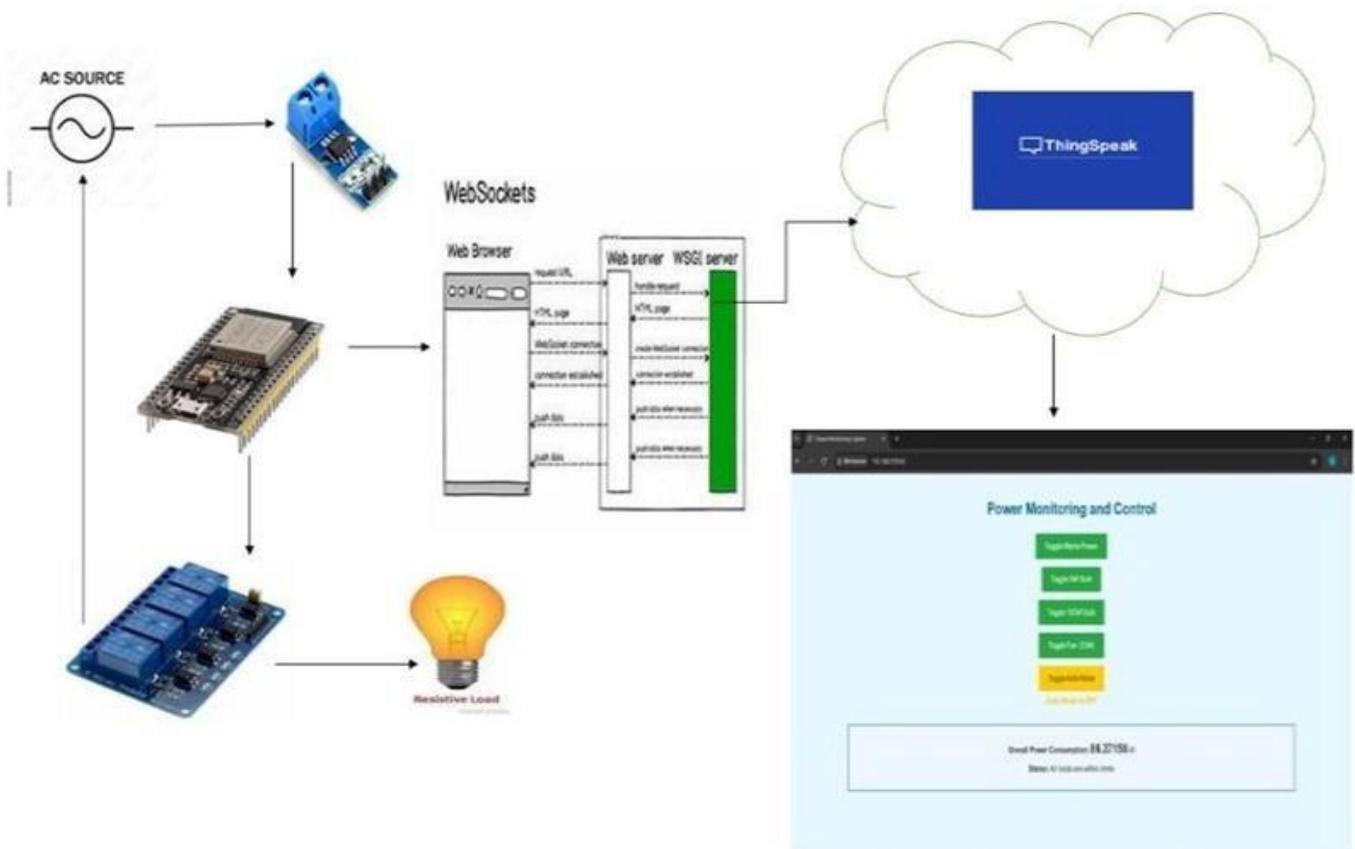

Fig. 1. Block Diagram of the System

threshold.

IV. METHODOLOGY

The system workflow consists of the following steps:

1) Current Measurement: The ACS712 sensor continuously monitors the current flowing through the loads.

2) Power Calculation: The system computes power consumption using the formula:

$$P = V \times I \times PF \quad (1)$$

where V is the voltage, I is the measured current, and PF is the power factor (assumed to be 1 for purely resistive loads).

3) Threshold Comparison: The calculated power is compared with a predefined threshold of 135W.

4) Relay Control: If the power exceeds 135W, the ESP32 microcontroller sends a signal to the relay module to disconnect the highest consuming load.

5) Data Transmission: The ESP32 transmits power consumption data to the WebSocket server for real-time monitoring.

6) User Interface Update: The web-based user interface displays real-time power data, allowing users to monitor and control loads remotely.

7) Automation Logic: In automatic mode, the system dynamically adjusts load connections to maintain power within the permissible limit.

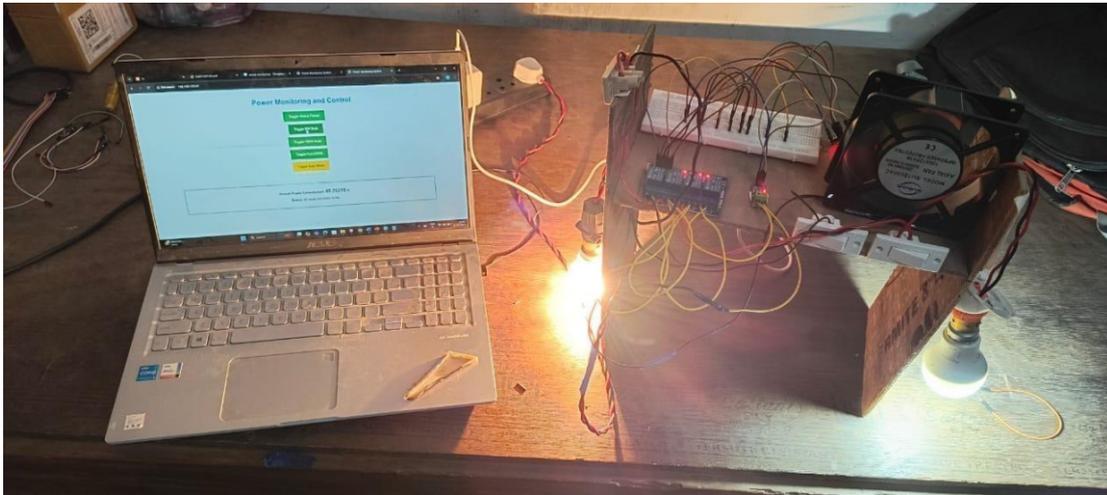8) ThingSpeak Data Logging: Power consumption data is logged on ThingSpeak for historical
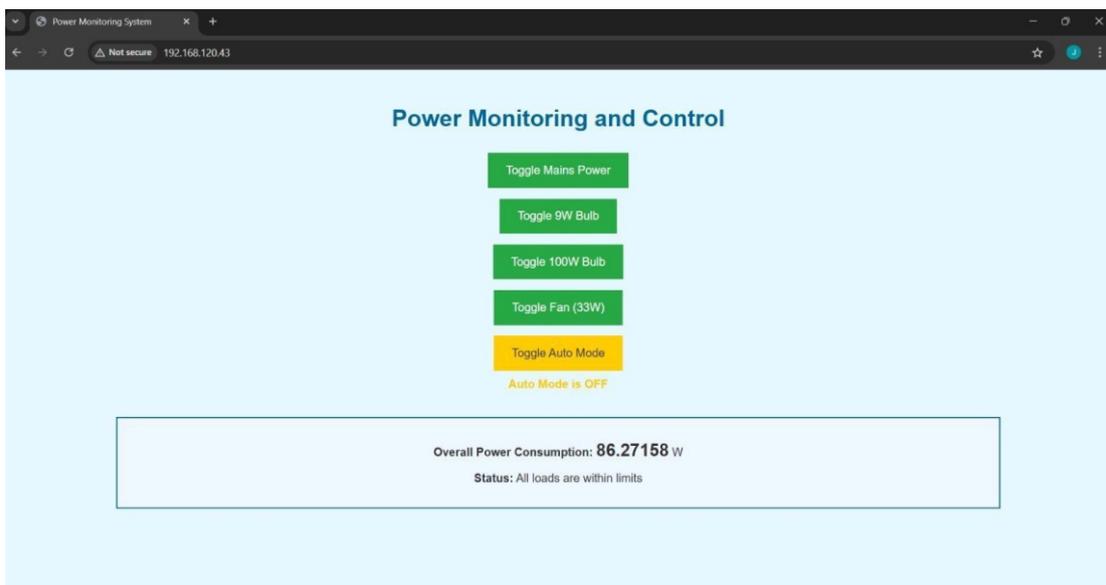

Fig. 2. System Architecture

Fig. 3. User Interface of the Power Management System

analysis and visualization.

V. RESULTS AND DISCUSSION

The system successfully detects and manages power consumption. The web interface provides real-time status updates, as shown in Fig. 3.

When the threshold of 135W is exceeded, the system notifies the user and automatically turns off the last activated load in Auto Mode. The system logs power data and user actions on ThingSpeak. The system was tested with various load combinations. Table I presents the power readings obtained during testing.

TABLE 1
POWER READINGS FOR DIFFERENT LOAD CONDITIONS

LOAD COMBINATIONS	MEASURED POWER(W)
33W Fan	33W
100W Bulb	100W
9W + 33W	42W
33W + 100W	133W
9W + 33W + 100W	142W

Experimental results confirm that the system successfully identifies and disconnects excess loads when power consumption exceeds 135W. The automation feature effectively prevents overload situation.

VI. CONCLUSION

This paper presented an IoT-based mains power cut system that ensures overload protection through real-time monitoring and automation. The proposed system provides an efficient and user-friendly approach to managing power loads, reducing risks associated with excessive consumption. Future work will involve extending the system with machine learning for predictive analysis, improving energy efficiency through dynamic load adjustments, and integrating adaptive thresholding mechanisms to enhance performance .

In the future, the system can be enhanced with Implementing machine learning algorithms for predictive maintenance. Moreover, Integrating renewable energy sources for enhanced energy for better user interaction and remote access.

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