

IoT Based Undervoltage and Overvoltage Protection System

Ms. B. Sruthi¹, Ch. Ajay²

Guide, EEE Department, Andhra Loyola Institute of Engineering and Technology, Vijayawada¹

BTech, EEE Department, Andhra Loyola Institute of Engineering and Technology, Vijayawada²

Abstract: Electrical equipment is highly sensitive to voltage variations such as overvoltage and undervoltage, which may cause severe damage, reduced efficiency, and safety risks. To overcome this problem, this project proposes an IoT-based voltage monitoring and protection system using the ESP32 microcontroller. In the proposed system, an AC voltage sensor and AC current sensor continuously measure the electrical parameters of the supply.

Keywords: IoT, ESP32, Overvoltage Protection, Undervoltage Protection, Voltage Monitoring, Relay Module

I. INTRODUCTION

Electrical and electronic equipment used in homes, industries, and laboratories requires a stable and reliable power supply for proper operation. However, in many power distribution systems, voltage fluctuations such as **overvoltage** and **undervoltage** frequently occur due to load variations, faults in transmission lines, or unstable power sources. These abnormal voltage conditions can cause serious damage to electrical devices, reduce their lifespan, and may even lead to fire hazards or system failures. Therefore, protecting electrical equipment from such voltage variations is an important requirement in modern power systems.

Traditional protection methods such as stabilizers and circuit breakers provide basic protection but often lack real-time monitoring and remote alert capabilities. With the advancement of **Internet of Things (IoT)** technology, it has become possible to design intelligent monitoring and protection systems that can continuously observe electrical parameters and respond immediately to abnormal conditions.

This paper presents an IoT-based overvoltage and undervoltage protection system using ESP32. The system monitors voltage continuously, detects abnormal conditions, and disconnects the load automatically using a relay. It also provides real-time monitoring through cloud platforms.

II. LITERATURE REVIEW

Voltage Variations

Many researchers have identified that a significant amount of energy in electrical systems is lost due to inefficiencies and fluctuations in voltage. Voltage variations occur due to load changes, transmission losses, and faults in the power system. These variations can negatively affect the performance and lifespan of electrical equipment, making proper monitoring and control essential.

Undervoltage and Overvoltage

Overvoltage and undervoltage are common types of voltage variations in power systems. Overvoltage occurs when the supply voltage exceeds the rated value, which can cause overheating and damage to electrical components. Undervoltage occurs when the voltage drops below the required level, leading to poor performance and increased current draw. Both conditions can severely impact the efficiency and safety of electrical systems.

IoT Based Monitoring

IoT-based monitoring systems provide an advanced solution for real-time voltage monitoring and control. These systems use sensors and microcontrollers to continuously measure electrical parameters and transmit data to cloud platforms. This enables remote monitoring, quick fault detection, and immediate response to abnormal conditions, thereby improving system reliability and protection.

III. SYSTEM DESIGN AND COMPONENTS

The proposed IoT-based overvoltage and undervoltage protection system is designed to monitor the supply voltage continuously and protect electrical loads from abnormal voltage conditions. The system integrates sensing, control, protection, and communication modules to ensure safe and reliable operation.

The overall system consists of a voltage sensing unit, a microcontroller unit, a relay protection unit, display and alert devices, and an IoT communication module. Each component plays an important role in the proper functioning of the system.

Voltage Sensor Module

The voltage sensor module is used to measure the input supply voltage. It converts high AC voltage into a proportional low-voltage signal that can be safely read by the microcontroller. The sensor continuously monitors the voltage and sends real-time data to the controller for processing.

Microcontroller (ESP32)

The ESP32 microcontroller is used for processing sensor data and transmitting it to the cloud using Wi-Fi. It plays a key role in enabling the Internet of Things based monitoring system.

Relay Module

The relay module is used to control the connection between the power supply and the load. When the voltage exceeds or drops below the safe limits, the microcontroller sends a signal to the relay to disconnect the load. This prevents damage to electrical equipment.

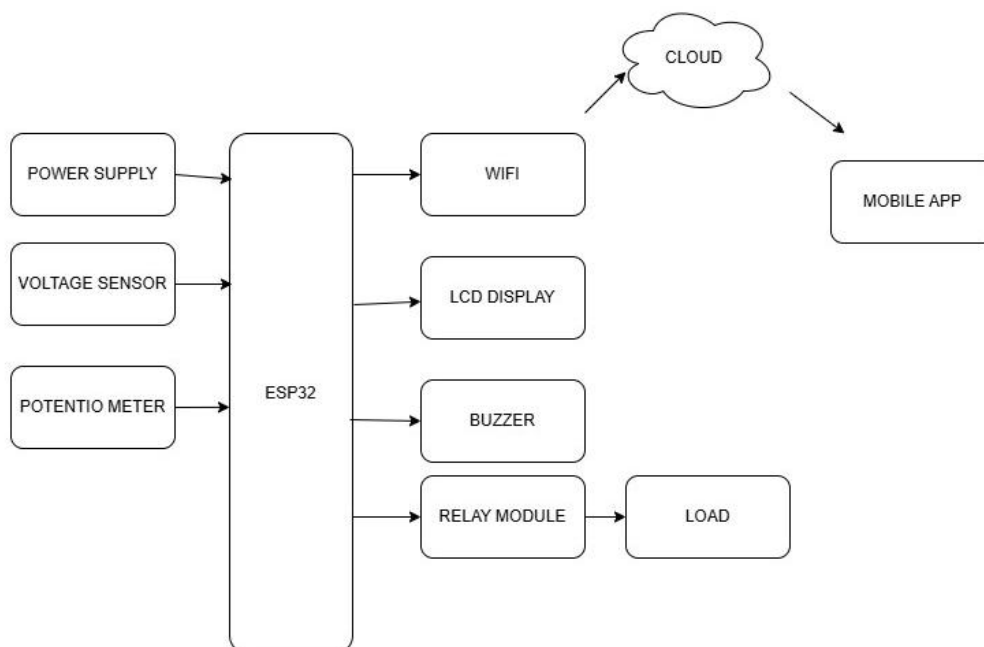


Fig 1: Block Diagram

The proposed IoT-based overvoltage and undervoltage protection system consists of input, processing, output, and communication sections integrated around the ESP32 microcontroller. The power supply provides the required DC voltage to operate the system, while the voltage sensor continuously measures the input AC voltage and sends it to the ESP32 for analysis. A potentiometer is used to set the threshold limits for overvoltage and undervoltage conditions. The ESP32 processes the sensor data and compares it with the preset values to detect any abnormal voltage levels.

Based on the result, it controls the output devices such as the LCD display, which shows real-time voltage values, and a buzzer that provides an alert during fault conditions. The relay module is used to connect or disconnect the load, ensuring protection of electrical equipment from damage. Additionally, the built-in Wi-Fi of the ESP32 enables communication with a cloud platform, allowing users to monitor system parameters remotely through a mobile application. This integrated design ensures efficient monitoring, quick response, and reliable protection of electrical systems.

IV. WORKING

The given circuit diagram represents an **IoT-based Overvoltage and Undervoltage Protection System** using an **ESP32 microcontroller**. The circuit includes a **voltage sensor module, relay module, LCD display, buzzer, and load (bulb)** to monitor and protect electrical appliances from abnormal voltage conditions.

The proposed IoT-based overvoltage and undervoltage protection system operates by continuously monitoring the input AC supply voltage using a voltage sensor connected to the ESP32 microcontroller. The measured voltage is converted into a suitable signal and processed by the ESP32, which compares it with predefined threshold values set using a potentiometer. Under normal conditions, the relay remains energized, allowing power to flow to the load (lamp). When the voltage exceeds the upper limit (overvoltage) or drops below the lower limit (undervoltage), the ESP32 immediately deactivates the relay, disconnecting the load to prevent damage. At the same time, the LCD display shows real-time voltage values and system status, while the buzzer provides an audible alert to indicate abnormal conditions. Additionally, the ESP32 uses its built-in Wi-Fi capability to transmit data to a cloud platform, enabling remote monitoring through a mobile application. This ensures quick response, continuous monitoring, and reliable protection of electrical equipment.

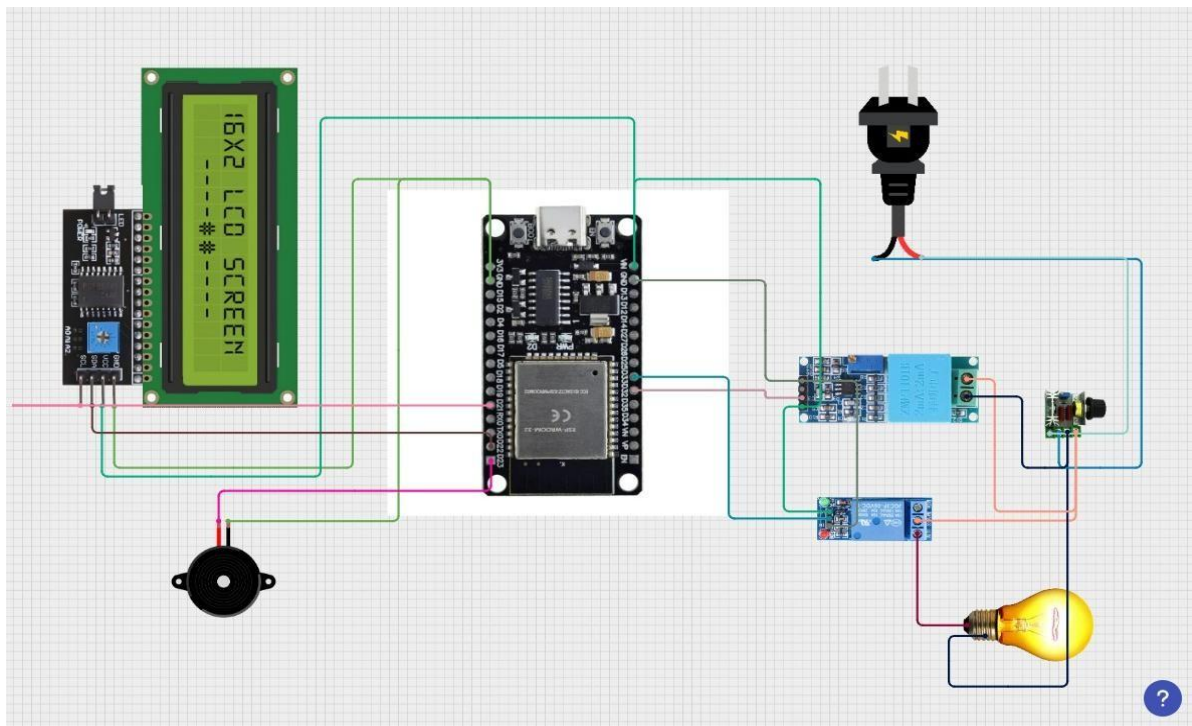


Fig. 2 Circuit Diagram

V. RESULT

The **IoT-based Overvoltage and Undervoltage Protection System** was successfully designed and implemented using an ESP32 microcontroller, voltage sensor module, relay module, LCD display, and buzzer. The system continuously monitors the input voltage and automatically protects electrical loads from abnormal voltage conditions.

System Performance Under Different Voltage Conditions

S. No.	Input Voltage	System Condition	Condition	Relay Status	Load (Bulb)	Buzzer	LCD Display Message
1	180 V	180 V	Undervoltage	OFF	OFF	ON	Under Voltage
2	195 V	195 V	Undervoltage	OFF	OFF	ON	Under Voltage
3	210 V	210 V	Normal Voltage	ON	ON	OFF	Voltage Normal
4	220 V	220 V	Normal Voltage	ON	ON	OFF	Voltage Normal
5	230 V	220 V	Normal Voltage	ON	ON	OFF	Voltage Normal
6	245 V	245 V	Overvoltage	OFF	OFF	ON	Over Voltage
7	255 V	255 V	Overvoltage	OFF	OFF	ON	Over Voltage

Fig. 3 Output with Hardware

The experimental results showed that the system effectively detects electrical power while simultaneously monitoring system parameters through IoT technology.

VI. CONCLUSION

The proposed IoT-based overvoltage and undervoltage protection system using ESP32 provides an effective solution for protecting electrical equipment from harmful voltage fluctuations. In this system, the AC voltage sensor and AC current sensor continuously monitor the electrical parameters of the power supply. The ESP32 microcontroller processes the collected data and compares it with predefined threshold values to detect abnormal conditions.

VII. ACKNOWLEDGMENT

I would like to express my sincere gratitude to the management and faculty of Andhra Loyola Institute of Engineering and Technology, Vijayawada, for providing the necessary facilities to carry out this project. I would also like to thank my project guide Ms. B. SRUTHI for their valuable guidance, support, and encouragement throughout the development of this work.

REFERENCES

- [1]. Kumar and B. Singh, "Design and Implementation of Overvoltage Protection System," *International Journal of Electrical Engineering*, vol. 10, no. 2, pp. 45–50, 2019.
- [2]. S. Patel and R. Shah, "IoT Based Smart Voltage Monitoring System," *International Journal of Engineering Research & Technology (IJERT)*, vol. 8, no. 5, pp. 234–238, 2020.
- [3]. Espressif Systems, "ESP32 Technical Reference Manual," 2021.
- [4]. H. Johnson, "Power System Protection and Switchgear," *McGraw-Hill Education*, 2018.
- [5]. M. A. Mazidi, S. Naimi, and S. Naimi, "The ESP32 Microcontroller and Embedded Systems," *Pearson Education*, 2021.
- [6]. P. Kundur, "Power System Stability and Control," *McGraw-Hill*, 1994.
- [7]. Blynk Inc., "IoT Platform Documentation," 2022.