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IoT Power Theft Detection System using ESP32

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Abstract:. *The IoT Power Theft Detection System using ESP32 is a smart electricity monitoring and protection system designed to detect unauthorized power usage and monitor electrical parameters in real time. The system uses an ESP32 microcontroller integrated with voltage, current, LDR, temperature, and gas sensors for continuous monitoring and analysis of electrical conditions. The proposed system detects abnormal current flow, meter tampering, gas leakage, and overheating conditions, improving electrical safety and reducing energy losses.*

The ESP32 microcontroller processes sensor data and displays real-time information on a web-based dashboard through WiFi connectivity. The dashboard allows users to monitor voltage, current, power consumption, gas level, temperature, and theft status remotely using mobile phones or computers. If theft or dangerous conditions are detected, the system automatically activates a buzzer alarm, warning LEDs, and relay protection to disconnect the electrical load.

The project provides a low-cost, efficient, and intelligent solution for electricity theft prevention and smart energy monitoring. The system can be widely used in homes, industries, commercial buildings, and smart grid applications..

Keywords: IoT, ESP32, Power Theft Detection, Smart Energy Monitoring, Web Dashboard, Smart Grid

I. INTRODUCTION

Electricity theft is one of the major challenges faced by electricity distribution companies worldwide. Illegal power usage through meter tampering, direct hooking, and unauthorized electrical connections causes huge financial losses and power instability. Traditional electricity monitoring systems are unable to detect theft conditions in real time, resulting in delayed action and reduced efficiency.

The IoT Power Theft Detection System using ESP32 provides a smart and automated solution for real-time monitoring and electricity theft detection. The system uses voltage sensors, current sensors, LDR sensors, gas sensors, and temperature sensors to continuously monitor electrical and environmental conditions. The ESP32 microcontroller processes the sensor data and uploads the information to a web-based dashboard using WiFi communication.

The system can automatically detect abnormal power usage, meter tampering, overheating, and gas leakage. During abnormal conditions, the system activates alarms, warning LEDs, and relay protection to improve electrical safety and prevent power loss.

II. PROBLEM STATEMENT

Electricity theft and unsafe electrical conditions are major problems in modern power distribution systems. Existing traditional energy meters do not provide real-time theft detection or remote monitoring facilities. Manual inspection methods are time-consuming, less accurate, and require continuous human effort.

The major problems include:

- Illegal electricity usage
- Meter tampering

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- Direct line hooking
- Power loss and revenue reduction
- Lack of real-time monitoring
- Absence of automatic alert systems
- Unsafe electrical conditions
- Gas leakage and overheating risks

To overcome these limitations, a smart IoT-based monitoring and theft detection system is required.

III. OBJECTIVES

The main objectives of the project are:

- To monitor voltage and current in real time.
- To detect electricity theft automatically.
- To provide IoT-based remote monitoring.
- To generate alarms during abnormal conditions.
- To improve electrical safety using gas and temperature sensors.
- To provide automatic relay protection.
- To reduce manual monitoring effort.
- To develop a low-cost smart monitoring system.

IV. LITERATURE REVIEW

Several researchers have proposed IoT-based smart energy monitoring systems for electricity theft detection and power management.

The literature survey shows that IoT technology improves power monitoring and theft detection efficiency.

Sr. No.	Paper Title	Technology Used	Findings
1	IoT Based Smart Energy Meter Monitoring	IoT, WiFi	Real-time monitoring
2	Electricity Theft Detection using Smart Meter	Smart Meter, IoT	Theft identification
3	ESP32 Based Monitoring System	ESP32	Wireless monitoring
4	Smart Grid Monitoring System	IoT, Smart Grid	Improved power management
5	Wireless Energy Meter	GSM, IoT	Automatic alert generation

Table 6.1. **Literature Review**

V. METHODOLOGY

The proposed system continuously monitors electrical parameters using sensors connected to the ESP32 microcontroller.

Working Steps:

- ESP32 initializes all sensors.
- Voltage and current sensors monitor power consumption.
- LDR sensor detects meter tampering.
- Temperature and gas sensors monitor safety conditions.
- ESP32 processes sensor values.
- Data displayed on web dashboard.
- Theft conditions activate buzzer and relay protection.

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VI. BLOCK DIAGRAM

Components Used:

- ESP32 Microcontroller
- ACS712 Current Sensor
- ZMPT101B Voltage Sensor
- LDR Sensor
- DHT11 Temperature Sensor
- MQ2 Gas Sensor
- Relay Module
- Buzzer
- LEDs
- WiFi Web Dashboard

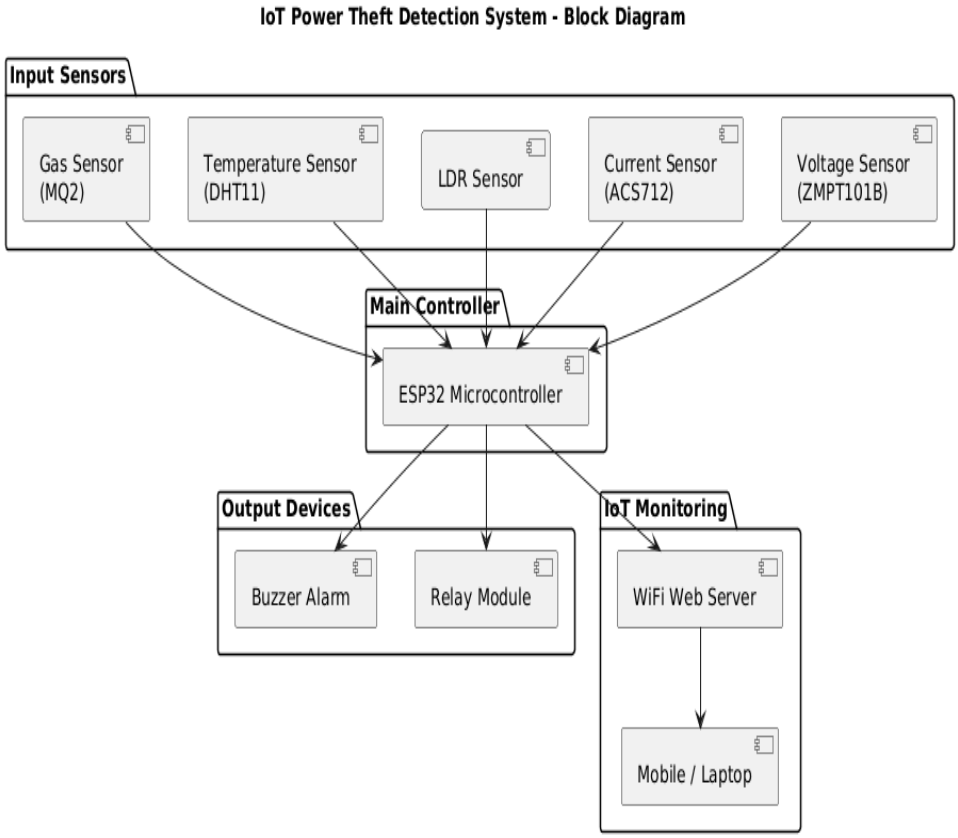

Fig.7.1. Block Diagram

VII. HARDWARE COMPONENTS

Component	Purpose
ESP32	Main controller
ACS712	Current measurement
ZMPT101B	Voltage measurement

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LDR	Meter tampering detection
DHT11	Temperature monitoring
MQ2	Gas leakage detection
Relay Module	Load control
Buzzer	Alarm indication
LEDs	Status indication

VIII. SOFTWARE REQUIREMENTS

Software	Purpose
Arduino IDE	ESP32 programming
Embedded C++	Code development
Web Browser	Dashboard monitoring

IX. SOFTWARE CODE

```
#include <WiFi.h>
#include <WebServer.h>
#include <DHT.h>

const char* ssid = "PowerTheftSystem";
const char* password = "12345678";

#define VOLTAGE_PIN 35
#define CURRENT_PIN 34
#define LDR_PIN 32
#define GAS_PIN 33
#define DHTPIN 4

#define RELAY_PIN 26
#define BUZZER_PIN 27
#define RED_LED 12
#define GREEN_LED 14

#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);

WebServer server(80);

void setup() {
Serial.begin(115200);
}

void loop() {
}
```

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X. WORKING

The system continuously monitors voltage, current, temperature, gas level, and meter tampering conditions. Sensor data is processed by the ESP32 microcontroller and displayed on a web dashboard. During abnormal conditions such as theft detection or gas leakage, the system activates alarms and disconnects the load through a relay module.

The IoT Power Theft Detection System using ESP32 is designed to monitor electrical parameters and detect electricity theft in real time using IoT technology. The methodology of the proposed system involves sensor data collection, data processing, theft analysis, safety monitoring, and web-based visualization using the ESP32 microcontroller.

The system continuously monitors voltage, current, temperature, gas leakage, and meter tampering conditions through multiple sensors connected to the ESP32. The collected sensor data is processed and analyzed to identify abnormal power usage or illegal electricity consumption.

The ESP32 then displays the data on a web-based dashboard through WiFi communication. If theft or dangerous conditions are detected, the system activates alarms and automatically controls the relay module to disconnect the power supply. The proposed methodology improves electricity monitoring accuracy, reduces manual inspection, and enhances electrical safety through au

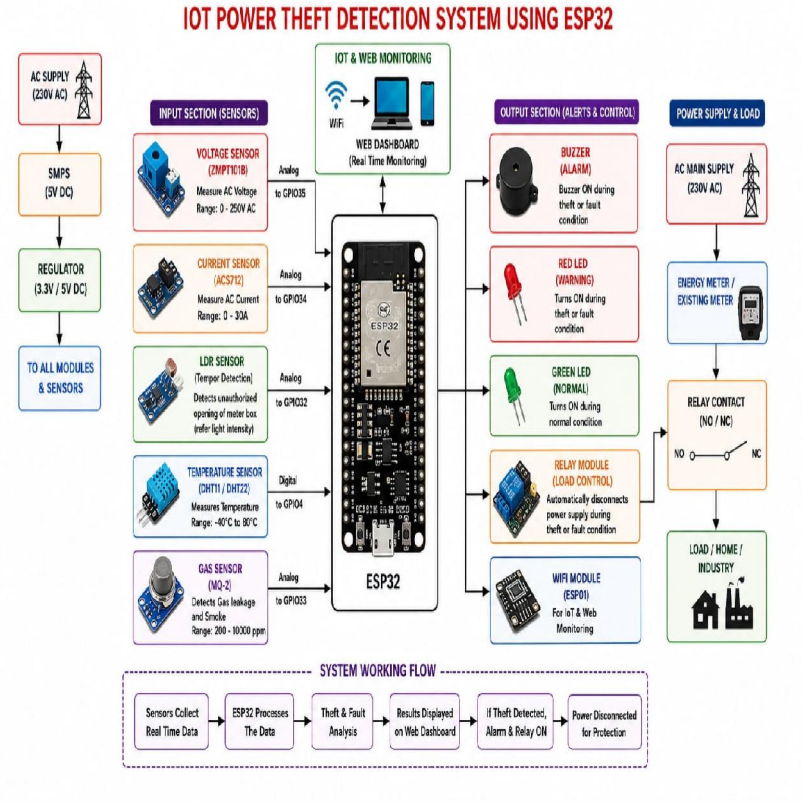

Fig.10.1.block diagram

XI. OBSERVATION AND RESULT

Parameter	Observation	Result
Voltage Monitoring	Stable readings obtained	Successful
Current Monitoring	Load variation detected	Successful
Theft Detection	Meter tampering detected	Successful
Gas Detection	Gas leakage identified	Successful

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Temperature Monitoring	Overheating detected	Successful
Web Dashboard	Real-time monitoring achieved	Successful

The project successfully achieved real-time monitoring and electricity theft detection.

XII. ADVANTAGES

- Real-time monitoring
- Automatic theft detection
- Smart web dashboard
- Remote monitoring
- Automatic relay protection
- Improved electrical safety
- Low-cost implementation
- Reduced human effort

XIII. FUTURE SCOPE

Future enhancements of the project include:

- Mobile application integration
- Cloud-based monitoring
- AI-based theft prediction
- GSM alert system
- Smart billing integration
- Renewable energy monitoring
- Smart grid implementation

XIV. CONCLUSION

The IoT Power Theft Detection System using ESP32 successfully provides a smart and efficient solution for electricity theft detection and real-time power monitoring. The system improves electrical safety, reduces power loss, and enables remote monitoring using IoT technology. The proposed system is reliable, low-cost, and suitable for smart homes, industries, and smart grid applications.

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