

IoT-Based Smart Power Monitoring and Control System with Cloud Integration

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ABSTRACT: The rapid growth of smart infrastructure has increased the demand for efficient power monitoring and control systems. This project presents an Internet of Things (IoT)-based power system monitoring and control solution integrated with cloud technology for real-time data analysis and remote operation. The system utilizes sensors to measure key electrical parameters such as voltage, current, power consumption, and energy usage. These sensors are interfaced with a microcontroller (such as ESP32), which processes the data and transmits it to a cloud platform via Wi-Fi connectivity. The cloud platform visualizes, and analyzes the data, enabling users to monitor system performance through a web or mobile dashboard. Additionally, the system supports remote control of electrical loads using cloud-based commands, allowing users to switch devices ON/OFF and optimize energy usage from anywhere. Advanced features such as fault detection, are implemented to enhance system reliability and safety. This IoT-enabled solution provides a cost-effective, scalable, and intelligent approach for modern power management, making it suitable for applications in smart homes, industries, and energy management systems.

I. INTRODUCTION

The Internet of Things (IoT) has significantly transformed modern power management systems by enabling real-time monitoring and intelligent control of electrical devices. With the increasing demand for energy efficiency and smart infrastructure, traditional power monitoring methods are no longer sufficient to meet current needs. This project presents an IoT-based smart power monitoring and control system integrated with cloud technology for enhanced performance and accessibility. The system uses sensors to continuously measure key electrical parameters such as voltage, current, and energy consumption. These parameters are processed using a microcontroller like ESP32 and transmitted to the cloud via Wi-Fi connectivity. The integration of Cloud Computing allows users to monitor data in real time through web or mobile applications. In addition to monitoring, the system enables remote control of electrical appliances, providing convenience and energy optimization. Advanced features such as overload detection, fault identification, and alert notifications improve system safety and reliability. This solution is cost-effective, scalable, and suitable for applications in smart homes, industries, and energy management systems, contributing to efficient power utilization and sustainable development.

OBJECTIVES

- To design an Internet of Things based system for real-time power monitoring. It aims to improve efficiency by continuously tracking electrical parameters like voltage and current.
- To measure and analyze power consumption using sensors and a microcontroller such as ESP32. This helps in accurate data collection and efficient processing of electrical values.
- To integrate the system with Cloud Computing for data storage and visualization. Users can access real-time and historical data through web or mobile dashboards.
- To enable remote control of electrical appliances through cloud-based commands. This allows users to switch devices ON/OFF from anywhere, improving convenience.
- To implement fault detection and overload protection mechanisms. This ensures system safety by preventing damage to devices and electrical circuits.

II. LITERATURE SURVEY

[1] Sharma P, Verma R, "IoT-Based Smart Power Monitoring System," 2021. The main objective of this system is to develop a smart solution for monitoring electrical parameters using Internet of Things technology. The system uses

sensors to measure voltage and current and transmits the data to a cloud server for analysis. It enables users to monitor energy consumption remotely and improves overall efficiency in power usage

[2] Kumar S, Singh A, “Cloud Integrated Energy Monitoring System,” 2022. This work focuses on integrating Cloud Computing with IoT devices for real-time energy monitoring. The system stores data on a cloud platform and provides visualization through dashboards. It helps users analyze energy patterns and make better decisions to reduce power wastage.

[3] Reddy K, Naik V, “Smart Energy Meter Using IoT,” 2022. The proposed system introduces a smart energy meter that automatically records energy consumption and sends data wirelessly. It eliminates manual meter reading and provides accurate billing information. The system also enhances transparency between consumers and electricity providers.

[4] Gupta R, Mehta D, “Real-Time Power Monitoring Using ESP32,” 2023. This study utilizes the ESP32 for real-time data acquisition and transmission. The microcontroller processes sensor data efficiently and sends it to a cloud platform via Wi-Fi. The system ensures low-cost implementation with high performance and reliability.

[5] Khan M, Ali S, “IoT-Based Home Energy Management System,” 2023. The system is designed to monitor and control home appliances using IoT technology. It allows users to remotely operate devices and track energy usage through mobile applications. This improves user convenience and promotes efficient energy consumption in households.

III. EXISTING & PROPOSED SYSTEM

EXISTING SYSTEM

The existing power monitoring systems are mainly based on traditional methods that involve manual data collection and limited automation. In most cases, energy consumption is measured using conventional energy meters, where readings are recorded manually at regular intervals. These systems do not utilize Internet of Things technology, which restricts their ability to provide real-time monitoring and remote accessibility. As a result, users cannot continuously track electrical parameters such as voltage, current, and power consumption, leading to inefficient energy management and delayed decision-making.

PROPOSED SYSTEM

The proposed system introduces an advanced Internet of Things based smart power monitoring and control solution designed to overcome the limitations of traditional systems. It enables real-time monitoring of electrical parameters such as voltage, current, power, and energy consumption using smart sensors. These sensors continuously collect data and provide accurate measurements, ensuring efficient energy tracking. The system improves visibility and helps users understand their power usage patterns for better management.

BLOCK DIAGRAM

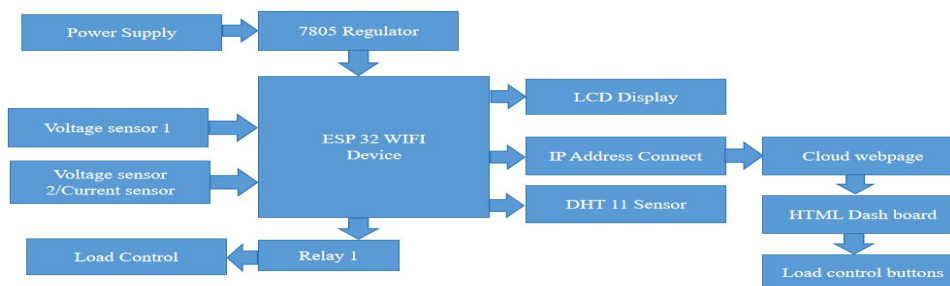


Fig No: 1 Hardware & Software block diagram

IV. HARDWARE REQUIREMENTS

1. POWER SUPPLY

A power supply is an electrical device that converts electric current from a source (such as a wall outlet) into the correct voltage, current, and frequency required to power a specific load (electronic components). Often called power converters, they ensure devices receive stable, usable power while protecting against surges.



Fig No: 2 Power Supply

2. IC 7805 REGULATOR

The IC 7805 is a popular three-terminal linear voltage regulator that provides a fixed +5V DC output from a higher input voltage (typically 7V-35V). It is widely used in electronics for stable power supplies, delivering up to 1.5A current while featuring built-in short-circuit and thermal overload protection.

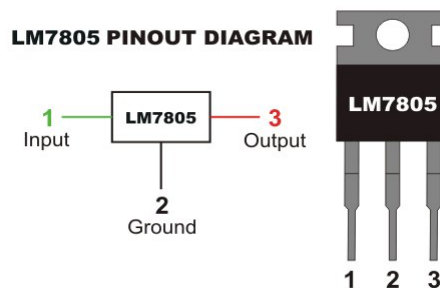


Fig No: 3 IC 7805 REGULATOR

3. ESP32 Microcontroller

The ESP32 is a powerful, low-cost, and energy-efficient System on Chip (SoC) developed by Espressif Systems. It is widely used in Internet of Things (IoT) applications due to its dual-core processor, built-in Wi-Fi and Bluetooth connectivity, and rich peripheral interfaces. The ESP32 has become one of the most preferred modules for modern embedded projects requiring wireless data communication, cloud connectivity, and remote monitoring.



Fig No: 4 ESP32

4. LCD Display

An LCD (Liquid Crystal Display) is a thin, flat-panel display technology that uses the light-modulating properties of liquid crystals, sandwiched between polarizers and electrodes, to display images or text. It acts as a digital shutter system—not emitting light directly but instead manipulating backlight (via LEDs) or reflected light to create visual output.



Fig No: 5 LCD Display

5.DHT 11 Sensor

The DHT11 is a low-cost, digital temperature and humidity sensor that utilizes a capacitive sensor element and a thermistor to measure surrounding air, outputting a 40-bit serial digital signal. It operates within 0-50°C and 20-90% RH ranges, providing reliable and economical data for hobbyist projects like Arduino-based weather stations.

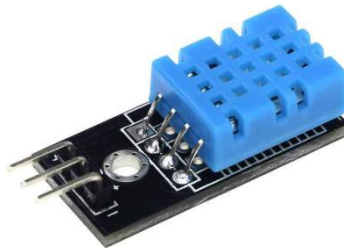


Fig No: 6 DHT 11 Sensor

6. Relay

A relay is an electrically operated switch that uses a low-power signal to control a high-power circuit, providing electrical isolation between the two. It functions through an electromagnet (coil) that moves contacts to open or close, commonly used in automation, power systems, and electronics to control motors, lights, or high-voltage devices safely.



Fig No: 7 Relay

7. Voltage Sensor

A voltage sensor is a device that detects and measures the electrical potential difference (voltage) between two points in an AC or DC circuit, converting it into a readable signal (analog, digital, or audio). These sensors are crucial for monitoring, controlling, and ensuring safety in electrical systems by providing constant feedback, preventing overloads, and managing power consumption.



Fig No:8 Voltage Sensor

V. RESULT

The implementation of the Internet of Things based smart power monitoring and control system with cloud integration produced effective and reliable outcomes in real-time energy management. The system successfully monitored electrical parameters such as voltage, current, power, and energy consumption with high accuracy. Using the ESP32, the collected data was processed efficiently and transmitted to the cloud without significant delay. The integration of Cloud Computing enabled seamless data storage, visualization, and remote access through web dashboards. Users were able to monitor system performance and control electrical devices from any location. The system also demonstrated effective fault detection and overload protection, enhancing operational safety. Instant alert notifications were generated during abnormal conditions, ensuring quick response. The overall performance showed improved energy efficiency and reduced power wastage. The system proved to be cost-effective, scalable, and easy to implement. Hence, the results confirm that the proposed system is suitable for smart homes and industrial applications.

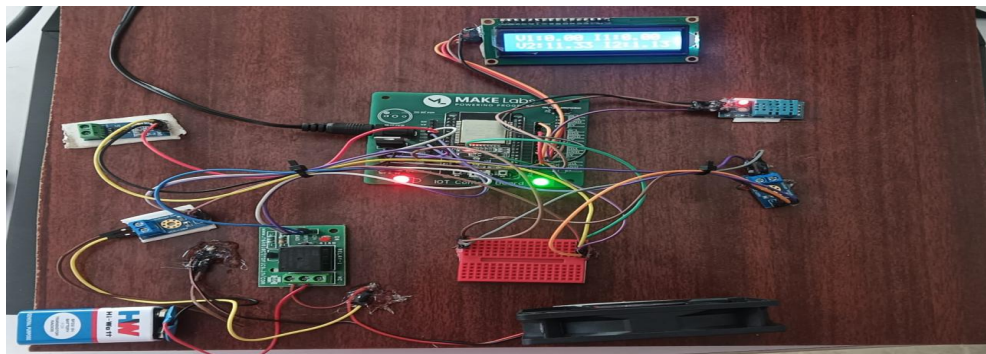


Fig 9 kit screen shot



Fig 10 temperature data

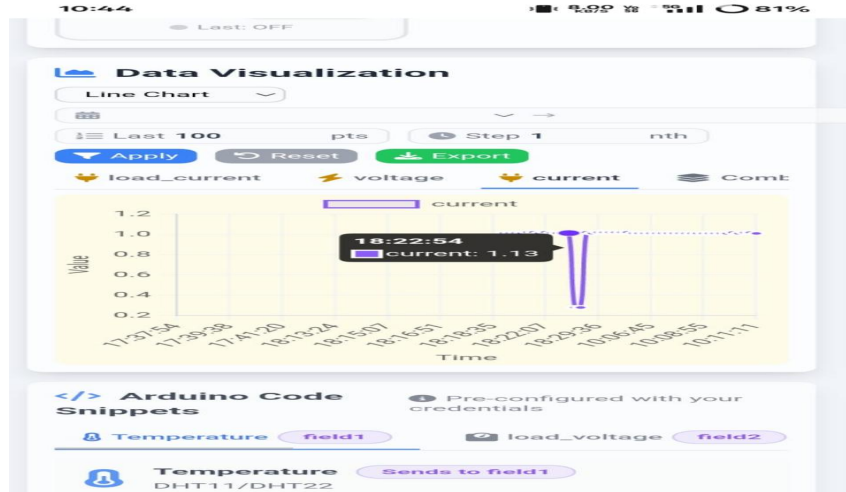


Fig 11 voltage data



Fig 12 load voltage

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- [3] A. Andharkar and P. Chaudhari, "IoT-Based Smart Energy Meter with Cloud Support," *Journal of Emerging Technologies and Innovative Research*, vol. 11, no. 6, pp. 334–340, 2025.
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