IoT Based Smart Energy Meter

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Abstract— **The rapid advancement of Internet of Things (IoT) technology has opened avenues for innovative solutions across various sectors, notably in energy management. This paper introduces the development and execution of an IoT-based smart energy meter leveraging the PZEM OO4T sensor and ESP8266 microcontroller. The primary objective is to deliver precise real-time monitoring and control of energy consumption in both residential and commercial infrastructures.**

The system's fundamental components encompass the PZEM-004T sensor for comprehensive measurement of voltage, current, power, and energy consumption, alongside the ESP8266 microcontroller for data acquisition, processing, and communication with the IoT infrastructure. Capable of wirelessly transmitting energy consumption data, the system integrates seamlessly with a cloud-based server for storage, analysis, and visualization.

***Keywords*— PZEM 004T, Esp 8266, IoT, Wi-Fi**

I. Introduction

The escalating global demand for energy, coupled with the urgent necessity for sustainable resource management, has spurred a search for innovative solutions in energy monitoring and conservation. In this context, the integration of Internet of Things (IoT) technology with energy management systems emerges as a transformative opportunity. By seamlessly linking physical devices, sensors, and data analytics, IoT facilitates the development of intelligent systems capable of monitoring, controlling, and optimizing energy usage across diverse environments.

This paper presents an IoT-based Smart Energy Meter that utilizes the PZEM-004T sensor and ESP8266 microcontroller (MCU). This pioneering solution is poised to redefine energy management approaches in residential, commercial, and industrial sectors. Leveraging IoT technologies, this Smart Energy Meter pledges to provide precise, real-time monitoring and management of energy consumption, equipping users with actionable insights to enhance efficiency and drive cost savings.

The proliferation of IoT devices and sensors enables the comprehensive collection of detailed data on energy consumption patterns, thereby offering insights into usage trends and inefficiencies. By harnessing advanced data analytics techniques, such as machine learning algorithms, this Smart Energy Meter can analyze vast datasets to identify optimization opportunities, predict future consumption patterns, and enable proactive energy management strategies.

At the heart of the proposed system lie the PZEM-004T sensor and ESP8266 microcontroller. The PZEM-004T sensor facilitates accurate measurement of crucial parameters, including voltage, current, power, and energy consumption. Concurrently, the ESP8266 microcontroller enables data acquisition, processing, and communication with IoT platforms, facilitating seamless integration with cloud-based services for data storage, analysis, and visualization.

Key features of the IoT-based Smart Energy Meter include real-time monitoring, remote accessibility via web or mobile applications, energy analytics capabilities, alerts and notifications for abnormal consumption levels, and scalability for integration with existing IoT ecosystems. These features collectively offer users unparalleled visibility and control over their energy usage, empowering them to make informed decisions to optimize consumption, reduce waste, and promote sustainability.

The significance of this research lies in its potential to address critical challenges in energy management, including rising energy costs and environmental concerns. By providing a cost-effective and scalable solution for energy monitoring and optimization, this IoT-based Smart Energy Meter holds promise for widespread adoption across various sectors, contributing to a more sustainable and efficient energy future.

II. Device Details

The ESP 8266 node MCU, PZEM004T, current transformer (CT), breadboard, and single 16x2 LCD display are the primary parts utilized in this project.

To run the code on ARDUINO IDE environment.

Figure 1. Shows the function block diagram of smart Energy meter

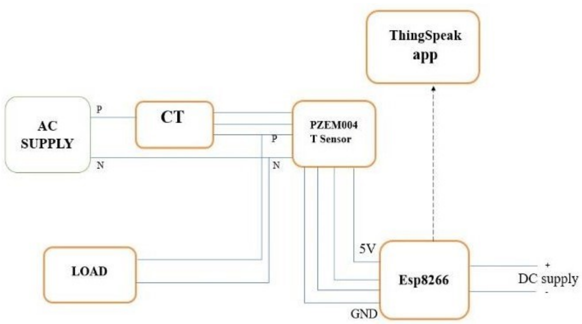


Fig. 1. Block diagram

A. Hardware Overview

The smart energy meter utilizes a combination of hardware components to accurately measure, monitor, and display energy consumption data. The core components of the system include the PZEM-004T sensor, ESP8266 microcontroller, current transformer, breadboard, and a 16x2 LCD display.

PZEM-004T Sensor: -

The PZEM-004T sensor is a versatile module capable of measuring voltage, current, power, and energy consumption.

It provides accurate readings of electrical parameters, making it ideal for monitoring energy usage in real-time. The sensor is typically connected to the main power line to capture electrical data. ESP8266 Microcontroller the ESP8266 microcontroller serves as the brain of the smart energy meter system. It is responsible for data acquisition, processing, and communication with other devices and IoT platforms. The ESP8266 facilitates wireless connectivity, enabling data transmission to cloud-based servers for storage and analysis.

Current Transformer: -

The current transformer is used to measure alternating current (AC) flowing through a conductor. It is typically connected in series with the electrical load to measure the current passing through the circuit. The current transformer provides the necessary input to the PZEM-004T sensor for accurate current measurements.

Breadboard: -

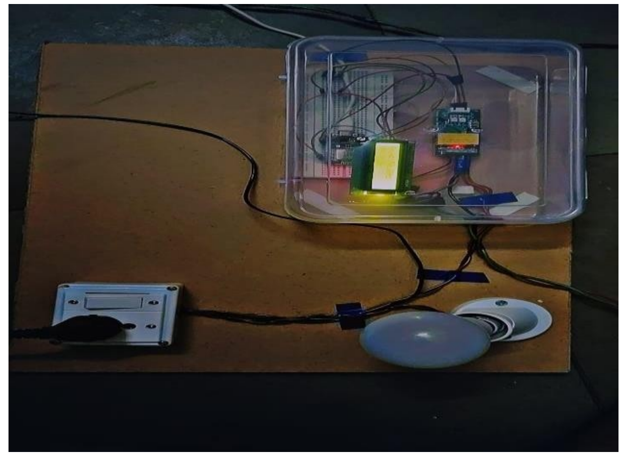
The breadboard serves as a platform for prototyping and connecting the various hardware components of the smart energy meter. It allows for easy and temporary connections between the components, facilitating testing and troubleshooting.

LCD 16x2 Display: -

The 16x2 LCD display provides a user-friendly interface for viewing energy consumption data. It displays relevant information such as voltage, current, power, energy consumption, and any system alerts or notifications.

The LCD display enhances the usability of the smart energy meter by providing real-time feedback to the user.By integrating these hardware components, the IoT-based smart Energy meter system can accurately measure energy consumption, process the data, and present it to the user in a clear and accessible format. This hardware setup forms the foundation of an efficient and effective energy monitoring solution for residential, commercial, and industrial applications.

Fig. 2. Prototype smart energy meter.



B. Software description

1) THING SPEAK

Things Speak serves as the IoT platform for the smart energy meter system, providing a robust infrastructure for data storage, analysis, and visualization. Leveraging the capabilities of Things Speak, the smart energy meter seamlessly communicates with cloud-based servers, enabling the transmission of energy consumption data in real-time. Things peak's intuitive interface allows users to easily access and visualize their energy usage data through customizable charts, graphs, and dashboards. Additionally, Things speak offers powerful data analytics tools, enabling users to gain deeper insights into their energy consumption patterns and trends. Moreover, Things Speak supports integration with third-party applications and services, facilitating interoperability and enabling users to extend the functionality of their smart energy meter system. Overall, Thingd Speak plays a pivotal role in enhancing the efficiency and usability of this energy meter, empowering users to make informed decisions to optimize energy usage and promote sustainability.

2) Arduino IDE

The Arduino Integrated Development Environment (IDE) plays a pivotal role in the development and implementation of the IoT-based smart energy meter system. As an open-source software platform, the Arduino IDE provides a user-friendly interface for programming the ESP8266 microcontroller, which serves as the central processing unit of the energy meter. Within the Arduino IDE, developers can write, compile, and upload firmware code to the ESP8266, enabling it to interface with the hardware components, including the PZEM-004T sensor, current transformer, and LCD display. the Arduino IDE provides a robust accessible environment for building and deploying the IoT-based smart energy meter, empowering developer to create efficient and scalable energy monitoring solutions for various applications.

III. RESULTS & DISCUSSION

Following a few procedures, the user can view the records in a browser on the internet once the gadget is ready. To gather and store data in the cloud and create further IoT apps, utilize the Thing Speak IoT platform.

A. Monitored the data on server: -

Although all readings—including voltage, current, power, energy, and power factor—can be shown in tabular form in the browser, graphical representation is favored in this study to provide a better understanding of the consumption pattern and associated signals. The user can observe usage patterns and adjust the load to meet targeted monthly consumption with the help of such routine monitoring. Conversely, the supply authorities are also able to quickly identify the pick load from those hourly graphs and effectively schedule their loads. Another option is to monitor the power factor. This makes it easy and quick to identify power factor lagging in any region. Figs. 3–8 display a few sample displays.

The figures demonstrate that the supply was maintained at 23.45 with no load, and that during that time, all of the displays displayed the appropriate data. The supply was turned off at 23.45, which resulted in a sudden decrease of all displays to zero. When the supply was restored at 23.45, all of the displays turned back on.

Fig. 3 Voltage display.

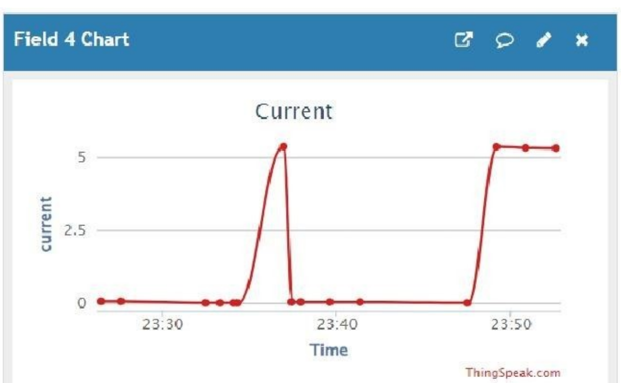


Fig.4 Current display

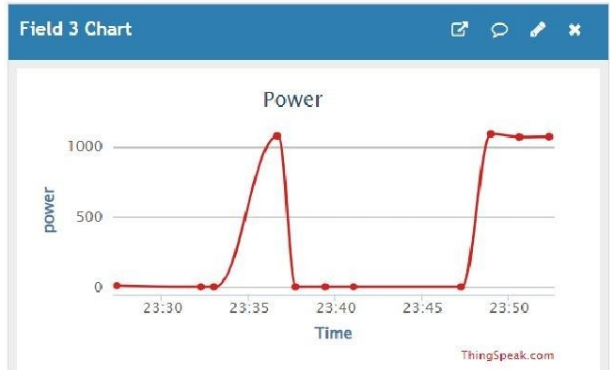


Fig. 5 Power display

Fig. 6 Energy display

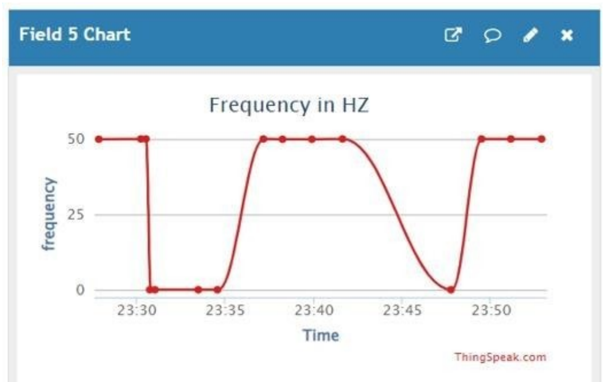


Fig. 7 Frequency display

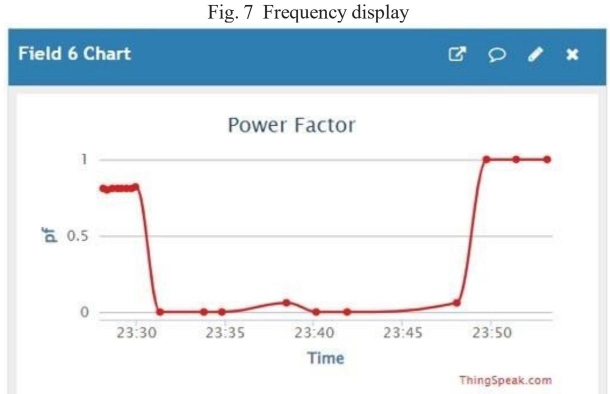
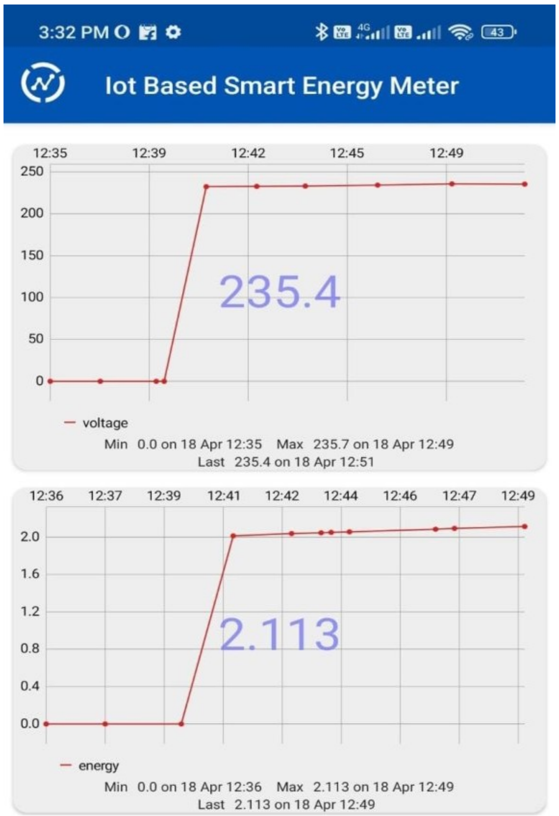


Fig. 8 Power Factor display

A. Display in Android mobile app

This smart meter is designed in the project not only shows results in a web browser but also has the ability to display results and graphs on an Android mobile app. This functionality significantly enhances the system's flexibility, allowing both consumers and supply operators to monitor energy consumption while on the move.



III. CONCLUSIONS

This article describes the development and operation of an Internet of Things (IoT)-based smart energy meter. It exhibits the following characteristics:

•A data management system gathers the data and uses the internet to give the user information about their energy consumption.

• Since the device operates online, all data is received instantly.

•One may view the day-by-day load analysis curve and the load data that is currently connected to the energy meter using the built app. Power optimization is therefore possible.

• Accessibility in identifying the pick loads and their timing, which facilitates load scheduling.

•The user can access the energy management system directly through the Android app. Consequently, every customer starts to play a part in effective energy management.

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IV. REFERENCES

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