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# DESIGN OF ENHANCED SMART GRIDS WITH A NEW IOT AND CLOUD BASED SMART METER TO PREDICT THE ENERGY CONSUMPTION

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**Abstract:** Energy monitoring and management have become essential for improving efficiency and reducing power wastage in industrial environments. Traditional energy meters provide limited monitoring capabilities and do not support real-time remote access to electrical parameters.

This paper presents the design and implementation of an IoT-based smart energy monitoring system using the ESP32 and the PZEM-004T Energy Meter Module. The system continuously measures important electrical parameters such as voltage, current, power, energy consumption, frequency, and power factor with high accuracy. The measured data is processed by the ESP32 microcontroller and transmitted through Wi-Fi for remote monitoring.

The real-time electrical data can be viewed through the Blynk application, enabling users to monitor energy usage from anywhere using a mobile device. This system provides an efficient and cost-effective solution for industrial energy monitoring and management.

Experimental testing with different electrical loads demonstrates that the system provides accurate and reliable measurement results. The proposed system can be applied in industrial environments for smart energy monitoring and improved power management.

**Keywords:** IoT, Smart Energy Meter, ESP32, PZEM-004T, Energy Monitoring.

## I. INTRODUCTION

The increasing demand for electrical energy and the need for efficient energy utilization have led to the development of smart energy monitoring systems. Traditional energy meters do not provide real-time monitoring or remote access, making it difficult to track energy consumption effectively. With the advancement of IoT technology, it is now possible to monitor electrical parameters in real time using smart devices.

This project presents an IoT-based smart energy monitoring system using ESP32 and PZEM-004T module. The system measures voltage, current, power, energy, and frequency of connected loads and transmits the data to a cloud platform. The use of IoT enables remote monitoring through mobile applications, allowing users to analyze and control energy usage efficiently. This system provides a reliable and intelligent solution for modern energy management.

### 1.2 Background and Motivation

The growing energy demand and increasing electricity costs require efficient monitoring and management systems. Conventional energy meters lack real-time monitoring and remote accessibility. IoT-based systems provide a smart solution by enabling real-time data monitoring and analysis.

The motivation of this paper is to develop a smart energy monitoring system that can measure electrical parameters accurately and provide real-time data through IoT platforms. This helps users optimize energy usage, reduce wastage, and improve efficiency.

### 1.3. OBJECTIVES

The primary objectives of this paper are:

- To design an IoT-based smart energy monitoring system

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- To measure electrical parameters such as voltage, current, power, and energy
- To implement real-time monitoring using IoT technology
- To analyze energy consumption of different loads
- To improve energy efficiency and reduce power wastage

### 1.4 Scope of the Project

This paper is suitable for:

- Smart homes and residential monitoring
- Industrial energy monitoring systems
- Smart grid applications
- Educational and research purposes

## II. LITERATURE SURVEY

**Gaikwad and Patil [1]**

Gaikwad and Patil [1] developed an IoT-based energy monitoring system using smart sensors to measure electrical parameters efficiently. Their system focuses on collecting real-time data and transmitting it through IoT platforms for remote monitoring. The use of smart sensors improves the accuracy of measurements and reduces manual intervention. The system enables users to track energy consumption patterns and optimize usage. It also helps in identifying power wastage and improving efficiency. However, the system depends heavily on internet connectivity for real-time data transmission. Overall, the proposed method enhances energy monitoring using modern IoT technologies.

**Sharma and Sinha [2]**

Sharma and Sinha [2] designed and implemented a smart energy meter using IoT technology for accurate energy measurement. Their system measures electrical parameters such as voltage, current, and power and sends the data to a cloud platform. The system provides real-time monitoring and helps users analyze their energy usage. It improves reliability and reduces errors compared to traditional meters. The use of IoT enables remote access and control of energy data. However, challenges such as network dependency and security issues are present. The system contributes to the development of smart energy solutions.

**Gubbi et al. [3]**

Gubbi et al. [3] presented a comprehensive study on the Internet of Things (IoT), including its architecture and applications. The paper discusses how IoT connects physical devices to the internet for data exchange. It explains key components such as sensors, communication networks, and cloud computing. The authors highlight the role of IoT in smart energy systems and automation. They also discuss challenges like scalability, security, and interoperability. The study provides a strong foundation for IoT-based applications. It is widely used as a reference for smart grid and monitoring systems.

**Alawadhi et al. [4]**

Alawadhi et al. [4] proposed an IoT-based smart energy meter for home automation systems. The system integrates energy monitoring with home automation for efficient control of appliances. It enables real-time tracking of energy consumption through IoT platforms. The system helps users reduce energy wastage and improve efficiency. It also supports remote monitoring and control of devices. The design focuses on user convenience and automation. However, it requires stable internet connectivity for proper operation. The system is suitable for smart home applications.

**Kumar et al. [5]**

Kumar et al. [5] introduced a cloud-based smart energy metering system for predictive energy management. The system uses cloud computing to store and analyse energy data. It enables forecasting of energy consumption patterns for better decision-making. The system improves efficiency in smart grid applications. It also helps in reducing power losses and optimizing energy usage. However, cloud dependency may introduce latency and security concerns. The proposed system enhances energy management using advanced analytics. It is useful for large-scale energy monitoring systems.

**Patel and Gupta [6]**

Patel and Gupta [6] designed a real-time energy monitoring system using ESP32 and PZEM-004T module. The system measures voltage, current, and power accurately and transmits data to the cloud. It provides real-time monitoring through IoT platforms. The ESP32 enables wireless communication and efficient data processing. The system is cost-effective and easy to implement. It helps in analysing energy consumption patterns. However, it depends on internet connectivity for remote monitoring. The system is suitable for smart energy applications.

  

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**Rahman et al. [7]**
Rahman et al. [7] proposed a smart energy metering system with real-time monitoring and load management. The system focuses on optimizing energy consumption and reducing wastage. It uses IoT technology to collect and transmit data continuously. The system also supports load control and management features. It helps in maintaining system stability and efficiency. However, implementation complexity and cost may be challenges. The system is useful for smart grid applications. It enhances overall energy efficiency.

**Yu et al. [8]**
Yu et al. [8] presented a survey on IoT-based energy monitoring and smart grid systems. The paper discusses various technologies used in energy monitoring systems. It highlights the importance of real-time data acquisition and communication. The study also covers challenges such as data security and scalability. It provides a comparison of different energy monitoring approaches. The authors emphasize the role of IoT in modern energy systems. The survey helps researchers understand current trends and technologies. It is useful for developing advanced smart grid solutions.

**Young et al. [9]**
Young et al. [9] discussed IoT-enabled smart grid systems for residential energy management. The system focuses on efficient energy distribution and automation. It enables users to monitor and control energy usage remotely. The integration of IoT improves system performance and reliability. It also supports real-time data analysis. However, implementation cost and complexity may be limitations. The system enhances energy efficiency in residential areas. It is suitable for smart home applications.

**Singh and Tripathi [10]**
Singh and Tripathi [10] implemented a smart energy meter using ESP32 integrated with a cloud platform. The system provides real-time monitoring and data storage capabilities. It allows users to access energy data remotely through IoT applications. The system improves accuracy and efficiency compared to traditional meters. It also supports data analysis for better energy management. However, it depends on network availability and cloud services. The system is cost-effective and easy to implement. It is suitable for modern energy monitoring applications.

## III. COMPONENTS AND THEIR FUNCTIONS

The components used for the project Enhanced smart grids using new IOT and cloud based smart meters for energy consumption prediction are:

AC Supply
Switch Board
CT sensor
Electrical loads
PZEM 004T Module
ESP32 Microcontroller
Blynk Application

**[1]. AC Supply**
The AC supply provides electrical power to the system and acts as the main input source. It supplies power to the connected loads and measurement devices.

**[2]. Switch Board**
The switch board is used to control the electrical loads. It allows safe switching of devices such as bulbs and chargers.

**[3]. CT Sensor**
The CT sensor measures the current flowing through the load without direct contact. It ensures safe and accurate current measurement.

**[4]. Electrical Loads**
Different loads such as LED bulbs, incandescent bulbs, and laptop chargers are used to analyze energy consumption under various conditions.

**[5]. PZEM-004T Energy Meter Module**
This module measures voltage, current, power, energy, and frequency. It processes the data internally and sends it to the microcontroller.

**[6]. ESP32**
The ESP32 processes data received from the PZEM module and transmits it to the cloud using Wi-Fi.

  

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**[7]. Blynk IoT**
The Blynk application displays real-time data on a mobile interface, allowing users to monitor energy consumption remotely.

**AC Supply**
The AC supply acts as the primary source of electrical energy for the system. It provides standard single-phase alternating current, typically 230V at 50Hz. This power is used to operate the connected loads such as bulbs and chargers. The AC supply is also fed into the measurement system for parameter analysis. It ensures continuous power availability for monitoring. Proper handling of AC supply is important for system safety. It forms the starting point of the entire system.

**Switch Board**
The switch board is used to control the flow of electricity to different loads. It contains switches and sockets that allow manual ON/OFF control of devices. This helps in safely connecting and disconnecting loads from the AC supply. It also provides flexibility in selecting different loads for testing. The switch board ensures user safety during operation. It acts as an interface between power source and load. It is an essential component for practical implementation.

**CT Sensor (Current Transformer)**
The CT sensor is used to measure the current flowing through the electrical load. It works on the principle of electromagnetic induction. The sensor provides isolation between high voltage circuits and low voltage devices. It does not require direct contact with the conductor, ensuring safety. The measured current is converted into a proportional signal. This signal is then sent to the PZEM module for processing. It enables accurate and safe current measurement.

Fig 3.1: CT Sensor and PZEM-004T Energy Meter Module

**PZEM-004T Energy Meter Module**
The PZEM-004T module is used to measure electrical parameters such as voltage, current, power, energy, and frequency. It receives voltage input directly from the AC supply and current input from the CT sensor. The module processes the data internally using built-in circuits. It provides accurate and real-time measurement results. The data is transmitted to the microcontroller through serial communication. It reduces the complexity of external calculations. It is a key component for energy monitoring.

**Electrical Loads (LED, Incandescent Bulb, Laptop Charger)**
Different electrical loads are used to analyse energy consumption. LED bulbs are energy-efficient and consume less power. Incandescent bulbs consume more power and generate heat. Laptop chargers represent practical electronic loads used in daily life. These loads help in comparing energy usage under different conditions. The variation in load helps in understanding system performance. It also demonstrates real-time monitoring capability. This improves analysis of energy efficiency.

**ESP32**
The ESP32 is the main controller of the system. It receives measured data from the PZEM module through UART communication. The controller processes the data and prepares it for transmission. It has built-in Wi-Fi capability for IoT applications. The ESP32 sends data to the cloud platform in real time. It enables remote monitoring and control of the system. It is highly efficient and suitable for smart applications.

  

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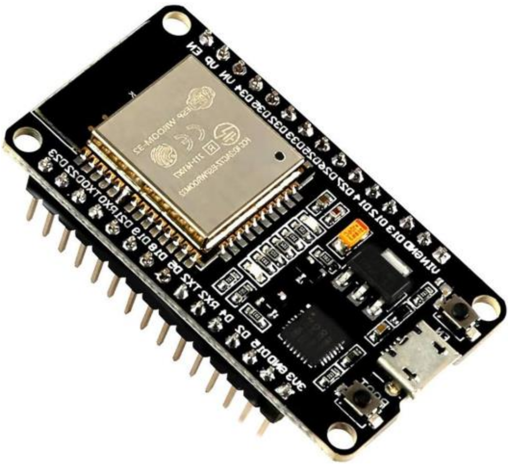

Fig 3.2: ESP32 Microcontroller

**Blynk IoT**

The Blynk application is used for real-time monitoring of system parameters. It displays voltage, current, power, and energy values on a mobile interface. The data is received from the ESP32 through cloud communication. It provides graphical visualization and easy understanding of energy usage. The application allows remote access from anywhere. It also supports alerts and notifications. It plays an important role in IoT-based monitoring systems.

## IV. WORKING

The proposed system operates using AC supply as the main input source, which provides power to the connected electrical loads through a switch board. When the switch is turned ON, current flows through the load such as LED bulb, incandescent bulb, or laptop charger. The CT sensor is placed in the circuit to measure the current flowing through the load without direct electrical contact, ensuring safety.

At the same time, the PZEM-004T Energy Meter Module measures the voltage directly from the AC supply and receives current data from the CT sensor. Using these inputs, the module internally calculates power, energy consumption, and frequency. These measured values are continuously updated and prepared for transmission.

The processed data from the PZEM module is sent to the ESP32 microcontroller through UART communication. The ESP32 reads the data, processes it, and formats it for IoT transmission. Since ESP32 has built-in Wi-Fi capability, it connects to a wireless network.

After establishing the connection, the ESP32 transmits the real-time data to the Blynk IoT cloud platform. The Blynk application displays the received data in the form of values and graphs on a mobile interface. This allows the user to monitor voltage, current, power, energy, and frequency remotely.

The system continuously monitors different loads and shows variations in energy consumption. LED bulbs consume less power, while incandescent bulbs consume more, and devices like laptop chargers show moderate usage. This helps in analyzing and comparing energy efficiency.

Overall, the system provides real-time monitoring, remote accessibility, and improved energy management using IoT technology.

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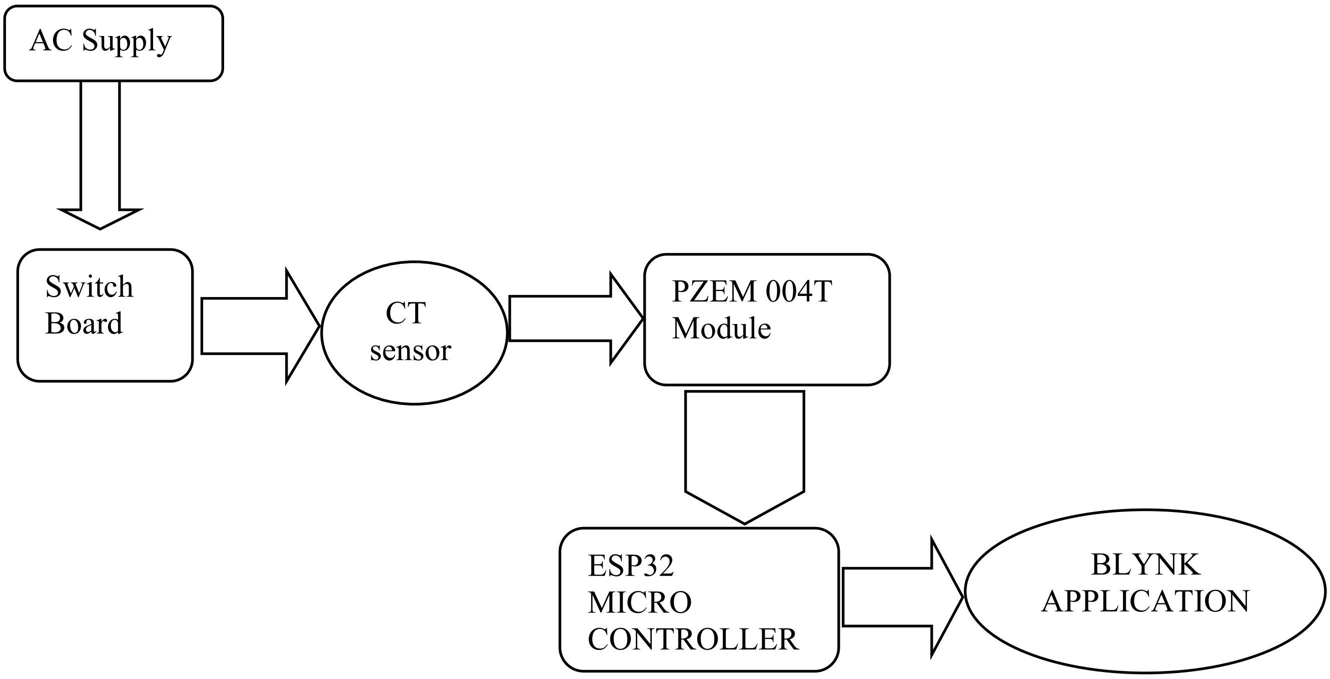


Fig 4: Block Diagram

## V. RESULTS

The system successfully measures and displays electrical parameters such as voltage, current, power, energy, and frequency. The data is transmitted in real time to the Blynk application, providing continuous monitoring.

Different loads show varying power consumption:

- LED bulbs consume less power
- Incandescent bulbs consume more power
- Laptop chargers show moderate consumption

The system provides accurate and stable readings, demonstrating its effectiveness.

The paper successfully demonstrates wireless power transfer for an electric vehicle using solar energy as a renewable source. It reduces the need for physical charging cables, making the charging process safer and more convenient. The integration of IoT using ESP32 enables real-time monitoring of voltage and system performance. The system efficiently detects vehicle presence and controls power transfer using sensors and a microcontroller. Overall, it provides an eco-friendly and intelligent solution for future electric vehicle charging systems.


Fig 5.1: Incandescent bulb output

 

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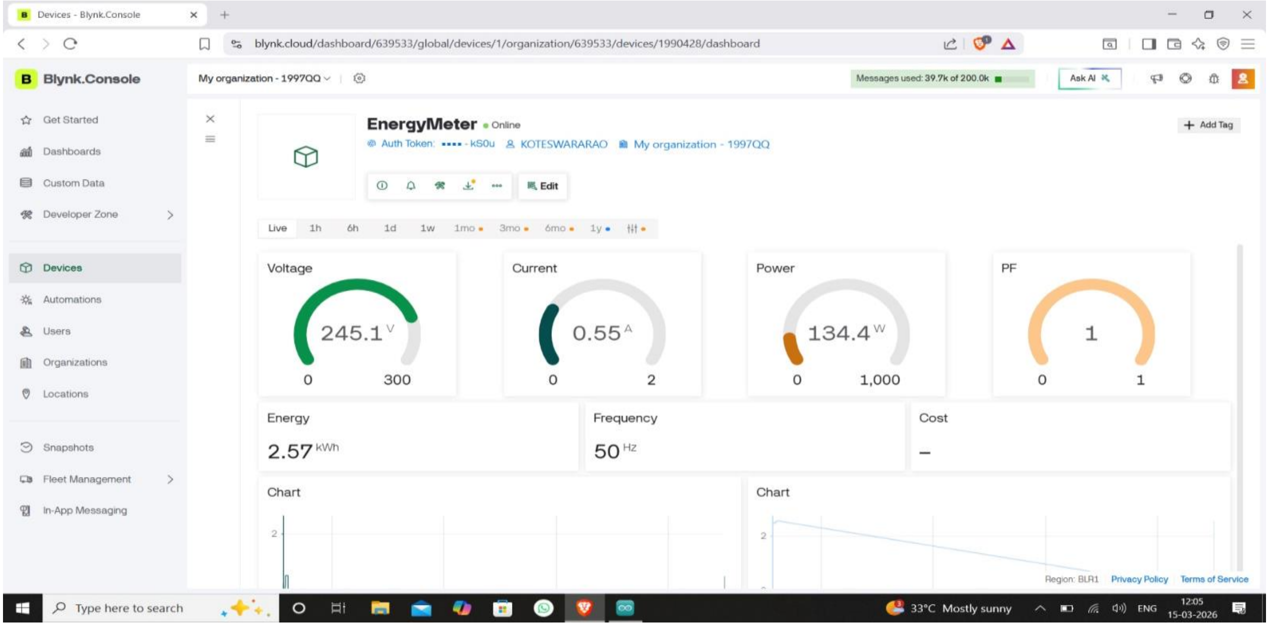


Fig 5.2 :Real time monitoring values

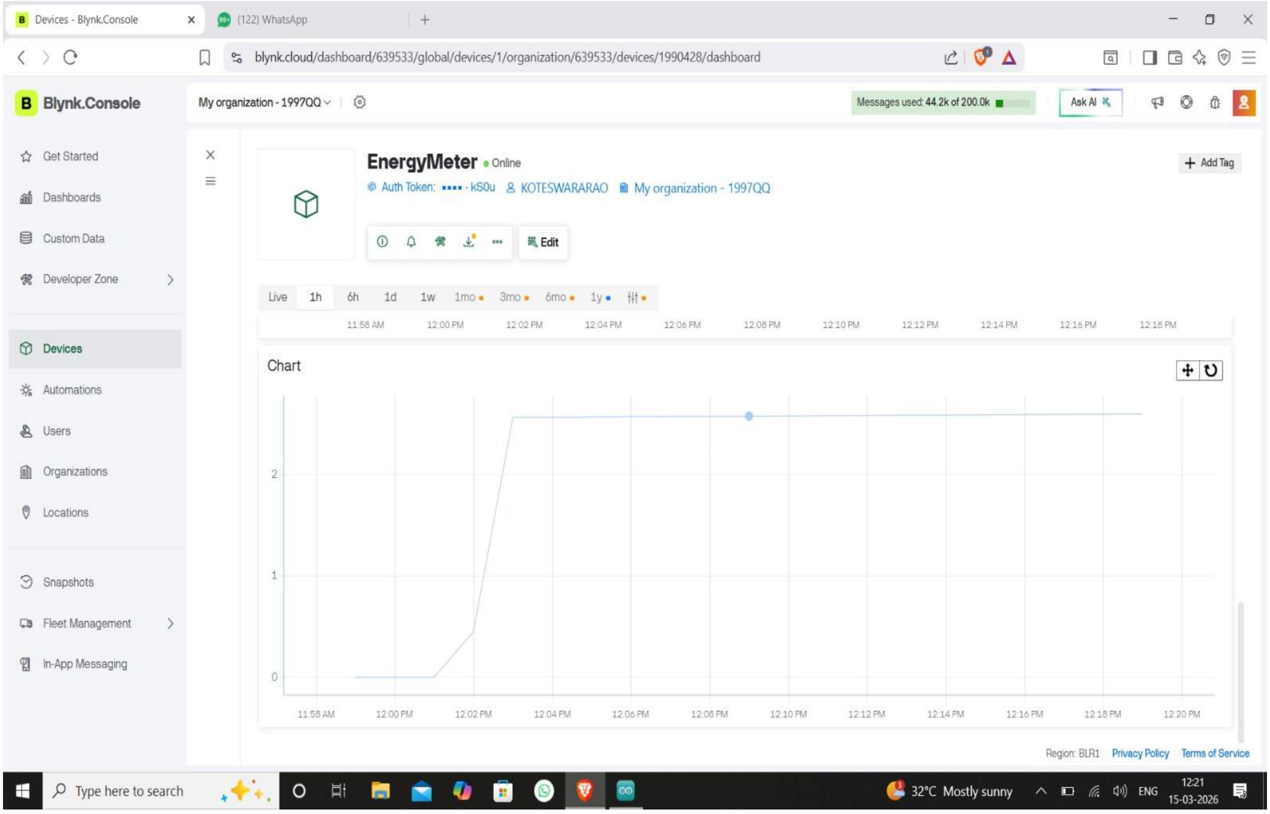


Fig 5.3: time vs energy graph

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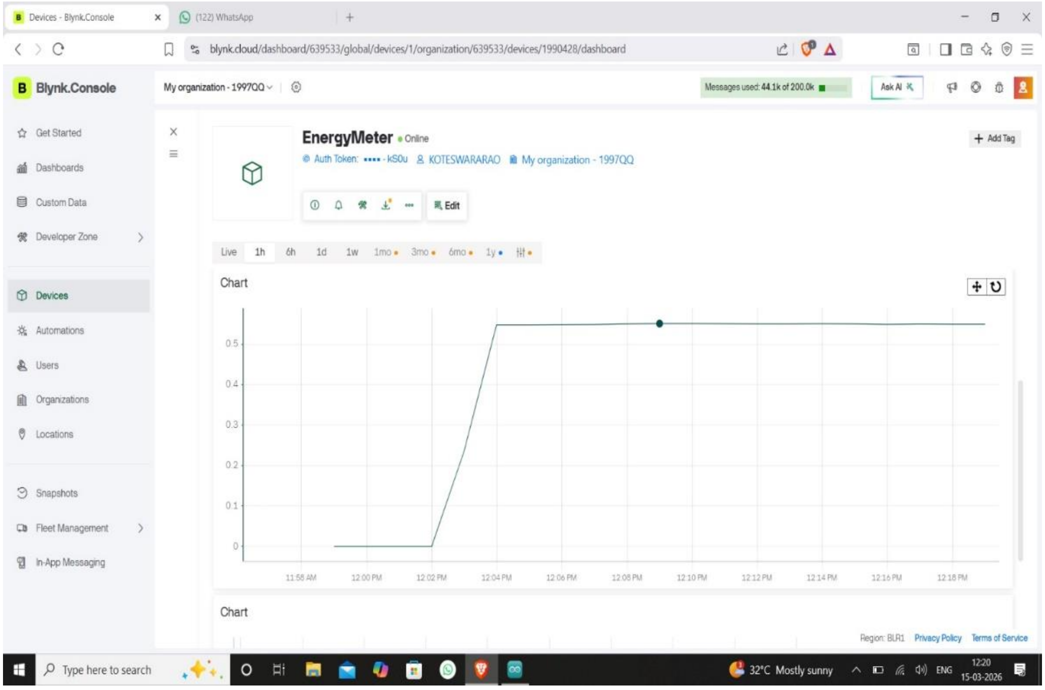


Fig 5.4 : time vs current graph

## VI. CONCLUSION

The IoT-based smart energy monitoring system provides an efficient and reliable solution for real-time energy monitoring. The integration of ESP32 and PZEM module enables accurate measurement and wireless communication. The use of IoT allows remote monitoring and better energy management.

This system helps in reducing energy wastage and improving efficiency. It is cost-effective, easy to implement, and suitable for modern smart grid applications.

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