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# Volt Vision

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***Abstract: Since the world is consuming more power and now it is much worried about sustainability, it is necessary to use intelligence in controlling and monitoring electricity. With a combination of intelligent automation and Internet of Things (IoT), we can monitor energy consumption in real time, automate the control systems, and make better use of energy.***

***Since the world is consuming more power and now it is much worried about sustainability, it is necessary to use intelligence in controlling and monitoring electricity. With a combination of intelligent automation and Internet of Things (IoT), we can monitor energy consumption in real time, automate the control systems, and make better use of energy.***

***This essay describes how smart energy systems through IoT are constructed and deployed. It considers important technologies such as smart meters, edge devices, cloud computing, and machine learning. These materials assist in saving energy, waste reduction, and cost reduction in homes, offices, and factories.***

***It also illustrates how artificial intelligence (AI) and forecasting tools can enable us to plan energy consumption more effectively, load management, and system automation according to real-time data. Intelligent grids—complex energy systems that integrate these technologies—make electricity more secure and enable greater amounts of solar and wind energy.***

***In brief, the paper clearly shows us the way in which AI and IoT are assisting in power monitoring, making our energy infrastructure more intelligent, efficient, and future-ready.***

***Keywords: IoT, Smart Automation, Power Monitoring, Energy Saving, Smart Meters, Edge Devices, Cloud Services, Machine Learning, AI, Smart Grids, Renewable Energy, Energy Forecasting, Intelligent Control Systems.***

## I. INTRODUCTION

Over the past few years, aggressive urbanisation and technological advancements have led to tremendous growth in energy consumption in all sectors of industry, commercial, and domestic. The increased energy demand has generated the necessity for more efficient and intelligent power monitoring systems to achieve maximum utilisation of energy and avoid unnecessary wastage.

Traditional energy monitoring techniques mainly depend on manual data collection and post-event analysis, which are not real-time and do not have predictive abilities. Therefore, these traditional practices tend to generate inefficiencies like overconsumption of energy, wastage, and increased operating expenses. In the absence of sophisticated monitoring systems, companies and homes are not able to monitor power efficiently, resulting in higher energy bills and a greater carbon footprint. In order to overcome such challenges, smart automation based on IoT has stepped in as a revolutionary solution. The Internet of Things (IoT) allows devices to become seamlessly interconnected and enables real-time data collection, analytics, and remote monitoring. With IoT-supported power monitoring systems, users are able to receive instant access to energy consumption metrics, identify inefficiencies, and automate energy-saving measures. Integrating smart sensors, cloud computing, and analytics powered by artificial intelligence (AI), these systems can greatly reduce energy wastage and optimise consumption. Importance of IoT-Based Power Monitoring Efficiency in energy usage has been a worldwide concern, with governments, industries, and homes attempting to reduce power consumption, minimise carbon footprint, and encourage eco-friendly practices. Nations across the globe are implementing energy conservation policies and embracing intelligent technologies to optimise energy management.

IoT-based power monitoring systems are important to address these issues by providing:

1) Real-time monitoring: Ongoing monitoring of energy usage with real-time access to consumption patterns.
2) Remote control and management: Customers are able to manage and optimise the use of power from any geographical location via web-based interfaces or mobile applications.
3) Automated power optimisation: Automatics can shift energy supply depending on set parameters or machine learning models to minimise wastage.
4) Predictive analytics: Analytical insights using AI enable analysis of trends in energy consumption and forecasting of upcoming usage patterns.
5) Cost savings: Identifying inefficiencies and optimising the use of energy, companies and consumers can considerably lower electricity.

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Fig.1 Prototype

## II. RELATED WORKS

Anitha *et al.* [1] designed an IoT-based smart energy meter surveillance using an Arduino ESP8266 and GSM modules. The system tracks meter readings and alerts consumers via mobile once usage exceeds a predefined limit. Data is also displayed on an LCD, minimising manual effort and enabling quick response.

Devadhanishini *et al.* [2] proposed an Arduino-Wi-Fi and SMS-integrated power monitoring system with a motion sensor that disables electricity when no occupants are detected, promoting power conservation and user convenience.

Mohammed Hosseiu *et al.* [3] explored IoT's role in future smart grids. Their Smart Energy Metering (SEM) framework monitors household energy use and environmental parameters to support demand-side management and dynamic energy sourcing.

Patel *et al.* [4] demonstrated a GSM-enabled Arduino-based smart meter for automated readings, bill alerts, and remote disconnection via relay when dues are unpaid, thereby reducing human interaction and billing errors.

Barman *et al.* [5] implemented a full-duplex communication–capable meter using ESP8266-12E for IoT data upload to the cloud. It enables consumers to actively monitor consumption and detect energy losses, enhancing energy control and home automation.

Garrab *et al.* [6] introduced an AMR (Automated Meter Reading) assistant combined with Power-Line Communication using an MSP430FE423A microcontroller, focusing on energy-saving and grid robustness.

Landi *et al.* [7] developed a low-cost ARM-based energy management system featuring real-time web server access for monitoring consumption, power quality, and enabling load shifting.

Koay *et al.* [8] investigated Bluetooth-connected digital meters in Singapore using AMR and Automatic Polling Mechanism, facilitating remote, wireless meter readings to minimise manual intervention.

## III. PROPOSED METHODOLOGY

The Smart Metering Infrastructure for Intelligent Facilities and IoT (SMIFI) is designed as a comprehensive solution for real-time energy monitoring, control, and analysis. It addresses the inefficiencies of traditional electricity meters by incorporating advanced embedded hardware, wireless communication, and cloud-based visualisation.

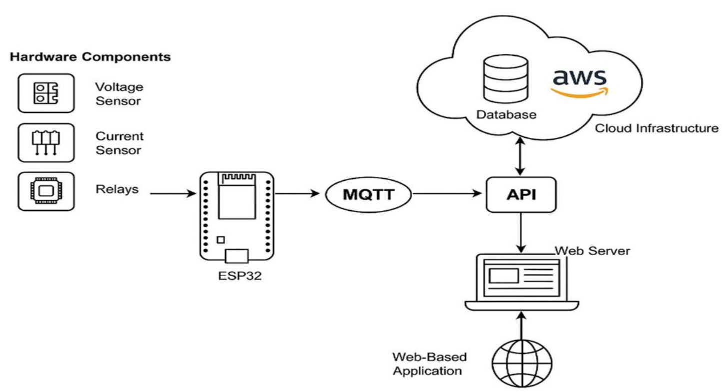


Fig.2 Flowchart

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At the heart of the system is the **ESP32 microcontroller**, a versatile dual-core chip with built-in Wi-Fi and Bluetooth. It functions as the central processing unit, managing sensor data acquisition, device control, and network communication.


Fig.3 ESP32

For accurate electrical measurements, the system integrates the following components:

- ZMCT102 system employs the current sensor to accurately measure AC load current in a non-invasive manner, enabling reliable real-time monitoring essential for energy management and analysis.

Fig.4 ZMCT102

- Current Transformer (CT) sensor to detect load current safely and non-invasively.
- HLW8012 energy monitoring IC, which consolidates real-time voltage, current, and power readings, interfacing with the ESP32 via digital protocols.


Fig.5 HLW8012

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To power the system reliably, a Switch Mode Power Supply (SMPS) is used, supported by an ACS1117-3.3 voltage regulator to provide a consistent 3.3V output required by the ESP32 and associated peripherals.


Fig.7 SMPS

The setup also includes **electromechanical relays**, enabling remote switching of electrical loads. Each relay channel is paired with an **LED indicator** to show its active (ON) or inactive (OFF) state, enhancing user feedback and fault detection.


Fig.6 Relay

A core innovation of SMIFI lies in its communication strategy. All sensor readings and status updates are transmitted using the **MQTT protocol**, a lightweight and efficient messaging system tailored for IoT deployments. The ESP32 publishes data to an

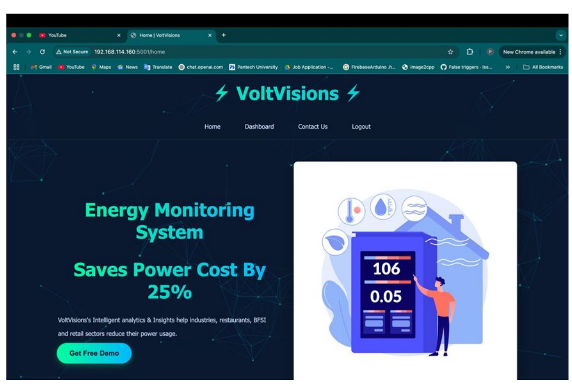


Fig.8 Webpage

MQTT broker, which then routes the information to a **web-based dashboard**.

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This dashboard, accessible through standard web browsers, provides users with intuitive controls, real-time visualisation of energy metrics, and historical data trends. Users can monitor power usage and manage connected devices from any location with internet access.

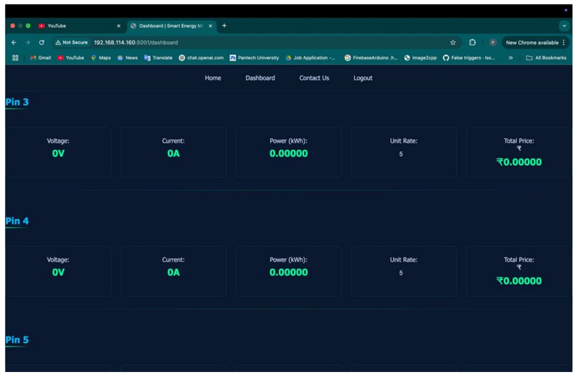


Fig.9 Dashboard

By combining embedded sensing, wireless communication, and cloud-based analytics, the SMIFI system supports intelligent energy usage, minimises manual intervention, and lays the groundwork for scalable smart grid integration.

## IV. RESULTS AND DISCUSSIONS

The implemented SMIFI system successfully demonstrated accurate and real-time monitoring of electrical parameters, including voltage, current, and active power. During testing, the ZMPT101B and CT sensors, paired with the HLW8012 IC, provided reliable readings under various load conditions. The ESP32 efficiently processed sensor data and maintained stable communication with the MQTT server, ensuring minimal latency in data transmission.

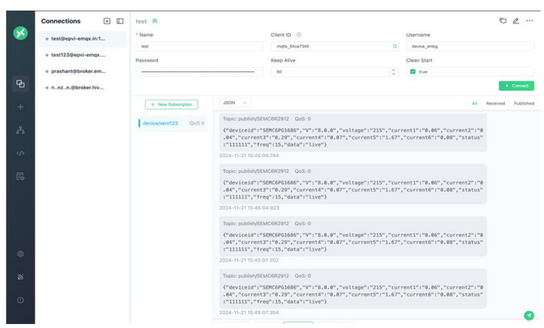

Fig.10MQTT Dashboard

The web-based dashboard displayed real-time updates without noticeable delay, allowing users to monitor and control appliances remotely. Relay operation was responsive, and the LED indicators effectively conveyed the status of connected loads. The system also maintained consistent voltage regulation through the ACS1117-3.3, preventing instability in microcontroller operation.
Overall, SMIFI achieved its intended objectives: enabling remote energy monitoring, reducing manual dependency, and enhancing user control through a cost-effective and scalable IoT-based infrastructure.

## V. CONCLUSIONS

The development of the Smart Metering Infrastructure for Intelligent Facilities and IoT (SMIFI) has demonstrated an effective approach to modern energy monitoring and control. By integrating the ESP32 microcontroller with the ZMCT102 current sensor, relays, and cloud communication via MQTT, the system delivers real-time insights into power consumption and enables remote appliance control.

The web dashboard further enhances user interaction by providing a clear and accessible interface for data visualisation and device management. Overall, SMIFI offers a scalable, cost-efficient solution for smart energy systems, contributing to improved energy efficiency and reduced manual intervention in residential and industrial environments.

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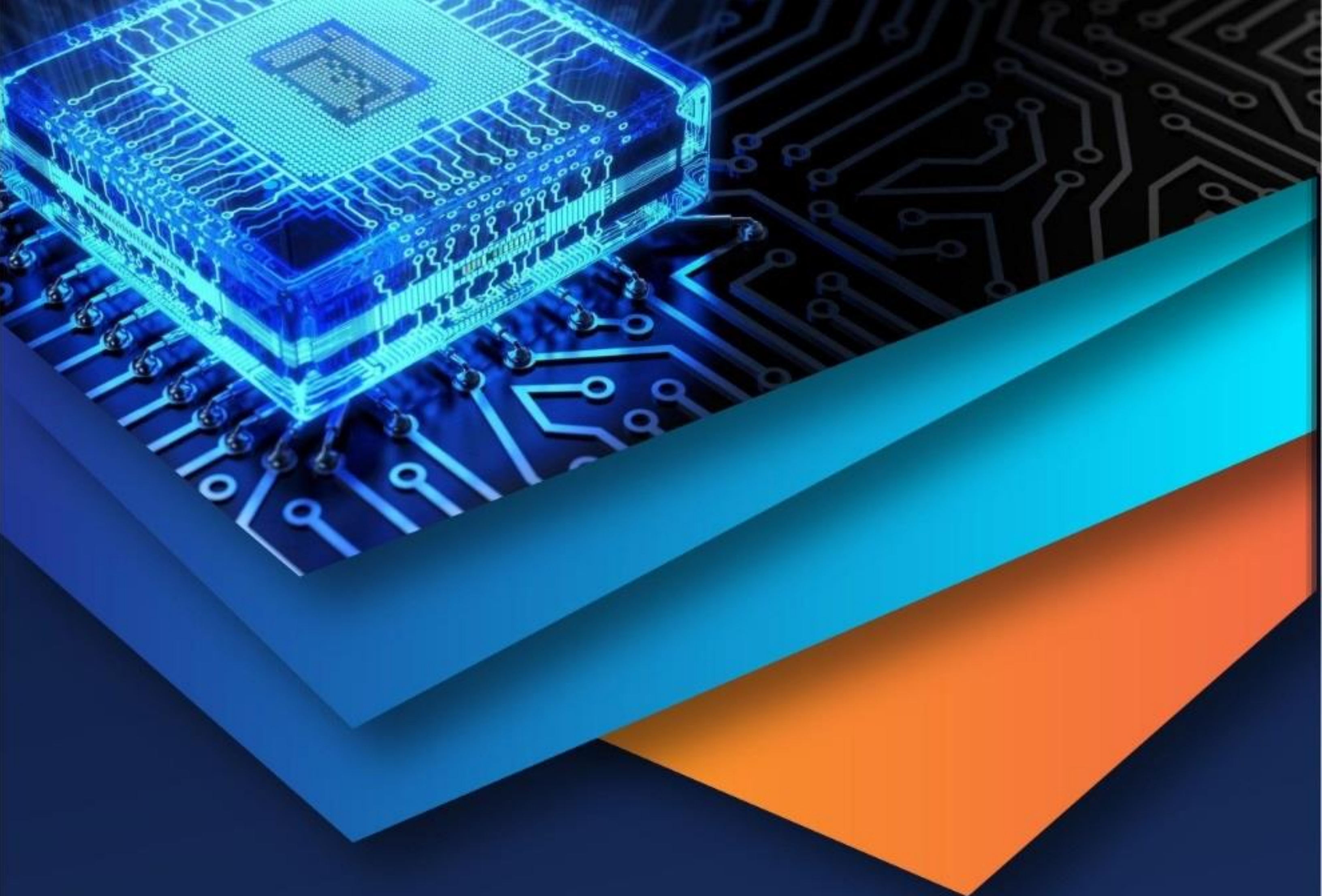

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