International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 04 | April - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

IOT Based Smart Real Time Energy Monitoring & Device Control Using Modbus, Node-Red, Thingspeak

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ABSTRACT

Today, saving electricity is very important for homes and industries. This project helps in smart energy management using low-cost and easy tools. It uses the ESP8266 Wi-Fi module to read energy usage in real-time. The system uses MODBUS protocol to collect data from the energy meter. ESP8266 sends this data to Node-RED, which shows it in a user-friendly way. Users can see energy usage through graphs and dashboards. If the electricity usage goes too high, the system can turn off some devices automatically. This helps in saving power and reducing electricity bills. The data is also sent to ThingSpeak, a cloud platform for storing and analyzing data. Users can check their energy use anytime from their mobile or laptop. They can also download the data in Excel format for reports. The system helps to find patterns and detect any problems. It supports smart decision-making for energy saving. This project is low-cost, easy to use, and useful for both small and large setups. It promotes green energy habits and better control over electricity usage.

KEYWORDS

ESP8266, Node-Red, Thingspeak, MODBUS, I2C Display, Energy Module

I. INTRODUCTION

This project is about creating a smart energy monitoring and control system to help save electricity in homes or offices. It uses the ESP8266 Wi-Fi module to collect real-time power usage data from energy meters through the MODBUS communication protocol. A visual dashboard is created using Node-RED, where users can easily see how much electricity they are using and also control connected devices. If the energy usage goes beyond a certain limit, the system can automatically turn off or control devices to save power. The collected data is also sent to the ThingSpeak cloud, where it can be stored, analyzed, and downloaded in Excel format for further study. This helps users track their past energy consumption and find ways to reduce waste. The whole system works in real-time and helps people make smart decisions about their electricity usage. By using this system, users can manage their energy better, reduce their bills, and support an eco-friendlier lifestyle.

II. PROBLEM STATEMENT

Traditional energy monitoring systems rely on manual electricity meters, which require periodic readings by utility providers. These systems do not offer real-time monitoring, remote access, or automated device control, leading to inefficient energy management and higher electricity costs. Some existing solutions incorporate standalone IOT-based energy meters, but they often lack seamless integration, real-time visualization, and intelligent automation features.

III. METHODOLOGY

The working of this IoT-based smart energy meter includes both hardware and software parts to make sure the system works smoothly. The hardware setup uses a Node MCU microcontroller as the main brain of the system. It is connected to a PZEM-004T module, which measures voltage, current, power, and energy use. The built-in Wi-Fi in Node MCU allows the system to send data to the cloud. Extra parts like relays can be added to control home appliances automatically when energy usage is too high. The PZEM-004T collects live energy data and sends it to the Node MCU, which then processes it and uploads it to a cloud server using MQTT or HTTP. This data is saved and organized for viewing and analysis. A dashboard or mobile app is created for users

to see their energy usage clearly, including live and past data like voltage, current, frequency, and power factor. Features like alerts and automation are also added for better control. The system studies the data to find usage habits and spot unusual behavior. It can then automatically turn devices on or off when energy usage goes above set limits and sends alerts to the user. To ensure everything works well, the system is tested for accuracy, real-time updates, and good Wi-Fi connection. This complete method gives users a smart, reliable, and easy-to-use system for managing their electricity in a more efficient and eco-friendly way.

IV. BLOCK DIAGRAM

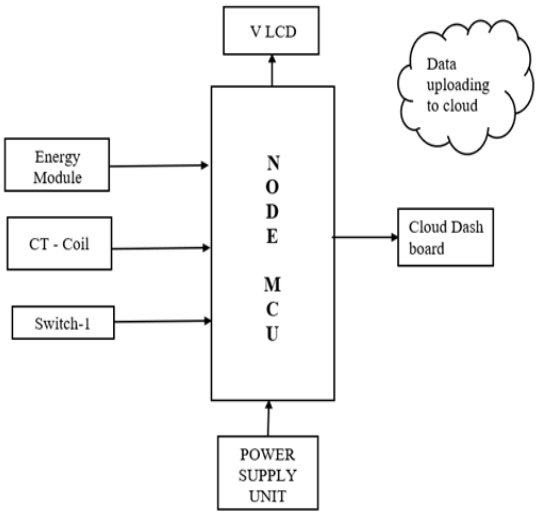


Fig: BLOCK DIAGRAM

V. COMPONENTS USED

1.ESP8266 MICRO CONTROLLER:

The ESP8266 is a small and affordable Wi-Fi microcontroller used in Internet of Things (IoT) projects. It helps devices connect to the internet wirelessly. It works on 3.3V power and supports different communication methods like UART, I2C, and SPI. It can be programmed using simple tools like the Arduino IDE. Because of its low cost and easy setup, it is widely used for home automation, smart gadgets, and remote monitoring systems.

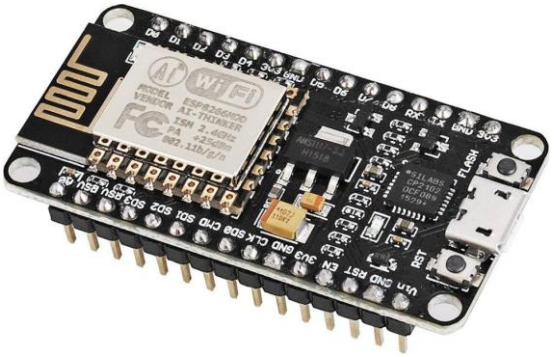
Fig: ESP8266 MICRO CONTROLLER

2. ENERGY MODULE:

An IoT-based Energy Module is a smart system that helps monitor and manage electricity usage using IoT technology. It uses microcontrollers like ESP8266 and communicates through Wi-Fi or Bluetooth to send real-time data to cloud platforms. This allows users to track and control their energy consumption remotely. The PZEM-004T module is used in the system to measure voltage, current, power, energy, frequency, and power factor. This setup is ideal for homes and buildings to ensure efficient energy use and reduce wastage.

Fig: Energy Module

3. CT COIL:



A CT (Current Transformer) Coil is a device used to measure AC current safely by reducing high current to a lower, proportional value using electromagnetic induction. It is commonly used in energy meters, power monitoring systems, industrial automation, and IoT-based smart energy solutions. The CT coil allows non-intrusive current sensing, meaning it can measure current without direct contact with high-voltage lines. This makes it a safe and efficient choice for monitoring electricity in high-power electrical circuits.

Fig: CT coil

4. RELAY MODULE:

A Relay Module is an electronic switch used in IoT systems to control high-voltage devices using microcontrollers like ESP8266, ESP32, or Arduino. It receives a low-power signal from the controller to turn connected appliances ON or OFF. Relay modules are useful in home automation, industrial systems, smart farming, and security setups. They can be connected to cloud platforms like Blynk, MQTT, or Firebase for remote control over the internet.

Fig: Relay Module

5. I2C MODULE:

I2C is a two-wire communication system used in IoT to connect microcontrollers like ESP8266 and Arduino with multiple devices. It supports up to 127 devices on a single bus, making it ideal for smart homes, sensor systems, and industrial automation. With low power usage and fast data transfer, it helps send data to cloud platforms like AWS, Firebase, and ThingSpeak for real-time monitoring and control.

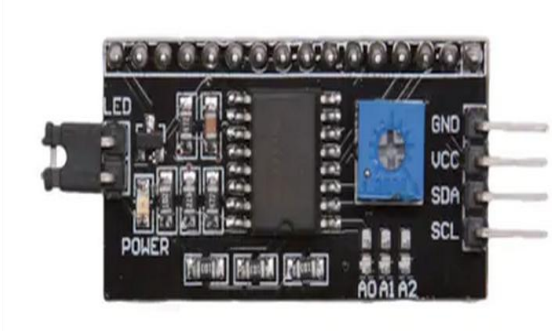


Fig: I2C Module

6. LCD DISPLAY:

An LCD (Liquid Crystal Display) in IOT-based systems is a screen used to visually display real-time data collected from sensors and microcontrollers in smart home automation, industrial monitoring, and embedded applications**.** It allows IOT devices to present vital information such as temperature, humidity, energy consumption, or security alerts in a user-friendly manner.

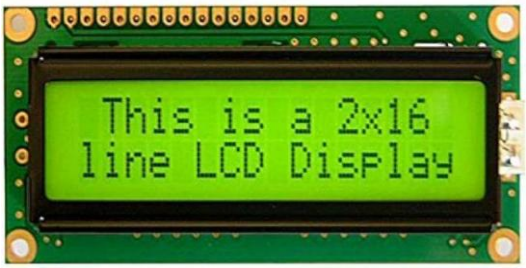


Fig: LCD Display

7.Arduino Software (IDE):

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connectsto the Arduino and Genuino hardware to upload programs and communicate with them.

8.NODE-RED SOFTWARE:

Node-RED is an easy-to-use tool for IoT that connects devices, sensors, and cloud services through a visual interface. It was made by IBM and is useful for home automation and industrial projects. Users can create data flows by dragging and dropping blocks, without heavy coding. It runs on Node.js and works well on devices like Raspberry Pi and ESP32. Node-RED is great for real-time data handling, automation, and smart system development.

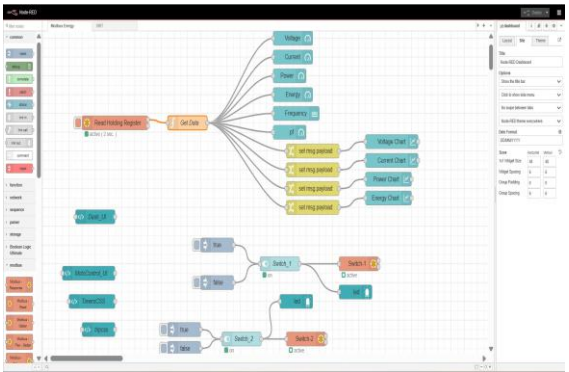


Fig: The workspace design the nodes in energy monitoring and controlling.

Fig: Node-Red Dashboard design.

9. THINGSPEAK:

ThingSpeak is a cloud platform used in IoT to collect, store, and show data from devices like sensors. Devices send data to ThingSpeak using HTTP or MQTT, and users can check it from anywhere. It shows live data in charts and graphs and supports MATLAB for data analysis. It works well with sensors for temperature, humidity, and motion. ThingSpeak is easy to use.

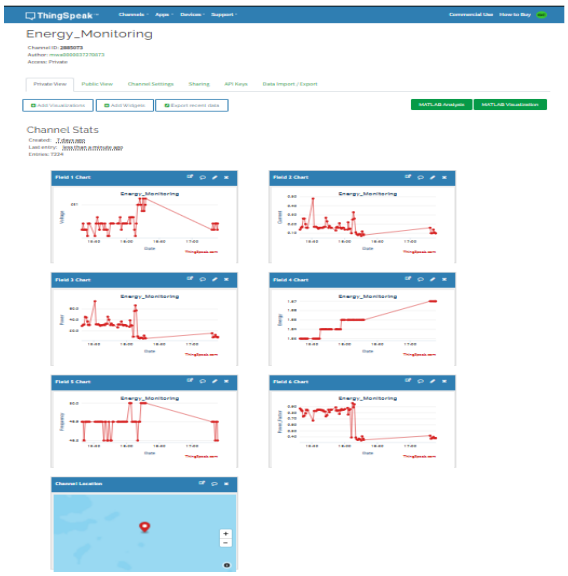


Fig: Thingspeak Dashboard

	A	B	C	D	E	F	G	H	I	J	K	L
1	created_at	entry_id	field1	field2	field3	field4	field5	field6	latitude	longitude	elevation	status
2	2025-03-20	1	230.2	0.27	57.2	0.73	50	0.91				
3	2025-03-20	2	230.2	0.26	54.8	0.73	50	0.93				
4	2025-03-20	3	230.2	0.25	53.8	0.73	50	0.93				
5	2025-03-20	4	230.2	0.25	54.6	0.73	50	0.93				
6	2025-03-20	5	230.3	0.25	53.3	0.73	50	0.94				
7	2025-03-20	6	230.2	0.25	53.2	0.73	50	0.93				
8	2025-03-20	7	230.2	0.25	53.4	0.73	50	0.94				
9	2025-03-20	8	230.2	0.28	57.1	0.73	50	0.89				
10	2025-03-20	9	230.2	0.25	53.4	0.73	50	0.92				
11	2025-03-20	10	230.3	0.26	55.2	0.73	50	0.91				
12	2025-03-20	11	230.2	0.27	55.7	0.73	50	0.91				
13	2025-03-20	12	230.6	0.12	9.9	0.73	50	0.37				
14	2025-03-20	13	230.6	0.12	10.3	0.73	50	0.37				
15	2025-03-20	14	230.5	0.12	9.9	0.73	50	0.37				
16	2025-03-20	15	230.1	0.37	72.8	0.73	50	0.85				
17	2025-03-20	16	230.2	0.34	67.7	0.73	49.9	0.85				
18	2025-03-20	17	230.2	0.27	58.1	0.73	50	0.92				
19	2025-03-20	18	230.2	0.29	59.4	0.73	50	0.89				

Fig: Thingspeak Excel sheet Real Time Energy Data

VI RESULT:

This smart energy system uses NodeMCU and PZEM-004T to measure electricity usage. It gives important values like voltage, current, power, and frequency. The data is sent to a server and can be seen on mobile or computer. People can check their usage anytime and from

anywhere. It helps save electricity.

VII CONCLUSION:

The proposed smart energy meter system uses IoT technology with Node MCU and PZEM-004T to monitor electricity usage in real-time. The PZEM-004T sensor measures values like voltage, current, and power, while the Node MCU sends this data to a server. Users can easily check and control their energy usage through a mobile app or website. The system includes basic hardware like relay module, CT coil, LCD display, and the energy meter module. This setup helps users save electricity, reduce monthly bills, and support a more energy-efficient and eco-friendly lifestyle.

This smart energy system has a bright future and can become even smarter with AI and machine learning. It can give power-saving tips, predict usage, and support smart billing. A mobile app with voice assistant and better security can make it easier and safer to use. With more features like edge computing, long-range communication.

VIII REFERENCES:

[1.] Dr. Sabu George , Gopika B "IoT Based Smart Energy Management System using Pzem-004t Sensor & Node MCU", International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Published by, www.ijert.org ICCIDT - 2021 Conference Proceedings.

[2.] PZEM-004T V3.0 User Manual

[3.] "An internet of things-based smart energy meter for monitoring device-level consumption of energy", Shishir Muralidhara , Niharika Hegde, Rekha PM JSS Academy of Technical Education, Bangalore, India.

[4.] Tekler, Z.D.; Low, R.; Yuen, C.; Blessing, L. Plug-Mate: An IoT-based occupancy-driven plug load management system in smart buildings. Build. Environ. 2022, 223, 109472.

[5.] Veloso, A.F.d.S.; de Moura, M.C.L.; Mendes, D.L.d.S.; Junior, J.V.R.; Rabêlo, R.A.L.; Rodrigues, J.J.P.C. Towards Sustainability using an Edge-Fog-Cloud Architecture for Demand-Side Management. In Proceedings of the 2021 IEEE International Conference on Systems, Man, and Cybernetics (SMC), Melbourne, Australia, 17–20 October 2021; pp. 1731– 1736.

[6.] Tekler, Z.D.; Low, R.; Blessing, L. User perceptions on the adoption of smart energy management systems in the workplace: Design and policy implications. Energy Res. Soc. Sci. 2022, 88, 102505. [CrossRef]

[7.] Ida Bagus Gede Purwania, I Nyoman Satya Kumara, and Made Sudarma," Application of IoT-Based System for Monitoring Energy Consumption", International Journal of Engineering and Emerging Technology, Vol.5, No.2, December 2020.