iJRASET

International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** IV **Month of publication:** April 2024

DOI: https://doi.org/10.22214/ijraset.2024.60620

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue IV Apr 2024- Available at www.ijraset.com

Review of Cloud-Based Smart Energy Meters

Smita P. Kamble
Dy.EE MSEDCL (Student of M-Tech Electrical Power System) Jawaharlal Nehru college of Engineering, Affiliated to MGM University Aurangabad (Ch. Sambhaji Nagar) Maharashtra India

Abstract: Smart meters represent a pivotal advancement in energy management, offering numerous benefits to consumers and utility providers. This report provides an overview of smart meters, their functionalities, advantages, challenges, and broader implications for the energy industry.

A smart meter is an advanced device that accurately measures electricity consumption. It's better than traditional meters, providing efficient tracking and insights into energy usage habits. Upgrade to a smart meter to make informed decisions and save money on electricity bills. These devices are a vital component of smart grid technology, which aims to enhance energy distribution and consumption efficiency, reliability, and sustainability.

Modern technologies, such as the Internet of Things (IoT), have many applications in the energy sector. IoT can help to improve energy efficiency, increase the utilization of renewable energy sources, and reduce the environmental impact of energy use. It can achieve these goals in energy supply, transmission, distribution, and demand.

This paper reviews the literature on IoT in energy metering systems and its essential components, functionality, and advantages over conventional metering systems.

I. WHAT IS CLOUD-BASED SMART METER

A smart meter is a meter that meets all features as specified in IS 16444 and as amended from time to time according to all.

1) New interface Meters and Energy Accounting and Audit Meters shall be of static type and shall have automatic remote meter reading facility;
2) all new Consumer Meters shall be Smart Meters with prepayment features:

They provided that the existing meters, other than Smart Meters, shall be replaced with Smart Meters with a prepayment feature within a time frame specified by the Central Government.

Hence, a smart meter is an advanced electronic device that measures and records electric energy consumption more sophisticatedly than traditional meters. These devices are a vital component of smart grid technology, which aims to enhance energy distribution and consumption efficiency, reliability, and sustainability.

Modern technologies such as the Internet of Things (IoT) offer many applications in the energy sector, i.e., energy supply, transmission and distribution, and demand. IoT can be employed to improve energy efficiency, increase the share of renewable energy, and reduce the environmental impacts of energy use. The incorporation of IOT or cloud-based smart metering is also called Advanced Metering Infrastructure (AMI).

Significant components of Cloud-based SMART Metering (AMI):

- Smart Meters
- Communication Network
- Head-End System (HES)
- Meter Data Management System (MDMS)
- Network Arrangement System (NAS)

A. Smart Meter

1) an intelligent meter unit can apply as follows:

a) Static watt-hour direct connected meters consisting of measuring element(s), time of use of register(s), display, load switch, and built-in type bi-directional communication module, all integral with the meter housing.

b) Alternatively, the bi-directional communication module could be plug-in type on a dedicated slot with a suitable sealing arrangement. The plug-in module shall be field-swappable with a suitable integrated communication module as agreed between the Buyer and seller.

c) The smart meter types, as specified in (a) and (b), shall be suitable for indoor/outdoor usage and capable of forward (import) or both forward (import) and reverse (export) energy measurement.

2) It does not apply in the case of the following conditions:
a) Watt-hour meters where the voltage across the connection terminal exceeds 600 V (line-to-line voltage for meters for polyphase systems,
b) Meters operated with external current transformers,
c) Portable meters and meters without internal load switch.

Architecture of Smart Meter:

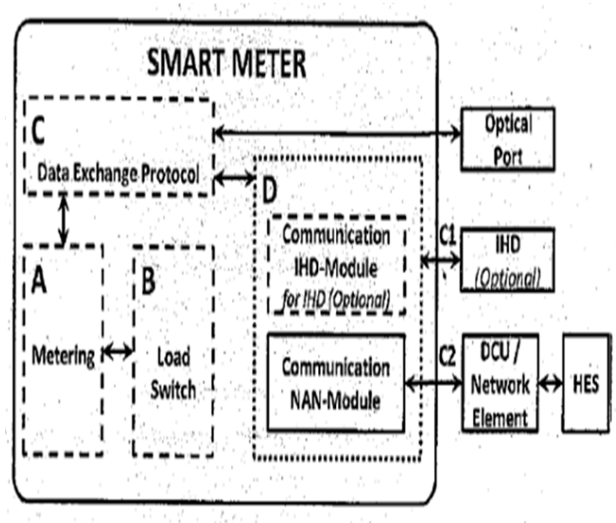


Fig1. per IS 16444

- Metrology
- Load Switch for Control
- Metering Control
- Communication

Optical Port - As per IS 15959 (part-2)
C1-IHD Connectivity
C2-NAN Connectivity

I. SMART METER ARCHITECTURE

1) The smart meter is a component of Advanced Metering Infrastructure. For this standard, the smart meter is conceived as a single unit comprising the following functional zones:
a) Metering,
b) Load switch,
c) Metering protocol and
d) Communication modules.
2) The Smart Meters may be widely used, and the Buyer may choose desired features to meet the objectives of their overall system and site conditions. The Smart Meter architecture is categorized into two variants to facilitate such a flexible approach. Based on the technical feasibility, the Buyer may choose the combination of the best-suited variants for a given geographical area. The Smart Meter shall have a NAN or WAN module as a mandatory communication module for communicating with DCU or HES, respectively. If IHD is chosen, a suitable additional communication module within the Smart Meter could be available.

3) Load Switching Capability

The smart meter shall be provided with switching elements integral to the meter enclosure to control the flow of electricity to the load at the instance of connect/disconnect commands per the system's functional needs. Two load switches, one in-phase and neutral, shall be provided for a Single-Phase Smart Meter.

A. Data Exchange Protocol

The requirements as per IS 15959 (Part 1) shall apply. The data exchange protocol chosen for the Smart Meter shall be as per IS 15959 (Part 2), including specific requirements for Smart Meters at the application layer. This application layer protocol, primarily DLMS/COSEM, shall work through the other layers.

B. Communication Requirement

The NAN, WAN, and IHD communication modules shown in Fig. 1 are for establishing connectivity with Smart Meter by external entities such as DCU and HES, respectively, and optionally with IHD. These are either wired or wireless communication technology. The Buyer shall choose the technology best suited for a given geographical area. The communication module(s) may be PLC or RF for NAN and cellular or OFC technology for WAN.

1) Neighborhood Area Network [NAN] —

This network comprises a group of intelligent meters and other network elements, such as DCU, all communicating in a two-way mode.

2) Data Concentrator Unit [DCU] —

This device is part of NAN. It acts as a secured aggregate router and interfaces between the smart meter and HES. It shall facilitate secured two-way data transfer in transparent/store or forward mode as per system designs. Other terminologies like Network Element/Grid Router/Access point/Edge Router shall be synonymously used in place of DCU. This standard does not cover the requirements of DCU.

3) Head End System [HES] —

This entity is a set of ICT-based systems situated at the top of the AMI system and receives data and events over NAN/WAN. HES is responsible for using this data/information and managing NAN/WAN components, intelligent meters, and IHD. HES also handles security keys and passwords for smart meter programmability, firmware upgrades, and hosting applications such as remote connect/disconnect, analytics, billing, messaging, etc. This standard does not cover HES's requirements.

4) In-Home Display [IHD] —

This is a compact display module meant for mounting inside the consumer premises. The IHD shall receive data/ messages from the smart meter and send responses to the smart meter as and when required by HES. This standard does not cover the requirements of IHD.

5) Hand Held Unit [HHU] —

This device communicates locally over the optical port to the smart meter. The communication functionality requirements are mentioned in IS 15959 (Part 2).

C. Smart Meter Functional Requirements

The Smart Meter developed as per this standard is required to support the handling of the following operational requirements:

1) Disconnection Mechanism

The Smart Meter shall support disconnection (all the switches shall operate) under the following conditions:

a) Over-current (minimum 105% of Imax in any phase for predefined persistence time),
b) Load control limit (programmable and set by utility),
c) Pre-programmed event conditions (factory set),
d) Disconnect the signal from the utility control center and

e) In the case of the pre-paid facility under defined/ agreed conditions.

2) Reconnection Mechanism

a) The switch reconnection shall be decided locally by the meter. It will try to reconnect the load to a predefined time with a predefined interval (time and interval are programmable by utility). If the consumption is within limits, the meter shall remain in normal connect mode,

b) If the consumption exceeds the programmed limits, it will lock out and wait for 30 min (lockout period). After this period, the meter shall reconnect the load, and if the consumption is still above the limit, the procedure as defined above in (a) shall be repeated with a status update to HES and

c) In all conditions other than 'Over current and load control limit, ' reconnection shall usually be done from HES. In case of communication failure with HES, reconnection shall be made through a local optical port with specified security.

The Smart Meter shall support disconnection (all the switches shall operate) under the following conditions:

- Over-current (minimum 105% of Imax in any phase for predefined persistence time),
- Load control limit (programmable and set by utility),
- Pre-programmed event conditions (factory set),
- Disconnect the signal from the utility control center, and
- In the case of the pre-paid facility under defined/ agreed conditions.

3) Reconnection Mechanism

The local reconnection due to disconnection under over current and load control limit shall be as follows:

a) The switch reconnection shall be decided locally by the meter. It will try to reconnect the load to a predefined time with a predefined interval (time and interval are programmable by utility). If the consumption is within limits, the meter shall remain in normal connect mode,

b) If the consumption exceeds the programmed limits, it will lock out and wait for 30 min (lockout period). After this period, the meter shall reconnect the load, and if the consumption is still above the limit, the procedure as defined above in (a) shall be repeated with a status update to HES and

c) In all conditions other than ‘Over current and load control limit, ’ reconnection shall usually be done from HES. In case of communication failure with HES, reconnection shall be made through a local optical port with specified security.

II. LITERATURE REVIEW

Internet of Things (IoT) is highly desirable in the energy field; in this framework, customers can control administration by Knowing vitality utilization from time to time; the Buyer needs to pay the bill on the plan. If it can't, the availability of electric power can be killed by self-ruling from the far-off host. [1] Explained the modeling and working of different system units and discussed the components and their functions, such as IoT and its working microcontroller and architecture. It reduces energy consumption and monitors the units consumed. To make the electrical apparatuses insightful, give solace to devour, and lessen control utilization in web applications. [2] I suggested it in light of the ARDUINO UNO controller and IOT innovation. If any altering happens, the controller will send information to the server and naturally chop down the vitality supply. At the pointwhen the most extreme request for vitality expenses is shown in the meter utilized by the customer, [3] Clarified after surpassing the most significant request, the meter and, subsequently, the association will be disengaged by an installed framework embedded in the meter sensor. The LDR (Light et al.) sensor is placed on an energy meter that senses an LED blinking pulse. At that time, the microcontroller sent this reading via the GSM module and sent this message to the electricity board.

In this framework, a keen vitality meter is introduced in each customer unit, and a server is maintained on the specialist co-op side. [4] We implemented the meter and a server with a GSM module, encouraging bidirectional correspondence between the two closures utilizing the current GSM foundation. The shopper can energize their vitality meter without much stretch by sending an SMS message with a stick number covered in a scratch card to the server.

To avoid all these drawbacks, we have intended toconstruct an IoT-based energy meter so that the proposed energymeter measures the amount of power consumed and uploadsit to the cloud from which the concerned person can view the reading. The power reading is sent to the cloud using ESP8266, aWi-Fi module. [5] The power reading from the digital wattmeter is read using the coupler and transmitted digitally to the Arduino. So, it automates the process of measuring home power consumption using IOT.

[6] "Landi, C.; Dipt. di Ing. dell"Inf., Seconda Univ. di Napoli, Aversa, Italy; Merola, P.; Ianniello, G", "ARM-based management system using smart meter and Web server," 2011.

This paper describes a proposed low-cost, real-time ARM-based energy management system. It is conceived as part of a distributed system that measures the main power system quantities and manages the whole power plant. An integrated Web Server allows power consumption and quality statistics and can interface devices for load displacement. The device is characterized by easy access to information, and the combination of a smart meter and data communication capability allows local and remote access. In this way, it is possible to manage the power consumption of the power system, leading to an overall reduction in consumption and costs.

[7] "Garrab, A.; Bouallegue, A.; Ben Abdallah," "A new AMR approach for energy saving in Smart Grids using Smart Meter and partial Power Line Communication," 2012.

In this paper, they described the growing energy demand, the capacity limitations of energy management, one-way communication, the need for interoperability of the different standards, the security of the communication, and the greenhouse gas emissions, leading to the emergence of a new infrastructure grid: Smart Grid. Smart Meters are one of the proposed solutions for the Smart Grid. In this paper, an AMR solution that provides enhanced end-to-end application. It is based on an energy meter with a low-power microcontroller MSP430FE423A and the Power Line Communication standards. The microcontroller includes an energy metering module ESP430CEl. This work aims to realize real-time pricing thanks to the proposed communication infrastructure. This solution is of great interest from an economical and low-carbon society point of view.

[8] "B. S. Koay, S. S. Cheah, Y. H. Sng, P. H. Chong, P. Shum, Y. C. Tong, X. Y. Wang, Y. X. Zuo, and H. W. Kuek," "Design and implementation of Bluetooth energy meter," 2012.

In this paper, they described that electronic energy measurement is continuously replacing existing technology of electro-mechanical meters, especially in China and India. By 2004, digital meters have started replacing electromechanical meters in Singapore. A wireless digital energy meter would offer greater convenience to the meter reading task. Bluetooth technology is chosen as a possible wireless solution to this issue. This paper presents the design and implementation issues of a Bluetooth-enabled energy meter. The energy reader can wirelessly collect the energy consumption reading from the energy meter based on Bluetooth.

[9] "Darshan Iyer N, Dr. KA Radhakrishna Rao M Tech. student, Dept. of ECE, PES College of Engineering, Mandya, Karnataka, India", "IoT Based Energy Meter Reading, Theft Detection and Disconnection using PLC modem and Power optimization," Vol. 4, Issue 7, July 2015.

This paper describes the PIC18F46k22 Microcontroller design and implementation of an energy meter using the IoT concept. The proposed system design eliminates human involvement in electricity maintenance. The Buyer needs to pay for electricity usage on schedule; if he cannot pay, the electricity transmission can be turned off autonomously from the distant server. The user can monitor the energy consumption in units from a web page by providing the device's IP address. The theft detection unit connected to the energy meter will notify the company side when meter tampering occurs in the energy meter. It will send theft detection information through the PLC modem. Theft detection will be displayed on the company's terminal window. The Wi-Fi unit performs the IoT operation by sending energy meter data to a web page that can be accessed through an IP address.

IoT is a twenty-first-century phenomenon in which physical consumer products connect to the web and communicate using measuring and controlling mechanisms [10]. The Internet of Things can be viewed from three different perspectives: "Things Oriented," "Internet Oriented," and "Semantic Oriented" [11]. IoT devices such as RFID tags [12], sensors, actuators, and NFC are emphasized in "Things Oriented". In the "Internet Oriented" approach, the focus is on protocols such as IPv6 for low-rate personal area networks (6LoWPAN), Constrained Application Protocols (CoAP), and Routing Protocols for Low power Lossy Networks (RPL). The "Semantic oriented" approach looks at semantic descriptions and representations of sensors/devices, device discovery, and service compositions for application development, enabling "a worldwide network of interconnected objects uniquely addressable, based on standard communication protocols" [13]. According to the Cluster of European Commission projects [14] on the IoT, "Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts." IETF is developing protocols such as 6LoWPAN, RPL, and CoAP to enable IoT applications based on open standards-based approach becomes possible. These protocols will address many of the interoperability challenges. This paper looks at how intelligent metering applications can be realized based on some of these protocols. Smart Meters can compute, store, and communicate the energy meter data to the head-end system upon request or can initiate a communication based on specific configuration settings. Also, it can receive information from the head-end system and act upon it. For example, utilities can communicate time-dependent tariffs to incentivize customers to have lower utilization during peak times. In India, Electric Utilities plans to deploy smart meters on a pilot basis.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue IV Apr 2024- Available at www.ijraset.com

Various forums, including the Bureau of Indian Standards (BIS), India Smart Grid Forum (ISGF), and India Smart Grid Task Force (ISGTF), are working to bring standards in Smart Metering to help in utilities' compliance. Also, it is understood from the utilities' experience that in most cases, the conventional electronic meters supplied by various vendors use proprietary communication protocols, and implementing Automated Meter Reading successfully and integrating it with the entire system will be a challenge.

Many studies have used IoT to design electrical energy meters [15]. Table 1 illustrates the statistics of the literature review's different technological and functional aspects.

TABLE 1. SMART ENERGY METER TECHNOLOGIES COMPARISONS

Ref	Sensor	Microcontroller	Communication	Remote control	Timing	Alert	Billing	Display
[18]	ACS712 ZMPT101B	Arduino Uno, ESP8266	Wi-Fi	Yes	No	No	Yes	Mobile App
[19]	ACS712 ZMPT101B	Arduino Uno, ESP8266	Wi-Fi	No	No	Email	Yes	Web (Adafruit)
[20]	ACS712 ZMPT101B	Arduino Uno, Raspberry Pi	Wi-Fi	Yes	Yes	Email	Yes	Mobile App, Web
[21]	ACS712 ZMPT101B	Arduino Uno, ESP8266	Wi-Fi	No	No	No	No	Blynk App
[22]	ACS712 ZMPT101B	ESP8266	Wi-Fi	No	No	No	Yes	MobileApp
[23]	ACS712 ZMPT101B	ESP32	Wi-Fi	No	No	Mob. App	No	Blynk App
[24]	ACS712 ZMPT101B	ESP32	Wi-Fi	No	No	No	No	Web (Ubidots)
[25]	ACS712 ZMPT101B	Arduino Uno, Raspberry Pi, LoRa Shield	LoRa	Yes	Yes	Yes	No	Mobile App, Web
[26]	ACS712 ZMPT101B		Wi-Fi	Yes	No	No	Yes	Web, Mobile, LCD
[27]	ACS712 ZMPT101B	Arduino Mega, ESP8266, ZigBee Module	ZigBee	No	No	No	Yes	Web, Android App, LCD
[28]	ACS712 ZMPT101B	Arduino Mega, ESP8266,	Wi-Fi	Yes	No	No	No	Thing Speak, Blynk App, LCD
[29]	ACS712 ZMPT101B	Arduino Uno, ESP8266	Wi-Fi	No	No	No	Yes	Web (Adafruit), LCD
[30]	ACS712 ZMPT101B	Arduino Nano, ESP8266	Wi-Fi	No	No	No	No	Web (Thing Speak)
[31]	PZEM-004T	ESP8266	Wi-Fi	No	No	Email	No	Web (Grafana)
[32]	PZEM-004T	ESP8266	Wi-Fi	Yes	No	No	No	Web (local host)
[33]	PZEM-004T	Arduino Uno, ESP8266	Wi-Fi	Yes	No	Email, Mob. App	No	LCD, Mobile App

[34]	PZEM-004T	Raspberry Pi, Lora gate	Lora	Yes	No	No	No	Web Things Board, Mobile
[35]	SCT-013 CT, Volt. transformer	Arduino Uno, ESP8266	Wi-Fi	Yes	No	No	No	Mobile App
[36]		Arduino Uno, GSM module	GSM	No	No	SMS	No	LCD
[37]		Arduino Uno, GSM module	GSM	Yes	No	SMS	Yes	LCD
[38]		ARM7, ZigBee Modul	ZigBee	No	No	SMS	Yes	LCD
Proposed paper	CT,PZEM-004T	ESP8266	Wi-Fi	Yes	Yes	Mob. App	Yes	LCD, Mobile App

Measuring two fundamental quantities, voltage and current, is necessary to know electrical quantities. For electric current, there are two basic techniques: intrusive and non-intrusive. The ACS712 sensor from Allegro Microsystems (USA) represents the first technical group, and the current sensor STC-013 of YHDC (China) represents the second group. There are the following techniques for voltage: i) AC/AC step-down transformer and voltage divider, and ii) ZMPT101B sensor.

After obtaining the current and voltage in one of the above ways, calculations are required to get electrical parameters like active power and power factor, which adds to the processor's processing time.

Instead of using the solution of individual sensors, using the PZEM004T module makes it easier and more convenient. This module helps measure and calculate voltage, current, power factor, active power, and energy quantities. In the investigated studies, the ACS712 current sensor and a ZMPT101B voltage sensor were used in the studies [16]-[28]; the PZEM004T module used in the studies [29]-[32]; SCT- 013 current transformer (CT) and AC/AC step-down transformer and voltage divider used in the research [33].

A central processor is required for the device to work properly and fully perform its designed functions. With IoT devices, there is also a need for an additional component that sends data over the wireless network to end-user applications. There are two leading technical solutions to perform both functions (data processing and communication): i) using two separate microcontrollers and ii) microcontrollers with built-in functions. Currently, the microprocessors commonly used in research include Arduino, ARM, Raspberry Pi, ESP8266, and ESP32. Arduino microcontrollers have three leading product families: Nano, MKR, and Classic. Arduino Uno is used in projects [16]-[19], [23], [27], [31], [33]-[35], and Arduino Mega used in projects [25] and [26] are microcontrollers of the classic family and belong to the group of technical solutions i) which means that communication modules are not integrated. Despite using the same solution i) as above, the article [32] uses a Raspberry Pi microcontroller while the article [36] uses the ARM7 microcontroller, which is a product of Arm Holdings Ltd. ESP8266, developed by Express if Systems, is a microcontroller with an integrated WiFi module and is widely used in IoT projects [37]. ESP32 is an upgraded version of ESP8266 with more features and processing speed [38]. ESP8266 is used in projects [20], [29], [30]; ESP32 is used in projects [21], [22] which are in the solution group ii).

Regarding communication technology, there are different communication methods, such as WiFi, LoRaWAN, Zigbee, and GSM [39]. As mentioned in the literature review, most smart metering systems use WiFi communication networks, [16]-[22], [24], [26]-[31], [33] while only a few systems use LoraWan [23], [31], Zigbee [25], [36], or GSM [34], [35]. Communication over WiFi is realized in a short range and is suitable for household applications, while the remaining methods are suitable for projects that need longer signal transmission distances.

For the functions of the surveyed meters, these intelligent meters generally have essential functions such as measuring and displaying quantities such as current, voltage, power, and energy. In addition, some projects add features such as controlling the device remotely, controlling timer settings, sending alerts to users via email, SMS, mobile app, or both email and mobile app, and calculating electricity bills.

Some studies have solutions to display the collected and calculated data, such as on a liquid crystal display (LCD), website, mobile applications, or a combination of the two or all three of the above solutions. For example, the research team [20] presented an intelligent meter with remote control functions, electricity bill calculation, and parameter display via a mobile application. Moreover, the research team [21] implemented a power meter that can calculate electricity bills, send alerts to users via email, and display the data on the website via the Adafruit IoT application. The research of the group [22] presents a device that can be remotely controlled, set the timing, calculate the bills, send email notifications, and display data via a website and mobile app. In general, each of the surveyed studies needed certain features, mainly because they could not export data through the Google Sheets application, a popular application of Google. Google Sheets is user-friendly and easy to access. It processes data anywhere and can be accessed by many people simultaneously.

Following the previous studies, this research aims to design and build an intelligent power meter with morefeatures. This device can measure current, voltage, power, and energy, calculate electricity bill calculation, and present a real-time display on mobile apps and LCD. In addition, the device can control and schedule the switch remotely via a mobile phone. Furthermore, this device can contribute to conserving energy and help households calculate their bills

III. METHOD

The development process of the proposed system includes the following steps: hardware design, software design, and testing and evaluation of device features. After testing the device's features with stable operation, the complete prototype will be built. The device's hardware is designed from today's standard electronic components. Software programming includes programming for the ESP32 microcontroller and applications on the Blynk application. The details of these processes are presented in the following sections.

A. Hardware design

The system proposed in this paper consists of the main blocks, as shown in Figure 1. The major components of the device are the power PZEM-004T module, ESP32, relay, LCD, and source module. The hardware design for the smart energy meter is presented in Figure 2. PZEM-Z004T module, as shown in Figure 3, is used to detect voltage, current, activepower, frequency, power factor, and energy [30], [40]. PZEM- 004T is chosen for its ease of use and excellent performance [41]. Specifications of PZEM004T are described in Table 2. The device communicates with the ESP32 using the universal asynchronous receiver and transmitter (UART) protocol.

ESP32, shown in Figure 4, is a low-cost microcontroller with many outstanding features. The module supports SPI, UART, I2C, and I2S communication standards. It can connect with many peripherals, such as sensors, amplifiers, and SD cards. ESP32 supports both Wi-Fi and Bluetoothconnectivity [42]. Table 3 describes the specifications of theESP32 module.

Figure 5 shows the relay module used in this paper. It is a 4-channel 5 V relay with each channel's driving current of 15-20 mA. This relay can be applied to control high-power devices. The relay's operating current is below AC 250 V 10 A or DC 30 V 10 A. The relay can communicate with the microcontroller to control the deviceprogrammatically.

In this project, the LCD module used is 20X4 type. The power module feeds the components in the circuit. The power module used in this study has the brand Hi-Link, which can convert 230 V AC to 5 V DC power. Hi-Link is chosenbecause of its popularity and cheap price.

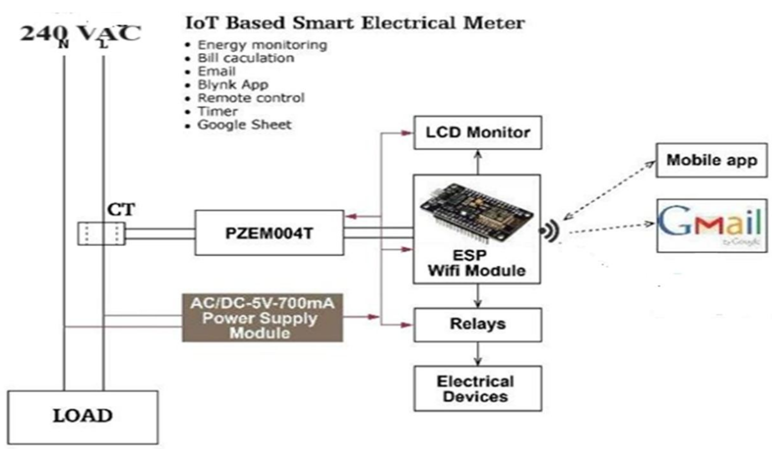


FIGURE 1. GENERAL BLOCK DIAGRAM OF THE PROPOSED DEVICE

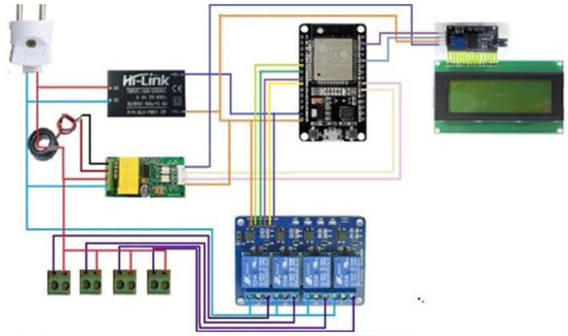


FIGURE 2. CONNECTION DIAGRAM OF MAIN DEVICES

FIGURE 3. THE PZEM-Z004T MODULE

TABLE 2. SPECIFICATIONS OF PZEM004T

Parameters	Specification
Voltage supply	5 V DC
Operating voltage	80–260 V AC/50–60 Hz
Operating current	0-100A
Rated power	100 A/22000 W
Measurement accuracy	1.0

TABLE 3. SPECIFICATIONS OF ESP32 MODULE

Parameters	Specification
Microcontrollers	ESP-WROOM-32
GPIO	30
Peripheral	UART, SPI, I2C, I2S, CapacitiveTouch GPIOs, PWM, ADC, DAC
Flash memory	4 MB
SRAM	520 KB
Clock speed	240 MHz
Wi-Fi	802.11b/g/n Wi-Fi transceiver
Supply	5 V DC
Bluetooth	Bluetooth 4.2/BLE

FIGURE 4. ESP-WROOM-32

FIGURE 5. RELAY MODULE

IV. CONCLUSION

This article mainly introduces innovative smart meters that meet all required features and can be widespread in smart grids to enhance grid functionality and load monitoring. This can be achieved by:-

1) Fundamental design & affordable electronic components
2) API data storage in a cloud-based SQL server database.
3) Energy estimate & consumption with time series technique.
4) User & utility interaction utilizing IoT technology.

These developed smart meters can facilitate:-

- Monitor the energy consumed by a consumer.
- Send consumption information to a database.
- Display it to the user instantly via web & mobile applications.
- It enables the user to determine the monetary amount of monthly consumption and track the amount spent.
- It will warn the user if the total consumption exceeds the recommended monetary amount.
- The various charts allow the user to view the consumption amounts by months, days, and hours of the days and to predict feature consumption.
- It will facilitate the utility in tracking the future load demand according to hours, days, and month requirements and can track the high-demand pockets.
- In addition, the device can detect the consumer's and energy provider's geographical location and monitor energy flow through a consumer-friendly mobile application.

REFERENCES

[1] Sasanenikita N, "IOT-based energy meter billing and monitoring system," the International Research Journal of Advanced Engineering and Science, (2017).
[2] Pandit S, "Smart energy meter using Internet of things (IoT)," VJER Vishwakarma Journal of Engineering Research, Vol.1, No.2, (2017).
[3] Maitra S, "Embedded Energy Meter-A New concept to measure the energy consumed by a consumer and to pay the bill," Power system technology and IEEE Power India conference, (2008).
[4] Depuru SSSR, Wang L & Devabhaktuni V, "Electricity theft: Overview, issues, prevention and a smart meter based approach to control theft," Energy Policy, Vol.39, No.2, (2011), pp.1007–1015.
[5] Giri Prasad S, “IOT based energy meter,” International Journal of Recent Trends in Engineering & Research (IJRTER), (2017). D. V. Lindberg and H. K. H. Lee, "Optimization under constraints by applying an asymmetric entropy measure," J. Comput. Graph. Statist., vol. 24, no. 2, pp. 379–393, Jun. 2015, doi: 10.1080/10618600.2014.901225.

[6] Landi, C.; Dipt. Di Ing. dell"Inf., Seconda Univ. di Napoli, Aversa, Italy; Merola, P.; Ianniello, G, "ARM-based energy management system using smart meter and Web server," IEEE Instrumentation and Measurement Technology Conference Binjiang, pp. 1 – 5, May 2011.

[7] Garrab, A.; Bouallegue, A.; Ben Abdallah, "A new AMR approach for energy saving in Smart Grids using Smart Meter and partial Power Line Communication," IEEE First International Conference on Renewable Energies and Vehicular Technology (REVET), pp. 263 – 269, march 2012

[8] Darshan Iyer N, Dr. KA Radhakrishnan Rao, "IoT Based Energy Meter Reading, Theft Detection & disconnection using PLC modem and Power optimization," IRJET, (2015)

[9] (2017 Jan. 31) ACS712 [Online] Available: https://www.sparkfun.com/datasheets/BreakoutBoards/0712.pdf

[10] Hazenberg W, Huisman M. Meta Products: Building the Internet of Things. Amsterdam, NL: BIS Publishers; 2011.

[11] Luigi Atzori, Antonio Iera,and Giacomo Morabito. The Internet of Things: A survey. Computer Networks, 54(15):2787–2805, 2010.

[12] L. Srivastava, Pervasive, ambient, ubiquitous: the magic of radio, in European Commission Conference "From RFID to the Internet of Things" Bruxelles, Belgium, March 2006.

[13] I. Vázquez, Social Devices: Semantic Technology for the Internet of Things, Week@ESI, Zamudio, Spain, June 2009.

[14] H. Sundmaeker, P. Guillemin, P. Friess, S. Woelfflé, Vision and challenges for realizing the Internet of Things, Cluster of European Research Projects on the Internet of Things - CERP IoT, 2010.

[15] W. Yaïci, K. Krishnamurthy, E. Entchev, and M. Longo, "Recent advances in Internet of Things (IoT) infrastructures for building energy systems: a review," Sensors, vol. 21, no. 6, Mar. 2021, doi: 10.3390/S21062152.

[16] S. Somantri, I. Yustiana, and A. Nugraha, "Electrical consumption monitoring and controlling system based on IoT and mobile application," in Proceeding of International Conference on ICT for Smart Society (ICISS), Indonesia, November 2020, pp. 1–5, doi: 10.1109/iciss50791.2020.9307556.

[17] V. S. M et al., "Internet of Things based smart energy meter with fault detection feature using MQTT protocol," in Proceedings of the 8th International Conference on Advanced Computing and Communication Systems (ICACCS), India, March 2022, pp. 1592–1596, doi: 10.1109/ICACCS54159.2022.9785026.

[18] M. O. Agyeman, Z. Al-Waisi, and I. Hoxha, "Design and implementation of an IoT-based energy monitoring system for managing smart homes," in Proceeding of the Fourth International Conference on Fog and Mobile Edge Computing (FMEC), Italy, June 2019, pp. 253–258, doi: 10.1109/FMEC.2019.8795363.

[19] S. Khalid, M. Sarfraz, V. Singh, Aafreen, and A. Allahloh, "A novel model for IoT-based meter using ATmega328P microcontroller and google cloud store," in Lecture Notes in Mechanical Engineering, Singapore, Springer, 2021, pp. 639–648, doi: 10.1007/978-981-15- 5463-6_57.

[20] Y. Maulana, R. Darmawan, L. Kamelia, E. Mulyana, M. R. Effendi, and M. I. Pamungkas, "The development of the home electrical power consumption system prototype in real-time," in Proceeding of the 7th International Conference on Wireless and Telematics (ICWT), Indonesia, August 2021, pp. 1–5, doi: 10.1109/ICWT52862.2021.9678420.

[21] A. Othman and N. H. Zakaria, "Energy meter based wireless monitoring system using blink application via smartphone," in Proceeding of the 2nd International Conference on Artificial Intelligence in Engineering and Technology (IICAIET), Malaysia, September 2020, pp. 1–5, doi: 10.1109/IICAIET49801.2020.9257827.

[22] F. Jonathan and T. W. O. Putri, "Prototype of home power monitoring tool for electrical outlet using ESP32," in Proceeding of International Conference on ICT for Smart Society (ICISS), Indonesia, August 2021, pp.1–5,doi: 10.1109/ICISS53185.2021.9533189.

[23] S. Z. R. Hussain, A. Osman, M. A. Moin, and J. A. Memon, "IoT enabled real-time energy monitoring and control system," in Proceeding of the 9th International Conference on Smart Grid (icSmartGrid), Portugal, 29 June 2021 - 01 July 2021, pp. 97–102, doi: 10.1109/ICSMARTGRID52357.2021.9551208.

[24] M. O. Onibonoje, "An IoT design approach to residential energy metering, billing, and protection," in Proceeding of International IoT, Electronics and Mechatronics Conference (IEMTRONICS), Canada, April 2021, pp. 1–4, doi 0.1109/IEMTRONICS52119.2021.9422580.

[25] S. S. Chowdary, M. A. A. E. Ghany, and K. Hofmann, "IoT based wireless energy efficient smart metering system using zigbee in smart cities," in Proceeding of the 7th International Conference on Internet of Things: Systems, Management, and Security (IOTSMS), France, December 2020, pp. 1–4, doi:10.1109/IOTSMS52051.2020.9340230.

[26] V. V. Gavhane, M. R. Kshirsagar, G. M. Kale, S. Katangle, S. B. Deosarkar, and S. L. Nalbalwar, "IoT based energy meter with smart monitoring of home appliances," in Proc. of the 6th International. Conference for Convergence in Technology (I2CT), India, April 2021, pp. 1–5, doi: 10.1109/I2CT51068.2021.9417886.

[27] H. Mubarok and A. Ardiansyah, "Prototype design of IoT (Internet of Things) - based load monitoring system," in Proceeding of the 3rd International Seminar on Research of Information Technology and Intelligent Systems (ISRITI), Indonesia, December 2020, pp. 377–382, doi: 10.1109/ISRITI51436.2020.9315454.

[28] J. Y. Lin, H. L. Tsai, and G. H. Lu, "Development of wireless AC power-monitoring module," in Proceeding of the 8th International Conference on Applied System Innovation (ICASI), Taiwan, April 2022, pp. 1–4, doi: 10.1109/ICASI55125.2022.9774467.

[29] K. Chooruang and K. Meekul, "Design of an IoT energy monitoring system," in Proceeding of the 16th International Conference on ICT and Knowledge Engineering (ICT&KE), Thailand, November 2018, pp. 1–4, doi: 10.1109/ICTKE.2018.8612412.

[30] A. I. Satriananda, L. Kamelia, M. R. Efendi, and A. Kusnawan, "The prototype of smart power meter at home based on internet of things," in Proceeding of the 7th International Conference on Wireless and Telematics (ICWT), Indonesia, August 2021, pp. 1–3, doi: 10.1109/ICWT52862.2021.9678480.

[31] T. D. Nguyen, V. K. Tran, T. D. Nguyen, N. T. Le, and M. H. Le, "IoT- based smart plug-in device for home energy management system," in Proceeding of the 4th International Conference on Green Technology and Sustainable Development (GTSD), Vietnam, November 2018, pp. 734–738, doi: 10.1109/GTSD.2018.8595615.

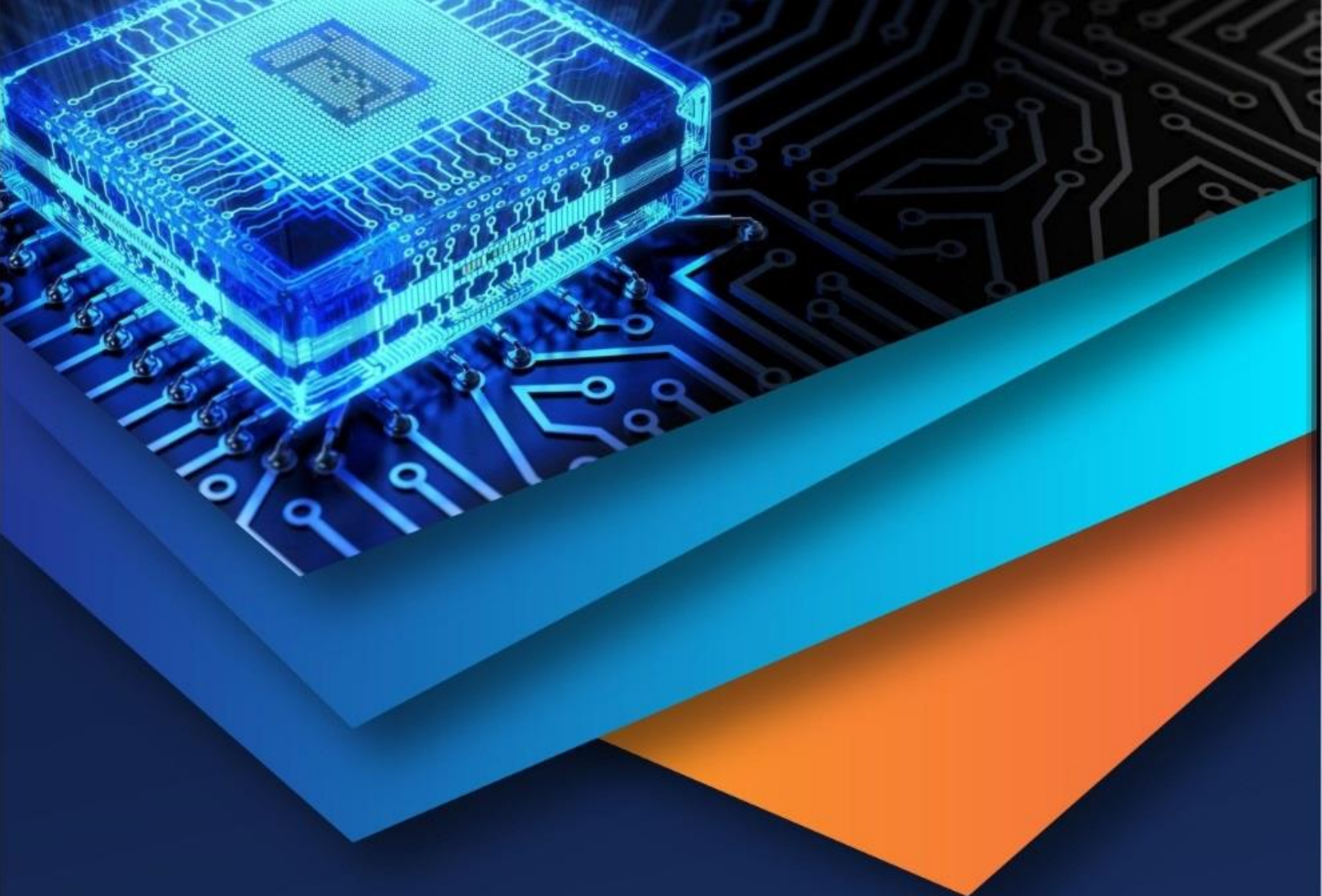
[32] N. M. Khoa, L.V. Dai, N. A. Toan, and D. D. Tung, "A new design of IoT-based network architecture for monitoring and controlling power consumption in distribution grids," International Journal of Renewable Energy Research, vol. 11, no. 3, pp. 1460–1468, 2021, doi: IJRER.V11I3.12337.G8293.

[33] K. Khanchuea, and R. Siripokarpirom, "A multi-protocol IoT gateway and WiFi/BLE sensor nodes for smart home and building automation: design and implementation," in Proceeding of the 10th International Conference of Information and Communication Technology for Embedded Systems (IC-ICTES), Thailand, March 2019, pp. 1–6, doi: 10.1109/ICTEmSys.2019.8695968.

[34] C. Santhosh, S. V. A. Kumar, J. G. Krishna, M. Vaishnavi, P. Sairam, and P. Kasulu, "Iot-based smart energy meter using GSM," Materials Today: Proceedings, vol. 46, no. 9, pp. 4122–4124, 2021, doi: 10.1016/j.matpr.2021.02.641.

[35] J. Deny, A. B. Narasimha, R. G. V. Reddy, and S. Sathish, "Electricity monitoring and auto bill generation using IoT," in Proceeding of the 3rd International Conference on Signal Processing and Communication (ICPSC), India, May 2021, pp. 695–698, Doi: 10.1109/ICSPC51351.2021.9451738.

[36] V. Preethi, and G. Harish, "Design and implementation of smart energy meter," in Proceeding of International Conference on Inventive Computation Technologies (ICICT), India, August 2016, pp. 1–5, doi: 10.1109/INVENTIVE.2016.7823225.
[37] A. Gehlot, R. Singh, P. K. Malik, L. R. Gupta, and B. Singh, Internet of Things with 8051 and ESP8266, 1st Ed., CRC Press, 2020
[38] A. Maier, A. Sharp, and Y. Vagapov, "Comparative analysis and practical implementation of the ESP32 microcontroller module for the Internet of things," in Proceeding of Internet Technologies and Applications (ITA), UK, September 2017, pp. 143–148, doi:10.1109/ITECHA.2017.8101926.
[39] K. Ahuja, and A. Khosla, "Network selection criterion for ubiquitous communication provisioning in smart cities for the smart energy system," Journal of Network and Computer Applications, vol. 127, pp. 82–91, 2019, doi: 10.1016/j.jnca.2018.11.011.
[40] N. M. Khoa, L. V. Dai, D. D. Tung, and N. A. Toan, "An advanced IoT system for monitoring and analyzing chosen power quality parameters in micro-grid solution," Archives of Electrical Engineering, vol. 70, no.1, pp. 173-188 2021, doi: 10.24425/aee.2021.136060.
[41] R. Khwanrit, S. Kittipiyakul, J. Kudtonagngam, and H. Fujita, "Accuracy comparison of present low-cost current sensors for building energy monitoring," in Proceeding of International Conference on Embedded Systems and Intelligent Technology and International Conference on Information and Communication Technology for Embedded Systems (ICESIT-ICICTES), Thailand, May 2018, pp. 1–6, doi: 10.1109/ICESIT-ICICTES.2018.8442066.
[42] H. Kareem and D. Dunaev, "The working principles of ESP32 and analytical comparison of using low-cost microcontroller modules in embedded systems design," in Proceeding of the 4th International Conference on Circuits, Systems, and Simulation (ICCSS), Malaysia, 26-28 May 2021, pp. 130–135,doi: 10.1109/ICCSS51193.2021.9464217.
[43] T. B. Nguyen and P. H. Van, "Design, simulation and economic analysis of a rooftop solar PV system in Vietnam," EAI Endorsed Transactions on Energy Web, vol. 8, no. 35, 2021, doi: 10.4108/eai.27–1-2021.168504.



10.22214/IJRASET

INDEX COPERNICUS
45.98

ISRA JIF
IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY