International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
doi : https://doi.org/10.32628/IJSRST523103135

Smart Energy Meter Using IoT

D. Venkatnath Dass, S. Akhila, R. Prasanjith
Bachelor of Technology, Bachelor of Technology, Bachelor of Technology, Electronics and Communication Engineering, Nalla Narasimha Reddy Educational Society's Group of Institution, Hyderabad, India

ARTICLEINFO

Article History:
Accepted: 01 June 2023
Published: 06 June 2023

Publication Issue
Volume 10, Issue 3
May-June-2023

Page Number
693-699

ABSTRACT

The increasing demand for efficient energy management and the rapid growth of Internet of Things (IoT) technology have led to the development of smart energy metering systems. This abstract presents a conceptual design of a smart energy meter that leverages IoT capabilities for enhanced monitoring, control, and optimization of energy consumption in residential and commercial settings. The proposed smart energy meter integrates advanced metering infrastructure (AMI) with IoT sensors, connectivity, and data analytics to enable real-time energy monitoring, intelligent load management, and energy efficiency improvements. The meter collects data on energy consumption, voltage levels, power quality, and other relevant parameters, which are transmitted wirelessly to a central monitoring system. By utilizing IoT connectivity, the smart energy meter facilitates two-way communication, allowing consumers to access their energy usage data remotely via mobile applications or web portals. This empowers users to monitor their energy consumption patterns, set energy-saving goals, and receive personalized recommendations for optimizing their energy usage.

Furthermore, the smart energy meter employs data analytics algorithms to analyze the collected energy data and generate actionable insights. These insights can be used to identify energy wastage, detect anomalies, and suggest energy-saving strategies. Additionally, the meter can automatically adjust energy loads based on peak demand periods, optimizing energy distribution and reducing overall energy costs. The proposed smart energy meter offers several benefits, including real-time monitoring, increased energy efficiency, cost savings, and reduced environmental impact. It enables consumers to make informed decisions about their energy usage, promotes sustainable practices, and contributes to the development of smarter and greener communities.

Keywords: Advanced Metering Infrastructure, IoT, Identify Energy Wastage

I. INTRODUCTION

The primary purpose of a smart energy meter is to provide accurate and detailed information about electricity consumption. Unlike conventional meters, smart meters have additional capabilities, including two-way communication with the utility company. This enables both the user and the utility company to have access to real-time energy usage data. Smart energy meters typically have the following features: Real-time monitoring: Smart meters provide up-to-date information about electricity consumption. Users can view their energy usage in real-time, enabling them to make informed decisions about their energy consumption habits. Remote reading: Utility companies can remotely read the meter data without the need for physical visits to the premises. This eliminates the need for manual meter reading, reducing costs and improving efficiency. Time-based tariffs: Smart meters support time-of-use (TOU) pricing, allowing utility companies to charge different rates for electricity consumed during peak and off-peak hours. This encourages users to shift their energy usage to off-peak times when electricity demand is lower, resulting in cost savings.

Energy consumption feedback: Smart meters provide detailed information on energy consumption patterns, allowing users to identify energy-intensive appliances or behaviors. This feedback empowers consumers to make more informed decisions about their energy usage and find ways to reduce consumption. Integration with smart home systems: Smart meters can be integrated with other smart home devices and systems, allowing users to automate energy management. For example, users can set up rules to automatically adjust thermostats or turn off appliances when they are not in use. Billing accuracy: Smart meters eliminate estimation errors in energy bills by providing accurate and actual consumption data. This leads to fairer and more precise billing for consumers.

II. NEED OF THE STUDY

Connectivity and Data Management: IoT allows smart energy meters to be connected to a network, enabling seamless communication between the meters and utility companies. This connectivity facilitates real-time data collection and management, providing accurate and timely information on energy consumption. IoT enables the transfer of data from smart meters to central systems, making it easier for utilities to monitor and manage energy resources efficiently. Remote Monitoring and Control: IoT-enabled smart energy meters can be remotely monitored and controlled. Utility companies can access real-time data on energy usage, enabling them to detect abnormalities, identify energy wastage, and respond quickly to issues such as power outages or equipment failures. This remote monitoring and control capability improves the reliability and efficiency of the energy grid. Demand Response and Load Management: IoT-connected smart meters support demand response programs, allowing utility companies to manage peak demand periods effectively. By analyzing real-time data from smart meters, utilities can incentivize consumers to reduce their energy usage during high-demand periods, helping to balance the grid and avoid potential blackouts. IoT technology enables the timely and automated communication between utility companies and consumers for load management purposes.

Energy Efficiency and Conservation: IoT-enabled smart energy meters provide detailed and granular data on energy consumption. This data can be utilized by consumers to gain insights into their energy usage patterns, identify areas of inefficiency, and take appropriate measures to conserve energy. By promoting energy awareness and behavior change, IoT-connected smart meters contribute to overall energy conservation efforts. Integration with Renewable Energy Sources: As the use of renewable energy sources such as solar and wind power increases, IoT-connected smart meters play a crucial role in managing the integration of these sources into the grid. Smart meters can measure the energy generated by renewable sources and facilitate their seamless integration, ensuring efficient utilization of clean energy. Billing and Revenue Management: IoT-enabled smart energy meters provide accurate and real-time data on energy consumption, eliminating the need for manual meter readings and estimation. This leads to precise and fair billing for consumers. Additionally, utility companies can streamline their revenue management processes by automating meter reading, reducing costs, and improving billing accuracy.

3.1 Objective

Understanding Technology Integration: By studying IoT in smart energy meters, researchers and practitioners aim to gain a deep understanding of how IoT technology can be effectively integrated into energy metering systems. This includes exploring the technical aspects of connectivity, data collection, communication protocols, and interoperability between devices. Evaluating Performance and Efficiency: Researchers study the performance and efficiency of IoT-enabled smart energy meters in real-world scenarios. This involves assessing factors such as data accuracy, reliability, latency, and the ability to handle large-scale deployments. Understanding the strengths and limitations of IoT technology in energy metering is crucial for optimizing its use and identifying areas for improvement. Assessing Energy Management Capabilities: IoT-connected smart meters offer advanced energy management capabilities, such as real-time monitoring, load management, and demand response. The objective of studying IoT in smart energy meters is to evaluate the effectiveness of these capabilities in achieving energy efficiency, demand-side management, and grid stability goals.

Analyzing Consumer Behavior and Engagement: IoT-enabled smart energy meters provide consumers with detailed insights into their energy usage patterns. Research in this area aims to analyze how the availability of real-time data impacts consumer behaviour, energy conservation practices, and the adoption of energy-efficient technologies. Understanding consumer engagement and behaviour change is essential for designing effective energy conservation programs. Identifying Security and Privacy Considerations: IoT introduces new security and privacy challenges, as smart meters are connected devices that collect and transmit sensitive energy consumption data. Studying IoT in smart energy meters includes evaluating the security mechanisms, protocols, and encryption techniques used to protect data and ensure user privacy. This objective helps in identifying vulnerabilities and developing robust security measures.

3.2 Existing system

Electromechanical Meters: Electromechanical meters, also known as analogy meters, have rotating discs or dials that measure energy consumption. They typically display energy usage in kilowatt-hours (kWh) and require manual reading by utility personnel. These meters are gradually being phased out in favour of digital meters due to their limitations in data collection and communication capabilities.

Digital Meters: Digital meters, also called electronic meters, use digital displays to show energy consumption. They are more accurate and reliable than electromechanical meters and often include additional features such as a programmable display, tamper detection, and communication ports for data retrieval. However, most digital meters still require manual reading, although some models have the capability for remote data retrieval.

3.3 Proposed system

IoT Connectivity: Smart energy meters are equipped with connectivity capabilities, allowing them to communicate with a central system or the utility company. This connectivity can be achieved through various wireless communication protocols such as Wi-Fi, cellular networks, or dedicated IoT networks like LoRaWAN or NB-IoT.

Real-Time Data Monitoring: Smart meters continuously collect and transmit real-time energy consumption data to the utility company or a centralized server. This enables both consumers and utility providers to access up-to-date information on energy usage, facilitating better energy management and decision-making. Remote Data Retrieval: Instead of relying on manual meter reading, the proposed system enables remote data retrieval from smart meters. Utility companies can remotely access the meter data without the need for physical visits, streamlining the metering process and reducing operational costs. Energy Consumption Analytics: Smart meters capture detailed energy consumption data, which can be analyzed to provide valuable insights. Advanced analytics algorithms can identify usage patterns, peak demand periods, and energy-saving opportunities. This information can be used by consumers to optimize their energy usage and by utility companies for load forecasting and demand-side management.

Time-of-Use Pricing and Demand Response: Smart meters support time-based tariffs, allowing utility companies to implement time-of-use pricing models. Consumers can benefit from lower rates during off-peak hours, encouraging energy consumption during times of lower demand. Moreover, smart meters enable demand response programs, where utility companies can remotely adjust energy consumption or provide incentives for load reduction during peak periods. Integration with Smart Grid: The proposed system allows for seamless integration with smart grid infrastructure. Smart meters can communicate with other components of the smart grid, such as distribution automation systems, renewable energy sources, and energy management systems. This integration facilitates efficient grid management, optimal utilization of renewable energy, and improved grid reliability.

Consumer Engagement and Energy Conservation: Smart meters empower consumers by providing them with real-time information on energy usage. Consumers can access their energy consumption data through web portals or mobile apps, enabling them to monitor their usage, set energy-saving goals, and make informed decisions about their energy consumption habits. This increased awareness promotes energy conservation and behavior change.

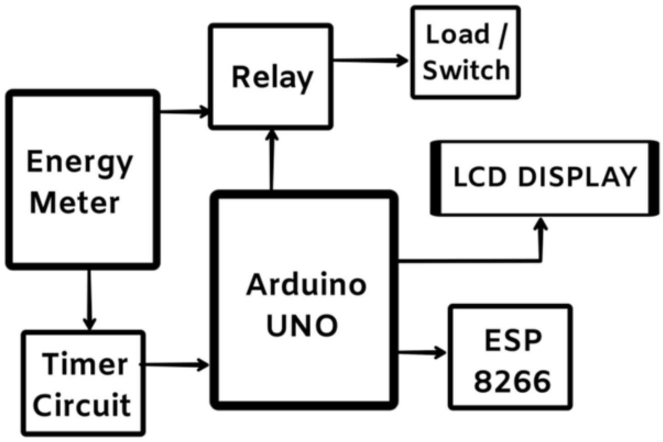
3.3 Theoretical framework

Internet of Things (IoT): The IoT itself serves as a foundational theoretical framework for understanding the interconnection of devices, data collection, and communication within the proposed system. The IoT framework encompasses concepts such as sensor networks, connectivity, data transmission, and device interoperability. Smart Grid: The smart grid framework provides insights into the integration of advanced technologies, including IoT, into the electricity grid infrastructure. It encompasses concepts related to grid modernization, energy management, demand response, renewable energy integration, and grid reliability. Understanding the smart grid framework helps in designing smart energy meters that align with broader grid objectives.

Information Systems and Technology: The theoretical framework from information systems and technology studies can be applied to analyse the technological aspects of smart energy meters. This includes concepts such as system architecture, data management, network protocols, cybersecurity, and data analytics. The framework helps in assessing the technological feasibility, scalability, and security of the proposed system. Behaviour Change and Consumer Engagement: Theoretical perspectives from behavioural sciences, including psychology and sociology, can inform the framework for understanding consumer behaviour and engagement in the context of smart energy meters. Concepts such as behaviour change models, social norms, incentives, and decision-making processes are relevant in analysing how consumers interact with the system and respond to energy information.

Energy Economics and Policy: Theoretical frameworks from energy economics and policy studies can provide insights into the economic and regulatory aspects of implementing IoT-enabled smart energy meters. Concepts such as pricing mechanisms, cost-benefit analysis, market structures, policy frameworks, and regulatory frameworks help in assessing the economic viability, market dynamics, and policy implications of the proposed system. Sustainable Energy Transition: The theoretical framework for sustainable energy transition considers the broader societal and environmental implications of the proposed system. Concepts such as energy efficiency, renewable energy adoption, carbon footprint reduction, and sustainable development goals can guide the analysis of how smart energy meters contribute to a sustainable energy future.

3.4 Block diagram:



4.1 Working:

The circuit has been made using all the hardware components like Arduino UNO board, energy meter, relay, transformer, timer circuit, pulse generator, load switch, wifi module. After this, we can complete the circuit by connecting all the connections and operate it . when the external load is connected then through the energymeter the pulses are generated which are further given to timer circuit. The data of pulses is given to the Arduino UNO board which calculates 16 pulses and there are few commands in the code that will calculate the energy consumed and the cost in Rs /- and that data is given to a LCD display which will display and even that's given to ESP8266 WIFI Module. The data is then sent to a mobile app when we connect to the Ip address of this WIFI module. We even have a relay circuit when in case the energy is not in use then the user can turn off the whole supply through his mobile. Vice versa he can even turn on when ever required using his mobile rather turning off the main.

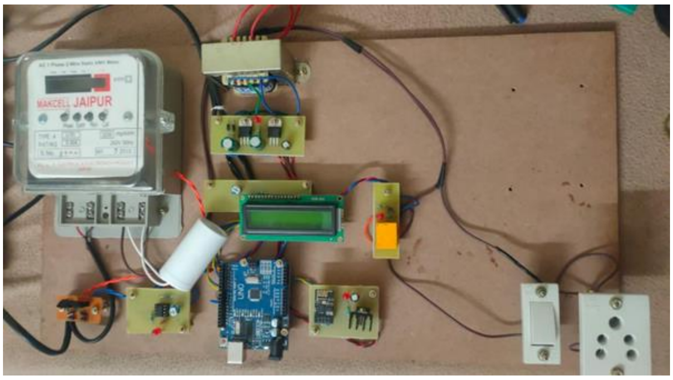


Fig:1 circuit connection

Firstly a supply is given to the Energy meter. The Energy meter has Input and Output. Now coming to the Output of Energy meter there are 2 they are positive and ground. The positive terminal is given to the pole of the relay . the pole will switch to Normally close or Normally open as per the input of the load Suppose if the Load is in condition then the pole of the relay is connected to Normally close pin and that establishes a closed circuit. If the load is in off condition then the pole is connected to Normally open pin and there's an open circuit. And the output of the relay is connected to Load switch. So this is the positive terminal of Energy meter , so now neutral or ground is directly connected to the Load switch. Now coming to Input side when the Load is on then the current utilized by load is sensed and it sends the output to Square pulse generator. The Square pulse generator then generates the square pulses and it sends the data to the Arduino UNO board. Arduino is programmed in such a way that when the count of pulses reach 16 then it considers as 0.01 unit and there's a equation programmed to calculate the total amount here in this prototype we have set 0.01 units = 1 Rs /-So the data will be sent to the LCD Display and ESP8266 WIFI Module. The LCD will display the energy consumed in units and the bill cost in Rs /-.

The same data is given to the wifi module and there's a mobile app called WIFI controller we have to install that and enter the ip address and port of the wifi module and we have to get our device connected to Wi-Fi___33 signals delivered by WIFI Module . Now Run the whole model and wait until the readings get updated in the LCD display and mobile app.

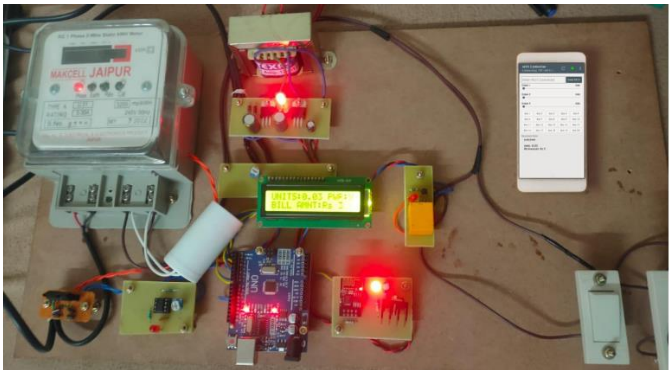


Fig: 1.1 Final output

Advantages:

The main advantage of the system is, in addition to the display of consumed energy, the system allows consumer to monitor consumption in money terms.The other important advantage is, with the help of this kind of AMR system lot of manpower can be reduced. For Ex: The person who is taking Meter reading, need not visit each and every house for collecting the energy consumption data, the data is transmitted through air, hence he can be dispensed with. The consumer can avoid penalties for late payments, because facility is provided such that the consumed energy amount to be paid to the department is displayed directly, so that the consumer can take the necessary action in time. The advantages of using electronic energy meter is as follows

a)The meter is designed to produce pulses according to the consumed energy, so that

data can be stored and displayed in digital systems or data can be transmitted

b) The resolution of the meter is very high so that it can measure the low values also very accurately.

c) The system is designed such that, energy pilferage can be avoided effectively (totally tamper proof).

d) Human error can be avoided because of the digitalized display

e) Finally electronic meters provide many new features like remote metering that can improve the efficiency of the utility.

In this project workload monitoring and control circuit is utilized, such that this circuit protects the energy meter as well as electrical household gadgets burning due to the overloads..

The advantage of using the WIFI is that the data can be monitored on timely basis using a mobile app. The usage of realy in this circuit is when the user is not in home or going out then he can turn off the whole supply through mobile app rather than switching off the supply by switching off the main , he can even turn on whenever needed by using the same app.

III. Application:

The nature of a smart energy meter using microcontroller, for secure data storage and processing capacity, may be used simultaneously for several applications -- means that it is an extremely versatile technology. Smart energy meter applications are often classified under the broad functional headings of access control, data transmission, data storage, financial, or data carrier. The main application of the system is AMR. This kind of systems is quite suitable for the state electricity departments. Most of the state electricity departments in our country, facing so many problems because of energy pilferage and improper auditing.

IV. Disadvantages:

The main disadvantage of the system is, because of huge electronic hardware involved in the system, the overall system consumes more electric energy. When the hardware is minimized naturally the system consumes less power. SMART ENERGY METER USING IOT Since it is a prototype module, because of huge hardware the system occupies more space. Because of the low power WIFI module used in this project work, the range between the transmitter and receiver is restricted for less than 20-30 feet.

V. REFERENCES

[1]. Anitha.k ,prathik, Smart Energy Meter surveillance Using IoT Institute of Electrical and Electronics Engineers(IEEE), 2019.
[2]. Devadhanishini, et.al Smart Power Monitoring Using IoT5th International Conference on Advanced Computing & Communication Systems (ICACCS) 2019.
[3]. Mohammad Hossein Yaghmaee Design and Implementation of an Internet of Things Based Smart Energy Metering 6th IEEE International Conference on Smart Energy Grid Engineering 2018.
[4]. Himanshu kpatel arduino based smart energy meter 2nd Int'l Conf. on Electrical Engineering and Information &Communication Technology (ICEEICT) 2018.
[5]. Bibek Kanti Barman, et.al proposed paper smart meter using IoT department of international electronics and electrical engineering (IEEE) 2017.
[6]. Garrab.A, Bouallegue.A, Ben Abdullah, A new AMR approach for energy savings in Smart Grids using Smart meter and partial power line communication, IEEE First International Conference on ICICS,vol 3, pp. March 2012.
[7]. Landi,c.: Dipt. Di Ing.dellInf, SecondaUniv di Napoli,Aversa,Italy; Merola p.ARM-based energy management system using smart meter and Web server,IEEE instrumentation and measurement technology conference binjing, pp.1-5 may 2011

Cite this article as :

D. Venkatnath Dass, S. Akhila, R. Prasanjith, "Smart Energy Meter Using IoT", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 10 Issue 3, pp. 711-716, May-June 2023. Available at doi : https://doi.org/10.32628/IJSRST523103135
Journal URL : https://ijsrst.com/IJSRST523103135