STM JOURNALS

International Journal of
Advanced Control and
System Engineering

Volume 2, Issue 1, 2024
January–April
DOI (Journal): 10.37591/IJACSE

https://journals.stmjournals.com/ijacse

Review IJACSE

Evaluating Smart Energy Meter Technologies for Optimized Smart Grid Performance

Naman Chouhan[1], Vishal Saini[1,*], Pravin Sonwane[2]

Abstract

The population is growing and there is an increased need for energy due to industrial development. Customers must become more conscious of their energy use if they hope to increase energy efficiency. Utilities have been creating new electric energy meters, or "smart meters", in recent years. Compared to a typical energy meter, a smart meter is a digital energy meter that measures electrical energy use and gives additional information. The goal is to make energy monitoring simple for both suppliers and consumers. Because they will enable greater interaction between the supplier and the customer, smart meters are regarded as a crucial part of the smart grid. Real-time and two-way communication between the provider and the customers will be made possible by smart meters. The creation of a smart meter based on ZigBee and GSM is presented in this study. This energy meter can measure the energy and transmit the data to the service provider, who can store it and alert the customer online or through SMS messages.

Keywords: Energy meter, smart grid, GSM, ZigBee, short messaging service (SMS)

INTRODUCTION

Data is first digitalized and compressed before being sent via the GSM digital mobile communication system. The primary benefits of the GSM are its global use and the ability to send short messaging service (SMS) messages via subscriber identity module (SIM) cards. ZigBee connectivity is another emerging technology that smart meters use [1–4]. ZigBee is a wireless network connection protocol that is inexpensive and low power. For local protection, such Home Area Networks (HANs), it works well. ZigBee is an essential component of the smart grid because of its lower installation and upgrade costs, device control capabilities, and automated appliance controllability. ZigBee has the capacity to provide remote home condition surveillance and meter-to-meter connectivity [5, 6].

A key element of the distributed energy system is the smart meter. Detailed load flow can be provided by such meters to the distributors so they can manage the grid effectively. Other features like recording the power quality, detecting any unauthorized access to the meter and storage capability will all help and improve the grid. Smart grid is a type of electrical grid that intelligently responds to the behaviour and performance of all electric power components to deliver electricity services efficiently. The smart grid delivers electricity from suppliers to the consumers by using digital technologies to save energy, reduce cost and increase reliability of the system [7–9]. In this paper, the authors designed and developed a simple smart meter prototype that uses both GSM and ZigBee. The meter takes advantage of the widespread use of the GSM network with its SMS capability and the easy-to-use ZigBee network to send and collect energy consumption data. Zigbee is used to

*Author for Correspondence
Vishal Saini
E-mail: vk.sharma@poornima.org

[1]Student, Department of Electrical Engineering, Poornima College of Engineering, Jaipur, Rajasthan, India
[2]Assistant Professor, Department of Electrical Engineering, Poornima College of Engineering, Jaipur, Rajasthan, India

Received Date: May 09, 2024
Accepted Date: June 25, 2024
Published Date: July 29, 2024

Citation: Naman Chouhan, Vishal Saini, Pravin Sonwane. Evaluating Smart Energy Meter Technologies for Optimized Smart Grid Performance. International Journal of Advanced Control and System Engineering. 2024; 2(1): 19–24p.

communicate with other devices [10, 11]. Furthermore, this paper also explains how the data can be collected by the service provider and distributed to the consumers.

RELATED WORK

Several studies approached the problem of designing a smart energy meter. Numerous amounts of research focused on using GSM based meters. A GSM energy metre and a database that gives the customer the information was created by Tan *et al.* [12]. The study created a GSM-based power metre that uses GPRS as the primary communication method and SMS as a backup. An automatic metre reading system based on Zigbee and GSM was created in. The metres have Zigbee installed, which transmits data to a data collecting device that connects to the central computer via GSM. Furthermore, a Zigbee-based smart metre that gathers data and acquires outage event data was built in the study. Additionally, studies on other communication technologies, such as PLC and Wi-Fi, have been conducted to build smart metres. Along with a website and a mobile application, we design entire systems, from data management systems to smart metres. The Arduino microcontroller was used in the development of the GSM-Zigbee smart metre. Like other GSM techniques, all data flow occurs wirelessly, negating the need for external wiring. The user can access the data via the website, mobile application, and SMS.

SYSTEM OVERVIEW

The system is made up of two devices, the smart energy meter for the consumer and the receiver for the provider. The meter uses both ZigBee and GSM to send the data. The receiver also uses both technologies (ZigBee is used for testing purposes). Figure 1 depicts the system's overview. The energy can be read by the metre and transmitted via GSM or ZigBee to the recipient. The information is gathered, stored, and uploaded to the internet by the data management system. Thus, the user can access his information via the internet by means of a website portal or a specially designed Android application. Through the GSM network, the recipient can also send the user an SMS message with the consumption data.

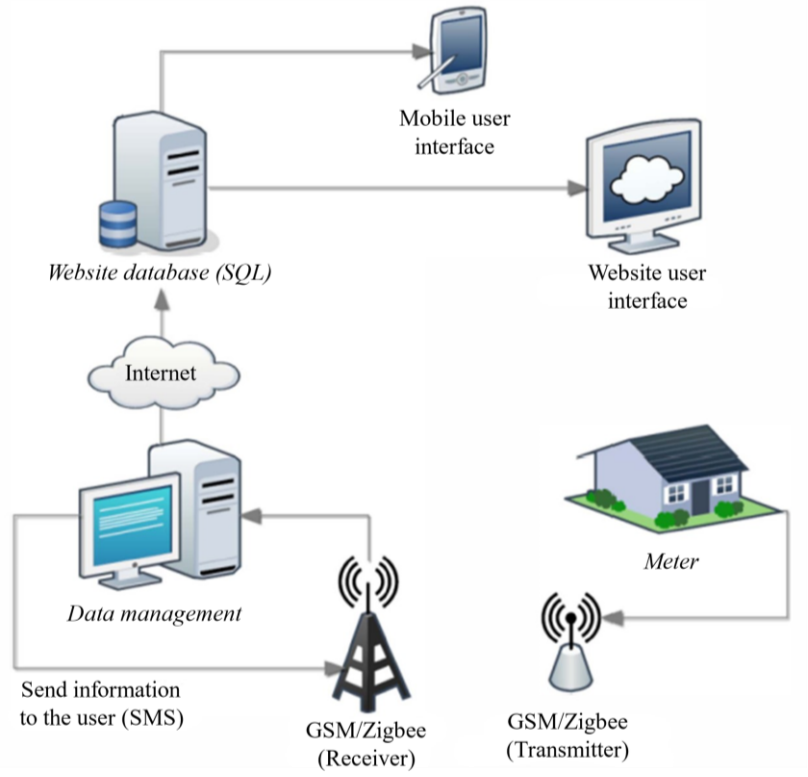

Figure 1. Data cycle.

Data Transmission

The choice of data transmission methods should be vital for this system. In order to achieve minimum time required for monitoring and making less immune to surrounding impacts, the transmission method is selected which fulfils the reliability and required necessary conditions. As discussed earlier, the system uses two different data transferring protocols which are described further.

PLCC (Power Line Carrier Communication)

Coming to the efficient and preferable medium of transmission, Power line carrier communication (PLCC) or Power line networking (PLN) which utilizes the same wired medium through which power is delivered to the customer as communication channel. The measured data is transmitted through the main power channel to the monitoring hub by superimposing the data signals (which may be in a range of several kilo-Hertz) on to the 50 Hz power frequency. Thus saves the separate transmission protocol.

GSM Network (Global System of Mobile Communication)

GSM, the running generation's communication system has totally changed the meaning of modem communication era. SMS (Short Messaging Service), a salient feature of GSM, has made it quite easy to transmit data cheaply through nationwide which in Pakistan, operates at 900 MHz (dual carrier) frequency band.

Consumer Interface

The Android program and the website can provide a graphical user interface (GUI) for the user to check for his information like his bills and energy consumption.

Website

The website, developed using HTML and PHP, was built for the consumers to provide them with their live energy usage data and to access their detailed history. It will receive the data from the data management program every 5 min and graph this data to provide a visual representation of the consumer's consumption. The website is updated every 5 min to avoid overloading the website as shown in Figure 2.

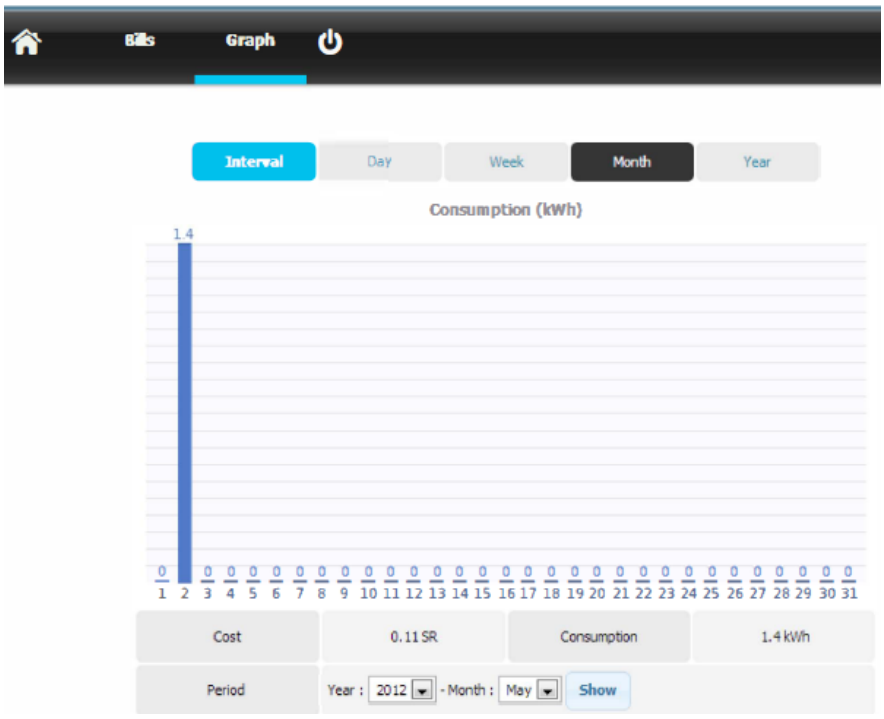

Figure 2. View of the website.

Mobile

The program was developed for the Android operating system using Eclipse (Java and XML). This program can download the data from the internet to provide the user with a simple, easy and elegant way to check on his energy consumption information. Snapshot of the android program is shown in Figure 3.

SMART ENERGY METER

Anti-Power Theft Solution

One extraordinary feature of the system is its capability to prevent the theft of electrical energy. The stealing is done using several techniques as mentioned in which have to be minimized. This Digital meter is especially designed to face this severe problem for which it has a feed-back monitor system that continuously monitors and compares the delivered power with the users' actual consumption which is also being measured by the same device. If the controller does not find both the readings matched, it is evident that there is some illegal energy usage on consumer's node and since this information is also being transferred to the remote monitoring and controlling hub therefore the power in such a locality can easily be switched off by the controller. The system is made almost immune and capable of detecting any kind of possible tampering with the meter as mentioned in. As the current and power both are measured from entering as well as from leaving terminals of the meter, it is made almost impossible that the mentioned methods of tampering in could possibly tamper the meter's reliability. Furthermore, it is also made immune to the “Cavdar's method for illegal usage of Electricity” as mentioned in.

Economical Resolution

These days, maintaining control over even the smallest costs is crucial to the competitiveness of the market. Even though the installation of this system is a bit more costly than that of the outdated billing/account management system and conventional energy metres, it will only be necessary once. Since the preparation and distribution of electric energy bills represent a great amount of expenses for the companies, which has been omitted in this new system, therefore it is proved to be a cost-effective solution. We suggest this system, a need of present. India's mobile subscriber base is expected to reach

Figure 3. Snapshot of the Android program.

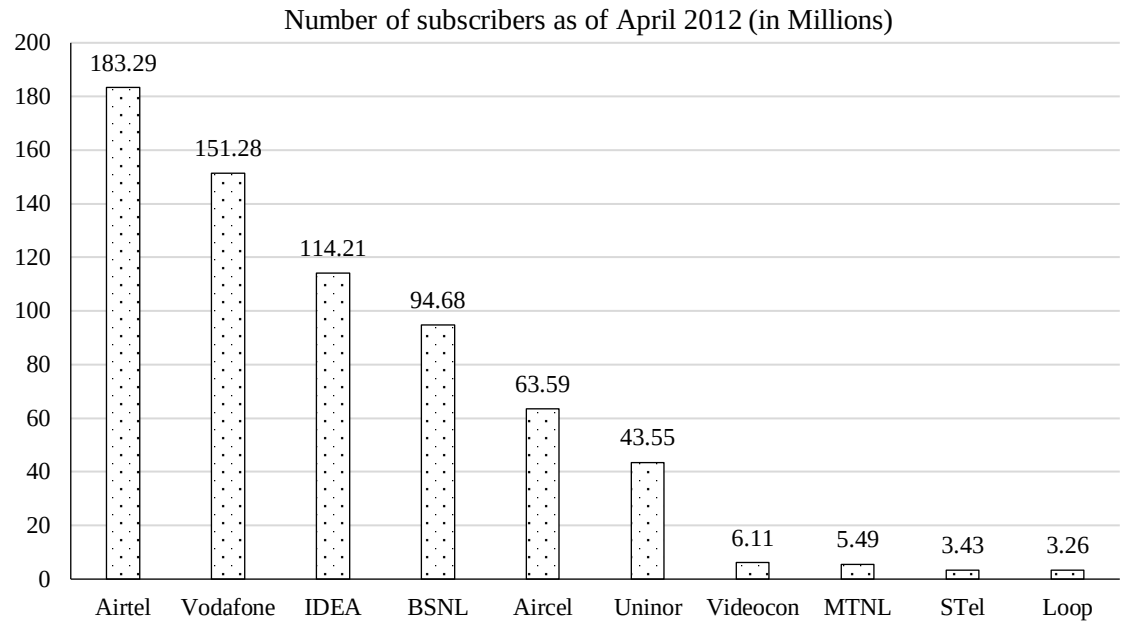

Figure 4. Number of subscribers.

993 million by 2014, according to the most recent study from analyst Gartner. This indicates that India will end 2010 as the world's fastest growing mobile market, with over 660 million users. Based on figures from the nation's telecom authority, India had 618 million mobile subscribers at the end of May, making it the second largest cellular market globally behind China. By the end of 2009, there were 525 million mobile connections. The Cellular carriers Association of India (COAI) released the most recent figures, which indicated that GSM carriers added 6.68 million subscribers in November 2012, bringing the total to 632.08 million. According to figures issued by the COAI, GSM carriers gained 7.55 million new users in December, bringing the total number of GSM users in the nation to 639.64 million as shown in Figure 4.

The software used in this project consists of two main parts, one is for the Arduino and the other is on the Pc. Using the Arduino Integrated Development Environment (IDE) software [11], which is comparable to C++, the Arduino microcontroller is programmed to communicate with the other components. The Arduino has been configured to function as both a transmitter and a receiver.

For the PC part, two programs are developed along with a website. The first program is the data management software developed by using Visual Basic. The second program is an Android program for the mobile phone developed using Java and Xml.

The Arduino microcontroller is the main component in this device as it will have the responsibility of coordinating with the other equipment. The Arduino will receive data from the kWh Power Meter by sending a string request, and the response will be a stream of data that contains kWh, current, voltage and power factor. The Arduino program is able to extract the kWh consumption details from the stream and sends it using either the GSM modem or the X Bee chip to the data management system.

CONCLUSION

The goal was to create a gadget that tracks energy usage and transmits data via a wireless transmission method. A data management system gathers the data and uses the internet to give the user information about their energy consumption. The GSM and ZigBee protocols were used for wireless communication. The device works online so all the data are received in real time. In this study, Zigbee is used by the receiver to test this technology and provide the ability to communicate with in house

equipment and other smart meters. These Zigbee features will be further exploited in future work. Other future work will consider the use of a different way for reading the energy. Also, future work will include building new prototypes and testing the device in real scenarios such as installing it in a house. Customers may easily track and monitor their energy usage using this device. These days, people manually read their electricity metres to determine how much energy they are using. This is inefficient and yields very little information. Concerns over community awareness and energy consumption are intensifying. Customers will be able to track and reduce their energy use using this gadget by using the internet or a smartphone application. People will be able to save money and energy by reducing their energy consumption when they are better informed about how much energy they are using.

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