

Review on Smart Electric Metering System Based on GSM/IOT

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Abstract - Arduino and GSM based smart energy meters for advanced metering and billing system is able to read and send data via wireless protocol using GSM technology through GSM modem, capable of managing the meters as well as the line connections. For GSM module uses the network coverage of the SIM. Smart Energy Meter uses SMS or/and Wi-Fi to send the power/unit data to cloud, so that user can access the data room module Apps and websites. Using cutting edge technology smart energy meters will save money, labour, efforts and time and at the same time it will effectively monitor the electricity consumption, usage and fraud. It is safe and easy to use and user friendly. The metering system uses cheap components which will decrease the overall cost of the equipment increasing its affordability and penetration in non-metered areas.

Keywords: Smart Meter, GSM, IOT, Tariff Based Metering, Wii-Fi Data Logging

I. INTRODUCTION

The new era of Internet of Things (IoT) referred to uniquely identifiable objects representing in an “internet like” structure. IoT has been playing major role in our daily life in terms of intelligence and automation of conventional objects. By creating connectivity, IoT, as intelligent system, connect things like universal global neutral network. As the technology is advancing, the IoT’s automation management system is applied in many basic infrastructures such as electricity, gas and water management systems in order to make it more convenient for individuals and organizations. Therefore, the system can overcome the issues of human error and efforts in terms of controlling and management. To achieve this sophisticated system, the communication and networking has the major role to track all kind of connectivity among the individual devices.

The challenge is to build the network system which is robust, at the same time low power consuming and inexpensive.

Monitoring and keeping tracking of electricity consumption for verification is a tedious task today since manual meter reading and recording is in vogue. It is important to know from the customer view point that if one is charged fairly and according to the need. Automation of the system will allow users to monitor energy meter readings over the internet in the real-time.

Watt hour meter or energy meter is the most common instrument which is used to measure the amount of electrical energy used by the consumers. Utilities install these instruments at every place like homes, industries, organizations to charge the electricity consumption by loads such as lights, fans and other appliances. Most interesting type is used as prepaid electricity meters.

Basic unit of power is watts. One thousand watts is one kilowatt. If we use one kilowatt in one hour, it is considered as one unit of energy consumed.

$$Pulse = \frac{pulse\ rate * Watt * time}{1000 * 3600} \quad (1)$$

$$PF = \frac{Watt}{Hour * Pulses} \quad (2)$$

$$Units = \frac{PF * Total\ Pulse}{1000} \quad (3)$$

The energy meters measure the instantaneous voltage and currents, calculate its product and gives instantaneous power. This power is integrated over a period which gives the energy utilized over that time period. These may be single or three phase meters depending on the supply utilized by domestic or commercial installations. For small service measurements like domestic customers, these can be directly connected between line and load. But for larger loads, step down current transformers must be placed to isolate energy meters from higher currents.

A. Types of Electric Meters

Energy meter or watt hour meter is classified in accordance with several factors like type of display: analog or digital; type of metering point: grid, secondary transmission, primary and local distribution; end applications: domestic, commercial and industrial; and technical: three phases, single phase, HT, LT and accuracy class meters. The three major types of meters are electromechanical induction, electronic energy and smart meters.

1. Electromechanical induction type of meter is commonly used age-old watt hour meter. It consists of rotating aluminum disc mounted on a spindle between two electro magnets. Speed of rotation of disc is proportional to the power and this power is integrated

by the use of counter mechanism and gear trains. This type of meter is simple in construction and accuracy is somewhat less due to creeping and other external fields. A major problem with these types of meters is that they are prone to tampering and theft. These are very commonly used in domestic and industrial applications.

2. Electronic Energy meters are fairly accurate and reliable types of measuring instruments as compared to conventional mechanical meters. It consumes less power and starts measuring instantaneously when connected to load. These meters might be analog or digital. In analog meters, power is converted to proportional frequency or pulse rate and it is integrated by counters placed inside it. In digital electric meter power is directly measured by high end processor. The power is integrated by logic circuits to get the energy and also for testing and calibration purpose. It is then converted to frequency or pulse rate.
3. Smart Energy Metering system is an advanced metering technology involving placing intelligent meters to read, process and feedback the data to customers. It measures energy consumption, remotely switches the supply to customers and thus remotely controls the maximum electricity consumption. Smart metering system uses the advanced metering infrastructure system technology for better performance. These are capable of communicating in both directions. They can transmit the data to the utilities like energy consumption, parameter values, alarms, etc. and also can receive information from utilities such as automatic meter reading system, reconnect/disconnect instructions, upgrading of meter software and other important messages. These meters reduce the need to visit while taking or reading monthly bill. Modems are used in these smart meters to facilitate communication systems such as telephone, wireless, fiber cable, power line communications. Another advantage of smart metering is complete avoidance of tampering of energy meter where there is scope of using power in an illegal way.

II. SMART METERS

A Smart meter is the improved version of a conventional analog electricity meters being used in 95% of the places throughout the world. They come with an in-home display screen that shows you exactly how much energy one is using in pounds and pence, in near real time and will bring an end to estimated bills. Smart meters measure how much gas and electricity one is using, as well as at what cost and display this in on a handy in-home display. With a smart meter, the complicated meter readings will have to go. The smart meter shows a digital meter reading and automatically sends the reading to the energy supplier at least once a month, so consumer will receive accurate, non-estimated bills.

Advantages to Electric Companies:

1. Eliminates manual monthly meter readings
2. Monitors the electric system much more quickly

3. Makes it possible to use power resources more efficiently
4. Provides real-time data that is useful for balancing electric loads while reducing power outages (i.e., blackouts)
5. Enables dynamic pricing, which raises or lowers the cost of electricity based on demand
6. Avoids the capital expense of building new power plants
7. Helps to optimize income with existing resources

Usually the present Smart meters available in the market have the following features:

1. They have a built in LCD for displaying the real-time data.
2. They are based around a micro-controller (ATMEGA328/AT89S51)
3. They use GSM for communicating the billing and unit's information to user and Power Company.
4. Displays real time units used/left, power consumed and bill data.
5. CT and Voltage transformer interface for energy calculations.
6. The operating frequency is 50Hz.
7. The operating voltage is 250V.
8. The pulse rate of smart meter is 3200/kwh.
9. GSM modem: tri band GSM modem.

Addition features:

1. IOT based monitoring on Think Speak Cloud using website and app.
2. Integration to the Smart Home.
3. One to many monitoring.

III. EXISTING SYSTEM

Some of the recently published works on smart meters have been reviewed as under:

This paper proposed and demonstrated Smart Energy Meter that the users will be able to monitor their current power consumptions (bill) anytime, anywhere by using their mobile phone via Short Message Services (SMS). Arduino UNO, main controller, was the interface between energy meter and Global System for Mobile communication (GSM) module. GSM module connects the energy meter to users' mobile phone. Real Time Clock (RTC) DS1307 was used to get the real time to count and store the usage into the EEPROM. The program developed in C language with the Arduino syntax in the Arduino IDE. The proposed system demonstrated its capability to check the current usage (bill), notify when reaching the limit, reset the usage (bill) successfully, only via accessing GSM-based mobile phone. [1]

The present system of energy metering as well as billing in India uses electromechanical and somewhere digital energy meter. It consume more time and labor. One of the prime reasons is the tradition billing system which is incorrect.

Many times slow, costly and lack in flexibility as well as reliability. Today accuracy in electrical billing is highly recommended. The smart energy meter gives real time consumption as well as accurate billing. A possible solution is a Wireless Energy Meter which is able to send its data via wireless communication to PC or a remote device where monitoring and analysis of the data will be easily made. In smart metering there is a different technique in communication system like AMI, WIMAX, and Zig-bee etc. This paper presents a brief literature review of the work carried out by the various researchers in this field by using AMI techniques. And also, the various communication system used in smart metering technology. [2]

Automatic meter reading (AMR) system give the information of meter reading, power cut, total load used, power disconnect and tempering on request or regularly in particular interval through SMS. This is aim to measure and monitor the electricity consumed by consumers in a locality and transmitting the consumed power to the station as well as issuing the bill of consumed power automatically and online payment is also possible. It is also aims to find the malpractices in the meter. Provider Company with the help of Global system for mobile communication (GSM) network access prepaid energy metering system to control electricity theft. Server station is also served by a GSM module for transmission and reception of data as energy auditing. Constraints are accurate metering, energy theft and implementation of proper tariff as well as billing system. This can be achieved by using Smart Meters. This paper makes the consumer an active part of Energy Management. [3]

In this system, smart energy meter is designed to get telemetering, tampering detection and supplier can disconnect service to the consumer in the event of meter tampering or unauthorized use of energy. It makes the relation between utility and user more transparent and reliable. Power saving is possible which contributes towards the minimization of the problem of energy crisis. [4]

In this paper, we focus mainly on IoT's energy monitoring. The proposed design is to implement a very low cost wireless sensor network and protocol for smart energy and web application capable of automatically reading the unit and sending the data automatically for the power users to view their current energy meter reading. By using this system, the users will be aware of the electricity usage in his/her home to reduce the power wastage and cost of consumption. The system consists of a digital energy meter, ESP8266 Wi-Fi module and web applications for management system. The ESP8266 Wi-Fi module will be embedded into the meter and implement the TCP/IP protocol for the communications between the meter and web application. The experimental results show that the proposed system works very well with efficiency, and it is feasible to implement in practical applications for very low cost-build automatic energy meter reading. [5]

This paper describes PIC18F46k22 Microcontroller based design and implementation of energy meter using IoT concept. The proposed system design eliminates the human involvement in Electricity maintenance. The Buyer needs to pay for the usage of electricity on schedule, in case that he couldn't 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 device IP address. Theft detection unit connected to energy meter will notify company side when meter tampering occurs in energy meter and it will send theft detect information through PLC modem and theft detected will be displayed on the terminal window of the company side. Wi-Fi unit performs the IoT operation by sending energy meter data to web page which can be accessed through IP address. The Hardware interface circuit consists of PIC18F46k22 Microcontroller, MAX232, LCD display, theft detection unit, Triac switch circuit, DB18B20 temperature sensor, PIR sensor, PLC modem, and ESP8266 Wi-Fi module. Wi-Fi unit performs the IoT operation by sending energy meter data to web page which can be accessed through IP address. [6]

The main objective of the project is to develop an IOT based electricity meter reading displayed for units consumed and cost there upon over the internet. A digital meter whose blinking LED signal is interfaced to microcontroller through LDR the blinking LED flashes 3200 times for 1 unit the LDR sensor gives an interrupt each time the meter LED flashes to the programmed micro controller that takes this reading and displays it on an LCD duly interfaced to the microcontroller. The reading of the energy meter is also sent to Ethernet shield module being fed from the micro controller via level shifter IC and RS 232 link which transmit data directly to a dedicated web page for display anywhere in the world. The power supply consists of a step down transformer 230/12V which steps down the voltage to 12V AC. This is converted to DC using a bridge rectifier and it is then regulated to 5V using a voltage regulator 7805 which is required for the operation of the microcontroller and other components.

Electricity is an important invention without which life on Earth is impossible. So obviously there is a need for measuring the consumed electricity. It is accomplished by the wattmeter, but a person from TNEB has to visit each house for measuring the power consumption and for calculating the bill amount. So it requires much of manual work and consumes time. In order to avoid all these drawbacks we have intended to construct an IoT based energy meter. So the proposed energy meter measures the amount of power consumed and uploads it to cloud, from which the concerned person can view the reading. The power reading is sent to cloud using ESP 8266, a Wi-Fi module. The power reading from digital wattmeter is read using the Opto-coupler and transmitted digitally to the Arduino. So it automates the process of measuring the power consumption at homes using IoT and thereby enabling remote access and digitalization. [8]

Smart meter is a next generation meter which is highly efficient and user friendly, which provides a great way to save and control the usage of energy. The smart meter is wirelessly connected to users by the means of IoT. This means user can easily have control on the meter as per his needs. The advantage of smart meter is it can be used by utilities to communicate information to bill customers and operating their electric system. Earlier the system utilized one way communication to collect meter data and was referred as AMR. But now due to sophisticated technology, AMI the system can communicate in two ways for both data collection, billing and to control the device.

In conventional method of electricity billing, the responsibility of billing for each consumer is a time consuming job for the distribution grid. Despite this, the consumer can consciously consume extra amount of power than required and still cease from paying the bill. So, nothing can be done to strict the electric power supply. This paper spotlights the design of Smart Energy Meter (SEM) using GSM Technology for domestic consumers. This SEM would insist consumers to consume power during off-peak hours by providing incentives and thereby help to achieve a uniform load curve. This is implemented by time-of-day billing also known as variable billing scheme in which consumers would be charged a higher tariff for power consumption during peak hours. For these reasons it uses Wireless Peak-Hour Timing Update (WPTU) and Wireless Tariff Update (WTU) schemes.

In addition, this system also implements Prepaid Billing which would go a extended way in making consumers conscious of the energy they use and be more economical. This device uses ATMEGA 328P Micro Controller for computational purposes, GSM Modem and RF Module for data transfer and updates. The prototype model of this proposed energy meter was developed and was validated with various loads in our laboratory during 19-1-2016 to 25-1-2016(Scale down period as 2 months). It proves, this device is user friendly, make consumers conscious about the amount of energy they spend and help to conserve the already depleting resources. The automation of billing system eliminates labor resources involvement, hence is more accurate.[10]

In this paper the idea of smart energy meter using IoT and Arduino have been introduced. In this method we are using Arduino because it is energy efficient i.e. it consume less power, it is fastest and has two UARTS. In this paper, energy meters which are already installed at our houses are not replaced, but a small modification on the already installed meters can change the existing meters into smart meters. The use of GSM module provides a feature of notification through SMS. One can easily access the meter working through web page that we designed. Current reading with cost can be seen on web page. Automatic ON & OFF of meter is possible. Threshold value setting and sending of notification is the additional task that we are performing.

IV. PROPOSED SYSTEM

The proposed smart energy meter with advanced prepaid billing system is a device to make electricity billing user friendly and much more readable to the common man. The Smart Energy meter contains an energy meter, a GSM modem, a microcontroller (Arduino) and a relay circuit, which is connected between the energy meter and the load. The proposed smart energy meter is able to provide all the metering and billing services like counting the consumed energy, sending the generated bill by the SMS (short message service) over the GSM network as well as the security services like tempering etc. Factually at present, the metering and billing system of our country is totally conventional and it is very much slowed, faulty and corrupted so our proposed smart energy meter is highly deserved for national implementation.

A Smart meter works by communicating directly with wireless data protocol with your energy supplier, so the company will always have an accurate meter reading and there is no need for us to take a meter reading by ourselves. Smart meters can work in a variety of different ways, including using wireless mobile phone type technology to send data.

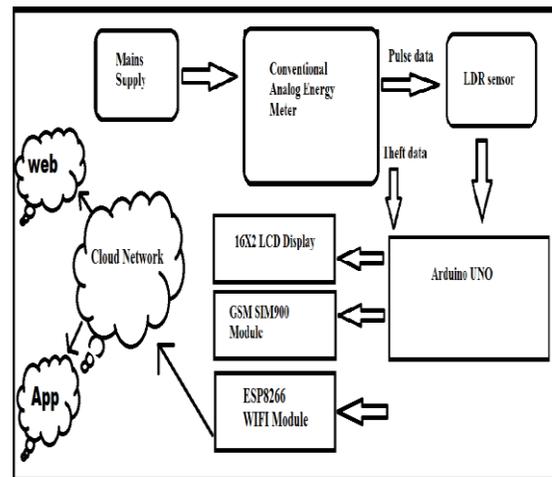


Fig. 1 Proposed System

After switching power on the Arduino and the GSM modem, turn on the relay and connect the energy meter to load via relay. Then read the EEPROM and display the current data. Arduino checks the impulse from energy meter i.e. If impulse occurs increase the data and display current data. GSM modem checks the new SMS. If there is a new SMS and read it. If the SMS is "DATA", send data to the specific number. If the SMS is "LINE CUT", turn OFF the relay, so load will disconnect. Again the SMS is "LINE OK" and then turn ON the relay so load will connect. If there is any other SMS in any other formats, then delete the SMS. Any tampering attempt occurs in the metering unit; Arduino turns OFF the relay, turns ON the buzzer and sends SMS to the service provider.

Our proposed system is also having some unique features like

1. Operating frequency 50hz
2. Operating voltage 250v
3. Pulse rate 3200/kwh
4. GSM modem: tri band GSM modem
5. Memory: non-volatile

A. Advantages of Proposed System over Existing System

The present power usage reading is made manually by moving to the consumer locations. This requires large number of labor operators and long working hours to accomplish the task. Manual billing is sometimes restricted and delayed by bad weather conditions. The printed billing also has the tendency of getting lost. Over the last few years, Smart (Prepaid) Energy Meter has been proposed as an innovative solution aimed at facilitating affordability and reducing the cost of utilities. This mechanism, essentially, requires the users to pay for the electricity before its consumption. In this way, consumers hold credit and then use the electricity until the credit is exhausted. If the

available credit is exhausted then the electricity supply is cut off by a relay. Readings made by human operators are prone to errors. This project addresses the above mentioned problems. The development of GSM infrastructure in past two decades made meter reading system wireless. The GSM infrastructure, which has national wide coverage, can be used to request and retrieve power consumption notification over individual houses and flats. Apart from making readings using GSM communication, billing system is needed to be made prepaid to avoid unnecessary usage of power. The use of Prepaid Energy Meter is still controversial. On the one hand, those that support the diffusion of prepaid meters claim that they benefit both consumers and utilities because they help users to consume more efficiently and to improve the management of their budget, while allowing firms to reduce financial costs. On the other hand, those that are against prepaid meters argue that their adoption is expensive for firms and risky for low income consumers, as the insecurity and volatility of their income may force them to make little use of the service, or ultimately, bring about involuntary self-disconnection.

TABLE I DIFFERENCE BETWEEN THE CONVENTIONAL, CURRENTLY AVAILABLE AND NEWLY PROPOSED METERING SYSTEMS

Type	Conventional Meter	Current design	Proposed Design
Communication type	None	GSM	Wi-Fi
Payment Method	Post-paid	Prepaid	Prepaid
Data Display	Units	Units, Bill data, recharge, power data	Units, Bill Data, recharge, power data Low balance/Power cut warnings
User Interface	Gear Based Display	LCD	LCD, Android App
Energy control methods	No control	No control	Relay control
Back end interface	No interface	No interface	Website and graph plots
Sensing Technology	Magnetic coupling	CT and Voltage transformers integrated to Current sensors.	LDR
Cost	1K	Around 5-7K	Around 1K
Data collection	Manual	SMS	Cloud and SMS

V. CONCLUSION

Arduino and GSM based Smart Energy Meter for advanced metering and billing system is built which is able to read and send data via wireless protocol using GSM technology through GSM modem, capable of managing the meter as well as the line connection. However, this project needs more modification for more reliable and higher degree of satisfaction and safety. For GSM module the network coverage of the SIM used is one might be bit complicated due to network strength issues.

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