

GSM & Zigbee Based Automatic Energy Meter Reading System with Instant Billing

SURI REVIDI¹, M. VEDACHARY², A. KISHORE REDDY³

¹PG Scholar, Dept of ECE, CMR College of Engineering & Technology, Hyderabad, TS, India.

²Associate Professor, Dept of ECE, CMR College of Engineering & Technology, Hyderabad, TS, India.

³Assistant Professor, Dept of ECE, CMR College of Engineering & Technology, Hyderabad, TS, India.

Abstract: The technology of e-metering (Electronic metering) has gone through rapid technological advancements and there is increased demand for a reliable and efficient Automatic Meter Reading (AMR) system. This paper presents on implementation of a wireless Automatic Meter Reading system incorporating the widely used GSM and Zigbee network. The proposed system replaces traditional meter reading methods and enables remote access of existing energy meter by the energy provider. Also they can monitor the meter readings regularly without physical visiting. Cortex-M3 integrated with a GSM receiver at the other end, which contains the data base, acts as the billing point. The usage amount of bill from various places will be transferred to main central data base using Zigbee technology. The complete monthly usage bill is messaged to the customer using GSM technology.

Keywords: Energy Meter, GSM, Zigbee, Cortex-M3 (LPC1768), Relay.

I. INTRODUCTION

Electrical power has become indispensable to human survival and progress. Apart from efforts to meet growing demand, automation in the energy distribution is also necessary to enhance people's life standard. Traditional meter reading by human operator is inefficient to meet the future residential development needs. So there is increased demand for Automatic Meter Reading (AMR) systems which collect meter readings electronically, and its application is expanding over industrial, commercial and utility environment. Electronic utility meters are an important step towards automating the utility metering process. Automated utility meters have many new features that help to reduce the cost of utilities to customers and the cost of delivering utilities to the utility provider. Collection of meter readings is also inefficient, because a meter reader has to physically be on-site to take the readings. This method of collecting of meter readings becomes more problematic and costly when readings have to be collected from vast, and often scattered rural areas. Meter readers are reluctant to make the effort to travel to such areas and will often submit inaccurate estimations of the amount of electricity consumed. For households at the top of high buildings and luxury housing plots, traditional meter reading is highly inefficient. There exists chance for missing bills, absence of consumer etc. Even though these conventional meters were replaced with more efficient electronic energy meters these problems still persist. So a system which will provide the bill in users mobile will be more suitable in the current scenario. Here a new method of post paid electronic energy metering is introduced in this paper which will automatically sense the used energy, records these reading continuously, then sends it to the service

provider through Zigbee network. Finally after processing the collected data, bill will be generated and is send to the customer as SMS (Short Messaging System) through GSM network. As it is web oriented once the data is updated, the registered users and authority can monitor and analyze the generated bill of any month by sitting anywhere in the world. If the bill is paid by the customer without delay then the power will be ON. If not, the power will be OFF automatically.

II. RELATED WORK

A. Cortex-M3 LPC1768

Here, the Cortex-M3 LPC1768 microcontroller acquires different meter readings from energy meter through Zigbee. Cortex-M3 LPC1768 microcontroller plays a main role in this project. The microcontroller is fed with the required input signals from various parameters. The various parameters send signals, each to individual pins of the microcontroller. The microcontroller then branches out to any one of the logical paths and delivers the output at one of its pins. The controller is used to check the authentication process. All the devices are connected to the controllers to control the device actions. The LCD block is provided for displaying the meter readings and it also displayed whether the bill has paid or not. Microcontroller will receive the readings from energy meter through Zigbee network and it will transmit the data to the respective customer through GSM network. If the bill was paid by the customer via GSM, then GSM will send commands to the microcontroller to keep power ON. If the bill was not paid by the customer via GSM, then GSM will send commands to the microcontroller to keep power OFF.

B. Energy Meter

The energy meter is an electrical measuring device, which is used to record Electrical Energy consumed over a specified period of time in terms of units as shown in Fig.1. The energy measuring unit consists of a standard calibrated energy meter along with the tampering detection circuit. The ADE77581 is a high accuracy, 3-phase electrical energy measurement IC with a serial interface and two pulse outputs. The ADE7758 incorporates second-order Σ - Δ ADCs, a digital integrator, reference circuitry, a temperature sensor, and all the signal processing required to perform active, reactive, and apparent energy measurement and rms calculations. Highly accurate; supports IEC 60687, IEC 61036, IEC 61268, IEC 62053-21, IEC 62053-22, and IEC 62053-23 Compatible with 3-phase/3-wire, 3-phase/4-wire, and other 3-phase services Less than 0.1% active energy error over a dynamic range of 1000 to 1 at 25°C Supplies active/reactive/apparent energy, voltage rms, current rms, and sampled waveform data Two pulse outputs, one for active power and the other selectable between reactive and apparent power with programmable frequency. It sends the reading units to AT89C51 microcontroller which stores in it. Further it sends the data to main central server having Cortex-M3 through Zigbee network.



Fig.1. Energy Meter.

C. Zigbee

In this application, Zigbee transfers and receives the data of meter readings and billing payments to and from microcontroller. In this application we are using XBee S2 series. Zigbee is the name of a specification for a suite of high level communication protocols. It is short-range, low power, low cost and low complexity of wireless communications technology as shown in Fig.2. The technology is applies value in the home automation, building automation, industrial control and industrial areas of logistics. Zigbee uses FM technology and spread spectrum technology to work in the 2.4GHz (global epidemic), 868MHz (Europe, popular) and 915MHz (U.S.), and in these three bands can transit high data rapidly with 250kbps, 20kbps and 40kbps. When using the 2.4GHz band, Zigbee technology can transmit 10 meters in the indoor, while in the outdoor transmission distance can reach 200 meters; in other uses spectrum, the indoor distance is 30 meters, while in the outdoor transmission distance can reach 1000 meters. The actual distance will be based on the size of the transmission power. Compared with other networks,

Zigbee has the following advantages: low power, low cost, short time delay, network large capacity, reliability and safety.



Fig.2. Zigbee Module.

XBee Specifications:

- Supply voltage:
 - XBee: 2.8 - 3.4 VDC
 - XBee-PRO: 2.8 - 3.4 VDC
 - XBee Footprint Recommendation: 3.0 - 3.4 VDC

Transmit current:

- XBee: 45 mA (@ 3.3 V) boost mode 35 mA (@ 3.3 V) normal mode
- XBee-PRO: 215 mA (@ 3.3 V)

Receive current:

- XBee: 50 mA (@ 3.3 V)
- XBee-PRO: 55 mA (@ 3.3 V)

D. Real Time Clock (RTC)

This is used to maintain the real time and date in off line processing. RTC counts seconds, minutes, hours, date of the month, month, day of the week, and year with leap-year compensation valid up to 2100. The RTC selected here is DS1307. It is low cost, easy to solder, and can run for years on a very small coin cell (3 V CMOS battery) which runs continuously even in power failure.

- **RTC Event 1:** It checks whether the microcontroller is ready to receive the meter readings.
- **RTC Event 2:** It will send the meter readings to respective customer via main server.
- **RTC Event 3:** It will check whether the bill has paid in time or not. If it was not paid then the power will be turned OFF automatically.

E. Relay

It provides the useful functionality of remotely switching the power ON/OFF to the user. It consists of a protective relay, breaker control circuit & line breaker.

F. GSM Module

In this application, we are using SIM900 GSM. It receives the data from microcontroller and sends it to the customers.

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GSM (Global System for Mobile communications) is an open, digital cellular technology used for transmitting mobile voice and data services as shown in Fig.3. GSM supports voice calls and data transfer speeds of up to 9.6 kbit/s, together with the transmission of SMS (Short Message Service). Power supply range is the DC supply voltage : 3.3V-4.2V, Typical value : 4.0V. Current consumption is Off mode <100mA and sleep mode is 2mA(min). GSM is the world's most popular standard for mobile telephony systems GSM is used by over 1.5 billion people across more than 212 countries and territories. GSM also pioneered low-cost implementation of the short message service (SMS) which allows parties to exchange delay-tolerant short text messages. The popularity and wide coverage of cellular networks have attracted researchers to consider the use of SMS service.



Fig.3. GSM Module.

III. SYSTEM IMPLEMENTATION & RESULTS

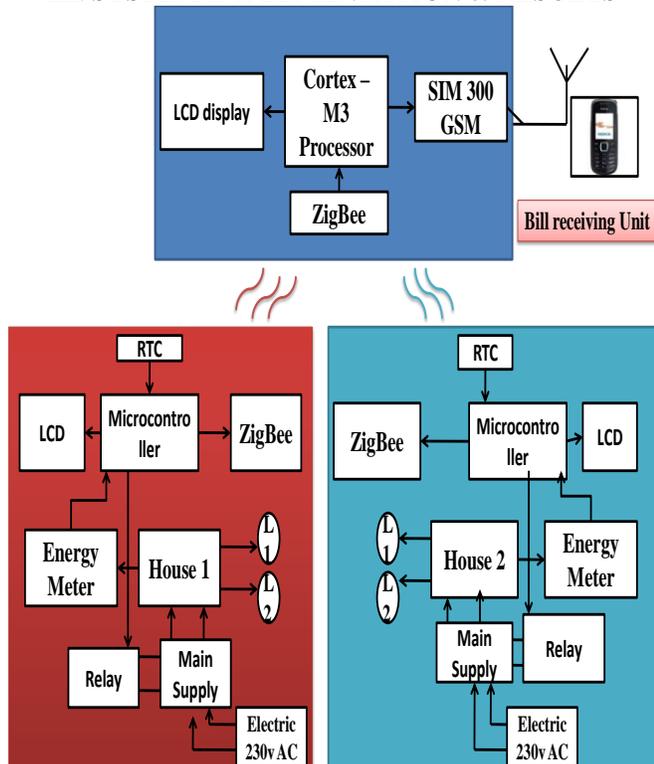


Fig.4. Block Diagram.

Cortex-M3 LPC1768 Microcontroller plays an important role in this project as shown in Fig.4. It receives the signals from the various parameters in form of bits and delivers the output. In this project, it contains three modules namely main server, house 1 and house 2. House 1 and House 2 have meter 1 and meter 2 respectively.

Functional Flow Chart: Functional flow chart is as shown in Figs.5 and 6.

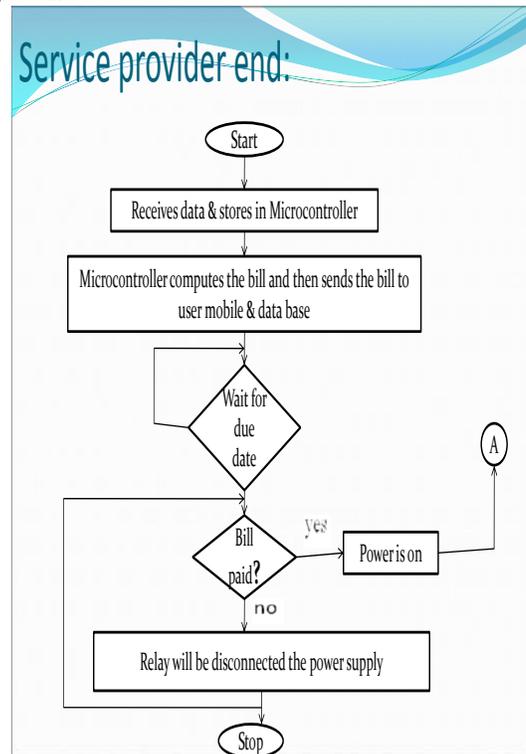


Fig.5. Flow chart At Service Provider End.

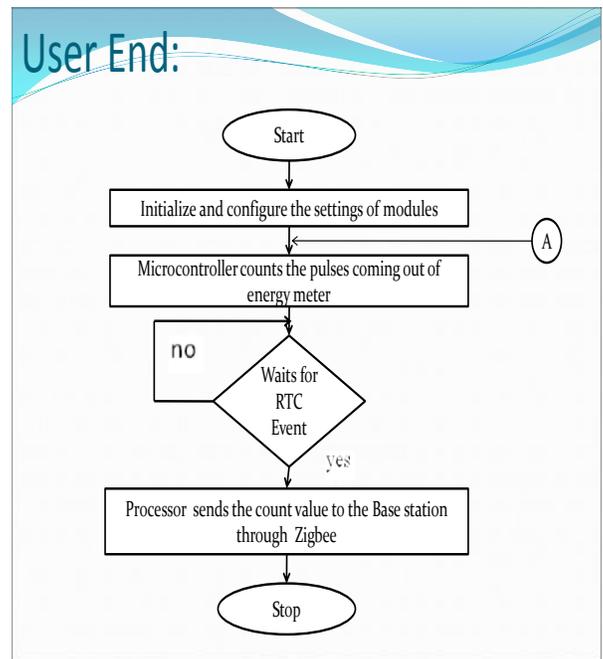


Fig.6. Flow chart At User End.

Energy meter gives the reading units of meter 1 and meter 2 which is shown on LCD display. It sends the reading units to 8051 microcontroller which sends to main server through Zigbee. Main server stores the data of reading units in Cortex-M3 LPC1768 microcontroller and send it to the respective customer through GSM network as shown in Figs.7 to 9. Here billing can be sent and paid through mobile instead of going to the place. It can reduce time. If the bill was paid by the customer through mobile, then GSM send commands to Cortex-M3 LPC1768 microcontroller to keep power ON automatically. If the bill was not paid by the customer, then GSM send commands to Cortex-M3 LPC1768 microcontroller to turn power OFF automatically.



Fig.7. Hardware module of Service Provider.



Fig.9. Hardware module of Energy Meter 2 at another User end.



Fig.8. Hardware module of Energy Meter 1 at User end.

Fig.10 represents, Service provider initiating the SIM and ask the customer to give missed call and register the phone number. After successful registration, the following message will be sent to the register mobile phone.

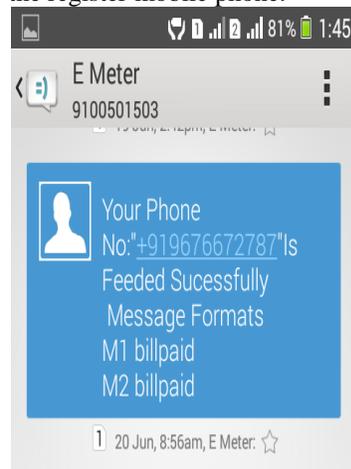


Fig.10. SIM Registered successfully.

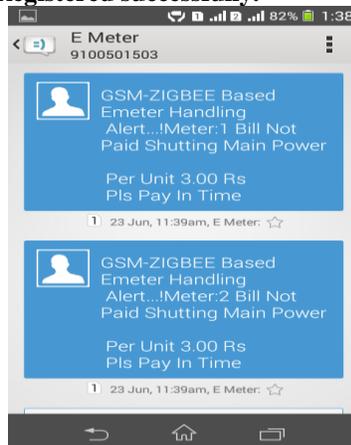


Fig.11. Bill not paid message sent to customer.

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Fig.11 represents, If the bill was not paid in time the main power will be shutting down automatically and message will be sent to the customer. The following message will be sent to the register mobile phone. Fig.12 represents, If the customer 1 paid the bill, Meter 1 power is ON and if the bill was not paid, Meter 2 power will be turned OFF automatically. The following message will be sent to the register mobile phone.

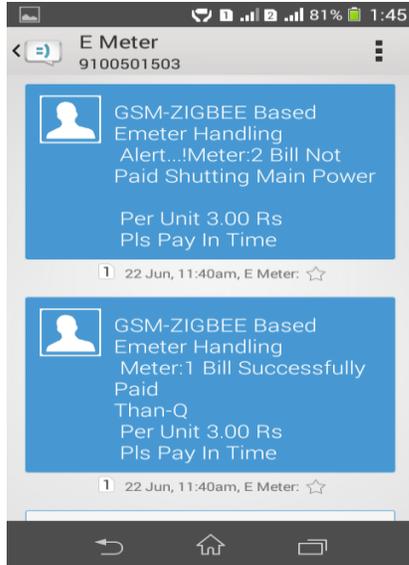


Fig.12. Meter 1 bill paid and Meter 2 bill is not paid.

Fig.13. represents, Electricity Bill was generated and it will be displayed on LCD.



Fig.13. Generating bill.

Fig.14 represents, It was showing on LCD display that customer had to pay the bill in time.



Fig.14. Bill Time.

Fig.15. represents, If the Meter 1 bill was not paid, it will be displayed on LCD.



Fig.15. Meter 1 bill not paid displaying on LCD display.

Fig.16. represents, Meter2 bill paid message was displayed on LCD.



Fig.16. Meter 2 bill paid displaying on LCD display.

Fig.17. represents, If the bill was not paid by the customer within time then the power will be turned OFF automatically. The following message will be displaying on LCD.

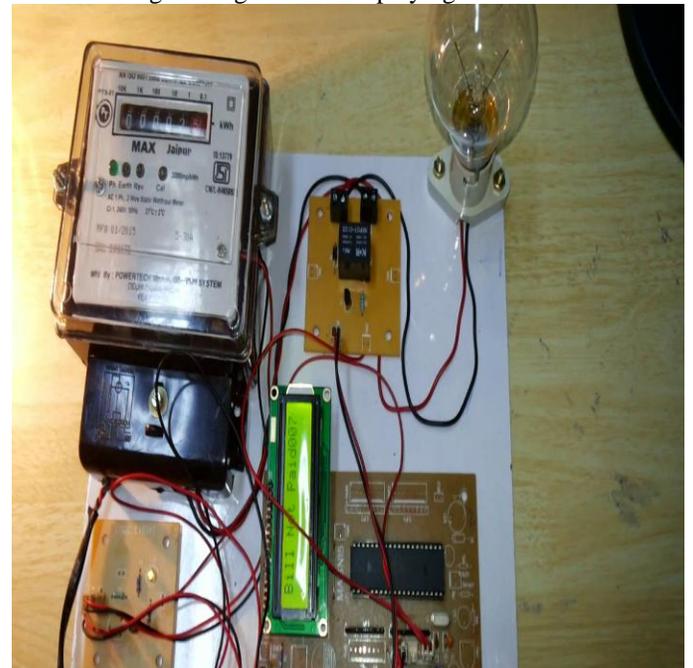


Fig.17. Indication to power OFF status.

Fig.18. represents, If the bill was paid by the customer within time then the power will be ON automatically. The following message will be displaying on LCD.



Fig.18. Indication to power ON status.

IV. CONCLUSION

Hence the GSM and Zibee based Automatic Energy Meter Reading System with Instant Billing was implemented. This system combines Zigbee technology with GSM network. It is using Cortex-M3 LPC1768 as important processor to do communication in short distance and SIM900 to achieve communication function in long distance, using RS-232 link communication joint to connect the communication between Zigbee and GSM technology. This system has many significant excellences , such as wireless, low cost, a little power consumption, great quantity of data transmission , while it has great extension & security. The using of embedded system improves the stability of wireless data transmission. The cost efficient transmission of readings ensures that power consumption values can be transmitted more frequently to a remote station. The generated bill is available as SMS at the time of generation itself. The same idea can be expanded to water and gas meter reading system by proper modification.

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Author's Details:



Suri Revidi is pursuing M. Tech in Embedded Systems at CMR College of Engineering and Technology, Kandlakoya, Hyderabad, TS-India.



M. Veda Chary received his M. Tech degree in Electronics & Communication Engineering from JNTU, Hyderabad, currently working as an Associate Professor, ECE Department in CMR College of Engineering & Technology, Hyderabad, TS-India.

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A. Kishore Reddy received his M. Tech degree in Electronics & Communication Engineering from JNTU, Hyderabad, currently working as an Assistant Professor, ECE Department in CMR College of Engineering & Technology, Hyderabad, TS-India.