ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 3, Special Issue, March-April 2013, An ISO 9001: 2008 Certified Journal.
E-NSPIRE, A National Level Conference held at Pravara Rural Engineering College, Loni, Maharashtra, INDIA.

Energy Meter Automation using ZigBee Protocol

Prof. Vishal Pande, Gurmukh Singh Ghatorora, Deepak Bhondekar, Mayur Haldankar, Shemal Gandhi.

Abstract- In a country like India with over millions of kilometers of transmission lines and billions of consumers the task of collecting information related to energy consumption of each and every consumer is a tedious job. The meter reader has to travel extensively and take reading manually to collect the required data. This reading is then feed in a central database. Then the bill gets generated later with help of software. This paper intends to reduce this tedious work by automating the process of collecting data from consumer's electricity meter. This paper proposes use of GSM modem to send alerts to the consumer regarding the energy consumption of a particular energy meter unit. In case of failure of payment of dues by a consumer the controller can disconnect the power supply of consumer. This paper also proposes to automate this step by using a SPDT Relay.

Keywords-Energy meter, ZigBee, GSM Module, Visual Basics.

I. INTRODUCTION

TheEnergy meter reading is a tedious and an expensive affair. The meter reader has to go and take the reading manually to issue the bill, which will be generated later with help of some software. If we automate the billing and payment system, it will help reduce the tedious task and help in saving precious resources [1]. This paper proposes a new network communication system for energy meter reading by integrating communication technology and software system along with the existing meters. A wireless or wired communication system will be integrated with electronic energy meter to have remote access over the usage of electricity [2]. Now-a-days there has been a rapid growth in wireless networking based on high speed communications and relatively long range applications like IEEE 802.11 wireless local area network(WLAN) standards.Some well known devices like Bluetooth, WiFi, GPRS, GSM, CDMA to name a few. For such wireless applications we require longer battery life, lower data rates and less complexity then those from existing standards. For such wireless applications a new standard called IEEE 802.15.4 has been developed. The new standard is called as ZigBee [3]. ZigBee is a low cost, low power wireless mesh networking standard. This allows the technology to be widely deployed in wireless monitoring and control applications, the low power allows longer life wit smaller batteries and mesh networking provides high reliability and larger range.An efficient implementation of IEEE 802.15.4 compliant radio-on-a-chip is demonstrated by identifying potential low power features in the standard, suitable transreceiver and CMOS designs [4]. Even though they are two different modules it is simple to interface them. The energy meter delivers this reading details as and when it is demanded by the controller system. The communication system is further connected with electricity regional/sub-regional office, which will rather act as a base station[5]. Instead of creating a separate communication system and backbone, any of the secure existing communication service infrastructures may also be utilized to avoid any initial investments. The communication channel is identified by the consumer's number and it is secured by any cryptographic standards .Base office can verify the energy meters performance by checking the day to day consumption of energy. This will also help to avoid any tampering or break down of energy meter.

II. ZIGBEE CONCEPT

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for wide personal area networks. ZigBee devices are often used in mesh network form to transmit data over longer distances, passing data through intermediate devices to reach more distant ones [6]. Any ZigBee device can be tasked with running the network. ZigBee is targeted at applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 kbps. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth[10] ZigBee is a low-cost, low-power, wireless mesh network standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications. Low power-usage allows longer life with smaller batteries. Mesh networking provides high reliability and more extensive range. ZigBee chip vendors typically sell integrated radios and microcontrollers with between 60 KB and 256 KB flash memory. ZigBee operates in the industries at 2.4 GHz in most parts. Data transmission rates vary from 20 to 900 kilobits/second. The ZigBee network layer natively supports both star and tree typical networks, and generic mesh networks. Every network must have one coordinator device, tasked with its creation, the control of its parameters and basic

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 3, Special Issue, March-April 2013, An ISO 9001: 2008 Certified Journal.
E-NSPIRE, A National Level Conference held at Pravara Rural Engineering College, Loni, Maharashtra, INDIA.

maintenance. Within star networks, the coordinator must be the central node. Both trees and meshes allows the use of ZigBee routers to extend communication at the network level. ZigBee builds upon the physical layer and medium access control defined in IEEE standard 802.15.4 (2003 version) for low-rate WPANs. The specification goes on to complete the standard by adding four main components: network layer, application layer, *ZigBee device objects* (ZDOs) and manufacturer-defined application objects which allow for customization and favor total integration.ZigBee protocols are intended for embedded applications requiring low data rates and low power consumption.

III. ENERGY METER

The circuit starts with the Mains 230V AC Input, followed by a SPDT Relay.The load is connected to a current sensor. When current is consumed by the load it is sensed by the current sensor & a respective proportional reading is passed on to the Energy Meter. Energy Meter consists of two main components, analog to digital converter (ADC) & frequency generator. The output of the current sensor which is a voltage proportional to current consumed is given to the ADC, wherein ADC converts the analog voltage into digital voltage.This DC voltage is in the form of pulses. The frequency generator converts these signal into pulses of certain frequency. Frequency generator generates a pulse at its output after receiving a predefined set of pulses from the ADC. This pulse is given to the micro – controller PIC 16f877 for further processing. Micro – controller performs multiple tasks at its output.It displays the energy meter readings on the LCD display.It also encodes the reading and transmits it through the ZigBee module, to the control room.[12] ZigBee comprises of a transmiting hardware using which the encoded information is transmitted. Thus use of ZigBee provides complete automation without any human intervention,thus upgrading its security & efficiency. ZigBee transmits this information in the radio frequency range.The GSM Modem gets information from the micro–controller.This GSM modem is used to alert the consumer regarding the consumption details of the respective meter unit.In case a consumer fails to pay the bill, then a predefined warning can be sent to the consumer requesting to clear the dues failing to which their power supply can be disconnected. SPDT Relay is used to disconnect the mains from the Load. Relay will perform this action, when it is instructed by the micro-controller.This can be done by receiving a signal from the control room

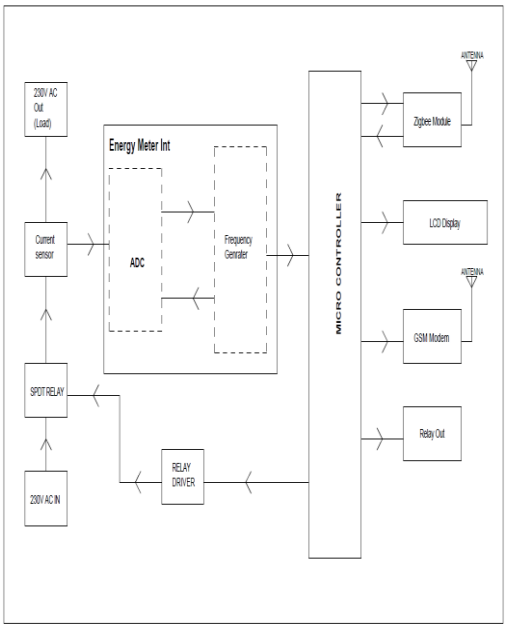

Fig1. General Block Diagram of Meter Side

IV. COMMUNICATIONHARDWARE

A. IEEE 802.15.4

The ZigBee Qualification Process involves a full validation of the requirements of the physical layer. All radios derived from the same validated semiconductor mask set would enjoy the same RF characteristics. An uncertified physical layer that malfunctions could cripple the battery lifespan of other devices on a ZigBee network. ZigBee radios have very tight constraints on power and bandwidth. Thus, radios are tested with guidance given by Clause 6 of the 802.15.4-2006 Standard is standard specifies operation in the unlicensed 2.4 GHz. Sixteen channels are allocated in the 2.4 GHz band, with each channel requiring 5 MHz of bandwidth. The 2.4 GHz band provides up to 250 kbit/s, 915 MHz provides up to 40 kbit/s and 868 MHz provides a data rate up to 20 kbit/s. The actual data throughput will be less than the maximum specified bit rate due to the packet overhead and processing delays. The radios use direct-sequence spread spectrum coding, which is managed by the digital stream into the modulator. Binary phase-shift keying (BPSK) is used in the 868 and 915 MHz bands, and Offset quadrature phase-shift keying (OQPSK) that transmits two bits per symbol is used in the 2.4 GHz band. The raw, over-the-air data rate is 250 kbit/s per channel in the 2.4 GHz band, 40 kbit/s per channel in the 915 MHz band, and 20 kbit/s in the 868 MHz band. Transmission range is between 10 and 75 meters (33 and 246 feet) and up to 1500 meters for ZigBee PRO although it is heavily dependent on the particular environment. The output power of the radios is generally 0 dBm (1 mW)

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 3, Special Issue, March-April 2013, An ISO 9001: 2008 Certified Journal.
E-NSPIRE, A National Level Conference held at Pravara Rural Engineering College, Loni, Maharashtra, INDIA.

B. GSM Modem

GSM (Global System for Mobile communications) is the most popular standard for mobile phones in the world..GSM differs from its predecessors in that both signaling and speech channels are digital, and thus is considered a *second generation* (2G) mobile phone system.[11] This has also meant that data communication was easy to build into the system. The ubiquity of the GSM standard has been an advantage to both consumers and also to network operators.GSM also pioneered a low-cost (to the network carrier) alternative to voice calls, the short message service, which is now supported on other mobile standards as well. Another advantage is that the standard includes one worldwide emergency telephone number-112. GSM is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity. GSM networks operate in a number of different frequency ranges . Most 2G GSM networks operate in the 900 MHz or 1800 MHz bands.

GSM-900 uses 890–915 MHz to send information from the mobile station to the base station (uplink) and 935–960 MHz for the other direction (downlink), providing 125 RF channels (channel numbers 0 to 124) spaced at 200 kHz. Duplex spacing of 45 MHz is used. Time division multiplexing is used to allow eight full-rate or sixteen half-rate speech channels per radio frequency channel. There are eight radio timeslots grouped into what is called a TDMA frame. Half rate channels use alternate frames in the same timeslot. The channel data rate for all 8 channels is 270.833 kbit/s, and the frame duration is 4.615 ms. The transmission power in the handset is limited to a maximum of 2 watts in GSM850/900 and 1 watt in GSM1800/1900.

V. DESIGN CONSIDERATION

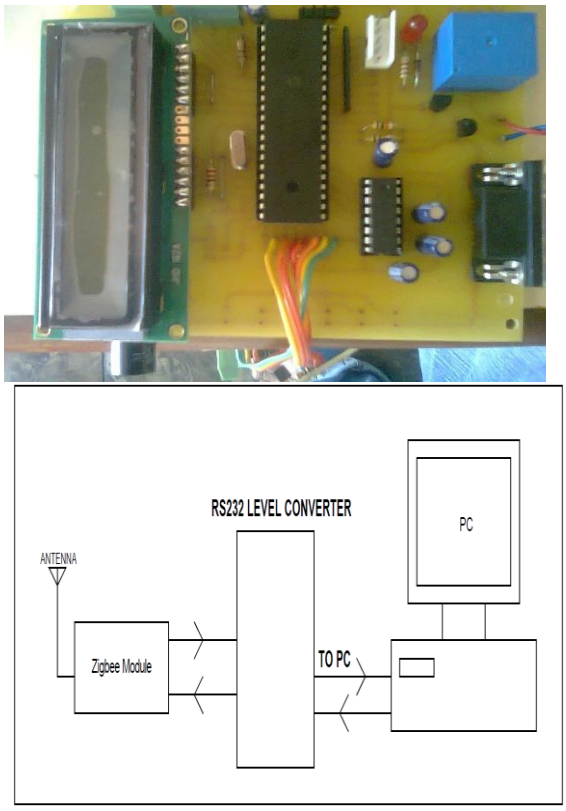

Fig 2. Control Room Section

1. The current sensor resistor is of value 0.038 ohms, hence because of the low value of resistance there is less power dissipation.
2. The energy meter IC CS757 works on a low voltage of 5 volts hence can work on digital signals also.
3. ZigBee Trans-receiver works on 2.4 GHz frequency.
4. The operating current of ZigBee Trans receiver is 45mA.
5. Relay driver switches voltage from 12V to 5V.
6. The operating speed of the PIC 16f877 is 20MHz.
7. RS232 circuit converts 5V signal from ZigBee to 12V for PC[8].

VI. SOFTWARE

Visual Basic (VB) is a third-generation event-driven programming language and integrated development environment (IDE) from Microsoft for its computer programming model first released in 1991. Visual Basic is designed to be relatively easy to learn and use. A programmer can put together an application using the components provided with Visual Basic itself.[9] Like the BASIC programming language, Visual Basic was designed to be easily learned and used by beginner programmers. The language not only allows programmers to create simple GUI applications, but to also develop complex applications. Programming in VB is a combination of visually arranging components or controls on a form, specifying attributes and actions of those components, and writing additional lines of code for more functionality.

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 3, Special Issue, March-April 2013, An ISO 9001: 2008 Certified Journal.
E-NSPIRE, A National Level Conference held at Pravara Rural Engineering College, Loni, Maharashtra, INDIA.

Since default attributes and actions are defined for the components, simple program can be created without the programmer having to write many lines of code.

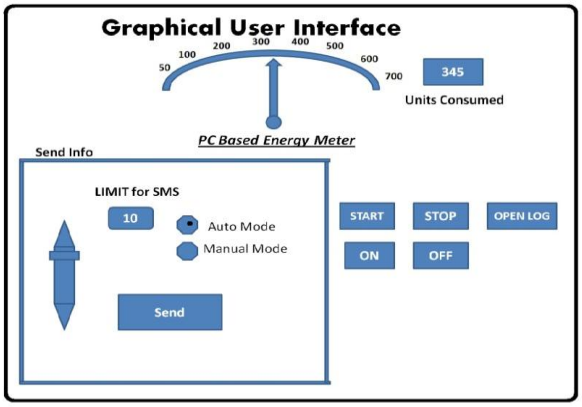

Fig 3. Graphical User Interface on Computer

VII. CONCLUSION

We have presented a basic wireless sensor network based on IEEE 802.15.4 on ZigBee alliance standards, with emphasis to requisite used in the development of a wireless sensing network for automation of energy meter.The sensor network which is developed is implemented to transmit readings of multiple energy meters. The result shows that ZigBee can be used to transmit the data continuously for a distance of 85 meters. To extend the range of data transmission we can add routers to extend the range upto 100s of kilometers. ZigBee is the best option for low data rate sensor network with small size low power requirement.

VIII. FUTURE SCOPE

By increasing the range of ZigBee transreceivers we can increase the number of areas under one control room. With wide range success of this project in the near future, we may switch from ZigBee to Internet service for wireless communication because it is costlier than ZigBee.

REFERENCES

[1] "A Survey of Communication Protocols for Automatic Meter Reading Applications" by Tarek Khalifa, Kshirasagar Naik and Amiya Nayak at IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 13, NO. 2, SECOND QUARTER 2011.

[2] "A Solution to Remote Detection of Illegal Electricity Usage via Power Line Communications" by I. Hakki Cavdar, Member, IEEE at IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 19, NO. 4, OCTOBER 2004.

[3] "Wireless Sensor Network for Process Automation using ZigBee Protocol" by S.L. Patil, Sachin Negi and U.M Chaskar at CiiT International Journal of Wireless Communication, vol 2, No. 2, Feb 2010.

[4] "Wireless Design of a Multi-Sensor System for Physical Activity Monitoring" by Lingfei Mo, Shaopeng Liu, Robert X. Gao*, Dinesh John, John Staudenmayer, and Patty S. Freedson.

[5] "Intelligent Online Measurement and Management of Energy Meter Data Through Advanced Wireless Network" by Tanmoy Maity, Department of Electrical Engineering Indian School of Mines and Partha Sarathi Das, Department of Electrical EngineeringDurgapur Institute of Advanced Technology andManagement.

[6] C.Qiang, S.J.ping, Z.Zhe, Z. Fan, ZigBee Based Intelligent Helmet forCoal Miners, IEEE World Congress on Computer Science andInformation Engineering, 2009, 433-35.

[7] 2001 Microchip Technology Inc. PIC16F87X Data Sheet28/40-Pin 8-Bit CMOS FLASH Microcontrollers.

[8] MAX 232 EIA-232 Driver/ Receiver by SLLS047L –H.

[9] "The Complete Reference Visual Basic 6" By Noel Jerke published by Tata McGrow Hill Education. Chapter 6- Designing User Interfaces (Page No. 187 to 243).

[10] "Wireless Communication & Networking" By Vijay K. Garg, (Page No. 688 to 710).

[11] "Wireless Communications" By T. L. Singal, (Page No. 400 to 441).

[12] "Wireless Communication & Networking" By Vijay K. Garg, GSM (Page No. 469 to 538).