

WIRELESS XBEE-BASED ENERGY METER MONITORING SYSTEM

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ABSTRACT

In this project, automatic meter reading (AMR) has been studied. Automatic meter reading (AMR), is the technology of automatically collecting consumption, diagnostic, and status data from water meter or energy metering devices (gas, electric) and transferring that data to a central database for billing, troubleshooting, and analysing. This technology mainly saves utility providers the expense of periodic trips to each physical location to read a meter. Another advantage is that billing can be based on near real-time consumption rather than on estimates based on past or predicted consumption. AMR technologies include handheld, mobile and network technologies based on telephony platforms (wired and wireless), radio frequency (RF), or power line transmission. For this study, AMR system in the form of handheld device has been developed. PIC Microcontroller unit has been used to continuously monitors and records the energy meter reading in its EEPROM. The meter reading will be sent to another microcontroller unit (handheld device) wirelessly to be displayed on LCD display. For transmission of data from the energy meter to the handheld device, XBee RF module has been used. Two XBee modules have been used in this project. The XBee modules have been used as RF transceiver to transmit and receive the energy meter reading. Result of this project is the meter reading displayed at both the sending-end LCD and receiving-end LCD.

ABSTRAK

Dalam projek ini, bacaan meter secara automatik telah dikaji. Bacaan meter secara automatik, adalah suatu teknologi di mana data penggunaan tenaga dikumpulkan secara automatik, diagnostik, dan status data dari meter air atau barangan permeteran tenaga (gas, elektrik) dan memindahkan data kepada pangkalan data pusat untuk bil, penyelesaian masalah, dan untuk dianalisis. Dengan teknologi ini, pembekal utiliti (TNB) dapat menjimatkan kos perbelanjaan perjalanan berkala untuk setiap lokasi fizikal untuk membaca meter. Selain itu, bil yang dikeluarkan adalah berdasarkan kepada penggunaan masa yang sebenar dan bukannya kepada anggaran yang berdasarkan pada masa lalu atau penggunaan yang diramalkan. Teknologi ini termasuklah alatan mudah alih, teknologi mudah alih dan rangkaian berdasarkan platform telefoni (berwayar dan tanpa wayar), berfrekuensi radio (RF), atau talian penghantaran kuasa. Untuk kajian ini, sistem bacaan meter automatik dalam bentuk alatan mudah alih telah dibangunkan. Pengawal mikro telah digunakan untuk memantau secara berterusan dan merekod bacaan meter tenaga ke dalam EEPROM. Bacaan meter akan dihantar ke pengawal mikro satu lagi (di peranti mudah alih) secara tanpa wayar dan kemudian dipaparkan pada paparan LCD 16x2. Bagi penghantaran data dari meter tenaga ke peranti mudah alih, modul XBee berfrekuensi radio telah digunakan. Dua modul XBee telah digunakan dalam projek ini. Modul XBee telah digunakan sebagai penghantar signal berfrekuensi radio untuk menghantar dan menerima bacaan meter tenaga. Hasil akhir projek ini adalah bacaan meter dapat dipaparkan di kedua-dua LCD yang telah dipasang pada pengawal mikro yang terdapat pada meter tenaga dan alatan mudah alih.

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LIST OF ABBREVIATIONS

AMR	-	Automatic Meter Reading
API	-	Application Program Interface
CD	-	Compact Disc
CPU	-	Central Processing Unit
CDMA	-	Code Division Multiple Access
DC	-	Direct Current
EDR	-	Enhanced Data Rate
EEPROM	-	Electrically Erasable Programmable Read Only Memory
EMI	-	Electromagnetic Interference
EUSART	-	Enhanced Universal Asynchronous Receiver Transmitter
GSM	-	Global System for Mobile Communications
GHz	-	Giga Hertz
GPRS	-	General Packet Radio Service
IC	-	Integrated Circuit
IEEE	-	Institute of Electrical and Electronics Engineers
kWh	-	kilowatt hour
LAN	-	Local Area Network
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
LPC	-	Large Power Consumer
MAC	-	Medium Access Control
MHz	-	Mega Hertz
OEM	-	Original Equipment Manufacturer

PCB	-	Printed Circuit Board
PIC	-	Peripheral Interface Controller
RM	-	Ringgit Malaysia
RF	-	Radio Frequency
S1	-	Series 1
S2	-	Series 2
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TNB	-	Tenaga Nasional Berhad
UART	-	Universal Asynchronous Receiver/Transmitter
USART	-	Universal Synchronous/Asynchronous Receiver/Transmitter
USB	-	Universal Serial Bus

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Nowadays, TNB send meter reader officer to read energy meters at their consumer houses monthly. However, this way is not practical anymore because it is quite costly. It is costly because the number of consumers has been greatly increased from year to year. Thus, TNB need to send more meter reader officer to residential areas for taking the energy meter reading. Although TNB still can send meter reader officers to take the energy meter reading, there still another problem arise. The problem is the energy meter at consumer's house maybe inaccessible. This may due to several factors such as weather condition or maybe guarding dog at the consumer house that prevent the officer from taking the meter reading.

There is already GSM-based Automatic Meter Reading (AMR) technology was used. However, this technology was used for Large Power Consumers (LPC) only. In this technology, GSM module is attached to each LPC's energy meter. Thus, the meter reading is done automatically without meter reader officer visiting the LPC site. But, this technology can't be applied to domestic consumers because it cost is very high since the number of domestic consumers are large.

For this research, “Wireless XBee-Based Energy Meter Monitoring System” was introduced. For this research, an automatic meter reading or AMR in the form of handheld device has been invented. This system is a one-way or continuous broadcast type system. The transmitter broadcasts readings continuously every few seconds. This means the reading device can be a receiver only, and the meter AMR device a transmitter only. Data goes one way, from the meter AMR transmitter to the meter reading receiver. The purpose of this project is to read the Domestic Energy Meter reading and transmit the reading to a display unit through XBee-based wireless transmission. This system enables the Electricity Department (TNB) to read the energy meter reading regularly without a meter reader officer visiting each consumer house. This can be achieved by the use of microcontroller unit (PIC18F4550) that continuously monitors and records the energy meter reading in its permanent (non-volatile) memory location. The energy meter reading will be displayed on 16x2 LCD display before it is transmitted to the receiving-end PIC and display it on 16x2 LCD at the receiving-end PIC.

There are two controlling modules (PICs) will be used in this system. The first PIC use to continuously record the energy meter reading and display it on 16x2 LCD display and the other one is the receiving-end PIC that will display the energy meter reading that has been displayed at sending-end LCD. The sending-end PIC that continuously records the energy meter reading will store the energy meter reading in its memory location before the data is forwarded to the receiving-end PIC and then display it on 16x2 LCD. The data transmissions between these two PICs are via UART serial connections of XBee modules which were connected to each PIC.

The major advantage of this system is the use of XBee modules which helps in wireless data transmission. Main features of this project are it is XBee-based wireless data transmission; the transmission line is secured and dynamic update of energy meter reading.

1.2 Objectives

Objectives of this project are:

- i. Continuously monitor the energy meter reading and display it on 16x2 LCD display
- ii. Monitors energy meter reading wirelessly and records the reading in microcontroller unit memory location
- iii. Using XBee RF modules as transceivers because of its low cost, low power consumption and has mesh networking capability which are high-reliability
- iv. Display energy meter reading on 16x2 LCD display wirelessly

1.3 Problems Statement

Due to the increasing number of consumers and residential areas, TNB need to send more energy meter officers to read the energy meter at consumer's house. It is quite costly to send more officers just to read the energy meter reading.

Sometimes, the energy meter in consumer's house is inaccessible by the energy meter officer. The energy meter maybe inaccessible by the energy meter reader officer due to bad weather condition (raining or stormy), the consumer's pet such as guarding dog or the gate is locked while the consumers is not at their house.

Due to the inaccessibility of the energy meter, the meter reader officer will do the estimate reading. The estimate reading is not accurate because the estimation is done by comparing energy usage by the consumer of the previous months.

1.4 Scopes Of Project

Scopes of this project are:

- i. This system is only for transmission of meter reading data from sending end-PIC connected to the energy meter to the receiving end-PIC
- ii. XBee RF modules used as transceivers only, not to store data or count pulses from energy meter
- iii. This system is for monitoring domestic analogue energy meter only

1.5 Thesis Outline

This development of Wireless Xbee-Based Energy Meter Monitoring System final draft is consists of five chapters. The brief outline of each chapter is presented below:

Chapter 1 (Introduction) introduces the background of this project. Objectives and scopes of project also have been presented in this chapter.

Chapter 2 (Literature Review) presents the reviews on previous researches conducted that is related to this project. There are ten literature reviews presented in this chapter.

Chapter 3 (Methodology) explained about the methods and procedure that has been done in this project. The system block diagram and all circuits for this project are shown in this chapter. This chapter also presented the hardware and software development for this project.

Chapter 4 (Result and Discussion) presents the results of this project. The results are shown in the form of pictures of the demonstrated project. The result has been discussed in this chapter.

Chapter 5 (Conclusion) explained conclusions of this project. Recommendations and commercialization of this project also has been presented in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Automatic Meter Reading, AMR

Automatic meter reading, or AMR, is the technology of automatically collecting consumption, diagnostic, and status data from water meter or energy metering devices (gas, electric) and transferring that data to a central database for billing, troubleshooting, and analysing ^[1]. This technology mainly saves utility providers the expense of periodic trips to each physical location to read a meter. Another advantage is that billing can be based on near real-time consumption rather than on estimates based on past or predicted consumption. This timely information coupled with analysis can help both utility providers and customer better control the use and production of electric energy, gas usage, or water consumption.

AMR technologies include handheld, mobile and network technologies based on telephony platforms (wired and wireless), radio frequency (RF), or power line transmission.

2.1.1 Radio frequency-based AMR

Radio frequency based AMR can take many forms. The more common ones are handheld, mobile, and fixed network. There are both two-way RF systems and one-way RF systems in use that use both licensed and unlicensed RF bands ^[1].

In a two-way or "wake up" system, a radio transceiver normally sends a signal to a particular transmitter serial number, telling it to wake up from a resting state and transmit its data. The meter attached transceiver and the reading transceiver both send and receive radio signals and data. In a one-way "bubble-up" or continuous broadcast type system, the transmitter broadcasts readings continuously every few seconds. This means the reading device can be a receiver only, and the meter AMR device a transmitter only. Data goes one way, from the meter AMR transmitter to the meter reading receiver. There are also hybrid systems that combine one-way and two-way technologies, using one-way communication for reading and two way communication for programming functions.

RF based meter reading usually eliminates the need for the meter reader to enter the property or home, or to locate and open an underground meter pit. The utility saves money by increased speed of reading, has lower liability from entering private property, and has less chance of missing reads because of being locked out from meter access.

The technology based on RF is not readily accepted everywhere. In several Asian countries the technology faces a barrier of regulations in place pertaining to use of the radio frequency of any radiated power. For example in India the radio frequency which is generally in ISM band is not free to use even for low power radio of 10 mW. Majority of manufacturers of electricity meters have radio frequency devices in the frequency band of 433/868 MHz for large scale deployment in European countries. The frequency band of 2.4 GHz can be now used in India for outdoor as well as indoor applications but few manufacturers have shown products within this frequency band. Initiatives in radio frequency AMR in such countries are being taken up with regulators wherever the cost of licensing outweighs the benefits of AMR.

2.2 ZigBee-GSM Based Automatic Meter Reading System

AMR technology has proved effective in reading meter readings with TNB's Large Power Consumers ^[2]. In the AMR system, Global System for Mobile communication-based (GSM) AMR has been used. In this system, GSM module is attached to each LPC's energy meter. Thus, the energy meter reading can be done automatically by using GSM-based communication without visiting the consumer's site. However, TNB did not use this AMR system for their domestic customers because the cost is quite high since the number of domestic customers is increasing from year to year.

In the paper, AMR technology with least cost has been described. The new system is a combination of GSM and Zigbee technology. In the system, Zigbee module will be attached to domestic customer energy meter by using interface board and the data collector are connected to the central computer by using GSM. The system is suitable with this country environment which was already implemented GSM-based AMR in LPC. With this system, TNB can save their cost in doing meter reading and provide better services to their customers.

2.3 Networked Wireless Meter Reading System Based on Zigbee Technology

Automatic meter reading (AMR) system based on GSM/GPRS communication technology belongs to wireless AMR system. GSM/GPRS has overlay 95% country already in the recent 10 years. The overcasting range is vast, including country and city. But the fee of using GSM/GPRS network is needed and the cost of hardware system for the GSM/GPRS network is very high ^[3]. In the paper, a remote real time AMR system based on wireless networks was presented. The system structure consists of measure meters, sensor nodes, data collectors, server and wireless communication network.

For short distance transmission, Zigbee communication was used by data collectors to collect data from the meter sensors. For long distance transmission, from the data collector to the server, TCP/IP protocol was used. The system presented advantages are networked, wireless, moveable, high-reliability and lower power-consuming. Using of embedded system improves stability of wireless data transmission. By using this system, meter reading task can be finished at the management department of residence area or Electricity Department (TNB).

2.4 Automatic Electric Meter Reading System Based on Zigbee

Automatic Electric Meter reading is one method of reading and processing data automatically with computer and communication. It is the need of improving the automatic level of energy consumption and the necessity of rapid development of computer and communication technology. AMR system may relieve energy meter reader officer's labour intensity, reduce meter reading mistake and also has the advantage of high speed and good real-time ^[4].

2.5 Remote Real Time Automatic Meter Reading System Based on Wireless Sensor Networks

A remote real time AMR (Automatic Meter Reading) system based on wireless sensor networks is presented in this paper. The structure of system employs distributed structure based on wireless sensor networks, which consists of measure meters, sensor nodes, data collectors, server and wireless communication network. For a short distance transmission, the data collector collects data from the water meter sensors using the RF and ZigBee communication. For a long distance transmission, from the data collector to the server, system uses CDMA (Code Division Multiple Access) cellular network. The water meter data are received at the server through LAN using TCP/IP protocol. Along with the development of country economic and the improvement of national power, people demand more and more

intelligent residences. In the meantime, the power supply, water supply, gas supply, heat supply and the management department of residence area press for transform the conventional meter reading method which is time consuming, strenuous and low-veracity ^[5].

2.6 Wireless Communication System for Energy Meter Reading

Energy meter reading is a boring and costly affair. The meter reader has to go and take the reading manually to issue the bill, which will later be entered in the software to automate the billing and payment system. It would have reduced the laborious task and financial wastage if can automate the manual meter reading process and bill data entry process ^[6]. In this paper, a new network communication system for energy meter reading by integrating communication technology and software system along with the existing meters has been proposed. Electronic energy meter will be integrated with a wireless or wired communication system to have remote access over the usage of electricity. The communication system is further connected with electricity regional/sub-regional office. This regional/sub-regional office will rather act as a base station. 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. Besides, any tampering or break down of energy meter can be avoided.

A theoretical model of an efficient and secure Network Communication System for Energy Meter Reading problems has been proposed in this paper. When the Automatic Electronic Energy Meter is introduced, the overhead expense for meter reading will be almost zero.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Project Overview

Figure 3.1 below shows the whole system block diagram. Two units of PIC18F4550 have been used for this project. One of the PIC Microcontroller functions as sending-end PIC while the other one functions as receiving-end PIC. The sending-end PIC has been interfaced with energy meter pulse counter circuit. The PIC has been programmed to count the pulse from energy meter and then convert the pulse count into energy meter reading by using mathematical formula. The programming for the energy meter pulse counter circuit was shown in Appendix B. After that, the energy meter reading will be displayed on 16x2 LCD display. The meter reading data will be stored in PIC EEPROM.

After the meter reading has been displayed at the sending-end LCD, the meter reading data will be sent to receiving-end PIC via XBee module serial communication. The receiving-end PIC has been programmed to display meter reading data received from the sending-end PIC on another 16x2 LCD display.

Two XBee modules have been used as transceiver in this system. The first XBee module has been attached to the sending-end PIC for use as meter reading data transmitter while the other XBee module has been attached to receiving-end PIC for use as meter reading data receiver. An LCD display has been attached to each PIC to display the energy meter reading data from energy meter pulse counter or received at receiving-end PIC. Two 4 MHz crystal oscillators have been used in the system. The

purpose of the crystal oscillator is to create an electrical signal with a very precise frequency in the system.

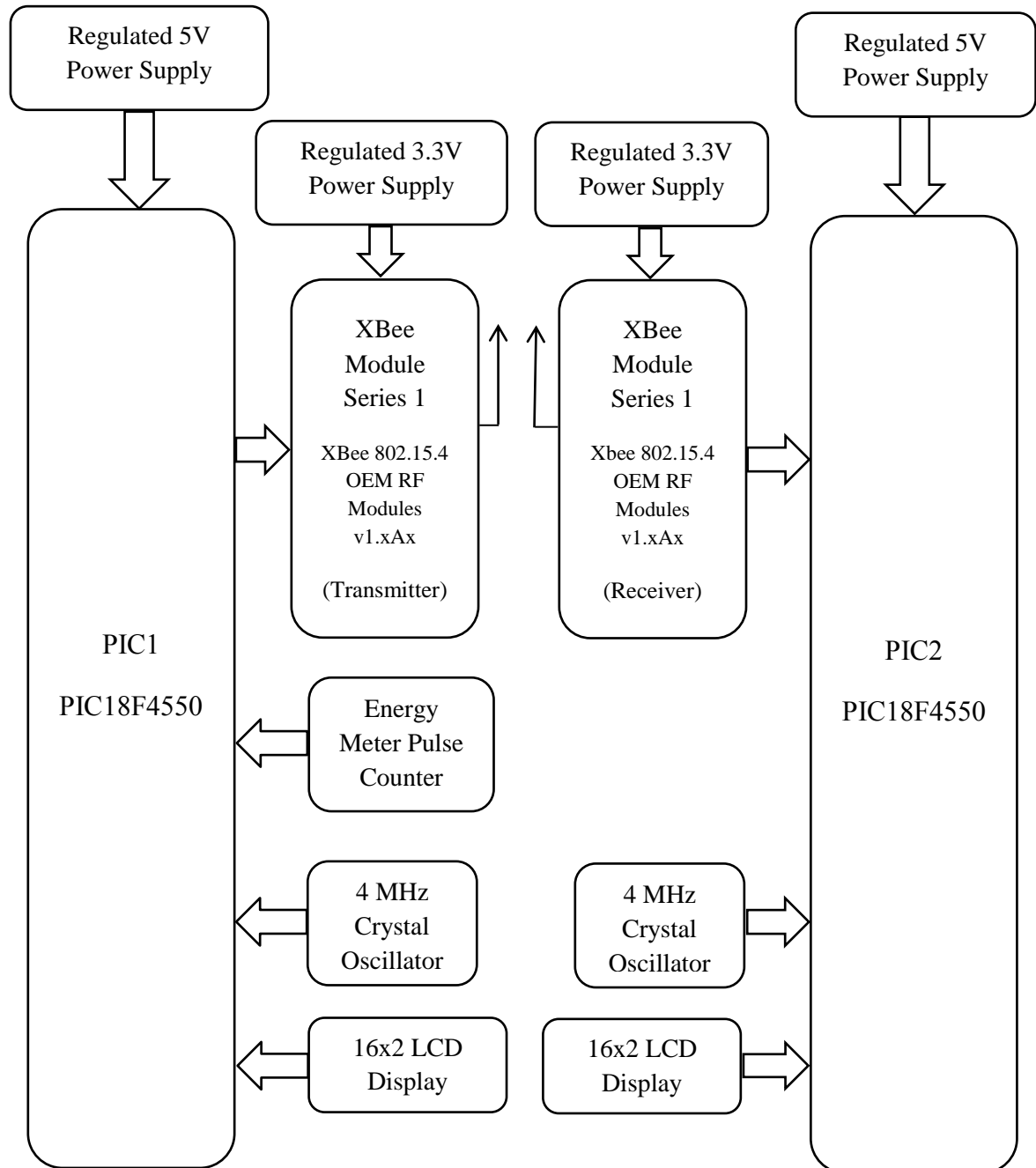


Figure 3.1: Block Diagram of the System