



UNIVERSITI PUTRA MALAYSIA

**IMPLEMENTATION OF DATA TRANSMISSION USING X-10
PROTOCOL WITHIN HOUSEHOLD WIRING**

TAN LAY KHIM

ITMA 2007 3



**IMPLEMENTATION OF DATA TRANSMISSION USING X-10 PROTOCOL
WITHIN HOUSEHOLD WIRING**

By

TAN LAY KHIM

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements for the Degree of Master of Science**

December 2007



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Professor Mohd. Yusof bin Sulaiman, PhD

Institute: Institute of Advanced Technology

Home automation refers to applications of technology to control function in the house and communications within the inside and outside world. One of the major benefits of smart homes to consumers is its ability to incorporate energy management features. One smart home system manufacturer claims to be able to reduce the electricity bill by 30% depending on the home consumption. Smart homes can even go further in energy management by keeping track of the energy usage of each and every appliances in the house. Such features allow the user to know what is using too much electricity and adjust things accordingly. It is obvious that if cost is to be minimized, usage of the electricity has to be monitored more accurately and carefully. An automated electrical power meter can be used to achieve this objective. In one version of the automated electrical power meters the power consumption of an appliance can be read remotely by using the existing electrical wiring. In this mode data transmission plays an important role. In this work the transmission of data between the transmitter and the receiver of a



house using X-10 protocol is studied and applied. X-10 protocol is a scheme of transmitting signal through existing electrical household cable to control appliances. Therefore, the main objective of this research is to design and assemble the hardware of a transmitter and a receiver for data transmission using power line and to develop the software for a micro-controller.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**IMPLEMENTATION OF DATA TRANSMISSION USING X-10 PROTOCOL
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Oleh

TAN LAY KHIM

Disember 2007

Pengerusi: Profesor Mohd. Yusof bin Sulaiman, PhD

Institut: Institute of Advanced Technology

Rumah pintar merujuk kepada aplikasi teknologi untuk mengawal pelbagai fungsi dalam rumah serta komunikasi dengan dunia dalaman dan luaran. Salah satu kelebihan rumah pintar kepada pengguna ialah kemampuannya untuk digabungkan dengan fungsi pengurusan tenaga. Malah, salah satu pengeluar sistem rumah pintar mendakwa mampu mengurangkan bil elektrik sebanyak 30%, bergantung kepada penggunaan elektrik di rumah. Dalam pengurusan tenaga, rumah pintar boleh juga dilanjutkan fungsinya dalam pengawasan penggunaan tenaga bagi setiap alat elektrik di dalam rumah. Alat elektrik yang menggunakan tenaga yang banyak boleh dipadamkan apabila tidak diperlukan untuk membantu menurunkan kosnya. Jika kosnya ingin dikurangkan, maka penggunaan tenaga perlu diawasi dengan lebih tepat dan prihatin. Meter kuasa elektrik automasi boleh digunakan untuk mencapai matlamat ini. Salah satu versi meter kuasa elektrik automasi membolehkan pembacaan jarak jauh penggunaan tenaga bagi suatu perkakas dengan menggunakan pewayaran elektrik yang sedia ada. Menggunakan mod ini,

transmisi data akan memainkan peranan yang penting dalam meter kuasa elektrik automasi. Dalam kerja ini, transmisi data antara alat penghantar dan penerima menggunakan protokol X-10 dikaji dan digunakan. Protokol X-10 adalah satu skema penghantaran isyarat melalui pewayaran elektrik sedia ada untuk mengawal alat elektrik. Dengan demikian, objektif bagi penyelidikan ini adalah untuk mereka dan memasang perkakasan bagi transmisi data dengan menggunakan pewayaran talian kuasa dan menghasilkan perisian program bagi mikropengawal.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my most sincere gratitude to my supervisor, Prof. Dr. Mohd Yusof bin Sulaiman for his invaluable guidance, advice, and patience throughout the duration of completing this research. Without his untiring guidance, I could not have completed my work successfully.

I would like to take this opportunity to extend my indebtedness to all the supervisory committee members, Dr. Abdul Rahman Ramli, and Dr. Zukifly Abbas for their guidance and advice.

Words cannot truly express my deepest gratitude and appreciation to my beloved parents, my brother, and my sister for their support and belief in me; and most of all, a special thank to Chong Hui Yng, for her encouragement, attentiveness and devotion.



I certify that an Examination Committee has met on 7th December 2007 to conduct the final examination of Tan Lay Khim on his Master of Science thesis entitled “Implementation of Data Transmission Using X-10 Protocol Within Household Wiring” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the degree of Master of Science.

Members of the Examination Committee were as follows:

Nor Mariah Bt. Adam, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Zaidan B. Abdul Wahab, PhD

Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Zainal B. Abidin Sulaiman, PhD

Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Mohd Alauddin Mohd Ali, PhD

Professor
Department of Electrical, Electronic and Systems Engineering
Faculty of Engineering
Universiti Kebangsaan Malaysia
(External Examiner)

HASANAH MOHD. GHAZALI, PhD

Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 1 April 2008



This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Mohd Yusof bin Sulaiman, PhD

Professor
Institute of Advanced Technology
Universiti Putra Malaysia
(Chairman)

Abdul Rahman Ramli, PhD

Professor
Institute of Advanced Technology
Universiti Putra Malaysia
(Member)

Zukifly Abbas, PhD

Professor
Faculty Science
Universiti Putra Malaysia
(Member)

AINI IDERIS, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 10 April 2008



DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

TAN LAY KHIM

Date: 14 Feb 2008



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CHAPTER I

INTRODUCTION

Introduction

The world evolving around us today is filled with a wide range of advanced technology. Advances in technology continue to make a tremendous impact on all of our lives. Personal computers, cellular phones, faxes and the internet have transformed how and where business is transacted in the present being. It has become an essential part of the daily human lives that most systems are developed to be automatic systems. These automated systems are used largely in industrial sectors, and are gradually applied in houses, known as home automation. Home automation technology holds the potential for even greater change in the way we live by making our homes safer, more convenient and more connected to the outside world. Home automation refers to applications of technology to control functions in the home and communications with the outside world. Emerging home automation technology has great potential to help people with disabilities and other adults to live more independently in their own homes - improving their quality of life and reducing reliance upon others to meet daily living needs. Home automation offers smart living technologies, thus able to provide comfortable and convenient living. Today, while we still have to dress ourselves, many of our homes' functions, such as lighting, heating and air conditioning, entertainment, security, water management and etc, can be monitored and controlled automatically. Furthermore, this can be extended to electrical power meter.



Energy management

Energy management is an activity organised to optimise the use of energy by avoiding waste or recovering unused energy in processes or facilities. Energy management primarily seeks to utilise energy (electricity and fuel) more efficiently without reducing production levels or lowering product quality, safety and environmental standards. When an organisation practices good energy management, top management and employees become more aware of how energy is used, the actual cost of energy and the methods and equipment that can be used to control and reduce energy waste (32). In industrial sector, there are a few of implied benefits and positive aspects of energy management that is worth to be aware of:

- Saving energy always leads to lower emissions (eg less smoke and less emission of green house gases) from the manufacturing sector.
- Firms achieving savings in energy cost can improve their resilience and competitive position against other competitors amongst domestic firms and in export markets.
- Effective energy management improves ability to better withstand future energy cost increases or energy curtailments.
- Energy management programmes can help identify productivity improvement and costs reduction opportunities that may relate to areas other than energy. Since energy management incorporates many disciplines (for example, engineering, management, human relations) it often results in improved utilisation of other resources such as raw materials and manpower (32).

Given that there are so many benefits of energy management implementation, energy management should not only apply to industrial company, it could further expand to residential sector.

Problem Statement

In Malaysia, the demand for energy continues to grow, with not many changes to the supply, while the cost of energy production is steadily increasing. As our country is experiencing rapid industrial growth, additional consumers requires more housing area, transportation facilities and other services. This increasing industry escalates projected energy demands. The cost of increasing the energy supply of a country is significant due to the increase cost in construction of new electrical generation sources, the increase cost of raw energy material, and the increase cost of transporting and distributing the energy produced. By curbing the wastage of energy, the impact of the escalating cost of energy usage on the economy can be reduced (7). There is great potential for reducing the cost of utilizing electrical energy through energy management. To implement energy management, it is important that energy consumption information to be obtained (32). It is obvious that if costs are to be minimized, usage of the electrical energy has to be monitored more accurately and carefully. Data collection is important to enable the data to be analyzed. An automated electrical power meter can be used to achieve this objective. The automated electrical power meter consists of measurement device for electrical power measurement, and a transmitter to transfer the reading to a PC for monitoring and billing purposes. A receiver will be used to capture the data, which is obtained from the meter. This will enable the reading of the electrical energy usage or

power consumption of an electrical device be carried out remotely. Data transmission will play an important role in achieving the purpose above; this leads to the introduction of data transmission implementation using X-10 protocol within the household wiring. The data transmission will take advantage of the existing electrical wiring. Thus, no costly rewiring is necessary.

Scope

The current work concentrates on the design and development of prototype transmitter and receiver, including the program software to control a microcontroller, for data transmission. The development of the transmitter and the receiver of this proposed system could be used to connect the power meter, resulting in an integrated automated electrical power meter for household application. This is for the purpose of energy monitoring to increase the efficiency of energy management. The device is designed using programmable microcontroller, ICs and electrical components. Programmable microcontroller is used for controlling data communication between the transmitter and the receiver, and for sending and receiving signals over the power line wiring. The language used to program the dedicated microcontroller is assembly language. X10 protocol is implemented for the data transmission.

Objective

The objectives of this work are as follows:

1. To design and assemble the hardware of the transmitter and receiver for data transmission using power line.
2. To develop the program software for control the microcontroller.

Thesis Layout

This thesis consists of five chapters and its layout can be summarized as follows:

Chapter 1 gives a general background and overview of the thesis. Chapter 2 covers the literature review. Chapter 3 presents the methodology used in designing the proposed system. The results and discussion are fully documented in Chapter 4. Finally, Chapter 5 summarizes the finding and conclusion; and suggestions for future studies are also given.

CHAPTER II

LITERATURE REVIEW

Home Automation

Webster's dictionary defines automation as: (a) the technique of making an apparatus, a process, or a system to operate automatically, (b) the state of being operated automatically, (c) automatically controlled operation of an apparatus, process, or system by mechanical or electronic devices that take the place of human organs of observation, effort, and decision, reducing human intervention to a minimum. The term home automation is defined as the control of lighting, audio/video, heating, air conditioning, appliances, draperies, sprinklers, and more, by one or more of the following: remote control, timer, sensor, telephone, voice command, or situation (1).

Home automation, a concept that dates back to the utopian fantasies of the 1950s, is often still regarded in the public imagination as a sci-fi collection of smart appliances, with robotic washing machines and elaborate mechanisms for controlling room lighting. Home automation, also referred to as home control, smart home, smart house, or intelligent home, is actually a collection of devices, systems, and subsystems which have the ability to interact with one another or function independently. Home automation has emerged from the realm of science fiction to the ordinary living. During the 1990s, the home automation industry grew from infancy into young adulthood. The development of control and communications protocols, allowing exciting new products to interact with



each other, has opened the door to real automation (2). A smart home allows the entire home to be automated and therefore provide ease and convenience to everyday activities in the home. Automated control, edutainment features, communication features and smart appliances all contribute to the ease and convenience a smart home permits, and remote access to these features through telephone or Internet makes it even more convenient (20). In Malaysia, the percentage of houses that are involved in home automation is still very low. This, however, is believed to grow gradually over the years to come.

One of the major benefits of smart homes to consumers is their ability to incorporate energy management features. One smart home system manufacturer claims to be able to reduce the electricity bill by 30% depending on the home. Smart homes can even go further in energy management by keeping track of the energy usage of each and every appliance in the house, from the coffee maker o the washing machine. Such features allow you to know what is using too much electricity and adjust things accordingly. An appliance that is using too much energy can be turned off when it is not needed and help lower the costs (20).

X10 is the original home automation system. It uses the AC electric wires in your home to carry signals between remote controls and devices. X10 can be used for virtually any home automation task you want to perform. X10 is easy for almost anyone to install (21).

The home automation standard for do-it-yourself home control is X10. X10 is the recognized leader in home automation technology. X10 products have been available for years and because of this, it had been made a popular choice for both individuals and installers who want the benefits of home automation (1). More than 5 million homes have X10 devices installed, and more than 100 million X10 devices have been shipped – numbers that far exceed any other home automation technology. As compared to others systems, X10 offers quite a few advantages for home control:

- The many parts of the X10 system can be self-installed. No electrician is required.
- X10 products are inexpensive and easily expandable.
- X10 is a modular system. Buyer simply buys what he wants whenever he needs it.
- X10 can be controlled on a time basis.
- X10 can be operated remotely. For example, X10 appliances can be controlled through a telephone by installing a touch-tone controller that connects to the telephone line and the X10 system.
- X10 can be programmed. By using a home computer to interface with an X10 system, macros can be created to trigger multiple events (21).

An X10 system has two basic components:

- A module that receives signals from the X10 transceiver through your home's AC wiring and controls the device connected to it.
- A controller that sends X10 signals to the module (21).

Berlo (1999) described in a traditional electrical installation, where an installation of this type has the following disadvantages which no intelligence can be applied, wiring is costly and permanent, other command initiators cannot access command receivers and lastly diagnostics on devices must be conducted locally. In traditional electrical installation, each sensor is connected directly to one or more actuators. A sensor is a command initiator such as a switch, brightness sensor or a thermometer. An actuator is a command receiver such as a light, a window blind or a heating system (3).

Power monitoring

The technology of power monitoring has evolved over the last decade from simple failure notification to the delivery of data about a wide range of different conditions. Today, the number of unmanned, remote telecommunications sites has increased from ten to 100 folds. Hoover (2000) proposed an insight into some of the challenges and solutions for providing networked power monitoring systems through public switched telephone network (PSTN). The networked power monitoring system can integrate and carry a variety of power and facility alarms (4).

Khan (2002) approached automatic meter reading through power line carrier that make data on the energy consumption available out at the street transformer pole to be read by the utility personnel. This will result in the electric power utilities reducing the time taken from meter reading to the consumer receiving a bill. The consumed energy units are digitalized and data is transmitted to a nearby data acquisition board through power line carrier, PLC, using PLC modem. However, problems may arise if neighboring

buildings or apartments are then fitted with PLC systems, and the building is furnished with a large number of electronic systems (5).

Power Line Communication

One of the alternative technologies for communications that is currently being debated widely across the globe is Power Line Communications (hereinafter “PLC”) technology. Power Line Communications is a term used to identify technologies, equipment, applications and services aimed at providing end users with communications means over existing "power lines" (cables transmitting electricity). The concept of running data over electrical wiring is not new. PLC is a technology that has been around for many years. Since the 1950s, power companies have been using PLC to send control messages and had been limited to low data rates for the power company’s own internal applications. It was never seriously thought of as a medium for communications due to its low speed, minimal functionality and high deployment cost. The major challenge was trying to use the same wire that carries strong current, to also accommodate data signals (22). The idea of combining communications signals and electricity on a single transport medium is an obvious one. With approximately 95% worldwide coverage, the electricity grid is the largest network of all. Power line communication implements communication links over existing power transmission networks. Though this is not a new area of communication, active research is being conducted all over the world for the effective use of this emerging technology. (23).

