2005－UBI－8（10）
2005／6／9

Implementation of PLC Home Network System based on Embedded Linux

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Kyung-Hwan Cha,　Yu-Seok Hyun,　Jong-Jin Yoon

* Division of Internet Engineering, Dongseo University, Korea khcha@dongseo.ac.kr
** Division of Internet Engineering, Dongseo University, Korea, squashno76@hotmail.com
*** Graduate school of Software, Dongseo University, Korea, jjyoon@sdteclc.com

ABSTRACT

The present study proposes Hybrid PAM modulation /demodulation method in Power Line Communication for the purpose of power supply control, and describes a home network system that control home appliances through power line using a home server based on Embedded Linux without separate communication line work.

The home server can provide various types of interface to users who can't use a machine well.

In the age of ubiquitous system, the result of this study may be applied to embedded Linux-based PLC control systems in realizing home automation and attaining the convenience of smart home.

Keywords: PLC, home network, embedded, PAM

1. INTRODUCTION

Power line communication is a method of communication available anywhere as long as there is electricity and an electricity outlet without the necessity of a separate exclusive communication line.

Power line communication is divided into long-distance communication and short-distance communication. Currently long-distance power line communication is not in the stage of commercialization yet but research and realize communication in noise environment. Second, coupling technology that couples communication signals to power line and separate is necessary to load frequency on power line. Third, data should be converted to a code system to lower the error rate of data. Besides, it is necessary to add the function of TCP/IP socket server to Embedded OS in the home server to remove the limitation of communication distance for remote control using a wireless terminal.

The present study purposes to combine power line communication and an embedded system, and describe the following things. First, it proposes Hybrid PAM as a modulation/ demodulation method of power line communication with the object of power supply control. Second, it describes H/W developed for power line communication. Third, it describes a long-distance home network system, which adopts a power line communication module based on the Hybrid PAM modulation/demodulation method, that can control and monitor appliances at home using a wireless terminal.

In addition, this study establishes reliable communication environment for short-distance power line communication, and implement various types of interface and long-distance communication by mounting Embedded OS on the server module.

2. Hybrid PAM METHOD

The hybrid PAM modulation/ demodulation method is to check the logic level interval. It reads data by checking the entire high interval between demodulated data. That is, it lowers the error rate by checking intervals.

In the Hybrid PAM modulation/ demodulation method, carrier frequency is generated as the interval between transmission bits is constant but the logic level HIGH interval is different depending on whether the transmission bit is '1' or '0'. Figure 1 and 2 shows modulated and demodulated forms in the Hybrid PAM method.

As in Figure 1, when the transmission bit is '1' the logic level HIGH interval is 225us and when the transmission bit is'0'it is 75us. The interval between transmission bits is constant at 300us.

The receiver side checks the logic level HIGH interval of demodulated signals and reads data after checking whether the data is'1'or'0'.

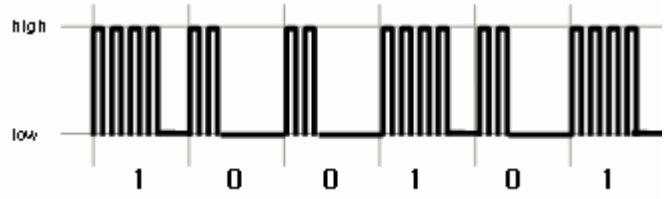

Figure 1. Hybrid PAM modulation

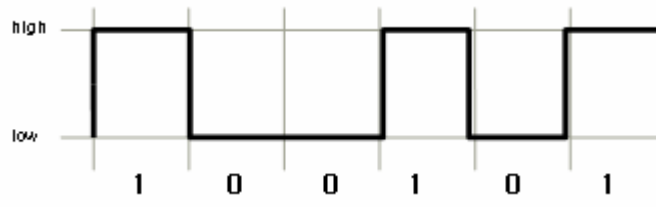

Figure 2. Hybrid PAM demodulation

The advantage of this method is that the data recognition standard HIGH interval is adjustable. By adjusting the data recognition interval, it can cope actively with various restrictions that may happen in the power line.

In the transmission mode, the start bit and the stop bit are'1'. Figure 3 and 4 shows the block diagram of Hybrid PAM.

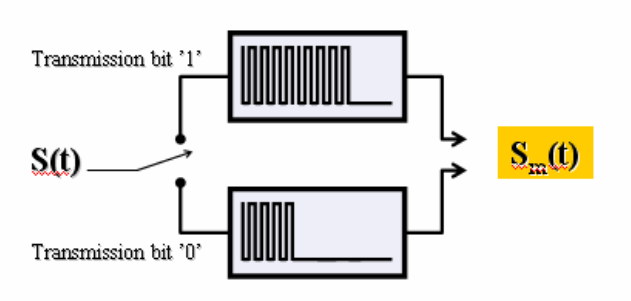

Figure 3. Hybrid PAM modulation method

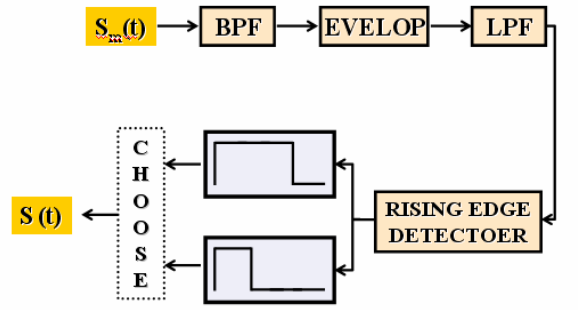

Figure 4. Hybrid PAM demodulation method

3. SYSTEM STRUCTURE

The system structure is as follows. TCP/IP socket communication was implemented for remote control using a wireless terminal. A server module was configured to process data in the wireless terminal and to send them through power line. In addition, a client module was configured, which receives data from the server module and controls home appliances directly.

All home appliances are basically controlled from the home server, and control through a wireless terminal is available. Data is sent from a wireless terminal to the server module using communication software. The server module converts data from the wireless terminal into a new form of data using Hybrid PAM algorithm and sends the data to a client module through the power line. The client module processes data from the server module and, if the data are

coincident with data in its address, it turns ON/OFF the corresponding appliance.

MCU of the server module used PXA255 and that of the client module used PIC16F84A.

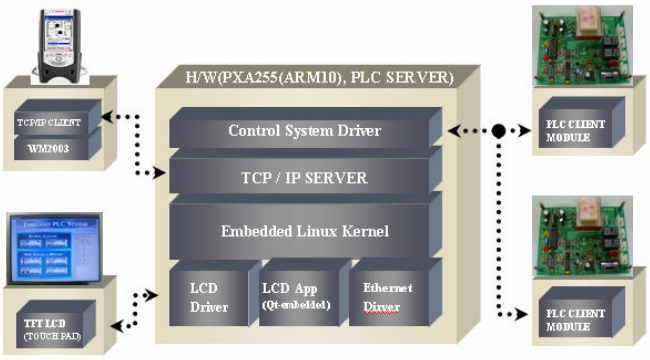

Figure 5. System Structure

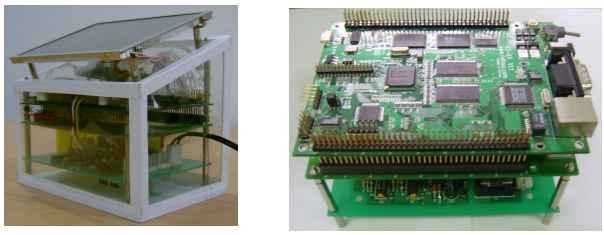

Figure 6-1. PLC Server

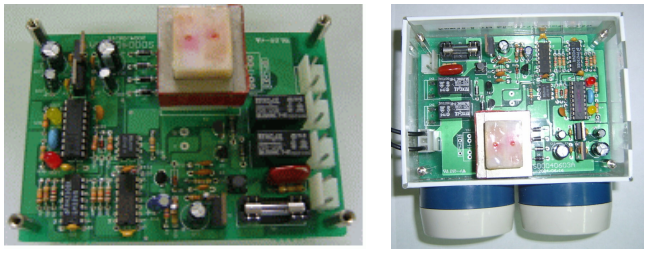

Figure 6-2. PLC Client

3-1. H/W COMPOSITION

H/W composition for power line communication is as follows.

Transmitting equipment includes magnetic number generator (MCU), carrier frequency generator that generates carrier frequency, carrier frequency modulator that modulates digital signal into carrier frequency, and amplification & coupling device that amplifies modulated signal and couples it to the power line.

Receiving equipment includes signal separation device that separates signal transmitted in the form of carrier frequency through the power line from the power line, noise removing device that removes noise from the separated signal from the separation device, amplification & demodulation device that amplifies the separated signal and demodulates into digital signal, recognition device (MCU) that recognizes the magnetic number in the recovered digital signal data, and power control device (MCU) that controls power according to control signal recognized by the recognition device.

3-2. EMBEDDED HOME SERVER & CLIENT

For remote communication, home servers (target board) are established in home and office and clients are controlled in a stable and reliable way through long-distance control technology using TCP/IP based socket. The home server module is PXA255-400 embedded with ARM10 core.

This study implemented TCP/IP socket algorithm using Linux-based embedded system so that users can select an appliance to control. If selected control data are sent to the home server and the server recognizes the control data, the corresponding address signal is generated.

The address signal generation algorithm in the server was implemented based on the modulation/demodulation method explained above. The developed home server can control power line clients by combining PXA255 module with power line module.

In addition, a LCD touch pad was installed to the home server to support graphic user interface to users. Using the pad, users can control appliances simply by touching the screen.

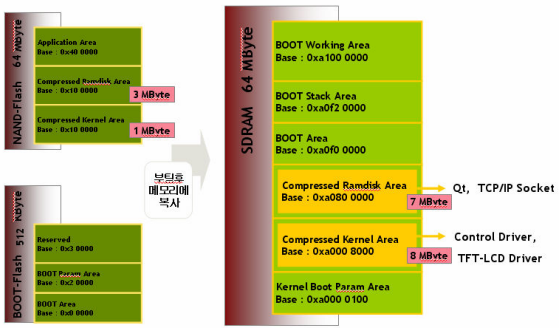

Figure 7. Target Board Memory Map

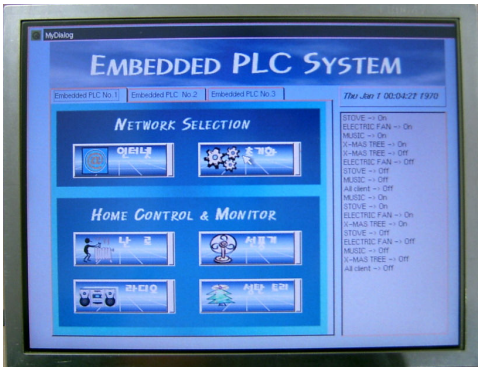

Figure 8. Home Server LCD Application

3-3. WIRELESS TERMINAL INTERFACE

In this study, long□distance power line communication through a wireless terminal used TCP/IP socket communication. Embedded Visual C++ was used in development. It is possible to check the ON/OFF status of home appliances through the wireless terminal. In addition, times when home appliances were turned on/off are displayed on the monitor.

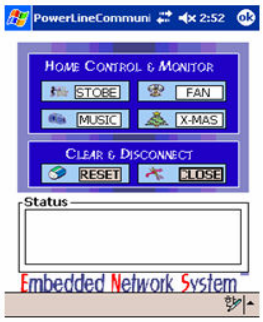

Figure 9. Wireless Terminal Interface

4. EXPERIMENTS & RESULTS

The present study performed two experiments. One was to compare recognition rate between the PAM modulation/demodulation method and the Hybrid PAM modulation/demodulation method when they were applied to power line communication. The other was to analyze the results of applying hybrid PAM modulation/demodulation to short-distance power line communication.

First, the two modulation/demodulation methods were compared using oscilloscope. Figure 10 shows waveform modulated/demodulated in the PAM method and Figure 11 in the hybrid PAM method. This study compared communication reliability by applying the PAM method and the hybrid PAM method to the power line communication module developed through stand ON/OFF experiment. The experiment recorded the error rate in 100 times of communication by applying each communication method. As shown in Table 1, the error rate of the hybrid PAM method was 5% lower than that of the PAM method.

That is, the hybrid PAM method is more appropriate in power line communication for power supply control than the PAM method.

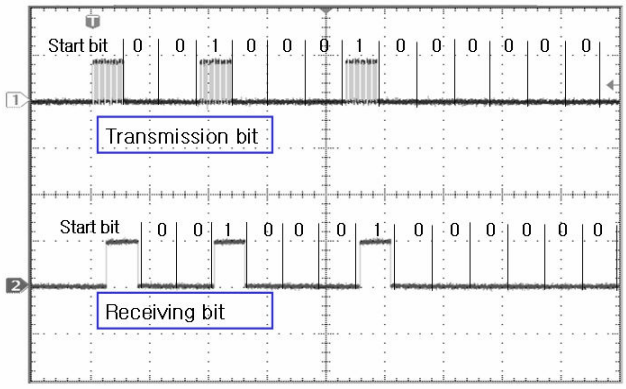

Figure 10. PAM method

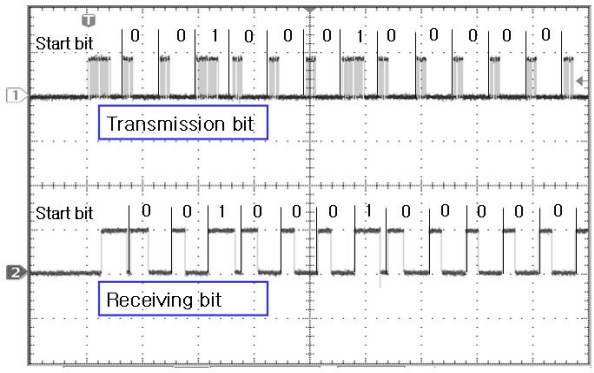

Figure 11. Hybrid PAM method

Section	PAM	Hybrid PAM
Error Rate (%)	5%	0%

Table 1. Error rate comparison

5. CONCLUSION

The present study established reliable communication environment by applying the hybrid PAM modulation /demodulation method to self-developed power line communication H/W in power line communication for power supply control.

In addition, it implemented a home network system providing various functions to users by constructing embedded Linux-based home servers.

Although the experiment environment has limitations, this study proposed a model of home network system structure using power line communication. The result of this study may be used as an index of short-distance power line communication. The addition of TCP/IP socket communi-cation to short-distance power line communication removed the limitation in communication distance for home network.

ACKNOWLEDGEMENTS

This work was supported by u-IT NURI Project at Dongseo University.

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