Audio-signal Transfer System Design and Evaluation based on Power Line Communication

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The paper is to solve the problem of existing audio signal transfer system which has a difficulties of system organization and the increase of additional install cost and unfriendly interior. To solve the existing system, we drew the new audio signal transfer system based on PLC and evaluated it. A transmitter and a receiver were designed using the PLC chip INT5500CS. An audio signal transfer system was configured with a CD player to which audio signals are sent from the transmitter and a speaker connected to the receiver. For performance evaluation of this system, a USBPre external sound card and Smaart Live 5 which is a PC-based sound measuring program were added. As a result of our experiment, the measured signal level is 2~3 dB lower than reference signal, latency is 16.69 ms, and the specific character of coherency is bad in high frequency band. Otherwise, this system transmits and receives signals over 90 % in good condition as a result of measuring pink noise, frequency (1 kHz), and phase, magnitude. In view of the result so far achieved, the system designed this study has excellent performance, it resolves defect of existing audio signal transfer system.

Keywords : PLC, Home network, Audio system

1. INTRODUCTION

PLC(Power Line Communication) is a communication method, which uses the power line that is originally installed for power supply. Commercial low frequency 50/60 Hz signal through the power line delivers the high frequency signal up to several tens MHz for transferring data[1-3].

Among new IT communication technologies such as the next generation mobile communication, digital TV, home network, IT SOC(System On Chip), next generation PC, imbedded software, digital contents, telematics, PLC is included in home network, which is essential technology for future growth, technology researches are being researched rapidly in ubiquitous and home network field[4].

Already power lines for power supply are installed on all the home and buildings, which means huge electricity distribution infra-structure is already constructed, so any receptacle indoor is available for communication. Therefore, it would be one of the benefits of PLC that no new wire is needed. Thus if we use power line as communication media, we can use very practical and economic network compared to other system[5].

Specially, as we have high interests in smart home recently, PLC is being considered as an effective solution for home networking and internet appliance[6-9]. Thus the research has been conducted vigorously to use power line as communication media world widely, as a consequence of some researches, preoccupied developments of low and high speed modem chip are being announced[10].

These chips are being used in almost every area including electricity and energy management, security services, medical information, Internet services, communications, and electronics. The frontier companies in PLC filed are DS2, Intellon, Xeline, etc. Those companies extends applied area by raising the speed and stability through the continuous research and development, and DS2, Xeline succeeded to develop 200[Mbps] PLC chip[3,11,12].

This paper consists of three parts: The main part outlines the system to be designed including the components of the system, the transmitter and receiver of the designed system; the experiment and performance evaluation part describes the equipment and method for experiment; and the final part summarizes general conclusions.

2. SYSTEM MODEL

The power line communication technology is a next-generation information and communication technology which the home network industry is researching with keen interest. In particular, this study designed an audio signal transfer system which is essential for our life and connected it to the network using the power line communication technology[13,14].

On this study, we want to check the application possibility of PLC in audio system of home network and the niceness of the performance, and we try to examine the possibility of applicability to various fields based on constructed system.

The audio signal transfer system based on power line communication used the commercial AC 220 V, 60 Hz power line as the communication medium, and consists of a transmitter and a receiver. When audio signals are sent from a CD player or MP3 player to the transmitter, the transmitter transfers them to the receiver through the power line. Then the receiver receives the signals carried through the power line and outputs them to the speaker. The transmitter and receiver were designed based on the PLC chip INT5500CS[15]. For evaluation of performance of the audio signals, a USBPre external sound card and Smaart Live5[16] which is a PC-based sound measuring program were used.

2.1 Construction of the system

Audio signal transfer system which will be designed in this paper by using PLC uses commercial AC power 220 V/60 Hz as communication media, and we construct the system as illustrated in Fig. 1 to transfer the audio signal.

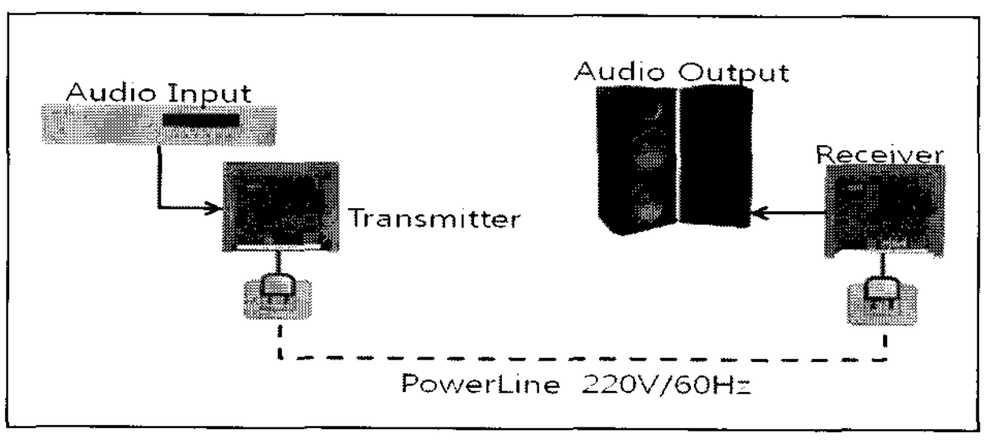


Fig. 1. System configuration.

The flow of the signal in system as follows : As Fig. 1, if we input the audio signal to transmitter, then transmitter handles the input signal and deliver it to power line. Receive position output through speaker, after process the signal by receiver which get signal from power line.

The transmitter and receiver of this system were designed to operate by separate power supply. INT5500CS was used for PLC chip, AL802 for multimedia network controller, CD player for audio signals, and a general speaker for signal output.

Transmitter and receiver are designed as acting on 6~7.5 V/500 mA, 6~7.5 V/510 mA, respectively, a cheap for only PLC is INT5500CS, multimedia network controller is AL802, and CD player is a source of audio signal.

INT5500CS includes the INT5500 and the INT1200. INT5500 is a power line MAC/PHY transceiver, which has MII(Media Independent Interface), also which are compatible with HomePlug 1.0 which is used the most widely in PLC. Also it has property that can transfer the data by 85 [Mbps] in power line. INT1200 is analog front end IC with 2.5 V(low voltage), which is used for high speed home networking. It can be connected to INT5500 directly. And it has functions of 10 bit ADC(Analog Digital Conversion) and 8 bit DAC(Digital Analog Conversion). INT5500CS is included in the configuration of transmitter and receiver during the constructing the system, it handles the power line signal, and functions ADC, DAC.

Multimedia network controller, AL802 is constituted of multimedia I/F unit and memory I/F unit, network I/F unit. AL802 supports HomePlug 1.0/AV, and can input and output the signal of audio, voice. Also it serves MII, and guarantees QoS(Quality of Service).

2.1.1 Transmitter

The block diagram of transmitter which transfers the audio signal in this paper is illustrated in Fig. 2. Stereo input of 2 channel(R-channel and L-channel) and ADC, MCU(Micro Controller Unit), EEPROM, RAM, Flash

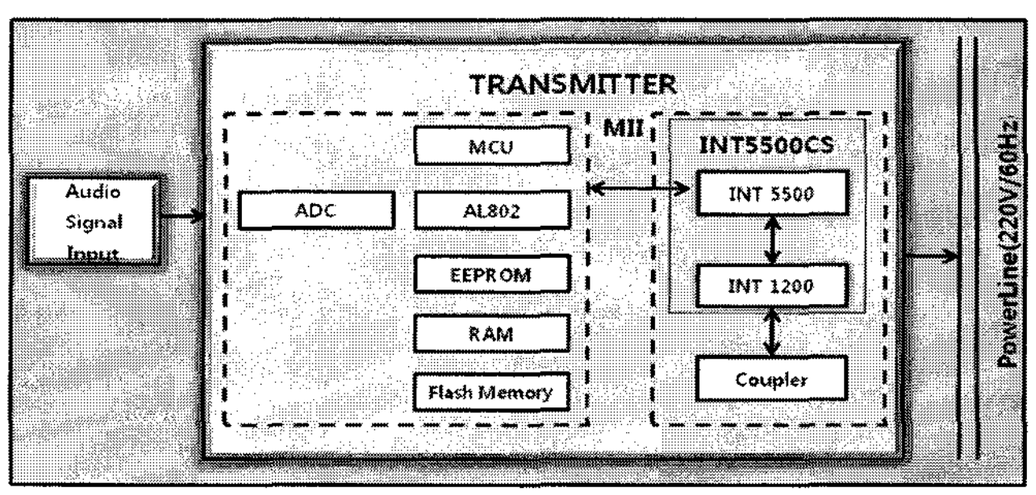


Fig. 2. Transmitter block diagram.

Memory, chip for only PLC, multimedia network controller(AL802), coupler, etc are devices of the system.

If audio signal is inputed, analog signal is converted to digital signal through ADC. The signal is DAC transformed through a chip for only PLC, after that, audio signal is separated through coupler, finally, signal is transferred to power line.

2.1.2 Receiver

The block diagram of Receiver system is illustrated in Fig. 3. Signal output terminal of 2 channel, R-channel and L-channel, and DAC, MCU(Micro Controller Unit), EEPROM, RAM, Flash Memory, chip for only PLC, multimedia network controller(AL802), coupler, etc are devices of the system, which are similar to transmitter.

The signal from the power line is divided into audio signal through coupler, and analog signal is converted to digital signal through a chip for only PLC. This signal is again converted to analog signal through DAC, and finally speaker outputs the signal.

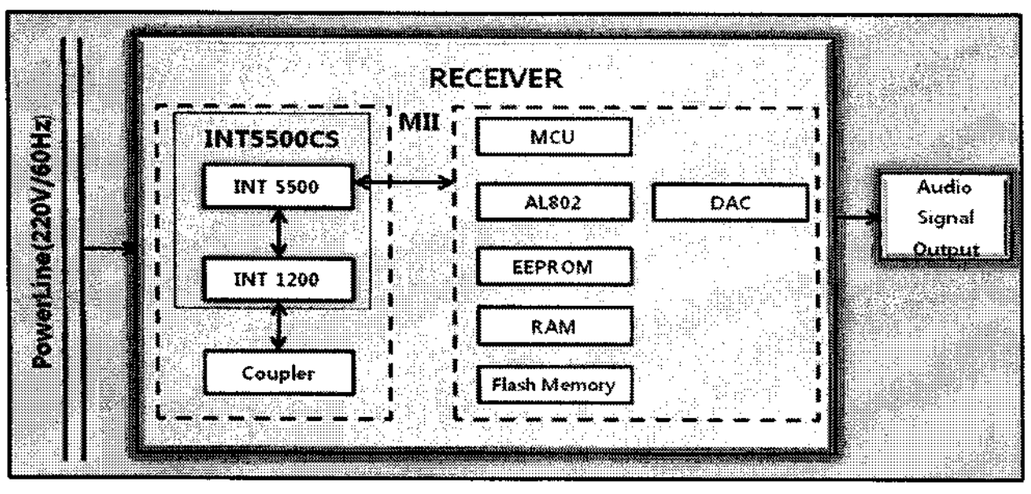


Fig. 3. Receiver block diagram.

2.2 Experiment and performance test

The experiment setting for performance evaluation of audio signal transfer system based on PLC constructed in this paper is illustrated in Fig. 4.

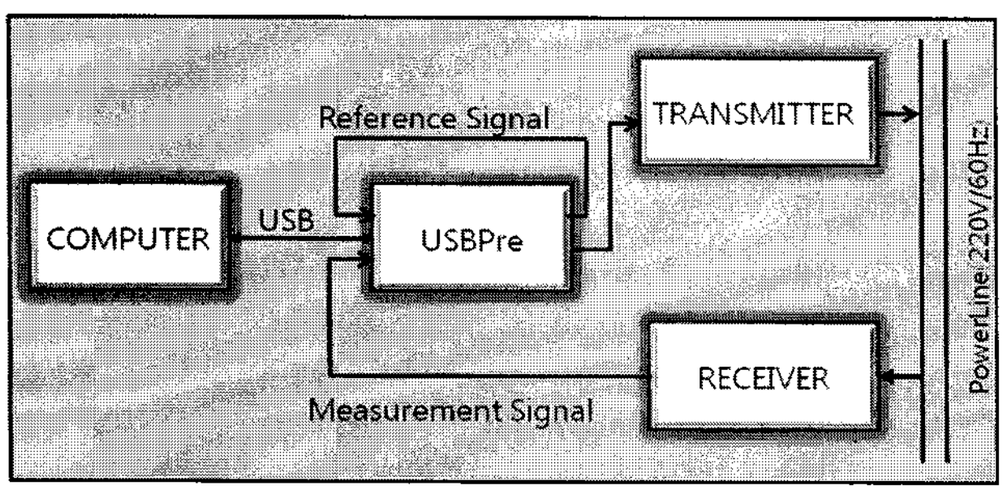


Fig. 4. Experiment setting.

To conduct an experiment of performance evaluation of audio signal transfer system, we add USBPre exterior sound card and PC based sound measurement/analysis program Smaart Live 5 to constructed system.

USBPre exterior sound card is an equipment for comparing the original signal from transmitter and audio signal from receiver.

Smaart Live 5 is a PC based sound measurement/ analysis program, which is used for analyzing the transferred audio signal.

How to do an experiment is as follows:

At first, we initiate the signal in a computer by using Smaart Live 5, and deliver the signal to USBPre. By using two terminals on USBPre, one signal goes to transmitter to examine the characteristics of the constructed system, other goes to input terminal of USBPre for pure reference signal. A signal arriving the transmitter goes to receiver through power line and it enters to again input terminals of USBPre.

Thus the signals from the computer are divided by two. One becomes the reference signal as standard, one becomes the measured signal to analyze the system, so we can analyze characteristics of two signals.

Figure 5 shows the result of comparing (a)Pink Noise, (b)Single Sine(1 kHz), (c)Phase, (d)Magnitude, (e) Coherence, (f)Impulse as standard by using Smaart Live 5.

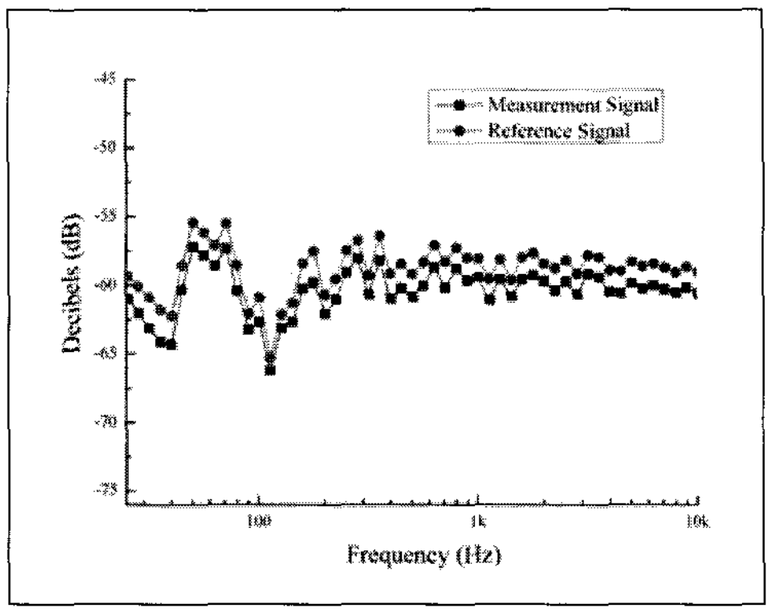
Furthermore, it was found that the severe distortions of signals in the 60 Hz band in Fig. 5(a) and the noise in the 60 Hz band in Fig. 5(b) were generated by the use of power line as communication medium. This noise is not a big problem for signal output because the play back frequency of general speakers is 120 Hz to 20 kHz. However, this can pose a problem when outputting the signal to a high-end speakers such as subwoofer.

Figure 5(c), (d) show the measurements of phase and frequency response characteristics, and Fig. 5(e) shows coherence. These figures show that while phase and frequency response characteristics are good, coherence continuously decreases from 200 Hz. This indicates lowering reliance of signals even if the transmitted and received signals are identical.

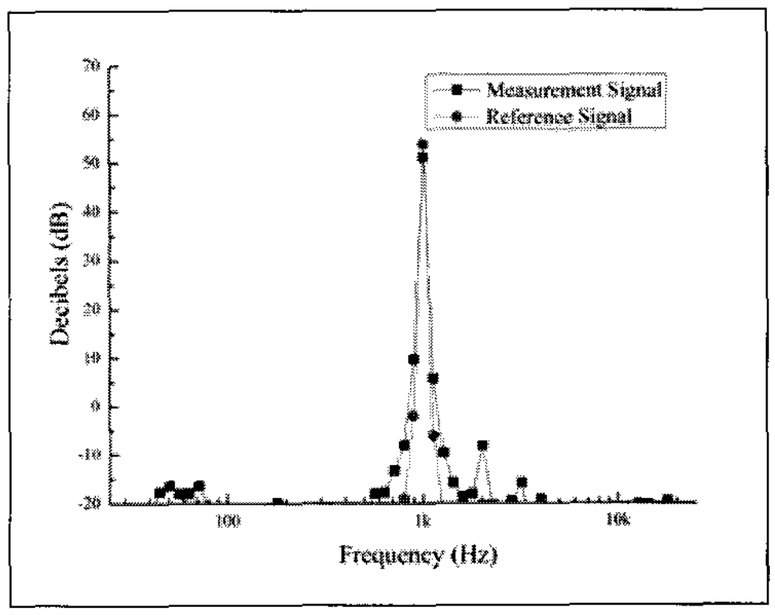
The Fig. 5(f) is the graph for the reaction after a momentary impact sound. I measured the latency by defining the impulse which is the time between input and output. I confirmed the 16.69 ms of latency value.

Because the noise level at 60 Hz from audio signal is very low in a designed system, phase, magnitude and coherence hardly appeared in graph. Noises seen in analysis of audio signal wave shape in Fig. 5 is caused by states of system connection and equipments for the experiment.

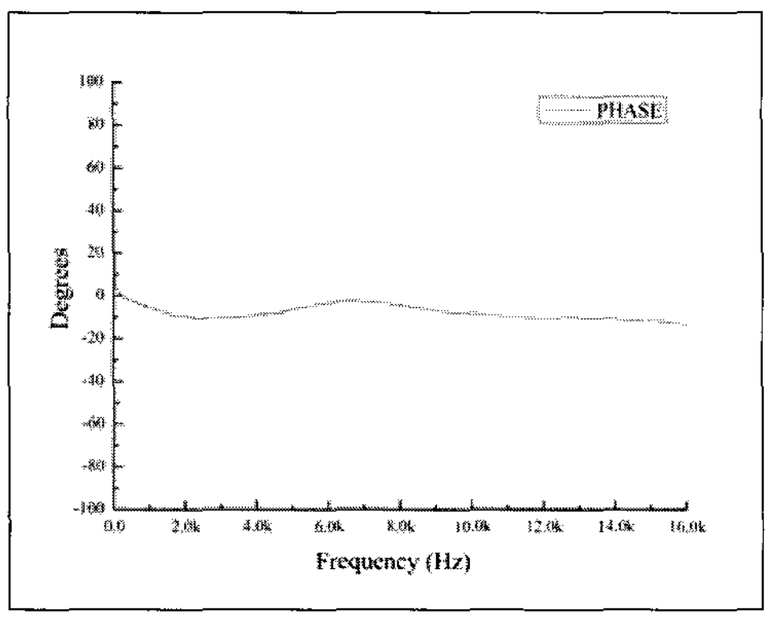
An analysis of the signal characteristics found that over 90 % of the transmission and reception of signals were normal. Also, the characteristics of 60 Hz noise from power line and other surrounding noises were checked.



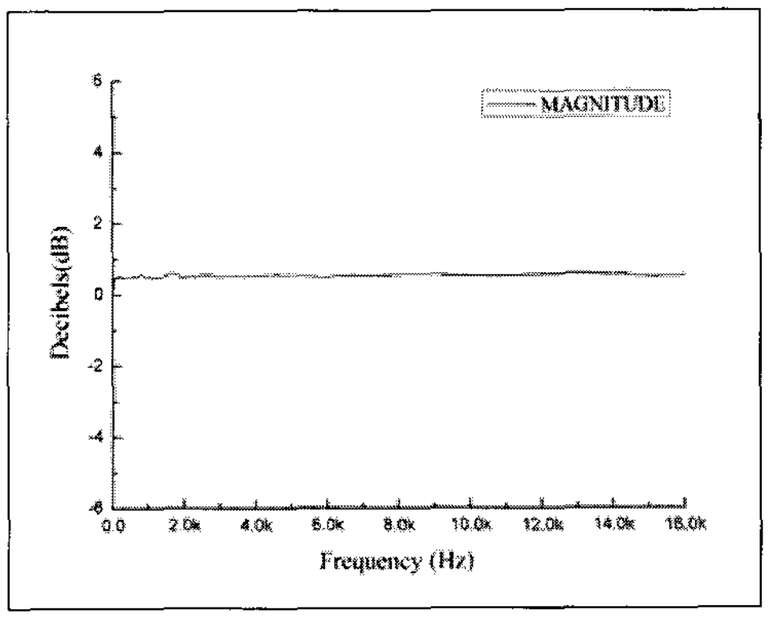
(a) Pink noise



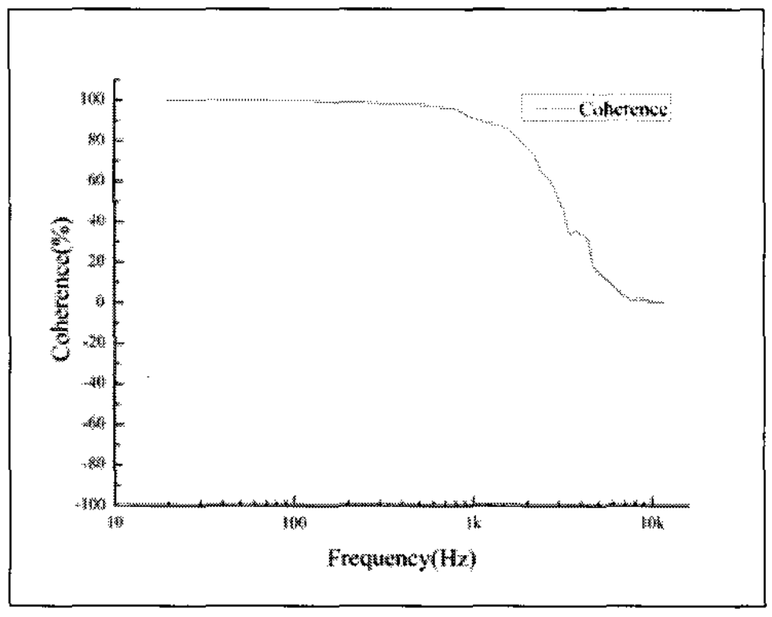
(b) Single sine(1 kHz)



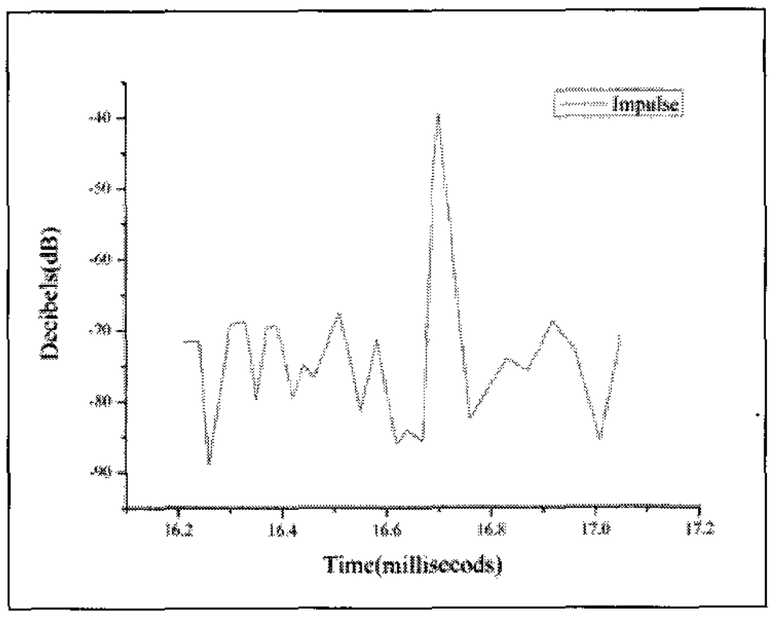
(c) Phase



(d) Magnitude



(e) Coherence



(f) Impulse

Fig. 5. Analysis of audio signal wave.

3. CONCLUSION

In this paper, we solve the problem of former audio-signal transfer system by using power line, which known electrical power supply, as communication media. For that, we constructed audio-signal transfer system based on PLC and evaluation of the system.

The system designed in this paper uses a chip for only PLC, INT5500CS to construct transmitter and receiver and 220 V/60 Hz power line.

For evaluation the performance of the system, we use USBPre and Smaart Live 5. As a result of our experiment, the measured signal level is 2~3 dB lower than reference signal, latency is 16.69 ms, and the specific character of coherency is bad in high frequency band. Otherwise, this system transmits and receives signals over 90 % in good condition as a result of measuring pink noise, frequency(1 kHz), and phase, magnitude. And we check the need of further research about noises and damping effect seen in analysis of

system characteristic.

The designed system in this paper has nice performance to use the power line as communication media, thus we can check that this system solves the problem of existing system such as additional installation cost, difficulty of construction, non-interior-oriented configuration.

Moreover, due to the system designed in this research, we could check the possibility of home networking, and PLC which is presently limited on medium, low speed communication technology can be extended to high speed communication technology, which can be applied to various fields.

ACKNOWLEDGMENTS

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