Construction of a Home Network System Using a Power Line Communication Method and a Voice Recognition Command Controller

Kyung Mog Lee

***Abstract*—A home network system with some electric devices was constructed with a power line communication method. The system had two kinds of modems, a central-side and a receive-side. The central-side modem was connected to a controller computer, and the receive-side modem was connected to the electric devices, which were operated by the computer. The devices' setup statuses were manipulated by an external voice recognition controller which was used as a user interface, and connected via Bluetooth communication to the serial port of the computer's COM6. The Bluetooth and the power line communication data rates were 9600 bps and 2400 bps, each. The Polling Process Technique was used for the computer to read the voice recognition result, and to send home-electric-device controlling data to the receive-side modems. The command-recognizing time of the controller was depended on the number of commands. For five commands, the responding time of the communication between the computer and the voice board, was less than 110 milliseconds. Also, the response time of the communication between the computer and the receive-side modem, was less than 100 milliseconds. The home electric device statuses were shown graphically on the computer screen according to the device's setup conditions. It was much more convenient to use a voice command than a key board or a mouse.**

***Index Terms*—remote voice controller, PLC communication, home network, auto-home network**

I. Introduction

RECENTLY, speedy communication infrastructure has been built, and Giga bit internet has been widely spread into our homes. And, auto home network technology, such as Smart Home, has been widely researched[1][2][3] .

Home automation technique has two kinds of communication methods, wireless and wire. In wire communication, there are Ethernet, IEEE1397, USB, and the power line communication(PLC)[4][5][6], etc. In wireless communication, there are wireless LAN in IEEE802.11x[7], Bluetooth[8][9], HomeRF, and Zigbee[10][11], etc.

For home networks, the PLC method is much more preferred because no extra wire is required, it's easy to use, safe from the electric wave interference, and still works well.

In this paper, a home network system, including a central control computer (PC), was constructed with the PLC method. The PC was controlled by an external voice recognition control board which was used as a user interface, and manipulated remote home electric devices. The PLC's communication data rate was 2400 bps, and the Polling control technology[12] was used to read and to setup the remote electric devices' status. To read the voice command from the external board, the PC also used the Polling method[13]. Voice commands were tested for the system of home electric devices such as a humidifier, a fan, a lamp, and a door lock.

II. Body Of Paper

Fig. 1 shows a PLC system that was constructed in this paper. Four home electric devices were connected to the home power line.

Fig. 2 shows the detailed PLC connection of a central control PC and an external voice recognition control board. Fig. 2(a) shows the external voice recognition control board connection. Fig. 2(b) shows the central control PC connected to the power line.

When a voice command was recognized on the external voice recognition control board, the code corresponding to the recognized command was transmitted to the central PC via Bluetooth communication. Then, the PC sent the home electric device control signal to the central-side PLC modem through RS-232C serial cable. Then, the modem broadcasted the information protocol into the home power line.

The central-side PLC modem of the control PC communicated to the one of the receive-side modems of the home electric devices through the power line. The

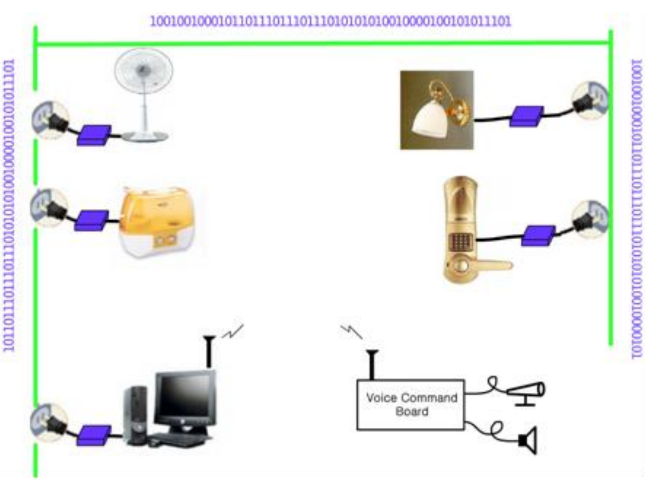

Fig. 1. Constructed PLC system.

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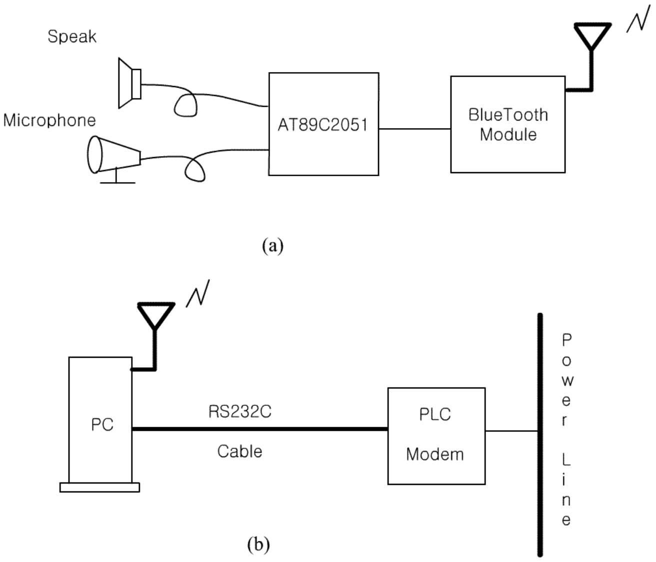

Fig. 2. Detailed PLC connection of a central control PC and an external voice recognition control board. (a) the external voice recognition control board (b) the central control PC connected to the power line.

receive-side modem sent the received information to the microprocessor of the AT89C2051 in serial. The distance between the central-side modem and the receive-side one was about 20 meters. The communication environment was clear and quite without any noise generating devices such as motors.

The receiver microprocessor of the AT89C2051 was programmed to use four ports as outputs for the device control and four ports as inputs of the device's on/off status. All the PLC modems were using the ST7537HS1 chips of SGS-THOMSON's company. The modulation rate was in half duplex asynchronous 2400 FSK. The central-side PLC modem was connected to the COM1 port of the PC with RS-232C serial cable. The receive-side PLC modem was connected to the AT89C2051 microprocessor made by the ATMEL company.

Fig. 3 shows the diagram of the program blocks of the constructed system. When the program of the central PC started, it checked the on/off status of the home electric devices and showed each device's status graphically on the screen. Then, it checked the voice command from the external voice recognition control board. If there was any voice command, it sent the device control signal to the PLC modem of the PC. The modem sent the protocol including the signal to the receive-side PLC modems. The receive-side PLC modem retrieved the signal from the protocol after performing the error check, and sent the signal to the AT89C2051's communication program. Then, the microprocessor outputted the setup signal to the chosen device, and vice versa, the microprocessor sent the central PC an "ACK" protocol including the status of the devices.

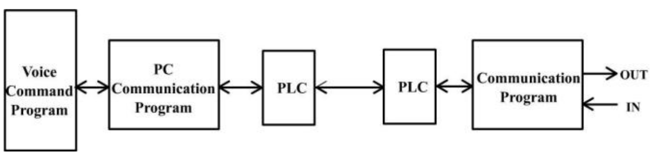

Fig. 3. Diagram of the program blocks of the constructed system.

Protocol Start	Portocol Type	Receiver Address	DATA	Check Sum

Fig. 4. The structure of a PLC communication protocol.

The PLC modems were communicating in the Polling process, so there were two kinds of stations, a primary one and a secondary one. The central-side PLC modem was the primary station and the receive-side the secondary. Also, the external voice control board was treated as a secondary station.

The primary modem broadcasted in half duplex the "Ready to receive" protocol, and awaited the "ACK (acknowledgement)" protocol from a secondary modem the same as the Stop-and-Wait process.

The ACK protocol contained data of the voice command code or of the statuses of the home electric devices.

The PC program checked the ACK protocol from the external voice control board for the voice command. When there was a voice command, it sent the "Ready to receive" protocol with the device control signal corresponding to the command. Then, the program checked the ACK protocol from the receive-side modem for the device status and changed the color of the device pictures on the screen into the corresponding status. The response delay time of this polling process between the PC and the receive-side modem was measured to be about 100 milliseconds.

Fig. 4 shows the structure of the protocol for the PLC communication. The protocol consisted of characters in 8 bits. It begins with "STF:" characters which mean the start of the protocol, following is "RTR:" characters for "ready to receive", an "ADDR" character for the receive-side PLC address, a "DATA" character for the port 0's output data of the ATMEL microprocessor, and "CS" as the check sum for some error detection. Therefore, the "Ready to receive" frame was as follows

"Ready to receive" frame:

"STF" +":"+ "RTR" + ":" + "ADDR" + ":" + "DATA"+ ":" + "CS"

Here,

"STF" : 3Bytes for a frame start,

"RTR" : 3 Bytes for the Ready-to-receive,

":" : 1 Byte for data separator,

"ADDR" : 1 Byte for the receiver PLC address,

"DATA" : 1 Byte for the data of the port 0,

"CS" : 1 Byte for the check sum.

The responding ACK protocol had the same structure as the "Ready to receive", except using "ACK" instead of "RTR".

Therefore, the "ACK" protocol was as follows;

"STF" +":"+ "ACK" + ":" + "ADDR" + ":" + "DATA"+ ":" + "CS"

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TABLE I
OUTPUT PORT'S DATA

Receive-side PLC address	"DATA" part of the protocol: Check Sum	output port
0x01	0xEF:0x43	P0.4 On
0x01	0xDF:0x53	P0.5 On
0x01	0xBF:0x73	P0.6 On
0x01	0x7F:0xB3	P0.7 On

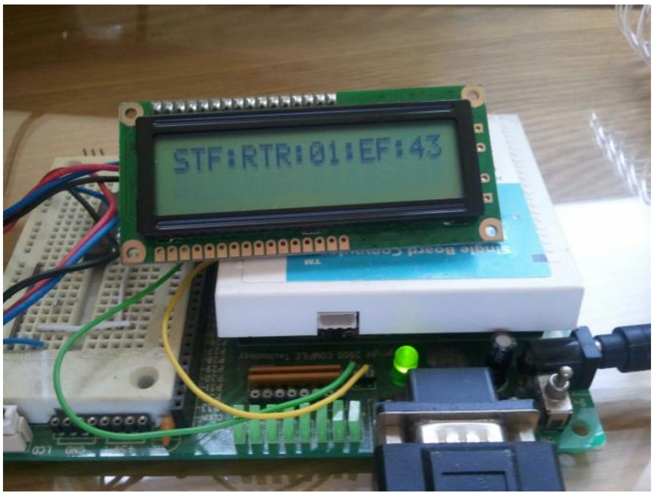

Fig. 5. The polling signal of the control computer PLC modem.

The "DATA" part consisted of two nibbles. The first one was for the output control signal and the last one for the input of the devices' statuses. The microprocessor's lower four ports (P0.0, P0.1, P0.2, P0.3) were used as inputs of the devices' statuses and higher four ports (P0.4, P0.5, P0.6, P0.7) as outputs for the electric device control signal. Table-I shows the output port's Data. The "on" state of the port P0.4 was 1110(&HE) in the first part of the byte of "DATA", the "on" state of the P0.5 was 1011(&HB), the P0.6 was 1101(&HD), and the P0.7 was 0111(&H7).

To get a voice command, the controller's program sent a poll signal to the voice control board. When a voice command was detected, it sent the corresponding electric device control signal to the receive-side microprocessor to setup the device. To detect the electric device status, it also sent a poll signal to the microprocessor and awaited the response protocol. Then, it changed the color of the device picture on the screen corresponding to the electric device status.

The connection of the receive-side AT89C2051 ports was as follows,

Port of the receive-side AT89C2051	Home electric devices
P0.4	Humidifier
P0.5	Fan
P0.6	Lamp
P0.7	Door Lock

Fig. 5 shows the polling signal of the central-side PLC modem. The start of the protocol was "STF" characters, followed by RTR: for "Ready to receive", the receive-side PLC address of "0x01", the "DATA" part of 11011111(0xEF), and the check sum of "0x43".

Fig. 6. The device setup status shown graphically on the screen.

Fig. 6 shows the device setup status graphically on the screen.

III. CONCLUSION

In this paper, a home network system was constructed with the Power Line Communication (PLC) technology. An external voice recognizing control board was also developed to control the home electric devices through the home power line. The control board sent the voice command to the central computer via Bluetooth communication in 9600 bps data rate. The communication between the PC's modem and the receive-side of the electric devices was in 2400 bps data rate. By the polling process, the central PC checked the voice command and set up the electric home devices. The devices' setup conditions were shown graphically on the PC screen. It was much more convenient to control home devices by the voice commands than by a key board or by a mouse selection. Although this experiment was performed in a quite environment condition, further research is required for the communication method in a noisy environment.

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