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THE TRANSMISSION OF REAL TIME DATA OVER POWERLINE

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1. INTRODUCTION

Electric power networks (also called electric powerlines) are designed not only to supply electricity to consumers but also to transmit data. The latter use is called Power Line Communication (PLC). Since 1920, data transmission through electric power networks was already considered, first for transmission over high-voltage networks/powerlines [1]. However, transfering PLC technology into reality meets some difficulties, such as in manufacturing capacitors for high-voltage loads or designing the encoding block in order to interconnect data transmission systems to the high-voltage powerlines. Nowadays, data transmission over powerlines receives growing attention thanks to increasing expansion of electricity coverage and advancements in electronic materials and components. Additionally, PLC technology has a major economic advantage because it utilizes existing electricity infrastructure and, thus, minimizes the cost of installing new transmission systems.

It was tested in [5] that data from a thermometer was transmitted and received through the powerlines. In this paper, we propose to design a system for real-time transmission data between two positions faraway from each other, consists in two subsystems: master and slave. The master subsystem, located at one position, generates real-time information based a clock IC and operates like a normal clock displaying hours, minutes, days and months. The slave subsystem, located at the other position, is to receive information from the master subsystem and converts it into a 7-segment LED display. Once the data have transmitted and received, it is easy to observe the results of real-time data at the two positions so as to evaluate the transmission quality.

In addition, potential applications to exploit advantages of the proposed system are also discussed. The data transmission through the powerline is carried out by connecting with two PLC modems. Signals are transmitted and received over 220 V cables which provide power for each subsystem. Since no new powerline is needed, the proposed system can be easily installed over the existing powerline; this advantage is much more pronounced when installing this system in existing furnished buildings or flats which are already equipped with interior decorations.

2. EXPERIMENTS

To make an experimental system, the receive and transmit modules are designed based on the microcontroller PIC 16F877A. Its block diagram is shown in figure 1. Both sides have its own display including four 7-segment LEDs. In terms of hardware, both receive and transmit modules share some similarities in terms of electronic devices, except that the transmit module has an additional real-time clock IC DS1307 – a product of Dallas Company [8].

In terms of software, two embedded software blocks are written in C and loaded into the microcontroller. These flow diagrams of these two blocks are fundamentally different. The block on transmission side reads data from the clock (DS1307) and transfers the data to the PLC modem and to the 7-segment LED display module. The other block on the receiving side reads received data and extracts information to display on the 7-segment LED display module.

It can be observed that the block diagram of the system is a bit simple but the task of writing data of receive and transmit software is complex so that it could not be described through a figure but divided into some flow charts. The first duty is to transfer and receive real time data between chips of real time data DS1307 and microcontroller PIC 16F877A in module which transmitted through bus I^2C. The block diagram of two embedded software packages is clearly described in Figure 2.

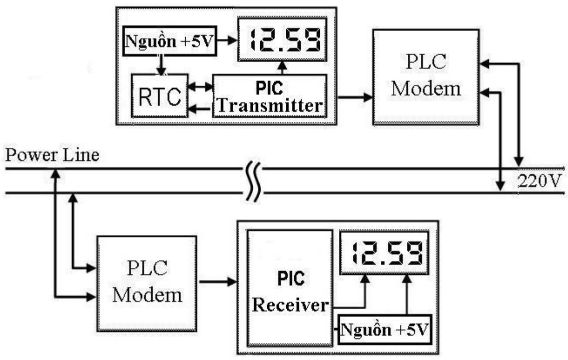

Figure 1. The block diagram of the real time data transmission and receiving

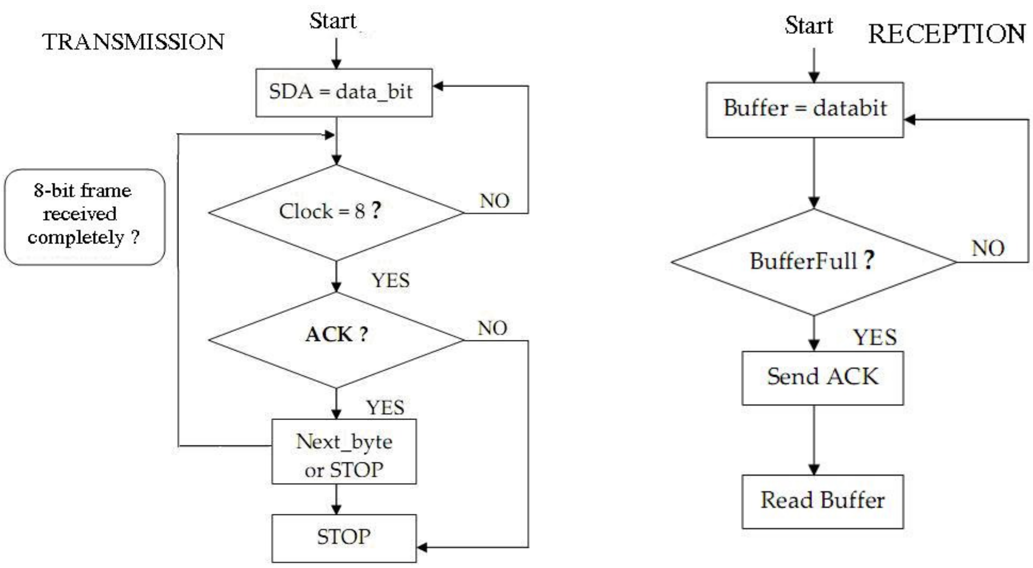

Figure 2. The flow chart of transferring and receiving data in bus I^2C

In a system of transferring and receiving through bus I^2C, there is only one Master but could be many Slaves. Only the Master can actively communicate with one another member; slaves could not directly communicate with each other but through the Master. Bus I^2C is comprised of two power-lines. Serial data (SDA) is a two-way transmission, whereas Serial Clock (SCL) is one way transmission from Master to Slave. Data which is transferred through bus I^2C is calculated by bit, data bit is transmitted in positive edge of clock pulse, the change of data bit occurred when SCL is at low level. Each data frame has a length of 8 bits; the amount of byte in a transmission is unlimited. Moreover, each transmitted byte is followed by an ACK bit in order to give the signal of receiving data. Bit which is most highly weighed will be transferred first; the next bit will be followed. After 8 clock pulses in SCL transmission, 8 data bit has been transmitted, received devices will put SDA under low level, creating a pulse of ACK which is compatible with pulse of clock number 9 in SDA power-line to inform receiving sufficient 8 bits. Once receiving ACK, transmitted device will continue to transmit or stop.

Each device in bus I^2C has its own single address to differentiate among devices. Length of each address is 7 bits, it means that in each bus I^2C, we could easily determine address or connect with up to 128 devices. When Master contact with a peripheral device in bus I^2C, it will send 7 bits of that device address into bus after a pulse of Start. The first transferred byte comprised of 7 bits of address and the 8^{th} bit which controls transferring way. If this bit is equal to '0', the next byte will transfer from Master to Slave, and vice versa if this bit is equal to '1'. The process of transmitting and receiving data within Master and Slave will be rotated as in Figure 2.

After receiving real time data from DS1307 real time data clock, PIC microcontroller starts transferring into PLC-modem which is belong to transmitted side.

To clearly distinguish two sides, we name the time data transmission as A side, and the time data receiving as B side. The A side has to transfer real time data into network. In contrast, the B side has to read real time data from power line and display on 7-segment LEDs.

The operation of the system can be described as following: the A side transfer real time data to power line. After one second, a new data is transferred. Due to the fact that only 4 LEDs are displayed, 2 transmitted modes have been created:

- Mode 0: minute and hour data transmission.
- Mode 1: day and month data transmission.

Selecting mode is up to the B side. If the B side required minute and hour data transmission, the A side would operate in mode 0, whereas if the B side needed day and month data transmission then the A side would hold at mode 1.

Data which is transferred between two devices A and B has been encoded according to code ASCII. A transmitted frame has 5 characters, including:

- The first character is the code of "$" indicating the start of process of transmission.
- The next two characters is hour (if mode 0) or month (if mode 1).
- The last two characters is minute (if mode 0) or day (if mode 1).

Supposedly, at 23h46 (minutes), a transmitted data in power-line, the code of transmission is clearly displayed in Figure 3.

Figure 3. Transmission code of data at 23h46

$	2	3	4	6
24 h	32 h	33 h	34 h	36 h

Therefore, the flow chart of transmitting and receiving data is described in Figure 5:

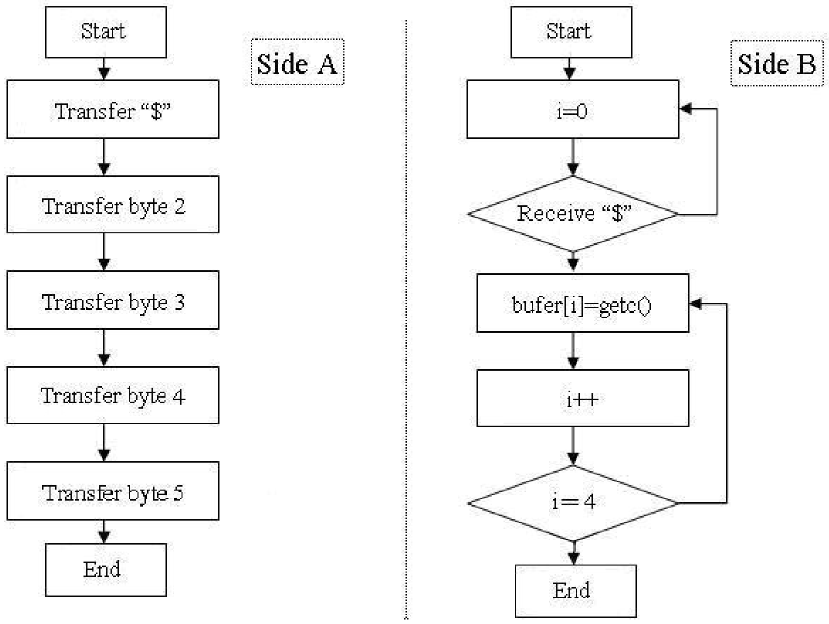

Figure 4. The flow chart of transmitting and receiving real time data

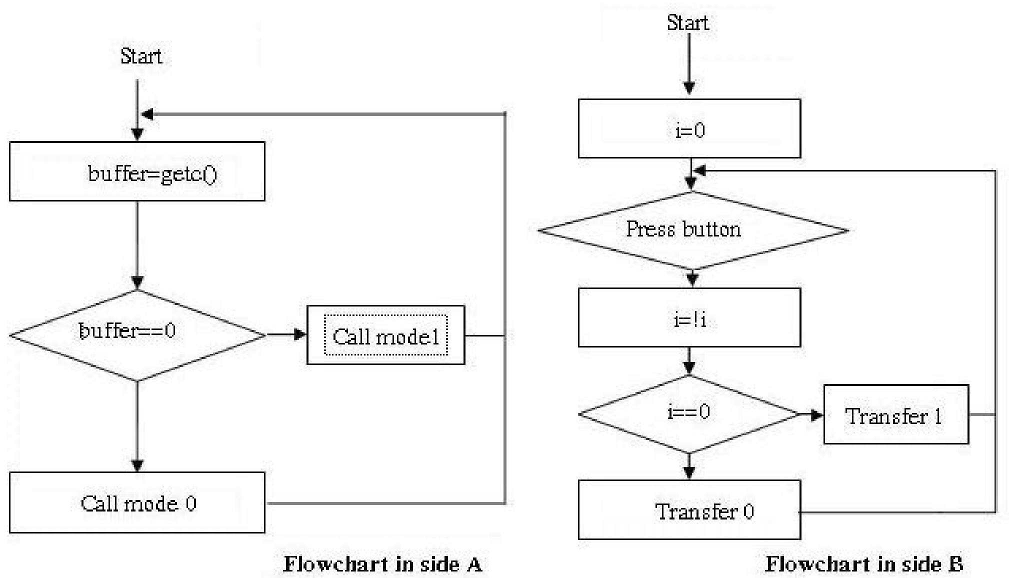

Figure 5. The flow chart of transmitting and receiving data into mode

The B side received time data in the power line and sent data through the power line to require the A side to run on mode 0 or mode 1. If data from the B side is number 0 and the A side receives code of ASCII which is code of number 0 (30 h), then the A side will operate at mode 0. On the contrary, if data from the B side is number 1 and the A side receives code of ASCII which is code of number 1 (31 h), then the A side will run on mode 1. Hence, the flow chart of transferring and receiving information into mode will be described as in Figure 5.

3. THE RESULTS AND CONCLUSION

In the system with block diagram as presented in the Figure 1, we have conducted experiment of the transfer of real time data from a module to a remote module through electric power line, specifically through electric socket with experimental distance above 150-200m between two sockets and have got expected display results. The two display modules on transmit and receive modules show the extremely similar value, in Figure 5 shows 12h59 (minutes).

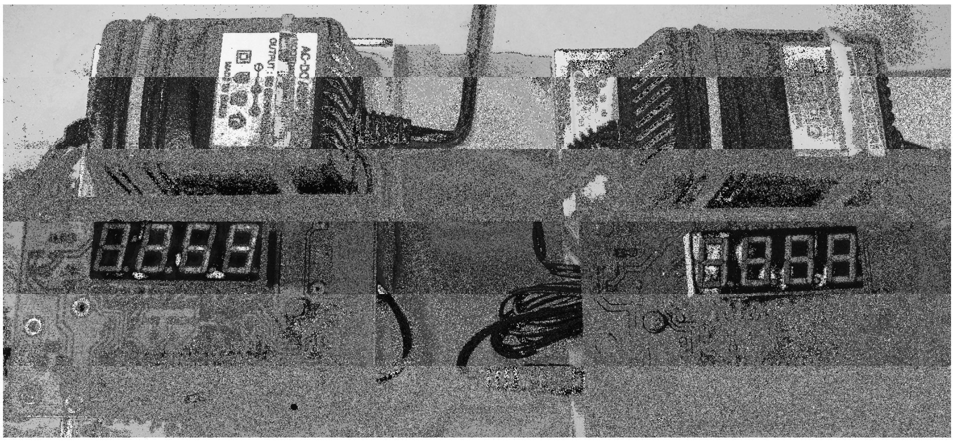

Figure 6. The results of display information between transferring and receiving sides after going through a 180m-long roll of cables which are compared directly

Overdue time between the two devices is approximately equal to transmission time; time of dealing with previous and after signals and the amount of time when signals are transferred over power line is overlooked because the amount of time is very little. As mentioned above, the frame of data transmission contained 5 characters; each has a length of 8 bits plus 2 bits of start and stop. As a result, the total bit of transferring in the data frame (4 numbers and a comma) is:

$$(8 + 2) \times 5 = 50 \text{ bits.}$$

The transmitting speed of modem which is used in the experiment is defined by producer at 300 bauds, or 300 bit per second (bps). Hence, the amount of time to transfer a data frame is:

$$50: 300 \approx 0.167 \text{ s} = 167 \text{ ms.}$$

This amount of time is so considerable (about 0.17s) that people can see it. We could easily affirm this conclusion by seeing on band-pass A (on side of transmitting time data). Due to transferring 5 characters continuously, microcontroller could not light LEDs. Consequently, LEDs are temporarily switched off. This amount of time is more than 1/24 seconds, so we could view the phenomenon of flickering on display LEDs. However, the amount of switched time is relatively short (167 ms), therefore the flickering of LEDs only shows its operation but not disturbs viewers. One way to stop LEDs from flickering is that data should be applied into interrupt buffer in the process of transferring data; then data is transferred from buffer to modem.

To survey the effects of noise on the transmitted result, we created interference by closing/disconnecting an engine 1kW in the same power line. The noice which occurred in the power line could be observed in oscilloscope (Figure 7); however, the result of real time data in the 7-segment LED display still remained unaffected.

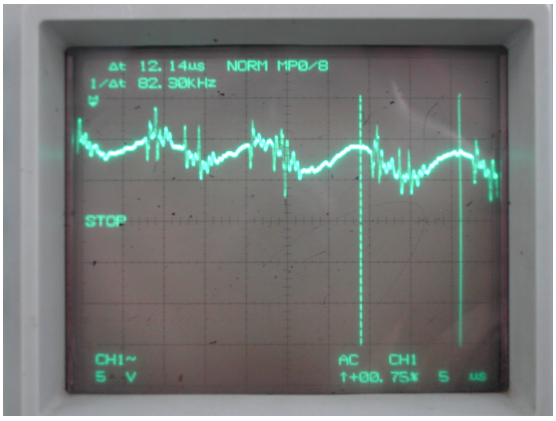

Figure 7. The noise on the signal waveform on the power-line when communicating between two PLC-Modem while motors operating

Connecting PLC modem through RS-485 bus enables us to increase the number of receive modules over 20 modules and brings a chance of displaying real time data in some modules at once. Increasing receive modules is dependent on expense and the potential chance of application into reality. The result expresses the capacity of making number-instructed clocks with several display sides (on the different floors in an office, or at different places in school, so on) without differences of time as using some clocks at the same time. If it is connected with transferring signal of closing/disconnecting on a relay, then the result shows that it can ring a bell or switch off some lights in some places.

4. CONCLUSION

Recent years, PLC technology has been transfered into some economies and into reality; however this research has successfully experimented the adaptation of PLC in transferring real time data (also measuring data) to aim at specific applications. The results can illustrate the capacity of PLC application with slow transmission speed to connect with the capacity of high transmission speed with an aim of enhancing technological applications in the power line.

The conduct of experiments on system has clearly shown advantages of transmitting data through electric power line which are utilizing the existing electricity transmission infrastructure, no need of making new power-line, saving time and money; these advantages are evidently expressed in buildings which are already fulfilled with interior decoration. The author is hopeful that, in the very near future, we could discover specific places of application to strengthen the practicality of the research.

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TÓM TẮT

TRUYỀN DỮ LIỆU THỜI GIAN THỰC TRÊN MẠNG ĐIỆN LƯỚI

Hệ thống truyền dữ liệu được thiết kế và lắp ráp để truyền dữ liệu thời gian thực từ xa qua đường truyền điện lưới. Trong trường hợp này, các môđun trong hệ thống được thiết kế trên cơ sở vi điều khiển Micro Chip 16F877A để truyền dữ liệu từ đồng hồ RTC DS1307 tới bộ hiển thị LED bảy thanh trên bản mạch và tới một môđun hiển thị khác ở xa qua ghép nối với các PLC-modem.

Phần mềm nhúng trong vi điều khiển được viết để điều khiển việc thu thập dữ liệu và hệ thống hiển thị, cụ thể là để đọc dữ liệu từ IC thời gian thực và gửi tới môđun tại chỗ và ở xa qua đường truyền điện lưới. Kết quả cho thấy hai bộ hiển thị LED ở môđun truyền và môđun nhận luôn hiển thị cùng một giá trị thời gian. Độ trễ về thời gian theo tính toán khoảng 167 mili giây, chỉ làm kết quả hiển thị đôi lúc bị nhấp nháy. Việc sử dụng kết hợp với bus RS-485 cho phép chế tạo đồng hồ thời gian thực với nhiều mặt hiển thị. Hệ thống được mô tả trong bài báo này có thể được cải biến để đo các thông số khác của môi trường như độ ẩm, áp suất v. v..., hoặc để điều khiển đóng/ngắt các thiết bị và truyền nhiều loại thông tin khác.

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