Wireless Sensors Module for Remote Room Environment Monitoring

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Abstract: For home networking system with a function of air quality monitoring, a wireless sensor module with several air quality monitoring sensors was developed for indoor environment monitoring system in home networking. The module has various enlargements for various kinds of sensors such as humidity sensor, temperature sensor, CO2 sensor, flying dust sensor, and etc. The developed wireless module is very convenient to be installed on the wall of a room or office, and the sensors in the module can be easily replaced due to well designed module structure and RF connection method. To reduce the system cost, only one RF transmission block was used for sensors' signal transmission to 8051 microcontroller board in time sharing method. In this home networking system, various indoor environmental parameters could be monitored in real time from RF wireless sensor module. Indoor vision was transferred to client PC or PDA from surveillance camera installed indoor or desired site. Web server using Oracle DB was used for saving the visions by web-camera and various data from wireless sensor module.

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Keywords: RF Wireless Multi-sensor Module, Room Environment Monitoring System, Home Networking.

1. INTRODUCTION

Nowadays, all electronic appliances in a home will be networked: PCs, telephones, stereos, refrigerators and even washing machines. Heating and air conditioning, previously controlled by a single, fixed, manual thermostat, can now be managed by an intelligent controller with remote-access capabilities [1,2]. Recently with increasing living standards and expectations for comfortableness, the use of residential air conditioning is becoming widespread. The control and monitoring of indoor atmosphere conditions represents an important task with the aim of ensuring suitable working and living spaces to people. However the comprehensive air quality monitoring which include monitoring of humidity, temperature, CO_2, flying dust particle density, and etc. is not so easy to be monitored and controlled [3.4].

In this study, RF wireless sensor module with optimal communication condition was developed and indoor air quality in a room or office could be monitored by web-based monitoring system together with other home networking system. Several offices and rooms can be monitored from terminal PC or PDA(Personal Digital Assistant) by using wireless sensor modules which are attached on the wall of the office or the room. The monitoring results in serve computer were saved and can be monitored following after.

2. EXPERIMENTS

2.1 Overview of the system

The environment of room or office was monitored via internet from PC terminal or PDA. Figure 1 shows system configuration of this study. Several sensors such as temperature sensor, humidity sensor, CO_2 sensor, flying dust sensor were built in a RF transmitter board for monitoring indoor environment conditions. These input sensors were chosen in considering parameters of comfortableness and helpfulness for human being. Commercial discrete sensor device can be built in a socket module for analog and digital sensors, and the adaptation was carried in software at server PC.

Several power switches which include lamp switches in room, power switches of consumer electronics can be controlled via stand-alone 8051 microcomputer board, and surveillance camera was installed surveillance room or indoors from unintended break.

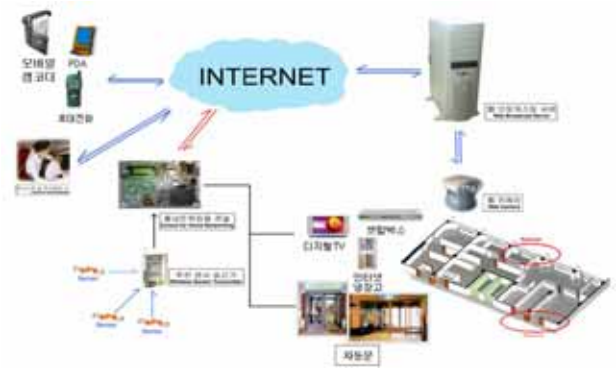
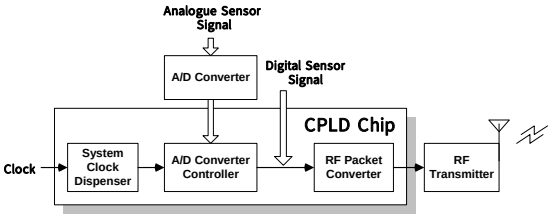


Fig. 1 System Configuration of the home networking system.

2.2 RF wireless sensor transmitter/receiver module

Wireless sensor transmitter and receiver modules were also designed and fabricated by using a CPLD (Complex Programmable Logic Device) chip for simple system structure and eventual system cost reduction separately. Figure 2 shows the detailed block diagram of the wireless sensor board and the fabricated board. As an input sensor for indoor environment monitoring, analogue and digital sensors can be used together as shown in Fig.2 (a). The commercialized UHF data transmitter and receiver module chips (TX2 transmitter, RX2 receiver, Radiometrix Ltd., England) were used as a RF transmitter and a receiver separately. The TX2 and RX2 commercial radio transmitter and receiver pair can transfer their data of an up to 160kbit/s at distances up to 75m in building and 300m open ground (in data sheet of Radiometrix Ltd.). So in best condition the RF sensor module can transfer

their data to several tens meters in room or office. To reduce system size and increase the operating speed of RF transmitter board, most of circuit of this system with the exception of A/D converter and RF transmitter were integrated in CPLD chip (Altera Ltd., USA).

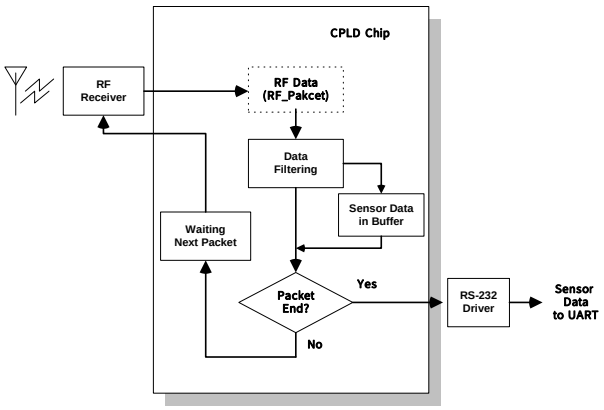


(a)

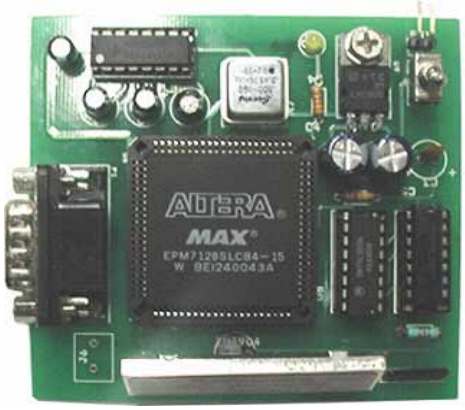
(b)

Fig. 2 The Structure of wireless sensor transmitter board.
(a) Block diagram of the board
(b) The fabricated transmitter board

RF receiver part was composed of CPLD chip with function of Fig.3 (a) and most of the function with the exception of RF receiver and RS-232 driver were integrated in a CPLD chip for same reason of RF transmitter board. Figure 3 (b) shows the fabricated RF receiver board part. The CPLD was designed by VHDL (VHSIC Hardware Description Language) and Max plus+II was used as a design tool package. A 10,000 gate level CPLD chip was used for the chip design separately.



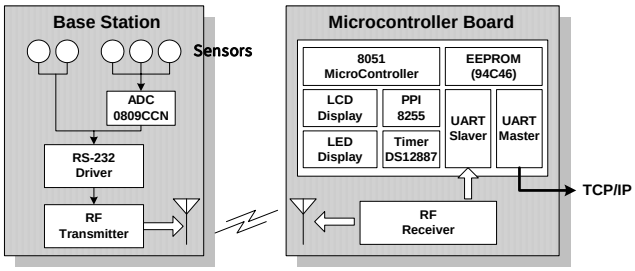
(a)



(b)

Fig. 3 The structure of RF receiver board.
(a) Block diagram of the board
(b) The fabricated receiver board.

2.3 Control Board



(a)

(b)

Fig. 4 Block diagram of fabricated 8051 microcontroller board
(a) Block diagram of a wireless sensor module (left)
8051 microcontroller board (right)
(b) The fabricated 8051 microcontroller board

In this system, stand-alone 8051 microcontroller board was designed and fabricated as a server board. The right side of Fig. 4 (a) shows the block diagram of the designed 8051 microcontroller board and Fig. 4 (b) shows the fabricated board. The 8051 compatible microcomputer (AT98C52 24PC, Atmel Co., USA), which received control signals from PC or PDA terminals via internet, give turn-on or turn-off signal for the power switches and some operating motors indoor. The control signals for lighting, heating, air conditioning and

switching electric appliances can be sent from PC or PDA terminal via TCP/IP (Transmission Control Protocol/Internet Protocol) or from push button switches on 8051 microcontroller board. This board was connected to internet through RS232 UART (Universal Asynchronous Receiver /Transmitter (MAX232CPE, Maxim Integrated Products, Inc., USA)).

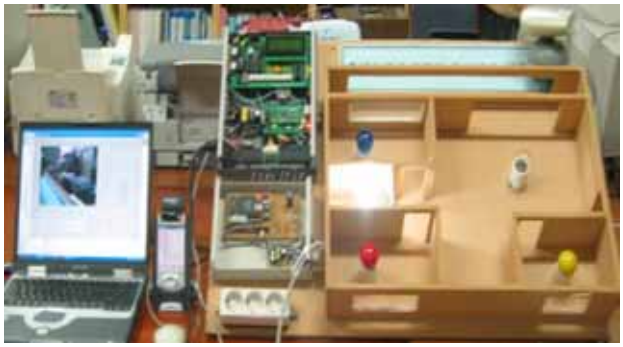
3. SYSTEM TEST

Figure 5 shows a miniature model of house for demonstration of the developed indoor environment monitoring and home networking system, and Fig. 5(b) shows the screen-captured client PC application program. From client PC, installed surveillance camera, 8051 microcontroller board and a server computer can be connected. The server computer was used for saving image from camera and sensor data from several sensors. The moving image or sensor date were saved in the server computer or transferred to client PC or PDA in real time via the server. The server computer used Oracle 8i as a database server.

In client PC program, the following 5 kinds of functions were included. The JPEG (Joint Photographic Experts Group) image was streamed by 3 frames for a second for moving image instead of MPEG(Moving Picture Experts Group) file.

(1) Moving image monitoring
(2) Sensor data monitoring
(3) Web-camera control
(4) Power switches control for illuminators, electronic appliances etc.
(5) Connectivity monitoring to 8051 microcontroller board, web-camera and server computer.

Sensor data such as temperature, humidity, CO_2 concentration, flying dust density etc. from each sensor can be monitored from client PC or PDA. And power switches of illuminators, air conditioner and electronic appliances can be also turned on or turned off from client PC or PDA program. The installed surveillance camera can be controlled to watch out special object from client PC or PDA program. The image data from surveillance camera can be monitored in real time and the unattended intrusion can be checked and the warning signal can be sent to appointed person's cellular phone or PDA (Personal Digital Assistant), for example. The image data and sensor data will be reserved in Web server computer and can be reproduced. Keypad console which was set up with 8051 microcontroller on the same board in Fig. 4 (b) can be used as a terminal as the same way as at client PC application program in Fig.5 (b).



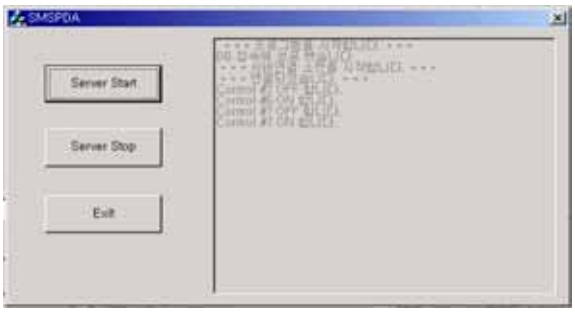
(a)

(b)

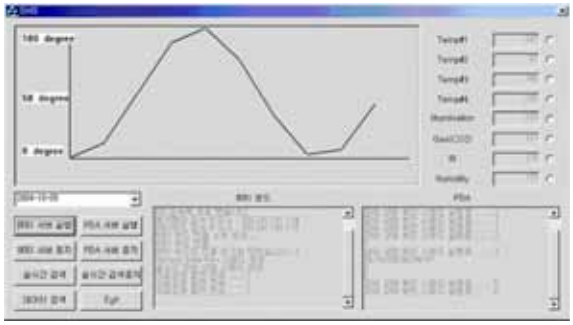
Fig.5 (a) A miniature model of house for demonstration
(b) control and monitoring screen of terminal PC

Figure 6 shows captured screens of camera image and sensor data management program in web server including PDA connection management program (a), Control board connection program (b), sensor data management program(c) and Camera image data management program (d) in server. By these management software, the moving views by camera or sensor data from several sensors for specified duration can be monitored again from terminal PC or PDA.

PDA (personal digital assistant) was also used as a client terminal. Figure 7 shows the client program image on PDA screen. Installed web-camera image can be monitored and controlled (Fig. 7 (a), and the sensor data can be checked and the power switch status can also be monitored well in the same way as PC client program (Fig. 7 (b)). From the saved sensor data, we can search the data of assigned time duration as shown in Fig. 7(c and d).



(a)



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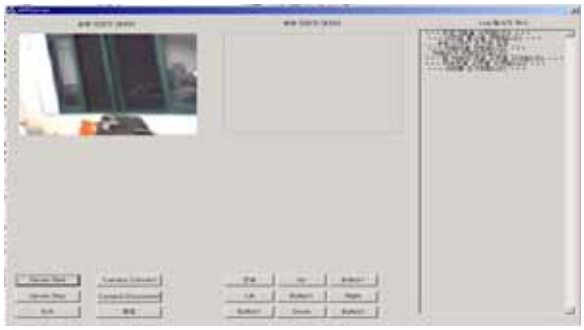
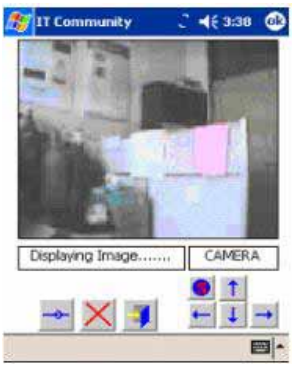
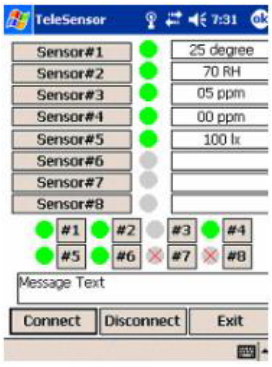


(d)

Fig.6 Camera image and sensor data management program.
(a) PDA connection management program
(b) Control board connection management program
(c) Sensor data management program
(d) Camera image data management program in server



(a)



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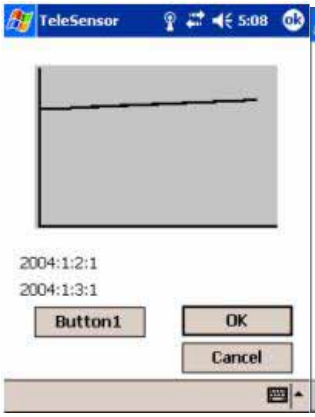

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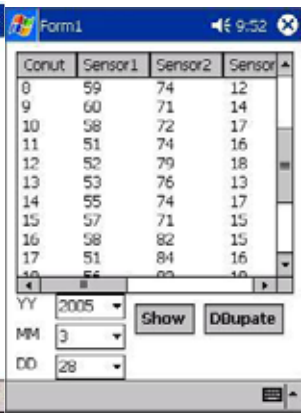

(d)

Fig. 7 Visualization in a PDA terminal program
(a) Camera vision
(b) Sensor outputs and electronic appliances operation status
(c) Sensor review for specified duration
(d) Data search function.

4. CONCLUSIONS

The comfortableness can be obtained from complex monitoring and controlling of many parameters, such as temperature, humidity, CO_2 concentration, O_2 concentration, density of fine particle dust etc. So the wireless multi-sensor module for the monitoring indoor is very important technology in near future home networking technology. In this study, most of system components were designed by ourselves and fabricated for system optimization and most of the transmitting and receiving functions were integrated in a CPLD chip separately. The wireless sensor module with 15.5cm long whip antenna transmitted the data well within 10m wide from a RF receiver. The 8 sensor data can be always monitored in real time and surveyed for designated duration through internet from PC or PDA terminal.

In next study, the data-mining neuro-software in server computer will be developed for human centered room environment control and mobile monitoring system will be studied more.

Acknowledgment

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