A Design of Remote and Wireless Control System using Bluetooth

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Abstract—In this paper a design and implementation method of remote control system for automobile is presented. For this, we used the Bluetooth technology for remote and wireless communications and microcontroller for system control. By using these techniques, we can design and implement automobile remote control system to improve data error rate, security and application.

Index Terms—Bluetooth, remote & wireless, micro controller system control.

I. INTRODUCTION

Most wireless communications of today are using cellular phone, broadband wireless service, home RF, Bluetooth that supports data and voice and so on. Among these, Bluetooth is very useful communication method that can embody into a low-cost. And it has market economic performance including various application profiles in specifications. 2.4GHz microwave frequency of Bluetooth is appointed common frequency domain by ISM (Industrial, Scientific, and Medical) band worldwide. Service has been activated most recently among ISM frequency band of identical function at technology flow. [1] Existent automobile remote control has security and extension problems between other devices, taking burdensomeness, frequently error operation. This paper has tried to propose an implementation method to improve system functions and to solve the problems.

II. WIRELESS COMMUNICATION USING BLUETOOTH

A. Wireless Network

Bluetooth was started from the concept that connected to all communication environments by single equipment integrating different communication devices. It also is short-distance digital information - communication mode that employs spectrum diffusion technology of communications. [2] Bluetooth forms ad-hoc network in extent within 10m. Also, both data and voice support. It is available worldwide because of act of ISM wide-band. Transceiver made simplify selecting shaped, binary FM modulation system. And reduced effect of interference and fading by fast frequency hopping. [3]

Bluetooth system supports point-to-point connection and point-to-multi point connection. More than two networks are formed by Bluetooth as shown is fig.1 calling this as Pico net. It is Bluetooth's minimum unit and in distance within master surrounding about 10m of one can connect same time to slave of maximum seven. Also, Scatter net is networking that composed connecting this Pico net. This can realize wireless connection that connects in extent about 100m.

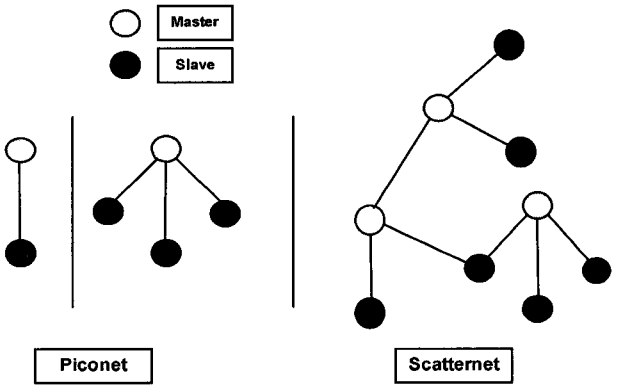

Fig. 1 Pico net & Scatter net

Table 1 Bluetooth standard and characteristics

Division	Characteristics
Frequency Band	2.400 ~ 2.4835GHz
Guard Band	- American/ Europe (low-2MHz high-3.5 MHz) - Japan (Low/High - 2MHz) - France (High/Low - 7.5MHz) - Spain (Low -4MHz High -26MHz)
Modulation System	BT=0.5 GFSK (Guard Frequency Shift Keying) Modulation rate: 1Mbps Modulation index:0.28~0.35
Transmission Mode	FHSS (Frequency Hopping Spread Spectrum) Per sec 1600th Hopping , 1 Time slot =625us, 79/ 23 channel Hopping (1MHz) Japan, France, Spain 23 channel
Power Class	Class 1: 1mW(0dBm) ~ 100mW(20dBm) Class 2: 0.25mW(-6dBm)~2.5mW(4dBm) Class 3: 1mW(0dBm)
Sensitivity	-More than 70dBm @ 0.1% BER

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Channel Connection	TDD(Time Division Duplex) Master: Even slot, Slave: odd slot
Connection Mode	SCO (Synchronous Connection Oriented) - Symmetry: Max 433.9kbps ACO (Asynchronous Connection Oriented) - Asymmetry: Max 723.2kbps
Error Correction	1/3FEC (Forward Error Connection) - Uniformity bit simplicity 3rd repeat (Header) 2/3FEC: Use Shortened Hamming code ARQ (Automatic Repeat Request) DM (Data-Medium Rate) DH (Data-High Rate) DV (Data-Voice) Do uniformity packet retransmission when receive part. Requires retransmission to type packet data.

B. Connection Process

Pass through paging process to communicate between Bluetooth devices. Paging unit becomes Master in this connecting process. And paged unit becomes slave. Master unit goes through the inquiry process while paging process. Master decides access code and frequency sequence from Slave unit's Bluetooth address data in this process (inquiry process). Connection situation acts by active, low power mode (sniff, hold, park) [1]

- park: Low consumption electric power state, recognition work of peripherals
- hold: Low consumption electric power status, status of air
- sniff: Low consumption electric power state (Low consumption electric power state than hold)

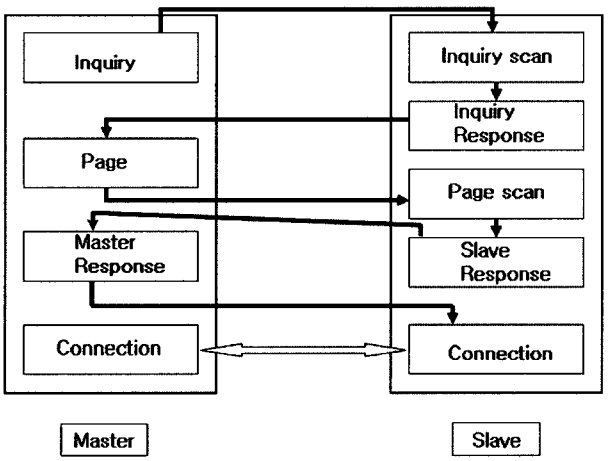

Fig. 2 Bluetooth Connection Process

Communication is achieved when each module between module matched characteristic address and communication establishment price to communication consists between Bluetooth modules. Also, offer security function and automatic connection function between modules at this process. Figure 3 and 4 show program that it can communication set of each module and security set and automatic connection function set through PC. Through this, establish communication of each module.

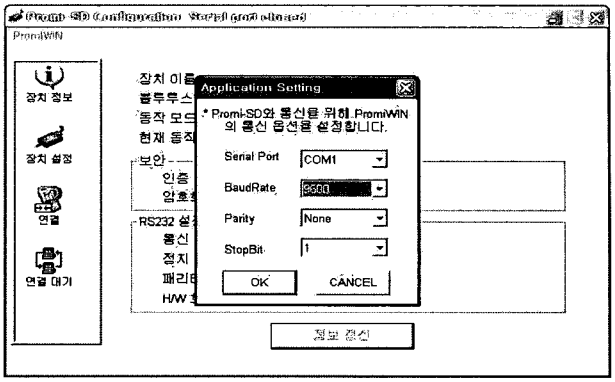

Fig. 3 Bluetooth Module Initializing program Process (1)

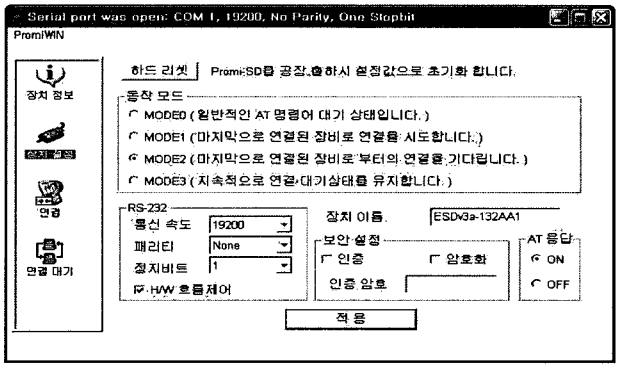

Fig. 4 Bluetooth Module Initializing program Process (2)

C. Security

Bluetooth technology supports suitable link class security in peer environment for user protection and information security.

- IEE address (BD-ADDR) use (486bit's size)
- Use produced authentication key while initialization
- Key size 128bit, using enhanced algorithm (SAFER = SK128)
- Random number use created by random number generator

Keep security by above 4 other individual used. Because of use frequency hopping diffusion mode that durability is shown in short impulse noise topology. Therefore, it is hard to decode sense of signal in any receiver.

III. H/W & S/W DESIGN

A. System H/W Design

Whole block diagram of system is as following in this experimentation.

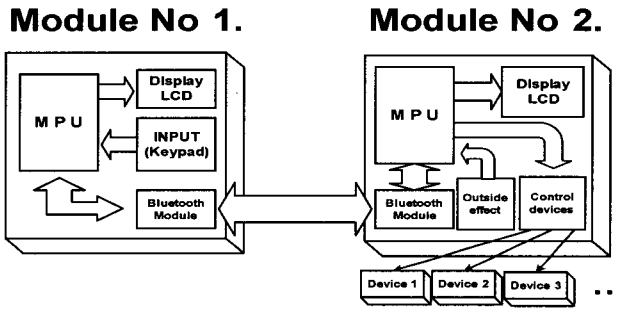

Fig. 5 System Block Diagram

Fig. 5 block diagram that show over is state after connection process between Bluetooth devices is made. Action progress process is as following. Preferentially, send specification sign from keypad of module 1. This sign does arithmetic, transaction in CPU. Then transmit data through Bluetooth by receive unit. CPU sends received data. And each controlled object device is controlled and managed through CPU. Also, embodied remote control system can check situation of module adversely. Fig. 6 is hardware picture that is manufactured for experimentation of automobile remote control system.

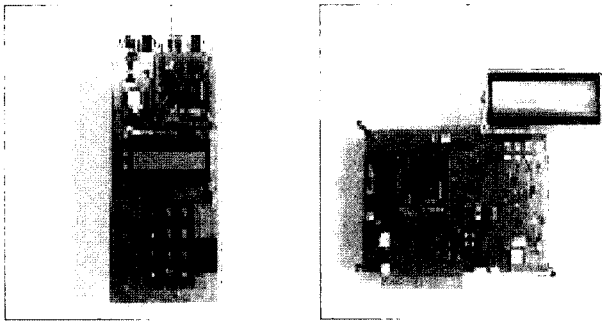

Fig. 6 Hardware pictures of automobile remote systems

B. System S/W Design

(1) Module 1 (Transmit unit)

Fig. 7 is Transmit unit's flow chart that talks action progress order of Module 1 (Transmit unit).

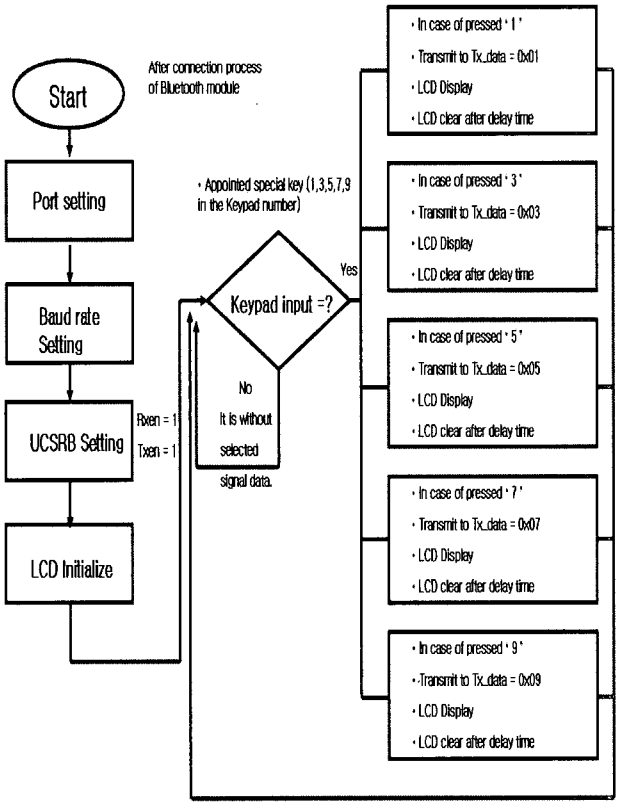

Fig. 7 Module 1(Transmit unit) Flow Chart

(2) Module 2 (Receive unit)

Fig. 8 is Receive unit's flow chart that talks action progress order of Module 2 (Receive unit).

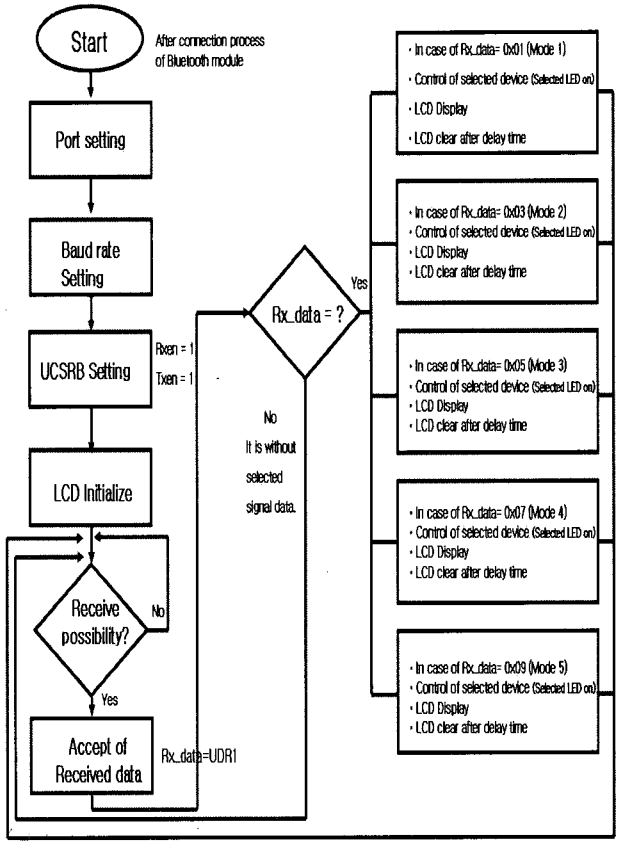

Fig. 8 Module 2 (Receive unit) Flow Chart

IV. EXPERIMENTATION

For the experimentation, we design and embody the remote control system hardware and software as shown in Fig 3, 4, 6. This experimentation did a remote control system test to use Bluetooth manufactured hardware for the automobile. Before experiment, Bluetooth module does to early setting (baud rate, parity, stop bit, security password, action mode etc.) through PC. Experimentation of correctness rate of data, security between communication, scanning time between Bluetooth module, interference of electromagnetic wave (wireless LAN etc.) tested by baud rate / distance. Also, we experimented in field as the case 1, inside of building (place that do not receive effect of electromagnetic wave interference with wireless LAN) as the case 2, inside of building (place that receive effect of electromagnetic wave interference with wireless LAN) as the case 3 by place. Then, analyzed interference degree of electromagnetic wave, transmission correctness of data, times of recognition between Bluetooth modules. And the study has meaning to it that known various advantage and function through use of Bluetooth.

A. Data transmission error rate test

Specification key of module 1 sends fixed data by CPU. Then, CPU transmits data through Bluetooth. Transmitted data is passed RS-232 cable through Bluetooth and sends by PC. Transmitted data confirms the data error rate to use hyper terminal program. Above process measures particularly the data error rate by each distance/baud rate

Table 2 Results of data transmission error rate test

Distance & Transmission Speed			Data Transmission Accuracy					
4800 bps	9600 bps	19200 bps	Character TU-PC	Sentence TU-PC	PC-TU	Communication Availability	RT	DT
0~10m	0~10m	0~10m	100%	100%	100%	Yes	0~3 sec	"
11~20m	11~20m	11~20m	100%	100%	100%	Yes		
21~35m	21~30m	21~30m	100%	100%	100%	Yes		
36~55m	31~49m	46~51m	100%	100%	100%	Yes	7~15 sec	"
56~64m	50~59m	46~51m	100%	100%	100%	Yes	60 sec	"
65m ~	60m ~	52m ~	Recognition disable between Bluetooth devices			No	Impossibility	

Remark: PC=Personal Computer, TU=Transmit Unit, RT=Recognition Time, DT=Delay Time

As shown in table 2, even though there was delay time and recognition time according to distance, but data transmission error was almost zero and communication was available in all transmission speed. According to the test results, the maximum distance for communication are different because of the transmission speed. 65m is limit distance for 4800bps, 60m is limit distance for 9600bps and 52m is limit distance for 19200bps. According to the results of comparison between the infield test data and indoor test data, we can examine that the difference of communication distance is affected by the minimization of outside electronic wave interference of building block. So, we can drive the conclusion that the surrounding environment of system influences data transmission and communication distance.

B. Bluetooth recognition time test

(1) Case 1: Field

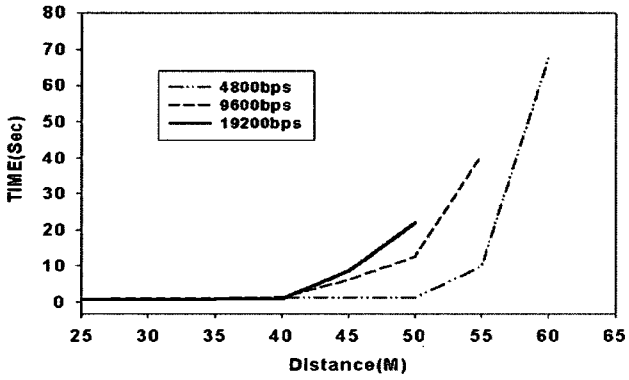

Fig. 9 Results of case 1

Occasion of 4800 bps: Section that module control is available, maximum recognition section is possible to 60m. Also, stable and fast recognition time was seen to section ago 50m.

Occasion of 9600 bps: Very unstable recognition was seen in 55m and 41 ~ 50 m section was shown abnormal recognition time. Stable and fast recognition section is 40m.

Occasion of 19200 bps: Maximum recognition section was 50m and did not recognize in more section. Section that recognize stably is 40m.

(2) Case 2: Indoor (without wireless LAN facility)

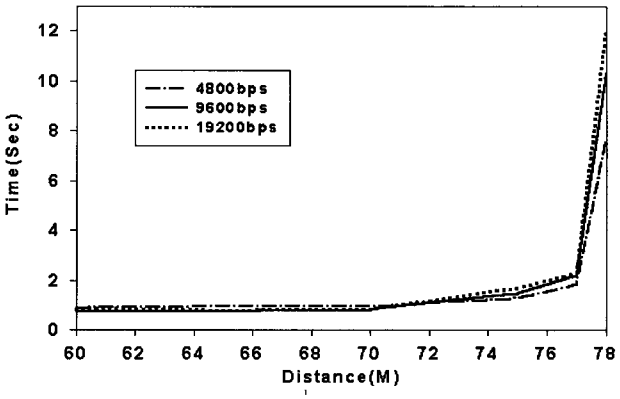

Fig. 10 Results of case 2

Confirmed that become recognition between Bluetooth devices as is stable and fast in section ago 70m. Recognition time between Bluetooth devices was changed from 77m sections by each baud rate change. It could know which recognition between devices is unstable from this section seeing this.

(3) Case 3: Indoor (with wireless LAN facility)

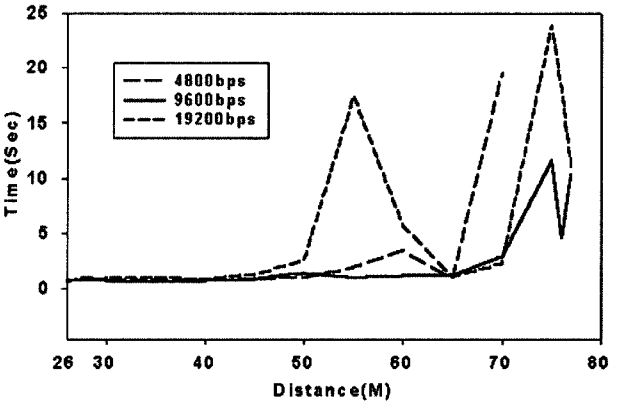

Fig. 11 Results of case 3.

Occasion of 4800 bps: 50m previous sections could see early recognition time. Know uncertainty static recognition in 51 ~ 70 m section. It was impossible recognition since 70m.

Occasion of 9600 bps: Stable and fast recognition time was seen in 45m previous section. Later in section, uncertainty static recognition (77m, 78m (5 ~ 10% (1~2th/ 20th)) do or recognition was impossible.

Occasion of 19200 bps: Was stable in 40m previous section but abnormal recognition time was seen to 41 ~ 77 m. Recognition was impossible from 78m sections.

V. CONCLUSION

Automobile remote control system is embodied in this experiment. As the results of data transmission test, data error rate shows zero under the given conditions. Also, communication is available by most stabilize and fast awareness in section within 30m. Furthermore, Bluetooth can be used in long distance wireless communication such as the RF communication by increase of antenna gain and electric power output. The control system that is used in this experiment is manufactured to embedded basis, but loading is available to cellular phone as that miniaturize to PCB base can reduce burdensomeness that have existent automobile remote control. And more, we can communicate and control an automobile using PDA or note PC without the remote control module. According to the recognition time test, we can realize that Bluetooth is affected and interfered by wireless LAN and magnetic field such as microwave. In this paper, we can design and implement remote control system using Bluetooth simply, but we can expand and utilize the design method to various applications such as ubiquitous networking platform, wireless and remote control devices and etc.

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