

HOME AND OFFICE ENVIRONMENTS USING BLUETOOTH TECHNOLOGY

RATNA KALOS ZAKIAH SAHBUDIN^{1*}, NURULAZA AZHAR², ISHAK ARIS³ & GOH KEAN JEET⁴

Abstract. Bluetooth technology which has gained the support from leading manufacturers is a promising solution to eliminate the need for wires, cables and the corresponding connectors between mobile phones, modems, computers, printers, PDAs and so on. This paper describes the development of home and office environment using Ericsson Bluetooth Modules (ROK101 008). The source code is written in Visual Basic 6.0 (VB) and used ActiveX component. The Bluetooth modules are able to transfer data and control the devices in the range of 10 meters. A personal computer (PC) is connected to a Bluetooth module and acts as a master. Another Bluetooth module is connected to a microcontroller PIC16F84A and the devices and acts as the slave. The devices can be controlled wirelessly via the Bluetooth modules.

Keywords: Bluetooth technology, wireless communication, master, slave, microcontroller

Abstrak. Teknologi *Bluetooth* yang mana telah mendapat sokongan daripada syarikat-syarikat terkemuka merupakan satu penyelesaian untuk menghapuskan penggunaan wayar-wayar, kabel-kabel dan penyambung-penyambung yang berkaitan di antara telefon bergerak, modem, komputer, pencetak, PDA dan sebagainya. Kertas kerja ini membentangkan pembangunan rangkaian kediaman dan pejabat secara wayarles dengan menggunakan *Ericsson Bluetooth Module* (ROK101 008). Kod punca telah ditulis dalam bahasa pengaturcaraan *Visual Basic 6.0 (VB)* dan juga menggunakan komponen *ActiveX*. Modul Bluetooth tersebut dapat menghantar data dan mengawal peranti-peranti yang berada dalam jarak 10 meter. Satu komputer disambungkan kepada satu modul Bluetooth dan dijadikan induk. Satu lagi modul Bluetooth disambungkan kepada mikropengawal PIC16F84A dan peranti-peranti dan dijadikan hamba. Peranti-peranti tersebut boleh dikawal secara wayarles melalui modul Bluetooth tersebut.

Kata kunci: Teknologi *Bluetooth*, komunikasi wayarles, induk, hamba, mikropengawal

1.0 INTRODUCTION

Wireless communication is currently becoming popular and evolving to support communication needs for wide range of applications [1]. It gives opportunity to wireless data transfer technologies such as Infrared, HomeRF, WiFi and Bluetooth to be

^{1,2&4} Department of Computer and Communication Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia. Tel: (03) 89466431, Fax: (03) 86567127
*Corresponding author: Email: ratna@eng.upm.edu.my

³ Department of Electrical and Electronics, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia. Tel: (03) 89466324, Email: ishak@eng.upm.edu.my

improved for future benefit. With the advancement of radio frequency (RF) and semiconductor technologies, researchers are now concentrating effort in developing pico-networks where electronic devices within a few meters to a maximum of 100 meters can communicate without requiring any fixed infrastructure [2]. The result is Bluetooth, a technology named after a 10th century king who brought warring Viking tribes under a common rule. The Bluetooth wireless technology has been developed by an industry-based association, the Bluetooth Special Interest Group (SIG) [3]. The choice of operating in the license-exempt band, that is ISM (Industrial Scientific Medical) band which ranges from 2.4 GHz to 2.4835 GHz enable the goals of global applicability, low power and high aggregate capacity to be met [3].

This paper demonstrates the development of the household and office devices that can be controlled using wireless Bluetooth technology, which is suitable for a wireless home or office environment [4, 5].

2.0 BLUETOOTH SYSTEM ARCHITECTURE

The Bluetooth 1.1 specification was released in February 2001 [6]. The standard is developed around the ISM band using the frequency-hopping system [7]. The hopping rate is 1600 hops per second. The operating frequency band is divided into 1MHz spaced channel, each supporting data rate of 1MHz. Frequency hopping is used to minimize the effect of interference from other users within the same band.

The Bluetooth architecture defines a small cell, called a piconet, and identifies four states for the stations: master (M), slave (S), standby (SB), and parked or hold (P) [8]. Each station can be in the master or slave state. Slave stations can participate in one or more piconets. A master station can handle seven simultaneous links, and up to 200 active slaves in a piconet. If access is not possible, a station enters the standby mode, waiting to join a piconet, but keeping its media-access control address. A station can be in the parked mode - that is, in a low power connection. But in this case, it must release its media-access control address. Up to 10 piconets can operate in one area.

The Bluetooth specification also provides mechanisms for Bluetooth devices to discover each other, exchange identities and establish communications with each other, all without prior knowledge of each other. This is referred to as *ad hoc* networking. Security is also an important issue. Therefore, for the purpose of security and privacy, encryption is used as a safeguard against eavesdropping, and authentication is used for verification of identity.

Documentation on Bluetooth is split into two sections, the Bluetooth specification and Bluetooth profiles. The specification describes the Bluetooth protocol architecture. The profiles describe how different parts of the specification can be used to fulfill a desired function for a Bluetooth device.

2.1 Bluetooth Protocol

Figure 1 shows the protocol stack consists of a radio layer at the bottom, which forms the physical connection interface. The baseband and Link Manager Protocol (LMP) that reside over it are basically meant to establish and control links between Bluetooth devices. These three bottom layers are typically implemented in hardware. The Host Controller Interface (HCI) layer is required to interface the Bluetooth hardware to the upper protocol, which is Logical Link Control and Adaptation Protocol (L2CAP). The host controller is required only when the L2CAP resides in software in the host. If the L2CAP is also on the Bluetooth module, this layer may not be required as then the L2CAP can directly communicate with the LMP and baseband.

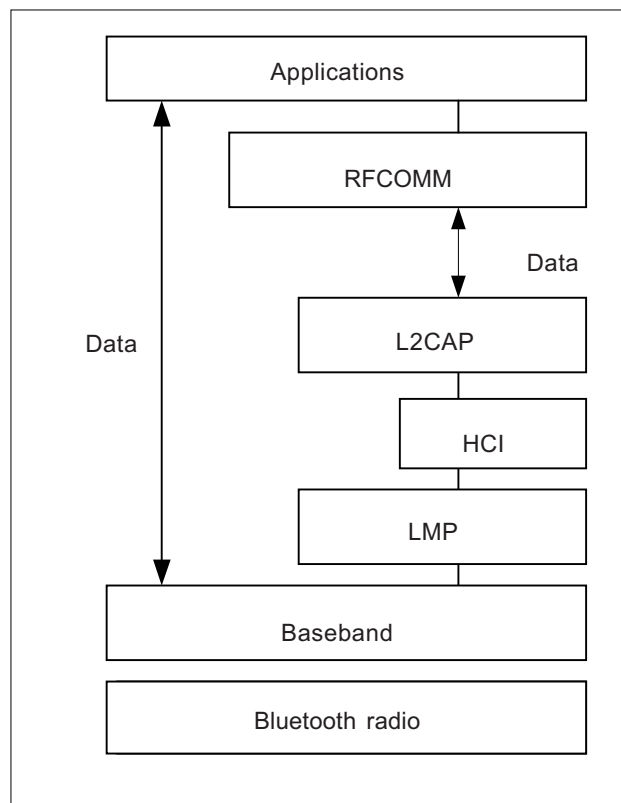


Figure 1 Bluetooth protocol stack

2.2 Bluetooth Profiles

The profiles have been developed in order to describe how implementations of user models are to accomplish. The user models describe a number of user scenarios where Bluetooth performs the radio transmission. A profile can be described as a vertical slice through the protocol stack. It defines options in each protocol that are

mandatory for the profile. The Bluetooth profile structure and the dependencies of the profiles are depicted in Figure 2.

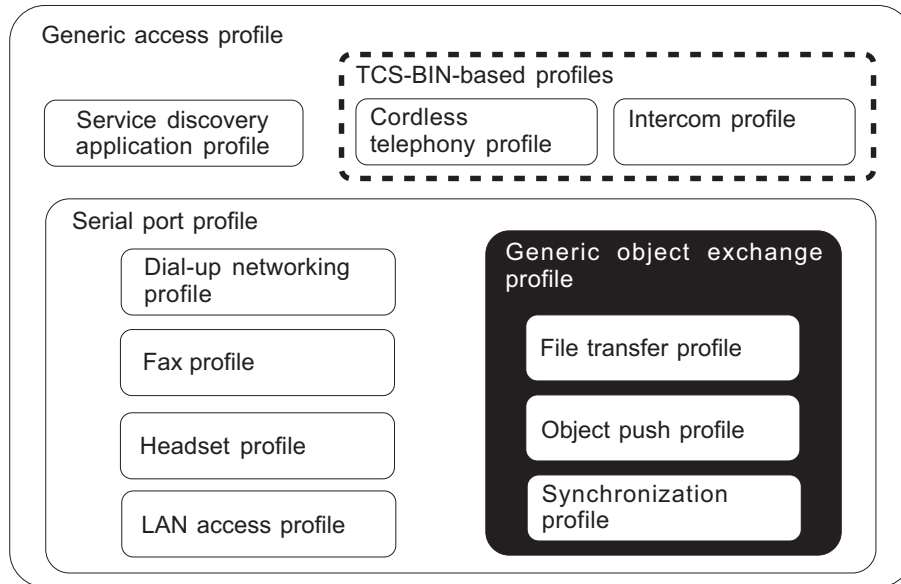


Figure 2 Bluetooth profile structure [6]

A profile is dependent upon another profile if it re-uses parts of that profile, by implicitly or explicitly referencing it. Dependency is illustrated in the figure. A profile has dependencies on the profile(s) in which it is contained – directly or indirectly.

3.0 HARDWARE AND SOFTWARE REQUIREMENTS

The hardware components required are two Ericsson's Bluetooth Application and Training Tool Kits (ROK 101 008), microcontroller, PC and the devices to control.

The Ericsson's Bluetooth kit consists of Host software for Windows 98/NT/2000, including Bluetooth protocol layers: HCI, L2CAP, RFCOMM and Service Discovery Protocol (SDP). This stack is delivered as an executable COM Server. The kit is equipped with RS232 serial port and USB port.

Microcontroller PIC16F84A is used in this project. It is an inexpensive single-chip computer, capable of storing and running a program. Its ability to perform math and logic functions allows it to mimic sophisticated logic and electronic circuits [8].

PICSTART Plus [9] is a device programmer that can be directly controlled by MPLAB [10]. It is used for downloading the compiled program done in MPLAB into PIC16F84A. PICSTART Plus enables quickly and easily program user software into PIC microcontroller devices.

Visual Basic 6.0 is used to develop a user interface program in this project. VB can develop very advance and powerful applications. For instance, Visual Basic can be used for computer interfacing, produces great pictures on the screen and can give more commands [11].

4.0 DEVELOPMENT OF HOME AND OFFICE NETWORKING USING BLUETOOTH TECHNOLOGY

Figure 3 shows the block diagram for the home and office networking using Bluetooth. A PC is connected with Bluetooth module, and acts as a master. The master is designed to perform as a remote control, which is used to control devices connected in its Bluetooth environment. A user interface program is written in VB in order to established connection and for user to be able to control devices. The slave consists of a Bluetooth module, microcontroller PIC16F84A and the devices. The slave Bluetooth module will receive the data being sent and loaded it into PIC16F84A. The PIC16F84A will then interpret the received control data. Finally this will enable the LEDs connected to the devices to be switched on and/or off according to data code received by the microcontroller. The communication range is up to 10 meters between the master and the slave.

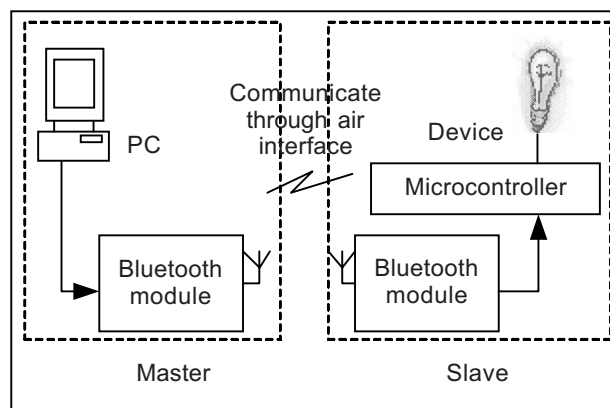


Figure 3 Block diagram of home and office networking using Bluetooth technology

The project is divided into two main parts, that is, setting up the master by installing Bluetooth protocol stack software into computer and setting up the slave by loading object language into chip using PICSTART Plus. The installed Bluetooth protocol stack and the loaded object language are configured and checked to make sure that they are working properly before the connection and program between master and slave start to execute. Figure 4 shows the flow chart of the step-by-step instruction on what need to be done for home and office networking.

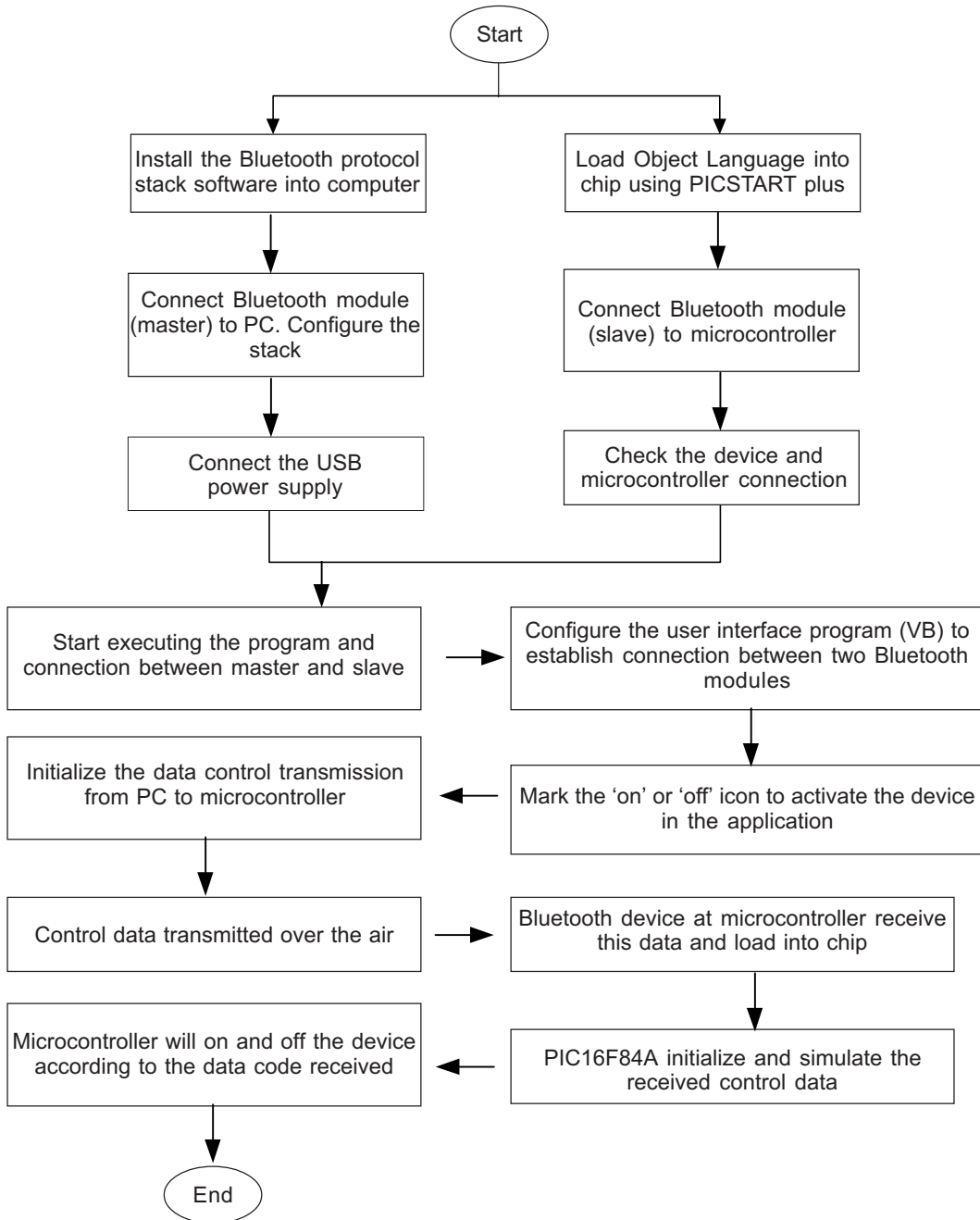


Figure 4 Flow chart of activities that need to be done for the home and office networking

4.1 Development of User Interface Program

The user interface program is able to interface with Bluetooth module connected to the PC COM port. It is also developed to provide user with a friendly and easy way to use it, and able to control the devices by sending a string of 0 s and 1s. Each string consists of 8 bits binary. Devices that are selected by the user to be activated or on are marked at the mark box for each device. At the same time the equivalent binary value for the number of devices that is selected will be displayed at the box below the data sent over Bluetooth module.

Thus the program written must provide declaration of the interface. Declaration of the interfaces that are used throughout the program:

```
Dim BT_CTRL_API As HBS_COMLib.ICtrlAPI
Dim BT_BSM_API As HBS_COMLib.IBSMAPI
Dim BT_HCI_API As HBS_COMLib.IHCIAPI
```

HBS_COMLib is a HandyBlueStack COM object. The COM object has five interfaces: IBSM API, ICTRL API, IHCI API, IL2CAPI and ISDP API. However, for the program only three of the interfaces are used:

(1) IBSM API

This the Bluetooth Stack Manager interface. This interface is a collection of stack configuration, device configuration, and device inquiry and name discovery (GAP) methods.

(2) ICTRL API

This is the Control interface. This interface is a collection of generic methods associated with command and event handling, communication port, stack control and status operations.

(3) IHCI API

This is the Host Controller interface. This interface is a collection of the HCI methods.

4.2 Programming the PIC16F84A Microcontroller

The program is written in Assembly Language using MPLAB software. This program is then converted to hexadecimal coding and downloaded into PIC16F84A using a programmer PICSTART Plus. Part of the program written for PIC16F84A is shown below. Parameters that need to be registered are:

```
tmr0    equ    0x01    ; Timer/counter register
status  equ    0x03    ; Status word register.
```

```

portA    equ    0x05    ; Port A register
portB    equ    0x06    ; Port B register
intCon   equ    0x0b    ; Interrupt control register
trisa    equ    0x85    ; File register in Bank 1.
trisb    equ    0x86    ; File register in Bank 1.

```

Then all the ports on PIC16F84A are declared to be activated according to the bit string it received.

```

movlw    h'ff'        ;Set input mode data
movwf    trisa        ;Set PORTA to Input mode
clrf     trisb        ;Set PORTB to Output mode
bcf      status,rp0   ;Change to Bank0
movlw    h'ff'        ;Set LED off data
movwf    portb        ;Display 8 LEDs according to the byte
                        receive

```

The following part is the program defines whether the PIC16F84A is able to receive data.

```

p00      equ          b'00000001'
movlw    p00         ;Set input data string
call     pbit        ;Call timer
movwf    portb       ;Output data

```

5.0 RESULTS AND DISCUSSION

All the results and discussion are based on the experiment done. The Bluetooth module should be connected to the PC, otherwise a message is displayed informing that the Bluetooth stack is not connected. Thus, user needs to wait several second, so that the connection between two Bluetooth modules is established and ready to transmit data.

The master and slave are placed within the area with a distance of 10 meters. The device is activated (switched on/off) when it is selected by the user. Figure 5 shows that the slave is detected within 10 meters range from the Bluetooth master. It also indicates that it is ready for data transmissions between any Bluetooth devices in that area. The device that is needed to be controlled is selected by marking the box and then pushed the "Switch On Selected Devices" to send the data string signal. "Bluetooth Stack Activities" box display the status of the transmission, which means the data is successfully sent. The binary string sent is 01111111 as displayed in the "Data sent to main control" box. Figure 6 shows that the slave has successfully received binary data sent. This is shown in the "Bluetooth Stack Activities".

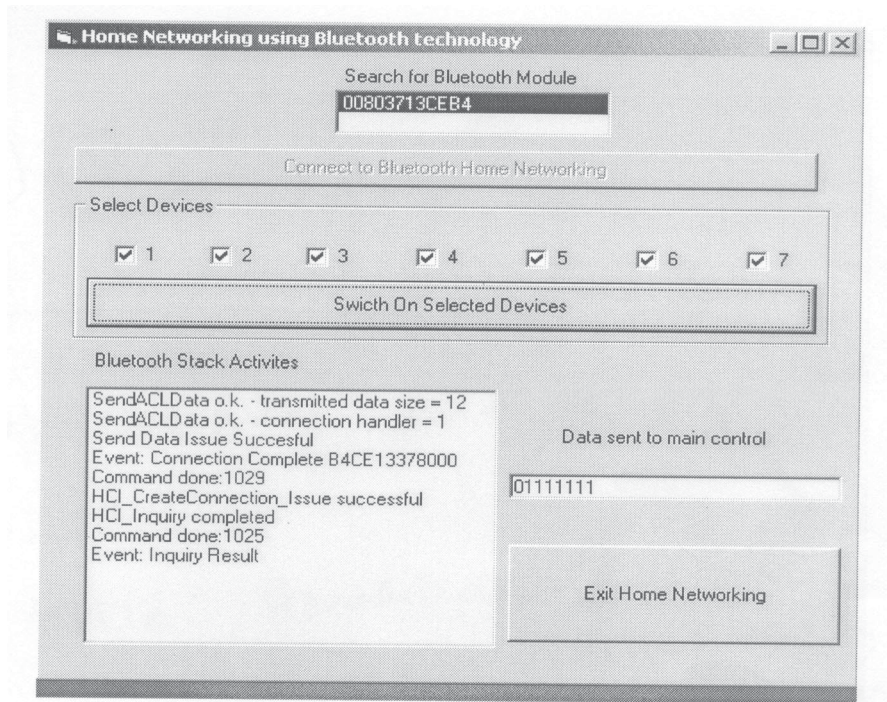


Figure 5 Inquiry has completed and all the devices were sent for transmission

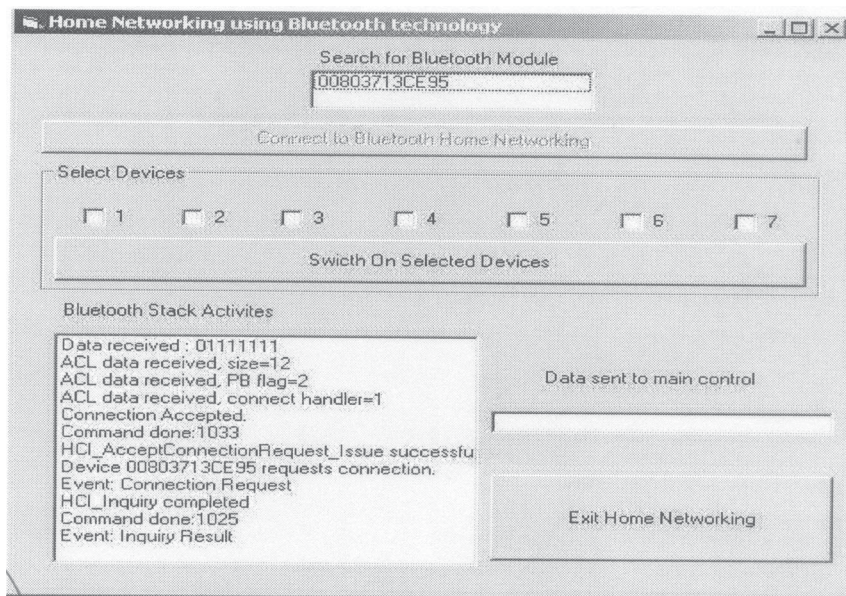


Figure 6 User interface program at the slave shows that the data has been successfully received

6.0 CONCLUSION

The project has demonstrated that the device has been successfully controlled by the Ericsson's Bluetooth modules and suitable for home and office environment. It is a simple system that can be used to control several devices. Based on the experiment and the Bluetooth technology today, the system could be improved by designing a remote control unit with Bluetooth enable that can also control the operation of the devices. The device could also respond to the signal sent by the remote control unit, indicating that the device works properly as required by the control unit.

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