Home Automation Management with WLAN (802.11g) and RF Remote Control

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ABSTRACT

The home automation becomes important, because it gives the user the comfort and ease for using the home devices. The implementation and design of wireless home automation control use two methods, WLAN technology and RF remote control handheld to control selective home devices with integral security and protected system. The devices have been distributed in two rooms, each room has own board, these boards are connected to the desktop personal computer (PC) through one serial port RS-232 via microcontroller. The software consists of Assembly Language for programming microcontroller (AT89C51and AT89C2051) and Visual Basic Language that use to communicate between PC and two boards, also it use to design Graphical User Interface (GUI) which involving all devices needed to display in Home PC screen . The system is low cost and flexible with the increasing variety of devices to be controlled.

Keywords: Microcontroller, Ad Hoc, TCP/IP, Wireless LAN (802.11g), RF Remote Control Handle, Laptop, Desktop PC, Smoke Sensor, Motion Detector Sensor.

إدارة نظام أتمتة المنزل مع (802.11g) WLAN وجهاز RF للتحكم عن بعد

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الملخص

نظام أتمتة المنزل أصبح ذات أهمية وذلك لأنه يعطي للمستخدم الراحة والسهولة في استخدام الأجهزة المنزلية. تنفيذ وتصميم نظام أتمتة المنزل لاسلكيا تتم باستخدام طريقتين, تقنية الشبكة اللاسلكية (WLAN) وجهاز التحكم عن بعد المحمول يدويا (RF Remote Control) وذلك للسيطرة على الأجهزة المنزلية المختارة مع منظومة حماية وامن متكاملة. الأجهزة تم توزيعها على غرفتين, كل غرفة تحتوي على لوحة سيطرة, ولوحات السيطرة ربطت إلى الحاسبة الشخصية (PC) من خلال منفذ تسلسلي واحد بواسطة المسيطر الدقيق.

الجزء البرمجي يتألف من لغة التجميع (Assembly Language) لبرمجة المسيطر الدقيق (AT89C51 and AT89C2051) وكذلك لغة (Visual Basic Language) التي تستخدم في عملية الاتصال بين الحاسوب الشخصي ولوحتا التحكم, وكذلك تستخدم في تصميم واجهة رسومية (GUI) المتضمنة جميع الأجهزة المراد عرضها على شاشة الحاسوب الشخصي المنزلي. المنظومة صممت لتكون اقل كلفة وأكثر مرونة مع زيادة الأجهزة المختلفة المسيطر عليها.

الكلمات المفتاحية: متحكم، Ad Hoc، TCP / IP، تقنية الشبكة اللاسلكية LAN (**802.11g**)، جهاز RF للتحكم عن بعد، حاسوب محمول، حاسبة شخصية PC، جهاز استشعار الدخان، جهاز استشعار الحركة الكاشف.

1. Introduction

The home automation is control of home devices from a central control point, automation is today's fact, where more things are being completed every day

automatically, usually the basic tasks of turning on or off certain devices and beyond, either remotely or in close proximity [1].

The concept of the RF-based systems is to use the underlying wireless data network such as IEEE 802.11 (Wi-Fi) [2].

The popularity of wireless networks in home has increased in recent years, and the advanced computer technology has made the personal digital device to commonly have the capability to communicate through the wireless network. Hence, it is suitable to use RF-based location determination system to estimate the location of the personal digital device in a home environment with high data rate transmission, supporting multimedia applications may be feasible in WLAN [3].

One of the possible applications are wireless networks for home automation. Imagine a private home equipped with motion, light, temperature and other sensors and actuators for opening the door, dimming the light, controlling the heating and so on [4]. It can be as basic as dimming lights with a remote control or as complex as setting up a network of items in your home (such as a thermostat, security system, lighting and appliances) that can be programmed using a main controller [3]. The basic idea of home automation is to employ sensors and control systems to monitor a dwelling, and accordingly adjust the various mechanisms that provide heat, ventilation, lighting, and other services. The automated "intelligent" home can provide a safer, more comfortable, and more economical dwelling [4].

In an intelligent home automation system there are many possible solutions for how and from where to control the automation system and single devices; a user interface can be a computer-based system, a mechanical switch, a single light, a loudspeaker with a microphone or a some kind of personal remote controller for all the home appliances, the home appliances can be controlled using normal PC, laptop or table PC by standalone software or web-based user interface [5]. In the near future 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 [6, 7, 8].

In this paper, a home automation control system has been designed by choosing two rooms, each room has control board with microcontroller, these two boards are connected to the desktop (PC) through one serial port (RS-232). By using RF remote control and WLAN between desktop and laptop being easily realized from any place in the home.

2. The WLAN System Design

This section focuses on the hardware part, which consists of designing two boards, RF remote control, WLAN (802.11g) and sensors. These two boards are connecting to the desktop Home PC through one serial port (RS-232) as shown in figure (1).

The Circuit in (board 1) as shown in figure (2) consist of several component such as AT9C51, MC1488, MC1489, 74LS374, 74LS244, comparator, ULN2803, relays and resistances, the heart of the wireless home control system is microcontroller type Atmel (AT89C51) which is running on 12 MHz clock speed. The inputs of microcontroller consist of (sensors, RF remote control and serial port RS-232) signals, the microcontroller receives these signals and analysis it then distributed these signals to devices to turn on/off. The board1 function is to control of all room1 devices with protection system through WLAN and RF remote control handheld.

The second board (board 2) as shown in figure (3) consist of several components such as Microcontroller (AT89C2051), MC1488, MC1489, 47LS244, 74LS374, ULN2803 and comparator, the board 2 function is to control room devices with protected system through WLAN and RF remote control handheld.

The input Red LEDs in the two boards represent as indicator, which represent the input signal coming from (RF remote control, Manual Switch and Master PC) to the

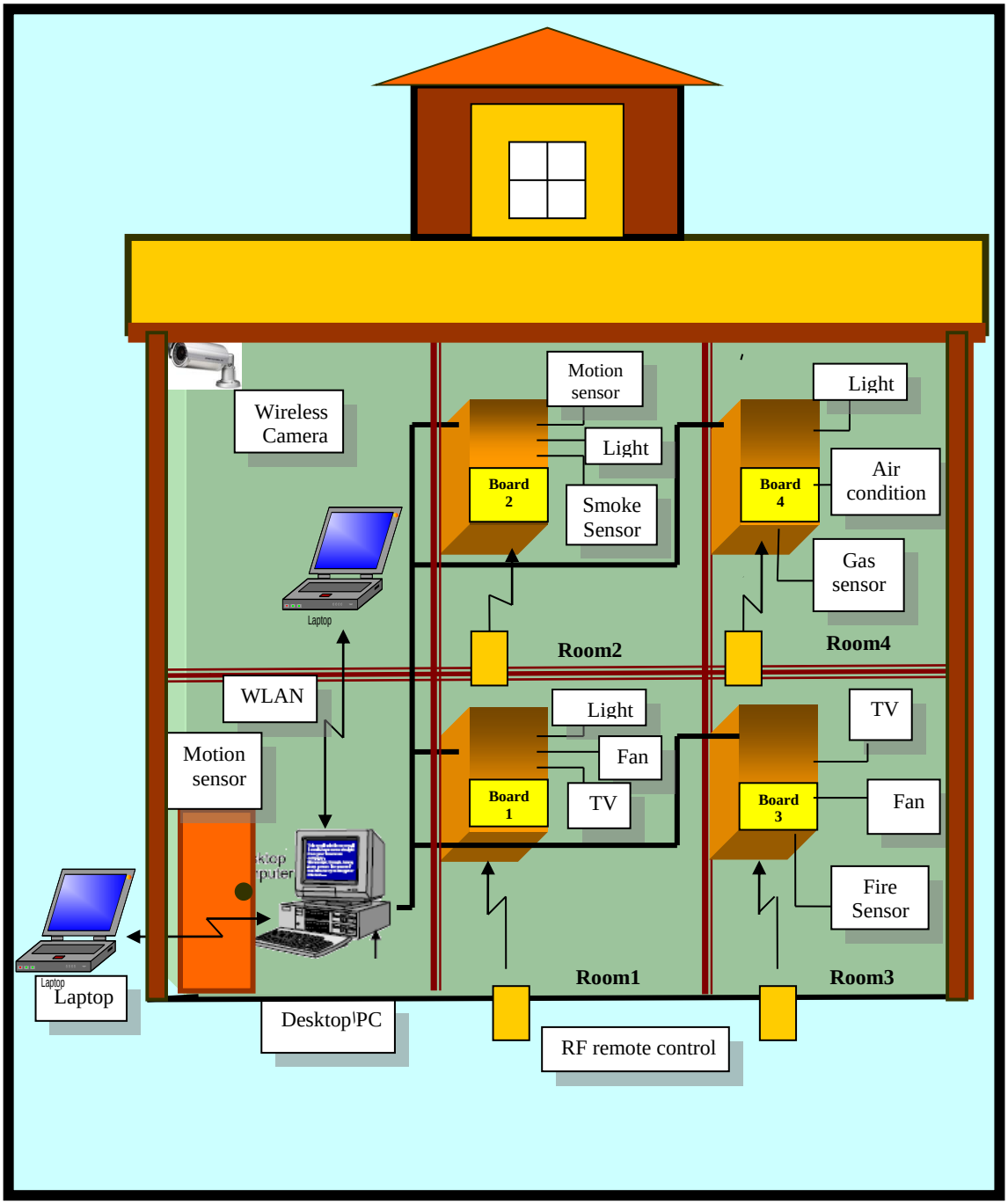

Fig.(1) General Block Diagram of Home Wireless Automation System

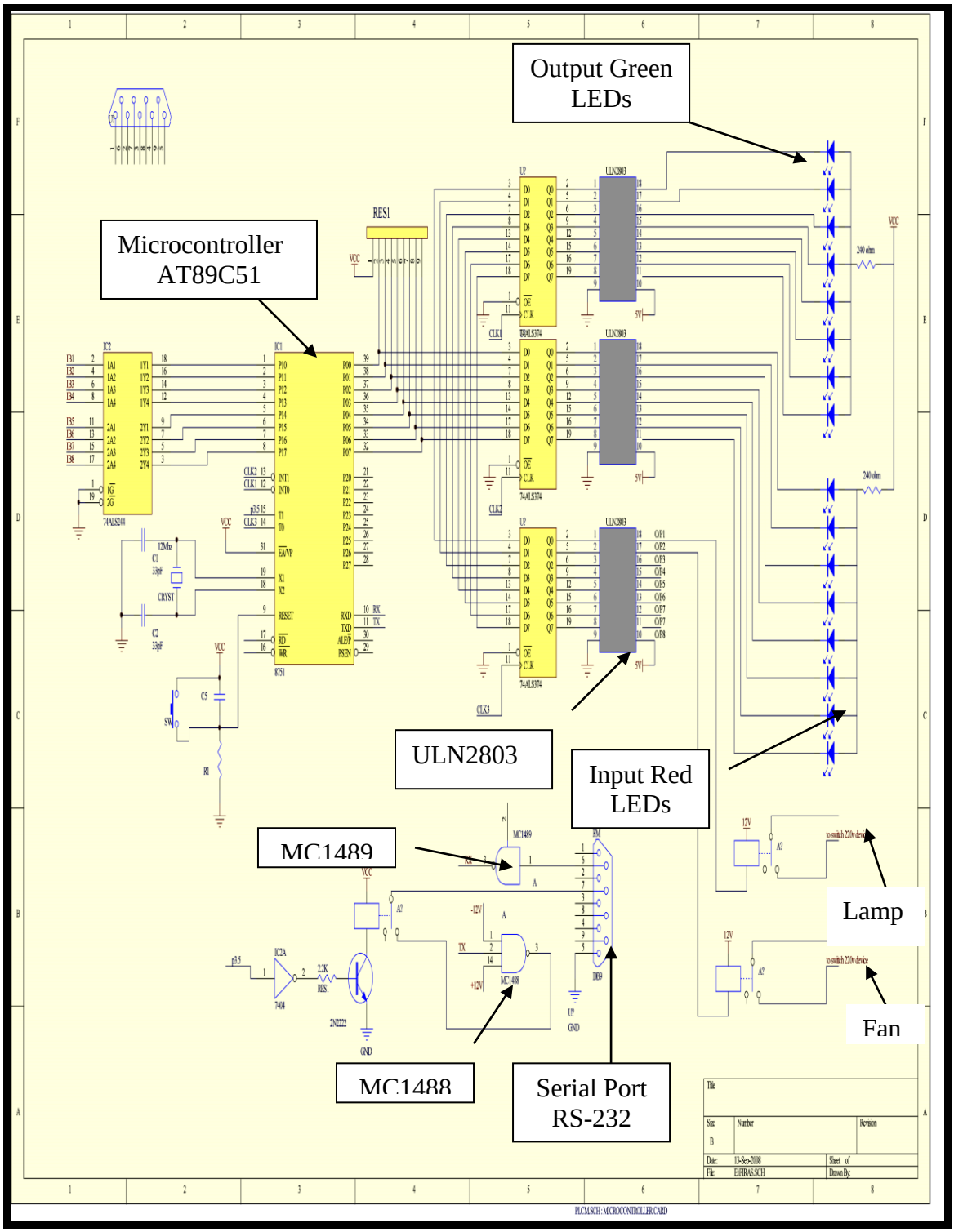

Fig.(2) The Schematic Diagram of Board 1

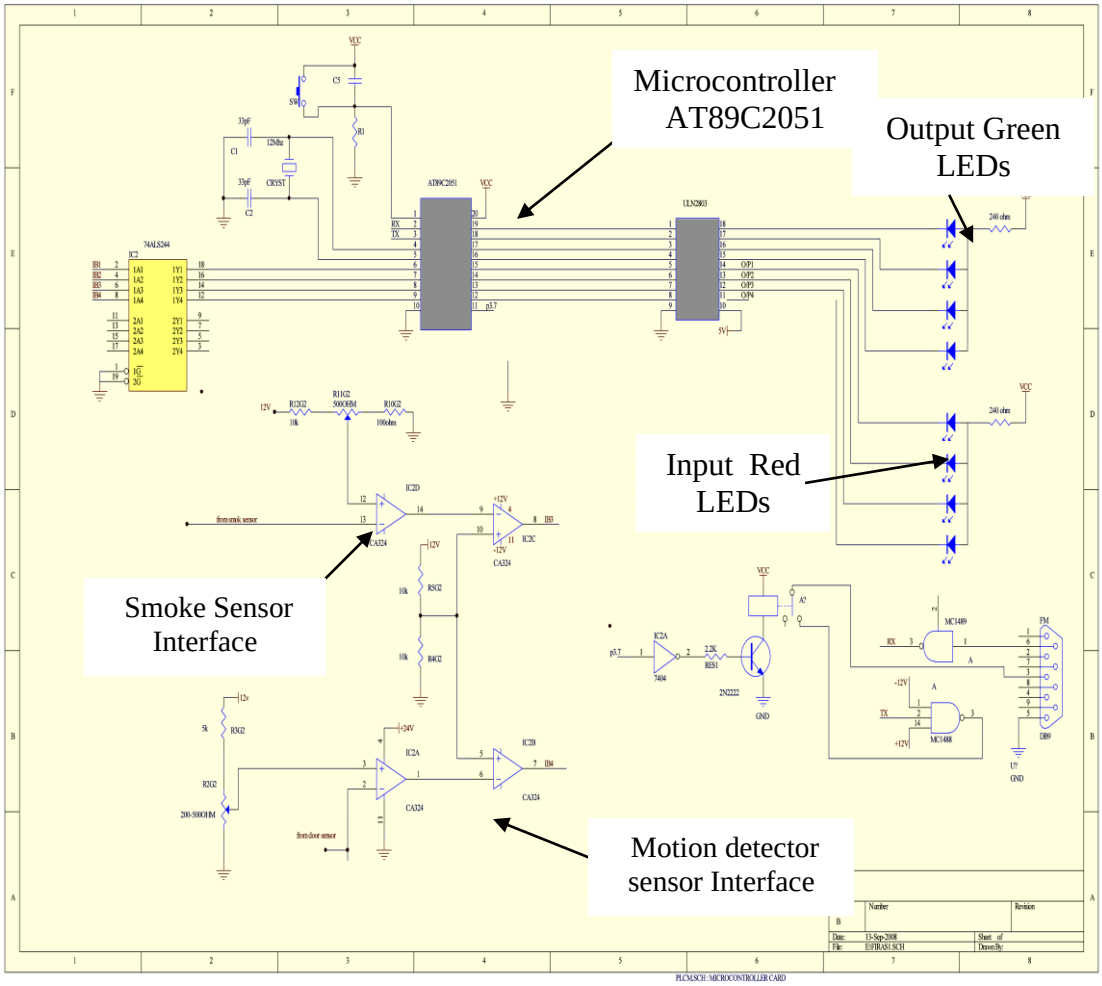

Fig.(3) The Schematic Diagram of Board 2

2.1 RF Remote Control Handheld

The RF remote control system is using 433MHz, which is a frequency allocated for all sorts of radio frequency controllers. Coding is necessary to prevent the interference and security. The RF remote control transmitter consist of four switches, each switch has different function for example the switch (SW1) use to turn the ceiling fan (ON) and the switch (SW2) use to turn the device (OFF). The microcontroller receives this signal through RF receiver circuit then provides the special code of the selective device.

Figure (4) explains the block diagram of interface RF receiver circuit with board 1. The microcontroller AT89C51 checks the store ceiling fan code and gives the chosen order, at the same time the code goes through serial port to the Home PC GUI to indicate the situation of the device.

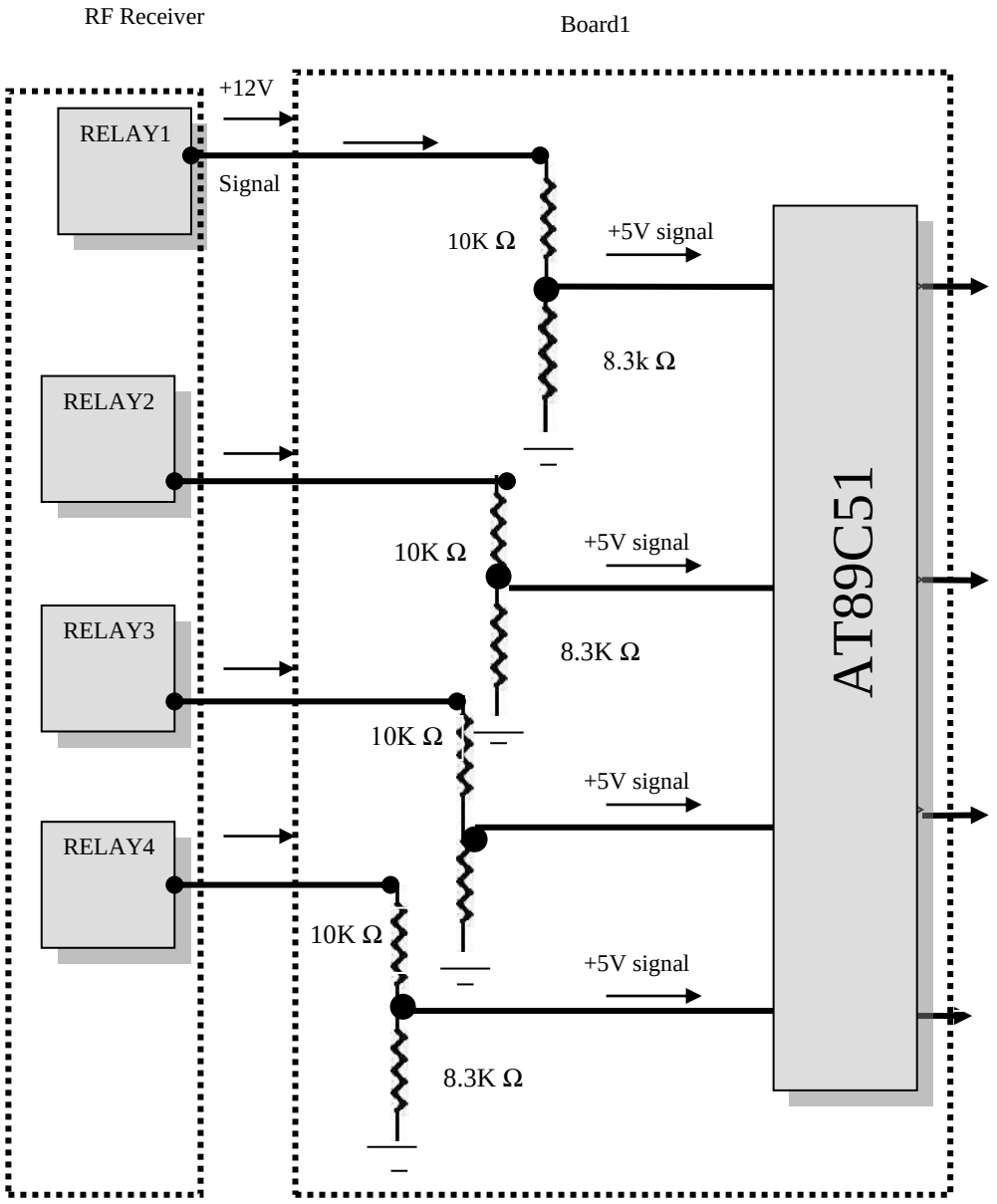

Fig.(4) Interface Between RF Receiver and AT89C51 in Board 1

2.2 WLAN (802.11g)

In 2003, IEEE released 802.11g that extended 802.11b Physical layer to support data transmission rates of up to 54 Mbps in the 2.4 GHz band. Many IEEE 802.11g WLANs are operated in a completely insecure manner, representing an easy-to attack target for even the most unskilled attackers, who happen to pass by near a building where an IEEE 802.11g WLAN is operating therefore, in WLANs there is a stronger need for security than in their wired counterparts [9]. The IEEE 802.11g group has been responsible for setting the standards in wireless LANs, focusing on Data link layer and Media access control sub-Layer of the Open System Interconnect (OSI) model [10].

The most widely used version of IEEE 802.11, has the maximum throughput of 11 Mbps. The most common standards for wireless network connectivity are the IEEE 802.11b/g/a [IEEE 80211]. The maximum theoretical speed is 54 Mbps, which is however shared among all the customers connected on the same wireless access point [11]. There are four methods that have been used for remote control of Desktop Home PC via WLAN:

1- Remote Desktop Control allows the user to remotely control any computer, running under the Microsoft Windows system in a TCP/IP local area network or the Internet. The user can see a remote desktop on his or her own screen and use the mouse and keyboard to control the connected computer remotely [12].
2- Netmeeting Method using your PC and the Internet, you can now hold face-to-face conversations with friends and family [13].
3- pcAnywhere method built-in 256-bit encryption and enhanced video performance help make communications much more secure and fast [14].
4- Client/server method describes the relationship between two computer programs in which one program, the client, makes a service request from another program, the server, which fulfills the request [15].

The above methods were applied to the system and pcAnywhere method is the best one because it has (40 m) long range, better security and it needs one person to communication between two computers.

2.3 Smoke Sensor Interfacing

The protected system is represented by the Smoke Sensor used for sensing the smoke in any place in rooms. This device is interfaced with the microcontroller AT89C2051 in board 2 as shown in figure (5). The activation of this device will alarming and shutting down all electrical devices by microcontroller. The same method as shown in figure (5) is use to connect Motion Detector Sensor.

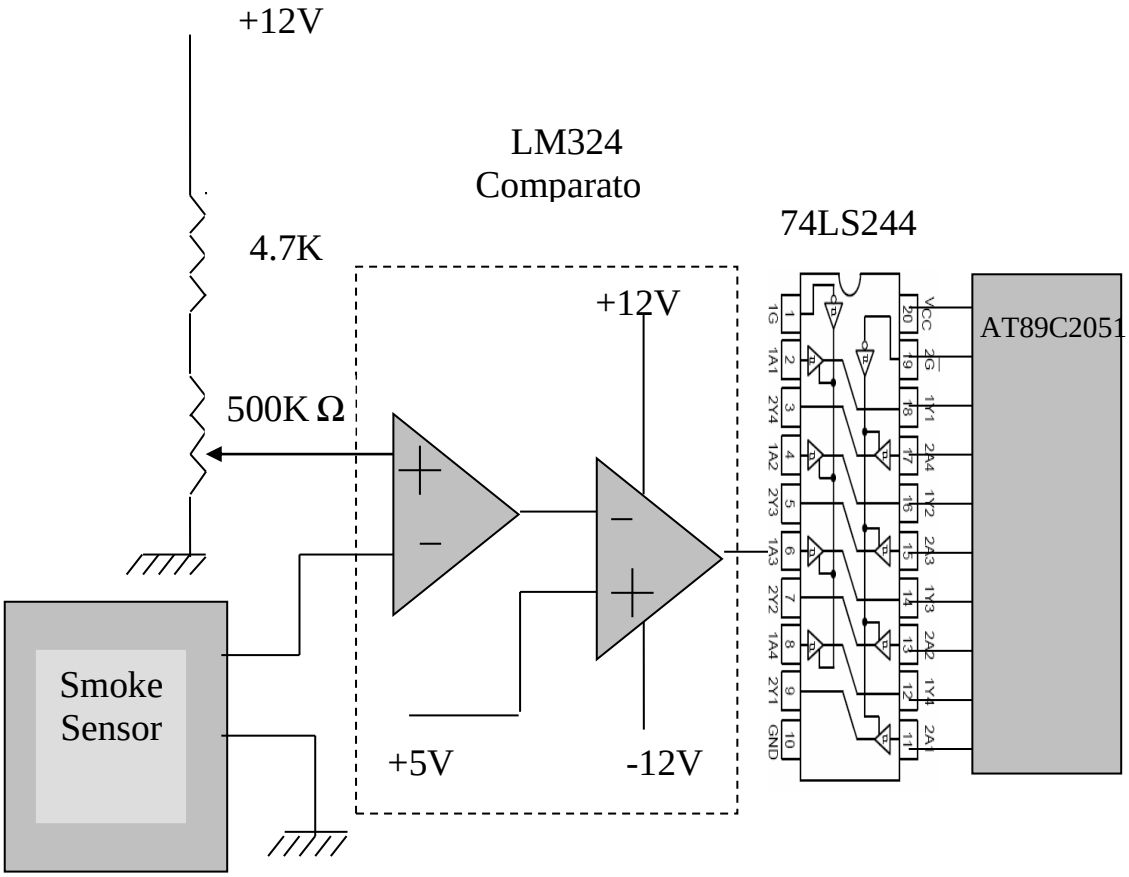

Fig.(5) Block Diagram of Interface Smoke Sensor with AT89C2051

An Ad-Hoc mode wireless network connects two computers directly (Laptop and desktop) without the use of a router or Access Point (AP), in order to monitoring and controlling the situation of the home devices, figure (6) illustrates this connection.

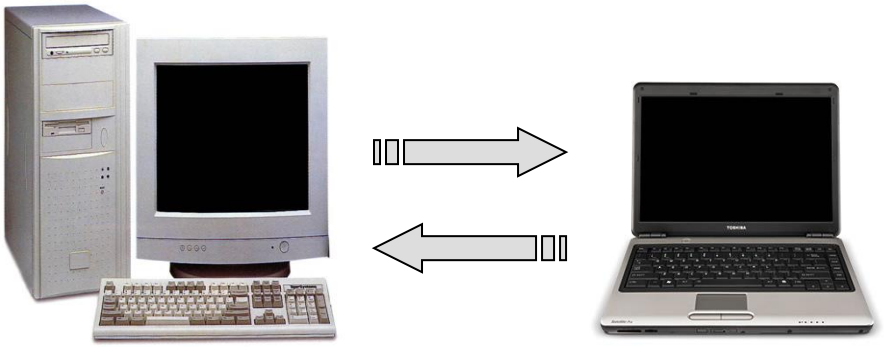

Fig.(6) Ad-hoc Connection

3. Software Development

The firmware for the microcontroller was developed using assembly language. Visual basic language was used to design the GUI (graphical user interface) screen that contains all devices in the home.

3.1 Assembly Language Program

The flowchart is shown in fig. (7) used for Home Automation by using the microcontroller. The initialization and reset (Serial Port, Timers and Variables) was selected then microcontroller read inputs (Sensor, RF, Manual Switch and Serial Port). The order goes to the device to turn on or off. At the same time the microcontroller give handshake signals to the Desktop PC to display the situation of the device.

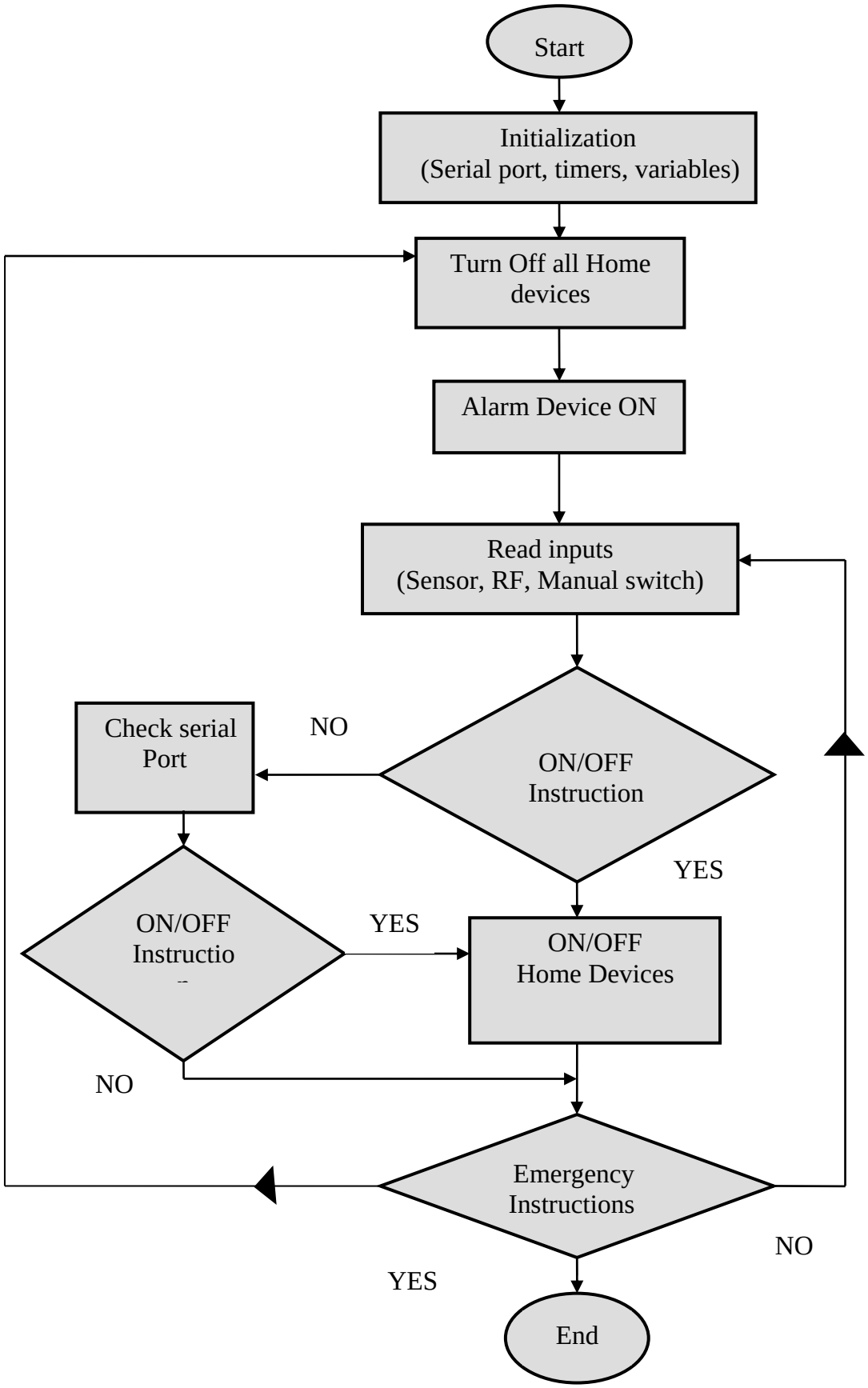

Fig.(7) Programming Microcontroller With Protection System Flow Chart

- **Programming Microcontroller (AT89C51)**

```
org    00
jmp    start
org    50h
start: mov    sp,#40h
mov    scon,#050h
mov    tmod,#21h
orl    pcon,#80h                ;k=1
mov    th1,#0f3h                ;B.R. 4800 b/s


clr    ri
clr    ti
setb   tr1
mov                20h,#00
mov                21h,#00
;;;;;;;;;;;off output
oof:   mov    p1,#00
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;read from serial port
dss:   mov    r5,#00
kk:              jnb    ri,vv
clr    ri
jmp                kk1
vv:                jmp        vvv
srp:   jnb    ri,$
clr    ri
kk1:   mov    a,sbuf
cjne   r5,#00,ck1
cjne   a,#16h,dss
inc    r5
jmp    srp
ck1:   cjne   r5,#1,ck2
cjne   a,#61h,dss
inc    r5
jmp    srp
ck2:   cjne   r5,#2,ck3
cjne   a,#0e0h,dss
inc    r5
jmp    srp
ck3:   cjne   r5,#3,ck4
cjne   a,#99h,cc1
inc    r5
jmp    srp
cc1:       cjne   a,#66h,dss
mov    r5,#00
jmp    oof
ck4:   cjne   r5,#4,ck2
mov    r5,#00
mov                25h,a
setb                 50
jmp                vv4
jj11:                clr        p3.7
;delay
jj:    mov    52h,#1
jj1:   djnz   50h,$
djnz   50h,$
djnz   51h,jj1
djnz   52h,jj1
```

```
;transmit to serial port
mov     a,#16h
mov     sbuf,a
jnb     ti,$
clr     ti
mov     a,#61h
mov     sbuf,a
jnb     ti,$
clr     ti
mov     a,#0e0h
mov     sbuf,a
jnb     ti,$
clr     ti
mov     a,#99h
mov     sbuf,a
jnb     ti,$
clr     ti
mov     a,21h
swap                    a
mov     sbuf,a
jnb     ti,$
clr     ti
setb                    p3.7
jmp                     vvv
;;;;;;;;;;;;;;;;;;;;;;;;;;;;
vv4:                    mov     a,25h
anl                     a,#0f0h
mov                     r3,a
mov                     a,25h
anl                     a,#0fh
cjne                    a,#1,hh1
cjne                    r3,#00,mm1
clr                     12
jmp                     mm
mm1:                    setb    12
jmp                     mm
hh1:                    cjne    a,#2,hh2
cjne                    r3,#00,mm2
clr                     13
jmp                     mm
mm2:                    setb    13
jmp                     mm
hh2:                    cjne    a,#3,hh3
cjne                    r3,#00,mm3
clr                     14
jmp                     mm
mm3:                    setb    14
jmp                     mm
hh3:                    cjne    a,#4,mm
cjne                    r3,#00,mm4
clr                     15
jmp                     mm
mm4:                    setb    15
mm:                     mov     a,21h
mov                     p1,a
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;read inputs
vvv:    mov             20h,p3
vv2:    jb      2,ss1
```

```
jmp    ss2
ss1:   setb   10
setb                    14
setb                    22
ss2:   jb     3,ss3
jmp    ss4
ss3:   clr    10
clr                     14
clr                     22
ss4:   jb     4,ss5
jmp    ss6
ss5:   setb   11
setb                    15
setb                    22
ss6:   jb     5,ss7
jmp    ss8
ss7:   clr    11
clr                     15
clr                     22
ss8:                    mov       a,21h
;write to output
mov                     p1,a
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
jb                   50,vv3
jmp                     dss
vv3:                    clr       50
jmp                     jj11
end
```

……

3.2 Visual Basic Language

In this paper has been used Visual Basic Language to make connection between master Home PC and boards through program written by using Visual Basic Language. Also the Visual Basic Language has been used to design the graphical user interface. The GUI consist of screen that contains the all devices in the home and by using this screen can the user turn the device on/off from any place inside the home or outside it. The figure (8) illustrate this screen.

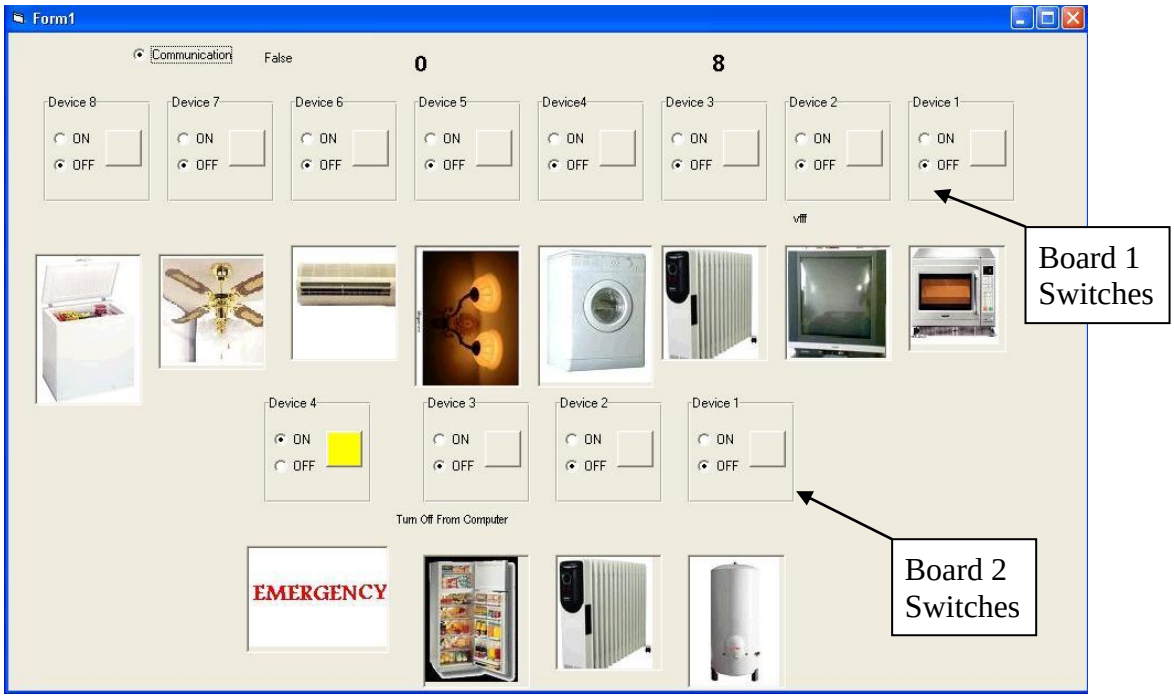

Fig.(8) GUI of Desktop PC Screen

4. Conclusion

1- For more security and high band width the IEEE 802.11g seems to be suitable for the setup of a wireless instrument control network. The 802.11g has 2.4MHZ and 54 Mbs, the range for 802.11g between Master PC and laptop is (27-45) m.

2- The Wireless transmission media was RF, it is more suitable than IR, because RF penetrate objects such as walls in the home, but Radio signals are susceptible to noise and electrical interference. The RF remote control handheld operating on 433 MHZ, the range distance between remote control handheld and device is (15-25) m.

3- The PCanywhere method is the best because it is more secure and confident from other methods and it needs one person to communication between two computers.

4- The system provides alarming and shutting down all electrical devices at fire and smoking conditions.

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