THE IMPLEMENTATION FOR THE INTELLIGENT HOME CONTROL SYSTEM BASED ON THE ANDROID AND ZIGBEE

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Submitted: Feb, 27, 20 ***Accepted: June 24, 2014*** ***Published: Sep. 1, 2014***

Abstract- The intelligent home system finished the wireless or remote control for all the indoor electric devices through the intelligent terminals. The description about the integrated network architecture and the interconnecting mechanisms for the reliable measurement of parameters by smart sensors and transmission of data via internet is being presented. The wireless communication technology includes the WiFi, Zigbee and mobile communications. The system presented the design of the hardware part and the software part. The forward are fixed in the variety of appliances based on CC2530 chip and sensors. The connection between different devices can be finished by the standard interfaces RS232 and RS485. The software can be installed in the tablet PC, the personal computer or smart telephones. It can be realized on the open Android platform or Eclipse. The system has been applied in the actual intelligent house. Results are encouraging as the reliability of sensing information transmission is with very little error in the peak of the internet. The home owners are satisfied with the test results. The prototype was tested to generate real-time graphical information rather than a test bed scenario. This will be widely applied in the future of the smart home.

Index terms*: Zigbee; WiFi; the intelligent home control system; android system*

I. INTRODUCTION

In recent years, the rapid development of Internet of Technology (IOT) makes the intelligent home come true as people expect [1]. The intelligent home system creates the more comfortable, safer, humane and intelligent living environment. It can determine the wellness of an elderly living alone in a smart home with the number of elderly people increasing rapidly around the world. The research [2] has modeled a framework integrating temporal and spatial contextual information for determining the wellness of an elderly. It has developed a novel behavior detection process based on the observed sensor data in performing essential daily activities to forecast the behavior and wellness of the elderly by monitoring the daily usages of appliances in a smart home. The paper [3] reported a mechanism for estimation of elderly well-being condition based on usage of house-hold appliances connected through various sensing units. It defined two new wellness functions to determine the status of the elderly on performing essential daily activities through the wireless sensor network. Based on the safe home monitoring system, the design intricacies and implementation details has been targeted for the elderly people to provide a safe, sound and secured living environment in the society [4]. Its system has minimized the number of false messages to be sent to care provider and supports inhabitant through suitable prompts when there is irregular behavior in the daily life. The owner can monitor the indoor environment and keep abreast of the situation at home remotely to ensure the safety. The researches [5] and [6] have reported an effective implementation used for monitoring regular domestic conditions or KNX Devices using low cost ubiquitous sensing system or USB/KNX Interfaces. The framework of the monitoring system is based on a combination of pervasive distributed sensing units, information system for data aggregation, and reasoning and context awareness. The longitudinal learning system can provide a self-control mechanism for better operation of the devices in monitoring stage.

Using several sensors to measure different vital signs, the person is wirelessly monitored within his own home. Some researches can be easily adapted to monitor athletes and infants [7]. The design and development of a Zigbee smart noninvasive wearable physiological parameters monitoring device can be used to monitor physiological parameters, such as

temperature and heart rate, of a human subject. The device detects if a person is medically distressed and sends an alarm to a receiver unit that is connected to a computer. This sets off an alarm, allowing help to be provided to the user. The research [8] presented the cognitive sensors provide information that can be used for monitoring the elderly by detecting any abnormality pattern in their daily activities around the house. The system will generate and send an early warning message to the care giver, when an unforeseen abnormal condition occurs.

The smart home system can not only monitor the elderly in the family but also can control the facilities at home at any time and at any place. The owner can open the air conditioning on the way home after work. In hot summer, they can feel cool when they come back home. He/she can control rice cookers, microwave ovens, water heaters and so on remotely. The dinner is ready soon. After dinner, they can go for bathing. With the development of the digital and intelligent building, the smart home system is gradually changing the way people live and work.

With the market of the smart home significantly increasing, several solutions are provided as follows. One uses the infrared controller, the touched tablet PC, LCD monitor and displayer, keyboard and other equipment for appliances' controller [9]. This requires the design for the control terminal is very complex. And appliances are compatible to support the controller. The cost is relatively high. And it is hard to support remote control. Now the popular terminal controller is a PC. But it has large volume, inconvenient enough for carrying, high cost for general family. So the second is using the ubiquitous intelligent phones as the control terminals. They control the home appliances based on the WiFi, Bluetooth, GSM, the wireless sensor internet based on the Zigbee and the CC2530 chip, and other systems [10-15]. The Android system has occupied 48% of the global smart phone market recently. It is dominant in the Asia-Pacific market. In China, it is up to 58%. Google introduced an application called Android @ Home program at the I / O developer conference in May 2011. The program can open household lamps, wireless stereo audio playback and even analyze burning calories in the fitness car through the Android phone or tablet PC [16].

This design of the intelligent home control system is using the tablet PC or the intelligent phones as the controller. Almost every family has one of them at least. This reduces the

hardware design complexity of the indoor intelligent devices. And it does not destroy the wall of the house and buy new electrical equipment. The cost is very low. The system can connect with the lighting or the usual electrical equipment. It has good scalability for other devices to adapt to the new needs of intelligent life in the future. It uses the Android graphical interface. The interface is intuitive and beautiful. It is a good experience for users. The system can control the home settings anywhere at any time to achieve its related functions. The intelligent home system is shown in the Figure 1. It almost includes all the electrical devices. It also can link other new devices in the future.

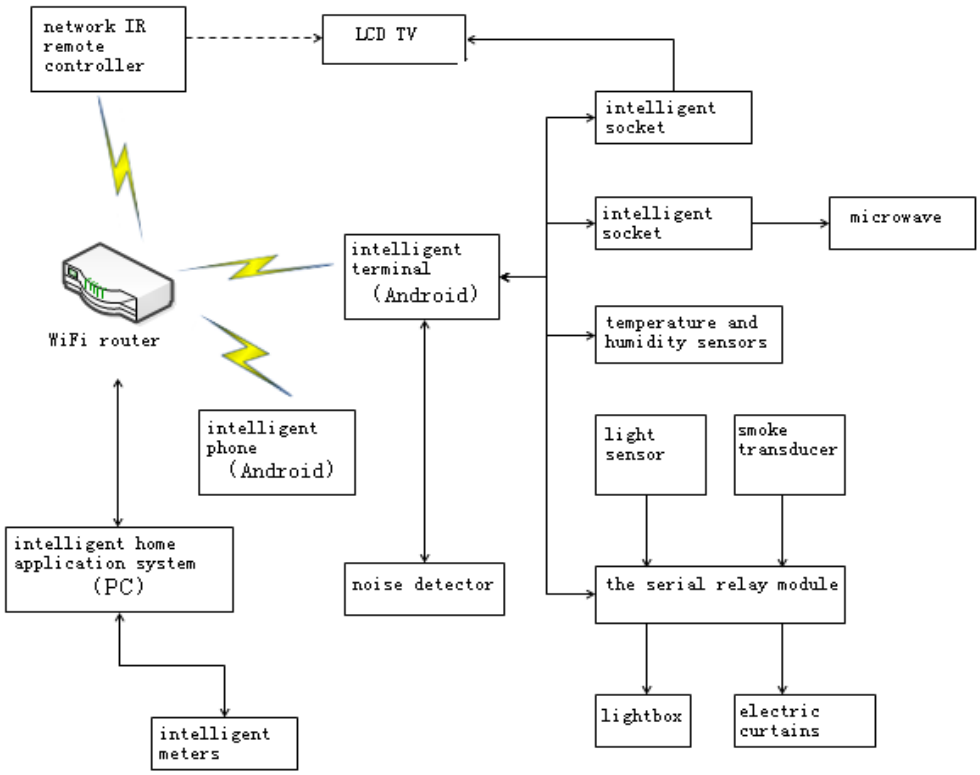

Figure 1. The connection chart of the electrical devices in the intelligent home system

The organization of the lecture is as follows. After a general introduction of the design of the intelligent home system, the design of hardware systems is presented in section II. In it, there are the circuit and connection diagrams of the intelligent home system. The software design has been discussed in section III. In section IV, experimental results of the actual specific smart home have been presented. The lecture has been concluded in section V. The section VI is the acknowledgements.

II. HARDWARE DESIGN

The actual layout future of the intelligent home system can be designed as shown in the Figure 2. It only displays part of appliances in the drawing room. The control module can be flexibly combined in accordance with the actual need of the family. The Figure 3 shows one of the control modules. The smart home control system consists of the control center, the infrared centralized control module, the lighting control module and the temperature control module based on Android, and so on. It uses the 2.4G wireless band.

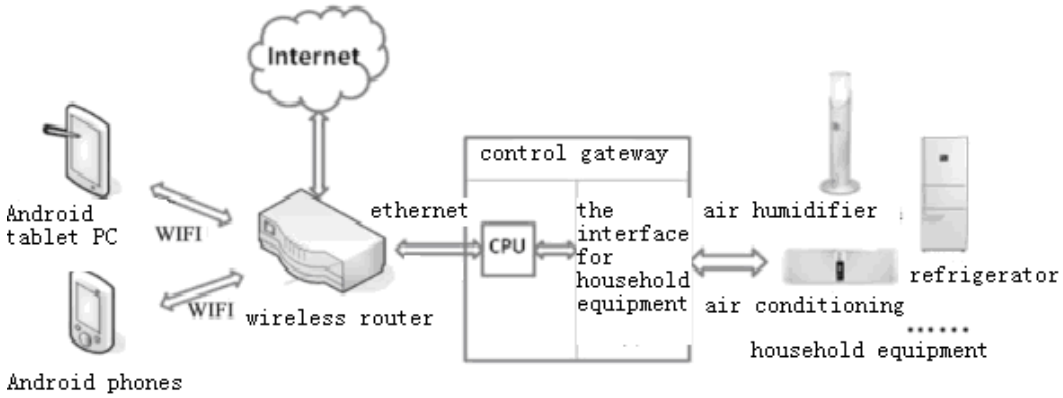

Figure 2. The physical connection system Flow

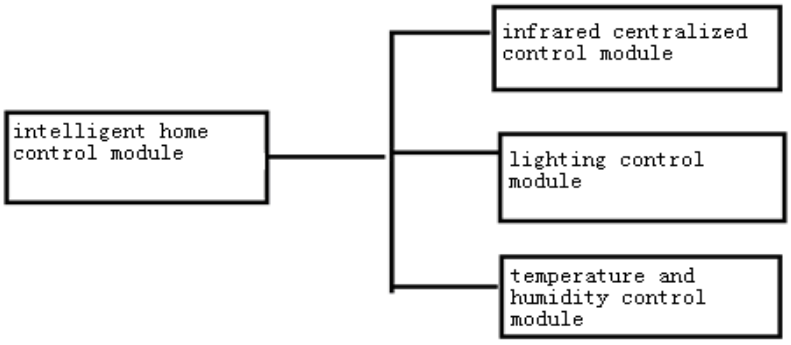

Figure 3. Block Diagram

In the Figure 1, Figure 2 and Figure 3, there are appliances that need the infrared remote controller, for example, the air condition. In the Figure 3, the infrared centralized control module can substitute for the appliances' self infrared remote controller. The device can control the Wifi and the infrared to launch commands with omni directions as shown in the Figure 4. Only one infrared centralized control module is enough in the entire room. It supports the interface for the TCP / IP / UDP protocol. It is embedded web page. The phone, IPAD, PC can access all the controlled devices through the web interface. It can learn all the

infrared remote controller of the television, air conditioning, stereo and VCD in the market. It supports the wifi wireless network, AP mode and STA workstation mode. The 802.11b/g/n wireless standards and the network architecture including bridges and routers are applicable. Users can control the infrared device by the internet anywhere and anytime. The IR carrier frequency width is from 10KHZ to 80KHZ. It is built-in the high-capacity storage and local 100 key commands memory. Once the power supply loses, the data and configuration is not lost. But it can upload the information to the serial module.

Figure 4. The infrared centralized control module

In our household life, we often adjust the light intensity at home. The lighting controller of the handheld Android terminal performs this function now. It connects the specific lighting control circuit through the 2.4G wireless module. It realizes to open, close and adjust the home lighting equipment. The lighting control module provides the information for the intelligent lighting controller.

The temperature monitor is consisted of the temperature sensor and the GPIO. It can achieve the related temperature inquiries from the temperature sensor at home detected by the 2.4G wireless module. The temperature monitoring module collects the temperature values via GPIO from the temperature sensor regularly. Then the received information is sent to the control center by the 2.4G wireless module. When the control center receives the temperature value, and its value will display on the system interface real-timely. The connected structures between temperature monitoring module and lighting control module are similar. Through the specific universal pins, the wireless module and temperature control circuit are connected together. The temperature monitoring module can provide information for the intelligent control home systems. All the associated temperature equipment is included.

The system uses the CC2530 chip. Its circuit is shown in the Figure 5. The Zigbee protocol has been transplanted in the CC2530 chip [12]. They are the basic Zigbee nodes of the

intelligent home system. When the CC2530 chip is embedded with some special materials, it becomes the wireless sensor. For example, the DB180 embedded in the CC2530 turns into the wireless temperature sensor. In the indoor environment, the temperature sensor, the humidity sensor, the smoke sensor can work well based on the Zigbee.

The intelligent curtains are part of the intelligent home system. When the light is too strong, the curtain should be pull down automatically. The connection of controlling the light and curtains is shown in the Figure 6. The voltage of appliances is 220V. The voltage of the general wireless sensor does not exceed 12V. In the Figure 6, the RS485 interface and the serial relay module play an important role in the actual wiring. And the charged cable has been marked in red color in the Figure 6 and Figure 7.

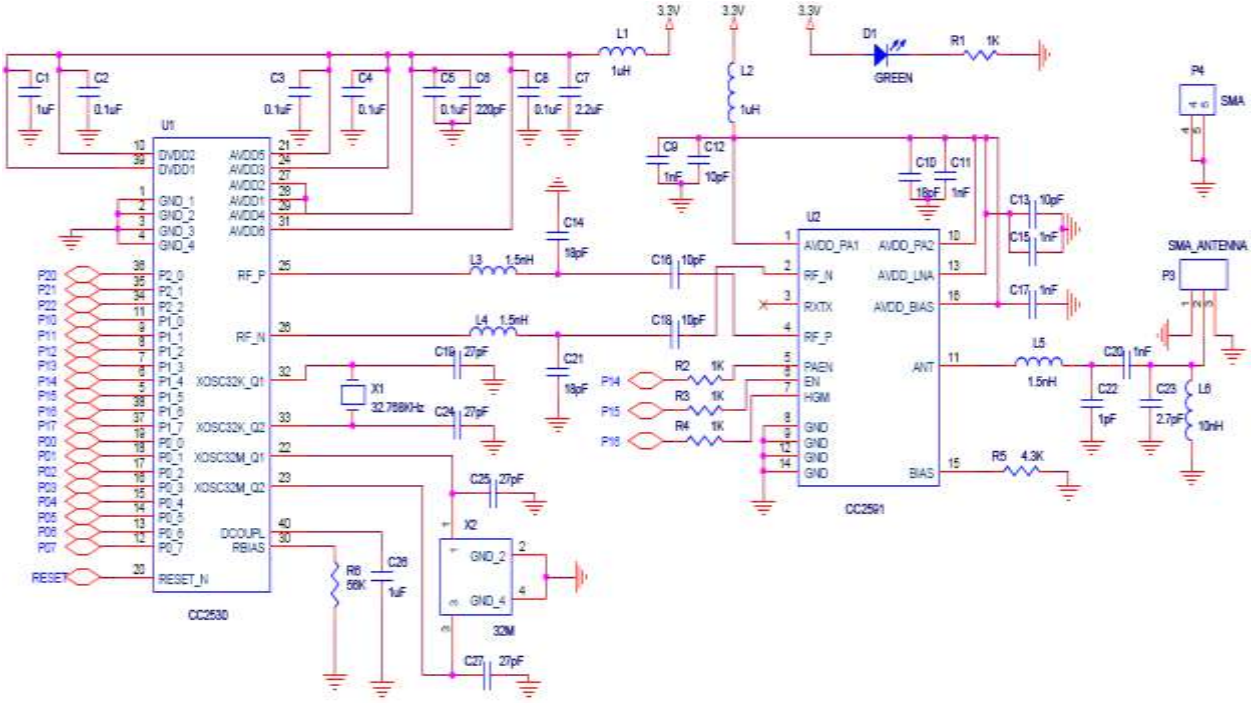

Figure 5. The circuit of the CC2530 Zigbee node

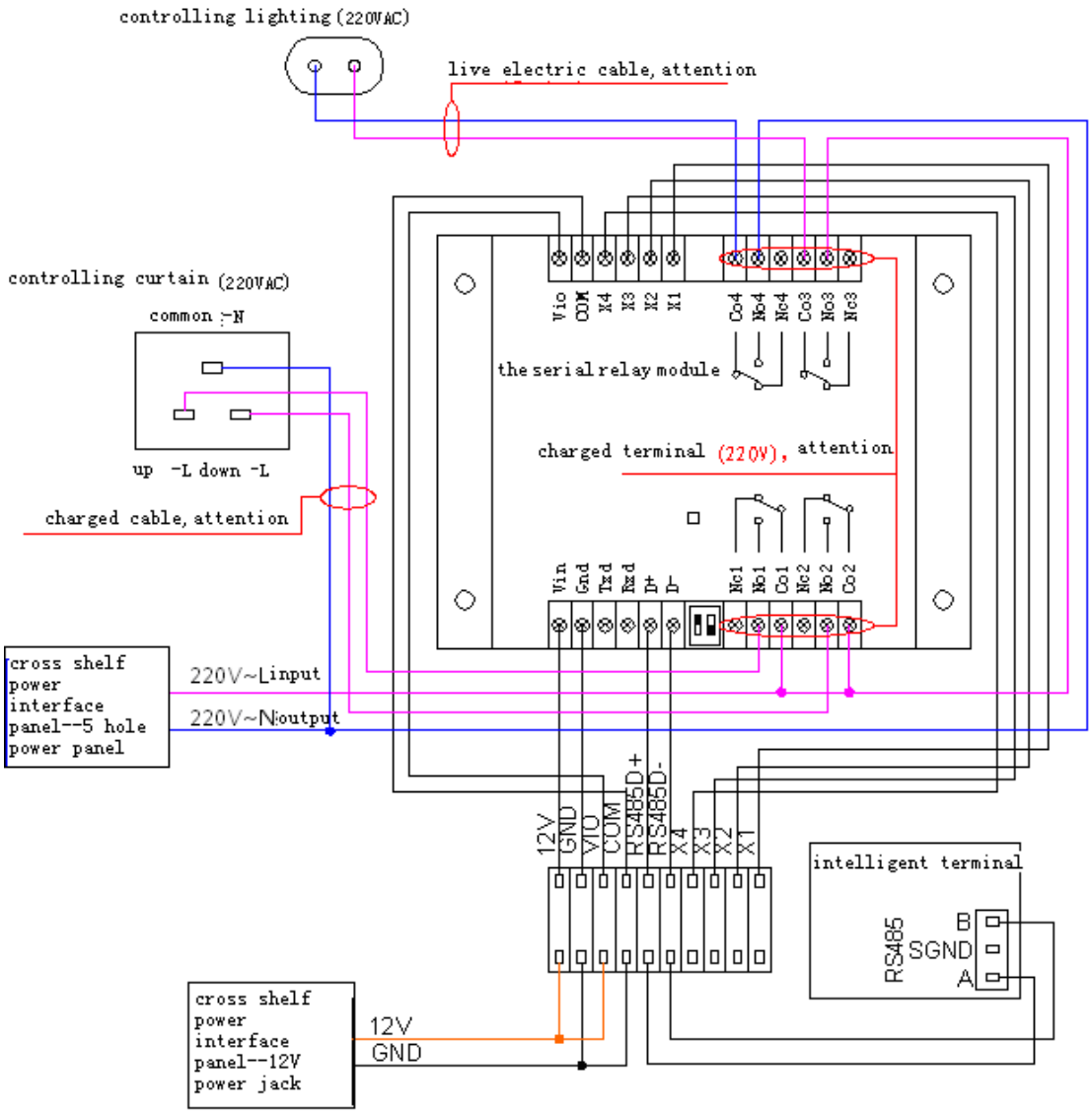

Figure 6. The circuit diagram of controlling lighting and the curtain

When there is high density smoke in the kitchen or some other place of the house, the exhaust fan and light alarm should work. The circuit wiring diagram of controlling the exhaust fan and light alarm is shown in the Figure 7.

The infrared centralized control module is consisted of the infrared transceiver module and 2.4G wireless module. The Infrared centralized control module completes the analysis and control functions. When it receives learning commands from the infrared control center, the 2.4G wireless module monitors for the serial data [13]. When the infrared transceiver module has received 17 infrared signals, it will transmit them to the serial of the 2.4G wireless module through GPIO. The 2.4G wireless module immediately put the package of the infrared signals to the control center. When the central control module receives the package from the infrared

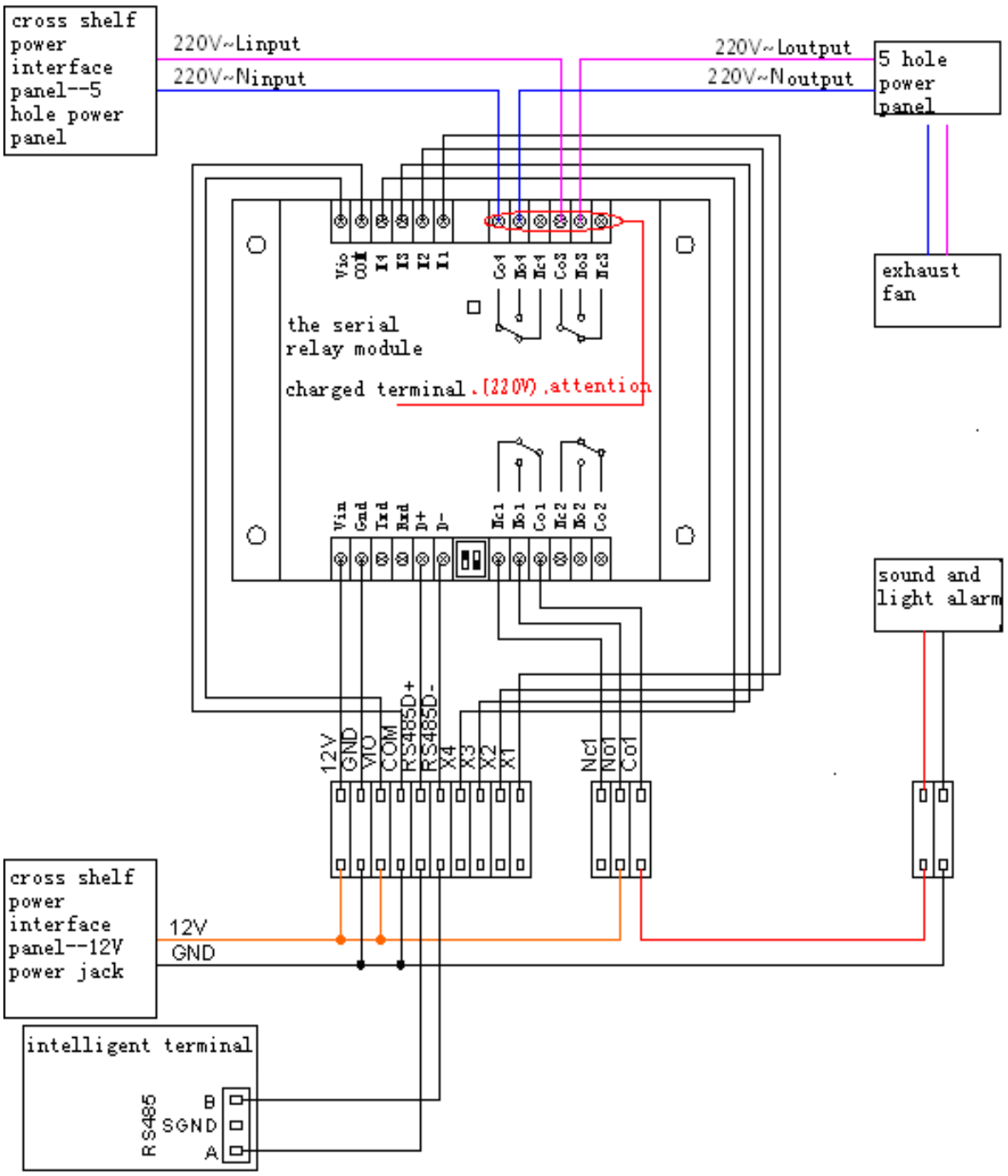

Figure 7. The circuit wiring diagram of controlling the exhaust fan and light alarm

control center, it controls the 2.4G wireless module to unpack this order. The released signals are sent to the infrared transceiver module through GPIO. The infrared transceiver is then modulated infrared signal and emits them to complete the infrared control process.

III. SOFTWARE DESIGN

To finish the system, windows 7 operating system is installed in the personal computer. Then the IAR system is used to program the wireless sensor based on CC2530. The jdk1.7 and android SDK are applied to develop the android system. The operating environment is using the ViewSonic Q7 tablet or android emulator.

The static IP of the intelligent gateway terminal in the user interface is configured to be 192.168.1.101. Open the software, enter the camera IP. The default IP of the login interface for the intelligent gateway is 192.168.1.178. The intelligent home system is divided into five modules. They are setting the home scene, controlling the appliance, controlling lights, the information inquiry and related configurations.

The home scenario is shown in Figure 8. First, enter the correct IP, click OK to enter the home scene. Then various operations can be performed via a button on the home video camera.

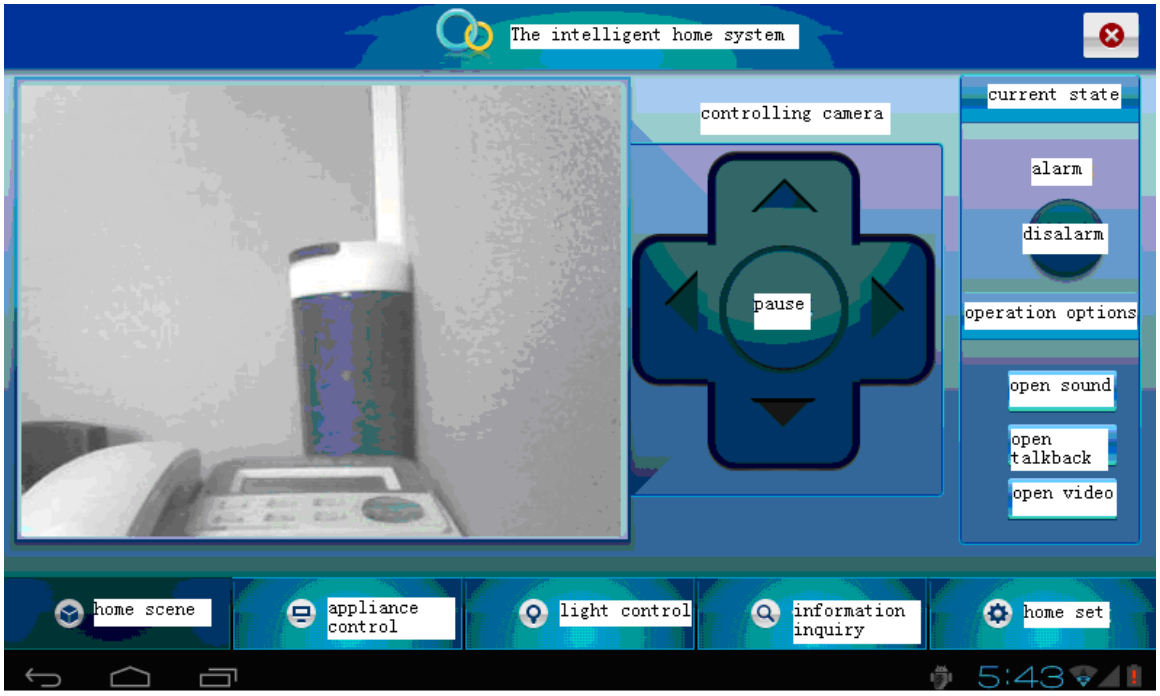

Figure 8. Entering the home scene interface

The interface of controlling the appliances is shown in Figure 9. First, users can switch the various electrical devices by clicking on the various labels on the top or sliding the screen.

Then a variety of operations for the electrical appliances can be achieved by clicking the buttons under the label.

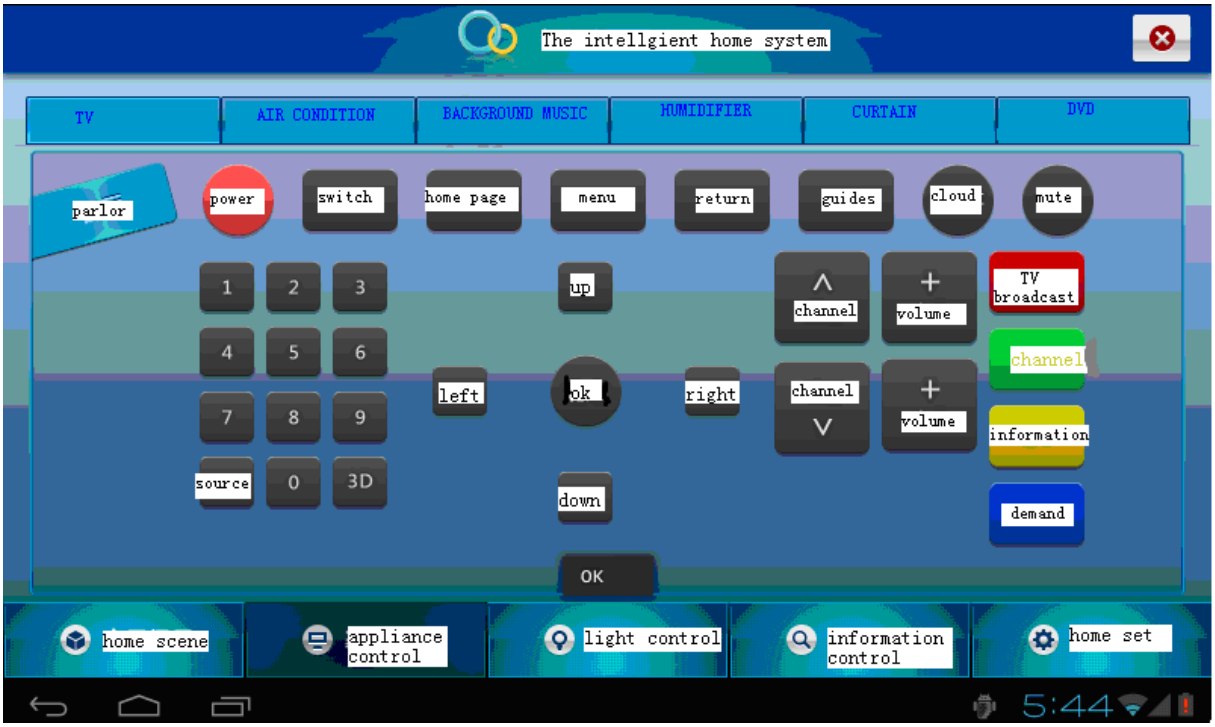

Figure 9. The interface for controlling appliances

The lighting control is by clicking on the button shown in Figure 10. All kinds of lights are under control by the intelligent terminal.

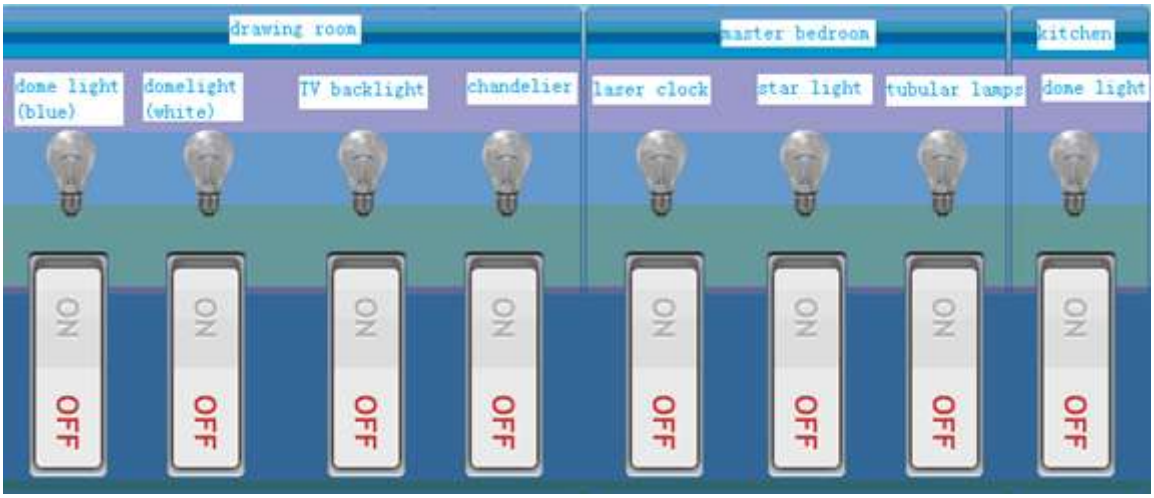

Figure 10. The Figure of controlling lighting

The information query is shown in Figure 11. After the deployment, the smart home system monitors the security devices real-timely, and records the alarming inquiry information timely. The electronic sphygmomanometer measurement results are automatically uploaded to the

smart home system, and timely recorded in order to check and compare measurements. Users can browse the results.

Figure 11. The figure of the information inquiry

The home settings are shown in Figure 12. First, the operator selected the system settings, and then entered the administrator password: 123456. Then after entering the system settings, you can configure the various communication nodes. In the Figure 12 B, the owner can change the Zigbee channel to avoid the conflict on wireless router.

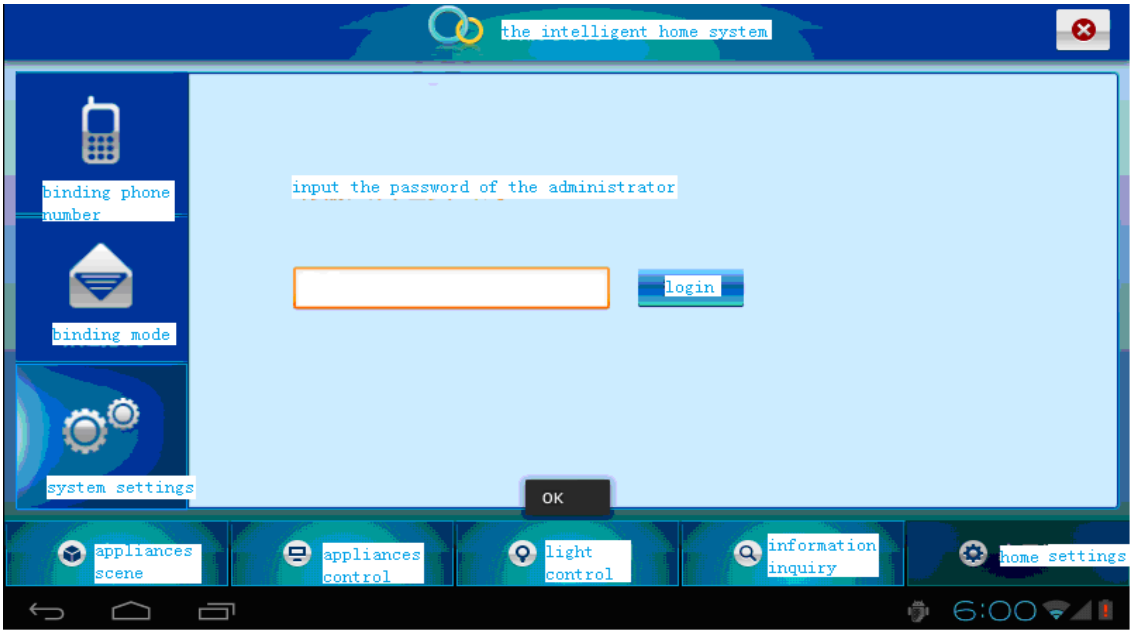

Figure 12 A. Home Settings

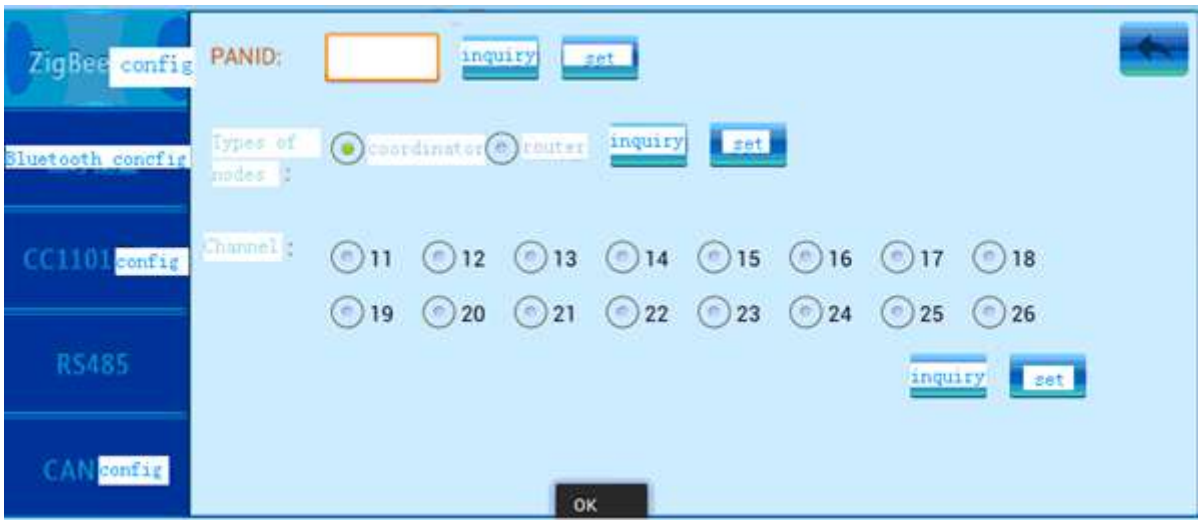

Figure 12 B. Home Settings

The tablet PC is also as the terminal. Its operations are the similar. The codes include setting the scene of the appliances, controlling appliances and lights, inquiring information and home settings.

IV. TEST RESULTS

The system supports the web applications. If the controller is configured to be STA mode and the intelligent phones join in the same local area internet, users can control all the devices through the web browser after they login the smart home system in their telephones. Figure 13 shows the login interface for the smart home system in the telephones.

Figure 13 login the smart system from the intelligent phones

The system uses the open communication protocol and also supports the remote control through the internet. General families use the way of the dial-up access to the internet. The IP address is dynamic. The software named by peanut shell can match the dynamic IP by the way of the fixed domain name. If there is router, then login the router and configure the IP. Figure 14 is using the intelligent phone to control the sound devices, video devices and so on remotely.

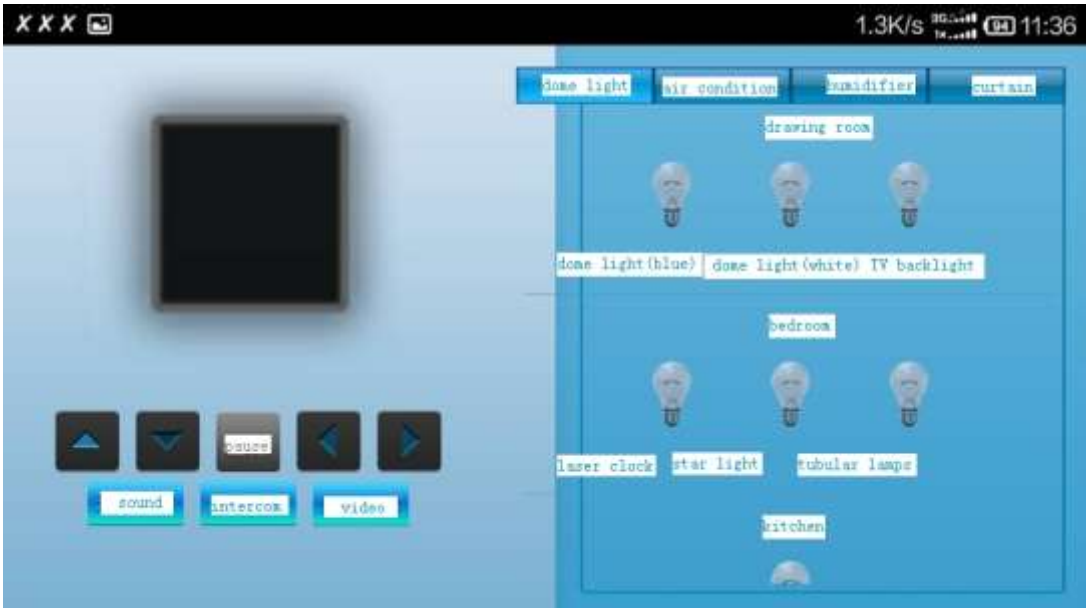

Figure 14 remote control of the appliances at home by the internet

Each of the above two functions is tested for 10000 times. The rate of success is 100%.

The control center sends the delay time of the trigger instruction to the lighting control module through the Mobile Internet Device (MID). The lighting control module sets the time to let the SCR trigger according to the received instruction. Thus the lighting control is achieved. The test results are shown in the following Table 1.

Table 1 Test Results

operation	Operation times	the number of successful operations
Click to open	10000	10000
Click Close	10000	10000
Set the delay time	10000	10000

The temperature control module transmits the data to the MID. And the data is stored and displayed on the MID. interface temperature accuracy testing. The test is completed indoors. In the duration of an hour, the temperature control module works well. Then it is tested in the

outdoor environment. In approximately the first 18 seconds, the tested value of the temperature is different from the real value. The main reason is that the temperature control module is brought for the outside testing immediately. Due to the different temperature between inside and outside, there is a period of time for the DS18B20 to adapt to the changing temperature. It generates the error in the first 18 seconds, but you can ignore this taking into account the position fixity of the temperature control module in the home environment.

In order to ensure the stability of the wireless communication between the ZIGBEE modules, we must adopt a serial of measures to test them based on the 2.4G wireless network control protocol.

First, the different three programs for protocols are downloaded to three different ZIGBEE modules by the CC Debugger. One is connected to the MID. The other two are connected to the USB ports in the two different computers as the AP node and the new equipment ED node respectively. The operator makes the MID be father and father from the AP.

Second, the debug program is started at the sending end and transmits data through the MID. At the receiving end, opening the serial port can get the data through the debugging tool. The results of data transmission are shown in the following Table 2. In it, the communication distance between two ZIGBEE module is less than or equal to ten meters, the communication is quite stable. But when the distance is further, there is a sharp decline in the stability of the wireless communication system.

Table 2 the results of the transferred data

The distance between the MID and the AP (meters)	The number of the sending data	The number for receiving data successfully
6	10000	10000
8	10000	10000
10	100	81
12	100	0

The main factor is not the protocol itself, but the distance interfering with the communication. In addition, all kinds of wireless signals are interfered with each other in the house. In order to verify our speculation, during the communication distance of 12 meters, ZIGBEE module

acting as RE in the middle also carries 100 times from the data transmission end, the ZIGBEE module of the receiving end gets the data correctly. Through testing, the system has good stability. During the peak of the user login time, the corresponding time unchanged substantially. And the utilization of the memory raises little. The system can process the illegal data interference.

The intelligent terminal can acquit the data from sensors. And it realizes the manual control or intelligent control for the electrical devices. Of course, the mode of the control can be set. The phone can achieve the same control function for the intelligent terminal device with the intelligent terminal. It can view data from sensors as same as the PC. The records can be formed after the statistics and analysis of raw data via PC.

The light sensors, electric curtains and light boxes achieve the indoor intelligent adjustment of the brightness. By setting up the network address of the infrared remote controller, the TV can be under its remote control. The smart socket can measure the power and the battery of the TV and microwave. When the wireless infrared remote controller turns off the TV and detects the output current of the jack below the threshold, the power socket is power off after the period of time. When the TV is turned on, the socket first is controlled to be powered. Then the wireless infrared remote controller sends the code for booting the TV.

The smart meter can measure the total electricity consumption of television sets, microwave ovens, intelligent socket, intelligent terminal, PC, network infrared remote control, light boxes, electric curtains. The intelligent terminal can measure the value of noise and the temperature and humidity.

V. CONCLUSIONS

This paper is concerned on the design of the intelligent home system. The lecture has started with effects of the intelligent systems. The detailed analysis of the hardware system and the software system has been presented. With some elimination of mathematical part the lecture can be presented to general public.

VI .ACKNOWLEDGEMENTS

This paper are sponsored by the Suzhou University student scientific research initiating projects (KYLXLKYB14-35, KYLXLKYB14-36, KYLXLKZD14-19), University science research project of Anhui Province (KJ2011B180, KJ2012A263, KJ2012B185), Quality project of Anhui Province (2012jyxm545) and Anhui Province Natural Science Research Major Project, Research on P2P multi-channel video encoding key technologies (KJ2014ZD31), Anhui Province Natural Science Research Key Project, Research on vegetable supply chain traceability Platform Based on the quality and safety(KJ2014A247). The innovation training program projects for the Anhui College students, Coal Mine Personnel Positioning System based on the RFID (201310379083), The implementation of embedded alarms management system based on A900 (201310379023).

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