



## THE SMART HOME SYSTEM BASED ON THE IAP15F2K61S2 AND GSM

Xin Zhenghua<sup>1</sup>, Chen Guolong<sup>1</sup>, Hong Li<sup>1</sup>, Qixiang Song<sup>1</sup>, Liangyi Hu<sup>2\*</sup>, Chen Lei<sup>1</sup>, Mao  
Youwen<sup>1</sup>, Xu Yexiang<sup>1</sup>

<sup>1</sup>School of Information Engineering

<sup>1</sup>Suzhou University, 234000, Anhui, China

<sup>1</sup>Emails: [begin0000@qq.com](mailto:begin0000@qq.com)

<sup>2</sup>School of Economics Management Engineering

<sup>2</sup>Suzhou University, 234000, Anhui, China

<sup>2</sup>Emails: [huliangyi@126.com](mailto:huliangyi@126.com)

---

*Submitted: Feb. 27, 2014*

*Accepted: Oct. 24, 2014*

*Published: Dec. 1, 2014*

---

*Abstract- At home, there are all kinds of electrical devices. Also the gas may leak to fire. Once the danger happens, it will result in the huge losses. The smart home system is necessary for the safety. The system integrated the sensors to monitor the appliances whether they work normally. Once the exceptions have been tested, the owner can get the text message immediately with the help of GSM. This system has a light cube. It has 512 lights. After test, this system works to monitor the home appliances very well at the low cost.*

**Index terms: IAP15F2K61S2; GSM; the smart home system**

## I. INTRODUCTION

The smart home system includes many aspects. Some system works for the health care for the elderly. A smart elderly home monitoring system (SEHMS) is designed and developed to survive a fall, heart attack or stroke with much greater chance if the senior gets help within an hour [1]. That project used the Android-based smart phone with 3-axial accelerometer as the telehealth device which could detect a fall of the carrier. The monitoring system connected the smart phone by using the TCP/IP networking method via Wi-Fi. A graphical user interface (GUI) is developed as the monitoring system which shows the information gathered from the sensor system.

The paper [2] and [3] tried to model contexts which are generally distributed in smart home environment using the ontology technology. The set of modeled contexts includes home domain-based contexts and social relationship-based contexts. It provided fully personalized healthcare service to a specific user in a smart home environment. It implemented a prototype of healthcare services.

The research [4] 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.

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 [5]. 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 researches [6] and [7] 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.

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 [8]. 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 paper [9] 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. The research [10] 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.

In this paper [11], the central controller unit has an in-built algorithm based on two level adaptive branch prediction techniques to detect the period of inactivity of sensor nodes. Further, only one wearable heart rate sensor node is included in the system which measures the heart rate and detects abnormality. The paper [12] presents a color sensor system that can process light reflected from a surface and produce a digital output representing the color of the surface. The end-user interface circuit requires only a 3-bit pseudo flash analog-to-digital converter (ADC) in place of the conventional/typical design comprising ADC, digital signal processor and memory. In the paper [13], based-on the algorithms research, a ubiquitous personal health monitoring and system is designed, which integrates health-related sensory devices with the healthcare center cost-effectively. It can aid senior citizens and patients, especially elderly, who need long-term attention to their physical condition, like chronic diseases and falls, with ubiquitous surveillance and remote management of the recorded health data, and timely help. Dr. Subhas Chandra Mukhopadhyay and his team have done a lot of work about ADL monitoring of elderly people in the smart home [14]. There are many kind

of technology applying in the field of the smart home. The infrared, the Bluetooth, the intelligent phones based on the Android platform, the wireless sensor network and all kinds of the sensors are the part of the smart home [15-20].

Some researches focus on the reducing the risks of the security. The intelligent home system will be convenient to monitor the electric devices or the safety of the elderly or infants in the family. The intelligent implementation can avoid accidents and other hazards to occur. When the owners are working, the home encounters a fire. Then the owner can get a message right now and take the appropriate measures. The damage can be minimized. The intelligent home system has the broad market prospects based on the internet of the things (IOT).

## II. THE HARDWARE STRUCTURE OF THE SYSTEM

The system is consisted of the master chip IAP15F2K61S2 module, the GSM module, the smoke sensor module, the clock module for timing, the wireless data transmission module using the 24L01, the power supply module of the system, 8 \* 8 \* 8 Light Cube module, the key module, the color display module, the temperature sensor module, the charged lights module, the charged heater module, the charged fan module and the charged MP3 module. The GSM module and the wireless communication module based on 24L01 receive commands from the microcontroller for data processing to achieve mutual wireless communication between the various modules. This makes the system more intelligent. The structure figure is shown in the Figure 1.

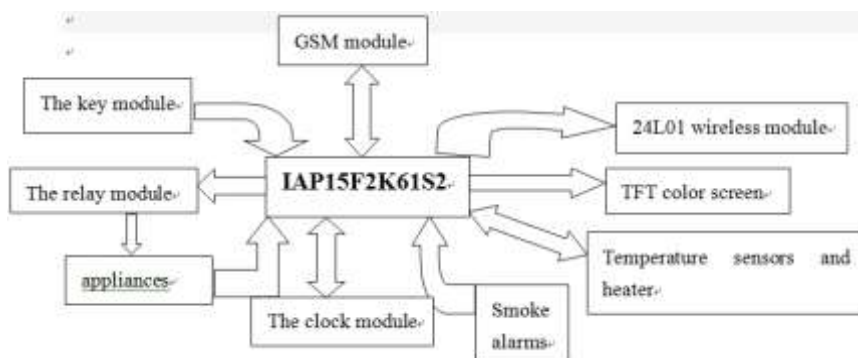


Figure 1. The architecture of the system

Dual control for the electrical devices includes the short message service (SMS) control and the manual control. The charged appliances not only retain the traditional manual control. But

also they are able to be controlled by the mobile phone text messages wirelessly. The intelligent remote control can collect and display the status of each electrical appliance. When the system has powered up, the status of every charged appliance has been detected automatically. The initializing status of all appliances is the close state by controlling the relay. When the operator uses the manual control, he / she switch the button into the opposite state of the corresponding switch to achieve the electrical devices to start or close. When users control the electrical devices by the SMS remotely, the system detects the acquired state after receiving the instruction automatically. And then it works appropriately according to the instructions. The control of SMS and manual control is independent with each other.

The system includes the sensor sensitive for harmful gases and the smoke sensor. Once the tested value exceeds the preset safety value, the system will start to alarm. When the hazardous gas leaks, there maybe happens to fire in the indoor environment. The smart home system will send the relational information by the way of SMS to the owner's phone.

The value of the temperature and the time will be transferred to the display of the 8 \* 8 \* 8 light cube by the wireless way. The distance for the wireless communication is up to 20 meters or more after test.

The water heater is equipped with a temperature sensor. And the system can set the value of the temperature which the heater is working up to through the keys or SMS. When the water temperature is heated to the set value, the system will disconnect the power of heater automatically.

The color screen displays the status of each module in real-time systems. The time, current temperature, the water temperature in the heater and the set value of the system can be changed by the SMS. After the system receives the SMS command, processes the command to the corresponding modules.

The system has its unique characteristics. It uses dual control. It is convenient and practical. The entire system finishes displaying the status of each sensor or module in the practical colorful TFT-LCD clearly. The 8 \* 8 \* 8 light cube displays the temperature and time of the system in the wireless way. It is dazzling and magnificent. The water heater can use the hand or SMS to set the value of the temperature. Some operators accustom to use the hand to control it. It has the automatically intelligent protection. The user at work can control the



The system contains the clock chip. Then the color screen can display the time through the microcontroller. The two temperature sensors measure the temperature at room and the heating temperature of the heater. And the two values are displayed on the color screen. The mobile phones send commands to the system. The smart home will send the room temperature back to the mobile phone. The water temperature sensor detects how hot the water is in the heater. When the heater temperature is more than the set value, the heating system will automatically shut down. When the smoke sensor detects the harmful fumes or gases, the system will send text messages to the mobile phones.

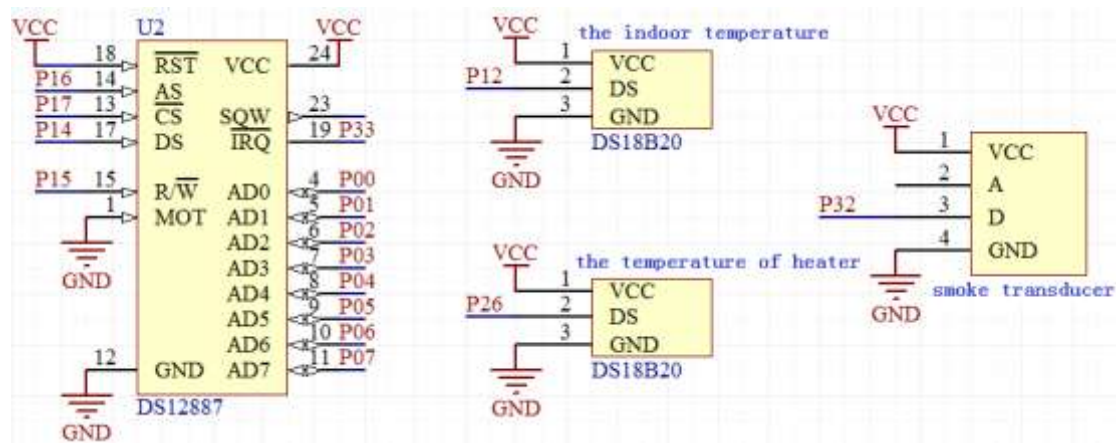


Figure 3. The connections of the temperature sensors

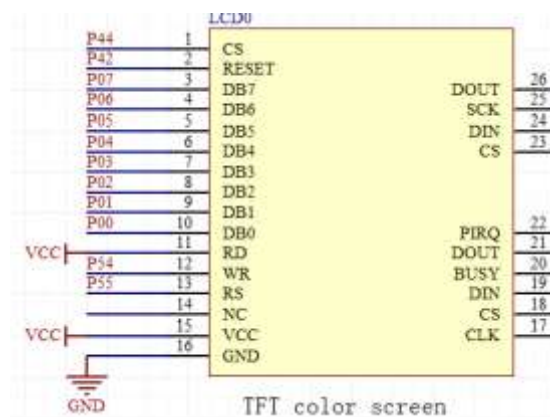


Figure 4. The schematic of the color display LCD

The status of each module in the system is displayed in real time, such as the time, the switch status of the electrical, the temperature at room, the temperature of water, the data transmitted to the GSM or received from the GSM, the concentration of the smoke, etc.

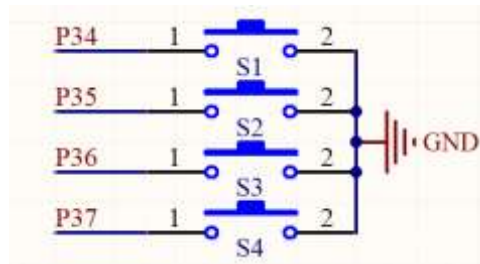


Figure 5. The schematic of scanning keys

The microcontroller detects which button is pressed by the scanning program and performs the appropriate procedures corresponding to the button. The functions of the buttons include the adjustment of the clock and setting the temperature of the heater.

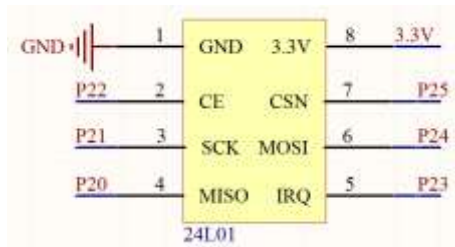


Figure 6. The connection pins of the 24L01

The time and the temperature is transferred to the light cube through this wireless 24L01 module. The light cube rolls to show that information within 20 meters long communication distance.



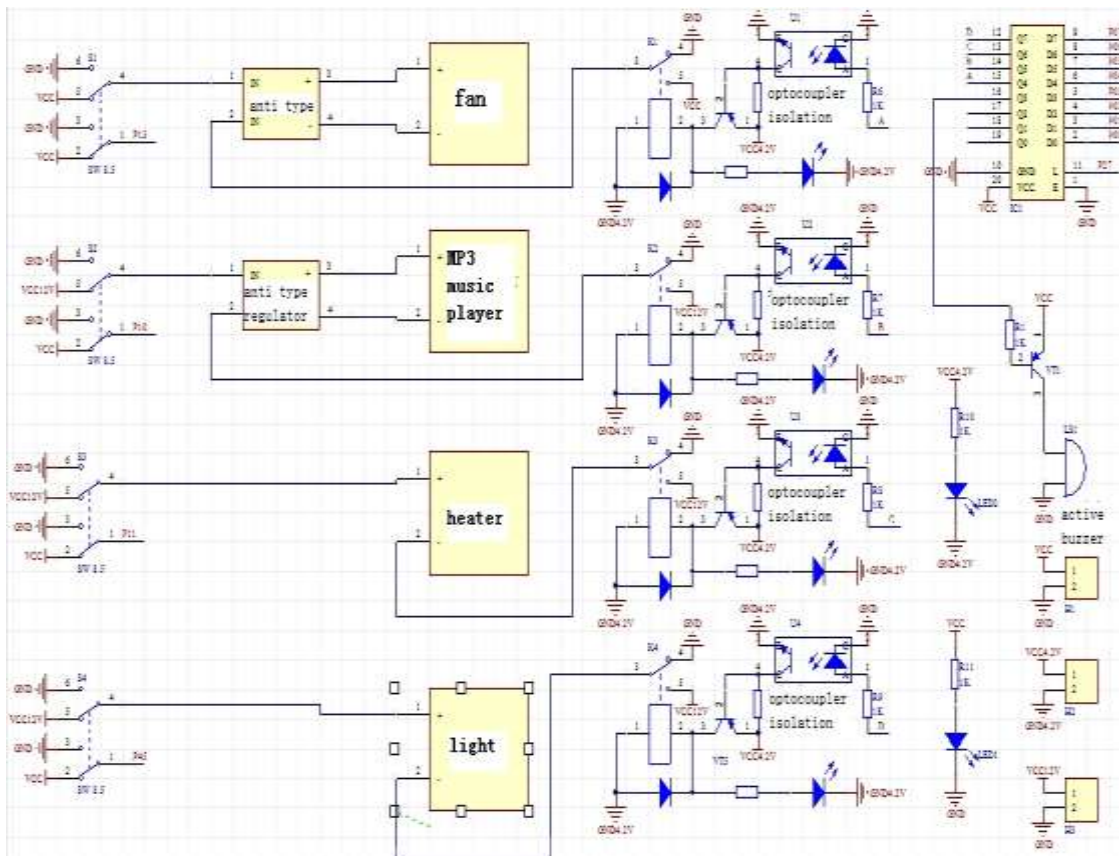


Figure 7. The schematic of the dual control about the SMS control and the manual control

The system uses the unique and innovative circuit design to achieve both the manual control and mobile phone text messages control for home appliances. The manual switch uses the double-pole-double-throw (DPDT) switch. The midline of the switch is used as the output side. The other two terminals are connected to the VCC and GND. The middle line can output high level or low level, the relay is the same as the midline. The other half of the DPDT switch is also linking as the above mention. But the middle line is connected to the I / O port of the MCU. Then the microcontroller can read the output status of the manual switch so that it executes the corresponding procedure. The relay connects with the 74HC573 chip via the optocoupler isolation. This chip can not only achieve the expansion of the I / O ports, but also enhance the drive current. The microcontroller can control the status of the corresponding relay for its electrical appliance. Based on it, the dual control of the manual and SMS has been achieved. For example, the lighting lamps open. The microcontroller first detects the output state of the light switch is high level or low level.

If the switch is required to output the high level, then the microcontroller controls the relay of lights to output the high level and Vice versa. So that regardless of what state the manual switch is before the boot, the state of lights is always turning off. The initialization of the system determines that. This design solves disadvantages of only one manual control way or the SMS control way. It is stable and easy to control and safe. When the working home appliances meet the failure of the electricity and users forget to turn off, the appliances do not work even they leave home to work and the power has restored. The security has been greatly enhanced. There is the anti-reverse device in the front of MP3 and fan based on the structure of the rectifier bridge. This improves the performance greatly. And it is practical. The schematic of the light cube LED lights is as follows.

This LED light cube uses the cube structure of 8 \* 8 \* 8. It includes 512 LED lights.

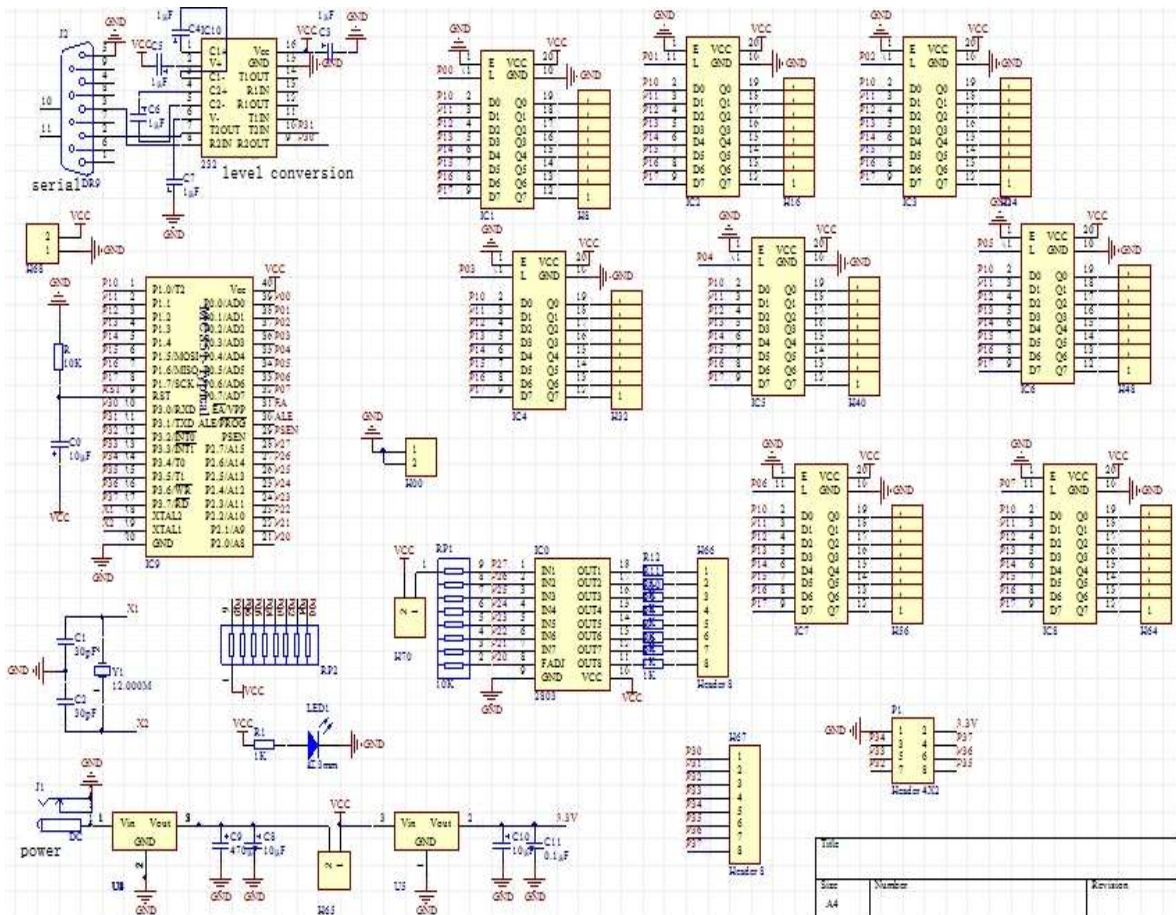


Figure 8. The circuit of the light cube

It can display numbers, letters and animation. And it communicates with the system by the 24L01 wireless module. The system will pass the time and temperature at room to the light

cube by the way of scrolling display. It is very dazzling. The communication distance is up to 20m.

### III. THE SOFTWARE OF THE SYSTEM

The system has been finished on the Keil C workbench. The main codes are as follows. The system includes 39 files and 2 folders. The files are shown in the Figure 9.

system.plg	2014/5/14 13:40	18b20.h	2013/8/7 23:55
GSM.h	2014/5/14 11:33	test.c	2013/8/6 15:40
system	2014/5/14 11:33	test	2013/8/6 15:40
system.hex	2014/5/14 11:33	system.uvproj	2013/8/6 1:00
system.lnp	2014/5/14 11:33	123_uvopt.bak	2013/7/31 13:17
system.LST	2014/5/14 11:33	123.uvproj	2013/7/31 13:12
system.M51	2014/5/14 11:33	123_uvproj.bak	2013/7/31 13:09
system.OBJ	2014/5/14 11:33	TFT.h	2013/7/30 20:16
system.uvopt	2014/5/13 20:50	define3232.h	2013/7/23 9:32
system.bak	2014/3/30 16:27	hanzi32.h	2013/7/18 16:44
define.h	2014/3/30 15:51	system_uvproj.	2013/7/18 15:23
12c887.h	2014/3/17 22:36	chushihua.h	2013/7/17 17:22
init.h	2013/10/26 16:34	mp3.h	2013/7/17 16:51
test.h	2013/10/19 11:24	hz3232.h	2013/6/20 17:08
system.c	2013/10/7 13:03	2424.h	2013/6/20 17:05
24L01.h	2013/10/7 12:49	1624.h	2013/4/26 2:12
123.plg	2013/10/4 12:24	16x8.h	2013/4/24 22:25
123.uvopt	2013/10/4 12:24	3232.h	2013/4/24 22:25
123_Target 1.dep	2013/10/4 12:24	GSM	2014/5/22 8:20
system.d	2013/10/4 12:24	remote control	2014/5/22 8:20
keyscan.h	2013/9/16 13:41		

Figure 9. The files of the software system

### IV. THE PRODUCTION OF THE SMART HOME

The system is shown as following figures. The system is divided two layers to consider the safety of the system. The bottom layer is consisted of the GSM, the temperature sensor, the smoke sensor, the wireless module and other chips, the circuit boards and the connection lines. The right on the top layer is the speakers. The switches are on the top layer. The left is the TFT LCD color screens that can display the information gathered by the sensors.



Figure 10. The smart home system based on the IAP15F2K61S2 and GSM

When the system boots, the “power” key is pressed. Before the system initializes, no matter other switches are in the “on” state, all appliances in the off state. Of course, all the electric equipments are manual control. When the switch for the heater is pressed, the heater starts to work. Also the “+” button is pressed, the room temperature can be increased one degree every once. Also all the electric equipments are controlled by the intelligent phone. As is shown in the following figure, the smart phone can tell the light to turn on. It can also set the value of the temperature for the heater. In the figure 11, the slave LCD can display and play the MP3 music. In the figure 12, the operator can turn off the MP3. When the smoke sensor of the system tests the concentration of the smoke is high, it will send the “SMOKE DANGER” message to the owner of the intelligent phone. After test, the system is running stablely. All functions have been finished.

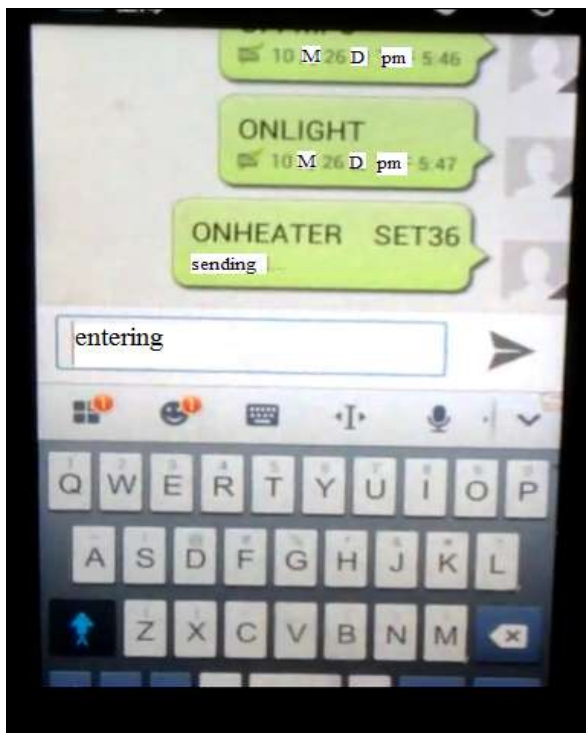


Figure 11. The intelligent phone controls the electric



Figure 12. The electric at home can send message to the smart phone

In the Figure 13, the master LCD displays the current state of the electrical at home. It displays the command from the intelligent phone.



Figure 13. The master LCD in work

The light cube is very dazzle. It can receive the command from the system to display the temperature and time. Whichever direction the user see from, he/she can see the three dimensional number.



Figure 14. The appearance of the light cube

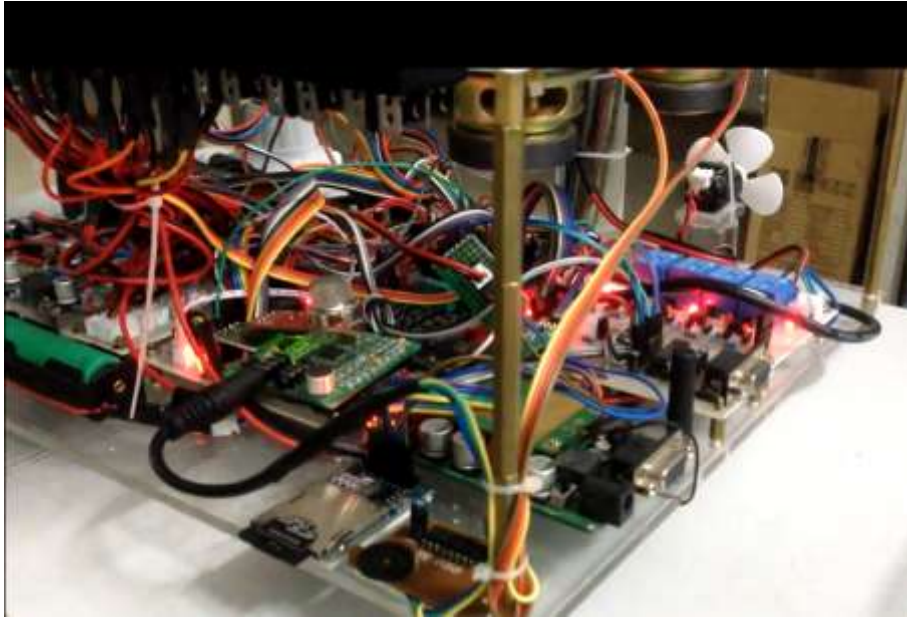


Figure 15. The internal structure of the system

## V. CONCLUSION

This smart system has been realized to prevent the fire, gas poisoning at home and so on. Once the exception occurs, the owner at work gets the message through the intelligent phone. This system completes from the designed circuit to the product. Its cost is very low. The operation is simple. But it is also a good smart home system in the practical application. It has the charming light cube.

## 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 (KJ2012A263), 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). Anhui Province College Humanities and Social Sciences Key

Research Base - Culture University Research Center, the tender: Research on Campus Culture Construction Evaluation System (SK2014A116).

## REFERENCES

- [1] Jer-Vui Lee, Yea-Dat Chuah and Kenny T.H. Chieng. Smart Elderly Home Monitoring System with an Android Phone. *International Journal of Smart Home*. Vol. 7, No. 3, May, 2013, pp. 17-32
- [2] Haesung Lee and Joonhee Kwon. Ontology Model-based Situation and Socially-Aware Health Care Service in a Smart Home Environment. *International Journal of Smart Home* Vol.7, No.5 (2013), pp.239-250
- [3] Xin Zhenghua, Chen Guolong, Hong Li, Qixiang Song, Chen Lei, Shi Yaqi and Wu Gang. THE IMPLEMENTATION FOR THE INTELLIGENT HOME CONTROL SYSTEM BASED ON THE ANDROID AND ZIGBEE. *INTERNATIONAL JOURNAL ON SMART SENSING AND INTELLIGENT SYSTEMS* VOL. 7, NO. 3, SEPTEMBER 2014, pp.1095-1113.
- [4]A. Gaddam, S. C. Mukhopadhyay and G. Sen Gupta, "Elderly Care Based on Cognitive Sensor Network", *IEEE Sensors Journal*, Vol. 11, No. 3, March 2011, pp. 574-581.
- [5]K. Kaur, S. C. Mukhopadhyay, J. Schnepfer, M. Haefke and H. Ewald, "A Zigbee Based Wearable Physiological Parameters Monitoring System", *IEEE Sensors Journal*, Vol. 12, No. 3, March 2012, pp.423-430.
- [6]Sean Dieter Tebje Kelly, Nagender Kumar Suryadevara, and S. C. Mukhopadhyay, "Towards the Implementation of IoT for Environmental Condition Monitoring in Homes" *IEEE SENSORS JOURNAL*, VOL. 13, NO. 10, OCTOBER 2013, pp. 3846-3853.
- [7]J.A. Nazabal, F. Falcone, C. Fernandez-Valdivielso, S.C.Mukhopadhyay and I.R. Matias, "Accessing KNX Devices using USB/KNX Interfaces for Remote Monitoring and Storing Sensor Data", *International Journal of Smart Homes*, Vol. 7, No. 2, March 2013, pp. 101-110.
- [8]N.K.Suryadevara, A. Gaddam, R.K.Rayudu and S.C. Mukhopadhyay, "Wireless Sensors Network based safe Home to care Elderly People: Behaviour Detection", *Sens. Actuators A: Phys.* (2012), doi:10.1016/j.sna.2012.03.020, Volume 186, 2012, pp. 277 – 283.



- [9]N.K. Suryadevara and S.C. Mukhopadhyay, "Wireless Sensor Network Based Home Monitoring System for Wellness Determination of Elderly", IEEE Sensors Journal, Vol. 12, No. 6, June 2012, pp. 1965-1972.
- [10]N.K. Suryadevara, S.C. Mukhopadhyay, R. Wang, R.K. Rayudu, Forecasting the behavior of an elderly using wireless sensors data in a smart home, Engineering Applications of Artificial Intelligence, Vol. 26, No. 10, November 2013, pp. 2641-2652.
- [11] N.Samanta, A.K.Chanda, C.RoyChaudhuri. AN ENERGY EFFICIENT, MINIMALLY INTRUSIVE MULTI-SENSOR INTELLIGENT SYSTEM FOR HEALTH MONITORING OF ELDERLY PEOPLE. INTERNATIONAL JOURNAL ON SMART SENSING AND INTELLIGENT SYSTEMS. VOL. 7, NO. 2, June 2014. pp. 762-780.
- [12] Maher Assaad, Israel Yohannes, Amine Bermak, Dominique Ginhac and, Fabrice Meriaudeau. DESIGN AND CHARACTERIZATION OF AUTOMATED COLOR SENSOR SYSTEM. INTERNATIONAL JOURNAL ON SMART SENSING AND INTELLIGENT SYSTEMS VOL. 7, NO. 1, MARCH 2014. pp.1-12.
- [13] Hou Honglun, Huo Meimei, Wu Minghui. SENSOR-BASED WIRELESS WEARABLE SYSTEMS FOR HEALTHCARE AND FALLS MONITORING. INTERNATIONAL JOURNAL ON SMART SENSING AND INTELLIGENT SYSTEMS VOL. 6, NO. 5, DECEMBER 2013, pp.2200-2216.
- [14] Suryadevara, N.K.; Mukhopadhyay, S.C.; Rayudu, R.K., "Applying SARIMA time series to forecast sleeping activity for wellness model of elderly monitoring in smart home," Sensing Technology (ICST), 2012 Sixth International Conference on , vol., no., pp.157,162, 18-21 Dec. 2012.
- [15] Xin Zhenghua, Chen Guolong, Qixiang Song, Hu Liangyi, Lu Hongmei, Jiang Pei, Sun Yayun, Chen Lei. The system of controlling the robot by the smart phones based on the Bluetooth. International Journal of Smart Home. VOL. 8, Issue 5, 2014. pp.269-278.
- [16] Xin Zhenghua, Song Qixiang, Hu liangyi. Research on the Wireless Audio Transmission System based on the Infrared. Information Technology Journal, (2013), Vol.12, Issue 23, pp.7610-7615
- [17] Jinsong Song, Zhenghua Xin, Wei Ding. Research on android intelligent phones controlling the car to run. TELKOMNIKA, (2013), Vol. 11, No.12, pp.7438-7445

[18] Su Benyue, Wang Guangjun, Zhang Jian, “Smart home system based on internet of things and Kinect sensor”, Journal of Central South University (Science and Technology). Vol. 44, Suppl. 1, July 2013, pp. 182-184.

[19] Suryadevara, N.K.; Mukhopadhyay, S.C., "Wireless Sensor Network Based Home Monitoring System for Wellness Determination of Elderly," Sensors Journal, IEEE , vol.12, no.6, pp.1965,1972, June 2012

[20] Jinsong Song, Zhenghua Xin, Wei Ding, “Research on android intelligent phones controlling the car to run”. TELKOMNIKA, Vol. 11, No.12, 2013, pp. 7438-7445.