

The Design of Wireless Smart Home System based on ZigBee

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Abstract. A functional and flexible wireless Smart Home system that based on GSM short message is presented. The design can control and monitor household equipments and environmental conditions. It uses the TMS320VC5402, CC2430 as the core hardware devices. Through ZigBee and the GSM integration, Smart Home remote monitoring and control are implemented. It has reflected the characteristic of low cost, low power dissipation, great practical and good scalability. All this work is significant for enhancing the actual application level and research level of Smart home control system further more.

Keywords: SmartHome; WirelessCommunications; GSM; ZigBee; DSP

1. Introduction

In the present, there are a large number of household appliances in people's home life, but these electric appliances are controlled directly, limited functionality and flexibility. With the popularity of mobile phones, development of its extended application will have broad market prospects. Mobile phone can rely on the public information network to control appliances, and check the situation at home. This paper discusses an attempt that combine the information processing technology with controlling the equipment to come true a digital home. In this way, people can enjoy the more convenience. The theme of this design is to establish an Smart Home control system based on GSM short message, in order to realize the control and monitor household equipments and environmental conditions. GSM short message modules implement receiving and sending short messages from users' mobile phone. It sets up a long distance communication functions between users' mobile phone and main-control module of DSP. The system connects sub-modules and main-modules by ZigBee wireless communication. The system also has advantages of convenient, fast and high efficiency.

2. The systematical Constructure of ZigBee Technology

In the technology of ZigBee, it's structure through layers to quantitate its each simplified standard [1]. Every layer is responsible for completing its task and offering service for its upper layer, and interfaces among this layers offer services through defined logic links. The protocol layer Structure of ZigBee technology is composed of three layers, while the systematical constructure is four layers: PHY layer, MAC layer, network/security layer and application frame layer. Of PHY layer and MAC layer which take the protocol standard of 802.15.4, PHY layer offers two kinds of services [2]. It offers service for both data and management of PHY layer through PLME. PHY layer can achieve its aim of service through transmitting and receiving PPDU by wireless physical channel. And the characteristic of it is that it can start shut off radio transceiver, detection power, quantity select channel, clear CCA, and transmit and receive packet through

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physical media .MAC layer also offers two kinds of services: it serves for both data and management of MAC layer through MLME-SAP. Data service of the MAC layer can send and receive MPDU of the layer through data service of the PHY layer. The character of the MAC layer are: beacon management, channel access, time slot management, sending confirm frame as well as the request question of connection .The network or security layer of ZigBee technology is mainly applied to the group network connection of LR—WPAN, data management, network security ,and so on. The application frame mainly offers some models of application frame for the practical Application of ZigBee technology [3].

3. The Designment Structures and the Theory of the System

This design establishes a wireless smart house system Based on the GSM and ZigBee technology group network. the system refer to DSP chips to achieve controlling and monitoring the home applications. The short messages module of GSM establishes the function of remote communications between subscriber of mobile phone and DSP control system through carrying out sending short messages to the subscriber of mobile phone and receiving the short messages from the subscriber of mobile phone [4]. The system achieves communications between sub-function module and master control module by using ZIGBEE of wireless communication technology. The master control module of the system mainly completes sending, receiving, explaining short messages and achieves controlling various function sub-modules. The purpose of designing Smart Home system: Only need we make use of mobile phone short messages, the functions we can get are as follows:1)the function of controlling home applications: achieving the function of remote controlling and operation, such as timing, on-off and monitor the condition of home applications.2)Fire alarming, smoking alarming, poisonous gas(coal gas) let out alarming. The system can immediately send short messages according to installed number.3)For getting the best comfort situation, the system automatic control starting/stopping the air conditioning and humidifier according to indoor temperature and humidity which are installed in advance. Smart House system is shown in Fig.1.

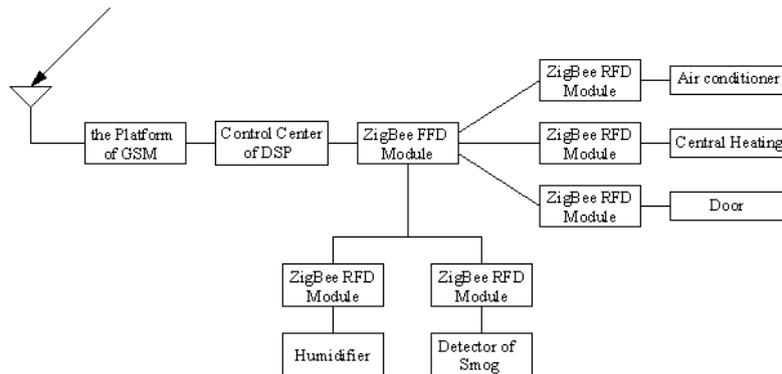


Figure 1. Smart House system

3.1 Main-control module of DSP

SMS platform module mainly provides a function of data transmission, the medium of external is the GSM network. The paper is based on the function of data transmission to realize the communication between systems and users. Main-control module of DSP is the core of this part, which bears tasks of sending and receiving short messages, explaining of short messages, sending the orders, dilivering and compressing of images and so on.

3.2 Design of communication interface circuit

Main-control module of DSP explains information after the SMS platform module receiving it, and then executes the corresponding commands. Therefore, the short message module and each sub-functional unit communicate with each other by serial interfaces. The main-control module of DSP and each sub-function modules and SMS platform modules also communicate with each other by serial interfaces

3.3 Preliminary design of home networking

As home networking, it includes main-control module of DSP and each unit modules for the entire system. They are in the different positions in the room. In order to realize effective communications, it requires connecting each module. This design uses a ZigBee network. It is very flexible for this network. It saves money, material and human resources, and also reliable. It is easy to realize by main-control module of DSP and several wireless communications ZigBee sub-energy-saving modules. There is a wireless network send-receive module (products accord with ZigBee technology standard) in main-control module of DSP. The data delivers through the gateway and sub-nodes via the wireless network transceiver. Ultimately, it realizes intelligent control of household appliances.

4. Smart Home Control System Components

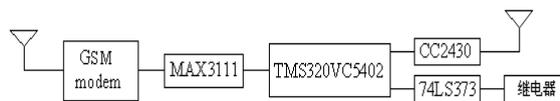


Figure 2. Smart Home Control System Components

Smart Home Control System Components is shown in Fig.2. Main control center module receive SMS, judge orders, implementation of the commands or direct drive, and send the working status of the machine to mobile phone by using SMS. In the design, it selects TMS320VC5402 as Controller Processor. DSP control module uses TMS320VC5402EVM evaluation board and emulator. TMS320VC5402 EVM provides two direct-connect lines I BCMSP J6 , J7, PHI drive port J2 and the interface of J5 and emulator. TMS320VC5402 EVM has 512K RAM data memory, 64K RAM for program storage and 4K FLASH memory ,which can be reserved for storing data.

ZigBee communication sub-nodes need to have the pulse-volume data acquisition, switching volume data acquisition, analog data acquisition, relay contact output function, and so on, and the master node is a full-featured FFD device, the realization of the family sub-node network management and communication with the master control module, to achieve the master control module and sub-node of information exchange. The nodes within the family in this design are composed mainly of CC2430 chips. The parts of CC2430 includes CC2430 RF receiver, as well as 8051MCU that is enhanced the performance, 8KBRAM, and so on. The performance of Enhanced 8051 MCU core is as 8 times as the standards. CC2430 also has a direct memory address(DMA) function, programmable watchdog timer, AES-128 security protocol processors, as many as 8 of 8 -14 bit input ADC, USART sleep mode timing, on-reset, brown-out Detection circuit, 21 programmable I / O pins, and so on. The selection of the design of DSP chips is the DSP5402. TMS320C5402 is a 16-bit fixed-point DSP, using the improved structure of Harvard to adapt to real-time embedded applications, such as long-range communications. TMS3205402 includes a group of procedures for bus and three groups of data bus and a high degree of parallelism of the Arithmetic Logical Unit ALU , dedicated hardware logic, on-chip memory, on-chip peripherals and specialized instruction set, these make the chip have more higher speed and more flexible operation . In this design, the GSM short messages module is the wireless module of HUAWEI_GTM900 GPRS. Household servers realize a home network and external network connections. DSP5402 is designed as a hardware platform, and CCS2.0 as a software development platform for the implementation of the remote user's commands, remote control and management. The design based on DSP5402 that is designed as a hardware platform and CCS2.0 that is designed as a software development platform realizes the function of remote control and management by carrying remote user's commands out.

5. The Process of Establishing Wireless Network Zigbee

The data transports by the connection of ZigBee network coordinator nodes and the control module. In ZigBee network, the sensor data of all nodes is sent to the node of coordinators through the routers. Each

sensor node can be set up to sleeping mode, when no data is sent to it, which could save power and prolong life. According to ZigBee protocol, each ZigBee main-device can be connected to 254 devices, and there can be as much as 100 independent and overlapping coverage ZigBee network in an area. Therefore, the network has enough capacity to meet most needs. It uses collision avoidance mechanism and fully confirmed data transfer mechanism in network data transmission. Both the network layer and MAC layer has a security policy and a security classification. And various applications can determine its safest properties. Therefore, the whole network has a higher reliability and security.

ZigBee standard provides a general that one wireless network ZigBee includes three types of devices: Coordinator, router, terminal node, corresponding to two types of devices: full-featured device FFD and streamline function device RFD. Router and Network Coordinator that achieve all functions prescribed by the standard are FFD devices, and the terminal devices which generally are various sensor nodes are RFD devices. In the ZigBee network, coordinator can only establish network.

This designment uses the star network. All devices can only communicate with Network Coordinator which is the center of the star network, so in the process of forming star network, the first step is to establish Network Coordinator .Any FFD devices have possible to become Network Coordinator, how a network determine its Network Coordinator is decided by the upper protocol .A simple strategy: After a FFD device is activated for the first time, first of all, broadcast the request of inquiring Network Coordinator, if received in response confirm that already exists Network Coordinator in the network, then through a series of certification process, the device become common equipment in the network. If not receive in response or the process of certification is not success, the FFD device can establish its own network and will be Network Coordinator of the network. Network Coordinator will select one sole symbol for network, all devices in the star network stipulate their master slave relationships by using the symbol. The devices come from different star network complete communications with each other by setting up specialized gateway. Choose a symbol, network coordinator allow other devices to join in the network and transmit data packet to them. If two devices in star network need to communicate with each other, first they should both send data packets to Network Coordinator, which then transmit the packets to each other.

6. The Designment of Software Debug for the Platform of Intelligence Household control to Send and Recieve Short Messages

This Send and receive short messages includes three encode modes: Block Mode, Text Mode and PDU (protocol description unit) Mode. Among them, Block Mode which has been gradually phased out is not frequently used at present. Text Mode is a pure text mode, it can use different character set, and technically can also be used to send short messages of Chinese, but the domestic mobile phone basically does not support, mainly for European and American regions. PDU Mode is supported by all mobile phone, it can use any character set, and this is the default encoding mode. The method to achieve to send and receive short messages under the PDU Mode: PDU string appears to be a string of ASCII code which is composed of numbers from "0" - "9" and letters from "A" - "F". They are 8-bit hexadecimal number or BCD code decimal number. PDU string contains not only the message itself ,which can be displayed, but also a lot of other information, such as the number of short messages service center, the target number, back number, encode mode, and operating hours, and so on. Smart Home control platform is carries on the compilation by C++Builder. Control devices by the module, and the sub-control device make the appropriate action after receiving the commands. There will be two actions when the sub-control terminal receiving orders. One is to make a appropriate action and to make a response to upper, then the master control center sends a short messages of sub-control terminal to users' mobile phones by GSM. It has completed the control and monitoring of inner family electronic by users remote control. In the intelligent home control platform, we can translate short message sent by users' mobile phones to PDU code, and household will behave as the order in PDU code.

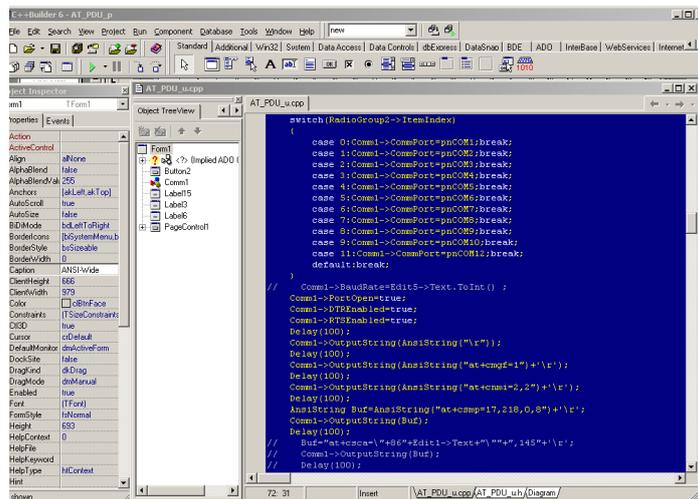


Figure 3. Smart home control platform test man-machine interface, which programmed by C++Builder

As shown in Fig.3, The Part of the program code is as follows:

```
//-----
String ansi2unicode(String s)
{
    // ->unicode
    String tmpStr;
    WideString InputStrW;
    int i, StrLen;
    InputStrW=s;
    StrLen=InputStrW.Length(); //
    tmpStr="";
    for (i=1;i<=StrLen;i++) //
        tmpStr=tmpStr + IntToHex(InputStrW[i],4);
    return tmpStr; //
}

//-----
AnsiString Unicode2Ansi(unsigned char *addr,int len)
{
    //unicode
    AnsiString t="";
    unsigned char p[5];
    p[4]='\0';
    char *endptr;
    wchar_t c;
    int lens=len/4*4;
    for(int i=0;i<lens;i+=4)
    {
        p[0]=(unsigned char)*(addr+i);
        p[1]=(unsigned char)*(addr+i+1);
        p[2]=(unsigned char)*(addr+i+2);
        p[3]=(unsigned char)*(addr+i+3);
        c=strtol(p,&endptr,16);
        if(c!='\0') t+=WideString(c);
    }
    return t;
}
```

7. Man-Machine Information Flow

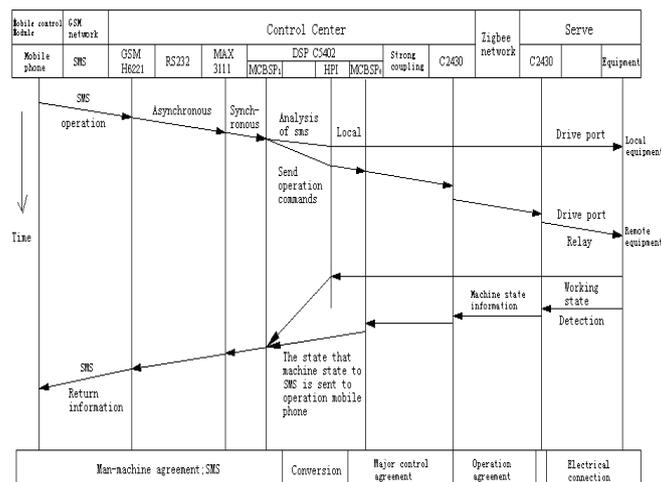


Figure 4. Man-machine information flow chart

8. System Debug

1. Send-receive SMS messaging module debugs: This part mainly completes the compatibility of the chosen GSM modem and AT commands. It can be debugged by super terminal in PC [5].
2. The debug of MCBSP1's synchronous serial interface of TMS320VC5402 and MAX3111's serial interface. It should guarantee receiving correct messages; and it should use TMS320VC5402 emulator while debugging process.
3. Connection of MCBSP0's synchronous serial interface of TMS320VC5402 and the CC2430. If there are problems, the problems of two chips will be found by two emulator computers [6].
4. ZigBee network debugs. The CC2430 of the center controller and the CC2430 of controlled part are debugged by emulators singly in order to make ZigBee connected.
5. Debug the drive port of CC2430 until it can drive electric relays as required.
6. Debug the control and management logic of Central controller.
7. Text all parts of system. TMS320VC5402 and CC2430 will be used.

9. Conclusions

The theme of this design is to establish a Smart Home control system based on GSM short message, in order to realize the control and monitor household equipments and environmental conditions. GSM short message modules implement receiving and sending short messages from users' mobile phone. It sets up a long distance communication functions between users' mobile phone and main-control module of DSP. The system connects sub-modules and main-modules by ZigBee wireless communication. The purpose of designing Smart Home system is remote controlling and operating home applications. Door alarming, smoking alarming, poisonous gas (coal gas) let out alarming and the system can immediately send short messages according to installed number. For getting the best comfort situation, the system automatic control starting/stopping the air conditioning and humidifier and so on according to indoor temperature and humidity which are installed in advance.

Advantages and innovation of the system:

1. It designs a new application program of Smart Home control system based on ZigBee wireless technology, which made it front ages and practicability of the development of Smart Home control technology.
2. According to the habits of communication, it is easy accepted that Smart Home control system based on GSM short messages, and it has advantages of convenient, fast, high efficiency.
3. The system uses DSP TMS320VC5402, which has not only a low price but also future upgrades of the system. In the future, we can take advantage of MMS or 3G mobile communication based on GPRS, which

could be as graphics, images of video information. At that time, the center controller should have sufficient capacity to handle with videos, where DSP will be fully used.

4. The design settles problems of the connection between DSP TMS320VC5402 and GSM module.

Therefore, there is a good prospect for social development of Smart Home control system based on GSM short messages.

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11. References

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