Home control system design based on internet of things[1]

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Abstract. In order to realize the remote management and wireless transmission function of the intelligent home system, Samsung's S3C2440 chip and the related peripheral devices are used to form a home gateway control platform of the entire system and home internal control network is designed based on ZigBee wireless network technology. The Texas Instruments CC2530 chip is used to achieve the functions of the coordinator node and the end node in the family internal control network. Finally, the experiment testing verifies that this system is feasible.

Key words. Home control system, Internet of things, ZigBee.

1. Introduction

With the rapid socio-economic development and Internet technology, control technology, information and communication technology and other advances in technology, and the sustained improvement of people's living standards, the relationship between people's daily life and information is becoming closer [1, 2]. How to make people have a safe, comfortable, energy-saving and convenient home environment has become the development trend of future household life, hence smart home control system came into being [3]. Smart home control system is based on the residential district as a platform environment, combined with computer technology, automatic technology, embedded software and hardware technology, wireless communication technology at an organic whole [4]. Achieve the goal of in close or remote control home appliance equipment and real-time monitoring the status of home appliance by users.

Based on the analysis of the shortcomings and development process of domes-

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tic and foreign smart home control system, an ARM9 processor-based smart home control system is proposed in this work [5, 6]. It has changed the characteristics of traditional smart home control system of writing difficulties, poor mobility, high cost of design system complexity and inhuman.

This system uses S3C2440 microprocessor chip as the family gateway controller module and family internal control network module adopts ZigBee as a communication module [7–9]. The system hardware circuit design mainly follows three basic principles. The first is to try to use the typical application circuit to avoid unnecessary mistakes happening. The second is that it can be used for simulating the operation of the system and is convenient for system development and debugging. The third point is the reserved corresponding expansion interface, providing the needed for future expansion.

2. Hardware design

For the design requirements of family gateway in this paper, some corresponding peripheral devices have been designed, including the power module, the module reset button, touch screen module, LED display module, alarm module, storage circuit module, communication interface module, etc. Power supply is the core part of the whole system, which is related to the normal operation of the whole system. The design of power circuit in the system mainly considers the following two aspects. In order to improve the stability of the whole system,power filter circuit and voltage stabilizing circuit are designed in the power supply module. Power circuit is shown in Fig. 1. In this design, in order to ensure the circuit in the system stable and reliable and monitor the power supply voltage and carry out reset operation, we select MAX811S reset chip having the relatively high cost performance specially used for system monitoring. As long as the system's power value is less than the threshold of system reset, the chip will immediately reset the system.

Nand Flash contains a number of bytes in one page and one storage block is made up of several pages. One Nand storage block size ranges from 8 to 32 kB. The biggest advantages of this structure is that the capacity can be extended and now capacity of more than 512 MB Nand Flash products are quite common. Owing to the high density of Nand Flash unit, the cost is low, erasing speed is fast and is commonly used to store the large capacity data. Of course, it can also be used to run the program. Nand Flash devices are prone to bad block and is a random distribution. Once occurs, it will not be able to be repaired. So when it is used, an initialized medium scan should be carried out to find bad block and mark it as unavailable. Nand Flash circuit is shown in Fig. 2.

WM8731 is a kind of audio codec module with integrated headset drive produced by Wolfson. The voice prompt module circuit's ADC and DAC is 24 bit, the chip price is low, it has good quality, low power consumption and internal integrated optional ADC high-pass filter, which can directly provide 50 mW output power for 16- ohm load. S3C2440 IIS interface support left alignment mode and IIS mode, at the same time, it has the IIC bus interface and greater flexibility when being programmed. The chip also integrates the headphone amplifier to direct drive head-
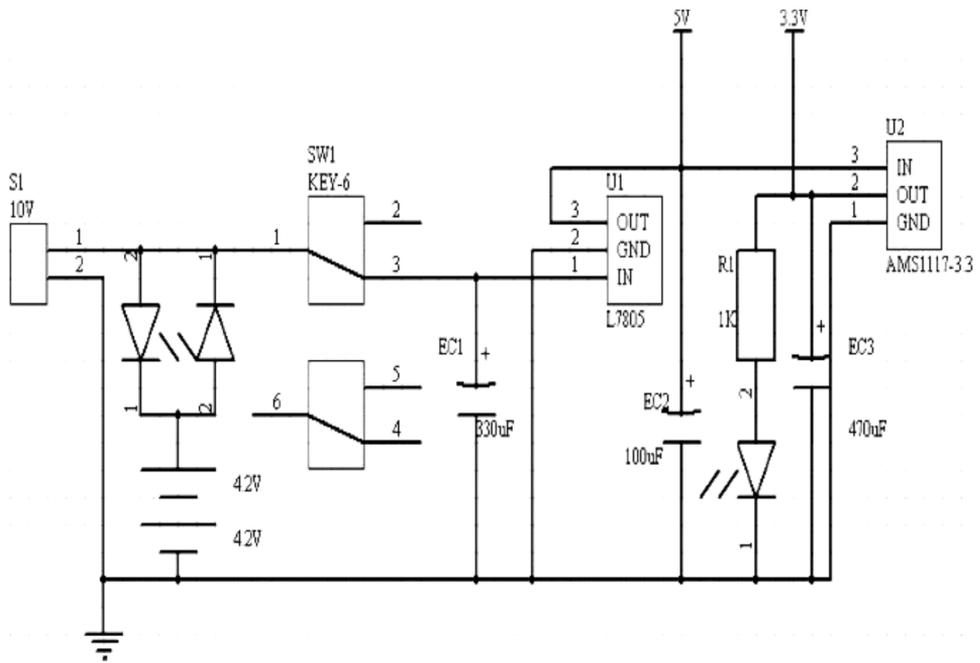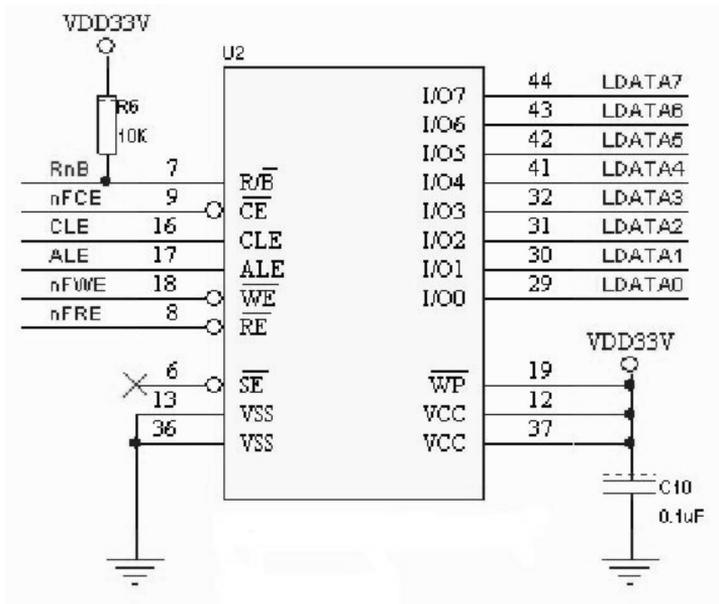
Fig. 1. Power circuit

Fig. 2. Nand flash circuit

phones, so as to omit the headphone amplifier circuit. S3C2440 IIS coding system clock output is selected as clock in order to obtain more accurate clock. Subsequent circuit adopts TDA2822M as power amplifier chip to drive the speakers.

This family internal control network adopts the ZigBee wireless technology supported by the star network topology structure, mainly involving the two logical device types of ZigBee coordinator node and end node in the network. Coordinator achieves data transmission to the home gateway through RS232 serial interface, which is mainly responsible for the wireless control network within the family and searches the effective channel and terminal nodes to complete data forwarding function. Terminal node is mainly responsible for receiving command from the coordinator, which realizes the control of temperature sensors and household appliances and feedbacks the corresponding information to the coordinator node and then transmits the information to the home gateway through the coordinator node.

CC2530 chip uses a new generation of SOC system of 2.4 GHz and also combines TI company's gold unit ZigBee protocol and Remo TI, which can support the IEEE 802.15.4 standard. So we can build a more powerful network at low cost. CC2530 integrates a more perfect RF transceiver in sensitivity and anti-jamming, and standard enhanced 8051 microprocessors. In order to shorten the development cycle for developers, we also can use a good network protocol stack of TI company to simplify their own product development. Temperature control circuit is shown in Fig. 3. This circuit is connected to CC2530.
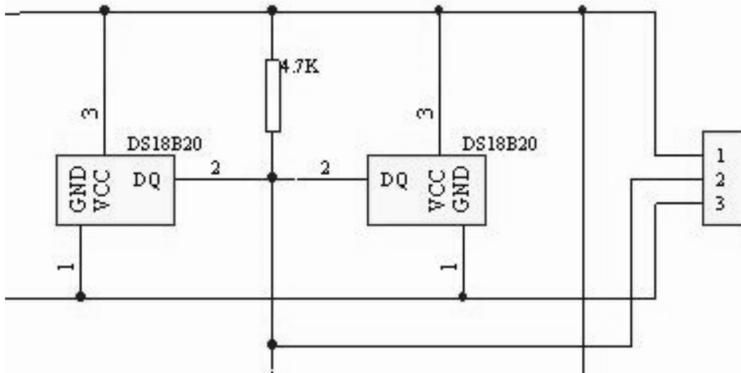

Fig. 3. Temperature control circuit

3. Workflow of Z-stack

The whole process of Z-stack is roughly divided into system and driver initialization, OSAL initialization and starting and entering task round. The focus of the system design is to carry out the ZigBee node related hardware initialized. The hardware initialization needs necessary configuration in Z-Stack protocol. The Z-Stack protocol can realize flexible, stable and energy efficient ZigBee wireless self-organizing network. In the application layer, it adds specific events and writes the

corresponding event handlers, in order to achieve specific functions. As the coordinator, routers and terminal node hardware design, it has different function in the ZigBee network. In the software design, there are the three kinds of nodes.

The implementation process of smart home application system based on ZigBee wireless network is as follows.

1. The coordinator system is initialized to set up the ZigBee wireless network.

2. Routers and terminal node system are initialized to join the established network and send the corresponding node number and web address information to the coordinator. Terminal node initializes the relevant sensors at the same time, the router waits for forwarding information and terminal nodes wait for control information.

3. As the coordinators set up the network successfully, after terminal nodes or routers joining the established ZigBee network, the coordinator will save the address of node in the address table.

4. Terminal node collects report on trigger events, reads sensor information and sends it to the coordinator.

5. Coordinator receives information and sends the upper machine via a serial port. Upper machine receives serial data, analyzes data and displays it on the interface.

6. Triggering the corresponding control information, and the control information is sent to the coordinator through the PC serial port.

7. The coordinator serial port receives information to produce a serial port interrupt, parses serial data and control information is sent to the corresponding terminal nodes.

8. Terminal nodes receive control information, parse and control curtain, light switches or opening and closing operation of sensors of the control nodes, etc.

9. Remote node is initialized and lights and appliances as well as curtain switches are controlled through remote control.

In the node initialization, the hardware initialization and the initialization of OSAL task is important. In the task initialization, we mainly consider ZDApp initialization in ZDO layer and initialization of the application layer. If we do not define HOLD_AUTO_START compiler options, in ZDApp task initialization, function ZDOInitDevice() is called to initialize the network. When HOLD_AUTO_START compiler, option is undefined, the equipment general startup process is shown in Fig. 4. If HOLD_AUTO_START compiler option is defined, in ZDApp task initialization, network is not initialized. After the application layer task initialization, initialization of network is completed in the event of tasks. When the compiler option HOLD_AUTO_START is defined, equipment general startup process is carried out. Due to different configuration files, equipment ZDO_StartDevice() initialization step is different. ZDO_StartDevice() starts the equipment according to

the different equipment types. In ZDO_StartDevice(), the coordinator carries out devState=DEV_COORD_STARTING to set equipment's status as the coordinator starting and call the NLME_NetworkFormationRequest() to form network. In ZDO_StartDevice(), the router executes devState=DEV_NWK_DISC to set the status of equipment as finding network status and then calls NLME_NetworkDiscoveryRequest () in the network layer to discovery network. It also performs NLME_-StartRouterRequest() to start the routing function, eventually it joins the network established by the coordinator.
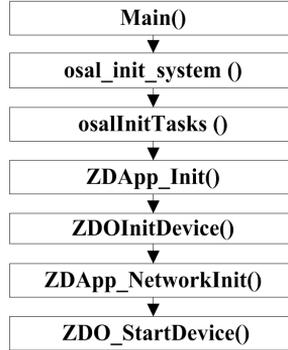
Main()
osal_init_system ()
osalInitTasks ()
ZDApp_Init()
ZDOInitDevice()
ZDApp_NetworkInit()
ZDO_StartDevice()

Fig. 4. Equipment general startup process when HOLD_AUTO_START is not defined

In ZDO_StartDevice(), terminal equipment executes devState = DEV_NWK_-DISC to set the status as finding network status of equipment, and then call NLME_-NetworkDiscoveryRequest() to discover network and join the network built up by coordinator eventually. If it does not join in the network successfully, a certain delay time is set and then reset the network initialization event ZDO_NETWORK_INIT to initialize the network.

4. System performance testing

Overall system performance testing is to test household system comprehensively. We mainly test o network stability, and power consumption. The chip itself has low power consumption, and the protocol stack can set terminal node in power saving mode. In power saving mode, when the terminal node will not send and receive data, it is in the sleep mode.Sleep mode has low power consumption, which almost can be ignored. Taking standby time as measurement of power consumption is not better. So we test power consumption when node is working. The node sends data continuously in the experiment. Two 1300 mAh rechargeable batteries can make the node keep sending data about 2600 to 3400 times or so. Because the battery charging has difference, average values of the sixty times measured results are shown in Table 1. The node does not send data most of the time, and we can ignore its low power consumption in the sleep mode. If data sending times is 20, battery life

of the node can reach about 150 days.

Table 1. Times of node sending data

Testing node	node 1	node 2	node 3	node 4	node 5
Times of sending data	3400	2850	2650	2600	2650

In the laboratory environment, tested ZigBee network includes a coordinator, two routers and five terminal nodes. It can keep connection with coordinator for 8 days. In 14 days, a terminal node disconnects the connection with the coordinator, but later it can access the network successfully. After four weeks of continuous testing, coordinator and routers basically are stable. Only the terminal nodes had a few broken accidents due to interference, but it basically can be recovered soon. After testing, it proves that this system has stable performance.

5. Conclusion

On the basis of the existing smart home system, we put forward a kind of home control system based on S3C2440 processor and ZigBee wireless technology. The design achieves the co-ordinate management of smart home system through a unified wireless protocol and the different control protocol. The structure is mainly four parts composed of family gateway, terminal controlled equipment, family internal control network and external communication network.

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