Intelligent Air Conditioning Control System Based on ZigBee

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Abstract
The type of intelligent control system based on ZigBee is proposed for the purpose of realizing the intelligent control of household air conditioning. It gives overall design scheme of remote control system for smart home air conditioning, finishes the design of acquisition module and sensor module on the basis of CC2530 and realizes the remote control and temperature acquisition on indoor air conditioning. System testing explains that this home system runs reliably, keeps high real-time performance and has capacity to do remote control on air conditioning which possesses good application prospect.
Key Words: ZIGBEE, CC2530, SMART HOME, REMOTE CONTROL

1. Introduction

With the increasing of popularity degree of smart home, people cannot accept smart home system based on wired communication technology with high production cost and complex installation any more, thus leading the application of emerging wireless communication technology to smart home system to become favored. Next, we do comparison analysis on several common short-distance wireless technologies.

Bluetooth is a sort of short-distance wireless transmission technology with low cost. It operates in ISM frequency band 2.4GHz whose maximum data rate is 1 Mb/s. Bluetooth technology is widely used in the communication between handheld computer and mobile communication equipment [1]. Bluetooth technology keeps advantages of high transmission rate, free use of frequency band, high security and low cost. However, it also keeps obvious disadvantages including high power consumption, complex networking, low network node number which is just 8 and long networking time which is about 10s. These disadvantages greatly restrict its development.

Infrared ray is electromagnetic wave whose wave length is between 750nm and 1mm [2]. It keeps poor diffraction capacity on obstacle because of the short wave length, thus determining that it is just suitable for short-distance wireless communication. Infrared

technology has the advantage of keeping transmission rate high when transmitting infrared data. As infrared interface must be strictly connecting, it has high reliability and security. While it has the disadvantage of communication distance being short. During the communication process, casual movement and obstacle are not allowed. In other words, the extensibility is weak. Features of infrared communication determine that it can just be applied to wireless communication with short distance and small data size such as home appliance remote control [3].

IEEE 802.11 series namely Wi-Fi is a kind of wireless communication technology operating in 2.4GHz frequency band [4] which is promoted from the original data service to the current voice, data and image services. IEEE802.11 series wireless communication technology has advantages of keeping high data transmission rate and large number of network node whose maximum value is 50. Disadvantages are high power consumption, long networking time being about 3s, complex networking, much equipment cost, etc. These features determine that it is appropriate for high-speed data transmission, for example indoor wireless local area network.

ZigBee Wireless Sensor Network is wireless data transmission network based on IEEE 802.15.4 Technical Standard and ZigBee Network Protocol [5]. ZigBee Technology keeps many advantages such as high communication efficiency, low complexity, low power consumption, low cost, high safety, etc. These advantages help perfectly exert technical features of wireless sensor network [6].

Taking the above-mentioned factors into consideration, we apply ZigBee Wireless Communication Technology to smart home which not only helps lower the cost but also does intranet Wi-Fi control. Intelligent air conditioning control system designed in this paper collects indoor temperature through temperature sensor in front end and makes a judgment on temperature value. If it goes beyond the set threshold, information would be sent to gateway. Then gateway sends commands to relevant front-end controller according to the current environmental message with the purpose of realizing automatic control.

2. Hardware Design of Intelligent Air Conditioning Control System

2.1. Overall Design of Intelligent Air Conditioning System

Wireless intelligent air conditioning control system based on ZigBee should be composed of coordinator, router and terminal module. The number of coordinator could just be 1 although that of the other two is unlimited, thus finishing basic wireless communication and data acquisition. Fig.1 is the system block diagram of intelligent air conditioning control system circuit. Structure of this system is star network consisting of one full-function coordinator namely acquisition module and one temperature measurement node carrying LCD and temperature sensor DS 18B20 which serves as terminal node namely sensor module.

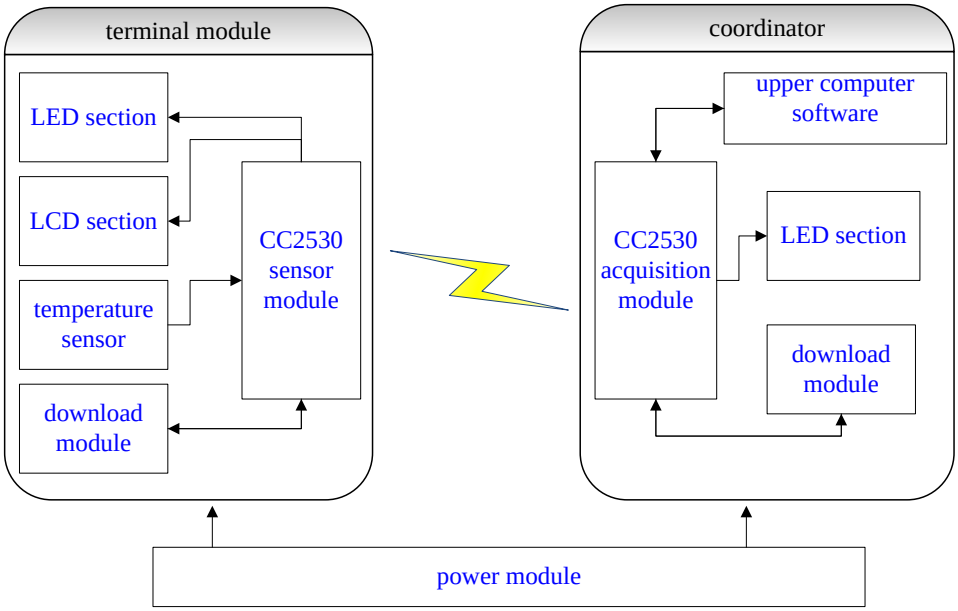

Figure 1. The overall block diagram of the system

Acquisition module is connected through USB line and PC. Sensor module is arranged on household air conditioning. DS18B20 does real-time detecting on indoor temperature and then data is transmitted to acquisition module in wireless way. Through serial communication, it is transferred to upper computer. Family members remotely view temperature through internet. In addition, family members can remotely set the temperature of their air conditioning in which temperature data is set through upper computer and then reverse transmitted to LCD of sensor module through ZigBee wireless communication technology. LED section shows the condition sensor module accessing to wireless network.

2.2. CC2530 and Typical Application Circuit

The CC2530 is a true system-on-chip (SoC) solution for IEEE 802.15.4, Zigbee and RF4CE applications. It enables robust network nodes to be built with very low total bill-of-material costs. The CC2530 combines the excellent performance of a leading RF transceiver with an industry-standard enhanced 8051 MCU, in-system programmable flash memory, 8-KB RAM, and many other powerful features. The CC2530 has various operating modes, making it highly suited for systems where ultralow power consumption is required. Short transition times between operating modes further ensure low energy consumption [7].

CC2530 typical application circuit mainly includes crystal oscillation circuit and RF circuit, which is externally connected with a 32MHz crystal oscillation circuit and a 32.768KHz crystal oscillation circuit. One 16MHzRC oscillator and one 32KHz RC oscillator exist inside the chip. 32MHz external crystal oscillation circuit is seen in Fig.2 and Fig.3 shows the 32.768KHz one.

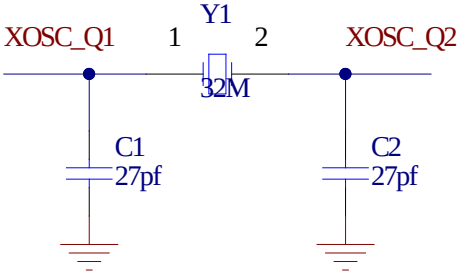

Figure 2. 32MHz external crystal oscillation circuit

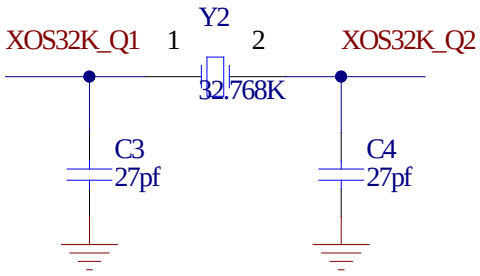

Figure 3. 32.768KHz external crystal oscillation circuit

CC2530 RF circuit means the matching circuit between antenna and chip transceiving pin which is shown in Fig.4.

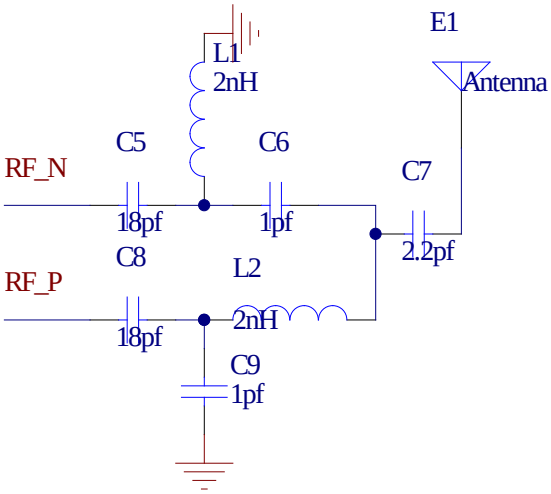

Figure 4. CC2530 RF Module Circuit

2.3. DS18B20 and Circuit of Temperature Acquisition

The DS18B20 has four main data components: 1) 64-bit lasered ROM, 2) temperature sensor, 3) nonvolatile temperature alarm triggers TH and TL, and 4) a configuration register. The device derives its power from the 1-Wire communication line by storing energy on an nternal capacitor during periods of time when the signal line is high and continues to operate off this power source during the low times of the 1-Wire line until it returns high to eplenish the parasite (capacitor) supply. As an alternative, the DS18B20 may also be powered from an external 3 volt - 5.5 volt supply[8]. Fig.5 describes the circuit of temperature sensor acquiring temperature.

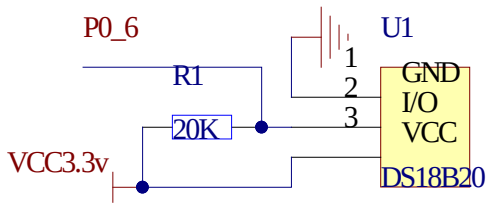

Figure 5. circuit of temperature sensor acquiring temperature

The design of power circuit is for providing other functional modules in intelligent air conditioning control system with power in order to guarantee their normal operation. Downloading equipment and debugging equipment of acquisition module and sensor module need power from SV. While main chip CC2530 needs 3.3V power supply. Therefore TPS73033 is utilized to do level conversion. Circuit diagram of power module is presented in Fig.6.

2.4. Power Module

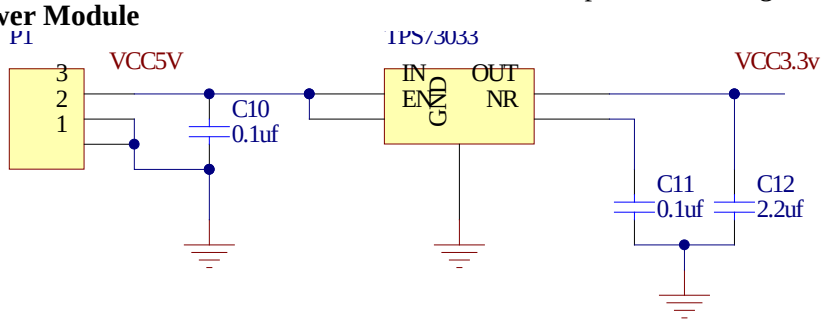

Figure 6. Circuit Diagram of Power Module

2.5. Downloading Interface Circuit

Seven pins in CC2530 chip are linked with Debug through which program is downloaded and debugged. Fig.7 is the schematic diagram showing connection of emulator and main chip.

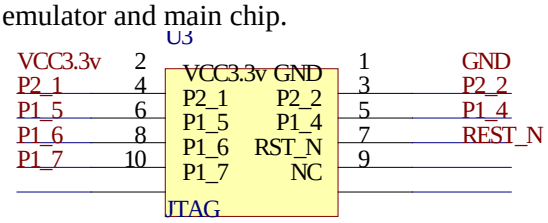

Figure 7. Emulator JTAG Interface Circuit

2.6. USB-to-UART Circuit

USB-to-UART circuit utilizes chip of MAX3232 which directly converts DART on the main chip to USB interface. This provides convenience for the connection with PC. This USB interface also supplies the whole circuit with power thus simplifying system design. Fig.8 is the USB-to-UART circuit diagram.

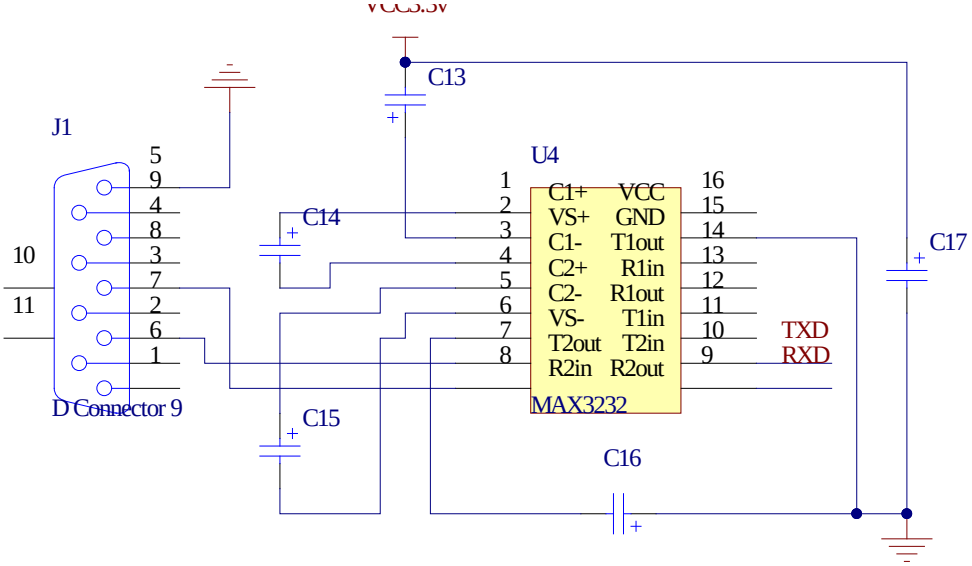

Figure 8. USB-to-UART circuit diagram

3. Software Design of Intelligent Air Conditioning Control System

Software development environment of intelligent home alliance system is IAR Embedded Workbench For C8051 and software development platform is Z-Stack 2007 PRO. Although the previously used 51 single chip microcomputer utilizes keil software to do programming, keil software can never directly use Z-Stack Protocol Stack of Texas Instruments Inc. However, IAR software can directly use it to do development in which users just need to modify application layer program and call API interface function. IAR software can utilize C/C++ to do programming, which supports at least 35 types of ARM microprocessors. Keeping the advantage of efficient programmable code, it becomes the most widely used development environment in embedded field.

3.1. Software Program Design of Acquisition Module

Main functions of acquisition module program in intelligent home alliance system are initializing each layer, establishing network, allowing binding, distributing ID address number, etc. Fig.9 is flow diagram of acquisition module.

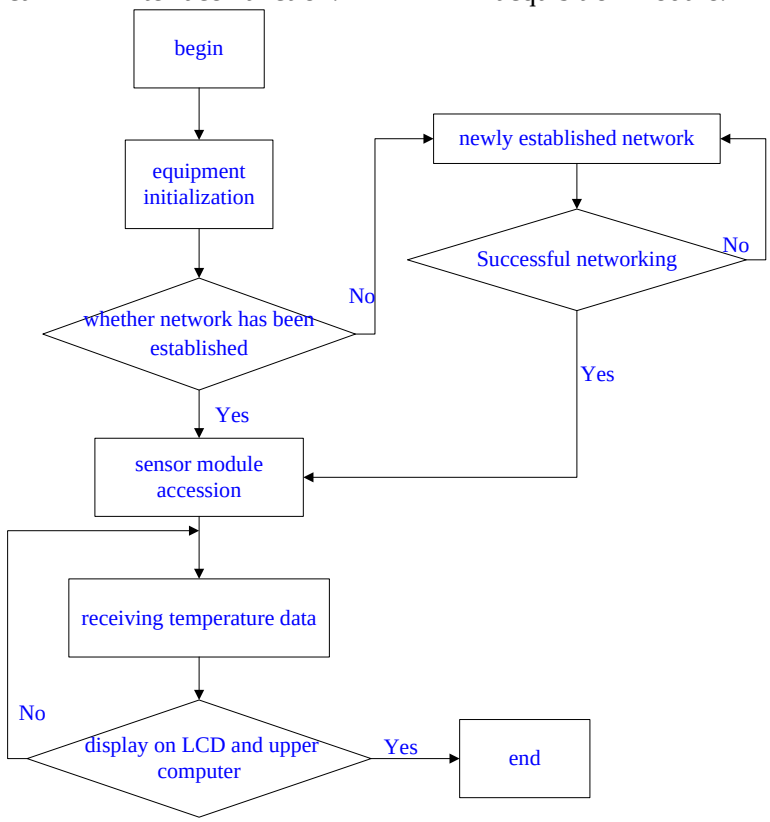

Figure 9. Flow chart of acquisition module

After beginning, system does initialization on each layer, establishes network, allows binding, distributes ID address number to the equipment which successfully accesses to the network and then enters listening state. After coordinator receives commands sent by wireless sensor module terminal, it would send control commands to nodes thus realizing the temperature control on intelligent air conditioning.

3.2. Software Program Design of Sensor Module

Sensor module checks network and then sends binding request. After allowed, it asks for joining network. It would distribute ID address number after receiving allowance from acquisition module. If there is no response, sensor module would periodically continue to do checking. If binding is successful, it would receive ID address number sent by acquisition module and send temperature data every other 1s. It is transmitted in two paths. One is transmitting data to acquisition module through wireless ZigBee technology. The other one is directly showing the data on LCD.

When sensor module receives command data sent by acquisition module through wireless ZigBee technology, the data would also be shown on LCD. Fig.10 is the flow chart of sensor module.

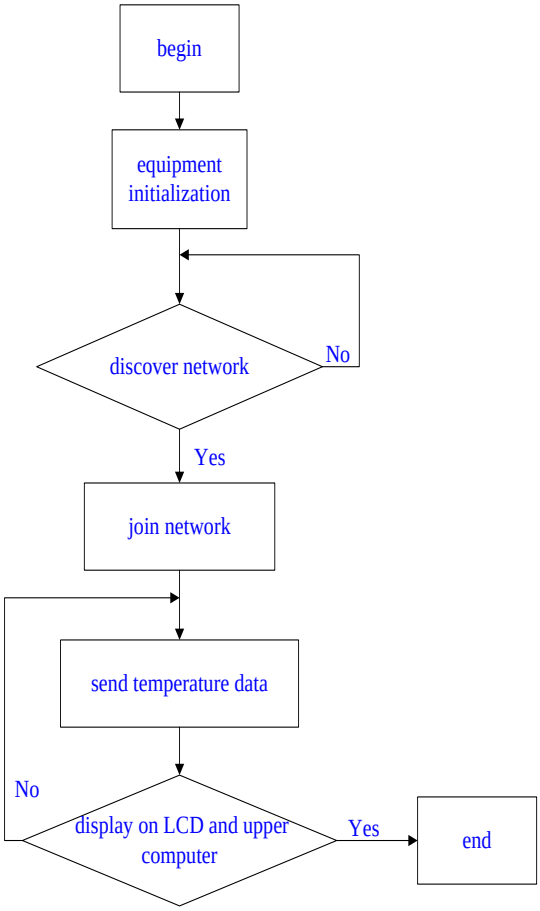

Figure 10. Flow chart of sensor module

After electrified, sensor module also does initialization on tasks, while sensor module has its own descriptor and port number. Although flow of it is the same with that of acquisition module, the equipment type is terminal equipment.

4. Conclusions

The experiment firstly measures indoor temperature through sensor module. Secondly it sends temperature data to acquisition module through ZigBee wireless communication technology thus leading data to be sent to serial debugging assistant. After that the hoped temperature data is set which would be inversely transmitted to sensor module through upper computer. Then acquired temperature and controlled temperature would be shown on LCD. With the changing of temperature on temperature sensor, temperature on serial debugging assistant also presents real-time change. Testing result shows that temperature on serial debugging assistant includes the acquired temperature and controlled temperature thus realizing the design of intelligent air conditioning control system based on ZigBee.

References

1. Gang Zhu, Zhenhui Tan (2002) *Principle and protocol of bluetooth technology*. Beiing Jiaotong University Press: Beijing.
2. Zhang Xiao-hong, Sasan Saadat (2003) IrDA Standard and Its Application. *Optoelecfronic Technology*, No.4, p.p.12-15.
3. Koorosh Akhavan, Mohsen Kavehrad, Fellow et al. (2002) High-Speed Power-Efficient Indoor Wireless Infrared Communication Using Code Combining. *IEEE Transactions on Communications*, 50(7), p.p. 1098-1109.
4. Cai Xing, Zhang Siquan (2003) A Summary of Short-range Wireless Communication, *Modern Electronic Technique*, No.3, p.p. 35-37.
5. Zoran Bojkovic, Bojan Bakmaz (2008) A Survey on Wireless Sensor Networks Deployment. *World Scientific and Engineering Academy and Society*, 7(12), p.p.1172-1181.
6. X.Hu, J.Wang, Qun Yu (2008) A Wireless Sensor Network Based on ZigBee for Telemedicine Monitoring System. *Bioinformatics and Biomedical Engineering*, 3(1), p.p.367-370.
7. http://www.ti.com.cn/product/cn/cc2530
8. http://pdf1.alldatasheetcn.com/datasheet-pdf/view/58557/DALLAS/DS18B20.html.