Research on the design of wireless control system for basketball stands elevator

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Abstract. To realize the lifting of basketball stands elevator scientifically and reliably. Through a portable control terminal equipped with a touch screen, we use the ZigBee wireless network to control each elevator node. The hand-held remote control terminal based on STM32F103 as the core processor, realizes data transmission by using CC2530 wireless communication chip, and the elevator control terminal, through ZigBee receiving nodes with the same CC2530 as the core, receives the command sent from the remote terminal. After testing, this system has friendly man-machine interface, low power consumption, low cost, high reliability, good expansibility and so on advantages. The system not only can be used in lifting system of basketball stands, but also can be easily transplanted into other specific applications with the broad application prospect and market value.

Key words. Basketball stands elevator, ZigBee wireless communication, control system.

1. Introduction

With the development of social material civilization, people's keen degree of sports activities also grows with each passing day. In addition, leisure fitness becomes the most effective way for people to relax the heart and alleviate the pressure of work, and the stadium has become the first choice of people in sports activities. On the other hand, with the rapid development of Chinese sports, more and more sports items have been widely promoted, except for basketball, badminton, table tennis and so on traditional items, billiards, yoga, aerobics and other emerging sports project has obtained more and more people's love and participation. In order to enrich the function of stadium, large stadiums are installed with basketball stands that can be moved up or down. Driving the winch by the motor, it drives the mechanical mechanism, and lifts the basketball stands to the ceiling, which makes the basketball stands do not interfere with the running of other sports activities [1]. How to realize

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the lifting and lowering of the basketball stands elevator quickly and scientifically has become an urgent problem to be solved. In the field of short distance communication, there is very fierce competition. However, ZigBee technology, with its low cost, low power consumption, high safety, large network capacity and many other advantages, showed itself in many short distance communication technologies [2].

ARM core design is more advanced, with higher frequency and more powerful processing capabilities; FPGA integration is greatly improved, having entered the era of 28 nm [3]. A single chip can integrate with hundreds of thousands or even millions of gates. In addition, through a portable control terminal equipped with a touch screen, we make use of the ZigBee wireless network, to control each elevator node. We can also record the elevator using information in the PC terminal database, easy to use, safe and reliable, low in cost, high in performance, and easy to modern management of the stadium.

2. Overview

ZigBee network is a short distance wireless network composed of up to 65536 wireless communication modules, and any of the two devices in the network can communicate with each other directly or indirectly. In the protocol stack, the theoretical communication distance between ZigBee network nodes is 75 meters. Through increasing the extra power amplifying circuit (such as low noise amplifier), it can greatly extend the communication distance. For instance, after making use of CC2591 power amplifier, the communication distance is up to several kilometers [4]. In addition, the ZigBee device can be connected to the mobile communication network or Ethernet, which is convenient for the remote monitoring of the equipment and greatly expands the application range. ZigBee technology has many advantages, such as low rate, low power consumption, low cost, large network capacity, short time delay, high safety, high reliability and so on [5], ZigBee technology applications field is very extensive, including industrial automation, building automation, lighting control, environmental control, medical monitoring system, smart card, remote control, wireless data acquisition system and so on. ZigBee technology in 2004 was named one of the ten latest technologies in the world's fastest-growing and most extensive market prospects.

The stadium elevator controller is mainly designed for lifting basketball stands in the stadium. The basketball stand is more common in foreign countries. In the 1960s, it was designed and produced by a professional company of lifting equipment, mostly installed in large gymnasium. The basketball stand is lifted up to the roof, avoiding the trouble for making room space to remove the basketball stand from the original place to the off-site, so the lifting basketball stand has been rapidly promoted. The traditional stadium lift control is wired, roughly divided into separate control mode for each lift and all lift networked control [6]. In our country, since that the stadium equipped with the lifting basketball stand is relatively small, the stadium elevator controller is blank. However, with the modernization grading of stadium construction and the development of control technology, the convenient and reliable lifting system is bound to have a broad market prospect.

3. Methods

3.1. Overall scheme design

The system is mainly composed of three parts: a hand-held remote controller, several lift control units and a plurality of ZigBee network modules. The hand-held remote controller provides man-machine interface, convenient for users to operate; elevator control units directly control the winch motor reversing and realize the lifting action of elevator; ZigBee network module is responsible for data transmission between the hand-held remote controller and the elevator control unit; in addition, the PC machine realizes the data record of the elevator operation case in the database, but also uploads the database to the network, so as to achieve the management of a number of stadium. The system structure is shown in Fig. 1.
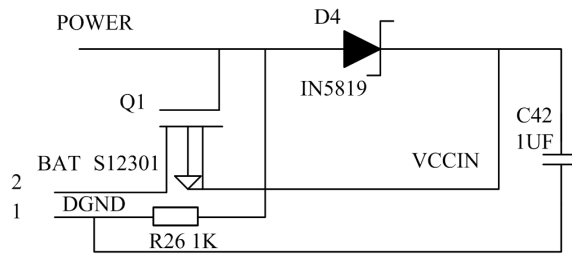

Fig. 1. Input power schematic circuit

3.2. System hardware design

The stadium elevator wireless control system is the complex system composed of hand-held remote controller, elevator control system units and ZigBee network modules. The hardware design contains a lot of contents, relating to the embedded ARM system hardware, CPLD programmable logic device system hardware, ZigBee RF module hardware, power management circuit, expansion interface circuit and so on hardware's design [7]. It is supposed to follow the modular, standardized, and generalized ideas, to make the hardware design simple and reliable, and to ensure the stability and good expansibility of each module circuit.

In the hand-held remote controller hardware system, power supply related circuit includes input power arbitration circuit, charging circuit, TFT-LCD backlight LED power supply and so on. The design of this part is more complex, which is one of the most important parts in the hand-held remote controller hardware design. The input power arbiter determines which power is used to provide power supply for the hardware system. The schematic diagram is shown in Fig. 1.

Hand-held remote controller uses the TFT-LCD screen. Because the system has not high requirements on the touch screen accuracy, for cost considerations, we select four-wire resistive touch screen. Figure 2 is the equivalent model of the resistive touch screen. The value of the output voltage Vmeas is determined by the

ratio of the two series resistors. Among them, the equivalent resistance R1 and the reference voltage Vref are connected, the other end of the resistance R2 grounding, and the Vmeas terminal can be connected to the ADC, for the voltage measurement.
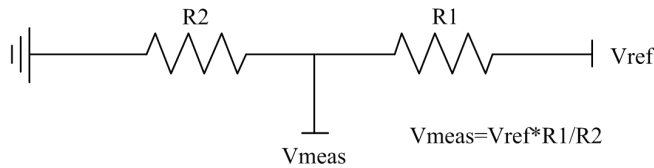

Fig. 2. Schematic diagram of resistive touch screen

In the hardware design of ZigBee network module, taking into account the design cost and the requirements of product technology, the elevator control unit and ZigBee module PC machine terminal use the similar minimum system hardware design. And hand-held controller end ZigBee module, except for the minimum system hardware design, in order to meet the need of communication distance, also adds the power amplification circuit and SMA omnidirectional antenna.

Power amplifier relevant circuit diagram is mainly the link part between the CC2530 and the CC2591, and the connection circuit is shown in Fig. 3.
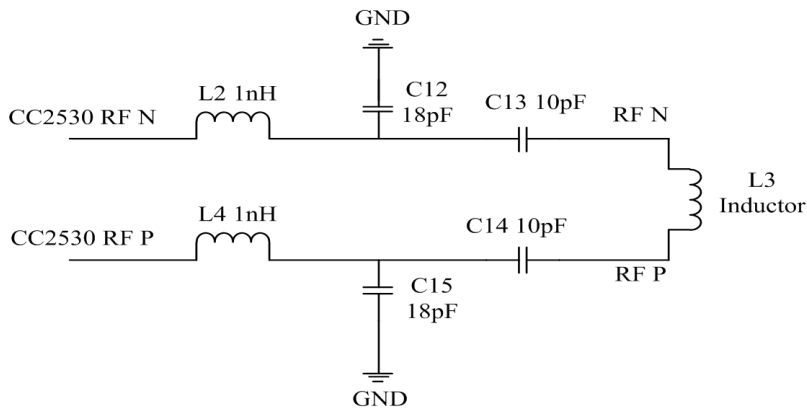

Fig. 3. Connection circuit diagram of CC2530 and CC2591

3.3. System software design

The software design is the core work of the elevator wireless control system design. The hardware of the system is equivalent to the human body. And the system software is equivalent to the brain of human, controlling the entire system for normal working. With the development of embedded technology and integrated circuit technology, the hardware circuit design more uses the integrated circuit and the design difficulty continuously decreases. The performance of the system mainly depends on

the quality of the software design, and it puts forward higher requirements to the software design.

The hand-held remote control is the most complex part in the whole system, and the corresponding software design is also the most difficult. The microcontroller uses STM32F103VC and uses the standard C language for programming it. It is worth mentioning that the ST company, in order to facilitate the user to develop software, provides a set of open source peripheral firmware library. Users only need to call the interface functions inside can it operate on all peripheral sources on the microprocessor, which greatly reduces the difficulty of software design. Figure 4 is the flow chart of main function of the hand-held remote controller.
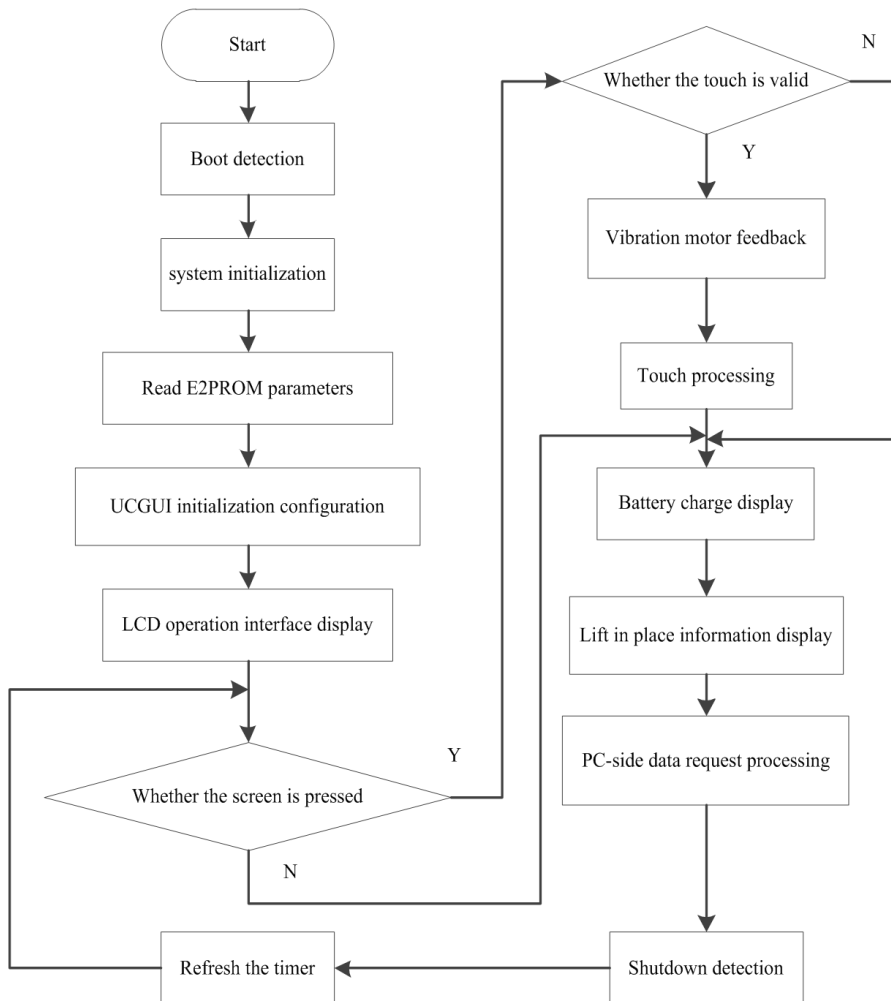

Fig. 4. Flow chart of main function of the hand-held remote controller

Lift control unit function is relatively simple, including the receiving of lifting

command data packets, sending a response packet and in place report data packets, and relay operation.

4. Results and discussion

After the design of hardware and software, whether the system can realize the design function accurately and reliably according to the design requirements needs comprehensive and systematical test. The test of the basketball stand lifting system mainly includes two parts: function test and performance test. The function test of the system is to mainly test the correctness of the system, including the function of the touch screen, the transmission function of the ZigBee network, the lifting function of the elevator and so on. The specific test cases and test results are shown in Table 1.

Table 1. System test cases

Number of cases	Test items	Expected results	Practical results
1	Click the function keys of touch screen to test whether each function key can send the correct instructions.	Each function key is normal in functions.	Each function key can be morally used.
2	The elevator motion command is sent by the touch screen, to test whether the wireless network communication is normal.	The elevator can successfully receive instructions.	Elevator can successfully receive instructions.
3	After the elevator receives the instructions, test whether the elevator is in accordance with the normal operation of the command.	The elevator can follow the instructions.	The elevator can follow the instructions.

Table 1 shows that the system function is normal.

The performance test of this system mainly tests the anti-interference of the system, because it is very important that the system can run stably and reliably. ZigBee network works in the 2.4 GHz band. In the laboratory, we use the Bluetooth signal of the mobile phone and the wireless routing signal as the interference source, respectively, to verify the anti-interference ability of the communication module. The specific results are shown in Table 2.

As can be seen from Table 2 that, there is no obstacle in the network communication in the interference of same frequency signal.

There is a high power relay in the elevator control unit, which is installed near the winch motor. If the number received currently minus the last number and the result equals to 1, it suggests that the control unit has high reliability; otherwise, it represents that the internal program of microcontroller is not normally operated under

electromagnetic interference. And it needs to take measures to further improve the anti-interference ability. The experimental results showed that the internal program of the microcontroller operates normally under the electromagnetic interference and it has high reliability.

Table 2. Anti-interference test of system communication function

Sources of interference	Communication situation of system ZigBee wireless network
Bluetooth signal	System wireless communication function is completely normal.
Wireless routing Wi-Fi signal	System wireless communication function is completely normal.
Radiotelephone signal	System wireless communication function is completely normal.

5. Conclusion

At present, the large-scale stadium often sets a number of basketball stands equipped with the elevator. In order to meet the sustainable development route in line with the green environmental protection and energy conservation, and to further realize the modernization management of stadium elevator control, based on the analysis of the shortcomings of the traditional control method, we put forward the stadium elevator wireless control system based on ZigBee short distance wireless RF technology, embedded technology and database technology.

The system designed in this paper has the advantages of friendly human-machine interface, low power consumption, low cost, high reliability, good expansibility and so on. At the same time, the system can be easily transplanted to other specific applications, with broad application prospects and market value.

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