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Research and Development of Hand Held Controller Based on Wireless Radio Frequency Communication

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Abstract: *Based on embedded RF wireless transceiver chip, a wireless handheld controller is designed to solve the problems of routing problem, high power-consumption and great error of data transmission occurred in traditional wire handheld controllers. The new controller succeeds in decreasing the power consumption, improving the flexibility and reducing errors of data transmission. The single-chip microcomputer stm32f051c8t6 is adopted as the central processing unit, and its expansion ports are used for the design of the wireless transceiver with the module nRF905. The test results indicate that the error rate increases with the distance but it doesn't exceed 0.02, which meet the system requirements.*

Keywords: *RF; handheld device; low consumption; wireless transmission*

I. Introduction

As the society continuously develops, more and more data transmission devices are used in various occasions. Wireless communication technology has the advantages of no need for wire arrangement, portability and low cost on maintenance, so it is applied in a wide range[1]. The greatest advantage which wire communication does not have is that wireless communication is not limited by wires. However, today, wire communication is gradually replaced by wireless communication due to the limitation of the environment. Wireless communication is changing corresponding technology, so the transmission becomes faster, and more stable and convenient[2]. In industrial control, a robot is controlled to run by a hand-held controller in the wireless mode. As wireless products bring us convenience, problems are also discovered, such as high power consumption of systems, and large size and short service life of power sources[3-5]. Therefore, a study should focus on how to design a small-size hand-held product with low power consumption and how to select an appropriate power source. In practice, the power source should meet requirements for small size, low noise and high efficiency[6-7].

II. General Design

The whole system comprises a demonstrator, a robot body and an upper computer, as shown in figure 1. The interface of the upper computer is responsible for showing the integral running status in real time after the robot receives the instruction from the hand-held device and online programming.The demonstrator and the robot body perform data transmission in the wireless mode. The press button has three states. The first and third states are respectively enable and scram. These two states work at 433MHz frequency band. When the press button is in the first or third state, the RF wireless transmission module in the demonstrator transmits an enable signal and a scram signal respectively. When receiving the signal from the transmitting terminal, the main body at the receiving terminal analyzes the signal and executes the corresponding enable or scram action. When the press button is in the second state, the demonstrator works at 2.4GHz frequency band; the PAD interface transmits instructions (such as speed, position and direction) to the robot body, and after analysis, the robot body executes corresponding action instructions.

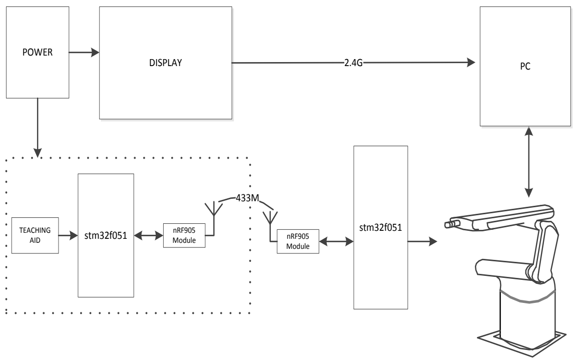

Fig.1 The system structure of the diagram

III. The Design of the Hardware

2.1 Selection of processor

The controller for the hand-held device adopts stm32f051c8t6 microcontroller. The stm32f051 series adopt 32-bit RISC core of high-performance ARM CortexTM-M0. The maximum working efficiency is 48MHz. The high-speed Embedded Flash is adopted (maximum memory of FLASH is 64K byte; maximum memory of SRAM is 8K byte). The controller is widely integrated with enhanced external and I/O ports. All devices provide standard communication interfaces. Quick interrupt processing can meet the application demands of the hand-held device. The detailed connection layout of the microcontroller is shown in figure 2

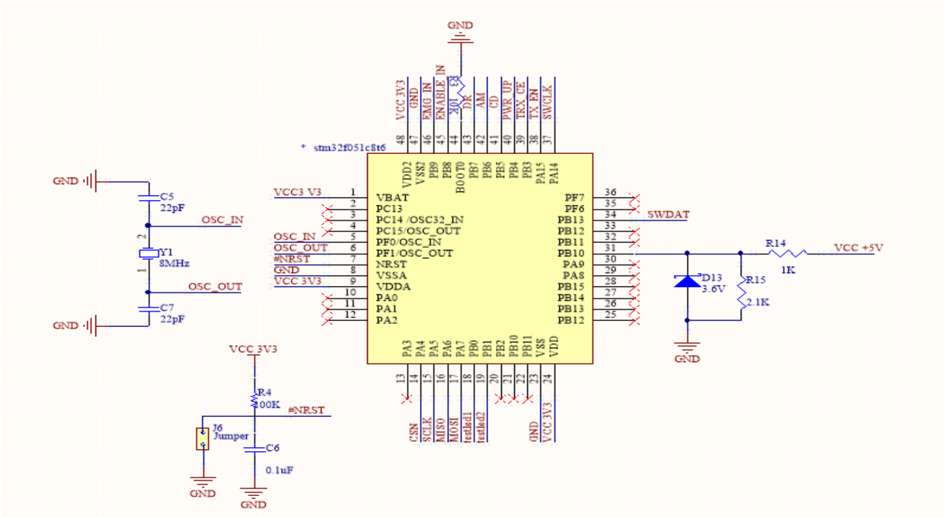

Fig. 2 Connection of the micro controller

2.2 Design of power module

The movability of the hand-held terminal is required to mainly adopt a movable power source. The selection of the power source takes into consideration of the size, the energy density, the cycle life, the environmental adaptability and the automatic discharge rate of the battery[8]. Finally, the lithium battery of 5V is selected as the power source. As the working voltage of both stm32f051 and nRF905 is 3.3V, LM1117I-3.3V is selected as the voltage stabilizing chip. The application circuit of the chip which is encapsulated by SOT-223,LDO is simple. During operation, the only work is to input and output tantalum capacitance for decoupling and lowering noise (as shown in figure 3).

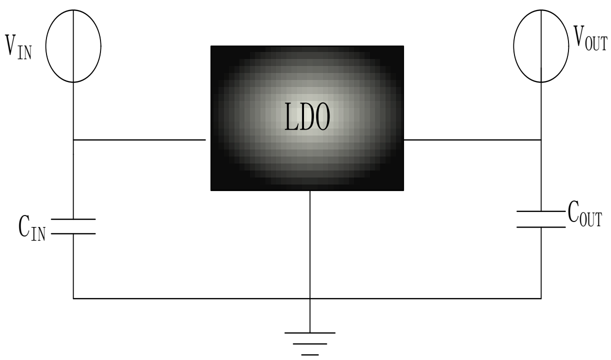

Fig3 The application circuit of LDO

The voltage of the output terminal $V_{OUT} = V_{IN} - V_{DROP}$, V_{DROP} is the voltage consumed by the voltage stabilizing chip $V_{IN} > V_{OUT}$, so the working efficiency of the chip is

$$\eta = \frac{P_{OUT}}{P_{IN}} = \frac{I_{OUT} \times U_{OUT}}{I_{IN} \times U_{IN}} = \frac{I_{OUT} \times U_{OUT}}{\left(I_{OUT} + I_{GND}\right) \times U_{OUT}} \qquad (1)$$

Ignore I_{GND} the efficiency is nearly:

$$\eta = \frac{P_{OUT}}{P_{IN}} = \frac{V_{OUT}}{V_{IN}} \quad (2)$$

The general efficiency is 60%~75%; the efficiency is higher when the quiescent current is small. The formula (2-1) shows that there is a big difference between and , it's best not use LDO, because at the moment the efficiency of LDO is too low, and excessive heat is consumed on the internal circuit of LDO. In the system, 5-3.3= 1.7V, meets the requirement of LDO.

2.3 Design of wireless communication module

The core technology based on the embedded integrated chip with wireless radio transceiver is the technology of the embedded integrated chip with wireless radio transceiver[9]. Signal modulation, transmission, reception and digital circuit interface are integrated on one chip. The wireless RF transceiver chip mainly comprises nRF401, nRF905, TRF6900, RF2915, BCC418, XE1201A CC400. Compared with other chips, nRF905 of Nordic company is a single-chip RF transceiver working in three ISM frequency bands (433/868/915MHz). High-efficiency GFSK modulation is adopted, so that the capacity of resisting disturbance is improved, and data transmission is more stable and reliable. The application circuit of nRF905 is shown in figure 4.

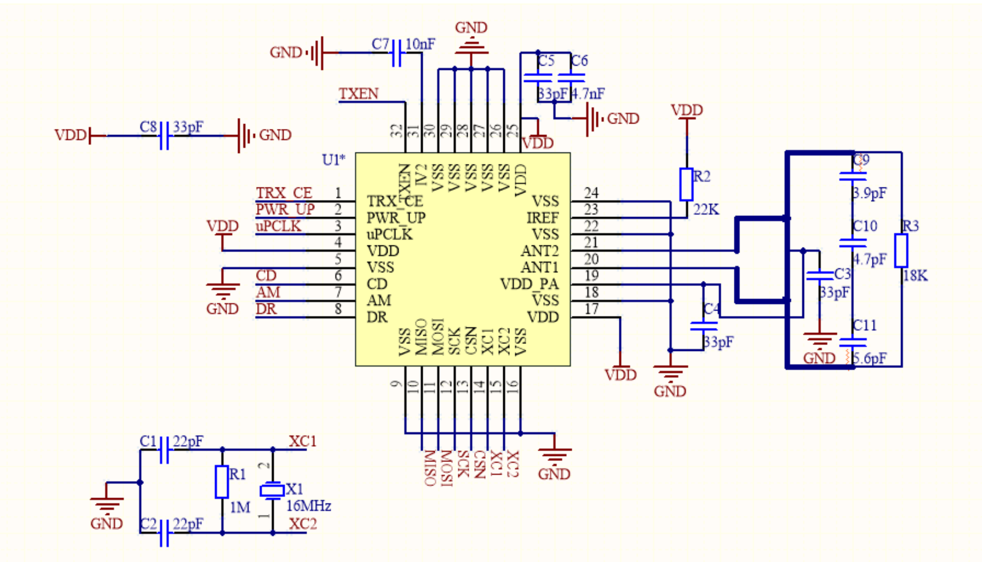

Figure 4 nRF905 application circuit

2.3.1 Modulation principle of communication

The wireless communication module works at ISM frequency band, and adopts the demodulation principle of GFSK modulation. The GFSK modulation adopts the Gauss function as the pulse shaping filter, so that the transmission bandwidth can be reduced. As digital signals are processed by Gauss pre-modulation filtering prior to modulation, the signal frequency spectrum modulated by GFSK is compact, and the bit error performance is good. The GFSK modulation is widely applied in digital mobile communication. The typical GFSK modulation is shown in figure 5.

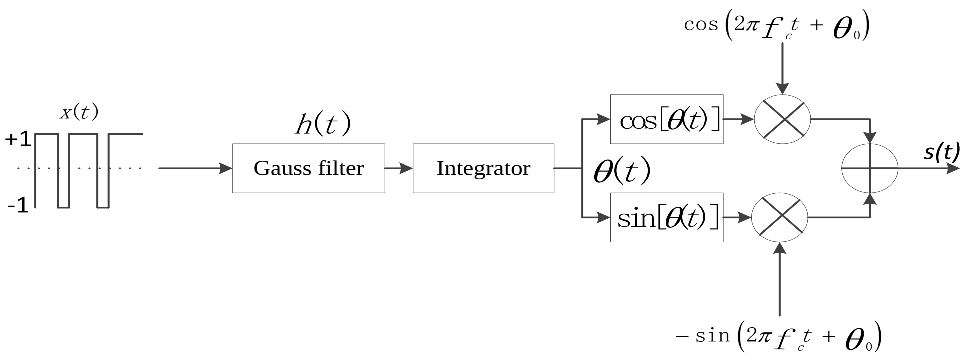

Fig 5 The GFSK modulation

2.3.2 Modulation principle of communication

Demodulation is performed by the method for frequency discrimination and phase discrimination at the receiving terminal, as shown in figure 6. The Gauss filter is adopted at the receiving terminal, so that the demands for bandwidth to transmit GFSK signals are reduced. However, the receiving terminal will have intersymbol interference.

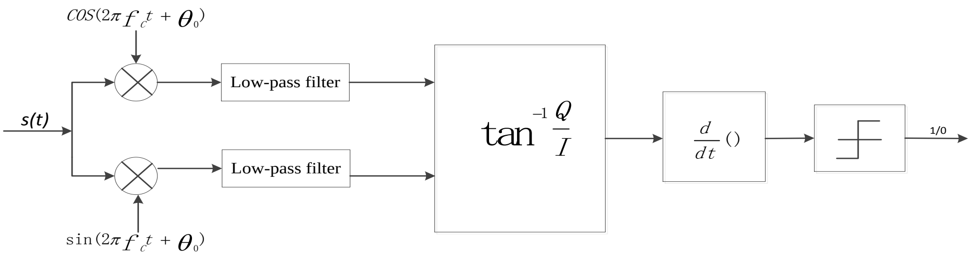

Fig 6 the GFSK demodulation

2.4 Receiving equipment

At the receiving terminal of the system, the receiving equipment mainly consists of an RF wireless module, a motor, a driver and a speed reducer. When the wireless module at the receiving terminal detects the information from the wireless module at the transmission terminal, the signals are demodulated, and then the robot body is controlled to execute corresponding action instructions.

IV. The Design of the Software

The software part of the system comprises a transmission terminal program and a receiving terminal program, wherein the main function of the transmission terminal program is to complete the real-time transmission of scram signals and enable signals. The receiving terminal is mainly used to complete the reception and judgment of data and response to different orders.

3.1 Definition of wireless user protocol

The definition of the wireless protocol of the system is shown in figure 7. The maximum data transmitted/received once in RF is 32 bytes. The system here is temporarily defined as 32 bytes. The address is 32bit.

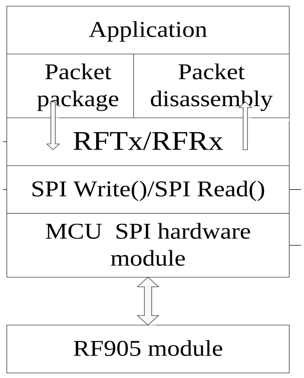

Figure 7 wireless subscriber agreement

The protocol of data area of table 1, during data transmission, the wireless module at the receiving terminal executes corresponding action according to the command type of Byte0 transmitted from the transmission terminal; table 2 is the definition of command types of Byte0 in table 1

Table 1 data area of the agreement

Byte 0	Byte 1	Byte 2~byte 5	Byte 6	Byte 7~byte 31
CMD_TYPE	D_LEN	SRC_LOG_ADDR	RESVERD	DATA

Table 2 the definition of command type

CMD_TYPE	0X01	0X02	0X03	0X04
MEANING	STOP	ACTION	ENABLE	DISABLE

3.2 Transceiver driving program

Before nRF905 does any reading/writing order through SPI, one pulse of CSN from high to low must be completed. After the data address is ready, the transmission must be completed by the change of TRX_CE from high to low. The data transmission procedures are shown in figure 8, and the procedures of the receiving terminal is shown in figure 9.

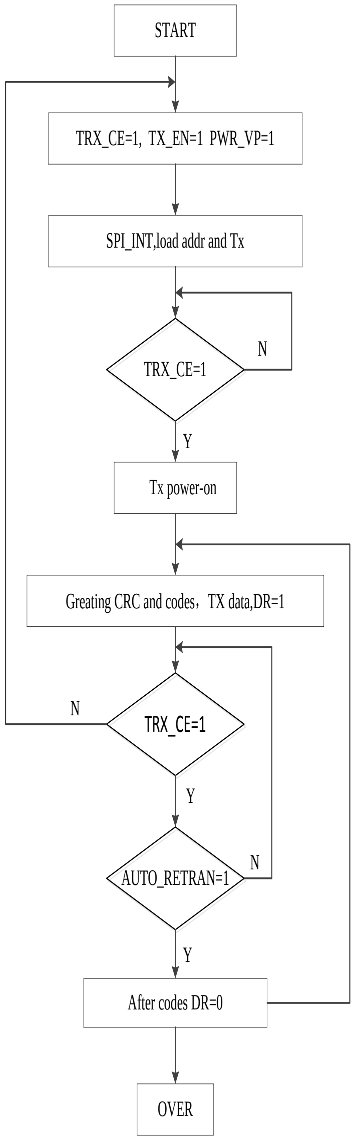

Fig 8 TX program flow diagram

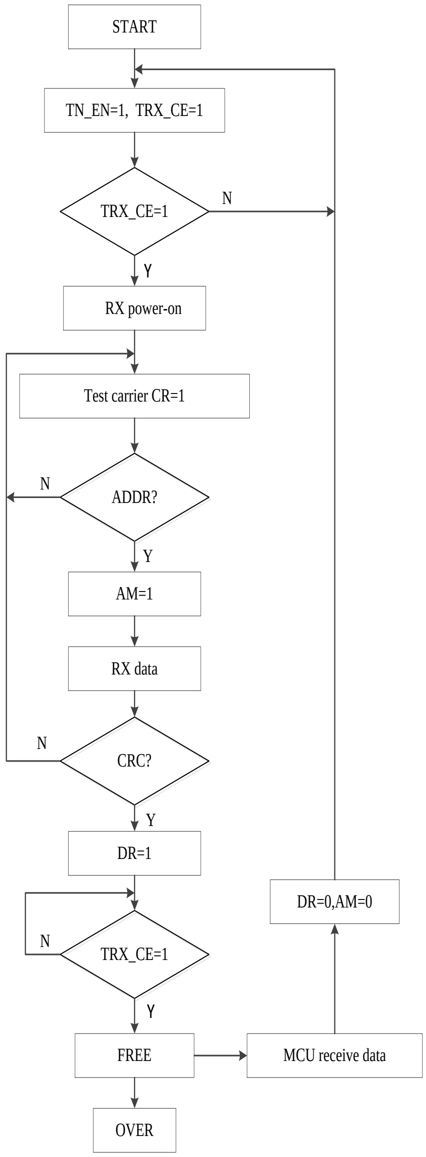

Fig 9 RX program flow diagram

3.3 Test results

The maximum transmission distance of the wireless module nRF905 is 300m, and the maximum transmission rate is 50kbps. In certain distance, error rates received from many tests are shown in figure 5.

Table 5 the system bit error rate test

		COMMAND			
		0X01	0X02	0X03	0X04
DIATANCE	5M	0.00002	0.00006	0.00002	0.00012
	10M	0.00019	0.00024	0.00055	0.00019
	25M	0.00155	0.00204	0.00129	0.00079
	40M	0.01239	0.02000	0.00998	0.01231

Through the analysis of test data, as the transmission distance is increased, the same instruction is transmitted to the robot body, the errors of data transmission are clearly increased; even in the same distance, when different data instructions are transmitted, error rates are different.

V. Conclusion

The hand-held controller substitutes the wire controller in the original version through the battery and wireless communication, and problems to users, such as wire arrangement caused by the connection of the communication wire and the power wire, are eliminated. With the upper computer, the running status of the robot body can be monitored at any time. The test results indicate that the wireless hand-held controller based on the embedded integrated chip with wireless radio transceiver has the features of high reliability, simple operation and high practical value.

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