Design and Implementation of an Industrial Intelligent Infrared Remote Controller

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Abstract. Aiming at the problems of the traditional electric actuator in the field of plant control, such as low control accuracy, low reliability and the unsuccessful debugging process, an intelligent infrared remote control system with MSP430F2111 as the core controller is designed. In the design, fuzzy clustering and structure recognition mean compression pulse width counting algorithm are used to identify and classify the collected remote control coded data effectively, which solves the problems of limited storage space, low transmission rate and high power consumption in the remote control system. UART (Universal Asynchronous Receiver/Transmitter ) protocol is used to communicate with the electric actuator, and its status information and data information are displayed on the LCD (Liquid Crystal Display) screen, which improves the transmission rate and accuracy of the whole electric actuator system. On this basis, the overall structure of the system and the corresponding functional modules are designed. Finally, the coding simulation test is carried out through the software platform. The practice results show that the remote controller can control the electric actuator quickly and stably, and the simulation results are in good agreement with the field debugging results.

Introduction

In order to collect data on site and modify operation instructions, the traditional industrial electric actuator must open the shell of the electric actuator to view, which is extremely inconvenient for the operator, and has low efficiency and reliability. At the same time, there are many types of infrared remote controllers in China, but some remote controllers use special transmitter chips. Special chip has high power consumption, high cost and high integration, which is not conducive to large-scale promotion for small enterprises. Compared with other chips, this intelligent infrared remote controller not only has the advantages of large memory, low power consumption, good accuracy, low cost, good reliability and high processing speed, but also has its own unique advantages: ultra-low power consumption [1]. Based on the above background, a low-power intelligent infrared remote controller with MSP430F2111 as the core control chip in the industrial field is designed. Because its design operator can not only effectively control the working state of the electric actuator, but also play an important role in the daily maintenance and real-time fault monitoring of the whole system. This application will play a positive role in promoting the infrared remote control market.

Introduction of Low Power Chip Function of Infrared Remote Controller

The new infrared remote controller uses MSP430F2111 chip as microcontroller, which has functions of sending, receiving data, data acquisition, data identification, storage, analysis and processing. Receiver MCU module is designed with MSP430F249 chip produced by Texas Instrument as the core. The advantages of using MSP430F2111 chip as microcontroller are as follows: the chip has five ultra-low power consumption modes and one active mode; the combination of powerful 16-bit advanced architecture and five low power consumption modes can prolong the working life of batteries and make batteries more usable for 1-2 months; the control oscillator can be used for a very short time. It can convert the analog signal to the digital signal and display it on the LCD screen in the independent frequency sensor system[2]. The infrared communication process of the whole hardware circuit is tested and simulated in Proteus simulation software. The design of infrared
remote control mainly completes the following functions: Infrared remote control should control and display the given value and setting parameters of the valve of electric actuator; Fault information is displayed through infrared feedback when internal faults occur in the system; Data Acquisition and Recognition Processing.

**Block Diagram of Hardware Circuit System**

MSP430F2111 chip as the control core mainly receives the key information transmitted by the key module, converts the key information into coding, then modulates and amplifies the 38kHz PWM(Pulse Width Modulation) wave and coding information to the receiving MCU(Micro Controller Unit) through the infrared transmitting module, and then displays it by the receiving MCU. The infrared remote control transmitting circuit is the core module of the system hardware circuit, which includes the following parts: key circuit, power circuit, clock circuit, reset circuit, infrared transmitting circuit; infrared information receiving and displaying circuit includes MSP430 microcontroller, 12864LCD(Liquid Crystal Display) display circuit and so on. The block diagram of the overall hardware circuit system is shown in Figure 1.

![Figure 1. Block diagram of overall hardware circuit system.](image)

According to the characteristics of low voltage power supply (1.8-3.6V) of MSP430F2111 chip, the I/O port of power supply circuit adopts low voltage power supply. The minimum power consumption of clock-off mode is only 0.1uA, and the voltage only needs a button battery of 3V. Clock circuit is to provide the clock signal circuit of microcontroller. Because the supply voltage VCC is larger than 2.8V, it needs to work in high-frequency mode. So the external 3.8MHz high-speed crystal oscillator is connected. At this time, the other two pins are connected with two small capacitors of 22pf, which not only reduces the cost of the system, but also reduces the power consumption of the system. The reset circuit is designed with the reset chip MAX810 of the special integrated circuit microprocessor. The chip can not only provide the reset signal of power on, manual reset of keys and automatic reset signal of timing, but also monitor the power supply voltage of the single chip computer and other logic systems. MAX810 resets the output signal to a high level.

In the actual industrial production, remote controllers are mostly short and compact. Independent key-press design is adopted in the key-press circuit, and each key has different functions. Four keys cooperate with each other to display the contents of the main menu and submenu. Functional keys as preparatory keys fail to return directly to the main menu.

The infrared signal receiving terminal MSP430 microcontroller uses the MSP430F249 chip to demodulate the infrared signal by connecting the data line, address line, signal line and the infrared transmitter module IRLINK module. After decoding the infrared signal, the whole encoding transmission information will be displayed through the 12864 LCD display screen to complete the entire data transmission.
Implementation of Key Hardware Technology

Infrared Emission Circuit and Reset Circuit

The infrared transmitting circuit uses MSP430F2111 chip, which has good low power performance. The whole system is dormant when no key is pressed. Only when the key is pressed, the system is in working state to send data. In order to improve the anti-jamming performance, the repetitive transmission mode of wide and narrow pulse with pilot code is adopted [3]. Because the interruption between the measured and actual values of high and low levels will bring errors, the fuzzy clustering algorithm is used to classify the infrared signal data. Infrared remote control pulse data can be divided into three categories: boot code, high-level data code "1", low-level data code "0". In this design, the pulse of infrared remote controller is received by MSP430F249, which receives remote control information. The code stream of remote control data is longer, the transmission time of upper and lower computers is too long, and the efficiency is greatly reduced. Therefore, in order to improve the transmission rate, the similar characteristic components of the width and time interval of the remote control data pulse are selected to re-encode the data code. Infrared signal transmission uses TIMER-A continuous counting mode and UP/DOWND mode to configure PWM wave. In order to see the infrared emission waveform more clearly, an oscilloscope is added to Proteus simulation to detect the waveform. The output and transmission circuit of 38KHZ signal is shown in Figure 2.

![Figure 2. Signal Output Transmitting Circuit.](image)

Infrared Receiving Circuit

Infrared receiving circuit uses infrared connection standard modem IRLINK, which has the advantages of long transmission distance, strong anti-interference ability and strong stability [4]. It overcomes the shortcomings of receiving only 38KHZ carrier signal and sending continuous 38KHZ carrier which will have instantaneous high and low levels. IRLINK module is connected with MSP430F249 MCU to demodulate infrared signal. The function of PNP transistor here is to amplify the infrared signal and the modulated signal current of 38KHZ, which improves the sensitivity of receiving infrared signal. After decoding the MSP430F249 MCU program, the code will be displayed on the 12864 LCD display screen. The infrared receiving hardware circuit is shown in Figure 3.
12864 LCD Display Circuit

LCD dot matrix screen uses the model WYM12864K9 LCD screen. It uses ST7567 as the main control program and uses 4-line serial interface to transmit data[5]. The LCD screen receives and displays the actual opening of the valve, fault information, operation status and the opening set by the valve through serial communication. It can also set up an icon display with special symbols on the LCD screen. Because MSP430F249 cannot set the main clock as the timing clock source of MCLK, it can only set the auxiliary clock SMCLK as the timing clock source. The hardware connection diagram between 12864 LCD display screen and MSP430F249 single chip computer is shown in Figure 4.

Software Design of the System

The software development environment used in the development process is the integrated development environment of IAR Company. The development and debugging environment IAR writes code in C language. The software has its own functions of running, debugging and testing. The user's work efficiency is improved by using embedded IAR tools.

Main Program Flow Chart Design

The infrared remote control transmitter program is to initialize the watchdog, clock and serial port, specify the header file to adjust the data acquisition function, determine whether the P1 port has pulse for data acquisition, and then call the data compression subroutine to improve the transmission rate and accuracy of the system through the above program. The flow chart of the main program is shown in Figure 5.
Data Acquisition Function
Designated Header File
Watchdog Clock Port
Initialization
Execute the while loop
Does the P1 port have pulses?

Pulse Data Acquisition

Data Compression Subprogram

Output decoding code subprogram

End

Figure 5. Main Program Flow Chart of Remote Controller.

Data Acquisition and Compression Programming

Fuzzy clustering analysis is applied to classify the infrared signal data in the program of remote control transmitting and receiving[6]. Data are collected for the pulse wave transmitted repeatedly by remote controller, the width H of pulse and the information bit expressed by the distance W between pulses, and the threshold value R is calculated by using the information bit when the classification is most reasonable. Because of the limited memory space of the single chip computer, the data are classified and identified. The structure recognition mean compression pulse width counting method is used to compress the collected coded data [7-8]. The position of "0" and "1" combination in statistical pulse width data is the beginning of data for the first time and the end of data for the last time. The encoding data between the beginning of data and the end of data is compressed every 8 bits for one byte, which improves the timeliness and reliability of system data sampling. The pulse data acquisition program is shown in Figure 6. The pulse data compression program is shown in Figure 7.

Data compression code
subprogram

start
Pulse width counter a = 1
Is the high level time greater than the set time?
Record current pulse width
Record high/low level duration
Pulse width length = a
Data acquisition completed?
Enter interrupt procedure

Figure 6. Data Acquisition Program.
Result Analysis

Analysis of Signal Waveform Simulation of Infrared Receiving and Transmitting Circuit

Pulse width modulation coding "0" is expressed by pulse width 0.45 ms, period 1.125 ms, interval 0.45 ms, and "1" is expressed by pulse width 0.45 ms, period 0.9 MS and interval 0.9 Ms. The "boot code" and "end code" identified in the storage process, while for instruction coding, only the compression coding between the beginning of data and the end of data is saved, and the compression ratio can reach 17:1, which greatly saves the storage space. The structure recognition mean compression pulse width counting algorithm can greatly reduce the sampling error of pulse wave data in remote control system. In order to ensure the success of UART(Universal Asynchronous Receiver/Transmitter) mode communication in the process of communication, first set the baud rate parameters in the corresponding registers.

The baud rate is determined by the clock factor N:

$$N = \frac{f_{BRCLK}}{B_{audrate}}$$  \hspace{1cm} (1)

The integer part of the clock factor is placed in the UCBRx register:

$$UCBRx = INT(N)$$  \hspace{1cm} (2)

The decimal part is placed in the UCBSRx register:

$$UCBSRx = round(N - INT(N)) \times 8$$  \hspace{1cm} (3)

The required baud rate in the design process is 9600Hz.

$$N = \frac{1MHz}{9600HZ} \approx 104.1667$$  \hspace{1cm} (4)

$$UCBRx = INT(N) = 104$$  \hspace{1cm} (5)

$$UCBSRx = round(N - INT(N)) \times 8 = 0.1667 \times 8 = 1.336 \approx 1$$  \hspace{1cm} (6)

After calculation, the parameters are put into the registers UCA0BRx and UCBSRx respectively.
Setting the same parameters at the transmitter and receiver can read 00011000. The transmitted data is put into the transmitter register UCAxTXBUF, and the corresponding data can be received only by the receiver register UCAxRXBUF. The oscilloscope displays the signal receiving waveform as shown in Figure 8. The simulation of infrared receiving LCD display signal output is shown in Figure 9.

![Figure 8. Oscilloscope Displays Signal Output Emission Waveform.](image1)

![Figure 9. Signal Output Simulation of Infrared Receiving LCD Display.](image2)

**Practical Test of Infrared Remote Control**

As shown in Figure 10, this paper designs an infrared remote control test device. The right picture is an infrared remote control operation unit, i.e. an electric actuator. The left picture is an information liquid crystal display module, i.e. a 12864 LCD display circuit. The operation test is to electrify the electric actuator, waiting for the successful connection between the wireless communication modules, and using infrared remote control pair. The electric actuator controls and displays the actual valve opening information.

![Figure 10. Infrared Remote Control Test and Detection Physical Chart.](image3)

**Conclusion**

Aiming at the problems of low control accuracy and reliability of electric actuators in factories and the difficulty of field debugging, a new infrared remote controller based on MSP430F2111 chip as
microcontroller is designed. The remote controller achieves the requirements of high speed, low cost and low power consumption. In the process of software coding and decoding of infrared remote control, fuzzy clustering and structure recognition mean compression pulse width counting algorithm are introduced to classify and identify the collected coded data, which solves the problems of errors in the process of data transmission and the complexity of the structure of repeated transmission, compresses the storage space of the system and improves the system. Efficiency and reliability. After testing, the product can operate the electric actuator quickly and conveniently in the factory application and practice, and has certain application value.

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