

Design of Temperature Converter Based on Microcontroller Control Unit

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Abstract

Design a temperature acquisition system based on ATmega16 Microcontroller Control Unit (MCU). The thermocouple's temperature signal will be send to the ATmega16 via the digital temperature sensor MAX31855 and communicate with the outside through the RS485 interface's MODBUS communication protocol. The converter has the function of temperature setting and temperature control. It is proved by the experiment that the converter has the accuracy of $\pm 1^{\circ}\text{C}$, thus it can be applied to the field of household appliance, automobile and refrigerator etc.

Keywords

ATmega16 Microcontroller Control Unit; MODBUS protocol; Temperature Converter.

1. Introduction

In different kinds of industrial manufacturing process, temperature monitoring and control is the main point to get the underlying parameter. The variation of physics and chemistry related to temperature can be got according to the live temperature detection. The automated disposing process needs to convert analogue signal outputted by thermocouple or thermos resistance into digital signal, therefore the importance of temperature converter increased rapidly.[1] The major function of temperature converter is Transform sensor's analogue signal into digital signal which can be handled conveniently, digitize transmission and processing of temperature value. Based on these factor, this paper is centered on the ATmega16 Microcontroller Control Unit, designing a temperature converter with the function of transforming analogue signal into digital signal, digitize transmission and live control. The communication interface utilize RS-485 port and it takes the MODBUS protocol as the standard communication protocol so that this converter can set temperature through the keyboard and store parameters into the EEPROM, besides it can also decide whether the refrigerator facility and the heater work according to the temperature condition collected. The converter has the advantages of low cost, long communication distance etc. It can provide better service in temperature collection and control to the user.

2. System hardware design

The design of temperature converter mainly aims to reach the objection of temperature collection, long-distance communication of temperature value, live temperature setting and control.

In the process of communication, in order to make this system more universal and more steady, the power supply section and the communication isolating section are special designed. The system's functional block diagram as shown in the fig.1. The control that MCU responsible for: MAX31855 complete the conversion of signal that come out from the thermocouple and convert the analogue signal into digital signal; the keyboard is used to set the controlling temperature while display the temperature on the screen; ADM2587 is a kind of conversion chip based on RS-485 protocol;[2] to

extent the converter's application field, the input voltage is widened as possible in the power design. The input voltage in this design is range from 15V to 40V.

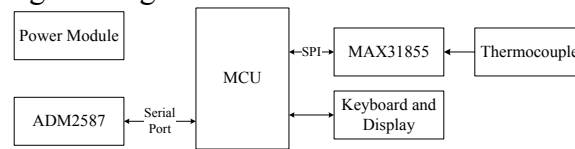


Fig.1 system functional block diagram

2.1 Selection of Microcontroller Control Unit

The ATmega16, a type of 8-bits Microcontroller Control Unit produced by ATMEL Corporation, is in charge of whole operation. This type of MCU's feature: the maximum clock frequency is 16MHz, three timers, watchdog timer, 512bits EEPROM, 8 channels of 10 bits ADC, integrated USART and SPI bus etc. [3]

2.2 Power module design

The power module design block diagram shown as fig.2. The LM2574-12 is selected to produce 12V

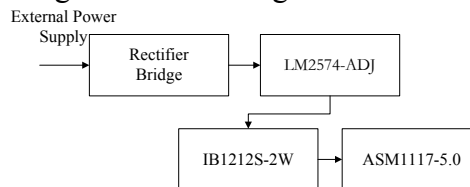


Fig. 2 power module design block diagram

supply voltage for the isolating power source when 15V-40V AC or DC voltage is provided. The IB1212S-2W produced by MORNSUM Corporation is selected as the isolating power source to produce 12V voltage for ASM1117-5.0 which is utilized to provide 5.0V voltage for MCU, MAX31855 and ADM2587.

2.3 MAX31855 interface design

MAX31855 has the function of Cold Junction Compensation (CJC) and converting the analogue signal of type K, J, N, T or E thermocouple. This device generates 14 bits signed data and it can be read out in Read-Only format through SPI™ compatible interface. The temperature resolution of this converter is 0.25°C, the maximum temperature reading is +1800°C and the minimum reading is -270°C. For type K thermocouple when the temperature is among -200°C to +700°C, it can keep the accuracy of ±2°C. [4]

SPI (Serial Peripheral Interface) is a kind of synchronous serial peripheral interface launched by Motorola corporation. The SPI interface use 4 lines: serial clock SCK, master in/slave out data line MISO, master out/slave in data line MOSI and slave device select line /CS. MCU ATmega16 has integrated SPI bus. PB5、PB6、PB7 correspond to SPI's MOSI, MISO and SCK respectively.

The interface between MAX31855 and MCU ATmega16 shown as fig.3

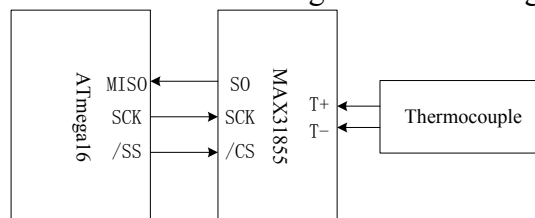


Fig.3 Interface between MAX31855 and MCU

2.4 RS-485 interface design

Due to complex environment circumstances the application apparatus in automatic control industry usually adopt isolated design scheme to ensure the stability of the system in long-distance communication process. This design scheme adopt the communication isolation module ADM2582 produced by ADI corporation. It is a kind of fully integrated isolation data transceiver with the

function of $\pm 15\text{kV}$ ESD protection, so it is suitable for high speed communication in multipoint transmission lines. This chip has the feature of overheating shut off so it can prevent output short-circuit and damage caused by excessive loss of power when overheated. It adopts ADI Corporation's isoPower™ technology and it integrates one 3channels isolator, one three states differential line driver, one differential receiver and a isoPower™ DC/DC converter. This device uses 5V or 3.3V single power, thus realized fully isolated RS-485 resolution.^[4] The interface circuit between MCU and ADM2582 shown as fig.4.

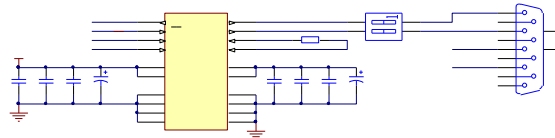


Fig.4 RS-485 interface with MCU

3. system software design

Program is developed under the circumstance of ICC launched by AVR company. The subprogram including: UART initialize, SPI initialize, keyboard, display initialize, MODBUS communication protocol, EEPROM read and write subprogram and temperature control subprogram. The main program shown as fig.5.

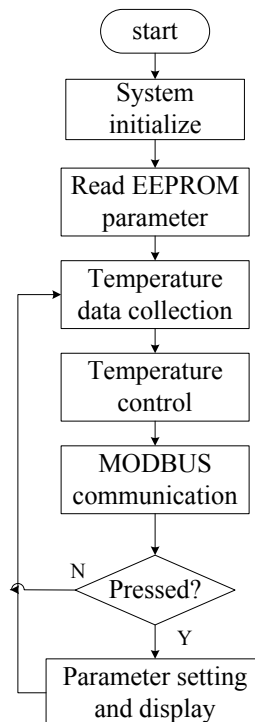


Fig.5 Main program flow chart

4. Practical application example of converter

After temperature converter's software and hardware design is complete, it should be put into practical use. In temperature control system of coffee bean fermentation tank, the converter collects related temperature in the fermentation tank. When the temperature is above 25°C , which is already in the system, the gate of the fermentation tank opens under the control of temperature converter. When the temperature is under 25°C the gate closes and the heating equipment start to work making the temperature in the tank increases. While in use, it compares with standard temperature collecting system so that the deviation of temperature can be controlled under $\pm 1^{\circ}\text{C}$. In the temperature collecting and control process, the collected value and control action communicate with central control devices via RS-485 bus under the MODBUS protocol. Through practical verification, the

temperature converter designed reaches the criterion of temperature collecting and control and it has characters of stability and sound effect.

5. Conclusion

This paper introduces a kind of temperature converter based on ATmega16 Microcontroller Control Unit in both software and hardware. It can realize conversion of temperature value and live control, besides it can communicate with corresponding devices through RS-485 bus under MODBUS protocol. In the application of coffee bean fermentation tank temperature control system, it acquires sound result and a certain engineering significance. This converter is easy to promote because it is portable and inexpensive.

References

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