A Temperature Measurement System Based on PT100

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***Abstract*—Temperature measurement system is mainly constituted by the Micro Controller Unit (MCU), the temperature sensor and the analog digital converter (ADC). The model of the MCU is STC10F12. The model of the ADC is AD7711, and the AD7711 can carry out the signal conditioning and analog digital (AD) conversion. It also can provide the constant current source for PT100. This temperature measurement system has many features, such as high accuracy, small size, micro-power, anti-interference ability.**

Keywords-temperature measurement system, MCU, PT100, AD7711, ADC

I. INTRODUCTION

There are many methods of measuring temperature in industry. The most commonly used method is to use the PT100. So many types of temperature measurement systems are constituted by the PT100. Building a constant current source or an electrical bridge consisting of resistances is the typical circuit for the PT100. As the PT100 own characteristics, making the signal conditioning circuit which is more complex. And the most important is the solution to the problem of the constant current source. After comparison, the chip of AD7711 had been selected as the core of the PT100 measuring circuit. Because the AD7711 can carry out the signal conditioning and AD conversion and provide the constant current source for the PT100. This can make the whole circuit design easy. Based on the above idea, a block diagram of the temperature measurement system can be formed. The temperature measurement system construction frame diagram is showed as Fig. 1.

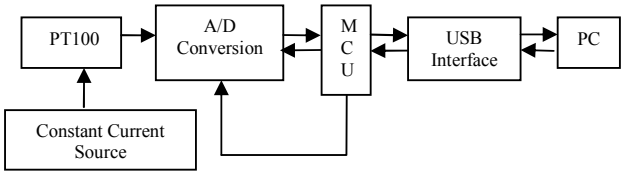

Figure 1. Temperature measurement system frame diagram

II. PT100

The resistance value of the metallic platinum (Pt) changes with the temperature, and its reproducibility and stability is good. The sensor made of platinum is called platinum resistance temperature sensor [1], such as PT100, PT1000. They are widely used in industrial temperature measurement. The thermocouple is more accurate and better linearity when the temperature is on -200℃～+850℃. The voltage drop of the PT100 is much larger than the output of the thermocouple. And the cold junction compensation is not needed. Furthermore, the PT100 also have some advantages, for example anti-vibration, anti-corrosion, good interchangeability, reproducibility and stability. It is often used to the low-medium temperature measurement. The "100" after "PT" means that the resistance is 100 ohms at 0℃. And the resistance is 138.5 ohms at 100℃ [2].

Equation (1) and (2) are the function relation of the resistance value of the PT100 and the temperature.

$$R_{Pt100} = R0[1 + \alpha t + \beta t^2 + \gamma t^3 (t - 100)] \quad -200℃ < t < 0℃ \quad (1)$$

$$R_{Pt100} = R0(1 + \alpha t + \beta t^2) \quad 0℃ < t < 850℃ \quad (2)$$

α=3.9083E-3; β=-5.775E-7； γ = -4.183E-12. R0=100Ω (the resistance is 100 ohms at 0℃).

If the measurement accuracy is not very high, the function relation can be expressed as (3).

$$R_{Pt100} = R0(1 + \alpha t) \quad (3)$$

α=3.92E-3, R0=100Ω (the resistance is 100 ohms at 0℃).

III. AD7711

The AD7711 [3] is a sigma-delta ADC with on-chip digital filtering for measuring wide dynamic range, low frequency signals such as those in Resistance Temperature Detector (RTD) applications [4], industrial control, or process control applications. It contains a sigma-delta (or charge-balancing) ADC, a calibration microcontroller with on-chip static random

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access memory (RAM), a clock oscillator, a digital filter, and a bidirectional serial communications port.

The AD7711 is a complete analog front end for low frequency measurement applications. The device accepts low level signals directly from a transducer and outputs a serial digital word. It employs a Σ - △ conversion technique to realize up to 24 bits of no missing codes performance [5].

The AD7711 is ideal for use in smart, microcontroller based systems. Gain settings, signal polarity, input channel selection, and RTD current control can be configured in software using the bidirectional serial port. The AD7711 contains self-calibration, system calibration, and background calibration options, and also allows the user to read and write the on-chip calibration registers. The part features one differential analog input and one single-ended analog input as well as a differential reference input. Normally, one of the input channels will be used as the main channel with the second channel used as an auxiliary input to periodically measure a second voltage. The part provides two current sources that can be used to provide excitation in 3-wire and 4-wire RTD configurations. The AD7711 thus performs all signal conditioning and conversion for a single- or dual-channel system.

The functional block diagram of the AD7711 is showed as Fig. 2.

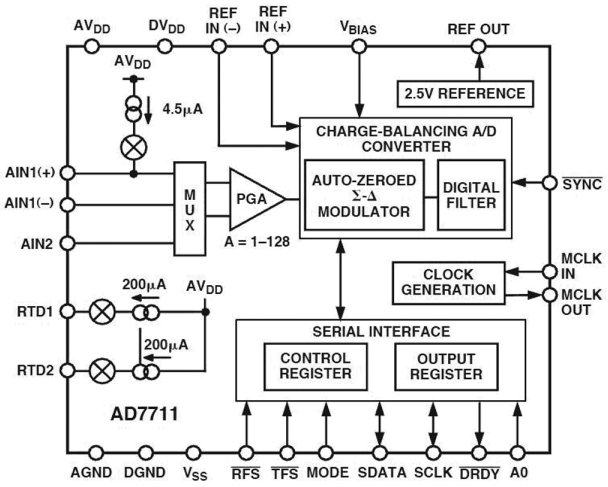

Figure 2. AD7711 Functional block diagram

IV. MCU

The MCU [6] style of the system is STC10F12. It has the character of in system program (ISP). So the general program machine is not needed, the user can download the program in the user's system, and don't need remove the MCU from the product to download. The boot program of the ISP had been written to the MCU. The code of the user can be downloaded to the MCU with the PC and the control application program. This MCU is Single clock/machine cycle. It is a new generation MCU with high-speed, low power, and super anti-jamming. Instruction code is fully compatible with the traditional 8051, but its speed is 8-12 times faster.

V. INTERFACE

A. *Interface of PT100 and AD7711*

There are three connection methods for PT100, 2-wire, 3-wire and 4-wire. As the connection is not same, the precision increases gradually. And the complexity of the circuit also subjoins. Trough comparison, the final system uses the 3-wire method in practice.

The diagram of the 3-wire method is showed as Fig. 3.

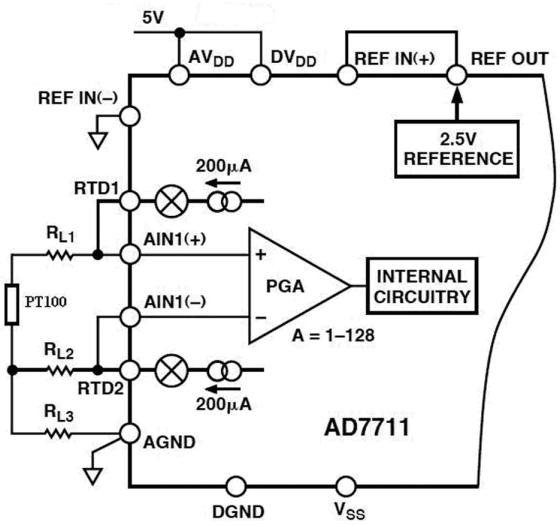

Figure 3. 3-wire Connection of PT100

B. *Interface of AD7711 and STC10F12*

Fig. 4 shows the specific circuit that the serial interface and port 1 of the STC10F12 and the interface of the AD7711. The serial interface works in the mode 0 in the circuit. In other words, the serial interface is used as a Synchronous Shift Register. The received data (RXD, P3.0) achieves the input and output of the data, and the transmit data (TXD, P3.1) exports the serial shift clock signal. The serial data output format is opposite between AD7711 and STC10F12, so an inverter is needed between the clock output side of the MCU and the serial clock side of the AD7711. And the data bit sequence should be inverted phase when you design the software.

C. *Interface of STC10F12 and CH341*

Fig. 5 shows that the MCU connects to the CH341 with the serial interface, and implements the communication between MCU and computer within the method of universal serial bus (USB). If the baud rate of the serial communication is too high or it is too late to receive for MCU, anyone output pin of the MCU can be used to control the pin TEN of the CH341. When the MCU is idle and can receive serial data, TEN should be set low level. When the MCU is busy or inconvenience to receive

serial data, TEN should be set high level. That can make CH341 [7] stop to transmit next byte. So it can control the speed.

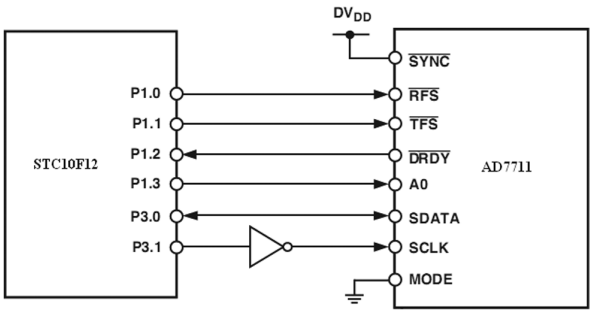

Figure 4. Interface circuit of AD7711 and STC10F12

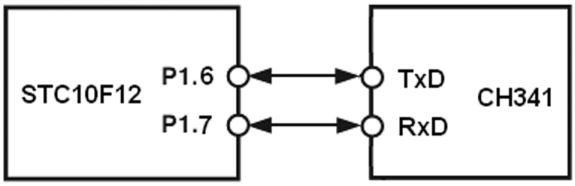

Figure 5. Interface circuit of CH341 and MCU

VI. CONCLUSION

The temperature signal is sent to the computer after treatment by the above circuit. The collected real-time temperature of the PT100 can be easily saw with a third-party software "serial debugging aid" on the computer. The entire temperature measurement system can display the real-time measuring temperature of the PT100. And it also has the features that small size, low power consumption, high precision and so on.

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