DOI: 10.18686/ahe.v6i17.5533

A high-Precision Temperature Detection Circuit Integrating Multiple Disciplines——The Practical Teaching Application Based on the OBE Concept

Zhaoxia Liu， **Jiawei Lv**
Beijing Union University，Beijing 100101
Beijing University of Civil Engineering and Architecture，Beijing 102699

Abstract: By detecting the temperature with Pt100 thermal resistance sensor, The operational amplifier, single-chip microcomputer, driver and other links are added to the circuit, and the software and hardware are combined to achieve functional requirements. The designed circuit involves the integration of multiple disciplines.
Keywords: Pt100; OBE conception; Temperature detection

Fund Projects: Beijing Union University Education and Teaching Research and Reform Project in 2021; Beijing Union University "Electronic Information Engineering (college upgrade)" professional construction project

"Sensor and Measurement Technology" is one of the compulsory courses for those students majoring in electronic information. The composition and principle of sensitive components include a lot of basic knowledge in physics, chemistry, and even biology, which are relatively abstract and difficult for students to understand; the conversion components involve circuits, analog electronics, digital electronics, etc. The professional knowledge is highly comprehensive and requires students to integrate and apply the existing knowledge content. According to the learning characteristics of this course, the OBE teaching concept is adopted to make students clear about their learning goals and teaching results.

According to the learning characteristics of the sensor, the typicality of the experiment should be considered when designing the experiment. Temperature is an important measurement parameter. There are many types of sensors, which can be divided into analog and digital according to the characteristics of the signal. Obviously, the sensor of the analog signal needs to be converted into a digital signal after A/D conversion to realize the functions of display and control.

The problem to be solved is to achieve high-precision temperature measurement, which requires a measurement range of 0-100 °C, a measurement accuracy of 0.5, and the realization of display and upper and lower limit alarm functions (alarm temperature value is adjustable).

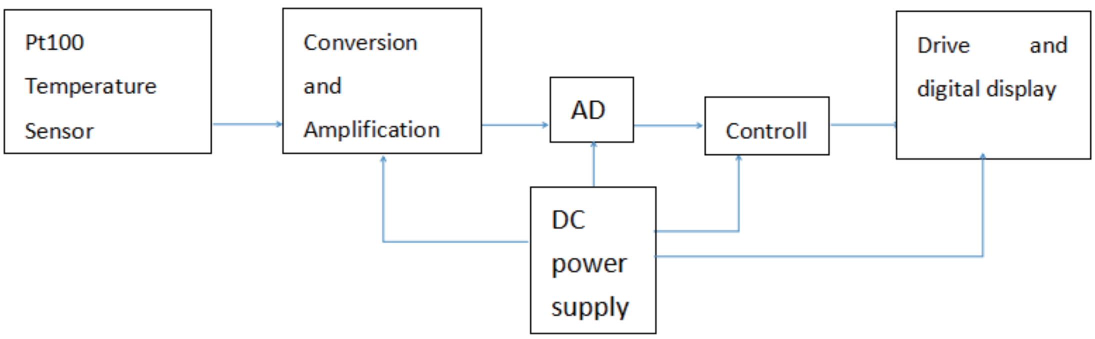

Fig 1. Temperature Measurement System Block Diagram

The sensor type is selected according to the design requirements. In this design, in order to comprehensively use the circuit knowledge learned, an analog temperature sensor, thermal resistance, is selected. After analysis and comparison, it is found that the thermal resistance of the Pt100 model can meet the measurement requirements and has a high cost performance. So, this kind of sensor will be used in the design. Since the temperature measurement principle of the thermal resistance is to convert the temperature signal into the corresponding resistance value change, it is necessary to use a lot of knowledge of the integrated operational amplifier, bridge circuit and other knowledge previously learned to convert the resistance value change into a voltage change. Design a closed-loop detection system, take the sensor as a part of the whole closed-loop, convert the analog voltage signal through A/D and sample it into the single-chip microcomputer for data processing, and realize the data display through the program. The block diagram of the specific implementation is shown in Figure 1.

Select the hardware implementation design scheme according to the block diagram.

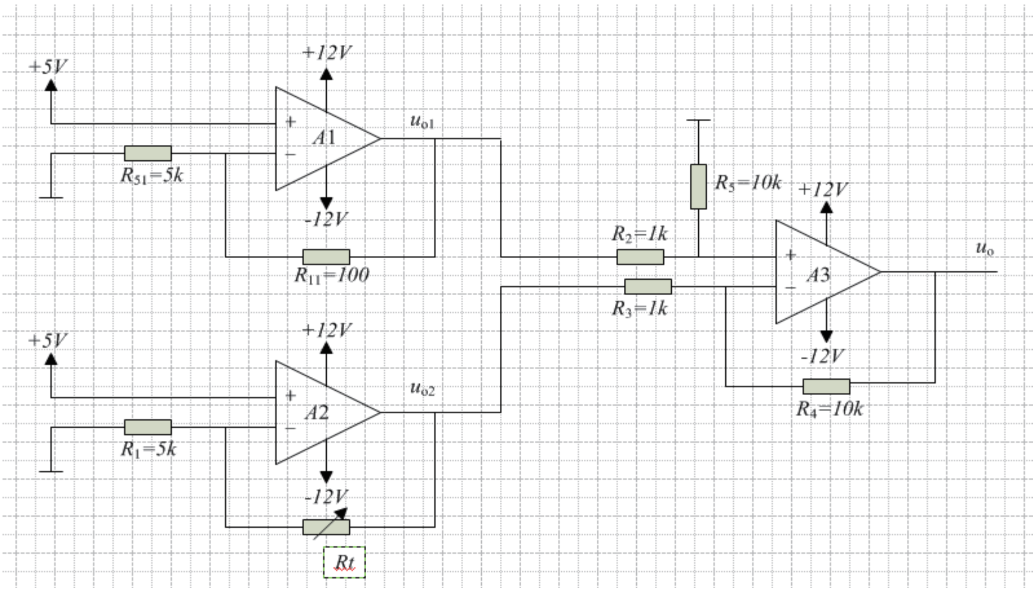

Fig 2. Resistance voltage conversion circuit diagram

The traditional thermal resistance measurement scheme generally uses a bridge to convert the resistance change into a voltage change. In this design scheme, an integrated operational amplifier is cleverly used to achieve signal conversion. As shown in Figure 2, A1, A2, and A3 are three integrated operational amplifiers, of which A1 and A2 are proportionally amplified in the same phase, and the two output voltage signals are sent to A3. When Pt100 is between 0-100°C, the resistance value corresponding to different temperature points can be obtained by consulting its graduation table. Looking up the table, it can be seen that its resistance value is 100 ohms at 0°C, and its resistance value is about 138.5 ohms at 100°C. Different resistance values make A2 voltage output different. The output voltage of A3 differential amplifier is $u0=R4/R3(u_{01}-u_{02})=10(u_{01}-u_{02})$. It can be seen that when the temperature to be measured is 0°C, the output voltages of A1 and A2 are equal, and the differential output of A3 is 0. When the temperature rises, $u_{02}>u_{01}$, and the inverting output voltage is obtained. In order to obtain the positive-phase voltage value, a first-stage op amp can be connected to invert and amplify, and finally the non-inverting output voltage value can be obtained.

This project is typical, although it is aimed at the circuit design of Pt100 thermal resistance, but students can draw inferences from one case, and have a good reference for the resistance type sensor, and the voltage type sensor can be directly connected with the microcontroller to realize conversion and display. It can be seen that from design to selection, from simulation to physical objects, the project involves the cross-integration of multiple disciplines, breaking the barriers of disciplines, and it is very comprehensive. Students in the implementation of the project can establish a certain engineering concept, which not only strengthens the understanding of circuits, electronics, etc.

References:

[1]Wen-Tsai Sung.Data fusion for PT100 temperature sensing system heating control model[J].Measurement,52 (2014) 94–101

[2]Syed Enamur Rahaman.Circuit effificiency of high power amplifier circuit[J].Sciencedirect, Int. J. Electron. Commun. (AEÜ) 123 (2020) 153283