Design of micro resistance measurement system

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Abstract. With the continuous progress and development of the electronics industry, the number and types of electronic components are also increasing. As the most widely used device in electronic components, the accuracy of resistors greatly affects the performance of the product. Therefore, we need to design a highly accurate and intelligent micro-resistance measurement system to meet the needs of the current society. This paper designs a micro-resistance measurement system. The system uses ST89C52 single-chip microcomputer as the data processing and control chip, and uses a constant voltage source to provide a stable voltage for the resistance to be measured. The measurement module of this system is based on the RC oscillator circuit, the pulse time is measured by the "pulse counting method", and then the measured frequency is calculated, because the frequency is a digital quantity that the single-chip microcomputer is relatively easy to identify and process; the selection module is mainly controlled by the 51 single-chip microcomputer. The gears correspond to different non-polar capacitors; LCD1602 displays the value and unit of the measured resistance. And the system uses the C language for software design, at the same time design the corresponding flow chart and write the complete source code for programming; finally, the corresponding physical objects are produced and corresponding debugging is carried out, and the debugging results meet the design requirements of the subject. By comparison, the general measurement methods have the disadvantages of complex calculations, and it is not easy to realize automatic measurement and intelligent. It has been verified that the system adopts these modules to make the test instrument more accurate and intelligent to achieve the required requirements.

1. Introduction
In recent years, many companies at home and abroad have quickly and effectively improved the function of the measurement system by using ultra-high precision, ultra-fast precision constant current sources and precision amplifiers. Japanese scholar Isao Minowa proposed the use of superconducting quantum devices to measure small resistance. British scholar H. Aichi recommended the use of electrolytic cell method to measure small resistance. Polish scholar Jerzy Kaczmarek recommended to use the third harmonic method to measure small resistance [3], but these research methods must be carried out in the laboratory. In practical applications, the traditional method is to measure the resistance of the loop by using the DC double-arm bridge method. However, when using a DC double-arm bridge to measure loops, since the double-arm bridge loop can only pass weak currents, the requirements on the equipment are very high. When large current or normal current is passed, excessive heating will increase the temperature. Small impedance intelligent measuring instruments have developed rapidly in recent years, and many companies in China have developed various products. For example, some companies produce micro-ohms, require a larger current constant current source, and use a high-frequency switching current source [4]. However, these measuring instruments
have high test current and long measurement time, so they have an effect on the temperature rise of the measured resistance and reduce the accuracy of the measurement. At the same time, these measuring instruments are bulky and inconvenient to carry on site, and the cost is relatively high. Resistance online testing technology is the top priority of the machinery manufacturing industry and the guarantee for the production of high-tech products. Without it, it is impossible to develop advanced products, ensure product quality, increase productivity, reduce costs, and shorten production cycles. With the world's high-tech development trend, China's electronic measuring instruments have also entered a path of rapid development. China's electronic measurement technology has made major breakthroughs in many scientific and technological fields, laying the foundation for China's electronic measurement instruments to reach the world's advanced level. GPS technology, RS technology, GIS technology, digital mapping technology and advanced ground measuring instruments are widely used in practical applications [5]. With the urgent need for the types and quantities of electronic components, its scope of adaptation has gradually spread to various fields. In research applications, the accuracy of resistance is more important. Therefore, a reliable, intelligent and convenient resistance measuring instrument has great practical application value. General measurement methods are difficult to calculate with poor accuracy, and need to ensure a good test environment, but also have the shortcomings of difficult automatic measurement. On-line measurement methods of resistance mainly include isolation technology methods and network conversion methods, as well as on-line measurement techniques of fully isolated resistance [6]. The resistance network transformation method is simple and easy to implement, with low cost, but requires arithmetic conversion to obtain the measurement results. The isolation technology is known as the essence of the online tester.

2. Roles and functions to be realized in the system

2.1. Multi-range measurement and automatic range conversion can be realized by pressing the button.

2.2. Capable of displaying the unit, range, accuracy and other parameters of the system with the LCD module.

2.3. The system can be adjusted by pressing the buttons to complete functions such as system switching, resetting, and shifting.

3. Scheme demonstration and comparison

3.1. Option One
The four-wire measurement method is used to separate the current and voltage wiring, the current flows into the loop, the voltage measurement loop, and a follower is designed at the voltage extraction end to make the current on the voltage measurement lead to zero. This method can avoid contact resistance and lead resistance the influence on the measurement of small resistance greatly improves the measurement accuracy and sensitivity of the system. This scheme uses modular design, which includes units such as power supply, constant current source, A/D conversion module, display and keys [7]. Four-wire measurement method circuit diagram.

3.2. Option two
The microcontroller AT89C52 is used as the main control chip to realize the automatic range conversion of the first three gears of the measured resistance and display the decimal point and unit. The measuring instrument first converts the measured resistance R into frequency f, and then selects the channel through the single-chip microcomputer to control the relay to determine the gear position. At the same time, the single-chip microcomputer collects the frequency and counts by the single-chip interrupt system. After the single-chip processing, the resistance value is finally sent to the LCD1602 for display. When you need to switch the unit, directly press the button M ohm to send a signal to the
single-chip microcomputer, which can be realized after the single-chip programming calculation processing. The working idea of the micro resistance measurement system is shown in the figure1.

3.3. Summary:
As the second option is easier to switch the range than the first option, the calculation is convenient, and the sensitivity is higher, so choose the second option.

4. Sign of measuring circuit
The measurement of the measured resistance adopts the "pulse counting method". According to the design requirements, an oscillating circuit is required to convert the resistance value of the resistance into the corresponding frequency signal value. And because the single-chip microcomputer has a relatively high counting accuracy for the frequency range of 10 ~ 10K, and the sensitivity is taken into account, the premise is to choose an appropriate capacitor and resistance. First of all, we need to determine the value range of the frequency of the corresponding gear, and then by determining the corresponding resistance value and capacitance value, the values of the 4 resistances and capacitances and the corresponding frequency range can be calculated. The corresponding range parameters of the oscillation measurement circuit are shown in Table 1. Calculate the size of the measured resistance by calculating the frequency of the oscillation output, the oscillation period is as follows:

\[ T = t_1 + t_2 = (\ln 2)(R_1 + R_x) \times C_1 + (\ln 2)R_x \times C_1 \]

Inferred:

\[ f_x = \frac{1}{(\ln 2)(R_1 + 2R_x)C_1} \]

Get conclusion \( R_x \).

| Gear | resistance | capacitance | Frequency Range(HZ) |
|------|------------|-------------|---------------------|
| R1   | 0-100Ω     | 100Ω        | 5.3uF               | 810-1620 |
| R2   | 100Ω-1KΩ   | 18KΩ        | 9.8uF               | 7988-8996 |
| R3   | 1KΩ-10KΩ   | 25KΩ        | 9.2uF               | 4210-5689 |
| R4   | 10KΩ-10MΩ  | 15MΩ        | 6.2pF               | 10052-15565 |

5. Design overall framework
The design is mainly composed of four parts: 1. The main chip adopts single-chip AT89C52; 2. The measurement part mainly adopts 555 timing circuit and RC oscillator circuit to realize the conversion between the resistance value and frequency of the measured resistance; 3. The channel selection part is converted by resistance The following frequency signal is selected through the relay to select the appropriate gear; 4. The display part mainly uses LCD1602 liquid crystal display in the figure2.
6. System main program design
The system is mainly based on the frequency to automatically switch the range. Get the frequency according to the resistance, and determine whether the frequency is within the frequency range corresponding to the gear, and then select the appropriate channel until it is appropriate. After the selection is made, the signal is input to the single-chip microcomputer control to obtain the corresponding resistance value, and finally the resistance value is displayed on the 1602 liquid crystal display in the figure3.

7. Conclusion
At present, high-precision digital instruments at home and abroad have many shortcomings. 1. Hardware circuit design is often more complicated. The instrument is relatively large and inconvenient to carry. 3. The price is also relatively expensive. In the 21st century, although China's digital display
instruments are mature, they need to be developed in terms of price, operation, and especially intelligence [2]. The development and application of smart instruments have huge room for development. The system is to meet the needs of today's social development and create a simple and easy to operate, with automatic range conversion, a small simple measuring instrument, make full use of digital circuits and some analog circuits, and play the role of integrated modules. Therefore, the tester is very convenient to use, with high accuracy and small measurement errors.

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