Research and Design of Electronic Measuring Instrument Based on Single Chip Microcomputer

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Abstract. This paper studies and designs a high-precision resistance inductance and capacitance measuring instrument based on single-chip microcomputer. It uses MAX038 monolithic voltage control function generator to generate high-precision sine wave signal flow, through the capacitor or inductor and the standard resistance string to be tested. Connect the circuit, use the voltage ratio calculation method to calculate the capacitance value or the inductance value, use the 51 single-chip microcomputer to control the measurement and calculation results, use the 1602 liquid crystal module to display the value in real time, and the sinusoidal signal generator can realize the amplitude and frequency. In order to improve the accuracy, the measured AC voltage is first passed through the ICL7650 to eliminate the error caused by the lower input resistance of the AD637. The experimental test results show that the measuring instrument has stable performance and high measurement accuracy.

1. Introduction

At present, electromechanical products are widely used in home appliances, communications, general industry and even aerospace and military. Whether in daily life or high-end technology, the application of electronic technology is getting deeper and deeper. Therefore, master the necessary basic knowledge of electronic technology design and production. The basic skills can meet the requirements of the current industrial structure of China for the basic quality of the majority of technical workers, engineering and technical personnel, and can develop the ability and quality of high-end electronic systems to adapt to the needs of the information age.

There are many types of instruments for measuring electronic component parameters on the market, and the methods, advantages and disadvantages are also different. The general measurement methods have the disadvantages of complicated calculation, difficulty in automatic measurement, and difficulty in achieving intelligence. There are many methods for measuring the resistance and capacitance inductance, but because the higher the precision is, the better the measurement instrument is. Therefore, the voltage comparison method with higher precision is used as the resistance and capacitance tester. The principle is to connect the AC signal of a certain frequency through the series. The voltage dividing circuit is converted into a voltage signal, and then converted into a frequency signal by a circuit to be subjected to a proportional operation by a single chip microcomputer, and finally the calculated
measured value is sent to the display module and the dimensions corresponding to the respective parameters are displayed.

2. Measurement principle
One of the better methods for measuring high-precision resistance is to use a method compared with a standard resistor. The main principle is to add a DC voltage \( V \) in the series circuit of the resistor to be tested and the standard resistor, and the AD sample is used to obtain the voltage on the \( R_x \). \( V_x \), the measured resistance is:

\[
R_x = \frac{V_x \cdot R}{V - V_x}
\]

This article uses the same method as measuring resistance - voltage proportional method [1-2] to measure inductance and capacitance; because the inductor and capacitor are reactive components, the AC signal should be used to generate the measurement signal; the AC signal at the angular frequency of \( \omega \) Capacitive reactance and inductive reactance obtained by capacitive inductors:

\[
X_C = \frac{1}{j \omega C}
\]

\[
X_L = j \omega L
\]

\( C, L \) is the capacitance and inductance to be tested. As a result, there are many methods for selecting standard components. However, in order to improve measurement accuracy and reduce cost, the meter uses a standard resistor and shares a standard resistor with the resistance measurement. So there is inductance:

\[
L = \frac{U_L \cdot R}{j \omega (U - U_L)}
\]

Capacitance:

\[
C = \frac{U_C}{j \omega R}
\]

When measuring the q value, add the AC signal to measure the inductance q value:

\[
Z_1 = R_s + j \omega_1 L
\]

\[
Z_2 = R_s + j \omega_2 L
\]

The two equations are connected to obtain the inductance:

\[
L = \sqrt{\frac{Z_1^2 - Z_2^2}{\omega_1^2 - \omega_2^2}}
\]

Among them, \( Z_1 \) is the inductance in the circuit, the angular frequency is \( \omega_1 \) equivalent impedance, \( Z_2 \) is the inductance in the circuit, the angular frequency is \( \omega_2 \) the equivalent impedance, \( L \) is the inductance.

In order to ensure the measurement accuracy, the accuracy of the resistor and the high stability of the \( W \) must be guaranteed. For this reason, the MAX038 monolithic voltage-controlled function generator [3] is used to generate a high-precision sine wave signal, and the output buffer uses an operational amplifier. In order to ensure the waveform accuracy, a closed-loop deep negative feedback method is adopted, and the sinusoidal signal is amplified without distortion.
3. Program design

3.1. Resistance inductance and capacitance test sampling module

(1) Using pure analog circuits
Although the trouble of programming is avoided, the circuit is complicated, the components used are many, the production is troublesome, the measurement precision is low, and the debugging is difficult, and it is rarely used.

(2) Programmable controller
It can be easily integrated into industrial control systems. Programmable controllers are fast, small, reliable and accurate. In this system, we can use plc to control the hardware, but the price of plc is quite expensive, and therefore costly used in applications where high requirements are required.

(3) Using the oscillating circuit combined with the single chip microcomputer
The 555-multiple resonant circuit is used to convert the resistance and capacitance into frequency, and the inductance is converted into frequency according to the three-point circuit of the capacitor, so that the analog quantity is approximated into a digital quantity, and the frequency is a digital quantity that the single-chip computer can easily handle. The program has high measurement accuracy and is easy to automate the instrument, and the system composed of the single chip has high reliability. The description of the hardware can be completely realized by software, and the cost is low. However, a large number of frequency multiplication, frequency division, mixing and filtering must be adopted. The link leads to complicated structure, large volume, high cost and difficulty in achieving high spectral purity, which increases the measurement error, and the peripheral circuit is very complicated. It does not meet the requirements of an independent signal generator.

(4) Voltage proportional method
The method is compared with the standard resistance, the principle is that the current I is applied in the series circuit of the original to be tested and the standard original, so that the voltages obtained on the measured component and the standard component are Vx and Vi, respectively; The measured value, this method is highly accurate, and requires a signal source with stable output frequency to provide excitation. This paper adopts this scheme.

3.2. Sinusoidal signal generator module
The sinusoidal signal source generator module is an important part of determining the system error, and requires a stable frequency. In addition, in order to test the reliability of the system, the frequency and voltage of the sinusoidal signal generator are required to be adjustable. The system requires a frequency range of 1 Hz~1 MHz. The voltage is greater than 5v, so the MAX038 signal generator is used in the design.

MAX038 is a precision high-frequency waveform generator produced by maxim that requires only a few external components. It produces accurate high-frequency sine, triangle, and square waves. The output frequency and duty cycle can be controlled separately by adjusting the current, voltage or resistance. The pin arrangement of MAX038 is shown in Figure 1.

![Figure 1. MAX038 pinout](image.png)
The desired output waveform can be set by the input data of addresses a0 and a1. Waveform switching can be performed at any time by program control without regard to the phase of the output signal at the time. Where x is any state, 1 is high level and 0 is low level.

Using the MAX038 monolithic voltage-controlled function signal generator to generate a sine wave, changing the value of the external resistor or capacitor can change the value of the output frequency, the frequency range from 0.1Hz to 20MHz, up to 40MHz, the output frequency is stable. Various waveforms the output amplitude is 2V, the amplitude can be adjusted through an amplifier. The duty cycle has a wide adjustment range, and the duty cycle and frequency can be adjusted separately without affecting each other. The maximum duty cycle adjustment range is 10%~90%. The waveform distortion is small. The sine wave distortion is less than 0.75%.

4. Circuit design

4.1. Sinusoidal signal generator

The core device of the circuit is MAX038, which has the characteristics of wide output frequency range, stable waveform, small distortion and convenient use. Figure 2 shows the sinusoidal signal generator in the circuit design.

![Figure 2. Sinusoidal signal generator](image)

4.2. Sampling circuit

The ICL7650 is a chopper-stabilized high-precision operational amplifier with low input bias current, small offset, high gain, common mode rejection, fast response, low drift, stable performance and low...
price. The ICL7650 uses 14 pins. Dual in-line and 8-pin metal case, Figure 3 shows the most commonly used 14-pin dual in-line package.

![ICL7650 Pin Arrangement Diagram](image)

**Figure 3. ICL7650 Pin Arrangement diagram**

As shown in Figure 3, the high-precision sine wave signal flows through the series connected standard resistor and the component to be tested, and the component to be tested is grounded at one end. The instrument measures the voltage from both ends of the standard resistor through relay conversion. The input resistance of the AD637 is lower. In order to reduce the error caused by its partial voltage, the measured AC voltage is first passed through a voltage follower composed of a precision operational amplifier ICL7650, and then converted into an effective value by a high-accuracy AC/RMS conversion chip AD637, which is converted into a digital value by adc. Signal, complete the proportional operation in the single-chip microcomputer to obtain the capacitance inductance value. When measuring different numerical values of inductance and capacitance, you can select the corresponding standard resistance and change the frequency of the MAX038 output signal to divide the voltage. This is realized by the single-chip control relay switching circuit and programming.

5. Conclusion

This design adopts single-chip microcomputer to improve the reliability and stability of the system, reduce the system volume, and is convenient to debug and maintain. The control system with the minimum system of 51 single-chip microcomputer can meet the requirements of the whole system, and the test system works normally. At the same time, the system also has a number of functions that can be extended to increase the voice function. When each measurement value is stable, it is reported by voice. It can also increase the online measurement function, so that it can measure the normal operation of the component, not just the value at static.

References

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