AC Standard Resistance Calibration System

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Abstract A recently developed AC standard resistance calibration system is described. It consists of AC standard resistors and an AC resistance measurement bridge. The AC standard resistors are calculable and has three value of 100Ω, 300Ω, 1000Ω.The key parts of the AC measurement bridge is a programmable binary inductive voltage divider. The working range of the system is 1Ω~10kΩ at the frequency 400Hz~5kHz.The system is controlled by computer and the best uncertainty is 1×10^{-5}.

Key Words Calculable AC standard resistor, AC resistance measurement bridges.

1 Purpose

With the growth of science and technology, the demand for the measurement and test technology is becoming higher and higher. The DC parameter reached the level that it is hard to develop. On the other hand, the AC parameter is becomes more and more important to develop, especially in the aerospace and aviation field. Many instruments, for instance, AC current source, power and energy standard and RLC tester need to be calibrated. The uncertainty of calibration to the AC current source is 2×10^{-4}. If we have the AC standard resistor, we can calibrate the AC currents throw the AC resistance and AC voltage. The uncertainty of this method can reach 5×10^{-5}.

The important technology performance of the AC standard resistor is frequency feature. By calibrating the value of the AC standard resistor at the different frequency, the user can use the different value of the AC standard resistor according the frequency they choose. This can reduce the error of the measurement process and improve the uncertainty of the calibration.

2 Method

The AC Standard Resistance Calibration System includes three Calculable AC standard resistors, the AC resistance measurement bridge, the temperature control system, the AC voltage source and the phase-luck amplifier. The important thing of the calibration system is how to transfer the ac resistance value. The task to keep the ac resistance value is undertaken by the ac calculable standard resistor. The value by which the ac calculable standard resistor kept is transferred to the UUT(unit under test) by the AC resistance measurement bridge. The AC resistance measurement bridge consists of the main inductive divider，the main current divider，the multi-bit inductive divider and the phase compensate device. The main parts of the AC resistance measurement bridge is a programmable binary inductive voltage divider. Because of a microprocessor was used in every device, so it can switch the inductive divider coil by control the relays. Every device of the system has IEEE 488 interface, so the system can control by a computer and so it can run the

Fig. 1 AC resistance calibration system

calibration procedure automatically. For more detail, see figure 1、figure 2 (physical diagram) and figure 3 (Principle diagram).

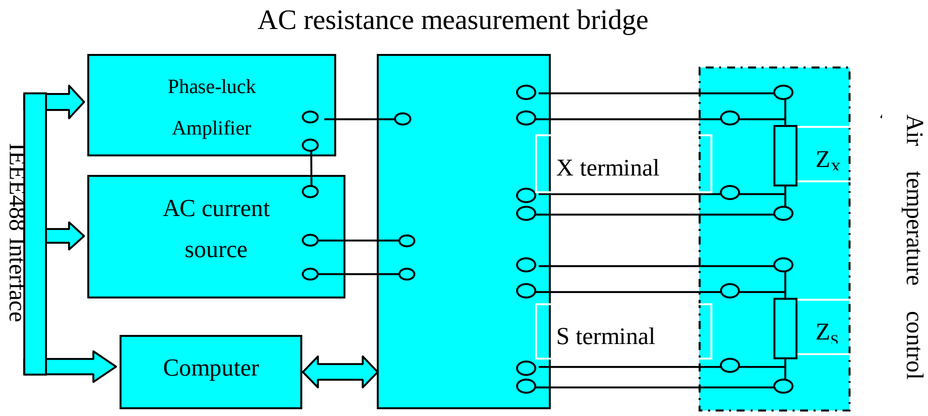

Fig. 2 AC standard resistance calibration system physical diagram

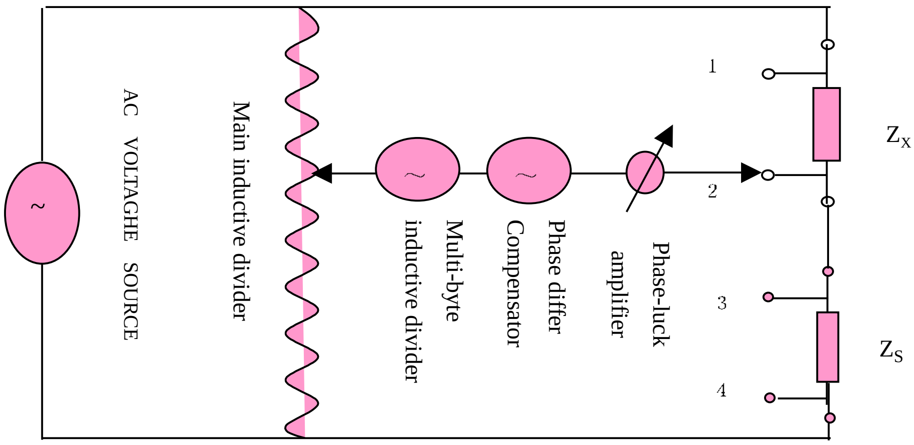

Fig. 3 AC standard resistance calibration system principle diagram

From the diagrams we know that the AC Resistance Measurement Bridge is an inductive voltage divider bridge. The main inductive voltage divider composes the two arms of the bridge. The Calculable AC Standard Resistor and the UUT (unit under testing) compose the other two arms. The Calculable AC Standard Resistor is designed by choosing the construction rationally so as to reduce the error caused by the AC distributive parameter such as the capacitance and inductance. The time constant of Calculable AC Standard Resistor reaches to 1 nanoseconds. When the frequency is below 5kHz, the error caused by time constant is less than 1×10^{-5}.

The balance process consist four steps, step 1,2,3,4. By adjusting the main inductive voltage divider, multi-byte inductive voltage divider and phase differ compensate voltage divider, each step can make the phase-luck amplifier tends to zero and the calibration system reaches the balance. The calibration program procedure is below, see Fig.4. The calibration procedure was edited by the TESTPOINT software plat. It can communicate with the office software, such as Microsoft word，Excel. The test data send to the office software, and the calibration report can be done automatically.

In the end, the last balance equation is below, see equation (1).

$$\frac{Z_1}{Z_2} = \frac{K_1 - K_2}{K_3 - K_4}\left(1 + j\omega\left(\frac{\tau_1 - \tau_2}{K_1 - K_2} - \frac{\tau_3 - \tau_4}{K_3 - K_4}\right)\right) \qquad (1)$$

The result can calculate by the equation (2) and (3).

$$R_x = \frac{K_1 - K_2}{K_3 - K_4} R_0 \qquad (2)$$

$$\tau_x = \left(\frac{\tau_1 - \tau_2}{K_1 - K_2} - \frac{\tau_3 - \tau_4}{K_3 - K_4}\right) + \tau_0 \qquad (3)$$

3 Results

A series of calibration was done and the results were obtained. The calibration results are below. See table 1.The testing frequency is 1kHz. The testing voltage is from 0.256 to 2.56V according the value of the UUT. The best uncertainty is less than 1×10^{-5},the repeatability is 5×10^{-6}, the uncertainty of time constant calibration is 1×10^{-9}s, the time constant resolution of the calibration system is 1×10^{-11}s.

4 Conclusion

An AC resistance calibration system was established in our institute. The working range of the sys tem is 1Ω to 10kΩ.The working frequency from 400Hz to 5kHz.The results can feet the demand of the defense system of China.

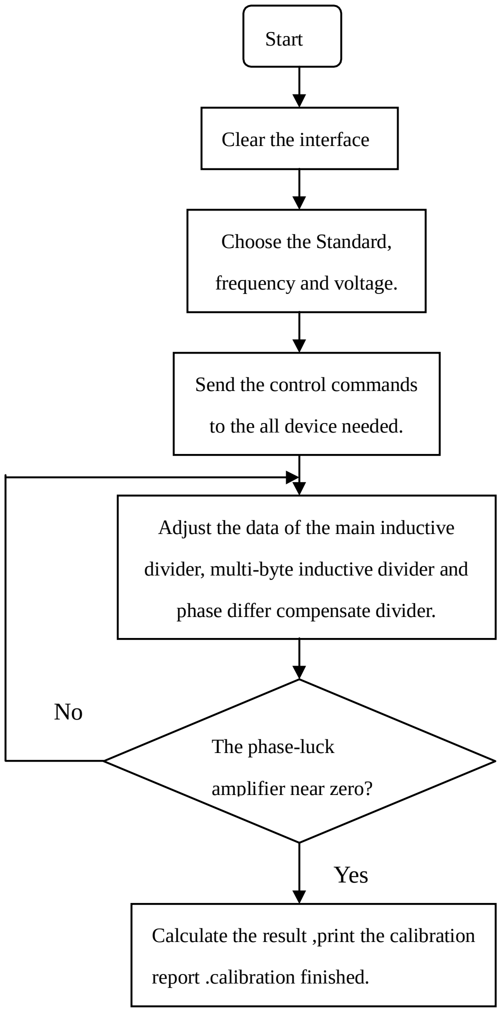

Fig.4 Calibration program procedure

Table 1 AC standard resistor calibration result

UUT			Standard		Calibration result	
Nominal Value (Ω)	Type	No.	Value (Ω)	Time constant (s)	Resistance value (Ω)	Time constant (s)
10000	5685A	269133	1023.81	-5.27×10^{-10}	9999.236	-6.621×10^{-8}
1000	5685A	269789	1023.81	-5.27×10^{-10}	999.9918	-4.015×10^{-8}
100	5685A	269782	110.5565	2.98×10^{-9}	100.00156	6.64×10^{-9}
10	5685A	269721	110.5565	2.98×10^{-9}	10.000638	7.264×10^{-8}
1	5685A	269708	10.000638	7.264×10^{-8}	1.0000927	2.897×10^{-8}

Reference

[1]. Research report of the AC resistance calibration system.
[2]. Test report of the AC resistance calibration system.