Explanation of Precise Measurement of MS Series Resistors

§0 . Abstract

The MS series products are resistors with alloy foil as the conductor. According to the classification of resistance value, they belong to low-resistance resistors. For the measurement of this type of resistors, it is necessary to choose a suitable circuit to eliminate the impact of wire resistance, leakage current, temperature, etc. in the circuit in order to minimize errors and ensure measurement accuracy. The bridge method is a method of measuring with the comparative law, which is to compare the measured resistance with the standard resistance under balanced conditions to determine the accuracy of the to-be-tested resistor. With high sensitivity, accuracy, the bridge method is ingenious, convenient, and has low requirements for power supply stability. Thus it has been widely used in electrical technology and non-electrical measurement.

§1. Testing Principle

Wheatstone bridge: It is a bridge circuit proposed by Wheatstone in 1843. It consists of four resistors and a galvanometer. RN is a precision resistor, and RX is the resistor to be measured (Figure 1). After the circuit is connected, adjust R1, R2, RN to make the current of the galvanometer zero, and the bridge is balanced. At this time, RX=R1 X RN/R2. RX is obtained by the exchange measurement method (exchange the position of RN and RX, and do not change R1, R2).

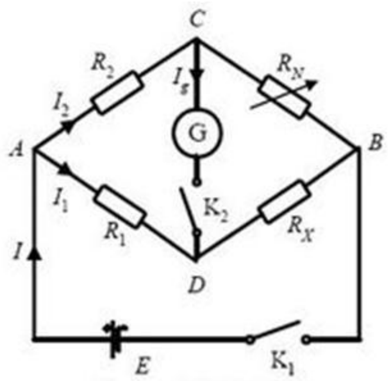

Fig.1: Wheatstone bridge circuit

Special contradiction in testing low resistance with Wheatstone bridge: The Wheatstone Bridge (single bridge) measures resistors, and its value is generally above 10 Ω. If a single bridge is used to measure low resistance, the additional resistances R 'and R' '(lead resistor and terminal contact resistor, etc.) and RX are directly connected in series (Figure 2), and the values of R' and R '' are equivalent to that of the measured resistor RX and cannot be ignored. The resistance RN is also a small resistor. Therefore, the formula RX=R1 X RN/R2 for measuring resistance using a single bridge cannot accurately determine the value of RX.

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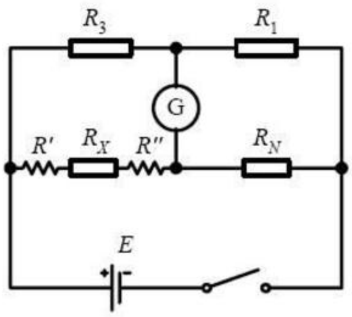

Fig.2: The effect of additional resistance on Wheatstone Single Bridge

Solution of Kelvin Double Bridge: Kelvin is the deformation of Wheatstone Bridge, which can give quite high accuracy when measuring small resistance. The structure is shown in Figure 3, where R1, R2, R3, and R4 are all adjustable resistors, RX is the measured low resistor, and RN is the low value standard resistor. Compared with Wheatstone Single Bridge, Kelvin Bridge has made two important improvements:

- **a.** Added a bridge arm composed of R2 and R4 ;
- **b.** RN and RX changed from two end connection to four end connection ;

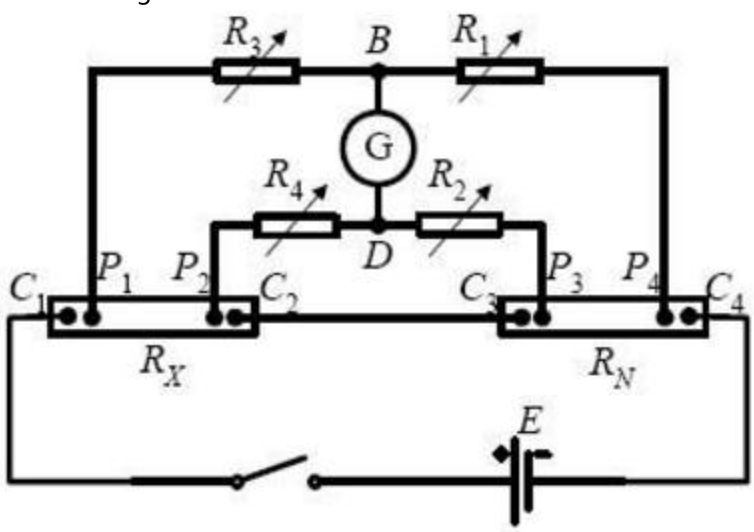

Fig.3: Schematic diagram of Kelvin Double Bridge

Among them, P1 P2 constitutes the measured low resistance RX, P3 P4 is the standard low resistance RN, P1 P2 and P3P4 are often referred to as voltage contacts, C1C2 and C3 C4 are called current contacts, cleverly transferring the wiring resistance and contact resistance of RN and RX to Internal resistance of the power supply and the bridge arm resistance with high resistance.

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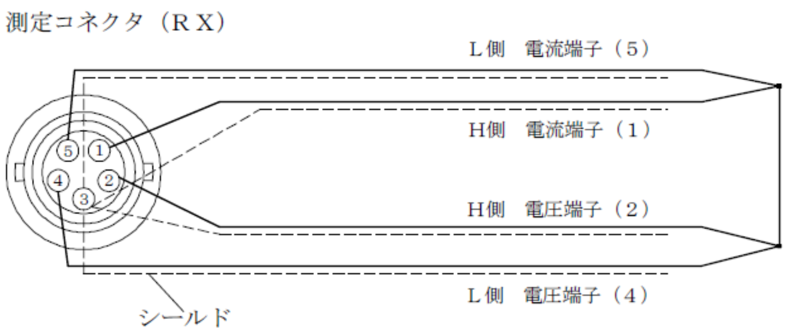
§2．Test equipment

Test conditions：

Scale	Measurement range	Resolution	Measurement current	Accuracy	Open terminal voltage
1 mΩ	0.0000 mΩ～1.5000Ω	0.1 μΩ	3 A	Within ±(0.01% rdg +1 μΩ) ±α digits	Appr. DC 4V
10 mΩ	0.000 mΩ～15.000 Ω	1 μΩ	1 A		
100 mΩ	0.00 mΩ ～ 150.00 mΩ	10 μΩ			
1 Ω	0.0000 Ω ～ 1.5000 Ω	100 μΩ	100 mA		
10 Ω	0.000 Ω ～ 15.000 Ω	1 mΩ			
100 Ω	0.00 Ω ～ 150.00 Ω	10 mΩ	10 mA		
1 kΩ	0.0 Ω ～ 1500.0 Ω	100 mΩ	1 mA		

Wiring method：



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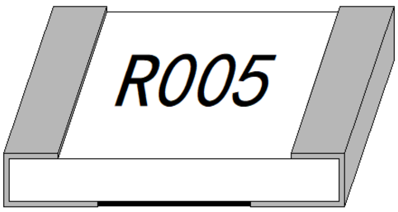
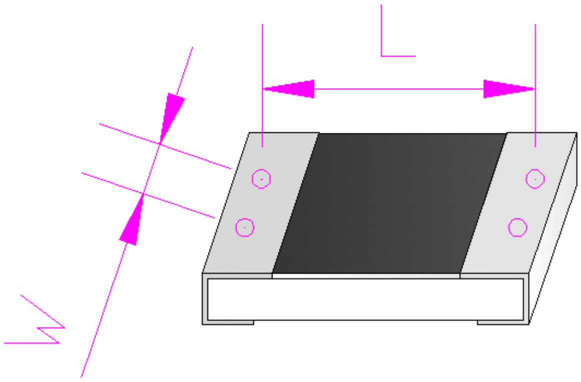
§3 . Measuring position of MS series resistors





Measuring needle size :

No.	Spec.	Needle tip diameter（±0.010）	Needle body diameter（±0.010）	L（±0.010）	W（±0.010）
1	**0402**	0.080	0.200	0.700	0.120
2	**0603**	0.100	0.200	1.050	0.400
3	**0805**	0.100	0.300	1.650	0.35
4	**1206**	0.100	0.350	2.600	0.800
5	**2512**	0.100	0.350	5.300	1.000
6	**2010**	0.100	0.350	4.300	0.500

§4. Summary

When measuring the resistance value of MS series resistors, it is necessary to pay attention to the following points: ensure that the testing instrument is grounded to reduce interference, and try to maintain stability during the testing process to reduce errors caused by poor contact.