

# 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.  $R_N$  is a precision resistor, and  $R_X$  is the resistor to be measured (Figure 1). After the circuit is connected, adjust  $R_1$ ,  $R_2$ ,  $R_N$  to make the current of the galvanometer zero, and the bridge is balanced. At this time,  $R_X = R_1 \times R_N / R_2$ .  $R_X$  is obtained by the exchange measurement method (exchange the position of  $R_N$  and  $R_X$ , and do not change  $R_1$ ,  $R_2$ ).

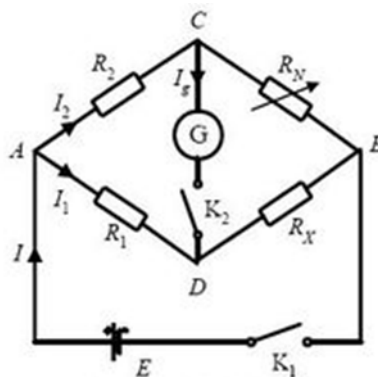


Fig.1: Wheatstone bridge circuit

**Special contradiction in testing low resistance with Wheatstone bridge:** The Wheatstone Bridge (single bridge) measures resistors, and its value is generally above 10  $\Omega$ . If a single bridge is used to measure low resistance, the additional resistances  $R'$  and  $R''$  (lead resistor and terminal contact resistor, etc.) and  $R_X$  are directly connected in series (Figure 2), and the values of  $R'$  and  $R''$  are equivalent to that of the measured resistor  $R_X$  and cannot be ignored. The resistance  $R_N$  is also a small resistor. Therefore, the formula  $R_X = R_1 \times R_N / R_2$  for measuring resistance using a single bridge cannot accurately determine the value of  $R_X$ .

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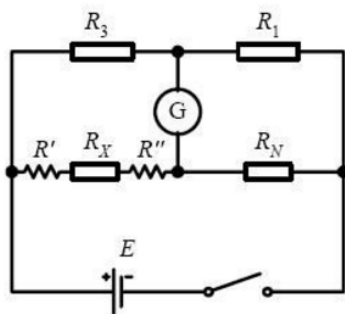


Fig.2: The effect of additional resistance on Wheatstone Single Bridge

**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  $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$  are all adjustable resistors,  $R_X$  is the measured low resistor, and  $R_N$  is the low value standard resistor. Compared with Wheatstone Single Bridge, Kelvin Bridge has made two important improvements:

- Added a bridge arm composed of  $R_2$  and  $R_4$  ;
- $R_N$  and  $R_X$  changed from two end connection to four end connection ;

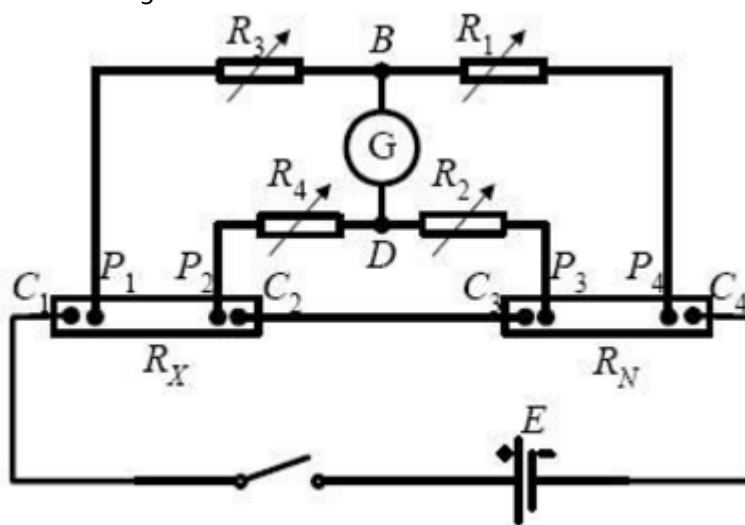


Fig.3: Schematic diagram of Kelvin Double Bridge

Among them,  $P_1 P_2$  constitutes the measured low resistance  $R_X$ ,  $P_3 P_4$  is the standard low resistance  $R_N$ ,  $P_1 P_2$  and  $P_3 P_4$  are often referred to as voltage contacts,  $C_1 C_2$  and  $C_3 C_4$  are called current contacts, cleverly transferring the wiring resistance and contact resistance of  $R_N$  and  $R_X$  to Internal resistance of the power supply and the bridge arm resistance with high resistance.

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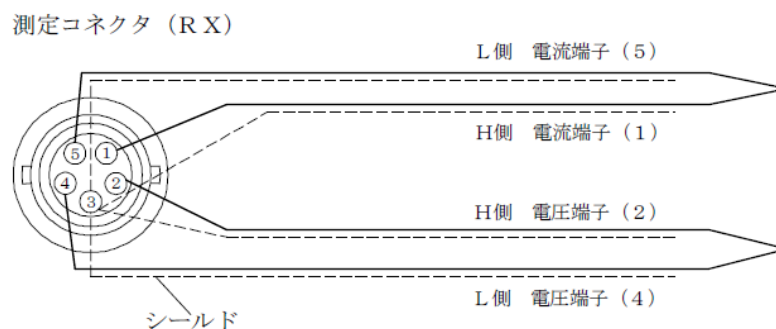
## §2 . Test equipment



### 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<br>+ 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                |                                          |                       |

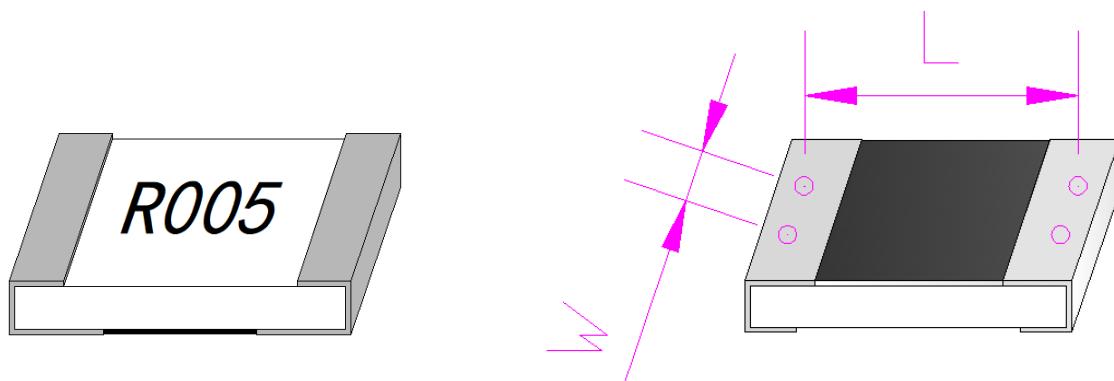
### Wiring method :



Note: This document may be changed without notice. For details, please consult the sales department

## Explanation of Precise Measurement of MS Series Resistors

### §3 . Measuring position of MS series resistors



### Measuring needle size :

| No. | Spec.       | Needle tip diameter<br>( $\pm 0.010$ ) | Needle body diameter<br>( $\pm 0.010$ ) | L ( $\pm 0.010$ ) | W ( $\pm 0.010$ ) |
|-----|-------------|----------------------------------------|-----------------------------------------|-------------------|-------------------|
| 1   | <b>0402</b> | 0.080                                  | 0.200                                   | 0.700             | 0.120             |
| 2   | <b>0603</b> | 0.100                                  | 0.200                                   | 1.050             | 0.400             |
| 3   | <b>0805</b> | 0.100                                  | 0.300                                   | 1.650             | 0.35              |
| 4   | <b>1206</b> | 0.100                                  | 0.350                                   | 2.600             | 0.800             |
| 5   | <b>2512</b> | 0.100                                  | 0.350                                   | 5.300             | 1.000             |
| 6   | <b>2010</b> | 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.