

2x4 wire resistance simplifies precision measurements

Application Note

Using two wires to measure resistance is convenient, but causes measurement error. You can virtually eliminate this error by using four leads and a multimeter with separate source and measure terminals. Unfortunately, adding additional leads and connections makes the measurement more complicated. You have additional leads to connect and you may have to swap clips and probes as you change from voltage to resistance. Now a new concept with new technology enables you to take four-wire resistance measurements with just two leads.

Why measure resistance with four wires?

Managing two leads can be challenging enough, especially when you are measuring tiny components in tight spaces. But trying to check a small solder joint, flex connector or chip resistor with four leads can be a real trial. Switching lead configurations can lead to swapped banana plugs and measurement mistakes. And changing from voltage probes to Kelvin leads and back takes time. So why measure resistance with four wires?

Using two wires to measure voltage does not seriously impact measurement accuracy. The voltage input on a multimeter generally has a 10 Megohm input impedance, so very little current flows in the leads, and the resulting voltage drop in the leads is negligible. Current measurements are also not significantly affected by series lead resistance. However, resistance measurements are subject to inaccuracies because of lead resistance.

When performing a resistance measurement the multimeter switches a current source into the measurement loop. The current is driven through the unknown resistance and the multimeter measures the resulting voltage drop. If there are only two leads, as shown in Figure 1, the source current travels on the same path used to measure the voltage drop. The measurement leads are not perfect conductors and have some series resistance of their own. By driving the current through the measurement leads, we see not only the voltage drop across the unknown, but also voltage drop for each lead. Thus, we end up measuring the combined resistance of the positive lead, the unknown, and the negative lead.

If we use four leads, the source current and the measurement can be separated. The meter terminals are called "Source" for the current supply and "Sense" for the voltage input.

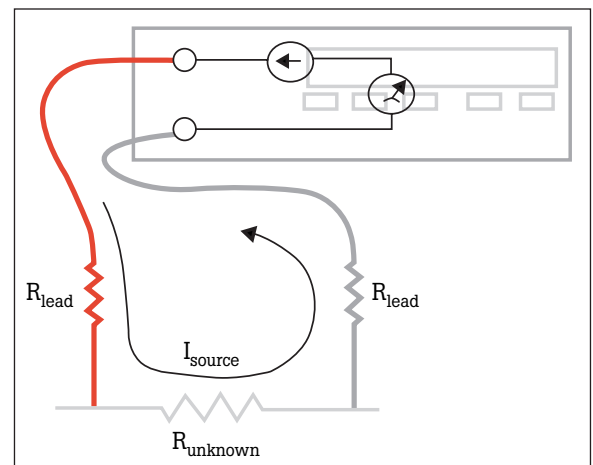


Figure 1: Two-wire resistance measurements introduce error due to voltage drop in the test leads.

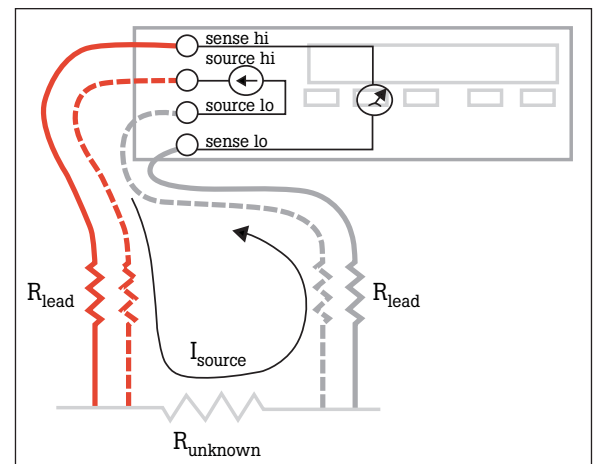


Figure 2: Four-wire resistance measurements eliminate current in the voltage leads and eliminate this source of error.

The series resistance in the Source leads does not affect the current flow. And the measure/sense leads have almost no current flow because of the meter's high input impedance. This means there is no $I \times R$ voltage drop in the measure leads. So, we measure only the voltage drop across the unknown resistor due to the source current flowing through it.

Introducing 2x4 wire ohms

A patented new technology from Fluke maintains the convenience of using two leads, but delivers the measurement performance of a 4-wire method.

The new Fluke 8845A and 8846A Precision Multimeters have a special set of input connectors. They are completely compatible with standard 4 mm banana plugs. But on the inside, each jack is split into two contacts: one source and one measure. Specially-designed test leads have two conductors per lead, again, one source and one measure. The leads align with the contacts inside the jacks and carry the separate source and measure signals over the full length of the leads.

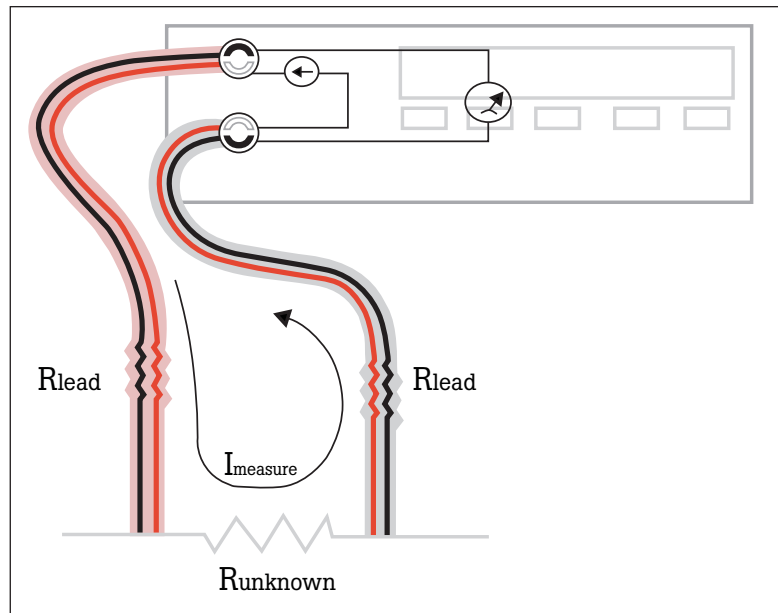


Figure 3: 2x4 wire ohms technology uses special split banana jacks and leads to deliver 4-wire performance with 2 leads.

At the far end of the leads, clips and probes that maintain separation between source and measure signals can deliver 4-wire performance right to the component under test. A new line of clips and probes is available, all of which bring four wires right up to the point of connection. They include:

- Test probes
- Alligator (Kelvin) clips
- Tweezers

All of these accessories may be used for measuring 4-wire resistance or voltage, so you won't be tempted to use bulky Kelvin clips to measure voltage.

2x4-wire ohms makes it easier to make accurate resistance measurements, without having to change cable configurations and without having to work with a bench full of silicone spaghetti.

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