

Four-Lead Measurement of Resistance

Most of the time we use a common ohmmeter to measure a resistance. The ohmmeter passes a known current through the object and measures the voltage drop produced by that current. Then, remembering the correct form of Ohm's Law, $R = V/I$.

The ohmmeter works well for large resistances (greater than a few 10s of ohms) and when it is possible for the probes to make good connections to the object.

If the resistance is very small, if it is difficult to make a good connection, or both, it is necessary to use a more complicated method to measure the resistance properly. The main problem in these two cases is that the resistance in the probes and connections becomes comparable to, or larger than, the resistance being measured.

1.0 Four-lead measurement technique

What is referred to as the “four-lead measurement” may also be known as “four-terminal sensing,” “four-wire sensing,” “four-point probes method,” “four-probe measurement,” and even “Kelvin sensing” after Lord Kelvin, who originated the technique. They are equivalent names for this method of making the measurements.

As shown in [Figure 1](#), the four-lead measurement technique uses a separate current source (schematically shown in the figure as a battery but any current source will work), ammeter, and voltmeter to determine the resistance.

The advantage of this method involves controlling the flow of current through all the connections – especially those used to measure the voltage. The measurement current flows through one set of connections, usually those that are farthest apart. If these connections are resistive (*i.e.*, the connections are poor) there will be significant voltage drop across them. However, this voltage drop doesn't matter as long as the power supply has a sufficiently high output voltage since the only parameter in which we are interested for these connections is the actual current flowing through the object. This current is being accurately measured by the ammeter in series between the object and the current source.

The voltage measurement uses a separate set of connections and the large input resistance (typically 10 M Ω for a digital voltmeter) means that the current flow through those connections will be very small. Thus, the voltage drop across these connections will be very small compared to the voltage drop across the object of interest unless the resistance being measured is comparable to the input resistance of the voltmeter. This means that we can get an accurate measurement of the resistance even if the resistance is very small or if it is not possible to make good connections.

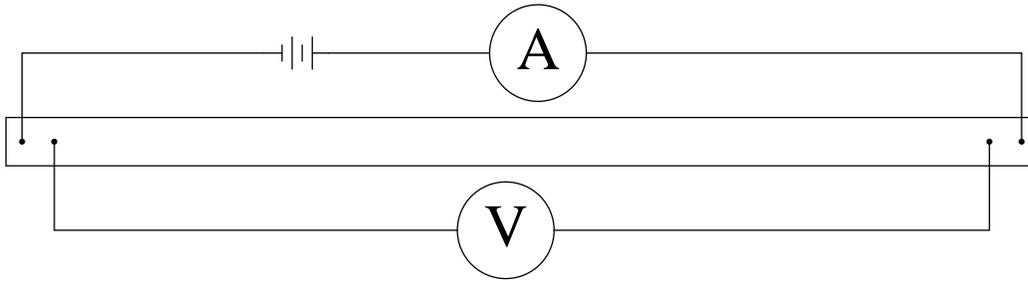


Figure 1: A schematic of a 4-lead measurement. Note that the current and voltage leads have *separate connections* to the object for which the resistance is to be determined. This is *critical* to the proper measurement of the voltage. Although the schematic indicates a battery in the lead with the ammeter, this can be replaced by any reasonable current source.

Note: the small clip leads do NOT make good connections. If you are using an ohmmeter to measure a resistance less than $10\ \Omega$ or $20\ \Omega$ you will not get good results. You can see this by just clipping the leads together and looking at the measured resistance – often 1 to $1.5\ \Omega$.

[Modified: January 16, 2019]