

Shunt Resistor Measurement Vol.5

Resistance Meter Series

This Technical Note introduces some considerations that apply to the testing and measurement of milliohm-order shunt resistor resistance values.

1. Resistance temperature coefficient

In low-resistance measurement, measured values vary greatly depending on the location at which the measurement current is applied and the location at which the voltage is detected, but the temperature coefficient also exhibits significant variation. Following is a specific example.

The resistance temperature coefficient of a shunt resistor such as that shown in Figure 1 was measured using the two methods illustrated in Figures 2 and 3. In Figure 2, the necessary connections have been made using pattern wiring with the land profile recommended for the component, while in Figure 3, the connections are made with lead wires. The measurement shown in Figure 2 yielded a temperature coefficient of $-46.8 \text{ ppm}/^{\circ}\text{C}$, while the measurement shown in Figure 3 yielded a temperature coefficient of $-421 \text{ ppm}/^{\circ}\text{C}$ —nine times higher than the value obtained for the mounted approach. These results suggest that application of current from fine probes, for example during component testing, has an adverse impact on the temperature coefficient.



Figure 1. Shunt Resistor Shape



Figure 2. Connections Using Mounted Patterns



Figure 3. Connections Using Lead Wires

2. Effects of Heating

The higher measurement currents generally used in low-resistance measurement result in increased

heating due to the resistance component of the measurement current path. Even when the low resistance value of the shunt resistor being tested means it generates almost no heat by itself, heating nonetheless results due to wiring resistance and probes' contact resistance. This heat is transmitted to the measurement target and affects measured values due to its relationship with the temperature coefficient as described above.

Figure 4 illustrates the results of measuring the resistance value while applying a measurement current using the connections shown in Figure 3. When the measurement current flows continuously, the resistance value decreases by 0.07%. Figure 5 provides a thermal image of the measurement target and surrounding area during resistance measurement. Since the measurement target has a low resistance value of approximately 0.5 mΩ, very little heating results. However, because the lead wires that comprise the measurement current path have a resistance of 3 mΩ/cm, they heat up, causing the temperature of the measurement target to rise 1.9°C. A calculation of the effects of the -421 ppm/°C temperature coefficient described above indicates an effect of -0.08%, a figure that closely resembles the observed decrease of -0.07%.

In this measurement example, the lead wires were soldered in place, but an even greater amount of heating would be expected if there were also probe contact resistance to factor into the calculation. The following two methods may be employed to avoid these effects:

- 1. Reduce the measurement current to lower the amount of heating.
- 2. Reduce the average amount of heating by using a pulsed measurement current, thereby shortening the amount of time that heating occurs.

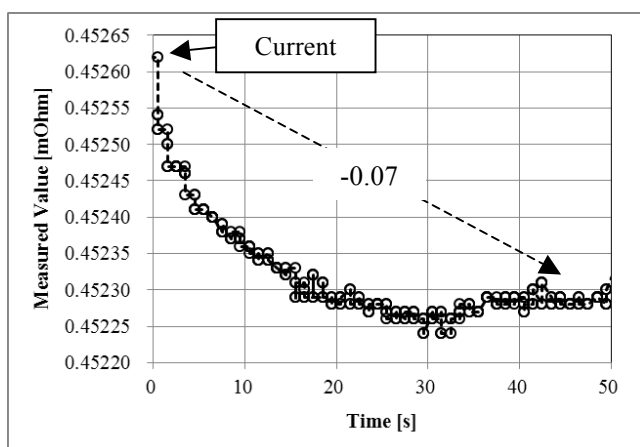


Figure 4. Measurement Value Drift When a Continuous Current Is Applied

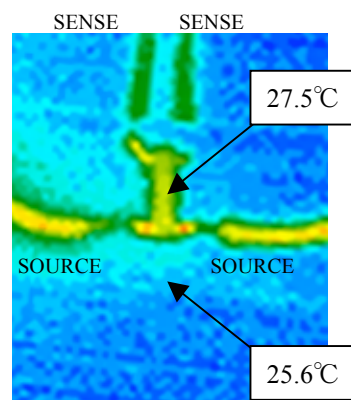


Figure 5. Heating during Measurement

Summary

When testing or measuring shunt resistors, it is necessary to exercise caution concerning heating caused by wiring resistance and contact resistance and to remain aware of fact that certain measurement methods may have an adverse impact on the resistance temperature coefficient. When it is not possible to keep the wiring resistance and contact resistance low, it is important to minimize

variations in resistance values caused by heating by lowering the measurement current or reducing the amount of time over which it flows.

Technical Notes explore measurement topics from a more in-depth perspective than conventional user guides. They are intended to be used in combination with product operating manuals, user guides, and other documentation.