Precautions when using Shunt Resistor

Effect of PCB Design on Temperature Coefficient of Resistance

● Summary

While resistance, power rating and size are important considerations when using shunt resistors, tolerances that affect the accuracy of the detected voltage must also be considered. These tolerances include the temperature coefficient of resistance and the tolerance of resistance at room temperature (Class F: ±1%).

The temperature coefficient of resistance indicates the change in resistance value due to a change in temperature of the resistor. Since resistance is affected by component temperature rise as current flows through and power is consumed, and ambient temperature changes, the temperature coefficient of resistance is an important factor in accurately detecting current values.

●Measuring the voltage across a shunt resistor

Shunt resistors typically have very low resistance, between a few μΩ and several hundred mΩ.

For voltage measurements at such low resistances, it is necessary to use a 4-terminal Kelvin connection. However, as shown in Figure 1, if the sensing lines are arranged outside the pads of the shunt resistor, an accurate measurement is not possible because the resistance of the copper foil and the solder in the wiring will be included.

In addition, the temperature coefficient of resistance of the wiring copper foil is about 3900 ppm/K, which is much larger than the intrinsic value of the shunt resistor, so the sensing lines must be arranged inside the pads of the shunt resistor, as shown in Figure 2, in order to reduce the influence of the copper foil from the perspective of temperature coefficient of resistance.

As an example, Figure 3 shows a comparison of the temperature coefficients of resistance (20ºC to 125ºC) for each sensing line for each resistance value of the GMR50.

For sensing lines (2) to (4), there is no significant difference, but for sensing line (1), the temperature coefficient of resistance is much higher. It can also be seen that the effect of the copper foil increases as the resistance decreases.

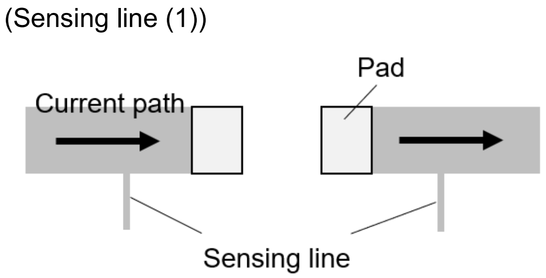


Figure 1. Example of incorrect sensing line layout

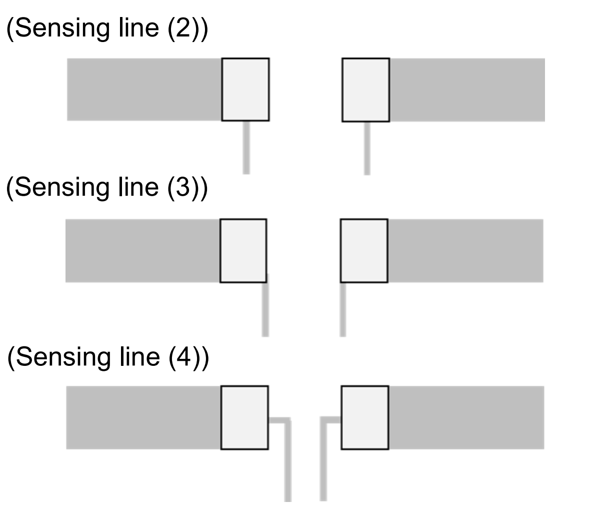


Figure 2. Example of correct sensing line layout

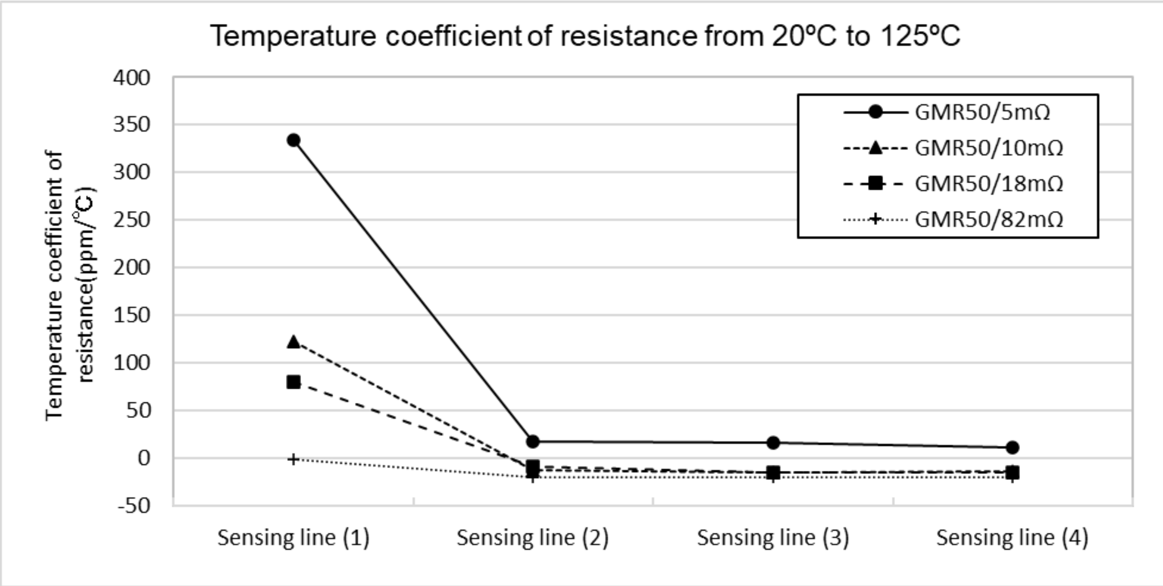


Figure 3. Comparison of the temperature coefficient of resistance of sensing lines

●Influence of temperature coefficient of resistance

[Resistance range: 10 mΩ or more]

There are two types of shunt resistors with resistance of 10 mΩ or more: thick film resistors and metal film resistors. Generally, thick film resistors use materials containing silver as the resistive element, which have a higher temperature coefficient of resistance, while metal film resistors use alloys with a lower temperature coefficient of resistance. Therefore, metal film resistors show better resistance temperature characteristics as the value of resistance decreases.

As a typical example, the following is the result of comparing change in resistance versus temperature for the thick film resistor LTR50 and the metal film resistor GMR50. (Figure 4)

*The resistance value at 20ºC is used as a reference.

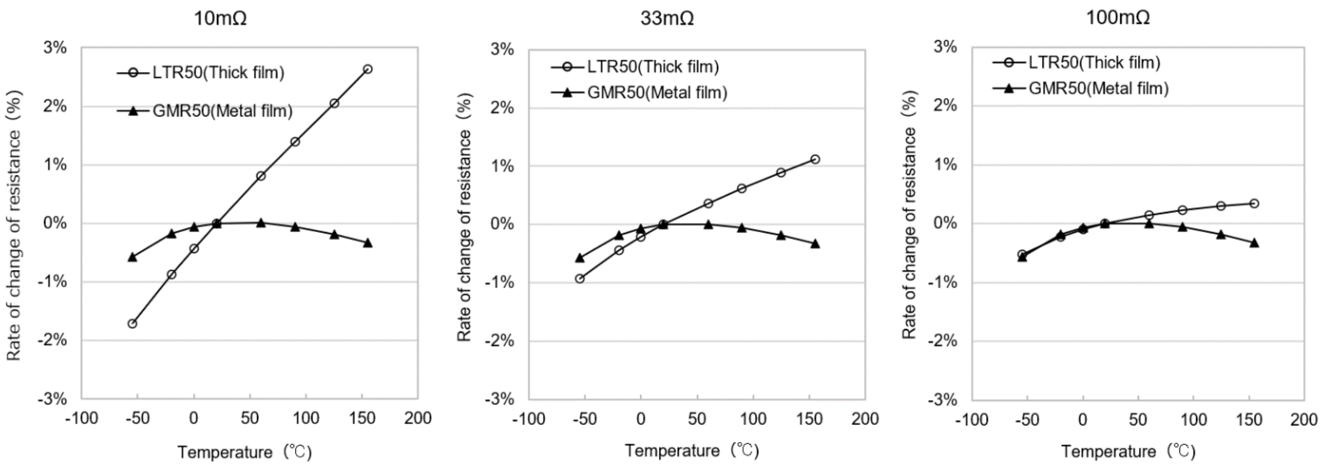


Figure 4. Comparison of change in resistance versus temperature for a thick film resistor and metal film resistor

[Resistance range: 10 mΩ or less]

When using shunt resistors of 10 mΩ or less, the temperature coefficient of resistance is affected by the copper foil of the mounting board and the copper electrodes of the product even if the sensing lines are arranged inside the pads of the shunt resistor as shown in Figure 2. This must be taken into account when designing the board. There are four factors that affect the temperature coefficient of the resistor:

- The location of the sensing lines
- The copper foil thickness
- The difference in gap width between a product's electrodes and its pads
- The current path

① Sensing line position

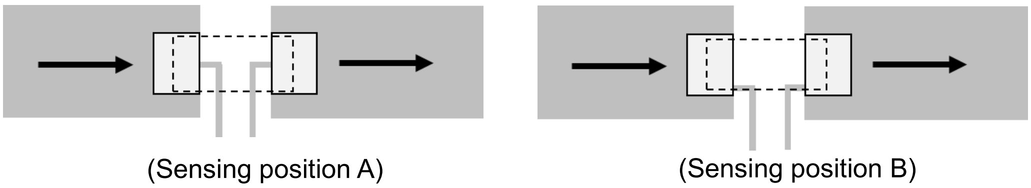
For shunt resistors of 10 mΩ or less, the temperature coefficient of resistance may vary depending on the location of the sensing lines, even within the pads, due to the influence of the copper foil and copper electrodes. In general, the lower the resistance value, the greater the effect.

Therefore, it is necessary to arrange the sensing lines in a position that minimizes these effects even within the pads.

As a typical example, the following shows the temperature coefficient of resistance (20ºC to 125ºC) of the PSR100/0.3 mΩ sensing lines measured from the centers (sensing location A) and the edges (sensing location B) of the pads. (Figure 5)

The results show that the temperature coefficient of resistance is higher when the sensing wires are positioned at the edges of the pads due to the copper foil.

The ROHM guaranteed values given in the datasheet are based on measurements taken on a board with the sensing lines arranged in the centers of the pads.



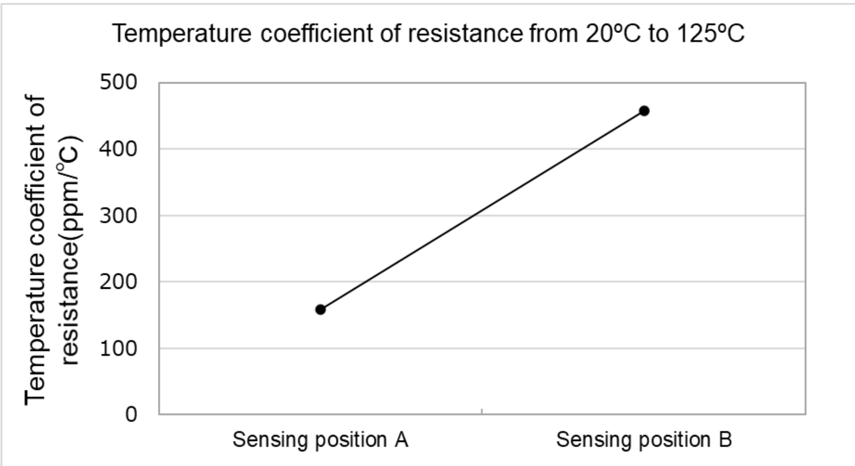


Figure 5. Comparison of temperature coefficient of resistance of PSR100/0.3 mΩ at different sensing positions

② Influence of copper foil thickness

In some cases, it is necessary to increase the thickness of the copper foil on the PCB to carry high currents or to improve heat dissipation. But the influence of temperature coefficient of resistance becomes larger as the thickness of the copper foil increases. As a typical example, the following is a comparison of the temperature coefficient of resistance (20ºC to 125ºC) of PSR100/0.3 mΩ at different board copper thicknesses. (Figure 6)

The temperature coefficient of resistance guaranteed by ROHM is based on the use of 35 μm copper foil.

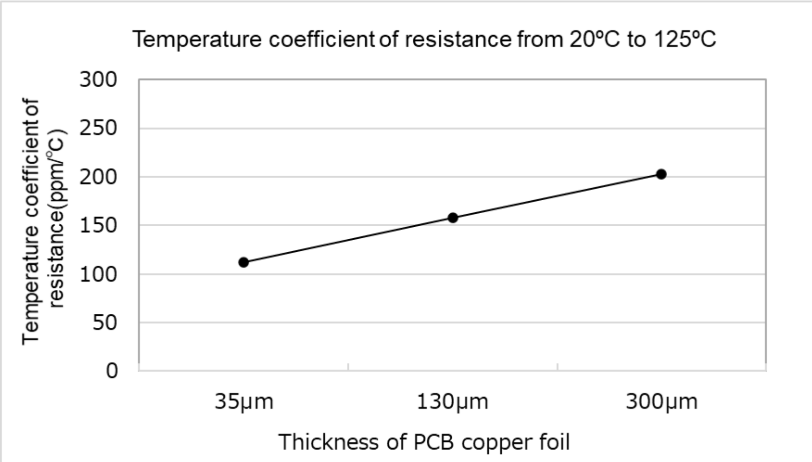


Figure 6. Comparison of temperature coefficient of resistance of PSR100/0.3 mΩ at different copper foil thicknesses

③ Difference in gap width between a product's electrodes and its pads

Since shunt resistors usually have different electrode dimensions, it is not always possible to use the manufacturer's recommended pad dimensions when purchasing from two suppliers. In this way, the temperature coefficient of resistance is also affected by the difference in gap width for the pads versus the product's electrode gap width.

As a typical example, the following is a comparison of the temperature coefficient of resistance (20ºC to 125ºC) of PSR100/1 mΩ at different pad gap widths. (Figure 7)

The results show that the temperature coefficient of resistance increases when the pad gap width is wider than the product's electrode gap width.

* This effect may vary depending on the structure of the product.

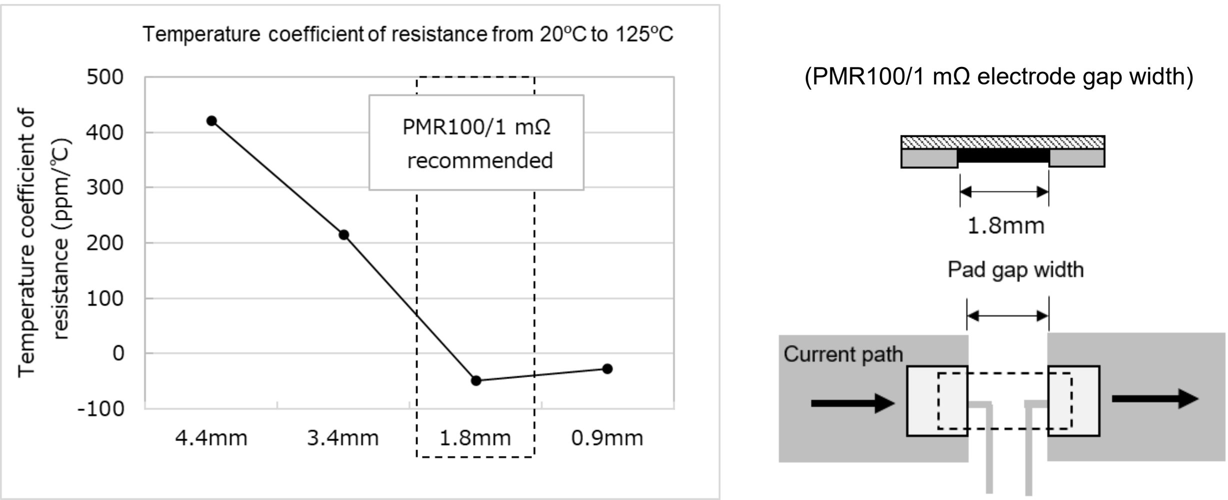


Figure 7. Influence of pad gap width on the temperature coefficient of resistance of PMR100/1 mΩ

④ Influence of current path

As explained earlier, the influence on temperature coefficient of resistance can be reduced if the sensing lines are arranged in the centers of the inner sides of the pads, but temperature coefficient of resistance is also influenced by the current path. As a typical example, the following is a comparison of the temperature coefficient of resistance (20ºC to 125ºC) of PSR100/0.3 mΩ for three different current paths. (Figure 8)

This comparison is based on the assumption that the product may be misaligned with respect to the sensing lines due to board manufacturing accuracy or mounting misalignment.

The results show that the influence of misalignment between the product and the sensing lines on the temperature coefficient of resistance varies depending on the current path.

In the case of current path B, it can be said that the temperature coefficient of resistance is improved when the sensing lines are designed to be shifted in the negative direction from the center of the product (pad), as shown in Figure 8.

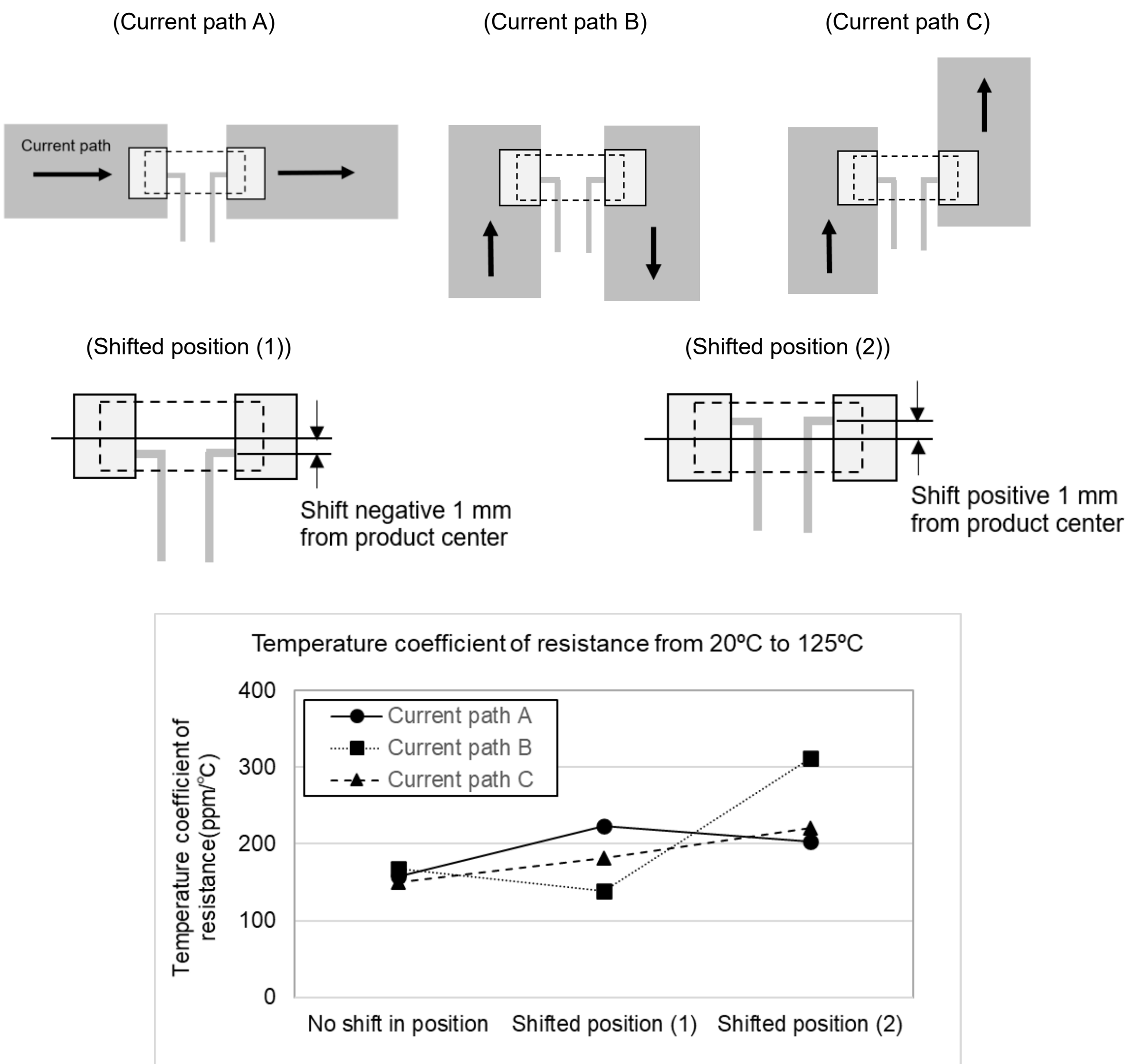


Figure 8. Influence of different current paths on temperature coefficient of resistance of PSR100/0.3 mΩ

Summary

The magnitude of these effects on the temperature coefficient of resistance depends on the product (product structure, size, copper electrode thickness, and resistance).

In general, the lower the resistance of the product, the greater the effect

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