Parallel Placement of Current Sensing Resistors

§0. Abstract

Generally, resistors with resistance value lower than few mΩ are used for current sensing. Voltage measurement using the low ohmic value resistors have the possibility of being effected by resistance value and T.C.R. of copper foil patterns, or current path and voltage measurement positions. When the current sensing resistors are mounted in parallel, the effect will become more complicated. The points that should be taken care in the design when minimizing the effect will be explained.

§1. Effects of resistance value and T.C.R. of copper foil pattern

The resistivity of copper foils used as patterns in the printed circuit board are only approximately 1.7μΩcm, so its resistance value and T.C.R. are not usually considered in general design of electronics. However, when it is for electronic circuits that use resistors with few mΩ or lower resistance value, it is important to correctly comprehend the effect of copper foil patterns and implement appropriate design.
Fig. 1 shows a recommended current path and voltage measuring position when a single current sensing resistor is used.

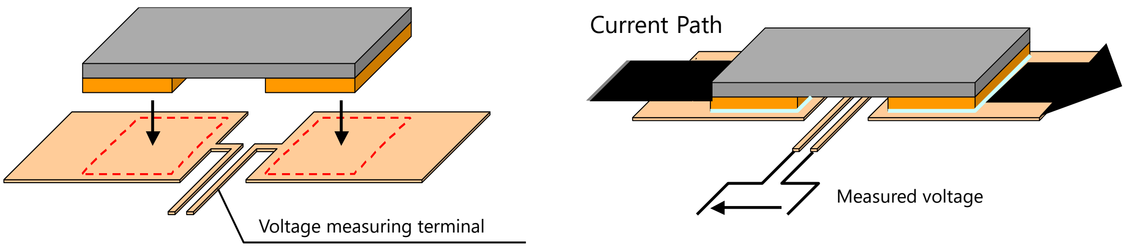
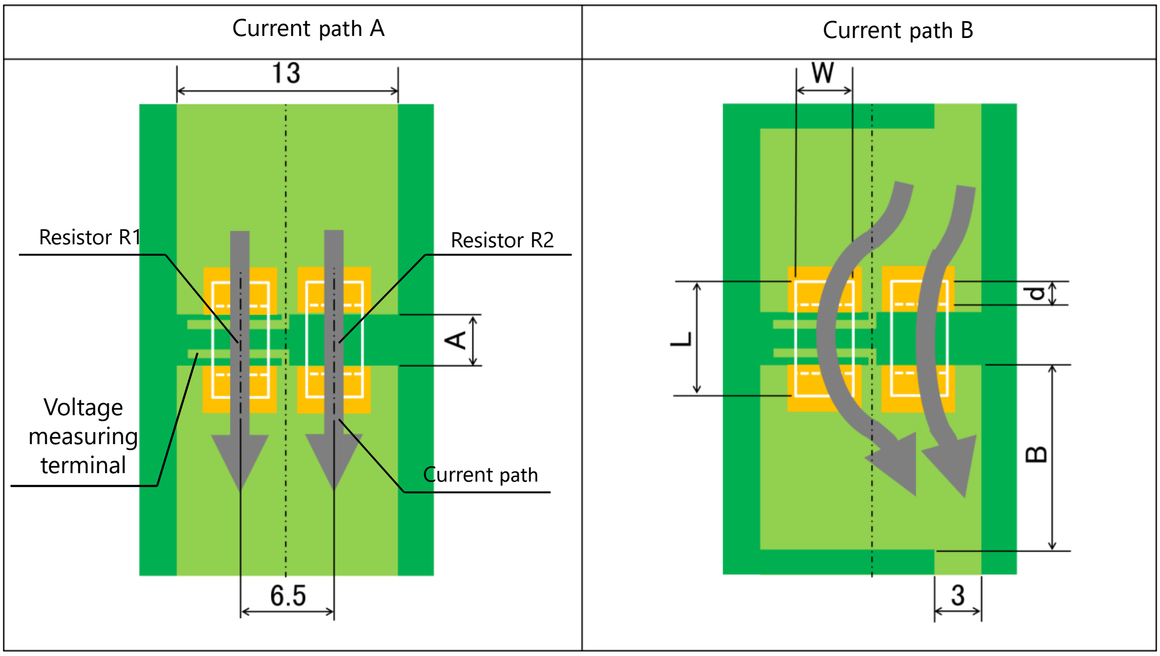


Fig.1 Recommended current path and voltage measurement position when using a single resistor.

In order to minimize the effect of copper foil pattern, it is necessary to layout the resistors so that the current flows in a straight line. The voltage measurement position is placed in the center, between the mounting pads.
If the current path and voltage measurement position cannot be implemented as shown in Fig.1, then it is necessary to correctly understand the increase of effect caused by the copper pattern and minimize the effect in the design.
For details, please refer to our Technical Note: "Voltage Measurement Using Current Sensing Resistor".

§2. Effects of Current path and Voltage Measuring Position in Parallel Placement

When current sensing resistors are placed in parallel, the effects of copper foil pattern can be very complex.
The error of the measured voltage and difference of the temperature coefficient of resistance will be explained for the following two examples: current flows through two resistors in a straight line (Current Path A), current enters two resistors from the right side and flows out in the same side (Current Path B).
Fig. 2 shows simulation models. The current sensing resistors used are TLR3AP of 1 mΩ, the copper foil pattern is 70μm thick, and the temperature coefficient of resistance of the resistors is 0ppm/K.



(mm)

L	W	d	A	B
6.35	6.35	2.2	1.45	11.275

Fig. 2 Simulation models

When the voltage measuring position is shifted to the left and right from the center (X=0 mm) of two resistors as in Fig. 3, the errors in measured voltage are as shown in Fig. 4, and the temperature coefficients of resistance are as shown in Fig. 5.

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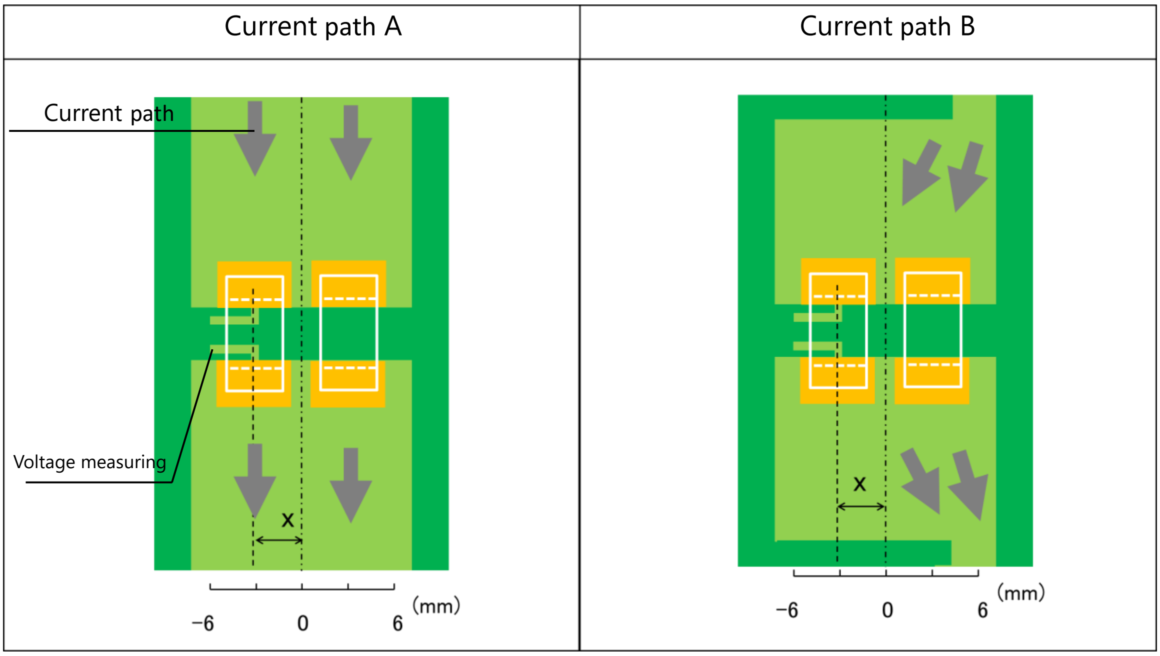

Fig. 3 Voltage measuring position

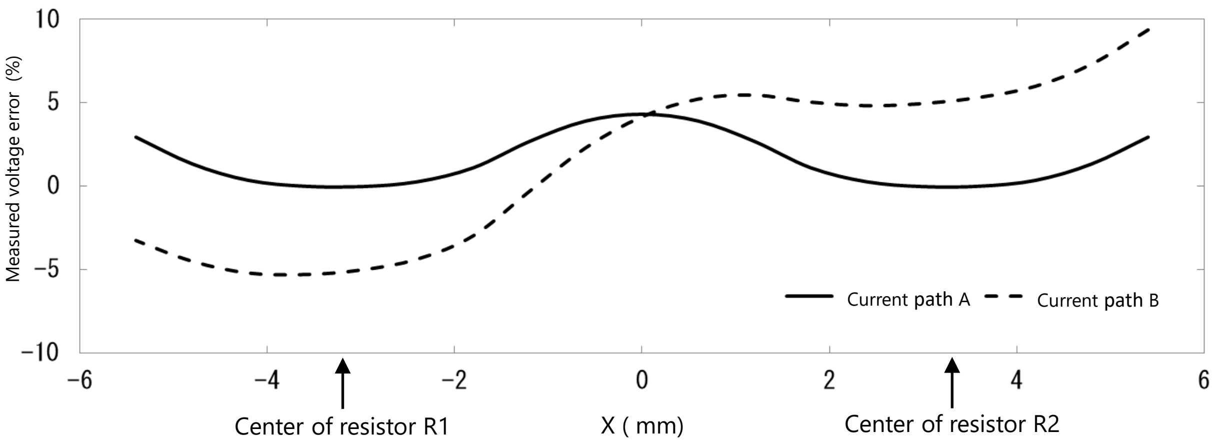

Fig. 4 Changes in measured voltage error effected by current path and voltage measuring position

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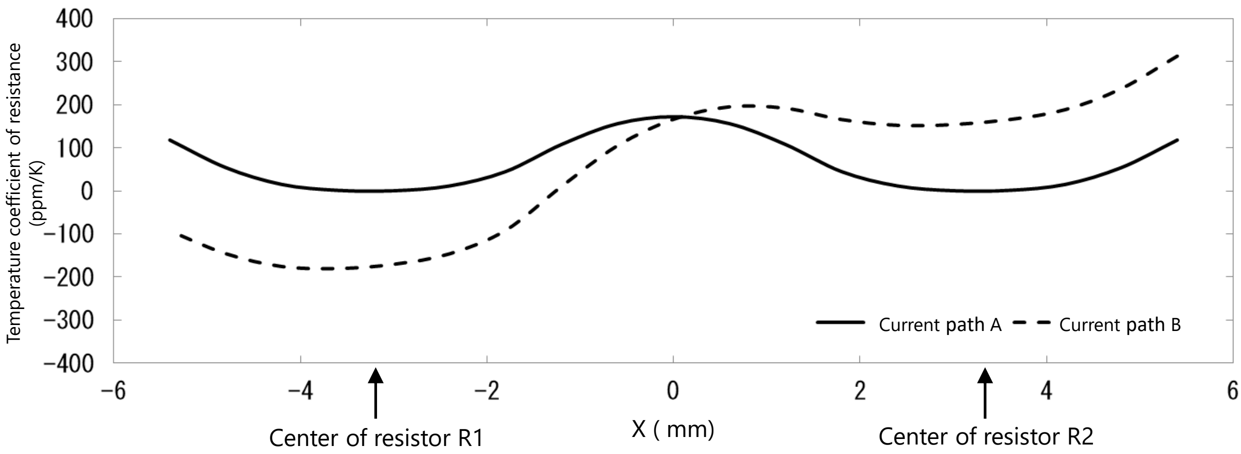

Fig. 5 Changes in T.C.R. effected by current path and voltage measuring position.

For current path A, the error in measured voltage and the temperature coefficient of resistance become minimum when the voltage measuring position is at the center of the resistor R1 or R2.
For current path B, the optimum voltage measuring position is near X=-1.3 mm. However, the graph shows a steeper slope near X=-1.3 mm, which means a slight deviation causes greater error in measured voltage and larger temperature coefficient of resistance. Therefore, it is necessary to pay attention to the manufacturing accuracy of the printed circuit board and the position gap of component mounting.
Also, it can be seen that the position near the center of resistor R1, which is the optimum voltage measuring position for current path A, is where the error in measured voltage and the temperature coefficient of resistance become maximum for current path B.
The case of current path B is simply an example, and therefore the optimum voltage measuring position can vary greatly depending on the component arrangement and current path.
From the above observation, design is recommended such that an optimum voltage measuring position be selected using a simulation when the current path is not straight.

§3. Conclusion

The following needs to be taken care of when current sensing resistors with resistance value below few mΩ are used in parallel.
The current path must be so arranged as to be as balanced as possible for all the resistors. In this case, the voltage measuring position must be at the midportion inside the mounting land of one of the resistors.
When the current path to the resistors are disproportionate, the optimum voltage measurement position will greatly vary depending on the current path and component layout. It is effective to use simulation for defining the optimum connection point of the voltage measurement position. If there are requests for us to review or make proposals, please provide us with design information such as pattern figure, copper foil pattern thickness etc.
For notes on voltage measurement using current sensing resistors, please refer to our Technical Note: "Voltage Measurement Using Current Sensing Resistor".