TOKEN

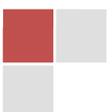# How to Design & Select Current Sense Devices

Token Electronics Industry Co., Ltd.

Taiwan: No.137, Sec. 1, Zhongxing Rd., Wugu District,
New Taipei City, Taiwan. 248012
Tel: +886 2981 0109   Fax: +886 2988 7487

China: 17P, Nanyuan Maple Leaf Bldg., Nanshan Ave.,
Nanshan Dist., Shenzhen, Guangdong, China. 518054
Tel: +86 755 26055363

Web: www.token.com.tw

Email: rfq@token.com.tw

Design & Selection

How to Design & Select Current Sense Devices

Generally, a resistor manufacturer will offer their most popular devices as standards creating a reference for Engineers to design from. Typically, and especially true in the Current Sensing category, a standard device is available for most common applications. However, for applications requiring parameters that are not currently considered industry standards, Token is uniquely equipped to offer design and development services at comparatively lower costs than our competitors. In this case, the following information is required to effectively design a current sensing resistor:

Point 1 - Power Rating
Calculate the power dissipation under operating conditions

Equation: $P_{avg} = I_{RMS}^2 \times R$; where Power (P), Current (I), Root Mean Square (RMS), Resistance (R).

Allowing for transient or fault conditions and high ambient temperature if applicable, select the required power rating.
For many current sense resistors, only the maximum temperature of the solder joints limits the power rating.
Power rating is thus a function of the PCB layout design as well as of component selection
(sees point 4.).

Point 2 - Resistance Value
Determine the minimum suitable resistance value. This is the lowest value of peak sense voltage consistent with an acceptable signal to noise ratio, divided by the peak current to be measured.

Point 3 - Temperature Coefficient of Resistance (TCR)
Establish the accuracy needed in terms of a tolerance on the value and of sensitivity to temperature. The latter factor is quoted as Temperature Coefficient of Resistance (TCR), defined as the value change in parts per million for a 1°C temperature rise. It is generally higher for low value resistors because the metallic leads or terminations, which have a very high TCR, make up a significant part of the total resistance value.

To achieve acceptable accuracy it is normally necessary to make four-terminal (Kelvin) connections to the resistor. This means connecting the current carrying tracks and the voltage sense tracks directly to the component pads. Even when this is done, there is still some pad area and solder in series with the resistor, which may compromise the actual tolerance and TCR of the soldered part. For very high accuracy or very low values, a four-terminal resistor type is the best choice.

Point 4 - PCB Layout
Care must be taken when laying out a PCB if the stated performance of a sense resistor is to be achieved. The current carrying tracks should be as wide as possible, using multiple layers connected by many vias near the component pad. This also improves the heat sinking of the joints.

The best way to make four-terminal connections to a two-terminal through-hole resistor is to use different sides of the PCB for the current and voltage connections. Failing this, current and voltage tracks should connect to opposite sides of the component pad.

In order to avoid interference from stray magnetic fields, the loop area contained by the sense resistor, the voltage sense tracks and the sense circuit input should be minimized. This means keeping the sense circuitry as close as possible to the sense resistor and running the voltage sense tracks close to each other.

Point 5 - High Frequency Applications

Where transient or AC currents involving high frequencies are to be sensed, the self-inductance of the resistor must be minimized. Wire wound or spiraled film parts should be avoided, in favor of bulk metal or low value chips.

Point 6 - High Heat Dissipation

When using a metallic element shunt with high heat dissipation and low sense voltage, consideration may need to be given to thermoelectric voltages. The junction between a metallic resistance element and metal terminations acts as a thermocouple, generating a voltage proportional to the temperature difference across it.

A leaded metallic element sense resistor is therefore like two thermocouples back to back. This means that, if the temperature differences across both junctions are equal, the error voltage is cancelled out. This is achieved by making the design thermally symmetrical, namely, by presenting both terminals with similar heat sinking and by keeping any other heat sources thermally distant.