Facts in Brief

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Vishay Bulk Metal® Foil Resistors Introduces New Generation of Power Current Sense Resistors With Excellent Thermal Stability and Long-Term Low Absolute TCR of 0.2 ppm/°C

The most precise measuring of electrical current is achieved by the current sensing resistor method. The precision and speed of response to changing current depend on thermal stability of the resistor, as determined by its low temperature coefficient of resistance (TCR) and related power coefficient of resistance (PCR). Vishay's new-generation Bulk Metal® foil resistor technology and internal design reduces maximum TCR to less than 0.5 ppm/°C, while a special construction reduces thermal distortion, resulting in a current detector with a precision of a few parts per million (PPM) within a fraction of a second.

Technological Breakthroughs

- Highly efficient thermally-conductive resin to bond the Bulk Metal Foil element to ceramic
- Highly efficient thermally conductive resin to bond the chips to heat sink
- Chip selection: all chips from the same production batch for very tight TC tracking
- Special chip calibration method to ensure a uniform heat dissipation
- Special concept of TCR compensation for almost zero TCR even at low values
- Different Lead diameters (cross section) for different current specs:
  e.g.: 1 mm (18 AWG) for 15 A
  1.3mm (16 AWG) for 20 A
  etc.

Flexibility of Construction Tailored Per Customer's Spec

- Size and type of heat sink: with or without mounting holes
- Size of resistor
- Mounting method with screws or bonded with conductive epoxy and clamps
- Wide range of resistive elements may be used to adapt the resistor to customer specification
- Special construction and connections to reduce the internal contact resistance points and to avoid noise and hot spots

Electrical Specifications

- Value range : 0.5mR to 500R
- Absolute tolerance: ± 0.01 %
- Absolute TCR: < ± 0.2 ppm/ºC (0˚C to + 60 ˚C, or + 20 ˚C to +70 ˚C)

- Working power : 20 W in free air, 60 W on heat sink
- Max. current: 22 A for > 10 mR, > 22 A for values less than 10 mR
- Thermal resistance (element to heat sink): 2˚C/W
- Power coefficient : < 1 ppm/W
- Stability: 0.005 % for 2000 hrs in free air
- Very low current noise
- Matched sets are available
- In-Process and Post Manufacturing Operations (PMO) tests are performed for high-end industrial, metrology, and instrumentation applications

How To Order
Please provide us the following information:

1. Resistance value
2. Tolerance
3. Maximum Power/Current/Voltage
4. Working conditioning
5. Temperature range
6. Total error budget or end of life tolerance
7. Pulse profile
8. Demand for increased stability using PMO

Please contact us at: Foil@vishay.com

Samples are available from 5 working days.

Technology Background:
The art of current sensing calls for a variety of solutions based on application requirements. Current sensing is best achieved with a Kelvin connection, which removes the unwanted influences of lead resistance and lead sensitivity to temperature. Other requirements such as high stability and short thermal stabilization time when the power changes may dictate a special resistor design. High-precision resistors used for current sensing are usually low ohmic value devices suitable for four terminal connections.

Two terminals, called "current terminals," are connected to conduct electrical current through the resistor, while voltage drop V_S is measured on the other two terminals, called "sense" or "voltage drop" terminals. According to Ohm's law, the sensed voltage drop V_S divided by the known resistance R_S gives the sensed current I_S. The accuracy of measurement depends on the stability of ohmic resistance R_S between the nodes, i.e. the points of connection of the sense leads. Since the voltage leads feed into an “infinite” resistance circuit, there is no current flowing through the voltage terminals and, therefore, no IR drop in the voltage sense leads. Thus, the four-terminal system eliminates the voltage-drop errors originated in the leads when the voltage terminations are connected close to the resistance element (excluding significant portions of the leads that carry the current.)

This arrangement, called a "Kelvin connection", reduces, especially for low ohmic resistance values, a measurement error due to the resistance of the lead wires and the solder joints as the sensing is performed inside the resistor, in or close to the active resistive bulk metal foil element.

Of the commonly used methods of measuring the magnitude of electrical current, this current sensing resistor method provides the most precise measurement. According to Ohm's law, V = IR, the voltage drop measured across a resistor is proportional to the current flowing through the resistor. With the known value of the resistance R, the voltage drop sensed on the resistor indicates the intensity of the current flowing through it.

Assuming an ideal current sense resistor that doesn't change its resistance value when there is a change in the magnitude of the current or a change in environmental conditions, like the ambient temperature or self heating, the measured voltage drop will yield a precise value of the current: I = V/R. But with a real-life resistor, such as a metal film resistor or a manganin bar, a change in current intensity (and in the dissipated power) will cause a change in the resistor's value which will involve a thermal transient period taking a few seconds or longer to stabilize.

Therefore, the key to a fast and precise measurement of current is the use of a real life current sensing resistor which approaches, as closely as possible, an ideal resistor. That is, a resistor that is not influenced by changes in the magnitude of the current flowing through it nor by changes in ambient temperature or any other environmental condition.

Real life resistors exhibit two temporary changes from their room-temperature values:

1. When they are cooled or heated by a changing ambient temperature, and
2. By self-heating due to the power they have to dissipate (Joule effect.)

When a high precision is required, these two effects induce a change in the resistive element's temperature, ΔT_a due to ambient and ΔT_{sh} due to self heating, both of which must be considered.

The ambient temperature changes slowly, and all parts of a resistor follow uniformly the change of the ambient temperature, but the effect of the dissipated power is different. The temperature of the resistive element — the active part of the resistor — will change rapidly with the change of the intensity of current. The power it has to dissipate will change proportionally to the square of the current and a rapid increase in current will cause a sudden increase in the temperature of the resistive element and in the heat that must be dissipated to the ambient air. A rapid decrease in current will take longer to register the current change because the heat build-up takes longer to dissipate through the physical encapsulants. These two effects of resistance changes are quantified by TCR – Temperature Coefficient of Resistance and by PCR – Power Coefficient of Resistance (called also "Power TCR").

A special design is needed to account for the different influence of these two factors and to get an essentially zero resistance drift through changes in either current applied or ambient temperature. The TCR is linked to the change of ambient temperature which usually occurs slowly and therefore it can be assumed that the resistor's resistive element and its substrate are at the same temperature. This is not the case with self heating by dissipation of power, especially for surface mounted devices.

Thermal EMF (electro-motive force, or voltage) is another factor to be considered in precision current sensing applications. Thermal EMF may become a significant DC offset voltage error or instability in high-precision resistors for low-value DC applications, and is considered a parasitic effect interfering with pure resistance measurement. It is caused by the dissimilarity of the materials used in the resistor construction, especially at the junction of the element and the lead materials.

The thermal EMF performance of a resistor can be degraded by external temperature differences between the two junctions, dissymmetry of power distribution within the element, and the dissimilarity of the molecular activity of the metals involved.

Figure 1: Short settling time following application of 19 A, value 10mR, ***TCR + 1 ppm/C*** *Temperature range + 20 °C to + 60 °C*

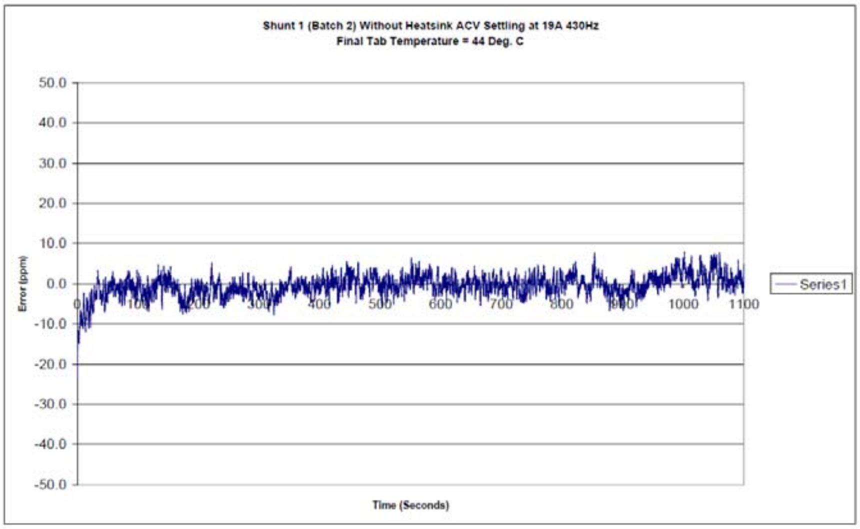


Figure 2: Short settling time following application of 19 A, value 10 mR, ***TCR - 0.5 ppm/C.*** *Temperature range + 20 °C to + 60 °C*

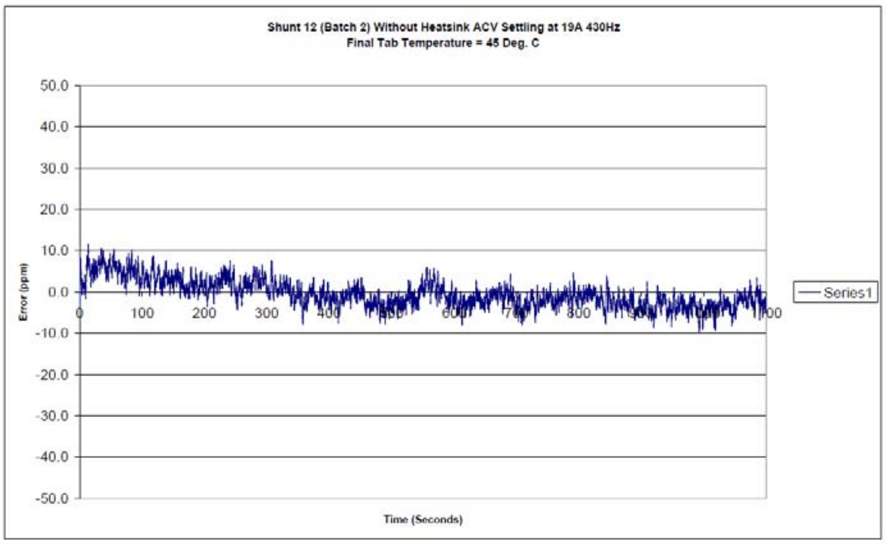
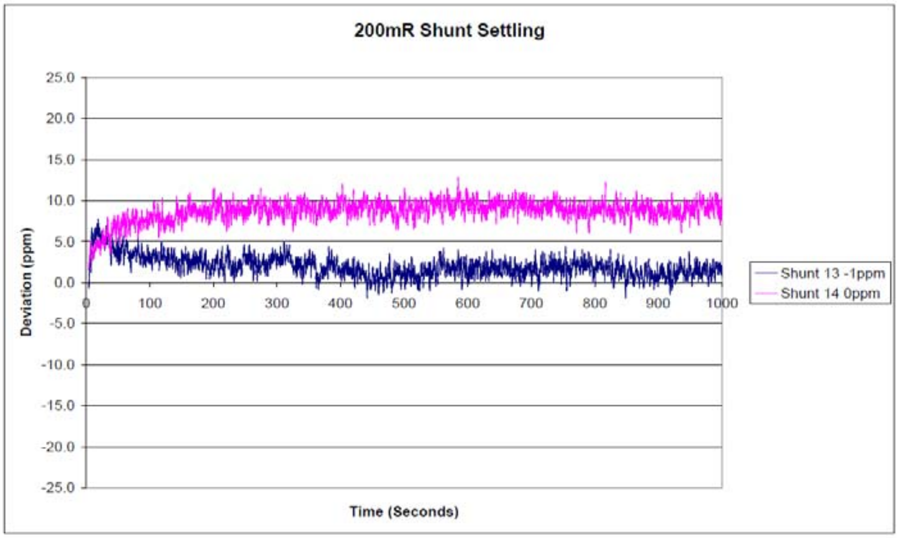


Figure 3: Excellent settling match of two resistors 0R2 each, mounted in parallel under power of 3 W



Images of the new generation Bulk Metal Foil current sense resistors: