VISHAY PRECISION GROUP

Facts at a Glance

From: Vishay Foil Resistors
January 1, 2011
FACTS #112

Original release: December 4, 2009

Author: Yuval Hernik
Tel: +972-3-557-0852
E-mail: Yuval.Hernik@vishaypg.com

TCR (Temperature Coefficient of Resistance) and PCR (Power Coefficient of Resistance) Improvements for High-Temperature Use

Over the past few months, there has been considerable growth in the demand for precise, stable and reliable resistors that can operate in harsh environments and especially at high temperatures.

Many analog circuits for industrial, military, aerospace, medical, down-hole, oil well and automotive applications require passive components such as resistors to have a minimal drift from their initial values when operating above + 175 °C and in humid environments.

In these applications, the most important factor is the end of life tolerance which is part of the stability and, to a lesser extent, the initial tolerance. Vishay Foil Resistors provide stabilities well under the maximum allowable drift required by customers' specifications through thousands of hours of operation under harsh conditions such as the extreme temperatures and radiation-rich environs of down-hole oil-well logging applications, in the frigid arctic, under the sea or in deep space.

All Bulk Metal® Foil resistors receive stabilization processing such as repetitive short-term power overloads to assure reliable service through the unpredictable stresses of extreme operation.

Compared to Bulk Metal® Foil, Thick and Thin Film resistor elements are produced with a non-controllable material. Heat or mechanical stresses on the resistive elements cause the particles forming the film to expand. However, after these stresses are alleviated, the particles in the film matrix do not return to the exact same original position which degenerates their overall stability.

Bulk Metal® Foil resistors come in a variety of configurations and chip packages with special gold or silver terminations to provide an array of power ratings, sizes, resistance values and other operating specifications to meet stability and reliability needs in extreme applications – especially for high temperatures. Wire-bondable chips start with the 0505 size and SMT chips start with the 0603 size.

Vishay Foil Resistors' ultra-high precision Bulk Metal® Foil technology includes many types of resistors with a variety of standard configurations that can withstand unconventional environmental conditions above and below the earth's surface using special post manufacturing operations specially developed for this purpose.

The stability of a resistor depends primarily on its history of exposures to high temperature. Stability is affected by:

1. Changes in the ambient temperature and heat from adjacent components (defined by the Temperature Coefficient of Resistance, or TCR)
2. Destabilizing thermal shock of suddenly-applied power (defined by the power coefficient, or PCR)
3. Long-term exposure to applied power (load-life stability)
4. Repetitive stresses from being switched on and off

In very high-precision resistors, these effects must be taken into account to achieve high stability with changes in load (Joule Effect) and ambient temperature.

Vishay Foil Resistors' new Z-Foil technology provides an order of magnitude reduction in the Bulk Metal® Foil element's sensitivity to temperature changes — both external and internal. This technology provides an absolute TCR of ±0.05 ppm/°C typical (instrument range), ±0.2 ppm/°C typical (military range) and a PCR of 5 ppm at rated power.

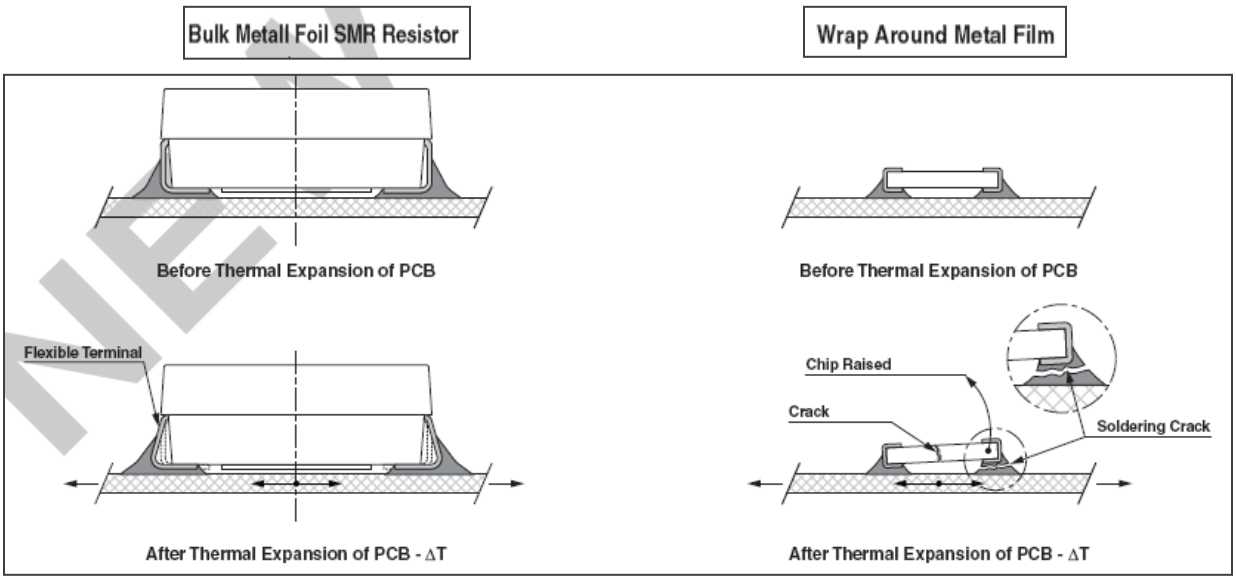
In order to take full advantage of this TCR improvement, it is necessary to take into account the differences in the resistor's response to each of the above-mentioned effects. As is described below, new products have been developed to successfully deal with these factors.

SMD 1206 reliability:

It is well known that chips of 1206 and larger dimensions occasionally fall off the printed circuit board or develop cracks especially in high-temperature conditions. This is due to stresses introduced into the chip by handling of the PC board and stress due to temperature changes.

Vishay Foil Resistors' new SMRXD Series of molded chips feature flexible terminations to prevent cracking of the body and delamination from the board even in resistors with high aspect ratios. (See Figure 1)

Figure 1:



Original release: December 4, 2009

ESD:
Electrostatic discharge (ESD) is another potential problem that can cause unpredictable failure. ESD damage to electronic devices can occur at any point in the device's life cycle, from manufacturing to field service. A resistor that is exposed to an ESD event may fail immediately, or may experience a latent defect. With latent defects, premature failure can occur after the resistor is already functioning in the finished product for a period of time. Vishay Foil Resistors are capable of withstanding electrostatic discharges above 25,000 volts without degradation.

Post Manufacturing Operations (PMO) for high temperature applications:
Foil technology allows Vishay Foil Resistors to produce customer-oriented products designed to satisfy unique and specific technical requirements.

In addition to the special Chip Stabilization in the production line, Vishay Foil Resistors offers additional specially oriented post manufacturing operations (PMO) for high-temperature applications that require an even higher degree of reliability and stability.

Examples of Products:

S102C/K, Z201, Z203:

Although standard ratings go to + 125 °C, Vishay Precision Group's customer experience with down-hole applications indicate operating temperatures of + 200 °C for hundreds of hours, with much higher temperature excursions. The unique design of the foil S102C/K or Z201/3 resistors prevents damage to the part due to possible solder reflow. The internal lead connection to the resistor element is at the opposite end of the resistor from where the leads enter the package. Additionally, the lead connection to the resistor is a welded connection, no solder is used (See Figure 2).

Figure 2:

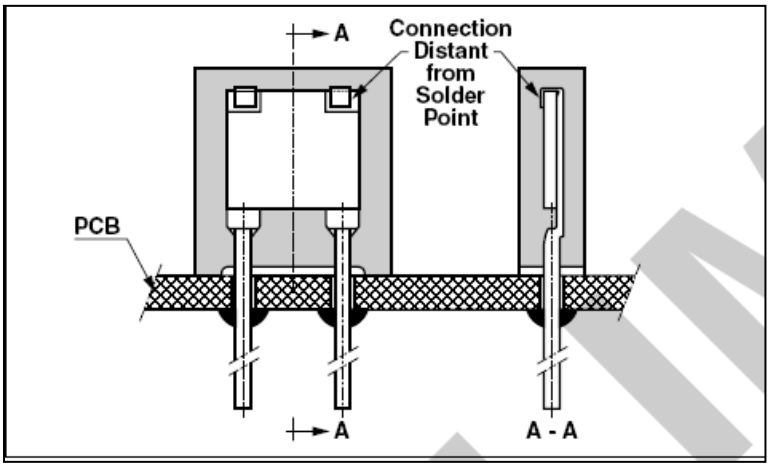


Table 1: examples of solutions for high temperature use

Type (*)	Configuration	Temperature 1000 hours	Termination Finish	Mounting Method	Comments
SMR1D(Z)	Surface Mount	175 °C	100 % Tin Plated Copper	Solderable	Flexible terminations
SMR3D(Z)	Surface Mount	175 °C	100 % Tin Plated Copper	Solderable	Flexible terminations
VSMP Series (0603-2512)	Surface Mount	180 °C	100 % Tin Plated Copper	Solderable	
VFCPH	Surface Mount	200 °C	Gold Plated Pads	Epoxy Bondable	Flip chip
L102	Leaded	200 °C	100 % Tin Plated Copper	Leaded	
300144HT	Leaded	200 °C	100 % Tin Plated Copper	Leaded	Voltage Divider
PRND network	Surface Mount/ Leaded	200 °C	Gold Plated Pads	Solderable	Hermetically sealed
VCS1625	Surface Mount	200 °C	Gold Plated Pads	Solderable	Current Sensor , power applied
Hybrid Chips V5x5 V 15 x 5 V 15 x 10	Wire bondable	200 °C	Gold Plated Pads	Epoxy Bondable	For Gold wire connections. Power applied.
V15 x25	Surface Mount	220 °C	Electrolytic or gold immersions terminations	Solderable	Current sensor for gold or aluminum wire connections Gold plated back side. Power applied.
VHD200 Style (Air Filled)	Leaded	200 °C	100 % Tin Plated Copper	Leaded	Hermitically sealed Voltage Divider

(*) all the products include PMO with a special high temperature treatment for increased stability

Our Applications Engineering department is always available to assist in any special requirements you might have. If you are not sure which resistor best suits your needs, please do not hesitate to contact them.

For more information about this product group, please contact us at: **Foil@vishaypg.com**.

Follow Vishay Foil Resistors on Twitter: **@VPGFoil** or “Like” our Vishay Precision Group fan page on **Facebook**.