Resistive Products | Tech Note TN-0026

Ultra-High Precision Vishay Bulk Metal® Foil Resistors in Extreme Environments

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

Many analog circuits for industrial, military, aerospace, medical, down-hole oil exploration, and automotive applications require passive components such as resistors to have a minimal drift from their initial values when operating above + 125 °C and in humid environments.

Vishay's 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 surface.

The high-performance capabilities of Bulk Metal foil resistors are due to the Bulk Metal foil alloy and ceramic substrate combination, which results in a resistor with characteristics unrivaled by any other resistor technology.

Compared to foil, thin film resistor elements are not a controllable material. Heat or mechanical stresses on the thin film element 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.

A variety of foil resistor configurations and chip packages from the 0805 size and up are used to provide an array of power ratings, sizes, resistance values, and other operating specifications to meet stability and reliability needs in extreme applications.

The stability of a resistor depends primarily on its temperature, which is affected by:

1. Changes in the ambient temperature and heat from adjacent components (defined by the Temperature Coefficient of Resistance, or TCR).
2. Self-heating as a result of load (defined by the power coefficient of resistance, or PCR; which is ΔR due to self-heating).

In very high-precision resistors, the difference between the two effects must be taken into account to achieve high stability with changes in load (Joule Effect) and ambient temperature. The foil resistor balances the coefficient of thermal expansion of the Bulk Metal alloy and the substrate, providing great stability and low TCR with significant variations in temperature. Vishay's Z-foil technology provides a tremendous reduction in the foil element's sensitivity to temperature changes - both external and internal. This technology provides a TCR of ± 0.05 ppm/°C typical (0 ºC to + 60 ºC), ± 0.2 ppm/°C typical (- 55 ºC to + 125 ºC, + 25 ºC ref.), and a PCR of 5 ppm typical at rated power.

Although standard ratings go to + 125 °C, Vishay's customer experience with down-hole applications indicate operating temperatures of + 200 °C for several hours, with much higher temperature excursions. In high temperature environments, even with the use of high-temperature solder, the solder on the resistor leads could reflow. The unique design of the foil S102C resistor 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 1)

Tests conducted by Vishay show acceptable usage up to temperatures of + 250 °C for a period of 24 h, with minimal resistance drift.

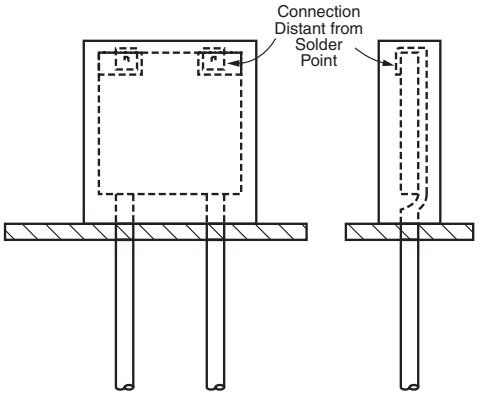

Figure 1.

Electrostatic discharge (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. In this case, premature failure can occur after the resistor is already functioning in the finished product for a period of time. Vishay's foil resistors are capable of withstanding electrostatic discharges above 25 000 V without degradation.

TECHNICAL NOTE

Ultra-High Precision Vishay Bulk Metal® Foil Resistors in Extreme Environments

Foil technology allows us to produce customer-oriented products designed to satisfy unique and specific technical requirements. Our standard production flow includes several 100 % screening tests, such as:

- Thermal shock: A major temperature change with a specified temperature gradient is imposed on the device. The test is applied in order to screen out internal connections and grid (foil) defects.
- CLT (Component Linearity Test): An effective in-line test to detect and eliminate potential infant mortality failures. This method is very useful in detecting abnormal foil resistor behaviors as the result of imperfections, such as resistive line continuity breakage (micro cracks or mechanically damaged grid lines), short circuits caused by metal particles adjacent to resistive lines, contact instability, etc. In addition, identifying resistors with a potential of excess parametric changes is possible through CLT.
- Short-Time Overload: High power for a short period of time - a load life stability simulation. The results of this test are influenced by temperature, time, and power.

The purposes of these tests are:

1. To detect and remove consequent construction defects.
2. To simulate unexpected stresses that may be applied during service.

The above-mentioned 100 % combined screening ensures the high reliability and unique long-term stability of Bulk Metal foil resistors.

In addition to these tests, we offer additional specially oriented post- manufacturing operations for sensitive applications requiring an even higher degree of reliability and 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.