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Solving Data Transmission Problems Using Vishay Foil Resistors Based on the New Z and Z1 Bulk Metal® Foil Technologies

Manufacturers of data acquisition equipment and DC/DC products use Vishay Foil Resistors' high-stability resistors to enhance their state-of-the-art basic data transmission circuits. The more common analog circuit design exhibits considerable instability with even minor variations of temperature over an extended time. This affects the accuracy of the subcarrier signal which carries the required information.

This unstable condition is due primarily to drift caused by ambient and inside-the-case temperature changes such as self heating, or electro-static discharge (ESD) pulses that affect components, particularly resistors. Therefore, prior to each data transmission, many time-consuming adjustments are required to avoid the transmission of numerous errors. The most critical sections that require precise long-term stability are in the core of the circuit, including the amplifier and the passive components around it.

Using the VSMP and FRSM series of resistors based on Z and Z1 technologies, manufacturers of data acquisition equipment and DC/DC converters can design circuits that eliminate possible sources of drift and instability. The high-stability characteristics of these new Bulk Metal® Foil resistors eliminate pre-program setup and maintenance adjustments, along with the need for analog or digital potentiometers. With Foil resistors, there are now only two factory-set calibration adjustments in the entire signal path, and these are for the signal processing.

Several factors need to be considered when choosing a resistor for analog circuits in data transmission applications, including TCR (ambient temperature), power TCR (self heating), load-life stability for more than 10,000 hours instead of the typical 2,000 hours, end-of-life tolerance (which is more important than the initial tolerance), thermal EMF (low values, DC), thermal stabilization, and ESD sensitivity. The VSMP and FRSM precision resistors feature a TCR of 0.05 ppm/°C between 0 °C and + 60 °C, a 0.01 % tolerance, non-measurable noise, non-inductance, stability of only 25 ppm per 2,000 hours, and are unaffected by ESD up to 25 kV.

Reliability is one of the key factors in designing data transmission equipment for use in some of the most remote locations on earth. For example, locations such as the Antarctic or the desert often have to wait out seasonal changes before replacements can be brought in. Failure to operate properly in such locations could result in the loss of as much as four to six months of data. Moreover, data transmission equipment must operate as well in very dry and cold Arctic locations as it does in very wet and hot tropical locations – without a constant human presence to tweak performance for locally extreme conditions. The electronics in

such equipment must withstand the challenges of extreme environmental and operational stresses, and the resistors in particular must operate uniformly and reliably.



Figure 1 - Weather stations represent a prime example of a resistor application requiring the utmost in reliability and performance

In all such applications, Bulk Metal Foil resistors have proven to be the most dependable resistor technology. With their very low TCR, the resistors make electronic circuits virtually insensitive to temperature-related changes. At remotely-operated stations, keeping power consumption low is an important consideration and Bulk Metal Foil resistors can withstand the destructive etching of low DC power in high-moisture atmospheres better than any other precision resistor technology. Also, the long-term load-life stability of the devices is better than any other type of resistor with typical stability levels of 0.005 % ΔR after 10,000 hours of operation at full rated power and temperature. In locations such as inside the rim of active volcanoes or deep inside the earth for oil well data-logging, Foil resistors withstand temperatures well above + 220 °C. No other resistor technology holds reliability and stability across the extremes of stress and operational life as well as Bulk Metal Foil.

There are essentially three resistance technologies widely used for precision resistors: thin film, wirewound, and Bulk Metal Foil. Each has its own balance of characteristics and costs that justify its selection in these applications. Thin films are the most cost effective within their normal range of characteristics, but have the highest TCR and noise, and least stability of the three technologies. Wirewound resistors offer low noise and TCR, and a high level of stability at a moderate cost, but also have high impedance, slow signal response, and are significantly larger. Wirewound devices can also have a higher power density, but some stability is lost through temperature cycling and load-life when made in smaller configurations. Bulk Metal Foil resistors have the lowest noise, lowest TCR, highest stability, and highest speed of any technology. The devices are competitively priced and offer long-term cost effectiveness. Wise designers often save overall

by using Foil resistors, where exceptional stability allows for the use of less-costly active devices, since Foil requires a smaller total error budget through all cumulative resistor life exposures. Also, Foil often eliminates extra circuitry added merely for the purpose of correcting the limitations of other resistor components.

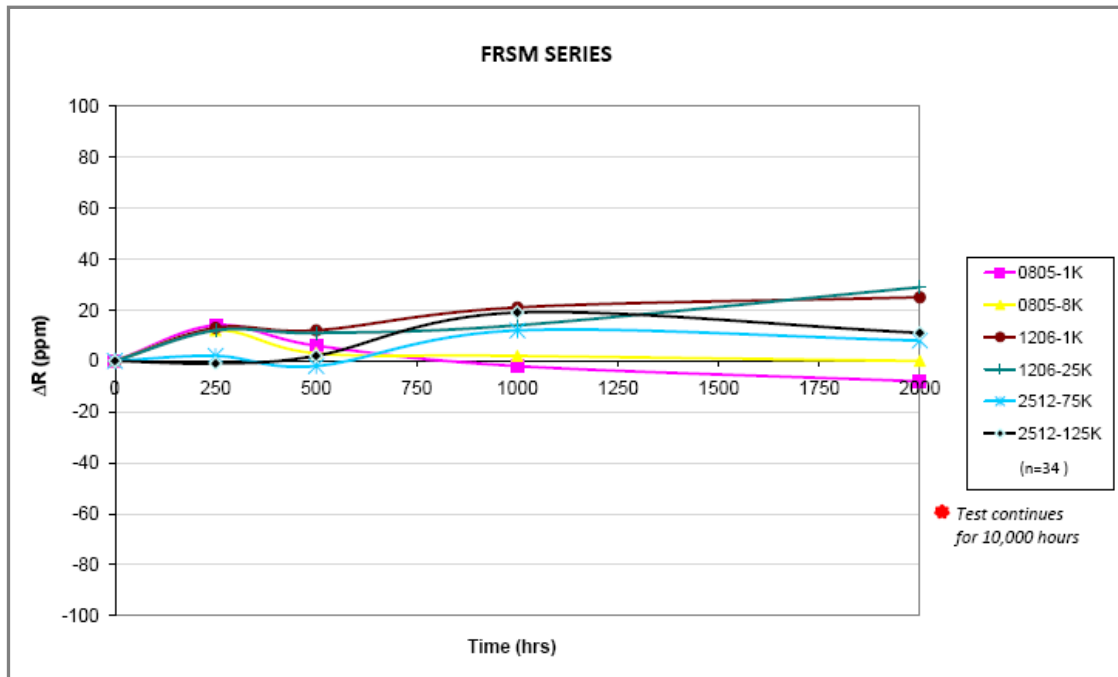
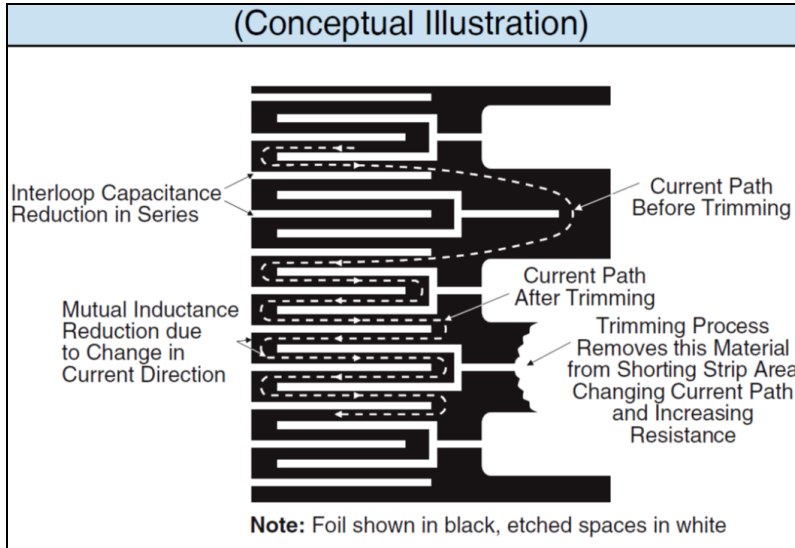


Figure 2 – FRSM series load-life test for 2,000 hours at + 70 °C and rated power

New-generation elements made with Z- and Z1-Foil technologies result from a new concept in resistor and trimmer manufacturing. A proprietary Bulk Metal Foil alloy of known and controllable properties is applied to a special ceramic substrate using a new adhesive. A resistive pattern is then photo-etched by an ultra-fine technique which was upgraded and refined by Vishay Foil Resistors Company (VFR). This process results in a new resistive element that combines the all-important characteristics of low TCR, long-term stability, ESD protection to at least to 25 kV, and increased stability through moisture and high-temperature environments.

Z and Z1 resistors consist of special alloys chosen for their electrical, mechanical, and thermal characteristics. They are bonded to substrates using a unique and proprietary process that does not subject the elements to the metallurgical changes that occur during production, such as is the case with thick and thin film resistor technologies. Because the alloy in Z- and Z1-Foil resistors is not subjected to stress in any way during the manufacturing process, the element maintains all of its original physical and electrical characteristics. Each step of the manufacturing process is rigidly controlled with extensive quality control, ensuring that the alloy is kept in its original state.



* To acquire a precision resistance value, the Bulk Metal® Foil chip is trimmed by selectively removing built-in "shorting bars." To increase the resistance in known increments, marked areas are cut, producing progressively smaller increases in resistance. This method eliminates "hot spot" and improves the long term stability of the resistor.

Figure 3 – To acquire a precise resistance value, VFR's Bulk Metal® Foil resistors undergo a unique trimming process

The temperature coefficient of the resistive element is carefully controlled through compensating techniques that essentially eliminate detrimental effects due to different coefficients of expansion of the materials used. The end result is a resistive element with a unique combination of performance characteristics – extremely low temperature coefficient, ultra-high stability, fast rise time, non-measurable noise, and low drift in high-temperature exposure.

For more information on data transmission, please visit Vishay Precision Group's website to review the following datasheets:

- VSMP Series, please visit <http://www.vishaypg.com/doc?63060>
- FRSM Series, please visit <http://www.vishaypg.com/doc?63209>

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

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