

**Product Group:** Vishay Foil Resistors

## Thermoresistive Characterization of Composite Materials



**Author:** Kalon Lasater, Research Assistant  
Erik T. Thostenson, Assistant Professor, Center for Composite Materials and Department of Mechanical Engineering at the University of Delaware

The Center for Composite Materials at the University of Delaware is an internationally recognized center of excellence in composite materials research, development and education.

**Industry/Application Area** Composite Materials  
**Product Used** HZ Series (Z-Foil) VHA518-11, 1 M $\Omega$

### The Challenge

To measure small changes in electrical resistance *in situ* during thermomechanical analysis of composite specimens, an extremely stable and accurate reference resistor was required. Tests were conducted over many hours under varying laboratory conditions where ceramic resistor technology introduced unwanted noise and instability.

### The solution

A hermetically sealed resistor with essentially zero TCR was chosen to replace a ceramic resistor following the recommendation of Vishay Foil Resistors engineers. The new reference resistor significantly improved the stability and repeatability of the electrical resistance measurements.

### The User Explains

The materials investigated were composites of carbon nanotubes and vinyl ester resin for *in situ* sensing and structural health monitoring applications, for example, aerospace and naval structures. Because this material changes electrical resistance under applied loads, when it is used in the matrix phase of fiber reinforced composites, the progression of stresses and damage can be measured. In practice, these applications experience large temperature gradients; therefore, characterizing how the electrical resistance of the material changes with temperature is of practical importance.



Fig 1: Image of a specimen mounted on a thermomechanical analyzer stage.

## Measurements

To make electrical resistance measurements *in situ* during thermomechanical analysis, a specimen was designed to meet the requirements of the thermomechanical analyzer (Fig 1.) and data acquisition device (NI-6218, National Instruments). As shown in Figure 2, the NI-6218 applied a voltage and measured the voltage drop across the reference resistor and specimen wired in series. The resistance of the specimen was determined through Ohm's Law. Because the HZ Series resistor is extremely stable over long periods and has very low noise, it was ideal for this type of measurement. Figure 3 shows the typical results for a 0.10 wt% CNT/VE specimen. This material had a negative, but ultra-low, TCR which could be desirable in real-world applications.

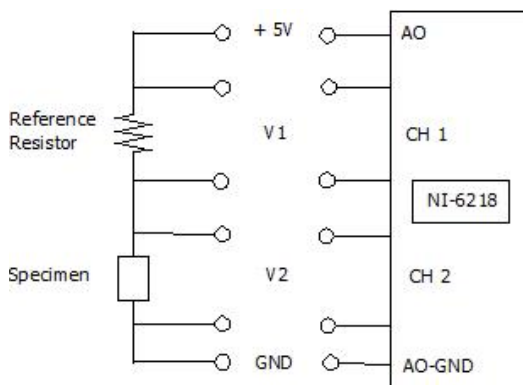


Fig. 2: Electrical circuit diagram and interface with the NI-6218.

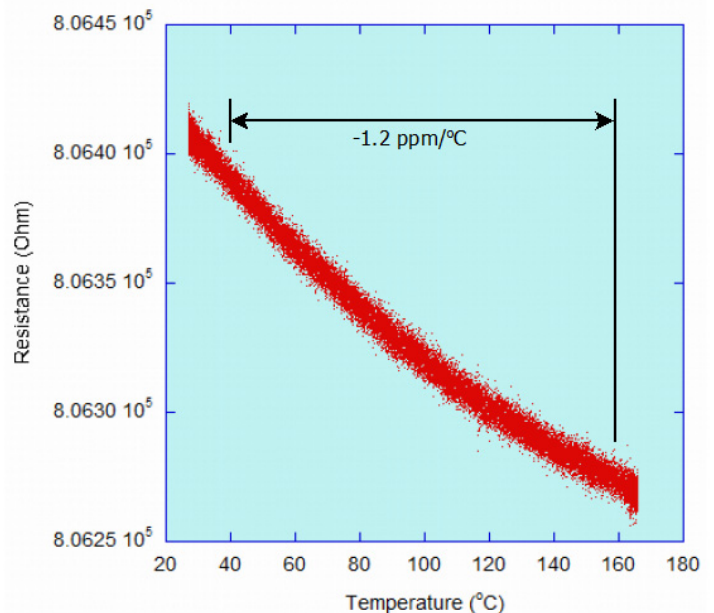


Fig. 3: Electrical resistance curve of 0.10 wt% CNT/VE specimen with ultra-low TCR.

## Contact Information

Kalon Lasater  
Research Assistant  
Center for Composite Materials  
University of Delaware  
USA, Newark, Delaware  
Email: [Lasater@udel.edu](mailto:Lasater@udel.edu)  
Phone: (302) 831-6484  
Website: [www.ccm.udel.edu](http://www.ccm.udel.edu)

Erik T. Thostenson  
Assistant Professor  
Department of Mechanical Engineering  
University of Delaware  
USA, Newark, Delaware  
Email: [Thosten@udel.edu](mailto:Thosten@udel.edu)  
Phone: (302) 831-3619  
Website: [sites.udel.edu/thostenson](http://sites.udel.edu/thostenson)

Vishay Precision Group, Inc. (VPG) - Vishay Foil Resistors  
Email: [foil@vishaypg.com](mailto:foil@vishaypg.com) [Click here for your regional VFR contact.](#)