VISHAY PRECISION GROUP

CASE STUDY

Product Group: Vishay Foil Resistors

High-Accuracy LHC Beam Screen Heaters for Particle Accelerators

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With its long-term stability and tight tolerance, Vishay Foil Resistors' VCS332Z Bulk Metal® Z-Foil resistor helped CERN create a Large Hadron Collider (LHC) beam screen heater for its particle accelerator.

Industry/Application Area: Precision instruments

Product Used: VCS332Z Bulk Metal® Z-Foil ultra-high-precision current sensing resistor with resistance of 0.25 Ω and tolerance of 0.1%.

The Challenge

The Large Hadron Collider (LHC) beam screen is used to prevent heat from reaching the beam pipe wall at 1.8 K; instead it is extracted by the beam screen, which operates at a temperature between 5 K and 20 K. The hydraulic circuit that cools the support posts of the LHC main magnets and the beam screen can reach up to 100 m in length. Thermoacoustic-induced oscillations may be present, resulting in a waste of cryogenic cooling power. Therefore, the beam screen heater is used to exceed a critical temperature, above which these oscillations are never present.

The driving electronics of the beam screen heater offer DC and AC modes of operation. For the DC mode, the supplied current has to be measured with a long-term accuracy of 0.5% for all DC current ranges that the card supports. The current sensing resistor should have long-term stability during its minimum lifetime of 10 years.

The Solution

With a tolerance of 0.1% and maximum TCR of 3 ppm, Vishay Foil Resistors' (VFR) VCS332Z Z-Foil current sensing resistor fulfills CERN's requirements for accuracy. The available data on Bulk Metal Foil technology also reveals excellent long-term stability characteristics. The VCS332Z provides extremely high thermal efficiency, well-distributed internal heat from power dissipation, very low thermal EMF, and fast thermal stabilization. All these characteristics are necessary to prevent errors caused by uneven heat from external sources such as power amplifiers and other circuit elements.

Harmonic distortion is an important consideration in the choice of precision resistors for sensitive applications. A significant signal voltage across the resistor may change the resistance value depending on the construction, material, and size. Under these conditions Bulk Metal Foil resistors — based on the planar construction of a cold-rolled Ni-Cr foil bonded to a flat ceramic substrate — behave more linearly than other resistor types.

In addition, the VCS332Z undergoes post manufacturing operations (PMO), including short-time overload, accelerated load life, and temperature cycling. VFR resistors are inherently stable as manufactured; however, these PMO exercises improve their performance by small but significant amounts.

Figure 1: Design photo of first prototype board, top view

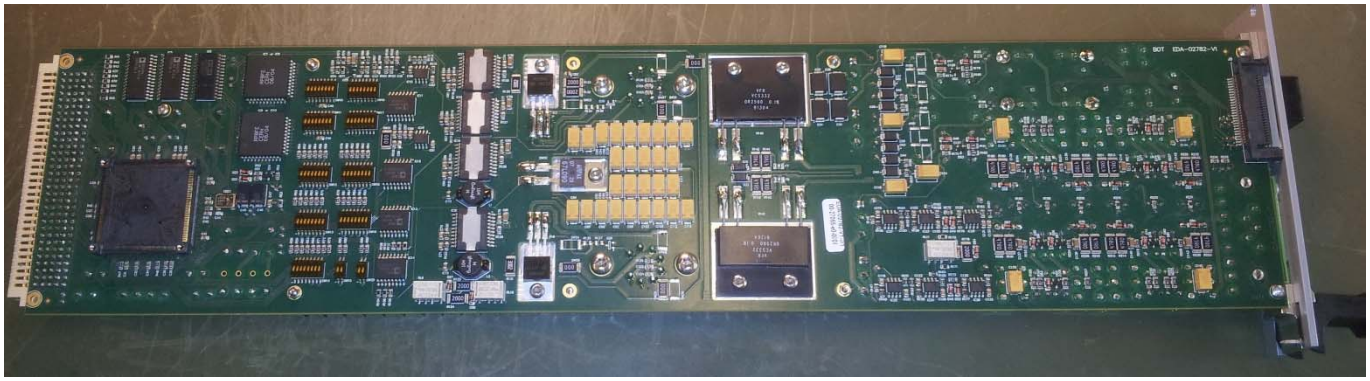

Figure 2: Design photo of first prototype board, bottom view

The User Explains

The card supports operation in a variety of current ranges. The feedback of the supplied current is part of a group of signals that are multiplexed and share a common amplification stage before digital conversion. A current sensing resistor with an exact value of 0.25 Ω had to be used. To preserve its

accuracy in the lowest current range, the current sensing resistor had to be 0.1% accurate with a small TCR for its operating temperature range of up to 80°C.

"We selected the VFR's Bulk Metal Foil current sensing resistor due to its long-term stability, tight tolerance, and excellent radiation tolerance."

Acknowledgement:

CERN, the European Organization for Nuclear Research, is where physicists and engineers are probing the fundamental structure of the universe. They use the world's largest and most complex scientific instruments to study the basic constituents of matter — the fundamental particles. The particles are made to collide together at close to the speed of light. The process gives the physicists clues about how the particles interact, and provides insights into the fundamental laws of nature.
The instruments used at CERN are purpose-built particle accelerators and detectors. Accelerators boost beams of particles to high energies before the beams are made to collide with each other or with stationary targets. Detectors observe and record the results of these collisions.
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