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measurement solutions

Improving Long-Term Stability of Batemika UT-ONE Thermometer Readouts with Hermetically-Sealed High Precision Resistors

Batemika Measurement Solutions was able to improve the accuracy of its UT-ONE family of thermometer readouts by implementing a VHP101T Hermetically-Sealed Bulk Metal® Foil resistor as the internal reference resistor. Long-term drifts were improved from over 20 ppm per year to less than 5 ppm per year.

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Company/Institute: BATEMIKA Measurement Solutions, www.batemika.com

Industry/Application Area: Precision Instruments

Products used:
- VHP101T Ultra-High Precision Hermetically-Sealed Bulk Metal® Foil Resistor
- SMR3DZ Ultra-High Precision Z Foil Molded Surface Mount Resistor

The Challenge

Precise measurement of temperature with platinum resistance thermometers requires resistance-measuring instrument with extremely tight accuracy requirements. To achieve 0.001°C accuracy in temperature requires 4 ppm accuracy in resistance for the industry-standard Pt-100 probe at 0°C. With the advent of modern 24-bit sigma-delta analog-to-digital converters, achieving linearity and effective resolution on the level of a few ppm has become relatively straightforward, so the main challenge now remains assuring low short-term and long-term drifts.

The Solution

At Batemika we started the development of UT-ONE family of thermometer readouts with the total accuracy target under 0.01°C. Our first generation of UT-ONE devices was able to achieve all our targets in effective resolution, linearity, temperature coefficients and short-term drift, but was struggling to achieve the expected long-term drift specifications. Based on the suggestion of the VPG Foil Resistors field design engineer, we replaced our internal reference resistor with the Vishay Foil Resistors VHP101T hermetically-sealed Bulk Metal® Foil resistor. This single step has dramatically improved the long-term stability of the entire instrument and gives a new level of confidence in its measurement results. The typical accuracy specification that we were able to achieve is 0.006°C for Pt-100 probe at 0°C, and as the long-term drift data is slowly accumulating, we are now considering further improving the accuracy specification.

Figure 1: Batemika UT-ONE B03A 3-channel thermometer readout

The User Explains

The measurement circuit of the UT-ONE thermometer readouts is based on the 24-bit sigma-delta analog-to-digital converter in 4-wire ratiometric configuration. The simplified measurement circuit consists of the current source with 1 mA measurement current, which creates a voltage drop on the unknown resistance RRTD and reference resistor RREF. The voltage drop over unknown resistance is amplified with the programmable-gain amplifier and fed into the ADC input. The voltage drop over the reference resistor is used as the reference voltage of the ADC.

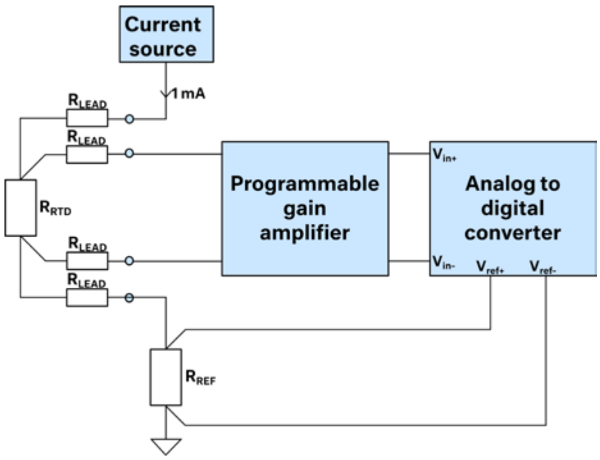

Figure 2: Simplified measurement circuit of UT-ONE thermometer readouts

The advantage of this configuration is that the accuracy and low-frequency noise of the current source has no effect on measurement results. The long-term drift is determined only by the reference resistor and the programmable-gain amplifier, and the contributions of these two sources can't be distinguished from each other. In our initial design, the reference resistor was a Bulk Metal® SMR3DZ molded Vishay Foil Resistor, which has a load life stability of 50 ppm at 70°C and rated power. As our instrument is specified only up to 36°C with almost negligible power, we assumed the stability of the resistor would be between 10 and 20 ppm per year. We also assumed that the stability of the programmable-gain amplifier would be in the same range, so further improvement of the reference resistor would be pointless. The long-term drift results presented in figure 3 appeared to confirm our assumptions. The long-term drift seems to have a yearly period and might be related to seasonal variation in relative humidity. The drift has no particular trend and does not accumulate over several years.

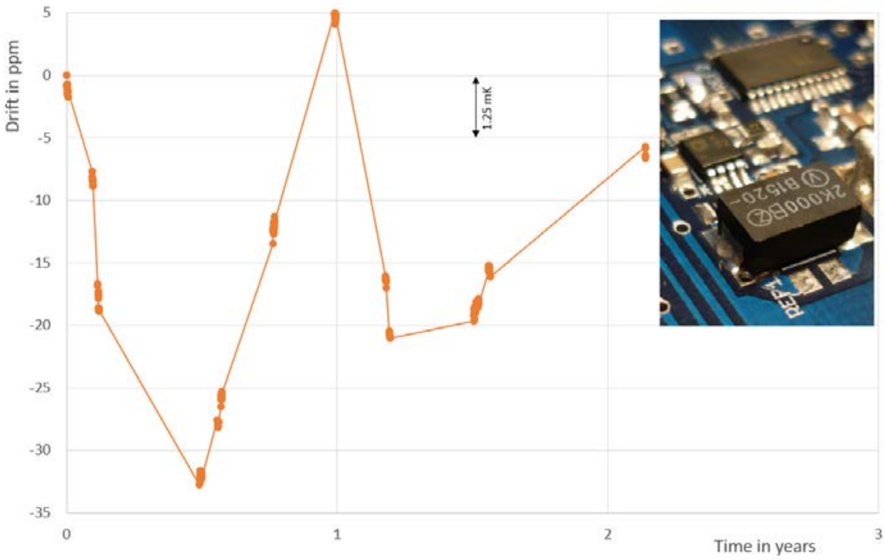

Figure 3: Long-term drift of the UT-ONE thermometer readout at 100 Ω with SMR3DZ resistors

The long-term drift results were shown to the VPG Foil Resistors field design engineer, who suggested the replacement of the Vishay Foil Resistors SMR3DZ molded resistor with the VHP101T hermetically-sealed resistor in order to improve further the long-term stability. We were initially very skeptical about the change, as the assumption was that the improvement in the reference resistor would be overshadowed by the drift of the programmable-gain amplifier. Nevertheless, we acquired one sample of the VHP101T 100 Ω unit for evaluation purposes. This resistor had been installed in a small metallic case, which provides good mechanical and electrical protection. We now produce it as a check standard in combination with our thermometer readouts.

This resistor was regularly recalibrated over a period of more than two years with the resistance bridge with uncertainty better than 1 ppm. The results in figure 4 show that the long-term drift for this particular unit is less than 1 ppm per year.

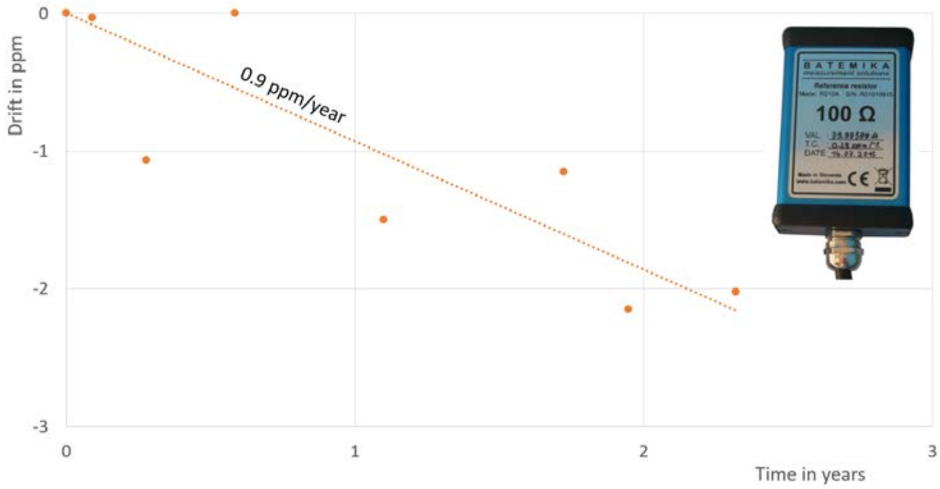

Figure 4: Long-term drift of the Vishay Foil Resistors VHP101T 100 Ω hermetically sealed resistor

Impressed by the long-term performance of the VHP101T resistor, we decided to replace the reference resistor in one of our UT-ONE units with the VHP101T. This would at least allow us to examine the drift of the programmable-gain amplifier, as in this case the influence of the reference resistor would be negligible. Contrary to our assumptions and expectations, the results for the long-term drift, as presented in figure 5, show a huge improvement. The scale in figures 3 and 5 is the same to simplify the comparison. The long-term drift was reduced from over 20 ppm per year to less than 5 ppm per year. This improvement is consistent with all units tested. The VHP101T resistor resulted also in a better short-term stability and lower initial drift after assembly, which simplifies our quality-control procedures and gives a new level of confidence in our products. We now use only VHP101T resistors as the reference in our thermometer readouts and we even retrofitted most of our existing units.

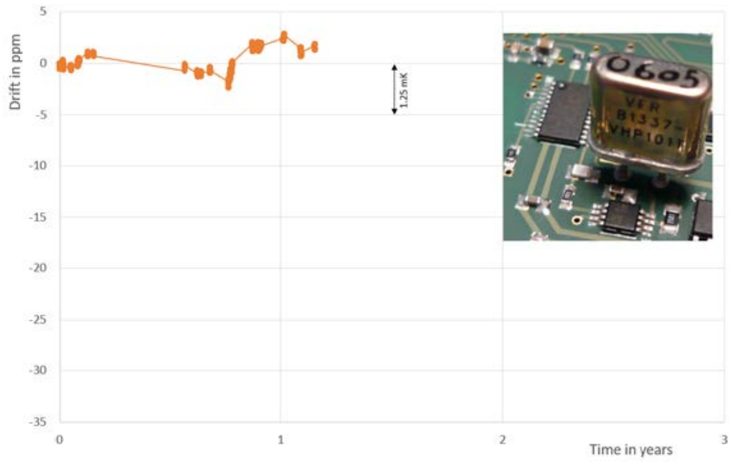

Figure 5: Long-term drift of the UT-ONE thermometer readout at 100 Ω with VHP101T resistors

"Replacing the reference resistor in our UT-ONE thermometer readout with Vishay Foil Resistors hermetically-sealed foil resistors resulted in a dramatic improvement of the long-term drift of our instrument from over 20 ppm to less than 5 ppm per year."

Acknowledgement:
Batemika specializes in measurement solutions in thermometry and temperature metrology. We produce high-precision instrumentation and measurement software solutions for calibration and R&D laboratories. Our lead product is the UT-ONE family of thermometer readouts, which is capable of measuring temperature with all commonly-used temperature probes with accuracy down to a few thousandths of a degree Celsius. Our background in both electrical engineering and temperature metrology allows us to provide solutions that are specifically tailored to your everyday measurement needs. www.batemika.com

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