Application Note 1

Testing Resistor Suitability for AMETRIX Picoammeters

Glenn Fasnacht, President, AMETRIX Instruments
gfasnacht@ametrixinst.com

I. Introduction

With the exception of the 500 MΩ resistor, all the Model 100 Series' resistors are known to have great long-term stability and low-temperature coefficients. They are either very low TC wirewound, bulk metal, or Caddock high-resistance parts. The 500 MΩ, however is a metal oxide and of questionable stability. This paper describes the tests performed to prove (or disprove) one resistor's suitability for use in the Model 100 Series calibrator.

II. The Resistor

The resistor is actually two Vishay TR10F1007M in parallel. This is a 1 GΩ, 20%, 300 ppm/°C part. It has a specified voltage coefficient of 1 ppm/V, so this non-ideality will result in an error of < 10 ppm. There is nothing in the Vishay spec that refers to long-term stability, either under power or shelf-life.

A better version of this part is available with a 100 ppm/°C temperature coefficient, but this resistor will be used to calibrate the 2 nA and 20 nA ranges which have ±3000 ppm and ±2000 ppm accuracy specs, so this ±300 ppm/°C nominal temperature coefficient is adequate.

III. The Tests

A. Setup

The resistor instrumented inside an aluminum shielding box with BNC connectors for connection to the resistor under test. This box was placed in an environmental chamber along with a 100 Ω platinum RTD to monitor the temperature.

The resistance was measured by using an AMETRIX® Model 101 and a 6½ digit DMM; the Model 101 provided a +10.00 V DC bias and measured the current through the resistor, and the DMM measured the actual voltage.

The setup is shown here in ***figure 1***. The entire test was performed inside a shielded aluminum box to reduce external noise effects. The RTD is a true Kelvin connection to the DMM.

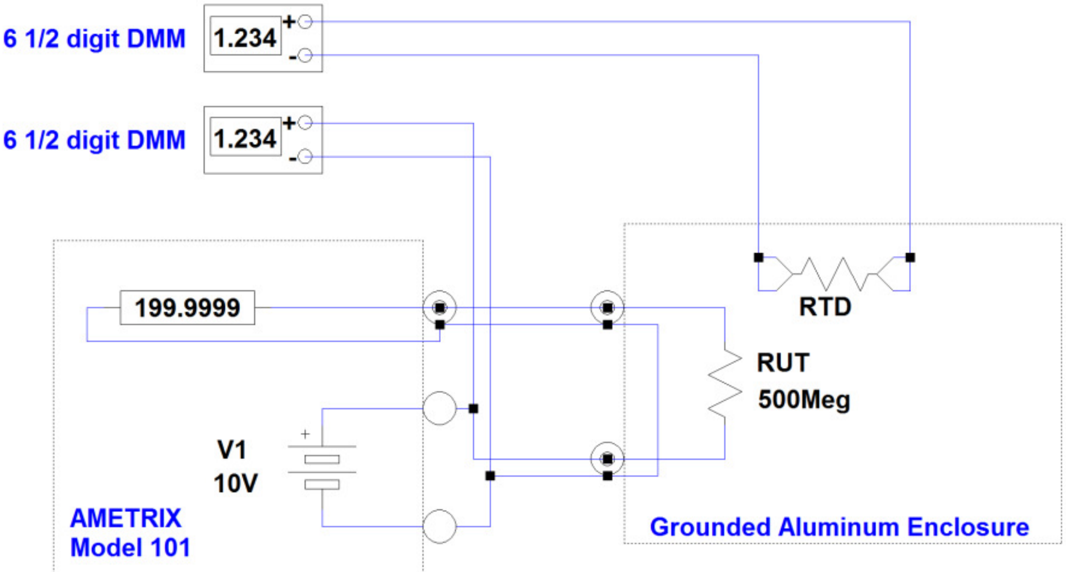

figure 1

B. Temperature Coefficient

Current, voltage, and temperature were recorded by hand at various temperatures over a four day period. The temperatures were somewhat randomized, but not deliberately, and (unfortunately) time was not recorded. In any event, there is a fairly clear curve of resistance vs. temperature.

We will always be operating in the green area ***(figure 2)*** and it appears that the resistance changes less than 40 ppm within that window. This indicates that the resistor is far better than the 300 ppm/°C specification. *Note that this specification may cover the entire operating range of the resistor and so may still be valid.*

Without proof, I do remember reading that the metallurgy for these resistors are optimized for 25 °C and that does appear to be the case here.

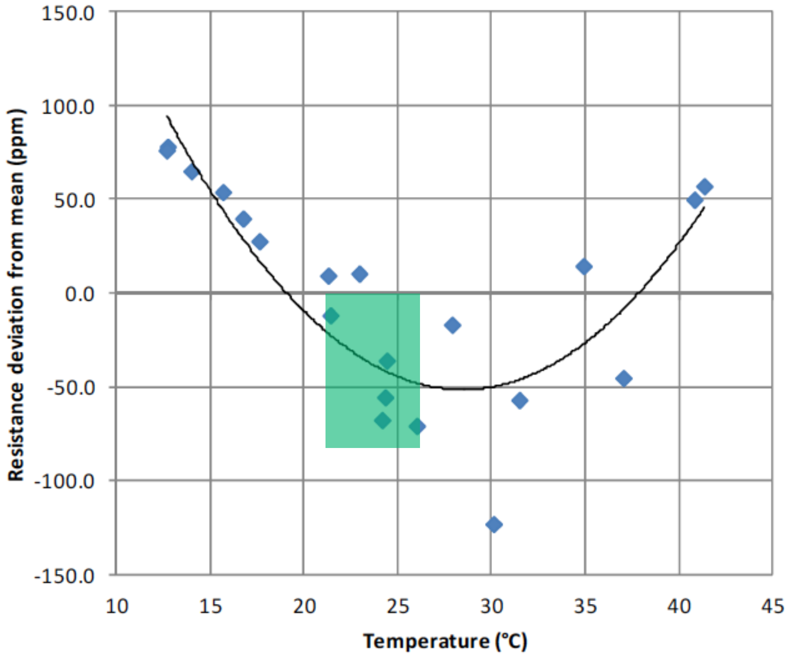

figure 2

C. Aging

While performing the temperature coefficient test I noticed there appeared to be a time dependency to the measurements, so after this test I performed a (more or less) fixed temperature aging test.

This test was electrically the same as the temperature coefficient test but the temperature was not adjusted. That is not to say it didn't change, but the power dissipation in the heating resistor was held constant. During this test, as with the temperature coefficient test, RUT voltage and current, and temperature were monitored and recorded, but this time, time was tracked as well.

The temperature was held at a nominal +42.5 °C and never varied more than ±0.9 °C from that.

Figure 3 is the result of that test.

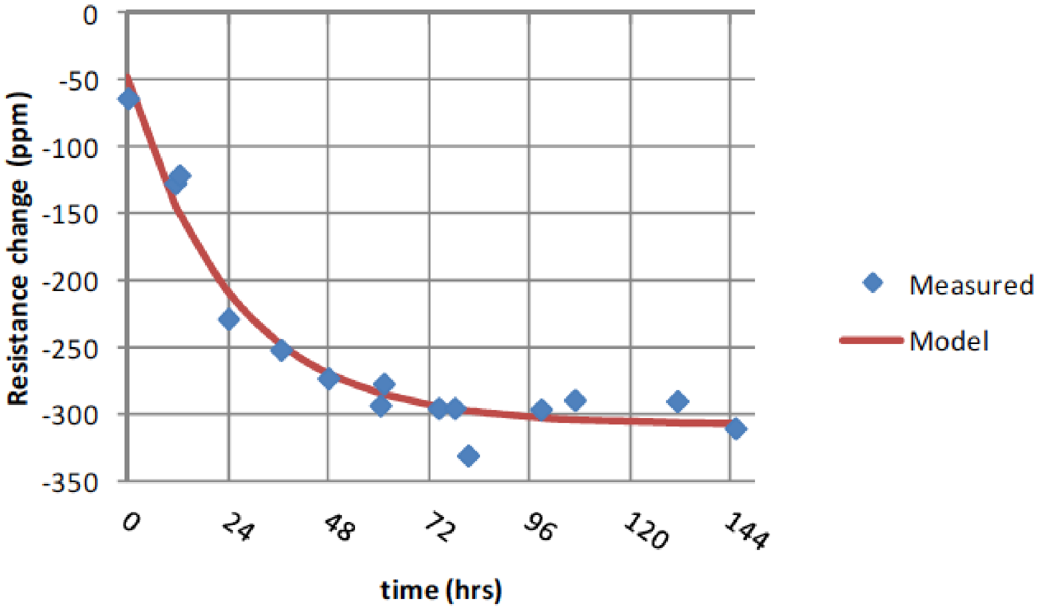

figure 3

The measured data looked quite exponential so I created a model that follows ***(figure 4)***:

$$Modeled = C + A \times e^{-\frac{t}{\tau}}$$

figure 4

Where C (-307), A (260), and τ (25.1) are constants, and t is the time in hours. The constants were initially guesses and Excel's Solver add-in was used to determine the actual values by minimizing the squared difference between the model and the measured.

This model fit quite well with an R^2 of 0.98, which can be interpreted as saying "98% of the variability in the data can be described by this model".

The aging is most likely due to induced mechanical stresses. These stresses are induced by lead bending and soldering. During the aging process these stresses are relieved. Higher temperatures relieve the stresses more quickly. More stresses are likely to be induced when these resistors are installed on the cal stand relay board, and so it is recommended that once the relay board is fully assembled that it be burned-in for at least 162 hours at 50 °C. This will stabilize both this resistor and the others as well.

III. Conclusions

The temperature effects are so small compared to our specification that they can be ignored.

The aging effects are significant but predictable. As such, a burn-in of the finally assembled calibration stand relay board is recommended.

Once the cal stand is fully operational, it is recommended that all of the resistor values are monitored on a regular basis to ensure their stability and the accuracy of the products that are calibrated using the stand. A proposed schedule would be an exponential one, the first and second weeks, the first, second, fourth, eighth month, and then annually. This proposed schedule is subject to change depending upon the findings.

AMETRIX Instruments
1 (216) 200-6405
sales@ametrixinst.com
techsupport@ametrixinst.com
8984 Darrow Rd Suite #2-110
Twinsburg, OH 44087