CASE STUDY

Product Group: Vishay Foil Resistors

Wheatstone-Bridge Calibration Scale Adjustments Based on Precision Resistor Shunt Measurements

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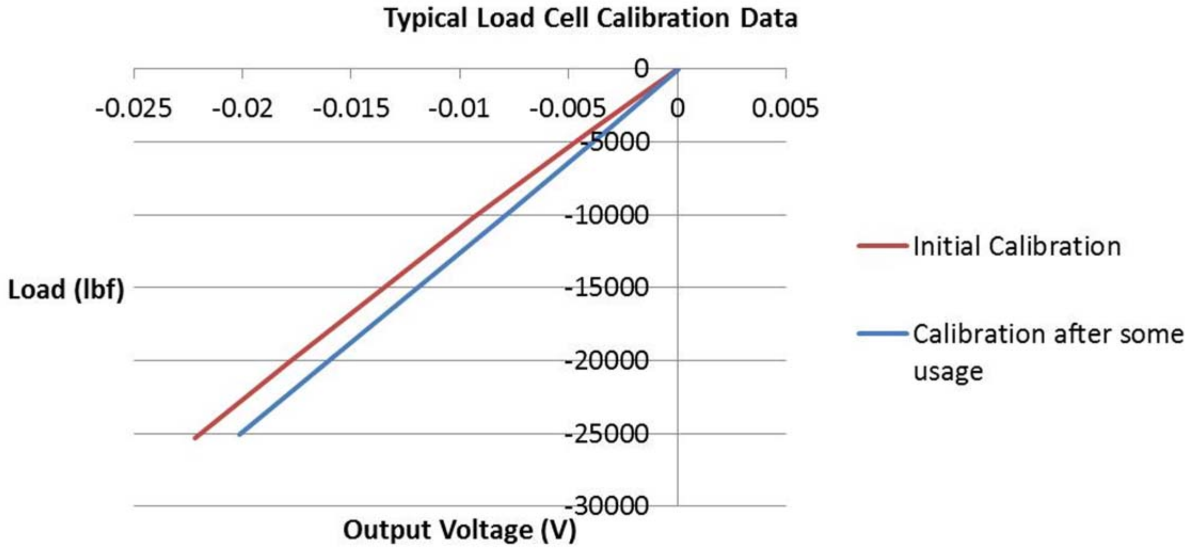
The University of Miami was able to successfully calculate and then compensate for drift in a load cell by using a S102C precision resistance shunt to recalibrate the instrument.

Industry/Application Area Wheatstone Bridge Sensor Calibration

Product Used S102C Bulk Metal® Foil resistor

The Challenge

The output of Wheatstone-bridged sensors networks will drift because of use over time, necessitating recalibration.



In cases where reference standards are not available or recalibration is temporally expensive, obtaining a new scale based on an applied physical metric, such as load or displacement, may not be possible. How can the new scale be calculated based on the original?

The Solution

Symbolically equate the linear equations for the metric before and after drift occurs. Do this twice with two different values of S102C Bulk Metal® Foil precision resistors from Vishay Precision Group (VPG) to yield a system of equations which can be solved for the gain and offset after drift has occurred.

The User Explains

Consider the equation for the voltage output of a Wheatstone bridge (1):

$$\text{Output of Wheatstone Bridge (initial calibration)}$$

$$V_0 = \left(\frac{R_x}{R_3 + R_x} - \frac{R_2}{R_1 + R_2}\right) V_s \qquad (1)$$

Now consider the equation for the voltage output of the same bridge after some drift has occurred Eqn. (2):

$$\text{Output of Wheatstone Bridge (after some drift has occured)}$$

$$V_{0D} = \left(\frac{R_x}{R_3 + R_x} - \frac{R_2}{R_1 + R_2} + D\right) V_s \qquad (2)$$

If metric is given by the initial linear scale

$$L_i = m_i V_0 + b_i \qquad (3)$$

And the metric after Drift is given by the linear scale

$$L_D = m_D V_{0D} + b_D \qquad (4)$$

Then we can see that the constant D will change the load L_x given the same input V_s. How do I account for this change in terms of a new gain and offset m_D and b_D?

Since the metric must be the same, given the same excitation V_s, we can equate Eqn. (3) and Eqn. (4). Thus, if we simulate an output with a shunt resistor R_{s1}, we then have $L_{iR_{s1}} = L_{DR_{s1}}$.

We can make a similar equivalency with a second shunt resistor R_{s2} giving us a second equation to work with.

Noting that V_0 is a measured value, we are left with two equations and two variables namely:

$$m_i V_{0R_{s1}} + b_i = m_D V_{0DR_{s1}} + b_D \quad (5)$$

where $V_{0R_{s1}}$ and $V_{0DR_{s1}}$ are the outputs of the R_{s1} shunted bridge (across R_x) initially and after some drift has occurred:

$$m_i V_{0R_{s2}} + b_i = m_D V_{0DR_{s2}} + b_D \quad (6)$$

where $V_{0R_{s2}}$ and $V_{0DR_{s2}}$ are the outputs of the R_{s2} shunted bridge (across R_x) initially and after some drift has occurred:

m_D

and

b_D

Solving for m_D *and* b_D.yields.

$$\boldsymbol{m_D} = \frac{\boldsymbol{V_{0R_{s1}} - V_{0R_{s2}}}}{\mathbf{V_{0DR_{s1}} - V_{0DR_{s2}}}} \boldsymbol{m_i} \quad (7)$$

$$b_D = \left[V_{0R_{s1}} - \left(\frac{V_{0R_{s1}} - V_{0R_{s2}}}{V_{0DR_{s1}} - V_{0DR_{s2}}} \right) V_{0DR_{s1}} \right] m_i + b_i \quad (8)$$

VPG’s Vishay Foil Resistors brand (VFR) precision resistors provide the long term stability that is required for this application.

According to Gerald Sanders, who supervised the project at the University of Miami: “VFR precision resistors provide the long term stability that is required for this application. Our load cells can be employed for decades, so we needed resistors whose values would not vary significantly over time or due to changing environmental conditions. Thanks to Aaron Ram, my VFR representative, we will be able to save many hours in our verification process for each load cell we use.

"The objective was to facilitate the verification process; we need to know if a sensor functions the same after it has been used. This solution provides us with much more. New gain and offset factors can be calculated based on any change in the bridge network; so not only can we adjust our gains and offsets, if the character of the sensor has changed, we can likewise adjust our scale factors if lead resistances or the excitation voltage changes. This is wonderful."

"VFR precision resistors provide the long term stability that is required for this application."

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