

Authors: Yuval Hernik

Tel: +972-54-3000191

E-mail: Yuval.Hernik@vishaypg.com

How Precision Resistors Enable Quick, Easy, and Cost-Effective Shunt Calibration of Strain Gage Sensors

Strain gages are fundamental sensing devices that function as the building blocks of many other types of transducers—including pressure, load, and torque sensors—used extensively in structural test and monitoring applications. An example of such a transducer is a load cell that converts a mechanical force to an electrical output signal. In these designs, gages are connected as a Wheatstone bridge, resulting in an accurate and rugged transducer that can operate in extreme environments. To achieve accuracy, the Wheatstone bridge is adjusted for manufacturing initial tolerance and ambient and self-heating temperature effects. "Compensation" high precision resistors are then added to correct for bridge unbalance, and to adjust the output sensitivity. Other compensation resistors correct for the errors that result when the transducer is used over a widely changing temperature range.

Even though strain gages are very common, acquiring reliable data from them can be a challenge. Several factors can affect the measurement performance of a strain gage: the signal conditioning, the construction and location of the Wheatstone bridge (the most common bridge type used to measure resistance), inductance and capacitance, the precision resistors used in the circuit, and the excitation source.

Precision resistors have two basic uses in standard strain gage circuits: shunt calibration of strain-measuring instruments and bridge completion. In shunt calibration, a fixed high-precision resistor is temporarily shunted across one of the bridge arms to produce a known and controlled resistance change in the bridge circuit. The resulting instrument indication is then compared to the calculated strain corresponding to the resistance change. In bridge-completion, a precision resistor is used in the adjacent arm of the Wheatstone bridge, and two additional precision resistors are used in the ratio arm. to complete the external half-Wheatstone bridge circuit when a single strain gage is connected in a quarter-Wheatstone bridge arrangement. In each of these applications, the accuracy of the strain measurement is affected, directly or indirectly, by the accuracy and stability of the precision resistors used in the circuit. That's why only the highest-precision, highest-stability resistors should be used; the choice is basically between Z Technology and Z1 Technology Bulk Metal® Foil resistors.

Vishay Precision Group

3 Great Valley Parkway, Suite 150 • Malvern, PA • USA • Phone +1-484-321-5300 • Fax +1-484-321-5301

Where the World Goes for Precision Measurement and Control www.vishayfoilresistors.com

Micro-Measurements • Vishay Foil Resistors • VPG On-Board Weighing • VPG Process Weighing • VPG Transducers

When choosing a precision resistor for shunt calibration, the following features are highly desirable:

- Fast field calibration of the pressure transducer and load cell
- Ease of use
- Low temperature coefficient of resistance
- Low thermal EMF and fast thermal stabilization
- High stability

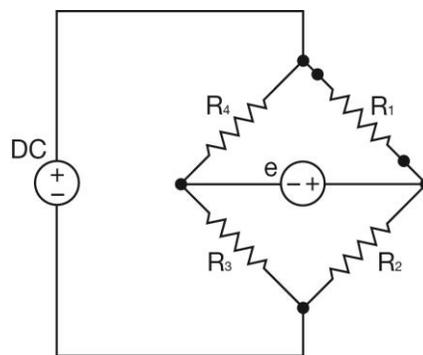
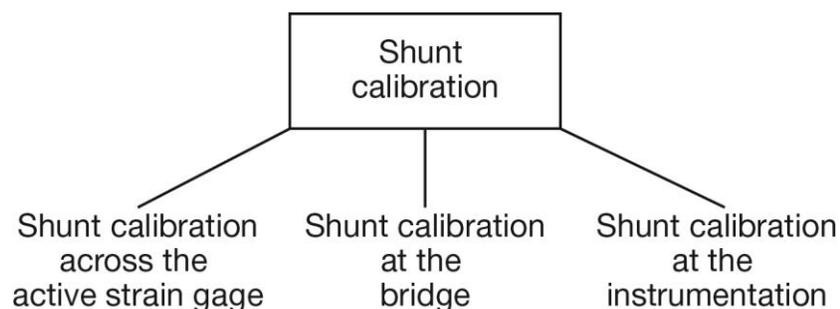


Figure 1. *Basic Wheatstone Bridge Circuit Diagram*

Shunt Calibration

Shunt calibration of a Wheatstone bridge strain gage circuit is a common and convenient method of periodically monitoring the gain or span of a signal conditioner being used in conjunction with a strain gage based transducer. A fixed precision resistor such as the leaded Z-Series or surface-mount VSMP Series is placed, or “shunted,” across one leg of the Wheatstone bridge. This doesn’t amount to a complete calibration, since no mechanical pressure is actually applied. Instead, the shunt calibration provides a simulation of the mechanical input to a transducer by unbalancing the bridge and providing a scenario that shows how to reduce the errors and shifts associated with the electrical characteristics of the strain gages and the connected electrical components. The shunt resistor that is added in parallel to the strain gages simulates what would happen if a real load were measured by the pressure transducer or any other load cell configuration.

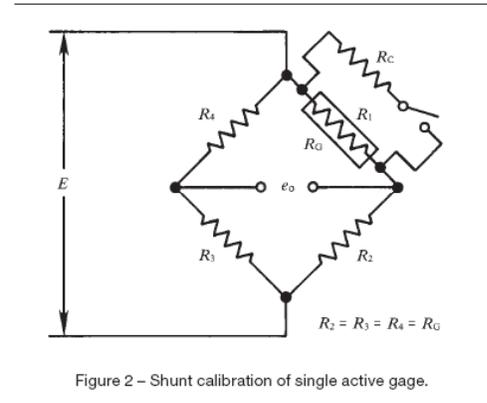


This approach works best when done using a high-precision resistor with a tight tolerance (such as the 0.001% to 0.01% VHP100, which is oil-filled and hermetically sealed), a known resistance, low sensitivity to temperature (especially power TCR), and low thermal EMF. The output in millivolts (mV) can be compared to what would be expected should actual pressure be applied. Then the difference in output signal can be compensated within the monitoring instrumentation.

Shunt calibration is accepted throughout the industry as means of constant calibration of a signal conditioner and transducer between calibrations of known, applied, traceable, mechanical, input values. It's important to remember that the shunt resistor can simulate either a tension or compression input in the Wheatstone bridge. Thermal EMF and TCR errors can affect the process and should be minimized by choosing a proper resistor. The shunt calibration can be applied conveniently and at any moment and most important during the test programs.

Consequently, strain-gage and transducer manufacturers supply shunt calibration data, along with a shunt calibration precision resistor, as a standard feature. Of course, regular physical calibration is recommended as well to ensure the accuracy, stability, reliability and linearity of the instrument itself.

Figure 2. *Shunt-calibration resistors are chosen to accurately simulate resistance change in a strain gage subjected to specified levels of compressive strain. Strain indicators generally will produce a linear output with a fully active half-bridge or full-bridge input circuit, and will be slightly in error when a single active arm is used. The same nonlinearity occurs whether the gage is actually strained in compression or simulated by shunting the gage with the corresponding calibration resistor.*



Strain gage installations in special projects such as naval vessels or other industrial applications usually will require long cable lengths between the strain gages' location and the strain control and measuring instrumentations due to the size of the body that contains the strain gage. The resistance of the signal cable will create an attenuation shift during the acquisition process of strain data. This error can be compensated for by performing a shunt calibration directly on each active strain gage. But since strain gages are often unreachable after their installation, the shunt calibration process may be performed at another part of the Wheatstone bridge or at the instrumentation. The long cable can also cause errors in the calibration if it isn't undertaken across the strain gages.

Example of Strain Gauge Applications

- Bridge Completion
 - Common values include 120R, 350R, 1K, 1K2
 - While shunt calibration is recommended for low value strain gages, in the case of 5K gages a low value series connected precision resistor can be used for calibration
 - To maintain long term precision of the measurements, the ratio arms of the bridge should also consist of high precision foil resistors
- Signal Conditioning
 - Classical amplifier “normal values”: 1 k Ω , 5 k Ω , 10 k Ω , 100 k Ω
- Calibration Shunts
 - High values: 75 k Ω and up
 - Low power, standard conditions
- A high-value Bulk Metal Foil resistor (typically 50K to 200K) may be placed in parallel across a strain gage or one leg of the Wheatstone bridge to produce a predictable mV offset shift which can be measured and used to calibrate a load cell instead of a more inconvenient weighing standard. This resistor should be stable over a wide variety of temperatures, a long period of time, and various humidity conditions.

Further information about Vishay Foil Resistors products is available at:
www.vishayfoilresistors.com

Follow Vishay Foil Resistors at: <http://twitter.com/FoilResistor>

For more information about this product group, please contact us at: foil@vishaypg.com