TECH NOTE #022:: Strain Gage based Wheatstone Bridge - why an exact gauge factor setup is so important

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Abstract

Every electrical strain gage has a specified gauge factor representing the ratio of relative change in electrical resistance to mechanical strain ε. The gauge factor highly depends on manufacturing and varies within a certain tolerance from batch to batch. Setting the exact value of the gauge factor is necessary for precise strain measurement. This Tech Note shows how the gauge factor influences the result and why it is so important taking the specified value from every individual HBM strain gage data sheet and parameterizing accordingly.

Intro

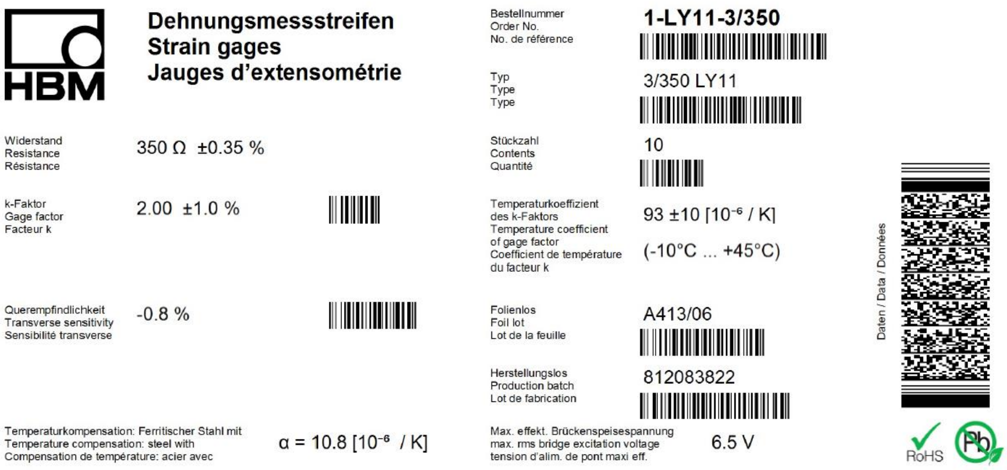
The gauge factor is a proportional factor between measured strain and the relative change in the bridge which can be measured by a suitable device supporting Wheatstone bridges such as QuantumX MX1615B from HBM.
In general the gauge factor depends on the grid material and varies around 2.0 (Constantan, used in HBM's Y-Series) and 2.2 (Modco, used in HBM's M-Series).

A high gauge factor increases the output signal on the Wheatstone bridge; a low gauge factor reduces the signal:

$$\frac{\Delta R}{R_0} = k \cdot \varepsilon$$

If a wrong gauge factor is set by the software strain measurement won't be precise as a consequence. This is why each HBM strain gauge batch or package shows the individual gage factor.

Illustration: Strain gages datasheet



HBM
Dehnungsmessstreifen
Strain gages
Jauges d'extensométrie

Widerstand / Resistance / Résistance: 350 Ω ±0.35 %

k-Faktor / Gage factor / Facteur k: 2.00 ±1.0 %

Querempfindlichkeit / Transverse sensitivity / Sensibilité transverse: -0.8 %

Temperaturkompensation: Ferritischer Stahl mit / Temperature compensation: steel with / Compensation de température: acier avec: α = 10.8 [10⁻⁶ / K]

Bestellnummer / Order No. / No. de référence: 1-LY11-3/350

Typ / Type / Type: 3/350 LY11

Stückzahl / Contents / Quantité: 10

Temperaturkoeffizient des k-Faktors / Temperature coefficient of gage factor / Coefficient de température du facteur k: 93 ±10 [10⁻⁶ / K] (-10°C ... +45°C)

Folienlos / Foil lot / Lot de la feuille: A413/06

Herstellungslos / Production batch / Lot de fabrication: 812083822

Max. effekt. Brückenspeisespannung / max. rms bridge excitation voltage / tension d'alim. de pont maxi eff.: 6.5 V

Daten / Data / Données

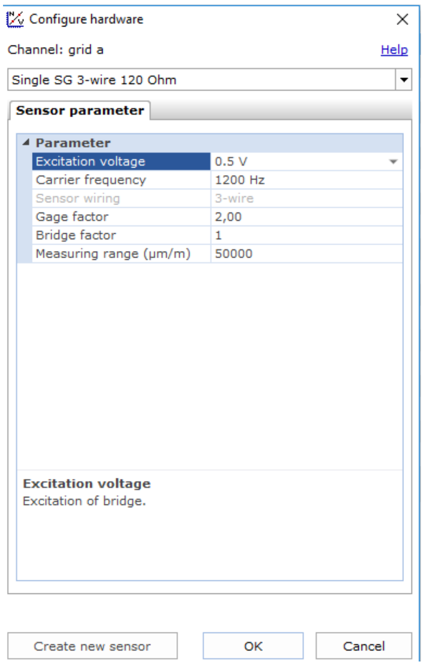
RoHS

The following experiment shows the error a wrong gauge factor generates.

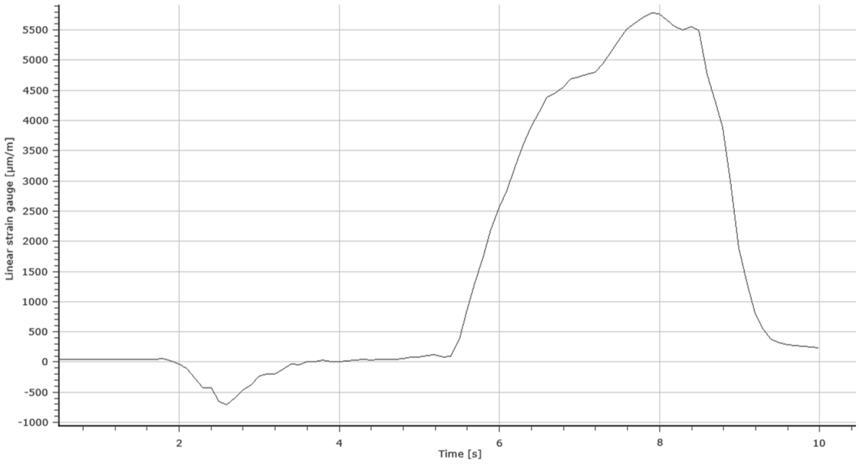
Workflow

Let's take a measurement chain which consists of a linear electrical strain gauge LY41-3/120 , 3-wire connection to the bridge amplifier module MX1615B and EVIDAS software from HBM. The following test is performed at room temperature.

For the first trial the gauge factor is set to 2.0.

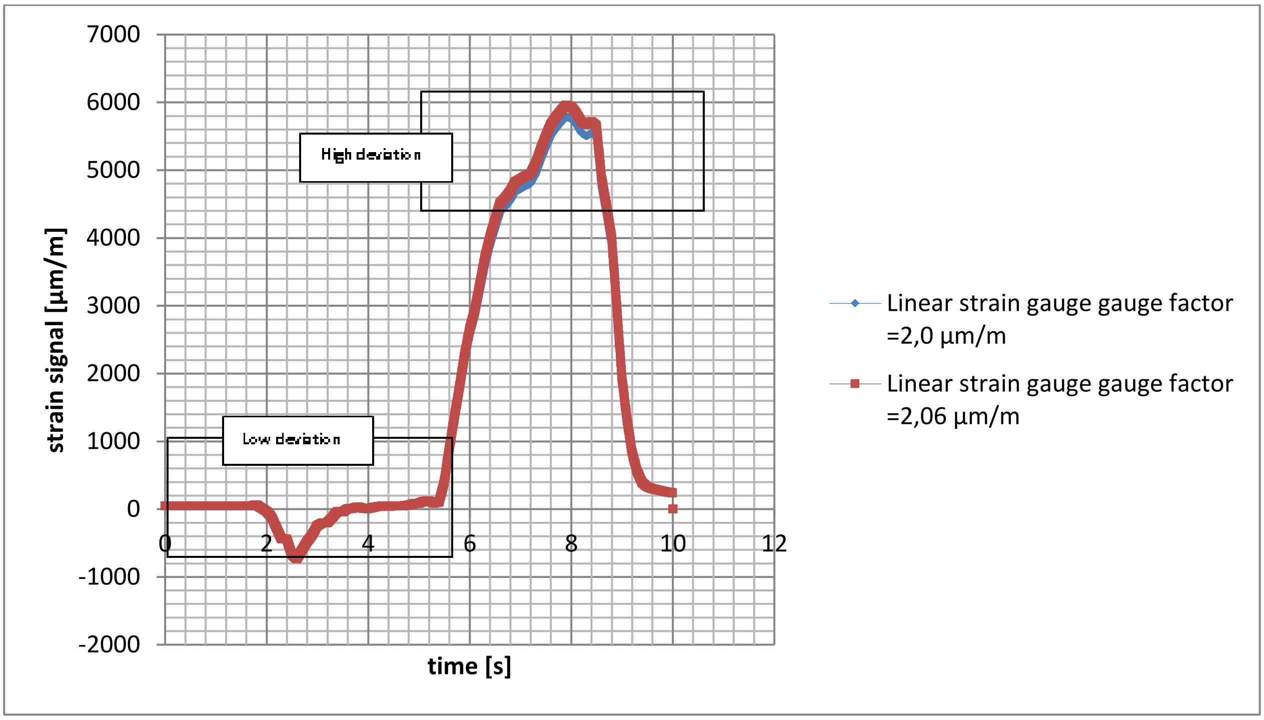


The strain gauge is applied on a bending beam and the following signal is created.



As described the gauge factor of a strain gauge varies from its batch slightly. It's important to store your strain gauge data sheet including the gauge factor or you save all data in your sensor database (as true digital data or / and complete PDF file). At first glance it seems that 2.0 or 2.06 doesn't make a big difference but the following experiment shows that we get a significant measurement error not considering the correct gauge factor.

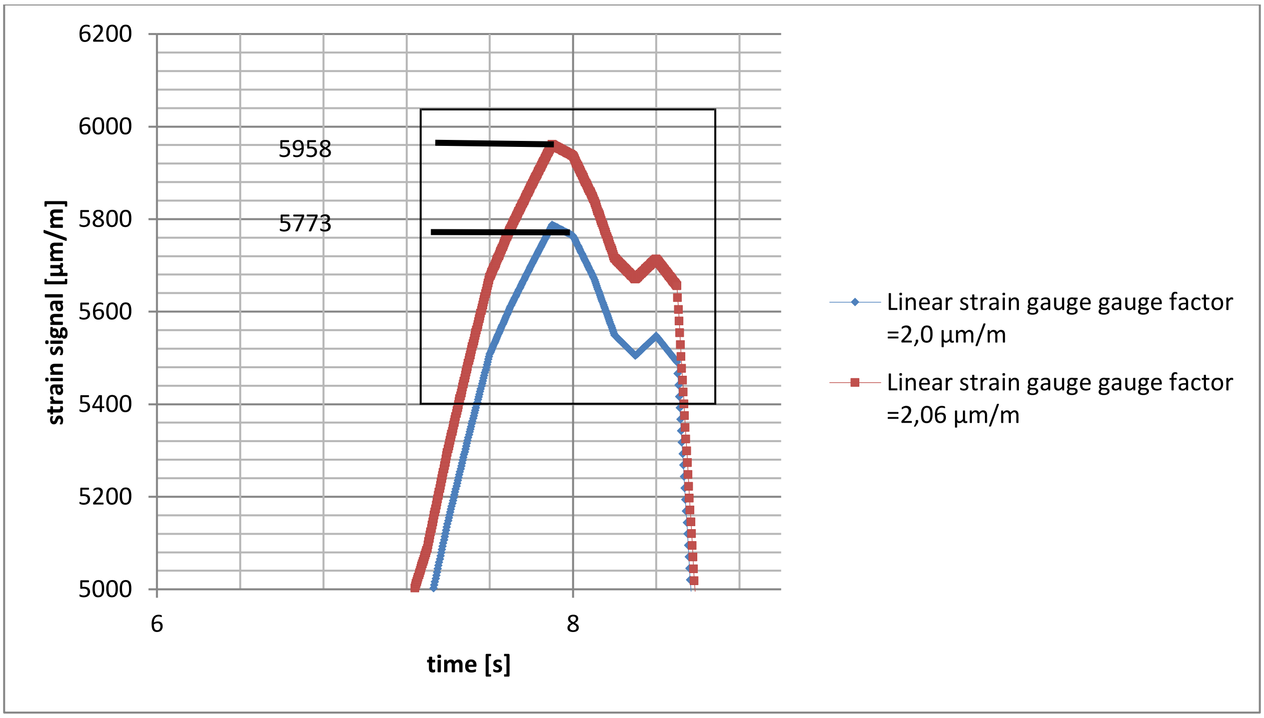
For this test two strain gages of the same lot are applied, one wheastone bridge channel is parameterized with a gauge factor 2.0 and the other one with 2.06. For low strains we can see more or less an overlap of the two graphs. If strain is higher there is a clearly visible offset of the result.



Looking closer to the measurement signal it's directly visible that this offset is not negligible.

With a gauge factor of 2.0 and strain of 5773µm/m (~0.577% strain) is measured while with a gauge factor of 2.06 a strain of 5958µm/m (~0.596%) is measured. This corresponds to a difference of 185µm/m!

In terms of relative measurement error this means 3.2%.



This experiment shows that an accurate measurement needs correct parameterization. This is valid too, when it comes to ambient or installation influences like measurement spot temperature, contact resistance, ambient temperature around the wires and device and electro-magnetic overall interference to the strain gage and wiring.

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