
# The key to new applications: precision

### Efficient in use: S-shaped S2M force transducer

**Using high-precision transducers, for example S2M from HBM, provides many benefits. Sensors offering an accuracy class of 0.02 enable force measurement chains to be designed with high mechanical reserves. And, in addition: The transducers can be flexibly used for different measurement tasks - a major economic benefit.**

The S-shaped S2M force transducer offers an accuracy class of 0.02 and sets new standards in its class. To be able to achieve such a high level of accuracy, all individual transducer characteristics need to be optimally matched.

### What is the accuracy of force transducers influenced by?

The following error groups are distinguished with strain gauge-based force transducers:

- Errors relative to the full scale value:
  Errors generating a specific output signal independent of the force applied, for example the temperature effect on the zero point ($TC_{zero}$) or non-linearity.

- Errors relative to the actual value:
  Errors whose magnitude is proportional to the force applied at the time of evaluation.

$TC_{zero}$ and linearity often are of vital importance. These errors are relative to the full scale value, i.e. to the output signal at full nominal (rated) force. This measurement uncertainty has a specific value, irrespective of how big the measured force is.

When measurements are taken in the upper sensor range, i.e. at high force levels, an error relative to the full scale value is uncritical, since its relative proportion is small compared to the high output signal. The situation looks quite different when a small force is measured using the same force transducer. In this case, the effect of an error relative to the full scale value is significantly greater: The value is the same, however, it needs to be related to a smaller force: The relative proportion increases.

Linearity and the zero point's dependency on temperature ($TC_{zero}$) are major error influences relative to full scale. Every improvement in these characteristic values enables the force transducer - assuming given accuracy requirements - to be used for ever smaller forces: Errors relative to the full scale value determine the force transducer's permissible measurement range. Small errors relative to full scale expand the possibility of measuring in the partial load range.

Errors relative to the actual value always take effect relative to the currently measured force. When small forces are measured, the influence of these error quantities therefore is rather small.

**Expanded field of application of high-presicion force transducers**

Users of the S-shaped S2M force transducer benefit from highest accuracy, because: Linearity errors, relative reversibility errors and temperature influences are less than 0.02 % relative to the full scale value. This clearly shows that HBM pursues the high accuracy standard both with selected products and standard products for industrial use that offer correspondingly rugged design.

When the transducer is used at 5% of its nominal (rated) force, the error caused by linearity and/or $TC_{zero}$ relative to the force applied is only 0.4%. With these properties, high-precision transducers open up new applications. They also enable small forces to be measured, because:

- Operating the measuring chain in the partial load range increases overload tolerance and enhances reliability. Significant measurement results are nonetheless guaranteed.

- The same force transducer can be used for different measurement tasks thanks to the minimal temperature effect on the zero point. Higher nominal (rated) forces can be applied without having to worry, when dynamic characteristics, for example higher vibration bandwidth or stiffness are required - a huge economic benefit. These mechanical parameters are dependent on the nominal (rated) force. Force transducers with higher nominal (rated) force possess greater stiffness and thus higher resonance frequencies. Relative vibrational stress decreases when a bigger model is being used.

| Sensitivity | Conventional force transducer | S2M [%] |
|---|---|---|
| Hysteresis | 0.1 | 0.02 |
| Linearity | 0.05 | 0.02 |
| TCzero | 0.05 | 0.02 |
| TCS | 0.05 | 0.02 |
| Creep | 0.05 | 0.02 |

*Table 1: Comparison of the major factors influencing measurement uncertainty*

| Force to be measured | Measurement uncertainty of conventional force transducers with 500 N nominal (rated) force | S2M/500 N measurement uncertainty |
|---|---|---|
| 150 N | 0.62 N = 0.41 % | 0.18 N = 0.12 % |
| 20 N | 0.61 N = 3 % | 0.18 N = 0.9 % |
| 5 N | 0.77 N = 12 % | 0.17 N = 3.4 % |

*Table 2: Calculation of the S2M force transducer's total error relative to the actual value compared with conventional transducers. (Temperature range: 23 … 45 °C, values given in % relative to the measured force)*

**Efficient production through precision**

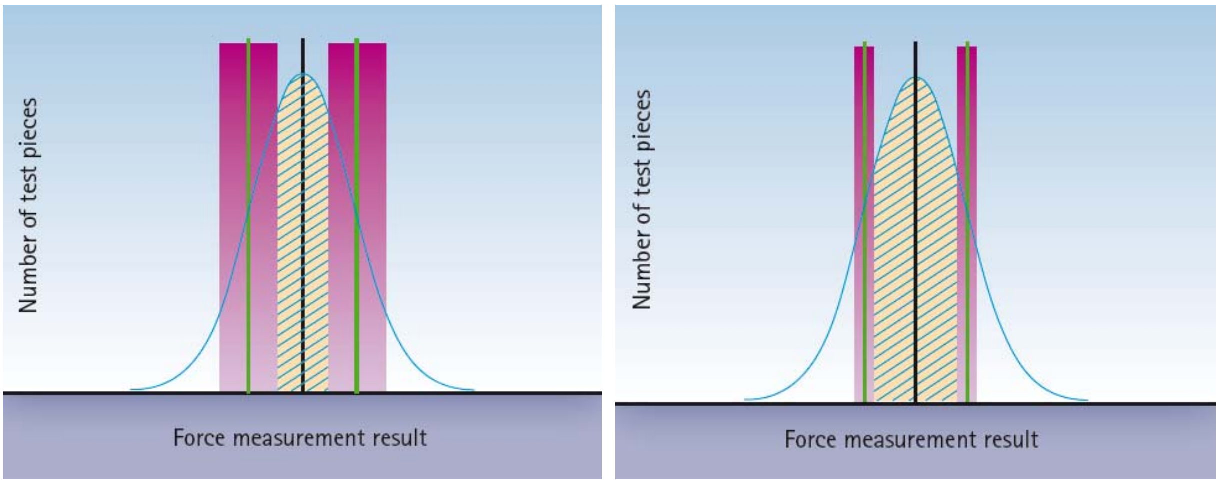
Precise force transducers such as S2M positively affect both the field of application that is expanded and the efficiency of manufacturing processes, which is illustrated in fig. 1.

The force to be measured for quality control purposes is shown on the X axis. The number of produced parts is indicated on the Y axis.

The scattering of the produced parts is distributed according to the Gaussian bell curve law. Green lines, indicating the permissible tolerances, are entered in the diagrams, and the measurement uncertainty of the force measurement chain can be seen to the left and right of these limits in red.

The transducer's measurement accuracy needs to be assessed to enable the process to be evaluated. To implement a good/bad evaluation, the components may only be evaluated as OK when they lie within the set-point range less the measurement tolerance - shown in the diagrams by the blue hatched lines.

It becomes obvious that the number of parts that can be tolerated increases with increasing measurement accuracy. In other words: The number of parts to be rejected is also dependent on the force measurement chain's measurement accuracy.



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