Analysis of comparison data of acceleration measurements

H. Moeck, PTB,Germany

Hartmut.Moeck@ptb.de

For key comparisons in the area of vibration and shock acceleration, accelerometers (ACM) are used as transfer standards. A piezoelectric ACM is an electromechanical transducer that generates an electrical output when subjected to vibration. The electrical output will be directly proportional to the acceleration of the ACM over a limited frequency range and dynamic range. The ratio of the ACM's electrical output to the mechanical input is defined as the sensitivity of the ACM. An ACM is being circulated between the different laboratories and it is calibrated by each laboratory. The resulting sensitivities are the quantities to be compared.

The sensitivities are determined for sinusoidal accelerations with fixed amplitudes over a range of frequencies, e.g. from *100* Hz to *10* kHz. The frequency dependence of the sensitivities *S(f)* over the frequency range from *100* Hz to *10* kHz can be modeled according to

$$S(f) = \frac{S_0}{1 - \left(f / f_0 \right)^2} G_f \qquad (1)$$

where f denotes the frequency, S_0 the unknown sensitivity at 0 Hz, f_0 the unknown resonance frequency and G_f known correction factors of the ACM used as transfer standard.

The standard analysis of comparison data of accelerometer calibrations is performed by analyzing the data at each frequency independently. For instance, in order to calculate the reference value at a specific frequency only the measurements at the same frequencies are considered.

As an alternative approach, a model-based analysis using the relation (1) is proposed. By this approach the unknown parameters S_0, f_0 of the physical model (1) are determined in a weighted least-squares sense using the data of all laboratories at all frequencies. The conformity of the model with the data has to be checked. If the model conforms to the data, it can then be used to calculate reference values at any frequency. Since more information has been considered than by standard analysis, namely the model relation (1), the uncertainties associated with the reference values obtained in this way become smaller. The model-based analysis can be viewed as an extension of the weighted mean in the presence of a physical model that describes the dependence of the sensitivities over the range of frequencies.

The concept of model-based analysis is proposed. The determination of a reference curve including its uncertainty is outlined. Furthermore, uncertainties associated with differences of single measurements and the reference curve are calculated. The approach is finally illustrated by its application to calibration data of a regional key comparison.