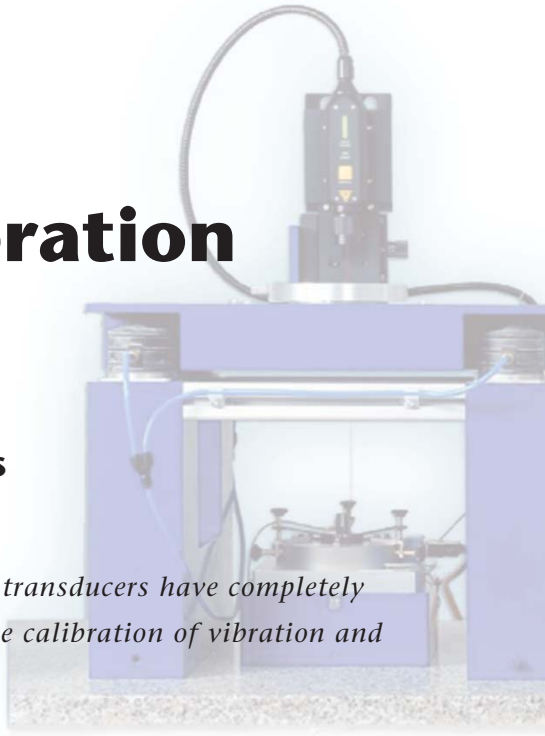

Primary Vibration Calibration
by Laser Interferometry

Requirements, Challenges and First Experiences with a New Calibration System

In recent years, the old standards for calibrating vibration and shock transducers have completely been revised. Result of these activities is a new series "Methods for the calibration of vibration and shock transducers, ISO16063-xx".

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This revision was sparked off by new international requirements and the possibility to use new and well-known technologies at a higher level. The method most frequently used for the calibration of vibration sensors is a secondary system in accordance with ISO 16063 Part 21. In this case, the device under test will be compared with a reference standard accelerometer. This reference standard must be calibrated at a higher level, e.g. by PTB in Germany using primary calibration.

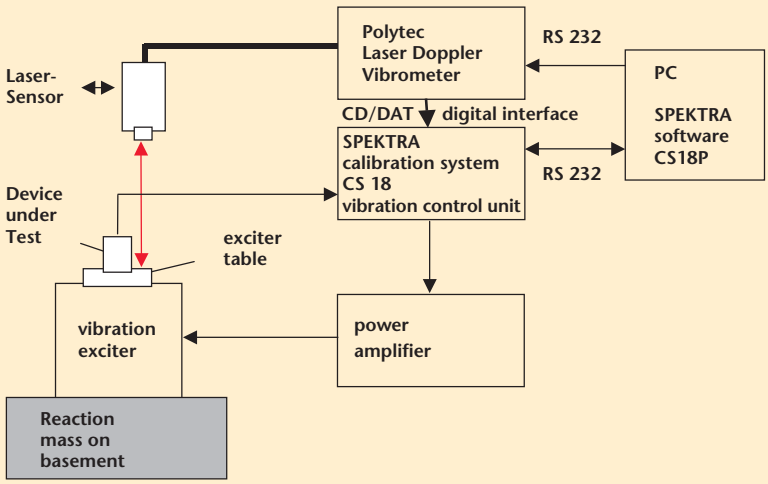
Calibration by Laser Interferometry

Part 11 of the new ISO standard describes methods of primary calibration by laser interferometry. Measurements of vibration acceleration, velocity or displacement are made with a precision that is traced back directly to the wavelength of laser light.

In the ISO standard, several methods of primary calibration are described. Because of the benefit of wide frequency and amplitude ranges, and the possibility to measure both amplitude and phase of the vibration signal, SPEKTRA integrated a Primary Option based on Method 3 "Sine-Approximation Method" into their Calibration System.

Due to the high precision of interferometers, primary calibration with very low measurement uncertainty is obviously not too difficult to achieve. As the prices of these systems are becoming more affordable, these will be installed not only in national metrology laboratories but also in highly specialized accredited industrial calibration laboratories.

To fulfill all requirements of ISO standard 16063-11, it is necessary to make use of a high quality measurement system. The vibrometer is without question an essential tool for carrying



Block diagram of the calibration system

out primary calibration. SPEKTRA successfully integrated the Polytec vibrometer with digital interface into their calibration control and measurement system.

The vibration exciter generates the mechanical excitation signal to which the device under test (DUT) is exposed. The instrumentation has to be so designed such that there are only minute transverse and rocking motions over a wide frequency and amplitude range. In practice this is definitely a major problem because it is not easy to generate the mechanical excitation signal only in the desired direction.

At first glance, it seems relatively easy to successfully make the primary calibration system by combining a good vibration exciter with a vibrometer and voltmeter. Unfortunately, this is more difficult than it seems. It is necessary to integrate these components in an optimized system that takes into consideration all requirements and influences that reduces the uncertainties of the calibration procedure to the lowest possible values.

Components and requirements

In the following list, the reader will find the important system components and parameters that have to be controlled. Also, values that are typically achievable are listed.

- Frequency stability and uncertainty: ± 0.05 %
- Acceleration stability and uncertainty: ± 0.05 %
- Total Harmonic Distortion THD: < 2 %
- Transverse, bending and rocking movements: f < 10 Hz: < 1 %, f > 10 Hz: < 10 %
- Voltage generation / measurement: < 0.1 %
- Environmental conditions: Noise, Humidity ...
- Vibration isolation between vibrometer and exciter
- Laser Interferometer: digital signal demodulation, choice of measuring points
- Combination of components: synchronized signal processing
- Dependence of the uncertainty of the sine approximation on the number of sample points

SUMMARY

Component integration for a calibration system is an optimization task. Requirements of the overall system and the individual requirements to each component have to be regarded.

This happens with consideration to the interaction between all components to reduce the calibration uncertainty to the lowest possible value.

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