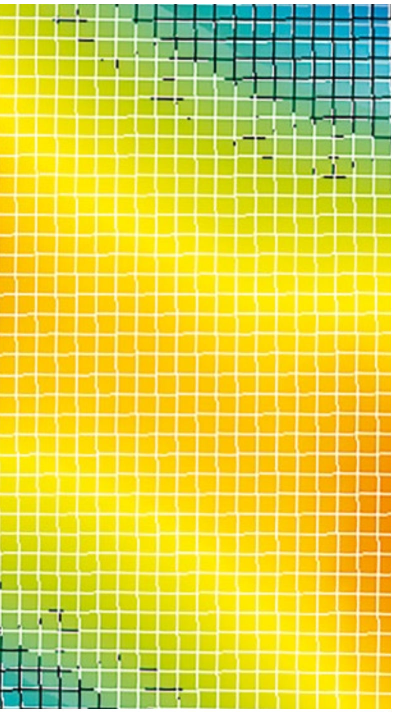
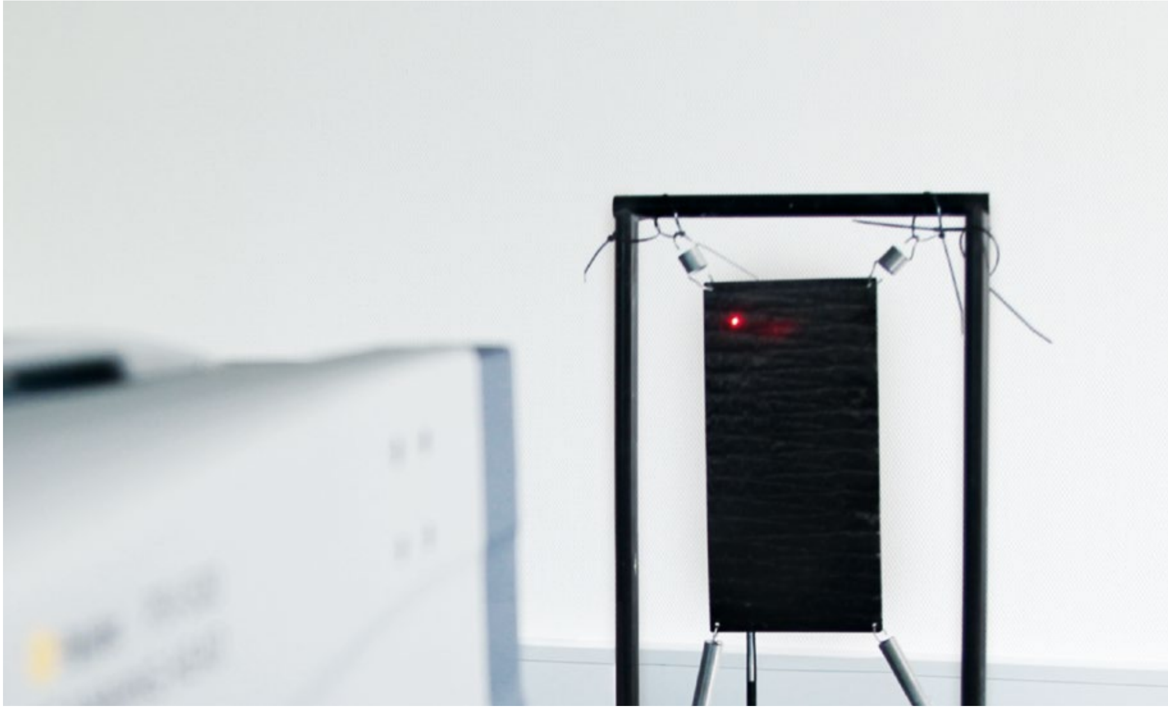




High spatial resolution

Analyzing true dynamics with optical vibration measurement

Application note

Laser vibrometers evaluate vibrating structure surfaces with unlimited point density and zero mass loading.

In research and product development, scanning laser vibrometry is used to measure the spatial and temporal vibration signature of an object. An analysis of these measurements is critical for intelligently adjusting and optimizing the vibrational characteristics of the object being developed or studied. For example, when used in the automotive, aerospace, data storage and microsystems industries, improvements in the engineering, performance, quality and production control are indispensable.

For characterizing operational deflection shapes (ODS) that require a complex measurement grid with high density measurement points, non-contact scanning laser vibrometry is optimal and has many advantages over tactile measurement systems where the physical size of the sensors limits the spatial resolution and placement.

The following text describes the comparison of a high point density measurement by a scanning vibrometer and a low resolution measurement with little measuring points (typically for accelerometers) on vibrating plates.

Test setup

To analyze the influence of spatial resolution on the representation of operational deflection shapes (ODS), a test setup consisting of a frame and a freely vibrating aluminum plate suspended within the frame was built (figure 1).

The plate (300 x 100 mm) was excited using a SAM Scalable Automatic Modal Hammer to cover a wide frequency range.

Point density makes a difference

In the following analysis, this aluminum plate was measured, using different point density settings one after the other. This experiment compares measurements for different deflection shapes with a low point density (45 measuring points) with high density (1,200 points).

The PSV Polytec Scanning Vibrometer served as the non-contact, vibration measurement system. The frequency bandwidth was 25.6 kHz with a frequency resolution of 2 Hz. These settings were used for all measurements, so the average temporal response spectrum of all measurements was almost identical.

In figure 2 the first comparison of ODS (2a, 2b) still seem to correspond, showing the same torsion at 100 Hz. At a higher frequency of 3 kHz, representation of the deflection shape using 45 points has reached its limit as is evident in figure 2c when compared to figure 2d (1,200 points). When raised to 7 kHz, the deflection shape of figure 2e (45 points) shows a lower spatial frequency when compared to the deflection shape shown in figure 2f (1,200 points).

1
Plates suspended with cable tie and spring, freely vibrating.

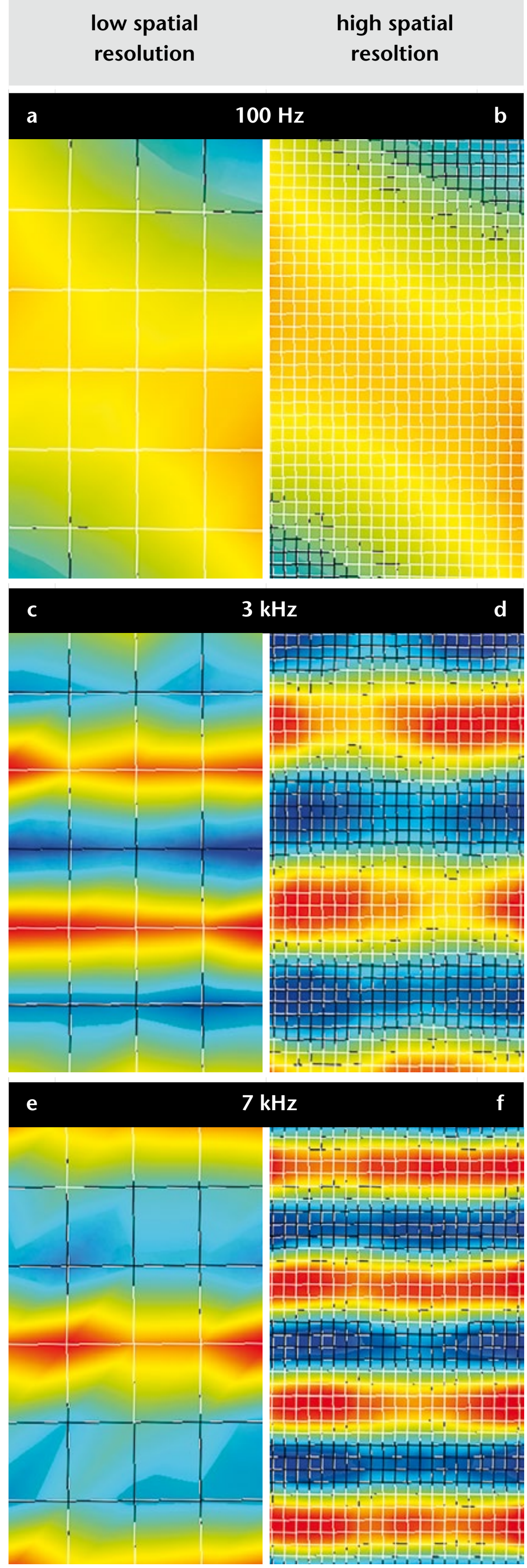
This effect comes from undersampling and is known as aliasing. The well-known Shannon-Nyquist sampling theorem applies to these measurements. When examining a freely vibrating cantilever, the first bending Eigen mode requires at least three scan points, the second Eigen mode requires minimum five scan points etc. Thus, a sufficient spatial resolution is essential for reliable visualization of an operational deflection shape and a subsequent modal analysis to determine the Eigen forms.

In the event of undersampling of the deflection shape due to lack of measurement point density, wrong conclusions might be derived, leading to a false interpretation of the measurement results. Through spatial aliasing, deflection shapes with lower spatial resolution are displayed, but these do not correspond to the correct high order resonance form. In the worst case, low point density vibration measurement leads to the wrong starting point for technical evaluations, to design errors and faulty products.

Conclusion

The comparison of high measurement point density with the PSV Polytec Scanning Vibrometer and low measurement point density with contacting methods like accelerometers clearly showed, that with a lower measurement point density the deflection shapes of higher modes can only be displayed to a limited degree. In order to describe a true and representative deflection shape, it requires a minimum of spatial resolution. If the resolution is too low, a deflection shape might be wrong due to spatial aliasing or even missed completely.

In many cases, the use of accelerometers as vibration sensors face the problem of a limited number of measuring points, due to the geometric dimensions of the sensor and its additional mass. The PSV Polytec Scanning Vibrometer solves this with a virtually unlimited number of measurement points and also provides reliable measurement data for complexly shaped structures.

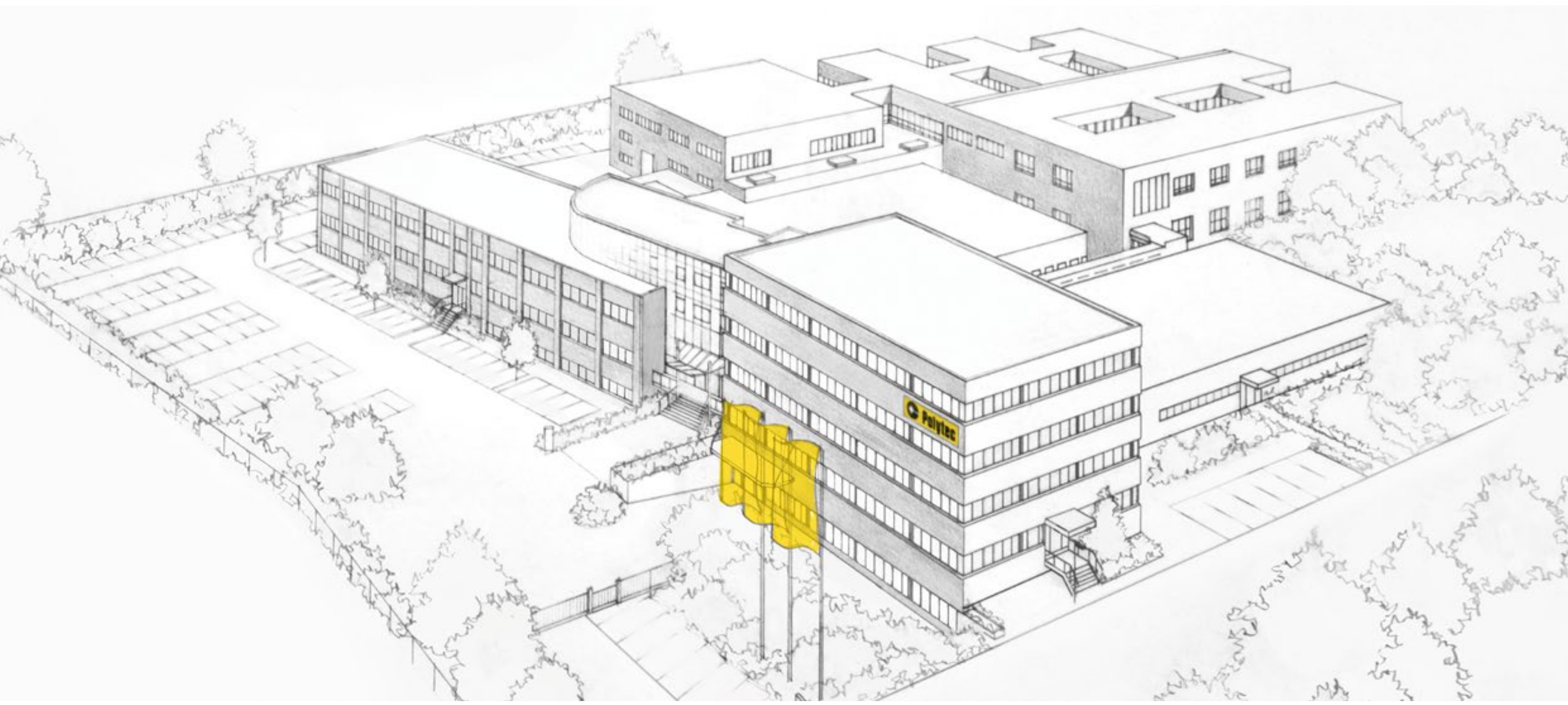


2
Operating deflection shapes a, c, e with 45 measuring points shall simulate a typical accelerometer setup, whilst b, d, f represent the high spatial resolution (1,200 measuring points) using Scanning Laser Doppler Vibrometers (SLDV).

Authors

Joline Dank, Polytec GmbH in cooperation with the Faculty of Electrical Engineering and Information Technology at the Karlsruhe University of Applied Sciences – Technology and Economy

Polytec



Polytec GmbH (Germany)
Polytec-Platz 1-7
76337 Waldbronn
Tel. +49 7243 604-0
info@polytec.de

Polytec GmbH (Germany)
Vertriebs- und Beratungsbüro
Schwarzschildstraße 1
12489 Berlin
Tel. +49 30 6392-5140

Polytec, Inc. (USA)
North American Headquarters
16400 Bake Parkway
Suites 150 & 200
Irvine, CA 92618
Tel. +1 949 943-3033
info@polytec.com

Central Office
1046 Baker Road
Dexter, MI 48130
Tel. +1 734 253-9428

East Coast Office
1 Cabot Road
Suites 101 & 102
Hudson, MA 01749
Tel. +1 508 417-1040

Polytec Ltd. (Great Britain)
Lambda House
Batford Mill
Harpenden, Herts AL5 5BZ
Tel. +44 1582 711670
info@polytec-ltd.co.uk

Polytec France S.A.S.
Technosud II
Bâtiment A
99, Rue Pierre Semard
92320 Châtillon
Tel. +33 1 496569-00
info@polytec.fr

Polytec Japan
Arena Tower, 13th floor
3-1-9, Shinyokohama
Kohoku-ku, Yokohama-shi
Kanagawa 222-0033
Tel. +81 45 478-6980
info@polytec.co.jp

Polytec South-East Asia Pte. Ltd.
Blk 4010 Ang Mo Kio Ave 10
#06-06 TechPlace I
Singapore 569626
Tel. +65 64510886
info@polytec-sea.com

Polytec China Ltd.
Room 402, Tower B
Minmetals Plaza
No. 5 Chaoyang North Ave
Dongcheng District
100010 Beijing
Tel. +86 10 65682591
info-cn@polytec.co

www.polytec.com

OM_AN_VIB_G_025_High_spatial_resolution_E_42495
2018/08 - Technical specifications are subject to change without notice.