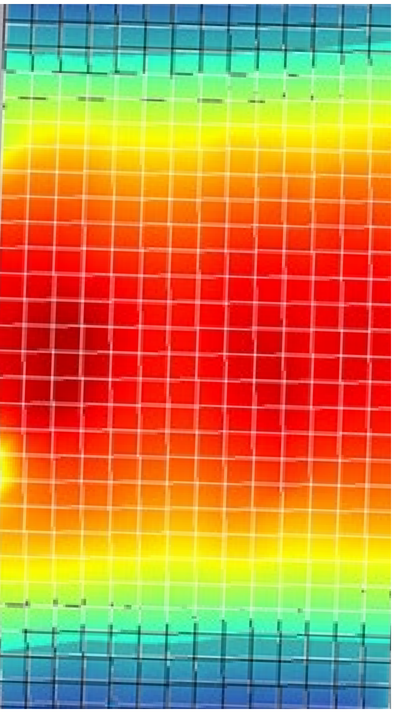
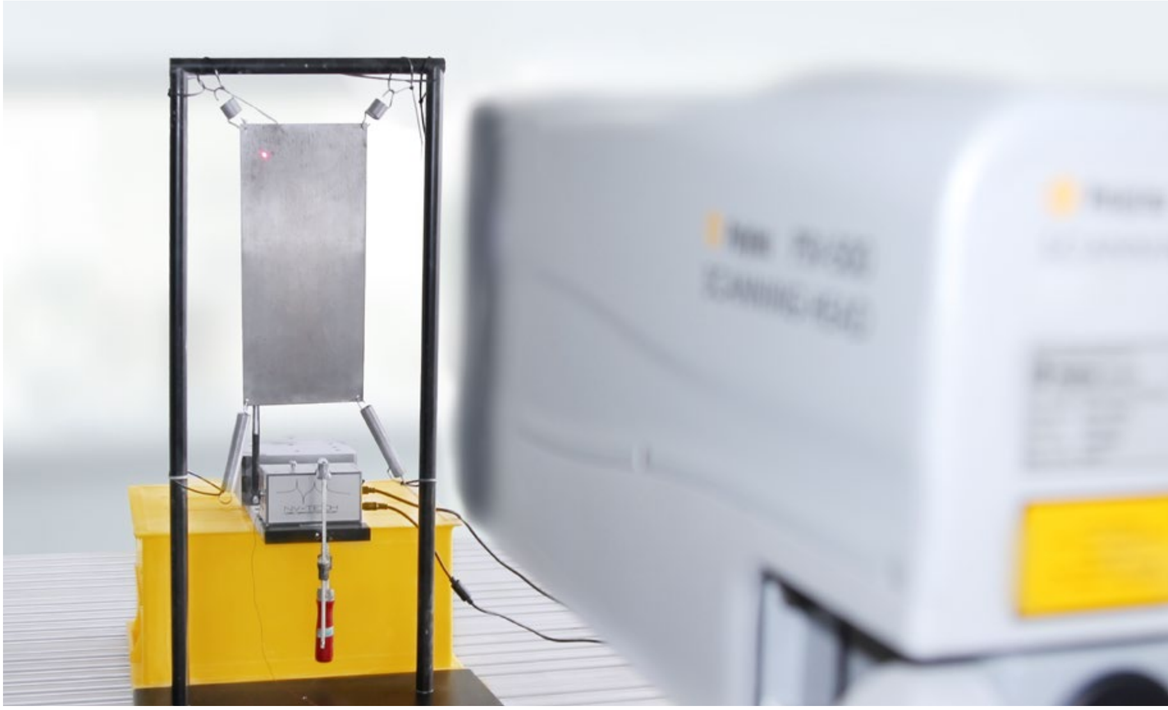
Polytec



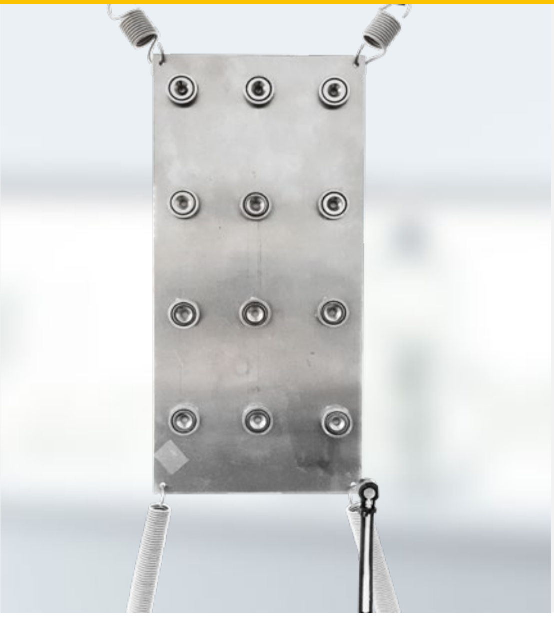


Zero mass loading

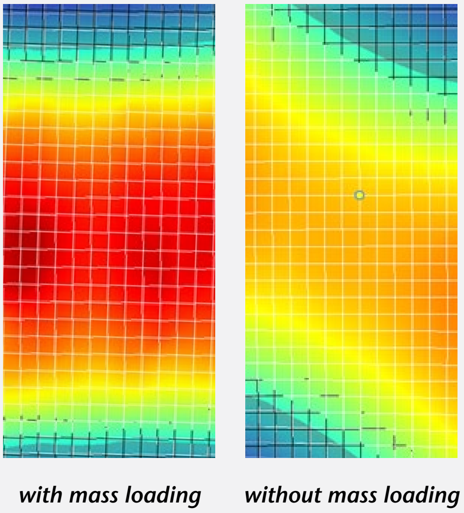
Effect and compensation in vibration analysis

Application note

Traditionally, analyzing the true dynamic response of a structure has been complicated by many factors including the excitation method, the boundary conditions and last but not least the influence of the mounted contact sensors. This is where laser Doppler vibrometers come in.



1
Mass loaded plate showing 12 dummy masses, which represent a typical accelerometer test setup excited by a modal hammer on the lower right



2
Operational deflection shapes of an aluminum plate: on the left at 144 Hz; on the right without mass loading using non-contact laser vibrometry, revealing the true structural dynamics

This application note shall demonstrate the quantitative and qualitative influence of the sensor's mass on Eigen frequencies and operational deflection shapes (ODS) comparing typical tactile methods like accelerometers with the non-contact and thus non-reactive sensor technology of the scanning laser Doppler vibrometry (SLDV).

Experimental setup

The underlying test object was an aluminum plate measuring 300 mm in length and 100 mm in width weighing 213 g. It was suspended using springs mounted in the corners to simulate free suspension. The excitation source was a SAM Scalable Automated Modal Hammer using pulse excitation. Figure 1 shows the measurement setup. Twelve masses of 12 g per piece (additional 144 g in total) were used as dummy masses to load thee plates and simulate the positioning and mass of mounted contact sensors (accelerometers). The masses corresponded approximately to the typical mass of an acceleration sensor. The masses were glued with adhesive tape. The PSV-500 Scanning Vibrometer was used as a non-contact optical measurement system. For a comparison, two measurements were carried out at a point density of 500 measuring points: one modal analysis with additional masses, simulating attached accelerometers and one without additional masses, representing a non-contact measurement with a PSV Polytec Scanning Vibrometer.

Vibrational behavior with and without mass loading

Figure 2 clearly shows the differing deflection shapes at 144 Hz, when measuring on an aluminum plate with and without mass loading. In the response spectrum of the two measurements shown in figure 3, an obvious frequency shift as well as increased attenuation can be observed.

3
Aluminum plate; blue curve = without mass loading; red curve = with 12 additional masses

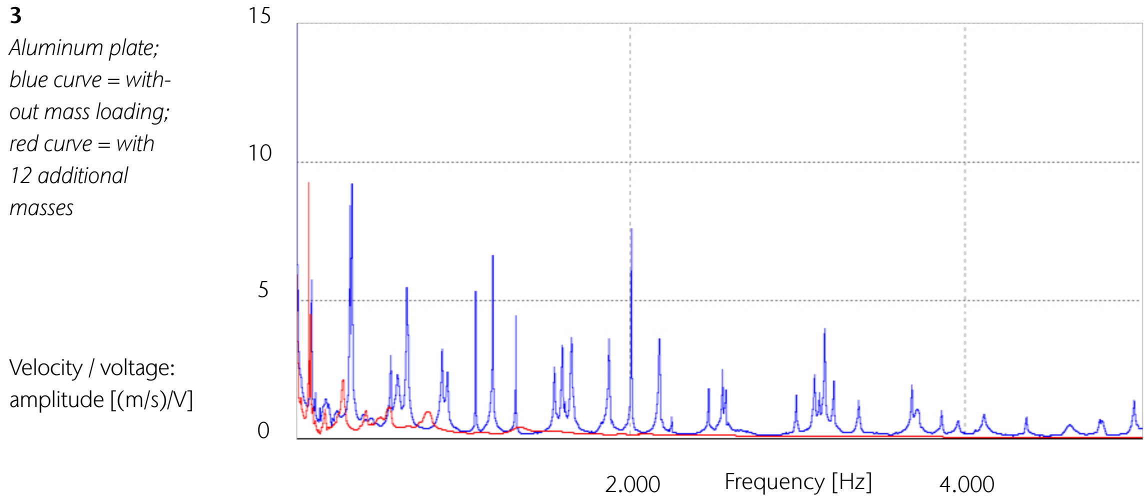


Table 1: *Comparison of the frequency shift and attenuation on an aluminum plate without mass loading and with mass loading (12 additional masses fixed with tape shall represent glued accelerometers)*

ODS	1	2	3
$f_{no\ mass}$ [Hz]	328	668	910
$f_{with\ mass}$ [Hz]	288	564	788
Δ f [%]	12.195	15.569	13.407
$Zeta_{no\ mass}$ [‰]	5.87	8.214	6.985
$Zeta_{with\ mass}$ [‰]	27.52	26.653	32.241

The damping value Zeta in table 1 is defined as

$$\text{Zeta} = \frac{-3\text{ dB [Hz]}}{2 * f\text{ Max [Hz]}}$$

the ratio of the half-width (at 3 dB) and the double frequency of the maximum of a mode peak. The damping was mainly caused by the additional carrier material of adhesive tape, while the pure mass loading had only a small influence on the vibration attenuation. Table 1 summarizes the results for the different frequencies f, the Δ f and the damping value Zeta.

Conclusion

The results in table 1 clearly show considerable shifts in the observed resonance frequencies caused by the additional masses. This also reveals, that attaching accelerometers influences the vibrational behavior on lightweight structures. Furthermore, we can observe an important increase in damping due to the adhesive tape used to fix these additional masses. These distorting effects should be taken into account when performing tests with attached vibration sensors. Laser vibrometry is a non-contact, optical measuring technique that does not affect the vibrational behavior of the test structures and thus reveals the true dynamics. This is especially important for vibration analysis with lightweight objects. Laser vibrometry also offers the additional benefit of a virtually unlimited number of sensor locations, allowing for a very detailed and exact representation of complex high-order deflection shapes, whilst showing zero mass loading.

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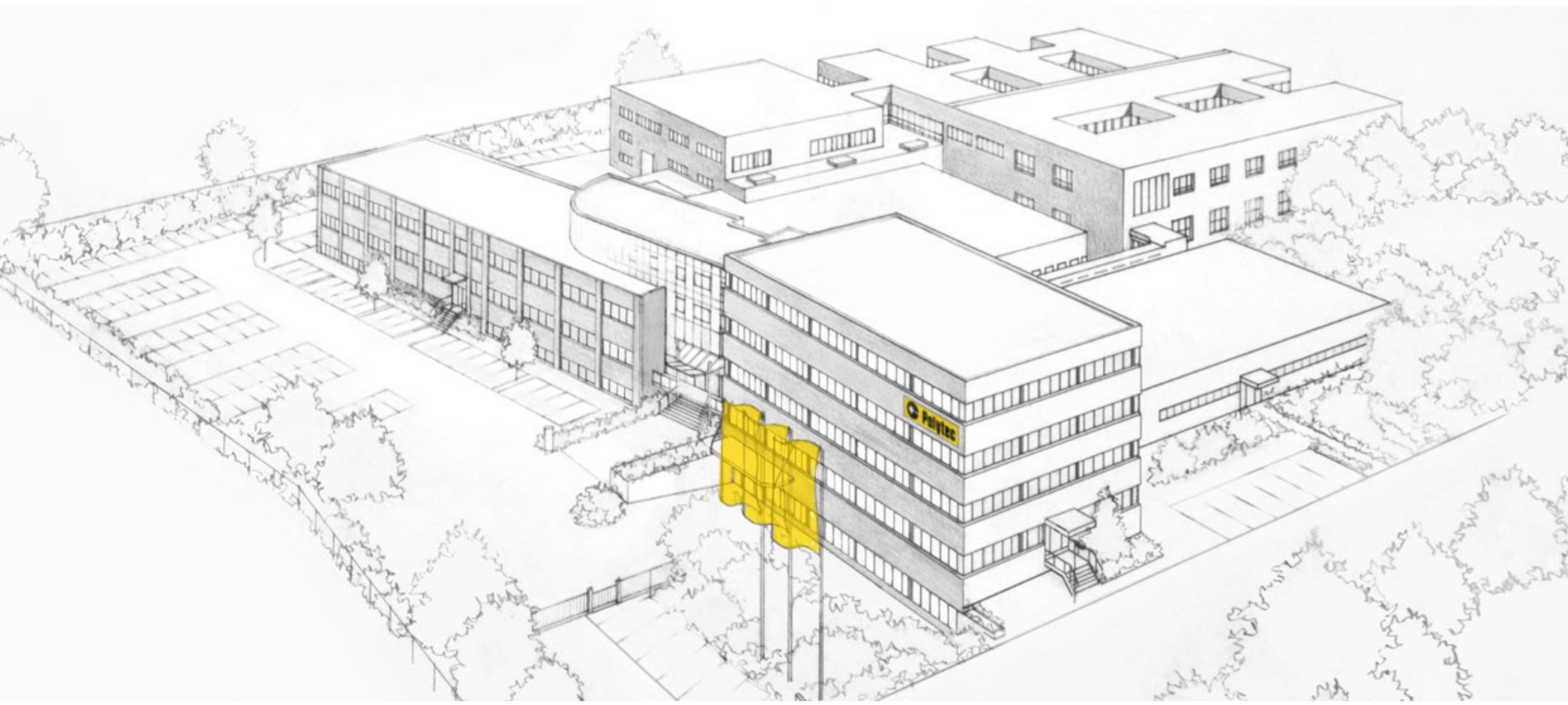

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2018/10 - Technical specifications are subject to change without notice.