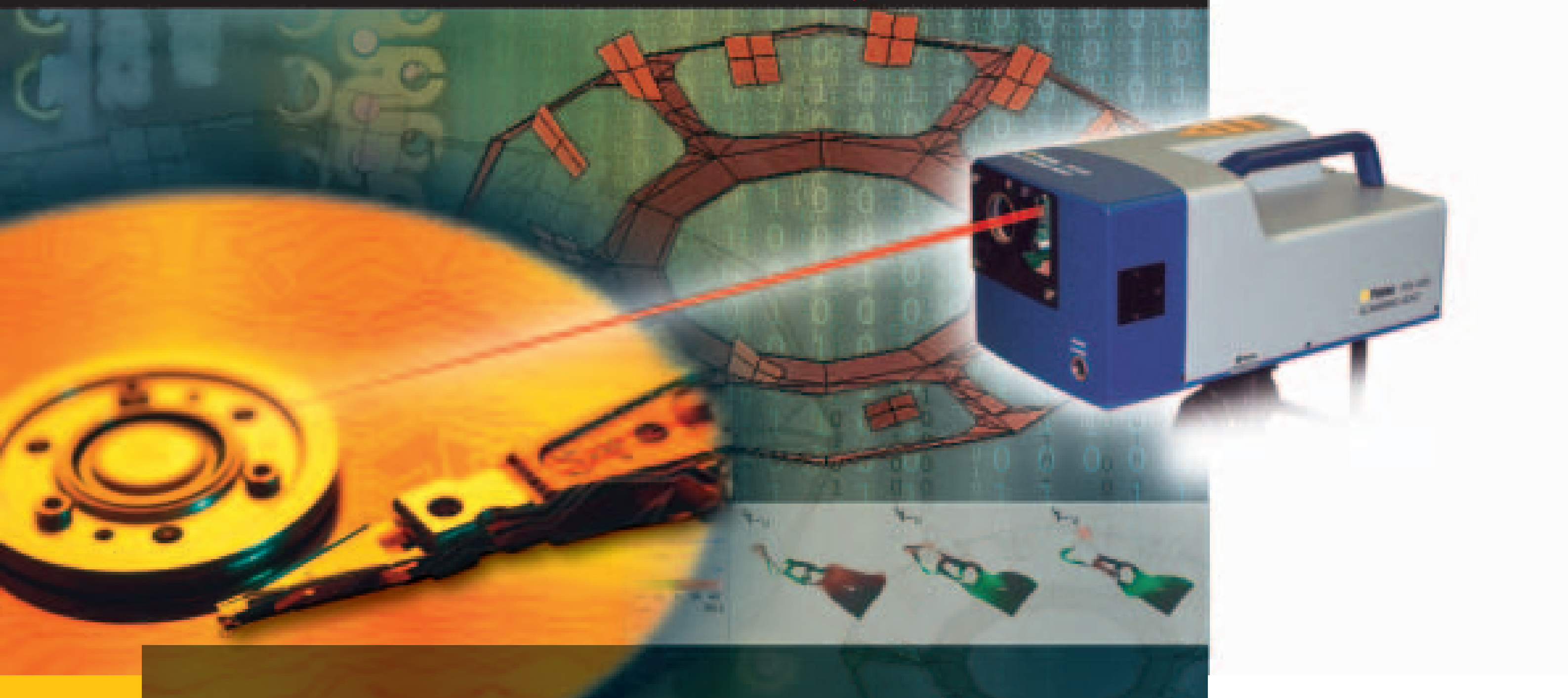
LM INFO Special

LASER MEASUREMENT SYSTEMS ISSUE 2/2004



MEASURING TO THE LIMITS

Laser Doppler Vibrometry is essential to designing next generation data storage devices that are more compact, powerful, reliable, and silent.

While often competing with accelerometers for dynamic testing, vibration imaging and modal analysis of macro structures, Laser Doppler Vibrometers stand alone as the dynamic measurement tool for data storage devices. By designing vibrometers that keep pace with the industry, Polytec advances the dynamic testing capability to meet higher capacity drives with faster access times, reduced misregistration and improving data transfer.

In this issue, learn how THôT Technologies incorporates Polytec's fiber optic vibrometers into an instrument to investigate the complex mechanical relationships between hard disk components (page 5). Also, discover how scanning vibrometers can characterize the acoustic signature of a hard disk drive motor and unravel the vibrational characteristics of its components (page 8) at PM°DM's research laboratories. Finally, encounter the sophisticated single-point and scanning methods used by Hitachi to study the stability of read-write heads flying above the disk surface (page 10).

CONTENT PAGE

EDITORIAL

Michael Frech

Dr. Helmut Selbach

Dear Reader,

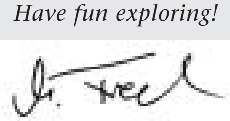
While everyone uses disk drive technology, few appreciate the engineering effort that stands behind even the simplest drive. Consider the effort behind these products that must become faster, more compact and offer higher storage density, but, at the same time, become cheaper and first to market.

After many years of poor overall performance, the global data storage market is primed for several years of significant growth and profit. This optimism is based on the rapidly expanding utilization of small hard drives in mobile phones, home entertainment centers, appliances and automobiles. We share in this optimism and have focused this LM Info Special issue on vibrometer applications in the data storage industry.

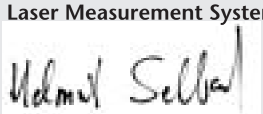
The data storage industry is but one example of the trend to miniaturize electro-mechanical systems to gain performance. MEMS devices have gained importance throughout our society. Polytec Vibrometers, especially the new microscope-based systems featured in this issue, are strongly influencing the development of new MEMS devices and applications.

You will also find an excellent tutorial devoted to explaining digital vibrometry, the best technology for high-precision measurements on demanding, high-speed technologies.

Have fun exploring!



Michael Frech
Head of Business Unit Laser Measurement Systems



Dr. Helmut Selbach
Managing Director Polytec GmbH

New *Polytec Offices and Representatives*

In the past few months Polytec has significantly improved its worldwide sales network, forming new subsidiaries in the USA and Japan, and establishing new local representation in Korea, Italy, Turkey, Poland and other Eastern European countries. With these changes, customers should experience improved distribution and customer care in their respective regions. Please see pages 21 and 24 (back) for a complete list of our world-wide offices and representatives.

USA – Polytec, Inc.

As reported in the previous issue, Polytec and PI have separated their North American operations in order to better focus on their distinct markets. **www.polytec.com/usa**

Japan – Polytec KK ポリテック株式会社

Polytec K.K. was incorporated on July 1, 2004. The corporate headquarters is located in the German Center for Industry and Trade in Hakusan High Tech Park in Yokohama and is headed by B. Sc. Hon. Kevin Gatzwiller. Prior to working for Polytec, Kevin has held several positions with Brüel & Kjær and PCB Piezotronics. He is fluent in Japanese, familiar with the Japanese market and experienced in vibration research, laser vibrometry, and modal analysis. **www.polytec.co.jp**

Polytec's MMA-400 *at the Forefront of Research on MEMS Dynamics*

Prof. Kimberly L. Turner from the Mechanical & Environmental Engineering Institute at the University of California Santa Barbara recently ordered a Polytec MMA-400 Micro Motion Analyzer (see page 4) for in-plane and out-of-plane dynamic characterization of MEMS devices.

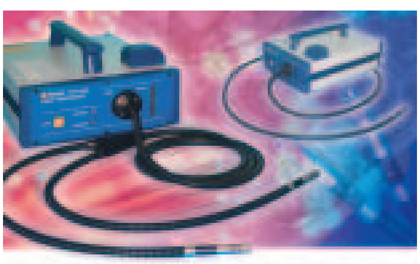
Prof. Turner's team is at the forefront of research on new MEMS sensors and actuators. Current research involves studying the non-linear and parametric dynamics of MEMS devices and applying their unique properties to novel switches, sensors and filters.

New Vibrometers *and Accessories*

Hard work has brought several new products to completion. Polytec is excited to introduce the new Microscope-based Vibrometers, Fiber-Optic Interferometers and high-performance signal decoders for the Modular OFV-5000 Vibrometer System. In addition, powerful accessories and new software releases greatly enhance measurements with our Scanning Vibrometers and Industrial Sensors. For the latest product information and data sheets, visit our new download page ***www.polytec.com/usa/Lm-download***

New OFV-551/552 Fiber-Optic Interferometer

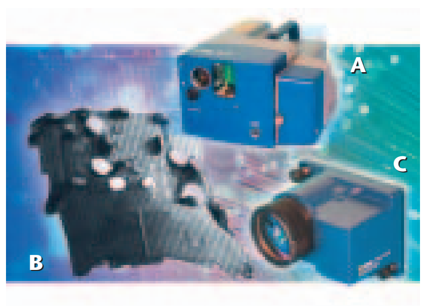
Polytec's Fiber-Optic Interferometers enable vibration measurement where physical access is difficult or where close stand-off distances are required. The new single-fiber model OFV-551 and dual-fiber model OFV-552 (designed for differential measurement between two points) combine the latest electronics and precision optics with improved opto-mechanical stability. An integrated power dimmer is now available, controlled by the OFV-5000 Vibrometer Controller. Adjusting the output intensity can be very helpful when working with microscope systems. The new Fiber-Optic Interferometers are part of our new microscope-based systems (see page 4).



New Accessories for the PSV-400 Scanning Vibrometer

Direct measurement of 3-D part geometry is now possible by using the **PSV-A-420 Geometry Scan Unit** (A). This unique laser-based distance sensor helps determine the external geometric shape of the sample (the image shows a gear box) (B) prior to the vibration measurements. It is mounted on the side of the PSV-400 Scanning Head and controlled by the PSV Software 8.2.

The **PSV-A-410 Close-Up Unit** (C) was designed for close-up part measurement and inspection and mounts to the front of the PSV.



VIB-A-100 Beam Deflector Reduces Speckle Dropouts

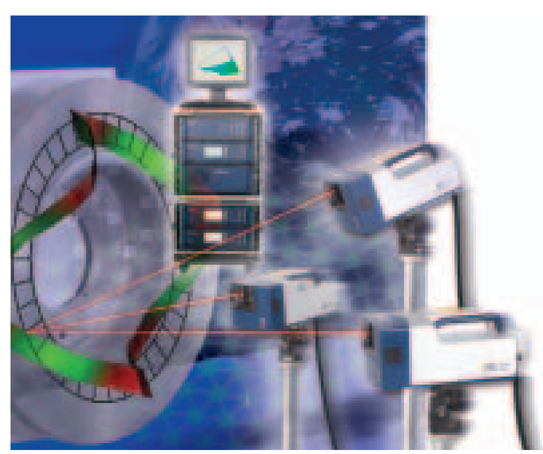
Speckle is an interference effect manifest when a coherent laser is reflected from a "rough" surface, and can affect the signal-to-noise of the vibrometer. Polytec has responded with the VIB-A-100 Beam Deflection Unit available for the IVS, CLV and PDV Industrial Sensor product lines. This device allows a remote-controlled, minimal deflection of the laser beam in order to avoid or reduce speckle dropouts and thus to improve the signal quality.

Bosch *Research Facilities Use Polytec PSV-400-3D Scanning Vibrometer Technology*

The PSV-400-3D Scanning Vibrometer is Polytec's premier measurement system for macro structure characterization. It combines three PSV-400 Scanning Laser Vibrometer heads, allowing true non contact visualization of 3-D motion.

Bosch is a leading manufacturer of high quality automotive parts. Corporate research and development labs in Gerlingen, Germany were the first to benefit from the unique advantages of Polytec's PSV-3D system. In February Bosch's European Center for Brake Development and Testing in Drancy, France installed a new PSV-400-3D. A third system was purchased in May for installation at Bosch Braking Systems USA.

The PSV-400-3D is quickly establishing itself as a new global standard for non-contact three-dimensional vibration measurements.



MORE INFO:

www.polytec.com/usa/psv3d

MSV-400 + PMA-400 = *MMA-400*

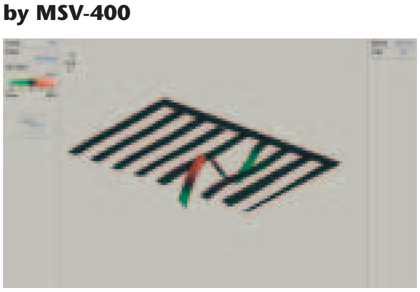
New Modular Family of Microscope-Based Vibrometers

Polytec's popular new line of modular microscope-based vibrometers takes vibration analysis on micro structures to the next level of simplicity and precision. Three basic models compose this product line: The MSV-400 Microscope Scanning Vibrometer uses the Doppler effect to measure out-of-plane vibrations. The PMA-400 Planar Motion Analyzer uses stroboscopic video microscopy to measure in-plane motion. The MMA-400 Micro Motion Analyzer combines both the MSV and the PMA into one convenient package for precise vibration measurements in all three dimensions. The OFV-5000 Vibrometer Controller, the new OFV-551/552 Fiber-Optic Interferometers and the new MSA-E-400 Junction Box are incorporated into this product family.

The **MSV-400 Microscope Scanning Vibrometer** is the successor to the award-winning MSV-300.

It is compatible with most CCD port equipped microscopes, offers full-field vibration mapping through the microscope optics with a laser spot size down to about 1 micron. Delivered and has PSV Software 8.2 (see page 20), the MSV-400 is available in a basic (1 MHz) and a high-frequency (20 MHz) version.

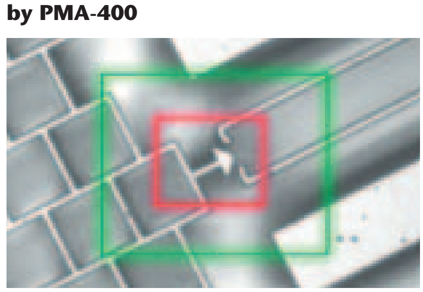
Out-of-Plane Measurement by MSV-400



The **PMA-400 Planar Motion Analyzer** offers stroboscopic video microscopy of in-plane (X, Y) motion of MEMS devices and microstructures. This allows for time-domain measurements of displacement at a frequency range of 0.001 Hz up to 1 MHz with a resolution better than 10 nm.

The PMA-400 comes with the latest PMA 2.0 software (see page 20) and can be easily upgraded to an MMA-400 by adding the appropriate MSV hardware.

In-Plane Measurement by PMA-400



The **MMA-400 Micro Motion Analyzer** incorporates the advantages of the MSV-400 and PMA-400 into one premier system, offering both out-of-plane and in-plane motion analysis. The extremely sensitive laser-Doppler technique can rapidly find all mechanical resonances of a device using wide-band excitation. Applying stroboscopic video microscopy, accurate amplitude and phase information of in-plane resonances can then be obtained.

Product News continued on page 20

MORE INFO?

www.polytec.com/usa/microsystems

Higher Density,
Higher Performance

Synchronization of Measurements on Hard Disk Drives Helps us Understand Complex Mechanical Relationships

It is a very common practice to measure the mechanical response of component assemblies, combine them with modeling software and predict the behavior of the full assembly. Sometimes it is impractical to measure the final assembly, sometimes the modeling is insufficient and, sometimes simply joining the assemblies can modify their behavior in unexpected ways.

Introduction

In the hard disk drive segment of the data storage industry, the challenges to understand the mechanical interactions are extreme as the fight for micro-inch control has progressed to nano-meters, Angstroms and now to understanding tenths of Angstroms. The next generation of disk drive will have heads flying at approximately three nanometers (30 Angstroms). The operative word is “flying”. The head must not touch the surface or it can cause premature failure of the head or media. The head must not fly too high or there will be an excessive data error rate.

Continued on page 6

The Structure of a Hard Disk Drive

Let us examine the head-to-disk interface structure, not from the surface of the head to the surface of the disk directly, first let us look at the component structures that comprise that interface.

To start, we have the ABS (Air Bearing Structure) of the head itself. This normally includes the size, general shape, curvature and finish of the surface of the head. All of this is simply the support structure to hold the read/write element at a stable altitude above the disk surface. The head is mounted on a gimbal to allow it to conform to the disk surface and the HGA (Head Gimbal Assembly) is attached to a spring flexure.

The flexure, in turn, is attached to a support arm that is a part of a track positioning device. The support arm is mounted to a positioning mechanism typically comprised of a pivot and servo positioner. As we have moved through the drive we have been dealing with larger and more massive structures until we come to the most massive one, the base plate.

The spindle is mounted to the base plate which forms the structural frame for the system. The spindle motor drives the spindle, mounting hub, disks, spacers and clamping mechanism. And finally we come to the disk surface with all of the pits and scratches, asperities, flatness, waviness and roughness issues.

Continuation of page 5

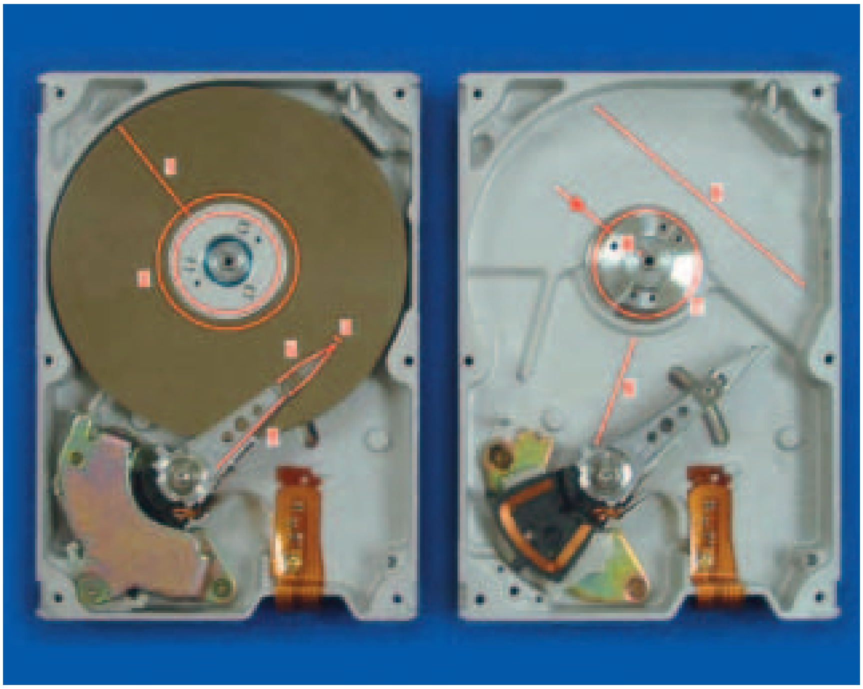


Figure 1:

Structure of a hard disk and possible locations of measurement

1. **Full surface disk scan for defects and surface morphology**
2. **Hub and disk ID scan for clamp distortion**
3. **Head and disk dual beam measurement for flyability, fly height modulation**
4. **Dynamic head flexure motion measurement**
5. **Head support arm measurement**
6. **Base plate flex and resonance**
7. **Disk mounting surface flatness and finish measurement**
8. **Spindle radial and axial synchronous and asynchronous error motion**

And that is the static view. Now, spin the disk at 5,400 rpm and fly the head over the surface at 30 Angstroms with no more than 6 Angstroms of variation. In addition, position the head over the track to within one millionth of an inch and follow the track.

Examining the Disk Surface

With LDV technology coupled with some innovative signal processing, creative data acquisition, elegant software and a little "out-of-the-box" thinking we can analyze the structures in-situ (Figure 1).

Starting with the disk surface we have several issues to examine. Pits, scratches and asperities ride on Angstrom level surface roughness with waviness features that are just several Angstroms to tens of Angstroms. Motor hub, spacers, disk runout and clamping distortion add microns and the natural resonance of the disk, excited by imbalances and uneven air flows add several additional microns of amplitude. The majority of the composite waveform is comprised of low frequency events that the head will comply to and have no effect on the read/write performance. It is essential that the low amplitude features that affect the fly height modulation be separated from this for examination and measurement. By separating the various components of the LDV signal by wavelength, it is possible to identify these elements. Limits can be established for features that impact the stability of the head as it flies over the surface such as micro-waviness, nano-waviness and roughness (Figure 2).

With the extreme resolution and repeatability of the measurement system, full surface measurements can be made of roughness to levels several hundred times better than an AFM (Atomic Force Microscope). Given the extreme measurement resolution of the LDV system, the next most important issue is the synchronization of the data acquisition to the disk surface position. Without this capability, the user would never be able to examine the resonance flutter or observe that it precesses around the surface at an approximate 8 1/3 rate causing high

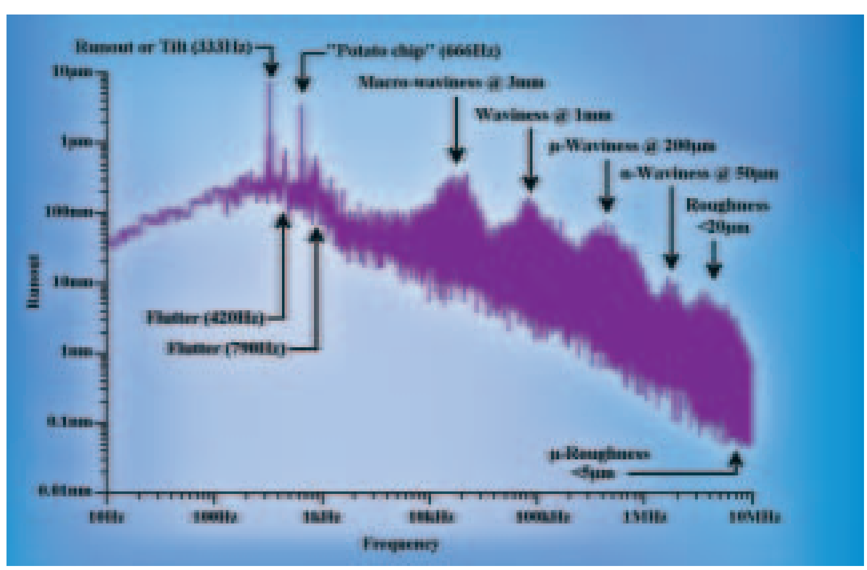


Figure 2: Full spectrum of laser data (courtesy THôT Technologies)

shifts in the surface acceleration toward the head (circumferential curvature).

Examining the Spindle

Moving down to the spindle, a whole new set of problems present themselves. First and foremost is the fact that we have to work with a rough surface. This is not a problem with an LDV if we are simply looking at the surface motion, i.e. as a vibration in a plane. However, we are now examining a rough surface at a high rotation speed and synchronization of the data acquisition to the rotation becomes critical for accurate measurements. The measurement requirements for the disk surface and the spindle are very different. With the disk, we accept as the baseline of measurement, the mean plane of the surface measurement. This cannot be done in a spindle measurement. The essential information for spindle measurements, especially in a disk drive environment, is the non-repeatable information.

The driving mechanical force in this system is the spindle motor. The imbalances of the spindle assembly, including the motor, hub, disks, spacers and clamp generate the vibrations in the other structures. While it is easy to take the individual assemblies and measure their structural dynamics on a test bed, i.e. scanning vibrometer and shaker, these measurements can also be performed on the full assemblies in-situ. Using the spindle as the “shaker” and carefully synchronizing the data acquisition, a series of measurements can be made across the base plate to the mounting point for the head positioning mechanism to understand the frame dynamics. This can be extended out the head flexure support element, across the flexure, to the HGA and even onto the head element itself.

Multiple Synchronized Measurements

Capturing information with sufficient bandwidth to provide meaningful data for an FFT analysis, component by component, is only part of the solution. We now need to understand the spatial relationship of these vibrations between the components. For example, if the HGA fixture point on the flexure displays a large vibration at a specific frequency and the spindle demonstrates the same response, it is important to understand the phase relationship between the two points. This becomes critical when we consider the non-synchronous nature of the spindle motion and the disk resonance. Simply capturing the frequency component is insufficient to analyze the structural relationships. The use of two independent measurement beams solves this problem.

This becomes obvious as we make our last measurement, the actual measurement of the change in distance between the head and the disk in operation (Figure 3). This measurement is extremely sensitive for many reasons starting with the ability to place the beam on the head at a point that will represent the true head flight response over the disk surface. Then the disk measurement beam must be located in very close proximity, corrections are going to have to be made for the radial and circumferential location differences. A differential measurement will not capture the disk surface shape and this information is required for the circumferential correction to be able to determine the proper disk-to-head spacing variation.

Further, the synchronization of the data acquisition takes on new meaning. Not only do we need the synchronization to the disk rotation to understand the changing shape of a dynamic structure but, the two data points, head and disk, must be captured in the same time frame. Any time difference between these will add significantly to the measurement error.

Conclusion

The wide frequency bandwidth and extreme resolution capabilities of the Polytec LDV systems coupled to a fast data acquisition and with a little effort to synchronize multiple measurements provide the enabling technologies. A little creativity and an understanding of the interaction of the elements of the structure should allow hard disk drive engineers to develop even higher density, higher performance products at lower costs.

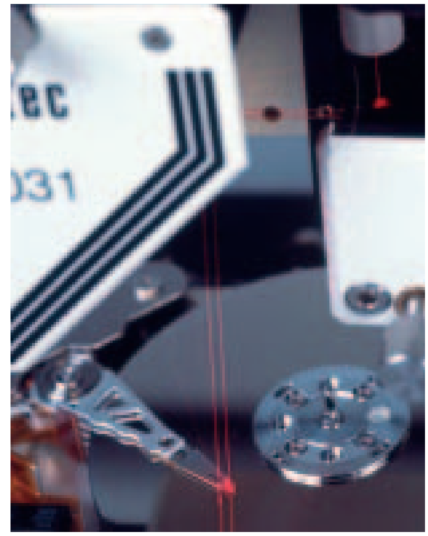


Figure 3: Measurement of disk-to-head spacing variation by dual-fiber LDV

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About THôT Technologies:

THôT Technologies was founded by Jim Eckerman and Dr. Ian Freeman in 1991 and incorporated in February of 1992. It develops, manufacturers and markets physics based test and measurement instruments. THôT Technologies has been using Polytec LDV systems in turn-key data storage measurement solutions for twelve years. Applications have grown to include measurement systems for machine tools, semiconductor wafers and photolithography masks.

If there is
a Whistling Noise in the Bedroom...

What causes annoying noise in a hard disk drive and where does it come from? PM°DM, manufacturer of modern brushless spindle motors for data storage units, is pinning down the source of the noise with the aid of Laser Scanning Vibrometer technology.

Introduction

While once found exclusively in PCs, small hard disk drives (HDD) are now found in modern video recorders, DVD players, MP3 players and games consoles, serving as high performance data storage units. With their rapidly increasing presence in our everyday lives, the restrictions on HDD noise is also increasing continuously. In the future we will download movies we want to see from the internet overnight onto the hard disk of the digital video recorder at home, which may be in the bedroom. No one will accept a generally noisy or even continually whistling power unit while trying to sleep.

Background

Whistling noises from electric motors are caused by the excitation of individual components as vibration sources during operation. An effect of this kind occurs, for example, when a tram accelerates. At full speed the whistling noise is masked by the normal running noises and therefore is not noticed by the rider. However, it is quite a different matter for hard disk drives that are often located in quite areas. The newest generation of liquid-borne hard disks emit (virtually) no

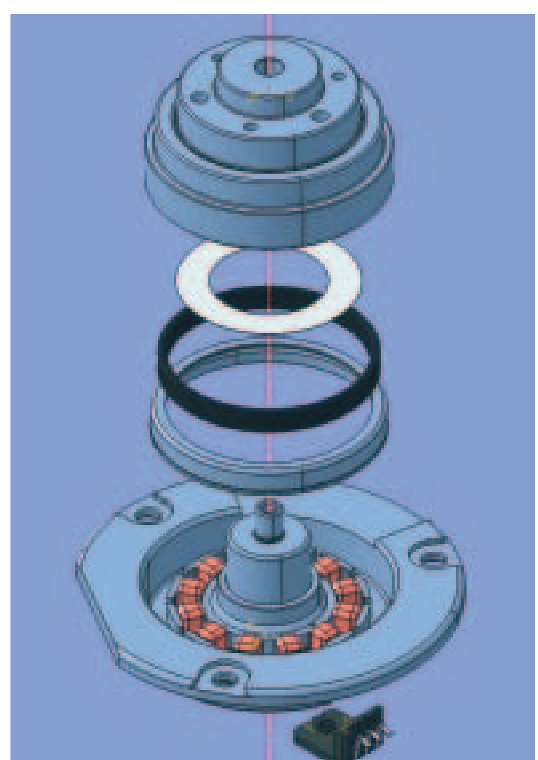

Figure 1: Design of a hard disk drive motor

audible noise during normal operation at 15,000 RPM. This means that any audible frequencies coming from the electromagnetic cycle of the motor stand out clearly in the spectrum and are perceived to be an annoying whistling noise (dominant tone).

Solution

The structure of the motor is depicted in Figure 1. It must be somewhere in the stator, in the winding or in the rotating magnet where the undesired noise is generated.

At PM°DM the vibrations and the factors which affect them are examined with the aid of a glass-encased, universally adjustable spindle motor and the Polytec Scanning Vibrometer. The glass motor provides an unimpeded view of the stator at full speed at 15,000 RPM. Each component can be moved individually and independently of the others. The position of the stator with respect to that of the rotor can be shifted and tilted. These parameters are provided in the design of the motor, but are heavily influenced by production tolerances.

In the glass universal motor it is now possible for the first time to adjust all fitting positions directly. Component dimensions are also strategically changed. In every fitting position, the frequency, amplitude and deflection shape of the stator vibrations are measured with the PSV-300 Scanning Vibrometer (Figure 2).

In Figure 3, the defined measurement surface on the stator and the accompanying deflection shape in z-direction are shown.

Figure 2: Measurement setup

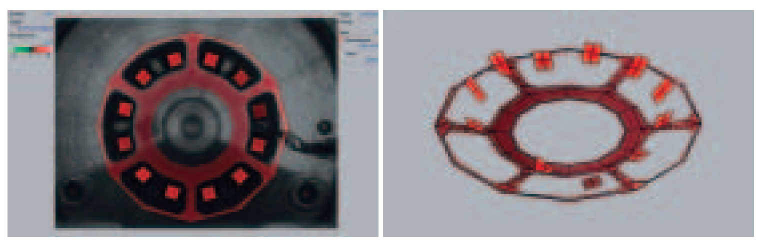

Figure 3: PSV-300 display showing out-of-plane deflection of the stator

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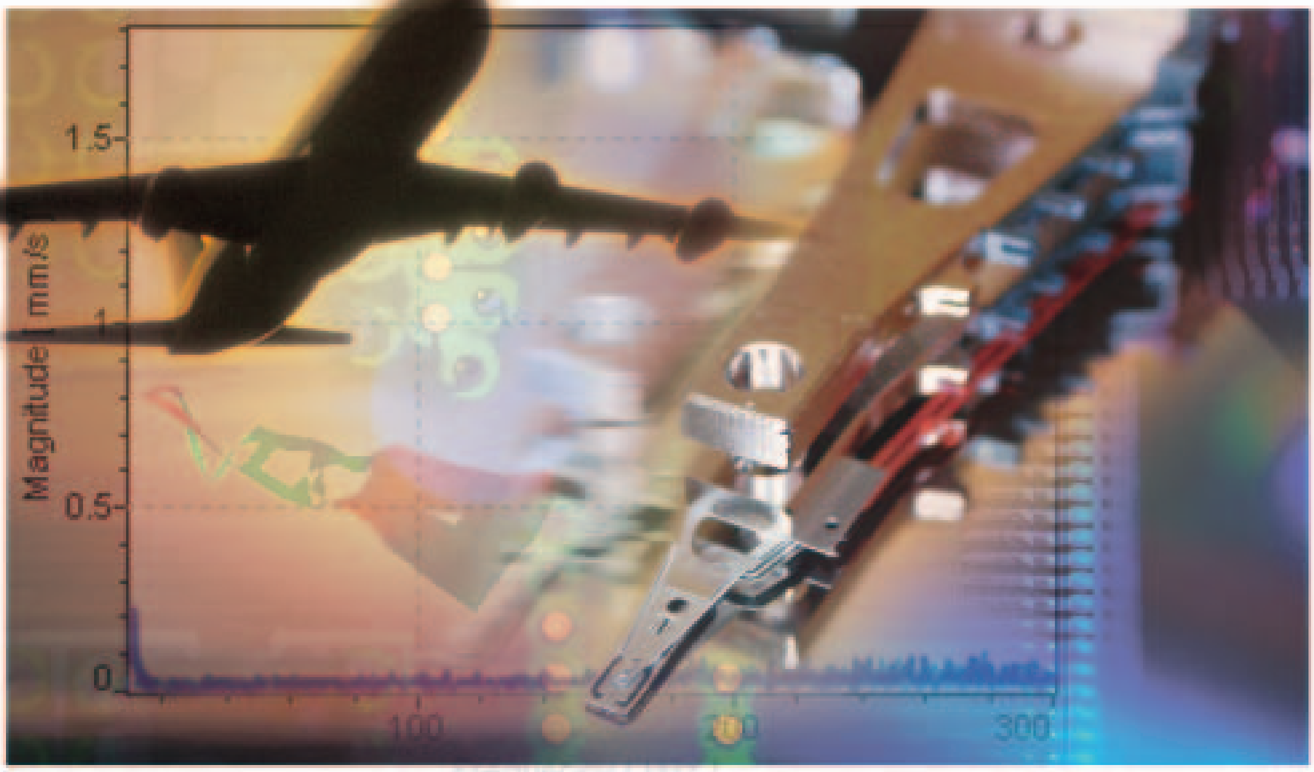
About PM°DM

PM°DM develops brushless direct and alternating current motors for a broad range of applications, from the miniaturized computer hard disk to electrical steering aids in cars. The new research center for small electrical motors in the Minebea Group can be found in Villingen-Schwenningen in the Black Forest.

Summary

With the aid of scanning vibrometry, the sources of the dominant tones are found and identified with the vibration characteristics of individual components. To reduce the undesired noises, some component dimensions must be changed and optimized for minimal audible noise. The relative positioning of the components to each other is also important If the optimization process reduces undesired tones below a minimum perception threshold then the consumer can finally download movies onto a digital video recorder without it disturbing his sleep.

Have a *Good Flight*



LDV Investigation of Unstable Air Bearing Resonance Effects on Low Flying Heads

Hard disk drives (HDD) with higher data density and faster access times rely heavily on the stability of the read-write head while flying over the magnetic media. Recognizing the importance of this stability, Hitachi development engineers have studied the air bearing between the head and the media for a sequence of successively lower flying heights (gaps) using a Polytec LDV to monitor the head response. Once instabilities were known, methods were developed to dampen out excessive vibration levels that might damage the head-media interface.

Introduction

The flying height of a head in a HDD can be decreased simply by reducing the ambient pressure in a vacuum chamber. During the "pump down condition", all the heads in the HDD fly much closer to the media than at ambient pressure. The lower flying height or separation between head and disk is necessary to determine the vibrations of the head and suspension when the head interacts with defects in the disk, i.e., asperities or disk defects. If a head or suspension can be developed which can counteract the harmful resonances then a more robust head/disk interface system can be easily developed for future HDD designs.

The vacuum chamber also simulates the effects of high-altitude on the HDD. A head flying at 10 nm at sea level will typically experience a 2 nm drop at 3000 meters (10,000 ft) due to reduced air pressure and fly at 8 nm. Any decrease in flying height poses a reliability problem in that some files will fail if the overall air bearing design doesn't allow some protection to changes in surrounding air pressure. New air bearing designs now are stressing low fly height sensitivity to pressure changes in ambient conditions.

When designing a HDD head-media interface, the flying height is often set as a compromise between competing effects. Generally, the greater the flying height the less likely an environmental shock or vibration will crash the head on the media. The smaller the flying

Figure 1: Read/write head showing laser vibrometer probe spots

Figure 2: PSV Scanning Vibrometer measurement of bending and torsional oscillation of the suspension

height, the greater the head read/write resolution for magnetic domains. This study was designed to measure the air bearing resonance sensitivity to various vacuum levels starting at one atmosphere.

Experiment

The front cover of the drive was modified with a glass plate and the drive was then placed in a vacuum chamber with a clear Plexiglas front door so a Polytec laser probe could be projected onto the top head in the drive (Figure 1).

Vibration resonance modes of the air bearing were investigated as air pressure was reduced from ambient. A strong resonance signal of 263 kHz, identified as a pitch mode signal, was discovered on the trailing edge of the slider. The vibration is initiated by the touchdown of one of the heads onto the disk surface during vacuum pump-down. It is surmised that the signal propagates from one head to all the other heads via the suspension and cable.

Results and Discussion

To corroborate the findings observed from a preliminary magnetic clearance test, both scanning and single point measurements were made. Figure 2 shows scanning measurements of the 263 kHz signal that causes the suspension at the area of the head mount to oscillate with both bending and torsional modes.

Regarding single point measurements, the 263 kHz signal from the pitch mode resonance of the head at higher vacuum levels is shown in Figure 3 (left). The flying height has decreased to a point where the head is influenced by the surface roughness of the disk and the lubricant levels coating the surface. The suspension was dampened by putting a suitable viscous fluid into the load dimple, resulting in disappearance of the signal (Figure 3, right).

Conclusion

Using an LDV, the vibration spectrum of a HDD head was monitored at different ambient pressures. An unstable pitch mode resonance signal was found at lower pressures corresponding to a reduced flying height and close proximity to the media surface. Due to the action of changing air pressure there is a probability that some of the heads in a file may start to approach the surface of the disk. To prevent the possibility of encountering this pitch mode resonance phenomenon, a viscous liquid was used as a dampening fluid.

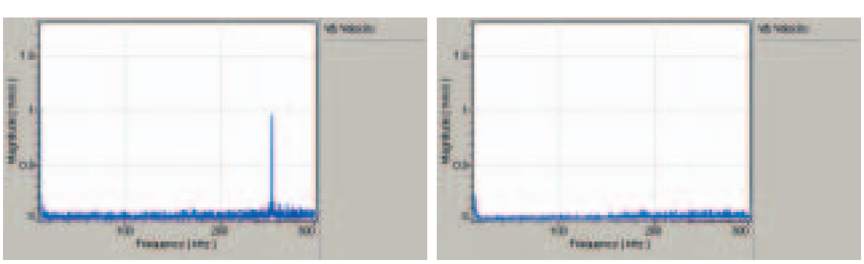


Figure 3: The 263 kHz resonance signal before (left) and after (right) application of viscous fluid

Future designs can either use this technique, i.e. dampening the suspension, or design a more insensitive air bearing to prevent changes in air pressure from allowing the head to come into contact with the surface of the disk. More work in this area is needed in the coming new generation of HDDs since flying heights will soon approach the surface roughness of the disk, i.e. around 4 nm.

The full text of this article is available as a Polytec Application Note and can be downloaded on **www.polytec.com/usa/Lm-download**

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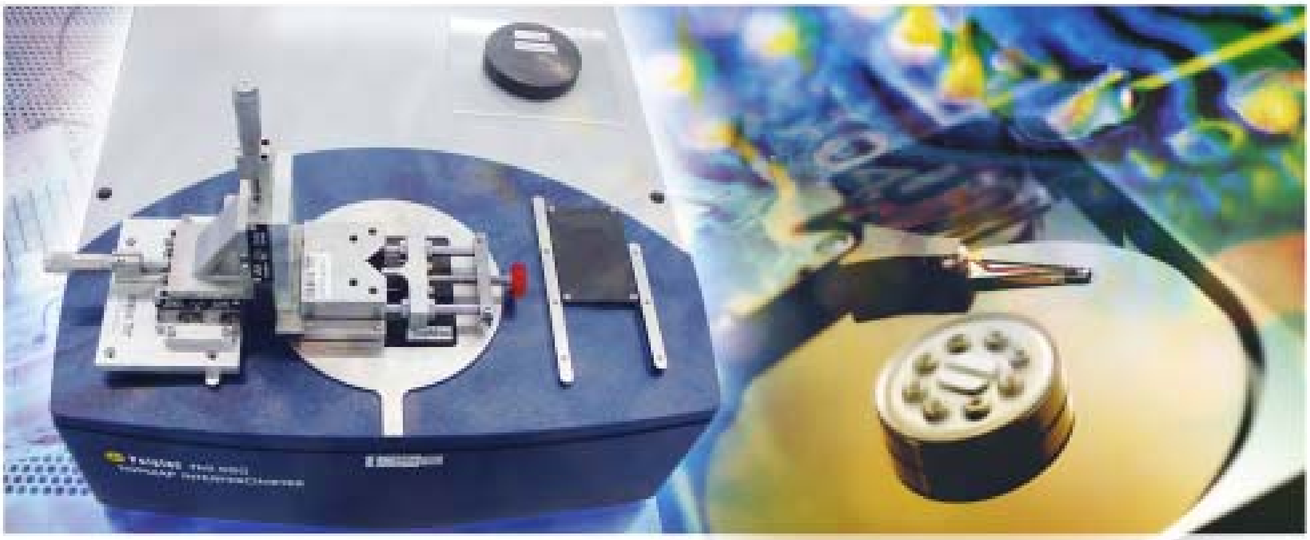
About

Hitachi Global Storage Technologies

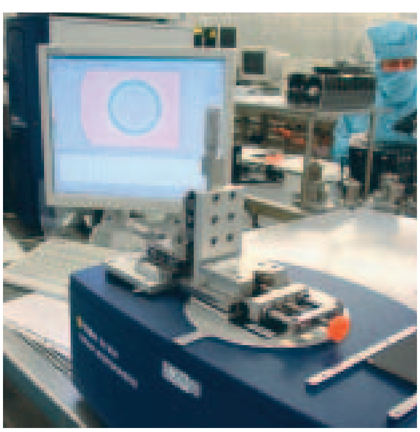
Hitachi Global Storage Technologies was founded in 2003 and was formed as a result of the strategic combination of IBM and Hitachi's storage technology businesses. Hitachi Global Storage Technologies is positioned to immediately advance the role of hard disk drives beyond traditional computing environments to consumer electronics and other emerging applications.

Surface Intact *with TopMap*



Non-destructive Quality Control for Hard Disk Components using the TopMap White Light Interferometer

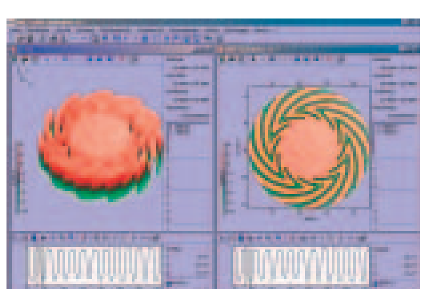
The classic contact stylus profilometer is not the best tool for measuring the surface topography of a component with a sensitive, high-quality surface finish since the stylus can damage the surface it is measuring, rendering the measurement and the component unusable. In contrast the TopMap scanning white light interferometer enables non-destructive topography and evenness measurements on surfaces up to 30 mm x 40 mm, with a vertical resolution of 10 nm.



PM°DM manufactures various components for hard disk drives such as bearing sleeves, shafts and disk hubs. Along with several other measurement techniques, PM°DM uses TopMap systems for quality control at its plants in Germany and Thailand. The quality of fluid dynamic bearings (FDB) which have appeared on the market in recent years as an alternative to ball bearings are of particular interest.

The sample shown in the figures is a grooved counter plate from an FDB positioned over the TopMap measurement area with the aid of a special mount. Once positioned, the TopMap can then determine the existing topography of the complex grooved surface with nanometer accuracy.

To measure the quality of the component, a cross-section along a circular line is analyzed for separation, width and depth of the steps. The results are visible in the lower part of the figure. This measurement benefits from the TopMap's telecentric imaging optics which measures the object with parallel light. In contrast to other measurement processes, this allows you to accurately test components with indentations, drill holes, steps and edges.



The TopMap white light interferometer has proven its value to PM°DM for their offline production quality control testing requirements. Their future plans include in-process, production line control with the TopCam system, an industrialized version of the TopMap technology designed for production process inspection.

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Polytec

Basics *of Digital Vibrometry*

FOR BEGINNERS AND EXPERIENCED USERS

New digital signal processing (DSP) hardware combined with affordable advanced PC platforms enables a new generation of digital laser-Doppler vibrometers (LDV). Based a heterodyne interferometer, high-speed A/D conversion and numerical demodulation algorithms, digital LDVs provide outstanding measurement accuracy and resolution. They are characterized by the following features:

- *Calibration accuracy that has minimal drift with time*
- *Amplitude resolution limited by shot noise (received laser power)*
- *Sub-nanometer displacement resolution within the full velocity and frequency range*
- *Flat frequency response from DC to 2 MHz*
- *Simple data acquisition and evaluation*

These outstanding properties enable numerous cutting edge applications where high accuracy, very low noise floor or numerical post-processing of the measurement information are important, ranging from next generation MEMS device and hard disk drive (HDD) technology test and characterization to higher precision general metrology.

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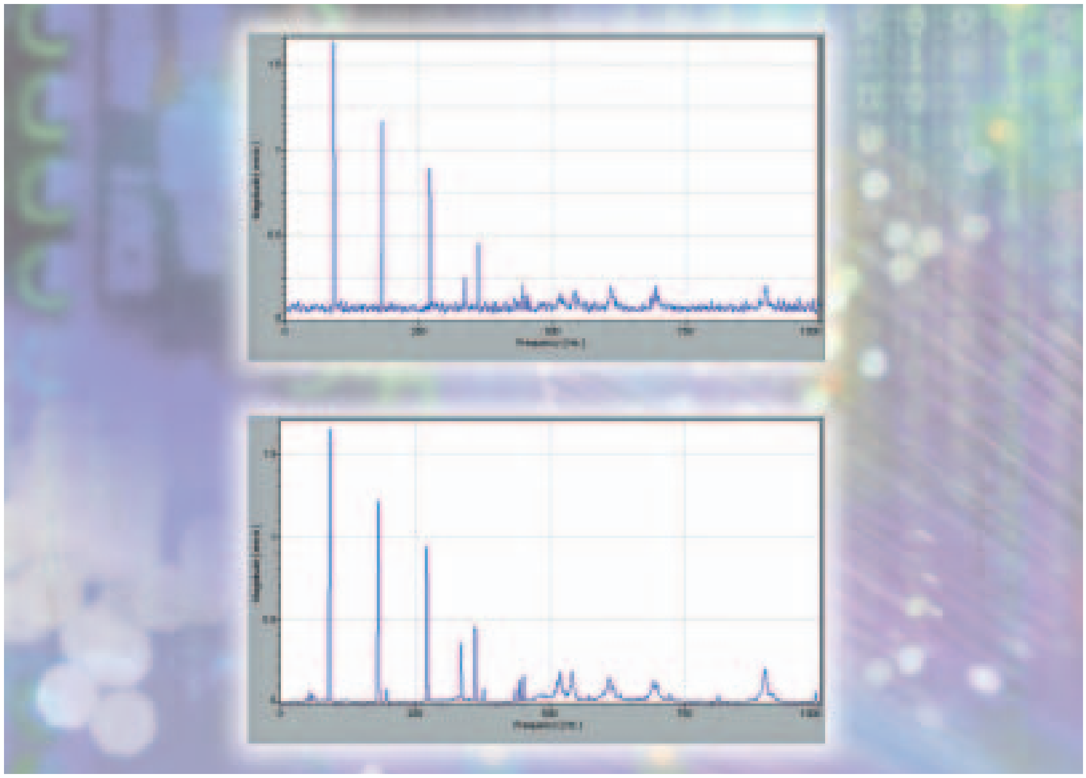
Figure 1: A comparison of analog and digital decoders shows a reduction in the noise floor for digital decoding. Vibration velocity measured out-of-plane on spinning HDD media.

Top: OFV-5000 Vibrometer Controller with analog VD-02 Velocity Decoder and VibSoft.

Bottom: VDD Digital Vibrometer with digital DD-600 Displacement Decoder (signal differentiated)



Introduction

Laser Doppler vibrometry is a proven technology for accurate, non-contact measurement of vibration or small displacements in industrial, engineering and scientific applications. Current analog velocity decoders acquire velocity peak amplitudes of 30 m/s in a frequency range from DC to >20 MHz. Due to the wide bandwidth of laser Doppler signals, the phase linearity of amplifiers and filters are a challenge for the designer. Accuracy strongly depends on each component in the analog signal processing chain, with particular emphasis on the quality of phase and frequency demodulators.

To overcome some of the drawbacks of analog signal processing, the Doppler signal is digitized and demodulated using numerical methods. High-speed hardware in combination with advanced numerical signal-processing algorithms can perform Doppler signal decoding in real-time. In Figure 1 we show the noise floor decrease as we examine the VD-02 Analog Velocity Decoder (top) compared to the DD-600 Digital Displacement Decoder (bottom). Depending on the particular application, the preferred solution can be either a PC-based system or a plug-in DSP decoder module.

Digital Demodulation Techniques

Displacement Decoding by Fringe Counting

The classical digital method to recover displacement information from a phase-modulated Doppler signal is a technique called fringe counting. At the photo detector, a complete interference fringe cycle corresponds to one complete period or a 2π-increment of the interferometric phase angle. This corresponds to a displacement of $\lambda/2$. More sophisticated methods utilize pulse interpolation techniques in order to increase resolution. Systems based on this method achieve a 2 nm per count resolution, but further improvements are not expected.

The Arctangent Phase Demodulation Method

In order to extract the maximum information from large bandwidth Doppler signals, high-speed A/D converters and powerful processors are absolutely necessary for high performance DSP-based vibrometer systems. Polytec's development team has successfully combined both standard PC platforms and tailored DSP chips to perform the required numerical high-speed processing. Signal decoding is based on the well known arctangent phase demodulation method. On the basis of an output signal in quadrature format, this method calculates the phase angle by simple trigonometric relationships. Since this demodulation method is very accurate and stable, it is one of the preferred methods for Doppler signal decoding according to ISO 16063-11 (Methods for the calibration of vibration and shock transducers - Part 11: Primary vibration calibration by laser interferometry).

The key prerequisite of the arctangent method is a signal pair comprised of I (in-phase) and Q (quadrature) components. Their voltage amplitudes depend on the interferometric phase angle $\varphi_m(t)$:

$$u_i(t) = U_i \; \cos \varphi_m(t)$$
$$u_q(t) = U_q \; \sin \varphi_m(t)$$

Such a signal combination is called an I & Q base band signal (Figure 2), as there is no frequency offset present. In the base band, a signal pair is needed to carry the complete Doppler information. While the absolute value of displacement is represented by each component, its sign can only be recovered from both signals in combination.

With increasing phase angle $\varphi_m(t) \sim s(t)$ the visualizing vector describes a perfect circle, centered on the coordinate origin. A quadrature signal pair can also be considered as real and imaginary parts of a complex phasor.

The I & Q format is an ideal starting point for numeric Doppler signal decoding. Recovering the object displacement s(t) simply requires the calculation of the phase angle $\varphi_m(t)$ from the sampled instantaneous voltage values of the I&Q signals based on the trigonometric relationship $\tan \alpha = \sin \alpha / \cos \alpha$. The inverse function provides the value of the phase angle at time t_n

$$\varphi(t_n) = \arctan \frac{u_q(t_n)}{u_i(t_n)} + 2m\pi$$

m = 0, 1, 2, ...

The ambiguity of the arctangent function can be removed by a phase unwrapping algorithm, which provides the integer number m, representing multiples of $\lambda/2$ The quotient $u_q(t)/u_i(t)$ eliminates the actual value of the signal amplitude U. This is crucial for the accuracy of this method. Finally, the discrete displacement function $s(t_n)$ is obtained.

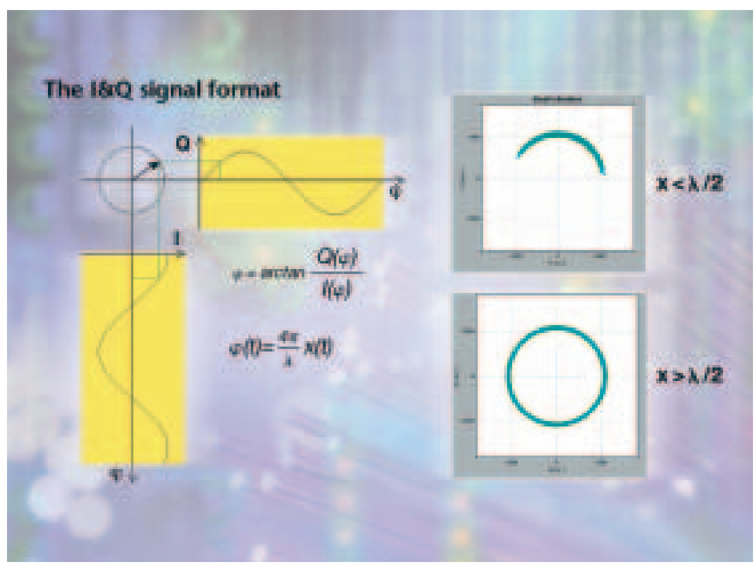
$$s(t_n) = \frac{\lambda}{4\pi} \; \varphi(t_n)$$

Digital Interfacing

Digital velocity decoders are equipped with both a serial data interface and an analog output. This allows the user to pick the most appropriate output for their application. Polytec implemented the S/P-DIF standard (Sony/Philips Digital Audio Interface) for data transmission of digitized vibration signals in the audio frequency range. S/P-DIF uses single-line transmission either via coaxial cable or optical fiber and enables data acquisition and recording with standard commercial equipment such as PC sound boards or digital audio recorders.

Current implementations support 24-bit amplitude resolution at a sample rate of 48 kSa/s or 96 kSa/s, resp. (OFV-5000), in the frequency range 0 - 22 kHz or 0 - 42 kHz, resp.

Figure 2: Representation of the I & Q signal in a vector diagram (left) and the resulting real display for different vibration amplitudes (right)



Polytec's Range of Digital Vibrometers

PDV-100 Portable Digital Vibrometer

The first single-box, portable and lightweight digital laser Doppler Vibrometer for field applications like predictive maintenance of machinery. In addition to the conventional analog output, a S/P-DIF standard digital output connects easily to sound cards, bypassing expensive data acquisition electronics.

IVS-300 Digital Industrial Vibration Sensor

A digital single-box vibrometer specifically developed for non-contact vibration measurement up to 22 kHz in production test applications. The robust and compact design is sealed to the IP-64 standard to meet the challenges of harsh industrial areas.

CLV Compact Laser Vibrometer

The CLV combines a robust, compact optical head with a modular controller optionally equipped with a digital signal decoder.Designed for vibration measurements up to 350 kHz, its small size makes it perfect for difficult-to-reach places or for production lines where space is limited.

OFV-5000/-50X/-55X Modular Vibrometer System

This state-of-the-art laser vibrometer system with modular design can be tailored to specific or multiple applications. It is available with OFV-505/503 standard sensors or OFV-551/552 fiber-optic sensor heads and powerful digital and analog velocity and/or displacement decoders covering frequencies up to 20 MHz.

VDD Digital Vibrometers

Combines the highest performance data acquisition, comprehensive "VibSoft" software package and either a compact front-end shownor a DD-600 decoder to be installed in an OFV-5000 Controller. Ultra-precise vibration measurements for data storage, MEMS, hearing dynamics or calibration applications can be accomplished.

PSV-400 Scanning Vibrometer

This measurement technology has been designed for the full-field analysis of structural vibrations. It can scan entire surfaces resolving noise and vibration issues for the automotive, aerospace, commercial manufacturing and R&D markets. It is available with a combination of analog and digital decoders for highly sophisticated and precise measurements.

More info: www.polytec.com/usa/Lm-digital

POLYTEC TUTORIAL SERIES

Principles of Vibrometry (Issue 1/2003) E1 – E4

Principles of Velocimetry (Issue 1/2004) E5 – E8

Basics of Digital Vibrometry (Issue 2/2004) E9 – E12

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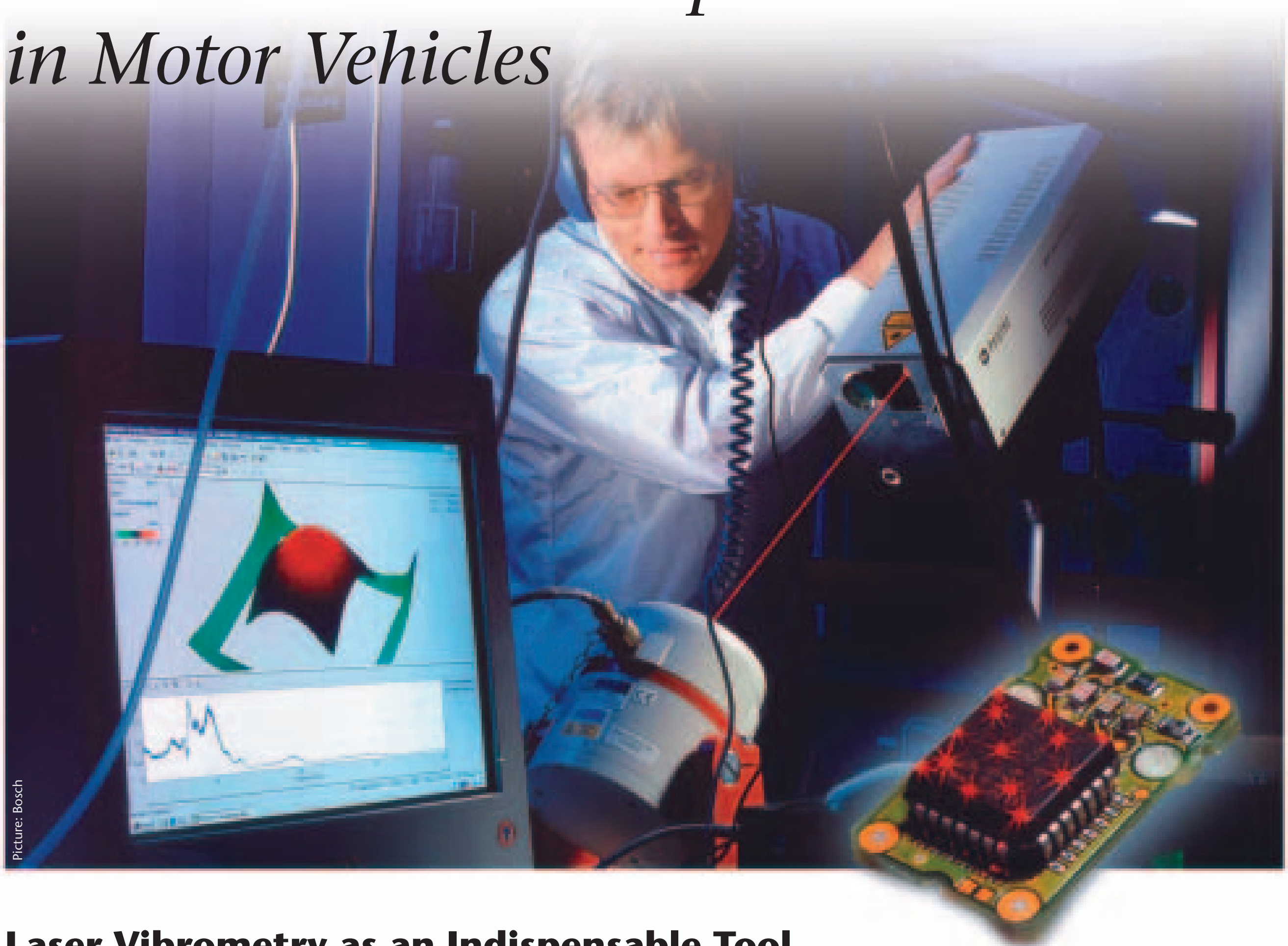
MEMS – *Reliable Helpers in Motor Vehicles*



Laser Vibrometry as an Indispensable Tool in MEMS Development

50 years ago, "sensor technology" in a car was limited to a handful of mechanical, or at best, electromechanical instruments, such as tachometers or rev counters. In contrast, a modern car, has numerous microprocessor-controlled electronic sensors and actuators that carry out complex measurement, monitoring and control tasks. An indispensable tool in the development and production of these silent assistants are modern, non-contact optical metrology processes.

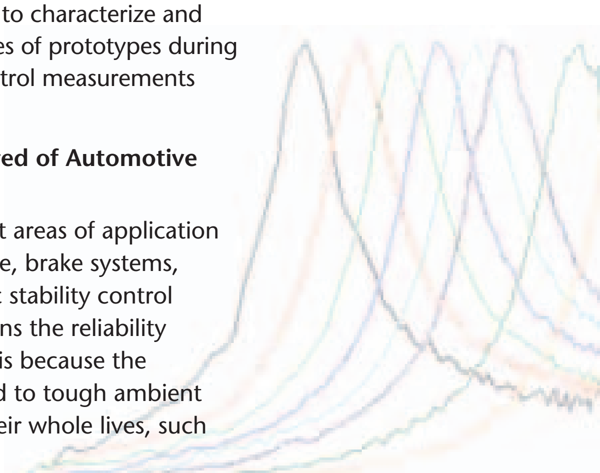
Modern sensor elements in cars have to a large extent been realized as micro-components, as so-called MEMS (Micro-Electro-Mechanical-Systems). They compactly combine mechanical, electrical and also electronic functions on a chip. MEMS can thus interact with their environment as sensors or actuators. This means that a system based on MEMS technology can react electrically or mechanically to corresponding physical or chemical "stimulants".

As MEMS components in modern cars are increasingly taking on safety-relevant tasks, high sensor precision combined with extremely high, lifelong reliability is of decisive importance. To reach these quality targets, you need precise measurement technology to characterize and verify the system properties of prototypes during development, and for control measurements during MEMS production.

High Reliability is Required of Automotive MEMS

Among the safety-relevant areas of application for MEMS are, for example, brake systems, airbag control or dynamic stability control systems. One of the reasons the reliability requirements are so high is because the components are subjected to tough ambient conditions throughout their whole lives, such

Continued on page 14



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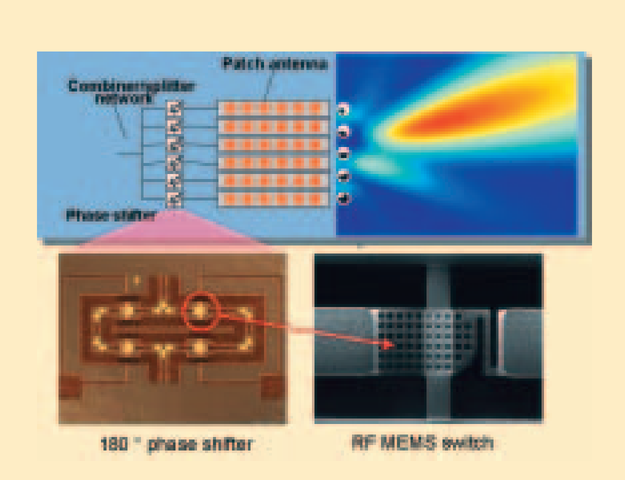

Figure 1: Design of a patch antenna

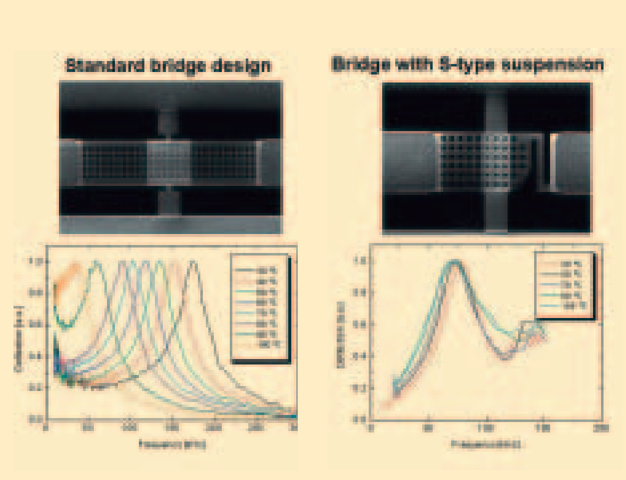

Figure 2: Resonance measurement on MEMS switches

as vibration, temperature changes and corrosion. The defect rates related to the service life of these components are therefore only in the range of a few ppm.

The precision required for sensors when used in the car industry is on the order of 1% over the whole life of the components, which corresponds to 15 - 20 years or an operational performance of approx. 200,000 km.

Of course all these requirements need to be met at the lowest possible production costs.

Vibrometry Makes it all Possible

Laser Doppler Vibrometry, as a flexible, high precision measurement technology, plays a major part in characterizing the mechanical properties of MEMS quickly, without a reaction, and precisely, thus ensuring the high quality of the components.

Single point vibrometers can be used to measure system resonances of the components. The movement properties of MEMS across the whole surface of the component are determined quickly and across a wide frequency range with the aid of special microscope scanning vibrometers. The animated graphic representation of the operational vibration shapes calculated from the readings is decisive in helping to understand the processes examined.

Adaptive Antennas

In high frequency technology there is a broad range of applications for adaptive antennas. The radiation characteristics, or the transmit/receive direction, can be adjusted to the actual traffic conditions.

Regarding radar applications, objects located in various distances can be detected by sequential scanning of the radiation angle and measurement of the time to reach the object and return. The adjustment of the radiation characteristics can be realized using planar patch antennas without any moving parts. Their radiation lobe results from the interference of electromagnetic waves generated by many single antenna elements ("patches").

The patches are switched together in rows and columns resulting in a fixed phase relation. This requires special phase shifters which can be realized by micro system technology. The phase shifters contain various RF MEMS switches which are used to set a fixed value for the phase relation (Figure 1).

The design goal of the Bosch development engineers is a clearly defined switching performance which is independent of ambient conditions and remains constant for the life of the component.

MEMS Design and Vibration Properties

The switch initially realized by the engineers, with a standard bridge design, exhibited switching performance which depended on the ambient temperature, clearly recognizableby the shift in the bridge resonance measuredusing the vibrometer (on the left of Figure 2). The reason for this is the difference in thermal expansion coefficients between the aluminum bridge and the silicon substrate. By modifying the bridge geometry, this effect can to a large extent be compensated for, as is shown in the spectrum on the right of Figure 2.

Scanning Tests

Testing the switching performance in the time domain shows pronounced bouncing or ringing behavior. To get a picture of the actual surface dynamics of the component during switching, tests were carried out using the Laser Scanning Vibrometer (Figure 3).

The visualized results show that, apart from the basic vibration, there are higher harmonics of the bridge surface present in the spectrum of the component. Laser vibrometry also provides important structural dynamic information here to optimize the functionality of the component (Figure 4).

Summary

Many of the advanced safety and comfort features offered in today's cars are based on microsystems using cutting-edge technologies. The most up-to-date optical measurement and testing processes, such as Laser Doppler Vibrometry, ensure that, during the development and production process of MEMS elements, the required functional and quality properties are attained or exceeded, making travel today safer than it has ever been before.

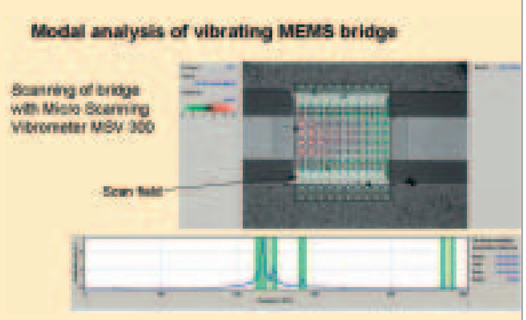

**Figure 3:
MEMS switch measured by the MSV-300 Microscope Scanning Vibrometer**

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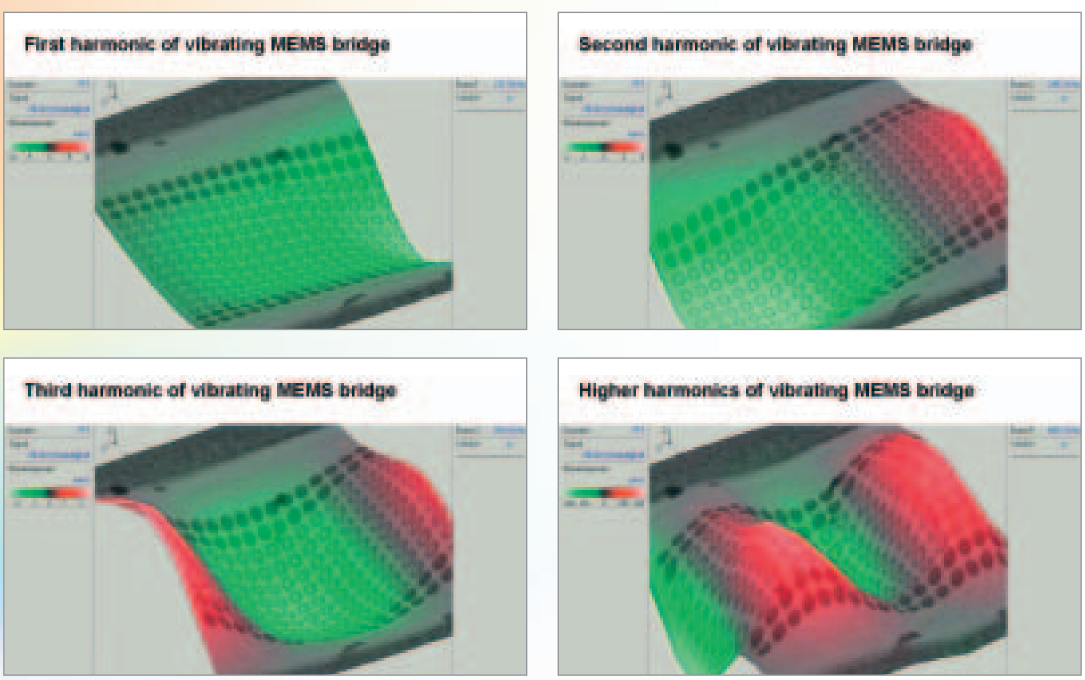


Figure 4: Deflection shapes of the MEMS switch

Silent *Steering*

Quality Control for Steering Gears – 100% Inspection Using PDV-100 Portable Digital Vibrometers

TRW Automotive in Gelsenkirchen wants to ensure that the pumps on hydraulic steering gears do not make any unwanted noises while driving. All motor pump assemblies (MPA) are subjected to numerous test steps as soon as they have been assembled and before being installed in the steering system. The vibration characteristics are measured by PDV-100 vibrometers and are used as an indicator of the actual noise under normal operating conditions. Based on the vibration spectrum the process controller either approves the assembly for subsequent processing or rejects it as being faulty.

Introduction

TRW manufactures modern steering gears with electro-hydraulic control at their facility in Gelsenkirchen, Germany. These electrically powered hydraulic steering (EPHS) systems are shipped to automotive assembly lines preassembled, filled with hydraulic oil and completely tested. Separate motor pump assemblies (MPA) are also supplied to auto manufacturers who prefer to install, attach hoses and fill with hydraulic fluid. Hydraulic pressure is generated by a motorized pump and is electronically regulated consistent with the vehicle speed, the steering force and the steering angle rate. The MPA is first assembled and then thoroughly checked for noise and performance values while passing through several automatic test stations. Production is approximately 1500 units per day per plant.

Test Procedure

The test cycle simulates typical operating conditions by filling the MPA with hydraulic oil and bringing it up to operating pressure with the pump (Figure 2). After mechanical, pressure and leak testing , the assembly passes to noise testing. During the noise testing all relevant operating modes are ingeniously simulated, from various pump speeds to standby operation with minimal pressure, to full capacity at pressures exceeding 100 bar.

The test-mode vibrations are measured by two PDV-100 vibrometers aligned to two critical positions: one primarily measures the radial and the other primarily the tangential vibrational movements. The vibrometers are fully integrated into the test stand and are protected by a transparent housing (Figure 1). In the plant at Gelsenkirchen, a total of more than ten PDV-100 vibrometers are currently installed on a number of test stands. Further expansion is planned.

An air wipe is used to protect the laser optics from the dirt and grime of the industrial manufacturing environment, The output signal of the PDV-100 is acquired and evaluated directly by the process control computer. The vibrometers are subject to the same quality control as all test equipment; every time there is a shift change, a calibration test run is made using a master sample. Diagnostics which can immediately detect a measurement or system error are also integrated into the analysis system.

Motor rotation can excite many different resonances. Particular attention is paid to the harmonics of the excitation frequency. Order analysis allocates these vibrational frequencies to certain components. Fourth order vibrations, for example, are due to inadequate true-running accuracy of the pump axis.

The correlations between vibration signature frequencies and component responses were determined in advance by TRW Research & Development. This reservoir of knowledge simplified the production line measurement task. The optimal positions for both sample points were determined in advance by using a PSV Scanning Vibrometer to analyze the operational deflection shape of the MPA's surface.

The test system displays the results of the various tests on a screen (Figure 3) and passes approximately 150 measurement values per test sample into the process control system. From these values, an algorithm determines whether all quality criteria have been fulfilled and either accepts or rejects the assembly.

Summary

TRW motor pump assemblies are 100% inspected before integration into the steering gears systems. The inspection process is fully automated with a noise spectrum test measurement performed by two non contact PDV-100 vibrometers. MPAs that pass this test assure that only quiet assemblies are put into manufactured vehicles and that drivers experience performance and reliability without distracting or annoying noise. The fact that noise levels in cars are continuously being reduced makes it increasingly important to reduce the noise level of individual components. Furthermore, the automated collection and storage of data provides traceability for component quality and an existing data base for correlation refinement through association with longer term events.

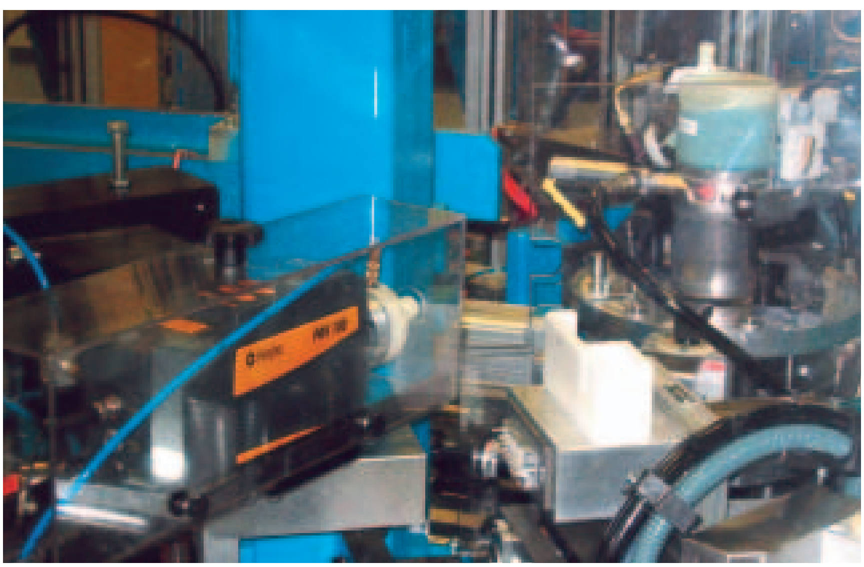
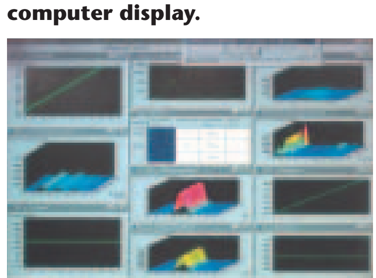


Figure 1: Integration of the PDV-100 in the test stand. To the right of the image is a MPA with a red laser reflection.

Figure 2: Motor pump assembly in the test stand

Figure 3: Graphical representation of the vibration spectra and time signals on the process control computer display.



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About TRW Automotive

TRW Automotive is one of the largest suppliers to the car industry worldwide. As a company, TRW is a major player in eight product areas: Spare parts market, brake systems, steering and chassis systems, steering systems for commercial vehicles, electronics, engine components, fastening systems and passenger protection systems.

LSV *has Solved the Twist in the Tail*

Laser Surface Velocimeters (LSVs) Regulate Undesired Rotational Motion in Steel Rolling Mills

Using two LSV Series 6000 Laser Surface Velocimeters to simultaneously measure the rotational and translational velocity of a rod at the exit of a planetary mill permits automatic control of rotational motion, thus minimizing (eliminating) tail swing exiting the mill.

Boschgotthardshütte (BGH) produces specialty steels and alloys to meet the toughest demands. Effective process control is vital to efficient and profitable plant operation. At BGH's Edelstahl Freital facility, the existing control loop for the planetary mill introduced unwanted rotational motion into the end of the rod, causing the tail end to swing to the side upon exiting the mill. This created a significant problem when feeding the rod into the next process. Two Polytec LSV Series 6000 Laser Surface Velocimeters were selected to provide process feedback of the rod's true rotational and translational motion. Traditional tachometers on the drive rollers are prone to slippage and consequent inaccuracies. In Figure 1, the two water-cooled LSV-026 sensor heads are shown aligned to a moving hot steel rod.

Laser Surface Velocimeters (LSV) are non contact sensors that directly measure the velocity and length of a moving rod, tube/pipe, steel strip, web or other moving material by detecting the Doppler frequency shift between two intersecting laser beams focused at the measurement surface. Polytec LSVs are mill-tough, high precision

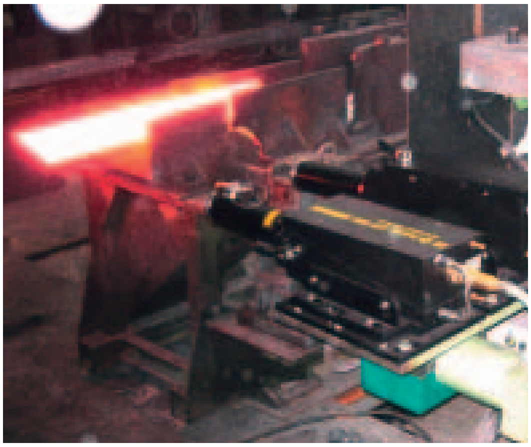


Figure 1: Two LSV-026 sensors heads simultaneously measure translational and rotational motion of the steel rod.

optical measurement systems with a proven history (record) of reliable service in continuous casters, rolling mills and other harsh industrial environments found in the process industries. The new LSV-6200 Velocimeter Controller uses a flexible interface concept that can easily integrate into existing process control systems for velocity control or cut-to-length applications (Figure 2).

In the outlet of the planetary mill, the rolled steel rods experience both a forward movement as well as a rotation, which causes undesirable effects in the next process. The second Laser Surface Velocimeter shown in Figure 1, measures the rotational velocity of the rod. This measurement is fed back into the drive system of the planetary mill to eliminate rotation of the rod before the next process.

The ability to regulate the process to zero rotational velocity is dependent on sensing both positive and negative velocities. The heterodyne detection technique used in the Polytec LSV is uniquely sensitive to the direction of motion. Heterodyne detection begins with a reference frequency shift between the two intersecting laser beams on a stationary part generating a zero velocity interference beat frequency of 40 MHz (the so-called carrier frequency). Now, motion in one direction increases the frequency to greater than 40 MHz, while motion in the opposite direction decreases the frequency to less than 40 MHz. This makes it possible for the LSV to recognize and directly output both the direction and magnitude of motion. With this information a control loop can be built to regulate the rotational motion to standstill (v = 0).

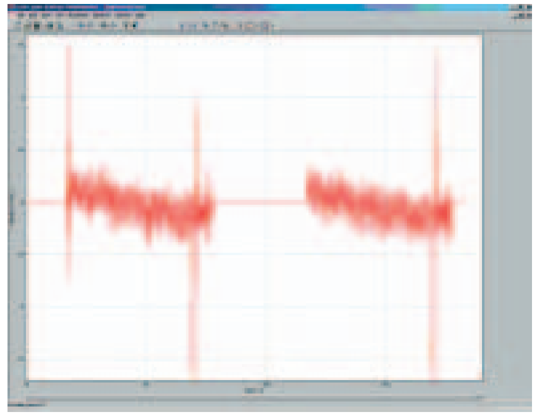


Figure 3: The measured rotational velocity during passage of two rods

Other non-contact measurement methods sense the magnitude of the velocity or the speed of the surface but do not resolve the direction of the motion.

The closest LSV shown in Figure 1 is aligned to measure the translational velocity and, thus, the length of the steel rod. The length measurement is used to achieve precision cutoff control.

The PC LSV Monitor Software enables acquisition, trending and recording of all relevant data for process development, system setup and diagnosis. The saved data can then be recalled and displayed for basic analysis with the LSV Software or exported to third party software for more detailed analysis and evaluation (Figure 3).

After only a few hours of operation it was already apparent that the installed LSVs fulfilled all expectations. Pleased with the LSV success story, BGH has installed more LSV systems for cutoff control in their high-grade steel plant in Siegen.

Figure 2: LSV-6200 Controllers for rotational and translational velocity in the switching cabinet

MORE INFO?

For more information, please visit our LSV homepage www.polytec.com/usa/lsv

About the BGH Group

The BGH Group includes plants in Freital, Siegen and Lungau. BGH Edelstahl Freital GmbH, with 650 employees the largest plant in the BGH Group, offers a complete selection of high-grade steel products, manufactured from unalloyed, light and high alloyed steel and special materials. These specialty alloys are used in many different products, such as cutlery, tools, implants or parts for machinery or vehicles.

Hardware and Software *News*

New Decoders for the OFV-5000 Vibrometer Controller

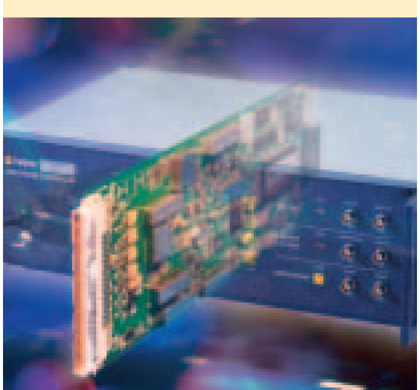
The modular OFV-5000 Vibrometer system is designed to accept a variety of signal processing modules known as decoders, each optimized for different frequency, velocity or displacement performance.
Please find more information on **www.polytec.com/usa/ Lm-decoder**

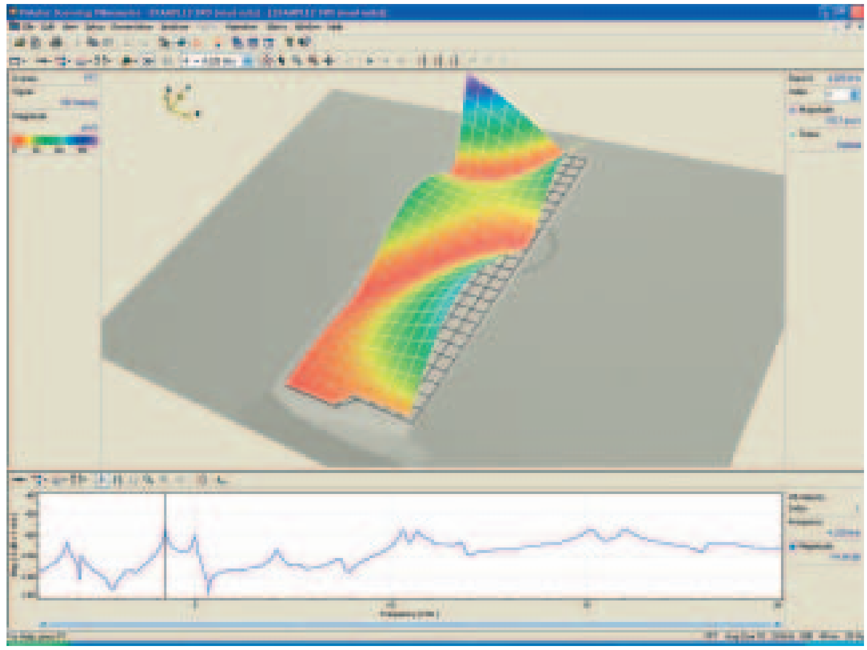
Adding to the extensive list of existing decoders, Polytec has released three new models:

VD-05: A 10 MHz analog velocity decoder for high-frequency ultra-sonic applications with a maximum velocity of 3 m/s.

DD-500: A digital displacement decoder designed for demanding applications in acoustics, micro systems and precision mechanics. The decoder can be set to 16 different displacement ranges with the smallest range resolving 16 pm displacements. Displacement bandwidth is from 0 – 350 kHz.

DD-600: An I&Q converter for digital data processing with VibSoft-VDD that allows dis-placement measurements on data storage devices or MEMS with outstanding linearity, accuracy and resolution. See also the supplement "Basics of Digital Vibrometry" in this issue.





PSV 8.2 Scanning Vibrometer Software

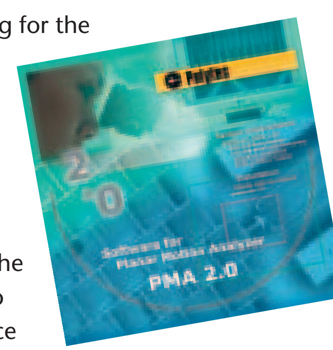
Building on the comprehensive functions introduced with PSV 8.1 (see LM INFO issue 1/2004), the PSV 8.2 release introduces an improved look for data visualization, integrated software control of the new geometry scan module, and some very convenient features inspired by our customers.

- Support of the Geometry Scan Unit for direct acquisition of geometry data from the part (see page 3)
- Polytec Signal Processor as an integrated tool used in presentation mode with Excel-like functionality
- Project Browser for easy management of all data and files connected with measurement projects
- Image processing for finding the laser beam in alignment mode
- Greatly improved visualization of spatial vibration data

PMA 2.0 Planar Motion Analyzer Software

The latest version of the PMA oper-ating software works with both the new PMA-400 and the prior model PMA-300 Planar Motion Analyzers. It has the following new features:

- Familiar out-of-plane MSV user interface for in-plane PMA measurements
- Bode plots and time domain data are now presented in the stan-dardized Polytec analyzer window layout with familiar features like cursors, zoom, scaling, legends, ASCII export and graphics export
- Pattern Matching Algorithm now integrated in the application
- Support for pulse excitation, e.g. analysis of transient phenomena like switching
- A revised dialog for the measurement settings with a graphical illus-tration to help find optimal settings



- Animation of the recorded video image sequence for a given frequency. Saving in AVI format
- Integrated help system

Polytec *World Wide*

Polytec

Polytec Companies

Polytec's global sales offices are located throughout Europe, the United States and Japan. Please see back page for more contact information.

Polytec Representatives

Polytec welcomes especially the new representatives which are highlighted in this list.

More contact information can be found on our web page **www.polytec.com**

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Team *up*

Polytec will be there – trade fairs, conferences, user meetings and road shows are opportunities where Polytec shares its unique expertise in vibrometry with customers and specialists all over the world.

On the Road Again – On-Site Product Shows in North America and Germany

Polytec goes out – product road shows have proven to be an effective means of reaching novice and expert customers interested in vibrometry. In 2004 Polytec conducted successful road shows in both North America and Germany, and we intend to go on – please keep informed by visiting **www.polytec.com**.

Between May 18 - 21, Polytec visited four locations in San Jose, California to introduce our newest products to the data storage industry. We demonstrated how the new PSV-400 Scanning Vibrometer, the OFV-5000 Modular System and the MMA Micro Motion Analyzer are used for vibration and shock testing, troubleshooting, and head/media dynamics. Over 50 participants took the opportunity to learn about new devices and upgrades, to see examples of measurements and to find solutions to their specific measurement needs with the help of Polytec's team of experienced engineers.

In Germany, from March 12-19 about 120 participants at five locations saw the latest applications of vibrometry to production testing and to 3-D measurement of vibrations on macro and micro structures. In addition to the live demos, the exchange of information between the experienced users turned out to be the highlight of the event.

North American tradeshows recently attended by Polytec, Inc.

NanoTech
March 8-10 Boston, MA

Smart Structures and Materials
March 16-17 San Diego, CA

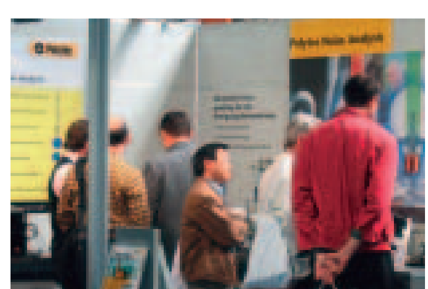
SEM International
June 7-9 Costa Mesa, CA

Quality Expo
June 9-10 Detroit,MI

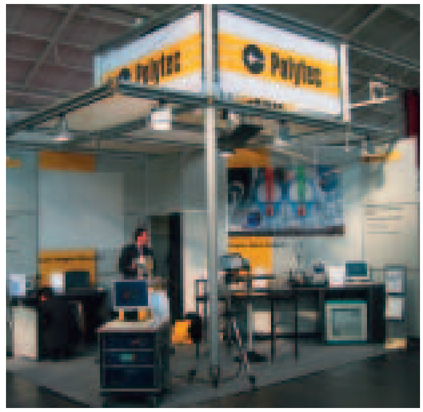
SemiCon West
July 14-16 San Jose, CA

Automotive Testing Expo Europe

Being Europe's only dedicated trade fair for automotive testing, evaluation and quality engineering, the Testing Expo attracted more than 280 exhibitors and nearly 8000 international attendees to the Stuttgart exhibition fair from May 25-27. Showing the new fiber-optic vibrometers and the state-of-the-art PSV-400-3D Three-Dimensional Scanning Vibrometer, Polytec presented its current product innovations in the field of non-contact vibration measurement. With numerous automotive applications of Laser-Doppler-Vibrometry many visitors came to the Polytec booth to get first-hand information from the market leader.



Control – International Trade Fair for Quality Assurance



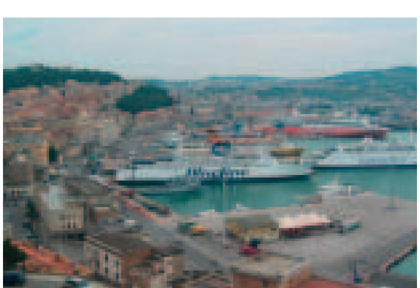
Almost 800 companies from 23 different countries exhibited their new products at the Sinsheim Exhibition Centre from May 11-14. Polytec demonstrated its expertise in Acoustic Quality Control using industrial laser vibrometers, in scanning vibrometry with the PSV-400 and in surface topography with the TopCam and TopMap. These instruments are highly effective tools for quality and process control and consequently attracted a lot of attention.

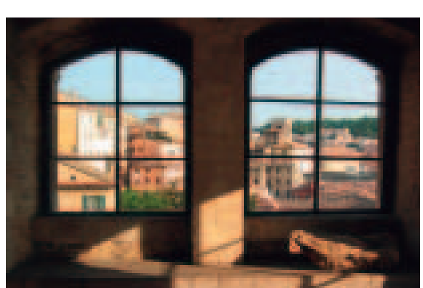
3rd Polytec Vibrometer Users' Meeting in UK

The 3rd UK Users' Meeting was hosted by the Photonics Cluster (UK) on the Aston Science Park and organized once again by Lambda Photometrics, the UK division of Polytec. The first day was a 'true' Users' Meeting, with over 40 participants and speakers from a very diverse range of vibration measurement disciplines, covering middle ear mechanics and quality control of parts and goods to synchronised scanning of rotating parts and crack detection in critical aerospace components. The second day was a more devoted 3-D technical seminar specifically attended by over 30 engineers. Basics of 1-D and 3-D vibrometry were covered, leading to the recently introduced, highly anticipated PSV-400-3D system. This 'Holy Grail' of vibrometry was first demonstrated on an automotive brake disk, and can quickly measure the in-plane and out-of-plane vibration modes and their relationships. There was plenty of free time to discuss application ideas and problems with attendees and Polytec personnel. These meetings are useful, enjoyed and considered a 'must attend' for UK vibrometer users.
www.lambdaphoto.co.uk

6th International Conference on Vibration Measurements by Laser Techniques

This renowned conference dedicated to laser vibrometry took place June 21- 25 in Ancona, Italy. Polytec presented well received papers on microscope-based vibrometry and on 3-D vibrational analysis of power tools. Polytec also sponsored a tradeshow booth that was very well attended. **www.aivela.org**



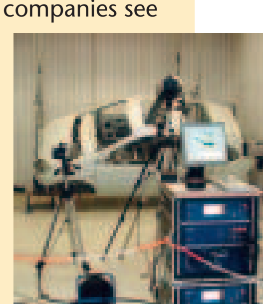


1st Vibrometry Seminar in Korea

The first Korean Vibrometry Seminar was held on March 18 – 19. About 70 participants from companies, national R&D Institutes and graduate schools came to learn more about measuring vibration and noise with vibrometers. They acquired concrete knowledge on the technology and application of PSV Scanning Vibrometry to innovative structure measurement. The seminar was successful and marked an enthusiastic start in the Korean market.
www.vibrometry.co.kr

1st Vibrometry Users' Meeting France

The "Séminaire des utilisateurs de Vibromètres Laser" took place June 15-16 in Rouen, France and attracted about 30 participants. Space for measurements and demos was provided by CEVAA, a company offering vibro-acoustic services to the French automobile industry. The PSV-400-3D was featured along with other systems relevant to automotive applications, like High Speed and Rotational Vibrometers. Numerous lectures on applications and future developments of laser vibrometry were presented, complemented by reports on experiences in other European countries. The meeting was very useful and convenient. It provided an opportunity for French automobile companies see the equipment up close and working and then to finalize their purchasing plans.
www.polytec-pi.fr



DISKCON USA *2004*

Discover How Polytec is Advancing Modal Analysis and Vibrometry in Data Storage, September 21-22, 2004 at the Santa Clara Convention Center

DISKCON USA, presented by IDEMA, is the premier event for the data storage industry. Companies that manufacture hard disk drives (HDD) for PCs and laptops, servers, storage area networks, and consumer devices come to learn about the latest products, materials, and services from vendors at the DISKCON exhibition.

This year's DISKCON will address the full spectrum of disk drive applications, both traditional as well as emerging, and how drive technology will evolve to meet these new requirements.

Polytec vibrometers are essential products that support emerging HDD product design, development, manufacturing and quality control. At Polytec's booth will be new, high-precision, digital laser Doppler vibrometers and microscope-based MMA micro motion analyzers. Polytec's product innovation has kept vibrometer technology ready for next-generation HDD applications. No matter the level of sophistication, all Polytec systems are surprising simple to operate and are designed with the end user in mind.

Experience the World of Laser Measurement and Meet Polytec at the Following Events and Trade Fairs!

Sept 14 – 16, 2004	Nanofair	St. Gallen, Switzerland	www.nanofair.ch
Sept 14 – 17, 2004	BIAS 2004	Milano, Italy	www.milanoenergia.it/personal/bias_eng
Sept 20 – 22, 2004	ISMA 2004	Leuven, Belgium	www.isma-isaac.be
Sept 20 – 22, 2004	Diskcon 2004	Santa Clara, CA, USA	www.idema.org
Sept 22 – 24, 2004	ALUMINIUM 2004	Essen, Germany	www.aluminium-messe.com
Sept 28 – 30, 2004	MeasComp 2004	Wiesbaden, Germany	www.meascomp.com
Oct 01, 2004	Grand Opening Seminar Polytec K.K.	Yokohama, Japan	www.polytec.com/int
Sept 28 – Oct 01, 2004	15th Micronora	Besançon, France	www.micronora.com
Oct 19 – 21, 2004	Mesurexpo	Paris, France	www.mesurexpo.com
Oct 25 – 26, 2004	Polytec Users Meeting	Detroit, MI, USA	www.polytec.com/usa
Oct 27 – 29, 2004	Automotive Testing Expo 2004	Detroit, MI, USA	www.testing-expo.com/usa
Nov 10 – 12, 2004	Micromachine 2004	Tokyo, Japan	www.micromachine.jp
Nov 15 – 18, 2004	RD&D Conference & Expo	Anaheim, CA, USA	www.rdexpo.com
Jan 25 – 27, 2005	Photonics West: MOEMS-MEMS 2005	San Jose, CA, USA	spie.org/Conferences/calls/05/pw
Jan 30 – Feb 03, 2005	MEMS 2005	Miami, FL, USA	www.mems2005.org
Jan 31 – Feb 03, 2005	IMAC-XXIII	Orlando, FL, USA	www.sem.org/CONF-IMAC-TOP.asp

Reference the web for the most up-to-date information on trade fairs and events!

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Polytec

Polytec was founded in 1967 to distribute commercial laser technology to industrial and research markets. Building on the company's early success, Polytec developed, and then manufactured, innovative laser-based test and measurement instruments beginning in the 1970's.

Old and new generations of these products are known around the world as the gold standard in non-contact, laser-based measurement of vibration, speed and length. Advanced product development remains a core strategic activity at Polytec with new electro-optical systems being designed for analytical process measurement, noise analysis, and factory automation.

Our Global Activities

Polytec is a global corporation with facilities in Asia, North America and Europe. With a reputation for innovative products, outstanding quality and world-class support, our success has enabled investment in the resources and flexibility to respond quickly to the ever-changing needs of our customers.

Polytec's innovative solutions allow our customers to maintain their own technical leadership across many fields. In markets from automotive, data storage and aerospace to biomedical, micro- and nano-technology, Polytec continues to lead and inspire confidence and trust from our customers. In addition, product distribution remains to this day as a core competency of Polytec by successfully representing manufacturers of innovative technologies.

Polytec is committed to providing the highest level of satisfaction for our customers, and we offer local expert application assistance and product service and support at facilities throughout Europe, North America, and Asia. Polytec has been ISO-9001 certified since 1994. Polytec is dedicated to continuous improvement in our mission

"Advancing Measurements by Light"

FAX Reply

Polytec

First Name

Last Name

Job Title

Company

Address 1

Address 2

City | ZIP-Code

State | Country

Phone | Fax

E-Mail

❑ I would like to receive my individual free copy of LM INFO special. Please enter my address in your LM INFO mailing list.

❑ I would like to receive regular information about Polytec product news and events.
Please enter my address in your vibrometry marketing database.

❑ Please contact me for technical advice

My Application: ____________________

❑ My mailing address data are incorrect. Please correct as above

How would you rate the quality of LM INFO special?	1 excellent	2	3	4	5 very poor
– Content of information	❑	❑	❑	❑	❑
– Design	❑	❑	❑	❑	❑
– Balance between product presentations and application reports	❑	❑	❑	❑	❑

What is missing? ____________________

Suggestions for improvements: ____________________

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For all other regions please refer to the list of Polytec representatives on page 21 of this LM INFO special issue.