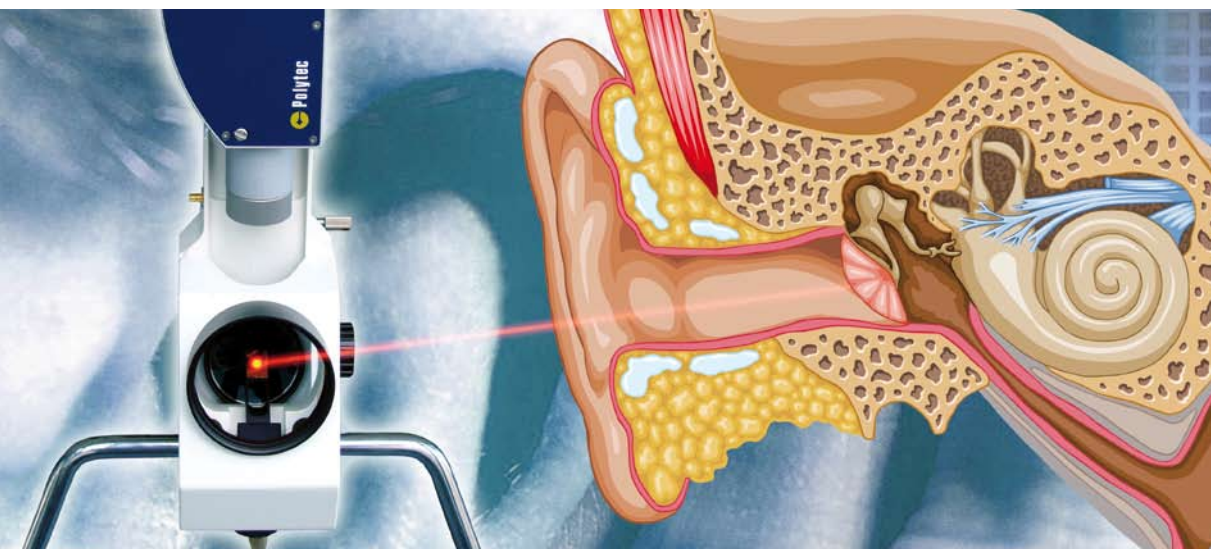


Laser Vibrometry in Ear Mechanics and Otology



Polytec Laser Vibrometers for Otology

- **Overview:**
Laser Vibrometry in Ear Mechanics and Otology
- CLV-2534 Compact Laser Vibrometer
- PSV-400 Scanning Vibrometer
- MSA-500 Micro System Analyzer

The human ear is one of the most sophisticated sound and vibration amplification systems. State-of-the-art laser-Doppler vibrometers reveal the vibrational and dynamic characteristics of hearing mechanics. Providing ease of use and unsurpassed accuracy and resolution, laser vibrometers open new dimensions in understanding hearing mechanics for the researcher. Laser vibrometry is indispensable to those actively involved in the design, development, quality control, calibration and certification of middle ear implants.

Point, Shoot, Measure!

Laser vibrometers are instruments for non-contact optical vibration measurement.

A low-power laser beam picks up the signature of a vibrating object and transfers it into an output proportional to velocity and displacement that the professional can easily interpret. The laser beam's micron-sized footprint is easy to accommodate in the smallest structures, even on inner ear structures! Interactive video imagery allows positioning of the laser beam manually or by remote control with a click of the mouse.

Unveil Minute Vibrations

Laser vibrometry can sense the smallest of vibrations. It gathers data to display how mechanical conductions take place. It delivers a full picture either of single-point frequency responses or of full-field structural deflection shapes, by way of scanning vibrometry.

One Step Ahead –

The Benefits of Laser Vibrometry

- Ease of use with simple point-and-shoot-operation
- Integration in operation microscopes
- Micrometer spot size for ossicle measurement
- Highly accurate: measures nanometer-scale displacements with ease, allowing excitation with low SPL amplitudes
- User friendly: dedicated software for data acquisition and image display via an integrated camera for laser positioning
- Safe to operate: low-power Class 2 laser (<1 mW)
- Full solution for data acquisition and analysis

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Wide Range of R&D Applications

Laser-Doppler vibrometry (LDV) is a well-established technique used throughout the hearing research community for dynamic measurement of:

- Temporal bones
- Ear models
- Hearing aids
- Cochlear structures
- Middle ear prostheses, implants and devices

These applications are widely documented in the literature. Designed with in-vivo measurements in mind, the LDV can perform measurements of the tympanic membrane, umbo and the ossicular chain including the stapes and foot plate. Pre- and post-prosthetic LDV evaluations (of TORPs, PORPs and Implantable Middle Ear Hearing Devices) could offer researchers a better understanding of prosthesis function and before/after performance.

LDV data showing the functional correlation of the umbo mechanical response help to understand a variety of common hearing disorders/diseases. LDV data assist in looking for correlations between the dynamic middle ear performance in respect to standard hearing tests (air conduction, bone conduction, air-bone gap, tympanometry, etc.). LDV applications in inner ear mechanics research include the complete apparatus of Corti dynamics, basilar and tectorial membranes, or even isolated hair cell motion.

Faster Diagnosis

Findings have led to novel and faster diagnosis procedures and could direct the clinician to more effective therapies. A trained MD can measure both ears (umbo) within 10 minutes during a regular clinic visit, without pain or discomfort. Vibrometry has been used during surgical procedures* to assess and “tune” the performance of implantable hearing devices and prostheses after implantation.

The Right Instrumentation

Vibrometers dedicated to hearing applications come in a variety of configurations tailored to the specific need of the researcher, clinician, development engineer, and quality assurance manager.

To show a typical and very versatile configuration, a CLV-2534 Compact Laser Vibrometer as a basic general purpose instrument for single-point dynamic response measurement is described below.

The CLV-2534 is the most versatile instrument for the audiologist and the otologist. Designed as an

all-in-one system, it comprises the laser sensor head with integrated optics and video camera. For beam steering and operation microscope integration the sensor head is mounted on to the Micro Manipulator. The head is fiber coupled to the CLV control unit containing the laser source and the latest digital demodulation electronics for low-noise measurement. It can resolve nanometer displacements with ease.

Data Acquisition and Management System

Besides a high-resolution optical sensor, an easy to handle data acquisition solution with appropriate software modules for response measurements is a must. Polytec recommends its VibSoft and PSV Software packages dedicated to LDV measurements, including the following:

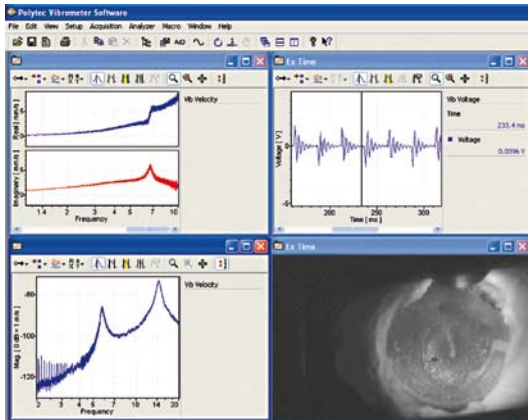
- Data acquisition and analysis both in time and frequency domains
- Multi-channel management and acquisition for signals coming from the vibrometer (velocity/displacement), probe microphones (sound pressure), voltage, etc.
- User selectable wave form generation
- Live video image and storage of object under test
- Easy export of results, plots and video stills
- Animated 3-D deflection shapes (for scanning measurements)
- Remote-controlled laser beam positioning (click on video image) and acquisition of selected grid of points (for scanning measurements)

Easy System Operation

The researcher, otologist, audiologist or engineer looks through the microscope (or optional video camera) and steers the micron-sized laser spot onto the desired measurement location using a joystick. The source generator of the Polytec software delivers sound excitation through an earphone. When making measurements of the tympanic membrane on a live subject, a small adapter connected to a standard Storz speculum and a probe microphone simultaneously measure the SPL a few millimeters from the tympanic membrane. The LDV sensor measures the frequency response at the umbo.



A-HLV-SPEC



The Right Configuration for Your Needs

Basic package for the Otologist (for details refer to the “Technical Data” section):

- **Laser**

CLV-2534-4 Compact Laser Vibrometer: low-power laser source, class 2, compact interferometer head, 4 m fiber cable to control unit, integrated video camera, digital demodulation, 100 kHz bandwidth, integrated high- and low-pass filters, beam shutter.

- **Data Acquisition and Visualization**

Data Management System running the VibSoft-84 Data Acquisition Software: 4 channels; 80 kHz acquisition bandwidth, integrated signal generator for excitation, live video display, beam shutter control, remote control of vibrometer settings.

- **Microscope Integration**

A-HLV-MM30 Micro Manipulator for positioning of the laser beam by joystick. The Micro Manipulator is attached together with the CLV-2534 sensor to the microscope and allows precise positioning of the laser beam onto the specimen or section of the ear. Suitable for Zeiss and Leica microscopes.

- **Accessories**

A-HLV-SPEC Speculum adapter for defined excitation with defined SPL. The speculum adapter features a laser-adapted sealing window that enables sound pressure generation in a closed space directly onto the tympanic membrane. The A-HLV-SPEC Speculum is suitable for all Bruening-compatible Storz specula. It is designed for the adaptation of the sound source ER-2 and the reference microphone ER-7C from Etymotic Research (sound source, microphone and specula not included).



**A-HLV-MM30
Micro Manipulator**



From Single Point to Full Field

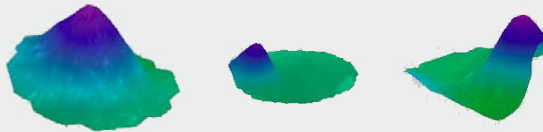
Laser vibrometry is also used to acquire full-field vibrational information about the tympanic membrane or other parts of the ear. The PSV-400 Scanning Vibrometer for mid-sized areas down to 1 mm x 1 mm can detect the deflection shapes of the tympanic membrane or of hearing aids and components, for example. For inner ear research and hearing aid development, microscope-based LDVs such as the MSA-500 Micro System Analyzer are available for micro-sized samples.



PSV-400

Full-field scanning measurements of the tympanic membrane (TM).

Left: normal; center: stapes fixation; right: TM perforation
(courtesy H. Mojallal, MHH Hannover)



Accessories

A-HLV-MM30 Micro Manipulator for manual deflection of the laser beam on the specimen

- Compatibility: Zeiss: OPMI 1FC, OPMI 111, OPMI PRO magis; Leica: OPMI M655. Other models on request.
- Sensor compatibility: OFV-534, CLV-2534
- Weight: approx. 2 kg

A-HLV-SPEC Speculum Adapter for excitation of the tympanic membrane

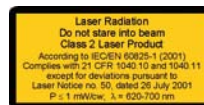
- With sealing window for laser input. Adapters for sound source and reference microphone.
- Compatible sound source: Etymotic Research ER-2
- Compatible microphone: Etymotic Research ER-7C
- Compatible specula: Storz sizes 1-5

Dedicated VibSoft Data Acquisition Packages for CLV-2534

Version	Channels	Bandwidth	Int. Generator	ICP®
VibSoft-20	2	20 kHz	-	yes
VibSoft-80	2	80 kHz	optional	yes
VibSoft-84	4	80 kHz	optional	yes

Compliance with Standards

Laser safety	IEC/EN 60825-1 (CFR 1040.10, CFR 1040.11)
Electrical safety	IEC/EN 61010-1
EMC	IEC/EN 61326



For CLV-2534-4 Compact Laser Vibrometer, PSV-400 Scanning Vibrometer and MSA-500 Micro System Analyzer please refer to the dedicated data sheets. ICP® is registered trademark of PCB, Inc.

*) Disclaimer: The laser measurement system is intended for research use only. It has no FDA approval. In-vivo applications require a local authorization protocol.

For more information, please visit our website www.polytec.com/vibrometers or contact your local Polytec sales/application engineer.

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