# **VDD** *Digital Laser Vibrometer*
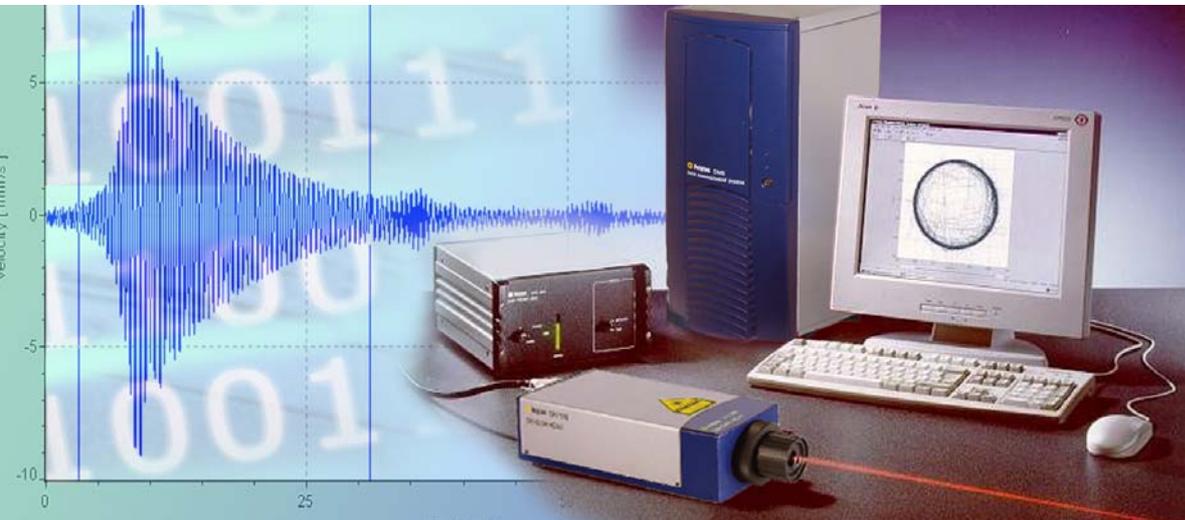
**MODULAR VIBROMETER SYSTEM**

- VDD Digital Laser Vibrometer
- OFV-5000 Vibrometer Controller
- OFV-505/503 Standard Sensor Heads
- OVF-551/552 Fiber Interferometers
- VibSoft Software

## PICOMETER DISPLACEMENT SENSITIVITY

*A Digital Laser Doppler Vibrometer (LDV) can respond when analog LDVs can not. New measurements in data storage, micro-electro-mechanical structures (MEMS) and hearing dynamics push a traditional analog LDV beyond its noise and resolution limits. Polytec customers can choose either the DFE-650 stand-alone digital system or a DD-600 equipped OFV-5000 vibrometer controller with analog and digital capability. The PC based digital LDV utilizes 5 MS/s, a multi-channel data acquisition, the VibSoft-VDD comprehensive software package for processing of the data and an analog front-end for conditioning of the signal prior to digitization.*

### Key Features and Benefits

- Measures displacement, DC – 2 MHz
- Cutting edge resolution < 1 picometer
- Outstanding linearity, accuracy, resolution and dynamic range compared to analog systems
- Existing OFV-5000 LDVs can be up-graded to digital demodulation to access both analog & digital signals (model DD-600)
- Stand alone digital controller DFE-650 front-end for application where only digital demodulation is required
- Comprehensive dual channel data acquisition software VibSoft-VDD for acquiring, processing and exporting of the data
- Data are acquired in displacement and can be converted to velocity and acceleration data in time and frequency (FFT) domains
- Excellent stability, insensitive to drift and ageing effects (all digital)

### Digital vs. Analog LDVs

Digital LDVs are recent additions to the Polytec product line. Their design opens the door to many new possibilities. One of the most significant advantages of the digital LDV is the extremely low noise floor and the exceptional < 1 picometer displacement resolution on mirror-like surfaces.

Digital LDVs are well-suited when extreme displacement accuracy is desired and the test object remains within the 2 MHz bandwidth and under the maximum velocity of 840 mm/s. In addition, a digital LDV is an excellent choice when signals are expected to be saved, processed or exported to sophisticated signal processing software. The VDD software functions and internal hardware are cost effective when they eliminate a spectrum analyzer, an arbitrary waveform generator and a data acquisition system. When real-time signal outputs are needed, the traditional analog LDV is the best choice. Currently the analog units also meet the need for larger velocities and displacements.

## Principle of Operation

The output signal from the LDV sensor head contains information about the velocity (signal frequency) and displacement (signal phase) of the test object. The VDD decodes the phase of the signal to measure the dynamic displacement of the test object. In the VDD system a quadrature demodulator generates the sine and cosine components of the sensor head signal. They are digitized by a high sampling rate ADC board inside the data management system.
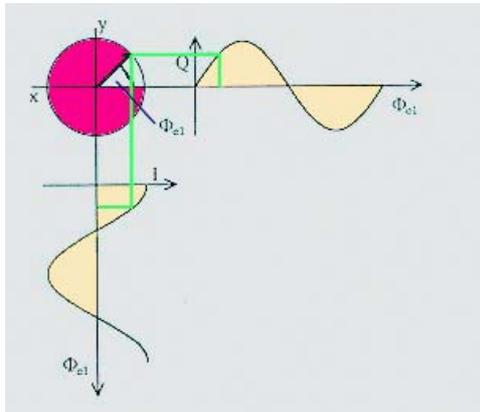


These 2 signals can be represented as a rotating vector whose phase is directly related to the displacement of the test object and the laser wavelength. By numerically decoding the phase with an arctan function, high displacement accuracy and resolution is achieved. Velocity and acceleration data are available through VibSoft-VDD by differentiation of the displacement signal.

## VibSoft-VDD Software

VibSoft-VDD is the software package that controls the real time acquisition of the LDV signal.

- Real-time acquisition, signal processing, display and export of all data
- Calculation of FRFs, Coherence and other signal properties
- Digital high, low and band pass filters. User can load custom ASCII format filters
- Differentiation and integration in time and frequency domain
- Time domain averaging of the input signal
- FFT transformation with 12,800 lines resolution

- Integrated signal generator software supporting many different waveforms
- Automatic test routines and interfacing to other software are programmed via Visual Basic scripting (VBS)
- Data export in ASCII format, Universal file UFF, direct data access to binary data using Poly File Access software and optional binary ME'Scope interface
- VibSoft gives full access to all settings of the OFV-5000 controller via RS-232 interface

## Applications

The VDD digital laser Doppler vibrometer is an excellent tool to characterize very small dynamic displacements. Both researchers and engineers use the large bandwidth, flat response and fine resolution to measure displacement in applications where traditional analog vibrometry does not have the resolution. A few of these situations are described briefly in what follows.

### Runout Testing of Precision Spindles

The hard disk drive (HDD) industry requires higher density storage in each successive product generation. With track densities approaching 250,000 TPI, a HDD manufacturer must control spindle runout so that tracking isn't lost. The VDD Digital laser Doppler vibrometer measures both the repetitive runout (RRO) and non repetitive runout (NRRO) with the fine precision necessary to verify the tight tolerances needed (NRRO < 5 nm). The low noise (high resolution) of the digital LDV between DC and 20 kHz enables this application. The acquired data is easily transferred to a computer for proprietary RRO and NRRO analysis.
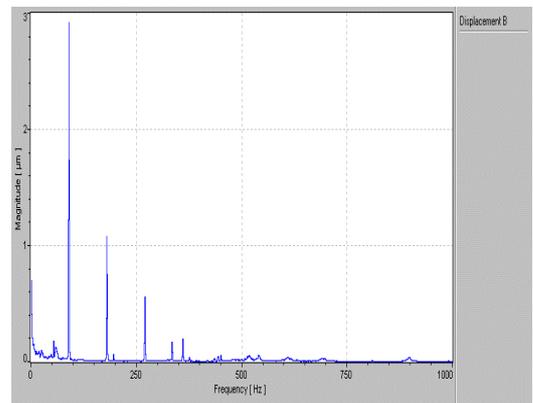


*VibSoft-VDD provides an FFT function for switching from time to frequency domain. The repetitive spindle runout (RRO) is obvious in the frequency domain.*

## Frequency Response Measurement

Frequency response testing on actuators and head gimble assemblies (HGA) has traditionally relied on an LDV plus a 2-channel FFT analyzer. With the VDD, Polytec provides a complete solution that eliminates the cost of an external spectrum analyzer and improves the resolution of the measurement. Measuring the resonance response of a part has never been easier.

## Calibration of Actuators and Sensors

The digital LDV does a direct and highly precise mathematical phase demodulation leading to a calibrated measurement of displacement. Its performance is so outstanding that it is the first Polytec LDV (DFE-650 with a standard optics head) to be used by the German National Standards Labs (PTB) as a primary calibration source.

## Slider Displacement Development

HDD researchers are interested in the precise, time-domain displacement history of a slider. The off-track motion of the slider is very small. Analog LDV systems have too much broadband noise to resolve the typical displacements. A digital LDV has one or two orders of magnitude better S/N and can easily detect the motion. Using the VDD system, it is possible to make a direct comparison between the exact slider dynamic position and the position error signal (PES). Using this comparison, contributions to the PES can be identified and minimized.
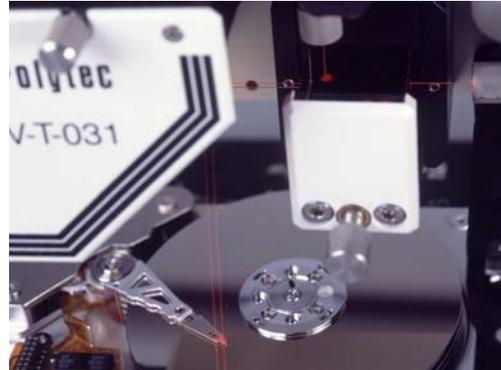


*Stable flying heights for a magnetic head are determined with a digital LDV.*

## Head/Media Interface Studies

The high resolution of the digital LDV permits accurate measurements of head/media interface dynamics. Engineers can characterize a given HGA and slider configuration with a particular media product. If not satisfactory, other product combinations can be tried until an appropriate solution is found that offers stable flight and minimal registration errors.

# VDD System Configuration

Polytec offers four LDV heads – the dual fiber OFV-552, the single fiber OFV-551 or the standard optic heads OFV-505 and OFV-503. The best choice depends on the exact measurement setup.

The signal from the head can go to one of two basic configurations – the digital only DFE-650 stand-alone front end or, for the greatest flexibility, the DD-600 decoder extension installed in the OFV-5000 vibrometer controller enabling digital and analog demodulation at the same time. The output from the front end passes to the data management and acquisition system where the displacement, velocity and acceleration can be calculated and displayed. A reference channel input is available for acquiring additional signals for phase and frequency response function (FRF) measurements. An internal arbitrary waveform generator output is also available and can be used to drive the device under test. The VibSoft-VDD software package manages the data acquisition, phase decoding, arbitrary waveform generator and data display. Measurements can be presented in time and frequency domains. Included with the software are an extensive number of functions including FRF, auto power spectra, cross power spectra, coherence and phase.

# Technical Data

| Front End Specifications | |
|---|---|
| DFE-650 Stand-Alone Digital Front End | |
| Dimensions (H x W x D) | 135 mm x 335 mm x 235 mm (5.3 x 13.3 x 9.3 in.) |
| Weight | 7 kg |
| Operating temperature | +5 °C  …  +40 °C  (41 °F … 104 °F) |
| DD-600 Digital Board Set for OFV-5000 Controller | |
| Output | EXT.DEC connector on rear of OFV-5000 controller |

## VDD System Performance Specifications

| | |
|---|---|
| Max. velocity | 405 mm/s or 810 mm/s; depends on sample frequency/sample time |
| Frequency range | 0 … 2 MHz |
| Maximum FFT lines | 12,800 |
| Maximum samples | Time mode: 524,288 FFT mode:  32,768 |
| Maximum displacement error | ± 1 % of RMS reading for 1 nm to 100 nm ± 0.2 % of RMS reading for displacements > 100 nm |
| Total harmonic distortions | < 0.1 % up to 50 kHz sinusoidal |
| Amplitude frequency response | Displacement:   typ. ± 0.1 %;      Velocity: typ. ± 0.2 % Acceleration:    typ. ± 0.2 % |
| Spurious signals | <10 pm  for 0 Hz < f ≤ 20 kHz 150 pm  for 20 kHz < f ≤ 2 MHz |
| Displacement resolution* | < 1 pm |
| Velocity resolution | 0.25 µm/s @20 kHz; 2.5 µm/s @200 kHz; 25 µm/s @2 MHz |

*Resolution is defined as the signal amplitude at which the signal-to-noise ratio is 0dB in a 1 Hz spectral bandwidth (RBW) measured on 3M Scotchlite Tape

## VDD Acquisition System Performance

| | |
|---|---|
| Data Management System | State-of-the-art PC with Windows® 2000 or Windows® XP Professional operating system |
| Acquisition board | 4 channel, 5 MS/s, 12 bits |
| Signal generator (optional) | 1 channel, 512 kHz, arbitrary waveforms |
| External signal generator (optional) | HP33120A or HP33250A connected GPIB to via USB adapter |
| **Junction Box VDD-Z-011** | |
| Signal input reference in | ± 32 V into 1 MΩ |
| Input coupling | AC or DC adjustable by software |
| Trigger input | TTL |
| Signal output | Internal generator output |

## VibSoft-VDD Standard Software

| | |
|---|---|
| VibSoft-VDD | Data acquisition and processing, time & frequency domain displays, time & frequency domain averaging, digital filter program, time domain integration & differentiation. 2 input channels for vibrometer & reference |
| VIB-S-GateIn | TTL Gate input software |
| VIB-S-FFT128 | Supports 12,800 FFT lines |
| VIB-S-VBEng | Creates Visual Basic Scripts for automation of measurements and data presentation. Includes User Defined Data Sets (UDDS) for adding external or post processed data |

## VibSoft-VDD Optional Software

| | |
|---|---|
| VIB-S-ExpUFF | Converts data to Universal File Format (UFF) |
| VIB-S-SIG-M | Controls internal arbitrary waveform generator |
| VIB-S-ExtSig | Controls external arbitrary waveform generator via optional adapter |
| Poly File Access | Software DLL to access data via Microsoft's standard Component Object Model (COM) |
| VIB-S-ExpME | Binary data interface for data exchange with ME'scope software |

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Complies with 21 CFR 1040.10 and 1040.11
except for deviations pursuant to
Laser Notice no. 50, dated 26 July 2001
P ≤ 1 mW/cw;  λ = 620-700 nm

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