

## Rotational Vibrometer 4000 Series



**An innovative, high performance  
instrument for non-contact  
measurement of rotational vibrations**

# Rotational Vibrometer 4000 Series

## Introduction

The Polytec Series 4000 Rotational Vibrometer system is a portable, non-contact laser Doppler system for measuring angular vibrations on rotating structures. It is eye-safe, and extremely simple to set-up and operate.

The novel design of the Polytec Rotational Vibrometer provides accurate measurements without first having to treat the rotating surface with retro-reflective materials. The system therefore sets up, measures, repositions to other locations and tears down without having to stop the test machinery. Measurements can be performed on heated surfaces where it is not possible to artificially improve reflectivity. The measured rotating surfaces can be any shape. Unlike conventional methods, there

are no unplanned stops due to transducer failure or broken wiring.

Another advantage of the Polytec design is its ability to measure anywhere within the range -7000 to +11000 RPM including directional changes, torsional transients and rotational vibrations around the rest position.

The Series 4000 Rotational Vibrometer comprises the OFV-400 optical sensor head and the OFV-4000 controller/processor. Polytec's long-standing experience in the development of laser vibrometers has been applied to the design of the OFV-400 measuring head, with a compact dual interferometer whose high optical sensitivity enables high resolution measurements on untreated objects.

Signals from the OFV-400 are processed by the OFV-4000 controller. The  $\mu$ C-driven controllers have four selectable AC angular velocity ranges, three AC angular displacement ranges, 28 selectable high- and low-pass filters, as well as IEEE and RS-232 computer interfaces. The controller can handle fast transients, e.g. sudden accelerations of a shaft during gear changes.

All instrument settings, signal strength from both laser beams, and DC RPM are shown on the OFV-4000's large, backlit display. Three BNC jacks provide analog signal outputs (angular vibrational velocity, angular vibrational displacement and RPM) for further signal processing, for example via an order tracking analyzer.

## Advantages of the OFV-4000 Series

- Eliminates down-time associated with contact methods
- Tests untreated surfaces where no contact is possible
- Easily repositioned to different areas of rotating machinery
- Senses direction, measures negative velocities and vibrations around standstill
- Wide dynamic range for high speeds, large transients and fine resolution
- Can be used for rotational and linear vibrations
- Portable, eye-safe class II visible laser
- Simple set-up and easy-to-use menu-driven operation with large LCD
- IEEE and RS-232 interfaces for remote control and fast RPM data transfer
- Separate analog outputs for vibrational velocity and displacement

## Typical Applications

- Reduction of noise and vibration
- Studies of rotational fatigue
- Minimizing speed variations in photocopiers, printing and lithographic machines
- Rotating shafts in motors, pumps and compressors
- Propshafts, crankshafts, gears and other rotating surfaces in vehicles
- Improving the precision and quality of tool-making machines
- Monitoring and trouble shooting in power plant and production machinery
- Marine and other propulsion systems
- Speeding up adjustment of torsional vibration dampers in vehicle drive shafts
- Studying run-up and run-down of machines (order tracking and Campbell plots)

## Principle of Operation

The Series 4000 Rotational Vibrometer uses two parallel laser beams which exit the OFV-400 front lens and strike the rotating surface, as shown in figure 1. Each back-scattered laser beam is Doppler shifted in frequency by the surface velocity vector in the beam direction. This velocity is made up of rotational and lateral components. Raw output signals from each beam are independently sent to the OFV-4000 for processing. Using a simple geometric relationship, the difference of the two velocity components is a direct measure for the pure rotational velocity of the object and eliminates lateral vibrations.

The advantage of Polytec's dual interferometer approach lies in optical gain that is orders of magnitude higher than designs using only one interferometer operating in an optically differential mode. The resulting high optical sensitivity allows measurements on poorly reflecting surfaces, thereby increasing the range of applications and ease of use.

The system can be adapted to measure linear as opposed to angular vibrations by means of a special cap which blocks one of the laser beams.

There are however resolution limitations when compared to our regular vibrometers. For measuring positive and negative rotations, vibrations around zero RPM, and sensing their direction, a Bragg cell is incorporated into the dual interferometer. The Bragg cell produces a constant angular velocity offset by frequency shifting the laser beams. The light source is a visible, low power laser meeting the requirements of a Class II laser product.

Fig. 1 Schematic diagram on the rotational vibrometer system

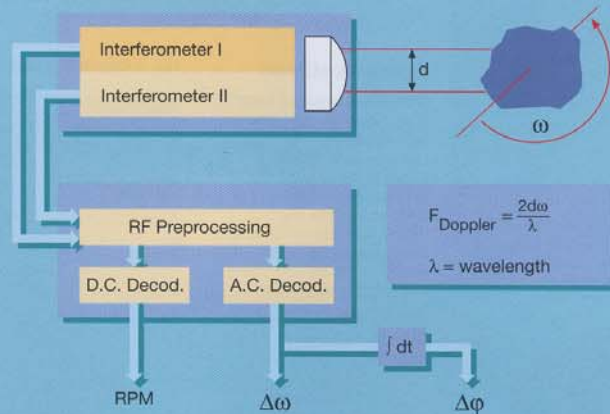


Fig. 2 Order tracking analysis with the rotational vibrometer

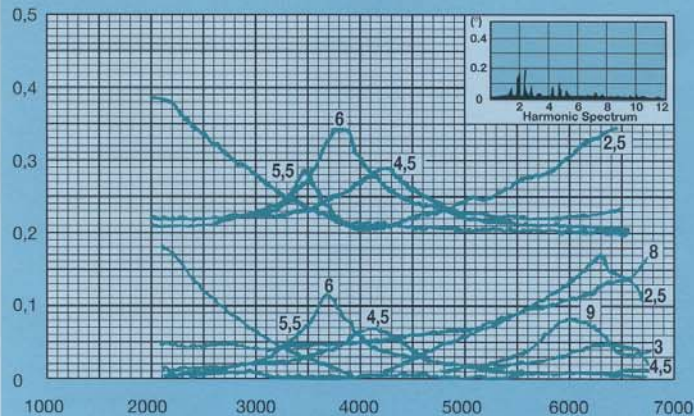


Figure 2 shows an order tracking analysis of a 5 cylinder automobile engine. The OFV-400 was aimed at the pulley. Results are compared with the output from a

magnetic encoder (lower display). Set-up, data acquisition and tear-down were accomplished by the rotational vibrometer in a fraction of the time needed to install the encoder.

## Specifications

### OFV-400 Measuring head

Dual interferometer system with frequency shift  
HeNe Laser < 1 mW (Class 2) per beam  
Measurement distance: 400 mm +/- 160 mm (200 or 600 mm on request)  
Measurement beam separation: 8 mm (standard)  
Graphic display of balance  
Multiple mounting positions

### OFV-4000 Controller

19" housing, rack mountable  
Back-lit LCD graphics display  
IEEE interface and RS-232 computer interface  
Separate analog outputs

### Vibrational angular velocity ( $\Delta \omega$ )

4 velocity ranges:  
100, 1000, 10 000 and 60 000 °/s (FSR)  
Analog output +/- 10 V  
Linearity error: <0.5%  
Frequency range: 0.5 Hz ... 10 kHz  
High- and low-pass filters, 4th order, wide range of cut-off frequencies

### Vibrational angular displacement ( $\Delta \varphi$ )

3 angle ranges:  
0.1 / 1 / 10° (FSR)  
Analog output +/- 10 V  
Frequency range: 1 Hz ... 10 kHz  
Linearity error: <0.5%

### Linear velocity ranges

14, 140 mm/s,  
1.4, 8.4 m/s (FSR)

### Linear displacement ranges

14, 140 and 1400 µm (FSR)

### RPM

Measurement range:  
-7000 ... +11 000 RPM  
Accuracy: +/- 1% (or +/- 5 RPM)  
Linearity error: <0.5%

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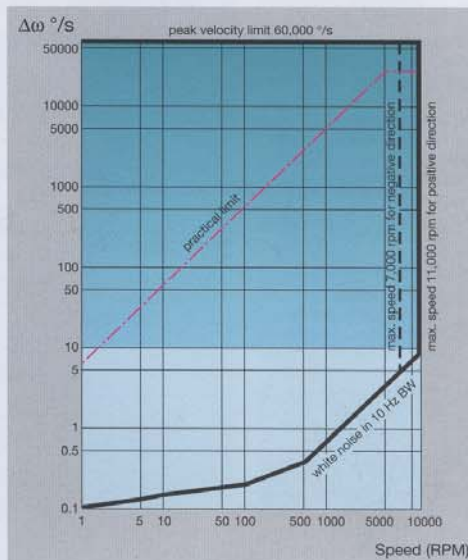
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Fig. 3 Operating range of the rotational vibrometer



Large 4-digit LCD display for RPM

DC signal output  
1 V/1000 RPM

Time constant switch slow/fast for detection of machine run-up characteristic

Data transfer via interfaces up to 500 samples/sec.

### Physical dimensions

Sensor head:  
315 mm x 120 mm x 80 mm (incl. front lens)

Controller:  
450 mm x 360 mm x 135 mm

### Operating temperature

+5 °C ... +40 °C  
(41 °F ... 104 °F)

## About Polytec

Polytec GmbH of Waldbronn, Germany, an ISO 9001 certified supplier, specializes in the development and manufacture of scientific and industrial measurement equipment. Polytec installs its products world-wide through its wholly-owned subsidiaries in North America, Japan, Britain and France and an extensive network of sales representatives. The Series 4000 Rotational Vibrometer is another addition to the world's most comprehensive line of laser-based vibration measurement systems.

## CAUTION

LASER RADIATION -  
DO NOT STARE INTO BEAM



Helium Neon Laser  
1 milliwatt max/cw  
CLASS II LASER PRODUCT