Polytec

User Manual

Portable Digital Vibrometer

PDV-100

Warranty and Service

The warranty for this equipment complies with the regulations in our general terms and conditions in their respective valid version.

This is conditional on the equipment being used as it is intended and as described in this manual.

The warranty does not apply to damage caused by incorrect usage, external mechanical influences or by not keeping to the operating conditions. The warranty also is invalidated in the case of the equipment being tampered with or modified without authorization

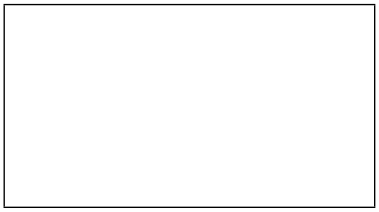
To return the equipment always use the original packaging. Otherwise we reserve the right to check the equipment for transport damage. Please mark the package as fragile and sensitive to frost. Include an explanation of the reason for returning it as well as an exact description of the fault. You can find advice on fault diagnosis in CHAPTER 6.

Trademarks

Brand and product names mentioned in this manual could be trademarks or registered trademarks of their respective companies or organizations.

Identification Labels

PDV-100



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1 Safety Information

1.1 General Safety Information

Notes

Please read this manual before using the instrument. It will provide you with important information on using the instrument and on safety. This will protect you and prevent damage to the instrument. Pay particular attention to the basic safety information in CHAPTER 1 and the information in installation, operation and maintenance in CHAPTER 3.

Please keep this manual in a safe place and make it available to people using the instrument. Never pass the instrument on without the manual.

In this manual the following graded safety and warning labels are used:

NOTE!

Identifies action required to simplify using the instrument!

CAUTION!

Danger from "Reason of Danger" ! Identifies the danger caused by an action which could result in damage to the instrument, if it is not avoided!

WARNING!

Danger from "Reason of Danger" ! Identifies a possible danger resulting from an action which could lead to death or (serious) injury, if it is not avoided!

Intended use

The instrument is intended for laboratory use and for use in an industrial environment. It may only be used within the limits given in the technical specifications (refer to CHAPTER 7).

Faultless and safe operation of the instrument depends on correct and proper transport and storage, installation and assembly as well as careful operation of the instrument.

When assembling, installing and operating the instrument, the safety and accident-prevention regulations for the respective use must be adhered to.

Qualification

This instrument may only be operated by persons who are familiar with electrical measurement equipment and have been instructed in the use of lasers. Please pay attention to the information on laser safety in SECTION 1.2.

Intervention for maintenance and repair work may only be carried out by the manufacturer himself or by qualified personnel authorized by the manufacturer.

Disposal

An instrument which is no longer required must be disposed of according to the local regulations unless otherwise provided by the manufacturer.

1.2 Information on Laser Safety

1.2.1 Safety Information

The light source of the instrument is a helium neon laser. It is important to understand that laser light has properties different from ordinary light sources. Laser light is generally extremely intense due to the beam's low divergence. Great care should be taken when handling lasers that the direct or reflected beam do not enter the eye.

NOTE!

Please see CHAPTER 7 for the detailed technical specifications!

The protective measures are described in the following support compliance with the safety standards for laser class 2:

- Polytec instruments generally comply with the standards **IEC** and **EN 60825-1** or **US 21 CFR 1040.10** and **1040.11** respectively except for deviations pursuant to Laser Notice No. 50, dated 24 June 2007.
- The optical output power of the laser beam emitted from the sensor head is less than 1 mW provided the equipment is used in the manner for which it was intended. This means that the instrument conforms with the **laser class 2** and is generally very safe. It is thereby usually assumed that the eyes are protected by prevention mechanisms including the blink reflex. This reaction offers appropriate protection under reasonable foreseeable operating conditions. This includes the use of optical instruments for observing the laser beam. Even when optimally focused, the laser beam is not intense enough to harm the skin.
- The instrument is equipped with a **beam shutter** to block the laser beam during the warm-up phase or when the vibrometer is not in use, although switched on.
- An **emission indicator** on the instrument signalize the activity of the installed laser and thus the potential hazard of laser beam emitted.
- The user should not attempt to open the housing of the instrument which contains the laser unit as he could be exposed to a higher level of laser energy that is potentially hazardous.

WARNING!

Danger from uncontrolled light emission ! Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

1.2.2 Safety Precautions

Pay attention to the following safety precautions when using the instrument:

- Only qualified and fully trained persons should be entrusted with setting up the instrument, adjusting and operating it!
- Avoid looking directly into the laser beam with the naked eye or with the aid of mirrors or optical instruments!

WARNING!

Danger from laser light! It can be dangerous to look directly into the laser beam for any length of time.

NOTE!

Wear suitable laser protection glasses when you have to look at the target area of the laser beam long and hard to set it up!

- Never intentionally direct the laser beam at anyone!

WARNING!

Danger from laser light! Do not use any reflective tools, watches etc. when you are working in the beam path of the laser!

- Only open the beam shutter when making measurements!
- To position the instrument, always close the beam shutter. The beam shutter should not be opened until the sensor head has been roughly aligned and mounted securely!
- The laser beam should be terminated at the end of its intended path where this is practically possible.
- Instruments which are not in use should be stored in places which unauthorized persons do not have access to.

1.2.3 Laser Warning Labels

Laser warning labels

The laser warning labels for the PDV are shown in FIGURE 1.1. For the countries in the European Union (EU), label **2** is affixed in the language of the customers country (see right-hand-side).

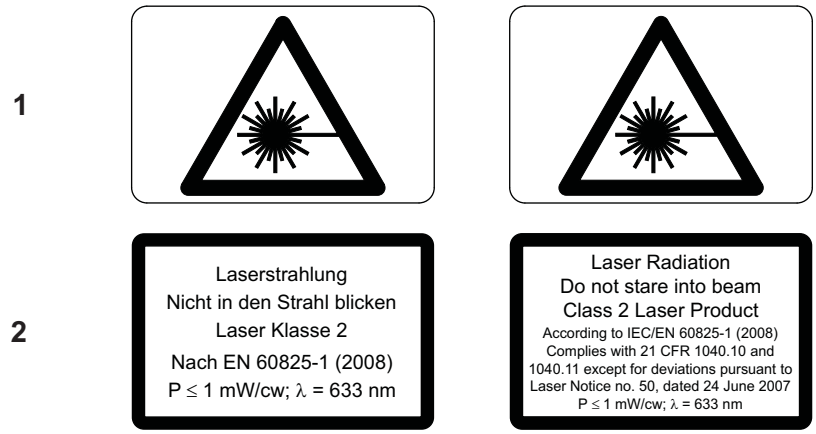

Figure 1.1: Laser warning labels for the PDV

Position

The position of the laser warning labels on the PDV is shown in FIGURE 1.2.

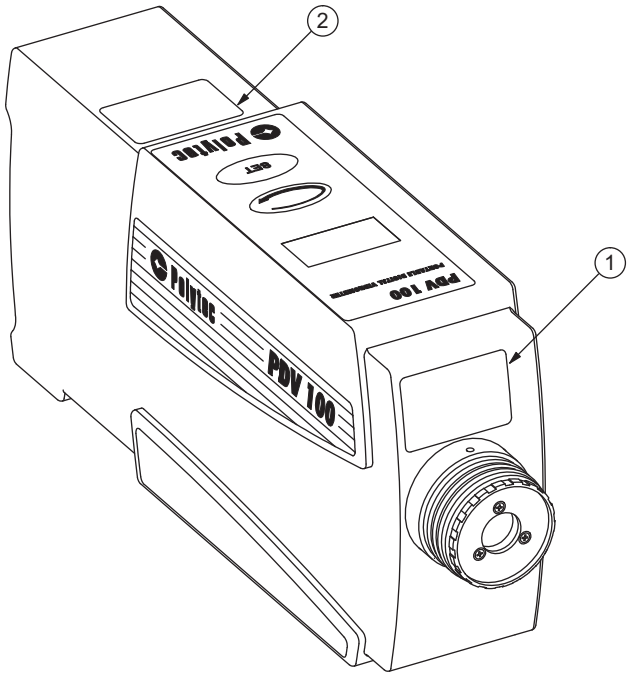

Figure 1.2: Position of the laser warning labels on the PDV

1.3 Information on Electrical Safety

PDV

The instrument is designed to be used powered by a low voltage (nominal 12 V DC) provided externally, which is accessible for constructional reasons. The instrument complies with the electrical protection class 1 in accordance with the EU directive 2006/95/EEC (low voltage directive). With correct mains connection and intended use, exposure to electric current is prevented by the closed, grounded metal housing.

The instrument is subjected to the EU directive 2004/108/EG (EMC directive) and therefore complies with the limit values for emission and immunity of the standards they are based on (refer also to SECTION 7.1and APPENDIX C).

The housing may not be opened when using the instrument as intended. Opening the housing will invalidate the warranty. None of the equipment may be operated with opened housing.

WARNING!

Danger from electrical current! Intervention for maintenance and repair work may only be carried out by the manufacturer himself or by qualified personnel authorized by the manufacturer!

Power supply

To avoid the danger of an electrical shock or faults, only use the plug-in power supply PDV-AC provided by the manufacturer. Do not expose the power supply to rain and moisture.

It is not nesessary to open the housing when using the power supply as intended. Always use the correct plug adapter.

Battery charger (optional)

Lithium ion batteries require a very strict compliance with the charging parameters. Thus only use the battery charger PDV-CH provided by Polytec. Using any other battery chargers may result in fire or explosion of battery.

CAUTION!

Danger of overheating! When loading the batteries it is recommended to open the cover of the carrier bag to ensure unimpeded air circulation.

1.4 Specific Safety Information for Lithium Ion Batteries

1.4.1 Safety Precautions for Using

Pay attention to the following safety precautions when using lithium ion batteries:

WARNING!

Danger from mishandling! Incorrect use of the battery may result in an excessive rise in temperature (heat accumulation), fire or explosion leading to serious personal injury!

- Do not throw the battery into fire or expose it to extreme heat!
- Do not leave the battery in the direct sun, near a radiator, or in a closed car on a warm day!
- Do not reconstruct, disassemble, deform, or short-circuit the battery.
- Do not touch the battery poles with metal objects like necklaces, keys, coins or hair pins! Replace the protective cap on the battery cable connector, if the battery is being stored.
- Do not allow the battery to come into contact with sea water or water of any kind!
- Do not drop the battery or subject it to great shocks!
- Do not use any batteries which are emitting a fluid or which show external damage.

1.4.2 Safety Precautions for Loading

Pay attention to the following safety precautions when using lithium ion batteries:

WARNING!

Danger from mishandling! Incorrect behavior when charging the battery may result in an excessive rise in temperature (heat accumulation), fire or explosion leading to serious personal injury!

- To charge the battery, only use the battery charger provided by the manufacturer!
- Never connect the battery directly to a mains supply or an on-board plug socket!
- While charging, do not place the battery in direct sunlight. If the battery gets too hot, a built-in safety device is activated, preventing the battery from charging further. Heating the battery can destroy this safety device and can cause an explosion or ignition of the battery.
- If the given charge time for the battery is significantly exceeded without the battery reaching full capacity, please abort the charging process. Doing so may cause the battery to overheat, explode, or ignite!

2 Introduction

2.1 Area of Application

Polytecs Portable Digital Vibrometer PDV-100 is used for non-contact measurements of surface vibrational velocities. The PDV-100 is a compact, portable laser vibrometer with state-of-the-art design of optics and signal processing. The PDV-100 is shown in FIGURE 2.1.

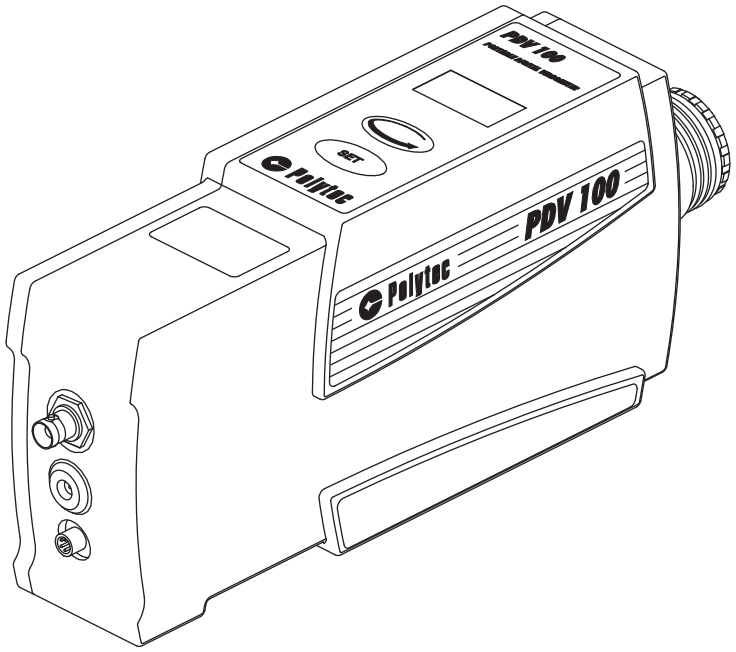

Figure 2.1: View of the PDV

In the frequency range from 0.05 Hz ... to 22 kHz the handy PDV-100 allows you to realize measurement accuracy which you previously needed a stationary measurement device in a calibration laboratory to achieve. With the three measurement ranges, which cover a velocity range from 0.05 µm/s to 0.5 m/s, and with precise digital filters you can optimally to adjust the PDV nearly all applications in the acoustic frequency range.

2.2 Measurement Principle

The PDV use the principle of the heterodyne interferometer to acquire the characteristics of mechanical vibrations or transient motion processes (refer to APPENDIX B). With this type of interferometer, a high-frequency carrier signal is generated on the photo detector with the aid of a Bragg cell. To make the vibration measurement, the beam of a helium neon laser is pointed at the vibrating object and scattered back from it. The velocity amplitude of a vibrating object generates a frequency modulation of the laser light due to the Doppler effect. This modulation is recovered in the signal processing unit with the aid of suitable demodulations (or decoders). A schematic layout of the signal path is shown as a diagram in FIGURE 2.2. The velocity information is recovered from the frequency modulation of the Doppler signal.

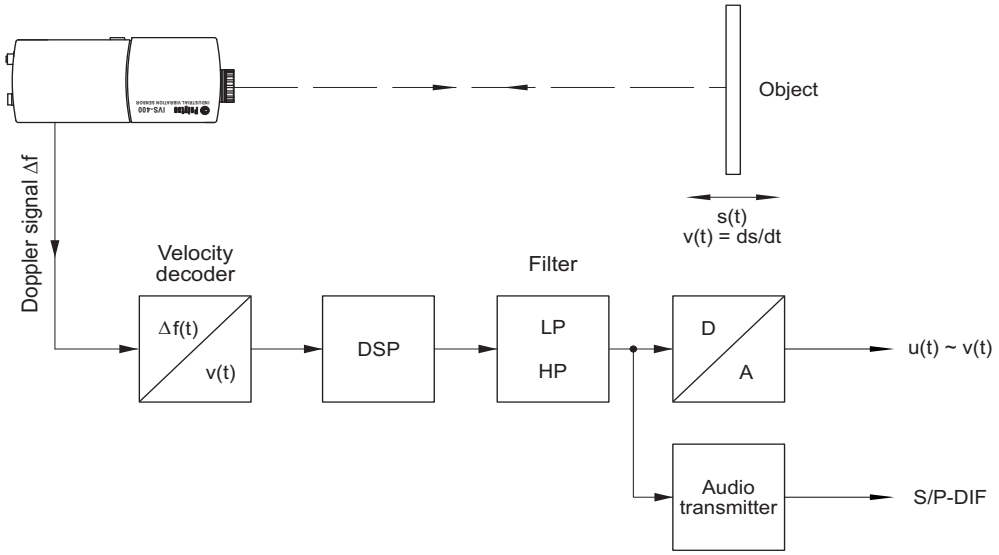

Figure 2.2: Signals in the vibrometer

In the PDV, the optics and the signal processing unit are inside the housing. The demodulation of the Doppler signal is purely based on a digital process. In contrast to the conventional vibrometers which use analog, this then means that the measurement accuracy is virtually independent of aging and environmental influences. State-of-the-art DSP technology makes it possible to realize excellent measurement system characteristics, despite the compact design and minimal energy consumption.

By using a serial interface proven in digital audio technology, the output signal ca be fed into the digital inputs of modern recording devices or signal analyzers without any loss of accuracy. For the conventional type of signal processing, an analog signal output with 24 bit amplitude resolution is also available.

3 First Steps

3.1 Unpacking and Inspection

unpacking

The scope of supply consists of the following components:

- Laser vibrometer PDV-100
- Plug-in power supply PDV-AC
- Carrier bag
- Digital audio cable (Triax/RCA)
- 1 Allen key size 1.5 mm
- 1 Sheet reflective film 3M Scotchlite Tape® (enclosed in the manual)

optional

- VIB-A-P07 (mounting plate)
- Carrier bag PDV-BS with integrated lithium ion battery PDV-LI (rechargeable) and battery charger PDV-CH
- Motor vehicle supply cable PDV-DC for the PDV being operated at a 12 V on-board plug socket or a motor vehicle cigarette lighter
- VIB-A-T01 (tripod with 3-axes head)
- VIB-A-T02 (tripod with fluid stage)

CAUTION!

Danger from dirt! Handle the front optics with care! Dirt may only be removed by using a soft, dry cloth, an optics brush and bellows!

Inspection

Please pay attention to the following steps when unpacking:

1. Check the packaging for signs of unsuitable handling during transport.
2. After unpacking, check all components for external damage (scratches, loose screws, damaged glass platesetc.).
3. In the case of wrong delivery, damage or missing parts, inform your local Polytec representative immediately and give them the serial number of the instrument. The identification label can be found on the underside of the instrument and also on the inside cover of this manual.
4. Carefully retain the original packaging in case you have to return the instrument.
5. Install the instrument as described in SECTION 3.4 and execute a first functional test as described in SECTION 3.5.

3.2 Operating and Maintenance Requirements

Ambient conditions

The PDV can be used in dry areas under normal climatic conditions (refer to CHAPTER 3.5). Avoid condensation on the optical components caused by a rapid change in temperature. Avoid exposure to direct sunlight to prevent the instrument from overheating.

Mains connection

To avoid the danger of an electrical shock or faults, only use the plug-in power supply PDV-AC provided by the manufacturer. Do not expose the plug-in power supply to rain or moisture.

Assembly

The PDV should not be provisional mounted but be mounted with help of fixing screw threads on the mounting plate (optional) or stable tripod. To ensure sufficient cooling, if possible mount the PDV on cooling metal surfaces.

Cooling from radiant

His essential to ensure unimpeded air circulation around the PDV and protect it from radiant heat. With high ambient conditions, if possible mount it on cooling metal surfaces to minimize heat built-up.

Connecting cable

Make sure that all jacks are connected properly and firmly. Protect the connecting cables against mechanical damage and high temperature.

Warming-up

After switching on, the helium neon laser in the PDV will take a little while to reach the optimal operating temperature after it has been switched on. The PDV therefore reaches its optimal properties after a warm-up period of approx. 20 minutes. After that you can be sure that all components are working property in accordance with the specifications. Less accurate measurements, such as to align the PDV for example, can however be carried out with usefully results before this warm-up period has expired.

Cleaning

The housing surfaces of the instrument can be cleaned with mild detergent or disinfectant solutions. Organic solvents must not be used!

Optical components

Handle all optical components with great care. Dirt may only be removed very carefully with a soft, dry cloth, an optics brush and bellows.

Installation of other components

Hard or software components which do not belong to the vibrometer system can damage the system. Using them will invalidate the warranty. If you want to install such components please contact Polytec.

Opening the instruments

It is not necessary to open the housings when using the equipment as intended and will invalidate the warranty. Exchanging or retrospectively installing modules may only be carried out by authorized service personnel of Polytec.

Battery and battery charger (optional)

The lithium ion battery for the PDV can be used at temperatures of between 0°C to +40°C (+32°F to +104°F). Make sure, that there are temperatures between +10°C to +30°C (+50°F to +86°F) when charging the battery.

3.3 Control Elements

View from above

The view from above of the PDV with its control elements is shown in FIGURE 3.1.

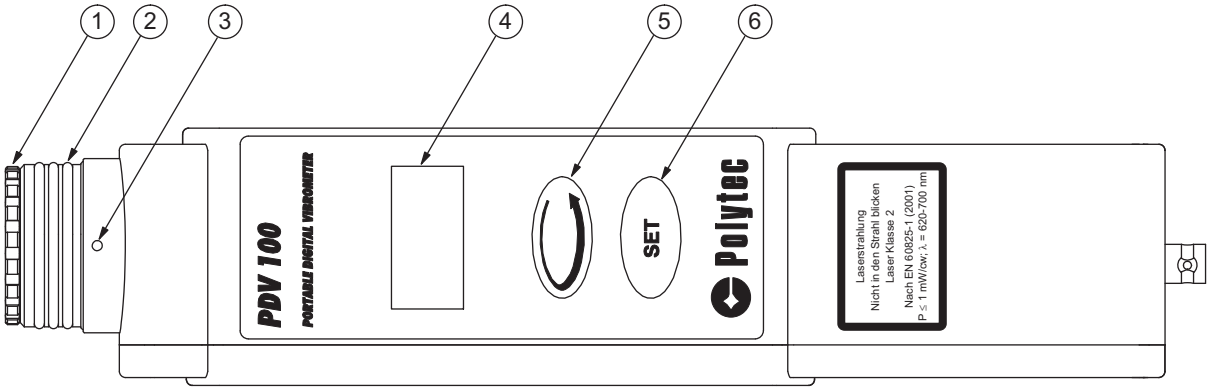

Figure 3.1: View from above of the PDV

1 Beam shutter

Beam shutter to block the laser beam (refer to SECTION 5.2)

WARNING!

Danger from laser light! Only open the beam shutter when you are making measurements!

2 Focusing ring

Ring to focus the laser beam (refer to SECTION 5.3)

3 Clamping screw for the focusing ring

Allen screw to fix the focusing ring after focusing the laser beam (refer to SECTION 5.5)

4 Liquid Crystal Display (LCD) with background lighting

The display shows the settings of the vibrometer. The organization of the display and how to use it to operate the vibrometer is described in detail in SECTION 5.6.

5 Selection key

By using this key the cursor ▶ is moved in a circle on the display from one parameter to the next. The cursor is used to select the parameter which should be changed (refer to SECTION 5.6).

6 SET key

By using this key the setting of the selected parameter is changed (refer to SECTION 5.6).

Rear view

The rear view of the PDV with its control elements is shown in FIGURE 3.2.

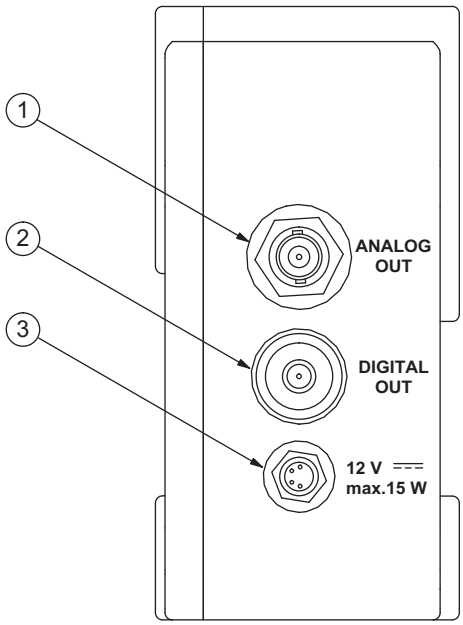

Figure 3.2: Rear view of the PDV

1 Analog voltage output **ANALOG OUT** (BNC jack)

The voltage at this output is proportional to the instantaneous vibrational velocity of the object. The voltage is positive when the object is moving towards the vibrometer optics.

2 Digital signal output **DIGITAL OUT** (Triax jack)

At this output the velocity information is available in S/P-DIF format (Sony/Philips Digital Audio InterFace), e.g. to display the output signal on a PC monitor using a sound card.

3 Connector for **12V** DC voltage (4-pin circular connector)

Socket for the connecting cable of the power supply or for the battery cable

View from the bottom

The view from the bottom of the PDV with its control elements is shown in FIGURE 3.3.

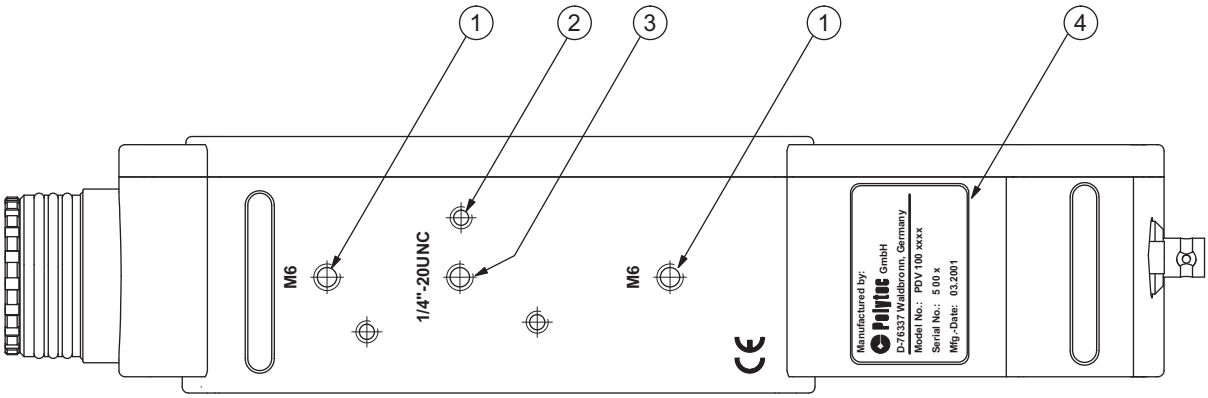

Figure 3.3: View from the bottom of the PDV

1 Mounting holes **M6**

Using these two mounting holes, the PDV can be mounted on cooling metal surfaces.

2 Three mounting holes **M5** for optional tripod VIB-A-T02

Here the quick release plate of the optional tripod will be fixed (refer to SECTION 3.4.1).

3 Mounting hole **1/4"-20UNC**

By using this mounting hole, the PDV can be mounted on camera tripods with an inch thread, e.g. the optional tripod with 3-axes head VIB-A-T01.

4 **Identification label**

On the identification label you will find, among other things, the serial number of the instrument.

3.4 Installation

3.4.1 Assembly

The PDV has serval threaded holes on the underside to mount the laser vibrometer:

- Two mounting holes M6 for assembly on cooling surfaces (if necessary)
- One mounting hole 1/4" for assembly on a camera tripod, e.g. the optional tripod with 3-axes head VIB-A-T01
- Three mounting holes M5 for assembly onto the optional tripod with fluid stage VIB-A-T02

Before you attempting to mount the PDV, check that all locking mechanisms of the tripod, particularly the screws are tight. Loose screws may cause the tripod to be unstable and possibly collapse.

Assembly onto tripod VIB-A-T01

To mount the PDV on the tripod VIB-A-T01, proceed as follows:

1. Assemble the tripod as described in the assembly instruction provided by the manufacturer MANFROTTO.
2. Then mount the 3-axes head onto the tripod as described in the assembly instructions provided by the manufacturer MANFROTTO.
3. Set the PDV onto the 3-axes head and fix it by using the central 1/4" screw.
4. Whenever you want to remove the PDV from the 3-axes head, you should hold the instrument while undoing the 1/4" screw.
5. Keep the assembly instructions for the tripod and the 3-axes head in a safe place.

Assembly onto tripod VIB-A-T02

To mount the PDV on the tripod VIB-A-T02, proceed as follows:

1. Assemble the tripod as described in the assembly instruction provided by the manufacturer MANFROTTO.
2. Then mount the fluid stage onto the tripod as described in the assembly instructions provided by the manufacturer MANFROTTO.
3. Open the locking mechanism on the fluid stage by simultaneously pressing the safety latch and opening the safety lever.
4. Mount the hexagonal quick release plate provided on the underside of the PDV using the 3 screw M5.
5. Use this plate to position the PDV on the fluid stage.

   The safety lever clicks automatically into place.
6. Ensure that the quick release plate is attached all the way round. This needs to be done, before the PDV is ready to use.
7. Whenever you want to remove the PDV from the fluid stage, you should hold the instrument while opening the safety lever.
8. Keep the assembly instructions for the tripod and the fluid stage in a safe place.

3.4.2 Electrical Connection

Mains operation

Only use the power supply PDV-AC provided by Polytec. The power supply has a wide range input and can be connected to all mains voltages with nominal values between 100 V to 240 V.

1. Plug the connecting cable into the socket 12 V on the back of the PDV.

   The connection must be easy to plug in. If not, check the plug for bent contact pins to avoid serious damage being incurred.

2. Plug the power supply to an earthed socket.

   The display on the PDV lights up and indicates that the PDV is ready to operate.

Battery operation (optional)

As an option you will get the carrier bag PDV-BS with battery and battery charger. By using the plug-in power supply PDV-AC supplied with the PDV, the battery charger can be connected up to all mains voltages with a nominal value between 100 V to 240 V. For this, connect the cable of the plug-in power supply with the 12 V circular jack on the top of the charger and put the power supply into an earthed.

Before you use the PDV with a battery, you have to charge the battery plug. You will find detailed information on this in SECTION A.1.2. There you will also find further information on battery operation.

NOTE!

Before you connect up the plug-in power supply to the mains voltage, make sure that the plug-in power supply is equipped with the right socket inset for your home country. If not, please contact your local Polytec representative !

3.5 Functional Test

To take the PDV into operation and execute a first functional test, proceed as follows:

Preparation

1. Make sure, that the beam shutter on the laser vibrometer is closed.

Cabling

2. Plug the connecting cable ot fhe power supplyinto the socket 12 V on the back of the PDV.

   The connection must be easy to plug in. If not, check the plug for bent contact pins to avoid serious damage being incurred.

Switching on

3. Connect the power supply to an earthed socket.

   On top of the PDV the display lights up. Laser light is not yet emitted as the beam shutter is still closed.

4. Before you now open the beam shutter, remember the information on laser safety in SECTION 1.2!

5. Open the beam shutter. To do so, turn the corrugated ring on the front lens to the left, when looking in the direction of the emitted laser beam.

   The laser beam is now emitted.

Test

6. Point the aperture of the PDV onto a matt white test surface, e.g. a piece of paper.

7. Position the PDV approximately 23 cm away from the test surface (measured from the retaining ring for the font lens, refer to SECTION 4.3 and SECTION 7.2.5). Focus the laser beam on the test surface using the focusing ring.

   If the signal level display on the display lights up, the optics and the input section of the electronics are working correctly.

8. Set the measurement range (Velo) 20 mm/s on the PDV.

9. Connect an oscilloscope to the BNC jack ANALOG OUT on the back of the PDV.

10. Set the oscilloscope to 1 V/DIV and move the test surface.

    If the voltage shown on the oscilloscope reacts to the movement of the test surface, the decoder and output section are working correctly.

NOTE!

Pay attention to the high pass filter being switched off (HP = N). Otherwise you have to move the test surface rapidly.

If the functional test has been successful, you can install the PDV in the measurement location as described in CHAPTER 4 and CHAPTER 5. Pay attention, that the PDV reaches its optimal properties after a warm-up period of approx. 20 minutes.

If your PDV does not perform as described above, read through the information on fault diagnosis in CHAPTER 6 and if necessary, contact your local Polytec representative.

4 Making Measurements

4.1 Start-up

To make a measurement with the PDV, proceed as follows:

Preparing

1. Make sure, that the beam shutter on the laser vibrometer is closed.
2. Position the PDV roughly so that its laser beam aperture points in the direction of the object under investigation. If possible, position the PDV at an optimal stand-off distance to the object. You will find information on optimal stand-off distances in SECTION 4.3.

Cabling

3. Plug the connecting cable of the plug-in power supply into the socket 12V on the back of the PDV.

   The connection must be easy to plug in. If not, check the plug for bent contact pins to avoid serious damage being incurred.

Switching on

4. Plug the power supply to an earthed socket.

NOTE!

Pay attention, that the PDV reaches its optimal properties after a warn-up period of approx. 20 minutes!

5. Adapt the PDV settings to your measurement task.

   You will find detailed information on how to set the settings in SECTION 4.2. Operating the PDV via the display and the function keys is described indetail in CHAPTER 5.

6. Before you now open the beam shutter, remember the information on laser safety in SECTION 1.2!
7. Open the beam shutter. To do so, turn the corrugated ring on the front lens to the left, when looking in the direction of the emitted laser beam.

   The laser beam is now emitted.

Measuring

8. Focus the laser beam on the test surface using the focusing ring.

   The signal-to-noise ratio is maximum if the signal level display fully lights up. You can often still make measurements, even if none of the bar graphs is displayed. The output signal in this case, nowever contains more noise.

Select now the suitable settings as described in SECTION 4.2 and operate the PDV as described in CHAPTER 5.

4.2 Selecting Suitable Settings

In SECTION 4.2.1 to SECTION 4.2.3 you will find information on how to configure the right controller settings for velocity measurements as well as to set the high and low pass filters.

4.2.1 Setting the Velocity Measurement Range

The PDV offers three velocity measurement ranges, whose full scale values are shown in mm/s (20 mm/s, 100 mm/s, and 500 mm/s) on the display in line Velo. When using the digital output, the full scale value is needed as a reference for the numerical value transmitted. If you divide the full scale values by four, corresponding to the output voltage swing of ±4 V, you get the respective scaling factors in $\frac{mm}{s}$/V (5 $\frac{mm}{s}$/V, 25 $\frac{mm}{s}$/V and 125 $\frac{mm}{s}$/V).

To optimize the signal-to-noise ratio, as a general rule the smallest possible measurement range should be used which is not exceeded under the given measurement conditions. Coming close to exceeding a measurement range (94% of the full scale) is shown by a circular symbol on the right next to the measurement range display. A brief appearance of the overrange indicator does not necessarily mean the measurement signal is causing overrange as noise peaks caused by brief disruptions of the optical signal level can trigger the display. However when using the filters, it is also possible that an internal overload outside the frequency pass band has occurred. In this case the overrange indicator would appear without overrange being apparent in the output signal. Despite this, the next highest measurement range would have to be selected to avoid waveform distortions.

4.2.2 Setting the Low Pass Filter

The PDV is equipped with a switchable, digital low pass filter, which you can activate or deactivate if necessary. Unlike as usual with analog filters, the three selectable cutoff frequencies 1 kHz, 5 kHz and 22 kHz mark the upper frequency limit for precise amplitude measurements (flatness ±0,1 dB) but not the −3 dB point. The changeover to the stop band has a steep frequency roll-off of −120 dB/dec, resulting in an effective suppression of noise at higher frequencies. The cutoff frequency of the low pass filter is set on the display in the line LP. On the technical specifications as for example the frequency response of the low pass filter please refer to SECTION 7.2.2.

4.2.3 Setting the High Pass Filter

To suppress low-frequency background vibrations, the PDV has got a switchable high pass filter of a 3rd order Butterworth with a cutoff frequency of 100 Hz (−3 dB). The high pass filter is switched on (Y) and off (N) on the display at HP.

For technical reasons this filter has been realized in conventional analog technnology and therefore only has an effect on the analog voltage output. The high pass filter can always be used beneficially for analog signal acquisition if you are working with high-level background interference e.g. caused by machine vibrations when a relatively small signal is to be measured at high frequencies. Under these conditions please take care of the internal saturation of the selected measurement range (refer also to SECTION 4.2.3). Attention has to be paid to the following properties for the high pass filter:

- The changeover from the pass band to the stop band occurs with a more gradual frequency roll-off (−60 dB/dec) than with the low pass filter.
- Near the cutoff frequency a significant amplitude error occurs (refer to FIGURE 4.1).
- For frequencies > 140 Hz, the amplitude error is < −0,5 dB (−5%).

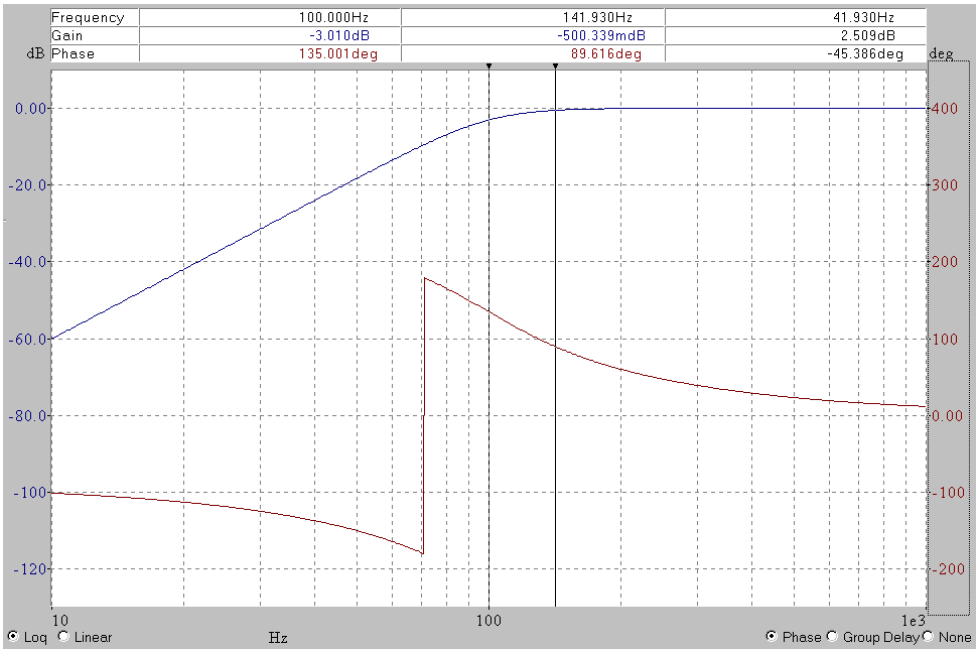

Figure 4.1: Amplitude and phase frequency response of a 3 rd order Butterworth high pass filter

The lower graph in FIGURE 4.1 represents the phase frequency response. The 360° phase jump can only be seen on the diagram for presentation reasons.

4.3 Setting the Optimal Stand-off Distance

4.3.1 Coherency between Stand-off Distance and Visibility Maximum

The light source of the PDV is a helium neon laser. This is a mulit-mode laser in which, depending on the laser cavity length, one or a maximum of two modes can exist. The laser cavity length can vary caused by small changes in temperature. Thus the laser changes between the one-mode and the two-mode state. If two modes exist, interference effects cause the intensity of the resulting optical signal varying periodically with the stand-off distance.

The diagram in FIGURE 4.2 shows the signal level depending on the stand-off distance. In the special case of having two modes with equal magnitude (black line), you have the strongest loss of signal level if the object is located inside a visibility minimum. But generally there are two modes of different magnitudes. In this case the signal level is hardly fluctuating (gray line). If only one mode exists, the signal level is always maximum, independent from the stand-off distance (dashed gray line).

The stand-off distances at which the signal level is maximal are called visibility maxima. The visibility maxima recur every 138 mm corresponding to the laser cavity length.

In practice, it is not usually necessary to search for the visibility maximum as the PDV is even sensitive enough to make a measurement close to the minimum. A visibility minimum is indicated during the warm-up phase by periodic fluctuation of the optical signal level. If you need an optimal resolution and sensitivity, you should select a stand-off distance close to the visibility maxima for the PDV.

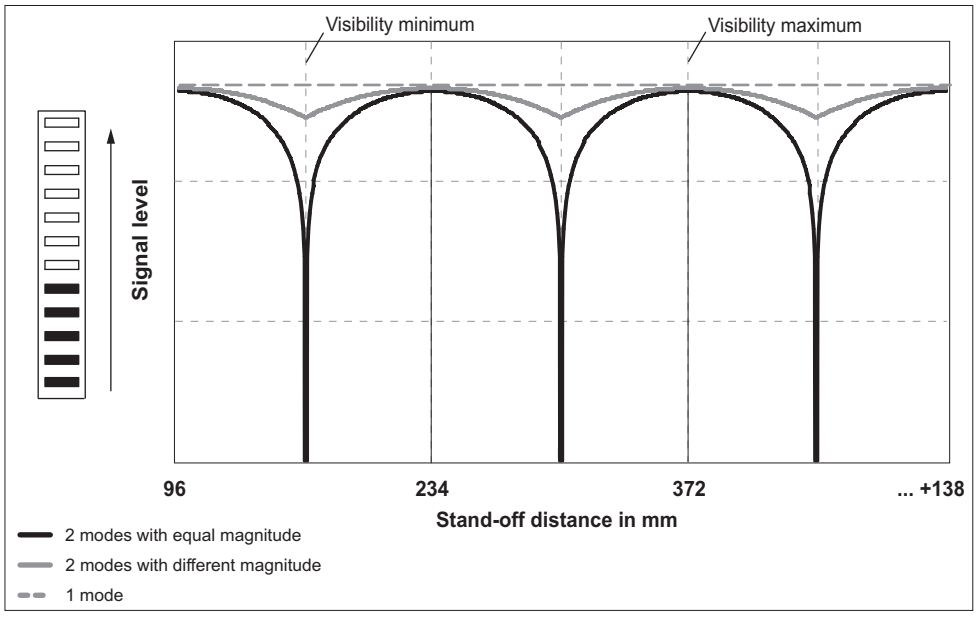

Figure 4.2: Coherency between stand-off distance and visibility maximum

4.3.2 Stand-off Distances

The stand-off distance is measured from the front edge of the retaining ring for the front lens (refer to SECTION 7.2.5). The optimal stand-off distances can be ascertained as follows:

$$\text{Optimaler Arbeitsabstand} = 96\text{mm} + (n \cdot l)\text{mm}$$ Equation 4.1

n	0; 1; 2;...
l	138 mm

i.e. for l = 138 mm the optimal stand-off distances are:

96 mm, 234 mm, 372 mm, 510 mm, etc (refer to SECTION 7.2.3 and SECTION 7.2.4).

5 Operating the PDV

5.1 Switching On and Off

Power Supply

You switch the PDV on by connecting the power supply to an earthed socket. The display on top of the PDV lights up and indicates that the PDV is ready to operate.

Battery operation

You switch the PDV on by connecting the vibrometer cable of the battery charger to the connect 12V on the back of the PDV and pressing the rocker switch on the top of the battery charger in the direction of the Laser LED. The display on the top of the PDV and the Laser LED on the battery charger light up and indicate that the PDV is ready to operate. The current battery status is shown on the display (refer to SECTION 5.8).

NOTE!

The background lighting of the display is equipped with a power saving mode. If no key is pressed for approx. 5 seconds, the lighting is switched off but the readout on the display is still active.

5.2 Blocking the Laser Beam

The PDV is equipped with a beam shutter. This can be used to block the laser beam without switching off the laser. This keeps the system in thermal equilibrium.

The beam shutter is the corrugated ring on the front lens. To block the laser beam, turn the corrugated ring to the left when looking in the direction of the emitted laser beam.

WARNING!

Danger form laser beam ! Only open the beam shutter when you are making measurements !

5.3 Focusing the Laser Beam

On the PDV the stand-off distance can be adjusted using the focusing ring. Before focusing the laser beam make sure that the clamping screw on the focusing ring is undone (refer to SECTION 5.5).

When you are looking in the same direction asthe emitted laser beam, focus the laser beam as follows:

Focus on infinity:	Turn clockwise (to the right)
Focus close-up:	Turn counterclockwise (to the left)

Please pay attention to the information on optimal stand-off distances in SECTION 4.3.

5.4 Using the Signal Level Display

The signal level display helps you to optimize the focus of the laser beam. The signal level is shown as a bar on the display of the PDV (refer to SECTION 5.6). The length of the bar is a measure of the amount of light scattered back from the object under investigation.

5.5 Fixing the Focus Position

You can fix the focus by locking the focusing ring using the clamping screw. To do so, first focus the laser beam and then hand-tighten the clamping screw with the provided Allen key (size 1.5 mm).

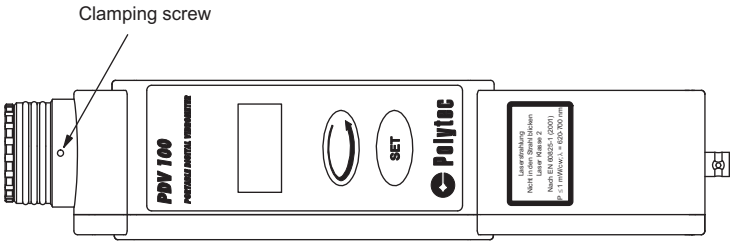

Figure 5.1: Clamping screw on the focusing ring

5.6 Setting Parameters via the Display

5.6.1 Philosophy

The PDV is operated via the display using the selection key and the key SET.

Selection key ⟲:	By using the selection key within the menus, a parameter is selected (▶).
Key SET:	By using the key SET, the setting of the selected ▶ parameter is changed.

The main menu is shown in FIGURE 5.2 as an example of the display.

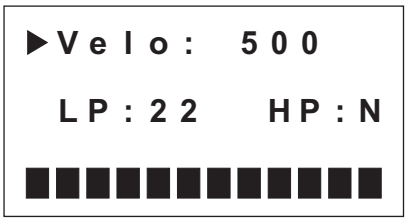

Figure 5.2: Exsample of the display

With help of the selection key ⟲ you run through the parameters on the display in a circle.

The cursor ▶ on the left side marks the selected parameter. You configure the parameter settings by using the function key SET. The new configured settings will be active in time.

As the control processor has a flash memory, the settings are stored when the PDV is switched off and reloaded when the PDV is switched on again. This saves time when making adjustments for repeated measurements.

5.6.2 Organization of the Menus

The menu structure is shown in FIGURE 5.3.

Figure 5.3: Organization of the menus in the PDV

The menus are organized as follows:

INTRO:	The start menu only appears only after switching on the PDV. After the menu INTRO is finished, the display automatically changes to the main menu.
MAIN MENU:	In this menu, all settings for a measurement are made, i.e. the measurement range and the filters are selected. It also displays the signal level.
SERVICE MODE:	In service mode, the laser can be switched on and off. In addition it provides information on the temperature in the laser vibrometer and test signals can be generated.

5.6.3 The Individual Menus

Menu INTRO After being switched on, the laser needs a certain settling time. During this settling time the menu INTRO plays. Once it is finished, the PDV indicates that it is ready to operate by automatically changing to the main menu.

You can shorten the menu INTRO by pressing any key on the PDV.

Main menu In the main menu you configure the measurement range and the filters. The individual settings are described in the following:

Velo: Here you configure the velocity measurement range in mm/s (full scale). You will find detailed information on this in SECTION 4.2.1.

LP: Here you configure the cutoff frequency of the low pass filter in kHz. You will find detailed information on this in SECTION 4.2.2.

HP: Here you configure the high pass filter. You activate with setting Y and deactivate with setting N the high pass filter. You will find detailed information on this in SECTION 4.2.3.

Service mode

Service mode is there to check and calibrate the PDV. You access service mode by holding the key SET pressed and then press the selecting key ⊂. In the service mode you can set the following operating modes:

Switching the Laser On: You can switch the laser on again in the service mode by pressing the key SET several times until the following display appears:

Service:
Laser: -On-

When you exit the service mode again via the selection key, the laser remains active.

Switching the Laser Off: You can switch the laser off in the service mode by pressing the key SET several times until the following display appears:

Service:
Laser: -Off-

When you exit the service mode again via the selection key, the laser remains deactivated.

Displaying Temperature: You can display the temperature in the PDV by pressing the key SET several times until the following display appears:

Service:
Temp: 30.5

The display shows the actual temperature in degrees Celsius. You exit the service mode using the selection key.

Generating the 2.80 V test signal: In service mode, you can generate a sinusoidal test signal of 2.80 V (RMS) with a frequency of approx. 1 kHz. This signal corresponds to 99% of the full scale and is available at the BNC jack ANALOG OUT on the back of the PDV. To generate the test signal you proceed as follows:

1. Paste a piece of reflective film (enclosed in the manual) on the measurement surface of the object under investigation.
2. Position the PDV at an optimal stand-off distance to the object (refer to SECTION 4.3).
3. Connect the object vibration-free to the PDV and mount them onto a solid base.
4. Open the beam shutter and focus the laser on the reflective film with the focusing ring.

   The bar graph display must fully light up.
5. Change into the service mode by holding the key SET pressed and then press the selection key ⊂.

6. Generate the 2.80 V test signal by then pressing the key SET several times until the following display appears.

ServiceMode:
Output=Full

The 2.80 V test signal with approximate full scale is only emitted while this display is shown. This signal is there to check the calibration of the analog signal voltage output.

7. Exit service mode using the selection key ⊂.

Generating 0 V test signal: In the service mode you can generate a test signal of 0 V at the BNC jack ANALOG OUT on the back of the laser vibrometer. To do so, proceed as follows:

1. Change into service mode by holding the key SET pressed and then press the selection key ⊂.
2. Generate the 0 V test signal by then pressing the key SET several times until the following display appears.

ServiceMode:
Output=Zero

The 0 V test signal is only emitted while this display is shown.

3. Exit service mode using the selection key ⊂.

5.7 Overrange Indicator

The overrange indicator is shown on the right of the PDV display next to the measurement range indicator Velo (refer to FIGURE 5.4).

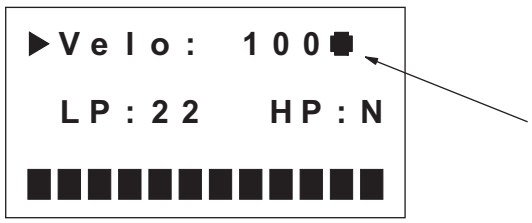

Figure 5.4: Display with overrange indicator

If the overrange indicator is lit up continuously, it means that the measurement range set is being exceeded. In this case, the next highest measurement range must be set. You will find detailed information on this in SECTION 4.2.1.

5.8 Battery Level Indicator

The battery level indicator is shown on the right of the PDV display next to the overrange indicator (refer to FIGURE 5.5).

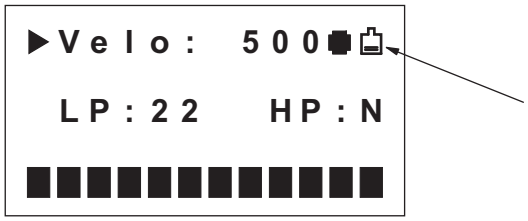

Figure 5.5: Display with battery level indicator

If the battery level indicator is lit up continuously, it means that the battery is very low. From now you have got approximately another 15 minutes operating time available. You will find information on lithium ion battery safety in SECTION 1.4. You will find further information on the battery and on charging the battery in APPENDIX A.

5.9 Measurement Signal Output

Analog The measurement signal is available at the BNC jack ANALOG OUT on the back of the PDV as an analog voltage signal.

Digital The measurement signal is available at the Triax jack DIGITAL OUT on the back of the PDV as a digital signal in S/P-DIF format.

6 Fault Diagnosis

Some simple tests are described in the following for you to carry out yourself in the case of malfunction. In the case of more difficult problems with the individual functions, please contact our service personnel. The tests described here are not meant to lead you to carry out maintenance work yourself but to provide our service personnel with information which is as accurate as possible.

Testing the PDV is limited to such tests in which the housing does not have to be opened. Opening the housing can cause a malfunction and will invalidate the warranty.

If required, please contact our service department. Based on your fault description, further procedure will be determined.

If the PDV has to be sent back for repair, always use the original packaging and enclose an exact description of the fault.

6.1 No Laser Beam

If no laser beam is emitted, check the following:

1. Is the beam shutter opened?
2. Is the PDV connected to the mains supply as described in SECTION 3.4.2?
3. Does the display on top of the PDV light up or does it show a menu?

   If the display is not lit up, or is not showing anything, it can be assumed that there is a fault with the mains supply.
4. Does the housing feel warm to the touch as normal after about 15 minutes in operation indicating that the laser is active?
5. Does the display show the following warning?

WARNING
Over Temp.
Laser: -Off-

   The laser has been switched off because the temperature limit inside the PDV has been exceeded. Switch off the instrument and let it cool down.

Only for battery operation

6. Is the display showing the following warning?

WARNING
Batt. empty
Laser: -Off-

The laser has been switched off because the battery is empty. To avoid completely draining the battery and thus shortening its useful life, set the rocker switch of the battery charger in the direction of the charge level indicator. Then reload the battery as described in SECTION *A.1.2 under Charging Battery.*

6.2 No Measurement Signal

If the laser beam is emitted but there is no measurement signal, proceed as follows:

1. Put a matt white test surface, e.g. a piece of paper, in the beam path approx. 23 cm away from the retaining ring for the front lens. Focus the laser beam on the test surface using the focusing ring. Does the signal level display react?

   If the signal level display does not react, either the optics or the input section of the electronics are faulty.

2. Connect an oscilloscope to the BNC jack ANALOG OUT on the back of the PDV and check if the output reacts to moving the test surface.

HINWEIS!

Pay attention to the high pass filter being switched off (HP = N). Otherwise you have to move the test surface rapidly.

3. If the output does not react, check if a significant DC offset is indicated.

   Normally a DC voltage less than ±10 mV can be measured.

4. Set the oscilloscope to 1 V / DIV and block the laser beam. Is the output signal noisy or does the oscilloscope show a straight line?

   Noise must occur when the laser beam is blocked.

6.3 Focusing Ring can not be Moved

Make sure that the clamping screw on the focusing ring is undone (refer to SECTION 5.5).

7 Technical Specifications

7.1 Standards Applied

Laser safety:	EN 60825-1:2008-05 (Safety of Laser Products, complies to US 21 CFR 1040.10 and 1040.11, except deviations pursuant to Laser Notice No 50, dated 24 June 2007)
Electrical safety:	IEC/EN 61010-1:2002-08 (Safety requirements for electrical equipment for measurement, control and laboratory use)
EMC:	IEC/EN 61326-1:2006-10 (EMV-Safety requirements for emission and immunity - electrical equipment for measurement, control and laboratory use)
Emission:	Limit class B IEC/EN 61000-3-2 and 61000-3-3
Immunity:	IEC/EN 61000-4-2 to 61000-4-6 and IEC/EN 61000-4-11

7.2 Laser Vibrometer PDV-100

7.2.1 General Data

Power Supply

Supply voltage:	11 VDC ... 14.5 VDC
Operational current:	max. 1.4 A
Power consumption:	max. 15 W
Socket type:	Binder 718/768 (M8)
Pin 1	internally used
Pin 2	+12 V (color of corresponding wire: white)
Pin 3	internally used
Pin 4	DV (color of corresponding wire: black)

CAUTION!

Danger from material damage! Do not connect the pins 1 and 3 as this could damage the PDV!

Ambient Conditions

Operating temperature:	+5°C…+40°C (41°F…104°F)
Storage temperature:	10°C…+65°C (14°F…149°F)
Operating altitude:	max. 3048 m (10000ft)
Relative humidity:	max. 80%, non-condensing

Housing

Protection reating:	IP 64 (corresponding to DIN EN 60529)
Dimensions:	refer to SECTION 7.2.5
Weight:	approx. 2.6 kg
Display:	LCD, 3-line, with background lighting

Calibration

Calibration recommended:	2 years

7.2.2 Metrological Properties

Signal Output ANALOG OUT

Signal voltage output for the velocity signal

Output swing:	±4 V
Frequency range:	0.5 Hz…22 kHz
Resolution of the D/A converter:	24 bit
Output impedance:	50 Ω
Load resistance:	min. 10 kΩ (−0.5% additional error)
Overrange indicator threshold:	typ. 94% of full scale value
DC offset:	max. ±10 mV
Best resolution:	$0.02 \frac{\mu m}{s} / \sqrt{Hz}$ (rms)
Spurious free dynamic range (SFDR):	> 90 dB
Harmonic distortions:	< 1% THD
Propagation delay:	typ. 1.1 ms
Calibration accuracy:	±1% (20 Hz…22 kHz)

Measurement Range

Measurement range[1] full scale (peak) mm/s	Scaling factor (analog output) $\frac{mm}{s}/V$	Resolution[2] $\frac{\mu m}{s}/\sqrt{Hz}$	Maximum acceleration m/s²
20	5	< 0.02	2760
100	25	< 0.02	13800
500	125	< 0.1	69000

[1] adjustable via the display

[2] The resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0 dB in a 1 Hz spectral bandwidth (RBW), measured on 3M Scotchlite Tape® (reflective film).

Signal Output DIGITAL OUT

Digital output for the velocity signal

Data format: S/P-DIF, 24 bit, 48 kSa/s
Frequency range: 0 Hz ... 22 kHz
Propagation delay: approx. 1 ms
Calibration accuracy: ±0.2% (0.05 Hz ... 22 kHz)

Low Pass Filter

Filter type: digital, FIR type
Cutoff frequencies (0.1 dB): 1 kHz, 5 kHz, 22 kHz (adjustable via the display)
Frequency roll-off: > 120 dB/dec
Stop band attenuation: > 100 dB
Frequency response: see the following table and FIGURE 7.1

Filter setting	Pass band ±0.1 dB	Stop band (attenuation > 40 dB)
1 kHz	0.5 Hz ... 1 kHz	> 4.3 kHz
5 kHz	0.5 Hz ... 5 kHz	> 8.4 kHz
22 kHz	0.5 Hz ... 22 kHz	> 25 kHz

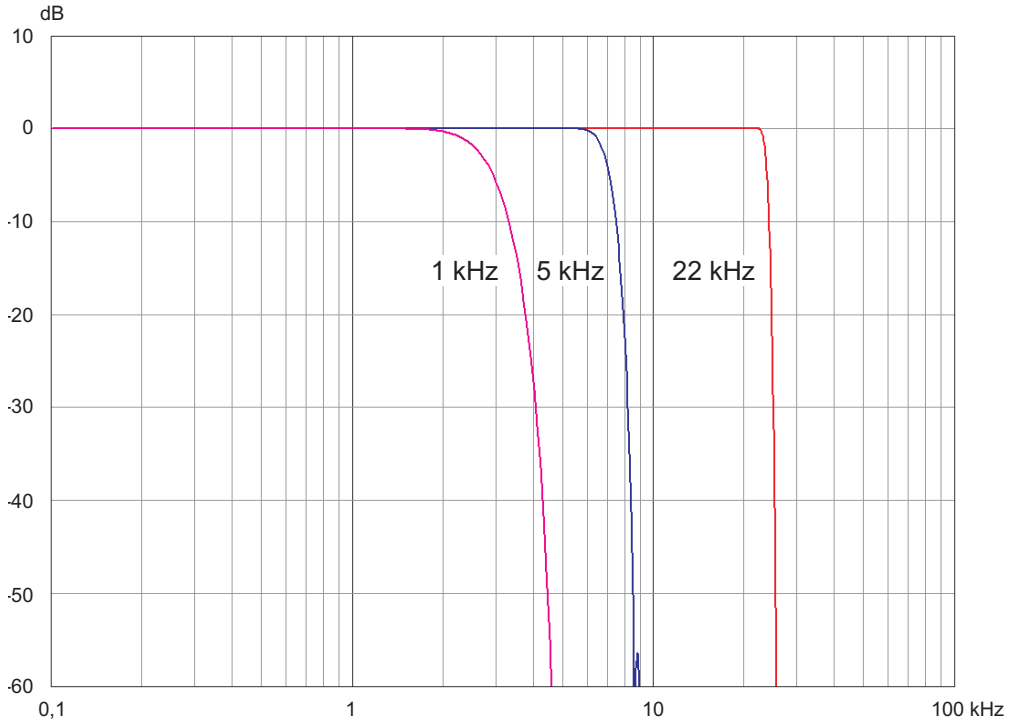

Figure 7.1: Frequency response of the low pass filter

High Pass Filter

Filter type:	analog, 3rd order Butterworth
Cutoff frequency (3 dB):	100 Hz ±10% (switchable via the display)
Frequency roll-off:	60 dB / dec

7.2.3 Optics

Laser

Laser type:	helium neon
Wavelength:	633 nm
Cavity length:	138 mm
Laser class:	2
Laser output power:	typ. 0.6 mW

Stand-off distance[1]	[m]	0.1 ... ca.30[2]
Aperture diameter (1/e²)	[mm]	typ. 6.5
Spot size (typ.)	[µm]	
@ 234 mm		30
@ 1 m		124
@ 2 m		250
@ 3 m		370
@ 5 m		616
@ each additional meter plus		130
Depth of focus[3] (2 m distance)	[mm]	210
Visibility maxima[1]	[mm]	96 + n · 138[4]

[1] Measured from the front edge of the retaining ring for the front lens refer to SECTION 7.2.5

[2] The maximum stand-off distance depends on the surface properties of the object.

[3] Max. 3 dB loss of signal of the optimum

[4] n = 0; 1; 2; ...

7.2.4 Table of the Visibility Maxima

Visibility maxima (in mm)					
96	1200	2304	3408	4512	5616
234	1338	2442	3546	4650	5754
372	1476	2580	3684	4788	5892
510	1614	2718	3822	4926	6030
648	1752	2856	3960	5064	6168
786	1890	2994	4098	5202	6306
924	2028	3132	4236	5340	6444
1062	2166	3270	4374	5478	...

7.2.5 Dimensions

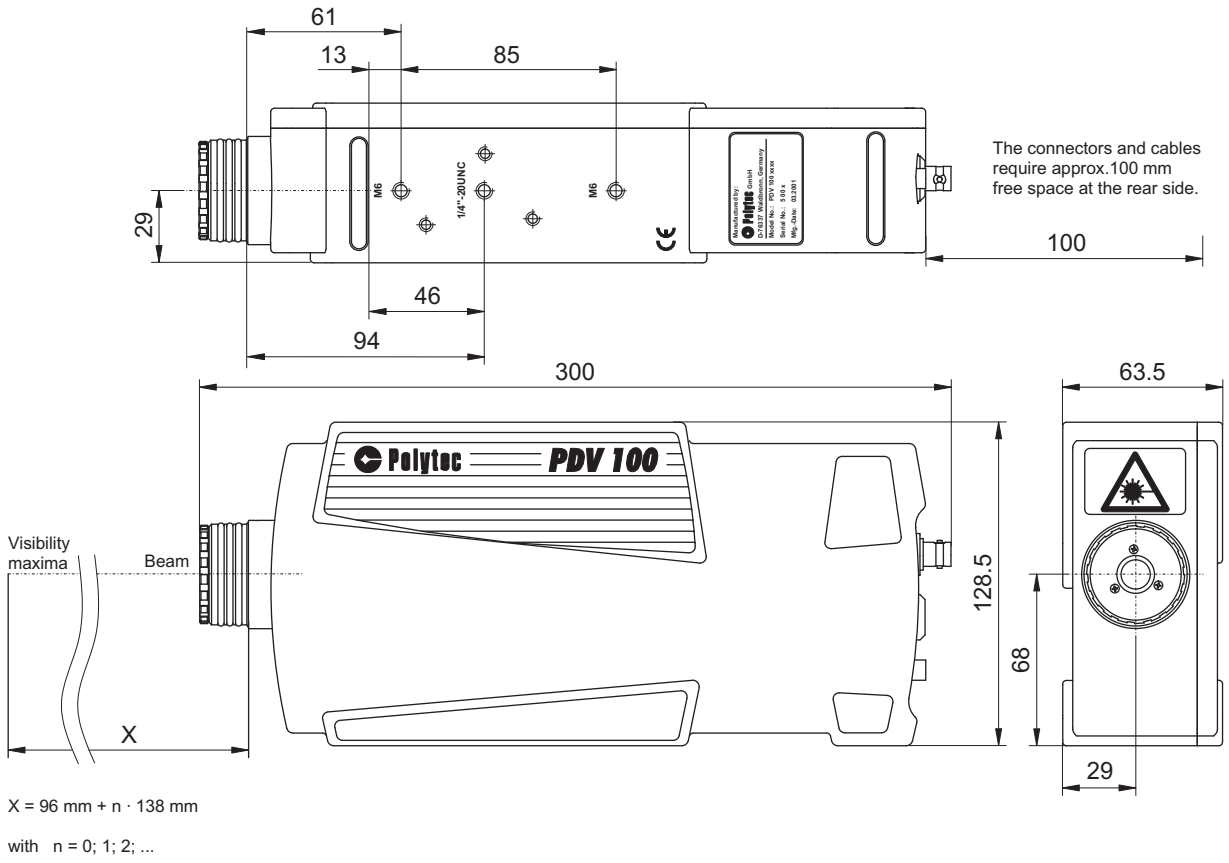

Figure 7.2: Views of the PDV-100 (Dimensions not specified are given in mm.)

7.3 Power Supply PDV-AC

Mains Connection

Mains voltage:	100…240 VAC ±10%, 50/60 Hz
Output voltage:	12 V DC
Power consumption:	max. 20 W

Housing

Protection rating:	with protective insulation, IP40 (correspond to DIN EN 60529)
Cable length:	3 m

7.4 Optional Accessories

7.4.1 Mounting Plate VIB-A-P07

Dimensions

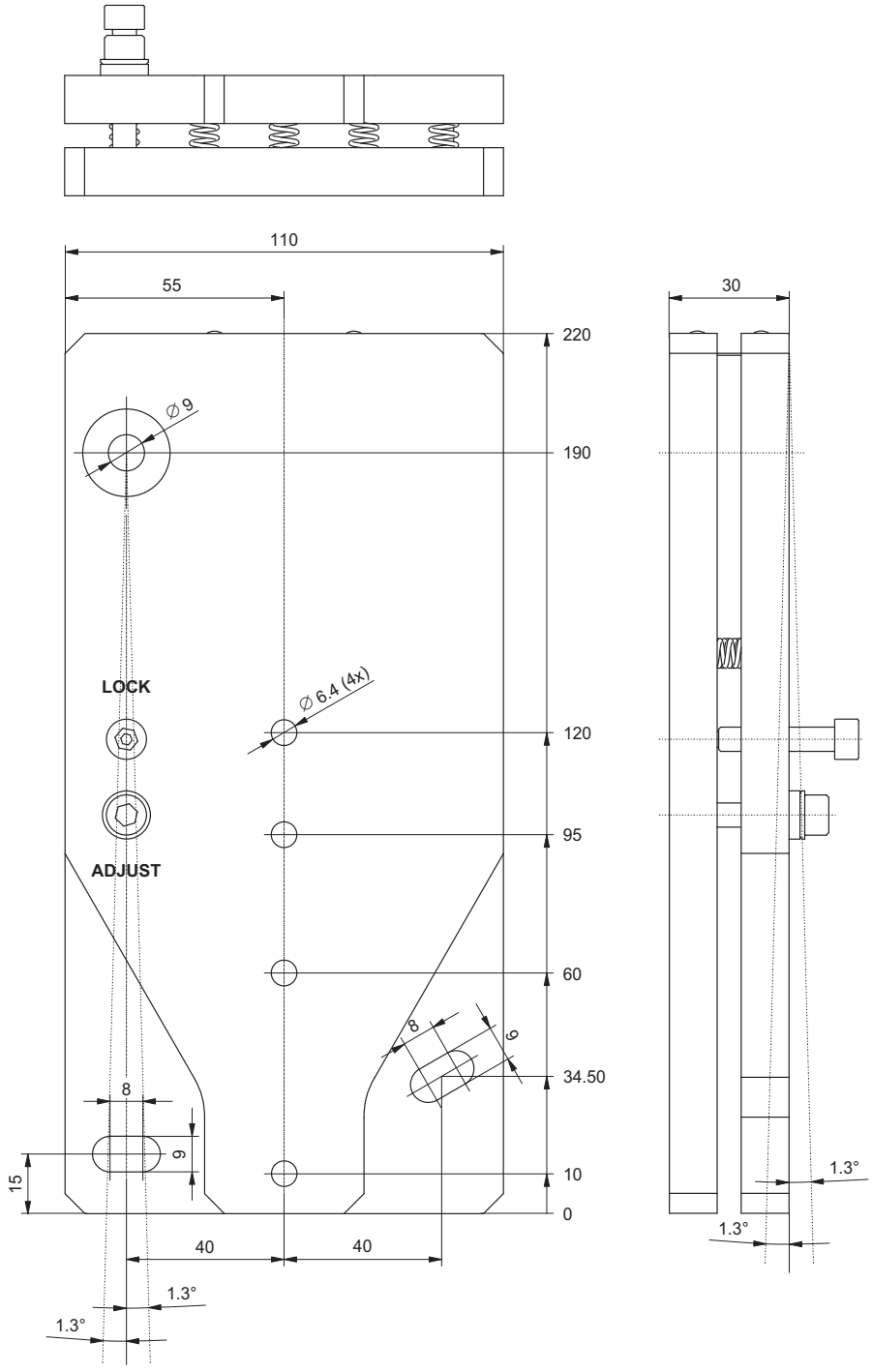

Figure 7.3: Views of the mounting plate VIB-A-P07 (Dimensions not specified are given in mm)

7.4.2 Battery Charger PDV-CH

Power Supply

Supply voltage:	12 V DC ±2 V (mains: 100…240 VAC, 50/60 Hz with plug-in power supply PDV-AC)
Power consumption:	max. 30 W
Charging current:	1.1 A
Charging time:	approx. 5 h

Ambient Conditions

Operating temperature:	+5°C…+40°C (41°F…104°F)
Storage temperature:	10°C…+65°C (14°F…149°F)
Relative humidity:	approx. 80%, non-condensing

Housing

Protection rating:	IP 65 (corresponding to DIN EN 60529)
Dimension:	110 mm x 45 mm x 120 mm
Weight:	0.5 kg
Length of the vibrometer cable:	2 m
Length of the battery cable:	0.3 m

7.4.3 Battery PDV-LI

Electrical Data

Type:	lithium ion battery (rechargeable)
Identification number:	8932
Voltage:	nom. 14.4 V
Capacity:	nom. 4.6 Ah
Operating time with PDV-100:	min. 4 h
Charge/discharge cycles:	min. 500 (with capacity decline to 60%)

Housing

Dimensions:	80 mm x 70 mm x 115 mm
Weight:	0.8 kg

7.4.4 Carrier Bag PDV-BS

Housing

Dimensions:	370 mm x 160 mm x 150 mm
Weight:	5.5 kg (incl. PDV, plug-in power supply, 1 battery and battery charger)

7.4.5 Motor Vehicle Supply Cable PDV-DC

Connection Data

Connector:	12 V DC on-board plug socket with built-in fuse
fuse:	2 A / slow-blow
Cable length:	4 m

Appendix A: Optional Accessories

A.1 Carrier Bag PDV-BS with Battery and Battery Charger

A.1.1 Introduction

The carrier bag PDV-BS contains the following components:

- Lithium ion battery PDV-LI
- Battery charger PDV-CH

Optional

- Motor vehicle supply cable PDV-DC
- Reserve lithium ion battery PDV-LI

The carrier bag PDV-BS with the PDV-100 is shown in FIGURE A.1. Ifrequired, you can store additional PDV accessories in the pockets and under the straps of the carrier bag.

Figure A.1: Carrier bag PDV-BS with battery, battery charger and PDV-100

The electrical installation of the carrier bag makes it possible to use the laser vibrometer as a mobile unit with the power supplied by the lithium ion battery or as a stationary unit connected up to the AC system using the plug-in power supply PDV-AC provided with the PDV. The plug/in power supply for the PDV can also be stored in the carrier bag as also shown in FIGURE A.1.

A.1.2 Battery Charger PDV-CH

Control elements

The view from above of the battery charger with its control elements is shown in ABBILDUNG A.2.

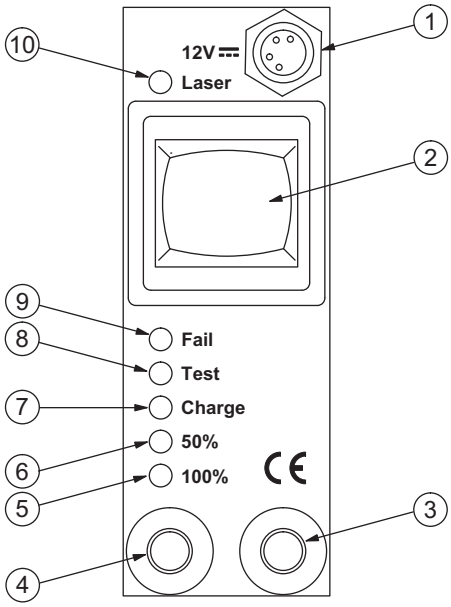

Figure A.2: View form above of the battery charger

1 Connector for **12V** DC voltage (4-pin circular connector)
Socket for the cable of the plug-in power supply PDV-AC to operate the battery charger or the PDV respectively.

2 Rocker switch for the operating modes of the battery charger

Switch in direction Laser LED:	The PDV is switched on and ready to use, the green Laser LED is lit.
Switch in middle position:	All functions are switched off.
Switch in direction charge level indicators:	The battery charger is switched on and a lamp test is carried out (refer to Charging battery). The PDV is switched off.

3 Vibrometer cable with 4-pin circular jack
Cable to connect up the laser vibrometer

CAUTION!

Danger from mishandling! Secure the cable junction at the laser vibrometer with the knurled nut! When disconnecting the cable, always pull the plug and not the cable.

4 Battery cable with 3-pin circular jack
Cable to connect up the lithium ion battery

5 Charge level indicator **100%** LED

The green 100% LED lights up when the battery has attaimed its specified capacity. While this LED is lit up, the battery is still charging to attain the maximum capacity possible.

The gree 100% LED flashes when the charging process has completely finished and the battery is switched off. You can then switch off the battery charger using the rocker switch.

6 Charge level indicator **50%** LED

The yellow 50% LED lights up, when the battery has attained at least half its capacity. This is not equivalent to half the duration of the charging process.

7 Charge level indicator **Charge** LED

The yellow Charge LED lights up when the charging process starts and during the entire charging process.

8 **Test** LED for the battery check

The yellow Test LED lights up, while the battery level is being tested. This can take up to 4 minutes (refer also to Charging battery).

9 **Fail** LED

The red Fail LED flashes if the battery is not connected or is faulty. First of all check the connection of the battery cable. With an exhaustively discharged battery the Fail LED can also initially flash. Switch the battery charger off and then on again. As a general rule, the fault state will not occur again the second time. If the fault state persists, then there is a fault with the battery. Disconnect the battery from the battery charger.

CAUTION!

Danger from mishandling! Do not attempt to charge a faulty battery again or try to repair it. Disconnect the faulty battery from the battery charger and dispose the battery appropriately!

10 **Laser** LED

The green Laser LED lights up when you have pressed the rocker switch in the direction of the Laser LED. Thus the PDV is switched on and the battery charger is switched off.

Mains connection

Using the plug-in power supply PDV-AC supplied with the PDV, the battery charger can be connected up to all mains voltages with a nominal value between 100 V to 240 V. To do so, connect the cable of the plug-in power supply with the 12 V circular jack on the top of the battery charger and plug the power supply into an earthed socket.

NOTE!

Before you connect the plug-in power supply to the mains voltage, check whether the plug-in power supply is equipped with a socket inset suitable for your country. If not, contact your nearest Polytec representative!

Charging battery

Before you take the PDV into operation with a battery, you have to charge the battery. To do so, proceed as follows:

1. Make sure that the rocker switch on the top of the battery charger is in the middle position.

2. Remove the protective cap from the battery cable connection of the battery and store the protective cap in a safe place.

NOTE!

If you carry the battery around with you in the carrier bag without using it, or store it for a long time, please make sure, that you put the protective cap back on the battery cable connection!

3. Connect the battery cable of the battery charger to the lithium ion battery.

NOTE!

The PDV can remain attached to the battery charger during the charging process but it is not switched on. If you want to operate the PDV while charging, you need to use a second plug-in power supply PDV-AC.

4. Connect the cable of the of the plug-in power supply PDV-AC to the top of the battery charger and plug the power supply into an earthed socket.

5. Press the rocker switch on the battery charger in the direction of the charge level indicators.

   The charging process starts with a lamp test, in which all LEDs light up twice briefly. After that the battery level is tested. The yellow Test LED lights up. The process can last up to 4 minutes, but is completed after a few seconds as a general rule.

   If the battery is faulty, the red Fail LED will flash.

CAUTION!

Danger from mishandling! Do not attempt to charge a faulty battery again or try to repair it. Disconnect the faulty battery from the battery charger and dispose the battery appropriately!

   If the battery level is perfect, the actual charging process will begin.

   The yellow Charge LED lights up during the entire charging process. It will take approximately 5 hours to charge a battery which has been completely discharged. A buzzing sound coming from the battery charger and the plug-in power supply during the charging process is normal.

6. If the battery is completely charged, press the rocker switch back into the middle position.

Charging phases

Loading the battery is done in several stages. Thereby the charge level of the battery is shown by the **50%** and the **100%** LED:

- As soon as the **50%** LED lights up, the battery has attained half its capacity. This state is attained after approx. 4 hours on a completely discharged battery.
- As soon as the green **100%** LED lights up the battery has attained its specified capacity. While the **100%** LED is lit, charging is continued for approx. 15 -30 minutes until the maximum available capacity has been attained.
- As soon as the **100%** LED flashes, the charging process has completely finished and the battery is switched off.

Pay attention to this additional information on charging the battery:

- The charging process can be interrupted during any phase and can be continued later. A partially charged battery can be used to operate the PDV but will not attain the maximum operating time.
- Overcharging the battery is safetly prevented through the charge electronics.
- It is a good idea to end the charging process after 2-3 hours for batteries which are to be stored - at the latest when the **50%** LED lights up.
- Batteries which have been stored for a long time must be completely recharged before being used.
- The battery charger can also be operated using the motor vehicle supply cable PDV-DC (refer to FIGURE A.2). To do so, instead of plugging the plug -in power supply into the 12 V socket on top of the battery charger, plug in the motor vehicle supply cable and plug it into a 12V on-board plug socket or into a motor vehicle cigarette lighter. The battery is charged in the same way as with mains operation.
- To charge a reserve battery, connect it to the battery cable of the battery charger instead of the first battery.

CAUTION!

Danger from mishandling! You only may use original lithium ion batteries from Polytec!

A.1.3 Battery Operation

To take the PDV with a battery into operation, proceed as follows:

1. Make sure that the rocker switch on the top of the battery charger is in the middle position.

2. Plug the vibrometer cable of the battery into the 12V socket on the back of the PDV and secure the jack with the knurled nut.

   The connection must be easy to plug in. If not, check the plug for bent contact pins to avoid serious damage being incurred.

3. Press the rocker switch in the direction of the Laser LED.

   The green Laser LED on the battery charger as well as the display on the PDV light up and indicate that the PDV is ready to operate.

NOTE!

The background lighting of the display is equipped with a power saving mode. If no key is pressed after approx. 5 seconds, the lighting is switched off but the readout on the display is still active.

With a completely charged battery, the PDV can be operated for 4-5 hours. As the battery gets older and in low ambient temperatures, the operating time gets shorter. About 30-60 minutes before the battery is exhausted, you will be given a warning. The battery level indicator in the display on the PDV lights up. If you continue to operate the laser, it will switch itself off for safety reasons after several minutes to prevent the battery from discharging exhaustively. The remaining charge in the battery is used to display the following warning message for 15-30 minutes on the display of the laser vibrometer.

WARNING
Batt. empty
Laser: -Off-

At the latest at this stage you should switch off the PDV and recharge the battery. Otherwise the internal battery protection will completely disconnect the battery from the charge once it has reached the exhaustive discharge threshold and both the display on the PDV as well as the Laser LED on the battery charger go out. To protect the battery, the PDV can be operated with the plug-in power supply if there is a mains connection available. The plug-in power supply can therefore also be connected to the battery charger when being run on batteries and can be kept in the carrier bag.

NOTE!

As soon as the plug-in power supply connected to the battery charger is plugged into a mains socket, the PDV connected to it is supplied with power from the mains connection and not from the battery.

A.1.4 Mains Operation

You can also operate the PDV using the mains connection with the aid of the plug-in power supply - even if the battery is connected. As soon as you plug the power supply connected to the battery charger into a mains earthedl socket and press the rocker switch in the direction of the Laser LED the power supply for the PDV is automaticlly changed over to mains operation. In doing so, no power is sourced from the battery, but it does not get charged either. The display of the PDV then remains lit up constantly, the power saving mode is deactivated.

A.1.5 Battery Return

The consumer is legally obliged to pass back batteries after use, e.g. at public collecting points or wherever batteries of this type are being sold.

NOTE!

Batteries must not be disposed in domestic waste!

A.2 Motor Vehicle Supply Cable PDV-DC

You use the motor vehicle supply cable PDV-DC, to operate the PDV or the battery charger PDV-CH from a 12V on-bord plug socket or a motor vehicle cigarette lighter. To do so, connect the 4-pin circular jack of the motor vehicle supply cable to the 4-pin circular connector 12V on the back of the PDV or on the top of the battery charger. Then plug the connecting plug into the 12V on-board plug socket or, using the red adapter into the motor vehicle cigarette lighter.

CAUTION!

Danger from mishandling! We do not recommend operating the PDV while the engine is running.

NOTE!

Use the red adapter for operation from a moter vehicle cigarette lighter.

Appendix B: Basics of the Measurement Procedure

Optical interference can be observed when two coherent light beams are made to coincide. The resulting intensity e.g. on a photo detector varies with the phase difference between the two beams according to the equation

$$I(\varphi) = \frac{I_{max}}{2} \cdot (1 + \cos\varphi)$$

Equation B.1

The phase difference is a function of the optical path difference L between the two beams according to

$$\varphi = 2\pi \cdot \frac{L}{\lambda},$$

Equation B.2

Whereby is the laser wavelength.

If one of the two beams is scattered back from a moving object (the object beam), the path difference becomes a function of time L = L(t). The interference fringe pattern moves on the detector and the displacement of the object can be determined using directionally sensitive counting of the passing fringe pattern.

The velocity component in the direction of the object beam is a function of the path difference L according to

$$\frac{dL(t)}{dt} = v(t) \cdot 2 .$$

Equation B.3

For a constant movement v

$$\left|\frac{dL(t)}{dt}\right| = \frac{\lambda}{2\pi} \cdot \left|\frac{d\varphi}{dt}\right| = f_D \cdot \lambda = |v| \cdot 2$$

Equation B.4

applies with

$$f_D = 2 \cdot \frac{|v|}{\lambda}$$

Equation B.5

Thus a constant movement of the object causes a frequency shift at the object beam which is called Doppler frequency f_D. Superimposing object beam and internal reference beam, i.e. two electromagnetic waves with slightly different frequencies, generates a beat frequency at the detector which is equal to the Doppler frequency. The ratio (B.5) to determine the velocity is, however, independent of its sign. The direction of the velocity can be determined by introducing an additional fixed frequency shift f_B in the interferometer to which the Doppler frequency is added with the correct sign.

Thus the resulting frequency at the detector f_{mod} is given by

$$f_{mod} = f_B + 2 \cdot \frac{v}{\lambda} .$$

Equation B.6

Interferometers of this type which are directionally sensitive are described as heterodyne.

Appendix C: Declaration of Conformity

CE

Konformitätsbescheinigung / Declaration of Conformity

für / for

Gegenstand / Object :	**Portable Digital Vibrometer**
Typ / Model :	**PDV-100**

Der Hersteller / The manufacturer

Polytec GmbH
Polytec Platz 1-7
76337 Waldbronn / Germany

bestätigt das Einhalten der Richtlinien 2004/108/EG und 2006/95/EG
confirms the compliance with the directive 2004/108/EC and 2006/95/EC.

Das Gerät stimmt überein mit den folgenden Normen / The unit complies to the following standards:

EN 60825-1:2008-05	Sicherheit von Laser-Einrichtungen / Safety of laser products
EN 61010-1:2002-08	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte / Safety requirements for electrical equipment for measurement, control and laboratory use
EN 61326-1:2006-10	EMV-Anforderungen an die Störaussendung und Störfestigkeit – Elektrische Betriebsmittel für Messtechnik, Leittechnik und Laboreinsatz / EMC requirements on the Emission and Immunity – Electrical equipment for measurement, control and laboratory use Störaussendung / Emission : - **Grenzwertklasse: Klasse B / Class B** - **EN 61000-3-2, EN 61000-3-3** Störfestigkeit / Immunity : - **EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6, EN 61000-4-11**

Ausgestellt von / Issued by

Dr. Hans-Lothar Pasch
Managing Director
Polytec GmbH

Datum / Date
25.11.2009

Figure C.1: Declaration of conformity for the PDV-100

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