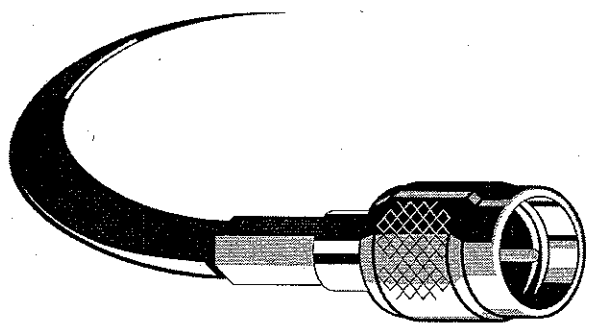
Polytec

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.

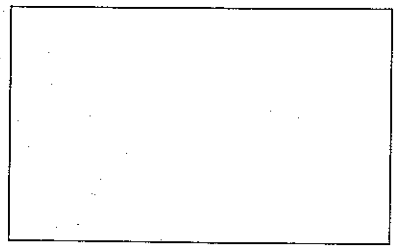
To return the equipment always use the original packaging. Otherwise we reserve the right to check the equipment for transport damage. Please mark the package as fragile and sensitive to frost. Include an explanation of the reason for returning it as well as an exact description of the fault. You can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



Contents

1 Safety Information

1.1 Laser Safety

The light source of the PDV 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. To ensure this, the following precautions have been taken:

- In general, Polytec equipment complies with the standards **EN 60825-1** (DIN VDE 0837) and **CFR 1040.10** (US).
- The optical output of the laser is less than 1 mW providing the equipment is used in the manner for which it was intended. This means that the PDV conforms with **laser class II** and is generally very safe. Even when optimally focused, the laser light is not intense enough to harm the skin.
- The PDV is equipped with a **beam shutter** which can be used to block the laser beam during the warm-up phase or when the PDV is not in use, although switched on.
- The display on the laser vibrometer indicates whether the laser is active and thus whether there is potential danger from emitted laser beams.
- It is **not necessary to open the housing** when using the PDV as intended. Opening the housing will invalidate the warranty.

Please pay attention to the following **safety precautions** when using the PDV:

- Avoid looking directly into the laser beam with the naked eye or with the aid of mirrors or optical instruments!
- Only open the beam shutter when making measurements!
- To position the PDV, always block the laser beam using the beam shutter. Only when the PDV is roughly in place, open the beam shutter for fine adjustment.
- Do not use any reflective tools, watches etc. when you are working in the beam path of the laser!

1.2 Laser Warning Labels

Position The position of the laser warning labels on the PDV is shown in figure 1.1.

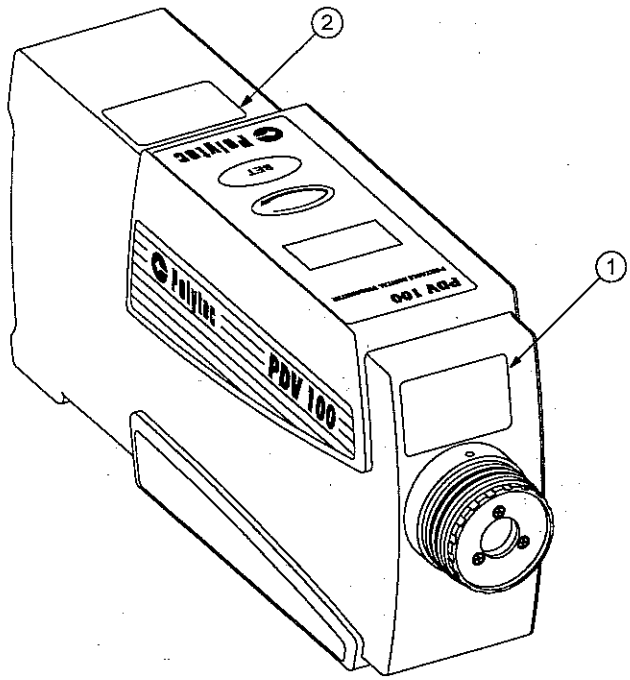


Figure 1.1: Position of the laser warning labels on the PDV

1.2.1 Non-EC Countries

Warning labels The laser warning labels for the PDV in non-EC countries are shown in figure 1.2. Label **2** is affixed either for USA or for all other non-EC countries.

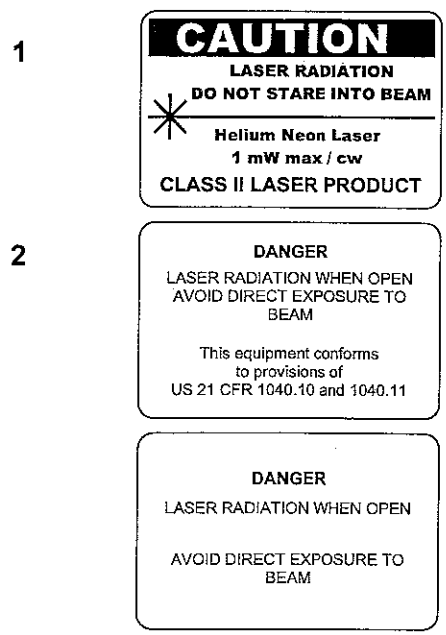


Figure 1.2: Laser warning labels for the PDV in non-EC countries

1.2.2 EC Countries

Warning labels

The laser warning labels for the PDV in EC countries are shown in figure 1.3. Label **2** is affixed either in English, French or Spanish. Their position on the PDV is shown in figure 1.1.

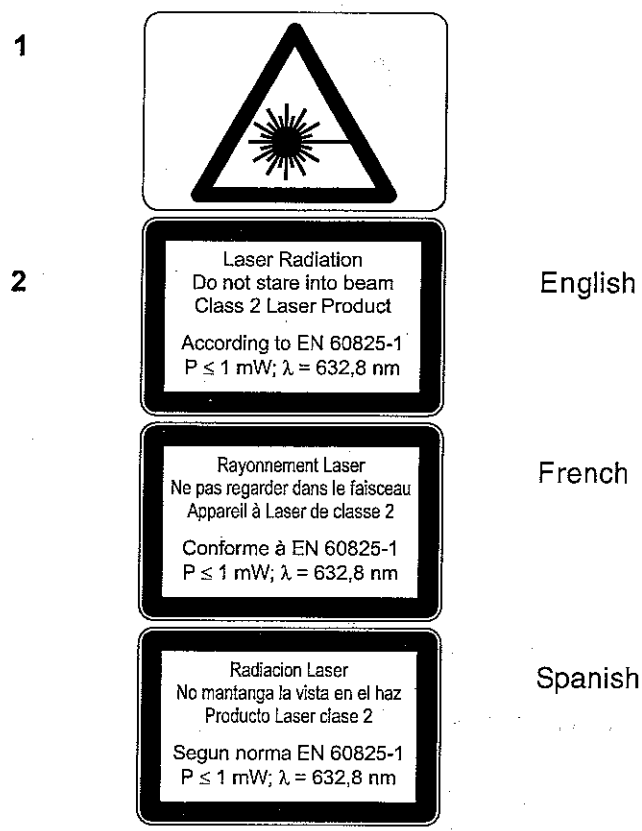


Figure 1.3: Laser warning labels for the PDV in EC countries

1.3 Electrical Safety

PDV

The PDV is designed to be used powered by a low voltage (nominally 12VDC) provided externally, which is accessible for constructional reasons.

Due to the insulation used and the encased construction, the high-voltage of the laser created internally can not be accessed, even in the case of malfunction. Protective grounding of the completely closed metal housing is therefore not necessary.

Power supply

The user of the PDV is responsible for ensuring that the power supply used complies with recognized safety standards with regards to electrical protection against accidental contact. We recommend only using power supplies with suitable safety approval with insulation standards which fulfil the requirements for safety extra low voltage (SELV) according to EN60950, UL1950, IEC950 or equivalent national standards.

Battery charger (optional)

To reduce the risk of shock hazard and annoying interference, use only accessories recommended by the manufacturer. Do not expose this equipment to rain or moisture.

It is not necessary to open the housing when using the battery charger as intended. There are no user serviceable parts inside. For servicing, contact the manufacturer's qualified service personnel, as also stipulated by the manufacturer.

Caution!

When loading the batteries it is **absolutely essential** to open the cover of the carrier bag to ensure unimpeded air circulation!

1.4 Safety when Using Lithium Ion Batteries

Warning!

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

Please pay attention to the following **safety precautions** when using lithium ion batteries:

- 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 terminals of the battery with metal objects such as necklaces, keys, coins and hairpins!
- Do not allow the battery to come into contact with sea water or water of any kind! Generally avoid moisture!
- Do not drop the battery or subject it to great shocks!
- Do not use any battery from which any kind of fluid has leaked, or which shows signs of external damage.

1.5 Safety when Charging and Discharging Lithium Ion Batteries

Warning!

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

Please pay attention to the following **safety precautions** when charging and discharging lithium ion batteries:

- When charging the battery, always use the charger or discharger specified by the manufacturer!
- Never connect the batteries directly to a mains supply or an on-board plug socket!
- While charging, do not place the batteries 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.
- Do not continue charging the battery if it does not recharge within the specified charging time. Doing so may cause the battery to overheat, explode, or ignite.

2 Introduction

2.1 Area of Application

Polytec's **P**ortable **D**igital **V**ibrometer **PDV** is used for non-contact measurement of surface vibrational velocities. The PDV is a compact, portable laser vibrometer with state-of-the-art design of optics and signal processing. The PDV is shown in figure 2.1.

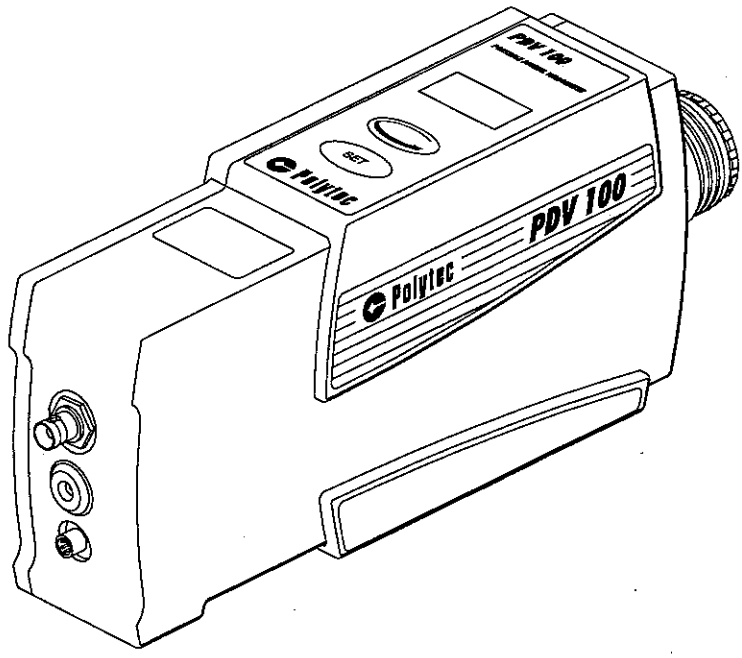


Figure 2.1: View of the PDV 100

In the frequency range from 0.05 Hz to 22 kHz the handy PDV 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 of 0.05 µm/s to 0.5 m/s and with precise digital filters, you can optimally adapt the PDV to nearly all applications in the acoustic frequency range.

2.2 Measurement Principle

The PDV measures vibrational velocity according to the heterodyne interferometer principle, which generates a high-frequency carrier signal at the photo detector with the aid of a Bragg cell. The beam of a helium neon laser is pointed at the vibrating object and scattered back from it. Velocity and amplitude of a vibrating object generate a frequency or phase modulation due to the Doppler effect. The object beam is thereby subjected to a small frequency shift which is described as the Doppler frequency f_D. The Doppler frequency is a function of the velocity component v in the direction of the object beam according to

$$f_D = 2 \cdot \frac{v}{\lambda}, \qquad \text{Equation 2.1}$$

whereby λ is the laser wavelength. The Bragg cell also generates an optical frequency shift f_B in the reference beam (70MHz). After superimposing the measurement and the reference beam, an electrical signal is generated at the photo detector with the instantaneous frequency

$$f_C(t) = f_B + f_D(t) = f_B + 2 \cdot \frac{v(t)}{\lambda}. \qquad \text{Equation 2.2}$$

This is a carrier frequency signal with the center frequency f_B, which is frequency modulated with the signed Doppler frequency $f_D(t)$. Through frequency demodulation the velocity signal can be decoded. In the PDV the demodulation of the Doppler signal is purely based on a digital process. In contrast to the conventional, analog vibrometers, 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 transmission method proven in digital audio technology, the output signal can 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 24bit amplitude resolution is also available.

3 First Steps

3.1 Operating and Maintenance Requirements

Operating environment

The PDV can be used in normal climatic conditions (refer to chapter 7). Avoid condensation on the optical components caused by a rapid change in temperature. Avoid direct sunlight in order to prevent the instrument from overheating.

Mains connection

The plug-in power supply provided for the PDV has a wide range input and can be connected to all mains voltages with nominal values between 100V and 240V.

The battery charger in the optional carrier bag PDV-BS has also a wide range input and can be connected to all mains voltages with nominal values between 100V and 240V.

Assembly

The PDV must be mounted vibration-free in comparison to the vibration to be measured. The surface it is mounted on must be level (planed) and the screws are to be tightened with a maximum torque of 2.5Nm. With high ambient temperatures, mount the PDV on cooling metal surfaces if possible (see below).

Cooling

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

Connecting cables

Make sure that all jacks are connected properly and firmly. Protect all connecting cables from mechanical damage and from high temperatures.

Warming-up

The optical components in the PDV require a warm-up period of approximately 20 minutes until the optimal operating temperature has been reached.

Front optics

Handle the front optics with care. Dirt may only be removed using a soft, dry cloth, an optics brush and bellows.

Cleaning

The housing surfaces of the instrument can be cleaned with mild detergent solutions or ethanol.

Opening up the equipment

It is not necessary to open the housing when using the equipment as intended and will invalidate the warranty.

Batteries and battery charger (optional)

The lithium ion batteries for the PDV can be used at temperatures of between 0°C and +40°C (32°F and 104°F). Ensure a temperature of between +10°C and +30°C (50°F and 86°F) when charging the batteries.

Caution!
When loading the batteries it is **absolutely essential** to open the cover of the carrier bag to ensure unimpeded air circulation!

3.2 Unpacking and Inspection

Unpacking

The scope of supply consists of the following components:

- laser vibrometer PDV 100
- power supply with connecting cable
- carrier bag
- digital audio cable (Triax/RCA)
- 1 sheet reflective film 3M Scotchlite Tape® (enclosed in the manual)

optional

- motor vehicle supply cable PDV-DC for the PDV being operated at a 12V on-board plug socket or a motor vehicle cigarette lighter
- carrier bag PDV-BS with integrated lithium ion battery supply set (rechargeable), battery charger with mains cable and switching box
- motor vehicle charging cable PDV-DCR for the battery charger being operated at a 12V on-board plug socket or a motor vehicle cigarette lighter
- tripod with fluid stage OFV-S2

Caution!

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

Inspection

Please pay attention to the following steps when unpacking:

1. After unpacking, check all components for external damage (scratches, loose screws etc.).
2. Check the packaging for signs of unsuitable handling during transport.
3. In the case of a 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.

After unpacking, carry out a first functional test as described in section 3.4.

3.3 Control Elements

View from above

The view from above of the laser vibrometer is shown with the control elements in figure 3.1.

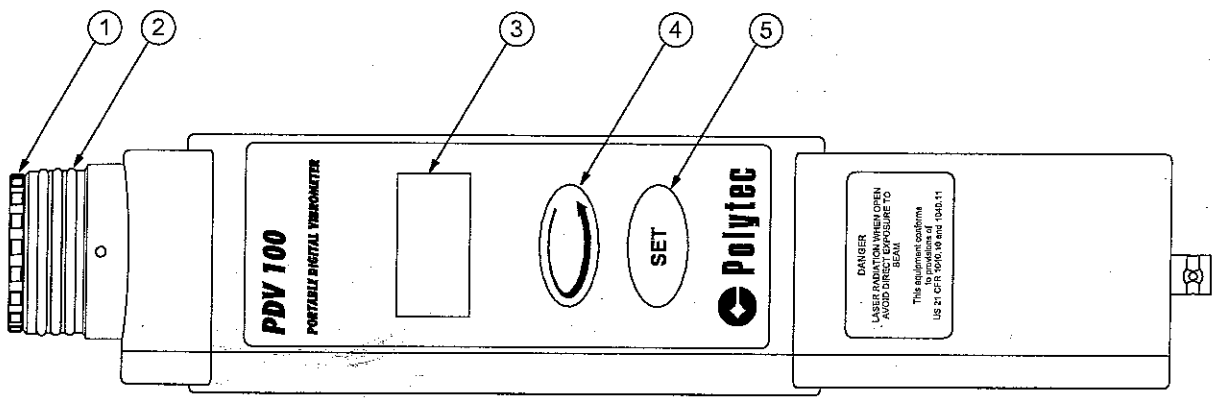


Figure 3.1: View from above of the laser vibrometer

1 Beam shutter

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

> **Warning!**
>
> **Only** open the beam shutter when you are making measurements!

2 Focusing ring

Focusing ring to focus the laser beam (refer to section 5.3)

3 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 5.5.

4 Selection key ⊂

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 5.5).

5 SET key

Using this key the setting of the selected parameter is changed (refer to section 5.5).

Rear view

The rear view of the laser vibrometer is shown with the control elements in figure 3.2.

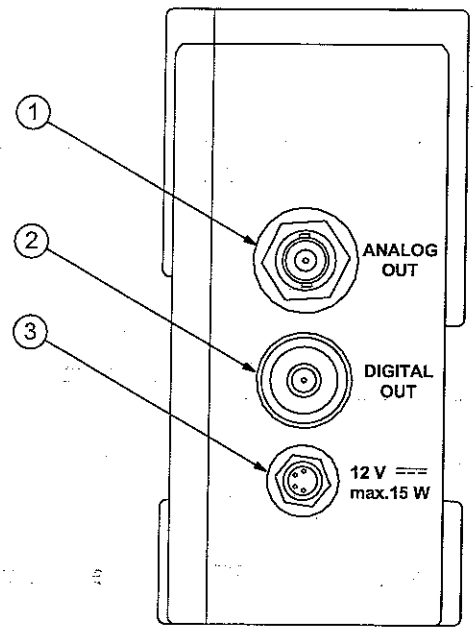


Figure 3.2: Rear view of the laser vibrometer

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 (**S**ony/**P**hilips **D**igital Audio Inter**F**ace), 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 laser vibrometer is shown with the control elements in figure 3.3.

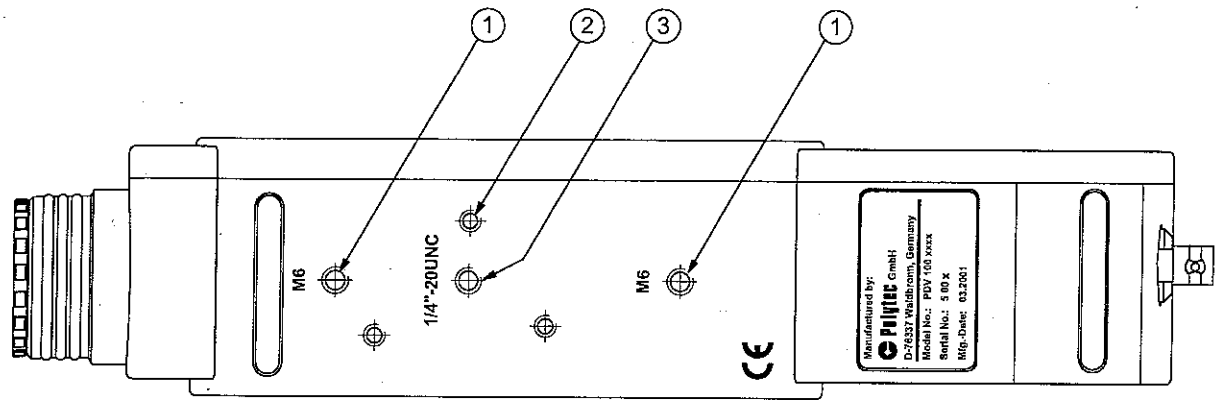


Figure 3.3: View from the bottom of the laser vibrometer

1 Mounting holes **M6**

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

2 Three mounting holes **M5** for the optional tripod OFV-S2

Here the quick release plate of the optional tripod will be fixed (refer to section 3.5.1).

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

Using this mounting hole, the PDV can be mounted on camera tripods with thread basing on inch-system.

3.4 Functional Test

For the first functional test of the PDV, proceed as follows:

Preparing

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

Cabling and switching on

2. Plug the connecting cable of the power supply into the socket 12V on the back of the laser vibrometer.

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

3. Plug the power supply to a wall socket.

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

4. Before now opening the beam shutter, remember the information on laser safety in section 1.1!

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 from the laser vibrometer.

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 front lens, refer to section 7.2.7) and 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 laser vibrometer, set the oscilloscope to 1 V/DIV and move the test surface.

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

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

If the functional test has been successful, you can now install the PDV in the measurement location as described in section 3.5.

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.

3.5 Installation

3.5.1 Assembly

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

- Two mounting holes M6 to mount the PDV on cooling surfaces if necessary
- One mounting hole 1/4" to mount the PDV onto a camera tripod
- Three mounting holes M5 to mount the PDV onto the optional tripod with fluid head OFV-S2

Assembly onto tripod OFV-S2

Before attempting to mount the laser vibrometer, all locking mechanisms of the tripod, particularly screws, should be checked to make sure they are tight. Loose screws may cause the tripod to be unstable and possibly collapse. Proceed with the assembly as follows:

1. Assemble the tripod as described in the assembly instructions 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 quick release hexagonal plate provided on the underside of the laser vibrometer using the three screws M5.
5. Use this plate to position the laser vibrometer 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 laser vibrometer from the fluid stage, you should hold the PDV while opening the safety lever.
8. Keep the assembly instructions for the tripod and the fluid stage in a safe place.

3.5.2 Electrical Connection

Mains operation

Only use the power supply 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 and 240 V.

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

   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 a wall socket.

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

Battery operation (optional)

As an option you get a carrier bag with an integrated lithium ion battery supply set with battery cable, battery charger with mains cable, and switching box. The battery charger has a wide range input and can be connected to all mains voltages with nominal values between 100 V and 240 V. Furthermore, you will find detailed information in section A.2.

First of all, you have to charge the batteries. To do so, proceed as follows:

1. Connect the mains cable to the battery charger through the opening at the side of the carrier bag and plug the other end into a wall socket.

   The LED POWER on the top of the battery charger lights up.

2. Put the toggle switch of the switching box in the carrier bag in position CHARGE.

   The charging procedure starts.

> **Caution!**
>
> When loading the batteries it is **absolutely essential** to open the cover of the carrier bag to ensure unimpeded air circulation!

3. Once both batteries are fully charged, disconnect the battery charger.

   It will take approximately 9 hours to charge batteries which have been completely discharged.

To connect the PDV to the batteries, proceed as follows:

4. Plug the battery cable of the carrier bag into the socket 12 V on the back of the laser vibrometer.

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

5. Put the toggle switch of the switching box in the carrier bag in position OPERATE.

   The LED LASER on the switching box and the display on the laser vibrometer 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 for approximately 5 seconds, the lighting is switched off but the readout on the display is still active.

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 laser vibrometer roughly so that its laser beam aperture points in the direction of the object under investigation. If possible, position the laser vibrometer at an optimal stand-off distance to the object. You will find information on optimal stand-off distances in section 4.2.4.

Cabling and switching on

3. Plug the connecting cable of the power supply into the socket 12V on the back of the laser vibrometer.

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

4. Plug the power supply to a wall socket.

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

5. From now on, the laser needs a warm-up period of approximately 20 minutes until it reaches the optimal operating temperature.
6. Before now opening the beam shutter, remember the information on laser safety provided in section 1.1!

Measuring

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 from the laser vibrometer.

8. Focus the laser beam on the surface of the object 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 graph is displayed. The output signal in this case, however, contains more noise.

You can now select suitable settings as described in section 4.2 and operate the PDV as described in chapter 5.

4.2 Selecting Suitable Settings

The settings necessary for a measurement are limited to selecting the velocity measurement range (VELO) and the low pass filter (LP), as well as setting the high pass filter (HP). Depending on the type of external signal acquisition, the measurement signal can be acquired from the analog voltage output ANALOG OUT or the digital output DIGITAL OUT.

4.2.1 Measurement Range

The PDV offers three velocity measurement ranges, whose full scale values are shown in mm/s in the line **Velo** of the display (20 mm/s, 100 mm/s and 500 mm/s). 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 for the analog output signal 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 Low Pass Filter

The PDV is equipped with a switchable, digital low pass filter to limit the bandwidth of the measurement signal. With the three cutoff frequencies 1 kHz, 5 kHz and 22 kHz which can be selected, high-frequency noise levels can be suppressed. The cutoff frequency of the low pass filter is set on the display at **LP**.

The digital filter principle (FIR type) realizes almost ideal filter properties at the digital output. With linear phase, the amplitude error remains less than 0.1% up to the given cutoff frequency and the changeover to the stop band has a steep frequency roll-off (−120 dB/dec).

The digitally conditioned signal is available at the analog voltage output after D/A conversion. Due to the analog signal conversion, the amplitude error can increase up to 1%.

4.2.3 High Pass Filter

To suppress low-frequency background vibrations, the PDV has got a switchable high pass filter type 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 technology 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 useful signal is to be measured at high frequencies. 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%)

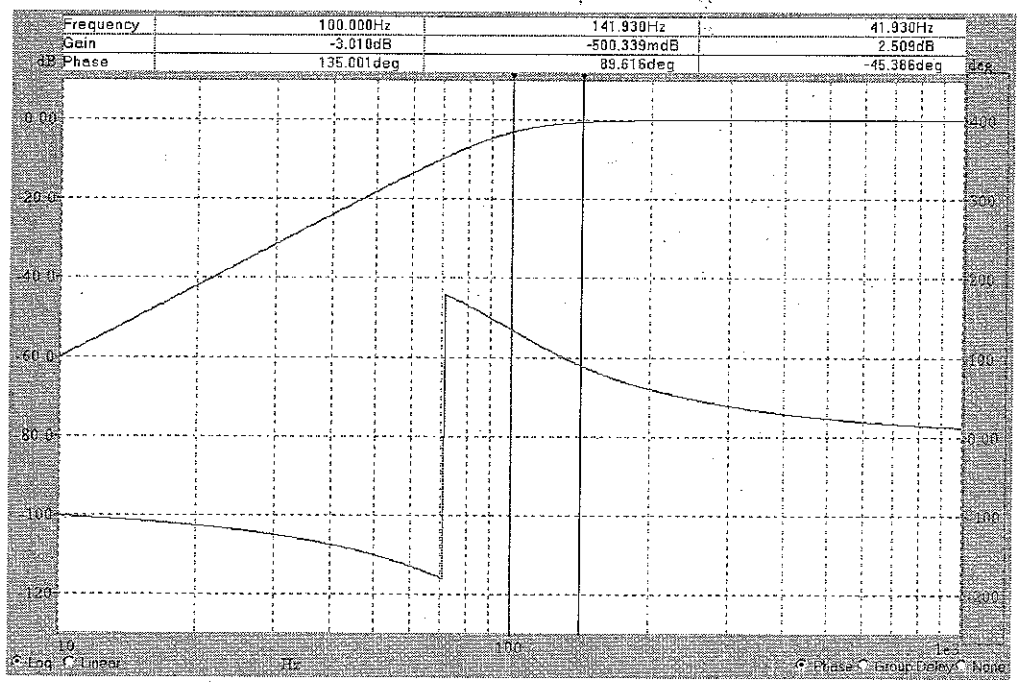


Figure 4.1: Amplitude and phase frequency response of a 3rd order Butterworth high pass filter

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.

4.2.4 Optimal Stand-off Distances

The stand-off distance is measured from the front edge of the retaining ring for the front lens (refer to section 7.2.7). The optimal stand-off distances are:

$96\text{mm} + n \cdot 138\text{mm}$, $n = 0; 1; 2; ...$

i.e. at 96mm; 234mm; 372mm; 510mm; etc.

Visibility maxima

The light source of the PDV is a helium neon laser. This is a multi-mode laser in which a maximum of two modes can exist. The interference of the two modes leads to the intensity of the resulting optical signal varying periodically with the stand-off distance. The intensity increases to a maximum, i.e. maximum visibility is present if the optical path difference is an even-numbered multiple of the laser cavity length (138mm). As the optical path difference is equal to twice the stand-off distance (the beam goes there and back), maximum visibility is present once per cavity length.

In practice, it is not usually necessary to search for maximum visibility as the PDV is even sensitive enough to make a measurement close to the minimum. A minimum is indicated during the warm-up phase by periodic fluctuation of the optical signal level.

5 Operating the PDV

5.1 Switching On and Off

Power supply

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

Battery operation

You switch the PDV on by connecting it to the battery cable of the battery supply set and setting the toggle switch on the switching box in the carrier bag to position OPERATE. The display on the top of the laser vibrometer and the LED LASER on the switching box light up and indicate that the PDV is ready to operate.

For the PDV, the battery level is shown on the display (refer to section 5.7).

> **Note!**
>
> The background lighting of the display is equipped with a power saving mode. If no key is pressed for approximately 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!**
>
> **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. When looking in the direction of the emitted laser beam, focus the laser beam as follows:

- Focus on infinity: Turn to the right
- Focus close-up: Turn to the left

Please pay attention to the information on optimal stand-off distances provided in section 4.2.4.

5.4 Optimizing the Focus of the Laser Beam

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 laser vibrometer (refer to section 5.5.1). The length of the bar is a measure of the amount of light scattered back from the object under investigation.

5.5 Setting Parameters via the Display

5.5.1 Philosophy

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

Selection key ⊂: Using the selection key within the menus, a parameter is selected (▶).

Key SET: Using the key SET, the setting of the selected ▶ parameter is changed.

The main menu is shown in figure 5.1 as an example of the display.

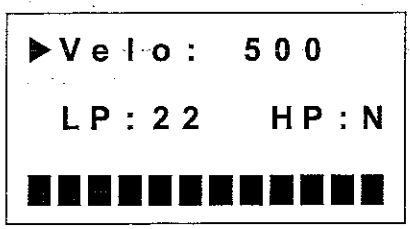


Figure 5.1: Example of the display

The parameters are run through on the display in a circle using the selection key ⊂.

The cursor ▶ on the left side marks a selected parameter. The parameter setting is changed with the key SET. Adjusted settings are activated immediately.

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

5.5.2 Organization of the Menus

The menu structure is shown in figure 5.2.

Figure 5.2: Organization of the menus in the PDV

The menus are organized as follows:

INTRO: The start menu only appears after switching on the laser vibrometer. 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.

5.5.3 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 laser vibrometer 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 laser vibrometer.

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

Velo

In this line you can set the velocity measurement range in mm/s (full scale). You will find information on setting the measurement range in section 4.2.1.

LP

At this point along the line you can set the cutoff frequency of the low pass filter in kHz. You will find information on setting the low pass filter in section 4.2.2.

HP

At this point along the line, you can set the high pass filter. Setting **Y** means that the high pass filter is switched on and setting **N** means that it is switched off. You will find information on setting the high pass filter in section 4.2.3.

Service mode

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

Switching Laser Off and On

In service mode, you can switch the laser off by pressing the key SET several times until the following display appears.

Service Mode
Laser: -Off-

Quit service mode with the selection key and the laser remains switched off.

In service mode, you can switch the laser on again by pressing the key SET several times until the following display appears.

Service Mode
Laser: -On-

Quit service mode with the selection key and the laser remains switched on.

Displaying Temperature

In service mode, you can display the temperature in the laser vibrometer by pressing the key SET several times until the following display appears.

Service Mode
Temp: 30.5

The display shows the actual temperature in degrees Celsius. Quit service mode with the selection key.

Generating Test Signals

In service mode, you can generate a sinusoidal test signal of 2.80 V (rms) with a frequency of ca 1 kHz. This signal corresponds to 99% of full scale and is available at the BNC jack ANALOG OUT on the back of the laser vibrometer. To generate this 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 laser vibrometer at an optimal stand-off distance to the object (refer to section 4.2.4).
3. Connect the object vibration-free to the laser vibrometer and mount them onto a solid base.
4. Open the beam shutter and focus the laser beam 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 2.80V test signal by pressing the key SET several times until the following display appears.

   Service Mode

   Output = Full

   The 2.80V 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. Quit service mode with the selection key ⊂.

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

1. Change into the service mode by holding the key SET pressed and then press the selection key ⊂.

2. Generate the 0V test signal by pressing the key SET several times until the following display appears.

   Service Mode

   Output = Zero

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

3. Quit service mode with the selection key ⊂.

5.6 Overrange Indicator

The overrange indicator is shown on the display of the laser vibrometer on the right next to the measurement range indicator **Velo** (refer to figure 5.3).

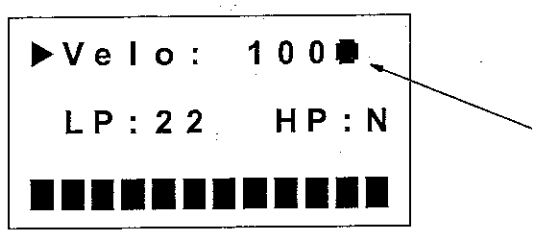


Figure 5.3: Display with overrange indicator

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 further information on setting the measurement range in section 4.2.1.

5.7 Battery Level Indicator

The battery level indicator is shown on the display of the laser vibrometer on the right next to the overrange indicator (refer to figure 5.4).

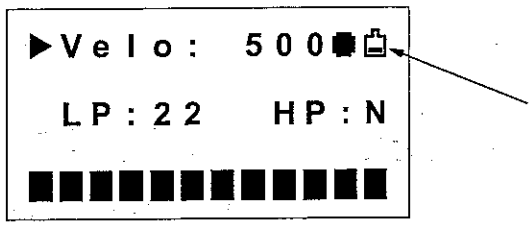


Figure 5.4: Display with battery level indicator

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 further information on the batteries and on charging the batteries in section 3.5.2 and in section A.2. For information on safe handling of lithium ion batteries refer to section 1.4 and section 1.5.

5.8 Measurement Signal Output

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

Digital The measurement signal is available at the Triax jack DIGITAL OUT on the back of the laser vibrometer 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 as described in section 3.5.2?
3. Is the display on the top of the laser vibrometer lit 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. Is the display showing the following warning?

   WARNING
   Over Temp.
   Laser: -Off-

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

Battery operation only

Is the display showing the following warning?

WARNING
Batt. empty
Laser: -Off-

The laser has been switched off because the batteries are empty. To avoid completely draining the battery and thus shortening its useful life,

set the toggle switch of the switching box to the position OFF. Then reload the batteries as described in section 3.5.2.

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 approximately 23cm 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 laser vibrometer and check if the output reacts to moving the test surface.

Note!
Make sure that the high pass filter is 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 ±10mV can be measured.

4. Set the oscilloscope to 1V/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.

7 Technical Specifications

7.1 Standards Applied

Electrical safety	EN61010 (IEC1010)
EMC:	Emission: EN50081-1 (FCC ClassB)
	Immunity: EN50082-1, EN61000-6-2 (IEC61000-6-2)
Laser safety	EN60825-1 (CFR1040.10, CFR1040.11)

7.2 Laser Vibrometer PDV 100

7.2.1 General Data

Supply voltage:	11V...14.5VDC
Power consumption:	max. 15W
Protection rating:	IP 64
Operating temperature:	+5°C...+40°C (41°F...104°F)
Storage temperature:	−10°C...+65°C (14°F...149°F)
Relative humidity:	max. 80%, non-condensing
Display:	LCD, 3-line, with background lighting
Dimensions:	refer to section 7.2.7
Weight:	ca. 2.6kg
Calibration recommended:	every 2 years

7.2.2 Signal Output ANALOG OUT

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

Measurement Ranges

Measurement range full scale (peak) mm/s	Scaling factor (analog output) $\frac{mm}{s}$/V	Resolution[1] µm/s	Maximum acceleration m/s^2
20	5	< 0.05	2,760
100	25	< 0.1	13,800
500	125	< 0.3	69,000

[1] The resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB in a 10Hz spectral bandwidth (RBW), measured on 3M Scotchlite Tape®.

7.2.3 Signal Output DIGITAL OUT

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

7.2.4 Low Pass Filter

Filter type:	digital, FIR type
Cutoff frequencies (–0.1dB):	1kHz, 5kHz, 22kHz (adjustable)
Frequency roll-off:	> 120dB/dec
Stop band attenuation:	> 100dB

7.2.5 High Pass Filter

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

7.2.6 Optics

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

Stand-off distance[1]	m	0.2...ca.30[2]
Aperture diameter ($1/e^2$) (typ.)	mm	4.2
Spot size (typ.)	µm	
@ 234 mm		50
@ 1 m		200
@ 2 m		400
Visibility maxima[1]	mm	96 + n · 138[3]

[1] Measured from the front edge of the retaining ring for the front lens, refer to section 7.2.7

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

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

7.2.7 Dimensions

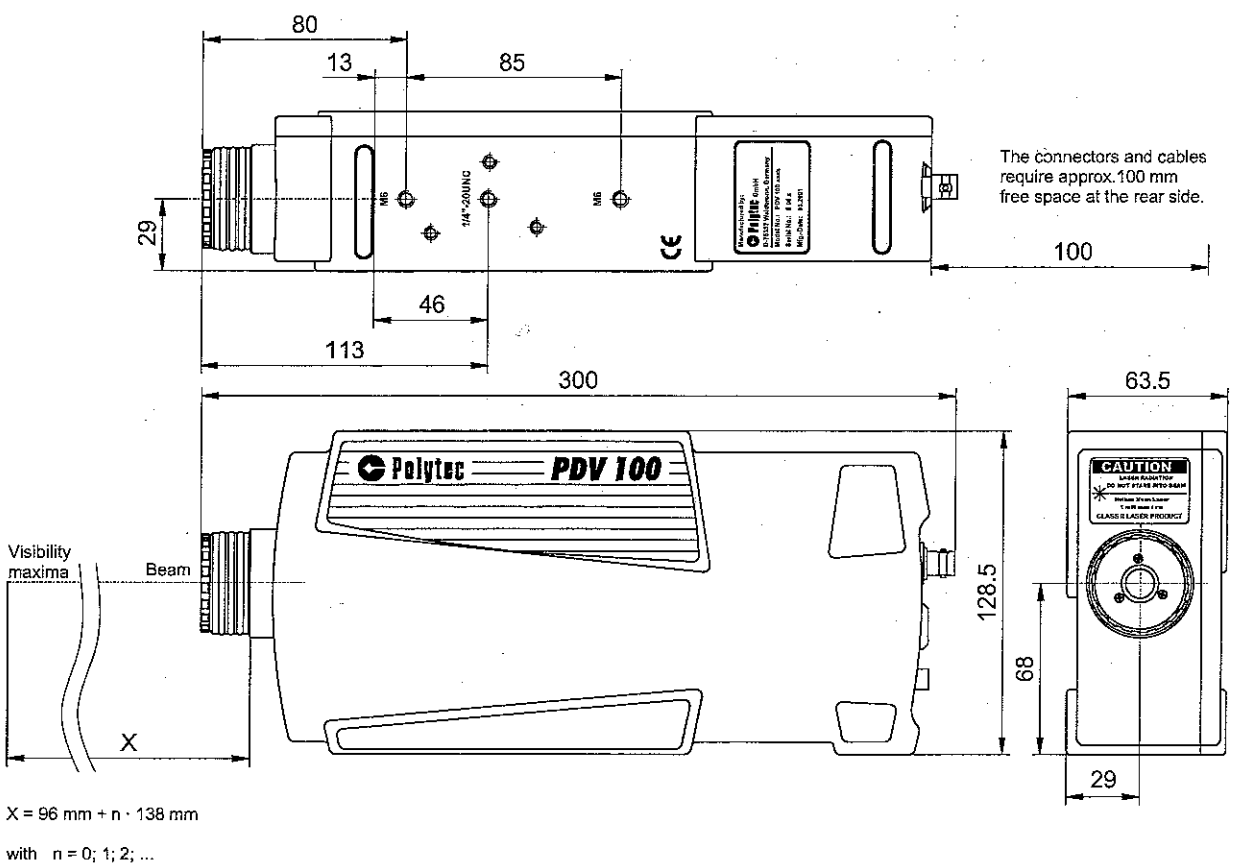


Figure 7.1: Views of the PDV 100 (Dimensions not specified are given in mm.)

7.3 Power Supply

Output voltage:	12VDC
Mains voltage:	100...240VAC ±10%, 50/60Hz
Power consumption:	max. 20W
Protection rating:	with protective insulation, IP40
Cable length:	5m

7.4 Carrier Bag PDV-BS (optional)

Batteries

Type:	2 x lithium ion accumulator, 7.2V/5.3Ah
Operating time:	ca. 5h

Battery charger

Supply voltage:	Mains: 100...240VAC ±10%, 50/60Hz On-board plug socket: 12VDC
Power consumption:	max. 35W
Charging time:	connected to the mains: 4h 30min. connected to a 12V on-board plug socket: 5h 20min.
Dimensions:	121mm x 56mm x 81mm
Weight:	0.3kg
Length of the mains cable:	2m

Carrier bag

Weight:	4.4kg (incl. PDV 100, batteries and battery charger)
Dimensions:	370mm x 160mm x 150mm

Appendix A: Optional Accessories

A.1 Motor Vehicle Supply Cable PDV-DC

You use the motor vehicle supply cable PDV-DC to operate the PDV from a 12V on-board plug socket **or** a motor vehicle cigarette lighter. It is not recommended to operate the PDV with running engine.

> **Note!**
>
> Use the red adapter for operation from a motor vehicle cigarette lighter.

A.2 Carrier Bag PDV-BS

The carrier bag PDV-BS contains a lithium ion battery supply set, a battery charger with a mains cable and a switching box. The carrier bag with the PDV 100 is shown in figure A.1.

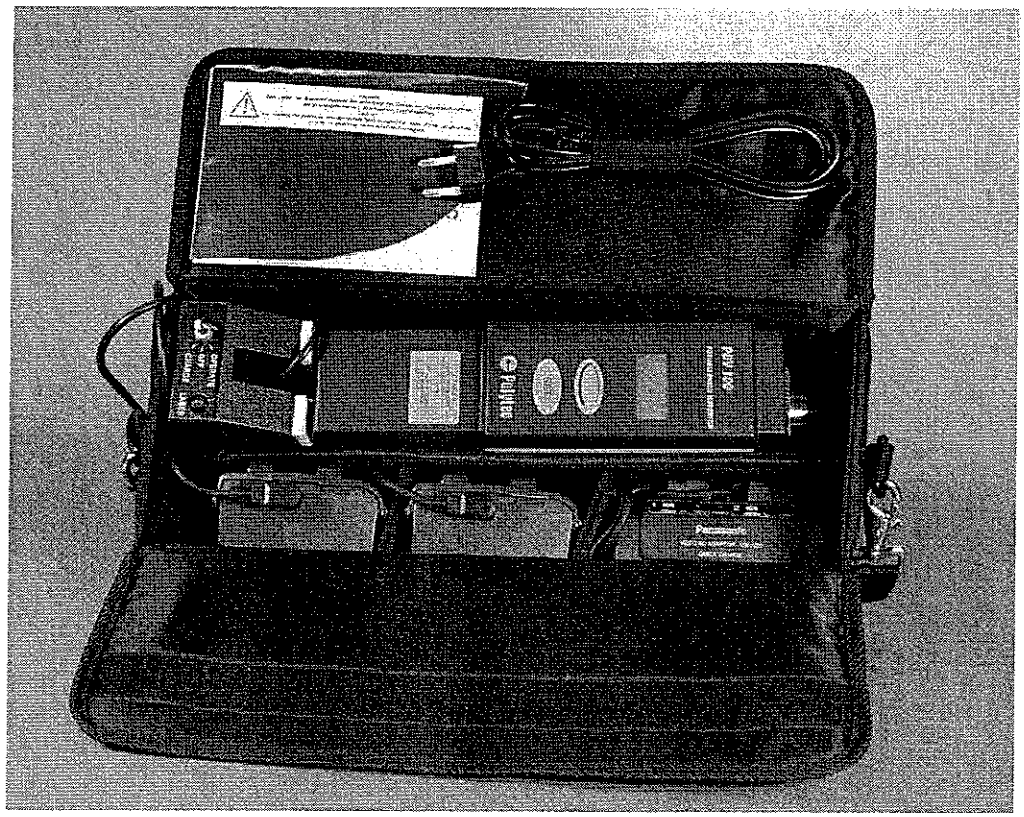


Figure A.1: Carrier bag PDV-BS

A.2.1 Battery Charger with Mains Cable

Mains connection

The battery charger has a wide range input and can be connected to all mains voltages with nominal values between 100 V and 240 V using the mains cable.

Charging batteries

You have to charge the batteries before you can start using the PDV. To do so, proceed as follows:

1. Connect the mains cable to the battery charger through the opening at the side of the carrier bag and plug the other end into a wall socket.

   The LED POWER on the top of the battery charger lights up.

> **Caution!**
>
> When loading the batteries it is **absolutely essential** to open the cover of the carrier bag to ensure unimpeded air circulation!

2. Put the toggle switch on the switching box in the carrier bag in position CHARGE.

   It starts charging. It will take approximately 9 hours to charge batteries which have been completely discharged.

3. Once both batteries are fully charged, disconnect the battery charger.

   The batteries' level of charge is displayed on the battery charger during charging. On this, refer to the operating instructions of the battery charger

Connecting the PDV 100

To connect the PDV to the batteries, proceed as follows:

4. Plug the carrier bag's battery cable into the 12 V socket on the back of the laser vibrometer.

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

5. Put the toggle switch on the switching box in the carrier bag in position OPERATE.

   The LED LASER on the switching box and the display on the laser vibrometer 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 for approximately 5 seconds, the lighting is switched off but the readout on the display is still active.

A.2.2 Optional Motor Vehicle Charging Cable PDV-DCR

You use the motor vehicle charging cable PDV-DCR to operate the battery charger from a 12V on-board plug socket **or** a motor vehicle cigarette lighter.

> **Note!**
>
> Use the red adapter to operate from a motor vehicle cigarette lighter.

Charging batteries

If you want to use the motor vehicle charging cable for the battery charger, please proceed as follows to charge the batteries:

1. The jack for the motor vehicle charging cable is on the opposite side to the jack for the mains cable. So rotate the battery charger by 180° so that the jack for the motor vehicle charging cable is positioned at the side opening of the carrier bag.

2. Connect the motor vehicle charging cable to the battery charger through the opening at the side of the carrier bag and plug the other end into a 12V on-board plug socket or a motor vehicle cigarette lighter.

   The LED POWER on the top of the battery charger lights up.

> **Caution!**
>
> When loading the batteries it is **absolutely essential** to open the cover of the carrier bag to ensure unimpeded air circulation!

3. Put the toggle switch on the switching box in the carrier bag in position CHARGE.

   It starts charging. It will take approximately 11 hours to charge batteries which have been completely discharged.

4. Once both batteries are fully charged, disconnect the battery charger.

   The batteries' level of charge is displayed on the battery charger during charging. On this, refer to the operating instructions for the battery charger.

Index

P

Q

R

S

T

U

V

W

Polytec Deutschland
(Deutschland, Österreich, Schweiz)

POLYTEC GmbH
Polytec-Platz 1-7
D-76337 Waldbronn
Tel.: (07243) 604-0
Fax: (07243) 69944
E-mail: info@polytec.de

POLYTEC Physikinstrumente
Vertriebs- und Beratungsbüro Berlin
Schwarzschildstraße 1
D-12489 Berlin
Tel.: (030) 6392-5140
Fax: (030) 6392-5141
E-mail: info@polytec.de

Besuchen Sie uns im Internet:
http://www.polytec.de

Polytec International

POLYTEC GmbH
Polytec-Platz 1-7
76337 Waldbronn, Germany
Tel.: (+49) 7243 604-0
Fax: (+49) 7243 69944
E-mail: Info-vi@Polytec.de

France
POLYTEC PI, S.A.
Division RMP, 32 rue Delizy
F-93694 PANTIN Cédex
Tel.: 1-48103930
Fax: 1-48100803
E-mail: ctrl-vision@polytec-pi.fr

UK
LAMBDA Photometrics
Ltd., Lambda House
Batford Mill, Harpenden,
HERTS AL5 5BZ
Tel.: 01582-764334
Fax: 01582-712084
E-mail: info@lambdaphoto.co.uk

Japan
PI-POLYTEC KK
Akebono-cho 2-38-5
Tachikawa-shi
TOKYO 190
Tel.: 0425-267300
Fax: 0425-267301

USA (West)
POLYTEC PI, INC.
1342 Bell Avenue
Suite A
TUSTIN, CA 92780
Tel.: (714) 850 1835
Fax: (714) 850 1831
E-mail: vibrometers@polytecpi.com

USA (East)
POLYTEC PI, INC.
23 Midstate Drive
Suite 212
AUBURN, MA 01501
Tel.: (508) 832 3456
Fax: (508) 832 0506
E-mail: vibrometers@polytecpi.com

Visit our Web site:
http://www.polytec.com