Polytec

User Manual

Vibrometer Controller

OFV-5000

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 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 will find information on fault diagnosis in CHAPTER 6.

Trademarks

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

Identification Labels

OFV-5000-3G Controller

Contents

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 allows you to protect yourself and prevents any damage being done to the instrument. Pay particular attention to the basic safety information in CHAPTER 1 and the information on installation, operation and maintenance in CHAPTER 3.

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 an action that simplifies the usage of the instrument as well as requirements for a safe usage!

CAUTION!

"Type and source of danger"! Identifies the danger caused by an action which could result in damage to the instrument and how you can avoid it!

WARNING!

"Type and source of danger"! Identifies a possible danger resulting from an action which could lead to death or (serious) injury and how you can avoid it!

Intended use

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

Faultless and safe operation of the instrument presume proper transport and proper 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 laser. It is important to understand that laser light has different properties from ordinary light sources. Laser light is generally extremely intense due to the beam's low divergence. When handling lasers, great care should be taken in any case to make sure that the direct or reflected beam does not enter the eye.

NOTE!

For the detailed technical specifications, see CHAPTER 7!

General

The protective measures 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** respectively **US 21 CFR 1040.10** and **1040.11** except for deviations pursuant to Laser Notice no. 50, dated 24 June 2007.
- The optical output power of the laser beam emitted from the instrument 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 **laser class 2** and is generally very safe. It is thereby usually assumed that eyes are protected by prevention mechanisms including the blink reflex. This reaction offers appropriate protection under reasonably 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 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 radiation that is potentially hazardous.
- Use of controls or adjustments or performance of procedures other than those specified here may result in hazardous radiation exposure.

Specific

- The sensor head 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 sensor head indicates the activity of the installed laser and thus the potential hazard of laser beams emitted.
- The laser is switched on using the **key switch** on the controller. The key can only be removed if the controller and therefore also the laser is switched off.

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!
- Wear suitable laser adjustment eyewear 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!
- If you are working in the beam path of the laser, do not use any reflective tools, watches etc. !
- Only open the beam shutter when making measurements!
- To position the sensor head, 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

You will find detailed information on the laser warning labels and on the position of the laser warning labels on the sensor heads in the respective manual of the sensor head.

1.3 Information on Electrical Safety

1.3.1 Safety Information

The instrument complies with the electrical protection class 1 in accordance with the EU Directive 2006/95/EC (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/EC (EMC Directive) and therefore complies with the limit values for emission and immunity of the standards they are based on (refer also to SECTION 7.1 and APPENDIX B).

1.3.2 Safety Precautions

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

- The instruments may only be connected up using a three-pin mains cable to AC systems 50/60 Hz with a grounded protective conductor, and a nominal voltage of between 100 V and 240 V.
- Defective mains fuses may only be replaced by fuses of the same kind with the rating given on the instrument.
- If the mains switch is not freely accessible the mains plug is used as a separator in case of danger. This means that the mains plug needs to be freely accessible. Otherwise an additional disconnection device must be installed.
- The housing may not be opened when using the instrument as intended. Opening the housing will invalidate the warranty. None of the instruments may be operated with opened housing.
- Maintenance and repair work may only be carried out by the manufacturer or by qualified persons authorized by the manufacturer.
- Disconnect the mains plug before you remove parts of the housing for installation and servicing purposes.
- Existing air inlets and outlets must always be kept free to allow sufficient cooling. If you notice that a cooling fan is not working, immediately switch off the affected instrument.

2 Introduction

2.1 Operating Principle

The OFV-5000 laser vibrometer uses the principle of the heterodyne interferometer to acquire the characteristics of mechanical vibrations or transient motion processes. 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. Velocity and displacement amplitude of a vibrating object generate a frequency or phase modulation of the laser light due to the Doppler effect. This modulation is recovered in the signal processing unit with the aid of suitable demodulators (or decoders). The velocity information is recovered from the frequency modulation of the Doppler signal, while the displacement signal can be reconstructed from the phase modulation available at the same time. A schematic layout of both signal paths is shown as a diagram in FIGURE 2.1.

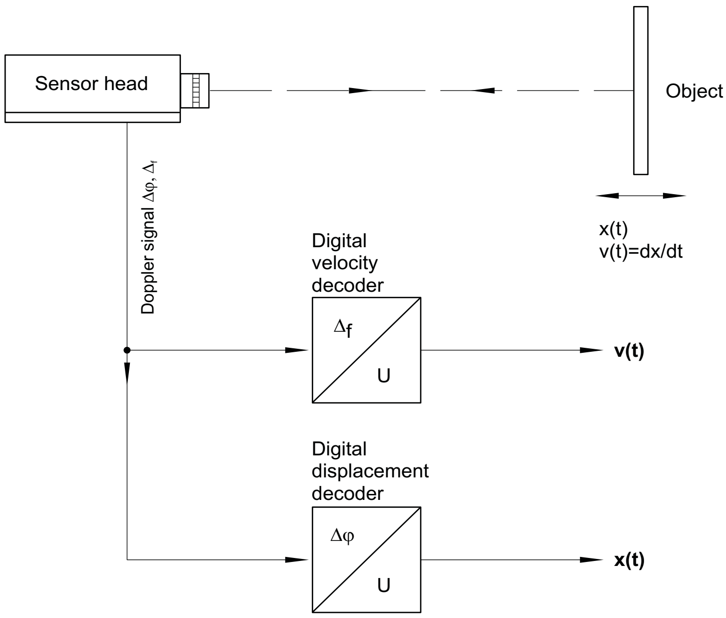

Figure 2.1: Signals in the vibrometer

The Doppler signal is decoded in the OFV-5000 controller with up to four different signal decoders. Depending on the equipment in the controller, these are digital or analog velocity and displacement decoders. The functions of the instrument can be controlled menu-assisted on the touch screen of the controller or via a PC interface.

To display and evaluate measurement results with a PC, as an option you can acquire the Polytec Vibrometer Software (VibSoft). This software is described in a separate manual.

2.2 Polytec's Modular Concept of the Controller

2.2.1 Principle

The construction of Polytec vibrometers is based on a modular principle and thus allows user-specific configuration. The modularity is initially achieved through strict separation of optics and electronics. The controller is designed so that it can be equipped with different signal processing modules optimized for the respective application. The various decoders with digital and analog technology can thereby be combined with all sensor heads. A schematic layout of the corresponding information flow in the controller is shown in FIGURE 2.2.

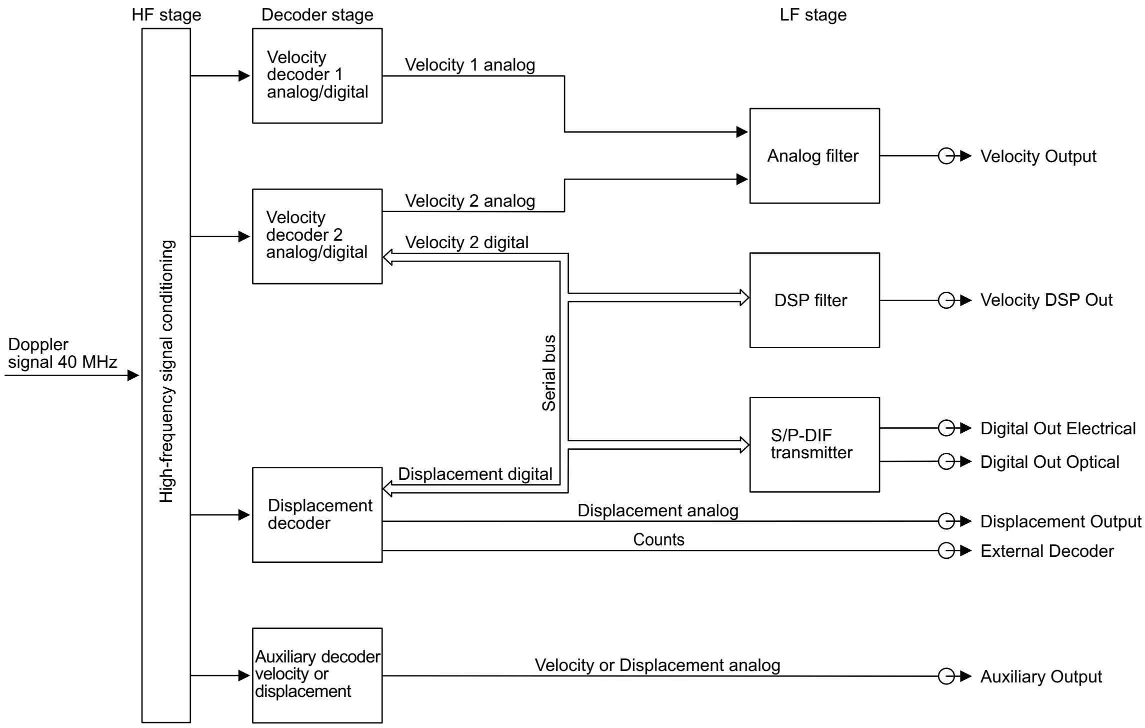

Figure 2.2: Schematic layout of information flow in the controller

The high-frequency Doppler signal coming from the sensor or scanning head initially enters into a high-frequency stage. Whichever decoders the controller has been equipped with, the measurement signal is optimally conditioned here and supplied to the decoder stage. In this stage velocity or displacement information respectively are recovered from the signal. The decoder stage is followed by a low-frequency stage, consisting of an analog filter module and a digital interface (S/P-DIF transmitter) as well as a digital filter module available as an option.

In the following, you will find the decoders listed which are available for the controller.

2.2.2 Velocity Decoders

For velocity acquisition the controller is equipped with an analog velocity decoder as standard. As an option, a digital velocity decoder or a second analog velocity decoder can be installed as well. The analog output signals from these decoders are directed over switchable high and low pass filters which limit the bandwidth and suppress noise and are then made available at the front view as an analog voltage signal. The data from the digital decoder is sent from the decoder to the internal serial bus of the controller and can thus be processed further with an optional digital filter module and also be made available at the front view of the controller. Alternatively the digital signals from the decoder can also be transmitted directly as a data stream via the digital interface (S/PDIF transmitter, refer to SECTION 2.2.6). In this case the data is made available at the back view of the controller as an optical or electrical digital output signal in S/PDIF format.

You will find detailed information on suitable settings for velocity acquisition in SECTION 5.4.

VD-01

The VD-01 is a velocity decoder for applications in the frequency range up to 50 kHz. In this range it provides excellent linearity and accuracy. With five measurement ranges from 1 $\frac{mm}{s}$/V to 1000 $\frac{mm}{s}$/V, it covers the entire dynamic range of the vibrometer with high resolution. In the measurement ranges 125 $\frac{mm}{s}$/V and 1000 $\frac{mm}{s}$/V you can make measurements from the frequency 0 Hz (DC capability).

VD-02

The VD-02 is a broadband velocity decoder and is universally suitable for applications in the frequency range up to 1.5 MHz. The four measurement ranges from 5 $\frac{mm}{s}$/V to 1000 $\frac{mm}{s}$/V cover most technical applications with sufficient amplitude resolution. The maximal velocity of 10 m/s can be acquired for the frequencies up to 1.5 MHz. Out of all decoders the VD-02 offers the least frequency-dependent phase shift.

VD-04

With three measurement ranges, the VD-04 velocity decoder covers the entire dynamic range of the vibrometer in the frequency range 0.5 Hz to 250 kHz.

VD-06

The VD-06 velocity decoder equipped with digital signal processing (DSP technology) has four measurement ranges which allow high-precision and high-resolution acquisition of vibrations or transient movements with a maximum velocity of 0.5 m/s. The upper three measurement ranges cover the full frequency range from 0 Hz to 350 kHz, while the lowest measurement range (1 $\frac{mm}{s}$/V) is limited to 20 kHz. Due to its strict bandwidth limitation, this measurement range provides the highest optical sensitivity and is therefore best suited for applications under unfavorable optical conditions. Apart from the usual analog voltage output, the VD-06 provides the option of transmitting measurement signals up to 42 kHz in digital form via the digital interface (S/PDIF format) directly to suitably equipped signal acquisition systems.

VD-09 The VD-09 is a digital broadband velocity decoder and is universally suitable for applications in the frequency range up to 2.5 MHz. It is equipped with the digital signal processing and has 8 measurement ranges which allow extremely accurate and high-resolution acquisition of vibrations or transient movements with a maximum velocity of 10 m/s. The lower cutoff frequency of 0 Hz (DC capability) enables the VD-09 decoder to be used unlimited also for the acquisition of uniform, intermittent or rotational movements.

2.2.3 Displacement Decoders

For displacement acquisition you have the option of installing a displacement decoder in the controller which works using fringe counting or a high-resolution DSP decoder. The analog displacement signal is made available directly at the DISPLACEMENT OUTPUT on the front view of the controller. The digital signal also generated by the DSP decoder is emitted directly via the S/PDIF transmitter as a data stream on the back view of the controller.

You will find detailed information on suitable settings for displacement acquisition in SECTION 5.6 and SECTION 5.7.

DD-100 The DD-100 displacement decoder works using fringe counting. It is especially suitable for acquiring relatively large displacement or vibration amplitudes respectively, for which a resolution of 80 nm is sufficient. Its eight finely graduated measurement ranges, each with a dynamic of 14 bits (> 80 dB), mean it can be optimally adapted to suit most measurement tasks in the frequency range from 0 Hz to 250 kHz.

DD-500 The DD-500 displacement decoder is based on state-of-the-art DSP technology. In contrast to fringe counting, the phase modulation of the Doppler signal is evaluated almost continuously in this case, thus attaining a displacement resolution of < 1 pm. A prerequisite for operating the DD-500 is that velocity decoder VD-06 is installed. The full operating frequency range is available in all displacement measurement ranges from 0 Hz to 350 kHz. The maximum speed of 0,5 m/s is also permissible in all displacement measurement ranges when the highest velocity measurement range of the VD-06 is set at the same time. The output signal of the DD-500 is available at the same time as the velocity signal of the VD-06 as a digital data stream in S/PDIF format at the digital interface.

DD-900 The DD-900 broadband displacement decoder is based on state-of-the-art digital technology. In contrast to fringe counting, the phase modulation of the Doppler signal is evaluated quasi-continuously in this case, thus attaining a displacement resolution of < 1pm. A prerequisite for operating the DD-900 is that the VD-09 velocity decoder is installed. The maximum velocity of 10 m/s and the maximum frequency of 2.5 MHz are available in all displacement measurement ranges if the selected velocity measurement range of the VD-09 allows these values.

2.2.4 Auxiliary Decoders

An additional displacement decoder installed for special applications is provided as an auxiliary decoder. Its analog output signal is available at the AUXILIARY OUTPUT on the front view of the controller.

You will find detailed information on suitable use of auxiliary decoders in SECTION 5.8.

VD-05 The VD-05 velocity decoder with two measurement ranges is suitable to acquire extremely high-frequency vibrations up to 10 MHz. Despite the wide bandwidth and the relatively rough scaling, the VD-05 attains excellent resolution values with spectral signal evaluation. Furthermore the VD-05 is suitable to acquire fast transient motions.

DD-300 The DD-300 displacement decoder has been developed especially for acquiring high-frequency vibrations and impulses in the frequency range from 30 kHz to 24 MHz. The amplitude range limited to ±75 nm is adapted to the physical limitations of high-frequency processes.

DD-400 With the DD-400 displacement decoder, displacement decoding is based on the analog integration of the velocity signal from the VD-04 velocity decoder. It is thus an alternative to real displacement decoders which directly evaluate the phase modulation of the Doppler signal. The measurement ranges 1 µm/V and 10 µm/V have been optimized for displaying the vibration amplitude of ultrasonic tools up to 250 kHz. A further measurement range 100 µm/V allows you to acquire vibration amplitudes in the acoustic frequency range of 10 Hz to 20 kHz.

DD-600 The DD-600 displacement decoder is not a complete signal decoder but is an I&Q converter used to operate the controller in connection with external signal decoding on the basis of the PC-based system VibSoft-VDD. Installing the DD-600 makes the Doppler signal available as a so-called quadrature signal pair (I&Q) for digital processing at the interface for external decoding External Decoder on the back.

2.2.5 Digital Filter Module

As an option, you can get an adaptive filter based on DSP technology for post-treatment of the velocity signal from the VD-06 velocity decoder in the frequency range from 0 Hz to 20 kHz. The specialty of this filter is suppressing noise and dropout distortions in stationary vibration signals.

You will find detailed information on using the adaptive DSP filter in SECTION 5.5.

2.2.6 S/PDIF Transmitter

The S/PDIF transmitter formats the serial data streams from the digitally operating modules to an output signal which corresponds to the S/PDIF standard (Sony / Philips Digital Audio Interface Format) familiar from audio technology. This signal is available on the back panel of the controller in both electrical and optical form and can be used to control suitably equipped signal processing systems.

You will find detailed information on using the digital output signals in SECTION 5.4.7.

2.2.7 Sensor Heads

The single point sensor heads and the fiber-optic respectively fiber-coupled sensor heads conform with the different requirements made of the vibrometer optics. For every sensor head a selection of lenses covers a wide range of stand-off distances. You will find a detailed description of the sensor heads in the respective manual of the sensor head.

Single point sensor heads

The OFV-503 and OFV-505 single point sensor heads are particularly suitable for long measurement distances. Focusing the laser beam with the OFV-505 sensor head can be effected manually or automatically and can also be controlled remotely via the controller or using a PC.

Fiber-optic sensor heads

The OFV-551 and OFV-552 fiber-optic sensor heads are particularly suitable for short measurement distances. Even almost inaccessible measurement points can be reached by using the flexible and slim optical fiber cables. In addition to that, the OFV-552 sensor head is capable of measuring differentially, i.e. it can acquire relative movements between two sample points. This technology allows high-resolution measurement on machine parts for example, while the whole machine is vibrating at an amplitude which would overload the measurement range necessary for making this measurement.

Fiber-coupled sensor head

The OFV-534 fiber-coupled sensor head is suitable for a wide range of stand-off distances. Even almost inaccessible measurement points can be reached by using the flexible and slim optical fiber cables. An integrated video camera can optionally be used for online monitoring the measurement volume. In addition, a microscope lens can be fitted directly onto the sensor head which makes it possible to measure vibration on microstructures.

3 First Steps

3.1 Unpacking and Inspection

Unpacking

The vibrometer is made up of the following components:

- OFV-5000 controller
- Interferometer cable between controller and sensor head
- RS-232(X) interface cable
- Mains cable
- Sensor head

NOTE!

The sensor head is described in detail in a separate manual!

Available as an option:

- S/PDIF cable (only for VD-06 velocity decoder)
- LF-02 adaptive DSP filter (only for VD-06 velocity decoder)

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 components etc.).
3. In the case of a wrong delivery, damage or missing parts, immediately inform your local Polytec representative, stating the serial number of the instrument. The serial number can be found on the identification label. You will find the identification label on the instruments (refer to SECTION 3.3) as well as on the inside cover of this manual.
4. Carefully retain the original packaging in case you have to return the instruments.

3.2 Operating and Maintenance Requirements

Ambient conditions

The instrument can be operated in dry rooms under normal climatic conditions (refer to specifications in CHAPTER 7). In particular the optical components are sensitive to moisture, high temperatures, vibrations and dirt.

If you start operating the instrument after storing it in a cold environment, allow a sufficient acclimatization period before switching it on. Avoid condensing moisture on the optical components as a result of a rapid temperature change.

Assembly

The vibrometer should not be set up provisionally. In particular the sensor head should be securely mounted as free of vibration as possible on a stable tripod or an alternative stable base using the fixing screw threads.

Cooling

Always keep the air inlets free. The distance to the wall must be at least 50 mm! Provide sufficient free space under the instrument as air vents are located there.

Connecting cable

As a general rule, the instrument may not be switched on until all connecting cables have been connected up. Make sure that all connections are connected properly and firmly.

Protect the connecting cables from mechanical damage and high temperatures. The bending radius may not fall below 50 mm.

Mains connection

The mains voltage inputs of the instruments are designed as wide range inputs and can be connected to all mains voltages with nominal values in the range from 100 V to 240 V.

Warming-up

The helium-neon laser requires some time to reach the optimal operating temperature after it has been switched on. The instrument does not reach its optimal metrological properties until a warm-up period of approx. 20 minutes. After that you can be sure that all components are working properly in accordance with the specifications. Less precise measurements, such as to align the vibrometer for example, can however be carried out with a useful result before this warm-up period has expired.

Transport

Several Polytec sensor heads are equipped with a transport safeguard. You will find detailed information on this in the manual of the sensor head.

Cleaning

Clean the housing surfaces with mild detergent or disinfectant solutions. Do not use organic solvents!

Switch off the instrument before cleaning it.

Installation of other components

Hardware or software components which do not belong to the system can damage the system or adversely affect the way the Polytec software functions. Using them will result in the loss of warranty. If you want to install such components, contact Polytec.

Opening the instruments Tampering with the instruments in any way is not necessary when using the equipment as intended and will invalidate the warranty. Exchanging or retrospectively installing subassemblies may only be carried out by authorized service personnel of Polytec.

3.3 Control Elements, Displays and Connections

Front view The front view of the controller is shown in the following figure.

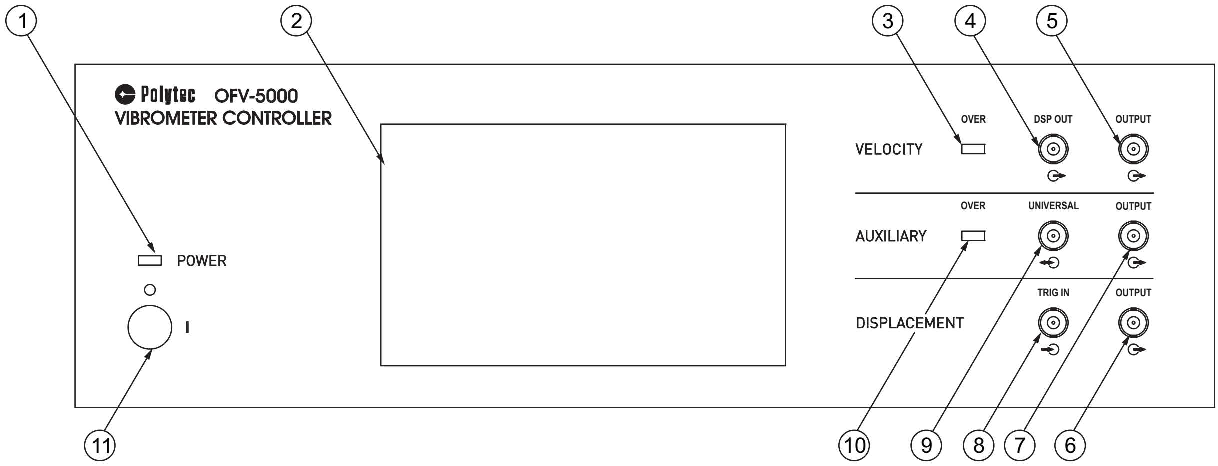

Figure 3.1: Front view of the controller

1 POWER LED

The LED lights up if the controller has been switched on with the key switch (position I) and indicates that the controller is ready to operate.

2 Touch screen

Display and modification of the configuration and settings of the controller

3 VELOCITY OVER LED for the velocity decoder

The LED lights up when the output voltage attains either the positive or the negative full scale value of the selected velocity measurement range. If the LED lights up permanently, the next highest velocity measurement range must be selected if available (refer also to).

4 VELOCITY DSP OUT signal output (BNC jack)

Output signal of the optional DSP filter. The output is only active when using the adaptive DSP filter.

5 VELOCITY OUTPUT signal output (BNC jack)

Output signal of the velocity decoder. 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 sensor head.

6 DISPLACEMENT OUTPUT signal output (BNC jack)

Output signal of the displacement decoder. The voltage at this output is in proportion to the current deflection of the object. The voltage increases when the object is moving towards the sensor head. The output is only active if an displacement decoder has been installed.

7 **AUXILIARY OUTPUT** signal output (BNC jack)

Output signal of the auxiliary decoder. The output is only active if an auxiliary decoder has been installed.

8 **DISPLACEMENT TRIG IN** signal input (BNC jack)

This signal input can be used to reset the displacement decoder remotely to the zero position. The input is only active if an displacement decoder has been installed.

9 **AUXILIARY UNIVERSAL** signal output (BNC jack)

Signal output for special functions of the auxiliary decoder. The output is only active if an auxiliary decoder has been installed.

10 **AUXILIARY OVER** LED for the auxiliary decoder

The LED lights up when the output voltage attains either the positive or the negative full scale value of the selected measurement range. If the LED lights up permanently, the next highest measurement range must be selected if available (refer also to). The LED is only active if an auxiliary decoder has been installed.

11 **I/O** mains switch

The key switch disconnects the controller from the mains (position O) and is used to switch it off in case of danger.

Back view The back view of the controller is shown in the following figure.

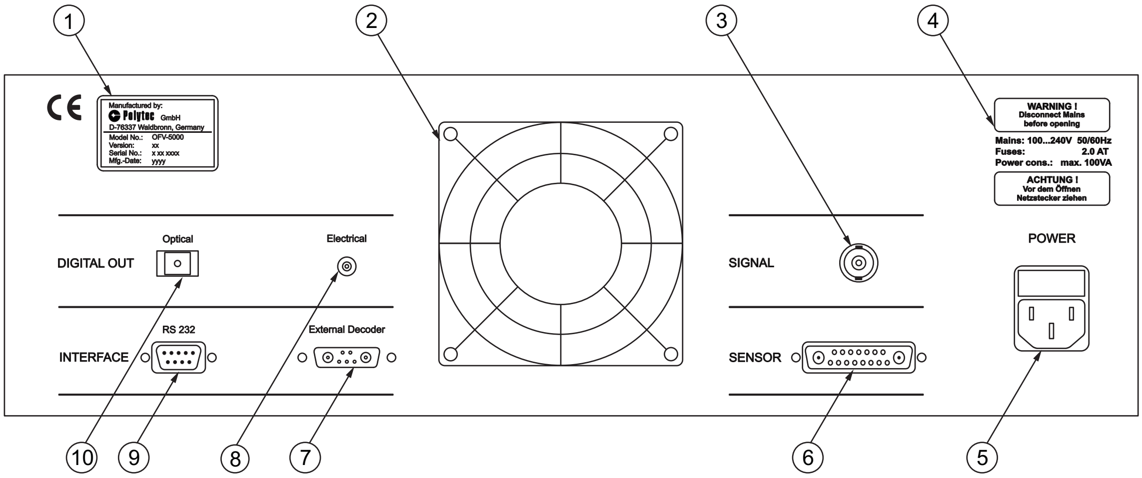

Figure 3.2: Back view of the controller

1 Identification label

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

2 Cooling fan

3 **SIGNAL** output (BNC jack)

The DC voltage at this output is proportional to the logarithm of the optical signal level. This signal can be used to monitor the optical measurement conditions externally.

4 Instrument warning label

On the instrument warning label you will find technical data for the fuses and the mains connection.

5 **POWER** mains connection (socket for standard power cord with built-in fuses)

The mains voltage input is designed as a wide range input.

6 **SENSOR** connection (Sub-D jack)

Connection for the interferometer cable

7 **External Decoder** interface (Sub-D jack)

Connection for PC-based displacement decoder

8 **Electrical** digital signal output (TRIAX jack)

Connection for the optional S/PDIF cable to transmit the S/PDIF signal

9 **RS 232** interface (9-pin Sub-D plug)

Connection for the RS-232(X) cable to control the controller via the software.

10 **Optical** digital signal output (TOSLINK jack)

Connection for an optical fiber cable with a TOSLINK plug to transmit the S/PDIF signal

3.4 Installation and Functional Test

CAUTION!

Damage caused by heat accumulation ! Always keep the air inlets and outlets free. The distance to the wall must be at least 50 mm! Provide sufficient free space under the instrument as air vents are located there!

NOTE!

First of all, always connect up all connecting cables. Switch on the PC as the last instrument so that the software detects the other instruments connected.

The implementation of a first functional test is described in the following. If the instrument does not perform as described, read through the information on fault diagnosis in CHAPTER 6 and if required, contact your local Polytec representative.

To start using the vibrometer and to carry out a first functional test, proceed as follows:

Prepare

1. Switch the key switch on the controller to position O and close the beam shutter on the sensor head.
2. Place a piece of retro-reflective film (enclosed in the manual) at a distance of approx. 30 cm from the front of the sensor head so that it is in the beam path of the sensor head.

Cabling

3. Plug the interferometer cable into the SENSOR Sub-D jack on the back of the controller and into the corresponding Sub-D jack on the sensor head. Secure all the connections with the screws provided.

   All connections must be easy to plug in. If not, check the plugs for bent contact pins to avoid serious damage being incurred.
4. Use the mains cable to connect up the controller to an earthed wall outlet.
5. If applicable, connect up an oscilloscope or another signal evaluation system (for example a PC with evaluation software) to the OUTPUT BNC jack in the VELOCITY field on the front of the controller.

Switch on

6. Switch on the controller by turning the key switch to position I.

   The POWER LED on the front of the controller lights up. If the interferometer cable between the controller and the sensor head is connected up correctly, then the LED for the emission indicator on the sensor head will also light up (refer to the manual of the sensor head). Laser light can not yet be emitted as the beam shutter is still closed.

NOTE!

Before you start working with laser light, pay attention to the information on laser safety in SECTION 1.2 and in the manual of the sensor head!

7. Open the beam shutter on the sensor head.

   The laser beam is now emitted from the sensor head.

WARNING!

Danger of injury caused by laser light! Do not look directly into the laser beam!

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

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

Test

8. Vibrometer systems with the sensor head OFV-505 are set to autofocus on delivery. As soon as you switch on the controller, the sensor head therefore focuses itself.

   When automatically focusing the sensor head, the focus range of the laser optics is traversed several times. In doing so, the point at which the laser beam hits the retro-reflective film changes its size and after several seconds will come to rest at a minimum diameter.

9. You will have to focus all other sensor heads manually. To do so, rotate the focusing ring on the sensor head until the point at which the laser beam hits the retro-reflective film has the smallest possible diameter.

   If the sensor head and the input section of the controller are working properly, the signal level display will light up fully after focusing. A base line can then be seen on a connected signal evaluation system. If you slightly move the retro-reflective film, you can now observe the deflections of the measurement signal.

NOTE!

The instrument does not reach its optimal metrological properties until a warm-up period of approx. 20 minutes.

If this functional test was successful, you can now make measurements with the vibrometer as described in CHAPTER 4 and CHAPTER 5.

Direction convention

The following direction convention applies to the output signals:

A movement towards the sensor head is seen as being positive. In this case the velocity output provides a positive voltage and the displacement output provides an increasing voltage.

4 Making Measurements

4.1 Switching On and Off

CAUTION!

Damage caused by wrong cabling! Before you switch on the instrument, connect up all connecting cables in the correct order!

You switch on the vibrometer by turning the key switch on the front of the controller to position I. The POWER LED above the key switch lights up and shows that the controller is ready to operate. At the same time the LASER or STANDBY LED on the sensor head will also light up respectively, if the interferometer cable between controller and sensor head is connected up correctly.

4.2 Operating the Controller via the Touch Screen

4.2.1 Operating Concept

The controller is operated via the menu shown on the touch screen. The contents of this menu control automatically adapt to the existing hardware configuration of the controller. The selection of the menus and the individual settings is done by touching on the touch screen.

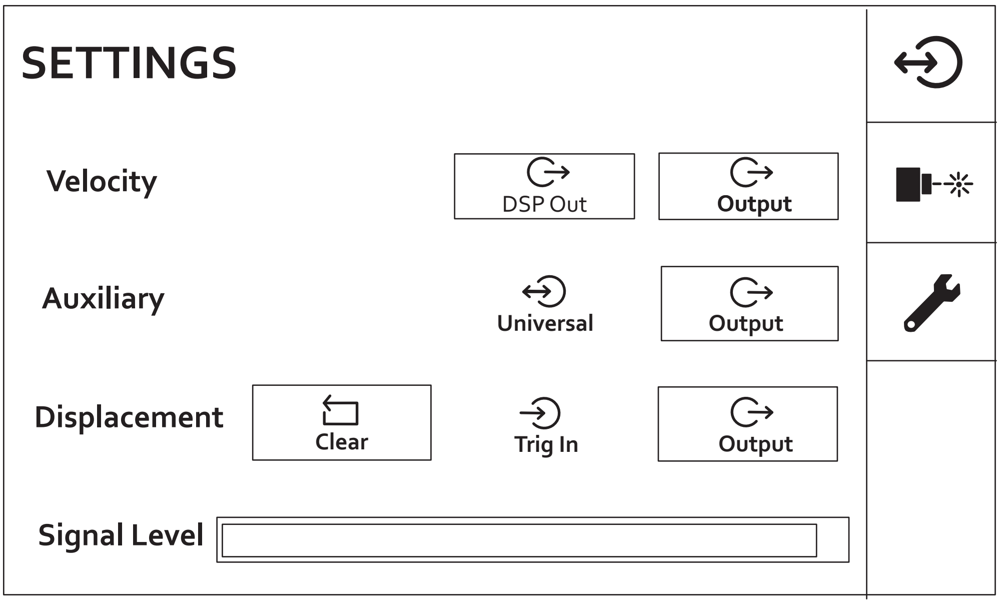

Figure 4.1: SETTINGS page on the touch screen

The adjustable parameters been assigned to the following three menus:

- The menu SETTINGS contains all parameters which can be set individually for a particular measurement.
- The SENSOR HEAD menu contains all parameters which concern the sensor head.

- The SETUP menu contains all the basic parameters for the controller which are not assigned to a particular measurement.

You will be informed of malfunction of the system, operating errors (such as the sensor head accidentally not being connected) and advice by various messages on the touch screen (refer also to SECTION 4.2.5 and SECTION 6.4).

4.2.2 Moving within the Menus

By taping on the menus you can access all sub-menus and parameters of the controller. Tap again on the menu to return from a sub-menu to the superordinate menu. To close the pages with the parameter settings, tap on .

These three menu items can be chosen:

SETTINGS: The SETTINGS menu contains all settings for the controller which are relevant for a measurement (decoder selection, measurement ranges, filter settings, etc.).

SENSOR HEAD: The SENSOR HEAD menu contains all settings which concern the sensor head (e.g. the focusing), if the sensor head connected can be controlled remotely from the controller.

SETUP: The SETUP menu contains the configuration of the controller and other settings which are not directly associated with a particular measurement (e.g. saving the settings, interface configuration).

4.2.3 Changing Settings

To change a setting, first of all you have to activate the corresponding parameter on the touch screen. After that you can change the value and confirm the change. To do so, proceed as follows:

1. Tap on the parameter.

   The page for the parameter settings is displayed.

2. Tap on or to change the parameter settings.

3. Tap on .

   The setting is assumed.

4. Tap on .

   The page is closed.

4.2.4 Saving and Loading Settings

Five profiles are saved in a nonvolatile memory. Before you switch off the controller you can select whether one of the three user settings (User1, User2, User3), or the default setting (Default), or the last used setting (Last) is loaded automatically when switching on the controller next time.

Save settings

To save settings, proceed as follows:

1. Tap on 🔧.

   The SETUP *page is displayed.*

2. Tap on PowerUp.

   The Setup | PowerUp Mode *page is displayed.*

3. Tap on < or > to select a saving name (User1, User2 or User3).

4. Tap on Save User Settings.

   Settings saved! *is displayed. The current settings are saved under the select saving name.*

5. Tap on ☑.

   The setting is assumed.

6. Tap on ☒.

   The page is closed.

Load settings

To load settings you have already saved, proceed as follows:

1. Tap on .
   The SETUP *page is displayed.*
2. Tap on PowerUp.
   The Setup | PowerUp Mode *page is displayed.*
3. Tap on or to select a saving name (User1, User2 or User3).
4. Tap on .
   The next time you switch it on, the controller will start up with the settings you saved under the selected name.

Default settings

The controller can be started with the default settings too. To do so, proceed as for loading saved settings. Select the Default entry instead of the saving name.

Settings last used

The controller can be started with the last used settings too. To do so, proceed as for loading saved settings. Select the Last entry instead of the saving name.

4.2.5 Touch Screen Messages

Messages which appear on the touch screen of the controller are divided into categories.

In SECTION 6.4 you will find all error messages, their possible causes and tips on how to rectify them.

All messages are closed by taping on .

4.3 Preparing and Making Measurements

Setup

To make a measurement, proceed as follows:

1. Switch off the controller and close the beam shutter of the sensor head.
2. Set up the sensor head as described in the manual of the sensor head.

Switch on

3. Switch on the controller.

NOTE!

The instrument does not reach its optimal metrological properties until a warm-up period of approx. 20 minutes.

4. Adapt the controller settings to suit your measurement task. To do so, tap on .

   The SETTINGS *page is displayed.*

   You will find a detailed description of how to operate the controller by the touch screen in SECTION *4.2.*

5. Tap on the area where you want to adjust the settings.

   The corresponding page is displayed.

6. On this page select the respective suitable decoder and adjust the measurement ranges and filter settings.

   You will find detailed information on suitable settings in CHAPTER *5.*

7. Before you open the beam shutter on the sensor head, pay attention to the information on laser safety in SECTION 1.2 and in the manual of the sensor head!

8. Open the beam shutter on the sensor head.

   The laser beam is now emitted from the sensor head.

NOTE!

The sensor head is described in detail in a separate manual!

Measure

9. Focus the laser beam on the measurement surface. You can look up how to focus the laser beam using the controller in SECTION 5.1.

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

10. If the signal level is low or fluctuating greatly, reduce the stand-off distance by approx. 10 cm, as it is possible that the sensor head in this case is positioned at an unfavorable distance to the object under investigation. You will find information on optimal stand-off distances in the manual of the sensor head.

The measurement signal is now available at the corresponding jacks of the controller and can be analyzed with a signal evaluation system.

In SECTION 4.4 you will find information on when velocity acquisition and when displacement acquisition provides the more meaningful measurement results.

In CHAPTER 5 you will find information which will help you to set up the controller optimally for your measurement task and thus receive the highest possible quality measurement signals.

4.4 Velocity or Displacement Acquisition

The vibrometer can supply the velocity and the displacement information independently from each other. If the vibrometer is equipped with velocity and displacement decoders, then for many applications you have to decide which is the optimal measured quantity. This applies in particular to harmonic vibrations, as here the velocity and displacement signal provide equivalent information due to the following relationship:

$$\hat{v} = 2\pi \cdot f \cdot \hat{x}$$ Equation 4.1

$\hat{v}$... Velocity amplitude

$\hat{x}$... Displacement amplitude

f... Frequency

In contrast to this, transient motion sequences in most cases are shown more clearly by the displacement signal.

Apart from these application-specific aspects, there are also some process-specific factors affecting the selection of the measured quantity. These are explained in the following.

Dynamic range

In the case of the DD-100 displacement decoder which works using fringe counting, due to the counting width of 14 bits, the relatively resolution of the displacement measurement ranges is 8192 increments with symmetrical modulation. This corresponds to a dynamic range of approx. 78 dB. For the displacement acquisition the noise floor as a general rule is below the resolution and thus is not evident.

In contrast to displacement acquisition, the resolution for velocity acquisition is only limited by the noise floor. With good optical signals (e.g. on reflective film) and measurement bandwidths of several hertz, the noise floor is usually more than 100 dB below the full scale value. This corresponds to a dynamic range more than 10 times larger than that available with displacement acquisition.

Resolution

If according to the equation (4.1) you translate the absolute noise-limited resolution of the velocity decoder (approx. 0.2 $\frac{\mu m}{s}/\sqrt{Hz}$) into the corresponding amplitude of a sinusoidal vibration with a frequency of 100 kHz, then you will get a value of approx. $3 \cdot 10^{-13}$ mm or resp. 0.3 pm! This means that with high frequencies in particular, a significantly higher resolution can be attained with velocity acquisition than with displacement decoders which work using fringe counting. The DD-500 and DD-900 DSP displacement decoders are the only ones with which a comparable resolution can also be attained directly from the displacement signal.

Signal-to-noise ratio

The vibration to be measured is usually superimposed by interfering vibrations from the surroundings or from the object under investigation itself. These interfering vibrations (e.g. building vibrations) often have low frequencies, but large displacement amplitudes. To avoid overloading, the displacement measurement range must be selected, taking this amplitude of the interfering vibration into consideration. Even if the wanted signal then shows up at all, you still get a bad signal-to-noise ratio at the output.

The situation is quite different for the velocity acquisition. With the same displacement amplitude but a higher frequency, the velocity amplitude of the wanted signal is a factor of $2\pi \cdot f_{Signal}/f_{Interfering}$ larger than the interfering vibration (refer to equation (4.1)). Therefore the signal-to-noise ratio is a priori greater with velocity acquisition. A realistic ultrasonic application should illustrate this:

Vibration to be measured:	e.g.	
	$f_{Signal} = 100\,kHz$,	$\hat{x}_{Signal} = 1\,\mu m$
=>	$\hat{v}_{Signal} = 6.28 \cdot 10^{-1}\,m/s$ (refer to equation (4.1))	
Interfering vibration:	typically	
	$f_{Interfering} < 100\,Hz$,	$\hat{x}_{Interfering} < 10\,\mu m$
=>	$\hat{v}_{Interfering} < 6.28 \cdot 10^{-3}\,m/s$	

The signal-to-noise ratio here is orders of magnitude greater for the velocity acquisition, even if the interfering vibration has an amplitude which is 10 times higher. If the displacement signal is explicitly required, then after separating out the low-frequency interference signal using a suitable high pass filter, it can be calculated very precisely through signal integration. This process is realized using the DD-400 displacement decoder which translates the velocity signal into a displacement signal using analog integration.

Vibration frequencies

Process-related the individual displacement decoders have different frequency bandwidths. While the decoders like DD-100, DD-300, DD-400 and DD-500 have fixed maximum vibration frequencies, the frequency bandwidth of the DD-900 depends on the set velocity measurement range. When acquiring high vibration frequencies always pay attention to the setting instructions and specifications of the installed displacement decoders.

5 Selecting Suitable Settings

5.1 Focusing the Laser Beam with the Aid of the Controller

To get the highest possible quality of the measurement signal, the laser beam has to be optimally focused. The laser beam is optimally focused when the diameter of the laser beam target area on the object is as small as possible. Due to blooming effects in the focus point, it is often difficult to ascertain when the smallest diameter has been reached. For this reason you can also view the signal level display either on the sensor head or on the controller. The signal level is shown as a bar in every menu of the controllers display. The more signal level is shown, the better the laser beam has been focused.

As the actual aim of focusing is to minimize the undesired noise signals, you can also use the output signal from the controller for orientation purposes when focusing. Observe the output signal on an oscilloscope or another signal evaluation system while focusing the laser beam on the unmoved object. The better the focus of the laser beam, the smaller the amplitude of the noise.

NOTE!

Please note that the setting options for the sensor head using the controller described in the following are only available for the OFV-505 sensor head! All other sensor heads have to be focused manually using the focusing ring. To do so, refer to the manual of the sensor head!

There are different ways to focus the laser beam:

- Manual focusing with the focusing ring on the sensor head (refer to the manual of the sensor head)
- Remote focusing via the touch screen on the controller (Remote Focus, refer to SECTION 5.1.1)
- Remote focusing via the RS-232 interface on the controller (refer to the separate manual)
- Automatic focusing via touch screen on the controller (Auto Focus, refer to SECTION 5.1.2)

Apart from that, you can remotely lock the manual focus via the touch screen on the controller. This avoids unintentional defocusing of the laser beam.

5.1.1 Remote Focus

To focus the sensor head using Remote Focus function via the touch screen of the controller, proceed as follows:

1. Tap on [sensor head icon].

   The SENSOR HEAD *page is displayed.*

2. Tap on [<] or [>] to change the focus distance of the optics at Remote Focus.

NOTE!

If you tap on the arrow symbols shortly the focus distance of the optics is changing step by step. If you keep holding your finger on the arrow symbols the optics is traveling longer ranges quickly.

3. When focusing, orientate yourself towards the signal level or the noise amplitude as also described in SECTION 5.1.

Alternatively you can also focus the sensor head remotely with the aid of suitable software (e.g. VibSoft) via the RS-232 interface on the controller. See the separate manual on this.

5.1.2 Auto Focus

The function Auto Focus available for the sensor head traverses the focus range of the optics and ascertains the position at which the intensity of the reflected light received reaches its maximum. To start the Auto Focus, proceed as follows:

1. Tap on .

   The SENSOR HEAD *page is displayed.*

2. Tap on Start Auto Focus.

NOTE!

The Auto Focus function only provides a meaningful result if the laser beam is pointed at an unmoving object while focusing!

The controller starts focusing the laser beam automatically. This changes the diameter of the target area of the laser beam on the object which makes the signal level display on the sensor head or respectively the touch screen of the controller fluctuate, depending on this diameter.

Automatic focusing is completed once the focus range of the sensor head has been traversed twice.

The laser beam is now focused and ready to make measurements. If the laser beam is not focused, the automatic focus was not successful (refer also to the following section).

Problems with Auto Focus

The Auto Focus function is not always able to focus the laser beam optimally in all cases. In such cases, you need to focus the laser beam either remotely via the touch screen on the controller (Remote Focus function, refer to SECTION 5.1.1) or manually using the focusing ring on the sensor head (refer to the manual of the sensor head).

Problems can occur with Auto Focus particularly if:

- the object under investigation has got an optically irregular surface or
- a very small object is to be measured in front of a reflective background.

In such cases, the signal level with a badly focused laser beam may be higher than with an optimally focused laser beam. The Auto Focus function then identifies out of focus as the supposedly optimal setting.

You may be able to solve the problem by:

- increasing the reflectivity of the surface to be measured with retro-reflective film or similar material or
- making measurements on small objects in front of a beam absorbing background, e.g. black felt.

5.1.3 Saving and Loading Focus Position

To save a focus position of the OFV-505 sensor head which is set in the controller in a flash memory of the controller and to load it again, proceed as follows:

1. Tap on .

   The SENSOR HEAD *page is displayed.*

Save

2. Tap on Save Position.

   The current focus position is saved in a flash memory in the controller.

NOTE!

The focus position is only saved while the controller is switched on. If you want the focus position to be saved permanently, you have to save the focus position and then the complete settings of the controller as described in SECTION 4.2.4.

Load

3. To reload a saved focus position, tap on Load Position on the SENSOR HEAD page.

   The most recently saved focus position is read from the memory and the optics travel to the corresponding position.

5.1.4 Locking Manual Focus

The laser beam can at any time also be focused manually directly using the focusing ring on the sensor head. This manual focusing can be locked remotely from the controller for the OFV-505 sensor head. This avoids unintentional defocusing of the laser beam. The focusing ring on the sensor head can then still be rotated, but this rotation has no longer any effect on the optics in the sensor head and thus on the focus of the laser beam.

To lock the manual focusing of the laser beam, proceed as follows:

1. Tap on .

   The SENSOR HEAD *page is displayed.*

2. Tap on to lock or on to unlock the manual focus.

NOTE!

This setting is now retained even after the device is switched off and can only be changed manually.

5.2 Dimming the Laser Beam with the Aid of the Controller (Optional)

There is an option at the controller to dim the laser beam and thus reduce the laser intensity on the fiber-optic sensor heads (new series OFV-551/-552).

To dim the laser of a fiber-optic sensor head, proceed as follows:

1. Tap on .

   The SENSOR HEAD *page is displayed.*

2. Tap on Dimmer.

   The SENSOR HEAD | Dimmer *page is displayed.*

3. Tap on or to select the value for the dimmer.

4. Tap on .

   The setting is assumed.

   The intensity of the laser has now been weakened in accordance with the settings you have made. In this, the value 0 corresponds to full laser power. You also have the option to select steps –1 to –7. The intensity of the laser is reduced by approximately half per step.

NOTE!

On making measurements with high dimmer values (depending on the light level) the switching frequency of the dimmer can occur in the measurement signal as an interference. In this case, select another switching frequency. You can set the switching frequency via the RS-232 interface (refer to RS-232 user manual)!

5.3 Switching the Laser Beam On/Off with the Aid of the Controller (Optional)

There is an option for fiber-optic sensor heads (new series OFV-551/-552) to switch on/off the laser beam at the controller.

To switch on/off the laser of a fiber-optic sensor head at the controller, proceed as follows:

1. Tap on .

   The SENSOR HEAD *page is displayed.*

2. Tap on Laser.

   The indicator is changing to On *when the laser is switched on or resp. to* Off *when the laser is switched off.*

5.4 Suitable Settings for Velocity Acquisition

This section gives you advice on how the controller needs to be set for velocity acquisition to attain optimum measurement results. You will find information on the VD-05 velocity decoder in the section on auxiliary decoders (refer to SECTION 5.8).

5.4.1 Selecting a Suitable Velocity Decoder

If your controller is equipped with several velocity decoders, you should first select the decoder optimally suited for your measurement task and set it up. The following information on the individual velocity decoders should support you in making this selection.

VD-01

If this decoder is installed alone, it covers the frequency range 0.2 Hz to 50 kHz, up to a maximum velocity of 10 m/s. In combination with a second decoder (usually VD-02), the velocity range is limited to a maximum of 1.25 m/s. In this case, for all measurements up to 50 kHz which do not exceed a velocity of 1.25 m/s, select the VD-01 due to its superior resolution. In the measurement ranges 125 $\frac{mm}{s}$/V and 1 000 $\frac{mm}{s}$/V, the lower cutoff frequency of the VD-01 velocity decoder is equal to zero, so that here uniform or intermittent movement can be acquired without falsifying its progress over time.

VD-02

With its frequency range between 0.5 Hz and 1.5 MHz and a maximum velocity of 10 m/s, the VD-02 velocity decoder has got the largest operating range and can be used universally. When the VD-02 is activated, you should switch off the VD-06 digital decoder, as otherwise high-frequency noise peaks can occur in the spectrum of the velocity signal. You will find detailed information on this in SECTION 5.4.6.

VD-04

The VD-04 velocity decoder is mainly installed along with the DD-400 displacement decoder (displacement decoder using integration, refer to SECTION 5.8.3). The same advice applies to using it as applies to using the VD-02.

VD-05

The VD-05 velocity decoder is designed for high-frequency applications up to 10 MHz and is installed optionally as an auxiliary decoder. Because of its slightly inferior linearity and accuracy due to the principle it works on, you are best to only use it when the frequency range of the main decoder is insufficient. You will find detailed information on this velocity decoder in SECTION 5.8.1.

VD-06

Of all the available velocity decoders, the VD-06 digital decoder has the best metrological properties within its frequency and velocity limits (350 kHz at velocities up to 0.5 m/s) and should therefore always be your first choice for all suitable applications. As its lower cutoff frequency is 0 Hz, the VD-06 is also suitable in all measurement ranges for acquiring uniform or intermittent movements or extremely low-frequency vibrations respectively.

For applications in the acoustic frequency range this decoder is equipped with a narrow-band, high-sensitivity measurement range (1 $\frac{mm}{s}$/V). In particular when measuring under unfavorable optical conditions, e.g. on large structures, this measurement range should be favored.

VD-09

Out of all available velocity decoders, the digital VD-09 decoder with its frequency range of 0 Hz to 2.5 MHz and a maximal velocity of 10 m/s has the largest operating range and can be universally used. As its lower cutoff frequency is 0 Hz, the VD-09 is also suitable in all measurement ranges for acquiring uniform or intermittent movements or extremely low-frequency vibrations.

NOTE!

In the case of measurement tasks with analysis of the vibration phase, attention must be paid to the signal propagation delay (phase shift) of the digital velocity decoders which is, due to the principle it works on, slightly longer than for analog decoders. Further features of the controller with the digital velocity decoders are described in SECTION 5.4.6.

Set the velocity decoder

To set the most suitable velocity decoder, proceed as follows:

1. Tap on .

   The SETTINGS *page is displayed.*

2. In the Velocity area, tap on Output.

   The SETTINGS | Velocity *page is displayed.*

3. Tap on Decoder.

   The page for the parameter setting is displayed.

4. Tap on or to select the velocity decoder.

5. Tap on .

   The setting is assumed.

6. Tap on .

   The page is closed.

5.4.2 Selecting the Velocity Measurement Range

Suitable settings

When selecting the measurement range, first of all take the expected maximum values on the measurement for the velocity and frequency or acceleration into account. To attain favorable modulation, i.e. an optimal signal-to-noise ratio and the best possible resolution of the measurement signal, you should always select the smallest possible measurement range with amplitude limits which are sufficient for the application (refer to CHAPTER 7).

If either the positive or the negative boundary of a measurement range has been reached, the OVER LED in the VELOCITY field lights up on the front panel of the controller. As a general rule, you should then select the next highest measurement range. However please note that this LED is activated even by very brief overloading which can also be caused by noise spikes. In such cases, the velocity measurement range can be maintained as long as it is suitable for the amplitude of the wanted signal. Monitoring the signal on an oscilloscope will definitely clarify this. For this purpose, connect up an oscilloscope to the OUTPUT BNC jack in the VELOCITY field on the front panel of the controller.

Set the measurement range

To set the measurement range for velocity acquisition, proceed as follows:

1. Tap on ⎆.

   The SETTINGS *page is displayed.*

2. In the Velocity area, tap on Output.

   The SETTINGS | Velocity *page is displayed.*

3. Tap on Range.

   The page for the parameter setting is displayed.

4. Tap on ‹ or › to select the measurement range.

5. Tap on ☑.

   The setting is assumed.

   The upper cutoff frequency of the measurement range set is displayed in the Max.Freq. *field.*

6. Tap on ☒.

   The page is closed.

5.4.3 Setting the Tracking Filter

Suitable settings

The tracking filter can be used to improve the signal-to-noise ratio of the input signal of the sensor head. This filter bridges brief dropouts which always occur due to the speckle nature of the light scattered back from the object.

The tracking filter can improve signals on all analog velocity decoder, as well as on the broadband VD-09 velocity decoder. Due to the used principle of decryption with the digital VD-06 velocity decoder, the tracking filter does not have any effect on the signal quality here.

To reduce noise, the tracking filter works best with a high time constant (corresponds to the tracking filter mode Slow). With a high time constant however, it may not be possible to track highly dynamic signals. In such cases, the tracking filter either needs to be switched to the Fast mode or needs to be switched off (Off). You will need to ascertain the most favorable setting for the tracking filter from case to case or estimate it based on the range diagram in FIGURE 5.1. The range diagram shows the performance data with the dynamic limits for both settings of the tracking filter plotted over the frequency.

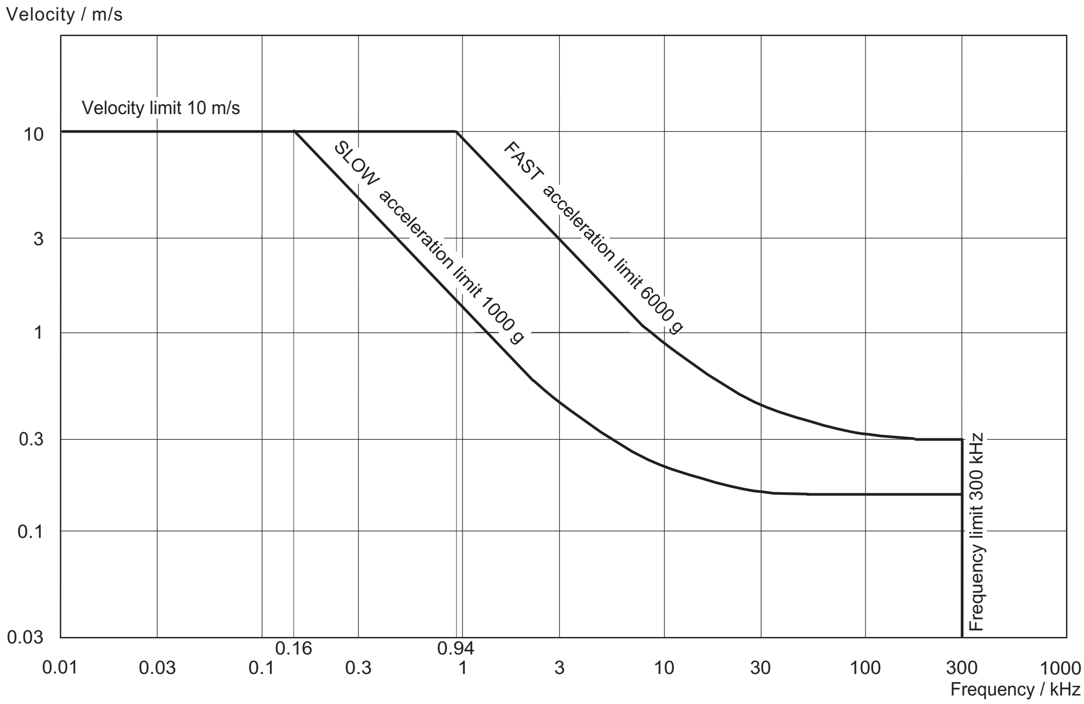

Figure 5.1: Schematic range diagram of the tracking filter

It is characteristic for the maximum velocity to decrease with increasing frequency. The maximum velocity of 10 m/s can only be processed up to a cutoff frequency of 160 Hz or 940 Hz respectively. Above that, the velocity limit transforms into an acceleration limit, i.e. the maximum velocity decreases inversely proportionally to the frequency. For velocities below 150 mm/s or 300 mm/s, acceleration no longer have to be taken into account.

For the setting of the tracking filter, the range diagram in FIGURE 5.1 can be summarized with the following rules of thumb:

- Use the tracking filter in connection with VD-01, VD-02, VD-04 and VD-09 velocity decoders to improve the signal noise if the optical signal is weak. If you have a good optical signal, it is not possible for the tracking filter to improve the signal-to-noise ratio for physical reasons. It should be switched off if detrimental effects can be identified.
- Select the Slow or Fast mode depending on the peak acceleration. Below a certain velocity, no acceleration limits need to be observed. For this reason, in the lower measurement ranges to 10 $\frac{mm}{s}/V$, you can usually set the tracking filter mode to Slow.
- For average velocities and frequencies, the acceleration limits of the tracking filter have to be taken into account. The optimum setting has to be found using the range diagram. If the velocity or acceleration limit of the tracking filter is exceeded, then the internal phase-locked loop loses lock. The signal is then distorted roughly. In FIGURE 5.2 you can see an example of an oscillogram showing a distorted signal. Signal A shows a sinusoidal velocity signal with the tracking filter switched off. Signal B shows the same signal with the tracking filter switched on in Slow mode. Here the tracking filter is at the limit of losing lock and the signal is partially being distorted.

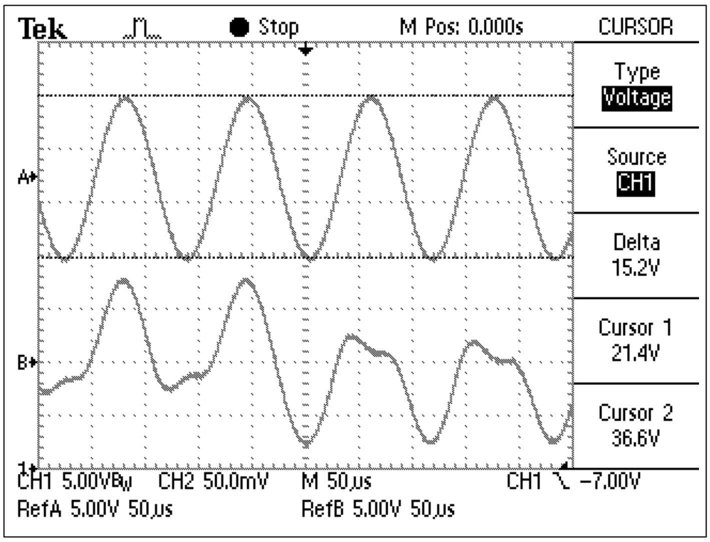

Figure 5.2: True velocity signal (A) and signal when the tracking filter loses lock (B)

- For particularly precise measurements, the tracking filter should be switched off because it can cause amplitude errors of up to 0.5 dB with high vibration frequencies. For measured frequencies which are above 300 kHz, as a general rule the tracking filter should always be switched off because here it can cause waveform distortions.

Set the tracking filter

To set the mode for the tracking filter, proceed as follows:

1. Tap on ⎆.

   The SETTINGS *page is displayed.*

2. In the Velocity area or in the Auxiliary area, tap on Output (if a auxiliary velocity decoder is installed).

   The SETTINGS | Velocity *or resp.* SETTINGS | Auxiliary *page is displayed.*

3. Tap on Track.Filter.

   The page for the parameter setting is displayed.

4. Tap on < or > to set the mode for the tracking filter.

5. Tap on ☑.

   The setting is assumed.

6. Tap on ☒.

   The page is closed.

5.4.4 Setting the Low Pass Filter

Suitable settings

The controller is equipped with adjustable low pass filters so that the measurement bandwidth of velocity acquisition can be adapted to suit the respective application. When presenting the measurement signals in the time domain, the signal-to-noise ratio can be improved by limiting the bandwidth to the necessary measure. For analysis in the frequency range with an external FFT analyzer, low pass filters only play a secondary role. Here you can reduce overloading the FFT analyzer which has been caused by noise effects.

You can select analog low pass filters with the cutoff frequencies 5 kHz, 20 kHz, 100 kHz or 1.5 MHz for the output signal of the respective selected velocity decoder. Using the Off setting the filter will be switched off, so that the frequency bandwidth is only determined by the velocity decoder.

Apart from that, the digital decoders offer you the possibility of limiting the bandwidth with a digital low pass filter. The most measurement ranges are available twice (refer to SECTION 7.5.4 and SECTION 7.5.5): Once with a maximum frequency and once with the reduced frequency. As digital filters have significantly better properties than analog filters, a bandwidth limitation should always be carried out with this digital low pass filter first when using this digital decoder. For further bandwidth limitations you can then use the analog low pass filters in addition.

For precise measurements, you must pay attention to the frequency response of the analog low pass filter. The corresponding diagrams for amplitude frequency response, amplitude error and phase frequency response of the low pass filter 5, 20 and 100 kHz, you will find in APPENDIX A. If you do not wish any additional bandwidth limitation, set the low pass filter in connection with the VD-09 broadband decoder in position Off, with all other decoders in position 1.5 MHz. Under these condition the specifications for amplitude and phase frequency response of the respective decoder are valid. The frequency response of the digital low pass filter in the VD-06 and VD-09 can be ignored as digital filters have got almost ideal properties.

The analog low pass filters 5, 20 and 100 kHz have got third order Bessel characteristics. The phase linearity from the frequency zero to the cutoff frequency is characteristic for this filter type, i.e. the phase shift increases in proportion to the frequency. However these filters cause amplitude errors in the pass band which can be roughly estimated:

- The amplitude error is less than –5% up to 40% of the cutoff frequency.
- In the range up to 70% of the cutoff frequency, the amplitude error increases to approx. –15%.
- The upper 30% of the pass band should only be used for orientation purposes. At the cutoff frequency set for the filter, the amplitude error is –3 dB (approx. –30%).

The phase shift increases in proportion to the frequency from close to zero degrees at a few hertz to approx. –100 degrees at the cutoff frequency (refer to FIGURE A.3). Due to the linear phase frequency response, the filter transmits pulses optimally, as all frequencies in a complex wave are subjected to the same time delay. The shape of the pulse is thus not distorted, but merely subjected to a time delay.

An additional time delay is caused by the velocity decoder. This depends on the velocity decoder used and also on the velocity measurement range and is several micro seconds long. The resulting phase shift $\Delta\Phi$ can be estimated using the following simple equation:

$$\hat{v} = 2\pi \cdot f \cdot \hat{x} = \text{konst.} \qquad \text{Equation 5.1}$$

$\hat{v}$ ... Velocity amplitude

$\hat{x}$ ... Displacement amplitude

f... Frequency

NOTE!

Apply the p_D value with the negative sign from SECTION 7.5, otherwise you will get incorrect results.

The values for the frequency-dependent phase shift (refer to SECTION 7.5) are valid for all decoders in conjunction with the 1.5 MHz filter setting. For the VD-09 velocity decoder these specifications are valid with the Off filter setting.

Set the analog low pass filter

To set the analog low pass filter, proceed as follows:

1. Tap on ⎆.

   The SETTINGS *page is displayed.*

2. In the Velocity area, tap on Output.

   The SETTINGS | Velocity *page is displayed.*

3. Tap on Low Pass.

   The page for the parameter setting is displayed.

4. Tap on ◁ or ▷ to select the cutoff frequency.

5. Tap on ☑.

   The setting is assumed.

6. Tap on ☒.

   The page is closed.

Set the digital low pass filter

To activate the digital low pass filter for the VD-06 or VD-09, proceed as follows:

1. Tap on ⎆.

   The SETTINGS *page is displayed.*

2. In the Velocity area, tap on Output.

   The SETTINGS | Velocity *page is displayed.*

3. Tap on Range.

   The page for the parameter setting is displayed.

NOTE!

With the digital decoder, various measurement ranges are available twice: Once at the maximum frequency (without LP) and once at the reduced frequency (with digital LP)!

---

4. Tap on ◁ or ▷ to set up a measurement range with the LP add on.

5. Tap on ☑.

   The digital low pass filter is now switched on for the selected measurement range. The corresponding reduced value is displayed in the Max.Freq. *field.*

6. To switch off the digital low pass filter again, select the same measurement range which is not marked with the add on LP.

   The corresponding value is displayed in the Max.Freq. *field.*

5.4.5 Setting the High Pass Filter

Suitable settings

The high pass filter is of type 4th order Butterworth. Here it can be said:

- At 150 Hz (corresponds to 1.5 times cutoff frequency f_c), the amplitude error is approx. –5%.
- The high pass filter generates a frequency-dependent phase shift (refer to SECTION A.2). Switch off the high pass filter if this phase shift is not desired.

Note that when the high pass filter is switched on, under certain circumstances it may no longer be possible to identify in the measurement signal when the decoder has been overloaded as the corresponding frequency is filtered out. Measurement tasks in which a small measurement signal is superimposed by a low-frequency machine vibration with a large amplitude are particularly critical. The measurement signal is then significantly distorted and the OVER LED in the VELOCITY field on the front of the controller is continuously lit up, even though overloading is not apparent in the measurement signal. To do so, proceed as follows:

1. Switch off the high pass filter.
2. Set up the smallest measurement range which is not overloaded for the decoder you have selected
3. Switch on the high pass filter for the actual measurement.

Please note that the OVER LED can also be lit up due to brief noise spikes resulting from inferior optical signal quality. This effect does not yet lead to signal distortions by overloading the decoder.

The complete amplitude frequency response of a 4th order Butterworth high pass filter as well as the corresponding amplitude error and phase frequency response are shown in SECTION A.2.

Set the high pass filter

To switch on or off the high pass filter, proceed as follows:

1. Tap on .

   The SETTINGS *page is displayed.*
2. In the Velocity area, tap on Output.

   The SETTINGS | Velocity *page is displayed.*
3. Tap on High Pass.

   The page for the parameter setting is displayed.
4. Tap on or to switch the high pass filter on (100 Hz) or off (Off).
5. Tap on .

   The setting is assumed.

6. Tap on [X].

   The page is closed.

5.4.6 Notes for Controllers with the Digital VD-06 Velocity Decoder

If you have a controller with an installed digital VD-06 velocity decoder, you should pay attention to a few special features.

The output data from the digital velocity decoder can be made available as a digital data stream via the S/PDIF interface on the back of the controller. However, in unfavorable conditions, the high-frequency pulses from this digital data can cause distortions in the analog signal of the digital velocity decoder. For this reason you should always deactivate making S/PDIF data available if you are not using the S/PDIF interface or the optional adaptive DSP filter.

NOTE!

If your controller is only equipped with the digital VD-06 velocity decoder in combination with the DD-100 displacement decoder, you must switch off the VD-06 to have the full bandwidth available for the displacement decoder! Please refer also to SECTION 5.6.2.

Deactivate S/PDIF data

To deactivate the S/PDIF data, proceed as follows:

1. Tap on [wrench].

   The SETUP *page is displayed.*

2. Tap on Digital Out.

   The SETUP | S/PDIF *page is displayed.*

3. Tap on [<] or [>] to select the Off entry by modifying the Data Rate parameter.

4. Tap on [✓].

   The setting is assumed.

5. Tap on [X].

   The page is closed.

   No more S/PDIF data is made available so that there is no danger of high-frequency distortions in the analog signal of the digital velocity decoder.

For measurements with the analog VD-02 velocity decoder, you should not only deactivate making the S/PDIF data available, but should also switch off the digital VD-06 velocity decoder. If the VD-06 stays switched on during an analog measurement, high-frequency noise peaks can appear in the spectrum of the analog velocity signal from VD-02.

Switch off the decoder

To switch off the digital velocity decoder, proceed as follows:

1. Tap on .

   The SETTINGS *page is displayed.*

2. In the Velocity area, tap on DSP Out.

   The SETTINGS | Velocity DSP *page is displayed.*

3. Tap on Range.

   The page for the parameter setting is displayed.

4. Tap several times on to set Off.

5. Tap on .

   The setting is assumed.

6. Tap on .

   The page is closed.

5.4.7 Using Digital Output Signals (only VD-06)

The measurement values from the digital velocity decoder are emitted as a digital data stream in S/PDIF format on the back view of the controller. The data is available as an optical signal at the Optical TOSLINK jack and also as an electrical signal at the Electrical TRIAX jack in the DIGITAL OUT field on the back view of the controller.

Digital recording or analysis equipment connected to the digital output should support 24 bit format to obtain an optimal signal-to-noise ratio. To evaluate the digital velocity signal, you can for example use a commercially available PC sound card with an S/PDIF input. The connecting cable (TRIAX / RCA) is supplied with the digital velocity decoder. To avoid measurement errors, you should make sure when choosing the PC sound card that the card does not automatically carry out amplitude reduction.

If required, you can get recommendations for suitable PC sound cards and software from your nearest Polytec representative.

The digital output signals of the VD-06 are available with two different data rates (48 kSa / s and 96 kSa / s). The data rate you use depends on which data rate the digital analysis systems you are using can work with.

If you want to rework the digital output signal from the VD-06 using the optional adaptive DSP filter, the data rate must be set at 48 kSa/s as the DSP filter can not process any higher data rate.

Set the data rate To set the data rate, proceed as follows:

1. Tap on .

   The SETUP *page is displayed.*

2. Tap on Digital Out.

   The SETUP | S/PDIF *page is displayed.*

3. Tap on or to set up the data rate by modifying the parameter Data Rate.

4. Tap on .

   The setting is assumed.

5. Tap on .

   The page is closed.

   The S/PDIF data is available at the data rate you have selected at both jacks in the DIGITAL OUT field on the back of the controller. If you have selected the Off *entry, the S/PDIF interface is not active.*

To set up the data rate alternatively on the Settings [Velocity DSP] page, proceed as follows:

1. Tap on .

   The SETTINGS *page is displayed.*

2. In the Velocity area, tap on DSP Out.

   The SETTINGS | Velocity DSP *page is displayed.*

3. Tap on Data Rate.

   The page for the parameter setting is displayed.

4. Tap on or to set up the data rate.

5. Tap on .

   The setting is assumed.

6. Tap on .

   The page is closed.

Assign channels

To be able to make full use of the transmission capacity of the controller's digital outputs and the properties of the subsequent signal acquisition systems, both channels (left and right channel) of the S/PDIF format are assigned output signals from the controller. The following rule applies for the assignment:

- The digital velocity signal is always on the left channel, with active DSP filter its output signal (DSP).
- For the right channel, you can select whether you want to transmit the unfiltered velocity signal (for example for comparisons), or the output signal of a digital displacement decoder DD-500 if installed (refer also to SECTION 5.7).

The channel assignment can be summarized in the following table:

Installed decoder and/or filter	Left channel	Right channel
VD-06	Velocity	-
VD-06 + DSP filter[1]	Velocity DSP	Velocity
VD-06 + DD-500	Velocity	Displacement
VD-06 + DSP filter[1] + DD-500	Velocity DSP	Velocity
	Velocity DSP	Displacement

[1] DSP filter activated with 48 kSa/s (refer to SECTION 5.5.3)

To select the assignment of the right channel, proceed as follows:

1. Tap on .

   The SETUP page is displayed.

2. Tap on Digital Out.

   The SETUP | S/PDIF page is displayed.

3. Tap on or to select a data rate by modifying the Data Rate parameter.

NOTE!

A data rate of 48 kSa/s must be selected when using the DSP filter.

4. Tap on or to select the configuration of the right channel by modifying the Right Channel parameter.

5. Tap on .

   The setting is assumed.

6. Tap on ☒.

   The page is closed.

   The S/PDIF data is available at the data rate you have selected at both jacks in the DIGITAL OUT field on the back of the controller. If you have selected the Off *entry the S/PDIF interface is not active.*

5.5 Using the Adaptive DSP Filter (optional)

5.5.1 Description and Operating Principle

Description

The adaptive DSP filter is a filter which adapts automatically. It receives its input signal in digital form from the VD-06 velocity decoder. It is designed for natural vibration signals up to 20 kHz and adapts itself to periodic signals. Random noise which occurs statistically independently is suppressed as well as possible by the adaptive filter. Harmonic components and multi-tone signals can also pass the filter due to its multiple band-pass properties. However the filter is not suitable for pulse signals and synthetic signals with a high proportion of harmonics. These signals are distorted in the time domain, as after the third harmonic signal component, noticeable attenuation occurs. The high order of the filter allows a very sharp cutoff as a prerequisite for effective noise suppression. The frequency response of the adaptive filter which has attained steady-state for a rectangular signal at 50 Hz is shown in FIGURE 5.3.

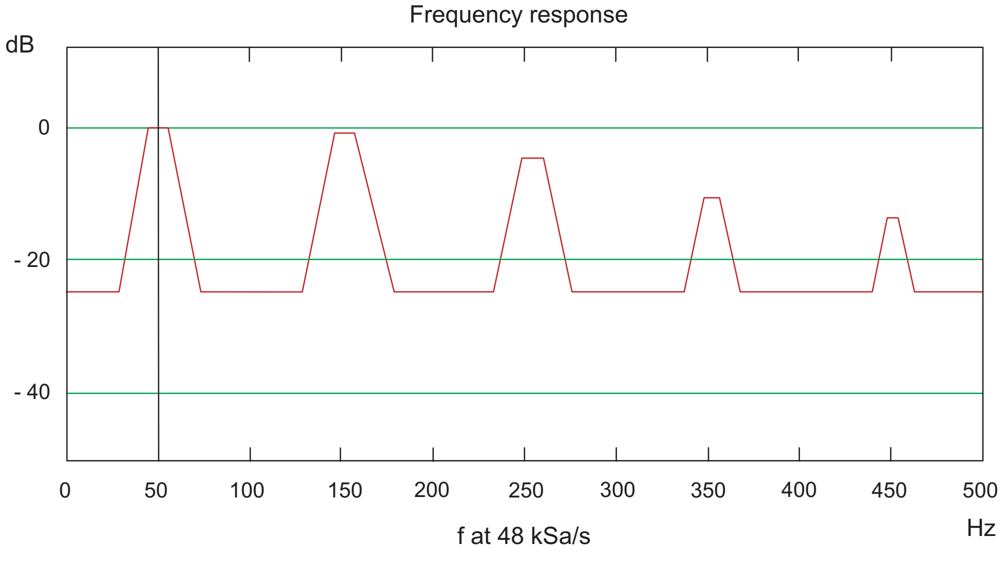

Figure 5.3: Diagram of frequency response of the adaptive filter for a rectangular signal

The individual band-passes for the harmonic components as well as the noticeable attenuation as of the third harmonics can be easily identified there. The filter optimizes according to the best possible signal-to-noise ratio. This however also allows spectral components with a low amplitude to be attenuated as well.

Operating principle

Due to the continuous real-time optimization of the filter, continuous adaptation to the current input signal takes place. However this new adaptation to changes of the input signal does not cause any failure of the output signal. The reaction of the adaptive filter to an abrupt amplitude and frequency change of the input signal from 200 Hz to 100 Hz is shown in FIGURE 5.4.

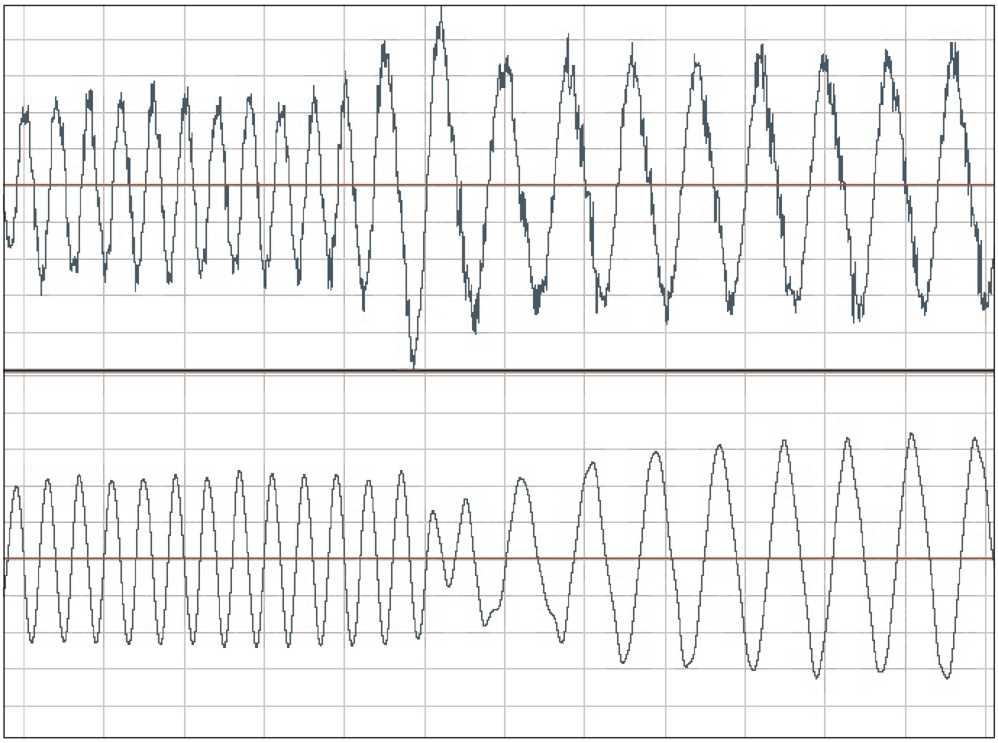

Figure 5.4: Example of the adaptation process of the adaptive filter

The filter can start operating without prior knowledge of the input signal values (amplitude, frequencies or signal shapes). After a settling time which is necessary to detect and set the periodic signal portions, filter characteristics optimally suited for the input signal are set. If the signal changes, the filter continuously adapts its characteristics with the aim of improving the signal-to-noise ratio.

With the aid of the frequency range which can be set on the touch screen of the controller, the efficiency of the noise output suppression can be significantly improved by adapting the upper cutoff frequency to the input signal (refer to SECTION 5.5.3).

In FIGURE 5.5 you can see the frequency responses of the individual frequency ranges for the input signal from FIGURE 5.3. In the 20 k range in the bandwidth shown (0 Hz … 1 kHz), no optimal frequency response can be identified. In the 2 k range, the filter limits the pass band to a band-pass which covers all useful signal frequencies and thus suppresses noise. In the 0.3 k range with several band-passes around the individual useful signal parts, the possible noise bandwidth is limited even further and the noise is suppressed even more.

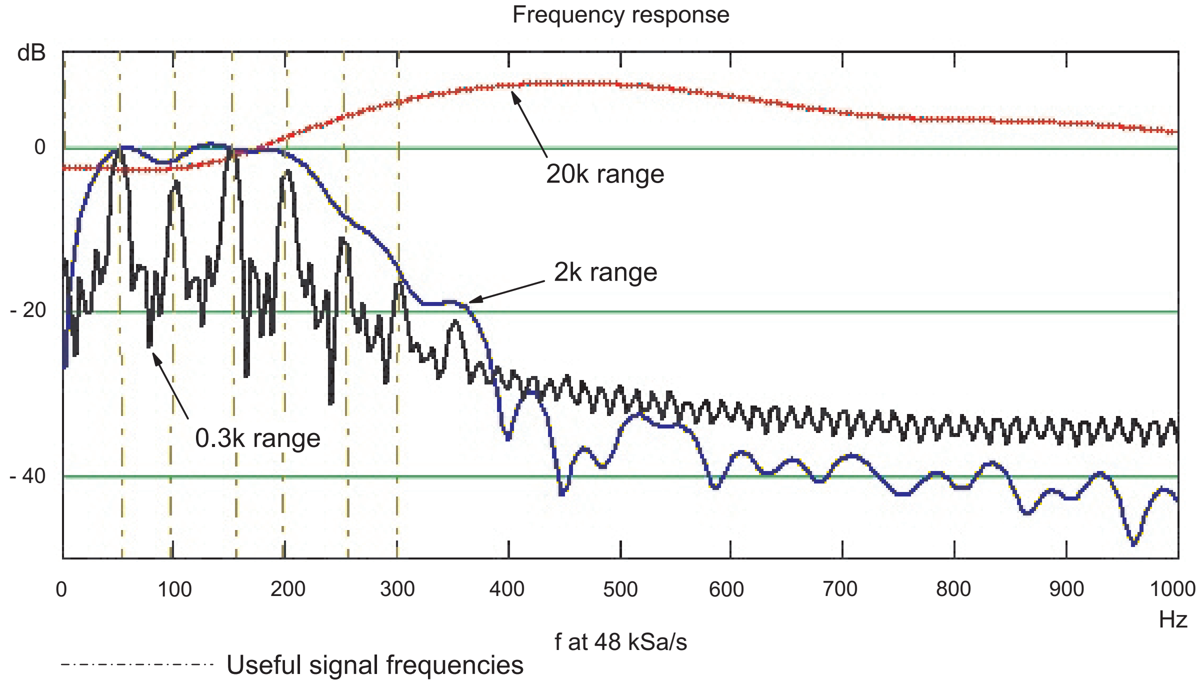

Figure 5.5: Filter characteristics of the individual frequency ranges

Speckles which occur due to transverse motion, as for example during vibration measurements on buildings, can be eliminated extremely well due to their random, statistically independent appearance (refer to FIGURE 5.6). The filter can not differentiate speckles which occur regularly from useful signals.

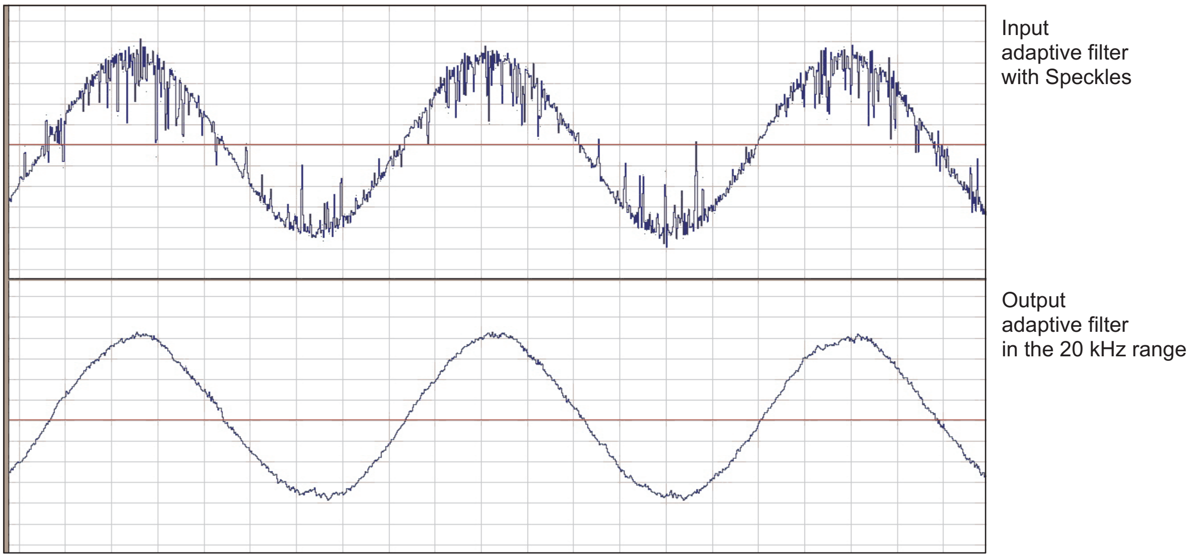

Figure 5.6: Example of the way the adaptive filter works in the case of stochastically occurring speckles

5.5.2 Area of Application

The adaptive DSP filter is suitable for improving the signal-to-noise ratio in the case of uncorrelated (= random, not periodic) noise in the acoustic range from 0 Hz (DC) up to approx. 20 kHz.

The three frequency ranges 0 Hz … 0.3 kHz, 0 Hz … 2 kHz and 0 Hz … 20 kHz allow optimal adaptation to the frequencies of the signal to be measured and thus increase the effectiveness and performance of the adaptive DSP filter.

Frequency bandwidth

At the analog DSP OUT output in the VELOCITY field on the front of the controller and also at the digital outputs on the back of the controller, a frequency bandwidth of 0 Hz … 22 kHz is available.

Analog DSP OUT output

A 24 bit D/A converter uses the digital velocity information from the decoder to generate an identically scaled but filtered, analog voltage signal in the range ± 10 V for conventional signal evaluation. Due to the analog components in the decoder, the calibration accuracy at this output (DSP OUT) is not as good as at the digital outputs.

Digital outputs

At the digital Optical and Electrical outputs in the DIGITAL OUT field on the back of the controller, the velocity signal is emitted in the shape of a serial data stream in the S/PDIF format widely used in audio technology. This signal is limited to the data rate 48 kSa/s when using the DSP filter, corresponding to the maximum signal frequency of 22 kHz. You will find information on further processing the digital output signal in SECTION 5.4.7.

5.5.3 Setting the Adaptive DSP Filter

To adjust the adaptive DSP filter to the input signal, proceed as follows:

1. Tap on .

   The SETTINGS *page is displayed.*

2. In the Velocity area, tap on DSP Out.

   The SETTINGS | Velocity DSP *page is displayed.*

3. Tap on Adapt.Filt..

   The SETTINGS | Velocity DSP | Adaptive Filter *page is displayed.*

4. Tap on or to select the frequency range.

   Please note that the DSP filter only works with a data rate of 48 kSa/s. If a higher or not data rate is set, in the Range *field the* Wrong Data Rate! *message is displayed. In this case first set the data rate to 48 kSa/s as described in SECTION 5.4.7.*

5. Tap on .

   The setting is assumed.

   Active *or* Off *is displayed under* Adapt.Filt..

6. Tap on ☒.

   The page is closed.

You can select the following entries for the adaptive DSP filter:

- Off (20 kHz) - You switch off the adaptive DSP filter and the input signal will loop through unchanged with a cutoff frequency of 20 kHz.
- < 20 kHz or < 2 kHz or < 0.3 kHz - You select the upper cutoff frequency of the adaptive DSP filter (refer also to SECTION 5.5.1).
- Loaded Response - You load filter settings which have been previously saved. You will find detailed information on this in SECTION 5.5.4.
- Test FullScale - You carry out a full scale test. During this test a test signal is generated which you can use to make sure that on a connected signal evaluation system the adaptive DSP filter is working. The test signal thus generated (frequency approx. 30 Hz, amplitude $20.0\,V_{p\text{-}p}$) is shown in FIGURE 5.7.

Figure 5.7: Test signal of the adaptive DSP filter

The plateaus of this signal should be exactly on the zero line. The maximums of the first two peaks should be exactly on +10 V or –10 V respectively. If this should ever not be the case, it is easy for you to read the amplitude emitted by looking at the plateaus of the last two peaks. If required, please contact our service department to decide how to proceed from here.

5.5.4 Saving and Loading DSP Filter Settings

A save function on the controller gives you the possibility of saving the current frequency response with the frequency range set in a flash memory of the adaptive DSP filter. When you load these filter settings again, the filter no longer continuously adapts to the changes in the input signal, but works like a fixed filter with the saved settings.

NOTE!

The filter has a very narrow band. I.e., even when there are very small changes in the frequency, the wanted signal can be very strongly attenuated!

To save and load filter settings, proceed as follows:

1. Tap on .

   The SETTINGS *page is displayed.*

2. In the Velocity area, tap on DSP Out.

   The SETTINGS | Velocity DSP *page is displayed.*

3. Tap on Adapt.Filt..

   The SETTINGS | Velocity DSP | Adaptive Filter *page is displayed.*

Save

4. Tap on Save Filter Response.

   The current frequency response is saved with the frequency range set in the flash memory of the DSP filter.

Load

5. Tap several times on until the Loaded Response indicator is displayed.

6. Tap on .

   The filter settings you saved are loaded again. The filter is now no longer adaptive but works with the saved settings like a fixed filter.

7. Tap on .

   The page is closed.

5.6 Suitable Settings for Displacement Acquisition (Fringe Counting)

This section gives you advice on how the controller needs to be set for displacement acquisition to attain optimum measurement results. As these recommendations strongly depend on the way in which the respective displacement decoder works, they have been treated separately. The information in this section applies exclusively to displacement decoders which work using fringe counting (DD-100).

You will find information on the suitable settings for the DD-500 and DD-900 DSP displacement decoders in SECTION 5.7.

You will find information on the DD-300, DD-400 and DD-600 displacement decoders in the section on auxiliary decoders (refer to SECTION 5.8).

5.6.1 Setting the Displacement Measurement Range

Suitable settings

The most important aspect for selecting the displacement measurement range is the expected maximum displacement. To make sure you avoid overloading the displacement decoder however, a higher displacement measurement range often has to be selected if the process is superimposed with low-frequency interfering vibrations. As a general rule, the displacement measurement range should be selected so that the output signal is as large as possible, however with peak values which are sure to remain below the control limits of ±8 V (refer also to SECTION 5.6.3).

A further consideration is the expected maximum velocity. Due to procedural limitations, the absolute maximum velocity of the vibrometer of 10 m/s can only be fully utilized in the upper displacement measurement ranges 320 µm/V to 10240 µm/V. In the lower displacement measurement ranges 2 µm/V to 160 µm/V, several counting pulses per fringe are generated by interpolation, whereby the signal bandwidth and the pulse counting frequency multiply correspondingly. Consequently, the permissible velocity decreases to approximately the same extent as the displacement resolution increases. Due to this correlation, the full scale values of the lower displacement measurement ranges can only be fully utilized up to frequencies of approx. 500 … 600 Hz. Above this value the maximum measurable amplitude decreases with increasing frequency according to the relationship $\hat{x}$

$$\hat{v} = 2\pi \cdot f \cdot \hat{x} = \text{konst.} \qquad \text{Equation 5.2}$$

$\hat{v}$ … Velocity amplitude

$\hat{x}$ … Displacement amplitude

f … Frequency

From the above described correlation, it can be said that the frequency also ultimately has to be taken into consideration when selecting the displacement measurement range. The specified maximum frequency can only be acquired in the upper displacement measurement ranges. In the lower displacement measurement ranges there are technical limits which can not be exceeded, even if the condition (5.2) is complied with.

The resulting limiting graphs for all measurement ranges are shown in FIGURE 5.8.

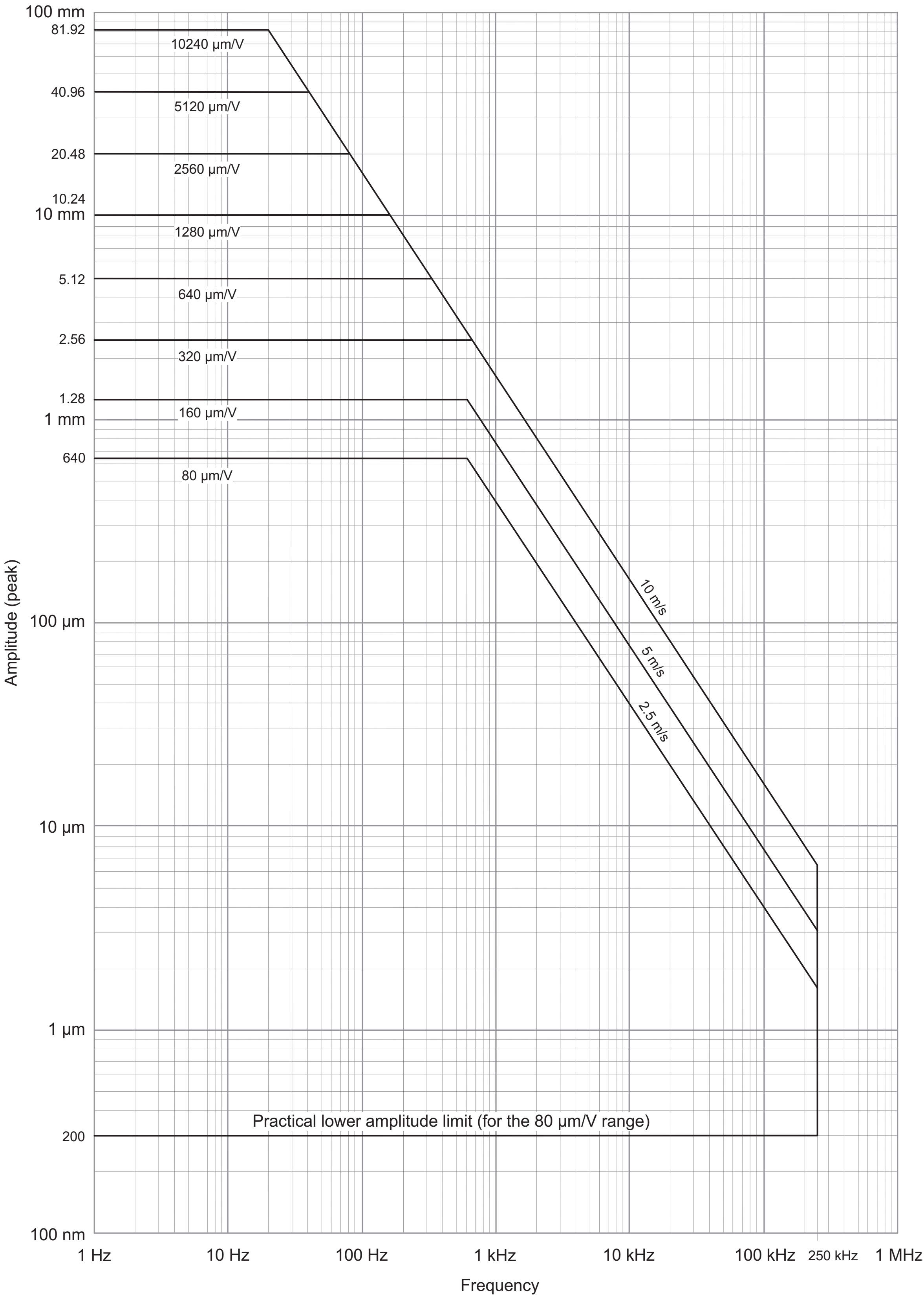

Figure 5.8: Measurement range limits of the DD-100 displacement decoder

If the measurement range limits shown in FIGURE 5.8 are exceeded, overload and losing lock become apparent which makes it impossible to meaningfully analyze the signal (refer also to FIGURE 5.10).

Set the measurement range

To set the measurement range for a displacement acquisition, proceed as follows:

1. Tap on ⎆.

   The SETTINGS *page is displayed.*

2. In the Displacement area, tap on Output.

   The SETTINGS | Displacement *page is displayed.*

3. Tap on Range.

   The page for the parameter settings is displayed.

4. Tap on ⟨ or ⟩ to select the displacement measurement range.

5. Tap on ☑.

   The setting is assumed.

6. Tap on ☒.

   The page is closed.

5.6.2 Optimizing the Displacement Signal with the HF Band-Pass Filter

The controller is equipped with a high-frequency band-pass filter which is upstream of both the velocity and the displacement decoders. The bandwidth of this HF band-pass filter is set automatically corresponding to the selected velocity measurement range to attain an optimal adaptation to the bandwidth of the Doppler signal. For this reason, selection of the velocity measurement range is also relevant, even if pure displacement acquisition are being made and only the signal of the displacement output is being used.

Set the Velocity Measurement Range for Displacement Acquisition

If the optical signal is good during the whole measurement, in the case of analog velocity decoders, the measurement range 1 000 $\frac{mm}{s}$/V should be selected, as this measurement range does not limit the bandwidth and thus its influence does not have to be taken into consideration.

NOTE!

If your controller is only equipped with the digital VD-06 velocity decoder in combination with the DD-100 displacement decoder, you must switch off the VD-06 to have the full bandwidth available for the displacement decoder! Please refer also to SECTION 5.6.2.

If the optical signal is bad however, the signal-to-noise ratio of the displacement acquisition can also be improved by purposefully limiting the HF bandwidth. To limit the bandwidth, the velocity measurement range should be selected to be as small as the application will allow. The maximum velocity which occurs should not exceed the respective full scale value, i.e. ten times the respective scaling factor (e.g. 50 mm/s for the measurement range 5 $\frac{mm}{s}$/V). If the OVER LED in the VELOCITY field on the front of the controller lights up or if the displacement signal fails, then the next highest velocity measurement range has to be set.

You will find detailed information on setting the velocity measurement range in SECTION 5.4.2.

5.6.3 Using the Clear Function

As there is no lower frequency limit for the displacement decoder, the output signal can also accept stationary values (DC). After setting a certain displacement measurement range there is a voltage at the output, the so-called DC offset, which changes with the average distance of the object under investigation from the sensor head and with the thermal drift of the interferometer. Dynamic displacement changes of the object (AC) are added with the correct sign to this DC offset as long as the output voltage does not exceed ±8 V. If this value is exceeded, then the output voltage jumps from the positive end of the measurement range to the negative end and vice versa as the counter overflows. As a result of this, the AC signal is distorted. An example of this distortion is shown in the oscillogram in the following figure.

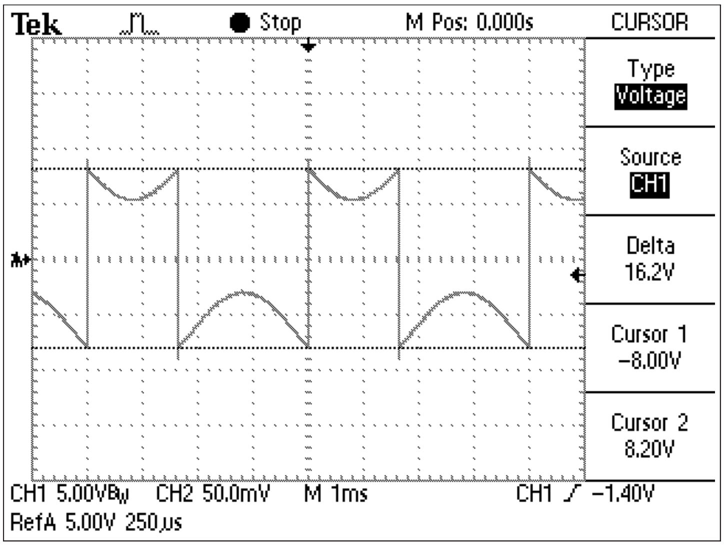

Figure 5.9: Displacement signal when the counter overflows due to a DC offset

To avoid such a signal distortion, the DC offset should be set back to zero before making a measurement. This is the only way to be able to utilize the whole displacement measurement range for the measurement. You can clear the DC offset in two different ways:

Reset at the touch screen

To reset the DC offset at the touch screen, please proceed as follows:

1. Tap on .

   The SETTINGS *page is displayed.*

2. In the Displacement area, tap on Clear.

   The DC offset is reset to zero.

Reset a the jack

Alternatively, a pulse can be fed into the TRIG IN BNC jack in the DISPLACEMENT field on the front of the controller.

The second method is particularly suitable for measurement tasks in which a periodic signal with a superimposed translatory movement is generated. In such cases, the counter overflows very quickly due to the DC signal of the translatory movement. Correspondingly a higher displacement measurement range would have to be set which, however, would give inferior resolution of the periodic signal. You can retain the best AC resolution if you periodically clear the counter and thus suppress the undesirable DC drift of the signal.

A Clear signal of this kind does not necessarily have to be made available externally, but in the simplest case can be gained from the OUTPUT signal in the VELOCITY field on the front of the controller itself. Every zero crossing of the velocity signal with a positive increase then clears the displacement decoder. However, for this purpose, a certain quality of the velocity signal is required. If the noise ratio is too high, the displacement signal may become unstable. Due to the phase shift between displacement and velocity signal, in this way there is no optimal utilization of the displacement measurement range possible.

5.6.4 Selecting the Tracking Filter

Suitable settings

The correlations for the tracking filter demonstrated in SECTION 5.4.2 for velocity acquisition also apply analogously to displacement acquisition with displacement decoders which work using fringe counting. If the range limits in FIGURE 5.1 are exceeded, the tracking filter loses lock and creates phase jumps in the input signal which make the displacement signal discontinuous.

The oscillogram in FIGURE 5.1 shows the distorted displacement signal of a sinusoidal vibration where the tracking filter can no longer follow the acceleration.

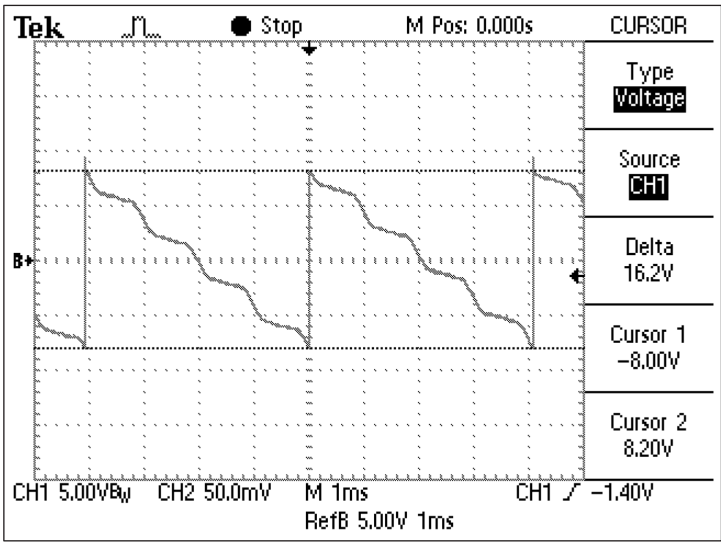

Figure 5.10: Displacement signal when the tracking filter loses lock

In this case, the velocity signal should be evaluated and the most practical setting for the tracking filter should be determined with the help of FIGURE 5.1.

It is very important that the acceleration limits are observed at pulse-shaped motion sequences as for example valve lifts. Here, by temporary exceedance of the acceleration limits, measurement errors may occur that can not be identified as clearly as shown for example in FIGURE 5.10. A relatively certain indicator for such a temporary loss of lock of the tracking filter are drift errors in the displacement signal measured. That means that the object under investigation apparently does not return to its initial position after the pulse-shaped movement but seems to move statically.

In the following figure, you will see such an example.

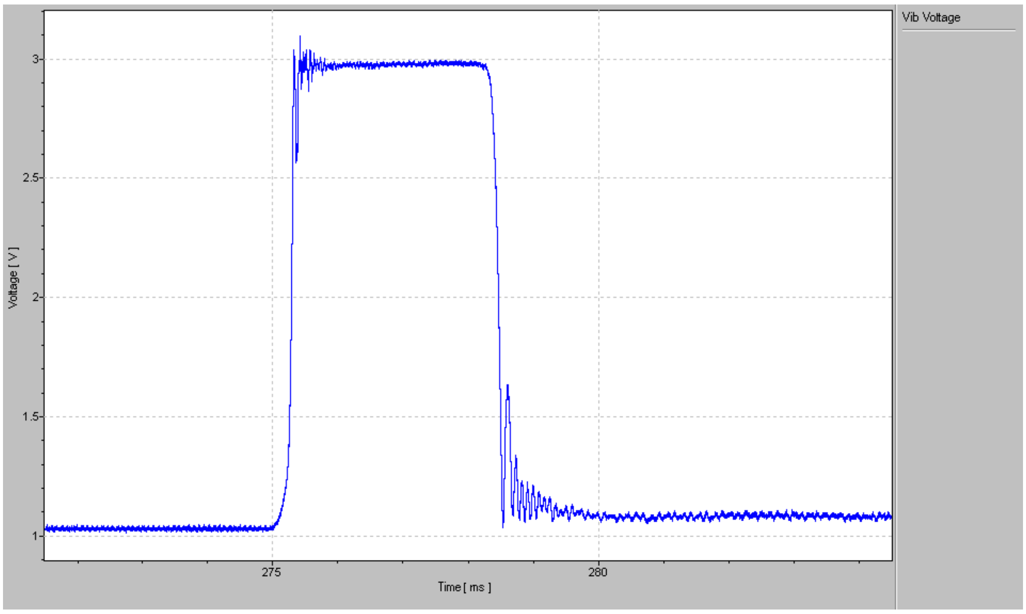

Figure 5.11: Pulse-shaped displacement course with drift error

Here, during the bounce/rebound effect in the rising phase a too high acceleration was reached which lead to a temporary loss of lock of the tracking filter and thus to a counting error in the displacement decoder. Due to this additive error, the object seems not to return exactly to its rest position after the movement impulse. Actually the measured amplitude between the starting position and the pulse roof is falsified due to the effect described.

Set the tracking filter

To set the tracking filter mode for displacement acquisition, proceed as follows:

1. Tap on ⎆.

   The SETTINGS *page is displayed.*

2. In the Displacement area, tap on Output.

   The SETTINGS | Displacement *page is displayed.*

3. Tap on Track.Filter.

   The page for the parameter settings is displayed.

4. Tap on ‹ or › to select the mode for the tracking filter.

5. Tap on ✓.

   The setting is assumed.

6. Tap on ✕.

   The page is closed.

5.7 Suitable Settings for Displacement Acquisition (DSP Displacement Decoder)

The DD-500 or DD-900 displacement decoder receives as input a digital data stream from the VD-06 or VD-09 velocity decoder respectively, which represents the interferometric phase as carrier of the displacement information. As the properties of this data stream are also determined by the settings of the velocity decoder with regards to resolution and bandwidth, the displacement decoder must always be seen in connection with the velocity decoder. In the displacement decoder itself, the input data is processed to become a displacement signal scaled into 16 measurement ranges which is then available at the displacement output (DISPLACEMENT OUTPUT) on the front view as an analog signal and with combination VD-06/DD-500 on the back view as a digital signal.

In the following you will be shown which settings on the controller are relevant for displacement signal acquisition using the digital displacement decoder and how to optimally use the properties of the digital decoder combination velocity decoder/displacement decoder.

In SECTION 5.6 you will find the corresponding information for the DD-100 displacement decoder which works using fringe counting.

Special features of the optional DD-300, DD-400 and DD-600 auxiliary decoders are described in SECTION 5.8.

NOTE!

Before using the DD-500, you have to select and set the digital VD-06 velocity decoder (refer to SECTION 5.4).

NOTE!

Before using the DD-900, you have to select and set the digital VD-09 velocity decoder (refer to SECTION 5.4).

5.7.1 Selecting the Displacement Measurement Range

Suitable settings

As the digital displacement decoder depends on the settings of the digital velocity decoder, you should always set the corresponding velocity decoder before starting displacement acquisition, in such a way that it will not overmodulate and will offer the required signal bandwidth. Only if the velocity decoder lets pass the measurement signal, the displacement decoder can be used, because the velocity limit and the maximum vibration frequency of the velocity decoder also affect the displacement decoder.

Selecting the displacement measurement range is primarily oriented towards the expected vibration amplitude which has to remain within the voltage limits of ±10 V. However with many technical applications, the required vibration signal is often superimposed by low-frequency background vibration with a relatively large amplitude which can lead to overload effects. In these cases the measurement range selected often has to correspond to the maximum interfering vibration which is at the expense of the resolution of the wanted signal. But even in such cases the high bit resolution of the digital displacement decoder in connection with special processes for dealing with overload allows a useful representation of the desired signal. The specified resolution (refer to SECTION 7.5.7 and SECTION 7.5.8 respectively) corresponds to the smallest voltage step in the digital-to-analog converter at the analog output (approx. 0.4 mV). At the digital output, due to the decimation of data and interpolation to 24 bit which are effective here, a greater displacement resolution can be attained with the DD-500. With spectral signal evaluation, a greater, noise-limited resolution can also be attained by selecting suitable FFT parameters.

Set the measurement range

To set the measurement range for a displacement acquisition, proceed as follows:

1. Tap on ⟲.

   The SETTINGS *page is displayed.*

2. In the Displacement area, tap on Output.

   The SETTINGS | Displacement *page is displayed.*

3. Tap on Range.

   The page for the parameter settings is displayed.

4. Tap on ‹ or › to select the displacement measurement range.

5. Tap on ✓.

   The setting is assumed.

6. Tap on ✗.

   The page is closed.

5.7.2 Setting the Velocity Measurement Range

Starting with the default settings (highest measurement range, complete bandwidth), the measurement range setting of the velocity decoder can be used to improve the signal-to-noise ratio of the displacement measurement signal.

As a general rule, in all cases in which frequencies above 100 kHz and 250 kHz respectively are not of interest, the velocity measurement ranges with bandwidth limitation should be switched on (identified on the touch screen by LP). This setting allows the velocity decoder to attain a better signal-to-noise ratio in unfavorable optical conditions which then also has a positive effect on the measurement ability of the displacement decoder. A low pass effect for the displacement signal is thus however only combined with the DD-900 and not with the DD-500.

A further improvement of the signal-to-noise ratio or the optical sensitivity can be attained by selecting a smaller velocity measurement range. With the DD-500 this effect can be seen in particular in the measurement range 2 $\frac{mm}{s}/V$ and 5 $\frac{mm}{s}/V$ respectively at 100 kHz bandwidth, providing the full scale value is not exceeded.

In case of sinusoidal vibrations, the peak velocity which occurs depends on the relationship of the displacement amplitude $\hat{x}$ and the vibration frequency f according to the equation

$$\hat{v} = 2\pi \cdot f \cdot \hat{x} \qquad \text{Equation 5.3}$$

If this value exceeds the full scale value of the selected velocity measurement range, then waveform distortions will also be seen in the displacement signal.

This condition can be easily identified by the analog velocity signal and is indicated by the OVER LED in the VELOCITY field lighting up. In this case the next highest velocity measurement range must be selected to obtain a correct displacement signal.

In contrast to displacement decoders which work on the principle of fringe counting, the frequency bandwidth of the digital displacement decoder does not depend on the selected displacement measurement range Thus even at the highest resolution, vibration frequencies of up 350 kHz resp. 2.5 MHz can be acquired, providing a velocity measurement range suitable for this purpose has been selected.

NOTE!

If you want to make a measurement with the DD-500, the measurement range 1 $\frac{mm}{s}/V$ of the VD-06 can not be used.

5.7.3 Behavior when the Measurement Range is Overrun (Overrun Mode)

Due to the ability of the displacement decoder to also acquire static shifts of the object, the measurement signal is generally superimposed by a DC offset. The motion signal will be added with the correct sign to the DC offset. However, because the output voltage is limited to ±10V, the full measurement range is no longer available for the vibration amplitude. In addition to that, in particular in the high-resolution measurement ranges, it is easy to reach the control limits by small shifts of the measurement object, or thermal expansion (Overrun). This means that initially it is no longer possible to display the signal shape correctly.

Clear function

You can manually reset the digital displacement decoder before or during a measurement with the aid of the Clear function. This means that the output signal is set to zero from the time when taping and is thus moved in y-direction. As the key is rarely taped at the zero crossing of a vibration signal, the optimal centering of the displayed trace is not possible that way.

NOTE!

Further resets with the Clear function can improve the result.

TRIG IN input

Usage of the displacement measurement range can be improved with the aid of an electric signal synchronized with the motion process which is fed in through the TRIG IN BNC jack. A positive pulse at the zero crossing of the displacement signal is ideal for vibration measurements, as it results in the measurement signal being precisely centered. Due to the trigger characteristic of the TRIG IN input, a signal amplitude of approx. 25mV effectuates already a safe zero setting of the output signal so that analog signals can be used as well. In many cases the signal can for example be fed from the velocity output to the TRIG IN jack to synchronize zero setting. Because of the phase shift of 90° between velocity and displacement however, this does not center the displacement signal. The lowest point of the displacement signal will touch the zero line and the signal moves exclusively in the top half of the control range.

Overrun mode

The high-performance DSP technology in the digital displacement decoder allows automatic correction of overrun. Even without additional external signals, in most cases this immediately generates a viewable output signal.

The R2Z (Return to Zero) and Clip operating modes provide two further different processes which can be selected under the Overrun menu item, depending on the measurement circumstances. With the help of the following information or by trial and error, you should find out which mode provides the better signal presentation for the respective measurement task in the actual case.

Return to Zero (R2Z)

If you select the R2Z operating mode the displacement signal at the output will immediately reset to zero if the upper or lower limit (±10 V) is reached. This process is shown for a vibration signal superimposed with a uniform movement ($\bar{v}$ = const.) in the following figure.

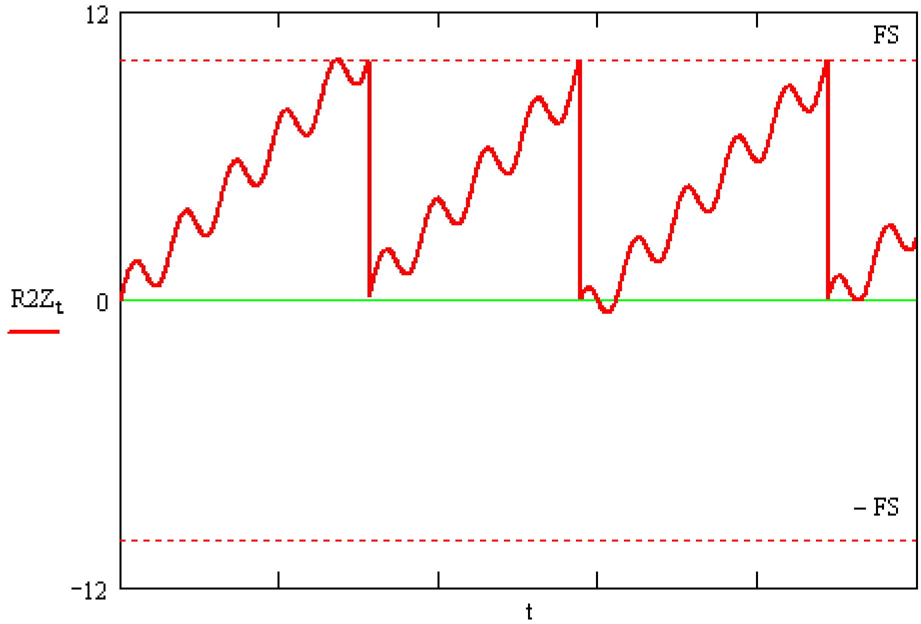

Figure 5.12: Sinusoidal vibration superimposed with a uniform movement

In the following figure you will find an example of a positioning process with a triangular displacement-time progression and a superimposed vibration.

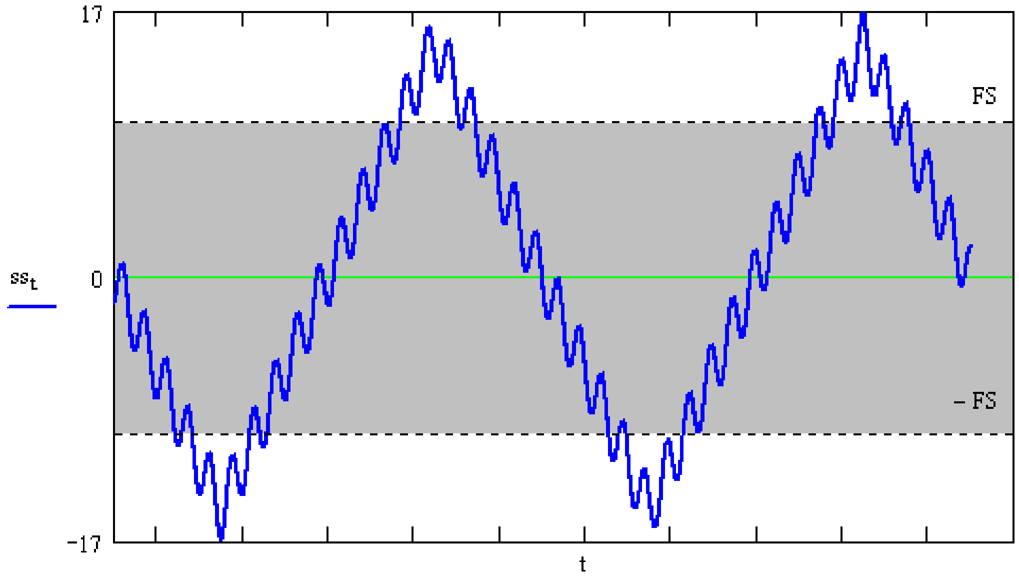

Figure 5.13: Complex displacement signal (original progress)

If this process is acquired with a measurement range setting for the digital displacement decoder where the modulation amplitude limits (FS/-FS) are overrun by the peak values of the original signal, then in R2Z operating mode, you will get the measurement signal shown in the following figure. This type of representation does not give any meaningful impression of the actual path of motion of the object under investigation.

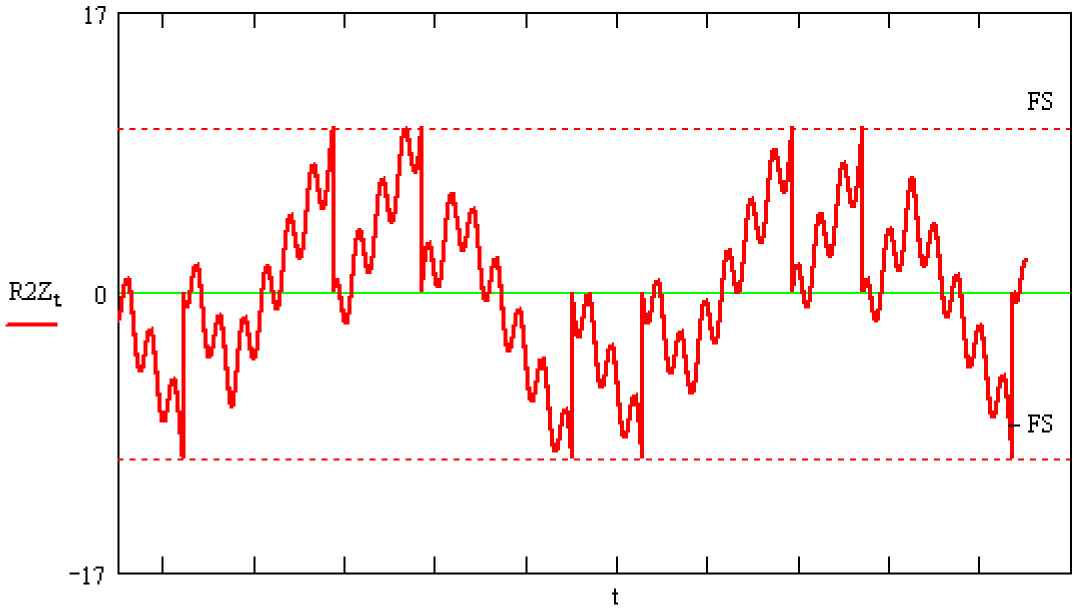

Figure 5.14: Measurement signal of the path of motion from FIGURE 5.13 in R2Z operating mode

The R2Z (Return to Zero) operating mode is thus more suited to acquiring vibrations which are superimposed by slow shifts, which only lead to overloading relatively infrequently. With the exception of the points of discontinuity caused by resetting, the vibration action is shown without distortion in R2Z operating mode (refer to FIGURE 5.12).

Clip

If you select CLIP operating mode a complex process is used which retains the displacement signal at the measurement range limits in the case of overrun, however without setting it back to zero.

The advantage of this process is that no points of discontinuity are generated in the measurement signal. Composite movements such as the positioning process shown in FIGURE 5.13 can thus also still be clearly seen, despite overrunning the measurement range as also shown in the following figure.

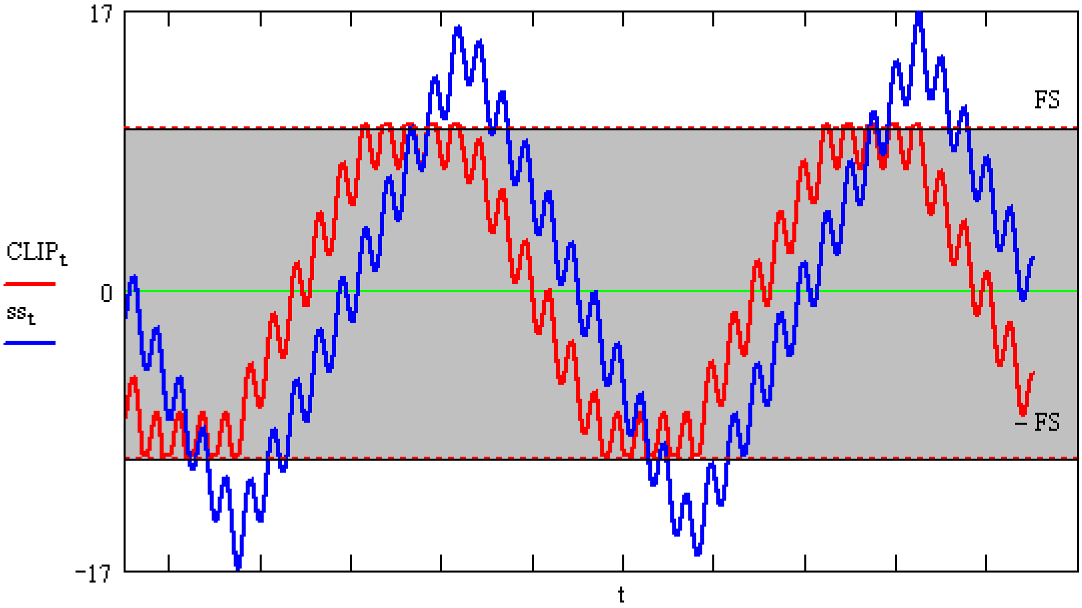

Figure 5.15: Original and measurement signal in Clip operating mode

In the area with a gray background you will find the clipped measurement signal. For comparison, the original signal is shown too. Despite overrunning due to the large positioning movement, the vibration process can still be shown with high resolution.

Due to the signal dynamics however, with this operating mode in overrun status, it is not possible to avoid affecting the signal shape of the AC content. This is shown in FIGURE 5.16 between points A and B. If the vibration signal (AC) is strongly superimposed by a shift (DC), once the measurement range limit is reached, the AC content does not reappear until the motion reversal (point B). Or in other words: During the measurement range overrun between points A and C (refer to FIGURE 5.16), the presentation of the vibration process is distorted.

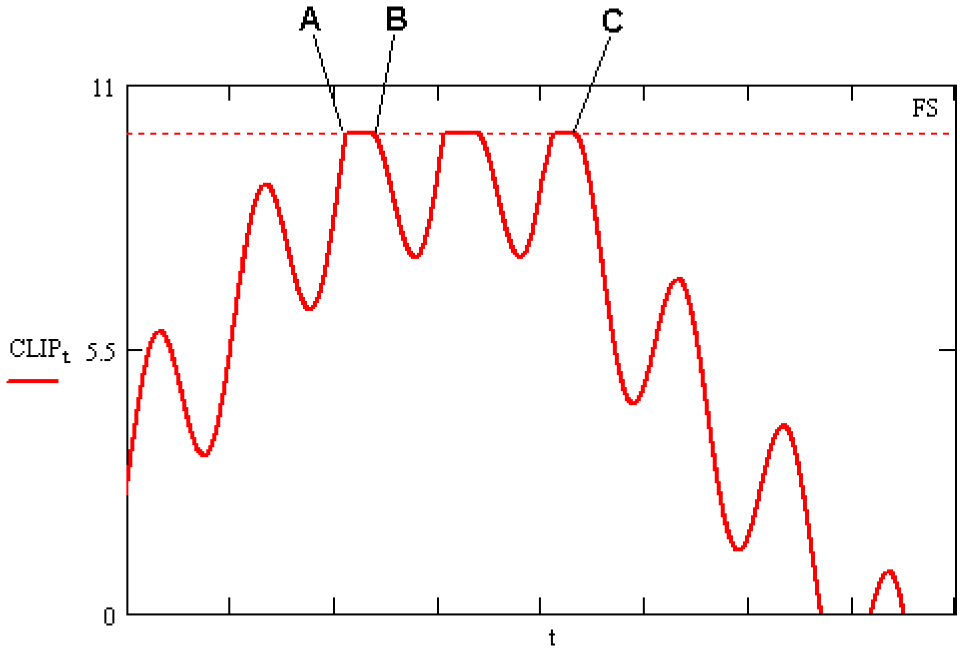

Figure 5.16: AC signal distortion with strong superimposition

However, as soon as the signal is back within the measurement range limits after motion reversal of the superimposed triangular shift (refer to FIGURE 5.16, point C), the AC signal is once again shown without any distortions.

CLIP mode is generally very well suited for presenting vibration motion with a superimposed, slow position drift of the object.

Set the operating mode

To set the mode for the automatic overrange revision, proceed as follows:

1. Tap on .

   The SETTINGS *page is displayed.*

2. In the Displacement area, tap on Output.

   The SETTINGS | Displacement *page is displayed.*

3. Tap on Overrun.

   The page for the parameter settings is displayed.

4. Tap on or to select the mode.

5. Tap on .

   The setting is assumed.

6. Tap on .

   The page is closed.

5.7.4 Using the Digital Output Signal

If the output signal of the digital DD-500 displacement decoder is to be further processed in digital form, then the S/PDIF interface of the controller has to be configured correspondingly (refer to SECTION 5.4.7). At this point it would be advantageous if on the left channel the velocity signal of the digital velocity decoder is transmitted and on the right channel the displacement signal of the digital displacement decoder. You can then use a two channel analyzer to show both signal shapes at the same time.

NOTE!

Depending of the data rate set, only a signal bandwidth of 22 kHz or 42 kHz is available at the digital output.

5.7.5 Using Filters

Low-/high pass filter

All the different filter settings for the analog low pass and high pass filters in the controller do not have any effect on the signals from the digital displacement decoder. With the combination of VD-09/DD-900, reducing the bandwidth can however be effected by the choice of the velocity measurement ranges with reduced bandwidth (identification LP).

Tracking filter

The tracking filter is only effective for the DD-900 (for details refer to SECTION 5.6.4).

5.8 Using Optional Auxiliary Decoders

The VD-05 velocity decoder and the DD-300, DD-400 and DD-600 displacement decoders have been developed especially to be used as auxiliary decoders for specific measurement applications.

The auxiliary decoders are working independently of the other decoders installed in the controller. Therefore while making measurements with an auxiliary decoder, you can use the output signals of the activated velocity decoder (VELOCITY) and displacement decoder (DISPLACEMENT) if the measurement signal is in their operating frequency range. To do so, after setting the measurement range for the auxiliary decoder change to the corresponding Settings menu of an other decoder to set it up as usual. The auxiliary decoder remains active at the AUXILIARY signal output with the settings selected.

5.8.1 VD-05

The VD-05 velocity decoder is suitable to acquire high-frequency vibrations up to 10 MHz and fast transient motions. Such applications are common for example in the domain of ultrasonic technology and micro mechanical systems. The maximum velocity of 3 m/s still allows vibration amplitudes of approx. 50 nm at the upper limit of the operating frequency range.

Output signal

The output signal of the VD-05 is available at the OUTPUT BNC jack in the AUXILIARY field on the front of the controller. The output voltage swing of the decoder is nominal ±5 V according to the full scale values ±0.5 m/s or ±2.5 m/s respectively of the two measurement ranges. However, there is a headroom of about 20% so that peak values up to 3 m/s can be acquired without distortions.

With signal frequencies in the megahertz range, the load connected to the signal output can have great influence on the frequency response and the signal shape. The signal output of the VD-05 is designed for connecting high-impedance inputs of oscilloscopes or other signal acquisition systems (mostly 1 MΩ || 47 pF) via a BNC cable with a maximum length of approx. 1.5 m. If you attach considerably longer cables, it is recommended to use a 50 Ω-termination at the input of the subsequent instrument. In this case, the scaling factors of the measurement ranges change to $200\ \frac{mm}{s}/V$ or $1000\ \frac{mm}{s}/V$ respectively, while the output voltage swing decreases to ±3 V.

Measurement range

Two measurement ranges with scaling factors of $100\ \frac{mm}{s}/V$ and $200\ \frac{mm}{s}/V$ are available for adapting to the vibration amplitude. If the positive boundary of a measurement range has been reached, the OVER LED in the AUXILIARY field lights up on the front view of the controller. Due to the headroom of about 20% you can also make measurements as long as no clipping is observed in the output signal.

Filter

The filters installed in the controller (tracking filter, low pass filter and high pass filter) do not have any effect on the signals of the VD-05.

Noise

Due to the wide frequency bandwidth of the VD-05 you can observe, even with good backscattering properties of the object, relatively high background noise in the time domain. This background noise limits the amplitude resolution for transient motions. It can only be reduced by using average procedures in the subsequent signal processing. With signal evaluation in the frequency range, spectral resolutions of some $\frac{\mu m}{s}/\sqrt{Hz}$ can be reached. For physical reasons, the noise power density increases with frequency on velocity decoding. For technical reasons, single noise peaks can occur at determined frequencies in the specified limits of the spurious free dynamic range.

Interferences

If your OFV-5000 is equipped with a digital velocity decoder (VD-06, VD-09), the decoder should be switched off for measurements with the VD-05 because interferences caused by crosstalk may occur (refer to SECTION 5.4.6).

When making measurements on good reflective surfaces, an interference frequency above 10 MHz can occur. If you are using an OFV-503 or OFV-505 sensor head, this interference can be suppressed by an OFV-A-001 neutral filter on the front of the lens. The neutral filter should not be used on less reflective surfaces because it raises noise markedly.

Impulse acquisition

The VD-05 velocity decoder can also be used for acquiring pulse-shaped signals. As in all systems with limited bandwidth, typical waveform distortions are generated which should be taken into consideration when evaluating the measurement results. In particular, rise time limitations for signals with a short ramp response and amplitude decay for square wave signals due to AC coupling can be expected. For signals with a steep rising edge, transient effects with overshooting of the amplitude up to 20% are also induced by technical reasons. As a rule of thumb, square wave signals should not exceed a repetition rate of about 2 MHz.

5.8.2 DD-300

The DD-300 displacement decoder can be installed instead of the VD-05 velocity decoder. The DD-300 displacement decoder is designed especially for ultrasonic applications. Using this decoder you can measure vibrations and pulse-shaped motions in a frequency range of 30 kHz to 24 MHz with amplitudes up to 75 nm (peak to peak). Thus the DD-300 is particularly suitable for amplitude measurements on ultrasonic transducers, for acquiring ultrasonic pulses or acquiring transient motion in the area of microsystems technology.

Furthermore, a special technique which suppresses vibrations in the acoustic range allows you to make measurements in a normal technical environment. Thus the measurement object under investigation does not have to be vibration-isolated.

NOTE!

Background vibration that exceed a velocity amplitude of approx. 10 mm/s (peak) can result in interferences in the measurement signal.

Output signal

The output signal of the DD-300 is available at the OUTPUT BNC jack in the AUXILIARY field on the front of the controller. To reach the specified properties the input impedance of the connected system must be 50 Ω. You can use a high-impedance termination for vibration measurements in the frequency range below 5 MHz (e.g. 1 MΩ || 47 pF), however the scaling of the output signal then changes to 25 nm/V.

Measurement range

Selecting a suitable measurement range is not necessary for the DD-300, as this decoder has only one measurement range available (50 nm/V).

Low pass filter

The filtered output signal of the DD-300 is available at the UNIVERSAL BNC jack in the AUXILIARY field on the front of the controller. The bandwidth of this signal is limited to 2 MHz. Using the filtered signal is recommended during signal analysis in the time domain to suppress noise if the signal bandwidth allows this.

Tracking filter

The tracking filter has no influence on measurements with the DD-300.

Noise The displacement resolution which can be obtained in the time domain depends directly on the rms value of white noise. The noise voltage, however, is generally relative high caused by the broad bandwidth of the DD-300. Therefore accurate focusing of the laser in the sensor head is very important when measuring amplitudes in the nanometer range. We recommend observing the displacement signal on an oscilloscope while optimizing the focus to attain a noise level as low as possible. On highly reflecting surfaces the signal level display is not sufficient to find the optimal focus position.

Please note that in a 24 MHz bandwidth the noise level is a few millivolts, even in optimal measurement conditions. As a result, when using an oscilloscope, it is not possible to detect amplitudes below a threshold of approx. 0.2 nm.

Otherwise, with good optical signal quality and a resolution bandwidth of just 10 kHz, the noise level will not exceed 0.2 mV (rms), which is equivalent to an amplitude of 0.01 nm. It is thus evident that in order to detect very small amplitudes it is always useful to limit the bandwidth, e.g. by using narrow-band filters, a spectrum analyzer or a lock-in amplifier. Using a spectrum analyzer, amplitudes of less than 1 pm can be measured in optimum conditions.

Interferences Two noise peaks with an amplitude of some millivolts can be observed in the spectrum of the measurement signal in the frequency range from 8 MHz to 25 MHz when making measurements on reflective surfaces. These noise peaks come from the high-frequency fluctuation of the laser power and can not be suppressed electronically. Their exact frequency depends on the sensor head but it is almost constant. It can thus be easily distinguished from the proper ultrasonic signal.

When making measurements on good reflective surfaces, an interference frequency above 10 MHz can occur. If you are using an OFV-503 or OFV-505 sensor head, this interference can be suppressed by an OFV-A-001 neutral filter on the front of the lens. The neutral filter should not be used on less reflective surfaces because it raises noise markedly.

5.8.3 DD-400

The DD-400 displacement decoder generates a displacement proportional voltage signal via integration of the analog velocity signal over the time. This means that its metrological properties depend on the properties of the VD-04 velocity decoder. A prerequisite for correctly operating the DD-400 is that the VD-04 velocity decoder is installed and activated. The combination DD-400/ VD-04 is suitable for vibration measurements in the frequency range of 10 Hz to 250 kHz. In particular with applications in the ultrasonic range, e.g. with bonding tools, you often get better results with the DD-400 integrator than with displacement decoders which work using fringe counting.

Output signal

The output signal of the DD-400 is available at the OUTPUT BNC jack in the AUXILIARY field on the front of the controller with an output swing of ±10 V. The UNIVERSAL BNC jack is not active.

NOTE!

For correctly operating the DD-400 the VD-04 velocity decoder has to be active! If your controller is equipped with two velocity decoders, you have to select the setting VD-04 in the SETTINGS menu. Otherwise the DD-400 displacement decoder provides wrong amplitude measurement values!

Displacement measurement range

Three measurement ranges with scaling factors of 1 µm/V, 10 µm/V and 100 µm/V are available for adapting to the vibration amplitude. The two lower measurement ranges are suitable for vibration frequencies of up to 250 kHz, while in the upper measurement range high vibration amplitudes up to 1 mm can only be acquired up to 20 kHz according to the physical conditions. The lower cutoff frequency is 10 Hz for the measurement range 100 µm/V, 100 Hz for the measurement range 10 µm/V and 1 kHz for the most sensitive measurement range 1 µm/V. The last one is therefore especially suitable for ultrasonic applications.

If the peak value of the measurement signal reaches the full scale value 10 µm, 100 µm and 1 mm respectively, the OVER LED in the AUXILIARY field lights up. In this case, select the next highest measurement range. A prerequisite for a trouble-free processing of the displacement signal is an optimally modulated velocity signal. In no case, an overloading of the velocity signal must occur. Apart from selecting the displacement measurement range hence you have to consider the optimal setting of the velocity measurement range.

Velocity measurement range

As the DD-400 displacement decoder processes the output signal of the VD-04 velocity decoder, its properties also depend on the measurement range set for the velocity decoder. When changing the velocity measurement range, the DD-400 displacement decoder automatically adapts its parameters to the current scaling of the velocity signal so that the selected scaling of the displacement signal is maintained. At the same time the noise characteristics changes due to technical reasons. As a general rule, you should select the smallest possible velocity measurement range which is not overloaded (OVER LED in the VELOCITY field lights up). You can also select the velocity measurement range in the Settings [Auxiliary-Displ] menu of the DD-400. Here you can also activate the VD-04 velocity decoder if another velocity decoder has been active before. Thus you do not have to change to the Settings [Velocity] menu.

Tracking filter

The tracking filter is effective for the DD-400 because it affects the signal of the preceding velocity decoder. Thus for the optimal setting of the tracking filter please read through the information given in SECTION 5.4.3.

5.8.4 DD-600 (I&Q Converter)

The DD-600 signal converter mainly works independently of the settings made in the controller, as the Doppler signal is already tapped off at a very early stage in processing. The metrological properties of the system DD-600/VibSoft-VDD are almost exclusively determined by the settings in the signal processing software VibSoft-VDD. Due to the internal bandwidth limitation of the controller and depending on its decoder and measurement range settings which in turn affect the measurement accuracy of VibSoft-VDD, it is possible that the I&Q signal may be influenced. Therefore when VibSoft-VDD is started, operating the controller via the front panel is blocked while the optimum bandwidth is set internally. Upon leaving VibSoft-VDD, operation via the front view is made available again.

If the I&Q output of the DD-600 is used in connection with other signal processing systems than VibSoft-VDD, then of course the optimum bandwidth is not set automatically internally, but depends on the settings of the internal velocity decoder. To attain the best possible signal properties, then in these cases the following settings on the controller should be selected:

- Digital VD-06 velocity decoder switched off (Range: Off, refer to SECTION 5.4.6)
- For the analog VD-01, VD-02 or VD-04 velocity decoders, the measurement range $125\,\frac{mm}{s}/V$ or $100\,\frac{mm}{s}/V$ must be set.

All other settings on the controller have no effect on the output signals from the DD-600. If required, a test mode for the I&Q signals can be activated via the PC interface (refer to VibSoft software manual).

5.9 Displaying the Configuration and Firmware Version of the Controller

To display the controller configuration and the firmware version at the touch screen, proceed as follows:

1. Tap on .

   The SETUP *page is displayed.*

2. Tap on Obligatory Components.

   The Obligatory Components *page with the standard components is displayed.*

3. Tap on .

   The page is closed.

4. Tap on Optional Components.

   The Optional Components *page with the optional components is displayed.*

5. Tap on .

   The page is closed.

5.10 Configuring the RS-232 Interface

To configure the RS-232 interface on the back of the controller via the touch screen, proceed as follows:

1. Tap on .

   The SETUP *page is displayed.*

2. Tap on Interface.

   The SETUP | RS-232 *page is displayed.*

3. Tap on  or  to set up the transfer rate by modifying the Baud Rate parameter.

4. Tap on  or  to set the echo mode of the interface to (On) or off (Off) by modifying the Echo Mode parameter.

5. Tap on .

   The setting is assumed.

6. Tap on .

   The page is closed.

NOTE!

You will find a description of the interface commands in a separate manual!

---

6 Fault Diagnosis

Procedure

Simple tests are described in the following for you to carry out yourself in the case of malfunctions. In the case of more difficult problems with 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 instrument is limited to such tests in which the housings do not have to be opened.

NOTE!

Tampering with the instruments in any way is not necessary 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.

If the faults or malfunctions can not be solved by the measures described here or if faults/malfunctions occur which are not mentioned here, please contact our service department. Based on your fault description, further procedure will be determined.

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

Checklist

Use the checklist in SECTION 6.5 which is applied to your sensor head, when you contact Polytec or your nearest representative.

6.1 General Tests

In case of a malfunction, first check the following:

1. Have you connected up the controller to the mains?
2. Have you turned the key switch on the front of the controller to position I?
3. Is the POWER LED on the front of the controller lit up?

WARNING!

Risk of injury caused by electric shock! In principle disconnect the mains plug before you check the fuses!

If the LED is not lit up, it can be assumed that there is a fault in the mains supply. Disconnect the mains plug and check the fuses on the back of the controller. Note that there are two active fuses which can both lead to failure.

6.2 Problems with the Laser

6.2.1 No Laser Beam

If no laser beam is emitted, check the following:

1. Have you installed the interferometer cable between the controller and the sensor head correctly?

2. Have you screwed in the plugs of the interferometer cable?

OFV-505/-503

3. Is the LASER LED on the back of the sensor head lit up?

   If the LED is not lit up, it can be assumed that there is a fault in the mains supply of the controller. Disconnect the mains plug and check both of the fuses on the back of the controller.

4. Have you turned the beam shutter on the back of the sensor head to position ON?

5. Can you feel with your hand that after 20 minutes of operation, the housing of the sensor head is warming up slightly indicating that the laser is working?

OFV-551/-552 and OFV-534

6. Is the STANDBY LED on the front of the sensor head and on the laser unit lit up respectively?

   If the LED is not lit up, it can be assumed that there is a fault in the mains supply of the controller. Disconnect the mains plug and check both of the fuses on the back of the controller.

7. Have you pressed the LASER beam shutter key on the front of the sensor head and on the laser unit respectively once after you have switched on the controller?

   The EMISSION LED lights up if the LASER beam shutter key has been pressed once, thus emitting the laser beam. At the same time the STANDBY LED goes out. If the LASER beam shutter key is pressed a second time, the beam shutter is closed, at the same time the EMISSION LED goes out and the STANDBY LED then lights up again.

8. Have you dimmed the laser beam (only OFV-551/-552)?

   If your sensor head is equipped with the option Dimmer, check the dimmer settings in the controller (refer to SECTION 5.2).

9. Do you assume a break of the fiber-optic cable?

6.2.2 Great Fluctuation of the Signal Level Display

If the signal level display on the sensor head or on the display of the controller fluctuates a lot periodically, check if the object is positioned unfavorably in a visibility minimum of the laser.

If so, change the distance between the sensor head and the object. You will find detailed information on optimal stand-off distances and visibility maxima of the various sensor heads in the manual of the respective sensor head.

6.2.3 Laser can not be Focused Manually (only OFV-505/-503)

If the laser beam can not be focused manually by turning the focusing ring on the sensor head, check if the manual focus lock on the controller has been switched on.

You will find detailed information on how to lock manual focus and release it again in SECTION 5.1.4.

6.3 No Measurement Signal or Implausible Measurement Signals

If the laser beam is emitted but no measurement signal is available, check the following:

Signal level display

1. Put the retro-reflective film at an optimal stand-off distance in the beam path in accordance with the instructions given in the manual of the sensor head. Focus the laser beam on the retro-reflective film. Is the signal level display on the tap screen of the controller lit up?

   If the signal level display does not light up, then the input section of the controller is faulty.

Velocity signal

Now check the output signals of the controller as follows:

2. Connect up an oscilloscope to the OUTPUT BNC jack in the VELOCITY field on the front of the controller. Does the output signal react to the retro-reflective film moving?

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

   Normally a DC voltage less than ±20mV can be measured.

4. Set the oscilloscope to 1V/DIV and point the laser beam at nothing or at a surface which completely absorbs the laser beam (e.g. black felt). Is the output signal noisy or does the oscilloscope show a straight line?

   Noise has to occur if the laser beam does not hit a surface which scatters light back.

Displacement signal (optional)

5. Connect up an oscilloscope to the OUTPUT BNC jack in the DISPLACEMENT field on the front of the controller. At the touch screen tap on Clear. You will find detailed information on the CLEAR function in SECTION 5.6.3. Does the output signal react to the retro-reflective film moving?

Auxiliary signals (optional)

6. If auxiliary decoders are installed with your controller, please also check the output signals here. Connect up an oscilloscope to the OUTPUT BNC jack in the AUXILIARY field on the front of the controller. Does the output signal react to the retro-reflective film moving?

6.4 Messages on the Touch Screen of the Controller

Messages which appear on the touch screen of the controller are divided into categories.

Note

Messages in the category Note are identified by ✅. These messages provide information on activities of the controller as a consequence of the settings just made.

Warning

Messages in the category Warning are identified by ⚠. These messages are errors which you can rectify yourself.

6.4.1 List for Notes

Message	Explanation
✅ Focus Position Saved	The focus position has been saved.
✅ Focus Position loaded	The focus position has been loaded.

6.4.2 List for Warnings

Message	Explanation
⚠ No Sensor Head found.	OFV-505, OFV-551/-552 and OFV-534 sensor heads: The sensor head has not been connected or is connected wrongly or the interferometer cable is defective. Check that the interferometer cable between the controller and the sensor head is connected up correctly. Other sensor heads: All other sensor heads can not yet be remotely controlled from the controller. So the controller can not recognize them yet either.
⚠ Loading Focus Position failed!	Loading the focus position failed.
⚠ Non-volatile storage is only possible with PowerUp Settings 'Last'	The current focus position can only be saved in the Last Power-Up mode. First of all, save the focus position in the Last Power-Up mode. Then change the Power-Up mode to User1, User2 or User3 and save the settings (refer to SECTION 4.2.4).
⚠ No Auto Focus available!	No sensor head connected. Function auto focus is not available for the sensor head.

6.5 Checklist for Fault Diagnosis

6.5.1 Controller with Single Point Sensor Head

Serial number of controller:

Serial number of sensor head:

OFV-505 OFV-503

You will find the serial numbers on the back of the instruments and on the inside cover of this manual or the manual of the sensor head respectively.

		Target	Actual
1.	Is the POWER LED on the front of the controller lit up?	Yes	
2.	Is the LASER LED on the back of the sensor head lit up?	Yes	
3.	Does the housing of the sensor head feel warm to the touch as normal after about 20 minutes in operation?	Yes	
4.	Is the laser beam being emitted?	Yes	
5.	Is the signal level display on the sensor head lit up?	Yes	
6.	Is the signal level display indicated at the touch screen?	Yes	
7.	Does the OUTPUT signal in the VELOCITY field on the front of the controller react to the reflective film moving?	Yes	
8.	If the output signal does not react: How high is the DC offset?	<20 mV	
9.	Is the output signal noisy when the laser beam is pointed at a non reflective surface (e.g. black felt)?	Yes	
10.	Only for controllers with displacement decoder: Does the OUTPUT signal in the DISPLACEMENT field on the front of the controller react to the reflective film moving?	Yes	
11.	Only for controllers with auxiliary decoders: Does the OUTPUT signal in the AUXILIARY field on the front of the controller react to the reflective film moving?	Yes	
Further observations:			

6.5.2 Controller with Fiber-Optic Sensor Head

Serial number of controller:

Serial number of sensor head:

OFV-551 OFV-552

You will find the serial numbers on the back of the instruments and on the inside cover of this manual or the manual of the sensor head respectively.

		Target	Actual
1.	Is the POWER LED on the front of the controller lit up?	Yes	
2.	Is the LASER ON LED on the front of the sensor head lit up?	Yes	
3.	Does the housing of the sensor head feel warm to the touch as normal after about 20 minutes in operation?	Yes	
4.	Is the laser beam being emitted?	Yes	
5.	Can you assume a break in the fiber-optic cable?	No	
6.	Is the signal level display on the sensor head lit up?	Yes	
7.	Is the signal level display indicated at the touch screen?	Yes	
8.	Does the OUTPUT signal in the VELOCITY field on the front of the controller react to the reflective film moving?	Yes	
9.	If the output signal does not react: How high is the DC offset?	<20 mV	
10.	Is the output signal noisy when the laser beam is pointed at a non reflective surface (e.g. black felt)?	Yes	
11.	Only for controllers with displacement decoder: Does the OUTPUT signal in the DISPLACEMENT field on the front of the controller react to the reflective film moving?	Yes	
12.	Only for controllers with auxiliary decoders: Does the OUTPUT signal in the AUXILIARY field on the front of the controller react to the reflective film moving?	Yes	
Further observations:			

6.5.3 Controller with Fiber-Coupled Sensor Head

Serial number of controller:

Serial number of sensor head:

OFV-534

You will find the serial numbers on the back of the instruments and on the inside cover of this manual or the manual of the sensor head respectively.

		Target	Actual
1.	Is the POWER LED on the front of the controller lit up?	Yes	
2.	Is the LASER ON LED on the front of the laser unit lit up?	Yes	
3.	Does the housing of the sensor head feel warm to the touch as normal after about 20 minutes in operation?	Yes	
4.	Is the laser beam being emitted?	Yes	
5.	Can you assume a break in the fiber-optic cable?	No	
6.	Is the signal level display on the sensor head lit up?	Yes	
7.	Is the signal level display indicated at the touch screen?	Yes	
8.	Does the OUTPUT signal in the VELOCITY field on the front of the controller react to the reflective film moving?	Yes	
9.	If the output signal does not react: How high is the DC offset?	<20 mV	
10.	Is the output signal noisy when the laser beam is pointed at a non reflective surface (e.g. black felt)?	Yes	
11.	Only for controllers with displacement decoder: Does the OUTPUT signal in the DISPLACEMENT field on the front of the controller react to the reflective film moving?	Yes	
12.	Only for controllers with auxiliary decoders: Does the OUTPUT signal in the AUXILIARY field on the front of the controller react to the reflective film moving?	Yes	
Further observations:			

7 Technical Specifications

7.1 Harmonized Standards Applied

Laser safety:	IEC/EN 60825-1:2008-05 (Safety of Laser Products, complies to US 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice no. 50, dated 24 June 2007)	
Electrical safety:	IEC/EN 61010-1:2011-07 (Safety requirements for electrical equipment for measurement, control, and laboratory use)	
EMC:	IEC/EN 61326-1:2006-10 (EMC requirements on 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 General Data

Mains Connection

Mains voltage:	100…240 VAC ±10 %, 50/60 Hz
Power consumption:	100 VA
Fuses:	2.0 A/slow-blow
Protection class:	1 (protective grounding)

Ambient Conditions

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

Calibration

Recommended calibration interval:	2 years

Housing

Protection rating:	IP 20
Dimensions (w x h x d):	Without angle brackets 450 mm x 150 mm x 360 mm (19", 84 HP/3 U) With angle brackets 485 mm x 150 mm x 360 mm (19", 84 HP/3 U)
Weight:	10 kg

Display

Type:	7" color LCD with resistive touch screen
Resolution:	480 x 800 points
Quality:	quality class A

7.3 Digital Interfaces

PC

RS-232:	8 data bits, 1 stop bit, no parity, transfer rates: 9600/19200/57600/115200 Baud, adjustable in the controller, RS-232(X) cable to the PC: 2 x 9-pin Sub-D jack, null modem cable
DIGITAL OUT:	Digital Audio interface complying with S/P-DIF standard, 2 independent signal channels with 24 bit amplitude resolution Data rate: 48 kSa/s and 96 kSa/s (adjustable) Frequency range: 0 Hz…22 kHz or 0 Hz…42 kHz (depending on the data rate) Electrical output: TRIAX jack Optical output: TOSLINK fiber connector

External Decoder

External Decoder:	Special interface for PC-based signal decoder

7.4 Analog Signal Inputs and Outputs

VELOCITY OUTPUT

Voltage output for the velocity signal

Voltage swing:	max. 20 V_{p-p}
Output impedance:	nom. 50 Ω
Load resistance:	min. 10 kΩ (−0.5% additional error)
Overrange indicator threshold:	typ. 95% of full scale
DC offset:	max. 20 mV

VELOCITY DSP OUT

Voltage output for the velocity signal after adaptive DSP filtering (only for VD-06 along with the LF-02 adaptive DSP filter)

Voltage swing:	max. 20 V_{p-p}
Output impedance:	nom. 50 Ω
Load resistance:	min. 10 kΩ (−0.5% additional error)
DC offset:	max. 10 mV

AUXILIARY OUTPUT

Voltage output of the signal of the optional auxiliary decoder (displacement or velocity signal depending on the decoder)

Electrical properties:	Depending on the decoder installed (refer to SECTION 7.5.9 and following)

AUXILIARY UNIVERSAL

Input or output for special functions of the optional auxiliary decoders

DISPLACEMENT OUTPUT

Voltage output for the displacement signal (only with a displacement decoder installed)

Voltage swing:	max. 20 V_{p-p} (depending on the displacement decoder)
Output impedance:	nom. 50 Ω
Load resistance:	min. 10 kΩ (−0.5% additional error)

DISPLACEMENT TRIG IN

Trigger input to set the DC offset of the displacement signal back to zero (only with a displacement decoder installed)

Input voltage:	max. ±15 V
Sensitivity threshold:	< 25 mV (rising edge)
Input impedance:	min. 10 kΩ
Pulse width:	min. 2 µs
Pulse frequency:	max. 100 kHz
Trigger delay:	< 10 µs (typ. 5 µs)

SIGNAL

Signal output for a DC voltage signal proportional to the logarithm of the optical signal level of the vibrometer

Voltage range:	0 V … 3 V, DC
Load resistance:	min. 10 kΩ

7.5 Metrological Properties of the Decoders

7.5.1 VD-01 Velocity Decoder

Measurement range	**1**	**5**	**25**	**125**	**1000**	$\frac{mm}{s}/V$
Full scale (peak)	0.01	0.05	0.25	1.25	10.0	m/s
Frequency range						
f_{min}	0.5	0.5	0.5	0	0	Hz
f_{max}	20	50	50	50	50	kHz
Max. acceleration	150	1600	8000	40000	320000	g
Frequency response[1]						
0.5 Hz … 20 Hz	±0.5	±0.5	±0.5	±0.1	±0.1	dB
20 Hz … 20 kHz	+0.1/−0.2	±0.05	±0.05	±0.05	±0.05	dB
20 kHz … 50 kHz	−	±0.2	±0.2	±0.2	±0.2	dB
Resolution[2]						
Frequency-dependent[3]	0.05 … 0.1	0.05 … 0.1	0.1 … 0.25	0.1 … 0.4	0.5 … 1.5	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.1	0.1	0.2	0.3	1.5	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−7.56	−2.75	−1.88	−1.86	−1.79	°/kHz
Signal delay t_D (typ.)	21.0	7.63	5.21	5.16	4.98	µs
Calibration error[5]						
T_a = (25 ±3)°C (T_a = (77 ±5)°F)	±1.0	±1.0	±1.0	±1.0	±1.0	%
T_a = +5°C … +40°C (T_a = 41°F … 104°F)	±1.2	±1.2	±1.2	±1.2	±1.2	%
Linearity error[6]	0.25	0.25	0.25	0.25	0.25	%
Harmonic Distortions	< −40	< −52	< −60	< −50	< −50	dBc
Spurious signals (non-harmonic)[7]	< −86	< −90	< −90	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error referred to the reference frequency of 1 kHz.

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

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10 Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote [5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of this is just a single peak, generated by the optical sensor, in the frequency range 20 … 25 kHz, whose amplitude depends on the stand-off distance.

7.5.2 VD-02 Velocity Decoder

Measurement range	**5**	**25**	**125**	**1000**	$\frac{mm}{s}/V$
Full scale (peak)	0.05	0.25	1.25	10.0	m/s
Frequency range					
f_{min}	0.5	0.5	0.5	0.5	Hz
f_{max}	250	1500	1500	1500	kHz
Max. acceleration	8000	240000	1200000	9600000	g
Frequency response[1]					
0.5 Hz … 20 Hz	±0.5	±0.5	±0.5	±0.5	dB
20 Hz … 100 kHz	±0.1	±0.1	±0.1	±0.1	dB
100 kHz … 250 kHz	+0.2/-1.0	±0.1	±0.1	±0.1	dB
250 kHz … 1.5 MHz	−	+0.5/−2.0	+0.5/−2.0	+0.5/−2.0	dB
Resolution[2]					
Frequency-dependent[3]	0.05 … 0.2	0.1 … 1.0	0.3 … 3.0	2.0 … 5.0	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.1	0.5	0.6	2.5	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−2.19	−0.45	−0.42	−0.36	°/kHz
Signal delay t_D (typ.)	6.08	1.25	1.17	1.01	µs
Calibration error[5]					
T_a = (25 ±3)°C (T_a = (77 ±5)°F)	±1.0	±1.0	±1.0	±1.0	%
T_a = +5°C … +40°C (T_a = 41°F … 104°F)	±1.5	±2.0	±2.5	±2.5	%
Linearity error[6]	1.0	1.5	1.0	1.0	%
Harmonic Distortions	< −52	< −46	< −50	< −50	dBc
Spurious signals (non-harmonic)[7]	< −86	< −86	< −86	< −86	dBFS

[1] The frequency response defines the frequency-dependent amplitude error referred to the reference frequency of 1 kHz.

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

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10 Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote [5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of this is just a single peak, generated by the optical sensor, in the frequency range 20 … 25 kHz, whose amplitude depends on the stand-off distance.

7.5.3 VD-04 Velocity Decoder

Measurement range	**10**	**100**	**1000**	$\frac{mm}{s}/V$
Full scale (peak)	0.1	1.0	10.0	m/s
Frequency range				
f_{min}	0.5	0.5	0.5	Hz
f_{max}	250	250	250	kHz
Max. acceleration	16000	160 000	1600 000	g
Frequency response[1]				
0.5 Hz … 20 Hz	±0.5	±0.5	±0.5	dB
20 Hz … 100 kHz	±0.1	±0.1	±0.1	dB
100 kHz … 200 kHz	±0.2	±0.2	±0.2	dB
200 kHz … 250 kHz	+0.2/−1.0	+0.1/−1.0	+0.1/−1.0	dB
Resolution[2]				
Frequency-dependent[3]	0.05 … 0.2	0.3 … 1.0	2.0 … 3.0	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.1	0.5	2.0	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−2.12	−1.52	−1.46	°/kHz
Signal delay t_D (typ.)	5.85	4.21	4.05	μs
Calibration error[5]				
T_a = (25 ±3) °C (T_a = (77 ±5) °F)	±1.0	±1.0	±1.0	%
T_a = +5 °C … +40 °C (T_a = 41 °F … 104 °F)	±1.5	±2.5	±2.5	%
Linearity error[6]	1.0	1.0	1.0	%
Harmonic Distortions	< −52	< −50	< −50	dBc
Spurious signals (non-harmonic)[7]	< −86	< −86	< −86	dBFS

[1] The frequency response defines the frequency-dependent amplitude error referred to the reference frequency of 1 kHz.

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

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10 Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote [5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of this is just a single peak, generated by the optical sensor, in the frequency range 20 … 25 kHz, whose amplitude depends on the stand-off distance.

7.5.4 VD-06 Velocity Decoder

Table 7.1: Characteristics VD-06 part 1 of 2

Measurement range	**1**	**2 (LP)**	**2**	$\frac{mm}{s}/V$
Full scale (peak)	0.01	0.02	0.02	m/s
Frequency range				
f_{min}	0	0	0	Hz
f_{max}	20	100	350	kHz
Max. acceleration	128	1280	4500	g
Frequency response[1]				
0.05 Hz … 14 kHz	±0.05	–	–	dB
14 kHz … 20 kHz	+0.05/−1.0	–	–	dB
0.05 Hz … 50 kHz	–	±0.05	–	dB
50 kHz … 100 kHz	–	+0.05/−1.0	–	dB
0.05 Hz … 250 kHz	–	–	±0.05	dB
250 kHz … 300 kHz	–	–	+0.05/−0.4	dB
300 kHz … 350 kHz	–	–	+0.05/−1.5	dB
Resolution[2]				
Frequency-dependent[3]	< 0.02	0.01 … 0.04	0.01 … 0.1	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.01	0.02	0.05	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−45.8	−3.96	−3.96	°/kHz
Signal delay t_D (typ.)	127.0	11.0	11.0	µs
Calibration error[5] T_a = +5°C … +40°C (T_a = 41°F … 104°F)	±1.0	±1.0	±1.0	%
Linearity error[6]	< 0.1	< 0.1	< 0.1	%
Harmonic Distortions	< −50	< −54	< −54	dBc
Spurious signals (non-harmonic)[7]	< −80	< −86	< −86	dBFS

[1] The frequency response defines the frequency-dependent amplitude error referred to the reference frequency of 1 kHz.

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

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10 Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote [5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of this is just a single peak, generated by the optical sensor, in the frequency range 20 … 25 kHz, whose amplitude depends on the stand-off distance.

Table 7.2: Characteristics VD-06 part 2 of 2

Measurement range	**10 (LP)**	**10**	**50 (LP)**	**50**	$\frac{mm}{s}/V$
Full scale (peak)	0.1	0.1	0.5	0.5	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	100	350	100	350	kHz
Max. acceleration	6400	22000	32000	110000	g
Frequency response[1]					
0.05 Hz … 14 kHz	–	–	–	–	dB
14 kHz … 20 kHz	–	–	–	–	dB
0.05 Hz … 50 kHz	±0.05	–	±0.05		dB
50 kHz … 100 kHz	+0.05/−1.0	–	+0.05/−1.0		dB
0.05 Hz … 250 kHz	–	±0.05	–	±0.05	dB
250 kHz … 300 kHz	–	+0.05/−0.3	–	+0.05/−0.1	dB
300 kHz … 350 kHz	–	+0.05/−1.0	–	+0.05/−1.0	dB
Resolution[2]					
Frequency-dependent[3]	0.01 … 0.04	0.01 … 0.1	0.04 … 0.2	0.04 … 0.2	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.02	0.05	0.05	0.06	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−3.96	−3.96	−3.96	−3.96	°/kHz
Signal delay t_D (typ.)	11.0	11.0	11.0	11.0	µs
Calibration error[5]					
T_a = +5°C … +40°C (T_a = 41°F … 104°F)	±1.0	±1.0	±1.0	±1.0	%
Linearity error[6]	< 0.1	< 0.1	< 0.1	< 0.1	%
Harmonic Distortions	< −54	< −54	< −54	< −54	dBc
Spurious signals (non-harmonic)[7]	< −90	< −90	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error referred to the reference frequency of 1 kHz.

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

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10 Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote [5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of this is just a single peak, generated by the optical sensor, in the frequency range 20 … 25 kHz, whose amplitude depends on the stand-off distance.

7.5.5 VD-09 Velocity Decoder

Table 7.3: Characteristics VD-09 part 1 of 4

Measurement range	**5**	**10**	**20 (LP)**	**20**	$\frac{mm}{s}/V$
Full scale (peak)	0.05	0.1	0.2	0.2	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	100	250	250	1 000	kHz
Max. acceleration	3 200	16 000	32 000	128 000	g
Frequency response[1]					
0.05 Hz … 50 kHz	±0.1	±0.1	±0.1	±0.1	dB
50 kHz … 100 kHz	+0.1/−1.0	+0.1/−0.2	±0.1	±0.1	dB
100 kHz … 250 kHz	–	+0.1/−1.0	+0.1/−1.0	±0.1	dB
250 kHz … 1 MHz	–	–	–	+0.2/−0.5	dB
Resolution[2]					
frequency-dependent[3]	0.01 … 0.04	0.01 … 0.07	0.02 … 0.08	0.02 … 0.25	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.02	0.04	0.05	0.12	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−7.45	−5.54	−5.8	−3.2	°/kHz
Signal delay t_D (typ.)	20.7	15.4	16.1	8.9	µs
Calibration error[5]					
T_a = (25 ±3) °C (T_a = (77 ±5)°F)	±1.0	±1.0	±1.0	±1.0	%
T_a = +5°C … +40°C (T_a = 41°F … 104°F)	±1.0	±1.0	±1.0	±1.5	%
Linearity error[6]	0.5	0.5	0.5	0.5	%
Harmonic distortions[7]					
0.05 Hz … 100 kHz	< −44	< −52	< −52	< −52	dBc
100 kHz … 250 kHz	–	< −46	< −46	< −46	dBc
> 250 kHz	–	–	–	< −38	dBc
Spurious signals (non-harmonic)[8]	< −83	< −86	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error referred to the reference frequency of 1 kHz.

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

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10 Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote [5]).

[7] Harmonic distortions are defined 70% of full scale for the wanted signal. In each case the bandwidth is specified, in which the distortion can occur.

[8] The maximum amplitude of the distortion refers to the full scale. An exception of this is just a single peak, generated by the optical sensor, in the frequency range 20 … 25 kHz, whose amplitude depends on the stand-off distance.

Table 7.4: Characteristics VD-09 part 2 of 4

Measurement range	**50 (LP)**	**50**	**100 (LP)**	**100**	mm/s/V
Full scale (peak)	0.5	0.5	1.0	1.0	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	250	1 500	250	1 500	kHz
Max. acceleration	80 000	480 000	160 000	960 000	g
Frequency response[1]					
0.05 Hz … 100 kHz	±0.1	±0.1	±0.1	±0.1	dB
100 kHz … 250 kHz	+0.1/−1.0	±0.1	+0.1/−1.0	±0.1	dB
250 kHz … 1 MHz	–	±0.2	–	±0.2	dB
1 MHz … 1.5 MHz	–	+0.2/−0.5	–	+0.2/−0.5	dB
Resolution[2]					
Frequency-dependent[3]	0.04 … 0.2	0.04 … 0.35	0.07 … 0.4	0.06 … 0.4	µm/s/√Hz
typically[4]	0.06	0.18	0.1	0.2	µm/s/√Hz
Frequency-dependent phase shift p_D (typ.)	−5.4	−2.94	−4.54	−2.94	°/kHz
Signal delay t_D (typ.)	15.0	8.16	12.6	8.16	µs
Calibration error[5]					
T_a = (25 ±3) °C (T_a = (77 ±5)°F)	±1.0	±1.0	±1.0	±1.0	%
T_a = +5°C … +40°C (T_a = 41°F … 104°F)	±1.0	±1.5	±1.0	±1.5	%
Linearity error[6]	0.5	0.5	0.5	0.5	%
Harmonic distortions[7]					
0.05 Hz … 100 kHz	< −52	< −52	< −54	< −54	dBc
100 kHz … 250 kHz	< −46	< −46	< −54	< −54	dBc
> 250 kHz	–	< −36	–	< −38	dBc
Spurious signals (non-harmonic)[8]	< −90	< −90	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error referred to the reference frequency of 1 kHz.

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

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10 Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote [5]).

[7] Harmonic distortions are defined 70% of full scale for the wanted signal. In each case the bandwidth is specified, in which the distortion can occur.

[8] The maximum amplitude of the distortion refers to the full scale. An exception of this is just a single peak, generated by the optical sensor, in the frequency range 20 … 25 kHz, whose amplitude depends on the stand-off distance.

Table 7.5: Characteristics VD-09 part 3 of 4

Measurement range	**200 (LP)**	**200**	**500 (LP)**	**500**	$\frac{mm}{s}$/V
Full scale (peak)	2	2	5	5	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	250	2500	250	2500	kHz
Max. acceleration	320000	3200000	800000	8000000	g
Frequency response[1]					
0.05 Hz … 100 kHz	±0.1	±0.1	±0.1	±0.1	dB
100 kHz … 250 kHz	+0.1/−1.0	±0.1	+0.1/−1.0	±0.1	dB
250 kHz … 1 MHz	−	±0.2	−	±0.2	dB
1 MHz … 1.5 MHz	−	±0.2	−	±0.2	dB
1.5 MHz … 2.5 MHz	−	+0.5/−1.5	−	+0.5/−1.5	dB
Resolution[2]					
frequency-dependent[3]	0.13 … 0.8	0.1 … 1.0	0.25 … 2.0	0.25 … 2.0	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.15	0.5	0.25	0.6	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−4.75	−1.35	−2.10	−1.34	°/kHz
Signal delay t_D (typ.)	13.2	3.76	5.83	3.73	µs
Calibration error[5]					
T_a = (25 ±3)°C (T_a = (77 ±5)°F)	±1.0	±1.0	±1.0	±1.0	%
T_a = +5°C … +40°C (T_a = 41°F … 104°F)	±1.0	±1.5	±1.0	±1.5	%
Linearity error[6]	0.5	0.5	0.5	0.5	%
Harmonic distortions[7]					
0.05 Hz … 100 kHz	< −54	< −54	< −54	< −54	dBc
100 kHz … 250 kHz	< −54	< −54	< −54	< −54	dBc
> 250 kHz	−	< −38	−	< −36	dBc
Spurious signals (non-harmonic)[8]	< −90	< −90	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1 kHz.

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

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10 Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote [5]).

[7] Harmonic distortions are defined 70% of full scale for the wanted signal. In each case the bandwidth is specified, in which the distortion can occur.

[8] The maximum amplitude of the distortion refers to the full scale. An exception of this is just a single peak, generated by the optical sensor, in the frequency range 20 … 25 kHz, whose amplitude depends on the stand-off distance.

Table 7.6: Characteristics VD-09 part 4 of 4

Measurement range	**1 (LP)**	**1**	$\frac{m}{s}/V$
Full scale (peak)	10	10	m/s
Frequency range			
f_{min}	0	0	Hz
f_{max}	250	1500	kHz
Max. acceleration	1600000	9600000	g
Frequency response[1]			
0.05 Hz … 100 kHz	±0.1	±0.1	dB
100 kHz … 250 kHz	+0.1/−1.0	±0.1	dB
250 kHz … 1 MHz	−	±0.2	dB
1 MHz … 1.5 MHz	−	+0.2/−0.5	dB
Resolution[2]			
frequency-dependent[3]	0.5 … 4.0	0.5 … 4.0	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.5	0.7	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−2.57	−2.14	°/kHz
Signal delay t_D (typ.)	7.13	5.95	µs
Calibration error[5]			
T_a = (25 ±3)°C (T_a = (77 ±5)°F)	±1.0	±1.0	%
T_a = +5°C … +40°C (T_a = 41°F … 104°F)	±1.0	±1.5	%
Linearity error[6]	0.5	0.5	%
Harmonic distortions[7]			
0.05 Hz … 100 kHz	< −54	< −54	dBc
100 kHz … 250 kHz	< −54	< −50	dBc
> 250 kHz	−	< −38	dBc
Spurious signals (non-harmonic)[8]	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1 kHz.

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

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10 Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote [5]).

[7] Harmonic distortions are defined 70% of full scale for the wanted signal. In each case the bandwidth is specified, in which the distortion can occur.

[8] The maximum amplitude of the distortion refers to the full scale. An exception of this is just a single peak, generated by the optical sensor, in the frequency range 20 … 25 kHz, whose amplitude depends on the stand-off distance.

7.5.6 DD-100 Displacement Decoder

Measurement range µm/V	Full scale[1] (peak-to-peak) µm	Resolution[2] nm	Frequency range kHz	Max. measurable velocity m/s	Max. frequency at full scale Hz
80	1280	80	0… 250	2.5	600
160	2560	160	0… 250	5	600
320	5120	320	0… 250	10	600
640	10240	640	0… 250	10	300
1280	20480	1280	0… 250	10	150
2560	40960	2560	0… 250	10	75
5120	81920	5120	0… 250	10	40
10240	163840	10240	0… 250	10	20

[1] The full scale values correspond to ±8V (peak-to-peak) maximum output voltage.

[2] The resolution is defined as 1 count or 1mV at the analog output respectively.

Linearity error: ± 1 increment

Amplitude frequency response:
0kHz…100kHz: ±0.5%
100kHz…200kHz: ±1%
200kHz…250kHz: +1%/−10%

Calibration error: ±(1% of the measurement value + 1 increment)
Conditions: sinusoidal vibration, f = 80Hz, amplitude 50% of full scale range, load resistance ≥ 1MΩ

7.5.7 DD-500 Displacement Decoder

Measurement range µm/V	Full scale[1] (peak-to-peak) µm	Resolution[2] (rounded) nm	Frequency range[3] kHz
0.05	1	0.015	0… 350
0.1	2	0.03	0… 350
0.2	4	0.06	0… 350
0.5	10	0.15	0… 350
1	20	0.3	0… 350
2	40	0.6	0… 350
5	100	1.5	0… 350
10	200	3	0… 350
20	400	6	0… 350
50	1000	15	0… 350
100	2000	30	0… 350
200	4000	60	0… 350
500	10000	150	0… 350
1000	20000	300	0… 350
2000	40000	600	0… 350
5000	100000	1500	0… 350

[1] The full scale values correspond to ±10V (peak-to-peak) maximum output voltage.

[2] The resolution corresponds to the quantization step of approx. 0.4mV at the analog output.

[3] When a suitable measurement range has been selected for the digital velocity decoder

Amplitude Frequency Response

Frequency response	Max. additional error with reference to f = 1kHz
0.05Hz…100kHz	±0.05dB
100kHz…200kHz	±0.1dB
200kHz…350kHz	+0.2/−1dB

Phase shift: typ. −3.96°/kHz

Delay: typ. 11µs

Noise-limited resolution: < 0.5 $\mathrm{pm}/\sqrt{\mathrm{Hz}}$
The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M Scotchlite™ Tape (reflective film).

Calibration error: ±1% of the measurement value (T_a = +5°C…+40°C)
Conditions: sinusoidal vibration, f = 1kHz, amplitude 70% of full scale range, load resistance ≥ 1MΩ

Harmonic distortions: < −54dBc

Spurious signals (non-harmonic): < 15 pm (rms)

7.5.8 DD-900 Displacement Decoder

Measurement range µm/V	Full scale[1] (peak-to-peak) µm	Resolution[2] (rounded) nm	Frequency range[3] MHz
0.05	1	0.015	0 … 2.5
0.1	2	0.03	0 … 2.5
0.2	4	0.06	0 … 2.5
0.5	10	0.15	0 … 2.5
1	20	0.3	0 … 2.5
2	40	0.6	0 … 2.5
5	100	1.5	0 … 2.5
10	200	3	0 … 2.5
20	400	6	0 … 2.5
50	1 000	15	0 … 2.5
100	2 000	30	0 … 2.5
200	4 000	60	0 … 2.5
500	10 000	150	0 … 2.5
1 000	20 000	300	0 … 2.5
2 000	40 000	600	0 … 2.5
5 000	100 000	1 500	0 … 2.5

[1] The full scale values correspond to ±10 V (peak-to-peak) maximum output voltage.

[2] The resolution corresponds to the quantization step of approx. 0.3 mV at the analog output.

[3] When a suitable measurement range has been selected for the digital velocity decoder

NOTE!

You will find the technical specifications for frequency response function, phase shift, signal delay, calibration error and linearity error in SECTION 7.5.5 for the current velocity measurement range.

Noise-limited resolution: $< 0.5\ \mathrm{pm}/\sqrt{\mathrm{Hz}}$
The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0 dB with 1 Hz spectral resolution, measured on 3M Scotchlite™ Tape (reflective film).

Spurious signals (non-harmonic): < 10 pm (rms)
An exception of which is a single peak, generated by the optical sensor, in the frequency range 20 … 25 kHz, whose amplitude depends on the stand-off distance (refer to SECTION 7.5.5).

NOTE!

The technical specifications for the harmonic distortions depend on the selected velocity measurement range, refer to SECTION 7.5.5. Take the corresponding data from the table and add −6 dB to each value.

7.5.9 VD-05 Auxiliary Decoder (Velocity Decoder)

Measurement range	**100**	**500**	$\frac{mm}{s}/V$
Full scale (peak)			
Nominal	0.5	2.5	m/s
Maximum	0.6	3.0	m/s
Frequency range			
f_{min}	0.5	0.5	Hz
f_{max}	10	10	MHz
Max. acceleration	320 000	1 600 000	g
Frequency response[1]			
0.5 Hz … 5 MHz	±0.2	±0.2	dB
5 MHz … 10 MHz	±0.5	±0.5	dB
Resolution[2]	< 3.0	< 3.0	$\frac{\mu m}{s}/\sqrt{Hz}$
Pulse response			
Rise time $t_{10\text{-}90}$	< 25	< 25	ns
Signal delay t_D	< 100	< 100	ns
Overshoot	< 20	< 20	%
Calibration error[3]			
T_a = (25 ±3) °C (T_a = (77 ±5) °F)	±2.0	±2.0	%
Linearity error[4]	2.0	2.0	%
Harmonic distortions	< −35	< −35	dBc
Spurious signals (non-harmonic)[5]	< −80	< −80	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 100 kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0 dB with 1 Hz spectral resolution, measured on 3M Scotchlite™ Tape (reflective film). The attainable resolution is frequency-dependent. The typical value refers to the center of the operating frequency range.

[3] Conditions: sinusoidal vibration, f = 100 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[4] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[3]).

[5] The maximum amplitude of the distortion refers to the full scale. The only exception to this is an individual peak generated by the optical sensor in the frequency range 5 … 10 MHz, which can attain an amplitude of up to −60 dBFS.

7.5.10 DD-300 Auxiliary Decoder (Displacement Decoder)

Measurement range:	±75 nm	
Frequency range:	30 kHz … 24 MHz (−3 dB)	
Noise-limited resolution:	< 0.02 $pm/\sqrt{Hz}$ at 100 % reflectivity < 0.05 $pm/\sqrt{Hz}$ when measuring on reflective film (corresponding to 0.25 nm (rms) at 20 MHz analysis bandwidth)	
Scaling factor:	50 nm/V at load resistance 50 Ω ±1 %[1] (25 nm/V at load resistance > 10 kΩ)	
Voltage swing:	±1.5 V at load resistance 50 Ω[1] (±3 V at load resistance > 10 kΩ)	
Output impedance:	50 Ω	
Load resistance:	50 Ω ±1 %[1]	
NF suppression:	Transition frequency:	typ. 30 kHz (−3 dB)
	Frequency roll-off:	−12 dB/oct.
Pulse response:	Propagation delay t_D:	< 140 ns
	Rise time $t_{10\text{-}90}$:	< 25 ns
	Overshoot:	< 20 %
Calibration error:	< ±5 % (sinusoidal vibration, frequency 500 kHz, amplitude 50 nm, load resistance 50 Ω)	
Amplitude frequency response:	refer also to FIGURE 7.1	
	BNC jack AUXILIARY OUTPUT:	±1 dB (50 kHz … 20 MHz)
	BNC jack AUXILIARY_UNIVERSAL:	+0.5/−1 dB (50 kHz … 2 MHz)
Linearity error:	< ±2 % to 60 nm Peak, refer also to FIGURE 7.2	
Spurious signals (non-harmonic):	< 100 µV (rms)[2]	

[1] The specifications apply for a load resistance of 50 Ω. With frequencies of less than 5 MHz or if the pulse has a slow rising/falling edge, the outputs can also be terminated with high impedance. In this case the data given in brackets are for information purposes.

[2] Non-harmonic interference signals are independent of the wanted signal. When making measurements on mirror-like surfaces two more peaks in the frequency range from 8 MHz to 25 MHz with higher amplitudes can occur, whose frequencies depend on the optical sensor.

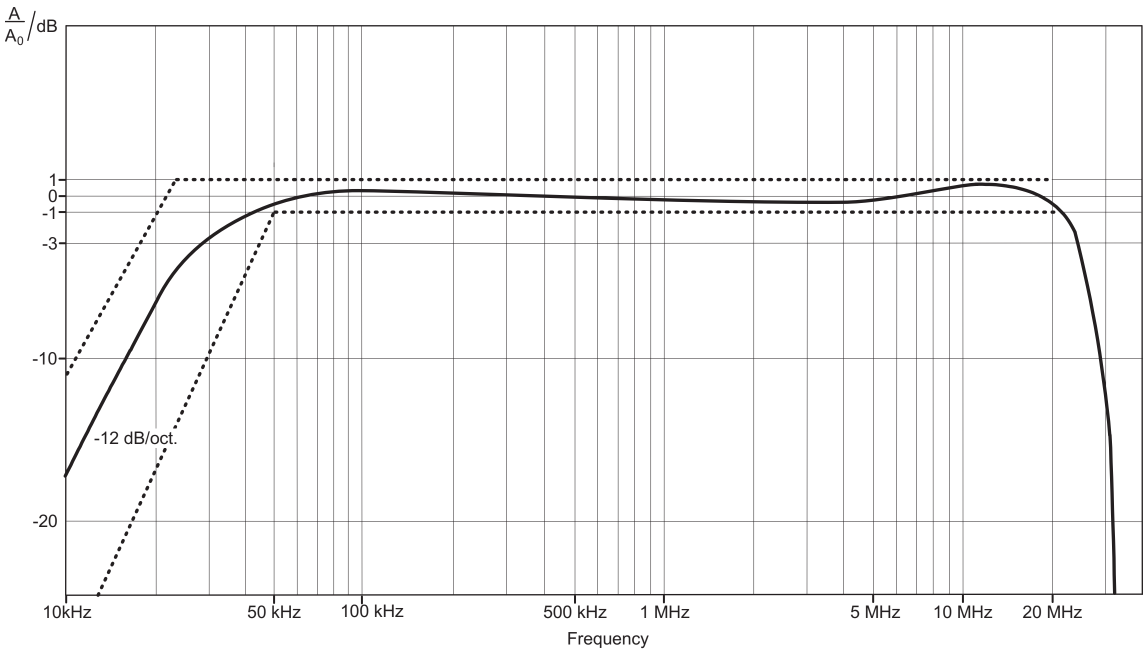

Figure 7.1: Typical amplitude frequency response with tolerance band

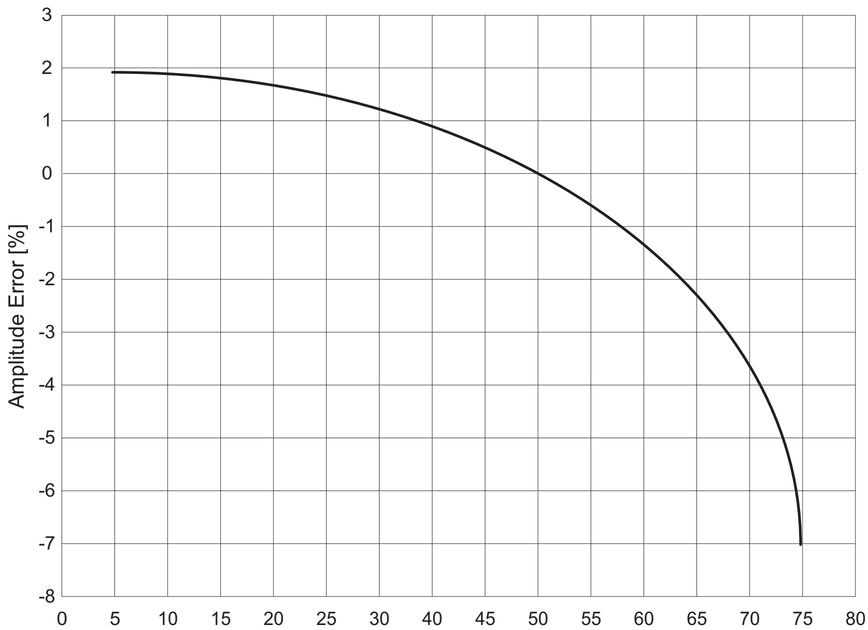

Figure 7.2: Typical linearity error of the DD-300

Harmonic Distortions

Vibration frequency	Vibration amplitude[1]	
	0…25 nm	25…50 nm
1 MHz	< −50 dBc	< −40 dBc
5 MHz	< −50 dBc	< −37 dBc
10 MHz	< −34 dBc	< −30 dBc

[1] Harmonic distortions are produced from multiples of vibration frequencies. They depend on the frequency and the amplitude of the wanted signal. The maximum amplitude in dBc corresponds to the amplitude of the base frequency.

7.5.11 DD-400 Auxiliary Decoder (Displacement Decoder)

Measurement range	1	10	100	µm/V
Full scale (peak)	10	100	1000	µm
Frequency range				
f_{min}	1000	100	10	Hz
f_{max}	250	250	20	kHz
Max. acceleration[1]	1600000	1600000	1600000	g
Amplitude frequency response[2]				
10 Hz…100 Hz	−	−	+0.6/−3.0	dB
100 Hz…1 kHz	−	+0.2/−2.5	±0.25	dB
1 kHz…10 kHz	+0.2/−2.5	±0.25	±0.25	dB
10 kHz…20 kHz	±0.25	±0.25	+1.5/−0.5	dB
20 kHz…200 kHz	±0.3	±0.35	−	dB
200 kHz…250 kHz	+1.2/−1.5	+1.7/−1.5	−	dB
Max. phase error[3]				
10 Hz…100 Hz	−	−	< 51	°
100 Hz…1 kHz	−	< 45	< 6	°
1 kHz…10 kHz	< 45	< 6	< 1	°
10 kHz…20 kHz	< 6	< 1	< 1	°
20 kHz…200 kHz	< 3	< 1	−	°
200 kHz…250 kHz	< 1	< 1	−	°
Calibration uncertainty @ f_{ref}				
T_a = (25 ±3) °C (T_a = (77 ±5)°F)	±2.5 (f_{ref} = 20 kHz)	±2.5 (f_{ref} = 20 kHz)	±2.5 (f_{ref} = 1 kHz)	%
T_a = +5°C…+40°C (T_a = 41°F…104°F)	±3.0 (f_{ref} = 20 kHz)	±4.0 (f_{ref} = 20 kHz)	±4.0 (f_{ref} = 1 kHz)	%

[1] Is valid for the measurement range 1000 $\frac{mm}{s}/V$ of the VD-04 and for the tracking filter being switched off (Off).

[2] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency f_{ref}.

[3] The phase error refers to the physical phase shift of −90° between velocity and displacement signal.

Frequency-Dependent Resolution

Measurement range	1	10	100	µm/V
Resolution[1]				
@ measurement range 1 000 $\frac{mm}{s}$/V of the VD-04				
10 Hz … 100 Hz	–	–	60.0	nm/$\sqrt{Hz}$
100 Hz … 1 kHz	–	4.0	2.0	nm/$\sqrt{Hz}$
1 kHz … 10 kHz	0.4	0.5	0.5	nm/$\sqrt{Hz}$
10 kHz … 20 kHz	0.05	0.05	0.04	nm/$\sqrt{Hz}$
20 kHz … 200 kHz	0.02	0.03	–	nm/$\sqrt{Hz}$
200 kHz … 250 kHz	0.003	0.004	–	nm/$\sqrt{Hz}$
@ measurement range 100 $\frac{mm}{s}$/V of the VD-04				
10 Hz … 100 Hz	–	–	60.0	nm/$\sqrt{Hz}$
100 Hz … 1 kHz	–	2.0	2.0	nm/$\sqrt{Hz}$
1 kHz … 10 kHz	0.1	0.15	0.15	nm/$\sqrt{Hz}$
10 kHz … 20 kHz	0.01	0.01	0.03	nm/$\sqrt{Hz}$
20 kHz … 200 kHz	0.003	0.003	–	nm/$\sqrt{Hz}$
200 kHz … 250 kHz	0.001	0.003	–	nm/$\sqrt{Hz}$
@ measurement range 10 $\frac{mm}{s}$/V of the VD-04				
10 Hz … 100 Hz	–	–	60.0	nm/$\sqrt{Hz}$
100 Hz … 1 kHz	–	0.15	2.0	nm/$\sqrt{Hz}$
1 kHz … 10 kHz	0.002	0.01	0.1	nm/$\sqrt{Hz}$
10 kHz … 20 kHz	0.002	0.004	0.03	nm/$\sqrt{Hz}$
20 kHz … 200 kHz	0.001	0.003	–	nm/$\sqrt{Hz}$
200 kHz … 250 kHz	0.001	0.003	–	nm/$\sqrt{Hz}$

[1] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0 dB with 1 Hz spectral resolution, measured on 3M Scotchlite™ Tape (reflective film).

7.5.12 DD-600 Auxiliary Decoder (I&Q Converter)

External decoder interface at the back of the controller.

Signal type:	Baseband Doppler signal in quadrature format
Bandwidth:	0 Hz … 5 MHz
Phase calibration:	$2\pi = \lambda/2 = 316.4$ nm
AC signal voltage:	1.2 $V_{P\text{-}P}$ ±1.5 dB at 50 Ω termination
DC offset:	max. ±10 mV
Noise-free range:	min. 55 dB (measuring on reflective film)
I/Q phase tolerance:	max. ±2.5°

7.6 Analog Low and High Pass Filters

Low Pass Filter

For a typical amplitude and phase frequency response, refer to SECTION A.1.

Filter type:	3rd order Bessel
Cutoff frequencies:	5 kHz, 20 kHz, 100 kHz (adjustable)
Frequency roll-off:	−60 dB/dec = −18 dB/oct
Stop band attenuation:	> 70 dB

High Pass Filter

For a typical amplitude and phase frequency response, refer to SECTION A.2.

Filter type:	4th order Butterworth
Cutoff frequency:	100 Hz
Frequency roll-off:	−80 dB/dec = −24 dB/oct
Stop band attenuation:	> 70 dB

7.7 Adaptive DSP Filter (Optional)

Analog Signal Output VELOCITY DSP OUT

Voltage swing: ±10 V

Digital Signal Output DIGITAL OUT

Data format: S/P-DIF, 24 bit, 48 kSa/s

Operating Frequency Range

Setting	Signal frequency
OFF	0 Hz … 20 kHz
20 k	0 Hz … 20 kHz
2 k	0 Hz … 2.35 kHz
0.3 k	0 Hz … 360 Hz

Settling Behavior

Setting	Maximum frequency change rate[1]
20 k	32 kHz/s
2 k	700 Hz/s
0.3 k	120 Hz/s

[1] For vibration signals with a sliding frequency, the filter's settling time causes an additional amplitude error. Up to the maximum frequency change specified, this error remains below −5%. The precise value depends on the signal to noise ratio of the input signal and this on the optical measurement conditions.

Harmonic distortions: < −60 dB (harmonic distortion < 0.1%)

Noise-free dynamic range: > 96 dB

Amplitude error: max. ±1% of the measurement value (additional error with stationary signal)

Appendix A: Filter Diagrams

A.1 Diagrams of a 3rd Order Bessel Low Pass Filter

The frequency is normalized to the cutoff frequency f_c.

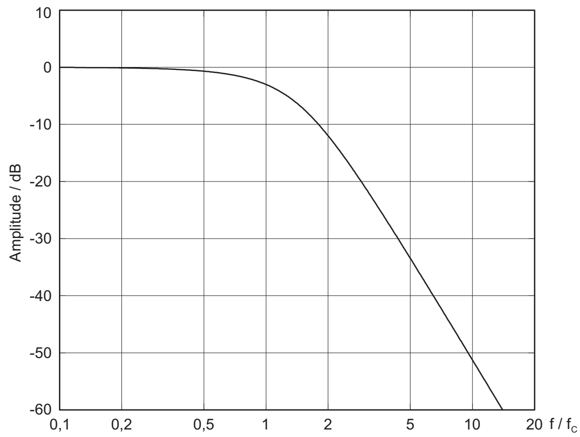

Figure A.1: Amplitude frequency response

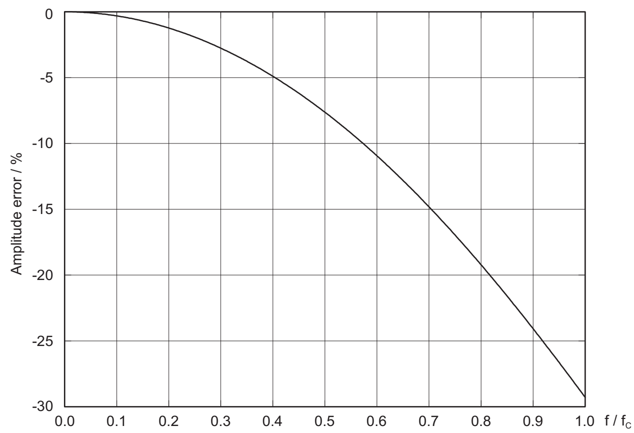

Figure A.2: Amplitude error in the pass band

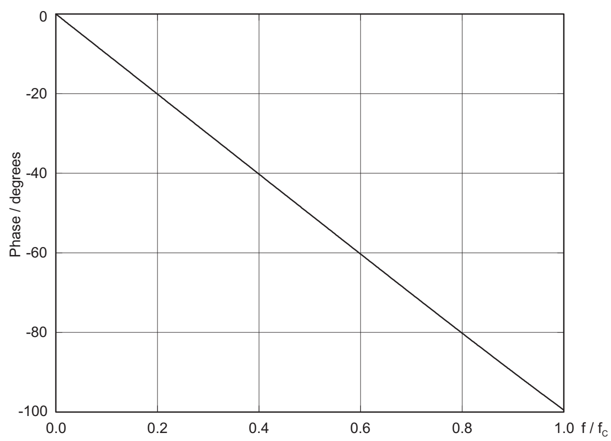

Figure A.3: Phase frequency response in the pass band

A.2 Diagrams of a 4th Order Butterworth High Pass Filter

The frequency is normalized to the cutoff frequency f_c.

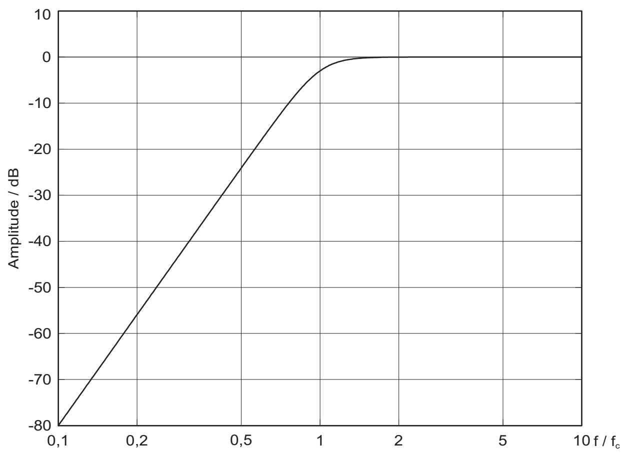

Figure A.4: Amplitude frequency response

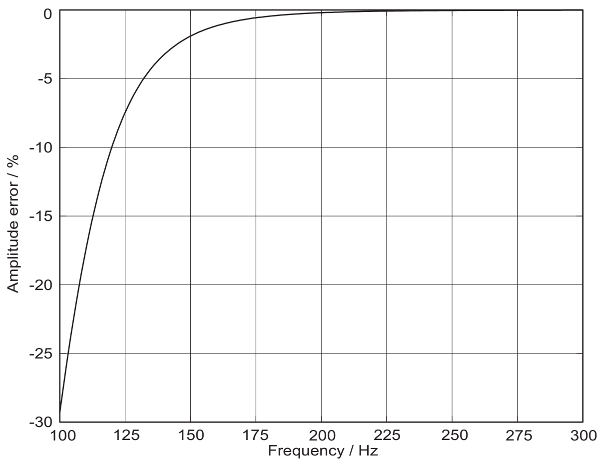

Figure A.5: Amplitude error in the pass band

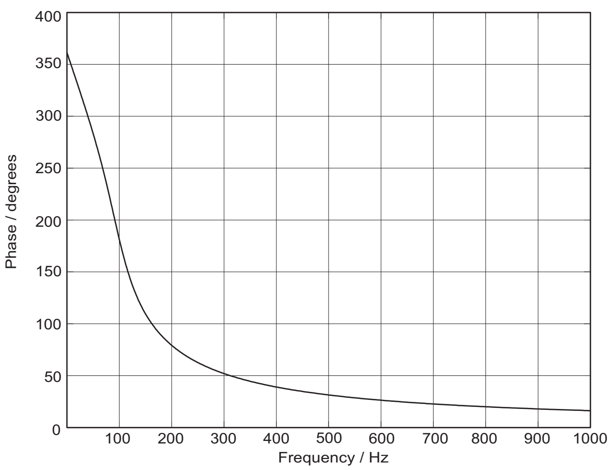

Figure A.6: Phase frequency response in the pass band

Appendix B: Declaration of Conformity

CE

Konformitätsbescheinigung / Declaration of Conformity

für / for

Gegenstand / Object :	**Vibrometer Controller**
Controller Typ / Model :	**OFV-5000-3G**
Sensor Typ / Model :	**OFV-505 / OFV-503** **OFV-551 / OFV-552** **OFV-534**

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 61010-1:2011-07	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

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Figure B.1: Declaration of conformity for the OFV-5000

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