Hardware Manual

Laser Surface Velocimeter

LSV-1000

Terminal Box LSV-A-110

Warranty and Service

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

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

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

To return the equipment always use the original packaging. Otherwise we reserve the right to check the equipment for transport damage. Please mark the package as fragile and sensitive to frost. Include an explanation of the reason for returning it as well as an exact description of the fault. You can find advice on fault diagnosis in CHAPTER 8.

Trademarks

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

Identification Labels

Sensor LSV-1000

Terminal Box LSV-A-110

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 will protect you and prevent damage 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.

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

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

> **NOTE !**
>
> Identifies action required to simplify using the instrument!

> **CAUTION !**
>
> **Danger from "Reason for Danger"!** - Identifies the danger caused by an action which could result in damage to the instrument if it is not avoided!

> **WARNING !**
>
> **Danger from "Reason for Danger"!** - Identifies a possible danger resulting from an action which could lead to death or (serious) injury if it is not avoided!

Intended use

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

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

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

Qualification

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

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 local regulations unless otherwise provided for by the manufacturer.

1.2 Information on Laser Safety

1.2.1 Safety Information

The light source of the instrument is a laser diode. The light from laser diodes with a wavelength between 620 nm and 700 nm is still visible. This means increased safety when working near the laser beam. 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.

The protective measures that have been taken and that are described in the following support compliance with the safety standards for laser class 3B:

NOTE !

Please see CHAPTER 9 for the detailed technical specifications!

- Polytec instruments generally comply with the standards **IEC** and **EN 60825-1** or **US 21 CFR 1040.10** and **1040.11** respectively, apart from the deviations in accordance with Laser Notice No. 50 dated July 26, 2001.
- The optical output power of the laser beam emitted from the sensor is less than 30 mW, provided the equipment is used in the manner for which it was intended. This means that the instrument complies with **laser class 3B**. The focused laser beam is not intense enough to harm the skin, but if a direct or reflected laser beam enters an unprotected eye, lasers in the class 3B are hazardous.

WARNING !

Danger from laser light! - Due to these hazards, only qualified persons who have appropriate training and are authorized by the Laser Safety Officer should be entrusted with operating this instrument. This training can be carried out by the manufacturer or the Laser Safety Officer.

- The laser is switched on using **the key switch**. You may only use key switches which have a key that can only be removed when the laser is switched off.

WARNING !

Danger from laser light! - The user is obliged to set up the connection himself using the key switch provided. If he does not comply with this, he is infringing the laser safety regulations.

- The **emission indicator** with the name EMISSION on the sensor signals that the laser system is switched on and thus the potential hazard of laser light emitted. The terminal box LSV-A-110 allows an additional emission indicator to be connected if the display on the sensor is not visible.
- After switching on the laser with the key switch, emission of laser light depends on other control signals and also the sensor temperature. The laser light is applied when the display READY lights up on the sensor.
- Various electrical switch options to ensure laser safety are available via the **Interlock contacts** and the control signal LASER_ON to increase the system safety.

- In addition to electrical shutdown, the sensor is also equipped with an electromechanical **beam shutter** to block the laser beam during both the warm-up phase and work breaks, without having to switch the instrument itself off. This beam shutter is set up to be fail-safe.
- The user **should not attempt** to open the housing of the instrument which contains the laser unit, as this could lead to being exposed to a higher level of laser energy that is potentially hazardous.

WARNING !

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

1.2.2 Safety Precautions

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

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

WARNING !

Danger from laser light! - In any case avoid looking directly into the laser beam, including with the aid of optical instruments as this could cause serious damage to your eyes. The operator should wear suitable eye protection in the hazard zone around the laser!

NOTE !

Wear suitable laser protection glasses if you are in the hazard zone around the laser!

- Inform the operator of the instrument of potential danger! A Laser Safety Officer should be nominated for laser instruments in the class 3B.
- Position the instrument so that under normal circumstances it is not possible to look into the direct or reflected laser beam!

WARNING !

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

- Please take particular care when directing the sensor at reflective surfaces. A significant part of the incident light could possibly be reflected towards an observer.
- Never intentionally direct the laser beam at anyone!
- Only open the beam shutter when making measurements!
- To position the sensor, always close the beam shutter. The beam shutter should not be opened until the sensor has been roughly aligned and mounted securely!
- The beam path must be terminated by a matt, dark beam trap. The laser beam may also not be reflected in an uncontrolled manner, even if there is no measurement object present!
- The laser should only be used in a controlled area!

- Protect every instrument not in use against unauthorized use by removing the key from the key switch!
- For laser class 3B instruments, additional safety precautions have to be complied with in the vicinity of the measurement location. These requirements vary from country to country. But generally at least the black and yellow laser warning symbols are required at the entrance to the room or area in which the laser system is operating. Use the interlock contacts in the terminal box, to install additional safety devices.

Please refer to the relevant laser safety regulations for your country!

1.2.3 Laser Warning Labels

Warning labels The laser warning labels for the sensor are shown in FIGURE 1.1. For the countries in the European Union (EU), labels **2** to **4** are affixed in the language of the customer's country (see right-hand-side).

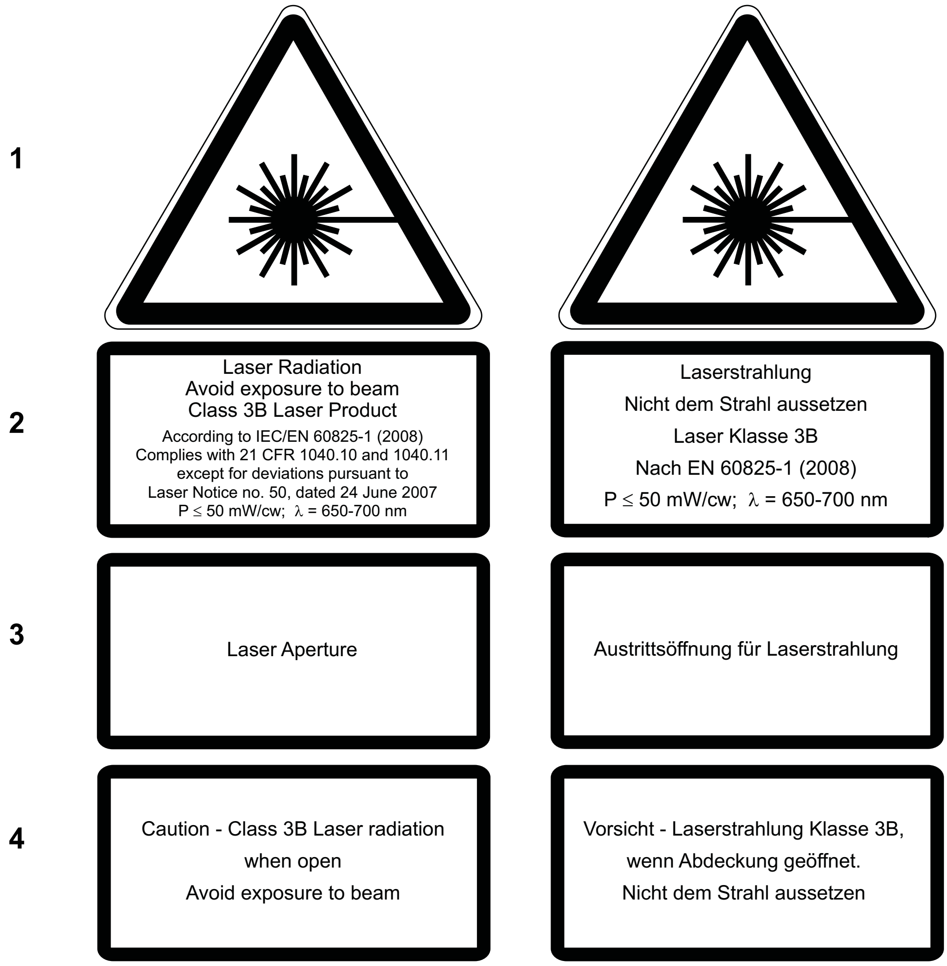


Figure 1.1: Laser warning labels for the sensor

Position

The position of the laser warning labels on the sensor and the beam exit aperture is shown in FIGURE 1.2.

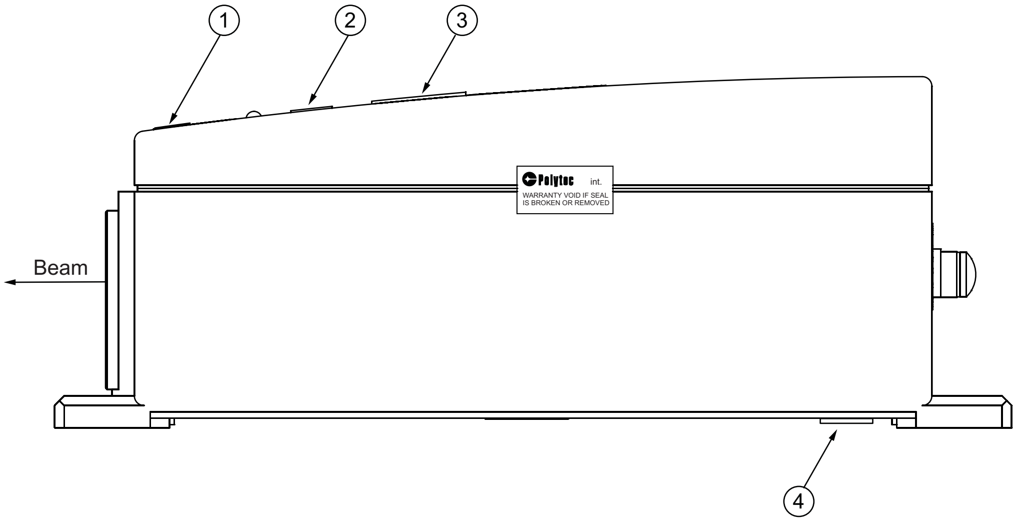


Figure 1.2: Position of the laser warning labels on the sensor and the beam exit aperture

1.3 Information on Electrical Safety

1.3.1 Safety Information

The sensor LSV-1000 is designed to be operated on safety extra low voltage with a nominal value of 24 VDC and can thus not cause a hazard through electric current itself. A condition of safe operation of the sensor is, however, it being supplied with a touch-proof supply voltage which fulfills the isolation requirements of safety extra low voltage (SELV). If you use the terminal box LSV-A-110, then safety is ensured through the design of the power supply used.

If the power supply in terminal box LSV-A-110 is not used to supply the sensor, then it is up to the user of the instrument to make a touch-proof supply voltage available.

The terminal box LSV-A-110 complies with the electrical protection class 1 in accordance with the EU directive 2006/95/EC (low voltage directive). Provided it is used with the correct mains connection and is used as intended, exposure to electric current is prevented by the closed, grounded metal housing.

WARNING !

Danger from electrical current! - When installing the mains connection, pay attention to the instructions on the electrical safety regulations given in SECTION 4.2!

The instrument is subject to the EU directives 2004/108/EC (EMC directive) and therefore complies with the limits for emissions and immunity specified in the standards referred to (refer also to SECTION 9.1 and APPENDIX C).

If the power supply in the terminal box LSV-A-110 is not used to supply the sensor, then it is up to the user of the instrument to make sure the limits for emission and immunity are complied with.

CAUTION !

Danger from radio interference! - This instrument is in Limit Class A and can cause radio interference in living areas. In this case, the user has to implement appropriate measures.

1.3.2 Safety Precautions

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

- The terminal box LSV-A-110 is only to be connected up using a three-pin mains cable to AC systems 50/60 Hz with a grounded protective conductor which has a nominal voltage of between 100 V and 240 V.
- As a disconnection device in the event of danger, use the mains plug of the terminal box. This means that the mains plug needs to be freely accessible. Otherwise an additional disconnection device must be installed.
- Inner parts of the terminal box carry hazardous voltage during operation. This is why the terminal box may only be operated with an open front flap by trained personnel to set up a measurement.
- Defective power supplies may not be repaired but must be replaced with identical or equivalent power supplies.

WARNING !

Danger from electrical current! - Repair work may only be carried out by the manufacturer himself or by qualified personnel authorized by the manufacturer.

NOTE !

Before removing parts of the housing for installation and servicing purposes, as a general rule the mains plug should always be unplugged.

1.4 Information on Plant Safety

Environmental conditions in a rough industrial environment or other external influences can cause a mismeasurement of the LSV. External influences are e.g.

- damage of the measurement system,
- breakdown of the power supply or
- breakdown of the coolant or the compressed air supply.

If the LSV provides a signal to control facilities as a cutting plant or separators, a redundant signal besides the LSV velocity and length signal should be available for controlling.

2 Introduction

2.1 System Summary

Polytec's **L**aser **S**urface **V**elocimeter **LSV** is an optical measuring instrument for non-contact measurement of one-dimensional surface velocities. The Laser Surface Velocimeter is made up of the LSV-1000 sensor and the LSV-A-110 terminal box. The system components are shown in FIGURE 2.1.

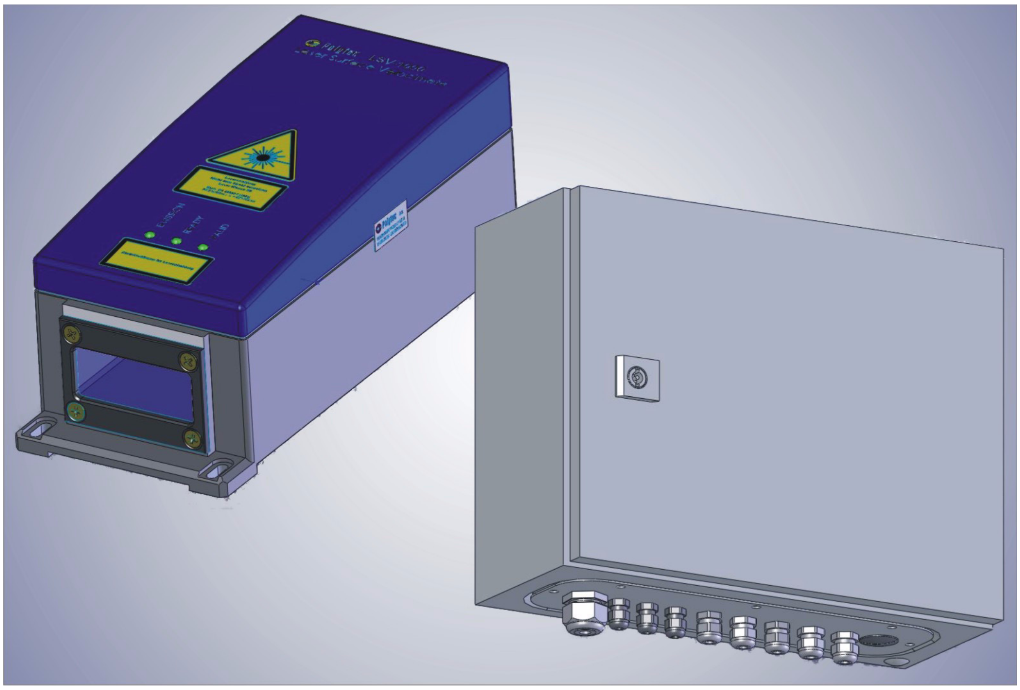


Figure 2.1: System components of the LSV

Various accessories are available for special application conditions. You will find further information on the accessories in a separate manual.

2.2 Area of Application

The LSV optically measures the speed of movement of solid surfaces with sufficient optical backscattering properties. Therefore it can be used for non-contact measurement of velocity or length on almost all technical surfaces. To be able to adapt to various operating conditions, sensor heads with stand-off distances of 300 mm, 500 mm, 700 mm and 1 000 mm are available. The selection of the stand-off distance is determined by:

- The spatial conditions at the measurement location
- The maximum velocity to be measured:
  The greater the stand-off distance is, the smaller the Doppler frequency that is generated by a given surface velocity. As the sensor can only evaluate Doppler frequencies up to a given maximum frequency, higher velocities can be measured with greater stand-off distances.
- The length of the measurement volume (refer also to APPENDIX A):
  The greater the stand-off distance, the longer the measurement volume is and the higher the tolerance of the system is to position changes of the measurement surface.
- The optical properties of the measurement object:
  The amount of back scattered light collected by the receiving optics decreases as the stand-off distance increases. So if the surface does not reflect the light very well, a long stand-off distance can mean that not enough light reaches the receiving optics. As a result of this, the data rate falls and the statistical variation of the measurement values increases.

Thanks to the extremely large dynamic range of the optical receiver, the LSV can make measurements on virtually any technical surface.

With smooth surfaces however, the photo detector may become saturated due to the high proportion of directed scattering if the sensor head is positioned exactly perpendicular to the measurement surface. Slightly tilting the sensor so that it is not quite at right angles to the beam plane (angle θ_x in FIGURE 4.1) usually provides better results in this situation.

Optically smooth surfaces (mirrors) only reflect the light (no scattering). The detector can then at best detect the reflection of one of the two laser beams. As a valid signal is only produced when parts of both object beams are superimposed, measurements can not be made on such surfaces using the LSV.

Diffuse scattering always occurs on optically rough surfaces, as shown schematically in FIGURE 2.2.

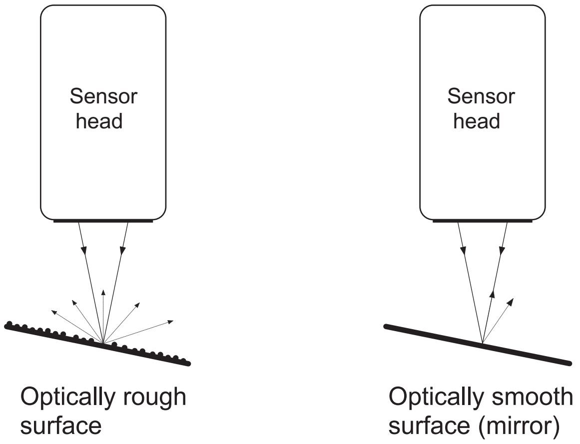


Figure 2.2: Schematic diagram of reflection and scattering

The LSV only records the exact velocity of a point on the measurement surface if its direction of movement is at right angles to the optical axis (refer also to APPENDIX A). With surfaces where the direction of movement is curved (e.g. on guide pulleys) however, the direction of movement of a point changes when it passes through the measurement volume. As a result of this, the average velocity recorded is smaller than the actual circumference velocity of the surface and a small negative measurement error occurs. The size of this error increases as the radius of curvature becomes smaller. Because of this effect, the LSV should be installed on a section of the material flow which is as flat as possible.

3 First Steps

3.1 Unpacking and Inspection

Unpacking

The LSV is made up of the following components:

- Sensor LSV-1000
- Terminal box LSV-A-110 with connecting cable and cable duct
- RS-232(X) cable (null modem cable, cross-wired)
- Ethernet patch cable with M12 connector (D-coded / open end)
- LSV software
- Calibration protocol of the sensor
- Key switch LSV-A-390
- Assembly kit

Optional:

- Laser warning light
- Air purge unit with quick release window LSV-A-120 (refer to accessory manual)
- Cooling housing LSV-A-121 (refer to accessory manual)
- Cooling plate LSV-A-122 (refer to accessory manual)
- Cooling plate with 93° alignment kit LSV-A-124 (refer to accessory manual)
- Assembly platform for cooling housing and cooling plate LSV-A-130 (refer to accessory manual)
- Installation bracket LSV-A-133 (refer to accessory manual)

CAUTION !

Danger from scratching! - Handle all optical components with great care! Dirt may only be removed very carefully with a soft, lint-free cloth and a commercially available glass cleaner!

Inspection

Please pay attention to the following steps when unpacking the LSV:

1. Check the packaging for signs of unsuitable handling during transport.

2. After unpacking, check all components for external damage (scratches, loose screws etc.).

3. In the case of a wrong delivery, damage or missing parts, please inform your local Polytec representative immediately and give them the serial number of the sensor. The identification label can be found on the back of the sensor and also on the inside cover of this manual.

4. Carefully retain the original packaging in case you have to return the LSV.

Before installing the LSV at the measurement location, carry out an initial functional test as described in SECTION 5.1.

3.2 Operating and Maintenance Requirements

Ambient conditions

The LSV should only be stored in an ambient temperature range of –15°C to +65°C (–5°F...+149°F), as otherwise irreversible damage can be done to the laser system. The LSV may only be used at an ambient temperature or respectively at a temperature of the mounting surface between –0°C and +45°C (+32°F...+113°F).

Outside of this temperature range, operation is possible using the optional cooling plate LSV-A-122 or the cooling plate with 93°alignment kit LSV-A-124.

NOTE !

Ensure that no moisture condenses on the front window, as this falsifies the measurement results!

Assembly

The sensor may only be mounted on a flat surface (if possible planed) and may have a maximum out-of-plane deviation of 200 µm. The maximum torque of the screws is 5.1 Nm. Please use the screws and washers provided for mounting the sensor.

Cooling

It is very important to ensure that there is sufficient air circulation to cool the sensor.

Connecting cable

Make sure that all connectors are connected properly and firmly. Protect the connector from mechanical damage and dirt. Protect the connecting cable between sensor and terminal box from mechanical damage and from high temperatures. The bending radius should not go below 50 mm. To install the connecting cable correctly, use the cable duct provided.

CAUTION !

Danger from electromagnetic interference! - Signal lines may not be installed in the immediate proximity of power cables to ensure interference immunity!

Mains connection

The multi-voltage power supply in the terminal box LSV-A-110 can be connected to all mains voltages with nominal values in the range from 100 V to 240 V.

WARNING !

Danger from electrical current! - When installing the mains connection, pay attention to the instructions on the electrical safety regulations given in SECTION 4.2.5!

Warming-up

The laser diode in the sensor head takes a little while to reach a stable operating temperature after the sensor has been switched on. Only after this has been reached, is the system ready to operate which is shown by the LED READY lighting up. The velocimeter reaches its optimal properties after a warm-up period of approx. 60 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 sensor for example, can however be carried out before this warm-up period has expired.

Mechanical influences

In the sensor there are optical precision parts which need to be adjusted precisely so that measurements made with the LSV are accurate and reliable. The sensor must therefore be protected from any kind of impact and other extreme mechanical influences.

Cleaning

The housing surfaces can be cleaned with mild detergent, disinfectant solutions or with ethanol. Other organic solvents must not be used.

Optical components

Handle all optical components with great care. Dirt may only be removed very carefully with a soft, lint-free cloth and a commercially available glass cleaner.

Calibration

Because the LSV sensor contains no moving components, the calibration of the sensor is determined only through the properties and arrangement of the optical components. As long as the sealed sensor will not be opened or exposed to extraordinary thermal load as well as mechanical load[1], it can be assumed that the properties will not change. Consequently the fringe spacing of the interference pattern determined during the calibration is constant and under practical aspects a new calibration is not necessary. In particular, this applies if the unchanged accuracy of the measurement system is verified e.g. by a manual part length measurement.

At a calibration, carried out by Polytec, besides of the determination of the fringe spacing the sensor will be checked, cleaned and preventively maintained. The user has the possibility, to accomplish this service by Polytec in periodical time intervals (e.g. every 24 months). As a general rule, the user decides within the monitoring process of measurement devices about the necessity of an external calibration.

Opening the sensor

The sensor is a sealed unit. It is not necessary to tamper with the instrument when using it as intended, it reduces the measurement accuracy and will invalidate the warranty.

[1] This means the operation outside the specifications listed in this manual. If you use the cooling housing, extended specifications are valid. You will find information on this in a separate manual.

3.3 Control Elements

3.3.1 Sensor LSV-1000

Top view The top view of the sensor is shown in FIGURE 3.1.

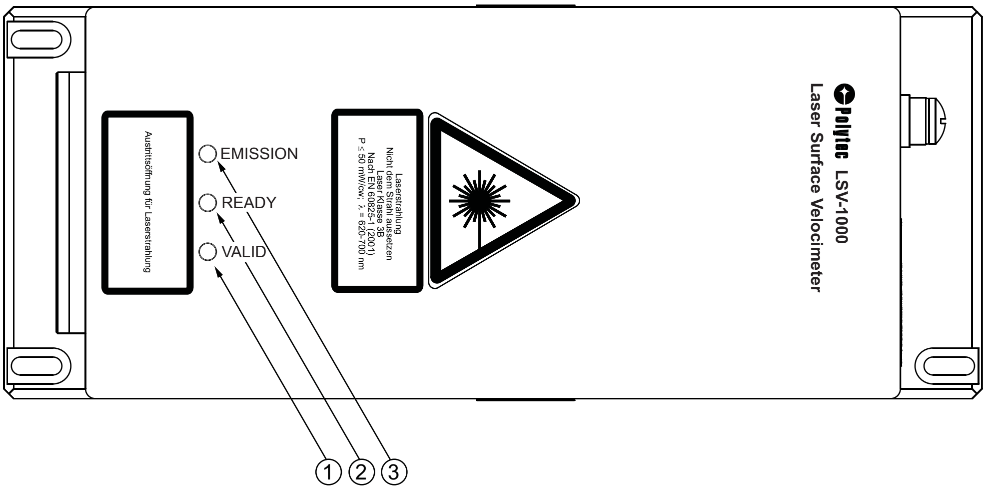


Figure 3.1: View of sensor from above

1 VALID LED

The LED lights up if valid measurement values have been attained.

2 READY LED

The LED lights up when the laser beam is emitted and the sensor is ready to make measurements.

3 EMISSION LED

The LED lights up when the laser is switched on with the key switch, even if the beam shutter is closed. Laser light can be emitted at any time!

WARNING !

Danger from laser light! - In any case avoid looking directly into the laser beam, including with the aid of optical instruments, as the laser beam can be emitted at any time! The operator should wear suitable eye protection in the hazard zone around the laser!

NOTE !

Wear suitable laser protection glasses if you are in the hazard zone around the laser!

Front and rear view

The front and rear view of the sensor is shown in FIGURE 3.4.

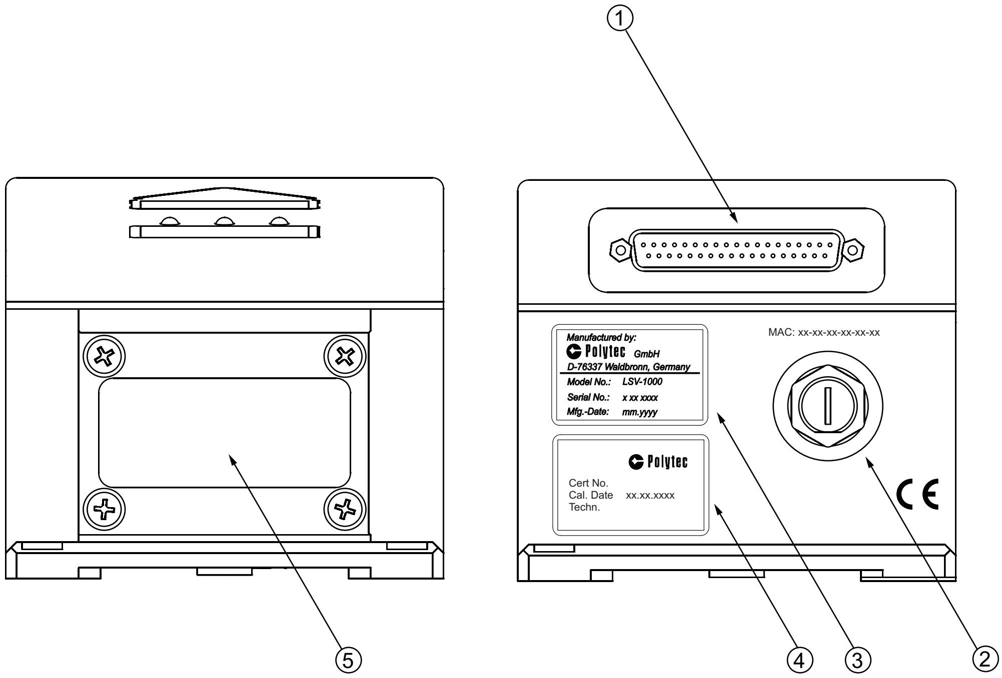


Figure 3.2: Front and rear view of the sensor

1 **Main connection** (37-pin Sub-D plug)
Connection for the connecting cable

NOTE !

Protect the connector on the sensor from moisture if the connecting cable is not connected.

2 Connection **Ethernet** (Ethernet M12 connector (D-coded)
Connection for the Ethernet cable

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

4 **Calibration label**
On the calibration label you will find the calibration data of the instrument.

5 **Exit window** of the laser beams

CAUTION !

Danger from scratching! - Handle all optical components with great care! Dirt may only be removed very carefully with a soft, lint-free cloth and a commercially available glass cleaner.

3.3.2 Terminal Box LSV-A-110

Front view The opened terminal box is shown in FIGURE 3.3.

WARNING !

Danger from electrical current! - Working with the housing open can cause personal injury and may only be carried out by expert personnel who are familiar with the safety standards of electrical engineering and industrial electronics.

NOTE !

Before opening the front flap for installation and servicing purposes, as a general rule the mains plug should always be unplugged.
If the internal fuse goes, then a system fault can be assumed. In this case it is necessary for the instrument to be checked over by Polytec!

As a general rule, electrical connections to the device may only ever be made by qualified personnel conversant with the electrical engineering and industrial electronics safety standards.

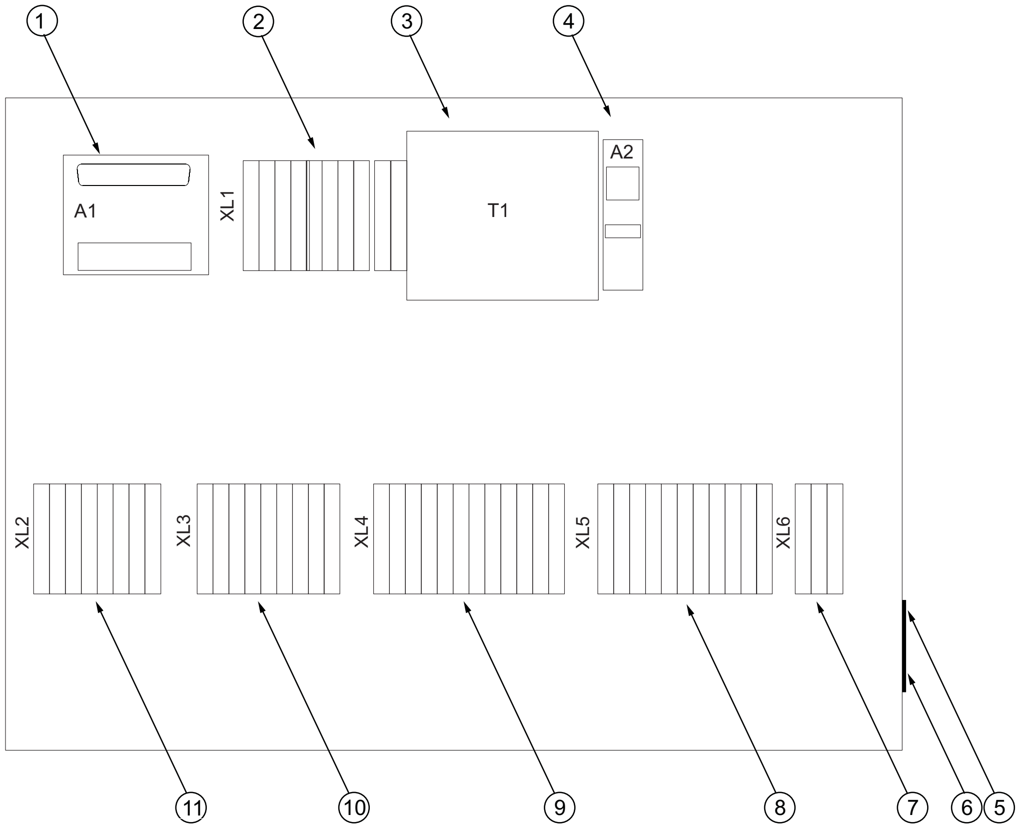


Figure 3.3: Front view of the opened terminal box LSV-A-110

1 RS-232 service interface connection module **A1** (9-pin Sub-D plug)

This serial interface enables an additional connection to an external computer for servicing, testing or configuring the sensor (refer to CHAPTER 6).

2 Terminal block **XL1**

24 V mains supply

3 Power supply **T1** with internal fuse

Power supply 24 VDC / 2.5 A for sensor and peripherals

4 Ethernet connection module **A2**

RJ45 jack to connect up to an Ethernet network and connection terminals for connecting the Ethernet cable to the sensor.

5 **Instrument warning label**

Label with technical data for the fuses and the mains connection

6 **Identification label**

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

7 Terminal block **XL6** for functional grounding

Possible connection point for functional grounding (e.g. cable shield)

8 Terminal block **XL5** for encoder interface and RS-422 interface

Output signals of the encoder interface and RS-422 interface. You will find a description of the encoder interface and RS-422 interface as well as the configuration at the terminal block in SECTION 6.4.

9 Terminal block **XL4** for the outputs of the control signals

Digital signal outputs of the sensor. You will find a description of the control signals and the configuration of the terminal block in SECTION 6.6.

10 Terminal block **XL3** for the inputs of the control signals

Digital signal inputs of the sensor. You will find a description of the control signals and the configuration of the terminal block in SECTION 6.5.

11 Terminal block **XL2** for safety equipment

Connections for the interlock loop, laser warning light and the key switch to switch off the laser. You will find a description of the safety equipment and the configuration of the terminal block in SECTION 4.2.2.

Bottom view The bottom of the terminal box LSV-A-110 is shown in FIGURE 3.4.

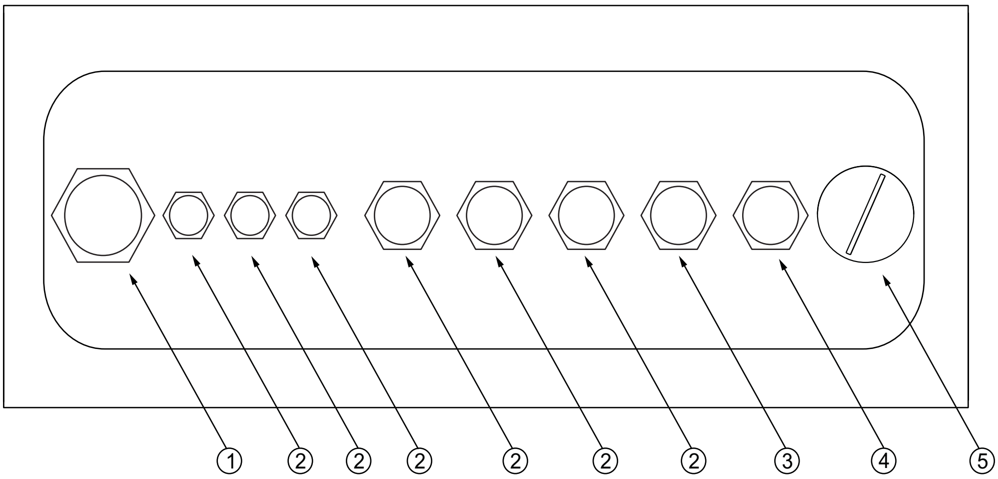


Figure 3.4: Bottom of terminal box LSV-A-110

1 **Cable gland** M25
Cable bushing for the connecting cable to the sensor

2 **Cable gland** M12 and M16
Cable bushing for control and interface cables

3 **Cable gland** M16
Cable bushing for the Ethernet cable to the sensor

4 **Cable gland** M16
Cable bushing for the mains cable

5 **Cable gland** M25
Cable bushing preferably for the Ethernet cable to the process control system

> **CAUTION !**
>
> **Danger from contamination!** - You must seal unused cable glands with blanking plugs to comply with the protection rating IP66!

4 Installation

4.1 Assembly

4.1.1 Sensor

Position The sensor should be mounted above or to the side of the object where possible to avoid the front window being damaged or soiled by falling particles. The longitudinal axis of the sensor must be at right angles to the surface of the measurement object in both directions and the plane of the laser beams must be in the direction of travel of the object under investigation (measurement direction), refer to FIGURE 4.1.

Alignment Alignment of the sensor in relation to the surface to be measured is shown in FIGURE 4.1.

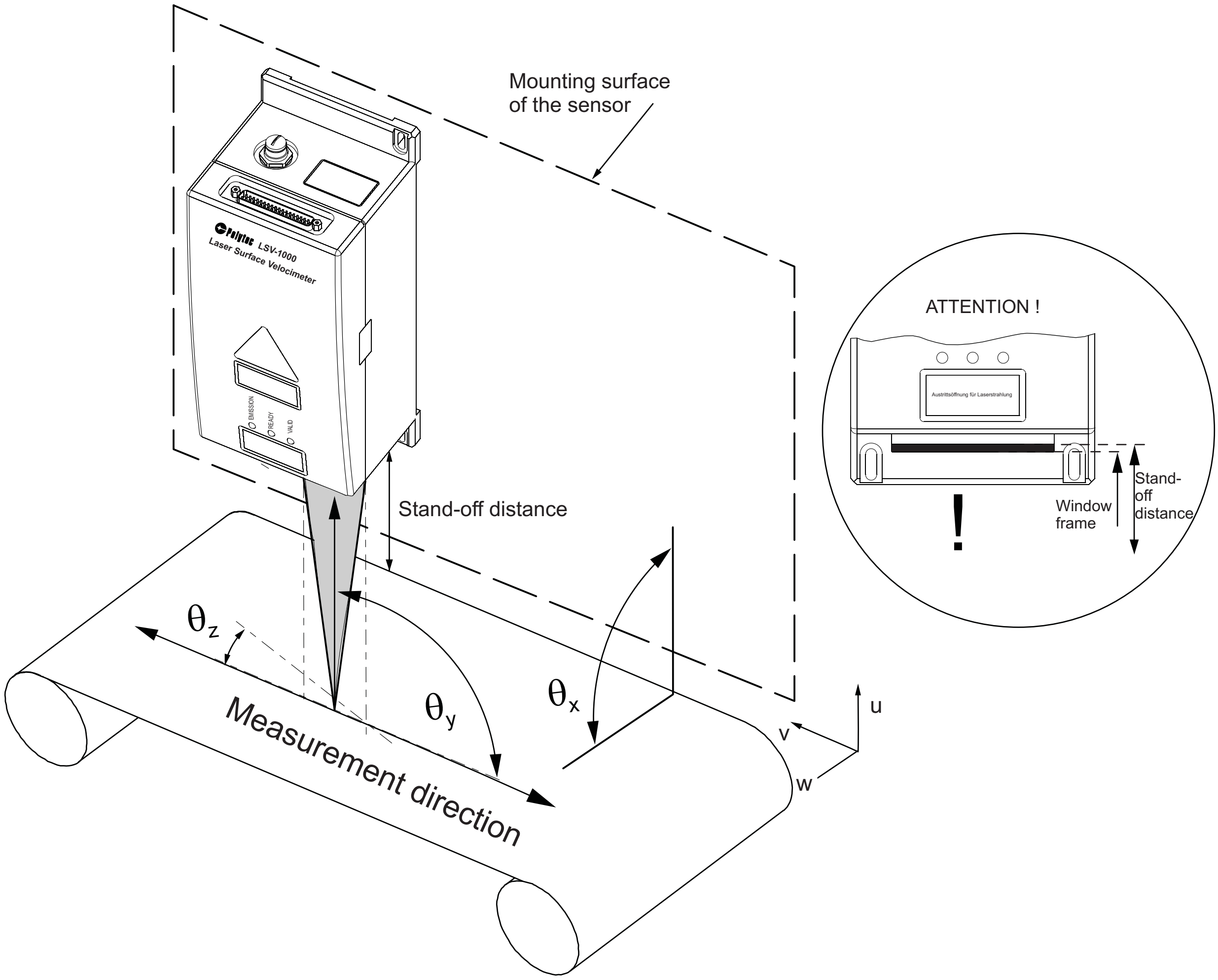


Figure 4.1: Aligning the sensor

Mount the sensor approximately at the specific stand-off distance away from the measurement surface. The stand-off distance is the distance between the mounting surface for the window frame and the measurement surface (refer to FIGURE 4.1). The maximum permissible deviation of the material surface from the specified stand-off distance while maintaining the specific measurement error of 0.1% is shown for the various sensor models in TABLE 4.1.

Table 4.1: Nominal stand-off distance and depth of field for the various sensor models

Sensor model	Nominal stand-off distance[1] mm	0.1 % depth of field mm
LSV-1000-30	300	±20
LSV-1000-50	500	±30
LSV-1000-70	700	±40
LSV-1000-100	1000	±60

[1] Measured from the mounting surface for the window frame (refer to FIGURE 4.1)

The measurement geometry is also shown in FIGURE 4.1. The mounting surface of the sensor head forms the angle θ_x with the material surface and the angle θ_z with the direction of movement. The longitudinal axis of the sensor head forms the angle θ_y with the direction of movement.

For a precise measurement, the following mounting angles of the sensor head to the measurement surface must be adhered to:

Angle between	Target value	Angle error $\Delta\theta_i$
Mounting surfaces (sensor) and measurement surface	$\theta_x = 90°$	±5° [1]
Longitudinal axis of sensor and measurement surface	$\theta_y = 90°$	±1.3°
Mounting surface (sensor) and direction of movement	$\theta_z = 0°$	±1.3°

[1] With polished surfaces the angle error has to be $2° < \Delta\theta_x < 5°$.

Mounting the sensor unsuitably leads to measurement errors due to angle deviations which are shown in TABLE 4.2.

Table 4.2: Measurement errors due to angle deviations when mounting the sensor

Angle	Target value	Error in %	Error at ±1.3°	Error at ± 2°
θ_x	90° ±5°	-	0	0
θ_y	90°	$(1 - \sin\theta y) \cdot 100$	0.026%	0.061%
θ_z	0°	$(1 - \cos\theta z) \cdot 100$	0.026%	0.061%

Beam trap

Take care that in any case the sensor can not receive an interpretable reflex from the area behind the measurement volume (run out table rolls, guide plate). Therefore a free space of minimum the double maximal depth of field is necessary. After the double maximal depth of field, there has to be a beam trap to avoid uncontrolled reflexes of the laser beams if no measurement object is in the measurement volume. A beam trap is e.g. an open cavity with absorbing wall material.

Temperature

It is imperative that the surface temperature of the mounting surface does not exceed the permissible ambient temperature of the sensor of +45°C (113°F). If the ambient temperature or irradiation is too high, then you have to reduce the temperature of the housing by taking suitable measures, e.g. by mounting the sensor on a cooling plate or by using a radiation shield. You will find more information on cooling plate available as an option in the accessories manual.

4.1.2 Terminal box

The terminal box LSV-A-110 is used as a power supply and central distributor for cabling the LSV measurement system in an industrial environment. Because of its robust design with protection level IP67, operation of the terminal box LSV-A-110 is also possible in harsh ambient conditions.

The installation concept of the LSV-1000 is designed so that all the electrical connections from all system components and data interfaces are grouped together near the sensor. Therefore you should keep the connecting cable to the sensor as short as possible.

NOTE !

Mount the terminal box close to the sensor in such a way that it is easily accessible for installation and maintenance work and is protected from excessive heat.

When selecting the position to mount it, take the maximum length of the connecting cable to the sensor into consideration as well (15 m). Longer connecting cables are possible if the service interface RS-232 is not required. For correct installation of the connecting cable, use the cable duct provided.

4.2 Electrical Connections

4.2.1 Installation Concept

The LSV-1000 is a compact sensor with integrated control and data interfaces. All electrical connections with the exception of the Ethernet interface are on the 37-pin Sub-D plug of the sensor. The recommended installation concept in accordance with FIGURE 4.2 is designed to run all contacts from the plug via a common shielded cable to a central distributor near the sensor. From here, only the signals required should be conducted to the peripheral system components at the measurement location or to the process control system respectively. As a distributor, we recommend using the terminal box LSV-A-110, which can also be used as a 24 V power supply for the sensor and peripheral components (refer to SECTION 4.1.2).

The terminal box LSV-A-110 allows clear and simple access to all signals with the aid of terminals. It supports starting up the LSV measurement system with prewired signal paths and standard jacks for the data communication via RS-232 and Ethernet. The terminals of the terminal box are grouped together according to functions, the use of which is described in detail in the following sections.

For secure contact at the terminals, you should use cables with a wire diameter of at least 0.25 mm². Remove the insulation from the wire to a length of approx. 10 mm and undo the spring terminals using a suitable tool, e.g. a small screwdriver.

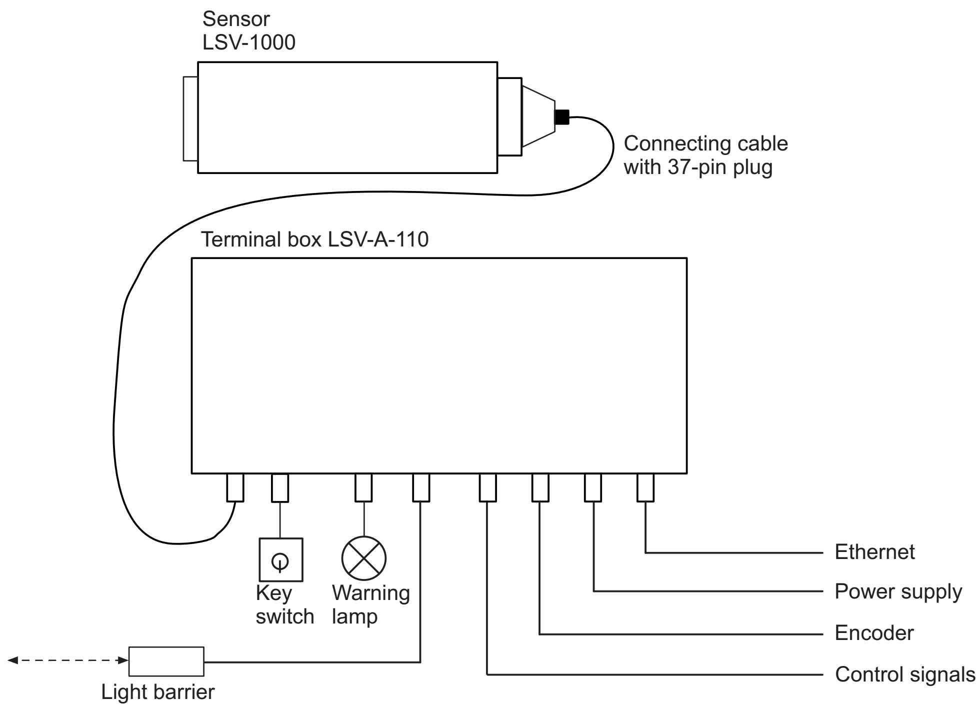


Figure 4.2: Typical installation of the LSV-1000 with terminal box LSV-A-110

For special applications in which the sensor LSV-1000 is a constituent part of a complete measurement system (e.g. C-brackets for rolling mills), it can of course also be operated without the terminal box. The wires from the connecting cable required in this case lead directly to their individual connection points. The power supply of the sensor and the peripheral components must in this case come from an external 24 V mains supply.

Reaching high interference immunity in complex control systems is supported in a user-friendly manner by the intricate grounding concept of the LSV-1000 with various galvanically isolated functional blocks. You will find more information on this in CHAPTER 6. You should pay particular attention to the grounding conditions when connecting very long cables in an environment with a high level of interference. In less critical cases however, you can also connect different grounding points to each other or with potential earth (PE) allowing several signal circuits to be fed from a common power supply.

4.2.2 Safety Equipment

Of central importance when installing laser systems is the safety concept to protect people from emitted laser radiation.

The sensor LSV-1000 is a laser system in the class 3B within the meaning of the European standard EN 60825-1, which requires certain protective measures to be taken for it to be operated safely (refer also to SECTION 1.2). It is imperative to have a key-operated main switch and an emission warning device. Both protective measures are constituent parts of the LSV-1000 scope of supply. Correct installation of the key switch by the user is essential prior to initially starting up the LSV-1000.

Special directives or guidelines can make it necessary to install additional safety precautions. The sensor LSV-1000 in connection with the terminal box LSV-A-110 makes all necessary signals and connections available for this. Installing and using the sensor according to regulations is the responsibility of the system engineer or operator respectively.

The following explanation applies to installation of the sensor LSV-1000 using the terminal box LSV-A-110. All connections for safety devices are grouped together in terminal panel XL2 (Laser Safety). The corresponding excerpt from the circuit diagram of the terminal box LSV-A-110 is shown in FIGURE 4.3.

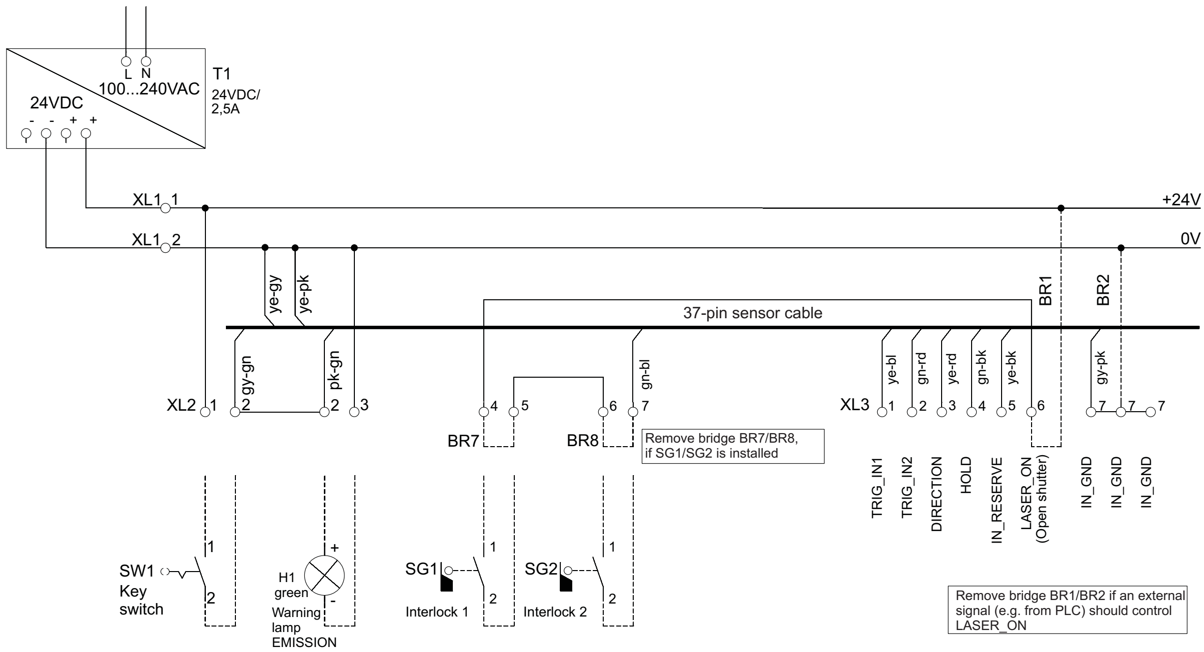


Figure 4.3: Excerpt from the overall circuit diagram (safety equipment)

For OEM models that are installed without the terminal box, the information is analogously applicable with reference to the corresponding signals at the 37-pin plug. Their allocation to the plug contact or wire colors of the connecting cable respectively can be found in the table in SECTION 9.2.4.

Key switch The key switch disconnects the power supply of the sensor (+24 V). Connect the key switch supplied or a functionally equivalent object using a bipolar cable to the terminals XL2:1 and XL2:2.

Warning light An additional laser warning light (Emission) can be connected between terminals XL2:2 and XL2:3. With poled lamps the plus pin is to be connected to terminal XL2:2. The lamp must be designed for +24 V and should take a maximum of 10 W.

Interlock contacts The terminal box has two pairs of terminals for remote controlled locking devices (Interlock contacts) which are delivered fitted with wire bridges. Both contacts are electrically switched in series with the control signal LASER_ON, the HIGH status of which effects release of the laser. Opening a contact disconnects the signal path (LASER_ON = LOW), which leads to the mechanical beam shutter being closed and the laser simultaneously being switched off.

NOTE !

In the delivery status, the status LASER_ON = HIGH is effected by the wire bridges BR1 and BR2. Remove these if you want to control the beam shutter with an external 24 V signal at terminal XL3:6.

4.2.3 Connecting Cable

A shielded cable with twisted pairs of wires and a 37-pin Sub-D plug at the sensor end is used as a connecting cable to the sensor. On delivery of the LSV-1000 with the terminal box LSV-A-110, the second cable end is connected to the terminals in the terminal box. As standard, connecting cables 5 m, 10 m or 15 m long are available. For special applications, longer cables with an open end can be supplied; however you will then no longer be able to use the service interface RS-232.

The connecting cable should preferably be laid on cross bars or brackets and not in parallel to high voltage cables. The minimum bending radius (once) is 50 mm. If it is necessary to lay it in tubes, you will have to undo the connecting cable from the terminals in the terminal box and remove it. We do not recommend removing the connector at the sensor end of the connecting cable. For correct installation of the connecting cable, use the cable duct provided.

When reconnecting the cable connections in the terminal box, you must make sure that the wire colors correspond to the correct terminals and that the cable shield is well connected in the gripper clamp. You will find the correct allocation in the terminal connection schema on the inside of the front flap of the terminal box.

CAUTION !

Danger from mishandling! - Before switching on the supply voltage, make sure that all wires in the connecting cable are correctly allocated to the terminals in the terminal box. Mixing up the wires can lead to the sensor LSV-1000 getting damaged.

4.2.4 Control and Data Lines

Control and data lines are fed into the bottom of the terminal box using suitably selected cable glands size M12x1.5, M16x1.5 and M25x1.5. When installing the control and data lines, please pay attention to the following advice:

- Unused signal wires from multi-core control lines should be cut off or insulated.
- Avoid unnecessarily long cable loops inside the terminal box.
- Never lay control and data lines in the immediate vicinity of or parallel to high-voltage lines.
- Please pay attention to the electrical connection conditions and the grounding concept of the individual functional groups (refer to CHAPTER 6).

Ethernet The Ethernet interface of the sensor can be connected up to a local area network (LAN) using an industrial Ethernet patch cable with male M12 connector (D-coded). When using the LSV-A-110 terminal box, the open end of the Ethernet cable supplied shall be connected to the screw terminals of terminal block A2 according to FIGURE 9.3. A patch cable with RJ45 connector can then be used to connect A2 to the LAN. For maintenance or configuration of the sensor a laptop can directly be connected to the terminal block A2 using a crossover patch cable.

4.2.5 Power Supply

Depending on the conditions of use of the LSV-1000, you have different power supply options for the sensor and peripheral components. In any case, please pay attention to the following advice to ensure the electrical safety of the instrument and the whole system. As a general rule, electrical connections to the device may only ever be made by qualified personnel conversant with the electrical engineering and industrial electronics safety standards.

Power supply The sensor LSV-1000 is designed for operation with an ungrounded DC voltage with a nominal value of 24V. If required however, the minus pin of the supply voltage (0V) can be connected with potential earth (PE). Please refer to CHAPTER 9 for the electrical connection values.

However, safe operation of the sensor is conditional upon it being supplied with an insulated supply voltage which fulfills the insulation requirements of safety extra low voltage (SELV). If you use the terminal box LSV-A-110, then safety is ensured through the design of the power supply used.

The power supply of the terminal box LSV-A-110 has a power reserve of approx. 1.5A and can be used in this capacity as an auxiliary voltage source (Auxiliary Voltage) for peripheral components of the LSV system, such as light barriers or laser warning lights. The voltage of 24V is available for this at terminals XL1:1 and XL1:2. In this case, please note that when using a joint power supply, galvanic isolation of the different grounding connections is no longer provided.

If the power supply in terminal box LSV-A-110 is not used to supply the sensor, then it is up to the user of the instrument to make a touch-proof supply voltage available. We recommend only using high-quality industrial power supplies with certified insulation and EMC properties.

> **NOTE !**
>
> Connect up the external supply voltage with the terminals XL:1 and XL1:2 after disconnecting the connections to the internal power supply.

Grounding

Housing and mounting plate of the terminal box LSV-A-110 are connected to the protective conductor (PE) if the mains connection has been done properly. The housing of the sensor LSV-1000 is also connected to the protective conductor via the brown and red wire at terminal XL6:1. This connection is however, not absolutely necessary for the electrical safety of the system and may be removed if, in unfavorable conditions of use, it leads to ground loop effects. However, the sensor housing is also connected to the protective conductor via the shielding of the main connection cable.

Mains Connection

The power supply of the terminal box LSV-A-110 is designed according to protection class 2 and does not need any earth conductor. The conducting wires (L/N) of the mains cable are connected directly to the designated screw terminals of the power supply. The protective conductor is connected to one of the PE terminals in terminal block XL1 which are connected internally with housing and mounting plate in the terminal box.

It is preferable for you to use the flexible mains cable fitted in the factory for connecting up to an earthed socket, providing ambient conditions allow this. The mains socket must be in an easily accessible position near the instrument, as it is used to disconnect the instrument in case of any danger. If this is not possible, then install an additional disconnecting device which is labeled appropriately and fulfills the requirements according to IEC 60947 -1 and -3.

Flexible connecting cable

If it should be necessary to exchange the original connecting cable, please only use material authorized for the respective ambient conditions with a conductor diameter of at least 0.75 mm^2 which fulfills the requirements according to IEC 60227 or IEC 60245 respectively (e.g. H03V-F3G, H05RR-F3G).

- When assembling the connecting cable, keep to the dimensions given in FIGURE 4.4. Pay particular attention to making sure that the protective conductor (green-yellow wire) is always longer than the other wires.
- Use suitable connector sleeves and make sure that all the conductor wires are captured.

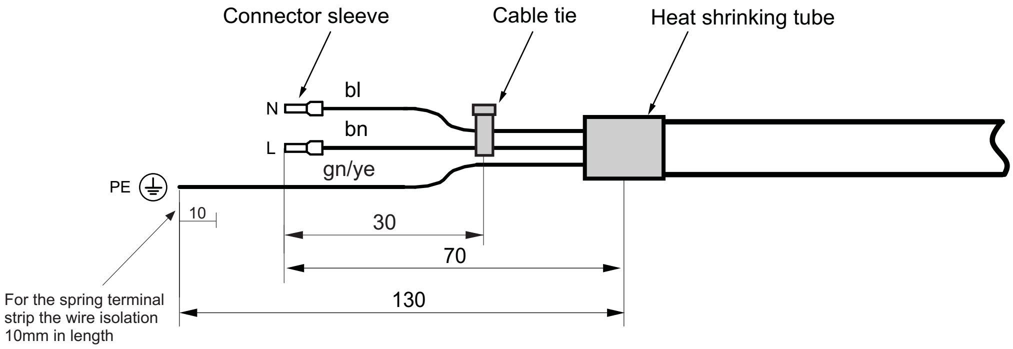


Figure 4.4: Diagram of the assembled mains cable (Dimensions without mm specification.)

- For cables with an outer diameter of up to 7 mm, use the mounted cable gland with the nominal size M12 x 1.5. If you use a different cable gland, you must ensure it provides effective strain relief.
- Tie the L/N wires together with a cable tie near the terminals.
- Avoid unnecessarily long cable loops inside the terminal box.
- Afterwards, tighten the cable glands to ensure it provides effective strain relief for the cable.

Permanent connecting cable

The mains connection of the LSV-1000 can also be permanently installed if required. The terminals are suitable for solid wires with a profile of up to 2.5 mm^2. Preferably a sheathed cable with a conductor profile of 1.5 mm^2 should be used. The instrument is internally equipped with a 3.15 A/slow-blow fuse. On installation, a disconnecting device should be installed in case of danger which complies with the requirements of IEC 60947 -1 and -3. It must be freely accessible and labeled appropriately.

Use one of the cable glands M16 x 1.5 supplied as a cable duct.

5 Initial Start-up

5.1 Functional Test (with Terminal Box)

Carry out the first functional test of the LSV-1000 with the terminal box LSV-A-110. The functional test can be carried out on a rotating shaft or disc. You can, of course, alternatively use any measurement object which is moved within the measurement volume. For an initial functional test, proceed as follows:

Preparation

1. Position the sensor so that its exit aperture points roughly at the measurement object. The distance from the object should correspond to the specified stand-off distance (refer to SECTION 9.2.2).

Cabling

2. Connect up the key switch in accordance with the laser safety guidelines and turn it to position OFF (key removable). You will find further information on safety equipment in SECTION 4.2.2.
3. Plug the connecting cable into the Sub-D plug on the back of the sensor.

   It must be easy to make the connection. If not, check the plug for bent contact pins to avoid serious damage being incurred.
4. Secure the connections with the knurled screws on the plug.
5. Connect up the mains cable to an earthed socket.

Switching on

6. Before now switching on the sensor, remember the information on laser safety provided in SECTION 1.2! During the functional tests in particular, make sure you are wearing suitable laser protection glasses for wavelengths from 620 ... 700 nm.
7. Switch the sensor on by turning the key switch to position ON.

   On the sensor, the LED EMISSION will immediately light up. Laser light is not yet emitted.

   After a temperature dependent delay period of max. 1 min, laser light is emitted and the LED READY lights up.

   Under certain circumstances the laser may switch itself off again briefly and the LED READY goes out. This is a normal reaction of the temperature control and is not a fault.
8. Move the object. Pay attention to the minimum velocity that is dependent on the specified stand-off distance (refer to SECTION 9.2.2).

   The fact that the LED VALID also lights up shows that the sensor is acquiring the object movement and is therefore functional in principle.

5.2 Configuring the LSV-1000

The LSV-1000 offers various options for adapting to the measurement task and the properties of the process control. Before installing the system, the requirements should be analyzed and the configuration should be planned on this basis. From a hardware point of view, you have to define which control and status signals you require and via which interface transmission of the measurement data is to be made. In this context, cable lengths, transfer rates and electrical properties of the peripheral components also play an important role. You will find detailed information on the various interfaces of the LSV-1000 in CHAPTER 6.

Once you have installed the LSV-1000 in accordance with the requirements of the measurement task, you have to make initial parameter settings for the sensor via a data interface. During this process, you select the internal settings of the LSV-1000 to be optimal for the measurement conditions and permanently save these in the flash memory of the instrument. Parameterization and monitoring of the LSV-1000 are optimally supported by the LSV software included in the scope of supply. Alternatively, the user can use communication software he has prepared himself. The information on the command set of the LSV-1000 necessary for programming can be found in APPENDIX B. Polytec will make an appropriate object bibliography available to you for preparing Microsoft® Windows® applications.

When you are starting up the LSV measurement system, it is an advantage if the user is near the measurement location and can observe the system directly. For this purpose, the terminal box LSV-A-110 offers easy access to the various data interfaces of the sensor. Access to the interfaces is, however, also possible without the terminal box LSV-A-110.

NOTE !

Please note that with cable lengths of more than 15 m between sensor and PC, interference-free communication via the service interface (RS-232) can no longer be warranted. For larger cables use the ethernet interface or the RS-422 interface.

RS-232

In the terminal box LSV-A-110 you will find a passive connection module (A1) with a 9-pin Sub-D plug for the serial service interface of the LSV-1000. For temporary connection of a PC with the RS-232 interface use the null modem cable supplied (cross-wired). For PCs without an RS-232 interface, you can use a commercially available converter cable from USB to RS-232 in connection with the pertinent driver software. The service interface can be used completely independently of the wiring of the other two data interfaces and in the state the LSV-1000 is delivered in, works at a transfer rate of 115 200 Baud.

Ethernet

You can permanently connect a PC with the LSV-1000 via a commercially available Ethernet cable with an RJ45 plug. The RJ45 jack is on the connection module A2 in the terminal box LSV-A-110. If you want to connect a PC directly without interconnected network components, you need a cross-wired patch cable. By using an industrial Ethernet cable with a circular plug M12 (D coding), you can also make the network connection directly on the sensor LSV-1000. You will find more detailed information on setting up the network connection in CHAPTER 7. Please note that the Ethernet interface only works if no active receiver is connected to the serial RS-422 interface.

RS-422

As an alternative to the Ethernet interface, you can use the serial RS-422 interface of the LSV-1000 for communication. In this case, no Ethernet connection may be connected. As no standardized pin configuration exists for RS-422, this interface is only accessible via terminals 6 to 10 in the terminal block XL5. This interface also works in the state the LSV-1000 is delivered in with a transfer rate of 115 200 Baud.

NOTE !

You will find detailed information on optimal sensor settings in SECTION 7.2.

6 Function of the Interfaces

6.1 Interface Concept

With its large number of digital control signals and data interfaces, the Sensor LSV-1000 offers the greatest possible flexibility for being linked into different process environments. All interface signals with the exception of the Ethernet interface are available at the 37-pin Sub-D plug of the sensor and are conducted along the connecting cable to the branching point. The terminal box LSV-A-110 offers optimal access to the individual signals. With its clearly arranged terminals, it fulfills all requirements of a flexible and efficient industrial installation system.

The various control and data lines for linking the LSV-1000 up to your process are grouped together to galvanically isolated groups with separate grounding connections. With the exception of the RS-232 interface only intended for start-up and service work, all signal lines are electrically isolated from the central signal processing unit as long as no external connections are made between various grounding connections of the sensor. This grounding concept is displayed schematically in FIGURE 6.1.

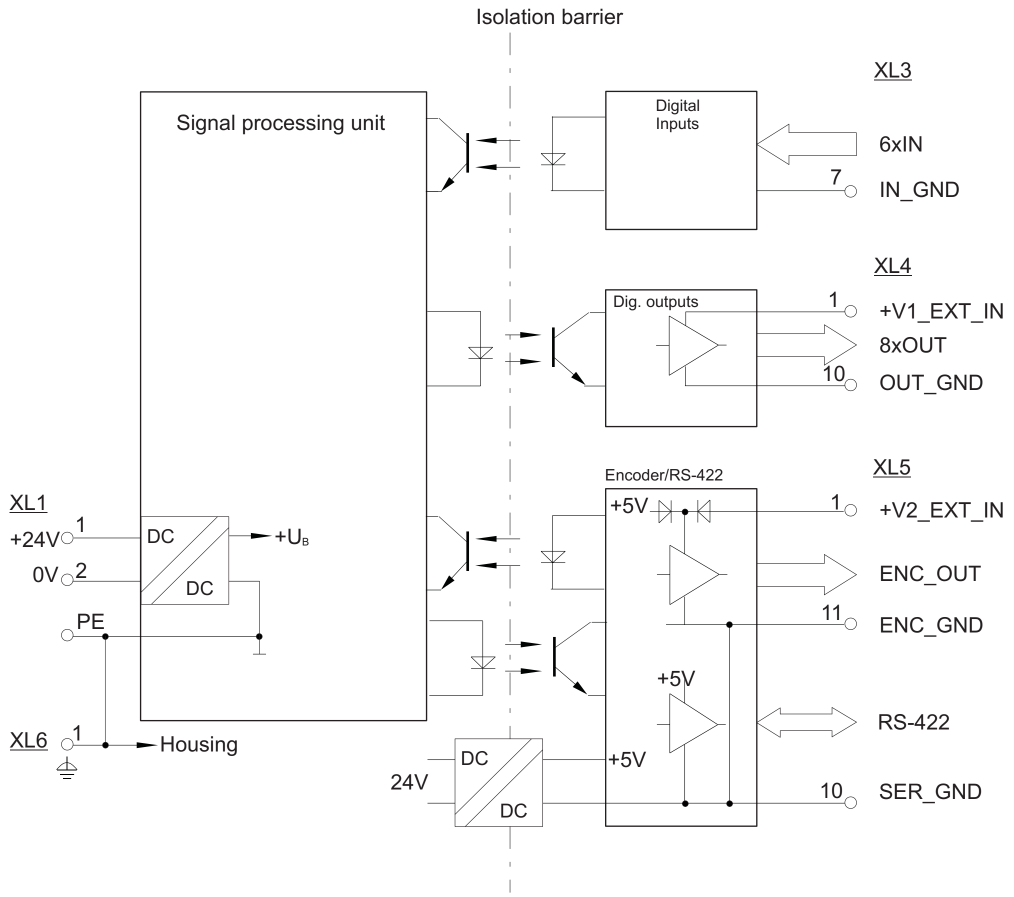


Figure 6.1: Grounding concept of the LSV-1000

The grounding concept selected allows secure communication between sensor and process control system, even in high interference environments or respectively, with small grounding potential differences (max. 50 V) between various points of the system, providing the tried and trusted installation rules of automation technology are complied with. However, it offers no secure electrical isolation for larger ground potential differences between the connected electric circuits.

NOTE !

Please note that to simplify initial start-up of the device, in the delivery status, the terminal box LSV-A-110 is fitted with wire bridges BR1 and BR2 which connect the input signal circuit with the sensor's 24 V mains supply.

6.2 Serial Interface RS-232

The RS-232 interface is only designed to temporarily connect a PC during start-up or maintenance of the sensor. The recommended installation concept of the LSV-1000 allows for this interface only be connected directly with a PC via the connection module A1 in the terminal box LSV-A-110 using an RS-232(X) cable (null modem cable, cross-wired).An extension of the RS-232 signal lines between sensor and PC beyond 15 m is not permitted for functional reasons. The service interface is not electrically isolated from the signal processing unit of the sensor and is thus more sensitive to electrical interference than other interfaces.

Using a special programming cable between the PC and connection module A1, which connects pin 9 to pin 5, the main processor of the LSV-1000 can be transferred into programming mode. In this state for example, a firmware update can be carried out by authorized personnel using special PC software.

Configuration The standard configuration of the interface RS-232 is as follows:

Transmission rate:	115 200 Baud
Data format:	8 data bits, 1 stop bit, no parity bit
RS-232(X)cable to PC:	2 x 9-pin Sub-D jack, null modem cable (cross-wired)

The pin configuration of the serial service interface is shown in FIGURE 6.2 and the following table:

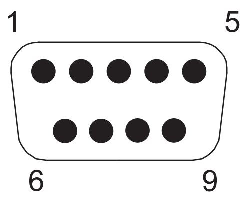


Figure 6.2: Pin configuration of the serial service interface RS-232

Pin	Signal	Function
1	N/A	Not used
2	SERV_RxD	Received data (←)
3	SERV_TxD	Transmitted data (→)
4	N/A	Not used
5	SERV_GND	Reference potential
6...8	N/A	Not used
9	PROG	Programming

6.3 Serial Interface RS-422

For permanent data communication with the process control system, there is the galvanically isolated RS-422-interface. Differential signal transmission allow interference-free communication along significantly longer cable lengths than with RS-232. If high quality cable is used with twisted pairs of wires, distances of up to more than 1 000 m can be bridged at a transfer rate of 115 200 Baud. In the interest of greater transmission reliability, if you are using longer lengths of cable, it could be practical to use terminating resistors at the receiving end. For cabling, the same information applies as for Encoder signal transmission in SECTION 6.4.

The terminals of the serial RS-422 interface are in terminal block XL5 (Encoder Out/RS-422). The serial interface and the Encoder interface are supplied internally from a common, ungrounded power supply, the minus pin of which is connected to the GND terminals XL5:10 and XL5:11. We recommend using shielded cable and connecting the shield to terminal XL5:10. If ground loop problems occur when RS-422 and Encoder interface are used simultaneously, then you can dispense with connecting the shield.

Configuration The standard configuration of the serial interface RS-422 is as follows:

Transmission rate: 115200 Baud

Data format: 8 data bits, 1 stop bit, no parity bit

The terminal configuration of the RS-422 interface is shown in the following table:

Terminal	Signal	Function
XL5:6	RxD+	Received data (+)
XL5:7	RxD–	Received data (–)
XL5:8	TxD+	Transmitted data (+)
XL5:9	TxD–	Transmitted data (–)
XL5:10	SER_GND	Reference potential (shield)

6.4 Encoder Interface

Application The encoder interface at terminal block XL5 emulates the digital quadrature signals of an incremental shaft encoder with direction acquisition and can be connected to a counter input in place of a friction wheel encoder. The waveforms of the generated signals are shown in FIGURE 6.3.

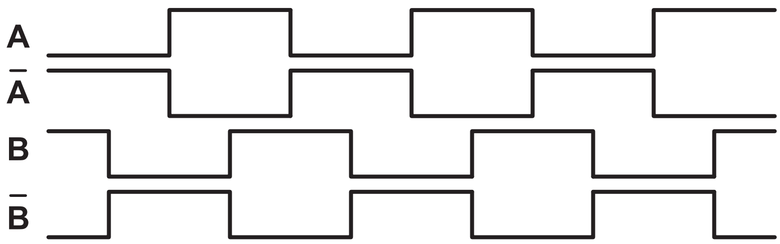


Figure 6.3: Signals at the encoder interface

The output of the counter pulses is activated and parameterized using the LSV software (refer to software manual). The number of output pulses is proportional to the measured length and the frequency of the output pulses is proportional to the velocity. The scaling is also set in the LSV software. Activating the function Enable Outputs with Trigger in the software prevents encoder pulses being output after the end of the material for the duration of the Hold Time set (refer to software manual).

Operating modes

An excerpt from the circuit diagram of the line driver is shown in FIGURE 6.4. Optocouplers galvanically isolate the short-circuit proof driver stages for the four signals $A/\overline{A}$ and $B/\overline{B}$ from the signal processing electronics. The Encoder interface is supplied from an internal, ungrounded power supply with 5V supply voltage and produces signal levels according to RS-422 standard. Alternatively the output circuit can be operated with an external voltage +V2_EXT in the range +5V...+30V (+ at XL5:1, − at XL5:11). The level of the output signals in this mode of operation corresponds approximately to the external supply voltage. If no galvanic isolation is necessary, you can also use the internal 24V supply voltage to feed the encoder interface. In this case, the bridges BR5 and BR6 need to be installed (refer to FIGURE 9.4).

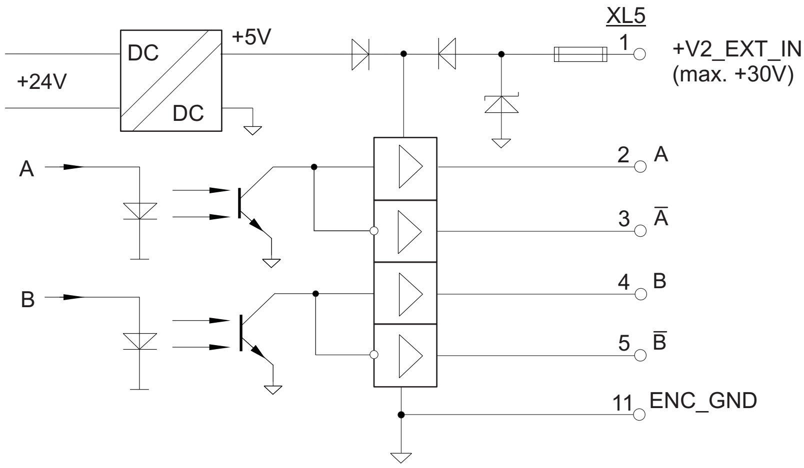


Figure 6.4: Circuit diagram of the encoder interface (simplified)

Cabling

The output signals of the encoder are differential signals. When using differential inputs at the receiver side and suitable cables, a high reliability will be reached with this type of signal. For signals $A/\overline{A}$ and $B/\overline{B}$ respectively, we strongly recommend using twisted pairs which are in a separately installed, shielded cable. In particular, this applies to cable lengths above 10 m. The shield should preferably only be grounded at the receiver side.

> **NOTE !**
>
> The encoder signal cable should not contain supply lines or carry along any other signals! Furthermore, it may not be laid in the immediate vicinity of power lines or other lines that are at risk of interference.

With cable lengths above 10 m or output frequencies above 100 kHz, the ends of line have to be terminated with a suitable resistor. Ideally the terminating resistor has the same value as the characteristic impedance of the line which typically lies in the range of 100...150 Ω for twisted pairs. Deviations of ±20% are uncritical here. Under these conditions, the encoder interface should preferably be operated in RS-422 mode, i.e. without external power supply + V2_EXT.

With cabling, you need to take the following into consideration:

- Use a shielded, twisted-pair cable (STP). It must contain at least 2 pairs, for $A/\overline{A}$ and $B/\overline{B}$ respectively.
- Ground the cable shield at the receiver side.
- Provide an appropriate termination of the lines at the receiver side. As a general rule, you can use a terminating resistor of 120 Ω.

Configuration

Configuration of the encoder interface:

Terminal	Signal	Function
XL5:1	+V2_EXT_IN	External supply voltage +5V...+30V
XL5:2	A	Count A
XL5:3	$\overline{A}$	Count $\overline{A}$
XL5:4	B	Count B
XL5:5	$\overline{B}$	Count $\overline{B}$
XL5:11	ENC_GND	Reference potential for ext. voltage +V2_EXT_IN

6.5 Control Signal Inputs

A total of five inputs with nominally 24 V High level are available to control the LSV-1000 using logical signals from the process. The inputs have got an ungrounded common reference potential (IN_GND) and are isolated from the internal signal processing unit of the sensor by optocouplers. In the delivery status of the terminal box LSV-A-110, the reference potential IN_GND is connected via wire bridge BR2 to the 0V connection of the internal power supply to be able to simply derive a High signal for the input LASER_ON via BR1 from the internal supply voltage. You have to remove these wire bridges to be able to control the signal inputs from a potential isolated source (refer to FIGURE 9.3).

The signal lines of the inputs are accessible in the terminal box LSV-A-110 via the terminals of the terminal block XL3. A simplified circuit diagram of the input stages is shown in FIGURE 6.5. All inputs are protected by special protective measures against reverse polarity and overvoltage and work at a wide range of levels. For the electrical properties, please see SECTION 9.2.3.

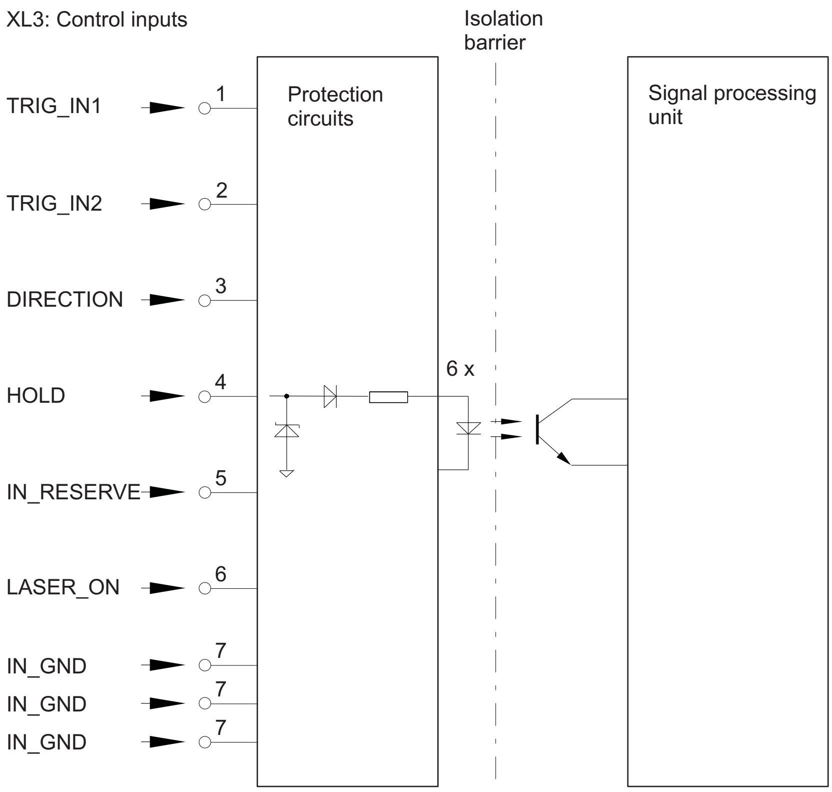


Figure 6.5: Excerpt from the overall circuit diagram (control inputs)

Functions The individual input signals have the following functions:

TRIG_IN1:	Input signal Trigger 1 to start and stop the length measurement: The internal acquisition of the run length is triggered by this signal. For example, the signal can be generated by a light barrier which detects the front edge of the measurement object.
TRIG_IN2:	Input signal Trigger 2 to start and stop the length measurement: Logical AND or OR operation with TRIG_IN1
DIRECTION	Using this input, the LSV-1000 can be fed with directional information from the process. This signal affects the sign of the velocity information at all signal and data outputs of the sensor. DIRECTION = L or open: Positive sign DIRECTION = H: Negative sign
HOLD	This input can be used to force the velocity and length measurement to stop. HOLD = L or open: Normal measurement operation HOLD = H: Measurement is stopped and the last velocity value is hold.
LASER_ON	This input operates the electromechanical beam shutter (Shutter) of the LSV-1000 while simultaneously switching the laser source on and off. The signal LASER_ON is a constituent part of the laser safety concept of the LSV-1000. LASER_ON = L or open: shut beam shutter, switch laser off LASER_ON = H: open beam shutter, switch laser on

NOTE !

Please note that when switching on the laser using the signal LASER_ON, there is a time delay of approx. 2 s. Switching off happens without delay. Switching the laser on is only possible if both interlock connections are closed (refer to SECTION 4.2.2).

Configuration

Configuration of the control inputs at terminal block XL3:

Terminal	Signal	Function
XL3:1	TRIG_IN1	Input signal for trigger source 1
XL3:2	TRIG_IN2	Input signal for trigger source 2
XL3:3	DIRECTION	Velocity sign
XL3:4	HOLD	Stop for measurement
XL3:5	IN_RESERVE	Not used
XL3:6	LASER_ON	Beam shutter and laser control
XL3:7	IN_GND	Reference potential for inputs

6.6 Control Signal Outputs

The LSV-1000 offers a total of 8 digital outputs for linking up control and status devices. The outputs are designed as High-Side switches (PNP type) and switch the externally fed in voltage +V1_EXT to the respective active output. All outputs are isolated from the sensor's signal processing unit by optocouplers. The connection OUT_GND is a common ungrounded reference point which needs to be connected with the minus pin of the external power supply for optimal interference immunity.

The signal lines of the outputs are accessible at the terminal box LSV-A-110 via the terminals of the block XL4. A simplified circuit diagram of the output stages is shown in FIGURE 6.6. All outputs are protected by special protective measures against reverse polarity and overvoltage and can switch voltages in the range +5V to +30V with a continuous current of 100 mA each. For the electrical properties, please see SECTION 9.2.3.

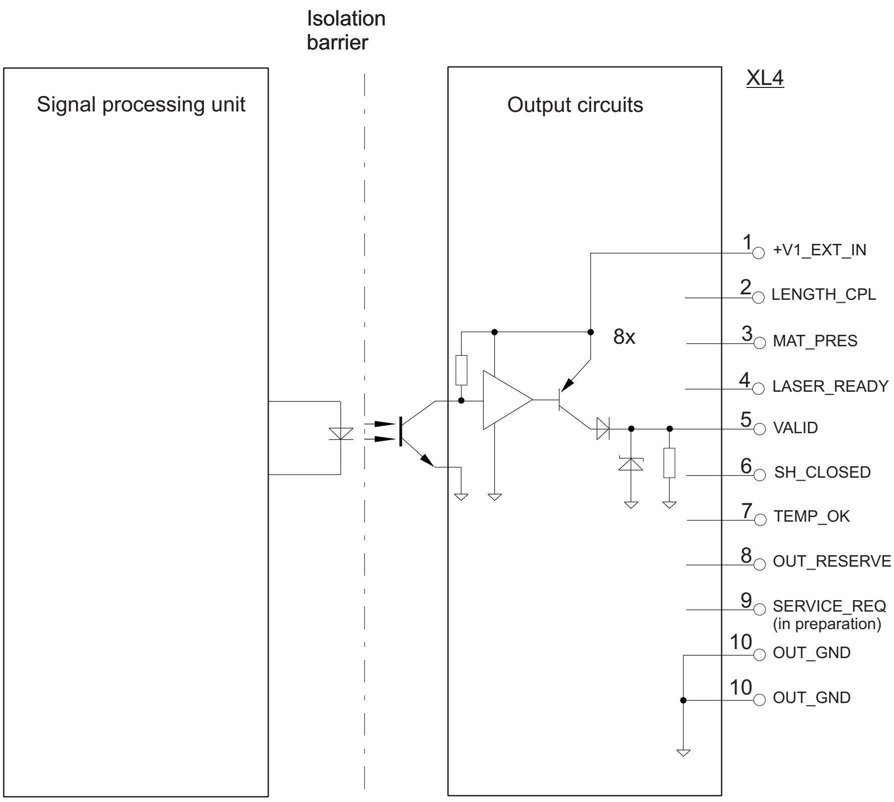


Figure 6.6: Excerpt from the overall circuit diagram (control outputs)

For simplified use, the digital outputs can be supplied from the internal 24V power supply of the terminal box LSV-A-110. To do this, connect OUT_GND (XL4:10) to the negative supply voltage (XL1:2) and +V1_EXT_IN (XL4:1) to the positive supply voltage (XL1:1).

Functions The individual output signals have the following functions:

LASER_READY: This output shows the status of the laser and thus the sensor's readiness to make a measurement.

LASER_READY = H:	laser active, sensor ready
LASER_READY = L:	laser off, sensor not ready

VALID: The active status of this signal shows that the current measurement value available at the interfaces is valid, as the system is actively measuring. As soon as the LSV-1000 can no longer detect a useful measurement value due to interruption of the Doppler signal or other interferences, this output is inactive.

VALID = H:	measurement values valid
VALID = L:	measurement values not valid

SH_CLOSED: This output shows the status of the beam shutter (Shutter). The output is only active (H) if the electromechanical beam shutter is completely shut, i.e. is in the safe position. The signal is fail-safe and can be included in the laser safety concept for the system.

SH_CLOSED = H:	Beam shutter is closed.
SH_CLOSED = L:	Beam shutter is open.

MAT_PRES This output reports as default the result of the internal material detection. The setting of the comparator threshold is decisive for this to function correctly (refer to SECTION 7.2.3).
If the LSV-1000 is configured for cut mode, then this output provides the advanced warning signal (LENGTH_VOR) which can be used in connection with the cutting signal (LENGTH_CPL) to control a saw (refer to SECTION 7.2.3).

MAT_PRES = H:	Material has been identified in the measurement volume
MAT_PRES = L:	No material in measurement volume

In cut mode:

LENGTH_VOR = H:	Notify length has been reached
LENGTH_VOR = L:	Notify length has not yet been reached

LENGTH_CPL In cut mode, this output signal indicates that the preselected cutoff length has been reached.

LENGTH_CPL = H:	Cutoff length has been reached
LENGTH_CPL = L:	Cutoff length has not yet been reached

TEMP_OK	This output depicts the status of the temperature stabilization for the laser. The signal is only of importance to the status diagnosis of the sensor in extreme ambient temperatures.

TEMP_OK = H:	The laser temperature is in the target range.
TEMP_OK = L:	The laser temperature is not in the target range. In this case the laser is automatically switched off.

SERVICE_REQ (in preparation)	If this signal is active, it indicates that it is necessary to start taking service measures, as the sensor sensitivity is starting to deteriorate. Causes can, for example, be a dirty front window or the age of the laser. This function is not yet supported by the current sensor software.

SERVICE_REQ = H:	Service necessary
SERVICE_REQ = L:	Normal operating status of the sensor

OUT_RESERVE	Reserve output, currently not used

Configuration

Configuration of the control outputs at terminal block XL4:

Terminal	Signal	Function
XL4:1	+V1_EXT_IN	Feed for output circuits +5V...+30V
XL4:2	LENGTH_CPL	Output for cutoff control
XL4:3	MAT_PRES	Output for material detection / cutoff control
XL4:4	LASER_READY	Output for readiness signal
XL4:5	VALID	Output for valid signal
XL4:6	SH_CLOSED	Output signal "Beam shutter closed"
XL4:7	TEMP_OK	Output for temperature monitor
XL4:8	OUT_RESERVE	Not used
XL4:9	SERVICE_REQ	Output for dirt warning (in preparation)
XL4:10	OUT_GND	Reference potential for outputs

7 Parameterization

7.1 Setting up Communication Interfaces

7.1.1 Communication via the Serial Interfaces

Usually, controlling the LSV-1000 is managed via one of the serial interfaces (refer to SECTION 5.2). There are several ways of doing this:

- With the aid of the LSV software supplied, control of the LSV-1000 can be managed on a PC with the operating system Microsoft® Windows®. You will find a detailed description in your software manual.
- The LSV-1000 can also be operated via the serial interfaces with the aid of a special set of commands. You will find a description of these commands in APPENDIX B.

NOTE !

Make sure that the LSV software is installed on your PC and that no network is connected to the Ethernet interface.

Setting up LSV software

To set up the LSV software, proceed as follows:

1. Start the LSV software. The application window for the LSV software appears.
2. Select LSV > Setup. The dialog LSV Setup appears.
3. In the field Interface select the required interface.
4. In the field Connection Settings select the respective necessary settings.
5. Click Apply.
6. Set the other parameters and make the measurement as described in your LSV software manual.

You will find information on suitable settings in SECTION 7.2.

7.1.2 Communication via the Ethernet Interface

As an alternative to the serial interface, you can operate the LSV-1000 via your Ethernet network (refer to SECTION 5.2). There are several ways of doing this:

- With the aid of the LSV software supplied, you can use a PC with the operating system Microsoft® Windows® to control the LSV. You will find a detailed description in your software manual.
- The LSV-1000 can also be operated via the Ethernet interface with the aid of a special set of commands. You will find a description of these commands in APPENDIX B.

NOTE !

Make sure that the LSV software is installed on your PC and that no data source is connected to the RS-422 interface.

Take the device into operation

Before you can operate the LSV-1000 via an Ethernet network, you have to connect and set up the sensor first. You can also set up several sensors at the same time on the network.

Network with DHCP / BootP

On delivery, the sensor is set up for DHCP operation as standard. If the sensor is being used in a network **with** a DHCP server, then it automatically applies a valid IP address. The LSV can now be operated via the network.

Network without DHCP / BootP

If the sensor is being used in a network **without** a DHCP server, then you will have to assign an IP address to the sensor. It depends on how the network is set up as to which IP addresses are valid. Allocate the sensor an IP address as described in the following section.

Identifying the sensor in the network and assigning the IP address

Identifying the sensor in the network and assigning a fixed IP address is done with the aid of the software DeviceInstaller. To identify one or several sensors on the network or to assign them an IP address, please proceed as follows:

1. Check whether the software Microsoft® .NET® Framework is installed on your PC. If not, install it from the directory \\Extras\dotnet\ on your LSV software CD.

2. Install the software DeviceInstaller from the directory \\Extras\Lantronix\Tools on your LSV software CD.

3. Start the software DeviceInstaller.

4. Click  in the toolbar or select Device > Search.

   The software searches for all sensors connected to the network and shows them in a list with their MAC address (hardware address) and IP address.

   Every sensor has an instrument-specific Ethernet address, also called MAC address. The label for the MAC address is near the Ethernet interface on the sensor to clearly identify it.

> **NOTE !**
>
> If you want to operate the sensor using the LSV software, make a note of the IP address.

5. If you want to assign a fixed IP address to the sensor, select the sensor which is to be configured. To do so, click it.

6. Click  in the toolbar or select Device > Assign IP Address. The dialog Assign IP Address appears.

7. Select Assign a specific IP address and click Next.

8. Enter the required IP address in the field IP Address and enter the appropriate subnet mask in the field Subnet Mask.

9. Click Next and confirm your input by clicking Assign.

   The software will update the settings on the sensor. This process takes several seconds.

10. Click Finish as soon as it is activated. How to assign IP addresses is also described in the DeviceInstaller manual. You will find the manual in the directory \\Extras\Lantronix\Manual on your LSV software CD.

11. Repeat steps 5 to 10 for all sensors.

> **NOTE !**
>
> If you want to operate the sensor using the LSV software, make a note of the IP address.

12. Close the DeviceInstaller.

The sensor can now be controlled via the network.

Setting up LSV software

To set up the LSV software, proceed as follows:

1. Start the LSV software. The application window for the LSV software appears.
2. Select LSV > Setup. The dialog LSV Setup appears.
3. In the field Interface select the required interface.
4. In the field Connection Settings select the respective necessary settings.
5. Click Apply.
6. Set the other parameters and make the measurement as described in your LSV software manual.

You will find information on suitable settings in SECTION 7.2.

7.2 Selecting Suitable Settings

7.2.1 Velocity or Length Measurement?

The LSV can measure velocities as well as lengths. To do so, the LSV calculates a length through integration of the measured velocity over time. So settings for the velocity measurement must also be made for a length measurement.

7.2.2 Settings for the Velocity Measurement

You will find detailed information on how to adjust the settings described here in the software manual.

Measurement Range

Adjusting the velocity measurement range to the application conditions, the behavior of the LSV-1000 concerning the search time after losing the signal can be optimized. If it takes too long time until the device provides valid measurement values after the material enters the measurement volume, please try to improve this behavior by limiting the measurement range. The measurement range limits v_{min} and v_{max} should be adapted preferably close to the actual velocity range but provide adequate reserve for potential extreme values. Outside the determined area, the LSV-1000 can not measure and shows this status (VALID LED off)

Zero Zone

The zero zone marks a velocity range, which is interpreted as a standstill of the object. If the zero zone is activated in the dialog LSV Setup, a value for v_{min} can be entered to determine this limit. For the LSV-1000 this parameter becomes less important in practice, because of its measurement principle, very small velocities can not be measured. The exact value for the least measurable velocity depends on the nominal stand-off distance of the sensor and is specified in SECTION 9.2.2. Thus, for most applications the activation of the zero zone is unnecessary. For defining a larger zero zone with special applications, only values above the specified minimum velocity are useful. If the value for the object velocity v_{obj} falls below this v_{min} value (Zero Zone v_{min}), but not yet below the lower measurement range limit set (Measurement Range v_{min}), the system status is furthermore VALID (VALID Led on). The emitted velocity will be set to zero and the length measurement is stopped during this time period.

Behavior when invalid

Using the standard setting Set velocity to zero the measurement value $v_{meas} = 0$ is emitted in case of invalid measurement values (VALID LED off) as long as v_{obj} is smaller than v_{min} (Measurement Range v_{min}). In the dialog Advanced Velocity Acquisition you can change this behavior alternatively so that instead of zero the last valid velocity measurement value is emitted (Hold velocity).

Hold Time The negative properties of a real measurement surface such as dirt or holes can lead to areas with invalid measurement values. The LSV can bridge these areas through a hold function. Invalid measurement values can be bridged up to the time corresponding to the Hold Time set. During this time the signal VALID continues to be given.

The displayed course of the velocity with a correctly set hold time is shown in FIGURE 7.1 in case a. During the time period with invalid measurement values, the last valid velocity value v_1 is output. The status signal VALID remains active.

> **NOTE !**
>
> The setting **Interpolate velocity readings** refers exclusively to length measurement. With velocity measurement it is not possible to generate interim values through interpolation.

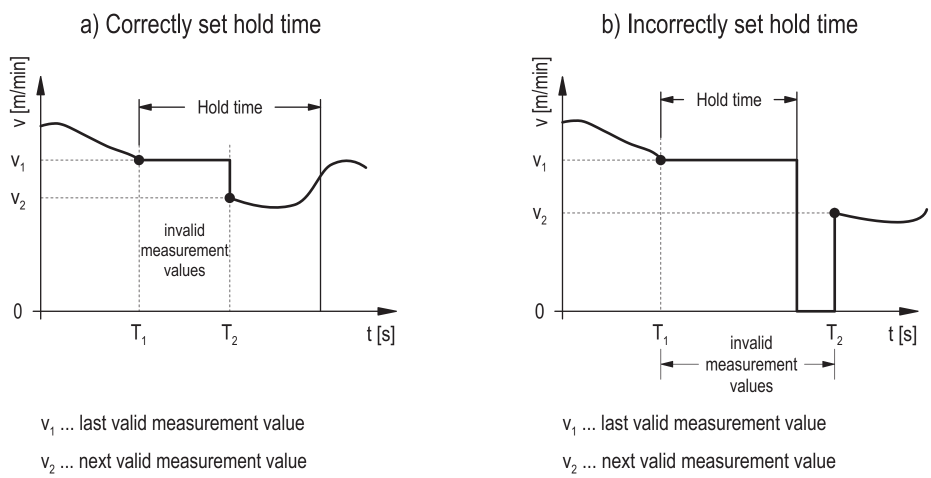


Figure 7.1: Interpolation during velocity measurement

The displayed course of the velocity with an incorrectly set hold time is shown in case b of FIGURE 7.1. As of the point in time T1, the last valid velocity value v_1 is shown. Once the hold time has expired, no further velocity values have been determined. The LSV now withdraws the status signal VALID and shows the velocity 0 until valid velocity values v_2 are determined again. Thus the measured course of velocity displayed shows dropouts.

> **NOTE !**
>
> Set the hold time according to your application as low as possible, but large enough so that areas with invalid measurement values can be bridged. Never set the Hold Time shorter than 0.1 s without consulting Polytec!

Track Delay The track delay is the time for which the sensor must obtain valid data during the search process before giving the status report VALID. The track delay prevents signals which are acquired only for a short time leading to the status report VALID. Temporary acquired signals are caused e.g. by water or dust. If the LSV finds an invalid measurement value within the track delay time, the search process starts again.

NOTE !

Set the track delay time according to your application as low as possible, preferably to zero. If the delay time is set too high, then it is possible that the LSV may not be able to complete the search process.

Moving Average Filter

Every velocity value measured by the sensor first runs through the main filter (Main). The main filter works out the moving average over the last N samples of the measurement signal, i.e. with every new sample, the sensor calculates a new average.

The function and effect of the moving average filter can be seen in FIGURE 7.2. By calculating an average, statistical measurement values variation is smoothed out. At the same time the system's response time changes.

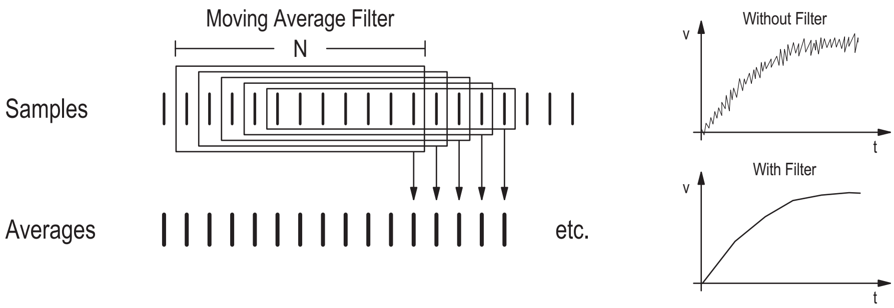


Figure 7.2: Function and effect of the moving average filter

The main filter time (average time) can be estimated as follows:

$$\frac{N}{\text{Data rate}} = \text{Main filter time} \qquad \text{Equation 7.1}$$

When taking an average over a small number of samples ($N < 50$), the time resolution of changes in temporal velocity is better, however the variation in the measurement values is greater.

When averaging over a large number of samples ($N \geq 50$), the variation in the measurement values becomes significantly lower, but the time resolution of the velocity change becomes worse.

Trigger Source

If you are making a pure velocity measurement, then you do not set a trigger source in the software (None). Thus you will attain the best performance (max. data rate) available for the velocity measurement.

7.2.3 Special Settings for Length Measurement

A condition for optimal acquisition of the run length is suitable settings for the velocity measurement, as the length measurement values are calculated by time integration of the velocity measurement values. Apart from that, the LSV-1000 offers additional setting options which are only effective for length measurement. Apart from interpolation, control of the length measurement through start and stop signals (triggering) is of great importance for attainable measurement accuracy. With a wide range of trigger options, the LSV-1000 supports optimal adaptation of the measurement system to the concrete application.

Interpolation

The LSV system determines a length by carrying out an integration of the measured velocity over time. The sensor is informed of the start or stop time of the length measurement by the trigger signals.

If the set logical trigger condition is true, the internal length measurement starts at zero. As soon as the trigger condition is no longer true, the last length measurement value is retained and the instrument is in the status Waiting for trigger.

During length measurement, time periods with invalid measurement values can be bridged through interpolation. The length values are then calculated on the basis of the last valid velocity value. Please note the information on hold time in SECTION 7.2.2 on this as well.

If there are still no valid measurement values after the hold time has expired, the LSV presumes that the end of the material has been reached. The length of the area with invalid measurement values will in this case **not** be taken into account. If this occurs during a measurement, then as a general rule, it is not possible to carry out a sufficiently accurate length measurement.

NOTE !

Set the hold time according to your application as low as possible, but large enough that areas with invalid measurement values can be bridged. Never set the Hold Time shorter than 0.1 s without consulting Polytec!

For length measurement you can choose between two different interpolation procedures to bridge areas with invalid measurement values. In many cases 1st order interpolation provides more accurate results for length than 0th order interpolation.

0 Order Interpolation

This interpolation procedure is used if you have **deactivated** the setting **Interpolate velocity readings** in the software (refer to software manual). The measured course of velocity used for integration with a correctly set hold time is displayed in FIGURE 7.3. During the length measurement, the area with invalid measurement values is replaced by the crosshatched surface which represents the length $l_{i0} = v_1 \cdot (T_2 - T_1)$.

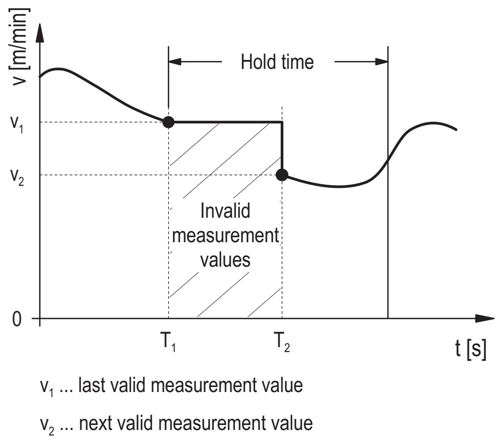


Figure 7.3: 0 order interpolation with correctly set hold time

1st Order Interpolation

This interpolation procedure is used if you have **activated** the setting **Interpolate velocity readings** in the software (refer to software manual). The course of velocity used for integration with a correctly set hold time is displayed in FIGURE 7.4. During the length measurement the area with invalid measurement values is replaced by the crosshatched surface which represents the length $l_{i1} = 1/2 \cdot (v_1+v_2) \cdot (T_2-T_1)$.

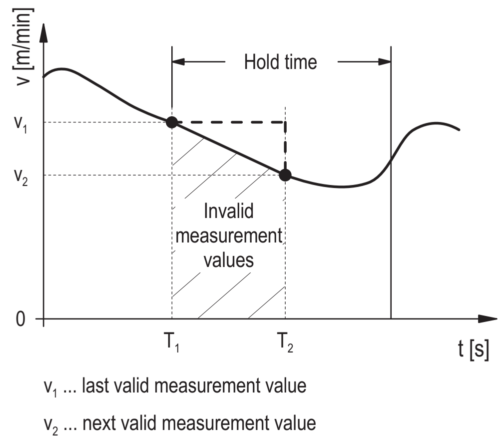


Figure 7.4: 1st order interpolation with correctly set hold time

External Trigger Inputs

You can control the length measurement via two external trigger inputs. These two external trigger inputs are logically connected. Select External Trigger Inputs as your trigger source and configure the inputs according to your application. You will find application examples for the use of the external trigger inputs in SECTION 7.3.

Offset length

In the case of length measurement with external triggering, a value X has to be added to the display value, which depends on the arrangement of the trigger sensors at the measurement point. The LSV-1000 automatically carries out this correction if the value X is saved as parameter Offset Length in the sensor. You will find more information on this in SECTION 7.3 and also in the software manual.

Material detection

You can also start and stop the length measurement with the internal signal Material Detect (trigger source Material Detect). With activated material detection, the sensor can independently identify whether the material is in the measurement volume. To do so, the signal level measured is compared to the signal level set. The signal level depends on the material, the measurement distance and if applicable, on the background (refer to SECTION 4.1.1). For this reason, the parameter Signal Level has to be set suitably for the actual application.

Invert the signal by activating Invert Sign, if in the case of a special application, the signal level with material in the measurement volume is smaller than without material (e.g. in the case of background reflection). The sensor can then recognize by the lower signal level that there is material in the measurement volume.

Cut Mode

You configure the LSV-1000 for cutting applications by selecting Cut Mode as the trigger source.

In this mode signals to cut material to length are emitted at the control signal outputs LENGTH_CPL and MAT_PRES (Cut Mode). You can optionally work with one or two signals.

If you only use one signal, only the cut length is given. Upon reaching this value, the sensor activates the signal LENGTH_CPL (Length complete, active high). If you use two signals, in addition to the Cut Length, a Notify Length can be given. Upon reaching the notify length, at the combined output MAT_PRES (refer also to SECTION 6.5) the signal LENGTH_VOR is activated, which can be used for example to reduce the feed speed when cutting to length.

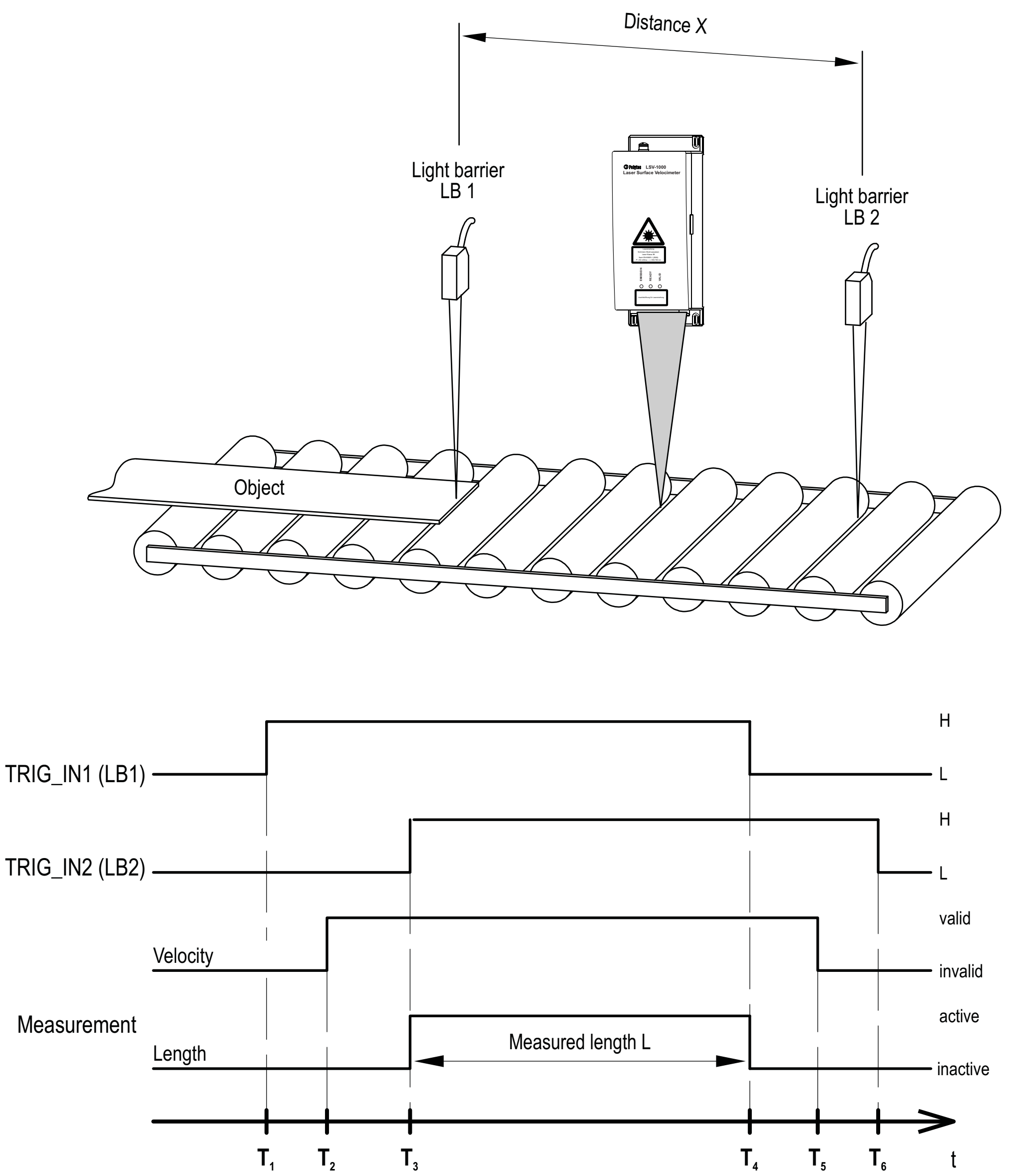
7.3 Application Examples for Length Measurement with External Trigger Sources

You can control a length measurement with the aid of the two trigger inputs TRIG_IN1 and TRIG_IN2 to increase the accuracy of the measurement. Usually the trigger signals are provided by light barriers, however other peripheral sensors are also suitable for this. For this purpose, a light barrier is mounted in the direction of movement before the LSV sensor head and one after the LSV sensor, as shown in FIGURE 7.5. In this setup, start and stop of the length measurement are carried out at points in time at which valid velocity values have already been acquired by the LSV. This then suppresses the error influence of track delay and hold time.

Logical AND Operation

The sequence of events is shown in the diagram in FIGURE 7.5 and is described as follows:

- Point in time T_1: The object reaches the light barrier LS 1.
  The trigger input TRIG_IN1 is set at HIGH. The length measurement is still inactive.
- Point in time T_2: The LSV recognizes the object.
  The LED VALID lights up. The LSV acquires valid velocity measurement values.
- Point in time T_3: The object reaches the light barrier LS 2.
  The trigger input TRIG_IN2 is set at HIGH. Through the logical combination of TRIG_IN1 **AND** TRIG_IN2, the length measurement is now started.
- Point in time T4: The object leaves the light barrier LS 1.
  The trigger input TRIG_IN1 is set at LOW. The trigger condition is now no longer true and the length measurement is stopped.
- Point in time T_5: The LSV no longer recognizes the object.
  The LED VALID switches off.
- Point in time T_6: The object leaves the light barrier LS 2.
  The trigger input TRIG_IN2 is set at LOW.



Length of the object = Measured length L + Distance X

Figure 7.5: Measurement setup for length measurement with high accuracy

Length of the Object

To determine the length of the object, the distance X between the two light barriers has to be added to the measured length L.

> **NOTE !**
>
> If you define the distance X as the offset length in the LSV software, then this correction is made automatically.

Length Measurement with Tilted Section

You can carry out a length measurement with two light barriers (LS 1, LS 2) with an tilted section of the measurement object. To determine the effective length of the measurement object minus the tilted section, you use a measurement setup as shown in FIGURE 7.5. Both light barriers are the same distance X away from the laser beam.

The sequence of events is shown in the diagram in FIGURE 7.5 and is described as follows:

- Point in time T_1: The object reaches the LSV.
  The LED VALID lights up. The LSV acquires valid velocity measurement values.
- Point in time T_2: The object reaches the light barrier LS 1.
  The trigger input TRIG_IN1 is set at HIGH. The length measurement is still inactive.
- Point in time T_3: The beveled edge of the object reaches the light barrier LS 2.
  The trigger input TRIG_IN2 is set at HIGH. Through the logical combination of TRIG_IN1 **AND** TRIG_IN2, the length measurement is now started.
- Point in time T_4: The LSV no longer recognizes the object.
  The LED VALID switches off. The Hold Time starts and the last valid velocity value is saved.
- Point in time T_5: Within the hold time, the object leaves the light barrier LS 2.
  The trigger input TRIG_IN2 is set at LOW. The trigger condition is now no longer fulfilled and the length measurement is stopped.
- Point in time T_6: The beveled edge of the object leaves the light barrier LS 1.
  The trigger input TRIG_IN1 is set at LOW.
- Point in time T_7: The hold time expires.

NOTE !

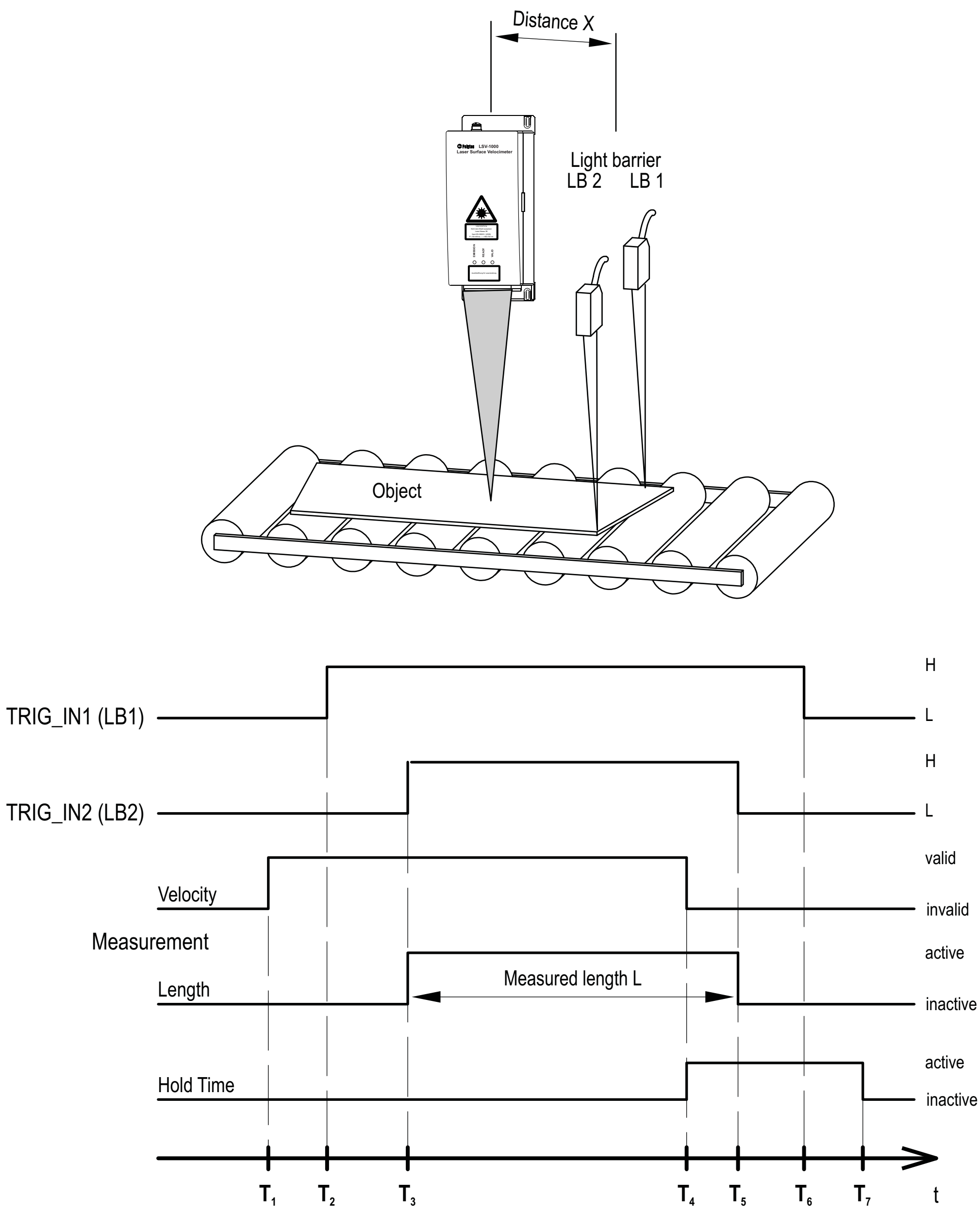
To prevent faulty length measurement, the hold time has to be at least as long as it takes for the object to cover the distance X (refer to equation 7.2) !

$$t_{HOLDmin} = \frac{X}{v_{min}} \qquad \text{Equation 7.2}$$

$t_{HOLDmin}$ … Minimum hold time

X … Distance between light barrier and laser beam

v_{min} … Minimum product speed



Length of the object without truncated end = Measured length L + Distance X

Figure 7.6: Measurement setup for length measurement with tilted section

Length of the Object

To determine the length of the object, the distance X between the light barriers and the laser beam has to be added to the measured length L.

> **NOTE !**
>
> If you define the distance X as the offset length in the LSV software, then this correction is made automatically.

Logical OR Operation

Length Measurement with Unknown Location

If the side position at which the object comes onto the roller conveyor is unknown, you can trigger the length measurement with the measurement setup shown in FIGURE 7.6. In doing so, the roller conveyor is scanned with two light barriers. Both light barriers are the same distance X away from the laser beam.

The sequence of events is shown in the diagram in FIGURE 7.6 and is described as follows:

- Point in time T_1: The object reaches the LSV.
  The LED VALID lights up. The LSV acquires valid velocity measurement values.
- Point in time T_2: The object reaches the light barrier LS 1 or LS 2 or both.
  Trigger input TRIG_IN1 **OR** TRIG_IN2 are set at HIGH. The length measurement is started.
- Point in time T_3: The LSV no longer recognizes the object.
  The LED VALID switches off. The hold time starts and the last valid velocity value is saved.
- Point in time T_4: The object leaves the light barrier LS 1 or LS 2 or both within the hold time.
  The trigger inputs TRIG_IN1 and TRIG_IN2 are set at LOW. The trigger condition is thus no longer fulfilled and the length measurement is stopped. The measured length L of the object is displayed in the display window of the sensor.
- Point in time T_5: The hold time expires.

NOTE !

To prevent incorrect length measurement, the hold time has to be at least as long as it takes for the object to cover the distance X (refer to equation 7.3) !

$$t_{HOLDmin} = \frac{X}{v_{min}} \qquad \text{Equation 7.3}$$

$t_{HOLDmin}$ … Minimum hold time
X … Distance between light barrier and laser beam
v_{min} … Minimum product speed

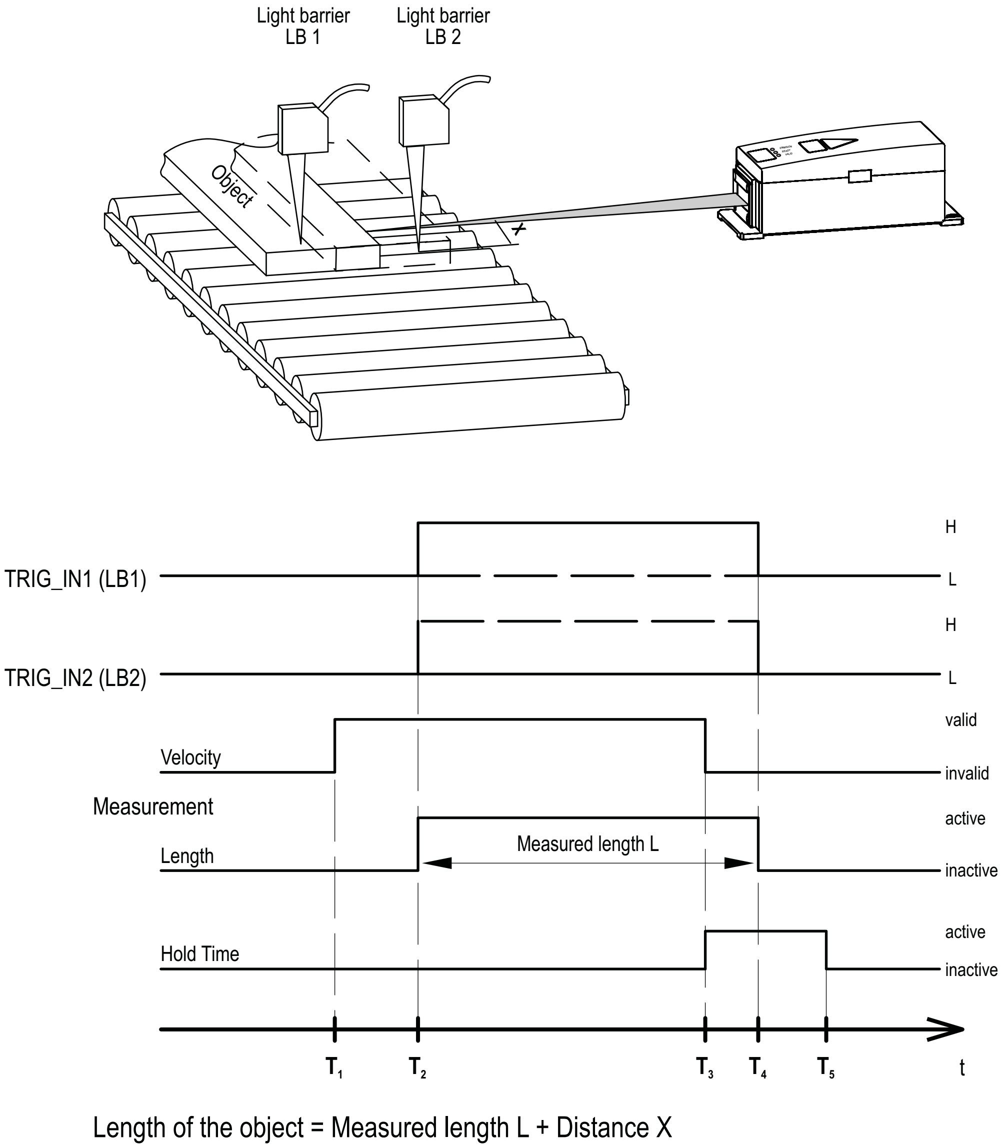


Figure 7.7: Measurement setup for length measurement with unknown location

Length of the Object

To determine the length of the object, the distance X between the light barriers and the laser beam has to be added to the measured length L.

> **NOTE !**
>
> If you define the distance X as the offset length in the LSV software, then this correction is made automatically.

8 Fault Diagnosis

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

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

8.1 General Tests

If the LSV malfunctions, please start by checking the following:

1. Has the power supply of the sensor been checked to be working and is the key switch in position ON?

2. Is the LED EMISSION on the top of the LSV lit up?

   If not, it can be assumed that there is a fault with the internal mains supply of the sensor.

3. Is the LED READY lit up when the control signal LASER_ON is active and has approx. 1 minute passed after switching on the sensor?

   If not, if you are using the terminal box LSV-A-110, please where applicable first of all check the function of any interlock contacts installed. The H status of the control signal LASER_ON must be verifiable at terminal XL2:7. As soon as the LED READY lights up, laser light should also be visible.

   If despite the LASER_ON signal being available, the LED READY does not light up after a short time, then a fault in the laser system can be assumed. The signal TEMP_OK can provide additional clarification: If it is at L-status, it is possible that the target temperature of the laser has not yet been reached. In this case, check and see if the ambient temperature of the sensor is within the specified range.

> **CAUTION !**
>
> **Danger from overheating!** - If the ambient temperature is too high, you have to use the sensor with the cooling plate LSV-A-122 or the cooling plate with a 93° alignment kit LSV-A-124.

8.2 Messages in the Software

Most error messages are displayed in the LSV software. Refer to your LSV software manual on this.

8.3 No Velocity Measurement Possible

If laser light is emitted but making a measurement is not possible, please check the following:

Is a moving measurement object with sufficient backscattering properties at the specified stand-off distance in the path of the beam? Is the LED VALID on the top of the sensor lit up?

If the LED is not lit up, first of all check whether the two laser beams meet at one point on the measurement surface. If so, check the parameter settings for the velocity measurement. Check whether the measurement settings are unfavorable (v_{min} and v_{max}). You will find more information on this in SECTION 7.2.2 and in the LSV software manual.

8.4 No Length Measurement Possible

If velocity measurement values are being emitted but it is not possible to start a length measurement, please check the following:

Using the LSV software, check whether the trigger source is set and configured according to your application. You will find detailed information on this in the software manual. In the case of external trigger sources, check if they are working properly by monitoring the signals TRIG_IN1 and TRIG_IN2. If triggered by internal material detection, check that the signal level has been set properly.

9 Technical Specifications

9.1 Standards Applied

Laser safety:	IEC/EN 60825-1:2008-05 (Safety of Laser Products, complies with 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 -1:2002-08 (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 A 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

CAUTION !

Danger from radio interference! - This instrument is in Limit Class A and can cause radio interference in living areas. In this case the user has to implement appropriate precautions.

9.2 Sensor LSV-1000

9.2.1 General Data

Laser

Laser type:	Laser diode
Wavelength:	690 nm
Laser class:	3 B
Laser power:	max. 25 mW
Beam cross-section (H x W):	2 mm x 4 mm

Ambient Conditions

Operating temperature:	+0°C ... +45°C (32°F ... 113°F)
Storage temperature:	−25°C ... +70°C (−13°F ... +158°F)
Relative humidity:	max. 80%, non-condensing

Power supply

Supply voltage:	18 ... 30 VDC
Power consumption:	max. 15 W

Housing

Dimensions:	refer to FIGURE 9.1
Weight:	4.3 kg
Protection rating:	IP 66 und IP 67 (according to DIN EN 60529)
Flatness of mounting surface:	200 µm
Torque of mounting screws:	max. 5.1 Nm

Calibration

You will find information on calibration in SECTION 3.2.

Vibration Reliability Tested According to EN 60068-2-6 (IEC 68-2-6)

Conditions

Frequency range:	10 ... 150 Hz
Acceleration amplitude (peak):	20 m/s^2
Frequency cycle:	1 octave / min
Testing direction:	3 axes
Test duration:	2.7 h

Shock Reliability Tested According to EN 60068-2-29 (IEC 68-2-29)

Conditions

Number of shocks per direction:	2 000
Maximum acceleration:	100 m/s^2
Shock duration:	16 ms
Testing direction:	3 directions
Shock form:	half-sine

Dimensions

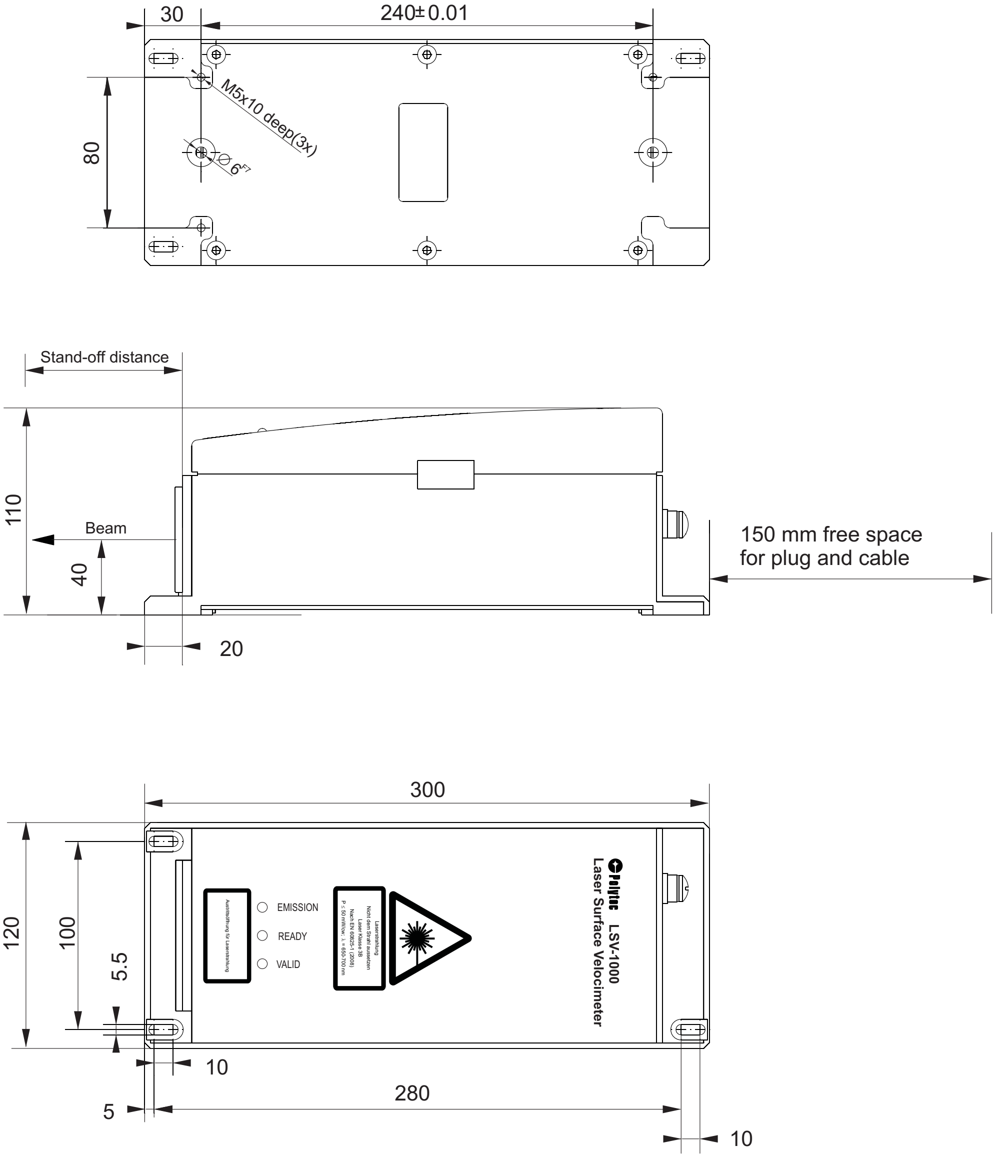


Figure 9.1: Views of the LSV-1000 (Dimensions not specified are given in mm)

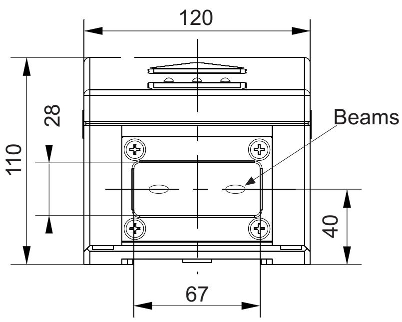


Figure 9.2: Front view of the LSV-1000 (Dimensions not specified are given in mm)

9.2.2 Metrological Properties

Measurement units:	Velocity: mm/s, m/min, ft/s, ft/min, Length: m, ft
Length measurement range:	100 km (328 084 ft)
Calibration error:	<0.1 % of the measurement reading (with optimal assembly)
Measurement rate:	max. 3200 readings/s (raw data rate)
Permissible object acceleration:	20 m/s²
Output data rate:	max. 1024 readings/s, adjustable
Search time after signal loss:	7 ... 25 ms (depending on signal quality and velocity, refer to SECTION 7.2.2)
Signal delay:	<5 ms
Time resolution at length measurement:	2 ms

Sensor model	Nominal stand-off distance[1] mm	Maximum depth of field[2] mm	0.1 % depth of field[3] mm	Fringe spacing (typ.) µm	Maximum velocity m/min.	Minimum velocity m/min.
LSV-1000-30	300	±20	±20	5.7	1330	2.1
LSV-1000-50	500	±30	±30	8.5	1990	3.2
LSV-1000-70	700	±50	±40	11.3	2650	4.2
LSV-1000-100	1000	±75	±60	15.2	3630	5.7

[1] Measured from the mounting surface for the window frame (refer to FIGURE 9.1).

[2] Maximum deviation from the stand-off distance

[3] Deviation from the stand-off distance for an additional error ≤0.1 %

9.2.3 Properties of Electrical Interfaces

Control Signal Inputs

You will find a detailed description of the control signals in SECTION 6.5.

Max. input voltage LOW:	U_{ILmax} = +5V
Min. input voltage HIGH:	U_{IHmin} = +11V
Max. input voltage HIGH:	U_{IHmax} = +30V
Typ. input current HIGH:	I_{IHtyp} = +7.5mA at U_{IH} = +24V
Protection from reverse polarity:	up to −30V
Min. trigger pulse width:	2ms
Isolation voltage:	50V (IN_GND against PE)

Control Signal Outputs

You will find a detailed description of the control signals in SECTION 6.6.

Switch type:	High-Side (PNP)
Switching voltage:	V1_EXT = +5V...+30V (protected from reverse polarity)
Max. continuous current:	I_{OHmax} = 0.1A per output (short-circuit proof)
Peak current:	I_{OHpeak} = 0.5A per output
Switching time:	< 100µs
Isolation voltage:	50V (OUT_GND against PE)
Min. output voltage HIGH:	U_{OHmin} = V1_EXT −0.5V at I_{OH} = 100mA

Encoder Interface

You will find a detailed description of the encoder interface in SECTION 6.4.

Signal type:	Quadrature pulse signal $A/\overline{A}$, $B/\overline{B}$
Signal level:	nom. 0/+5V (RS-422 mode, without ext. voltage) nom. 0/+V2_EXT (with ext. voltage V2_EXT = +5V...+30V)
Scaling:	Pulses per meter, can be configured
Pulse frequency:	max. 500kHz, can be configured
Accuracy:	0.1% of measurement reading (for v > v_{max}/1000)

Serial Process Interface RS-422

You will find a detailed description of the serial interfaces in SECTION 6.3.

Standard:	RS-422 (galvanically isolated)
Transfer rate:	max. 230400 Baud
Data format:	8 data bits, 1 stop bit, no parity bit
Cable to the PC:	Twisted Pair, shielded (STP)

Serial Service Interface RS-232

You will find a detailed description of the serial interfaces in SECTION 6.2.

Standard:	RS-232 (not galvanically isolated)
Transfer rate:	max. 115200 Baud
Data format:	8 data bits, 1 stop bit, no parity bit
Cable to the PC:	Null modem cable (cross-wired)

9.2.4 Pin Configuration of the 37-pin Sub-D plug on the Sensor LSV-1000

Pin No.	Color	Signal	Function
1	ye-bl	TRIG_IN1	Trigger input 1
2	ye-rd	DIRECTION	Measurement direction input
3	ye-bk	IN_RESERVE	Reserve
4	gy-pk	IN_GND	Reference potential for inputs
5	wh-bl	OUT_GND	Reference potential for outputs
6	pk-bn	SERVICE_REQ	Output for warning of dirt (in preparation)
7	bn-gn	MAT_PRES	Output for material detection
8	ye-bn	VALID	Output for valid signal
9	gy-bn	TEMP_OK	Output for temperature monitoring
10	wh-bk	SERV_GND	Reference potential for RS-232
11	bk	SERV_RXD	Received data RS-232
12	bl	TxD+	Transmitted data RS-422
13	pk	RxD–	Received data RS-422
14	ye	/B	Encoder signal B inverted
15	bn	/A	Encoder signal A inverted
16	wh-rd	ENC_GND	Reference potential for encoder signal output and RS-422 interface
17	ye-gy	0 V	Supply voltage (–)
18	ye-pk	0 V	Supply voltage (–)
19	bn-rd	GND	Main ground/ Functional ground
20	gn-rd	TRIG_IN2	Trigger input 2
21	gn-bk	HOLD	Measurement hold input
22	gn-bl	LASER_ON	Laser release input
23	gy-bl		Not used
24	rd-bl	+V1_EXT_IN	Feed for output circuits
25	wh-pk	OUT_RESERVE	Reserve
26	wh-gn	LENGTH_CPL	Output for cutoff control
27	wh-ye	LASER_READY	Output for readiness signal
28	wh-gy	SH_CLOSED	Output signal "Beam shutter closed"
29	vt	SERV_TXD	Transmitted data RS-232
30	bn-bk	PROG	Programming input
31	rd	TxD–	Transmitted data RS-422
32	gy	RxD+	Received data RS-422
33	gn	B	Encoder signal B
34	wh	A	Encoder signal A
35	bn-bl	+V2_EXT_IN	Feed for encoder signal output
36	gy-gn	+24 V	Supply voltage (+)
37	pk-gn	+24 V	Supply voltage (+)

9.3 Terminal Box LSV-A-110

9.3.1 General Data

Mains Connection

Input voltage:	100 VAC ... 240 VAC, ± 10 %
Frequency range:	45 Hz ... 65 Hz
Current consumption:	max. 0.4 A at 230 V max. 0.8 A at 115 V
Inrush current:	< 15 A
Primary fuse:	3.15 A slow-blow (internal)

Housing

Dimensions:	380 mm x 300 mm x 155 mm
Weight:	7.4 kg
Protection rating:	IP 66

Internal Supply Voltage (Auxiliary Voltage)

Nominal voltage:	24 VDC ± 1 %
Load current:	max. 1.5 A (freely available)
Electrical safety:	IEC 60950/VDE 0805 (SELV)
Isolation voltage:	4 000 VAC (type testing) 2 000 VAC (unit testing)

Ambient Conditions

Operating temperature:	−10°C ... +50°C (+14°F...+122°F)
Storage temperature:	−20°C ... +70°C (−4°F...+158°F)

9.3.2 Circuit Diagram

Part 1 of 2

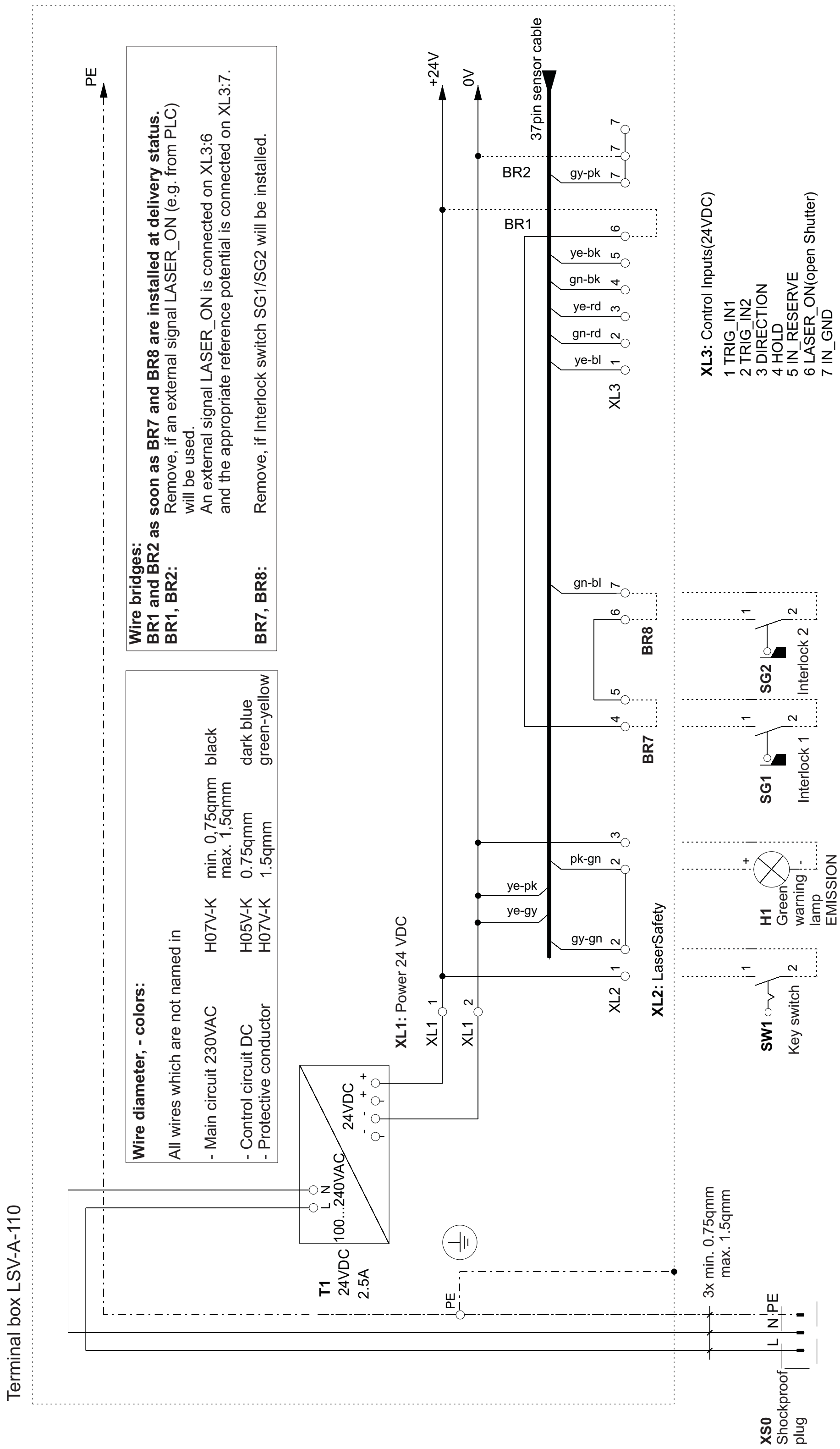


Figure 9.3: Overall circuit diagram terminal box LSV-A-110 (part 1)

Part 2 of 2

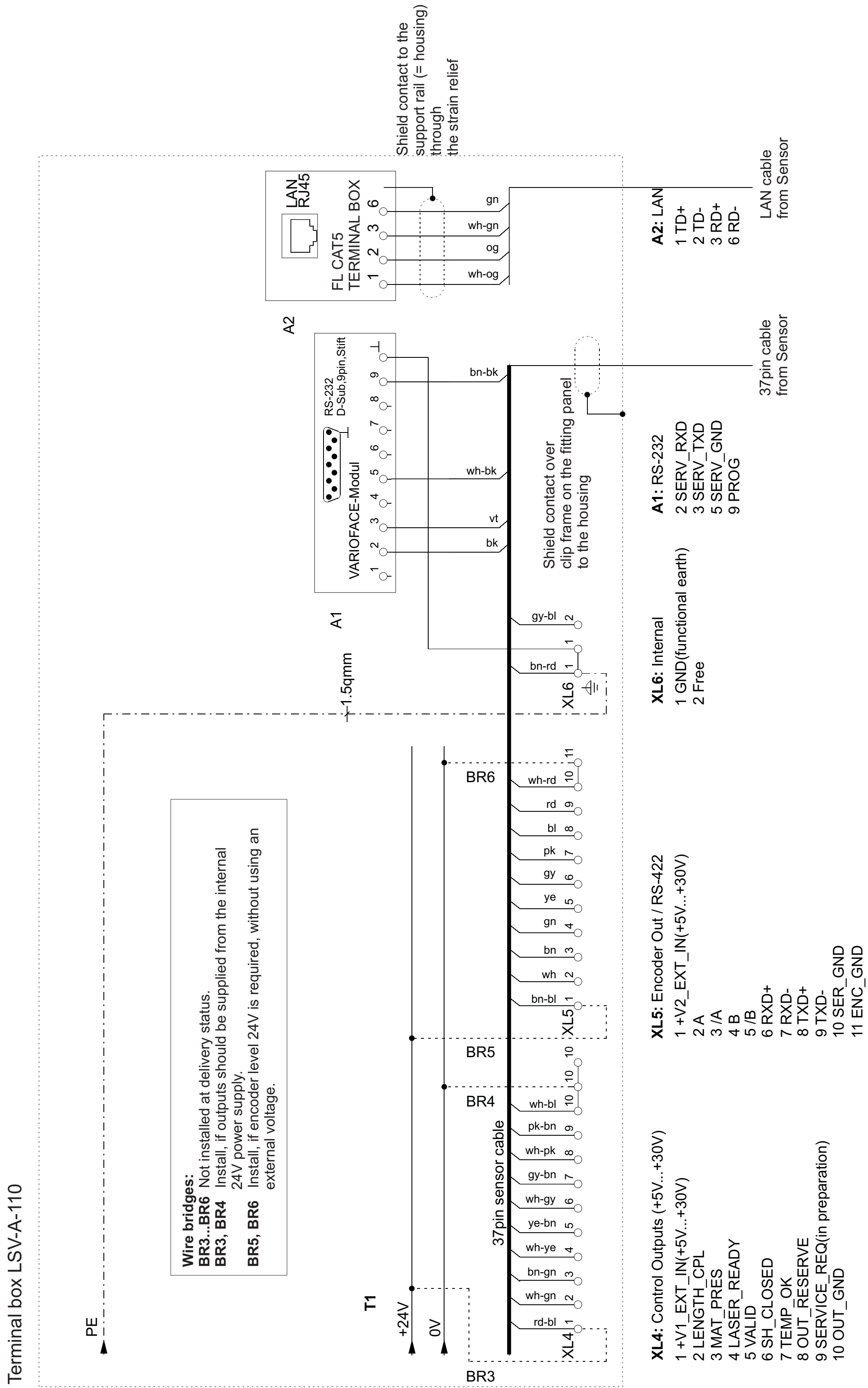


Figure 9.4: Overall circuit diagram terminal box LSV-A-110 (part 2)

9.3.3 Terminal Diagram

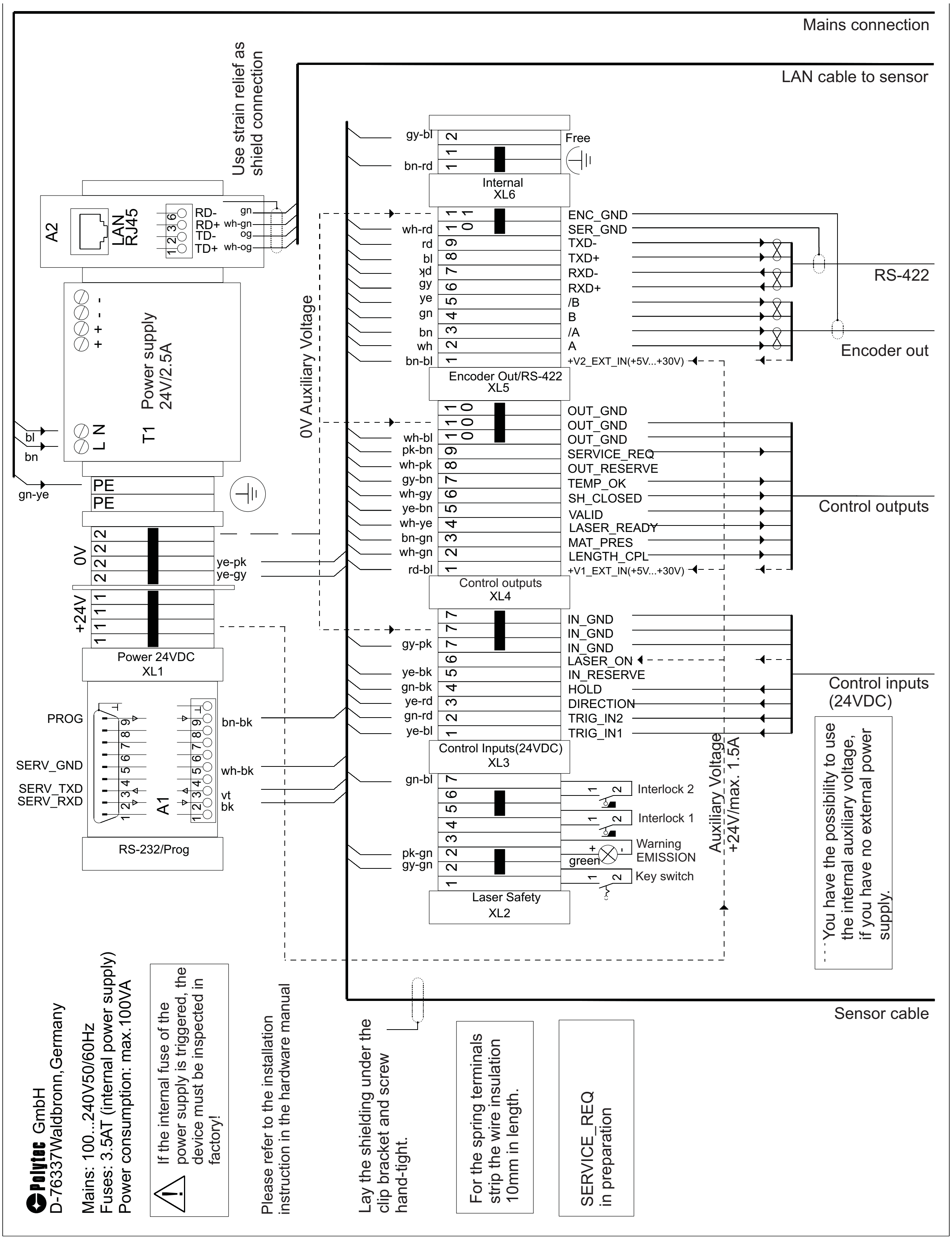


Figure 9.5: Terminal diagram terminal box LSV-A-110

Appendix A: Theory of the Measurement Procedure

The LSV operates on the basis of the differential laser Doppler method. The beam of a laser diode is split into two partial beams which are then superimposed again on the surface to be measured. This results in a three-dimensional space (measurement volume) which contains bright and dark fringes which are a distance Δs apart (refer to FIGURE A.1).

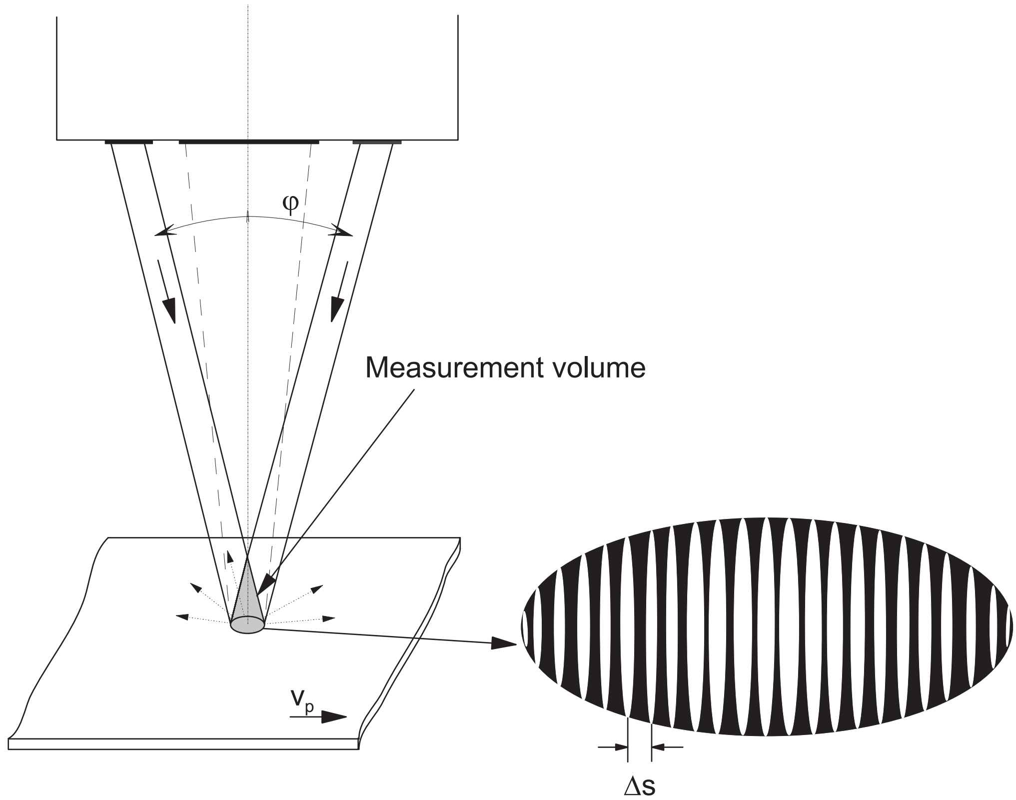


Figure A.1: Measurement principle of the LSV

Fringe spacing

The fringe spacing Δs is a system constant which depends on the laser wavelength λ and the angle between the laser beams φ.

$$\Delta s = \frac{\lambda}{2 \cdot \sin\frac{\varphi}{2}} \qquad \text{Equation A.1}$$

When a particle moves through the fringe pattern, the intensity of the light scattered back from it is modulated.

The photo detector in the sensor therefore generates an AC signal, with a frequency f_D which is direct proportional to the surface's velocity component in measurement direction v_p and is given by:

$$f_D = \frac{v_p}{\Delta s} \qquad \text{Equation A.2}$$

f_D...Doppler frequency

v_p...Velocity component in measurement direction

Δs...Fringe spacing in the measurement volume

The value of the fringe spacing Δs represents the etalon of the velocity and length measurement. It is exactly measured for each sensor and is printed in the calibration protocol. When calibrating the LSV sensor the fringe spacing is stored in the flash memory. There it forms the basis for calculating the measurement values.

In the sensor the modulation frequency is calculated by Fourier transformation and converted to the measurement value of the velocity v_p. The length measurement, performed by integrating velocity over time, is an additional function of the LSV.

The LSV is generally connected to a process control system, thus serving as an intelligent sensor for the measurement of velocity and length. For this reason it is possible to adapt the properties of the sensor to the requirements of the process control system. The configuration of the LSV sensor can be realized via a PC using the LSV software supplied (refer to software manual).

Appendix B: Command Description for the Interfaces

With the data interfaces you have the option to control the LSV-1000 with a PC. In doing so, you can acquire measurement data and carry out a complete parameterization of the device.

The device can be operated either with a 10/1000 MBit/s Ethernet interface or with a RS-422 interface (max. 230400 Baud). For servicing purposes a RS-232 interface is available (max. 230400 Baud)[1]. You can find a description of the pin configuration of the individual interfaces in SECTION 6.2 and SECTION 6.3.

To operate the device via a data interface, an instruction set is available. You can find a detailed description of these instruction set in the following sections.

B.1 Syntax of the Interface Commands

Command structure

The interface commands for the serial interfaces are the same as those for the Ethernet interface. The interface commands for the sensor are combined as follows:

Reading Out the Parameters

Function ? [Parameter1] [, Parameter2] [, ParameterN]

Setting the Parameters

Function : [Parameter1[=Value]] [, Parameter2[=Value]] [,ParameterN[=Value]]

If data is requested from the sensor, a question mark must appear after the function name. When the data is transferred from the host to the sensor, a colon must be entered between the function name and the first parameter.

The function name may be shortened but it must contain sufficient characters to be non-ambiguous. In the following tables, the necessary characters of the function description which need to be entered are given in capital letters. The parameter names may not be abbreviated. No distinction is made between capital and small lettering.

Values (or options) may be transmitted or received in decimal integer format (0...255) or hexadecimal format (0x00...0xff). Variables which must be entered in integer format are marked in the following text with [Parameter=N].

Several parameters have the size of one byte. In it, each bit can be set or reset individually. To do so you have to convert the bit pattern (binary code) of the byte into decimal or hexadecimal code. Bits which are not used or are reserved are thereby set to 0.

[1] For LSV-1000 a RS-232 interface up to max. 115200 Baud is available.

	Rn							
Nibble	high				low			
Bit	7	6	5	4	3	2	1	0

Example

Bit 3 and bit 1 of the parameter CTRL are to be set:

Binary code of the register:	0100	1001
Hexadecimal code:	4	9

To set these bits you enter:

SENS:CTRL=0x49 in hexadecimal format or **CTRL=73** in decimal format

> Real numbers will be entered in the format "nnnnnn.nnnnnn". Please note that the input must be made with a decimal point! (e.g. VOLT: VMAX=123.123456, Voltage output: 10V = 123.123456m/min).

Terminate the command

All transmissions to the sensor are terminated with the ASCII character <CR> (Carriage Return), i.e. decimal 13 or hexadecimal 0x0d. Thus you also have to terminate all commands using <CR>.

Answer structure

The answers to functions (Get, SAmple, Read Average = RAVG), which read out measurement values (velocity, length, etc.), are transmitted in binary form (refer to SECTION B.3).

For all other commands the answers are made up of strings (character strings). They start with the shortest form of the function name followed by a colon and the requested information.

All transmissions to the sensor are terminated with the ASCII character <CR> (Carriage Return), i.e. decimal 13 or hexadecimal 0x0d.

Base Unit

All information on lengths and velocities refer to the base units set in the sensor LSV-1000. You will find the syntax of the corresponding command in SECTION B.2.2.

In the ISO version	=	meters	or	meters/minute
In the US version	=	feet	or	feet/minute

In the US version additionally to the ft./min based units the metric unit m/s is available.

B.2 LSV Settings

B.2.1 Parameters for the Serial Interfaces RS-232 and RS-422

OM : [BAUD = N] [,PORT = N]

Sets the baud rate of the selected serial interface (refer to SECTION B.3, command Sample).

BAUD 9600
19200
38400
57600
115200
230400[1]

[1] Only available for RS-422

PORT 1 = COM1 (RS-232) (XL5 in the terminal box LSV-A-110)
2 = COM2 (RS-422) (A1 in the terminal box LSV-A-110)

B.2.2 Base Unit of the Sensor

UNIT ? [BASE]

UNIT : [BASE = N]

BASE 0 = ISO version (meters or meters/minute)
1 = US version (feet or feet/minute)

B.2.3 Velocity Measurement

ACQ ? [,ALL] [,ENZERO] [,VMIN] [,AVG] [,AVGD] [,RANGE]

ACQ : [ENZERO = N] [VMIN] [AVG = N] [AVGD = N] [RANGE = N]

Requests or sets the settings for velocity measurements.

ENZERO Sets a Zero Zone. The Zero Zone is the range around the velocity zero which is still supposed as a standstill.

0 = Disables the Zero Zone

1 = Enables the Zero Zone

VMIN Sets the minimum velocity for the Zero Zone. Every velocity v, for which $-v_{min} < v < +v_{min}$ applies, will be set to zero.

AVG Sets the number of samples N for the Main Filter, which should be used for averaging (N = 1 ... 255).

AVGD[1] Sets the number of samples N for the display filter (Front Panel Display Filter), which should be used for averaging (N = 1 ... 120).

RANGE Sets the measurement range for the velocity measurement. RANGE is interpreted as a byte. The 4 low nibble bits represent the parameter M and the 4 high nibble bits represent the parameter R.

Parameter M determines the velocity range. The lower and the upper limit are reduced by a factor of 2^M. Thus with M = 3 these values are at 1/8 of the values for M = 0.

Parameter R reduces the upper measurement range limit by the factor 2^R. For R applies: $M \leq R \leq (M+6)$.

[1] Not used for LSV-1000

B.2.4 Length Measurement

LENgth : [TRIGSRC = N] [,OFFS] [,INT = N] [,LAST = N] [,SYNC = N] [,TRACK] [,HOLD]

Sets the settings for length measurements.

TRIGSRC	Selection of the trigger source
	0 = No trigger signal is used
	1 = External trigger signal is used
	2 = Trigger signal is provided by the function Material Detect
	3 = Trigger signal is provided by the function Cut Mode
	4 = Trigger signal is caused by the command REMTRIG
OFF	Offset length (data type float)
INT	Order of interpolation
	0 = 0 order interpolation
	1 = 1st order interpolation
LAST	0 = Disables the function Display last complete length
	1 = Enables the function Display last complete length
SYNC	0 = Disables the function Enable outputs with trigger
	1 = Enables the function Enable outputs with trigger
TRACK	Sets the Track Delay in ms
HOLD	Sets the Hold Time in ms

Material ? [ALL] [LEVEL] (,POL] [,HOLD]

MATerial : [LEVEL = N] (,POL = N] [,HOLD]

Requests or sets the settings for the optional function Material Detect.

LEVEL	Sets the comparator threshold (Signal Level), N = 0…36
POL	Sets the Input Polarity of the trigger signals
	0 = Not inverted (trigger signal if material has been detected)
	1 = Inverted (trigger signal if no material has been detected)
HOLD	Sets the Hold Time in ms

EXTTRIG ? [ALL] [ARM] [,LOGIC] [,MODE] [,POL1] [,POL2]

EXTTRIG : [ARM = N] [,LOGIC = N] [,MODE = N] [,POL1 = N] [,POL2 = N]

Requests or sets the settings for the external trigger.

ARM	Sets the trigger function of the sensor
	0 = Trigger signal is used to start and stop the length measurement
	1 = Trigger signal is used to reset the length measurement

LOGIC Sets the logical operation (Trigger Logic) of both trigger signals
0 = Logical OR operation (Trigger 1 OR Trigger 2)
1 = Logical AND operation (Trigger 1 AND Trigger 2)

MODE Sets the trigger mode (Input Mode)
0 = Edge
1 = Level

POL1 Sets the trigger polarity (Input Polarity) at trigger input 1
0 = Invert (Low active)
1 = Not invert (High active)

POL2 Sets the trigger polarity (Input Polarity) at trigger input 2
0 = Invert (Low active)
1 = Not invert (High active)

REMTRIG : [Start] [Stop]

Starts or stops the length measurement.

CUT ? [ALL] [,LEN] [,NOTIFY] [,SIGNAL] [,DELAY1] [,DELAY2]

CUT : [LEN] [,NOTIFY] [,SIGNAL = N] [,DELAY1] [,DELAY2]

Requests or sets the parameter for the Cut Mode.

LEN Length at which the material is to be cut off (Cut Length)

NOTIFY Length at which an advance warning signal is to be set (Notify Length)

SIGNAL Parameters of the output signal:

Bit 0	0 = Cutting material to length by means of one output signal at output LENGTH_CPL (Cut Length) 1 = Cutting material to length by means of two output signals, Notify Length at output LENGTH_VOR and Cut Length at output LENGTH_CPL
Bit 1	Reserved
Bit 2	Reserved
Bit 3	Reserved
Bit 4	0 = Signal set by a high level 1 = Signal set by a low level
Bit 5	Reserved
Bit 6	Reserved
Bit 7	Reserved

DELAY1 Pulse Width 1 of the signal Cut Length in ms

DELAY2 Pulse Width 2 of the signal Notify Length in ms

B.2.5 Sensor

CAL[ibrate] ? [ALL] [,DELTA] [,CORR] [,TCOEF]

CAL[ibrate] : [DELTA] [,CORR] [,TCOEF]

Requests or sets the parameters of the sensor.

DELTA	Fringe Spacing in µm[1]
CORR	Correction Factor (Default = 1.000)
TCOEF	Temperature Coefficient (Default = 11.9961[1]

[1] Can not be set at the LSV-1000.

SENS[or] ? [ALL] [,CTRL] [,STAT] [,TEMP]

SENS[or] : [CTRL = N] [,STAT = N]

Requests or sets the parameters to monitor the sensor.

CTRL Parameters to switch on the laser:

Bit 0	Switches the laser on if all other switch-on requirements are met (Enable Laser).
Bit 1	Opens the beam shutter (Open Shutter).
Bit 2	Enables Auto Shutdown of the laser if the temperature of the sensor exceeds 50°C.
Bit 3	Enables Auto Restart of the laser if the temperature of the sensor has gone below 45°C (113°F) again.
Bit 4 ... 7	Reserved

STAT Status of the sensor

Bit 0	Laser Off
Bit 1	Beam shutter closed (Shutter Off)
Bit 2	Temperature warning: The temperature of the sensor exceeds 45°C (113°F).
Bit 3	Temperature warning: The temperature of the sensor exceeds 50°C.
Bit 4	Error message: The temperature of the laser diode is outside the permissible temperature range.
Bit 5	Reserved
Bit 6	Reserved
Bit 7	Reserved

TEMP Current temperature of the sensor with resolution of 0.01°C (data type float).

B.2.6 Configuration of the Encoder Interface

ENC[oder] ? [ALL] [,ENA] [,PPL] [,VMAX]

ENC[oder] : [ENA] [PPL] [,VMAX]

Requests or sets the settings for the optional encoder interface (Encoder Output).

ENA 0 = Disables the Encoder Interface
1 = Enables the Encoder Interface

PPL Number of pulses per length

VMAX Maximum velocity

B.3 Read Functions

You will find further information on the data format in SECTION B.5.

G[et] ? [ALL] [,VELO] [,LEN] [,SINAD] [,RATE] [,SENS]

Single read function: Requests a single reading of the defined values.

ALL All listed values

VELO Velocity

LEN Length

SINAD Signal to Interference, Noise and Distortion (SINAD)

RATE Data Rate: Number of measurements per second which are internally made by the sensor.

SENS Status of the sensor (Sensor Status, refer to SECTION B.2.5):
Byte 1 = STAT of function SENS,
Byte 2 = TEMP of function SENS

SA[mple] ? [ALL] [,VELO] [,LEN] [,SINAD] [,RATE] [,SENS]

SA[mple] : [ALL] [,VELO] [,LEN] [,SINAD] [,RATE] [,SENS] [,FREQ = N] [,STOP]

Continuous read function:

Reads the selected data at a predetermined frequency from the controller to the PC. Sample:STOP or any request command stops the data stream.

The sample frequency f_S (streaming rate) is given by $(1024/N)$Hz with N = 1...255. The maximum achievable transfer frequency is limited by the Baud rate and the amount of data to be transferred. The minimum achievable Baud rate depends on the frequency (f_S) as described in the table below:

f_S [Hz]	Baud rate	
128	≤	9600
256	≤	19200
512	≤	38400
1024	≤	115200

VELO Velocity

LEN Length

SINAD Signal to Interference, Noise and Distortion (SINAD)

RATE Data Rate: Number of measurements per second which are internally made by the sensor.

SENS Status of the sensor (Sensor Status, refer to SECTION B.2.5):
Byte 1 = STAT of function SENS,
Byte 2 = TEMP of function SENS

FREQ Parameter N sets the transfer rate for the data stream.

STOP Stops the data stream.

Example: SAM:VELO, FREQ=5
5 = N
f_S = (1024/N) Hz = (1024/5) Hz = 204.8 Hz
Reads velocity 204.8 times per second.

RAVG ? [ALL]

RAVG : [Start] [Stop]

Reads the average velocity value. The time period over which the average is taken commences with the start of the measurement or the last reading of the average value.

Data format:

4 Byte Floating-point value:
Velocity average since the start or last reading of the average value.

4 Byte Integer:
Numbers of valid velocity values since start or the last reading of the average value.

4 Byte Integer:
Number of invalid velocity values since start or the last reading of the average value.

STO[re] :

Saves all temporary settings in the flash memory of the sensor.

B.4 Identification

ID ? [ALL]

Reads the instrument identification.

SN ?

Reads the instrument serial number.

BUILD ? [ALL]

Reads date and version of the firmware.

B.5 General Information

Format of Data Sets (Velocity, Length, etc.)

Byte 1 shows the status of the sensor LSV-1000.

Bit 7, 6, 5	Reserved
Bit 4	Valid data available (VALID).
Bit 3	New length measurement is complete.
Bit 2	Length measurement is running (Length Measurement, trigger is active).
Bit 1	Status error of the sensor (Sensor Status Error, detailed information with SENS?STAT, refer to SECTION B.2.5)
Bit 0	Timing Error

Status byte 1 is directly followed by the data sets. Number and kind of data depends on the selected data sets (refer to SECTION B.3, commands Get and SAmple). If several data sets are selected, the data is transferred consecutively. The sequence is always: Velocity / Length / SINAD / Data Rate / Sensor Status.

The individual data sets have following formats:

Measured quantity	Data format (MSB first, LSB last)
Velocity	4 bytes IEEE floating point value in m/min. or ft./min.
Length	4 bytes IEEE floating point value in m or ft.
Signal to Interference, Noise and Distortion (SINAD)	2 bytes integer N representing SINAD: $\text{SINAD} = 10 \cdot \log\left(\frac{N}{256}\right)$ in dB
Data Rate	2 bytes integer N representing Data Rate: $\text{Data Rate} = 10 \cdot N$ in number of internal measurement/ seconds
Status of the sensor (Sensor Status)	2 bytes integer: Byte 1 = STAT of function SENS (refer to SECTION B.2.5) Byte 2 = TEMP of function SENS

IEEE 4-byte Floating Format (IEEE. 754)

1 Bit Mantissa sign:	1 ≡ negative / 0 ≡ positive
8 Bit Exponent with an offset of 127:	0 ≡ 2^{-127}
	127 ≡ 2^{0}
	128 ≡ 2^{1}
	255 ≡ 2^{128}
23 Bit Mantissa with 1 hidden bit (24)	

Appendix C: Declaration of Conformity

CE

Konformitätsbescheinigung / Declaration of Conformity

für / for

Gegenstand / Object :	**Laser Surface Velocimeter**
Typ / Model :	**LSV-1000 in Verbindung mit LSV-A-110 /** **LSV-1000 in conjunction with LSV-A-110**

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 Produkt stimmt überein mit den folgenden Normen / The product complies to the following standards:

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

Zusätzliche Information / Additional Information:

Das Produkt wurde getestet in der oben aufgeführten Zusammenstellung.
Bei Verwendung des LSV-1000 in der OEM-Ausführung (ohne LSV-A-110) ist der Systemintegrator für die Erfüllung der Lasersicherheit nach EN 60825-1 verantwortlich.
The product was tested in the configuration given above.
When using the LSV-1000 in the OEM version (without LSV-A-110), the system integrator is responsible for the compliance with the laser safety according to EN 60825-1.

Ausgestellt von / Issued by

Dr. Hans-Lothar Pasch
Managing Director
Polytec GmbH

07.07.2009
Datum / Date

Figure C.1: Declaration of conformity for the LSV -1000

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