RS-232, RS-422/RS-485, Analog, SSI, Optional Ethernet Interfaces

EtherNet/IP EtherCAT PROFINET

Laser Measuring Device LLB-502

Devices:
- _LLB502-00001
- _LLB502-00003
- _LLB502-01111
- _LLB502-01213

Exchangeable Interface Cover:
- _LLB502-20700
- _LLB502-20800
- _LLB502-20900

User Manual

TR-ELE-BA-DGB-0028 v06 09/17/2025

TR Electronic GmbH
D-78647 Trossingen
Eglishalde 6
Tel.: (0049) 07425/228-0
Fax: (0049) 07425/228-33
email: info@tr-electronic.de
www.tr-electronic.de

Copyright protection

Subject to modifications

The right to make any changes in the interest of technical progress is reserved.

Document information

Release date / Rev. date:	09/17/2025
Document / Rev. no.:	TR-ELE-BA-DGB-0028 v06
File name:	TR-ELE-BA-DGB-0028v06.docx
Author:	STB

Font styles

Italic or **bold** font styles are used for the title of a document or are used for highlighting.

`Courier` font displays text, which is visible on the display or screen and software menu selections.

″ < > ″ indicates keys on your computer keyboard (such as <RETURN>).

Contents

Revision index

Revision	Date	Index
First release	10/25/2019	00
Final version	12/11/2019	01
- Warning signs edited - General update	04/06/2020	02
Chapter 11 Accessories added	05/28/2020	03
- General update - Various error codes added in chapter 9.6	04/24/2024	04
Accessories LLB502-30000 and LLB502-30001 added	05/07/2025	05
Updated to IEC 60825-1 Ed. 3 and FDA laser notice 56	09/17/2025	06

1 General information

The User Manual includes the following topics:

- Basic safety instructions
- Transportation / Storage
- Introduction
- Technical data
- Electrical components
- Configuration
- Operation
- Command set
- Industrial Ethernet with exchangeable cover
- Accessories

As the documentation is arranged in a modular structure, this User Manual is supplementary to other documentation, such as product datasheets, dimensional drawings, leaflets etc.

The User Manual may be included in the customer's specific delivery package or it may be requested separately.

1.1 Applicability

This User Manual applies exclusively to the following measuring systems in combination with an exchangeable interface cover.

Measuring system Series with RS-232, RS-422/485, Analog and SSI:

- LLB502-00001
- LLB502-00003
- LLB502-01111
- LLB502-01213

Exchangeable interface cover:

- LLB502-20700, EtherNet/IP™
- LLB502-20800, PROFINET®
- LLB502-20900, EtherCAT®

The products are labeled with affixed nameplates and are components of a system.

The following documentation therefore also applies:

- the operator's operating instructions specific to the system,
- this User Manual

1.2 EU Declaration of conformity

The LLB devices have been developed, designed and manufactured under observation of the applicable international and European standards and directives.

A corresponding declaration of conformity can be requested from TR Electronic GmbH.

The manufacturer of the product, TR Electronic GmbH in
D-78647 Trossingen, operates a certified quality assurance system in accordance with ISO 9001.

1.3 Abbreviations and definitions

AOI	***A***dd-***O***n ***I***nstructions (used for EtherNet/IP™) are a kind of predefined function blocks to assist customers by doing calculations with the EtherNet/IP™ adapter data in “Studio 5000®” software (Rockwell Automation).
ASCII	***A***merican ***S***tandard ***C***ode for ***I***nformation ***I***nterchange
EMC	***E***lectro ***M***agnetic ***C***ompatibility
EU	***E***uropean ***U***nion
ESD	***E***lectro ***S***tatic ***D***ischarge
FLOAT	Single-precision floating point. Floating point with size: FLOAT32 –› 32 Bit
GSD / GSDML	Device description file written in XML format (used with PROFINET®)
IEC	***I***nternational ***E***lectrotechnical ***C***ommission
Industrial Ethernet	Industrial Ethernet interfaces e.g. PROFINET®, EtherCAT®, EtherNet/IP™ (Real-Time Ethernet interfaces)
LLB	Laser Measuring Device
PLC	***P***rogrammable ***L***ogic ***C***ontroller (e.g. Siemens S7)
R, R/W	Read access only (Read-only)
R / W	Read & Write access possible
SSBL	***S***econd ***S***tage ***B***ootloader
SSI	***S***erial ***S***ynchronous ***I***nterface
STRING	Character string of variable length. Character size of one Byte.
UINT	Unsigned integer. Integer value with size: UINT8 –› 8 Bit (0...255), UINT16 –› 16 Bit (0...65 535), UINT32 –› 32 Bit (0...4 294 967 295)
VDE	Association for Electrical, Electronic & Information Technologies

2 Basic safety instructions

- The following instructions are to enable the person responsible for the LLB device, and the user of the instrument, to anticipate and avoid operational hazards.
- The LLB device is made to be integrated into technical systems. Basic technical training is therefore essential. This device may only be operated by trained personnel.
- The person responsible for the instrument must ensure that all users understand these instructions and adhere to them.
- If the LLB device is part of a system, the manufacturer of such a system is responsible for all safety related issues, such as the manual, labeling and instruction.

2.1 Definition of symbols and instructions

⚠ WARNING	means that death or serious injury can occur if the required precautions are not met.
⚠ CAUTION	means that minor injuries can occur if the required precautions are not met.
NOTICE	means that damage to property can occur if the required precautions are not met.
	indicates important information or features and application tips for the product used.
	means that eye injury can occur from laser light if the stated precautions are not met.
	means that appropriate protective measures against ESD according to DIN EN 61340-5-1 supplementary sheet 1 must be applied.

2.2 Obligation of the operator before start-up

As an electronic device the measuring system is subject to the regulations of the EMC Directive.

It is therefore only permitted to start up the measuring system if it has been established that the system/machine into which the measuring system is to be fitted satisfies the provisions of the EU EMC Directive, the harmonized standards, European standards or the corresponding national standards.

2.3 General risks when using the product

The product, hereinafter referred to as **"*LLB device*"** or **"*LLB sensor*"**, is manufactured according to state-of-the-art technology and accepted safety rules. ***Nevertheless, improper use can pose a danger to life and limb of the user or third parties, or lead to impairment of the measuring system or other property!***

Only use the measuring system in a technically faultless state, and only for its designated use, taking safety and hazard aspects into consideration, and observing this ***User Manual***! Faults which could threaten safety should be eliminated without delay!

2.4 Safety information's

⚠ WARNING

NOTICE

Danger of physical injury and damage to property !

- Do not point the viewfinder directly at the sun, the viewfinder functions as a magnifying glass and can injure eyes and/or cause damage inside the LLB.
- De-energize the system before carrying out wiring work or opening and closing electrical connections.
- Do not carry out welding if the measuring system has already been wired up or is switched on.
- Ensure that the laser warning symbol on the measuring system is well visible anytime.
- No use of accessories from other manufacturers.

NOTICE

Ensure that the area around the assembly site is protected from corrosive media (acid, etc.).

The measuring system contains electrostatically endangered circuit elements and units which can be destroyed by an improper use.

- Contacts of the measuring system connection contacts with the fingers are to be avoided, or the appropriate ESD protective measures are to be applied.

NOTICE

Disposal

- If disposal has to be undertaken after the life span of the device, the respective applicable country-specific regulations are to be observed.

Cleaning

- Clean the lens opening of the measuring system regularly with a damp cloth. ***Do not use any aggressive detergents, such as thinners or acetone!***

Eye injury from laser radiation!

- The measuring system functions with a red-light laser Class 2. In the case of Class 2 laser devices, the eye is not endangered if the exposure to the laser radiation is very brief (up to 0.25 s) and accidental. For this reason, devices of this class can be used without additional protective measures, provided the application does not require one to look into the laser beam deliberately for longer periods, i.e. 0.25 s, or to look repeatedly into the laser beam or the reflected laser beam.
- The existence of the blinking reflex for the protection of the eyes may not be assumed. Therefore, eyes should be closed consciously, or the head should be turned away immediately!
- The measuring system must be installed in such a way that the exposure of persons to the laser beam can only occur accidentally.
- The laser beam must only extend as far as is necessary for the range measurement. The beam must be limited at the end of the useful range by a target area in such a way as to minimize the danger from direct or diffuse reflection.
- The area outside the operating range where the unshielded laser beam falls should be limited as far as possible and should remain out of bounds, particularly in the area above and below eye level.
- Heed the laser safety regulations according to DIN EN 60825-1 in their most current version.
- Observe the legal and local regulations applicable to the operation of laser units.

2.5 Laser classification

The LLB device produces a visible laser beam, which emerges from the front of the instrument.
It is a Class 2 laser product in accordance with:

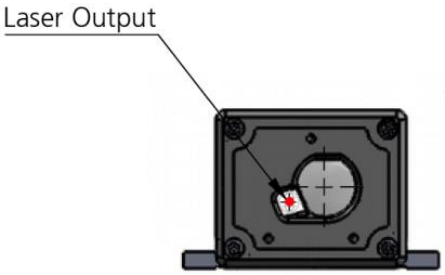
- IEC 60825-1 Ed. 3 ”Radiation safety of laser products”

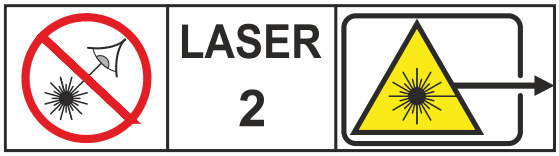
It is a Class II laser product in accordance with:

- FDA 21 CFR 1040.10 / 1040.11 and Laser Notice 56 (US Department of Health and Human Service, Code of Federal Regulations)

Laser Class 2/II products

Do not stare into the laser beam or direct it towards other people unnecessarily. Eye protection is normally afforded by aversion responses
including the blink reflex.





Wavelength: 620-690nm, Max Power < 1mW
Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No.56, dated May 8, 2019

Looking into the laser beam may be hazardous to the eyes.

- Do not look into the laser beam. Make sure the laser is aimed above or below eye level. (particularly with fixed installations, in machines, etc.).
- Do not look directly into the beam with optical aids (binoculars, telescopes) can be hazardous

2.5.1 Laser specification

Standard applied	IEC 60825-1 Ed. 3
Emitted wavelength	620...690 nm (typical 655 nm)
Beam divergence	0.16 x 0.6 mrad
Pulse duration	0.2...0.8 x 10^{-9} s
Max. radiant power	1 mW
Laser power measurement uncertainty	±5%

2.6 Permitted use

The permitted use of the LLB device is: Measuring distances in an atmosphere appropriate for permanent human habitation.

2.7 Prohibited use/Limits to use

⚠ WARNING

NOTICE

Prohibited use or ignoring limits to use can lead to injury, malfunction, and material damage.

- It is the duty of the person responsible for the instrument to inform the user about hazards and how to counteract them.
- The LLB devices must not be operated until the user has been adequately instructed.

Prohibited use:

- Use of the instrument without instruction
- Use outside the stated limits
- Deactivation of safety systems and removal of explanatory and hazard labels
- Opening of the equipment, except to open the cover for access to the screw terminal
- Carrying out modification or conversion of the product
- Operation after failure in operation
- Use of accessories from other manufacturers without the express approval of TR Electronic
- Aiming directly into the sun
- Deliberate dazzling of third parties; also, in the dark
- Inadequate safeguards at the surveying location (e.g. when measuring on roads, etc.)

Environmental limits to use. The device must not be used in environments such as but not limited to:

- Aggressive vapor or liquids (salt, acid, poison, etc.)
- Snow and rain
- Radiation (radioactive, heat, etc.)
- Explosive atmosphere
- High-gloss measurement surfaces

Limits to use by application. The device must not be used in applications such as but not limited to.

- Aerospace (Aviation & Space flight)
- Nuclear technology

Further limits to use. See chapter 4 Technical data on page 12.

2.8 Hazards in use

⚠ WARNING

NOTICE

The absence of instruction, or the inadequate provision of instruction, can lead to incorrect or prohibited use, and can give rise to accidents with far-reaching personal, material and environmental consequences.

- All users must follow the safety instructions given by the manufacturer and the directions of the person responsible for the instrument.

⚠ WARNING

NOTICE

Beware of erroneous distance measurements if the instrument is defective or if it has been dropped or has been misused or modified.

- Carry out periodic test measurements, particularly after the instrument has been subject to abnormal use, and before, during and after important measurements.
- Make sure the LLB device optic is kept clean.

⚠ WARNING

If labels are hidden when the LLB device is installed, this could lead to dangerous situations.

- Always ensure the visibility of LLB device labels at all times or add labels in accordance with the local safety regulations.

⚠ WARNING

NOTICE

When using the instrument for distance measurements or for positioning moving objects (e.g. cranes, building equipment, platforms, etc.) unforeseen events (e.g. breaking the laser beam) may cause erroneous measurements.

- Only use this product as a measuring sensor, not as a control device. The system must be configured and operated in such a way that no damage will occur in the event of an erroneous measurement, malfunction of the device or power failure due to installed safety measures (e.g. safety limit switch).

⚠ WARNING

NOTICE

Operate the equipment appropriately in accordance with the regulations in force.

- Always prevent access to the equipment by unauthorized personnel.

⚠ WARNING

NOTICE

Be careful when pointing a telescope towards the sun, because the telescope functions as a magnifying glass and can injure eyes and/or cause damage inside the LLB device.

- Do not point the telescope directly at the sun.

2.9 Warranty and liability

The General Terms and Conditions ("Allgemeine Geschäftsbedingungen") of TR Electronic GmbH always apply. These are available to the operator with the Order Confirmation or when the contract is concluded at the latest. Warranty and liability claim in the case of personal injury or damage to property are excluded if they result from one or more of the following causes:

- Non-designated use of the measuring system.
- Improper assembly, installation, start-up and programming of the measuring system.
- Incorrectly undertaken work on the measuring system by unqualified personnel.
- Operation of the measuring system with technical defects.
- Mechanical or electrical modifications to the measuring systems undertaken autonomously.
- Repairs carried out autonomously.
- Third party interference and Acts of God.

2.10 Organizational measures

- The User Manual must always be kept accessible at the place of use of the measuring system.
- In addition to the User Manual, generally applicable legal and other binding accident prevention and environmental protection regulations are to be observed and must be mediated.
- The respective applicable national, local and system-specific provisions and requirements must be observed and mediated.
- The operator is obliged to inform personnel on special operating features and requirements.
- The personnel instructed to work with the measuring system must have read and understood the User Manual, especially the chapter “Basic safety instructions” prior to commencing work.
- The nameplate and any prohibition or instruction symbols applied on the measuring system must always be maintained in a legible state.
- Do not undertake any mechanical or electrical modifications on the measuring system, apart from those explicitly described in this User Manual.
- Repairs may only be undertaken by the manufacturer or a facility or person authorized by the manufacturer.
- Carry out periodic test measurements, particularly after the instrument has been subject to abnormal use, and before, during and after important measurements. Make sure the LLB device optics are kept clean.

2.11 Personnel qualification; obligations

- All work on the measuring system must only be carried out by qualified personnel.
- Qualified personnel include persons, who, through their training, experience and instruction, as well as their knowledge of the relevant standards, provisions, accident prevention regulations and operating conditions, have been authorized by the persons responsible for the system to carry out the required work and are able to recognize and avoid potential hazards.
- The definition of “Qualified Personnel” also includes an understanding of the standards VDE 0105-100 and IEC 364 (source: e.g. Beuth Verlag GmbH, VDE-Verlag GmbH).
- Define clear rules of responsibilities for the assembly, installation, start-up and operation. The obligation exists to provide supervision for trainee personnel!

2.12 Maintenance

The LLB device is almost maintenance free. The only thing you have to do is to clean the surfaces of the lenses.

NOTICE

Dirty sensor optics can cause erroneous measurements.

- The sensor can be contaminated by dust, oil, ice, water etc.
- In dirty environments try to reduce contamination by design.
- Regularly check sensor optics and clean if necessary.

NOTICE

Inadequate cleaning methods can damage the sensor optics.

- Look after the surfaces of the lenses with same care that you would apply to spectacles, cameras and field glasses.
- Clean the optical parts (small laser output glass and the round lens) only with a clean soft glasses cleaning cloth and avoid scratching of the optical parts. All other cleaner or resolvent are not allowed.

2.13 Service

If you need to service the device, please contact TR Electronic GmbH for instructions.

The warranty is void if the device is opened except the exchangeable cover of the screw terminal. Removing the label is also understood as opening.

3 Transportation / Storage

Notes on transportation

Do not drop the device or expose it to strong shocks!
Device contains an optical system with glass elements.

Only use the original packaging!
The wrong packaging material can cause damage to the device during transportation.

Storage

Storage temperature: see product data sheet
Store in a dry place

4 Introduction

The LLB sensors are powerful distance-measuring instrument for integration into industrial applications. They allow accurate and contactless distance measurement over a wide range using the laser beam reflection on a measuring surface / target:

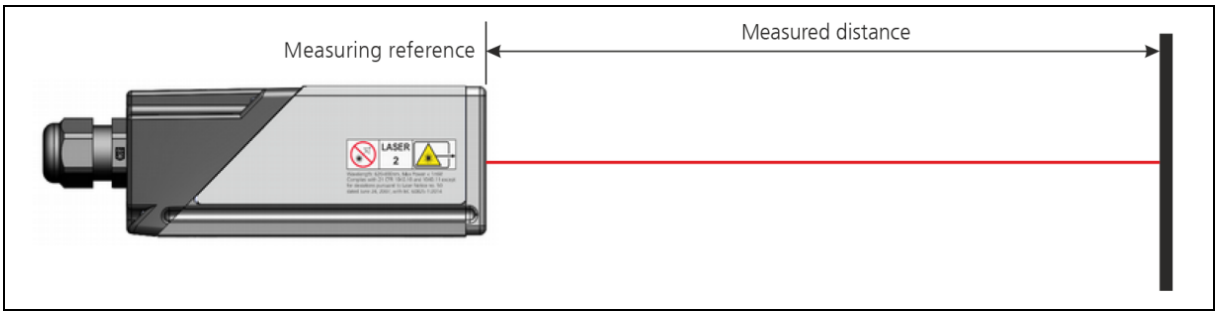


Figure 1: Standard application for measuring distances

Key features:

- Measurement range 0.05 up to 500 m
- Measuring accuracy up to ±1.0 mm (at 2σ)
- High measurement speed (up to 250 Hz, 1000 Hz output rate)
- Several serial interfaces (RS-232, RS-422 / RS-485, SSI and USB)
- Exchangeable cover for Industrial Ethernet (PROFINET®, EtherNet/IP™ or EtherCAT® interface as accessories)
- Connection of up to 100 sensors on a single RS-422 / RS-485 line
- Wide range of power supply (12...30 VDC)
- Programmable analog output (0/4...20 mA)
- One programmable digital input (DI1)
- Two programmable digital outputs (DO1 and DO2)
- Digital output for error signalization (DOE)
- Selectable digital output type (NPN, PNP, Push-Pull)
- 4 LED's for status signaling
- ASCII protocol to control external displays
- Screw terminal for easy connection of the LLB sensors
- IP65 (protected against ingress of dust and water)
- Wide range of operating temperature (down to -40°C and up to +60°C, for devices with extended temperature range)
- Visible red laser, laser class II (<0.95 mW)
- Configuration software “LLB-Utility”
- Accessories for easy use of the sensor

Use of controls, adjustments or performance of procedures other than those specified in this Technical Reference Manual may result in hazardous radiation exposure.

For easy starting with the device, please download and use the free configuration software “LLB-Utility” with the link “www.tr-electronic.de/f/zip/TR-ELE-SW-MUL-0001“ or from the Support DVD.

4.1 Labeling

The product is identified by the label on the top of the enclosure.

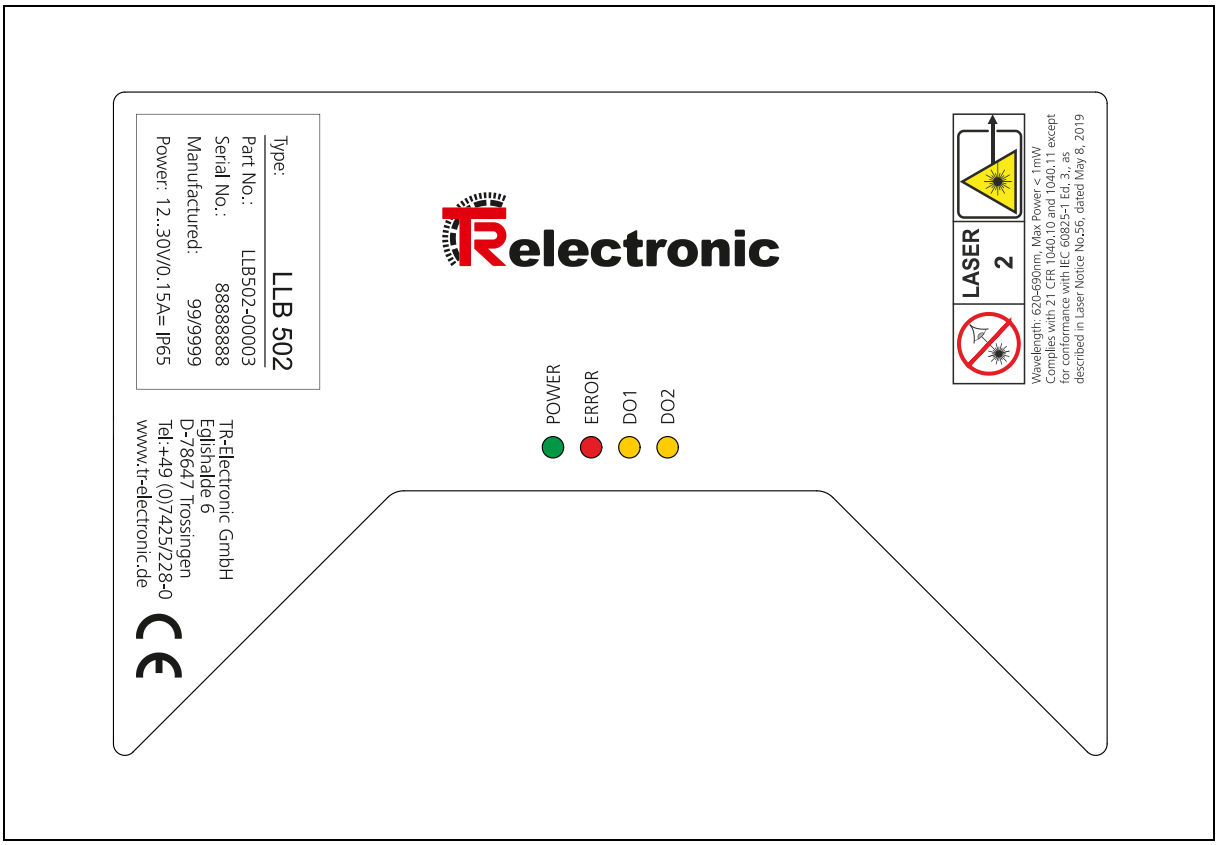


Figure 2: Complete LLB label with device type

4.2 Components

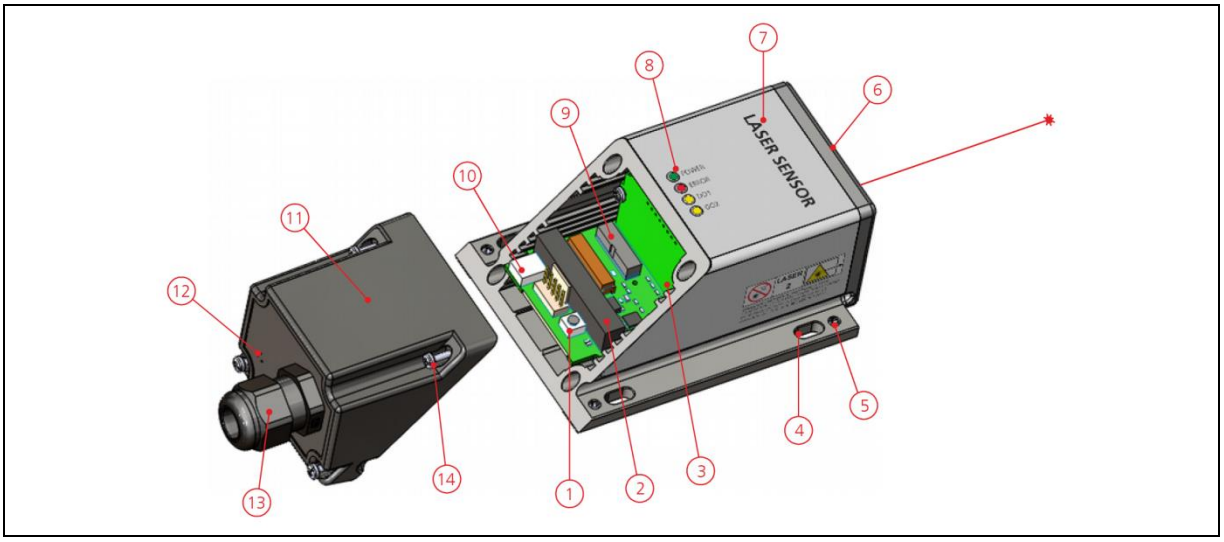


Figure 3: Sensor components with detail information

1) Reset push button
2) Screw terminal block & plug.
   For conductor cross section 0.14...1.5 mm^2.
   (Power supply, digital input / output, analog output, RS-232 and RS-422 / RS-485 / SSI)
3) Shield tab for an adequate receptacle
   (Contact size: 2.8 x 0.5)
4) Slot hole for installation and alignment
   (M4 or M3 screws)
5) Hexagon socket set screw for sensor alignment
6) Sensor front
   (Laser beam output and receiver lens)
7) Product label (for more details, see chapter 4.1)
8) Status LED's (Power, error, digital outputs)
9) Industrial Ethernet interface
10) USB 2.0 Mini-B
11) Exchangeable cover (Used for optional interfaces)
12) Valve diaphragm
13) Cable gland M16 x 1.5 mm
    (Cable diameter: 5...10 mm, tool size: 20 mm)
14) Screws, Philips Slotted Combo
    (Philips size 1, slot size 2).
    The target torque for these screws is 1.6 Ncm.

Take precaution against electrostatic discharge (ESD) when exchangeable cover is open.

- Generally, the sensor with removed exchangeable cover is a sensitive device and can be damaged by electrostatic discharge.
- Only handle the device properly grounded and with care.
- No warranty will be granted on improper handling and / or ESD caused problems.

The warranty is void if the device is opened except the exchangeable cover. Removing the label is also understood as opening.

4.3 Validity

This manual is valid for LLB devices with the following software version:

- Interface software version: **V1.21** or later
- Device software version: **V4.1** or later

To get the software version for the LLB use the command described in chapter 9.5.1 Get software version (`sNsv`).

5 Technical data

5.1 Device specifications

	LLB502-01111	LLB502-01213	LLB502-00001	LLB502-00003
Typical measuring accuracy [1) 2)] - at 2σ (95.4% confidence level) - at 1σ (68.3% confidence level)	 ±1.0 mm ±0.5 mm	 ±3.0 mm ±1.5 mm	 ±1.0 mm ±0.5 mm	 ±3.0 mm ±1.5 mm
Typical repeatability [1) 2)] - at 2σ (95.4% confidence level) - at 1σ (68.3% confidence level)	 ±0.3 mm ±0.15 mm	 ±0.7 mm ±0.35 mm	 ±0.3 mm ±0.15 mm	 ±0.7 mm ±0.35 mm
Measuring range on natural surfaces [3)]	0.05...~100 m	0.05...~100 m	0.05...~100 m	0.05...~100 m
Measuring range on orange Target plates [4)]	~0.5...500 m	~0.5...500 m	~40...150 m	~40...150 m
Measuring reference	From front edge (see chapter 5.2)			
Smallest unit displayed	0.1 mm			
Accuracy of the analog output	±0.1% (12 Bit, programmable span)			
Max. measuring rate [1)]	250 Hz	250 Hz	100 Hz [11)]	100 Hz [11)]
Max. output rate for tracking measurement [1)]	up to 1 kHz		up to 100 Hz [11)]	
Typical time for a measurement [1)] - Single measurement - Tracking	 0.05...4 s 0.004...4 s		 0.05...4 s 0.01...4 s	
Light source	Laser diode 620-690 nm (red, typical 655 nm) see also chapter 2.5.1 Laser specification IEC 60825-1 Ed. 3; Class 2 FDA 21 CFR 1040.10 / 1040.11 and Laser Notice 56			
Typical laser life time	50'000 h at 20 °C (see chapter 8.5)			
Typical diameters (elliptic) of laser spot on target at a defined distance [5)]	4 mm / 2 mm at 5 m 7 mm / 3 mm at 10 m 17 mm / 9 mm at 30 m 28 mm / 13 mm at 50 m 55 mm / 30 mm at 100 m			
Electromagnetic compatibility (EMC)	IEC/EN 61000-6-4 / 61000-6-3; IEC/EN 61000-6-2 / 61000-6-1			
Power supply - Voltage range [6)] - Current consumption (at 24 VDC) [7)] - Current consumption (at 12 VDC) [7)]	 12...30 VDC 0.5 A 0.8 A	 12...30 VDC 0.5 A 0.8 A	 12...30 VDC 0.15 A 0.2 A	 12...30 VDC 0.15 A 0.2 A
Temperature range during operation [8) 9)]	-40...+60 °C	-40...+60 °C	-10...+50 °C	-10...+50 °C
Temperature range during storage	-40...+70 °C			

…

…

Relative humidity (operation / storage)	Up to 85% (RH), non-condensing
Degree of protection	IP65 IEC 60529 (Protected against ingress of dust and water)
Shock and vibration testing	IEC 60068-2-27 (Shock); IEC 60068-2-6 (Vibration)
Dimensions	140 x 78 x 48 mm
Weight	350 g
Material - Main sensor body - Sensor front & Standard exchangeable cover	 Aluminum Alloy EN-AW 6060 (Anodized 20um) Mineral reinforced nylon resin [10)]
Standard integrated interfaces of sensor - Analog output 0/4...20 mA - Digital output (programmable) - Error output (programmable) - Digital input (programmable) - RS-232 - RS-422/485 with ID 0..99 - SSI - USB	 1 2 1 1 1 1 1 1
Possibility to install optional extended interfaces - PROFINET®, EtherNet/IP™, EtherCAT®	 Yes

1) The accuracy and measurement speed depend on the configuration of the measurement characteristic, see 7.3 Measuring characteristic and environmental conditions, see 8.3 Measuring performance influence.

2) Confidence level description, see 5.3 Measuring accuracy definition according the ISO-recommendation ISO/R 1938-1:2015.

3) Performance on natural surfaces depends on target reflectivity, background light and atmospheric conditions (see also 8.3 Measuring performance influence).

4) See chapter 11.1 Target plates.

5) The spot size can vary depending on production lot. Approximation about spot size: Increase about 0.6 mm / m for long and 0.3 mm / m for short diameter of laser spot ellipse.

6) Voltage range 12...30 VDC can be extended to about 9...30 VDC but with limitations using analog output. If analog output is used consider the min. needed input voltage according the following guideline: $V_{+min} \geq R_{AO\_LOADmax} * I_{AOmax} + 3.5$ V (for more details see 6.6 Analog output).

7) The current consumption of the device is defined without connected analog and digital outputs (AO, DO1, DO2 and DOE). The current consumption of analog and / or digital outputs has to be considered in addition.

8) In case of permanent measurement (continuous distance measurement) the max. temperature during operation may be reduced.

9) For LLB devices with an optional Industrial Ethernet interface (exchangeable cover) the max. operating temperature is limited to +50 °C.

10) Material with high mechanical strength, excellent balance of stiffness/toughness, good temperature performance and chemical resistance

11) 100 Hz valid for production date 09/2022 or newer. Before this date 50 Hz.

5.2 Physical dimensions of LLB device with standard hood

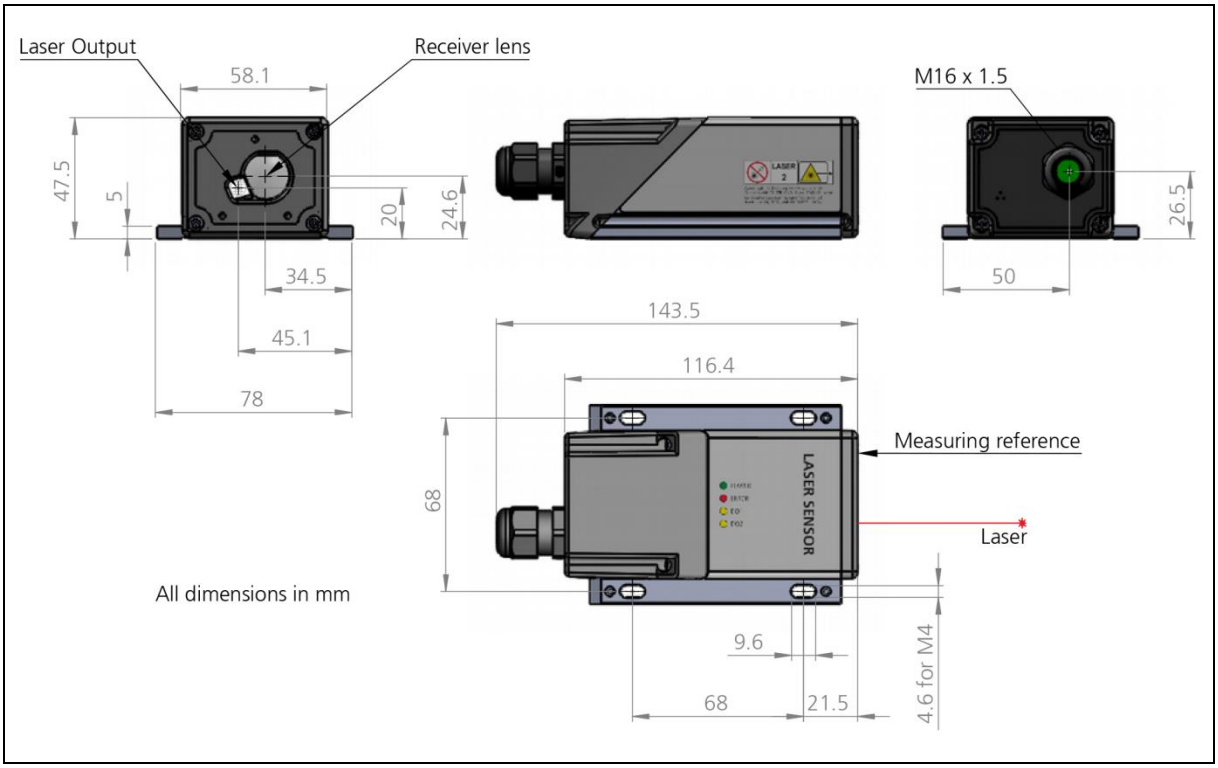


Figure 4: Physical dimensions of sensor

5.3 Measuring accuracy definition

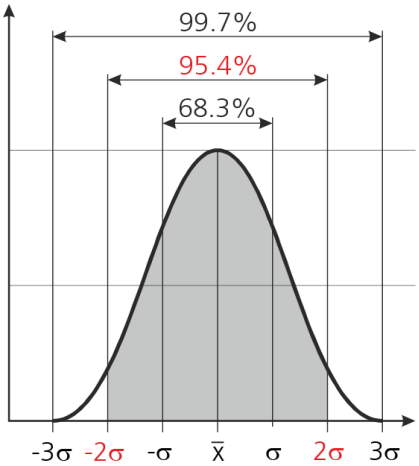


Figure 5: Measuring accuracy definition

The measuring accuracy corresponds to the ISO-recommendation ISO/R 1938-1:2015 with a statistical confidence level of 95.4% (i.e. ± twice the standard deviation σ, see Figure 5 on the left). The typical measuring accuracy relates to average conditions for measuring. It is ±1.0 mm for LLB502-00001 or LLB502-01111 and ± 3.0 mm for LLB502-00003 or LLB502-01213 valid in the tracking mode.
Maximum deviation may occur under unfavorable conditions such as bright sunlight or when measuring to poorly reflecting or very rough surfaces. Measuring accuracy may deteriorate by approximately ± 0.02 mm/m for distances above 30 m.

The LLB laser sensors do not compensate changes of atmospheric environment. These changes can influence the accuracy if measuring long distances (>150 m) under conditions very different from 20 °C, 60% relative humidity and 953 mbar air pressure. The influences of the atmospheric environment are described in *H. Kahmen & W. Faig: "Surveying", (1988)*.

6 Electrical components

The main electrical components of the LLB sensors are described in this chapter. The overview of the components is labeled in Figure 6.

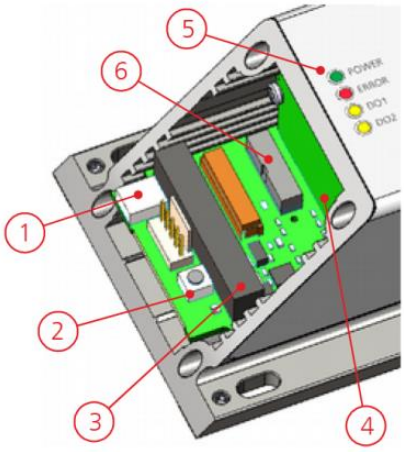


Figure 6: Overview electrical components

1) USB 2.0 Mini-B
   (see chapter 6.10 for details)
2) Reset push button
   (see chapter 6.2 for detailed reset process description)
3) Screw terminal block & plug
   (Pitch: 3.5 mm, conductor cross section: 0.14...1.5 mm^2).
   (Power supply and sensor interfaces, see chapter 6.1, 6.4, 6.5, 6.6, 6.7, 6.8 and 6.9)
4) Shielding tab
   (suitable for receptacle, see chapter 6.1 for details)
5) Status LED's (POWER, ERROR, DO1, DO2)
   (see chapter 6.3 for detailed LED status)
6) Industrial Ethernet interface (Exchangeable cover)
   (see chapter 6.11 for details)

The connection overview of the screw terminal block & plug is shown in the following table. The power supply and all available sensor interfaces (Power, DI/DO's, AO, RS-232 and RS-422 / 485 / SSI) can be accessed.

Pin	Designation	Description
1	V+	Power supply VCC / V+
2	GND	Power supply 0 V / V-
3	DO1	Digital output / input 1
4	DO2	Digital output 2
5	DOE	Digital error output
6	AO	Analog output (0 / 4...20 mA)
7	RX	RS-232 interface
8	TX	
9	T-	RS-422 / 485 / SSI interface
10	T+	
11	R-	
12	R+	

Take precaution against electrostatic discharge (ESD) when exchangeable cover is open.

- Generally, the sensor with removed exchangeable cover is a sensitive device and can be damaged by electrostatic discharge.
- Only handle the device properly grounded and with care.
- No warranty will be granted on improper handling and / or ESD caused problems.

6.1 Power supply

6.1.1 Specifications & Wiring

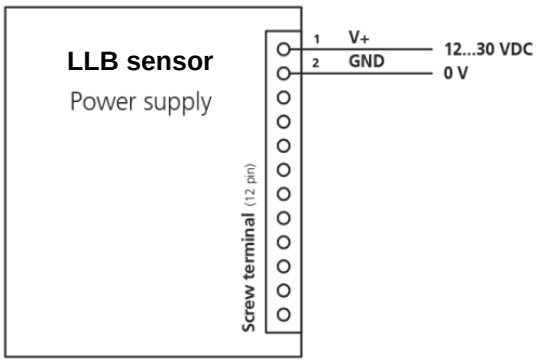


Figure 7: Connection of power supply (V+ and GND)

All the LLB devices are overvoltage and reverse voltage protected. But for proper operation of the sensors consider the power supply requirements and the corresponding specifications.

Specifications for power supply:

Voltage requirement: 12...30 VDC
Current requirement: Depends on sensor type (for details see chapter 5.1)

The green status LED (POWER) indicates a powered and running device.

NOTICE

Over voltage on power supply terminal can damage the device.

- Check wiring and nominal voltage of power supply before initial operation.

Reverse polarity voltage on power supply terminals can damage the device.

- Check wiring before initial operation.

⚠ CAUTION

NOTICE

Only use high-quality power supply equipment and consider the voltage and current requirements of the LLB sensors.

- For trouble-free operation it's recommended to use a separate power supply for the sensors.

6.1.2 Shielding

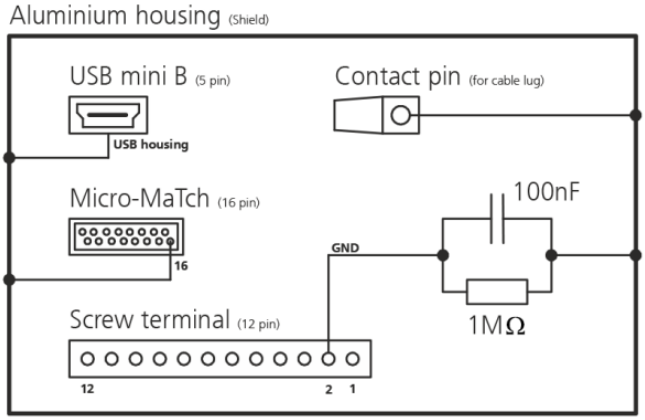


Figure 8: Shielding concept of the sensors

The shielding concept of the LLB sensors is shown in Figure 8. The aluminum housing of the sensor corresponds to shield and is also connected to the housing of the USB interface, to the Micro-MaTch connector and the shield tab. The shield tab can be used to connect the shield of a cable to the sensor shield (use an adequate receptacle).
The general GND of the device is connected to the shield / sensor housing by an R-C element (for details about the R-C element, see Figure 8).

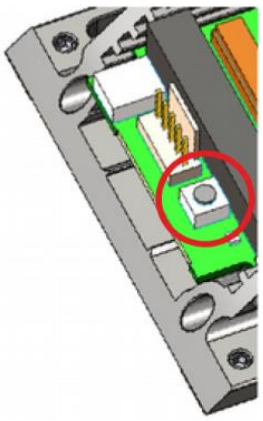
NOTICE

Inadequate shielding can cause inexplicable interference of the sensor, the control system or other problems.

- Implement a proper shielding concept.

6.2 Reset push button

The reset procedure sets the sensor configuration back to factory default (see 7.6 Factory settings). This also may help if there is a problem with the sensor e.g. no communication over serial interfaces. The following steps show the reset procedure with the reset push button inside the LLB sensors.



Reset procedure:

1) Switch off the power supply used for the device
2) Press the reset push button and keep it pressed
3) Switch on the power supply used for the device
4) Keep the reset push button pressed until all status LED's (POWER, ERROR, DO1, DO2) flash for a short time (about 0.5 seconds)
5) Release the reset push button
6) Switch off the power supply and wait 5 seconds
7) Switch on the power supply and wait until the green status LED (POWER) is on.
8) Reset procedure executed successfully

Figure 9: Reset push button

6.3 Status LED

The four status LED's (POWER, ERROR, DO1, DO2) on the top of the LLB device show the operating status of the sensor and the digital outputs (DO1, DO2). The possible LED status with the appropriate status description and some useful references are described in the table below.

POWER green	**ERROR** red	**DO1** orange	**DO2** orange	**Status of sensor – Description**
●				The device is powered and ready for operation –› Normal sensor operation.
●	●			The device is powered but an error occurred during the normal sensor operation. The error code is transmitted over the serial interfaces. For information about the error code number, see chapter 9.6.
●		●	●	The device is powered and running –› Normal sensor operation. One and / or both digital output (DO1, DO2) can be ON or OFF depending on the configured switching levels (for more details see chapter 6.4 and 7).
●	●	●	●	Flash for about 0.5 seconds during reset procedure with the reset push button (see chapter 6.2)
	●	●	●	The device is in error state. See the error code on the serial interface and contact TR Electronic GmbH if error persists after power cycle and reset. Normal case if power LED is off –› Sensor supply voltage too low / high. For information about the error code number, see chapter 9.6.
			●	The device is ready for interface board firmware download. For the download procedure use the “LLB Utility” software.

6.4 Digital output

The LLB sensors contains two (or one) digital outputs (DO1 and DO2) for level monitoring and one digital output (DOE) for error signalization. These outputs can be configured as NPN, PNP or Push-Pull output type. The digital outputs are able to drive up to 150 mA and are specified for an output voltage of 30 VDC. The details about the output specifications and types are described in 6.4.1 Specifications.

6.4.1 Specifications

	Properties / Possibilities
Output voltage LOW (active) NPN, Push-Pull	0.2 V at 10 mA (max.) 1.5 V at 100 mA (max.) 2 V at 150 mA (max.)
Output voltage HIGH (active) PNP, Push-Pull	(V+) - 0.2 V at 10 mA (max.) (V+) - 1.5 V at 100 mA (max.) (V+) - 2 V at 150 mA (max.)
Output voltage OPEN (inactive, high impedance) NPN, PNP	12...30 VDC (max.)
Output current	up to 150 mA
Output slew rate	max. 40 V/µs
Output types	**Types** / **Output ON** / **Output OFF** NPN / LOW (GND / 0 V) / OPEN (high impedance) PNP / HIGH (V+) / OPEN (high impedance) Push-Pull / HIGH (V+) / LOW (GND / 0 V)
Protections	Reverse polarity Over-voltage Current limited (max. 450 mA) Short circuit (thermal shutdown)
Cable length[1]	< 30 m unshielded cable possible (indoor only) ≥ 30 m or outdoor use shielded cables only

The typical connections for the configurable digital output types are shown in Figure 10. The load marked in the figure is a place holder for a specific load for example a relay or indicator light. If the digital output signal of the LLB sensor is used as a digital input signal e.g. for a PLC, the push-pull output has to be used. But it's also possible to use the NPN or PNP output type with an additional pull-up / pull-down resistor.

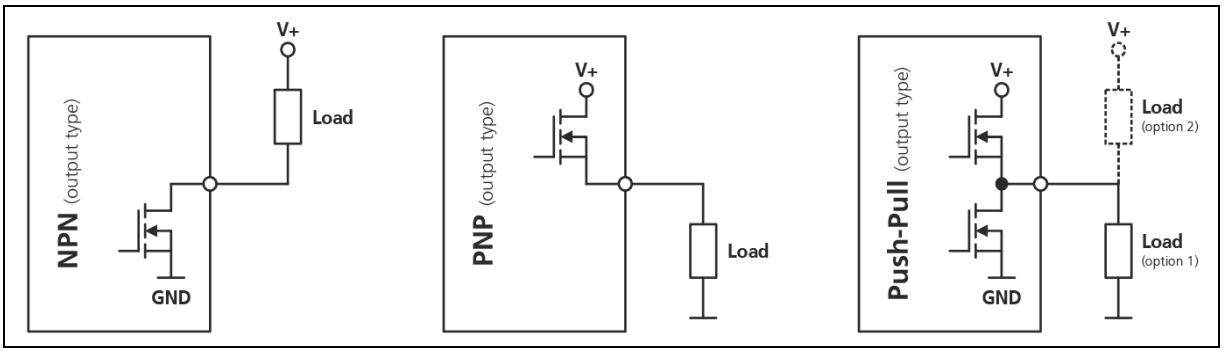
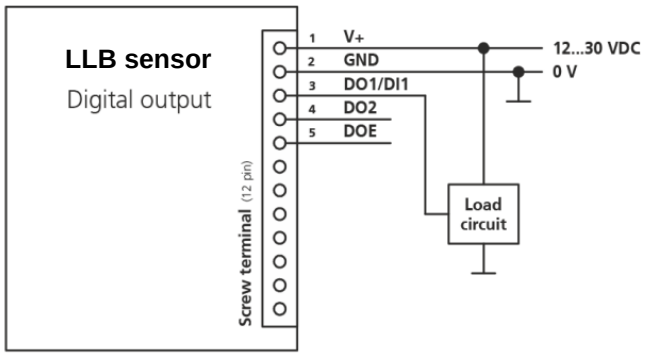


Figure 10: Digital output types (NPN, PNP, Push-Pull) with typical load connection

[1] Max. cable length of Analog Output (AO) interface depends on cable quality and ambient conditions

6.4.2 Wiring



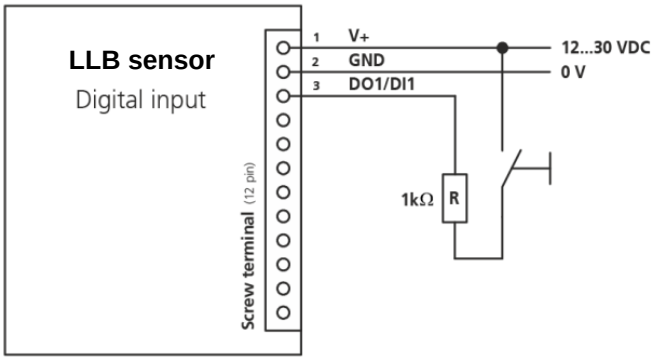
The connection to use the digital outputs of the LLB laser sensors is shown in Figure 11 (example with DO1, analogous for DO2 and DOE outputs).

For detailed information about the load circuit, see the descriptions of the digital output types in chapter 6.4.1 and Figure 10.

Figure 11: Connection for digital output (DO1, DO2, DOE)

6.5 Digital input

The digital output (DO1/DI1) can also be used as digital input. This digital input allows triggering or start / stop measurements by an external digital signal. There are different configuration possibilities available, for more details see the configuration command 9.3.8 Set/Get digital input function (`sNDI1`).



Specifications for digital input signals:

- Low level: U DI1 < 2 VDC
- High level: 9 VDC < U DI1 < 30 VDC

To protect the digital input / output against short circuit always use a 1 kΩ resistor before DO1/DI1 terminal.

The connection and wiring to use the digital input is shown in Figure 12.

Figure 12: Connection of digital input for external triggering

NOTICE

Improper wiring of digital input / output (DO1/DI1) can damage the sensor:

- Before initial operation configure input / output over USB or one of serial Interfaces, and check that wiring corresponds to the input/output configuration.

6.6 Analog output

The analog output of the LLB sensors is a current source and is capable of driving loads up to 500 Ω. The current range is programmable to 0...20 mA or 4...20 mA. For more details see the specifications.

6.6.1 Specifications

	Properties / Possibilities
Potential / reference	No galvanic isolation (signal referenced to GND of the sensor)
Max. load resistance	≤ 400 Ω (≤ 500 Ω with limitations) Generally the following guideline for min. device input voltage has to be considered: $V+_{min} \geq R_{AO\_LOADmax} * I_{AOmax} + 3.5\ V$ (e.g. $V+_{min} = 500\ \Omega * 20\ mA + 3.5\ V = 13.5\ V$)
Accuracy	0.1 % (of programmable distance span)
Resolution	12-Bit
Current range Minimum Maximum Error level	 0 mA / 4 mA (programmable min. current level) 20 mA 0...20 mA (programmable)
Cable length[2]	< 30 m unshielded cable possible (indoor only) ≥ 30 m or outdoor use shielded cables only

$$e_{Dist} = Accuracy_{Device} + \frac{(MaxDist_{Conf} - MinDist_{Conf}) * Accuracy_{AO}}{100}$$

$Accuracy_{Device}$	Device accuracy in mm
$MaxDist_{Conf}$	Configured max. distance in mm
$MinDist_{Conf}$	Configured min. distance in mm
$Accuracy_{AO}$	Accuracy of the analog output in (e.g. 0.1 for 0.1 %)
e_{Dist}	Total error in mm

Calculation example:

$$e_{Dist} = 1\ mm + \frac{(10\,000\ mm - 0\ mm) * 0.1\ \%}{100} = \mathbf{\pm 11\ mm}$$

LLB502-01111 (device specifications and configurations):

$Accuracy_{Device}$	± 1 mm
$MaxDist_{Conf}$	10 000 mm
$MinDist_{Conf}$	0 mm
$Accuracy_{AO}$	0.1 %
e_{Dist}	**± 11 mm** (Calculation see left side)

The stated errors include all possible errors as temperature drift, linearity, surface color and measurement distance.

The best accuracy for the LLB devices can only be achieved by using the digital serial interfaces (RS-232, RS-422/485, SSI or Industrial Ethernet).

[2] Max. cable length of Analog Output (AO) interface depends on cable quality and ambient conditions

6.6.2 Wiring

The connection of the analog output with a PLC (or other device) is shown in Figure 13. Consider that the analog output of the LLB sensors are not galvanic isolated and the GND (power supply 0 V) of the sensors are used for the analog output too.

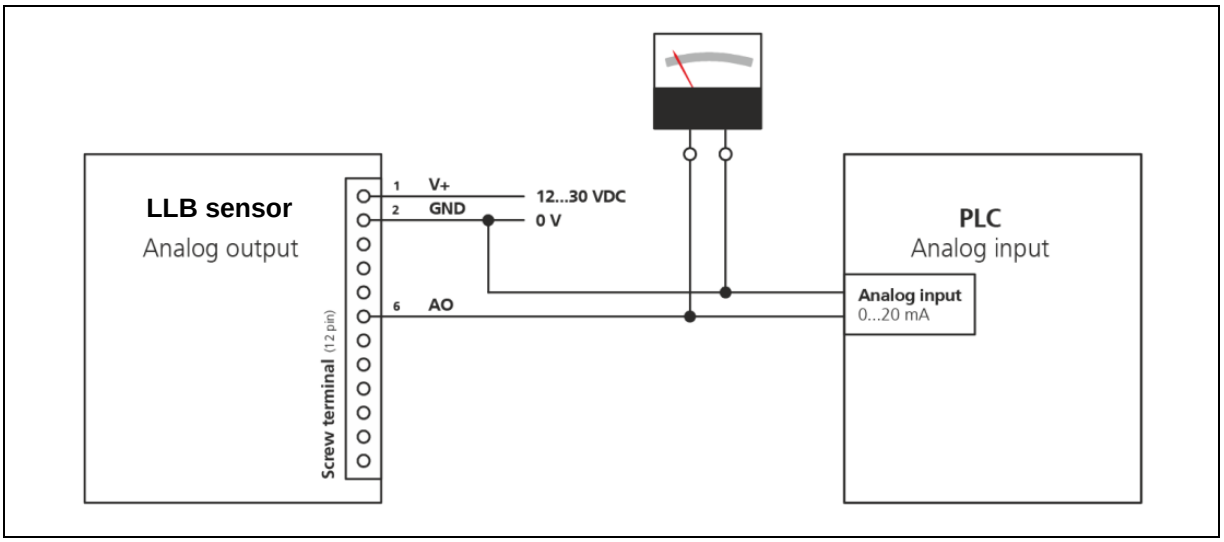


Figure 13: Connection of the analog output with a PLC (or other devices)

6.7 RS-232 interface

The RS-232 digital serial interface is mainly used for the device configuration. It allows the connection with a host (e.g. PC) to do the configuration with a terminal program (e.g. HTerm[3], HyperTerminal[4]) or the “LLB Utility” software.
The communication protocol is ASCII based, easy to understand and simple to use. For more details about the communication protocol and the available commands see 9 Command set on page 57. The factory settings of the RS-232 interface are specified in chapter 7.6 Factory settings.

Measurement rates faster than about 100 Hz are only possible if the baud rate is set to the maximum of 115'200 Baud. Lower baud rates reduce the measurement speed.

6.7.1 Specifications

The following specifications are in addition to the RS-232 standard specification (Standard specifications / guidelines are free available online).

	Properties / Possibilities
Voltage level	See RS-232 standard specifications / guidelines
Max. baud rate	115 200
Max. cable length (typical)[5]	≤ 15 m (unshielded cable for indoor use only)

[3] HTerm is a free communication terminal software

[4] HyperTerminal is a free communication terminal software from Microsoft (only available on Windows XP systems)

[5] Max. cable length of RS-232 interfaces depend on communication speed, cable quality and ambient conditions

6.7.2 Wiring

The connection of a LLB sensor over the RS-232 interface with a host (e.g. PC or PLC) is shown in Figure 14. With the RS-232 interface only point-to-point communication is possible.

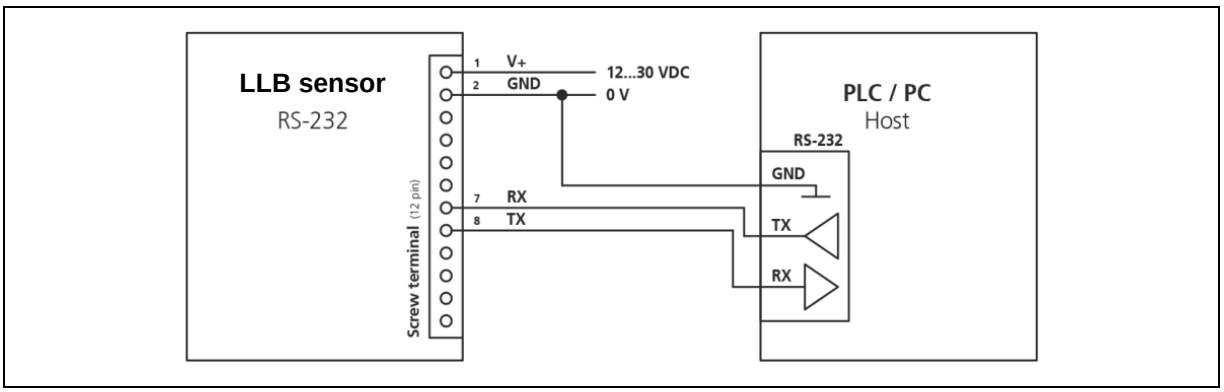


Figure 14: Connection of the RS-232 interface

Never connect multiple LLB devices on a single RS-232 line.

6.8 RS-422/485 interface

The RS-422/485 digital serial interface is made for industrial applications due to their robustness, max. cable length and the possibility of connection multiple devices on the same line. For this interface a shielded cable with twisted pairs for the data signals have to be used (see 6.8.1 Specifications for further information).
The communication protocol is unchanged and identical with the protocol for the RS-232 interface. For more details about the communication protocol and the available commands see 9 Command set on page 57. The factory settings of the RS-422/485 interface is specified in chapter 7.6 Factory settings.
It's important that the host has the control of the whole communication and never initiates a new communication before terminating the previous one (always waiting for the answer of the LLB device or timeout).

The RS-422/485 interface cannot be used simultaneous with the SSI interface.

For more than one device on a single line, never use commands with continuous answers (e.g. single sensor tracking).
Only use tracking with buffering (see 9.2.5 Tracking with buffering – Start (`sNf`)).

Measurement rates faster than about 100 Hz are only possible if the baud rate is set to the maximum of 115'200 Baud. Lower baud rates reduce the measurement speed.

6.8.1 Specifications

The following specifications are in addition to the RS-422/485 standard specifications. The standard specifications / guidelines are free available e.g. online.

	Properties / Possibilities
Voltage level	See RS-422/485 standard specifications / guidelines
Max. baud rate	115'200
Max. load for driver	≥ 100 Ω
Cable characteristics Cable type Characteristic impedance Z_0 (typical)	 Use shielded twisted pair cables only (twisted pairs: T+/T- and R+/R-) 100...150 Ω (typical)
Termination resistor R_T	100...150 Ω (typical), should be equal to cable impedance Z_0
Cable length vs baud rate (typical)[6]	≤ 500 m –› ≤ 200'000 Baud (all baud rates possible) ≤ 1000 m –› ≤ 100'000 Baud

6.8.2 Wiring RS-422

The connection of one or more LLB devices (up to 100) over the RS-422 interface with a host (e.g. PC or PLC) is shown in Figure 15. To use more than one LLB sensor on a single RS-422 line the device ID of every device has to be configured with different ID's. Available and configurable ID's are form 0 to 99 (see 9.3.2 Set device ID (`sNid`)).
For proper operation use a termination resistors R_T as shown in Figure 15. The termination resistor should be equal to the cable impedance Z_0 (typical 100...150 Ω).

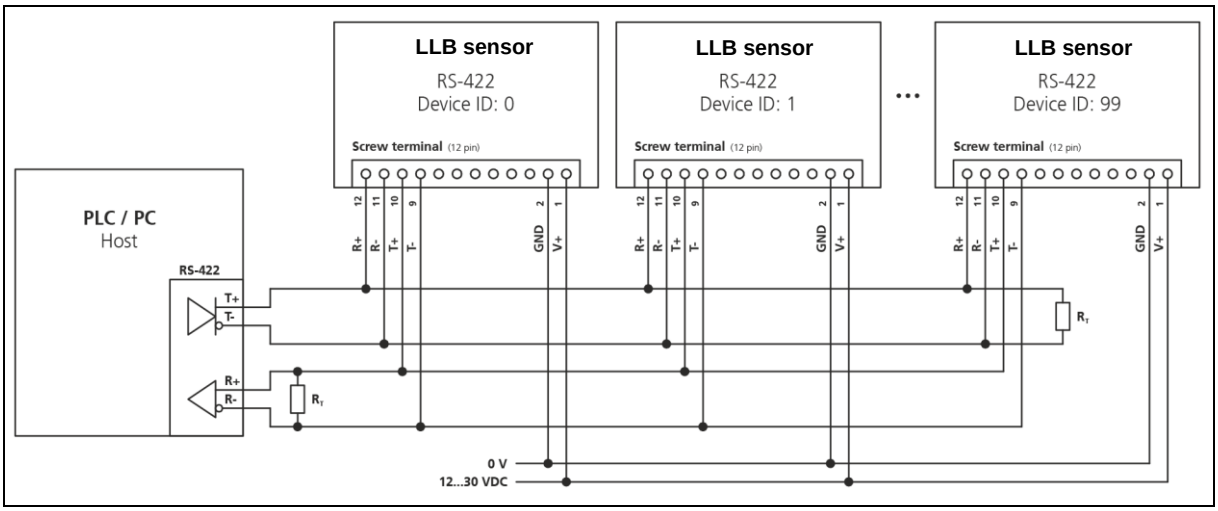


Figure 15: Connection of one or more RS-422 devices on one line, R_T –› Termination resistors

If there are multiple devices on the same RS-422 line ensure that all devices have different device ID's.

NOTICE

Using unshielded cables can cause communication problems or long-term damage to the sensor.

- Use shielded twisted pairs cables only. For details see 6.8.1 Specifications.

6 Max. cable length of RS-422 / RS-485 interfaces depend on communication speed, cable quality and ambient conditions

6.8.3 Wiring RS-485

The connection of one or more LLB devices (up to 100) over the RS-485 interface with a host (e.g. PC or PLC) is shown in Figure 16. To use more than one LLB sensor on a single RS-485 line the device ID of every device has to be configured with different ID's. Available and configurable ID's are form 0 to 99 (see 9.3.2 Set device ID (`sNid`)).

For proper operation use a termination resistors R_T as shown in Figure 16. The termination resistor should be equal to the cable impedance Z_0 (typical 100...150 Ω).

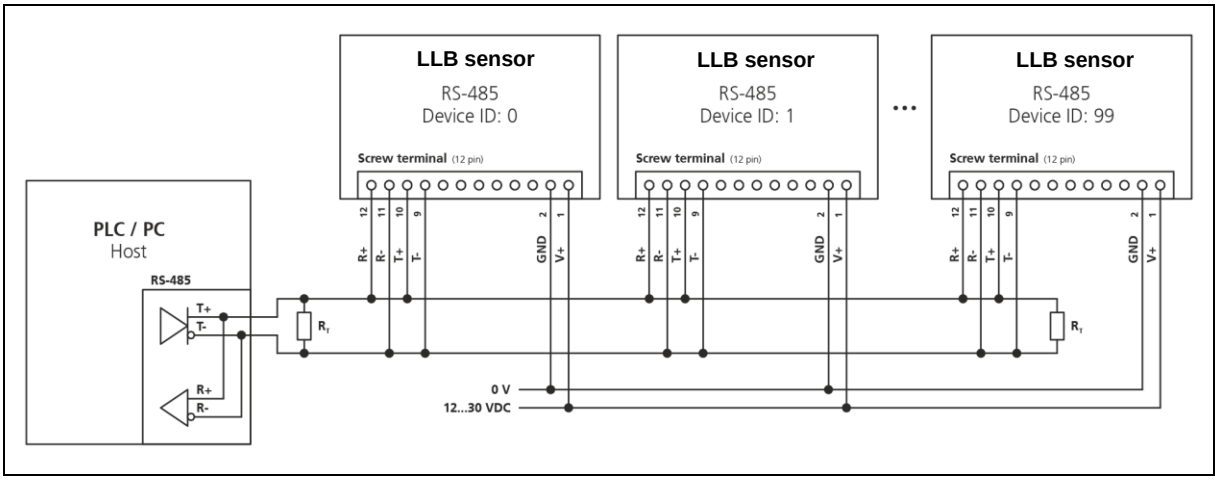


Figure 16: Connection of one or more RS-485 devices on one line, R_T –› Termination resistors

If there are multiple devices on the same RS-422 line ensure that all devices have different device ID's.

NOTICE

Using unshielded cables can cause communication problems or long-term damage to the sensor.

- Use shielded twisted pairs cables only. For details see 6.8.1 Specifications.

6.9 SSI interface

The SSI interface is also made for industrial applications due to their synchronous communication, the robustness (because of differential signals) and max. possible cable length. For this interface a shielded cable with twisted pairs for the data signals have to be used (see 6.9.1 Specifications for further information).
It's possible to configure the SSI interface with different data formats / sizes, data coding (binary or gray) and some other options. For detailed information see the configuration command in chapter 9.3.10 Set/Get configuration of RS-422/485 and SSI (`sNSSI`) and 9.3.11 Set/Get error value of SSI output (`sNSSIe`). The factory settings of the SSI interface are specified in chapter 7.6 Factory settings.

The SSI interface cannot be used simultaneous with the RS-422/485 interface.

6.9.1 Specifications

	Properties / Possibilities
Distance output values	0...16777215 1/10 mm (max. 1.67 km)
Resolution	0.1 mm
Data coding	Binary or gray, MSB first (configurable)
Data format / size Distance data State / Error data	 23 / 24-Bit (configurable) 0 / 1-Bit error state (configurable) 0 / 8-Bit error code (configurable)
Error value behavior	-2 / -1 / 0...16777215 (configurable)
Read out rate	≤ 1 kHz
Clock frequency (Clock from master device)	83 kHz to 1 MHz, depending on cable length
Pause time t_p (Time lag between two data packets)	> 1 ms
Monoflop time t_m	25 µs
Voltage level	See RS-422/485 guidelines (differential signals)
Cable characteristics	Use shielded twisted pair cables only (twisted pairs: T+/T- and R+/R-)
Cable length vs data rate (typical)[7]	≤ 100 m –› ≤ 1000 kBit/s ≤ 200 m –› ≤ 600 kBit/s ≤ 500 m –› ≤ 200 kBit/s ≤ 1000 m –› ≤ 100 kBit/s

6.9.2 Timing

The timing of the SSI interface is shown in Figure 17 and described below the figure.

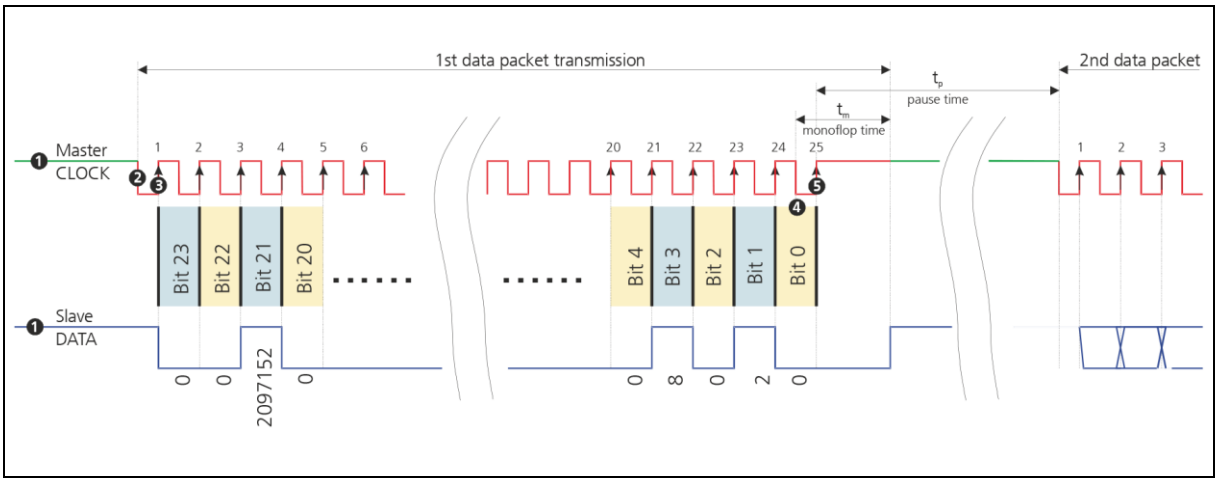


Figure 17: Timing diagram of SSI interface (t_m –› Monoflop time, t_p –› Pause time).

[7] Max. cable length of SSI interfaces depend on communication speed, cable quality and ambient conditions

The SSI is initially in the idle mode, where the DATA and CLOCK lines stay HIGH ❶ and the slave keeps updating its internal data. The transmission mode is evoked when the master initiates a sequence by pulling the CLOCK line to LOW. Once, the slave receives the resulting falling edge ❷ at the CLOCK signal line, it automatically stops updating its internal data. With the first rising edge ❸ at the CLOCK line, the MSB of the sensor data is transmitted and with consequent rising edges, the data bits are sequentially transmitted over the DATA line.
After the transmission of the complete data word ❹ (e.g. LSB is transmitted), an additional last rising edge ❺ at the CLOCK line sets the CLOCK to HIGH. The slave sets or leaves the DATA line to LOW and remains there for the monoflop time tm, to recognize the transfer timeout.
If a falling edge at the CLOCK line (Data-Output request) is received within the monoflop time tm, the same data as before will be transmitted again (Multiple transmission).

If there were no clock pulses within the monoflop time tm, the slave starts updating its internal data after setting the DATA line to HIGH (Idle mode). This marks the end of the data word transmission (Single transmission). Once the slave receives a clock signal at a time tp (>=tm,), the updated position data is frozen and the transmission of the new data begins as described earlier.

6.9.3 Wiring

The connection of the LLB devices to use the SSI interface with a SSI master (e.g. PLC) is shown in Figure 18. For details about the cable characteristics and the possible cable length (depends on data rates) see the specifications in chapter 6.9.1. The data rates must be set at the SSI master side.

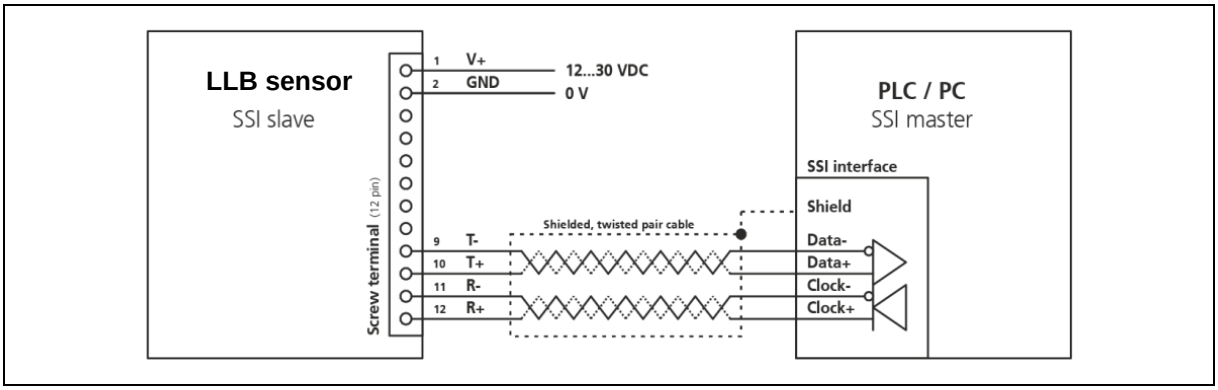


Figure 18: Connection of SSI interface with a master device

Never connect multiple LLB devices on a single SSI line.

NOTICE

Using unshielded cables can cause communication problems or long-term damage to the sensor.

- Use shielded twisted pairs cables only. For details see 6.8.1 Specifications.

6.10 USB interface

The USB interface is also mainly used for the device configuration. It allows the connection with a USB host (e.g. PC) to do the configuration with a terminal program (e.g. HTerm[8], HyperTerminal[9]) or the “LLB Utility” software.
The communication protocol is ASCII based, easy to understand and simple to use. It's the same protocol used for all configuration and other serial interfaces (RS-232, RS-422/485 and USB). For more details about the communication protocol and the available commands see 9 Command set on page 57.

6.10.1 Specifications & Wiring

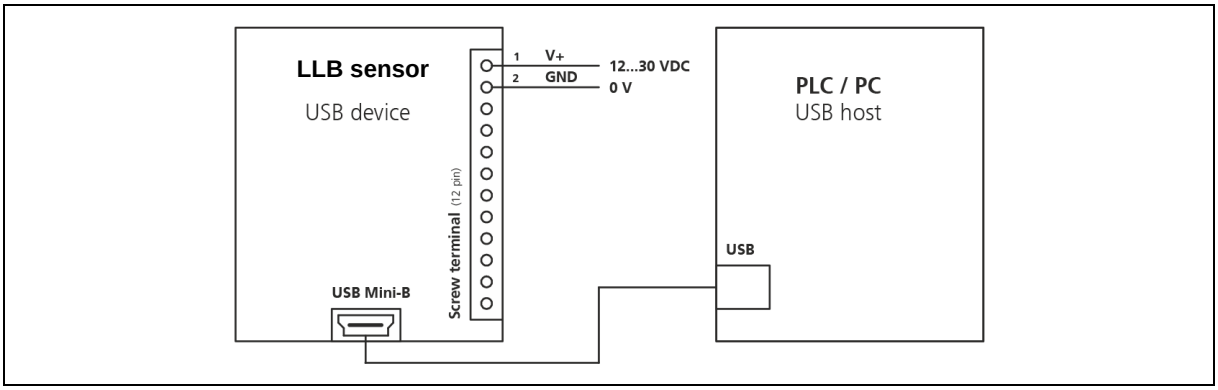


Figure 19: Connection of USB interface

Specifications for USB interface:

- USB Mini type B
- USB 2.0 FS (Full speed, max. 12 Mbps)
- Virtual COM port for LLB device
- LLB devices are not powered over USB interface (use separate power supply for the sensors)
- For other information not mentioned at this point, see the USB specifications and guidelines

The connection and wiring to use the USB Mini-B interface is shown in Figure 19.

6.10.2 Installation

The USB interface of the LLB laser sensor needs a basic USB driver installed on the host system. This has to be done only one time. If the driver installation was successful the LLB laser sensor will be identified correctly by the host system.

The LLB laser sensor is identified as a virtual COM port device with the device name “LLB USB Serial Port (COMxx)”. Check the device manager for the COM port number. This number is required to connect to the sensor with a terminal program or the “LLB Utility” software. The baud rate is the same as the baud rate configured for the other serial interfaces (RS-232 and RS-422/485).

Only use the TR Electronic USB driver in conjunction with the LLB USB port. Use the same baud rate for the USB interface as for the other serial interfaces (RS-232 and RS-422/485).

Download USB driver: www.tr-electronic.de/f/zip/TR-ELE-SW-MUL-0002

8 HTerm is a free communication terminal software

9 HyperTerminal is a free communication terminal software from Microsoft (only available on Windows XP systems)

6.11 Industrial Ethernet interface

The Industrial Ethernet interface extends the available interfaces with PROFINET®, EtherNet/IP™ or EtherCAT®. These optional interfaces are designed as exchangeable covers and can be connected (over the Industrial Ethernet interface connector) and attached to the back of the LLB sensors. The LLB laser sensor is configurable in its entirety over the Industrial Ethernet interface. For detailed information about the respective Industrial Ethernet interface, see the chapter 10 Industrial Ethernet with exchangeable cover.

6.11.1 Specifications

	Properties / Possibilities
Industrial Ethernet protocol (For detailed specifications see the technical reference manual of the Industrial Ethernet)	PROFINET® EtherNet/IP™ EtherCAT®
Control and configuration	Over Industrial Ethernet - Cyclic process data (Control of LLB laser sensor) - Acyclic parameter / data (Configuration of LLB laser sensor)
Cable and connector	20 pin ribbon cable to connect exchangeable cover

6.11.2 Wiring

The connection of the LLB device to use the Industrial Ethernet interface with the exchangeable cover is shown in Figure 20. To use the exchangeable cover with one of the Industrial Ethernet protocol (PROFINET®, EtherNet/IP™ or EtherCAT®) all other sensor connectors and interfaces have to be disconnected otherwise the sensor may damage.

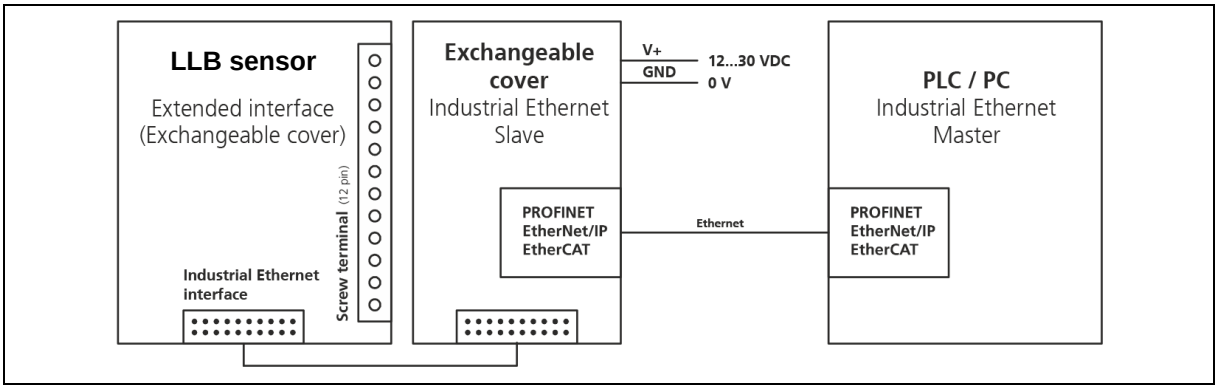


Figure 20: Connection of the exchangeable cover for Industrial Ethernet interfaces

NOTICE

Connecting the exchangeable cover for Industrial Ethernet to the sensor under voltage may damage one

- Switch of the power supply before connecting the exchangeable cover for Industrial Ethernet to the sensor.
- No warranty will be granted on improper handling.

NOTICE

Connecting the Exchangeable Cover for Industrial Ethernet simultaneously with one of the other interfaces of the sensor may damage one of these components.

- Disconnect all other interface cables before connecting the exchangeable cover for Industrial Ethernet to the sensor.

7 Configuration

The LLB sensors have a multiplicity of configuration options. On the one hand the integrated interfaces can be configured (e.g. baud rate of the serial interfaces) to reach a wide range of application requirements. Otherwise it's also possible to configure the behavior of the sensors (e.g. measurement characteristic).

The following table shows an overview of all configuration options and the corresponding references to the commands or chapters.

Interfaces / Features	Configuration possibilities	Commands
Digital input	Input functions (Trigger single measurement, trigger tracking, etc.)	9.3.8 Set/Get digital input function (sNDI1)
Digital output	Output type (NPN, PNP, Push-Pull)	9.3.6 Set/Get digital output type (sNot)
	Switching level (ON / OFF level)	9.3.7 Set/Get digital output hysteresis (sN1, sN2)
Analog output	Distance range (min. and max.) for 0/4...20 mA	9.3.5 Set/Get analog output distance range (sNv)
	Min. current level 0 mA or 4 mA	9.3.3 Set/Get analog output min level (sNvm)
	Current level in error case	9.3.4 Set/Get analog output value in error case (sNve)
RS-232, RS-422 / RS-485	Communication settings (Baud rate, etc.)	9.3.1 Set communication settings (sNbr)
	Sensor ID	9.3.2 Set device ID (sNid)
SSI	Communication settings (Data format, coding, etc.)	9.3.10 Set/Get configuration of RS-422/485 and SSI (sNSSI)
	Error behavior	9.3.11 Set/Get error value of SSI output (sNSSIe)
Industrial Ethernet	Configuration over Industrial Ethernet interface	-
Sensor behavior	Operation mode (see description in chapter 7.2)	9.3.14 Set/Get auto start configuration (sNA) 9.4.4 Set/Get user mode (sNum)
	Measurement characteristic (see description in chapter 7.3)	9.3.12 Set/Get measuring characteristic (sNmc)
	Data output (Filter, gain, offset, format) (see description in chapter 7.4)	9.3.13 Set/Get measurement filter configuration (sNfi) 9.4.2 Set/Get user distance offset (sNuof) 9.4.3 Set/Get user distance gain (sNuga) 9.4.1 Set/Get user output format (sNuo)

7.1 Configuration process

The configuration process describes how the sensors can be configured. There are different interfaces for connection available and also two configuration types. The configuration example in 7.1.3 shows a possible analog output configuration and gives an impression of the configuration process.

7.1.1 Connection

To be able to configure a LLB device it has to be powered and connected to a host (usually a PC). On the host side a terminal program (e.g. HTerm[10], HyperTerminal[11]) can be used to communicate with the sensor. The “LLB Utility” software is also available.

Connections available for configuration (see Figure 21 for details):

1) RS-232 interfaces
2) USB interface

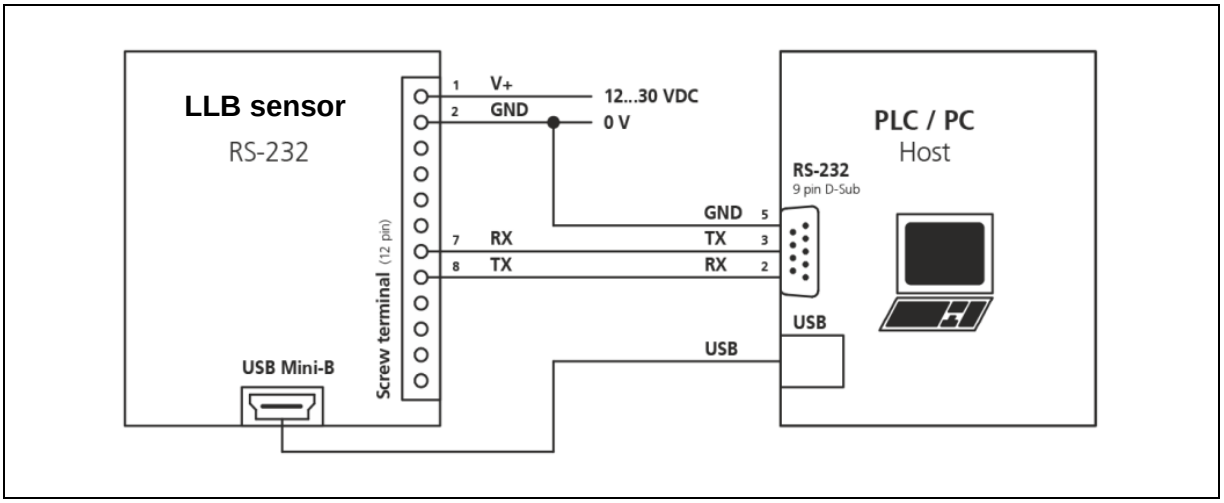


Figure 21: Connection of the RS-232 or USB interface for sensor configuration

The specifications for the RS-232 or the USB interface are described in 6.7 RS-232 interface or 6.10 USB interface. The connection for using the RS-232 or the USB interface for configuration is shown in Figure 21.

RS-232 / USB default settings of the LLB device:

COM port:	depends on PC / PLC[12]
Baud rate:	19'200 Baud
Data bits:	7
Parity:	Even
Stop bits:	1

[10] HTerm is a free communication terminal software

[11] HyperTerminal is a free communication terminal software from Microsoft (only available on Windows XP systems)

[12] The serial COM port number depends on host system. Check the serial COM port number in the device manager of the host system.

7.1.2 Configuration types

The LLB sensors can be configured with or without saving the configuration changes in the internal memory by using the save command (see 9.3.16 Save configuration parameters (`sNs`)). So there exist two types of using the configurations, volatile or non-volatile. To find out what configuration type should or can be used for a specific application see the description below.

The LLB sensors support two configuration types (volatile and non-volatile, see the table below):

- Volatile (after every power up cycle, the configuration will be set)
- Non-volatile (only one-time configuration, the configuration will be set and saved in sensor memory)

Steps		Volatile	Non-volatile
Power up			
Configuration	1	Configuration (all used features)	Configuration (all used features)
	2	- (no save, volatile configuration)	Save configuration (save configuration in sensor memory)
Measurement	3	Measurement 0	Measurement 0
	4	Measurement 1	Measurement 1
	5	...	...
	n	Measurement n	Measurement n
Power down			
Power up			
Configuration	1	Configuration (all used features)	- (not required)
Measurement	2	Measurement 0	Measurement 0
	3	Measurement 1	Measurement 1
	4	...	...
	n	Measurement n	Measurement n

7.1.3 Configuration example

The configuration example in the table below shows the differences of the volatile and non-volatile configuration type on the basis of the analog output. The analog output will be configured to 4...20 mA for the distance range of 0...10 m. In error case, the analog output level has to be 0 mA.

Steps		Volatile	Non-volatile	Description
Power up				
Configuration	1	s0vm+1 s0v+0+100000 s0ve+0	s0vm+1 s0v+0+100000 s0ve+0	➢ Set min. current level to 4 mA ➢ Set distance range to 0...10 m (for 4...20 mA) ➢ Set current level in error case to 0 mA
	2	–	s0s	➢ s0s for saving configuration in sensor memory
Measurement	3	s0g	s0g	➢ s0g for single distance measurement and update of analog output
	n	...	...	
Power down				
Power up				
Configuration	1	s0vm+1 s0v+0+100000 s0ve+0	–	➢ New configuration if not saved before power down (only for volatile configuration type)
Measurement	2	s0g	s0g	
	n	...	...	

7.2 Operation modes

The LLB laser sensors offer two types of operation modes, the controlled mode and the stand-alone mode to cover a wide range of applications. While the controlled mode provides maximum flexibility and needs to be triggered by a host system, the stand-alone mode can operate autonomous. Often, it's not suitable or welcome to control a device by the host system in an existing environment. In such cases the stand-alone mode might be preferred. The two types of operation modes are described in the table below.

Controlled mode	Stand-alone mode	
	Auto start	Manual start
The distance measurement is controlled / triggered by a host system. The available commands are listed below: • sNg –› Distance measurement • sNh –› Single sensor tracking • sNf –› Tracking with buffering	The distance measurement starts automatically after a power on cycle. The available commands are listed below: • sNA –› Auto start configuration • sNum –› User mode configuration	An external signal triggers distance measurements. This is possible by configuring the digital input DI1. The available command is listed below: • sNDI –› Digital input functions
See 7.2.1 Controlled mode for more details.	See 7.2.2 Stand-alone mode for more details.	See 7.2.2 Stand-alone mode for more details.

All interfaces of the laser sensor are updated internally (with new distance measurements or error codes) independently of the operation mode.

7.2.1 Controlled mode

In controlled mode each action / operation of the LLB sensor is triggered by a command sent from a host system over a serial interface (RS-232, RS-422/485 or USB). The basic configuration steps to use the controlled mode are listed in the table below.

Steps	Action	Description	Commands
1	Clear device	Clear the device before using the controlled mode by doing a clear followed by a save command. It's also possible to do a device reset (Factory default of the laser sensor)	9.2.1 Stop / Clear command (sNc) 9.3.16 Save configuration parameters (sNs) 6.2 Reset push button
2	Set communication parameters	Configure the desired communication parameters and device ID.	9.3.1 Set communication settings (sNbr) 9.3.2 Set device ID (sNid)
3	Operation	Use the operation commands to do distance measurements or to use other sensor functionality.	9.2 Operation commands

For this operation mode a host software is required to control the LLB laser sensor. Careful testing of the host software together with the device is strongly recommended prior to installation.

7.2.2 Stand-alone mode

The stand-alone mode is grouped in auto start configuration and manual start configuration. For details about the functionality and the configuration steps see the following sections.

Auto start configuration:

The following steps are needed to configure the LLB device for the stand-alone mode with auto start configuration. In this mode the distance measurement is started automatically after every power-up cycle. No external trigger or command is required to start measurement. All sensor interfaces are updated internally with distance or error data. For the default auto start configuration there is no serial output on the RS-232, RS-422/485 and USB interface. Optionally this output can also be activated by the user mode configuration command. See the configuration steps in the table below.

Steps	Action	Description	Commands
1	Clear device	Clear the device before using the stand-alone mode by doing a clear followed by a save command. It's also possible to do a device reset (Factory default of the laser sensor)	9.2.1 Stop / Clear command (sNc) 9.3.16 Save configuration parameters (sNs) 6.2 Reset push button
2	Set user mode	Do this step if auto start configuration with serial output on RS-232, RS-422/485 and USB interface is required (User mode 2 to activate serial output).	9.4.4 Set/Get user mode (sNum)
3	Set the auto start configuration	Configure the LLB device to the stand-alone mode with auto start. It's possible to select a desired sample rate. For more details see the command description.	9.3.14 Set/Get auto start configuration (sNA)

Manual start configuration:

The following steps are needed to configure the LLB device for the stand-alone mode with manual start configuration. In this mode the distance measurement can be triggered by an external signal event on the digital input (DI1). There are different actions of the LLB laser sensor available. All sensor interfaces are updated internally with distance or error data.

Steps	Action	Description	Commands
1	Clear device	Clear the device before using the stand-alone mode by doing a clear followed by a save command. It's also possible to do a device reset (Factory default of the laser sensor)	9.2.1 Stop / Clear command (sNc) 9.3.16 Save configuration parameters (sNs) 6.2 Reset push button
2	Set the digital input function	Configure the LLB device to react on a trigger event on the digital input (DI1) with a distance measurement. There are different actions available. For more details see the configuration command.	9.3.8 Set/Get digital input function (sNDI1)
3	Save configuration	The save configuration command stores this configuration in a non-volatile memory. The configuration persist in the device after a power cycle.	9.3.16 Save configuration parameters (sNs)

7.2.3 Error behavior

In case of a device, configuration or measurement error the LLB laser sensor show the error on the available sensor interfaces (Status LED's, analog output, digital outputs, RS-232, etc.). On the configurable interfaces the error code is transmitted according this configuration.

The error will be automatically cleared after another successful distance measurement, performing a stop / clear command (see chapter 9.2.1 Stop / Clear command (sNc)) or a power cycle.

The LLB devices automatically store the occurred measurement errors in a non-volatile error stack. After power-cycle the last errors are still available for diagnostic purpose. The error stack can be read or cleared with the Read/Clear error stack (sNre, sNce) command. For more details about the command, see chapter 9.2.9.

7.3 Measuring characteristic

Multiple measuring characteristics are available in the LLB measuring devices to meet different requirements for various applications. With these measuring characteristics measuring rate and accuracy can be optimized for specific application requirements.

The available measurement characteristic with the main properties (measuring rate and typical accuracy) are described in the table below.

Measuring characteristic		Max. measuring / output rate		Typical accuracy at 2σ		Description
No.	Name	LLB502-01111 LLB502-01213	LLB502-00001 LLB502-00003	LLB502-00001 LLB502-01111	LLB502-00003 LLB502-01213	
0	Normal	20 Hz 1) 2)	20 Hz 1) 2)	±1 mm	±3 mm	Normal measuring characteristic covers a wide range of applications. Measuring range on natural surface: Typical up to 100 m (depends on device type, see the specifications in 5.1). Configuration command: sNmc+0 3)
1	Fast	250 Hz 1) 2) 5)	100 Hz 1) 2) 6)	~±1.5 mm	~±4.5 mm	Increase measuring rate up to 100 Hz / 250 Hz (depends on device type, see the specifications in 5.1). Configuration command: sNmc+1 3)
2	Precise	10 Hz 1) 2)	10 Hz 1) 2)	~±0.8 mm	~±2.4 mm	Increase accuracy with longer measurement to ~±0.8 mm / ~±2.4 mm (depends on measuring conditions). To generally increase measuring performance, consider 5.3 Measuring performance influence. Configuration command: sNmc+2 3)
3	Timed	User program-med 250 Hz 2) 5)	User program-med 100 Hz 2) 6)	variable	variable	Timed measuring characteristic allows user defined measuring rates. The device does not consider measuring conditions to reach the specified accuracy. The measuring rate is fixed and the accuracy is variable (depends on measuring conditions). Configuration command: sNmc+3 3)
4	Moving target	250 Hz / 1 kHz 4) 5)	100 Hz 6)	±1 mm	±3 mm	Moving target measuring characteristic is specific designed for measurements on fast continuous moving targets. For reliable measuring results a good measuring signal is mandatory (good measuring conditions). Configuration command: sNmc+4 3)
5	Not used	-	-	-	-	-

1) The measuring rate depends on environmental conditions such as target surface, distance, background light (e.g. sun light), for more details see 8.3 Measuring performance influence. For good conditions (e.g. white target surface or orange reflective target plate and dark environment) the specified max. measuring rate can be reached. For bad conditions the measuring rate decrease.

2) For all measuring characteristic instead of Moving Target the output rate is identical to the measuring rate. After every measurement the output will be updated.

3) For more details about the configuration command, see 9.3.12 Set/Get measuring characteristic (sNmc).

4) Output rate is fixed to 250 Hz for serial interfaces, 500 Hz for Industrial Ethernet and 1 kHz for SSI, analog output and digital outputs.

5) Note that for measuring rates above about 100 Hz, the maximum baud rate 115200 must be used for the serial interfaces (RS-232, RS422/485), otherwise the measuring speed will be reduced.

6) 100 Hz valid for production date 09/2022 or newer. Before this date 50 Hz."

7.4 Data output

The data output of the LLB device is configurable with a wide range of possibilities (output format, user gain, user offset and some filter options). The details about the available configurations are described in the following chapters.

The Figure 22 gives an overview of the configuration possibilities and shows the effect on the LLB device interfaces. Please consider not all interfaces are affected in the same manner. For example, the user output format and user gain / offset are only available on the serial interfaces RS-232, RS-422/485 and USB.

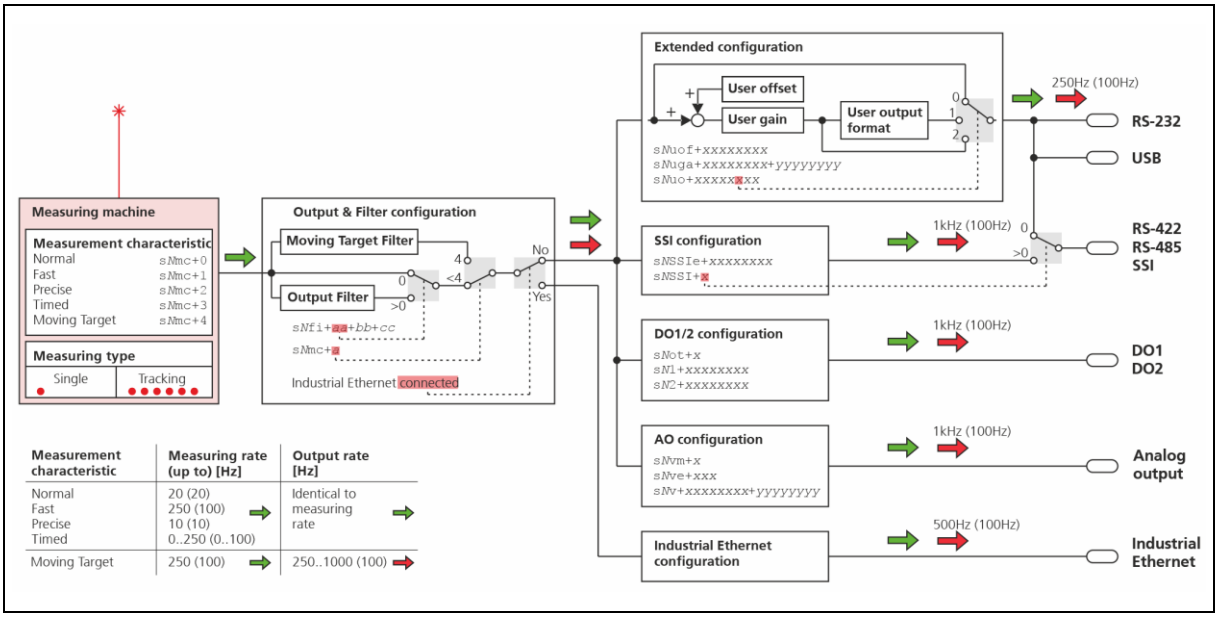


Figure 22: Configuration possibilities and flow chart of data output.

Colored arrows show the interface update rate depending on the available measurement characteristics. The measuring and output rates without parenthesis are for the devices LLB502-01111 and LLB502-01213. The measuring and output rates with parenthesis are for the devices LLB502-00001 and LLB502-00003. See also chapter 5.1 Device specifications. Note that for measuring rates above about 100 Hz, the maximum baud rate 115200 must be used for the serial interfaces (RS-232, RS-422/485), otherwise the measuring speed will be reduced.

7.4.1 User output format / protocol

The configurable output format / protocol of the LLB laser sensor allows the connection of an external ASCII display, to add some additional measurement information or the possibilities to set an individual user distance offset and / or user gain. The user output format is only available on the serial interface RS-232, RS-422/485 and USB.

The configuration command `sNuo` can be used to select the desired output format and to set some additional settings used for the external ASCII display (field length and position of decimal point). For more details see 9.4.1 Set/Get user output format (`sNuo`).

Available output format	Configuration example	Output
Default output format (Factory default)	sNuo+0 (User offset / gain configuration ignored)	"gNg+00012345\r\n"
Display output format (For external ASCII display, not applicable for RS-485)	sNuo+139, sNuga+1+10, sNuof+0 (User offset / gain configuration considered)	" 1.234"
Default format with user offset / gain active	sNuo+200, sNuga-1+1, sNuof-10000 (User offset / gain configuration considered)	"gNg-00002345\r\n"
Extended distance format with signal and temperature data and user offset / gain active	sNuo+300, sNuga+1+1, sNuof+0 (User offset / gain configuration considered)	"gNg+00012345+008384+254\r\n"
Extended distance format with signal, temperature and speed data and user offset / gain active	sNuo+301, sNuga+1+1, sNuof+0 (User offset / gain configuration considered)	"gNg+00012345+008384+254+000500\r\n"

The user output format is only available on the serial interface RS-232, RS-422/485 and USB.

7.4.2 User gain / offset

The user gain and offset configuration of the LLB device allow individual and application dependent offset and gain settings. For example, an individual gain configuration enables the conversion to other distance units (e.g. m, inch, etc.). The calculation of the user distance with user offset and user gain (Defined by numerator and denominator) is shown below.

$$Distance_{User} = (Distance + Offset_{User}) \frac{GainNum_{User}}{GainDen_{User}}$$

$Distance_{User}$	User distance with offset and gain in 1/10 mm
$Distance$	Measured raw distance of LLB device in 1/10 mm
$Offset_{User}$	User offset (+/-) in 1/10 mm
$GainNum_{User}$	User gain numerator
$GainDen_{User}$	User gain denominator in 1/10 mm

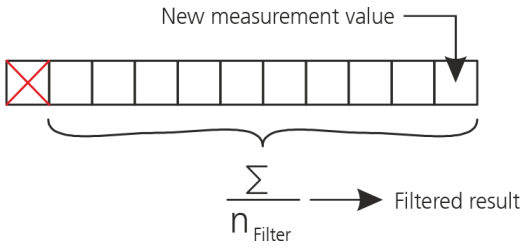
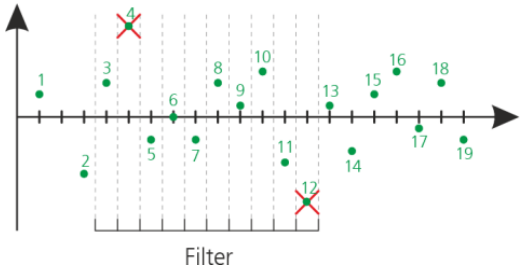
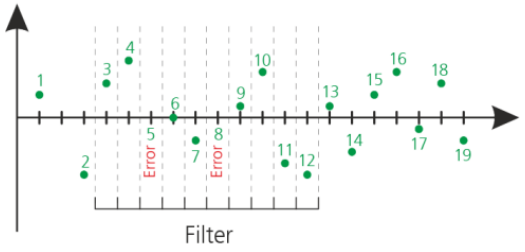
The commands to configure the user offset and user gain are described in 9.4.2 Set/Get user distance offset (sNuof) and 9.4.3 Set/Get user distance gain (sNuga).

7.4.3 Output filter (Distance / error)

The LLB laser sensor has a configurable output filter for the measurement values (Distance and error codes). There are different filter types available to allow a lot of filter possibilities. Please note that the filters only work and make sense for continuous distance measurement e.g. 9.2.3 Single sensor tracking (sNh) and others.
The output filter is available on the following measuring characteristics (for more details about the measuring characteristics, see 7.3 Measuring characteristic):

- Normal
- Fast
- Precise
- Timed

The output value filter is based on a moving average filter and supports in addition a spike suppression filter and error suppression filter. The filter functionality are described in the table below. The configuration command of the supported filter types are described in 9.3.13 Set/Get measurement filter configuration (`sNfi`).

	**Moving average filter** The moving average filter averages a specified number of measurements. A maximum of 32 measurement values can be averaged (Length of filter is configurable). If a new measurement value is present, this value will be added to the filter values, while the latest value will be removed. The sum of all measurement values divided by the size of the filter is the filtered measurement value and transmitted to all outputs.
	**Spike suppression filter** The spike suppression filter eliminates pairs of minimum and maximum values inside the filter values (Number of eliminated minimum / maximum pairs is configurable). Always the lowest and highest values are removed from the average filter calculation.
	**Error suppression filter** A maximum number of errors inside the average filter values can be suppressed (Number of suppressed errors is configurable). If the number of errors inside the average filter values is smaller than the specified number of error suppression, no error is shown at the output.

7.4.4 Moving Target filter

The LLB laser sensor has a specific Moving Target filter optimized for measuring on a continuous moving target.

This filter is automatically switched on for Moving Target measurement characteristic configurations. Consider no other filer can be used simultaneously (compare chapter 7.4.3 Output filter (Distance / error) for other filter options).

7.4.5 Additional filter functionality

The LLB laser distance sensors provide some additional measurement filter configurations. These configurations can be used at the same time than the Output filter (Distance / error) (see chapter 7.4.3) or the Moving Target filter(see chapter 7.4.4) unless otherwise stated. The corresponding command can be found in chapter 9.4.5 Set/Get additional measurement filter configuration (sNafi).

The configuration possibilities allow special functionalities e.g. for positioning applications in the logistics. For more details about the available additional filter configurations, see the table below.

No.	Description measurement filter configurations:	Configuration example
1	Distance jump detection (plausibility check of measured distance). 0 –› Filter disabled, > 0 –› Max. allowed distance change in [0.1 mm] Every new measured distance will be automatic checked against max. configured allowed distance jump / change. This feature is only available for tracking measurement.	sNafi+1+5000 Max. allowed distance jump / change: ± 500 mm.
2	Additional calming filter for distance measurements in Moving Target configuration. This filter smooths distance readings needed in some applications. 0 –› Filter disabled, 1...400 –› Calming filter length High filter lengths results in more distance calming / smoothing. Note that the response time of the sensor decreases accordingly when using long filter lengths. It's recommended to start with low filter lengths.	sNafi+2+100 Calming filter length of 100.
3	Additional plausibility check of the signal measurement data (signal monitoring). The max. allowed signal change / jump can be configured in %. 0 –› Filter disabled, > 0 –› Max. allowed signal change in [%] Signal change check between the last and newest measurement is done according above configuration.	sNafi+3+30 Max. allowed signal change against last valid signals ± 30%. Remark: Linear signal output configuration via sNum+5 command.
4…n	Not used.	

7.5 Digital Output

The digital outputs of the LLB laser distance sensors allows a wide range of configurations to be flexible for many applications. The following configurations are available for the digital output 1 and 2 independently:

- Data source: Distance (Default), speed, signal or temperature
- Switching function: Hysteresis (Default) or pulse
- Pulse width: Only for pulse function

In the following figure the configuration possibilities with the corresponding commands are shown for both digital outputs. The descriptions of the commands can be found in chapter 9.4.6 Set/Get additional digital output configuration (`sNado`) and 9.3.7 Set/Get digital output hysteresis (`sN1, sN2`).

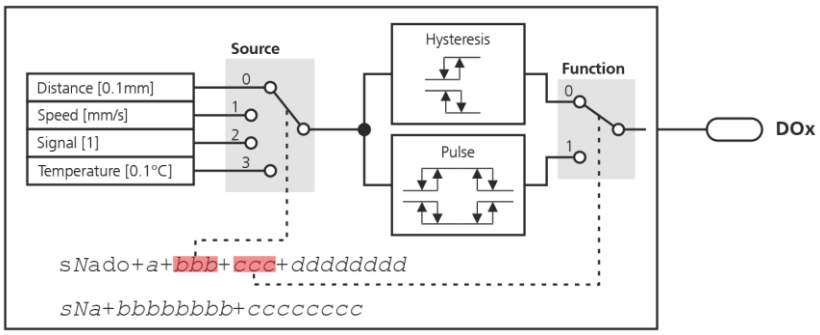


Figure 23: Configuration possibilities of the digital output 1 and 2 (Data source and switching function).

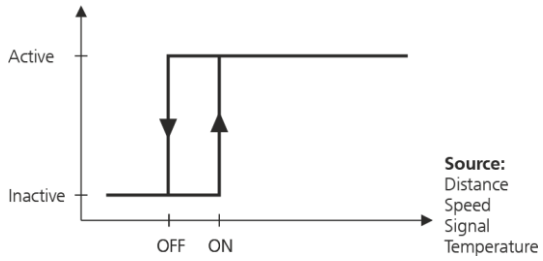
Remark: Configuration independently for digital output 1 and 2.

Note, the digital output type can also be configured if needed. However, this always applies to all outputs. For more details see chapter 6.4 Digital output and 9.3.6 Set/Get digital output type (`sNot`) for the corresponding configuration command.

7.5.1 Switching functions

There is a hysteresis and a pulse switching function available. Both of them can be configured with two polarities also shown in figure 26. The polarity will be selected by the values of the ON and OFF level of the first hysteresis. A total of four different configurations are thus possible.

1) Hysteresis: ON level > OFF level

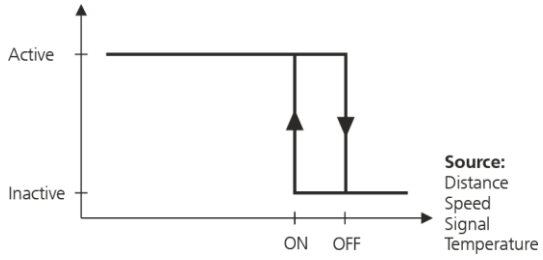


This description and figure is valid for hysteresis configuration and if the configured ON level of the hysteresis is greater than the OFF level.

Switching behavior of the shown hysteresis:

With a rising value (x-axis), the digital output is switched active as soon as the value exceeds the ON level. With a falling value, the digital output is switched inactive as soon as the value falls below the OFF level again.

2) Hysteresis: ON level < OFF level

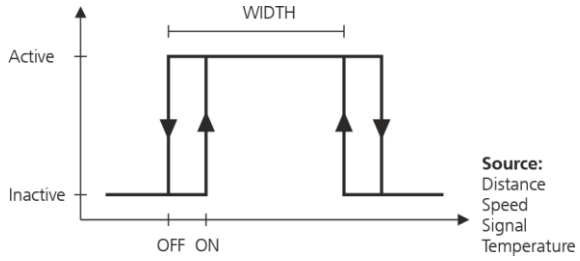


This description and figure is valid for hysteresis configuration and if the configured OFF level of the hysteresis is greater than the ON level.

Switching behavior of the shown hysteresis:

With a rising value (x-axis), the digital output is switched inactive as soon as the value exceeds the OFF level. With a falling value, the digital output is switched active as soon as the value falls below the ON level again.

3) Pulse: ON level > OFF level

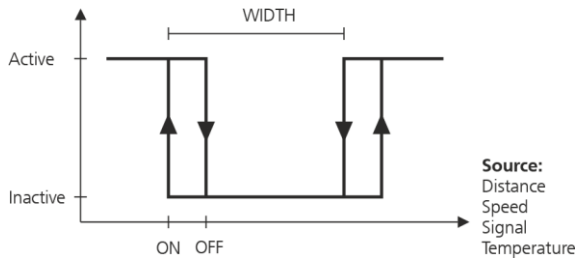


This description and figure is valid for pulse configuration and if the configured ON level of the first hysteresis is greater than the OFF level.

Switching behavior of the shown pulse:

With a rising value (x-axis), the digital output is switched active as soon as the value exceeds the ON level, but only until the value also exceeds the ON + WIDTH level. With a falling value, the digital output is switched active as soon as the value falls below the OFF + WIDTH level, but only until the value also falls below the OFF level.

4) Pulse: OFF level > ON level



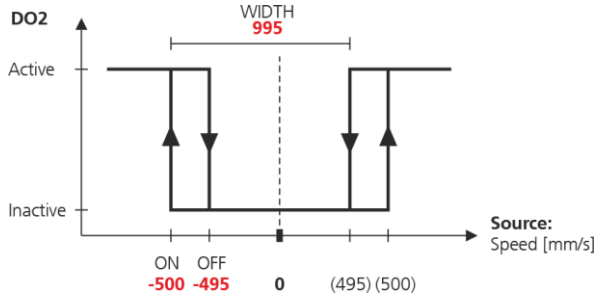
This description and figure is valid for pulse configuration and if the configured OFF level of the first hysteresis is greater than the ON level.

Switching behavior of the shown pulse:

With a rising value (x-axis), the digital output is switched inactive as soon as the value exceeds the OFF level, but only until the value also exceeds the OFF + WIDTH level. With a falling value, the digital output is switched inactive as soon as the value falls below the ON + WIDTH level, but only until the value also falls below the ON level.

Example:

In this example the digital output 2 (DO2) will be configured to supervise the moving speed of the sensor or accordingly of the measuring target. In case of a detected speed greater than ± 500 mm/s (± 0.5 m/s), the digital output 2 must indicate this by switching to the active state.



Used commands for this example:

1. Set additional digital output configuration:
(Number: 2, Source: Speed, Function: Pulse, Pulse width: 995) sNado+2+1+1+995

2. Set digital output hysteresis:
(Number: 2, ON level: -500, OFF level: -495)
sN2-500-495

7.6 Factory settings

The following table shows the default sensor configuration (factory settings). These configurations are set in a new sensor or after a successful reset. To reset the device to the factory default, see the reset process described in 6.2 Reset push button on page 27.

Configuration parameter	Factory default
Digital input 1 (DO1/DI1)	Inactive
Digital output type (DO1, DO2, DOE)	NPN output type
Digital output 1 (DO1/DI1)	ON level: 2005 mm OFF level: 1995 mm
Digital output 2 (DO1/DI1)	ON level: 995 mm OFF level: 1005 mm
Analog output	4...20 mA for 0...10 m distance 0 mA in error case
Sensor ID	0
Serial communication settings (RS-232, RS-422 / RS-485)	7 (19'200 Baud, 7 data bits, parity even, 1 stop bit)
RS-422 / RS-485	RS-422 / RS-485 active
SSI interface	SSI Inactive Data coding: Binary Data format: 24-Bit No error state and error code added Error value: 0
Sensor behavior – Operation mode	Controlled mode (Auto start and user mode inactive)
Sensor behavior – Measurement characteristic	0 (Normal)
Sensor behavior – Data output	Gain: 1 Offset: 0 mm Format: 0 (Default commands answers, no display output format) Filter: Inactive

8 Operation

8.1 Measurement overview

The LLB laser sensors supports different measurement possibilities to cover high variety of applications. The table below shows the available distance measurement commands and some basic commands. The distance measurement commands are separated in two groups. The “Distance measurement” group commands can be used for one or more sensors on a single line (e.g. multiple sensors on the RS-422 interface). The other command group “Single distance measurement” is only for one sensor on a single line. Otherwise there could be communication problems.

Group	Measurement possibilities	Commands
Basic measurement (one or more sensors on a single line)	Clear sensor / Stop measurement	9.2.1 Stop / Clear command (`sNc`)
	Laser on (Pointing for sensor adjustment)	9.2.10 Laser on (`sNo`)
	Signal measurement (Single tracking possible)	9.2.7 Signal measurement (`sNm`)
	Temperature measurement	9.2.8 Temperature measurement (`sNt`)
	Read / Clear error stack	9.2.9 Read/Clear error stack (`sNre, sNce`)
Distance measurement (one or more sensors on a single line)	Distance measurement	9.2.2 Distance measurement (`sNg`)
	Tracking distance measure-ment with buffering	9.2.5 Tracking with buffering – Start (`sNf`) 9.2.6 Read out – Tracking with buffering (`sNq`)
Single distance measurement (**only** one sensor on a single line)	Single tracking distance measurement	9.2.3 Single sensor tracking (`sNh`)
	Single tracking distance measurement with timer	9.2.4 Single sensor tracking with timer (`sNh`)

8.2 Installation

8.2.1 Connection of the device

The connection of the LLB laser sensor is done with two screw terminal plugs. It's essential to do the connections of the device according the following sequence:

1) Check if power supply is off and used interfaces do not already transmit data
2) Wiring of the screw terminal plugs with used ports (Power supply and used device interface)
3) Connect the screw terminal plugs (First the screw terminal plug with power supply)
4) Assemble the exchangeable cover and the LLB laser sensor carefully.
   - Before tighten the exchangeable cover: Check that the cover is properly aligned with the housing of the LLB device. Make sure the four centering bolts are in position before tighten the screws.
   - Tighten the four screws over cross to have an equably pressure on the gasket. The target torque for these screws (Philips Slotted Combo, Philips size 1, slot size 2) is 1.6 Ncm.
5) Switch on the power supply
6) The device is read for operation

NOTICE

Connect the screw terminal plugs under voltage or while some interfaces are already transmitting data can damage the device.

- ➢ Make sure that the sensors power supply and also the power supplies off all other devices connected to the senor are switched off when connection the screw terminals.
- ➢ No warranty will be granted on improper handling.

NOTICE

If the exchangeable cover or the cable gland is not assembled properly IP65 protection is not reached and the device can be damaged by entering water.

- ➢ Check if cover closes properly and that screws are turned tight. Use a target torque of 1.6 Ncm.
- ➢ Check if cable gland closes tight around the cable.

8.2.2 Mounting of the device

Generally, for outdoor applications it's recommend to use a protection against water, rain, snow, pollution, direct sunlight, etc. Since the LLB sensor is an optical measuring system with lenses, the sensor optics must always be clean to ensure reliable distance measurements. Install a roof or a housing to protect the sensors

Always follow all applicable safety regulations and never use the device outside the specifications stated under 5 Technical data on page 22.

NOTICE

When LLB laser sensors are mounted with the exchangeable cover facing upwards drooping water could enter through the valve diaphragm and damage the device.

- ➢ Cover the sensor to prevent water from dropping on the valve diaphragm.

8.2.3 Mounting of reflective plate

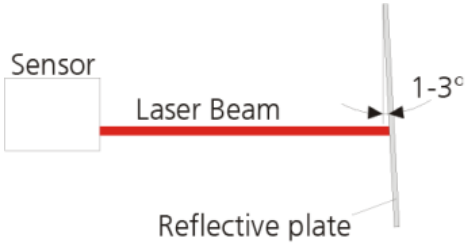


Figure 24: Mounting of reflective plates

Measuring to the reflective plate may generate erroneous measurements, if the reflective plate is mounted exactly at an angle of 90° to the laser beam. Therefore, mount the reflective plate like shown in Figure 24. This prevents the device from too high reflections direct to the receiver lens or laser output.

Avoid direct sunlight on the reflective plate to increase measurement performance.

The measuring range (min. / max. distance) on the reflective plate depends on the LLB device type. Please check the device specifications in chapter 5.1 Device specifications.

8.2.4 Alignment of the laser beam

The LLB sensor provides four hexagon socket set screw for easy sensor alignment. For more details see chapter 4.2. But alignment of the laser beam is often difficult when the target is far away. As a hint: As a coarse alignment at a nearer target distance may helps for such difficulties. Please contact TR Electronic GmbH for additional accessories.

For applications with two or more sensors measuring in the same or opposite direction ensure enough clearance between the laser spots. The laser must not point to another laser sensor directly.

NOTICE ***Never point with a laser sensor direct to the optics of another laser sensor. This may damage the sensor.***

- No warranty will be granted on improper handling.

8.3 Measuring performance influence

The LLB devices are optical instruments, whose operation is influenced by environmental conditions. Therefore, the measuring range and speed achieved in a specific application may vary. The following conditions can influence the measuring range and speed in a positive or negative manner:

Keywords	Factors increasing range / speed	Factors reducing range / speed
Target surface	Bright, matt and flat natural surfaces. Optimal natural surfaces: white, matt and flat Reflective surfaces such as the orange target plates.	Rough and dark surfaces
Airborne particles	Clean air	Dust, fog, heavy rainfall, heavy snowfall
Sunlight	Darkness, no sunlight	Bright sunlight on the target

The measurement range may also be influenced by the configuration of the measurement characteristic. See the descriptions of the measuring characteristics in 7.3 Measuring characteristic on page 45.

The LLB laser sensor does not compensate the influence of the atmospheric environment, which may be relevant when measuring long distances (e.g. > 150 m). These effects are described in H. Kahmen & W. Faig: “Surveying”, (1988).

8.4 Prevention of erroneous measurements

This chapter should help to prevent erroneous measurement with the LLB sensors. Please consider the following notes in the corresponding applications.

8.4.1 Rough surfaces

On a rough surface (e.g. coarse plaster) measure against the center of the illuminated area. To avoid measuring to the bottom of gaps in the surface use a target plate or board.

8.4.2 Transparent surfaces

To avoid measuring errors, do not measure against transparent surfaces such as colorless liquids (such as water) or (dust-free) glass. In case of unfamiliar materials and liquids, always carry out a trial measurement.

Erroneous measurements can occur when aiming through glass panes or if there are several objects in the line of sight.

8.4.3 Wet, smooth or high-gloss surfaces

- Aiming at an “acute” angle deflects the laser beam. The LLB device may receive a signal that is too weak (error message 255) or it may measure the distance targeted by the deflected laser beam.
- If aiming at a right angle, the LLB device may receive a signal that is too strong (error message 256).

NOTICE

Do not measure on high-gloss surfaces e.g. mirrors or other high reflective material. This may damage the sensor.

➢ No warranty will be granted on improper handling.

8.4.4 Inclined, round surfaces

Measurement is possible as long as there is enough target surface area for the laser spot. On irregular and round surfaces the arithmetic average of the illuminated surfaces will be measured.

8.4.5 Multiple reflections

Erroneous measurements may occur if the laser beam is reflected by other objects than the target. Avoid any reflective object along the measurement path.

NOTICE

Erroneous measurements may occur if the laser beam is reflected by other objects than the target.

➢ Avoid any reflective object along the measurement path.

8.4.6 Influence of other laser beams, sun light and others

NOTICE

Sunlight, flashlights or similar may disturb the distance measurement.

- Shading the sensor from the top and the sides can help to reduce these disturbances.

NOTICE

Aiming directly to the sun or the sun is exactly behind the target may disturb the distance measurement or damage the LLB laser sensor.

NOTICE

Air flickers may disturb the distance measurement.

NOTICE

Laser beams of other sensors or devices may disturb the distance measurement or damage the LLB laser sensor. No warranty will be granted on improper handling.

- Other laser beams must be aligned with enough clearance to the LLB sensor optic.
- No warranty will be granted on improper handling.

8.5 Laser life time consideration

Since the life time of the laser is limited, operate the device in a way, that the laser is switched on only when necessary. The laser life time stated under 5.1 Device specifications on page 22 relates to the time while the laser is on. The following conditions affects the laser life time in a positive manner:

- Low ambient temperature (high temperatures reduce laser life time)
- Switch laser off if possible (only do continuous measurements if necessary)

8.6 Heating functionality

This chapter is only relevant for devices with heating option used to extend the min. temperature range. To enable proper functionality with such devices the following points have to be considered:

- Consider the required supply current, see the specifications in 5.1
- The sensor heating procedure takes some heating time before distance measurements are possible. The heating time depends on operating temperature (e.g. TOperating: -40°C –› Heating time: ~2...4 min).
- For application with continuous attached power supply (LLB device powered, green power LED on) the heating procedure is running automatically. There is no heating time to wait before distance measurement is possible.

9 Command set

9.1 General

9.1.1 Command termination

Every command for the LLB devices are ASCII based and terminated with <CrLf>[13] at the end of every command. The LLB devices command answers are terminated in the same manner (<CrLf>).

9.1.2 Device identification *N*

The LLB device can be addressed with a configurable device ID. This ID is represented in the commands by the placeholder *N*. At the location of *N* insert the Device ID.

9.1.3 Parameter separator

The command syntax uses the '+' sign as parameter separator. The '+' sign can be replaced by the minus '-' sign if applicable by the command.

9.1.4 Set/Get commands

All configuration commands of the LLB device are used to set new configuration values. The same command without a configuration value can also be used to read the set value. The corresponding command syntax is described with an example command (sNeg) below:

	Set command	***Get command***
Command	sNeg+aaaaaaaa<CrLf>	sNeg<CrLf>
Return successful	gNeg?<CrLf>	gNeg+aaaaaaaa<CrLf>
Return error	gN@Ezzz<CrLf>	gN@Ezzz<CrLf>
Parameters	*N* Device ID *aaaaaaaa* Command parameter / configuration value; + positive / - negative *zzz* Error code	

As an example for a device with the ID of 3 (Device ID → 3) the command above looks like the following: s3eg+100<CrLf> where '3' is the device ID and '+100' is the command parameter.

9.1.5 Startup sequence

After power-on, the LLB device does the initialization and afterward a startup string gN? over the serial interfaces. As described before, *N* is the placeholder for the device ID of the connected LLB sensor. After sending this startup string, the LLB device is ready to use.

[13] <CrLf>: Cr –› Carriage return, Lf –› Line feed

9.2 Operation commands

9.2.1 Stop / Clear command (sNc)

Stops the current execution and resets the status LEDs as well as the digital outputs.

	Command	
Command	sNc<CrLf>	
Return successful	gN?<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	*N* Device ID *zzz* Error code	

9.2.2 Distance measurement (sNg)

Triggers simple measurement of distance. Each new command cancels an active measurement.

	Command	
Command	sNg<CrLf>	
Return successful	gNg+aaaaaaaa<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	*N* Device ID *aaaaaaaa* Distance in 1/10 mm *zzz* Error code	

9.2.3 Single sensor tracking (sNh)

Triggers continuous measurements of the distance. The measurements are made as fast as possible (Measurement speed depends on target conditions). The measurements are continued until the Stop / Clear command (sNc) is issued. The status LEDs and the digital outputs are updated corresponding to the new measured distance. Due to the continuous measurement output the following notes / cautions have to be considered on a RS-422 / RS-485 line:

Do not use this command on a RS-485 line. On RS-485 it is only possible to stop continuous measurement with a power off/on cycle.

For more than one device on a RS-422 line first stop tracking before communicating with an other device.

	Command	
Command	sNh<CrLf>	
Return successful	gNh+aaaaaaaa<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	*N* Device ID *aaaaaaaa* Distance in 0.1 mm *zzz* Error code	

9.2.4 Single sensor tracking with timer (sNh)

This command does the same as the sNh command but with the possibility to set a desired sampling time / timer. The timer triggers continuous measurements in the set interval time. For Moving Target characteristic only sample time 0 is allowed. The measurements are continued until the Stop / Clear command (sNc) is issued. Due to the continuous measurement output the following notes / cautions have to be considered on a RS-422 / RS-485 line:

Do not use this command on a RS-485 line. On RS-485 it is only possible to stop continuous measurement with a power off/on cycle.

For more than one device on a RS-422 line first stop tracking before communicating with an other device.

	Command	
Command	sNh+aaa<CrLf>	
Return successful	gNh+bbbbbbbb<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	*N* Device ID *aaa* Sampling time in 1 ms (Range: 0...86'400'000 ms, 0 –› max possible rate) *bbbbbbbb* Distance in 0.1 mm *zzz* Error code	

9.2.5 Tracking with buffering – Start (sNf)

Triggers continuous measurements of the distance with internal buffering in the device (buffer for one measurement). The rate of measurements is defined with the sampling time. If the sampling time is set to zero, the measurements are executed as fast as possible (Measuring speed depends on target conditions). For Moving Target characteristic only sample time 0 is allowed. The latest measurement can be read out from the LLB sensor with the command sNq. The measurements are continued until the sNc command is issued.

	Set command	***Get command***
Command	sNf+aaa<CrLf>	sNf<CrLf>
Return successful	gNf?<CrLf>	gNf+aaaaaaaa<CrLf>
Return error	gN@Ezzz<CrLf>	gN@Ezzz<CrLf>
Parameters	*N* Device ID *aaaaaaaa* Sampling time in 1 ms (Range: 0...86'400'000 ms, 0 –› max possible rate) *zzz* Error code	

9.2.6 Read out – Tracking with buffering (sNq)

After starting “tracking with buffering” with the command sNf, the latest measurement can be read out from the sensor with the command sNq. This command does not work if the tracking with buffering is not started.

	Command	
Command	sNq<CrLf>	
Return successful	gNq+aaaaaaaa+b<CrLf>	
Return error	gN@Ezzz+b<CrLf>	
Parameters	*N* Device ID *aaaaaaaa* Distance in 0.1 mm *b* 0: No new measurement since last sNq command 1: One new measurement since last sNq command, not overwritten 2: More than one measurement since last sNq command, overwritten *zzz* Error code	

9.2.7 Signal measurement (sNm)

Signal measurement can be done continuously or with a single measurement. The signal strength is returned as a relative number in the typical range of 0 to ~25'000. The value for the signal strength is just an approximate value, it differs from device to device, device series and also depends on environment conditions. The repetitive signal measurements are continued until the Stop / Clear command (sNc) is issued. Due to the continuous measurement output possibility the following notes / cautions have to be considered on a RS-422 / RS-485 line:

Do not use the repetitive signal measurement command on a RS-485 line. On RS-485 it is only possible to stop continuous signal measurement with a power off/on cycle.

For more than one device on a RS-422 line first stop repetitive signal measurement before communicating with an other device.

	Command	
Command	sNm+a<CrLf>	
Return successful	gNm+bbbbbbbb<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	*N* Device ID *a* 0: Single measurement 1: Repetitive measurements (Warning: Consider the listed notes and cautions!) *bbbbbbbb* Signal strength (range 0.. ~25'000) *zzz* Error code	

9.2.8 Temperature measurement (sNt)

Triggers measurement of the temperature of the device.

	Command	
Command	sNt<CrLf>	
Return successful	gNt+aaaaaaaa<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	N Device ID aaaaaaaa Temperature in 0.1°C zzz Error code	

9.2.9 Read/Clear error stack (sNre, sNce)

Reads or clears the error stack of the device. The errors in the error stack are stored permanently until a clear error stack command (sNce) is done.

	Read command	Clear command
Command	sNre<CrLf>	sNce<CrLf>
Return successful	gNre+aaa+aaa+aaa+..<CrLf>	gNce?<CrLf>
Return error	gN@Ezzz<CrLf>	gN@Ezzz<CrLf>
Parameters	N Device ID aaa List of occurred error codes (stored since last error stack clear command sNce) First list entry is the last occurred error code, 0 –› No error). zzz Error code	

9.2.10 Laser on (sNo)

Switches the laser beam on for easy sensor adjustment. The laser is on until the Stop / Clear command (sNc) is issued.

	Command	
Command	sNo<CrLf>	
Return successful	gN?<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	N Device ID zzz Error code	

9.3 Configuration commands

Generally, the configuration commands are volatile until the configurations of the device are saved with the 9.3.16 Save configuration parameters (sNs) command. There exist some exceptions where the configurations will be saved automatically but these are explicitly mentioned.
For details about the configuration process and the possible configuration types see chapter 7.1.

Use the Save configuration parameters (sNs) command to save device configurations permanently.

9.3.1 Set communication settings (sNbr)

Sets the communication settings for the serial interface RS-232 / RS-422 / RS-485. The settings number 7 (marked with gray) is the default communication setting (factory default or after a device reset).

A change in the communication setting number will be activated after power off sequence.

	Command	
Command	sNbr+*aa*<CrLf>	
Return successful	g*N*?<CrLf>	
Return error	g*N*@E*zzz*<CrLf>	
Parameters	*N* Device ID *aa* Number of communication setting:	

aa	Baud rate	Data bits	Parity	Stop bits
1	9600	8	None	1
2	19200	8	None	1
6	9600	7	Even	1
7	19200	7	Even	1
10	115200	8	None	1
11	115200	7	Even	1

zzz Error code

9.3.2 Set device ID (sNid)

Sets the device identification *N*. The device ID *N* is used for the most of all commands.

	Command	
Command	sNid+*aa*<CrLf>	
Return successful	g*N*?<CrLf>	
Return error	g*N*@E*zzz*<CrLf>	
Parameters	*N* Device ID *aa* New device ID, range 0...99 *zzz* Error code	

9.3.3 Set/Get analog output min level (sNvm)

This command sets the minimum analog output current level (0 or 4 mA).

	Set command	Get command
Command	sNvm+a<CrLf>	sNvm<CrLf>
Return successful	gNvm?<CrLf>	gNvm+a<CrLf>
Return error	gN@Ezzz<CrLf>	gN@Ezzz<CrLf>
Parameters	N Device ID a Minimum current for analog output 0: Minimum current is 0 mA 1: Minimum current is 4 mA zzz Error code	

9.3.4 Set/Get analog output value in error case (sNve)

This command sets the analog output current level in mA in case of an error. This level can be lower than the minimum level set with the sNvm command.

	Set command	Get command
Command	sNve+aaa<CrLf>	sNve<CrLf>
Return successful	gNve?<CrLf>	sNve+aaa<CrLf>
Return error	gN@Ezzz<CrLf>	gN@Ezzz<CrLf>
Parameters	N Device ID aaa Value in case of an error in 0.1 mA If the value is set to 999, in case of an error keep the last valid distance zzz Error code	

9.3.5 Set/Get analog output distance range (sNv)

Sets the minimum and maximum distances corresponding to the minimum and maximum analog output current levels.

0...20 mA	4...20 mA
$Aout = \frac{DIST - D_{min}}{D_{max} - D_{min}} * 20\text{mA}$	$Aout = \frac{DIST - D_{min}}{D_{max} - D_{min}} * 16\ mA + 4\ mA$
Aout Analog current output *DIST* Actual measured distance D_{min} Distance programmed for the minimum output current D_{max} Distance programmed for the maximum output current	

	Set command	Get command
Command	s*N*v+*aaaaaaaa*+*bbbbbbbb*<CrLf>	s*N*v<CrLf>
Return successful	g*N*v?<CrLf>	g*N*v+*aaaaaaaa*+*bbbbbbbb*<CrLf>
Return error	g*N*@E*zzz*<CrLf>	g*N*@E*zzz*<CrLf>
Parameters	*N* Device ID *aaaaaaaa* Minimum distance in 1/10 mm corresponding to 0 mA / 4 mA *bbbbbbbb* Maximum distance in 1/10 mm corresponding to 20 mA *zzz* Error code	

9.3.6 Set/Get digital output type (sNot)

Sets the output type for all digital outputs. It's possible to select NPN, PNP or Push-Pull outputs.

The configuration of the output type takes effect on all digital outputs (DO1, DO2, DOE).

	Set command	Get command
Command	s*N*ot+*a*<CrLf>	s*N*ot<CrLf>
Return successful	g*N*ot?<CrLf>	g*N*ot+*a*?<CrLf>
Return error	g*N*@E*zzz*<CrLf>	g*N*@E*zzz*<CrLf>
Parameters	*N* Device ID *a* Digital output type (for all digital outputs): 0: NPN (Low driven, load between V+ and DOx output) 1: PNP (High driven, load between DOx output and GND) 2: Push-pull (Low & High driven) *zzz* Error code	

9.3.7 Set/Get digital output hysteresis (sN1, sN2)

Sets or gets the individual digital output hysteresis of the two digital outputs 1 and 2. For every output a switching ON and OFF level must be configured. For details about the configuration possibilities and its functionality see chapter 7.5.

	Set command	Get command
Command	s*N*a+*bbbbbbbb*+*cccccccc*<CrLf>	s*N*a<CrLf>
Return successful	g*N*a?<CrLf>	g*N*a+*bbbbbbbb*+*cccccccc*<CrLf>
Return error	g*N*@E*zzz*<CrLf>	g*N*@E*zzz*<CrLf>
Parameters	*N* Device ID *a* Digital output port (1 or 2) *bbbbbbbb* ON level of the hysteresis (unit depends on data source, [0.1 mm], [mm/s], [1] or [0.1 °C]) *cccccccc* OFF level of the hysteresis (unit depends on data source, [0.1 mm], [mm/s], [1] or [0.1 °C]) *zzz* Error code	

9.3.8 Set/Get digital input function (sNDI1)

The digital output DO1/DI1 of the LLB sensors can also be used as digital input. The command sNDI1 configures a function / event for the device. The level of the digital input can be read with the command sNRI.

Activation of a digital input function of DI1, deactivate the digital output DO1 automatically.

	Set command	***Get command***
Command	sNDI1+aaaaaaaa<CrLf>	sNDI1<CrLf>
Return successful	gNDI1?<CrLf>	sNDI1+aaaaaaaa<CrLf>
Return error	gN@Ezzz<CrLf>	gN@Ezzz<CrLf>
Parameters	N Device ID aaaaaaaa Digital input functions: 0: Digital input DI1 deactivated (Digital output DO1 activated) 2: Trigger Distance measurement (sNg) 3: Start/Stop Single sensor tracking (sNh) 4: Start/Stop Tracking with buffering and time (sNf+)[14] 8: Start/Stop Single sensor tracking with time (sNh+)[15] zzz Error code	

9.3.9 Get digital input (sNRI)

Reads the digital input level (low / high) of DO1/DI1. Note for the use of DO1 instead of DI1, this command reads the logical level of the digital output.

	Command	
Command	sNRI<CrLf>	
Return successful	gNRI+a<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	N Device ID a 0: Input Off (Signal Low) 1: Input On (Signal High) zzz Error code	

14 sNf+: Uses the tracking time set by a previous tracking command sNf+aaaaaaaa / sNh+aaaaaaaa (a –› Measuring time)

15 sNh+: Uses the tracking time set by a previous tracking command sNh+aaaaaaaa / sNf+aaaaaaaa (a –› Measuring time)

9.3.10 Set/Get configuration of RS-422/485 and SSI (sNSSI)

The SSI interface is not available on all LLB devices (check the device specification for details, see chapter 5.1) and is deactivated by default. The SSI and the RS-422/485 interfaces uses the same differential output driver, so only one of them can be activated at the same time.

Only one interface (RS-422/485 or SSI) can be activated at the same time.

	Set command	***Get command***
Command	s*N*SSI+*aaa*<CrLf>	s*N*SSI<CrLf>
Return successful	g*N*SSI?<CrLf>	g*N*SSI+*aaa*<CrLf>
Return error	g*N*@E*zzz*<CrLf>	g*N*@E*zzz*<CrLf>
Parameters	*N* Device ID *aaa* Binary coded settings: Bit 0 = 0: Activate RS-422/485 interface (SSI is deactivated) 1: Activate SSI interface with the following settings (RS-422/485 is deactivated) Bit 1= 0: Binary coded data output 1: Gray coded data output Bit 2 = 0: No error bit output 1: Error bit attached to the output data value Bit 3 = 0: No additional error data output 1: Attach 8-Bit error data (Calculation: Error data = Error code[16] - 200)[17] Bit 4…5 = 00: 24-Bit data value 01: 23-Bit data value 10: 25-Bit data value Bit 6…15: not used *zzz* Error code	

Configuration example: SSI activated, 23-Bit data (binary), 8-Bit error data (binary) and error bit

MSB																					LSB	MSB							LSB	
Data (23 Bit binary)																						Error data (binary)								Error bit
22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	0

Configuration:	Binary data: 11101_2 –› 29 Bit 0 = 1: SSI interface activated Bit 1 = 0: Binary coded data output Bit 2 = 1: Error bit attached to the output data value Bit 3 = 1: Attach 8-Bit SSI error data (Error code - 200) Bit 4 = 1: 23-Bit data value
Command:	s*N*SSI+29

16 Possible error codes of sensor, see table in chapter 9.6 Error codes.

17 Adaptation of sensor error code range for SSI transmission within 8-Bit. E.g.: @E255 (Low signal) – 200 = 55 (SSI error data for SSI transmission)

9.3.11 Set/Get error value of SSI output (sNSSIe)

In case of an error the SSI output will show a value corresponding to this configuration. There can be a replacement value in a range of 0 to 16777215 (24-Bit) or 0 to 8388607 (23-Bit), the last valid distance value or the error code. All values are shown either as binary value or gray coded depending on SSI configuration.

	Set command	***Get command***
Command	s*N*SSIe+*aaaaaaaa*<CrLf>	s*N*SSIe<CrLf>
Return successful	g*N*SSIe?<CrLf>	g*N*SSIe+*aaaaaaaa*<CrLf>
Return error	g*N*@E*zzz*<CrLf>	g*N*@E*zzz*<CrLf>
Parameters	*N* Device ID *aaaaaaaa* 0…2^{24}-1 / 0..2^{23}-1 –› Replacement value (depending on the SSI settings, the value will be converted to gray code). In case of an error, the data value will be replaced by this replacement value. -1: In case of an error the last distance value will stay at the output. -2: In case of an error, the error code will be at the output. *zzz* Error code	

9.3.12 Set/Get measuring characteristic (sNmc)

The LLB device provides different measuring characteristics to allow an adjustment of the measuring process of the device. This functionality makes it possible to optimize measuring accuracy and measuring speed for a specific application and its requirement. For detailed information about the available measuring characteristics, see 7.3 Measuring characteristic.

	Set command	***Get command***
Command	s*N*mc+*aaaaaaaa*<CrLf>	s*N*mc<CrLf>
Return successful	g*N*mc?<CrLf>	g*N*mc+*aaaaaaaa*<CrLf>
Return error	g*N*@E*zzz*<CrLf>	g*N*@E*zzz*<CrLf>
Parameters	*N* Device ID *aaaaaaaa* 0: Normal 1: Fast 2: Precise 3: Timed 4: Moving target *zzz* Error code	

9.3.13 Set/Get measurement filter configuration (sNfi)

The filter applied to the distance measurement values can be configured with the following parameters and guidlines.

	Set command	Get command
Command	sNfi+aa+bb+cc<CrLf>	sNfi<CrLf>
Return successful	gNfi?<CrLf>	gNfi+aa+bb+cc<CrLf>
Return error	gN@Ezzz<CrLf>	gN@Ezzz<CrLf>
Parameters	N Device ID aa Filter length (0 –› Filter off, 2...32 –› Allowed filter length) bb Number of spikes to suppress (always pairs of min and max value) cc Maximum number of errors to suppress. Condition: 2*bb + cc <= 0.4*aa zzz Error code	

9.3.14 Set/Get auto start configuration (sNA)

This command activates the stand-alone mode with auto start of the LLB devices. It triggers continuous measurements of the distance. The analog, digital and SSI outputs are updated according to the measured distance values. The sampling time defines the measurement rate. If the sampling time is set to zero, the measurements are executed as fast as possible (depending on target conditions). For Moving Target characteristic only sample time 0 is allowed. The stand-alone mode with auto start is active until the Stop / Clear command (sNc) is received by the device. The Stop / Clear command only suspends the stand-alone mode with auto start temporarily. To deactivate this mode permanently a Save configuration (sNs) command after the Stop / Clear command is necessary.

The stand-alone mode with auto start is stored permanently in the device and activated immediately. This mode is activated automatically after power on.

To stop / clear the stand-alone mode with auto start permanently a Save configuration (sNs) command after the Stop / Clear command is necessary.

Internally, “Tracking with buffering” is started (see command: sNf). Therefore, the latest measurement can also be read out from the device with the command sNq.

	Command	Get Command
Command	sNA+aaaaaaaa<CrLf>	sNA<CrLf>
Return successful	gNA?<CrLf>	gNA+aaaaaaaa<CrLf>
Return error	gN@Ezzz<CrLf>	gN@Ezzz<CrLf>
Parameters	N Device ID aaaaaaaa Sampling time in 1 ms (Range: 0...86'400'000 ms, 0 –› max possible rate) zzz Error code	

9.3.15 Set configuration parameters to factory default (sNd)

This command restores all configuration parameters to their factory default values. The parameters are written to the flash memory and therefore permanently saved.

This will also reset the communication settings to the factory default.

	Command	
Command	sNd<CrLf>	
Return successful	gN?<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	*N* Device ID *zzz* Error code	

9.3.16 Save configuration parameters (sNs)

This command saves all configuration parameters, which are set by the configuration commands above. The parameters are written to the flash memory.

	Command	
Command	sNs<CrLf>	
Return successful	gNs?<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	*N* Device ID *zzz* Error code	

9.4 Extended configuration commands

9.4.1 Set/Get user output format (sNuo)

This command allows the configuration of a user specific output format. The configuration only affects the selected serial interface RS-232, RS-422/485 and USB. For more details about the data output of the LLB sensor, see 7.4 Data output.

The user output format can be configured to fit the requirement of an external ASCII display. A parameter for the output format between 100 and 199 defines the format for an external display (User gain / offset are used too). The parameter (b) defines the field length of the ASCII display (including decimal point). The decimal point will be inserted at the position (counted from the right) defined by the parameter (a). The distance on the display will be right aligned. This format configuration is not applicable for RS-485.

It is also possible to use the default output format / protocol (Factory default) with a configured user gain and offset. The command parameter value of 200 sets this default format with activated user gain and offset (9.4.2 Set/Get user distance offset (sNuof) and 9.4.3 Set/Get user distance gain (sNuga)).

	Set command	Get command
Command	s*N*uo+*aaaaaaaa*<CrLf>	s*N*uo<CrLf>
Return successful	g*N*uo?<CrLf>	g*N*uo+*aaaaaaaa*<CrLf>
Return error	g*N*@E*zzz*<CrLf>	g*N*@E*zzz*<CrLf>
Parameters	*N* Device ID *aaaaaaaa* Output format: 0: Default format (Factory setting), e.g. “g0g+00001234\r\n” 1ab: Display output format (For external display), e.g. “1.234\r\n” a –› Number of digits after decimal point b –› Field with (sign included) must be greater than 0 Conditions: a≤b, if a=b, no decimal point is output. 200: Default format with user offset / gain active, e.g. “g0g-00000234\r\n” Distance output = (Distance + Offset) * Gain 300: Extended distance format and user offset / gain active. Format: Distance [0.1 mm] + Signal [1] + Temperature [0.1°C] e.g. “g0g+00000234+008384+254\r\n” 301: Extended distance format with additional speed data and user offset / gain active. Format Distance: [0.1 mm] + Signal [1] + Temperature [0.1°C] + Speed [mm/s]) e.g. “g0g+00000234+008384+254+000500\r\n” Remark: Speed value of +999999 indicates invalid speed data (only in Moving Target with distance jumps). *zzz* Error code	

9.4.2 Set/Get user distance offset (s*N*uof)

The user can set an individual user offset to create a user defined distance output value. This configuration takes effect in all distance measurement commands but only if the corresponding user output format is activated (see 9.4.1 Set/Get user output format (sNuo) for more details). The calculation of the user offset is described in 7.4.2 User gain / offset.

The user distance offset is only considered for the corresponding user output format and on the selected serial interface RS-232, RS422/485 and USB.

	Set command	Get command
Command	s*N*uof+*aaaaaaaa*<CrLf>	s*N*uof<CrLf>
Return successful	g*N*uof?<CrLf>	g*N*uof+*aaaaaaaa*<CrLf>
Return error	g*N*@E*zzz*<CrLf>	g*N*@E*zzz*<CrLf>
Parameters	*N* Device ID *aaaaaaaa* Offset in 1/10 mm (+/- offset possible) *zzz* Error code	

9.4.3 Set/Get user distance gain (sNuga)

The user can set an individual user gain to create a user defined distance output value. This configuration takes effect in all distance measurement commands but only if the corresponding user output format is activated (see 9.4.1 Set/Get user output format (sNuo) for more details). The calculation of the user gain is described in 7.4.2 User gain / offset.

The user distance offset is only considered for the corresponding user output format and on the selected serial interface RS-232, RS422/485 and USB.

	Set command	***Get command***
Command	sNuga+*aaaaaaaa*+*bbbbbbbb*<CrLf>	sNuga<CrLf>
Return successful	gNuga?<CrLf>	gNuga+*aaaaaaaa*+*bbbbbbbb*<CrLf>
Return error	g*N*@E*zzz*<CrLf>	g*N*@E*zzz*<CrLf>
Parameters	*N* Device ID *aaaaaaaa* GainNum –› Numerator of gain calculation *bbbbbbbb* GainDen –› Denominator of gain calculation (Attention: GainDen ≠ 0, must not be zero) *zzz* Error code	

9.4.4 Set/Get user mode (sNum)

This command allows the configuration of special user modes. For more details see TBD.

	Set command	***Get command***
Command	s*N*um+*a*<CrLf>	s*N*um<CrLf>
Return successful	g*N*um?<CrLf>	g*N*um+aaaaaaaa<CrLf>
Return error	g*N*@E*zzz*<CrLf>	g*N*@E*zzz*<CrLf>
Parameters	*N* Device ID *a* User mode number: 0: Default mode, no user mode active 2: Activate user mode for auto start with serial output enable (RS-232, RS-422/485, USB) 5: Activate user mode for linear signal output (e.g. used for signal monitoring function) Other: Not used *zzz* Error code	

9.4.5 Set/Get additional measurement filter configuration (sNafi)

This command allows additional measurement filter / feature configurations. For more details about the available configurations see the corresponding chapter 7.4.5.

	Set command	*Get command*
Command	sNafi+a+bbbbbbbb<CrLf>	sNafi+a<CrLf>
Return successful	gNafi+a?<CrLf>	gNafi+a+bbbbbbbb<CrLf>
Return error	gN@Ezzz<CrLf>	gN@Ezzz<CrLf>
Parameters	*N* Device ID *a* Additional filter / feature number: 1: Max. allowed distance change / jump configuration 2: Calming filter configuration for distance measurements in Moving Target 3: Max. allowed signal change (signal monitoring) configuration Other –› Not used bbbbbbbb If a =1: Max. allowed distance change / jump in 0.1 mm (0: Filter / Feature disabled) If a =2: Calming filter length 1...400 (0 –› Filter disabled) If a =3: Max. allowed signal change / jump in % (0: Filter / Feature disabled) *zzz* Error code	

9.4.6 Set/Get additional digital output configuration (sNado)

This command allows additional digital output configuration possibilities (data source, function and pulse width) for the digital output 1 and 2. For every output the data source, switching function and pulse width can be configured. For details about the configuration possibilities and its functionality see the corresponding chapter 7.5.

	Set command	*Get command*
Command	sNado+a+bbb+ccc+dddddddd<CrLf>	sNado+a<CrLf>
Return successful	gNado+a?<CrLf>	gNado+a+bbb+ccc+dddddddd<CrLf>
Return error	gN@Ezzz<CrLf>	gN@Ezzz<CrLf>
Parameters	*N* Device ID *a* Digital output number (1 or 2) bbb Data source used for the corresponding digital output: 0: Distance. Digital output levels (ON, OFF) and pulse width in [0.1 mm] 1: Speed. Digital output levels (ON, OFF) and pulse width in [mm/s] 2: Signal. Digital output levels (ON, OFF) and pulse width in [1] 3: Temperature: Digital output levels (ON, OFF) and pulse width in [0.1°C] ccc Switching function of the corresponding digital output: 0: Hysteresis. Digital output levels (ON, OFF) used. 1: Pulse. Digital output levels (ON, OFF) and pulse width used. dddddddd Pulse width in [0.1 mm], [mm/s], [1] or [0.1°C] (only used for pulse switching function) *zzz* Error code	

9.5 Information commands

9.5.1 Get software version (sNsv)

Reads the software version of the LLB device.

	Command	
Command	sNsv<CrLf>	
Return successful	gNsv+aaaabbbb<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	N Device ID aaaa Internal measuring module software version bbbb Interface software version zzz Error code	

9.5.2 Get serial number (sNsn)

Reads the serial number of the LLB device.

	Command	
Command	sNsn<CrLf>	
Return successful	gNsn+aaaaaaaa<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	N Device ID aaaaaaaa Serial number of the device zzz Error code	

9.5.3 Get device type (sNdt, dt)

Reads the device type of LLB device.

Never use **dt** command if more than one device is connected to the serial interfaces.

	Command	
Command	sNdt<CrLf> dt<CrLf>	
Return successful	gNdt+0xyy<CrLf>	
Return error	gN@Ezzz<CrLf>	
Parameters	N Device ID x Device series number yy Device number Output for 0xyy zzz Error code	

9.5.4 Get device generation and type (dg)

Reads the device generation & type of the LLB devices. The answer includes the device type, device generation and the active communication setting. Works only for newer sensor generations (starting from device generation C).

Never use this command if more than one device is connected to the serial interfaces.

	Command	
Command	dg<CrLf>	
Return successful	g*N*dg+*aaa*+*bc*<CrLf>	
Return error	g*N*@E*zzz*<CrLf>	
Parameters	*N* Device ID *aaa* Bit coded number to identify the device *b* Internal information *c* Communication settings (see command s*N*br) *zzz* Error code	

9.6 Error codes

The following table lists the most important error codes of the LLB devices. For not listed error codes, please contact TR Electronic GmbH.

No.[1)]	Format	Description	Troubleshooting
0		No error	No troubleshooting
200		Boot-up event of sensor	Used for error stack to see boot-up of the sensor
203	@E203	Wrong command, parameter or syntax	Check command, parameter and communication settings (Baud rate, stop bits, parity and termination).
210	@E210	Sensor not in tracking mode	Start tracking measurement first.
211	@E211	Tracking measurement time too short	Tracking measurement time of the device is too short for the measurement conditions. Increase measurement time or improve measurement conditions.
212	@E212	Command cannot be executed, while tracking measurement is active	Measurement has to be stopped with Stop / Clear command s*N*c before execute the new command.
220	@E220	Error in the serial communication	Check communication settings (Baud rate, stop bits, parity and termination).
230	@E230	Distance value overflow caused by wrong user configuration.	Check user offset / gain configuration.
233	@E233	Number cannot be displayed	Check output format
234	@E234	Distance not in measurement range	Check measurement setup and distance to the measuring surface / target.
236	@E236	Conflict in digital input / output DI1/DO1 configuration	Check digital input / output DI1/DO1 configuration. Only input or output possible, otherwise input / output conflict.
252	@E252	Temperature too high	Reduce ambient temperature. Contact TR Electronic GmbH if the error occurs at room temperature.

…

…

253	@E253	Temperature too low	Increase ambient temperature. For device with heater functionality, wait until heater increased temperature. Contact TR Electronic GmbH if the error occurs at room temperature.
255	@E255	Received signal too low or distance not in range	Check measurement setup and use higher reflective measuring surface. Contact TR Electronic GmbH if the error persist after checking the measurement setup.
256	@E256	Received signal too high	Check measurement setup and use lower reflective measuring surface. Contact TR Electronic GmbH if the error persist after checking the measurement setup.
257	@E257	Signal to Noise (SNR) too low (Background light too strong)	Increase signal from measuring target (check measuring target) and / or reduce background lights / noise (sunlight or other strong light source).
258	@E258	Power supply voltage is too high	Check the supply voltage against the device specification.
259	@E259	Power supply voltage is too low	Check the supply voltage against the device specification.
260	@E260	Signal too unstable for a distance measurement	Check measurement setup and use stable measuring surface
261	@E261	Distance change/jump higher than set limit	Check the application for not allowed distance jumps or adapt the configured limit. Restart measurement to clear the error condition.
262	@E262	Signal change/jump higher than set limit	Check the application for not allowed signal changes or adapt the configured limit. Restart measurement to clear the error condition.
263	@E263	Measurement not on TR Electronic reflective surface	Check the measurement surface or the sensor alignment. Measurements on TR Electronic orange reflective surface only is active.
284	@E284	Signal disturbance in the laser output	Check the small laser output glass for pollution. Clean the optical part carefully with a clean soft glasses cleaning cloth or cotton buds and avoid scratching.
290	@E290	Signal disturbance in the sensor optic e.g. laser output or receiver lens	Check the small laser output glass and the receiver lens for pollution. Clean the optical parts carefully with a clean soft glasses cleaning cloth and avoid scratching. Contact TR Electronic if the error persist after checking the measurement setup.
400	@E400	Firmware download for Industrial Ethernet module not possible, module is busy	Check connection and power of the LLB device. Proceed a power cycle and restart firmware download.
401	@E401	Firmware download for Industrial Ethernet module not possible, no module connected	Connect the Industrial Ethernet to the LLB device before starting firmware download.
402	@E402	Firmware download for measu-rement module not possible	Check connection and power of the LLB device. Proceed a power cycle and restart firmware download.
501	@E501	Industrial Ethernet distance out of range	Check measurement setup and distance to the measuring surface / target. Distance value must not be out of range 0...500 m.
502	@E502	Industrial Ethernet speed integer out of range	Speed data must not exceed ±20 m/s. Check for plausibility and measurement setup.
503	@E503	Industrial Ethernet distance integer or float out of range	Check distance unit settings and distance value according range of integer value. Distance value must not exceed 500 m.
Not listed		Please contact TR Electronic GmbH	

[1)] To calculate the error code out of the SSI error data (see 9.3.10 Set/Get configuration of RS-422/485 and SSI (sNSSI)), do the calculation as follows: Error code = SSI error data +200.

Before contacting TR Electronic GmbH, please prepare information about the following subjects. This will help to find out the cause of a failure / error:

- Device type and serial number
- Error code / codes and status LED's
- Short description of measuring setup
  (Used interface, configuration, measuring target, measurement conditions, etc.)
- Short description of the device behavior before, during and after error

10 Industrial Ethernet with exchangeable cover

10.1 Introduction

The exchangeable cover with Industrial Ethernet is an optional and powerful extension of the LLB laser sensors with the most popular Industrial Ethernet protocols – PROFINET®, EtherNet/IP™ and EtherCAT®. It's possible to assemble the exchangeable cover with Industrial Ethernet to almost all of the LLB laser sensor.

PROFINET®	EtherNet/IP™	EtherCAT® [18]
PROFINET	EtherNet/IP	EtherCAT

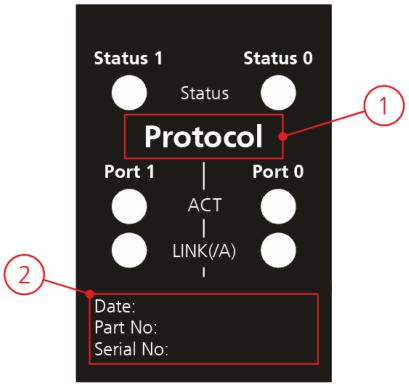
Key features:

- Most popular Industrial Ethernet interfaces available – PROFINET®, EthernNet/IP™ and EtherCAT®
- Simple assembling of the optional Industrial Ethernet interfaces to a LLB laser sensor
- Compact design of the exchangeable cover with Industrial Ethernet
- IP65 (Protected against ingress of dust and water) together with LLB laser sensor
- Wide range of power supply (12...30 VDC)
- Wide range of operating temperature (depends on LLB device)
- High cyclic measurement data exchange over Industrial Ethernet protocol (up to 500 Hz / ≥2 ms)
- Simple data structure of cyclic / acyclic data and integration in network
- Configuration possibilities of LLB laser sensor with cyclic and acyclic protocol communication

Use of controls, adjustments or performance of procedures other than those specified in this Technical Reference Manual may result in hazardous radiation exposure.

10.1.1 Product identification

The TR Electronic products are identified by the label on the top of the device. The identification on the label shows the main properties of each device. Every device has a unique identification. For more details see the figure below.



Identification of the exchangeable cover with Industrial Ethernet:

1) Description / Name of the Industrial Ethernet protocol running on the corresponding exchangeable cover with Industrial Ethernet Available Industrial Ethernet protocols: PROFINET®, EtherNet/IP™, EtherCAT®
2) Manufacturer data, part number and serial number of the corresponding exchangeable cover with Industrial Ethernet

Figure 25: Connection of digital input for external triggering

[18] EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

10.1.2 Components

The components of the exchangeable cover with Industrial Ethernet interfaces are marked in Figure 26.

1) Screws, Philips Slotted Combo (Philips size 1, slot size 2)
2) Industrial Ethernet protocol status LED's
3) Ribbon cable to connect exchangeable cover to LLB devices
4) Ethernet port 1 status LED's (Link, activity)
5) Ethernet port 0 status LED's (Link, activity)
6) Product label
7) Ethernet port 1
8) Valve diaphragm
9) Ethernet port 0
10) Power supply (for L device and exchangeable cover)

Figure 26: Components with detail information of the exchangeable cover with Industrial Ethernet

Take precaution against electrostatic discharge (ESD)

- The exchangeable cover with Industrial Ethernet is a sensitive electronic part and can be damaged by electrostatic discharge.
- Only handle the device properly grounded and with care.
- No warranty will be granted on improper handling and / or ESD caused problems.

10.1.3 Validity

This manual is valid for exchangeable cover with Industrial Ethernet and the following firmware version:

- Sensor interface board firmware version: **V1.21** or later
- Industrial Ethernet stack firmware version (for PROFINET®): **V4.3.0.9** or later
- Industrial Ethernet stack firmware version (for EtherNet/IP™): **V3.4.0.5** or later
- Industrial Ethernet stack firmware version (for EtherCAT®): **V4.7.0.4** or later

To get the firmware version see the parameter list of the corresponding Industrial Ethernet protocol.

10.2 Technical data

10.2.1 Specifications

	PROFINET®	EtherNet/IP™	EtherCAT®
Part number	**LLB502-20800**	**LLB502-20700**	**LLB502-20900**
Protocol specific Designator Specification	 PROFINET IO® See chapter 10.5.1	 EtherNet/IP™ See chapter 10.6.1	 EtherCAT® See chapter 10.7.1
Industrial Ethernet Number of ports Data rate	 2 100 Mbit/s (Full duplex)		
Power supply (LLB device incl. Industrial Ethernet) Voltage range Current consumption (at 24 VDC) [1)] Current consumption (at 12 VDC) [1)]	 12...30 VDC 0.25...0.6 A 0.8...1.0 A		
Temperature range during operation [2)]	-40...+50 °C		
Temperature range during storage	-40...+70 °C		
Degree of protection	IP65 (only if correct assembled with a LLB sensor)		
Relative humidity (operation / storage)	85% (RH), non-condensing		
Dimensions [3)]	68 x 58 x 47 mm		
Weight	90 g (with ribbon cable)		
Material	Polycarbonate (semi-transparent)		
Electromagnetic compatibility (EMC)	IEC/EN 61000-6-4 / 61000-6-3 IEC/EN 61000-6-2 / 61000-6-1		

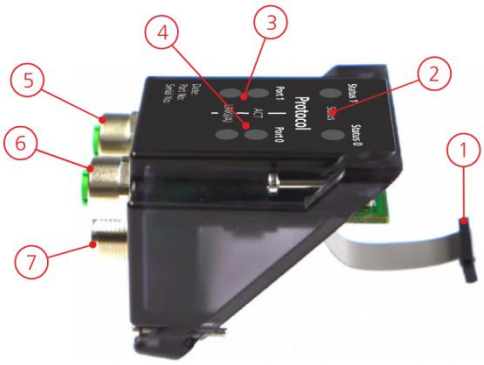
1) The current consumption is specified for an exchangeable cover with Industrial Ethernet connected to a LLB sensor. Consider that the current consumption of the LLB sensor depends on the supply voltage and the LLB sensor type. For details about the LLB sensor, see chapter 5 Technical data on page 22. Generally the exchangeable cover with Industrial Ethernet consumes about 1.6 W.

2) The temperature range for an exchangeable cover with Industrial Ethernet depends on the temperature range of the LLB sensor too.
Consider the specified temperature range of the connected LLB sensor. In case of permanent measurement (continuous distance measurement) the max. temperature during operation may be reduced.

3) The physical dimensions are specified for the exchangeable cover only. For the physical dimensions with a connected LLB sensor, see the device specific data sheet.

10.3 Electrical interfaces

The main electrical components of the exchangeable cover with Industrial Ethernet are described in the following chapter. The overview of the relevant components are labeled in Figure 27.



1) Ribbon cable (20 pin) to connect exchangeable cover with Industrial Ethernet to LLB devices
2) Industrial Ethernet protocol status LED's
3) Ethernet port 1 status LED's: LINK, ACT or L/A
4) Ethernet port 0 status LED's: LINK, ACT or L/A
5) Ethernet port 1 (M12 socket female, 4 pin, D coded)
6) Ethernet port 0 (M12 socket female, 4 pin, D coded)
7) Power supply (M12 socket male, 4 pin, A coded). Power supply used for LLB device and exchangeable cover with Industrial Ethernet.

Figure 27: Overview electrical components of the exchangeable cover with Industrial Ethernet

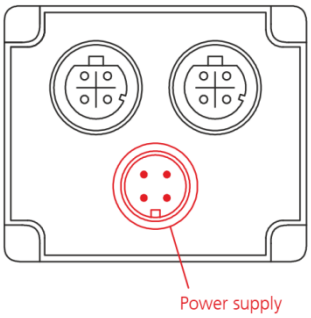
NOTICE

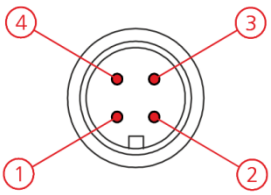
Take precaution against electrostatic discharge (ESD)

- The exchangeable cover with Industrial Ethernet is a sensitive electronic part and can be damaged by electrostatic discharge.
- Only handle the device properly grounded and with care.
- No warranty will be granted on improper handling and / or ESD caused problems.

10.3.1 Power supply

The connector for the power supply (M12 socket, A coded) is shown in Figure 28. The power supply of the exchangeable cover with Industrial Ethernet is also used for the LLB laser sensor. For this reason no additional power supply is needed for the LLB device. All of the exchangeable cover with Industrial Ethernet interfaces are overvoltage and reverse voltage protected. But for proper operation of the exchangeable covers consider the power supply requirements and the corresponding specifications. The metal case of the M12 connector is not connected to any shield or housing. For details about the shielding concept of the exchangeable cover and the connected LLB devices, see chapter 10.3.4.





Connection diagram of power supply connector (M12 socket male, 4 pin, A coded):

1) Supply voltage V+ (12...30 VDC)
2) Supply voltage GND (0 V)
3) Not connected (NC)
4) Not connected (NC)

Voltage and current requirements are detailed in chapter 10.2.1. Note that the current consumption depends on the LLB Series sensor type.

Figure 28: Connection of digital input for external triggering

⚠ CAUTION

NOTICE

Only use high-quality power supply equipment and consider the voltage and current requirements of the exchangeable cover with Industrial Ethernet.

- For trouble-free operation it's recommended to use a separate power supply for the sensors.

10.3.2 Ethernet ports

The connector for the Ethernet ports (M12 socket, D coded) are shown in Figure 29. There are two Ethernet ports for the Industrial Ethernet functionality available. How the Ethernet ports work depends on the Industrial Ethernet protocol. For more details see the protocol specific part in this manual.
The metal cases of the M12 connectors are connected individually over an R-C element to the aluminum housing (shield) of the LLB device. For details about the shielding concept of the exchangeable cover and the connected LLB devices, see chapter 10.4.

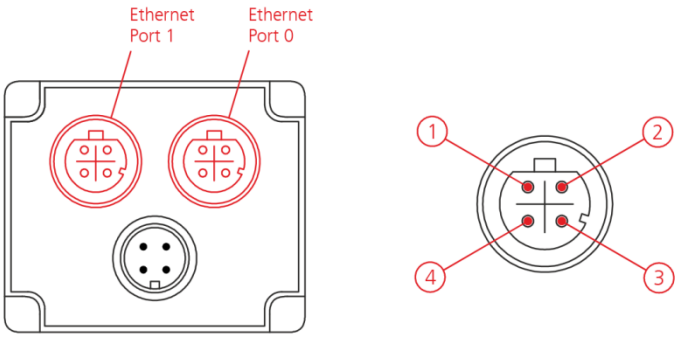


Figure 29: Connection diagram of the Ethernet port 0 & 1

Connection diagram of Ethernet port 0 and 1 (M12 socket female, 4 pin, D coded):

1) Transmit data positive (Tx+)
2) Receive data positive (Rx+)
3) Transmit data negative (Tx-)
4) Receive data negative (Rx-)

The Ethernet signals and connector are standard used in conjunction with Industrial Ethernet interfaces. For this reason no detailed specification is listed.

The following table lists the information about the Ethernet ports 0 & 1 (see figure 5) assignment used for the Industrial Ethernet protocol PROFINET®, EtherNet/IP™ and EtherCAT®.

Ethernet ports (Figure 29)	**PROFINET®**	**EtherNet/IP™**	**EtherCAT®**
Port 0	Port 1	Port 0	IN
Port 1	Port 2	Port 1	OUT

10.3.3 Ribbon cable

The ribbon cable of the exchangeable cover with Industrial Ethernet can be connected directly to a LLB laser sensor. The connection diagram is illustrated in Figure 30. This allows the extension of the available LLB device interfaces with optional Industrial Ethernet interfaces. For more details about the available Industrial Ethernet protocols, see the specification in 10.2.1.
To use the exchangeable cover with one of the available Industrial Ethernet protocols all other sensor connectors and interfaces have to be disconnected otherwise the LLB sensor or exchangeable cover may damage.

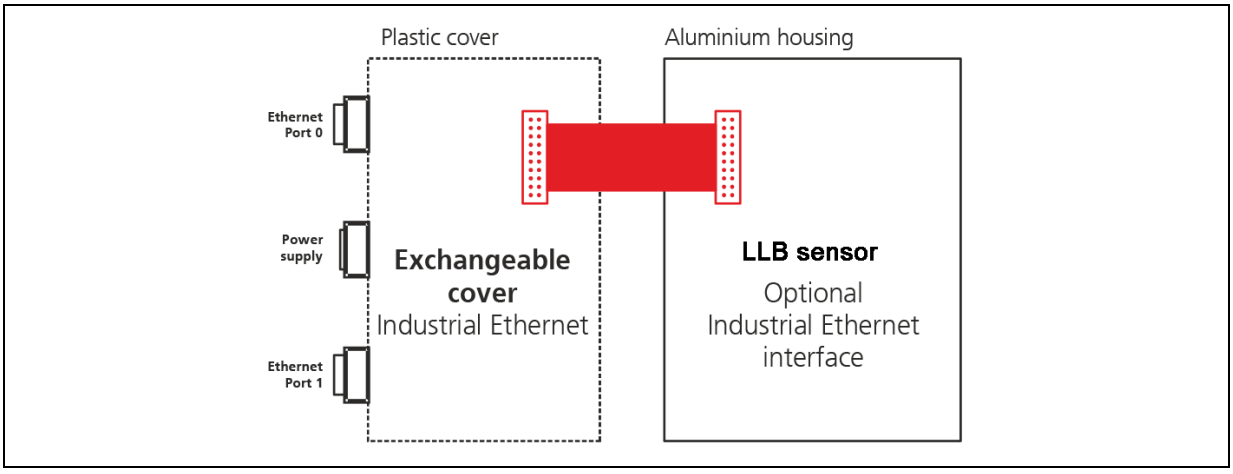


Figure 30: Connection diagram of exchangeable cover with Industrial Ethernet and LLB sensor

The connection of the exchangeable cover with Industrial Ethernet to a LLB sensor is done with the ribbon cable of the exchangeable cover.

Ribbon cable of exchangeable cover:

- 20 conductors with codded connectors
- Grid 0.635 mm
- Length 60 mm with connectors

The signals of the ribbon cable are not specified explicitly at this point. The optional Industrial Ethernet interface of the LLB devices is a TR Electronic specific interface.

Only use original TR Electronic flat ribbon cable to connect the LLB sensor with the exchangeable cover for Industrial Ethernet.

10.3.4 Shielding

The shielding concept of the exchangeable cover with Industrial Ethernet connected to a LLB laser sensor is shown in Figure 31 and described below.

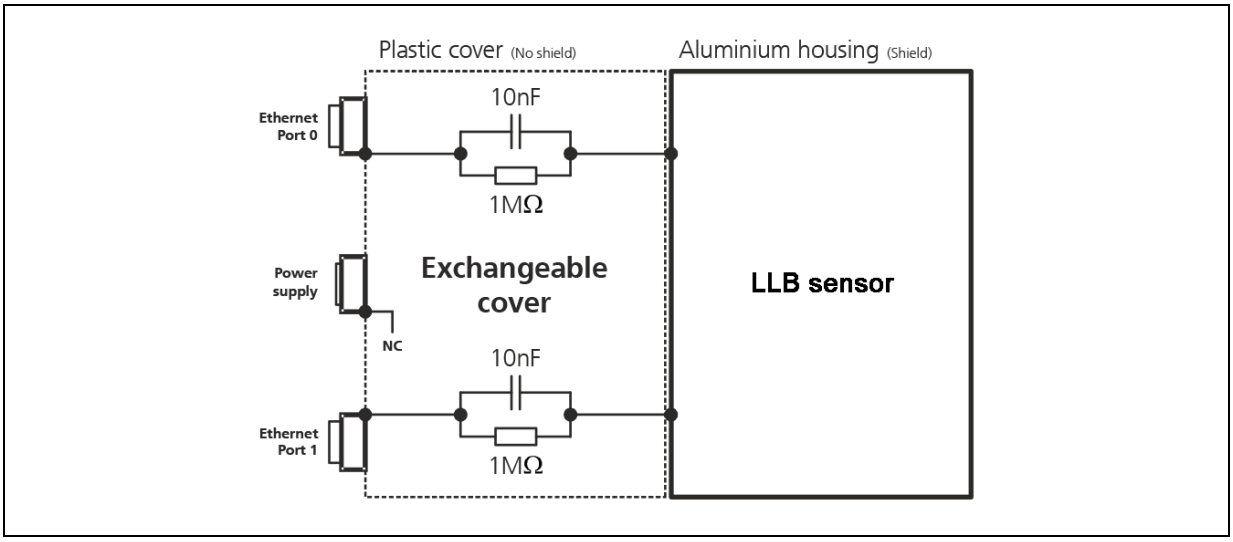


Figure 31: Shielding concept of the LLB sensor and the exchangeable cover with Industrial Ethernet

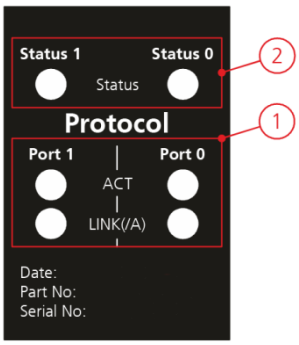
The exchangeable cover with Industrial Ethernet is made of plastic and so insulated (electrically). For that reason it's important to consider the shielding concept and the following information:

- The metal case of the power supply connector (M12 socket male, A coded) is not connected (NC) to the aluminum housing (shield) of the LLB device.
- The metal cases of the Ethernet port 0 & 1 connectors (M12 sockets female, D coded) are connected individually over an R-C element to the aluminum housing (shield) of the LLB device. Consider that this can only be guaranteed if the exchangeable cover is properly connected and assembled with the LLB laser sensor.

10.3.5 Status LED

The LED's on the exchangeable cover with Industrial Ethernet show the status of the corresponding Industrial Ethernet protocol (PROFINET®, EtherNet/IP™ or EtherCAT®) and the LINK, ACT and L/A on the Ethernet ports.

The meaning of the LINK and ACT LED's of the Ethernet port 0 & 1 is almost the same for all Industrial Ethernet protocols (see the description below). But the meaning of the status LED's for the Industrial Ethernet protocol is different and depends on the corresponding protocol. For details about the status and the Ethernet port conditions, see the chapter of the corresponding Industrial Ethernet protocol.



Identification of the existing status LED's of the exchangeable cover with Industrial Ethernet:

1) Link and activity LED for Ethernet port 0 & 1
   LINK (green) and ACT (yellow) LED –› PROFINET®, EtherNet/IP™
   L/A (green) LED –› EtherCAT®
2) Status LED's (Status LED 0 & 1) of the Industrial Ethernet communication protocol. The description of the status LED's depends on the protocol. For details about the status conditions, see the chapter of the corresponding Industrial Ethernet protocol. Available Industrial Ethernet protocols: PROFINET®, EtherNet/IP™, EtherCAT®

LINK (L/): On when a link has been established on the corresponding Ethernet port.

ACT (/A): Flashing when data is received or transmitted on the corresponding Ethernet port.

Figure 32: Status LED's on exchangeable cover with Industrial Ethernet

10.4 Operation

10.4.1 Installation

The available optional Industrial Ethernet interfaces are designed as exchangeable cover. The most of the available LLB devices can be easy extended with such an optional Industrial Ethernet interface.

The installation procedure of the exchangeable cover is described in steps. To ensure a correct and proper assembling the steps has to be followed accurately. See the installation procedure below:

Take precaution against electrostatic discharge (ESD)

- The exchangeable cover with Industrial Ethernet is a sensitive electronic part and can be damaged by electrostatic discharge.
- Only handle the device properly grounded and with care.
- No warranty will be granted on improper handling and / or ESD caused problems.

NOTICE

Connecting the exchangeable cover for Industrial Ethernet to the sensor under voltage may damage one of these components.

- Switch of the power supply before connecting the exchangeable cover for Industrial Ethernet to the sensor
- No warranty will be granted on improper handling.

NOTICE

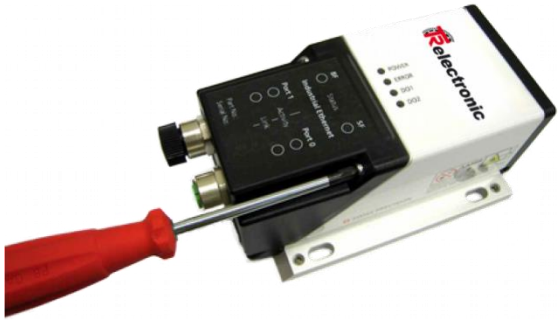
Connecting the exchangeable cover for Industrial Ethernet simultaneously with one of the other interfaces of the sensor may damage one of these components.

- Disconnect all other interface cables before connecting the exchangeable cover for Industrial Ethernet to the sensor.

1) Remove the standard cover with cable gland of the LLB laser sensor. Unbolt the four screws in the standard cover
(Philips Slotted Combo, Philips size 1, slot size 2)

2) Disconnect / Remove the screw terminal plug from the terminal block.
Never use the screw terminal block and the exchangeable cover with Industrial Ethernet together.

3) Connect the ribbon cable (20 conductors) of the exchangeable cover with Industrial Ethernet to the LLB device. The connection of the ribbon cable is shown on the left. Never connect the ribbon cable if any Ethernet port or power supply is connected to the exchangeable cover with Industrial Ethernet. For more details about the ribbon cable see chapter 10.3.3.



4) Assemble the exchangeable cover and the LLB laser sensor carefully. Check that the exchangeable cover fits the housing of the LLB device properly. Tighten the four screws in the exchangeable cover (Philips Slotted Combo, Philips size 1, slot size 2).

5) Connect the Ethernet connectors to the Ethernet ports 0 / 1 and the power supply connector to the exchangeable cover with Industrial Ethernet. For details about the connectors, see chapter 10.3.1 and 10.3.2.

6) The LLB laser sensor with exchangeable cover with Industrial Ethernet is ready for use.

10.4.2 General functionality

10.4.2.1 Cyclic / Acyclic data communication

The LLB device with Industrial Ethernet interface use cyclic (Process data) and acyclic communication for configuration, operation and identification. The cyclic and acyclic communication functionality is described below and illustrated in Figure 33.

- **Cyclic communication (Process data)**

  Used for measurement data and to control the LLB laser sensor. The cyclic process data consists of output and input data with fixed mapping and size. For the output data (Device input data) a data range check is done automatically. The sensor state parameter Sensor Output Data Limit Exceeded shows the state of this range check.

  For more details about the available cyclic process data (I/O data), see the marked rows in the table of chapter 10.4.3 Parameter description (Cyclic process data marked in the column Access – Cyclic).

- **Acyclic communication**

  Used to read sensor information (Serial number, part number, firmware versions, etc.) and to write some sensor configurations (Measurement speed, measurement characteristic and distance unit) acyclic to the cyclic communication. The acyclic data (/parameter) can be read and / or write independently according the defined acyclic access type.

  For more details about the available acyclic data access, see the marked rows in the table of chapter 10.4.3 Parameter description (Acyclic data access marked in the column Access – Acyclic).

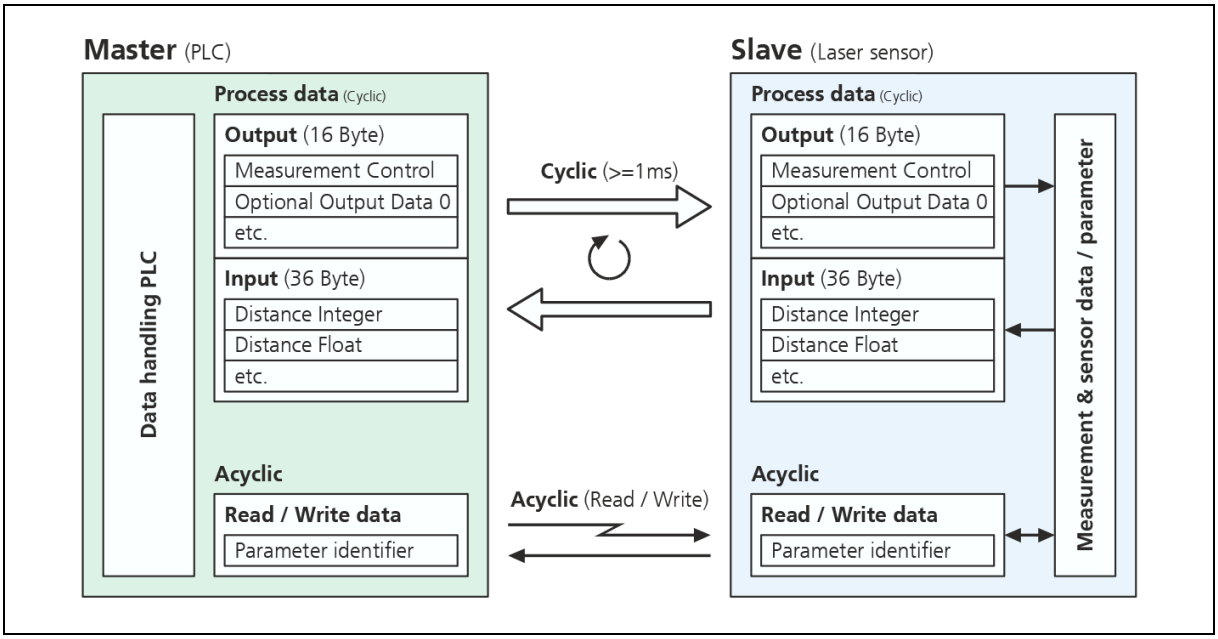


Figure 33: Cyclic (Process data) and acyclic communication between Industrial Ethernet Master (PLC) and the LLB device with Industrial Ethernet interface.

The cyclic and acyclic data access details (e.g. number, index, class, ...) are specified in separate tables for the available Industrial Ethernet interface protocols (PROFINET®, EtherNet/IP™, EtherCAT®). For details see the corresponding chapter.

For more details about the configuration and control possibilities and an example of a standard configuration and control sequence for a LLB laser sensor, see the following chapter 10.4.2.2 Control and configuration for details.

10.4.2.2 Control and configuration

The LLB laser sensor with Industrial Ethernet (exchangeable cover) can be controlled and configured in its entirety over the Industrial Ethernet interface with cyclic (Process data) and acyclic data communication. The control and configuration parameter are described in 10.4.3 Parameter description, see the parameter group “Measurement configuration”.

A standard configuration and control sequence for a LLB laser sensor with Industrial Ethernet is listed below. Precondition is the successful installation of the exchangeable cover with Industrial Ethernet, the connection of the power supply and the used Ethernet ports described in chapter 10.4.1.

STEP	Description	Access [1)]	Actions [2)]	Remark
1	Connection	-	Precondition is the correct installation / setup of the LLB device, see chapter 10.4.1.	
2		-	Turn on the power supply and check the green power LED on the LLB device.	Voltage range and current consumption in the specification (see chapter 10.2.1) have to be considered.
3	Control	Cycle	Set Measurement Control to 0 to stop distance measurement of LLB laser sensor.	For more details about the measurement control, see chapter 10.4.3 Parameter description.
4	Configuration	Acyclic	Set the Measurement Characteristic E.g. “Normal”	For the most application, the “Normal” measurement characteristic is fine. For more details about the available measurement characteristics, see chapter 10.4.3 Parameter description.
5		Acyclic	Set the Measurement Speed E.g. “0” for measurements as fast as possible	The measurement speed allows the configuration of an automatic distance measurement trigger in a defined speed range. For more details about the measurement speed, see chapter 10.4.3 Parameter description.
6		Acyclic	Set the Distance Unit E.g. “mm”	For more details about the available distance units, see chapter 10.4.3 Parameter description.
7	Control	Cycle	Set Measurement Control for start / stop of distance measurement of LLB laser sensor.	For more details about the measurement control, see chapter 10.4.3 Parameter description.
…	Operation	Cycle	Use cyclic process data with input and output data for measurement data (Distance, temperature, ...) and control	Cyclic process data will be updated with measurement data (only if Measurement Control was set to 1 / started before).
		Acyclic	Use acyclic read / write of data / parameter for additional information and configuration	Acyclic communication can be performed with low priority beside the cyclic process data communication. **Attention:** Some configurations take effect not before the measurement was stopped and restarted. For more details, see the corresponding configuration data in chapter 10.4.3 Parameter description.

1) The communication has to be cyclic or acyclic. Cyclic data (Process data) communication consists of output and input data (I/O data). Acyclic data communication allows read and / or write access. For details about the available cyclic / acyclic data access, see the markings in the table of chapter 10.4.3 Parameter description.

2) The used designation of cyclic and acyclic data (in italic) corresponds to the data / parameter table in chapter 10.4.3 Parameter description.

The sensor only considers changes in measurement speed and characteristics at measurement start. Setting Measurement Control to 0 stops the running measurement. When restarting the measurements the new configurations will be enabled.

10.4.3 Parameter description

The following table shows all available parameter (cyclic and acyclic data) of the exchangeable cover with Industrial Ethernet connected to a LLB laser sensor. For every single parameter with the specific designation the functionality, the data type with size, the lower / upper limits and the default value are described. The parameter are organized in parameter groups to simplify and make it clearly arranged.

Consider that the designations of every single parameter are exactly used in the descriptions of the cyclic process data and the acyclic data of the corresponding Industrial Ethernet protocol.

Group	Number	Designation	Description	Data type [1]	Default value	Limit		Access [2]	
						Lower	Upper	Cyclic	Acyclic
Measurement configuration	8193	Measurement Control	Measurement control to start and stop continuous distance measurement. 0 –› Stop / No measurement, 1 –› Start measurement (with configured speed and measurement characteristic) Remark: Configured measurement speed and measurement characteristic are only considered at measurement start. For another measurement configuration the measurement must be stopped first and then restarted again.	UINT16	0	0	1	O	R
	8194	Measurement Speed	Measurement time for a single distance measurement (Measurement speed of continuous measurement is calculated with 1 / Time). 0 –› Measurement as fast as possible, >0 –› Time in [ms] This configuration takes effect not before a new measurement is started. Remark: Measurement speed depends on measurement conditions and may vary.	UINT32	0	0	4000	-	R / W
	8195	Measurement Characteristic	Measurement characteristic configuration used for distance measurement. 0 –› Normal, 1 –› Fast, 2 –› Precise, 3 –› Timed, 4 –› Moving target Measurement characteristics enable the user to customize measurement behaviors in a specific measurement application. This configuration takes effect not before a new measurement is started. For more details about the available measurement characteristics, see chapter 7.3 Measuring characteristic on page 45.	UINT8	0	0	4	-	R / W
	8196	Distance Unit	Distance unit for distance output (configurable / selectable). 0 –› um, 1 –› mm, 2 –› cm, 3 –› m, 4 –› mil, 5 –› inch, 6 –› ft The distance unit configuration takes immediately effect on the distance parameters (Integer and float) of the LLB sensor.	UINT8	0	0	6	I	R / W

…

…

Measurement configuration	8197	Additional Measurement Filter 1	Additional plausibility check of the distance measurement by the max. allowed distance change / jump configuration. 0 –› Filter disabled, >0 –› Max. allowed distance change in [0.1 mm] Distance change check between the last and newest distance measurement is done according above configuration.	UINT32	0	0	5000000	-	R / W
	8198	Additional Measurement Filter 2	Additional calming filter for distance measurements in Moving Target (see parameter Measurement Characteristic) configuration. This filter smooths distance readings needed in some applications. 0 –› Filter disabled, 1...400 –› Calming filter length High filter lengths results in more distance calming / smoothing. Note that the response time of the sensor decreases accordingly when using long filter lengths. It's recommended to start.	UINT32	0	0	400	-	R / W
	8199	Additional Measurement Filter 3	Additional plausibility check of the signal measurement data (signal monitoring). The max. allowed signal change / jump can be configured in %. 0 –› Filter disabled, >0 –› Max. allowed signal change in [%] Signal change check between the last and newest measurement is done according above configuration.	UINT32	0	0	500	-	R / W
	8200	User mode	User mode for additional measurement functions. 0 (0x0000) –› Default (no additional functions) 32 (0x0020 –› Linear signal output enabled (e.g. used for signal monitoring function)	UINT16	0	0	0x003F	-	R / W
Options Output	8225	Optional Output Data 0	Optional output data. Currently not used.	UINT16	0	0	0x7FFF	O	R
	8226	Optional Output Data 1		UINT32	0	0	0x7FFFFFFF	O	R
	8227	Optional Output Data 2		UINT32	0	0	0x7FFFFFFF	O	R
	8228	Optional Output Data 3		UINT32	0	0	0x7FFFFFFF	O	R
Measurement	12289	Distance Integer	Measured distance as integer value in the configured / selected distance unit.	UINT32	0	0	0x7FFFFFFF	I	R
	12290	Distance Float	Measured distance as floating point value in the configured / selected distance unit.	FLOAT32	0.0	0.0	MAXFLOAT	I	R
	12291	Signal Strength	Signal strength of the active distance measurement. [1]	UINT32	0	0	0x7FFFFFFF	I	R
	12292	Temperature	Sensor temperature at the active distance measurement. [1/10 °C]	SINT16	0	-32768	32767	I	R

…

…

Measurement	12293	Measurement Actuality	Measurement actuality to show the state of the active distance measurement. 0 –› No new measurement, 1 –› New measurement, 2 –› Overwritten measurement	UINT8	0	0	2	I	R
	12294	Measurement Reserved	Reserved measurement data output. Currently not used.	UINT16	0	0	0x7FFF	I	R
Sensor State	12321	Sensor State	Sensor state for operation monitoring. 0 –› OK, 1 –› Info, 2 –› Warning, 3 –› Error	UINT8	0	0	0x7F	I	R
	12322	Sensor Output Data Limit Exceeded	Bit coded output data limit exceeded (lower or upper limit) warning. Limit exceeded indicator only used for process output data. Bit0 –› Measurement Control Bit1 –› Optional Output Data 0 Bit2 –› Optional Output Data 1 Bit3 –› Optional Output Data 2 Bit4 –› Optional Output Data 3 Bit5…7 –› Not used	UINT8	0	0	0xFF	I	R
	12323	Sensor Error Code	Sensor error code for troubleshooting (for error codes details see chapter 9.6 Error codes on page 74).	UINT16	0	0	0x7FFF	I	R
Options Input	12353	Optional Input Data 0	Optional input data. Currently not used.	UINT16	0	0	0x7FFF	I	R
	12354	Optional Input Data 1		UINT32	0	0	0x7FFFFFFF	I	R
	12355	Optional Input Data 2		UINT32	0	0	0x7FFFFFFF	I	R
	12356	Optional Input Data 3		UINT32	0	0	0x7FFFFFFF	I	R
Hardware Information	16385	Serial Number	Serial number of device LLB (without exchangeable cover).	UINT32				-	R
	16386	Part Number	Part number of device LLB (without exchangeable cover).	UINT32				-	R
	16387	Part Description	Part description of device LLB (without exchangeable cover).	STRING[20]				-	R
	16388	HW Version IF Board	Hardware version of device interface board LLB (without exchangeable cover).	UINT16				-	R
	16389	HW Version M Module	Hardware version of device measurement module LLB (without exchangeable cover).	UINT16				-	R
	16390	Serial Number RTE	Serial number of exchangeable covers with Industrial Ethernet.	UINT32				-	R
	16391	Part Number RTE	Part number of exchangeable cover with Industrial Ethernet.	UINT32				-	R
	16392	Part Description RTE	Part description of exchangeable cover with Industrial Ethernet.	STRING[20]				-	R
	16393	HW Version RTE	Hardware version of exchangeable cover with Industrial Ethernet.	UINT16				-	R

…

…

Firmware Information	16417	FW Version IF Board	Firmware version of device interface board LLB (without exchangeable cover).	UINT16				-	R
	16418	FW Version M Module	Firmware version of device measurement module LLB (without exchangeable cover).	UINT16				-	R
	16419	FW Version RTE SSBL	Not used. (Firmware version SSBL of the exchangeable cover with Industrial Ethernet)	UINT32				-	R
	16420	FW Version RTE Stack	Firmware version stack of the exchangeable cover with Industrial Ethernet.	UINT32				-	R

1) Data types: UINTx / SINTx used for unsigned / signed integer values, x for size / number of bits (e.g. UINT16 –› 16 Bit / 2 Byte). FLOATx used for floating point values, x for size / number of bits (e.g. FLOAT32 –› 32 Bit / 4 Byte). STRING[x] used for character string, x for size / number of bytes (e.g. STRING[20] –› 20 Byte).

2) Cyclic and acyclic data / parameter access: Column with cyclic access (process data), O –› Output data, I –› Input data. Column with acyclic access, R –› Read-only, R/W –› Read & Write.

10.4.4 Startup / Shutdown procedure

For startup or shutdown procedure the following points have to be considered:

- Power supply – Voltage range and current consumption (see the specifications in chapter 10.2.1)
- Do not switch on the power supply before the sensor finished the power down cycle properly.
- Do not switch off the power supply before the sensor finished the power up and configuration process properly.
- Stop measurement before switching off the sensors power supply.
- Do the sensor configuration (for more details see chapter 10.4.2.2) before starting the measurements

Power down before power up and configuration process is terminated properly may result in an unrecoverable problem condition.

10.4.5 Firmware download

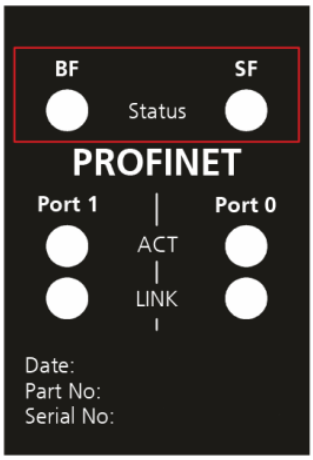
The exchangeable cover with Industrial Ethernet provides the possibility of a firmware download. Nonetheless the TR Electronic GmbH update policy comply with the following guidelines: It's not needed to generally update all Industrial Ethernet module. For normal operation a firmware update is often not necessary and the effort to do an update can be saved. For details or to check for needed updates please contact TR Electronic GmbH.

10.5 PROFINET®

10.5.1 Specifications

	Properties / Possibilities
Cyclic time	≥1 ms (RT_CLASS_1)
Baud rate	100 Mbit/s Full-Duplex mode
Topology recognition	LLDP, SNMP V1, MIB2, physical device
Cyclic process data	Distance data, measurement control, sensor state (For details see chapter 10.5.3.1)
Acyclic communication	Read and Write Record Service (For details see chapter 10.5.3.2)
Media redundancy	Media Redundancy Protocol (MRP) – Client
Supported protocols	RTC Real Time Cyclic Protocol, RT_CLASS_1 (unsynchronized) RTA Real Time Acyclic Protocol DCP Discovery and Configuration Protocol DCE/RPC Distributed Computing Environment /Remote Procedure Calls: Connectionless RPC LLDP Link Layer Discovery Protocol PTCP Precision Transparent Clock Protocol SNMP Simple Network Management Protocol
Identification & Maintenance	Reading / Writing of I&M1-3, Reading of I&M5
IRT support	Yes, 2 port IRT switch (no IRT application)
Additionally supported features	VLAN- and priority tagging
Multiple Application Relation (AR)	1 IO-AR, 1 Supervisor AR, 1 Supervisor-DA AR
PROFINET IO specification	V2.3, legacy startup of specification V2.2 is supported
Certification	PNIO version V2.33, net load class: CLASS III, conformance class (CC-B)
Supported topology	Star, Tree, Line or Ring

10.5.2 Status LED



The status LED's of the PROFINET® protocol are marked in Figure 34. The possible PROFINET® status conditions are displayed with two red status LED's with three LED states – OFF, ON or FLASHING.

Status LED's

- Bus Failure (BF) – Red LED
- System Failure (SF) – Red LED

The PROFINET® status conditions and some notes about troubleshooting are described in the table below.

Figure 34: PROFINET® status LED's

LED	Color	State	Measuring	Troubleshooting
SF (System Failure)	-	Off	No error	
	red	Flashing (1Hz)	DCP signal service is initiated via the bus.	
	red	Flashing (2Hz)	System error: Invalid configuration, Watchdog error or internal error	
BF (Bus Failure)	-	Off	OK: No error detected.	
	red	Flashing (2Hz)	Configuration fault: Device is not or not correctly configured.	Configure device or check configuration
	red	On	No error	Check wiring and connection
LINK	green	On	The device is linked to the Ethernet.	
	-	Off	The device has no link to the Ethernet	Check wiring and connection
ACT	yellow	Flashing	The device sends/receives Ethernet frames	
	-	Off	The device does not send/receive Ethernet frames	

10.5.3 Parameter list

10.5.3.1 Cyclic process data

The cyclic process data (grouped in input / output data with fixed mapping and size) of the LLB laser sensor with PROFINET® (exchangeable cover with Industrial Ethernet) are shown in the table below. Every single cyclic process data can be read with acyclic communication too (Remark: Read only, for more details see chapter 10.5.3.2).

Module Name IdentNumber	Submodule Name	Submodule IdentNumber	Slot	Subslot	Designation 1)	Data type	Access
Basic 0x00001000	Measurement Control	0x00001000	1	2	Measurement Control	UINT16	Output (Sensor input) 16 Byte
	Optional Output Data 0	0x00001001		3	Optional Output Data 0	UINT16	
	Optional Output Data 1	0x00001002		4	Optional Output Data 1	UINT32	
	Optional Output Data 2	0x00001003		5	Optional Output Data 2	UINT32	
	Optional Output Data 3	0x00001004		6	Optional Output Data 3	UINT32	
	Distance Integer	0x00002000		7	Distance Integer	UINT32	Input (Sensor output) 36 Byte
	Distance Float	0x00002001		8	Distance Float	FLOAT32	
	Signal Strength	0x00002002		9	Signal Strength	UINT32	
	Temperature	0x00002003		10	Temperature	SINT16	
	Distance Unit	0x00002004		11	Distance Unit	UINT8	
	Measurement Actuality	0x00002005		12	Measurement Actuality	UINT8	
	Measurement Reserved	0x00002006		13	Measurement Reserved	UINT16	
	Sensor State	0x00002007		14	Sensor State	UINT8	
	Sensor Output Data Limit Exceeded	0x00002008		15	Sensor Output Data Limit Exceeded	UINT8	
	Sensor Error Code	0x00002009		16	Sensor Error Code	UINT16	
	Optional Input Data 0	0x0000200A		17	Optional Input Data 0	UINT16	
	Optional Input Data 1	0x0000200B		18	Optional Input Data 1	UINT32	
	Optional Input Data 2	0x0000200C		19	Optional Input Data 2	UINT32	
	Optional Input Data 3	0x0000200D		20	Optional Input Data 3	UINT32	

1) The process data designation corresponds directly to the parameter designation in the chapter 10.4.3 Parameter description. For details and descriptions of the parameter, see this general parameter description.

10.5.3.2 Acyclic communication

The acyclic communication used for data read / write access of the LLB laser sensor with PROFINET® (exchangeable cover with Industrial Ethernet) are shown in the table below. The available access type of every data / parameter has to be considered. To access the data / parameter see the details about module, submodule, slot, subslot and index.

Module Name IdentNumber	Submodule Name IdentNumber	Slot	Sub slot	Index	Parameter-group	Designation [1]	Data type	Access type
Basic 0x00001000	Parameter Access Point 0x00000001	1	1	8193	Measurement Configuration	Measurement Control	UINT16	R
			1	8194		Measurement Speed	UINT32	R / W
			1	8195		Measurement Characteristic	UINT8	R / W
			1	8196		Distance Unit	UINT8	R / W
			1	8197		Additional Measurement Filter 1	UINT32	R / W
			1	8198		Additional Measurement Filter 2	UINT32	R / W
			1	8199		Additional Measurement Filter 3	UINT32	R / W
			1	8200		User mode	UINT16	R / W
			1	8225	Options Output	Optional Output Data 0	UINT16	R
			1	8226		Optional Output Data 1	UINT32	R
			1	8227		Optional Output Data 2	UINT32	R
			1	8228		Optional Output Data 3	UINT32	R
			1	12289	Measurement	Distance Integer	UINT32	R
			1	12290		Distance Float	FLOAT32	R
			1	12291		Signal Strength	UINT32	R
			1	12292		Temperature	SINT16	R
			1	12293		Measurement Actuality	UINT8	R
			1	12294		Measurement Reserved	UINT16	R
			1	12321	Sensor State	Sensor State	UINT8	R
			1	12322		Sensor Output Data Limit Exceeded	UINT8	R
			1	12323		Sensor Error Code	UINT16	R
			1	12353	Options Input	Optional Input Data 0	UINT16	R
			1	12354		Optional Input Data 1	UINT32	R
			1	12355		Optional Input Data 2	UINT32	R
			1	12356		Optional Input Data 3	UINT32	R
Laser Distance Sensor DX400 0x00000001	Parameter Access Point 0x00000010	0	1	16385	Hardware Information	Serial Number	UINT32	R
			1	16386		Part Number	UINT32	R
			1	16387		Part Description	STRING[20]	R
			1	16388		HW Version IF Board	UINT16	R
			1	16389		HW Version M Module	UINT16	R
			1	16390		Serial Number RTE	UINT32	R
			1	16391		Part Number RTE	UINT32	R
			1	16392		Part Description RTE	STRING[20]	R
			1	16393		HW Version RTE	UINT16	R
			1	16417	Firmware Information	FW Version IF Board	UINT16	R
			1	16418		FW Version M Module	UINT16	R
			1	16419		FW Version SSBL RTE	UINT32	R
			1	16420		FW Version Stack RTE	UINT32	R

[1] The acyclic data designation corresponds directly to the parameter designation in the chapter 10.4.3 Parameter description. For details and descriptions of the parameter, see this general parameter description.

10.5.4 Configuration

10.5.4.1 Overview

Name of Station	Factory default: “laserdistancesensor”

10.5.4.2 Device description file (GSDML)

General the GSDML are GSD files written in XML format and contains information about the basic capabilities and features of a PROFINET device. It allows system integrators the determination of basic data such as the communications options and the available diagnostics. The aim is to enable simple integration of PROFINET® devices into an engineering tool. GSDML editing can be accomplished with standard XML editors and should comply with ISO 15745, the base for device descriptions.
The required GSDML file for the PROFINET® protocol of the exchangeable cover with Industrial Ethernet can be downloaded from TR Electronic.

Download GSDML file: www.tr-electronic.de/f/TR-ELE-ID-MUL-0023

10.5.4.3 Software / Tools

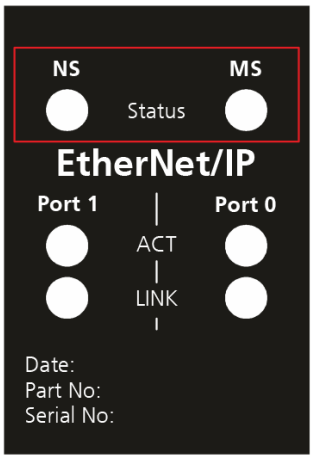
No additional software in needed. The configurations of the laser distance sensor can be done over the Industrial Ethernet interface.

10.6 EtherNet/IP™

10.6.1 Specifications

	Properties / Possibilities
IO Connection Types (implicit)	Exclusive Owner Listen Only Input only
IO Connection Trigger Types	Cyclic (min. 1 ms) Application triggered (min. 1 ms) Change of state (min. 1 ms)
Baud rate	10 / 100 Mbit/s
Duplex modes	Half duplex Full duplex Auto-Negotiation
MDI modes	MDI, MDI-X, Auto-MDIX
Data transport layer	Ethernet II, IEEE 802.3
Cyclic process data	Distance data, measurement control, sensor state (For details see chapter 10.6.3.1)
Acyclic communication	Set and Get Attribute (For details see chapter 10.6.3.2)
Predefined standard objects	Identity Object (0x01) Message Route Object (0x02) Assembly Object (0x04) Connection Manager (0x06) Ethernet Link Object (0xF6) TCP/IP Object (0xF5) DLR Object (0x47) QoS Object (0x48)
Features supported	DLR (Device Level Ring), beacon based “Ring Node” ACD (Address Conflict Detection) DHCP, BOOTP Integrated switch
Supported topology	Tree, Line or Ring

10.6.2 Status LED



The status LED's of the EtherNet/IP™ protocol are marked in Figure 35. The possible EtherNet/IP™ status conditions are displayed with two green and two red status LED's with three LED states – OFF, ON or FLASHING.

Status LED's

- Network Status (NS) – Green / Red LED
- Module Status (MS) – Green / Red LED

The EtherNet/IP™ status conditions and some notes about trouble-shooting are described in the table below.

Figure 35: EtherNet/IP™ status LED's

LED	Color	State	Measuring	Troubleshooting
MS (Module Status)	green	On	Device operational: The device is operating correctly.	
	green	Flashing (1Hz)	Standby: The device has not been configured.	
	red / green	Flashing (1Hz)	Selftest: The device is performing its power up testing.	
	red	Flashing (1Hz)	Minor fault: The device has detected a recoverable minor fault. E.g. an incorrect or inconsistent configuration can be considered as a minor fault.	Configure device or check configuration
	red	On	Major fault: The device has detected a nonrecoverable major fault.	
	-	Off	No power: The power supply to the device is missing.	Check wiring and connection
NS (Network Status)	green	On	Connected: The device has at least one established connection (even to the Message Router).	
	green	Flashing (1Hz)	No connections: The device has no established connections, but has obtained an IP address.	
	red / green	Flashing (1Hz)	Selftest: The device is performing its power up testing.	
	red	Flashing (1Hz)	Connection timeout: The device connections has timed out. This status will be finished only if timed out connections is reestablished or if the device is reset.	
	red	On	Duplicate IP: The device has detected that its IP address is already in use	Configure device or check configuration
	-	Off	Not powered, no IP address: The device does not have an IP address (or is powered off).	Check wiring and connection
LINK	green	On		
	-	Off	The device has no link to the Ethernet	Check wiring and connection
ACT	yellow	Flashing	The device sends/receives Ethernet frames	
	-	Off	The device does not send/receive Ethernet frames	

10.6.3 Parameter list

10.6.3.1 Cyclic process data

The cyclic process data (grouped in input / output data with fixed mapping and size) of the LLB laser sensor with EtherNet/IP™ (exchangeable cover with Industrial Ethernet) are shown in the table below. Every single cyclic process data can be read with acyclic communication too (Remark: Read only, for more details see chapter 10.6.3.2).

Assembly Name	Assembly	Class	Instance	Attribute	Designation [1)]	Data type	Access
Output Basic	0x64	0x64	1	1	Measurement Control	UINT16	Output (Sensor input) 16 Byte
		0x69	1	1	Optional Output Data 0	UINT16	
				2	Optional Output Data 1	UINT32	
				3	Optional Output Data 2	UINT32	
				4	Optional Output Data 3	UINT32	
Input Basic	0x96	0x82	1	1	Distance Integer	UINT32	Input (Sensor output) 36 Byte
				2	Distance Float	FLOAT32	
				3	Signal Strength	UINT32	
				4	Temperature	SINT16	
		0x64	1	4	Distance Unit	UINT8	
		0x82	1	5	Measurement Actuality	UINT8	
				6	Measurement Reserved	UINT16	
		0x87	1	1	Sensor State	UINT8	
				2	Sensor Output Data Limit Exceeded	UINT8	
				3	Sensor Error Code	UINT16	
		0x8C	1	1	Optional Input Data 0	UINT16	
				2	Optional Input Data 1	UINT32	
				3	Optional Input Data 2	UINT32	
				4	Optional Input Data 3	UINT32	

1) The process data designation corresponds directly to the parameter designation in the chapter 10.4.3 Parameter description. For details and descriptions of the parameter, see this general parameter description.

10.6.3.2 Acyclic communication

The acyclic communication used for data read / write access of the LLB laser sensor with EtherNet/IP ™ (exchangeable cover with Industrial Ethernet) are shown in the table below. The available access type of every data / parameter has to be considered. To access the data / parameter see the details about class, instance and attribute.

Class	Instance	Attribute	Parameter group	Designation [1)]	Data type	Access
0x64	1	1	Measurement Configuration	Measurement Control	UINT16	R
		2		Measurement Speed	UINT32	R / W
		3		Measurement Characteristic	UINT8	R / W
		4		Distance Unit	UINT8	R / W
		5		Additional Measurement Filter 1	UINT32	R / W
		6		Additional Measurement Filter 2	UINT32	R / W
		7		Additional Measurement Filter 3	UINT32	R / W
		8		User mode	UINT16	R / W
0x69	1	1	Options Output	Optional Output Data 0	UINT16	R
		2		Optional Output Data 1	UINT32	R
		3		Optional Output Data 2	UINT32	R
		4		Optional Output Data 3	UINT32	R
0x82	1	1	Measurement	Distance Integer	UINT32	R
		2		Distance Float	FLOAT32	R
		3		Signal Strength	UINT32	R
		4		Temperature	SINT16	R
		5		Measurement Actuality	UINT8	R
		6		Measurement Reserved	UINT16	R
0x87	1	1	Sensor State	Sensor State	UINT8	R
		2		Sensor Output Data Limit Exceeded	UINT8	R
		3		Sensor Error Code	UINT16	R
0x8C	1	1	Options Input	Optional Input Data 0	UINT16	R
		2		Optional Input Data 1	UINT32	R
		3		Optional Input Data 2	UINT32	R
		4		Optional Input Data 3	UINT32	R
0xA0	1	1	Hardware Information	Serial Number	UINT32	R
		2		Part Number	UINT32	R
		3		Part Description	STRING[20]	R
		4		HW Version IF Board	UINT16	R
		5		HW Version M Module	UINT16	R
		6		Serial Number RTE	UINT32	R
		7		Part Number RTE	UINT32	R
		8		Part Description RTE	STRING[20]	R
		9		HW Version RTE	UINT16	R
0xA5	1	1	Firmware Information	FW Version IF Board	UINT16	R
		2		FW Version M Module	UINT16	R
		3		FW Version SSBL RTE	UINT32	R
		4		FW Version Stack RTE	UINT32	R

1) The acyclic data designation corresponds directly to the parameter designation in the chapter 10.4.3 Parameter description. For details and descriptions of the parameter, see this general parameter description.

10.6.4 Configuration

10.6.4.1 Overview

Configuration control	Static / BOOTP / DHCP (Factory default: Static)
IP address	e.g. 192.168.0.20 (Factory default: 192.168.0.20
RUN / IDLE notification	RUN –› Cyclic process data exchange running IDLE –› Save values, no cyclic process data exchange

10.6.4.2 Electronic Data Sheet (EDS)

General the EDS (Electronic Data Sheet) files is an ASCII text file that describes the features of EtherNet/IP™ device and is used by software tools for device and network configuration.
The required EDS file for the EtherNet/IP™ protocol of the exchangeable cover with Industrial Ethernet can be downloaded from TR Electronic.

Download EDS file: www.tr-electronic.de/f/TR-ELE-ID-MUL-0022

10.6.4.3 Software / Tools

No additional software in needed. The configurations of the laser distance sensor can be done over the Industrial Ethernet interface.

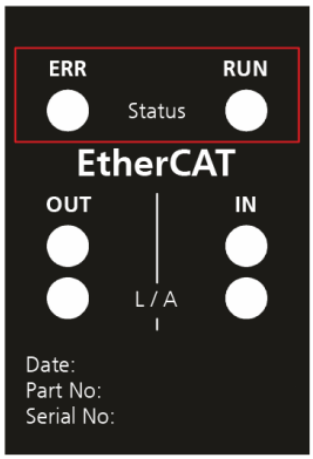
The “Ethernet Device Configuration” software (free of charge) from Hilscher can be used to find an EtherNet/IP™ device (e.g. MAC, IP,...). The software “BOOTP/DHCP Server” from Rockwell Automation can be used too to search and configure device settings. e.g. IP or configuration control (Static, DHCP, BOOTP).

10.7 EtherCAT®

10.7.1 Specifications

	Properties / Possibilities
Cyclic time	≥2 ms in Free Run Mode
Baud rate	100 Mbit/s
Cyclic process data	TxPDO with fixed mapping (For details see chapter 10.7.3.1)
Acyclic communication	SDO Master-Slave (For details see chapter 10.7.3.2)
Supported protocols	SDO client and server side protocol (CoE) File Access over EtherCAT® (FoE)
CoE (CAN application layer over EtherCAT®)	SDO Upload and SDO Download including SDO Complete Access SDO Information Service (Object Dictionary)
Mailbox size	Fix length of 128 Byte
SII (Slave Information Interface)	4 kByte
Type	Complex Slave
SYNC Manager	4
FMMU's (Fieldbus Memory Management Unit)	8
Explicit Device Identification	Set device identification by configuration tool
EtherCAT® Conformance	EtherCAT® Protocol: - EtherCAT® Conformance Test Tool V2.1.0.2 - EtherCAT® Conformance Test Record ETG7000-2 V1.2.8 ETG.1300 Indicator Specification ETG.9001 Marking rules Interoperability Test
Supported topology	Line or Ring

10.7.2 Status LED



The status LED's of the EtherCAT® protocol are marked in Figure 36. The possible EtherCAT® status conditions are displayed with a green and a red status LED's with three LED states – OFF, ON or FLASHING.

Status LED's

- Error status (ERR) – Red LED
- Run status (RUN) – Green LED

The EtherCAT® status conditions and some notes about troubleshooting are described in the table below.

Figure 36: EtherCAT® status LED's

LED	Color	State	Measuring	Troubleshooting
RUN	-	Off	INIT: The device is in INIT state.	
	green	Flashing (2.5Hz)	PRE-OPERATIONAL: The device is in PREOPERATIONAL state.	
	green	Flashing (10Hz)	BOOT: Device is in Boot mode.	
	green	Single Flash	SAFE-OPERATIONAL: The device is in SAFE-OPERATIONAL state.	
	green	On	OPERATIONAL: The device is in the OPERATIONAL state.	
ERR	-	Off	Slave has no errors	
	red	On	Slave has detected a communication error. The error is indicated in	Check wiring and connection the DPM.
LINK	green	On	The device is linked to the Ethernet.	
	-	Off	The device has no link to the Ethernet	Check wiring and connection
ACT	yellow	Flashing	The device sends/receives Ethernet frames	
	-	Off	The device does not send/receive Ethernet frames	

10.7.3 Parameter list

10.7.3.1 Cyclic process data

The cyclic process data (grouped in input / output data with fixed mapping and size) of the LLB laser sensor with EtherCAT® (exchangeable cover with Industrial Ethernet) are shown in the table below. Every single cyclic process data can be read with acyclic communication too (Remark: Read only, for more details see chapter 10.7.3.2).

PDO Name	PDO Index	PDO Subindex	Index	Subindex	Designation [1)]	Data type	Access
Output Basic	0x1600	0x01	0x2000	0x01	Measurement Control	UINT16	Output (Sensor input) 16 Byte
		0x02	0x2020	0x01	Optional Output Data 0	UINT16	
		0x03		0x02	Optional Output Data 1	UINT32	
		0x04		0x03	Optional Output Data 2	UINT32	
		0x05		0x04	Optional Output Data 3	UINT32	
Input Basic	0x1A00	0x01	0x3000	0x01	Distance Integer	UINT32	Input (Sensor output) 36 Byte
		0x02		0x02	Distance Float	FLOAT32	
		0x03		0x03	Signal Strength	UINT32	
		0x04		0x04	Temperature	SINT16	
		0x05	0x2000	0x04	Distance Unit	UINT8	
		0x06	0x3000	0x05	Measurement Actuality	UINT8	
		0x07		0x06	Measurement Reserved	UINT16	
		0x08	0x3020	0x01	Sensor State	UINT8	
		0x09		0x02	Sensor Output Data Limit Exceeded	UINT8	
		0x0A		0x03	Sensor Error Code	UINT16	
		0x0B	0x3040	0x01	Optional Input Data 0	UINT16	
		0x0C		0x02	Optional Input Data 1	UINT32	
		0x0D		0x03	Optional Input Data 2	UINT32	
		0x0E		0x04	Optional Input Data 3	UINT32	

1) The process data designation corresponds directly to the parameter designation in the chapter 10.4.3 Parameter description. For details and descriptions of the parameter, see this general parameter description.

10.7.3.2 Acyclic communication

The acyclic communication used for data read / write access of the LLB laser sensor with EtherCAT® (exchangeable cover with Industrial Ethernet) are shown in the table below. The available access type of every data / parameter has to be considered. To access the data / parameter see the details about the index and subindex.

Index	Subindex	Parameter group	Designation [1)]	Data type	Access
0x2000	0x01	Measurement Configuration	Measurement Control	UINT16	R
	0x02		Measurement Speed	UINT32	R / W
	0x03		Measurement Characteristic	UINT8	R / W
	0x04		Distance Unit	UINT8	R / W
	0x05		Additional Measurement Filter 1	UINT32	R / W
	0x06		Additional Measurement Filter 2	UINT32	R / W
	0x07		Additional Measurement Filter 3	UINT32	R / W
	0x08		User mode	UINT16	R / W
0x2020	0x01	Options Output	Optional Output Data 0	UINT16	R
	0x02		Optional Output Data 1	UINT32	R
	0x03		Optional Output Data 2	UINT32	R
	0x04		Optional Output Data 3	UINT32	R
0x3000	0x01	Measurement	Distance Integer	UINT32	R
	0x02		Distance Float	FLOAT32	R
	0x03		Signal Strength	UINT32	R
	0x04		Temperature	SINT16	R
	0x05		Measurement Actuality	UINT8	R
	0x06		Measurement Reserved	UINT16	R
0x3020	0x01	Sensor State	Sensor State	UINT8	R
	0x02		Sensor Output Data Limit Exceeded	UINT8	R
	0x03		Sensor Error Code	UINT16	R
0x3040	0x01	Options Input	Optional Input Data 0	UINT16	R
	0x02		Optional Input Data 1	UINT32	R
	0x03		Optional Input Data 2	UINT32	R
	0x04		Optional Input Data 3	UINT32	R
0x4000	0x01	Hardware Information	Serial Number	UINT32	R
	0x02		Part Number	UINT32	R
	0x03		Part Description	STRING[20]	R
	0x04		HW Version IF Board	UINT16	R
	0x05		HW Version M Module	UINT16	R
	0x06		Serial Number RTE	UINT32	R
	0x07		Part Number RTE	UINT32	R
	0x08		Part Description RTE	STRING[20]	R
	0x09		HW Version RTE	UINT16	R
0x4020	0x01	Firmware Information	FW Version IF Board	UINT16	R
	0x02		FW Version M Module	UINT16	R
	0x03		FW Version SSBL RTE	UINT32	R
	0x04		FW Version Stack RTE	UINT32	R

1) The acyclic data designation corresponds directly to the parameter designation in the chapter 10.4.3 Parameter description. For details and descriptions of the parameter, see this general parameter description.

10.7.4 Configuration

10.7.4.1 Overview

Configured Station Alias	Device Reset sets this back to 0

10.7.4.2 EtherCAT Slave Information (ESI)

General the ESI (EtherCAT® Slave Information) files is written in XML format and contains the complete description of its network accessible properties, such as process data and their mapping options, the supported mailbox protocols including optional features, as well as the supported modes of synchronization. The Network Configuration Tool uses this information for online and offline configuration of the network.
The required ESI file for the EtherCAT® protocol of the exchangeable cover with Industrial Ethernet can be downloaded from TR Electronic.

Download ESI file: www.tr-electronic.de/f/TR-ELE-ID-MUL-0021

10.7.4.3 Software / Tools

No additional software in needed. The configurations of the laser distance sensor can be done over the Industrial Ethernet interface.

The “Ethernet Device Configuration” software (free of charge) from Hilscher can be used to find an EtherCAT® device (e.g. MAC,...).

11 Accessories

11.1 Target plates

The target plates provide a defined measuring target. The orange reflective surface sends more light back to the LLB.

Part Number	Description	Picture	Download
49500040	Aluminum target plate, orange reflective, 210 x 297 mm		www.tr-electronic.de/f/TR-ELE-TI-DGB-0037
49500053	Target foil, orange reflective, 600 x 1200 mm		www.tr-electronic.de/f/TR-ELE-TI-DGB-0038

11.2 Alignment unit

The Alignment Unit for the LLB-502 makes it easy to align the laser beam to the desired measurement target.

Part Number	Description	Picture	Download
LLB502-30000	Alignment Unit		www.tr-electronic.de/f/TR-ELE-TI-DGB-0043

11.3 Protective cover

Although the LLB-502 sensors are protected to IP65, they should not be permanently exposed to adverse environmental conditions. This Protective Cover can only be used together with the Alignment Unit LLB502-30000.

Part Number	Description	Picture	Download
LLB502-30001	Protective Cover		www.tr-electronic.de/f/TR-ELE-TI-DGB-0044