Optical Sensor CHRocodile 2 LR

Non-Contact Measurement for Distance and Layer Thickness

User Manual

Version 01/2024 • EN • Translated Edition

Produced in the Federal Republic of Germany.

Translated Edition

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Version Control

Date	Firmware version	Type of change
04/2018	1.0.0	First edition
10/2018	1.1.0	Chapter 10.6 added trigger delay value
10/2019	chr2-r-1.1.1-release-0e5d8e77f-20190927-759	Editorial corrections and terminology changes
06/2020	chr2-r-1.1.1-release-2c111e6f1-20200518-961	New Release
02/2022	chr2-firmware-update-R1.3.1-1566-1d61cc939-20220217	Section 1.1 added also applicable documents Section 2.1 note on function influence of interfaces added Section 3.7 DLL added Section 3.9 changed data transfer rate of RS422 interface and LVDT removed
12/2022	chr2-firmware-update-R1.3.1-1566-1d61cc939-20220217	Section 10.4 Explanation to digital outputs added Section 9.2 Changed web address of website Chapter 3 and 5 new device housing dimensions integrated New Release
08/2024	R1.5.1	Section 5.7 Connecting CHRocodile to the PC added Section 6.14 Increasing Measuring Range added Section Accessories: Optical probe drawings removed Added reference to myCHRocodile New release

Contents

General

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1.1 About this User Manual

This user manual contains the most important information for the safe operation of the product.

Observe all instructions and guidelines in this documentation.

Moreover, the locally applicable regulations and codes for accident prevention at the use site must be observed.

Also applicable documents

This user manual refers in some places to documents that are included on the USB stick in the scope of delivery.

Further information can be found in the following documents:

- CHRocodile 2 Command Reference
- myCHRocodile Manual
- CHRocodileLib XX API Reference

1.2 Warranty and Liability

The general terms and conditions of delivery for products and services in the electronics industry along with the amendments and restrictions arising from the general terms and conditions of delivery for Precitec Optronik GmbH apply to all of our products.

We reserve the right to make changes to the device’s construction for the purpose of improving quality or expanding the range of possible applications as well as for production-related reasons.

Dismantling the device voids all warranty claims. The replacement of parts that are subject to wear and tear and require maintenance or calibration are excepted from this, provided that they are expressly indicated in this documentation.

Unauthorized changes made to the device exclude all liability.

Any attempt to copy or analyze the software will lead without fail to a system error and voids all warranty rights.

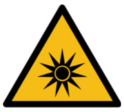
1.3 Symbols Used

Safety symbols

The following hazard symbols may be indicated in the user manual:

This symbol indicates a possibly hazardous situation. Disregard of this information can result in injuries.

Laser radiation – Warns of direct or indirect laser radiation.



Optical radiation – Warns of direct or indirect optical radiation.

Hot surface – This means the touching the assembly or surfaces can lead to injuries.

Hazardous electrical voltage – Indicates a hazard due to electric shock and warns of impending danger to the life and health of persons or of extensive material damage.

Overhead load – Indicates a hazard due to overhead or falling loads and warns of impending danger to the life and health of persons or of extensive material damage.

Crushing of hands – Warns of crushing hands due to moving parts.

Do not touch – Indicates that touching the contact or optical surfaces can cause damage or destruction of the component.

Additional symbols

The following informational symbols may be indicated in the user manual:

Important

Information which the user must pay attention to and be aware of in order to avoid disruptions in the course of processing or in product use.

Tip

Provides information that the user needs in order to achieve the intended result of an action most directly and without difficulties.

Additional information

Informs the user whenever additional information about a described context is available.

1.4 Hazard Levels

Safety information is indicated through the use of a signal word. The signal word represents a certain hazard level:

⚠DANGER	DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.
⚠WARNING	WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.
⚠CAUTION	CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

Basic Safety Instructions

2

2.1 Intended Use

Intended use

- The device is intended for use in the following applications:
  - Distance measurement
  - Thickness measurement
  - Surface measurement
  - Determination of position
- The device can be used as a stand-alone device or as part of a measurement system.
- The device must only be used in a dry environment.
- The device must only be operated within the context of the specifications given in the technical data (the specified accuracy is achieved at room temperature).

Any use deviating from the intended use is considered improper.
The user assumes liability for the consequences in these cases.

Foreseeable misuse

The following use of the device is expressly prohibited:

- Operation with the enclosure open
- Repairs, structural changes or modifications to the system
- Use in disregard of the instructions set out in this manual.

Electromagnetic compatibility

Both as an individual device and in combination with the devices designated for this purpose in this documentation, the optical sensor fulfills the standards EN 61326-1:2013-07 and EN 61010-1:2011-07 and complies with directives 2014/30/EU, 2014/35/EU and 2011/65/EU. The optical sensor is classified according to DIN EN 55011 as Device Class B and Group 1. Observe the following rules with respect to electromagnetic compatibility:

- Only use the parts/devices included in delivery or original replacement parts.
- Observe the information for EMC-compliant installation in the respective manuals.
- If the device is operated in the context of a system: Ensure that the entire system complies with the provisions of the EU directives.
- Only use data cables that are shorter than 30 m and are shielded.

During line-related disturbances, the function of the interfaces may be affected.

In terms of emitted interference, the sensor is a Class A device according to DIN EN 55011.

Medical or safety-relevant usage

If the device is used in medical or safety-relevant applications, the operator must ensure that the device is suitable for the specific application. This includes both the optical characteristics of the measured sample as well as the influence of temperature and vibration on the device.
Furthermore, the user must check the device at regular intervals for correct measurements and for cases in which the specified measuring uncertainty is exceeded.

2.2 Obligations of Owner and Personnel

The owner of the device is obligated to allow only persons to work on the device who:

- are familiar with the basic regulations concerning workplace safety and accident prevention and have been instructed in the operation of the device,
- have read and understood the Safety chapter in this user manual and have confirmed this with their signature.

Personnel must be trained in compliance with the regulations and safety instructions and must have been informed of possible hazards.

2.3 Safety during Operational Start-up, Normal Operation and Maintenance

⚠WARNING

Electrical hazard

Take note that after the housing has been opened or parts have been removed, energized parts are exposed. Touching such components is life-threatening.

- Do not use the device when the enclosure is open.
- Do not perform repairs, structural changes or modifications to the system (unless explicitly described in the Maintenance chapter).

Note

The emitted invisible laser beam of measuring light corresponds to IEC 60825 Laser Class 1. This means that the device is safe during normal operation and no damage to the eye is to be expected even in the event of a longer exposure.

Maximum emitted power	0.89 mW
Mean wavelength	880 nm

For devices with the pilot laser option
Note

The emitted beam of visible light from the Pilot Laser corresponds to IEC 60825 Laser Class 1. This means that the device is safe during normal operation and no damage to the eye is to be expected even in the event of a longer exposure. However, looking directly into a Class 1 laser which emits visible radiant energy can have an irritating effect on one’s vision.

- Avoid looking directly into the laser beam.
- Do not observe the light emitting opening on the device or the probe with a magnifying glass.

Maximum emitted power	0.39 mW
Mean wavelength	520 nm (green pilot laser) 650 nm (red pilot laser)

⚠CAUTION

Hazard due to laser beam

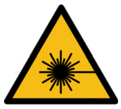
The opened device corresponds to IEC 60825 Class 3B. Retina damage due to the invisible or visible radiation emitted during operation of the device with the enclosure open cannot be ruled out.

- Do not open the device’s enclosure.

2.4 Warning Signs on the Device

Warning signs

The following table describes the locations where the warning signs are applied on the device:

Warning sign	Meaning	Location
	Warning of laser beam	Device front panel next to fiber optic cable connector
	Laser class indicating label	Rear of device

Additional signs

The following table describes the locations where additional signs are applied on the device:

Sign	Meaning	Location
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	Note that the device complies with regulations of the American FDA and may be imported into the USA	Rear of device

Product Description

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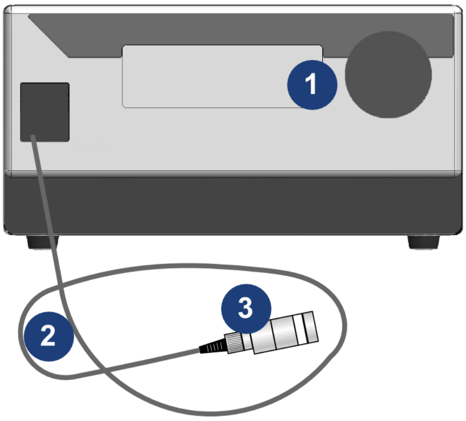
3.1 Overview Product Description

Illustration

The optical sensor consists of the control unit (1), optical fiber (2) and optical probe (3):



Control unit

The control unit contains the electronic and optical components for the analysis of the measured signals as well as the light source. The front panel contains the power switch, a display and the fiber optic connector for the optical probe. The menu navigation controls are also located here.

Optical fiber

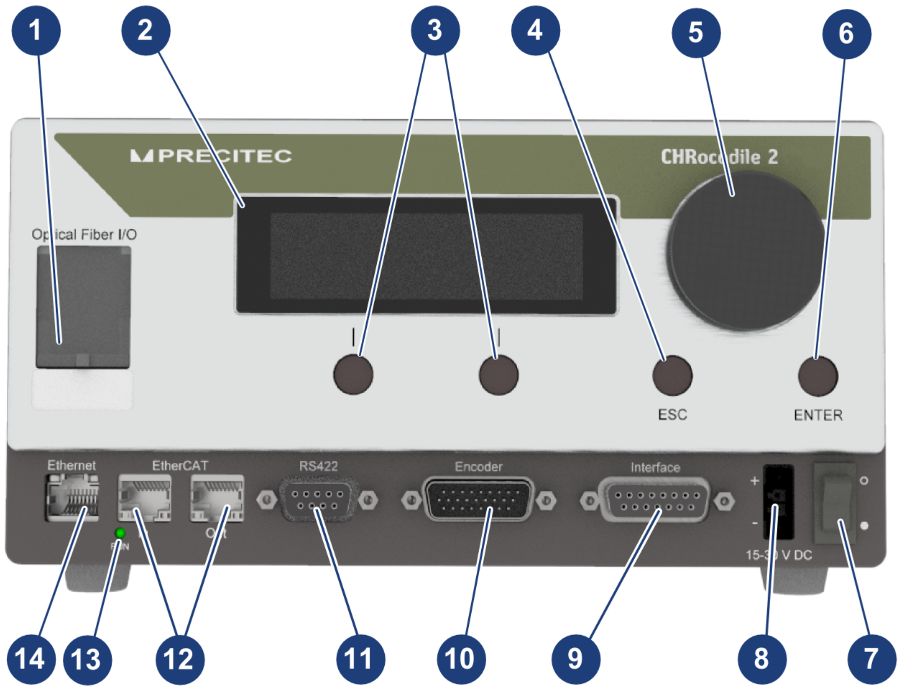
The control unit and the optical probe are connected by an optical fiber. This makes it possible to spatially separate the optical probe from the control unit. The optical fiber is available in different lengths depending on the customer's requirements and with steel sheathing as an option.

Optical probe

The optical probe contains no moving parts or electronic components which could influence the accuracy and stability of the measurement by being a heat source. Consequently, it is very robust and can be employed under extreme ambient conditions.

3.2 Front View

Illustration



No.	Designation	Function
1	Optical fiber connector	Connect the optical fiber
2	Display	Read information, set and modify values and parameters
3	Function buttons	Context sensitive, depending on the menu (see text on display)
4	Escape button	Go back to the previous level in the configuration menu
5	Jog wheel	For menu navigation and to make settings: • Turn: Move up/down in the menu or increase/decrease a value • Press: Open a menu or edit a value
6	Enter button	Open the configuration menu Confirm a set value Go to a selected menu
7	Power switch	Switch the device on and off
8	Power supply jack Molex 39505-1002	Connector for the power supply unit
9	Interface female connector (15-pin D-sub female connector)	Analog and sync interface Output of results

No.	Designation	Function
10	Encoder input (26-pin D-sub HD male connector)	Encoder connection
11	RS422 port (9-pin D-sub female connector)	RS422 serial interface
12	EtherCAT In EtherCAT Out (EtherCAT option)	RJ-45 ports for EtherCAT In and Out connections
13	EtherCAT RUN LED (EtherCAT option)	LED displaying EtherCAT bus states (see below for details)
14	RJ-45 port	Ethernet connection

EtherCAT RUN LED (EtherCAT option)

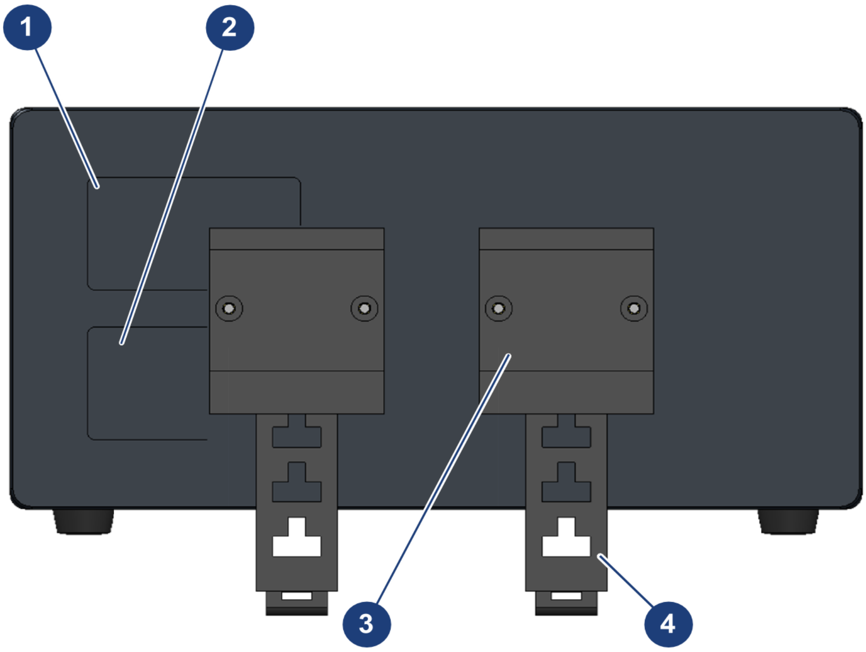
The following table provides a key to the EtherCAT RUN LED signals and their meaning:

Color	Meaning
Off	Device is in UNINIT bus state.
Green / blinking fast	Device is in INIT bus state.
Green / blinking	Device is in PREOP bus state.
Green / blinking slowly	Device is in SAFEOP bus state.
Green / lights up continuously	Device is in OP bus state.

The two LEDs in the EtherCAT RJ-45 socket indicate the successful connection and its activity. Further information can be obtained from Beckhoff GmbH (www.beckhoff.com).

3.3 Rear View

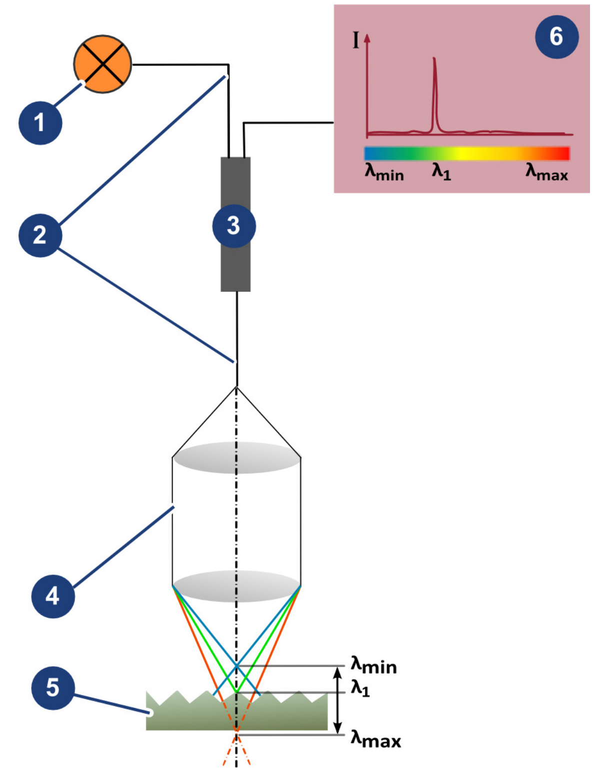
Illustration



No.	Designation	Function
1	Type label	Indicates the manufacturer, type designation, item number and serial number
2	Laser class indicating label	Information on the laser class
3	Bracket for top-hat rail mounting	To mount the control unit
4	Operating latch	Remove the control unit from the top-hat rail

3.4 Principle: Chromatic Confocal Distance Measurement

Illustration



Description

In a chromatic confocal distance measurement, the light emitted from the light source (1) is transmitted through an optical fiber (2) and a fiber coupler (3) to the optical probe (4). As this takes place, light with a broad spectral range is focused on the surface of the sample (5) by means of a lens having a pronounced chromatic aberration. The light reflected from the sample is received on the return path by the optical probe and is subsequently analyzed by the spectrometer (6). The wavelength for which the surface is in focus is reflected maximally. The spectrum of the reflected light exhibits a pronounced peak and from its spectral position, the distance to the surface can be determined.

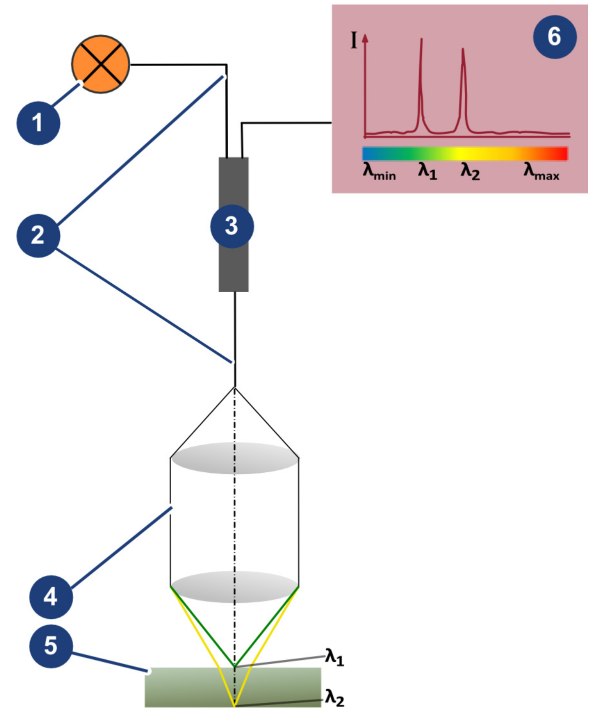
Application examples

The optical sensor can be employed for a wide range of different tasks. Typical examples are:

- Topography, profile and roughness measurement, e.g. for tool surfaces
- Determination of positions and dimensions, e.g. for microelectronic components
- Topography measurements on injection molded parts
- Contactless 3D measuring technology for endoprotheses

3.5 Principle: Chromatic Confocal Thickness Measurement

Illustration



Description

In a chromatic confocal thickness measurement, the light emitted from the light source (1) is transmitted through an optical fiber (2) and a fiber coupler (3) to the optical probe (4). Chromatic distance and thickness measurements are carried out with the same optical probe. The light on the return path is received by the optical probe and is subsequently analyzed by the spectrometer. If there is a transparent material (5) within the measuring range, the spectrum of the reflected light exhibits two peaks (6). Each peak is due to the reflection from one of the boundary surfaces of the layer. The layer thickness can be determined from the spectral distance and the refractive index of the layer material.

A chromatic confocal thickness measurement requires a minimum layer thickness so that the two peaks in the spectrum can be distinguished. The minimum thickness depends on the optical probe used.

Some prerequisites for the measurement of a single layer:

- Transparency of the layer to be measured in the wavelength range to be used
- Refractive index difference of the two boundary surfaces

Special case: Layer systems

Chromatic confocal thickness measurements not only enable measurement of the thickness of a single transparent layer, but also allow simultaneous measurement of different layers in a layer system.

Some prerequisites for the measurement of a layer system:

- Transparency of the layers to be measured in the wavelength range to be used
- Different refractive indexes of the layers to be measured

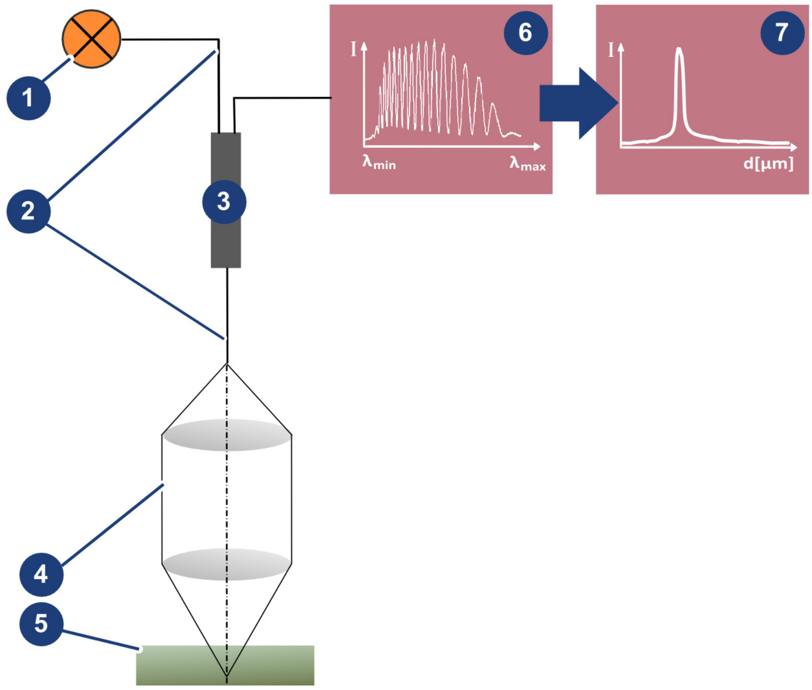
Application examples

The optical sensor can be employed for a wide range of different tasks. Typical examples are:

- Thickness measurement of glass
- Thickness measurement of plastic coatings
- Thickness measurement of packaging films
- Measurement of transparent liquid layers and liquid levels

3.6 Principle: Interferometric Thickness Measurement

Illustration



Description

The sample to be examined has two boundary surfaces with a material layer between them having a constant refractive index. The light emitted from the light source (1) is transmitted through an optical fiber (2) and a fiber coupler (3) to the optical probe (4). The light is focused on the sample (5). There is a reflection from both the upper and lower boundary surfaces of the sample (5). The light reflected from the sample is directed to the spectrometer via the fiber coupler and is there detected as a function of its wavelength. Due to the layer thickness, a wavelength-dependent phase shift occurs between the beams reflected from the upper and the lower boundary surfaces. The resulting wavelength-dependent interference creates a modulation (6) in the spectrum whose period contains the required information about the layer thickness. The layer thickness (7) is determined from the interference pattern by means of a Fourier transformation. The greater the path length difference, the lower the period of the modulation and therefore the greater the indicated layer thickness.

Some prerequisites for the measurement of a single layer:

- Transparency of the layer to be measured in the wavelength range to be used
- Refractive index difference of the two boundary surfaces

Special case: Layer systems

Interferometric thickness measurement not only enables the measurement of the thickness of a single transparent layer, but also allows simultaneous measurement of different layers in a layer system. When one of two superimposed layers of an existing layer system is measured, the sensor measures three thicknesses (the two individual layer thicknesses as well as the overall thickness).

Some prerequisites for the measurement of a layer system:

- Transparency of the layers to be measured in the wavelength range to be used
- Different refractive indexes of the layers to be measured

Application examples

The optical sensor can be employed for a wide range of different tasks. Typical examples are:

- SI wafer thickness measurement during grinding and etching
- Film thickness measurement
- Air gap thickness measurement
- Epoxy thickness measurement during wafer packaging
- Thickness measurement of conformal coatings
- Thickness measurement of eyeglass lenses and contact lenses
- Wall thickness measurement for medicinal packaging

3.7 Scope of Delivery

Incoming inspection

After delivery, the device must be inspected carefully including checking for possible damage. If damage is found or parts are missing, please contact Precitec Optronik promptly.

Scope of delivery

- Control unit
- Power supply unit and power cord
- USB flash drive with operating manual, DLL and software
- Calibration report or IT Certificate
- Cleaning sticks
- Connection set: Ethernet cable, bracket for top-hat rail mounting, connector housing and solder pots
- Optical probe (optional)
- Optical fiber (optional)

3.8 Operating Modes and Installation Situations

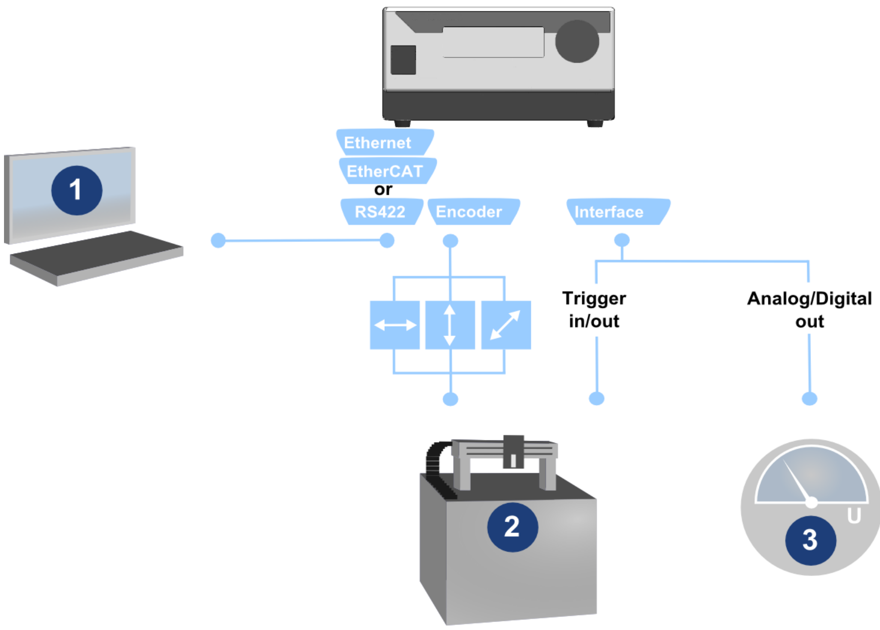
Stand-alone measuring operation

The device can be used as stand-alone equipment without being connected to a computer to carry out individual point measurements. In this case, the device can be operated using the controls on the front panel. The measurement results are shown on the device's display. The display offers a choice between numerical values or a bar chart presentation.

In the stand-alone mode, only individual point measurements are possible. A survey of topographies requires the device to be operated in a measuring system.

Integrated operation in a measuring system

The interfaces allow the device to be integrated into measuring systems or production facilities, for example for autonomous monitoring and control of a production process. The following figure shows an example configuration:



A computer (1) obtains the measurement data via the data interface (Ethernet/EtherCAT®/RS422); Precitec provides a DLL for communication with the device. Encoder positions, e.g. from a translation stage (2), are imported via the encoder input and allow precise allocation of the measuring points to the axis positions. Measurement values can be output as analog voltages (3) via the analog/sync interface. In addition, this interface is used for position-related triggering of measurements.

3.9 Technical Data

Technical data

Specification	Value
Measuring principle	Interferometric, chromatic confocal
Measurement values	Layer thickness, distance
Number of measuring channels	1
Synchronization with external devices	Trigger input, synchronizing output, 5 encoder inputs
Interfaces	Ethernet, EtherCAT®, RS422, 2 x analog (-10 V – +10 V, 16 bit)
Transmission rate	Ethernet (100 Mbit/s), EtherCAT® (optional, 100 Mbit/s), RS422 (up to 10 MBaud)
Light source	SLD
Fiber optic cable length [1)]	2 m – 40 m (single mode fiber)
Operating temperature	+5 °C – +50 °C
Storage temperature	-20 °C – +70 °C
Relative humidity (in operation)	30 – 75%
Relative humidity (in storage)	10 – 90%
Control unit dimensions (W x H x D)	Old housing: 220 mm x 110 mm x 125 mm New housing: 220 mm x 110 mm x 135 mm
Weight	2 kg
Supply voltage	16 – 30 V_{DC} (with separate power supply unit, 90 – 264 V_{AC})
Rated power	20 W

[1)] Also available with steel sheath up to 15 m in length

	Measuring rate [Hz]	Measuring range [µm]	Wavelength [nm]	Axial resolution [nm]	Linearity (nominal) [µm]
2 LR (interferometric)	As contractually agreed	16 – 1900 (nominal) 32 – 3900 (extended)	880	1	0.35
2 LR (chromatic confocal)		Depends on optical probe	880	Depends on optical probe	Depends on optical probe

Transport, Storage and Disposal

4

4.1 Transport

After delivery, the device must be inspected carefully including checking for possible damage. If damage is found or parts are missing, please contact Precitec Optronik promptly.

Rules

The following rules must be observed in order to avoid damage during transport:

- Observe the information for safe transport and storage provided on the packaging.
- Take suitable measures to avoid any damage from moisture, vibration or impact.
- Before unpackaging, a temperature adaptation to the ambient conditions may be advisable to protect the device from condensation.
- Only remove the protective caps immediately prior to connecting the device to prevent the entry of dirt and water.

4.2 Storage

Rules

The following rules must be observed in order to avoid damage during storage:

- Take suitable measures to avoid any damage from moisture, vibration or impact. Always store in the original packaging.
- Observe the information for safe transport and storage provided on the packaging.
- Comply with the storage temperature and humidity range indicated in the technical data.
- Do not store in or near strong magnetic fields (e.g. permanent magnet or strong alternating electrical field).
- Only remove the protective caps immediately prior to connecting the device to prevent the entry of dirt and water.

4.3 Disposal

Rules

The device has been manufactured in compliance with Directive 2011/65/EU (RoHS) and must be disposed of accordingly. Observe the following rules for disposal:

- Remove all interface cables.
- Dispose of the device in accordance with all respective country-specific regulations.

The device along with all electronic parts included in delivery must not be disposed as household waste. After use, take the device to an authorized collection point for electrical and electronic scrap or have it disposed of by an accredited disposal company.

Operational Start-up

5

5.1 Overview of Operational Start-up

Purpose

This chapter lists the activities which are required for the operational start-up of the device.

Workflow

Step	
▼	Set up the device.
▼	Connect the optical probe.
▼	Make the remaining connections.
▼	Connect the device to the power supply and switch it on.
▼	Install the necessary software.
▼	Connecting CHRocodile to the PC.

5.2 Setting up the Device

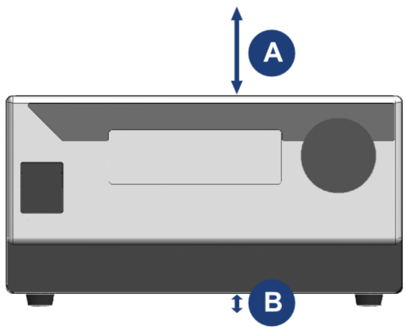
Site requirements

- Ensure that ambient temperature and humidity are in accordance with the technical data.
- Do not cover the ventilation holes on the top and bottom of the device.
- Do not stack devices one on top of the other.
- Set up the device in a dry, dust-free location.
- Avoid direct sunlight.

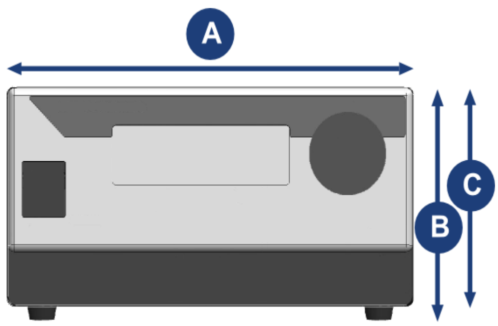
The normal ambient lighting typical of production environments has no influence on the measurement results.

Minimum clearances

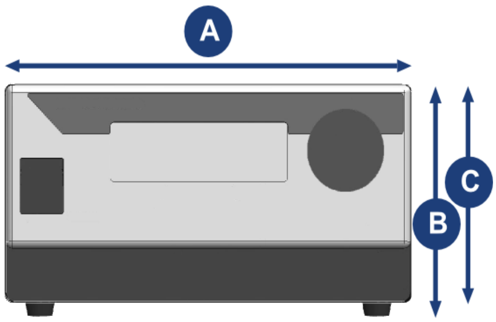
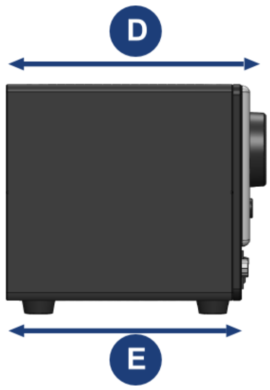
Take care to ensure that the following minimum clearances are maintained in order to provide adequate air circulation:

Illustration	Minimum clearance
	A: 50 mm
	B: 7 mm (equals the height of the feet)

Dimensions old housing

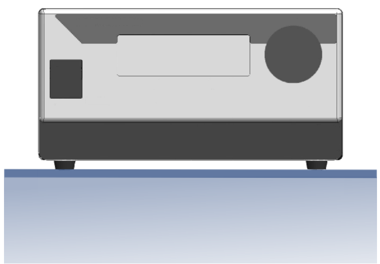
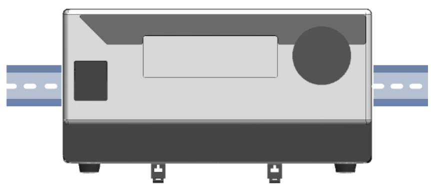
Dimensions, front view	Dimensions, side view
	
A: 220 mm	D: 125 mm
B: 117 mm	E: 117 mm
C: 110 mm	

Dimensions new housing

Dimensions, front view	Dimensions, side view
	
A: 220 mm	D: 135 mm
B: 118 mm	E: 127 mm
C: 110 mm	

Set-up options

The device can be operated as a table-top unit or mounted on a top-hat rail:

Table-top unit	Top-hat rail
	
The device must only be operated with the feet.	The device must only be secured with the brackets for top-hat rail mounting provided in the connection set (see Scope of Delivery; observe the assembly instructions included).
–	Specification: Top-hat rail TS 35 to DIN EN 60715 Screws M3x8, 0,25 Nm

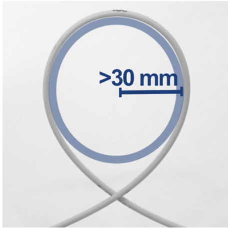
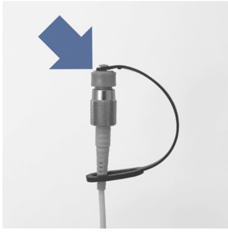
Vibration

Especially during distance measurements, care must be taken to ensure that the device and the sample are not exposed to vibration because this can result in large measurement value fluctuations. For thickness measurements, this effect is negligible.

5.3 Connecting the Optical Probe (E-2000)

Rules for handling optical fibers

The optical fiber is very sensitive to mechanical wear and must be handled with great care accordingly. Consequently, the following rules must be observed when handling the optical fiber:

Rule	Illustration
The minimum bending radius is 30 mm.	
The protective caps included in delivery must be screwed on to the ends of the fiber during transport and storage (the example shows an FC/APC connector).	
The ends of the fiber are very sensitive to dirt and must not be touched.	

Soiling on the end of the fiber creates a great deal of stray light which impairs the dynamics of the measurement. If the fiber end becomes dirty or is touched unintentionally, follow the cleaning instructions in the Maintenance section.

Types of fibers

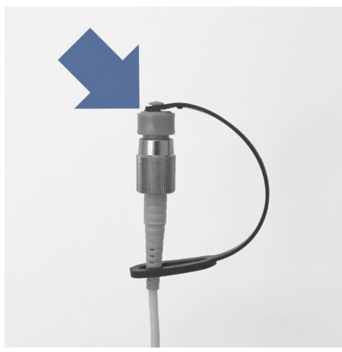
The special fiber type required depends on the wavelength used by the device. This is why the lever of the E-2000 connector is color coded (custom fibers may vary; contact our sales representatives in this case):

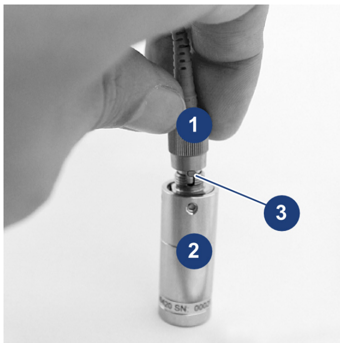
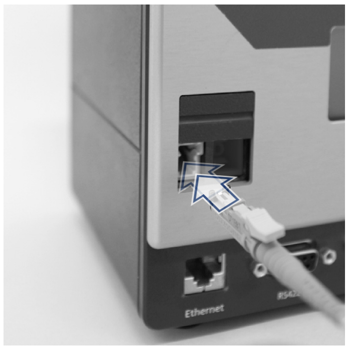
Device	Lever color (E-2000)	Illustration
CHR 2 S, 2 SE, 2 HS, 2 DPS	red	
CHR 2 IT, 2 IT RW	yellow	
CHR 2 IT DW, 2 IT HDW, 2 K	orange	
CHR 2 LR	green	

Prerequisites

- The device must be set up or mounted at the desired location.

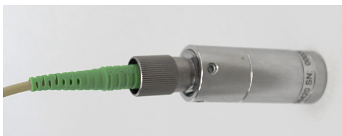
Instructions: Connecting the optical probe

Step	Action	
1	Remove the protective cap from the optical probe.	
2	Remove the protective cap from the FC/APC connector.	

Step	Action	
3	Place the thread closure (1) of the fiber connector into the fiber socket on the optical probe (2). Note: Ensure that the feather key (3) engages in the groove of the socket. During positioning, the exposed end of the fiber must not be allowed to touch the thread of the optical probe.	
4	Screw in the threaded closure (1) until finger tight.	
5	Attach the optical probe at the desired location. When doing so, ensure that the sample is located within the working distance. The probe should be aligned as perpendicularly as possible to the sample.	
6	Fiber optic connector on the control unit: Connect the optical fiber. Result: The connector engages with a clearly audible click. To remove, press down the clip on the plug and carefully pull it out of the socket.	

Special case of FI/APC

Due to the compact design of some optical probes, these do not have FC/APC connectors for directly screwing in, but instead use an FI/APC plug.

Plug	Illustration	Comment
FI/APC		Must **not** be screwed off
FC/APC		May be screwed off

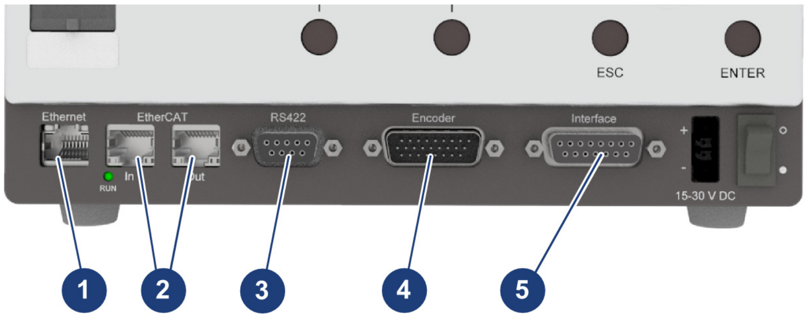
An FI/APC plug connection between the optical probe and the optical fiber must not be disconnected by the customer because if mounted incorrectly, the measurement optics have to be recentered. When replacing optical probes and optical fibers on FI/APC connectors, please contact Precitec Optronik.

5.4 Making the Remaining Connections

Purpose

If the device is to be integrated into a measuring system, additional connections must be made. This section describes how these connections are to be made. Information on the connector's pin configuration can be found in the appendix.

Illustration



No.	Designation	Function
1	Ethernet interface	Ethernet connection
2	EtherCAT In port EtherCAT Out port (EtherCAT option)	EtherCAT connection with standard Ethernet cables (2x RJ-45 connectors)
3	RS422 port	RS422 serial interface
4	Encoder input	Encoder connection
5	Interface female connector	Analog and sync interface

Instructions: Making the remaining connections

Step	Action
1	Connect the plug to the respective socket. Tighten the screws if present in order to secure the connector.
2	Connect the cable to the respective peripheral.

5.5 Connecting the Power Supply

Moisture can accumulate on and inside the device when it is brought from a cold environment into a warm one. Be certain not to put the device into service until the cold device has warmed up to room temperature. Depending on the room temperature and the ambient humidity, this process can take up to three hours.

Especially when using a device with a laser diode as a light source (CHRocodile 2 S HP, CHRocodile 2 DPS HP): For longer downtimes (several hours), it is advisable to switch off the light source with `LAI 0` to extend its lifetime.

Power supply unit

The direct current side of the power supply unit is equipped with two small plastic guides to prevent reversal of the polarity. Only use the original power supply unit delivered with the device.

Prerequisites

- The device must be set up or mounted at the desired location.

Instructions: Connecting the device to the power supply

Step	Action	
1	Supply power by connecting the power supply unit included in delivery to the control unit. Tighten the screws if present in order to secure the connector.	
2	Switch the device on using the power switch (1). Result: The device is initialized. The display shows the device type, serial number and firmware version. A progress bar indicates the progress of the initialization procedure.	

After switching on

Before beginning a measurement, the device's most important settings should be checked and reconfigured if needed. These include the measuring mode, measuring rate and averaging. More information on this can be found in the Configuration chapter.

5.6 Installing Drivers and Further Software

Installing drivers

No driver installation is necessary for this device.

Installing myCHRocodile

myCHRocodile is a Human Machine Interface which facilitates operations such as sensor configuration, visualization of the measurement, saving data, etc. myCHRocodile can manage all PRECITEC point sensors.

Detailed installation instructions and further information can be found in the myCHRocodile user manual.

5.7 Connecting CHRocodile to the PC

Overview

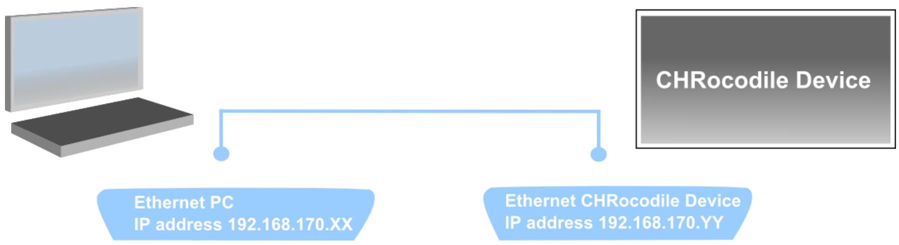
Depending on the CHRocodile device, there are different interfaces available for connecting the CHRocodile device to a PC or a machine environment. This section deals with a connection via the Ethernet interface. After successfully establishing a connection, the communication with the CHRocodile device can be realized using Precitec Tools, the Precitec DLL or your own software.

Purpose

For the PC to be able to communicate with the CHRocodile device requires that an IP address from the same IP address range be assigned. The step-by-step instructions describe how to use the PC to assign an IP address from the IP address range of the CHRocodile device.

Illustration

The following illustration shows the Ethernet connection between a PC and a CHRocodile device. The standard IP addresses of the CHRocodile devices can be found in the table below.



Standard IP addresses

CHRocodile device	IP address
CHRocodile 2	192.168.170.2
CHRocodile C series	192.168.170.4
CHRocodile Mini/Mini+	192.168.170.4
Focus Finder	192.168.170.4
CHRocodile CLS	192.168.170.2
CHRocodile CLS 2 series	192.168.170.3

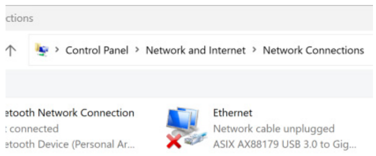
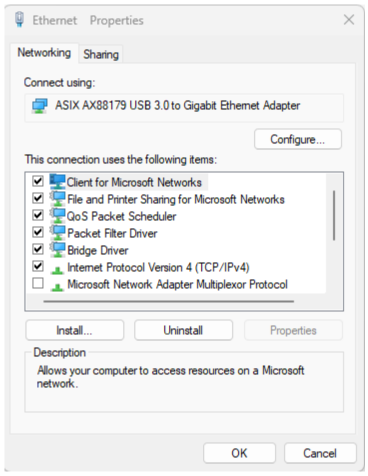
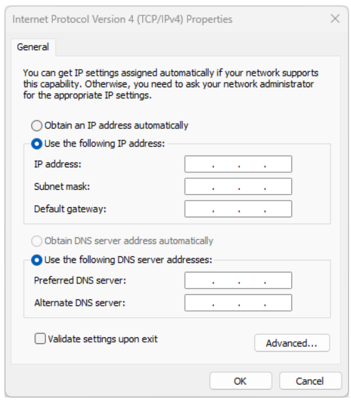
Required tools

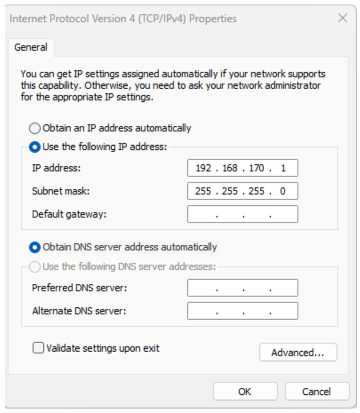
- Ethernet cable

Prerequisites

- The CHRocodile device and the PC must be switched on.
- The PC and the CHRocodile device must be connected by an Ethernet cable.

Instructions: Connecting CHRocodile to the PC

Step	Action	Illustration
1	Enter “Network connections” in the Windows search field and open the item “Show Network Connections”. Result: The `Network Connections` window opens.	
2	Select the Ethernet adapter to which the CHRocodile device is connected. Make a right click and select the `Properties` button. Result: The `Ethernet Properties` window opens.	
3	Select the item `Internet Protocol Version 4 (TCP/IPv4)` and select the `Properties` button. Result: The `Internet Protocol Version 4 (TCP/IPv4) Properties` window opens.	

Step	Action	Illustration
4	Select the `Use the following IP address` radio button. Enter an IP address that is within the IP address range of the CHRocodile device, e.g. 192.168.170.1, subnet mask 255.255.255.0. Select the `OK` button. In the `Internet Properties` window: Select the `Close.` button. Result: The Ethernet adapter has been assigned the IP address 192.168.170.1.	
5	myCHRocodile software: Start myCHRocodile. Note: If the CHRocodile device does not automatically connect to myCHRocodile, select the `Disconnected` button. Result: myCHRocodile is connected to the CHRocodile device. CHRocodile Explorer software: Start CHRocodile Explorer. Select the `Auto Connect` button. Result: CHRocodile Explorer is connected to the CHRocodile device.	

Linux users must use the same IP address settings as Windows users to connect to the CHRocodile device. An example for the IP address and the subnet mask can be found in step 4 of the step-by-step instructions.

A detailed description of myCHRocodile can be found in the myCHRocodile user manual (see the USB stick included in delivery).

A detailed description of the DLL can be found in Command Reference for the device (see the USB flash drive included in delivery).

Configuration

6

6.1 Overview of Configuration

Purpose

This chapter lists the activities which are required to configure the device. This includes the selection of the measuring mode, the measuring rate and the interface parameters, for instance. This allows the device to be configured for the application case and the measurement task.

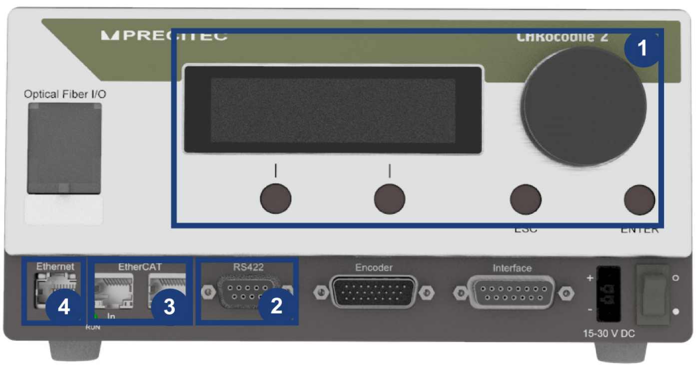
Workflow

The following workflow is an example of what the initial configuration of the device for a specific measurement task can look like. It is frequently necessary to optimize a few parameters in the course of the measurements:

Step	
▼	Select the measuring mode.
▼	Select the measuring rate.
▼	Make the exposure settings.
▼	Set the material parameters, if needed.
▼	Set the measurement parameters.
▼	Set the interface parameters.
▼	Save the settings.

Configuration methods

The following methods can be used to configure the device:



- Using the controls on the front panel of the device (1)
- Using the RS422 interface (2)
- Using the EtherCAT interface (3)
- Using the Ethernet interface (4)

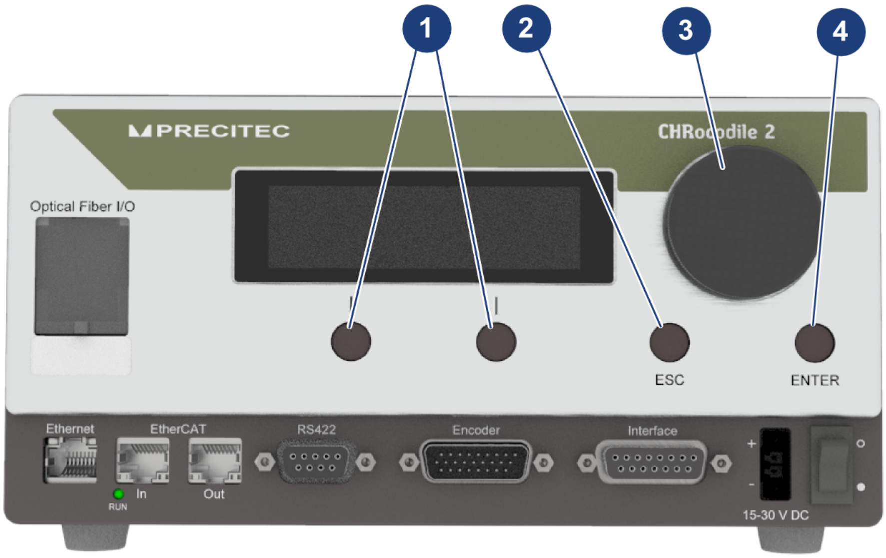
This chapter provides a detailed description of the procedure using the controls on the device’s front panel. A paragraph at the end of this description presents the command with which the same configuration steps can be carried out via the interfaces.

A more detailed description of the commands can be found in Command Reference of the device (see the USB stick included in delivery).

6.2 Operation and Operating Levels

Controls

The following controls are used to operate the device:



No.	Designation	Function
1	Function buttons	Context sensitive, depending on the menu (see text on display)
2	Escape button	Go back to the previous level in the configuration menu
3	Jog wheel	For menu navigation and to make settings: • Turn: Move up/down in the menu or increase/decrease a value • Press: Open a menu or edit a value
4	Enter button	Open the configuration menu Confirm a set value Go to a selected menu

Operating levels

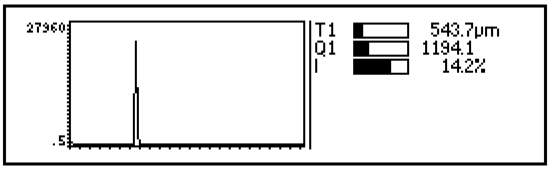
There are two operating levels when using the controls on the device's front panel for operation:

- Data mode
- Setup mode

The left function button can be used to toggle between these two modes.

Data mode

The data mode is the mode for monitoring the measurement (in the figure: interferometric operation):

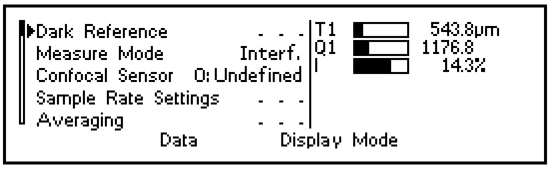


The graphic display is divided into two parts. The left part shows measurement data or spectra either as a line chart or a numerical display, as desired (can be switched using `Display Mode`). The right part shows measurement values and bar charts. The following signals are displayed:

Signal	Description
Distance (D)	The D bar indicates the current distance measurement value on a linear scale. The measured distance is indicated as a number in μm (only available in the confocal mode).
Thickness (T)	The T bar indicates the current thickness measurement value. The measured thickness is indicated as a number in μm.
Quality (Q)	The quality value is an index representing the quality of the measurement. Ideally, the Q-value should be as high as possible (only available in the interferometric mode).
Intensity (I)	The I bar indicates the intensity of the measurement signal on a logarithmic scale.
CCD (C)	The C bar indicates the saturation of the detector (only available in the confocal mode).

Setup mode

The setup mode is the mode for configuring the device (in the figure: interferometric operation):



The left part is the menu area. Here it is possible to navigate within the individual menus. The right part shows measurement values and bar charts. Changing the display mode switches the right part from a display as a bar chart to a line chart.

6.3 Menu Structure

- Dark Reference
- Measure Mode
- Calibration Tables
  - List of Sensor Tables
- Sample Rate
  - Sample Rate
  - Arbitrary Rate
- Averaging
  - Data averaging
  - Spectra averaging
  - Median Width
- Lighting/Exposure Settings
  - Exposure mode
  - (Duty cycle)
  - (Lamp intensity)
  - (Exposure level)
- Peak Detection Settings
  - No of Peaks
  - Peak Order
  - (Q Threshold)
  - (Chrom. Threshold)
- Material Settings
  - No of Peaks
  - Layer Material Setting
    - Table Num
    - Ref. Idx.
    - Abbe
- Detection Window Settings
  - Det. Win. Enable
  - Detection Windows
    - Detection Windows
- CCD Range
  - Start Pixel
  - Stop Pixel
- Analog Output Settings
- Display Contrast

Communication Settings	TCP/IP Configuration	TCP/IP Con. Mode
		IP Address
		Subnet Mask
		Ethern.Packet Size
	RS422 Connection Config.	Baud Rate
		Handshake
		Data av., ser.port
Special Functions	Reset Analog Output	
Save Device Setup		
Factory Reset		
Factory Reset Incl. Network		

Some of the submenus are placed in parentheses. These functions depend on settings in other menus. `Lamp Intensity`, for example, is only enabled in the exposure mode `Fixed` or `Double`.

6.4 Selecting the Measuring Mode

Purpose

There are two different measurement principles to measure distance and thickness:

- Confocal
- Interferometric

These principles can be selected by setting the measuring mode.

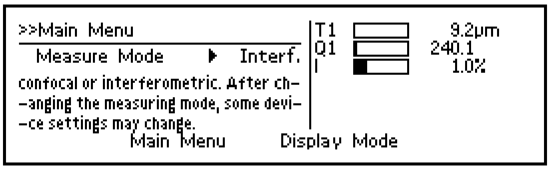
Scope

The device must support the respective measuring mode.

Path

`Setup > Measure Mode`

Illustration



Description

This dialog can be used to switch between interferometric and confocal. A few of the device settings may change after the measuring mode has been changed.

Command: `MMD`

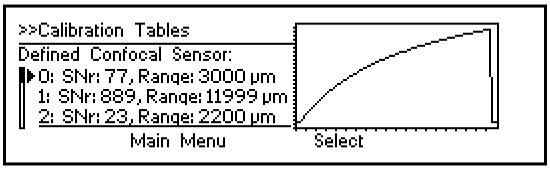
6.5 Selecting a Chromatic Optical Probe

Purpose This dialog is for selecting the chromatic optical probe. If the optical probe that is connected is to be replaced, the corresponding calibration table must be selected in this dialog.

Scope Only of relevance in the chromatic confocal mode.

Path `Setup > Calibration Tables`

Illustration



Description The dialog shows the available optical probes (serial number `SNr` and measuring range `Range`). The currently activated optical probe is marked with an arrow. The device contains 16 storage locations from No. 0 to No. 15. For a device that is delivered with only one optical probe, storage location No. 0 is always occupied.

The chromatic optical probe and the control unit are calibrated in the factory as a pair. The calibration data are stored in the control unit in the form of a calibration table. It is only meaningful to select a different optical probe number if the assigned optical probe was calibrated with the device. If the device is refitted with a different optical probe of the same or a different type, the device must be sent in to Precitec Optronik for calibration.

Command: `SEN`

6.6 Setting the Measuring Rate

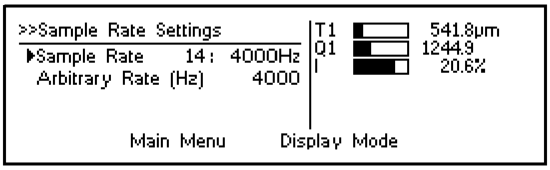
Purpose

The measuring rate is a parameter that defines how often measurement values are captured during a certain time period. A measuring rate of 4000 Hz means 4000 measurement values per second.

Path

`Setup > Sample Rate Settings`

Illustration



Description

The `Sample Rate` menu allows the selection of preset measuring rates. Freely configurable measuring rates can be set using the `Arbitrary Rate (Hz)` menu item. Keep the following in mind when setting the measuring rate:

- Increase the measuring rate in order to capture as many measurements per unit of time as possible. This is useful when a highly reflective surface is to be measured.
- The measuring rate can be decreased for weakly reflective surfaces. A low measuring rate has the effect that the detector is exposed longer, which allows even weakly reflective surfaces to be measured with precision. It is important to remember, however, that the longer exposure time can also lead to any possible stray light having a greater influence on the measuring result.

A good indicator for the suitability of the selected measuring rate is the intensity value (I) represented on the display by a bar. Higher values here are to be preferred. Nonetheless, it is also possible for the reflected light to have an intensity that is too high, thereby leading to the detector being saturated (intensity bar blinks). If saturation occurs, the measuring rate should be increased.

Command: `SHZ`

6.7 Making Exposure Settings

Purpose

Various different exposure modes are available:

- Fixed
- Adaptive
- Double

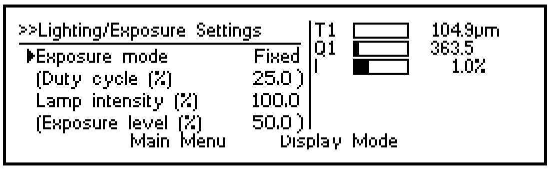
Scope

The `Double` exposure mode is only relevant in the chromatic confocal mode.

Path

`Setup > Lighting/Exposure Settings`

Illustration



Description

In the `Fixed` exposure mode, the amount of light per measuring point depends only on the measuring rate and the intensity of the lamp. The `Duty cycle` and `Exposure level` menu items are irrelevant in this mode and are therefore disabled. It is possible to set the lamp intensity, however.

In the `Adaptive` exposure mode, the device automatically controls the amount of light within the measurement time period, which in turn is determined by the measuring rate, and thereby allows measurements on surfaces which differ greatly in terms of reflectivity. An algorithm attempts to keep the level of the detector signal at the value specified by the `Exposure level` parameter by continuously adjusting the exposure time. The results of previous measurements are used as reference values.

Command: `AAL`

The `Double` exposure mode is suitable for surfaces with differing reflective behaviors for which the `Adaptive` exposure mode cannot make adjustments quickly enough due to the very strongly varying reflectivities. Depending on the measuring point, the reflection is either too strong or too weak in this case, which results in measurement signals that are either saturated or too weak (example: chrome mask on anti-reflective glass). To counteract this, two measurements with different exposure times are made in the `Double` exposure mode. If the longer exposure time results in a saturated signal, the result from the measurement with the shorter exposure time is used.

In the `Double` exposure mode, the menu items `Duty cycle` and `Lamp intensity` are enabled and the `Exposure level` menu item is disabled. The `Duty cycle` parameter is used to set the ratio of the short exposure time to the overall exposure time. For example, if a measuring rate of 1000 Hz and a Duty cycle of 25% have been selected, the duration of the short exposure time is 250 µs and the duration of the long exposure time is 750 µs. Nonetheless, the result of the longer measurement is given priority. If it becomes saturated, the result of the shorter measurement is used. Please note here that the measuring rate can only be at most up to one half of the maximum possible measuring rate.

Command: `DCY`

6.8 Setting the Lamp Intensity

Purpose

This function allows the effective brightness of the light source to be set. Depending on the device type, this takes place via changing the intensity of the light source or via changing the exposure time of the detector.

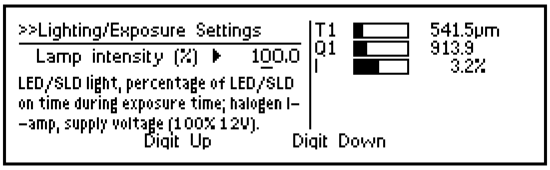
Scope

The lamp intensity can only be set in the exposure modes `Fixed` or `Double`.

Path

`Setup > Lighting/Exposure Settings > Lamp intensity`

Illustration



Description

The intensity of the light source (`Lamp intensity`) should only be set to less than 100% if the device goes into saturation. If a highly reflective surface is being measured on which the highest measuring rate still results in saturation, then the exposure time must be reduced.

Note that the feedback of the device indicates the portion of the exposure time in the cycle time. For this reason, a target value of 100% cannot always be achieved.

Command: `LAI`

6.9 Defining Averaging

Purpose

In addition to the output of individual measurement values, it is also possible to group a freely definable number of individual measurements and to have the average of these calculated. This average value is then displayed and can be transferred via the interface if so desired. Whether or not averaging should be performed depends to a great degree on the current measurement task and must be determined on a case by case basis. Averaging can be useful in the following situations, for example:

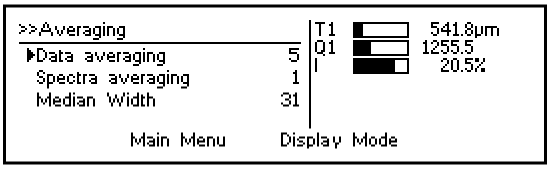
- To minimize noise
- To reduce the influence of vibration
- To reduce the measuring rate

The use of averaging for the measurement values is recommended when the shape of the peak is stable, but its location is not. In addition to the averaging of individual measurement values, averaging of spectra can also be selected. The use of averaging for spectra is recommended when individual points of the peak are noisy or the shape of the peak varies. This can be caused by weak lighting.

Path

`Setup > Averaging`

Illustration



Description

`Spectra averaging` defines the number of spectra which are to be averaged. In the interferometric mode, these are the Fourier spectra and in the chromatic confocal mode, the white-balanced spectra. `Data averaging`, however, defines the number of measurement values which are to be averaged before a result is output. If both averaging calculations are enabled, then spectra averaging is performed first and afterwards the averaging of measurement values is carried out.

The averaging function can be used to reduce the measuring rate. Averaging of n exposures reduces the output rate by a factor of n as compared to the situation with no averaging. In combinations of spectra averaging and data averaging, the measuring rate is reduced by a factor of n1 * n2. For example, with a measuring rate of 4000 Hz, using a spectra averaging value of 10 (`AVS 10`) and a data averaging value of 5 (`AVD 5`) reduces the output rate to 80 Hz.

Selecting the value of 1 (default setting) switches off the averaging function. Invalid measurement values (e.g. if the quality is too low) are not included in the averaging.

`Median Width` defines how many measurement values are to be used for the calculation of the median. Calculating the median always makes sense if a considerable number of outliers are to be expected which would unnecessarily falsify the average value of the measurement. This is the case, for example, when there are cyclically incorrect values due to the motion of a machine. Calculating the median does not reduce the measuring rate, as the median is sent as an extra signal.

Command: `AVD` (Average value of measurement data)
Command: `AVS` (Average value of spectra)
Command: `MED` (Calculation of the median)

6.10 Making Material Settings

Purpose

When making layer thickness measurements, the optical properties of the material must be taken into account. Depending on the material being measured, light will be refracted differently at the boundary surfaces. The measurement result can be corrected using:

- Refractive index and Abbe number
- Refractive index table

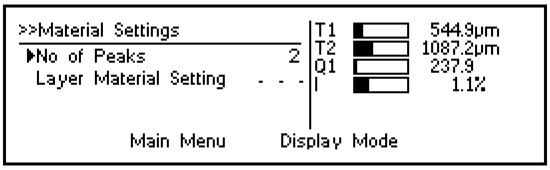
Scope

Only relevant for thickness measurement

Path

`Setup > Material Settings`

Illustration



Description

Material settings can be made in the `Layer Material Setting` submenu. For interferometric thickness measurement, a refractive index (`Ref. Idx`) can be specified. This makes it possible to display the actual thickness directly on the display. The preset value is `1.000`.

The refractive index is also dependent on the wavelength (dispersion). The Abbe number (`Abbe`), which can also be set, describes how the refractive index changes with the wavelength. A low Abbe number represents strong dispersion while a high Abbe number represents low dispersion.

As an alternative, refractive index tables can also be used to calculate the actual layer thickness. A refractive index table can be selected under `Table Num`. If no table has been selected (`Table Num 0`), this causes the fields for the refractive index (`Ref. Idx`) and the Abbe number (`Abbe`) to be enabled.

This dialog is only relevant for thickness measurements. In the case of interferometric thickness measurements, it is only possible to assign one refractive index table or one refractive index with Abbe number for the entirety of all layers. For chromatic confocal thickness measurements, this is possible for every individual layer.

Command: `SRI` (refractive index)
Command: `ABE` (Abbe number)
Command: `SRT` (refractive index table)

6.11 Defining Thresholds

Purpose

A threshold can be set between the measurement-value noise and the measurement signal. Peaks that lie below this threshold are considered to be invalid and are discarded. Setting the thresholds higher means that noise and other weak peaks will not be considered to be peaks.

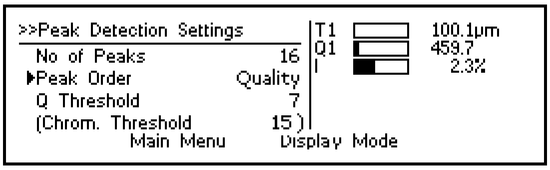
Scope

Intensity threshold only in the chromatic confocal mode
Quality threshold only in the interferometric mode

Path

`Setup > Peak Detection Settings`

Illustration



Description

`Peak Detection Settings` specifies the number of peaks which are to be detected and output up to a maximum of 16. `Peak Order` is the criterion for sorting the detected peaks.

`Q Threshold` is the quality threshold. This can only be defined in the interferometric mode. Generally speaking, a higher Q value indicates a clearer measurement signal. A higher, narrower peak delivers a higher Q value. This is normally dependent on the roughness of the surface (the rougher, the lower the Q value) and the parallelism of the boundary surfaces (the greater the plane parallelism, the higher the Q value). For the most common samples, we suggest a value of around 80.

`Chrom. Threshold` corresponds to the Intensity threshold. This can only be defined in the chromatic confocal mode. For a given optical probe, the intensity depends on the capacity for reflection of the surface being examined, the slope of the surface, the exposure time of the detector (and thus, the measuring rate) and the lamp intensity.

Command: `THR` (Intensity threshold)
Command: `QTH` (Quality threshold)
Command: `POD` (Sorting of the peaks)

6.12 Setting Detection Windows

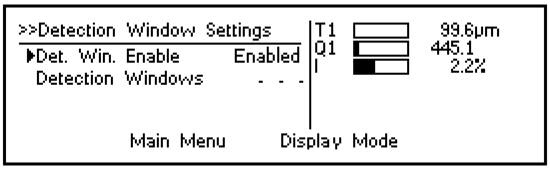
Purpose

Detection windows can be set for the purpose of selecting peaks. This serves to mask undesired signals.

Path

`Setup > Detection Windows Settings`

Illustration



Description

The detection window function can be enabled and disabled under `Det. Win. Enable`. When the detection window function is disabled, then the detection window extends across the entire measuring range.

The borders of the individual detection windows can be defined under `Detection Windows` and new detection windows can also be created here. The left and right borders are specified in µm. Up to 16 detection windows can be defined within the measuring range.

Command: `DWD`

6.13 Selecting the Detector Range to be Used

Purpose

This function serves to restrict the range of pixels on the detector that is used for the calculation so that the highest possible quality value can be attained for an interferometric layer thickness measurement.

The default settings are ideal for most of the measuring situations and should only be changed in exceptional cases.

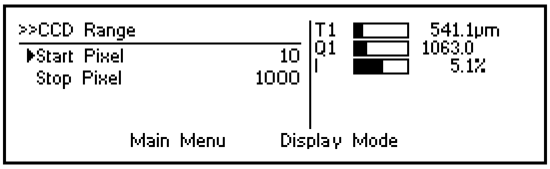
Scope

Only relevant for the interferometric mode.

Path

`Setup > CCD Range`

Illustration



Description

`Start Pixel` defines the starting position of the valid range of the detector. `Stop Pixel` defines the stop position of the valid range. The upper pixel limit is hardware-dependent and differs depending on the device type. If the `Start Pixel` and the `Stop Pixel` are too close together, the distance is automatically set to 50 pixels.

Command: `CRA`

6.14 Increase Measuring Range

Purpose

This section explains how to increase the interferometric measuring range of the device.

Only to be activated in interferometric mode.

Scope

Only available for CHRocodile 2 LR with Detector V2 and firmware ≥ R1.4.1.

Path

The extended measuring range can only be activated via the serial command `SENI`, not via operating elements on the front of the device.

Description

With the help of the `SENI` command, the interferometric measuring range of the device can be approximately doubled (e.g., from 1900 µm to 3900 µm on CHRocodile 2 LR). The following table describes further characteristics of both modes:

Standard measuring range `SENI 0`	Extended measuring range `SENI 1`
• All detector pixels are read out • Pixel binning activated • Minimum layer thickness as stated in technical data • Minimum signal noise	• Half of the detector pixels are read out • Pixel binning off • Twice the minimum layer thickness • Higher signal noise

Note: After changing the measuring range using the command `SENI`, a dark reference has to be carried out.

Command: `SENI`

6.15 Activating HDR Mode

Purpose

The High Dynamic Range (HDR) mode extends the dynamic range of a detector exposure. This is useful when a measurement provides a very high and a very low peak, both of which are to be evaluated. Example: Simultaneous measurement of front side (strong signal) and back side (weak signal) of a dark glass.

Path

The HDR mode can only be activated via the serial command `GAN`, not via controls on the front panel of the device.

Description

The HDR readout function offers the possibility to read out the photo load of an exposure with two different amplification levels in order to extend the dynamic range of the exposure by a factor of 6. High and low gain levels are thus combined into one overall signal. This is done within one exposure, so the measuring rate is not reduced.

With the command `GAN` the HDR mode can be activated and deactivated (for a detailed description of the command see the Command Reference of the device).

Good to know

- HDR works in chromatic confocal and in interferometric mode. However, HDR mode does not provide any improvement in interferometric measurement and its use is therefore not recommended.
- In certain cases (e.g. when measuring on inclined surfaces), the measurement accuracy may be reduced in this mode. Use is only recommended if an increased dynamic range is necessary, e.g. if surfaces/ layers with significantly different reflectivity are measured simultaneously.

Command: `GAN`

6.16 Configuring the Analog Output

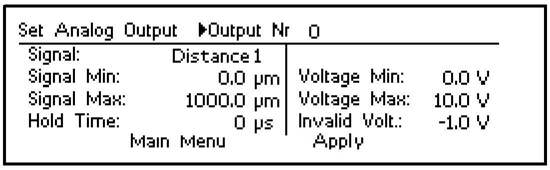
Purpose

There is a 15-pin D-sub connector on the front of the device. Among other things, measurement values can be captured here as analog voltages (for the pin configuration, see interface description in the appendix).

Path

`Setup > Analog Output Settings`

Illustration



Description

`Output Nr` defines which of the two analog outputs is set. The signal can be selected under `Signal` (for example `Thickness 1`). `Signal Min` and `Signal Max` are lower and upper measurement value limits in µm to which the corresponding voltage values `Voltage Min` and `Voltage Max` are assigned. After the two limit values have been set, the measurement values that lie between the limits are output as voltage values. This allows even very small measurements, for example of 10 µm, to be output with high resolution.

`Hold time` indicates how long the last valid measurement value is held until a new valid measurement value arrives. `Invalid Volt.` indicates the voltage that is output when source signal measurement values are invalid for a duration that is longer than the `Hold time`.

Command: `ANAX`

6.17 Setting the Display Contrast

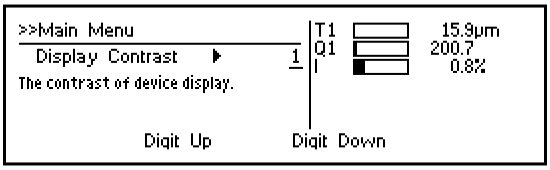
Purpose

The contrast of the display can be adjusted to suit the ambient conditions at the site.

Path

`Setup > Display Contrast`

Illustration



Description

The value range for the contrast of the display (`Display Contrast`) is from 0 to 255. A value of 0 represents a high contrast and 255 a low contrast.

Command: –

6.18 Making Communication Settings

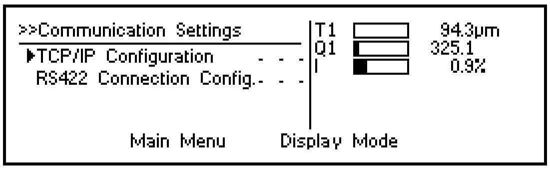
Purpose

The Communication Settings menu item is used to configure the necessary settings for all TCP/IP and RS422 communication.

Path

`Setup > Communication Settings`

Illustration



Description

The `TCP/IP Configuration` submenu is for defining the TCP/IP settings. If the device needs to have a fixed IP address, then the parameters `IP Address` and `Subnet Mask` must be defined. In this case, the IP address and the subnet mask can be entered as usual via the controls on the device's front panel. In addition, it is possible to define the packet size within a value range of from 1500 to 9000. If there is a DHCP server in the network, then `DHCP Client` must be selected so that the device is automatically given an IP configuration.

Command: `IPCN`

The `RS422 Connection Config.` submenu is for making settings for communication via the RS422 interface. The `Baud Rate` sub-item allows the serial interface transfer rate to be set. Hardware handshaking can be set in the `Handshake` submenu using `true` for enable and `false` for disable.

Command: `BDR`

6.19 Saving User-Specific Parameters

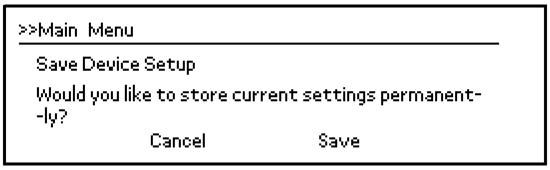
Purpose

Generally, the device settings made via the menu are not saved automatically. The exceptions to this are the settings for the display contrast and for the IP address. Other settings must be saved using the menu dialog or a command.

Path

`Setup > Save Device Setup`

Illustration



Description

Modified settings are saved to the device's non-volatile memory using `Save`. A confirmation prompt prevents unintentional overwriting. When the device is powered up, the last-saved settings are then loaded.

Command: `SSU`

6.20 Restoring the Factory Settings

Purpose

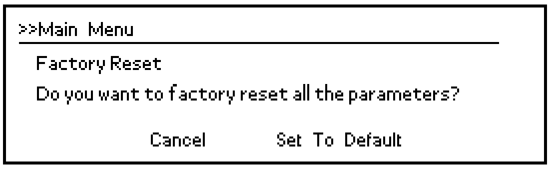
In certain cases, it may be necessary to restore the device's factory settings, for example:

- The device was unintentionally configured in such a way that meaningful measurements have become impossible.
- The device is to be sold.

Path

`Setup > Factory Reset`
`Setup > Factory Reset Incl. Network`

Illustration



Description

Two dialogs are available:

- `Factory Reset:` All of the settings except for the network settings are deleted and the factory settings are restored.
- `Factory Reset Incl. Network:` All of the settings including the network settings are deleted and the factory settings are restored.

A confirmation prompt prevents unintentional resetting to the factory settings..

Bear in mind that the factory settings do not necessarily correspond to the as-delivered settings.

Command: `SFD`

Performing Measurements

7

7.1 Overview of Performing Measurements

Purpose

This chapter describes how measurements can be carried out. Point measurements are described here. For profile or topographic measurements, the probe is moved across the surface using a corresponding measurement setup so that the surface topography can be compiled from the individual measurements.

Workflow

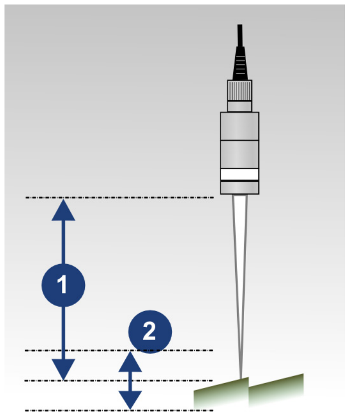
Step	
▼	Position the probe.
▼	Carry out a dark reference.
▼	Perform a measurement.

7.2 Positioning the Optical Probe (Chromatic Confocal)

Purpose

Correct positioning of the probe is a prerequisite for a successful measurement. This section describes how the probe must be adjusted.

Working distance and measuring range

Dimension	Illustration
1: Working distance	
2: Measuring range	

Rules

- The probe must be aligned as perpendicularly as possible to the sample.

Prerequisites

- The device must be connected and switched on.
- The optical probe must be connected.

Instructions: Positioning the optical probe (chromatic confocal)

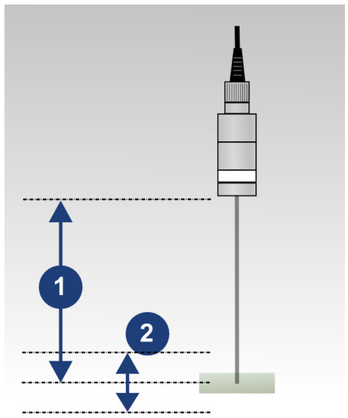
Step	Action
1	When using a clamping device: Clamp the probe into the device. Note: The clamping screw for securing the probe must only be tightened finger tight to avoid damaging the probe.
2	Change the distance from the sample to the optical probe step by step until the intensity is maximal (coarse adjustment).
3	Look for the location on your sample that has the least distance to the optical probe. Look at the spectrum on the display and change the distance of the optical probe so that the peak is located at the left end of the spectrum (fine adjustment). This ensures that when the measuring position is changed, valid distance values can be measured. Result: The probe is positioned at the correct working distance.

7.3 Positioning the Probe (Interferometric)

Purpose

Correct positioning of the probe is a prerequisite for a successful measurement. This section describes how the probe must be adjusted.

Working distance and measuring range

Dimension	Illustration
1: Working distance	
2: Depth of field	

Rules

- The probe must be aligned as perpendicularly as possible to the sample.

Prerequisites

- The device must be connected and switched on.
- The optical probe must be connected.

Instructions: Positioning the probe (interferometric)

Step	Action
1	When using a clamping device: Clamp the probe into the device. Note: The clamping screw for securing the probe must only be tightened finger tight to avoid damaging the probe.
2	Adjust the distance of the probe to the sample until the spot appears in clear focus (coarse adjustment).
3	Change the distance from the sample step by step until the intensity value is at maximum. Note: Once the intensity value is saturated (100%), increase the measuring rate or decrease the lamp intensity.
4	Change the distance from the sample step by step until the quality value is at maximum (fine adjustment). Result: The probe is positioned at the correct working distance and the layer to be measured is within the depth of field.

7.4 Performing the Dark Reference

Purpose

The detector of the sensor also receives signals when there is currently no sample present within the measuring range. These signals are caused by stray light in the fiber coupler, reflections on the fiber connectors, ambient light as well as through detector noise. The higher the intensity of these so-called dark signals, the more the sensor's measuring dynamics are restricted. The influence of these dark signals can be minimized by performing a dark reference.

Reasons for the dark reference

A dark reference is performed for every device before it leaves the factory. However, this must also be performed by the customer in different situations:

- Before carrying out new measurement tasks
- After changing the optical probe
- After changing the optical fiber
- If there are unusual measurement results, e.g. due to soiled fiber ends

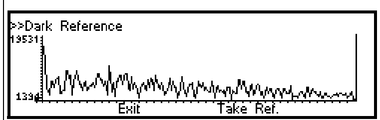
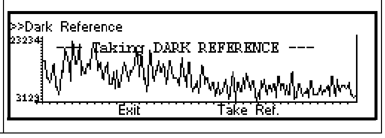
Prerequisites

- The device must be connected and switched on.
- The device has reached its operating temperature (warm-up time is about 30 minutes, depending on the ambient temperature).
- The optical probe must be connected.
- The optical probe must be positioned.

Path

`Setup > Dark Reference`

Instructions: Performing the dark reference

Step	Action	
1	Check to be sure the following circumstances are given: • The probe must not be aimed directly toward a light source. • There must be no samples within a range of two times the working distance along the measurement light beam.	
2	Ensure that as little stray light as possible reaches the probe, for example, by covering the probe with a piece of dark paper. If this is not possible due to construction constraints, aim the probe at nothing.	
3	On the display on the front of the device: Open the `Dark Reference` dialog.	
4	Press `Take Ref.` Result: The dark reference is performed, which takes about 2 to 3 seconds.	

Results assessment

The result is shown on the display once the dark reference has been performed. The value shown indicates the amount of stray light that was registered. It represents the lowest possible measuring rate in Hz before the detector becomes saturated in the darkened state. The lower the measured dark reference result, the less stray light influences the measuring dynamics.

The dark reference value depends on many factors, including the light source, spectrometer and condition of the optical fibers. For this reason it is not possible to give a generally valid guideline value which must not be exceeded in the context of the dark reference. Nonetheless, pay attention to unusually high values and follow the instructions in the chapter on Troubleshooting if needed.

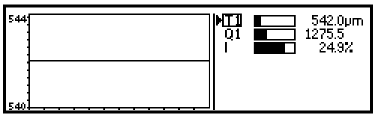
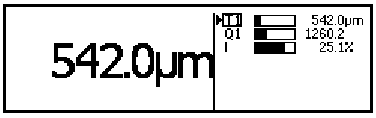
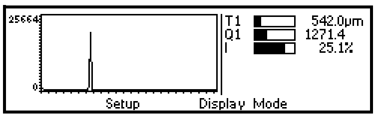
7.5 Performing a Chromatic Confocal Distance Measurement

Purpose

This section provides a step by step description of how to carry out a chromatic confocal distance measurement.

Display mode

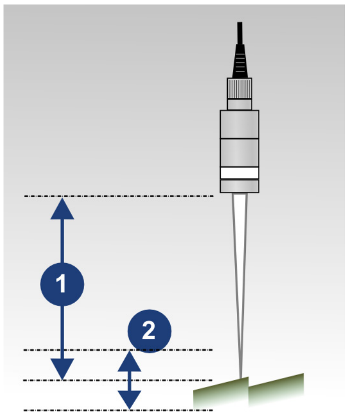
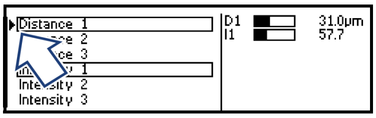
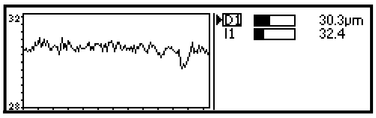
The measurement can be followed on the display in various different views. The user can switch back and forth using the right function button (`Display Mode`):

Display mode	Description
Data View 	• Shows measurement values as a line chart (measurement value over time). • The signal which is to be output can be chosen as desired.
Numerical Value View 	• Shows measurement values as a number. • The signal which is to be output can be chosen as desired.
Spectrum View 	• Shows the spectrum.

Prerequisites

- The device must be configured correctly (especially the measuring mode and measuring rate).
- The correct measuring mode (chromatic confocal) must have been selected.
- The correct chromatic optical probe must have been selected.

Instructions: Performing a chromatic confocal distance measurement

Step	Action	
1	Check whether the probe is positioned correctly; see the section Positioning the Probe (1: working distance, 2: measuring range).	
2	In the Data View or Numerical Value View: Press the `ENTER` button and select the desired signal (here: `Distance 1`).	
3	In the Data View or Numerical Value View: Use the jog wheel to select the desired signal and follow the measurement on the display.	
4	Adjust the configuration of a few parameters if needed. For chromatic confocal distance measurements, these will typically be: • Measuring rate • Lamp intensity • Intensity threshold • Detection windows	

Measuring problems

Incorrect or unexpected measuring results can be due to a number of different factors. The Troubleshooting chapter lists the most frequent malfunctions and provides information on correcting them.

Monitoring measurements with myCHRocodile

myCHRocodile is a Human Machine Interface which facilitates operations such as visualization of the measurement, saving and analyzing data, etc. myCHRocodile can be used to manage all Precitec point sensors.

Information on how to install myCHRocodile and how to follow measurements in myCHRocodile can be found in the myCHRocodile manual.

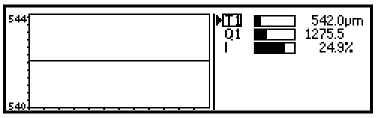
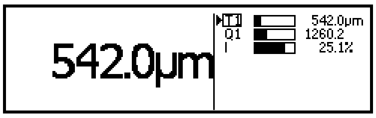
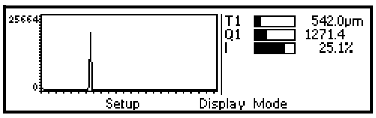
7.6 Performing a Chromatic Confocal Thickness Measurement

Purpose

This section provides a step by step description of how to carry out a chromatic confocal thickness measurement.

Display mode

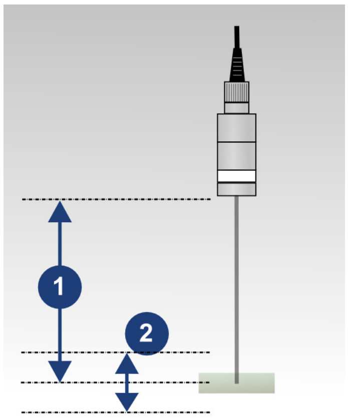
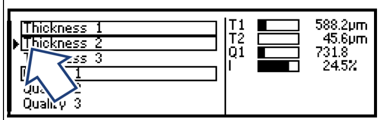
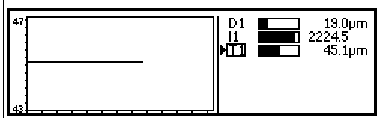
The measurement can be followed on the display in various different views. The user can switch back and forth using the right function button (`Display Mode`):

Display mode	Description
Data View 	• Shows measurement values as a line chart (measurement value over time). • The signal which is to be output can be chosen as desired.
Numerical Value View 	• Shows measurement values as a number. • The signal which is to be output can be chosen as desired.
Spectrum View 	• Shows the spectrum.

Prerequisites

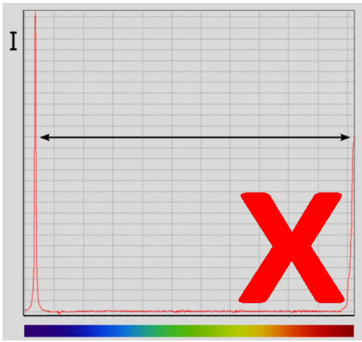
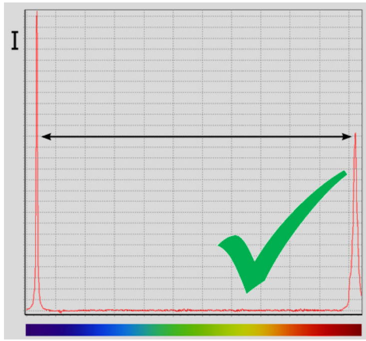
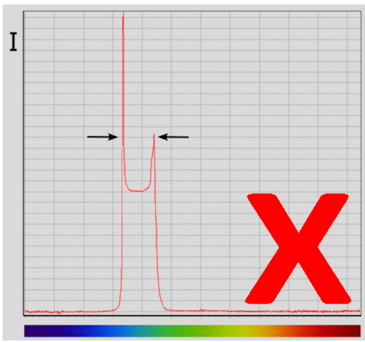
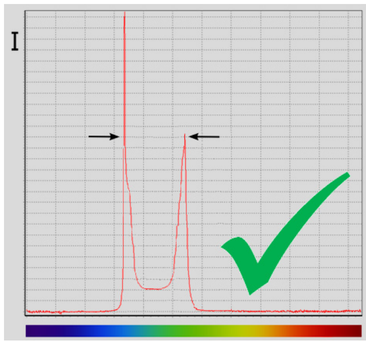
- The device must be configured correctly (especially the measuring mode and measuring rate).
- The material settings must have been configured (refractive index, Abbe number).
- The correct measuring mode (chromatic confocal) must have been selected.
- The correct number of peaks must have been selected (on the display under `Setup > Material Settings > No. of Peaks` or command `NOP`).
- The correct chromatic optical probe must have been selected.

Instructions: Performing a chromatic confocal thickness measurement

Step	Action	
1	Check whether the probe is positioned correctly; see the section Positioning the Probe (1: working distance, 2: measuring range).	
2	In the Data View or Numerical Value View: Press the `ENTER` button and select the desired signal (here: `Thickness 1`).	
3	In the Data View or Numerical Value View: Use the jog wheel to select the desired signal and follow the measurement on the display.	
4	Adjust the configuration of a few parameters if needed. For chromatic confocal thickness measurements, these will typically be: • Measuring rate • Lamp intensity • Intensity threshold • Detection windows	

Limits of chromatic confocal thickness measurements

There are two limiting cases for chromatic confocal measurements (upper and lower measuring range limit) for which a thickness measurement is not possible:

Layer is too thick: The peak is outside of the measuring range	If the geometric thickness of the object lies above the measuring range of the optical probe in use, then the boundary surfaces are no longer both in the focal range. If one of the peaks is not in the measuring range, then the thickness cannot be determined.		
Layer is too thin: The two peaks are too close together	For a meaningful evaluation of two measured distances and the layer thickness to be determined from these, the two peaks must be differentiable. This means that the minimum between the two peaks must be no less than half of the height of the smaller peak.		

Measuring problems

Incorrect or unexpected measuring results can be due to a number of different factors. The Troubleshooting chapter lists the most frequent malfunctions and provides information on correcting them.

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Information on how to install myCHRocodile and how to follow measurements in myCHRocodile can be found in the myCHRocodile manual.

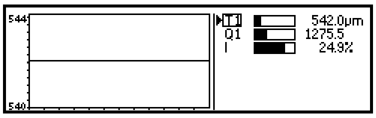
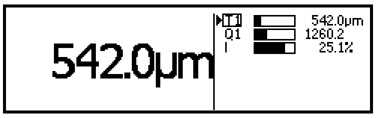
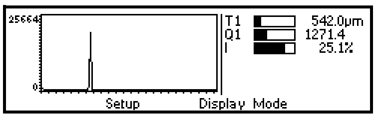
7.7 Performing an Interferometric Thickness Measurement

Purpose

This section provides a step by step description of how to carry out an interferometric thickness measurement.

Display mode

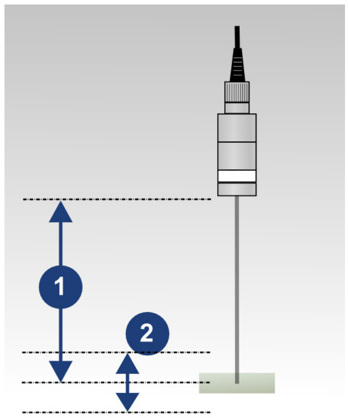
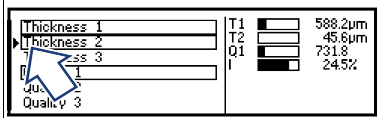
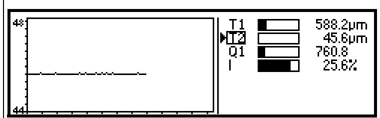
The measurement can be followed on the display in various different views. The user can switch back and forth using the right function button (`Display Mode`):

<table>
<tr><th>Display mode</th><th>Description</th></tr>
<tr><td>Data View
</td><td>• Shows measurement values as a line chart (measurement value over time).
• The signal which is to be output can be chosen as desired.</td></tr>
<tr><td>Numerical Value View
</td><td>• Shows measurement values as a number.
• The signal which is to be output can be chosen as desired.</td></tr>
<tr><td>Spectrum View
</td><td>• Shows the Fourier spectrum.</td></tr>
</table>

Prerequisites

- The device must be configured correctly (especially the measuring mode and measuring rate).
- The material settings must have been configured (refractive index, Abbe number).

Instructions: Performing interferometric thickness measurement

Step	Action	
1	Check whether the probe is positioned correctly; see the section Positioning the Probe (1: working distance, 2: depth of field).	
2	In the Data View or Numerical Value View: Press the `ENTER` button and select the desired signal (here: `Thickness 2`).	
3	In the Data View or Numerical Value View: Use the jog wheel to select the desired signal and follow the measurement on the display.	
4	Adjust the configuration of a few parameters if needed. For interferometric thickness measurements, these will typically be: • Measuring rate • Lamp intensity • Quality threshold • Detection windows	

Measuring problems

Incorrect or unexpected measuring results can be due to a number of different factors. The Troubleshooting chapter lists the most frequent malfunctions and provides information on correcting them.

Monitoring measurements with myCHRocodile

myCHRocodile is a Human Machine Interface which facilitates operations such as visualization of the measurement, saving and analyzing data, etc. myCHRocodile can be used to manage all Precitec point sensors.

Information on how to install myCHRocodile and how to follow measurements in myCHRocodile can be found in the myCHRocodile manual.

Maintenance

8

8.1 Maintenance Overview

Purpose

This chapter lists the activities which are required to maintain the device in proper working order or to restore this in the event of a failure.

Maintenance activities

The following maintenance and service activities on the device are allowed:

- Cleaning the optical fiber
- Cleaning the probe
- Updating the firmware

Repairs, structural changes or modifications to the system which are not described in this user manual are expressly forbidden. The Precitec Optronik GmbH is not liable for damage due to improper installation or procedures by non-authorized persons.

WARNING

Electrical hazard

Take note that after the housing has been opened or parts have been removed, energized parts are exposed. Touching such components is life-threatening.

- Do not use the device when the enclosure is open.
- Do not perform repairs, structural changes or modifications to the system (unless explicitly described in the Maintenance chapter).

CAUTION

Hazard due to laser beam

The opened device corresponds to IEC 60825 Class 3B. Retina damage due to the invisible or visible radiation emitted during operation of the device with the enclosure open cannot be ruled out.

- Do not open the device's enclosure.

8.2 Cleaning the Optical Fiber

Purpose

If measurements of known samples do not attain the usual measurement sensitivity or incorrect measurements occur, this may be due to contaminated optical components. In this case, the front lens on the optical probe and the optical fiber ends must be inspected and cleaned if needed. This section explains how to proceed in order to clean the optical fiber.

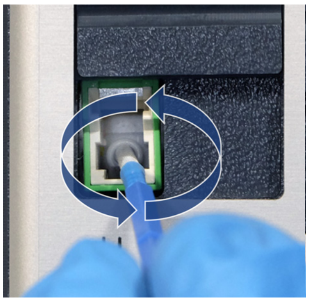
Required tools

- Cleaning sticks (included in delivery, item number: 5001793)
  or
  Cleaning pen (optional accessory, item number: 5009508)
- Possibly gloves

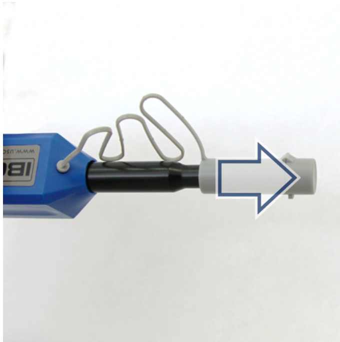
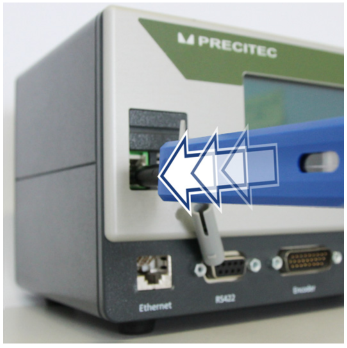
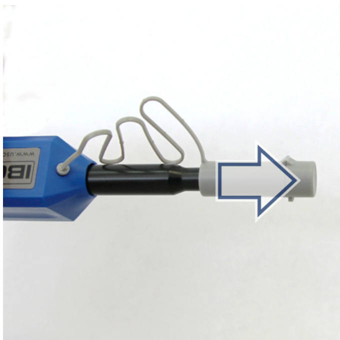
Prerequisites

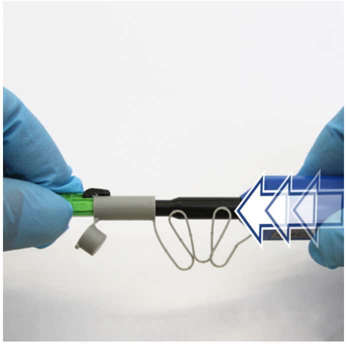
- The device must be switched off.

Instructions: Cleaning the optical fiber with cleaning sticks

Step	Action	
1	Fiber ends: Open the protective caps on the ends of the fiber with one finger and clean the end of the optical fiber (an E-2000 connector is shown here as an example). Note: Only use dry, unused cleaning sticks.	
2	Repeat the procedure on the other fiber end.	
3	Fiber optic connector on the control unit: Insert the white end of the cleaning stick into the connector. When doing so, the metal spring must be pushed downward lightly.	
4	Rotate the cleaning stick once about its axis and then remove it again.	

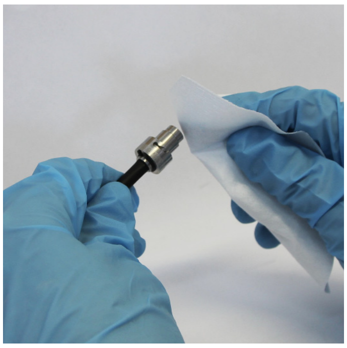
Instructions: Cleaning the optical fiber and fiber connection with the cleaning pen

Step	Action	
1	Remove the guide cap from the cleaning pen to clean the optical fiber connection of the control unit.	
2	Place the cleaning pen onto the optical fiber connector.	
3	Press the cleaning pen in the direction of the control unit until a firm resistance can be felt. Result: An audible click indicates the completion of the cleaning process.	
4	Open the cover of the guide cap on the cleaning pen to clean the fiber end.	

Step	Action	
5	Place the cleaning pen onto the optical fiber connector and press the cleaning pen in the direction of the fiber until a firm resistance can be felt (an E-2000 connector is shown here as an example). Result: An audible click indicates the completion of the cleaning process.	
6	Repeat the procedure on the other fiber end.	

Special case SC duplex

In the case of an SC duplex connector, observe the following procedure:

Procedure	Illustration
At the probe end of the optical fiber: To remove dust, use clean, greasefree and dry gas from a pressurized can or bellows. Then clean the fiber end of grease with a lint-free cloth moistened with ethanol. Note: There is an anti-reflection coating on the end of the fiber which can be damaged by chemical reactions. Therefore, do not use any aggressive solvents for cleaning.	

8.3 Cleaning the Probe

Purpose

If measurements of known samples do not attain the usual measurement sensitivity, this may be due to contaminated optical components. In this case, the front lens on the optical probe and the optical fiber ends should be inspected and cleaned if needed. This section explains how to proceed in order to clean the front lens on the optical probe.

Required tools

- Soft, lint-free cloth, ethanol
- Possibly a can of pressurized gas or a bellows
- Possibly gloves

Prerequisites

- The device must be switched off.

Instructions: Cleaning the lens

Contaminant	Cleaning
Dust	To remove dust, use clean, grease-free and dry gas from a pressurized can or bellows. When doing so, hold the pressurized can or bellows at a distance from the probe to avoid leaving any residues on the optical surface or inadvertently touching it.
Grease	Use a soft, lint-free cloth for degreasing and moisten it with ethanol. Wipe the optical surface carefully with the moistened cloth. When doing so, avoid applying too much pressure. Note: There is an anti-reflection coating on the front lens of the probe which can be damaged by chemical reactions. Therefore, do not use any aggressive solvents for cleaning the front lens.

8.4 Updating the Firmware

Purpose

It may be necessary to update the firmware if a software problem occurs that can only be corrected by means of a firmware update. In addition, an update may also be useful when new features are to be made available for use. If a firmware update is available, it can be installed in the manner described here. The required update file can be obtained upon request from Precitec Optronik.

For questions concerning network addresses or network settings, contact your network administrator.

Required tools

- Control unit and PC
- Ethernet cable
- Firmware update file: *.chrfmw

Prerequisites

- The device must be switched on.
- The device must have an IP address assigned to it (default: 192.168.170.2).
- The PC must have an IP address assigned to it which matches this IP address range, e.g. 192.168.170.1, subnet mask: 255.255.255.0.

Different firmware update paths

Depending on the firmware version used, different firmware update paths are available. Up to firmware version 1.4.X follow the instructions "Updating the firmware up to firmware version 1.4.X". From firmware version 1.5.1 follow the instructions "Updating the firmware from firmware version 1.5.1" or the instructions "Updating firmware from firmware version 1.5.1 (myCHRoco-dile)".

Instructions: Updating the firmware up to firmware version 1.4.X

Step	Action
1	Connect the PC and the control unit using an Ethernet cable.
2	Open an Internet browser.
3	Enter the sensor’s address in the address bar and confirm the entry (default: 192.168.170.2). Result: The firmware update dialog opens.
4	In the firmware update dialog: Select the new firmware file and upload the firmware. Note: Do not switch the device off during the upload and do not discon-nect the LAN connection. Result: The firmware update file is uploaded. Once the firmware has been uploaded completely, the device reboots automatically.
5	Remove the Ethernet cable from between the control unit and the PC if it is no longer needed.

Instructions: Updating the firmware from firmware version 1.5.1

Step	Action
1	Connect the PC and the control unit using an Ethernet cable.
2	Open an Internet browser.
3	Enter the sensor's address/legacy in the address bar and confirm the entry (default: 192.168.170.2/legacy). Result: The firmware update dialog opens.
4	In the firmware update dialog: Select the new firmware file and upload the firmware. Note: Do not switch the device off during the upload and do not discon-nect the LAN connection. Result: The firmware update file is uploaded. Once the firmware has been uploaded completely, the device reboots automatically.
5	Remove the Ethernet cable from between the control unit and the PC if it is no longer needed.

Instructions: Updating the firmware from firmware version 1.5.1 (myCHRocodile)

Step	Action
1	Connect the PC and the control unit using an Ethernet cable.
2	Open an Internet browser.
3	Enter the sensor's address in the address bar and confirm the entry (default: 192.168.170.2). Result: myCHRocodile is opened.
4	In myCHRocodile: Select the menu entry `App settings` and set `Applicator` or `Developer` under `User level`. Result: User level applicator or developer is selected.
5	Switch to the `Service` tab and click on the `FIRMWARE UPDATE` tile. Result: The firmware update dialog opens.
6	In the firmware update dialog: Select the new firmware file and upload the firmware. Note: Do not switch the device off during the upload and do not discon-nect the LAN connection. Result: The firmware update file is uploaded. Once the firmware has been uploaded completely, the device reboots automatically.
7	Remove the Ethernet cable from between the control unit and the PC if it is no longer needed.

Troubleshooting

9

9.1 Malfunctions, Causes and Measures

Troubleshooting and error correction

The following table lists malfunctions and possible causes as well as suggestions for correcting errors. If the error cannot be corrected, please contact Precitec Optronik.

Malfunction	Possible cause	Measure
Display does not light up.	No supply voltage.	Check the power connection.
The dark reference reports too much stray light.	Contamination on the probe or on the optical fiber	Inspect the probe and optical fiber for contamination and clean if necessary (see the Maintenance chapter).
	Defective probe or defective optical fiber	Inspect the probe and the optical fiber for damage, replace if needed.
The device does not show any valid measurements.	The sensor is saturated.	Increase the measuring rate or reduce the lamp intensity (see the Configuration chapter).
	Detection window is set incorrectly.	Check the detection window settings (see the Configuration chapter).
	Sample is outside of the focus area.	Position the sample in the measuring range (see the Performing Measurements chapter).
	The probe is angled too sharply with respect to the measurement surface.	Change the angle between the sample and the probe (see the Performing Measurements chapter).
	Probe is not connected or is connected improperly.	Inspect the connection of the probe (see the Operational Start-up chapter).
	Intensity or quality threshold too high.	Reduce the threshold.
	Measuring rate too high for sample or lamp intensity is too low.	Reduce the measuring rate or increase the lamp intensity (see the Configuration chapter).
	Quality of the measuring results is too poor.	Perform dark reference (see the Performing Measurements chapter).
	Sample is not transparent for the wavelength in use.	Check the transparency of the sample.
No valid data (distance/thickness = 0)	For IT-devices in interferometric mode: Sample to thin or too thick.	Check with Precitec Optronik, if a CHRocodile with needed measurement range is available.
	Fiber is broken.	Replace fiber.
	Continuous dark reference is active.	Deactivate continuous dark reference and record a new dark reference.

Malfunction	Possible cause	Measure
The measurement values shown fluctuate heavily or more than usual.	The dark reference is not up to date.	Carry out a dark reference (see the Performing Measurements chapter).
	The sample or the probe is vibrating.	Check the measurement system and the probe and sample holder for possible sources of interference.
	In the interferometric mode: Quality threshold too low.	Set the quality threshold higher (see the Configuration chapter).
	There is an additional, unexpected layer in the measuring range which is being measured and whose measurement value is being accepted as valid in the context of the selected thresholds and measurement windows.	Adapt the measurement window. Modify the thresholds. Remove the interfering layer or change the working distance is such a way that the interfering layer is no longer measured.
Working distance is too short.	Optical fiber is not properly connected.	Ensure that the fiber is connected correctly with the key in the slot and/or that the bayonet catch is correctly closed.
Noisy measurement	Fiber is dirty.	Clean all fiber connections and check stray light level.
	Very small intensity level	First: increase light intensity, second: reduce sample rate.
Artefact distance/thickness	IT-devices: Wrong fiber type connected.	Connect correct fiber.
	Dark reference was recorded while measuring beam was not blocked.	Record the dark reference anew.
The sensor is not sending any measurement values via the interface.	An `STO` command was sent.	Send an `STA` command, then save the configuration with `SSU`.
	Device is waiting for trigger (`TRG`, `TRE`, `TRW` command).	Deactivate trigger mode (`CTN`).
The Intensity (I) display is blinking.	The sensor is saturated.	Increase the measuring rate or reduce the lamp intensity (see the Configuration chapter).
The measured thickness displayed does not match the expected value.	The refractive index is set incorrectly.	Adjust the refractive index (see the Configuration chapter).
	Additional, undesired layer in the beam path.	Check whether there are layers between the sample and other surfaces that are being measured.
Device settings are lost every time the device is turned off.	Configuration was not saved to the non-volatile memory.	Save the user-specific parameters (see the Configuration chapter).

9.2 Support

Purpose

Please contact the Support team in the following cases:

- If you have questions about the device that go beyond the information provided in this user manual
- To arrange for having maintenance and repair work performed
- To order replacement parts

Prerequisites

Have the following information on the device ready:

- Model
- Serial number
- Version number (firmware and additional software)
- Accessories in use (esp. probe type)

Contact

For support requests, please contact your local sales representative. The Support team will assist you personally with all problems related to the device. General information on products and applications can be found at www.precitec.com.

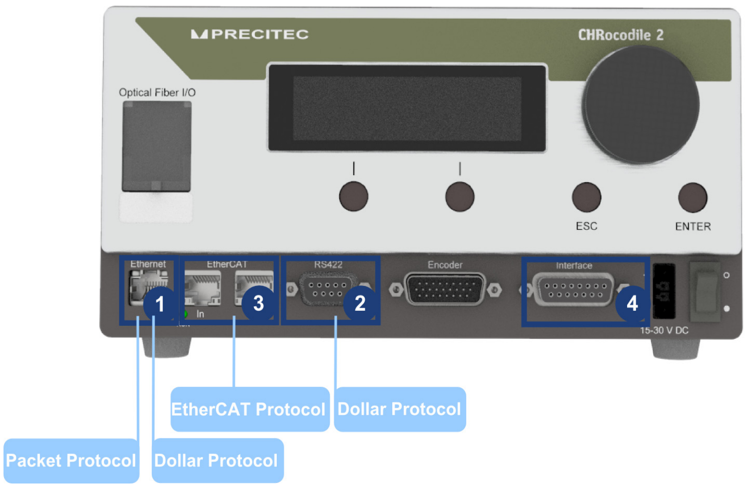
Appendix

10

10.1 Interfaces and Data Transfer

Data interfaces

The device supports different interfaces for data transfer: Ethernet interface (1), RS422 interface (2) and EtherCAT interface (3, optional). In addition, the signals measured by the device can be read off the display of the control unit or can be taken as voltages from the two analog outputs of the analog/sync interfaces (4). The following illustration shows the interfaces and data flows:



EtherCAT communication protocol (optional)

EtherCAT® stands for "Ethernet for Control Automation Technology". It is an Ethernet-based fieldbus system invented by Beckhoff Automation. The protocol is standardized in IEC 61158 and is suitable for both hard and soft real-time computing requirements in automation technology. EtherCAT can be used for metrological purposes to realize a fast and efficient communication. EtherCAT does not send data to individual slave nodes on the network, instead, it passes Ethernet frames through all of the slave nodes.

A more detailed description of the EtherCAT and its use with CHRocodile devices can be found in the Command Reference of the device (see the USB stick included in delivery).

Precitec communication protocols

There are two Precitec proprietary communication protocols, which facilitate communication between the sensor and the PC. One is the dollar protocol which is also used by the first generation of sensors, and the other is the binary packet protocol. The following table presents the main characteristics of the two protocol types by way of comparison:

Dollar protocol	Packet protocol
• Available via Ethernet TCP/IP (port 7890) and the RS422 serial connector • Economical measurement value transfer (2 bytes per measurement value plus 2 bytes as the telegram header) • Command format readable by humans; enables setup and parametrization using a simple terminal program • Optional ASCII measurement value output so that the data output can be read by humans using a simple terminal program • Real-time data output (via serial interface) • In ASCII format or binary format	• Available via Ethernet TCP/IP (port 7891) • Multi-client (3 clients per sensor) • Multichannel (only for multichannel sensors) • Simple packet structure with reasonable packet overhead • Data packets, data format packets, command packets • Easily decodable • Easily extendable

Up to four simultaneous network connections are supported; each can support the dollar or the packet protocol, which is decided by the port via which the connection is opened.

A more detailed description of the dollar and packet protocols and the data packets they use can be found in the Command Reference of the device (see the USB stick included in delivery).

10.2 Interfaces: RS422 Serial Interface

Interface

This interface is for reading the measurement values as well as for controlling and configuring the device. The serial interface supports hardware handshaking. The handshake and baud rate can be set using the function buttons on the control unit or using the `BDR` command.

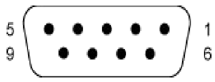
The device can be configured via commands it receives via this interface. In addition, various different functions can be carried out, such as the dark reference function. A more detailed description of the commands can be found in the Command Reference of the device (see the USB stick included in delivery).

Further communication parameters for the serial port are:

- 8 bit data
- no parity
- 1 stop bit

Illustration

9-pin D-sub female connector (for 9-pin D-sub male connector)



Pin configuration

Pin	Signal	Input Output Power	Ground reference
1	/RXD	I	RS422 GND
2	RXD	I	RS422 GND
3	TXD	O	RS422 GND
4	/TXD	O	RS422 GND
5	RS422 GND	P	
6	/RTS	O	RS422 GND
7	RTS	O	RS422 GND
8	CTS	I	RS422 GND
9	/CTS	I	RS422 GND

10.3 Interfaces: EtherCAT Interface (Optional)

Interface

The CHRocodile firmware has been extended to support the EtherCAT fieldbus according to the IEC 61158 standard with no specific device profile. The implementation provides CANopen-over-EtherCAT (CoE) capabilities and the transfer of global and peak signals via the EtherCAT Tx PDO mechanism, including an oversampling mechanism.

Interface, cables and connectors

For connecting EtherCAT devices only Ethernet cables that meet the requirements of at least category 5 (CAt5) according to EN 50173 or ISO/IEC 11801 should be used. EtherCAT utilizes 4 wires for signal transfer.

EtherCAT® uses RJ-45 connectors. The pin assignment is compatible with the Ethernet standard (ISO/IEC 8802-3).

The cable length between two EtherCAT devices must not exceed 100 m.

10.4 Interfaces: Ethernet Interface

Interface

Standard Ethernet interface, transfer rate of 100 Mbit/s, 10BASE-T/ 100BASE-TX, RJ-45 socket

The device can be configured via commands it receives via this interface. In addition, various different functions can be carried out, such as the dark reference function. A more detailed description of the commands can be found in the Command Reference of the device (see the USB stick included in delivery).

10.5 Interfaces: Analog/Sync Interface

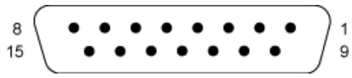
Interface

This interface provides the connection points for synchronization and for the analog outputs. A voltage signal is output via the analog outputs which has a defined relationship to the measurement values. The voltage values can be set using the function buttons on the control unit or using the `ANAX` command.

A more detailed description of the commands can be found in the Command Reference of the device (see the USB stick included in delivery).

Illustration

15-pin D-sub female connector (for 15-pin D-sub male connector)



Pin configuration

Pin	Signal	Input Output Power	Ground reference
1	GND	P	
2	SYNC OUT GND	P	
3	SYNC OUT	O	SYNC OUT GND
4	SYNC IN	I	GND
5	ANALOG GND	P	
6	ANALOG OUT 2	O	ANALOG GND
7	ANALOG GND	P	
8	ANALOG OUT 1	O	ANALOG GND
9	AUX OUT 3	O	GND
10	AUX OUT 2	O	GND
11	AUX OUT 1	O	GND
12	AUX OUT 0	O	GND
13	AUX OUT VCC	P, O	Voltage for AUX OUT buffer (max. 24 V DC)
14	ANALOG GND	P	
15	LVDT CARRIER	I	ANALOG GND

Analog interfaces

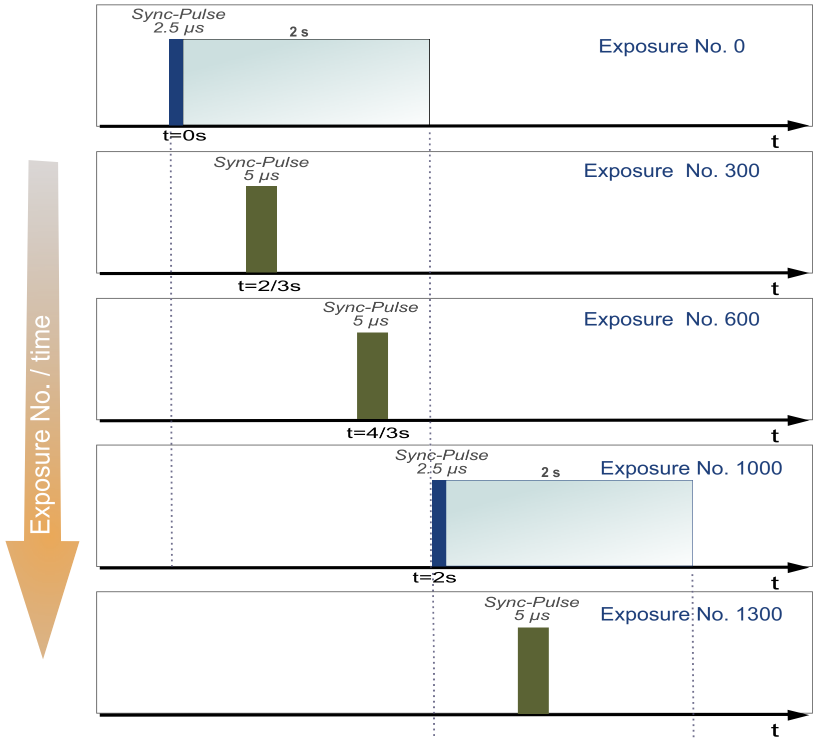
Interface	Function	Description
ANALOG OUT 1	Analog output for measurement values	Output of analog measurement values as an analog voltage of from -10 V to +10 V (configurable)
ANALOG OUT 2	Analog output for measurement values	Output of analog measurement values as an analog voltage of from -10 V to +10 V (configurable)

The analog outputs have a slew rate of 1.5 V/µs. As a result, the measurement values can no longer be mapped without errors at high measuring rates. If the complete voltage range from -10 V to +10 V is to be used, Precitec Optronik recommends a measuring rate of up to 35000 Hz. For a measuring rate between 35000 Hz and 70000 Hz, a halved voltage range is commended, e.g. -5 V to +5 V.

Sync interfaces

Interface	Function	Description
SYNC IN	Trigger input	Input for triggering measurements; positive edge of from 0 V to 24 V (threshold: 2,2 V) causes the following depending on the device's settings: • Start of continuous measurement from the "Wait for Trigger" state • Starts a single measurement in the "Trigger Each" measuring mode Notice: The input is equipped with an internal 10 kΩ pullup-resistance at 5 V. Therefore, for triggering, a voltage of 0 V must be applied at the input.
SYNC OUT	Sync output	This is for synchronizing several sensors when their Sync In inputs are connected to the Sync Out. Positive edge of from 0 V to 5 V at the start of each individual measurement. The pulse duration is normally 5 µs.

Illustration of exposure and Sync out pulses:



An alternative protocol format is available for simultaneous synchronization which synchronizes the clocks in several devices which deliver the time stamp. If interested, please contact Precitec Optronik.

Digital interfaces

The four digital outputs AUX-OUT 3..0 (pin 9–12) can be switched between two states, high (5 V) and low (0 V), issuing the command `OFN`.

There is the possibility to increase the output voltage of the pins 9–12. Up to 24 V can be applied to pin 13 in order to increase the output voltage of all four digital outs. E.g. if 12 V are applied to pin 13, the state high is at 12 V and the state low at 0 V. The outputs can be used for different applications, e.g. a fiber switch.

A more detailed description of the `OFN` command can be found in the Command Reference of the device (see the USB stick included in delivery).

10.6 Interfaces: Encoder Interface

Interface

The encoder interface makes it possible to assign an exact position coordinate to measurement values. This facilitates the communication with encoders for the capture of position changes. The 26-pin encoder connector supports up to 5 encoder channels simultaneously. The operation of the encoder is controlled using the `ENC` command. The encoder counters of the encoder channels can be set and queried using this command.

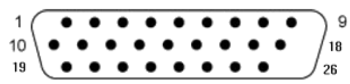
A more detailed description of the commands can be found in the Command Reference of the device (see the USB stick included in delivery).

The device supports operation of up to five encoder channels. The electrical encoder interface consists of 5 differential input pairs (An+, An- / Bn+, Bn-) with controllable 120 Ohm termination. The voltage difference between the + and - inputs must be larger than ±0.2 V. This is similar to the RS422 signaling standard.

NOTICE! The voltages on these pins must not exceed the interval 0 V – 5 V with respect to Ground to avoid damage to the termination resistors switches.

Illustration

26-pin D-sub HD male connector (for 26-pin D-sub female connector)



Pin configuration

Pin	Signal	Input Output Power	Description
1	A0-	I	Differential encoder input with switchable termination, 120 Ohms
2	A0+	I	
3	B0-	I	
4	B0+	I	
5	A1-	I	
6	A1+	I	
7	B1-	I	
8	B1+	I	
9	GND	P	Ground
10	A2-	I	Differential encoder input with switchable termination, 120 Ohms
11	A2+	I	
12	B2-	I	
13	B2+	I	
14	GND	P	Ground

Pin	Signal	Input Output Power	Description
15	NC	–	Not connected
16	A3-	I	Differential encoder input with switchable termination, 120 Ohms
17	A3+	I	
18	B3-	I	
19	B3+	I	
20	Termination ON/OFF	I	Low = Termination ON, NC or 5 V = Termination OFF [1]
21	+5V FUSED	P, O	Supply, 5 V / 120 mA for external encoder
22	Termination ON/OFF	I	Low = Termination ON, NC or 5 V = Termination OFF [2]
23	A4-	I	Differential encoder input with switchable termination, 120 Ohms
24	A4+	I	
25	B4-	I	
26	B4+	I	

(1) The input on pin 20 is used to specify whether a termination is used for the encoder inputs 0, 1 and 2.

(2) The input on pin 22 is used to specify whether a termination is used for the encoder inputs 3 and 4.

Encoder clock frequency

Before further processing, the encoder signals and the Sync In signal are passed through a parameterizable low-pass filter. The low-pass filter influences the clock frequency of the encoder interface and is set with the command `ENC`. If the low-pass filter is operated with default values, the clock frequency of the encoder interface is approximately 22 MHz in quadrature count mode. In pulse count mode, the clock frequency of the encoder interface is approximately 5.6 MHz.

The command `ENC x 4 0` can be used to increase the clock frequency of the encoder interface to approximately 68 MHz in quadrature count mode. In pulse count mode, the clock frequency of the encoder interface is approximately 17 MHz. The `x` parameter determines the encoder signal to which the low-pass filter is applied.

A more detailed description of the command `ENC` can be found in the Command Reference of the device (see the USB stick included in delivery).

Integration of encoder signals

The interfaces allow the device to be integrated into measuring systems or production facilities, for example for autonomous monitoring and control of a production process.

Encoder counter values can be monitored as signals which are included in the data telegram. Output data can be selected using the `SODX` command. The signal IDs of the encoder counters are as follows:

ID	Signal	Data format	Description
65	Start_PositionX	int 32 bit	Encoder position X at the start of the exposure
66	Start_PositionY	int 32 bit	Encoder position Y at the start of the exposure
67	Start_PositionZ	int 32 bit	Encoder position Z at the start of the exposure
68	Start_PositionU	int 32 bit	Encoder position U at the start of the exposure
69	Start_PositionV	int 32 bit	Encoder position V at the start of the exposure
70	Stop_PositionX	int 32 bit	Encoder position X at the end of the exposure
71	Stop_PositionY	int 32 bit	Encoder position Y at the end of the exposure
72	Stop_PositionZ	int 32 bit	Encoder position Z at the end of the exposure
73	Stop_PositionU	int 32 bit	Encoder position U at the end of the exposure
74	Stop_PositionV	int 32 bit	Encoder position V at the end of the exposure

For example

```
SODX 256 257 65 66
```

This command selects the peak 1 position (256) and the intensity (257) as well as the encoder counter values from axes X and Y at the point in time at which the exposure starts. This allows the axis position at the time of the measurement to be made available for every measurement.

Setting up the encoder counter

The encoder counter can be configured using the `ENC` command.

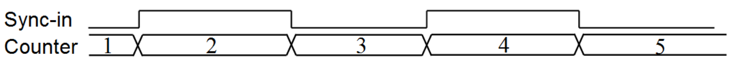
A more detailed description of the commands can be found in the Command Reference of the device (see the USB stick included in delivery).

Pulse count mode

If a single encoder signal A_x or B_x or Sync In is selected as the count source, the counter is in the pulse count mode. It increments with every edge and never counts downwards.

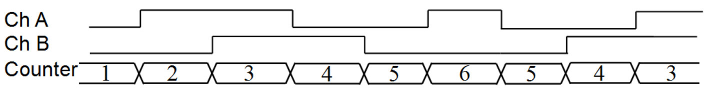
Another special point in this mode is that bit 0 of the counter value indicates the state of the input: When the input signal is at a logical low, the count value is always odd, and when the signal is at a logical high, the count value is always even. This allows the state of the input to be monitored.

In the example, it is assumed that Sync In has been selected as the count source for encoder counter 0 (`ENC 0 1 10`):



Quadrature count mode

In the quadrature count mode (default), the phase shift between the rectangle signal at A and B determines whether the counter is incremented or decremented. As an example, a quadrature signal is assumed on encoder channel 0 (`ENC 0 1 15`):



10.7 Timing Diagrams

Overview

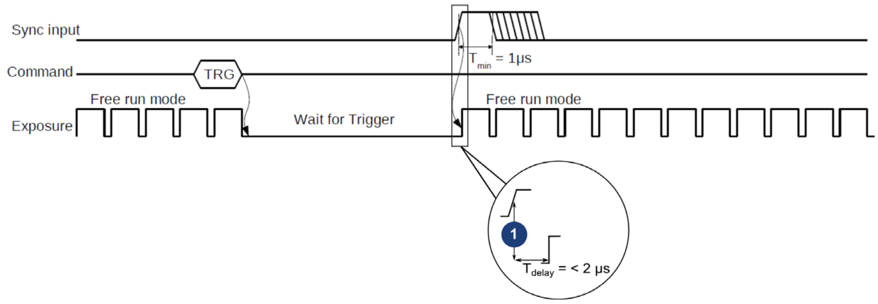
The sensor can perform measurements either in regular intervals (the so-called free run mode) or as a reaction on external events in one of the so-called trigger modes. There are 3 different trigger modes:

- Trigger Once
- Trigger Each
- Window Trigger

The trigger modes can be left by sending the `CTN` command or every other trigger mode command.

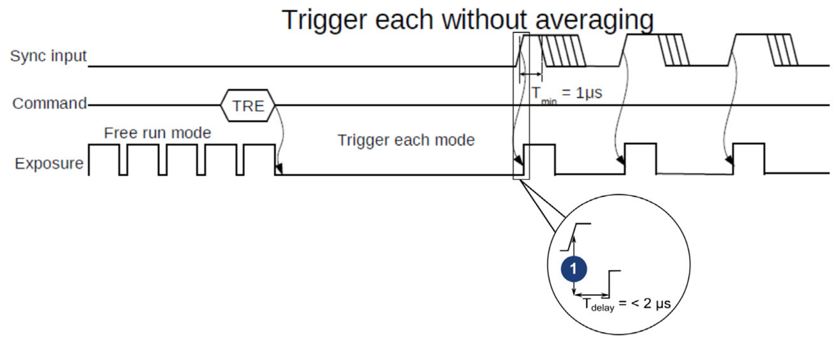
Trigger Once mode

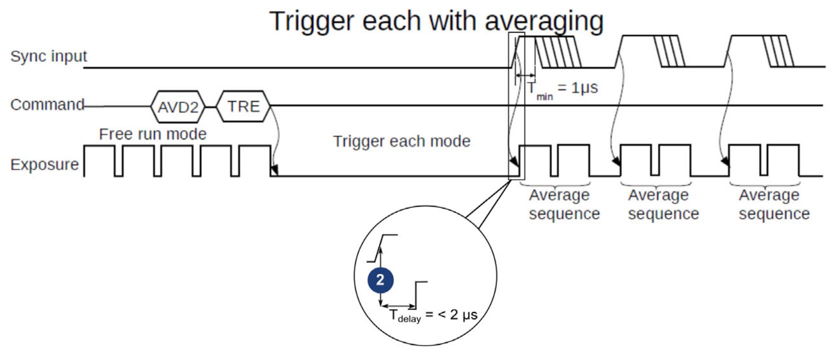
The Trigger Once command (`TRG`) stops the free run mode and puts the device into a wait for trigger state. Upon arrival of a trigger event (1), the device resumes free run mode with the currently programmed sample rate (`SHZ`). So, in fact, `TRG` is not really a trigger mode but rather a trigger state that is left with the arrival of the trigger event. The first exposure starts with a delay of < 2 µs when the trigger event occurs and is not aligned with any previous sampling interval.

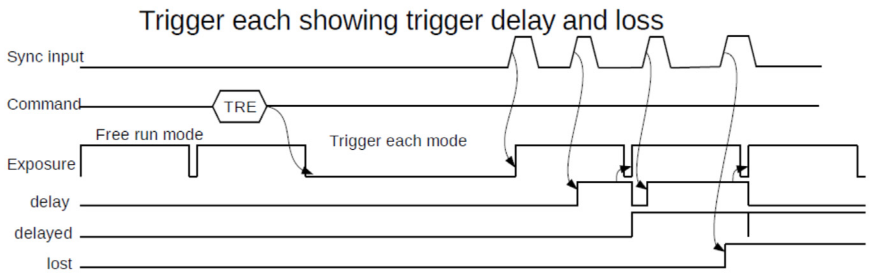


Trigger Each mode

In the Trigger Each mode, which is invoked by the `TRE` command, every trigger event (1) triggers one exposure. If averaging with `AVD` (Data averaging) and/or `AVS` (Spectra averaging) is selected, every trigger event (2) triggers one complete averaging sequence of exposures. An averaging sequence is a burst of `AVD*AVS` detector exposures that is averaged into one result sample. The burst of exposures is executed with the current sample frequency (`SHZ`). `AVS` is the number of exposures averaged in the spectral domain and `AVD` is the number of distance results averaged into one output sample. Thus, every trigger event yields one output sample. If a second trigger event occurs when a previous exposure is still under way (i.e. triggering too fast) then it will be stored and the trigger will be executed immediately when then the previous sample is finished. The trigger will thus be delayed but not lost. Also in this case, the exposure is performed with a delay of < 2 µs. If a trigger event occurs when a preceding trigger event is already waiting for execution, it will be dropped. It can be monitored in the flags result output signal (ExposureFlags, signal ID 76), if the current sample was due to a delayed trigger or if a trigger event was lost (dropped).

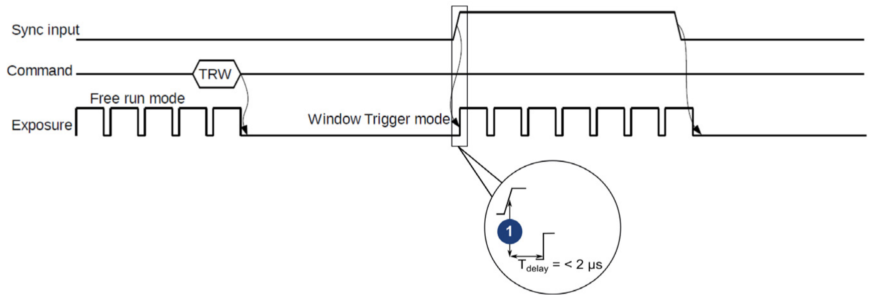






Window Trigger mode

The Window Trigger mode, invoked by the `TRW` command, waits for a start event, and then enters free run mode, similarly to the `TRG` mode, but it stops again after a stop event. Normally, the start event is a rising edge of the sync signal and the stop event is a falling edge. As in the `TRG` mode, the first exposure is aligned with the start trigger event (1) with a delay of < 2 µs. In contrast to the `TRG`, it does not leave the `TRW` mode with the start event. The Window Trigger mode can be combined with the (special) average setting of 0, which means window average, to produce one result sample that averages all the exposures between the start and the stop event. Like this, an averaging length can be realized that is determined by the Sync input's high time. This results in one sample per high period of Sync input.



The external events that control the measurements in the trigger modes can be signal edges on the Sync input or position encoder values that are monitored by the encoder interface. The choice between the Sync input and the Encoder state machine as trigger source is made with the `ETR 3 x` command. `ETR 3 0` (default) chooses the Sync input, whereas `ETR 3 1` activates the encoder trigger state machine as trigger source.

Sync input signal and STR

The Sync input signal is the result of a logical XOR between the electrical signal on the SYNC IN pin of the device and a signal controlled by the software command STR. In the default configuration, both of these signals are high so that each of them alone can define the level of the Sync input signal.

10.8 Accessories

Interferometric probes

Several probes are available. They differ in terms of construction, working distance, spot diameter, etc. The measuring range of interferometric probes is dependent on the control unit.

For available optical probes, see the corresponding data sheet. For illustrations, please contact your local sales representative.

Rules for handling of probes

The included optical components can be damaged by incorrect handling of the optical probe. Observe the following rules:

- Never screw the two halves against each other.

Chromatic confocal probes

The chromatic probes for distance and layer thickness measurement cover a measuring range of a few hundred micrometers up to several millimeters, so that a suitable probe is available for every application.

For available optical probes, see the corresponding data sheet. For illustrations, please contact your local sales representative.

Optical fibers and additional accessories

Accessories	Description	Item number
Optical fiber, sheathed in plastic 3 m 5 m 15 m (Custom lengths on request)	Single mode fiber, plastic sheathing, E-2000 connector, FC/APC connector	Dependent on the device type
Optical fiber, metal covered, 10 m (Custom lengths on request)	Single mode fiber, metal sheathing, E-2000 connector, FC/APC connector	Dependent on the device type
Cleaning sticks	Cleaning sticks for single use; see scope of delivery	5001793
Cleaning pen	Cleaning pen for multiple uses; best cleaning results due to efficient cleaning mechanism	5009508

Optional accessories

Accessories	Description	Item number
Reference box	Using the reference box allows the sensor to be employed for measuring distances in addition to layer thicknesses.	Upon request
Fiber switch	The fiber switch facilitates alternating operation using several different probes on one control unit.	Upon request