CHRocodile C

Compact sensor for non-contact distance and thickness measurement

Operation Manual

Imprint

Responsible for Contents
Original Edition

Precitec Optronik GmbH
Schleussnerstrasse 54
63263 Neu-Isenburg / Germany
Telephone: 0049 (0)6102 / 36 76 – 100
Telefax: 0049 (0)6102 / 36 76 – 126
e-mail: info@precitec-optronik.de
Website: http://www.precitec.de/en/precitec-group-start-page/

Representatives

Please visit our website to know the current addresses of our representatives.
PRECITEC OPTRONIK's regional contacts for the Optical Measuring Technology can be found here:

http://www.precitec.de/en/contact/precitec-worldwide/

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Basic Safety Instructions

This operation manual contains the most important instructions 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.

1.1 Warranty and Liability

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

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

Dismantling the device voids all warranty claims. The exception to this is the replacement of parts that are subject to wear and tear and require maintenance or calibration, to the extent that these are expressly identified in this documentation.

Changes made to the device on own authority render liability claims void.

1.2 Safety Symbols

The following terms and symbols for hazards and instructions are used in the operation manual.

WARNING

This symbol indicates a possibly dangerous situation. Failure to heed these instructions can result in minor injuries or cause property damage.

WARNING

High voltage hazard – indicates a hazard from electrical shock and warns of immediate or impending danger to the life and health of persons or of extensive property damage.

WARNING

Do not touch – indicates that touching the contact/optics surface can cause damage/destruction of the component.

IMPORTANT

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

TIP

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

PREREQUISITE

Describes all components as well as all conditions that must be present/ be fulfilled in order to the action to be successfully completed.

ADDITIONAL INFORMATION

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

1.3 Proper Use

The optical sensor is intended as a stand-alone device or as part of a measurement apparatus for measuring distance, thickness and surfaces for quality and dimensional control.

Only use the optical sensor in a dry environment. The device may only be operated within the specifications given in the technical data.

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

Electromagnetic Compatibility (EMC)

Both as an individual device and in combination with the devices designated in this documentation, the optical sensor fulfils the requirements of the standards DIN EN 61326-1:2013-07 and DIN EN 61010-1:2011-07, and therefore corresponds to the EU-Directive 2014/35/EU and 2014/30/EU. This declaration is valid for all units with the CE label on it, and it loses its validity if a modification is done on the product.

When customer-supplied devices or cables are used this can mean that these Norms may not be fulfilled. For this reason, you should only use the original devices and replacement parts and observe the instructions for EMC-compliant installation in the handbooks that come with them.

If the optical sensor is operated inside a facility with other devices, the entire facility must comply with the provisions in the EC-Guidelines in the demands of the general operating permit.

1.4 Duty of Operator and Personnel

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

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

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

1.5 Safety Measurements in Normal Operation

When it is assumed that the device can no longer be operated safety, the device or the plant must be taken out of operation. The device must be secured against unintended use. Unauthorized interventions will void your rights to assert warranty claims.

Any attempt to copy or analyze the software will lead without fail to the voiding of all rights to assert warranty claims.

1.5.1 Protection from Electronic Shock

Please make sure that the live components are uncovered after opening the housing or removing components. Touching these components presents a potentially lethal hazard.

When service- and repair work is performed on opened devices and modules, the main power supply must be reliably shut off (mains cable unplugged).

1.5.2 Protection from Optic Radiation / Eye Safety

When performing service and maintenance work, make sure that you do not look directly into the LED’s light. The light can harm your eyes.

1.5.3 Grounding the device

Make sure that the device is grounded in compliance with regulations. Please make sure that the optical sensor is supplied with power via a grounded main power input line (cold device plug).

1.6 Medical or safety-relevant usage

If the CHRocodile Line Sensor is used in medical or safety-relevant applications, the operator must ensure that the CHRocodile Line Sensor is qualified for the specific application. This includes the optical characteristics of the measured sample as well as the influence of temperature and vibrations to the CHRocodile sensor.

Furthermore the user has to check the CHRocodile Line Sensor for correct measurements and for exceeding the specified measuring uncertainty.

1.7 Storage and Transport

In order to avoid damages in storage and transport, the following ground rules are to be observed:

- Maintain the storage temperature range allowed in the technical specifications
- Take suitable measures to avoid any damage from humidity or moisture, vibrations or impact
- Do not store in or near magnetic fields (e.g. permanent magnet or alternating electrical field)

1.8 Emergency Procedures

- Disconnect the plant from the main power supply
- Extinguish any flames with a Class B fire extinguisher

Product Description

2.2 General Description

The CHRocodile C is a single-point compact optical sensor dedicated to non-contact surface measurement. This sensor is based on confocal chromatic principle and offers high precision distance and thickness measurement.

The CHRocodile C has an original architecture, with no optical fibers, which consists in all elements embedded in one optoelectronic unit. PRECITEC is the first company to propose this unique architecture for confocal chromatic sensor, which allows to overcome the device integrating constraints met in industrial environment.

With its robust and integrated design, the CHRocodile C is ideally suited for industrial inline use and easily integrable into any kind of inspection machine.

The CHRocodile C can accommodate different types of optical probes. The optical probes interchangeability is straight forward, as the operator just need to exchange optical probes and move to the right calibration table. Finally, data transmission is carried out by Ethernet communication up to 4000 measurements per seconds. CHRocodile C characterisctics are described in *Section 2.7.*

The extraordinary high dynamic range and the outstanding signal-to-noise ratio of the CHRocodile sensors ensure the best measuring results on any kind of surfaces.

Thanks to its compact dimensions and excellent performance/price ratio, CHRocodile C is the ideal alternative to classical laser triangulation sensors.

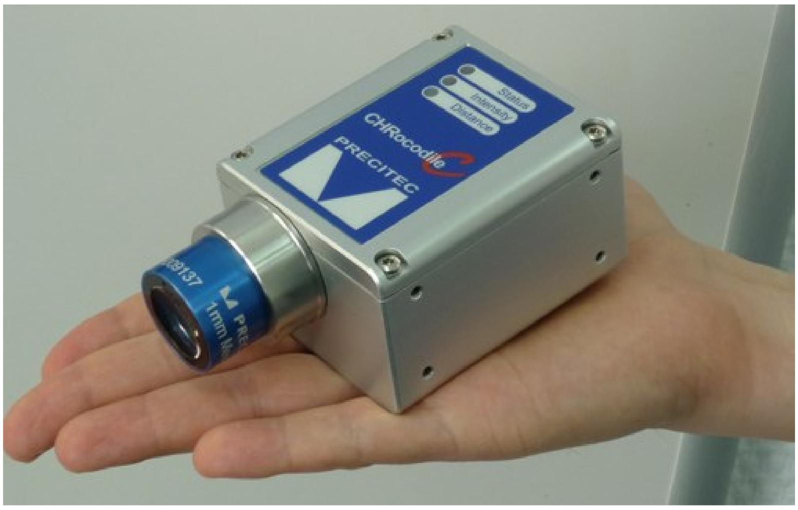


Fig 2-1: CHRocodile C 3D view:

2.3 Measuring principle

2.3.1 Optical principle

For most industrial applications the chromatically coded distance detection method turned out to be very well suited. CHRocodile C is based on this method and more precisely on the Confocal Chromatic principle. This principle combines the properties of confocality and axial chromatism.

Axial Chromatism:

That method takes advantage from a lens optical error commonly known as axial chromatic aberration: the axial position of the focal point depends on the wavelength (color) of the light to be focused. For example, in the visible spectral range, the focal distance for blue light is shorter than for red light. The focal points of intermediate wavelengths are located in between according to a continuous axial position variation. Thus, considering white light passing through an optical objective provided with axial chromatic aberration, a continuum of color along the optical axis is generated, as an axial rainbow.

Confocality:

That method also takes advantage from confocal opto-mechanical configuration. A confocal optical system uses illumination point source and a pinhole in an optically conjugate plane in front of the detecting system to eliminate out-of-focus signal. As only in focus light can be detected, the image's optical lateral and axial resolution is improved. Consequently the pinhole act as a spatial filter which block light which is out of focus or light which come from an external light source.

Confocal Chromatic Imaging:

Considering both confocality and axial chromatism properties, a white light illumination point is imaged through the chromatic objective on a target object. Depending on the distance of the target from the focusing chromatic objective, light of just a very narrow wavelength bandwidth is perfectly focused on the target’s surface. All other spectral components of the light source are out of focus. In the back path, from the target’s surface to the detector, the reflected light passes through the chromatic objective, the optically conjugate pinhole which is in front of the spectrometer. The pinhole filters all wavelengths except the narrow bandwidth which is in focus. The spectrometer analyses the spectrum of the light reflected back by the target’s surface, and only a chromatic peak is observed corresponding to the narrow wavelength bandwidth perfectly in focus. The analysis and the barycenter calculation of this chromatic peak allow to determine the distance of the target surface from the chromatic objective. (*Cf. Fig. 2.2*)

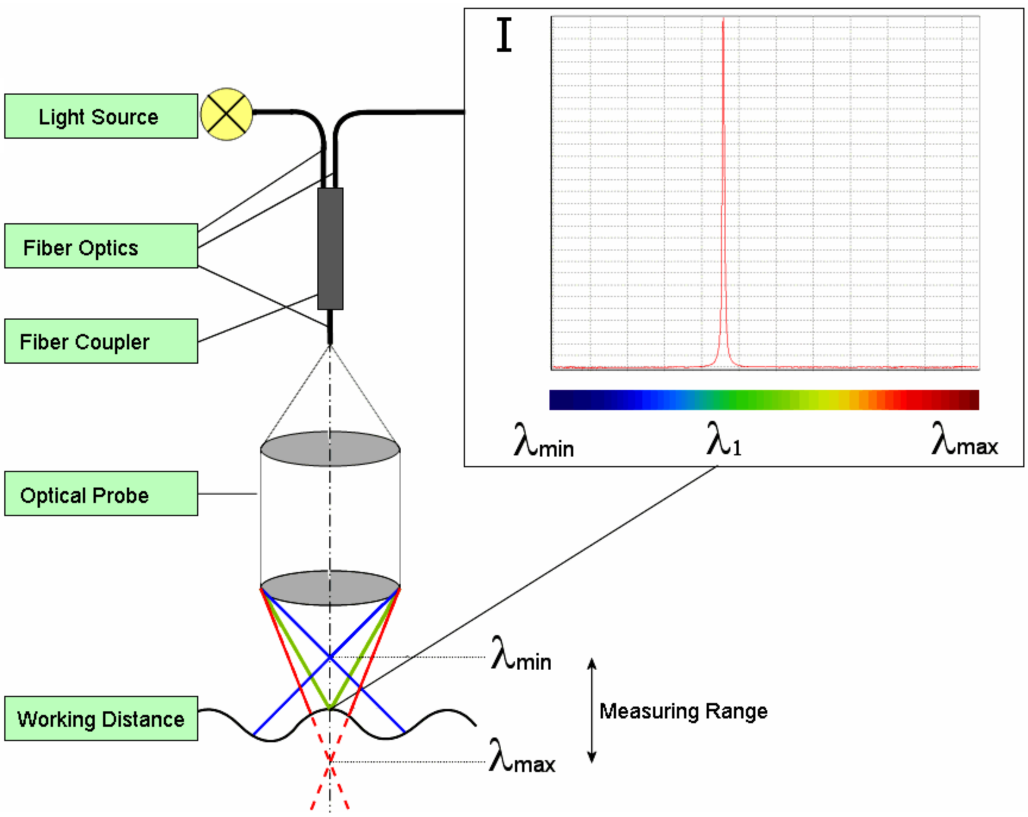


Fig. 2-2: Chromatic Confocal Imaging principle (point sensor)

2.4 Sensor Functionalities

The CHRocodile C can transmit two different data: distance and thickness measurements. The principle of these two applications are explained hereafter.

Application type 1 **Chromatic distance measurement**

Topographic, profile or roughness measurements are performed with distance data measurement. With single-point sensors, i.e. CHRocodile C, one spot is focused on the surface of the measured object using an optic with a known chromatic aberration. The reflected light is more intense for the wavelength in focus on the surface. Reflected light is spectrally analyzed and the spectral response is a peak centered on focused wavelengths. The spectral peak positions determine the distance to the surface information. The distance is calculated and transmitted to host computer at up to 4KHz frequency See *Fig. 2-3*.

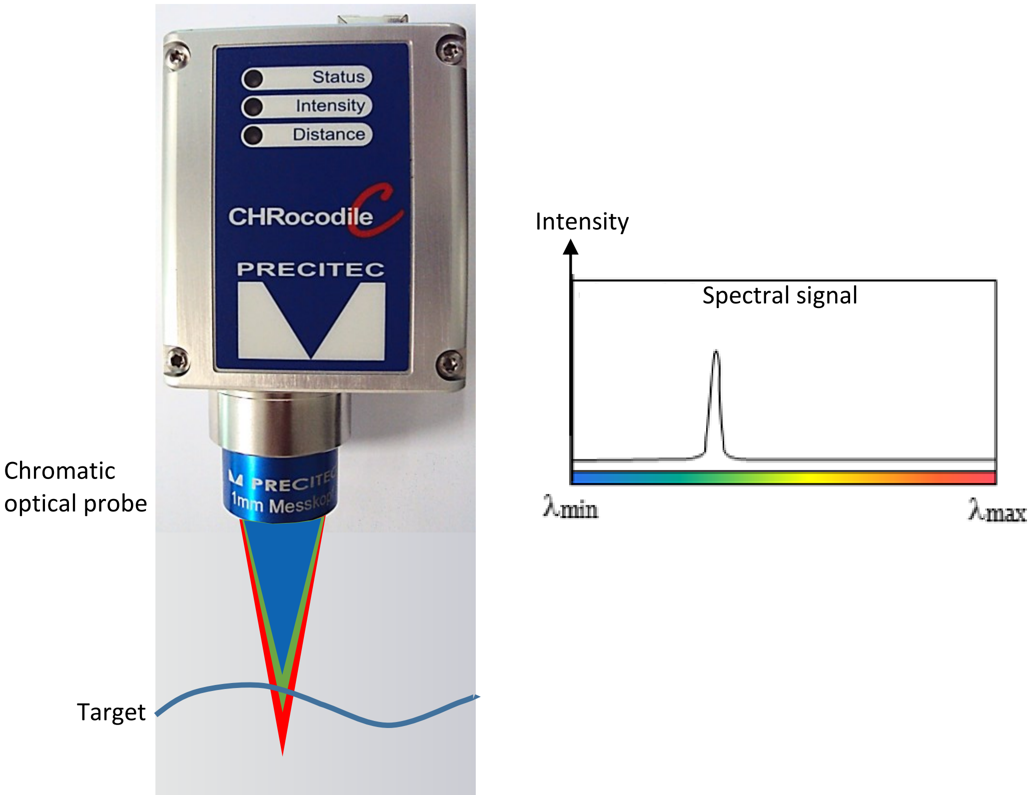


Fig. 2-3: Chromatic measurement principle, distance measurement

Application type 2

Chromatic thickness measurement

Thickness measurements can be performed when thickness data is selected. If a transparent material is within the measurement volume of the chromatic optical probe, the white light spot is focused on both the two surfaces of the measured object. The reflected light is more intense for the two wavelengths in focus on the two surfaces. Reflected light is spectrally analyzed and the spectral response is constituted of two peaks centered on focused wavelengths. Considering the refractive index of the object, one can determine the thickness of the object at the spot light location. This thickness data is calculated and transmitted to host computer at up to 4KHz frequency. See *Fig. 2-4*.

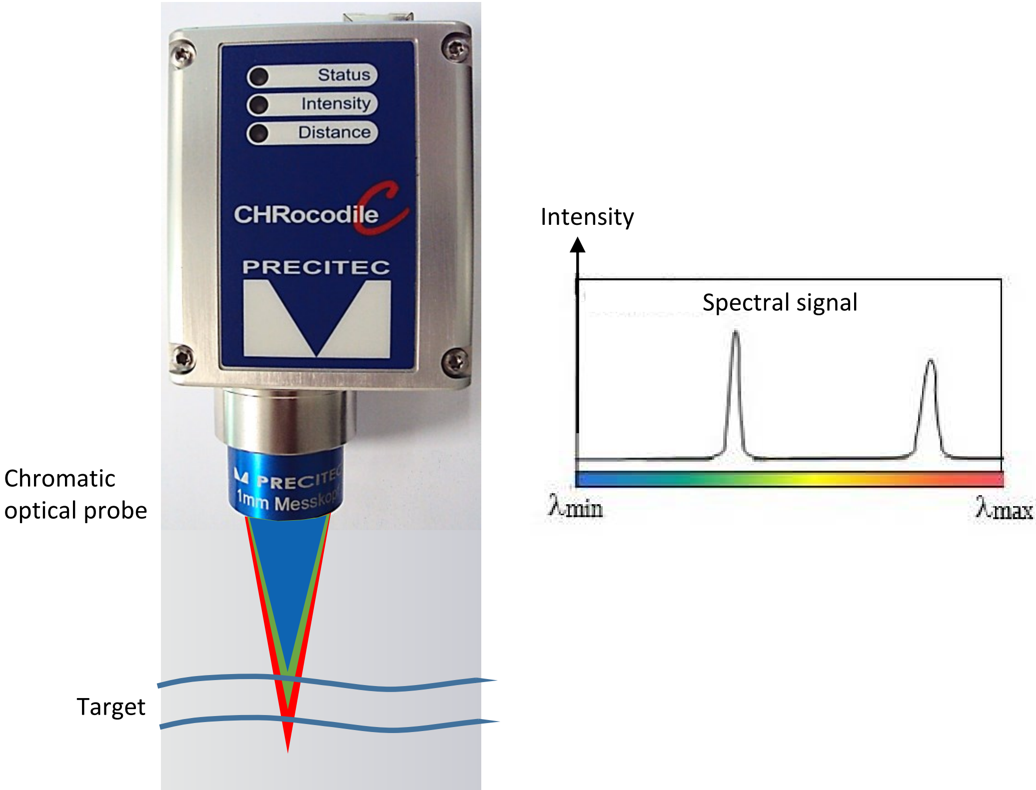


Fig. 2-4: Chromatic measurement principle, thickness measurement

2.5 Typical applications (Overview)

A broad range of possible applications is available to this highly precise sensor.

The CHRocodile C is the most compact sensor based on confocal chromatic imaging principle. This sensor is perfectly suitable for demanding measuring tasks, like non-contact measurement of microtopography, layer thickness measurements. It could be used both on various reflecting and scattering surfaces.

The PRECITEC confocal chromatic compact sensor is very well adapted to industrial environment, as no optical cable are connected to the CHRocodile C unit. The absence of optical cables, promotes robustness and compactness of the measuring device, and also facilitates the integration and use on a motorized moving system, such as a coordinate measuring machine (CMM). Then this new type of sensor overcomes the industrial constraints induced by fiber optic cables that are known to deteriorate when the measuring device is subject to high accelerations and / or rotational movements.

The CHRocodile C offers the ability to perform fast and accurate metrological control of production, by being built on automatic or semi-automatic inspection machines, or by being directly integrated on production line for 100% inspection of manufactured parts. In this, this new technology fully meets the current needs of the industry as it is suitable for many applications:

- The measurement of wafer in the field of semiconductor and generally microelectronics,
- The measurement and online control of mechanical or optical parts,
- Or even the measurement and control of glass or plastic film thickness.

Other fields of applications exist, the common point is to seek a cost effective measurement system going, more and more compact, as flexible as possible, and highly accurate. It is the case in laboratory environment and even more in industrial environment. It appears clearly here that the CHRocodile C unit of measurement meet these different needs.

Optical Head / Application	Probe 200µm	Probe 1mm	Probe 4mm	Probe 10mm
Electronics		*	*	*
Micro-Electronics	*	*		
Mechanics		*	*	*
Micro-Mechanics	*	*		
Optics		*	*	*
Micro-Optics	*	*		
Shape		*	*	*
Flatness	*	*		
Roughness	*	*		
Plastic and glass thickness	*	*	*	*
Thin film thickness	*	*		
Coating thickness	*			

Table 2.1: Sensor applications

2.6 List of Deliverables

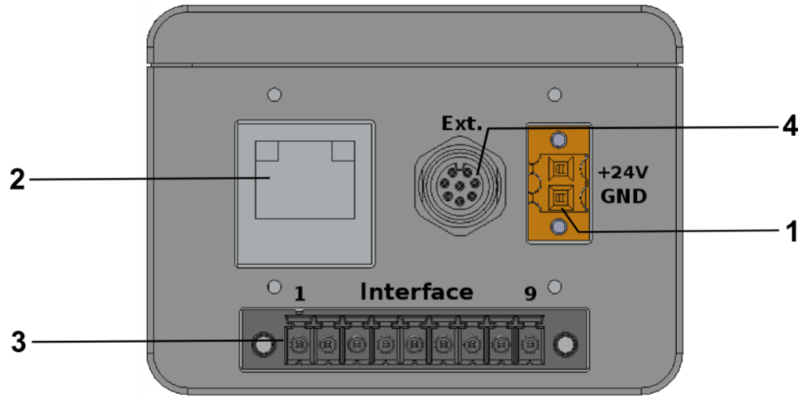
- One operational confocal chromatic unit (*see Fig. 2-5*),
- One operational optical probe (*see Fig. 2-6*),
- Power Supply Adapter (100-240V_{AC} to 24V_{DC} +/-10%),
- Ethernet cable,
- A CD with DLL and firmware,
- Software user guide,
- Operation Manual,
- Calibration report.

Fig 2-5: CHRocodile C unit 3D view:

Fig 2-6: Optical Head 3D view: a- 0.2mm b- 1mm c- 4mm d- 10mm

2.7 Connections and Interfaces

All of the connection ports for the sensor unit are located at the rear of the system (*see Fig 2-7*):



1. **Power supply jack,**
2. **Ethernet interface, RJ45 port**
3. **9-PINS Multipoint interface connector (Trigger / Serial communication)**
4. **8-PINS round connector (analog converter module connection)**

Fig. 2-7: CHRocodile C rear panel: Connections

2.7.1 Power supply jack

The CHRocodile C has two pluggable screw terminal for power supply with $24V_{DC}$ +/-10%.
Connect the set of power cable supply associated to the Power Supply Adapter (100-240VAC to $24V_{DC}$ +/-10%) delivered with the CHRocodile C unit.

2.7.2 Ethernet connector

The CHRocodile C has a RJ45 standard connector for Ethernet communication.
Connect the isolated RJ45 standard connector from the CHRocodile C unit to an Ethernet network (PC). Ethernet supports the data transfer and can also be used for setting configuration by using $ command protocol (Cf. command SODX in Appendix 1), or for loading Calibration Table (Cf. command TABL in Appendix 1). Ethernet communication allows to transmit a maximum of 16 data values at 4 KHz.

2.7.3 Trigger Input/Output and RS422 serial communication

The Trigger input/output use a multipoint connector interface (9 pins). This connector is used for trigger Input / Output and for RS422 serial communication (*Cf. Table 2-2 and Table 2-3*).

The trigger options make the lighting cycle externally controllable and the synchronization between e.g. a scanning system cycle and the CHRocodile C measurement rate. This means that external triggering is possible for every measurement up to the full measurement rate of 4000Hz.

The interface contains the connection points for the synchronization and RS422 or RS232 serial communication.

The serial RS232/RS422 is interfaced on the multipoint connector interface (9 pins). Serial communication are mostly used for sending command as a hyper-terminal, and can also support data transfer. The maximum transfer rate RS232/RS422 is 1843200 Bd.

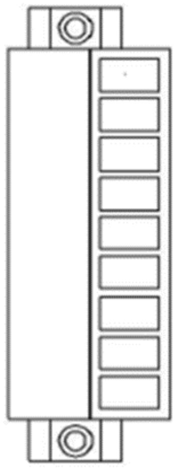
	PIN	SIGNAL
	1	RS232 TX / RS422 TX-
	2	RS232 RTS / RS422 TX+
	3	RS232 CTS / RS422 RX-
	4	RS232 RX / RS422 RX+
	5	GND
	6	Sync In
	7	Sync Out
	8	Reserve
	9	GND

Table 2.2: Multipoint connector PIN / Signal correspondence

Signal	Function	Description
RS422	RS422 Interface	RS422 (differential signaling) Interface, internally terminated, no handshaking
RS232	RS232 interface	RS232 interface, RTS/CTS handshaking possible
Sync In	Sync. Input	Positive slope from 0V to 5-24V causes according to the settings of the sensor: • starts the continuous measurement, if the command wait for trigger was received first (TRG Command) • starts the single measurement in mode trigger each (TRE Command) When in TRW mode, a positive slope starts continuous measuring, a negative slope stops the measurement the input has an internal 10 kΩ pullup-resistor to 5 V.
Sync Out	Sync. Output	Sync Output Positive slope 0 V to 5 V with the start of each measurement.

Table 2.3: Interface

Remark: As the Sync-input has a weak pull-up to 5V, your trigger source definitely needs to be able to sink that current in order to pull the input down to Gnd. So as a trigger source, you can use an open collector transistor output, that pulls to ground or a push pull output. The input can support 24V, but the trigger threshold is always at approximately 2V. The trigger occurs on the rising edge, that means when the external pulldown transistor releases the input or when the pushpull drives to 5V.

Wait for trigger – signal characteristics to Analog Out

The sensor stops after the current data telegram is transmitted and goes into a standby mode.

The last transmitted analog value persists until the next exposure (also see TRG command).

2.7.4 External analogue converter box connection

The 8 pins round connector is used for external analogue converter box connection. This option can be added to the CHRocodile C in order to obtain an analogue output. Also it is possible to add up to 2 encoder-input using this external analogue converter box connection.

The incremental encoder-input makes it possible to precisely assign the measurement point and axis position without additional hardware. The CHRocodile C can manage with 2-axis encoders if the optional analogue converter box is connected to the CHRocodile C 8-pins mini-DIN connector.

For an exact distance measurement it is necessary for every measurement value to be assigned to the exactly correct spatial coordinates. This data must be recorded in the system and transferred to the evaluation processing unit over the internal interface. To accomplish this, the sensor must be equipped with the analogue box accessory.

2.7.5 Status LED

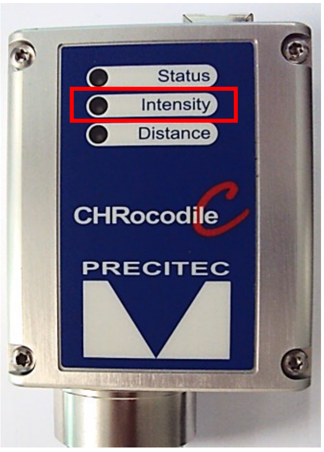
	LED status / CHRocodile C Status
	Power OFF Power ON, Firmware boot failure Power ON, Firmware is configured / Continuous measurement (blink) Power ON, Triggering session (1) Power ON, Waiting for trigger (1) green when triggered at high frequency
	No signal (blink) Saturated intensity signal High intensity signal Optimal intensity signal Medium intensity signal Low intensity signal
	No signal (blink) Out of range : too far Far Range Mid Range Near Range (blink) Out of range : too close

Table 2.4: Status LED during functioning

2.8 Sensor Characteristics

2.8.1 Sensor unit characteristics

Optical sensor	
Measuring principle [(1)]	Confocal Chromatic
Measuring data [(1)]	Distance, Thickness [(1)]
Light source	LED
Dimensions (sensor unit)	99.3 x 65 x 47 mm (L x W x H) [(2)]
Weight	425g
Data Transmission	
Measurements / second	Up to 4000 Hz
Interfaces	Ethernet, RS422, external analogue converter box as accessory
Transfer rate	Ethernet (100Mbits); RS422 (9600 – 921600 Baud)
Synchronization with ext. devices	Trigger-input / Output (TTL)
Encoder-inputs	Optional: 2 encoders input available through analogue converter box accessory
SDK	DLL written in C, C++ / SDK written in C# with .NET framework 4
OS	Windows XP, Windows 7, Windows 8
Data processing / calculation	Embedded processing unit
Standard to be met	
Supply voltage	$24V_{DC}$ +/-10% with separate main supply unit 100 to $240V_{AC}$ – 50Hz to 60Hz
Rated power	4W
Operating temperature	0 °C to +50 °C
Storage temperature	-20°C to +70°C
CE marking / EMC	Compliant with applicable regulation
RoHS	Compliant with applicable regulation
Protection class	IP50 (DIN 40050/ IEC 144)
Metrological specifications	
Axial resolution / Repeatability [(3)] [(4)]	$3x10^{-5}$ x Measuring Range
Accuracy [(4)]	$2x10^{-4}$ x Measuring Range
Optical probes specifications	See Table 2.7
Order number	5009276

Table 2.6: Sensor Characteristics

(1) See section 2-3: Sensor functionalities. With CHRocodile C, the transmitted data are limited to up to 4 Altitudes, up to 4 Intensities and up to 3 Thicknesses.
(2) See Fig A2-2 Sensor unit mechanical plan in Appendix 2 CHRocodile C unit mechanical plan.

(3) See section 2.9: CHRocodile C performance Specifications.
(4) Resolution / Repeatability is given for optimal conditions (with a high intensity signal).

2.8.2 Optical probes characteristics

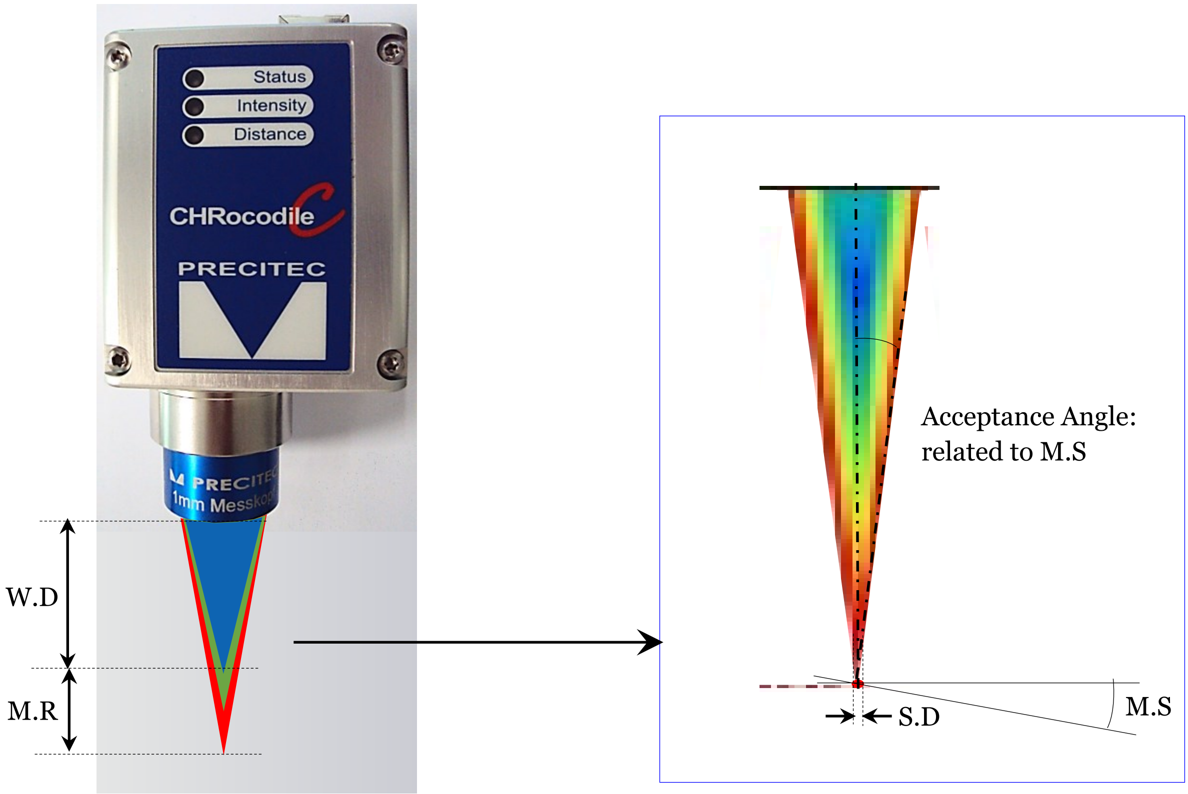
Specifications \ Optical probe		Probe 200µm	Probe 1mm	Probe 4mm	Probe 10mm
DISTANCE MODE	Measuring range (1)	200µm	1mm	4mm	10mm
	Axial resolution / Repeatability (R_{min})(4)(5)(6)	8nm	30nm	120nm	300nm
	Accuracy (4) (5)	50nm	200nm	0.8µm	2µm
THICKNESS MODE	Min. measurable thickness (4) (7)	8µm	40µm	160µm	400µm
	Max. measurable thickness (4) (7)	300µm	1.5mm	6mm	15mm
	Axial resolution / Repeatability (4)	20nm	75nm	300nm	750nm
GLOBAL SPECIFICATIONS	Working distance (1) (2)	4.7mm +/- 0.3mm	15.7mm +/- 0.5mm	36.7mm +/- 0.7mm	68.7mm +/- 1mm
	Spot diameter (1)	3.4µm	5µm	8µm	16µm
	Lateral resolution	1.7µm	2.5µm	4µm	8µm
	Max object slope (1) (3)	+/- 45deg	+/- 28deg	+/- 20deg	+/- 14deg
MECHANICAL DIMENSIONS	Length	17mm (8)	23.7mm (8)	26.6mm (8)	35.3mm (8)
	Diameter	28mm (8)	28mm (8)	33.8mm (8)	40mm (8)
	Weight	33g	30g	44g	50g

Table 2.7: Optical Head Specifications

(1) See section 2.9: Optical probe specifications definitions
(2) Bottom of the optical probe to middle of the measuring range
(3) Decreasing accuracy on the limits
(4) See section 2.10: CHRocodile C performance Specifications
(5) Measurement on perpendicular mirror at 20°C with optimal Signal to Noise ratio.
(6) Axial Resolution varies with intensity signal in %. Axial Resolution = 10 x R_{min} x $I^{-0.5}$
(7) Refractive index n=1.5
(8) See Fig A2-1: Optical probes mechanical plan
(9) See Fig A2-2: CHRocodile C unit mechanical plan

Optical probes are interchangeable: the same CHRocodile C unit can store up to 8 different calibration tables corresponding to different optical probes. The optical probe is totally passive, only the CHRocodile C unit has an internal light source and electronic board which can be considered as heat and electrical sources. However the optical probe is highly isolated from these heat and electrical sources in order to avoid any thermal expansion which could affect the accuracy of the sensor measuring process. Considering this opto-mechanical architecture the CHRocodile C unit has no visible optical cable and the user don't need to take care with this particularly sensitive component.

2.9 Optical Head Specifications definitions



W.D : Working Distance

M.R : Measuring Range

S.D: Spot Diameter (Size)

M.S: Max Object Slope (specified for specular object. On diffuse object, it is possible to measure on slope up to 85°)

Fig 2-8: Optical probes specification definition

2.10 CHRocodile C performance specifications:

Axial Resolution / Repeatability:

Axial resolution / Repeatability corresponds to the static noise (standard deviation 1σ) on altitude or thickness measurements. Axial resolution is measured on 1000 continuous points at different target positions inside the measuring range. By default axial resolution specification corresponds to the minimum value (R_{min}) along the measuring range (*See Fig. 2-9*). The minimum value (R_{min}) corresponds to the target position where the signal to noise ratio is maximum. Resolution is inversely proportional to the signal intensity.

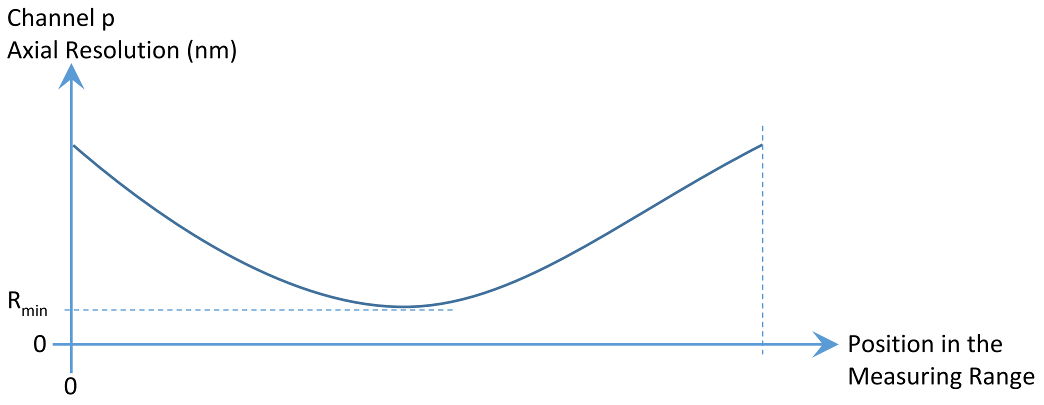


Fig 2-9: Axial Resolution as a function of target position in measuring range.

Accuracy:

Accuracy corresponds to the altitude deviation between the CHRocodile C and a calibrated interferometric reference sensor as a function of target position in the measuring range. Consequently, accuracy is an experimental specification. By default accuracy specification corresponds to the maximum of absolute value (A_{max}) (*See Fig. 2-10*).

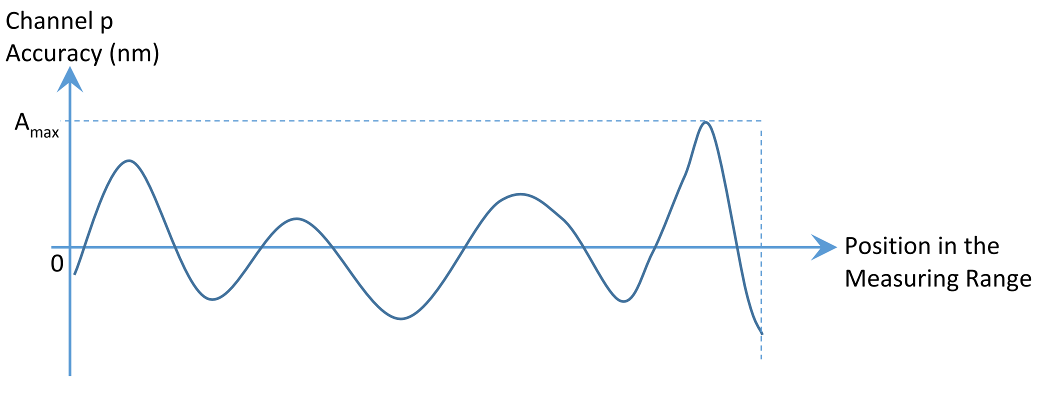


Fig 2-10: Accuracy as a function of target position in Measuring Range.

Minimum and Maximum Measurable Thicknesses:

The minimum and maximum measurable thickness specification is given for n=1.5 refractive index. It is measured on a standard sample in the center of measuring range. $T = n \times (D_1 - D_2)$

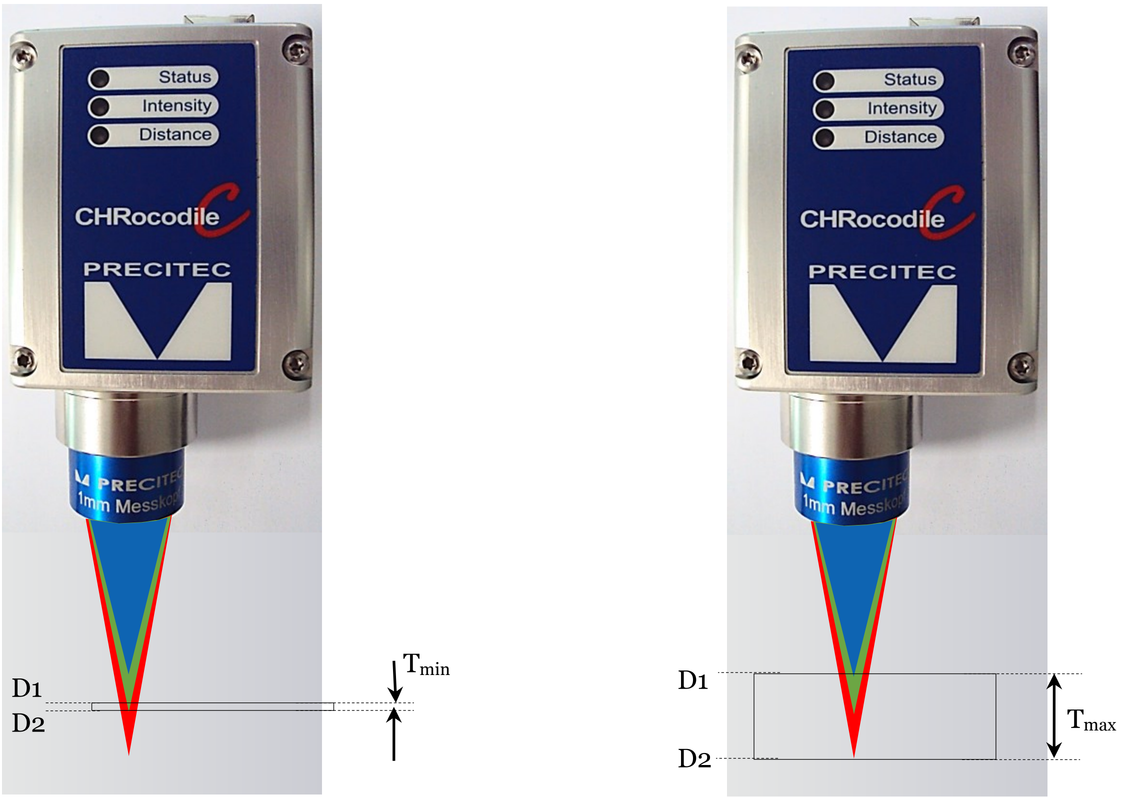


Fig 2-11: Minimum and maximum measurable thicknesses

Operational Start up

3.1 Connections and Interfaces

All of the connection ports are located at the rear of the CHRocodile C (Cf. section 2.6 Connections and Interfaces):

- The power supply jack,
- The RJ45 standard connector for Ethernet communication,
- The multipoint connector interface (9 pins) for trigger input / output and RS422/RS232 serial communication,

3.1.1 CHRocodile C Stand Alone device:

The device can be used as a stand-alone device in order to perform selective distance or thickness measurements. In this condition, only the power supply and Ethernet connector or multipoint connector are useful.

Power supply

The CHRocodile C has two pluggable screw terminal for power supply with $24V_{DC}$ +/-10%.
Connect the set of power cable supply associated to the Power Supply Adapter (100-240VAC to $24V_{DC}$ +/-10%) delivered with the CHRocodile C unit.

Ethernet connector

Connect the isolated RJ45 standard connector from the CHRocodile C unit to an Ethernet network (PC). Use shielded cable for the data port connection (minimum category 5 cable).

The default CHRocodile C IP address is: **192.168.170.4**
Configure the PC Ethernet port to the following address: **192.168.170.X (X≠4)**
The CHRocodile C can also be configured to use auto-configuration of the IP-Address through a DHCP server.

To configure the Ethernet port of your PC, you must open the '*Network connection properties'* menu. After selecting the right Ethernet card (connected to the sensor), click on '*network protocol (TCP/IPv4)'* and click '*Properties'*. Set the IP address of the PC and the mask. For a standard use the mask should be set to 255.255.255.0.

If you need to configure the sensor to another IP address (different than 192.168.170.4), you need to use the $IPCN command (Cf. Appendix 1). This could be useful in case of multiple CHRocodile C connection on a single computer.

Multipoint connector interface

Data transmission can be done through RS422/RS232 serial communication, using the so called $-protocol. Two formats are available (ASCII/BIN) for sending the data from the optical sensor via the RS422.

The data can thus be transferred to a computer as ASCII-symbols (telegram format*)* and e.g. viewed with a terminal program (e.g. Tera Term, Freeware).

Output in BIN format, command: $BIN
Output in ASCII format, command: $ASC

The transfer rate for the serial interface port is selected under **serial port baud rate**.

The standard Baud rates available for selection are 9600, 19200, 38400, 57600, 230400, 460800 , 921600 Baud and 1843200 Baud. Arbitrary nonstandard Baud rates can also be configured.

3.1.2 CHRocodile C integrated on measurement system:

In addition to the Power supply and Ethernet connector or multipoint connector interface used for stand-alone device, the CHRocodile C needs to be connected to other interfaces to be integrated into complex measurement configuration systems. The other possible interfaces are described hereafter:

- The multipoint connector interface for Trigger Input/Output and Serial interface RS422,
- The 8 pins mini-DIN connector for external analogue converter box to add 2 encoder inputs.

Encoder-input

The incremental encoder-input makes it possible to precisely assign the measurement point and axis positions without additional hardware. The CHRocodile C can manage with 2-axis Encoders if the optional analogue converter box is connected to the CHRocodile C 8-pins mini-DIN connector.

For an exact distance or thickness measurement it is necessary for every measurement value to be assigned to the exactly correct spatial coordinates. This data must be recorded in the system and transferred to the evaluation processing unit over the internal interface. To accomplish this, the sensor must be equipped with the analogue box accessory.

Default are the encoder inputs not terminated.
Tye Sw0t02 to GND to terminate with 120 Ohm channel 0 to 2
Tye Sw3t04 to GND to terminate with 120 Ohm channel 3 to 4

If the encoder-signals are fed through the sensor and additional other devices are connected (e.g. for axis control), the 120 Ohm termination can also be deactivated. Since the device has to be opened to do this, you should contact Precitec Optronik before beginning any work of this kind.

Trigger Input/Output

The trigger options make the lighting cycle externally controllable and the synchronization between e.g. a scanning system and the CHRocodile C measurement rate. This means that external triggering is possible for every measurement up to the full measurement rate of 4000Hz.

The interface contains the connection points for the synchronization and RS422 serial communication.

Data transmission / sensor configuration

Data transmission and sensor configuration can be done through RS422 serial communication through the multipoint connector interface or through Ethernet port.

3.2 CHRocodile Explorer and Drivers installations

3.2.1 CHRocodile Explorer installation:

CHRocodile Explorer is a Man-Machine interface which allows to configure, to visualize measurement, to save data etc… CHRocodile Explorer can manage with all PRECITEC CHRocodile point sensors.

Refer to CHRocodile Explorer Manual to obtain more specifics information.

3.3 Communication with CHRocodile C

There are three possible ways to communicate with the CHRocodile C: via Precitec CHRocodile Explorer software, via the CHRocodile C DLL and using the ASCII commands sent to the CHRocodile C through serial interface (RS 422) or Ethernet communication. Up to 10 CHRocodile C can be connected and controlled by a single computer (Windows XP, Windows 7 or Windows 8 OS, 32 and 64bits). CHRocodile C is automatically detected through Ethernet network (broadcast mode).

3.3.1 Via CHRocodile Explorer:

CHRocodile Explorer software is delivered with the sensor and is useful to configure sensor, to visualize continuous measurements and to save data.

In order to obtain further detailed on CHRocodile Explorer functionalities, please refer to CHREplorerManual.

3.3.2 Via CHRocodile C DLL:

DLL is used to interface the sensor with a general-purpose user program. This CHRocodile C DLL is written in C, C++ language and is intended for .NET compatible language. This DLL allows to use whole CHRocodile C functionalities. In order to obtain further detailed refer to CHRocodile C DLL documentation.

A CD containing the DLL, some code examples and the operating Manual is delivered with the CHRocodile C.

3.3.3 ASCII command communication

The ASCII commands can be sent to the controller via the RS422 interface using a specific command structure described on Appendix 1.

Serial interface communication can be used to configure the sensor and receive measurement data.

As an example, the Windows™ « Hyper Terminal »™ utility can be used to send the commands and configure the sensor via the RS232 or RS422 communication port.

Measurements Start Up

4.1 Calibration Table

The CHRocodile C unit can store up to 8 different calibration tables corresponding to different optical probes. In order to start measurement you need to download or select the calibration which corresponds to the used optical probe (Cf. command $SEN in Appendix 1). Calibration table consists in a look up table which gives the correspondence between the peak position (Barycenter data) and the Altitude data.

The CHRocodile C is calibrated at factory with a certified calibration bench.

The calibration table depends on both spectrometer and optical probe. Consequently a calibration table is specific to one set of CHRocodile C sensor (CHRocodile C unit + optical probe), it can't be used on another set even if you are using the same optical probe type (i.e same measuring range).

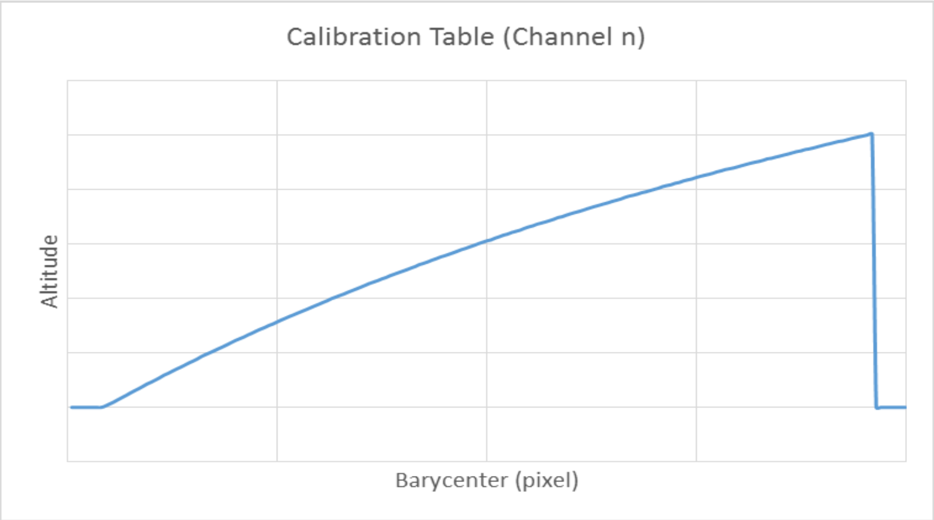


Fig 4-1: Example of calibration table for a single channel

4.2 Dark Acquisition

Even when there is no surface in the probe's measurement range, the signal on the detector is not zero. These non-zero values for each pixel on the detector is due to electronic dark and mostly to flare corresponding to unwanted back-reflected light on optical lenses surfaces. This Dark signal which limits the measurement dynamics of the sensor can be remove from the useful signal.
In order to eliminate the influence of this undesirable light, a dark reference is performed on the sensor (Cf command DRK in Appendix 1). The Dark reference acquisition must be done when no object is in the measurement range.

4.3 Mechanical interfacing

After completing the operational startup, i.e. connecting with the power supply, proceed with initializing, then communication is ready and mechanical interfacing should be done.

Mechanical interfacing consists in:

- Connecting the optical probe, which suits to your application, to the CHRocodile C unit. The optical probe is simply screwed on the CHRocodile C unit (Cf. Figure 4.2).

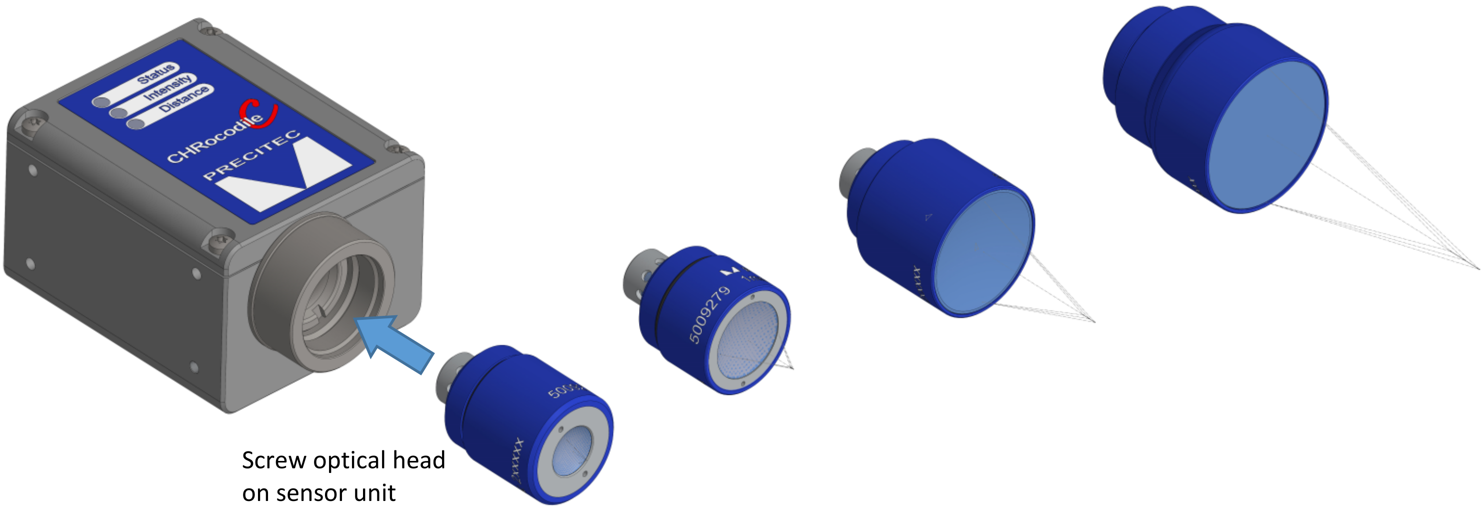


Fig 4-2: Interchangeable optical heads

- And, fixing the CHRocodile C on your system using the interface threaded M3 holes located on the soleplates and on the lateral surfaces of the CHRocodile C unit or using the ring surrounding the optical probe (Cf. *Fig 4-3*).

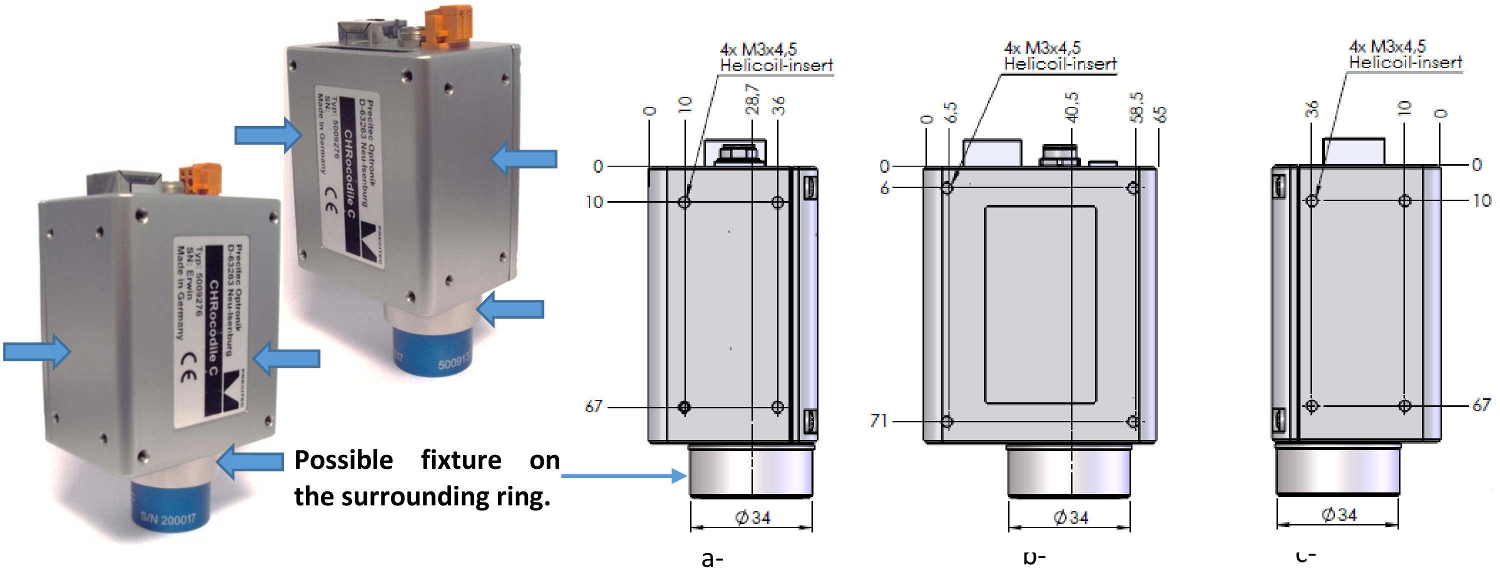


Fig 4-3: CHRocodile C unit mechanical interface: fixture holes on:
a- lateral surface 1
b- soleplate,
c- lateral surface 2.

4.4 Basic Settings Configuration

In order the CHRocodile C to be operational for startup some basic parameters should be set up. You can also refer to the *CHRocodile C quick start guide* documentation.

Basic setting configuration consists in selection of:

- Measuring Range: The CHRocodile C could accept up to 8 calibration tables. Each calibration table corresponds to a unique optical probe. Consequently, depending on the optical probe which is mounted on the CHRocodile C unit, the operator must select the right measuring range or calibration table. (Cf. command $SEN in Appendix 1)

- Data transmission: The CHRocodile C can transmit different data: up to 4 Altitudes, up to 4 Intensities and up to 3 Thicknesses. Depending on the application, operator must select the right data. (Cf. command $SODX in Appendix 1)

- LED intensity level: The LED intensity Level can be adjusted from 0 to 100%. As for measuring rate, this adjustment essentially depends on object reflectivity. Adjust LED intensity in order to obtain a high signal intensity, but avoid saturating the detector (intensity LED blinks orange). In order to adjust LED intensity, use the LAI command (Cf. Appendix 1).

- Measuring Rate: Instead of adjusting intensity or in addition to LED intensity adjustment, it is also possible to adjust the measuring rate. The measuring rate is related to data transmission frequency. The CHRocodile C maximum measuring rate is 4KHz. The higher the measuring rate is the lower the signal intensity is. Consequently, depending on the object reflectivity under measurement, the measuring rate (measuring frequency) must be adjusted in order to remove saturation or too low intensity signal. In order to adjust measuring frequency, use the SHZ command (Cf. Appendix 1).

4.5 Data measurement Training

When mechanical interfacing is done, the object to be measured must be positioned inside the measuring range of the CHRocodile C optical probe.

This procedure is valid for altitude and thickness measurement, i.e. to perform topographic measurement on reflecting object or to perform thickness measurement on transparent object.

Measuring altitude procedure consists in:

- Adjusting the axial position of the target in order the target is centered inside the optical sensor measuring range. To do this, one can move the optical probe or the target along the optical axis. Thus, it is recommended to fix the optical probe or the target on a translation plate.

- Adjusting the spot on the area to be measured.

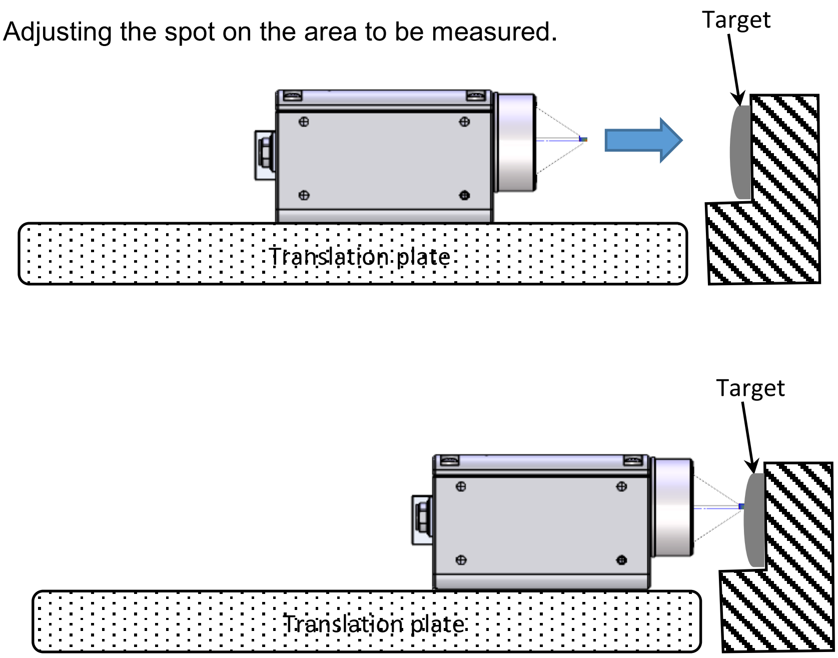


Fig 4-5: Axial position adjustment

When the target is correctly positioned in front of the optical head and basic configuration is correctly set, it is possible to collect the needed data using the SODX command (Cf. Appendix 1).

In order to record the data corresponding to the CHRocodile C unit, the Ethernet port or the RS422/RS232 communication port must be connected to the computer.

It is now possible to perform an area scan:

- In order to scan the target, one can move the optical probe or the target inside optical axis perpendicular plan. Thus, a 2 axis translation system is required. The altitude or thickness data is recorded during the scan. In order to synchronized the data acquisition with the moving session, one need to connect the trigger in/out to the translation system. The command TRG, enables an exact alignment of the sensors sampling intervals with the movement of a scanning axis.
- However, if scan velocity is not constant, the pitch between each recorded point is not constant and the global topography will be distorted. To overcome this image deformation it is important to assign precisely each measured points and axis positions. To do so, one need to connect the incremental encoder-input. The CHRocodile C can manage with 2-axis Encoders using the analogue converter box accessory.

Appendix 1: Advanced Configuration

1. Commands List

command	arguments	answer on query	comments
AAL	<0,1>/<0..100> or <?>	<0,1> <detector level>	Auto Adapt Light source: First parameter: auto adapt on(1) or off(0, default) Second parameter, only needed in case first param is 1: desired detector level in % of saturation level (0-100), 33 is default. The autoadapt mode is also disabled by the LAI command!
ABE	<0 .. 500, ?>	<abbe number>	Abbé number: Dispersion, only active, if SRT 0 selected (no preloaded Index table) 0 (default): no dispersion You should give as many Abbé numbers as there are layers to be measured, that is (number of Peaks - 1). The first parameter describes the nearest Layer.
AVD	<1 . . . 999, ?>	<number of averaged data values>	Average Data
AVS	<1 . . . 999, ?>	<number of averaged spectra>	Average Spectrum
BDR	<Index or custom Baud rate> <0,1>	<Index or custom baud rate> <effective baudrate> <0,1>	BauD Rate for serial port Command: "Baud rate" If 1st arg <= 8, then baudrate index is selected, otherwise free custom baudrate is given index of baud rate in [bit/s] 0: 9600; 1: 19200; 2: 38400; 3: 57600; 4: 115200; 5: 230400; 6: 460800; 7: 921600; 8: 1843200 2nd arg: HW Handshake on/off Response: 2nd arg: effective baudrate (may deviate)
CTN		Continue (Measuring)	free running mode See also: TRE, TRG, TRW
CRDK	<0 . . . 65535, ?>	<Replacement rate>	Continuously Refresh DarK 0 (default, no refresh)-65535 (full replacement with every spectrum) See also: DRK, FDK
DRK		<n>(<x>) n: Index of the lowest measuring rate x: lowest frequency in Hz, floating point	"Dark reference" take and store dark reference The execution of this command takes approx. 0.8sec. The result will be valid and used for all exposure settings. Due to the storage to nonvolatile memory, the dark calibration will be restored on the next powerup. See also: FDK, CRDK

DWD	*<0..n1><0..n2>* *[<0..n1><0..n2>]* *...*	*<0..n1><0..n2>* *[<0..n1><0..n2>]* *...*	*Detection WinDow* *Up to 16 windows (window1left, window1right, window2left, window2right...), in micrometers* *See also: LMA*
ENC	<0..4> [<0..3>] < -2147483648 .. 4294967295, ?>	-	*ENCoder Position:* *$ENC <axis#> <function> <arg>* *-index of axis -optional: Function* *-position (treated modulo 2^32)* *Defined functions:* *• 0: Set / Read Pos.* *• 1: set count source <value>* *(0..9: A0, B0, A1, B1, . . . ; 10: SyncIn; 11..14: n.a., 15: Quardr.)* *• 2: set preload value <value>* *• 3: set preload event <value>* *- Query currently supported for position only.* ***For detailed description see below***
ETR	<func. Index> <arguments>	-	*Encoder TRigger* ***For detailed description see below***
FDK	*[<1..300>]* *[<0..32767>]*	*(<x>)" x being the (virtual) exposure rate in Hz at which the CCD would saturate*	*Fast Dark* *The dark reference is taken with current exp. settings and is not stored to nonvolatile memory.* *When changing the exposure settings, the dark settings acquired by the last DRK command are restored.* *See also: DRK, CRDK*
IDE			*IDEntification* *String with key-value pairs that enable identification of the device*
IPCN	*<0,1>,* *[eight numbers <0..255>]*	*<DHCP, IP address, subnet MASK>*	*IP-Address change* *Configure TCP address and subnet mask. 1st arg: DHCP on/off, args 2.5: fixed IP addr. args 6..9: subnet mask (only if DHCP off, i.e. 1st arg = 0)*
LAI	*<0...100, ?>*	*<value in %>*	*LAmp Intensity* *Set on-time of LED between 1-100% of the exposure time. This command also disables the autoadapt mode!*
LTC			*LaTenCy* *Experimental parameter, is not saved to nonvolatile. Determines the time after which a packet is closed and sent.* *Default 1ms.*
LMA	*<0,1, ?>*	*<0,1>*	*LiMits Active* *Detection Limits active, 0(default) or 1. See also: DWD* *See also: DWD*
MOD	*<0,1,127, ?>*	*either:* *0 (confocal, 1 surface) or:* *1 (confocal, 2 surfaces) or:* *127 (more than 2 peaks)*	*measurement MODe* *For compatibility: 0: one surface (default), 1: thickness, 127: different mode (detect more than 2 peaks)*

MMD	<0,?>	<0,?>	Measuring MoDe Only argument <0>, chromatic mode supported
NOP	<1..4>	<1..4>	Number Of Peaks 1(default)-MaxNOP. The MaxNOP value is a characteristic of the device and can be read back by the IDE command. In confocal mode, if less than NOP peaks are detected, all thickness signals will be invalidated because peak identification is not possible.
OPD	<?>	<Operation time in seconds, number of powerups>	OPeration Data Query command, must contain the query arg. First parameter 2: Operation time in seconds First parameter 3: number of powerups
PSM	<10 .. 90>	<10 .. 90>	Peak Separation Minimum The fraction in % of the height of the smaller peak that the signal must go below in order to separate 2 peaks.
RST			ReSeT device
SCA	<?>	<Scale value>	SCAle Query full scale value in micrometers of the currently selected probe.
SEN	<0 .. 7, ?>	<optical probe Index>	Select SENsor (probe) 0(default) - 7 (depending on the existence of the calibration tables) See also: SENX
SENX	<?>	<(probe index), SNr: (serial number of probe), Range: (measuring range)um>	Query details of SENsor (probe) Without parameter: returns a string with serial number and measuring range of the currently selected probe in the following format: (probe index), SNr: (serial number of probe), Range: (measuring range)um When used with enum as string parameter, the device enumerates all available calibrated probes in one string, separated by ; See also: SEN
SFD	-	-	Set Factory Defaults Without parameter: reset the normal operation parameters. With parameter: reset also the communication parameters (IP). The parameter set is NOT automatically stored in nonvolatile memory. To do so, please issue the SSU command!
SHZ	<30 .. 4000, ?>	<x>Hz x meaning the exact sample rate in Hz in floating point format	Set measurement cycle frequency in HZ 30 - 4000(default) See also: SRA
SODX	<0..17> <0..17> ...<0..17> (max 16 times) or <?>	<0..17> <0..17> ... <0..17> (max 16 times)	Set output data extended Set the content of the output telegram

SRA	*<3..17, ?>*	*<index of sample rate>* *<sample rate in Hz>HZ*	*set Sample Rate* *Compatibility command 3:32Hz, 4:100Hz, 5:320Hz, 6:1000Hz, 7:2000Hz, 8: 3200Hz, 9: 4000Hz(default)* *See also: SHZ*
SRI	*<1..5>*	*<refractive index> at spectral d-line (587,567 nm)*	*Set/query Refractive Index* *Only active, if SRT 0 selected (no preloaded Index table)* *1.0(default)-5.0* *You should give as many indices as there are layers to be measured, that is (number of Peaks - 1). The _rst parameter describes the nearest Layer.* *See also: ABE, SRT*
SRT	*<0..16>*	*<0..16>:name of table [CR/LF]*	*Set Refractive index Table* *Preloaded Tables can be used instead of SRI/ABE.* *SRI/ABE is active when table 0 is choosen (SRT 0)* *You should give as many table indices as there are layers to be measured, that is (number of Peaks - 1). The _rst parameter describes the nearest Layer.* *See also: SRI, ABE*
SSQ	*two binary bytes*	-	*Synchronisation SeQuence* *2 Byte sync sequence used only in $-protocol*
SSU	-	-	*Save SetUp* *Saves the current setting to nonvolatile memory. The Sensor will restart on the next power-up with this configuration.*
STA	-	-	*STArt data flow* *(default) Sending of measurement data enabled.* *See also: STO*
STO	-	-	*STOp data flow* *Sending of measurement data disabled. Only Command responsesor updates are transmitted.* *See also: STA*
THR	*<0..4094, ?>*	*<threshold value>*	*detection THReshold* *threshold for peak detection in the confocal modes (0 and 1)* *0-4095, default is 50*
TRE	-	-	*TRigger Each Mode* *Every exposure (or exposure burst in case of averaging) needs a trigger event (e.g. rising edge on Trigger input). All exposures will begin exactly at the trigger events as long as the previous exposure is ended. If the previous exposure is still ongoing, the trigger will be delayed. If the device receives a trigger event, while the precedent trigger still waits for execution, the trigger event will be lost and the trigger lost counter will be incremented.* *See also: TRG, TRW, CTN*
TRG	-	-	*TRiGger* once *Stops the free running measurement and waits for a trigger event. The trigger event restarts free running*

			mode. *The first exposure start will occur immediately at the trigger.* *See also: TRE, TRW, CTN*
TRW	-	-	*TRigger Window* *The device runs freely as long as the trigger condition is fulfilled. The first exposure start will occur immediately at the trigger* *See also: TRG, TRE, CTN*
VER	-	-	*VERsion* *Responds with a string containing several lines with Key-Value pairs* *See also: IDE*

Table A1.1: Commands list

2. Detailed Commands Description

2.1 CTN Command

This command lets the sensor exit any of the above trigger modes and returns to freerun.
No parameters are needed, so the syntax is just $CTN.

2.2 DRK Command

This command lets the sensor acquire a background spectrum that the incoming spectra will be corrected for during normal operation. The acquisition of this background will take about one second. The resulting background spectrum will be saved in the internal non-volatile memory.

This command does not take any parameters, so the syntax is just $DRK.

It is important to remove any object within the measuring range before applying the command.

The command response contains a number which is a measure of the background intensity. A high background intensity can be related to e. g. stray light.

Command syntax:

$DRK

Command	Description
$DRK	Execute a Dark reference
Response: $DRK127 (63.2Hz)ready[CR/LF].	

2.3 ENC Command

The encoder inputs and related commands ETR or ENC are available only with the analogue converter box accessory.

This is an encoder control command. It has the following format:
ENC <Axis index> <arg1> <arg2> where *arg1* denotes a certain function and *arg2* some parameter related to it.

The following functions are defined:

Arg1	Function	Arg2
0	Set / Read current encoder counter value	Encoder counter value to set
1	Set count source	0: Pulse on A0, 1: Pulse on B0, 2: Pulse on A1 . . . 9: Pulse on B4
		10: Pulse on SyncIn
		11..14: not used
		15: Quadrature A/B on encoder input <axis index>
2	Set preload value	Value to load into encoder counter on preload event
3	Set preload function	See table below

The preload function defines under which condition the value set with function 2 will be loaded into the encoder counter. The respective argument 2 is a bit field as defined below:

Preload function value calculation	
Bit(s)	Function
0	0: Preload once, 1: Preload each time
1	0: preload event on raising edge or high level, 1: falling edge or low level
2	0: the preload event is triggered by an edge 1: it is triggered by the level
3	0: Preload function inactive, 1: active (in case of “preload once”, this bit will be automatically reset)
7 .. 4	0: Pulse on A0
	1: Pulse on B0
	2: Pulse on A1
	…
	9: Pulse on B4
	10: Pulse on SyncIn
	11..14: not used
	15: Immediate preload

2.4 ETR Command

The encoder inputs and related commands ETR or ENC are available only with the analogue converter box accessory.

The settings will not be saved in the nonvolatile memory by the $SSU command.

This command groups several functions related to encoder triggering. The encoder trigger can work in two ways:

1. Roundtrip trigger (scanning application)
2. Endless trigger

Roundtrip trigger (scanning application)

The encoder trigger is implemented as a state machine (see figure below). In the idle state, it waits for the encoder counter of the selected axis to pass the start position (in either direction) where it generates the first trigger event. Then the trigger interval value is added to the current position and when this position is reached, the next trigger event is generated. This step is repeated until the stop position is encountered.

The generation of trigger events is now stopped. If triggering during return movement is selected, the state machine waits for the stop position to be passed once again and generates trigger events similarly to the forward movement (the trigger interval is now subtracted instead of added) until the start position is reached. The state machine then goes back to the idle state. If no Trigger during return movement is selected, the state machine waits for the start position to be passed over (during return movement) and then passes to the idle state.

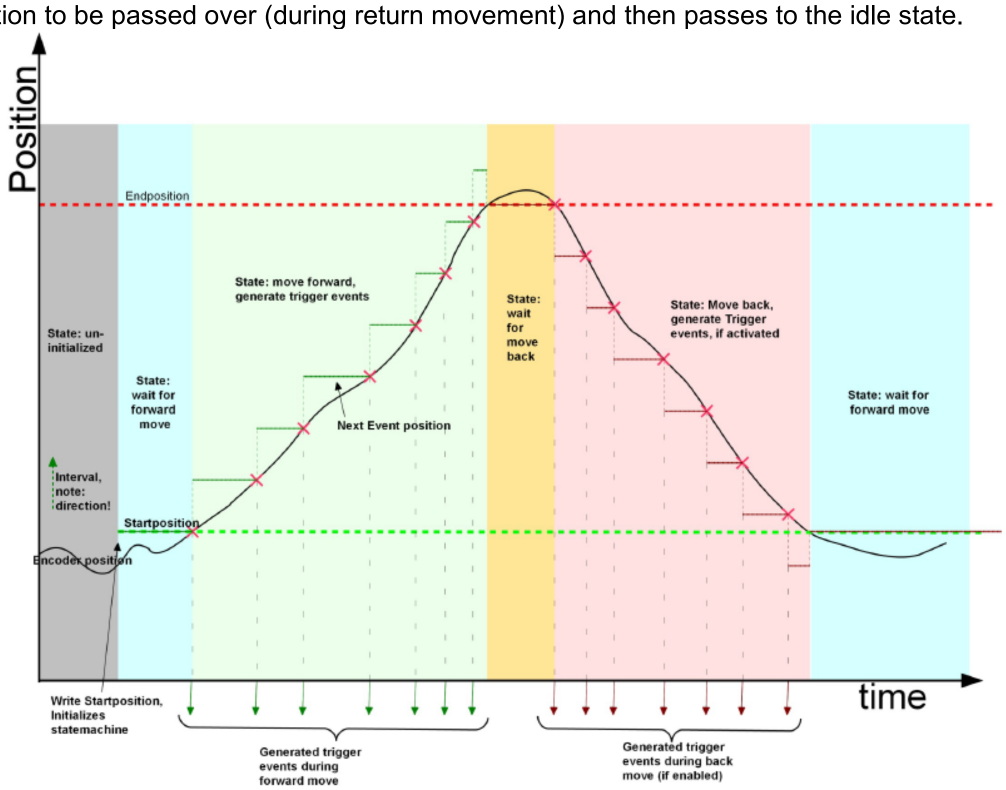


Fig A1-1: Roundtrip Trigger

Endless trigger

This mode is destined for applications where the encoder primarily moves in one direction as in production lines and where equidistant sampling is needed. In order to use this mode, only a trigger interval has to be parametrized.

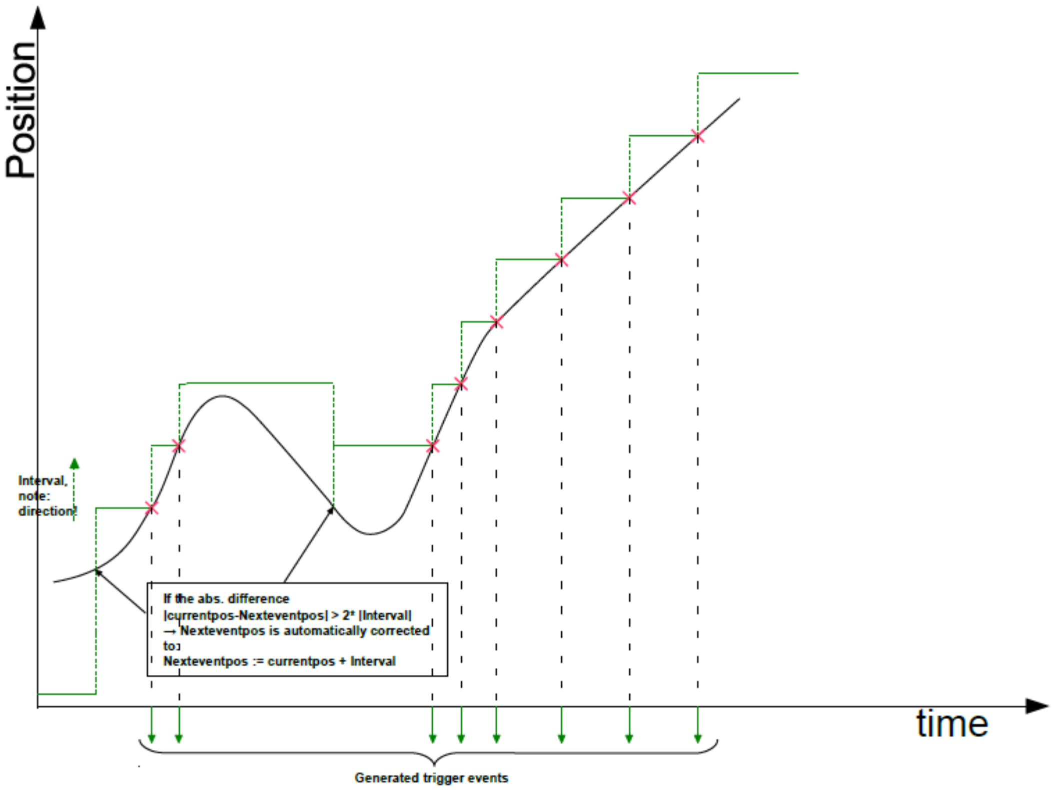


Fig A1-2: Endless Trigger

Format

The command has the following format: ETR <function> <arg> where function is:
0: Set start position ((int) arg = start position to set, see figure)
1: Set stop position ((int) arg = stop position to set, see figure)
2: Set trigger interval ((float) arg = trigger interval, see figure) Note that the interval can be given in fractions of encoder counts.
3: Enable encoder (0: disabled, 1: enabled)
4: Enable triggering during return move, see figure. 0: disabled, 1: enabled.
5: Select encoder counter
6: reserved
7: Enable endless triggering (in this mode, start and stop positions are ignored, trigger events will be generated on the current position and the trigger interval) 0: disabled, 1: enabled.

2.5 IPCN Command

Short description:

This command allows to configure TCP/IP address and subnet mask.

Command syntax:

$IPCN <DHCP> <IPA> <IPB> <IPC> <IPC> <MA> <MB> <MC> <MD> <MTU>

Command	Description
$IPCN 1 $IPCN <DHCP>	Configured as DHCP client
$IPCN 0 192 168 170 4 255 255 255 0 0 $IPCN <DHCP> <IPA> <IPB> <IPC> <IPC> <MA> <MB> <MC> <MD> <MTU>	Configured as static IP address IP Address = 192.168.170.4 Subnet Mask = 255.255.255.0 MTU = 0 (no jumbo packets) MTU argument gives the maximum transferable unit which can be anything between 1500 and 9000 bytes per TCP packet (jumbo packets).

2.6 LAI Command

Short description:

This command allows to adjust LED intensity in order i.e. to remove saturation.

Command syntax:

$LAI <I>

Param: <I> is Led intensity (0...100%)

Command	Description
$LAI 95 `Response: $LAI 95[CR]ready[CR/LF].`	Write Led intensity 95%
$LAI ? `Response: $LAI ?  95ready[CR/LF].`	**Read Led Intensity**

2.7 NOP Command

Short description:

This command allows to set the number of peak to evaluate.

WARNING: In confocal mode, if less than NOP peaks are detected, all thicknesses signals will be invalidated because peak identification is not possible.

Command syntax:

$NOP <I>

Param: <I> is Number of Peak from 1 to 4

Command	Description
$NOP 3 `Response: $NOP 3[CR]ready[CR/LF].`	Write Number of Peak (3)
$NOP ? `Response: $NOP ?  3ready[CR/LF].`	Read Number of Peak

2.8 SCA Command

Short description:

The command Scale allows to query of Full Scale in micrometers.
A distance value of 32768 on the serial interface would mean a distance in (Full Scale) micrometers. To convert the integer distance value (d) received from the serial interface to a value in micrometers (D), use the formula:
D[µm] = d[integer] / 32768 * Full Scale.

Command syntax:

$SCA

Command	Description
$SCA ? `Response: $SCA ?  3320ready[CR/LF].`	Read Full Scale

2.9 SEN / SENX Command

Short description:

The $SEN command is used to activate the chromatic—confocal calibration related to a specific sensor head. With the single channel device, up to sixteen calibrations can be uploaded and stored in the device. With the Chrocodile C device, up to eight calibrations are supported.

The format of the command is as follows:

$SEN n where n is the calibration table index. As the possible measuring range of each probe is much higher than the range for which it is specified and guarateed to adhere to the specifications, there is a way to use the full range with degraded precision. This might be useful in applications where not the full precision is required. In order to enable the full range, send $SEN n 1.

The currently active calibration table can also be queried:

$SEN? (or query flag in case of packet protocol) – returns active calibration index and if the extended range is enabled (1) or not (0)

$SENX? - returns more details of the active calibration, I. e. index, serial number of the related probe and the current range in micrometers:

$SENX?0, SNr: 0, Range: 7999umready

$SENX enum? - ("enum" as a string argument in case of packet protocol) returns complete list of calibrations.

Command syntax:

$SEN

Command	Description
$SEN? `Response: $SEN?  0 0ready[CR/LF].`	Returns active calibration index and if extended range is selected
$SEN1 1 `Response: $SEN1  1ready[CR/LF].`	Set calibration table n°1 with extended range

2.10 SHZ Command

Short description:

The command SHZ set sample rate in Hz
It is possible with this command to realize any sample rates between 100Hz and 2000Hz.

If the value is not accepted, the sensor responds with the string "**not valid**".
Due to the nature of the internal time base, not every sample rate can be realized exactly. In order to give the user the possibility to know the exact frequency, to which the sample rate has been "rounded", the frequency can be queried with "?" and will be returned as ASCII floating point number with 6 decimals.

Command syntax:

$SHZ <I>

Param: <I> is sample rate (32Hz…4000Hz)

Command	Description

$SHZ 1000 `Response: $SHZ 1000[CR]ready[CR/LF].`	Write Sample Rate (1000 Hz)
$SHZ ? `Response: $SHZ ?  1000ready[CR/LF].`	Read Sample Rate

2.11 SODX Command

Short description:

Select Output Data (extended)
SODX directly selects the data words that will be included in the output telegram by specifying their indices.
For example SODX 83, 16640, 16641 will output the sample counter, the distance and the intensity.

Command syntax:

$SODX [A0] [A1]…[AN]

[Ax] is optional parameters

Signal ID's scheme

	CLS02	CLS1	CLS2,3	CLS0,5	CLS4										
Grandissement	**25,4**	**12,7**	**15,9**	**15,9**	**5,1**										
MR	0,2		1			**2,3**	0,5	**4**							

Table A1.2: SODX command: Signal Identity's scheme.

Global Exposure Information:

Definition: Bit 8 = 0 (Bit 8 to 15 = 0)

Type:

Float

Command	Description
$SODX 64 `Response: $SODX 64[CR]ready[CR/LF].`	Start of exposure Time (in nanoseconds)
$SODX 65 `Response: $SODX 65[CR]ready[CR/LF].`	Start of exposure PositionX(X encoder position on beginning of exposure)
$SODX 66	Start of exposure PositionY(Y

`Response: $SODX 66[CR]ready[CR/LF].`	encoder position on beginning of exposure)
$SODX 67 `Response: $SODX 67[CR]ready[CR/LF].`	Start of exposure PositionZ(Z encoder position on beginning of exposure)
$SODX 68 `Response: $SODX 68[CR]ready[CR/LF].`	Start of exposure PositionU(U encoder position on beginning of exposure)
$SODX 69 `Response: $SODX 69[CR]ready[CR/LF].`	Start of exposure PositionV(V encoder position on beginning of exposure)
$SODX 70 `Response: $SODX 70[CR]ready[CR/LF].`	End of exposure PositionX(X encoder position on end of exposure)
$SODX 71 `Response: $SODX 71[CR]ready[CR/LF].`	End of exposure PositionY(Y encoder position on end of exposure)
$SODX 72 `Response: $SODX 72[CR]ready[CR/LF].`	End of exposure PositionZ(Z encoder position on end of exposure)
$SODX 73 `Response: $SODX 73[CR]ready[CR/LF].`	End of exposure PositionU(U encoder position on end of exposure)
$SODX 74 `Response: $SODX 74[CR]ready[CR/LF].`	End of exposure PositionV(V encoder position on end of exposure)
$SODX 75 `Response: $SODX 75[CR]ready[CR/LF].`	FirstExposureCount
$SODX 76 `Response: $SODX 76[CR]ready[CR/LF].`	ExposureFlags
$SODX 77 `Response: $SODX 77[CR]ready[CR/LF].`	RealExpTimeNs(Effective exposure period in nanoseconds)
$SODX 78 `Response: $SODX 78[CR]ready[CR/LF].`	RealLightingTimeNs(Effective lighting period in nanoseconds)
$SODX 79 `Response: $SODX 79[CR]ready[CR/LF].`	TriggerLostCounter (Accumulates trigger events that have occurred during exposure and therefore have been ignored.
$SODX 80 `Response: $SODX 80[CR]ready[CR/LF].`	NumberOfValidPeaks (Number of peaks that have been found in the spectrum)
$SODX 83 `Response: $SODX 83[CR]ready[CR/LF].`	SampleCounter

Peak Signal:

Definition: Bit 8 = 1

Type:

• Value encoding (Bits 15, 14):

For geometrical quantities like thickness or distance

• 00: float in micrometers, including refractive index (geometrical thickness)
• 01: integer 16bit, scaled as fraction of measurement range, without refractive index (optical thickness).
Distance and thickness values are given as: d[µm] = value * $SCA[µm] / 32768.
In order to get the geometrical thickness, the value has to be multiplied by the index of refraction of the material.
• 10: 32bit integer value in nanometers, including refractive index (geometrical thickness)
• 11: integer 32bit, scaled as fraction of measurement range, without refractive index (optical thickness)
Distance and thickness values are given as: d[µm] = value * $SCA[µm] / (1 << 31).
In order to get the geometrical thickness, the value has to be multiplied by the index of refraction of the material. This format yields the highest theoretical resolution.

For non-geometrical quantities (like intensity)

• Floating point values:
  • 00: float
  • 01: truncated 16bit integer value
  • 10: 32bit integer value in 16.16 format
  • 11: undefined

• Integer Values:
  • 00: 32bit integer
  • 01: least significant 16 bit
  • 10: most significant 16 bit
  • 11: undefined

BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Peak Signal	Value encoding		Statistics			0	Measuring Mode	1	0	0	0	Peak Number		Peak Signal Offset		

13	12	11	Statistics
0	0	0	Average
0	0	1	Std. Deviation
0	1	0	Number of valid values
0	1	1	Minimum
1	0	0	Maximum
1	0	1	Peak-to-peak difference (max-min)

4	3	Peak Number
0	0	1st peak
0	1	2nd peak
1	0	3rd peak
1	1	4th peak

Statistics are not supported by CHRocodile C. Consequently the respective bit 11 to 13 are set to 0.

9	2	1	0	Measuring Mode / Peak Signal Offset
1	X	X	X	Thickness
0	0	0	0	Altitude
0	0	0	1	Intensity (%)
0	0	1	0	Intensity Level
0	0	1	1	Barycenter
0	1	0	0	Peak Value Median
0	1	0	1	Peak Width

Example:

BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Peak Signal	0	1	0	0	0	0	Measuring Mode	1	0	0	0	Peak Number		Peak Signal Offset		

Value encoded in integer 16 bits

4	3	Peak Number
0	0	1st peak
0	1	2nd peak
1	0	3rd peak
1	1	4th peak

9	2	1	0	Measuring Mode / Peak Signal Offset
1	X	X	X	Thickness
0	0	0	0	Altitude
0	0	0	1	Intensity (%)
0	0	1	0	Intensity Level
0	0	1	1	Barycenter
0	1	0	0	Peak Value Median
0	1	0	1	Peak Width

BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Peak Signal	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0
	28840															

Command	Description
$SODX 28840	Altitude, 2nd peak
Response: $SODX 16648[CR]ready[CR/LF].	

Additional information:

Peak Signal Offset (Bits 0 to 2)

Signal ID Offset	Signal Name	Remarks
0	Peak Value	Scaled peak distance
1	PeakIntensity	Intensity of peak
2	CCDSaturation	max. CCD illumination of related spectrum
3	PeakPos	CCD pixel pos
4	reserved	
5	PeakWidth	confocal mode only: given in CCD pixels
6	reserved	
7	reserved	

Peak Number (Bits 3 and 4)

Bits 3 and 4 are used to define the Peak Number which will be processed to calculate the demanded data. The following quantities are available:

Measuring Mode (Bit 9)

Thickness: If bit 9 is set to 1, then the resulting value is thickness corresponding to the difference of the peak as defined in bits 3 and 4 and the next peak. This facility is used to request thicknesses directly.

NOTE

This difference value is not corrected for the index of refraction. Consequently, in order to obtain the real thickness data, one must divide the result by the refractive index.

Altitude: If bit 9 is set to 0, then the resulting value is the Altitude corresponding to the peak number defined in bits 3 and 4.

Statistics (Bit 11 to 13)

Statistics are not supported by CHRocodile C. Consequently the respective bit 11 to 13 are set to 0.

2.12 SSU Command

Short description:

The command SSU saves Setup
Saves current setup to non-volatile memory. The Setup will be restored upon next power up.

Command syntax:

$SSU

Command	Description
$SSU `Response: $SSU [CR]ready[CR/LF].`	Saves current setup

2.13 STA Command

Short description:

The command STA starts serial data output
This mode can be stored in the nonvolatile memory. If stored, the CHRocodile C will begin immediately to output data telegrams on the next power-up.

Command syntax:

$STA

Command	Description
$STA `Response: $STA [CR]ready[CR/LF].`	Starts serial data output

2.14 STO Command

Short description:

The command STO stops serial data output
This mode can be stored in the nonvolatile memory, so on the next power up the CHRocodile C will not begin to send measurement data until the output is restarted by the "STA" command.

Command syntax:

$STO

Command	Description
$STO Response: $STO [CR]ready[CR/LF].	Stops serial data output

2.15 THR Command

Short description:

The command THR lets you specify an intensity threshold for the distance detection.
It may be useful to specify a high threshold to reject all noise spikes during a measurement or to specify a low threshold to get a (noisy) result from very black surfaces. When the signal is below the threshold, 0 is output for distance and intensity. The threshold is in arbitrary units which may be subject to change in future software versions.

At faster sample rates, lower settings for threshold can be used than at slower sampling rates. The reason is, that at slower sampling rates, the stray light of fiber and coupler is integrated longer on the detector. Even though this signal is automatically subtracted as "dark reference", the statistical variations of this signal are stronger, the higher the dark signal becomes. If a typical value for good noise suppression and maximum sensitivity at 2kHz sampling rate could be 20, at 100Hz 50 would be needed.

If the sensor doesn’t detect a signal which passes the threshold, 0 is output for distance and intensity.

Command syntax:

$THR <I>

Param: <I> is intensity threshold

Command	Description
$THR 35 Response: $THR 35[CR]ready[CR/LF].	Write Intensity Threshold
$THR ? Response: $THR ? 35ready[CR/LF].	Read Intensity Threshold

2.16 TRE Command

Short description:

This command lets the sensor enter a trigger mode where one trigger event will produce one sample. Trigger signals can be SyncIn or Encoder inputs, depending on $ETR settings, see $ETR description below. $TRE is particularly useful in conjunction with encoder based trigger generation as described in the $ETR section below.

The encoder inputs and related commands ETR or ENC are available only with the analogue converter box accessory.

The maximum frequency (or the shortest interval of two consecutive trigger events) is defined by the cycle frequency ($SHZ). Trigger events that occur while the sensor is idle will cause an immediate exposure. If a trigger event occurs during an ongoing acquisition cycle, then the respective exposure will be delayed until the current cycle is completed. In this case, the TriggerDelayed – Flag (Bit 2) is set in the flags signal of the delayed exposure. This flags signal is a global signal (ID = 76) that can be requested just like any other signal using $SODX. If more than one trigger event occurs during an ongoing exposure cycle, then only the first event will result in a delayed exposure cycle as described above, all consecutive trigger events will be ignored. In this case, the TriggerIgnored – Flag (Bit 1) will be set in the flags signal of the delayed exposure.

Command syntax:

$TRE

Command	Description
$TRE `Response: $TRE[CR]ready[CR/LF].`	Trigger each

2.17 TRG Command

Short description:

The command TRG is a Wait For Trigger. The command enables an exact alignment of the sensors sampling intervals with the movement of a scanning axis.
It stops the sensor after completion of the current data telegram and puts it in a waiting state. This state is left by a trigger event (rising edge on the Sync in, Encoder Trigger).

Command syntax:

$TRG

Command	Description
$TRG `Response: $TRG[CR]ready[CR/LF].`	Wait For Trigger

2.18 VER Command

Short description:

The command VER give the Version of CHRocodile C.

The command sends back an ASCII string which gives information on the serial number of the CHRocodile C (SN: ...), the DSP software (DSPsoft: ...) and the microcontroller software (C: ...).

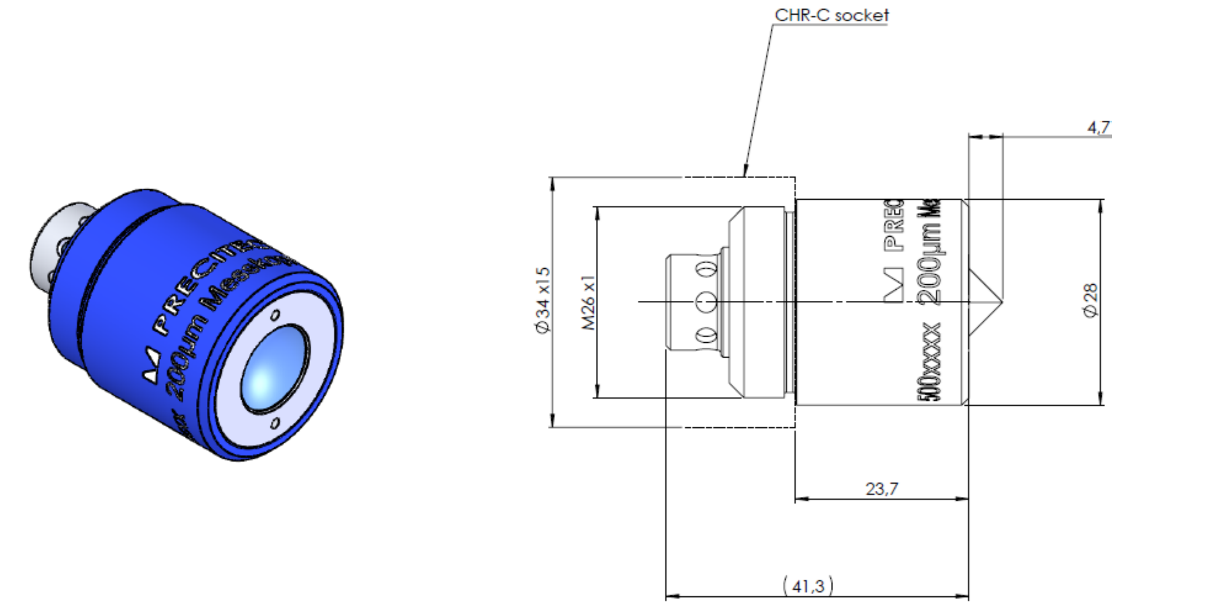
Command syntax:

$VER

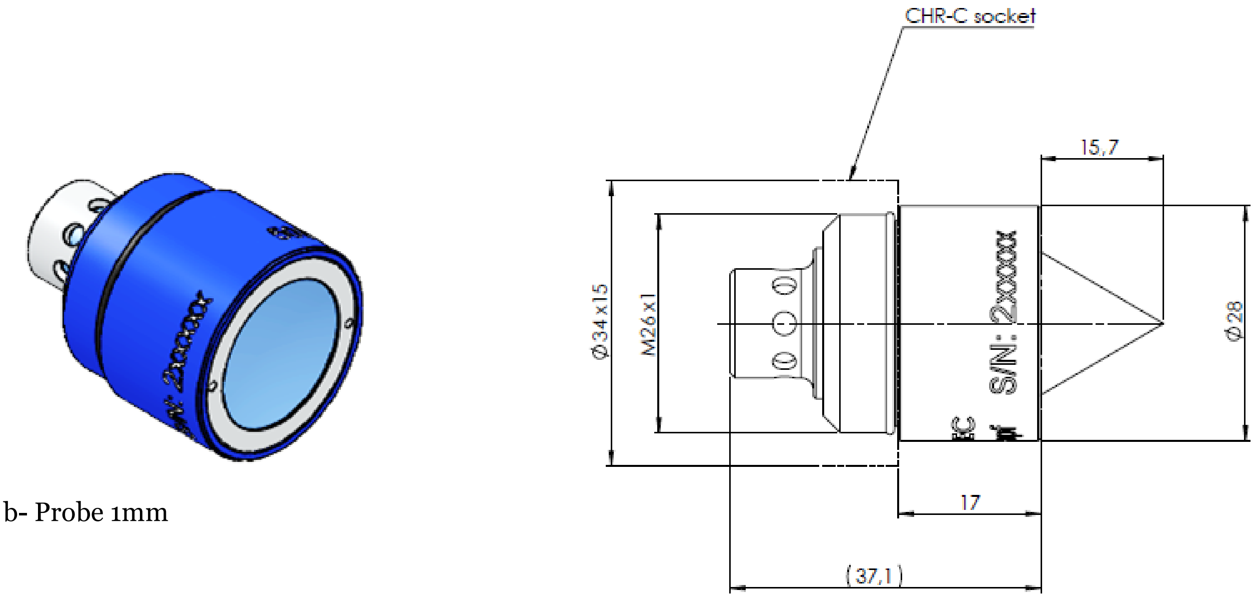
Command	Description
$VER Response: ChrocodileCompact[CR] device_serial_number = 201223[CR] firmware-version = 1.2.3[CR] build = 2016-09-29 427f188cbd[CR] ready[CR/LF]. >>	Read Versions

Appendix 2: Mechanical Plans

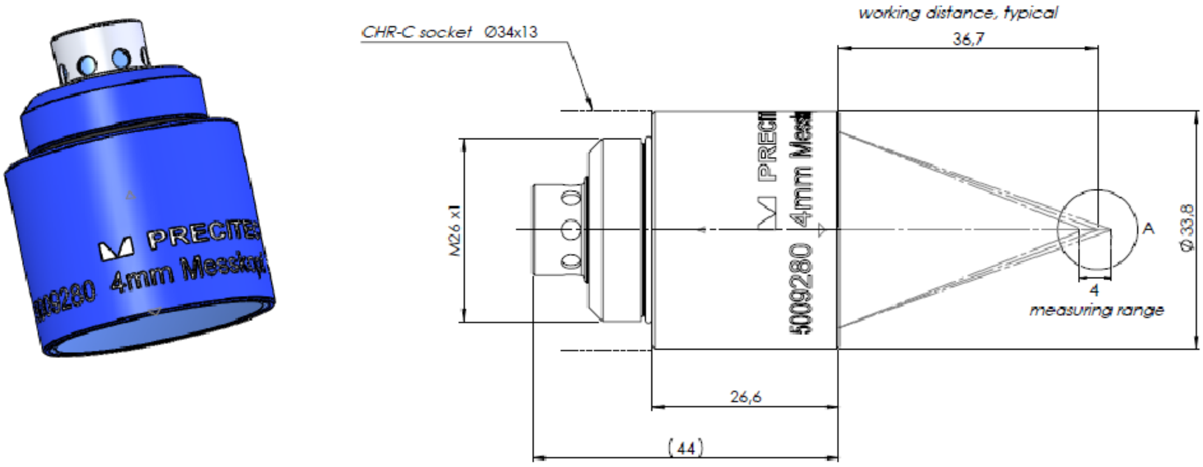
1. Optical probe mechanical plans



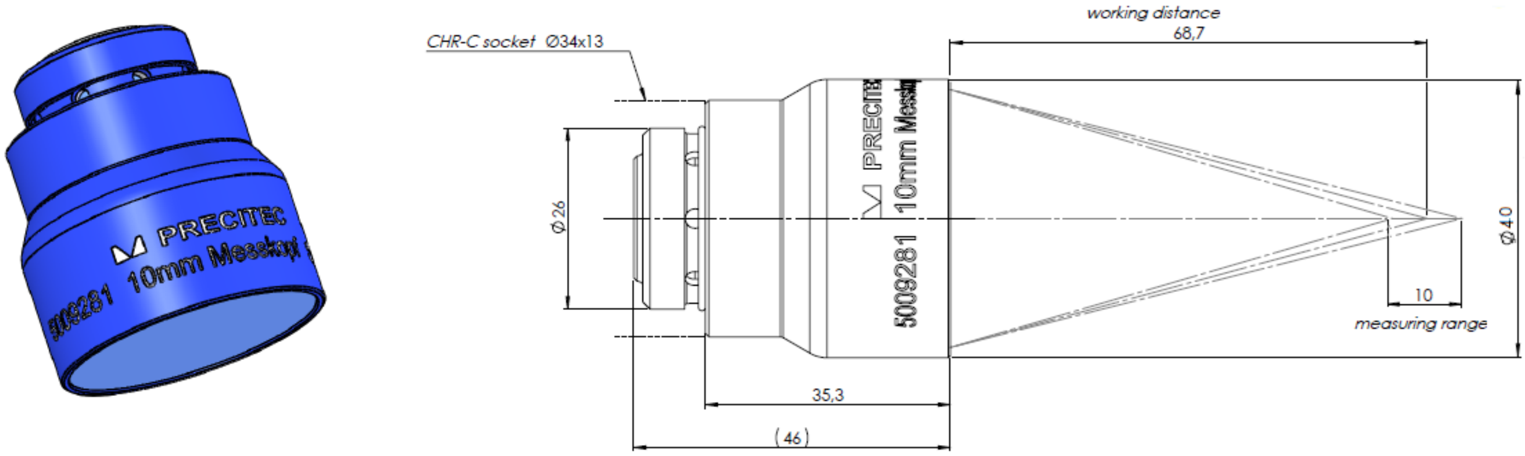
a- Probe 0.2mm



b- Probe 1mm



c- Probe 4mm



d- Probe 10mm

Fig A2-1: Optical Head Mechanical plans: a- 0.2mm b- 1mm c- 4mm d- 10mm

2. CHRocodile C unit mechanical plans

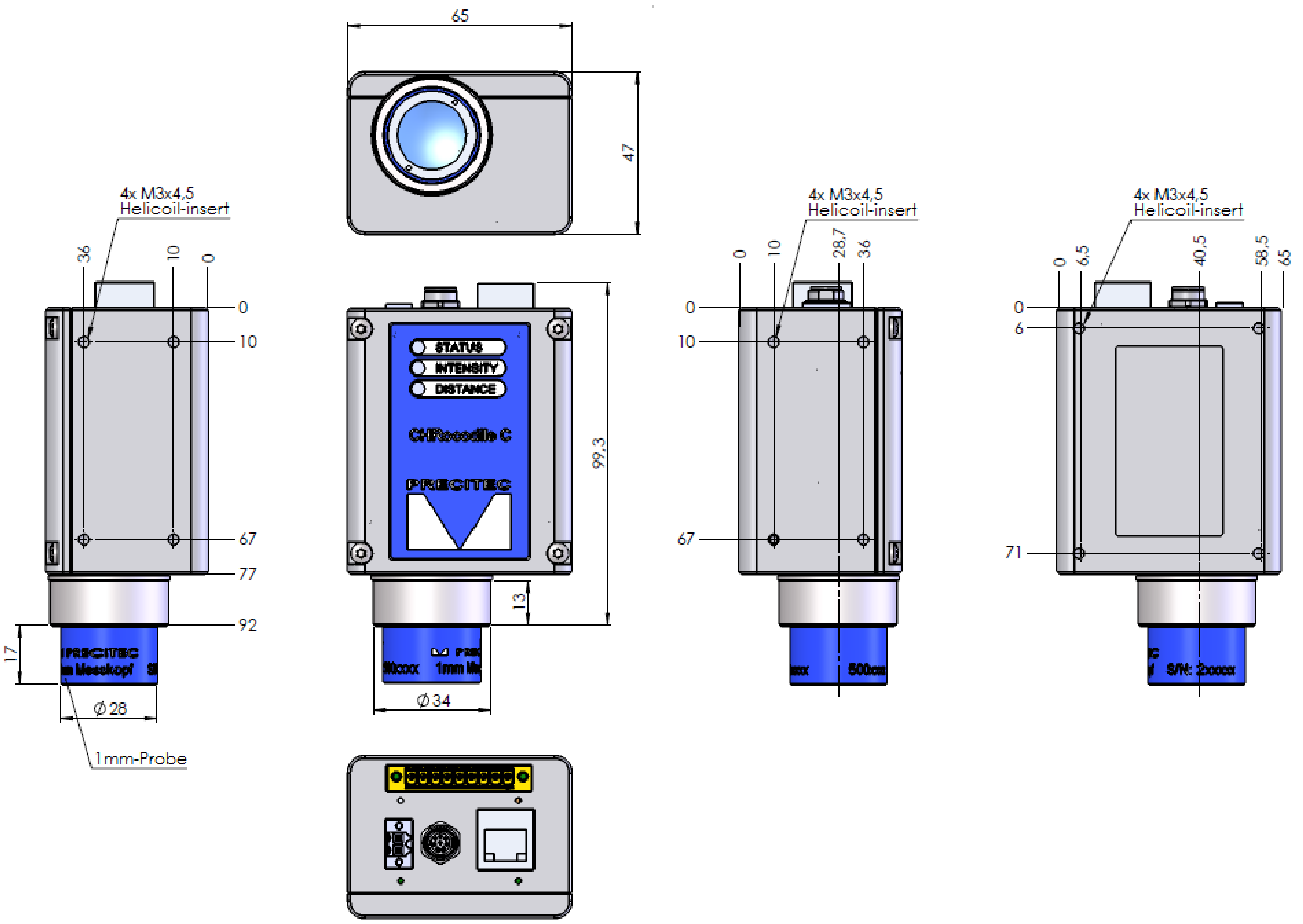


Fig A2-2: CHRocodile C sensor unit mechanical plans:

3. CHRocodile C unit mechanical interface plans

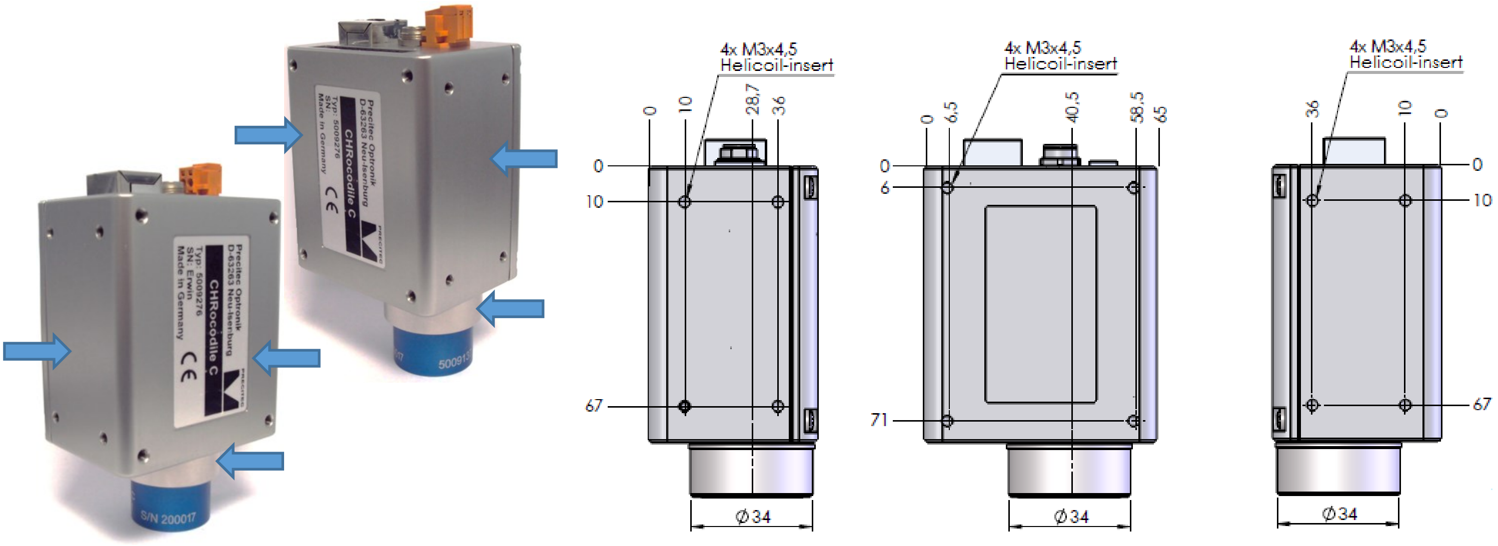


Fig A2-3: CHRocodile C unit mechanical interfaces

Three surfaces are designed to fix the CHRocodile C unit on customer system. On these 3 surfaces, 4 M3x4.5 threaded holes are available. Positions of threaded holes are specified on the Figure A2-3.

It is also possible to fix the CHRocodile C unit on the front ring of 34mm diameter.

Consequently several mechanical interfaces are available on this sensor in order to ease the integration on customers / integrators systems.

Appendix 3: Trouble Shooting

1.1 Power off

The Status LEDs are off when the power supply cable is not connected:

- Check the power cable.

1.2 Communication error:

No possible Ethernet communication between CHRocodile C and your computer:

- Check the Ethernet cable is plugged correctly in RJ45 sensor unit connector.
- Check the IP configuration for your PC and the CHRocodile C unit (Cf. $IPCN command in Appendix 1).
- If you are using a switch, then try to connect directly from your LAN network to the sensor unit.
- If possible, a Peer-to-Peer connection is recommended.

No possible serial communication between CHRocodile C and your computer:

- Check the multipoint cable is plugged correctly in multipoint connector (9 pins),
- Check the baud rate is correct.

1.3 Distance Measurement:

The target is positioned in front of the sensor, and no distance measurement is collected for all channels.

- Set the measuring frequency to minimum ($SHZ100).
- Set the LED intensity to maximum ($LAI100).
- Check if a white light spot is emitted from the optical probe and if it is focused on the target.
- Check if the target is inside the measuring range of optical probe (Cf. section 2.8).

- Check if the target surface is normal to the optical probe axis. The maximum angle between target surface and optical axis is given by the maximum measurable slope (Cf. section 2.8).
- Check if the distance is transmitted ($SODX 16640 or SODX 256),
- Check that a calibration table is uploaded ($SCA?)
- Then, check and store the raw signal (this file could be demanded by PRECITEC technical support team). The raw signal should show one peak.

1.4 Thickness measurement:

The target is positioned in front of the sensor, and no thickness measurement is collected for all channels.

- Check that the target thickness is inside minimal and maximal measuring thickness range,
- Check the target transparency,
- Set the measuring frequency to minimum ($SHZ100).
- Set the LED intensity to maximum ($LAI100).
- Check if a white light spot is emitted from the optical probe and if it is focused on the target.
- Check if the two surfaces of the target are inside the measuring range of the optical probe (Cf. section 2.8).
- Check if the target surface is normal to the optical probe axis. The maximum angle between target surface and optical axis is given by the maximum measurable slope (Cf. section 2.8).
- Check if the two distance peaks are transmitted ($SODX 16640 16648),
- Then, check and store the raw signal (this file could be demanded by PRECITEC technical support team). The raw signal should show two peaks.

If after reading the previous section you didn’t succeed in resolving your problem, please contact your vendor for technical support. In order to be more efficient, we recommend to fill the following technical support datasheet and if necessary prepare the files which are demanded in previous section.

Appendix 4: Technical support

PRECITEC **Technical Support**		
Date :	CUSTOMER :	PRECITEC Number:
PRODUCT IDENTIFICATION		
Sensor Unit Serial Number :	Optical Head Serial Number :	Firmware Serial Number :
PROBLEM IDENTIFICATION		
Type : ☐ Software ☐ Optic ☐ Mechanic ☐ Electronic		
Description :		
Photos:		
Attached files : ☐ Photos ☐ Raw data ☐ Diagnostic file		