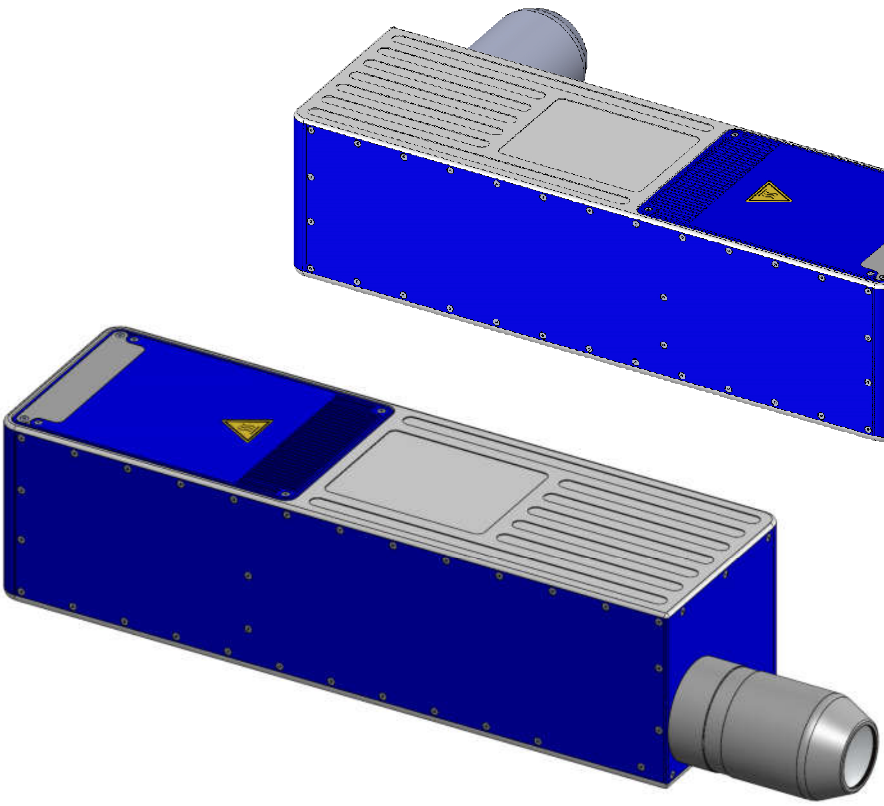
CHRocodile CLS

Optical line sensor for non-contact distance and thickness measurement

Operation Manual



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Version Control

Version – Manual	Date	Type of Change
1.0.0.0	2014/01/29	Original edition
1.0.0.1	2014/03/13	Updated Mechanical plans and specifications
1.0.0.2	2014/05/12	Auto Reference procedure
1.0.0.3	2014/05/22	Specifications correction
1.0.0.4	2014/09/09	EMC compatibility + Jumbo packet + Medical or safety-relevant usage
1.0.0.5	2014/11/06	Ethernet connection + Status LED + Optical head specifications
1.0.0.6	2015/09/17	Optical head specifications + Sync In additional information + CLS Explorer + 6KHz measuring mode + CLS Explorer Library coming soon + DLL C++.
1.0.1.0	2016/03/10	New Optical Head CLS2.3
1.0.1.1	2016/07/18	Encoder interface modification + CLS Explorer Ultimate version + High frequency mode used with CLS2.3 + Auto-reference procedure disabled

Table of Contents

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

2.1 General Description

The CHRocodile CLS is a multi-point optical sensor dedicated to non-contact surface measurement. This sensor is based on Confocal Chromatic principle which authorizes high resolution and high speed thickness and altitude measurement. The CHRocodile CLS can measure 192 points simultaneously with a measuring rate of 2000 Lines/s corresponding to 384000 points/s.

This device consist in a sensor unit that contains a light source, an optical probe, a spectrometer and all electronic and software for data processing and transmission.

In addition to be very fast and precise, the CHRocodile CLS has an original architecture with no exposed optical cable. This unique architecture makes CHRocodile CLS sensor ideally adapted for industrial control. CHRocodile CLS thus overcomes the device integrating constraints met in industrial environment, e.g. on production line, induced by optical fiber cable presence.

Due to their length, their low capability to resist to torsional and elongation stress, their photometric transmission intensity loss according to imposed radius of curvature, optical fiber cables are subject to damage when the measuring device is exposed to high acceleration and/or rotational displacement. PRECITEC is the first company to propose a confocal chromatic device, with all elements embedded in one Optoelectronic unit (no apparent optical cables) in order to adapt to industrial changing requirement.

The CHRocodile CLS can accommodate different types of optical head. These Optical Heads can be mounted on CHRocodile CLS in a straight version or in a right angled version *(see Fig. 2-1)*. The Optical Head interchangeability is straight forward, as the operator just need to exchange Optical Head and move to the right calibration table. Finally, data transmission is carried out by ETHERNET communication. All CHRocodile CLS characterisctics are described in *Section 2.7.*

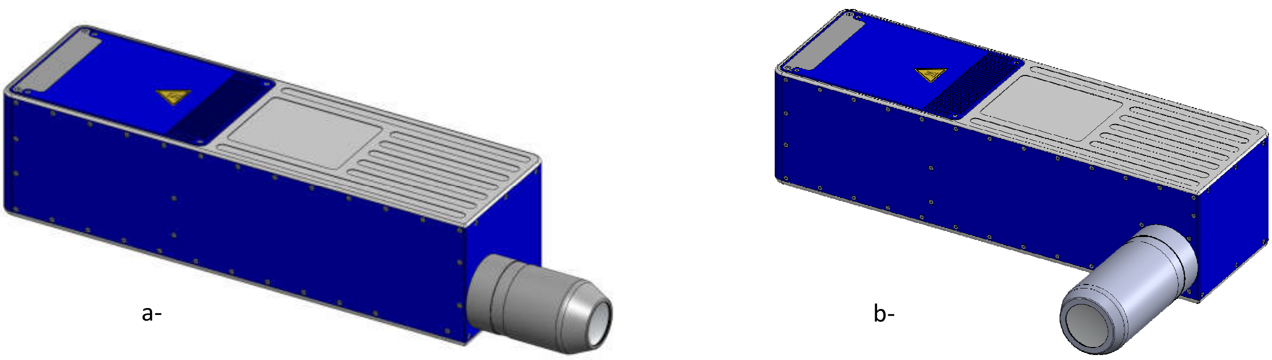


Fig 2-1: CHRocodile CLS 3D view: a- Straight version   b- Right angled version

2.2 Measuring principle

2.2.1 Optical principle

For most industrial applications the chromatically coded distance detection method turned out to be very well suited. CHRocodile CLS 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 (~ 400nm) is shorter than for red light (~ 700nm). 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 and 2.3*)

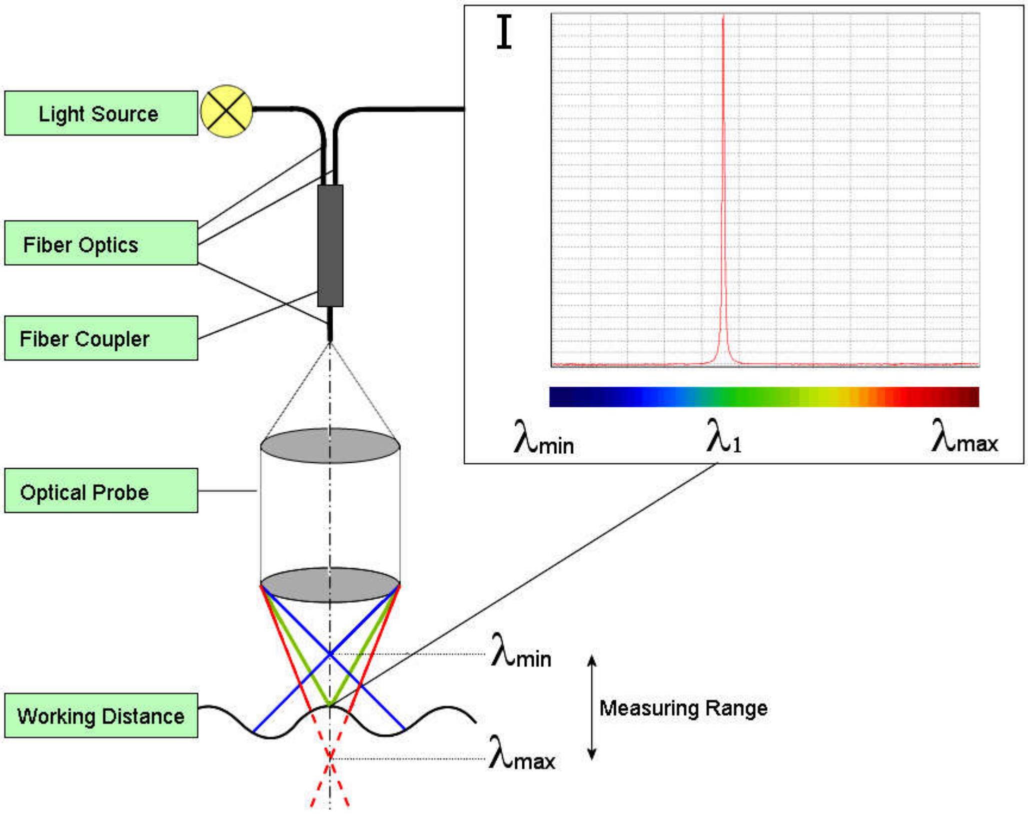


Fig. 2-2: Chromatic Confocal Imaging principle (point sensor)

2.2.2 Principle applied to multiple points sensor

Applying Confocal Chromatic Imaging to multipoint sensor consists in increasing the number of illumination point's source and the number of pinhole in front of the detector spectrometer. In this configuration, the spectrometer is preferably bidimensionnal. One direction corresponds to the channel number and the other direction carry the wavelength information. Consequently the spectrometer carry the information of each point focused on the target's surface, and the distance of the target surface from the chromatic objective can be calculated for all the focused points. According to CHRocodile CLS, the focused points describe a line composed of 192 equally separated points.

2.3 Sensor Functionalities

The CHRocodile CLS has two different measuring mode: Distance and Thickness measurement. The principle of these two measuring mode are explained hereafter.

Mode 1 **Chromatic Distance Measurement**

Topographic, profile or roughness measurements are performed in Mode 1 (confocal distance measurement). In this process, 192 points along a white light line are 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. For each of the 192 channels, reflected light is spectrally analyzed and the spectral response is a peak centered on focused wavelengths. The 192 spectral peak positions determine the distance to the surface of each of the 192 points along the line. The 192 distances are simultaneously calculated and transmitted to host computer at up to 2KHz frequency See *Fig. 2-3*. A high frequency mode is now available to measure up to 6KHz. See Section *2-7-2*.

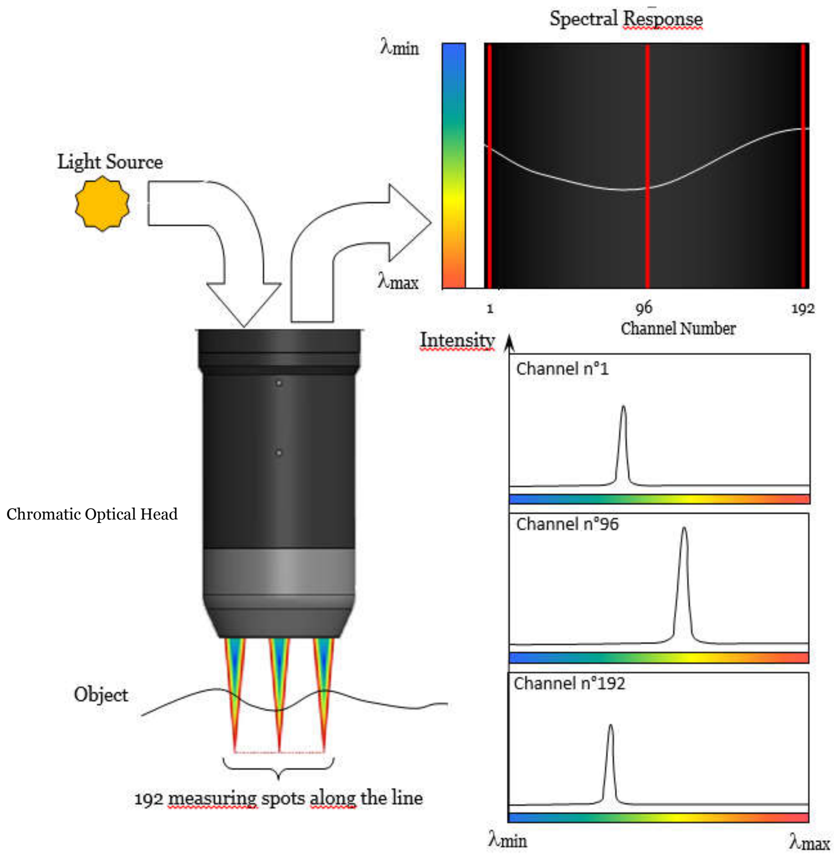


Fig. 2-3: Chromatic measurement principle, distance measurement

Mode 2 **Chromatic Thickness Measurement**

Thickness measurements are performed in Mode 2 (confocal thickness measurement). If a transparent material is within the measurement volume of the Chromatic Optical Head, 192 points along a white light line are 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. For each of the 192 channels, 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 for the 192 points along the line. The 192 thicknesses are simultaneously calculated and transmitted to host computer at up to 2KHz frequency. See *Fig. 2-4*. A high frequency mode is now available to measure up to 6KHz. See Section *2-7-2*.

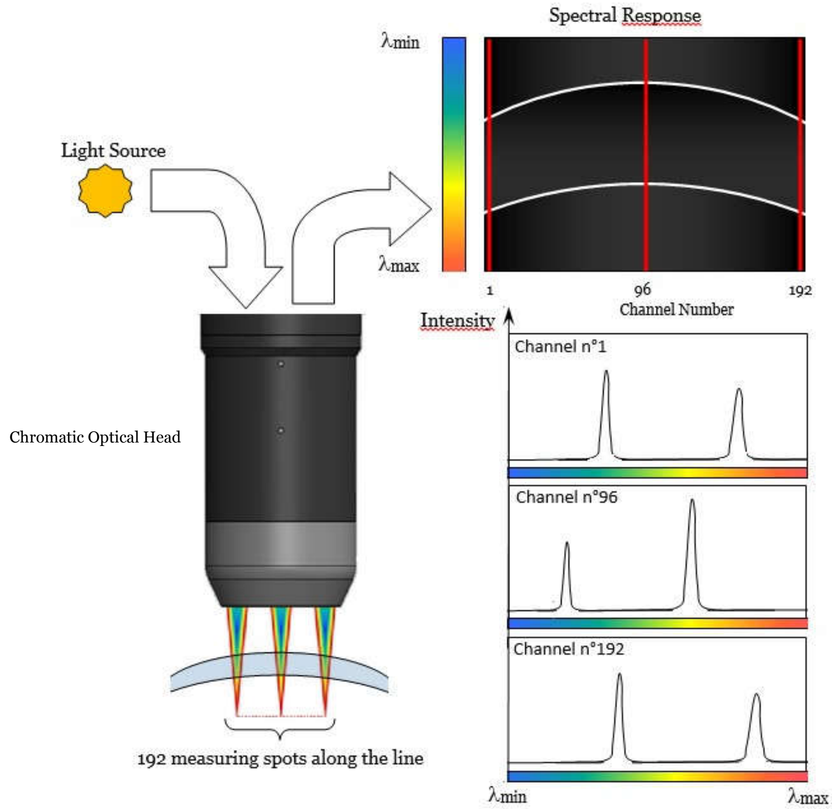


Fig. 2-4: Chromatic measurement principle, thickness measurement

2.4 Typical applications (Overview)

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

The CHRocodile CLS is the fastest sensor based on confocal chromatic imaging principle. They are 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 line sensor is very well adapted to industrial environment, as no optical cable are connected to the CHRocodile CLS 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 CLS 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 measurement system going faster and faster, more and more compact and as flexible as possible, it is the case in laboratory environment and even more in industrial environment. It appears clearly here that the CHRocodile CLS unit of measurement meet these different needs.

Optical Head / Application	CLS 200µm	CLS 1mm	CLS 2.3mm	CLS 4mm
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

2.5 List of Deliverables

- One operational Confocal Chromatic Line Sensor unit (*see Fig. 2-6*),
- One operational Optical Head (*see Fig. 2-7*),
- One set of electric cables (power supply) (*see Fig. 2-8*),
- Power Supply Adapter (100-240V_{AC} to 24V_{DC} +/-10%) (*see Fig. 2-8*),
- A CD with DLL and firmware,
- Software user guide,
- Operation Manual,
- Qualification Test report.

Fig 2-5: CLS deliverables

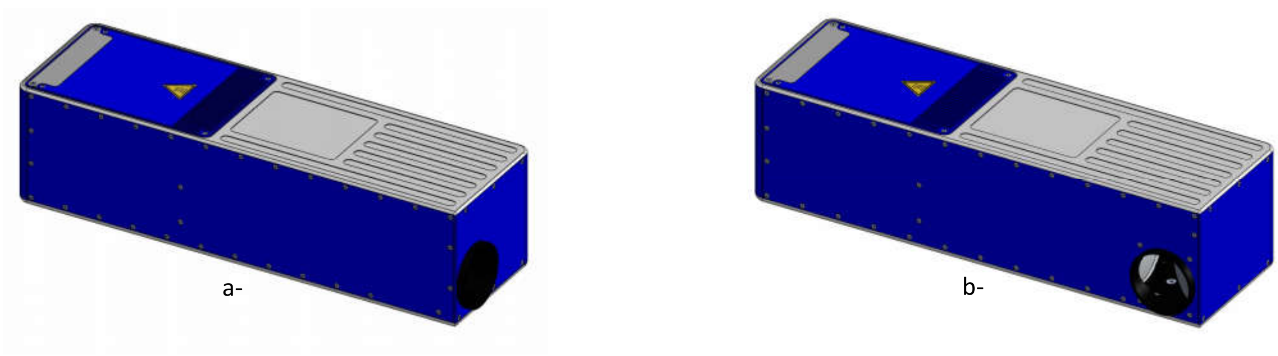


Fig 2-6: CHRocodile CLS unit 3D view: a- Straight version b- Right angled version

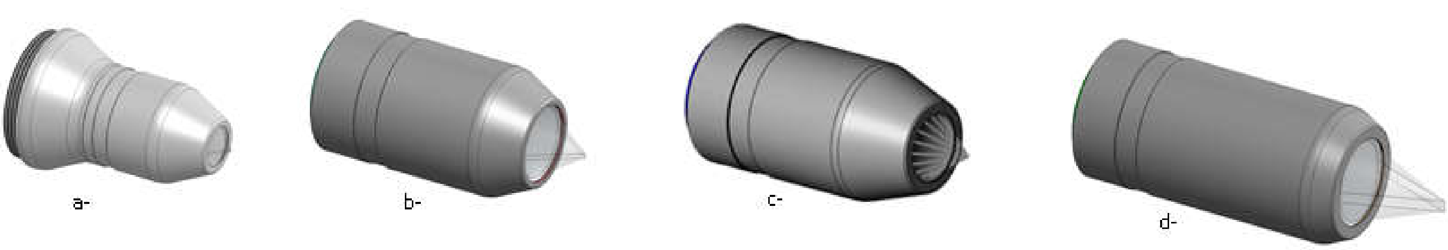
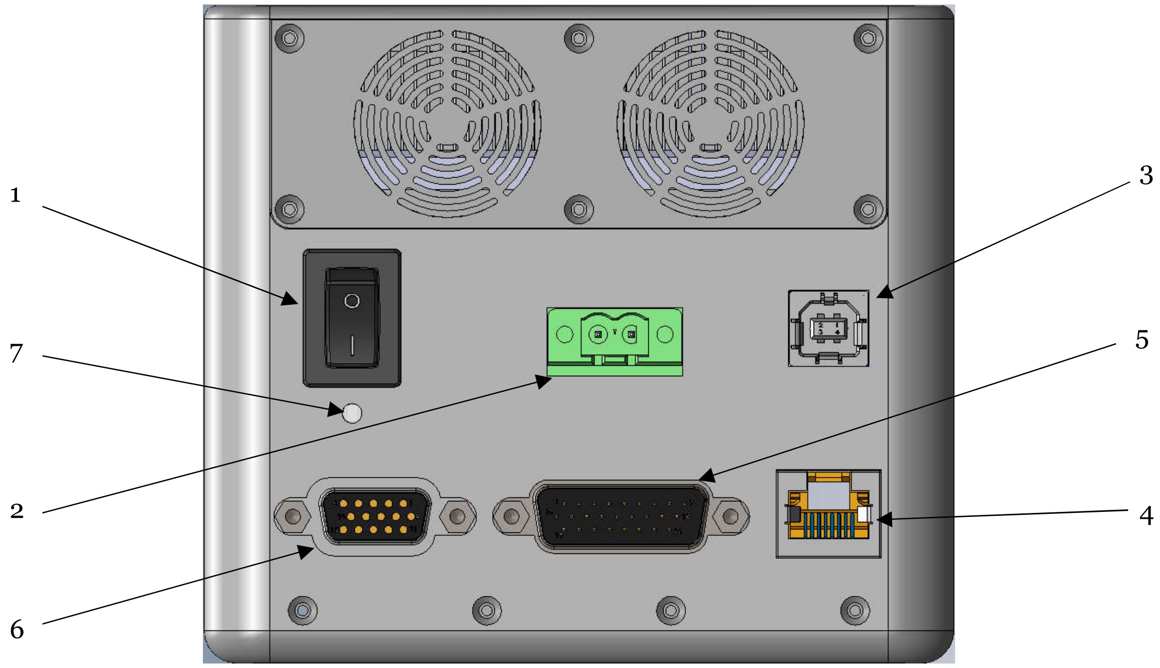


Fig 2-7: Optical Head 3D view: a- CLS0.2 b- CLS1 c- CLS2.3 d- CLS4

Fig 2-8: Set of electrical cables: a- Power supply b- Adapter

2.6 Connections and Interfaces

All of the connection ports for the sensor unit are located at the rear of the system (*see Fig 2-9*):



1. ON / OFF Switch button,
2. Power supply jack
3. Serial interface RS232, USB port,
4. Ethernet interface, RJ45 port
5. Encoder-Input, Sub-D26 male connector
6. Trigger Input/Output + RS422, Sub-D15 female connector
7. Status LED

Fig. 2-9: CHRocodile CLS rear panel: Connections

2.6.1 ON / OFF Switch button

The CHRocodile CLS has a Power switch ON / OFF button.

2.6.2 Power supply jack

The CHRocodile CLS 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 CLS unit.

2.6.3 USB port RS232 serial communication

The serial RS232 is interfaced on the USB port. Serial communication are mostly used for sending command as a hyper-terminal. As the number of channel is high with a huge amount of data, serial communication port cannot support data transfer.

2.6.4 Ethernet connector

The CHRocodile CLS has a RJ45 standard connector for Ethernet communication.
Connect the isolated RJ45 standard connector from the CHRocodile CLS unit to an Ethernet network (PC). Ethernet is the only port which can support the data transfer. Ethernet is also used for setting configuration through commands (Cf. command SODX in section 5.2), for loading Calibration Table (Cf. command TABL in section 5.2). Use shielded Ethernet cable for the data port connection.

Ethernet communication allows to transmit 6 data at 2KHz. If more than 6 data are requested, it is possible to use Jumbo Packet configuration. In that case, you need to check network hardware for Jumbo Packet support and use the IPCN command to configure the Jumbo Packet size. Disconnect the sensor and configure the PC network hardware for the identical size and reconnect the sensor.

2.6.5 Encoder-input

The incremental encoder-input makes it possible to precisely assign each measurement points along the line and axis positions without additional hardware. The CHRocodile CLS can manage with 5-axis Encoders.

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 is equipped with an encoder-interface.

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.

PIN	Signal	Input	Signal to which ground	Sub-D26
1	A0-	I	Differential encoder input 120 Ohm terminated	
2	A0+	I	Differential encoder input 120 Ohm terminated	
3	B0-	I	Differential encoder input 120 Ohm terminated	
4	B0+	I	Differential encoder input 120 Ohm terminated	
5	A1-	I	Differential encoder input 120 Ohm terminated	
6	A1+	I	Differential encoder input 120 Ohm terminated	
7	B1-	I	Differential encoder input 120 Ohm terminated	

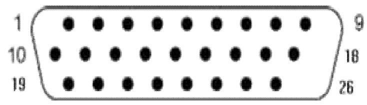
8	B1+	I	Differential encoder input 120 Ohm terminated	
9	GND	P	ground	
10	A2-	I	Differential encoder input 120 Ohm terminated	
11	A2+	I	Differential encoder input 120 Ohm terminated	
12	B2-	I	Differential encoder input 120 Ohm terminated	
13	B2+	I	Differential encoder input 120 Ohm terminated	
14	GND	P	ground	
15	NC	-	Not connected	
16	A3-	I	Differential encoder input with switchable 120 Ohm	
17	A3+	I	Differential encoder input with switchable 120 Ohm	
18	B3-	I	Differential encoder input with switchable 120 Ohm	
19	B3+	I	Differential encoder input with switchable 120 Ohm	
20	Sw0t02	-	Low = termination ON, NC or 5V = termination OFF	
21	+5V/ 120mA	P,O	5V /120mA supply for external encoder	
22	Sw3t04	I	Low = termination ON, NC or 5V = termination OFF	
23	A4-	I	Differential encoder input with switchable 120 Ohm	
24	A4+	I	Differential encoder input with switchable 120 Ohm	
25	B4-	I	Differential encoder input with switchable 120 Ohm	
26	B4+	I	Differential encoder input with switchable 120 Ohm	

Table 2.2: Encoder interface (PIN-Configuration)

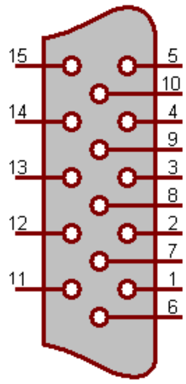
2.6.6 Trigger Input/Output / RS422 serial communication

The Trigger output use a Sub-D 15 female connector. This connector is used for trigger Input / Output and for RS422 serial communication (*Cf. Table 2-3 and Table 2-4*).

The trigger options make the lighting cycle externally controllable and the synchronization between e.g. a scanning system cycle and the CHRocodile CLS measurement rate. This means that external triggering is possible for every measurement up to the full measurement rate of 2000Hz.

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

The serial RS422 is interfaced on the Sub-D15 female connector. Serial communication are mostly used for sending command as a hyper-terminal. As the number of channel is high with a huge amount of data, serial communication port cannot support data transfer.



Signal	Pin
SyncIn	1
GND	2
SyncOut	3
Isolated-GND	4
[A] RS422 (CTS)	5
[A] RS422 (RTS)	6
[A] RS422 (RXD)	7
[A] RS422 (TXD)	8
Isolated-GND	9
Isolated-GND	10
Isolated-GND	11
[B] RS422 (CTS)	12
[B] RS422 (RTS)	13
[B] RS422 (RXD)	14
[B] RS422 (TXD)	15

Table 2.3: Interface (pin configuration)

Signal	Function	Description
RS432	RS422 Interface	Isolated (Isolated-GND) RS422 Interface
Sync In	Trigger-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) • the input is equipped with 10 kΩ pullup-resistance at 5 V.
Sync Out	Sync. Output	Isolated Sync Output Positive slope 0 V to 5 V with the start of each measurement. The pulse duration is 50µs in general and every second one pulse is shorted to 10µs. This is for synchronizing more sensors when their Sync-In is connected with the Sync-Out.

Table 2.4: 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 (using the standard settings, *but the edge can also be inverted by software command) 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).

2.6.7 Status LED

LED Status	CHRocodile CLS Status
No Signal	Power OFF
RED LED	Power ON, Firmware badly configured
Flashing GREEN LED	Power ON, Firmware is configuring
BLUE LED	Power ON, Firmware is configured / Continuous Measurement
Flashing BLUE / GREEN LED	Power ON, Triggering session
GREEN LED	Power ON, Waiting for Trigger

Table 2.5: Status LED definition

2.7 Sensor Characteristics

2.7.1 Sensor unit characteristics

Optical sensor	
Measuring principle [(1)]	Confocal Chromatic
Measuring data [(1)]	Distance, Thickness
Number of Channel [(1)]	192
Light source	LED
Dimensions (sensor unit)	391 x 100 x 114 mm (L x H x T) [(2)]
Weight	4 kg
Data Transmission	
Measuring rate	100 – 2000 Hz (up to 6KHz [(3)])
Interfaces	Ethernet, RS232, RS422
Communication Protocol	Ethernet
Synchronization with ext. devices	Trigger-input / Output (TTL)
Encoder-inputs	Yes (5 axis)
SDK	Via a DLL, compatibility .NET and C++
OS	Windows XP, Windows 7, Windows 8
Data Processing / Calculation	Embedded processing unit
Standard to be met	
Power Supply	$24V_{DC}$ +/-10% / 40W with separate main supply unit 100 to $240V_{AC}$ – 50Hz to 60Hz
Operating Temperature	+5 °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)
Optical Head Specifications	**See Table 2.8**

Table 2.6: Sensor Characteristics

(1) See section 2-3: Sensor Functionnalities

(2) See Fig 6-2 Sensor unit mechanical plan in section 6.2 CHRocodile CLS unit mechanical plan

(3) See section 2.7.2: High frequency mode

2.7.2 High Frequency Mode

A high frequency mode is now available. This optional mode gives access to frequencies measurements above the 2KHz nominal frequency and allows to measure up to 6KHz.

Using this measurement mode has several impacts:

- Reduction of the measuring range based on the selected frequency,
- Decrease the number of transmitted data,
- Change the center of the measuring range depending on the frequency,
- Need for a DARK procedure when changing frequency.

1- Measuring range and number of transmitted data:

The following table defines the accessible measuring range and number of transmitted data as a function of the selected frequency.

Frequency	**Measuring Range**				**Maximum number of transmitted data**
	CLS0.2	CLS1	CLS2.3	CLS4	
Up to 2KHz	200 µm	950 µm	2300 µm	3900 µm	6
3KHz	120 µm	580 µm	1400 µm	2380 µm	3
4KHz	85 µm	425 µm	1000 µm	1740 µm	2
5KHz	65 µm	320 µm	760 µm	1320 µm	2
6KHz	50 µm	240 µm	580 µm	1000 µm	1

Table 2-7: Measurement range based on the frequency measurement

2- Need for a DARK procedure when changing frequency:

When changing measuring frequency, it is sometimes necessary to perform a Dark procedure to ensure the performances of the sensor. A systematic Dark procedure must be done in the following cases:

- When changing frequency from a high frequency (> 2 KHz) and a low frequency (<= 2 KHz),
- When whanging frequency from a high frequency (> 2 KHz) to any other frequency,

Only the transition from a low frequency (<= 2 KHz) to another low frequency (<= 2 KHz) does not requires any Dark operation.

To achieve a Dark refer to section 4-2.

2.7.3 Optical Heads characteristics

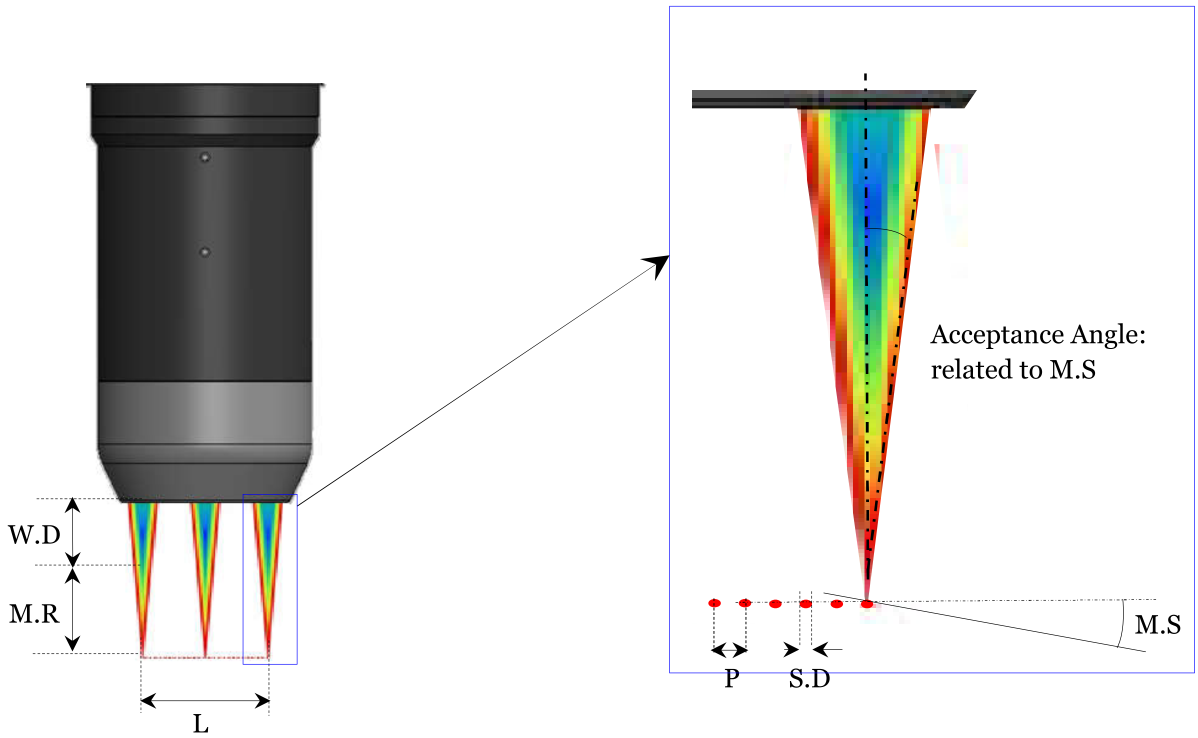
	Specifications \ Optical Head	CLS0.2	CLS1	CLS2.3	CLS4
GLOBAL SPECIFICATIONS	Line Length (1)	0.96mm +/- 0.01mm	1.91mm +/- 0.02mm	1.53mm +/- 0.02mm	4.78mm +/- 0.04mm
	Working Distance (1) (2)	5.3mm +/- 0.4mm	18.5mm +/- 0.5mm	15.6mm +/- 0.5mm	36.4mm +/- 0.6mm
	Pitch along the line (1)	5 +/- 0.05µm	10 +/- 0.1µm	8 +/- 0.08µm	25 +/- 0.25µm
	Spot diameter (1)	2µm	4µm	3.2µm	10µm
	Max Object Slope (1) (3)	+/- 44deg	+/- 33deg	+/- 33deg	+/- 20deg
DISTANCE MODE	Measuring Range (1)	200µm	950µm	2300µm	3.9mm
	Axial Resolution (R_{min}) (4) (5) (6)	20nm	80nm	200nm	320nm
	Accuracy (4) (5)	80nm	300nm	780nm	1.2µm
THICKNESS MODE	Min. Measurable Thickness (4) (7)	20µm	75µm	200µm	300µm
	Max. Measurable Thickness (4) (7)	280µm	1.35mm	3.1mm	5.5mm
	Axial Resolution (4)	60nm	200nm	500nm	800nm
MECHANICAL DIMENSIONS	Length	70.35mm (8)	93.3mm (8)	99.5mm (8)	120mm (8)
	Diameter	37mm (8)	54mm (8)	54mm (8)	58mm (8)
	Weight	190g	430g	390g	510g
	Model	Right angled or Straight (9)	Right angled or Straight (9)	Right angled or Straight (9)	Right angled or Straight (9)

Table 2.8: Optical Head Specifications

(1) See section 2.8: Optical Head Specifications definitions
(2) Bottom of the optical probe to middle of the measuring range
(3) Decreasing accuracy on the limits
(4) See section 2.9: CHRocodile CLS 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 6-1: Optical Head Mechanical plan
(9) See Fig 6-2: CHRocodile CLS unit mechanical plan

Optical Heads are interchangeable: the same CHRocodile CLS unit can store up to 5 different calibration tables corresponding to different Optical Heads. The Optical Head is totally passive, only the CHRocodile CLS unit has an internal Light Source and Electronic board which can be considered as heat and electrical sources. However the Optical Head 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 CLS unit has no visible optical cable and the user don't need to take care with this particularly sensitive component.

2.8 Optical Head Specifications definitions



W.D : Working Distance

M.R : Measuring Range

L: Line length

P: Pitch between measuring spot

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 2-10: Optical Head Specification definition

2.9 CHRocodile CLS performance specifications:

Axial Resolution:

Axial resolution corresponds to the static noise (standard deviation 1σ) on altitude or thickness measurements. It is an experimental specification. It is measured on 1000 continuous points along the measuring range for each channel along the line. Axial resolution as a function of object position inside measuring range is calculated for each channel along the line. By default axial resolution specification corresponds to the minimum value (R_{min}). (*See Fig. 2-11*),

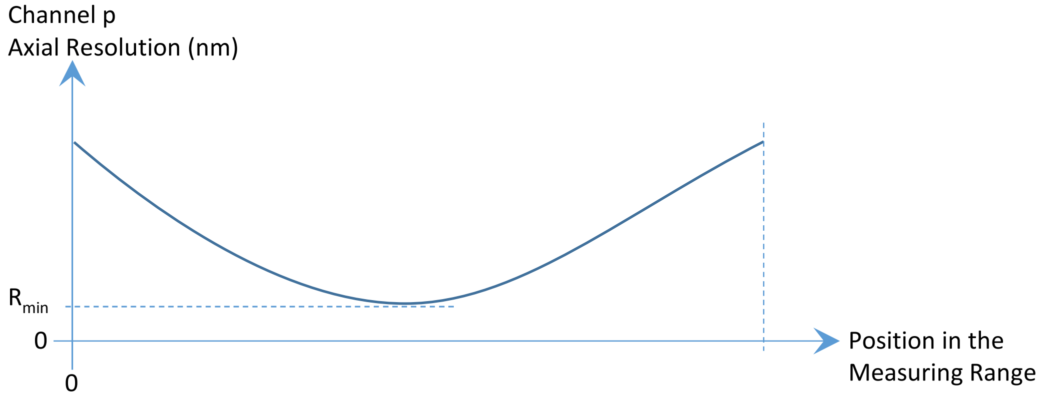


Fig 2-11: Axial Resolution as function of object position in Measuring Range for one channel

Accuracy:

Accuracy corresponds to the altitude deviation for each channel along the measuring range between the CHRocodile CLS and a calibrated interferometric reference sensor. Consequently, accuracy is an experimental specification. Accuracy as a function of object position inside measuring range is calculated for each channel along the line. By default accuracy specification corresponds to the maximum of absolute value (A_{max}). (*See Fig. 2-12*),

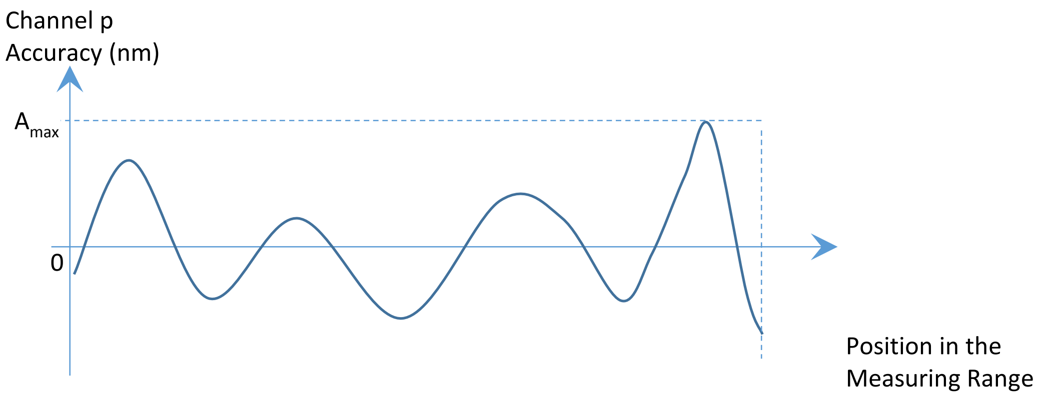


Fig 2-12: Accuracy as function of object position in Measuring Range for one channel

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 for each channel. $T=n.(D_1-D_2)$

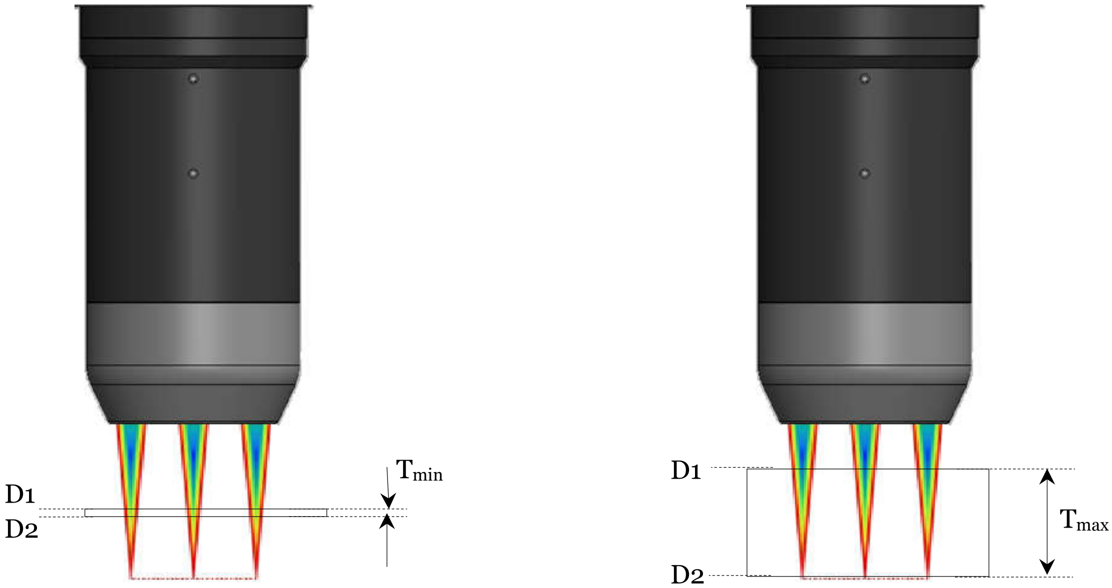


Fig 2-13: Minimum and Maximum measurable thicknesses

Operational Start up

3.1 Connections and Interfaces

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

- the connection ports for the serial interfaces RS232/RS422
- the connection for the encoder
- the interface port for synchronization with external devices and
- the power supply jack.

3.1.1 CHRocodile CLS Stand Alone device:

The device can be used as a stand-alone device in order to perform selective distance or thickness measurements.

Power supply

The CHRocodile CLS 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 CLS unit.

Ethernet connector

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

The default CHRocodile CLS IP address is: **192.168.170.2**
Configure the PC Ethernet port to the following address: **192.168.170.X (X≠2)**

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 192.168.170.2), contact your vendor. This could be useful in case of multiple CHRocodile CLS connection on 1 computer.

ON / OFF Switch button

Switch on the Power button.

3.1.2 CHRocodile CLS integrated on measurement system:

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

- The USB port (Serial interface RS232),
- The Sub-D15 female connector (Trigger Input/Output and Serial interface RS422),
- And the Sub-D26 male connector (Encoder-input),

Encoder-input

The incremental encoder-input makes it possible to precisely assign each measurement points along the line and axis positions without additional hardware. The CHRocodile CLS can manage with 5-axis Encoders.

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 is equipped with an encoder-interface.

Default are the encoder inputs not terminated.
Tye Sw0t02 to GND to terminate with 100 Ohm channel 0 to 2
Tye Sw3t04 to GND to terminate with 100 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 100 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 CLS measurement rate. This means that external triggering is possible for every measurement up to the full measurement rate of 2000Hz.

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

Serial interface RS232 and RS422

The serial RS232 and RS422 are interfaced on respectively the USB port and the Sub-D15 female connector. Serial communication are mostly used for configuring the sensor by sending command as a hyper-terminal. As the number of channel is high with a huge amount of data, serial communication port cannot support data transfer.

3.2 CHRocodile CLS Explorer and Drivers installations

3.2.1 CHRocodile CLS Explorer installation:

CHRocodile CLS Explorer is a Man-Machine interface which allows to configure, to visualize measurement, to update firmware, to load calibration table, to save data etc…

Two versions of CLS Explorer are now available:
- Premium version is delivered with the CLS sensor,
- Ultimate version allows to perform sample scanning.

Refer to CHRocodile_CLS_Explorer_User_Manual to obtain more specifics information.

3.3 Communication with CHRocodile CLS

There are three possible way to communicate with the CHRocodile CLS: via the CHRocodile CLS Explorer software, via the CHRocodile CLS DLL and using the ASCII commands sent to the CHRocodile CLS via serial interface (RS232 or RS 422) or Ethernet. Up to 3 CHRocodile CLS can be connected and controlled by a single computer (Windows XP, Windows 7 or Windows 8 OS, 32 and 64bits). CHRocodile CLS is automatically detected through Ethernet network (broadcast mode).

3.3.1 Via CHRocodile CLS Explorer:

Premium version of CHRocodile CLS Explorer software is delivered with the sensor and is useful to configure sensor, to visualize continuous measurements, to perform statistic and to save data.

Additionally to these functionalities, Ultimate version of CHRocodile CLS Explorer allows to perform 3D scanning acquisition. In order to use the Ultimate version you need:

- A 2-axis scanning system,
- An interface DLL allowing to interpret the standard commands of your 2-axis system (move, free run etc…). This slight DLL has to be written by the customer following interface specifications given by PRECITEC (Cf. CHRocodile_CLS_Explorer_User_Manual),
- A non-free license (USB key).

A demo license can be activated remotely, in order to allow customer testing the Ultimate version.
As demo license has a limited duration, it is preferable to activate this demo license when the interface DLL is ready.

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

3.3.2 Via CHRocodile CLS DLL:

DLL may be used to interface the sensor with a general-purpose user program. The CHRocodile CLS DLL is intended for .NET compatible language. A new DLL intended for C++ compatible language is now available and allows to use most of CLS functionalities. Refer to C++ DLL documentation.

A CD containing the DLLs, some code examples and the operating Manual is delivered with the CHRocodile CLS. Sensor configuration, processing and data transmission can be performed through CHRocodile CLS DLL.

The CHRocodile CLS .NET DLL functions are described in section 5.4. Also refer to CLS_SDK_Manual to obtain detailed information. CLS .NET DLL functions have the same properties as the ASCII Commands. Consequently, what can be done using ASCII commands can be done using the CHRocodile CLS .NET DLL.

3.3.3 ASCII command communication

The ASCII commands can be sent to the controller via the RS232 or RS422 interface using a specific command structure described on section 5.2.

Serial interface communication can be used to configure the sensor, but cannot be used to receive measurement data, due to the high amount of data simultaneously transmitted by CHRocodile CLS. Only Ethernet allows unlimited data transmission at measuring rate up to 2KHz (or 6KHz in high frequency mode).

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.

3.4 CLS Explorer Library

The ClsExplorerLibrary DLL is a library of tools to ease the development of applications based on CLS sensors. ClsExplorerLibrary is compatible with any version subsequent to Visual studio 2010.

This Development Kit is a very quick and easy way to evaluate and use CHRocodile CLS Sensor. In just a few minutes you can start testing, configuring, integrating your new devices, and developing your customized applications.

The Development Kit is composed of some source code examples and a lot of useful tools. It also includes a license USB key.

ClsExplorerLibrary DLL has two available license levels: a free *demo* license, and non-free *premium* license which have been designed to save you both time and money by speeding up the integration of our products into your applications. A ClsExplorerLibrary DLL ultimate license will be available in September 2016 with the possibility to integrate sample scanning functionalities.

Please refer to CLS Explorer Library Manual.

Measurements Start Up

4.1 Calibration Table

The CHRocodile CLS unit can store up to 5 different calibration tables corresponding to different Optical Heads. In order to start measurement you need to download or select the calibration which correspond to the used Optical Head (Cf. section 5.2 in user manual). Calibration table consists in a Look Up Table which give the correspondence between the peak position (Barycenter data) and the Altitude data.

The global calibration table contains 192 single calibration tables for each of the 192 points (or channel) in the line. Consequently, each channel are calibrated independently at factory.

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

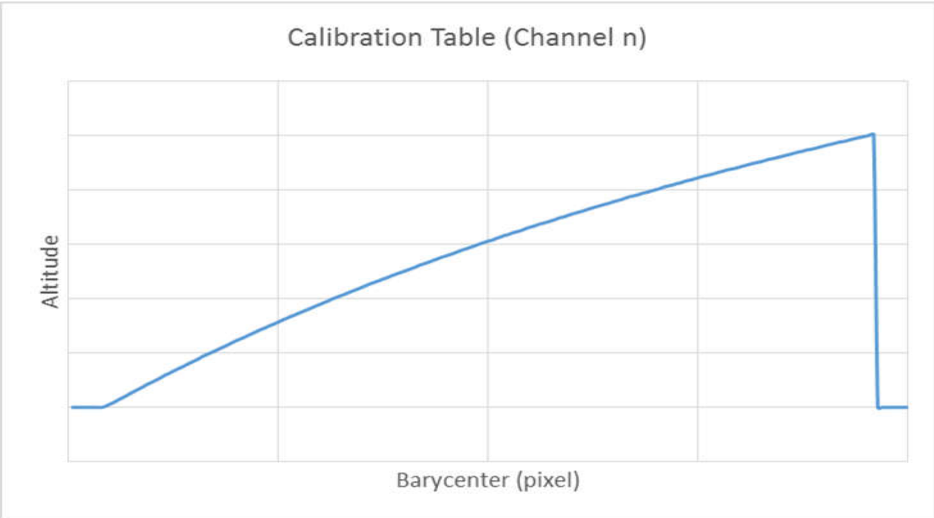


Fig 4-1: Example of calibration table for a single channel

4.2 Dark Acquisition

Even when there is no surface in the probe's measurement range, the signal on the detector is not zero. This 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 section 5). The Dark reference acquisition must be done when no object is in the measurement range.

4.3 Auto Reference procedure

This procedure is no longer necessary. It has been disabled from CLS Explorer version 1.0.1.1. The use of this procedure can modify the calibration of your sensor, consequently if required, this procedure must be done by PRECITEC, as a maintenance operation.

4.4 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 Head which suit to your application to the CHRocodile CLS unit. The Optical Head is simply screwed on the CHRocodile CLS unit (Cf. Figure 4.2),
- And, fixing the CHRocodile CLS on your system using the interface threaded M4 holes (x11) located on the soleplate of the Line sensor (Cf. section 6.3).

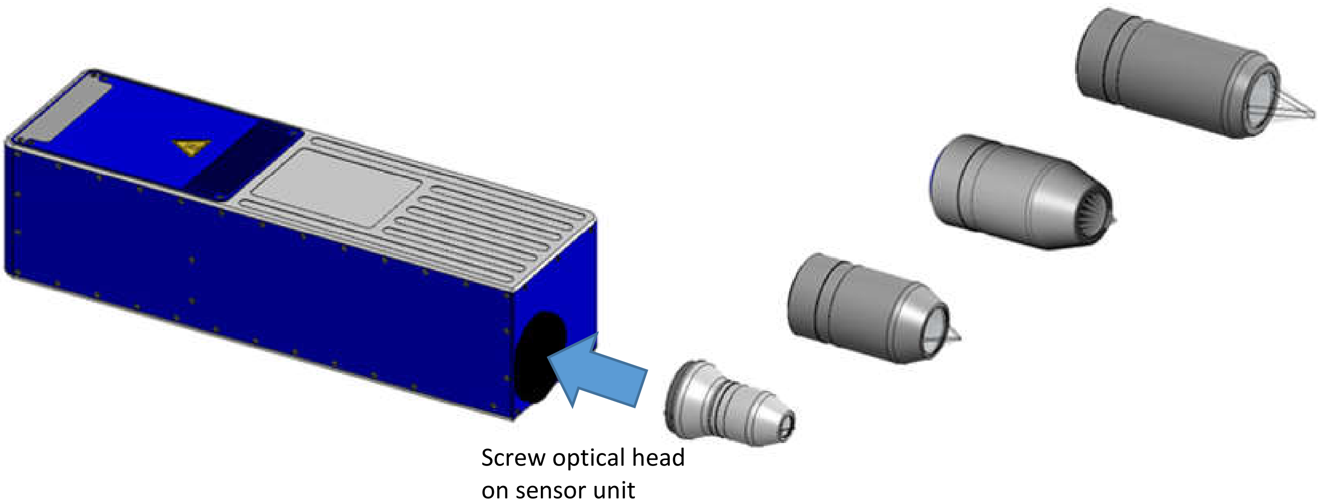


Fig 4-2: Interchangeable optical heads

4.5 Basic Settings Configuration

In order the CHRocodile CLS to be operational for startup some basic parameters should be set up.

Basic setting configuration consists in selection of:

- Measuring Range: The CHRocodile CLS could accept 5 calibration tables, and each calibration table corresponds to a unique Optical Head. Consequently, depending on the Optical Head which is mounted on the CHRocodile CLS unit, the operator must select the right Measuring Range or Calibration Table. (Cf. command $TABL in section 5.2)
- Measuring Mode: The CHRocodile CLS has two measuring mode: Altitude and Thickness measurement. Depending on the application, operator must select the right Measuring Mode. (Cf. command $MOD in section 5.2)
- 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 on the 192 channels of the line sensor. The goal is to obtain the higher intensity without saturation. On homogeneous target, each channel's intensity is mostly the same, this is not the case on inhomogeneous target and in that case, it is recommended to adjust intensity in order to obtain the maximum intensity close to saturation. In order to adjust LED intensity, use the LAI command or the equivalent .NET DLL function (Cf. sections 5.2 and 5.4).
- Measuring Rate: Instead of adjusting intensity, it is also possible to adjust the measuring rate. The Measuring Rate is related to data transmission frequency. The CHRocodile CLS maximum measuring rate is 2KHz. 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 or the equivalent .NET DLL function (Cf. sections 5.2 and 5.4).

4.6 Data measurement Training

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

This procedure is valid for Altitude and Thickness mode, 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 head or the target along the optical axis. Thus, it is recommended to fix the optical head or the target on a translation plate.

- Adjusting the Line on the area to be measured. The first measuring channel is at the opposite from the soleplate, and the channel n° 192 is close to the soleplate. Consequently depending on your configuration, you will possibly need to mirror the measured line from left to right.

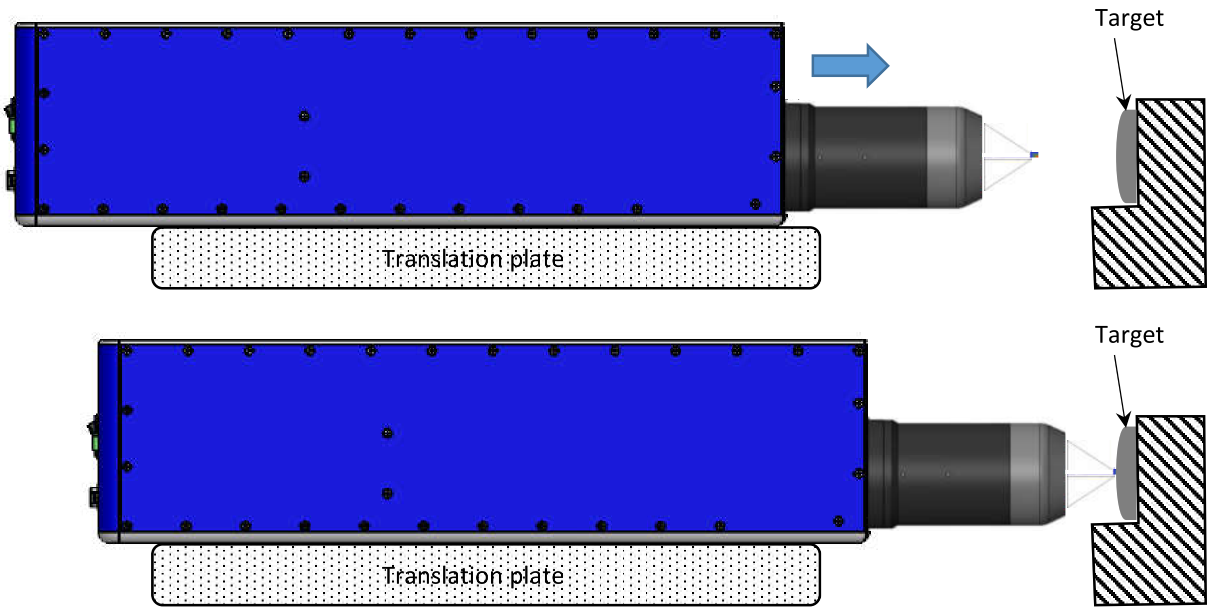


Fig 4-5: Axial position adjustment

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 or the equivalent .NET DLL function (Cf. sections 5.2 and 5.4). In order to record the data corresponding to the 192 channels of the Line sensor, the Ethernet cable must be connected with the right IP address to enable the communication between CHRocodile CLS and the computer.

When the sensor is configured to measure simultaneously the 192 channel's data, then it is possible to perform an area scan:

- In order to scan the target, one can move the optical head or the target along the axis which is perpendicular to the measuring line. Thus, a 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 line is not constant and the global topography will be distorted. To overcome this image deformation it is important to assign precisely each measurement points along the line and axis positions. To do so, one need to connect the incremental encoder-input. The CHRocodile CLS can manage with 5-axis Encoders.

Advanced Configuration

5.1 Commands List

command	arguments	answer on query	comments
CTN		*Continue (Measuring)*	
DRK		*<n>(<x>)* *n: Index of the lowest measuring rate* *x: lowest frequency in Hz, floating point*	*"Dark reference"* *take dark reference and save to flash*
DNLD	*<1..3>*	-	*Download spectrum. Currently for packet connections only.*
ENC	*<0..4> [<0..3>] < -2147483648 .. 4294967295, ?>*	*encoder position*	*"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.*
ETR	*<func. Index> <arguments>*	*see detailed description*	*"Encoder Trigger",* *see detailed description*
IPCN	*<0,1>, [eight numbers <0..255>]*	-	*Configure TCP address and subnet mask. 1st arg: DHCP on/off, args 2.5: fixed IP addr. args 6..9: mask (only if DHCP off, i.e. 1st arg = 0)*
LAI	*<0...100, ?>*	*<value in %>*	*"Lamp intensity"* *LED version: set on-time of LED between 1-100% of the exposure time.*
NOP	*<1..16>*	*<1..16>*	*Set number of peaks to evaluate.* *WARNING: see detailed description below.*
SCA	-	-	*distance or thickness value [µm] for output value 32768*

SEN	*<0 .. 15, ?>*	*<optical probe Index>*	*„optical probe“ index of used optical probe*
SHZ	*<32 .. 2000, ?>*	*<x>Hz x meaning the exact sample rate in Hz in floating point format*	*“Set sample rate in Hz”.*
SODX	*<0..17> <0..17> … <0..17> (max 16 times) or <?>*	*<0..17> <0..17> … <0..17> (max 16 times)*	*“Set output data extended” definition of the output telegram by enumeration of the indices of the data.*
SSU	-	-	*“Save Setup”, saves Setup Parameters to Eeprom Memory*
STA	-	-	*Start serial data output.* *This mode will be stored in the Eeprom when executing the SSU command. If stored the CHR will begin immediately to output data telegrams on the next power up.*
STO	-	-	*Stop serial data output* *This mode will be stored in the EEPROM when executing the SSU command, so on the next power up the CHR will not begin to send measurement data until the output is restarted by the “STA” command*
TABL	*<Table ID> <args...> <binary data, ?>*		*Upload table to device (or read back in case of '?'). See below for details.*
THR	*<0..4094, ?>*	*<threshold value>*	*„threshold“ threshold for peak detection in the confocal modes (0 and 1)*
TRE	-	-	*“Trigger Each” – Mode*
TRG	-	-	*”Wait For Trigger” Stops the sensor after completion of the current data telegram and puts it in a waiting state.*
VER	-		*output version data*
WHT	*3141*	*Int. ok![CR/LF] or Int. too weak![CR/LF] or Int. too high![CR/LF]*	*White Reference*

Table 5.1: Commands list

5.2 Detailed Commands Description

5.2.1 DNLD Command

Short description:

Clients use this command to request a spectrum from the device. Since acquiring spectra can take up several sample periods, a DNLD request from the client causes the device to first respond with a DNLD response that does not contain any spectrum data. It just acknowledges the request. Later, when the spectrum is available, the device sends one or more command packets ("update" packet) containing the real spectrum data. Data packets may arrive in the meantime, i.e. between the response and the spectrum. Update packets are structured exactly like command (response) packets, only with the "update" flag set.

Currently, DNLD command does not function for ASCII command connections.

5.2.2 ETR Command

This command groups several functions related to encoder triggering.

WARNING: The settings will not be saved in the EEPROM by the $SSU command.

The encoder trigger is implemented as a state machine. 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.

5.2.3 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	NET	
$IPCN 1 $IPCN <DHCP>	Configured as DHCP client	✓	`Client.Network.DhcpMode = true;`

$IPCN 0 192 168 170 2 255 255 255 0 0
$IPCN <DHCP> <IPA> <IPB> <IPC> <IPC> <MA> <MB> <MC> <MD> <MTU>
	Configured as static IP address
	IP Address = 192.168.170.2
	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).
		✓	`Client.Network.DhcpMode = false;`
			`Client.Network.IPAdress = "192.168.170.2";`
			`Client.Network.SubnetMask = "255.255.255.0";`

5.2.4 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	NET	
$LAI 95 Response: $LAI 95[CR]ready[CR/LF].	Write Led intensity 95%	✓	`Client.LedIntensity = 90;`
$LAI ? Response: $LAI ? 95ready[CR/LF].	**Read Led Intensity**	✓	**float Led = Client.LedIntensity;**

5.2.5 NOP Command

Short description:

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

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

Command syntax:

$NOP <I>

Param: <I> is Number of Peak from 1 to 16

Command	Description	NET
$NOP 3 `Response: $NOP 3[CR]ready[CR/LF].`	Write Number of Peak (3)	✓ `Client.NumberOfPeaks = 3;`
$NOP ? `Response: $NOP ?  3ready[CR/LF].`	Read Number of Peak	✓ `int Number = Client.NumberOfPeaks;`

5.2.6 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	NET
$SCA ? `Response: $SCA ?  3320ready[CR/LF].`	Read Full Scale	✔ `int FullScale = client.Scale;`

5.2.7 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 (100Hz…2000Hz)

Command	Description	NET
$SHZ 1000 `Response: $SHZ 1000[CR]ready[CR/LF].`	Write Sample Rate (1000 Hz)	✓ `Client.FreeSampleRate = 1000;`
$SHZ ? `Response: $SHZ ?  1000ready[CR/LF].`	Read Sample Rate	✓ `float SampleRate = Client.FreeSampleRate;`

5.2.8 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

<table>
<tr><th>Bit:</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>Global Exposure Information</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td colspan="8">Global Exposure Signal ID's</td></tr>
<tr><td>Peak Signal</td><td>0</td><td>1</td><td colspan="3">Statistics=0</td><td>0</td><td>Measuring mode</td><td>1</td><td>0</td><td>0</td><td>0</td><td colspan="2">Peak Number</td><td colspan="3">Peak Signal Offset</td></tr>
</table>

Table 5.4: SODX command: Signal Identity's scheme.

Global Exposure Information:

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

Type:

Float

Command	Description	NET	
$SODX 64 `Response: $SODX 64[CR]ready[CR/LF].`	StartTime (in nanoseconds)	✓	`sodx.GlobalSignalStartTime = true;` `(Acquisition Format : UInt32)`
$SODX 65 `Response: $SODX 65[CR]ready[CR/LF].`	StartPositionX(X encoder position on beginning of exposure)	✓	`sodx.GlobalSignalStartPositionX = true;` `(Acquisition Format : UInt32)`
$SODX 66 `Response: $SODX 66[CR]ready[CR/LF].`	StartPositionY(Y encoder position on beginning of exposure)	✓	`sodx.GlobalSignalStartPositionY = true;` `(Acquisition Format : UInt32)`
$SODX 67 `Response: $SODX 67[CR]ready[CR/LF].`	StartPositionZ(Z encoder position on beginning of exposure)	✓	`sodx.GlobalSignalStartPositionZ = true;` `(Acquisition Format : UInt32)`
$SODX 68 `Response: $SODX 68[CR]ready[CR/LF].`	StartPositionU(U encoder position on beginning of exposure)	✓	`sodx.GlobalSignalStartPositionU = true;` `(Acquisition Format : UInt32)`
$SODX 69 `Response: $SODX 69[CR]ready[CR/LF].`	StartPositionV(V encoder position on beginning of exposure)	✓	`sodx.GlobalSignalStopPositionV = true;` `(Acquisition Format : UInt32)`
$SODX 70 `Response: $SODX 70[CR]ready[CR/LF].`	StopPositionX(X encoder position on end of exposure)	✓	`sodx.GlobalSignalStopPositionX = true;` `(Acquisition Format : UInt32)`
$SODX 71 `Response: $SODX 71[CR]ready[CR/LF].`	StopPositionY(Y encoder position on end of exposure)	✓	`sodx.GlobalSignalStopPositionY = true;` `(Acquisition Format : UInt32)`

$SODX 72 Response: $SODX 72[CR]ready[CR/LF].	StopPositionZ(Z encoder position on end of exposure)		sodx.GlobalSignalStopPositionZ = true; (Acquisition Format : UInt32)
$SODX 73 Response: $SODX 73[CR]ready[CR/LF].	StopPositionU(U encoder position on end of exposure)		sodx.GlobalSignalStopPositionU = true; (Acquisition Format : UInt32)
$SODX 74 Response: $SODX 74[CR]ready[CR/LF].	StopPositionV(V encoder position on end of exposure)		sodx.GlobalSignalStopPositionV = true; (Acquisition Format : UInt32)
$SODX 75 Response: $SODX 75[CR]ready[CR/LF].	FirstExposureCount		sodx.GlobalSignalFirstExposureCount = true ; (Acquisition Format : UInt16)
$SODX 76 Response: $SODX 76[CR]ready[CR/LF].	ExposureFlags		sodx.GlobalSignalExposureFlags = true; (Acquisition Format : UInt16)
$SODX 77 Response: $SODX 77[CR]ready[CR/LF].	RealExpTimeNs(Effective exposure period in nanoseconds)		sodx.GlobalSignalRealExposureTime = true ; (Acquisition Format : UInt32)
$SODX 78 Response: $SODX 78[CR]ready[CR/LF].	RealLightingTimeNs(Effective lighting period in nanoseconds)		sodx.GlobalSignalRealLightningTime = true; (Acquisition Format : UInt32)
$SODX 79 Response: $SODX 79[CR]ready[CR/LF].	TriggerLostCounter (Accumulates trigger events that have occurred during exposure and therefore have been ignored.		sodx.GlobalSignalTriggerLostCount = true ; (Acquisition Format : UInt16)
$SODX 80 Response: $SODX 80[CR]ready[CR/LF].	NumberOfValidPeaks (Number of peaks that have been found in the spectrum)		sodx.GlobalSignalNumberOfValidPeaks = true; (Acquisition Format : UInt16)
$SODX 83 Response: $SODX 83[CR]ready[CR/LF].	SampleCounter		sodx.GlobalSignalSampleCounter = true ; (Acquisition Format : UInt32)

Peak Signal:

Definition: Bit 8 = 1 (Bit 8 and 14 = 1)

Type:

For geometrical quantities like thickness or distance

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.

For non-geometrical quantities (like intensity)

Truncated 16bit integer value

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

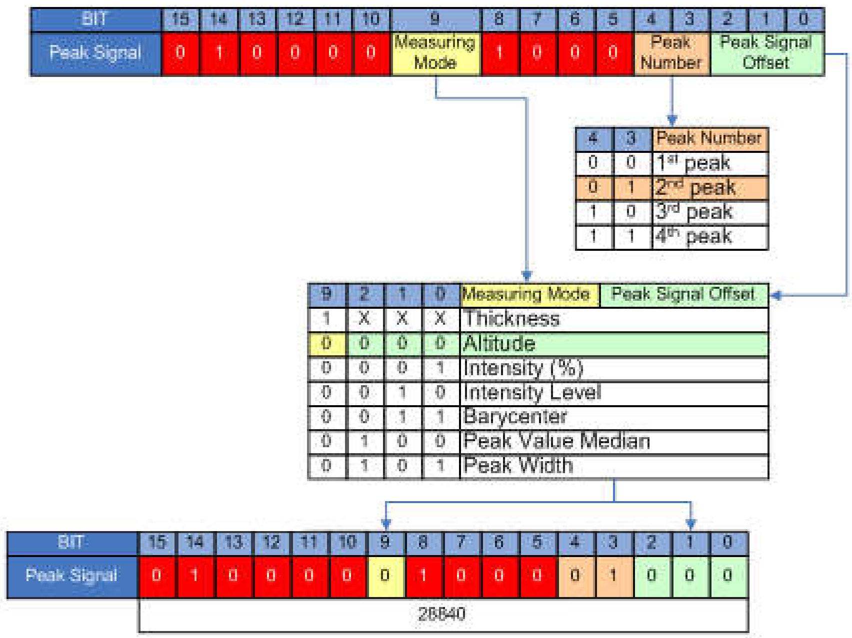
4	3	Peak Number
0	0	1st peak
0	1	2nd peak
1	0	3rd peak
1	1	4th peak

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

Statistics are not supported by CLS. Statistics are supported by CLS explorer. Consequently the respective bit 11 to 13 are set to 0. Corresponding to .NET function:

```
sodx.AltitudePeakSignalOffset1 = eSodxPeakSignalOffset.Average;
See Following Example
```

Example:



Command	Description	NET

$SODX 28840
Response: $SODX 28840[CR]ready[CR/LF].
	Altitude, 2nd peak	✔ `sodx.Altitude = true;`
		`sodx.AltitudePeak2 = true;`
		`sodx.AltitudePeakSignalOffset1 = eSodxPeakSignalOffset.Average;`

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	PeakValue Median	median of peak value (CHRocodile 2 only)
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 CLS. Statistics are supported by CLS explorer. Consequently the respective bit 11 to 13 are set to 0. Corresponding to .NET function:

sodx.AltitudePeakSignalOffset1 = eSodxPeakSignalOffset.Average;

5.2.9 SSU Command

Short description:

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

Command syntax:

$SSU

Command	Description	NET
$SSU Response: $SSU [CR]ready[CR/LF].	Saves current setup	✓ `Client.SaveSetup();`

5.2.10 STA Command

Short description:

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

Command syntax:

$STA

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

5.2.11 STO Command

Short description:

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

Command syntax:

$STO

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

5.2.12 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	NET	
$THR 35 `Response: $THR 35[CR]ready[CR/LF].`	Write Intensity Threshold	✔	`client.Threshold = 35;`
$THR ? `Response: $THR ?  35ready[CR/LF].`	Read Intensity Threshold	✔	`float Thr = client.Threshold;`

5.2.13 TRE Command

Short description:

The command TRE is a Trigger each.

Trigger each mode. Every exposure will be started by a rising edge of the sync-in-input. The exposure time of the detector is determined by the selected sample rate ($SHZ).

Command syntax:

$TRE

Command	Description	NET
$TRE `Response: $TRE[CR]ready[CR/LF].`	Trigger each	✓ `client.TriggerEach();`

5.2.14 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	NET
$TRG	Wait For Trigger	✔ `client.TriggerStartStop();`
`Response: $TRG[CR]ready[CR/LF].`		

5.2.15 VER Command

Short description:

The command VER give the Version of CHRocodile CLS.

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

Command syntax:

$VER

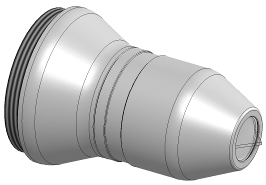
Command	Description	NET
$VER `Response:$VER 73;C:V5.95/240909; DSPsoft:V5.95/160909ready[CR/LF]`	Read Versions	✔ `string versions = client.Version;`

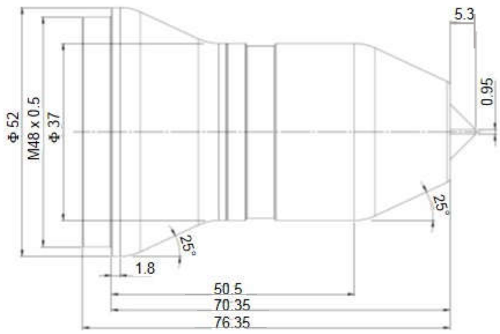
5.2.16 Calibration Table Download Function

It is also possible to upload calibration tables using the CHRocodile CLS Explorer with the ultimate version (Cf. section 3.2.1). Calibration table is downloaded at factory and this should not be done at customer site.

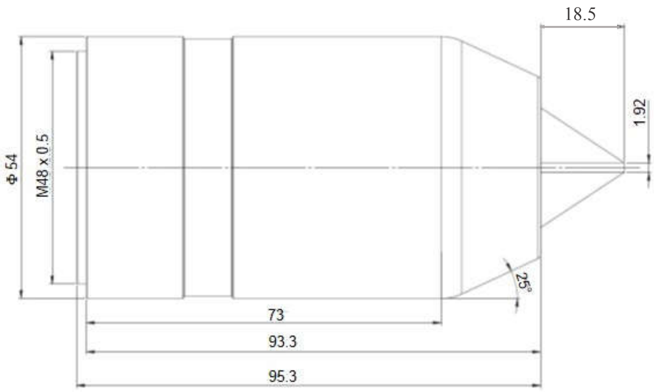
Mechanical Plans

6.1 Optical Head Mechanical plans

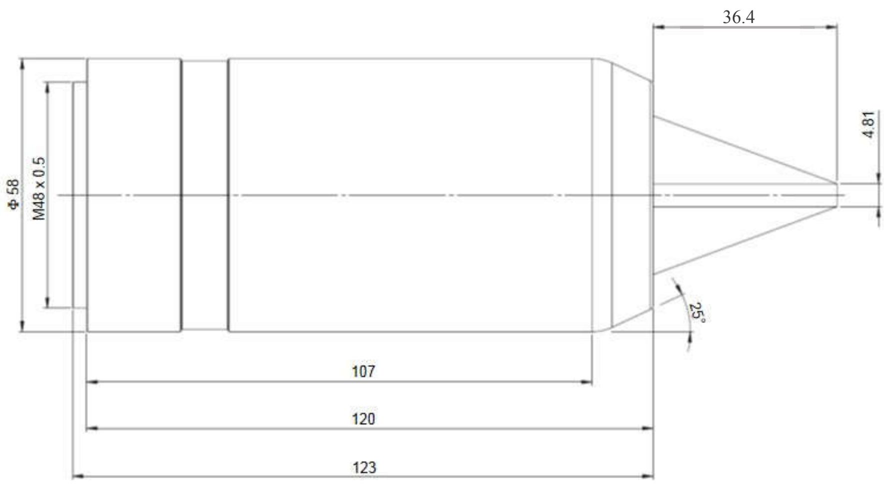




a- CLS02



b- CLS1



c- CLS4

d- CLS2.3

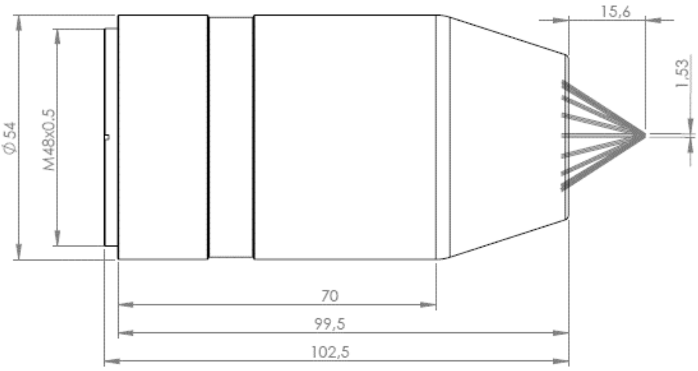
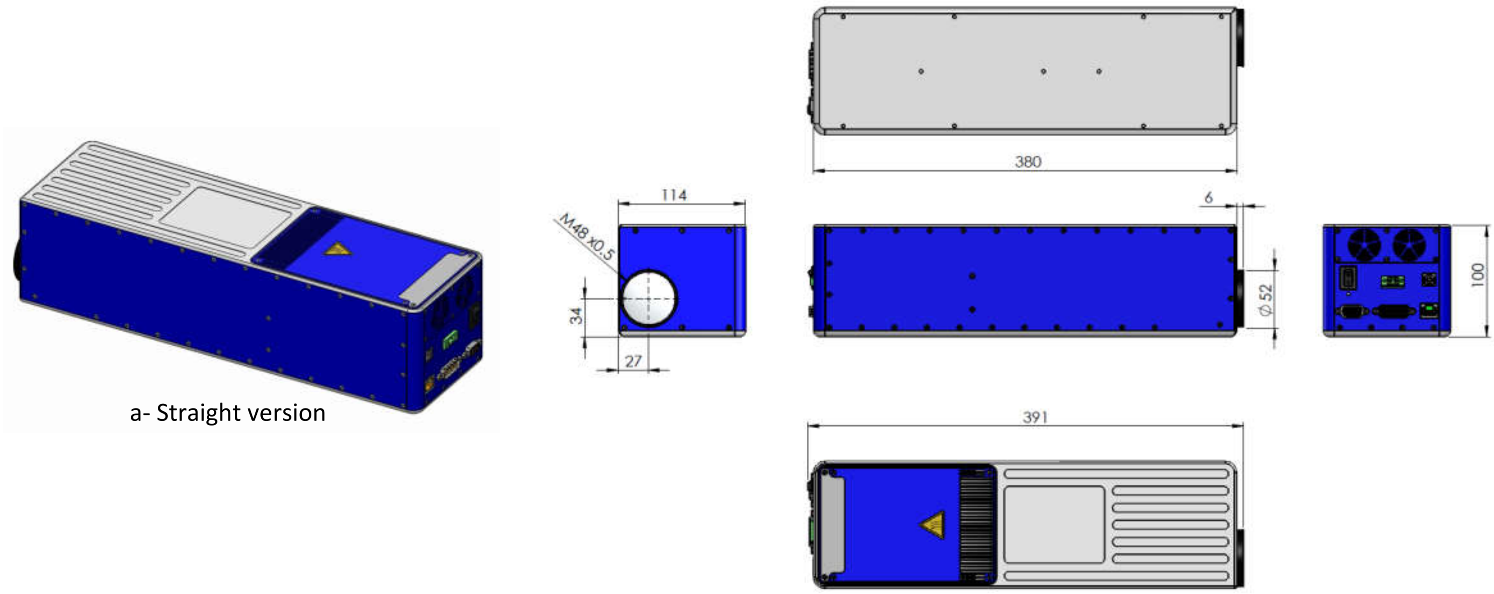
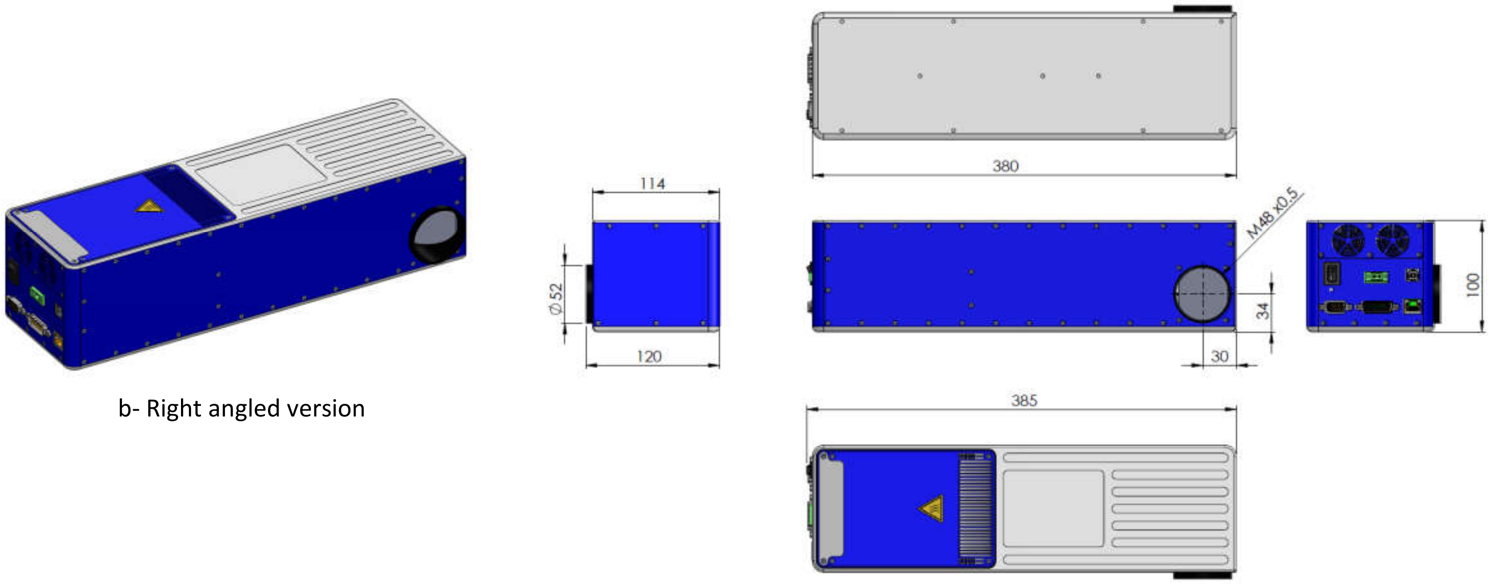


Fig 6-1: Optical Head Mechanical plans: a- CLS0.2 b- CLS1 c- CLS4 d- CLS2.3

6.2 CHRocodile CLS unit mechanical plans



a- Straight version



b- Right angled version

Fig 6-2: CHRocodile sensor unit mechanical plans: a- Straight version b- Right angled version

6.3 CHRocodile CLS unit mechanical interface plans

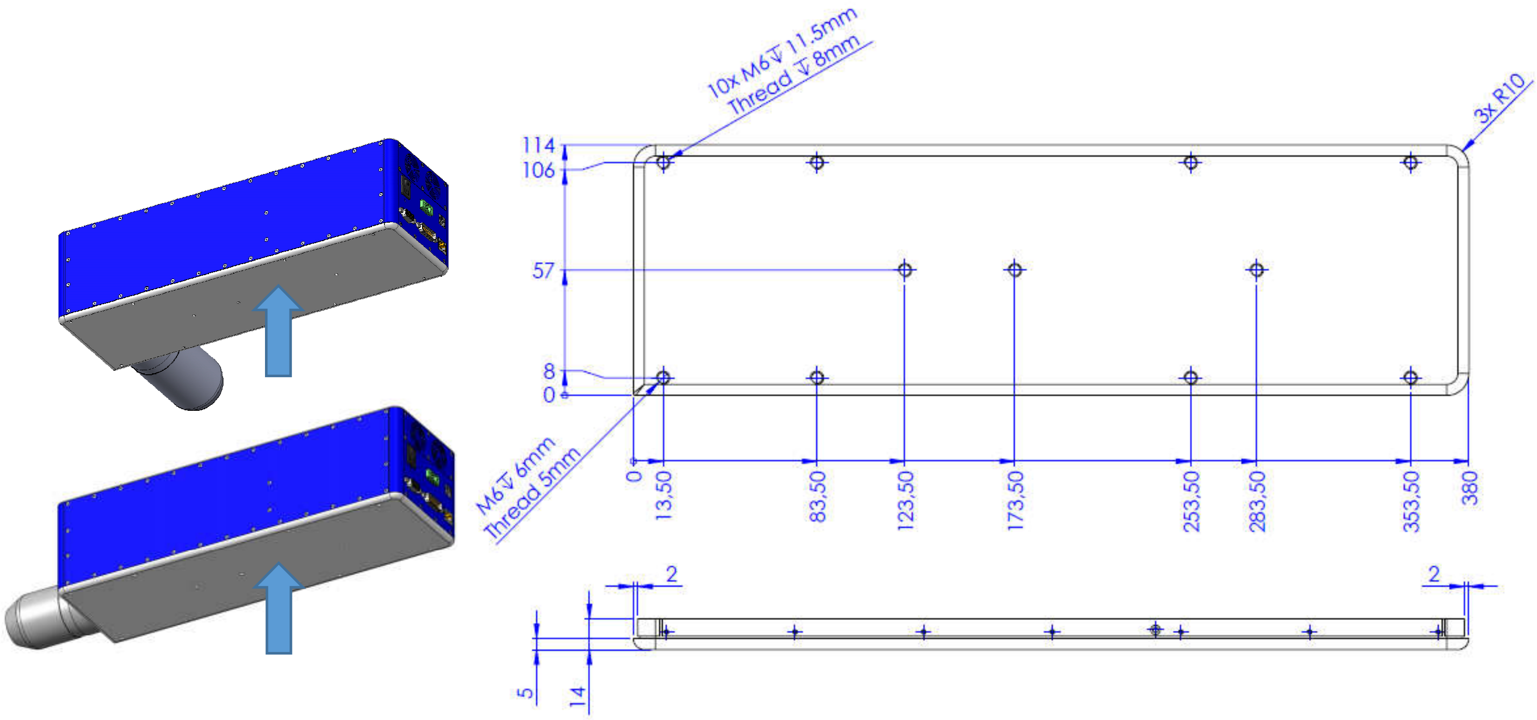


Fig 6-3: Line sensor mechanical interface: Soleplate

The two version of the CHRocodile CLS unit (straight version and right angled version) have a common soleplate. Consequently mechanical interfaces are the same for both versions.

Maintenance

7.1 How to change fans

The goal of this document is to explain how to change the heat sink's fans as a replacement. Inside the CHRocodile CLS, there are two fans which allow to dissipate heat induce by light source and electronic boards. In case of fans malfunctioning, temperature inside the CHRocodile unit will increase. A thermal switch has been integrated inside the line sensor unit. This thermal switch is a protection against high temperature which could damage the device, and it consists in power off the line sensor unit when too high temperature occurs. Therefore, when the line sensor CHRocodile turns off unexpectedly, check the fan operation.

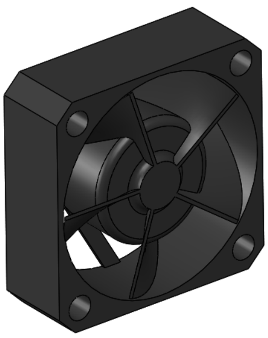


Fig 7-11: Fan: COPAL F310-12LB

Step by step procedure

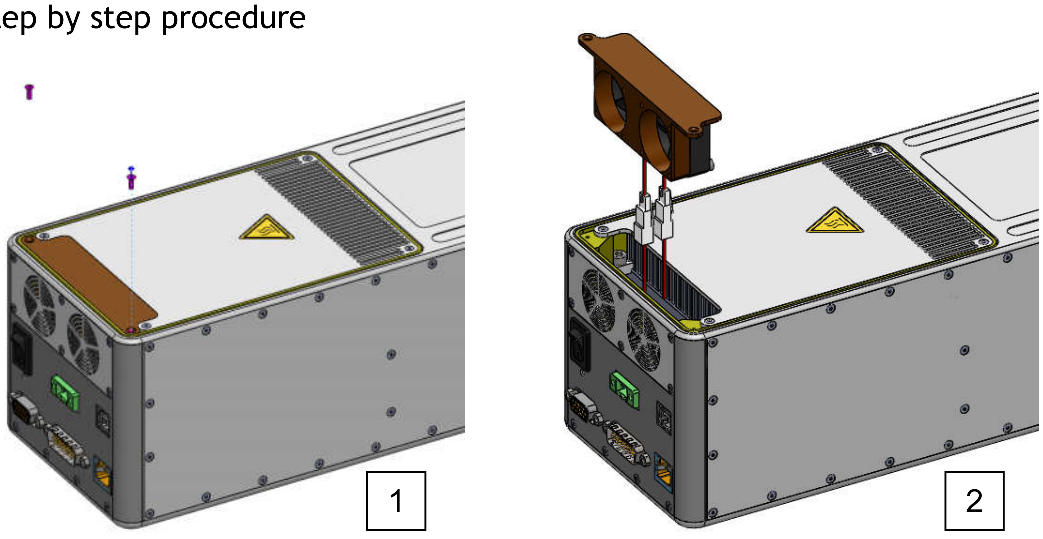


Fig 7-12: Steps 1 and 2

1. Remove the 2 FHC M2 screws on the top of the box on the fan side
2. Pull the fan support. You will see some wire connected.

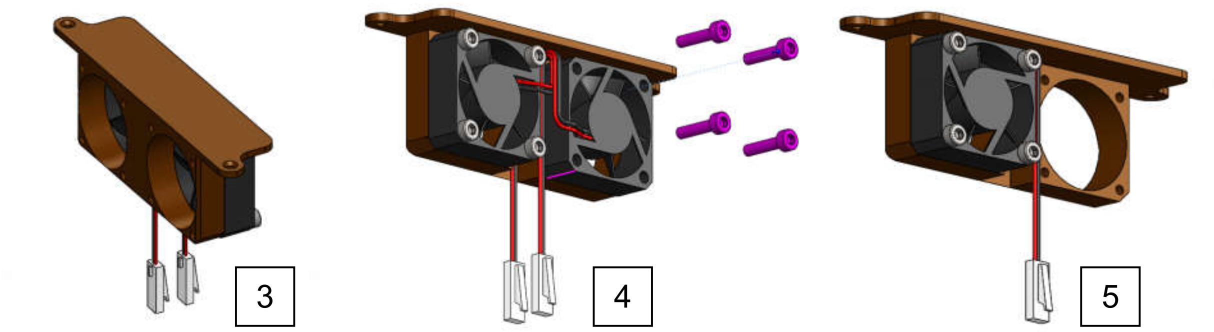


Fig 7-13: Steps 3 to 5

3. Disconnect the two fans for an easier access
4. Remove the 4 CHC screws of the fan you need to replace
5. Remove the fan to replace

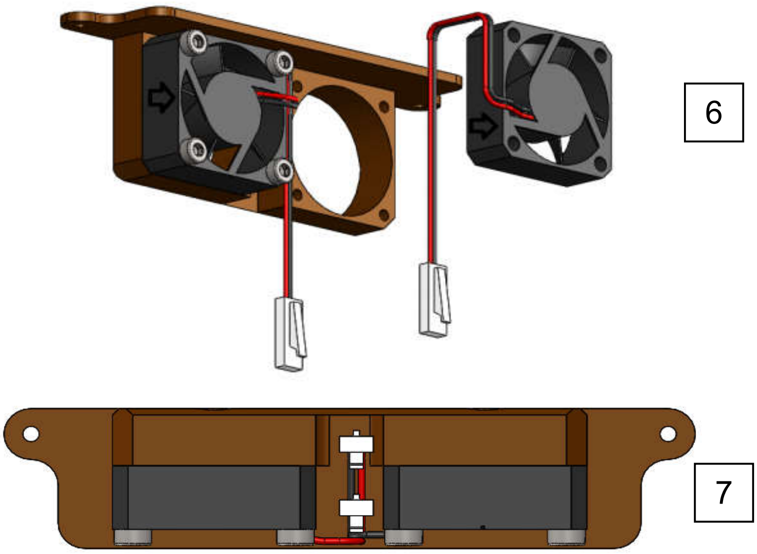


Fig 7-14: Steps 6 and 7

6. Repeat the steps in reverse with a new fan. The wire going out of the fan must be directed to the other fan. Watch out the arrow direction on the fan
7. Place the wires and connector in the space between the 2 fans (see the bottom view below)

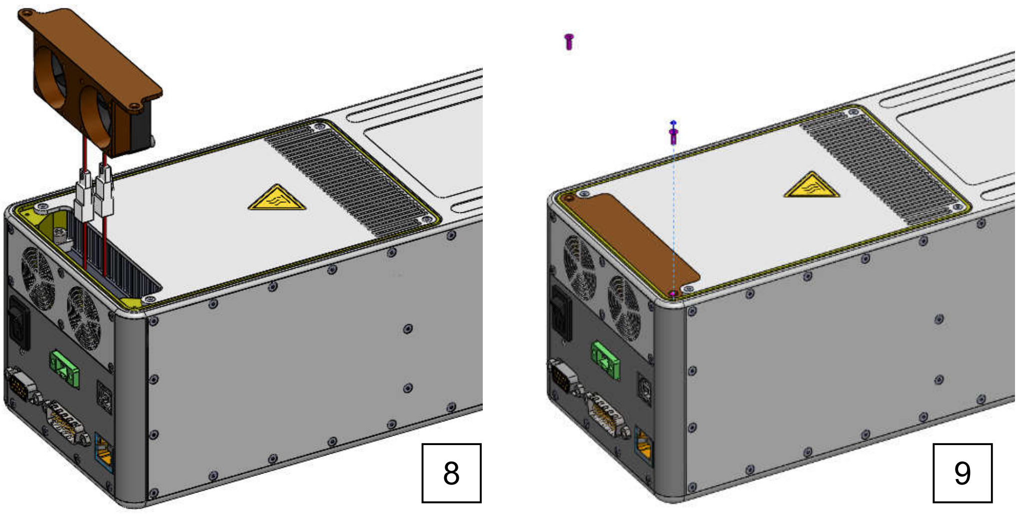


Fig 7-15: Steps 8 and 9

8. Connect back the fan wires to the body
9. Install back the fan support in the body. Check, and readjust the fan wire (if necessary), they still must be in the room between the 2 fans. Then fix the support with 2 FHC M2 screws. The fan replacement is done.

7.2 Optional accessories

7.2.1 Fans

It is recommended to buy the fan reference F310-12LB. You can ask to your CHRocodile CLS vendor to supply additional fans, or you can buy it directly to COPAL Company. In case of malfunctioning of a fan, a protection thermal switch power off the line sensor unit (in case of high temperature). Thus it is preferable to have fans in stock in order to proceed to a rapid replacement.

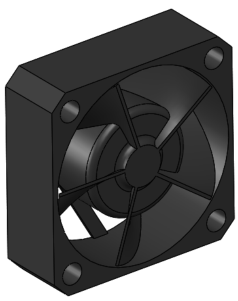


Fig. 2-9: Fan: COPAL F310-12LB

7.2.2 Cables

The following list of cables are available at your PRECITEC vendor site.

- Sub-D-15 cables (for trigger in/out)
- Sub-D26 cables (for encoders input)
- Ethernet cables (Use shielded cable)
- Power supply cables

Trouble Shooting

8.1 Power off:

The Status LEDs are off when the power supply cable is connected:

- Check the CHRocodile CLS Switch button is ON.
- Check the power cordon.

8.2 Communication error:

No possible Ethernet communication between CLS 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 CLS unit (Cf. $IPCN command in section 5.2.2).
- 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.

8.3 Distance Measurement:

Case 1: The target is positioned in front of the sensor, and no distance measurement is collected for all channels.

- Set the measuring frequency to minimum ($SHZ100 or equivalent .NET DLL function).
- Set the LED intensity to maximum ($LAI100 or equivalent .NET DLL function).
- Check if a white light line emitted from the optical head is focused on the target.
- Check if the target is inside the measuring range of the 192 channels (Cf. section 2.9.1).
- Check if the target surface is normal to the optical head axis. The maximum angle between target surface and optical axis is given by the maximum measurable slope (Cf. section 2.9.1).
- Check if the measuring mode is Distance mode.
- Check if the distance is transmitted ($SODX 16640 or equivalent function),

- Then, check and store the raw signal (this file could be demanded by PRECITEC technical support team). The raw signal should show a peak for channels which contribute to the measurement.

Case 2: The target is positioned in front of the sensor, and distance measurement is valid only for some channels:

- Set the measuring frequency to minimum ($SHZ100 or equivalent .NET DLL function).
- Set the LED intensity to maximum ($LAI100 or equivalent .NET DLL function).
- Check if the sample topography variations along the line are fitting with optical head measuring range; i.e. - Peak to Valley altitude variation should be less than measuring range - , - maximum local slope on target should be less than maximum measuring slope -, - target is not homogeneous and show high reflectivity variations along the line -
- Set a mirror in place of your target and store the raw signal for each channels (this file could be demanded by PRECITEC technical support team).

8.4 Thickness measurement:

Case 1: 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 ($SHZ100 or equivalent .NET DLL function).
- Set the LED intensity to maximum ($LAI100 or equivalent .NET DLL function).
- Check if a white light line emitted from the optical head is focused on the target.
- Check if the two surfaces of the target are inside the measuring range of the 192 channels (Cf. section 2.9.1).
- Check if the target surface is normal to the optical head axis. The maximum angle between target surface and optical axis is given by the maximum measurable slope (Cf. section 2.9.1).
- Check if the measuring mode is Thickness mode.
- Check if the Thickness is transmitted ($SODX 17152 or equivalent function),

- Then, check and store the raw signal (this file could be demanded by PRECITEC technical support team). The raw signal should show two peaks for channels which contribute to the measurement.

Case 2: The target is positioned in front of the sensor, and thickness measurement is valid only for some channels:

- Set the measuring frequency to minimum ($SHZ100 or equivalent .NET DLL function).
- Set the LED intensity to maximum ($LAI100 or equivalent .NET DLL function).
- Check if the sample thickness variations along the line are fitting with optical head measuring range; i.e. - Peak to Valley thickness variation should be inside minimal and maximal measuring thickness range -, - maximum local slope on both target surface should be less than maximum measuring slope -, - one or two target surface(s) are not homogeneous and show high reflectivity variations along the line -
- Set a mirror in place of your target and store the raw signal for each channels (this file could be demanded by PRECITEC technical support team).

If after reading the previous section you didn't succeed in resolving your problem, please contact your vendor for technical support. In order to help 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.

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