OPERATING INSTRUCTIONS

OC Sharp

SHORT RANGE DISTANCE SENSORS

SICK
Sensor Intelligence.

Described product OC Sharp

Manufacturer SICK AG

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Original document This document is an original document of SICK AG.

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1 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 SICK AG 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 Norms DIN EN 61326-1 (2013-07) and DIN EN 61010-1 (2011-07), compliant with the provisions of guidelines 2006/95/EG and 2004/108/EG. Its area of use is industry.

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 Electric 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 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)

1.7 Emergency Procedures

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

2 Product Description

2.1 General View

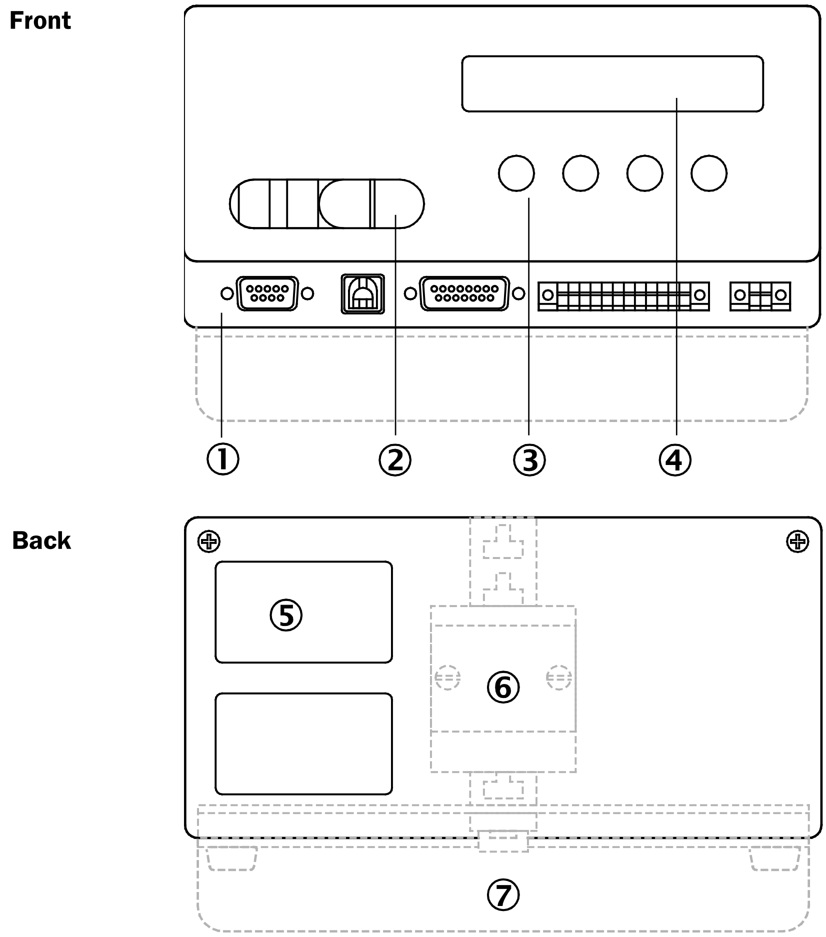


Fig. 2-1: Optical sensor, overall view

① Multi-point connector / connector block
② Sliding switch
③ Function button
④ LC-Display
⑤ Label for connector block
⑥ Wall mount bracket
⑦ Bracket guide

2.2 Connections, Interfaces

Front

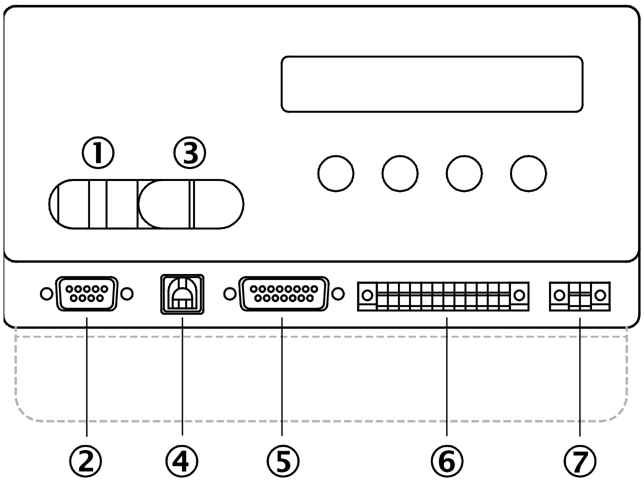


Fig. 2-2: Device connections, overview

① Connection port, fiber optic
② Serial interface RS232/RS422, Sub-D9-port
③ Port for external light source
④ USB port
⑤ Encoder-Input, Sub-D15-connector
⑥ Multi-point connector interface
⑦ Jack for main power supply via external power supply unit

2.3 Sensor Characteristics

Based on the measurement procedures in use, the optical sensor provides the following advantages:

- Sampling rate: up to 4 kHz
- Excellent signal-to-noise ratio and a wide dynamic range. That means on surfaces with rapidly changing reflectance properties can be reliably measured with the same sampling rate.
- The object being measured can reflect either dispersively or specularly, absorb or even be transparent. The color of the surface is irrelevant.
- Low maintenance due to long-lasting LED light source.
- Automatic lighting control.
- The sensor can process up to 3 encoder signals.
- The sensor offers multiple trigger options.
- It has 2 analog outputs with 16 Bit resolution.
- Data output both via USB and serial interface port. (USB port is not recommended to use in industrial environment as a process data line, as there is a higher risk of communication disturbances caused by EMC.)
- The probe is completely passive. It contains no electronic or moving parts. This guarantees a high measurement rate for this optical sensor. The probe is very robust and can even be used in difficult environmental conditions.
- The only connection between the probe and the sensor unit consists of an optical fiber which can have different lengths up to 50m. The probe and sensor unit can thus be operated at a distance from each other.
- The high numeric aperture of the probes makes it possible to take distance measurements on reflective surfaces, even if these are significantly tilted.
- The optical sensor makes coaxial measurement possible. Shadows cast by interfering edges, such as in triangulation measurement procedures, do not occur.
- Cap rail mount.

2.3.1 Description of Function

The optical sensor has three different modes of operation:

Mode 1

Chromatic Distance Measurement
Distance measurement is performed in Mode 1 (confocal distance measurement). In this process, white light is focused on the surface of the measurement object using an optic with a pronounced chromatic aberration. The reflected light is maximized for the wavelength in focus on the surface. The spectrum of the reflected light shows a pronounced peak whose spectral position determines the distance to the surface. See Figure.

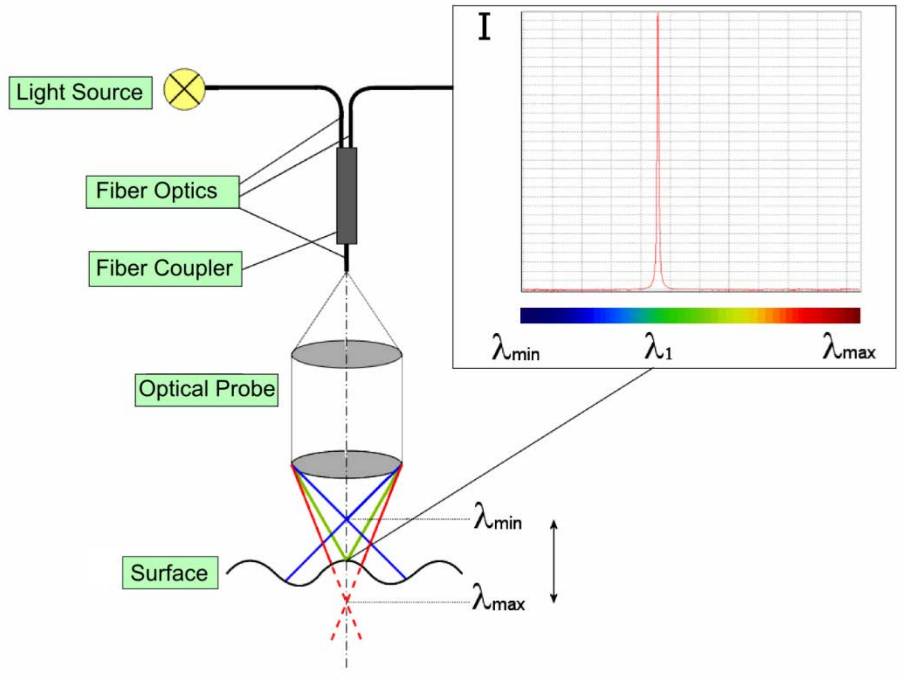


Fig. 2-3: Chromatic measurement principle, distance measurement

Mode 2

Chromatic Thickness measurement
If a transparent material is within the measurement area, two peaks appear in the spectrum of reflected light, whereby each in the reflection is attributable to one of the boundary surfaces on the layer. One can determine the layer density from the spectral distance and the refraction index of the layer material in Mode 2 (confocal thickness measurement).

Confocal thickness measurement (Mode 2) requires a minimum layer density that depends on the type of probe is used, so that the two peaks in the spectrum can still be clearly differentiated from each other (see *Fig. 2-*, page *14*).

Distance and thickness measurements in Modes 1 and 2 are performed using the same type of probe.

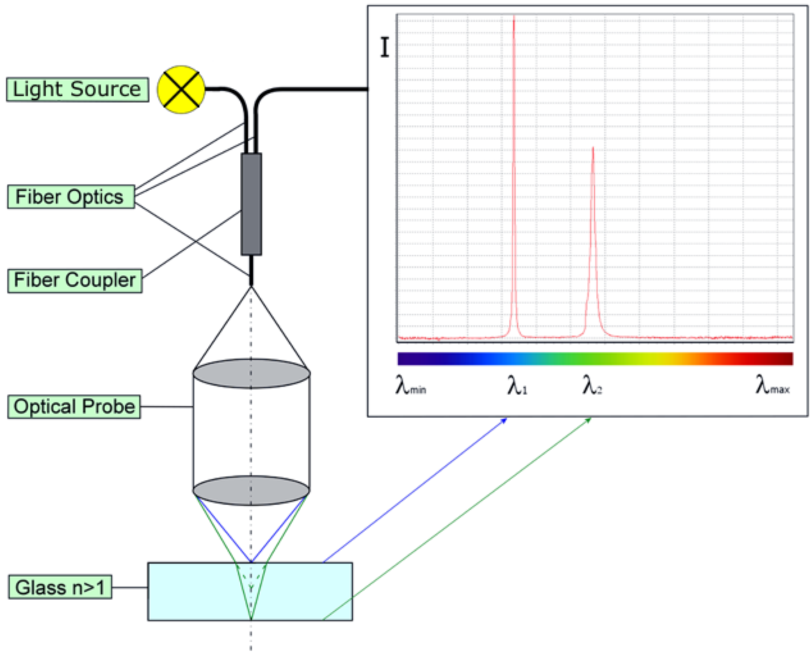


Fig. 2-4: Chromatic measurement principle, thickness measurement

Mode 3

Interferometric Thickness Measurement
This mode can be used only with the specific probe for interferometric measurement. In this mode the measurement of thinner layers (3 – 180 µm optical thickness). An achromatic probe is required for these measurements. This thickness measurement is based on the overlapping of the light reflected from both layers. If the refractive index of the material is known, the thickness can be calculated from the spectrum of the reflected light.

Mode 3 can be unlocked for 5 minutes for testing purposes.

To do this, select Mode 3 under Config > and then enter the password: 0000000001.
You will see the message "*eval. of interf. mode CHR will stop in 5 min*."

You can order the unlock key for Mode 3 from SICK at any time, if it is not included in the items delivered.

Applications

The probe is used for a broad spectrum of different tasks. Typical examples are:

- Measurement of surface topographies
- Thickness measurement of transparent layers
- Roughness measurement
- Verification of optical components
- Measuring films or coatings
- Checking dimensioning on the smallest components and microstructures.

2.3.2 Construction

The optical sensor consists of a probe and a sensor unit. Both components are connected via an optical fiber. Various probes can be used interchangeably on the sensor unit, and only one probe can be attached at a time. By changing the probe, you have the option of covering different measurement ranges in distance or topographic measurement, or switching between topographic and thickness measurement.

The device can be used as a table top device with a pedestal or *optionally,* it can be used mounted on a cap rail.

Sensor Unit

The sensor unit contains the LED-light source as well as the electronic and optic components for evaluating the measured signals.
In the future, it will be possible to attach an external light source as well.

The four function buttons for the LCD are located on the front plate.

The sensor unit can be completely configured with these four function buttons **[F1]** ... **[F4]** (see Chap. *5.3* starting on page *44*).
The two-line display shows both the numeric values as well as a bar diagram. In distance mode, the measured distance and the intensity of the light reflected from the surface are evaluated and displayed. In thickness mode, one sees both the measured thickness and the intensity of the reflections from both of the coating's boundary layers.

There is also a plate-slide on the front plate, behind which the fiber port for connecting the probe is located. There is also another port for an external light source.

All of the connection ports for the sensor unit are located beneath the front plate:

- the connection ports for the serial interfaces RS-232/RS-422 and USB
- the connection for the encoder
- the interface port for synchronization with external devices and
- the power supply jack.

Stand-alone

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

Measurement Systems

The device can be integrated into complex measurement systems via the serial ports (RS-232/RS-422, USB), the analog outputs and the trigger input.

The incremental encoder-input makes it possible to precisely assign measurement points and axis positions without additional hardware. New trigger options make the lighting cycle externally controllable. This means that external triggering is possible for every measurement up to the full measurement rate of 4000Hz.

If the probe is mounted on a linear axis, the profile of a surface or the gradient of the thickness of a layer along the [measurement] route can be measured. An **XY**-cross table with two linear axes makes it possible to measure the topography or the thickness of the surface.

Measuring the topography of surfaces with height variations that exceed the measurement range of the probe requires an **XYZ**-table, in which the distance of the probe from the surface can be adjusted during measurement.

Probe and Optical Fiber

Fig. 2-5: Probes and optical fiber

Probe

The user has a complete range of different probes at his disposal, depending on need. The size of the particular probe varies with its measurement range. The probe contains no moving components or electronic components that could acts a heat sources and thereby influence the precision and stability of the measurements.

Along with the standard probes, other probes with specially adapted properties can be provided for certain applications, e.g. angled or higher numerical aperture probes that enable measurement of surfaces with even more pronounced inclines.

- You can find an overview of standard probes in Chap. *Accessories* starting on page *22*.

Optical Fiber

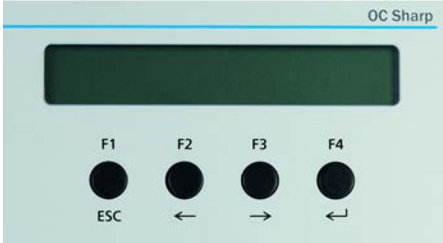
Optical fiber is sensitive to mechanical wear and must be handled carefully.

To that end, the following must be strictly observed when handling the optic fiber:

- the fiber has a minimum bend radius of 30 mm
- the ends of the fiber are polarized and must not be touched by hand
- during transport, the protective caps provided in shipping must be put on the ends of the fibers and the pin sockets on the device.

When the end surfaces of the fibers get dirty, they must be carefully cleaned with a lint-free cloth, using ethanol if necessary (see Chap. *7.1*, starting on page *87*).

2.3.3 Control Elements and their Function



Call Up Main Menu / Cancel Function

Using the function button **[F1]**, you can call up the main menu or cancel the currently executed function at any time. The device will then automatically switch back to the next higher menu level or close the main menu.

You can find extensive information on calling up the main menu and on its structure in Chap.*5* "Configuration" starting on page *38*.

Display Software Version
Hold down **[F1]** during start-up.

Select Function

Using the function buttons **[F2]** / **[F3]**, you can select from the menu points shown in the menu window. In number-input mode, the blinking digit is increased/decreased incrementally by pushing **[F2]** / **[F3]**.

Confirm Function / Execute

Using the function button **[F4]**, you can accept an entry or switch to the next subordinate menu level.

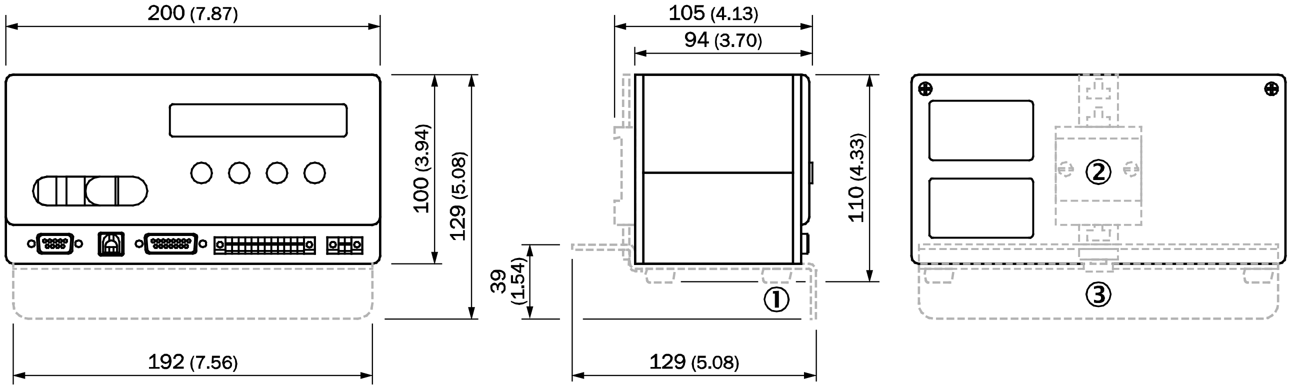
2.4 Technical Data

Optical sensor	
Measuring principle	**Chromatic, interferometric**
Measuring data	Distance, Thickness
Measuring rate	32 – 4000 Hz
Measuring range	Chromatic: according to probe interferometric: 3-180 µm (optical path length)
Pitch error *[1)]	< ± 0,001
Linearity Deviation	0.033 % of the measurement range
Resolution	0.003 % of the measurement range (15 bit); optional 0.00001 % (23bit)
Reproducibility	0.009 % of the measurement range
Synchronization with ext. devices	Trigger-input, 3 Encoder-inputs, Synchronization outputs
Interfaces	USB, RS-232, RS-422 and Analog (16 Bit)
Transferrate	RS- 232 (9600 – 921600 Baud); RS-422 (9600 – 921600 Baud); USB: virtual comport (921600 Baud)
Light source	LED / external light source
Operating temperature	+5 °C to +50 °C
Dimensions (sensor unit)	200 x 100 x 93 mm (B x H x T)
Weight	1,1 kg
Optical fibers	2 – 40 m, optional metal covered up to 15 m
Power supply	15 – 32 V with separate mains supply unit 90 – 264 V
Measurement output	10 W
Number of measuring channels	1
Storage temperature	-25 °C to +55 °C
Relative humidity	5% to 80% (not condensing)
Enclosure rating	IP 40 (DIN 40050/ IEC 144)
Protection class	III

Tab. 2-1: Technical data

[1)] Measuring accuracy **=** linearity deviation **+** pitch error **x** used measuring range

2.4.1 Dimensional drawing



All dimensions in mm (inch)

2.5 Accessories

2.5.1 Optical Fiber

The optical fibers are available in various configurations. Special configurations (e.g. special lengths or special casings) can be requested from SICK.

2.5.2 Optical Probes

The high numerical aperture and small measuring spot diameter are ideal for a great number of metrological applications, mechanical dimensions.

Chromatic probes used for distance and thickness measurements encompass a measurement range from a few hundred micrometers to several millimeters, so that a suitable probe is available for every application.

The upper and lower halves of some of the probes have different diameters. Please note that the probe is always mounted on the underside (light-emission side with the larger diameter).
A mounting bracket on the side of fiber optic connection can cause damage.

Never screw the two halves against each other!

2.5.2.1 Chromatic Probes

Sensor OC Sharp
Application Distance and thickness
Measuring principle Chromatic confocal

Footnote
1) bottom of probe to middle of measuring range
2) decreasing accuracy on the limits
3) refractive index n = 1.5

Measuring range	600 µm	3 mm	12 mm
Working distance[1], ca.	6,5 mm	22,5 mm	54 mm
Spot diameter	4 µm	12 µm	30 µm
Lateral resolution	2 µm	6 µm	15 µm
Numerical aperture	0,5	0,5	0,27
Measurement angle to surface[2]	90°+/-30°	90°+/-30°	90°+/-15°
Thickness measuring range[3]	to 900 µm	to 4,5 mm	to 18 mm
Dimensions (LxD mm)	125 x 19	105,8 x 49	l = 61,1 mm d = 36 mm
Weight	71 g	501 g	281 g
Order number	6053131	6053132	6053133

Tab. 2-2: Chromatic probes, technical data

A = fiber connector **B** = average working distance

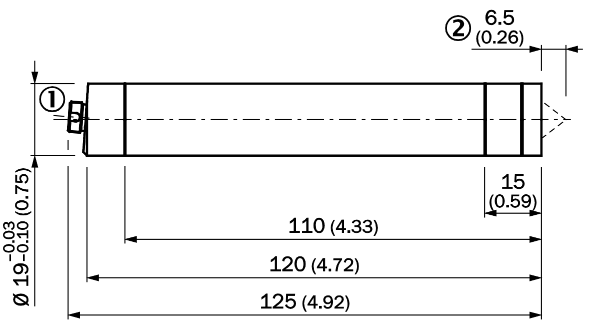


Fig. 2-6: 600 µm Probe

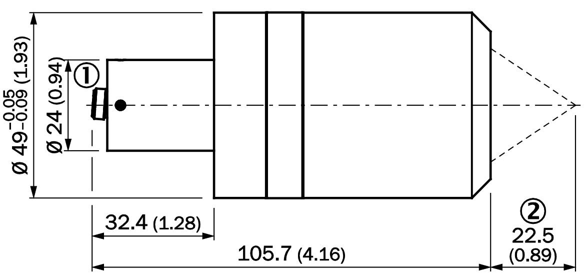


Fig. 2-7: 3 mm Probe

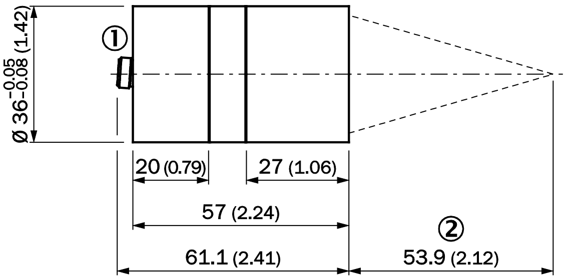


Fig. 2-8: 12 mm Probe

2.5.2.2 Interferometric Probes

Interferometric probes impress with their compact construction and provide thickness measurement s on thin, transparent films or coatings from 3 µm – 180 µm (optical distance).

Sensor OC Sharp
Application Thickness measurement
Measuring principle Interferometric

Footnote
[1] bottom of probe to middle of measuring range
[2] decreasing accuracy on the limits

Measuring range	**3 – 180 µm** [1]
Working distance[1]**, ca.**	27 mm
Spot diameter	40 µm
Lateral resolution	20 µm
Numerical aperture	0,09
Measurement angle to surface[2]	90°+/-5°
Thickness measuring range	depends on the used OC Sharp
Dimensions (LxD mm)	53,6 x 15
Weight	21 g
Order number	6053134

1) For refrective index n=1

Tab. 2-3: Interferometric probes, technical data

A = fiber connector **B** = average working distance

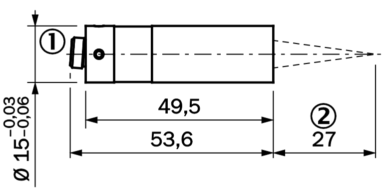


Fig. 2-9: Interferometric Probe 3–180 µm, 40 µm Spot

3 Operational Start Up

3.1 Overview of Operational Start Up

WARNING

Moisture accumulation in device!
Moisture accumulates on and inside the device during extreme temperature variations, whenever it is brought out of a cold room into a warm one. Do not put the device into service until the moisture has evaporated and the cold device has warmed up to room temperature. Depending on the room temperature and the ambient humidity, this can take up to three hours.

Operational start-up of the device can proceed as follows:

1. Connect the probe and the sensor unit to each other with the optical fiber

- **Fiber connection to the probe**: Carefully remove the protective caps on the ends of the fibers, insert them into the fiber optic ports on the probe and hand-tighten them.
  When inserting the ends of the fiber lines into the ports, make sure that the pin engages in the matching nut in the port.
- **Fiber connection to sensor:** The fiber ends of the E2000 plug system have no protective caps and are directly inserted into the matching ports on the device until the locking mechanism catches. When removing, press the clip down and carefully pull the fiber out.

2. Connect device with separate mains adapter

After connecting with the power supply, proceed with initializing. Informational displays (version number of the internal software) will appear on the display for a few seconds.

Before beginning a measurement, you should check the device's settings and reconfigure them if needed. For example:

- Mode
- Measurement Rate
- Averaging, etc.
  (see Chap. *5.3*, Configure Device [Config], page *47*).

3.2 USB Driver Installation

USB Driver Installation

Driver installation must be completed before data transfer from the sensor can be done via the USB port.

Driver installation has to be completed for each OC Sharp.

Driver installation for the USB-interface is described in the following. The Baud rate for this process is set at 921600 Baud:

After activating the sensor and the computer with the appropriate driver-installation CD, the hardware assistant will start automatically with the following window. Select according to the following pictures:

Depending on sensor and operating system version, the windows can be displayed differently.

Installing USB Device Driver

This procedure must be repeated twice.

Fig. 3-1: Driver installation, start window

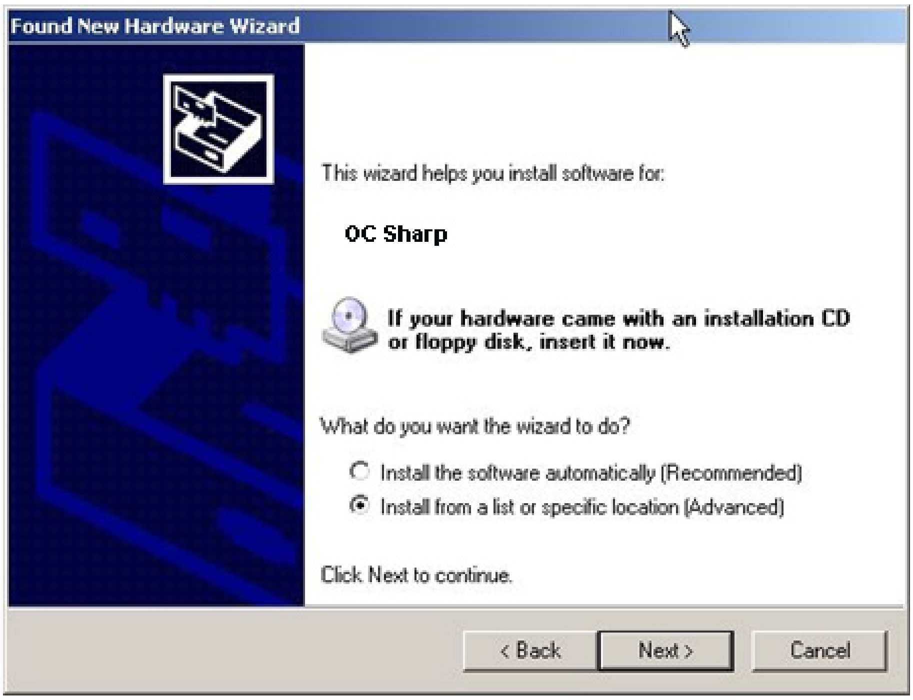


Fig. 3-2: *Driver installation*

Set the pathway to the driver location.

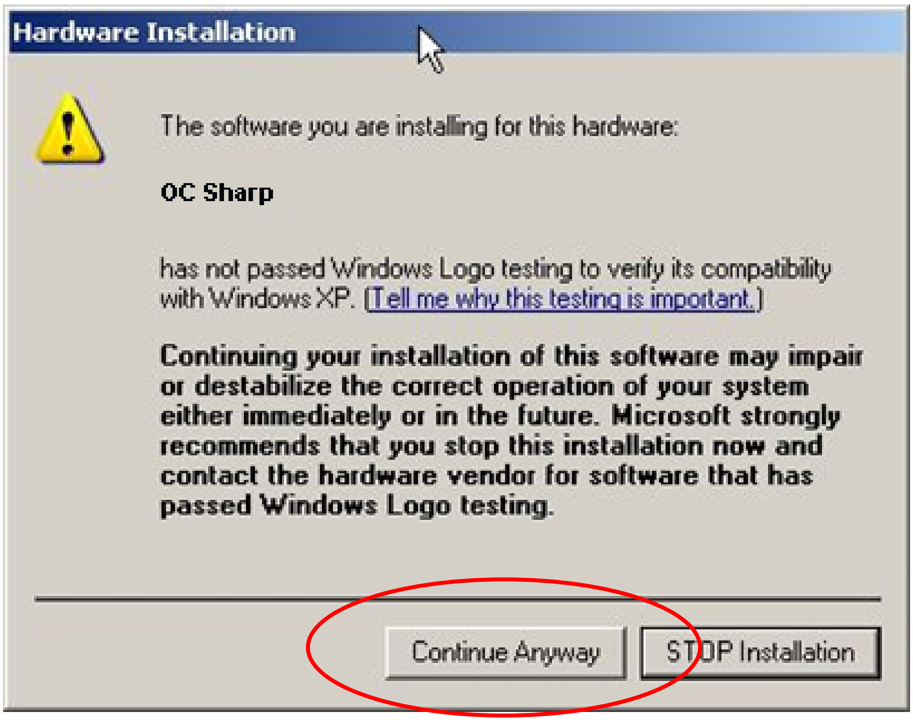


Fig. 3-3: *Driver installation ready*

After the installation is complete, confirm the command to complete the process.

Install the driver for the virtual com-port.

Fig. 3-4: Driver installation, second round; start window

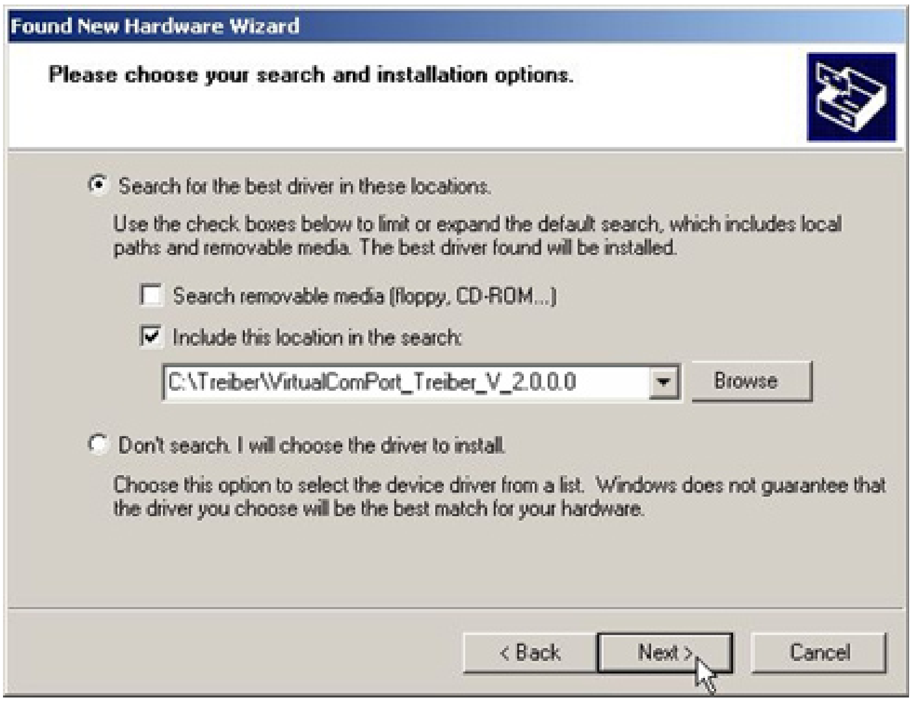


Fig. 3-5: Driver installation, second round; pathway

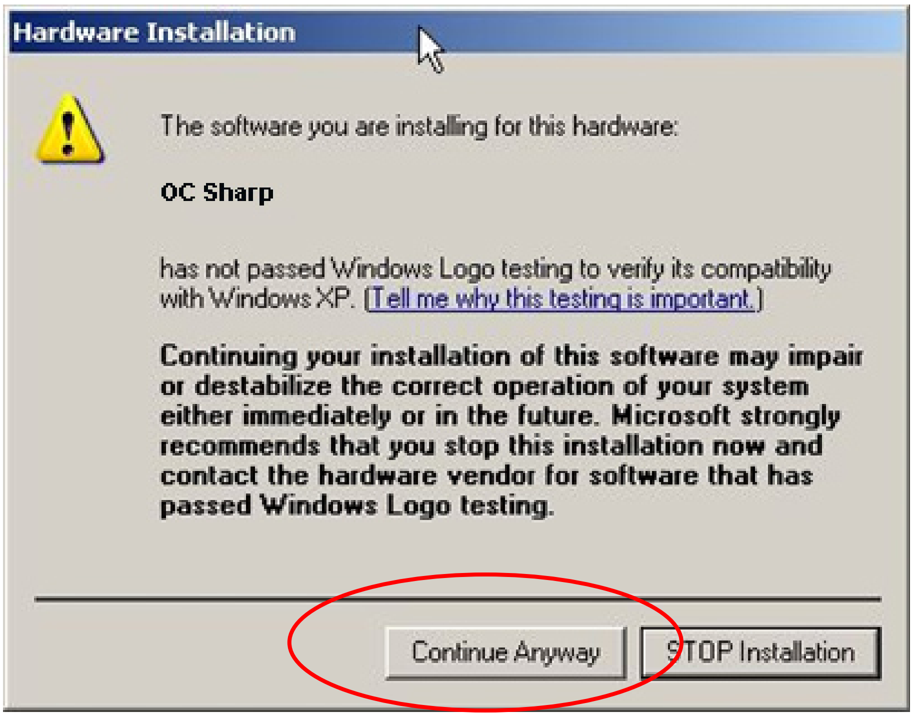


Fig. 3-6: *Driver installation; installment*

Fig. 3-7: *Driver installation completed*

Setting the COM port

Enter the COM-Port in use in the user program.
Enter this under system properties in the device manager (settings/ control panel/system/ system properties).

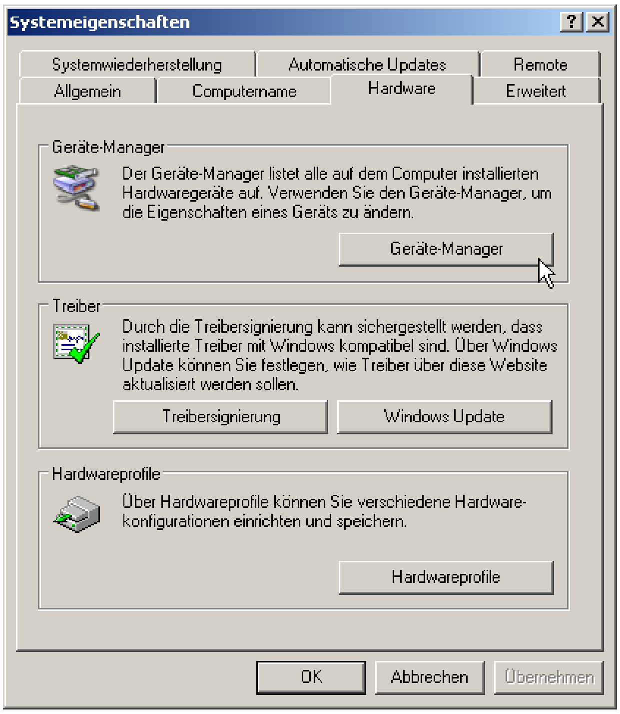


Fig. 3-8: System settings; device manager

In Device Manager, all system properties can be found.

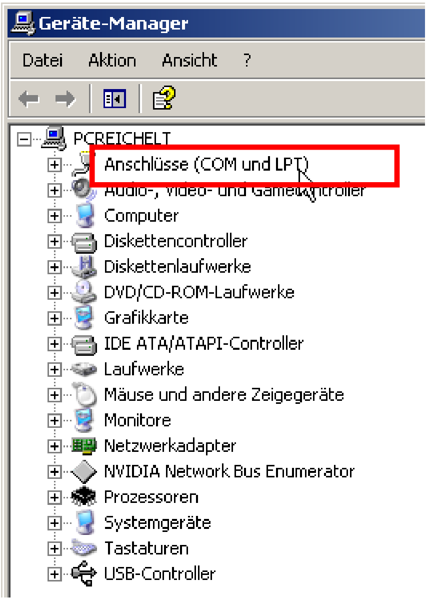


Fig. 3-9: Device Manager – overview

A double click on connections (COM and LPT) will bring up a display of the COM-port and sensor currently in use.

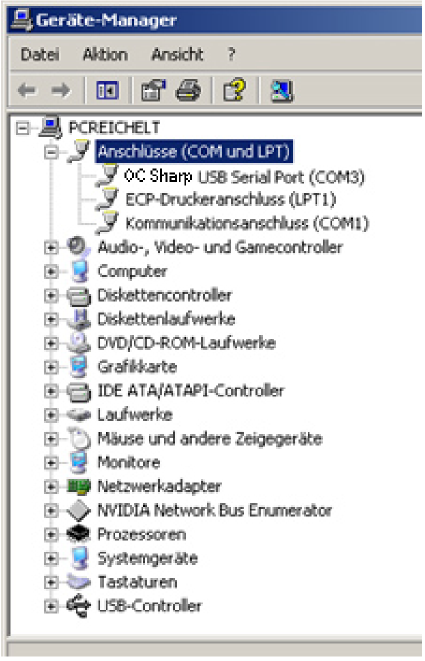


Fig. 3-10: Device Manager – COM-Interface

Here, the COM-port used for the sensor is number 03. This designation is to be entered, if necessary, in the user software with the Baud rate to be used

The current version of the driver can be downloaded from the SICK Homepage.

4 Performing Measurements

In this section we will describe (with respect to the practical aspects) how to perform measurements of thickness or distance after the device has been put into service (see Chap. *3.1* on page *25*)
Point measurements at a specific location are described.

For profile or topographic measurements, the probe with the corresponding sensor equipment (e.g. NEMESIS 3D-measurement system) is moved across the surface so that the topography and thickness over a particular area can be compiled from the sequence of individually recorded measurements.

Procedure

After operational start-up (see Chap. *3.1* on page *25*), the configuration of the optical sensor has to be set to correspond to the measuring task. You can find the setting for the matching parameters in Chap. *5.3* starting on page *44*.

Depending on which unit is being measured (distance or thickness), we recommend a warm-up time of 10 minutes and the following steps after activating the device:

1. Perform darkness compensation.
See Chap *5.1* "Perform Dark Reference " on page *40*.

2. Show measurement rate, adjust if needed.
See Chap.*5.2.1* "set measurement rate [S.Rate]" starting on page *41*.

3. Select Mode.
See Chap. *5.3* "Select Measuring Mode" starting on page *53*.

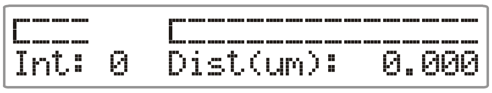
4. Check configuration if necessary, adjust if needed (e.g. probe, etc.).
See Chap. *5.3* "Configure Device [Config]" starting on page *44*.

You will find extensive information about the corresponding measurements for thickness given in the following Chapter *4.1*.

4.1 Chromatic Distance Measurement

Mode 1
(mode 0)

If the device is set for Mode 1 (**confocal, 1 surface**), this display will appear after the device is activated.

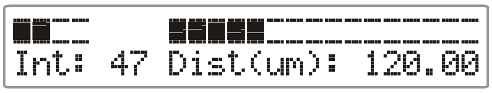


No surface is located in the sensor's operational range. No light is being reflected, the intensity is "0" and no distance is being measured.

In order to measure a distance, a surface must be brought into the probe's measurement range. Use a highly reflective surface (e.g. a coin) for the first test measurement.

The small measurement range of the 300 µm-probe requires either a very steady hand or a positioning device with fine adjustment capability in the Z-axis (height/vertical), into which the probe will be inserted.

As soon as the probe's distance to a surface is set so that the surface lies within the measurement range, the display will change as seen below.



Intensity

The left bar diagram shows the intensity of the measurement signal in a logarithmic scale. Beneath it the intensity is shown in relative units as a numeric value between 0 and 999.

Distance

The right bar diagram shows in current measurement value in a linear scale. The measured distance is given as a number in µm beneath the bar diagram.

Measurement Range

The distance to the surface within the measurement range here is 120 µm. As the probe gets closer, the distance shown in µm will get smaller. When the object whose surface is being measured is moved, variation will be observed in the distance reading on the display (**only** in the measurement range).

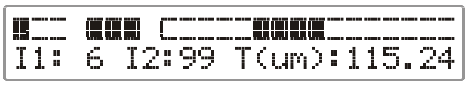
If the distance to a poorly reflecting surface is being measured, the intensity of the reflected light can be low. In this case, the measurement rate must be decreased (see Chap. 5 starting on page *41*). Conversely, overmodulation of the sensor (intensity reading: 999, blinking) can cause measurement errors.
If overmodulation occurs, a higher measurement rate needs to be selected. To this end, observe the instructions for the threshold intensity (see Chap. *5.3* starting on page *44*).

4.2 Chromatic Thickness Measurement

Mode 2
(mode 1)

In Mode 2 (thickness) the thickness of a transparent material can be measured if both boundary layers of this film are in the probe's measurement range.

If the device is set for Mode 2 (**confocal, 2 surfaces**), the following display appears after the device is activated.



This display indicates that a transparent layer of 115.24 µm thickness is within the probe's measurement range.

If the layer is located in the lower half of the available measurement range, the bar whose thickness represents the thickness is left of the center of the bar display.

Intensity

If a transparent material (e.g. wall thickness of glass) is measured, the intensity of the reflected light off the upper boundary is as a rule lower than that of the second surface or lower boundary.

If however one measures the thickness of a layer of paint or lacquer on a polished sheet of metal, then the intensity of the reflection from the upper boundary will be small, and that of the lower boundary higher.

Thickness

In chromatic thickness measurement mode, the display shows the measured thickness in µm.

In general, the refractive index of transparent materials is not a constant in the range of visible wavelengths. Its range however can be adequately approximated for technical applications by indicating an average refractive index n_d and possibly the Abbe number v_d. This can be done using the sensor, see Chapter *5.3.8*, starting on page *53* . Along with the dispersive characteristics of the material, the geometric characteristics of a transparent material, such as the curvature of the upper boundary when measuring lenses, will play a role in the precision of the measurement. This geometric correction together with a dispersion correction can be run through a computer using special software via interface after the data has been read. This process then allows us to achieve the most precise possible measurements of the absolute thickness of transparent materials.

The software can be ordered from SICK.

Material / **Property**	**Polymethyl-methacrylate** PMMA	**Polycarbonate** PC	**Cycloolefin-Polymer** COP	**Cycloolefin-Copolymer** COC	**Glass** BK7
Trade Name	*Plexiglas*	*Makrolon*	*Zeonex*	*Topas*	--
Refractive Index [n_d]	1.49	1.59	1.53	1.53	1.52
Abbe Number [ν_d]	61	34	56	58	64
Density [g/cm^3]	1.2	1.2	1.01	1.02	2.5

Tab. 4-1: Example, Abbe numbers (plastic, optical glass)

You can find an interactive Abbe diagram for engineering glasses on the internet: www.schott.com/advanced_optics/english/community/technical-papers-and-tools/Abbe-diagramm.html#

As long as a refractive index of n = 1 (**refractive index**, default value) is set, the refractive index of the light on entry into the material that you're measuring is not taken into account and the value displayed will be smaller than the actual thickness of the measured object. The value of the thickness can be determined through multiplying it after the fact by the specific refraction (n) index of the measured object.

Please note that the refraction index you input **only** affects the indicator on the display but **not** the output value from the interface.

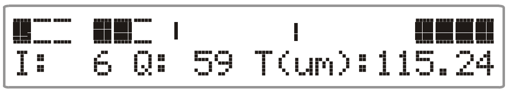
The dispersion correction via the Abbe number will however be retained.

In the case of chromatic thickness measurement in Mode 2, please note that the intensity of the reflected light can be too low when measuring a surface with low reflectivity. In this case the measurement rate needs to be reduced. Conversely, you must also avoid measurement errors owing to overmodulation of the sensor in measurements of highly reflected surfaces. When overmodulation occurs, you need to increase the measurement rate. Please observe all of the instructions in the section on setting measurement rates (see *Chap. 5* starting on page *41*) as well as the instruction for threshold intensity (see *Chap. 5.3* starting on page *44*).

4.3 Interferometric Thickness Measurement

Mode 3
(mode 2)

If the device is set to Mode 3 (**interfer. thickness**), then this display will appear after the device is activated:



Display

Both the numeric value and the bar diagram will appear on the display:

- **I:** the intensity of the reflected light
- **Q:** the quality of the strongest measured signal (see Chap. *5.3.6* starting on page *51*) and
- **T(µm):** the thickness of the layer matching the strongest measured signal.

Measures up to 3 different thicknesses simultaneously, whereby the optical thickness of these layers must differentiate from each other by at least 2.5 µm.

Material Thickness

However, the geometric material thickness will only be displayed if the specific refractive index of the measured object was set when the Mode was selected (see Chap.*5.3*, Page *44* Section "Mode 3"). If the measurement is executed with n=1, then measured values must then be divided by n.

Please note that the refractive index you input **only** affects the indicator on the display but **not** the output value from the interface.

The dispersion correction via the Abbe number will however be retained.

In the display line shown above, a vertical dash is shown which moves to the right with increasing thickness.

If one or more transparent films or coats are in the active measurement range, then up to three vertical dashes will appear, and their length will be proportional to the quality of the specific measurement signal.

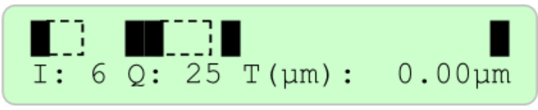
Restrictions to the Measurement Range

By restricting the active measurement range, it is possible to show a measurement other than that which has the best quality (see Chap. *5.3.6*, starting on page *51*) on the display. To this end, the measurement range is restricted so that the measurement of best quality does not always lie within certain limits.

The quality value for interferometric thickness measurements must be at least 25.

Measurement range

By pushing **[F4]** twice, the measurement range restriction can be activated and deactivated in interferometric measurement mode. When the measurement range restriction is active, the restriction on the measurement range is shown in the display by a thick bar.



If the restriction is not active, the range limits are shown by lines.

F2 / F3

Using **[F2]** / **[F3]** either the lower or upper limit can be moved to the left or the right.

When setting the lower limit for the measurement range, e.g. "*Low Limit: 59.6 µm, active*" will be displayed.

This means that the measured value for layers thinner than 59.6 µm will not be displayed. The analogous applies to the upper limit.

F4 x F4

By pressing **[F4]** twice, you set which of the range limits can be moved, the lower or the upper limit.

Range limits can be moved both when the measurement range limitation is active or inactive.

Changes to the measurement range limitation are not automatically saved and are lost when the device is deactivated, if not permanently stored using the button sequence **[F1]** – **[F4]** – **[F1]** – **[F4]**.

Layer System

Interferometric measurement does not just make it possible to measure the thickness of a single transparent layer such as a film or coat, but also the thicknesses of a system of layers.

Multiple Layers

If a system of layers stacked on top of each other is being measured, the sensor measures 3 thicknesses; both of the individual layers and the total thickness.

Along with the necessary transparency of the layers to be measured, it is also important that the refractive index between the successive layers differs, so that an adequately intense degree of reflectivity occurs at the boundary layer (the greater the refractive index changes at a boundary layer, the more light is reflected).

Examples

The following examples can be taken into consideration as measurement objects for thickness measurement.

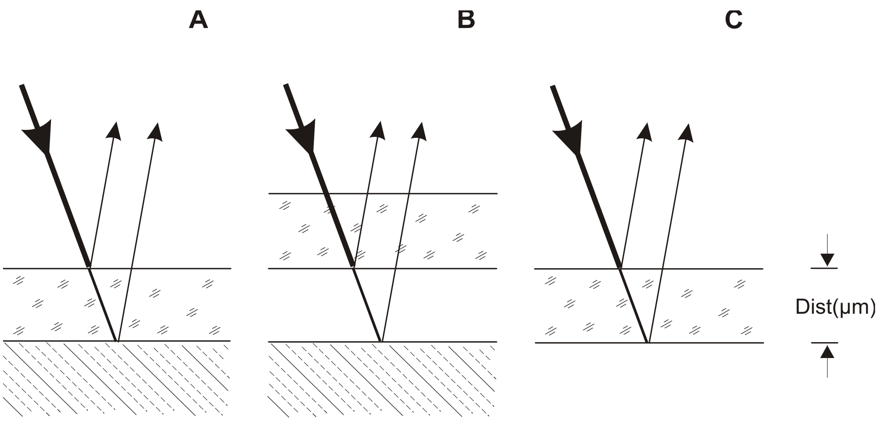


Fig. 4-1: Interferometric thickness measurement

A Transparent layer on a reflective substrate

B Air pocket between transparent layer and reflecting substrate

C Thin, transparent measurement object
The thickness can be determined from the spectrum of the reflected light and the refractive index of the material.

The measurement distance should be selected in such a way that the light emerging from the probe is focused on a single point on the measurement object, so that as much reflected light as possible is available for the measurement signal (see measurement rate, Chapter *5.2.1* starting on page *42*).

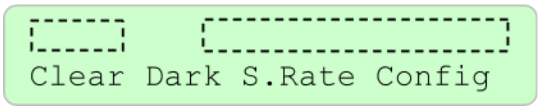
5 Configuration

Elements belonging to system configuration (device configuration) include, among others, selecting the measurement rate and the mode (measurement mode), configuration of the sensor parameters and interface parameters. Essentially, there are three options for configuring the device:

- using the function buttons **[F1]** … **[F4]**, on the control panel
- using the RS-232/RS-422-interface (see Chap. *6* on page *78*) and
- using the USB-interface (see Chap. *6* on page *78*).

In the following, configuration will be described with the assistance of the function buttons and recommendations will be given for properly setting the menus and their functions.

The main menu is called up with **[F1]**.



Each one of the functions displayed in this menu corresponds to one of the function buttons assigned to it on the control panel.

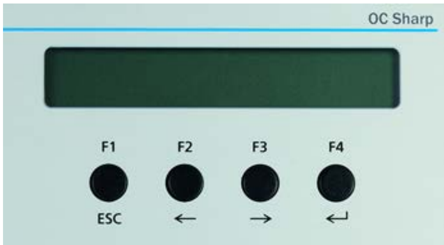


Fig. 5-1: Function buttons

Main Menu

The following menus are available for configuration:

[F1] Clear
closes the main menu

[F2] Dark
starts the darkness compensation for the sensor, to compensate for the influence of the dark signal (see Chap. *5.1* starting on page *40*)

[F3] S.Rate
"Measurement rate", parameter, at which the sensor records the distance or thickness (see Chap.*0* starting page *41*)

[F4] Config
Configuration menu: Sensor, interface and device parameter, service functions (see Chap. *5.3* starting on *44*).

5.1 Perform Dark Reference

Even when there is no surface in the probe's measurement range, the signal in the CCD-line of the sensor is not zero. This dark signal, which can be traced back to dispersed light in the fiber coupling, reflections in the fiber-optic plug and ambient light, limits the measurement dynamics of the sensor. In order to eliminate the influence of this light, a dark reference is performed on the sensor.

A dark reference is completed in the factory before the device is delivered, but must be repeated every time the probe or optical fibers are switched out. Even if the device indicates that there is no measurement object in the measurement range, a dark reference must still be performed.

Rapid Dark Reference via interface

If the device is used as a readings recorder in a measurement facility with automatic process control which is configured via serial RS-232/RS-422- or USB-interface, we recommend that the dark reference be performed before each measurement procedure (**$FDK**)(see Chap. *9.3* starting on page *92*).

Please note that in completing a dark reference, the device needs to be at its normal operating temperature (warm-up time of around 10 minutes, depending on ambient temperature) and that **no** measurement object should be within measurement range of the probe.
The probe may **not** be directly aimed at a light source!

Dark Reference

F1 / ESC

Call up main menu with **[F1]**.

```
Clear Dark S.Rate Config
```

F2

After calling up **[F2] Dark** you will be asked if the dark signal should be acquired or not.

```
Acqu. of dark signal
     No         Yes
```

F4

The dark reference starts with **[F4] Yes**.

```
Acqu. of dark signal
Taking dark reference!
```

If the dark reference is successfully completed, the device will then switch to operationally ready mode.

Display of Dark Reference

After the dark reference is completed, the dispersed light acquired will be displayed. This value will depend on various factors, e.g. contamination of the end surfaces of the fibers, fiber length, light source, etc. Basically, the smaller the value shown, the less the dispersed light will influence the sensor's measurement dynamics.

The value displayed will show the lowest possible measurement rate in Hz. Generally, it should not be above 150. The more dispersed light reflected by the end surfaces of the fibers, the higher this number will be.

If, for example, too much dispersed light was acquired by the probe during dark reference after a probe has been newly installed or replaced, the cause is usually found in contaminated end-surfaces on the fibers.

Extensive information on cleaning end surfaces of fiber optic lines can be found in the Chapter "Maintenance" (see Chap. *7.1* starting on page 87).

Command: **$DRK**

5.2 Setting the Measurement Rate

The measurement rate sets the number of measured values the optical sensor records per unit time. E.g. when the measurement rate is set at 4000 Hz, 4000 measurement values are taken per second. The intensity indicator on the display can help in selecting the correct setting.

Setting Range

As a rule, the user should strive to measure at the highest possible measurement rate in order to acquire as many measurement values in as little time as possible.

In the case of surfaces with very low reflectivity, it can be necessary to reduce the measurement rate. This has the effect of illuminating the optical sensor‘s CCD-line longer and thus making it possible to measure even if the reflected intensity is very low.

Overmodulation of the CCD-line on highly reflective surfaces and at small measurement rates can lead to measurement errors. If the intensity indicator displays a blinking "**Int: 999**", overmodulation is occurring. When overmodulation occurs, the next-highest measurement rate should be selected.

If the maximum measurement rate (4000 Hz) is already set, the reflected intensity can be reduced:

by positioning the probe in the upper or lower threshold of the measurement range

by manually reducing the exposure time or engaging the autoadapt-function (see Chapter *5.3.9*, starting on page *57*)

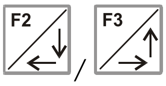
*If the last point is performed, then you **absolutely must** perform a **dark reference**!*

5.2.1 Set Measurement Rate [S.Rate]


```
Clear Dark S. Rate Config
```

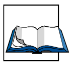

```
CCD-Scan rate:    1000 Hz
```

The current measurement rate will be displayed, e.g. 1000 Hz.



The measurement rate can be changed gradually using **[F2]**, from the next lowest or with **[F3]** to the next highest value (32, 100, 320, 1000, 2000, 3200, 4000).

The selection is confirmed with **[F4]**.



Command: **$SRA<index measurement rate >**

5.2.2 Adjust Exposure Mode [free/double Exposure]

The double exposure mode serves to measure surfaces with variable surfaces of different reflectivities in one single measurement procedure.

Exposure Time

To this end, the cycle frequency or period duration will be set while two measurements are performed with differing exposure times. The cycle frequency ranges from 950 Hz to 5 Hz, with matching exposure times from 1 ms (e.g. for polished metal) to 200 ms (e.g. for black surfaces).

Double Exposure Mode

Procedure

Call up exposure mode.

Select **[F1]** > **[F3] S.Rate** > **[F3] free/double Exposure**.


```
< free/double Exposure >
```

```
Cycle frequency  (Hz) 300
    Esc down up next
```

Set the cycle frequency using **[F2]**/ **[F3]** and **[F4]**, **maximally** however to **950 Hz**, which corresponds to an exposure time of 1 ms.

Press **[F1]** to end the input and start the confirmation prompts.


```
Cycle frequency  (Hz) 100
    Esc down up next
```

```
Accept value?          100
     No          Yes
```

Confirm your entry with **[F4]**. The following window will open.

```
Double Exposure cycle:
Set E.time ratio: 10/90%
```

The ratio of exposure times can be changed incrementally using **[F2]** or **[F3]**.

For example, with a **cycle frequency of** 100 Hz, i.e. a total exposure time of 10 ms, this can be arbitrarily distributed within certain limits.

For example, a ratio of 10/90 %, corresponds to An exposure time of 1/9 ms while 23/77 % corresponds to exposure times of 2.3/7.7 ms.

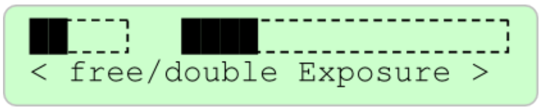
For a cycle frequency of 100 Hz, for example, the smallest possible ratio that can be set is 5/95 % with exposure times of 0.5/4.5 ms etc.

Command: **$DCY**< shorter exposure interval %>

Adjustable Measurement Rate

Call up the main menu.

Select **[F1]** > **[F3] S.Rate** > **[F3] free/double Exposure: [F4]** > **[F1]**.



Using **[F2]**/ **[F3]** select **Set E.time ratio:100/0%**.

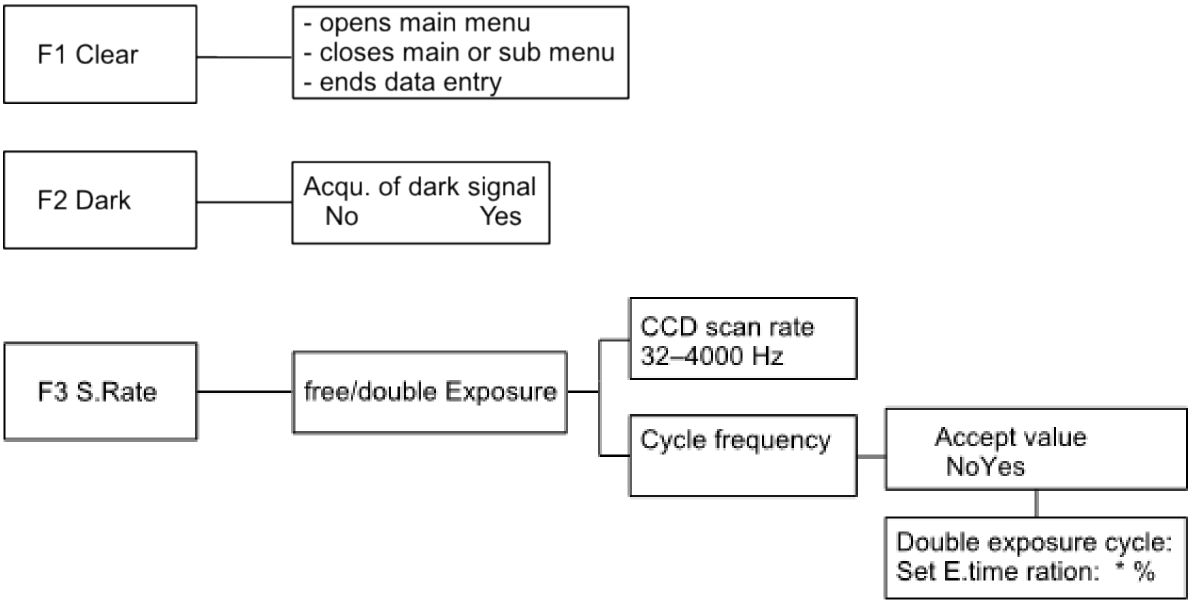
The "adjustable measurement rate" offers an advantage over the measurement rate (see **S.Rate** *Chap. 5.2.1* on page *42*) in which the **CCD-Scanrate** can only be set at discrete values.
Using the **cycle frequency** dialogue box, the measurement rate can be varied in 1 Hz-increments, within the range of 5 Hz to the maximum measurement rate of 4000 Hz.

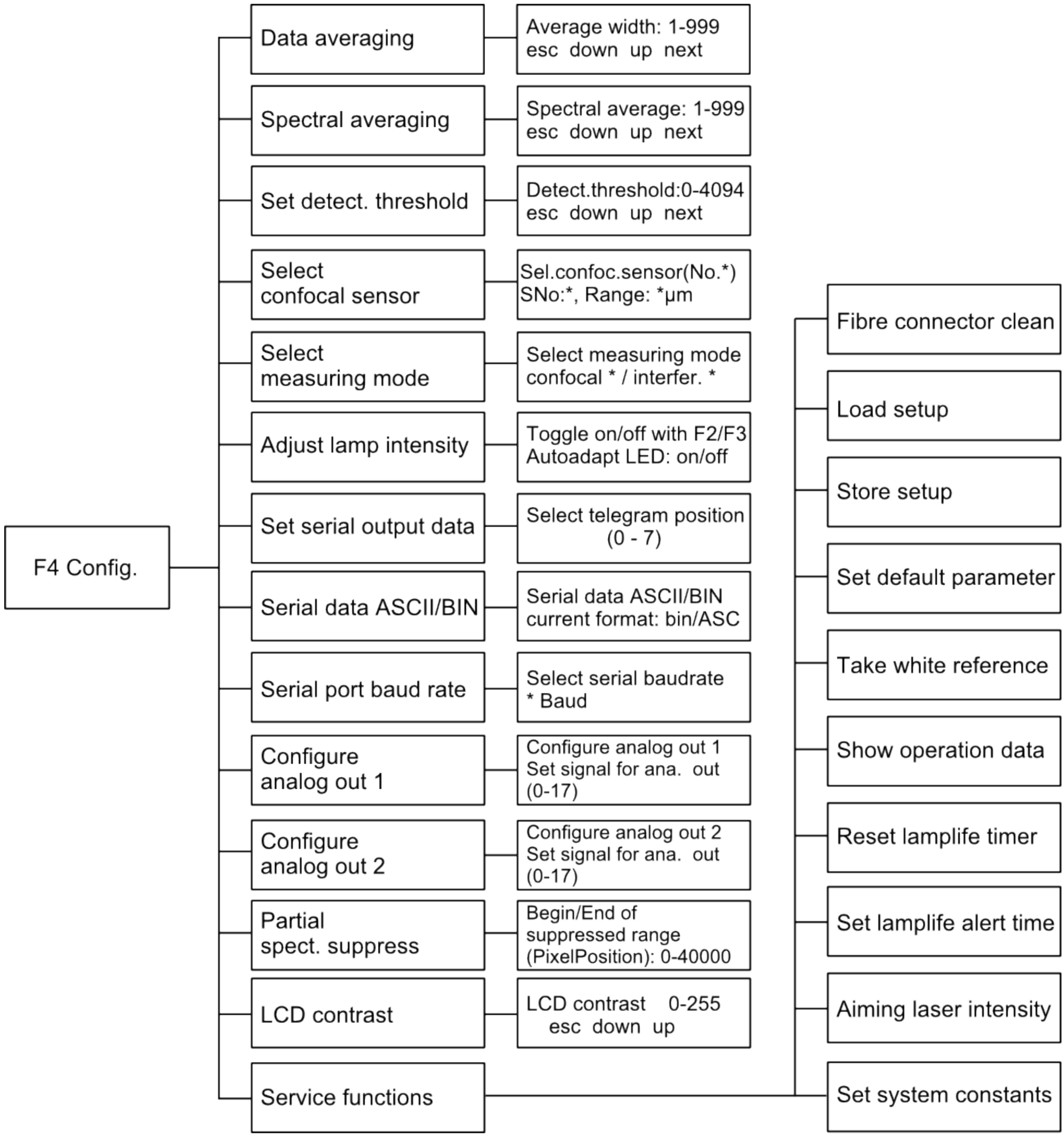
Command: **$SHZ**< Measurement rate in Hz

5.3 Configure Device [Config]

5.3.1 Menu Structure

* Value depends on probe, type of connection, metering method etc.




F4 Config.
Data averaging
Average width: 1-999
esc down up next
Spectral averaging
Spectral average: 1-999
esc down up next
Set detect. threshold
Detect.threshold:0-4094
esc down up next
Select confocal sensor
Sel.confoc.sensor(No.*)
SNo:*, Range: *µm
Select measuring mode
Select measuring mode
confocal * / interfer. *
Adjust lamp intensity
Toggle on/off with F2/F3
Autoadapt LED: on/off
Set serial output data
Select telegram position
(0 - 7)
Serial data ASCII/BIN
Serial data ASCII/BIN
current format: bin/ASC
Serial port baud rate
Select serial baudrate
* Baud
Configure analog out 1
Configure analog out 1
Set signal for ana. out
(0-17)
Configure analog out 2
Configure analog out 2
Set signal for ana. out
(0-17)
Partial spect. suppress
Begin/End of
suppressed range
(PixelPosition): 0-40000
LCD contrast
LCD contrast 0-255
esc down up
Service functions
Fibre connector clean
Load setup
Store setup
Set default parameter
Take white reference
Show operation data
Reset lamplife timer
Set lamplife alert time
Aiming laser intensity
Set system constants

5.3.2 Configuration

- In the following, configuration using the function buttons is described and
- Recommendations are given for suitable menu settings and their functions.

Call Up Configuration Menu

Procedure

Select **[F1]** > **[F4]** **Config**.

[F4]

```
Clear Dark S.Rate Config
```

```
Config.:  sel. function
<   data averaging    >
```

Data averaging will appear on the display (first entry).

[F2] / [F3]

Using **[F3]** or **[F2]**, you can scroll up/down between the various functions in the configuration menu.

[F4]

The selected function is called up with **[F4]**.

Store Configuration

After leaving the configuration menu, the user will be asked whether the changes performed should be saved before returning to the main menu.

```
Save Settings to EEPROM?
    No             Yes
```

Save [F4]

If the query is confirmed with **[F4]**, the changed configuration will be saved in an EEPROM and will be available after the device is turned off and restarted.

Cancel [F1 ESC]

If the query is confirmed with **[F1]**, the changed configuration is saved only until the device is turned off. When the device is turned on again, the last saved configuration will be active.

Configuration Menu

The Selection Options for the Configuration Menu **Config** are:

Menu	Mode			Function
	1	2	3	
data averaging	✓	✓	✓	Measurement value: averaging (1 ... 999)
spectral averaging	✓	✓	✓	Spectrum: averaging (1 ... 999)
set detect. threshold	✓	✓	✕	Select a threshold value for the intensity
set Q threshold	✕	✕	✓	Threshold for quality
set display hold time	✕	✕	✓	Holds the display for a specific time
select used CCD range	✕	✕	✓	Select the range of usable wavelengths
select confocal sensor	✓	✓	✕	Select probe
select measuring mode	✓	✓	✓	Select mode (1: distance, 2: thickness, 3: thickness, interf.)
adjust lamp intensity	✓	✓	✓	Adjustment: voltage or brightness of light source
set serial output data	✓	✓	✓	Select the data transferred via RS-232/RS-422 and USB
serial data ASCII/BIN	✓	✓	✓	Select the data structure for the RS-232/RS-422
serial port baud rate	✓	✓	✓	Transfer rate USB (fixed 921.6 kB) or RS-232/RS-422
configure analog out 1	✓	✓	✓	Configuration of analog output 1
configure analog out 2	✓	✓	✓	Configuration of analog output 2
partial spect. Supress	✓	✓	✕	Targeted suppression of spectral regions
LCD contrast	✓	✓	✓	Display contrast settings
Service function	✓	✓	✓	Service menu (see Table 5-2)

Tab. 5-1: Menu – Configuration, functions

Menu/ Functions are **only** active if one of the corresponding mode 1, 2 or 3 has been selected (see **select measuring mode**, Chap. *5.3.8* starting on page *53*).

Service-Functions:

Menu	Mode 1	Mode 2	Mode 3	Function
Fiber connector clean	✓	✓	✓	Displays the light currently returned over the fiber connection port in %,
Load setup	✓	✓	✓	Load saved user-specific setup-data
Store setup	✓	✓	✓	Store user-specific setup-parameters
Set default parameter	✓	✓	✓	Re-set to standard settings (default parameters)
take white reference	✓	✓	✓	Acquisition of "White -Reference"
Show operation data	✓	✓	✓	Displays total operating time and lamp operating time, number of starts
Reset lamplife timer	✓	✓	✓	Re-sets lamplife timer to 0
Set lamplife alert time	✓	✓	✓	Sets the alert time
Set system constants	✓	✓	✓	Place holder for selecting various light sources

Tab. 5-2: Menu – Service functions

5.3.3 Data Averaging

Under **data averaging,** the number of successive individual measurements can be set that are then used to calculate an average. This average value is then displayed and if needed also transferred over the interfaces.

The indicated or transferred intensity is likewise averaged using the individual measurements.

Call Up Data Averaging for Measurement

Select **[F1]** > **[F4] Config** > **[F4]**...: **data averaging**.

```
Config.:  sel. function
<   data averaging    >
```

When selecting **data averaging,** the current number of measurement values compiled in an average will be displayed.

```
average width:      001
    esc down up next
```

Using **[F2] down** and **[F3] up,** the marked number can be changed.
[F4] next lets you move the cursor between the numbers and
[F1] esc concludes the entry. The device will close the editing window and switches to the configuration menu.

The standard setting for the device is no data averaging (default 001). With the default-setting, one receives the maximum number of measurement values corresponding to the selected measurement rate.

In order, for example, to compensate for possible vibrations in a measurement sample, it can be sensible to increase the number of averaging procedures.

Command: **$AVD**< average>

5.3.4 Spectral Averaging

With the function **spectral averaging,** the spectra recorded are averaged before the evaluation.

Menu / Function are **only** significant in **Mode 3**, in interferometric measurement procedures.
In order to suppress disruptive frequencies that may occur in the measurement signal, an average is taken before the thickness is calculated.

Call Up Spectral Averaging

Select **[F1]** > **[F4] Config** > **[F3]**...: **spectral averaging**.

```
Config.:  sel. function
< spectral averaging   >
```

```
average width:        001
   esc down up next
```

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers and
[F1] esc concludes the entry. The device will close the editing window and switches to the configuration menu.

The default value 001 is set as standard.

This value should be kept for Mode 1 and Mode 2, since a change will only influence data averaging and this is set or selected under **data averaging**.

In double exposure mode, spectral averaging makes no sense for practical reasons, and for this reason it is not possible.

Command: **$AVS**< average>

5.3.5 Set Detect. Threshold

Under **set detect. threshold,** the value for the threshold between noise and the measurement signal can be set.
Peaks falling beneath this threshold are recognized as invalid and shown on the display as the measurement value "**0**".

Menu/ Function are **only** active in **Mode 1** and **Mode 2**, in the chromatic measurement procedure.

Call Up Threshold Intensity

Select **[F1]** > **[F4] Config** > **[F3]**...: **set detect. threshold**.

```
Config.:  sel. function
< set detect. threshold
```

```
detect.-threshold:  0035
     esc down up next
```

The current threshold is shown on the display.

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers and
[F1] esc concludes the entry. The device will close the editing window and switches to the configuration menu.

For a valid measurement, the intensity should fall between 0 and 999; otherwise, the measurement rate must be changed (see Chap. *4.2* starting on page *41).*

If the distance to a surface with low reflectivity is measured, the intensity of the reflected light can be too low and the measurement rate must be reduced.
For a measurement rate **under 1 kHz,** a threshold of **40** is recommended. This prevents measurement values of too low an intensity, which rise only slightly above the noise, which would falsify the measurement. At a measurement rate **of 1 kHz and higher,** a threshold of **15** is expedient in fully exploiting the device's dynamics.

Command: **$THR**< quality value>

Intensity Range

If too **high** a threshold is selected, areas of the surfaces being examined, where too little light is reflected either due to the reflectivity or the angle, will be recognized as invalid.

Too **low** a threshold will lead to accidental results if no or a very weak signal hits the CCD-line.

Relative-Unit, Resolution

Intensity is measured in relative units. Inside the device, the intensity is determined with 12 bit resolution as a numeric value between "0" and "4095" and transferred the same way over the interfaces (RS/232/RS/422, USB).

The intensity between "0" and "999"_ is shown in the display, where the display value "999" corresponds to the internal value of "4095".

Distance measurement to a surface using the optical sensor is based on the spectral analysis of the light reflected by the surface. The spectrum of reflected light shows a pronounced peak. To measure the distance, the wave length of this peak is calculated. The intensity of the peak is irrelevant for the measurement, as long as it is high enough to make it possible to distinguish the peak from the noise in the CCD-line.

The intensity of the peak for a specific probe depends on the reflectivity of the surface being examined, the angle of the surface in the measurement spot and the exposure time of the CCD-line in the device, i.e. the selected measurement rate.

5.3.6 Set Q Threshold

The quality threshold is an index for the quality of the measurement. The higher the Q-value is, the better the interferometric measurement.

The quality of the interferometric thickness measurement is higher when the boundary layers are more parallel to each other. It also depends on the degree of light reflected on both boundary layers and their roughness.

Menu/ Function are active **only** in **Mode 3**, in interferometric measurement procedure.

F4

```
Config.:  sel. function
< set Q threshold        >
```

```
Q threshold:         0025
     esc down up next
```

The current threshold is shown on the display.

F ..

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers and
[F1] esc concludes the entry. The device will close the editing window and switches to the configuration menu.

The Q-value should be set at 25 as standard.

Quality: The spectral range of light reflected by a layer or system of layers derives from the constructive or destructive interference of the various partial waves depending on their wavelength. If one plots the intensity of the radiation reflected over the number of waves, one gets a periodic, harmonic progression. The spectrum recorded in the internal spectrograph needs to be equalized in order to get this progression. Using a transformation of this periodic harmonic progression in the output spectrum, one can calculate the period duration and from it thickness. The product of this transformation is a peak in the position space. Its output with respect to the output of the entire measurement object is the quality of a thickness measurement.

Quality is an index for the degree of signal modulation.

Command: **$QTH**< value>

5.3.7 Select Confocal Sensor

Under **select confocal sensor,** the device is told which chromatic sensor is connected.

Menu/ Function are **only** active in **Mode 1** and **Mode 2**, in the chromatic measurement procedure.

Call Up Select Confocal Sensor

Select **[F1]** > **[F4] Config** > **[F3]** ...: **select confocal sensor**.

```
Config.:  sel. function
< select confocal sensor>
```

```
sel. confoc.sensor(Nr. 1)
SNr.:  77, Range:  330µm
```

The currently activated sensor will be shown (e.g. disc location (Nr.1), sensor serial number (SNr.: 77), measurement range (Range:330 µm)).
This example means that the device is calibrated and set for a 300 µm-sensor. In practice, sensors can have a somewhat larger measurement range than is given in their technical specifications. In the example above, the sensor has a measurement range of 330 µm.

You can scroll between the various sensors within the selection list using **[F3] / [F2]**.

The selection list contains all 16 disc locations from No. 0 to Nr. 15.

The selection is confirmed using **[F4]**. The device will close the selection window and switches to the configuration menu.

In a device that is delivered with only one sensor "No.: 0" is always occupied (the other entries in the selection list are meaningless; They are just placeholders).

Selecting another probe number (for the measurement range) is only logical, if the assigned probe was calibrated with the device in the factory.

If for whatever reason the device is upgraded or refitted with a probe of the same or another type, the device will have to be shipped to SICK for calibration.

An overview of the optical probes available in serial production from SICK can be found in Chap.*2.5.2* "Accessories" on page 22.

Command: **$SEN**< sensor table location>

5.3.8 Select Measuring Mode

Measurement of distances/thicknesses of transparent, thin layers using the optical sensor can be performed in different modes.

One can switch between the modes under **select measuring mode**.

Modes

The following selection is implemented in the device:

- Mode 1 [confocal, 1 surface] for distance measurement,
- Mode 2 [confocal, 2 surfaces] for thickness measurement and
- Mode 3 [interfer. thickness] for measuring the thickness of single-layer and multi-layer systems (Option).
  If Mode 3 is not implemented in the device, the device will ask for a valid password and the option can be upgraded with this option.

One can simply switch between Modes 1 and 2. All chromatic sensors are designed for both modes, but must however be calibrated on the device.

The interferometric method of measurement Mode 3 (Option), can **only** be performed with a specialized, interferometric probe.
This requires specialized software and calibration which you can have back fitted by SICK at any time.

Mode 3 can be unlocked for test purposes for 5 minutes.

To do this, select Config > ...Mode 3 and then enter the password: 0000000001.
You will receive the message "*eval. of interf. mode OC Sharp will stop in 5 min.*"

Call Up Mode

Mode 1
(Distance)

Select **[F1]** > **[F4] Config** > **[F3]** ...: **select measuring mode**.

```
Config.:  sel. function
< select measuring mode >
```

```
Select measuring mode
confocal, 1 surface
```

The currently selected mode will be displayed.

You can scroll between the 3 Modes within the selection list using **[F3]** / **[F2]**.

The selection is confirmed using **[F1]**. The device will close the selection window and switches to the configuration menu.

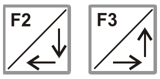
Mode 2
(chromatic thickness)

Select **[F1]** > **[F4] Config** > **[F3]** ...: **select measuring mode**.


```
Config.:  sel. function
< select measuring mode >
```

```
Select measuring mode
confocal, 2 surface
```

The currently selected Mode will be displayed.



You can scroll between the 3 Modes within the selection list using **[F3]** / **[F2]**.

The selection is confirmed using **[F1]**. The device will close the selection window and switches to refractive index (input window).

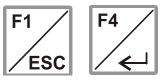
Refraction Index

The refractive index of the transparent material can be selected in a thickness measurement.
This causes the geometric thickness to be shown directly on the display.

```
refr. index nd:    1.0000
     esc  down  up next
```

The current refractive index is shown (default value 1.0000).

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers and
[F1] esc concludes the entry. The device will close the editing window and activates the security query for changes.



[F4] *yes* confirms the refractive index, while
[F1] *no* cancels the entry.

Abbe Number

If a refractive index of n=1 is set as shown above, the geometric thickness of a transparent material can also be calculated through multiplication by an average refractive index.

In general, the refractive index of transparent materials is not constant in the range of visible wavelengths; however, its range can be adequately approximated for engineering purposes through giving an average refractive index $\mathbf{n_d}$ and entering the Abbe number $\mathbf{v_d}$.

If a value of $\mathbf{n_d}$ >1 is entered, a new window opens in which the Abbe number can be entered.

RS-232/RS-422- and USB-Interface!
If a refractive index of $n \neq 1$ is set, this is irrelevant for the interface. The thickness data acquired over the interface in **Mode 2** must be multiplied by the refractive index n, in order to obtain the actual thickness.

The correction of the measurement values by the Abbe number is however retained.

If only the average refractive index is known, but not the Abbe number, the value $\mathbf{v_d}$ =199 can be entered. This means that $\mathbf{n_d}$ will be practically treated as a constant.

Mode 3
(interferometric thickness)

Select **[F1]** > **[F4] Config** > **[F3]** ...: **select measuring mode**.

```
Config.:  sel. function
< select measuring mode >
```

```
Select measuring mode
Interf thickness
```

The currently selected Mode will be shown.

You can scroll between the 3 Modes within the selection list using **[F3]** / **[F2]**.

The selection is confirmed using **[F4]**. The device will close the selection window and switches to refractive index (input window).

Refraction Index

When measuring thickness, the refractive index of the transparent material can be selected.
This causes the measured thickness to be shown directly on the display.

```
refr. index nd:     1.0000
      esc  down  up next
```

The current refractive index is shown (default value 1.0000).

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers and
[F1] esc concludes the entry. The device will close the editing window and activates the security query for changes.

[F4] *yes* confirms the refraction index, while
[F1] *no* cancels the entry.

To provide a complete description of a material's dispersion, the change in the material's refractive index n under variation in the wavelength λ of the light is shown as the function $n(\lambda)$.

By entering the average refractive index **n** and the Abbe number $\boldsymbol{\nu}$**,** the refractive characteristics of a transparent material are taken into account.

One only gets to the menu point for changing the Abbe number if a refractive index of ≠ 1 was entered. The default value of the Abbe number is199. In the standard settings, the analysis assumes a constant refractive index in the entire spectral range of the sensor.

Select Measurement Mode
Command: **$MOD**<0...2>
0=chromatic distance measurement
1=chromatic thickness measurement
2=interferometric thickness measurement

Select Refractive Index
Command: **$SRI**<refraction index>

Select Abbe Number
Command: **$ABE**<Abbe Number>

5.3.9 Adjust Lamp Intensity

Under **adjust lamp intensity,** the relative pulse duration of the LED and with it the effective brightness of the light source can be selected.

If, for example, a highly reflective surface is being measured, on which the highest measurement rate still results in over modulation, then it makes sense to reduce the exposure time.

If a poorly reflecting surface is to be measured with a high measurement rate, this can be achieved by means of a longer pulse duration.

WARNING

Dark reference is absolutely necessary after every change to the exposure time!

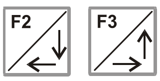
Call Up Lamp Intensity

Select **[F1]** > **[F4] Config** > **[F3]** ...: **adjust lamp intensity.**

The optical sensor comes equipped with a standard LED – light source. As soon as the device recognizes it, the following menu sequence will appear.

Function Autoadapt OFF

When the Autoadapt function is turned off, the light intensity of the LED can be parameterized in the range from 0% to 100%. The PWM (pulse width modulation) corresponds to the flash time during an exposure time as shown in brackets on the display.




```
Toggle on/off with F2/F3
  Autoadapt LED:   off
```

Function Autoadapt ON

The independent adjustment of flash time for the LED during an exposure time makes it easier for the user to automatically receive the best intensity settings when measuring on variable surfaces and with it an optimal signal-to-noise-ratio.

The brightness of the lamp is modulated such that a defined percentage of the modulation amplitude is achieved. The value can lie in the range of 0% to 75%. For most applications, a brightness value between 20 % and 40 % is recommended.

```
Toggle on/off with F2/F3
  Autoadapt LED:    on
```

Confirm the selection using **[F4]**.

Autoadapt on/off
Command: **$AAL**<0 or 1,saturation in percent>

Lamp intensity:
Command: **$LAI**<exposure time in %>

Use with a Halogen Light Source

The following menu level assumes the selection of a halogen lamp as light source.

```
Config.:  sel. function
< adjust lamp intensity >
```

```
Adjust lamp intensity
Voltage:  11.75 V  (98%)
```

The currently selected lamp intensity is shown.

You can increase or decrease lamp voltage using **[F2]** and **[F3]**.

The selection is confirmed using **[F4]**. The device will close the selection window and switches to the configuration menu.

As a rule, limits between 80% and 100% of lamp voltage are recommended.

5.3.10 Select Used CCD Range

Under **select used CCD range,** the device is told what usable pixel range should be analyzed. It should lie between 10 and 750.

To achieve the highest possible quality value in thickness measurement, it can be helpful to limit the number of pixels used in the interferometric measurement mode.

Menu/ Function are active **only** in **Mode 3**, interferometric measurement procedure.

Call Up Usable CCD-Pixel Range

Select **[F1]** > **[F4] Config** > **[F3]** ... **select used CCD range**.

```
Config:  sel. function
< select used CCD range
```

```
Adjust lamp intensity
Voltage:  11.75 V  (98%)
```

Start-Pixel Range

```
Start-Pixel:         010
  Esc  down  up  next
```

The current pixel range is shown.

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers and
[F1] esc concludes the entry. The device will close the editing window and activates the required entry for the stop-pixel range.

Stop-Pixel Range

```
Stop-Pixel:          750
   Esc  down  up  next
```

The current pixel range is displayed.

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers and
[F1] esc concludes the entry. The device will close the editing window and activates the security question for changes.

```
Password:    0000000000
   Esc  down  up  next
```

```
Accept value? 0000000001
     No         Yes
```

This pixel range can be confirmed with **[F4] yes** or
the entry cancelled with **[F1] no**.
Device shuts the selection window and switches to the configuration menu.

Command: **$CRA**<start pixel, stop pixel>

5.3.11 D Contrast

Under **LCD contrast,** the display's contrast can be adjusted to the local conditions.

Call Up Contrast Settings
Select **[F1]** > **[F4] Config** > **[F3]** ...: **LCD contrast**.

```
Config.:  sel. function
< LCD contrast          >
```

```
< LCD contrast    200
      ESC  down  up
```

The current setting will be shown.

The contrast is changed incrementally using **[F2]** down or **[F3]** up.

The selection is confirmed using **[F1]**. The device will close the selection window and switches to the configuration menu.

5.3.12 Set Display Hold Time

Menu/ Function are active **only** in **Mode 3,** interferometric measurement procedure.

Using **set display hold time,** one has the option of shutting down the measurement range in the Z-Axis when doing a "manual measurement." The best-quality measurement for the time set will then be displayed.

If the sensor measures a quality value that exceeds the selected threshold **Q: xx** (see **set Q threshold** Chap.*5.3.6*, page *50*) it will be displayed for the selected time, unless a higher value is found.

Call Up Display Settings
Select **[F1]** > **[F4] Config** > **[F3]** ...: **set display hold time.**

F4

```
Config.:  sel. function
<set display hold time >
```

```
Interf. Mode best-Q dis-
play holdtime:   0.0 sec
```

F2 F3

The time can be changed (in intervals of 0.5 sec. from 0 to 60 sec.) using **[F2] down** and **[F3]**.

F1 ESC F4

The entry is concluded using **[F1] esc** or **[F4] next**. The device will close the input window and switches to the configuration menu.

5.3.13 Set Serial Output Data

via RS-232/RS-422 and USB

Under **set serial output data**, we set which of the measurements in which mode will be transferred via the RS-232/RS-422- or USB-interface.

Select Output-Data
Select **[F1]** > **[F4] Config** > **[F3]** ...: **set serial output data**.

```
Config.:  sel. function
<Set serial output data >
```

The individual data can be selected depending on the selected measurement mode in which the data telegram is recorded. Up to 16 telegram positions are available to do this (0-15).

The telegram position to which a value shall be assigned is selected using **[F2]** or **[F3]** (see Chap. *6.1* on page *78*).

```
Select telegram position
0      (0) distance
```

Using **[F4]**, the selection of the telegram position is confirmed and the following window opens.

```
Select data item
0      (0) distance
```

Now the data that is to be sent out is selected using **[F2]** or **[F3]** (see Chap. *6.1* on page *78*).

The data selection is confirmed using **[F4]** and one then returns to select telegram position.

If confirmed using **[F1]**, the device will close the selection window and then the user will be asked if the configured parameters are to be saved EEPROM. Then the device switches to the main menu.

One can switch between select telegram position and data values using **[F4]**.

The last position automatically sets the sensor to *(-1) End of telegram*. In order to send additional data beyond this, desired data can simply be selected at this position.

Command: **$SODX**<Indices of desired data>

If, for example, the data for distance, intensity and LED temperature are to be sent in distance mode, the command would be:
$SODX<0,3,17>
Position 4 will be automatically set to (-1) End of telegram.

Output Data

index	**mode 0:** 1 surface	**mode1:** 2 surfaces	**mode 2:** interferometric
(0)	Distance	Thickness	Thickness 1 (best Quality)
(1)	not occupied	Distance 1	Thickness 2 (second-best Quality)
(2)	not occupied	Distance 2	Thickness 3 (third-best Quality)
(3)	Intensity	not occupied	Quality 1
(4)	not occupied	Intensity 1	Quality 2
(5)	not occupied	Intensity 2	Quality 3
(6)	CCDpos*	CCDpos1*	Total intensity of refl. light
(7)	not occupied	CCDpos2*	not occupied
(8)	Flags#		
(9)	Exp. Time: exposure time in units of 1/640000 seconds		
(10)	Enc. 0 MSW: (Encoder 0 Position, most significant word)		
(11)	Enc. 0 LSW: (Encoder 0 Position, least significant word)		
(12)	Enc. 1 MSW: (Encoder 1 Position, most significant word)		
(13)	Enc. 1 LSW: (Encoder 1 Position, least significant word)		
(14)	Enc. 2 MSW: (Encoder 2 Position, most significant word)		
(15)	Enc. 2 LSW: (Encoder 2 Position, least significant word)		
(16)	Sample counter		
(17)	LED temperature		
(-1)	End of telegram		

Tab. 5-3: Output-data, overview

The values for CCDpos1 and CCDpos2 serve for calibration and are with one exception irrelevant in the identification of disruptive dispersed light sources

The flags indicate the following:

Bit 0: in double exposure mode 1 is given for the second, long exposure time and 0 for the first, short exposure time.

Bit 1: if the light source is defective or poorly adjusted – lamp problem

Bit 2: IGNOREDTRIGGER
Trigger-signal was received, but the sensor wasn't ready.

Bit 3: DELAYEDTRIGGER
Verspäteter Trigger im "Trigger each"- oder "External timing"- Modus: Der Belichtungstrigger war verzögert in Bezug auf den Triggerpuls, weil er zu kurz auf den vorhergehenden Puls folgte.

Bit 4: CCD_SATURATED

Bit 6: SHORTSYNCMARKERSENT
The sensor transmits every 5 seconds a short sync-out pulse, which makes it possible to synchronize with similar sensors (slave).

Bit 7: SHORTSYNCMARKERRECEIVED:
The sensor detects a shorter sync-in pulse (<12 µs), which makes it possible to synchronize with the master.

Bit 8: INDEX_INP_TOGGLE
This bit is inverted with each rising edge of encoder input 0 Z. That allows to synchronize the sensor data stream with external events.

Bit 9: ALARM_LAMPLIFE
The default lifetime of lamps has been achieved. The lamp should be replaced.

Bit 10 – 15: reserved

5.3.14 Serial Data ASCII/BIN

Two formats are available (ASCII/BIN) for sending the data from the optical sensor via the RS-232/RS-422- and USB-interface.

Call Up Data Format
Select **[F1]** > **[F4] Config** > **[F3]** ...: **serial data ASCII/BIN**.

```
Config.:  sel. function
<serial data  ASCII/BIN >
```

```
<serial data  ASCII/BIN>
current format:ASCII ASCII/BIN>
```

The currently selected format is shown.

ASCII- or **binary**-format is selected using **[F2]** or **[F3]**.

The selection is confirmed using **[F1]**. The device will close the selection window and you will be asked to save the configured parameters in the EEPROM. Then the device switches to the main menu.

The data can thus be transferred to a computer as ASCII-symbols (telegram format c.f. Chap. *2.5.2* on page *22)* 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**

5.3.15 Serial Port Baud Rate

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

Call Up Serial Port Baud Rate
Select **[F1]** > **[F4] Config** > **[F3]** ...: **serial port baud rate**.

```
Config.:  sel. function
< serial port baud rate >
```

```
select serial baud rate
115200 Baud
```

The currently selected Baud rate is displayed.

The Baud rates available for selection are 9600, 19200, 38400, 57600, 230400, 460800 Baud and 921600 Baud. You can find the particular data transfer rates on page *20*.

The Baud rate can only be transferred via **RS-232/RS-422**-interfaces.

For data throughput rate via **USB**-interface, the data rate is fixed at the maximum value of **921600 Baud**.

The data throughput rate is dependent both on the transfer rate, on the data format (see Chap. *5.3.14* on page *65*) and the data structure.

Using **[F3]** / **[F2]**, you can scroll up/down within the Baud rate selection list.

Confirm the selection using **[F1]**. The device will close the selection window and switch to the configuration menu.

You will find detailed information about the maximum number of readings that can be used with various formats, Baud rates and measurement rates for data throughput in Chap. *6.1* starting on page *78* or Tab. 6-1 on page *81* and Tab. 6-2 on page *81*.

Command: **$BDR**<index of Baud rate>

5.3.16 Configure Analog 1 / Configure Analog 2

Under **configure analog 1** and **configure analog 2**, you can configure both analog-interfaces.

Among other things, there is a female connector interface on the front of the device. At pin 10 (OUT 2) and pin11 (OUT 1) of this connector interface, the data can be acquired as analog voltage (see 2.2 on page 11).
The outputs supply analog voltage of 0 to +10 V_{DC}.

Call Up Analog Outputs
Select **[F1]** > **[F4] Config** > **[F3]** ...: **configure analog 1** or
[F1] > **[F4] Config** > **[F3]** ...: **configure analog 2**.

```
Config.:  sel. function
< configure analog out >
```

```
configure analog out 1
Set signal for ana. out
```

The following selection can be made using **[F2]** or **[F3]**:

set signal for ana. out for output-data

set lower limit value and **set upper limit value** for readings

After setting the two limits, the measurement values that lie between the limits will be transmitted as a voltage output between 0 and 10 V. This produces a very small span of e.g. 10 µm high resolution analog between 0 and +10.

Open the selection input window using **[F4]**
(**set signal for ana. Out**, **set lower limit value**, **set upper limit value**).

Output Data

Select Output Data

```
Config.:  sel. function
< configure analog out 1>
```

```
Select signal f. a. out 1
(0) distance
```

The currently active output data is shown.

Depending on the mode selected, you can select from among the various listed readings using **[F2]** or **[F3]**.

Confirm the selection using **[F4]** and the next user-defined analog parameter, such as **Set lower limit value** or **Set upper limit value** can be set.

Limit Value

Set Lower Limit Value

```
configure analog out 1
Set lower limit value
```

```
Value for 0V.:(µm)  +0000
    ESC down up next
```

The currently selected value is shown (default value +0000).

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers.

The entry is concluded with **[F1]**. The device will close the input window and switches to the selection window for the analog parameters.
You can **Set upper limit value** using this method or make the next selection on the level of the configuration menu.

Set Upper Limit Value

```
configure analog out 1
Set upper limit value
```

```
Value for 10V.:(µm) +3080
     ESC down up next
```

The currently selected value is shown.

The maximum upper limit is set by the (active) sensor that is currently attached to the device.
The upper limit value shown in the example (default +3080) for the 3 mm-probe.

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers.
The entry is concluded with **[F1]**. The device will close the input window and switches to the selection window for the analog parameters.
You can **Set lower limit value** using this method or make the next selection on the level of the configuration menu.

Command: **$ANA**<index analog output, data index, value corresponds to 0 V, value corresponds to 10 V>

5.3.17 Partial Spect. Supress

Under **partial spect. supress,** a portion of a spectrum (e.g. the process spectrum of a light source) can be blacked out.

This can be necessary if there is, for example, a laser in the vicinity of the sensor and stray light strikes the CCD-line.
In order to localize a disrupting intensity on the CCD, the value of the **CCDpos** (e.g. stray light from 18413) must be read over the RS-232/RS-422 or USB-interface.

Call up spectral range

Select **[F1]** > **[F4]** Config > **[F3]** ...: partial spect. supress.

```
Config.:  sel. function
<partial spect. Suppress>
```

```
<Begin suppressed range >
Begin (Pixelpos.):     0
```

```
Begin (Pixelpos.):  0000
     ESC down up next
```

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers.

```
<End of suppressed range>
End (Pixelpos.):       0
```

Using **[F3]** / **[F2]** you can scroll up and down the pixel position in the selection list between **Begin / End**.

```
Begin (Pixelpos.): 00000
     ESC down up next
```

```
End (Pixelpos.): 00000
     ESC down up next
```

Use **[F4]** to open the input window.

The following values are recommended for the sample selected value **CCDpos** = 18413 :
Begin (Pixelpos.): 18300 and **End (Pixelpos.): 18600**

The marked number can be changed using **[F2] down** and **[F3] up**.
[F4] next allows you to move the cursor between the numbers.

The input is concluded with **[F1]**. The device will close the input window and switches to the selection window for the spectrum range.
With this procedure you can set **Begin / End**.

Confirm the selection using **[F1]**. The device will close the selection window and switch to the configuration menu.

5.3.18 Fiber Connector Clean

Contaminants on the ends of the fiber optics cause increased stray light and can have a negative influence on the measurement readings. This function makes it easy for the user to localize which fiber ends are contaminated.

When this function is activated, the amount of stray light currently measured appears in the display.
Now you can clean the fibers.
Afterward, it will be necessary to perform dark reference.

Call Up Fiber Connector Clean
[F1] > [F4] **Config** > [F3]/[F2] ...: service functions > [F4] ...[F3]/[F2] ...:**fiber connector clean**

```
Choose service functions
Fiber connector clean.  >
```

Start the process with **[F4]**.

```
Fiber cleaning monitor.
Stray light =  64.0
```

Now, check the stray light in the following combinations:

- Sensor-only without the connected fibers and probe
- Sensor with connected fibers, without probe
- Sensor with fibers and probe.

Once the fiber end with the highest level of stray light is found, you can clean it with a clean, lint-free cloth.
The fiber optic connector port in the plotting unit [evaluation processor] itself can be cleaned with the cleaner rod (see Chap.*9.4*, page *115*).

The dark reference query can be started using any function button.

```
Acqu. of dark signal
     No         Yes
```

Start dark reference using **[F4] Yes**.

```
Acqu. of dark signal
Taking dark reference!
```

When the dark reference has been successfully completed, the device is ready to operate.

You can find detailed information on cleaning the optic fiber end surfaces in the Chapter "Maintenance" (see Chap. *7.1* starting on page *87*).

5.3.19 Load Setup

This menu point offers you the option of loading user-defined settings.

Call Up Load Setup Function

[F1] > [F4] Config **> [F3] ... service functions > [F3] ...**load setup

```
Choose service functions
Load setup     >
```

Start the process using **[F4]**. It will always begin with the display of the smallest index (0).

```
Select Setup Index: 0
Testparameter 05
```

The user-defined settings for test parameter 05, which are stored at storage location index 0 will be loaded.

Using **[F2]** / **F3]**, you can scroll through the selection menu for the indices and any already existing entries.

The parameters are loaded using **[F4]**; the sensor then switches back to the main menu.

The function is cancelled using **[F1]**; the menu level is closed and the [device] returns to the main menu.

The sensor configuration can be downloaded and copied again in the form of an ascii file in *.csu format. If interested, please contact SICK.

5.3.20 Store Setup

Using this function, you have the option of saving user-defined settings. The sensor has up to 16 storage locations reserved for this function.

Call Up Store Setup Function

[F1] > [F4] Config **> [F3] ... service functions > [F3] ...**store setup

```
Choose service functions
Store setup    >
```

Start the process using **[F4]**. It will always begin with the display of the smallest index (0).

```
Select setup index: 0
Testparameter 05
```

The test parameters 05 are stored under 0 in the user-defined settings.

Using **[F2]**/**[F3]**, you can scroll through the selection menu for the indices and any already existing entries.

The storage location is set using **[F4]** and the menu level for entering the set-up name.

```
Edit setup name
_
```

You can scroll back and forth through the symbol selection list using **[F2]**/**[F3]**.

[F4] takes you to the next position in the input field.

Once the input is complete, confirm it using **[F1]**.

```
Reedit (F1) / Accept (F4)
```

The name can be corrected using **[F1]**; The input is accepted with **[F4]**. The device will close the editing window and switch to the main menu.

The function can be cancelled with **[F1]**.

```
Operation canceled!
    --- empty ---
```

5.3.21 Set Default Parameters

Under **set default parameters**, the optical sensor's configuration parameters are re-set to the default parameters (factory settings).

The settings for the interface parameters ***data format***, ***transfer rate*** and ***output-data*** are retained.

Call Up Default Parameters

Select **[F1]** > **Config [F4]** > **[F2]** ... > service functions...> **Set default parameters**.

No security query becomes active prior to re-setting the parameters to the default values.

```
Choose service functions
< Set default parameters
```

While this function is being completed, the following display will appear:

```
Choose service function
Default parameters set!
```

Default Parameter (Overview of Factory Settings)

Parameter	Default Value
data averaging	1
spectral averaging	1
set detect. threshold	15
set Q threshold	18
set display hold time	0
Select used CCD range	0-999
select sensor	Last setting active
select measuring mode	Last setting active **refractive index = 1**
lamp intensity	98% /auto adapt Off
set serial output data	Confocal 1: distance; Confocal 2: thickness; interf: thickness 1
Serial data ASCII/BIN	Last setting active
serial port baud rate	Last setting active
configure analog out 1	(0) **Distance** active, remaining outputs inactive
configure analog out 2	(4) **Intensity 1** active, remaining outputs inactive
partial spect. supress	**Begin 0; End 0** (pixel position)
LCD contrast	128
Analog output	lower limits = 0 upper limits = full value: – Dist(µm): = 330 (dependent on probe) – Int: = 4096
Measurement rate	1 kHz and **double exposure mode** deactivated

Tab. 5-4: Menu – default parameters, factory settings

This command can only be executed using function buttons **[F1]** to **[F4]** .

5.3.22 Take White Reference

It is not necessary to take a white reference during normal operation of the device!

If one switches from an LED to a halogen light source or if the type of halogen is changed, a white reference is absolutely necessary.

Prior to performing a white reference, make sure that the device is warmed up for operation and that a dark reference is performed.

White Reference

A white reference is completed using a special auxiliary tool and should be performed as follows (the auxiliary tool can be ordered from SICK, see Chap. *9.4* page *115).*

1. Unscrew the fiber optic cable from the probe.
2. Perform dark reference on the device once it is warmed up to operating status. For detailed information, see Chap. *5.1* on page *40*.
3. Remove the protective cap from the fiber optic port on the auxiliary tool.
4. Set the fiber optic line on the white reference tool's jack and tighten the coupling nut finger-tight.
5. **Call up the white reference menu.**
   Select [F1] > [F4] **Config** > [F3] ...: service function> [F3] ...**take white reference**.

F4

```
< take white reference >
Pl. mirror at fiber end!
```

F4

Start the process with **[F4]**.

1. If the quantity of light is not sufficient, you will be asked to align the auxiliary tool's mirror.
   Follow the instructions on the display.
   Following the instructions, the fiber's distance to the mirror will need to be increased or decreased.
   ```
   Not enough light on CCD!
   Reduce mirror distance!
   ```
   or
   ```
   Too much light on CCD!
   Increase mirror distance
   ```
   To do this, you will need to loosen the screw on the tool with a screw driver. Then, following the instructions on the display, the distance of the fiber to the mirror can be increased by pulling the tool open in small increments or by lightly unscrewing it.
   If the user is instructed to reduce the distance between the fiber and the mirror, the tool must be pressed closed after the screw is loosened.
   After aligning the mirror, the tool's screw can be locked again.
2. A measurement rate for which the white reference will be completed will appear. This measurement rate should be set in normal cases 300 Hz and 4000 Hz.
   In unusual cases, please contact SICK.
3. After the reference has been successfully taken, the process should be

stored.

Store

If the query is confirmed with **[F4] store**, the changed configuration will be stored in an EEPROM and will be available once the device has been shut off and turned back on.

Escape

If the query is confirmed with **[F1] ESC**, the changed configuration will be retained only until the device is turned off. After the device is reactivated, the last stored configuration will be active again.

Command: **$WHT**

5.3.23 Show Operation Data

Displayed here you can have the

- total operating time
- lamplife timer
- number of starts

Call Up Show Operation Data Function

[F1] > [F4] Config **> [F2]/[F3] ...: service functions >**
[F4] ...[F2]/[F3] show operation data

Select the function using **[F4]**.

You can select from the individual displays using **[F2]** / **[F3]**.

Query total operating time, Command:	**$ OPD2,?**.
Query number of starts, Command:	**$OPD3,?**
Query total lamplife hours, Command:	**$OPD0,?**

5.3.24 Reset Lamplife Timer

Here you can set the lamplife time for your light source back to "0" after a lamp has been changed.

Call Up **Reset Lamplife Timer** function
[F1] > [F4] Config **> [F2]/[F3] ...: service functions >**
[F4] ...[F2]/[F3] Reset lamplife timer

Select the function using **[F4]**.

The number shown on the display must be entered using **[F2] / [F3]**.

Once confirmed with **[F4]**, the operating time is re-set to "0".

Command: **$ OPD0,314**.

5.3.25 Set Lamplife Alert Time

This function sets the alert time for the lamplife counter in x hours. When the operating hours counter reaches x hours, the alert flag (Bit 9) is set in the flag source term.

Call Up **Set Lamplife Alert Time** function
[F1] > [F4] Config **> [F2]/[F3] ...: service functions >**
[F4] ...[F2]/[F3] Set lamplife alert time

Select the function using **[F4]**.

Enter the desired time using **[F2]/[F3]**.

The alert time is set once confirmed using **[F]**.

Command: **$ OPD1,x**
x=Operating hours until alert

5.3.26 Set System Constants

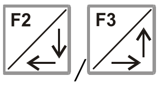
Under this service function, you will have the option in the future of selecting different light sources for the sensor. The sensor is delivered standard with an LED.

Additional light source options are planned for coming expansions.

Call Up **Set system constants** function

[F1] > [F4] Config **> [F3]** ...: service functions **> [F3] ...**set system constants


```
Choose service functions
< Set system constants
```



You can scroll up and down within the entries in the selection menu using **[F2]**/**[F3]**.


```
Choose Lightsource:
< Halogen/ext. source >
```

Select the light source being used with **[F4]**.

6 Data Transfer (Interfaces)

Analog OUT1, OUT2

The distance and thickness values measured by the optical sensor and the intensity of the particular signal being evaluated can be read in the display or acquired as voltage at both of the analog outputs (OUT 1, OUT 2).
Additionally, the measurement data can be transferred to a computer using the RS-232/RS-422/ USB-interface.

All functions can be executed using control commands sent from a computer using one of the serial interfaces.

RS-232/RS-422, USB

The serial interface functions **without** hardware- or software-handshake. To assure correct transfer of measurement data, the computer must be ready to receive incoming data at any time.

Baud Rate

The Baud rate for RS-232/RS-422 can be set in the range between 9600 Bd and 921600 Bd. We recommend the highest Baud rate supported by the host computer in order to be able to use the fastest possible measurement rate. For the (virtual) USB-interface, the Baud rate is fixed at 921600 Baud.

The Baud rate can be selected on the device's control panel under **Config: serial port baud rate** (see Chap.*5.3.15*, starting on page *65*) or via the command $BDR (see command **$BDR**, Chap*. 9.3,* starting on page *92*).

In the following, transfer of data via RS232/RS422-/USB-interface and configuring the device based on commands will be described.

6.1 Transfer Measured Values

Data Packet

During normal operation, the probe constantly sends data packets with the selected readings and control characters.
If one divides the selected measurement rate by the selected number of measured values, which are being averaged (see **data averaging** Chap. *5.3.3*, on page *48*, or **$AVD** *Tab. 6-3* "Overview of commands: Excerpt , on page *82*), you will get the number of data packets transferred per second.

In every data packet, up to 16 data items, each 16 bits long, are transferred. These items represent measured values, and they can be represented either as ASCII-symbols or in a 2 byte binary format.
In the optical sensor's different modes for distance and thickness measurement, the different measured values (distance, thickness, intensity) are transferred.

The transfer of each of successive measured values can be engaged in the particular mode. This can be done either using the function buttons on the device (see **set serial output data** Chap. *5.3.13*, starting on page *62*) or using the command **$SODX** over the RS232/RS422-/ USB-interface (see Chap. *9.3*, starting on page *92*).

Intensity

An intensity value will be transferred without a unit as a number between 0 and 4095, if the transfer is released inside the device (see Chap. *5.3.13* starting on page *62*).

On the display, the intensity will be displayed as a value between 0 and 999, whereby a blinking intensity of 999 indicates overmodulation.

Distance

Both the distance value Mode 1, as well as thickness, distance 1 and distance 2 in Mode 2 and the thickness in Mode 3 will be transferred as whole numbers between 0 and 32767.

One can calculate the actual distances in µm, by dividing the values after transfer by 32768 and multiplying them with the sensor's **FullRange** value. The value **FullRange** indicates the greatest distance to be measured and is a specific characteristic of each probe.

In order to be able to calculate the actual distance values [µm] from the transferred distance data, the value of the probe's **FullRange** must be read over the interface (see command **$SCA**, Chap. *9.3,* starting on page *92*).

ASCII Format

In ASCII format, every measured value is coded with 5 ASCII symbols. The individual values which belong to the same measurement point are separated by a "comma". At the end of every measurement, the control symbol **CR LF** is attached.

BIN Format

For transfer in binary format, every measured value is transferred as 2 bytes (the MSB first).

Regardless of the selected format, every byte consists of **1 Start-Bit, 8 Data-Bits, 1 Stop-Bit**.
"0xFF 0xFF" is transferred in front of every data item for synchronization ("0x" represents the hexadecimal notation system).

Data Throughput

The maximum number of measured values to be transferred per each individual reading depends on the selected format (ASCII/ binary) and the data structure along with the transfer speed.

In transfer using binary format, multiple measurement values can be read even at a high measurement rate (c.f. *Tab. 6-1*, page *81*).

Synchronizing Data Transfer

Since the value "0xFF" can also appear in the flow of binary, simply waiting on the indicated synchronization sequence ("0xFF 0xFF") is not sufficient for synchronization. This synchronization sequence only serves to indicate the start of the transfer of data, but not the start of each individual data packet.

Since the individual data packets have a known length, synchronization is not necessary in the transfer of each individual data packet. The synchronization sequence only serves to control the synchronization status.

The synchronization sequence can be exchanged with any other using the command $SSQ.

Synchronization can be achieved in two ways:

One stops the data flow from the device by sending a command from the computer. After the device has executed this command, it will send a "**ready CR/LF**" message and begin to transfer a new data packet.

If the synchronization sequence is not received at the expected place, it can wait on the correct synchronization sequence.

Transfer Time

When selecting the Baud rate, the measurement rate, number of measurement values to be averaged, data format and the measured values that are to be transferred, the following must be taken into account for the transfer time.

The T_B-time, time necessary for the transfer of each byte, is calculated as

$$T_B = \frac{10}{\text{Baud rate}} + 1\,\mu s$$

The total time available for the transfer of a data packet is the direct inverse of the selected measurement rate (if not averaged over several individual measurements). If the inverse of the selected measurement rate is divided by T_B, one obtains the number of bytes (N_B) that can be transferred in a single cycle.

Example

At a measurement rate of 1000 Hz and a transfer rate of 115200 Baud, the N_B is calculated as follows:

$$N_B = \frac{(1/1000)\ \text{Hz}}{T_B} = 11{,}39 \text{ (rounded down to 11)}$$

For the data given here, 10 bytes can be transferred per measurement cycle.

Sync	Sync	byte 0	byte 1	byte 2	byte 3	byte 4	byte 5	byte 6	byte 7
		MW 1		MW 2		MW 3		MW 4	

For every data item in binary format, two bytes are assigned to the synchronization sequence and 8 bytes to the transferring measured values. Every measured value is represented as a two-byte long data item, so that in this example, four measured values can be transferred.

In ASCII-format, for a given number **n** (bytes/s), the number **N** (number of readable measured values from the interface per cycle) is calculated as follows: **N = (n-1)/6** (see following table).

You can get an overview of the maximum number of measured values that can be transferred in the different formats, Baud rates and measurement rates from the following table.

Data Throughput of Measured Values 1/2

Baud rate	9600		19200		38400		57600	
Measurement rate [Hz] / Format	BIN	ASCII	BIN	ASCII	BIN	ASCII	BIN	ASCII
32	14	4	16	9	16	16	16	16
100	4	1	8	3	16	6	16	9
320	–	–	2	–	5	1	8	2
1000	–	–	–	–	1	–	2	–
2000	–	–	–	–	–	–	–	–
3200	–	–	–	–	–	–	–	–
4000	–	–	–	–	–	–	–	–

Tab. 6-1: Data throughput of measurement values via the interfaces 1/2

Data throughput of Measured Values 2/2

Baud rate	115200		230400		460800		921600	
Measurement rate [Hz] / Format	BIN	ASCII	BIN	ASCII	BIN	ASCII	BIN	ASCII
32	**16**	**16**	**16**	**16**	**16**	**16**	**16**	**16**
100	**16**	**16**	**16**	**16**	**16**	**16**	**16**	**16**
320	**16**	**5**	**16**	**11**	**16**	**16**	**16**	**16**
1000	**4**	**1**	**10**	**3**	**16**	**7**	**16**	**13**
2000	**2**	**–**	**4**	**1**	**10**	**3**	**16**	**6**
3200	**1**	**–**	**2**	**–**	**6**	**2**	**12**	**4**
4000	**–**	**–**	**2**	**–**	**4**	**1**	**9**	**3**

Tab. 6-2: Data throughput of the measured values via the interfaces 2/2

6.2 Configure Device (serial RS/232/RS/422, USB)

The sensor can be configured using a number of different commands received by the device over the RS/232/RS/422-/ USB-interface, and various functions, such as e.g. dark reference can be executed. You can find the complete list of commands described in the Appendix in Chap. *9.3* starting on page *92*.

Menu/ Function	Mode 1	Mode 2	Mode 3	RS/232/RS/422/ USB Command
Main Menu				
Dark (Dark reference)	✓	✓	✓	**$DRK / $FDK [**<*averagenumber*>**],[**<*updatefactor*>**]**
S.Rate (Measurement rate)	✓	✓	✓	**$SRA** <n> / **$SHZ** <32...4000> / **$DCY** <n>
Menu Configuration				
data averaging	✓	✓	✓	**$AVD** <1 ... 999>
spectral averaging	✓	✓	✓	**$AVS** <1 ... 999>
set detect. threshold	✓	✓	•	**$THR** <0 ... 4094>
set Q threshold	•	•	✓	**$QTH** <1 ... 999>
set display hold time	•	•	✓	*Not supported*
select confocal sensor	✓	✓	•	**$SEN** <0 ... 15> "Sensor", Choice of optical probe

Menu/ Function	Mode			RS/232/RS/422/ USB Command
	1	2	3	
select used CCD range	•	•	✓	*Not supported*
select measuring mode	✓	✓	✓	**$MOD** <n> "Mode", Measuring mode
adjust lamp intensity	✓	✓	✓	**$LAI** <1 ... 100>
set serial output data	✓	✓	✓	**$SOD** <$x_0$,$x_2$,... x_{15}>
serial data ASCII/BIN	✓	✓	✓	**$ASC** / **$BIN** "Change Output Format" (ASCII/Binary)
serial port baud rate	✓	✓	✓	$**BDR** <n>
configure analog out 1	✓	✓	✓	**$ANA** <0>,<0 ... 7>,<0 ... 65535>,<0 ... 65535>
configure analog out 2	✓	✓	✓	**$ANA** <1>,<0 ... 7>,<0 ... 65535>,<0 ... 65535>
partial spect. supress	✓	✓	✓	*Not supported*
LCD contrast	✓	✓	✓	*Not supported*
Save set up	✓	✓	✓	$**SSU**
take white reference	✓	✓	✓	$**WHT** <n>

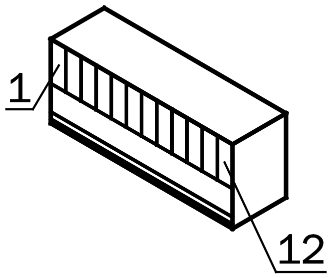
Tab. 6-3: Overview of commands: Excerpt

6.3 Multipoint Connector Interface

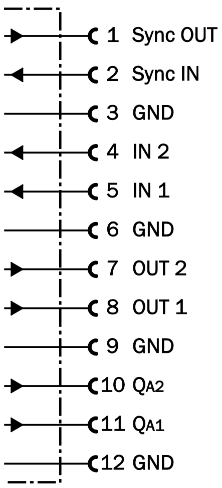
INTERFACE

The interface contains the connection points for the synchronization and analog outputs. They are numbered from left to right. Pin 1 is on the left!

INTERFACE



GND – *reference level*



Signal	Function	Description
Analog Out 1	Output	Measured value as analog voltage 0 - 10 V, adjustable
Analog Out 2	Output	Measured value as analog voltage from 0 - 10 V, adjustable
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 (see Chap. 6 starting on page 78); • starts the single measurement in mode **trigger each** • Start and stop of a single measurement in mode **ext. timing** • increment of encoder counter for axis 0 if encoder is in mode **pulse counter** • the sensor differentiates between pulses < 13 µs and >13 µs. This information is attached to the output telegram which is triggered by this pulse. This way more sensors can be synchronized. • the input is equipped with 10 kΩ pullup-resistance at 5 V.
Sync Out	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.

Tab. 6-4: Interface

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 command: $TRG).

6.4 RS-232/RS-422 – Serial Interfaces

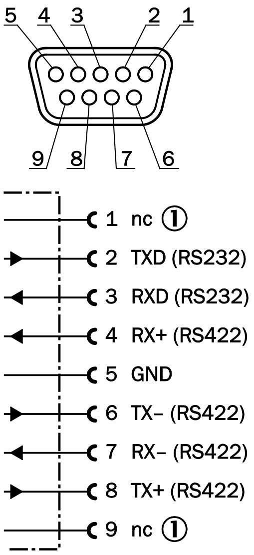
RS-422/RS-232

To read the measured values according to *Tab. 4-2 a*nd for controlling and configuring the device. The maximum transfer rate RS-232/RS-422 is 921600 Bd.

Both ports are located on the same connector. Automatic selection between RS-232 and RS-422. If a signal is present (quiescent signal about-5V) on the RX input of the RS-232 interface, the input is active. Otherwise, the input of the RS-422 interface is active.
Simultaneous output to both interfaces.

Note: An existing USB connection is automatically enabled as data input, RS-232/422-inputs are disconnected (parallel data output via the RS-232/422-outputs).

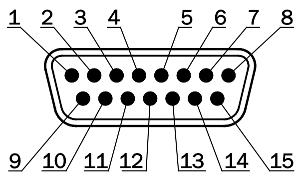
SUB-D9-connector configuration for sensor connection cable:

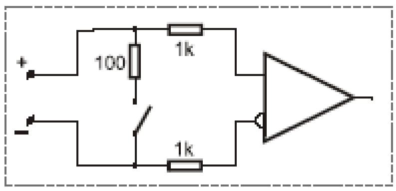


① not connected

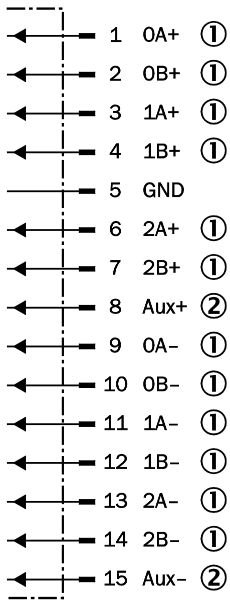
6.5 Encoder – Interface

Sub-D15





differential Input, 1 Channel



① 0, 1, 2: Axes index
A+, A–, B+, B-: differential signal pair of encoder

② Aux+, Aux–: differential signal pair auxiliary input

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.

The encoder input is sealed off with 100 Ohm.

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 SICK before beginning any work of this kind.

7 Maintenance

General Safety Rules

Knowledge of and action in compliance with the following generally applicable safety regulations are assumed:

VDE	Regulations, especially VDE 0100/ 0837
BGV A1	General Regulations
BGV A3	Electrical Equipment and Devices

or the analogous regulations of the particular country.

Personnel Requirements

All maintenance activities and any actions taken to solve faults require specialized knowledge and may only be performed by trained technicians.

Technicians must be instructed in compliance with the applicable regulations and safety instructions and made aware of possible hazards. The prescribed protective gear must be used.

SICK AG is not liable for damages that are caused by improper installation or by improper intervention on the part of unauthorized persons.

WARNING

High Voltage Hazard
This device must be secured against accidental activation prior to performing any maintenance or service.

Maintenance Tasks

Maintenance is simple and is limited to the external optical components of the measurement system.

Allowed maintenance tasks on the optical sensor:
Cleaning the probe and optical fibers,
if an optical light coupling is not reached in the fiber lines (see Chap. *7.1* starting on page *87*).

7.1 Cleaning or Maintaining the Probe and Optical Fibers

If the usual measurement sensitivity is not being obtained on known measurement objects, the optical components (front lens on the probe and the fiber ends) should be checked and cleaned if needed.

① Front lens, probe
② Fiber optic connector, probe
③ Optical fiber
④ Fiber optic connector, device

Fig. 7-1: Maintenance – maintaining the sensor, probe

WARNING

Front lens!
On the front lens of the probe there is an anti-reflection coating, which can be damaged by solvents that affect plastics. The use of such solvents can cause lasting damage to the probe for this reason.

To remove dust, you can use clean, oil-free, dry gas from aerosol cans.

To de-grease, use a soft, lint-free cloth soaked in ethanol or use objective cleaner from a camera shop.

To clean the connections on the sensor, a package of cleaning rods is included in the materials delivered with the equipment. These can be used for the connections on the E-2000 System as well as for the FC/APC- connections on the sensor.

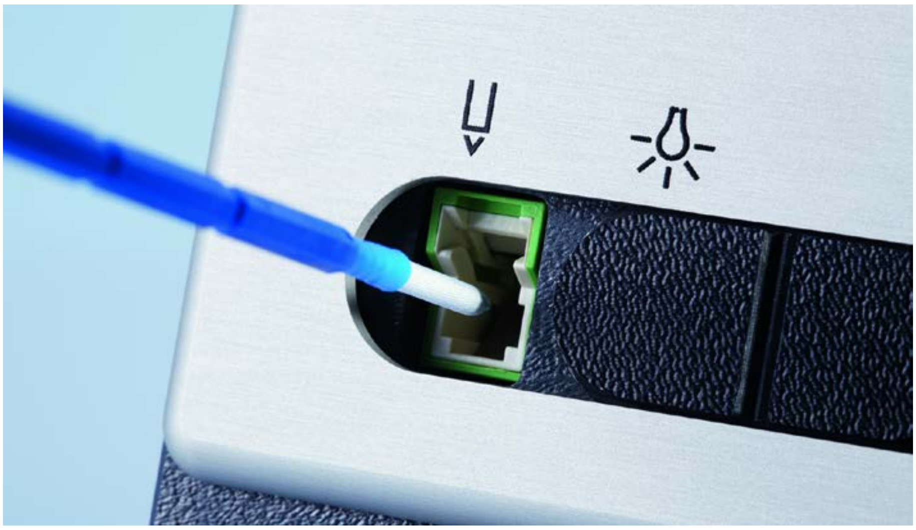


Fig. 7-1: Using cleaning rods

To clean, the rods are inserted with the white end first into the ports. For the ports on the E2000-Systems, the metal spring must be pressed down lightly.

Turn the rod once around the longitudinal axis and then remove it. Use the rod only if it is dry and only once.

The contamination of the light coupling in the fiber optic line can be quickly and effectively tested using dark reference on the device. This can be done for the device in steps without a connected optical fiber all the way to complete connection of the probe to the device. This allows you to precisely identify where the fault is: in the fiber optic port on the device, the optical fibers (their end surfaces) or on the probe (front lens).

A failed dark reference indicates that there is contamination.
(See Chap.*5.3.18* starting on page *70)*

8 Trouble Shooting

Malfunction	Cause	Solution
Display doesn't light up	No power supply	Check power cord.
Error indicated during dark reference	Contaminated light coupling on the probe, the optical fiber or the device	Check the following components for contamination, clean if needed: - Front lens of the probe - Fiber ends and fiber optic ports on the probe and on the device. If the malfunction cannot be remedied on-site, the device must be sent to SICK for repair.
	Defective probe or defective optical fiber.	- Optically check the probe, replace if needed (order a new one). - Optically check fiber, replace if necessary.
Display, white reference "too much light on CCD!" or "not enough light on CCD!"	Lamp intensity to strong or too weak	Adjust lamp intensity, repeat white reference
Display shows no valid measurement. (Intensity and Distance = 0)	Measurement object is significantly outside of focus area. Probe is not vertical to measuring surface.	Position the measurement object in the measurement range (see *Tab. 2-2).*
	Probe is not or not properly connected.	Check the connection of the probe, if needed, replace defective part
	Threshold intensity is too high.	Reduce threshold (see Chap. *5.3.5*).
	Measurement rate is too high for the object.	Reduce measurement rate (see Chap. *5.2.1*).
No data over the interface	$STO was sent.	Send $STA and $SSU.
Intensity indicator is blinking (Int: 999)	Sensor is overmodulated, saturated.	Increase measurement rate (see Chap. *5.2.1*) or reduce lamp intensity (See Chap. *5.3.9.*).
Display of measured thickness does not agree with expected value	Refraction index set incorrectly.	Adjust refraction index, see "Select Mode" Chap.*5.3.8*.
Changes to the configuration are lost every time the device is turned off	Configuration was not stored in the EEPROM.	Save the configuration after changes, confirm save on leaving the configuration menu (confirm with YES)

Tab. 8-1: Trouble shooting

9 Appendix

9.1 Data Interface

9.1.1 Types of Interfaces

The sensor provides 3 different interfaces for data communication:

1. USB Full speed (12MBit/sec)
2. RS-232 up to 921600Bits/sec
3. RS-422 up to 921600Bits/sec)

The selection, which interface is active, conforms with the following pattern:
If the USB is connected (and enumerated by the host PC) it will be selected as the active interface. However, the sensor will also send the data telegrams and command responses over the serial port as well (at a speed of 921600Bits/sec), but it won't receive data from the serial port.
If USB is disconnected and a RS-232 with standard Pin out is connected to the serial port connector, RS-232 communication will be active. The sensor uses the (temporarily present) negative voltage on the RXD pin to detect a RS-232 host connection.
If none of the 2 above mentioned conditions is true, the RS-422 interface on the serial port connector is active.
The USB connection comes with a PC driver that presents the interface as a virtual Com Port on the PC. So for all 3 types of data interfaces only one software implementation is needed.

The serial RS-232/422 interfaces do not use hardware or software handshake*. The computer must therefore be able to receive the incoming data flow at any time in order to receive the acquired data correctly. Using an interface board with some fifo memory should therefore be considered on the PC side when using the serial interface.*

The Baud rate for the serial ports is set via the keyboard (**[F4]** > **[F3]**...: **serial port baud rate),** or by using the **"$BDR" command**, see command description.
The possible Baud rate on the serial ports ranges from 9600Bits/sec to 921600Bits/sec, but the highest possible Baud rate should be preferred in order to be able to use the high measuring rate of up to 2kHz which is provided by the sensor. On the (virtual) USB-serial port, the Baud rate is fixed to 921600Bd.

The remaining communication parameters for the serial port are:

- 8 Bit data
- no parity
- 1 stop bit
- no flow control

9.2 Data Telegram Format

During free running operation the sensor continuously sends data telegrams. The telegram rate is determined by the CCD-Scan rate divided by the selected average number.
The telegram consists of up to 16 data words, each 16 bits wide. These words can be transmitted either as decimal numbers represented in **ASCII characters** or **binary as 2 bytes** with the MSB transmitted first.
The data words to be transmitted are chosen from a list of possible values, where each entry can be enabled or disabled. The meaning of the data is specific to the different operation modes of the sensor and is explained in detail in section *5.3.13* from page *62*.

ASCII mode

Telegram format: <data 0>,<data 1>,....,<data N>CR/LF
(the string "data *n*" between the < > signs mean one transmitted ASCII data word.

The enabled data words (selected by **$SOD** command) are output in ASCII representation, each 5 characters long, ranging from 00000 to 65535, separated by commas.
The telegram is concluded with carriage return / linefeed.

It should be noted that the ASCII mode does not enable the transmission of the results at the full measuring speed of 4 kHz due to the inefficiency of the coding. For high speed data transfer, the binary mode must be used.

Binary mode

Telegram format: (the values between the <> signs mean one transmitted byte. The prefix 0x indicates hexadecimal notation.)
<0xFF>,<0xFF>,<data 0 MSB>,<data 0 LSB>,...,<data N MSB>,<data N LSB>

Each telegram consists of the selected data words, high byte first, and begins with a synchronization sequence (default 0xFF,0xFF, but can be changed by the **$SSQ**-Command). It should be pointed out that in order to achieve synchronization, it is not sufficient to wait simply for the occurrence of this synchronization sequence since it can occur also in the binary data stream (like the stop and start bit in continuous serial transmission can be ambiguous). It is intended that this sequence is used only to synchronize the entire data flow, not a single telegram. Since the length of the telegram is known, a transmission once synchronized will stay synchronous and the synchronization sequence is only used to prove the state of synchronization.

There are two ways to achieve synchronization:
stop the data flow by sending a command. After completion of the command the sequence "readyCR/LF" will be sent and the sensor starts with a new telegram.
When you don’t receive the synchronization sequence at the expected place, wait for the synchronization sequence. This will synchronize the data flow in a few cycles since the transmitted data words are usually changing.

Be careful that the chosen combination of baud rate, sample rate, average, data format and selected output data permits full telegrams to be sent.
You should calculate 10/Baud rate+1 µsec per byte sent.

$$T_B = \frac{10}{\text{Baud rate}} + 1\ \mu s$$

Example

This permits for example at a connection speed of **115200Bd** an **1000Hz** sample rate

1/1000Hz /(10/115200Bd+0.000 001sec) =11,39

$\approx$ 10 bytes

= **2Bytes (synchronization sequence) + 4*2 Bytes (Data)**

to be transmitted at 1 kHz sample rate in binary mode.

9.3 RS-232/RS-422, USB Commands

9.3.1 Typographic Conventions

Courier bold: Anything that must be sent or is received exactly as written. For example commands, command responses.

<x> Values or names enclosed in < > are function arguments sent to the sensor or setting values received as a command response. Unless specially mentioned, numerical values are integer values.

<0 .. 500> 2 numerical values separated by ".." denote a range. Any value between the limits including the limits may be used. Used both for integer and floating point values.

<0,1> Values separated by commas define a fixed set of possibilities for a value. Only values from this set may be chosen (or can appear in a response).

[<x>] Arguments enclosed in brackets are optional. If a command has more than one optional argument, the sensor interprets the received arguments from left to right. This means that if for example one argument is not sent, the sensor will interpret the last argument of the list as missing.

[CR] means a carriage return character (#13)

[LF] means a linefeed character (#10)

[CR/LF] means a carriage return character followed by a linefeed character(#13 #10)

9.3.2 General Command Format

$COMMAND <Argument1> <Argument2> ….<Argument n>[**CR**]

Every command begins with **$**, and is followed by at least three capital characters.

All characters except the "**$**" will be ignored and not echoed outside of a command sequence.

After receiving the "**$**" character, which precedes each command, the optical sensor stops sending data telegrams (after having completed the pending telegram) and echoes the received command characters and arguments (including the "**$**"). It is not necessary to wait for the data stream to stop before sending the command.

During the command sequence, the sensor does not react to keyboard operation.

The arguments have to be separated by a non-numeric character (preferably a whitespace, don't use a comma, as some parameters are in floating point format and the comma would be mistaken as decimal point). Unless specially mentioned, parameters are integer values

Regardless of the fact if ASCII or binary format for the telegrams is chosen, all argument and response values are in ASCII.

Commands which expect parameter values must be finished with a carriage return (#13), (which is also echoed).

Some commands accept a question mark (**?**) as argument and then send back the current parameter setting as response.

When the optical sensor has received the complete command and when it has terminated the related actions, it will send a command specific response.

The command sequence always terminates by the string "ready[CR/LF]" (CR/LF means carriage return, linefeed or binary characters #13,#10) sent by the sensor.

After the command sequence the sensor will resume normal operation.

9.3.3 Short Form Table of Commands

com-mand	arguments	answer	answer on query with ? instead of argument	comments	valid for version >=
AAL	<0, 1> [<0 .. 255>] or <?>	-	<0,1> <exposure level>	Set "Auto Adapt" on or off, exposure level of CCD. The autoadapt mode is also disabled by the LAI command!	5.95
ABE	<0 .. 500, ?>	-	<Abbe number>	Set "Abbe number" for dispersion correction for thickness measurements, argument in floating point ("." or "," as decimal point - 0 means "no aberration"	5.95
ANA	<0,1> <n> <v0> <v10> or <0,1> <?>	-	<index of data value>, <Lower Limit>,<Upper Limit> values separated by commas	"Configure analog Output" - output number (0 or 1), - n: index of data value, - v0: data value for 0 V - v10: data value for 10 V	
ASC	-	-	-	"ASCII": telegrams in ASCII	
AVD	<1 ... 999, ?>	-	<number of averaged data values>	"Data averaging" depth of data averaging.	
AVR	<1...999, ?>	-	<n> n is the number of averaged data samples * number of averaged spectra	"Average" (obsolete command, use AVD and AVS instead) depth of data averaging. When using this command for setting the averaging, the raw spectra averaging is reset to 1!.	
AVS	<1 .. 999, ?>	-	<number of averaged spectra>	" Spectral averaging" depth of spectrum averaging	5.90
BIN	-	-	-	"binary": telegrams come in binary code	5.90
BDR	<0 ... 7>	-	<Index of baud rate>	"Baud rate" index of baud rate in [bit/s] 0: 9600; 1: 19200; 2: 38400; 3: 57600; 4: 115200; 5: 230400; 6: 460800; 7: 921600	5.90

com- mand	arguments	answer	answer on query with ? instead of argument	comments	valid for version >=
CRA	<0…999> <0…999> or **?**	When not successful: **Error PrepInterfMODE=**<x> x being an error code	<StartPixel> <Stoppixel>	"CCD-Range" Set CCD Range for interferometric mode (start pixel, stop pixel). The validity of the parameters has to be confirmed by monitoring the success of the command!	5.93
CTN	-	-	-	Continue (Measuring)	5.90
DCY	<1..49, 100, ? >	when the setting is not valid: **not valid**	length of shorter exposure subinterval in % of sampling interval	"Duty cycle" for double exposure in % (1-49%, or 100% for single exposure) only valid in confocal modes! **CAUTION** **Not all combinations of SHZ and DCY settings are valid, check the success by reading back the setting**	5.90
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	5.90
ENC	<0,1,2> <-2147483648 .. 4294967295, ? >	-	encoder position	"Encoder Position" : -index of axis -position (treated modulo 2^32) -the position argument can be replaced by "?" to query the position	5.90
EQN	equalize noise	-		in interferometric mode only	5.90
ETR	<func. Index> <arguments>	-	see detailed description	"Encoder Trigger", see detailed description	5.90
EXT	-	-		"External Timing" see detailed description	5.90
FDK	[<1..300>] [<0..32767>]	**(**<x>**)**" x being the (virtual) exposure rate in Hz at which the CCD would saturate	-	"Fast Dark", doesn't save to flash -optional: number of exposures to average (if not specified: 50) -optional: refresh factor. 0 leaves the old dark ref unchanged, 32767 replaces the old dark ref completely	5.90
IDE	-	*Key-value pairs separated by [**CR/LF**] similar to Ini-file format>*	-	"Identification" Expandable command for sensor identification. See detailed description	5.95
LAI	<0…100, ?>	-	<value in %>	"Lamp intensity" LED version: set on-time of LED between 1-100% of the	5.90

com- mand	arguments	answer	answer on query with ? instead of argument	comments	valid for version >=
				exposure time. This command also disables the autoadapt mode! Halogen version: lamp voltage 12 V in %, 1-104%	
LLM	<0...32767, ?>	-	<left limit value >	"Left Limit" lower boundary peak detection in the interferometric mode (2), 32768 = full scale	5.90
LMA	<0,1, ?>	-	<0,1>	"Limits active" Activate limits for the peak detection in the interferometric mode. "0" for deactivated "1" for activated	5.90
LOC	<0,1>	-	-	"Lock Keyboard" "0" for unlock "1" for lock	5.90
LRT	<1..16> <1024> Table	-	-	Load Refractive index Table	5.96
MOD	<0...2, ?>	Nothing, if successful else: **Error PrepInterfMODE=**<x> x beeing an error code **not valid** if interf. Mode not licensed	either: **0(confocal, 1 surface)** or: **1(confocal, 2 surfaces)** or: **2(interfer. thickness)**	"Mode" select measuring mode: 0 = confocal, distance 1 = confocal, thickness 2 = interferometric, thickness	5.90
OPD	<Index of function> <value, ?>	See detailed description	See detailed description	"Operation data" Index of function 0= lamplife timer 1= lamplife alert time 2= operation time 3= number of power ups	5.95
QTH	<1 .. 999, ?>	-	<Quality threshold>	"Quality threshold"	5.90
RLM	<0 .. 32767, ?>	-	<left limit value>	"Right Limit" upper boundary, peak detection in interferometric mode (2), 32768 = full scale	5.90
SCA	-	<scale> Full scale in µm	-	distance or thickness value [µm] for output value 32768	5.90
SEN	<0 .. 15, ?>	-	<optical probe Index>	"optical probe" index of used optical probe	5.90
SENX?	-	<n**>, SNr:** <x>**, Range:** <*y*>**um** n: Index of probe x: Serialnumber of probe y: measuringrange	-	Extended optical probe query	5.93
SHZ	<32 .. 4000, ?>	-	<x>**HZ**	"Set sample rate in Hz".	5.90

com-mand	arguments	answer	answer on query with ? instead of argument	comments	valid for version >=
			x meaning the exact sample rate in Hz in floating point format	**CAUTION** **A $DCY setting other than 100% will lead to double exposure mode**	
SOD	<0,1> <0,1> <0,1> ...<0,1> (max 16 times) or <?>	-	<0,1>,<0,1>,...,<0,1> (16 times)	"Set Output Data", 16 possible data words 1 selects the word for transmission, 0 deselects the word **CAUTION** **Don't mix SOD and SODX!**	5.90
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 **CAUTION** **Don't mix SOD and SODX!**	5.94
SRA	<3..7, ?>	-	<index of sample rate> <sample rate in Hz>**Hz**	"Sample Rate" index of sample rate (exposure time): 3:32 Hz; 4:100 Hz; 5:320 Hz; 6:1 kHz; 7:2 kHz; 8:3,2 kHz, 9:4 kHZ 127 means sample rate selected by $SHZ command	5.90
SRI	<1..4>	-	<refractive index> at spectral d-line (587,567 nm)	"Set Refractive Index" refractive index at spectral d-line (587,567 nm) argument in floating point ("." or "," as decimal point	5.90
SRT	<0..16>	<0..16>**:***name of table* [**CR/LF**]	<0..16>**:***name of table* [**CR/LF**]	Select Refractive index Table. 0 means no Table (Dispersion model by n_d and v_d)	5.96

com-mand	**arguments**	**answer**	**answer on query with ? instead of argument**	**comments**	**valid for version >=**
SSQ	<0..255> <0..255>	-	-	"Synchronization sequence"	5.90
SSU	-	-	-	"Save Setup", saves setup parameters to EEPROM memory	5.90
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.	5.90
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	5.90
STS	-	status report, gives back the settings of some parameters		"Status" (command obsolete)	5.90
THR	<0..4049, ?>	-	<threshold value>	"threshold" threshold for peak detection in the confocal modes (0 and 1)	5.90
TRE	-	-	-	"Trigger Each" – Mode	5.90
TRG	-	-	-	"Wait For Trigger" Stops the sensor after completion of the current data telegram and puts it in a waiting state.	5.90
VER	-	Version string		output version data	5.90
WHT	**3141**	**Int. ok!** [**CR/LF**] or **Int. too weak!** [**CR/LF**] or **Int. too high!** [**CR/LF**]		White reference	5.90

Tab. 9-1: List of commands

9.3.4 Detailed Commands Description

When the optical sensor has received the complete command and when it has terminated the related actions, it will send the string "**ready[CR/LF]**" and resume.

$AAL<0,1> <0 .. 255>
or
$AAL?

Auto Adapt LED
If the light source of the sensor is a LED or SLD, the intensity can be controlled automatically in order to achieve optimal measuring results. The algorithm tries to keep the intensity level on the sensor CCD at a certain level by adjusting the light source intensity. The setpoint level can be entered as fraction of the saturation level of the CCD by the second parameter. If the second parameter is not specified, the sensor will keep its current setting.
First parameter: 0 for "autoadapt off" or 0 for "autoadapt off".
Second parameter: value for CCD exposure level (255=saturation).
A setting of 80 (=30%) is recommended.

Example 1: **$AAL1 80**[**CR**]
response: **$AAL1 80**[**CR**]**ready**[**CR/LF**]

Example 2: **$AAL?**

Response: **$AAL?1 80ready**[**CR/LF**]

Related commands: $LAI

$ABE<0 .. 500, ?>

Abbe number
Set Abbe number to achieve a correct thickness measure by modelling the dependency of the refractive index from the wavelength (dispersion).
A low Abbe number means a strong dispersion, a high number means only a slight dispersion.
ABE =0 disables the dispersion! (implemented from version 5.94)
The value can be given as a floating point number, as well a "," as a "." can be used as decimal separator.

Example 1: **$ABE55,8**[**CR**]
response: **$ABE55,8**[**CR**]**ready**[**CR/LF**]

Example 2: **$ABE?**
response: **$ABE?55.8ready**[**CR/LF**] (note that a "." is used as decimal point)

Related commands: $SRI, $SRT, $MOD, $CRA

$ANA <0,1> <0 .. 17>
<0 .. 65535> <0 .. 65535>
or
$ANA <0,1> ?
or
$ANA?

"Configure Analogue output"
Each of the internal result values can be attributed to one of the 2 analog outputs of the OC Sharp. The value is linearly scaled so that the lower limit value corresponds to an output voltage of 0 V and the upper limit value corresponds to an output voltage of 10V. Values outside the programmed range are clipped to 0V and 10V, respectively.
First parameter: index of analog output to be configured (0 for out1 or 1 for out2)
Second parameter: index of data value to be sent (for meaning of indexes, see list (yyyyyyy)
Third parameter: lower limit (for 0V)
Fourth parameter: upper limit (for 10V)
There are 2 methods of querying the current settings, one for both outputs together (sending back index0, lower lim.0, upper lim.0, index1, lower lim.1, upper lim.1)and one for a single output . See examples:

Example 1: **$ANA1 3 0 4095**[**CR**]
response: **$ANA1 3 0 4095**[**CR**]**ready**[**CR/LF**]

Example 2: **$ANA1 ?**
response: **$ANA1 ? 3, 0, 4095ready**[**CR/LF**]

Example 3: **$ANA?**
response: **$ANA? 0, 0, 32767,3, 0, 4095ready** [**CR/LF**]

$ASC

Change Output Format to ASCII
Related commands: $BIN

$AVD <1 .. 999, ?>

Data averaging.

This command relates to averaging of distance / intensity data

Averages the results of n samples before outputting. Averaging is **not** implemented as sliding average, so it slows down the output rate by a factor of n.

Invalid samples (due to low signal intensity, or low quality) are not taken into account for averaging and thus do not disturb the result. In the case of invalid samples, these are skipped, but the averaging interval is not extended! So, the output rate is not affected.

CAUTION

Be careful when using the data averaging in the interferometric mode: The 3 detected thicknesses in the interferometric mode are ordered according to their signal quality. These qualities tend to vary locally quite heavily. Hence the thicknesses of different layers in a multilayer system could be erroneously mixed together by averaging!

In **double exposure mode** ($DCY other than 100%), **the intensity result value doesn't contain useful information when averaging is active**, as intensities from short and from long exposures might be averaged.

In Trigger each mode, there will be only one pulse on the sync out signal per n samples to be averaged. The pulse marks the beginning of the first exposure of the averaging interval. In the other modes, there is one sync-out pulse for every CCD exposure, regardless of averaging.

Example 1: **$AVD 10**[**CR**]
response: **$AVD 10**[**CR**]**ready**[**CR/LF**]

Example 2: **$AVD?**
response: **$AVD? 200ready**[**CR/LF**]

Related commands: $AVR, $AVS

$AVR <1 .. 999, ?>

Data averaging. note: **Obsolete, replace by $AVD**
For description, see **$AVD**

Due to compatibility with older software versions, **this command resets the spectra averaging to 1**.
Related commands: $AVD, $AVS

$AVS <1 .. 999, ?>

Spectral averaging
Before treatment the raw spectra obtained from the spectrometer can be averaged in order to reduce the noise. This allows for the extension of the dynamic range of the optical sensor as the noise is reduced by a factor of 1/sqrt (n) while the saturation limit stays the same. To make use of the extended dynamic, the detection threshold (**$THR**) should be lowered correspondingly.

Caution is required when using spectral averaging in the following situations:
- interferometric mode and moving test sample, especially at high thicknesses. The interferometric footprint in the spectrum moves and tends to average out.
- confocal mode and rapidly changing distances. The spectral response peak will be broadened and thus the calculation of the result is less reliable.
- in double exposure mode (DCY other than 100%), spectral averaging is not possible!

In Trigger each mode, there will be only one pulse on the sync out signal per n samples to be averaged. The pulse marks the beginning of the first exposure of the averaging interval. In the other modes, there is one sync-out pulse for every CCD exposure, regardless of averaging.

Example 1: **$AVS 10**[**CR**]
response: **$AVS 10**[**CR**]**ready**[**CR/LF**]

Example 2: **$AVS?**
response: **$AVS? 200ready**[**CR/LF**]

Related commands: $AVD, $AVR

$BDR <0,1,2,3,4,5,6,7>

Baud rate
The baud rate of the serial port can be adjusted to values between 9600 and 921600 (115200 (default)) is recommended on the RS-232 port),

setting	Baud rate
0	9600
1	19200
2	38400
3	57600
4	115200
5	230400
6	460800

7	921600

For the virtual USB port the baud rate is fixed at 9216200 Baud.

Note: in order to apply the command, you have to be connected at the correct baud rate. After applying the command, the baud rate is immediately switched, thus you won't receive the usual **ready**[**CR/LF**] response. In order to continue communication, close the PC port and reopen it with the new baud rate.

$BIN

Change output format to binary
Related commands: $ASC

$CRA<0 .. 999> <0 .. 999> or $CRA?

Set CCD Range
Set start and stop pixel for the CCD range in the interferometric mode.
First parameter: start pixel
Second parameter: stop pixel
typical values for the OC Sharp are start:40 and stop:600

CAUTION
If the values are not set appropriately the sensor won't enter interferometric mode.

Example 1: **$CRA 40 600**[**CR**]
response: **$CRA 40 600**[**CR**]**ready**[**CR/LF**]

Example 2: **$CRA 40 50**[**CR**]
response: **$CRA 40 50**[**CR**]**Error PrepInterfMODE=FFready**[**CR/LF**] (note: range was not valid)

Example 3: **$CRA?**
response: **$CRA 40, 600ready** [**CR/LF**]

$CTN

Continue

Resumes normal operation. Returns from Trigger mode, Trigger each mode and external timing mode to free running operation

$DCY <0..49, 100, ?>

Related command: $SHZ

Duty Cycle
Only to be used in conjunction with the $SHZ command!
In order to obtain a higher dynamic range than offered by the CCD-Sensor, the sampling interval can be split in two sub-intervals of different lengths by the use of this command (**double exposure mode**). The result of the longer exposure interval is output as a result if the CCD was not saturated, otherwise the short exposure result is taken into account. As a consequence, the intensity values should be interpreted with care, because they don't reflect whether they were generated in the long or short exposure subinterval. In order to obtain exact intensity values, the according flag in the flag output word should be regarded. It tells if the results come from the short or from the long subinterval. Alternatively, the exact exposure time can be output (result word n° 9). Nevertheless, saturation and low-light conditions can be detected as usual.
The value given in the command specifies the ratio of the shorter sub-interval to the whole sampling interval, expressed in percent. The length of the shorter subinterval cannot be reduced to values less than 1 ms, thus imposing a lower limit for the "Duty cycle" which is dependent of the current sample rate. For example, at 100 Hz sample rate, values smaller than 10% are not allowed. Values higher than 49% are not permitted either, with the exception of 100%, which enables the single exposure mode.

If the value is not accepted, the sensor responds with the string "**not valid**".
If the value is too low (the shorter interval is too short) the setting will automatically be adapted to the lowest possible value. Check by reading back the setting.
As in the case of the **$SHZ** command, the exact Duty cycle can be read back by **$DCY?** It is output in ASCII decimal floating point with 6 decimals.

Note that double exposure mode is available only in the confocal modes of operation only

Note to set the duty cycle via commands the scan rate needs to be set with $SHZ. If the scan rate is set with $SRA, the sensor will switch to single exposure mode

Example 1: **$DCY 10**[**CR**]
Response: **$DCY 10**[**CR**]**ready**[**CR/LF**]

Example 2: **$DCY 90**[**CR**]
Response: **$DCY 90**[**CR**]**not validready**[**CR/LF**]

Example 3: **$DCY?**
Response: **$DCY22.123456ready**[**CR/LF**]

$DRK

Dark Reference

Related command: $FDK

Takes a dark reference and stores the result in the (non volatile) flash memory.
The operation takes about 3 seconds

The action takes place immediately after the command. That means that before sending this command the measuring probe must not point to an object in the measuring range!

The sensor returns the index number for the lowest possible scanning rate (see **$SRA** for index numbers) as well as the (virtual) scan rate in Hertz at which the CCD would be saturated by the stray light. If this value is very high (>100Hz) try to get it lower by cleaning the fiber end faces. (see yyyyyyyyy)

Example 1: **$DRK**[**CR**]
Response: **$DRK**[**CR**] **4 (39.2)ready**[**CR/LF**]

$ENC <0,1,2> <-2147483648 .. 4294967295>
or
$ENC <0,1,2>?

Encoder Position
The incremental encoder counters of the 3 encoder channels can be preset or queried by this command. All counters have 32Bit width, permitting a counting range from -2^{31} to $2^{31}-1$. When the counters reach the end value, they wrap around. The command accepts signed as well as unsigned as position inputs (4294967295 = -1)
First parameter: axis index
Second parameter: position in increments
Between the axis index and "?" must be sent a separator (e.g. whitespace).

Example 1: **$ENC 1 1234**[**CR**]
Response: **$ENC 1 1234**[**CR**]**ready**[**CR/LF**]

Example 2: **$ENC 0 ?**
Response: **$ENC 0 ?-2147483640**[**CR**]**ready**[**CR/LF**]

$EQN

Equalize noise
applies only to interferometric mode.
This command determines the amplification function (FFT-Pixel) in the interferometric mode to achieve the same noise level over the measuring range. It will be saved permanent in flash.
This command may only be necessary after significant changes of the CCD range in interferometric mode.

It is essential to do the following procedure for the correct processing of this command.

Set lamp intensity to zero ($LAI 0), wait 10 seconds and run a dark reference. Then issue the command $EQN. Finally reset the lamp intensity to the usual level and make a new dark reference

$ETR <0 .. 6> <arg1>

Encoder Trigger
this command groups several functions related to encoder triggering. 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

First parameter: function index

Second parameter: Function dependent argument

There are the following functions (with their respective indices):

0: Set start position
The argument is the start position for an encoder triggered scan in increments. Selecting this function also sets the trigger-state-machine into the idle state (wait for start position to be passed over).
Example 1: **$ETR 0 1234**[**CR**]
Response: **$ETR 0 1234**[**CR**]**ready**[**CR/LF**].

1: Set stop position
The argument is the stop position in increments. When the encoder counter passes

beyond the stop position value, the encoder trigger stops.
Example 1: **$ETR 1 -2345678**[**CR**]
Response: **$ETR 1 -2345678**[**CR**]**ready**[**CR/LF**].

2: Set trigger interval (float)
The argument is the distance between adjacent trigger-points in increments. **This value can be entered as a floating point value ("." or "," as decimal point allowed)**
Example 1: **$ETR 2 –111.234**[**CR**]
Response: **$ETR 2 –111.234**[**CR**]**ready**[**CR/LF**].

3: enable encoder-trigger,
argument = 0: trigger by rising edge on sync-in-port (default, no encoder trigger)
argument = 1: trigger by encoder. Sets also the trigger-state-machine back into the idle state (wait for start position to be passed over).
Example 1: **$ETR 3 1**[**CR**]
Response: **$ETR 3 1**[**CR**]**ready**[**CR/LF**].

4: enable trigger during return movement:
argument = 0: (default) encoder-trigger is only active during the movement from start position to stop position.
argument = 1: encoder-Trigger is also active during the return movement from stop position to start position.
Example 1: **$ETR 4 1**[**CR**]
Response: **$ETR 4 1**[**CR**]**ready**[**CR/LF**].

5: choose axis:
The argument is the index of the axis used as trigger source for trigger.
Example 1: **$ETR 5 0**[**CR**]
Response: **$ETR 5 0**[**CR**]**ready**[**CR/LF**].

6: count sync pulses with axis 0 encoder counter
argument = 0: (default) count encoder pulses on axis 0 counter
argument = 1: count the pulses on the sync–in port with the axis 0 encoder counter.
in sync-in pulse counting mode, the behavior of the counter is as follows:
Bit 0 (LSB) reflects the inverted state of the sync-in input (1 at 0V, 0 at 5V)
Bits 1 .. 31 count the rising edges of the sync-in signal.
The minimum pulse width is 1us (500kHz counting frequency) in order to suppress errors due to ringing

Example 1: **$ETR 6 1**[**CR**]
Response: **$ETR 6 1**[**CR**]**ready**[**CR/LF**].

Related commands: $TRG, $TRE, $EXT

$EXT

External Timing
In this mode the exposure of the CCD is controlled by trigger events. With this mode, the timing can be synchronized for example to another OC Sharp which runs in free running mode or triggered mode. In order to do this, the Sync-out of the master OC Sharp has to be connected to the sync-in of the slave OC Sharp.

The ext mode is also useful when the full measuring frequency of 2kHz has to be exploited and every measurement has to be triggered externally. (In the "Trigger each"-mode, the max. sample rate is limited to 1kHz)

Every Trigger event ends the ongoing exposure and starts a new one. The terminated exposure is read out and measuring results are calculated.

That means the first data telegram is invalid because the exposure time is not known. The actual exposure time can be included in the data telegram as data word No.10 as a multiple of 1/640000 sec.
The external timing mode is ended by the following commands: $CTN, $SRA, $SHZ, $TRE.
The intensity control by $LAI and the automatic intensity adaption ($AAL1) are not possible in external timing mode because the length of the exposure interval is not known in advance.

Related commands: $TRG, $TRE, $ETR

$FDK [<1 .. 999>] [<0 .. 32767]

Fast Dark
This command takes a dark reference at the current sample rate, which is **not stored** in the FLASH-prom.

It enables very fast dark references to be taken frequently, for example in an inline application. As no save to flash takes place, the delay of that operation and wearout of the flash memory is avoided.

Average number, gives the number of scans to be averaged for the dark reference. The parameter is optional (50 is default)

Update factor (optional, 32767 is default), gives the influence of the averaged scans on the new dark reference, according to the formula:

newRef= 1/32768*(Updatefactor* Av.Scans + (1-Updatefactor)*OldRef)

r Update factor replaces the old reference by the new one, a small value modifies the old Reference only a bit.

The Command string must always be concluded with [**CR**]. The parameters are optional: without parameter, **$FDK** must be followed by [**CR**] and the default Average number = 50 and Update factor = 32767 (replace old ref) are used. When **$FDK** is used with one parameter, this parameter gives the Average number and the Update factor defaults to 32767 (replace old ref).

The command responds with the (virtual) scan rate in Hertz at which the CCD would be saturated by the stray light (see example). If this value is very high (>100Hz) try to get it lower by cleaning the fiber end faces. (see yyyyyyyyy)

When there is too much light on the CCD, the string "**not valid**[**CR/LF**]**ready**[**CR/LF**]" is output and the previous dark reference is restored.

Example 1: **$FDK 30 32767**[**CR**] (note 30 averages, complete replacement of old dark ref)
Response: **$FDK 30 32767**[**CR**] **(33.1)** [**CR**]**ready**[**CR/LF**].

Example 2: **$FDK 1 327**[**CR**] (no average, only 1% replacement by the new dark ref)
Response: **$FDK 1 327**[**CR**] **(32.8)** [**CR**]**ready**[**CR/LF**].

Example 2: **$FDK 100**[**CR**] (100 averages, complete replacement by the new dark ref)
Response: **$FDK 100**[**CR**] **(25.7)** [**CR**]**ready**[**CR/LF**].

Example 2: **$FDK**[**CR**] (50 averages, complete replacement by the new dark ref)
Response: **$FDK**[**CR**] **(28.5)** [**CR**]**ready**[**CR/LF**].

*For the usual dark correction you should apply the easy to use **$DRK** command (see above).*

$IDE

Identification
Expandable command to identify the sensor. The query delivers key-value pairs analog an Ini-file. For example

Key-string	Value-string (examples)	comment
Device	*OC Sharp*	
FPGA-Vers	*A.12.1*	A means Sony CCD B means NIR InGaAs 12 means version, 1 is the release
PNr	*800*	Production ID of the PCB
PDate	*22.07.2009*	Production date of the PCB
HWVers	*4*	Hardware version ID

IDE

IDEDevice:OC Sharp[**CR/LF**]
FPGA-Vers: A.12.1[**CR/LF**]
PNr: 471[**CR/LF**]
PDate:18. 4.2008[**CR/LF**]
HWVers: 1[**CR/LF**]
ready[**CR/LF**]
Related commands: $VER

$LAI <0 .. 104, ?>

Lamp intensity
In case of a device with LED or SLD light source (OC Sharp):
Ontime of the LED/SLD in % of the exposure time (0-100%)

In case of a device with a halogen lamp:
Lamp intensity in % (0-104%), 100% means 12V supply voltage, 104% means 12.5V

If the Auto adapt function is active it will be disabled.

Example 1: **$LAI 95**[**CR**]
Response: **$LAI 95**[**CR**]**ready**[**CR/LF**].

Example 2: **$LAI ?**
Response: **$LAI ?   10ready**[**CR/LF**].

Related commands: $AAL

$LLM <0 .. 32767, ?>

Left Limit
Left Limit of thickness detection range for interferometric mode. Scaled to interferometric full scale range. That means that a value of 32767 corresponds to the full scale thickness (which can be queried by the $SCA command)

Example 1: **$LLM 450**[**CR**]
Response: **$LLM 450**[**CR**]**ready**[**CR/LF**].

Example 2: **$LLM ?**
Response: **$LLM ? 450ready**[**CR/LF**].

Related commands: $RLM, $LMA

$LMA <0,1, ?>

Limits active
Enables or disables limits for thickness detection range for interferometric mode.

0: The full thickness detection range is active.

1: The preset limits are used, only thicknesses in the range between the left and the right limit are detected.

Example 1: **$LMA 1**[**CR**]
Response: **$LMA 1**[**CR**]**ready**[**CR/LF**].

Example 2: **$LMA ?**
Response: **$LMA ?   1ready**[**CR/LF**].

Related commands: $RLM, $LLM

$LOC <0,1>

Lock Keyboard
1 = lock
0 =unlock
To prevent undesired user interaction for automated measurements, you can disable the keyboard control. However, after power off/on, the keyboard will be active again.

$LRT <1 .. 16> <1024> <*byte0 byte1 .... byte1023*>

"Load Refractive index Table"

Up to 15 different refractive index vs. wavelength tables can be uploaded and stored into flash memory. Table 16 is volatile and thus not stored in the flash. Table 16 has to be activated directly after the upload by the $SRT16 command, otherwise it might be corrupted.

The command begins with $LRT, then the table index (1 .. 16) as ascii number, then a whitespace, then 1024 as ascii number (indicating the data length), then a whitespace, then the table data in the following format:

64 bytes: Table name as 0 terminated string, unused chars should be zero-filled.

60 bytes: reserved. To be zero-filled

4 bytes: reference refractive index as float, **big endian**!

896 bytes: up to 112 pairs wavelength, ref. index

Wavelength in micrometers, float, big endian

Ref. index as float, big endian.

For unused pairs at the end of the table, repeat the last valid pair

$MOD <0 .. 2, ?>

Measuring mode:

0 = confocal, 1 surface;

1 = confocal, 2 surfaces;

2 = interferometric;

After changing the mode, query the full scale value with the $SCA command, as it may have changed.

When selecting the interferometric mode, please monitor the command response as selecting this mode may fail for several reasons:

The interferometric mode is not licensed on this unit. However, a password enabling the interferometric mode can be obtained from SICK.
In this case, the response is "**not valid**".

Due to invalid settings of the CCD-range ($CRA) or the refractive index ($SRI)or the Abbe number ($ABE), the interferometric mode fails to initialize. Try other settings for these parameters.
In this case, the response is "**Error PrepInterfMODE=**<x>"
x beeing an error code.

ıen queried (**?**), the response is, according to the active measuring mode

ıer: **0(confocal, 1 surface)**
or: **1(confocal, 2 surfaces)**
or: **2(interfer. thickness)**

Example 1: **$MOD0**[**CR**]
Response: **$MOD0**[**CR**]**ready**[**CR/LF**].

Example 2: **$MOD 2**[**CR**]
Response: **$MOD 2**[**CR**]**not validready**[**CR/LF**].

Example 3: **$MOD?**
Response: **$MOD? 2(interfer. thickness)ready**[**CR/LF**].

Related commands: $SCA, $CRA, $SRI, $ABE

$OPD <0 .. 2> <arg>

"Operation data"

This command comprises several functions related to operation statistics of the unit. The first parameter selects the index of the function the second is passed as an argument to the function.

The available functions (with their respective indices) are:

Lamplife timer
314 as argument resets the Lamplife timer to 0.
"**?**" as argument queries the Lamp operation time:
Example: **$OPD0 ?**
response: **$OPD0 ? 335h, 21minready**[**CR/LF**].

Set Lamplife alarm time
The argument sets the lamp operation time in hours, when the lamplife alarm bit in the flag output word will be set. It can be queries by "**?**".
The setting has to be saved to Eeprom with the "$SSU" command
Example1: **$OPD1 1000**[**CR**]
response: **$OPD1 1000**[**CR**]**ready**[**CR/LF**].
Example2: **$OPD1 ?**
response: **$OPD1 ? 1000**[**CR**]**ready**[**CR/LF**].

query system operation time
the accumulated system operation time can be queried by sending "**?**" as argument.
Example: **$OPD2 ?**
response: **$OPD2 ? 1325h, 57minready**[**CR/LF**].

query number of powerups
the number of on/off cycles of the system can be queried by sending "**?**" as argument.
Example: **$OPD3 ?**
response: **$OPD3 ? 543ready**[**CR/LF**].

$QTH <1 .. 999, ?>

Quality threshold
Detection threshold for the quality of a signal in interferometric mode.

Example1: **$QTH 30**[**CR**]
response: **$QTH 30**[**CR**]**ready**[**CR/LF**].
Example2: **$QTH ?**
response: **$QTH ?   30ready**[**CR/LF**].

$RLM <0 .. 32767, ?>

Right Limit
Right Limit of thickness detection range for interferometric mode. Scaled to interferometric full scale range. That means that a value of 32767 corresponds to the full scale thickness (which can be queried by the $SCA command)

Example 1: **$RLM 20150**[**CR**]
Response: **$RLM 20150**[**CR**]**ready**[**CR/LF**].

Example 2: **$RLM ?**
Response: **$RLM ?20150ready**[**CR/LF**].

Related commands: $LLM, $LMA

$SCA

Scale
Query of Full Scale in micrometers.
A distance value of 32768 on the serial interface would mean a distance of (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.

Note
For thickness measurements in the two surface mode (mode1), this value must be multiplied with the refractive index of the measured material at 587.567nm.
In interferometric mode(2), this value must be divided by the refractive index of the measured material at 587.567 nm.
CAUTION
The full scale is affected by the commands $MOD, $SRI, $ABE, $CRA. Thus, always query the Full Scale value after issuing these commands!

Example: **$SCA**
response: **$SCA 3320**[**CR/LF**]**ready**[**CR/LF**].
Related commands: $MOD, $SEN, $SRT, $SRI, $ABE

$SEN <0 .. 15, ?>

Sensor
The parameter gives the index of the optical probe. The sensor then uses the corresponding calibration table.
CAUTION
For exact measurements, assure that the calibration table selected by this command matches the probe serial number as all probes are individually calibrated! If you are not sure about the serial number of the calibration table, use the SENX? command which outputs more information

Example 1: **$SEN 2**[**CR**]
Response: **$SEN 2**[**CR**]**ready**[**CR/LF**].

Example 2: **$SEN ?**
Response: **$SEN ?   2ready**[**CR/LF**].

Related commands: $SENX, $SCA, $MOD

$SENX?

Probe information

Sends back the index of the probe, serial number, range in micron.

Format: <n0>**,**	**SNr:** <n1>,	**Range:** <n2>**um**
n0= Index of probe	n1= serial number	n2=range in µm

Example: **$SENX?**
Response: **$SENX? 2, SNr: 123, Range: 3320umready**[**CR/LF**]

Related commands: $SEN, $SCA, $MOD

$SHZ <32 .. 4000, ?>

Set sample rate in Hz
It is possible with this command to realize sample rates other than the standard ones selectable by the **$SRA** command. Every value between a lower boundary given by the parasitic light during dark reference and 4000 Hz may be specified.
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
If the sample rate has been set with the $SHZ command, a query of the sample rate index returns index 127, indicating thus that the sample rate doesn't correspond to a sample rate index. (see $SRA)

Example1: **$SHZ101**[**CR**]
Response: **$SHZ101**[**CR**]**ready**[**CR/LF**]

Example2: **$SHZ?**
Response: **$SHZ?101.010100HZready**[**CR/LF**]

CAUTION
If you don't intend to use the double exposure mode, check that the Duty cycle setting ($DCY) is 100% (or simply set it to100%)
related commands: $SRA, $DCY

$SOD <0,1> [<0,1>] [<0,1>] .. [<0,1>] *(up to 16 times)* or $SOD?

Select Output Data
Note: Command can be replaced by new command $SODX.
CAUTION
Use either SOD or SODX exclusively.

"Select Output Data" selects which of up to 16 data words are included in the output telegram.

Format: if 1 is sent as n-th parameter, the result word with index n is included in the output telegram. If the n-th parameter is 0, the result word with the according index is not included. The sensor provides up to 16 Data words, so the command string may contain up to 16 "0" or "1". When less than 16 parameters are sent, the words with higher indices will not be included in the telegram.
The result words with indices greater than 15 can't be included in the telegram by this command. If you want to include them, use the alternative command **$SODX** instead

In response to a query, the sensor always sends back the status of the 16 possible data words.

Indices and significations for the possible result words are

index	**mode 0:** 1 surface	**mode1:** 2 surfaces	**mode 2:** interferometric
(0)	**Distance 1**	**Thickness**	Thickness 1, best signal quality
(1)	not used	**Distance 1** (smaller)	Thickness 2, second best signal quality
(2)	not used	**Distance 2** (bigger)	Thickness 3, third best signal quality
(3)	**Intensity 1**	not used	Signal quality of signal with best quality
(4)	not used	**Intensity 1**	Signal quality of signal with second best quality
(5)	not used	**Intensity 2**	Signal quality of signal with third best quality
(6)	Pixelpos 1	Pixelpos 1	Intensity
(7)	not used	not used	not used
(8)	Bit0: SECOND_FIRST (In double-Exposure-Mode: 1: second(long)exposure or 0: First (short) exposure) Bit2: IGNOREDTRIGGER in trigger-each or external timing mode: Trigger pulse was ignored because it arrived too soon after preceding trigger pulse and there was already a delayed trigger pending. Bit3: DELAYEDTRIGGER in trigger-each or external timing mode: Trigger of the exposure was delayed with respect to the trigger pulse because it arrived too soon after preceding trigger pulse. Bit4: CCD_SATURATED Bit6: SHORTSYNCMARKERSENT: every 5 sec., the OC Sharp sends a shorter syncout pulse (10us) in order to allow synchronization with slave OC		

	Sharp. Bit7: SHORTSYNCMARKERRECEIVED: the OC Sharp detects a shorter (<12us) Sync-In pulse in order to allow for synchronization to another master OC Sharp Bit8: INDEX_INP_TOGGLE this Bit toggles with the rising edge of the signal on the Encoder0 Z input, thus permitting synchronization of the OC Sharp measurement data stream to external events Bit9: ALARM_LAMPLIFE The preprogrammed Lamp lifetime has been exceeded. You should consider changing the lamp Bit10..15: reserved
(9)	actual exposure time in units of 1/640000 sec
(10)	Encoder 0 Position, most significant word
(11)	Encoder 0 Position, least significant word
(12)	Encoder 1 Position, most significant word
(13)	Encoder 1 Position, least significant word
(14)	Encoder 2 Position, most significant word
(15)	Encoder 2 Position, least significant word
(16)	Sample counter
(17)	LED temperature

Example1: **$SOD1,0,0,1**[**CR**]
Response: **$SOD1,0,0,1**[**CR**]**ready**[**CR/LF**]
This example includes the output words Distance1 and Intensity1 in the output telegram

Example2: **$SOD?**
Response: **$SOD? 1,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0ready** [**CR/LF**]

Related commands: $SODX

$SODX <0 .. 17> [<0 .. 17>] ... [<0 .. 17>] (up to 16 times) **or $SODX?**

Select Output Data (extended)
CAUTION
Use either SOD or SODX exclusively (using SOD to query the setting will change the output telegram to a setting that can be represented by the SOD command).
The command gives access to additional output data items. SODX directly selects the data words that will be included in the output telegram by specifying their indices. (see table for $SOD command).
For example in mode 1 SODX 0,3,16 will output the distance, the intensity and the sample counter.

Example1: **$SODX0 3 16**[**CR**]
Response: **$SODX0 3 16**[**CR**]**ready**[**CR/LF**]

Example2: **$SODX?**
Response: **$SODX? 0, 3, 16ready**[**CR/LF**]

Related commands: $SOD

$SRA <3 .. 7, ?>

Scan Rate
selects the Scan Rate of the CCD-sensor by specifying an index

Index	Sample rate
3	32 Hz
4	100 Hz
5	320 Hz
6	1000 Hz
7	2000 Hz
8	3200 Hz
9	4000 Hz
127	Free sample rate selected by $SHZ command

The Index of 127 may not be specified as parameter, but may be received as response to a query. It signifies that a sample rate has been programmed by the $SHZ command. When querying the sample rate, the response not only contains the sample rate index, but also the corresponding frequency in Hz.
If the selected sample rate is not available (e.g. no valid dark reference stored), the string "**not valid**" is returned and the current sample rate is not changed
Any setting of the sample rate by the **$SRA** command will bring back the sensor to single exposure mode, i.e. set the duty cycle to 100% (cf. **$DCY** command).

Example1: **$SRA7**[**CR**]
Response: **$SRA7**[**CR**]**ready**[**CR/LF**]

Example2: **$SRA?**
Response: **$SRA 7 4000HZready**[**CR/LF**]

Example3: **$SRA?**
Response: **$SRA? 127 1235HZready**[**CR/LF**]
note: in example 3 the sample rate of 1235Hz has been programmed by the $SHZ command before

Related commands: $SHZ, $DCY

$SRI <1 .. 4, ?>

"Set Refractive Index" to correct display of thickness and correct dispersion model in measuring mode 2 and mode 3.
The parameter is given in floating point format.

Note
In order to obtain correct thickness values, the thickness results have to be multiplied (or divided in the case of interferometric measurements) by the refractive index in the user application according to the formula specified in the description of the SCA command! The SRI setting on the OC Sharp is responsible for the dispersion correction and a correct absolute value on the display. The thickness and position output values on the analogue outputs and the serial interface are still normalized to the respective full scale value and are only slightly affected by this parameter through the dispersion correction function (Abbe number).

CAUTION
Changing the refractive index may fail in interferometric mode (if the dispersion model calculation fails). Monitor the response in order to detect this situation and try other settings for CRA.

Example1: **$SRI1.465**[**CR**]
Response: **$SRI1.465**[**CR**]**ready**[**CR/LF**]

Example2: **$SRI?**
Response: **$SRI?1.465ready**[**CR/LF**]

Example3: **$SRI3.99**[**CR**]
Response: **$SRI3.99**[**CR**]**Error PrepInterfMODE=FFready**[**CR/LF**]

Related commands: $SRT, $CRA, $MOD, $ABE, $SCA

$SRT <0 .. 16, ?>

"Select Refractive index Table"
Instead of modelling the refractive index vs. wavelength function by a rather simple model based on n_d and the Abbe number v_d, the OC Sharp offers up to 15 different dispersion functions which are stored in the flash memory in tabular form. With $SRT command, one of these tables can be activated (the table corresponding to the parameter is selected).

One additional table can be uploaded in volatile memory and activated by the index 16. The following restriction applies to the volatile table: due to memory constraints, this volatile table has to be activated immediately after its upload (with the $LRT 16 command)

The parameter 0 deselects refractive index tables and instead enables the dispersion model based on n_d and the Abbe number v_d

If a selected table is not filled with valid data, the OC Sharp will default to the n_d/ v_d dispersion model. The user has to interpret the response of the OC Sharp to the $SRT command in order to know, if the selected setting was accepted and applied.

After the command the OC Sharp responds with the active table index and its name.

When an index table is active, the output values are normalized to a fixed reference refractive index value (as with the n_d/ v_d dispersion model, where n_d is the reference refractive index). This reference refractive index value is included in the table and has to be queried by the $SRI? command in order to scale the output values correctly.

Example1: **$SRT0**[**CR**]
Response: **$SRT0**[**CR**] **0: no table active**[**CR/LF**]**ready**[**CR/LF**]

Example2: **$SRT1**[**CR**]
Response: **$SRT1**[**CR**] **1:Silizium**[**CR/LF**]**ready**[**CR/LF**]

("Silizium" being the given table name, which can be up to 64 characters long)

Example3: **$SRT16**[**CR**]
Response: **$SRT16**[**CR**]**16:volatile user table**[**CR/LF**]**ready**[**CR/LF**]

Example4: **$SRT5**[**CR**]
Response: **$SRT5**[**CR**] **0: no table active**[**CR/LF**]**ready**[**CR/LF**]

(table 5 was not defined or corrupted)

Related commands: $LRT, $SRI, $ABE, $SCA, $MOD

$SSQ<byte0><byte1>

Synchronization sequence
Allows the user to set a new telegram start sequence.

The 2 bytes immediately following the command will be used to indicate the beginning of every new data telegram (in binary mode). These bytes must follow the command directly with no separation character in between and must not be sent in hexadecimal notation!
By default the sync sequence is 255, 255.
There can be a permanent ambiguity about the start of the telegram when using this default sequence and the last telegram value is an intensity and the sensor is in saturation. Under these circumstances, external data acquisition software will not be able to synchronize

safely and it is good practice to change the sync sequence.

The following table depicts this situation:

<table>
<tr><td>transmitted Byte</td><td>x</td><td>x</td><td>15</td><td>255</td><td>255</td><td>255</td><td>x</td><td>x</td></tr>
<tr><td>correct interpretation</td><td colspan="2">data val.</td><td colspan="2">intens. val.
(saturation)</td><td colspan="2">default sync
sequence</td><td colspan="2">data val. ,
new telegram</td></tr>
<tr><td>erroneous interpretation</td><td>x</td><td>x</td><td>x</td><td colspan="2">default sync
sequence</td><td colspan="2">data val. , new
telegram (wrong!)</td><td>x</td></tr>
</table>

Note
The custom sync sequence will not be memorized in non volatile memory
Example1: **$SSQ**#254#253 (note: #254#253 means the binary byte values 254 and 253)
Response: **$SSQ**#254#253**ready**[**CR/LF**]

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

$STA Start serial data output

This mode can be stored in the Eeprom. If stored the CHR will begin immediately to output data telegrams on the next powerup

Related commands: $STO

$STO Stop serial data output

This mode can be stored in the EEPROM, so on the next powerup the CHR will not begin to send measurement data until the output is restarted by the "STA" command

Related commands: $STA

$STS Status
Note
This command is obsolete as it gives only a fraction of all parameters
Reports some of the current settings with the following information:
"SRAx,MODx,SENx,SRCx,BIN/ASC,AVRx,AVDx,AVSx,SODx$_0$,x$_1$,...x$_{15}$,ANAx,x,x,x,x,x,SCAx"

For further explanation of the format details, look at the respective command description.
Example1: **$STS**
Response: **$STS SRA6,MOD0,SEN1,SRC0,BIN,AVR 40,AVD 40,AVS 1,SOD1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0ANA0, 0, 32767,3, 0, 4096,SCA 3000ready[CR/LF]**

$THR <0 .. 4094, ?> Threshold

Note

This command applies only to confocal modes!

It 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 CCD. Even though this signal is 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. However, this behavior doesn't disturb the averaging algorithm, as invalid results are excluded from averaging

Example1: **$THR35**[**CR**]
Response: **$THR35**[**CR**]**ready**[**CR/LF**]

Example2: **$THR?**
Response: **$THR?35ready**[**CR/LF**]

$TRE Trigger each

Trigger each mode. Every exposure will be started by a rising edge of the sync-in-input or by an encoder trigger event, if selected by the according **$ETR** command. The exposure time of the CCD is determined by the selected sample rate (**$SRA** or **$SHZ**).

Note

Because of technical reasons only half of the maximum measuring rate can be realized. A trigger pulse which does not fulfill this condition will be ignored.

Spectral and result averaging (AVS, AVD) is possible in Trigger Each mode: One Trigger pulse will start a sequence of AVS*AVD exposures. The timing of this exposure sequence is given by the sample rate setting. One (averaged) result will be output after the exposure sequence.

The command **$CTN** resumes normal operation.

Related commands: $TRG, $EXT, $ETR

$TRG Trigger

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). The "Wait for Trigger" state can also be left by sending "$$CTN".

CAUTION

This is the only situation, when sending a "$" restarts the sensor in all others states, "$" stops the sensor sending data. If you can't determine in which state the sensor is, sending "$$" to stop the sensor for sending a command resolves this ambiguity.
Related commands: $TRE, $EXT, $ETR

$TXG <0 … 7, -1, ?>

Transmit Buffer control: This setting controls the size of the internal transmit buffer of the sensor. It is never stored in the EEProm. In order to be compatible with previous firmware versions, the sensor always starts with the minimal buffer setting of 256 Bytes. For settings higher than 256 Bytes, the sensor supports RTS/CTS flow control over the USB link, which can be enabled on the PC-side when opening the port. (On the RS-232/422 connector, the hardware handshake lines are not connected, so the hardware handshake feature is not available for RS-232/422).
A parameter value of -1 flushes the transmit buffer immediately.

ATTENTION
Flushing can cause a part of the command echo to be flushed as well, so don't wait for the command echo!

parameter value	Transmit buffer size	Comment
0	256	default, legacy mode, no RTS/CTS control possible
1	512	RTS / CTS flow control can be used on USB
2	1024	RTS / CTS flow control can be used on USB
3	2048	RTS / CTS flow control can be used on USB
4	4096	RTS / CTS flow control can be used on USB
5	8192	RTS / CTS flow control can be used on USB
6	16384	RTS / CTS flow control can be used on USB
7	32768	RTS / CTS flow control can be used on USB
-1	–	flush current transmit buffer content
?	–	query transmit buffer size

Example: $TXB?
Response: $TXB? 0ready[CR/LF]
Example: $TXB-1[CR]
Response: $Tready[CR/LF] <- Command echo was partially killed by buffer flush, depending on timing

Answer: <current Buffer setting>
Comment: Set transmit buffer size, flush transmit buffer
Version: ≥ 5.97

$VER
Related commands: $IDE

Version
The command sends back an ASCII string which gives information on the serial number of the CHR (SN: …), the DSP software (DSPsoft: …) and the microcontroller software (C: …).
Example: **$VER**
Response: **$VER 73; C:V5.95/240909; DSPsoft:V5.95/160909ready**[**CR/LF**]

WHT<3141>

White reference

Note: Before taking a white reference, a fresh dark reference should be made!

Action takes place immediately after the command. That means that before sending this command the special white reference tool must be connected to the sensor!
The command may fail due to inappropriate intensity conditions. Therefore the response has to be monitored and if necessary the command has to be repeated after correcting the white reference tool reflectivity.

Example: **$WHT3141**[**CR**]
If successful:
Response: **$WHT3141**[**CR**] **Int. ok!** [**CR/LF**]**ready**[**CR/LF**]

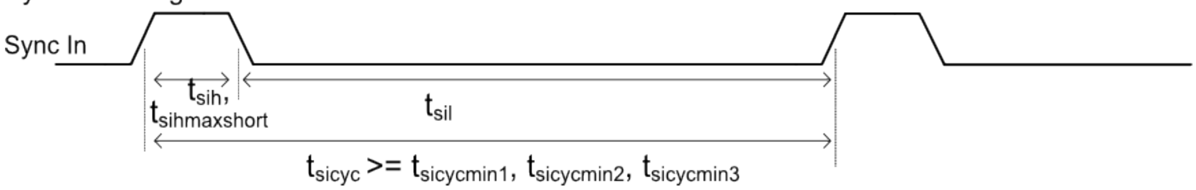
If not enough light:
Response: **$WHT3141**[**CR**] **Int. too weak!** [**CR/LF**]**ready**[**CR/LF**]

If too much light:
Response: **$WHT3141**[**CR**] **Int. too high!** [**CR/LF**]**ready**[**CR/LF**]

9.4 Timing

9.4.1 Sync Input

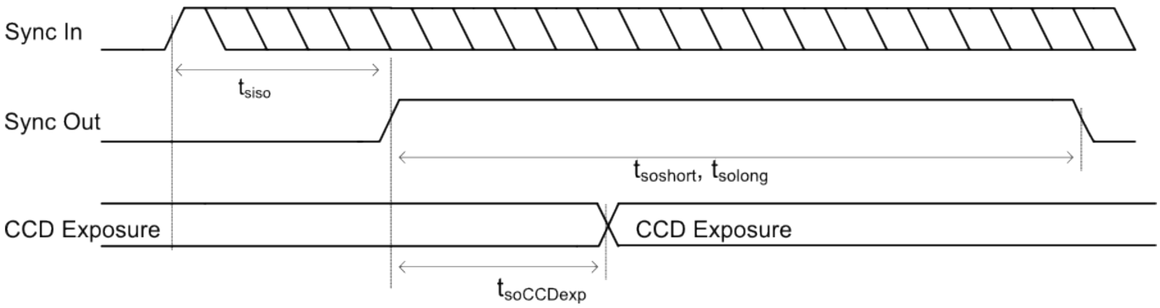
Sync In Timing



Symbol	Description	min. (µs)	typ. (µs)	max. (µs)
t_{sil}	Sync-in low	1		
t_{sih}	Sync-in high	0.1		
$t_{sihmaxshort}$	Sync-in high max for short Trigger pulse			12
t_{sicyc}	Sync-in min cycle	$t_{sicycmin}$		
$t_{sicycmin1}$	Sync-in min cycle for pulse recognition	2		
$t_{sicycmin2}$	Sync-in min cycle for valid trigger (ext. timing mode)	500		
$t_{sicycmin3}$	Sync-in min cycle for valid trigger (trigger each mode)	$t_{sample} + t_{tre\_wait}$		
t_{tre_wait}	wait time after end of exposure (Trigger each mode)	250		

9.4.2 Sync In – CCD Exposure – Sync Out

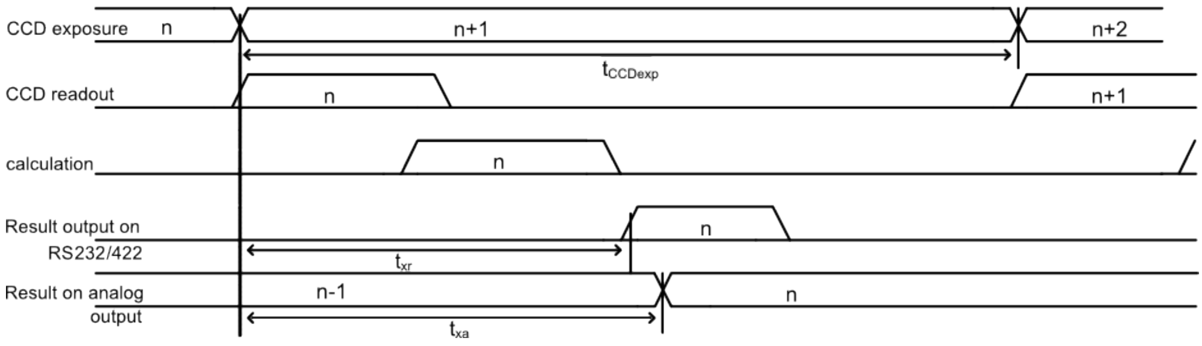
Sync In - CCD Exposure - Sync Out



Symbol	Description	min. (µs)	typ. (µs)	max. (µs)
t_{siso}	Delay Sync-in high to Sync-out high	1.2	1.4	1.6
$t_{soCCDexp}$	Delay Sync-out to start CCD exposure	2.6	2.8	3.0
$t_{soshort}$	Sync-out short pulse	10	10	10
t_{solong}	Sync-out long pulse	50	50	50

9.4.3 CCD Exposure to Result Output Timing

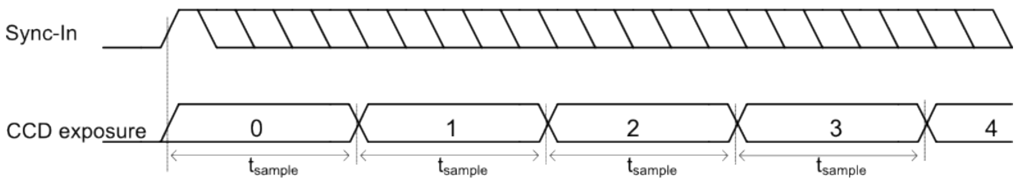
CCD Exposure to Result Output Timing



Symbol	Description	min.(µs)	typ.(µs)	max.(µs)
t_{CCDexp}	CCD exposure time	250		
t_{xr}	time from end of CCD-exposure to start result output	350	450	550
t_{xa}	time from end of CCD-exposure to analog out	550	550	550

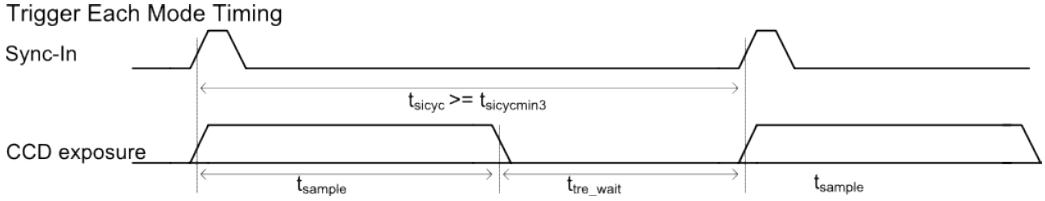
9.4.4 Normal Trigger Mode Timing

Normal Trigger Mode Timing



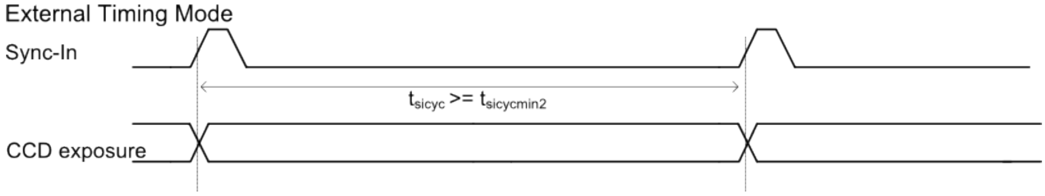
9.4.5 Trigger Each Mode Timing

Trigger Each Mode Timing



9.4.6 External Timing Mode

External Timing Mode



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