MICRO-EPSILON

Instruction Manual

optoNCDT 1402

ILD1402-5
ILD1402-10
ILD1402-20
ILD1402-50
ILD1402-100
ILD1402-200
ILD1402-250VT
ILD1402-400
ILD1402-600
ILD1402-5SC
ILD1402-10SC
ILD1402-20SC
ILD1402-50SC
ILD1402-100SC
ILD1402-200SC
ILD1402-250SC
ILD1402-600SC

Intelligent laser optical displacement measurement

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Certified acc. to DIN EN ISO 9001: 2008
Software-V1.003

Contents

1. Safety

Knowledge of the operating instructions is a prerequisite for sensor operation.

1.1 Symbols Used

The following symbols are used in this instruction manual:

⚠ CAUTION	Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.
NOTICE	Indicates a situation which, if not avoided, may lead to property damage.
➪	Indicates an user action.
i	Indicates an user tip.

1.2 Warnings

Avoid unnecessary laser exposure to the human body
- Turn off the sensor for cleaning and maintenance.
- Turn off the sensor for system maintenance and repair if the sensor is integrated into a system.

Caution - use of controls or adjustments or performance of procedures other than those specified may cause harm.

⚠ CAUTION

Connect the power supply and the display/output device in accordance with the safety regulations for electrical equipment.
> Danger of injury, damage to or destruction of the sensor

The power supply may not exceed the specified limits.
> Danger of injury, damage to or destruction of the sensor

NOTICE

Avoid shock and vibration to the sensor.Damage to or destruction of the sensor

Avoid continuous exposure to fluids.
> Damage to or destruction of the sensor

Avoid contact with aggressive materials (washing agent, penetrating liquids or similar).
> Damage to or destruction of the sensor

1.3 CE Compliance

The following applies to the optoNCDT1402: EMC regulation 2004/108/EC

Products which carry the CE mark satisfy the requirements of the EMC regulation 2004/108/EC 'Electromagnetic Compatibility' and the European standards (EN) listed therein. The EC declaration of conformity is kept available according to EC regulation, article 10 by the authorities responsible at

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The sensor is in compliance with the following standards
- EN 61 326-1: 2006-10
- DIN EN 55011: 2007-11 (Group 1, class B)
- EN 61000-6-2: 2006-03

The sensor fulfills the specification of the EMC requirements, if the instructions in the operating manual are followed.

1.4 Proper Use

- The series optoNCDT1402 measuring system is designed for use in industrial areas.
- It is used
  - for measuring displacement, distance, position and thickness
  - for in-process quality control and dimensional testing
- The measuring system may only be operated within the limits specified in the technical data, see Chap. 3.3, see Chap. 3.4.
- The sensor should only be used in such a way that in case of malfunctions or failure personnel or machinery are not endanged.
- Additional precautions for safety and damage prevention must be taken for safety-related applications.

1.5 Proper Environment

- Protection class sensor: IP 67 (IP 69K [1] for ILD1402SC)

1) Temperature of the cleaning agent temporarily 80 °C

- Optical surfaces are excluded from protection class. Contamination of the lenses leads to impairment or failure of the function.
- Operating temperature: 0 to +50 °C (+32 to +122 °F)
- Storage temperature: -20 to +70 °C (-4 to +158 °F)
- Humidity: 5 - 95 % (no condensation)
- Pressure: atmospheric pressure
- EMC: According to EN 61 326-1: 2006-10
  DIN EN 55011: 2007-11 (Group 1, class B)
  EN 61000-6-2: 2006-03

The protection class is limited to water (no penetrating liquids or similar)!

2. Laser Class

The sensors operate with a semiconductor laser with a wavelength of 670 nm (visible/red). The laser emits a permanent beam. The maximum optical power is ≤ 1 mW. The sensors are classified for Laser Class 2 (II).

The laser warning labels for Germany have already been applied. Those for other non German-speaking countries an IEC standard lable is included in delivery and the versions applicable to the user's country must be applied before the equipment is used for the first time.

Attach the following warning labels on the sensor housing front side:

IEC label Only for USA

If both warning labels are disguised in operation mode the user must add additional warning labels.

During operation of the sensor the pertinent regulations acc. to IEC 60825-1: 2007 on „radiation safety of laser equipment“ must be fully observed at all times. The sensor complies with all applicable laws for the manufacturer of laser devices.

⚠ CAUTION

Do not look directly into the laser beam! Possible injury of the eyes. Close your eyes or turn away promptly if laser radiation strikes your eyes.

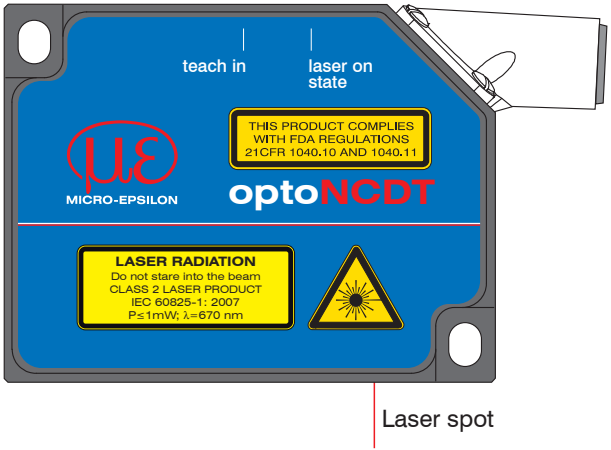


Fig. 1 True reproduction of the sensor with its actual location of the warning labels

Laser operation is indicated by LED.

Although the laser output is low looking directly into the laser beam must be avoided. Due to the visible light beam eye protection is ensured by the natural blink reflex.

The housing of the optical sensors optoNCDT1402 may only be opened by the manufacturer, see Chap. 14.. For repair and service purposes the sensors must always be sent to the manufacturer.

3. Functional Principle, Technical Data

3.1 Functional Principle

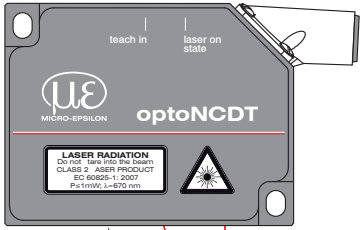
The sensor uses the principle of optical triangulation, i.e. a visible, modulated point of light is projected onto the target surface.

The diffuse element of the reflection of the light spot is imaged by a receiver optical element positioned at a certain angle to the optical axis of the laser beam onto a high-sensitivity resolution element (CCD), in dependency on distance.

The controller calculates the measured value from the CCD-array. An internal closed-loop control enables the sensor to measure against different surfaces.

A LED on the sensor indicates:

- In range
- Out of Range (upper and lower range values), poor target (unfit or no object)
- Mid range



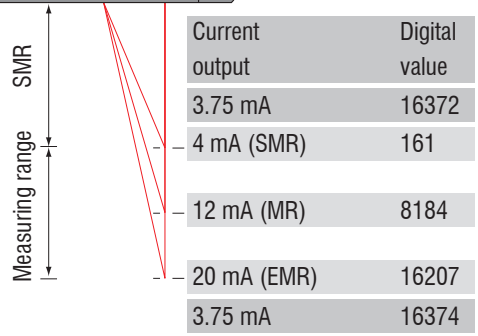


Fig. 2 Definiton of terms, output signal

SMR = Start of measuring range | MR = Midrange | EMR = End of measuring range

3.2 Functions

3.2.1 Fitting the Measurement Range

The analog measuring range can be reduced with aid of the “Teach“ function, see Chap. 6.2. This enables you to scale only a part of the measuring range to the full scale current output. Thus the resolution of analog evaluation systems like displays or PLCs will be used better.

3.2.2 Exposure Control

Dark or shining objects to be measured may require a longer exposure time. However, the controller is not capable of providing exposure which is any longer than permitted by the measurement rate. For a longer exposure time, therefore, the measurement rate of the sensor has to be reduced, see Chap. 6.4, by command.

3.2.3 Peak Select

For measurements on mirroring or transparent surfaces like glass plates or plastic layers spurious reflections from the front or rear side can be suppressed by command, see Chap. 8.4.17.

3.2.4 Trigger, Time-based Measurement Value Output

Single measurements can be output via the trigger input. You can also output the measurements in a programmable timing period, see Chap. 8.4.12.

3.2.5 Error Behavior

The sensor may replace or hold up to 99 consecutive errors by the last valid value. In addition, all error values at the analog output can be replaced by the last valid value.

Details about the behaviour of the analog output, see Chap. 8.4.13.

3.2.6 Averaging

The sensor enables an averaging of the measured values with the median or moving average, before they are output. This does not reduce the measurement rate.

3.2.7 Sensor Emulation (Compatibility)

For a replacement or retrofitting, the ILD1402 can also be operated in the configuration of the previous type ILD1401. This reduces the data word width of 14 to 12 bit and the functions of the ILD1401 are usable only.

3.2.8 Command Compatibility

The sensor ILD1402 uses the same commands (Stop, Info, etc.) for the same functions as the type ILD1700. This means that existing programs of the ILD1700 can be easily adapted.

More informations, see Chap. 8.4.4.

3.2.9 Video Signal

The sensor can use different peaks in the CCD array for displacement measuring.

This function is auxiliary, if the sensor measures against glass or transparent targets, see Chap. 8.4.17 also.

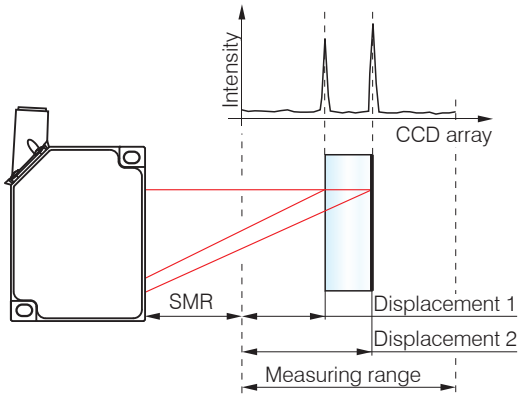
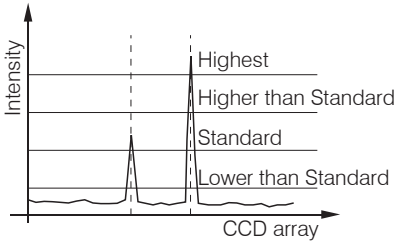


Fig. 3 Video signal

3.2.10 Programmable Search Threshold

The sensor can use different thresholds to detect a valid peak in the CCD array for displacement measuring.



Parameters, see Chap. 8.4.18 (for parameter setting):

- lower than standard
- Standard
- higher than standard
- highest

i Changing the threshold from factory default (standard) may influence linearity and resolution.

3.3 Technical Data ILD 1402-x

Model	ILD	1402-5	1402-10	1402-20	1402-50	1402-100	1402-200	1402-250VT	1402-400	1402-600
Measuring range	mm	5	10	20	50	100	200	250	400	600
Start of range	mm	20	20	30	45	50	60	100	200	200
Midrange	mm	22,5	25	40	70	100	160	225	400	500
End of range	mm	25	30	50	95	150	260	350	600	800
Linearity	µm	5 ... 9	5 ... 18	7 ... 36	12 ... 90	20 ... 180	40 ... 360	50 ... 1200	120 ... 2000	120 ... 3000
		≤ 0.18 % FSO						≤ 0.5 % FSO		
Resolution	Averaged over 64 values, µm	0.6	1	2	5	10	13	32	80	80
	dynamic, µm	1 ... 3	2 ... 5	5 ... 10	6 ... 25	12 ... 50	13 ... 100	32 ... 300	80 ... 480	80 ... 600
	1.5 kHz	0.02 ... 0.05 % FSO						0.02 ... 0.12 % FSO		
	digital	14 bit								
Measurement rate, programmable		1.5 kHz; 1 kHz; 750 Hz; 375 Hz; 50 Hz								
Light source		Semiconductor laser 1 mW, 670 nm (red)								
Laser class		Class 2 (II) acc. to IEC 60825-1: 2007								
Spot diameter	SMR, µm	110	110	210	1100	1400	2300	5000	2.6 x 5 mm	2.6 x 5 mm
	MR, µm	380	650	530	110	130	2200	5000	2.6 x 5 mm	2.6 x 5 mm
	EMR, µm	650	1200	830	1100	1400	2100	5000	2.6 x 5 mm	2.6 x 5 mm
Protection class		IP 67								
Vibration		15 g / 10 Hz ... 1 kHz						20 g / 10 Hz ... 1 kHz	15 g/ 10 Hz ... 1 kHz	
Shock		15 g / 6 ms (DIN EN 60068-2-29)								
Weight (without cable)		approx. 83 g						approx. 130 g		
Temperature stability		0.03 % FSO/°C				0.08 % FSO/°C				
Operation temperature		0 ... 50 °C								

Model	ILD	1402-5	1402-10	1402-20	1402-50	1402-100	1402-200	1402-250VT	1402-400	1402-600
Storage temperature		-20 °C ... 70 °C								
Measurement value output	analog	4 ... 20 mA 12 bit (1 ... 5 V with cable PC 1402-3/U) or								
	digital	RS422								
Supply		11 ... 30 VDC, typical 24 VDC / 50 mA								
Controller		integral signal processor								
Elektromagnetic compatibility (EMC)		EN 61 326-1: 2006-10 DIN EN 55011: 2007-11 (Group 1, class B) EN 61000-6-2: 2006-03								

The specified data apply to a white, diffuse reflecting surface (Reference: Ceramic).
FSO = Full Scale Output
SMR = Start of measuring range MMR = Midrange EMR = End of measuring range
ILD1402-250VT: 20 g, especially shock and vibration-resistant design for use on motor vehicles

3.4 Technical Data ILD 1402-xSC

Model	ILD	1402-5SC	1402-10SC	1402-20SC	1402-50SC	1402-100SC	1402-200SC	1402-250SC	1402-600SC
Measuring range	mm	5	10	20	50	100	200	250	600
Start of measuring range	mm	20	20	30	45	50	60	100	200
Midrange	mm	22.5	25	40	70	100	160	225	500
End of measuring range	mm	25	30	50	95	150	260	350	800
Linearity	µm	5 ... 9	5 ... 18	7 ... 36	12 ... 90	20 ... 180	40 ... 360	50 ... 1200	120 ... 3000
	% FSO	≤ 0.18						≤ 0.5	
Resolution [1]	averaged with averaging factor 64	0.6 µm	1 µm	2 µm	5 µm	10 µm	13 µm	32 µm	80 µm
		0.01% d.M.							
	dynamic 1.5 kHz	1 ... 3 µm	2 ... 5 µm	5 ... 10 µm	6 ... 25 µm	12 ... 50 µm	13 ... 100 µm	32 ... 300 µm	80 ... 600 µm
		0.02 ... 0.05 % FSO						0.02 ... 0.12 % FSO	
Measuring rate, programmable		1.5 kHz; 1 kHz; 750 Hz; 375 Hz; 50 Hz							
Exposure rate, programmable		0.6 ms; 1 ms; 1.3 ms; 2.6 ms; 20 ms							
Light source		Semiconductor laser < 1 mW, 670 nm (red)							
Laser safety class		Class 2 IEC 60825-1: 2007							
Spot diameter	MBA, µm	110	110	210	1100	1400	2300	5000	2.6 x 5 mm
	MBM, µm	380	650	530	110	130	2200	5000	2.6 x 5 mm
	MBE, µm	650	1200	830	1100	1400	2100	5000	2.6 x 5 mm
Protection class		IP 69 K							
Vibration		15 g / 10 Hz …1 kHz						20 g / 10 Hz ... 1 kHz	
Shock		15 g / 6 ms (IEC 60068-2-29)							

Model	ILD	1402-5SC	1402-10SC	1402-20C	1402-50SC	1402-100SC	1402-200SC	1402-250SC	1402-600SC
Weight (without cable)		approx. 173 g						180 g	
Temperature stability	FSO/°C	0.03 %				0.08 %			
Operation temperature		0 … +50 °C							
Storage temperature		-20 ... +70 °C							
Output	analog	4...20 mA (1...5 V with cable PC 1402-3/U); free scalable within the normal range							
	digital	RS422 / 14 bit							
Control I/O		1x open collector output (switching output, switch, error); 1x input (trigger)							
Power supply		11...30 VDC, 24 VDC / 50 mA							
Controller		Integrated signal processor							
Software		Free setup and aquisition tool + SDK (software development kit)							
Electromagnetic compatibility (EMC)		EN 61 326-1: 2006-10 DIN EN 55011: 2007-11 (Group 1, class B) EN 61000-6-2: 2006-03							

FSO = Full scale output All specifications apply for a diffusely reflecting matt white ceramic target
1) Resolution digital output 14 bit
SMR = Start of measurement range; MMR = Midrange; EMR = End of measuring range

3.5 Control and Indicator Elements ILD 1402-x

LED State	Color
Measuring object within measurement range	green
Midrange	yellow
Error - e.g. poor target or out of range	red
Laser turned off	off

The touch key “select” is used to scale the sensor [1]. By factory default this key is only active for the first 5 minutes after the power up. After that it will be automatically locked. Via the software tool the auto lock feature can be disabled. With the select key you spread the analog output over a part of the nominal measuring range.

1) The sensor ILD 1402-xSC is fitted without a touch key. The scaling of the sensor measuring range is exclusively effected by software via the RS422 interface.

4. Delivery

4.1 Scope of Delivery

1 Sensor optoNCDT1402

1 Assembly instructions

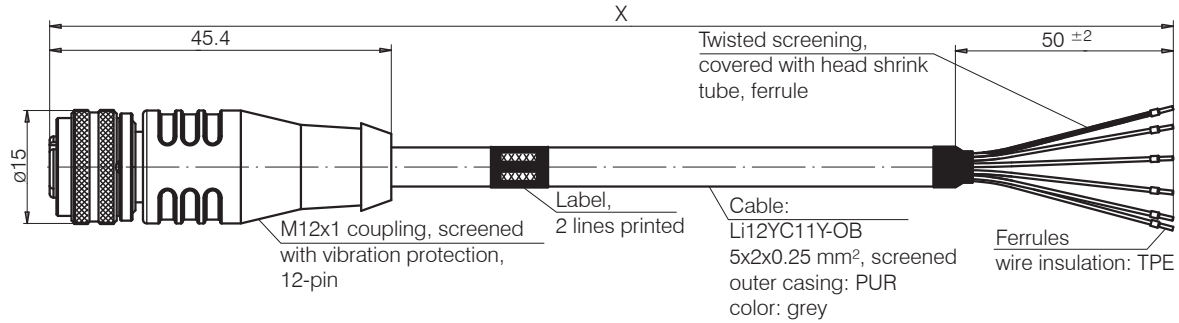
5 Sealing screws for connector

1 CD with driver and demo program

Optional accessory, packed separately:

- 1 PC1402-x/I cable carriers suitable interface and supply cable for current output, one end of the cable has a molded M12 female connector, the other end has free leads with ferrules.
- 1 PC1402-x/U cable carriers suitable interface and supply cable for voltage output (250 Ohm load, U_{out} = 1 … 5 V), one end of the cable has a molded M12 female connector, the other end has free leads with ferrules.

A full list of all available cables, see Chap. 17..



➡ Check for completeness and shipping damage immediately after unpacking. In case of damage or missing parts, please contact the manufacturer or supplier.

4.2 Storage

Storage temperature: -20 up to +70 °C (-4 to +158 °F) Humidity : 5 - 95 % (no condensation)

5. Installation and Mounting

The sensor is an optical sensor for measurements with micrometer accuracy.

Make sure it is handled carefully when installing and operating.

5.1 Sensor Mounting ILD 1402-x

- Mount the sensor via 2 screws M4.
- Mount the sensor in such a way that the laser beam is directed perpendicularly onto the surface of the target. In case of misalignment it is possible that the measurement results will not always be accurate, see Chap. 9.. also.

Minimum bending radius PC1402-x

- once: 39 mm
- continuous: 78 mm
- cable ø PC 1402-x: 8 mm

Rotate the connector:

- Loosen the 4 screws M2 and rotate the male connector.
- Fasten the male connector. Use new sealing screws M2. Connector is sealed (IP 67) waiting 12 hours.

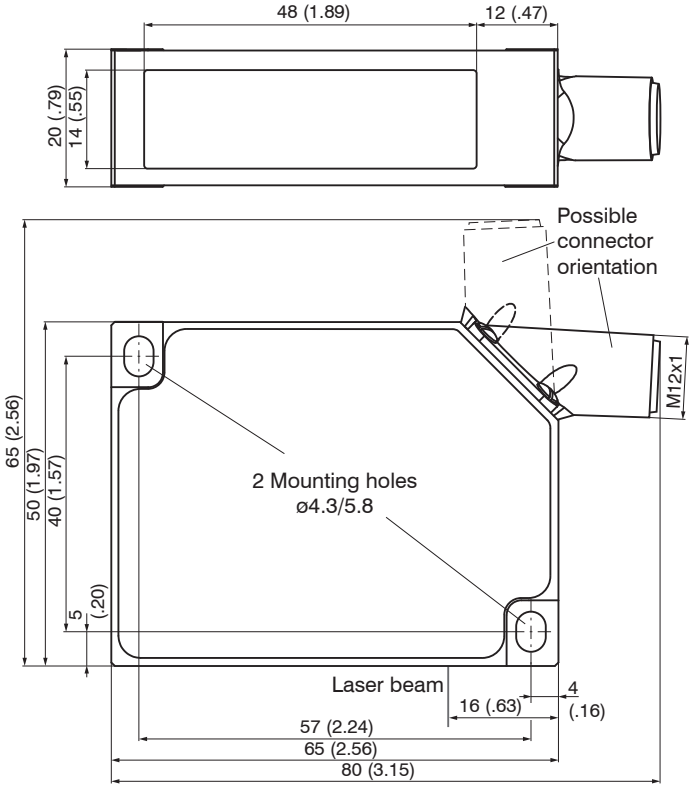


Fig. 4 Dimensional drawing ILD1402-x, dimensions in mm (inches), not to scale

5.2 Sensor Mounting ILD 1402-xSC

- Mount the sensor via 2 screws M4.
- Mount the sensor in such a way that the laser beam is directed perpendicularly onto the surface of the target. In case of misalignment it is possible that the measurement results will not always be accurate, see Chap. 9. also.

Minimum bending radius PC1402-xSC

- once: 39 mm
- continuous: 78 mm

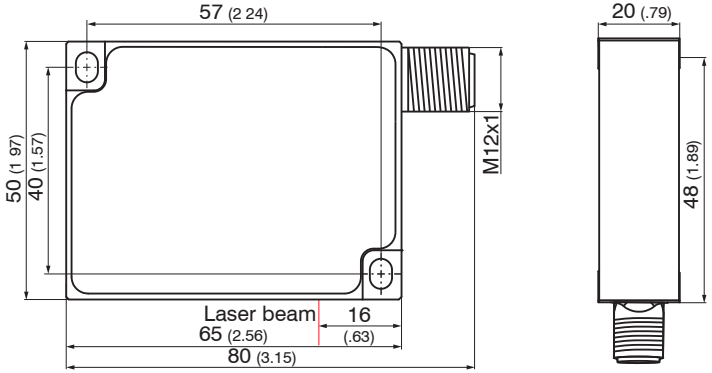


Fig. 5 Dimensions ILD1402-xSC, dimensions in mm (inches), not to scale

5.3 Pin Assignment ILD 1402-x

Pin	Description		Color code PC1402-x/I	Specification
3	RS422 Rx+	Serial input	green	Internally terminated with 120 Ohm
4	RS422 Rx-		yellow	
5	RS422 Tx+	Serial output	grey	Terminate externally with 120 Ohm
6	RS422 Tx-		pink	
7	$+U_B$		red	11 ... 30 VDC, typical 24 VDC / 50 mA
8	Laser off	Switch input	black	Laser is active, if pin 8 is connected with GND
9	Teach in		violet	Connected to GND for at least 30 ms
10	Error	Switch output	brown	Open-Collector (NPN), I_{max} = 100 mA, U_{max} = 30 VDC, short circuit proof, turn off the power supply to reset the short circuit protection
11	I_{OUT}	4 ... 20 mA	white	R_{Load} = 250 Ω results U_{OUT} 1 ... 5 V with U_B > 11 V R_{Load} = 500 Ω results U_{OUT} 2 ... 10 V with U_B > 17 V
12	GND		blue	Supply and signal ground
1/2	n.c.			

The shield of the cable is connected with the housing of the connector. The supply and output cable PC1402-x/I is cable carriers suitable.
One end of the cable has a molded M12 female connector, the other end has free leads with ferrules.

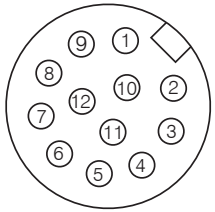


Fig. 6 Front view male sensor connector

5.3.1 Switching off the Laser

➡ Connect pin 8 with pin 12 to switch on the laser.

If you open this connection
- the laser switches off,
- the error output switches on,
- the “State“ LED switches off.

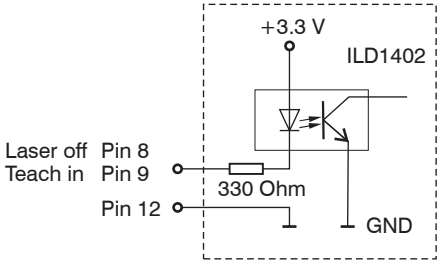


Fig. 7 Circuit for laser off, analog scaling and trigger input

5.3.2 Input for Analog Scaling and Triggering

If pin 9, see Fig. 7, is selected as input to scale the analog output in the sensor configuration, see Chap. 8.4.16, and if pin 9 is connected with pin 12 more than 2 sec, the scaling of the analog output starts, see Chap. 6.2. The minimum pulse duration is 30 ms, see Fig. 14.

This external input can be configured as a trigger input to output the measurements also. If pin 9 is connected with pin 12 measurements are output at the serial or analog output. The maximum trigger frequency is 500 Hz.

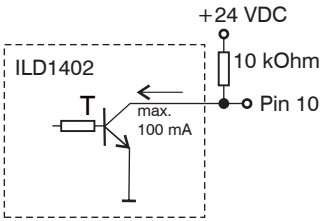
Trigger conditions:

Wiring	connect with ground, e.g. a relay or open-collector (NPN)

5.3.3 Error Output ILD1402-x

The error message is generated by:

- no measuring object or measuring object beyond measuring range
- poor target (reflectivity to small, transparent or mirroring object) or laser off



$U_{CE\ max.}$ = 30 VDC

No error: T locked

Error: T conductive

The error output is low-active and short circuit proof.

Fig. 8 External wiring for the error output

i With a user defined output scaling, see Chap. 6.2, you can use the hysteresis-free error output as a programmable limit switch.

5.4 Pin Assignment ILD 1402-xSC

Pin	Description		Color code PC1402SC-x/I PC1402SC/90-x/I	Specification
1	I_{OUT}	4 ... 20 mA	white	R_{Load} = 250 Ω results U_{OUT} 1 ... 5 V with U_B > 11 V R_{Load} = 500 Ω results U_{OUT} 2 ... 10 V with U_B > 17 V
2	Error	Switch output	brown	Open-Collector (NPN), I_{max} = 100 mA, U_{max} = 30 VDC, short circuit proof, Turn off the power supply to reset the short circuit protection.
3	RS422 Rx+	Serial input	green	Internally terminated with 120 Ohm.
4	RS422 Rx-		yellow	
5	RS422 Tx+	Serial output	grey	Terminate externally with 120 Ohm.
6	RS422 Tx-		pink	
7	GND		blue	Supply and signal ground
8	$+U_B$		red	11 ... 30 VDC, typ. 24 VDC / 50 mA
-	Twisted screening		black	---

The laser is active in the sensor, if the power supply at the sensor is on.

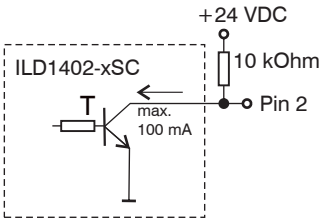
The shield of the cable is connected with the housing of the connector. The supply and output cable PC1402-xSC/I is cable carriers suitable.
One end of the cable has a molded M12 8-pole female connector, the other end has free leads with ferrules.

Fig. 9 Pin side male sensor connector

Error Output ILD1402-xSC

The error message is generated by:

- no measuring object or measuring object beyond measuring range
- poor target (reflectivity to small, transparent or mirroring object) or laser off



$U_{CE\ max.}$ = 30 VDC

No error: T locked

Error: T conductive

The error output is low-active and short circuit proof.

Fig. 10 External wiring for the error output

With a user defined output scaling, see Chap. 6.2, you can use the hysteresis-free error output as a programmable limit switch.

5.5 Pin Assignment for RS422 Interface

The lines have to be crossed for the connection between sensor and PC.

Sensor	Terminal (USB converter)	Colors PC1402-x/I
Tx+ (Pin 5)	Rx+ (Pin 3)	grey
Tx - (Pin 6)	Rx - (Pin 4)	pink
Rx+ (Pin 3)	Tx+ (Pin 2)	green
Rx - (Pin 4)	Tx - (Pin 1)	yellow
GND (Pin 12, 7 [1])	GND (Pin 5)	blue

Disconnect or connect the D-sub connection between RS422 and USB converter when the sensor is disconnected from power supply only.

1) For ILD1402-xSC sensors

6. Operation

6.1 Getting Ready for Operation

➥ Install and assemble the optoNCDT1402 in accordance with the instructions set out, see Chap. 5.1 and connect it with the indicator or monitoring unit and the power supply, having full regard to the connection instructions set out, see Chap. 5.3.

The laser diode in the sensor ILD 1402-x can only be activated if
- the input “Laser on/off“ (Pin 9) or
- the black wire in the PC1402 sensor cable

is connected to GND.

The laser diode in the sensor ILD 1402-XSC is activated automatically with applying the operating voltage.

Once the operating voltage has been switched on the sensor runs through an initialization sequence. The sensor ILD 1402-x indicates this by the momentary activation of the “State” LED. If initialization has been finished, the sensor transmits the info string once in ASCII format via the serial interface independent of the selected interface. The initialization including the info string transmission takes up to 5 seconds. Within this period, the sensor neither executes nor replies commands.

To be able to produce reproducible measurements the sensor typically requires a start-up time of 15 minutes.

Once this has elapsed the sensor will be in measurement mode and, in accordance with the factory settings, only the “State“ LED on ILD 1402-x sensor is illuminated.

If the “State“ LED on the sensor ILD 1402-x is off, this means that
- either there is no operating voltage or
- the laser has been switched off.

Operating Voltage
- Nominal value: 24 VDC (11 ... 30 V, max. 50 mA).
- Use the power supply unit for measurement instruments only, and not for drive units or similar sources of pulse interference at the same time.

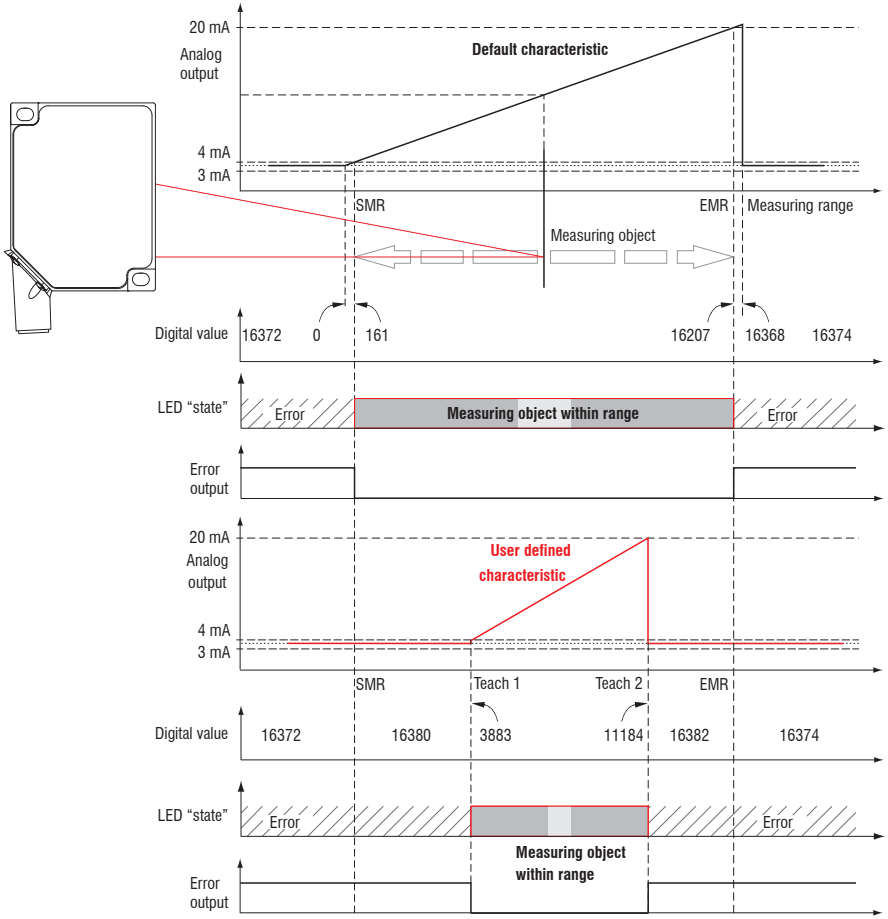
➥ Switch on the power supply unit, if wiring is done.

6.2 Output Scaling

The “teaching” scales the analog output (4 to 20 mA) for a part of the measuring range. This allows you to optimize the resolution for the analog measurement range. Only the current and error output will be affected by the 2 point calibration. Therefore you define a new start and end for the measurement range. This “teaching” procedure can be performed live via the select key or via pin 9 of the connector.

i With a user defined output scaling you can use the error output, see Chap. 5.3.3, as a programmable limit switch.

i Output scaling with the sensor ILD1402-xxxSC is only possible via the serial interface.



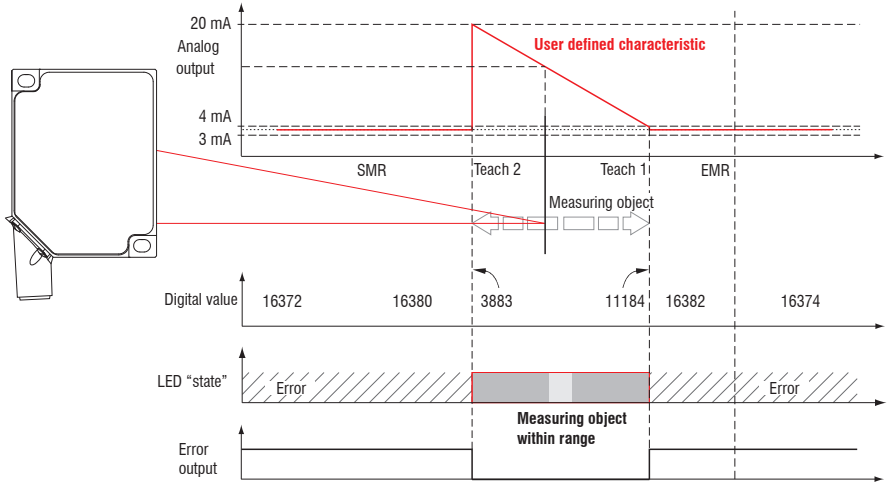


Fig. 11 Reverse user defined characteristic

The minimum distance of the teach values 1/2 to one other is 10 % of the measurement range.

The teaching process requires a valid measuring signal. The teaching process is terminated at „no target“, „target not evaluated“, „to close to the sensor“ - beyond SMR“ or „to far from the sensor - beyond EMR“.

6.2.1 Output Scaling via the “Select“ Key

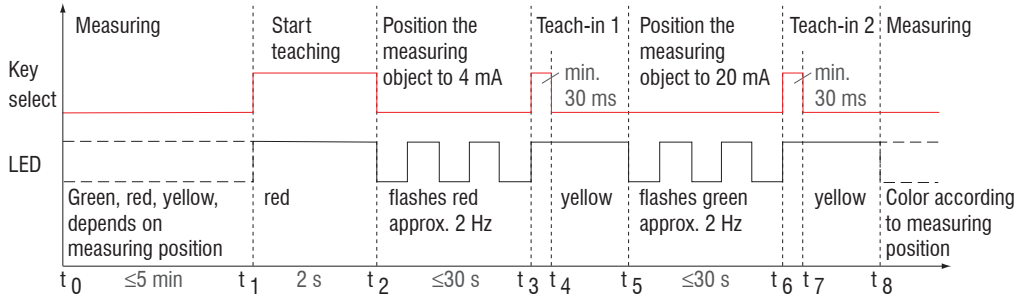


Fig. 12 Timing for the output scaling

The scaling is also available via the software tool.

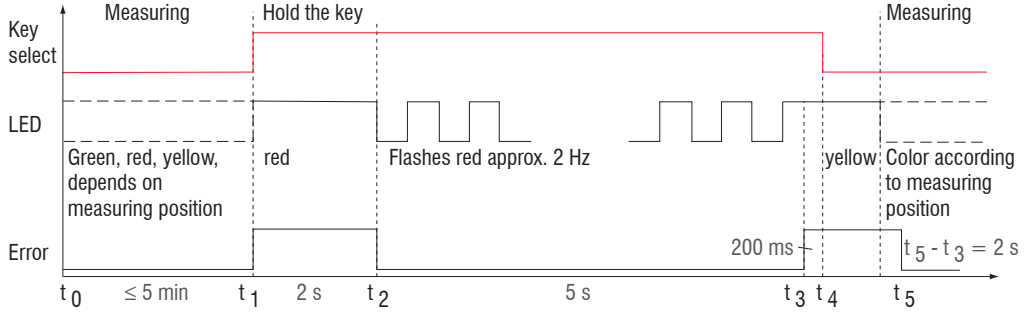


Fig. 13 Timing for the reset of the output scaling

The output scaling with ILD1402SC is only possible via the serial interface.

6.2.2 Output Scaling via the Hardware Input, “Teach in“

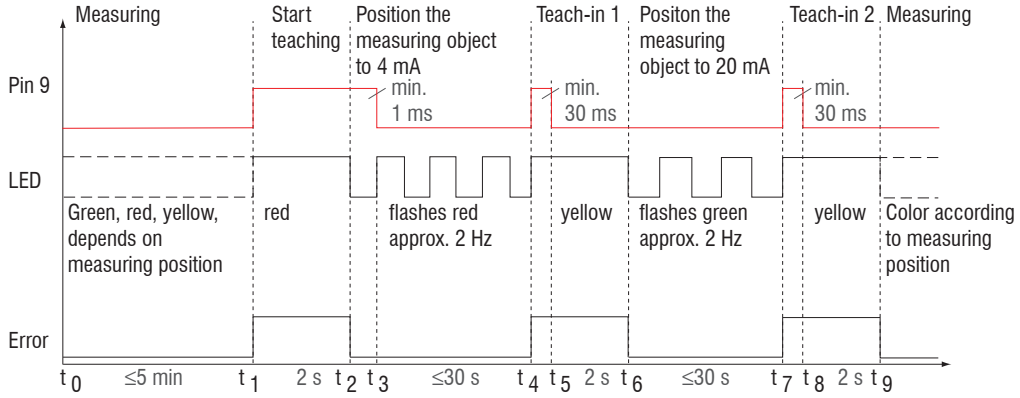


Fig. 14 Timing for the output scaling

The scaling is also available via the software tool.

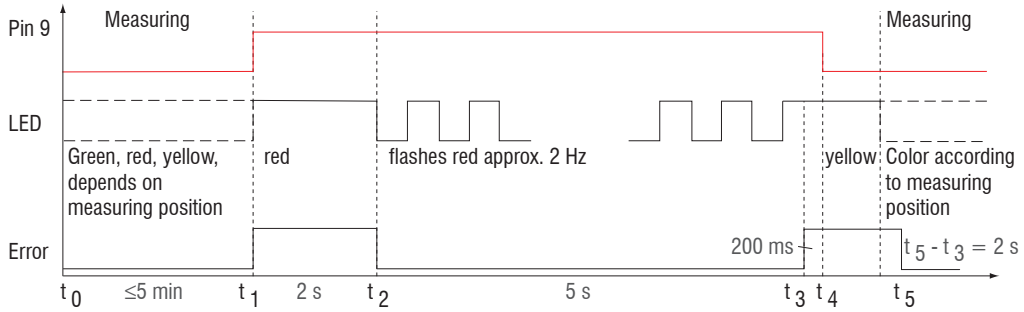


Fig. 15 Timing for the reset of the output scaling

The output scaling with ILD1402SC is only possible via the serial interface.

6.3 Average

The optoNCDT1402 is supplied ex factory with the default setting „moving averaging, number of averaging N = 1“ (no averaging activated).

Implemented averaging methods in the sensor:
- Moving average
- Median

The purpose of averaging is to:
- Improve the resolution
- Eliminate signal spikes
- “Smooth out“ the signal.

Averaging has no effect on linearity. A combination of the two averaging methods is not possible. The averaging is recommended for static measurements or slowly changing measurement values.

6.3.1 Averaging Number N

In every measurement cycle (at a measurement rate of 1.5 kHz every 0.66 ms) the internal average is calculated anew. The averaging number N indicates the number of consecutive measurement values to be averaged in the sensor.

Averaging does not affect the measurement rate or data rates in digital measurement value output.

6.3.2 Moving Average (Default Setting)

The selected number N of successive measurement values (window width) is used to generate the moving average value M_{gl} on the basis of the following formula:

$$M_{gl} = \frac{\sum_{k=1}^{N} MW(k)}{N}$$

MW = Measuring value,
N = Averaging number,
k = Running index
M_{gl} = Averaging value respectively output value

Mode:

Each new measurement value is added and the first (oldest) measurement value from the averaging process (from the window) taken out again. This results in short transient recovery times for jumps in measurement values.

Example: N = 4

... 0, 1, 2, 2, 1, 3	... 1, 2, 2, 1, 3, 4	Measurement values
$\frac{2, 2, 1, 3}{4} = M_{gl}(n)$	$\frac{2, 1, 3, 4}{4} = M_{gl}(n+1)$	Output

The moving average in the optoNCDT1402 can only be generated for up to a maximum of 128 values.

6.3.3 Median

The median is generated from a pre-selected number of measurement values. To do so, the incoming measurement values (3, 5, 7 or 9 measurement values) are resorted again after every measurement. The average value is then given as the median. In generating the median in the controller, 3, 5, 7 or 9 measurement values are taken into account, i.e. there is never a median of 1. This permits individual interference pulses to be repressed, but the measurement value curve is not smoothed to any great extent.

Example: Average from five measurement values

... 0 1 2 4 5 1 3	→ Sorted measurement values: 1 2 **3** 4 5	$Median_{(n)} = 3$
... 1 2 4 5 1 3 5	→ Sorted measurement values: 1 3 **4** 5 5	$Median_{(n+1)} = 4$

6.4 Measurement Rate and Output Rate

The measurement rate defines the number of measurements performed by the sensor per second. The measurement rate may be 1.5 kHz, 1.0 kHz, 750 Hz, 375 Hz or 50 Hz. Details of how to change the measurement rate, see Chap. 8.4.15.

The output rate gives the actual number of measurement values at the sensor output per second. The maximum output rate can never exceed the measurement rate.

Recommendations:
- Use a high measurement rate for light colored and matt objects to be measured.
- Use a low measurement rate for dark or shiny objects to be measured (e.g. surfaces covered in black lacquer), for better measurement results.

Output	Maximum output rate
Current	Measurement rate
RS422	Output rate ≤ Measurement rate; Dependent on the transmission rate (baud rate) and data format (ASCII code).

The sensor continues to measure internally but holds back the output until the last measurement value has been issued in full. The next measurement value is the last valid value, with other values between being lost.

Fig. 16 Output rates for the output types

Calculation of the output rate using the RS422 serial interface:

Output rate = Measuring rate / n

n = int (b * 10 * MR / BR) + 1

Abbreviations used:
n = Partial factor
int = Integral part of ( )
b = Byte/measurement value (binary format b=2, ASCII b=6)
MR = Measurement rate [Hz]
BR = Baud rate [Baud]

Example:
Measurement rate = 750 Hz, ASCII-Format (b=6), Baud rate = 115200 Baud
--> n = int (0.39) + 1 = 1
--> Output rate = 750 Hz / 1 = 750 Hz.

6.5 Timing

The controller operates internally with real time cycles in a pipeline mode:

1. Exposure: Charging the image detector in the receiver (measurement).
2. Reading: Reading out of the imaging device and converting into digital data.
3. Computation: Measurement computation.
4. Controlling.

The output through the analog and digital interface starts with the beginning of every new cycle. The analog value and digital switch outputs are updated immediately and the digital output starts with the start bit.

Each cycle takes 666 µs at a measuring rate of 1.5 kHz. The measured value N is available after each cycle with a constant lag of four cycles in respect to the real time event. The delay between the input reaction and the signal output is therefore 2 up to 2.7 ms. The processing of the cycles occurs sequentially in time and parallel in space (pipelining, see Fig. 17). This guarantees a true constant real time data stream.

Cycle		1.	2.	3.	4.	5.	6.	
Time	max. 5 s	666 µs	1322 µs	1998 µs	2664 µs	3330 µs	3996 µs	
	Initialisation including the output of the info string	Exposure N	Reading N	Computation N	Controlling N	Output N		
			Exposure N+1	Reading N+1	Computation N+1	Controlling N+1	Output N+1	
				Exposure N+2	Reading N+2	Computation N+2	Controlling N+2	...
		First exposure after power up of the sensor			Exposure N+3	Reading N+3	Computation N+3	...
						Exposure N+4	Reading N+4	...
							...	...

Fig. 17 Sensor timing at a measurement rate of 1.5 kHz

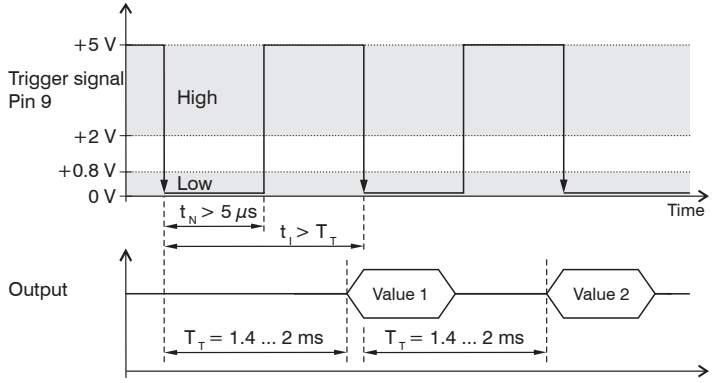
The sensor needs time until measuring values are available according to the set averaging number N.

6.6 Triggering on ILD 1402-x

The ILD1402 measurement output is controllable through an external signal on the trigger input. Therefore the external input “Teach in“ must be configured for triggering, see Chap. 8.4.16. This can be done with the “ILD1402 Tool“ (“Configuration“ > “General Settings“ > “Digital Input: trigger acquisition“) also.

Basics, procedure:

- The sensor measures and calculates also, if no trigger pulses are pending.
- The data output starts with a falling edge of the trigger signal.
- Sensor outputs the measurement value with a delay T_T of 1.4 up to 2 ms.
- A new trigger pulse can be sent.



t_N Non-pulse period
t_I Pulse interval
T_T Delay time

T_T = 1.4 … 2 ms
true for a measurement rate of 1.5 kHz and a baud rate of 115.200 Baud

Maximum trigger rate: appr. 500 Hz

Fig. 18 Timing

You get a digital measurement value on the output for each trigger signal, see Chap. 8.4.10, see Chap. 8.4.11 (data output). The analog output is actualized with any trigger signal, if you use the analog output.

i An averaging of the measuring values has no effect on the delay time T_T. Consider certainly, that the controller needs time for the averaging, until measuring values are available according to the set averaging number N.

7. Measurement Value Output

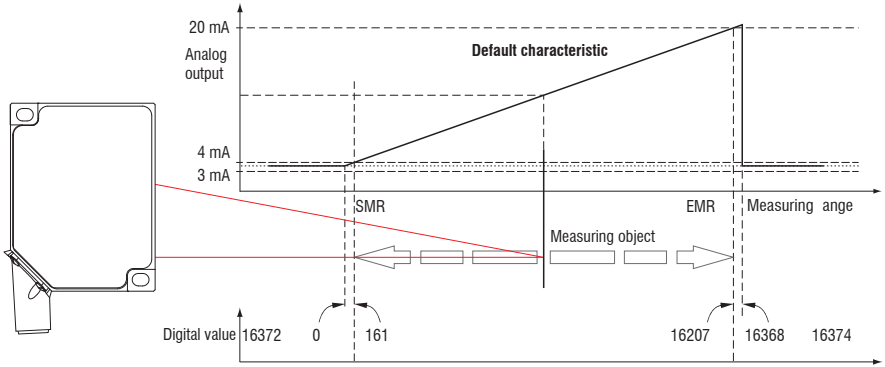
The optoNCDT1402 can issue the measurement values either via the analog output or the RS422 serial interface. The two different types of output cannot be used concurrently. When using the cable PC1402-x / U, the voltage output is 1 ... 5 V, see Chap. 5.3.

7.1 Current Output

Max. range 4 mA ... 20 mA

Output amplification $\triangle I_{OUT}$ 16 mA = 100 % Measuring range

Error value: 3.75 mA (±10 µA)



Proceed as follows to set the sensor into operation after a short circuiton the analog output:

- Switch off the sensor's power supply.
- Wait appr. 3 s.
- Switch on the sensor's power supply.

Fig. 19 Current signal output

Calculation of measurement value x in mm from analog current

Reference value SMR

$$x\ [mm] = (I_{OUT} - 4\ mA) * \frac{MR\ [mm]}{16\ [mA]}$$

Reference value MMR:

$$x\ [mm] = (I_{OUT} - 4\ mA) * \frac{MR\ [mm]}{16\ [mA]} - MR/2$$

Example: Measuring range = 10 mm, I_{OUT} = 12 mA; Result: x = 5 mm or x = 0 mm

7.2 Digital Value Output

7.2.1 Data Protocol ILD1401

The digital measurement values are issued as unsigned digital values (raw values).

Digital value	Used for
0 ... 39	SMR back-up
40 ... 4055	Measurement range
4056 ... 4095	EMR back-up

Calculation of a measurement value in mm from digital output:

Reference value Start of Measuring Range:

$$x\ [mm] = (digital_{OUT} * \frac{1.02}{4096} - 0.01) * MR\ [mm]$$

Reference value Midrange

$$x\ [mm] = (digital_{OUT} * \frac{1.02}{4096} - 0.51) * MR\ [mm]$$

Example: MR =10 mm, digital value = 2048, measurement value = 5 mm or 0 mm

Note: A digital value can be calculated from a measurement value (millimeter) as follows:

$$digital_{OUT} = \left[\frac{x\ [mm]}{MR\ [mm]} + 0.01\right] * \frac{4096}{1.02}$$

7.2.2 Data Protocol ILD1402

The digital measurement values are issued as unsigned digital values (raw values).

Digital value	Used for
0 ... 16367	Value range
0 ... 160	SMR back-up (1 %)
161 ... 16207	Measurement range

Digital value	Used for
16208 ... 16367	EMR back-up (1 %)
16370 ... 16383	Error codes

Calculation of a measurement value in mm from digital output:

Reference value Start of Measuring Range:

$$x\,[mm] = (digital_{OUT} * \frac{1.02}{16368} - 0.01) * MR\,[mm]$$

Reference value Midrange

$$x\,[mm] = (digital_{OUT} * \frac{1.02}{16368} - 0.51) * MR\,[mm]$$

Example: MR =10 mm, digital value = 8184, measurement value = 5 mm or 0 mm

Note: A digital value can be calculated from a measurement value (millimeter) as follows:

$$digital_{OUT} = \left[\frac{x\,[mm]}{MR\,[mm]} + 0.01\right] * \frac{16368}{1.02}$$

7.3 Digital Error Codes

Digital error codes are issued in the same way as measurement values.
Value range for error codes: 16370 ... 16384 ($digital_{OUT}$)

- 16370 no object detected
- 16372 too close to the sensor
- 16374 too far from the sensor
- 16376 target can not be evaluated
- 16378 external laser off
- 16380 target moves towards the sensor
- 16382 target moves away from sensor
- 16383 internal error

8. Serial Interface RS422

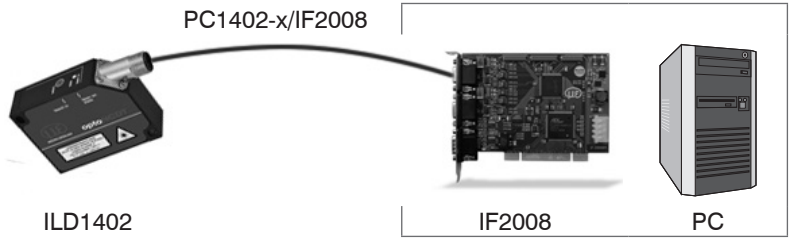


Fig. 20 System structure to operate the interface card IF2008

	Pin	Signal		Signal	Pin	
Sensor 1, Sensor 3 12-pol. connector	7 (8 [1])	24 V		+24 V supply		IF2008, X1 und X2, 15-pol. Sub-D
	3	Rx + (Input)		Sensor 1/3 TxD+	2	
	4	Rx - (Input)		Sensor 1/3 TxD -	1	
	5	Tx + (Output)		Sensor 1/3 RxD+	4	
	6	Tx - (Output)		Sensor 1/3 RxD -	3	
	12 (7 [1])	GND		0 V supply	5	
				Sensor 1/3 TRG+	6	
				Sensor 1/3 TRG -	7	
				Sensor 2/4 TRG+	8	
				Sensor 2/4 TRG -	9	
Sensor 2, Sensor 4 12-pol. connector	7 (8 [1])	24 V		+24 V supply	10	
	3	Rx +		Sensor 2/4 TxD+	12	
	4	Rx -		Sensor 2/4 TxD -	11	
	5	Tx +		Sensor 2/4 RxD+	14	
	6	Tx -		Sensor 2/4 RxD -	13	
	12 (7 [1])	GND		0 V supply	5	

Fig. 21 Pin assignment PC1402-x/IF2008 *Pin assignment IF2008*

Required cables and program routines

- IF2008
  RS422 interface card, for 1 to 4 laser-optic sensors from the ILD1402 series and 2 encoders, including MEDAQlib programming interface.

- PC1402-x/IF2008
  Power supply and output cable,
  x = length with 3, 6 or 8 m.

Alternatively, data can be transferred with the demo software (ILD1402 Tool) and a RS422 converter to USB, see Chap. 11..

1) For the ILD1402-xSC sensors resp. the PC1402SC-x/IF2008 cables.

8.1 Interface Parameter

The optoNCDT1402 comes with a RS422 serial interface to enable the sensor to be operated from a standard computer and measurement values and error codes to be transferred.

The sensor can operate with two different data protocols:
- Data protocol ILD1401
- Data protocol ILD1402

Default settings	Data protocol ILD1401	Data protocol ILD1402
Baud rate	38400	115200
Parity	none	
Data bits	8	
Start/stop bit	1	

8.2 Data Format for Measurement Values and Error Codes

8.2.1 Binary Format

The data word is comprised of two consecutive bytes (H-byte/L-byte). One flag bit in each byte differentiates a high from a low byte.

Start	1	7 Bit MSB	Stop	Start	0	7 Bit LSB	Stop

Conversion of the binary data format:
For conversion purposes the high and low bytes must be identified on the basis of the first bit (flag bit), the flag bits deleted and the remaining 2 x 7 bits compiled into 14 bit data word.
Reception:

H-Byte	1	D13	D12	D11	D10	D9	D8	D7
L-Byte	0	D6	D5	D4	D3	D2	D1	D0

Result of conversion

0	0	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

If the sensor operates with the ILD1401 data protocol, the measurement value is a 12 bit word, e.g. the bits D12 and D13 are 0.

Replies with a length of 4 Bytes must be swapped according to the following rule:

Reception: 0 1 2 3 4 5 6 7

Conversion: 3 2 1 0 7 6 5 4

This rule does not apply to values.

8.2.2 ASCII Format

Output of 5 characters (digits) in ASCII code for the digital value + 1 tag „CR“ (= 0x0D), i.e. a total of 6 characters. Digital values with just 3 or 4 digits are preceded by blank characters.

Example: Digital value 2099

Transfer: “_2099“ (preceded by 1 blank character) „CR“

ASCII code (Hex.)	0x20	0x32	0x30	0x39	0x39	0x0D
Characters	SP	2	0	9	9	CR

ASCII characters can be easily shown using a terminal program.

8.2.3 Request the Data Protocol

PC transmits “---R”.

Sensor replies

“---14CI1“ Sensor operates with the ILD1401 data protocol or

“---14CI2“ Sensor operates with the ILD1402 data protocol.

8.3 Data Protocol ILD1401

8.3.1 Setup of the Commands

The commands for the sensor are transmitted in full duplex mode. Each instruction has a head, the ID, the command, the quantity and data if required (parameter, if quantity > 0).

The head contains 4 bytes to identify a connection towards the sensor. The ID consists of 2 bytes, the command and quantity) consists of 1 byte. The complete string (without parameter) has a length of 8 bytes. The quantity is a equivalent of the subsequent bytes.

Each complete command is returned by the sensor. The answer contains the 2 ID bytes (equivalent to the transmitted ID), the modified command byte, the quantity and response informations. The modified command byte = command OR masked with $0x80_{hex}$ if the command was transmitted successful. If an error happens the modified command byte = command OR masked with $0xC0_{hex}$. In the case of an error the quantity is 1 and contains the error code.

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
Head				ID		Command	Quantity	Parameter

Fig. 22 Set-up of a command in the transmitter

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
ID		Command OR masked with 0x80 hex	Quantity	Parameter

Fig. 23 Set-up of a command in the receiver, error-free transmitted

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
ID		Command OR masked with 0xC0 hex	Quantity = 1	Error code

Fig. 24 Set-up of a command in the receiver, faulty transmission

Error code

Description	Bytes	Value
Command error	1	2
Faulty number of parameters	1	3
Time out	1	4

8.3.2 Overview of Commands

Information commands			
0x0900	Chap. 8.3.4	VERSION	Shows the software version
0x0C00	Chap. 8.3.3	INFO	Shows the sensor data
Filter			
0x1001	Chap. 8.3.5	MEDIAN	Median filter over 3 values, on/off
Measurement value output			
0x0E01	Chap. 8.3.6	OUTPUTCHANNEL	Output analog / digital
Error output (analog output)			
0x0F01	Chap. 8.3.7	SAVELASTMV	Behavior of the analog output in case of errors
Reset			
0x0100	Chap. 8.3.8	BOOT	Reboots the sensor
Switch data protocol ILD1401 / ILD1402			
0x1100	Chap. 8.3.9	SET_CIMODE_1402	Sensor operates with data protocol ILD1402
$0x2D2D2D52_h$	Chap. 8.3.10	GET_CI_MODE	Requests the command interpreter state of the sensor

8.3.3 Reading the Sensor Parameters, INFO

Name: INFO

Description: Supplies the info string.

Format

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
“+”	“+”	“+”	0x0D	„I“	„L“	0x0C	0x00	none

Reply

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
„I“	„L“	0x8C	Quantity [1]	Info string

Byte 1	Byte 2	Byte 3	Byte 4
“I“	“L“	0x8C	0x89
Info is a readable ASCII string Article 4120154 Option 000 Series 1234570 MR 50 SoftVer 1.001 Date 09/01/23 Out Channel analog Anlog Error error value Filter off			

Command error-free

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
“I“	“L“	0xCC	0x01	Error code

Faulty command

1) Number of bytes depends on the content of the response.

8.3.4 Reading the Software Version, VERSION

Name: VERSION

Description: The sensor transmitts the software version.

Format

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
“+”	“+”	“+”	0x0D	„I“	„L“	0x09	0x00	none

Reply

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
„I“	„L“	0x89	Quantity	Info string

Command error-free

Byte 1	Byte 2	Byte 3	Byte 4
“I“	“L“	0x89	0x07
Version is a readable ASCII string: 1.001			

Faulty command

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
“I“	“L“	0xC9	0x01	Error code

8.3.5 Average On/Off, MEDIAN

Name: MEDIAN

Description: Switches between „Averaging on“ and „Averaging off“. The median is generated from a preset number of measurement values. Here the inputted measurement values (3 measurement values) are resorted after each measurement. The average value is then outputted as the median. When the median is generated in the controller only 3 measurement values are taken into account, i.e. a 0 median is not possible. This means that individual interference pulses can be suppressed. The measurement value curve is not smoothed to a great extent.

Default setting:
Median off

Byte 9 = 0; Median off

Byte 9 = 1; Median on

Format	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
	“+”	“+”	“+”	0x0D	„I“	„L“	0x10	0x01	Median ON/OFF

Reply	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
	„I“	„L“	0x90	0x00	none

Command error-free

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
“I“	“L“	0xD0	0x01	Error code

Faulty command

8.3.6 Digital or Analog Data Output, OUTPUTCHANNEL

Name: OUTPUTCHANNEL

Description: Selects the output channel (analog / digital) for the sensor. If the digital output is selected the serial interface transmits measured values with a data rate of 1.5 kHz. If the analog output is selected the serial interface transmits the commands and the responses only.

Default setting:
analog output

Byte 9 = 0; analog

Byte 9 = 1; digital

Format	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
	“+”	“+”	“+”	0x0D	„I“	„L“	0x0E	0x01	Channel

Reply	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
	„I“	„L“	0x8E	0x00	none

Command error-free

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
“I“	“L“	0xCE	0x01	Error code

Faulty command

8.3.7 Sensor Behavior in Error Case, SAVELASTMV

Name: SAVELASTMV

Description: Switches between „Hold last value“ and „Error code“ of the analog output.

Default setting:
„Error code“, also 3.75 mA on the analog output

Format

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
“+”	“+”	“+”	0x0D	„I“	„L“	0x0F	0x01	Output type

Reply

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
„I“	„L“	0x8F	0x00	none

Command error-free

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
“I“	“L“	0xCF	0x01	Error code

Faulty command

Output type

Description	Bytes	Value
Output type = „Hold last value“ (in the case of an error the last valid measured value is shown on the analog output)	1	0
Output type = „Error code“ (in the case of an error a value < 4 mA is output)	1	1

8.3.8 Reset Sensor, BOOT

Name: BOOT

Description: The sensor makes a software reset. The default settings for output and filter are used.

- Current output: error code
- Median off

The response is sent before the reset is done.

Format	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
	“+”	“+”	“+”	0x0D	„I“	„L“	0x01	0x00	none

Reply	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
	„I“	„L“	0x81	0x00	none

Command error-free

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
“I“	“L“	0xC1	0x01	Error code

Faulty command

8.3.9 Changing Data Protocol, SET_CIMODE_1402

Name: SET_CIMODE_1402

Description: Switches the sensor into the ILD1402 data protocol. The sensor replies with the ILD1401 data protocol, after sending the reply the sensor switches to the mode and maintains a reset.

Format	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
	“+”	“+”	“+”	0x0D	„I“	„L“	0x11	0x00	none

Reply	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
	„I“	„L“	0x91	0x00	none

Command error-free

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
“I“	“L“	0xD1	0x01	Fehlercode

Faulty command

8.3.10 Request Data Protocol, GET_CI_MODE

Name: GET_CI_MODE

Description: Requests the state of the sensors command interpreter.

Format:

31	24	23	16	15	8	7	0	hex
„-“		„-“		„-“		„R“		0x2D2D2D52

Reply:

31	24	23	16	15	8	7	0	hex
„-“		„-“		„-“		„1“		0x2D2D2D31
„4“		„C“		„I“		0x3X		0x3443493X

Options for X:

X = 1, the command interpreter of the sensor operates with the ILD1401 data protocol.

X = 2, the command interpreter of the sensor operates with the ILD1402 data protocol. Note: The sensor uses a different protocol!

8.4 Data Protocol ILD1402

8.4.1 Setup of the Commands

The commands for the sensors are comprised of command data which are transmitted in full duplex mode. Each command packet is comprised of a whole number multiple of 32 bit words, see Fig. 25.

	31	24	23	16	15	8	7	0
1	Header							
2	ID							
3	Command (16 Bit)				Package length (16 Bit)			
4	Data 1							
5	...							
6	Data (n)							

Contents	
Start word	Command header (2 words)
Sensor identifier, e.g. “ILD1“	
Command code	Data word quantity n+2
1 st Data word (4 Bytes)	
...	
n th Data word (4 Bytes)	

Fig. 25 Structure of a command packet

Since most serial interfaces use an 8 bit data format, 4 consecutive bytes are combined into a 32 bit word. Each command packet has a header consisting of two 32 bit words followed by the command and, if required, other data as well. The top two bits (No. 31 and 30) are always “0“ in the transmitted command.

8.4.2 Communication without Error

No start word is transmitted if the sensor replies to a command. The 1st word is then the sensor identifier. The second word is the command with set MSB (Bit 31 = 1, corresponding an OR operation of the command with 0x8000) and the new package length if there was no error during communication. With longer answers (e.g. GET_INFO) the package length is larger according to the quantity of data words to be transmitted. A firm 32 bit word 0x20200D0A forms the conclusion of the answer. The conclusion word is not a data word.

8.4.3 Communication with Error

If the sensor detects an error during the execution of a command, the second highest bit (bit 30) of the command is also set (the command is OR operated with 0xC000). Additionally a command error code is transferred as data word, see Fig. 26. The resulting package length now amounts to 3 data words. The reply is finished with a 32 bit word 0x20200D0A (2 blank charecters + CR + LF).

Error Code X	Description
1	Command unknown
2	Incorrect parameter value
3	Invalid parameter
4	Time out
5	Command failed
6	Warning for averaging type and averaging number [1]

Fig. 26 Command error codes

1), see Chap. 8.4.7

8.4.4 Overview

Information command			
0x20490002	Chap. 8.4.5	GET_INFO	Shows sensor data
0x204A0002	Chap. 8.4.6	GET_SETTINGS	Shows sensor settings
Average			
0x207F0004	Chap. 8.4.7	SET_AV	Sets average type and value
Measurement value output			
0x20760002	Chap. 8.4.8	DAT_OUT_OFF	Stops measurement value output
0x20770002	Chap. 8.4.9	DAT_OUT_ON	Permanent measurement value output
0x20F40003	Chap. 8.4.11	SET_OUTPUTMODE	Output mode
0x20F50003	Chap. 8.4.12	SET_OUTPUTTIME_MS	Output time in ms
Switch output settings			
0x20900003	Chap. 8.4.10	SET_OUTPUT_CHANNEL	Output: current or RS422
Speed			
0x20800003	Chap. 8.4.14	SET_BAUDRATE	115.2 / 57.6 / 38.4 / 19.2 / 9.6 kBaud
0x20850003	Chap. 8.4.15	SET_SCANRATE	Measurement rate: 1.5 kHz; 1.0 kHz; 750 Hz; 375 Hz
Error output (analog output)			
0x20810003	Chap. 8.4.13	SET_ANALOG_ERROR_HANDLER	Behavior of the analog output in the case of an error
External input			
0x20F80003	Chap. 8.4.16	SET_EXT_INPUT_MODE	Scaling, triggering
Switching off the laser (external)			
0x20870002	Chap. 8.4.19	LASER_ON	Switches the laser on
0x20860002	Chap. 8.4.19	LASER_OFF	Switches the laser off
Measurement value data format			
0x20880003	Chap. 8.4.20	ASCII_OUTPUT	Options: ASCII / Binary
Key lock			
0x20600003	Chap. 8.4.21	SET_KEYLOCK	Key enabled / locked / auto lock
Reset			
0x20F10002	Chap. 8.4.23	SET_DEFAULT	Reset to default factory settings
0x20F00002	Chap. 8.4.22	RESET_BOOT	Reboot the sensor

Memory mode			
0x20F70003	Chap. 8.4.24	SET_SAVE_SETTINGS_MODE	Volatile / nonvolatile
Scaling values			
0x20F90004	Chap. 8.4.25	SET_TEACH_VALUE	Sets T1 + T2 0 ... 16368
0x20FA0002	Chap. 8.4.26	RESET_TEACH_VALUE	Sets T1 = 0 / T2 = 16368
Search algorithm			
0x20FB0003	Chap. 8.4.17	SET_PEAKSEARCHING	First peak, last peak, global maximum
Threshold			
0x20FC0003	Chap. 8.4.18	SET_THRESHOLD	Lower than standard, standard, higher than standard, highest
Switch data protocol			
0x20F20002	Chap. 8.4.27	SET_CIMODE_1401	Sensor operates with ILD1401 data protocol
0x2D2D2D52	Chap. 8.4.28	GET_CI_MODE	Requests the command interpreter state of the sensor

8.4.5 Reading the Sensor Parameters, GET_INFO

Name: GET_INFO

Description: Supplies the info string. This shows all parameters currently stored in the sensor.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x49	0x00	0x02	0x20490002

Reply:

31	24	23	16	15	8	7	0	hex
„I“		„L“		„D“		„1“		0x494C4431
0xA0		0x49		0x00		0xxx		0xA04900xx
Info string is a readable ASCII character string:								
ILD 1402: Standard A/N: 4120154 O/N: 000 S/N: 1234570 MR: 50 SoftVer: 1.001.796 BootVer: 1.001.16 Date: 09/01/23 Out Channel: analog | digital Analog Error: last value | error value | error value after cycles xx //xx is 2 up to 99 Filter Type: moving average | median Filter Number: xx //with moving average xx is 1 up to 128, with median xx is 7, 5, 7 or 9 Scanrate: xxHz //xx is 1500 Hz, 1000 Hz, 750 Hz, 375 Hz type of digital output: binary | ascii mode of analog/digital output: continuous | time | trigger output time: xx //xx is time in ms [1] key status: unlock | lock | auto lock mode of save setting: no save | save at each time mode of extern input: as teach in | as output trigger peak searching: global maximum | first peak | last peak Teach value 1: xx //(xx is 1.0 up to 16368.0 Teach value 2: xx //xx is 1.0 up to 16368.0								
0x20		0x20		0x0D		0x0A		0x20200D0A

| = separates variants from each other
// = beginning of a comment
1) Output time is available only, if ”mode of analog/digital output“ is set to ”time”

8.4.6 Reading the Sensor Settings, GET_SETTINGS

Name: GET_SETTINGS

Description: Supplies the current sensor settings.
Swap the received bytes according, see Chap. 8.2.1.

These are as follows:

Output channel
- 0 = Current
- 1 = Digital

Teach value 1

0.0 … 16368.0

e. g. float: 3027.426 = hexadecimal: 0x453d36d1

Teach value 2

0.0 … 16368.0

e. g. float: 11068.851 = hexadecimal: 0x462cf367

Analog error handler
- 0 = hold last value
- 1 = error output
- 2…99 hold last value for 2…99 images respectively cycles

Average type
- 0 = moving average
- 1 = Median

Average value
- 1…128 moving average, if average type = 0
- 3, 5, 7, 9 Median, if average type = 1

Measurement rate
- 0 = 1500 Hz
- 1 = 1000 Hz
- 2 = 750 Hz
- 3 = 375 Hz
- 4 = 50 Hz

Baud rate
- 0 = 115200 Baud
- 1 = 57600 Baud
- 2 = 38400 Baud
- 3 = 19200 Baud
- 4 = 9600 Baud

Digital output type
- 0 = Binary
- 1 = ASCII

Analog, digital output mode
- 0 = continuously each measurement, depending on baud rate and the measuring frequency;
  delay = (Bit quantity / Baud rate) * measuring frequency [Hz]
  (if delay < 0, delay = delay +1)
  delay = number of cycles with no serial output
- 1 = time-based, see output time [ms]
- 2 = trigger controlled, see external input mode

Output time [ms]

1…65535

Key lock
- 0 = key enabled
- 1 = key locked
- 2 = automatic key lock after 5 min power is on

Save settings mode
- 0 = transmitted settings are stored in the RAM and are valid until power off
- 1 = transmitted settings are stored in the FLASH and are valid, even after power off/on

External input type
- 0 = external input is used for scaling
- 1 = external input is used as trigger input (trigger controlled output)

Peak searching
- 0 = peak with global maximum
- 1 = first peak, direction pixel 0 up to pixel 127, left to right
- 2 = last peak, direction pixel 0 up to pixel 127, left to right

Threshold
- 0 = lower than standard
- 1 = standard
- 2 = higher than standard
- 3 = highest

Measuring range [mm]
- XXX X = 1 ...65535

Reserved 1

Reserved 2

Reserved 3

Reserved 4

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x4A	0x00	0x02	0x204A0002

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x4A	0x00	0x17	0xA04A0017
Output channel				
0x00	0x00	0x00	0x0X	0x0000000X
Teach value 1				
0xXX	0xXX	0xXX	0xXX	0xXXXXXXXX
Teach value 2				
0xXX	0xXX	0xXX	0xXX	0xXXXXXXXX
Analog error handler				
0x00	0x00	0x00	0xXX	0x000000XX
Average type				
0x00	0x00	0x00	0x0X	0x0000000X
Average value				
0x00	0x00	0x00	0xXX	0x000000XX
Measurement rate				
0x00	0x00	0x00	0x0X	0x0000000X
Baud rate				
0x00	0x00	0x00	0x0X	0x0000000X
Digital output type				
0x00	0x00	0x00	0x0X	0x0000000X
Analog digital output mode				
0x00	0x00	0x00	0x0X	0x0000000X
Output time				
0x00	0x00	0xXX	0xXX	0x0000XXXX

Key lock				
0x00	0x00	0x00	0x0X	0x0000000X
Save settings mode				
0x00	0x00	0x00	0x0X	0x0000000X
External input type				
0x00	0x00	0xXX	0xXX	0x0000XXXX
Peak searching				
0x00	0x00	0x00	0x0X	0x0000000X
Threshold				
0x00	0x00	0x00	0x0X	0x0000000X
	Measuring range			
0x00	0x00	0xXX	0xXX	0x0000XXXX
	Reserved 1			
0x00	0x00	0x00	0x0X	0x00000000
	Reserved 2			
0x00	0x00	0xXX	0xXX	0x00000000
	Reserved 3			
0x00	0x00	0x00	0x0X	0x00000000
	Reserved 4			
0x00	0x00	0x00	0x0X	0x00000000
Last data word				
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.7 Average Type and Average Number, SET_AV

Name: SET_AV

Description: Sets the average type and the average number N.

Default setting:
moving average 1, thus no averaging

Parameter:

- Average type
  - X = 0 --> Moving average
  - X = 1 --> Median
- Average number
  - XX = 1 ... 128 --> Moving average, if average type = moving average
  - XX = 3, 5, 7, 9 --> Median, if average type = Median

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x7F	0x00	0x04	0x207F0004
0x00	0x00	0x00	0x0X	0x0000000X
0x00	0x00	0x00	0xXX	0x000000XX

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x7F	0x00	0x02	0xA07F0002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.8 Stopping the Measurement Value Output, DAT_OUT_OFF

Name: DAT_OUT_OFF

Description: Switches off the digital output for the measurement values. This has no effect on communication with the sensor via the digital interface. This command has a higher priority in trigger mode. The command is volatile. Therefore data out is on after power on.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x76	0x00	0x02	0x20760002

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x76	0x00	0x02	0xA0760002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.9 Starting the Measurement Value Output, DAT_OUT_ON

Name: DAT_OUT_ON

Description: Switches on the digital data output for the measurement values. The output channel (output type) must also be set to the digital output, otherwise the measurement data cannot be received from the sensor.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x77	0x00	0x02	0x20770002

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x77	0x00	0x02	0xA0770002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.10 Digital or Analog Data Output, SET_OUTPUT_CHANNEL

Name: SET_OUTPUT_CHANNEL

Description: Sets the output type for the measurement values.

Parameter:

Default setting:
analog output

- X = 0 --> Analog output (4 ... 20 mA)
- X = 1 --> Digital output (RS422)

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x90	0x00	0x03	0x20900003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x90	0x00	0x02	0xA0900002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.11 Characteristics for Digital or Analog Data Output, SET_OUTPUTMODE

Name: SET_OUTPUTMODE

Description: Sets the output characteristics.

Default setting: continuously

- X = 0 --> continuously each measurement, depending on baud rate and the measuring frequency; delay = (Bit quantity / Baud rate) * measuring frequency [Hz], if delay < 0, delay = delay +1) delay = number of cycles with no serial output
- X = 1 --> time-based, see Chap. 8.4.12.
- X = 2 --> trigger controlled, see Chap. 8.4.16.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xF4	0x00	0x03	0x20F40003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xF4	0x00	0x02	0xA0F40002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.12 Set Output Time, SET_OUTPUTTIME_MS

Name: SET_OUTPUTTIME_MS

Description: Sets the output time for the analog or digital output value to be updated.

Will be applicable at time-based measurement value output, see Chap. 8.4.11.

Default setting:
500 ms

Parameter:

- XXXX = 1 … 65535 [ms].

Format:

31 … 24	23 … 16	15 … 8	7 … 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xF5	0x00	0x03	0x20F50003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 … 24	23 … 16	15 … 8	7 … 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xF5	0x00	0x02	0xA0F50002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.13 Error Output (Analog output), SET_ANALOG_ERROR_HANDLER

Name: SET_ANALOG_ERROR_HANDLER

Description: Hold or not hold last measurement value.

Parameter:

Default setting: error value

- X = 0 --> hold last measurement value
- X = 1 --> error value (3.75 mA)
- X = 2 … 99 --> hold last measurement value for 2 … 99 images respectively cycles

This command only affects the analog output. If set to X = 0, the last valid measurement value will continue to be issued if an error occurs (no object, invalid object, object outside the measurement range or laser turned off). If set to X = 1, an error signal will be generated for the current output that has an error value of 3.75 mA. If set to X = 2 ... 99, the last valid measurement value will continue to be issued for X measuring cycles before an error signal is generated on the analog output.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x81	0x00	0x03	0x20810003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x81	0x00	0x02	0xA0810002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.14 Set Baud Rate, SET_BAUDRATE

Name: SET_BAUDRATE

Description: Sets the transmission rate.

Default setting:
115200 Baud

Parameter:

- X = 0 --> 115200
- X = 1 --> 57600
- X = 2 --> 38400
- X = 3 --> 19200
- X = 4 --> 9600

The sensor still sends the reply with the old baud rate and only switches to the new baud rate once the reply has been sent. The output rate reduces automatically when the baud rate is changed because individual measurement values are skipped.

Do not forget to change your programs baud rate.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x80	0x00	0x03	0x20800003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x80	0x00	0x02	0xA0800002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.15 Set Measurement Rate, SET_SCANRATE

Name: SET_SCANRATE

Beschreibung: Sets the measurement rate [Hz].

Default setting:
1500 Hz

Parameter:

- X = 0 --> 1500
- X = 1 --> 1000
- X = 2--> 750
- X = 3 --> 375
- X = 4 --> 50

Procedure: The sensor replies and then reboots. The string of the boot message contains “CI140x“, “CR“ “LF“ and the answer of “GET_INFO“.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x85	0x00	0x03	0x20850003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x85	0x00	0x02	0xA0850002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.16 Input for Scaling and Trigger, SET_EXT_INPUT_MODE

Name: SET_EXT_INPUT_MODE

Description: Defines the function of the switching input “Teach in“ (Pin 9 on the sensor connector).

Default setting:
Scaling

Parameter:

- X = 0 --> external input operates as scaling input
- X = 1 --> external input operates as trigger controlled input for the data output

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xF8	0x00	0x03	0x20F80003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xF8	0x00	0x02	0xA0F80002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.17 Peak Detection with Video Signal, SET_PEAKSEARCHING

Name: SET_PEAKSEARCHING

Description: Specifies the search algorithm.

Parameter:

- X = 0 --> peak with global maximum
- X = 1 --> first peak, direction pixel 0 up to pixel 127, left to right
- X = 2 --> last peak, direction pixel 0 up to pixel 127, left to right

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xFB	0x00	0x03	0x20FB0003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xFB	0x00	0x02	0xA0FB0002
0x20	0x20	0x0D	0x0A	0x20200D0A

A peak inside the video signal is limited by overrun and subsequent shortfall the threshold limit. Several valid peaks are evaluated when measuring glass. Measurements on metal surfaces can also produce multiple peaks. Determine the valid peaks in the software tool (video signal).

8.4.18 Search Threshold, SET_THRESHOLD

Name: SET_THRESHOLD

Description: Defines the characteristics of the search threshold.

Parameter:

- X = 0 --> lower than standard
- X = 1 --> Standard
- X = 2 --> higher than standard
- X = 3 --> highest

i Changing the threshold from factory default (standard) may influence linearity and resolution. Modify the sensor only with specific materials as with semitransparent plastics and so educate the sensor recently.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xFC	0x00	0x03	0x20FC0003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xFC	0x00	0x02	0xA0FC0002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.19 Switching off the Laser (External), LASER_OFF

Name: LASER_OFF

Description: Switches off the laser. This command is volatile e.g. the laser is on after power on.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x86	0x00	0x02	0x20860002

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x86	0x00	0x02	0xA0860002
0x20	0x20	0x0D	0x0A	0x20200D0A

i The command LASER_OFF is volatile. This means that the laser is switched on again if the power supply was switched off or the sensor was rebooted by means of the RESET_BOOT command and pin 8 is connected with GND.

Name: LASER_ON

Description: Switches on the laser

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x87	0x00	0x02	0x20870002

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x87	0x00	0x02	0xA0870002
0x20	0x20	0x0D	0x0A	0x20200D0A

i The command LASER_ON is effective only if pin 8 is connected with GND.

8.4.20 Change Data Format, ASCII_OUTPUT

Name: ASCII_OUTPUT

Description: Switches the data format for the measurement value output via the digital interface. The command replies will remain unaffected.

Default setting:
Binary format

Parameter:

- X = 0 --> Binary output (2 Byte)
- X = 1 --> ASCII output (6 Byte)

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x88	0x00	0x03	0x20880003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x88	0x00	0x02	0xA0880002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.21 Key Lock, SET_KEYLOCK

Name: SET_KEYLOCK

Description: Locks or enables the key “select“. The set status is not volatile.

Parameter:

- X = 0 --> enable key
- X = 1 --> lock key
- X = 2 --> key locked automatically after 5 min power on

Default setting:
key locked automatically after 5 min power on

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0x60	0x00	0x03	0x20600003
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0x60	0x00	0x02	0xA0600002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.22 Reset Sensor, RESET_BOOT

Name: RESET_BOOT

Description: Starts the sensor's initialization phase. Duration about 900 ms.

Procedure: The sensor replies and then re-boots. The string of the boot message contains "CI140x", "CR" "LF" and the answer of "GET_INFO".

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xF0	0x00	0x02	0x20F00002

Antwort:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xF0	0x00	0x02	0xA0F00002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.23 Set Default Setting, SET_DEFAULT

Name: SET_DEFAULT

Description: Resets the set parameters to the default settings (factory settings).
This concerns:

- Data protocol ILD1401
  - Output channel: 0 --> analog output,
  - Analog error handler: 1 --> in the case of an error: 3.75 mA on the analog output,
  - Filter: 0 = Median off,
- Data protocol ILD1402
  - Output channel: 0 --> analog output,
  - Teach value 1 --> 0.0
  - Teach value 2 --> 16368.0
  - Analog error handler: 1 --> in the case of an error: 3.75 mA on the analog output,
  - Average type: 0 --> moving average,
  - Average value: 1 --> no averaging,

- Measurement rate: 0 --> 1500 Hz,
- Baud rate: 0 --> 115200 Baud,
- Digital output type: 0 --> binary,
- Analog digital output mode: 0 --> continuous,
- Output time --> 500 ms,
- Key lock: 2 --> key locked automatically after 5 min power on,
- Save settings mode: 1 --> transmitted new settings are stored in the FLASH,
- External input type: 0 --> external input for scaling

Procedure: The sensor replies and then re-boots. The string of the boot message contains “CI140x“, “CR“ “LF“ and the answer of “GET_INFO“.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xF1	0x00	0x02	0x20F10002

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xF1	0x00	0x02	0xA0F10002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.24 Save Settings in RAM or FLASH, SET_SAVE_SETTINGS_MODE

Name: SET_SAVE_SETTINGS_MODE

Description: Saves the transmitted settings into the RAM or the FLASH.

Parameter:

- X = 0 --> transmitted new settings are stored in the RAM and valid until power off.
- X = 1 --> transmitted new settings are stored in the FLASH and are thus are generally valid.

Default setting:
Save in FLASH

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xF7	0x00	0x03	0x20F70002
0x00	0x00	0x00	0x0X	0x0000000X

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xF7	0x00	0x02	0xA0F70002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.25 Scaling Values for the Analog Output, SET_TEACH_VALUE

Name: SET_TEACH_VALUE

Description: Sets the scaling values.

Parameter:

- Teach value 1, XXXXXXXX --> 0.0 up to 16368.0
- Teach value 2, XXXXXXXX --> 0.0 up to 16368.0

Default setting:
Teach value 1: 0.0
Teach value 2: 16368.0

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xF9	0x00	0x04	0x20F90004
0xXX	0xXX	0xXX	0xXX	0xXXXXXXXX
0xXX	0xXX	0xXX	0xXX	0xXXXXXXXX

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xF9	0x00	0x02	0xA0F90002
0x20	0x20	0x0D	0x0A	0x20200D0A

The teaching process requires a valid measuring signal. The teaching process is terminated at „no target“, „target not evaluated“, „to close to the sensor“ - beyond SMR“ or „to far from the sensor - beyond EMR“.

8.4.26 Reset Scaling Values for the Analog Output, RESET_TEACH_VALUE

Name: RESET_TEACH_VALUE

Description: Resets the scaling values.

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xFA	0x00	0x02	0x20FA0002

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xFA	0x00	0x02	0xA0FA0002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.27 Changing Data Protocol, SET_CIMODE_1401

Name: SET_CIMODE_1401

Description: Switches the sensor into the ILD1401 data protocol.

The sensor replies with the ILD1402 data protocol, after sending the reply the sensor switches the data protocol.

The following parameters can be changed in the ILD1401 data protocol:

- Digital or analog data output
- Behavior in case of an error
- Averaging

The other parameters remain fixed:

- Baud rate: 38400
- Measurement rate: 1000 Hz
- Type of digital output: binary
- Mode of analog/digital output: continuous
- Key status: auto lock
- Mode of save setting: save at each time
- Mode of external input: as teach in
- Teach value 1: 0.00 resp. taught value T1 remains
- Teach value 2: 16368.00 resp. taught value T2 remains

Format:

31 24	23 16	15 8	7 0	hex
„+“	„+“	„+“	0x0d („CR“)	0x2B2B2B0D
„I“	„L“	„D“	„1“	0x494C4431
0x20	0xF2	0x00	0x02	0x20F20002

Reply:

31 24	23 16	15 8	7 0	hex
„I“	„L“	„D“	„1“	0x494C4431
0xA0	0xF2	0x00	0x02	0xA0F20002
0x20	0x20	0x0D	0x0A	0x20200D0A

8.4.28 Request Data Protocol, GET_CI_MODE

Name: GET_CI_MODE

Description: Requests the state of the sensors command interpreter.

Format:

31	24	23	16	15	8	7	0	hex
„-“		„-“		„-“		„R“		0x2D2D2D52

Reply:

31	24	23	16	15	8	7	0	hex
„-“		„-“		„-“		„1“		0x2D2D2D31
„4“		„C“		„I“		0x3X		0x3443493X

Options for X:

X = 1, the command interpreter of the sensor operates with the ILD1401 data protocol. Note: The sensor uses a different protocol!

X = 2, the command interpreter of the sensor operates with the ILD1402 data protocol.

9. Instructions for Operating

9.1 Reflection Factor of the Target Surface

In principle the sensor evaluates the diffuse part of the reflected laser light, see Fig. 27.

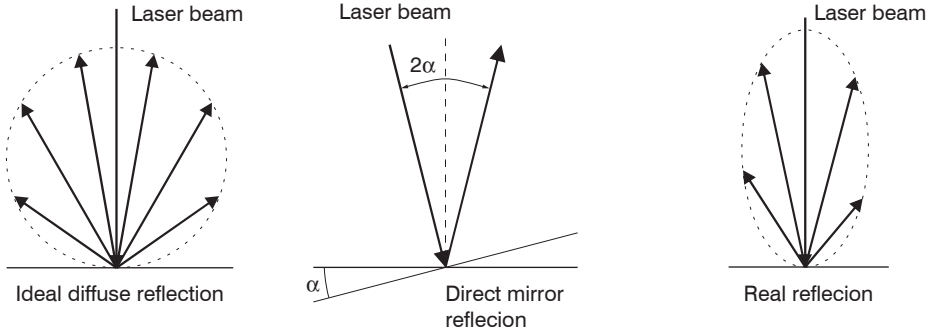


Fig. 27 Reflection factor of the target surface

A statement concerning a minimum reflectance is difficult to make, because even a small diffuse fraction can be evaluated from highly reflecting surfaces. This is done by determining the intensity of the diffuse reflection from the CCD array signal in real time and subsequent compensation for intensity fluctuations, see Chap. 3.2. Dark or shiny objects being measured, e.g. black rubber, may require longer exposure times. The exposure time is dependent on the measurement rate and can only be increased by reducing the sensor's measurement rate.

9.2 Error Influences

9.2.1 Light from other Sources

Thanks to their integrated optical interference filters the optoNCDT1402 sensors offer outstanding performance in suppressing light from other sources. However, this does not preclude the possibility of interference from other light sources if the objects being measured are shiny and if lower measurement frequencies are selected. Should this be the case it is recommended that suitable shields be used to screen the other light sources. This applies in particular to measurement work performed in close proximity to welding equipment.

9.2.2 Color Differences

Because of intensity compensation, color difference of targets affect the measuring result only slightly. However, such color differences are often combined with different penetration depths of the laser light into the material. Different penetration depths then result in apparent changes of the measuring spot size. Therefore color differences in combination with changes of penetration depth may lead to measuring errors.

9.2.3 Temperature Influences

When the sensor is commissioned a warm-up time of at least 20 minutes is required to achieve uniform temperature distribution in the sensor. If measurement is performed in the micron accuracy range, the effect of temperature fluctuations on the sensor holder must be considered. Due to the damping effect of the heat capacity of the sensor sudden temperature changes are only measured with delay.

9.2.4 Mechanical Vibrations

If the sensor should be used for resolutions in the µm range, special care must be taken to ensure stable and vibration-free mounting of sensor and target.

9.2.5 Movement Blurs

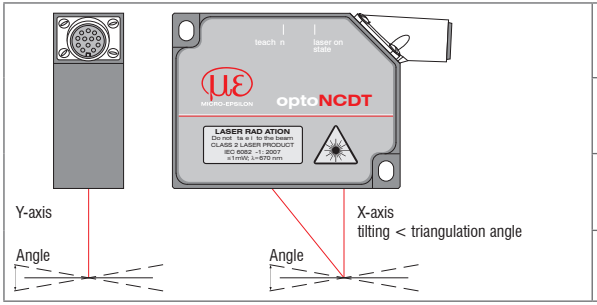
If the objects being measured are fast moving and the measurement rate is low it is possible that movement blurs may result. Always select a high measurement rate for high-speed operations, therefore, in order to prevent errors.

9.2.6 Surface Roughness

In case of traversing measurements a surface roughness of 5 µm and more leads to an apparent distance change (also-called surface noise). However, they can be dampened by averaging, see Chap. 6.3.

9.2.7 Angle Influences

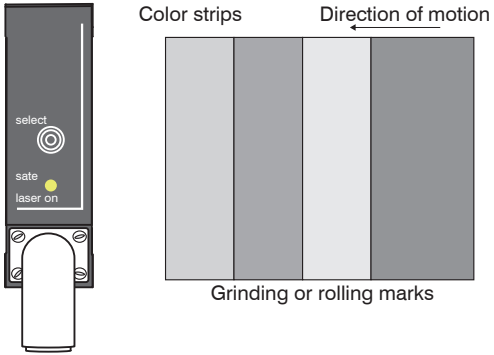
Tilt angles of the target both around the X and the Y axes of less than 5 ° only have a disturbing effect with surfaces which are highly reflecting. Tilt angles between 5 ° and 15 ° lead to an apparent distance change of approx. 0.12 ... 0.2 % of the measuring range, see Fig. 28. Tilt angles between 15 ° and 30 ° lead to an apparent distance change of approx. 0.5 % of the measuring range. These influences must be considered especially when scanning structured surfaces. In principle the angle behavior in triangulation also depends on the reflectivity of the target.



Angle	X-axis %	Y-axis %
±5 °	typ. 0.12	typ. 0.12
±15 °	typ. 0.2	typ. 0.2
±30 °	typ. 0.5	typ. 0.5

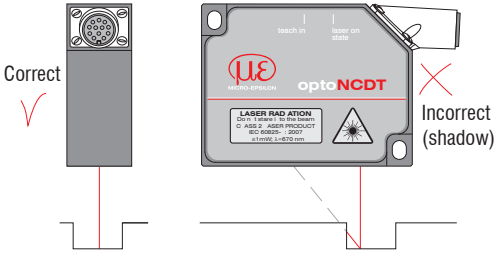
Fig. 28 Measurement errors through tilting with diffuse reflection

9.3 Optimizing the Measuring Accuracy



In case of rolled or polished metals that are moved past the sensor the sensor plane must be arranged in the direction of the rolling or grinding marks. The same arrangement must be used for color strips, see Fig. 29.

Fig. 29 Sensor arrangement in case of ground or striped surfaces



In case of bore holes, blind holes, and edges in the surface of moving targets the sensor must be arranged in such a way that the edges do not obscure the laser spot, see Fig. 30.

Fig. 30 Sensor arrangement for holes and ridges

9.4 Cleaning the Protective Glasses

A periodically cleaning of the protective housings is recommended.

Dry cleaning

This requires a suitable optical antistatic brush or blow off the panels with dehumidified, clean and oil free compressed air.

Wet cleaning

Use a clean, soft, lint-free cloth or lens cleaning paper and pure alcohol (isopropanol) for cleaning the protective housing.

Do not use commercial glass cleaner or other cleansing agents.

10. Default Setting

- Data protocol ILD1402, Binary format
- Current output with error value (3.75 mA)
- Measuring rate : 1.5 kHz
- Interface: 115.2 kBaud, binary format (no ASCII)
- Moving average avg =1 (no averaging)
- Teach value 1: 0.0
- Teach value 2: 16368.0
- External input for scaling [1]
- Continuous measurement output
- Output 1. measuring value after switching on: 500 ms
- Key lock after 5 min power on [1]
- Settings saved into FLASH
- Measuring range:
  - 100 % FSO: I = 20 mA , digital 16207
  - 0 % FSO: I = 4 mA, digital 161
- Maximum output (101 % FSO): 20.16 mA / digital 16367
- Minimum output (-1 % FSO): 3.84 mA / digital 0

Set sensor on default settings: [2]

➡ Switch off the sensors power supply.

➡ Keep the key “Select“ pressed.

➡ Switch on the sensors power supply.

LED on sensor flashes green.

➡ Press the key “Select“ again.

LED flashes green three times, approx. 1 Hz. During this time the factory parameters are set. Then the sensor re-boots.

1) Only with sensor ILD 1402-x

2) Restoring the factory setting with ILD 1402-xSC is only possible via the serial interface.

11. ILD1402 Tool

The ILD1402 Tool is an application to configure the ILD1402 sensor. In addition it supports a 1 channel data acquisition through RS422, RS422/USB converter or IF2008 interface card. It is for demonstration purposes only.

System requirements:

- Windows 2000/Windows XP/Windows Vista/Windows 7
- Pentium III, 256 MB RAM

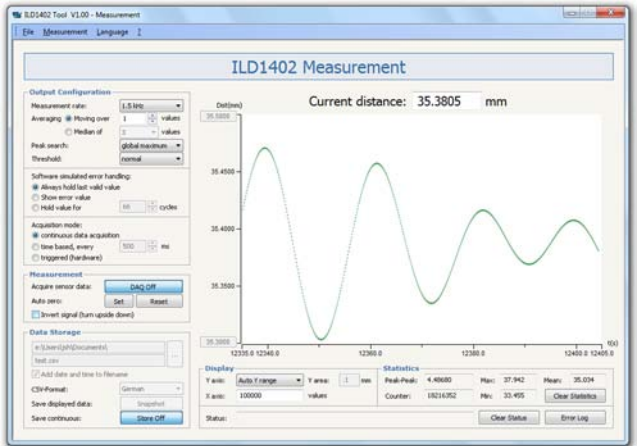
➔ Install the PC based program. Use the corresponding setup.exe supplied from the attached CD.

➔ Follow the advices during the installation.

You will find the actual drivers respectively program routines under:

www.micro-epsilon.com/link/opto/1402

- This program part is evidence of acquisition, calculation and data storage of ILD1402.



i If the sensor's analog output is to be used after termination of the ILD1402 tool, it previously has to be defined as output version. Do not forget to save the settings made.

i Disconnect or connect the D-sub connection between RS422 and USB converter when the sensor is disconnected from power supply only.

12. Software Support with MEDAQLib

The Micro-Epsilon Data Acquisition Library offers you a high level interface library to access optoNCDT laser sensors from your Windows application in combination with

- RS422/USB converter (optional accessory) and a suitable PC1402-3/D-SUB/9pol cable or
- PC1402-3/USB/IND cable or
- IF2008 PCI interface card and PC1402-3/IF2008 cable

into an existing or a customized PC software.

You need no knowledge about the sensor protocol to communicate with the individual sensors. The individual commands and parameters for the sensor to be addressed will be set with abstract functions. MEDAQLib translates the abstract functions in comprehensible instructions for the sensor.

MEDAQLib

- is a DLL/LIB usable for C, C++, VB, Delphi and many other Windows programming languages,
- supports functions to talk to the sensor
- hides the details on how to talk to the communication interface (RS232,RS422,USB,TCP)
- hides the details of the sensor protocoll
- converts the incoming data to „expected data values“
- provides a consistent programming interface for all Micro-Epsilon sensors
- provides many programming examples many different programming languages
- the interface is documented in a large *.pdf file

You will find the latest MEDAQLib version at:

www.micro-epsilon.com/link/software/medaqlib

13. Warranty

All components of the device have been checked and tested for perfect function in the factory. In the unlikely event that errors should occur despite our thorough quality control, this should be reported immediately to MICRO-EPSILON.

The warranty period lasts 12 months following the day of shipment. Defective parts, except wear parts, will be repaired or replaced free of charge within this period if you return the device free of cost to MICRO-EPSILON. This warranty does not apply to damage resulting from abuse of the equipment and devices, from forceful handling or installation of the devices or from repair or modifications performed by third parties.

No other claims, except as warranted, are accepted. The terms of the purchasing contract apply in full. MICRO-EPSILON will specifically not be responsible for eventual consequential damages. MICRO-EPSILON always strives to supply the customers with the finest and most advanced equipment. Development and refinement is therefore performed continuously and the right to design changes without prior notice is accordingly reserved. For translations in other languages, the data and statements in the German language operation manual are to be taken as authoritative.

14. Service, Repair

In the event of a defect on the sensor or sensor cable:

- If possible, save the current sensor settings in a parameter set, see ILD1402 Tool, menu ?, Help, in order to load the settings back again into the sensor after the repair.
- Please send us the effected parts for repair or exchange.

The opening of the sensor is only subjected to the manufacturer. In the case of faults the cause of which is not clearly identifiable, the whole measuring system must be sent back to

MICRO-EPSILON MESSTECHNIK
GmbH & Co. KG
Königbacher Straße 15
94496 Ortenburg / Germany

Tel. +49 (0) 8542 / 168-0
Fax +49 (0) 8542 / 168-90
e-mail info@micro-epsilon.de
www.micro-epsilon.com

15. Decommissioning, Disposal

➡ Disconnect the power supply and output cable on the sensor.

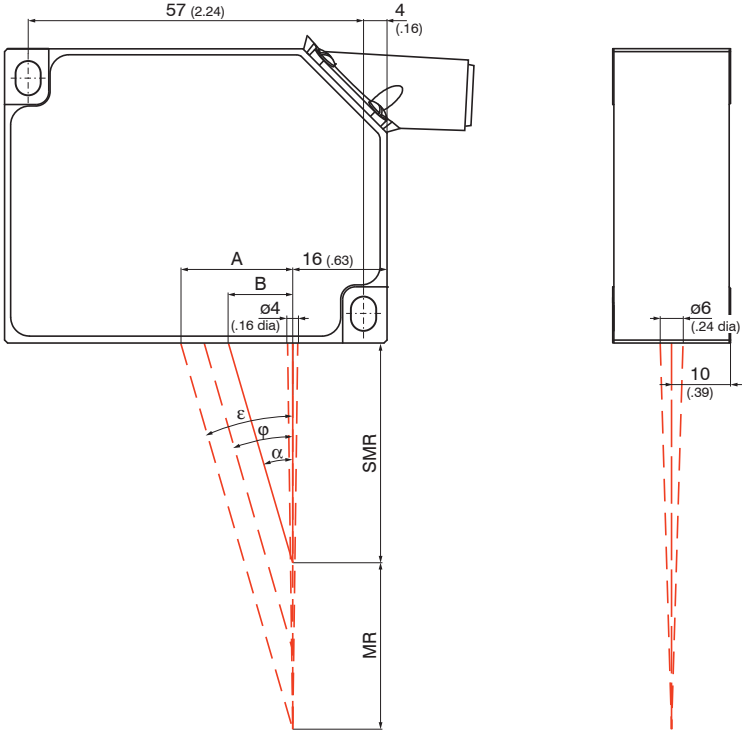
The optoNCDT1402 is produced according to the directive 2011/65/EU („RoHS“). The disposal is done according to the legal regulations (see directive 2002/96/EC).

16. Free Space for Optics

16.1 ILD 1402-x

Dimensions in mm (inches),
not to scale

MR	SMR	α	φ	ε	A	B
5 (0.20)	20 (0.79)	33.5 °	35.5 °	37.1 °	18.9 (0.74)	13.2 (0.52)
10 (0.40)	20 (0.79)	33.5 °	32.9 °	32.4 °	19.1 (0.75)	13.2 (0.52)
20 (0.79)	30 (1.18)	31.2 °	27.9 °	25.8 °	24.2 (0.95)	18.2 (0.72)
50 (2.00)	45 (1.77)	25.1 °	19.6 °	16.9 °	28.9 (1.14)	21.1 (0.83)
100 (3.94)	50 (2.00)	23.1 °	14.4 °	11.3 °	30.1 (1.19)	21.3 (0.84)
200 (7.87)	60 (2.36)	20.1 °	9.4 °	6.8 °	30.8 (1.21)	22.0 (0.87)
250VT (9.84)	100 (3.94)	14.7 °	7.6 °	5.5 °	33.9 (1.33)	26.2 (1.03)
400 (15.7)	200 (7.87)	9.7 °	5.3 °	3.8 °	41.4 (1.63)	33.7 (1.33)
600 (23.6)	200 (7.87)	9.7 °	4.3 °	2.9 °	41.6 (1.64)	33.7 (1.33)



MR = Measuring range

SMR = Start of measuring range

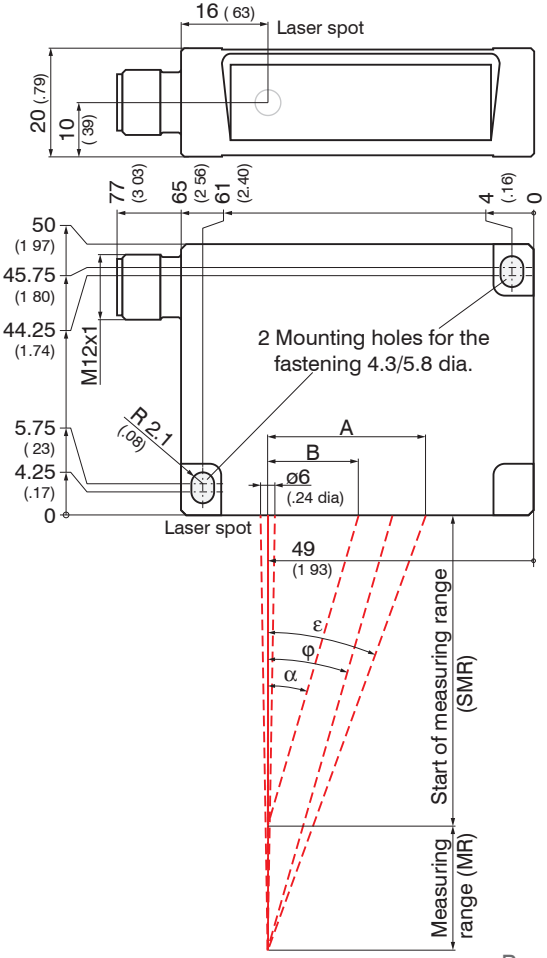
16.2 ILD 1402-xSC

Dimensions in mm (inches), not to scale

MR	SMR	α	φ	ε	A	B
5	20.0	33.5	35.5	37.1	18.9	13.2
10	20.0	33.5	32.9	32.4	19,1	13.2
20	30.0	31.2	27.9	25,8	24.2	18.2
50	45.0	25.1	19.6	16.9	28.9	21.1
100	50,0	23.1	14.4	11.3	30.1	21.3
200	60.0	20.1	9.4	6.8	30.8	22.0
250	100.0	14.7	7.6	5.5	33.9	26.2
600	200.0	9.7	4.3	3	41.6	33.7

MR = Measuring range

SMR = Start of measuring range



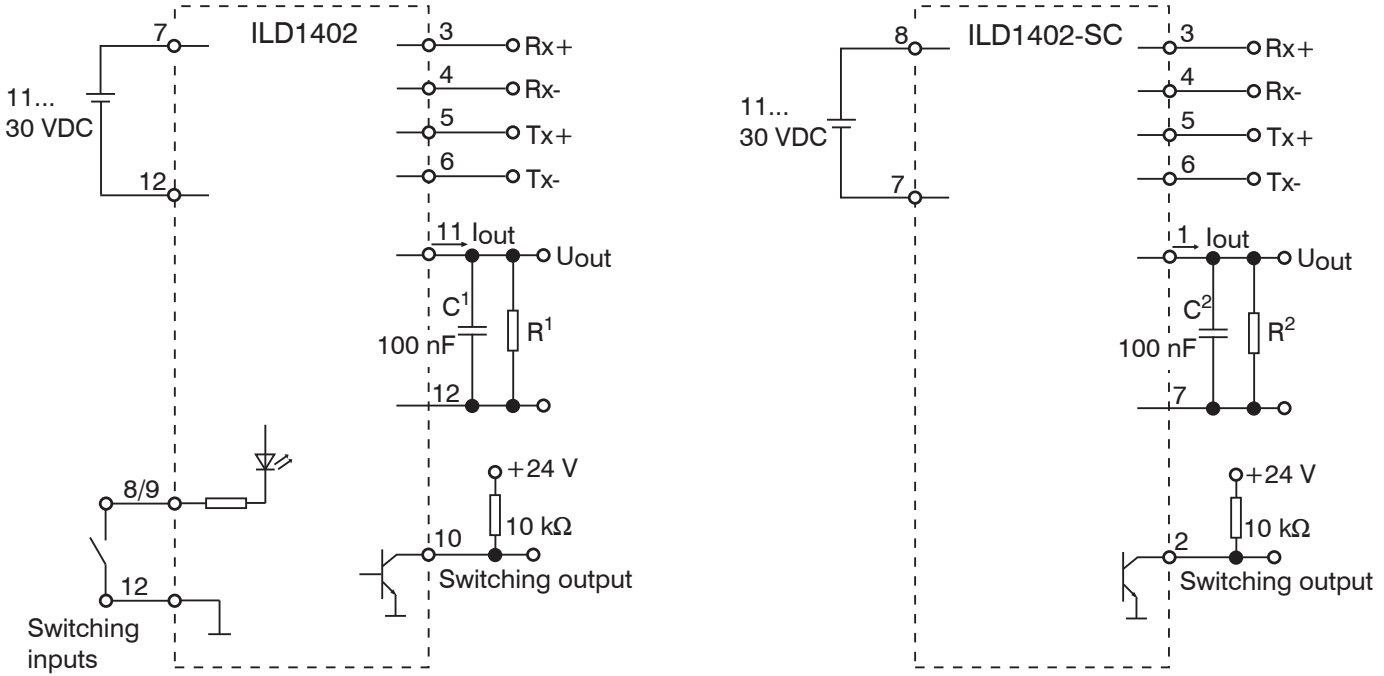
17. Available Cables

All cables are cable carriers suitable.

Type	Cable length	Characteristics
PC1402- 3/I, PC1402-6/I, PC1402-8/I	3 m 6 m 8 m	Interface und supply cable for current output, one end of the cable has a molded M12 female connector, the other end has free leads with ferrules.
PC1402-3/U, PC1402-6/U, PC1402-8/U	3 m 6 m 8 m	Interface und supply cable for voltage output (250 Ohm load, U_{out} = 1 … 5 V), one end of the cable has a molded M12 female connector, the other end has free leads with ferrules.
PC1402-3/U(01) PC1402-6/U(01)	3 m 6 m	Interface und supply cable for voltage output (500 Ohm load U_{out} = 2 … 10 V), 12 pol male connector on sensor side, open ends on other side, cable carriers suitable,
PC1402-3/USB/IND	3 m	Power and output cable, one end of the cable has a molded M12 female connector, the other end a 9 pol D-SUB for RS422/ USB converter; a RS422/USB converter is not enclosed. Disconnect or connect the D-sub connection between RS422 and USB converter when the sensor is disconnected from power supply only.
PC1402-3/CSP, PC1402-8/CSP, PC1402-10/CSP	3 m 8 m 10 m	Connecting cable with straight connector on both sides to connect an ILD1402 sensor to a CSP2008.
PC1402-3/IF2008, PC1402-6/IF2008, PC1402-8/IF2008	3 m 6 m 8 m	Connecting cable, one end of the cable has a molded M12 female connector, the other end a D-SUB to connect an ILD1402 sensor to an IF2008 PCI interface card.
PC1401/1402-0.2	0.2 m	Patch cable, 12 pol to 7 pol.

PC1402SC-3/I PC1402SC-8/I PC1402SC-10/I	3 m 8 m 10 m	Interface and supply cable IP 96K for sensor type ILD1402-xxxSC, output 4-20 mA; 8 pol male connector (cable jack) on sensor side, open ends on other side, cable carriers suitable, particular wiring
PC1402SC/90-3/I	3 m	Interface and supply cable for sensor type ILD1402-xxxSC, output 4-20 mA; 8 pol male connector (cable jack) on sensor side 90 °, IP 69K, open ends on other side, cable carriers suitable, particular wiring
PC1402SC-12/IF2008	12 m	Interface und supply cable for sensor type ILD1402-xxxSC with 8 pol male connector, connection cable to 4 channel interface card IF2008, power supply via interface card

18. Input /Output Circuit



$R = 250\ \Omega : U_{OUT}$ 1 ... 5 V with $U_B > 11$ V
$R = 500\ \Omega : U_{OUT}$ 2 ... 10 V with $U_B > 17$ V

1) Components contained in PC 1402-x/U and PC1402-x/U(01); are required for voltage output.
2) External circuit necessary for voltage output

19. Converter RS422-USB

The system ground must be connected with the terminal ground (USB converter, pin 5) before connecting the RX and TX lines.

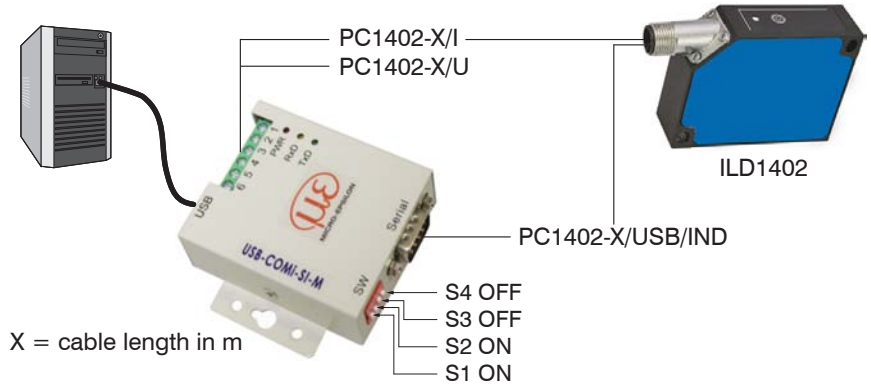


Fig. 31 Principle setup

Cross the lines for connections between sensor and PC.

ILD 1402		Converter	
Signal	Color PC1402-X/I PC1402-X/U	Signal	Pin
RX-	Yellow	TX-	1
RX+	Green	TX+	2
TX+	Gray	RX+	3
TX-	Pink	RX-	4
GND (Pin 12)	Blue	Ground	5

Fig. 32 Pin assignment and wiring

Disconnect or connect the D-sub connection between RS422 and USB converter when the sensor is disconnected from power supply only.

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