MICRO-EPSILON

Operating Instructions

confocalDT 2410/2415 Ethernet

IFD2410-1	IFD2415-1
IFD2410-3	IFD2415-3
IFD2410-6	IFD2415-10

Confocal chromatic distance and thickness measurement

MICRO-EPSILON MESSTECHNIK
GmbH & Co. KG
Koenigbacher Str. 15

94496 Ortenburg / Germany

Tel: +49 (0) 8542 / 168-0
Fax: +49 (0) 8542 / 168-90
info@micro-epsilon.com
https://www.micro-epsilon.com

Contents

1 Safety

1.1 Symbols used

System operation assumes knowledge of the operating instructions.

The following symbols are used in these operating instructions:

⚠ CAUTION	Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.
NOTICE	Indicates a situation that may result in property damage if not avoided.
►	Indicates a user action.
i	Indicates a tip for users.
`Measurement`	Indicates hardware or a software button/menu.

1.2 Warnings

⚠ CAUTION

Connect the power supply and the display/output device according to the safety regulations for electrical equipment.

- Risk of injury
- Damage to or destruction of the controller

The surface of the sensors or controller heats up to a temperature of over 50°C when all interfaces are used.

- Risk of injury

NOTICE

The supply voltage must not exceed the specified limits.

- Damage to or destruction of the controller

Avoid shocks and impacts to the sensor and the controller.

- Damage to or destruction of the components.

Never fold the optical fiber and do not bend it in tight radii.

- Damage to or destruction of the optical fiber, failure of measuring device

Protect the ends of the optical fiber against contamination (use protective caps).

- Incorrect measurement
- Failure of the measuring device

Protect the cables against damage.

- Failure of the measuring device

1.3 Notes on product marking

1.3.1 CE marking

The following apply to the product:

- Directive 2014/30/EU ("EMC")
- Directive 2011/65/EU ("RoHS")

Products which carry the CE marking satisfy the requirements of the EU Directives cited and the relevant applicable harmonized European standards (EN).

The product is designed for use in industrial and laboratory environments.

The EU Declaration of Conformity and the technical documentation are available to the responsible authorities according to the EU Directives.

1.3.2 UKCA marking

The following apply to the product:

- SI 2016 No. 1091 ("EMC")
- SI 2012 No. 3032 ("RoHS")

Products which carry the UKCA marking satisfy the requirements of the directives cited and the relevant applicable harmonized standards.

The product is designed for use in industrial and laboratory environments.

The UKCA Declaration of Conformity and the technical documentation are available to the responsible authorities according to the UKCA Directives.

1.4 Intended use

The confocalDT IFD241x is designed for use in industrial and laboratory applications.

It is used for

- Displacement, distance and thickness measurements
- Measuring the position of parts or machine components

The system must only be operated within the limits specified in the technical data, see Chap. 2

The system must be used in such a way that no persons are endangered or machines and other material goods are damaged in the event of malfunction or total failure of the system.

Take additional precautions for safety and damage prevention in case of safety-related applications.

1.5 Proper environment

	confocalDT IFD2410/2415
Protection class	IP64 (front)
Operating temperature range	+5 ... +50 °C
Storage temperature range	-20 ... +70 °C
Humidity	5 ... 95% (non-condensing)
Ambient pressure	Atmospheric pressure
Shock (DIN EN 60068-2-27)	15 g / 6 ms in XY axis, 1000 shocks each
Vibration (DIN EN 60068-2-6)	2 g / 20 ... 500 Hz in XY axis, 10 cycles each
EMC	In accordance with EN 61000-6-3 / EN 61326-1 (Class B) Electromagnetic emissions; EN 61 000-6-2 / EN 61326-1 Electromagnetic immunity

2 Functional principle, technical data

2.1 Brief description

With the IFD2410/2415, the sensor and controller form a single unit.
It is not possible to exchange the sensor.

The measuring systems use a white LED as an internal light source.

The controller converts the light signals received from the sensor using a spectrometer, calculates distance and thickness values via the integrated signal processor (CPU), and transmits the measured data via the digital interfaces and the analog output.

2.2 Measuring principle

Polychromatic light (white light) is beamed through the sensor onto the target surface. The sensor's lenses are designed to focus each wavelength of light used at a specific distance through controlled chromatic aberrations. The light reflected by the target surface is received by the sensor on the way back and directed to the controller. This is followed by spectral analysis and the calculation of distances using calibration data saved in the controller.

i	The sensor and controller form a single unit, as the linearization table of the sensor is stored in the controller.

This unique measuring principle enables high-precision measurement of applications. It can capture both diffuse and reflective surfaces. With transparent layer materials, a direct thickness measurement can be carried out in addition to the displacement measurement. The transmitter and receiver are arranged on one axis to prevent shadowing.

Excellent resolution and small light spot diameter make it possible to measure surface structures. However, it should be noted that deviations in measured values can occur as soon as the structure is in the order of magnitude of the light spot diameter or the permissible tilt is exceeded, for example at groove walls.

2.3 Term Definitions, Glossary

SMR	Start of measuring range. A start of measuring range (SMR) must be kept between each sensor and the target. Minimal distance between the front sensor face and the target.
MMR	Mid of measuring range
EMR	End of measuring range (start of measuring range + measuring range)
	Maximum distance between the front sensor face and the target
MR	Measuring range

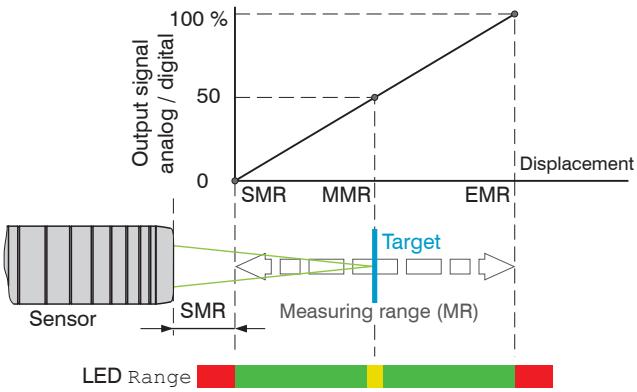


Fig. 2.1: Measuring range and measuring system output signal

Minimum target thickness	see chapter Technical data: • IFD2010, see Chap. 2.4 • IFD2015, see Chap. 2.5
Maximum target thickness	Sensor measuring range x Refractive index of target

2.4 Technical data confocalDT IFD2410

Model		IFD2410-1 Ethernet	IFD2410-3 Ethernet	IFD2410-6 Ethernet
Measuring range		1 mm	3 mm	6 mm
Start of measuring range		approx. 15 mm	approx. 25 mm	approx. 35 mm
Resolution	Static [1]	< 6 nm	< 18 nm	< 40 nm
	Dynamic [2]	< 50 nm	< 125 nm	< 250 nm
Measuring rate		Continuously adjustable from 100 Hz to 8 kHz		
Linearity [3]	Displacement and distance	< ±0.25 µm	< ±0.75 µm	< ±1.5 µm
	Thickness	< ±0.5 µm	< ±1.5 µm	< ±3.0 µm
Multi-peak measurement		1 layer		
Light source		Internal white LED		
Permissible ambient light		30.000 lx		
Light spot diameter[4]		12 µm	18 µm	24 µm
Measuring angle [5]		±25°	±19°	±10°
Numerical aperture (NA)		0.45	0.35	0.18
Min. target thickness		0.05 mm	0.15 mm	0.3 mm
Target material		Reflective, diffuse as well as transparent surfaces (e.g. glass)		
Supply voltage		24 VDC ±10 %		
Power consumption		< 5.3 W (24V)		
Signal input		3 x encoders (A+, A-, B+, B-) 2 x HTL/TTL multifunction input: trigger in, slave in, zeroing, master, teach; 1 x RS422 synchronization input: trigger in, sync in, master/slave, master/slave alternating		
Digital interface		Ethernet / RS422		
Analog output		4 … 20 mA / 0 … 5 V / 0 ... 10 V (16 bit D/A converter)		

[1] All data at constant ambient temperature (24 ±2 °C). Average from 2,048 values at 1 kHz, in the mid of the measuring range onto optical flat

[2] RMS noise relates to mid of measuring range (1 kHz)

[3] Maximum deviation from reference system over the entire measuring range, measured on front surface of ND filter

[4] In the mid of the measuring range

[5] Maximum sensor tilt angle that produces a usable signal on polished glass (n = 1.5) in the mid of the measuring range. The accuracy decreases when approaching the limit values.

Switching output		Error1-Out, Error2-Out	
Digital output		Sync out	
Connection		12-pin M12 connector for supply, Ethernet, RS422 and Sync 17-pin M12 connector for I/O analog and encoder optional extension to 3 m / 6 m / 9 m / 15 m possible (see accessories for suitable connection cables)	
Mounting		Radial clamping (see accessories for mounting adapter), threaded holes	
Temperature range	Storage	-20 … +70 °C	
	Operation	+5 ... +50 °C	
Shock (DIN EN 60068-2-27)		15 g / 6 ms in XY axis, 1000 shocks each	
Vibration (DIN EN 60068-2-6)		2 g / 20 … 500 Hz in XY axis, 10 cycles each	
Protection class (DIN EN 60529)	Sensor	IP64 (front)	
	Controller	IP65	
Material		Aluminum housing, passive cooling	
Weight		approx. 490 g	approx. 490 g	approx. 490 g
Control and indicator elements		Correct button, LEDs for Intensity, Range, Link and Data	

2.5 Technical data confocalDT IFD2415

Model		IFD2415-1 Ethernet	IFD2415-3 Ethernet	IFD2415-10 Ethernet
Measuring range		1 mm	3 mm	10 mm
Start of measuring range		approx. 10 mm	approx. 20 mm	approx. 50 mm
Resolution	Static [1]	< 4 nm	< 8 nm	< 18 nm
	Dynamic [2]	< 38 nm	< 80 nm	< 204 nm
Measuring rate		Continuously adjustable from 100 Hz to 25 kHz		
Linearity [3]	Displacement and distance	< ±0.2 µm	< ±0.6 µm	< ±2 µm
	Thickness	< ±0.4 µm	< ±1.2 µm	< ±4 µm
Multi-peak measurement		5 layers		
Light source		Internal white LED		
Permissible ambient light		30.000 lx		
Light spot diameter[4]		8 µm	9 µm	16 µm
Measuring angle [5]		±30°	±24°	±17°
Numerical aperture (NA)		0.55	0.45	0.30
Min. target thickness		0.05 mm	0.15 mm	0.5 mm
Target material		Reflective, diffuse as well as transparent surfaces (e.g. glass)		
Supply voltage		24 VDC ±10 %		
Power consumption		< 7 W (24V)		
Signal input		3 x encoders (A+, A-, B+, B-) 2 x HTL/TTL multifunction input: trigger in, slave in, zeroing, master, teach; 1 x RS422 synchronization input: trigger in, sync in, master/slave, master/slave alternating		
Digital interface		Ethernet / RS422		
Analog output		4 … 20 mA / 0 … 5 V / 0 ... 10 V (16 bit D/A converter)		

[1] All data at constant ambient temperature (24 ±2 °C). Average from 2,048 values at 1 kHz, in the mid of the measuring range onto optical flat

[2] RMS noise relates to mid of measuring range (1 kHz)

[3] Maximum deviation from reference system over the entire measuring range, measured on front surface of ND filter

[4] In the mid of the measuring range

[5] Maximum sensor tilt angle that produces a usable signal on polished glass (n = 1.5) in the mid of the measuring range. The accuracy decreases when approaching the limit values.

Switching output		Error1-Out, Error2-Out		
Digital output		Sync out		
Connection		12-pin M12 connector for supply, Ethernet, RS422 and Sync 17-pin M12 connector for I/O analog and encoder optional extension to 3 m / 6 m / 9 m / 15 m possible (see accessories for suitable connection cables)		
Mounting		Radial clamping (see accessories for mounting adapter), threaded holes		
Temperature range	Storage	-20 … +70 °C		
	Operation	+5 ... +50 °C		
Shock (DIN EN 60068-2-27)		15 g / 6 ms in XY axis, 1000 shocks each		
Vibration (DIN EN 60068-2-6)		2 g / 20 … 500 Hz in XY axis, 10 cycles each		
Protection class (DIN EN 60529)	Sensor	IP64 (front)		
	Controller	IP65		
Material		Aluminum housing, passive cooling		
Weight		approx. 500 g	approx. 600 g	approx. 800 g
Control and indicator elements		Correct button, LEDs for Intensity, Range, Link and Data		

3 Delivery

3.1 Scope of delivery, confocalDT IFD2410/2415

1 Sensor	IFD241x-x
1 PC2415-1/Y	Length 1 m
1 acceptance protocol	
1x Quick Manual	

- Carefully remove the components of the measuring system from the packaging and ensure that the goods are forwarded in such a way that no damage can occur.
- Check the delivery for completeness and shipping damage immediately after unpacking.
- If there is damage or parts are missing, immediately contact the manufacturer or supplier.

3.2 Return of packaging

Micro-Epsilon Messtechnik GmbH & Co. KG offers customers the opportunity to return the packaging of products purchased from Micro-Epsilon by prior arrangement so that it can be reused or recycled.

To arrange the return of packaging, for questions about the costs and / or the exact return procedure, please contact us directly at

info@micro-epsilon.de

3.3 Storage

Temperature range:	-20 ... +70 °C
Humidity:	5 ... 95 % RH (non-condensing)

i Protect the sensor lens against contamination.

4 Installation

4.1 Preliminary remarks

The optical sensors/measuring systems of the confocalDT IFD2410/2415 series measure in the nanometer range. Observe the maximum tilt between sensor and target.

i Ensure careful handling during installation and operation.

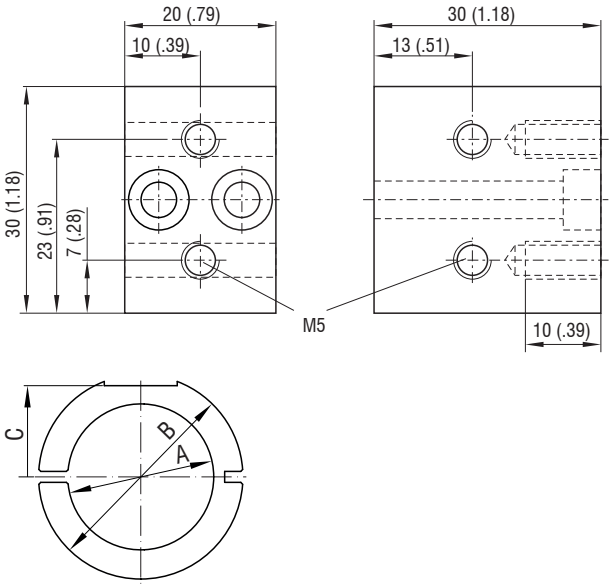
4.2 confocalDT IFD2410/2415

4.2.1 Circumferential clamping

► Mount the IFD241x using a mounting adapter.

Fig. 4.1: Circumferential clamping with MA240x mounting ring, consisting of mounting block and mounting ring

i Micro-Epsilon recommends using the circumferential clamping.

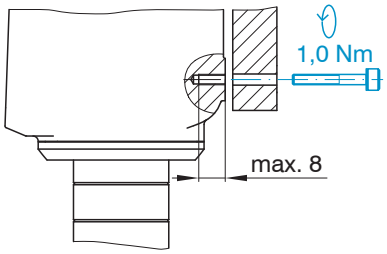


Mounting ring	Dimension A	Dimension B	Dimension C
MA2400-27	ø27	ø46	19.75
MA2405-34	ø34	ø50	22
MA2405-54	ø54	ø70	32

Tab. 4.1: Mounting block and mounting ring MA240x

4.2.2 Direct screw connection

► Mount the IFD241x using three M3 screws.



Screwing depth		Screw	Tightening torque Screw
Minimum	Maximum	ISO 4762	
mm	mm	3 pieces	Nm
6	8	M3	1.0

Tab. 4.2: Mounting conditions IFD2410 / IFD2415

IFD2410-	1	3	6
MR	1	3	6
SMR	15	25	35
A	56		
B	33		
C	150		
D	27		

IFD2415-	1	3	10
MR	1	3	10
SMR	10	20	50
A	82	85	118
B	59	62	---
C	176	179	212
D	27	34	54

Dimension in millimeters

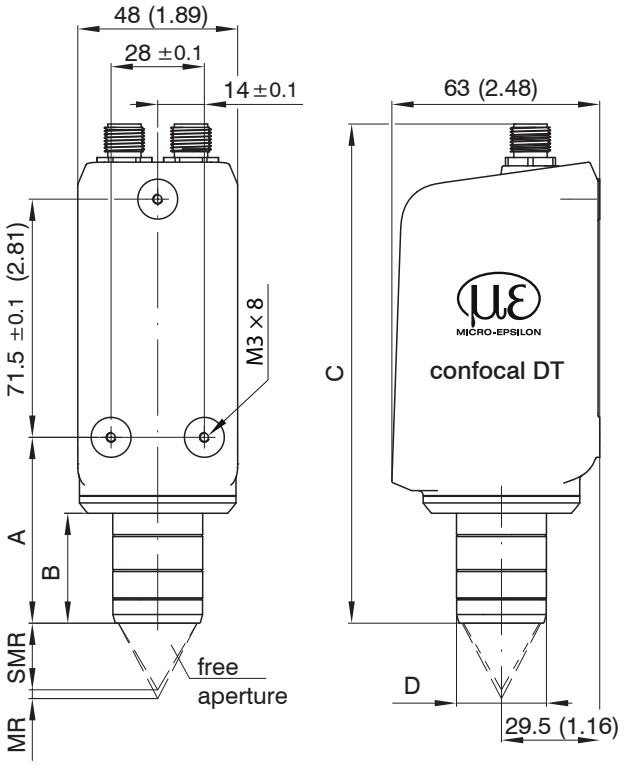
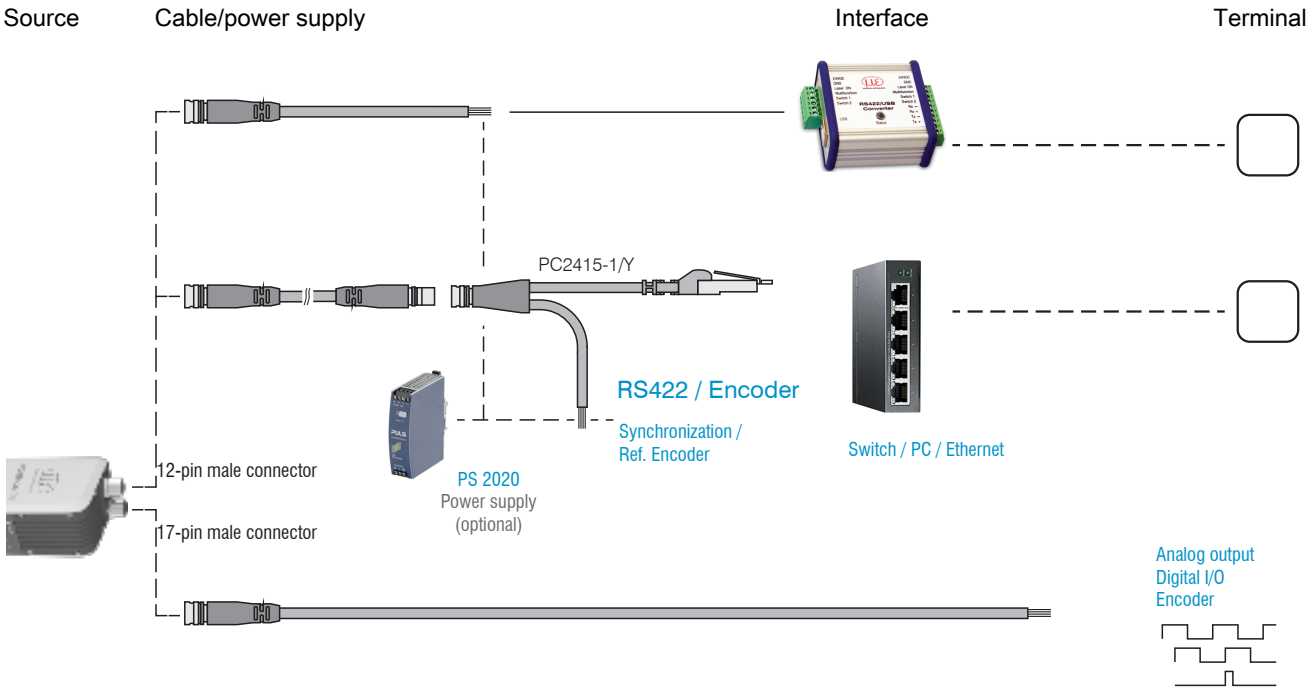


Fig. 4.2: Dimensional drawing IFD2410 / IFD2415, dimensions in mm

The support surfaces around the fastening holes are slightly raised.

4.2.3 Electrical connections, pin assignment



Tab. 4.3: Connection examples with confocalDT IFD2410/2415

IFD2410/2415, 12-pin connector			PC2415-x/OE	PC2415-1/Y		IF2001
Signal		Pin	Wire color	Wire color	RJ45, pin	Signal
V_+		1	Red	Red	---	24VDC
Supply GND		2	Blue	Blue	---	GND
Data Rx+	Encoder 2A + [6]	3	Brown	Brown	---	Tx +
Data Rx -	Encoder 2A -	4	White	White	---	Tx -
Data Tx +	Encoder 2B +	5	Green	Green	---	Rx +
Data Tx -	Encoder 2B +	6	Yellow	Yellow	---	Rx -
SYNC +	Encoder 2Ref +	7	Gray	Gray	---	---
SYNC -	Encoder 2Ref -	8	Pink	Pink	---	---
Shield		Housing	Black	Black	---	---
Industrial Ethernet		9	White/green	---	3	---
		10	Green	---	6	---
		11	White/orange	---	1	---
		12	Orange	---	2	---

The PC2415-1/Y cable is included in the scope of delivery.

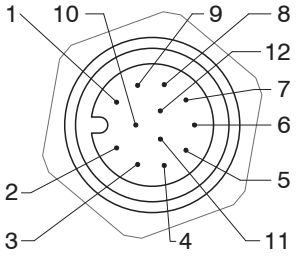


Fig. 4.3: 12-pin sensor connector, pin side

Tab. 4.4: Pin assignment for 12-pin sensor connector

IFD2410/2415, 17-pin connector		SC2415-x/OE
Signal	Pin	Wire color
Analog output	1	White, inside
Analog GND	2	Black
Switching output 2 GND	3	Black
Switching output 2	13	Violet
Multifunction input 1	5	Red
Multifunction input 2	14	Blue
Encoder 1B +	8	Gray
Encoder 1B -	15	Pink
Encoder 1Ref +	9	Green
Encoder 1Ref -	16	Yellow
Switching output 1 GND	10	Brown
Switching output 1	11	White
Encoder 1A -	12	Red/ blue
Encoder 1A +	17	Gray/pink
Shield	Housing	Black

The SC2415-x/OE cable is available as an optional accessory.

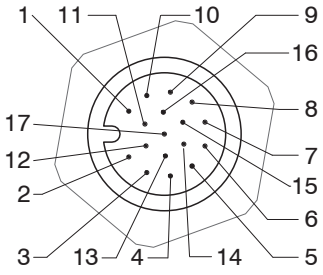


Fig. 4.4: 17-pin sensor connector, pin side

Tab. 4.5: Pin assignment 17-pin sensor connector

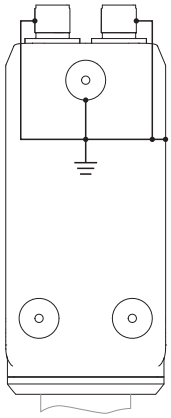
[6] You can use the pins for
- serial communication (TIA/EIA-422-B) and synchronization or
- encoder signals.

4.2.4 Grounding concept, shielding

All inputs and outputs are galvanically connected to the supply ground (Supply GND); the Ethernet/EtherCAT connections are potential-free.

The ground connections (supply GND, switching output GND and analog GND) of each connection group are galvanically connected internally via filters.

The shield connections of each connection group are only connected to the controller housing. They are used to connect the cable shieldings for individual connections (power, analog output, switching outputs, synchronization and trigger input).

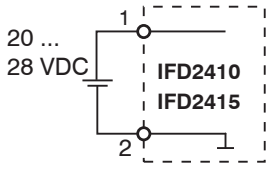


i For reasons of electromagnetic immunity, use the corresponding GND connection for the analog output and the two switching outputs.
Only use screened cables shorter than 30 m and connect the cable screen to the Shield or the connector housing.

4.2.5 Supply voltage (power)

Nominal value: 24 VDC (20 ... 28 V, P < 7 W).

The sensor is supplied via cable PC2415-1/Y or PC2415-x/OE.



IFD2410/2415 12-pin connector	Power supply	PC2415-1/Y PC2415-x/OE
1	V_+	Red
2	GND	Blue

Only turn on the power supply after wiring has been completed.

► Connect the inputs Pin 1 and Pin 2 at the sensor with a 24V power supply.

i Voltage supply only for measuring devices, not to be used for drives or similar sources of impulse interference at the same time. Micro-Epsilon recommends using an optional available power supply unit PS2020 for the sensor.

4.2.6 RS422

In addition to Industrial Ethernet, the IFD2410/2415 also supports serial communication via RS422. The PC2415-1/Y or PC2415-x/OE cables enable serial communication. The IF2001/USB RS422-to-USB converter is available as an optional accessory.

- Differential signals according to EIA-422, galvanically connected to supply voltage.
- Receiver Rx with 120 ohm internal terminating resistor.

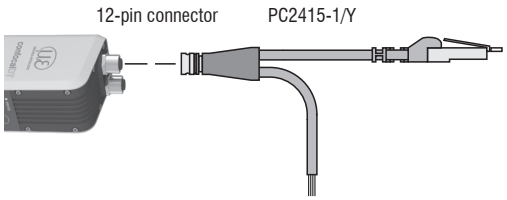
- ► Use a shielded cable with twisted wires.
  Cable length must be less than 30 m.
- ► Connect the ground connections.

IFD2410/2415 12-pin connector	Signal	PC2415-1/Y PC2415-x/OE	IF2001/USB
3	RX +	Brown	TX +
4	RX -	White	TX -
2	Supply GND (blue)		GND
5	TX +	Green	RX +
6	TX -	Yellow	RX -
Housing	Shield	Cable shield	---

4.2.7 Ethernet

Connection

- with Ethernet network (PC)



IFD2410/2415, 12-pin connector		PC2415-x/OE	PC2415-1/Y
Signal	Pin	Wire color	RJ45, pin
Industrial Ethernet	9	GND	3
	10	White/green	6
	11	White/orange	1
	12	Orange	2

- ► Connect the IFD2410/2415 and network with a shielded Ethernet cable (Cat5E, patch cable 2 m from the scope of delivery, total cable length less than 100 m).

The two LEDs `RUN` and `ERR` indicate that the connection was successful and is active.

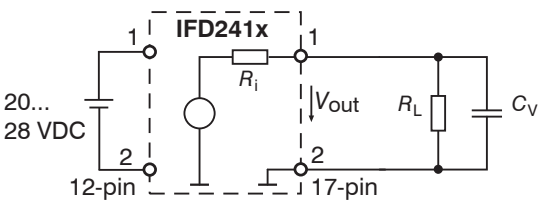
The measuring device can be configured via the web interface or by ASCII commands at command level (e.g. Telnet).

4.2.8 Analog output

The alternative analog output (voltage or current) is connected to the 17-pin sensor plug and is galvanically connected to the supply voltage.

IFD2410/2415, 17-pin connector		SC2415-x/OE
Signal	Pin	Wire color
Analog output	1	White, inside
Analog GND	2	Black [7]

Voltage: Pin U/I_{out} and Pin GND,



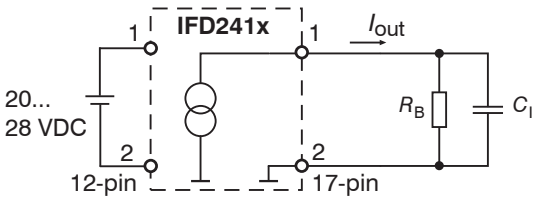
R_i approx. 50 Ohm, R_L > 10 MOhm

Slew rate (without C_V, R_L ≥ 1 kOhm) typ. 0.5 V/µs

Slew rate (with C_V = 10 nF, R_L ≥ 1 kOhm) typ. 0.4 V/µs

Current: Pin U/I_{out} and Pin GND,

[7] Analog output in shielded cable area



R_B ≤ 500 Ohm

Slew rate (without C_I, R_B = 500 Ohm) typ. 1.6 mA/µs

Slew rate (with C_I = 10 nF, R_B = 500 Ohm) typ. 0.6 mA/µs

► Use a shielded cable. Cable length less than 30 m.

As an alternative, the output range can be set to the following values:

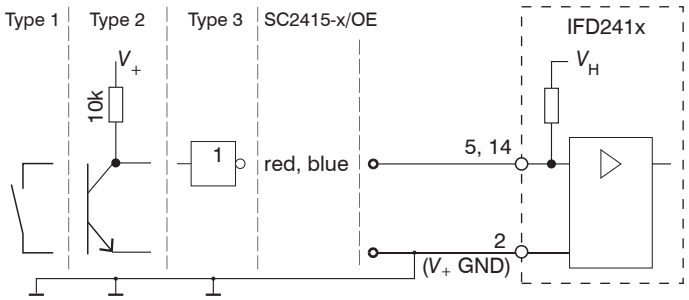
Voltage: 0 ... 5 V; 0 ... 10 V;

Current: 4 ... 20 mA.

The measured values can only be output as voltage or current.

4.2.9 Multifunction inputs

A switching transistor with an open collector (e.g. in an optocoupler), a relay contact or a digital TTL or HTL signal are suitable for switching.



The inputs are not electrically separated.
24V logic (HTL): Low ≤ 3 V; High ≥ 8 V (max 30 V),
5V logic (TTL): Low ≤ 0.8 V; High ≥ 2 V
Minimal pulse width 50 µs
Internal pull-up resistor, an open input is detected as High.
Maximum switching frequency 25 kHz

An external resistor is not required for current limitation. The ground of the logic circuit must be galvanically connected to the supply ground.

4.2.10 Switching outputs (digital I/O)

The GND connections of the switching outputs are separated from the supply GND by filters.

The switching behavior (NPN, PNP, push-pull) is programmable, I_{max} 100 mA.

The maximum auxiliary voltage for a switching output with NPN switching behavior is 28 V.

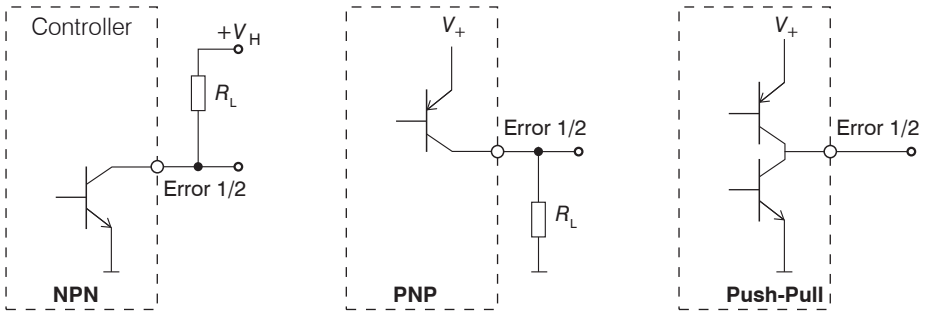


Fig. 4.5: Output behavior and wiring of the TTL switching outputs `Error 1/2`

IFD2410/2415, 17-pin connector		SC2415-x/OE
Signal	Pin	Wire color
Switching output 2 GND	3	Black
Switching output 2	13	Purple
Switching output 1 GND	10	Brown
Switching output 1	11	White

All GND conductors are interconnected with one another and to the supply ground.

► Use a shielded cable. Cable length less than 30 m.

Output level (without load resistor) at a supply voltage of 24 VDC	Low < 1 V; High > 23 V
	Low < 2.5 V (output - GND)
Saturation voltage with I_{max} = 100 mA	High < 2.5 V (output - $V+$)

The saturation voltage is measured

- between output and GND, at output = Low, or
- between output and $V+$, with output = High.

Name	Output active (error)	Output passive (no error)
NPN (Low side)	GND	$V+$
PNP (High side)	$V+$	GND
Push-pull	$V+$	GND
Push-pull, negative	GND	$V+$

Tab. 4.6: Switching behavior of the switching outputs

i The load resistor R_L can be dimensioned according to the limit values (I_{max} = 100 mA, V_{Hmax}= 28 V). When connecting inductive loads, e.g. a relay, the parallel protective diode must not be missing.

4.2.11 Synchronization (in-/outputs)

4.2.11.1 General

- The `SYNC+` and `Sync-` pins on the 12-pin sensor connector: Symmetrical output/input for synchronization of two or more sensors
- The pins `Multifunction input 1` or `Multifunction input 2` on the 17-pin sensor connector: Input for synchronizing a sensor with an external synchronous source, e.g. function generator
- The termination resistor R_T (120 Ohm) can be switched on or off via software.

4.2.11.2 Internal synchronization

An IFD2410/2415 (master) synchronizes one or more sensors (slaves).

IFD2410/2415, 12-pin connector			PC2415-x/OE	PC2415-1/Y
Signal	Pin	Level	Wire color	Wire color
Supply GND	2		Blue	Blue
SYNC +	7	RS422 (EIA422)	Gray	Gray
SYNC -	8		Pink	Pink

Tab. 4.7: Connections and signal level internal synchronization

► Activate the termination resistor (120 ohm) in the last sensor (slave n) in the chain.

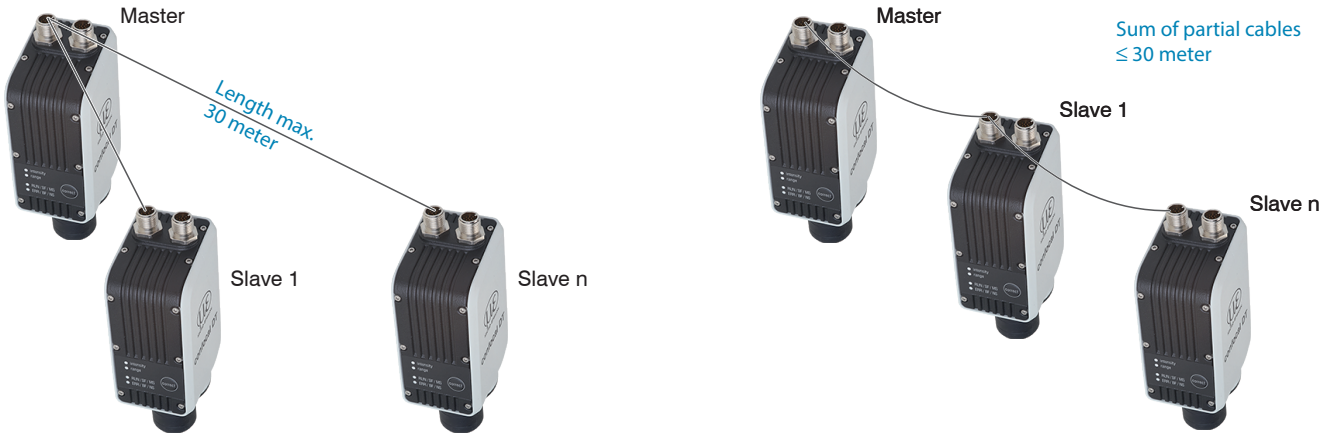
Star synchronization

- ► Connect the `Sync+` and `Sync-` pins of sensor 1 (master) in a star configuration with the `Sync+` and `Sync-` pins of sensor 2 (slave) to sensor n in order to synchronize two or more sensors with each other, see Tab. 4.8
- Sub-loop length less than 30 m in star synchronization

Chain synchronization

- ► Connect the `Sync+` and `Sync-` pins of sensor 1 (master) to the `Sync+` and `Sync-` pins of sensor 2 (slave 1). Connect the pins of the following sensors to synchronize two or more sensors with each other, see Tab. 4.8
- Total line length less than 30 m in chain synchronization

- ► Use shielded cables with twisted wires.
- ► Connect the cable shield to the housing.
- ► Program sensor 1 to `Master` and all other sensors to `Slave`.



Tab. 4.8: Synchronization of multiple sensors, star-shaped on the left, daisy-chained on the right

- ► Connect all GND connections of the supply to each other if the sensors are not supplied by a common power supply.

4.2.11.3 External synchronization

An external synchronous source synchronizes one or more IFD2410/2415 (slaves).

IFD2410/2415, 17-pin connector				SC2415-x/OE
Signal	Pin	Level		Wire color
Multifunction input 1	5	TTL Low level ≤ 0.8 V; High level ≥ 2 V Minimal pulse width 50 µs	HTL Low level ≤ 3 V; High level ≥ 8 V (max. 30 V) Minimal pulse width 50 µs	Red
Multifunction input 2	14			Blue

IFD2410/2415, 12-pin connector		PC2415-x/OE	PC2415-1/Y
Signal	Pin	Wire color	Wire color
Supply GND	2	Blue	Blue

Tab. 4.9: Connections and signal level external synchronization

- ► Activate the termination resistor (120 ohm) in the last sensor (slave n) in the chain.

Star synchronization

- ► Connect the pin `Multifunction input 1` or `2` of slave 1 to the external synchronous source.
- ► Connect the `Supply GND` of the sensor to the ground connection of the synchronization source.

Further sensors can be synchronized in the same schematic.

- Sub-loop length less than 30 m in star synchronization.

► Use shielded cables with twisted wires.
► Connect the cable shield to the housing.
► Program all sensors to `Slave`.

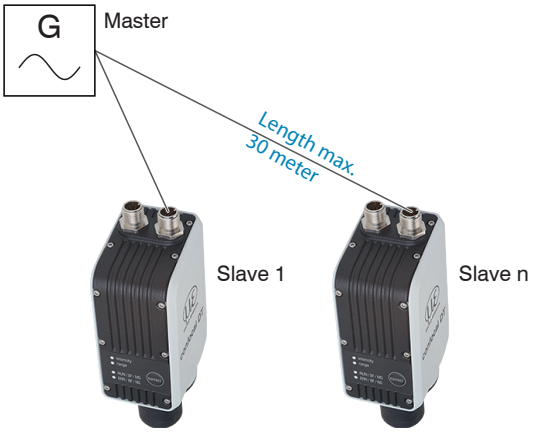


Fig. 4.6: Synchronization of multiple sensors, star-shaped

► Connect all GND connections of the supply to each other if the sensors are not supplied by a common power supply.

4.2.12 Triggering

4.2.12.1 General

Data acquisition or output can be triggered with:

- multifunction inputs 1/2,
- synchronization inputs Sync+ and Sync-,
- encoder 1.

► Use a shielded cable with twisted wires. Cable length less than 30 m.

Switching contacts, transistors (NPN, N-channel FET) or PLC outputs can be used as trigger sources.

4.2.12.2 Triggering with multifunction input

IFD2410/2415, 17-pin connector				SC2415-x/OE
Signal	Pin	Level		Wire color
Multifunction input 1	5	TTL Low level ≤ 0.8 V; High level ≥ 2 V Minimal pulse width 50 µs	HTL Low level ≤ 3 V; High level ≥ 8 V (max. 30 V) Minimal pulse width 50 µs	Red
Multifunction input 2	14			Blue

► Connect the `Multifunction input pin 1` or `2` to the external trigger source.
► Connect the `Supply GND` of the sensor to the ground connection of the external trigger source.

Program the sensor's `multifunction input` connections to the trigger input function.

4.2.12.3 Triggering with synchronization input

IFD2410/2415, 12-pin connector			PC2415-x/OE	PC2415-1/Y
Signal	Pin	Level	Wire color	Wire color
SYNC +	7	RS422 (EIA422)	Gray	Gray
SYNC -	8		Pink	Pink

► Connect the Sync+ and Sync- pins to the external trigger source.

Program the sensor's sync connections to the trigger input function.

The trigger source (master) must supply a symmetrical output signal according to the RS422 standard. For asymmetrical trigger sources, Micro-Epsilon recommends inserting the SU4 level converter (3 channels TTL/HTL to RS422) between trigger signal source and sensor.

4.2.12.4 Triggering with Input Encoder 1

A connected encoder at the encoder 1 inputs can be used for triggering.

IFD2410/2415, 17-pin connector			PC2415-x/OE
Signal	Pin	Level	Wire color
Encoder 1B +	8	RS422 (EIA422)	Gray
Encoder 1B -	15		Pink
Encoder 1A -	12		Red/ blue
Encoder 1A +	17		Gray/pink

Program the encoder's sync connections to the trigger input function.

4.2.13 Encoder inputs

The measuring system supports up to three encoders.

Two encoder inputs:

- Incremental signals A, B
- Reference pulse

The maximum pulse frequency is 1 MHz.

RS422 level (symmetrical) for A, B, Ref

IFD2410/2415, 12-pin connector		PC2415-x/OE	PC2415-1/Y	IFD2410/2415, 17-pin connector		SC2415-x/OE
Signal	Pin	Wire color		Signal	Pin	Wire color
Supply GND	2	Blue	Blue	Encoder 1B +	8	Gray
Encoder 2A + [8]	3	Brown	Brown	Encoder 1B -	15	Pink
Encoder 2A -	4	White	White	Encoder 1Ref +	9	Green
Encoder 2B +	5	Green	Green	Encoder 1Ref -	16	Yellow
Encoder 2B +	6	Yellow	Yellow	Encoder 1A -	12	Red/ blue
Encoder 2Ref +	7	Gray	Gray	Encoder 1A +	17	Gray/pink
Encoder 2Ref -	8	Pink	Pink			

Tab. 4.10: Pin assignment for two encoder inputs

Three encoder inputs:

- Incremental signals A, B

The maximum pulse frequency is 1 MHz; no reference pulse.

RS422 level (symmetrical) for A, B

[8] If encoders 2 and 3 are used, neither serial communication via RS422 and nor synchronization of the IFD2410/2415 is possible.

IFD2410/2415, 12-pin connector		PC2415-x/OE	PC2415-1/Y	IFD2410/2415, 17-pin connector		SC2415-x/OE
Signal	Pin	Wire color		Signal	Pin	Wire color
Supply GND	2	Blue	Blue	Encoder 1B +	8	Gray
Encoder 2A + [8]	3	Brown	Brown	Encoder 1B -	15	Pink
Encoder 2A -	4	White	White	Encoder 3A +	9	Green
Encoder 2B +	5	Green	Green	Encoder 3A -	16	Yellow
Encoder 2B +	6	Yellow	Yellow	Encoder 1A -	12	Red/ blue
Encoder 3B +	7	Gray	Gray	Encoder 1A +	17	Gray/pink
Encoder 3B -	8	Pink	Pink			

Tab. 4.11: Pin assignment for three encoder inputs

► Use a shielded cable. Cable length less than 3 m. Connect the cable shield to the housing.

Connection conditions

- The encoders must supply symmetrical RS422 signals.
- If there are no RS422 outputs on the encoder, Micro-Epsilon recommends inserting the SU4 level converter (3 channels TTL/HTL to RS422) between trigger signal source and controller.

[8] If encoders 2 and 3 are used, neither serial communication via RS422 and nor synchronization of the IFD2410/2415 is possible.

5 Initial operation

5.1 Communication options

i	The measuring system is ready for operation approx. 3 s after the supply voltage is applied. To ensure precise measurements, let the measuring system warm up for approx. 50 minutes.

The controllers start in Ethernet mode.

Communication with the controller

Ethernet communication

- Parameterization via web interface,
- Data output via Ethernet
- programming on command level, e.g., with Telnet,

Connect the controller and the PC with a LAN cable.
Start your web browser and type the standard IP address 169.254.168.150 of the sensor into the address bar.

Communication via RS422

- Programming via web interface,
- programming on command level, e.g., with Telnet,
- Data output via RS422

Connect the controller, e.g., via an IF2001/USB RS422 converter from Micro-Epsilon via USB to a PC.

- Start the `sensorTOOL` program.
- Download at https://www.micro-epsilon.de/download/software/sensor-TOOL.exe.
- Click on the `Sensor` button.
- The program will now search for connected controllers.
- Select the desired controller. Click the `Open Website` button.

Saved settings are retained permanently in the controller across all interfaces.

5.2 Access via web interface

► Launch the web interface of the measuring system.

Interactive web pages for configuring the measuring system now appear in the web browser. The measuring system is active and provides measured values. Real-time measurement with the web interface is not guaranteed. The ongoing measurement can be controlled with the function buttons in the `chart type`.

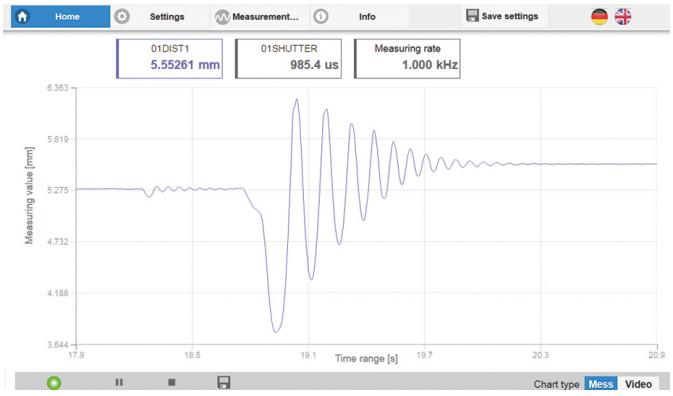


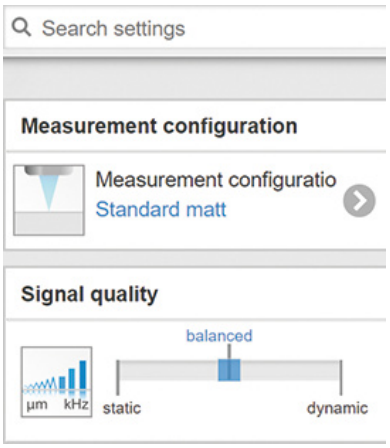
Fig. 5.1: Start page after accessing the web interface in Ethernet mode

You can switch between the video signal and a display of the measured values over time for configuration. The appearance of the web sites can change depending on the functions. Dynamic help texts with excerpts from the operating instructions aid you in configuring the measuring system.

i	Depending on the selected measuring rate and the PC used, measured values may be reduced dynamically in the display. This means that not all measured values are sent to the web interface for display and saving.

Horizontal navigation includes the following functions:

- `Home`. The web interface automatically starts in this view with measurement chart, `measurement configuration` and `signal quality`.
- `Settings`. Configuration parameters, including triggering, measuring rate and zeroing/mastering.
- `Measurement chart`. Measurement chart or show video signal.
- `Info`. Contains information on the sensor, including measuring range, serial number and software version.
- Web interface language selection

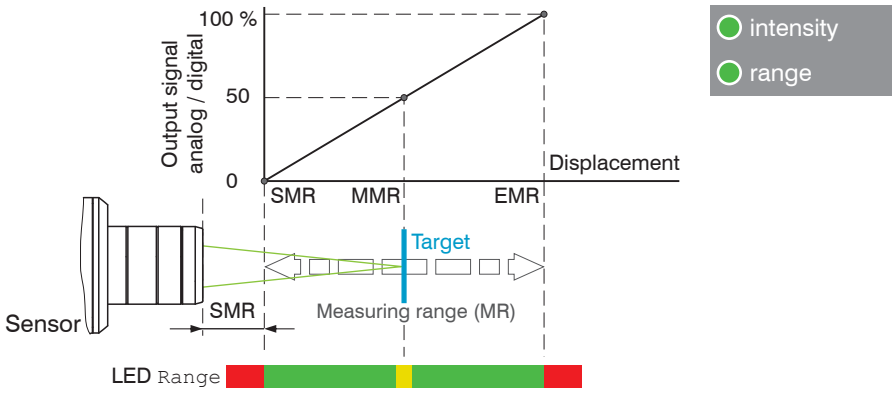


The vertical navigation is related to the context of the selection in the horizontal navigation and contains the following functions for the `Home` menu:

- The `Find settings` function enables time-saving access to functions and parameters.
- `Measurement configuration`. Enables selection of predefined measurement settings.
- `Signal quality`. You can switch between three predefined basic settings for the measuring rate and averaging with a mouse click.

5.3 Positioning the target

► Position the target as centrally as possible within the measuring range.



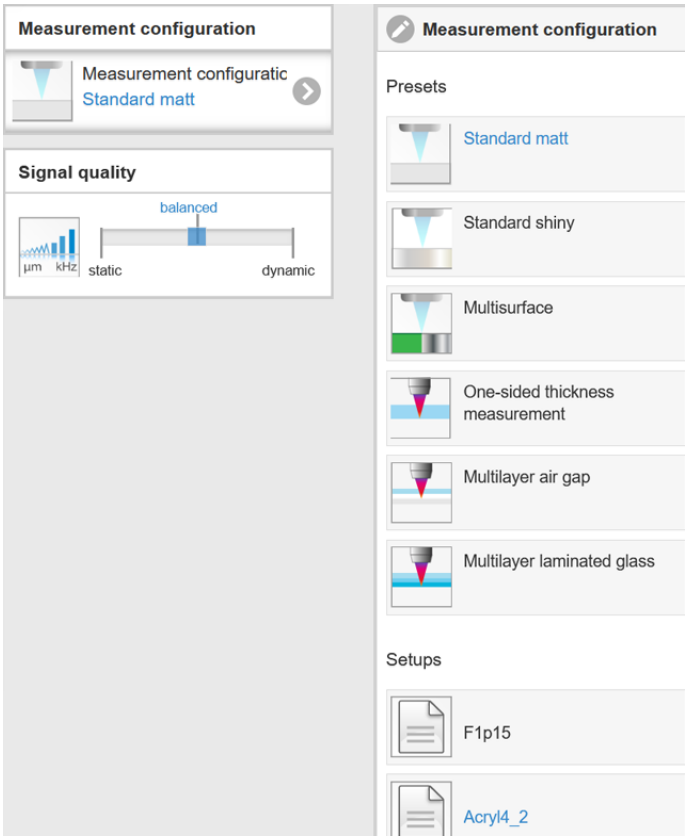
LED Range	
Red	No target present or target outside of measuring range
Yellow	Target close to mid of measuring range
Green	Target within the measuring range

The `Range` LED on the front of the measuring system indicates the position of the target relative to the sensor.

5.4 Presets, setup, selection of measurement configuration

Definition

- Preset: Manufacturer-specific program containing settings for common measuring tasks that cannot be overwritten
- Setup: User-specific program containing the relevant settings for a measuring task
- Initial setup at boot (start measuring system): a favorite setting which is automatically activated upon start-up can be selected from the setups. If no favorite is selected from the setups, the measuring system activates the `Standard` preset upon start-up.



Upon delivery of the measuring system from the factory:

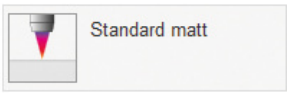
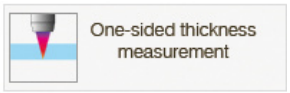
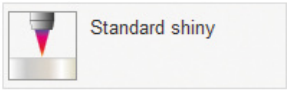
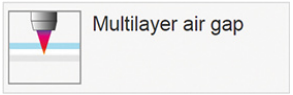
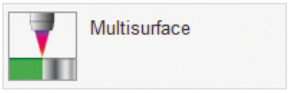
- the presets `Standard matt`, `Standard shiny`, `Multisurface` and `One-sided thickness measurement` are available.
- for the IFD2415 sensor, the presets `Multi-layer air gap` and `Multilayer laminated glass` are also available,
- no setup is available.

You can select a preset in the `Home > Measurement configuration` tab.

You can select a setup in the menu `Home > Measurement configuration` tab or `Settings` in the `System settings > Load & save`.

A setup can be permanently saved in the measuring system.

These presets enable quick startup of the respective measurement task. Basic features to suit the target surface, such as peak and material selection and the calculation functions are already set in the preset.

	Distance measurement e.g. for ceramic material, non-transparent plastics. Highest peak, averaging, distance calculation.		One-sided thickness measurement, e.g., for glass, BK7 material. First and second peak, averaging, thickness calculation.
	Distance measurement e.g. for metal, polished surfaces. Highest peak, median over 5 values, distance calculation.		One-sided thickness measurement[9] against glass, 1st layer BK7, 2nd layer vacuum, first and second peak, 3 measured values, median over 5 values, thickness calculation.
	Distance measurement e.g. for PCBs, hybrid materials. Highest peak, median over 9 values, distance calculation.		Layer thickness measurement[9] against laminated glass, e.g. windshield, 1st layer BK7, 2nd layer PC, 3rd layer BK7, 1st and 2nd peak, 4 measured values, thickness calculation.

5.5 Video signal

► Go to the `Measurement chart` menu. Show video signal display with `Video`.

The diagram in the large graphic window on the right shows the video signal of the receiver line in different post-processing states.

The video signal in the graphics window shows the spectral distribution over the pixels of the receiver line. Left 0 % (small distance) and right 100 % (large distance). The corresponding measured value is marked by a vertical line (peak marking).

[9] Only possible with IFD2415.

The diagram starts automatically when the website is accessed.

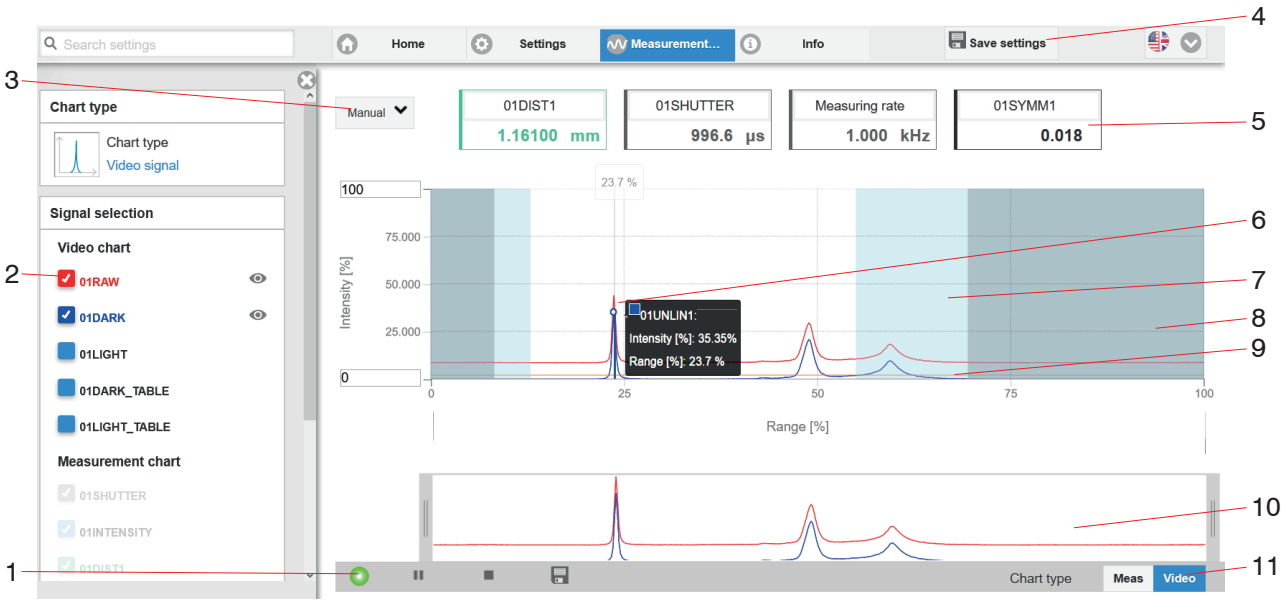


Fig. 5.2: `Video signal` web page

The `Video signal` website contains the following functions:

1 The LED visualizes the status of the transmission of measured values.
- green: measured value transmission in progress
- yellow: waiting for data in trigger state
- gray: measured value transmission paused

The data query is controlled with the `Play/Pause/Stop/Save` buttons of the measured values that were transmitted. `Stop` halts the diagram; data selection and the zoom function are still possible. `Pause` pauses the recording. `Save` opens the Windows selection dialog for the file name and the save location to save the selected video signals to a CSV file. This contains all pixels, their (selected) intensity in % and other parameters.
Click on the ► button (Start) to display the measurement results.

2 In the left-hand window, the video curves to be displayed can be switched on or off during or after the measurement. Inactive curves are grayed out and can be added by clicking on the check mark. The changes become effective when you save the settings.
You can show or hide the individual signals using the eye symbols. The calculation continues in the background.
- 0xRAW: Raw signal (uncorrected CCD signal)
- 0xDARK: Dark-corrected signal (raw signal minus dark level table)
- 0xLIGHT: Light-corrected signal (dark-corrected signal corrected with the light source table)
- 0xDARK_TABLE: Dark value table (generated in response to dark correction)
- 0xLIGHT_TABLE: Light value table (generated in response to light referencing)

3 To scale the intensity axis in the graph for the measured values (Y axis), you can use `Auto` (= automatic scaling) or `Manual` (= manual scaling).

4 All changes only become effective when you click on the `Save settings` button.

5 The current values of the exposure time and the selected measuring rate are also displayed above the graphic.

6 Mouseover function. Moving the mouse over the graph, marks curve points or the peak marking with a circle symbol and displays the corresponding intensity. The corresponding x-position in % appears above the graphic field.

7 The region of interest can be restricted if ambient light of a certain wavelength (blue, red, IR) causes interference in the video signal, for example. The value for the "Start of range" must be smaller than the value for the "End of range". Value range between 0 ... 100 %.

8 The linearized range lies between the gray shades in the chart and cannot be changed. Only peaks whose middles lie within this range can be calculated as a measured value. The masked area can be restricted if necessary and is then limited by an additional light blue shading on the right and left. The peaks remaining in the resulting range are used for the evaluation.

9 The detection threshold, in relation to the dark-corrected signal, is a horizontal straight line corresponding to the preselected value. It should be just high enough so that no unwanted peaks in the video signal are included in the evaluation. Aim for the lowest possible threshold to get a good signal-to-noise ratio. The detection threshold should not be changed if possible.

10 X axis scaling: The diagram shown above can be enlarged (zoomed in on) with the two sliders on the right and left in the lower entire signal. The overall signal can also be moved to the side using the mouse in the center of the zoom window (arrow cross).

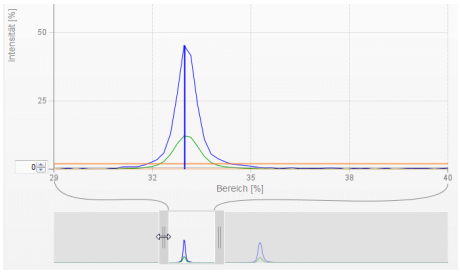


Fig. 5.3: Zooming with slider: one-sided with arrow cross

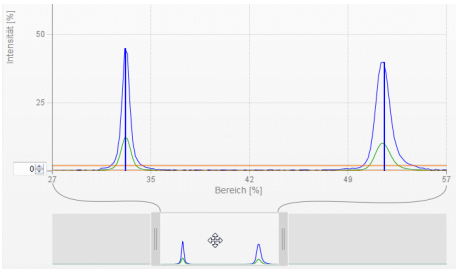


Fig. 5.4: Zooming with slider: range shift with arrow cross

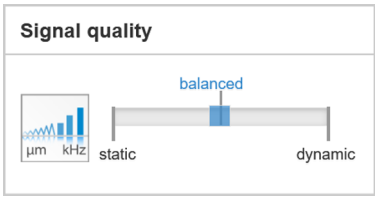
11 The two buttons allow you to switch between the display of the video signal and the measured value.

5.6 Signal quality

A good measurement result can be achieved if the video signal is sufficiently intense. Reducing the measuring rate increases the exposure time for the CCD row and thus improves the measurement quality.

You can switch between three basic settings (Static, Balanced and Dynamic) in the `Signal quality` section. The reaction in the chart and system configuration is immediately visible.

► Go to the `Home > Signal quality` menu and adjust the measurement dynamics as required. Monitor the result in the video signal.



	Measuring rate	Averaging[10]
`Static`	200 Hz	Moving, 128 values
`Balanced`	1 kHz	Moving, 16 values
`Dynamic`	5 kHz	Moving, 4 values

i If the sensor starts up with a user-defined configuration (setup), the signal quality cannot be changed.

5.7 Distance measurement with website display

► Align the sensor perpendicularly to the object to be measured.

► Then move the sensor (or the measuring object) closer and closer from a distance until the start of the measuring range corresponding to the sensor used is approximately reached.

As soon as the object is within the measuring field of the sensor, this is shown by the `Range` LED (green or yellow). Alternatively, you can watch the video signal.

[10] Applies for the presets Standard and One-sided thickness measurement.

LED	Status	Description
Intensity	Red	Signal saturated
	Yellow	Signal too low
	Green	Signal OK
Range	Red	No target or target outside of measuring range
	Yellow	Target in center of measuring range
	Green	Target within the measuring range

Tab. 5.1: Meaning of LEDs during distance measurement

Opening the `Meas` chart type in the `Measurement chart >` opens the following website. The chart starts automatically when the website is accessed. The large graphic window on the right shows the value-time graph.

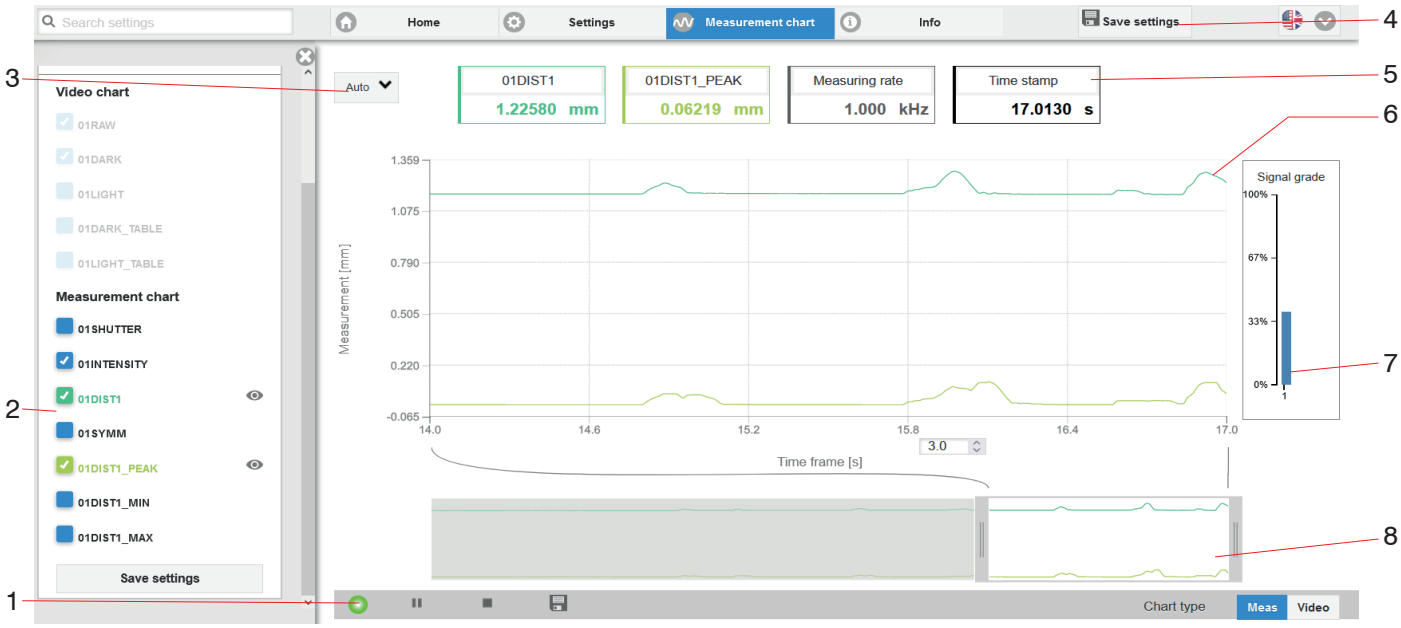


Fig. 5.5: Website `Meas` (distance measurement)

1 The LED visualizes the state of measured value transmission.
- green: measured value transmission in progress
- yellow: waiting for data in trigger state
- gray: measured value transmission paused

The data query is controlled with the `Play/Pause/Stop/Save` buttons of the measured values that were transmitted. `Stop` stops the diagram; you can still continue to use the data selection and zoom functions. `Pause` pauses the recording. `Save` opens a Windows selection dialog for the file name and save location to save the last 10,000 values in a CSV file (separation using semicolon).

Click on the ► button (Start) to display the measurement results.

2 In the left-hand window, the signals of channel 1/2 to be displayed can be switched on or off during or after the measurement. Inactive curves are grayed out and can be added by clicking on the check mark. The changes become effective when you save the settings.

You can show or hide the individual signals using the eye symbols . The calculation continues in the background.
- 0xSHUTTER: Exposure time
- 0xINTENSITY: Signal quality of the underlying peak in the video signal
- 0xDIST: Distance signal curve over time

3 To scale the intensity axis in the graph for the measured values (Y axis), you can use `Auto` (= automatic scaling) or `Manual` (= manual scaling).

4 All changes only become effective when you click on the `Save settings` button.

5 Current values for distance, exposure time, current measuring rate and time stamp are shown in the text boxes above the graph. Errors are also displayed.

6 Mouseover function. When the chart has been stopped and you move the mouse over the graph, points on the curve are marked with a circle and the associated values are displayed in the text boxes above the graph. The intensity bars are also updated.

7 Peak intensity is displayed as a bar chart.

8 X axis scaling: During an ongoing measurement, you can use the left-hand slider to enlarge the entire signal (zoom). The time range can also be defined using an input field under the time axis. When the chart has been stopped, the right-hand slider can also be used. You can also move the zoom window with the mouse in the center of the zoom window (four-sided arrow).

5.8 Dark correction

The measuring system requires a warm-up time of approx. 30 min before performing a dark correction. Dark correction is required after prolonged operation or if the sensor becomes dirty, and it is stored in the controller.

Work steps:

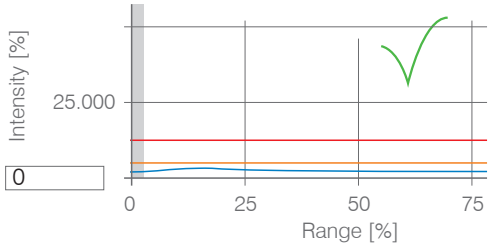
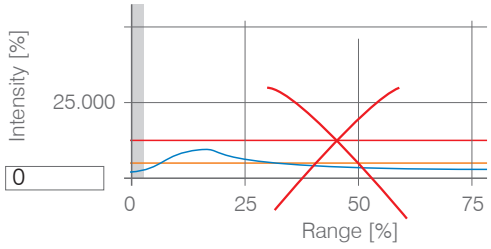
► Remove the measuring object from the measuring range or cover the sensor front with a piece of dark paper.

i During the dark correction, no object may be within the measuring range under any circumstances, nor may ambient light enter the sensor.

Correction using the button	Correction via software/web interface
IFD2410/2415	Switch to the `Settings > Sensor > Dark reference` menu. Click on the `Start` button to start the correction.
Press the `correct` button on the IFD2410/2415 for approx. 4 s[11], to start the correction.	

The LEDs `Intensity` and `Range` start to flash. The sensor now records the current dark signal for about 50 s.

After dark correction, the video signal appears nearly smooth directly along the x-axis.

IFD2410/2415	Dark signal evaluation
Remove the covering paper from the sensor. This sensor can be used normally again.	 *Fig. 5.6: Dark signal OK*
Carefully clean the glass surface on the sensor. Repeat the dark correction.	 *Fig. 5.7: Dark signal too high*

With each new dark correction, the current brightness value is determined as the quotient of the sum of all intensities and the current exposure time. If a major change is detected from the previously saved value, this can be interpreted as a contamination level and a warning is given.

You can also ignore this message. For time-critical measurements, however, you should remember the current exposure time.

[11] If you press this button for more than 10 seconds, the factory setting is loaded.

Exclusively use pure isopropyl alcohol and fresh lens cleaning paper for cleaning.

You can use an ASCII command to set the warning threshold for contamination if required

- permissible deviation in %,
- the factory setting is 50 %.

The warning threshold is saved so that it is specific to the setup.

6 Setting sensor parameters, web interface

6.1 Inputs

6.1.1 Synchronization

Legend of the menu structure:

	Fields with gray background require a selection.	Value	Fields with dark border require entry of a value.

► In the `Settings` tab, switch to the `Inputs` menu.

Synchronization	*Master / Slave / Multifunction input 1 / Multifunction input 2*	*If multiple measuring systems are to measure the same target at the same time, the controllers can be synchronized with one another. The synchronization output of the first controller (master) controls the controllers (slaves) connected at the synchronization inputs.*
	Inactive	

6.1.2 Encoder inputs

6.1.2.1 Overview, menu

The IFD2410 and the IFD2415 support up to three encoders, see Chap. 4.2.13.

A maximum of three encoder values can be assigned to the measuring data exactly, output and also used as triggering condition. This precise assignment to the measured values is ensured by outputting exactly the encoder values that were present halfway through the exposure time of the measured value (the exposure time may vary due to the control). Tracks A and B enable direction recognition.

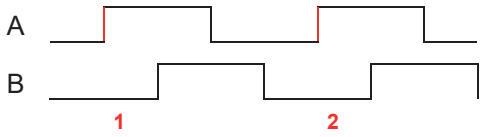
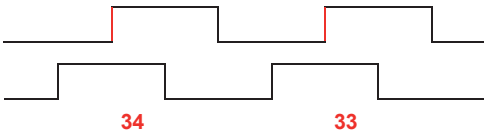
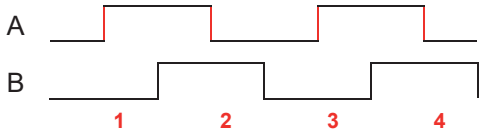
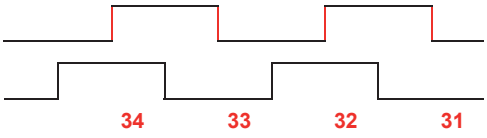
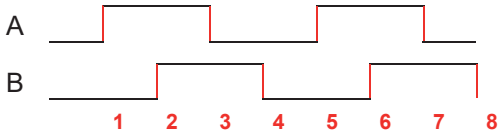
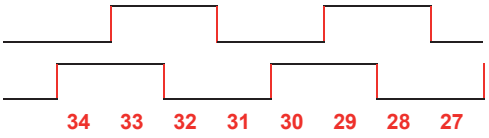
Encoders 1 / 2 / 3	Interpolation	*single / double / quadruple resolution*
	Maximum value	*value*
	Effect on reference track	*no effect / set once for mark / set for all marks*
	Set to value	*value*
	Set encoder value via software	
	Reset detection of first reference marker	

6.1.2.2 Number of encoders

The number of encoders determines how many of the encoders are used. With 2 encoders, data output via RS422 and synchronization cannot be used. With 3 encoders, the reference tracks of encoder 1 and encoder 2 cannot be used.

6.1.2.3 Interpolation

Interpolation increases the resolution of an encoder. The counter reading is incremented or decremented with each interpolated pulse edge.

Adding the encoder value	Decreasing the encoder value
Single resolution 	
Double resolution 	
Quadruple resolution 	

Tab. 6.1: Impulse image of encoder signals

6.1.2.4 Maximum value

If the encoder exceeds this maximum value, the encoder counter restarts the count at zero. This could be the pulse count of an encoder without zero pulse (reference track). The maximum counter reading before an overflow is 4294967295 (2^32-1).

6.1.2.5 Effect of reference track

`No effect`. The encoder counter keeps on counting; the resetting takes place when the sensor/controller is switched on or when the `Set to value` button is pressed.

`Set to value once for mark`. Sets the encoder counter to the defined value when the first reference marker is reached. The applicable mark is the first one after sensor/controller switch-on.

`Set for all marks`. Sets the encoder counter to the start value in the case of all marks.

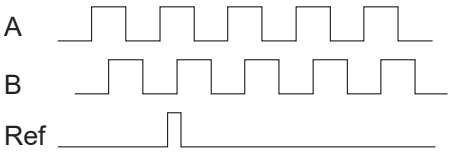


Fig. 6.1: Reference signal of an encoder

The reference track is not available when using a third encoder.

6.1.2.6 Set to value

This function sets the encoders to this value

- every time the controller is switched on,
- with the `Set to value` button.

The starting value must be lower than the maximum value and should not exceed 4.294.967.294 (2^32-2).

6.1.2.7 Reset reference marker

Resets the reference marker detection.

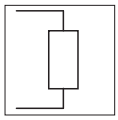
6.1.3 Level function inputs

The level must be selected for the inputs:

- Synchronization
- Multifunction

Input level	*TTL / HTL*	*Defines the input level for the input stages.* *TTL: Low ≤ 0.8 V; High ≥ 2 V* *HTL: Low ≤ 3 V; High ≥ 8 V*

6.1.4 Terminating resistor



The terminating resistor at the Sync/Trig synchronization input is switched on or off to avoid reflections.
ON: with terminating resistor
OFF: no terminating resistor

The terminating resistor with 120 Ohm must be activated in the last slave.

6.2 Data recording

6.2.1 Measuring rate

IFD2410: The measuring rate can be set continuously in a range from 0.1 kHz to 8 kHz. The increment is 1 Hz.

IFD2415: The measuring rate can be set continuously in a range from 0.1 kHz to 25 kHz. The increment is 1 Hz.

The selection of the measuring rate is made in the menu `Settings > Data acquisition > Measuring rate`.

► Select the required measuring rate.

Observing the video signal is useful for selecting the measuring rate.

Procedure:

► Position the target in the mid of the measuring range, see Fig. 6.2. Keep adjusting the measuring rate until you get a high signal intensity that is not saturated.

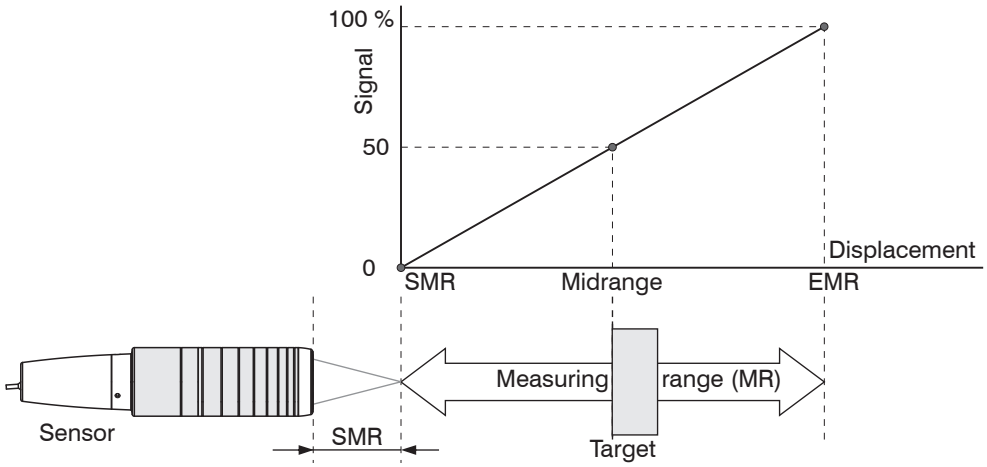


Fig. 6.2: Definition of measuring range and output signal

► To do this, observe the `Intensity` LED.

LED	Status	Description
Intensity	Red	Signal saturated
	Yellow	Signal too low
	Green	Signal OK

- If the `Intensity` LED changes to red, increase the measuring rate.
- If the `Intensity` LED changes to yellow, reduce the measuring rate.

- ► Select the measuring rate so that the `Intensity` LED lights up green.
- ► If necessary, change the exposure mode, use the `Manual mode`.
- ► Use the required measuring rate and adjust the exposure time. Otherwise, the exposure time defines the possible measuring rate.

If the signal is saturated (the `Intensity` LED is red), the controller will continue to measure, but the measurement accuracy may not meet the specified technical specifications.

6.2.2 Triggering

6.2.2.1 General

The data recording on the confocalDT IFD241x can be controlled using an external electrical trigger signal or commands.

- The triggering does not affect the preselected measuring rate.
- Factory setting: no triggering, the controller starts with the data transmission output immediately after being switched on.
- The pulse of the trigger signal is at least 5 µs.

Sync / Multifunction input 1/2	Trigger type	*Level*	Trigger level	Low / falling edge	
		Edge	Trigger level	High / increasing edge	
			Number of measured values	*Manual selection*	*Value*
				infinite	
Software			Number of measured values	*Manual selection*	*Value*
				infinite	
Encoder 1			Lower limit		*Value*
			Upper limit		*Value*
			Increment		*Value*
Disabled			*Continuous data acquisition*		

`Pegel-Triggerung`. Kontinuierliche Messwertaufnahme/-ausgabe, solange der gewählte Pegel anliegt. Danach beendet der Controller die Messwertaufnahme/-ausgabe. Die Pulsdauer muss mindestens eine Zykluszeit betragen. Die darauffolgende Pause muss ebenfalls mindestens eine Zykluszeit betragen.
S = Wegsignal

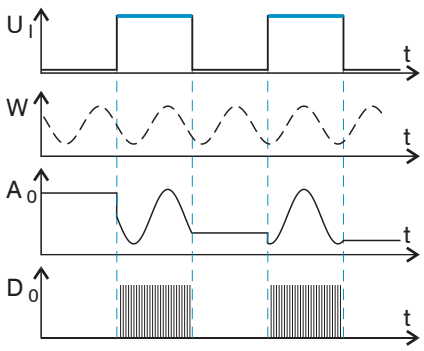


Fig. 6.3: Triggerung mit aktivem High-Pegel (U_I), zugehöriges Analogsignal (A_O) und Digitalsignal (D_O)

`Edge triggering`. Starts measured value input/output as soon as the selected edge is active to the trigger input. The pulse must be at least 5 µs.
S = displacement signal

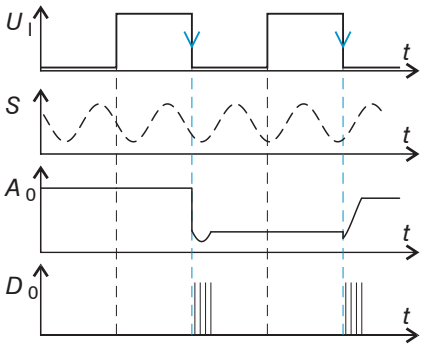


Fig. 6.4: Triggering with falling edge (U I), associated analog signal (A O) and digital signal (D O)

`Software triggering`. Starts the data acquisition as soon as a software command is issued (instead of using the trigger input) or the `Initiate trigger` button is pressed.

`Encoder triggering`. Starts the data acquisition with Encoder 1.

6.2.2.2 Triggering data acquisition

The current line signal is only processed and measured values are calculated from it after a valid trigger event. The measurement data is then transferred for further calculation (e.g. averaging), as well as the output via a digital or analog interface.

When calculating averages, measured values immediately before the trigger event cannot be included; instead older measured values are used, which had been entered during previous trigger events.

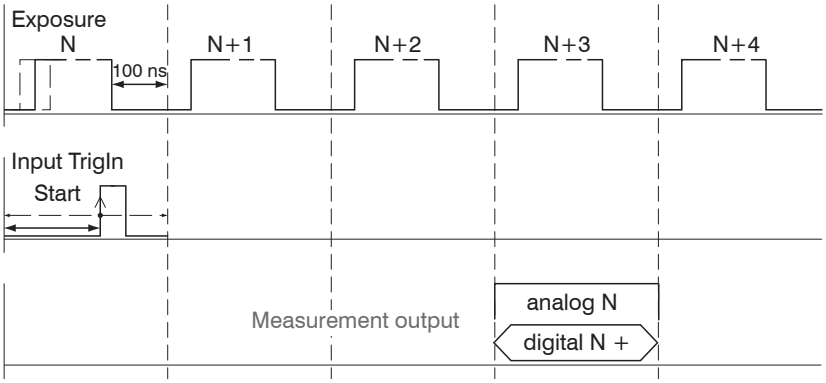


Fig. 6.5: Output of measured values after trigger event

i	Cycle start does not mean the start of the exposure time. There is only a fixed difference of 100 ns between the start of the cycle and the end of the exposure time.

6.2.3 Reset measurement counter

The measurement counter can be used to check if the data are output completely or if a package is missing. Counting begins at zero. Time stamps and measurement counters can be reset by pressing the respective button.

6.2.4 Masking the region of interest

Masking limits the range that the video signal uses for distance or thickness calculations. This feature is used, for example, if ambient light with certain wavelengths (blue, red, IR) causes video signal interference. It is also possible to mask the background if it reaches into the measuring range.

Masking (start and end) is entered into the two boxes on the left (in %). The factory settings are 0 % (start) and 100 % (end).

i If you limit the video signal, a peak is detected only if it is completely within the masked area, i. e., above the threshold. This can reduce the measuring range.

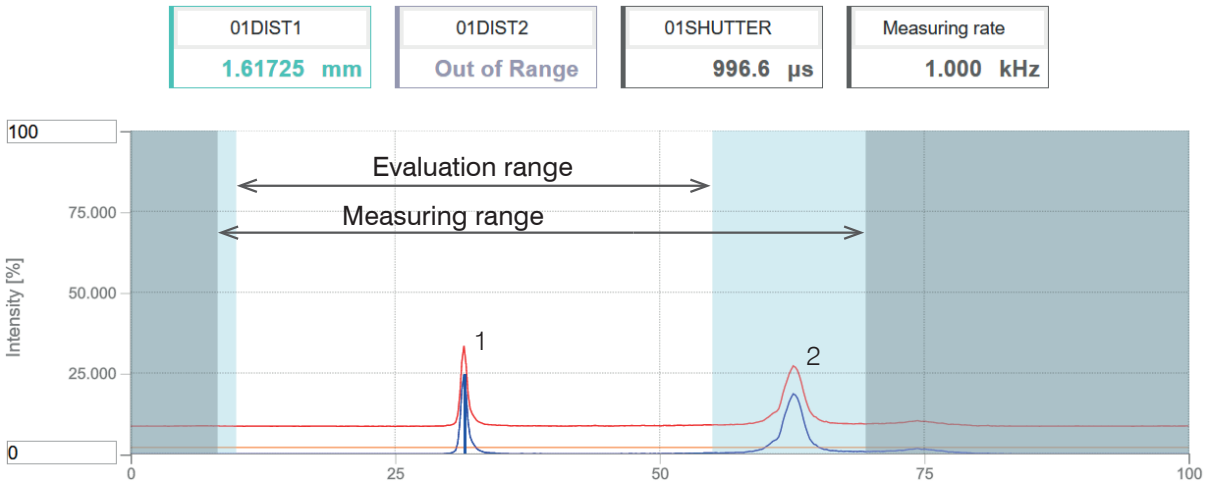


Fig. 6.6: Limiting the video signal used

The example shown in the figure uses peak (1) for the evaluation while peak (2) is not used.

6.2.5 Exposure mode

Measurement mode		
Manual mode	Exposure time 1 in µs	*IFD2410: Value (3 µs ... 10,000 µs)* *IFD2415: Value (3 µs ... 10,000 µs)*
Alternating two-time mode	Exposure time 1 in µs	*IFD2410: Value (3 µs ... 10,000 µs)* *IFD2415: Value (3 µs ... 10,000 µs)*
	Exposure time 2 (shorter) in µs	*Value (value is lower than exposure time 1)*
Automatic two-time mode	Exposure time 1 in µs	*IFD2410: Value (3 µs ... 10,000 µs)* *IFD2415: Value (3 µs ... 10,000 µs)*
	Exposure time 2 (shorter) in µs	*Value (value is lower than exposure time 1)*

► Select the desired exposure type.

`Measurement mode`. The required or appropriate measuring rate is maintained and only the exposure time is controlled. A smaller control range is used to achieve faster results. This mode also enables the user to work with targets with different reflections that have the same measuring rates. Lasts 1 up to a maximum of 7 measurement cycles (change from no target to good reflective target with 0.1 kHz measuring rate).

`Manual mode`. No automatic adjustments. Set optimized parameters are maintained. This makes sense for fast changes due to targets with identical surfaces moving in and out or for highly dynamic movements (no signal overshoot). It is not recommended to use this mode for strongly varying target surfaces. Manual mode can also be used for several layers if the brightest peak should not be captured. The appropriate measuring rate and exposure time can be selected from the video signal display in the measurement mode.

`Alternating two-time mode`. Operating mode with two manually preset exposure times that are always used alternately. Suitable for two very different high peaks when measuring thickness. We recommend using this mode in particular if the smaller peak disappears or the larger peak becomes saturated.

`Automatic two-time mode`. Fastest mode with two manually preset exposure times. The more suitable time is automatically selected. We recommend using this mode to measure distances for rapidly changing surface properties, such as mirrored or anti-glare glass.

6.2.6 Peak separation

6.2.6.1 Peak modulation

Peak modulation is used e.g. when measuring thin layers. A peak detected with the detection threshold may consist of two or more overlapping peaks. The peak modulation indicates to which degree the video signal must be modulated in order to separate the peak again for the subsequent signal processing.

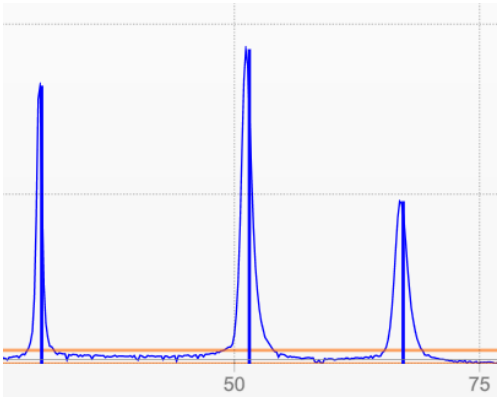


Fig. 6.7: Separated peaks: measurement possible

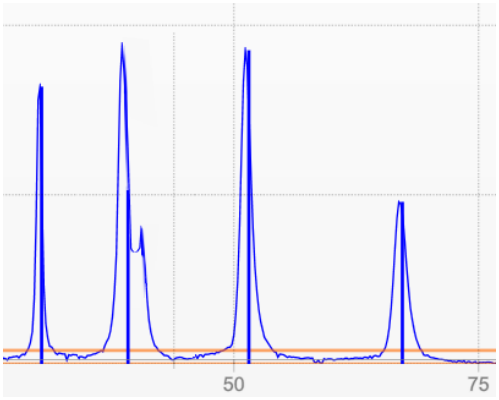


Fig. 6.8: Peaks interlocking: probable measurement uncertainty

The modulation is individually evaluated for each peak detected with the detection threshold.

Default value is 50 % as a compromise between the separability of the peaks and the measurement uncertainty due to mutual peak interference.

- Increase the value when the controller separates peaks which should be processed together.
- Decrease the value when the controller does not separate peaks which should be processed separately.

Example 1: With the default setting, no peak separation is carried out. The controller determines a distance from the center of gravity in the video signal.

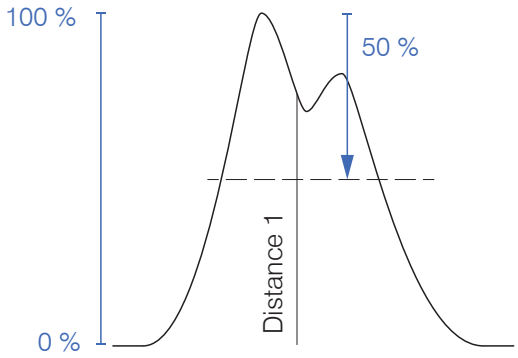


Fig. 6.9: Example 1 for peak modulation

Example 2: With a lower peak modulation value, the controller detects two separate peaks in the video signal and calculates the two distances.

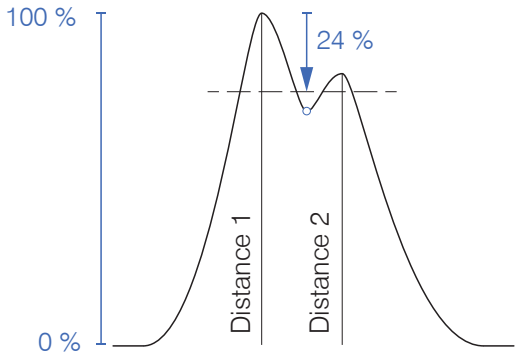


Fig. 6.10: Example 2 for peak modulation

Changing the `peak modulation` is only necessary in special cases. Use this function carefully.

6.2.6.2 Detection threshold

The detection threshold (in % relative to the dark-corrected signal) defines the intensity as of which a peak in the video signal is included in the analysis. For that reason, it is essential to evaluate the video curve for this determination.

Minimum threshold	*Value*	*Value in %, default 2 %*

Defining the detection threshold.

- For very weak signals typical of extremely high measuring rates, choose a low detection threshold, as only signal parts above this threshold will be included in the calculation.

- In general, set the threshold high enough to prevent any interfering video signal peaks from being detected.

The detection threshold affects linearity, so it is recommended to adjust it as little as possible.

6.2.7 Number of peaks, peak selection

The number of peaks is equivalent to the number of transitions between different materials of a target within the measuring range.

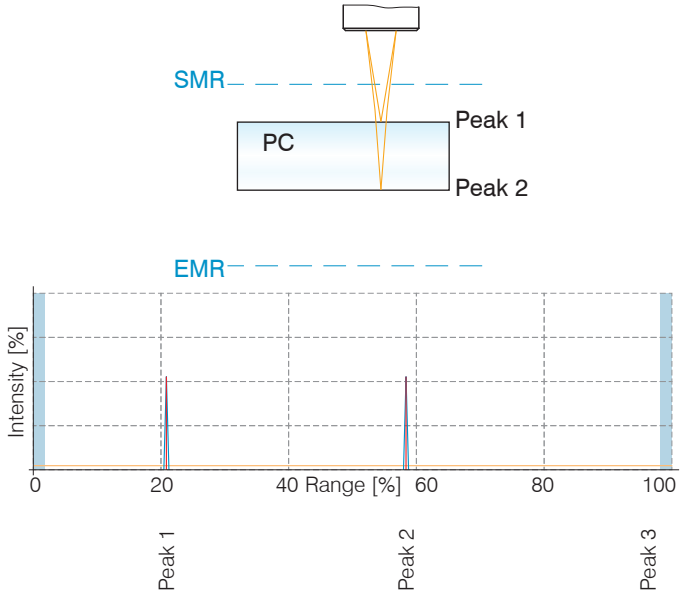


Fig. 6.11: Transparent measuring object with one layer

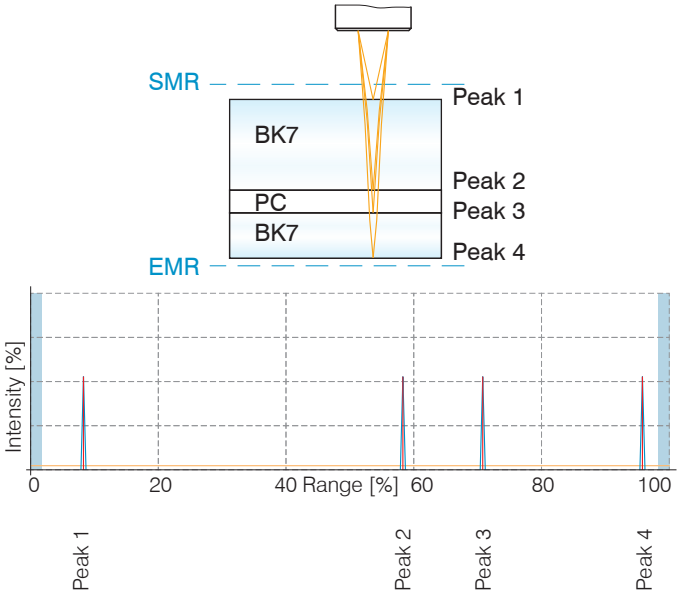
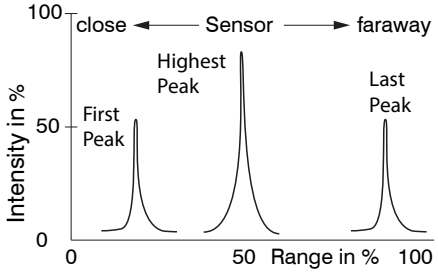


Fig. 6.12: Transparent measuring object with three layers

The selection of peak/peaks dictates which regions in the signal are used for the distance or thickness measurement. In the case of a target consisting of several transparent layers, the material must be assigned to the individual layers, see Chap. 6.2.8.

The peaks are counted starting at the start of the measuring range toward the end of the measuring range.

Peak selection	*First peak / Highest peak / Last peak*	*Defines which signal in the array signal is used for the evaluation.* *First peak: Nearest peak to sensor.* *Highest peak: Standard, peak with the highest intensity.* *Last peak: Peak furthest away from sensor.* 

IFD2410	IFD2415	Measurement values	Peak selection
•	•	1 measurement value	First peak / Highest peak / Last peak
•	•	2 measurement values	First and second peak / First and last peak / Highest and second highest peak / Last peak and second to last peak
	•	3 measurement values	Individual
	•	4 measurement values	Individual
	•	5 measurement values	Individual
	•	6 measurement values	Individual

Tab. 6.2: Options for peak selection

Peak heights are determined based on the light-corrected signal.

The refractive index correction is performed with the standard setting. However, if more than two peaks are within the measuring range, an exact refractive index correction is performed only when the same number of peaks is present. If, for example, the first or last peak of 3 peaks sometimes leaves the measuring range, it is better to switch off the refractive index correction. Otherwise the refractive index correction would apply to the wrong layer and the material assignment becomes ambiguous.

6.2.8 Material selection

Before selecting a material, define the number of layers of the target or the number of peaks to be expected in the video signal. Otherwise, it will not be possible to assign the material.

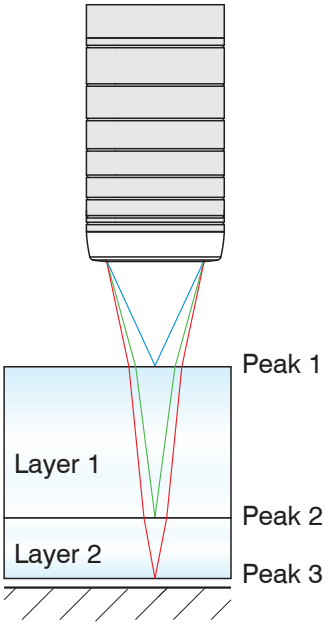
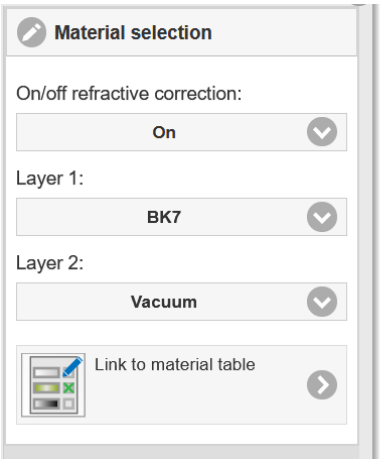


Fig. 6.13: Layer structure of a target

The refractive index needs to be corrected in the controller for an exact distance or thickness measurement.

- ► Switch to the `Settings > Data acquisition > Material selection` menu.
- ► Activate the refractive correction. To do so, click the `On` button in the menu `On/off refractive correction`.
- ► Assign the materials to the individual layers according to the target used.

The `Link to materials table` button can be used to expand or reduce the material database in the controller. For a new material, a refractive index and the Abbe number vd are required or three refractive index numbers are required if there are different wavelengths (also approximately the same).



pos	material name	definition	nF at 486nm	nd at 587nm	nC at 656nm	VD - Abbe number	description
1	Vacuum	NX	1.000000	1.000000	1.000000		vacuum, air (approximately)
2	Water	NX	1.337121	1.333044	1.331152		a liquid
3	Ethanol	NX	1.361400	1.361400	1.361400		ethyl alcohol, pure alcohol (a liquid)
4	Acrylic	NX	1.497828	1.491668	1.488938		acrylic resin, adhesive, lacquer

Fig. 6.14: Selection of material-specific refractive indices

6.3 Signal processing, calculation

6.3.1 Data source, parameters, calculation programs

One calculation operation can be performed in each calculation block. The calculation program, the data sources and the parameters of the calculation program must be set for this.

`Thickness`	Calculating the difference	Two signals or results, Signal distance B < Signal distance A
`Formula`	Distance A - Distance B	

`Calculation`	Summation	Two signals or results
`Formula`	Factor 1 * Distance A + Factor 2 * Distance B + Offset	

`Median`	Sorts the measurement values and outputs the mean value as the median.

`Moving`	Forms the arithmetic average

`Recursive`	Each new measured value is weighted and added to the sum of the previous average values

`Duplicate`	Creates a copy of a signal

Sequence for creating a calculation block.

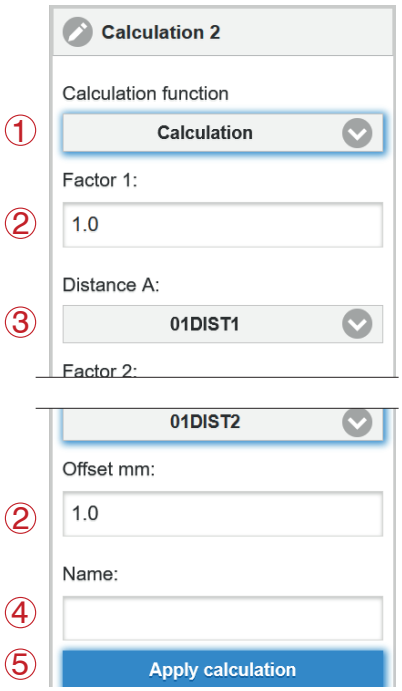


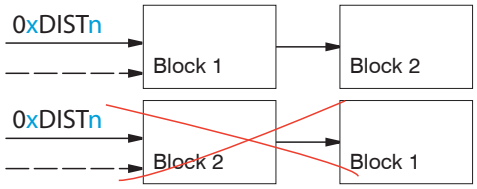
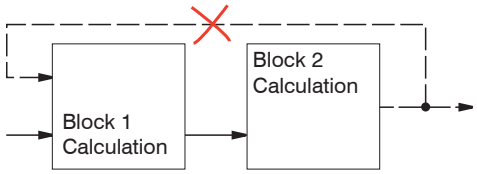
Fig. 6.15: Sequence for the program selection

- ► Select a program (1), e.g. average.
- ► Define the parameters (2).
- ► Define the data source(s) (3).
- ► Enter a block name (4).
- ► Click on the button `Store calculation`.

The programs Calculation and Thickness have two data sources. The Averaging and Duplicate programs each have one data source.

Calculation parameters (Calculation program)	Factor 1 / 2	*value*	-32768.0 … 32767.0
	Offset	*value*	-2147.0 ... 2147.0
Calculation parameters (Median program)	Averaging type	Recursive / Moving / Median	
	Number of values	*value*	Recursive: 2 ... 32000
			Moving: 2 / 4 / 8 / 16 / 32 / 64 / 128 / 256 / 512 / 1024 / 2048 / 4096
			Median: 3/5/7/9
The number of values for the median indicates over how many sequential measured values in the controller should be averaged.			

6.3.2 Definitions

Distance value(s)	01DIST1, 01DIST2, ... 01DIST6
Max. 10 calculation blocks per channel/sensor. The calculation blocks are processed sequentially.	
Feedback couplings (algebraic loops) over one or several blocks are not possible. Only the distance values or the calculated results from the previous calculation blocks can be used as data sources.	
Processing sequence: 1. Unlinearized distances 2. Linearization of distances 3. Refractive index correction of distances 4. Error handling on wrong measurement values 5. Calculation blocks 6. Statistics	

6.3.3 Measurement value averaging

Measurement averaging is performed after measured values have been calculated, and before they are issued through the relevant interfaces or processed.

Measurement averaging

- improves the resolution,
- allows hiding individual interference points, or
- “smooths” the measurement result.

> i Linearity is not affected by averaging. Averaging has no effect on measuring rate and output rate. The defined type of average value and the number of values must be saved in the sensor to ensure they are maintained after it has been switched off.

The internal average value is recalculated in each measuring cycle.

The controller is delivered with “moving average, averaging value = 16” as factory settings, i.e. averaging is not enabled by default.

Moving Average

The arithmetic average M_{mov} is calculated and output for a series of consecutive measured values according to the selectable filter width N. Each new measured value is added, and the first (oldest) value is removed from the averaging (from the window).

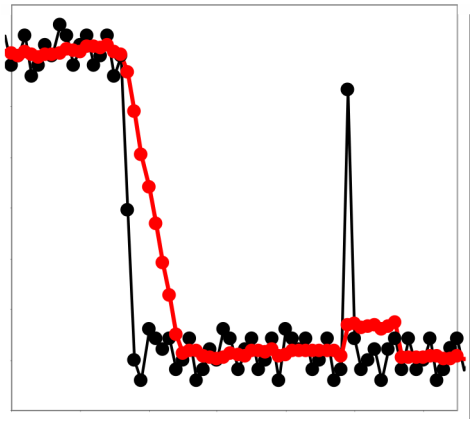
$M_{mov} = \frac{\sum_{k=1}^{N} MV(k)}{N}$	MW = measured value
	N = averaging value
	k = continuous index (in the window)
	M_{mov} = average value or output value

This produces short settling times in case of measurement jumps.

Example: N = 4

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

Note	For the moving average, only powers of 2 are permitted for the averaging number *N*. The highest averaging value is 4096.



Application tips

- Smoothing of measured values
- In contrast to recursive averaging, the effect can be finely controlled.
- With uniform noise of the measured values without spikes
- In the case of a slightly rough surface whose roughness is to be eliminated.
- Also suitable for measured value jumps with relatively short settling times

Signal without averaging

Signal with averaging

Tab. 6.3: Moving average, N = 8

Recursive average

Each new measured value *MW*(n) is weighted and added to (n-1) times the previous average value.

Formula:

$$M_{rec}(n) = \frac{MW_{(n)} + (N\text{-}1) \times M_{rec\,(n-1)}}{N}$$

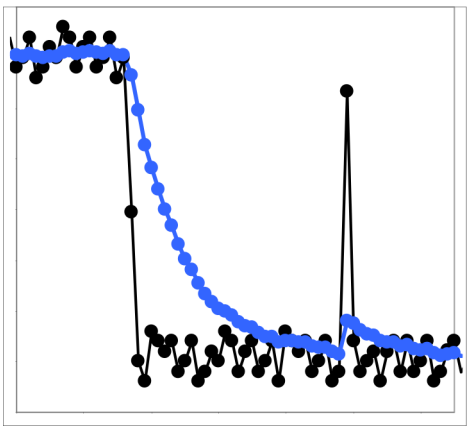
N = averaging number, *N* = 1 ... 32767

n = measured value index

MW = measurement value

M_{rec} = mean value or output value

Recursive averaging allows for very strong smoothing of the measurements, however it requires long response times for measurement jumps. The recursive average value shows low-pass behavior.



Application tips

- Permits a high degree of smoothing of the measured values. Long settling times in the case of measured value jumps (low-pass behavior).
- High degree of smoothing for noise without strong spikes
- To especially smooth signal noise for static measurements
- To eliminate the roughness when performing dynamic measurements on rough target surfaces, e.g., roughness of paper.
- To eliminate structures, e.g., parts with uniform groove structures, knurled turned parts or coarsely milled parts
- Unsuitable for highly dynamic measurements

Signal without averaging

Signal with averaging

Tab. 6.4: Recursive average, N = 8

Median

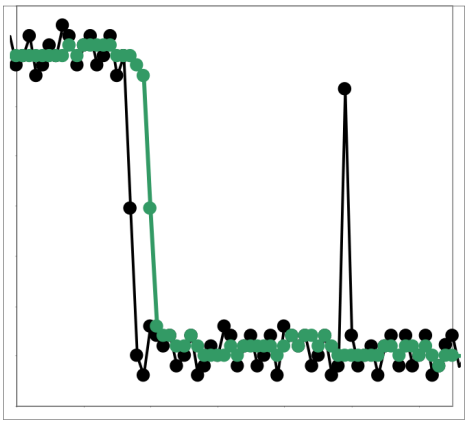
A median value is formed from a preselected number of measured values.

When creating a median value for the sensor, incoming measured values are sorted after each measurement. Then the average value is provided as the median value.

3, 5, 7 or 9 readings are taken into account. This means that individual interference pulses can be suppressed. However, smoothing of the measurement curves is not very strong.

Example: Median value from five readings

... 0 1 2 4 5 1 3 → Sorted measurements: 1 2 3 4 5 Median$_{(n)}$ = 3
... 1 2 4 5 1 3 5 → Sorted measurements: 1 3 4 5 5 Median$_{(n+1)}$ = 4



Application tips

- The measured value curve is not smoothed to a great extent; it primarily eliminates spikes
- Suppresses individual interference pulses
- In short, strong signal peaks (spikes)
- Also suitable for edge jumps (only minor influence)
- To eliminate dirt or roughness in a rough, dusty or dirty environment
- Further averaging can be used after the median filter

Signal without averaging
Signal with averaging

Tab. 6.5: Median, N = 7

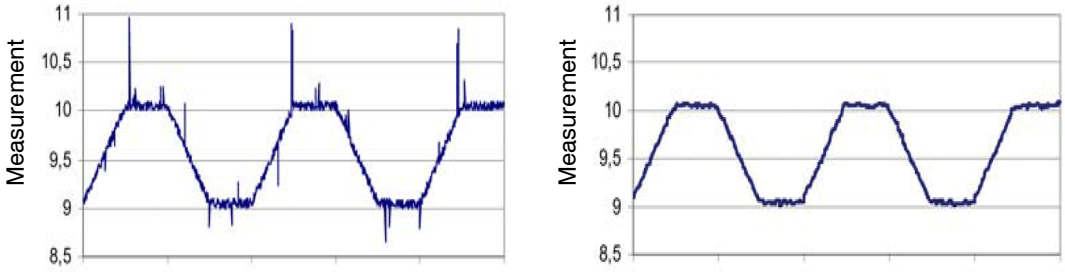


Fig. 6.16: Signal Curve – Profile without Median (Left), with Median N = 9 (Right)

6.4 Post-Processing

6.4.1 Zeroing, mastering

Use zeroing and mastering to define a nominal value within the measuring range. This shifts the output range. This feature can be useful, for example, when several sensors carry out measurements simultaneously in thickness and planarity measurements. When measuring the thickness of a transparent target, you need to specify the actual thickness of a master object as `Master value`.

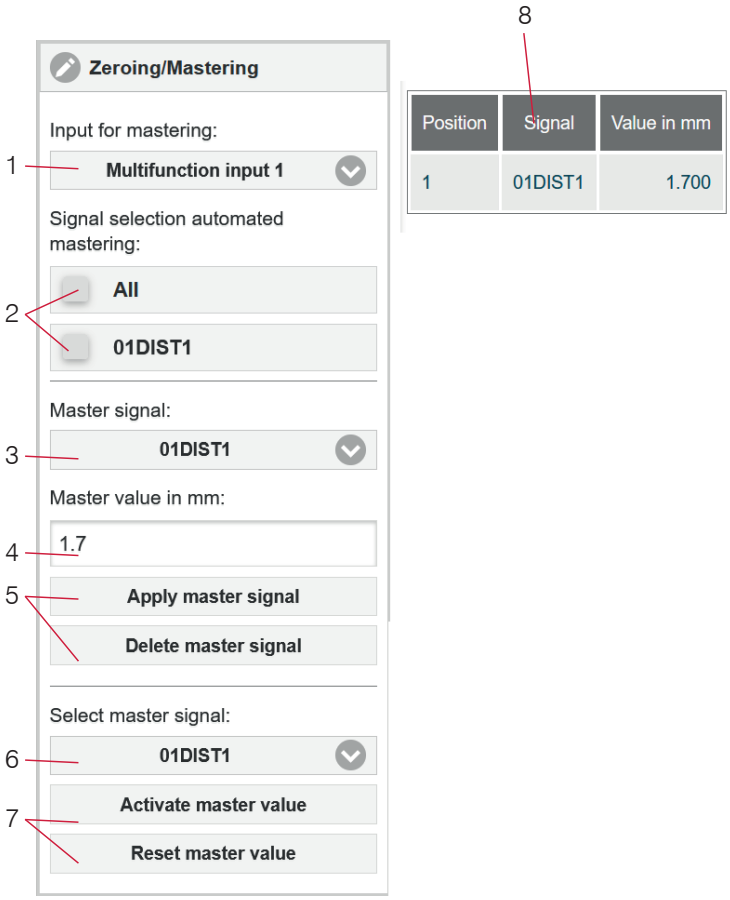
Master value in mm	*Value*	*Specify the thickness (or other parameter) of a master object.* *Value range: -2147.0 ... +2147.0 mm*

Mastering (setting masters) is used to compensate for mechanical tolerances in the sensor measurement setup or to correct chronological (thermal) changes to the measuring system. The master value, also called calibration value, is defined as the nominal value.

The measured value provided at the controller output when measuring a master object is the `Master value`. Zeroing is a special feature of mastering, since the master value is “0” here.

The mastering/zeroing function is not channel-specific. The controller manages up to 10 master signals. These 10 signals can be applied to any internally determined value, including calculated values.

i "Mastering" or "Zeroing" requires a target to be present in the measuring range. “Mastering” and “zeroing” affect both analog and digital outputs, as well as the web interface display.



1 Trigger or undo mastering via multifunction inputs MFI 1/2 through an external source.

2 Selection of signals to be mastered via the multi-function inputs (1).

3 Overview of all existing signals for the function. Selection of a signal to assign the master value with (4) and (5).

4 Enter master value.

5 Button for saving or deleting a signal (3).

6 Apply selection of a specific signal or master to all defined signals (8).

7 Start or stop function for signal (6) via software.

8 Overview of all existing signals and their master value for the function.

Fig. 6.17: Mastering dialog, overview of individual master values

When setting a master, the output characteristic is moved in parallel. Moving the characteristic reduces the relevant measuring range of a sensor (the further master value and master position are located, the greater the reduction).

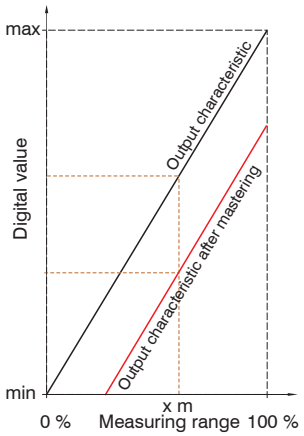


Fig. 6.18: Moving the characteristic during mastering

Mastering / zeroing:

- ► Place measuring object and sensor into their desired positions to one another.
- ► Define the `Master value`, web interface/ASCII.

After setting the master, the controller will issue new readings that relate to the master value. By resetting with the `Reset master value` button, the status before mastering is restored.

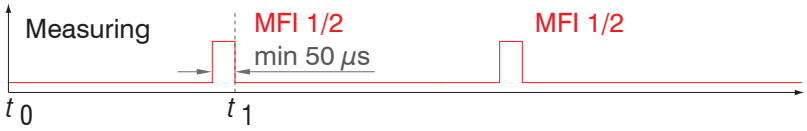


Fig. 6.19: Flowchart for zeroing, mastering (Multifunction key)

The zeroing/mastering function can be applied several times in a row.

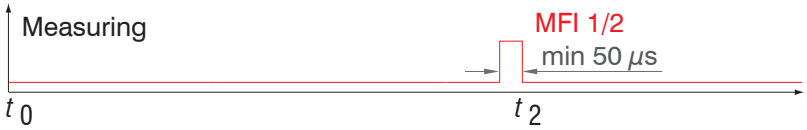


Fig. 6.20: Flowchart for resetting zeroing, mastering

6.4.2 Statistics

The measuring system derives the following statistical values from the result of the measurement:

- Minimum,
- Maximum and
- Peak-to-Peak.

Statistical values are calculated from measured values within the region of interest. The region of interest is reset for each new measured value. The statistical values are displayed via the web interface in the `Measurement chart`, or are output via the interfaces.

The statistical values are not channel-specific. The controller can manage up to 3 statistic signals. These 3 signals can be applied to any internally determined value, including calculated values.

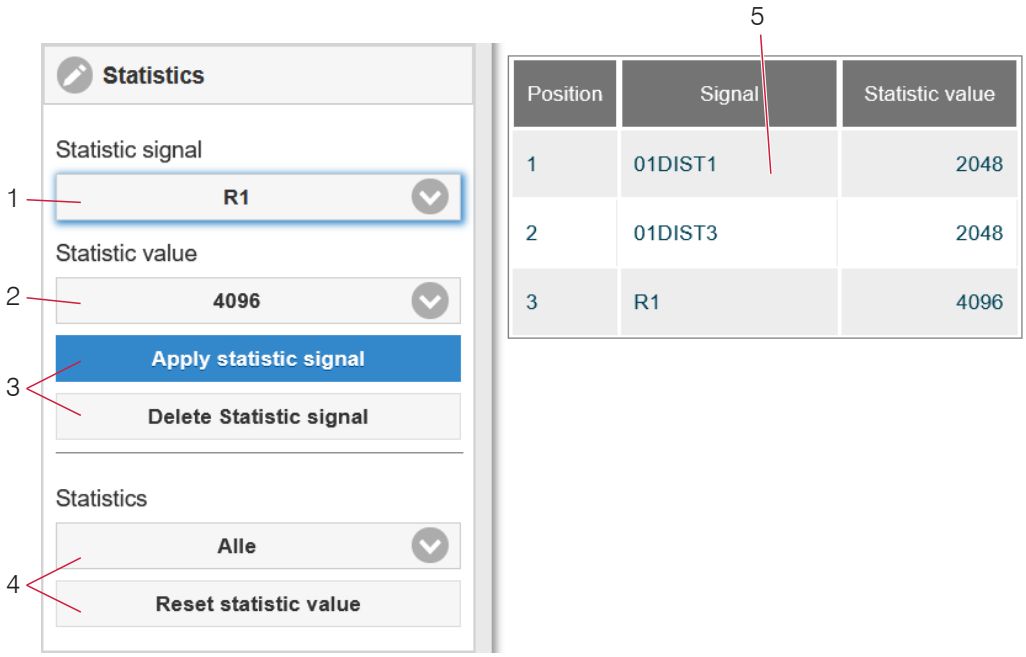


Fig. 6.21: Statistics dialog, overview of the individual statistic signals

1 The `Reset statistic value` button can be used to reset a specific signal or all statistics signals and thus initiate a new evaluation cycle (storage period). When a new cycle starts, previous statistical values are deleted.
2 Deletes a signal
3 Number of measurement values based on which minimum, maximum and peak-to-peak are determined for a signal. The range of values used for calculation can be between 2 and 8192 (in powers of 2) or include all measured values.
4 Selects a signal for the function
5 Overview of all existing signals for the function.

Sequence for creating a statistical evaluation:

- Change to the tab `Settings` > `Postprocessing` > `Statistics`.
- Choose a signal (4) for which the statistical values should be calculated.
- Define the region of interest via the `Statistic value`.

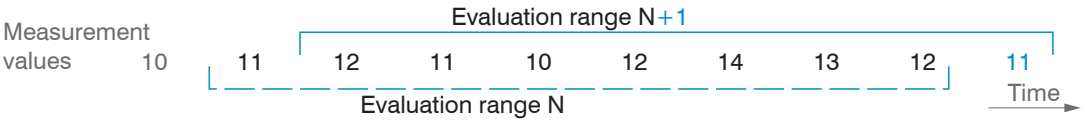


Fig. 6.22: Dynamic updating of the region of interest via the measured values, statistical value = 8

6.4.3 Data reduction, output data rate

Data reduction	*Value*	*Instructs the controller which data are excluded from the output, thus reducing the volume of data transmitted.*
Reduction applies to	RS422 / Analog	*The interfaces which are provided for the sub-sampling are to be selected with the checkbox.*

You can reduce the measurement output in the sensor if you set the output of every nth measured value in the web interface or by command. Data reductions causes only every nth measured value to be output. The other measured values are rejected. The reduction value n can range from 1 (each measured value) to 3,000,000. This allows you to adjust slower processes, such as a PLC, to the fast controller without having to reduce the measuring rate.

6.4.4 Error handling (hold last value)

If no valid measured value can be determined, an error is output. Alternatively, if this interferes with further processing, the last valid value can be held, i.e. output repeatedly, for a certain amount of time.

Error handling	Error output, no measured value		*Interfaces output an error instead of a value.*
	Hold last value infinitely		*Interfaces output the last valid value until a new, valid measured value is available.*
	Hold last value	Value	*Possible number of values to be maintained between 1 and 1024.* *When number = 0, the last value is maintained until a new, valid value is displayed.*

6.5 Outputs

6.5.1 RS422

Output data are selected for both interfaces separately from all internally determined values and from the calculated values from the computing modules. These are issued in a fixed order.

- Go to the *Settings* tab and select *Data output RS422* under *Outputs*

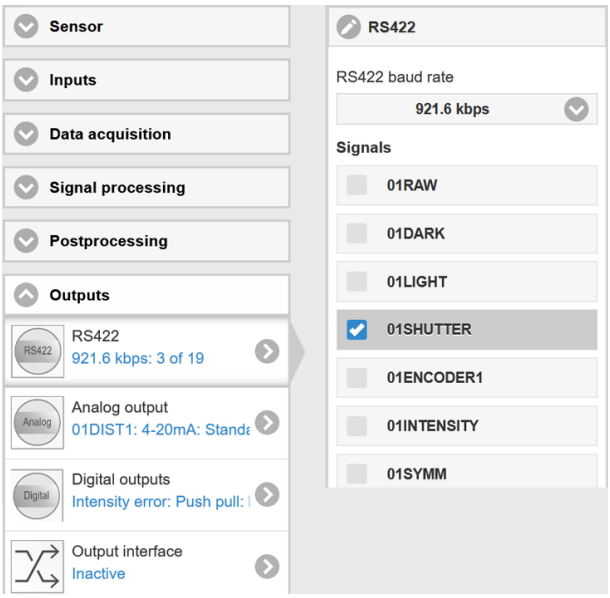


Fig. 6.23: Selecting the output data for RS422

Further details on data output via RS422, see Chap. 8

6.5.2 Ethernet

Measurement data can be output via Ethernet and RS422 in parallel. Output data are selected for both interfaces separately from all internally determined values and from the calculated values from the computing modules. These are issued in a fixed order.

► Switch to the tab *Settings* and choose *Data output Ethernet* under *Outputs*.

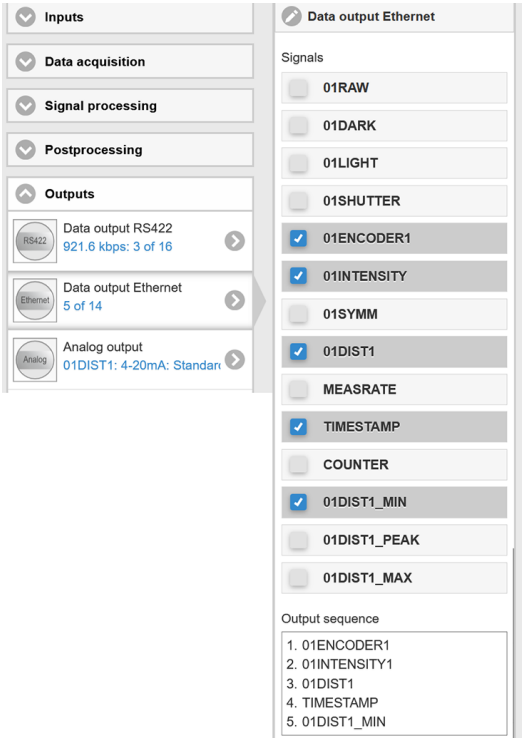


Fig. 6.24: Data output, data selection in the web interface

6.5.3 Analog output

6.5.3.1 Analog output, scaling

► Go to the *Settings* tab and select *Analog output* under *Outputs*.

Fig. 6.25: Data output, data selection in the web interface

Only one measured value can be transmitted. The resolution of the analog output is 16 bit.

Output signal	*01DIST1 / ... 01DIST6 / ...*	The data selection depends on the current setting and includes, in addition to the distance values, also the results from the calculation modules.	
Output range	*4 ... 20 mA / 0 ... 5 V / 0 ... 10 V*	Either the voltage or the current output can be used on the IFC241x.	
Scaling	*Standard scaling*	Scaling to 0 ... Measuring range	
	Two-point scaling	Start of range corresponds to (in mm):	value
		End of range corresponds to (in mm):	value

The first value corresponds to the start of the measuring range and the second value to the end of the measuring range. If the analog range needs to be moved, we recommend using the zeroing or mastering function.

Two-point scaling enables the user to specify separate start and end values (in mm) for the sensor's measuring range. The available output range of the analog output is then spread between the minimum and maximum measured values. This also allows a decreasing analog characteristic, see Fig. 73.

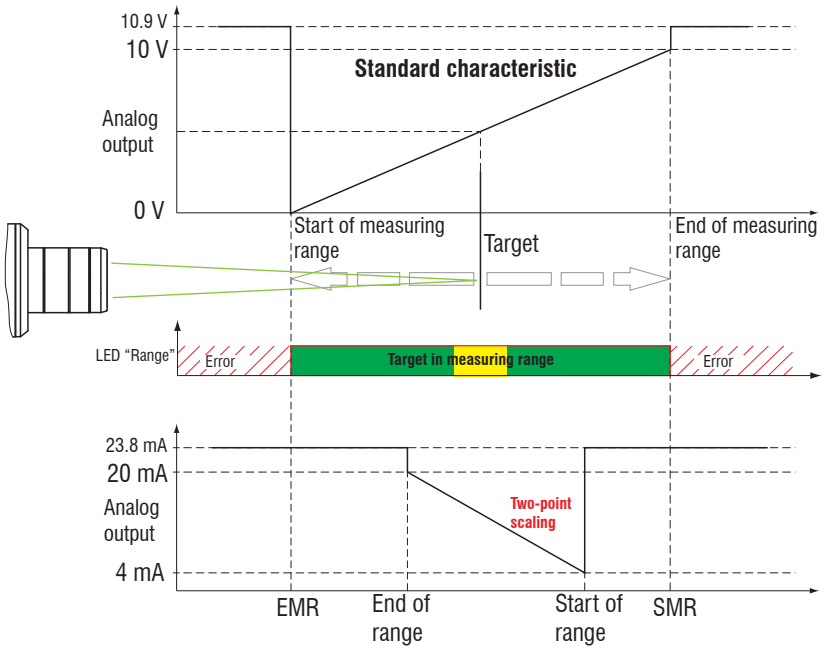


Fig. 6.26: Scaling the analog signal

6.5.3.2 Calculation of the measured value from the current output

Current output (without mastering, without two-point scaling)		
Variables	**Value range**	**Formula**
I_{OUT} = Current [mA]	[3.8; <4] SMR reserve [4; 20] Measuring range [>20; 20.2] EMR reserve	$d\ [mm] = \frac{(I_{OUT}\ [mA] - 4)}{16} * MR\ [mm]$
MR = Measuring range [mm]	{0.1 to 30}	
d = Distance [mm]	[-0.01MR; 1.01MR]	

Current output (with two-point scaling)		
Variables	**Value range**	**Formula**
I_{OUT} = Current [mA]	[3.8; <4] SMR reserve [4; 20] Measuring range [>20; 20.2] EMR reserve	$d\ [mm] = \frac{(I_{OUT}\ [mA] - 4)}{16} * \lvert n\ [mm] - m\ [mm] \rvert$
MR = Measuring range [mm]	{0.1 to 30}	
m, n = Teach range [mm]	[0; MR]	
d = Distance [mm]	[m; n]	

6.5.3.3 Calculation of the measured value from the voltage output

Voltage output (without mastering, without two-point scaling)		
Variables	**Value range**	**Formula**
V_{OUT} = voltage [V]	[-0.05; <0] SMR reserve [0; 5] Measuring range [>5; 5.05] EMR reserve	$d = \frac{V_{OUT}}{5} * MR$
	[-0.1; <0] SMR reserve [0; 10] Measuring range [>10; 10.1] EMR reserve	$d = \frac{V_{OUT}}{10} * MR$
MR = Measuring range [mm]	{0.1 to 30}	
d = Distance [mm]	[-0.01*MR*; 1.01*MR*]	

Current output (with two-point scaling)		
Variables	**Value range**	**Formula**
V_{OUT} = voltage [V]	[-0.05; <0] SMR reserve [0; 5] Measuring range [>5; 5.05] EMR reserve	$d = \frac{V_{OUT}}{5} * \lvert n - m \rvert$
	[-0.1; <0] SMR reserve [0; 10] Measuring range [>10; 10.1] EMR reserve	$d = \frac{V_{OUT}}{10} * \lvert n - m \rvert$
MR = Measuring range [mm]	{0.1 to 30}	
m, n = Teach range [mm]	[0; MR]	
d = Distance [mm]	[m; n]	

6.5.3.4 Ethernet settings

Address Type	*Static IP address* *DHCP*	*Values for IP address / gateway / subnet mask* *Only for static IP address*		
Ethernet Measurement value transmission	*Server TCP / IP*	Server port	*Value*	
		Send keep-alive signal	Active / inactive	
		No. of frames	Automatic	
			Set number	*value*
	Client TCP / IP *Client UDP / IP*	Server address	*Value*	
		Server port	*Value*	
		Send keep-alive signal	Active / inactive	
		No. of frames	Automatic	
			Set number	*value*
	inactive			

When using a static IP address it is necessary to enter the values for the IP address, Gateway and Subnet mask; this is not required when DHCP is used.

The controller is set at the factory to the static IP address 169.254.168.150.

The controller transmits the Ethernet packets at a transmission rate of 10 Mbit/s or 100 Mbit/s, which is set automatically according to the network or PC that is connected.

All output values and additional information intended for transmission that were captured at a certain time are consolidated into a measured value frame. Several measured value frames are consolidated into a measured value block. A header is added at the beginning of each measured value packet.

During the transmission of measured value data, the controller sends each measured value (measured value block) to its connected counterpart after the connection has been successfully established. No specific request is required for this.

In the event of changes to the transmitted data or the frame rate, a new header is sent automatically.

This measured value block can also consist of several Ethernet packets, depending on the size of the FFT signal.

Further details on data output via Ethernet can be found in the Chapter Ethernet interface , see Chap. 9

6.5.4 Switching Output

The IFD2410 and the IFD2415 each have two switching outputs. The switching output can, for example, be used to monitor errors and limit values in relation to the 01DIST1 (distance) output value or in relation to calculated values.

Signal	01DIST1 / / ... 01DIST6 / ...calculated values			
Switching level with error	PNP / NPN / Push pull / Push-Pull negated			
Configuration	Intensity error / Measuring range error / Intensity or measuring range error			
	Limit values for measurement value	Hysteresis (in mm)	value	
		Valid limit values	Upper limit (in mm)	value
			Lower limit (in mm)	value
			Both limits (in mm)	Values

The switching output is activated based on the set switching behavior.

Example

- Switching output: Distance outside limit values, both, NPN switching level

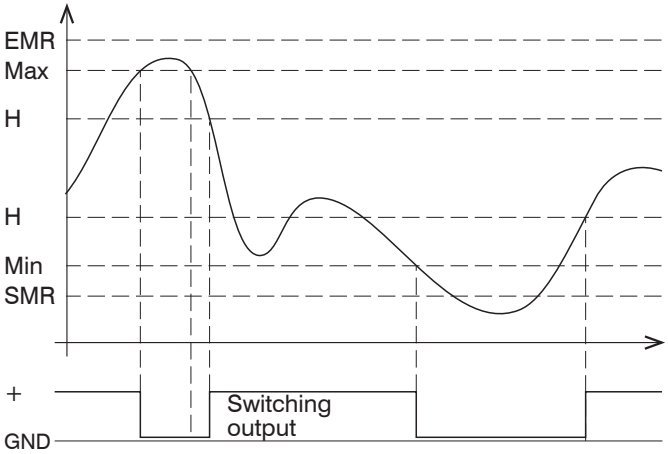


Fig. 6.27: Switching output with limit values (both limits, NPN)

EMR = End of measuring range
Max = Maximum
HV = Hysteresis value
Min = Minimum
SMR = Start of measuring range

When the upper limit value (Max) is exceeded, the switching output with NPN switching behavior is activated (conducting state). It is deactivated again as soon as the hysteresis value is subsequently undershot. The same principle applies when the lower limit value is undershot (Min).

The function of the switching output is generally independent of the analog output.

In the active state, the relevant transistor of a switching output is conducting. The switching output is short-circuit proof.

Resetting the short-circuit protection:

- Eliminate external short circuit,
- switch sensor off and on again, or
- send `Reset` software command to sensor.

6.6 System Settings

6.6.1 Web interface unit

Specifies the unit for display on the web page and for all input parameters related to units. You can select between mm and inches.

i Data output via Ethernet/analog output is not affected by this setting.

6.6.2 Language support

The web interface is available in German and English, among other languages. Switch the language in the menu bar.

6.6.3 Key lock

The key lock prevents unauthorized or unintentional execution of the key functions. A key lock can be set individually for the `Multifunction` and/or `Correct` key.

Key lock	Automatic	Value (1 ... 60 min)	*The button function will be blocked after a defined period of time has elapsed.*
	Active		*The button function is blocked immediately.*
	Disabled		*No key lock*

The key lock can only be deactivated with `Professional` access authorization.

6.6.4 Loading and Saving

This chapter describes how to save a setup with either measurement settings or with device settings. Here you can also find the functions for setup import and setup export, see Chap. 6.7.

6.6.5 Access authorization, login, logout

Assigning passwords prevents unauthorized changes to settings. The password protection is disabled in the delivery condition and the `Professional` level is active. When the configuration has been completed, you should enable password protection. The standard password for the Professional level is “000”.

i A software update will not change the default password or a user-defined password. The Professional password is independent of the setup and is therefore not loaded or saved together with the setup.

Users have the following functions available:

Action	**User**	**Professional**
Password required	no	yes
View settings	yes	yes
Change settings, change passwords	no	yes
View measured values, video signals	yes	yes
Scale graphs	yes	yes
Restore factory settings	no	yes

Tab. 6.6: Rights in the user hierarchy

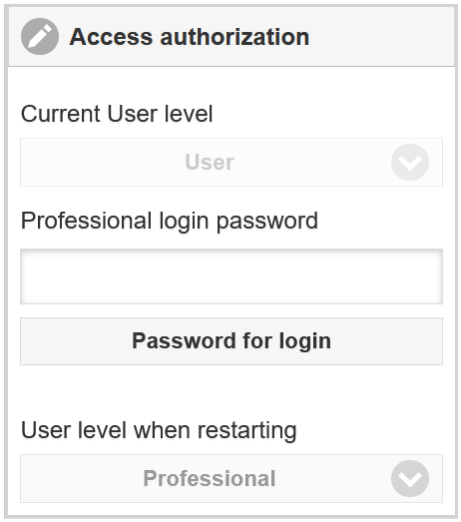


Fig. 6.28: Changing to Professional level

Changing to Professional level

- Switch to the tab `Settings` > `System settings` > `Access authorization`.
- Enter the standard password “000” or a custom password into the `Professional login password` box, and click `Password for login`.

The user management enables the assignment of a user-defined password in operating mode `Professional`.

Password	*value*	*All passwords are case-sensitive; numbers are allowed. Special characters are not permitted.*
User level on restart	*User / Professional*	Defines the user level that is enabled after restart. Micro-Epsilon recommends the selection Professional here.

6.6.6 Reset System

You can reset individual settings to the factory setting in this menu area.

Device settings	*The settings for the following commands are reset to the factory settings:* *ANALOGRANGE, BAUDRATE, ECHO, KEYLOCK, LED, LANGUAGE, UNIT* *The operating mode is not affected by the device settings.*
Measurement settings	*Resets the preset to* `Standard matt`*e and all parameters, except for interface settings, to the factory setting.*
Reset of the materials table	*All settings for the materials table are set to factory setting.*
Reset all	*Resets the device and measurement settings to factory settings.*
Reboot sensor	*Starts the system with the last saved settings.*

6.6.7 Light source

You can switch the light source for the system on or off. You can switch the light source for the system on or off. This can be done via software or with the multifunctional inputs MFI1/2.

6.6.8 Materials table

In this menu area, you can add target materials (layers) to the material table or adjust existing entries. A material is characterized either by three refractive indices or by one refractive index and Abbe number.

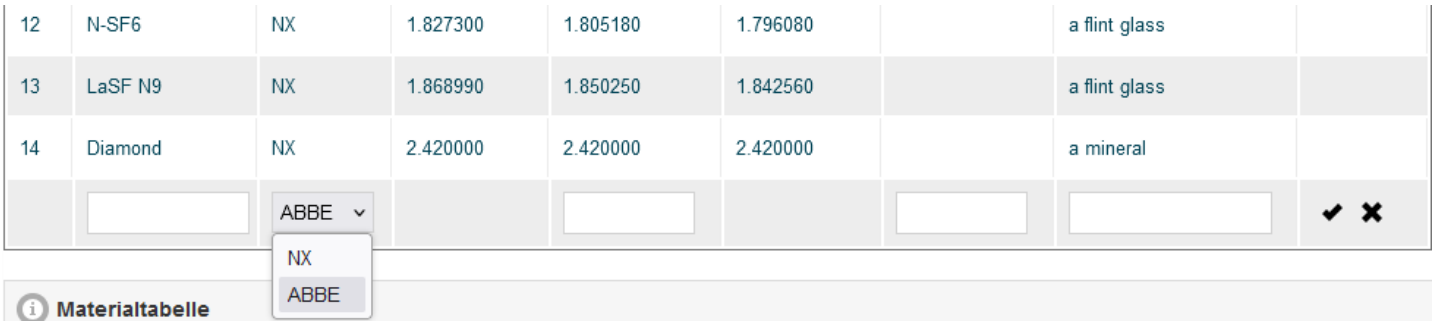


Fig. 6.29: Mask for the addition of a material

The refractive index of a material is described using NX or ABBE:

- NX describes the material using the three refractive indices nF, nd, and nC,
- ABBE describes the material using a refractive index (nd) and an Abbe number (vd).

6.7 Save/load settings

This menu enables you to save current device settings in the controller or activate saved settings. You can permanently save eight different parameter sets in the controller.

Unsaved settings will be lost when the device is switched off. Save your settings in Setups.

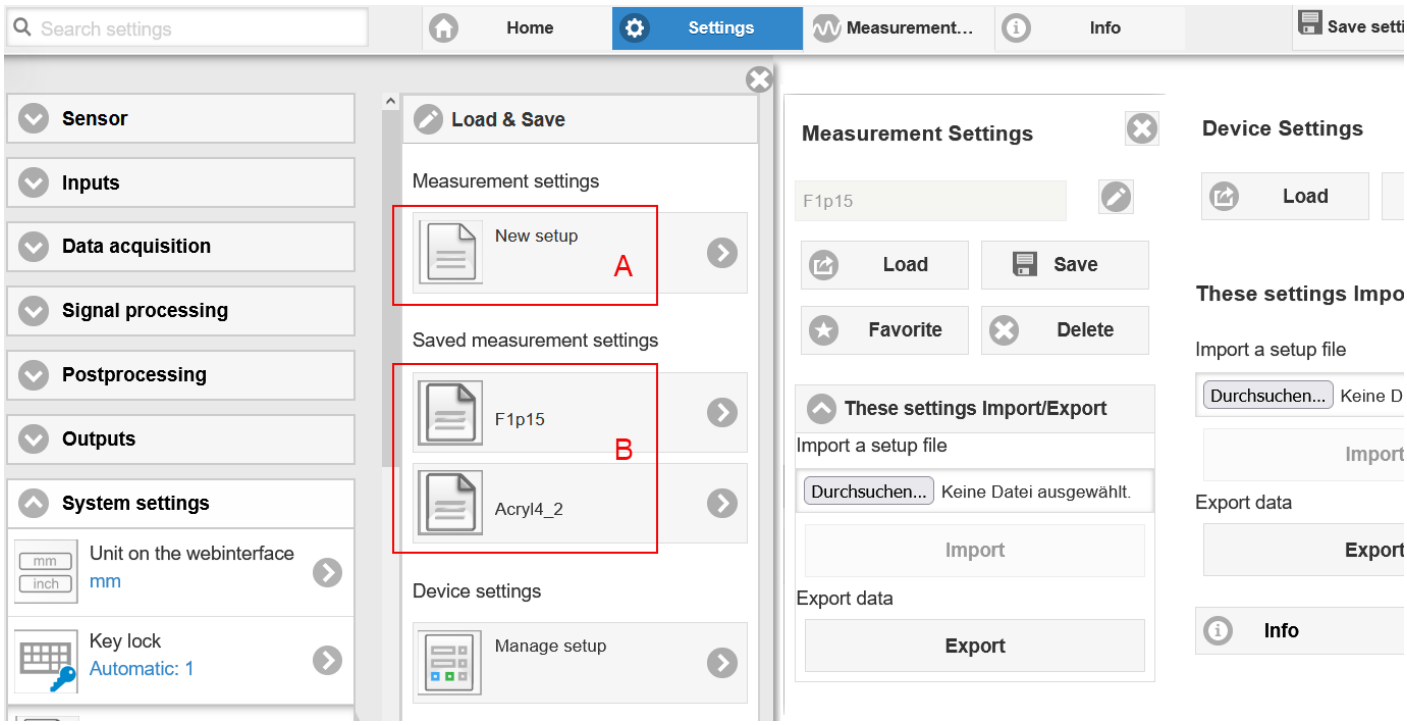


Fig. 6.30: Managing user programs

► Switch to the `Settings > Load & Save` menu.

Manage setups in the controller, options and sequence			
Saving the settings	**Activating existing setup**	**Save changes in the active setup**	**Determining setup after booting**
Menu `New setup`, see A	`Load & Save` menu	Menu bar	`Load & Save` menu
Enter the name for the setup, e.g. F1p15 and confirm the entry with the `Save` button.	Click on the desired setup with the left mouse button, area B. The `Measurement settings` dialog opens. Click the `Load` button.	Click on the `Save settings` button	Click on the desired setup with the left mouse button, area B. The `Measurement settings` dialog opens. Click the `Favorite` button.

You can also use the Save settings button at top right, in each settings page as quick cache for the last parameter set saved.

i When switching on, the last parameter set saved in the controller is loaded.

Switch setups with PC/notebook, options	
Saving setup on PC	**Loading setup from PC**
Load & Save menu	Load & Save menu
Click on the desired setup with the left mouse button, area B. The Measurement settings dialog opens. Click on the button Export.	Left-click on New setup. The Measurement settings dialog opens. Click on the button Search. A Windows dialog for file selection opens. Select the desired file and click the Open button. Click on the Import button.

7 Thickness measurement, one-sided transparent measuring object

7.1 Requirement

For a one-sided thickness measurement of a transparent target, the controller evaluates two signals reflected at the surfaces. Based on these two signals, the controller calculates the distances from the surfaces and, from this, derives the thickness.

► Align the sensor perpendicularly to the object to be measured. Make sure that the target is approximately in the mid of the measuring range (SMR + 0.5 x MR).

i The light beam must strike the surface of the object at a perpendicular angle. Otherwise, measurements might be inaccurate.

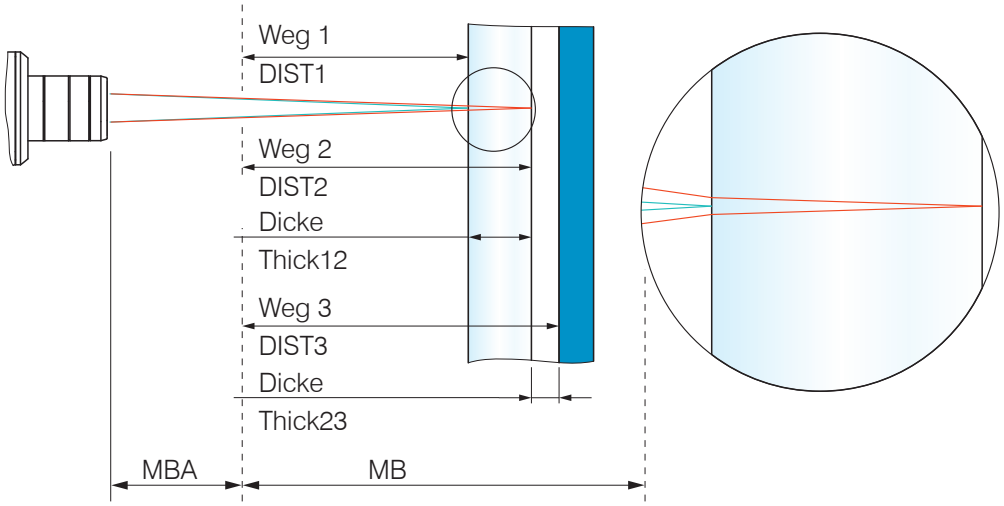


Fig. 7.1: One-sided thickness measurement on a transparent target

SMR	Start of measuring range
MR	Measuring range
Minimum target thickness	see Chapter Technical data
Maximum target thickness	

7.2 Preset

confocalDT IFD2415	confocalDT IFD2410
Switch to the `Home` menu.	
Choose `Multilayer airgap` in the configuration selection.	Choose `One-sided thickness measurement` in the configuration selection.

This presetting prompts the controller to use the first and second peak in the video signal for the thickness calculation.

`Calculation 1` in controller: `thickness` Difference between `DIST2` and `DIST1`	`Calculation 1` in controller: `thickness` Difference between `DIST2` and `DIST1`

`Calculation 2` in controller: `thickness` Difference between `DIST3` and `DIST2`	---

7.3 Material selection

Before selecting a material, define the number of layers of the target or the number of peaks to be expected in the video signal. Otherwise, it will not be possible to assign the material.

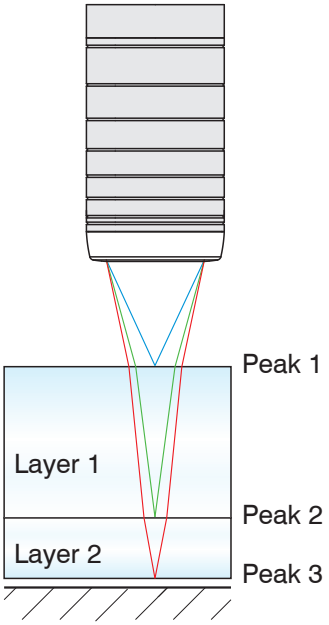
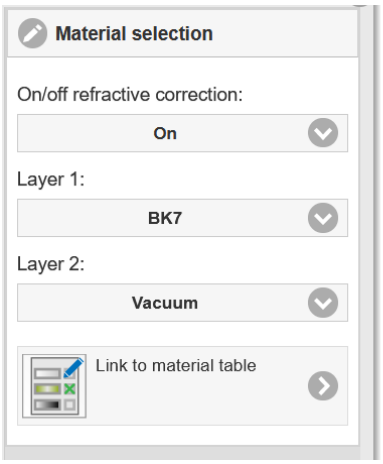


Fig. 7.2: Layer structure of a target

The refractive index needs to be corrected in the controller for an exact distance or thickness measurement.

- Switch to the `Settings > Data acquisition > Material selection` menu.
- Activate the refractive correction. To do so, click the `On` button in the menu `On/off refractive correction`.
- Assign the materials to the individual layers according to the target used.

The `Link to materials table` button can be used to expand or reduce the material database in the controller. For a new material, a refractive index and the Abbe number vd are required or three refractive index numbers are required if there are different wavelengths (also approximately the same).



pos	material name	definition	nF at 486nm	nd at 587nm	nC at 656nm	VD - Abbe number	description
1	Vacuum	NX	1.000000	1.000000	1.000000		vacuum, air (approximately)
2	Water	NX	1.337121	1.333044	1.331152		a liquid
3	Ethanol	NX	1.361400	1.361400	1.361400		ethyl alcohol, pure alcohol (a liquid)
4	Acrylic	NX	1.497828	1.491668	1.488938		acrylic resin, adhesive, lacquer

Fig. 7.3: Selection of material-specific refractive indices

7.4 Video signal

If a surface of the target lies outside the measuring range, the controller will send only one signal for the distance, intensity and center of gravity. This may also occur if a signal is below the detection threshold.

Two boundary surfaces are active when the thickness of a transparent material is measured. As a result, two peaks are visible in the video signal.

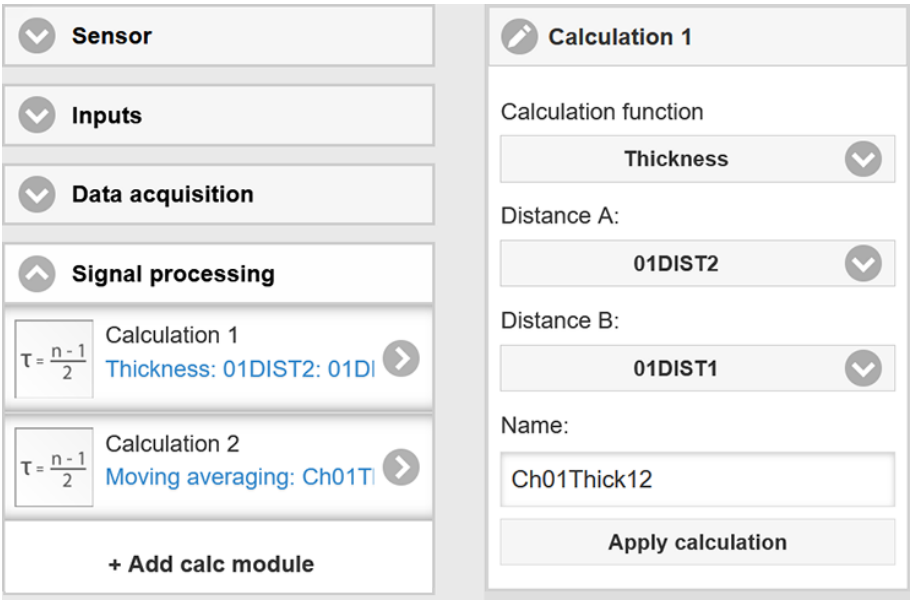
Fig. 7.4: Video signal website, one-sided thickness measurement

7.5 Signal processing

The configuration selection `One-sided thickness measurement` also contains presets for the thickness calculation from the two distance signals `Displacement1` and `Displacement2`.

In the downstream second calculation block `Calculation 2`, the thickness values undergo a moving averaging with an averaging depth of 16 values.

- Adapt the signal processing to your measurement task.



7.6 Measurement chart

- Switch to the `Measurement chart` tab and select `Mess` as the chart type.

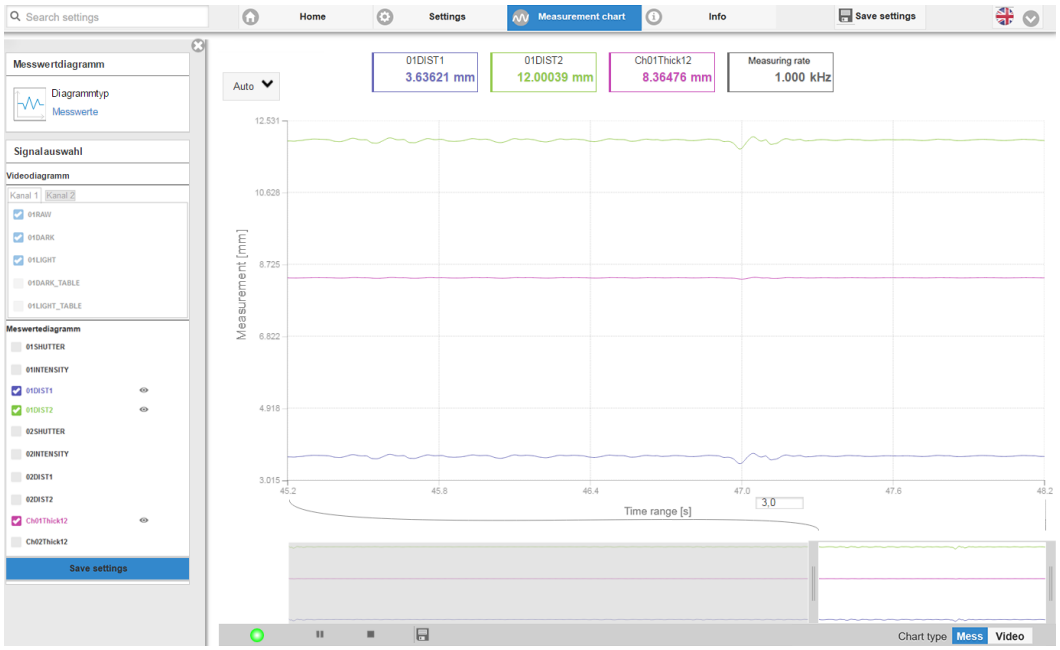


Fig. 7.5: Measured thickness results based on a one-sided thickness measurement with one sensor

The two distances and the thickness (difference between `01DIST2` and `01DIST1`) are shown graphically and numerically on the website, and the intensities for both peaks (Peak 1 = near, Peak 2 = far) can also be displayed as an option.

8 Digital interface RS422

8.1 Interface parameters

The RS422 interface has a maximum baud rate of 4000 kBaud. The baud rate is set to 921.6 kBaud when the interface is delivered. Use ASCII commands or the web interface to configure.

The transmission settings of the controller and of the PC must match.

Data format: Binary. Interface parameters: 8 data bits, no parity, 1 stop bit (8N1). Selectable baud rate.

The RS422 interface transmits 18 bits per output value. The maximum number of measured values that can be transmitted for a measuring point depends on the measuring rate of the controller and the transmission rate set for the RS422 interface. Use the maximum available transmission rate (baud rate) where possible.

Output data are selected for both interfaces separately from all internally determined values and from the calculated values from the computing modules. These are issued in a fixed order.

8.2 Data Format

The output of distance measurement values and other measured values via RS422 requires a subsequent conversion into the relevant unit. The measurement data, if requested, always follows a video frame.

<Preamble>	<Size>	<video data>	<End>
Start identifier 64 bit 0xFFFF00FFFF000000	Size 32 Bit Volume of the video data in bytes	16 Bit unsigned	End identifier 32 bit 0xFEFE0000

Tab. 8.1: Structure of a video frame

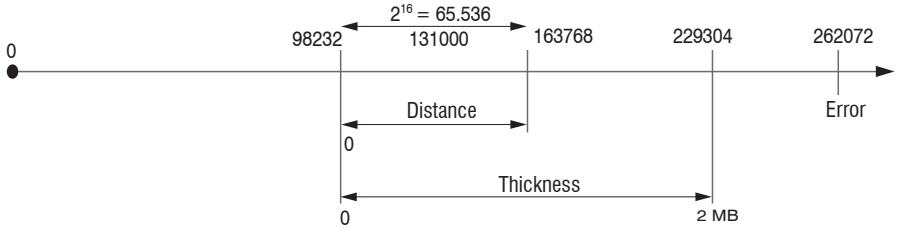
Output value 1:

	Preamble		Data bits					
L-byte	0	0	D5	D4	D3	D2	D1	D0
M-Byte	0	1	D11	D10	D9	D8	D7	D6
H-byte	1	0	D17	D16	D15	D14	D13	D12

Output value 2...32:

	Preamble		Data bits					
L-byte	0	0	D5	D4	D3	D2	D1	D0
M-Byte	0	1	D11	D10	D9	D8	D7	D6
H-byte	1	1	D17	D16	D15	D14	D13	D12

Value range for the distance and thickness measurement:



131000 = mid of measuring range for the distance measurement

MR = Measuring range

The linearized measured values can be converted into millimeters according to the following formula:

$$x = \frac{(d_{OUT} - 98232) * MR}{65536}$$

x = distance / thickness in mm
dOUT = digital output value
MR = Measuring range in mm

8.3 Output values, scaling

Signal name	RS422, min	RS422, max	Scaling	Unit	2410	2415
01RAW (512 x 16 Bit)	0	4095	value / 4096 * 100	%	x	x
01DARK (512 x 16 Bit)	0	4095	value / 4096 * 100	%	x	x
01LIGHT (512 x 16 Bit)	0	65535	value / 65536 * 100	%	x	x
01SHUTTER	0	65536	Value / 9	µs	x	x
01ENCODER1	0	262143	Value	Encoder ticks	x	x
01ENCODER2	none	none	none	Encoder ticks	x	x
01ENCODER3	none	none	none	Encoder ticks	x	x
01INTENSITY[1..6]	0	2048	Value / 1024 * 100	%	x	x
01DIST[1..6]	0	262071	(value - 98232) / 65536 * measuring range	mm	x	x
01SYMM[1..6]	0	262143	value / 16	Position center	x	x
MEASRATE	2250	180000	18000 / value	kHz	x	
MEASRATE	720	180000	18000 / value	kHz		x
TIMESTAMP	0	262143	value	µs	x	x
TIMESTAMP_HI	0	65535	value * 65536	µs	x	x
TIMESTAMP_LO	0	65535	Value	µs	x	x
COUNTER	0	262143	Value		x	x
*_MIN		262071	identical 01DIST*	mm	x	x
*_PEAK	00	262071	identical 01DIST*	mm	x	x
*_MAX		262071	identical 01DIST*	mm	x	x

Tab. 8.2: Output values RS422

8.4 Error codes

All values greater than 262072 are error values and are defined as follows:

Error code	Description
262073	Scaling error RS422 interface underflow
262074	Scaling error RS422 interface underflow
262075	Data volume too large for selected baud rate[12]
262076	No peak is present.
262077	Peak is before the measuring range (MR)
262078	Peak is behind the measuring range (MR)
262079	Measured value cannot be calculated

For all other data outputs except the measured value data, the limitations are defined in the relevant sections.

[12] This error occurs when more data is to be output than can be transmitted at the selected baud rate at the selected measuring frequency.

9 Ethernet interface

9.1 Transmission of measured data to a measurement server via Ethernet

During the transmission of measured value data to a measurement server, the controller sends each measured value to a measurement server or a connected client after the connection (TCP or UDP) has been successfully set up. No specific request is required for this.

All distances and additional information intended for transmission that were captured at a certain time are consolidated into a measurement frame. Several measured value frames are consolidated into a measured value block, which is given a header and fits into a TCP/IP or UDP/IP packet. The header must be located at the start of a UDP or TCP packet. In the event of changes to the transmitted data or the frame rate, a new header is sent automatically.

All measured data and the header are transmitted in little-endian format.

Preamble (32 bits)
Article number (32 bits)
Serial number (32 bits)
Length video data (32 bits)
Length measurement data (32 bits)
Frame number (32 bits)
Counter (32 bits)

The structure of a header is the same for video and measurement data transfer.

Header entry	**Description**
Preamble	uint32_t - 0x41544144 “DATA”
Article no.	
Serial number	
Length video data	[Byte]
Length measure-ment data	[Byte]
Number of frames	Number of frames covered by this header For video output, the field for the number of measurement data frames in the package is set to one.
Counter	Counter with the number of measurements processed

9.2 Output values, scaling

Output value	Ethernet, min	Ethernet, max	Scaling	Unit	2410	2415
01RAW (512 x 16 Bit)	0	4095	value / 4096 * 100	%	x	x
0xSHUTTER	0	UINT32_MAX	value / 36	µs	x	x
0xENCODER1	0	UINT32_MAX	Value	Encoder ticks	x	x
0xENCODER2	0	UINT32_MAX	Value	Encoder ticks	x	x
0xENCODER3	0	UINT32_MAX	Value	Encoder ticks	x	x
0xINTENSI-TY[1..6]	0	0x3fffffff	(value & 0x7ff) / 1024 * 100	%	x	x
0xDIST[1..6]	INT32_MIN	0x7ffffeff	Value / 1000000	mm	x	x
MEASRATE	4500	360000	36000 / value	kHz	x	
MEASRATE	1440	360000	36000 / value	kHz		x
TIMESTAMP	0	UINT32_MAX	Value	µs	x	x

COUNTER	0	UINT32_MAX	Value		x	x
_MIN	INT32_MIN	0x7ffffeff	identical 0xDIST*	mm	x	x
_PEAK	INT32_MIN	0x7ffffeff	identical 0xDIST*	mm	x	x
_MAX	INT32_MIN	0x7ffffeff	identical 0xDIST*	mm	x	x

Tab. 9.1: Output values with Ethernet

10 Errors, repair

10.1 Web interface communication

► If an error page is displayed in the web browser, please check the following points.

- Check to make sure the controller is connected correctly.
- Check the IP configuration of PC and controller, find the controller with the `sensorTOOL` program.
  If the controller and PC are connected directly, it can take up to two minutes to agree on the IP addresses.
- Check proxy settings used. If the controller is connected to the PC via a separate network card, then it will be necessary to disable the use of a proxy server for this connection. Please ask your network manager or administrator about this!

11 Software support with MEDAQLib

MEDAQLib is a documented driver DLL. This allows you to integrate the confocal measuring system into existing PC software or that of the customer.

Connection options:

- RS422/USB converter (optional accessories) and suitable PC2415-x/OE connection cable for IFD2410/2415.

No knowledge of the underlying protocol of the respective controller is necessary to be able to contact the controller. The individual commands and parameters for the controller to be addressed are set via an abstract function and converted into the protocol of the controller by the MEDAQLib accordingly.

MEDAQLib

- contains a DLL that can be imported into C, C++, VB, Delphi and many other programs,
- takes care of data conversion for you,
- works regardless of the type of interface used,
- uses the same functions for communication (commands),
- provides a uniform transmission format for all Micro-Epsilon sensors.

For C/C++ programmers, an additional header file and a library file are integrated into MEDAQLib.

You can find the current driver routine including documents at:

www.micro-epsilon.de/download

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

12 Disclaimer

All components of the device have been checked and tested for functionality in the factory. However, should any defects occur despite careful quality control, these shall be reported immediately to Micro-Epsilon or to your distributor / retailer.

Micro-Epsilon undertakes no liability whatsoever for damage, loss or costs caused by or related in any way to the product, in particular consequential damage, e.g., due to

- non-observance of these instructions/this manual,
- improper use or improper handling (in particular due to improper installation, commissioning, operation and maintenance) of the product,
- repairs or modifications by third parties,
- the use of force or other handling by unqualified persons.

This limitation of liability also applies to defects resulting from normal wear and tear (e.g., to wearing parts) and in the event of non-compliance with the specified maintenance intervals (if applicable).

Micro-Epsilon is exclusively responsible for repairs. It is not permitted to make unauthorized structural and / or technical modifications or alterations to the product. In the interest of further development, Micro-Epsilon reserves the right to modify the design or the firmware.

In addition, the General Terms of Business of Micro-Epsilon shall apply, which can be accessed under Legal details | Micro-Epsilon https://www.micro-epsilon.com/legal-details/.

13 Service, repair

If the sensor, controller or sensor cable is defective:

- If possible, save the current sensor settings in a parameter set , see Chap. 6.7 to reload them into the controller after the repair.
- Please send us the affected parts for repair or exchange.

If the cause of a fault cannot be clearly identified, please send the entire measuring system to:

MICRO-EPSILON MESSTECHNIK
GmbH & Co. KG
Koenigbacher Str. 15
94496 Ortenburg / Germany

Tel: +49 (0) 8542 / 168-0
Fax: +49 (0) 8542 / 168-90
info@micro-epsilon.com
www.micro-epsilon.com/contact/worldwide/
https://www.micro-epsilon.com

14 Decommissioning, disposal

In order to avoid the release of environmentally harmful substances and to ensure the reuse of valuable raw materials, we draw your attention to the following regulations and obligations:

- Remove all cables from the sensor and/or controller.
- Dispose of the sensor and/or the controller, its components and accessories, as well as the packaging materials in compliance with the applicable country-specific waste treatment and disposal regulations of the region of use.
- You are obliged to comply with all relevant national laws and regulations.

For Germany / the EU, the following (disposal) instructions apply in particular:

- Waste equipment marked with a crossed garbage can must not be disposed of with normal industrial waste (e.g. residual waste can or the yellow recycling bin) and must be disposed of separately. This avoids hazards to the environment due to incorrect disposal and ensures proper recycling of the old appliances.

- A list of national laws and contacts in the EU member states can be found at https://ec.europa.eu/environment/topics/waste-and-recycling/waste-electrical-and-electronic-equipment-weee_en. Here you can inform yourself about the respective national collection and return points.

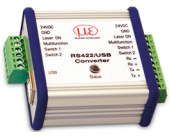
- Old devices can also be returned for disposal to Micro-Epsilon at the address given in the legal details at https://www.micro-epsilon.com/legal-details.

- We would like to point out that you are responsible for deleting the measurement-specific and personal data on the old devices to be disposed of.

- Under the registration number WEEE-Reg.-Nr. DE28605721, we are registered at the foundation Elektro-Altgeräte Register, Nordostpark 72, 90411 Nuremberg, as a manufacturer of electrical and/or electronic equipment.

15 Optional accessories

15.1 Optional accessories, confocalDT IFD2410/2415

SC2415-x/OE		Connection cable with 17-pole M12 socket and open ends for analog output, digital I/O and encoder; drag chain-compatible, cable length x = 3 m, 6 m, 9 m or 15 m
PC2415-x		Cable extension with 12-pin M12 socket and 12-pin M12 plug for power supply, RS422 or encoder, Industrial Ethernet; suitable for drag chains, cable length x = 3 m, 6 m, 9 m or 15 m
PC2415-x/OE		Connection cable with 12-pin M12 socket and open ends, suitable for PC2415-x, supply, RS422 or encoder, Industrial Ethernet; suitable for drag chains, cable length x = 3 m, 6 m, 9 m or 15 m
PC2415-1/Y		Supply/interface cable for IFD241x; with 12-pin M12 socket and open ends or RJ45 plug, cable length = 1 m
IF2001/USB		IF2001/USB 1-channel RS422/USB converter Connections: 1 x 10-pin socket strip (cable clamp) type: Würth 691361100010, 1 x 6-pin socket strip (cable clamp), type: Würth 691361100006
PS2020		Power supply unit for DIN rail mounting Input 230 VAC, output 24 VDC/2.5 A

15.2 Services

- confocalDT measuring system linearity check and adjustment
- confocalDT measuring system calibration

16 Factory settings

16.1 confocalDT IFD2410/2415

Number of peaks	1 measurement value, highest peak
Region of interest	Start of range corresponds to 0% End of range corresponds to 100%:
Exposure mode	Measurement mode
User group	Professional, password “000”
Data reduction	Inactive
Detection threshold	2 %
Error handling	Error output, no value
Measuring mode	Distance measurement, “Standard matt”
Measuring rate	1 kHz
Peak modulation	50 %

RS422	921.6 kBps
Switching output 1	Intensity error, switching level for error: Push Pull
Switching output 2	Error measuring range, switching level for error: Push Pull
Interface	Ethernet
Signal processing	01DIST1, moving averaging, 16 values
Synchronization	no synchronization
Key function	Change operating mode, dark referencing, factory setting
Key lock	Inactive
Trigger mode	No trigger

17 Cleaning optical components

17.1 Tools and cleaning agents

Isopropyl alcohol	Q-Tip, suitable for clean rooms	Pressurized gas, dry and oil-free
		
For the protective glass of the sensor	Use with isopropyl alcohol for protective glass of the sensor	Removes loose particles

17.2 Protective glass of sensor

Loose sticking particles:

- ► Blow off loose particles with dry, oil-free compressed air.

Sticking particles:

- ► Clean the protective screen with a clean, soft, lint-free cloth or lens cleaning paper and pure alcohol (isopropanol).

Fig. 17.1: Cross-section of protective glass

- ► Perform a dark correction.

If the video signal corresponds to the condition before the dark correction, you must clean the boundary surfaces within the measuring system.

18 ASCII communication with controller

18.1 General

The ASCII commands can be sent to the sensor/controller via the RS422 or Ethernet interfaces (port 23). All commands, inputs and error reports are in English. A command always consists of the command name and zero or several parameters that are separated with a space and end in LF. If spaces are used in parameters, the parameter must be placed in quotation marks, e.g. “Password with space”.

Example: Switching on output via RS422

OUTPUT RS422 <Enter>

Reference	<Enter>	Must include LF, but can also be CR LF
Explanation	<LF>	Line feed (hex 0A)
	<CR>	Carriage return (hex 0D)
	<Enter>	hex 0A or hex 0D0A depending on the system

The currently set parameter value is reset if a command is invoked without parameters.

The output format is:

<Command name> <Parameter1> [<Parameter2> […]]

The response can be used again without changes as a command for setting the password. Optional parameters are only returned as well if this is necessary.

After a command is processed, a line break and a prompt (“->”) is always returned. In the event of an error, an error message beginning with Exx, where xx stands for a unique error number, comes before the prompt. Moreover, instead of error messages, warning messages (“Wxx”) may be output. Warnings are structured analogously to error messages. Warnings do not prevent commands from being executed.

18.2 Commands overview

Group	Command	Brief description
General		
	HELP	Help
	GETINFO	Controller information
	ECHO	Reply type
	PRINT	Parameter overview
	SYNC	Synchronization
	TERMINATION	Termination resistor
	RESET	Boot sensor
	RESETCNT	Reset counter
User level		
	LOGIN	Changing the user level
	LOGOUT	Changing to User level
	GETUSERLEVEL	User level query
	STDUSER	Set standard user
	PASSWD	Change password
Inputs		
	MFILEVEL	Input level multifunction inputs
Sensor		

Group	Command	Brief description
	SENSORINFO	Information on sensor
	DARKCORR	Start dark correction
	LED	LED on/off
	LEDSOURCE	Control input for the measuring light source
Triggering		
	TRIGGERSOURCE	Trigger source
	TRIGGERAT	Effect of trigger input
	TRIGGERMODE	Trigger type
	TRIGGERLEVEL	Active level of trigger input
	TRIGGERSW	Generate a software trigger pulse
	TRIGGERCOUNT	Number of measured values to be output
	TRIGGERLEVEL	Level for the trigger input (TTL / HTL)
	TRIGGERENCSTEPSIZE	Step size encoder triggering
	TRIGGERENCMIN	Minimum encoder triggering
	TRIGGERENCMAX	Maximum encoder triggering
Encoder		
	META_ENCODERCOUNT	Number of available encoders
	ENCINTERPOLn	Set interpolation depth
	ENCREFn	Set reference track
	ENCVALUEn	Setting encoder value
	ENCSET	Set encoder value
	ENCRESET	Reset encoder value
	ENCMAXn	Set maximum encoder value
Interface		
	BAUDRATE	RS422 setting
Parameter management, load/save settings		
	BASICSETTINGS	Load connection settings
	CHANGESETTINGS	Show changed parameters
	EXPORT	Export parameter sets
	SETDEFAULT	Set factory settings
	MEASSETTINGS	Edit measurement settings
Measurement		
	PEAKCOUNT	Number of measurement peaks
	MEASPEAK	Peak selection
	REFRACCORR	Refractive index correction
	SHUTTERMODE	Exposure mode
	SHUTTER	Exposure time
	ROI	Mask the region of interest (ROI)
	MIN_THRESHOLD	Minimum threshold peak detection
	PEAK_MODULATION	Modulation of peaks
	PEAK_THRESHOLD	Peak minimum threshold
Materials database		

Group	Command	Brief description
	MATERIALTABLE	Materials table
	MATERIAL	Select material
	MATERIALINFO	Show material property
	META_MATERIAL	Existing materials, material names
	META_MATERIAL_PROTECTED	Protected materials
	MATERIALEDIT	Edit materials table
	MATERIALDELETE	Delete material
	MATERIALADD	Add material
Edit measured value		
	STATISTIC	Selection of signals for statistics
	META_STATISTIC	List of possible statistics signals
	META_STATISTICSIGNAL	List of selectable statistics signals
	META_MASTERSIGNAL	List of possible signals to be parameterized
	MASTERSIGNAL	Parameterization of master signals
	META_MASTER	List of possible signals for mastering
	MASTER	Trigger mastering
	MASTERSIGNALSELECT	Determine signal for mastering with external source
	MASTERSOURCE	Select external source for mastering
	COMP	Calculation in channel
	META_COMP	List of possible calculation signals
	SYSSIGNALRANGE	Two-point scaling data outputs
Data output		
	OUTPUT	Digital output selection
	OUTREDUCEDEVICE	Output data rate
	OUTREDUCECOUNT	Reduction counter
	OUTHOLD	Error handling
	MEASCNT_ETH	Ethernet frame counter
Selection of measured values to be output via interfaces		
	OUT_RS422	Data selection for RS422
	META_OUT_RS422	List of possible signals RS422
	GETOUTINFO_RS422	List of selected signals, sequence via RS422
	OUT_ETH	Data selection for Ethernet
	META_OUT_ETH	List of possible signals Ethernet
	GETOUTINFO_ETH	List of selected signals, sequence via Ethernet
Switching outputs		
	ERROROUTn	Selection of error signal for output
	META_ERRORLIMITSIGNAL	List of possible signals for error output
	ERRORLIMITSIGNALn	Set signal to be evaluated
	ERRORLIMITCOMPARETOn	Set limit values
	ERRORLIMITVALUESn	Set value
	ERRORLEVELOUTn	Switching behavior of switching outputs
	ERRORHYSTERESIS	Switching hysteresis of switching outputs
Analog output		

Group	Command	Brief description
	ANALOGOUT	Data selection for analog output
	META_ANALOGOUT	List of possible signals for analog output
	ANALOGRANGE	Set current/voltage range of the digital-to-analog converter (DAC)
	ANALOGSCALEMODE	Set scaling for DAC
	ANALOGSCALERANGE	Set scaling range
System settings for key functions		
	KEYLOCK	Key lock configuration
	LANGUAGE	Web interface language selection
	IPCONFIG	IP address Ethernet
	MEASTRANSFER	Ethernet measured value transmission

18.3 General commands

18.3.1 General

18.3.1.1 Help

```
HELP [<Command>]
```

Output help for each command. If no command is given, a general help is output.

18.3.1.2 Controller information

```
GETINFO
```

Requests sensor information. See example output below:

```
->GETINFO
Name:            IFD241x
Serial:          12345678
Option:          000
Article:         1234567
MAC-Address:     00-0C-12-01-E2-0C
Version:         004.004
Hardware-rev:    01
Boot-version:    001.018
BuildID:         57
Output-variant:  Ethernet
->
```

Name:	Model name of controller / controller series
Serial:	Controller serial number
Option:	Controller option number
Article:	Controller article number
MAC address:	Address of network adapter
Version:	Version of the booted software
Hardware-rev:	Hardware revision used
Boot version:	Bootloader version
BuildID:	Identification number for generated software

18.3.1.3 Reply type

```
ECHO ON | OFF
```

The reply type describes the structure of a command reply.

ECHO ON:	The command name and the command reply or an error message is output.
ECHO OFF:	Only the command reply or an error message is returned.

18.3.1.4 Parameter overview

```
PRINT ALL
```

without parameters:	This command outputs a list of all setting parameters and their values.
ALL :	This command outputs a list of all setting parameters and their values, as well as information such as, e.g., the sensor table or GETINFO.

18.3.1.5 Synchronisation

```
SYNC NONE | MASTER | SLAVE_SYNCTRIG | SLAVE_TRIGIN
```

Einstellen der Synchronisationsart:

- NONE: Keine Synchronisation
- MASTER: Controller ist Master, d. h. er gibt Synchronisationsimpulse am Ausgang Sync/Trig aus
- SLAVE_SYNCTRIG: Bei dieser Einstellung ist der Controller der Slave und erwartet Synchron-Impulse von z. B. einem anderen Controller oder einer ähnlichen Impulsquelle am Eingang Sync/Trig.
- SLAVE_TRIGIN: Controller ist Slave und erwartet Synchron-Impulse von einem Frequenzgenerator am Eingang TrigIn.

Eingang	Verhalten
Sync/Trig	Differenziell
TrigIn	TTL / HTL

Sync/Trig ist alternativ ein Ein- oder ein Ausgang, d. h. es ist darauf zu achten, dass immer einer der Controller auf Master und die anderen auf Slave geschaltet sind.

Außerdem dient der Eingang TrigIn ebenfalls als Triggereingang für die Triggerarten Flanken- und Pegeltriggerung.

18.3.1.6 Termination resistor at Sync/Trig

```
TERMINATION OFF | ON
```

The termination resistor 120 ohm at the Sync/Trig synchronization input is switched on or off.

18.3.1.7 Boot sensor

```
RESET
```

The controller is restarted.

18.3.1.8 Reset counter

```
RESETCNT [TIMESTAMP] [MEASCNT]
```

The counter is reset after the selected trigger edge occurs.

TIMESTAMP:	resets the time stamp
MEASCNT:	resets the measurement counter

18.3.2 User level

18.3.2.1 Change user level

```
LOGIN <Password>
```

Enter the password to access another user level. There are the following user levels:

- USER: Read access to all elements + use of web diagrams
- PROFESSIONAL: Read/write access to all elements

18.3.2.2 Wechsel in die Benutzerebene Bediener

`LOGOUT`

Setzen der Benutzerebene auf USER.

18.3.2.3 User level query

`GETUSERLEVEL`

Queries the current user level.

Possible outputs, “Change User Level”.

18.3.2.4 Set standard user

`STDUSER USER|PROFESSIONAL`

Sets the standard user who is logged in after the system starts.

18.3.2.5 Change password

`ASSWD <Old password> <New password> <New password>`

Change the password for the PROFESSIONAL user. The factory standard password is “000”.

For this, the old password must be entered and the new password must be entered twice. If the new passwords do not match, an error message will be output. The password function is case-sensitive. A password may only contain the letters A to Z and numbers without umlauts/special characters. The maximum length is limited to 31 characters.

18.3.3 Level of multifunction inputs

`MFILEVEL HTL | TTL`

Selection of input level of the multifunction inputs. (MFI). Select input level of multifunction input (MFI).

- HTL: HTL level
- TTL: TTL level

18.3.4 Sensor

18.3.4.1 Sensor information

`SENSORINFO`

Output of information about the sensor (name, measuring range and serial number).

```
->SENSORINFO
Position:                0
Name:                    BG
Measurement range:       3.000 mm
Serial:                  12345678
->
```

18.3.4.2 Dark correction

`DARKCORR`

Performs the dark reference for the current sensor. The dark reference depends on the sensor and is saved in the controller for each individual sensor.

`DARKCORR_PRINT`

Lists the values of the dark correction table.

18.3.4.3 LED

`LED OFF | ON`

Switches the LED of the respective channel on or off.

18.3.4.4 Control input for the measuring light source

`LEDSOURCE [SOFTWAREONLY | MFI1 | MFI2]`

- SOFTWAREONLY: The measuring light source can only be controlled by software; via ASCII command `LED ON/OFF` or web interface
- MFI1: Control of the measuring light source via selected multifunction input MFI1
- MFI2: Control of the measuring light source via selected multifunction input MFI2

18.3.5 Triggering

18.3.5.1 Select trigger source

`TRIGGERSOURCE NONE | SYNCTRIG | TRIGIN | SOFTWARE | ENCODER1 | ENCODER2`

- NONE: No trigger source used
- SYNCTRIG: Use input `Sync/Trig`
- TRIGIN: Use the input `TrigIn`
- SOFTWARE: Triggering is initiated by the command `TRIGGERSW`.
- ENCODER1: Encoder triggering of encoder 1
- ENCODER2: Encoder triggering of encoder 2

18.3.5.2 TRIGGERAT, Effect of the Trigger Input

`TRIGGERAT [INPUT|OUTPUT]`

- INPUT: Triggers data acquisition. Values measured immediately before the trigger event are not included in the average value calculation, but older measured values that were output during previous trigger events are included instead.
- OUTPUT: Triggers measured value output. Values measured immediately before the trigger event are included in the average value calculation.

18.3.5.3 TRIGGERMODE

`TRIGGERMODE [EDGE|PULSE]`

Selection of trigger type.

- PULSE: Level triggering
- EDGE: Edge triggering

18.3.5.4 TRIGGERLEVEL, Active level triggering

`TRIGGERLEVEL [HIGH|LOW]`

- HIGH: Edge triggering: Rising edge, level triggering: High active
- LOW: Edge triggering: Falling edge, level triggering: Low active

18.3.5.5 TRIGGERSW, Software Trigger Pulse

`TRIGGERSW [SET|CLR]`

Generates a software trigger pulse.

- SET: Generates one single trigger pulse when edge triggering (EDGE) is active. Continuously generates trigger pulses with level triggering (PULSE)
- CLR: Stops trigger pulses with level triggering (PULSE). With edge triggering, an ongoing task is aborted. Abortion is also possible when selecting the trigger sources MFI and SyncIO.

18.3.5.6 TRIGGERCOUNT, Number of Output Measurement Values

```
TRIGGERCOUNT [INFINITE | <n>]
```

Number of Output Measurement Values with Triggering

- INFINITE: Start of continuous output after first trigger event
- <n>: Number of values to be output after each trigger event n = 1 to 16382.

18.3.5.7 TRIGGERLEVEL, Active level triggering

```
TRIGGERLEVEL [HIGH|LOW]
```

- HIGH: Edge triggering: Rising edge, level triggering: High active
- LOW: Edge triggering: Falling edge, level triggering: Low active

18.3.5.8 Step size encoder triggering

```
TRIGGERENCSTEPSIZE [value of step size]
```

Sets the number of encoder steps after which a measured value is output each time (min: 0, max: 2^{31}-1). At 0, measured values are continuously output between min and max.

18.3.5.9 Minimum encoder triggering

```
TRIGGERENCMIN [minimum value]
```

Sets the minimum encoder value from which triggering takes place (min: 0 max: 2^{32}-1).

18.3.5.10 Maximum encoder triggering

```
TRIGGERENCMAX [maximum value]
```

Sets the maximum encoder value up to which triggering takes place (min: 0 max: 2^{32}-1).

18.3.6 Encoder

18.3.6.1 Number of available encoders

```
META_ENCODERCOUNT
```

Lists the number of available encoders that can be selected with `ENCODERCOUNT`.

Encoder interpolation depth

```
ENCINTERPOL1 1 | 2 | 4
ENCINTERPOL2 1 | 2 | 4
ENCINTERPOL3 1 | 2 | 4
```

Sets the interpolation depth of the respective encoder input.

Effect of reference track

```
ENCREF1 NONE | ONE | EVER
ENCREF2 NONE | ONE | EVER
```

Sets the effect of the encoder reference track.

- ONE: One-time setting (the first time the reference marker is reached, the encoder value, see Chap. 18.3.6.1.3 will be adopted).
- EVER: Setting for all markers (every time the reference marker is reached, the encoder value, see Chap. 18.3.6.1.3 will be adopted).

Encoder value

```
ENCVALUE1 <encoder value>
```

```
ENCVALUE2 <encoder value>
ENCVALUE3 <encoder value>
```

Indicates the value which the corresponding encoder should be set to when a reference marker is reached (or via software).

The encoder value can be between 0 and 2^{32}-1.

Setting the ENCVALUE automatically resets the algorithm for recognizing the first reference marker, see Chap. 18.3.6.1.2.

Set encoder value via software

```
ENCSET 1 | 2 | 3
```

Set the encoder value, see Chap. 18.3.6.1.3, in the specified encoder via software (only possible with ENCREF NONE, otherwise the command immediately returns without an error message).

Reset detection of first reference marker

```
ENCRESET 1 | 2
```

Reset the detection of the first reference mark, see Chap. 18.3.6.1.2 (only possible with ENCREF ONE, otherwise the command returns immediately without an error message).

Maximum encoder value

```
ENCMAX1 <encoder value>
ENCMAX2 <encoder value>
ENCMAX3 <encoder value>
```

Indicates the maximum value of the encoder after which the encoder jumps back to 0. Can be used for rotary encoders without reference track. Can be used for rotary encoders without a reference track, for example.

The encoder value can be between 0 and 2^{32}-1.

Number of active encoders

```
ENCODERCOUNT 1 | 2 | 3
```

- 1: Encoder 1 is active, encoders 2 and 3 are inactive
- 2: Encoders 1 and 2 are active, encoder 3 is inactive
- 3: Encoders 1 to 3 are active

Command is valid with the IFD2410/2415.

18.3.6.2 Setting the RS422 baud rate

```
BAUDRATE <Baudrate>
```

Baud rates can be set in Bps for the RS422 interface:

9600, 115200, 230400, 460800, 691200, 921600, 2000000, 3000000, 4000000

18.3.7 Parameter administration, load / save settings

18.3.7.1 Load / save connection settings

```
BASICSETTINGS READ | STORE
```

- READ: Reads the connection settings from the controller flash.
- STORE: Saves the current connection settings from the controller RAM to the controller flash.

18.3.7.2 Show changed parameters

```
CHANGESETTINGS
```

Outputs all changed settings.

18.3.7.3 Export parameter sets to PC

```
EXPORT (MEASSETTINGS <SetupName>) | BASICSETTINGS | MEASSETTINGS_ALL | MATERIALTABLE | ALL
```

Saves parameters in an external device, e.g. PC.

The export file is formatted as readable JavaScript Object Notation, or JSON for short.

- MEASSETTINGS <SetupName>: Exports the specified measurement settings. Nothing is deleted before importing.
- BASICSETTINGS: Export the currently saved basic settings. The basic settings are deleted before importing.
- MEASSETTINGS_ALL: Export all saved measurement settings, including the initial setting. All existing measurement settings are deleted before importing.
- MATERIALTABLE: Exports the saved materials table. The existing materials table is deleted before importing.
- ALL: Complete export of all saved settings (Basic and Meas), the materials table and all sensor data saved. Everything is deleted before importing.

18.3.7.4 Factory settings

```
SETDEFAULT ALL | MEASSETTINGS | BASICSETTINGS | MATERIAL
```

Set the default values (reset to factory settings), delete the corresponding settings in the flash.

- ALL: All setups are deleted and the default parameters are loaded. The current materials table is also overwritten by the standard materials table.
- MEASSETTINGS: Settings for measurement task.
- BASICSETTINGS: Basic settings such as IP, baud rate, language, unit.
- MATERIAL: Only overwrite the current materials table with the standard materials table.

18.3.7.5 Editing, storing, displaying, deleting measurement settings

```
MEASSETTINGS <Subcommand> [<Name>]
```

Settings for measurement task. Moves application-dependent measurement settings between controller RAM and controller flash. Either the manufacturer-specific presets or the user-defined settings are used. Each preset can be used as a user-defined setting.

Subcommands:

`PRESETMODE <mode>`	Defines the preset dynamics.
`<mode> = NONE|STATIC|BALANCED|DYNAMIC`	With NONE, there is no selection for a preset.
`PRESETLIST`	Lists all existing presets (names): “Name1” “Name2” “…”
`READ <Name>`	Loads a basic setting or measurement setting/preset (specify name) from the controller flash.
`STORE <Name>`	Stores a basic setting or a measurement setting in the controller Flash. Enter name or it will be saved under the current name.
`DELETE <Name>`	Deletes the named measurement setting from the controller flash.
`RENAME <NameOld> <NameNew> [FORCE]`	Changes the name of a measurement setting in the controller flash. An existing measurement setting can be overwritten with FORCE.
`LIST`	Lists all stored measurement settings (names) "Name1" "Name2" "…". The order is based on the internal slot numbers, that is, not the order of saving.
`CURRENT`	Outputs the current measurement setting / preset (name)
`INITIAL AUTO`	When starting the controller, the settings which were saved last or the first preset are loaded if no setups exist.
`INITIAL <Name>`	Loads a named measurement setting upon starting the controller. Presets cannot be indicated.

18.3.8 Measurement

18.3.8.1 Peak count

```
PEAKCOUNT <n>
```

Indicates the maximum number of peaks to be evaluated.

- For distance measurement <n> = 1
- For thickness measurement <n> = 2
- For multi-layer measurement <n> >2

18.3.8.2 Peak selection

```
MEASPEAK F_L|L_SL|F_S|H_SH
```

Selection of the peaks used for the measurement

Distance measurement		Thickness measurements	
F_L:	first peak	F_L:	first and last peak
L_SL:	last peak	L_SL:	second-last and last peak
F_S:	first peak	F_S:	first and second peak
H_SH:	highest peak	H_SH:	highest and second highest

18.3.8.3 Number of peaks and switching on/off refractive index correction

```
REFRACCORR on | off
```

- On: The refractive index correction is carried out with the set materials, standard setting.
- Off: The refractive index 1.0 is assumed for all layers.

18.3.8.4 Exposure mode

```
SHUTTERMODE MEAS|MANUAL|2TIMEALT|2TIMES
```

- MEAS: Automatic exposure time control with fixed measuring rate, recommended for measurement
- MANUAL: Selectable exposure time and measuring rate.
- 2TIMEALT: Mode with 2 manually set exposure times which are always applied alternately, for 2 peaks of very different height in the thickness measurement. We recommend using this mode in particular if the smaller peak disappears or the larger peak becomes saturated.
- 2TIMES: Fastest mode with two manually preset exposure times. The more suitable time is automatically selected. Recommended for distance measurements with rapidly changing surface properties, such as mirrored or anti-glare glass.

18.3.8.5 Exposure time

```
SHUTTER <exposure time1> [<exposure time2>]
```

Indication of exposure times for manual and two-time exposure modes.

The exposure time is processed with three decimal places. The minimum step size is 0.1 µs.

18.3.8.6 Mask the region of interest (ROI)

```
ROI <Start> <End>
```

Sets the "Region of interest" for the respective channel. Start and end must be between 0 and 511. The entry is made in the unit pixels. The start value must be less than the end value.

18.3.8.7 Minimum threshold peak detection

```
MIN_THRESHOLD <n>
```

Sets the minimum detection threshold. A peak must be above this threshold for it to be recognized as peak.

The entry is made in % and relates to the dark corrected signal.

18.3.8.8 Peak minimum threshold

`PEAK_THRESHOLD`

Sets the minimum peak threshold. A peak must be above this threshold for it to be recognized and isolated as a peak value. The entry must be made in %. The `PEAK_THRESHOLD` value must be less than `MIN_THRESHOLD`.

Value range: 0.0 ... 100.0.

18.3.8.9 Peak modulation

`PEAK_MODULATION <n>`

Specifies the peak modulation through so that peaks running into each other are separated. At 100%, there is no peak separation and at 0% (factory setting), all peaks are separated.

This way, the relevant peak artefacts can be removed or not be considered as individual peaks.

18.3.9 Measurement value processing

18.3.9.1 Reset statistical calculation

`STATISTIC ALL | <signal> RESET`

Resets the statistical data of the selected signal or of all signals (minimum, maximum, peak).

- `<signal>`: Resets the statistical data of the corresponding thickness signal
- `ALL`: Resets all statistical data

18.3.9.2 List of statistics signals

`META_STATISTIC`

Provides a list of the active statistics signals.

These signals were defined under `STATISTICSIGNAL`.

18.3.9.3 List of possible statistics signals to select

`META_STATISTICSIGNAL`

Lists all possible signals that can be included in the statistics.

Command is mapped in SDOs 0x3A10, 0x3A11 and 0x3A12.

18.3.9.4 Liste der möglichen Signale, Masterfunktion

`META_MASTERSIGNAL`

Listet alle möglichen Signale auf, die für das Mastern verwendet werden können.

18.3.9.5 Parameterization of master signals

`MASTERSIGNAL [<signal>]`

`MASTERSIGNAL <signal> <master value>`

`MASTERSIGNAL <signal> NONE`

Defines the signal to be mastered.

The parameter `NONE` resets the signal. The function itself is triggered with MASTER.

- `<signal>`: Selecting a specific measured or calculated signal on which the master value should be set.
- `<master value>`: master value in mm, value range: -21.47 ... 21.47

18.3.9.6 List of possible signals for mastering

`META_MASTER`

Lists all defined master signals from the `MASTERSIGNAL` command. These can be used with the command `MASTER`.

18.3.9.7 Mastering / zeroing

```
MASTER [<signal>]
MASTER [ALL|<signal> [SET|RESET]]
```

There are up to 10 master signals in the controller.

This command sets or resets the mastering for the corresponding signal.

- `ALL`: use all signals for mastering
- `<signal>`: use a specific measured or calculated signal for mastering
- `SET|RESET`: Start or end function

If the master value is 0, the mastering function has the same functionality as zeroing.

The master command waits a maximum of 2 seconds for the next measured value and uses this as the master value. If no measured value was recorded within this time, in case of external triggering, for example, the command returns with the error “E32 Timeout”.

The master value is processed with six decimal places.

18.3.9.8 Signal for mastering with external source

Select the measured or calculated signal that can be mastered with the multifunction inputs or with an external source. `META_MASTER` provides a list of all defined master signals. The signals are configured using `MASTERSIGNAL`.

```
MASTERSIGNALSELECT [ALL | NONE | <signal1> [ | <signal2> [...]]]
```

- ALL: All configured signals are mastered with the selected input source.
- NONE: no mastering.
- signal: signal is mastered with external source.

18.3.9.9 Mastering with external source

```
MASTERSOURCE [NONE|MFI1|MFI2]
```

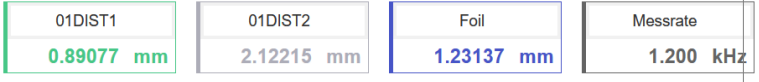
Select the input with which a mastering/zeroing is to be triggered.

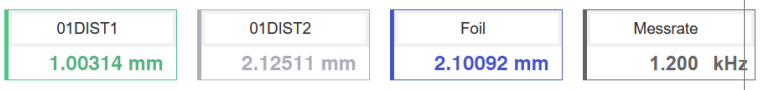
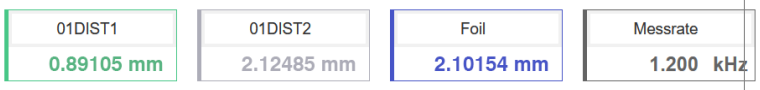
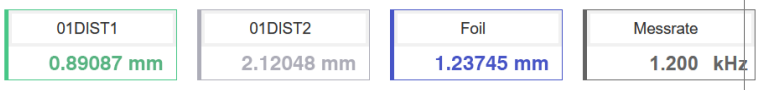
- NONE: No port selected. (Controlling by commands is possible.)
- MFI1: Use MFI1-port to control the mastering function.
- MFI2: Use MFI2-port to control the mastering function.

18.3.9.10 Mastering example

For the example, the preset `Standard matt Opposite thickness measurement` was selected in the controller, the commands are executed with the Telnet program, no variables are defined.

->o 169.254.168.150	

->META_MASTERSIGNAL META_MASTERSIGNAL 01DIST1 01DIST1 FOIL	// List all variables that can be mastered to
->META_MASTER META_MASTER NONE	// List all variables that have been assigned a master value
->MASTERSIGNAL 01DIST1 1.0 ->MASTERSIGNAL FOIL 2.1	// Set variable 01DIST1 to the value 1.0 // Set variable FOIL to the value 2.1
->META_MASTER META_MASTER 01DIST1 FOIL	// List all variables that have been assigned a master value; the variable 01DIST1 has now been assigned
->MASTER ALL MASTER 01DIST1 INACTIVE MASTER FOIL INACTIVE MASTER NONE ... MASTER NONE MASTER NONE	// List all 10 possible variables and show their status 

->MASTER ALL SET	// Triggers a master measurement for all assigned variables 
->MASTER 01DIST1 RESET	// the offset (master value) is undone for the variable 01DIST1 
->MASTER ALL MASTER 01DIST1 INACTIVE MASTER FOIL ACTIVE MASTER NONE ... MASTER NONE MASTER NONE	
->MASTER FOIL RESET	// the offset (master value) is reset for the FOIL variable 
->MASTERSIGNAL 01DIST1 NONE ->MASTERSIGNAL FOIL NONE	// The variable 01DIST1 is deleted // The variable FOIL is deleted
->MASTER ALL MASTER NONE ... MASTER NONE	// No variable on which a master measurement could be applied

18.3.9.11 Calculation in channel

```
COMP [<channel> [<id>]]
COMP <channel> <id> MEDIAN <signal> <median data count>
COMP <channel> <id> MOVING <signal> <moving data count>
COMP <channel> <id> RECURSIVE <signal> <recursive data count>
COMP <channel> <id> CALC <factor1> <signal> <factor2> <signal> <offset> <name>
COMP <channel> <id> THICKNESS <signal> <signal> <name>
COMP <channel> <id> COPY <signal> <name>
COMP <channel> <id> NONE
```

This command defines all channel-specific as well as controller-specific calculations.

<channel> CH01|CH02|SYS	*Channel selection*
<id> 1...10	*Calculation block number*
<signal>	*Measuring signal; you can query the available signals with the command META_COMP*
<median data count> 3|5|7|9	*Averaging depth Median*
<moving data count> 2|4|8|16|32|64| 128|256|512|1024| 2048|4096	*Averaging depth Moving average*
<recursive data count> 2 ... 32000	*Averaging depth Recursive average*
<factor1>, <factor2> -32768,0 … 32767,0	*Multiplication factor*
<offset> -2147.0 ... 2147.0	*Correction value in mm*
<name>	*Name of calculation block; length min. 2 characters, max. 15 characters. Permitted characters a-zA-Z0-9, the name must start with a letter.* *Command names such as STATISTIC, MASTER, CALC, NONE, ALL are not permitted.*

You can use the COMP command to create new calculation blocks, modify or delete calculation blocks.

Functions:

- MEDIAN, MOVING and RECURSIVE: averaging functions
- CALC: Calculation function according to the formula
  calculation function based on formula (<factor1> * <signal>) + (<factor2> * <signal>) + <offset>
- Thickness: Thickness calculation according to the formula <signal B>) - <signal A> under the condition that signal B is larger than signal A
- COPY: Duplicates a signal; this effect can also be achieved with the CALC command, e.g. with (1 * <signal>) + (0 * <signal>) + 0
- NONE: deletes a calculation block

18.3.9.12 List of possible calculation signals

`META_COMP`

Lists all possible signals that can be used in the calculation.

18.3.9.13 Two-point scaling data outputs

`SYSSIGNALRANGE <start of range> <end of range>`

Calculated values may exceed the range that the controller can display. The range of values is determined with this command.

Default is 0 to 10 mm.

18.3.10 Materials database

18.3.10.1 Materials table

`MATERIALTABLE`

Output of the materials table saved in the controller.

```
->MATERIALTABLE
                              Refraction index                Abbenumber
Pos,   Name,        nF at 486nm,     nd at 587nm,  nC at 656nm,      vd          Description
0      Vakuum,      1.000000,        1.000000,     1.000000,         0.000000    Vakuum; Luft(naeherungsweise)
1      Wasser,      1.337121,        1.333044,     1.331152,         0.000000
1      Ethannol,    1.361400,        1.361400,     1.361400,         0.000000
7      PC,          1.599439,        1.585470,     1.579864,         0.000000    Polycarbonat
8      Quarzglas,   1.463126,        1.458464,     1.456367,         0.000000    Siliziumdioxid, Fused Silica
9      BK7,         1.522380,        1.516800,     1.514320,         0.000000    Kronglas
->
```

18.3.10.2 Select material

`MATERIAL <Materialname>`

Change the material between distance 1 and 2 for the respective channel.

The material name must be entered, including spaces. The command supports case sensitive input, distinguishing between uppercase and lowercase letters. The maximum length of the material name is 30 characters.

18.3.10.3 Show material property

`MATERIALINFO`

Output of the material properties of the selected layer. Layer 1 is between distance 1 and 2, layer 2 is between distance 2 and 3 etc. If no parameters are specified, the data for layer 1 are output.

Example:

```
->MATERIALINFO
Name:                                   BK7
Description:                            Kronglas
Refraction index nF at 486nm:           1.522380
Refraction index nd at 587nm:           1.516800
Refraction index nC at 656nm:           1.514320
Abbe value vd:                          0.000000
->
```

18.3.10.4 Existing material in controller

`META_MATERIAL`

Lists the material names already saved in the controller.

18.3.10.5 Protected materials in controller

`META_MATERIAL_PROTECTED`

Displays a list of all material names saved in the controller during calibration. These materials cannot be edited or deleted.

18.3.10.6 Edit materials table

`MATERIALEDIT <Name> <Description> (NX <nF> <nd> <nC>)|(ABBE <nd> <vd>)`

Edits an existing material. A material is characterized either by three refractive indices or by one refractive index and Abbe number.

- Name: Name of the material
- Description: Brief description of the material
- nF: Refractivity index nF at 670 nm (1.000000 ... 4.000000)
- nd: Refractivity index nd at 587 nm (1.000000 ... 4.000000)
- nC: Refractivity index nC at 656 nm (1.000000 ... 4.000000)
- vd: Abbe value (10.000000 ... 100.000000)

If the material name has already been assigned, this material will be edited. Otherwise, a new material will be created.

There is a maximum of 20 materials.

18.3.10.7 Delete a material

`MATERIALDELETE <Name>`

Deletes a material.

- Name: Name of the material (length: max. 30 characters)

18.3.10.8 Add material

`MATERIALADD <Name> <Description> (NX <nF> <nd> <nC>)|(ABBE <nd> <vd>)`

Adds a material to the materials table. A material is characterized either by three refractive indices or by one refractive index and Abbe number.

- Name: Name of the material
- Description: Brief description of the material
- nF: Refractivity index nF at 670 nm (1.000000 ... 4.000000)
- nd: Refractivity index nd at 587 nm (1.000000 ... 4.000000)
- nC: Refractivity index nC at 656 nm (1.000000 ... 4.000000)
- vd: Abbe value (10.000000 ... 100.000000)

18.3.11 Data output

18.3.11.1 Digital output selection

`OUTPUT [NONE|([RS422 | ETHERNET] [ANALOG] [ERROROUT])]`

- NONE: No output of measurement values
- RS422: Output of measured values via RS422
- ETHERNET: Output of measured data via Ethernet
- ANALOG: Output of measured values via analog output
- ERROROUT: Error or status information via the error outputs

Command starts the output of measured values. The connection to the measurement server can already exist or can now be established.

18.3.11.2 Output data rate

```
OUTREDUCEDEVICE [NONE|([RS422] | [ANALOG]] | [ETHERNET])]
```

Reduction of output of measured values via specified interfaces.

- NONE: No reduction of output of measured values
- RS422: Reduction of output of measured values via RS422
- ANALOG: Reduction of output of measured values via analog interface
- ETHERNET: Reduction of measured value output via Ethernet

18.3.11.3 Reduction counter for output of measured values

```
OUTREDUCECOUNT <count>
```

Reduction counter for output of measured values.

Only each nth measured value is output. The other measurement values are discarded.

- Number: 1...3000000 (1 means all frames)

18.3.11.4 Error handling

```
OUTHOLD NONE|INFINITE|<count>
```

Sets the measured value output behavior in the event of an error.

- NONE: Last measured value not held; error value output
- INFINITE: Last measured value held indefinitely
- Number: Holds the last measured value via measurement cycle count and then outputs the error value (maximum 1024)

18.3.11.5 Measurements per frame

```
MEASCNT_ETH [0 | <count>]
```

Set the maximum frame number per packet for transmission of measurements via Ethernet.

0: Automatic assignment of the frame number per packet

`count`: Maximum number of frames per packet (0 ... 350)

18.3.12 Selection of the measurement values to be output

18.3.12.1 General

Setting the values to be output via the RS422 interface.

A limitation of the data volume via the RS422 depends on the measuring frequency and the baud rate.

In multi-layer measurement mode, any desired distances and differences can be selected for output.

18.3.12.2 Data selection for RS422

```
OUT_RS422 [<signal1>] [<signal2>] … [<signalN>]
```

Selection of data to be output via this interface.

18.3.12.3 List of possible signals for RS422

`META_OUT_RS422`

List of possible data for the RS422.

18.3.12.4 List of selected signals, sequence via RS422

`GETOUTINFO_RS422`

Returns the order of the signals via this interface.

18.3.12.5 Data selection for Ethernet

`OUT_ETH [<signal1>] [<signal2>] ... [<signalN>]`

Describes which data is output via this interface.

18.3.12.6 Liste der möglichen Signale für Ethernet

`META_OUT_ETH [MEAS | VIDEO | CALC]`

Liste der möglichen Ausgabedaten für Ethernet.

- `MEAS`: Messwerte
- `VIDEO`: FFT-Signal
- `CALC`: Rechenergebnisse

Eine zusätzliche Aktivierung über den Befehl `OUTPUT` ist notwendig.

18.3.12.7 Liste ausgewählter Signale, Reihenfolge über Ethernet

`GETOUTINFO_ETH`

Gibt eine Liste aller ausgewählten Signale sowie deren Reihenfolge über Ethernet wieder.

18.3.13 Switching Outputs

18.3.13.1 General

Commands are valid for the IFD2410 and 2415.

Controller	Switching output 1	Switching output 2
IFD2410	•	•
IFD2415	•	•

18.3.13.2 Error-Schaltausgänge

`ERROROUT1 [01ER1|01ER2|01ER12|ERRORLIMIT]`

`ERROROUT2 [01ER1|01ER2|01ER12|ERRORLIMIT]`

Einstellen der Fehler-Schaltausgänge.

- `01ER1`: Schaltausgang wird bei einem Intensitätsfehler geschaltet
- `01ER2`: Schaltausgang wird bei einem Messbereichsfehler geschaltet
- `01ER12`: Schaltausgang wird bei einem Intensitätsfehler oder einem Messbereichsfehler geschaltet
- `ERRORLIMIT`: Schaltausgang wird bei Messwert außerhalb der Grenzwerte geschaltet; Basis sind die Einstellungen für ERRORLIMITSIGNAL1/2, ERRORLIMITCOMPARETO1/2 und ERRORLIMITVALUES1/2

18.3.13.3 List of possible signals for error output

`META_ERRORLIMITSIGNAL1`

`META_ERRORLIMITSIGNAL2`

List of all signals that are possible for the `ERRORLIMITSIGNALn` command.

18.3.13.4 Setzen des auszuwertenden Signales

```
ERRORLIMITSIGNAL1 [<signal>]
ERRORLIMITSIGNAL2 [<signal>]
```

Anzeige oder Auswahl des Signals, das für den jeweiligen Schaltausgang verwendet werden soll.

18.3.13.5 Setzen der Grenzwertfunktion

```
ERRORLIMITCOMPARETO1 [LOWER | UPPER |BOTH]
ERRORLIMITCOMPARETO2 [LOWER | UPPER |BOTH]
```

Anzeige oder setzen der Vergleichsfunktion für den jeweiligen Schaltausgang.

- `LOWER`: Unterschreitung
- `UPPER`: Überschreitung
- `BOTH`: Unter- und/oder Überschreitung

18.3.13.6 Set value

```
ERRORLIMITVALUES1 [<lower limit [mm]> <upper limit [mm]>]
ERRORLIMITVALUES2 [<lower limit [mm]> <upper limit [mm]>]
```

Sets the values for Lower and Upper limit values.

- <lower limit [mm]> = -2147,0 ... 2147,0
- <upper limit [mm]> = -2147,0 ... 2147,0

18.3.13.7 Switching behavior of error outputs

```
ERRORLEVELOUT1 [PNP|NPN|PUSHPULL|PUSHPULLNEG]
ERRORLEVELOUT2 [PNP|NPN|PUSHPULL|PUSHPULLNEG]
```

Switching behavior of error outputs Error 1 and Error 2.

- PNP: Switching output is High in the case of an error and open without error
- NPN: Switching output is Low in the case of an error and open without error
- PUSHPULL: Switching output is High in the case of an error and Low without error
- PUSHPULLNEG: Switching output is Low in the case of an error and High without error

18.3.13.8 Switching hysteresis of error outputs

```
ERRORHYSTERESIS1 <hysteresis [mm]>
ERRORHYSTERESIS2 <hysteresis [mm]>
```

Sets the hysteresis for the switching outputs, see also function ERRORLIMIT.

- <hysteresis [mm]> = (0..2) * measurement range [mm]

18.3.14 Analog output

18.3.14.1 Data selection

```
ANALOGOUT signal
```

Selection of the signal to be output via the analog output. The signal is specified as a parameter. A list with the possible signals can be shown with META_ANALOGOUT, see Chap. 18.3.14.2.

18.3.14.2 List of possible signals for analog output

```
META_ANALOGOUT
```

Lists all signals that can be connected to the analog output.

18.3.14.3 Output range

```
ANALOGRANGE 0-5V | 0-10V | 4-20mA
```

- 0-5 V: The analog output provides a voltage of 0 to 5 volts.
- 0-10 V: The analog output provides a voltage of 0 to 10 volts.
- 4-20mA: The analog output puts out a current of 4 to 20 milliamperes.

18.3.14.4 Set scaling for DAC

```
ANALOGSCALEMODE STANDARD | TWOPOINT
```

Selects whether to use one-point or two-point scaling of the analog output.

- STANDARD --> One-point scaling
- TWOPOINT --> Two-point scaling

The standard scaling is designed for distances -MR/2 to MR/2 and for thickness measurement from 0 to 2 MR (MR = measuring range).

Minimum and maximum measured values must be specified in millimeters. The available output range of the analog output is then spread between the minimum and maximum measured values. The minimum and maximum measured values must be between -2147.0 and 2147.0.

The minimum and maximum measured values are processed with three decimal places.

18.3.14.5 Set scaling range

```
ANALOGSCALERANGE <limit 1> <limit 2>
```

Two-point scaling requires the start and end of the range to be entered in millimeters.

- <limit 1> = (-2147.0 ... 2147.0) [mm], and different from <limit 2>.
- <limit 2> = (-2147.0 ... 2147.0) [mm], and different from <limit 1>.

The values cannot be identical.

18.3.15 System Settings

18.3.15.1 Key lock

```
KEYLOCK NONE | ACTIVE | (AUTO [<value>])
```

Key lock configuration

- NONE: Key always functions; no keylock
- ACTIVE: Keylock is activated immediately after restart
- AUTO: Keylock is only activated <time> minutes after restart, value range 1 ... 60 min

18.3.15.2 Web interface language

```
LANGUAGE DE | EN | CN | KR | JP
```

18.3.15.3 Ethernet IP settings

```
IPCONFIG DHCP | (STATIC [<IPAddress> [<Netmask> [<Gateway>]]])
```

Setting of the Ethernet interface.

- `DHCP`: IP address and gateway are automatically queried via DHCP. If no DHCP server is available, a link-local address is searched for after approx. 2 minutes.
- `STATIC`: Sets an IP address, the net mask and the gateway in the format xxx.xxx.xxx.xxx

If the IP address, netmask and/or gateway are not specified, their values remain unchanged.

18.3.15.4 Protocol for Ethernet measured value transmission

```
MEASTRANSFER NONE
MEASTRANSFER SERVER/TCP [<port>]
```

`MEASTRANSFER CLIENT/TCP [<IP> [<port>]]`

`MEASTRANSFER CLIENT/UDP [<IP> [<port>]]`

Indicates or configures the Ethernet connection for exchanging measured values.

- NONE: No Ethernet connection
- SERVER/TCP: Controller includes a TCP/IP server
- CLIENT/TCP: Controller functions as a TCP/IP network client
- CLIENT/UDP: Controller functions as a UDP/IP client
- IP: IP address of network server
- Port: Communication port (1024 .. 65535), factory setting is 1024

18.4 Measurement value format

18.4.1 Measured value format, structure

The structure of measured value frames depends on the selection of the measured values or on the selection of a preset. In the following overview, you will find a summary of commands which you can use to query the available measured values.

OUT_RS422	OUT_ETH	Data selection for RS422, Ethernet
META_OUT_RS422	META_OUT_ETH	List of possible signals RS422, Ethernet
GETOUTINFO_RS422	GETOUTINFO_ETH	List of selected signals, sequence via RS422, Ethernet

Examples of the structure of a data block, query with Tera Term for RS422:

Preset `Standard matt`	Preset `One-sided thickness measurement`
->META_OUT_RS422 META_OUT_RS422 01RAW 01DARK 01LIGHT 01SHUTTER 01ENCODER1 01INTENSITY 01SYMM 01DIST1 MEASRATE TIMESTAMP TIMESTAMP_HIGH TIMESTAMP_LOW COUNTER 01DIST1_MIN 01DIST1_PEAK 01DIST1_MAX ->	->META_OUT_RS422 META_OUT_RS422 01RAW 01DARK 01LIGHT 01SHUTTER 01ENCODER1 01INTENSITY 01SYMM 01DIST1 01DIST2 MEASRATE TIMESTAMP TIMESTAMP_HIGH TIMESTAMP_LOW COUNTER Ch01Thick12 Ch01Thick12_MIN Ch01Thick12_PEAK Ch01Thick12_MAX ->
->GETOUTINFO_RS422 GETOUTINFO_RS422 01SHUTTER 01INTENSITY1 01DIST1 ->	->GETOUTINFO_RS422 GETOUTINFO_RS422 01SHUTTER 01INTENSITY1 01DIST1 01INTENSITY2 01DIST2 Ch01Thick12 ->

A measured value frame is built dynamically, i.e., values not selected are not transmitted.

18.5 Warning and error messages

E200	I/O operation failed
E202	Access denied
E204	Received unsupported character
E205	Unexpected quotation mark
E210	Unknown command
E212	Command not available in current context
E214	Entered command is too long to be processed
E230	Unknown parameter
E231	Empty parameters are not allowed
E232	Wrong parameter count
E233	Command has too many parameters
E234	Wrong or unknown parameter type

E236	Value is out of range or the format is invalid
E262	Active signal transfer, please stop before
E270	No signals selected
E272	Invalid combination of signal parameters, please check measure mode and signal selection
E276	Given signal is not selected for output
E277	One or more values were unavailable. Please check output signal selection
E281	Not enough memory available
E282	Unknown output signal
E283	Output signal is unavailable with the current configuration
E284	No configuration entry was found for the given signal
E285	Name is too long
E286	Names must begin with an alphabetic character, and be 2 to 15 characters long. Permitted characters are: a-zA-Z0-9_
E320	Wrong info-data of the update
E321	Update file is too large
E322	Error during data transmission of the update
E323	Timeout during the update
E324	File is not valid for this sensor
E325	Invalid file type
E327	Invalid checksum
E331	Validation of import file failed
E332	Error during import
E333	No overwrite during import allowed
E340	Too many output values for RS422 selected
E350	The new passwords are not identical
E351	No password given
E360	Name already exists or not allowed
E361	Name begins or ends with spaces or is empty
E362	Storage region is full
E363	Setting name not found
E364	Setting is invalid
E500	Materials table is empty
E502	Materials table is full
E504	Material name not found
E600	ROI begin must be less than ROI end
E602	Master value is out of range
E603	One or more values were out of range
E610	Encoder: minimum is greater than maximum
E611	Encoder‘s start value must be less than the maximum value
E615	Synchronization as slave and triggering at level or edge are not possible at the same time
E616	Software triggering is not active
E618	Sensor head not available
E621	The entry already exists
E622	The requested dataset/table does not exist.
E623	Not available in EtherCAT mode
E624	Not allowed when EtherCAT SYNC0 synchronization is active

W505	Refractivity correction deactivated, vacuum is used as material
W526	Output signal selection modified by the system
W528	The shutter time has been changed to match the measurement rate and the system requirements.
W530	The IP settings has been changed.

19 Tera Term

19.1 General

The Tera Term service allows communication between the IFC241x and the PC. To communicate with Tera Term, you will need

- a connection between the IFC241x and your PC,
  - Ethernet
  - RS422 communication
- the ASCII commands, see

19.2 Establishing the connection

- ► Start the `Tera Term.exe` program via Start > Run.
- ► Establish connection using `192.254.168.150` or the IP address of the controller.
- ► Define terminal setup, e.g., `Local echo` for commands.

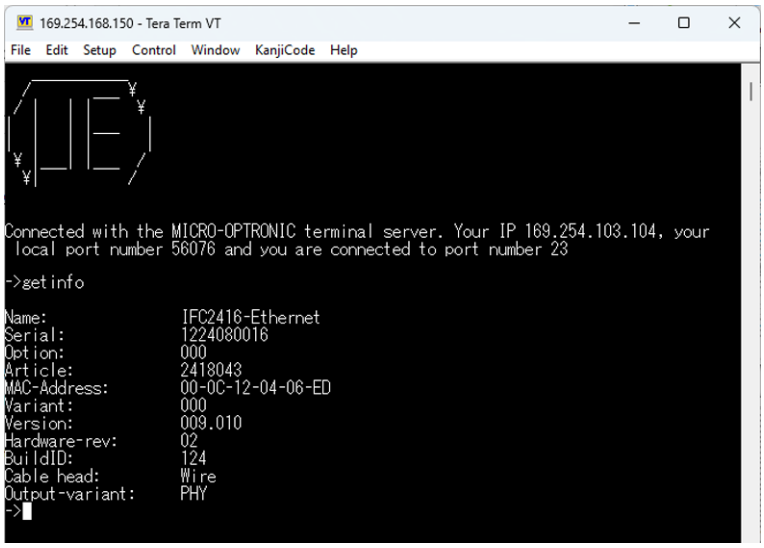


Fig. 19.1: Tera Term start screen of the IFC2416

A command always consists of the command name(s) plus several parameters separated by spaces. The currently set parameter value is returned when a command is called without any parameters.

The output format is:

The returned command can be used again without changes for setting the password. After a command is processed, a line break and a prompt (“->”) is always returned. In the event of an error, an error message beginning with Exx, where xx stands for a unique error number, comes before the prompt.

> i If no connection is confirmed after sending the IP address, send a `c` to close the connection. Now send the command o `192.254.168.150` again to establish the connection.

19.3 Help on a command

Tera Term can output information about a command. For this, enter the sequence “HELP <command name>”.

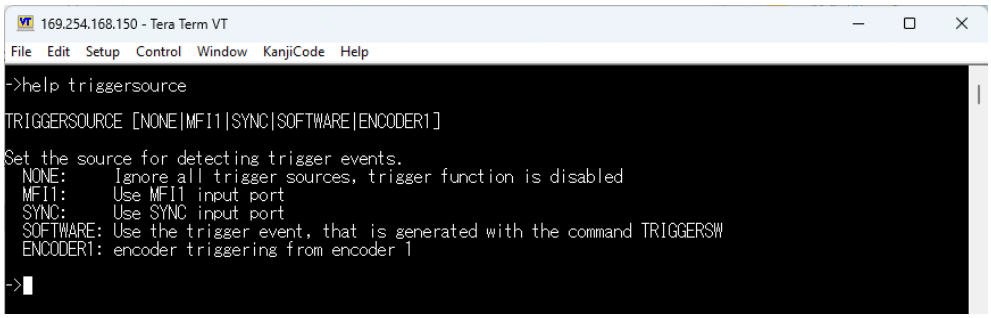


Fig. 19.2: Retrieving information about the TRIGGERSOURCE command

MICRO-EPSILON MESSTECHNIK GmbH & Co. KG
Koenigbacher Str. 15 94496 Ortenburg / Germany
Tel. +49 (0) 8542 / 168-0 Fax +49 (0) 8542 / 168-90
info@micro-epsilon.com https://www.micro-epsilon.com
Your local contact: www.micro-epsilon.com/contact/worldwide/

X9751458.05 A012046EKA