MICRO-EPSILON

Operating Instructions
colorSENSOR CFO

CFO100
CFO200
CFO250

Sensor system for testing opaque, transparent and self-luminous objects

Contents

Appendix

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 or the measuring system

The supply voltage must not exceed the specified limits.
> Risk of injury

> Damage to or destruction of the controller or the measuring system

NOTICE

Avoid shocks and impacts to the controller or the sensor or the measuring system. Damage to or destruction of the controller or the measuring system.

Never fold the sensor (optical fiber) and do not bend it in tight radii.
> Damage to or destruction of the sensor, partial failure of the measuring system

Protect the ends of the sensor against contamination (use protective caps).
> Failure of the test instrument

1.3   Notes on Product Marking

1.3.1   CE Marking

The following applies 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 applies 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. [3]

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 colorSENSOR CFO is designed for use in an industrial environment. It is used for
  - Relative color measurement or inspection
  - Intensity measurement
  - Completeness check (presence and absence)
  - Measurement of surface properties or texture
  - Material recognition/identification
  - Position determination
  - Product sorting
- The system must only be operated within the limits specified in the technical data, see 2.6.
- 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

- Protection class: IP65

- Temperature range
  - Operation: -10 ... +55 °C (+14 ... +131 °F)
  - Storage: -10 ... +85 °C (+14 ... +185 °F)
- Humidity: 20 ... 80 % RH (non-condensing)
- Ambient pressure: Atmospheric pressure

The controller can be used in a wide temperature range and is stable. When all sockets are in use or plugged with a protective cap, the sensor can be used safely even under contaminated environmental conditions.

2. Functional Principle, Technical Data

2.1 Short Description

The colorSENSOR CFO is an optical controller for precise color recognition for industrial measurement, built into a sturdy aluminum housing. The controller is distinguished by high color accuracy, state-of-the-art interfaces and intuitive operation. Sensors with optical fiber cables, which can be adapted for various measuring tasks, are connected to the controller. The rear of the controller allows fixation using the dovetail principle. A mounting adapter (DIN rail mounting kit) for DIN rail mounting is available separately, see A 1.

2.2 Measuring Principle

The measuring system for relative color measurement/inspection consists of an evaluation unit – the CFO controller – and a CFS sensor. The sensor is connected to the controller via an optical fiber.
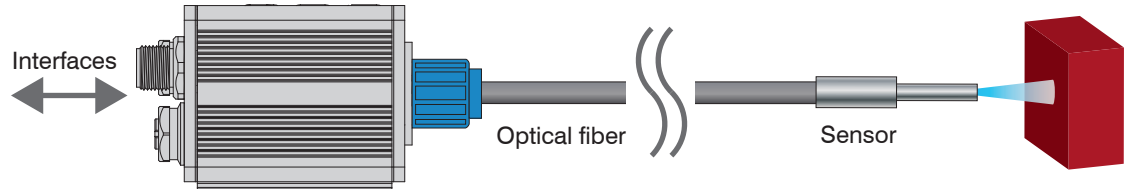
Fig. 1 Measuring principle

The specimen is illuminated with homogeneous, white light from an LED. A CFS sensor is used to project a point of illumination onto the surface to be inspected. The light is reflected diffusely at a specified angle and transmitted by the same sensor to a perceptive True Color receiver (XYZ) where it is analyzed.

The three wavelength ranges, i.e.

- X = long wave,
- Y = medium wave and
- Z = short wave light portions

from the specimen are used to determine the diffuse color reflections and thereby transformed into a selected color space. These color values are calculated according to the procedure described in DIN 5033.

The transformed values (colors), are stored in the controller and continuously compared to the current color. When the colors are all within the entered tolerance range, a recognition signal is sent to the digital switching outputs and the keypad indicators. This process allows storage of multiple colors in various color spaces. In the same manner, the color values and the recognized color are output as data protocol via the available interfaces as required.

2.3 Color Spaces

With the colorSENSOR CFO you can measure the following color spaces:

XYZ, xyY, L*a*b*, L*u*v*, L*u'v'

The colorSENSOR CF0250 can also measure in the L*C*h° color space.

i For more details on color spaces, please refer to https://www.micro-epsilon.com/download/products/dat--Basics-of-colorimetry--en.pdf.

2.4 Color Tolerance Models

Relative color measurement is often referred to as color inspection. The color of the measuring object and the reference sample is detected with the same sensor and the color distance (Delta E_{rel}) is evaluated based on the difference of the values.

i Note: The color distance between target and reference sample is determined with the same sensor (Delta E_{rel}).

The CFO controller works with a relative color measurement and thus with different tolerance models.

The permissible color distance for the color to be controlled is stored in a tolerance model. If the measured value is outside the tolerance, the CFO controller outputs the switching output for Color not recognized. If the measured value is within the tolerance, the corresponding output for the detected color is signaled.

For the XYZ, xyY, L*a*b*, L*u*v*, L*u'v' color spaces, the system can be set to the tolerance models `Sphere` (ΔE), `Cylinder` (ΔL; Δab), `Box` (cuboid, ΔL; Δa; Δb) and `Classify`. Only the tolerance model `Segment` is available in the L*C*h° color space. These models form a tolerance space around the learned colors.
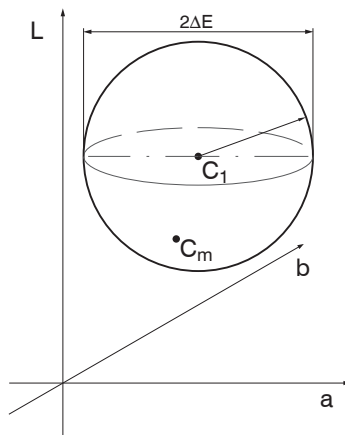
Fig. 2 Tolerance space `Sphere`   Fig. 3 Tolerance space `Cylinder`   Fig. 4 Tolerance space `Box`
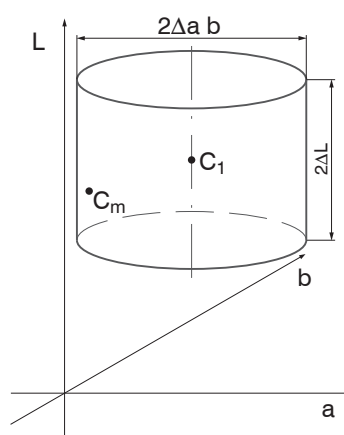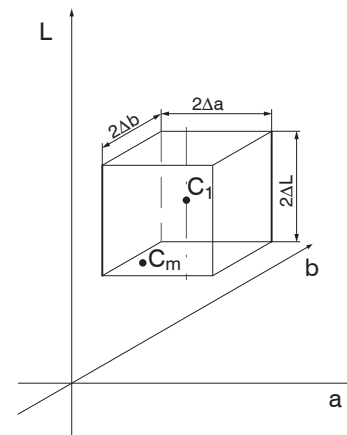
C_1 = learned color 1

C_m = detected color

For an evaluation of color deviations, the color tolerance parameters should be based on the perception thresholds for color differences. In the Lab color space, a tolerance threshold of $\Delta E > 1$ is frequently used for perceptible color differences.

Influencing factors for setting color tolerance parameters:

- Required accuracy for color recognition
- Tolerance for reading variations.

A change in the color readings for one and the same specimen can have two causes:

- Internal factors. Change in readings due to detector noise, changes in brightness of the light source or modulated ambient light.
- External factors. Deviations in color or surface texture of specimens or in measuring conditions (distance, angle).

Define the color distance tolerances so that the tolerance limits are greater than the change in the readings for acceptable specimens.

The `Sphere` tolerance space or rather ΔE denotes the color distance in a color space or how far apart the colors of the target and the reference object to be compared are in the spatial model. The larger the difference between the colors, the more clearly the difference can be perceived. For the tolerance model `Sphere` only one value can be set, ($\Delta E = root(\Delta L^2 + \Delta a^2 + \Delta b^2)$). With this tolerance model, it is not possible to determine in which color parameter the decisive change in color is present.

If you select the tolerance space `Cylinder`, tolerance values are set and evaluated separately for the brightness value L and the color values a/b.

ⁱ Tolerance space `Cylinder` is useful if higher distance variants are present during the measurement, since here the value for brightness L and the values for color a and b are assigned to separate tolerance parameters.

In the `Box` tolerance model, separate tolerance values can be set for the L, a and b color values. This enables more precise color inspections.

With `Classify` the current color readings are associated with the closest color value (shortest direct distance) saved in the color table. In this mode, classification is always accomplished regardless of the actual similarity between the selected colors.

For example, if red is the only color saved in the table, all color readings are associated with this color. In the diagram below, three colors are stored in the controller, C1...C3. Cm corresponds to the currently measured color. In the Classify mode, the controller now determines to which stored color the delta E (D1 ... D3) from Cm to C1 ... C3 is the smallest, see Fig. 6.

Since the distance D3 between Cm and C3 is the smallest, the detected color is assigned to the color output of color C3 and output by the controller.

Since the L*C*h° color space is a polar coordinate system, the tolerance space is also rotated into the space by the angle value h. Therefore, there is no longer a tolerance space `Box`, but the tolerance space `Segment`, which is limited by the angle value h in degrees (ΔH) and by the chromaticity C (ΔC) color saturation. By rotating the tolerance model `Box` in the L*C*h° color space, the recognition accuracy increases by 10 % compared to human color perception.
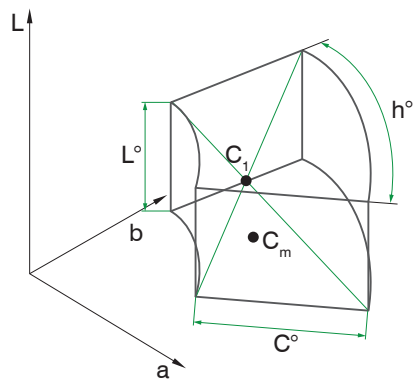
Fig. 5 Distance model (tolerance model) `Segment`
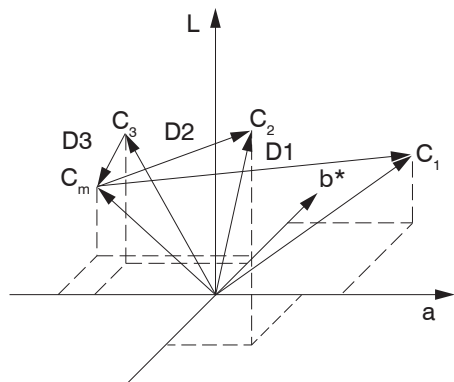
Fig. 6 Distance model (tolerance model) `Classify`

2.5   Functions

2.5.1   General

- Recognition of learned colors
- Control interfaces
  - Keys and displays
  - REST API, described in Interface Instructions, see A 3
  - RS232, described in Interface Instructions, see A 3
  - Trigger inputs
- Signaling/monitoring of recognition results via
  - Switching outputs
  - all interfaces mentioned above

2.5.2   Color Processing

- Compilation of colors to form recognition groups
- Variable color tolerance for each recognition group
- Selection of various color spaces
- Flexible averaging

2.6 Technical Data CFO100

Type	CFO100	CFO100(100)
Article number	10234670	10234670.100
No. of measurement channels	1	
Repeatability [1]	ΔE ≤ 0.5	
Color distance	ΔE ≤ 1.0	
Spectral range	400 ... 680 nm	
Color spaces	XYZ, xyY, L*a*b*, L*u*v*, u'v'L	
Illuminants	D65	
Standard observer	10°	
Tolerance model	Classification; sphere (ΔE); cylinder (ΔL, Δab); box (ΔL, Δa, Δb)	
Color memory	Max. 256 colors in non-volatile EEPROM with parameter sets	
Measuring rate	max. 10 kHz, standard 1 kHz (depending on number of colors learned and setting for averaging)	
Temperature stability	< 0.1 % FSO / K	
Light source	White light LED (425 ... 750 nm), AC operation (luminous flux at 1 kHz 130 lm) (adjustable or OFF for primary light source, switchable via software)	
Permissible ambient light	max. 5000 lx	
Synchronization	Possibility of synchronization is given	
Supply voltage	18 ... 28 VDC	
Max. current consumption	500 mA	
Signal input	1 (IN0), configurable via keypad or website (trigger, teach, delete, lock, calibration)	
Digital interface	RS232 (Standard 19200 Baud) [2], Ethernet	Ethernet, Modbus (TCP/RTU), PROFINET [3], EtherNet/IP [3], EtherCAT [3]
Switching output	OUT0-OUT2 Push-Pull / NPN / PNP (color recognition, binary coding 6 color groups)	

Type		CFO100	CFO100(100)
Connection	Optical	Screwable optical fiber via FA socket M18x1, length 0.3 m ... 2.4 m, min. bending radius 18 mm	
	Electrical	8-pin flange connector M12A (Power/PLC); 4-pin flange socket M12D (PC/Ethernet DHCP-capable) (connection cable see accessories)	
Assembly		DIN rail mounting/screw connection via adapter (see accessories)	
Temperature range	Storage	-10 ... +85 °C (+14 ... +185 °F)	
	Operation	-10 ... +55 °C (+14 ... +131 °F)	
Humidity		20 … 80 % r. H. (non-condensing)	
Shock (DIN EN 60068-2-27)		15 g / 6 ms in 3 axes, two directions and 1000 shocks each	
Vibration (DIN EN 60068-2-6)		2 g / 10 … 500 Hz in 3 axes, 10 cycles each	
Protection class (DIN EN 60529)		IP65 (when connected)	
Material		Aluminum, black anodized	
Weight		approx. 200 g	
Compatibility		with all CFS sensors [4]	
Control and indicator elements		Operation via keypad and web interface, visualization with 13 white LEDs	
Special features		Multi-color teach function, automatic adjustment of illumination brightness, measurement signal amplification and averaging depending on the measurement frequency, adjustable hold time of > 30 μs	

FSO = Full Scale Output
1) Maximum color distance ΔE of 1000 successive measurements of the color value of a red and a dark gray reference tile (R = 5 %), measured with sensor CFS4-A20 at 1000 Hz and brightness adjustment with a white standard (R = 95 %)
2) Adjustable up to max. 115200 kBaud
3) Optional connection via interface module
4) Also compatible with previous series (FAR, FAD, FAL, FAZ and FAS)

2.7 Technical Data CFO200

Type	CFO200	CFO200(100)
Article number	10234671	10234671.100
No. of measurement channels	1	
Repeatability [1]	ΔE ≤ 0.3	
Color distance	ΔE ≤ 0.6	
Spectral range	400 ... 680 nm	
Color spaces	XYZ, xyY, L*a*b*, L*u*v*, u'v'L	
Illuminants	D65	
Standard observer	10°	
Tolerance model	Classification; sphere (ΔE); cylinder (ΔL, Δab); box (ΔL, Δa, Δb)	
Color memory	Max. 320 colors in non-volatile EEPROM with parameter sets	
Measuring rate	max. 10 kHz, standard 1 kHz (depending on number of colors learned and setting for averaging)	
Temperature stability	< 0.1 % FSO / K	
Light Source	White light LED (425 ... 750 nm), AC operation (luminous flux at 1 kHz 220 lm) (adjustable or OFF for primary light source, switchable via software)	
Permissible ambient light	max. 5000 lx	
Synchronization	Possibility of synchronization is given	
Supply voltage	18 ... 28 VDC	
Max. current consumption	500 mA	
Signal input	4 (IN0-IN3) via keypad; IN0-IN3 or web page configurable (trigger, teach, clear, lock, adjust)	
Digital interface	RS232 (Standard 19200 Baud) [2], Ethernet, USB	Ethernet, Modbus (TCP/RTU), USB, PROFINET [3], EtherNet/IP [3], EtherCAT [3]
Switching output	OUT0-OUT2 Push-Pull / NPN / PNP (color recognition, binary coding 254 color groups)	

Type		CFO200	CFO200(100)
Connection	Optical	Screwable optical fiber via FA socket M18x1, length 0.3 m ... 2.4 m, min. bending radius 18 mm	
	Electrical	8-pin flange socket M12A (Power/PLC); 8-pin flange socket M12A (signal); 4-pin flange socket M12D (Ethernet DHC capable); 5-pin flange socket M12A (USB) (connection cable see accessories)	
Assembly		DIN rail mounting/screw connection via adapter (see accessories)	
Temperature range	Storage	-10 ... +85 °C (+14 ... +185 °F)	
	Operation	-10 ... +55 °C (+14 ... +131 °F)	
Humidity		20 … 80 % RH (non-condensing)	
Shock (DIN EN 60068-2-27)		15 g / 6 ms in 3 axes, two directions and 1000 shock each	
Vibration (DIN EN 60068-2-6)		2 g / 10 … 500 Hz in 3 axes, 10 cycles each	
Protection class (DIN EN 60529)		IP65 (when connected)	
Material		Aluminum, black anodized	
Weight		approx. 200 g	
Compatibility		with all CFS sensors [4]	
Control and Indicator Elements		Operation via keypad and web interface, visualization with 13 white LEDs	
Special features		Multi-color teach function, automatic adjustment of illumination brightness, measurement signal amplification and averaging depending on the measurement frequency, adjustable hold time of $> 30\,\mu s$	

FSO = Full Scale Output
1) Maximum color distance ΔE of 1000 successive measurements of the color value of a red and a dark gray reference tile (R = 5 %), measured with sensor CFS4-A20° at 1000 Hz and brightness adjustment with a white standard (R = 95 %)
2) Adjustable up to max. 115200 kBaud
3) Also compatible with interface modules
4) Also compatible with previous series (FAR, FAD, FAL, FAZ and FAS)

2.8   Technical Data CFO250

Type	CFO250
Article number	10235603
No. of measurement channels	1
Repeatability [1]	ΔE ≤ 0.3
Color distance	ΔE ≤ 0.6
Spectral range	400 ... 680 nm
Color spaces	XYZ, xyY, L*a*b*, L*u*v*, u'v'L*, L*C*h°
Illuminants	D65
Standard observer	10°
Classify model	Classify model; sphere (ΔE); cylinder (ΔL, Δab); box (ΔL, Δa, Δb); Segment tolerance (ΔL, ΔC, ΔH)
Color memory	Max. 320 colors in non-volatile EEPROM with parameter sets
Measuring rate	Standard 1 kHz; max. 30 kHz
Output of measurement values	Lab, XYZ max. 500 Hz via UDP and USB max. 380 Hz via RS232 max. 20 Hz via Rest API max. 5 Hz via Modbus
Temperature stability	< 0.1 % FSO / K [2]
Light source	White light LED (425 ... 750 nm), AC operation (adjustable or OFF for primary light source, switchable via software)
Permissible ambient light	max. 40.000 lx (depending the CFS sensor)
Synchronization	Possibility of synchronization is given
Supply voltage	18 ... 28 VDC
Max. current consumption	500 mA
Signal input	44 inputs (IN0 - IN3): IN0 via keypad; IN0 - IN3 configurable via web page (trigger, teach, clear, lock, adjust)
Digital interface	RS232 (Standard 9600 Baud), Ethernet, USB, Modbus (TCP/RTU) [3] [4]
Switching output	OUT0-OUT7 Push-Pull / NPN / PNP (max. 30 kHz, color recognition, binary coding 254 color groups)

Type		CFO250
Connection	Optical	Screwable optical fiber via FA socket M18x1, length 0.3 m ... 2.4 m, min. bending radius 18 mm
	Electrical	Power/PLC: 8-pin flange connector M12A; signal: 8-pin flange socket M12A; Ethernet: 4-pin flange socket M12D (DHCP-capable); USB: 5-pin flange socket M12A
Assembly		DIN rail mounting/screw connection via adapter
Temperature range	Storage	-10 ... +85 °C (+14 ... +185 °F)
	Operation	-10 ... +55 °C (+14 ... +131 °F)
Humidity		20 … 80 % RH (non-condensing)
Shock (DIN EN 60068-2-27)		15 g / 6 ms in in 3 axes, two directions and 1000 shock each
Vibration (DIN EN 60068-2-6)		2 g / 10 … 500 Hz in 3 axes, 10 cycles each
Protection class (DIN EN 60529)		IP65 (when connected)
Material		Aluminum, black anodized
Weight		approx. 200 g
Compatibility		With all CFS sensors [5]
Control and indicator elements		Operation via keypad and web interface, visualization with 13 white LEDs
Special features		Multi-color teach function, automatic adjustment of illumination brightness, measurement signal amplification and averaging depending on the measurement frequency, adjustable hold time of $> 30 \mu s$

1) Maximum color difference ΔE of 1000 consecutive measurements of the color value of a red and a dark gray (R= 5%) reference tile, measured with sensor CFS4-A20 at 1000 Hz and brightness adjustment to white standard (R= 95 %) 2) FSO = Full Scale Output 3) RS232 adjustable up to max. 115200 kBaud
4) Optional connection via PROFINET, Ethernet/IP or EtherCAT via interface module
5) Also compatible with previous series (FAR, FAD, FAL, FAZ and FAS)

2.9   Display Elements

The controller displays indicate the following information:

- Operating mode (ON / OFF)
- Current state of switching outputs
- Key lock
- Selected submenu

The following settings are visible depending on the submenu selected:

- LED intensity
- Output coding
- Tolerance
- Tolerance model
- Hold time
- Trigger
- Teach function (single or multiple)

3.   Delivery

3.1   Unpacking, Included in Delivery

1   colorSENSOR CFO controller

1   Assembly instruction

➡ Carefully remove the components of the test 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.

Optional accessories are listed in the appendix, see A 1.

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.com

3.2   Storage

Temperature range (storage): -10 ... +85 °C

Humidity: 5 ... 95 % RH (non-condensing)

4. Installation and Assembly

4.1 Installation and Mounting

i Ensure careful handling during installation and operation.

The colorSENSOR CFO can be placed on a level surface or fastened with the dovetail on the rear of the controller.

i Position the controller so that the connections, controls and displays are not concealed. We recommend maintaining a clearance of 2 - 3 cm at the cooling ribs on the left and right sides.

A mounting adapter is available separately for mounting with screws or with a mounting rail (TS35 top-hat rail) according to DIN EN 60715 (DIN rail), see A 1.

Fig. 7 colorSENSOR CFO100/CFO200/CFO250 dimensional drawing, dimensions in mm (inches, rounded off)
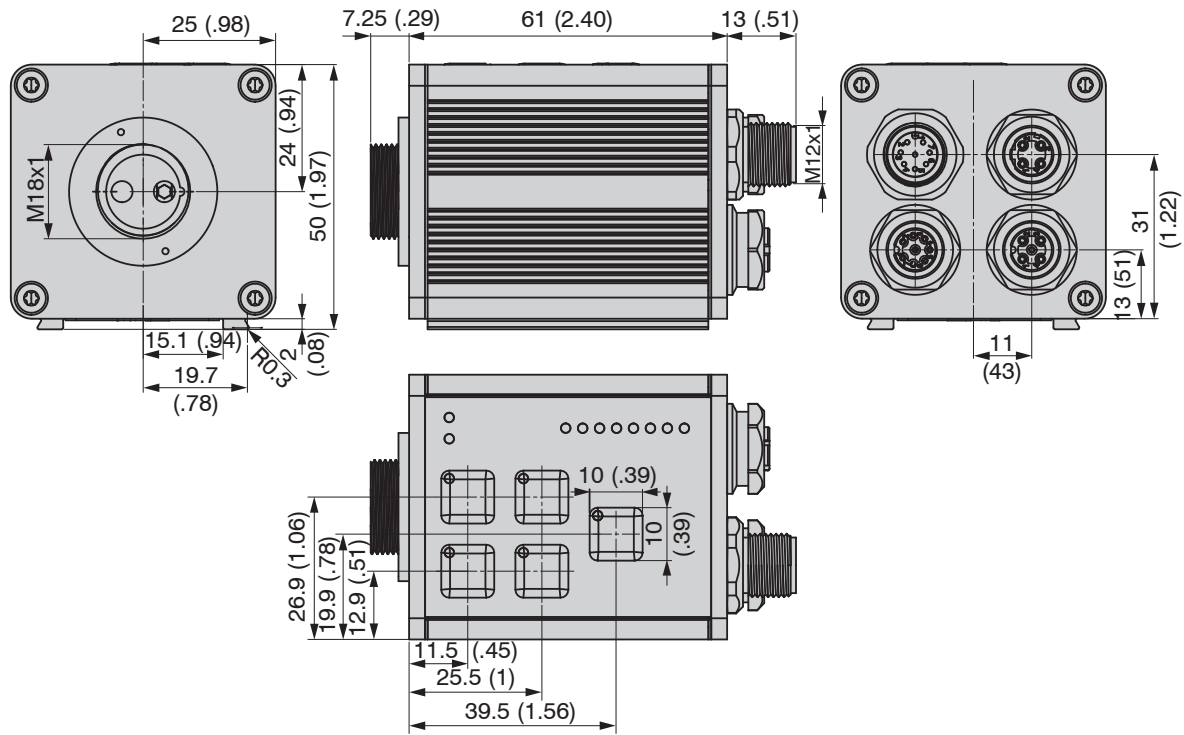
NOTICE

Do not allow the end surfaces of the sensor plug to hit against edges or surfaces. Reduced signal quality or measuring device.

4.2   Operating Elements

The operating concept, as well as the function of the membrane keypad, are described in the chapter Membrane Keys, see 5.2.

The following table provides an overview of the individual controls:

Key	Meaning	Location
TEACH AUTO	Teach / Automatic modulation	
INT ←	Illumination intensity Enter / Save	
CLR ←	Clear Arrow pointing left	
OPT →	Select options Arrow pointing right	
ESC TOL	Escape / quit without saving Color tolerances	

Fig. 8 Operating elements

4.3   Controller LEDs

On the front membrane of the controller there are eight LEDs for output indication in the lower right corner. The function keys are located on the top left of the front panel. Each key also has an LED embedded in the upper right corner for key indication. There are two status LEDs on the top right of the front panel.

The LEDs can assume the following states:

- Switched off
- Continuously illuminated
- Various flashing rhythms

LED	Color	Meaning	Location
⏻	Green	Supply voltage connected	
⚷	Red	Key lock active	
TEACH AUTO	White	Color teach menu	
INT ⏎	White	Menu for automatic illumination adjustment	
CLR ←	White	Clear memory menu	
OPT →	White	Option selection menu	
ESC TOL	White	Tolerance adaptation menu	

Fig. 9 Controller LEDs - keys

To the right of the eight output LEDs is an ascending numbering (1 ... 8), see Fig. 10. This assigns the eight output LEDs to the eight switching outputs or, for each output configuration, the respective LED is signaled to match the 8 outputs.

This means:

If OUT0 is switched, LED1 lights up. If OUT1 is switched, LED2 lights up, etc. LED8 lights up if OUT7 is switched.

Overview:

OUT0 corresponds to LED1	OUT4 corresponds to LED5
OUT1 corresponds to LED2	OUT5 corresponds to LED6
OUT2 corresponds to LED3	OUT6 corresponds to LED7
OUT3 corresponds to LED4	OUT7 corresponds to LED8

The options are located on the left of the eight output indicators, see Fig. 9, see Fig. 10.

Options	OUT	LEVEL	Color	Meaning
	Output configuration for color recognition	Level indicator for receiver intensity		
GATE	1	1	White	Triggered recognition
TEACH	2	2	White	Triggered teach
HOLD	3	3	White	Hold time
MULTI	4	4	White	Multiple teach
CLASSIFY	5	5	White	Classification
SPHERE	6	6	White	Sphere (ΔE)
CYLINDER	7	7	White	Cylinder (ΔL, Δab)
BOX	8	8	White	Box (ΔL, Δa, Δb)

Fig. 10 Controller LEDs

1) The colorSENSOR CFO100 has only three switching outputs which correspond to the LEDs 1 … 3.

4.4   Electrical Connections

The cable shields are connected to the connector housings. The connector housings are in contact with the controller housing.

⚠ CAUTION

Perform all electrical connections only in the switched-off state.
> Risk of injury from high voltage
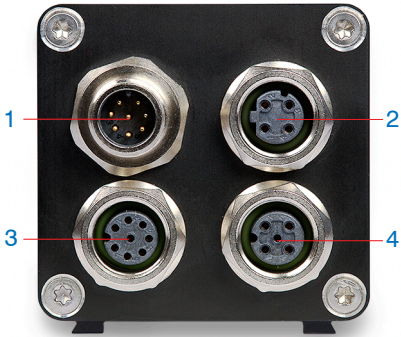
Fig. 11 Connector location on colorSENSOR CFO200

Fig. 12 Electrical connections on colorSENSOR CFO200

1 SYS = System (Power/PLC)	Power supply, switching outputs, switching input, RS232
2 ETH = Ethernet	Connection to PC
3 I/O = Digital I/O (PLC), CFO200 only	Switching inputs and outputs
4 USB, CFO200 only	USB process interface (RS232 log)

The widely used and standardized M12 sockets allow the use of commercially available cables suitable for the special requirements of the respective operating environment. For example, cables are available which are oil-resistant or suitable for use with drag chains.

The input and output signals from the controller as well as the power supply and communication connections are accessible using standardized M12 connectors (male and female). All connection cables with the features required for the application (e.g. drag chain compatibility or resistance to oil) and the matching coding can be used with the controllers.

To achieve IP65 class protection it is necessary to seal unused sockets with a protective cap (including gasket), and use a sensor with CFS or FA connector and corresponding gaskets.

4.4.1   System, Power and PLC (SYS)

For connecting the power supply, one digital input, the process RS232 interface and three digital outputs directly to a PLC.

- 8-pin plug
- 24 VDC $\pm$ 15 %, I_{max} < 500 mA
- not electrically separated, polarity reversal protection, GND is electrically connected to GND of switching outputs.

Pin	Color [1]	Function	Description
1	White	IN0	Trigger input
2	Brown	V_+	Supply voltage (10 ... 28 VDC)
3	Green	TX	Terminal (RS 232 transmit)
4	Yellow	RX	Terminal (RS 232 receive)
5	Gray	OUT0	Switching output (NPN/PNP/PP)
6	Pink	OUT1	Switching output (NPN/PNP/PP)
7	Blue	GND	Ground connection
8	Red	OUT2	Switching output (NPN/PNP/PP)
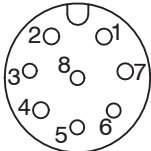
View of controller flange connector

Pin sequence, 8-pin cable socket, view from solder side
1) Conductor color CAB-M12-8P-Bu-ge

Fig. 13 SYS Power / PLC connector

The three switching outputs are switchable push-pull outputs. The switching output logic level depends on the supply voltage V_+ connected.

Use: Direct for 3 individual colors or binary for 6 color groups

The switching state `zero` is not used to ensure reliable test performance in the face of a discontinuity.

The switching state `all switched` is recommended as the standard error output.
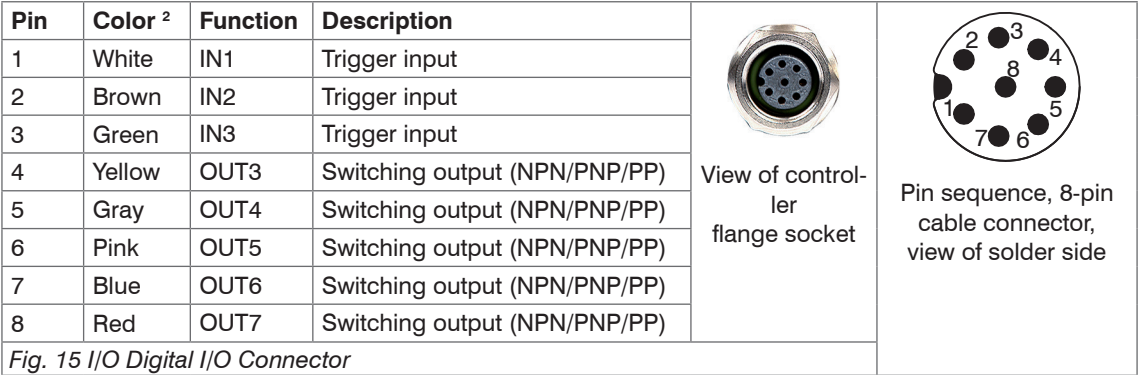
➡️ Use a shielded cable with a length of < 30 m.
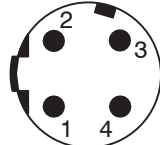
ℹ️ Micro-Epsilon recommends the optionally available CAB-M12-8P-Bu-ge cable, see A 1.

4.4.2 Ethernet (ETH)

For establishing data transfer to an RJ45 Ethernet socket on a PC, for displaying the web interface or to a PLC for transmitting measured values via REST API, described in the Interface Instructions, see A 3.
- 4-pin socket
- with Ethernet network (PC)

➡️ Connect the controller to the network using a shielded Ethernet cable (Cat5E) with a length of < 100 m. Micro-Epsilon recommends the optionally available cable CAB-M12-4P-St-ge ... RJ45-Eth with the PS2020 power supply unit, see A 1.

Pin	Color [1]	Function	Description [2]		
1	Orange/white	TX+	Ethernet		
2	Blue/white	RX+	Ethernet	View of controller flange socket	Pin sequence, 4-pin cable connector, view of solder side
3	Orange	TX-	Ethernet		
4	Blue	RX-	Ethernet		
Fig. 14 ETH Ethernet socket					

The controller can be configured using the HTTP-API commands, see A 3.

1) Conductor color CAB-M12-4P-St-ge ... RJ45-Eth   2) Specification according to 100BASE-TX

4.4.3 Digital I/O (I/O)

The five push-pull switching outputs on the 8-pin connector I/O 1 are electrically connected to the power supply. The switching output logic level depends on the supply voltage V_+ connected.

Use:

- Direct for a total of 8 individual colors or binary for 254 color groups.

The switching state `zero` is not used to ensure reliable test performance in the face of a discontinuity.

The switching state `all switched` is recommended as the standard error output.

The cable shield is connected to the housing.

➡ Connect the cable shield to the evaluation unit.

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

➡ Use a shielded cable with a length < 30 m.

Micro-Epsilon recommends the optionally available CAB-M12-8P-St-ge cable, see A 1.

Pin	Color [2]	Function	Description		
1	White	IN1	Trigger input	View of controller flange socket	Pin sequence, 8-pin cable connector, view of solder side
2	Brown	IN2	Trigger input		
3	Green	IN3	Trigger input		
4	Yellow	OUT3	Switching output (NPN/PNP/PP)		
5	Gray	OUT4	Switching output (NPN/PNP/PP)		
6	Pink	OUT5	Switching output (NPN/PNP/PP)		
7	Blue	OUT6	Switching output (NPN/PNP/PP)		
8	Red	OUT7	Switching output (NPN/PNP/PP)		

Fig. 15 I/O Digital I/O Connector

The color outputs can be programmed using the keypad.

1) Applies only for colorSENSOR CFO200/CFO250.
2) Conductor color CAB-M12-8P-St-ge

4.4.4 USB

Via the USB interface, the same protocol is output as via the RS232 interface, described in the Interface Instructions, see A 3. Just like the RS232 interface, it acts as process interface. This means that no special software is provided for parameter setting via a PC using a USB interface.
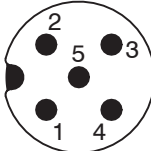
The cable shield is connected to the housing.

➡ Connect the cable shield to the evaluation unit.

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

Use a shielded cable with a length of max. 5 m.

Micro-Epsilon recommends the optionally available CAB-M12-5P-St-ge cable, see A 1

Pin	Color	Function	Description		
1	Brown	USB-VDD	USB (host or client)		
2	White	USB Data-	USB (host or client)	View of controller flange socket	Pin sequence, 5-pin cable connector, view of solder side
3	Black	USB Data+	USB (host or client)		
4	Blue	NC (USB-ID)	USB (host or client)		
5	Green/yellow	USB-GND	USB (host or client)		

Fig. 16 USB connector

1) Applies only for colorSENSOR CFO200/CFO250

4.4.5 Switching Input Circuit

The switching input IN can be connected to the supply voltage potential V_+ as follows.
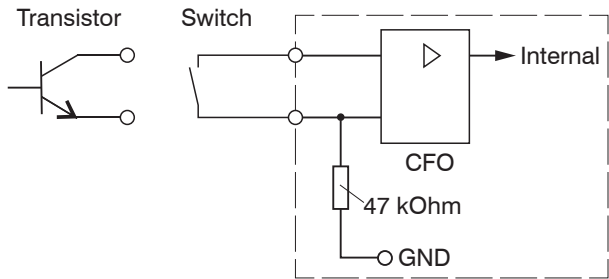
Fig. 17 Switching input circuit (schematic)

Model CFO100 and CFO200/CFO250				
Pin	Color CAB-M12-8P-Bu-ge	Function	Description	Comment
1	White	IN0	Switchable via keypad trigger input : measurement trigger or learn color; Configurable via web page: measurement trigger, learn color, learn color as new group, add color to current group, learn and group colors continuously, clear color table, automatic modulation of controller sensitivity, white balance, key lock.	Not electrically separated, comparator input with threshold at $V_+/2 \pm 5\,\%$, low level $< V_+/2 \pm 5\,\%$, high level $> V_+/2 \pm 5\,\%$ (max. 30 V), internal pull-down resistor, open input is recognized as low.

Model CFO200/250				
Pin	**Color** **CAB-M12-8P-St-ge**	**Function**	**Description**	**Comment**
1	White	IN1	Configurable trigger input, reading trigger, teach color, teach color as new group, add color to current group, continuously teach and group colors, delete color table, automatic controller sensitivity adjustment, white balance, key lock	Not electrically separated, comparator input with threshold at $V_+/2 \pm 5$ %, low level $< V_+/2 \pm 5$ %, high level $> V_+/2 \pm 5$ % (max. 30 V), internal pull-down resistor, open input is recognized as low.
2	Brown	IN2		
3	Green	IN3		

Switching input not electrically separated, open input recognized as low.	
Comparator input with threshold at $V_+/2 \pm 5$ %	
Low Level	$< V_+/2 \pm 5$ %
High Level	$> V_+/2 \pm 5$ % (max. 30 V)

i   Switching levels always refer to V_+ (10 V - 28 V) for all inputs.

4.4.6   Output Configuration

The switching outputs are connected as follows:
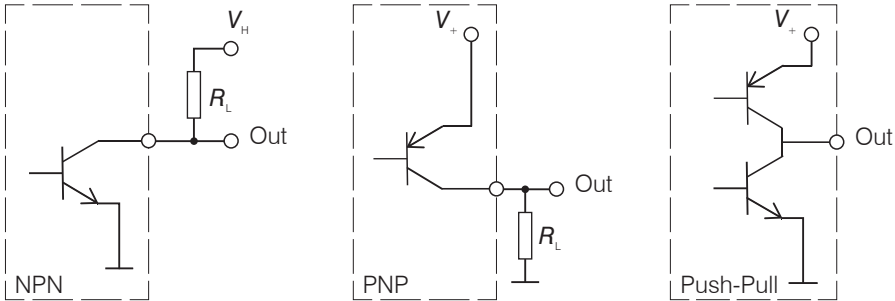
Fig. 18 Output configuration (schematic)

The switching behavior (NPN, PNP, Push-Pull) is programmable, see 5.6.7.

The NPN output is, for example, suitable for adaptation to a local TTL logic circuit with auxiliary voltage of V_H = 5 V.

The switching outputs are protected against polarity reversal, overload (< 100 mA), excessive temperature and have an integrated self-induction recuperation diode for inductive loads.

Not electrically separated, 24 V logic (HTL), low level GND,
high level V_+ (max. 28 V)

Model CFO100 and CFO200/CFO250				
Pin	Color CAB-M12-8P-Bu-ge	Function	Description	Comment
5	Gray	OUT0	Switching output, switchable NPN, PNP, PP, outputs correspondingly programmed, detected color or color group directly or in binary code.	Not electrically separated, 24V logic (HTL), low level = GND, high level = V_+, I_{max} = 100 mA
6	Pink	OUT1		
8	Red	OUT2		

Model CFO200/CFO250				
Pin	Color CAB-M12-8P-Bu-ge	Function	Description	Comment
4	Yellow	OUT3	Switching output switchable, NPN, PNP, PP, outputs correspondingly programmed, detected color or color group directly or in binary code.	Not electrically separated, 24V logic (HTL), low level = GND, high level = V_+, I_{max} = 100 mA
5	Gray	OUT4		
6	Pink	OUT5		
7	Blue	OUT6		
8	Red	OUT7		

i Switching levels always refer to V_+ (10 V - 28 V) for all outputs.

	High Level		Low Level	
Output voltage	V_+		GND	
Saturation voltage	I_{out} = 10 mA	V_+ -0.3 V	I_{out} = 10 mA	GND +0.2 V
	I_{out} = 100 mA	V_+ > -1.5 V	I_{out} = 10 mA	GND < +1.5 V

4.5   CFS Sensor

➡ Insert the plug of the sensor (optical fiber) so that the coding of the plug matches the groove of the socket on the controller. Now screw the plug tight.

ⓘ The coding on the sensor connector (CFS or FA) is on the side of the illumination LED.

Fig. 19 Sensor connection on the controller   Fig. 20 Mounting of sensor (optical fiber)

NOTICE

Keep the end surfaces of the sensor free of dust, avoid any damage or soiling, e.g. by touching. This also applies to the plug connectors at the controller.

> Error-free recognition of colors no longer guaranteed

> Erroneous measurements

> Damage to sensor

ⓘ For this reason clean soiled end surfaces with pure alcohol and a clean, lint-free microfiber cloth.

i Please observe the permissible minimum bending radius of the integrated optical fiber.
Failure to observe the minimum bending radius (depending on the sensor model) leads to breakage of the integrated optical fiber.

As the sensor (optical fiber) consists of a glass fiber bundle with several individual fibers, a break in the illumination fibers causes a drop in the illumination intensity, and a reduced measurement signal of the signal fibers. Fiber breakage leads to a loss in the measuring sensitivity up to complete loss of the measuring signal.

i Replace the sensor only with the light source switched off to prevent dazzle.

5. Operation

5.1 Initial Operation

▶ Mount the controller as per the assembly instructions, see 4.1, see 4.5.

▶ Connect the controller to the sensor (optical fiber), see 4.5.

Fig. 21 Overall view of CFO controller with CFS sensor

▶ Connect the controller to a power supply, see 4.4.1.

▶ Switch on the power supply.

After switching on the controller, the green LED flashes and the red LED illuminates continuously as long as the controller is booting, see Fig. 22.

Fig. 22 Green LED flashing, red LED illuminated continuously

The controller is in the operating mode when only the green Power LED is illuminated, see Fig. 23.

Fig. 23 Green LED illuminated continuously (operating mode reached)

Then, depending on whether the key lock is active and colors are detected, the corresponding LEDs illuminate or the set output configuration for color is not detected.

In the delivery state, all outputs are set to `high` when no color is detected.

This basic setting can be changed via the REST API, described in the Interface Instructions, see A 3, or web interface, see 5.5.

i   During the boot process, which takes > 90 seconds, the controller is not yet operable. However, the internal color evaluation is already active after a few ms.
This means that after a brief voltage loss/power failure, the controller reboots independently and can reliably detect and evaluate the colors again within ms, and signal them accordingly at the switching output.

5.2 Configuration of the CFO Controller

The colorSENSOR CFO can be configured using the network interface, the web interface, the serial interface and the keypad integrated into the housing. Due to the controller's range of functions, only the most important settings are possible via the keypad. So for special applications, it may be necessary to use the web interface, see 5.5, network interface or serial interface for initial setup.

5.3 Membrane Keys

The keypad has a number of keys and LEDs.
The most important settings and controller operations can be activated via the keys:
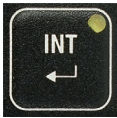
- Adjusting illumination intensity `(INT)`
- Teaching colors (incl. tolerance) `(TEACH` or `TOL)`
- Clear color groups / color table `(CLR)`
- Setting the controller behavior `(OPT)`
  - Triggered teach
  - Triggered evaluation
  - Hold time
  - Single/multiple teaching operations `(Multi teach)`
  - Changing tolerance model
- Adapting standard tolerance `(TOL)`

i The keys can be locked and unlocked with the key combination `ESC – ENTER – ESC`.

5.3.1 Key Functions

The keypad comprises the following keys:

TEACH AUTO	Teach
	Automatic modulation
INT	Intensity setting
	Enter / save
OPT	Select options
	Arrow pointing right
ESC TOL	Escape / Quit without saving
	Adapt standard tolerance
CLR	Delete
	Arrow pointing left

The key label indicates the operating function when the key is depressed for a longer period (e.g. a menu). The label below the key indicates the short key actuation available within a menu.

The key assignment changes to the longer actuation function after 2 seconds. From this time on the LED in the key illuminates continuously. The short actuation function is accomplished each time the key is pressed shortly. The function becomes effective when the key is released.

5.3.2   Operation Using Membrane Keypad

Various keypad actions are shown below. LED states:

- Continuously illuminated or off.
- Flashing with various rhythms.

For operation, a keypad is depicted at the left showing the current status of all indicators as well as any key actuations. Key actuations are differentiated between

- short (pressing for less than two seconds) and
- long (holding down for two seconds or longer).

All descriptions start in the operating mode. If no learned color is currently recognized, the following representation typically applies.

The sensor is in the operating mode.

In the delivery state all outputs are set to `high` when no color is detected. For this reason the first three switching output LEDs light up with the CFO100; with the CFO200 all switching output LEDs light up.

The following instructions do not describe any specific procedure; they are simply a compilation of typical key actuations in the operating mode, see Fig. 24 and in the menu mode, see Fig. 25. Detailed descriptions of all actions, see 5.2 or, see 5.3.2
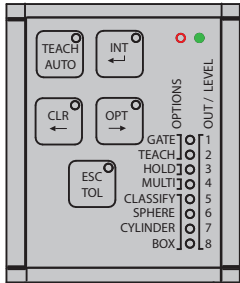
Fig. 24 Screen shot, operating mode

Fig. 25 Screen shot, menu mode

Before	After	Action
Operating mode	Menu mode	▣ Press (hold) for more than 2 sec. one of the keys to enter different menus from the operating mode.
		After 2 seconds, the key LED will start flashing to indicate that it has been pressed long enough.
Menu mode	Submenu	Except for the ESC/TOL key, all keys lead to a separate menu, whose content is defined by the key label. Pressing the TOL key in the TEACH menu calls the submenu for Tolerance adaptation.
Switch within menu	Switch within menu	▣ (Press) one of the ←/→ keys (CLR/OPT) for less than 2 sec to switch between colors, options, etc. within a menu.
Menu mode	Start action	▣ Press the TEACH/AUTO key for less than 2 sec. to trigger an event.

Before	After	Action
Menu mode ➡	Save all changes / return to operating mode	➡ Press (hold) the ENTER key for more than 2 sec. (INT) to save all changes made and return to the operating mode.
Menu mode ➡	Discard all changes / return to operating mode	➡ Press (hold) the ESC key (TOL) for more than 2 sec. to throw out all changes and return to the operating mode without saving.

5.3.3   Intensity

System adjustment is required after installing the measuring system and, typically, following any change in the optical conditions, such as:
- Distances
- Alignment
- Lenses
- Sensor replacement

➡ Match the intensity settings of the system to the brightest object expected.

i Each time the optical conditions are adjusted, the intensity settings of the system should be readjusted to the brightest object to be expected.

In addition to the illumination intensity, the sensitivity of the photo receiver is also indirectly adjusted during this process.
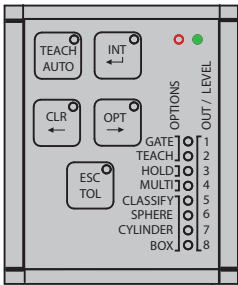
➡ Starting in the operating mode, first select the intensity menu by pressing (holding) the INT key for more than 2 sec.

The intensity menu is then active.
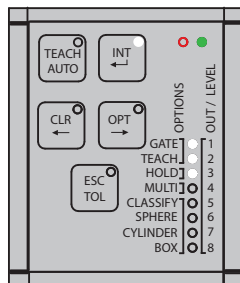
The number of illuminated output LEDs indicates the relative intensity currently being received by the controller.

i All output LEDs 1 - 8 flash on and off simultaneously to indicate overmodu-
   lation of the photo receiver.

5.3.3.1   Automatic Modulation

The automatic modulation determines a suitable combination of internal controller parameters for the current optical situation. Here, the modulation of the receiver is adjusted so that it detects enough light, but not too much. (standard setting 80 %)

The controller internally sets the best combination of measurement averaging, LED intensity and amplifying factors depending on the selected measurement frequency.
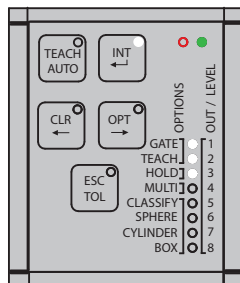
➡ Press the AUTO key for less than 2 sec.

This starts an automatic modulation

i The modulation of the controller parameters should be set for the brightest
   color to be tested.

The controller should have reached operating temperature. Depending on the ambient conditions, this is the case after approx. 45 min. warm-up time.
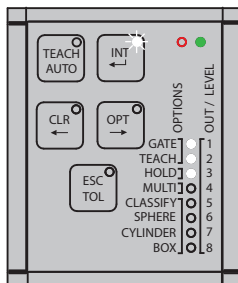
The automatic modulation process requires several seconds. Meanwhile, the output LEDs 1 - 8 flash alternately, i.e. the even LEDs and the odd LEDs alternately flash together between on and off.

i The automatic modulation sets the photo receiver to 80 % saturation.
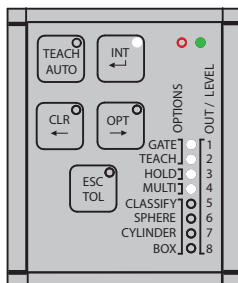
After the completion of the automatic modulation, the INT LED is permanently lit. The output indicators visualize the achieved level of modulation.

5.3.3.2   Manual Intensity Control

Typically, the automatic modulation determines a suitable combination of LED intensity, amplification, measurement averaging and other internal parameters, depending on the measurement frequency. If a higher modulation is desired, perform the following steps in the intensity menu.
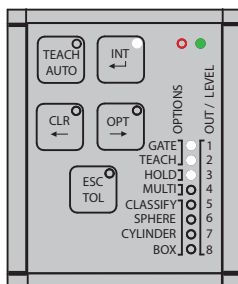
Press the ⟶ key for less than 2 sec.

If a lower modulation is desired, press the ⟵ key for less than 2 sec.

i   The photo receiver modulation can be increased or decreased by 10% by pressing the corresponding arrow key.
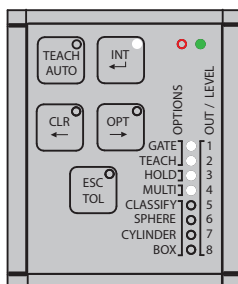
After the new modulation is completed, the level of control achieved can be seen from the output LEDs.
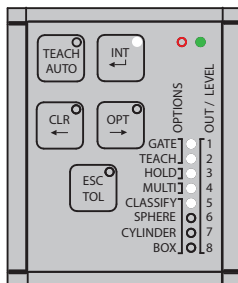
Save:

➡️ Press the `Enter` key for longer than 2 sec.

The results of the modulation are saved. The display returns to the operating mode.

To quit:

➡️ Press the `ESC` key for longer than 2 sec.

The results of the modulation are ignored. The display returns to the operating mode without saving the settings.

5.3.4   Color Management

After having installed and adjusted the color measuring system, see 5.3.3, you can now teach colors or color groups for the recognition task.
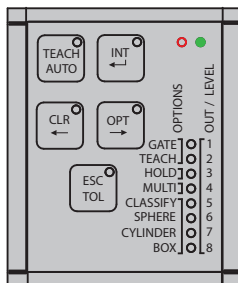
➡️ Press the `TEACH` key for longer than 2 sec.

You are now in the `TEACH` (color teach) menu.
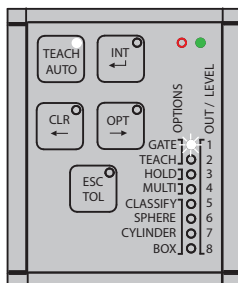
The switching outputs of the selected recognition groups flash rhythmically. The flashing rate indicates the status of the current recognition group.

- Medium-fast flashing indicated that the current recognition group contains no colors (1-pulse period 100/900 ms).

- Fast flashing indicates that the recognition group comprises at least one color. However, the latter is not being recognized (2-pulse periods (50/50/50/850 ms).

- Slow flashing indicates that one color of the recognition group is being recognized (nearly continuous illumination 900/100 ms).

All color groups or switching outputs to the color groups can be selected individually by pressing the arrow key ⟶ or ⟵ .

5.3.4.1   Teaching Colors

The CFO200 controller has 8 switching outputs (OUT0 ... OUT7) which can be used to output the colors recognized as correct. The CFO100 controller has 3 switching outputs (OUT0 ... OUT2).

For each output configuration, 8 color groups (3 color groups for CFO100) can be stored directly (1-out-N) (group 1 to OUT0 ... group 8 to OUT7). If the output configuration is binary, then 6 color groups with a total of 256 colors can be stored with the CFO100, and 254 color groups with a total of 320 colors can be stored with the CFO200.

Each color group can contain any number of individual colors. All colors detected within a group are signaled with the same output configuration. The advantage of this multi-teach function is that changes in the distance or angle of the test specimens can be stored as a separate color in the same color group, thus increasing process reliability.

The 1-out-of-N codes are easily accessible via the keyboard (only one of the output lines is active). The subsequent binary encodings can be switched through individually, but due to the large number of possible combinations (up to 254 for the CFO200) this may be more convenient via the web interface, additional software or the REST API described in the Interface Instructions, see A 3.
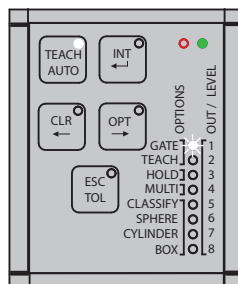
➡️ Press the TEACH key for less than 2 sec.

The new color is then saved.

Slow flashing indicates that this color is naturally detected at this moment, as long as the current target object has not moved.

➡️ Press the ⟶ key for less than 2 sec. to switch to the next recognition group.
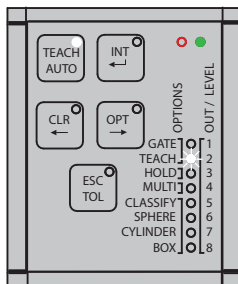
The new selected recognition group is indicated by medium-fast flashing.

➡ Press the TEACH key for less than 2 sec. to teach a color to the next recognition group.

Color tolerance adaptation, see 5.3.6.

i If the multi-teach function is activated, see 5.3.7.3, you can continue teaching colors as long as the TEACH key is held down. The first color is learned after a long actuation time, any further color is learned every second (1 Hz). The key LED flashes briefly (100 ms) for each color learned.

5.3.4.2 Deleting Individual Color Groups
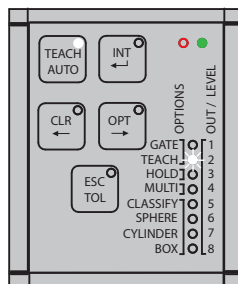
The selected recognition group is indicated by the LED flashing.

➡️ Press the arrow keys ← or → for less than 2 sec to select the recognition group to be deleted.

➡️ Press the `CLR` key for longer than 2 sec. to delete the colors in the current recognition group.

Delete complete color table, see 5.3.5.

5.3.4.3 Saving or Quitting upon Completion of Teaching Process
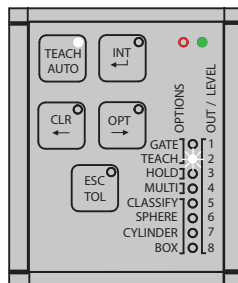
Save:

➡️ Press the `ENTER` key for longer than 2 sec. to save all changes to the color table and return to the operating mode.

The detected color or the output configuration for `No color recognized` (all outputs on) is displayed depending on whether or not the last color learned is still beneath the sensor.

Quit:

➡️ Press the `ESC` key for longer than 2 sec to discard all changes to the color table and return to the operating mode without saving.

5.3.5 Deleting Color Table

When switching to a new recognition task, it is recommended to delete the color table completely.
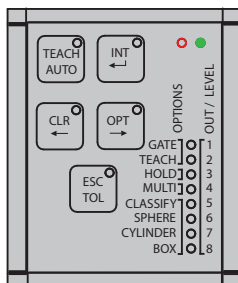
➡️ Press the `CLR` key for longer than 2 sec. to delete the color table completely. Output LEDs 1 - 8 are flashing.
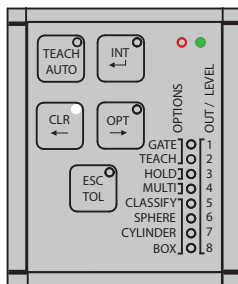
Save:

➡️ Press the `ENTER` key for longer than 2 sec. to confirm deletion of all colors. Output LEDs 1 - 8 output the set output configuration signal for `No color recognized`. By default, 3 output LEDs are illuminated with the CFO100, 8 output LEDs with the CFO200.

Quit:

➡️ Press the `ESC` key for more than 2 sec. to cancel the deletion of all colors and return to the operating mode without saving. The output LEDs indicate either the recognition group or the output configuration for `No color recognized`, depending on the color detected.

5.3.6   Tolerance Setting

Changing the tolerance of a color group is an optional feature. The default tolerance is already sufficient for many applications. It roughly corresponds to the color distinction ability of the human eye (Delta E = 2.0).

The tolerance is subdivided into the following stages:

	Tolerance space								
	L*a*b*						L*C*h°		
	Sphere	Cylinder		Box			Segment		
Tolerance stage	ΔE_{rel}	ΔL	Δab	ΔL	Δa	Δb	ΔL	ΔC	Δh°
1	0.3	0.6	0.3	0.6	0.3	0.3	0.6	0.4	0.40
2	0.5	1.0	0.5	1.0	0.5	0.5	1.0	0.7	0.70
3	1.0	2.0	1.0	2.0	1.0	1.0	2.0	1.4	1.40
4	2.0	4.0	2.0	4.0	2.0	2.0	4.0	2.8	2.80
5	4.0	8.0	4.0	8.0	4.0	4.0	8.0	5.7	3.75
6	6.0	12.0	6.0	12.0	6.0	6.0	12.0	8.5	5.70
7	8.0	16.0	8.0	16.0	8.0	8.0	16.0	11.3	7.10
8	12.0	24.0	12.0	24.0	12.0	12.0	24.0	17.0	8.50

The tolerance is accessible in a color management submenu. All colors in one recognition group have the same tolerance.
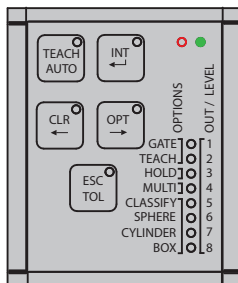
➡️ Press the `TEACH` key for longer than 2 sec. to access the (color) `TEACH` menu.
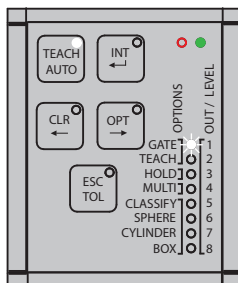
➡️ Press the ◀— `or` —▶ key as often as required, for less than 2 sec. to select the desired recognition group.
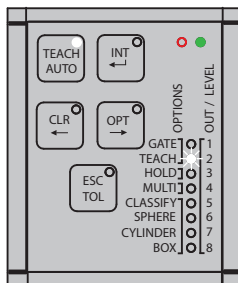
➡️ Press the `TOL` key for less than 2 sec. to enter the tolerance submenu.
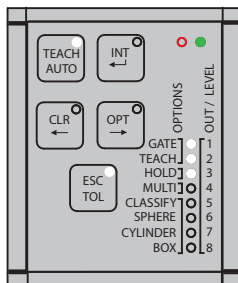
The current color tolerance for the selected recognition group is displayed.

➡️ Press the ⟶ key for less than 2 sec. to increase the color tolerance.

The changed color tolerance stage is displayed.
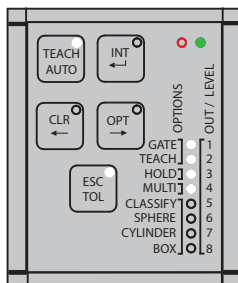
➡️ Press the ⟵ key for less than 2 sec. to decrease the color tolerance.

The changed color tolerance stage is displayed.

➡️ Press the TEACH key for less than 2 sec. to return from the tolerance sub-menu to the color teach menu.

Teaching completed, see 5.3.4.3.

5.3.7   Options

The most important operating modes for the color measuring system can be controlled via the keyboard for special applications.
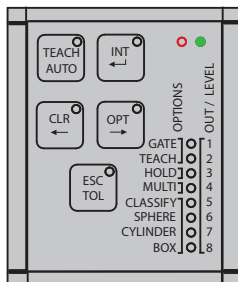
➡ Press the OPT key for longer than 2 sec. to enter the options menu.
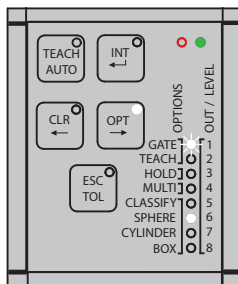
The current controller configuration is displayed.

The currently selected GATE option (triggered color evaluation) and/or TEACH is indicated by flashing. The indicators for the selected option are visualized by flashing whereby (1900/100 ms) indicates ON and (100/1900 ms) OFF.

The option menu is subdivided into four option groups:

- Function of switching input IN0 (GATE and TEACH)

- Hold time for switching outputs (HOLD)

- Teaching process for color groups (MULTI)

- Color recognition profile (CLASSIFY, SPHERE, CYLINDER, BOX)

You can switch back and forth between these option groups by shortly pressing the ◄— or —► arrow key (less than 2 sec.) to make the settings in the group.

You can change the settings in an option group by shortly pressing TEACH (less than 2 sec.) to change or switch through the settings.

5.3.7.1   IN0 Switching Input Function Assignment

Using the keys it is possible to assign switching input IN0 to `GATE` for triggered color evaluation or to `TEACH` for triggered color teaching.
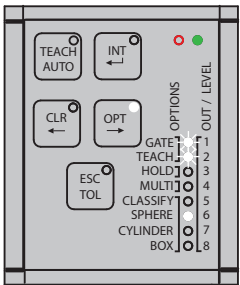
i If neither of the two functions is selected, the LEDs flash slowly (100/1900 ms). As soon as a function is selected, the set function flashes rapidly (1900/100 ms).

Triggered color evaluation `GATE`	If the triggered color evaluation (gate) is active, the controller switching outputs are only evaluated and updated if the configured voltage is currently present at the trigger input. Here the input is configured as an edge trigger with rising edge.
Triggered teach-in of colors `TEACH`	Triggered teach can be used to make run time changes to the color table without direct human intervention. Here the input is configured as level trigger as level high.
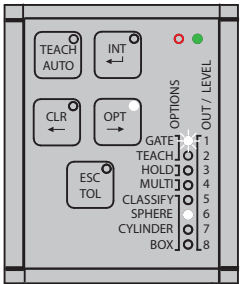
➡ Press the `TEACH` key for less than 2 sec. to switch triggered color evaluation on and off via IN0.

`GATE` flashes slowly to indicate that triggered color evaluation is switched off.

`GATE` flashes rapidly to indicate that triggered color evaluation is switched on via IN0.
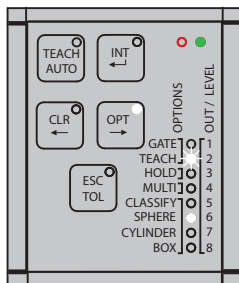
➡ Press the `TEACH` key for less than 2 sec. to switch the triggered color teach feature on and off via `IN0`.

`TEACH` flashes slowly to signal that the triggered color teach feature is switched off.

`GATE` flashes rapidly to signal that the triggered color teach feature is switched on via `IN0`.

Other functions of the trigger inputs can be configured via the REST API, described in the Interface Instructions, see A 3, or via the web interface, see 5.5.

5.3.7.2 Hold Time

Extending the hold time of a detection result beyond the actual duration of the color match is useful if the actuators controlled by the color measuring system require a certain minimum hold time of the switching level or the measurement is faster than the reaction time of the downstream evaluation unit.

The hold time can be set to one of three different stages in the option menu.

Stage	Hold Time	Description of LED display
1	0 ms	1x flashing with 150 / 150 ms, followed by 900 ms off = 1200 ms
2	10 ms	2x flashing with 150 / 150 ms, followed by 600 ms off = 1200 ms
3	1000 ms	3x flashing with 150 / 150 ms, followed by 300 ms off = 1200 ms
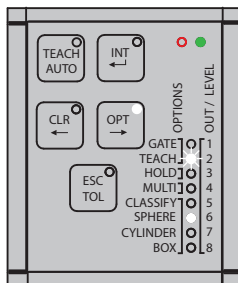
Press the ⟶ key for less than 2 sec. to select the option group.
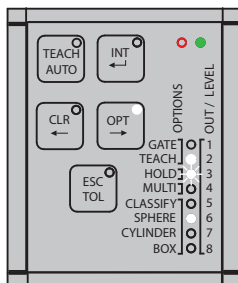
Press the TEACH key for less than 2 sec. to activate the hold time for all outputs.

The activated hold time is signaled by the associated LED flashing.

5.3.7.3 Multi-Teach Mode

The multiple teach mode / Multi-Teach allows keyboard selection of whether each recognition group may contain only the last color saved, or whether it can be assigned a number of colors. This setting has no influence on the behavior of the other user interfaces, described in the Interface Instructions, see A 3.

If the multi-teach feature is activated during color teaching, see 5.3.4.1, hold down the TEACH key for a longer period to teach a number of colors quickly in one color group. The colors continue to be learned as long as the TEACH key is held down.

The first color is learned after the long actuation time (greater than 2 seconds), and each additional color learned every second.

The key LED flashes briefly (100 ms) for each color learned.

i   The color memory is limited and can be filled very quickly with this function (color memory for CFO100 max. 256, for CFO200 max. 320).

After reaching the maximum for the color memory, no further colors are learned.
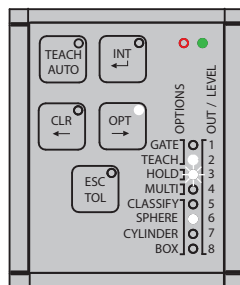
➡ Press the ⟶ key for less than 2 sec. to switch to the next option group.
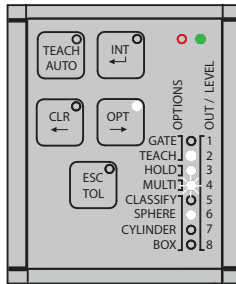
➡️ Press the `TEACH` key for less than 2 sec. to switch over to the multiple teach mode.

The LED flashes rapidly (1900/100 ms) to signal that the multi-teach mode is activated.

5.3.7.4   Tolerance Mode

Changing the tolerance mode is useful if your application requires specific color tolerances, see 2.4.
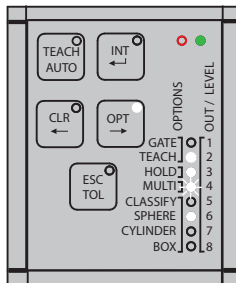
➡️ Press the ➡️ key for less than 2 sec. to switch to the next option group.
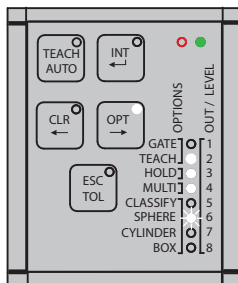
→ Press the TEACH key for less than 2 sec. to switch to the next tolerance mode.

The LED then flashes rapidly to signal the tolerance mode selected.

→ Press the TEACH key for less than 2 sec. again to switch to the next tolerance mode.
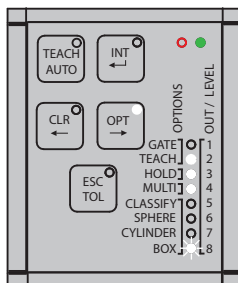
The Box tolerance mode is reached.

5.3.7.5 Conclusion of Option Settings: Save or Quit

After completing the changes to the settings, they can all be stored or discarded.
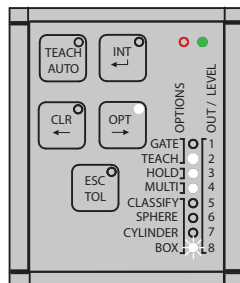
Save:

▶ Press the ENTER key for longer than 2 sec. to save all changed options and return to the operating mode.

Quit:

▶ Press the ESC key for longer than 2 sec to discard changes to the settings and return to the operating mode without saving.

5.3.8 Key Lock

The keys can be locked using a key combination to prevent unauthorized settings.

The key lock can be activated in the main menu.

▶ Briefly press the following keys: ESC > INT > ESC.

▶ To release the key lock, actuate the keys in the same sequence: ESC > INT > ESC.

If the key LED lights up red continuously, the keypad is locked. If the LED is off, the keyboard is enabled.

Via the web page or REST API, described in the Interface Instructions, see A 3, the switching input can also be configured to lock or unlock the controller keypad.

5.4   Configuration via Ethernet

The CFO controller allows creation of dynamic web sites containing the current settings for the controller and peripheral devices. Operation is only possible while there is an Ethernet connection to the controller.

5.4.1   Requirements

Current web browser (for example Mozilla Firefox version 54, Google Chrome version 60 or Microsoft Edge version 14) on a PC with a network connection. The controller is factory-set to direct connection to facilitate initial operation of the controller. If you have configured your browser so that it accesses the Internet via a proxy server, please add the IP address of the controller (169.254.168.150) in the browser settings to the list of addresses which should not be routed via the proxy server. The MAC address of the measuring device is given on the controller rating plate.

Using the `sensorTOOL` program, you can search for connected CFO series controllers on your PC via the available interfaces and establish a connection.

The `sensorTOOL` program is available online at

https://www.micro-epsilon.com/download/software/sensorTOOL.exe

➡ Start the `sensorTOOL` program.

➡ Set the `Sensor group` Color in the drop-down menus and the corresponding `CFO` type in `Sensor type`.
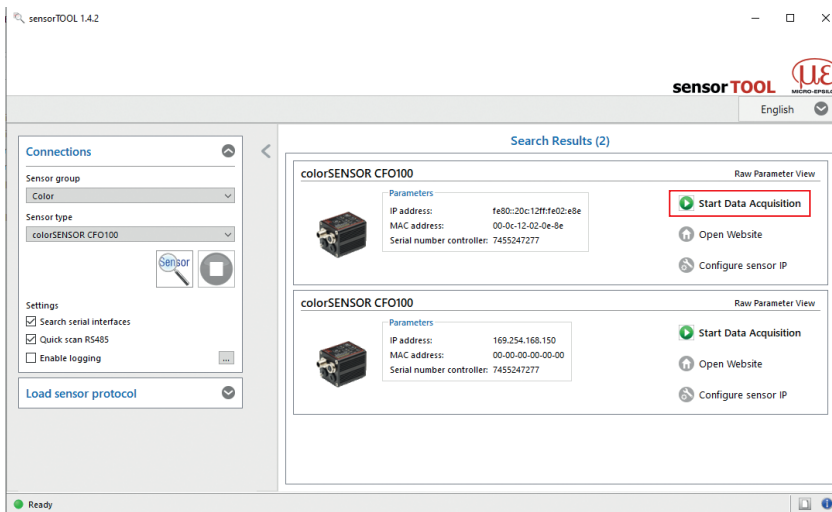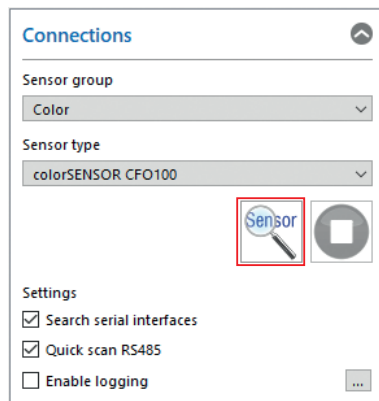
Fig. 26 Utility for sensor search and start of web interface

➡ Click on the button with the magni-
fying glass icon .

The program searches the available interfaces
for connected colorSENSOR CFO controllers.

You need an HTML5-compatible web browser on a PC/notebook.

➡ Select a desired sensor.   Click the `Open Website` button.

5.4.2   Access via Ethernet (Connection Establishment)

Direct connection to PC, controller with static IP (factory setting)		
PC with DHCP	PC with static IP	
➡ Connect the controller to a PC using a direct Ethernet connection (LAN) 2.		
For this purpose, use the CAB-M12-4P-St-ge;Xm-PUR-Cat5e;RJ45-Eth cable, see A 1.		
Connect via `sensorTOOL`		Connect via web browser
➡ Wait until Windows has established a network connection (connection with limited connectivity). ➡ Start the `sensorTOOL` program, see 5.4.1. ➡ Click the [Sensor] button. Now select the desired controller from the list. ➡ Click on the `Start Browser` button to connect the controller to your standard browser.	➡ Start the `sensorTOOL` program, see 5.4.1. ➡ Click the [Sensor] button. Now select the desired controller from the list. ➡ Click on the `Start Browser` button to connect the controller to your standard browser. ➡ To change address settings, click on the `Change IP Address` button. • Address type: static IP address • IP address: 169.254.168.150 [1] • Subnet mask: 255.255.0.0 ➡ Click on the `Change` button to transmit the changes to the controller. ➡ Click on the `Start Browser` button to connect the controller to your standard browser.	➡ Start a web browser. ➡ Click the task bar and enter the static IP address for the controller. In the delivery state, this is 169.254.168.150. Address type: static IP-Address • IP address: 169.254.168.150 [1] • Subnet mask: You can customize this IP address in the `Settings > System settings > Ethernet settings` web page. ⓘ After changing the IP address, please make a note of the new IP address in order to find the controller again later on.
Interactive web pages for controller and peripherals settings now appear in the web browser.		

1) This assumes that the LAN connection on the PC uses the following IP address, for example: 169.254.168.1.

2) Some Ethernet modules in the PC may cause long waiting times when establishing a connection. To avoid this, we recommend using a Belkin Ethernet to USB 3.0 adapter

Network
Controller with dynamic IP address, PC with DHCP
➡ Connect the controller to a switch using a direct Ethernet connection (LAN). For this purpose, use the CAB-M12-4P-St-ge;Xm-PUR-Cat5e;RJ45-Eth cable, see A 1.
➡ Enter the controller in the DHCP / register the controller with your IT department. Your DHCP server assigns an IP address to your controller. You can request this IP address from your IT department. ➡ Start the `sensorTOOL` program, see 5.4.1. ➡ Click the Sensor button. Now select the desired controller from the list. ➡ Click on the `Start Browser` button to connect the controller to your standard browser. Alternative: When using DHCP with the DHCP server coupled to the DNS server, access to the controller is possible using a host name with the structure "CFO-<Serial number>". ➡ Start a web browser on your PC. To reach a CFO100 with the serial number "7454229522", enter "CFO-7454229522" in the web browser address line.
Interactive web pages for controller and peripherals settings now appear in the web browser.

5.5   Web Interface

▣▶ Launch the web interface of the color measuring system, see 5.4.2.

Interactive web pages for programming the controller now appear in the web browser.
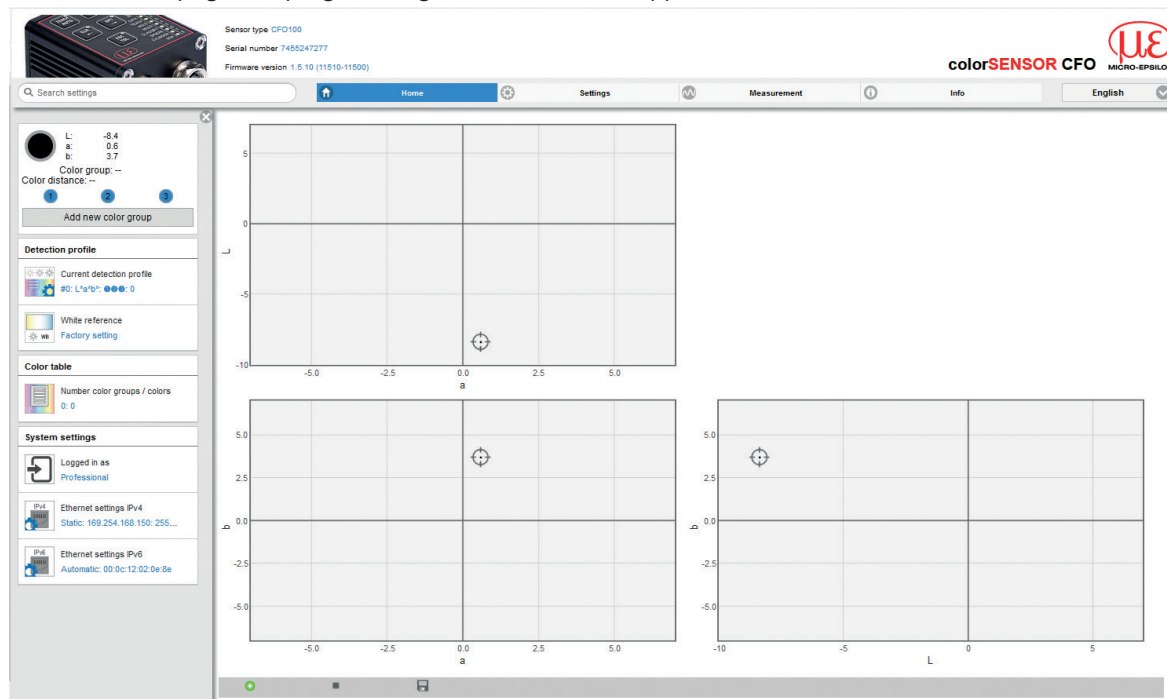
Fig. 27 First interactive web site after calling the web interface

In the top navigation bar, other functions (Settings, Measurement, Info etc.) are available. The appearance of the web pages can change depending on the functions and the peripherals. Each page contains parameter descriptions and tips on filling in the website or configuring the controller.

The controller is active and supplies measurement values. The currently running measurement can be controlled using the function buttons in the `Measurement` section, see 5.7. Parallel control via web browser and API commands is possible (REST API, described in Interface Instructions, see A 3), the last setting is valid and is saved automatically every 30 seconds.

5.5.1   Home Menu

When the web interface is started, first the `Home` page opens, see Fig. 27.

The language can be set on the web sites at the top right. The language setting in your control system (PC) is taken over in the basic System settings. You can choose `German, English, Chinese, Japanese` and `Korean` as web interface language.

Fig. 28 Language selection window

The following symbols and functions are available in the `Home`, `Settings` and `Measurement` menus.

🟢	Measurement is active
⚫	Measurement stopped
⬛	Stop measurement
▶	Start measurement
💾	Save measurement results

5.5.2 Color Display

On the left side is the display of the color and the color values currently detected by the sensor. If the color has already been saved in the color table and if it is within the set tolerance values, the corresponding color group and the relative distance ΔE_{rel} are also output.

In addition, the output from the set output configuration is available at 3 or 8 outputs. Here 1 corresponds to OUT0 and 8 to OUT7 on the `SYS` connector, see 4.4.1 and the I/O socket. When the output is switched to `LOW`, white is displayed and when switched to `HIGH`, green is displayed.
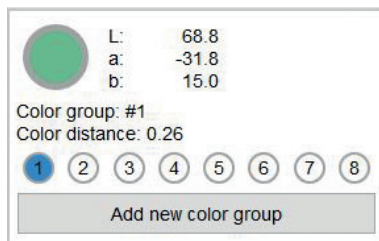
Fig. 29 Color display window

➡ Click on the `Add new color group` button to create a new color group.

This is also possible in the `Settings` and `Measurement` menus.

You can make settings for the color group in the `Settings > Color group` menu, see 5.6.4.

In the `Home` view, the following windows are displayed on the left side including the settings you have selected under the `Settings`, see 5.6 menu.

5.5.3 Settings Display

Detection Profile

Detection profile	
☼☀☼ 📊⚙	Current detection profile #4: L*a*b*: ❶❷❸: 0
☼ WB	White reference Factory setting

Displays settings which you have chosen under `Settings > Detection profile`.

Example:

#4	Name of selected detection profile
L*a*b*	Selected color space
(1)(2)(3)	Output configuration for output Color not recognized
0	Hold time for the output Color not recognized

Color table

Color table	
📋	Number color groups / colors 1: 6

Displays the number of learned color groups and the total number of learned colors that you have taught in under the `Settings > Color table` menu.

Example:

1 color group with a total of 6 colors

System Settings
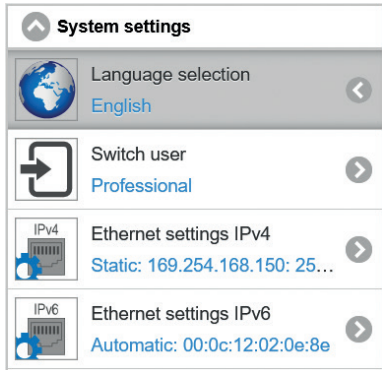
Displays the settings you have chose in the `Settings > System settings` menu.

Example:	
Professional	Logged user
... IPv4	Method and IP address
... IPv6	Method and MAC address

5.5.4 Measurement Menu

➡ Start the Measurement menu.

The diagram control and display are loaded in the browser as HTML5 where they continue to run autonomously, while the controller continues to operate independently.

i If you allow the diagram display to run in a separate browser tab or window, it is not necessary to restart the display each time.

The diagrams start automatically when the function is called.

Fig. 30 Measurement menu

Fig. 31 Location diagram

Fig. 32 Timeline diagram

In the measurement chart, you can choose between location diagram and timeline.

Add new color group	1, 2, 3 ... 255		Adds a new color group, also see *Home, see 5.5.1* menu and *Settings, see 5.6* menu.
Diagram selection	*Timeline*	*L a b*	*View can be set individually,* see Fig. 32, see Fig. 31.
	Location diagram	*a-L, L-b, a-b* *a-L* *a-b* *L-b*	

Fields with gray background require a selection.

Value — Fields with dark border require entry of a value.

Controls, see 5.5.1	Start	The diagram starts automatically when the program is called. Displays the measurement chart.
	Stop	Stops the measurement chart.
	Save	Allows the measured values to be saved after stopping the measurement. Both with the language selection `German` and `English`, the measured values are stored with a point as decimal separator.
		$\mathbf{i}$ Only a limited number of recorded measurements can be stored (about 50,000). If more readings are saved, the oldest readings are deleted.
Displays	XYZ, xyY, L* a* b*, L* u*v*, L*u'v'	Defines the channels to be displayed in the diagram, see Fig. 31 depending on the selected color space.

i   For more details on color spaces, please refer to https://www.micro-epsilon.com/download/products/dat--Basics-of-colorimetry--en.pdf.

Fields with gray background require a selection.

| Value | Fields with dark border require entry of a value.

5.5.4.1 Location Chart / Third Angle Projection

⮕ Select the `Measurement > Location diagram` menu.

Now, depending on the color space, the learned colors including the set tolerance range are displayed.

i Depending on the accuracy of the display medium, the coloring of the displayed tolerance ranges approximates the color values acquired by the controller.

RGB cannot represent all real colors. However, since most display media are based on RGB technology, but the measuring system operates in the XYZ range, the colors displayed do not correspond to reality and can only be approximated (see also Basics of Colorimetry).
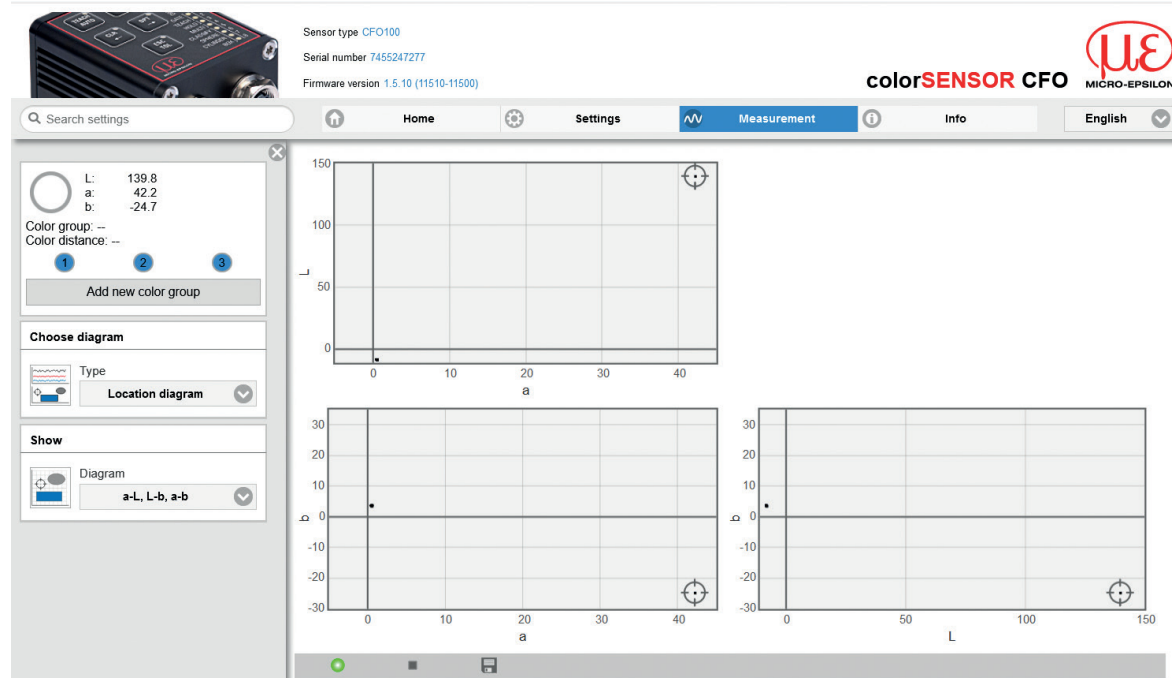
Since the representation on the monitor is only 2-dimensional, but the color space has 3 dimensions, it is represented in a third angle projection, such as in the Lab color space from a to L; a to b; and L to b. The individual diagrams can also be displayed separately.

5.5.4.2 Timeline

➡️ Select the `Measurement > Timeline` menu.

Now a measurement recording starts depending on the runtime when the diagram is activated/start. Via the time diagram, color changes can be recorded over a longer period of time (up to 50,000 measurements).

ℹ️ If you need a longer recording, you can use the `sensorTOOL` program, see 5.4.1.
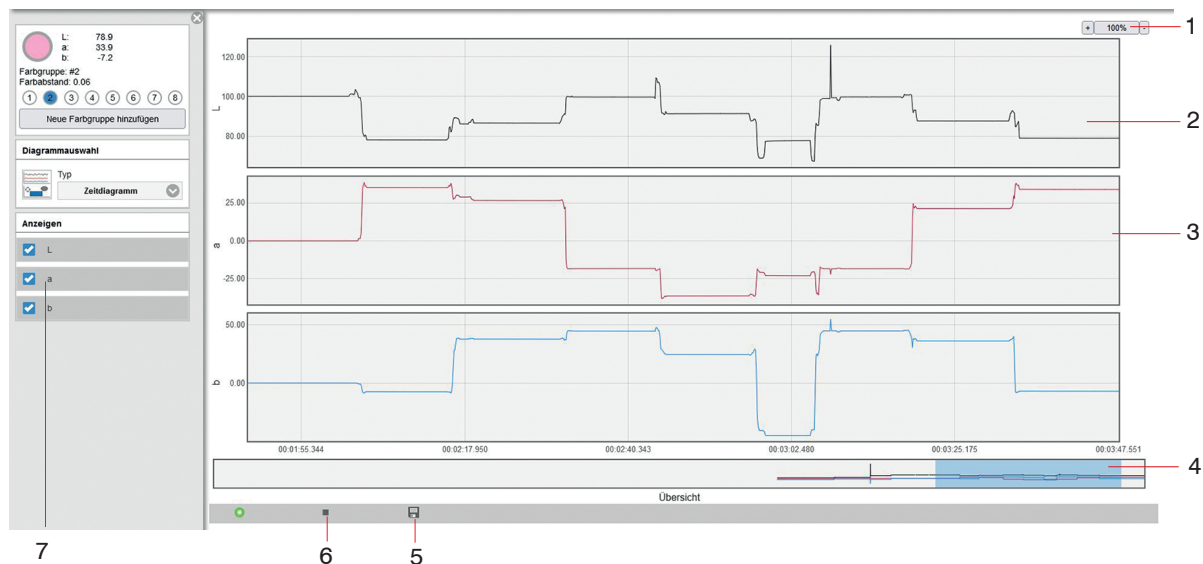
Fig. 33 Measurement chart and timeline menu

The Timeline, see Fig. 33, shows the chronological sequence of the currently tested color in the selected color space.

1   For the display in the diagram you can zoom in the measuring points in fixed steps from 100 % up to 4000 % and zoom with the switches - and +. If you stop the diagram, you can zoom in a range from 20 up to 4000%. Clicking on the button with the % display returns the view to the default values. The y-axis of the three timelines is scaled automatically.

2   The upper part of the measurement chart can be moved and simultaneously resized with the mouse while holding the left mouse button.

Double clicking on the upper diagram or clicking on the button with the % display returns the view to the default values.

3   The right margin of the diagram is the reference for the current color values.

4   With the slider bar (blue area) you can scroll in the diagram and display previous color values (of the last 10 minutes) during an ongoing measurement. The area with dark background defines the view (and thus the time range) for the upper three diagrams. You can shift or change the size of this dark area with the mouse by holding down the left mouse button.

5   With the color inspection, you can record the color values from the last 10 min. and save them to a CSV file (time column and measured value column) with the `Save`, see Fig. 33 button.

6   The diagram display starts automatically. Use the `Stop` button to stop displaying the diagram. Then the display changes to Play (>). Play starts a new recording.

7   You can select and deselect the color values to be displayed in the diagram.

i   Note that the view in the upper diagram is limited when a measurement is in progress. If the display area is shifted while the measurement is in progress, the diagram stops. The incoming readings are saved. The diagram continues to run if the display area is shifted back to the right edge of the bottom section or the diagram is reset.

The color values to be shown in the diagram can be defined with the selection, see Fig. 31, see Fig. 32.

i It is always necessary to select at least one channel for display!

On the left side of the screen, you will find the color inspection indicator, see Fig. 34 on each menu page (exception: Info menu).
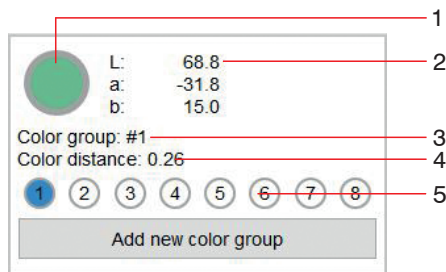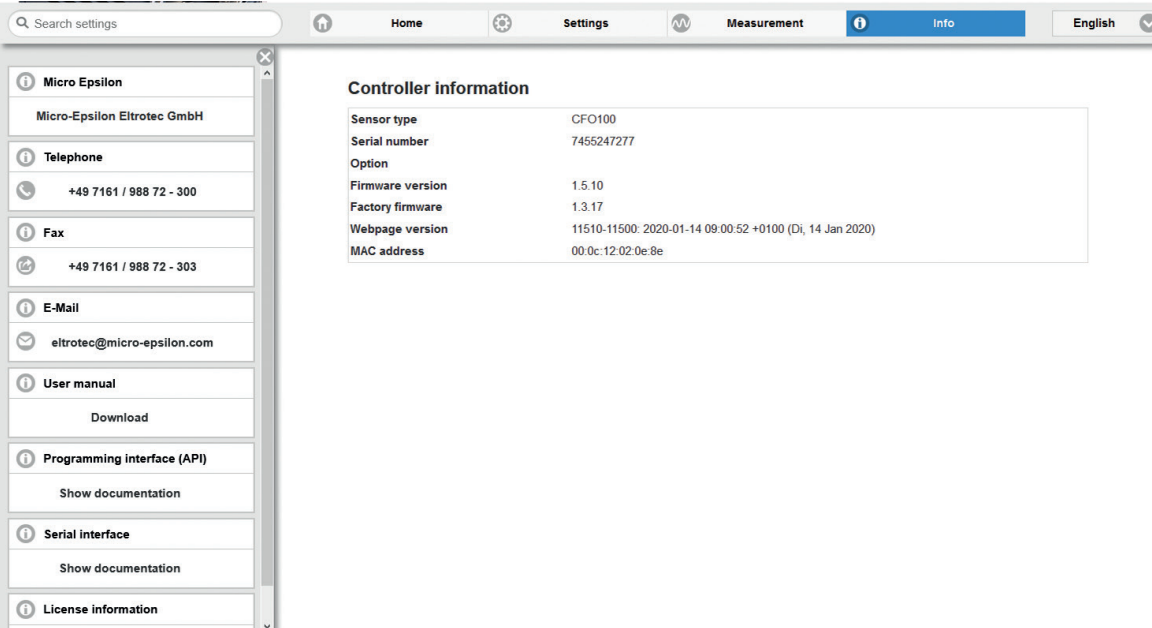
Fig. 34 Color inspection display

1   Here the relative color of your monitor in relation to the color values of the color currently detected by the measuring system is displayed in the color circle.

2   The current color values are located on the right next to the color display.

3   If a color group is recognized, the corresponding group name is displayed.

4   If a color group is recognized, the relative distance ΔE_{rel} from the recognized color in the color table is displayed.

5   When a color group is detected, the current output wiring is displayed.

5.5.5 Info Menu

➡️ Go to the `Info` menu.

On this page you can find the controller information such as sensor type, serial number, optional variant, firmware version, factory firmware, webpage version and MAC address of the used controller. In the left info bar you will find our contact details for your support request if you need help with the controller or the interface.

Fig. 35 Info menu view

In addition, you will find the interface logs for the respective programming interface (Ethernet / REST API) and the serial interface (RS232 / USB), described in the Interface Instructions, see A 3.

5.6 System Parameterization via Web Interface (Menu Settings)

5.6.1 Preliminary Remarks about the Settings

You can program the system using two different methods simultaneously:

- using web browser via the controller web interface, see 5.5
- with API command set and terminal program via RS232 or MEDAQLib, described in the Interface Instructions, see A 3.

i   After programming, save all settings permanently in a parameter set, so that they will be available again the next time you switch on the controller, `System settings > Manage settings > Export settings.`
The controller automatically saves the changes internally every 30 seconds.

5.6.2 Parameters Overview

You can set or change the following parameters in the colorSENSOR CFO, see `Settings` menu:
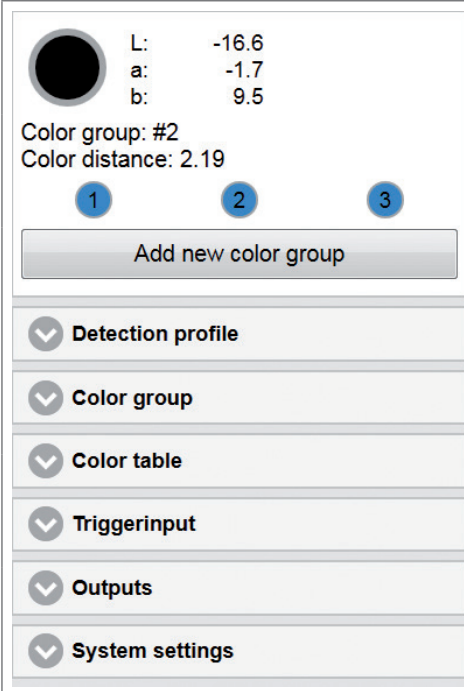
L: -16.6 a: -1.7 b: 9.5 Color group: #2 Color distance: 2.19 1 2 3 Add new color group Detection profile Color group Color table Triggerinput Outputs System settings	Detection profile, see 5.6.3	Manage detection profiles, Current detection profile, Automatic modulation, White reference
	Color group, see 5.5.2	Distance model, Hold time
	Color table, see 5.6.5	Number of color groups
	Trigger input, see 5.6.6	Level High, Level Low, Rising edge, Falling edge
	Outputs, see 5.6.7	Switching behavior
	System settings, see 5.6.8	Language selection, Switch user, Ethernet settings, Manage settings, Reset sensor, Update firmware

Fig. 36 Overall view of Settings menu

5.6.3 Detection Profile

➡️ Go to the menu `Settings > Detection profile.`
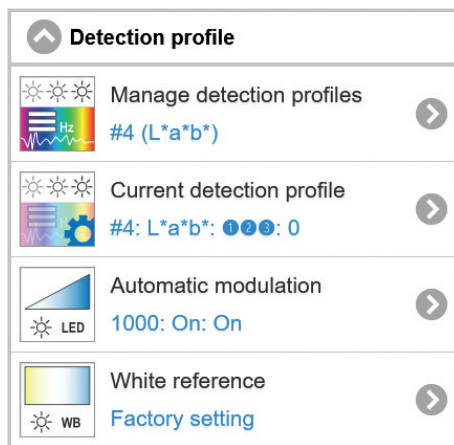
Fig. 37 Detection profile window

In the detection profile you can set and save the basic settings for the colorSENSOR CFO, such as color space, measurement frequency, automatic modulation and white reference.

5.6.3.1 Manage Detection Profiles

➡️ Go to the menu `Settings > Detection Profile > Manage detection profiles.`
In order to create a new detection profile, you must first create a profile under `Add detection profile`.
Then you can perform the automatic adjustment, color space setting and teach-in of the colors. In this menu, you can also switch between the individual detection profiles.

Manage detection profiles

Current detection profile

#0 (L*a*b*) ⌄

Add detection profile

Delete detection profile
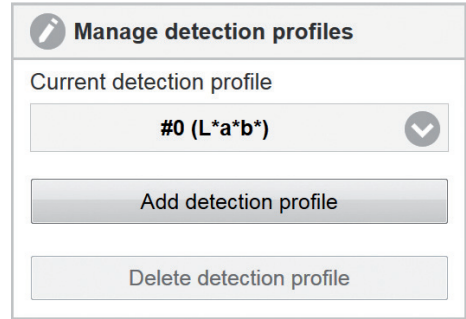
Fig. 38 Manage detection profiles

Fields with gray background require a selection.			

Fields with dark border require entry of a value. (Value)			

Manage Detection Profiles	Current detection profile	#0 (L*a*b*), #1 (L*a*b*) ... #9 (XXX)	*Allows for the detection profiles/setups to be created, deleted and switched. Supports up to ten detection profiles.*
	Add detection profile		*When adding a detection profile, a name with* `#n+1 (color space)` *is automatically generated. You can adapt it under* `Current detection profile`.
	Delete detection profile		ℹ The web pages are refreshed with every event.

Up to 10 detection profiles can be stored and switched in the controller. Not only the settings but also the color table are stored in the detection profile, as they are interdependent and cannot be converted.

5.6.3.2 Current Detection Profile

➡️ Go to `Settings > Detection profile > Current detection profile.`

Under this menu item you can set the name, color space and settings for an incorrect color (color not recognized).

Current detection profile	Name	#0 up to #10	Explanation see below
	Color space	XYZ, xyY, L*a*b*, L*u*v*, L*u'v', L*C*h° [1]	Explanation see below
	Output configuration	Binary coded for CFO100 OUT0...OUT2, for CFO200 OUT0...OUT7	Explanation see below
	Hold time	0 [ms]; time in milliseconds	Explanation see below

Fields with gray background require a selection.

Value — Fields with dark border require entry of a value.

Current detection profile

Name

#0

Color space

L*a*b* ⌄

Output circuit: Color not recognized

① ② ③

Hold time: Color not recognized (ms)

0

Submit

Name defines name of recognition profile. The name may be a maximum of 64 characters long and contain only alphanumeric characters (a-z, A-Z, 0-9, no umlauts), spaces and the special characters +-#,.().

Color space defines the color space to be used for detection. Changing the color space refreshes the website.

ℹ️ If colors have already been taught in and the color space is subsequently changed, the colors and tolerance values are not transferred to the new color space. The reference colors must therefore be taught in again after changing the color space.

With the CFO250, the L*a*b* color space (Cartesian coordinates) is converted to the L*C*h° color space (polar coordinates) and vice versa on the sensor website. All other color spaces are also not converted by the measuring system. The previously set tolerance values are reset to default values during the conversion.

Fig. 39 Current detection profile

1) Only available with the CFO250

The **Output configuration: Color not recognized** defines the outputs to be switched for the state "Color not recognized" (blue ist set to high).

Hold time: Color not recognized defines for how long the output configuration is held. The hold time must not be negative.
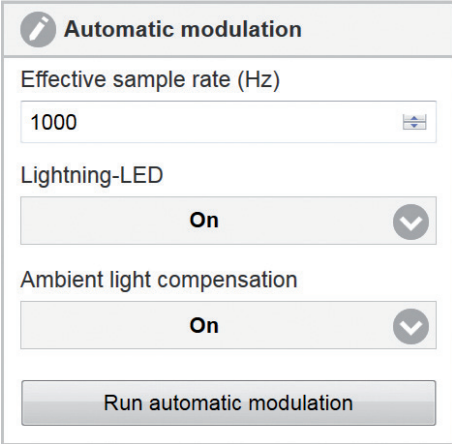
i   If possible, the hold time should not be longer than a few seconds, otherwise changes in state will no longer be perceived.

➡   Click the `Apply` button to apply all settings.

5.6.3.3 Automatic Modulation

➡ Go to `Settings > Detection profile > Automatic modulation.`

Automatic modulation is required after replacing the sensor (optical fiber) with changed measurement arrangement or when the measurement environment has changed.

Automatic modulation

Effective sample rate (Hz)

1000

Lightning-LED

On

Ambient light compensation

On

Run automatic modulation

Fig. 40 Automatic modulation

The automatic modulation determines a suitable combination of internal controller parameters for the current optical situation. The modulation of the receiver is adjusted so that it detects enough, but not too much light (default setting 80 %).

The controller internally sets the best combination of measurement averaging, LED intensity and amplifying factors depending on the selected measurement frequency.

i The modulation of the controller parameters should be set for the brightest color to be tested. The controller should have reached operating temperature; depending on the ambient conditions. This is the case after approx. 45 min. warm-up time.

Since a combination of control parameters such as amplification, averaging, receive brightness and LED brightness is taken during automatic modulation, one needs a control variable. This is the measurement frequency at which the data is to be output via the digital I/Os.

Automatic modu-lation	Effective measurement frequency (Hz)	*Value* [1]	*Starts automatic modulation of the controller. Depending on the measurement frequency, a maximum of 200 values are averaged. You can define the minimum measurement frequency. The measurement frequency can be between 0.01 and 10,000 Hz for the CFO100 and 30,000 Hz for the CFO200.*
	LED	*On*	*The internal LED and ambient light compensation can be switched off or on for testing self-luminous objects.*
		OFF	
	Compensation for ambient light	*On*	
		OFF	

➡️ Click on `Run automatic modulation` to modulate the system.

ℹ️ The measurement frequency indicates only the minimum output update. If the set measurement frequency is less than 1000 Hz, the digital outputs are still updated to a minimum of 1000 Hz.

ℹ️ During automatic modulation, the lightest color to be detected should be placed under the sensor.

1) Numerical value for CFO100 between 0.01 ... 10,000, for CFO200 between 0.01 ... 30,000

Fields with gray background require a selection.

Value Fields with dark border require entry of a value.

5.6.3.4 White Reference

➡️ Go to `Settings > Detection profile > White reference`.

Since the sensor (optical fiber) can have an influence on the color accuracy of the measurement, we recommend a white balance after replacing a sensor (fiber optics) if the measuring arrangement or measuring environment has changed.

```
✏️  White reference

Current white reference

        Factory setting

           Set new
```

Fig. 41 White reference

White reference	Current white reference	User-specific	Reset	Displays the currently used white reference.
				It is possible to set a customized white reference which overwrites the factory set white reference. During setting, a white reference should be located in the measuring position.
		Factory settings	Set	
				You can reset the customized white reference to factory settings.

Fields with gray background require a selection.

Value — Fields with dark border require entry of a value.

➡️ Click on `Set new` to perform a white reference.

Performing White Balance

We recommend performing a white balance after replacing a sensor (fiber optics) or if the measurement environment has changed.

➡ Switch to `Settings` > `Detection profile` > `White reference`.

i Recommendation:
Position the white standard, see optional accessory, see A 1, at the permissible measurement distance to the sensor.
➡ Click the `Set new` button, see Fig. 41.

During white balancing: A dynamic field in the web interface provides information on the current progress. The result of the correction process is stored directly in the controller and does not have to be saved separately in a setup. If the white balancing process fails, the previous white balance continues to be used.

i You should perform an automatic modulation before white balancing and then wait approx. 45 min. before starting the white balance.
This improves the stability of the measurement accuracy over the long term.

i Do not change the light source brightness of the LED after white balancing. Repeat the white balancing process after changing the light source or the sensor arrangement and after sensor replacement.

i The white balance can also be used to spread the signal thus improving the difference between light and dark. In this case the lightest color to be detected is defined as white (L = 100, a = 0, b = 0).

5.6.4 Color Group (Matcher)

▶ Go to the `Settings` > `Color group` menu.
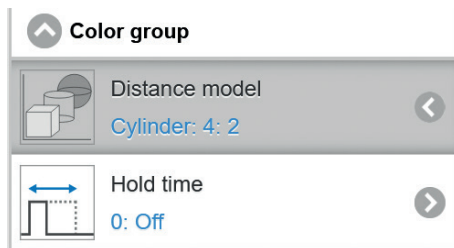
Fig. 42 Color group

Depending on the version, the colorSENSOR CFO controller can save up to 320 colors in up to 254 color groups in the internal color table and use them for color recognition.

Model	Colors	Color groups
CFO100	256	in 6 color groups
CFO200	320	in 254 color groups
CFO250	320	in 254 color groups

In this menu item, basic settings for learning new color groups such as tolerance model, see 5.3.7.5, tolerance limits depending on the tolerance model and hold times for output configuration can be set.

i These parameters are applied for every new color group added. When these parameters are changed, color groups that have already been learned remain unaffected.

A color group is an assignment of several individual colors to one and the same switching output. You can store an arbitrary number of individual colors in a color group.
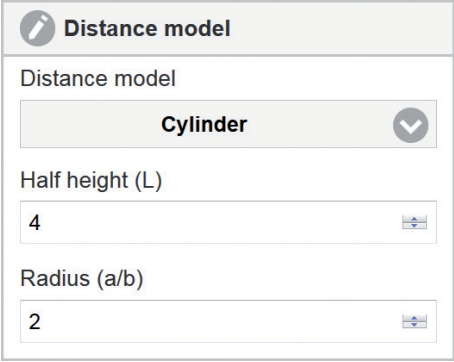
This allows motion unrest in product positioning to be stored as individual colors in a recognition group (matcher).

In the color group menu you can directly set the distance model (tolerance model) and the hold time, as well as in the `Settings` > `Color table` menu by pressing the ✏ button.

5.6.4.1   Distance Model / Tolerance Space

⏩ Go to the `Settings > Color group > Distance model` menu.

The system can be set to the distance models (tolerance models) `Sphere` (ΔE), `Cylinder` (ΔL; Δab), `Box` (cuboid, ΔL; Δa; Δb) and `Classify` for the color spaces XYZ, xyY, L*a*b*, L*u*v*, L*u'v'. With the CFO250, the `Segment` distance model (ΔL; ΔC; ΔH) is available for the L*C*h° color space. These models form a tolerance space around the learned colors. For more details, please refer to, see 2.4.

✎ **Distance model**
Distance model
Cylinder ⌄
Half height (L)
4
Radius (a/b)
2

Fig. 43 Distance model (tolerance model)

Distance model	Distance model	Classification			Set the tolerance assessment that is used for new color groups.
		Sphere	Radius (Δe)	Value	
		Cylinder	Half height (L)	Value	
			Radius (a/b)	Value	
		Box	Edge length (L)	Value	The following distance models (tolerance models) can be set: Classification, Sphere, Cylinder and Box (cuboid) with the respective range settings.
			Edge length (a)	Value	
			Edge length (b)	Value	
		Segment (for CFO250 only)	Half height (L)	Value	
			Half distance (C)	Value	
			Half angle (h°)	Value	

Fields with gray background require a selection.

Value Fields with dark border require entry of a value.

5.6.4.2   Hold Time

➡️ Go to the menu `Settings > Color group > Hold time`.

The hold time determines how long the output configuration of the detected color is held. The hold time must not be negative.

In high-speed production lines, the measuring object is detected by the sensor for just a few μs. With a measurement frequency of 30,000 Hz, up to 7,500 parts/sec (up to 15,000 parts/s with synchronous operation) can be reliably detected without synchronous operation and signaled at the switching outputs. This corresponds to a change of state at the switching output of $> 33\ \mu$s. Downstream processing can often only handle processes with a change in the ms range. For this purpose, the hold time is used to output the state at the output of the detected color (e.g. for 5 ms) until the downstream processes have processed the output further.

Hold time
Hold time (ms)
0
Automatic reset
Off

Fig. 44 Hold time

Hold time	Hold times (ms)	Value	Set the hold time of the output signal that is used for new color groups.
	Reset automatically	On	Automatic reset of the output configuration is only useful for triggered measurements. This setting is ignored in case of a continuous measurement.
		OFF	

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

i   If possible, the hold time should not be longer than a few seconds, otherwise state changes can no longer be perceived.

> **i** If you use the trigger outputs switch, then the hold time is on until you get a new trigger signal. In this case, it is recommended to reset the output configuration to `Color not recognized` after the hold time has elapsed.

5.6.5 Color Table

➡ Go to the `Settings` > `Color table` menu, see Fig. 45, see Fig. 46.

The color table shows the learned colors and color groups.

In the color table, the individual colors are assigned to the color groups and thus to the output configuration. In the color table, the color name, the distance model (tolerance model), the tolerance sizes and the hold time, can be customized for each color group.
Auto-resetting the hold time is only useful for a triggered measurement.
The color values of the learned colors can be changed individually.
New colors can be taught and added to the corresponding color group memory. Individual colors, entire color groups or the entire color table can be deleted.

> **i** The `Add new color group` button teaches the current color to the next free color group memory.

Color table

| Number color groups / colors |
| 0: 0 |

Fig. 45 Color table window

Fig. 46 Settings - Color table menu

5.6.5.1 Add Color Group

➡️ Click on the Add new color group button. The button is always located on the upper left side of the web interface, except in the Info menu.

Use the button `Add new color group` to teach the current color detected by the sensor with your own output configuration, tolerance model, tolerance values and hold time. The settings applied correspond to the ones selected under, see 5.6.4 The new color group is always taught (binary coded) to the smallest free output combination. The output configuration and parameters can be changed under, see 5.6.5.2, yet.
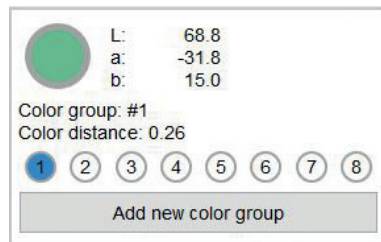
Fig. 47 Color display window

5.6.5.2   Teaching and Editing Colors

▶ Go to `Settings > Color table >` ➕ `Teach color` and/or 🖊 `Edit`.

New colors can be taught and added to the corresponding color group memory. Individual colors, entire color groups or the entire color table can be changed and deleted, see 5.3.5, see 5.6.5.3 (Delete color table).

If the color table is still empty, create a new color group , see 5.6.5.1 (Add color group).

The ➕ button can be used to add further individual colors to the color group.

The 🖊 button allows you to make custom settings for each color group. These settings include a custom name, a tolerance model with custom tolerance values, the output configuration and the hold time for the switching outputs.

➕	Teaching colors	Teaches current color (1) and adds it to the corresponding color group memory, see Fig. 48.
🖊	Edit	Allows editing and setting the color group (2). The settings of a color group can be changed, such as `Name` (13), `Distance model` (12), tolerance size, `Hold time` (8) of the output signal, output configuration.
		The name may be a maximum of 64 characters long and contain only alphanumeric characters (a-z, A-Z, 0-9, no umlauts), spaces and the special characters +-#,.(), see Fig. 48.
🗑	Delete	Deletes a color group (3) or color (4), see Fig. 48.
✔	Apply	Applies the current entry (5), see Fig. 48.
✖	Cancel	Discards the current entry without saving (6), see Fig. 48.

ⓘ   Before creating a new color table, set the parameters for the color space and controller modulation, see `Settings > Detection profile` menu, see 5.5.3.
If you subsequently change the controller modulation, all colors must be learned again.

Fig. 48 Excerpt, color table

1   The ✚ Teach color button adds the color currently detected by the sensor to the respective color group.

ⓘ   It is also possible to teach the new color with the Teach menu using the keypad on the controller, see 5.3.4.1.

Recently taught colors are also stored after switching off the controller.

2   Allows you to change and set the color group parameters for the selected color group.

3   Deletes the entire color group including the stored individual colors.

4   Deletes the selected individual color.

5   The ✔ Apply button saves the changes to this color group.

6   The ✖ Cancel button discards the changes to this color group.

7   The Auto-Reset is only useful for a triggered measurement, otherwise the last value will remain until a new trigger is set. Via the `Reset` function the output is reset to output `Color not recognized` in between.

8   In the input field `Hold time` you can enter a time in ms. If the color group is detected, the output configuration (10) for this color group is held for the selected time.

     During this time the outputs are not updated and thus, further colors are not detected.

     i Production errors occurring in the meantime are not detected, also see chapter Hold time, see 5.3.7.2.

9   Here, the learned color values, depending on the selected color space, are displayed and can also be edited. The color space can be changed in the detection profile, see 5.6.3.1.

10   The output configuration defines the outputs to be switched upon recognition of this color group.

     The outputs can be set to `high` = blue or `low` = white by clicking on the output configuration.

     i The color table is automatically sorted in the output configuration sequence.

11   Every color is described by the color space coordinates and the permissible tolerance values. Up to three tolerance limits per color can be specified depending on the distance model (12). If the current measured value is within these tolerances, the color is recognized and indicated, see 2.4.

     If the controller detects a color within the tolerance limits, it indicates the status on the left side of the window with a depiction of the current color.

12 As the distance model (tolerance model) for the color spaces XYZ, xyY, L*a*b*, L*u*v*, L*u'v'), you can choose between the distance models `Sphere` (ΔE), `Cylinder` (ΔL; Δab), `Box` (cuboid, ΔL; Δa; Δb) and `Classify`, and for the color space L*C*h° for the CFO250 `Segment` (ΔL; ΔC; ΔH), see 5.6.4.1.

Depending on the distance model selected, it is possible to set the tolerance values (11) to 1 .. 3.

These values describe the size of the tolerance space around the learned color.

Within a color group, the same distance model and the same tolerance values are used for all learned colors.

No tolerance parameters are set for `Classify`, because the currently measured color is always associated to the color saved in the color table with the smallest distance to the measured color, see 2.4.

When teaching a new color group, the values selected under Color group settings, see 5.6.4 (Color group) are used for the distance model and the tolerance values (11).

Example: Cylinder distance model

Half height (L) = 8

Radius (a/b) = 4

These can be manually adjusted in the edit mode of the group between 0 ... 50.

13 The maximum name length is 64 characters and may consist of only alphanumerical characters (a-z, A-Z, 0-9, no foreign character attributes), spaces and the special characters +-#,.().

Name	Value		The maximum length is 64 characters and may consist of only alphanumerical characters (a-z, A-Z, 0-9, no foreign character attributes), spaces and the special characters +-#,.().
Color values	L	0 … 130 (150)	Value	*Numerical value with two decimal places (9)*
	a, b	-130 … + 130	Value	
	X, Y, Z	0 … 130	Value	
Output	Binary 1 .. 8 or 1 ... 255			
	high			*Selected by clicking the outputs for binary or direct coding; blue is set to high, white is set to low*
	low			
Hold time (ms)	Value			
Auto-Reset	Off, on			

Distance model		Classify / Sphere / Cylinder / Box	
Tolerance value	ΔE	Value	0.00...50.00
	ΔL / Δab	Value	0.00...50.00
	ΔL / Δa / Δb	Value	0.00...50.00
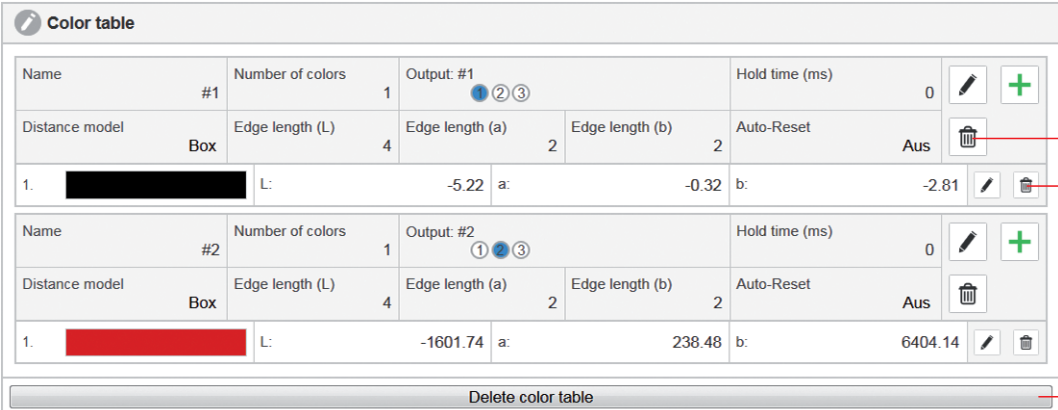
Fields with gray background re-quire a selection.

Value Fields with dark border require entry of a value.

5.6.5.3 Deleting Colors, Color Table

➡ Go to `Settings > Color table >` 🗑 `Delete`.

The 🗑 icon can be used to delete individual colors or entire color groups.
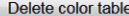
Fig. 49 Excerpt color table

1. You can remove a complete color group from the color table using the 🗑 button, located to the right of the Auto-Reset parameter, see Fig. 49.

2. You can remove a single color from the table using the 🗑 button, located directly to the right of the corresponding color values.

3. ➡ Go to the menu `Settings > Color table > Delete color table`.

   Via the button `Delete color table` (3), you remove all colors and color groups from the color table.

   You can delete the color groups, see 5.3.4.2 and color table, see 5.3.6, also via the key control or a trigger event, see 5.6.6.

5.6.6 Trigger Input

▶ Go to the menu `Settings` > `Trigger input 1 ... 4`.

Determines one or several functions that are executed when a trigger event occurs.

The CFO100 series provides you with one trigger input 1 (`IN 0`), the CFO200/CFO250 series with four parameterizable trigger inputs 1 ... 4 (`IN 0 ... IN 3`).

Here, four different functions can be assigned to each trigger input to four different states.

The following trigger events are possible: Level High, Level Low, Rising edge, Falling edge, see Fig. 50.

> **i** Triggers are part of the detection profile.
> Switching the detection profile therfore also switches the settings of the trigger inputs to those of the detection profile which is the active.

Trigger inputs can be used for the following purposes: Switching outputs, teaching or removing colors or color groups, removing color table, running autogain (automatic modulation) of the receiver or activating key lock.

Each trigger can be linked to one or several of the above activities, see also more differentiated list of functions, see Fig. 51.

Trigger inputs can be used for the following purposes:

- Switching the outputs
- Teaching colors as new group
- Adding colors to current group (Multi-teach function)
- Teaching and grouping colors continuously
- Deleting color table
- Automatic modulation for sensor LED
- Rerecording white reference
- Activating key lock

Each trigger can be linked to one or several of the above activities, see also more differentiated list of functions, see Fig. 52.
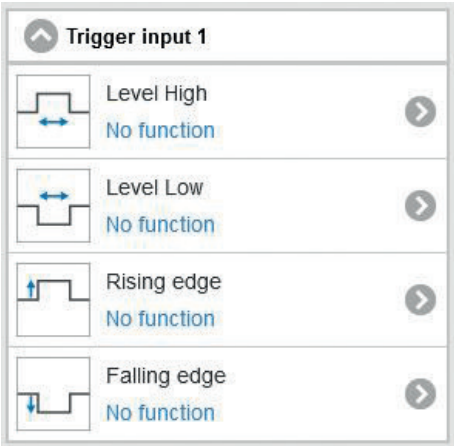
Fig. 50 Trigger input window
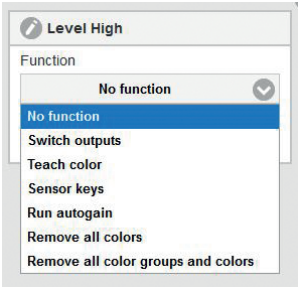
Fig. 51 Example: Level High - No function

➡️ After selecting a trigger input, click the `Apply` button to activate the selected trigger event.

Trigger input	High level	No function, Switch outputs, Teach color, Sensor keys, Run autogain, Remove all colors, Remove all color groups and colors	Determines one or several functions that are executed when a trigger event occurs. The following trigger events are possible: Level High, Level Low, Rising edge, Falling edge
	Low level		
	Rising edge		
	Falling edge		

Fields with gray background require a selection.

Value: Fields with dark border require entry of a value.

No function		
Switching the outputs		The signal at the outputs is updated when the corresponding input signal is set. For example, if the outputs are switched when the signal level is high, the update will continue as long as the level is present.
		i The measured values are sent via the interfaces at 15 Hz regardless of this setting.
Teaching colors	New color group	Here, a new color group with the color currently detected by the sensor is created for each trigger event.
	Output (color group)	Here, the new color is learned to the color group with the selected output configuration, regardless of whether this color group already exists or not. This allows, for example, to always learn the color to output 1 (OUT0 on high). With this setting, you can then additionally select whether all previous colors in this group should be deleted beforehand or whether additional colors should be learned.
	Color group: #Name	If color groups have already been learned, then colors can also be taught to an existing color group. All color groups that have already been learned can be selected under this function. If no color group has been learned yet, this function is not available for selection. With this setting, you can also select whether all previous colors in this group are to be deleted beforehand or whether they are to be added.
Sensor keys	Unlock	Here, the `Membrane keypad` on the controller is unlocked with the corresponding trigger signal.
	Lock	In this case, the keyboard is locked when the corresponding trigger signal is received.
		i Locking the keypad is recommended, as the controller is then protected against unintentional adjustment.
Automatic modulation		Here , see 5.6.3.3, the controller settings are adjusted depending on the measurement frequency and the detector modulation.
Delete learned colors		This function deletes all learned colors in all color groups. However, the color groups remain.

Fields with gray background require a selection.

Value — Fields with dark border require entry of a value.

Delete learned color groups and colors	This function deletes the complete color table.

Fig. 52 Differentiated list of functions

Trigger Type	Selection	Meaning
Level:	High (H; 1) or Low (L; 0)	State is present at the input for a longer period.
H		High, is live and logical 1
L		Low, logical 0
Low level		As long as a low level $< V_+/2 \pm 5$ % is present at the input, the stored function is executed.
High level		As long as a high level $> V+/2 \pm 5$ % (max. 30 V) is present at the input, the stored function is executed.

When the state changes from Low to High or from High to Low, signal edges occur. These are meaningfully referred to as positive or negative edge-triggered.

Rising edge	Change of state between L ($< V_+/2 \pm 5$ %) to H ($> V_+/2 \pm 5$ %). During this change, the stored function is executed.
Falling edge	Change of state between H ($> V_+/2 \pm 5$ %) to L ($< V_+/2 \pm 5$ %). During this change, the stored function is executed.

Fields with gray background require a selection.

| Value | Fields with dark border require entry of a value. |

The following are used as triggering conditions:

Level triggering with high level / low level.

Execution of the parameterized function as long as the selected level is present.

The pulse duration must be at least as long as one cycle. The subsequent pause must also be at least as long as one cycle.
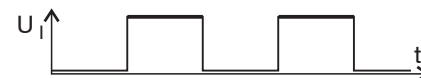

Fig. 53 Trigger level High

Edge triggering with rising or falling edge.

Starts parameterized function as soon as the selected edge is detected at the trigger input. The sensor executes the parameterized function when the trigger condition is fulfilled. The duration of the pulse must be at least 5 μs.
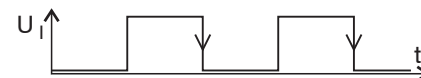

Fig. 54 Trigger edge HL

Software triggering. Data recording is caused by the `TRIGGERSW SET` command. The sensor outputs the previously set number of measured values or initiates a continuous measured value output after the trigger event.

The measured value output can also be stopped using a command.

Further functions of the trigger inputs can be configured via the `REST API`, described in the Interface Instructions, see A 3, or via the web page.

Level High	
Representation	
Default	⌄
Function	
No function	⌄
Apply	

Fig. 55 Trigger setting Extended 1

Level High	
Representation	
Extended	⌄
Remove all colors	
Active	⌄
Remove all color groups and colors	
Inactive	⌄
Enable detection profile	
Active	⌄
Detection profile	
#0 (L*a*b*)	⌄

Run autogain	
Active	⌄
Teach color	
Active	⌄
Teach color in	
New color group	⌄
Switch outputs	
Inactive	⌄
Sensor keys	
Inactive	⌄
Apply	

Fig. 56 Trigger setting Extended 2

In the `Represnentation > Default` setting, only one function can be selected per trigger signal, see Fig. 55.
In the `Representation > Extended` setting, multiple assignments of functions to a trigger action are possible. These are then carried out in the order shown from top to bottom.

> ℹ If you have difficulties parameterizing the outputs, you can contact customer support, see 8, or perform a hardware reset, see 5.7. This resets the controller to factory defaults.

All combinations can be reset using the `Reset` function, see 5.7.

5.6.7 Outputs

5.6.7.1 CFO100/CFO200

⏩ Go to the menu `Settings > Outputs`.

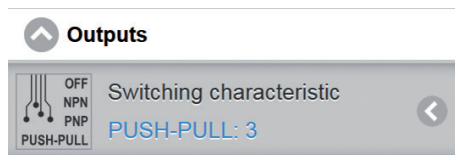The switching characteristics of the outputs can be set in this menu point.

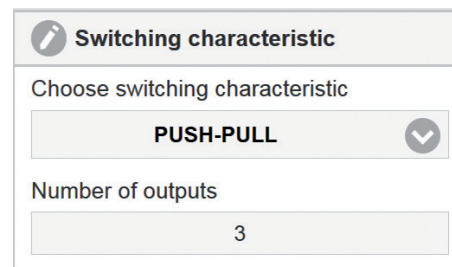*Fig. 57 Outputs / Switching characteristic window*   *Fig. 58 Switching behavior*

Here it is possible to select between `OFF, NPN, PNP` and `PUSH-PULL`. More details on the output configuration, see 4.4.6. The outputs to be physically switched for `Color not recognized` can be set in the Detection profile, see 5.6.3.2.

The outputs to be physically switched for the recognized color can be set in the color table and the corresponding color group, see 5.6.5.

The switching output, see Fig. 58, becomes active when the measured color is within the specified tolerance parameters (L & a & b), the color is then considered to be recognized.

If the color is not within the specified parameters, the output for `Color not recognized` becomes active. In the delivery state this is `all outputs at high`.

Switching charac-teristic	Choose switching characteristic	Determines the switching behavior of the switching outputs. The following interfaces are available:	
		OFF	
		NPN	Outputs OUT switch to ground (GND) when color group is detected (activated)
		PNP	Outputs OUT switch according to supply voltage (V_+) when color group is detected (activated)
		PUSH-PULL	Push-pull outputs OUT switch to supply voltage (V_+) when color group is detected (activated) and to ground (GND) when not detected
	Number of out-puts	Value	

5.6.7.2   CFO250

➡ Go to the menu `Settings > Outputs > Binary data output`.

The binary data output of the outputs can be set in this menu point. For binary data output, you can choose between the network (UDP), RS232 or USB interfaces.

A maximum of 500 Hz can be transmitted via the network (RJ45) and USB and a maximum of 380 Hz via the RS232 interface.

Fields with gray background require a selection.

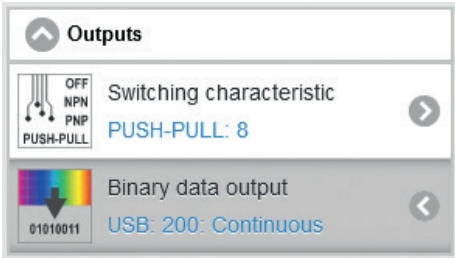Value | Fields with dark border require entry of a value.
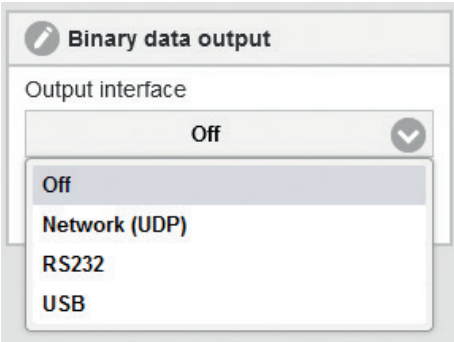
Fig. 59 Outputs window / Binary data output

Fig. 60 Binary data output view

Binary data output	Output interface	*Deaktiviert*
		Netzwerk (UDP)
		RS232
		USB

i Only one interface can be active. When using the RS232 or USB interface, the corresponding command interface is therefore deactivated.

If you select `Binary data output` via the `Network UDP`, see Fig. 61, you must specify the receive address, the port and the output frequency to the system. The transmission can be continuous, see Fig. 61, or triggered by edge triggers, see Fig. 63 or level triggers, see Fig. 62. When using triggered data output, measured values are only output via the set interface if a corresponding signal is present at the selected trigger input.

The level trigger, see Fig. 62, can be triggered at a high or low level. As long as the level is active, the measured values are transmitted at the selected frequency.

Fields with gray background require a selection.

Value — Fields with dark border require entry of a value.

Fig. 61 Binary data output view - Network (UDP) - Continuous

Fig. 62 Binary data output view - Network (UDP) - Level trigger

The edge trigger, see Fig. 63, triggers on a rising or falling edge. You can specify how many measured values are transmitted with edge triggering at the selected frequency.

Binary data output

Output interface

Network (UDP)

Recipient IP address

169.254.100.217

Recipient port

1024

Output frequency (Hz)

200

Output of measurement data

With rising edge
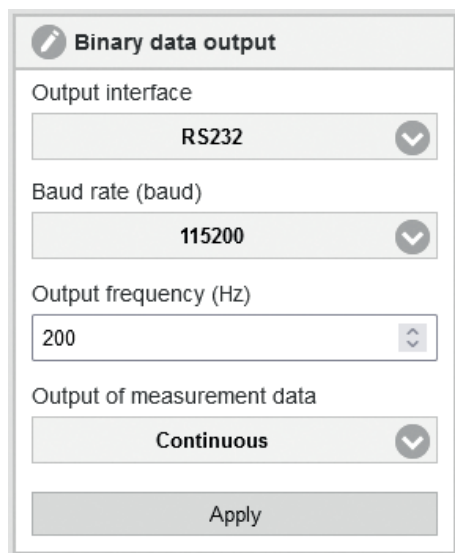
At trigger input

1

Number of output values with edge trigger

1

Apply

Fig. 63 Binary data output view - Network (UDP) - Level trigger
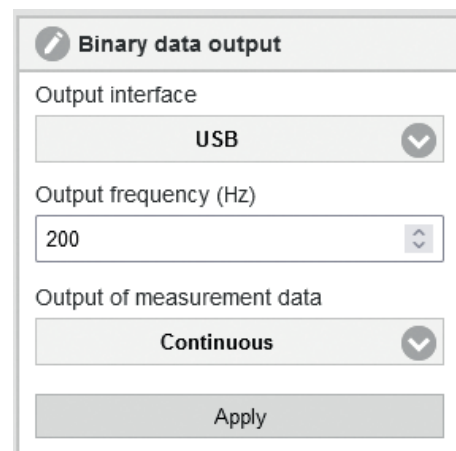
If binary data output via RS232 is selected, the baud rate 115200 (standard) 19200 and 9600 as well as the output frequency and triggering can be set.

If binary data output via USB is selected, the output frequency < 500 Hz and the output triggering can be set.

Fig. 64 Binary data output view - RS232

Fig. 65 Binary data output view - USB

5.6.8   System Settings

▣➡ Go to menu `Settings` > `System settings`.

System settings such as `Language selection`, `Switch user`, `Ethernet settings`, `Reset sensor` and `Update firmware` are set under this menu item.
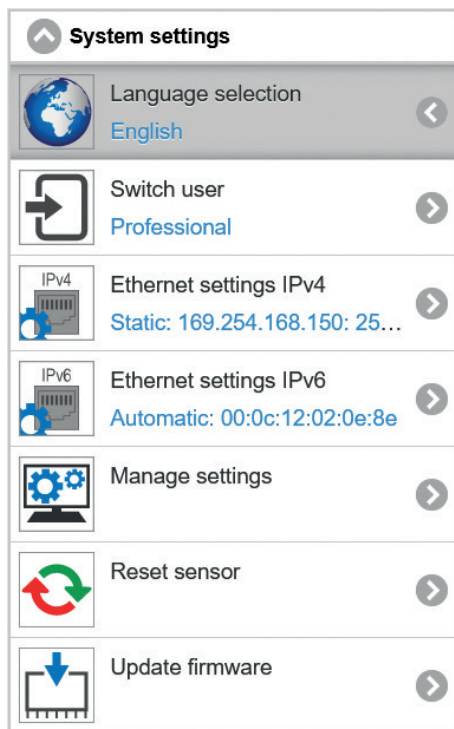
Fig. 66 System settings window

5.6.8.1 Select Language

➡ Go to `Settings > System settings > Language selection.`

You can choose German, English, Chinese, Japanese and Korean as language for the web interface. You can select your preferred language from the drop-down menu, see Fig. 67. The language selection can also be made via the menu bar, see Fig. 28. In the factory settings, see A 2, the language selection is set to `Browser`. This means that the web pages are always displayed in the language you have selected in the system settings of your PC.

✎ **Language selection**

Language at startup
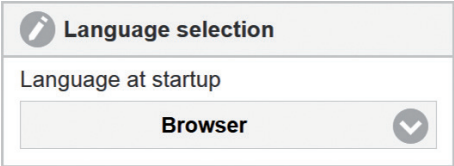
Browser ⌄

Fig. 67 Language selection

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

Select language	Language when loading	Browser	Determines the language used when loading the web page.
		English	
		German	
		Chinese	
		Japanese	
		Korean	

5.6.8.2 Switch User

⮕ Go to the menu `Settings` > `System settings` > `Switch user`.

Two rights groups are available: `User` and `Professional`.
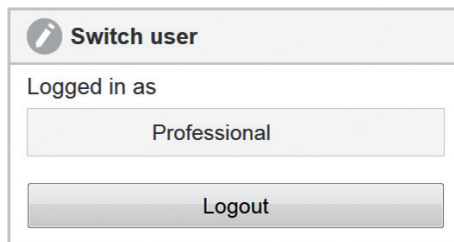
Fig. 68 Switch user

`Users` have read-only rights, i.e. they can only view the settings, but not change them. Professionals can change all settings. To change settings, you must be logged in as a `Professional`. In the delivery state, the `Professional` level is active.

After logging off the `Professional`, you return to the `User` level. For further settings you must log in again.

Assigning passwords prevents unauthorized changes to the controller settings. The password protection is not activated in the delivery condition. The controller works on the `Professional` level. After the controller has been configured, you should enable password protection. The standard password for the Professional level is 000. The password can be changed after the first logout and login, see Fig. 69.
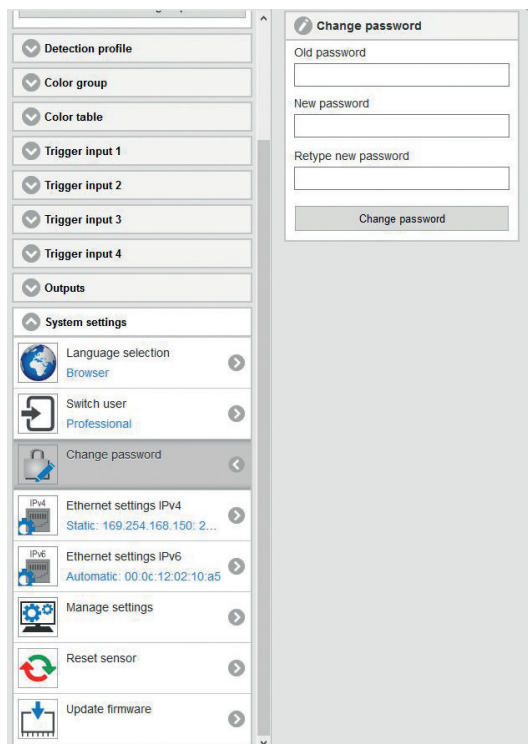
Fig. 69 Change password

i   A software update will not change the default password or a user-defined password. The Professional
    password is independent from Setup and is thus not loaded or stored with Setup.
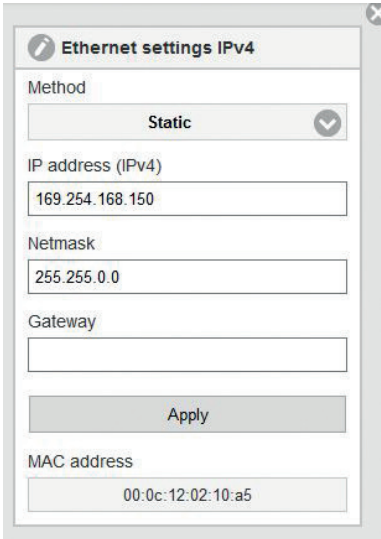
5.6.8.3 Ethernet Settings

➡ Go to the menu `Settings > System settings > Ethernet settings IPv4`.

An IPv4 connection is the Internet Protocol standard or IP standard. IPv4 stands for Internet Protocol version four. Here, the address is structured as a 12-digit number separated by dots. For sensors from Micro-Epsilon the default IP address is 169.254.168.150, see Fig. 70.

Here you can change the IPv4 settings of the controller.

i   After changing the IP address, you may also have to adjust the address space of the PC you are using to re-establish a connection to the sensor.

Fig. 70 Ethernet settings IPv4

Assign a static IP address or activate DHCP.

When DHCP is activated, the controller is accessible in the network under its DHCP Host name. The DHCP host name must be at least one and at most 63 characters long and may only contain alphanumeric characters (a-z, A-Z, 0-9, no umlauts) and the special character -.

With DHCP it may be necessary to enable the controller MAC address in the network.

➡ Go to the `Apply` button to apply the settings you have made.

Ethernet settings IPv4	Method	Static	IP address	Value	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.
			Subnet mask	Value	
			Gateway	Value	
		Dynamic (DHCP)	DHCP Host name	Value	When DHCP is activated, the controller is accessible in the network under its DHCP Host name. With DHCP it may be necessary to enable the controller MAC address in the network.
		MAC address		Value	

➡ Go to the menu `Settings > System settings > Ethernet settings IPv4`.

With IPv4, approx. 4.3 billion different addresses can be generated. With IPv6, approx. 340 sextillion addresses can be assigned. IPv6 has been considered the successor to IPv4 since 1998.

An IPv6 address is 128 bits long (IPv4: 32 bits). The first 64 bits form the so-called prefix, the last 64 bits consist of a unique interface identifier. The IPv6 address usually consists of 32 hexadecimal digits. The address from example, see Fig. 72, fe80::20c:12ff:fe02:10a5 (leading zeros within a block are omitted; consecutive 0000 are abbreviated by ::), means written out fe80:0000:0000:020c:12ff:fe02:10a5.

Fields with gray background require a selection.

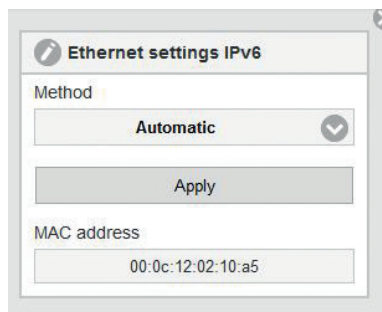Value Fields with dark border require entry of a value.

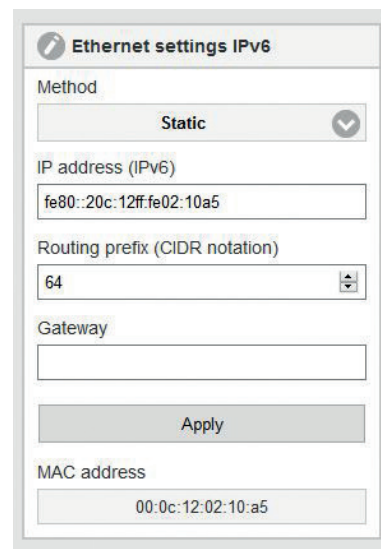Fig. 71 Window Ethernet settings IPv6 - Automatic method

Fig. 72 Window Ethernet settings IPv6 - Static method

Ethernet set-tings IPv6	Method	*Automatic*			*Using Stateless Address Autoconfiguration (SLAAC, specified in RFC 4862), a host can establish a functional Internet connection fully automatically. To do this, it communicates with the routers responsible for its network segment to determine the necessary configuration*, see Fig. 71.
		Dynamic (DHCP)	*DHCP Host name*	*Value*	*When DHCP is activated, the controller is accessible in the network under its DHCP Host name. With DHCP it may be necessary to enable the controller MAC address.*
		Static	*IP address*	*Value*	*When using a static IPv6 address, the values for IP address, prefix length, and gateway must be specified; this is omitted when using DHCP or Automatic.*
			Prefix length	*Value*	
		MAC address		*Value*	*see DHCP*

The Ethernet interface is not only used for parameter setting of the measuring system via the web pages or via the API command set, see A 3, but also enables non-real-time data transfer (packet-based data transfer). The color values for measured value capture are transferred for one subsequent analysis without direct process control. Data transmission takes place at a maximum of 15 Hz.

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 changed IP settings are active immediately and it may be necessary to enter the new IP address in the browser to access the web interface again.

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

The controller transfers the TCP/IP or UDP/IP packages at the Ethernet transfer rate of 10 MBit/s or 100 MBit/s, which is set automatically depending on the network or PC connected.

All output values and additional information to be transmitted, which were acquired at a certain point in time, are combined to a measured value frame, described in the Interface Instructions, see A 3.

Fields with gray background require a selection.

Value | Fields with dark border require entry of a value.

5.6.8.4 Serial Interface
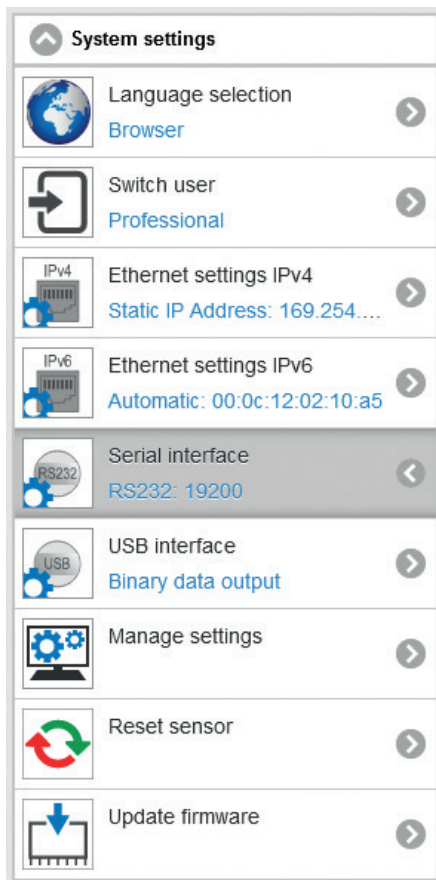
Fig. 73 View of serial interface CFO250
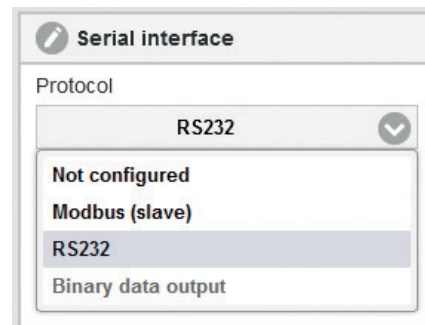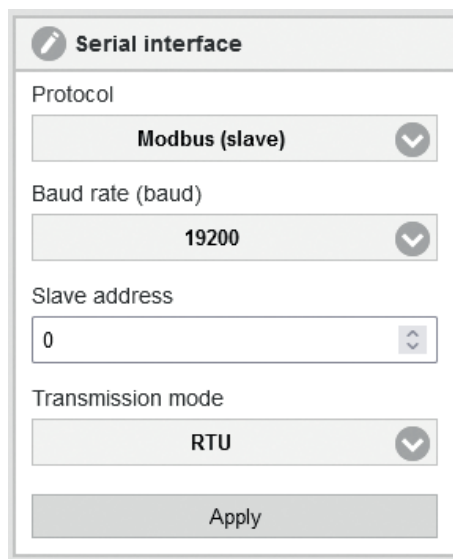
Fig. 74 View of serial interface CFO250 - RS232

With the CFO100(100) and CFO200(100) Modbus options and the CFO250, the serial RS232 interface can be switched between Modbus (slave), RS232 and binary data output (CFO250 only). The binary data output is configured, see 5.6.7.2.
When selecting the RS232 interface, the baud rate can also be set.

Fig. 75 View of serial interface CFO250 - Modbus (slave)

When selecting Modbus (slave), the baud rate, the slave address and the transmission type (RTU or ASCII) can be adjusted.

5.6.8.5 USB Interface

With the CFO200(100) Modbus and CFO250 options, the USB interface can be switched between Modbus (slave), RS232 and binary data output (CFO250 only). The binary data output is configured, see 5.6.7.2.
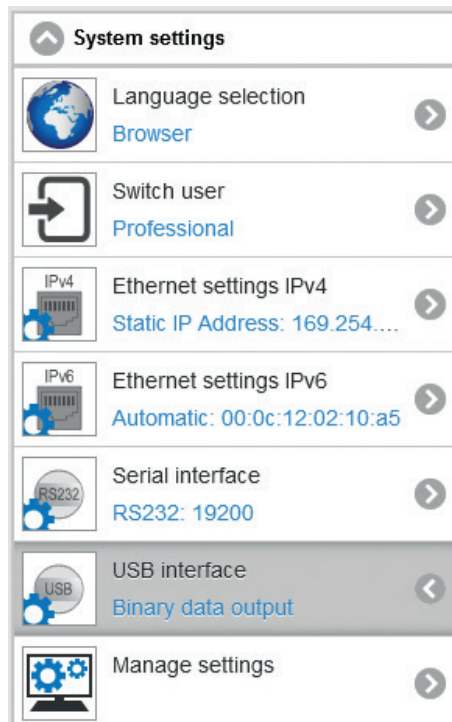
Fig. 77 View of USB interface CFO250
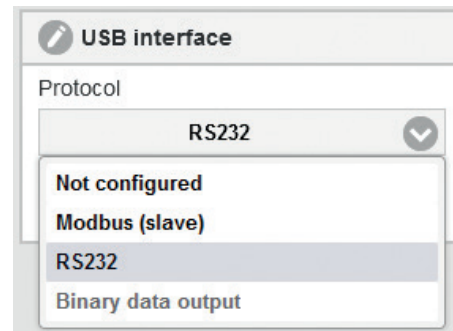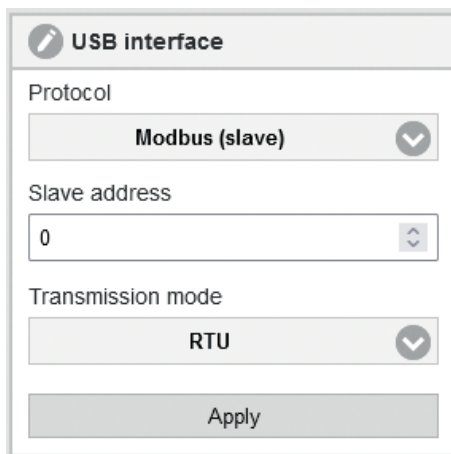
Fig. 76 View of USB interface CFO250 - RS232

Fig. 78 View of USB interface CFO250 - Modbus (slave)

When selecting Modbus (slave), the baud rate, the slave address and the transmission type (RTU or ASCII) can be adjusted.

5.6.8.6 Managing Settings

⏩ Go to the menu `Settings` > `System settings` > `Manage settings`.

All settings on the controller, e.g. controller settings, colors, Ethernet settings, can be permanently stored in user programs, so-called parameter sets.
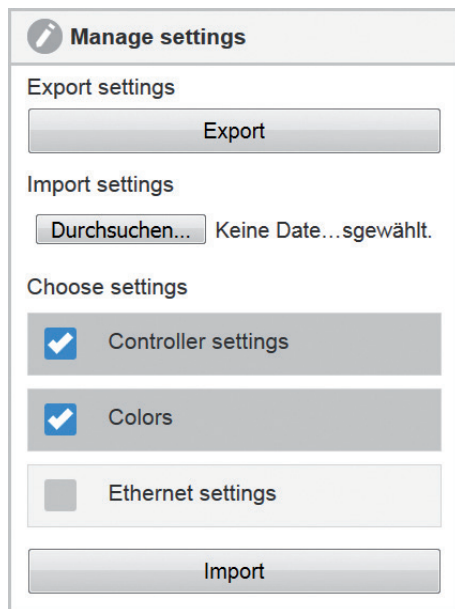
During programming, all settings are saved in the controller regularly (every 30 s at the latest) so that they are available again the next time the controller is switched on.

ℹ️ However, it is recommended to save the data in an external parameter set to be able to reconstruct them in case of a system failure.

⏩ To do this, select `Manage settings` > `Export settings` > `Export`.

Fig. 79 Manage settings window

Managing settings	Export settings	Controller settings	Exports all settings of colorSENSOR CFO to a file.
		Colors	
		Ethernet settings	
	Import settings	Controller settings	Imports settings from a file to the colorSENSOR CFO.
		Colors	
		Ethernet settings	

Export: The file can be used to transfer settings from one colorSENSOR to another or to send to support in case of problems.

i The exported file contains all sensor settings + learned color values in the color table.

➡ Click the Export button to export the settings to a file.

Import: The settings to be imported can be selected, see Fig. 79:

- Controller settings
  - Outputs, internal settings,...
- Colors
  - Recognition profile, color table,...
- Ethernet settings
  - IP address, subnet mask, ...

➡ After your selection, click the Import button to load settings from a file.

Fields with gray background require a selection.

Value Fields with dark border require entry of a value.

5.6.8.7   Reset Sensor

▣➡ Go to the menu `Settings` > `System settings` > `Reset sensor`.

Here you can reset the colorSENSOR CFO to the factory settings or restart it.

Reset sensor
Factory defaults
Factory defaults
Reboot
Reboot
Trigger settings (detection profile)
Reset
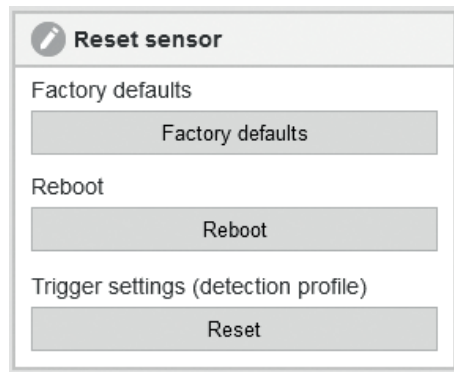
Fig. 80 Reset sensor

Clicking `Factory defaults` overwrites the currently used settings with the factory settings, including all changes related to the detection profile, color table, interface configuration. You can find the factory defaults in the appendix, see A 2.

i   After resetting, the controller is assigned a fixed IP. Communication with the web interface may need to be re-established.

Previous firmware updates are retained. If these are also to be reset, you must proceed as described in the chapter Factory Reset, see 5.7.

Clicking `Reboot` restarts the colorSENSOR CFO. This may take a few minutes.

i   After a firmware update, the computer restarts automatically.

Click on `Reset` to reset all trigger settings in the detection profiles. You can set a large number of different triggers. You can use this function to reset all trigger settings in all created detection profiles. This avoids having to search for the trigger settings in your individually created detection profiles.

5.6.8.8   Update Firmware

⏩ Go to the menu `Settings` > `Systems settings` > `Update firmware.`

This function allows you to update the colorSENSOR CFO with the selected firmware file.
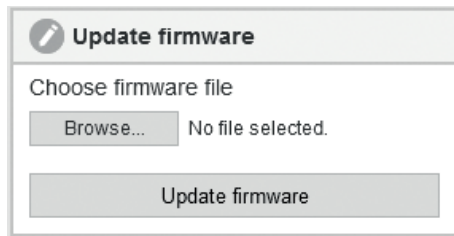
Fig. 81 Update firmware

⏩ Click the `Browse` button to select your firmware file.

⏩ Now click on the `Update firmware` button.

ℹ️ The firmware update may take up to 15 minutes. Please keep the browser window in the foreground. Do not disconnect the colorSENSOR from the power supply or the PC during the update.

If the selected firmware file is not valid, you will get the following error message:
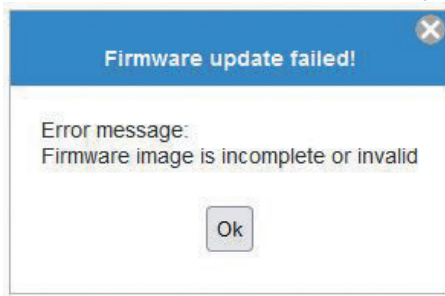
After a successful update, you will receive a message that the update was performed successfully and the controller will restart.

i   After a firmware update, it is recommended to reset the sensor, as the factory settings may also have changed, see 5.6.8.7.

You can then load your previously saved parameters, see 5.6.8.6 back onto the controller.

5.7 Factory Reset

A factory reset can be triggered as follows:

▶ Disconnect the controller from the power supply.

▶ Hold the `INT` and `ESC` keys depressed.

NOTICE

Avoid pressing any other keys during this procedure. Otherwise the process can become stuck in an undefined state.
> Damage of the controller

▶ Switch the power supply back on.

▶ Keep the keys pressed for > 2 seconds and then release them as soon as the LEDs start flashing.

The controller then starts resetting to factory defaults, see A 2. During this operation all controller settings as well as all firmware updates performed in the meantime are discarded. Resetting requires approx. 5 minutes. In the event of an error, e.g. interrupted power supply, the reset is continued during the next restart. No color recognition is indicated and no entries are possible during the reset operation. Key actuation is acknowledged by error flashing (3x100 / 300 ms).

Indicators

Output LEDs: Pulsating progress bar (indeterminate progress bar)
Key LEDs: Not illuminated
Power LED: Illuminated continuously
Key-lock LED: Illuminated continuously

6. Notes for Operation

6.1 Cleaning

Cleaning of the sensor end faces is recommended at regular intervals.

Dry Cleaning

This can be accomplished with an anti-static lens brush or by blowing off the lens with dehumidified, clean, oil-free compressed air.

Wet Cleaning

Use a clean, soft, lint-free cloth or lens cleaning paper and lens cleaner to clean the lens.

Never use commercially available glass cleaner or other cleaning agents.

7.   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.

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/.

8. Service, Repair

If the measuring system is defect, please send in the affected parts for repair or replacement.

If possible, save the current settings in a parameter set to reload them into the sensor after the repair.

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

MICRO-EPSILON Eltrotec GmbH
Manfred-Wörner-Straße 101
73037 Göppingen / Germany

Tel: +49 (0) 7161 / 98872-300
Fax: +49 (0) 7161 / 98872-303

eltrotec@micro-epsilon.com
www.micro-epsilon.com

9. 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

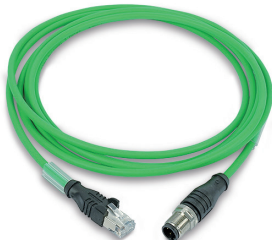For Germany / the EU, the following (disposal) instructions apply in particular:

- 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.

Appendix

A 1   Optional Accessories

Name	Photo	Description	Article number
Power supply cable			
CAB-M12-8P-Bu-ge;2m-PUR;open		Connection cable; 2 m long	11234717
CAB-M12-8P-Bu-ge;5m-PUR;open		Connection cable; 5 m lang	11234718
CAB-M12-8P-Bu-ge;5m-PUR-D;open		Connection cable; 5 m long; for use with drag chain	11234719
Ethernet cable			
CAB-M12-4P-St-ge;2m-PUR-Cat5e;RJ45-Eth		Ethernet cable; 2 m long	11234735
CAB-M12-4P-St-ge;5m-PUR-Cat5e;RJ45-Eth		Ethernet cable; 5 m long	11234736
CAB-M12-4P-St-ge;5m-PUR-Cat5e-D;RJ45-Eth		Ethernet cable; 5 m long; for use with drag chain	11234737

Name	Photo	Description	Article number
Digital I/O			
CAB-M12-8P-St-ge;2m-PUR;open		Connection cable; 2 m lang	11234722
CAB-M12-8P-St-ge;5m-PUR;open		Connection cable; 5 m lang	11234723
CAB-M12-5P-St-ge;2m-PUR;open		Connection cable; 2 m lang	11234727
CAB-M12-5P-St-ge;5m-PUR;open		Connection cable; 5 m lang	11234728
CAB-M12-8P-St-ge;5m-PUR-D;open		Connection cable; 5 m long; for use with drag chain	11234724
CAB-M12-5P-St-ge;5m-PUR-D;open		Connection cable; 5 m long; for use with drag chain	11234729
Name	**Photo**	**Description**	**Article number**
USB cable			
USB cable CAB-M12-5P-St-ge;2m-PUR;USB		USB cable; 2 m long	11234732
USB cable CAB-M12-5P-St-ge;5m-PUR;USB		USB cable; 5 m long	11234733
CAB-M12-5P-St-ge;5m-PUR-D;USB		USB cable; 5 m long; for use with drag chain	11234734

Name	Photo	Description	Article number
Power supply			
PS2020		Power supply for top-hat rail installation, input 230 VAC, output 24 VDC/2.5 A	2420062
PS2031		Plug-in power pack 24V/24W/ 1A; 2m-PVC; Terminal-2P-BU-ge	2420096

Name	Photo	Description	Article number
CFS Sensor (Color Fiber Sensor)			
CFS4-C20		Reflex sensor	10810568
Further sensors can be found in the catalog or are available on request.			

Name	Photo	Description	Article number
Mounting accessories			
CFO mounting adapter		For fastening colorSENSOR CFO100 or CFO200 or as replacement for colorSENSOR LT-1-LC-10 and LT-1-ST	11234713
CFO DIN rail mounting kit		Accessory for CFO mounting adapter (Part No.: 11234713) for mounting on standard mounting rail (top hat rail TS35)	11234762

Name	Photo	Description	Article number
CFO DIN rail mounting adapter		For mounting colorSENSOR CFO100 or CFO200 on standard mounting rail (top hat rail TS35)	11234763

Protective caps			
Protective cap M12 for cable box		Protective cap for covering open, unused connection sockets for IP65 protection	11234789
Protective cap M18 for FA adapter		Protective cap avoids soiling of LED and receiver	37930128

Name	Photo	Description	Article number
Additional information			
White standard		White standard; reflection 99 %	11234694 11234695
Vacuum feed-through		Vacuum feed-through	10811916
C-mount lens		C-mount lens	11293186

A 2   Factory Settings

Parameter name	Value
IP address	169.254.168.150
Language ´settings	Browser
Light source	LED on
Exposure mode	AC
Measurement frequency	1000 Hz
Triggering	None, controller starts data transfer after configuration of output signals, as well as selection of interface or after diagram is called in browser.
Primarily used interface	Web diagram, Color OUT (SYS, Digital I/O)
Measuring program	Color inspection
Switching output `Color not recognized`	All outputs to `high`
Color database	Default data, deletes all learned colors
Measurement averaging	Automatic depending on measurement frequency using max. 200 values
Color space	Lab
Color tolerance space	Cylinder (ΔL, Δab)
Color tolerance stage	4 (ΔL = 8.0; Δab = 4.0)
Operating mode after system start	Ethernet

A 3   Interface Instructions

The current Interface Instructions for the colorSENSOR CFO contains the interfaces:

- REST API

- RS232 or USB

- Modbus

The documentation is available at
https://micro-epsilon.com/download-file/man--colorSENSOR-CFO-Interfaces--en.pdf

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