MICRO-EPSILON

Instruction Manual

colorSENSOR CFO

CFO100
CFO200

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

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Contents

1. Safety

The handling of the system assumes knowledge of the instruction manual.

1.1 Symbols Used

The following symbols are used in this instruction manual:

⚠ CAUTION	Indicates a hazardous situation which results in minor or moderate injuries if not avoided.
NOTICE	Indicates a situation which results in property damage if not avoided.
➪	Indicates a user action.
i	Indicates a user tip.

1.2 Warnings

⚠ CAUTION

Connect the power supply and the display/output device in accordance with the safety regulations for electrical equipment.
> Danger of injury

> Damage to or destruction of sensor

The power supply must not exceed the specified limits.
> Danger of injury

> Damage to or destruction of sensor

NOTICE

Avoid shocks and impacts to the sensor.
> Damage to or destruction of sensor

Never fold the optical fiber and do not bend them in tight radii.
> Damage to or destruction of fiber optics, partial failure of the measuring device

Protect the ends of the optical fibers against contamination (use protective caps).
> Failure of the measuring device

1.3 Notes on CE Marking

The following applies for the colorSENSOR CFO: EMC regulation 2014/30/EU

Products which carry the CE mark satisfy the requirements of the quoted EU directives and the European standards (EN) listed therein.

The EU declaration of conformity is kept available according to EU directive article 10 by the authorities responsible at

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The measuring system is designed for use in industry and satisfies the requirements.

1.4 Proper Use

The colorSENSOR CFO is intended for use in the industrial sector. It is used for color measurement in

- Printing
- Packaging
- Cleaning
- Quality control
- Process documentation

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

- The sensor must be used in such a way that no persons are endangered or machines and other material goods are damaged in the case of malfunctions or total failure of the controller.
- Take additional precautions for safety and damage prevention for safety-related applications.

1.5 Proper Environment

- Protection class: IP 65
- Operating temperature: -10 °C ... +55 °C
- Storage temperature: -10 °C ... +85 °C
- Humidity: 20 - 80 % relative humidity (non-condensing)
- Ambient pressure: Atmospheric pressure

The sensor is stable and can be used in a wide temperature range. When all sockets are in use or covered 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 sensor for precise color recognition in industrial applications, built into a sturdy aluminum housing. The controller is distinguished by high color accuracy, state-of-the-art interfaces and intuitive operation. Optical fibers, which can be adapted for various measuring tasks, are connected to the controller. The rear of the sensor allows fixation using the dovetail principle. A coupling is available separately for mounting on a DIN rail, see Chap. A 1.

2.2 Measuring Principle

The specimen is illuminated with homogeneous, white light from an LED. An illuminated dot is projected with the aid of a optical fiber onto the surface to be checked. The light is reflected diffusely at a specified angle and transmitted by the same optical fiber to a perceptive True Color Sensor (XYZ) where it is analyzed.

The three light wavelength ranges, i.e.

- X = long wave,
- Y = medium wave and
- Z = short wave frequency ranges

from the specimen are used to determine the diffuse color reflections and transformed to 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 sensor 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 keyboard 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 Functions

2.3.1 General

- Recognition of stored colors
- Control interfaces
  - Keys and displays
  - REST API
  - Terminal (RS232)
  - Trigger inputs
- Signaling/monitoring of recognition results via
  - Switching outputs
  - all interfaces mentioned above

2.3.2 Color Processing

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

2.4 Technical Data

Model	CFO100	CFO200
Object distance	Depending on optical fiber used as well as front lens attachment Reflex optical fiber typ. 2 mm - 25 mm with lens typ. 5 mm - 100 mm [1)]	
Light spot diameter	Depending on optical fiber used as well as front lens attachment Reflex optical fiber typ. dia. 0.6 mm - 20 mm [1)]	
Color distance	ΔE ≥ 1.0	ΔE ≥ 0.5
Color spaces	XYZ, xyY, L*a*b*, L*u*v*, u'v'L*	
Distance models for color recognition	Classification, sphere (ΔE), cylinder (ΔL, Δab), box (ΔL, Δa, Δb) with custom tolerance parameters for each color group learned	
Averaging	Automatic adaptation using a maximum of 200 values	Automatic adaptation using a maximum of 57600 values
Size of color memory	Max. 255 colors in non-volatile EEPROM with parameter sets	Max. 4000 colors in non-volatile EEPROM with parameter sets
Switching frequency	Max. 10 kHz (depending on number of colors learned and setting for averaging)	Max. 30 kHz (depending on number of colors learned and setting for averaging)
Reproducibility	ΔE ≥ 0.5	ΔE ≥ 0.25
Temperature drift X,Y	0.1 % / 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)	White light LED (425 - 750 nm); AC operation; DC operation (luminous flux at 1 kHz 220 lm) (adjustable or OFF for primary light source, switchable via software)
Type of illumination	via optical fiber	
Effect from illumination	Automatically adaptable	
Ambient light	Up to 5000 Lux	
Alternating light operation	AC: typ. 1 kHz; max. 10 kHz	AC: typ. 1 kHz; max. 10 kHz

1) Model: FAR-T-A2.0-2.5-1200-67° Reflex
Model: FAD-T-A2.0-2.5-1200-67° transmitted light

Model	CFO100	CFO200
Power supply	+18 - 28 V DC	
Power consumption	Typ. 500 mA	
Max. switching current	100 mA	
TEACH key/inputs	5 keys and IN0 for externally teaching color reference, tolerance stage and configuring sensor	5 keys and IN3 for externally teaching color reference, tolerance stage and configuring sensor
Outputs	OUT 0 - OUT 2, digital (0V/+Ub), 100 mA max. switching current	OUT 0 - OUT 27, digital (0V/+Ub), 100 mA max. switching current
Switching state display	Visualization with 13 white LEDs	
Interface	Ethernet and RS232 Process interface	Ethernet, RS232 and USB Process interface
Type of connector	To Power/PLC: 8-pin Male flange connector (M12A) to PC: 4-pin Female flange connector (M12D) (Ethernet DHCP compatible)	To Power/PLC: 8-pin Male flange connector (M12A) to PLC: 8-pin Female flange connector (M12A) to PC: 4-pin Female flange connector (M12D) (Ethernet DHCP compatible)
Connection cable	To Power/PLC: Part No. 11234717/ to PC: Part No. 11234735 (Ethernet)	To Power/PLC: Part No. 11234717/ to PLC: Part 11234722 to PC: Part No. 11234735 (Ethernet)
Receiver	3-color filter detector (XYZ TRUE COLOR Detector, color filter curve according to CIE1931)	
Software	Web browser operation	
Pulse extension	Adjustable > 30 μs	
Signal amplification	2 Stages, automatic	5 Stages, automatic
Housing material	Aluminum, anodized black	
Operating temperature	-10 °C to +55 °C	
Storage temperature	-10 °C to +85 °C	
Protection class	IP 65	
Weight	190 g	

2.5 Displays

The sensor 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 Sensor

1 instruction manual

- Carefully remove the testing system parts from the packaging and ensure furthermore 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.
- In case of damage or missing parts, please contact the manufacturer or supplier immediately.

You will find optional accessories in appendix, see Chap. A 1

3.2 Storage

Storage temperature: -10 to +85 °C

Humidity: 5 to 95 % (non-condensing)

4. Assembly

4.1 Attachment and Mounting

Pay attention to careful handling during mounting and operation.

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

Position the sensor 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 Chap. A 1.

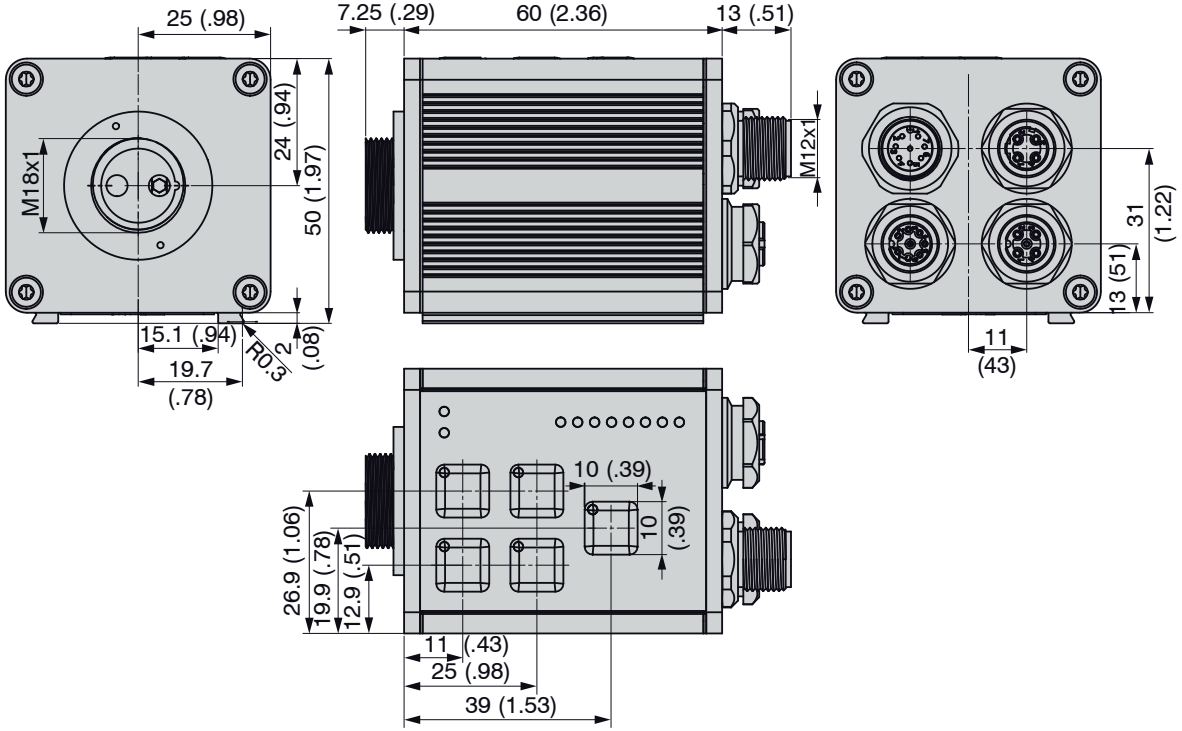


Fig. 1 Scale drawing of colorSENSOR CFO100/CFO200, dimensions in mm, not to scale

NOTICE

Do not allow the end surfaces of the optical fiber to hit against edges or surfaces. Reduced signal quality or failure of the measuring device.

4.2 Operating Elements

The operating concept, as well as the function of the foil keyboard, are described in the Chapter Foil Keyboard, see Chap. 5.2.

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

Fig. 2 Controls

4.3 Sensor LEDs

Eight LEDs (output indicators) are located at the bottom right edge of the keyboard. Moreover an additional LED (key indicator) is embedded in each key at the top left.

The LEDs can assume the following states:

- Switched off
- Continuously illuminated
- Various flashing rhythms

LED	Color	Meaning	Location
	Green	Operating voltage present	
	Red	Key lock active	
TEACH AUTO	White	Color teach menu	
INT ↵	White	Menu for automatic illumination adjustment	
CLR ←	White	Delete memory menu	
OPT →	White	Option selection menu	
ESC TOL	White	Tolerance adaptation menu	

Fig. 3 Sensor LEDs - keys

A list of increasing numbers (1 ... 8) is located to the right of the eight output LEDs, see Fig. 4. These are used to assign the eight output LEDs to the eight switching outputs available[1]. The options are located to the left of the eight output indicators, see Fig. 3, see Fig. 4.

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

Fig. 4 Sensor LED‘s

1) Only three switching outputs are present on the colorSENSOR CFO100. These correspond to LEDs 1 ... 3. These correspond to 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.
> Injury hazard from high voltage

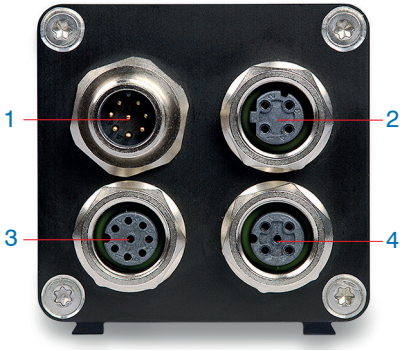


Fig. 5 Connector location on colorSENSOR CFO200

Fig. 6 Electrical connections on colorSENSOR CFO200

1 SYS = System (Power/PLC)	Power supply, switching outputs, switching inputs, 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

The frequently used and standardized M12 sockets allow use of standard commercial cables to match the specific, special requirements of the specific 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 sensor 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 sensors.

All sensor connections are unique in terms of number of pins and gender so that mix-ups are not possible.

To achieve IP65 class protection it is necessary to seal unused sockets with a protective cap (including gasket), and use a optical fiber with FASOP connector and corresponding gaskets.

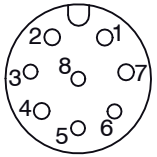
4.4.1 System, Power and PLC (SYS)

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

- 8-pin Male connector
- 24 VDC ± 15 %, I_{max} < 500 mA
- not electrically separated, polarity reversal protection, GND is electrically connected to GND for switching outputs.

Pin	Color [1]	Function	Description
1	White	IN0	Trigger input
2	Brown	+UB	Operating voltage (10 ... 28 VDC) Operating 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 sensor flange connector



Pin sequence, 8-pin Cable socket, viewed from solder side

1) Conductor color CAB-M12-8P-Bu-ge

Fig. 7 SYS Power / PLC connector

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

Use: Direct for 3 individual colors or binary for 7 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 shielded cable with a length < 30 m.

i Micro-Epsilon recommends use of CAB-M12-8P-Bu-ge cable, available as an option, see Chap. A 1.

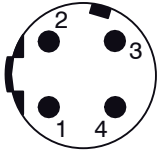
4.4.2 Ethernet (ETH)

For data transmission connection to an RJ45 Ethernet connector
- 4-pin Female connector
- with Ethernet network (PC)

➪ Connect the sensor to the network using a shielded Ethernet cable (Cat5E) with a length < 100 m. Micro-Epsilon recommends use of the optionally available cable CAB-M12-4P-St-ge ... RJ45-Eth, see Chap. A 1.

Pin	Color [1]	Function	Description [2]
1	Orange/ white	TX+	Ethernet
2	Blue/ white	RX+	Ethernet
3	Orange	TX-	Ethernet
4	Blue	RX-	Ethernet

View of sensor flange socket



Pin sequence, 4-pin Cable connector, view of solder side

Fig. 8 ETH Ethernet socket

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

1) Conductor color CAB-M12-4P-St-ge ... RJ45-Eth

2) Specification pursuant 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 operating voltage +UB 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.

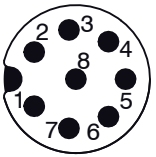
All GND conductors are interconnected with one another and to operating voltage ground.

➡ Use shielded cable with a length < 30 m.

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

Pin	Color [2]	Function	Description
1	White	IN1	Trigger input
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)

View of sensor flange socket



Pin sequence, 8-pin Cable connector, view of solder side

Fig. 9 I/O Digital I/O Connector

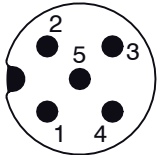
The color outputs can be programmed on the keyboard.

1) Applies only for colorSENSOR CFO200.

2) Conductor color CAB-M12-8P-St-ge

4.4.4 USB

It should be possible at a later time to incorporate additional communication modules via the USB interface [1], for example, to establish a WiFi or Bluetooth connection to the sensor.

Pin	Color	Function	Description		
1	Brown	USB-VDD	USB (Host or Client)	 View of sensor flange socket	 Pin sequence, 5-pin Cable connector, view of solder side
2	White	USB Data-	USB (Host or Client)		
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. 10 USB connector					

1) Applies only for colorSENSOR CFO200

4.4.5 Switching Input Circuit

The switching input IN can be connected to the operating voltage potential +UB as follows.

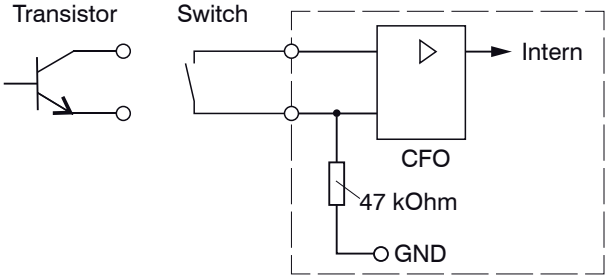


Fig. 11 Switching input circuit (schematic)

Model CFO100 and CFO200				
Pin	**Color CAB-M12-8P-Bu-ge**	**Function**	**Description**	**Remarks**
1	White	IN0	Switchable trigger input, Teach reading trigger or color	Not electrically separated, comparator input with threshold at UB/2 +/-5 %, low level < UB/2 +/- 5 %, high level > UB/2 +/- 5 % (max. 30 V), internal pull-down resistor, open input is recognized as low.

Model CFO200				
Pin	**Color CAB-M12-8P-St-ge**	**Function**	**Description**	**Remarks**
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 Sensor LED level adjustment, white balance, key lock	Not electrically separated, comparator input with threshold at UB/2 +/-5 %, low level < UB/2 +/- 5 %, high level > UB/2 +/- 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 UB/2 +/- 5 %	
Low level	< UB/2 +/- 5 %
High level	> UB/2 +/- 5 % (max. 30 V)

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

4.4.6 Switching Output Circuit

The switching outputs are connected as follows:

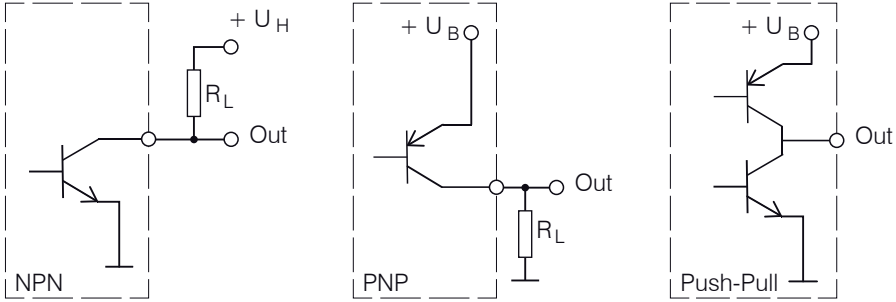


Fig. 12 Switching output circuit (schematic)

The switching behavior (NPN, PNP, Push-Pull) is programmable, see Chap. 5.7.5.4.

The NPN output is, for example, suitable for adaptation to a local TTL logic circuit with auxiliary voltage of U_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, 24V Logic (HTL), low level GND, high level +UB (max 28 V)

Model CFO100 and CFO200				
Pin	**Color CAB-M12-8P-Bu-ge**	**Function**	**Description**	**Remarks**
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 = +UB, I^{max} = 100 mA
6	Pink	OUT1		
8	Red	OUT2		

Model CFO200				
Pin	**Color CAB-M12-8P-Bu-ge**	**Function**	**Description**	**Remarks**
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 = +UB, I_{max} = 100 mA
5	Gray	OUT4		
6	Pink	OUT5		
7	Blue	OUT6		
8	Red	OUT7		

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

	High Level		**Low Level**	
Output voltage	+UB		GND	
Saturation voltage	Iout = 10 mA	+UB -0.3 V	Iout = 10 mA	GND +0.2 V
	Iout = 100 mA	+UB > -1.5 V	Iout = 10 mA	GND < +1.5 V

4.5 Optical Fiber, Sensor Cable

Plug the optical fiber into the optical fiber connector on sensor.

Fig. 13 Optical fiber connector on sensor

Fig. 14 Installation of optical fiber cable

The coding for the optical fiber connection (FA) is located on the illumination LED.

NOTICE

Keep the end surfaces of the optical fiber cable free of dust, avoid any damage or soiling, e.g. by touching with fingers. This also applies for the plug connector on the sensor.

> Error-free recognition of colors no longer guaranteed

> Incorrect measurements

> Damage to optical fiber

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

Please observe the permissible minimum bending radius for the optical fiber used.
Failure to observe the minimum bending radius (depending on the type of optical fiber used) leads to breakage of the optical fiber.

Since the optical fiber cable consists of multiple fibers, breakage of any of the optical fibers leads to a reduction in the illumination intensity and, in the case of signal cables, to a decrease in the measuring signal. Fiber breakage leads to a loss in the measuring sensitivity up to complete loss of the measuring signal.

Replace the optical fiber only with the light source switched off to prevent dazzle.

5. Operation

5.1 Commissioning

Connect the sensor to the optical fiber cable, see Chap. 4.5.

Fig. 15 Overall view of colorSENSOR CFO with optical fiber

Connect the sensor to a power supply, see Chap. 4.4.1.

Switch on the power supply.

After switching on the sensor, the green LED flashes and the red LED illuminates continuously as long as the sensor is booting, see Fig. 16.

Fig. 16 Green LED flashing, red LED illuminated continuously

The sensor is in the operating mode when only the green Power LED is illuminated, see Fig. 17.

Fig. 17 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 circuit for color is not detected.

In the delivery state, all outputs are set to `high` when a color is not detected.

This basic setting can be changed via the Rest-API, see Chap. A 3.

5.2 Membrane Keys

The colorSENSOR CFO can be configured using the network interface, the serial interface and the keyboard integrated into the housing. Due to the functional scope and the accessibility of the sensors, only the most important settings are accessible via the keyboard. For special applications it may therefore be necessary to use the network or serial interface to make initial settings.
The keyboard has a number of keys and LEDs.
The most important settings and sensor operations can be activated via the keys:

- Adjusting illumination intensity (`INT`)
- Teaching colors (incl. tolerance) (`TEACH` or `TOL`)
- Deleting color groups / color table (`CLR`)
- Adjusting sensor behavior
  - Triggered teach
  - Triggered evaluation
  - Hold time
  - Single/multiple teaching operations
  - Changing tolerance model
- Adapting standard tolerance

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

5.2.1 Keys and Key Assignments

The keyboard comprises the following keys:

	Teach
	Automatic level adjustment
	Intensity setting
	Enter / save
	Select options
	Arrow pointing right
	Escape / Quit without saving
	Adapt standard tolerance
	Delete
	Arrow pointing left

The inscription on the key indicates the operating function when the key is depressed for a longer period (e.g. a menu). The inscription below the key indicates the momentary 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 momentarily. The function becomes effective when the key is released.

5.3 Brief Instructions

The instructions below do not describe any specific sequence of activity; they are simply a diverse compilation of typical key actuations in the operating mode, see Fig. 18 and in the menu mode, see Fig. 19. Detailed descriptions of all actions, see Chap. 5.2 or, see Chap. 5.4.

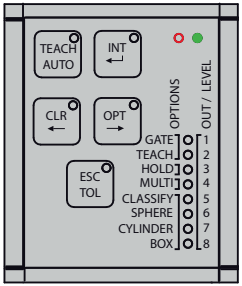


Fig. 18 Screen shot, operating mode

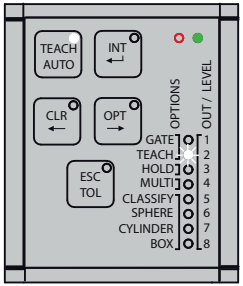


Fig. 19 Screen shot, menu mode

Before		After	Action
Operating mode	→	Menu mode	⇨ Depress (hold down) one of the keys for longer than 2 sec. to change over from the operating mode to various menus.
Menu mode	→	Submenu	With the exception of the `ESC/TOL` key, all keys call a separate menu, whose contents is defined by the inscription on the key. Pressing the `TOL` key in the `TEACH` menu calls the submenu for `Tolerance adaptation`.
Change-over within menu	→ ←	Change-over within menu	⇨ Press one of the ← / → keys (`CLR/OPT`) for less than 2 sec. to change over between colors, options, etc. within a menu.
Menu mode	→	Start action	⇨ Press the `TEACH/AUTO` key for less than 2 sec. to start an action.

Before		After	Action
Menu mode	→	Save all changes / return to operating mode	Depress (hold down) the ENTER key (INT) for longer than 2 sec. to save the changes made previously and return to the operating mode.
Menu mode	→	Reject all changes / return to operating mode	Depress (hold down) the ESC key (TOL) for longer than 2 sec. to throw out all changes and return to the operating mode without saving.

5.4 Operation Using Foil Keyboard

Various key actions are shown below. The illustration of the LEDs reflects their state:

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

For operation, a keyboard 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 colors are detected, the following illustration is typically applicable.

The sensor is in the operating mode.

In the delivery state all outputs are set to `high` when a `color is not detected`. For this reason the first three switching output LEDs illuminate on the CFO100; on the CFO200 all switching output LEDs illuminate.

5.4.1 Intensity

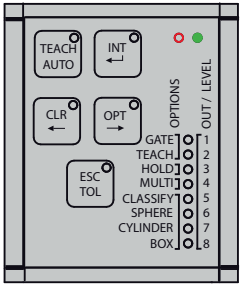
Adjustment of the sensor level is required after installing the sensor and, typically, following any change in the optical conditions, such as:

- Distances
- Alignment
- Lenses

Adjustment of the sensor level is required after installing the sensor and, typically, following any change in the optical conditions, such as:

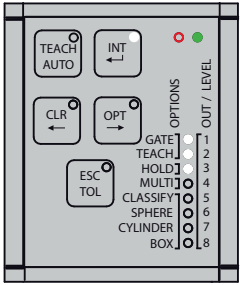
➡ When adapting the intensity settings, always aim the sensor at the brightest specimen anticipated.

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 depressing (holding down) the `INT` key for longer than 2 sec.

The intensity menu is then active.



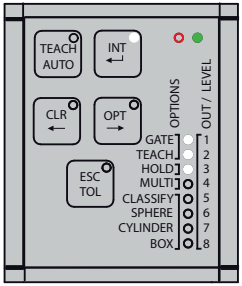
The number of illuminated output LEDs provides for visualization of the relative intensity currently being received by the sensor.

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

In the delivery state the `No color detected` output is set to `All high`. Therefore: All output LEDs 1 - 8 (with CFO100 all output LEDs 1 - 3) illuminate simultaneously when a color is not detected.

5.4.1.1 Automatic Level Adjustment

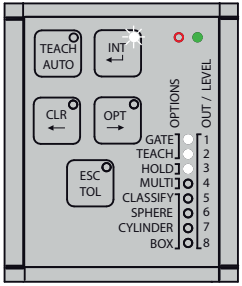
The automatic level adjustment determines a suitable combination of internal sensor parameters for the current optical situation. The primary factor here is the level setting for the illumination LED:



➡ Press the AUTO key for less than 2 sec.

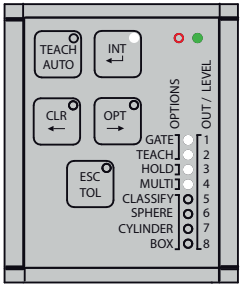
This starts an automatic level setting process

i The level for the sensor parameters should be set for the brightest color to be tested.



The automatic level adjustment process requires several seconds. During this time, output LEDs 1 - 8 flash alternately, i.e. the even numbered LEDs and the uneven numbered LEDs flash on and off together in groups.

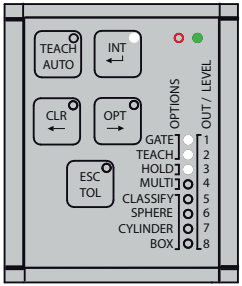
i The automatic level adjustment sets the photo receiver to 80 % saturation.



After conclusion of the automatic level adjustment process the INT LED illuminates continuously. The output indicators provide for visualization of the level achieved.

5.4.1.2 Manual Intensity Control

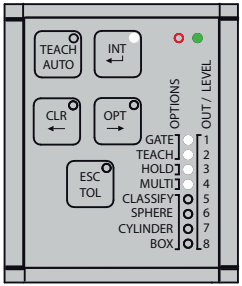
Typically the automatic level adjustment determines a suitable combination of LED intensity, amplification and other internal settings. If a higher level is desired, perform the following steps in the intensity menu.



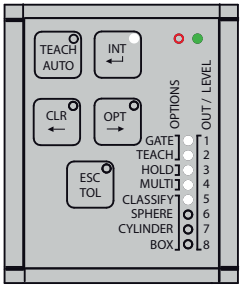
➡ Press the → key for less than 2 sec.

If a lower level is desired, press the ← key for less than 2 sec.

i The photo receiver level can be increased or decreased by 10% by pressing the corresponding arrow key.



After conclusion of the new level setting, the level reached is indicated by the output LEDs.



To save:

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

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

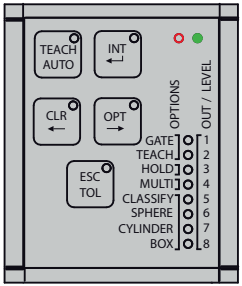
To quit:

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

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

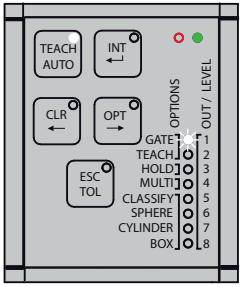
5.4.2 Color Management

After assembly and initial adjustment of the color sensor, see Chap. 5.4.1, the teaching process for colors or color groups can be accomplished for the recognition operation.



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

The display then changes to the (color) `TEACH` menu.



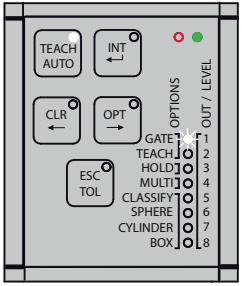
The switching outputs for the selected recognition groups flash rhythmically. The flashing rate indicates the status of the current recognition group.

- Slow flashing indicates that the current recognition group does not presently contain any colors (1 pulse period 100/900 ms).
- Medium-fast flashing indicates that the recognition group comprises at least one color, which, however, has not been detected currently (2 pulse periods (50/50/50/850 ms).
- Rapid flashing indicates that one color in the recognition group has been detected currently (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 ←.

5.4.2.1 Teaching Colors

One or more colors can be learned for each recognition group, see Chap. 5.4.5.3. The recognition groups are differentiated according to their output coding. The 1-out-of-N codes are easily accessible via the keyboard (only one of the output lines is active). Although the subsequent binary codes can be scrolled though individually, the large number of possible combinations (up to 256 for the CFO200) makes it more convenient to use an auxiliary program or the HTTP-API for this purpose.

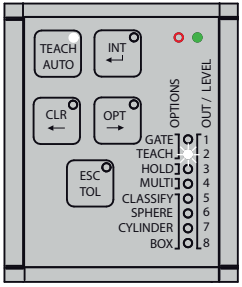


➡ Press the TEACH key for less than 2 sec.

The new color is then saved.

Rapid 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 change to the next recognition group.



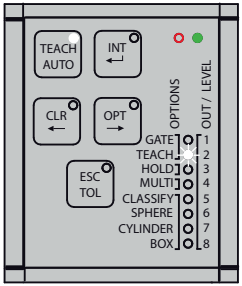
The newly selected recognition group is indicated by slow flashing.

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

Color tolerance adaptation, see Chap. 5.4.4.

i If the multi-teach function is activated, see Chap. 5.4.5.3, you can continue teaching colors as long as the TEACH is held down. In this case the first color is learned after reaching the long actuation time and each additional color is learned in rhythm with the effective scanning rate, however a maximum of 100 colors per second. During this operation the LED in the key flashes momentarily (100 ms) each time a new color is learned.

5.4.2.2 Deleting Individual Color Groups

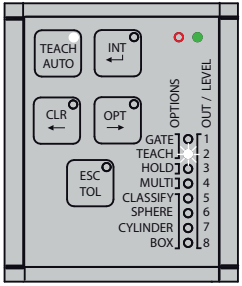


The selected recognition group is indicated by the LED flashing.

- Press one of the arrow keys ← or → for less than 2 sec to selected 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 Chap. 5.4.3.

5.4.2.3 Saving or Quitting upon Conclusion of Teaching Process



To save:

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

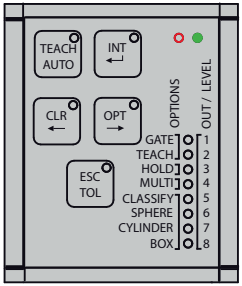
The detected color or the output circuit for `No color detected` (all outputs on) is displayed depending on whether or not the last color learned is still beneath the sensor.

Quit:

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

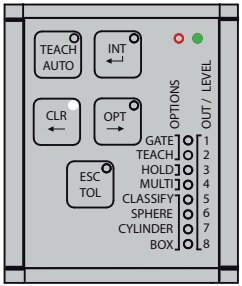
5.4.3 Deleting Color Table

When changing to a new recognition assignment, it is recommendable 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 flash.



To save:

➡ Press the `ENTER` key for longer than 2 sec. to confirm deletion of all colors.

Output LEDs 1 - 8 output the set output circuit signal for `No color detected`.

With the factory settings 3 output LEDs illuminate on the CFO100 and 8 output LEDs on the CFO200.

Quit:

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

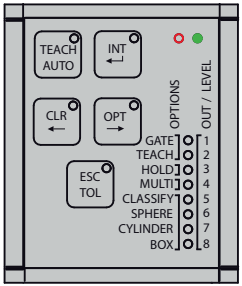
5.4.4 Tolerance Setting

Changing the tolerance of a recognition group is an optional feature. The default tolerance is already sufficient for many applications. It corresponds approximately to the ability of the human eye to differentiate colors (Delta E = 4.0).

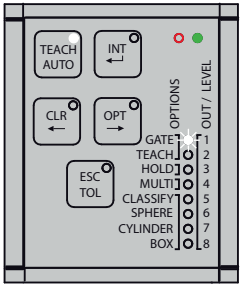
The tolerance is subdivided into the following stages:

	Tolerance space					
	Sphere	Cylinder		Box		
Tolerance stage	ΔE_{rel}	ΔL	Δab	ΔL	Δa	Δb
1	0.5	1.0	0.5	1.0	0.5	0.5
2	1.0	2.0	1.0	2.0	1.0	1.0
3	2.0	4.0	2.0	4.0	2.0	2.0
4	4.0	8.0	4.0	8.0	4.0	4.0
5	6.0	12.0	6.0	12.0	6.0	6.0
6	8.0	16.0	8.0	16.0	8.0	8.0
7	12.0	24.0	12.0	24.0	12.0	12.0
8	20.0	40.0	20.0	40.0	20.0	20.0

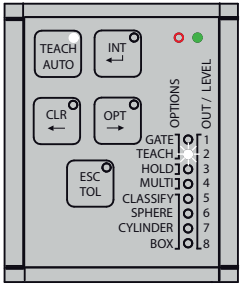
The tolerance is accessible in a color management submenu. All colors in one recognition group have the same tolerance.



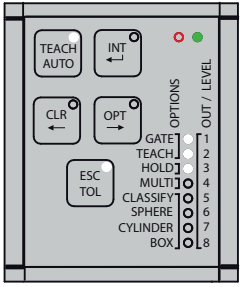
Press the TEACH key for longer than 2 sec. to gain access to the (color) TEACH menu.



➡ Press the ◄— or —► key as often as required, for less than 2 sec. to select the desired recognition group.



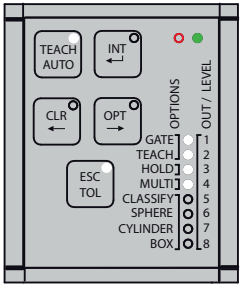
➡ Press the TOL key for less than 2 sec. to enter the tolerance submenu.



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.

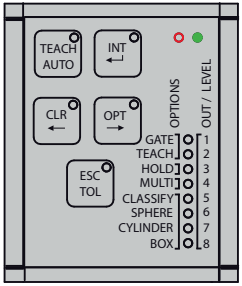
The changed color tolerance stage is displayed.

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

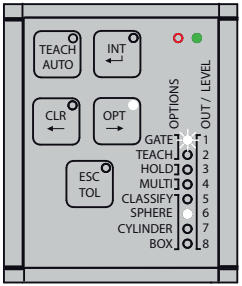
Conclusion of teach operation, see Chap. 5.4.2.3.

5.4.5 Options

The most important operating modes for the color sensor 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 sensor 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:

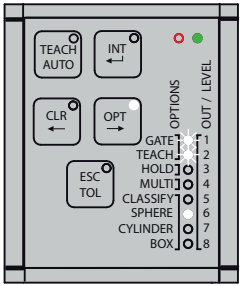
- Function of switching input (GATE and TEACH)
- Holding time for switching outputs (HOLD)
- Teaching process for color groups (MULTI)
- Color recognition profile (CLASSIFY, SPHERE, CYLINDER, BOX)

You can switch back and forth between the option groups by pressing the ← or → arrow key momentarily (less than 2 sec.) to make the settings in the group.

You can change the settings in a option group by pressing the TEACH key momentarily (less than 2 sec.) to change or scroll through the settings.

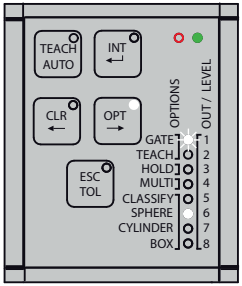
5.4.5.1 IN0 Switching Input Function Assignment

Using the keyboard it is possible to assign switching input IN0 to GATE for triggered color evaluation or to TEACH for triggered color teaching.



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).

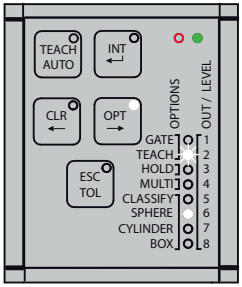
GATE Triggered color evaluation	When the gate is active, the sensor switching outputs are evaluated and updated only when the configured voltage is currently present at the trigger input.
TEACH - Triggered color teach	Triggered teach can be used to make run time changes to the color table without direct human intervention.



➡ 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 signal 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.

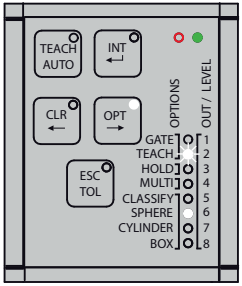
GATE flashes rapidly to signal that the triggered color teach feature is switched on via IN0.

5.4.5.2 Hold Time

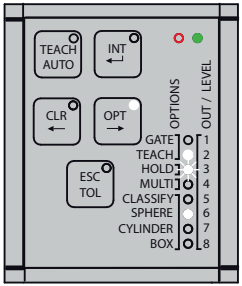
Extending the hold time for a recognition result beyond the actual duration of color matching is practical when the actuators controlled by the color sensor require a certain minimum hold time for the switching level.

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	off
2	10 ms	flashes at 100 /1900 ms
3	1000 ms	flashes at 1900 /100 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.

5.4.5.3 Multiple Teach Mode

The multiple teach mode 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 (HTTP-API or own software).

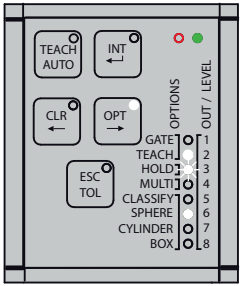
If the multi-teach feature is activated during color teaching, see Chap. 5.4.2.1, hold down the TEACH key for a longer period to teach a number of colors quickly in one color group. The colors continue to be learned as long as the TEACH key is held down.

The first color is learned after reaching the long actuation period (longer than 2 seconds); each additional color is learned in rhythm with the effective scanning rate, however a maximum of 100 colors per second.

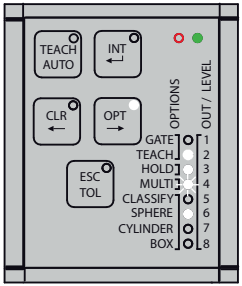
The key LED flashes momentarily (100 ms) each time a color is learned.

i The color memory is limited and can be filled very quickly with this function (color memory for CFO100 max. 256, for CFO200 max. 4000).

After reaching the maximum for the color memory, no further colors are learned.



➡ Press the → key for less than 2 sec. to change to the next option group.

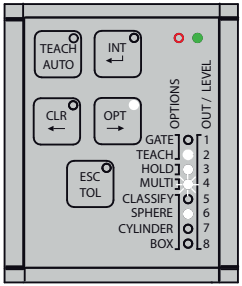


➡ Press the TEACH key for less than 2 sec. to switch over to the multiple teach mode.

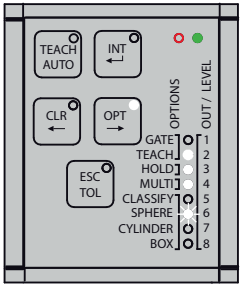
The LED flashes rapidly (1900/100 ms) to signal that the multiple teach mode is activated.

5.4.5.4 Tolerance Mode

It is practical to change the tolerance mode, when your application requires specific color tolerances, see Chap. 5.4.5.5.



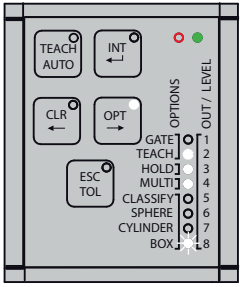
➡ Press the → key for less than 2 sec. to change to the next option group.



➡ 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.

5.4.5.5 Color Tolerance Parameters

The system can be set to the distance models `Box` (ΔL; Δa; Δb), `Cylinder` (ΔL; Δab), `Sphere` (ΔE) and `Classification`. These models form a tolerance space around the learned colors.

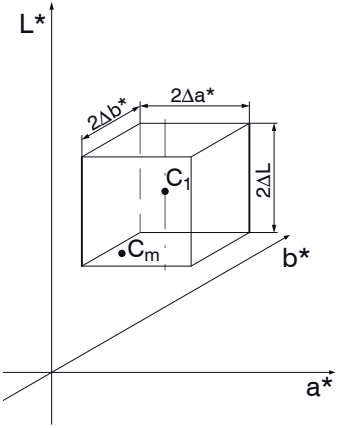


Fig. 20 Tolerance space Box

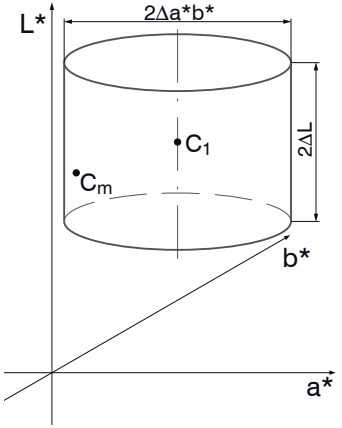


Fig. 21 Tolerance space Cylinder

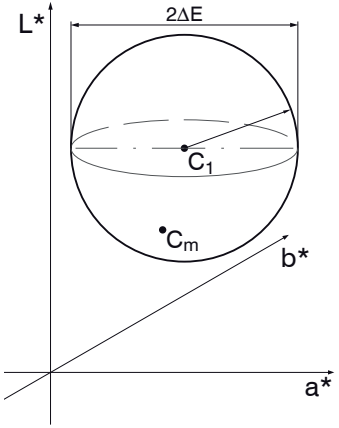


Fig. 22 Tolerance space Sphere

C_1 = learned color 1

C_m = detected color

For evaluation of color deviations, the color tolerance parameters should be based on the perception thresholds for color differences. In the L*a*b* color space, a tolerance threshold of ΔE > 1 is frequently used for perceptible color differences.

Influential 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.

During `classification` the current color readings are associated with the closest color value 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. The following diagram shows an example of how the current color reading Cm is associated with the saved color value C3, see Fig. 23. This association is accomplished based on the smallest distance D3 between Cm and C3.

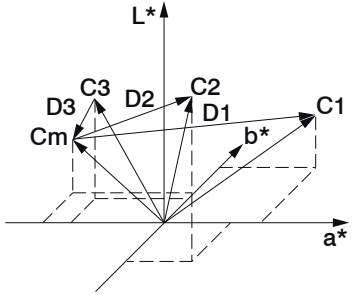
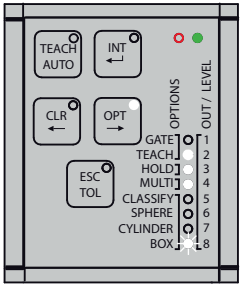


Fig. 23 Distance model classification

5.4.5.6 Conclusion of Option Settings: Save or Quit

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



To 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.

5.5 Trigger Inputs

The trigger inputs can be configured to teach new colors.

Trigger inputs can be used for the following purposes:

- Starting color evaluation
- Teaching colors
- Teaching colors as new group
- Adding colors to current group
- Teaching and grouping colors continuously
- Deleting color table
- Automatic level adjustment for sensor LED
- Rerecording white reference
- Activating key lock

Each trigger can be linked with one or more of the activities above. This can be controlled via the HTTP-API.

5.6 Key Lock

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

The key lock can be activated from the main menu.

➡ For this purpose momentarily press the following keys: `ESC` > `INT` > `ESC`.

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

The key LED illuminates red continuously when the keyboard is locked. When the LED is off, the keyboard is unlocked.

5.7 Operation Via Web Interface

The CFO controller allows creation of dynamic web sites containing the current settings for the controller and peripheral devices. Control is possible only when an Ethernet link exists to the controller.

5.7.1 Prerequisites

A current web browser is required (for example Mozilla Firefox ≥ 54, Google Chrome ≥ 60 or Microsoft Edge ≥ 14) on a PC with network connection. The controller is set to direct connection to facilitate initial commissioning of the control. If your browser is set to access the Internet via a proxy server, please add the controller IP address to the IP addresses in the browser settings, which are not to be routed over the proxy server. The MAC address of the measuring device is given on the controller rating plate.

<table>
<tr><td>Direct connection to PC, controller with static IP
(factory setting)</td><td>Network</td></tr>
<tr><td>PC with static IP</td><td>Controller with dynamic IP, PC with DHCP</td></tr>
<tr><td>➡ Connect the controller to the PC using a direct Ethernet connection (LAN). For this purpose the cable: CAB-M12-4P-St-ge;Xm-PUR-Cat5e;RJ45-Eth.</td><td>➡ Connect the controller to a switch using a direct Ethernet connection (LAN). For this purpose the cable: CAB-M12-4P-St-ge;Xm-PUR-Cat5e;RJ45-Eth</td></tr>
<tr><td>➡ Start a web browser.
➡ Click the task bar and enter the static address for the sensor.
i In the delivery state, this is 169.254.168.150.
• Address type: static IP address
• IP address: 169.254.168.150 [1]
• Subnet mask: 255.255.0.0
This IP address can be adapted on the web site under <code>Settings > Ethernet settings</code>.
i After changing the IP address, please note the new IP address, to find the sensor again later.
1) This assumes that the LAN connection on the PC uses the following IP address, for example: 169.254.168.1.</td><td>➡ Enter the controller in the DHCP / register the sensor 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 a web browser.
➡ Click the task bar and enter the sensor IP address you received from your IT department.
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.</td></tr>
<tr><td colspan="2">The interactive web sites for setting the controller and peripheral devices then appear in the web browser.</td></tr>
</table>

5.7.2 Access via Ethernet

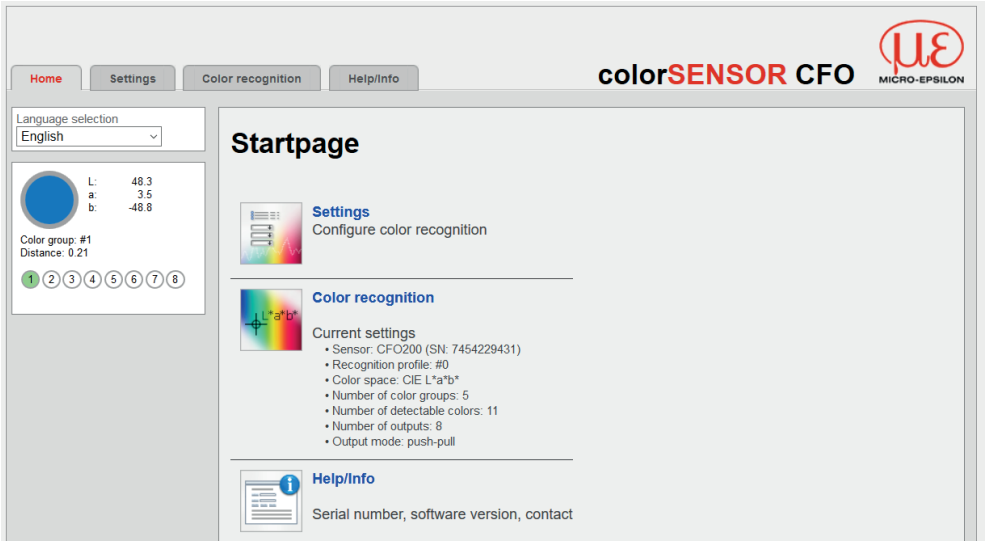


Fig. 24 First interactive web site after calling IP address

The function menus (`Home`, `Settings`, `Color test` and `Help/Info`) can now be accessed in the upper navigation bar.

All settings on the web site are active immediately in the controller after pressing the `Accept` button.

Parallel control via web browser and API commands is possible; the last setting applies and is saved automatically.

The appearance of the web sites can change depending on the functions and peripheral devices. Many sites include descriptions of the parameters and thus tips on configuring the controller.

5.7.3 Displaying Readings Via Web Interface

Start the reading display in the `Color test` menu on the horizontal navigation bar.

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.

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.

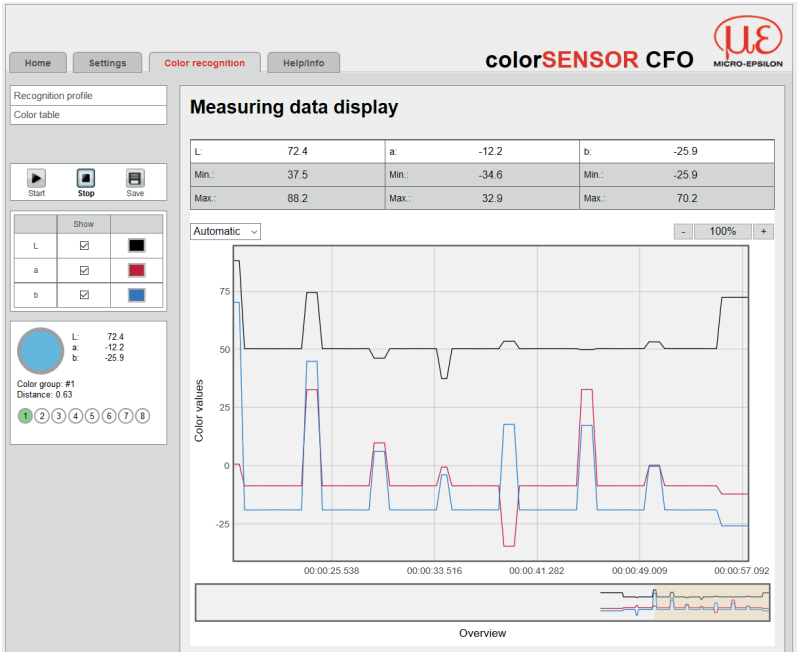


Fig. 25 Display of reading results

5.7.4 Home Menu

When the web site control is started, the `Home` page opens first, see Fig. 24.

The language can be set on the web sites at the top left. The language setting in your control system (PC) is taken over in the basic `System` settings. On the web interface you can select between German and English as languages.

Home	*System*	*All entry fields are case sensitive, consisting of 64 characters from the set of letters (not including foreign character attributes), numbers, spaces and the following special characters: -+#,.()*
	English / German	*Interactive web site language*

Fields with gray background require a selection.

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

The display for the current color located beneath the sensor and its associated color values is located below the language setting. 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 circuit is available at 3 or 8 outputs. Here 1 corresponds to OUT0 and 8 to OUT7 on the male `SYS` connector, see 4.4.1 and the female `I/O` connector., see Chap. 4.4.3.

When the output is switched to `LOW`, white is displayed and when switched to `HIGH`, green is displayed.

5.7.5 Menu Settings

5.7.5.1 Preliminary Remarks

You can program the system using two different methods simultaneously:
- Using the web browser via the control web interface
- With the API commands and terminal program via RS232 or Ethernet (Telnet).

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.

5.7.5.2 Recognition Profile

Go to the menu `Settings > Recognition Profile`.

In the recognition profile you can set and save the basic settings for the colorSENSOR CFO, such as color space, measuring frequency, automatic illumination setting and white reference.

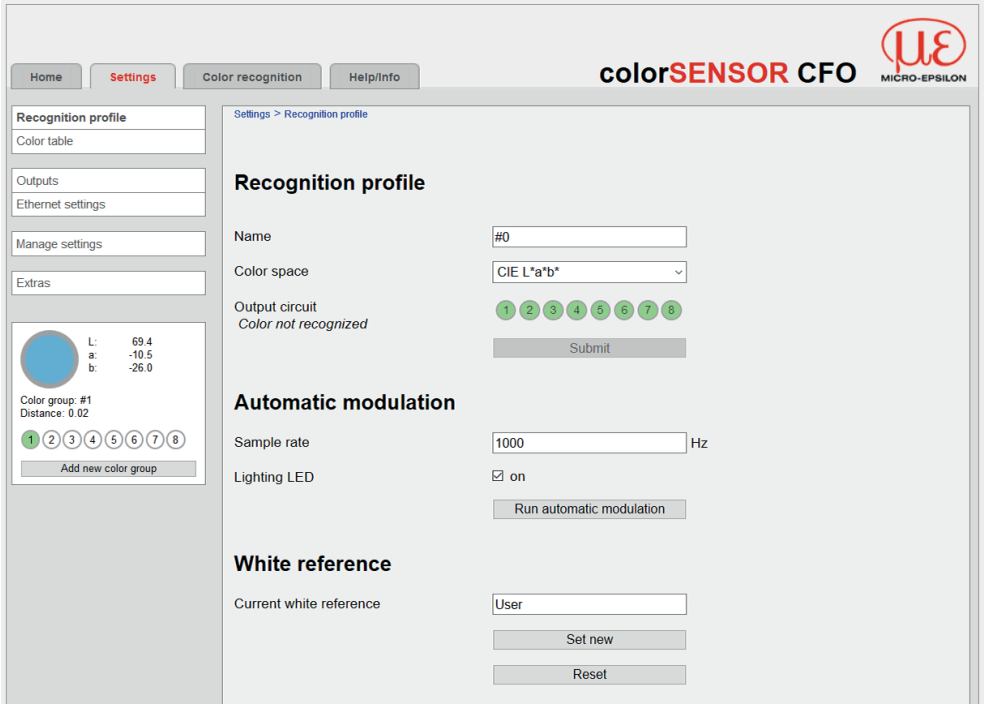


Fig. 26 Screen shot, recognition profile

Recognition Profile	Name	Accept		*Defines name of recognition profile. 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 +-#,.().*
	Color space	*CIE L*a*b*, CIE L*u'v', CIE L*u*v*, CIE xyY, CIE XYZ*		*Selection of color space to be used for recognition.*
	Output circuit	Binary coded for CFO100 OUT0...OUT2, for CFO200 OUT0...OUT7		*Defines outputs to be switched for the state " Color not detected" (green is set to `high`).*
Automatic Level Adjustment	Measuring frequency	Numerical value for CFO100 between 1...10,000, for CFO200 1...20,000		*This setting makes it possible to define a minimum measuring rate.*
	Lighting LED	Switch on	check mark	*Defines whether illumination LED is to be switched on or off during automatic level adjustment. (Required to test primary light sources.)*
		Switch off	no check mark	
	Remeasure level			*Starts automatic level adjustment for illumination LED. Averaging is accomplished using a maximum of 200 values depending on the measuring frequency.*
White reference	Current White reference	Own / factory		
		Set		*Overwrites the factory setting for the white reference, during this process the white reference should be located in the measuring position.*
		Reset		*Sets the white reference back to the factory setting.*

Fields with gray background require a selection.

Value

Fields with dark border require entry of a value.

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

During automatic level adjustment, the lightest color to be detected should be positioned beneath the sensor.

Performing White Balance

A white balance is required after replacing the sensor (optical fiber) or when the measuring environment has changed.

- Switch to the menu `Settings` > `Recognition Profile`.
- Recommendation: Position the white standard (optional accessory) at the permissible measuring distance to the sensor.
- Click on the `Set` button, see Fig. 26.

During white balancing process:
A dynamic field on the web interface provides information on the current progress.
The results of the correction process are not saved directly in the controller; it is necessary to save them separately in a setup process. If the white balancing process fails, the previous white balance continues to be used.

Do not change the light source brightness of the LED following white balancing. Repeat the white balancing process after changing the light source.

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).

5.7.5.3 Color Table

➡ Switch to the menu `Settings > Color Table`, see Fig. 27.

Depending on the version, the colorSENSOR CFO can save up to 4000 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 7 color groups
CFO200	4000	in 254 color groups

Add new color group	Teaches current color in next free color group memory.
Add new color	Teaches current color and adds it to the corresponding color group memory.
Edit	Allows changes in color group settings. Changes can include the name, tolerance evaluation, holding time for output signal, output circuit. 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 +-#,.(). The `Edit` 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 circuit and the holding time for the switching outputs.
Delete	Deletes a color group or color.

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

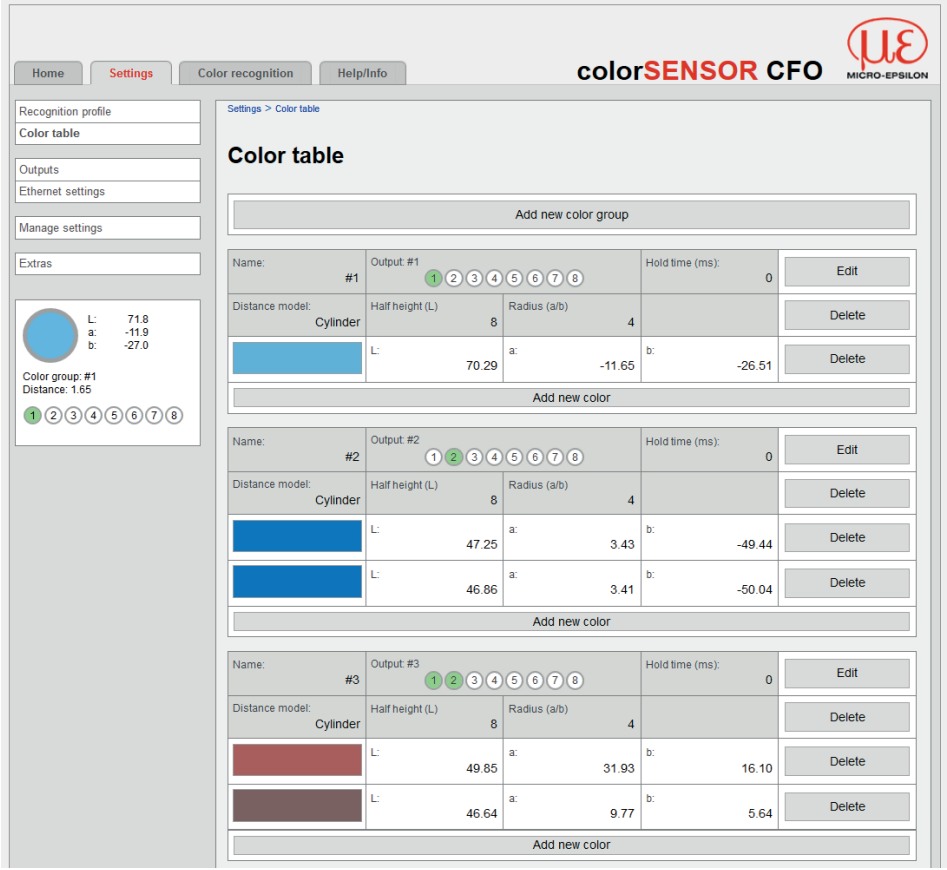


Fig. 27 Screen shot, color table

Creating, Editing Colors

➡ Switch to the menu `Settings > Color Table`, see Fig. 27.

➡ Click on the `Edit` button for a color group, see Fig. 27.

The `Edit` 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 circuit and the holding time for the switching outputs.

i Before creating a new color, define the parameters for the color space and illumination LED. See menu `Settings > Recognition Profile`. If the level adjustment for the illumination LED is changed subsequently, it is necessary to reteach the colors.

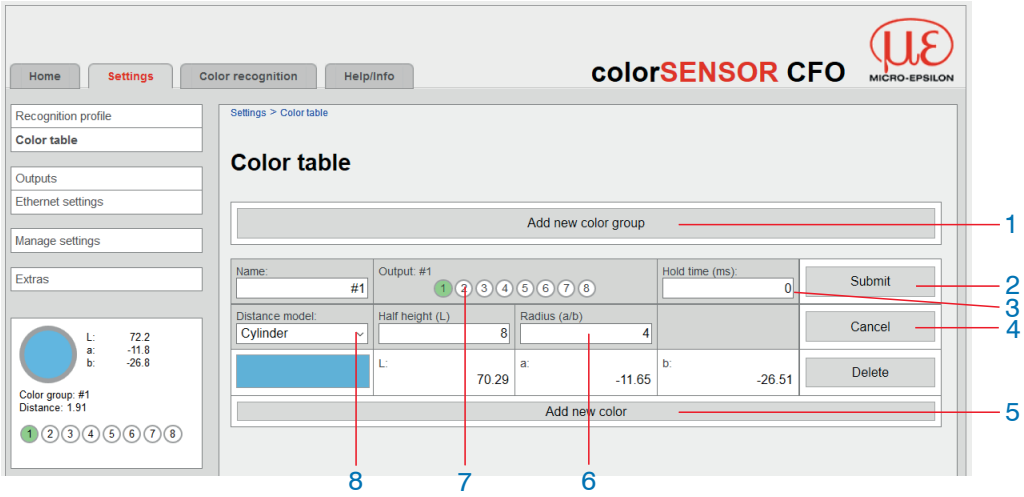


Fig. 28 Excerpt, color table

Color 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 +-#,.().*
Described by	L*	0 … 130 (150)	*Value*	*Numerical value with four decimal places*
	a*, b*	-130 … + 130	*Value*	
	X, Y, Z	0 … 130	*Value*	
Output circuit	Binary 1 .. 8 or 1 ... 255			
	Select by clicking the outputs for binary or direct coding (green is set to `high`)			

Fields with gray background require a selection.

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

Use the button `Add new color group` (1), see Fig. 28, to teach the current color located beneath the sensor with your own output circuit, tolerance model, tolerance values and holding time.

The color located beneath the sensor can be added to the specific, existing color group using the button `Add new color` (5).

i It is also possible to teach the new color with the Teach menu using the keyboard on the controller, see Chap. 5.4.2.1.

Newly learned colors are also saved when the controller is switched off.

The time can be entered in ms in the holding time entry field (3). When the color group is detected, the output circuit (7) for this color group is held for the selected time.

NOTICE

During this time the outputs are not updated and thus, further colors are not detected.
> Production errors occurring in the meantime are not detected.

The output circuit (7) defines the outputs to be switched upon recognition of this color group. The outputs can be set to `high` = green or `low` = white by clicking on the output circuits.

The changes to this color group can be saved with the `Accept` button (2)

The changes to this color group can be discarded with the `Quit` button (4).

Distance Model and Tolerance Value Settings

Distance model		Classification / Sphere / Cylinder / Box	
Tolerance value	ΔE*	*Value*	*0.00...50.00*
	ΔL* / Δa*b*	*Value*	*0.00...50.00*
	ΔL* / Δa* / Δb*	*Value*	*0.00...50.00*

Color, space, tolerances. 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 color space. If the current reading is within these tolerances, the color is detected and signaled, see Chap. 5.4.4, see Chap. 5.4.5.5.

The model color space can be changed in the `Recognition Profile, see Chap. 5.7.5.2`.

If the sensor 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, see Chap. 5.7.4.

No tolerance parameters are set for classification, because the currently measured color is always associated with the color saved in the color table with the last distance to the measured color, see Chap. 5.4.5.5.

When learning a new color group, the standard values are used for the distance model (8) and the tolerance values (6).

Distance model, cylinder

Half height (L) = 8

Radius (a/b) = 4

Fields with gray background require a selection.

This can be adapted manually in the editing mode for the group between 0 ... 50. This can be adapted manually in the editing mode for the group between 0 ... 50. For the distance model it is possible to select between `Box` (ΔL; Δa; Δb), `Cylinder` (ΔL; Δab), `Sphere` (ΔE) and `Classification, see Chap. 5.4.5.5`.

Value

Fields with dark border require entry of a value.

Depending on the distance model selected, it is possible to set the tolerance values 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.

Deleting Colors, Color Table

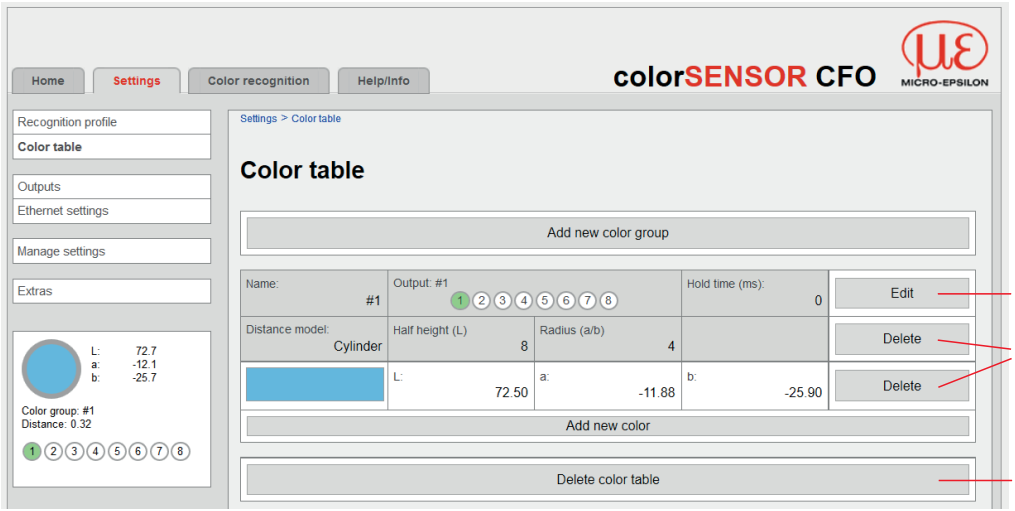


Fig. 29 Excerpt, color table

To remove a complete color group from the color table (1) click the `Delete` button, located on the right next to the tolerance parameters, see Fig. 29.

To remove an individual color from the color table (2) click the `Delete` button, located immediately to the right of the corresponding color values.

All colors and color groups can be deleted from the color table with the button `Delete Color Table` (3).

The color groups, see Chap. 5.4.2.2 and color table, see Chap. 5.4.3, can also be deleted via the keyboard.

5.7.5.4 Outputs

Go to the menu `Settings > Outputs`.

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

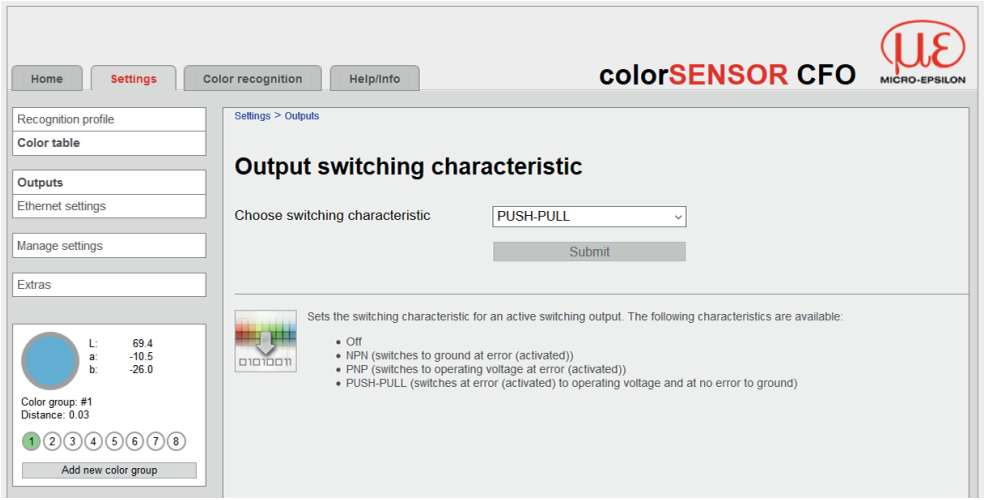


Fig. 30 Screen shot, outputs

Here it is possible to select between `Off`, `NPN`, `PNP` and `PUSH-PULL`. For details on the output circuit, see Chap. 4.4.6.

The outputs to be physically switched for `Color not recognized` can be set in the `Recognition Profile, see Chap. 5.7.5.2`.

The outputs to be physically switched for the recognized color can be set in the `Color Table` and the corresponding color group, see Chap. 5.7.5.3.

The switching output, see Fig. 30, becomes active when the measured color is within the specified 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`.

5.7.5.5 Settings Ethernet

Go to the menu `Settings > Ethernet settings`.

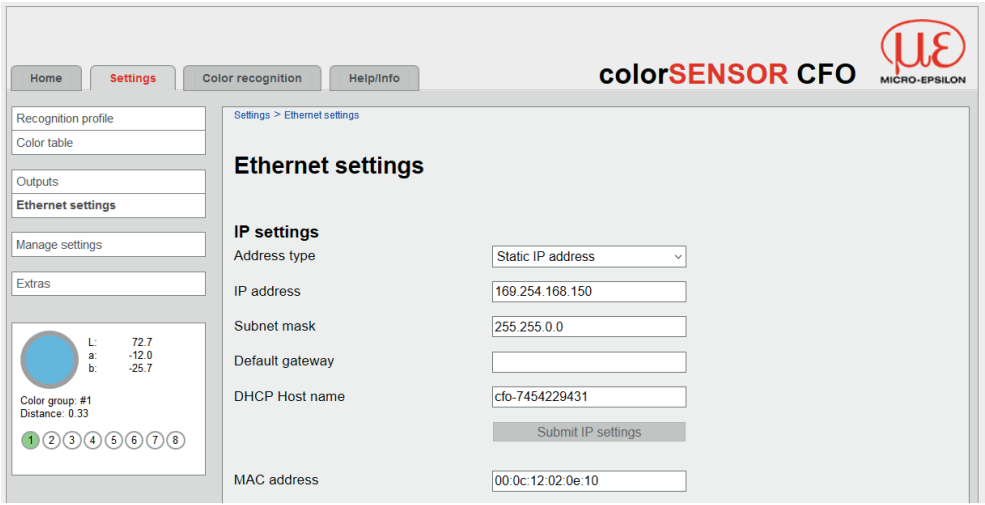


Fig. 31 Screen shot, Ethernet settings

Ethernet settings	IP settings	Address type	*Static IP address / DHCP*	*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.*
		IP address	*Value*	
		Subnet mask	*Value*	
		Default gateway	*Value*	
		DHCP Host name		*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.*
		MAC address	*Fixed value*	

In addition to setting the sensor parameters via the web site or using the API commands, the Ethernet interface also allows rapid data transfer, which is not real-time-compatible (packaged-based data transfer). The color values for measured value capture are transferred for one subsequent analysis without direct process control.

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 a 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 transferred, saved at a certain time, are consolidated to a measured value frame. Example, see Chap. A 3.4.

Fields with gray background require a selection.

Value

Fields with dark border require entry of a value.

5.7.5.6 Managing Settings

Go to the menu `Settings > Manage settings`.

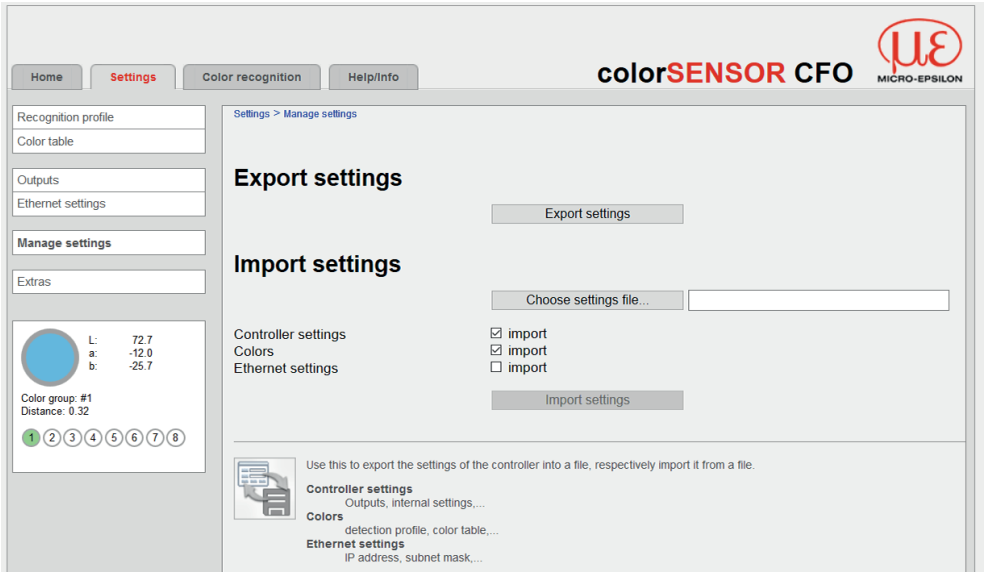


Fig. 32 Screen shot, Manage settings

All sensors settings, e.g. controller settings, colors. Ethernet settings, can be saved permanently in user programs, so-called parameters sets.

Export settings	*Export settings*			*Here you can export all controller settings it one file*
Import settings	*Choose file ...*	Controller settings	*Outputs, internal settings, ...*	*Here you can reimport all controller settings from a file.*
		Colors	*Recognition profile, color table, ...*	
		Ethernet settings	*IP address, subnet mask, ...*	

Fields with gray background require a selection.

Value

Fields with dark border require entry of a value.

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

5.7.5.7 Extras

Go to the menu `Settings > Extras`.

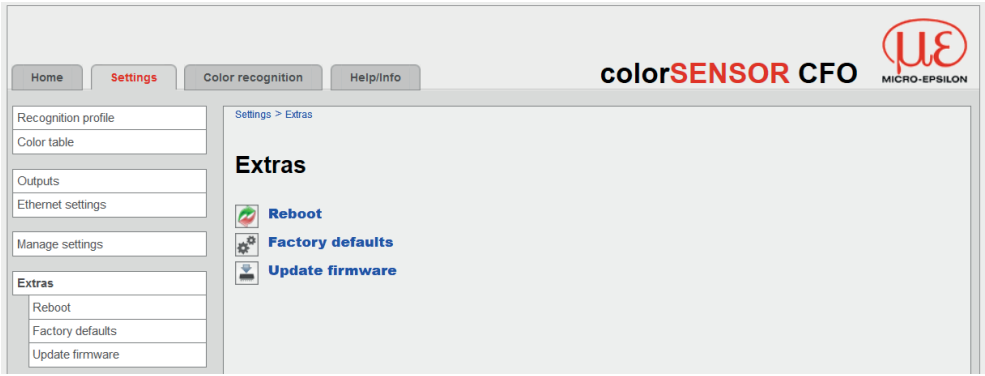


Fig. 33 Screen shot, Extras

Reboot	The sensor is switched off and then back on. After a firmware update, the computer restarts automatically.
Factory defaults	The sensor is reset to the factory default settings and the color table is deleted. For factory defaults, see Chap. A 2. i After rebooting the controller is assigned a fixed IP; it may be necessary to reestablish communication with the web interface.
Update firmware	This function allows you to load a selected firmware file for updating.

NOTICE

The firmware update may take up to 15 minutes. The web interface does not display a progress message during the update. Do not disconnect the colorSENSOR from the power supply or the PC during the update!
> Destruction of sensor

5.7.6 Color Test Menu

Go to the `Color Test menu, see Fig. 34`.

The measuring data display appears.

Recognition Profile	Link	*The link leads to the menu `Settings > Recognition profile`*
Color table	Link	*The link leads to the menu `Settings > Color table`*
Controls	Start / Stop	*The diagram starts automatically when the program is called. The measuring data display can be started and stopped with these buttons.*
	Save	*Allows the measured values to be saved after stopping the measurement. If the language is set to German, the measured values are saved with a comma as decimal separator, otherwise with a decimal point.* *Caution: It is only possible to save a limited number of readings (approx. 500,000). If more readings are saved, the oldest readings are deleted.*
Show	Lab, Luv, XYZ, xyZ	*Defines the channels to be displayed in the diagram.*
Diagram color	Custom color selection for lab	*Defines the color for displaying the channel or channels in the diagram. Clicking on the color opens a color selection window.*
Color test display	Display	*Display of current color values for the color beneath the sensor as well as the color groups, output assignment and relative distance ΔE_{rel} to the recognized color in the color table.*
Time range	*Value*	*100 ... 4000 %*

Fields with gray background require a selection.

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

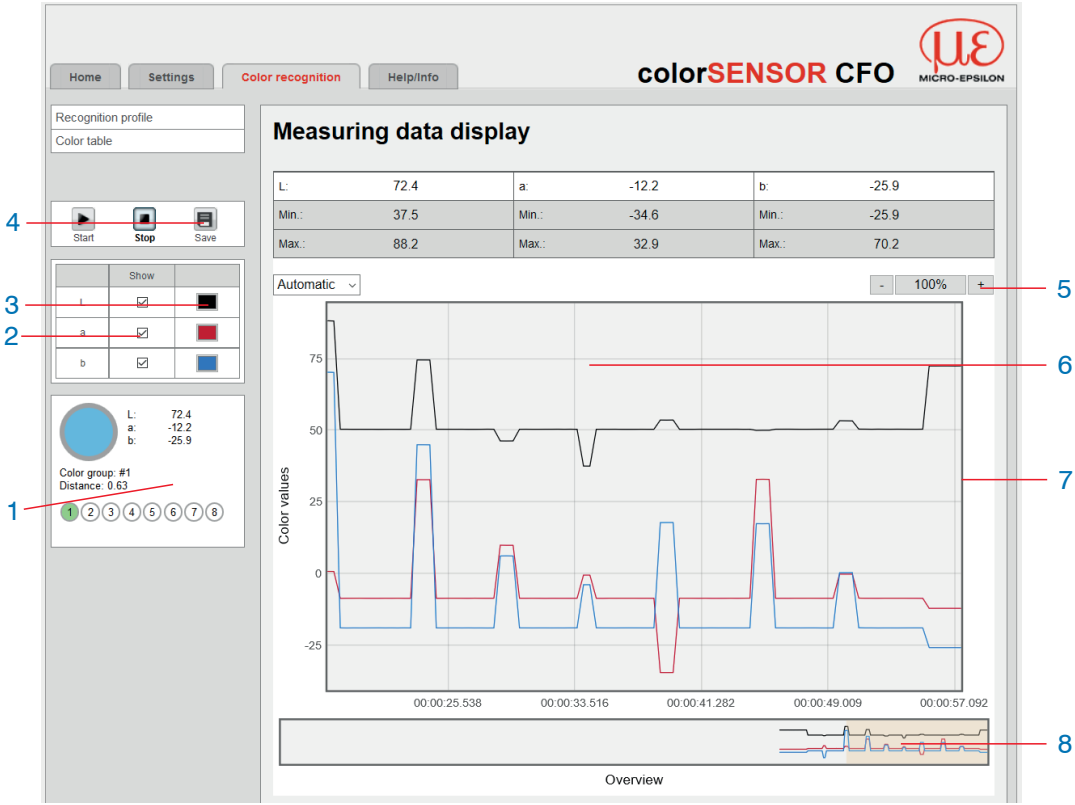


Fig. 34 Measuring data display

With the color test, you can record the color values for the last 10 min. and save them in a CSV file with the `Save` button (4), see Fig. 34

You can select and deselect the color values for depiction in the diagram (2), as well as increase the depiction of the measuring points from 100 % to 4000 % (5).

The color test diagram, see Fig. 34, shows the chronological sequence of the currently tested color in the selected `color space` (8).

The diagram display starts automatically. Use the `Stop` button, to stop display of the diagram. You can scroll in the diagram with the slider (8) and zoom in and out with the + and – buttons (5). You can save the data in a CSV file (time column and reading columns) with the `Save` button(4).

The right margin of the diagram (7), is the reference for the current color values. The slider (8) allows previous color values to be displayed while a measurement is in progress.

The reading display consists of two parts. The lower section (Overview (8)) shows approximately the last 10 minutes of the measurement. The area with dark background defines the view (and thus the time range) for the upper diagram (6). This area can be shifted or its size changed with the mouse by holding down the left mouse button. The size of the upper section of the reading display can be changed with the mouse in the same manner. Moreover, the view can also be adapted in fixed stages with the aid of the + and – buttons (5).

Double clicking on the upper diagram or clicking on the button with the % display returns the view to the default values. The y axis in the upper diagram can be scaled manually or automatically.

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 (2).

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

The color values for the display colors in the diagram can be selected individually (3).

The color test display is located on the left in the display on every menu page (1).

Here the relative color of your monitor in relation to the color values for the color currently beneath the sensor (optical fiber) is displayed in a color circle. The current color values are located on the right next to the color display. Upon recognition of a color group, the name of the group and the relative distance ΔE_{rel} to the recognized color in the color table as well as the current output circuit are shown below the color.

5.7.7 Help/Info Menu

Go to the `Help/Info` menu

This page shows the version, serial number, firmware build, MAC address and web site version for the sensor used. Our contact data is also shown here if you require support or need help with the sensor or the GUI.

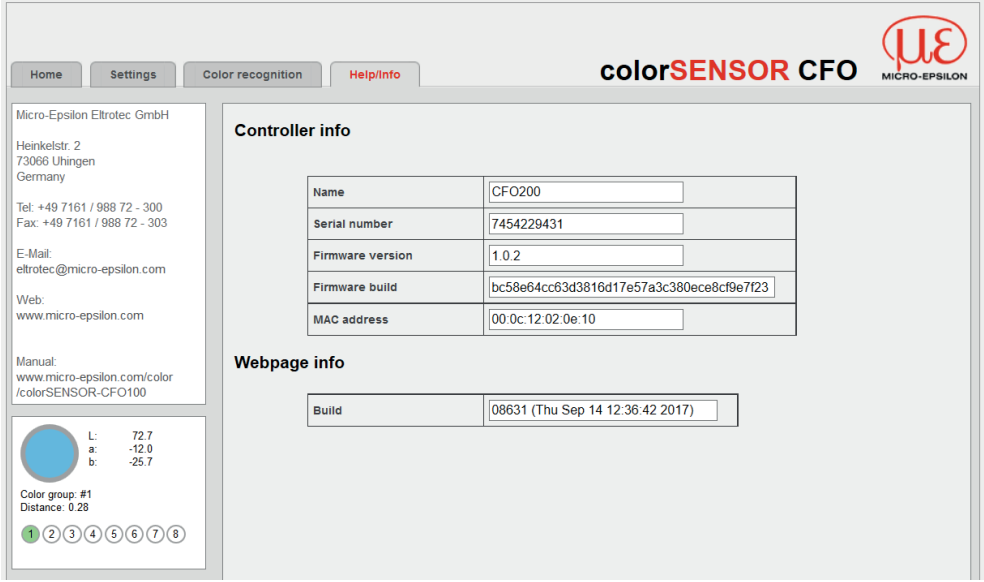


Fig. 35 Help/Info Menu

5.8 Factory Reset

A factory reset can be accomplished as follows:

➡ Disconnect the sensor 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 to sensor

➡ Switch the power supply back on.

➡ Release the keys.

The sensor then starts to reset to the factory default settings. During this operation all sensor 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. interruption in power supply, the reset is continued during the next restart. No sensor states are signaled and no entries are possible during the reset operation. Pressing a key 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. Instructions for Operation

6.1 Cleaning

We recommend cleaning the protective glass at regular intervals.

Dry Cleaning

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

Moist Cleaning

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

Never use commercially available glass cleaner or other cleaning agents.

7. Warranty

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

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

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

8. Service, Repair

In the event of a defect on the sensor or optical fiber, please send us the affected parts for repair or exchange. In the case of faults the cause of which is not clearly identifiable, the entire measuring system must be sent back 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.de
www.micro-epsilon.de

9. Decommissioning, Disposal

➡ Disconnect the power supply and output cable on the sensor. Remove the optical fiber from the sensor.

Incorrect disposal may cause harm to the environment.

➡ Dispose of the device, 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.

Appendix

A 1 Accessories

Designation	Photo	Description	Part 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

Designation	Photo	Description	Part number
CFO DIN rail mounting adapter		For mounting colorSENSOR CFO100 or CFO200 on standard mounting rail (top hat rail TS35)	11234763
Power supply cable			
CAB-M12-8P-Buge;2m-PUR;open		Connection cable; 2 m long	11234717
CAB-M12-8P-Buge;5m-PUR;open		Connection cable; 5 m long	11234718

Designation	Photo	Description	Part number
CAB-M12-8P-Stge;2m-PUR;open		Connection cable; 2 m long	11234722
CAB-M12-8P-Stge;5m-PUR;open		Connection cable; 5 m long	11234723
CAB-M12-5P-Stge;2m-PUR;open		Connection cable; 2 m long	11234727
CAB-M12-5P-Stge;5m-PUR;open		Connection cable; 5 m long	11234728
CAB-M12-8P-Buge;5m-PUR-D;open		Connection cable; 5 m long, for use with drag chain	11234719

Designation	Photo	Description	Part number
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
Power supply			
PS2030		Plug-in power pack 24V/24W/ 1A; 2m-PVC; Terminal-2P-BU-ge	2420065

Designation	Photo	Description	Part 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 cable	11234734
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

Designation	Photo	Description	Part number
Protective caps			
Protective cap M12 for cable box		Protective cap for covering open, unused connection sockets to guarantee IP 65 protection	11234789
Protective cap M18 for FA adapter		Protective cap for protection against soiling illumination LED and receiver	37930128
Optical fiber cable			
FAR-T-C2.0-2,5-1200		Reflex optical fiber	10810568
Other optical fibers or optical fiber illumination units available on request.			

A 2 Factory Settings

Parameter name	Value
IP address	169.254.168.150
Light source	LED on
Exposure mode	AC
Measuring 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 test
Switching output `Color not recognized`	All outputs to `high`
Color database	Default data, deletes all learned colors
Reading averaging	Automatic depending on measuring 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 following system start	Ethernet

A 3 API Communication with Controller (Version 0.7.1)

A 3.1 Overview

The HTTP-based API allows interrogation and modification of the sensor configuration and current states.

All sensor details are available in this manner. For example, the integrated web application communicates with the sensor exclusively via the API.

The API thus allows integration of the sensors in your own tool chain and processes (data collection, ERP integration, backup, monitoring, ...).

The API is REST compatible, thus supporting following HTTP requests:

- `GET`
  - Resource query, (e.g. current sample)
- `POST`
  - Generation of a resource (e.g. new color sample)
- `PUT`
  - Modification of a resource (e.g. changing a tolerance)
- `DELETE`
  - Deleting a resource (e.g. trigger action)

A 3.2 Examples of Manual Queries

The following manual queries are intended only as examples for use of the API.

All programming languages and development environments typically provide HTTP libraries with simple access for integration of your own tools.

A 3.3 Sample Tools for Manual Queries

Environment	Tool recommendation
Command line	cURL
Windows PowerShell	Invoke RestMethod

A 3.4 Query Example

Every web browser uses `GET` requests to fetch contents. Further request methods such as curl can be used. When used on colorSENSOR CFO, for example, the query

```
curl -X GET
http://169.254.168.150/api/sensor/
samples/current
```

results in the following reply in the form of a json package:


```
{
  "errors": [],
  "data": {
    "representations": {"RGB": [
      -1813.4023969679429,
      -2379.379187218209,
      -2491.1024745468035
    ]},
    "detection": {
      "distances": [],
      "output_pattern": {
        "uuid": "6f375796-48e1-4c17-a882-e3eb303c9ead",
        "states": [false, false, false, false,
                   false, false, false, false]
      },
      "matcher": null
    },
    "timestamp": 72943065089.0,
    "transformed_color": {
      "values": [
        1.0894557958758746,
        -1.0710343211531166,
        -1.544761799042288
      ]
    },
    "corrected_color": {
      "values": [
        0.0005728547694161534,
        0.0007082736119627953,
        0.0006567371310666203
      ]
    }
  }
}
```

A 3.5 API

A 3.5.1 General

- Collections (arrays and lists) can be queried with `GET`.
  - Filtering operations using defined attributes as query parameters are possible.
- Optional: Some collections allow `POST` requests to create additional collection elements.
  - If required, attributes for the new collection entries deviating from their standard values can be overwritten using query parameters.
  - Errors when creating objects are signaled with the HTTP status code 400 (Bad Request).
- Optional: Some collections support deletion of elements.
  - The collection is emptied when a filter is not specified.
  - Filter rules correspond to those of `GET` Requests for this collection.
  - A `DELETE` request is always successful, regardless of the number of objects actually deleted.
- Individual entries can be queried via `GET`.
  - Typically the path corresponds to the following scheme: /COLLECTION_PATH/UNIQUE_ID.
  - Requests for IDs not present are acknowledged by the HTTP status code 404 (Not Found).
  - Filtering operations using defined attributes as query parameters are possible.
- Optional: Some types of entries can be modified with `PUT` requests.
  - The data set to be changed is transferred as a JSON data set in the body of the request.
  - Attributes missing in the data set remain unchanged.
  - The values for read-only attributes must not differ from the previous state - otherwise an HTTP status code 400 (Bad Request) is returned.
  - As a matter of principle it is not possible to change the unique ID for an entry (typically the key uuid).
  - A successful request is acknowledged with the new entry state in the body of the response.
- Optional: Some types of entries can be deleted with `DELETE` requests.
- All properties of `GET` requests for collections also apply for their `POST` requests.
- All properties of `GET` requests for entries also apply for their `PUT` requests.

A 3.5.2 Response Format and Error Handling

The API returns a data package in the following form for all requests:

```
{
        "errors": [...errors ],
        "data": { ...data }
}
```

`Data` includes the actual information in reply to the specific request. `Errors` include errors which occurred when processing the requests. Each element in `errors` has the following structure:

```
{
        "message": string,
        "mapping": string|null,
        "code": string
}
```

Attribute	Model	Content
message	String	Description of error in English.
mapping	String / zero	Either zero when mapping is not present, or string, describing a resource attribute, for which an error was detected. Mapping usually occurs when a resource is updated and, for example, validation for the new values fails. The expression in `mapping` is valid JavaScript. An error for the attribute `foo` for the second element in the bar list would be described by `bar[1].foo`.
code	String	The error code describes the type of error, which occurred, in a general manner.

The attribute `code` describes the nature of the error using a unique string. This facilitates association of multiple language error texts with error codes. The error codes are separated hierarchically by dots, for example `LPLC.validation.missing_input` or `LCOL.autogain.invalid_target_level`. If an API request can return error codes, they are to be documented for each query.

Generally the following error codes can be anticipated for all write access operations (`POST` or `PUT`):

```
LPLC.validation
LPLC.validation.missing_input
LPLC.validation.readonly
LPLC.validation.non_negative_integer
LPLC.validation.positive_integer
LPLC.validation.smaller_integer
LPLC.validation.single_character
LPLC.validation.string
LPLC.validation.boolean
LPLC.format.encoding.utf8
LPLC.format.malformed.json
```

A 3.5.3 API Endpoints

Here API endpoints are intended as a supplement to the basic URL (http://). For example, here is a browser call (GET request) for the colorSENSOR CFO to query the output configuration:

http://169.254.168.150/`api/peripherals/outputs`

Basic URL | `API Endpoint`

A 3.5.3.1 api/access/users

User management

`GET`

The filter name allows selection of a user.

A 3.5.3.2 /api/access/users/USER

`GET`

The following attributes are provided:

Attribute	Model	Content
name	Text	Name of user

`POST`

Add user with name and password (e.g.: {“name”:“Max”, “password”:“Passwort_for_Max”}

`DELETE`

Deletion is permissible.

Error codes:

`LPLC.not_found.collection.item`

A 3.5.3.3 /api/device

Information on sensor itself

`GET`

The following attributes are provided:

Attribute	Model	Content
model	Text	Name of sensor model
model key	Text	Unique identification for sensor model
device id	Text	Serial number
vendor	Text	Name of sensor manufacturer

Example

errors :

data :

model : “CFO100”

model_key : “me_cfo_100”

device_id : “7454229892”

vendor : “Micro-Epsilon Eltrotec GmbH”

A 3.5.3.4 /api/firmware/images

`POST`

Creation of a firmware image with following attributes:

The upload is accomplished in separate requests via `/api/firmware/images/UUID/upload` (see below).

The approach shown above for creating an image followed by uploading individual blocks is designed for applications.

Error codes:

```
LPLC.validation.missing_input
LPLC.validation.string
LPLC.validation.non_negative_integer
LPLC.validation.positive_integer
LPLC.validation.smaller_integer
```

A 3.5.3.5 Firmware Upload with Form (Multipart)

In addition, the firmware image API endpoint also allows simple upload of a firmware image file using a form (as part of a multipart request body):

firmware_file:	Firmware image file to be uploaded (required)
apply:	Selection of immediate application of firmware image uploaded (Standard: 0).

When this field is assigned a value of 1, the apply operation is accomplished immediately after receipt of the firmware image (/api/firmware/images/UUID/apply - see below). Otherwise the request supplies the details for the uploaded firmware image, to allow a separate apply request.

Example:

simple upload

curl -X POST --form “firmware_file=@firmware.img” http://169.254.168.150/api/firmware/images

Upload followed by activation of uploaded firmware image

curl -X POST --form “firmware_file=@firmware.img” --form “apply=1” http://169.254.168.150/api/firmware/images

The POST request is acknowledged with an empty reply, if no errors occurred.

In the event of an error, the Status Code 400 (Bad Request) is returned as early as possible after recognition of a permanent error status.

Error codes:

`LPLC.format.malformed.upload`

A 3.5.3.6 api/firmware/images/UUID

`GET`

Requests for information on a partially or completely transferred firmware image

The content of the `status` field is to be interpreted as follows:

`incomplete`:	Number of bytes uploaded does not yet equal number of bytes predicted.
`complete`:	Image has been uploaded completely and can be used.
`invalid_signature`:	Erroneous check sum detected while uploading image.
`processing_failure`:	Internal (undefined) error occurred while processing upload.
`malformed_content`:	Uploaded image does not corresponded to expectations (e.g. erroneous check sums).
`device_mismatch`:	Uploaded image does not contain any data to match sensor. The image was probably intended for a different sensor (with a different sensor ID).

Error codes:

`LPLC.not_found.collection.item`

A 3.5.3.7 /api/firmware/images/UUID/apply

`POST`

Application of firmware image (permanent transfer to internal data storage medium) followed by sensor restart

Error codes:

`LPLC.format.malformed.upload`

`LPLC.internal_error`

A 3.5.3.8 /api/firmware/images/UUID/upload

The firmware image is uploaded in data blocks (see `max_chunk_size`). The HTTP header `Content Range` is used by the client to notify the server of the range to be transferred with the current POST request. The transfer is accomplished without gaps (i.e. the start address for the subsequent block corresponds to the end address for the previous block incremented by 1).

It is permissible to upload additional blocks as long as the firmware image status is `incomplete`. All other statuses indicate successful or erroneous conclusion of the firmware upload. In the event of a permanent error status for the upload operation (e.g. erroneous check sum), each request is acknowledged with the Status Code 400 (`Bad Request`).

Error codes:

`LPLC.header.content_range.missing`
`LPLC.header.content_range.invalid`
`LPLC.header.content_range.conflicts`
`LPLC.upload.missing_chunk`
`LPLC.upload.payload_too_big`
`LPLC.format.malformed.upload`

A 3.5.3.9 /api/firmware/recovery/upgrade-from-current

Saving currently used firmware image as recovery image. This function is useful for updating an older recovery image to the latest (currently installed) status.

The factory image contains only the firmware. Currently valid settings are not included.

`POST`

No attributes are expected

Error codes:

`LPLC.system.action_failed`

A 3.5.3.10 /api/firmware/settings

`GET`

The following attributes are provided:

Attribute	Model	Content
release_channel	Text	Type of publication

A 3.5.3.11 /api/firmware/status

`GET`

The following attributes are provided:

Attribute	Model	Content
source_url	Text	Address of firmware source
build_id	Text	Build Version
version	Text	Current version

A 3.5.3.12 /api/network

Network configuration of sensor

`DELETE`

Reset sensor network settings to delivery state

A 3.5.3.13 /api/network/interfaces

Status and collection of network interfaces available in system
`GET`

There are no filters.

A list of dictionaries is supplied under the key `network_interfaces`. Each element in this list describes an interface. The associated information is defined under the API endpoint `/api/network/interfaces/NAME`.

A 3.5.3.14 /api/network/interfaces/NAME

Query and change of network interface based on unique name.
`GET`

The following attributes are provided:

Attribute	Model	Content
iface	Text	Unique name of interface
hardware_address	Text	MAC address of network interface
has_link	Logical value	Current interface status (cable connected or not)
ipv4	Dictionary	See below
ipv6	Dictionary	See below

The current statuses for the address family IPv4 (key: `ipv4`) and IPv6 (key: `ipv6`) are contained under the dictionary key `current_addresses` and the configurations under the dictionary key `address_configurations`.

The current statuses are themselves a dictionary, containing only the key `address`. The associated value is the IPv4 or IPv6 address in the prefix length notation (e.g. `192.168.0.100/24` or `fe80::10f1:82ff:fe0a:e0d/64`).

The configurations for an interface and address family consist of a list of dictionaries with the following contents:

method	Text	Configuration method (`static, dhcp` (IPv4 only) or `auto` (IPv6 only)
address	Text	Static IP address (for `method=static` only)
gateway	Text	Default gateway (for `method=static only, optional`)

PUT

New contents can be set for the address configurations lists in the dictionary keys ipv4 and ipv6. All previous address configurations for this address family are replaced by the new list. Only the address families contained in the data configurations for the data sets are changed - all address families not mentioned remain unchanged. Transfer of an empty list removes the address configurations present for this address family.

Examples:

Delete IPv6 configurations: {"ipv6": {"address_configurations": []}}

Replace IPv4 configurations with DHCP: {"ipv4": {"address_configurations": [{"method": "dhcp"}]}}

Set static and dynamic IPv4 configuration: {"ipv4": {"address_configurations": [{"method": "dhcp"}, {"method": "static", "address": "192.168.0.100/24"}]}}

i The address_configurations field is laid out as a list. However, presently (as of August 2017) only the use of one signal configuration is supported by the API backend. API clients should therefore initially set only one address configuration per family (IPv4 / IPv6).

Error codes:

LPLC.not_found.collection.item
LPLC.validation

A 3.5.3.15/api/peripherals/emitters

Collection of light sources for current profile

GET

The profile_id filter allows selection of a recognition profile. The standard value is current.

A 3.5.3.16 /api/peripherals/emitters/HARDWARE_ID

Light source query. The UUID for the light source is permissible as a selector.

`GET`

The following attributes are provided:

Attribute	Model	Content
hardware_id	Number	Unique number for light source (internal, hardware-specific) name of interface
name	Text	Predefined name for light source
intensity	Floating-point number	Configured light intensity for this light source (0 .. 1) for selected recognition profile

`PUT`

Only the intensity can be changed.

Error codes:

`LPLC.not_found.collection.item`

A 3.5.3.17 /api/peripherals/keypad

`GET`

The following attributes are provided:

Attribute	Model	Content
locked	Logical value	Key lock status
visualization_url	Text	URL of vector graph for keyboard (for simulation)

`PUT`

The attribute `locked` can be changed.

A 3.5.3.18 /api/peripherals/keypad/events

Query for last keypad actions

A 3.5.3.19 /api/peripherals/keypad/inputs

Determination of keypad interface inputs present

`GET`

The following attributes are provided:

Attribute	Model	Content
name	Text	Key name
capabilities	Object	Name of function and ULR

A 3.5.3.20 /api/peripherals/keypad/inputs/NAME/up|down

The URLs for each input can be queried via `/api/peripherals/keypad/inputs`.

`POST`

Triggering specified input action (key actuation)

Error codes:

`LPLC.resource.unspecified`
`LPLC.resource.invalid`
`LPLC.illegal_request`

A 3.5.3.21 /api/peripherals/keypad/outputs/NAME

Determination of outputs for keypad interface

Error codes:

`LPLC.resource.invalid`

A 3.5.3.22 /api/peripherals/outputs

`GET`

The following attributes are provided:

Attribute	Model	Content
count	Number	Number of available outputs
output_driver	Text	Mode for outputs

A 3.5.3.23 /api/sensor/capabilities

`GET`

The following attributes are provided:

Attribute	Model	Content
maximum_sample_rate	Whole number	Highest sample rate supported by sensor
tolerances	Object	Includes type of tolerance `shape` and tolerance value `limits`.
output_drivers	Array	Includes a list of supported electrical output characteristics.
trigger_sources	Array	Contains a list of TriggerSource Objects with `type`, `name`, and `events` attribute. The name attributes for the specific event can be used as source for an ActionTrigger.
output_pin_count	Whole number	Number of sensor output pins
actions	Array	Contains a list of possible actions, which can be used in an ActionTrigger.
colorspaces	Array	List of color space specifications describing a color space from the viewpoint of the sensor. Contains the `space_id` for referencing (e.g. in the RecognitionProfile), the `name` as Name, and the `axes`, describing the axes and spatial distension.

A 3.5.3.24 /api/sensor/colorspaces

`GET`

The following attributes are provided:

Attribute	Model	Content
colorspaces	Object	Returns available color spaces.

A 3.5.3.25 /api/sensor/colorspaces/COLOR_SPACE

`GET`

The following attributes are provided:

Attribute	Model	Content
name	Text	Name of color space
axes	Object	Axis labelling (`minimum`, `label`, `maximum`)
space_id	Text	Color space ID

A 3.5.3.26 /api/sensor/detectables

Collection of learned color coordinates

`GET`

The `profile_id` filter allows selection of a recognition profile. The standard value is current.

The `matcher_id` filter allows delivery of all color coordinates assigned to a matcher.

`POST`

All valid attributes for a PUT request for a detectable object are permissible.

`DELETE`

Deletion is permissible.

Error codes:

`LCOL.samples.unavailable`

A 3.5.3.27 /api/sensor/detectables/UUID

Color coordinate query. The UUID for a color coordinate is permissible as selector.

`GET`

The following attributes are provided:

Attribute	Model	Content
representations	Object	Other representation form for color values, e.g. “RGB” for display on monitor
uuid	Text	Unique ID for detectable
matcher_id	Text	Reference to associated matcher object
color	Object	Color information for this color coordinate (without specifying color space - this is given in the RecognitionProfile.)

`PUT`

There are no particular unchangeable attributes.

`DELETE`

Deletion is permissible.

A 3.5.3.28 /api/sensor/recognition-profiles

Collection of recognition profiles present

`GET`

There are no filters.

`POST`

All valid attributes for a PUT request are permissible for a RecognitionProfile Object.

`DELETE`

Deletion is permissible.

A 3.5.3.29 /api/sensor/recognition-profiles/(UUID|current)

Recognition profile query. The uuid for the profile or the magic string current is permissible as selector.

Manual manipulation of the attribute `sampling_settings` is typically not recommendable. These are determined automatically by an `autogain` operation.

`GET`

The following attributes are provided:

Attribute	Model	Content
uuid	Text	Unique profile ID
name	Text	Freely selectable profile name
colorspace	Object	Color space used for this profile incl. any references (e.g. `{'name': 'CIE L*a*b*', 'references': [1.0, 0.7, 0.6]}`)
white_reference	Object	
normalization_constant	Object	
sampling_settings	Object	Settings for sampling characteristics
non_matching_output	Object	Logical treatment of outputs upon recognition failure

`PUT`

There are no particular unchangeable attributes.

`DELETE`

Deletion is permissible.

Error codes:

`LCOL.not_found.recognition_profile`

A 3.5.3.30 /api/sensor/recognition-profiles/(UUID|current)/autogain

`POST`

Triggering of automatic level adjustment with following (optional) parameters:

Attribute	Model	Default value	Content
level	Floating-point number	0.8	Target value for level adjustment (between 0 and 1)
minimum_sample_rate	Floating-point number	Current sample rate (or 1000)	Desired sample rate
enable_internal_emitter	Floating-point number	true	Activate or switch off internal light source

Error codes:

`LCOL.autogain`
`LCOL.autogain.invalid_target_level`
`LCOL.autogain.invalid_sample_rate`
`LPLC.validation.boolean`

A 3.5.3.31 /api/sensor/recognition-profiles/(UUID|current)/white-reference

`GET`

Read out non-factory white reference

`POST`

Set white reference (without parameters; current sample is used)

`DELETE`

Deletion is permissible. (Reset white reference to factory state)

Error codes:

`LCOL.white_reference.too_dark`

A 3.5.3.32 /api/sensor/matchers

Collection of learned recognition results

`GET`

The `profile_id` filter allows selection of a recognition profile. The standard value is current.

`POST`

All valid attributes for a PUT request are permissible for a matcher object.

`DELETE`

Deletion is permissible

A 3.5.3.33 /api/sensor/matchers/UUID

Recognition result query. The UUID for a recognition result is permissible as selector.

`GET`

The following attributes are provided:

Attribute	Model	Content
uuid	Text	Unique ID for matcher
name	Text	Freely selectable matcher name
tolerance	Object	Description of ColorTolerance object
hold time	Floating-point number	Defined minimum duration of output signal in seconds
output_pattern	Object	Output pattern of the type SensorOutputPattern
signal_color	Text	Name of color (see CSS4, Section “Color”:“Named Colors”)

`PUT`

There are no particular unchangeable attributes.

`DELETE`

Deletion is permissible.

A 3.5.3.34 /api/sensor/samples

Provision of historical readings (standard) or subscription of continuously incoming reading `stream`.

The query argument `stream` selects the desired mode.

A 3.5.3.35 Historical readings (stream=0)

When further parameters are not specified, the last readings present in the buffer are returned without delay.

`GET`

The two optional and combinable filters min_age and max_age allow limitation of the returned entries to a defined time range (defined as seconds in comparison to time of query).

The details provided correspond to the data set described under `/api/sensor/samples/current`.

A 3.5.3.36 Stream Output (stream=1)

The query is switched over to the stream mode upon transfer of the query argument stream=1.

When a stream is queried the output formats `JSON` and `CSV` are selectable.

This query returns new sample values continuously line for line, until the client closes the connection.

The following parameters are accepted:

Attribute	Possible contents	Standard value	Content
format	json / csv	json	Output format
stream_count	Natural number	0	Endless data set query (=0) or defined number of data sets (>0)
delimiter	Character string	, (comma)	Column separation character for CSV output

The returned attributes correspond to those in the `/api/sensor/samples/current` query.

The CSV output format is derived from the primary JSON output format. The CSV output format always begins with a table header. The keys contained therein for the JSON data set elements correspond to the format `representations.RGB[0]`. Dictionary keys are separated by a dot. Array indices are enclosed in brackets. The numbering for the columns in the CSV output format is not specified and may change in the future. The column number for the desired values must be derived dynamically from the position of the associated column header.

Error codes:

```
LPLC.validation.single_character
LPLC.validation.non_negative_integer
LPLC.validation.keyword.csv|json
```

A 3.5.3.37 /api/sensor/samples/current

A query for the last recognition results is possible via this URL.

If, in special situations (e.g. automatic level adjustment currently in progress or overmodulation), it is not possible to capture new, valid samples, the last valid sample continues to be provided (with its old time stamp).
`GET`

The following attributes are provided:

Attribute	Model	Content
representations	Object	Other representation form for color values, e.g. “RGB” for display on monitor
raw_color	Object	Dictionary of light/dark/compensated values (in each case tuple from three floating-point values)
corrected_color	Object	Color coordinate (without specification of color space) in XYZ color space
transformed_color	Object	Color coordinate (without specification of color space) in color space defined in recognition profile.
recognition	Object	Dictionary of matcher (matcher object), distance (distance from next color coordinate as floating-point number) and output_pattern (SensorOutputPattern object)
timestamp	Floating-point number	Time stamp (sensor run time) for color value

A 3.5.3.38 /api/settings

`DELETE`

Sensor configuration reset

`GET`

Returns base64 based configuration data.

`POST`

Upload of a base64-coded configuration file (file is expected as `settings_file` attribute, typically as part of a multipart/form-data).

`PUT`

Upload of a base64-coded configuration data set

Error codes:

`LPLC.format.malformed.base64`

`LPLC.format.malformed.json.not_dict`

A 3.5.3.39 /api/system

Provision/change of system settings

`GET`

The following attributes are provided:

Attribute	Model	Content
hostname	Text	Host name used in DHCP queries and elsewhere in network

`PUT`

Only host name can be changed.

Error codes:

`LPLC.system.action_failed`

A 3.5.3.40 /api/system/factory-reset

Sensor reset to factory settings followed by reboot:

Restoration of original firmware version

All settings are reset

It is possible to reset the settings without rebooting via `/api/settings/`.

`POST`

No attributes are expected

Error codes:

`LPLC.system.action_failed`

A 3.5.3.41 /api/system/reboot

Reboot sensor.

`POST`

No attributes are expected.

Error codes:

`LPLC.system.action_failed`

A 3.5.3.42 /api/system/time

Query and change of time settings

`GET`

The following attributes are provided:

Attribute	Model	Content
now	Text	Representation of date corresponding to ISO 8601
timezone	Text	Name of currently configured time zone
ntp_servers	Text list	One or more currently used time servers (IP / Hostname)
default_ntp_servers	Text list	Specified standard NTP server

`PUT`

All attributes can be written.

Error codes:
`LPLC.system.action_failed`

A 3.5.3.43 /api/system/time/zones

Query for time zones available

`GET`

The key `timezone_names` provides a list of time zones (text) (e.g. Europe/Berlin). There are also time zones without slash-based grouping (e.g. UTC).

A 3.5.4 Websockets

A 3.5.4.1 Overview

`/websocket/notifications/websocket`

Websocket clients establish a connection to this URL to receive application data continuously. This includes new sample values, as well as events such as learning new colors or changing the color space.

Attribute	Model	Content
id	Text	UUID of Websocket data set
source	Text	Source / reason for data set (e.g. “recognition_profile.matcher”)
timestamp	Number	Sensor uptime in seconds
payload	Object	Dictionary always contains an `event` attribute (e.g. “changed” or “created”). The attributes “`uuid` (with regard to new or modified element) and `data` (new / modified element) are optional

A 3.5.4.2 Fallback Techniques

If the browser is not capable of communicating with websockets, the `/websocket/notifications` path is available as the endpoint for the SockJS client library, which provides automated and abstracted alternatives such as XHR streaming, JSONP, Long Polling, etc.

A 3.6 Errata

The following API Endpoints are still open or not completely documented:

Path	Description
`/api/download-proxy`	API for provision of a payload as download
`/api/sensor/action-triggers`	End point for processing event strings

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