Interface Description

True-Color-Sensor with IO-Link

Ordering code: **BFS000M**
Part number: **BFS 33M-GSI-F01-S75**

Document number: 920685 E | 0726 | 03.123343 | Edition K16 replaces Edition F16 | Subject to changes

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1. Introduction

Function

The BFS 33M is a so-called true color sensor. It operates in the CIELab color space, which covers all colors perceptible to the human eye.
The sensor sends white LED light to the target object. The components reflected back from the object are detected and analyzed by the sensor. This enables the object color to be determined with high accuracy.

This manual describes how objects and object colors are parameterized. A total of 255 colors (0x01…0xFF) plus a background color can be learned. Each color can also have a tolerance assigned to it.
Alternately both CIELab color values and XYZ color values can be read out directly using the parameter data. In this case the higher level controller evaluates the results.

Application

The sensor has two different work modes. In “Best-Fit” mode the sensor automatically selects the closest matching object. In “Precise” mode an object and its color are only detected if the values are within the specified tolerance. These possibilities open up a broad application spectrum from object detection to quality control.

Calibration

In order to achieve maximum color detection accuracy, first a stable measuring configuration is necessary. The next step is to perform a calibration. For this the included reference card is recommended for parameterizing the printed Y-value. Alternately you can also use regular white printing paper and set the Y-value to 90,0.

Communication

Communication with the master or the controller takes place only through IO-Link. This allows all the functions described below to be selected and used. The 2 bytes of process data contain the product number of the product which fits best to the target. Only one of the learned colors can be active at one time. If the current color cannot be assigned to any of the products or if the background color is detected, then this is also displayed in the process data.

Cycle time

The sensor has minimum cycle time of 9.2 ms. Therefore the sensor is not suitable for fast processes. For fast processes we recommend sensor BFS000L which has a maximum switching frequency of 1.5 kHz.

Confirm the performance capability of the sensor by carrying out the individual steps from the manual in order. Please maintain this order during commissioning of the device. Only then will you get the maximum from your new Balluff product.

2. Safety Instructions

These photoelectric sensors may not be used in applications in which the safety of persons depends on functioning of the device (not a safety component as defined by the EU Machine Directive).

Read the manual carefully before commissioning.

Exempt Group per IEC 62471:2009
DO NOT LOOK DIRECTLY INTO THE LIGHT BEAM!
Risk of glare and irritation!

The sensor should be installed such that it is not possible to look directly into the light source during operation.

The CE Mark confirms that our products conform to the requirements of the EC Directives 2014/30/EG and the EMC Law.
In our EMC Laboratory, which is accredited by the DATech for Testing of Electromagnetic Compatibility, we have verified that Balluff products meet the EMC requirements of EN 60947-5-2.

3. Technical Data

3.1. *General*

No. of products:	255 + background

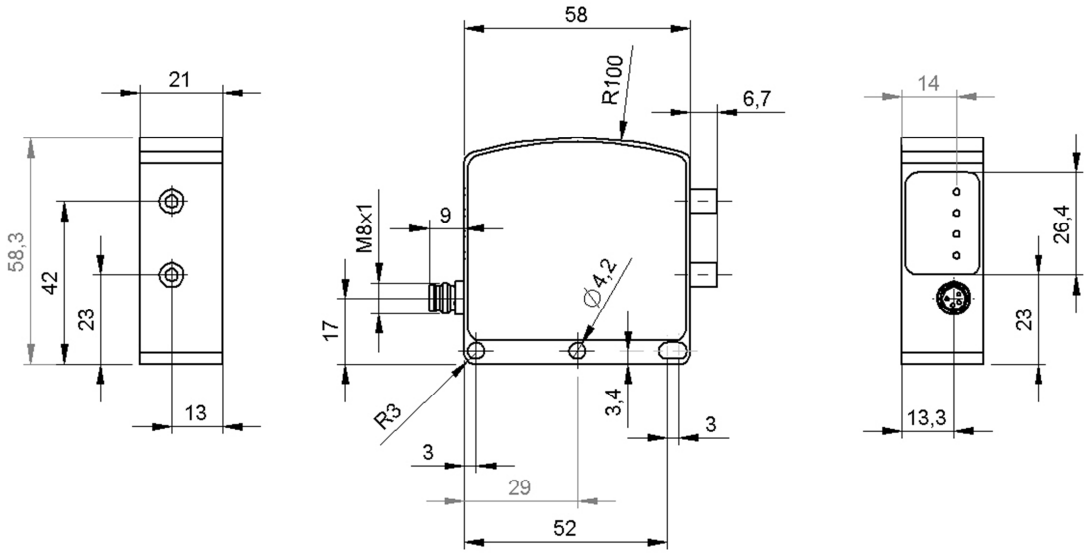
3.2. *IO-Link*

Operating voltage:	24 VDC +/-10 %
Current draw:	< 60 mA
Connection:	M8 plug, 4-pin
IO-Link version:	V1.1
Transmission rate:	230.4 kbit/s (COM3)
Process data length:	2 bytes
Frame type:	TYPE_2_V
Minimum cycle time:	9.2 ms

3.3. *Display elements*

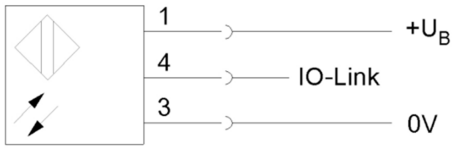
Power (LED green):	On when 24 VDC power is present Flashing when sensor firmware is being updated
Com (LED green):	On when IO-Link connection is active
Out (LED yellow):	On when one of the products (1…255) was detected by the sensor
Error (LED red):	On when the sensor signal is overdriven

3.4. *Installation*



The sensor is fastened using two or four M4 screws. Then the fiber optics are attached. Note the correct routing of the emitter and receiver. See the corresponding labeling on the sensor and fiber optic cable.

3.5. *Connection*



The sensor is connected to the master using a 4-pin M8 plug. Pin 2 is not used.

4. Commissioning

The sensor is started up in five steps. The order given below must be followed.

4.1. *Step 1: Installation*

1. Attach BFS 33M sensor using two M3 screws
2. Attach fiber optics to sensor (ensure correct routing of the emitter and receiver)
3. Position fiber optic head so that reliable detection of the target object is possible.

Notes:

- The permissible object distances depend on the fiber optics and on optional added lenses
- Position the fiber optic head at a slight angle for shiny objects (approx. 20°)
- Install the sensor, fiber optics and their head firmly and such that they are not subject to vibration.

4. Connect sensor to IO-Link
5. Parameterize sensor (see Steps 2 to 5)

4.2. *Step 2: Ambient light compensation*

This function is **optional** for especially critical applications.

Example of especially critical applications:
Use of a lens in which the beams of the emitter and receiver pass through a common 'opto-mechanical' path.

1. Point fiber optics into empty space
2. Send value 0xA3 (Compensate Environment) to Index 0x0002 (system command)
3. Wait 20 s while not changing the position of the fiber optics
4. Querying Index 0x0407 Subindex 0x03 will return the current compensation status
5. Repeat query until status 0x01 is returned

Status values and their meaning:

Value 0x05: Compensation on
Value 0x01: Compensation successfully completed (parameters are stored)
Value 0x07: Error (repeat compensation)

6. Send value 0x01 to Index 0x00BF Subindex 0x00: Compensation is activated.

4.3. *Step 3: Calibrate sensor*

1. Place reference card for calibration into measuring position. The card is included with the sensor. The position of the reference card must be equal to the position of the target.
2. Set sensor gain to autogain. Therefore send value 1 to Index 0x00BE Subindex 0x02.
   Alternatively send value 0 to Index 0x00BE Subindex 0x02 to deactivate autogain. Use Index 0x00BE Subindex 0x01 to set the sensor gain so that the sensor signal is not overdriven. (See Bit 15 / Byte 0 in the process data.)
   If the signal is overdriven, reduce gain, and / or increase object distance.
3. Use Index 0x0401 to specify the Y target value for the calibration (Y-value is printed on the reference card). If there is no reference card available, use a white piece of paper. (Use 90,0 as Y-value).
4. Send 0xA4 to Index 0x0002 (system command) to execute calibration.
5. Wait 10 s until calibration is completed
6. Querying Index 0x0407 Subindex 0x02 returns the current calibration status
7. Continue querying until status 0x01 is returned

Status values and their meaning:

Value 0x05: Calibration on
Value 0x01: Calibration successfully completed (parameters are stored)
Value 0x07: Error (repeat calibration)

4.4. *Step 4: Select work mode*

The sensor has two different work modes.

Send 0x01 to Index 0x0402 Subindex 0x00: Precise-Mode is activated.
Send 0x00 to Index 0x0402 Subindex 0x00: Best-Fit Mode is activated.

For standard applications Best-Fit Mode is recommended.

4.5. *Step 5: Teach and assign products*

The sensor provides **four** options for teaching in products.

The **Best-Fit Mode** provides **two** options

Option **A1** is a convenient, automated process for teach-in directly onto the product to be queried. **This option is recommended for standard applications.**
Option **A2** involves entering the numeric values manually.

The **Precise-Mode** provides **two** options

Option **B1** is a convenient, automated process for teach-in directly onto the product to be queried.
Option **B2** involves entering the numeric values manually.

A1: Teach-In procedure (automatic with object in Best-Fit mode)

1. Position product in front of sensor.
2. Observe wait time (see Table W).
3. Select Index 0x0400 Subindex 0x1: Product number (1…255).
   (The product is then automatically activated; the tolerance is automatically set in this mode.)
4. Repeat procedure if needed for different products. A new product number (1...255) must be assigned each time.
5. Remove product (sensor detects the background).
6. Observe wait time (see Table W).
7. Enter Index 0x0400 Subindex 0x1: Product number for background (65535) (The background is automatically taught and activated.)

   Only now is the sensor fully ready!

The wait time after positioning the sensor ensures that it has established a stable working state before the actual measurements from the sensor are accepted. The wait time depends directly on the set value for averaging, i.e. a higher value requires a longer wait time.

Averaging	Wait time
1	20 ms
2	40 ms
4	80 ms
16	300 ms
64	1.3 s
256	5.1 s
1024	20.5 s

Table W: Wait time after positioning the sensor.

A2: Manual specification of the target values for products (without object) in Best-Fit mode

1. Select Index 0x0404: Select product number (1...255).
2. Index 0x0405 Subindex 0x2 to 0x4: Enter CIELab target values for the product.
   (The tolerance is automatically determined in this mode.)
3. Activate Index 0x0405 Subindex 0x1: Release product (1…255).
4. Repeat procedure if needed for different products. A new product number (1...255) must be assigned each time.
5. Index 0x0403 Subindex 0x2 to 0x4: Enter CIELab target values for the background.
6. Index 0x0403 Subindex 0x1: Enable background approval.

   (The tolerances are automatically determined in this mode.)

Only now is the sensor fully ready!

B1: Teach-In procedure (automatic with object in Precise mode)

1. Position product in front of sensor.
2. Observe wait time (see Table W).
3. Enter Index 0x0400 Subindex 0x2: Tolerance Delta E.
4. Select Index 0x0400 Subindex 0x1: Product number (1…255 or 0x01…0xFF).
   (The product is then automatically activated.).
   Only after this is the teach-in process completed!
5. Repeat procedure if needed for different products. A new product number (1...255) must be assigned each time.

Optionally the background can be taught as follows:

6. Remove product (sensor detects the background).
7. Observe wait time (see Table W).
8. Enter Index 0x0400 Subindex 0x2: Tolerance Delta E.
9. Enter Index 0x0400 Subindex 0x1: Product number (65535 or 0xFFFF) for background (the background is automatically activated.)

Only now is the sensor fully ready!

The wait time after positioning the sensor ensures that it has established a stable working state before the actual measurements from the sensor are accepted. The wait time is directly linked to the set value of the averaging, i.e. a longer waiting time is required for a higher value.

Averaging	Wait time
1	20 ms
2	40 ms
4	80 ms
16	300 ms
64	1.3 s
256	5.1 s
1024	20.5 s

Table W: Wait time after positioning the sensor.

Post-setting the tolerance:

To adjust the tolerance after the teach-in process, first use Index 0x0404 to select the product number and then use Index 0x0405 Subindex 0x5 to select the tolerance. Index 0x0403 Subindex 0x5 is used for the background.

B2: Manual specification of the target values for products (without object) in Precise mode

1. Select Index 0x0404: Select product number (1...255).
2. Index 0x0405 Subindex 0x2 to 0x4: Enter CIELab target values for the product.

3. Enter Index 0x0405 Subindex 0x5: Tolerance Delta E.
4. Index 0x0405 Subindex 0x1: Enable product approval.
5. Repeat procedure if needed for different products. A new product number (1...255) must be assigned each time.

   Optionally the background can be taught as follows.
6. Index 0x0403 Subindex 0x2 to 0x4: Enter CIELab target values for the background.
7. Enter Index 0x0400 Subindex 0x5: Enter Tolerance Delta E for the background.
8. Index 0x0403 Subindex 0x1: Enable background approval.

   Only now is the sensor fully ready!

Post-setting the tolerance:

To adjust the tolerance after the teach-in process, first use Index 0x0404 to select the product number and then use Index 0x0405 Subindex 0x5 to select the tolerance. Index 0x0403 Subindex 0x5 is used for the background.

Repeat the process with a new product number for additional products.

4.6. *Explanations*

Explanation for Step 2 (ambient compensation)

The ambient compensation function is used only if the sensor receives scattered light from its own light source (for example, within separate optics). This scattered light leads to an offset that makes it difficult to evaluate the signal competently.

During the compensation, nothing (no product and no object) is allowed to be in front of the optics.

Ambient compensation is activated on the sensor by enabling release of compensation (Index 0x00BF – Value = 0x01). If release is disabled, the sensor uses no ambient compensation.
When compensation is active, the sensor uses the last stored ambient compensation. Each time the status of compensation release is changed, the respective status is automatically stored on the sensor.

Explanation for Step 3 (calibrate sensor)

The values returned with Index 0x0409 correspond to the tristimulus values currently determined by the sensor. These form the numerical basis for converting into the CIELab color space. Put simply, a normalized tristimulus input value range is assumed which varies in a range of 0…100. These values are linear, which does not however apply to the CIELab values. This means tristimulus values are better suited for example for deriving the dynamic level of the sensor.
In practice, effects arise which depend on the fiber optics cable, lenses, measuring distances and angles. For conversion into the CIELab color space to function, but also

in order to adapt to the wide variety of measuring conditions and applications, a calibration should be performed after final installation. The goal of calibration is to force a defined brightness result for a defined measuring condition.
White cards having known reference values are generally used for this. But this is only necessary if the CIELab results need to agree as precisely as possible with the laboratory values for example. Often this method cannot be used, when for example the contour of the product does not permit affixing of a reference. The calibration can therefore “any” target values. This also makes it possible for example to create a “golden producte” whereby one assumes a brightness value which can be estimated from a gray scale. A “100% white” would have the value 100 as the target, a 50% white (light gray) would have the target value 50. A common sheet of printing paper (non-glossy) can be assumed to have a value of 90.

Explanation for Step 4 (select work mode)

Best-Fit mode

Function:

In ‘Best-Fit‘ mode the sensor does not take into account any specified product tolerances. The sensor always processes the parameters for all active products internally and always returns the product number that most closely matches the current actual sensor values. Determining the Best-Fit product involves calculating the Delta-E between the current actual sensor values and the target values for each stored product.

In this mode one of the products is always determined to be the ‘best’ matching product regardless of the set product parameters.

Note: If multiple stored products have exactly the same deviation from the actual value, the lowest of the product numbers is returned.

Application:

The work mode ‘Best-Fit‘ is suitable for selecting an object from among several possible (and known) ones. You can for example check whether objects having the right color have been brought into a production process without requiring adherence to an exact color shade. This also makes this mode very good for sorting tasks.

Precise mode

Function:

In *‘Precise‘* mode a product number is returned as a result only if the current actual sensor values lie within the specified tolerances for the respective product. If the actual values lie within the tolerances for multiple products, no unambiguous product association is possible. In this case the corresponding bit is set (Byte 0, Bit 6).

If the actual values lie outside the tolerances for all stored products, once again no product is detected and the corresponding bit is set (Byte 0, Bit 5).

The process data only return a correct product number if the actual sensor values lie exactly within the tolerances for a single product. The tolerance specification is based on the product parameter *'Delta-E'* for the product.

Application:

'Precise' mode is suitable for example in quality assurance of products, since here the tolerances for color and intensity have to be held in order for the object to be detected and evaluated as good.

Explanation for Step 5 (teach and associate products)

The procedure for teaching in a product differs, depending on whether the current actual values of a product positioned in front of the sensor are to be applied **or** the target values of a product are to be specified manually.

To teach in a product, a Delta E tolerance value must first be specified in Precise operating mode via Index 0x0400 Subindex 0x2.

This does not trigger a teach-in of the product yet! Then the product number to be used is transferred via Index 0x0400 Subindex 0x1. When this is done, the current CIELab actual values of the sensor are stored on the sensor as target values of the transferred product number. At the same time, the product is automatically enabled on the sensor (see Index 0x0403 Subindex 0x1 or Index 0x0405 Subindex 0x1).

Before reading in or storing the parameters for a product, you must first send the desired product number (1…255) to the sensor using Index 0x0404 'Product Number'. Then you can read or change the parameters for the set product number.

When the sensor is turned on the value 0 is always defaulted to as the current product number. The value of the current deviation Delta E to be read in using Index 0x0406 'Product Deviation' always refers to the currently set product number.

Teaching background:

The special product *'Background'* (Index 0x0403) is used for setting the product parameters for the background. If when evaluating the current measurement values the *'Background'* product is determined to be the best fitting product, the corresponding bit is set (Byte 0, Bit 6).

In 'Best-Fit' mode this product can be used for example to detect that 'no' object was introduced.

In *'Precise'* mode on the other hand this product can be used for example to define a range within which the actual values for an object should never lie.

5. Read current sensor status

Index 0x0407: This function reads out the complete current status of the sensor.

5.1. *Explanations*

Index 0x0407 Subindex 0x01 returns the bit-coded status of the sensor.

Meaning:

Byte 0 / Bit 1	Auto-Gain is active
Byte 0 / Bit 2	Ambient compensation is active
Byte 0 / Bit 3	Light source is turned on
Byte 0 / Bit 4	Red sensor channel overdriven
Byte 0 / Bit 5	Green sensor channel overdriven
Byte 0 / Bit 6	Blue sensor channel overdriven
Byte 1 / Bit 4	Best-Fit mode is active
Byte 1 / Bit 6	Reset to factory setting is running

Index 0x0407 Subindex 0x02 returns the current calibration status.

Meaning:

0 Idle	Initialization value after sensor start
1 Success	Calibration successfully completed
5 Busy	Sensor being calibrated
7 Error	Sensor calibration error

Index 0x0407 Subindex 0x03 returns the current status of ambient compensation (scattered light compensation).

Meaning:

0 Idle	Initialization value after sensor start
1 Success	Ambient compensation successfully completed
5 Busy	Ambient compensation in process
7 Error	Sensor ambient compensation error

6. Read current measurement values

Index 0x0408: Current CIELab color values are read out
Index 0x0409: Current XYZ tristimulus color values are read out

7. Process Data

Process data structure:

Byte 0								Byte 1							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Signal Overload (Signal übersteuert)	Multiple Products (mehrere Produkte)	No Product (kein Produkt)	Background (Hintergrund)					Product Number (Produktnummer)							

Explanations:

- The sensor sends 2 bytes of process data to the master
- The sensor receives no process data from the master

Byte 1 contain the product number (1…255) currently detected by the sensor

Byte 0 contain bit coded status information

- Signal Overload – the signal of the sensor is overloaded (Bit 7)
- Multiple Products – the actual color cannot be clearly assigned to the target values of only one product (Bit 6)
- No Product – the actual color does not fit to any target color (Bit 5)
- Background – the actual color fits the background (Bit 4)

8. Service Data

8.1. *System parameters*

Index		Sub-index		Data format	Access	Value range	Remarks
0x000D (13)	Profile Char-acteri-stic	0x01	Device Profile ID	UINT16	R	0x0001	Smart Sensor Profile
		0x02	FunctionID	UINT16		0x8000	Device Identification
		0x03	FunctionID	UNIT16		0x8002	PDV
		0x04	FunctionID	UINT16		0x8003	Diagnosis
0x000E (14)	PD-Input Descri-ptor	0x01	Product-number	3 * UINT8	R	UInteger, Length 8, Offset 0	0x02 0x08 0x00
		0x02	Background	3 * UINT8		Boolean, Length 1, Offset 12	0x01 0x01 0x0C
		0x03	No Product	3 * UINT8		Boolean, Length 1, Offset 13	0x01 0x01 0x0D
		0x04	Multiple Products	3 * UINT8		Boolean, Length 1, Offset 14	0x01 0x01 0x0E
		0x05	Signal Overload	3 * UINT8		Boolean, Length 1, Offset 15	0x01 0x01 0x0F

Table 1 : System Parameters

8.2. *Identification parameters*

Index		Data format	Access	Contents	Remarks
0x0010 (16)	Vendor Name	StringT (7 Byte)	R	BALLUFF	
0x0011 (17)	Vendor Text	StringT (15 Byte)	R	www.balluff.com	
0x0012 (18)	Product Name	StringT (19 Byte)	R	BFS 33M-GSI-F01-S75	
0x0013 (19)	Product ID	StringT (7 Byte)	R	BFS000M	
0x0014 (20)	Product Text	StringT (30 Byte)	R	True-Color-Sensor with IO-Link	
0x0015 (21)	Serial Number	StringT (13 Byte)	R		e.g. 1870010AEB5A
0x0016 (22)	Hardware Revision	StringT (16 Byte)	R		e.g. 1.0
0x0017 (23)	Software Revision	StringT (30 Byte)	R		e.g. 1.0
0x0018 (24)	Application Specific Tag	StringT (16-32 Byte)	R/W		Factory setting: „Sensors Worldwide“

Table 2 : Identification Parameters

8.3. *Diagnostic parameters*

Index		Sub-index	Data format	Access	Value range	Remarks
0x0024 (36)	Device Status	0x00	UINT8	R	0x00 = Device OK	
					0x03 = Functional Check	For calibration and ambient compensation
0x0025 (37)	Detailed Device Status	0x00	3 * UINT8	R	0x00 0x00 0x00	No information
0x0028 (40)	Process Data Input	0x00	UINT16	R		See also process data

Table 3 : Diagnostic Parameters

8.4. *System command*

Index		Data format	Access	Value range	Remarks
0x0002 (2)	System Command	UINT8	W	0x80 = Device reset	Warm start sensor
				0x82 = Restore factory setting	Factory settings all parameter
				0xA3 = Compensate Environment	Scattered light compensation
				0xA4 = Calibration	Perform sensor calibration

Table 4 : System command

Explanations for Table 4

Value 0x80 (Device reset)

This function enables a warm start of the sensor.

Value 0x82 (Restore factory setting):

This system command resets all of the sensor's parameters to their factory setting.
This process may take several seconds (until fully executed on the sensor).

8.5. *Sensor-specific parameters*

Index		Sub-index		Data format	Access	Value range	Remarks
0x00BD (189)	Averaging Cycles	0x00		UINT32	R/W	1/2/4/16/64/256/1024	Averaging
0x00BE (190)	Gain	0x01	Gain	UINT16	R/W	1…8	Gain
		0x02	Auto-Gain	UINT32		0 = Off / 1 = On	Auto-Gain On/Off
0x00BF (191)	Enable Compen-sation	0x00		UINT16	R/W	0 = Off / 1 = On	Scattered light compensation On/Off
0x0400 (1024)	Teach-In Product	0x01	Product Number	UINT16	W	1…255 / 65535	Product Number (1…255) or 65535 for Background
		0x02	Target Delta E	FLOAT 32	W		Maximum Deviation (target / actual) for Product Number or Background
		0x03	Spare	FLOAT 32	W		Reserved for future expansion
0x0401 (1025)	Calibration Target	0x00		FLOAT 32	R/W	Value > 0,0	Target value Y for calibration
0x0402 (1026)	Work Mode	0x00		UINT16	R/W	0 = Best-Fit / 1 = Precise	Work mode
0x0403 (1027)	Background Parameter	0x01	Enable Product	UINT16	R/W	0 = Disabled 1 = Enabled	Enable/disable background
		0x02	Target CIELab L	FLOAT 32			CIELab L target value for background
		0x03	Target CIELab a	FLOAT 32			CIELab a target value for background
		0x04	Target CIELab b	FLOAT 32			CIELab b target value for background
		0x05	Target Delta E	FLOAT 32			Max. deviation actual/target for background
		0x06	Spare	FLOAT 32			Reserved for future expansion
0x0404 (1028)	Product Number	0x00		UINT16		1…255	Product number
	Product Parameter	0x01	Enable Product	UINT16		0 = Disabled / 1 = Enabled	Enable/disable product

0x0405 (1029)		0x02	Target CIELab L	FLOAT 32			CIELab L target value for product
		0x03	Target CIELab a	FLOAT 32	R/W		CIELab a target value for product
		0x04	Target CIELab b	FLOAT 32			CIELab b target value for product
		0x05	Target Delta E	FLOAT 32			Max. deviation actual/targtet for product
		0x06	Spare	FLOAT 32			Reserved for future expansions
0x0406 (1030)	Product Deviation	0x01	Act. Delta E	FLOAT 32	R		Currrent deviation Delta E for current product
		0x02	Spare 1	FLOAT 32			Reserved for future expansions
		0x03	Act. Delta E Bck.	FLOAT 32			Current deviation Delta E for Background
		0x04	Spare 2	FLOAT 32			Reserved for future expansions
0x0407 (1031)	Actual Status	0x01	Status Sensor	UINT32	R		Bit-coded sensor status
		0x02	Status Calibration	UINT8		0 = Idle / 1 = Success / 5 = Busy / 7 = Error	Calibration status
		0x03	Status Compen-sation	UINT8		0 = Idle / 1 = Success / 5 = Busy / 7 = Error	Scattered light compensation status
0x0408 (1032)	Actual CIELab	0x01	Act. CIELab L	FLOAT 32	R		CIELab L measurement value
		0x02	Act. CIELab a	FLOAT 32			CIELab a measurement value
		0x03	Act. CIELab b	FLOAT 32			CIELab b measurement value
0x0409 (1033)	Actual Tristimulus	0x01	Act. Tristimu-lus X	FLOAT 32	R		Tristimulus X measurement value
		0x02	Act. Tristimu-lus Y	FLOAT 32			Tristimulus Y measurement value
		0x03	Act. Tristimu-lus Z	FLOAT 32			Tristimulus Z measurement value

Table 5 : Sensor-specific Parameters

Explanations for Table 5

Index 0x00BD (Averaging):

Averaging can be set in 7 steps (1/2/4/16/64/256/1024). The steps are chosen so that each higher level cuts the noise on the sensor signal by half. At the same time the time until a stable measurement value is present increases.

We recommend value 16 for standard applications.

Note: The best setting for the average value is a compromise between the available process time and the required accuracy of the measurement values.

Index 0x00BE (Gain):

This parameter is for switching between autogain and manual gain. When using manual gain, the value can be entered manually.

For standard applications the autogain function is recommended. When using this function the sensor automatically uses the optimal gain.

Alternatively the gain can be adjusted manually. The values range from 1....8. For low gain at short object distances, a value of 1 is selected for example, or a value of 8 for maximum gain at great object distances.,

Index 0x00BF (Enable Compensation):

This function is used to enable ambient compensation. First the ambient compensation must have been carried out. See Commissioning, Step 2 (Ambient light compensation).

Index 0x0400 (Teach-In-Procedure)

This function is used to teach products automatically.

Index 0x0401 (Calibration Target / Kalibrierung):

This function calibrates the sensor. See Commissioning, Step 3 (Calibrate sensor).

Index 0x0402 (Work Mode):

This parameter sets the work mode of the sensor. See Commissioning, Step 4 (Select work mode).

Index 0x0403 (Background Parameter):

This parameter is used to set the background. Values for CIELab L, a and b are defined. Subindex 0x01 enables background. Subindex 0x05 is used to set the allowed deviation for ‘Precise’ mode. In ‘Best-Fit’ mode the parameter is disabled and can be set to 0.0.

Note for deviation Delta E value: At a value of approx. 1 and higher a difference is detectable for a trained eye. At a value of 2 to 4 a color difference is perceived.

Index 0x0404 (Product Number):

This parameter is used to set the desired product number.

Index 0x0405 (Product Parameter):

Use this parameter to define the target value for the corresponding product. Values for CIELab L, a and b are defined. Subindex 0x01 enables the product. Subindex 0x05 sets the allowed deviation for ‘Precise’ mode. In ‘Best-Fit’ mode the parameter is disabled and can be set to 0.0.

Note for deviation Delta E value: At a value of approx. 1 and higher a difference is detectable for a trained eye. At a value of 2 to 4 a color difference is perceived.

Index 0x0406 (Product Deviation):

This index contains the deviation (Delta E) of the current sensor measurement values from the target values of the product number set with Index 0x0404 and the target values for the background.

Index 0x0407 (Actual Status):

This Index contains the complete sensor status. See also 4.6 (Read sensor status).

Index 0x0408 (Actual CIELab):

This Index contains the current CIELab measurement values (the actual color in the CIELab color space) of the sensor.

Index 0x0409 (Actual Tristimulus):

This Index contains the current XYX measurement values (the actual color in the XYZ color space) of the sensor.

9. Error Numbers

Error	Error code	Additional code	Remarks
Index not available	0x80	0x11	Index Number not available
Subindex not available	0x80	0x12	Subindex Number not available
Access denied	0x80	0x23	Access to index not allowed
Parameter value out of range	0x80	0x30	The value of a parameter lies outside the valid range
Parameter length overrun	0x80	0x33	The length of a parameter exceeds the permissible length
Parameter length underrun	0x80	0x34	The length of a parameter is below the permissible length
Function not available	0x80	0x35	Function not available

Table 6 : Error Numbers