

Manual

Software SPECTRO3-Scope V2.0

(PC software for Microsoft® Windows® Vista, XP, 2000, NT® 4.0, Me, 98, 95)

for color sensors of SPECTRO-3 Series with internal temperature compensation and white light balancing

This manual describes the installation of the PC software for the SPECTRO-3 color sensor. As a support for commissioning of the color sensor this manual explains the functional elements of the Windows® user interface.

The SPECTRO-3 provides highly flexible signal acquisition. For example, the sensor can be operated in alternating-light mode (AC mode), which makes the sensor insensitive to extraneous light. It also can be set to constant-light mode (DC mode), which makes the sensor extremely fast and allows a scan-frequency of more than 30KHz. If the integrated light source at the sensor is turned off and the sensor is set to DC mode, the sensor is able to detect so-called "self-luminous objects". With the stepless adjustment of the integrated light source and the selectable gain of the receiver signal the sensor can be set to almost any surface or any "self-luminous object".

When the integrated light source of the SPECTRO-3 color sensor is activated, the sensor detects the radiation that is diffusely reflected from the object. As a light source the SPECTRO-3 color sensor uses a white-light LED with adjustable transmitter power. An integrated 3-fold receiver for the red, green, and blue content of the light that is reflected from the object, or the light that is emitted by a "self-luminous object", is used as a receiver. As mentioned above, a special feature here is that the gain of the receiver can be set in 8 steps. This makes it possible to optimally adjust the sensor to almost any surface and to different "self-luminous objects".

The SPECTRO-3 color sensor can be "taught" up to 31 colors. For each of these taught colors it is possible to set tolerances. In X/Y INT or s/i M mode these tolerances form a color cylinder in space. In X/Y/INT or s/i/M mode the tolerances form a color sphere in space. Color evaluation according to s/i M is based on the lab calculation method. All modes can be used in combination with several operating modes such as "FIRST HIT" and "BEST HIT". Raw data are represented with 12 bit resolution.

Color detection either operates continuously or is started through an external PLC trigger signal. The respective detected color either is provided as a binary code at the 5 digital outputs or can be sent directly to the outputs, if only up to 5 colors are to be detected. At the same time the detected color code is visualised by means of 5 LEDs at the housing of the SPECTRO-3.

With a TEACH button at the sensor housing the color sensor can be taught up to 31 colors. For this purpose the corresponding evaluation mode must be set with the software. The TEACH button is connected in parallel to the input IN0 (green wire at cable cab-las8/SPS).

Parameters and measurement values can be exchanged between a PC and the SPECTRO-3 color sensor through the serial RS232 interface. All the parameters for color detection also can be saved to the non-volatile EEPROM of the SPECTRO-3 color sensor through this serial RS232 interface. When parameterisation is finished, the color sensor continues to operate with the current parameters in STAND-ALONE mode without a PC.

The sensors of the SPECTRO-3 series can be calibrated (white-light balancing). Balancing can be performed to any white surface. A ColorChecker™ table with 24 color fields is available as an alternative.

As a light source the SPECTRO-3-...-UV color sensor uses a UV-LED (385nm) with adjustable transmitter power to excite the luminescent marking. These UV-sensors can be optimally adjusted to almost any luminescent colorant that can be excited in the long-wave UV range (365nm or 385nm). The sensors of the SPECTRO-3-...-UV series also can be calibrated. Analogous to white-light balancing with color sensors, balancing of the SPECTRO-3-...-UV could be performed to any luminescent color marking.

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Shortcuts:

SEND	F9
GET	F10
GO	F11
STOP	F12

1 Installation of the SPECTRO3-Scope software

Hardware requirements for successful installation of the SPECTRO3-Scope software:

- IBM PC AT or compatible
- VGA graphics
- Microsoft® Windows® Vista, XP, Me, 2000, 98, NT® 4.0 or 95
- Serial RS232 interface at the PC
- Microsoft-compatible mouse
- Cable for the RS232 interface
- CD-ROM drive
- Approx. 5 MByte of free hard disk space

The SPECTRO3-Scope software can only be installed under Windows. Windows must therefore be started first, if it is not yet running.

Please install the software as described below:

1. The software can be installed directly from the installation CD-ROM. To install the software, start the SETUP program in the INSTALL folder of the CD-ROM.
2. The installation program displays a dialog and suggests to install the software in the C:\"FILENAME" directory on the hard disk. You may accept this suggestion with **OK** or **[ENTER]**, or you may change the path as desired. Installation is then performed automatically.
3. During the installation process a new program group for the software is created in the Windows Program Manager. In the program group an icon for starting the software is created automatically. When installation is successfully completed the installation program displays "Setup OK".
4. After successful installation the software can be started with a left mouse button double-click on the icon.

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2 Operation of the SPECTRO3-Scope software

2.1 Functions of the individual SPECTRO3-Scope control elements

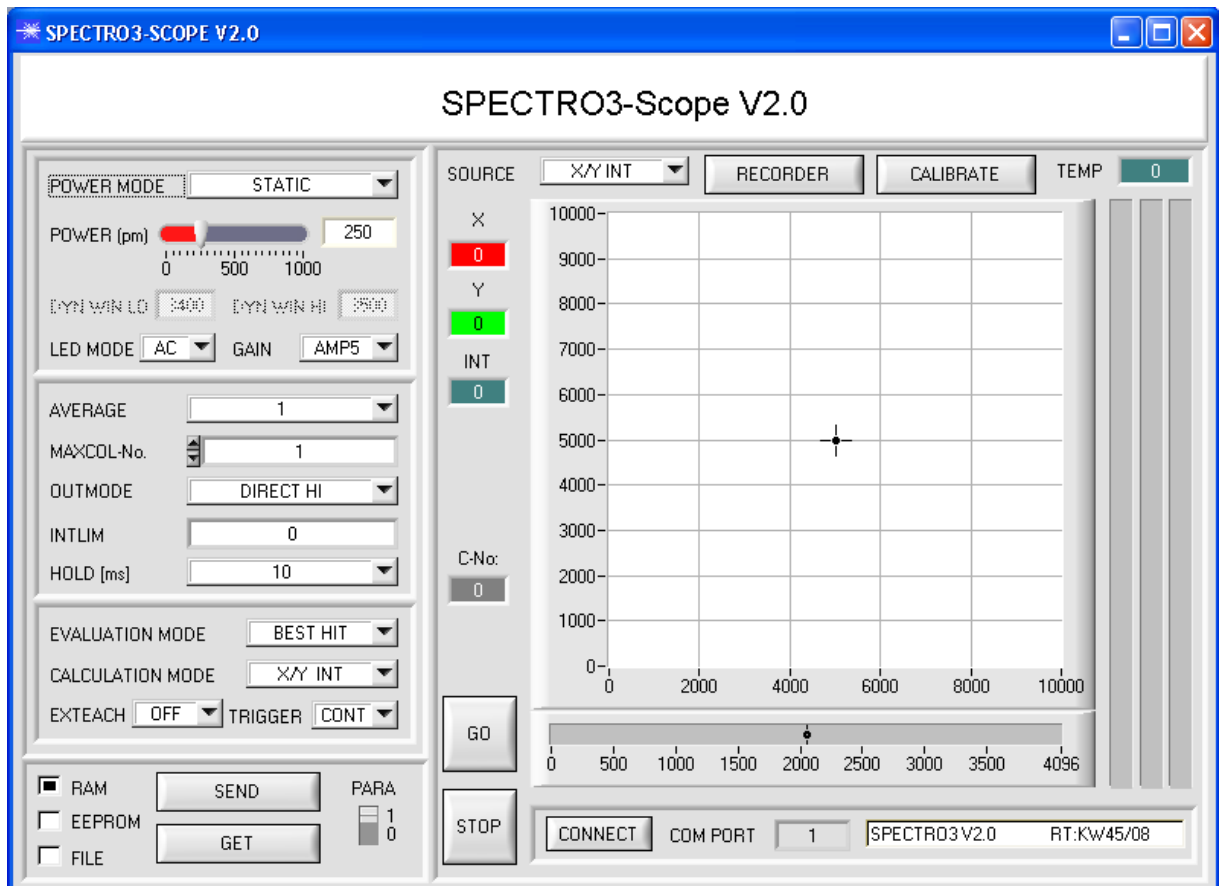
Please read this chapter first before you start to adjust and parameterise the SPECTRO-3 color sensor.

Pressing the right mouse button on an individual element will call up a short help text.

The function of the RECORDER is explained in passage 2.5.

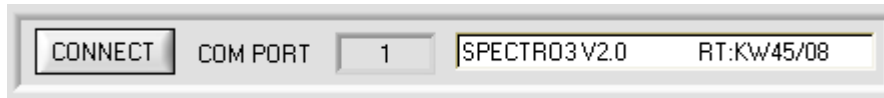
The function of the CALIBRATE button is explained in passage 2.7.

When the SPECTRO3-Scope software is started, the following window appears on the Windows interface:



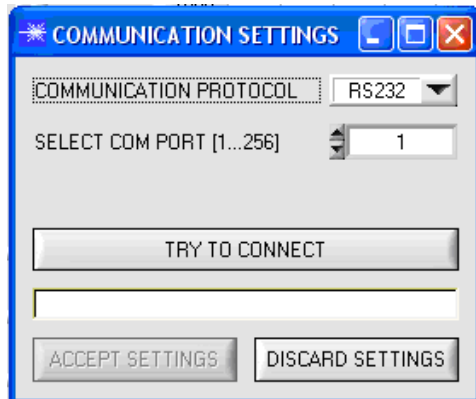
2.1.1 Explanation of general function groups and display elements

The SPECTRO3-Scope software starts with the standard configuration COM1 and the respective communication status.



CONNECT:

Pressing the CONNECT button opens a window for selecting and configuring the interface. The currently set connection type is displayed beside the CONNECT button.



CONNECT:

The COMMUNICATION PROTOCOL function field is used for selecting either an RS232 or a TCP/IP protocol.

If RS232 is selected, a port from 1 to 256 can be selected with SELECT COM PORT, depending on which port the sensor is connected to.

If the sensor should communicate through a local area network, an RS232 to Ethernet adaptor will be needed. This adapter makes it possible to establish a connection to the sensor with the TCP/IP protocol.

The network adaptors that are available from us are based on the Lantronix XPort module. For parameterising these adapters (assigning of an IP address, setting of the Baud rate of 19200) please download the "DeviceInstaller" software that is provided free of charge by Lantronix at <http://www.lantronix.com/>. DeviceInstaller is based on Microsoft's ".NET" framework. Detailed operating instructions for the "DeviceInstaller" software also are available from Lantronix.

In order to establish a connection to the adaptor, its IP address or HOST name must be entered in the field INSERT IP ADDRESS (xxx.xxx.xxx.xxx) OR HOST NAME. The DROP DOWN menu (down arrow) shows the last 10 IP addresses that were used. An address from this list can be directly selected by clicking on the respective item. The DROP DOWN list is saved and is thus always available when the software is closed.

The PORT NUMBER for the XPort-based network adaptors is 10001. This port number must not be changed.

When you press the TRY TO CONNECT button, the software tries to establish a connection with the set

parameters. The communication status is shown in the display field. If the sensor answers with its FIRMWARE ID, the set connection type can be accepted by pressing ACCEPT SETTINGS. You will then be returned to the main panel. If you get a CONNECTION FAILURE message, the software could not establish a connection to the sensor. In this case please check if the interface cable is correctly connected, if the sensor is supplied with power, and if the set parameters are correct. Pressing DISCARD SETTINGS exits the COMMUNICATION SETTINGS panel with the parameters that were set before the panel was started. If a connection has been accepted by pressing ACCEPT SETTINGS, the software starts automatically with these settings when called the next time.



ATTENTION !

The stable function of the interface is a basic prerequisite for measured value transfer from the PC to the SPECTRO-3 color sensor.

Due to the limited data transfer rate through the serial RS232 interface (19200 bit/s) only slow changes of the raw signals at the sensor front end can be observed in the graphic output window of the PC.

For maintaining maximum switching frequency at the sensor data communication with the PC must be stopped (press the STOP button).

ATTENTION!

A change of the transmitter power only becomes effective at the SPECTRO-3 color sensor after actuation of the SEND button in the MEM function field!

The screenshot shows two menu boxes. The top box is labeled 'EVALUATION MODE' and has a dropdown menu currently showing 'FIRST HIT'. The dropdown list includes: 'FIRST HIT' (with a checkmark), 'BEST HIT', 'MIN DIST', and 'COL5'. The bottom box is labeled 'CALCULATION MODE' and has a dropdown menu currently showing 'X/Y INT'.

EVALMODE:

This function field serves for setting the evaluation mode at the SPECTRO-3 color sensor.
(→ See below.)

CALCULATION MODE:

X/Y INT:

The X/Y pairs of the individual red, green, and blue components, and the intensity are used for evaluation. For X/Y a color tolerance CTO can be set, and for the intensity an INT tolerance ITO can be set. With the individual tolerances the color is represented as a cylinder in space (see picture below). CTO defines the diameter of the cylinder, and ITO the height of the cylinder.

s/i M:

The s/i pairs of the individual red, green, and blue components, and M are calculated for evaluation. This calculation method follows the Lab calculation method. For s/i a color tolerance siTO can be set, and for the intensity an M tolerance MTO can be set. With the individual tolerances the color is represented as a cylinder in space (see picture below). siTO defines the diameter of the cylinder, and MTO the height of the cylinder.

X/Y/INT:

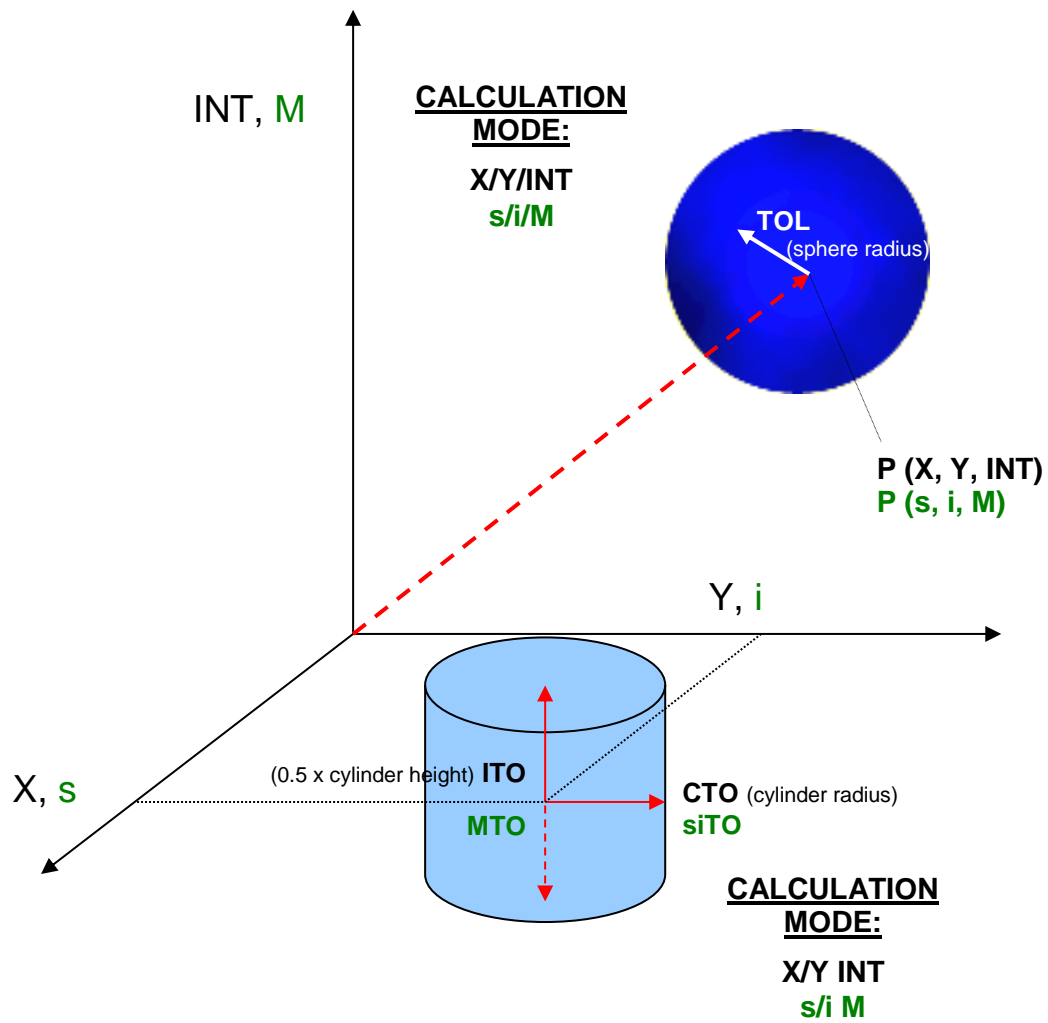
For evaluation, X, Y, and INT are calculated from the individual red, green, and blue components. These three values define a point in three-dimensional space. The tolerance value that is entered defines a sphere in space with radius TOL (see picture below).

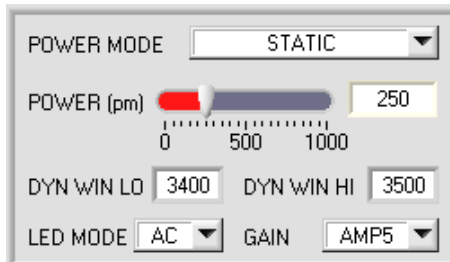
s/i/M:

For evaluation, s, i, and M are calculated from the individual red, green, and blue components following the Lab calculation method. These three values define a point in three-dimensional space. The tolerance value that is entered defines a sphere in space with radius TOL (see picture below).

Calculation of coordinates:

X	X-value of the taught color (in the color triangle numerical value on the x-axis: RED color content)
s	$X = \frac{R}{R + G + B} * 4095$ <p>s is calculated on the basis of the Lab color evaluation method.</p>
Y	Y-value of the taught color (in the color triangle numerical value on the y-axis: GREEN color content)
i	$Y = \frac{G}{R + G + B} * 4095$ <p>i is calculated on the basis of the Lab color evaluation method.</p>
INT	Teach-in value for the intensity of the respective color.
M	$INT = \frac{R + G + B}{3}$ <p>M is calculated on the basis of the Lab color evaluation method.</p>
CTO	In CALCULATION MODE X/Y INT or s/i M, CTO or siTO is the color tolerance radius around the respective taught X/Y or s/i pair. CTO or siTO defines the radius of the color cylinder in space. Within the thus defined "tolerance circle" the current color is recognised as the taught color.
siTO	
ITO	In CALCULATION MODE X/Y INT or s/i M, ITO or MTO is the intensity tolerance window around the respective taught intensity INT or M. ITO or MTO defines the height of the color cylinder in space. Within the thus defined "tolerance window" the current color is recognised as the taught color.
MTO	
TOL	In CALCULATION MODE X/Y/INT or s/i/M, TOL is the tolerance radius around the respective taught point X/Y/INT or s/i/M in space. TOL defines the radius of the color sphere in space. Within this sphere the current color is recognised as the taught color.



**POWER MODE:**

In this function field the operating mode of automatic power correction at the transmitter unit (transmitter LED) can be set.

STATIC:

The transmitter power is constantly kept at the value set with the POWER [pm] slider (recommended operation mode). The power can be set with the slider or by entering a value in the edit-box. A value of 1000 means full intensity at the transmitter unit, a value of 0 sets the lowest intensity at the transmitter.

DYNAMIC:

The LED transmitter power is dynamically controlled in accordance with the amount of radiation that is diffusely reflected from the object. By using the intensities measured at the receivers the automatic control circuit attempts to adjust the transmitter power in such a way that the dynamic range, which is determined by DYN WIN LO and DYN WIN HI, is not exceeded.

LED MODE:

This item serves for setting the control mode for the integrated light source of the sensor.

In AC mode the sensor is insensitive to extraneous light, which is achieved by "modulating" the integrated light source, i.e. by turning the light on and off. The extraneous content in the signal is determined in off status and is simply subtracted from the on status.

In DC mode the sensor operates extremely fast and reaches a scan frequency of more than 30KHz. Unfortunately the sensor is somewhat sensitive to extraneous light in DC mode, but if the extraneous light source does not directly shine into the sensor's receiver, the signal only is influenced to a very small extent.

If the sensor's internal light source is turned off in DC mode by POWER [pm] = 0, the sensor can be used for so-called "self-luminous objects". Self-luminous objects are light sources that actively emit light (LEDs, lamps, etc.)

GAIN:

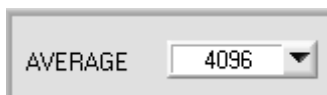
This item is used for setting the gain of the receiver in 8 different gain stages (AMP1 to AMP8). GAIN should be set such that with a medium POWER value the sensor operates in its dynamic range (red, green, blue between 2750 and 3750).

In AC mode, GAIN directly influences the scan frequency. The scan-frequency table on the software CD shows the different scan frequencies.

INFO:

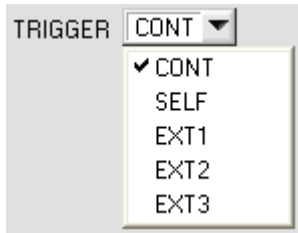
The POWER slider only is operative in POWER MODE = STATIC.

DYN WIN LO and DYN WIN HI only are operative in POWER MODE = DYNAMIC.

**AVERAGE:**

This function field is used for adjusting the number of scanning values (measurement values) over which the raw signal measured at the receiver is averaged. A higher AVERAGE default value reduces noise of the raw signals at

the receiver unit and there will be a decrease of the maximal available switching frequency of the SPECTRO-3 color sensor.



TRIGGER:

This function field serves for setting the trigger mode at the SPECTRO-3 color sensor.

CONT:

Continuous color detection (no trigger event required).

SELF:

By selecting SELF the sensor can be operated in self-trigger mode.

The "free status" must be taught to row 0. With a split optical fibre in transmitted-light operation the free status, for example, is the uncovered status. In reflected-light operation the free status is the status when there is no part. Color detection is started when row 0 is no longer detected (self-trigger). After the trigger, i.e. when color 0 is detected again, the color from the taught colors will be output that was detected most frequently during triggering.

EXT1:

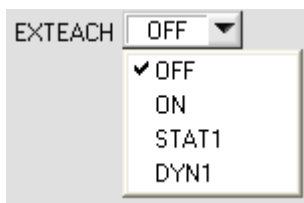
Color detection is started through the external trigger input (IN0 pin3 green of cable cab-las8/SPS) or by means of a click on the TEACH button. A trigger event is recognized as long as +24V is present at the IN0 input (HIGH-active). After the trigger input goes to LOW again, the state (color no.) that was last detected will be held at the outputs.

EXT2:

Same behaviour as in EXT1 mode, with the difference that an error state (color no. = 255) will be output after the trigger input goes to LOW again.

EXT3:

Color detection is started through the external trigger input (IN0 Pin3 grn at cable cab-las8/SPS) or by pressing the TEACH button. After triggering the color from the taught colors will be output that was detected most frequently during triggering.



EXTEACH:

In all the evaluation modes teaching of a color can be performed externally through IN0 or by means of the button at the sensor housing.

OFF: The external TEACH feature is deactivated.

ON : See below

STAT1:

In static power mode, a color is taught to position 0 in the COLOR TEACH TABLE.

The POWER MODE is automatically set to STATIC. A fixed transmitter poser must be set with the POWER slider. When the button at the sensor housing is pressed, or after a positive signal (+24V) at input IN0, the current color is taught to row 0.

DYN1:

In dynamic power mode, a color is taught to position 0 in the COLOR TEACH TABLE, and evaluation is then performed statically.

The POWER MODE is automatically set to STATIC. When the button at the sensor housing is pressed, or after a positive signal (+24V) at input IN0, the transmitter power is set such that the sensor is in the dynamic range, which is defined by DYN WIN LO and DYN WIN HI. The current color is then taught to position 0 in the COLOR TEACH TABLE.

The sensor then continues to operate statically with the established POWER value.

MAXCOL-No.

PARA

☐ 1
☒ 0

TEACH PROCESS WITH EXTEACH=ON:

Through IN0 or by way of the button at the sensor housing, the sensor can be taught up to 31 colors.

In EVALUATION modes Best Hit, Min Dist, and Col5 a single row in the table can be selected with the button or through IN0.

In EVALUATION mode First Hit the currently present color is taught to all active rows depending on MAXCOL-No.

evaluation mode BEST HIT.

The example shows the external teaching of 4 colors in

Select the EXTERN TEACH = ON function.

Select how many colors you wish to teach from extern.

Click on the "0" field in the PARA switch to change to the COLOR TEACH TABLE.

Then enter the corresponding tolerances for the colors you want to teach.

No.	X	Y	CTO	INT	ITO	COLOR
0	1	1	150	1	150	Red
1	1	1	150	1	150	Green
2	1	1	150	1	150	Blue
3	1	1	150	1	150	Black
4	1	1	1	1	1	Pink
5	1	1	1	1	1	Yellow
6	1	1	1	1	1	Olive

SEND

In this example, MAXCOL-No. = 4 was selected, i.e. the sensor should detect the color information that is stored in the first 4 rows of the COLOR TEACH TABLE by means of external teaching through IN0. Since the sensor cannot calculate the tolerances for color (CTO) and intensity (ITO) itself, these values must be entered once (in this case 150 at all places) and must be stored in the EEPROM (see MEM) together with the MAXCOL-No. and with EVALMODE = ON.

Now select the setting EEPROM in the MEM function field, and then click on SEND.

From now on, the PC is no longer necessary, as long as you only wish to teach colors up to the MAXCOL-No. and do not want to change the tolerances.

INFO:

Of course the taught colours can be viewed at any time with the PC.

Colors that are taught by way of EXTEACH (external teach) are stored in the EEPROM of the sensor, i.e. the information will not be lost when the system is turned off.

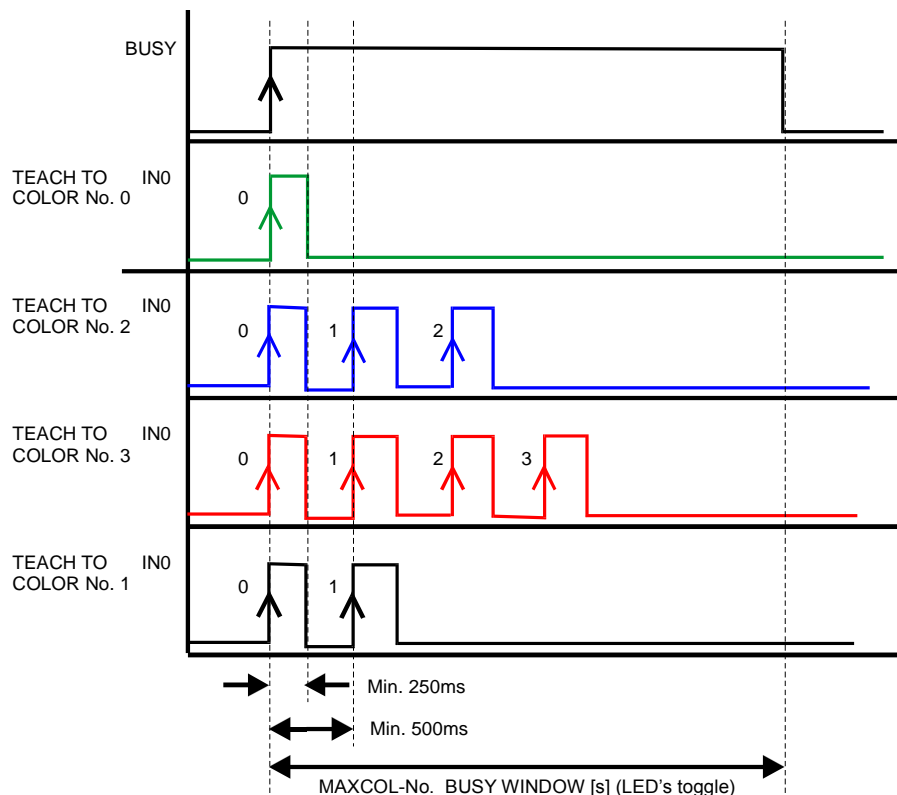
Before the external teach-process can be started, the color to be taught must be presented to the sensor. The external teach process is started with a positive edge at IN0 (green wire). When such a positive edge is applied, the output LEDs (OUT0 ... OUT4) start to blink. From now on, the user has a certain number of seconds time to inform the sensor about the position at which the color information (X,Y,INT) should be placed in the COLOR TEACH TABLE. The period of time, in which the user can teach the color information to the sensor depends on the value that is set in MAXCOL-No. (e.g. approx. 5 seconds when MAXCOL-No. = 5).

The first positive edge (start edge 0) selects position 0 in the COLOR TEACH TABLE. Every additional positive edge selects one position higher (see table below).

Example:

If you wish to save the current color to position 3 in the COLOR TEACH TABLE, the following steps have to be performed:

1. Start of the external TEACH process with a positive edge (0) at IN0 → Position 0 is selected, the LEDs start to blink.
2. An additional positive edge (1) selects position 1 in the COLOR TEACH TABLE. This position 1 is indicated by the LEDs. The LED with binary value 1 remains on HIGH level all the time, while the other 3 LEDs continue to blink.
3. An additional positive edge (2) selects position 2 in the COLOR TEACH TABLE. This position 2 is indicated by the LEDs. The LED with binary value 2 remains on HIGH level all the time, while the other 3 LEDs continue to blink.
4. An additional positive edge (3) selects position 3 in the COLOR TEACH TABLE. This position 3 is indicated by the LEDs. The LEDs with binary value 3 remain on HIGH level all the time, while the other 2 LEDs continue to blink.
5. The desired position is now selected.
6. When the BUSY window is over (the LEDs stop to blink), the sensor starts the evaluation.
7. To teach another color → go to pos. 1



INTLIM:

This edit box is used for setting an intensity limit. Color evaluation is stopped, if the current intensity INT arriving at the receiver unit falls below this limit, and ERROR STATE is output.

Attention: ERROR STATE if: $INT < INTLIM$

MAXCOL-No.:

This function field serves for setting the number of colors to be checked.

In the BINARY mode the maximum number of colors to be checked is 31. In the DIRECT HI or DIRECT LO mode the maximum number of colors to be checked is 5 (colors no. 0,1,2,3,4). The numerical value set here determines the currently possible scanning rate of the color sensor. The less the colors to be checked, the faster the operation of the SPECTRO-3 color sensor. The numerical value set here refers to the number of rows (starting with row 0) in the COLOR TEACH TABLE (→ COLOR TEACH TABLE).

OUTMODE:

This group of buttons offers the method of how to control the 5 digital outputs.

BINARY:

If in this row-by-row comparison the current color values correspond with the teach-in parameters entered in the COLOR TEACH TABLE, this color in the COLOR TEACH TABLE is displayed as a color number (C-No.) and is sent to the digital outputs (OUT0 ... OUT4) as a bit pattern. The maximum number of colors to be taught is 31.

DIRECT:

In this mode the maximum number of colors to be taught is 5.

If in this row-by-row comparison the current color values correspond with the teach-in parameters entered in the COLOR TEACH TABLE, this color in the color teach table is displayed as a color number (C-No.) and is sent **direct** to the digital outputs (OUT0 ... OUT4).

DIRECT HI:

If DIRECT HI is activated, the specially digital output is set to HI. If the current color does not correspond with any of the teach-in colors, all digital outputs are set to LOW (no LED is lighting).

DIRECT LO:

If DIRECT LO is activated, the specially digital output is set to LO, while the other ones are set to HI. If the current color does not correspond with any of the teach-in colors, all digital outputs are set to HIGH (all LEDs are lighting).

HOLD:

The SPECTRO-3 color sensor operates with minimum scanning times in the magnitude of less than 150µs. This is why most of the PLCs that are connected to the digital outputs

OUT0 ... OUT4 have difficulties with the safe detection of the resulting short switching state changes. For the digital outputs of the SPECTRO-3 color sensor pulse lengthening of up to 100 ms can be set by selecting the corresponding HOLD value.

PARA:

With this switch the display of the COLOR TEACH TABLE at the PC screen can be switched on and off.

1: Display of function fields for entering and selecting general monitoring parameters.

0: Display of the COLOR TEACH TABLE for entering the individual parameters for the teach-in colors.

No. CTT	CO_OR GROUPS					RowCOLOR
	X	Y	CTO	INT	ITO	
0	1489	1523	150	2432	150	Red
1	1466	2023	150	897	150	Green
2	2843	827	150	1079	150	Blue
3	1097	1574	150	1467	150	Black
4	1988	1841	150	1731	150	Pink
5	895	1066	150	767	150	Yellow
6	2203	1426	150	1181	150	Olive
7	1792	1960	150	1736	150	Purple
8	1531	1136	150	3030	150	Cyan
9	2310	734	150	1294	150	Magenta
10	1	1	1	1	1	Dark Blue
11	1	1	1	1	1	Bright Magenta
12	1	1	1	1	1	Dark Green
13	1	1	1	1	1	Teal
14	1	1	1	1	1	Dark Red

COLOR TEACH TABLE:

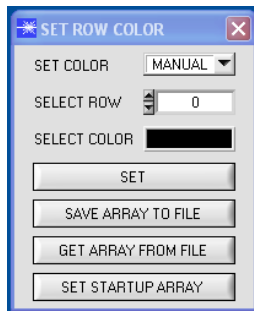
A click on switch position 0 of the PARA switch (MEM function field) opens the COLOR TEACH TABLE shown here.

The COLOR TEACH TABLE shows the currently set parameters.

After a left mouse button double click (or a click on shortcut key button F2) on the respective field the default values can be changed by entering numerical values with the PC keyboard.

The COLOR TEACH TABLE is organized in rows, i.e. the individual parameters for the teach-in colors are arranged side by side in the respective row.

The SPECTRO-3 color sensor is able to check up to 31 teach-in colors. The number of the respective teach-in color is given in the left column of the table.



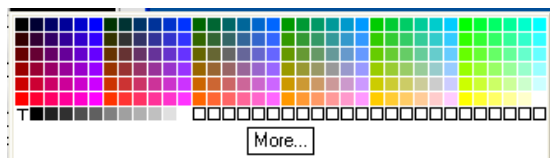
ROW COLOR:

A click on ROW COLOR opens a panel where the row color in which the individual tolerance circuits are represented can be individually chosen or these can be automatically replaced by the color detected by the system.

If SET COLOR is set to MANUAL, the row color that should be changed must be set under SELECT ROW.

A click on the colored area of SELECT COLOR opens a color palette where the desired color can be selected.

After a click on the SET button, the color will be displayed in the 6th column and the selected row of the COLOR TEACH TABLE.



If SET COLOR is set to AUTO, the system will automatically calculate the corresponding row color, display the color in a color display beside the graph and, after a click on TEACH DATA TO, automatically insert it in the corresponding row.

The SAVE ARRAY TO FILE and GET ARRAY FROM FILE functions allow you to save specified color-arrays on the hard disk, or to load previously saved color-arrays.

SET STARTUP ARRAY is used for setting the selected path of an existing ARRAY.

When the software is restarted, the corresponding ARRAY is automatically loaded and displayed in the COLOR TEACH TABLE.

No.: Inc ☐

No.:

When TEACH DATA TO is pressed, the currently displayed data for X, Y, INT or s, i, M are transferred to the row in the COLOR TEACH TABLE that is selected under No.:

No.: also is used to select which INT or M tolerance window is shown in the respective graphs for the intensity or for M.

Inc:

When Inc is activated, and the TEACH DATA TO button is pressed, the No.: input field is automatically incremented (increased) by 1, i.e. the next row in the COLOR TEACH TABLE is selected.

TEACH DATA TO

TEACH DATA TO:

A click on this button starts an automatic teach-in process. The current measured values are defined as teach-in values. The teach-in values are assigned to the teach-in color selected in the **No.:** function field.

The taught colors are only transferred to the sensor and activated when the SEND button is pressed.

TEACH MEAN VALUES

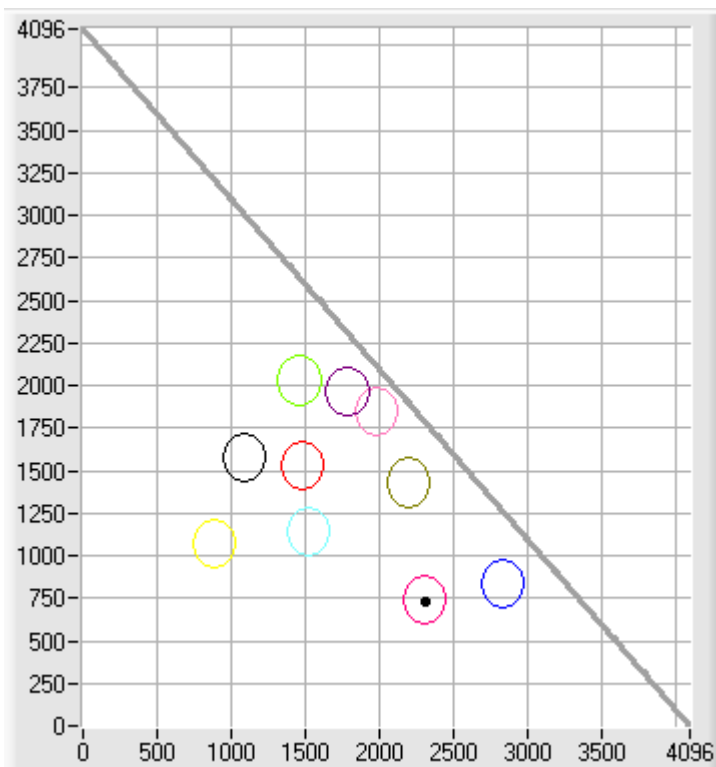
See chapter 2.6

APPLY FROM ALL

APPLY FROM ALL:

If X/Y is selected under SOURCE, a click on this button displays all the teach-in colors entered in the COLOR TEACH TABLE in the color triangle with the corresponding "tolerance circle" (radius=CTO or siTO).

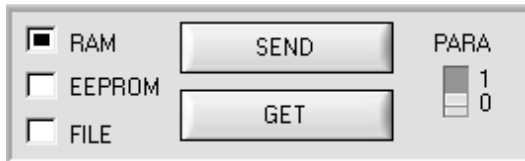
The picture below shows 10 color tolerance circles with the teach-in values (X,Y) and CTO (tolerance radius) preset in the COLOR TEACH TABLE.



RESET TABLE

RESET TABLE:

A click on this button resets the COLOR TEACH TABLE (RESET value = 1).



RAM, EEPROM, FILE :

This group of buttons controls parameter exchange between PC and sensor through the serial RS232 interface.

PARA:

With this switch the display of the TEACH TABLE at the PC screen can be switched on and off.

1: Display of function fields for entering and selecting general monitoring parameters.

0: Display of the TEACH TABLE for entering the individual parameters for the teach-in vectors.



SEND:

When the SEND button is clicked (or shortcut key button F9 is pressed), all the currently set parameters are transferred between PC and sensor. The target of the respective parameter transfer is determined by the selected button (RAM, EEPROM, or FILE).



GET:

The currently set values can be interrogated from the sensor by clicking on the GET button (or with shortcut key button F10). The source of data exchange is determined by the selected button (RAM, EEPROM, or FILE).

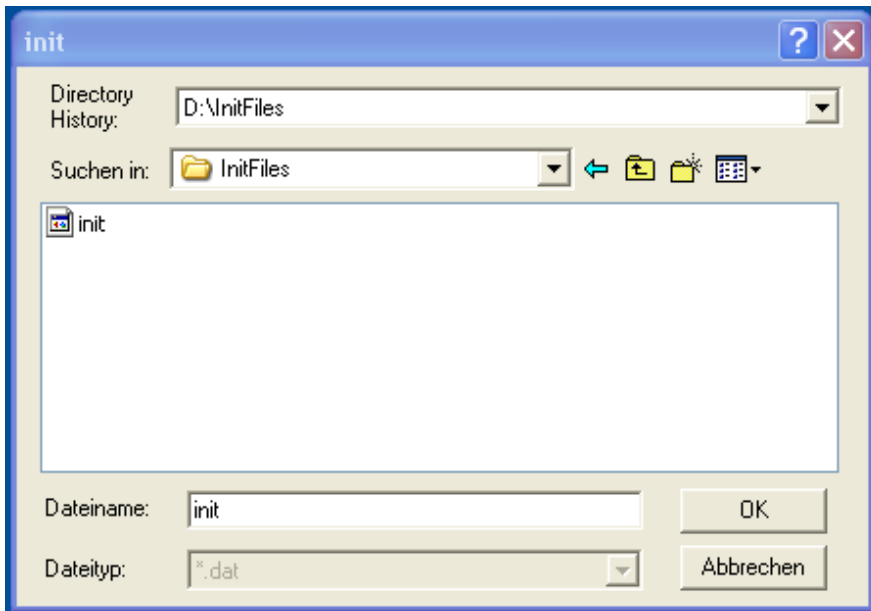
RAM: The current parameters are written into the RAM memory of the sensor, or they are read from the RAM, **i.e. these parameters are lost when the voltage at the sensor is switched off.**

EEPROM: The current parameters are written into the non-volatile memory of the EEPROM in the sensor, or they are read from the EEPROM, **i.e. the parameters in the internal EEPROM are stored when the voltage at the sensor is switched off.**

FILE: A click on this button opens an info field with the file name of the current parameter file.

PLEASE NOTE:

The current parameters are only stored in the current output file, or retrieved from the current output file, when the SEND or GET button is activated with a mouse click.



If another output file should be accessed, the file button must first be activated with the mouse pointer. Another dialog field then opens, in which an existing output file can be selected, or in which a file name for a new output file can be entered.



[F11]

GO:

A click on this button (or pressing shortcut key button F11) starts data transfer from the SPECTRO-3 color sensor to the PC through the serial RS232 interface.

If RGB is selected under SOURCE RAW, the raw signals of the individual color components for red, green, and blue are displayed.

If X/Y or s/i is selected under SOURCE, the X/Y coordinates of the current color are displayed in the graph.

If INT or M is selected under SOURCE, the intensity of the current color and the intensity window of the color set under No.: (0 ...30) are visualised in the graph.

A view mode that shows the color circles and the intensity at the same time can also be selected.



[F12]

STOP:

A click on this button (or pressing shortcut key button F12) stops data transfer from the SPECTRO-3 color sensor to the PC through the serial RS232 interface.



X or s:

This numerical value output field displays the RED content (x-axis) of the scattered light currently arriving at the receiver.

Y or i:

This numerical value output field displays the GREEN content (y-axis) of the scattered light currently arriving at the receiver.

INT or M:

This numerical value output field displays the currently measured intensity (proportional to the average of the intensities at the triple receiver).



TEMP:

This display shows the temperature prevailing in the sensor housing.
The display **DOES NOT** show degrees Centigrade or Fahrenheit.



C-No.:

This numerical value output field displays the currently detected color number in accordance with the entry in the COLOR TEACH TABLE. The currently detected color number is sent to the digital outputs OUT0 ... OUT4 as a corresponding bit pattern.

The value 255 means that none of the taught colors is recognised.

A double-click on the display opens a larger display window.

Please note:

The above-mentioned output fields are only updated when data transfer between PC and SPECTRO-3 color sensor is active (GO button pressed).

SOURCE

SOURCE:

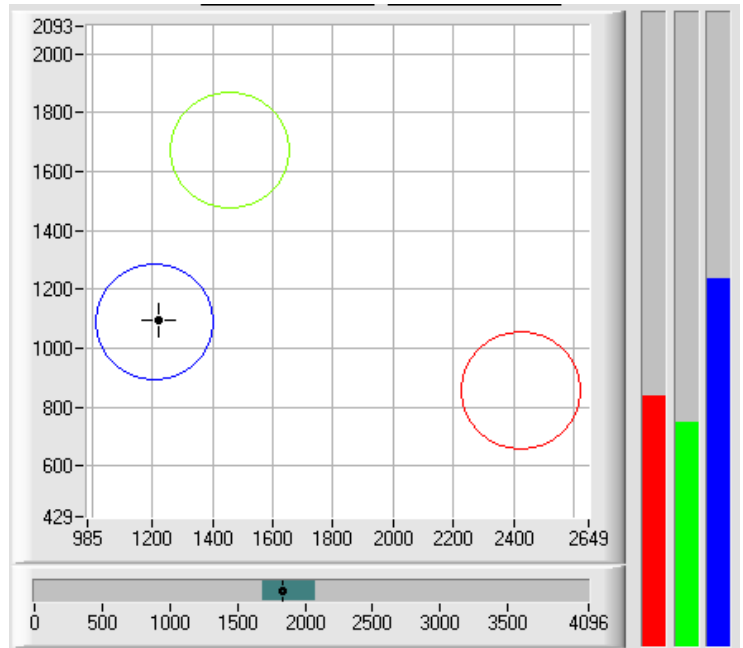
A click on the arrow button opens a selection field for the selection of a display mode in the graphic display window.

RAW RGB : The current raw signals of the 3-fold receiver (red, green, blue) are displayed.

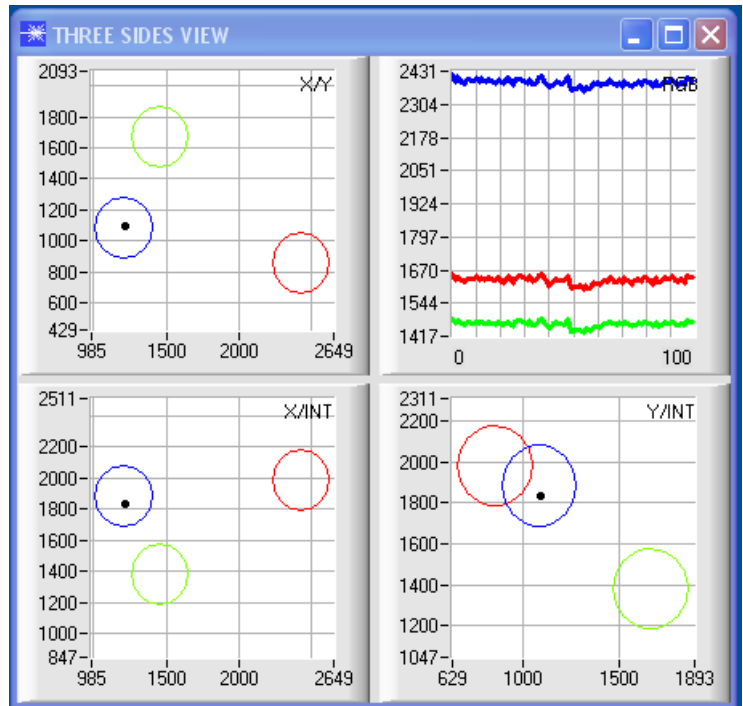
XY or s/i : Display of the color triangle as well as of the X/Y or s/i coordinates of the currently determined color.

INT or M: The currently determined intensity INT or M is displayed.

**X/Y INT
or
s/i M:** X/Y or s/i pairs are displayed in a zoomed graph. The intensity INT or M with the tolerance window set under No.: is shown directly below. Two-side view of the color cylinder in space.



**X/Y/INT
or
s/i/M:** A panel opens that shows the taught color spheres and the current color position. For improved representation a three-side view with the graphs X/Y (s/i), X/INT (s/M) and Y/INT (i/M) was chosen.

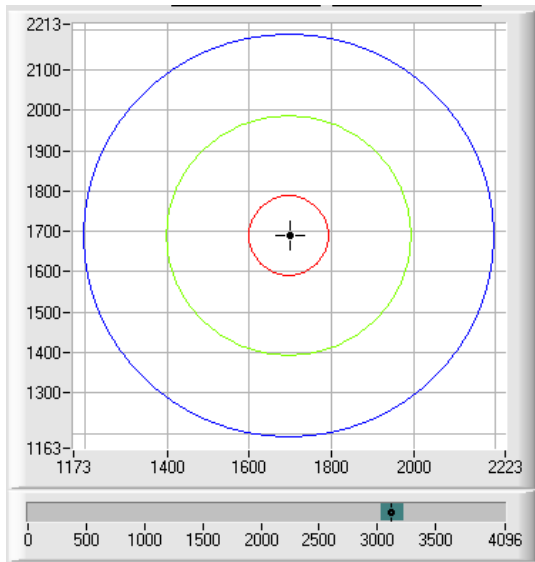


2.1.2 Evaluation modes

All the evaluation modes apply to all CALCULATION MODES X/Y INT, s/i M, X/Y/INT and i/i/M.
The Color Teach Table is correspondingly adapted depending on the CALCULATION MODE.
The following explanation uses CALCULATION MODE X/Y INT

EVALUATION MODE FIRST HIT

No. CTT	X	Y	CTO	INT	ITO	ROWCOLOR
0	1451	1673	100	1522	100	
1	2418	859	100	2305	100	
2	1202	1089	100	2182	100	
3	1598	1598	100	3488	100	
4	1	1	1	1	1	



FIRST HIT:

The currently measured color values are compared with the default values in the COLOR TEACH TABLE, starting with teach-color 0. If in the row-by-row comparison the current color values correspond with the teach-parameters entered in the COLOR TEACH TABLE, this first "hit" in the COLOR TEACH TABLE is displayed as a color number (C-No.) and is output at the digital outputs (OUT0 ... OUT4) according to the settings of the OUTMODE parameter (see OUTMODE).

If the current color does not correspond with any of the teach-colors, the color code C-No. = 255 will be set ("error status").

Tip! This mode is used if only one color is taught, and this color must be checked to avoid "drifting away". With the rising tolerance windows this can be detected very well, and countermeasures can be initiated, if necessary.

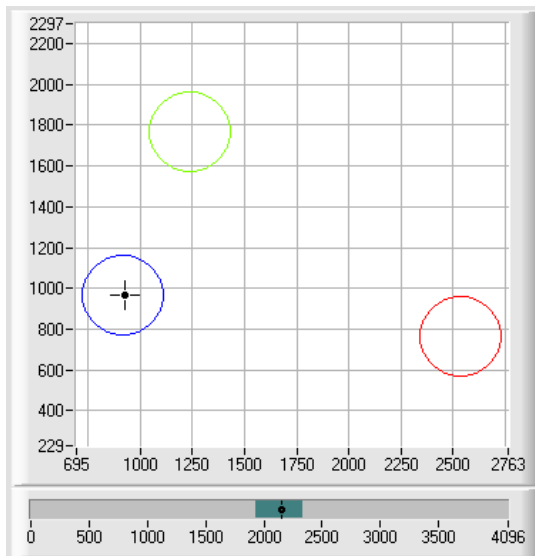
Tip! If, for example, only the X/Y coordinates should be checked, and intensity INT is of no importance, a tolerance of 4000 can be selected for ITO. This inspection criterion is thus always fulfilled.

Tip! Values can be entered in a cell of the table either by double-clicking on the respective cell, or by highlighting the respective cell and then pressing F2.

Tip! The teach colors are only activated when the SEND button is pressed!

EVALUATION MODE BEST HIT

No. CTT	COLOR GROUPS					ROWCOLOR
	X	Y	CTO	INT	ITO	
0	1451	1664	200	1574	200	Red
1	2448	841	200	2164	200	Green
2	1206	1091	200	2143	200	Blue
3	1588	1588	200	3509	200	Black
	1	1	1	1	1	Pink



BEST HIT:

The currently measured color values are compared with the default values in the COLOR TEACH TABLE, starting with teach-color 0. If in the row-by-row comparison the current color values correspond with several of the teach parameters entered in the color table, the teach parameter that has the shortest x/y distance from the current color value will be a hit.

This "hit" in the COLOR TEACH TABLE is displayed as a color number (C-No.) and is output at the digital outputs (OUT0 ... OUT4) according to the settings of the OUTMODE parameter (see OUTMODE).

If the current color does not correspond with any of the teach-in colors, the color code C-No. = 255 will be set ("error status").

Tip! This mode is used if several colors must be separated from each other, and only certain surface fluctuations are allowed.

Tip! Since what you are looking for here with several "hits" is the shortest distance of the current color to the centres of the taught colors, the individual tolerance windows (circles) may overlap here. The sensor detects the **"best hit"**.

Tip! Values can be entered in a cell of the table either by double-clicking on the respective cell, or by highlighting the respective cell and then pressing F2.

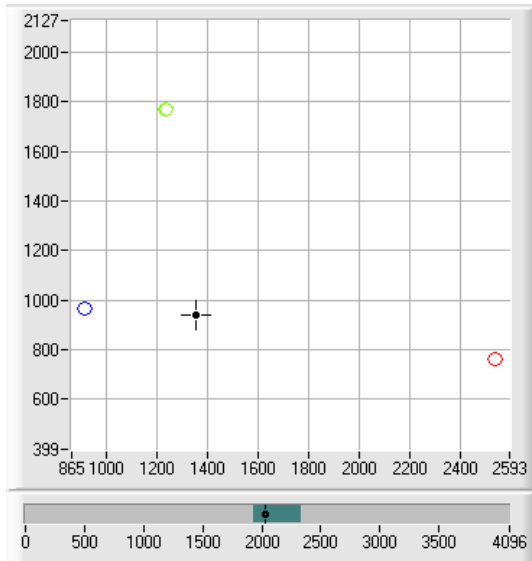
Tip! In calculation mode X/Y/INT or s/i/M the shortest distance in a three-dimensional space is calculated.

Tip! The teach colors are only activated when the SEND button is pressed!



EVALUATION MODE MIN DIST

No. CTT	COLOR GROUPS			ROWCOLOR		
	X	Y	INT	ITO		
0	1454	1664	40	1594	100	Red
1	2423	856	40	2300	100	Green
2	1212	1094	40	2187	100	Blue
3	1597	1597	40	3489	100	Black
4	1	1	1	1	1	Pink



MIN DIST:

The individual teach-in colors defined in the COLOR TEACH TABLE are present as points in the color triangle, defined by their (X,Y) value pairs. When this evaluation mode is set at the SPECTRO-3 color sensor, the evaluation algorithm, starting from the currently measured color value (X,Y), calculates the distance to the individual teach-in colors in the color triangle. The current color value (X,Y) is assigned to the teach-in color that is closest in the color triangle.

It is furthermore checked whether the intensity condition for this color also is true. If the intensity condition is not true, the second shortest distance will be checked, etc.

The color detected this way is output at the digital outputs (OUT0 ... OUT4) according to the settings of the OUTMODE parameter (see OUTMODE).

C-No. will only be set to 255, if the current intensity falls below the value set under INTLIM (see INTLIM).

Comment:

The value of 40 is only entered here in order to be able to represent the coordinates of the individual teach colours in the graph. It has no meaning for evaluation.

Tip! This mode is used if you have taught several surfaces of separate colors, and a current color in any case must be assigned to one of the taught colors. This applies, for example, if you want to compensate a product variation, or if you have to solve sorting tasks. .

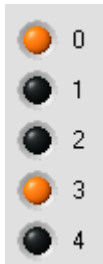
Tip! If, for example, only the X/Y coordinates should be checked, and intensity INT is of no importance, a tolerance of 4000 can be selected for ITO. This inspection criterion is thus always fulfilled.

Tip! Values can be entered in a cell of the table either by double-clicking on the respective cell, or by highlighting the respective cell and then pressing F2.

Tip! In calculation mode X/Y/INT or s/i/M the shortest distance in a three-dimensional space is calculated.

Tip! The teach colors are only activated when the SEND button is pressed!

EVALUATION MODE COL5



COL5:

In this evaluation mode the rows 0 to 4 in the COLOR TEACH TABLE are evaluated.

Every match of current vector (row number) and teach vector is directly sent to the corresponding output.

Example.

If the result of evaluation is that both row 0 and row 3 is a hit, outputs OUT0 and OUT3 will be set to high (+24V).

Tip! If the result of evaluation is that both row 0 and row 3 are hits, outputs OUT0 and OUT3 will be set to high (+24V).

Tip! Values can be entered in a cell of the table either by double-clicking on the respective cell, or by highlighting the respective cell and then pressing F2.

Tip! The teach vectors are only activated when the SEND button is pressed!

No. CTT	COLOR GROUPS					ROWCOLOR
	X	Y	CTO	INT	ITO	
0	1	1	1	1	1	

COLOR GROUPS:

It is possible to form color groups in evaluation modes FIRST HIT, BEST HIT, and MIN DIST. This means that in a special table the individual rows are assigned to a group.

GROUP PANEL

COLOR GROUPS ON

	GROUP
0	0
1	0
2	1
3	1
4	2
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0

RESET

CLOSE GROUP PANEL

C-No:

3

GRP

1

In this example, COLOR GROUPS has been set to ON, i.e. group evaluation is activated.

Rows 0 and 1 have been assigned to group 0.

Rows 2 and 3 have been assigned to group 1, and row 4 to group 2.

A GRP display is shown under the C-No: display.

If, as in this example, row 3 is detected in the evaluation, this row and the corresponding group will be visualised.

The group number will be output through outputs OUT0 to OUT4.

In evaluation mode DIRECT HI and LO 31 different colors can be taught. However, a maximum of only 5 groups can be formed (group 0 to group 4).

A maximum of 31 groups (group 0 to group 30) can be formed in evaluation mode BINARY.

All the cell values can be set to 0 by pressing RESET.

The GROUP PANEL can be closed by clicking on CLOSE GROUP PANEL.

PLEASE NOTE:

Once you have formed groups, they must be reported to the sensor by pressing SEND.

A double-click on the GRP display opens a larger display window.



2.2 SPECTRO3-Scope software as an aid for sensor adjustment

Prior to the use of the software aids (graphic display of sensor signals) the sensor must be manually adjusted to the respective target or background as accurately as possible. The reference distance of the sensor to the target is defined in the data sheet of the respective sensor.

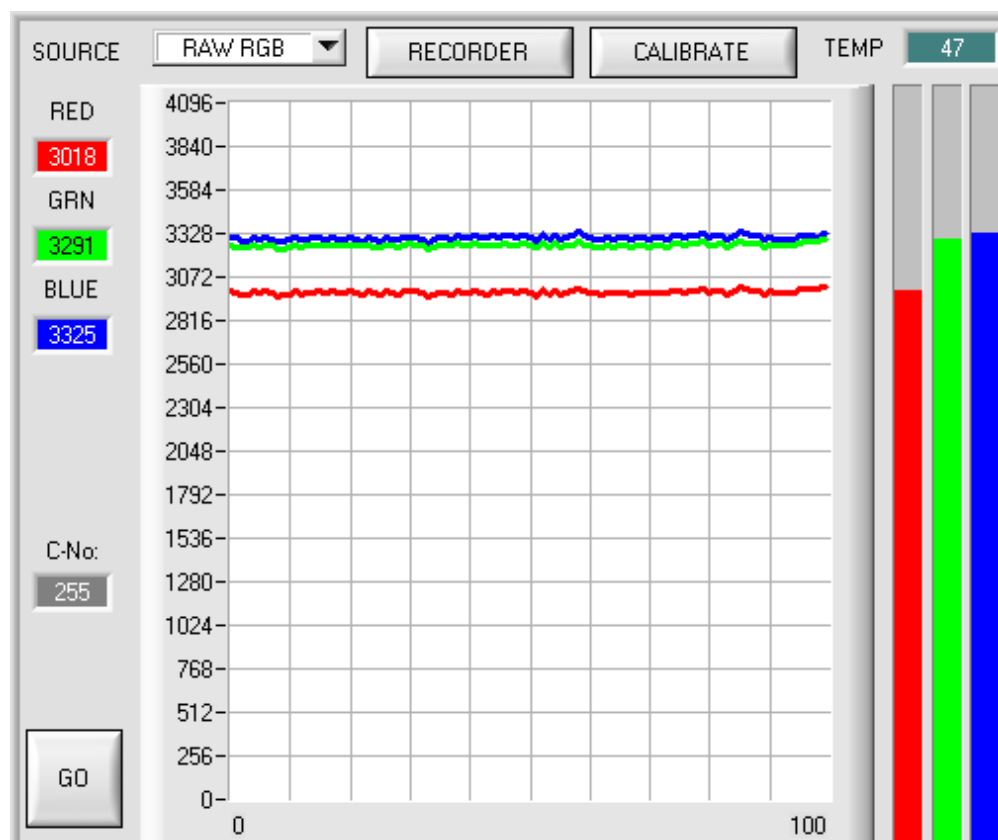
Fine adjustment of the SPECTRO-3 color sensor is facilitated by the graphic display of the analog. First of all measurement data transfer from the SPECTRO-3 color sensor to the PC must be activated by clicking on the GO button.

SOURCE

For this purpose the option RAW must be selected in the SOURCE selection field. With this setting the analog channels measured at the receiver unit are represented in the graphic display window.

GO

Activation of measurement data transfer between PC and sensor. The current measured values are shown in the graphic display window in "scroll mode".



A suitable POWER value must be found such that none of the individual channels is in saturation, and that the strongest channel lies in the upper third of the display (0...4096 12-Bit A/D converter). For this purpose the transmitter-LED-mode must be set to STATIC in the POWER MODE function field, and the POWER slider must then be adjusted such that this condition is true.

Tip! There is a trick for finding a suitable power value in no time at all. Set POWER MODE = DYNAMIC. The sensor then tries to find a suitable power value. Check this by pressing GO. Press STOP when the bars have "levelled out". Then press GET. The power value that was found now is shown in the POWER function field. Now set POWER MODE = STATIC, and press SEND.

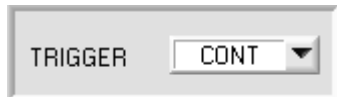
SEND

Please note: The change of laser power only becomes active at the SPECTRO-3 color sensor after a click on the SEND button !

2.3 SPECTRO3-Scope software as an aid for teach-in

The SPECTRO-3 color sensor is able to learn up to 31 different colors in the COLOR TEACH TABLE, either automatically or by manual parameter input.

Actual parameterization can be started when the target has been positioned at the reference distance and the intensity lies in the dynamic range ($INT > INTLIM$) (if necessary, readjust POWER).

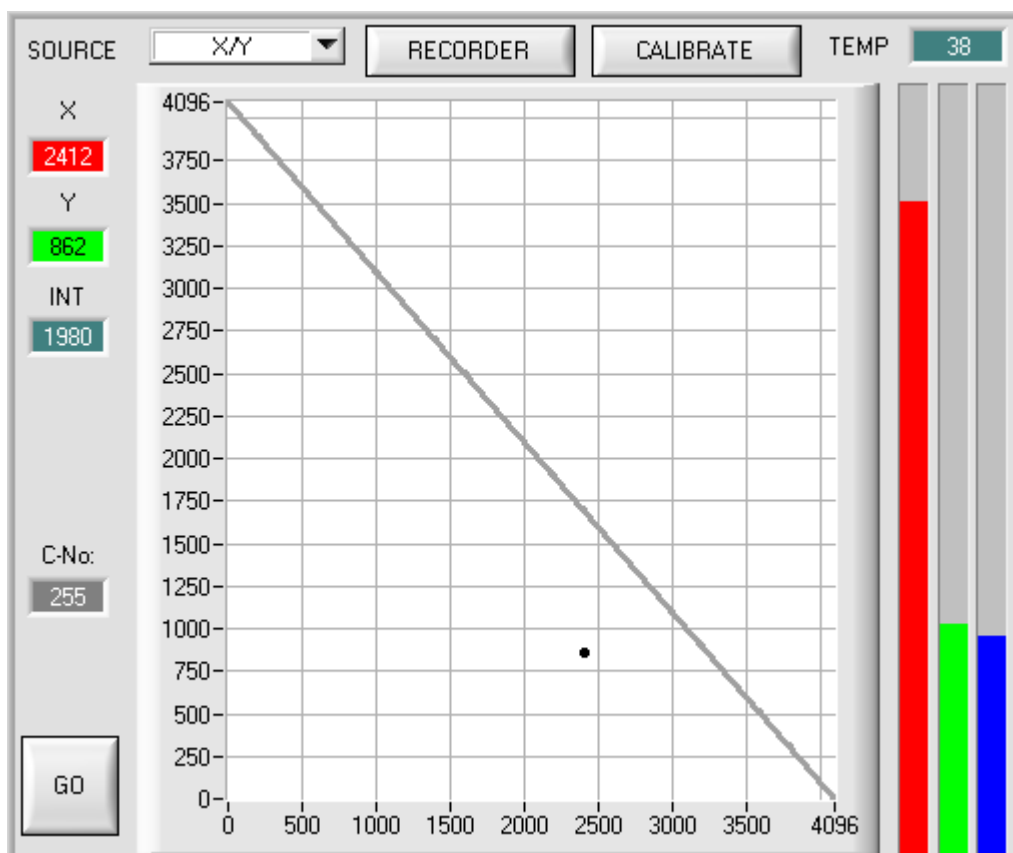


First the trigger mode should be set to CONT, which means that color detection is continuously active, also without external triggering.

With a click on the SEND button this setting is activated at the color sensor.



When this option is selected, the color triangle is shown in the graphic display window with the current teach-in colors and the current intensity with the tolerance window that is set under No.:



In the color triangle the currently measured color is represented by a (X,Y) value pair.

The RED content of the currently measured color corresponds with the X coordinate, the GREEN content corresponds with the Y coordinate in the color triangle. The BLUE content in the color triangle is proportional to the distance of the (X,Y) value pair from the hypotenuse.



After a click on the GO button measured values are transferred from the color sensor to the PC and displayed as (X,Y) value pairs in the color triangle.

No.:

Now the number of the current teach-in color (0 ... 30), in the row of which the current teach-in values should be entered, can be selected.



With a click on the TEACH DATA TO button the current measured values are entered as teach-in values in the previously selected row of the COLOR TEACH TABLE.



After a click on the GO button, a TEACH panel will be opened which allows the user to combine several measurement values in a teach value.
See chapter 2.6.

No.	COLOR TEACH TABLE					
	X	Y	CTO	INT	ITO	
0	1648	1234	100	962	50	Blue
1	2504	901	100	1753	50	Red
2	1738	1225	100	818	50	Black
3	1366	1020	100	1945	50	Pink
4	1505	1551	100	2706	50	Green

The tolerance ITO that is applied symmetrically around the intensity measurand INT, also should be increased at first, because otherwise there is a danger that color detection fails due to intensity evaluation.
Both criteria, color (X,Y) and intensity (INT), must be fulfilled for the detection of a teach color !

Almost identical color value pairs (X,Y) often can be separated with the intensity criteria INT and ITO (tolerance).

INTLIM

It must also be observed that in the INTLIM input field the lower limit for color evaluation may have to be corrected depending on the current intensity INT that is diffusely reflected to the color sensor.

Please note:
No color evaluation if: $INT < INTLIM$

MAXCOL-No.

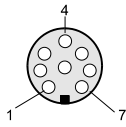
The number of colors to be checked must be entered in the MAXCOL-No. input field.

When suitable parameters for the respective color detection have been established by observing the signal characteristics, the current parameters must be written to the non-volatile EEPROM memory of the SPECTRO-3 color sensor by clicking on the SEND button.

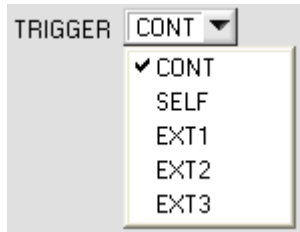
ATTENTION ! The selection button in the MEM field must be set to EE !

When the parameters have been entered and the sensor has been adjusted with the help of the graphical representation provided by the SPECTRO3-Scope software, the PC is no longer required for the actual measuring task. The PC and the RS232 interface cable can then be disconnected from the SPECTRO-3 color sensor. The SPECTRO-3 color sensor then performs the measuring task in STAND-ALONE operation.

2.4 External triggering of the SPECTRO-3 color sensor



External triggering is performed through pin no. 3 (grn) at the 8-pole socket of the SPECTRO-3/PLC connection.



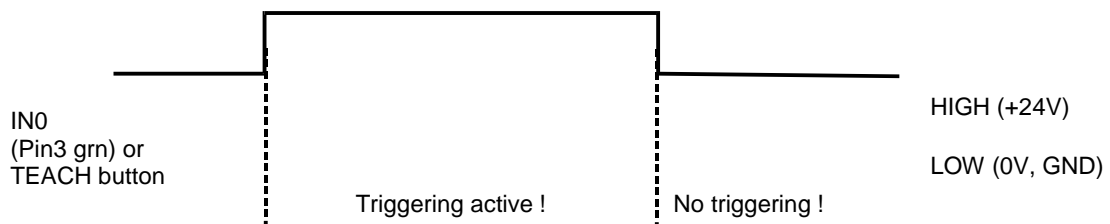
EXTERN:

First the external trigger mode must be set at the color sensor. For this purpose option EXT1, EXT2, or EXT3 must be selected in the TRIGGER selection field.

PLEASE NOTE:

The new setting is only activated at the SPECTRO-3 control unit after a click on the SEND button!

Please note: The trigger input (IN0 PIN3 green of cable cab-las8/SPS) is HIGH-active, i.e. a trigger event is detected as long as IN0 = HIGH (+24V).



2.5 Function of the data recorder (RECORDER)

The SPECTRO3-Scope software features a data recorder that allows the saving of RED, GREEN, BLUE, X, Y, INT, C-No: and TEMP. The recorded file is saved to the hard disk of the PC and can then be evaluated with a spreadsheet program.

The file that is created has eight columns and as many rows as data frames were recorded. A row is structured as follows: Date and time, RED, GREEN, BLUE, X, Y, C-No:, INT, TEMP

The following steps describe how data frames are recorded with the recorder:

PLEASE NOTE:

Recording depends on the EVALUATION MODE that is chosen. Several EVALUATION MODES do not need certain data, therefore these data will be set to 0, i.e. for these data the value 0 will be recorded.

When TRIGGER=EXT1 or EXT2 is selected, only those data will be recorded which are calculated during triggering.

Step 1:

Press the RECORDER button. The following window will be displayed:



SHOW GRAPH

When the SHOW GRAPH button is pressed, a panel will be displayed that allows the user to monitor the different signals. The individual signals can be activated from the SIGNAL drop-down menu.



Step 2:

If you want to automatically record several data frames, please select AUTO RECORDING under SELECT DATA RECORDING.

Enter a time interval for recording (in this example: 1, i.e. a new value is called from the sensor every second). Then enter the maximum number of values you wish to record in the second input field.

Please note:

Recording can also be stopped earlier, the data recorded so far will not be lost.

These fields indicate how long recording will take (in days, hours, minutes, and seconds) if all data are recorded.

Step 3:

By pressing the button SELECT RECORD FILE a file can be selected in which the data frame will be stored. If you select an already existing file name, you will be asked whether you want to overwrite the existing file or not.

Step 4:

Pressing the START AUTO RECORD button starts automatic data recording.

The recorder starts to record data, and the button is red to indicate that recording is active.

The respective data frames are shown in the display windows.

In the two display fields RECORDED VALUES and REMAINING you can check how many data frames have been recorded, and how many frames remain to be recorded.

Please note:

During recording the two input fields RECORD-TIME INTERVAL and VALUES TO BE RECORDED are inactive.

SELECT DATA RECORDING AUTO RECORDING ▼

RECORD-TIME INTERVAL IN SECONDS 1
 VALUES TO BE RECORDED (MAX 50 000) 1

TOTAL RECORDING TIME (days hours minutes seconds)

0
0
0
1

SELECT RECORD FILE

d:\Filename\record.dat

START AUTO RECORD

RED	0			
GRN	0			
BLUE	0			
X	0			
Y	0			
INT	0			
C-No:	0			
TEMP	0			

RECORDED VALUES	REMAINING
6	994

Step 5:

When all the data frames set under VALUES TO BE RECORDED have been recorded, or when the STOP AUTO RECORD button is pressed, a pop-up window will appear which confirms that the file is stored.

STOP AUTO RECORD

Step 6:

Press the CLOSE RECORDER button to close the recorder and return to the main program.

CLOSE RECORDER

If you want to record an unlimited number of data, select the AUTO UNLIMITED function under SELECT DATA RECORDING. Then select the desired recording interval and press START AUTO RECORD.

The screenshot shows the 'RECORDER' window with the 'SELECT DATA RECORDING' dropdown set to 'AUTO UNLIMITED'. Below this, the 'RECORD-TIME INTERVAL IN SECONDS' is set to '1'. The 'RECORDED VALUES' field shows '0'. On the right, there are seven status indicators: RED (0), GRN (0), BLUE (0), X (0), Y (0), INT (0), and C-No: (0). At the bottom, there is an 'ID' field and a 'SELECT RECORD FILE' button with a 'Filename' input field.

If you want to record data "manually", select the MANUAL RECORDING function under SELECT DATA RECORDING.

You can start reading data from the sensor by pressing the START POLLING button. These data are visualised in the display window. Pressing the CAPTURE DATA FRAME button saves a data frame in the file that was selected under SELECT RECORD FILE. The RECORDED VALUES field shows the sum of the frames already recorded.

The screenshot shows the 'RECORDER' window with the 'SELECT DATA RECORDING' dropdown set to 'MANUAL RECORDING'. Below this, there are two buttons: 'START AUTO POLLING' and 'STOP POLLING'. The 'RECORDED VALUES' field shows '0'. On the right, there are seven status indicators: RED (0), GRN (0), BLUE (0), X (0), Y (0), INT (0), and C-No: (0). At the bottom, there is an 'ID' field and a 'SELECT RECORD FILE' button with a 'Filename' input field.

If AUTO TRIGGERED is selected under SELECT DATA RECORDING, and TRIGGER = SELF, EXT1, EXT2 or EXT3 is selected, the sensor will automatically send a data frame after each drop of the trigger when START TRIG RECORD is pressed. This data frame is captured and recorded by the recorder. Pressing the STOP TRIG RECORD button terminates the automatic sending function of the sensor again.

Please note:

When you press START AUTO RECORD, the file that is selected under SELECT RECORD FILE will be deleted. With RECORD FRAME MANUALLY, the file will be created if it does not already exist. If the file already exists, the data are added to the existing file.

2.6 Function of the Teach Panel (TEACH MEAN VALUES)

The Teach Panel can be used in every EVALUATION and CALCULATION MODE. The explanation herein uses the EVALUATION MODE=BEST HIT and the CALCULATION MODE=X/Y INT.

The following panel will be displayed after a click on TEACH MEAN VALUES.

	R	G	B	X	Y	INT
1	1909	1717	2814	1213	1091	2146
2	1909	1717	2814	1213	1091	2146
3	1920	1726	2823	1215	1092	2156
4	1920	1726	2823	1215	1092	2156
5	1904	1712	2807	1213	1091	2141
6	1908	1717	2813	1213	1092	2146
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0

	R	G	B	X	Y	INT
MEAN	1911	1719	2815	1213	1091	2148

d(X/Y) 2 dINT 8

The main panel remains active, and data are automatically picked up from the sensor and are displayed.

A click on the CAPTURE button enters a parameter frame in the table.

The COUNTER display field shown how many frames have already been recorded.

The last frames that were entered in the table can be deleted again by pressing UNDO.

RESET TABLE sets the whole table back to 0.

After every activation of CAPTURE, UNDO, or RESET TABLE, the mean values for the individual parameters are calculated automatically and are displayed in the mean value table.

Furthermore, a maximum color deviation d(X/Y) and a maximum intensity deviation dINT for the average values will be formed.

When the TEACH TO TABLE button is pressed, the respective mean values are taught to the row in the COLOR TEACH TABLE that is selected under ROW No.:

Teaching of the circular tolerance and of the intensity tolerance can be set by way of TEACH CTO WITH and TEACH ITO WITH, respectively.

- If the setting is VALUE CTO, the value that is set under VALUE CTO will be taught (ditto intensity).
- If the setting is d(X/Y), the value that is determined under d(X/Y) will be taught (ditto intensity).
- If the setting is d(X/Y) + VALUE CTO, the value that is determined under d(X/Y) + VALUE CTO will be taught (ditto intensity).
- With NO CHANGE, the value that is set in the COLOR TEACH TABLE will remain unchanged.

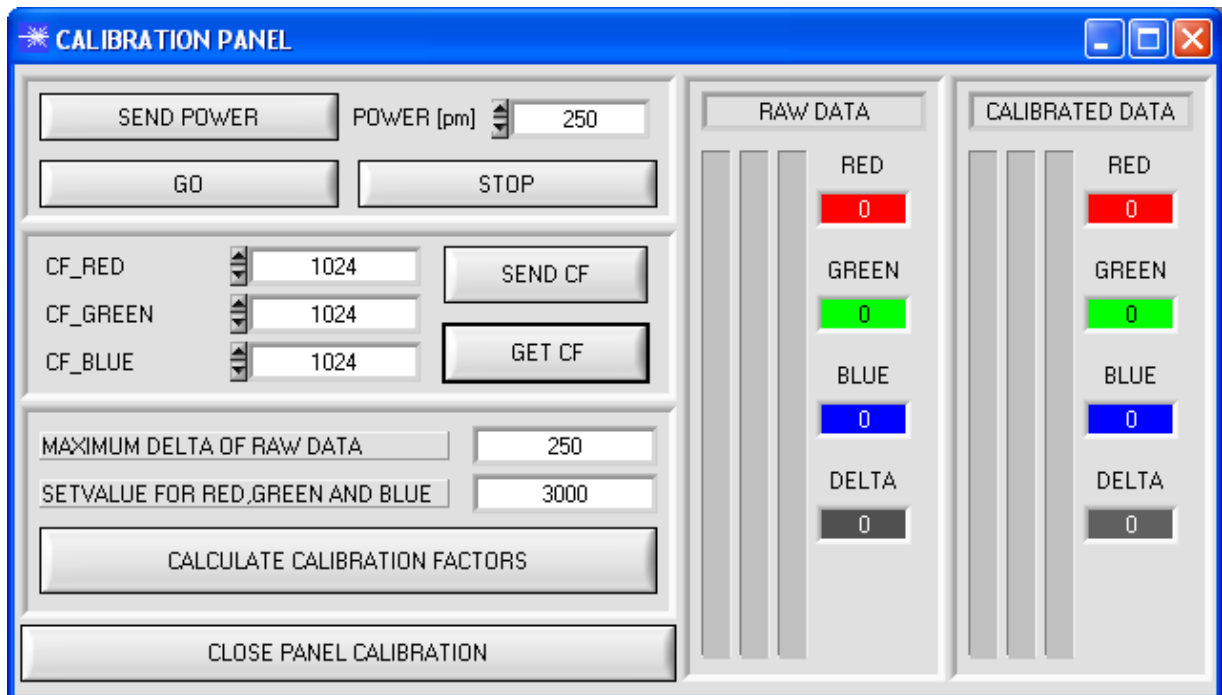
A click on the CLOSE TEACH PANEL button will take you back to the main panel.

2.7 Calibration or white light balancing

White light balancing can be performed with the sensors of the SI-COLO series. Balancing can be performed to any white surface. A ColorChecker™ table with 24 color fields according to CIE standard is available as an alternative, and white light balancing or calibration can then be performed to one of the white fields

ATTENTION: White light balancing **must** be performed after a firmware update.

The following panel will be displayed after a click on CALIBRATE:

A software window titled "CALIBRATION PANEL" with a blue header bar. It contains several control elements: a "SEND POWER" button next to a "POWER [pm]" slider set to 250; "GO" and "STOP" buttons; three color calibration fields labeled "CF_RED", "CF_GREEN", and "CF_BLUE", each with a numeric input set to 1024 and a "SEND CF" button; a "GET CF" button; a "MAXIMUM DELTA OF RAW DATA" input set to 250; a "SETVALUE FOR RED, GREEN AND BLUE" input set to 3000; a "CALCULATE CALIBRATION FACTORS" button; and a "CLOSE PANEL CALIBRATION" button at the bottom. On the right side, there are two vertical panels: "RAW DATA" and "CALIBRATED DATA". Each panel displays color bars and numerical values for RED, GREEN, BLUE, and DELTA, all of which are currently set to 0. The "RAW DATA" panel has colored bars (red, green, blue) next to the values, while the "CALIBRATED DATA" panel has grey bars.

Calculation example for determining the calibration factors

In the example in the picture below, a POWER value at which the three bars of the raw signals are in the dynamic range has been set. Each of the three bars is at approx. 3600 digits. It is thus appropriate to set a setpoint value of 3600 (see SETVALUE) for the three bars. When calibration is now started by pressing CALCULATE CALIBRATION FACTORS, the software automatically calculates the calibration factors for channel RED, channel GREEN, and channel BLUE. The calibration factors are normalized as integers to the value 1024.

Formula:

$$\begin{aligned} \text{CF_RED} &= (\text{SETVALUE} / \text{RAW DATA RED}) * 1024 = (3600 / 3512) * 1024 = 1049 \\ \text{CF_GREEN} &= (\text{SETVALUE} / \text{RAW DATA GREEN}) * 1024 = (3600 / 3694) * 1024 = 997 \\ \text{CF_BLUE} &= (\text{SETVALUE} / \text{RAW DATA BLUE}) * 1024 = (3600 / 3625) * 1024 = 1015 \end{aligned}$$

RAW DATA		CALIBRATED DATA	
RED	3512	RED	3597
GREEN	3694	GREEN	3596
BLUE	3625	BLUE	3593
DELTA	182	DELTA	4

When the calibration factors have been calculated by the software on the user interface, they are automatically saved to the non-volatile EEPROM memory of the sensor. Calibration is then finished, work can then be continued in the main panel.

When the sensor detects a raw signal, it applies the calibration factor saved in the EEPROM to this raw signal according to the following formula:

$$\begin{aligned} \text{CALIBRATED RED} &= (\text{RAW DATA RED} * \text{CF_RED}) / 1024 = (3512 * 1049) / 1024 = 3597 \\ \text{CALIBRATED GREEN} &= (\text{RAW DATA GREEN} * \text{CF_GREEN}) / 1024 = (3694 * 997) / 1024 = 3596 \\ \text{CALIBRATED BLUE} &= (\text{RAW DATA BLUE} * \text{CF_BLUE}) / 1024 = (3625 * 1015) / 1024 = 3593 \end{aligned}$$

I.e. in the main panel only the calibrated data for the RED, GREEN, and BLUE channels are displayed. Evaluation by the micro-controller also is exclusively done with the calibrated data.

In the following the individual steps for calibrating the sensors are described:

INFO: The individual pop-up windows are intended as a help to guide you through the calibration process.

ATTENTION: It is a prerequisite for successful calibration that the sensor front-end is calibrated to a white surface.

Step 1:

Click on START CALIBRATION.

The software automatically establishes a connection to the sensor and starts to record raw data from the sensor front-end. These raw data are visualized under RAW DATA.

Set the value for POWER [pm] such that all three bars are in the dynamic range, i.e. each of the three bars should lie between 3000 and 4000 digits.

Attention: A change of the POWER value only becomes effective when SEND POWER is pressed again.

Data exchange can be started and stopped with the GO und STOP buttons.

RAW DATA	
RED	3081
GREEN	3123
BLUE	2944
DELTA	179

Step 2:

When you have set a suitable POWER value, determine a SETVALUE FOR RED, GREEN, AND BLUE. The software now calculates the calibration factors in such a way that this SETVALUE is reached for the raw data (see calculation example above).

MAXIMUM DELTA OF RAW DATA	250
SETVALUE FOR RED, GREEN AND BLUE	3000
CALCULATE CALIBRATION FACTORS	

Step 3:

Determine a MAXIMUM DELTA OF RAW DATA (the software suggests 250).

Calibration is only permitted, if the current DELTA of the RAW DATA is smaller than the MAXIMUM DELTA OF RAW DATA.

DELTA is the maximum of RED, GREEN, and BLUE, minus the minimum of RED, GREEN, and BLUE. This is necessary in order to ensure that the sensor functions properly and calibration is performed on a white surface.

DELTA
155

Step 4:

Start calibration by pressing **CALCULATE CALIBRATION FACTORS**.

The button starts to flash in RED, and at the same time 100 raw data are recorded through the interface, of which the respective mean value of RED, GREEN, and BLUE is formed. The individual calibration factors are formed from these mean values and from the SETVALUES FOR RED, GREEN, and BLUE, and they are then entered in the corresponding edit-boxes.

The calibration software automatically saves the calculated calibration factors to the EEPROM of the sensor.

Then the software changes to the GO mode and displays the RAW DATA and the CALIBRATED DATA.

Please note that the DELTA of the CALIBRATED DATA is considerably lower than the DELTA of the RAW DATA, and that the values for RED, GREEN, and BLUE in the CALIBRATED DATA approximately are equal to the value of SETVALUE.

You may also change the calibration factors CF_RED, CF_GREEN, CF_BLUE manually by entering new values in the corresponding input fields. Please note that these factors are saved to the EEPROM by pressing **SEND CF**. **GET CF** reads the calibration factors that are currently saved in the EEPROM.

If pressing **CALCULATE CALIBRATION FACTORS** should not be successful, please follow the information provided in the pop-up windows.

Calibration only is completed successfully, if the following pop-up window is displayed:

CALCULATE CALIBRATION FACTORS

CALCULATE CALIBRATION FACTORS

CF_RED [pm]	968	SEND CF
CF_GREEN [pm]	949	GET CF
CF_BLUE [pm]	997	

RAW DATA

RED
3081
GREEN
3123
BLUE
2944
DELTA
179

CALIBRATED DATA

RED
2999
GREEN
3001
BLUE
2998
DELTA
3

CALIBRATION PASSED!
✕

Calibration successful!
 Calibration factors were sent to the EEPROM of the sensor.
 GO mode will be activated.
 Press CLOSE PANEL CALIBRATION to leave calibration scope.

OK

Step 5:

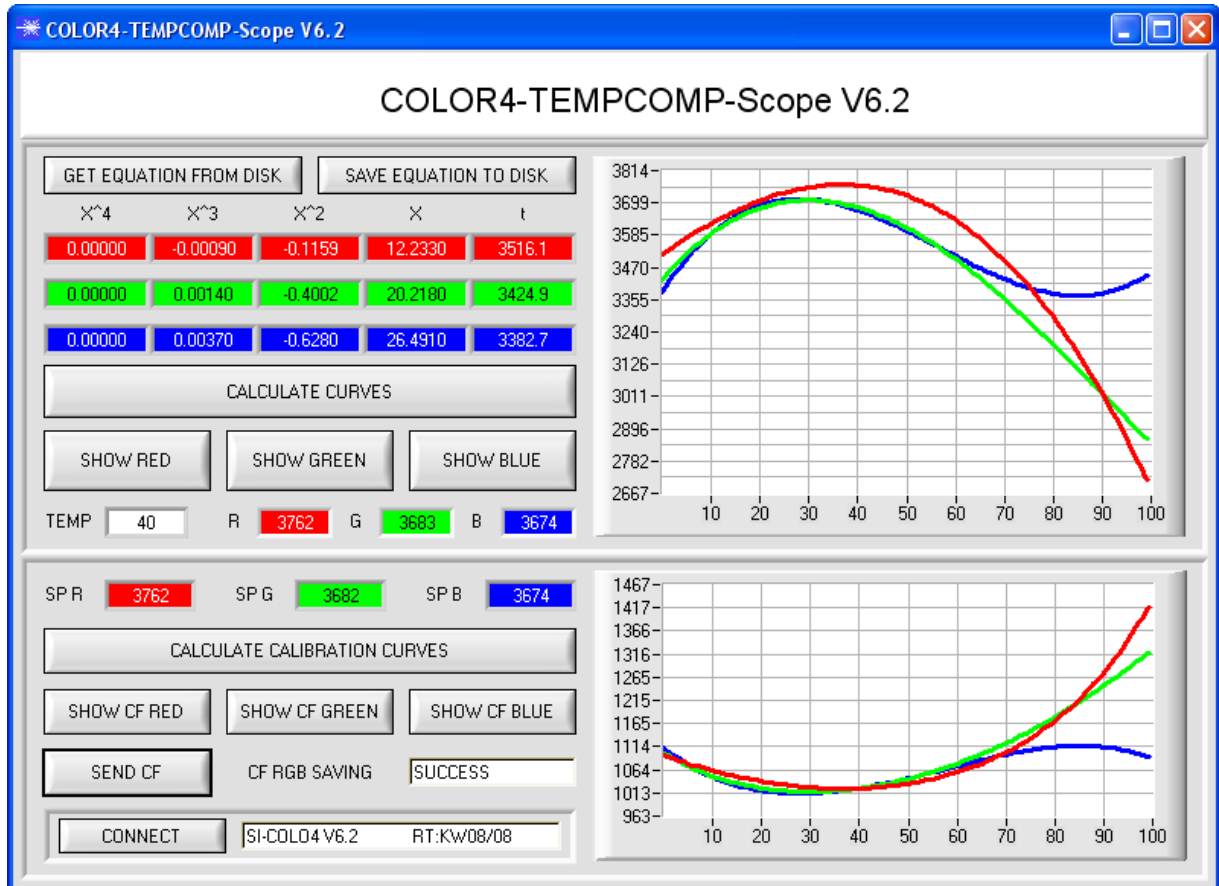
Press the **CLOSE PANEL CALIBRATION** button to close the recorder and return to the main program.

CLOSE PANEL CALIBRATION

2.8 Temperature compensation

Temperature compensation of the sensor must be performed after every firmware update. A file with corresponding data is required for this purpose. This file can be obtained from your supplier. To perform temperature compensation please start the corresponding TEMPComp-Scope software that is included on the supplied CD.

Please make sure that you have a functioning sensor connection. If necessary, select the corresponding connection with the CONNECT field.



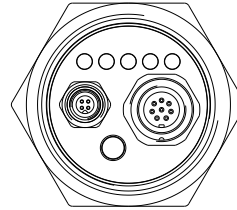
- Step 1: Load the temperature compensation file that you have received from your supplier with GET EQUATION FROM DISK.
- Step 2: Press CALCULATE CURVES to display the data in the graph.
The buttons SHOW RED, SHOW GREEN, and SHOW BLUE show the individual curves.
- Step 3: Select the sensor-internal operating temperature (not in °C) that the sensor has at an ambient temperature of 20°. The value should be included in the file designation.
- Step 4: Press CALCULATE CALIBRATION CURVES to calculate the mean straight line.
The buttons SHOW CF RED,... again show the individual curves.
- Step 5: Pressing the SEND CF button saves the mean straight lines in the EEPROM of the sensor.
- Step 6: Temperature compensation is successfully finished if the SUCCESS status message is then displayed.

Comment!

If you do not immediately have the temperature compensation file at hand, simply start the TEMPComp-Scope software. Establish a connection, if it is not already established, and simply press SEND-CF. The sensor then functions as before, but it is not temperature-compensated.

2.9 Function of the LED display

LED display:



BINARY

The color code is visualised by way of 5 yellow LEDs at the housing of the SPECTRO-3 color sensor. At the same time in the binary mode (OUT BINARY) the color code indicated on the LED display is output as 5-bit binary information at the digital outputs OUT0 to OUT4 of the 8-pin SPECTRO-3/PLC socket.

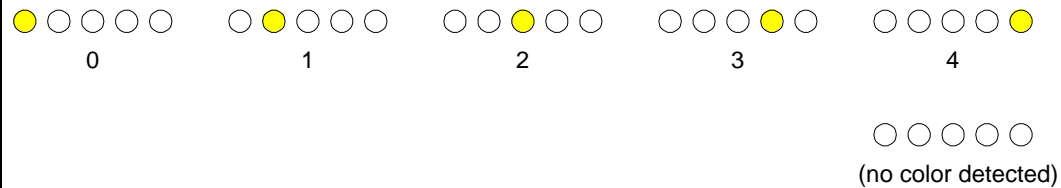
The SPECTRO-3 color sensor is able to process a maximum of 31 colors (color code 0 ... 30) in accordance with the corresponding rows in the COLOR TEACH TABLE. An "error" respectively a "not detected color" is displayed by the lighting of all LED (OUT0 .. OUT4 digital outputs are set to HIGH-level).

○ ○ ○ ○ ○	● ○ ○ ○ ○	○ ● ○ ○ ○	● ● ○ ○ ○
0	1	2	3
○ ○ ● ○ ○	● ○ ● ○ ○	○ ● ● ○ ○	● ● ● ○ ○
4	5	6	7
○ ○ ○ ● ○	● ○ ○ ● ○	○ ● ○ ● ○	● ● ○ ● ○
8	9	10	11
○ ○ ● ● ○	● ○ ● ● ○	○ ● ● ● ○	● ● ● ● ○
12	13	14	15
○ ○ ○ ○ ●	● ○ ○ ○ ●	○ ● ○ ○ ●	● ● ○ ○ ●
16	17	18	19
○ ○ ● ○ ●	● ○ ● ○ ●	○ ● ● ○ ●	● ● ● ○ ●
20	21	22	23
○ ○ ○ ● ●	● ○ ○ ● ●	○ ● ○ ● ●	● ● ○ ● ●
24	25	26	27
○ ○ ● ● ●	● ○ ● ● ●	○ ● ● ● ●	● ● ● ● ●
28	29	30	Error or not detected

DIRECT HI:

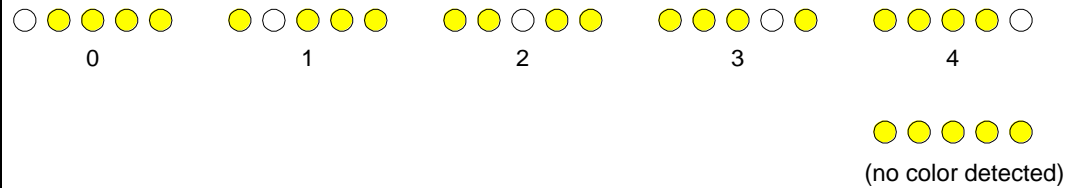
In the DIRECT mode (OUT DIRECT HI or OUT DIRECT LO) the maximum numbers of colors to be taught is 5 (color no. 0, 1, 2, 3, 4).

If DIRECT HI is activated, the specially digital output is set to HI, while the other 4 are set to LO. If the current color does not correspond with any of the teach-in colors, color C-No = 0 is set, i.e. all digital outputs are set to LOW (no LED is lighting).



DIRECT LO:


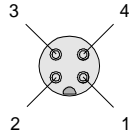
If DIRECT LO is activated, the specially digital output is set to LO, while the other 4 are set to HI. If the current color does not correspond with any of the teach-in colors, color C-No = 255 is set, i.e. all digital outputs are set to HIGH (all LED are lighting).




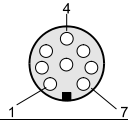


3 Connector assignment of the SPECTRO-3 color sensor

Connection of SPECTRO-3 to PC:

4-pole fem. M5 connector (type Binder 707) SPECTRO-3/PC-RS232			 
Pin-No.:		Assignment:	
1		+24VDC	
2		0V (GND)	
3		Tx0	
4		Rx0	

Connection of SPECTRO-3 to PLC:

8-pole female connector (type Binder 712) SPECTRO-3/PLC			 
Pin No.:	Color:	Assignment:	
1	White	0V (GND)	
2	Brown	+12VDC ... +30VDC	
3	Green	IN0	
4	Yellow	OUT0 (Digital 0: Type 0 ... 1V, Digital 1: Type +Ub – 10%)	
5	Grey	OUT1 (Digital 0: Type 0 ... 1V, Digital 1: Type +Ub – 10%)	
6	Pink	OUT2 (Digital 0: Type 0 ... 1V, Digital 1: Type +Ub – 10%)	
7	Blue	OUT3 (Digital 0: Type 0 ... 1V, Digital 1: Type +Ub – 10%)	
8	Red	OUT4 (Digital 0: Type 0 ... 1V, Digital 1: Type +Ub – 10%)	

4 RS232 communication protocol

RS232 communication protocol PC ↔ SPECTRO-3 Sensor (SPECTRO3-Scope V2.0)

- Standard RS232 serial interface without hardware-handshake

- 3-wire: GND, TX0, RX0

- Speed: 19200 baud, 8 data-bits, no parity-bit, 1 stop-bit in binary mode, us (unsigned), MSB (most significant byte) first.

The control device (PC or PLC) has to send a data frame of 18 words to the Sensor. All bytes must be transmitted in binary format (us, MSB). The meaning of the parameters is described in the software manual.

Info: 1 word = 2 bytes

Method:

The hardware is permanently reading (polling) the incoming byte at the RS232 connection. If the incoming word is 0x0055 (synch-word), then the 2. word (order-word) is read in, after this, 16 words (parameters) will be read. After reading in the completely data frame, the Sensor executes the order which is coded at the 2. word (order-word).

Format of the data frame:

Word No.	Format	Meaning	Comment:
1	Word	sync-word = 0x0055	hex-code 0x0055, binary: 0000 0000 0101 0101, synchronisation word
2	Word	ORDER NUMBER	order word
3	Word	Para POWER	LED intensity (0 ... 1000) Attention intensity in thousandth!
4	Word	Para POWER MODE	LED mode: STATIC, DYNAMIC coded to (0, 1)
5	Word	Para AVERAGE	Signal averaging 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384 or 32768
6	Word	Para EVALUATION MODE	Evaluation mode: FIRST HIT, BEST HIT, MIN DIST, COL5 coded to (0,1,2,3)
7	Word	Para HOLD[ms]	Hold time 0,1,2,3,5,10,50 or 100ms
8	Word	Para INTLIM	Intensity limit (0 ... 4095)
9	Word	Para MAXCOL-No.	Number of the colours (1,2,3,...,31)
10	Word	Para OUTMODE	Function of the digital output: direct/HI, binary, direct/LO coded to (0,1,2)
11	Word	Para TRIGGER	Trigger mode: CONT, SELF, EXT1, EXT2 or EXT3 coded to (0, 1, 2, 3, 4)
12	Word	Para EXTEACH	External teach mode: OFF, ON, STAT1, DYN1 coded to (0,1,2,3)
13	Word	Para CALCULATION MODE	Calculation mode: X/Y INT, s/i M, X/Y/INT, s/i/M coded to (0,1,2,3)
14	Word	Para DYN WIN LO	Low limit for dynamic window when POWERMODE=dynamic (0...4095)
15	Word	Para DYN WIN HI	High limit for dynamic window when POWERMODE=dynamic (0...4095)
16	Word	Para COLOR GROUPS	Color groups enable: OFF, ON coded to (0,1)
17	Word	Para LED MODE	How to control the internal light source DC or AC coded to (0,1)
18	Word	Para GAIN	Amplification of the integrated receiver AMP1, AMP2, AMP3, AMP4, AMP5, AMP6, AMP7, AMP8 coded to (1, 2, 3, 4, 5, 6, 7, 8)

Value	ORDER NUMBER	(parameter byte no. 2)
0	nop	no operation
1	Save parameter from PC into RAM	Cf. Example 1
2	Save one selectable row of TEACH TABLE into RAM	Cf. Example 2
3	Send parameter from RAM to PC	Cf. Example 3
4	Send one selectable Row of TEACH TABLE from RAM to PC	Cf. Example 4
5	Send data from RAM to PC	Cf. Example 5
6	Save parameter from RAM to EEPROM	Cf. Example 6
7	Send connection OK to PC	Cf. Example 7
8	Load Parameter from EEPROM to RAM	Cf. Example 8
20	Send line ok = 0x00AA, 0x0014, 0x00AA, 15 Dummies to PC	Cf. Example 20
30	Save Calibration factors RED, GREEN, BLUE from PC into EEPROM	Cf. Example 30
31	Send Calibration factors RED, GREEN, BLUE from EEPROM to PC	Cf. Example 31
50	Start or Stop an automatic send of a data frame after trigger	Cf. Example 50

Example 1: DATA FRAME with ORDER NUMBER = 1:

ORDER NUMBER (second word = 1): WRITE parameters from PC into RAM of the sensor!

The completely data frame = 18 words must be sent to the sensor hardware in binary form (sync-word / order-word / 16 parameter words).

DATA FRAME PC → Sensor (18 WORDS)

0x0055	SYNC.-WORD
1	ORDER-WORD
200	POWER
0	POWER MODE
1024	AVERAGE
0	EVALUATION MODE
10	HOLD
10	INTLIM
5	MAXCOL-No.
0	OUTMODE
0	TRIGGER
0	EXTEACH
0	CALCULATION MODE
3000	DYN WIN LO
3500	DYN WIN HI
0	COLOR GROUPS
1	LED MODE
80	GAIN

DATA FRAME Sensor → PC (18 WORDS)

0x00AA	SYNC.-WORD
1	ORDER-WORD
200	POWER
0	POWER MODE
1024	AVERAGE
0	EVALUATION MODE
10	HOLD
10	INTLIM
5	MAXCOL-No.
0	OUTMODE
0	TRIGGER
0	EXTEACH
0	CALCULATION MODE
3000	DYN WIN LO
3500	DYN WIN HI
0	COLOR GROUPS
1	LED MODE
80	GAIN

Example 2: DATA FRAME with ORDER NUMBER = 2:

ORDER NUMBER (second word = 2): WRITE one selectable row (vector) of TEACH TABLE into RAM of the sensor!

The completely data frame = 18 words must be sent to the sensor in binary form (sync-word / order-word / ROW-NO / 4 parameter words = vector, 11 dummies).

Fill unused words of the TEACH VECTOR by value word=1 in binary form.

DATA FRAME PC → Sensor (18 WORDS) (Example, when CALCMODE = X/Y INT)

0x0055	SYNC.-WORD
2	ORDER-WORD
0	ROW-No. (0...30)
1200	X respectively s
1500	Y respectively i
100	CTO respectively siTO
2000	INT respectively M
100	ITO respectively MTO
0	Group
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY

DATA FRAME Sensor → PC (18 WORDS) (Example, when CALCMODE = X/Y INT)

0x00AA	SYNC-WORD
2	ORDER-WORD
0	ROW-No. (0...30)
1200	X respectively s
1500	Y respectively i
100	CTO respectively siTO
2000	INT respectively M
100	ITO respectively MTO
0	Group
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY

Example 3: DATA FRAME with ORDER NUMBER = 3:

ORDER NUMBER (second word = 3): READ parameters out of sensor-RAM memory!

The same frame as example 1 must be sent to the sensor except of the order word that must be **3**. The values for the parameters must be sent as Dummies.

The complete DATA FRAME which is responded by the sensor is 18 words.

DATA FRAME PC → Sensor (18 WORDS)

DATA FRAME Sensor → PC (18 WORDS)

0x00AA	SYNC-WORD
3	ORDER-WORD
200	POWER
0	POWER MODE
1024	AVERAGE
0	EVALUATION MODE
10	HOLD
10	INTLIM
5	MAXCOL-No.
0	OUTMODE
0	TRIGGER
0	EXTEACH
0	CALCULATION MODE
3000	DYN WIN LO
3500	DYN WIN HI
0	COLOR GROUPS
1	LED MODE
80	GAIN

Example 4: DATA FRAME with ORDER NUMBER = 4:

ORDER NUMBER (second word = 4): READ one selectable row (vector) from RAM of the sensor! The same frame as example 2 must be sent to the sensor except of the order word that must be **4**. The values for the parameters must be sent as Dummies.

The complete DATA FRAME which is responded by the sensor is 18 words.

DATA FRAME PC → Sensor (18 WORDS)

DATA FRAME Sensor → PC (18 WORDS) (Example, when CALCMODE = X/Y INT)

0x00AA	SYNC-WORD
4	ORDER-WORD
0	ROW-No. (0...30)
Value	X respectively s
Value	Y respectively i
Value	CTO respectively siTO
Value	INT respectively M
Value	ITO respectively MTO
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY
1	DUMMY

Example 5: DATA FRAME with ORDER NUMBER = 5:

ORDER NUMBER (second word = 5): READ SPECTRO-3 RAW DATA

Parameters must be sent for a constant parameter frame as dummies.

At order word 5 they do not affect the RAM or EEPROM.

DATA FRAME PC → Sensor (18 WORDS)

0x0055	SYNC.-WORD
5	ORDER-WORD
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY

DATA FRAME Sensor → PC (18 WORDS)

0x00AA
5
R
G
B
X
Y
INT
C-No.
RAW R
RAW G
RAW B
TEMP
GRP
DUMMY
DUMMY
DUMMY
DUMMY

Example 6: DATA FRAME with ORDER NUMBER = 6:

ORDER NUMBER (second word = 6): SAVE parameters from RAM to EEPROM of the sensor!

The complete data frame = 18 words must be sent to the sensor in binary form (sync-word / order-word / 16 parameter words).

DATA FRAME PC → Sensor (18 WORDS)

0x0055	SYNC.-WORD
6	ORDER-WORD
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY

After sending this data frame, the sensor saves all the parameters and teach vectors from its RAM (volatile memory) to its EEPROM (non volatile memory).

ATTENTION: The right parameters and teach vectors must be in the RAM of the sensor. To save the parameters and teach vectors into RAM see **Example 1** and **Example 2**.

After completing the sensor writes back an echo of the same frame.

DATA FRAME RLS-GD → PC (18 WORDS)

0x00AA	SYNC-WORD
6	ORDER-WORD
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY

Example 7: DATA FRAME with ORDER NUMBER = 7:

ORDER NUMBER (second word = 7): SEND CONNECTION OK from the Sensor! Cf. example 1:
 Send the same DATA FRAME but with ORDER NUMBER 7 to the sensor.
 The sensor will reply with 18 words which tell the version of the sensor.

Example 8:

DATA FRAME with ORDER NUMBER = 8:

ORDER NUMBER (second word = 8): Load parameters from EEPROM to RAM of the sensor!
 The complete data frame = 18 words must be sent to the sensor in binary form (sync-word / order-word / 16 parameter words).

DATA FRAME PC → Sensor (18 WORDS)

0x0055	SYNC.-WORD
8	ORDER-WORD
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY

After sending this data frame, the sensor loads all the parameters and teach vectors from it's EEPROM (non volatile memory) to it's RAM (volatile memory).

ATTENTION: The EEPROM parameters must be load first to the RAM to read it from the sensor.
 To get the parameters and teach vectors from RAM see **Example3** and **Example4**.

After completing the sensor writes back an echo of the same frame.

DATA FRAME Sensor → PC (18 WORDS)

0x00AA	SYNC-WORD
8	ORDER-WORD
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY

Example 20: DATA FRAME with ORDER NUMBER = 20:

ORDER NUMBER (second word = 20): SEND LINE OK from the Sensor to PC! Cf. example 1:

Send the same DATA FRAME but with ORDER NUMBER 20 to the sensor.

The sensor will reply with the same 18 words but with SYNC-WORD=0x00AA which tell that there is a connection.

Example 30: DATA FRAME with ORDER NUMBER = 30:

ORDER NUMBER (second word = 30): Write calibration factors RED, GREEN, BLUE from PC into EEPROM!

The completely data frame = 18 words must be sent to the sensor hardware in binary form

(sync-word / order-word / 16 parameter words).

DATA FRAME PC → Sensor (18 WORDS)

0x0055	SYNC.-WORD
30	ORDER-WORD
VALUE	CF RED
VALUE	CF GREEN
VALUE	CF BLUE
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY

DATA FRAME Sensor → PC (18 WORDS)

0x00AA	SYNC.-WORD
30	ORDER-WORD
VALUE	CF RED
VALUE	CF GREEN
VALUE	CF BLUE
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY

Example 31: DATA FRAME with ORDER NUMBER = 31:

ORDER NUMBER (second word = 31): READ calibration factor RED, GREEN, BLUE from the EEPROM of the sensor! The same frame as example 30 must be sent to the sensor except of the order word that must be **31**. The values do not affect the sensor.

The complete DATA FRAME which is responded by the sensor is 18 words.

DATA FRAME PC → Sensor (18 WORDS)

DATA FRAME Sensor → PC (18 WORDS)

0x00AA	SYNC-WORD
31	ORDER-WORD
VALUE	CF RED
VALUE	CF GREEN
VALUE	CF BLUE
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY

Example 50: DATA FRAME with ORDER NUMBER = 50:

ORDER NUMBER (second word = 50): Start or Stop an automatic send of a data frame after a trigger.

The complete data frame = 18 words must be sent to the Sensor hardware in binary form (sync-word / order-word / 16 parameter words).

DATA FRAME PC → Sensor (18 WORDS)

0x0055	SYNC-WORD
50	ORDER-WORD
0	0=autosend off, 1=autosend on
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY
0	DUMMY

After activation an automatic send (autosend=1) the sensor writes after each trigger a dataframe.
 Cf. DATA FRAME Sensor → PC (18 WORDS) in Example 5.