Manual

Software SI-COLO-GD-Scope V1.1

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

for color gloss sensors of SI-COLO-GD Series
with internal temperature compensation and white light balancing

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

The SI-COLO-GD color gloss sensor detects both the color and the gloss of an object. The color and gloss information of an object hereinafter is referred to as a **vector**. A surface only is recognised if its vector data match a previously taught teach vector.

The SI-COLO-GD color gloss sensor features a white-light LED as a light source.
An integrated 3-fold receiver for the red, green, and blue component of the light that is reflected from the object to be measured is employed for determining the color information. An X-value, a Y-value, and an intensity INT are formed from red, green, and blue. Color evaluation according to siM uses the Lab calculation method, which means that an s-value, an i-value, and an M-value are determined from red, green, and blue.
In addition to the color receiver there are 3 other channels. A reference channel (REF) that continuously detects the light emitting from the light source, another channel that detects the direct reflection (DIR) of the object to be measured, and a third channel that records the diffuse reflection (DIF). For determining the gloss information the DIF and DIR channels are normalised against each other and form the gloss norm value GN.

The SI-COLO-GD sensor can be "taught" up to 31 vectors (surfaces). There are 8 different methods of representing a vector. The first two methods can be visualised as two-dimensional methods (X/Y INT GN or s/i M GN), where the tolerances define a color cylinder in space, the diameter of which is set by an X/Y (or s/i) tolerance. The height of the color cylinder is defined by the intensity tolerance. For a vector to be recognised, the gloss norm value (GN) also must lie in a certain adjustable tolerance window.

The two X/Y/INT GN and s/i/M GN modes are three-dimensional methods. In these modes the tolerances define a color sphere in space. For a vector to be recognised, the gloss norm value (GN) also must lie in a certain adjustable tolerance window.

The two X/Y/GN INT and s/i/GN M modes also are three-dimensional methods. The tolerance defines a sphere of color and gloss in space. For a vector to be recognised, the color intensity INT or M also must lie in a certain adjustable tolerance window.
The X/Y/INT/GN and s/i/M/GN modes are four-dimensional representations of a vector.
All the modes can be used in combination with the "FIRST HIT", "BEST HIT", "MIN DIST" and "VECTOR 5" operating modes. Raw data are represented in 12-bit resolution.

Vector detection either operates continuously or is started by means of an external SPC trigger signal. The respective detected vector either is output as binary code at the 5 digital outputs, or it can be sent directly to the outputs, if only up to 5 vectors are to be detected. Simultaneously the detected vector code is visualised at the SI-COLO-GD housing by means of 5 LEDs.

With the TEACH button at the sensor housing the sensor can be taught up to 31 vectors. 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 of cable cab-las8/SPS).

Through the RS232 interface parameters and measured values can be exchanged between the PC and the SI-COLO-GD color gloss sensor. All the parameters for vector detection can be stored in the non-volatile EEPROM of the SI-COLO-GD color gloss sensor. When parameterization is finished the sensor continues to operate with the current parameters in "stand alone" mode without a PC.

The sensors of the SI-COLO-GD V1.1 series can be calibrated (white light balancing). Balancing can be performed to any white surface. A ColorChecker[TM] 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.

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Shortcuts:

SEND	F9
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1   Installation of the SI-COLO-GD-Scope software

Hardware requirements for successful installation of the SI-COLO-GD-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 SI-COLO-GD-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 SI-COLO-GD-Scope Software
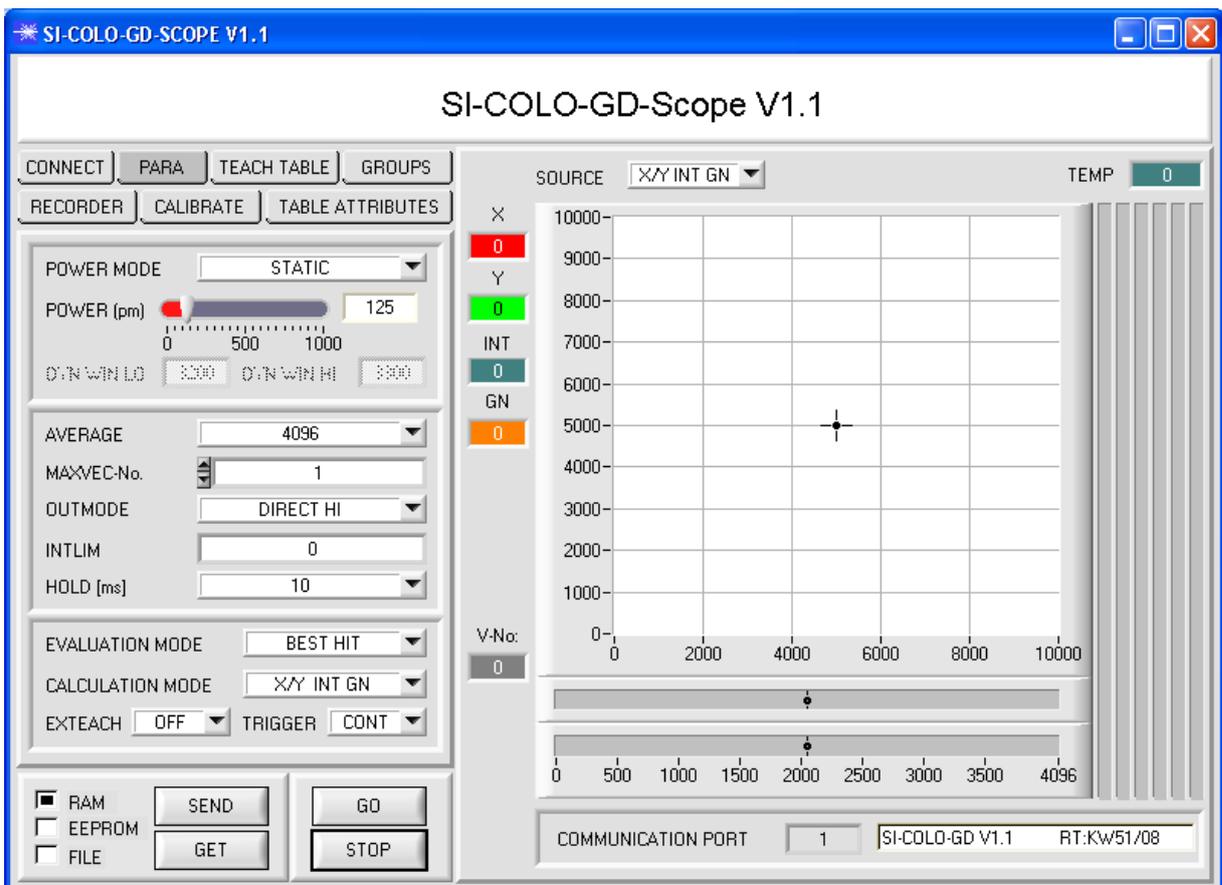
2.1 Functions of the individual SI-COLO-GD-Scope control elements

Please read this chapter first before you start to adjust and parameterise the SI-COLO-GD color gloss sensor.

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

When the SI-COLO-GD-Scope software is started, the following window appears on the Windows interface:

2.1 Tab CONNECT

| CONNECT | PARA | TEACH TABLE | GROUPS |
| RECORDER | CALIBRATE | TABLE ATTRIBUTES |

COMMUNICATION PROTOCOL RS232 ▼

SELECT COM PORT [1...256] ▲▼ 1

TRY TO CONNECT

ACCEPT SETTINGS | DISCARD SETTINGS

INSERT A PANEL ID

COMMUNICATION PROTOCOL TCP/IP ▼

IP ADRESS (xxx.xxx.xxx.xxx) OR HOST NAME
▼ 192.168.3.151

PORT NUMBER (Default 10001) 10001

CONNECT:
Pressing the CONNECT tab opens a window for selecting and configuring the interface.

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 an adaptor is used, the COMPORT number can be determined by way of the hardware manager in the system control panel.
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 ADRESS (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 PARA tab. 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 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).**

2.2 Tab PARA, button SEND, GET, GO, STOP

PARA:
Pressing the PARA tab opens a window for setting the sensor parameters.

ATTENTION!
A change of the parameter function groups only becomes effective at the sensor after actuation of the SEND button in the MEM function field!

SEND [F9]:
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 [F10]:
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:
After a click on the SEND button the current parameters are written into the RAM memory of the sensor, or they are read from the RAM by clicking on the GET button, i.e. these parameters are lost when the voltage at the sensor is switched off.

EEPROM:
After a click on the SEND button the current parameters are written into the non-volatile memory of the EEPROM in the sensor, or they are read from the EEPROM by clicking on the GET button, i.e. the parameters in the internal EEPROM are stored when the voltage at the sensor is switched off.

FILE:
After pressing SEND, the current parameters can be written to a selectable file on the hard disk. With GET parameters can be read from such a file. When the SEND or GET button is pressed, a dialog box opens for selecting the desired file.

GO [F11]:
A click on this button (or with shortcut key button F11) starts data transfer from the sensor to the PC through the serial RS232 interface.
SOURCE is used to select which signals should be shown in the displays and graphs.

STOP [F12]:
A click on this button (or with shortcut key button F12) stops data transfer from the sensor to the PC through the serial RS232 interface.

EVALUATION MODE	BEST HIT ▼

EVALUATION MODE:
This function field serves for setting the evaluation mode at the SI-COLO-GD sensor.

All the evaluation modes apply to all CALCULATION MODE = X/Y INT, s/i M, X/Y/INT and i/i/M.
The TEACH TABLE is correspondingly adapted depending on the CALCULATION MODE.
The following explanation uses CALCULATION MODE = X/Y INT GN.

EVALUATION MODE	FIRST HIT ▼

|	X	Y	CTO	INT	ITO	GN	GTO	
0	2574	801	100	2006	100	378	100	
1	2574	801	300	2006	200	378	200	
2	2574	801	500	2006	300	378	300	
3	1	1	1	1	1	1	1	

FIRST HIT:
The currently measured vector values are compared with the default values in the VECTOR TEACH TABLE, starting with teach-vector 0. If in the row-by-row comparison the current vector values correspond with the teach-parameters entered in the VECTOR TEACH TABLE, this **first "hit"** in the VECTOR TEACH TABLE is displayed as a vector number (V-No.) and is output at the digital outputs (OUT0 ... OUT4) according to the settings of the OUTMODE parameter (see OUTMODE).
If the current vector does not correspond with any of the teach-in vectors, the vector code V-No. = 255 will be set ("error status").
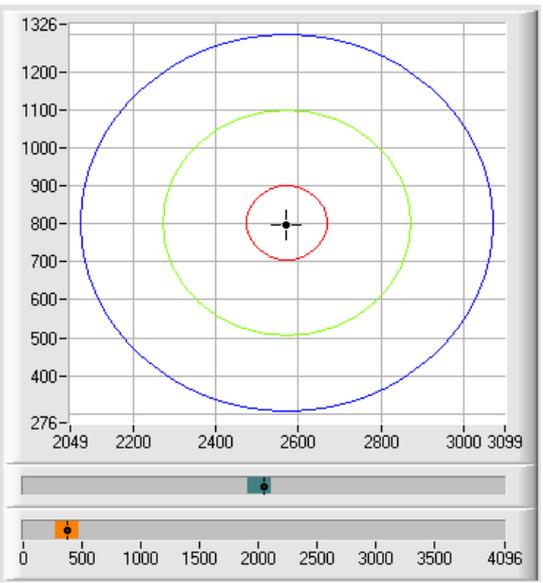
Tip! This mode is used if only one surface (vector) is taught, and this vector must be checked to avoid "drifting away". With the rising tolerance windows this can be detected very well, and countermeasures can be initiated, if necessary.
Tip! If, for example, only the X/Y coordinates should be checked, and the intensity INT or the gloss GN are not important, tolerances of 4000 can be chosen for ITO or GTO hence the test criteria are fulfilled in any case.
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!

	X	Y	CTO	INT	ITO	GN	GTO	
0	2623	757	200	2033	200	380	200	
1	1265	2050	200	1244	200	643	200	
2	1179	1385	200	1437	200	666	200	
3	1	1	1	1	1	1	1	
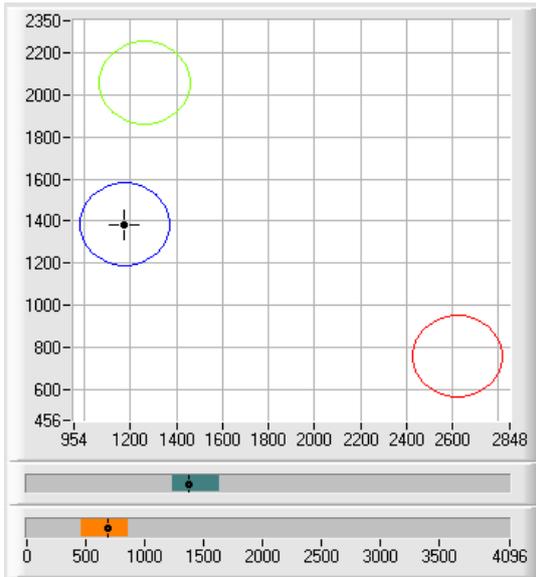
BEST HIT:

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

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

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

Tip! This mode is used if several surfaces (vectors) 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 vector to the centres of the taught vectors, the individual tolerance windows (circles) may overlap here. The sensor detects the "**best hit**".
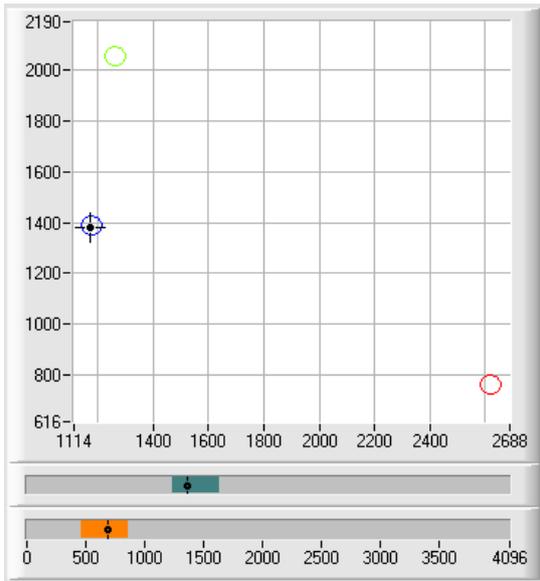
Tip! Values can be entered in a cell of the table either by double-clicking on the respective cell, or by highlighting the respective cell and then pressing F2.

Tip! In the calculation modes in the three- and four-dimensional space the shortest distance in the three- respectively four-dimensional space is calculated.

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

MIN DIST:
The individual teach-in vectors defined in the VECTOR 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 SI-COLO-GD sensor, the evaluation algorithm, starting from the currently measured color value (X,Y), calculates the distance to the individual teach-in vectors in the color triangle. The current color value (X,Y) is assigned to the teach-in vector that is closest in the color triangle. It is furthermore checked whether the intensity condition and the gloss condition for this vector also are true. If intensity condition and gloss condition are not true, the second shortest distance will be checked, etc.

The vector detected this way is output at the digital outputs (OUT0 ... OUT4) according to the settings of the OUTMODE parameter (see OUTMODE).
V-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 vectors in the graph. It has no meaning for evaluation.
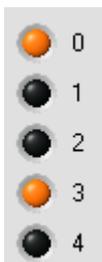
Tip! This mode is used if you have taught several surfaces of separate colors, and a current vector in any case must be assigned to one of the taught vectors. This applies, for example, if you want to compensate a product variation, or if you have to solve sorting tasks.
Tip! If, for example, only the X/Y coordinates should be checked, and intensity INT or gloss GN is of no importance, tolerances of 4000 can be selected for ITO respectively for GTO. These inspection criterions are 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 the calculation modes in the three- and four-dimensional space the shortest distance in the three- respectively four-dimensional space is calculated.

	X	Y		INT	ITO	GN	GTO	
0	2623	757	40	2033	200	380	200	red
1	1265	2050	40	1244	200	643	200	green
2	1179	1385	40	1437	200	666	200	blue
3	1	1	1	1	1	1	1	black

VECTOR5:
In this evaluation mode the rows 0 to 4 in the VECTOR TEACH TABLE are evaluated.
Every match of current vector and teach vector (row number) is directly sent to the corresponding output.

Tip! This evaluation mode is used if certain vectors are overlapping. If both outputs are activated at the same time, this indicates that the value lies in the overlapping range.
Another possibility is to teach certain intensity ranges, for example, to row 1 to 4. The vector with large tolerances for INT and GN is then taught to row 0. When row 0 is then detected, the color is recognised. The other outputs then provide information about the intensity.
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!

	X	Y	CTO	INT	ITO	GN	GTO	
0	1997	1157	200	2500	2500	2500	2500	red
1	1350	1350	2500	600	600	2500	2500	green
2	1350	1350	2500	1600	600	2500	2500	blue
3	1350	1350	2500	2600	600	2500	2500	black
4	1350	1350	2500	3600	600	2500	2500	pink
5	1	1	1	1	1	1	1	yellow

CALCULATION MODE	X/Y INT GN ▼

CALCULATION MODE:

X/Y INT GN:
From the individual components of red, green, blue, DIR channel and DIF channel, the X/Y pairs, the color intensity INT, and the gloss norm value GN are calculated for evaluation. For X/Y a color tolerance CTO, for INT an intensity tolerance ITO, and for GN a gloss tolerance GTO can be set. Based on the individual tolerances the vector can be visualised as a color cylinder in space that is defined by X/Y and INT (see picture below). CTO defines the diameter, and ITO defines the height of the cylinder.
A vector is recognised if its coordinates lie within the taught color cylinder in space, and if at the same time its GN value lies within the corresponding gloss tolerances.

s/i M GN:
Corresponds with the CALCULATION MODE X/Y INT GN, if X is replaced by s, Y is replaced by i, INT is replaced by M, CTO is replaced by siTO, and ITO is replaced by MTO.

X/Y/INT GN:
From the individual components of red, green, blue, DIR channel and DIF channel, the values for X, Y, the color tolerance INT, and the gloss norm value GN are calculated for evaluation.
X, Y and INT define a point in the three-dimensional color space. The tolerance input TOL forms a sphere with radius TOL in the color space (see picture below).
A vector is recognised if its coordinates lie within the taught color sphere in space, and if at the same time its GN value lies within the corresponding taught gloss norm tolerance GN ± GTO.

s/i/M GN:
Corresponds with the CALCULATION MODE X/Y/INT GN, if X is replaced by s, Y is replaced by i, and INT is replaced by M.

X/Y/GN INT:
From the individual components of red, green, blue, DIR channel and DIF channel, the values for X, Y, the color tolerance INT, and the gloss norm value GN are calculated for evaluation.
X, Y and GN define a point in thee-dimensional space. The tolerance input TOL forms a sphere with radius TOL in space (see picture below).
A vector is recognised if its coordinates lie within the taught sphere in space, and if at the same time its INT value lies within the corresponding taught intensity tolerance INT ± ITO.

s/i/GN M:
Corresponds with the CALCULATION MODE X/Y/GN INT, if X is replaced by s, Y is replaced by i, INT is replaced by M, and ITO is replaced by MTO.

X/Y/INT/GN:
From the individual components of red, green, blue, DIR channel and DIF channel, the values for X, Y, the color intensity INT, and the gloss norm value GN are calculated for evaluation.
These values define a four-dimensional point.
A vector is recognised if its coordinates lie within this point with a corresponding tolerance TOL.

s/i/M/GN:
Corresponds with the CALCULATION MODE X/Y/INT/GN, if X is replaced by s, Y is replaced by i, and INT is replaced by M.

Calculation of coordinates:

X X-value of the teach color (in the color triangle numerical value on the x-axis: RED color component)

s $$X = \frac{R}{R+G+B} * 4095$$

   s is calculated according to the Lab color evaluation method.

Y Y-value of the teach color (in the color triangle numerical value on the y-axis: GREEN color

i component)

   $$Y = \frac{G}{R+G+B} * 4095$$

   i is calculated according to the Lab color evaluation method.

IN Intensity value of the respective color.
T $$INT = \frac{R+G+B}{3}$$
M
   M is calculated according to the Lab color evaluation method.

GN Norm gloss value
   $$GN = \frac{DIR}{DIR+DIF} * 4095$$

CTO In CALCULATION MODE X/Y INT GN or s/i M GN, CTO or siTO is the color tolerance radius around
siTO the respective taught X/Y or s/i pair. CTO or siTO defines the radius of the color cylinder in space.
     Within the "tolerance circle" that is defined by this the current color is recognised as the teach color.

ITO ITO defines the intensity tolerance window around the respective taught intensity INT or M. Within the
MTO "tolerance window" that is defined by this the color intensity is recognised as the teach intensity.

     In CALCULATION MODE X/Y INT GN or s/i M GN, ITO or MTO defines the height of the color cylinder
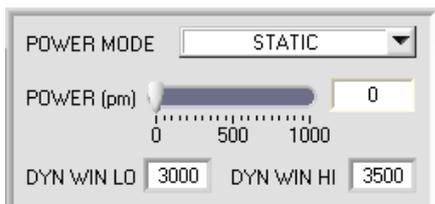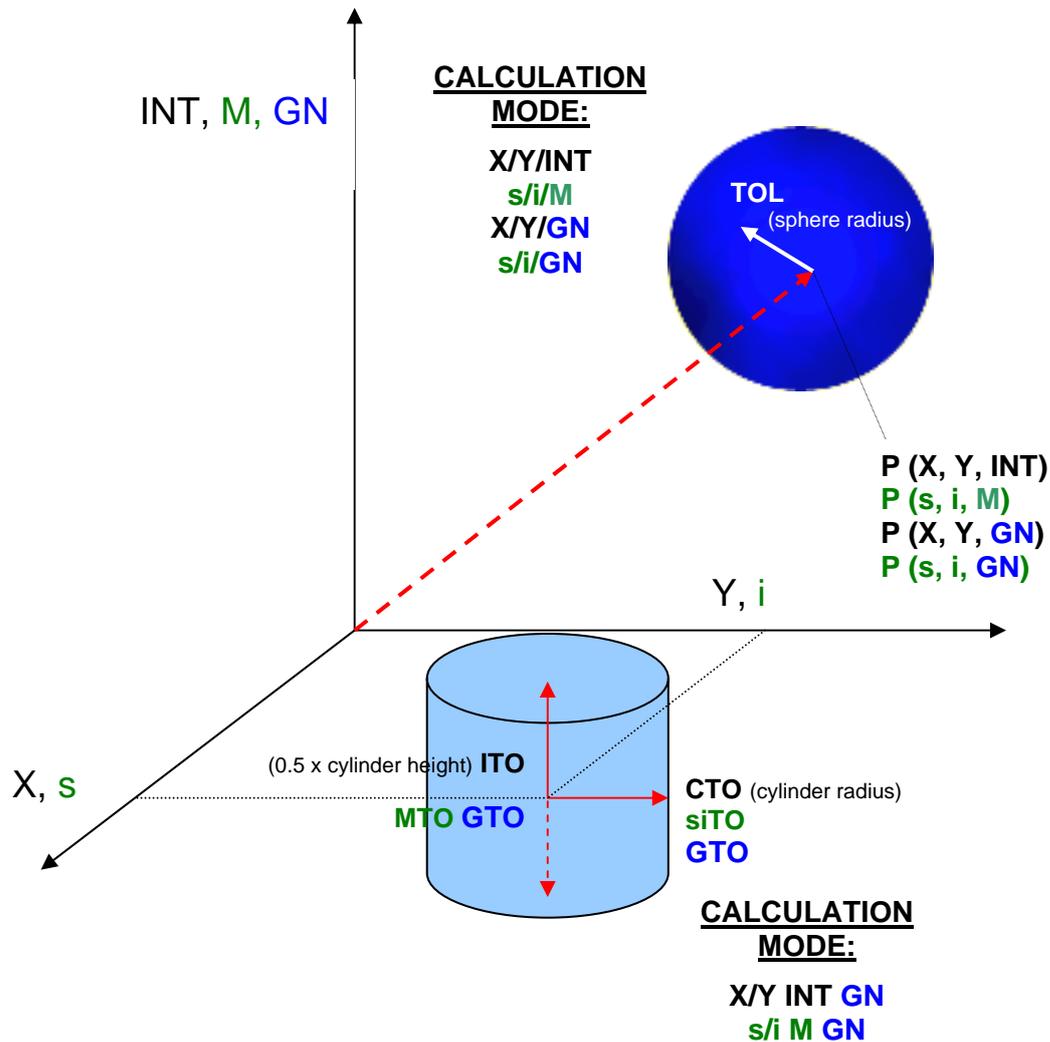   in space.

     ITO or MTO is a plus/minus tolerance.

GTO In CALCULATION MODE X/Y INT GN or s/i M GN, GTO is the gloss tolerance window around the
     respective taught gloss norm value GN. Within the "tolerance window" that is defined by this the gloss
     norm value is recognised as the teach gloss.

     GTO is a plus/minus tolerance.

TOL In CALCULATION MODE X/Y/INT GN, s/i/M GN, X/Y/GN INT or s/i/GN M, TOL is the tolerance radius
     around the respective taught point in space. TOL defines the radius of the sphere in space. Within
     this sphere the current vector is recognised as the teach vector.

     In CALCULATION MODE X/YINT/GN or s/i/M/GN, TOL defines a tolerance around a point in four-
     dimensional space.

CALCULATION
MODE:

X/Y/INT
s/i/M
X/Y/GN
s/i/GN

TOL
(sphere radius)

P (X, Y, INT)
P (s, i, M)
P (X, Y, GN)
P (s, i, GN)

INT, M, GN

Y, i

X, s

(0.5 x cylinder height) **ITO**

MTO GTO

CTO (cylinder radius)
siTO
GTO

CALCULATION
MODE:

X/Y INT GN
s/i M GN

| POWER MODE	STATIC ▼
POWER (pm)	0
	0 500 1000
DYN WIN LO	3000	DYN WIN HI	3500

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** slider (recommended operation mode).

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.

POWER [pm]: In this function field the intensity of the transmitter LED can be adjusted by using the slider or by entering a value in the edit box. A value of 1000 means full intensity at the transmitter LED, a value of 0 stands for the lowest transmitter intensity adjustment!

INFO: The **POWER** slider is only effective in the **POWER MODE = STATIC**.
DYN WIN LO and **DYN WIN HI** are only effective in **POWER MODE = DYNAMIC**.
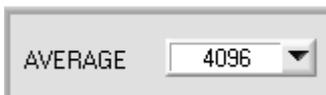
AVERAGE:
This function field is used for adjusting the number of scanning values (measurement values) over which the raw signal measured at the receiver is averaged. A higher AVERAGE default value reduces noise of the raw signals at the receiver unit and there will be a decrease of the maximal available switching frequency of the sensor.
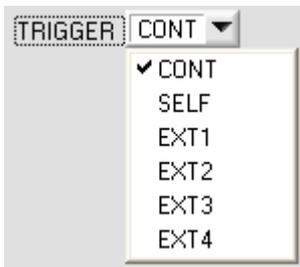
TRIGGER:
This function field serves for setting the trigger mode at the SI-COLO-GD sensor.

CONT:
Continuous 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.
Detection is started when row 0 is no longer detected (self-trigger). After the trigger, i.e. when vector 0 is detected again, the vector from the taught vectors will be output that was detected most frequently during triggering.

EXT1:
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 (**VEC 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 (**VEC No.** = 255) will be output after the trigger input goes to LOW again.
EXT3:
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 vector from the taught vectors will be output that was detected most frequently during triggering.
EXT4:
Same behaviour as in **EXT1.** However, in contrast to **EXT1** in this mode the transmitter source will be switched off if no trigger event (IN0 or TEACH button) is given.
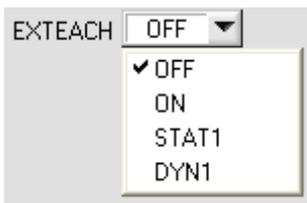
EXTEACH:
In all the evaluation modes teaching of a state (vector) can be performed externally through IN0 or by means of the button at the sensor housing.

OFF: The external TEACH feature is deactivated.
ON: See below

STAT1:
In static power mode, a vector is taught to position 0 in the 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 vector is taught to row 0.
DYN1:
In dynamic power mode, a vector is taught to position 0 in the 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 vector is then taught to position 0 in the TEACH TABLE. The sensor then continues to operate statically with the established POWER value.
The taught vector is stored only in the RAM and not in the EEPROM of the sensor.

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 vectors.

In EVALUATION MODE = FIRST HIT the currently present color is taught to all active rows depending on MAXVEC-No.
In EVALUATION MODE = BEST HIT, MIN DIST, and VEC5 a single row in the TEACH TABLE can be selected with the teach button or through IN0.

The example shows the external teaching of 4 vectors in EVALUATION MODE = BEST HIT.
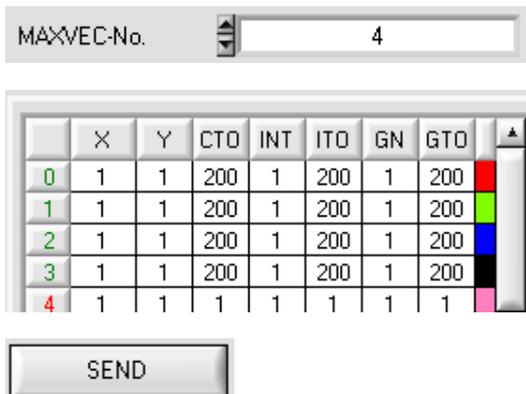
Select the EXTERN TEACH = ON function.
Adjust the power value such that the sensor is neither overloaded nor that a too low signal arrives at the sensor.
Select how many vectors you wish to teach from extern.
Click on the TEACH TABLE tab to switch to the TEACH TABLE.
Then enter the corresponding tolerances for the colors you want to teach.

MAXVEC-No.		4

	X	Y	CTO	INT	ITO	GN	GTO	
0	1	1	200	1	200	1	200	
1	1	1	200	1	200	1	200	
2	1	1	200	1	200	1	200	
3	1	1	200	1	200	1	200	
4	1	1	1	1	1	1	1	

SEND

In this example, MAXVEC-No. = 4 is selected, i.e. the sensor should detect the information that is stored in the first 4 rows of the TEACH TABLE by means of external teaching through IN0. Since the sensor cannot calculate the tolerances for color circle (CTO), the intensity (ITO) and the gloss (GTO) itself, these values must be entered once only (in this case 200 at all places) and must be stored in the EEPROM (see above) together with the MAXVEC-No. and with EXTEACH = ON.

Now select the setting EEPROM in the 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 MAXVEC-No. and do not want to change the tolerances.

INFO:
Of course the taught vectors can be viewed at any time with the PC.
Vectors that are taught by way of EXTEACH = ON are stored in the EEPROM of the sensor, i.e. the information will not be lost when the system is turned off.
This function rather is intended for "after-teaching", because the sensor does not automatically adjust its POWER

Before the external teach-process can be started, the surface (vector) 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 vector information (X,Y,INT,GN) should be placed in the VECTOR TEACH TABLE. The period of time, in which the user can teach the vector information to the sensor depends on the value that is set in MAXVEC-No. (e.g. approx. 5 seconds when MAXVEC-No. = 5).

The first positive edge (start edge 0) selects position 0 in the VECTOR 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 VECTOR 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 VECTOR 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 VECTOR 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 VECTOR 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 vector → go to pos. 1
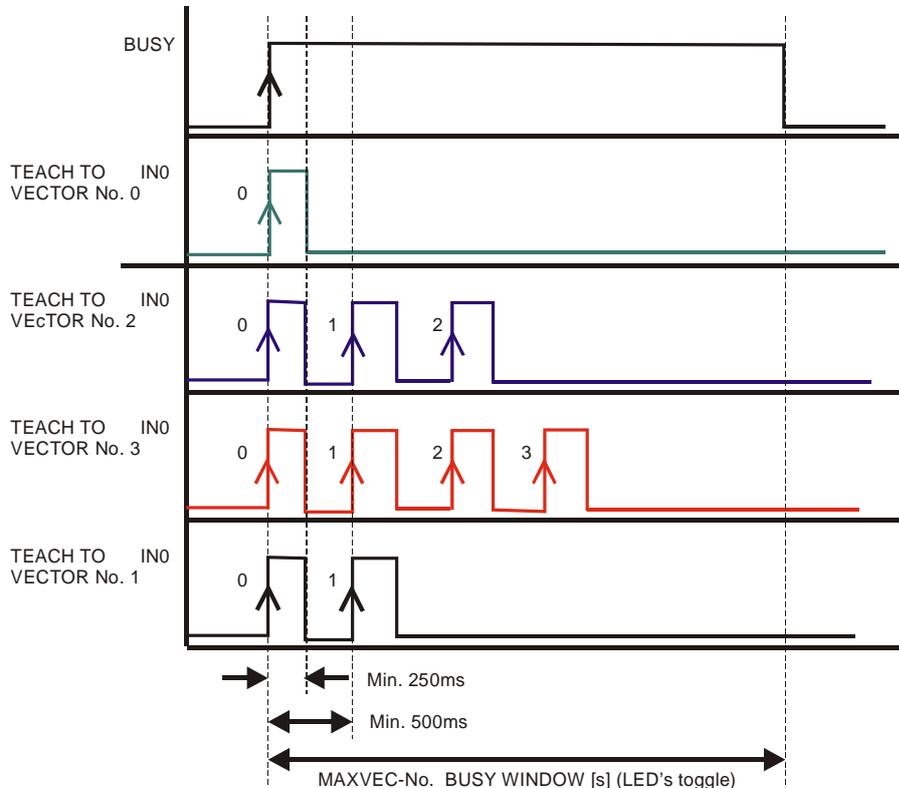
INTLIM:
This edit box is used for setting an intensity limit. Evaluation is stopped, if the current intensity INT arriving at the receiver unit falls below this limit, and ERROR STATE is output.

Attention: ERROR STATE if: INT < INTLIM

MAXVEC-No.:
This function field serves for setting the number of vectors to be checked.

In the BINARY mode the maximum number of vectors to be checked is 31. In the DIRECT HI or DIRECT LO mode the maximum number of vectors to be checked is 5 (no. 0,1,2,3,4). The numerical value set here determines the currently possible scanning rate of the sensor. The less the vectors to be checked, the faster the operation of the SI-COLO-GD sensor.

The numerical value set here refers to the number of rows (starting with row 0) in the vector teach table → 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 vector values correspond with the teach-in parameters entered in the TEACH TABLE, this vector in the TEACH TABLE is displayed as a vector number (V-No.) and is sent to the digital outputs (OUT0 ... OUT4) as a bit pattern.
The maximum number of vector to be taught is 31.

DIRECT:
In this mode the maximum number of vectors to be taught is 5.
If in this row-by-row comparison the current vector values correspond with the teach-in parameters entered in the TEACH TABLE, this vector in the TEACH TABLE is displayed as a vector number (V-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 vector does not correspond with any of the teach-in vectors, 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 vector does not correspond with any of the teach-in vectors, all digital outputs are set to HIGH (all LEDs are

HOLD:
The 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 sensor system pulse lengthening of up to 100 ms can be set by selecting the corresponding HOLD value.

2.3 Tab TEACH TABLE

When the GO button is pressed, data transfer from the sensor to the PC is started. The respective RED, GREEN, and BLUE contents are shown by way of the bars beside the graph. The calculated X, Y, INT, GN or s,i,M, GN values are visualised in the displays.
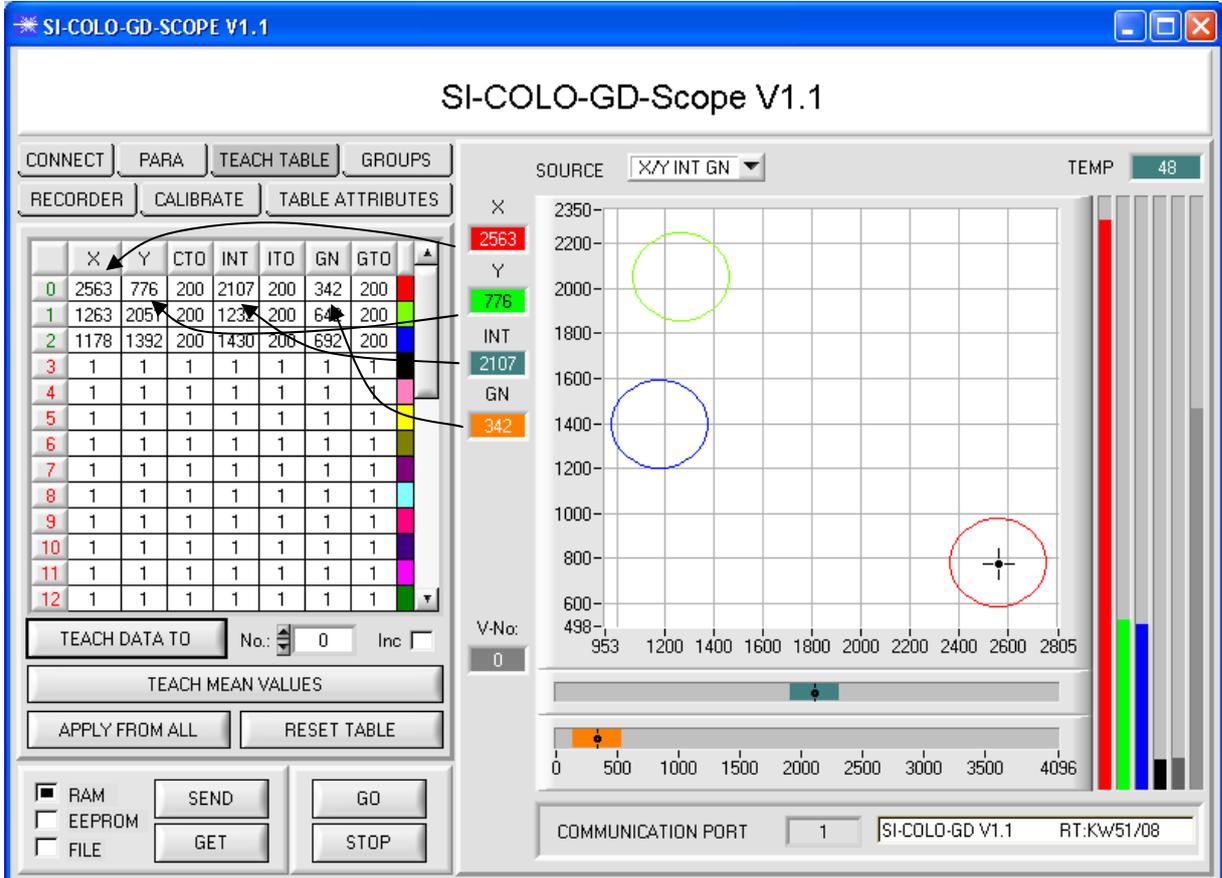
X bzw. s:
This numerical value output field displays the RED component (x-axis) of the scattered light currently arriving at the receiver.

Y bzw. i:
This numerical value output field displays the GREEN component (y-axis) of the scattered light currently arriving at the receiver.

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

GN:
This numerical value output field displays the currently measured gloss norm value.

V-No.:
This numerical value output field displays the currently detected vector number in accordance with the entry in the TEACH TABLE. The currently detected vector number is sent to the digital outputs OUT0 … OUT4 as a corresponding bit pattern.
The value 255 means that none of the taught vectors 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 sensor is active (GO button pressed).**

TEACH TABLE:
TEACH TABLE opens a view where vectors can be taught to the TEACH TABLE.

Please note: The sensor must be informed about the teach vectors by pressing SEND.

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 TEACH TABLE is organized in rows, i.e. the individual parameters for the teach-in vectors are arranged side by side in the respective row.
The sensor is able to check up to 31 teach-in vectors. The number of the respective teach-in vector is given in the left column of the table.
Only the green rows are used for evaluation in the sensor. The number of rows to be inspected is set with MAXVEC-No. .

When **TEACH DATA TO** is pressed, the currently displayed data for X, Y, INT, GN or s, i, M, GN are transferred to the row in the TEACH TABLE that is selected under **No.:**
A Color Tolerance (CTO), an Intensity Tolerance (ITO) and a Gloss Tolerance (GTO) also are set. If necessary, these tolerances, as well as the teach values, can be changed as described above.
No.: also is used to select which INT or M tolerance window is shown in the respective graphs for the intensity or for M. The same applies to the gloss tolerance window.

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 TEACH TABLE is selected

A click on the **RESET TABLE** button resets the TEACH TABLE (RESET value = 1)
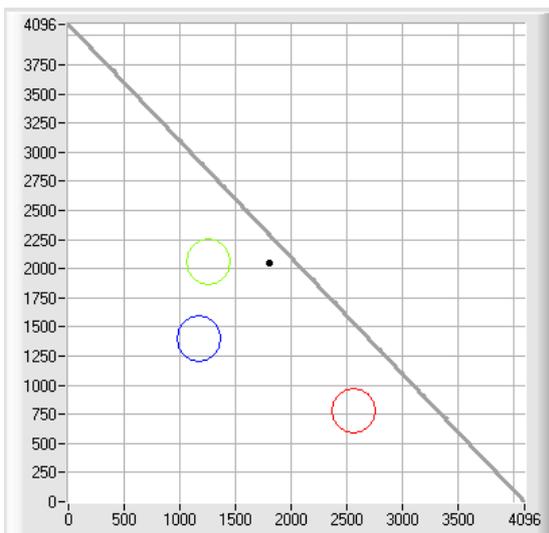

APPLY FROM ALL:
If X/Y or s/i is selected under SOURCE, a click on this button displays all the teach-in vectors entered in the TEACH TABLE in the color triangle with the corresponding "tolerance circle" (radius = CTO or siTO).
The opposite picture shows 3 color tolerance circles with the teach-in values (X,Y) and CTO (tolerance radius) preset in the TEACH TABLE.

The following panel will be displayed after a click on **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 GN.
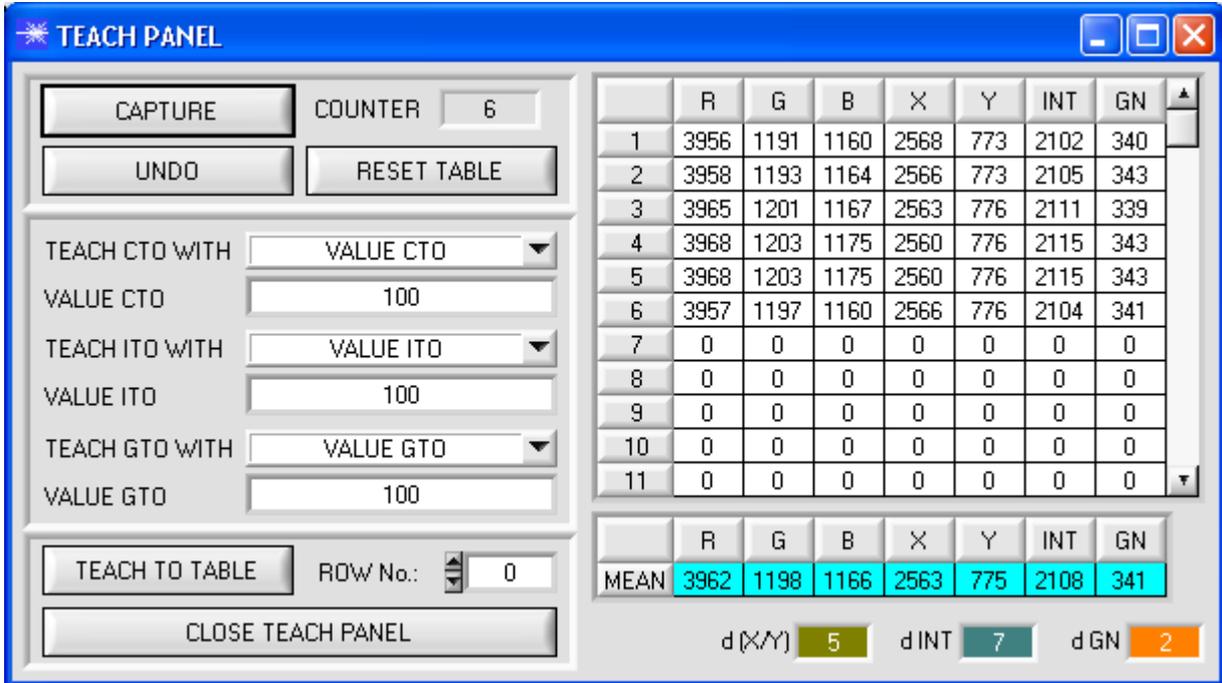
The main panel remains active, and data are automatically picked up from the sensor and are displayed.
A click on the **CAPTURE** button enters a parameter frame in the table.
The **COUNTER** display field shown how many frames have already been recorded.
The last frames that were entered in the table 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)**, a maximum intensity deviation **dINT**, and a gloss deviation **dGN** 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 **TEACH TABLE** that is selected under **ROW No.:** (→ Tab TEACH TABLE).
Teaching of tolerances can be set by way of **TEACH CTO WITH, TEACH ITO WITH,** and **TEACH GTO WITH**.
- If the setting is **VALUE CTO**, the value that is set under **VALUE CTO** will be taught (ditto intensity, gloss).
- If the setting is **d(X/Y)**, the value that is determined under **d(X/Y)** will be taught (ditto intensity, gloss.
- If the setting is **d(X/Y) + VALUE CTO**, the value that is determined under **d(X/Y)** plus **VALUE CTO** will be taught (ditto intensity, gloss).
- With **NO CHANGE**, the value that is set in the **TEACH TABLE** will remain unchanged.

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

2.4   Tab TABLE ATTRIBUTES
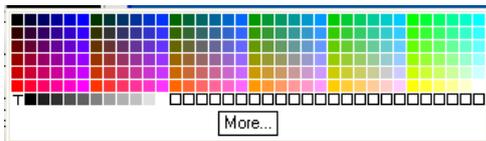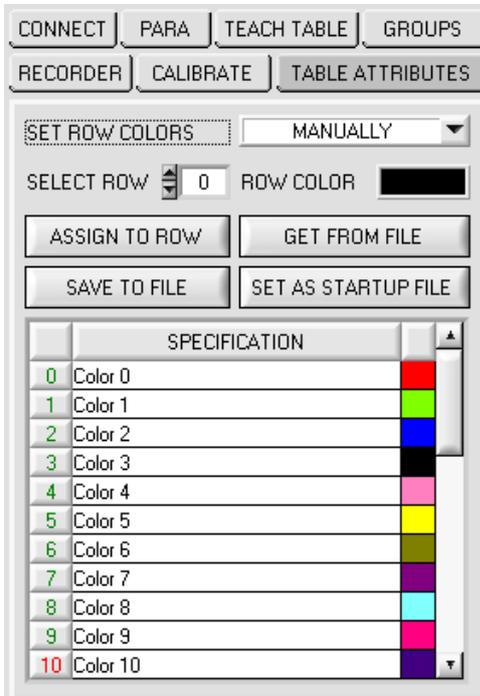
TABLE ATTRIBUTES:
A click on **TABLE ATTRIBUTES** opens a panel where the row color in which the individual tolerance circuits are represented can be individually chosen or these can be automatically replaced by the color detected by the system.

Furthermore, designations for the individual rows can be entered in the **SPECIFICATION** table. These designations are saved on the PC's hard disk and can be loaded again, if necessary.

If **SET ROW COLOR** is set to **MANUALLY**, 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 **TEACH TABLE**.

If **SET ROW COLOR** is set to **AUTOMATICALLY**, 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 row color arrays and the **SPECIFICATION** table on the hard disk, or to load previously saved arrays.

SET AS STARTUP FILE saves the current settings as startup array.

When the software is restarted, the corresponding **ROW COLOR** table as well as the **SPECIFICATION** table are automatically loaded from the startup array and displayed in the respective fields.

2.5 Tab GROUPS
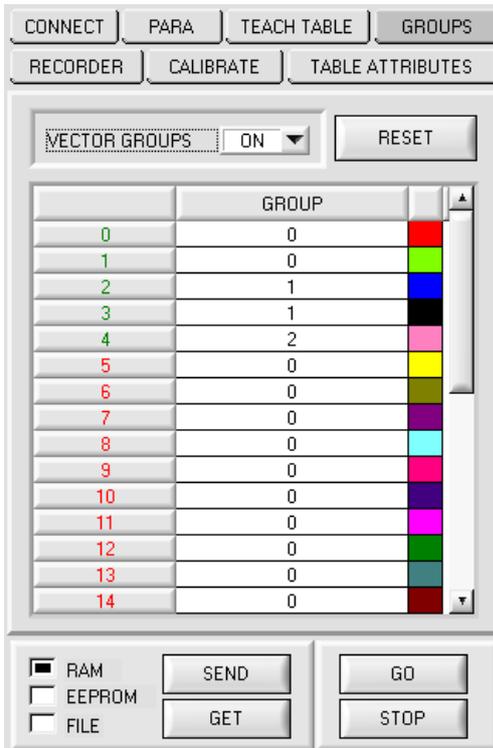
GROUPS:
The tab GROUPS opens a view where colors in the TEACH TABLE can be assigned to certain groups.

Please note: The sensor must be informed about the vector groups by pressing SEND.

It is possible to form vector 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.

In this example, **VECTOR 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 **V-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 **DIRECT LO** 31 different vectors 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**.

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

2.6 Tab RECORDER

The SI-COLO-GD-Scope software features a data recorder that allows the saving of RED, GREEN, BLUE, X, Y, INT, REF, DIR, DIF, V-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 14 columns and as many rows as data frames were recorded.
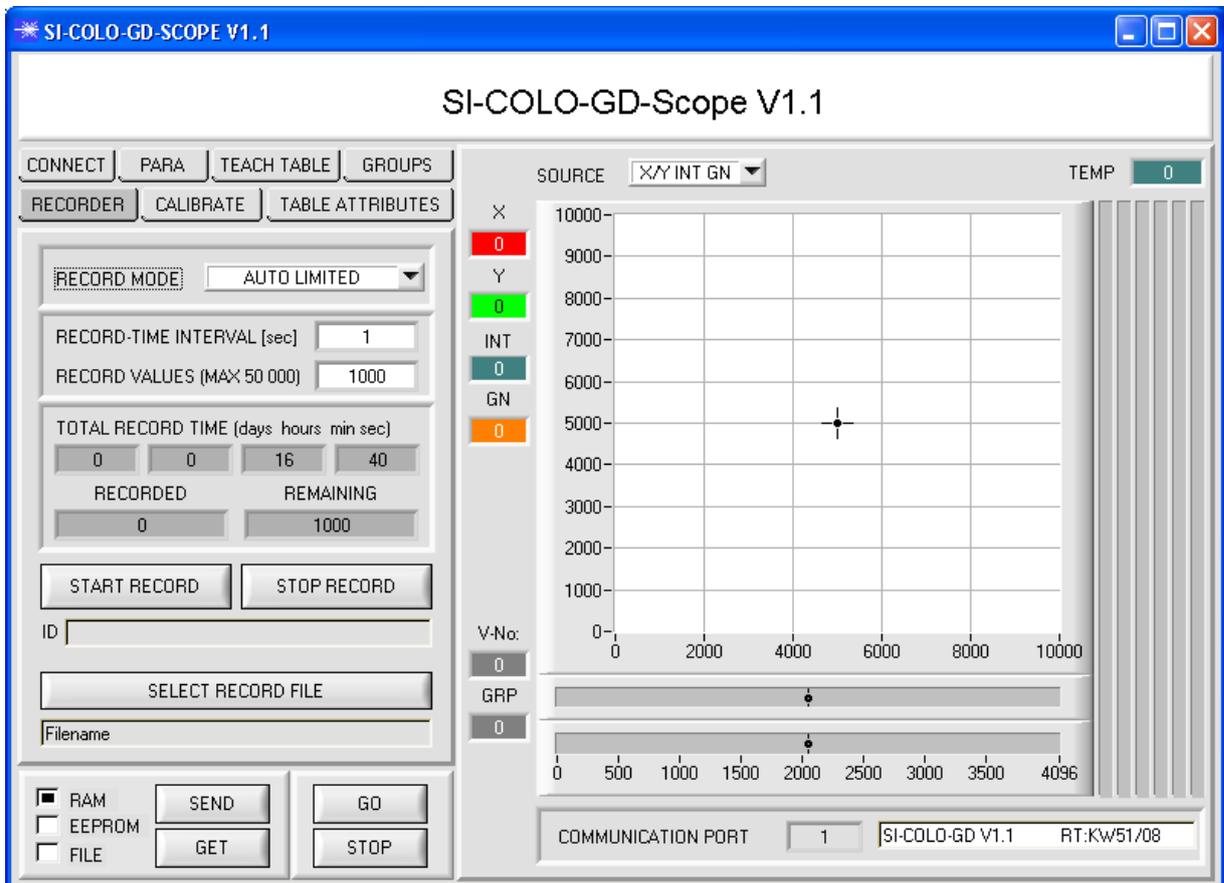
The following steps describe how data frames are recorded with the recorder:
Please note:
Recording depends on the EVALUATION MODE that is chosen. Several EVALUATION MODES do not need certain data, therefore these data will be set to 0, i.e. for these data the value 0 will be recorded.

Step 1:
When the RECORDER button is pressed, the following window will be displayed:

RECORD MODE	AUTO LIMITED ▼

RECORD-TIME INTERVAL [sec]	1
RECORD VALUES (MAX 50 000)	1000

TOTAL RECORD TIME (days hours min sec)

0	0	16	40

RECORDED	REMAINING
0	1000

START RECORD	STOP RECORD

ID [   ]

SELECT RECORD FILE	SHOW GRAPH

Filename

Step 2:
If you want to automatically record several data frames, please select **AUTO LIMITED** under **RECORD MORE**.
Enter a time interval for recording under **RECORD-TIME INTERVAL [sec]**, 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 **RECORD VALUES [MAX 50 000]** field.
Please note: Recording can also be stopped earlier by clicking **STOP RECORD**, the data recorded so far will not be lost.

The **TOTAL RECORD TIME** field indicates 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 RECORD button starts automatic data recording.

The recorder starts to record data, and the button **START RECORD** is red to indicate that recording is active.
The respective data frames are shown in the display windows.

In the two display fields **RECORDED** 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 RECORD VALUES [MAX 50 000] are inactive.

Step 5:
When as many data frames as set under **RECORD VALUES [MAX 50 000]** 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.

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

If you want to record data "manually", select the **MANUAL RECORDING** function under **RECORD MORE**.
You can start reading data from the sensor by pressing the **GO** 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** field shows the sum of the frames already recorded.

If **AUTO TRIGGERED** is selected under **RECORD MORE**, and **TRIGGER** = **SELF**, **EXT1**, **EXT2**, **EXT3**, or **EXT4** is selected, the sensor will automatically send a data frame after each drop of the trigger when **START RECORD** is pressed. This data frame is captured and recorded by the recorder.
Pressing the **STOP RECORD** button terminates the automatic sending function of the sensor again.

Please note:
When you press START 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.

2.7 Tab CALIBRATE

White light balancing can be performed with the sensors of the SI-COLO-GD series. Balancing can be performed to any white surface. A ColorChecker[TM] 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

The following panel will be displayed after a click on CALIBRATE:
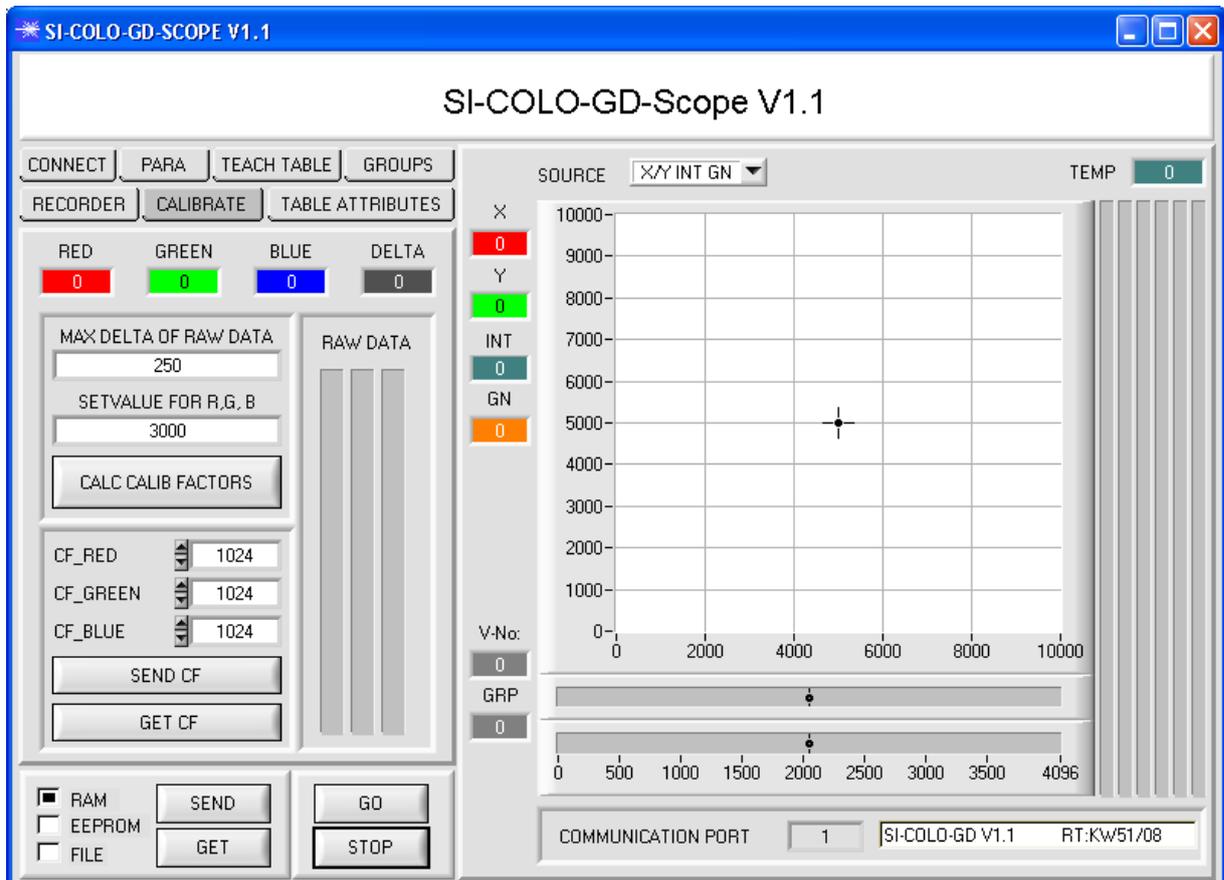
<u>Calculation example for determining the calibration factors</u>

In the example in the picture below, a POWER value at which the three bars of the raw signals **RAW DATA** 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 R,G,B**) 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:

CF_RED = (SETVALUE / RAW DATA RED) * 1024 = (3300 / 3714) * 1024 = 909
CF_GREEN = (SETVALUE / RAW DATA GREEN) * 1024 = (3300 / 3462) * 1024 = 976
CF_BLUE = (SETVALUE / RAW DATA BLUE) * 1024 = (3300 / 3183) * 1024 = 1061
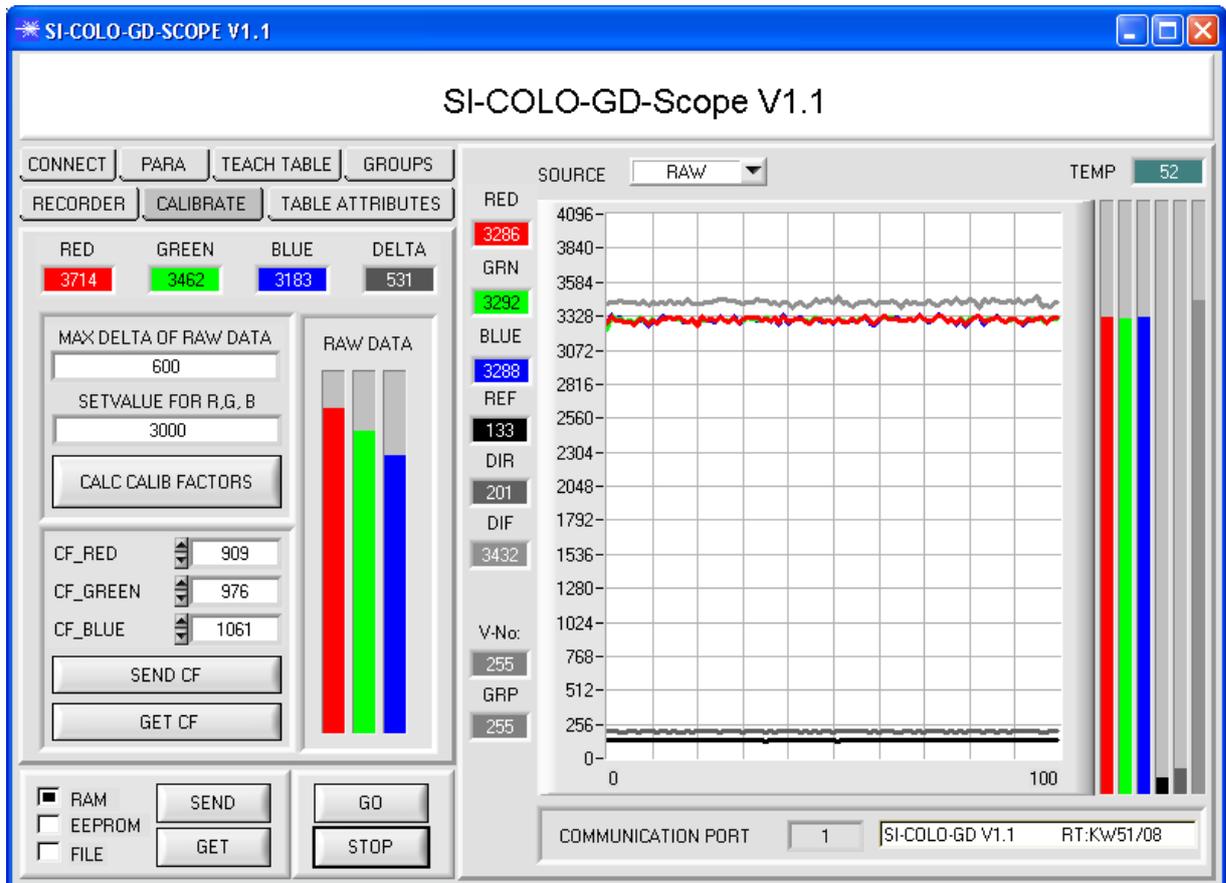
When the calibration factors have been calculated by the software on the user interface, they are automatically saved to the non-volatile EEPROM memory of the sensor. Calibration is then finished, work can then be continued in the main panel.

When the sensor detects a raw signal, it applies the calibration factor saved in the EEPROM to this raw signal, 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.
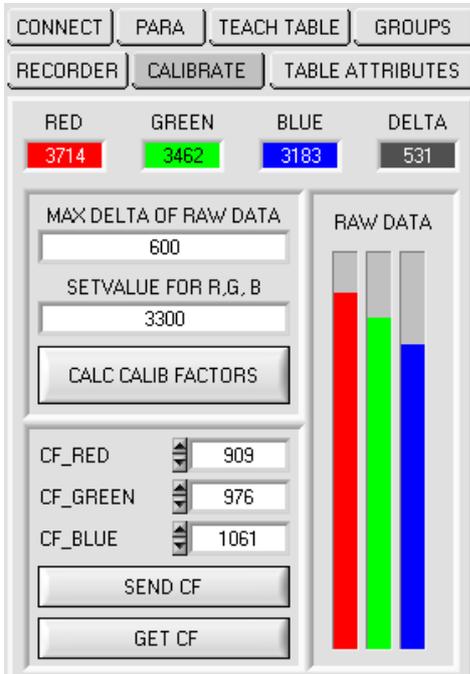
Step 1:
First of all a suitable **POWER** value must be found such that the **RAW DATA** for RED, GREEN and BLUE lie in the dynamic range (upper third of the bar display).

Step 2:
When you have set a suitable POWER value, determine a **SETVALUE FOR R,g,B**. The software now calculates the calibration factors in such a way that this SETVALUE is reached for the raw data (see calculation example above).

Step 3:
Determine a **MAX DELTA OF RAW DATA** (the software suggests 250).
Calibration is only permitted, if the current **DELTA** of the **RAW DATA** is smaller than the **MAX 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.

Step 4:
Start calibration by pressing **CALC CALIB 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 R,g,B** 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 in the main panel.
Please note that the values for **RED**, **GREEN**, and **BLUE** in the main panel 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 CALC CALIB 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:

CALIBRATION PASSED!

Calibration successful!
Calibration factors were sent to the EEPROM of the sensor.
GO mode will be activated.

OK
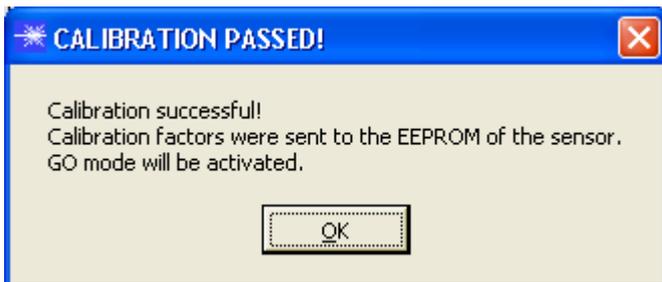
2.7   Graphic display elements

SOURCE	XY ▼

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

RAW :   The current raw signals of the 3-fold receiver (red, green, blue) and the channels reference (REF), direct (DIR), and diffuse (DIF) are shown in the graph.

X/Y 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.

GN: The currently determined gloss norm value GN is displayed.

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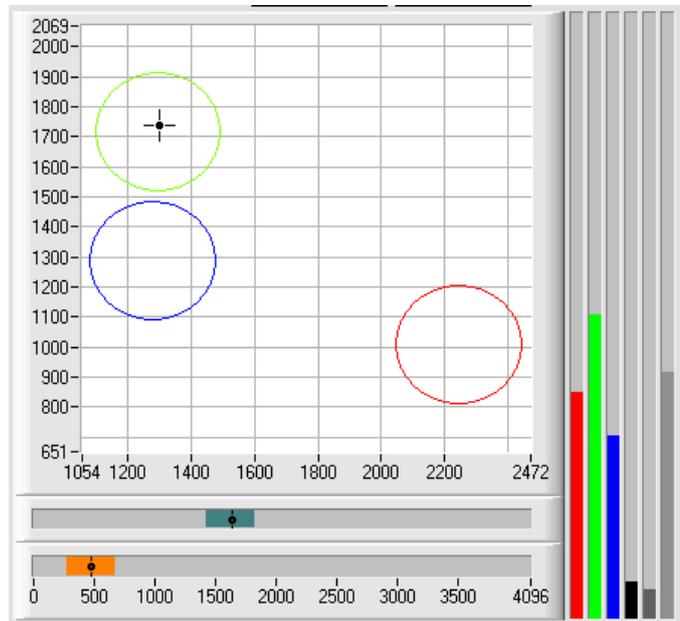s/i M GN: intensity INT or M with the
                    tolerance window set under
                    No.: is shown directly below.
                    Two-side view of the color
                    cylinder in space and of the
                    gloss norm value with the
                    tolerance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

X/Y/INT GN   The panel that opens shows
or   the taught X/Y/INT color
s/i/M GN: spheres and the current
                    gloss norm value GN.
                    The current vector is shown
                    as a black cursor.
                    A three-side view with the
                    graphs X/Y (s/i), X/INT
                    (s/INT) and Y/INT (i/INT) was
                    chosen for improved
                    representation.
                    The gloss norm value with
                    the tolerance window set
                    under No.: is displayed in a
                    separate graph.
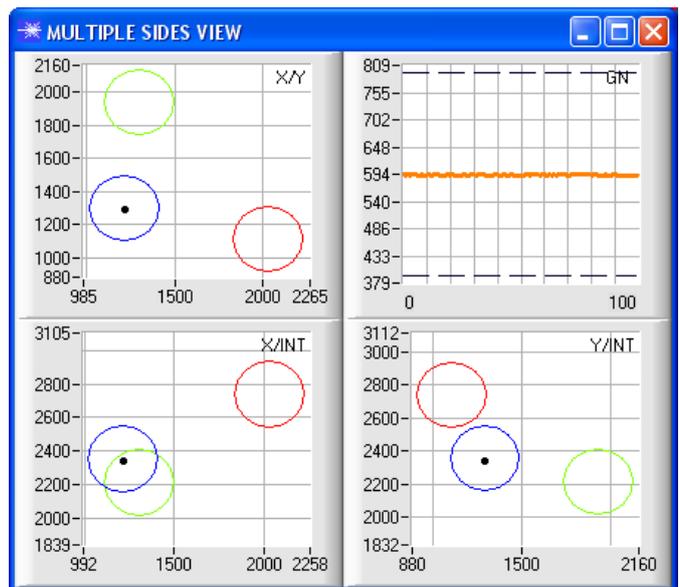
X/Y/GN INT or s/i/GN M:	The panel that opens shows the taught X/Y/GN spheres and the current color intensity INT or M. The current vector is shown as a black cursor. A three-side view with the graphs X/Y (s/i), X/GN (s/GN) and Y/GN (i/GN) was chosen for improved representation. The color intensity with the tolerance window set under No.: is displayed in a separate graph.
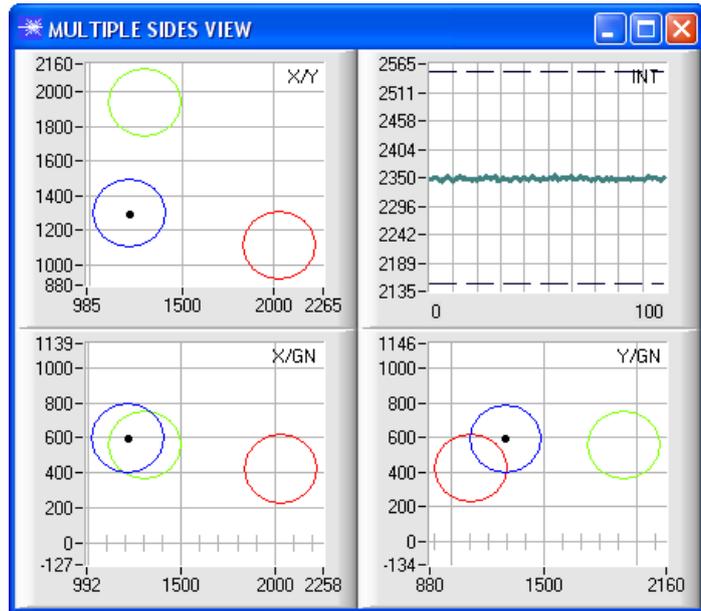
X/Y/INT/GN or s/i/M/GN:	The panel that opens shows the taught four-dimensional vector X/Y/INT/GN or s/i/M/GN. The current vector is shown as a black cursor. A six-side view with the graphs X/Y (s/i), X/INT (s/M), X/GN (s/GN), Y/GN (i/GN), Y/INT (i/M) and INT/GN (M/GN) was chosen for improved representation.
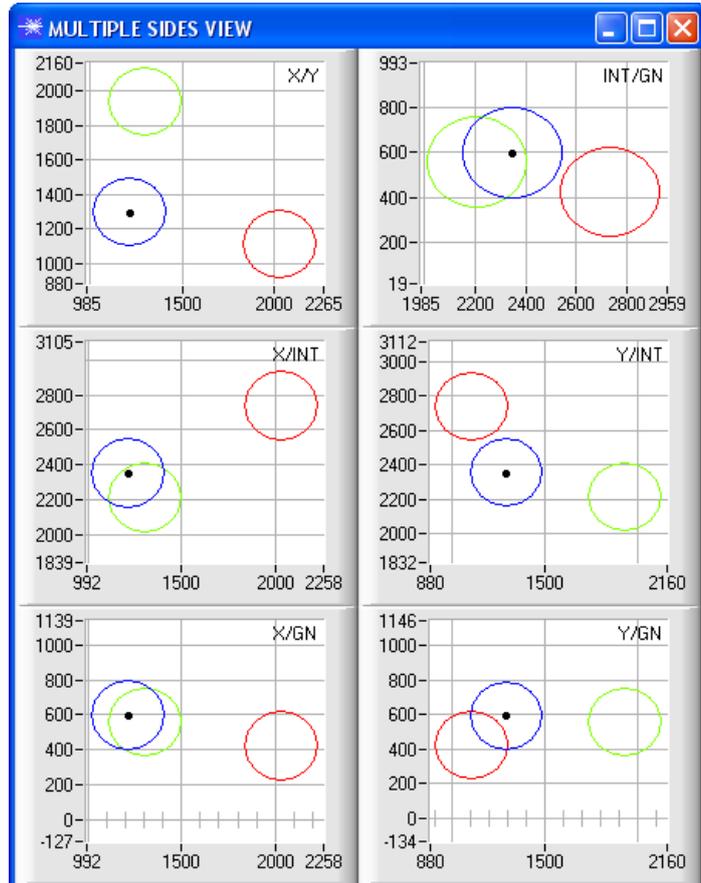
TEMP:
This display shows the temperature prevailing in the sensor housing.
The display **DOES NOT** show degrees Centigrade or Fahrenheit.

3. Short instructions for the operation of color sensors with the SI-COLO4-Scope V6.3 software

These instructions describe how to perform quick teaching of the color gloss sensors of SI-COLO-GD series with the **SI-COLO-GD-Scope V1.1** software interface.

Basically there are 4 methods of teaching a surface vector. These methods can be set with CALCULATION MODE:

CALCULATION MODE X/Y INT GN (or s/i M GN) considers a color cylinder in space with radius CTO or siTO and with height ITO or M. In addition the gloss norm value GN with a correspondingly adjustable tolerance window is also evaluated here.
CALCULATION MODE X/Y/INT GN (or s/i/M GN) considers a color sphere in space with radius TOL. As above the gloss norm value also is evaluated here.
CALCULATION MODE X/Y/GN INT (or s/i/GN M) considers a color gloss sphere in space with radius TOL. Here the color intensity INT or M is evaluated in addition.
CALCULATION MODE X/Y/INT/GN (or s/i/M/GN) considers a four-dimensional vector in space with tolerance TOL.

Color evaluation according to **s/i M** uses the **Lab calculation method**.
The teach process if the same for both methods.
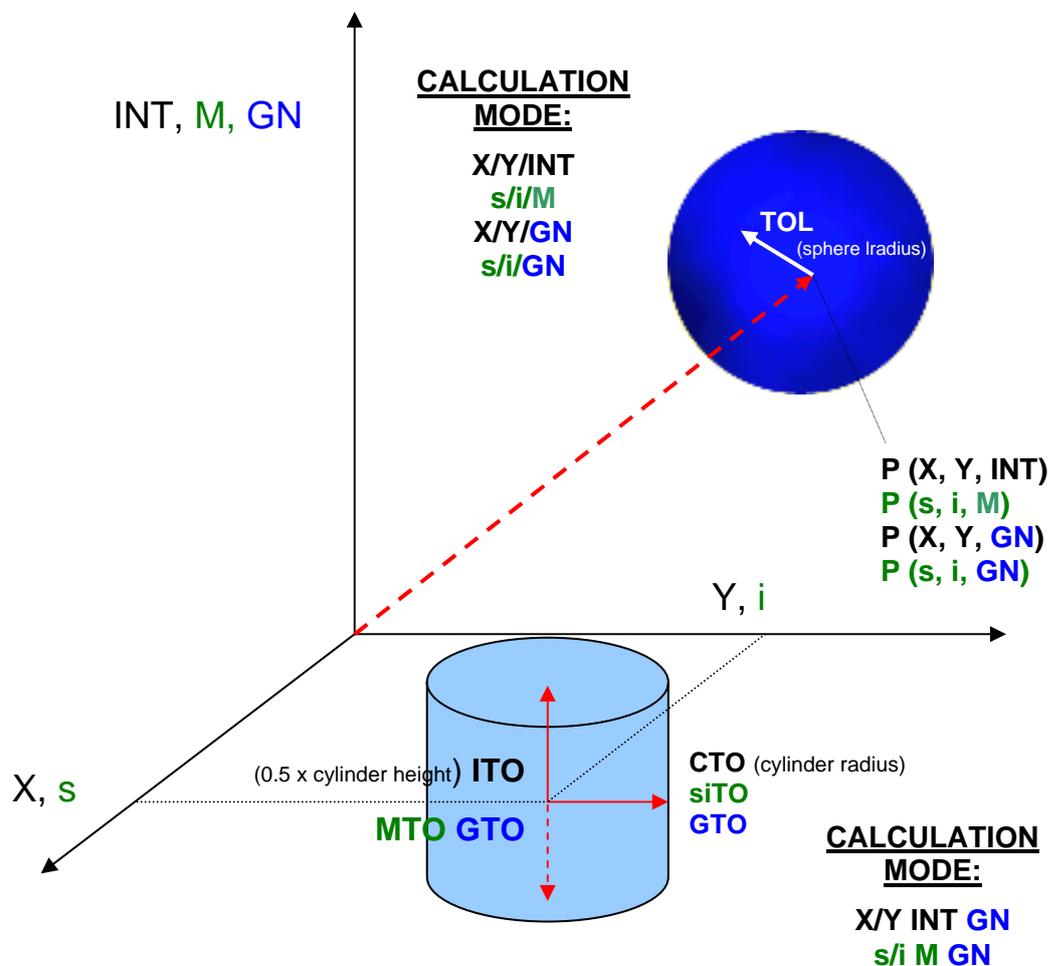
The text below describes a teach process with **EVALUATION MODE = BEST HIT** and **CALCULATION MODE = X/Y/GN INT**.

Step 1:
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 sensor.
Please make sure that the sensor is properly connected and supplied with power. Furthermore the sensor head must be directed onto the brightest surface (paper, leather, glass, etc.) of the color to be taught. This is absolutely necessary for being able to set a suitable **POWER** value for the sensor.

Step 2:
Start the SI-COLO-GD-Scope V1.1 software. Please check whether the status line at the right bottom displays the „SiColoGd V1.1   RT:KWxx/xx " message.
Info: Moving the mouse cursor to a control element and clicking with the right mouse button displays a short info on the respective individual control element.
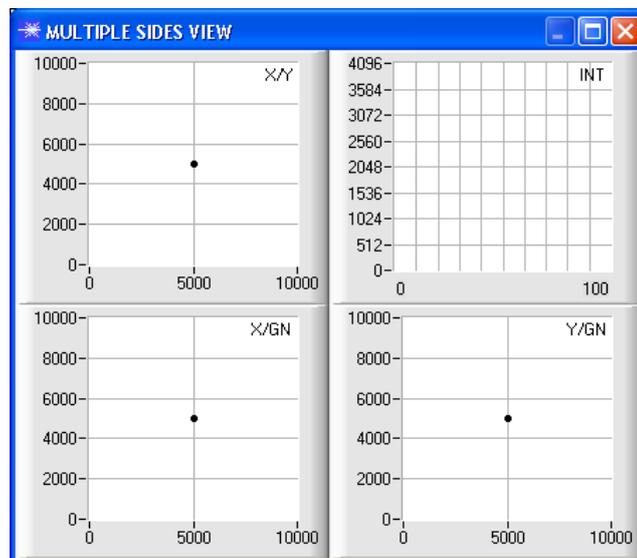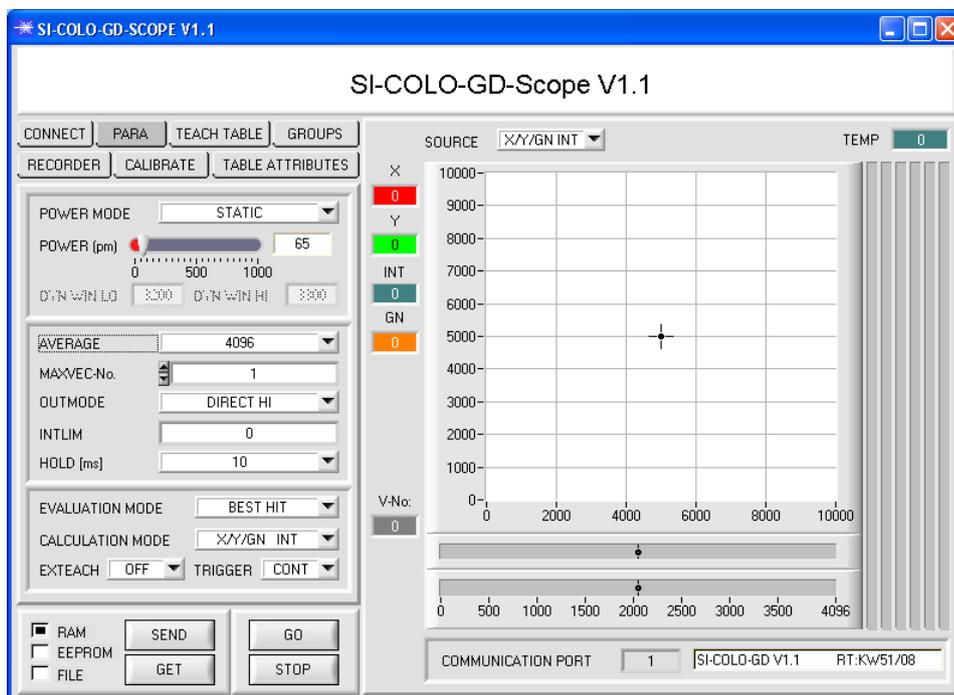
Step 3:
Please make sure that for the time being RAM and not EEPROM is selected for the data exchange with the sensor (RAM is a volatile memory in the sensor, i.e. the data will be lost when power is turned off. EEPROM is a non-volatile memory in the sensor, i.e. the data will not be lost when power is turned off.)
All the other parameters should be set as shown in the picture below. Press the tab PARA to show the parameters. (See the FILE function in the manual.)
Now press the GO button. Data exchange between sensor and PC will then start. The contents for RED, GREEN, BLUE, REF, DIR, and DIF that are reflected from the surface are represented as bars on the PC software interface. Set the POWER value in such a way that at least one of the three bars is in the upper third of its dynamic range, but none of them is in saturation.

ATTENTION: The sensor must be informed when you have changed the POWER value. Press the SEND button to send this information to the sensor. Check the bars by pressing GO again. Repeat this process until you have a suitable POWER value.
Optimally the three bars for RED, GREEN, and BLUE should be at approximately the same level on white paper.
If the bars vary too much, you need to perform white light balancing.
(For white light balancing see the "SI-COLO-GD-Scope" manual on the supplied CD.)

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.
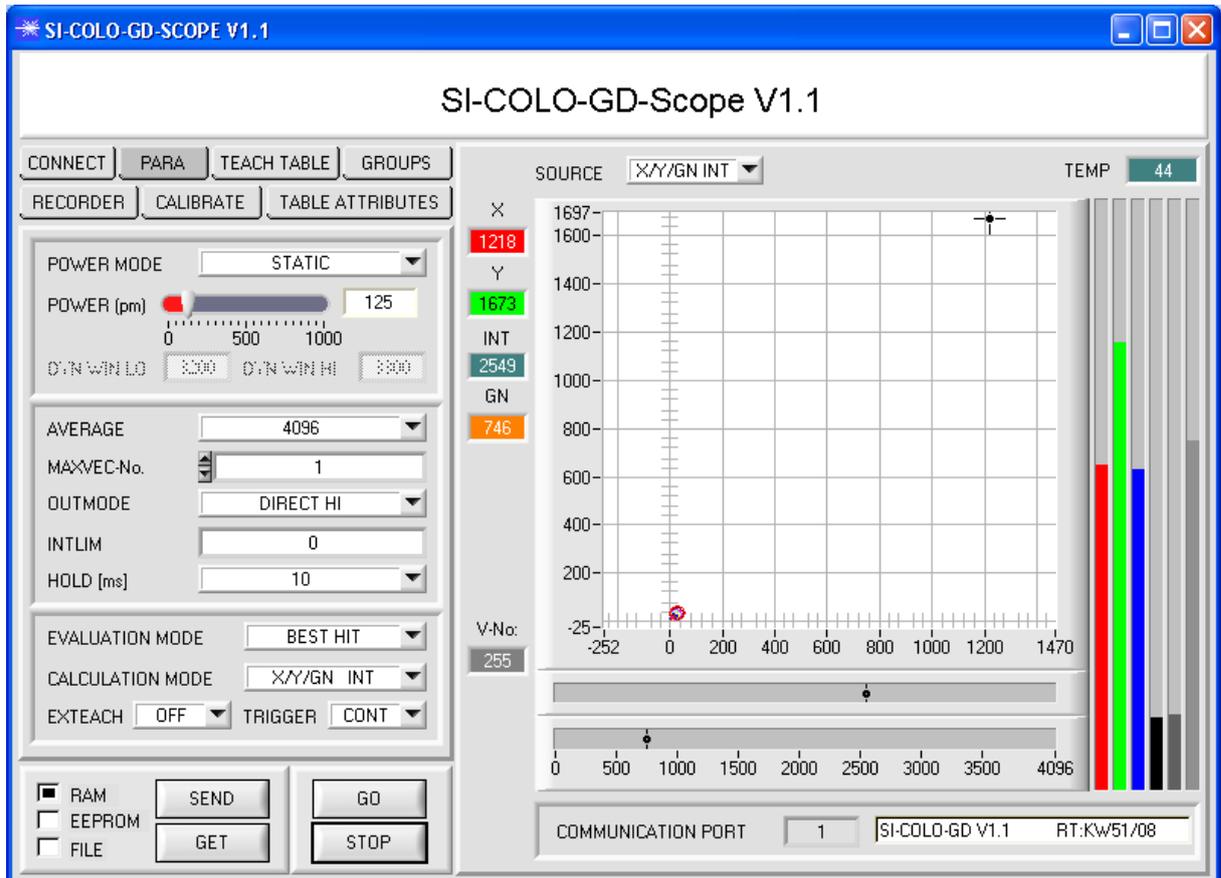
Step 4:
An **X** and a **Y** coordinate as well as an intensity **INT** are calculated from the **RED**, **GREEN**, and **BLUE** data.
$X = (R*4095) / (R+G+B)$
$Y = (G*4095) / (R+G+B)$
$INT = (R+G+B) / 3$
A gloss norm value is calculated from DIR and DIF.
$GN = (DIR*4095) / (DIR+DIF)$

Press the **GO** button once again to read out the current data.
Press **STOP** to stop the data exchange.
Now use the tab **TEACH TABLE** to switch to the TEACH TABLE.
Select a row under No.: to which the currently present vector should be taught.
(ATTENTION: Only the rows marked with green numbers are evaluated by the sensor. If you want to teach more vectors, use the MAXVEC-No. parameter to select how many colors you want to teach.)
Now press the **TEACH DATA TO** button. The calculated values for **X**, **Y**, **INT**, and **GN** are transferred to the **TEACH TABLE** in the row that was selected under **No.:**.
The graphic display then shows a circle. This is the tolerance circle for the X/Y coordinates. The radius of this circle can be set under **TOL** (tolerance). To change the TOL value please double-click on the corresponding cell in the TEACH TABLE with the left mouse button.
The two small graphs show the intensity INT with tolerance window in turquoise, and the gloss norm value GN with tolerance window in orange.
In accordance with a row vector the display of the respective tolerance window is selected with No.:
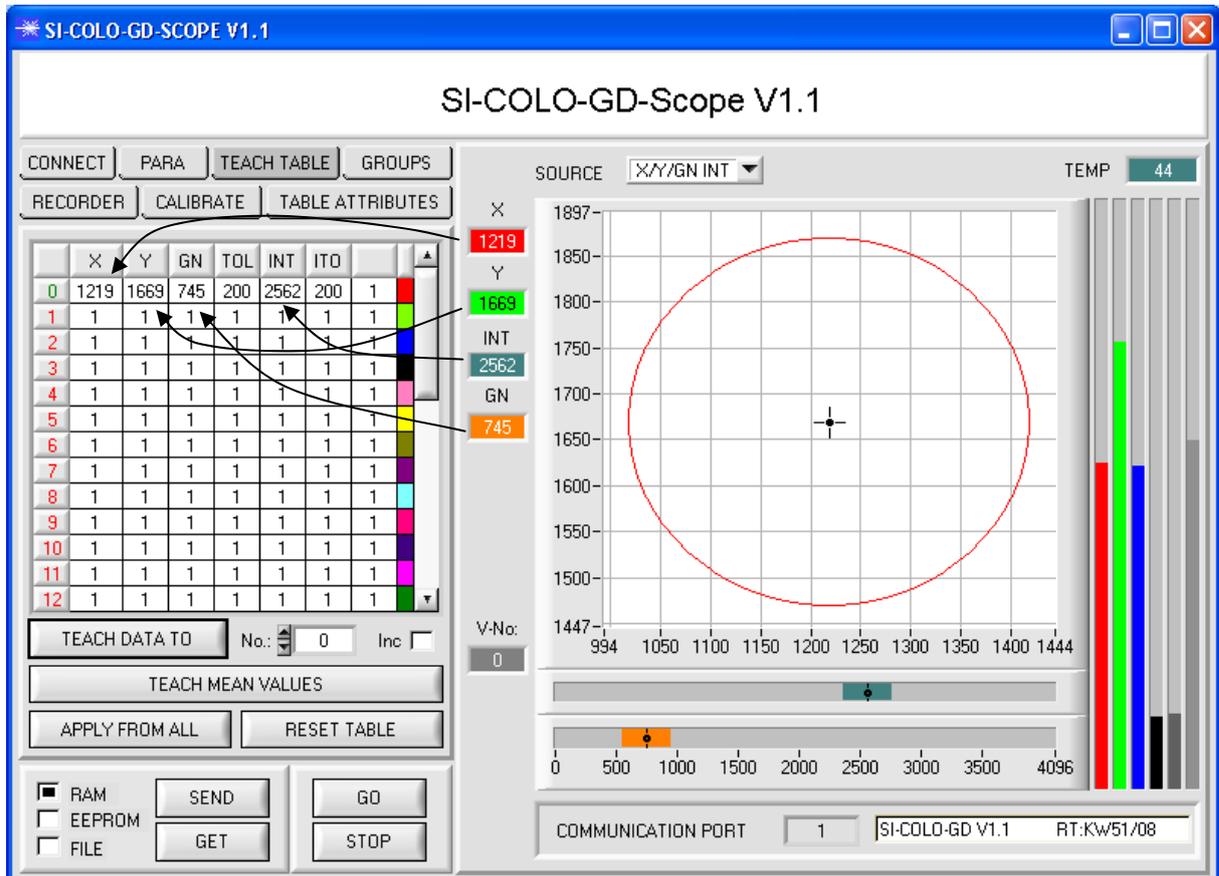
Now press the **SEND** button again to inform the sensor about the taught color. Then activate the **GO** mode again. When the sensor recognises a row vector, the corresponding row number is visualised on the software interface under **V-No.:** A value of 255 means that none of the taught vectors were recognised.

As you know the **X/Y/GN INT** mode uses a color gloss sphere in space. To provide a better visual representation of this sphere, an additional panel is displayed here that shows the color gloss sphere in a three-side view with the axes X/Y, X/GN, and Y/GN. Furthermore the current intensity with the tolerance window set under No.: is also displayed (see below).
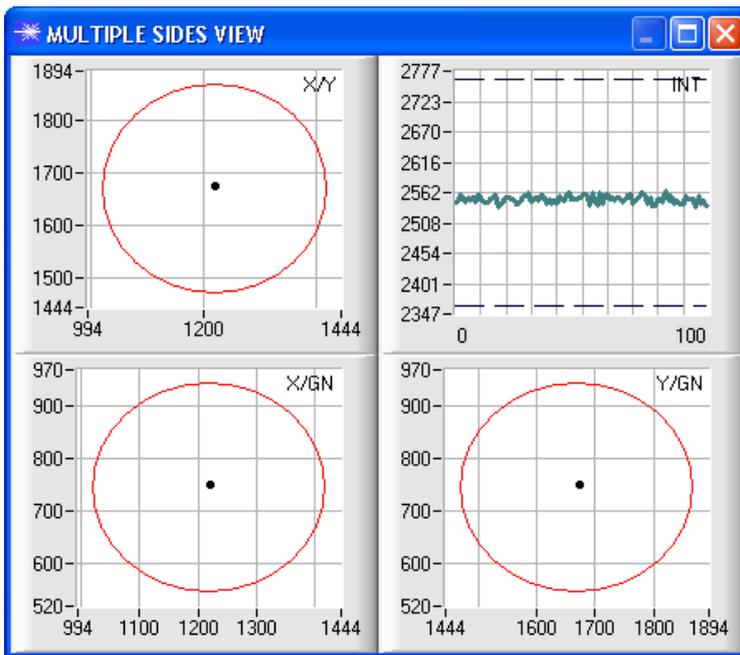
A vector is only recognised if its current coordinates lie in the tolerance circle and if the current intensity lies in the corresponding tolerance window.

Step 5:
For teaching additional vectors please make sure that the sensor head is directed onto the respective color.
Then repeat the procedure starting from step 4.

Step 6:
When you have taught all the channels, please select **EEPROM** and press **SEND** to save the data to the non-volatile memory of the sensor.

For the meaning and handling of the remaining parameters please refer to the manual.

4. Operation of the TEMPCOMP-Scope software

If a firmware update should go wrong and the temperature characteristics that are stored in the EEPROM should be lost, these characteristics must be created anew. For this purpose you will need a file with the corresponding data. 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. It may be necessary to select the connection with **CONNECT**. Set the correct sensor under **SELECT SENSOR**, if this is not done automatically.
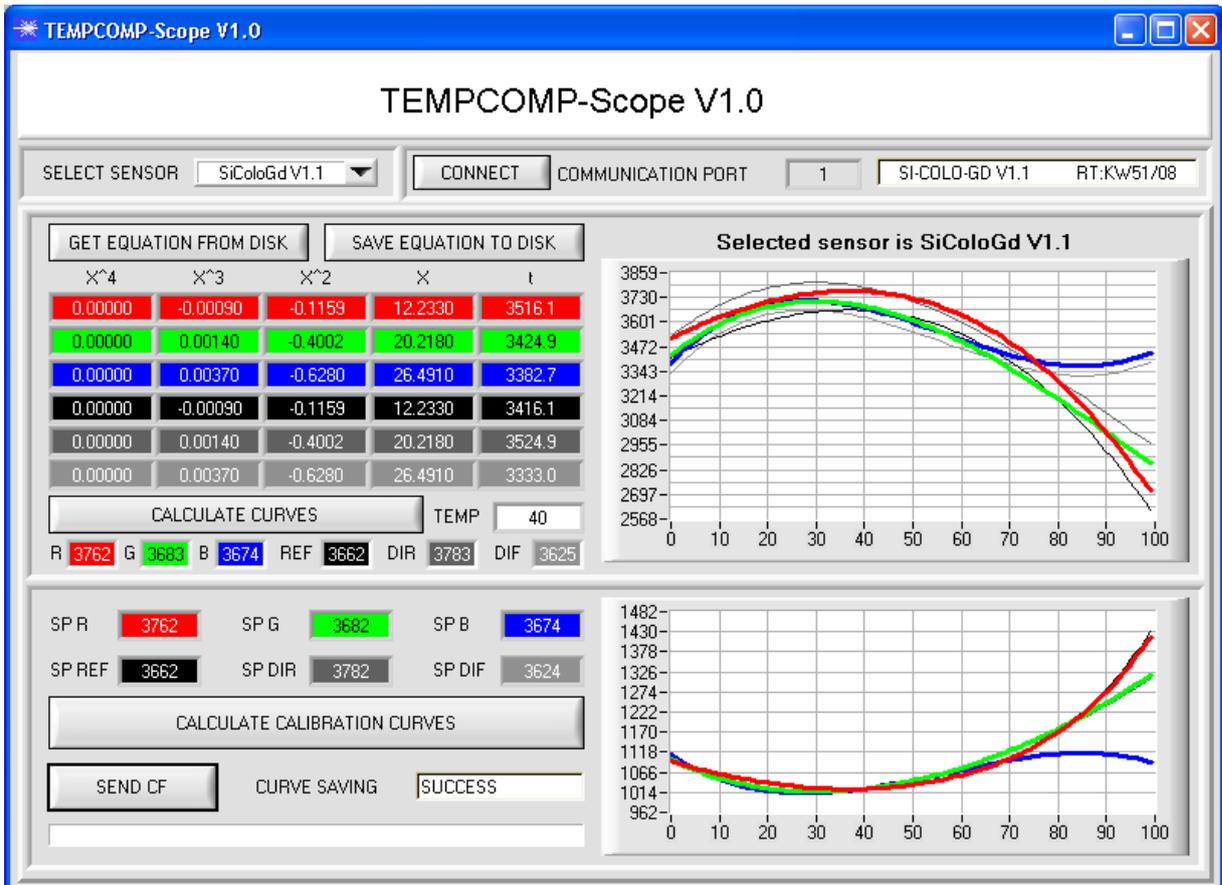
Step 1:   Load the temperature compensation file that you have received from your supplier with **GET EQUATION FROM DISK**.

Step 2:   Press **CALCULATE CURVES** to display the data in the graph.

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.

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.

5. External triggering of the SI-COLO-GD sensor
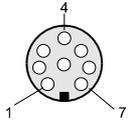
External triggering is performed through pin no. 3 (grn) at the 8-pole socket of the SI-COLO-GD/PLC connection.
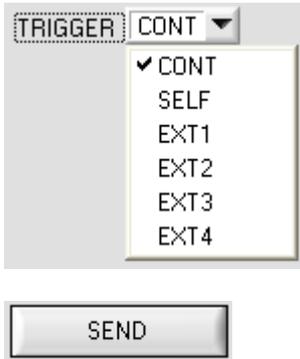
EXTERN:
First the external trigger mode must be set at the sensor. For this purpose option EXT1, EXT2, EXT3, or EXT4 must be selected in the **TRIGGER** selection field.

PLEASE NOTE:
The new setting is only activated at the sensor 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).

IN0
(Pin3 grn) or
TEACH button

Triggering active !   No triggering !

HIGH (+24V)

LOW (0V, GND)
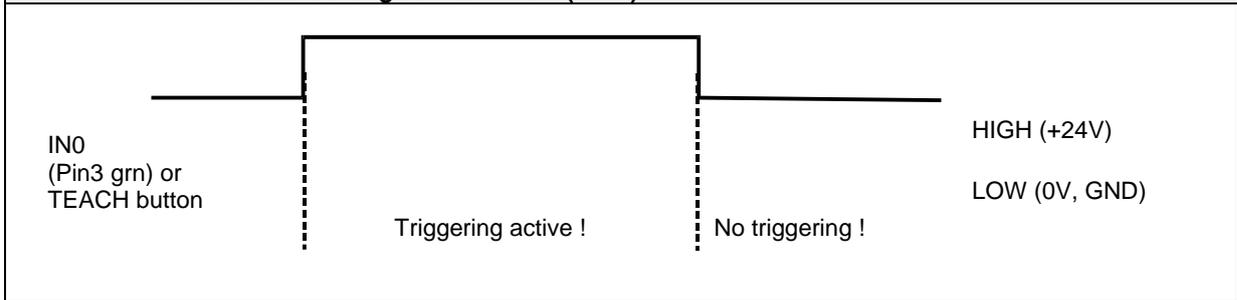
6. Function of the LED display

LED display:	
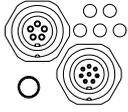
BINARY

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

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

„Error" or
„not detected"

DIRECT HI:

In the DIRECT mode (OUT DIRECT HI or OUT DIRECT LO) the maximum numbers of vectors to be taught is 5 (vector 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 vector does not correspond with any of the teach-in vectors, all digital outputs are set to LOW (no LED is lighting).

0   1   2   3   4

(no vector detected)
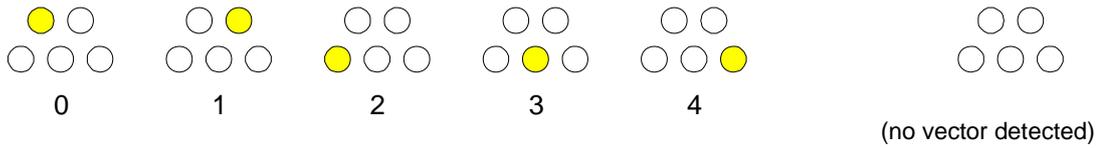
DIRECT LO:

If DIRECT LO is activated, the specially digital output is set to LO, while the other 4 are set to HI. If the current vector does not correspond with any of the teach-in vectors, all digital outputs are set to HIGH (all LED are lighting).

0   1   2   3   4

(no vector detected)
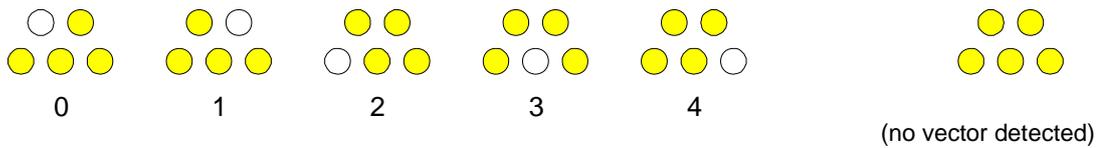
7. Connector assignment of SI-COLO-GD sensors

Connection of SI-COLO-GD to PC:

5-pole female connector (type Binder 712) SI-COLO-GD/PC-RS232		
Pin No.:		**Assignment:**
1		0V (GND)
2		Tx0
3		Rx0
4		Not connected
5		Not connected
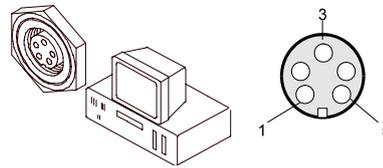
Connection of SI-COLO-GD to PLC:

8-pole female connector (type Binder 712) SI-COLO-GD/PLC		
Pin No.:	**Color:**	**Assignment:**
1	white	0V (GND)
2	brown	+24VDC (± 10%)
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%)
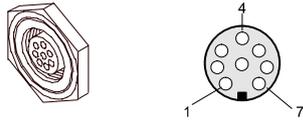
8. RS232 communication protocol

RS232 communication protocol PC ⇔ SI-COLO-GD Sensor (SI-COLO-GD-Scope V1.1)

- 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 thousendth!
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 MAXVEC-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,EXT3,EXT4 coded to (0,1,2,3, 4,5)
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 GN), (s/i M GN), (X/Y/INT GN), (s/i/M GN), (X/Y/GN INT), (s/i/GN M), (X/Y/INT/GN), (s/i/M/GN) coded to (0,1,2,3,4,5,6,7)
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 VECTOR GROUPS	Vector groups enable: OFF, ON coded to (0,1)
17,18	Word	free	Must be sent as dummy (e.g. 6x value 0)

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	MAXVEC-No.
0	OUTMODE
0	TRIGGER
0	EXTEACH
0	CALCULATION MODE
3000	DYN WIN LO
3500	DYN WIN HI
0	VECTOR GROUPS
0	DUMMY
0	DUMMY

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	VECTOR GROUPS
0	DUMMY
0	DUMMY

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 / 8 parameter words = Vector, 7 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 GN)

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
1200	GN
100	GTO
0	Group
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 GN)

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
1200	GN
100	GTO
0	Group
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	MAXVEC-No.
0	OUTMODE
0	TRIGGER
0	EXTEACH
0	CALCULATION MODE
3000	DYN WIN LO
3500	DYN WIN HI
0	VECTOR GROUPS
0	DUMMY
0	DUMMY

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 GN)

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
Value	GN
Value	GTO
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 Sensor 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

DATA FRAME Sensor → PC (18 WORDS)

0x00AA
5
R
G
B
X
Y
INT
V-No.
RAW R
RAW G
RAW B
TEMP
GRP
REF
DIR
DIF
GN

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

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 Sensor → 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

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

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

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 same18 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

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

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

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.