Manual
Software COLOR4-Scope V2.1

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

for color sensors of SI-COLO4 Series with internal temperature compensation and white light balancing

This manual describes the installation of the PC software for the SI-COLO4 color sensor. As a support for commissioning of the color sensor this manual explains the functional elements of the Windows® user interface.

The SI-COLO4 color sensor detects the radiation that is diffusely reflected by the target. The SI-COLO4 color sensor uses a white-light LED with adjustable power as a light source. A triple receiver for the RED, GREEN, and BLUE content of the light reflected from the target is used as a receiver.

The SI-COLO4 color sensor can be "taught" up to 31 colors. Three different color-detection modes as well as four contrast-detection modes for the respective primary color are available for selection. Evaluation always is performed with 12-bit accuracy.

Color-detection either operates continuously or is started by means of an external SPC trigger signal. The respective detected color 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 colors are to be detected. Simultaneously the detected color code is visualised at the SI-COLO4 housing by means of 5 LEDs.

With the TEACH button at the sensor housing the 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 of cable cab-las8/SPS).

Through the RS232 interface parameters and measured values can be exchanged between the PC and the SI-COLO4 color sensor. All the parameters for color detection can be stored in the non-volatile EEPROM of the SI-COLO4 color sensor. When parameterization is finished the color sensor continues to operate with the current parameters in "stand alone" mode without a PC.

Calibration of SI-COLO4 V4.0 color sensors with the COLOR4-CALIB-Scope V2.1 software:

The sensors of SI-COLO4 series can be calibrated by means of the separate COLOR4-CALIB-Scope software. Color balancing can be performed on any white target. As an alternative, a ColorChecker™ is available, which has 24 different color areas according to CIE standard. Calibration can be done on any of the white areas (→ separate manual for COLOR4-CALIB-Scope V2.1).

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0 Contents

Shortcuts:

SEND	F9
GET	F10
GO	F11
STOP	F12

1 Installation of the COLOR4-Scope software

Hardware requirements for successful installation of the COLOR4-Scope software:

- IBM PC AT or compatible
- VGA graphics
- Microsoft® Windows® 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 COLOR4-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".

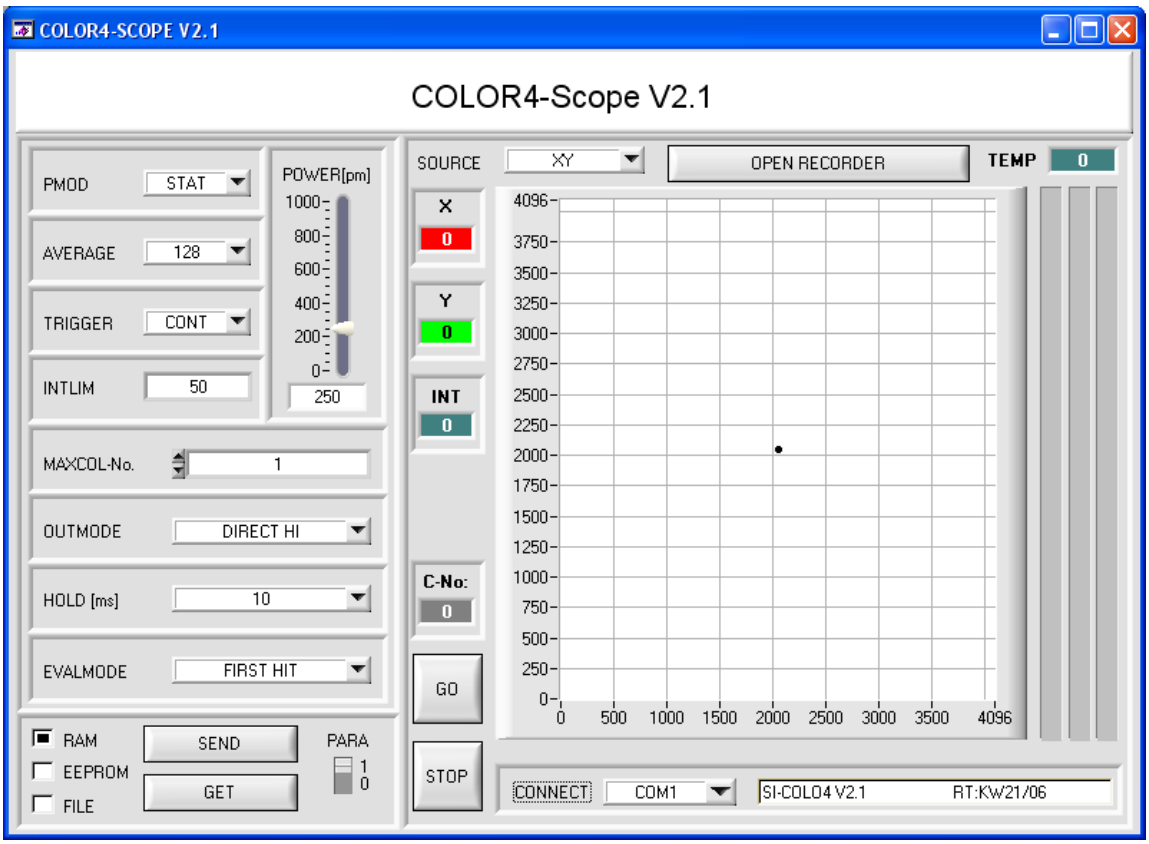
4. After successful installation the software can be started with a left mouse button double-click on the icon.

2 Operation of the COLOR4-Scope software

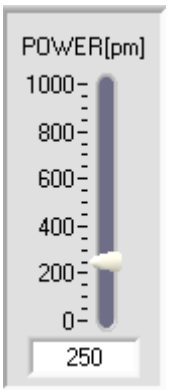
2.1 Functions of the individual COLOR4-Scope control elements

Please read this chapter first before you start to adjust and parameterise the SI-COLO4 color sensor.
Pressing the right mouse button on an individual element will call up a short help text.
The function of the OPEN RECORDER is explained in passage 2.7.

When the COLOR4-Scope software is started, the following window appears on the Windows interface:



Functions of the individual COLOR4-Scope control elements:



POWER:
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‰ [pm] means full intensity at the transmitter LED, a value of 0 stands for the lowest transmitter intensity adjustment!

The POWER slider is only effective in the PMOD STAT.

ATTENTION!
A change of the transmitter power only becomes effective at the SI-COLO4 color sensor after actuation of the SEND button in the MEM function field!

PMOD:

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

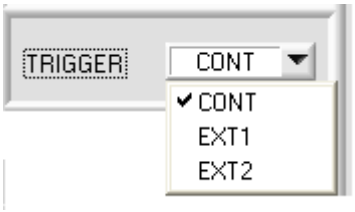
STAT:
The LED transmitter power is constantly kept at the value set with the POWER slider.

DYN:
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 triple receiver the automatic control circuit attempts to adjust the transmitter power in such a way that the dynamic range is not exceeded.

ATTENTION!	**The setting of the POWER slider has no effect in this operating mode.**

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 SI-COLO4 color sensor.



TRIGGER:

This function field serves for setting the trigger mode at the SI-COLO4 color sensor.

CONT:
Continuous color detection (no trigger event required).

EXT1:
Color detection is started through the external trigger input (IN0 pin3 green of cable cab-las8/SPS). 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.

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 modus the maximum number of colors to be checked is 31. In the DIRECT HI or DIRECT LO modus 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 SI-COLO4 color sensor.
The numerical value set here refers to the number of rows (starting with row 0) in the color 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 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:

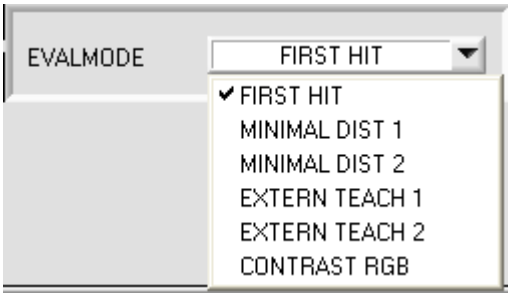
In this mode the maximum number of colors to be taught is 4 !
If in this row-by-row comparison the current color values correspond with the teach-in parameters entered in the color table, this color in the color teachtable is displayed as a color number (C-No.) and is sent direct to the digital outputs (OUT0 ... OUT04).

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).

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:

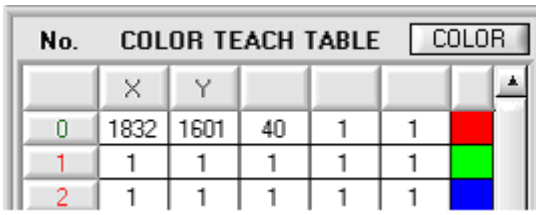
The SI-COLO4 color sensor operates with minimum scanning times in the magnitude of less than 150µs. This is why most of the PLCs that are connected to the digital outputs OUT0 … OUT4 have difficulties with the safe detection of the resulting short switching state changes. For the digital outputs of the SI-COLO4 color sensor pulse lengthening of up to 100 ms can be set by selecting the corresponding HOLD value.



EVALMODE:

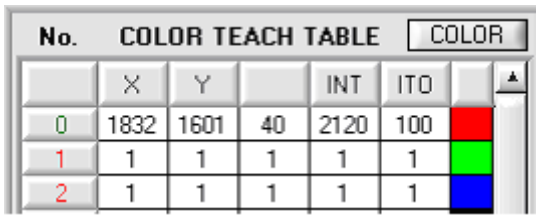
This function field serves for setting the evaluation mode at the SI-COLO4 color sensor.
→ See also function group **OUTMODE**.

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 line-by-line comparison the current color values correspond with the teach-parameters entered in the color table, this first "hit" in the color 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").



MINIMAL DIST 1:
The individual teach-in colors defined in the color 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-COLO4 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. 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.



MINIMAL DIST 2:
The individual teach-in colors defined in the color 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-COLO4 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. In contrast to MINIMAL DIST 1, it is furthermore checked whether the intensity condition for this color is also 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 colors in the graph. It has no meaning for evaluation.

EXTERN TEACH 1:
This evaluation mode allows the user to teach 31 colors externally through the IN0 input respectively via teach button, which offers the advantage of not having to start the parameterization software for this purpose. Teaching is performed through the external IN0 input. When the input is activated, the currently present colour is stored in the non-volatile EEPROM memory.

EXTERN TEACH 2:
With this evaluation mode, teaching can only be done to line 0 in the COLOR TEACH TABLE. Upon activation of input IN0, the sensor automatically adjusts the transmission power such that the three bars are in their dynamic range. The sensor then continues to operate with this transmission power.
Then the sensor calculates the X,Y-coordinates and the intensity, and stores these values in line 0 in the COLOR TEACH TABLE.

Please note that when this evaluation mode is selected, the tolerance for the intensity and the color itself must be stored once in the EEPROM at the beginning.

Furthermore, the MAXCOL-No. must be set first in the ETXERN TEACH 1 function field and must be stored in the EEPROM as well.

TEACH PROCESS:

The following chapter explains the teach process for EXTERN TEACH 1.

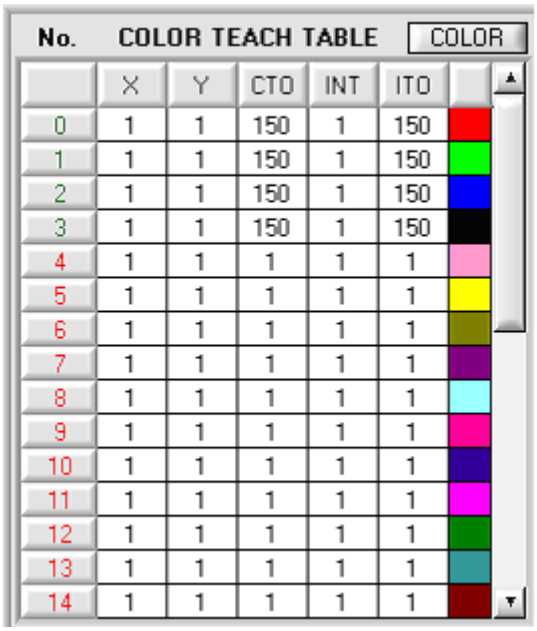
EXTERN TEACH 2 only differs from EXTERN TEACH 1 insofar that maximally one color can be taught, and that the sensor at the beginning of the teach process automatically adjusts the transmission power for this color. With EXTERN TEACH 2, the teach process consequently is started by way of a single signal at IN0. There are no blinking LEDs. Furthermore, the taught color only is stored in the RAM.

Click on the EVALMODE window to scroll the pull-down menu. Choose the function "EXTERN TEACH 1".

Select how many colors you wish to teach externally.

Click on the field "0" of the PARA switcher to change into the COLOR TEACH TABLE.

Now enter the corresponding tolerances for the colors you wish to teach.
(CTO = COLOR tolerance, ITO = INTENSITY tolerance).



	X	Y	CTO	INT	ITO
0	1	1	150	1	150
1	1	1	150	1	150
2	1	1	150	1	150
3	1	1	150	1	150
4	1	1	1	1	1
5	1	1	1	1	1
6	1	1	1	1	1
7	1	1	1	1	1
8	1	1	1	1	1
9	1	1	1	1	1
10	1	1	1	1	1
11	1	1	1	1	1
12	1	1	1	1	1
13	1	1	1	1	1
14	1	1	1	1	1

In this example, MAXCOL-No. = 4 was selected, i.e. the sensor should detect the color information that is stored in the first 4 lines 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 = EXTERN TEACH.

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.

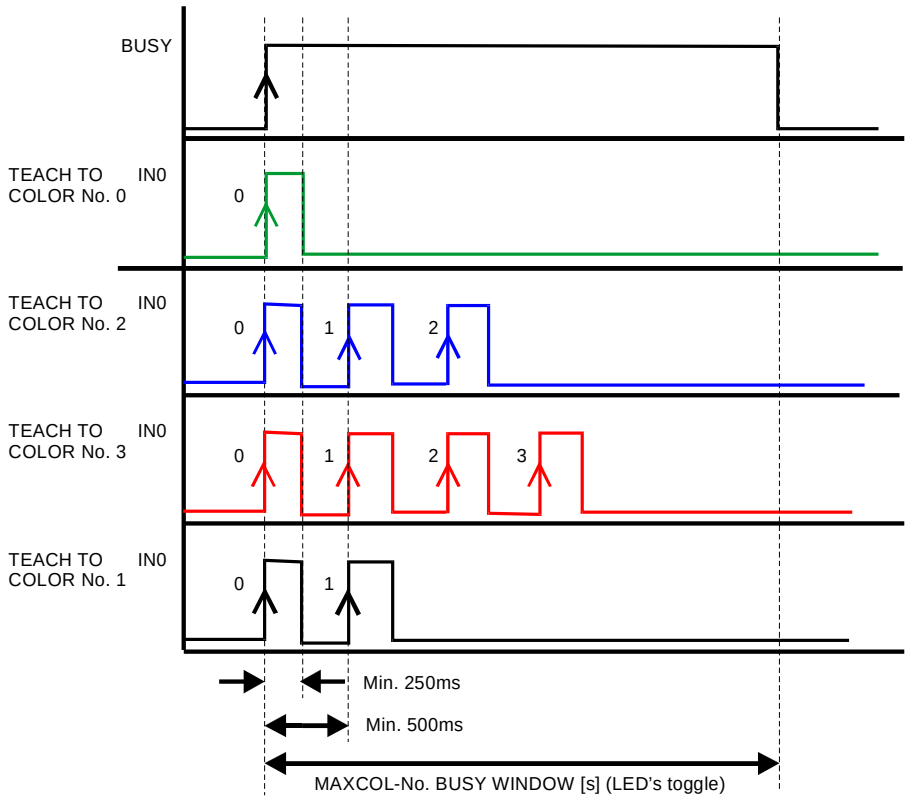
TEMP:
This display shows the temperature prevailing in the sensor housing.

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).

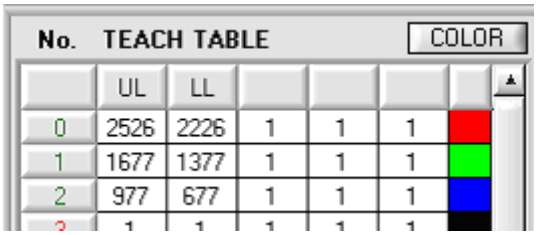
Example:
If you wish to save the current color to position 3 in the COLOR TEACH TABLE, the following steps have to be performed:

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 4 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 4 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 3 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

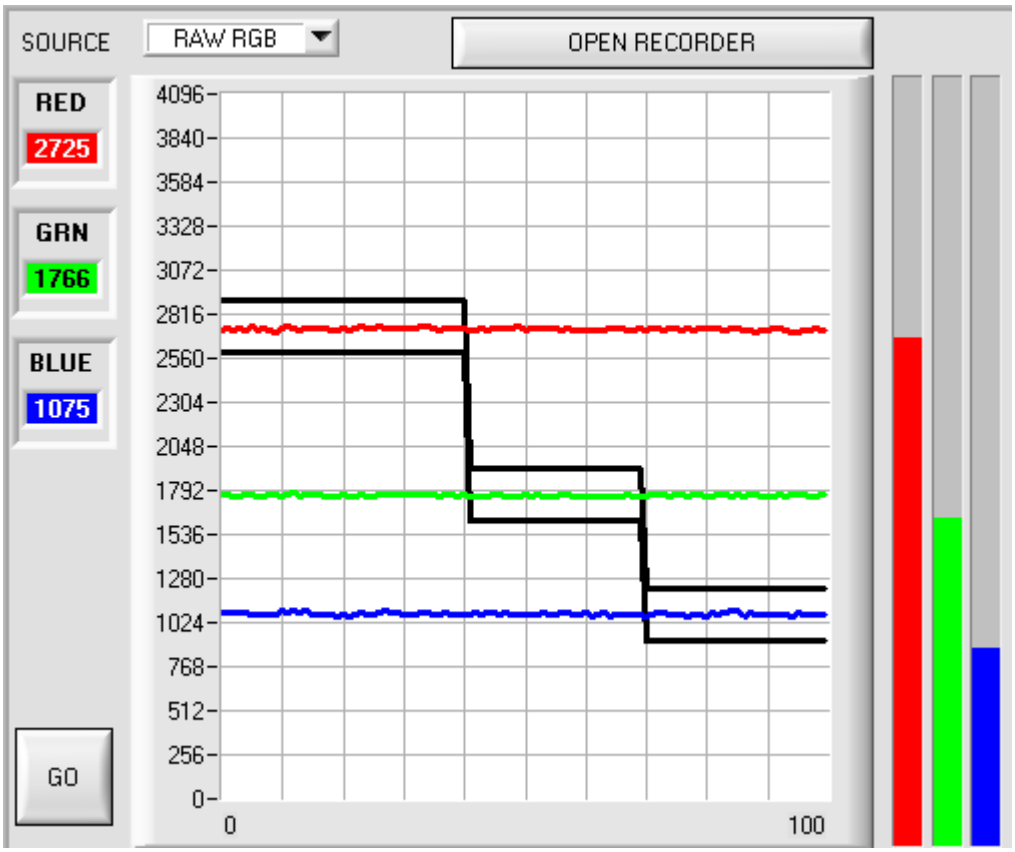


CONTRAST RGB:

If this function field is selected, contrast evaluation is activated at the SI-COLO4 color sensor after a click on the SEND button.



In CONTRAST RGB evaluation mode all three primary colors (RED, GREEN, and BLUE) are evaluated for their intensity INT. Since only the receiver signals are evaluated and no X-, Y-, INT calculation is done, a very high switching frequency (depending on AVERAGE) can be maintained.



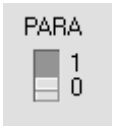
For each channel (RED, GREEN, BLUE) there is an upper limit (UL) as well as a lower limit (LL). These limits constitute an intensity window of the contrast transition to be detected. The limits UL and LL will be entered for channel RED in line 0 of the COLOR TEACH TABLE, for channel GREEN in line 1 and for channel BLUE in line 2, or they must be automatically taught with TEACH DATA TO. In case of automatic teaching, a certain upper and lower limit are suggested. These limits can of course be changed by entering different values in the corresponding fields (UL, LL).

Signal evaluation:
OUT0 = 1, if channel RED is in the intensity window that is set in line 0.
OUT1 = 1, if channel GREEN is in the intensity window that is set in line 1.
OUT2 = 1, if channel BLUE is in the intensity window that is set in line 2.
OUT3 = 1, if all channels are in the respective intensity windows.
OUT4 = 1, if no channel is in the respective intensity window.

After pressing the GO button, the intensities of the three individual channels will be visualized in the graphic display. In addition, one of the three intensity windows can be displayed. The desired intensity window can be selected with the help of the function field No.:

RAM, EEPROM, FILE:

This group of buttons controls parameter exchange between PC and SI-COLO4 color sensor through the serial RS232 interface.

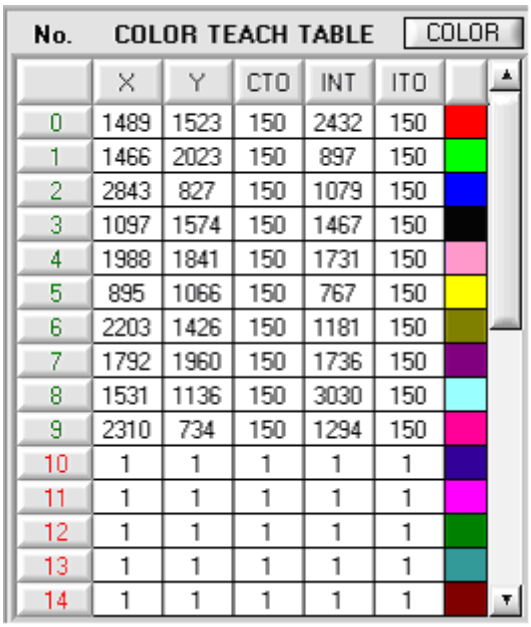


PARA:

With this switch the display of the color table (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 table (COLOR TEACH TABLE) for entering the individual parameters for the teach-in colors.



	X	Y	CTO	INT	ITO	
0	1489	1523	150	2432	150	
1	1466	2023	150	897	150	
2	2843	827	150	1079	150	
3	1097	1574	150	1467	150	
4	1988	1841	150	1731	150	
5	895	1066	150	767	150	
6	2203	1426	150	1181	150	
7	1792	1960	150	1736	150	
8	1531	1136	150	3030	150	
9	2310	734	150	1294	150	
10	1	1	1	1	1	
11	1	1	1	1	1	
12	1	1	1	1	1	
13	1	1	1	1	1	
14	1	1	1	1	1	

COLOR TEACH TABLE:

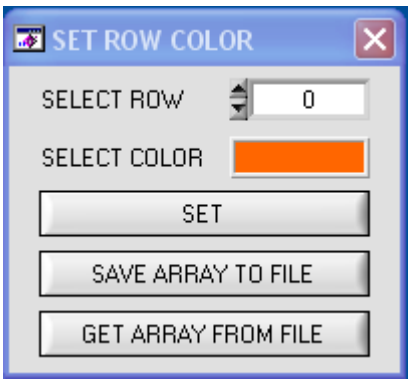
A click on switch position 0 of the PARA switch (MEM-function field) opens the color teach table shown here.

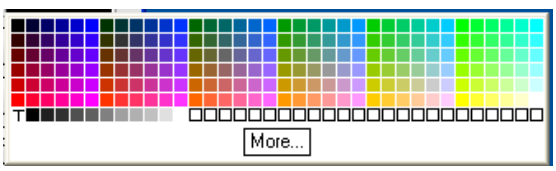
The color teach table shows the currently set parameters.

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 SI-COLO4 color sensor is able to check up to 131teach-in colors. The number of the respective teach-in color is given in the left column of the table.





COLOR:
A click on COLOR opens a panel where the row color in which the individual tolerance circuits are represented can be individually chosen.
Set the row for which you want to change the color with SELECT ROW.
A click on the colored area of the SELECT COLOR field opens a color palette from which the desired color can be selected.
After a click on the SET button, the color is displayed in the 6th column and in the selected row of the COLOR TEACH TABLE.
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.

X — X-value of the teach-in color (in the color triangle numerical value on the x-axis: RED color content) $X = \frac{R}{R+G+B}$ * 4095

Y — Y-value of the teach-in color (in the color triangle numerical value on the y-axis: GREEN color content) $Y = \frac{G}{R+G+B}$ * 4095

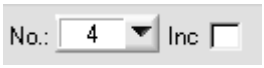
CTO — Color tolerance: "Tolerance circles" around the teach color in the color triangle that is defined as an (X,Y) point. The sensor internally calculates a "hysteresis ring". The numerical value of CTO determines the radius of the "tolerance circle" around the teach color. Within the "tolerance circle" defined by this method, the current color is recognised as the teach color.

INT — Teach-in value for the intensity of the respective color.

$$INT = \frac{R+G+B}{3}$$

Please note: For the detection of a teach-in color both criteria - color (X,Y) and intensity INT - must be fulfilled, i.e. the currently measured values for color and intensity must both lie within the respective preset tolerance limits CTO (color) and ITO (intensity).

ITO — Default value for the permitted tolerance band around the intensity teach-in value (intensity tolerance).



No.:
Selection of the current number of the teach-in color (0 .. 30) from the color table.

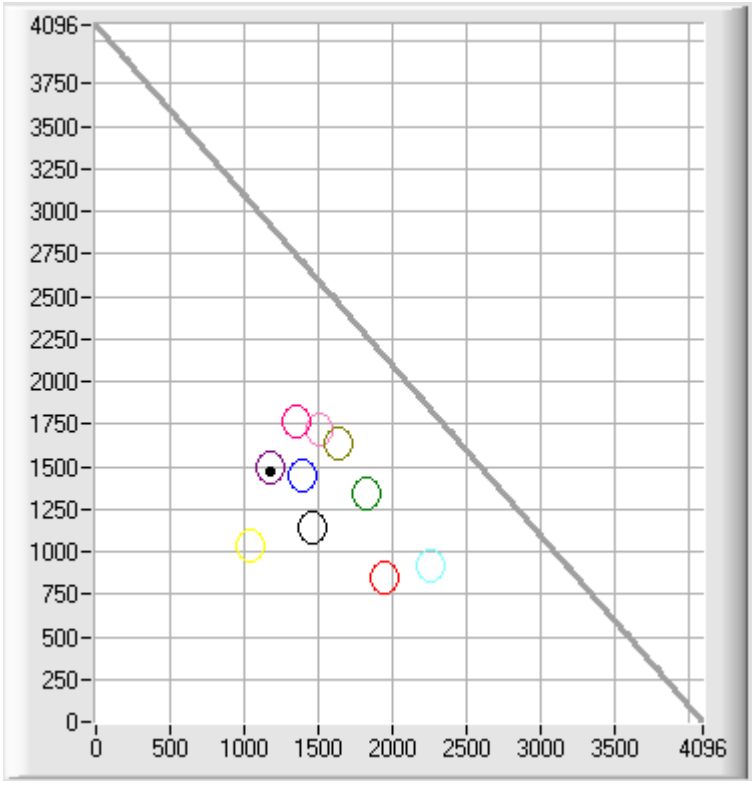
Inc:
When Inc is activated, and the TEACH DATA TO button is pressed, the No.: input field is automatically incremented (increased) by 1, i.e. the next line in the COLOR TEACH TABLE is selected.

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.

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



AUTO ADJUST:

A click on this button initiates automatic adjustment of the circle tolerances (CTO).
A circle tolerance of max. 200 DIGITS is allowed in calculation.
Circles may overlap if they are definitely separated by the intensity (please note: ITO must be set first!)
The number of circle tolerances to be calculated is determined by MAXCOL-No. (e.g. MAXCOL-No. = 5 → CTO adjustment up to and including line 4).
When the CTO values have been adjusted, a large graphic window appears, displaying the color circles. This graph features a zoom function (see ZOOM).

ZOOM:

A click on the ZOOM button opens a large graphic window. This graphic window features a zoom function. For zooming, the cursor that is visualised by a cross in the graphic window, is moved to the desired position in the graph with the mouse or the arrow keys.
The graph can be exited either by pressing the right mouse button, or by pressing the APPLY FROM ALL button.

RESET TABLE:

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

F9

SEND:

When the SEND button is clicked (or shortcut key button F9 is pressed), all the currently set parameters are transferred between PC and SI-COLO4 color sensor. The target of the respective parameter transfer is determined by the selected button (RAM, EEPROM, or FILE).

F10

GET:

The currently set values can be interrogated from the SI-COLO4 color 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).

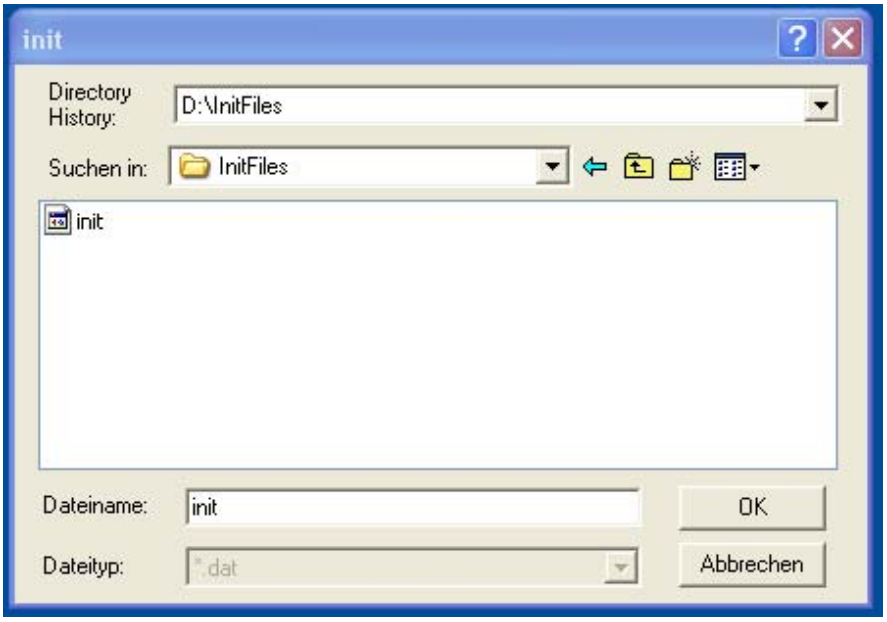
RAM: The current parameters are written into the RAM memory of the SI-COLO4 color sensors, or they are read from the RAM**, i.e. these parameters are lost when the voltage at the SI-COLO4 color sensor is switched off.**

EEPROM: The current parameters are written into the non-volatile memory of the EEPROM in the SI-COLO4 color sensor, or they are read from the EEPROM, **i.e. the parameters in the internal EEPROM are stored when the voltage at the SI-COLO4 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 SI-COLO4 color sensor to the PC through the serial RS232 interface.
If *X/Y* is selected under SOURCE, the X/Y coordinates of the current color are displayed in the graph.
If *RAW INT* 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.

[F12]

STOP:
A click on this button (or pressing shortcut key button F12) stops data transfer from the SI-COLO4 color sensor to the PC through the serial RS232 interface.

X:
This numerical value output field displays the red content of the color currently arriving at the receiver.

Formula for calculation:

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

Y:
This numerical value output field displays the green content of the color currently arriving at the receiver.

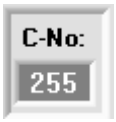
Formula for calculation:

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

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

Formula for calculation:

$$INT = \frac{R+G+B}{3}$$



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.

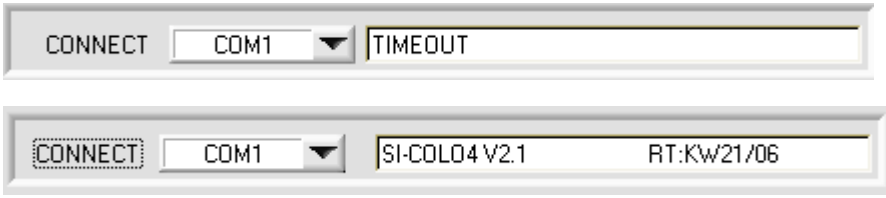
PLEASE NOTE:	**The above-mentioned 5 output fields are only updated when data transfer between PC and SI-COLO4 color sensor is active (GO button pressed).**

SOURCE:

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

XY :	Display of the color triangle and of the currently determined color.
RAW RGB :	The current raw signals of the 3-fold receiver (red, green, blue) are displayed.
RAW INT :	The currently determined total intensity is displayed.

The COLOR4-Scope software starts with the standard configuration COM1 and the respective communication status.



The system provides the following status messages:

Init COM-PORT		The PC tries to establish a connection with the SI-COLO4 color sensor through the respective selected interface.
SI-COLO4 V2.1	RT:KW21/06	The connection between PC and SI-COLO4 color sensor could be established successfully.
TIMEOUT:		A connection between SI-COLO4 color sensor and PC could not be established, or the connection is faulty. **In this case it should first be checked whether the SI-COLO4 color sensor is supplied with voltage, and whether the RS232 interface cable is correctly connected.** If the interface assignment at the PC is not known, a selection can be made from COM1, COM2, …, COM9 by clicking on the [↓] selection field in the CONNECT group.
Invalid port number:		The selected interface is not available at the PC.

ATTENTION!	**The stable function of the RS232 interface („SI-COLO4 V2.1 RT:KW21/06 " status message after program start) is a basic prerequisite for measured value transfer from the PC to the SI-COLO4 color sensor.**

ATTENTION !	**Due to the limited data transfer rate through the serial RS232 interface (9600 Baud) 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 SI-COLO4 color sensor data communication with the PC must be stopped (press the STOP button).**

2.2 COLOR4-Scope software as an aid for sensor adjustment

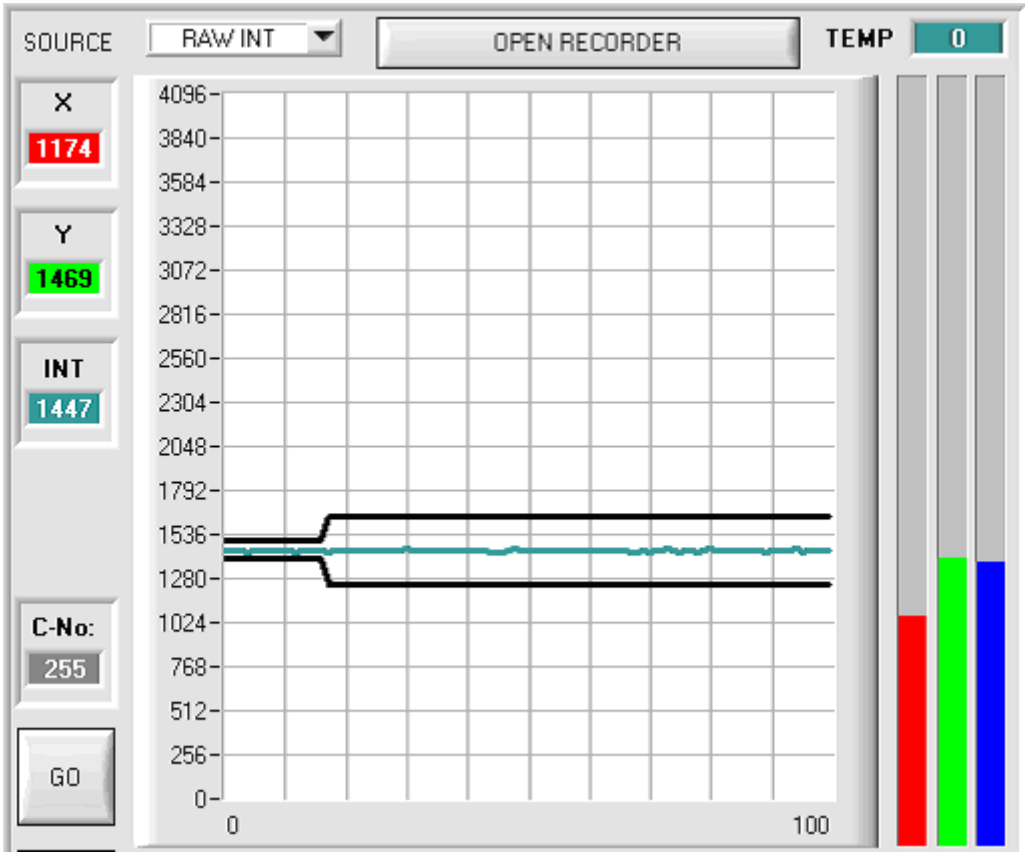
Prior to the use of the software aids (graphic display of sensor signals) the SI-COLO4 color sensor frontend must be manually adjusted to the respective target or background as accurately as possible. The reference distance of the color sensor to the target is to be taken from the respective data sheet!

ATTENTION! **By using the SI-COLO4-LWL color sensor with an fiber optics frontend, there should be a working distance of approx. 2 … 10mm between the optical fiber head-end and the measuring object.**

Fine adjustment of the SI-COLO4 color sensor is facilitated by the graphic display of the analog signals (raw signals from the triple receiver diode). First of all measurement data transfer from the SI-COLO4 color sensor to the PC must be activated by clicking on the GO button.

For this purpose the option RAW INT must be selected in the SOURCE selection field. With this setting the intensity measured at the receiver unit is shown in the graphic display window.

Activation of measurement data transfer between PC and SI-COLO4 color sensor. The current measured values are shown in the graphic display window in "scroll mode" (in the display window the most recent values appear on the left side).



The measured intensity value from the receiver diode of the SI-COLO4 color sensor should now appear in "scroll mode" in the graphic display window (red). If one of the 3 measuring channels lies at the upper=4096 or lower=0 limit (observe the bar display), it must first be ascertained that the intensity of the transmitter LED is correctly set.

For this purpose the laser mode is set to STAT (static) in the PMOD function field, and the POWER slider is then adjusted until the intensity value INT (pink curve) ideally lies in the middle of the measuring range (0 .. 4096 12-bit A/D converter).

If less intensity is diffusely reflected from the target, the color sensor can also be operated with less intensity. Color evaluation, however, is only possible, if the following is valid for the measured intensity INT:

INT > INTLIM

Please note: **The change of laser power only becomes active at the SI-COLO4 color sensor after a click on the SEND button !**

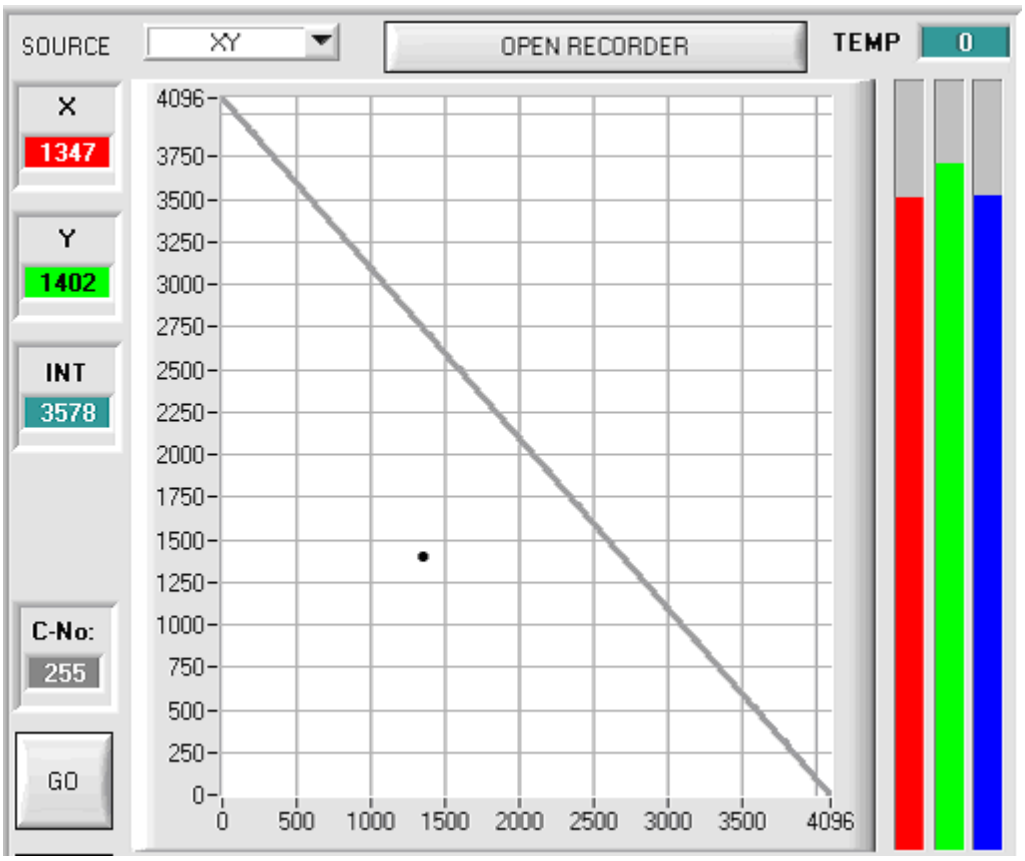
2.3 COLOR4-Scope software as an aid for teach-in

The SI-COLO4 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.



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.

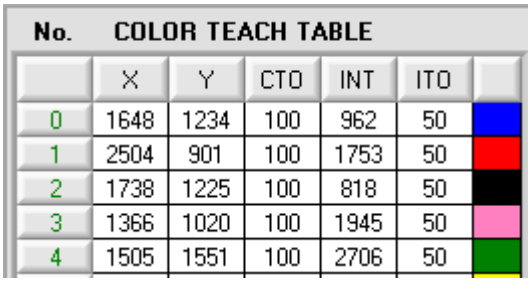
After a click on the GO button measured values are transferred from the color sensor to the PC and displayed as (X,Y) value pairs in the color triangle.

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 automatic TEACH-IN the tolerance circle around the teach-in color should first be slightly corrected, i.e. increased, by entering CTO (depending on the scatter of the measured value).

The position (push button APPLY FROM ALL pressed) of the taught tolerance circles around the respective teach-color in the color triangle determines the possible choice of the tolerance circles (radius=CTO). They should be chosen so, that they don't overlap each other.



No. COLOR TEACH TABLE

	X	Y	CTO	INT	ITO	
0	1648	1234	100	962	50	
1	2504	901	100	1753	50	
2	1738	1225	100	818	50	
3	1366	1020	100	1945	50	
4	1505	1551	100	2706	50	

Tolerance ITO, which lies symmetrically around intensity INT, also should be increased first, because otherwise color detection might fail due to intensity evaluation.
For the detection of a teach-in color both criteria, color (X,Y) and intensity INT must be fulfilled !

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

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

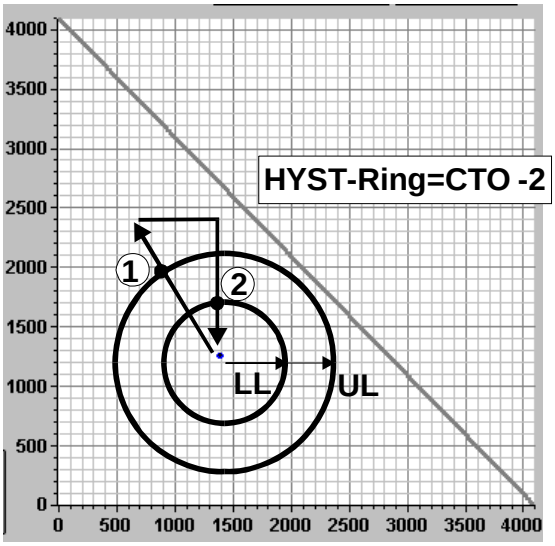
The number of colors to be checked must be entered in the MAXCOL-No. input field.

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 SI-COLO4 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 COLOR4-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 SI-COLO4 color sensor. The SI-COLO4 color sensor then performs the measuring task in STAND-ALONE operation.

2.4 Position of the hysteresis ring in the color tolerance circle



The tolerance circle (radius = CTO) lies symmetrically around the (X,Y) value pair of the respective teach-in color in the color triangle.

For avoiding unstable switching states at the digital outputs OUT0 … OUT4 the sensor defines internally a hysteresis ring around each teach-in color.
This internal hysteresis ring, which cannot be adjusted by the software user, is calculated by the following formula:
HYST-RING=CTO-2.

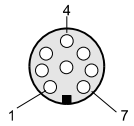
A teach-in color is detected until the tolerance circle (radius=CTO) is exceeded at point (1). When this happens, the switching state at the digital outputs changes.

When the current measured value (X,Y value pair) enters the tolerance circle again, the teach-in color is only detected again when the value drops below the HYST-RING at point (2).

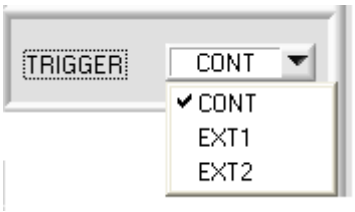
The hysteresis range is defined by the ring area between the outer tolerance circle (radius=CTO) and the inner circle (HYST-RING).

Please note:	**The inner circle (radius=HYST-RING) for the lower hysteresis threshold is not shown in the graphic output field.**

2.5 External triggering of the SI-COLO4 color sensor



External triggering is performed through pin no. 3 (grn) at the 8-pin socket of the SI-COLO4/PLC connection.

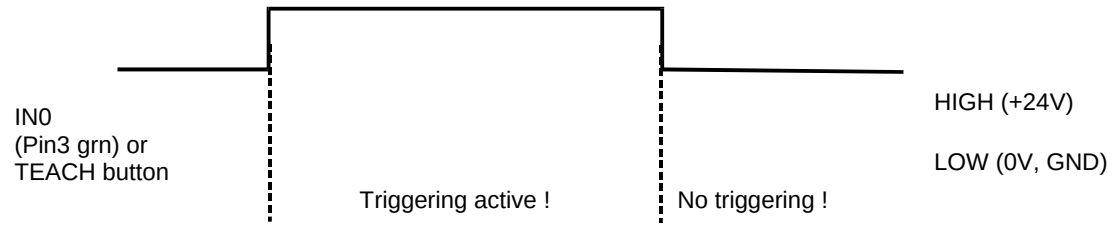


EXT:
First the external trigger mode must be set at the color sensor. For this purpose option EXT must be selected in the TRIGGER selection field.

PLEASE NOTE:
The new setting is only activated at the SI-COLO4 control unit after a click on the SEND button!

The TRIGGER = EXT mode is only available for the two evaluation cases FIRST HIT and MINIMAL DIST.

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).**



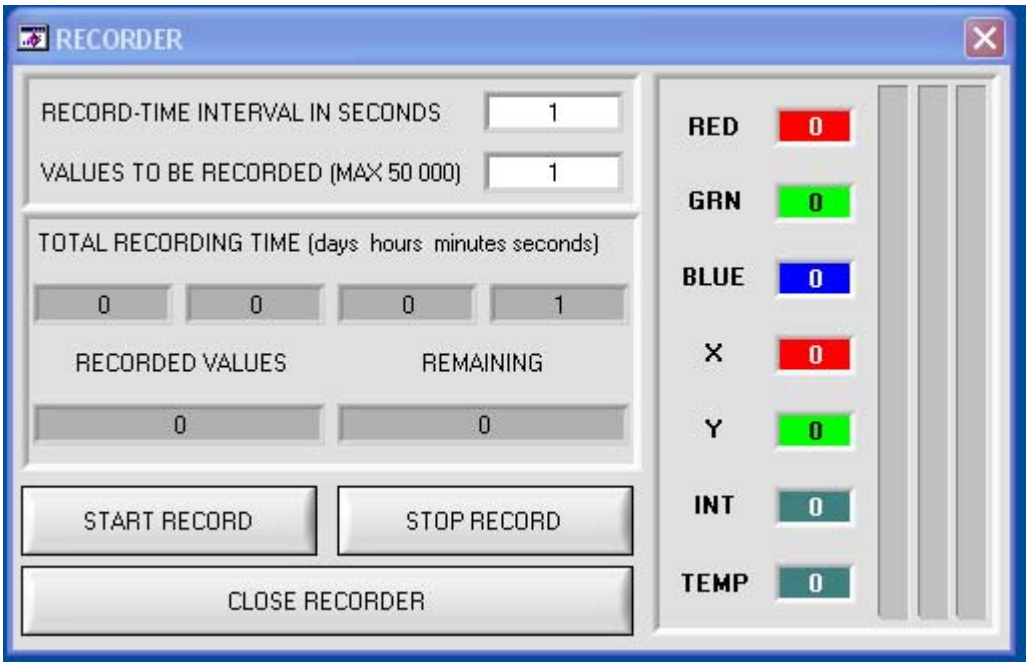
2.6 Function of the data recorder (OPEN RECORDER)

The COLOR4-Scope software features a data recorder that makes it possible to save a certain number of RED/GREEN/BLUE/X/Y/INT frames. The recorded file is saved to the hard disk of your PC and can then be evaluated with a spreadsheet program.

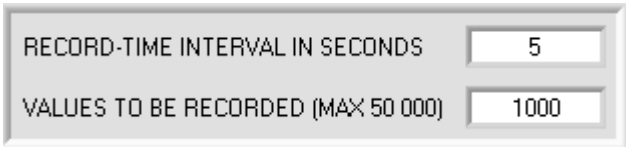
The file that is created has six columns and as many lines as data frames were recorded.
A line is structured as follows: RED, GREEN, BLUE, X, Y, INT.

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

Step 1
Press the OPEN RECORDER button. The following window will be displayed:



Step 2:
Enter a time interval for recording (in this example: 5, i.e. a new value is called from the sensor every 5 seconds).
Then enter the maximum number of values you wish to record in the second input field.

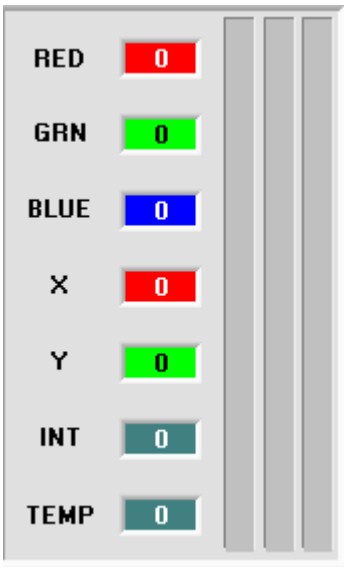


Please note:
Recording can also be stopped earlier, the data recorded so far will not be lost.

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

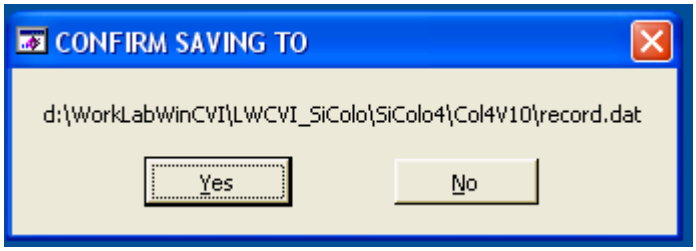
Step 3:
Start data recording by pressing the START RECORD button.
You will be asked to which file the data should be saved when recording is finished. If you select an already existing file name, you will be asked whether you want to overwrite the existing file or not.

If you press YES, the recorder starts to record data. The button will become red to indicate that evaluation 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.

Step 4:
When all the data frames set under VALUES TO BE RECORDED have been recorded, or when the STOP RECORD button is pressed, a pop-up window will appear and ask you to confirm that you really want to save the recorded values. The pop-up window again displays the path you set for your file.



Attention:
If you press NO here, the data will be discarded.

Step 5:
Press the CLOSE RECORDER button to close the recorder and return to the main program.

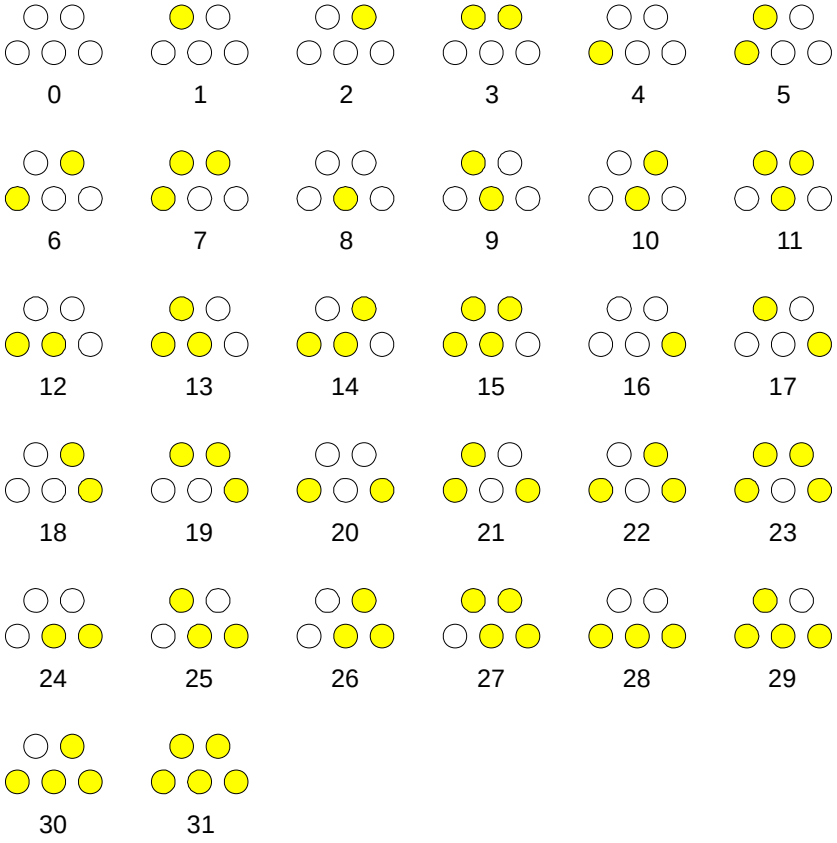
2.7 Function of the LED display

LED display:

BINARY

The color code is visualised by way of 5 yellow LEDs at the housing of the SI-COLO4 color sensor. At the same time in the binary modus (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 SI-COLO4/PLC socket.

The SI-COLO4 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” is displayed by the lighting of all LED (OUT0 .. OUT4 digital outputs are set to HIGH-level).



“Error” respectively
“not detected”

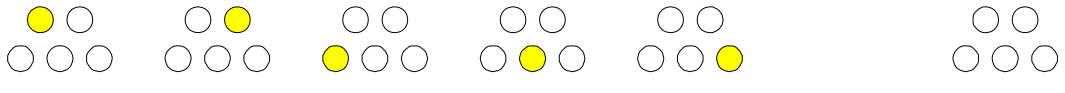
DIRECT

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. 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).

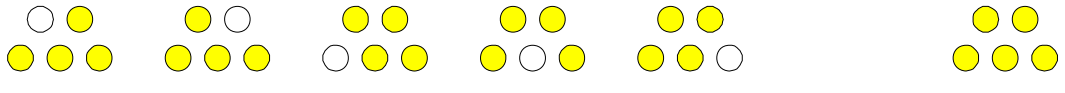
DIRECT HI:

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).



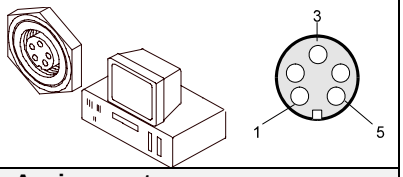
DIRECT LO:

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).

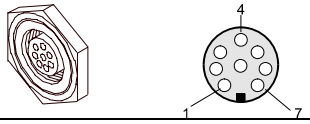


3 Connector assignment of the SI-COLO4 color sensor

Connection of SI-COLO4 to PC:

5-pole female connector (type Binder 712) ***SI-COLO4/PC-RS232***		
Pin No.:		**Assignment:**
1		0V (GND)
2		TX0
3		RX0
4		Not connected
5		Not connected

Connection of SI-COLO4 to PLC:

8-pole female connector (type Binder 712) ***SI-COLO4/PLC***		
Pin No.:	**Color:**	**Assignment:**
1	wht	0V (GND)
2	brn	+12VDC .. +30VDC
3	grn	IN0
4	yel	OUT0 (Digital 0: Type 0 … 1V, Digital 1: Type +Ub – 10%)
5	gry	OUT1 (Digital 0: Type 0 … 1V, Digital 1: Type +Ub – 10%)
6	pnk	OUT2 (Digital 0: Type 0 … 1V, Digital 1: Type +Ub – 10%)
7	blu	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 ⇔ SI-COLO4 Sensor (COLOR4-Scope V2.1)
- Standard RS232 serial interface without hardware-handshake - 3-wire: GND, TX0, RX0 - Speed: **9600 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 SI-COLO4 hardware. All bytes must be transmitted in binary format (us, MSB). The meaning of the parameters is described in the software manual COLOR4-Scope. Info: 1 word = 2 bytes Method: The SI-COLO4 hardware is permanently reading (polling) the incoming byte at the RS232 connection. If the incoming word = 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 SI-COLO4 hardware 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	parameter POWER	LED intensity (0 ... 1000) Attention intensity in thousendth!
4	Word	parameter PMOD	LED mode STAT, DYN (0, 1)
5	Word	parameter AVERAGE	Signal averaging 1,2,4,8,16,32,64,128,256,512,1024,2048,4096,8192,16384 or 32768
6	Word	parameter EVAL MODE	Evaluation mode FIRST HIT, MINIMAL DIST 1, MINIMAL DIST 2, EXT TEACH 1, EXT TEACH 2, CONTRAST RGB coded to (0,1,2,3,4,5)
7	Word	parameter HOLD[ms]	Hold time 0,1,2,3,5,10,50 or 100ms coded to (0,1,2,3,5,10,50 or 100)
8	Word	parameter INTLIM	Lower intensity limit (0 ... 4095)
9	Word	parameter MAXCOL-No.	Number of the colours (1,2,3,…,31)
10	Word	parameter OUTMODE	Function of the digital output (0=direct/HI, 1=binary, 2=direct/LO)
11	Word	parameter TRIGGER	Trigger mode CONT, EXT1 or EXT2 (0, 1, or 2)
12 … 18	Word	free	Must be sent as dummy (e.g. 7x value 0)

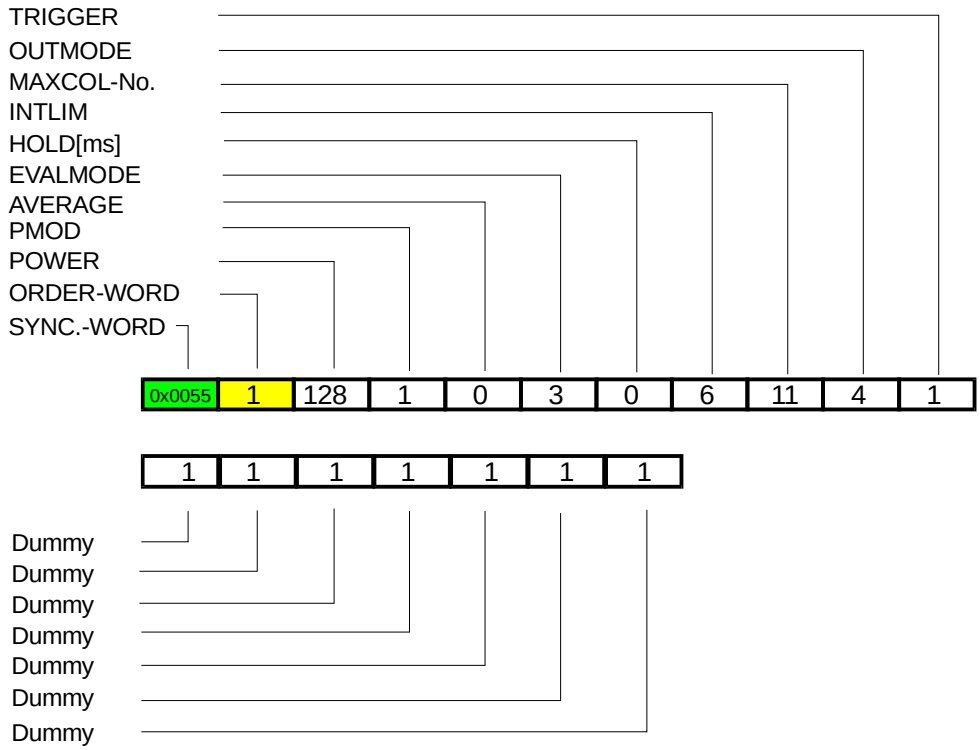
Value	ORDER NUMBER (parameter byte no. 2)	
0	nop	no operation
1	Save parameter from PC into RAM	volatile: 18 words PC⇒SI-COLO4
2	Save one selectable row of TEACH TABLE into RAM	volatile: 18 words PC⇒SI-COLO4
3	Send parameter from RAM to PC	171 words binary SI-COLO4 ⇒ PC
4	Send parameter from EEPROM to RAM + to PC	171 words binary SI-COLO4 ⇒ PC
5	Send data from RAM to PC (R,G,B,X,Y,INT,COL, RAW R, RAW G, RAW B, TEMP, 5 DUMMIES)	16 words binary SI-COLO4 ⇒ PC
6	Save parameter from RAM to EEPROM	18 words PC⇒SI-COLO4
7	Send connection OK to PC	48 words binary SI-COLO4 ⇒ PC
20	Send line ok = 0x0055, 0x0014, 0x00AA to PC	3 words binary SI-COLO4 ⇒ PC

Example 1: DATA FRAME with ORDER NUMBER = 1:

ORDER NUMBER (second word = **1**): **WRITE parameters from PC into RAM of the SI-COLO4!**

The completely data frame = 18 words must be sent to the SI-COLO4 hardware in binary form (sync-word / order-word / 16 parameter words).

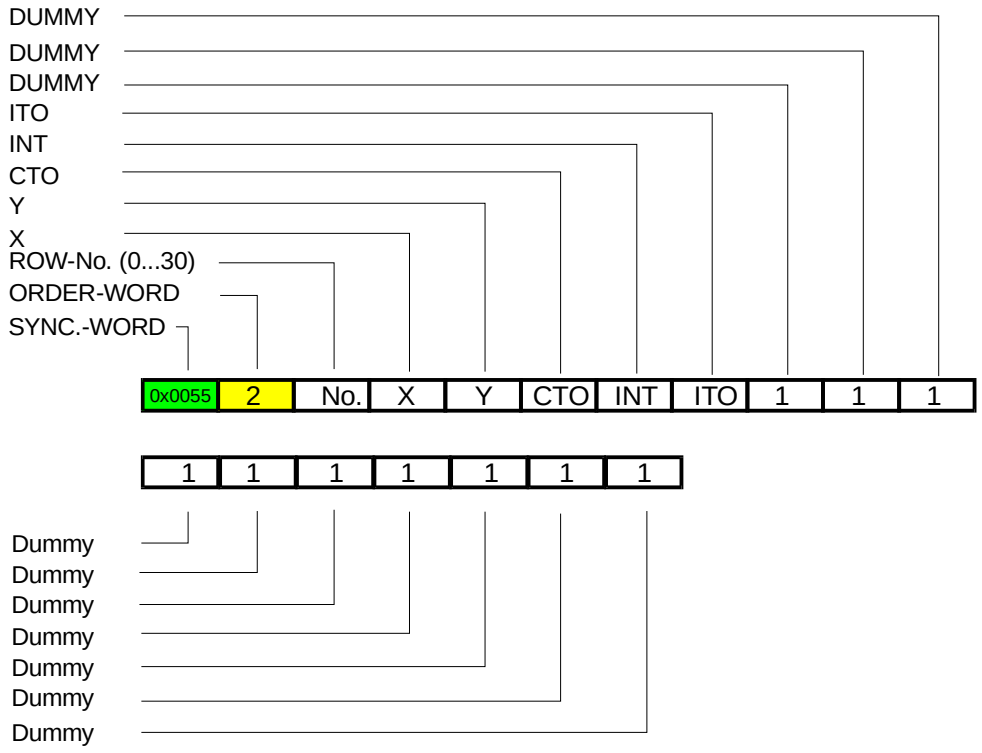
Fill unused words of the TEACH VECTOR by value word=1 in binary form.



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 SI-COLO4!**

The completely data frame = 18 words must be sent to the SI-COLO4 hardware in binary form (sync-word / order-word / 6 parameter words = vector, 10 dummies).
Fill unused words of the TEACH VECTOR by value word=1 in binary form.

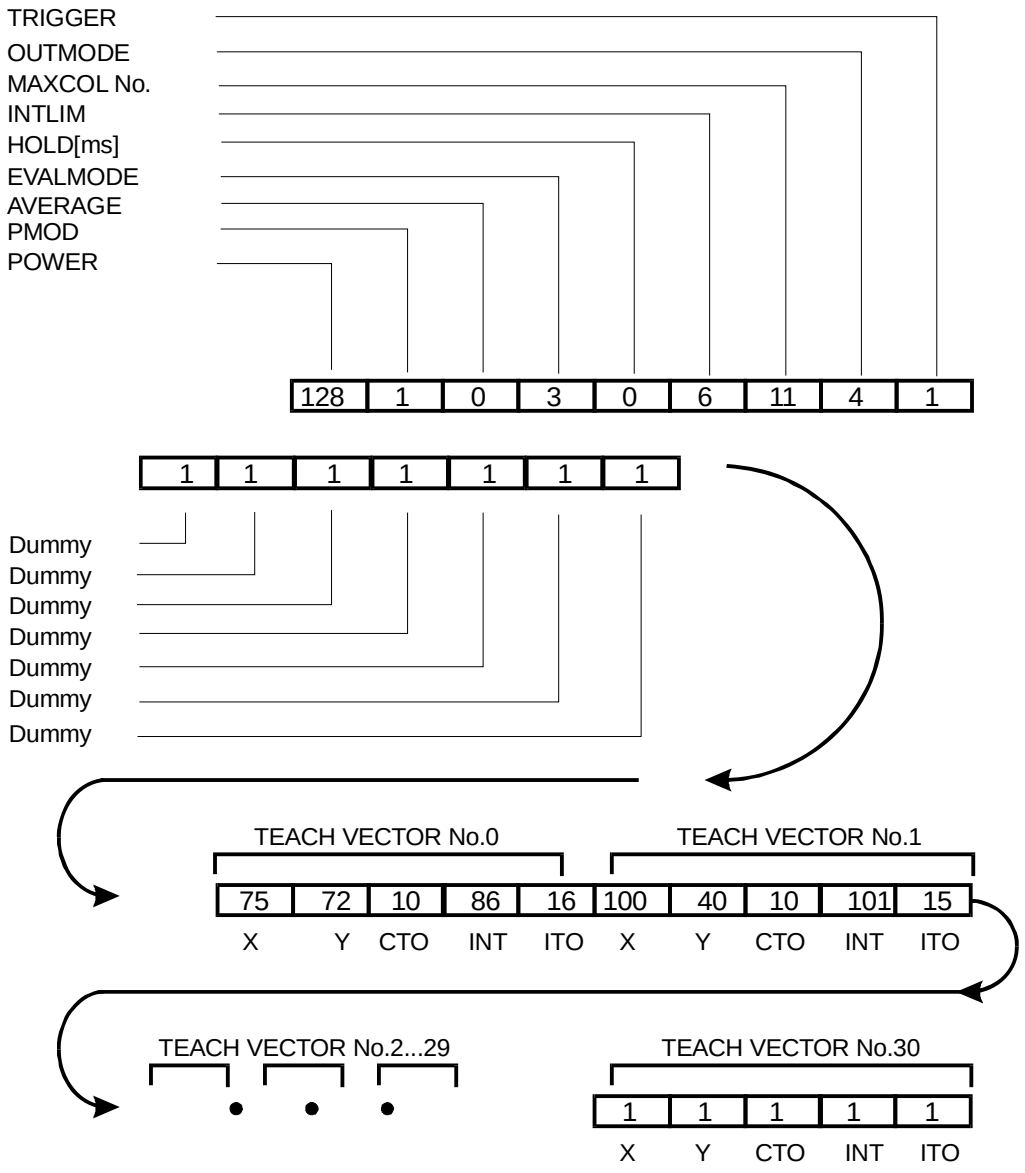


Example 3: DATA FRAME with ORDER NUMBER = 3:

ORDER NUMBER (second word = **3**): **READ parameters out of SI-COLO4 RAM memory!**
The complete DATA FRAME which is responded by the SI-COLO4 hardware **is 171 words** long.

DATA FRAME PC → SI-COLO4 (18 WORDS)
The same frame as example 1 must be sent to the SI-COLO4 hardware except of the order word that must be 3. The values for the parameters must be sent as Dummies.

DATA FRAME SI-COLO4 → PC (171 WORDS)



Example 4: DATA FRAME with ORDER NUMBER = 4:

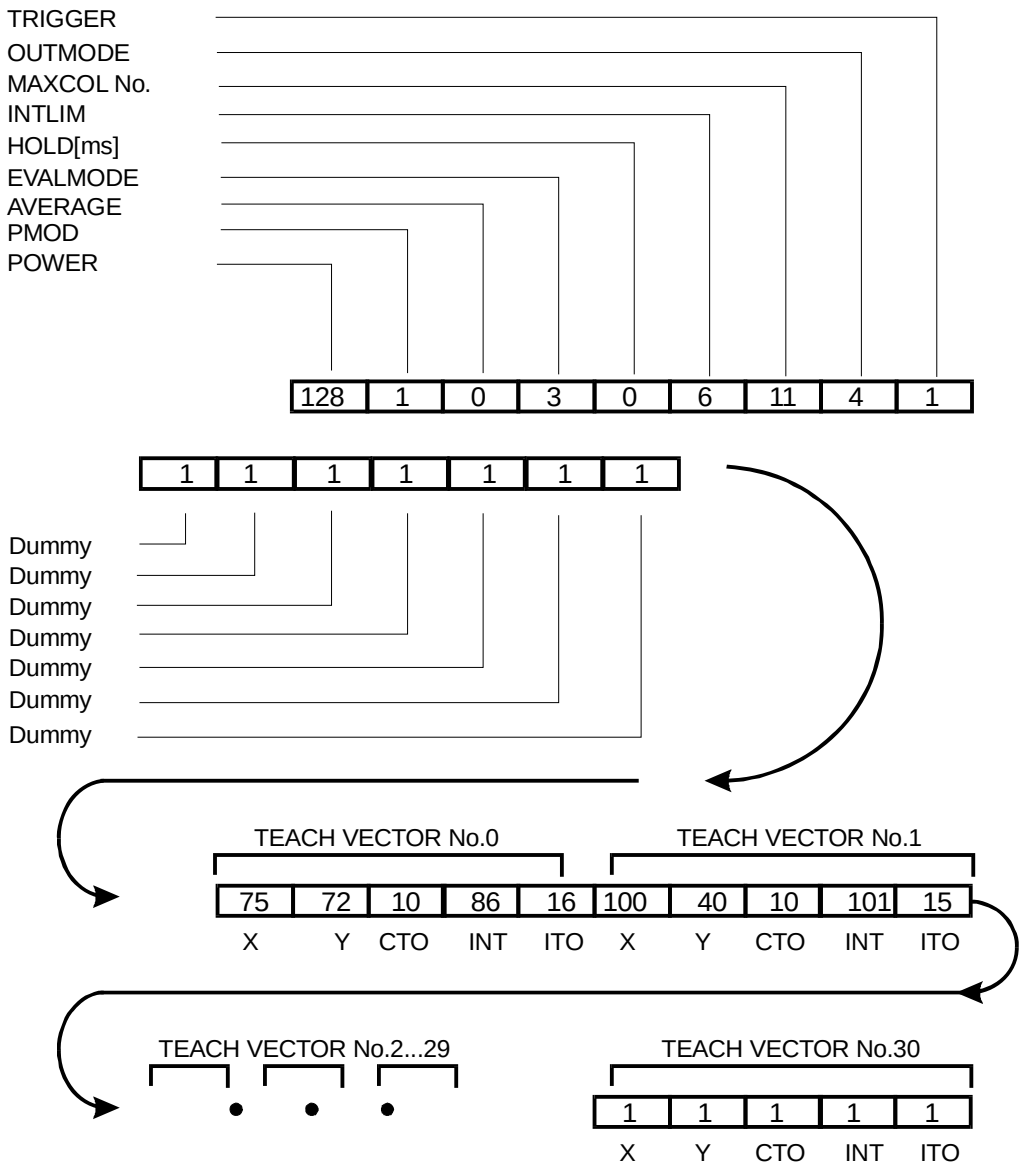
ORDER NUMBER (second word = **4**): **READ parameters out of SI-COLO4 EEPROM memory!**

The complete DATA FRAME which is responded by the SI-COLO4 hardware **is 171 words** long.

DATA FRAME PC → SI-COLO4 (18 WORDS)

The same frame as example 1 must be sent to the SI-COLO4 hardware except of the order word that must be 4. The values for the parameters must be sent as Dummies.

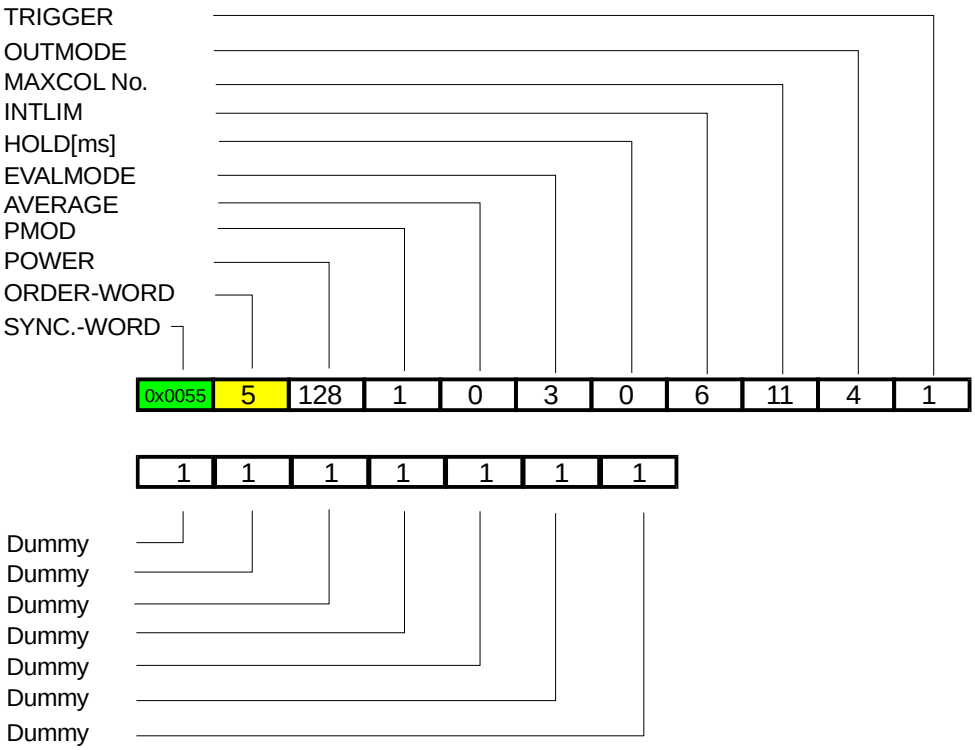
DATA FRAME SI-COLO4 → PC (171 WORDS)



Example 5: DATA FRAME with ORDER NUMBER = 5:

ORDER NUMBER (second word = **5**): **READ SI-COLO4 RAW DATA**

DATA FRAME PC → SI-COLO4 (18 WORDS)
Parameters must be sent for a constant parameter frame as dummies.
At order word 5 they do not affect the RAM or EEPROM.

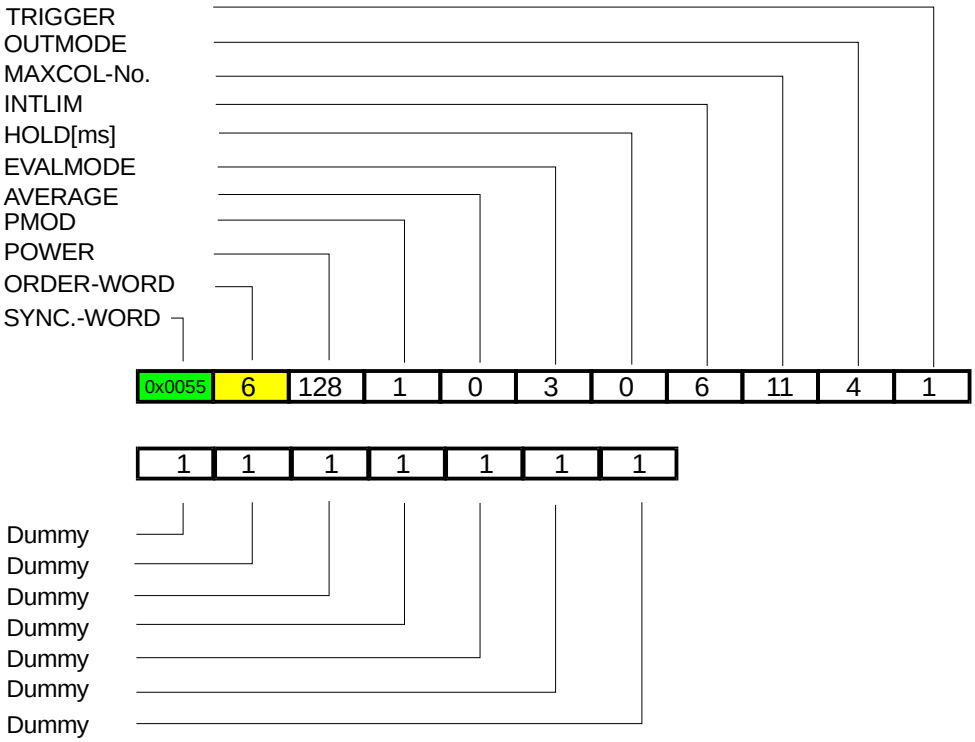


After sending this frame the sensor writes back 16 RAW DATAS.

Example 6: DATA FRAME with ORDER NUMBER = 6:

ORDER NUMBER (second word = **6**): **SAVE parameters from RAM to EEPROM of the SI-COLO4!**

The completely data frame = 18 words must be sent to the SI-COLO4 hardware in binary form (sync-word / order-word / 16 parameter words).
Fill unused words of the TEACH VECTOR by value word=1 in binary form.



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 the RAM use **example 1** and **example 2**.

Example 7: DATA FRAME with ORDER NUMBER = 7:
ORDER NUMBER (second word = **7**): **SEND CONNECTION OK from the SI-COLO4 to PC!** Cf. **example 1:** Send the same DATA FRAME but with ORDER NUMBER 7 to the sensor. The sensor will reply with 48 words which tell the version of the sensor.

Example 8: DATA FRAME with ORDER NUMBER = 20:
ORDER NUMBER (second word = **20**): **SEND LINE OK from the SI-COLO4 to PC!** **Cf. example 1:** Send the same DATA FRAME but with ORDER NUMBER 20 to the sensor. The sensor will reply with 3 words which tell that there is a connection.