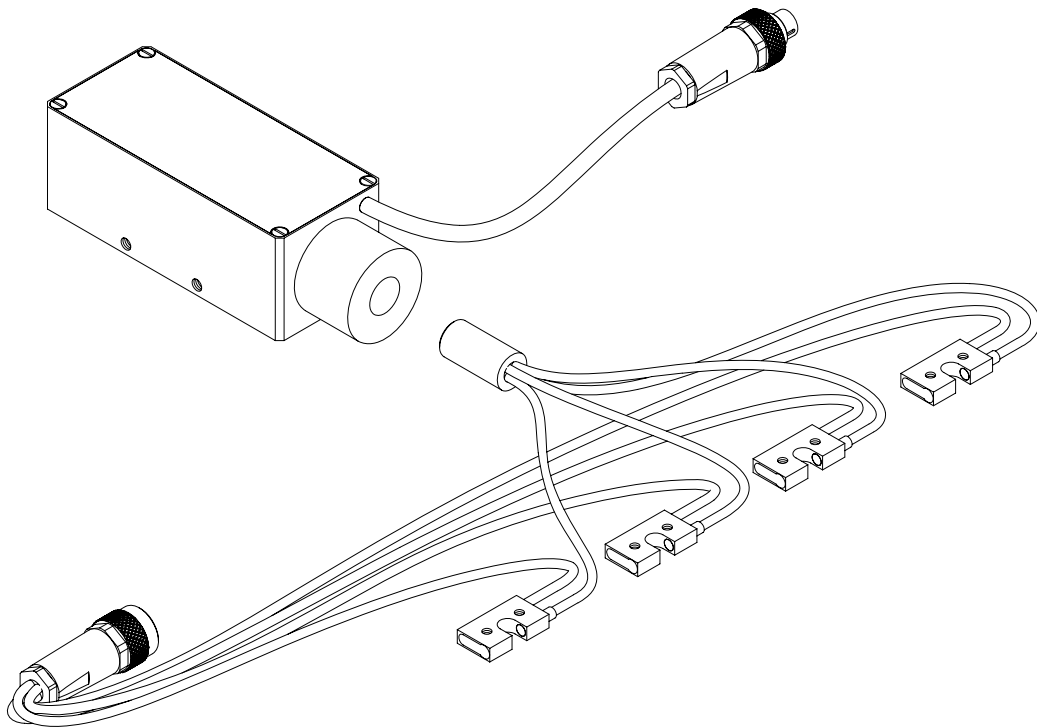


# Manual

## Software **SI-COLO-MUX-Scope (V1.0)**

### for color sensor **SI-COLO2-MUX4**



This manual describes the installation of the PC software for the SI-COLO2-MUX4 color sensor. As a support for commissioning of the color sensor this manual explains the functional elements of the Windows® user interface.

The SI-COLO2-MUX4 color sensor operates according to the transmitted-light principle. As a light source the 4 color sensor frontend use each a white-light LED with adjustable transmitting power. A 3-fold receiver (integrated in the control unit) for the RED, GREEN, and BLUE content of the light that is reflected from the measuring object serves as a receiver. This special sensor features 4 optical-fibre front-ends, each with a white-light LED. Only one receiver is used, however, which means that the 4 white-light LEDs in the front-ends must be switched in series in order to detect the corresponding color plus intensity for each of the 4 objects in the front-ends, the color detector is connected with the 4 color sensor frontends via the 4 fiber optics.

The SI-COLO2-MUX4 color sensor can be "taught" up to 4 colors. The system can be calibrated with an external calibration signal. The respective detected color either is output as binary code at the 4 digital outputs. Simultaneously the detected color code is visualised at the SI-COLO2-MUX4 housing by means of 4 LEDs.

Through the RS232 interface parameters and measured values can be exchanged between the PC and the SI-COLO2-MUX4 color sensor. All the parameters for color detection can be stored in the non-volatile EEPROM of the SI-COLO2-MUX4 color sensor. When parameterization is finished the color sensor continues to operate with the current parameters in "stand alone" mode without a PC.

## 1 Installation of the SI-COLO-MUX-Scope Software

Hardware requirements for successful installation of the SI-COLO-MUX-Scope software:

- IBM PC AT or compatible
- VGA graphics
- Microsoft® Windows® XP, Me, 2000, 98, NT® 4.0 oder 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-MUX-Scope software can only be installed under Windows. Windows must therefore be started first, if it is not yet running.

Please install the SI-COLO-MUX-Scope software as described below:

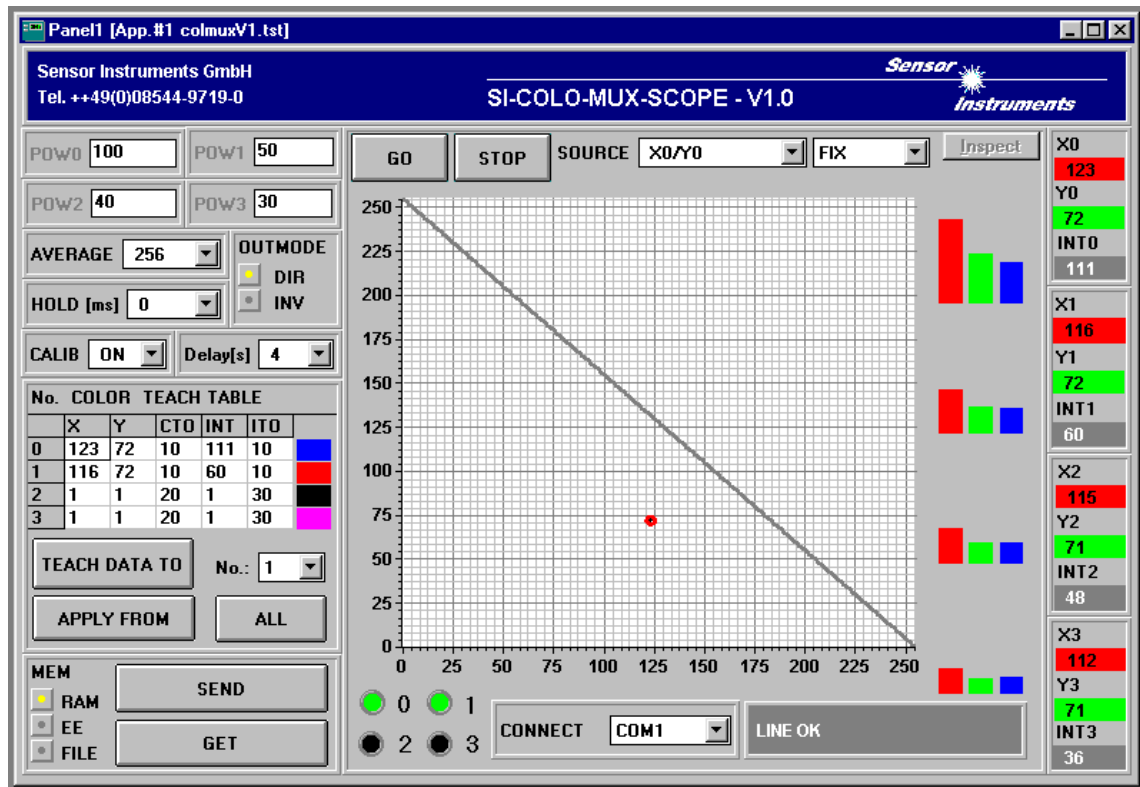
1. The software can be installed directly from the installation CD-ROM. To install the software, start the SETUP program in the INSTALL folder of the CD-ROM.
2. The installation program displays a dialog and suggests to install the SI-COLO-MUX-Scope software in the C:\ COLMUXV1" directory on the hard disk. You may accept this suggestion with **OK** or **[ENTER]**, or you may change the path as desired. Installation is then performed automatically, until the PC prompts you for the second and third floppy disk. When prompted, insert the second floppy disk DISK2 into the drive, and press **OK** or **[ENTER]**.
3. During the installation process a new program group for the SI-COLO-MUX-SCOPE software is created in the Windows Program Manager. In the SI-COLO-MUX-SCOPE 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 SI-COLO-MUX-SCOPE icon.

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MS-DOS® is a registered trademark of the Microsoft Corp.  
VGA™ is a trademark of the International Business Machines Corp.

## 2 Operation of the SI-COLO-MUX-Scope software

Please read this chapter first before you start to adjust and parameterise the SI-COLO2-MUX4 color sensor.

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



### Functions of the individual SI-COLO-MUX-Scope control elements:



#### POWER:

In these function fields the intensity of the respective transmitter LED can be adjusted by entering a value in the edit boxes.

A value of 255 means full intensity at the transmitter LED, a value of 0 stands for the lowest transmitter intensity adjustment!

The POW edit-boxes are only effective with CALIB = OFF.

If CALIB = ON, the sensor automatically adjusts its power values for the individual front-ends in such a way that the sensor is in the dynamic range (see CALIB edit-box).

**ATTENTION!** A change of the transmitter power only becomes effective at the SI-COLO2-MUX4 color sensor after actuation of the SEND button in the MEM function field!

CALIB  Delay[s]

CALIB:

OFF:

Automatic calibration is off, delay has no effect.

ON:

If this function is activated, the sensor calibrates itself to the object at the sensor front-end. This means that if CALIB=ON has been selected, and there is a positive edge at IN0, delay is started. When delay is over, the sensor attempts to regulate all the 4 front-ends in the dynamic range (neither RED, GREEN, BLUE at the top or bottom limit). For this purpose it searches a suitable POWER value for each transmitter unit. Using the set POWER value it then calculates its X-, Y-, and INT-values and transfers these to the COLOR-TEACH-TABLE.

The sensor then returns to normal measuring mode and detects any change deviating from the calibrated values.

Please note:

With the GET button the calibrated POWER values and the taught X-, Y-, and INT-values can be displayed on the user interface.

**ATTENTION!**

**With CALIB=ON, the POWER values can NOT be changed on the user interface!**

AVERAGE

AVERAGE:

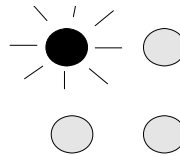
This function field is used for adjusting the number of scanning values (measurement values) over which the raw signal measured at the receiver is averaged. A higher AVERAGE default value reduces noise of the raw signals at the receiver unit and there will be a decrease of the maximal available switching frequency of the SI-COLO2-MUX4 color sensor.



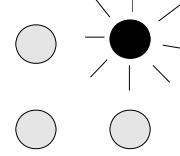
**OUTMODE:**

Determines the polarity change of the digital outputs upon color detection.

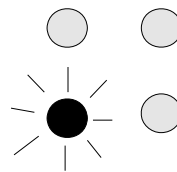
Color 0 is detected:



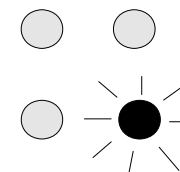
Color 1 is detected:



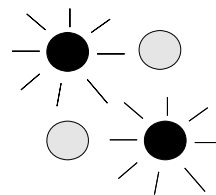
Color 2 is detected:



Color 3 is detected:



Color 0 and color 3 are detected:



**DIR:**

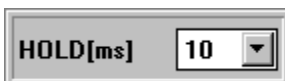
If DIR is activated, the specially digital output is set to HI, while the other 3 are set to LO.

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).

**INV:**

If INV is activated, the specially digital output is set to LO, while the other 3 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).



The SI-COLO2-MUX4 color sensor operates with minimum scanning times in the magnitude of 100µs. This is why most of the PLCs that are connected to the digital outputs OUT0 - OUT3 have difficulties with the safe detection of the resulting short switching state changes. For the digital outputs of the SI-COLO2-MUX4 color sensor pulse lengthening of up to 100 ms can be set by selecting the corresponding HOLD value.

**ATTENTION!**

**With high transport speed and low HOLD value, AVERAGE should be set to values below 64 (experience figures).**

No. COLOR TEACH TABLE						
	X	Y	CTO	INT	ITO	
0	69	61	10	122	10	
1	100	100	150	210	30	
2	100	100	150	115	65	
3	100	100	150	25	25	

TEACH DATA TO	No.: <input type="text" value="0"/>
APPLY FROM	ALL

**COLOR TEACH TABLE:**

The color teach table shows the currently set parameters.

After a left mouse button click 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-COLO2-MUX4 color sensor is able to check up to 4 teach-in colors. The number of the respective teach-in color is given in the left column of the table.

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

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

$$Y = \frac{G}{R + G + B}$$
- 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.  
**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.:

No.: Selection of the current number of the teach-in color (0 ... 3) from the color table.

TEACH DATA TO

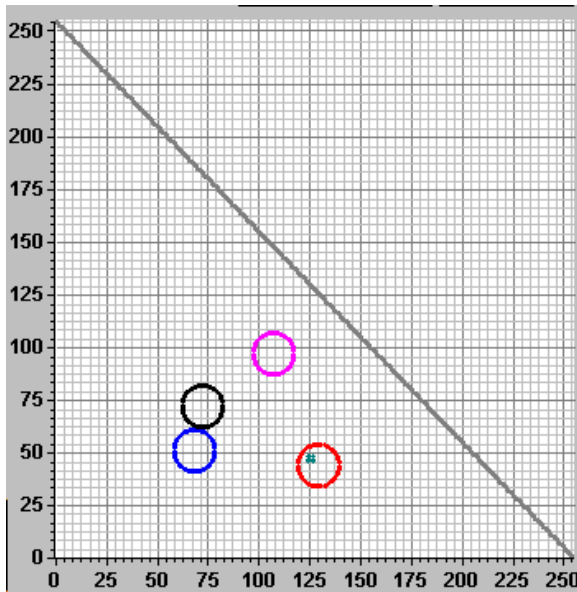
**TEACH DATA TO:**

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

APPLY FROM

**APPLY FROM:**

After a click on this button the currently selected **teach-in color** (cf. No.: function field) is displayed in the color triangle in accordance with its teach-in values with the corresponding "tolerance circle".



**ALL**

**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 on the left shows 4 color tolerance circles with the teach-in values (X,Y) and CTO (tolerance radius) preset in the color table.

<b>MEM</b>	<b>SEND</b>
<input type="checkbox"/> RAM	<b>GET</b>
<input type="checkbox"/> EE	
<input type="checkbox"/> FILE	

**MEM:**  
This group of buttons controls parameter exchange between PC and SI-COLO2-MUX4 color sensor through the serial RS232 interface.

**SEND**

**SEND:**  
When the SEND button is clicked, all the currently set parameters are transferred between PC and SI-COLO2-MUX4 color sensor. The target of the respective parameter transfer is determined by the selected button (RAM, EE, or FILE).

**GET**

**GET:**  
The currently set values can be interrogated from the SI-COLO2-MUX4 color sensor by clicking on the GET button. The source of data exchange is determined by the selected button (RAM, EE, or FILE).

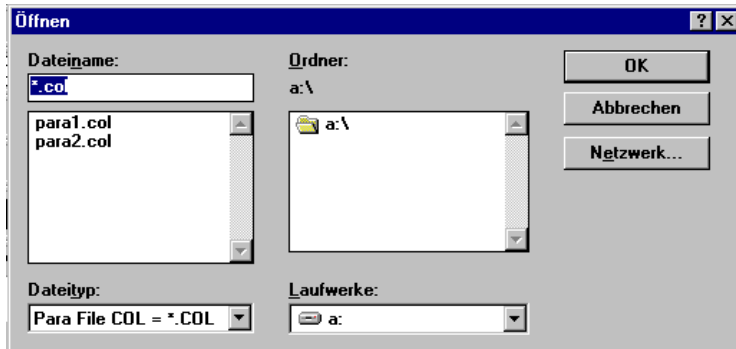
**RAM:** The current parameters are written into the RAM memory of the SI-COLO2-MUX4 color sensor, or they are read from the RAM, **i.e. these parameters are lost when the voltage at the SI-COLO2-MUX4 color sensor is switched off.**

**EE:** The current parameters are written into the non-volatile memory of the EEPROM in the SI-COLO2-MUX4 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-COLO2-MUX4 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.



**GO:**

A click on this button starts data transfer from the SI-COLO2-MUX4 color sensor to the PC through the serial RS232 interface.

If *X0/Y0* is selected under *SOURCE*, the *X0,Y0* coordinates of the current color are displayed in the graph.

If *INT0* is selected under *SOURCE*, the intensity of the current color is visualised in the graph.



**STOP:**

A click on this button stops data transfer from the SI-COLO2-MUX4 color sensor to the PC through the serial RS232 interface.



X0	123
Y0	72
INT0	111
X1	116
Y1	72
INT1	60
X2	115
Y2	71
INT2	48
X3	112
Y3	71
INT3	36

For each of the 4 front-ends, an own X and Y as well as a corresponding intensity INT are calculated. After a click on the GO button, these calculated values are shown in the display elements shown here. In addition, the intensities of the individual RED, GREEN, and BLUE contents are visualised by bar displays.

**X0, X1, X2, X3:**

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

Formula for calculation:

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

**Y0, Y1, Y2, Y3:**

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

Formula for calculation:

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

**INT0, INT1, INT2, INT3:**

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

Formula for calculation:

$$INT = \frac{R + G + B}{4} + \frac{R + G + B}{16}$$

For reasons of a higher program execution speed, division by 4 respectively 16 is performed on the microcontroller level.





On the graphic user interface, these LED indicators visualise the detected colors in green according to lines 0 to 3.

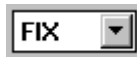
**PLEASE NOTE:** The above-mentioned 4 output fields are only updated when data transfer between PC and SI-COLO2-MUX4 color sensor is active (GO button pressed).



**SOURCE:**

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

- X0/Y0 : Display of the color triangle and of the currently determined color of frontend 0
- X1/Y1 : Display of the color triangle and of the currently determined color of frontend 1
- X2/Y2 : Display of the color triangle and of the currently determined color of frontend 2
- X3/Y3 : Display of the color triangle and of the currently determined color of frontend 3
- INT0 : The currently determined total intensity of frontend 0 is displayed.
- INT1 : The currently determined total intensity of frontend 1 is displayed.
- INT2 : The currently determined total intensity of frontend 2 is displayed.
- INT3 : The currently determined total intensity of frontend 3 is displayed.
- R0/G0/B0 : The current raw signals of the 3-fold receiver (red, green, blue) of frontend 0 are displayed.
- R1/G1/B1 : The current raw signals of the 3-fold receiver (red, green, blue) of frontend 1 are displayed.
- R2/G2/B2 : The current raw signals of the 3-fold receiver (red, green, blue) of frontend 2 are displayed.
- R3/G3/B3 : The current raw signals of the 3-fold receiver (red, green, blue) of frontend 3 are displayed.



**FIX:**

This setting has the effect that the y-axis of the graphic display window remains unchanged. The display shows a y-value range of 0 ... 255 A/D units. The value range results from the converter values of the 8-bit analog/digital converter in the electronic evaluation unit SI-COLO2-MUX4.



**AUTO:**

This setting has the effect that the y-axis of the graphic display window is automatically scaled (zoom function). Scaling of the y-axis is automatically adapted in accordance with the values to be displayed.



**Inspect Taste:**

This button fixes the current screen of the display window. A dialog box then opens and offers different possibilities for further processing of the display window under Windows. The individual function elements of the inspect button are excellently suited for documentation purposes.

**Print:** Prints the current display window.

**Copy Page:** Copies the display window to the Windows clipboard, from where it can be inserted and further processed in various Windows programs (documentation in the word processor, graphics software, spreadsheet, ...).

**Zoom:** For zooming in or zooming out of the display window.

The SI-COLO-MUX-Scope software starts with the standard configuration COM1 and the respective communication status.



The software provides the following status messages:

- TRY SER LINE : The PC tries to establish a connection with the SI-COLO2-MUX4 color sensor through the respective selected interface.
- LINE OK: The connection between PC and SI-COLO2-MUX4 color sensor could be established successfully.
- TIMEOUT: A connection between SI-COLO2-MUX4 color sensor and PC could not be established, or the connection is faulty.  
**In this case it should first be checked whether the SI-COLO2-MUX4 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, COM3, and COM4 by clicking on the [↓] selection field in the CONNECT group.
- NOT AVAIL: The selected interface is not available at the PC.
- FILE READ: Parameter fields would have been read from a file of parameters.

**ATTENTION!** The stable function of the RS232 interface (LINE OK status message after program start) is a basic prerequisite for measured value transfer from the PC to the SI-COLO2-MUX4 color sensor.

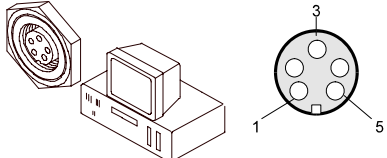


Due to the limited data transfer rate through the serial RS232 interface (9600 bit/s) only slow changes of the raw signals at the sensor front end can be observed in the graphic output window of the PC.

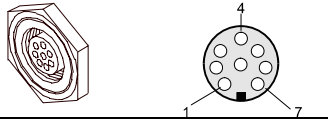
**ATTENTION !** For maintaining maximum switching frequency at the SI-COLO2-MUX4 color sensor data communication with the PC must be stopped (press the STOP button).

### 3 Connector assignment

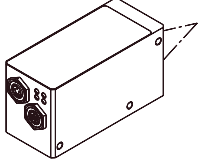
Connection of SI-COLO2-MUX4 to PC:

<b>5-pin female connector (type Binder 712)</b> <b>SI-COLO2-MUX4/PC-RS232</b>		
Pin No.:		Assignment:
1		GND (0V)
2		TX0
3		RX0
4		n.c.
5		n.c.

Connection of SI-COLO2-MUX4 to PLC:

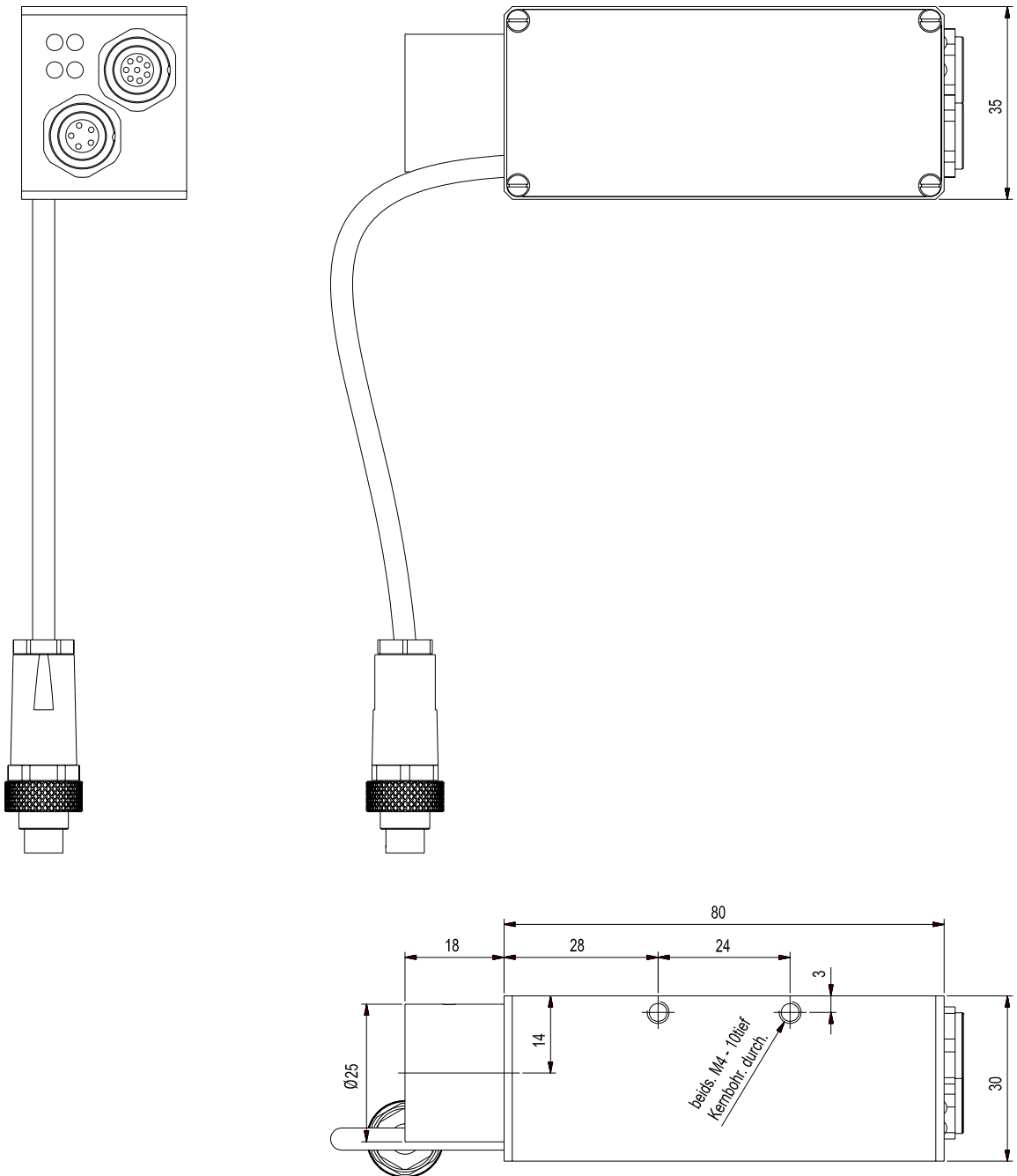
<b>8-pin female connector (type Binder 712)</b> <b>SI-COLO2-MUX4/PLC</b>		
Pin No.:	Color:	Assignment:
1	wht	GND (0V)
2	brn	+12VDC .. +30VDC
3	grn	IN0
4	yel	OUT0 (Digital 0: Type 0 ... 1V, Digital 1: Type +Ub - 10%)
5	gry	OUT1 (Digital 0: Type 0 ... 1V, Digital 1: Type +Ub - 10%)
6	pnk	OUT2 (Digital 0: Type 0 ... 1V, Digital 1: Type +Ub - 10%)
7	blu	OUT3 (Digital 0: Type 0 ... 1V, Digital 1: Type +Ub - 10%)
8	red	n.c.

## 4 Technical Data

<b>SI-COLO2-MUX4</b>		
Light sources	4 x white-light LED, modulated 100 kHz	
Reproducibility	In the x,y color range 1 digit each with 8 bit A/D conversion	
Receiver	3-color photodiode (red, green, blue)	
Pulsating light operation	100 kHz	
Ambient light	up to 5000 Lux	
Type of protection	IP 64	
Current consumption	typ. 180 mA	
Interface	RS232, parameterizable under Windows®	
Connector type	8-pin flanged female connector (PLC), type Binder series 712 5-pin flanged female connector (PC), type Binder series 712	
EMC testing	IEC – 801 ... CE	
Housing	Aluminium, anodized in blue	
Operating temperature range	-20°C to +55°C	
Storage temperature range	-20°C to +85°C	
Pulse lengthening	Adjustable under Windows® (0 ms ... 100 ms)	
Max. switching current	100 mA, short-circuit-proof	
Switching frequency	Max. 5 kHz	
Outputs	OUT0 – OUT3, short-circuit protected	
Averaging	Over 32768 values max.	
Voltage supply	+12VDC ... +30VDC, protected against polarity reversal, overload-protected	
Switching state display	Visualisation by means of a yellow LED for switching output, 2 red LEDs and 1 green LED for operating range indication	

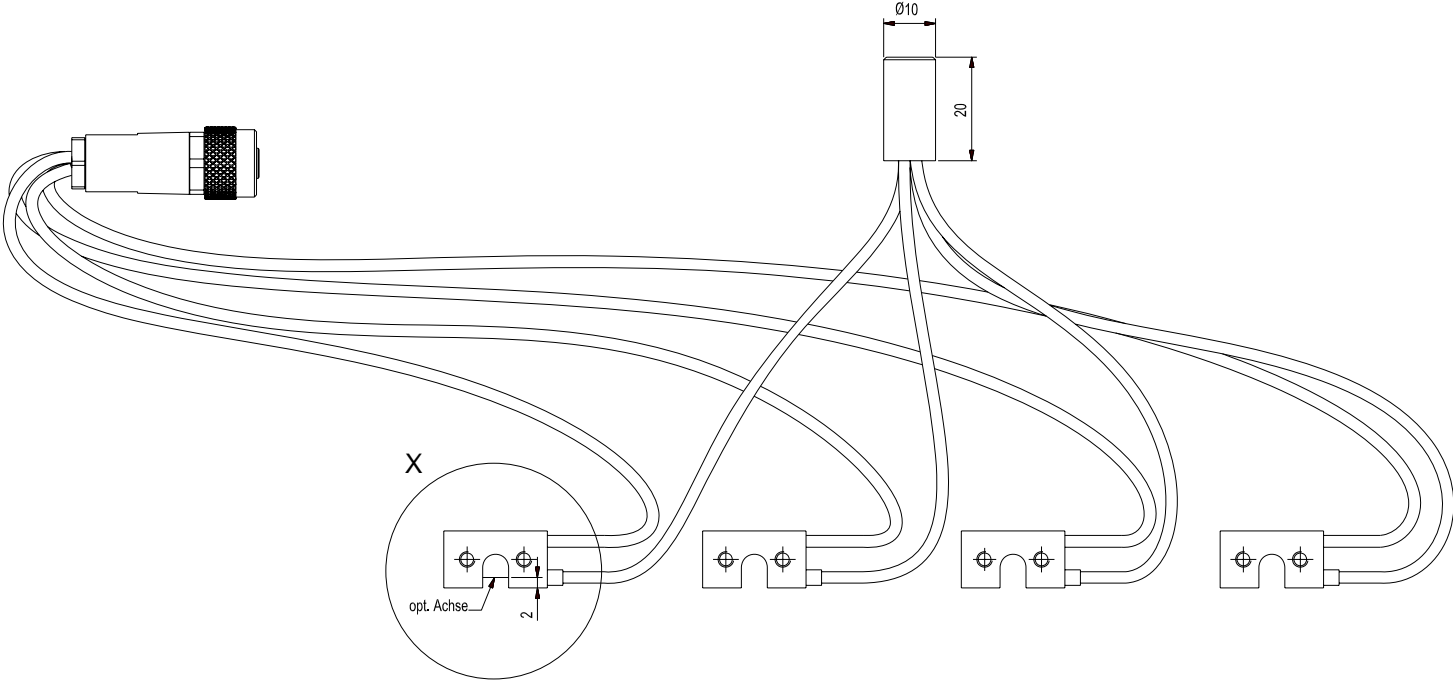
## 5 Dimensions

### 5.1 Dimensions of SI-COLO2-MUX4 color sensor

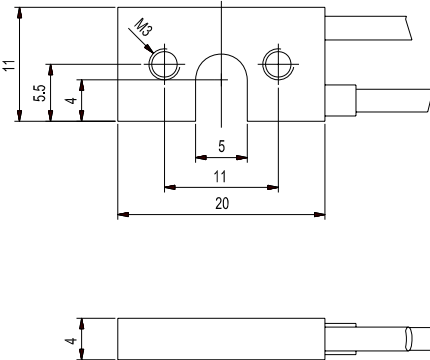


All dimensions in mm

**5.2 Dimensions of FE-MUX4 frontend**



**X (2:1)**



All dimensions in mm

## 6 RS232 communication protocol

RS232 communication protocol PC ↔ SI-COLO-MUX-Scope V1.0
<ul style="list-style-type: none"> <li>- Standard RS232 serial interface without hardware-handshake</li> <li>- 3-wire: GND, TX0, RX0</li> <li>- Speed: 9600 baud, 8 data-bits, no parity-bit, 1 stop-bit in binary mode</li> </ul> <p>The control device (PC or PLC) has to send a data frame of 31 bytes to the SI-COLO2-MUX4 hardware. All bytes must be transmitted in binary format. The meaning of the parameters is described in the software manual SI-COLO-MUX-Scope.</p> <p><u>Method:</u> The SI-COLO2-MUX4 hardware is permanently reading (polling) the incoming byte at the RS232 connection. If the incoming byte = 0x55 (synch-byte), then the 2.byte (order-byte) is read in, after this, 9 bytes (parameters) and then 4 teach vectors (4 x 5Bytes = 20Bytes) will be read. After reading in the completely data frame, the SI-COLO2-MUX4 hardware executes the order which is coded at the 2. byte (order-byte).</p>

Format of the data frame:		
Byte No.	Meaning:	Comment:
1	sync-byte = 0x55	hex-code 0x55, binary: 01010101, synchronisation byte
2	<b>ORDER NUMBER</b>	order byte
3	parameter POWER0	LED intensity FRONTEND0 (0 ... 255) Attention inverse operation!
4	parameter POWER1	LED intensity FRONTEND1 (0 ... 255) Attention inverse operation!
5	parameter POWER2	LED intensity FRONTEND2 (0 ... 255) Attention inverse operation!
6	parameter POWER3	LED intensity FRONTEND3 (0 ... 255) Attention inverse operation!
7	parameter AVERAGE	Signal averaging 1,2,4,8,16,32,64,128,256,512,1024,2048,4096,8192,16384 or 32768 coded to (0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15)
8	parameter HOLD[ms]	Hold time 0,1,2,3,5,10,50 or 100ms coded to (0,1,2,3,4,5,6,7)
9	parameter OUTMODE	Function of the digital output (0=direct, 1=inv)
10	parameter CALIB	Auto calibration (coded 0=on, 1=off)
11	parameter DELAY[s]	Delay time (after delay time the calibration starts) 1sec. to 16 sec. coded to 1,2,...,16
12 ... 31	4 teach vectors with each 5 bytes for every frontend	Teach-vector 5-byte-format: X, Y, CTO, INT, ITO ; value range of each parameter is from 1 to 255

Value	ORDER NUMBER	(parameter byte no. 2)
0	nop	no operation
1	save parameter from PC into RAM	volatile: 31 bytes PC⇒SI-COLO2-MUX4
2	save parameter from PC into RAM + EEPROM	nonvolatile: 31 bytes PC⇒SI-COLO2-MUX4
3	Send parameter from RAM to PC	29 bytes binary SI-COLO2-MUX4 ⇒ PC
4	Send parameter from EEPROM to RAM + to PC	29 bytes binary SI-COLO2-MUX4 ⇒ PC
5*	Send data from RAM to PC R0, G0, B0, R1, G1, B1, R2, G2, B2, R3, G3, B3, X0, Y0, I0, X1, Y1, I1, X2, Y2, I2, X3, Y3, I3, COL	25 bytes binary SI-COLO2-MUX4 ⇒ PC Red, green, blue, X, Y, intensity of each of the 4 frontends + COL (the 4 LSB of COL represent the 4 rows in the color teach table)
6	nop	no operation
7	Send line ok = 0xAA to PC	1 byte binary SI-COLO2-MUX4 ⇒ PC

\*) With order no. 5 **no parameters and teach vectors** will be transmitted from the SI-COLO2-MUX4 hardware to the PC or PLC:

Byte Frame transmitted by PC (PC ⇒ SI-COLO2-MUX4): [ 0x55, 5 ]

Byte Frame response of SI-COLO2-MUX4: (SI-COLO2-MUX4 ⇒ PC): [ see ORDER NUMBER 5 ]

**Example 1: DATA FRAME with ORDER NUMBER = 1:**

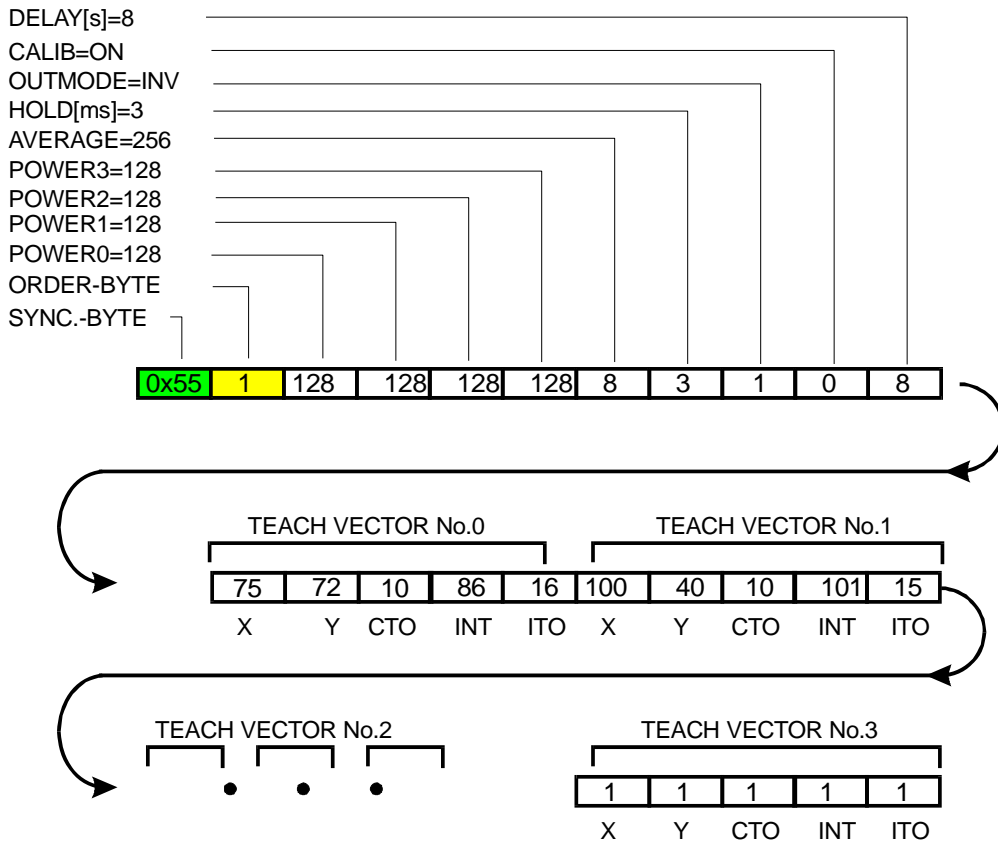
ORDER NUMBER (second byte = 1):

**WRITE parameters from PC into RAM of the SI-COLO2-MUX4!**

**The completely data frame = 31 bytes** must be sent to the SI-COLO2-MUX4 hardware in binary form:

( sync-byte / order-byte / 9 parameter bytes / 4 x 5 bytes teach-vectors ).

Fill unused bytes of the TEACH VECTOR by value byte=1 in binary form.

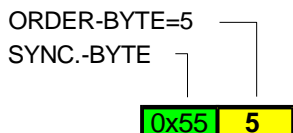




**Example 2: DATA FRAME with ORDER NUMBER = 5:**

ORDER NUMBER (second byte = 5): READ SI-COLO2-MUX4 RAM DATA

**DATA FRAME PC → SI-COLO2 (2 BYTES)**



**DATA FRAME SI-COLO2 → PC (25 BYTES)**

R0	G0	B0	R1	G1	B1
x	x	x	x	x	x
R2	G2	B2	R3	G3	B3
x	x	x	x	x	x
X0	Y0	I0	X1	Y1	I1
x	x	x	x	x	x
X2	Y2	I2	X3	Y3	I3
x	x	x	x	x	x
COL					
x					

**Please note:**

COL is coded like this:

COL = 1 byte, i.e. it consists of 8 bits (COL0, COL1, ..., COL7).  
Every bit means one line in the COLOR TEACH TABLE (4 colors → 4 LSB are used)

Every bit (COL0, ..., COL3) that is set, means color in this line is detected.

COL7	COL6	COL5	COL4	COL3	COL2	COL1	COL0
x	x	x	x	LINE3	LINE2	LINE1	LINE0