# Manual
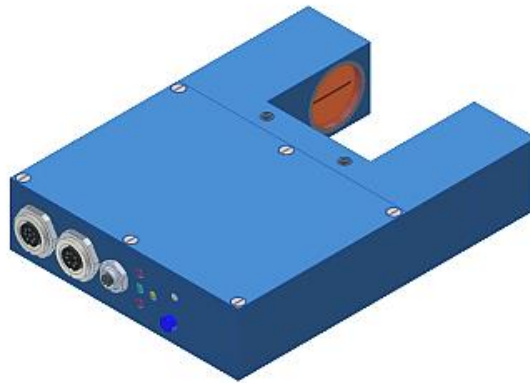
# L-LAS-TB-MS-Scope V3.04

(**PC software for Microsoft® Windows®** XP, VISTA, 7)

**for laser line sensors of the *L-LAS-TB-…-MS (Master-Slave) series***

e.g.

L-LAS-TB-50-MA/SL

L-LAS-TB-75-MA/SL

L-LAS-TB-100-MA/SL

L-LAS-TB-F-8x1-40/40-MA/SL

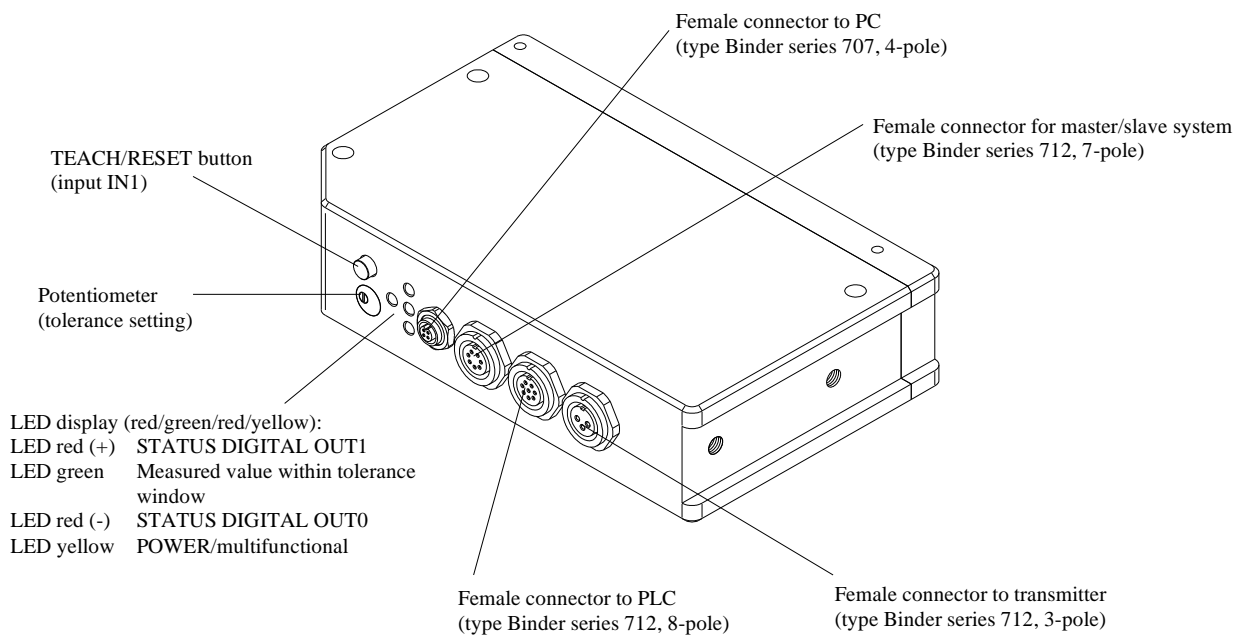L-LAS-TB-F-16x1-40/40-MA/SL

L-LAS-TB-8-CON1-MA/SL

# 0 Contents

# 1  Functional principle: *L-LAS-TB-...-MS Master-Slave* control system

## 1.1  Technical description

In the laser line sensors of the *L-LAS-TB-MS series* the laser beam of a laser diode ($\lambda$=670nm, 1mW power, laser class 2) through suitable collimators and apertures is emitted from the optical transmitter unit as a laser line, i.e. as parallel laser light with homogeneous light distribution. The laser line impinges on the opposite mounted receiver unit L-LAS-TB-...-SL (slave) in transmitted light mode (TB=Through-beam). This CCD line comprises many closely adjacent individual receiver elements (pixels) that are arranged in a line. The light quantity of each of these receiver elements that is collected during the integration time can be separately read out as an analog voltage and, after performing analog-digital conversion, can be stored in a data field as a digital value.

When there is a measuring object in the laser line, the parallel laser light only illuminates those receiver elements (pixels) of the line that lie outside the shadow zone of the measuring object. The illuminated pixels, compared to the unilluminated pixels, emit a much higher analog voltage. By way of suitable software algorithms the areas of the shadow zones can be determined from the previously stored data field. Since the distance of the pixels on the CCD line is known, the size and position of the measuring object can therefore be determined.

The micro-controller of the *L-LAS-TB-...-MS (Master) sensor* can be parameterized through the serial RS232 interface by means of a Windows PC software. The sensor can be set to operate with different evaluation modes. The housing of the control unit features a TEACH/RESET button and a potentiometer for tolerance setting. Switching states are visualized by means of 4 LEDs (1x green, 1x yellow, and 2x red) that are integrated in the housing of the L-LAS-TB-…-MS sensor. The *L-LAS-TB-...-MA control unit* has three digital outputs (OUT0, OUT1, OUT2), the output polarity of which can be set with the software. Two digital inputs (IN0, IN1) make it possible to realize an external TEACH/RESET functionality and an external TRIGGER functionality through a PLC. In addition the control unit features a high-speed analog output (0 ... +10V) with 12-bit digital/analog resolution.

Female connector to PC
(type Binder series 707, 4-pole)

Female connector for master/slave system
(type Binder series 712, 7-pole)

TEACH/RESET button
(input IN1)

Potentiometer
(tolerance setting)

LED display (red/green/red/yellow):
LED red (+)    STATUS DIGITAL OUT1
LED green      Measured value within tolerance window
LED red (-)    STATUS DIGITAL OUT0
LED yellow     POWER/multifunctional

Female connector to PLC
(type Binder series 712, 8-pole)

Female connector to transmitter
(type Binder series 712, 3-pole)

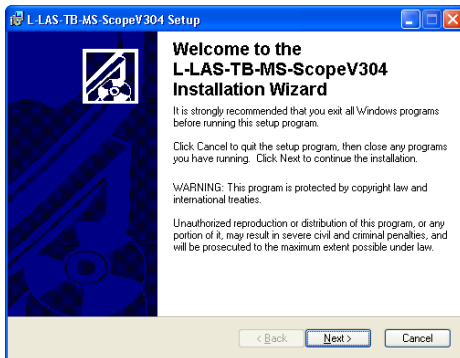# 2 Installation of the *L-LAS-TB-MS-Scope* software

Hardware requirements for successful installation of the *L-LAS-TB-MS-Scope* software:

- 500 MHz Pentium-compatible processor or better.
- CD-ROM or DVD-ROM drive
- Approx. 10 MByte of free hard disk space
- SVGA graphics card with at least 800x600 pixel resolution and 256 colors or better.
- Windows 98, Windows NT4.0, Windows 2000, Windows XP or Windows Vista operating system
- Free serial RS232 interface or USB port with USB-RS232 adaptor at the PC

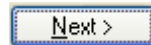Please install the *L-LAS-TB-MS-Scope* software as described below:

1. Insert the installation CD-ROM in your CD-ROM drive. In our example we suppose that this is drive "D".

2. Start the Windows Explorer and in the folder tree of your CD-ROM drive go to the installation folder D:\Install\ .
Then start the installation program by double-clicking on the SETUP.EXE symbol.

As an alternative, software installation can also be started by clicking on **START-Run...** and then entering "D:\Install\setup.exe", which must be confirmed by pressing the **OK** button.

The installation program then displays a dialog box for *L-LAS-TB-MS-Scope* installation.
This dialog box shows some general information about installation.

Click on Next> to start the installation

or on Cancel to quit the installation of the L-*LAS-TB-MS-Scope* software
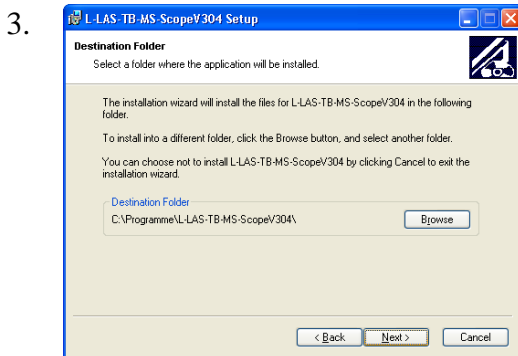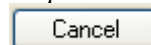
3. When you click on the Next> button, a new dialog appears for selecting the folder where the application will be installed (destination folder).

You may accept the suggested folder with Next>, or you may change the installation folder as desired by clicking on the Browse button

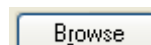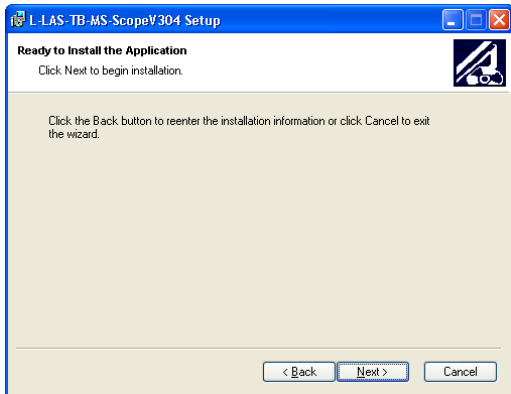| | |
|---|---|
| 4. | Another *L-LAS-TB-MS-Scope* Setup dialog will be displayed. |
| | << Back |
| | Click on the Back button if you want to change the installation folder again. |
| | Next >> |
| | Click on Next>> to start the installation, or |
| | Cancel |
| | click on Cancel to quit the installation process. |
| | When installation is completed, a dialog box informs you about successful installation. |
| | A new *L-LAS-TB-MS-Scope* program group has been created under Start-All-Programs. |
| | Finish |
| | Click on the Finish button to finish the installation |
| 5. | |
| | The *L-LAS-TB-MS-Scope* software can now be started by clicking on the respective icon in the newly created program group under: Start >Alle Programme > L-LAS-TB-MS-ScopeV3.0x |
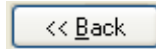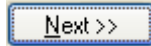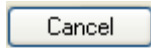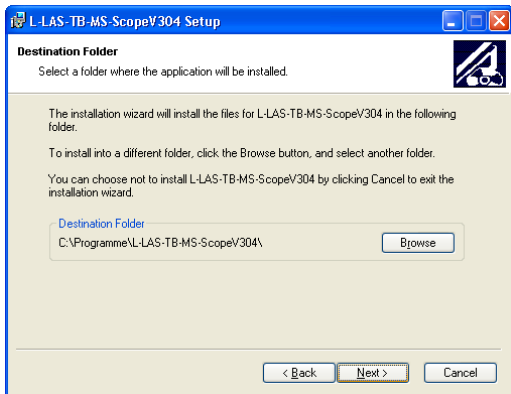
Deinstallation of the L-LAS-TB-MS-Scope software:

| | |
|---|---|
| Software | Please use the Windows deinstallation tool to remove the software. The Windows deinstallation tool can be found under Start / Settings / Control Panel. |

# 3 Operation of the *L-LAS-TB-Scope* software

The *L-LAS-TB-MS-Scope* software is used for parameterizing the electronic control unit used for controlling the *L-LAS-TB-...-MA (MASTER)* sensor. The measured values supplied by master and slave can be visualized with the PC software, which means that the software among others can be used for adjustment purposes and for setting suitable tolerance limits for the inspection of the measuring object.

Data exchange between the PC user interface and the sensor system is effected through a standard RS232 interface. For this purpose the sensor is connected to the PC with the serial interface cable cab-las-4/PC. When parameterization is finished, the setting values can be permanently saved in an EEPROM memory of the *L-LAS-TB-...-MA control unit*. The sensor system then continues to operate in "STAND-ALONE" mode without the PC.

When the *L-LAS-TB-MS-Scope* software is started, the following Windows® user interface will be displayed:



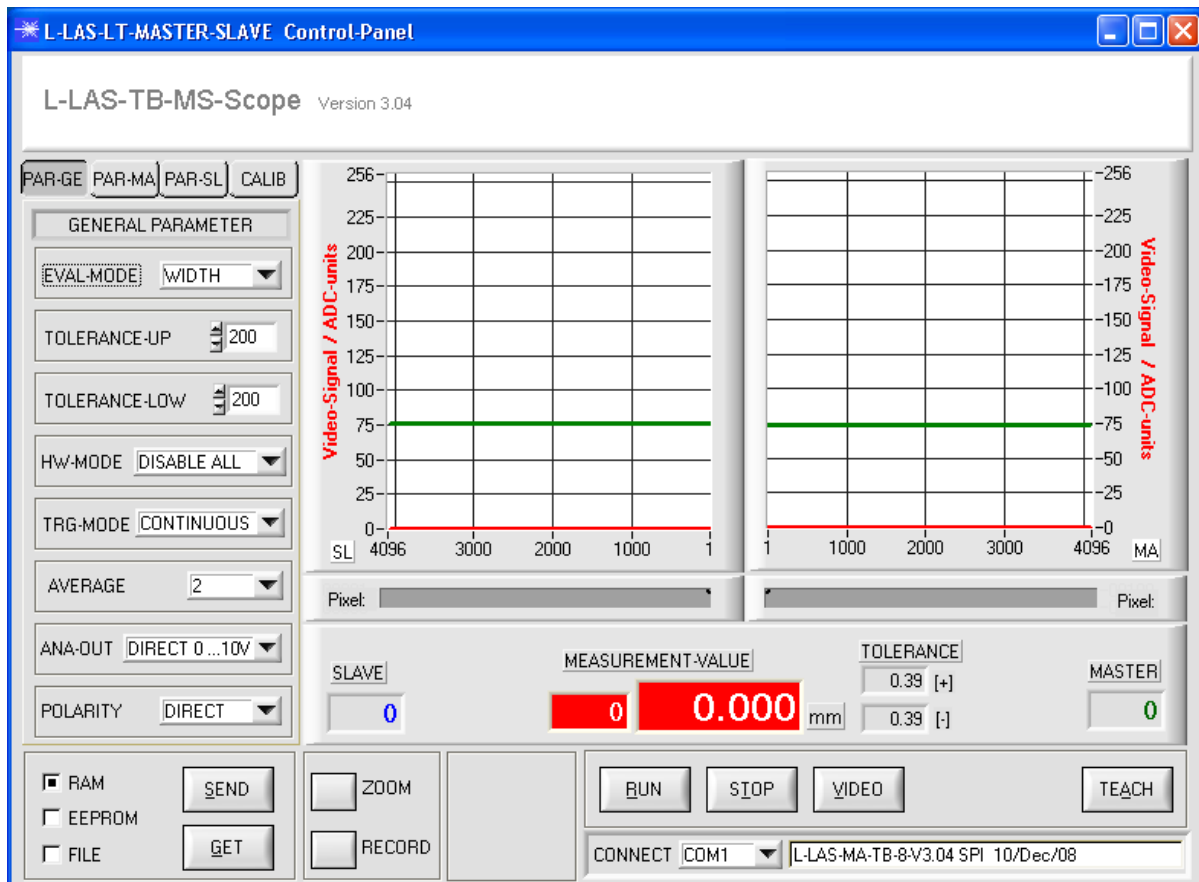The *L-LAS-TB-MS-Scope* CONTROL PANEL provides a great variety of functions:
- Visualization of measurement data of master and slave in numeric and graphic output fields.
- Setting of the laser power for the respective laser transmitter.
- Setting of the polarity of the digital switching outputs OUT0, OUT1, and OUT2.
- Selection of a suitable evaluation mode.
- Presetting of setpoint value and tolerance band.
- Saving of parameters to the RAM, EEPROM memory of the control unit, or to a configuration file on the hard disk of the PC.

**The following chapters provide explanations of the individual control elements of the *L-LAS-TB-MS-Scope* software.**

## 3.1 Control elements of the *L-LAS-TB-MS-Scope* software:

GENERAL PARAMETER

EVAL-MODE [ WIDTH ▼ ]

TOLERANCE-UP ↕ 400

TOLERANCE-LOW ↕ 400

HW-MODE [ ENABLE BTN ▼ ]

TRG-MODE [ CONTINOUS ▼ ]

AVERAGE [ 2 ▼ ]

ANA-OUT [ DIRECT 0 ...10V ▼ ]

POLARITY [ DIRECT ▼ ]

[ PAR-GE | PAR-MA | PAR-SL | CALIB ]
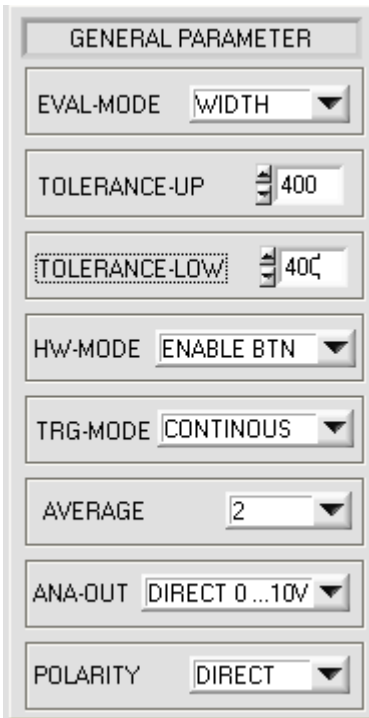
A click on the PARA-GE button opens the GENERAL PARAMETER window, where various general parameters at the L-LAS-TB-…-MA master control unit can be set.
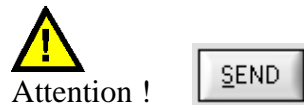
⚠ Attention !    [ SEND ]

**Changes that are made in the function fields described below only become active at the control unit of the *L-LAS-TB-…-MA* master control unit after a click on the SEND button!!**

EVAL-MODE [ WIDTH ▼ ]

SLAVE
MASTER
✓ WIDTH
CENTER
DIFF
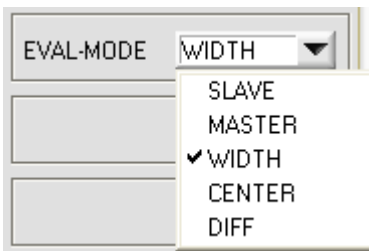
### EVAL-MODE:

This list selection field serves for setting the evaluation mode at the *L-LAS-TB-…-MA sensor*. Depending on the evaluation mode that is currently set, the edges created from the video signal (intensity profile) of the master and slave will be assessed differently.

SLAVE:
Only the light/dark edge transition detected by the SLAVE sensor is used as the measured value. The intersection point between the video threshold (green horizontal line) and the intensity profile (red curve) on the SLAVE sensor is calculated; this pixel value determines the measured value.

MASTER:
Only the light/dark edge transition detected by the MASTER sensor is used as the measured value. The intersection point between the video threshold (green horizontal line) and the intensity profile (red curve) on the SLAVE sensor is calculated; this pixel value determines the measured value.

WIDTH:
The measured value is the sum of the SLAVE measured value and the MASTER measured value from the respective light/dark transitions:

WIDTH = MASTER + SLAVE

## EVAL-MODE:

**CENTER:**
The difference between the light/dark transitions from MASTER and SLAVE is used as the measured value. A fixed offset (offset=SUBPIXEL, e.g. 2048) is added to the difference:
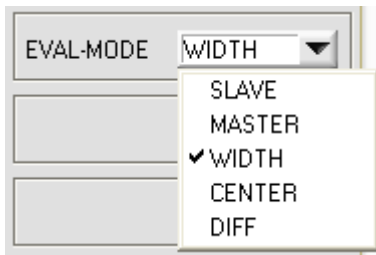
CENTER = SUBPIXEL + (MASTER – SLAVE)

**DIFF:**
The measured value results from the deviations between the teach-in and the current measured value on both the MASTER and the SLAVE. The measured value is provided with a fixed offset (number of SUBPIXELS):

DIFF = SUBPIXEL + [ (MASTER-Teach_MA) – (SLAVE-Teach_SL) ]
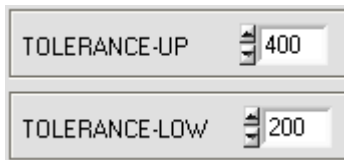
## TOLERANCE –UP, TOLERANCE-LOW:

In these two numerical input fields, tolerance default values in pixels for the upper (UP) and lower (LOW) tolerance limits can be set by entering numerical values or by clicking the arrow buttons with the mouse.
The two tolerance limits form a tolerance band around the nominal value (TEACH-VALUE). The tolerances currently set on the sensor are displayed in two numeric display fields in the unit [mm] below the graphic display window.
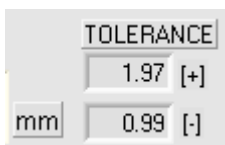
E.g. together with the SLOPE value (sensitivity) of the master sensor this results in

$$TOL[+] \, [mm] = SLOPE * TOLERANCE \_ HIGH$$
*Here: TOL [mm] = 4.93[µm/Pixel] * 400 Pixel =1.97 mm*

$$TOL[-] \, [mm] = SLOPE * TOLERANCE \_ LOW$$
*Here: TOL [mm] = 4.93[µm/Pixel] * 200 Pixel =0.99 mm*
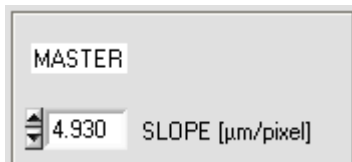
## TRIGGER-MODE:
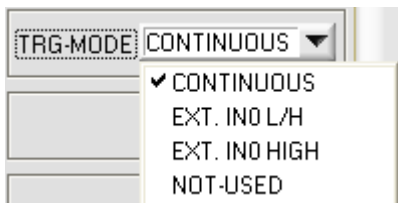
**CONTINUOUS:**
Continuous evaluation of the current measured values.

**EXT. IN0 L/H:**
External edge-controlled (LOW/HIGH) triggering of the measured value evaluation via the digital input IN0/Pin3/green at the 8-pin PLC connection socket of the MASTER sensor.

**EXT. IN0 HIGH:**
External triggering of the measured value evaluation via a high level (+Ub) at digital input IN0/Pin3/green of the MASTER sensor.
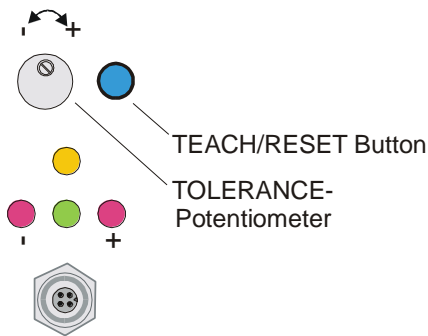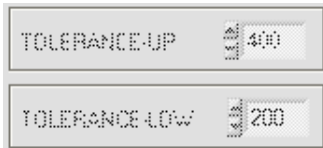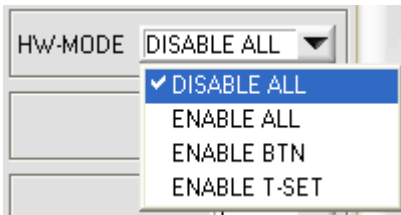
## HARDWARE (hardware mode):

The TOLERANCE potentiometer and/or the TEACH/RESET button at the housing of the L-LAS-TB-…-MS master sensor can be activated (ENABLE) or deactivated (DISABLE) by clicking on the respective item in the list selection field.

The TOLERANCE potentiometer allows the presetting of a tolerance window around the setpoint value. If the function field is set to ENABLE ALL or ENABLE T-SET, it is not possible to enter numerical values in the TOLERANCE-UP/LOW input field of the PC software. The respective function fields will be grayed.

DISABLE ALL
Both the TEACH/RESET button and the TOLERANCE potentiometer at the housing are deactivated.

ENABLE ALL:
The TOLERANCE potentiometer at the housing is activated (clockwise turning increases the tolerance bandwidth).
The TEACH/RESET button at the housing is activated.
Button pressed for a short time (t < 0.7s) : RESET function.
Button pressed for a long time (t > 1.5s) : TEACH function.

ENABLE BTN:
Only the TEACH/RESET button at the housing is activated.

ENABLE T-SET:
Only the TOLERANCE potentiometer at the housing is activated

TEACH/RESET Button

TOLERANCE-Potentiometer
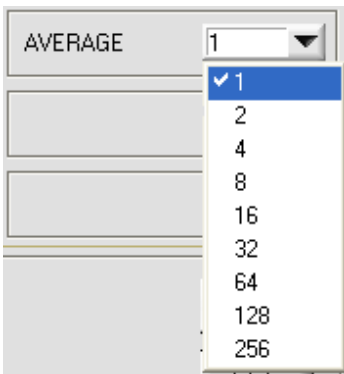
## AVERAGE:

In this function field the averaging at the L-LAS-TB-…-MA master sensor can be selected with a mouse-click on the respective list item. With every cycle of the main program the current measurement value is stored in a ring memory field, and then the average of these values in the ring memory field is calculated.

The average of the ring memory field is used as the MEASUREMENT_VALUE. With the AVERAGE value the size of the ring memory can be set from 1 to 256.
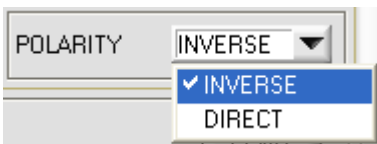
## POLARITY:

In this function field the output polarity at the L-LAS-TB-…-MA master sensor can be set with a mouse-click. The L-LAS-TB-…-MA master sensor has 3 digital outputs (OUT0, OUT1, OUT2) through which error states can be sent to the PLC.

DIRECT:
In case of an error, the respective digital output is set to +Ub (+24VDC ± 10%, red LED on).

INVERSE:
In case of an error, the respective digital output is set to the reference potential (GND/0V, red LED on).
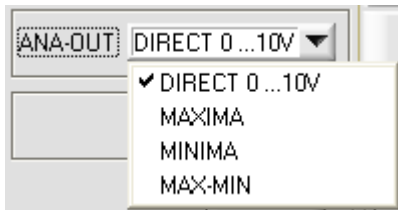
## ANALOG-OUT (Analog-Output-Mode):

Function element for selecting the output mode of the analog voltage at the L-LAS-…-MA sensor (pin8/red 8-pole PLC/POWER female connector). The analog voltage is output in the range from 0 to 10V with a resolution of 12 bit.

DIRECT 0...10V:
A voltage (0 ... 10V) that is proportional to the current measurement value is provided at the analog output pin8/red.

MAXIMA:
The current maximum value is provided at the analog output pin8/red/ (drag pointer principle, resetting by input IN1/pin4/yellow pulse of <750ms length, or by pressing the TEACH/RESET button).
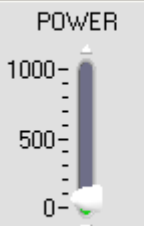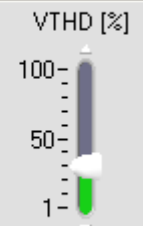
MINIMA:
The current minimum value is provided at the analog output pin8/red/ (drag pointer principle, resetting by input IN1/pin4/yellow pulse of <750ms length, or by pressing the TEACH/RESET button).

MAX-MIN:
The current difference between maximum and minimum value is provided at the analog output pin8/red/ (drag pointer principle, resetting by input IN1/pin4/yellow pulse of <750ms length, or by pressing the TEACH/RESET button)

A click on the PARA-MA button opens the MASTER PARAMETER window, where additional parameters at the master sensor control unit can be set.
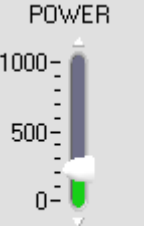
⚠️ **Attention !**

**SEND**

**Changes that are made in the function fields described below only become active at the control unit of the L-LAS-TB-…-MA sensor after a click on the SEND button!**
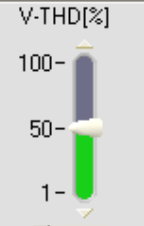


## POWER:
**(only relevant with POWER-MODE = STATIC, this is the standard operating mode for the transmitted light sensors of the L-LAS-TB series)**
In this function field the laser power at the laser transmitter unit of the L-LAS-TB-…-MA master sensor can be set by using the arrows or the slider, or by entering a numerical value in the respective input field.
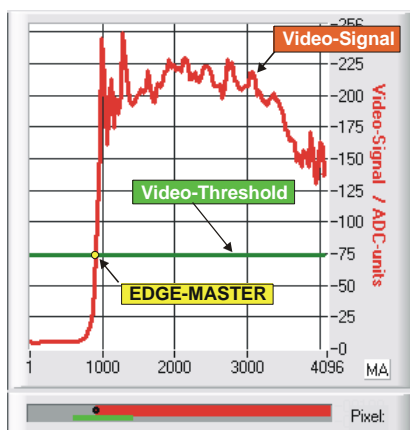


## VTHD[%]:
In this function field the video threshold at the L-LAS-TB-…-MA master sensor can be set by entering a numerical value or by using the slider or the arrows. With the help of this video threshold the measurement values can be derived from the intensity characteristic (video signal) of the CCD line from the bright/dark transitions.

For this purpose the intersection points between the intensity profile (red curve) and the adjustable video threshold (green horizontal line) are calculated and stored.

The x-value of the respective intersection point is assigned to a pixel on the CCD line. The measurement value can be calculated from this information and from the known distances of the pixels on the CCD line. The intersection points between intensity profile and video threshold that are provided by this method are hereinafter referred to as edges.
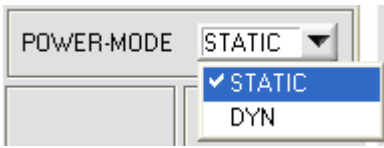
**POWER-MODE:**
This function icon is used to set the laser operating mode on the L-LAS-TB-...-MA sensor.

STATIC:
The laser power on the sensor is not automatically controlled.
The value set on the POWER slider is used as the setting value for the laser power

DYNAMIC**:**
If the operating mode is set to dynamic, the laser power at the L-LAS-TB-...-MA master sensor is controlled automatically. Here the laser power is adjusted so that the maximum value of the "video intensity profile" is approx. 80-90% of the analog dynamic range.

**CCD-MODE:**
This function icon is used to set the operating mode on the L-LAS-TB-...-MA master Sensor.
Depending on the CCD line receiver used, the amplification level (HIGH-GAIN, LOW-GAIN) or the readout mode (ADC-CONV, DIG-CMP) can be set here.

HIGH-GAIN/LOW-GAIN:
Binary switch, which can be used to set the gain on the CCD line.
Note: This function is not available for all L-LAS-TB-...-MA sensor types
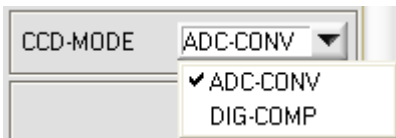
ADC-CONV/DIG-COMP**:**
Setting the readout mode, ADC-CONV:= the CCD line is converted via the analog-digital converter (ADC) of the L-LAS-TB-...-MA sensor.
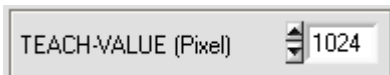




**TEACH-VALUE (Pixel):**
In this function field a teach value can be preset on the L-LAS-TB-...-MA sensor by entering a numerical value or using the arrow keys.

Please note:
A change of the teach value is only updated after clicking the SEND button on the control electronics.
The TEACH-VALUE is given in pixels. The conversion into µm can be done in the same way as for the tolerance via the SLOPE-VALUE (sensitivity - µm/pixel).

e.g. for the *L-LAS-TB-...-MA-80:*
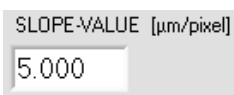


$TEACH\_VALUE\ [mm] = SLOPE * TEACH\ [Pixel]$
*TEACH_VALUE [mm] = 5.000[um/Pixel] * 1024[Pixel] = 5.120 mm*

E-BEG 1     E-END 2048

**E-BEG, E-END:**
These two numeric input fields are used to specify the start and end of the evaluation on the L-LAS-TB-...-MA sensor.

E-BEG:
The CCD line is evaluated from the pixel entered here. The analog information of the pixels to the left of E-BEG is not used for evaluation.

E-END:
The intensity information of the CCD line is evaluated up to this pixel. Pixels which are located to the right of the pixel value entered here are not evaluated.

**SLAVE PARAMETER**

POWER     VTHD [%]

1000-     100-

500-      50-

0-        1-

200       30

POWER-MODE  STATIC

CCD-MODE    ADC-CONV

TEACH VALUE     1024

TRIGGER THRESHOLD  200

E-BEG 1     E-END 2048

PAR-GE PAR-MA PAR-SL CALIB

After clicking the PARA-SL button, the SLAVE PARAMETER window opens on the user interface. Here you can make further parameter settings on the control electronics of the SLAVE sensor.

⚠ Attention !

SEND

**Only after clicking the SEND button, changes made in the function fields described in the following will become active on the control electronics of the L-LAS-TB-...-MA sensor!**

**As the functions of the individual control elements in the SLAVE PARAMETER window are identical to those of the MASTER Parameter window, they are not explained in detail (see pages above).**

**CCD-CALIBRATION**

512-pixel; 12.5µm pixel-pitch
2048-subpixel
resolution  = +/-5µm
working-range = 55mm +/-5.0mm

**SETPOINT-VALUE**

55000    [ µm ]

**MASTER**

4.930    SLOPE [µm/pixel]

**SLAVE**

4.920    SLOPE [µm/pixel]

---

PAR-GE | PAR-MA | PAR-SL | CALIB

After clicking the CALIB button the CCD-CALIBRATION window opens on the user interface.

⚠ Attention !

SEND

**Only after clicking the SEND button will changes made in the following function fields become active in the control electronics of the L-LAS-TB-...-MS Master/Slave system!**

---

1024-pixel; 7.8µm pixel-pitch
4096-subpixel
resolution   = +/- 2µm
working-range = 8mm

### CCD-INFO:

After clicking on the CONNECT function field, information about the currently detected sensor hardware is automatically exchanged via the serial RS232 interface. This hardware information is displayed in the CCD-INFO text field.

---

**SETPOINT-VALUE**

50000    [ µm ]

### SETPOINT-VALUE:

Numerical input field for setting an offset value. The offset value set here is added to the measured value obtained from the evaluation of the CCD line information.

---

**MASTER**

4.930    SLOPE [µm/pixel]

### SLOPE-VALUE [µm/pixel]:

Numerical input field for setting the sensitivity of the L-LAS-TB-...-MA sensor. The numerical value set here determines how many micrometers of displacement correspond to each pixel change.

These sensitivity values result from the respective type of CCD receiver and should not be changed.

**SLAVE**

4.920    SLOPE [µm/pixel]

---
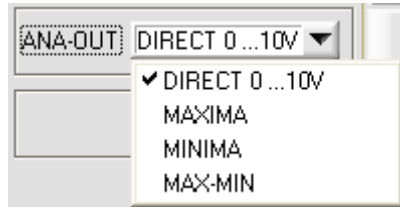
## RESET button:

The RESET button can be used to reset the current slave pointer values of the maximum value or minimum value determination.

The current maximum value MAX and the current minimum value MIN since the last RESET is displayed in a numeric output field. The numerical values shown here are pixel values. The current measured value in pixels is displayed in the output field marked M-VALUE. The adjacent numeric display elements are only displayed in the analog output mode ANA-OUT:
MAX, MIN or MAX-MIN
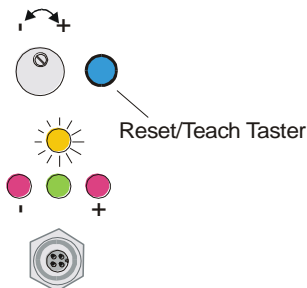
## TEACH button:

By clicking the TEACH button, the learning process is triggered on the L-LAS-TB-...-MA/SL sensor. The current pixel measurement values are displayed on the L-LAS-TB-...-MA/SL Master/Slave sensor system evaluated. Depending on the evaluation mode, the calculated value is written to the volatile RAM memory of the control electronics as a teach-in.

After the teach process has been carried out, the yellow LED on the housing of the L-LAS-TB-...-MA sensor flashes briefly 3 times.

The teach process can also be triggered by means of the TEACH/RESET button on the housing (press t >1.5s) or by a HIGH pulse at digital input IN1/yellow/Pin4 of at least 1.5s duration.
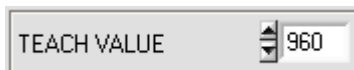
Alternatively, the current teach-in in pixels (setpoint) can also be set by entering numerical values in the numerical input fields. The teach-in set in this way is only activated after clicking the SEND button on the L-LAS-TB...-MA/SL sensor.

Translated with www.DeepL.com/Translator (free version)
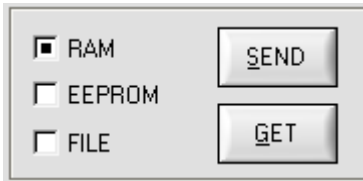
## PARAMETER TRANSFER:

This group of function buttons is used for transferring parameters between the PC and the *L-LAS-TB-…-MA control unit* through the serial RS232 interface.

SEND:
When the SEND button is clicked, the parameters currently set on the user interface are transferred to the *L-LAS-TB-…-MA control unit*.
The target of data transfer is determined by the selected radio-button (RAM, EEPROM, or FILE).

GET:
When the GET button is clicked, the setting parameters are transferred from the *L-LAS-TB-…-MA control unit* to the PC and are updated on the user interface. The source of data transfer again is determined by the selected radio-button.

RAM:
The currently set parameters are written to the volatile RAM memory of the *L-LAS-TB-…-MA control unit*, or they are read from the RAM and transferred to the PC.
Please note: The parameters set in the RAM will be lost when the power supply at the *L-LAS-TB-…-MA control unit* is turned off.

EEPROM:
The currently set parameters are written to the non-volatile EEPROM memory of the L-LAS-TB-…-MA control unit, or they are read from the EEPROM and transferred to the PC. Parameters that are saved in the EEPROM will not be lost when the power supply is turned off.
If parameters are read from the EEPROM of the L-LAS-TB-…-MA control unit, these must be written to the RAM of the L-LAS-TB-….-MA control unit by selecting the RAM button and then clicking on SEND. The L-LAS-TB-….-MA control unit then continues to operate with the set RAM parameters.

FILE:
When the FILE radio-button is selected, a click on the SEND/GET button opens a new file dialog on the user interface. The current parameters can be written to a freely selectable file on the hard disk of the PC, or parameters can be read from such a file..
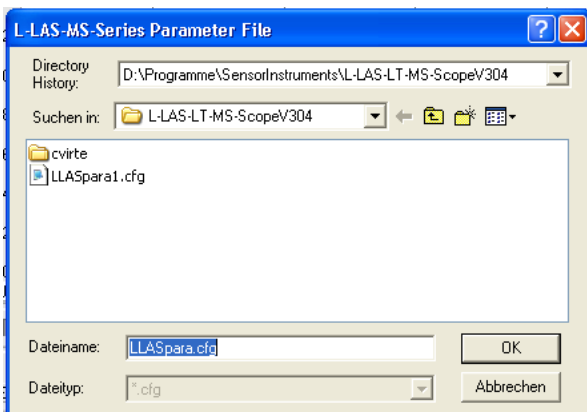
## FILE dialog window:

The standard output file for the parameter values has the file namen
„LLASpara.cfg".

The output file can be opened e.g. with the standard Windows "EDITOR" program.

## 3.2 Numerical and graphic display elements:

**VIDEO button:**

After a click on the VIDEO button, the intensity profile measured at the CCD receiver is transferred to the PC and is shown as a red curve in the graphic display window. The graphic window of the SLAVE sensor is located on the left, while that of the MASTER sensor is displayed on the right side of the user interface. Due to the limited data transfer rate of the serial interface (19200 Baud/s), the graphic can only be updated every second.
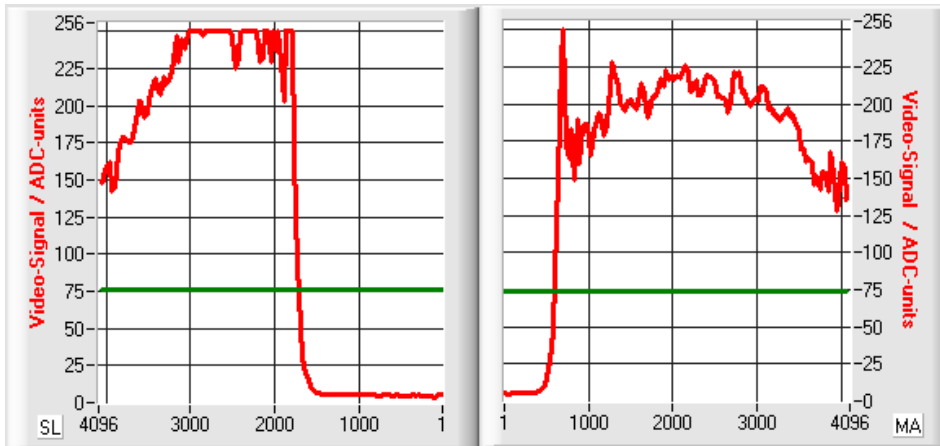


On the y-axis the analog signals of the individual pixels are displayed. The video signals of the CCD line are converted by means of an AD converter with 8-bit resolution. For this reason the value range for the y-axis is 0...256. On the x-axis the pixels of the CCD-line are displayed (e.g.: Pixel: 1...4096).

The currently set video threshold (V-THD) is displayed as a green horizontal line in the graphic.
The edge values (pixels) are derived from the intersection points of the intensity profile (red curve) with the video threshold (green line).



Below the graphical output windows there are two further display elements which show the currently detected shaded areas (grey) and the exposed areas (red) of the respective CCD line. Furthermore, the currently detected edge position is indicated in these display elements by a black dot-shaped circle. A green horizontal bar indicates the size of the set tolerance band around the teach value.

**SLAVE:**

Numerical display field for output of the current pixel position of the SLAVE sensor. The pixel position is calculated from the intersections of the light/dark transitions, between the intensity profile (red curve) and the video threshold (green line).

**MASTER:**

Numerical display field for output of the current pixel position of the MASTER sensor. The pixel position is calculated from the intersections of the light/dark transitions, between the intensity profile (red curve) and the video threshold (green line).

**MEASUREMENT-VALUE:**

Numerical display field for output of the current measured value (depending on the set evaluation mode). The left numerical display field indicates the current measured value in pixels, the right display field shows the measured value converted into millimeters.

If the current measurement value is within the tolerance band around the teach-in value, the display fields are shown with a green background. If the measured value is outside the tolerance band, the display elements are shown with a red background.

**RUN button:**
After a click on the RUN button, the current measurement data will be transferred from the *L-LAS-TB-...-MA sensor* to the PC via the serial interface.

**STOP button:**
A mouse click on the STOP button stops the data transfer between the *L-LAS-TB-...-MA sensor* and the PC.
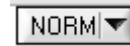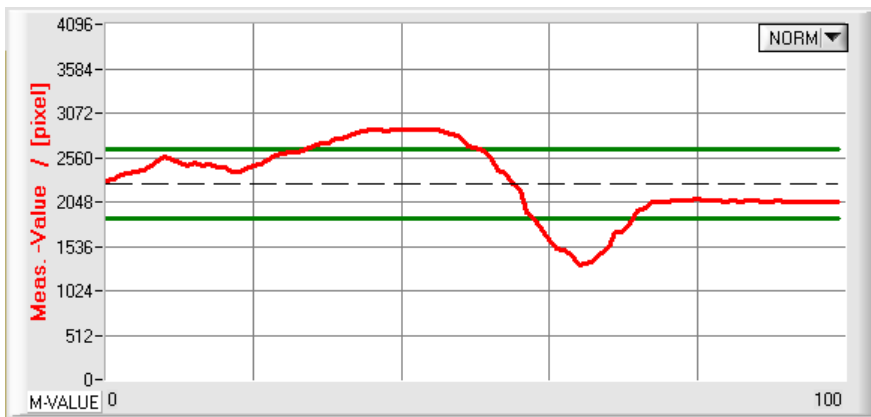


After clicking the RUN button, the current measured value is displayed in the graphic display window in "roll mode".

The measured values run as a red curve from right to left through the graphic display window.

The division of the y-axis corresponds to the pixels available on the CCD line and the respective evaluation mode set.
The most recent measured value is shown in the graphic at the right end at x-value = 100.
The currently set nominal value (TEACH value) is displayed as a black dotted horizontal line.
In addition, the currently set tolerance window is represented by two horizontal green lines around the setpoint.
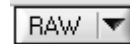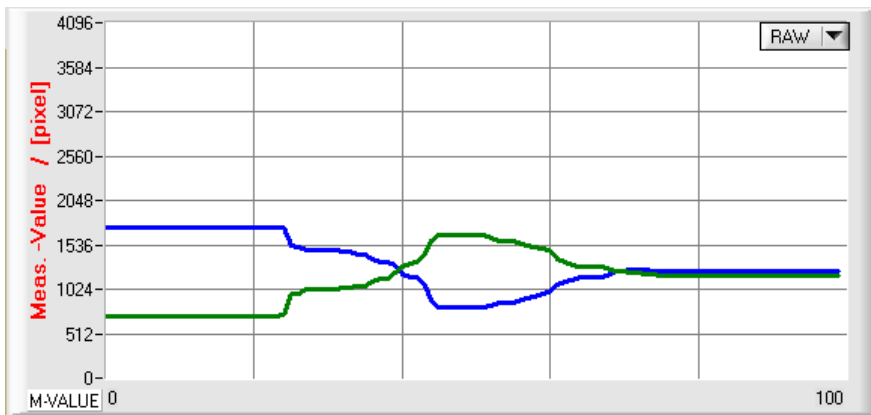


After clicking the RUN button, the current pixel positions of the Master (green) and SLAVE (blue) edges are displayed in the graphic display window in "roll mode".

The division of the y-axis corresponds to the pixels or subpixels of the CCD line. The current edge positions of the CCD line are displayed as a green (MASTER) or blue (SLAVE) curve.

The length of the data frame, which is transmitted via the serial interface in "RUN mode", is limited to 18 words (36 bytes). This allows the numerical and graphical display elements to be updated more quickly.

The data transfer via the serial RS232 interface therefore does not take so much time compared to the "VIDEO mode" (in the VIDEO mode the intensity information for each pixel of the CCD line must be transferred).
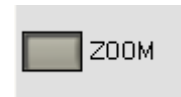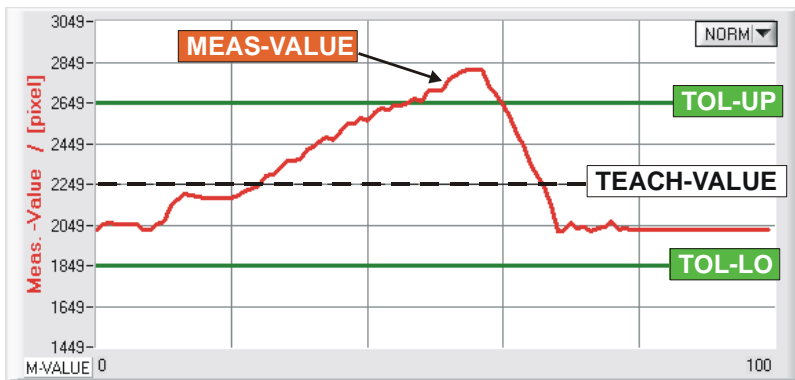
By clicking the ZOOM button, the Y-axis of the graphics window is automatically rescaled so that the changes in measured values can be displayed more clearly.

In the figure above, the time course of the measured value changes is shown as a red curve and the tolerance band is shown with two green lines. The teach-in value is shown as a dashed horizontal black line.

## 3.3    Serial RS232 data transfer:

**RS232 COMMUNICATION:**

- Standard RS232 serial interface without hardware-handshake.
- 3-line-connection: GND, TXD, RXD.
- Speed: 19200 baud, 8 data bits, no parity bit, 1 stop bit in binary mode, MSB first.

⚠️ **Attention !**

**The stable function of the RS232 interface (status message after program start) is a basic prerequisite for data transfer between the PC and the L-LAS-TB-…-MA control unit. Due to the low data transfer rate of the serial RS232 interface (19200 bit/s) only slow changes of the analog values can be observed in the graphic display at the PC. In order to guarantee the maximum switching frequency of the L-LAS-TB-…-MA control unit it is therefore necessary to stop the data exchange during the normal monitoring process (click on the STOP button).**

**The serial RS232 interface must be established between the PC and the MASTER control electronics in the Master/Slave system!**

| CONNECT | COM1 ▼ | L-LAS-MA-TB-8-V3.04 SPI 10/Dec/08 |
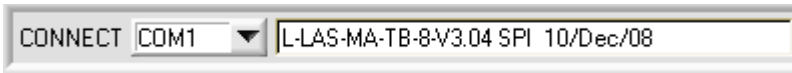
**CONNECT:**

When the software is started, it attempts to establish a connection to the *L-LAS-TB control unit* through the standard COM1 interface. If connection could be established successfully, the current firmware version is displayed in the status line.

| PAR-GE | PAR-MA | PAR-SL | CALIB |

CCD-CALIBRATION

1024-pixel; 7.8µm pixel-pitch
4096-subpixel
resolution    = +/- 2µm
working-range = 8mm
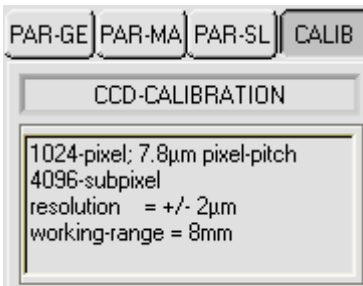
Furthermore, the sensor type recognized by the software and other parameters are displayed in the CCD-INFO field.

If a different sensor type is connected to the RS232 interface, it is essential that the CONNECT function field is selected again, so that the current sensor type can be correctly recognized by the PC software.

Timeout-RS-232...
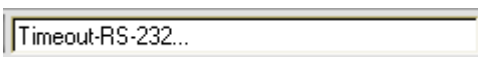
The serial connection between the PC and the *L-LAS-TB-...-MA control unit* could not be established, or the connection is faulty.

**In this case it should first be checked whether the *L-LAS-TB-…-MA control unit* is connected to the power supply, and whether the serial interface cable is correctly connected to PC and control unit.**

If the number of the serial interface that is assigned at the PC should not be known, interfaces COM1 to COM9 can be selected by using the CONNECT drop-down list.

Invalid port number
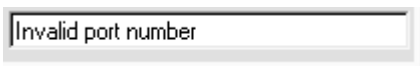
If there is an "Invalid port number" status message, the selected interface, e.g. COM2, is not available at your PC.

Cannot open port

If there is a "Cannot open port" status message, the selected interface, e.g. COM2, may already be used by another device.

## 3.4   *L-LAS-TB-MS-Scope* as an aid for sensor adjustment:

**VIDEO:**

The fine adjustment of the sensors relative to the measured object can be carried out after clicking the VIDEO button on the graphical display window. Due to the limited data transmission rate of the RS232 interface, the display window can only be updated every second.



Adjustment ok – center:

In the graphical display window, the intensity profile is shown as a red curve. The numerical values 1..1024 on the x-axis represent the individual pixels of the CCD line. The analog values of the CCD line are converted by means of an AD converter with 8-bit resolution. For this reason the value range for the y-axis is 0 ... 256.

As can be seen in the adjacent figure, the MASTER-CCD line and the SLAVE-CCD line are each covered about half (pixels 1 to approx. 500) by the measured object.



Measuring range limit – upper limit reached:

Both CCD-receivers are completely covered by the measuring object. The alignment of the MASTER or SLAVE sensor must be adjusted in such a way that the CCD receivers of MASTER and SLAVE are again covered approximately halfway.



Measuring range limit – upper limit reached:

Both CCD receivers are hardly covered by the target. Large areas of the laser line fall unhindered onto the CCD receivers. The alignment of the MASTER or SLAVE sensor must be adjusted in such a way that the CCD receivers of MASTER and SLAVE are again covered approximately halfway.



Alternatively, the sensor adjustment of MASTER and SLAVE can be followed simultaneously in "roll mode" after clicking the RUN button in the graphical display window. The adjustment of the sensors is optimal if the measured values are in the middle of the measuring range.

The current position of the video spot (= distance to the measurement object) is displayed as a green (MASTER) or blue (SLAVE) curve.

## 3.5   *L-LAS-TB-MS-Scope* as an aid for sensor adjustment:
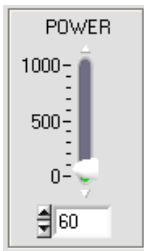
**POWER:**

With the help of the POWER slider or by entering numerical values in the corresponding input field, the laser power can be adjusted at the laser transmitter unit of the L-LAS-TB-...-MA sensor.

⚠️ **Attention !**

The laser power at the transmitter unit of the *L-LAS-TB-...-MA sensor* is only updated when the SEND button is pressed.

SEND
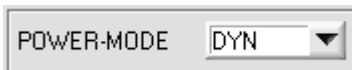
DYNAMIC**:**

If the operating mode is set to DYNAMIC, the laser power at the L-LAS-TB-...-MA sensor is controlled automatically. Here the laser power is adjusted so that the maximum values of the "intensity peaks" are about 80-90% of the analog dynamic range.

**Settings on the POWER slider have no effect in this operating mode! --- The DYNAMIC mode is recommended as standard mode !**
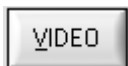
VIDEO

**VIDEO:**

After a click on the VIDEO button, the current intensity profile is transferred from the *L-LAS-TB-...-MA sensor* to the PC and is shown in the graphic display window. When the VIDEO function is active, the sensor's laser power can be changed (press the SEND button), and the effect of such a change can be observed in the intensity profile.
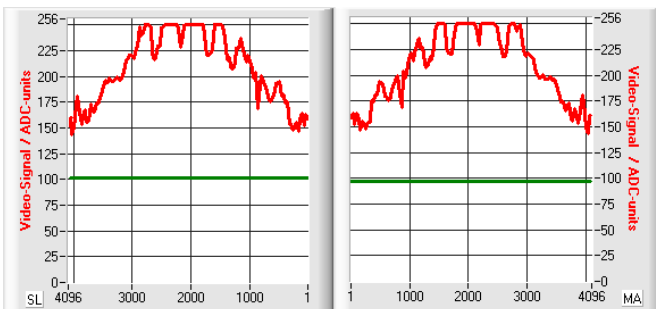
Optimal adjustment:

In the graphical display window the intensity profile is shown as a red curve. The intensity curve is in the evaluation range (pixels 1 .. 4096) above the video threshold (green line).
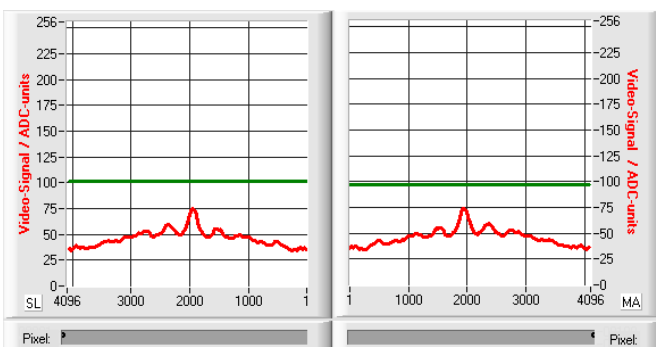
Transmitter power too low:

The intensity profile (red curve) on the CCD receiver of the MASTER and the SLAVE sensor is too low.

The maximum values are below the video threshold (green horizontal line).

No light/dark transition (intersection of red and green curve) can be detected.

# 4 Evaluation modes

## 4.1 SLAVE:
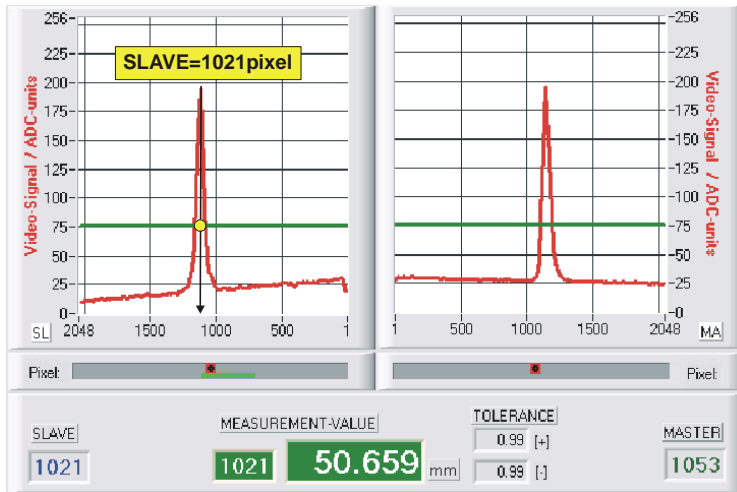




The measured value is calculated from the intersections (light/dark transitions) of the video signal at the SLAVE sensor (left graphic window).

$$MVAL[pixel] = SLAVE$$
here: 1021

## 4.2 MASTER:
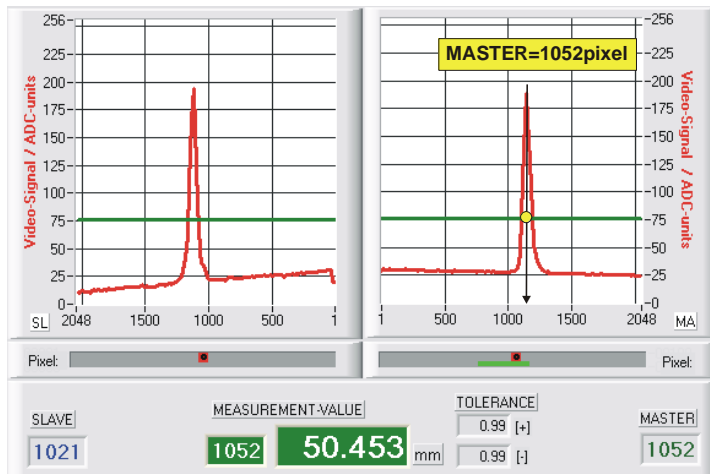




The measured value is calculated from the intersections (light/dark transitions) of the video signal at the MASTER sensor (right-hand graphics window).

$$MVAL[pixel] = MASTER$$
here: 1052

## 4.3 WIDTH:



**EVAL-MODE** WIDTH ▼
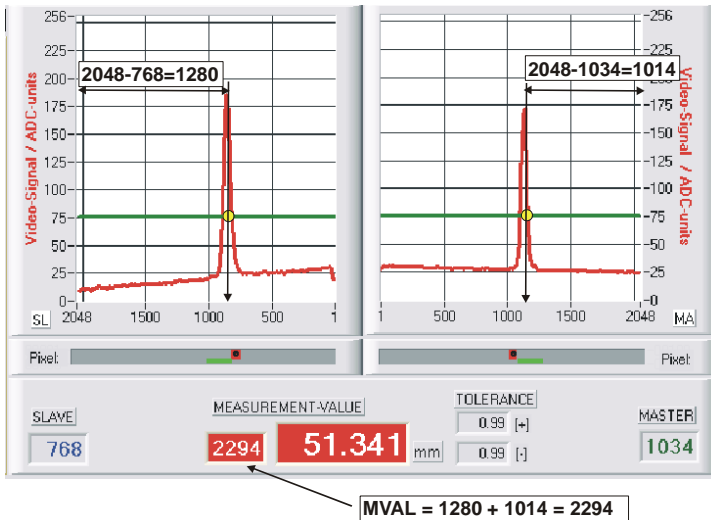
In the WIDTH evaluation mode, the width of the measurement object is calculated by adding the measured values of MASTER and SLAVE.

The Master sensor is located on one side of the measurement object, the SLAVE sensor on the opposite side.

If the measurement object becomes wider, the distance to the sensor optics is reduced, i.e. the video spots move to smaller pixel values.

$$MVAL[pixel] = MASTER\# + SLAVE\#$$
with:
$$MASTER\#[pixel] = MAXPIXEL - MASTER$$
$$SLAVE\#[pixel] = MAXPIXEL - SLAVE$$

here: MVAL = 2294 = (2048-1034) + (2048-768)

The measured value in WIDTH mode must therefore be calculated indirectly from the known maximum pixel number (e.g. 2048) of the CCD line and the measured pixel values of MASTER and SLAVE. For this purpose, the two intermediate values MASTER# and SLAVE# are first calculated by subtraction. By adding these two values, the width of the measured object in pixels is obtained.

## 4.4 CENTER:



**EVAL-MODE** CENTER ▼
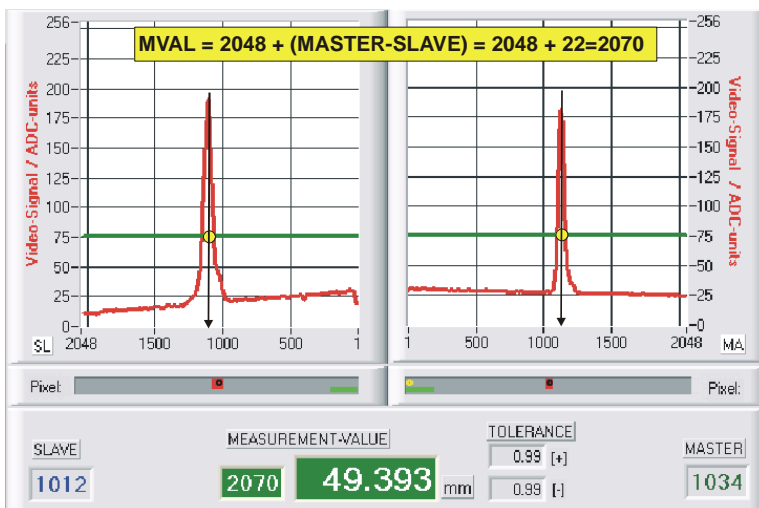
In this evaluation mode the center position (center of gravity) is calculated based on the two measured values of master and slave.

The difference between master and slave measured value thus determined is provided with an offset of 2048 (maximum number of pixels on CCD line).

$$MVAL[pixel] = MAXPIXEL + (MASTER - SLAVE)$$
here: MVAL = 2070 = 2048 + (1034-1012) = 2048 + 22

## 4.5 DIFF:
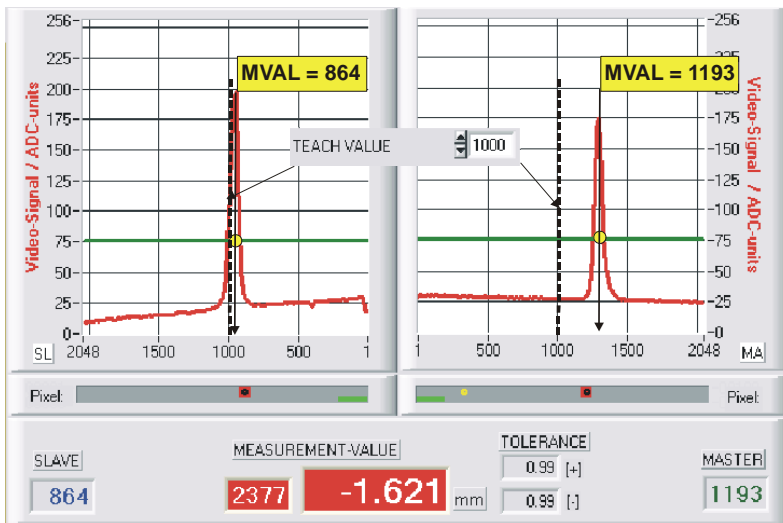


EVAL-MODE [DIFF ▼]

In this evaluation mode, the deviations between the actual measured value MVAL and the respective teach-value TEACH-VALUE are calculated both at the master and at the slave.

The difference between the measured values and the teach-in values thus determined is provided with an offset of 2048 (maximum number of pixels on CCD line).

$$MVAL\,[pixel] = MAXPIXEL + (DELTA\_MA - DELTA\_SL)$$
with:
$$DELTA\_MA\,[pixel] = MASTER - TEACH\_MA$$
$$DELTA\_SL\,[pixel] = SLAVE - TEACH\_SL$$

here:
DELTA_A = 1193-1000 = 193
DELTA_B = 864 – 1000 = -136

MVAL = 2048 + (193 – (-136)) = 2377

# 5 Function of the data recorder
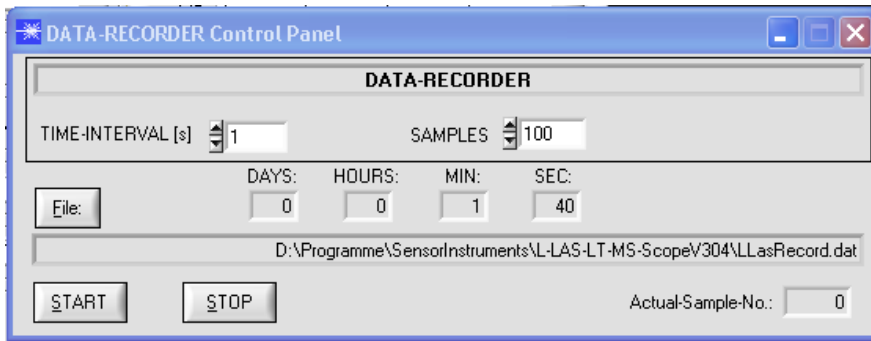




After clicking the RECORD button, a new window opens for setting the data recorder.
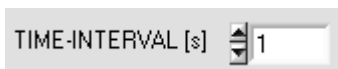


With the help of the numeric input field a time interval in seconds can be entered. After this time interval has elapsed, the PC software automatically transfers measurement data from the sensor to the PC and stores them on the hard disk in an output file.
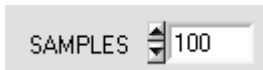


Numerical input field for setting the maximum number of measured values to be stored. Values from 10 to 30000 are adjustable.



These numeric display elements show the period of time that the recorder is active after its activation.
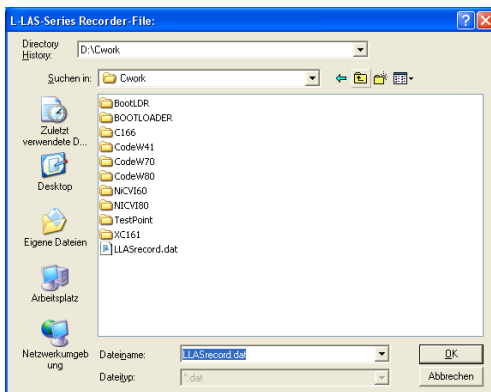




After clicking the File button, a dialog window opens, which is used to specify the file name or to set the location of the output file.

The currently selected location and the file name of the output file are shown in the following text display.
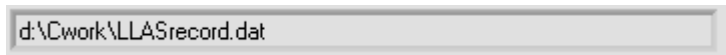




With the help of the START button the automatic recording can be started. If the recording should be stopped before reaching the maximum number of samples specified by SAMPLES, this can be done by clicking the STOP button.
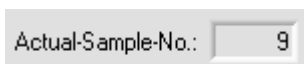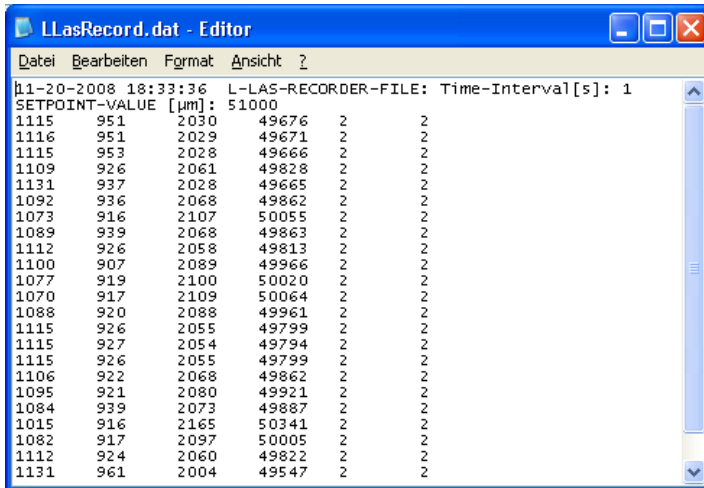


Numerical display field that shows the current number of already stored measured values.

## 5.1   Data format of the output file

The output file of the data recorder consists of 2 header lines, followed by the actual measurement data. The measurement data are written to the output file line-by-line. Each line comprises 6 columns that are separated from each other by a TAB control character.

The output file can be opened with a simple text editor or a spreadsheet program (e.g. Microsoft EXCEL).



1. column = Measurement value (pixel) MASTER
2. column = Measurement value (pixel) SLAVE
3. column = Measurement value (pixel) MVALUE
4. column = Measurement value MVALUE in micrometer
5. column = Number of edges MASTER
6. column = Number of edges SLAVE

# 6    Annex

## 6.1    Laser warning

<table>
<tr><td align="center"><b>LASER WARNING</b></td></tr>
<tr><td align="center">Solid-state laser, λ=670 nm, 1mW max. optical power,<br>laser class 2 acc. to EN 60825-1<br>Therefore no additional protective measures are required for the use of these laser transmitters.<br><br>LASER RADIATION<br>DO NOT STARE INTO THE BEAM<br>CLASS II LASER PRODUCT</td></tr>
</table>

## 6.2    Function of the Teach/Reset button

The housing of the *L-LAS-TB-…-MA sensor* features a pushbutton with two functions:

RESET: t<750ms    1x flashing

TEACH/RESET Push-Button
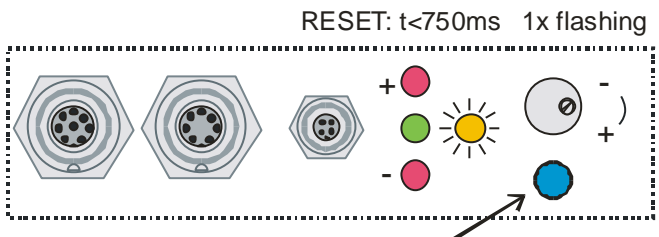
### RESET function:

When the button is pressed for a short time (t < 750ms), the current maximum and minimum values (drag pointer values) are reset.
A hardware/software RESET is <u>not</u> performed!

TEACH: t>1.5s    3x flashing

TEACH/RESET Push-Button
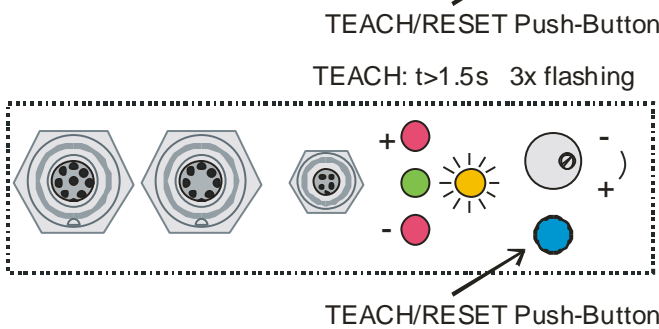
### TEACH function:

When the button is pressed for a longer time (t > 1.5s), the current edge coverings are stored as teach value in the RAM memory. When the teach process has been performed successfully, the green LED blinks three times.

## 6.3 Function of the Tolerance potentiometer

The housing of the *L-LAS-TB-…-MA sensor* features a potentiometer for setting the tolerance band width.
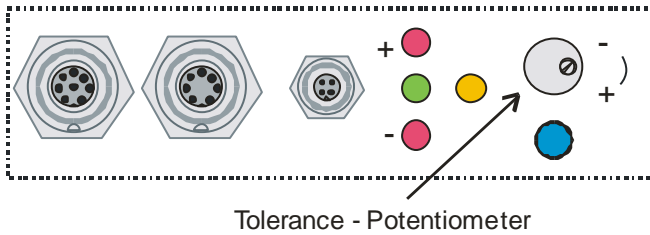
**TOLERANCE potentiometer:**

Turning the potentiometer clockwise increases the tolerance band width.

Turning it counter-clockwise decreases the tolerance band width.

The potentiometer must be activated (switch position ENABLE ALL or ENABLE TOL SET) in order to use it for setting the tolerance band width at the L-LAS-TB-…-MA sensor.

Tolerance - Potentiometer

## 6.4 Function of digital inputs IN0 and IN1

The *L-LAS-TB-…-MA sensor* has two digital inputs IN0 and IN1 that can be contacted through the 8-pole female connector (type Binder 712).
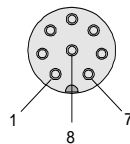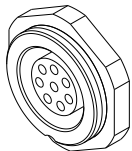
| Pin: | Color: | Assignment: |
|---|---|---|
| 1 | white | 0V (GND) |
| 2 | brown | +Ub (+24VDC ± 10%) |
| **3** | **green** | **IN0 (EXT TRIGGER)** |
| **4** | **yellow** | **IN1 (TEACH/RESET)** |
| 5 | gray | OUT0 |
| 6 | pink | OUT1 |
| 7 | blue | OUT2 |
| 8 | red | ANALOG voltage (0…+10V) optionally in case of **type -4/20**: ANALOG current (4…20mA) |

**DIGITAL INPUT IN0 (pin3/green) EXT-TRIGGER:**

IN0 / EXT-TRIG (Pin 3, green) — Logic 1 (+U_B), Logic 0 (GND, 0V), Trigger Event
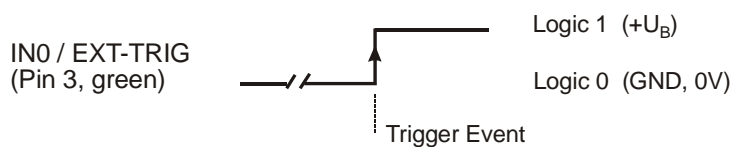
TRG-MODE EXT. IN0 L/H
External edge-controlled (LOW/HIGH) triggering of measurement value evaluation through digital input IN0.

IN0 / EXT-TRIG (Pin 3, green) — Trigger Active — Logic 1 (+U_B), Logic 0 (GND, 0V)
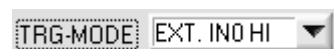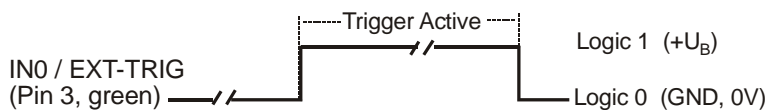
TRG-MODE EXT. IN0 HI
External triggering of measurement value evaluation through a HIGH level (+Ub) at digital input IN0.

## DIGITAL INPUT IN1 (pin4/yellow) TEACH/RESET:

RESET function:
When a HIGH pulse of less than 750 ms duration is applied, the RESET function is performed at the L-LAS-TB-…-MA sensor. This resets the current maximum and minimum values (drag pointer).
A hardware/software RESET is not performed! When a RESET pulse is detected, the yellow LED flashes shortly one time.

IN1 / RESET
(Pin 4, yellow)

$T_R$ < 750ms

Logic 1  (+$U_B$)

Logic 0  (GND, 0V)
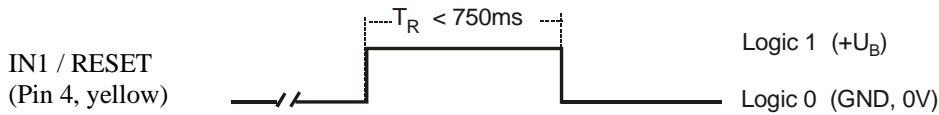
TEACH function:
When a HIGH pulse of more than 1.5s duration is applied, the TEACH function is performed at the L-LAS-TB-…-MA sensor. When a TEACH pulse is detected, the yellow LED at the housing flashes shortly three times.

IN1 / TEACH
(Pin 4, yellow)

$T_{TEACH}$ > 1.5sec

Logic 1  (+$U_B$)

Logic 0  (GND, 0V)
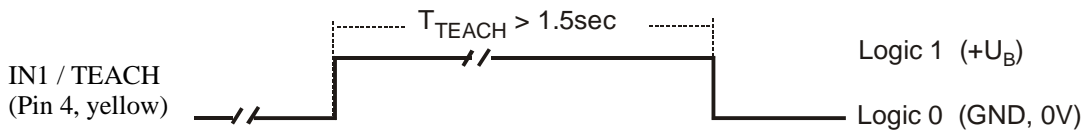
## 6.5    Connector assignment
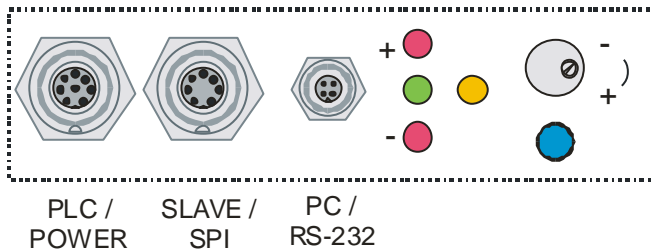
At the housing of the *L-LAS-TB-...-MA sensor* there is a female connector for power supply connection (8-pin type Binder 712), a 7-pin female connector (type Binder 712) to connect the SLAVE sensor, as well as a third female connector to connect the serial RS232 connection line (4-pin type Binder 707).

PLC / POWER

SLAVE / SPI

PC / RS-232

For connection sketches, pin assignments and connection cables see points 6.5.1, 6.5.2 and 6.5.3

### 6.5.1 Connection of the Master/Slave systems L-LAS-TB-50-MS, L-LAS-TB-75-MS, L-LAS-TB-100-MS

Connection sketch valid for:

L-LAS-TB-50-R-MA + L-LAS-TB-50-R-SL + 2x L-LAS-TB-50-T
L-LAS-TB-75-R-MA + L-LAS-TB-75-R-SL + 2x L-LAS-TB-75-T
L-LAS-TB-100-R-MA + L-LAS-TB-100-R-SL + 2x L-LAS-TB-100-T
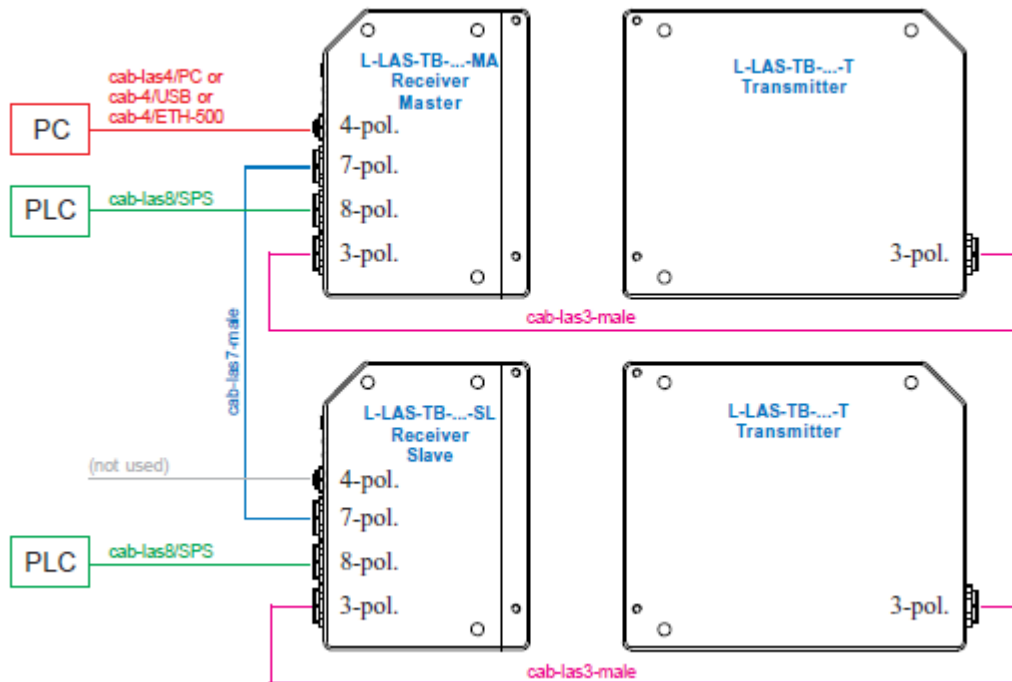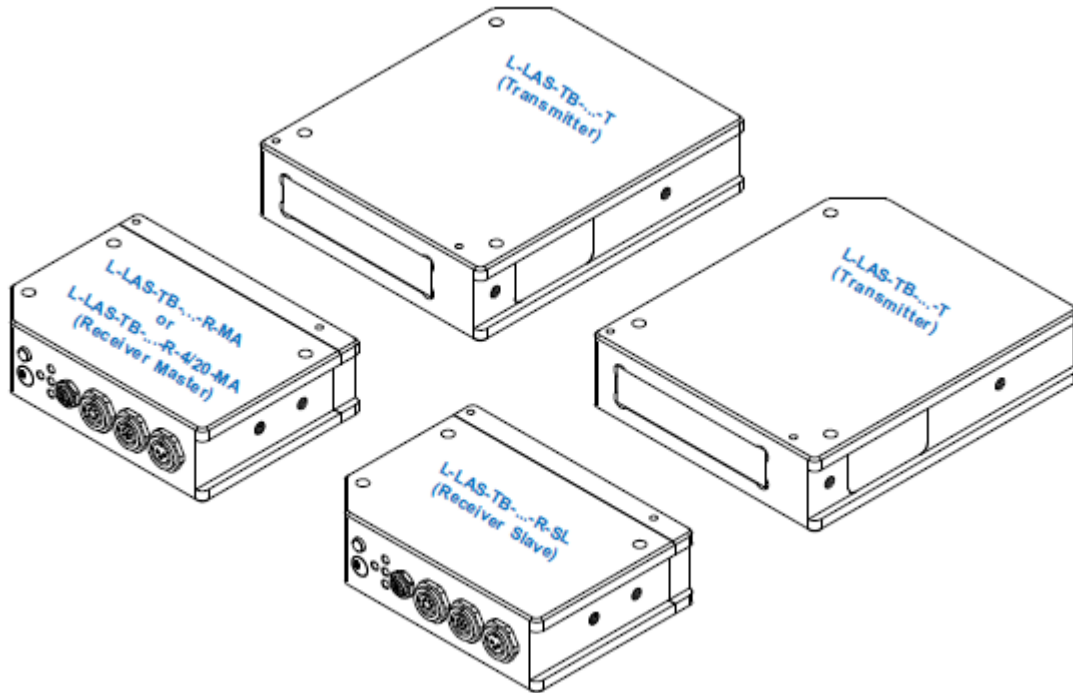
Connector assignment for:

L-LAS-TB-50-R-MA + L-LAS-TB-50-R-SL + 2x L-LAS-TB-50-T
L-LAS-TB-75-R-MA + L-LAS-TB-75-R-SL + 2x L-LAS-TB-75-T
L-LAS-TB-100-R-MA + L-LAS-TB-100-R-SL + 2x L-LAS-TB-100-T

**Connection L-LAS-TB-...-R-MA (or L-LAS-TB-R-4/20-MA) to PLC:**
**8-pole fem. connector Binder Series 712**

| Pin: | (Color of wire:) | Assignment: |
|---|---|---|
| 1 | white | GND (0V) |
| 2 | brown | +24VDC (± 10%) |
| 3 | green | IN0 (EXT TRIGGER) |
| 4 | yellow | IN1 (TEACH / RESET) |
| 5 | grey | OUT0 (-) |
| 6 | pink | OUT1 (+) |
| 7 | blue | OUT2 (OK) |
| 8 | red | ANA (0 ... +10V) |
| | | in case of version -4/20: |
| | | ANA (4 ... 20mA) |

Connecting cable:
cab-las8/SPS-(length) or
cab-las8/SPS-w-(length) (angle type: 90°)
(standard length 2m)

**Connection L-LAS-TB-...-R-SL to PLC:**
**8-pole fem. connector Binder Series 712**

| Pin: | (Color or wire:) | Assignment: |
|---|---|---|
| 1 | white | GND (0V) |
| 2 | brown | +24VDC (± 10%) |
| 3 | green | (not used) |
| 4 | yellow | (not used) |
| 5 | grey | (not used) |
| 6 | pink | (not used) |
| 7 | blue | (not used) |
| 8 | red | (not used) |

Connecting cable:
cab-las8/SPS-(length) or
cab-las8/SPS-w-(length) (angle type 90°)
(standard length: 2m)

**Connection L-LAS-TB-...-R-MA (or L-LAS-TB-R-4/20-MA) to PC:**
**4-pole female connector Binder Series 707**

| Pin: | Assignment: |
|---|---|
| 1 | +24VDC (+Ub, OUT) |
| 2 | GND (0V) |
| 3 | Rx0 |
| 4 | Tx0 |

*Connection via RS232 interface at the PC:*
Connecting cable:
cab-las4/PC-(length)
cab-las4/PC-w-(length) (angle type 90°)
(standard length 2m)

_alternative:_
*Connection via USB interface at the PC:*
Connecting cable (incl. driver software):
cab-4/USB-(length)
cab-4/USB-w-(length) (angle type 90°)
(standard length 2m)

_alternative:_
*Connection to local network via Ethernet bus:*
Adapter (incl. software „SensorFinder"):
cab-4/ETH-500
(standard length 0.5m)

Optional: External CAT5 cable, e.g. cab-eth/M12D-RJ45-flx-(length)

**Connection L-LAS-TB-...-R-MA (or L-LAS-TB-R-4/20-MA)**
**and L-LAS-TB-...-R-SL**
**(SPI data transfer):**
**2x 7-pole fem. connectors Binder Series 712**

| Pin: | Assignment MASTER: | Pin: | Assignment SLAVE: |
|---|---|---|---|
| 1 | GND (0V) | 1 | GND (0V) |
| 2 | +3.3VDC (OUT) | 2 | +3.3VDC (IN) |
| 3 | SS\ (Slave Select) | 3 | SS\ (Slave Select) |
| 4 | MISO (Master In Slave Out) | 4 | MISO (Master In Slave Out) |
| 5 | MOSI (Master Out Slave In) | 5 | MOSI (Master Out Slave In) |
| 6 | CLK | 6 | CLK |
| 7 | +3.3VDC (IN) | 7 | +3.3VDC (OUT) |

Connection cable:
cab-las7-male-(length)
cab-las7-male-w-(length)
(standard length 2m)

**Connection L-LAS-TB-...-R-MA and L-LAS-TB-...-T**
**and**
**Connection L-LAS-TB-...-R-SL and L-LAS-TB-...-T:**
**2x 3-pole fem. connectors Binder Series 712**

| Pin: | Assignment: |
|---|---|
| 1 | +5VDC |
| 2 | GND (0V) |
| 3 | I-CONTROL (0V ... +5V) |

Connecting cable:
cab-las3-male-(length)
cab-las3-male-w-(length)
(standard length 2m)

Connecting cables for:

L-LAS-TB-50-R-MA + L-LAS-TB-50-R-SL + 2x L-LAS-TB-50-T
L-LAS-TB-75-R-MA + L-LAS-TB-75-R-SL + 2x L-LAS-TB-75-T
L-LAS-TB-100-R-MA + L-LAS-TB-100-R-SL + 2x L-LAS-TB-100-T

**Connection L-LAS-TB-...-R-MA (or L-LAS-TB-R-4/20-MA) to PLC:**

Connecting cable:
cab-las8/SPS-(length)   or
cab-las8/SPS-w-(length) (angle type 90º)
(standard length: 2m)

cab-las8/SPS-w-... (picture left) or
cab-las8/SPS-... (picture right)
(length each max. 25m, outer jacket: PUR)
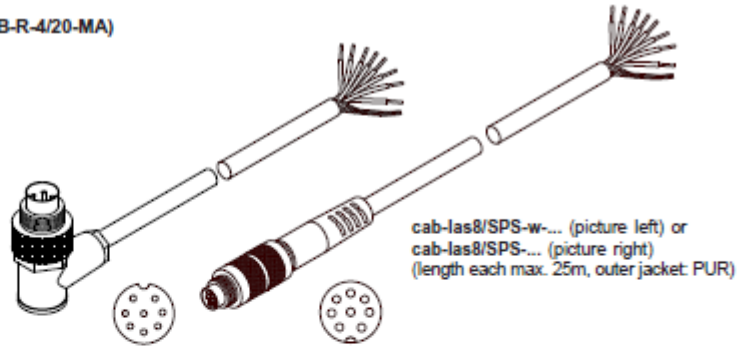
**Connection L-LAS-TB-...-R-MA (or L-LAS-TB-R-4/20-MA) via RS232 interface at the PC:**

Connecting cable:
cab-las4/PC-(length)
cab-las4/PC-w-(length) (angle type 90º)
(standard length 2m)
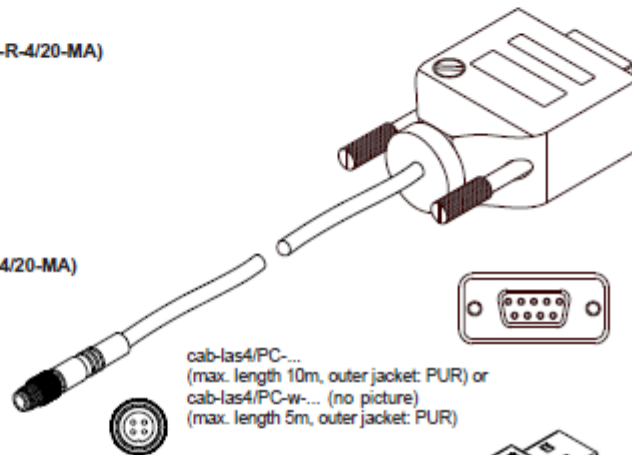
alternative:
**Connection L-LAS-TB-R-MA (or L-LAS-TB-R-4/20-MA) via USB interface at the PC:**

Connecting cable (incl. driver software):
cab-4/USB-(length)
cab-4/USB-w-(length) (angle type 90°)
(standard length 2m)

cab-las4/PC-...
(max. length 10m, outer jacket: PUR) or
cab-las4/PC-w-... (no picture)
(max. length 5m, outer jacket: PUR)
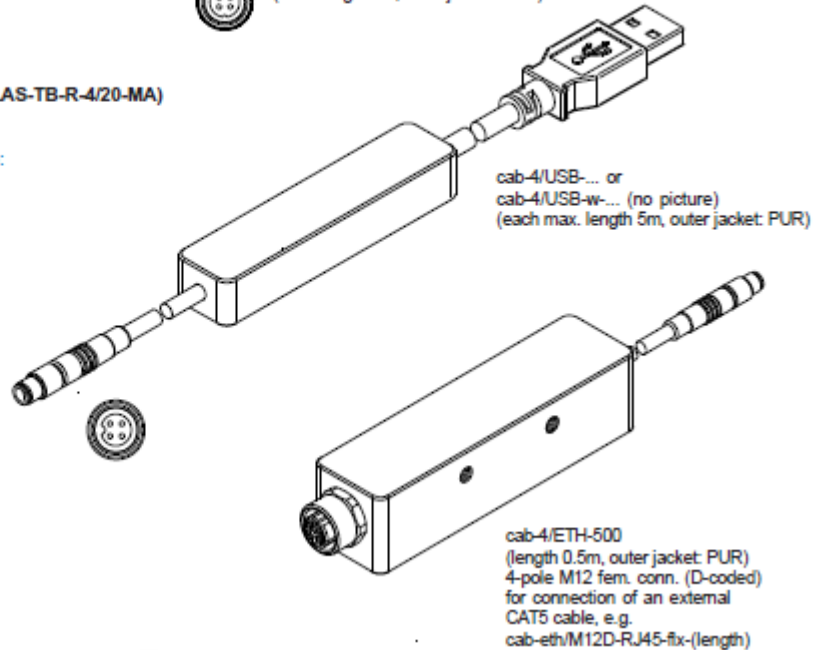
alternative:
**Connection L-LAS-TB-R-MA (or L-LAS-TB-R-4/20-MA) to local network via Ethernet bus:**

Adapter (incl. software „SensorFinder"):
cab-4/ETH-500
(standard length 0.5m)

Optional: External CAT5 cable, e.g.
cab-eth/M12D-RJ45-flx-(length)

cab-4/USB-... or
cab-4/USB-w-... (no picture)
(each max. length 5m, outer jacket: PUR)

cab-4/ETH-500
(length 0.5m, outer jacket: PUR)
4-pole M12 fem. conn. (D-coded)
for connection of an external
CAT5 cable, e.g.
cab-eth/M12D-RJ45-flx-(length)

### 6.5.2 Connection of the Master/Slave systems L-LAS-TB-F-…-MS (fork design)

Connection sketch valid for:

L-LAS-TB-F-8-40/40-MA + L-LAS-TB-F-8-40/40-SL
L-LAS-TB-F-8-200/40-MA + L-LAS-TB-F-8-200/40-SL
L-LAS-TB-F-8-200/40-BL-MA + L-LAS-TB-F-8-200/40-BL-SL
L-LAS-TB-F-8-200/65-BL-MA + L-LAS-TB-F-8-200/65-BL-SL
L-LAS-TB-F-16-40/40-MA + L-LAS-TB-F-16-40/40-SL
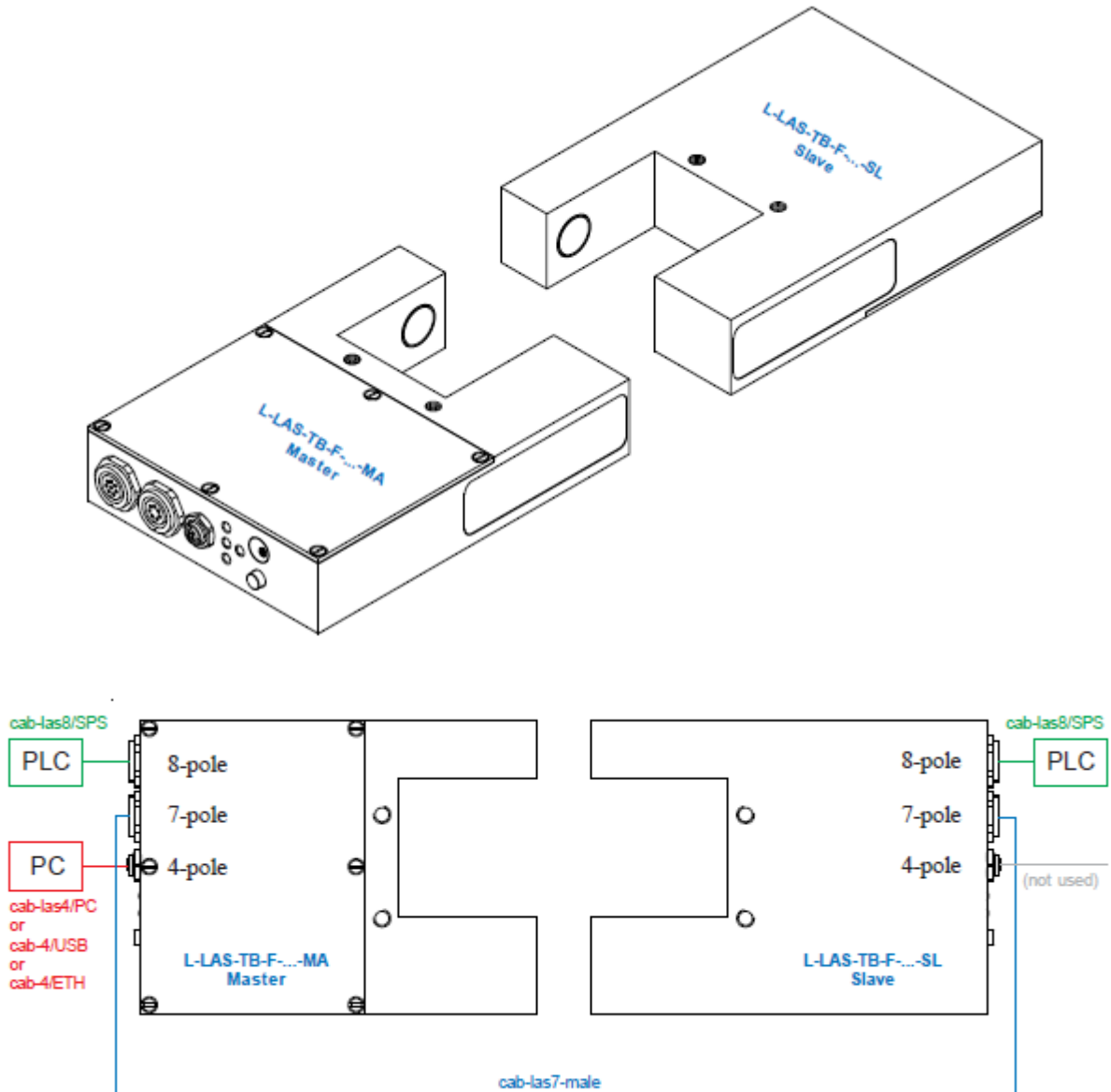
Pin assignment and connection cable valid for:

L-LAS-TB-F-8-40/40-MA + L-LAS-TB-F-8-40/40-SL
L-LAS-TB-F-8-200/40-MA + L-LAS-TB-F-8-200/40-SL
L-LAS-TB-F-8-200/40-BL-MA + L-LAS-TB-F-8-200/40-BL-SL
L-LAS-TB-F-8-200/65-BL-MA + L-LAS-TB-F-8-200/65-BL--SL
L-LAS-TB-F-16-40/40-MA + L-LAS-TB-F-16-40/40-SL

**Connection Master and Slave to PLC:**
**8-pole fem. connector Binder Series 712**

| Pin: | Color: | Assignment: |
|------|--------|-------------|
| 1 | white | GND (0V) |
| 2 | brown | +24VDC (±10%) |
| 3 | green | IN0 (EXT TRIGGER) |
| 4 | yellow | IN1 (TEACH / RESET) |
| 5 | grey | OUT0 (-) |
| 6 | pink | OUT1 (+) |
| 7 | blue | OUT2 (OK) |
| 8 | red | ANA (0 ... +10V) |
| | | in case of version -4/20: |
| | | ANA (4 ... 20mA) |

Connecting cable:
cab-las8/SPS-(length)
cab-las8/SPS-w-(length) (angle type, 90°)
(standard length 2m)

cab-las8/SPS-...
(max. length 25m, outer jacket: PUR)

cab-las8/SPS-w-...
(max. length 25m, outer jacket: PUR)

**Connection Master to PC:**
**4-pole fem. connector Binder Series 707**

| Pin: | Assignment: |
|------|-------------|
| 1 | +24VDC (+Ub, OUT) |
| 2 | GND (0V) |
| 3 | RxD |
| 4 | TxD |

**Connection via RS232 interface at the PC:**
Connecting cable:
cab-las4/PC-(length)
cab-las4/PC-w-(length) (angle type 90°)
(standard length 2m)

_alternative:_
**Connection via USB interface at the PC:**
USB converter (incl. driver software):
cab-4/USB-(length)
cab-4/USB-w-(length) (angle type 90°)
(standard length 2m)

_alternative:_
**Connection to local network via Ethernet bus:**
Ethernet converter (incl. software „SensorFinder"):
cab-4/ETH-500
(standard length 0.5m)

Optional: External CAT5 cable, e.g.
cab-eth/M12D-RJ45-flx-(length)

cab-las4/PC-...
(max. length 10m, outer jacket: PUR) or
cab-las4/PC-w-... (no picture)
(max. length 5m, outer jacket: PUR)

cab-4/ETH-500
(length 0.5m, outer jacket: PUR)
4-pole M12 fem. conn. (D-coded)
for connection of an external
CAT5 cable, e.g.
cab-eth/M12D-RJ45-flx-(length)

cab-4/USB-... or
cab-4/USB-w-... (no picture)
(each max. length 5m, outer jacket: PUR)

### 6.5.3 Connection of the Master/Slave system L-LAS-TB-8-CON1-MS

Connection sketch valid for:

L-LAS-TB-8-CON1-MA, L-LAS-TB-8-CON1-SL, 2x L-LAS-TB/90-…-T, 2x L-LAS-TB/90-…-R
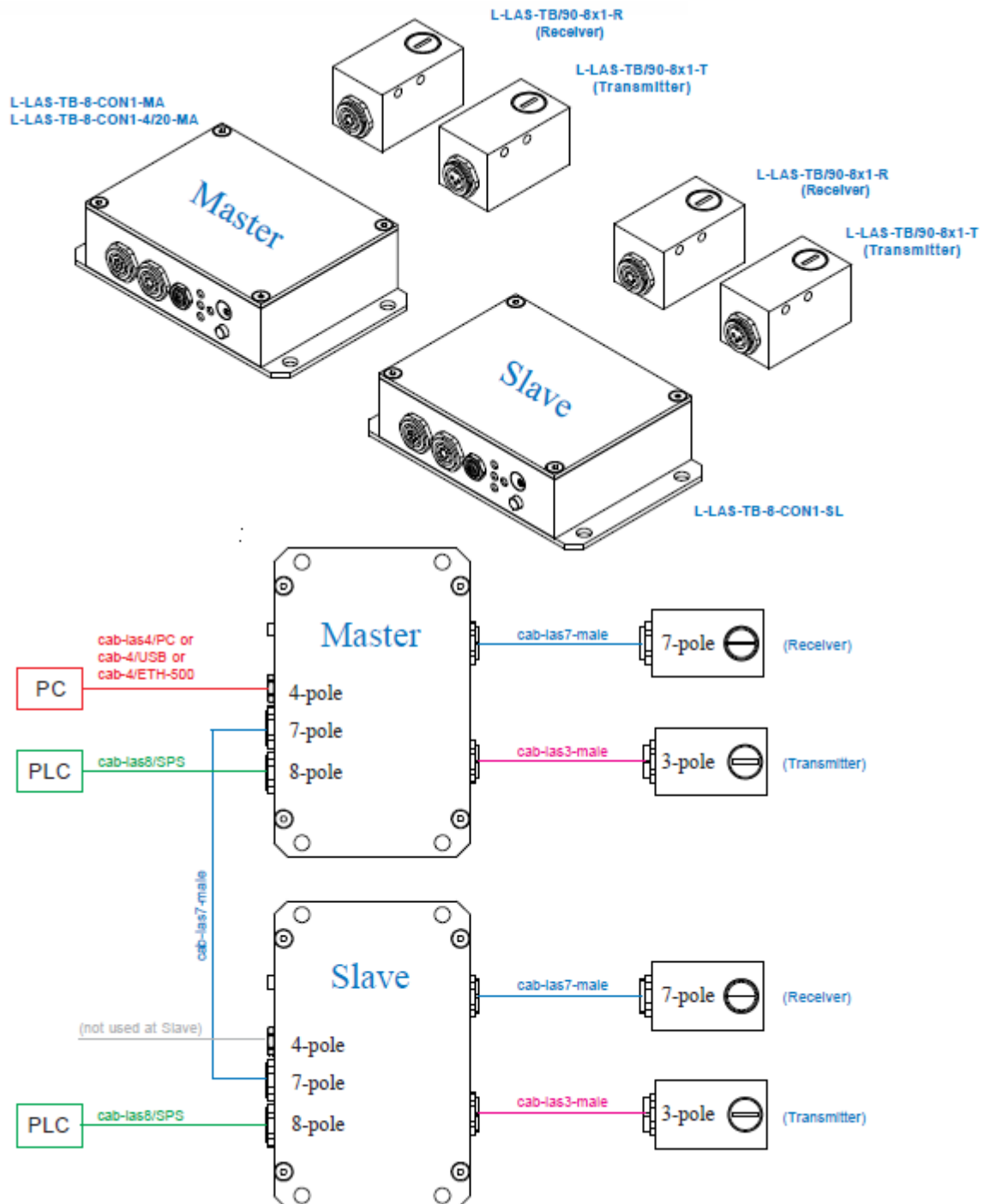
Connector assignment valid for:

L-LAS-TB-8-CON1-MA, L-LAS-TB-8-CON1-SL, 2x L-LAS-TB/90-…-T, 2x L-LAS-TB/90-…-R

**Connection L-LAS-TB-8-CON1-MA to PLC:**
**8-pole fem. connector Binder Series 712**

| Pin: | (Color of wire:) | Assignment: |
|---|---|---|
| 1 | white | GND (0V) |
| 2 | brown | +24VDC (± 10%) |
| 3 | green | IN0 (EXT TRIGGER) |
| 4 | yellow | IN1 (TEACH / RESET) |
| 5 | grey | OUT0 (-) |
| 6 | pink | OUT1 (+) |
| 7 | blue | OUT2 (OK) |
| 8 | red | ANA (0 ... +10V) |
| | | In case of version -4/20: |
| | | ANA (4 ... 20mA) |

Connecting cable:
cab-las8/SPS-(length)
cab-las8/SPS-w-(length) (angle type, 90°)
(standard length 2m)

**Connection L-LAS-TB-8-CON1-MA to PC:**
**4-pole fem. connector Binder Series 707**

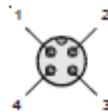| Pin: | Assignment: |
|---|---|
| 1 | +24VDC (+Ub, OUT) |
| 2 | GND (0V) |
| 3 | RxD |
| 4 | TxD |

Connecting cable:
cab-las4/PC-(length)
cab-las4/PC-w-(length) (angle type, 90°)
(standard length 2m)

_alternatively:_
_Connection via_
_USB interface_
_or_
_connection to_
_local network via_
_Ethernet bus_

Connecting cables:
cf. page 8



L-LAS-TB-8-CON1-MA
(Master)

cab-las8/SPS-…

cab-las4/PC-... or
cab-4/USB-... or
cab-4/ETH-500

PLC

Slave

cab-las7-male-…
(length max. 5m)

PC

L-LAS-TB-8-CON1-MA
L-LAS-TB-8-CON1-SL
(Master or Slave)

L-LAS-TB/90-…-T
(Transmitter)

L-LAS-TB/90-…-R
(Receiver)

cab-las3-male-…
(length max. 2m)

cab-las7-male-…
(length max. 2m)
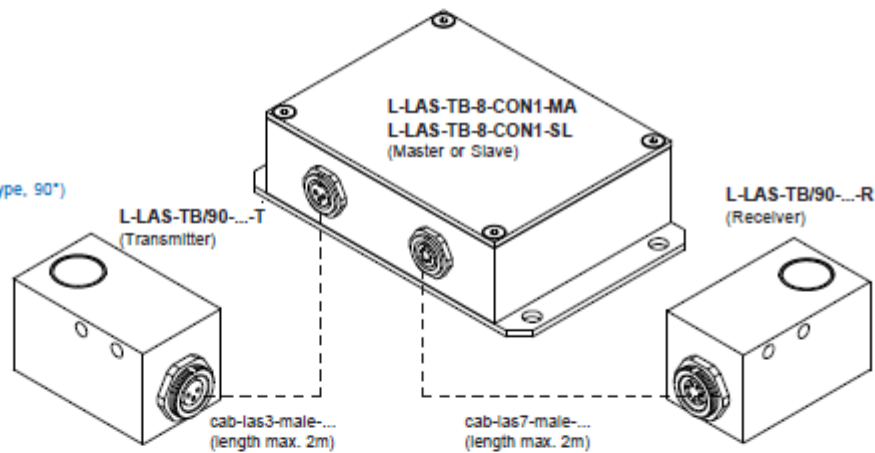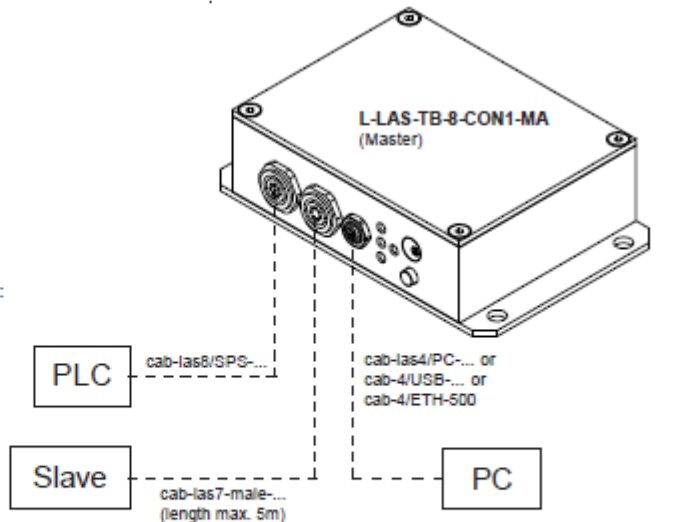
**Connection transmitter L-LAS-TB/90-(8)-T to**
**L-LAS-TB-8-CON1-MA or to**
**L-LAS-TB-8-CON1-SL:**
**3-pole fem. connectors Binder Series 712**

| Pin: | Assignment: |
|---|---|
| 1 | +5VDC |
| 2 | GND (0V) |
| 3 | I-CONTROL (0V ... +5V) |

Connecting cable:
cab-las3-male-(length)
cab-las3-male-w-(length) (angle type, 90°)
(standard length 2m)

**Connection receiver L-LAS-TB/90-(8)-R to**
**L-LAS-TB-8-CON1-MA or to**
**L-LAS-TB-8-CON1-SL:**
**7-pole fem. connectors Binder Series 712**

| Pin: | Assignment: |
|---|---|
| 1 | GND (0V) |
| 2 | +6.9VDC |
| 3 | START |
| 4 | CLOCK |
| 5 | GAIN |
| 6 | GND (0V) |
| 7 | VIDEO |

Connecting cable:
cab-las7-male-(length)
cab-las7-male-w-(length) (angle type, 90°)
(standard length 2m)

Connecting cables for:

L-LAS-TB-8-CON1-MA, L-LAS-TB-8-CON1-SL, 2x L-LAS-TB/90-…-T, 2x L-LAS-TB/90-…-R

**Connection L-LAS-TB-8-CON1-MA (or L-LAS-TB-8-CON1-4/20-MA) to PLC:**

Connecting cable:
cab-las8/SPS-(length) or
cab-las8/SPS-w-(length) (angle type, 90°)
(standard length 2m)
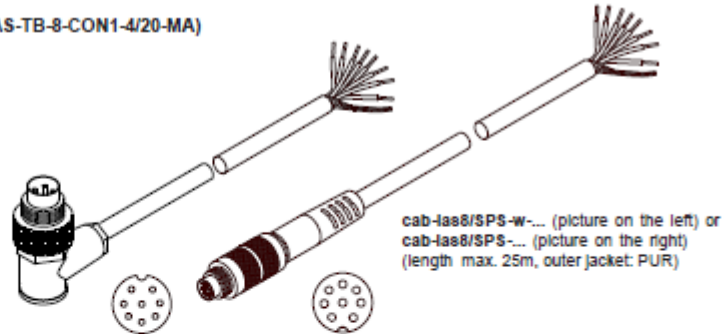
cab-las8/SPS-w-... (picture on the left) or
cab-las8/SPS-... (picture on the right)
(length max. 25m, outer jacket: PUR)

**Connection to PC:**
**4-pole fem. connector Binder Series 707**

| Pin: | Assignment: |
|---|---|
| 1 | +24VDC (+Ub, OUT) |
| 2 | GND (0V) |
| 3 | RxD |
| 4 | TxD |

**Connection via RS232 interface at the PC:**
Connecting cable:
cab-las4/PC-(length)
cab-las4/PC-w-(length) (angle type 90°)
(standard length 2m)

**alternative:**
**Connection via USB interface at the PC:**
USB converter (incl. driver software):
cab-4/USB-(length)
cab-4/USB-w-(length) (angle type 90°)
(standard length 2m)

**alternative:**
**Connection to local network via Ethernet bus:**
Ethernet converter (incl. software „SensorFinder"):
cab-4/ETH-500
(standard length 0.5m)

Optional: External CAT5 cable, e.g.
cab-eth/M12D-RJ45-fix-(length)

cab-las4/PC-...
(max. length 10m, outer jacket: PUR) or
cab-las4/PC-w-... (no picture)
(max. length 5m, outer jacket: PUR)

cab-4/ETH-500
(length 0.5m, outer jacket: PUR)
4-pole M12 fem. conn. (D-coded)
for connection of an external
CAT5 cable, e.g.
cab-eth/M12D-RJ45-fix-(length)

cab-4/USB-... or
cab-4/USB-w-... (no picture)
(each max. length 5m, outer jacket: PUR)

Connection L-LAS-TB/90-(8)-R to
L-LAS-TB-8-CON1-MA, /-SL and
connection L-LAS-TB-8-CON1-MA to
L-LAS-TB-8-CON1-SL:

Connecting cable:
cab-las7-male-(length) or
cab-las7-male-w-(length) (angle type, 90°)
(standard length: 2m)
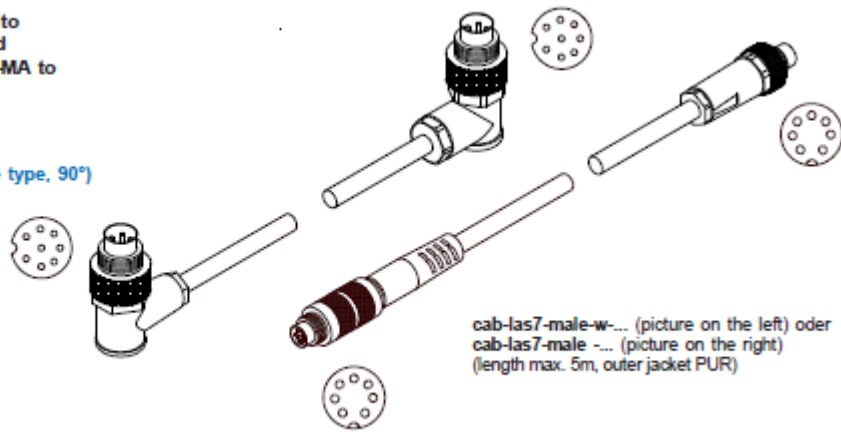
cab-las7-male-w-... (picture on the left) oder
cab-las7-male -... (picture on the right)
(length max. 5m, outer jacket PUR)

Connection L-LAS-TB/90-(8)-T to
L-LAS-TB-8-CON1-MA, /-SL:

Connecting cable:
cab-las3-male-(length) or
cab-las3-male-w-(length) (angle type, 90°)
(standard length: 2m)
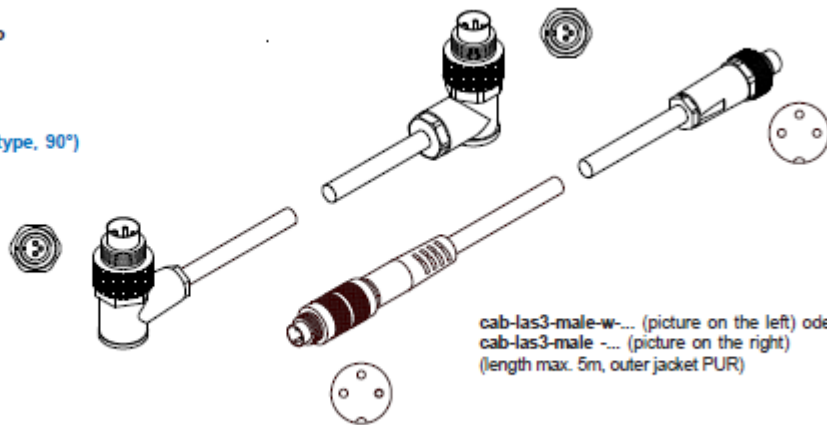
cab-las3-male-w-... (picture on the left) oder
cab-las3-male -... (picture on the right)
(length max. 5m, outer jacket PUR)

## 6.6    RS232 interface protocol

---

### RS232 interface protocol PC ⇔ L-LAS-TB-...-MA sensor
### Firmware version 3.03

- Standard RS232 serial interface, no hardware handshake
- 3-wire-connection: GND, TXD, RXD
- Speed: 19200 Baud,
- 8 data-bits
- No parity-bit,
- 1 stop-bit,
- binary-mode

The control device (PC or PLC) have to send a frame of *18-words (1 word = 2 byte = 16 bit)* to the *L-LAS-TB-...-MA* hardware. All words must be transmitted in binary format. The most significant byte must be transmitted first (MSB-first).

METHOD:
The microcontroller of the *L-LAS-TB* sensor is permanently reading (polling) the input-buffer of the RS-232 module. If the incoming word = *0x0055 (0x55 hexadecimal = 85 decimal),* this is interpreted as the synchronisation-event ( **<sync-word>** ). After this, the 2.nd word with the order number ( **<order-word>** ) is read in by the microcontroller.

The order word (**<order-word>**), is followed by a further word, which contents parameter-set number 0 or 1 ( **<para-set>** ). The para-set-word is followed by 15 further words  **<parameter-word>,** which contents the actual parameters.

After reading the complete data-frame (18-words = 36 bytes), the *L-LAS-TB* sensor-hardware executes the order which is coded at the 2.nd word ( **<order-word>** ) of the data-frame (c.f. order-table).

---

DATA FRAME:   PC/PLC ➡   SENSOR (18-Words=36Bytes, MSB first)

<para-set>=0
<order-word>=5
<sync.-word>

<15 parameter>

| 0x55 | 5 | 0 | 1 | 2 | ... | 13 | 14 | 15 |

1           4                18

---

| | Format of the data-frame: &lt;para-set = 0&gt; GENERAL-PARAMETER | |
|---|---|---|
| **Wort No.** | **Meaning** | **Comment** |
| **1** | &lt;sync-word&gt; | hex-code 0x55, binary=0000 0000 0101 0101, dec.=85 |
| **2** | &lt;order-word&gt; | Order word |
| **3** | &lt;para-set&gt; = 0 | 0 = parameter set GENERAL |
| **4** | EVALMODE | Evaluation mode<br>(0=SLAVE, 1=MASTER, 2=WIDTH, 3=CENTER, 4=DIFF) |
| **5** | TRIGGERMODE | Trigger mode<br>(0=CONTINUOUS, 1=EXT-IN0-L/H, 2=EXT-IN0-HIGH, 3=INTERN) |
| **6** | ANAMODE | Analog output mode:<br>(0=DIRECT 0..10V, 1=MAXIMA, 2=MINIMA, 3=MAX-MIN) |
| **7** | HWMODE | Enable/disable TOL-potentiometer and button at housing:<br>(0=DISABLE ALL, 1=ENABLE-ALL, 2=EN.-BTN, 3=EN.-POTI) |
| **8** | AVERAGE | Average setting ( 1,2,4,8,16,32,64,128, or 256 ) |
| **9** | POLARITY | Output polarity (0=DIRECT, 1=INVERS) |
| **10** | TOLLO | Lower tolerance value (1 ... MAXPIXEL) |
| **11** | TOLUP | Upper tolerance value (1 ... MAXPIXEL) |
| **12** | PARA9 | 0, currently not used |
| **13** | PARA10 | 0, currently not used |
| **14** | PARA11 | 0, currently not used |

## Format of the data-frame: <para-set = 0> GENERAL PARAMETER

| Word No. | Meaning | Comment |
|---|---|---|
| 15 | PARA12 | 0, currently not used |
| 16 | PARA13 | 0, currently not used |
| 17 | umSETPOINT LO-WORD | Reference value in micrometer, low-order 16-bit word |
| 18 | umSETPOINT HI-WORD | Reference value in micrometer, high-order 16-bit word |

## Format of the data-frame: <para-set = 1> MASTER PARAMETER

| Word No. | Meaning | Comment |
|---|---|---|
| 1 | <sync-word> = 0x0055 | hex-code 0x55, binary=0000 0000 0101 0101, dec.=85 |
| 2 | <order-word> | Order word (c.f. table below) |
| 3 | <para-set> = 1 | 1 = parameter set MASTER |
| 4 | POWER-MASTER | Output power laser transmitter ( 0 ... 1000) |
| 5 | POWER-MODE-MASTER | Laser transmitter operating mode: 0=STATIC, 1=DYNAMIC |
| 6 | VIDEO-THRESHOLD-MA | Video threshold (0 ... 100) in percent |
| 7 | TEACH-VALUE-MASTER | Teach-in value (Pixel) (0 ... max. number of pixels of CCD line) |
| 8 | EVAL-BEGIN-MASTER | Start of evaluation: Pixel (1 ... E_END-1) |
| 9 | EVAL-END-MASTER | End of evaluation: Pixel (E_BEGIN+1 ... MAXPIXEL of CCD line) |
| 10 | CCD OP-MODE-MASTER | Operating mode CCD line: 0=LOW-GAIN, 1=HIGH-GAIN |
| 11 | TRIGGER-THRESH.-MA | Trigger threshold for INT-TRIGG.: (1 ... MAXPIXEL of CCD line) |
| 12 | Parameter 9 | 0 , currently not used |
| 13 | Parameter 10 | 0 , currently not used |
| 14 | Parameter 11 | 0 , currently not used |
| 15 | SLOPE VALUE L-WORD MA | Sensitivity Master (x 1024), low-order 16-bit-word |
| 16 | SLOPE VALUE H-WORD MA | Sensitivity Master (x1024), high-order 16-bit-word |
| 17 | REF-OFFSET L-WORD MA | 0, currently not used |
| 18 | REF-OFFSET H-WORD MA | 0, currently not used |

## Format of the data-frame: <para-set = 2> SLAVE-PARAMETER

| Word No. | Meaning | Comment |
|---|---|---|
| 1 | <sync-word> = 0x0055 | hex-code 0x55, binary=0000 0000 0101 0101, dec.=85 |
| 2 | <order-word> | Order word (c.f. table below) |
| 3 | <order-word> = 2 | 2 = parameter set MASTER |
| 4 | POWER-SLAVE | Output power laser transmitter (0 ... 1000) |
| 5 | POWER-MODE-SLAVE | Operating mode laser transmitter: 0=STATIC, 1=DYNAMIC |
| 6 | VIDEO-THRESHOLD-SL | Video threshold (0 ... 100) in percent |
| 7 | TEACH-VALUE-SLAVE | Teach-in value (Pixel) (0 ... max. number of pixel of CCD line) |
| 8 | EVAL-BEGIN-SLAVE | Start of evaluation: Pixel (1 ... E_END-1) |
| 9 | EVAL-END-SLAVE | End of evaluation: Pixel (E_BEGIN+1 ... MAXPIXEL of CCD line) |
| 10 | CCD OP-MODE-SLAVE | Operating mode CCD line: 0=LOW-GAIN, 1=HIGH-GAIN |
| 11 | TRIGGER-THRESH.-SL | Trigger threshold for INT-TRIGG.: (1 ... MAXPIXEL of CCD line) |
| 12 | Parameter 9 | 0 , currently not used |
| 13 | Parameter 10 | 0 , currently not used |
| 14 | Parameter 11 | 0 , currently not used |
| 15 | SLOPE VALUE L-WORD SL | Sensitivity Slave (x 1024), low-order 16-bit-word |
| 16 | SLOPE VALUE H-WORD SL | Sensitivity Slave (x1024), high-order 16-bit-word |
| 17 | REF-OFFSET L-WORD SL | 0, currently not used |
| 18 | REF-OFFSET H-WORD SL | 0, currently not used |

| Meaning of the 2.nd word of the data-frame: <order-word> | | |
|---|---|---|
| **Value** | **Meaning / Action** | |
| 0 | Nop | no operation |
| 1 | Send parameter from PC to L-LAS-RAM | 18 words, PC ⇒ L-LAS-RAM |
| 2 | Get parameter from L-LAS-RAM | 18 words, L-LAS-RAM ⇒ PC |
| 3 | Send parameter from PC to EEPROM | 18 words, PC ⇒ L-LAS-EEPROM |
| 4 | Get parameter from EEPROM of L-LAS | 18 words, L-LAS-EEPROM ⇒ PC |
| 5 | Echo check: Get echo of L-LAS hardware,line Ok = 0xAA | 18 words, first word=0x00AA (echo=170) |
| 6 | Activate teach, store in RAM | 18 words PC ⇒ L-LAS-RAM |
| 7 | Get firmware version info of L-LAS | 72-bytes, L-LAS ⇒ PC |
| **8** | **Get measured values from L-LAS-RAM** | **18 words, L-LAS-RAM ⇒ PC** |
| 9 | Get video-buffer info from L-LAS | 64 words, L-LAS-RAM ⇒ PC |
| 10 | Get hardware information from L-LAS | 18 words L-LAS-RAM ⇒ PC |
| 11 | Reset maximum/minimum values | 18 words PC ⇒ L-LAS-RAM |

**Examples for the data-transfer**:

| Echo check: <order-word>=5 |
|---|
| **<order-word> = 5**<br>Echo check: L-LAS-TB-...-MA sensor sends echo:  word=0xAA=170 to PC<br><br>**DATA FRAME:**  **PC** → **SENSOR**  (18-Words=36Bytes, MSB first)<br><para-set>=0<br><order-word>=2<br><sync.-word><br>                    4                    15  16  17  18<br>0x55  5  0  0  0  0  • • •  0  0  0  0<br><br>**DATA FRAME:**  **SENSOR** → **PC**  (18-Words=36Bytes, MSB first)<br>ECHO=0xAA=170<br><sync.-word><br>                    4                    15  16  17  18<br>0x55  170  0  0  0  0  • • •  0  0  0  0 |
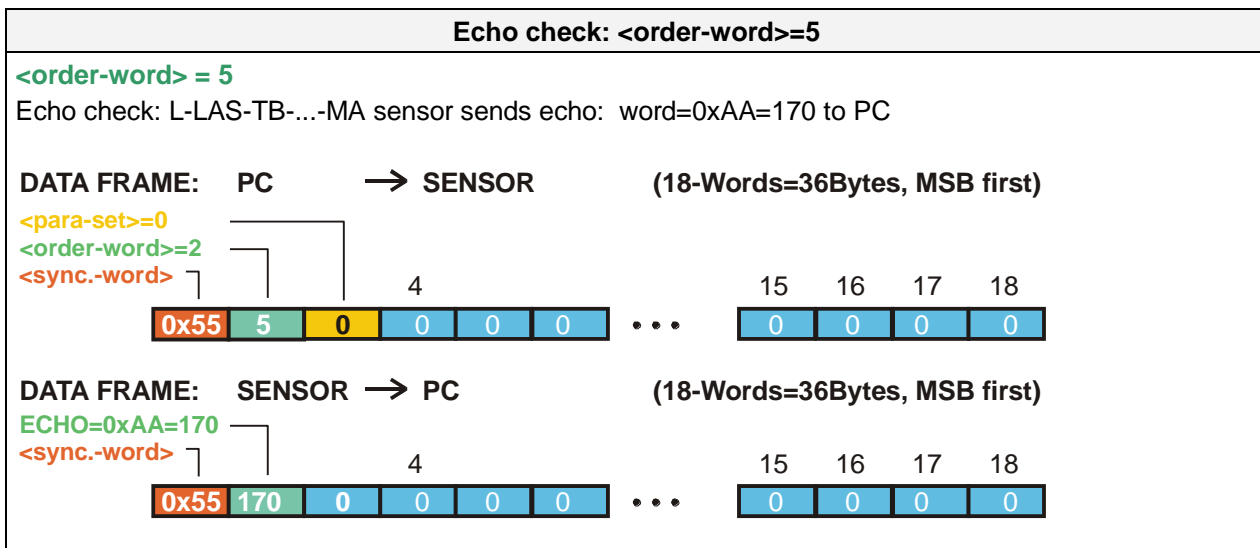
## SEND parameter-set = 0 to L-LAS-RAM  <order-word>=1
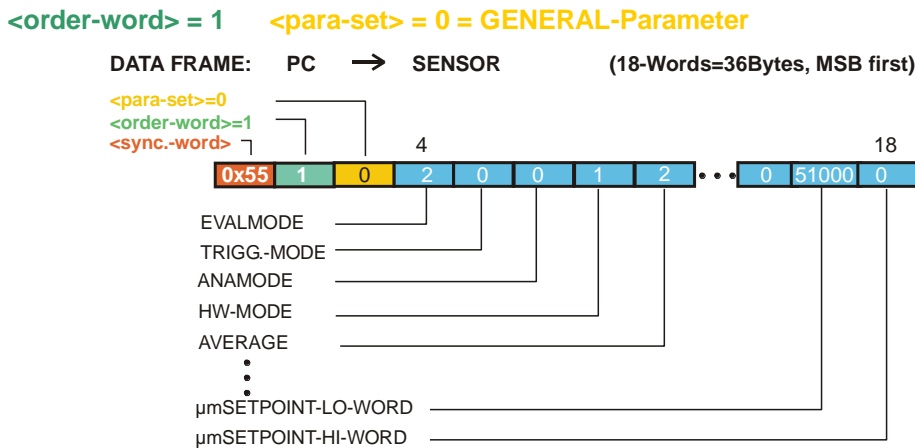
**<order-word> = 1    <para-set> = 0 = GENERAL-Parameter**

DATA FRAME:    PC  →  SENSOR        (18-Words=36Bytes, MSB first)

<para-set>=0
<order-word>=1
<sync.-word>

|      |   |   | 4 |   |   |   |   |     |   | 18 |   |
|------|---|---|---|---|---|---|---|-----|---|-------|---|
| 0x55 | 1 | 0 | 2 | 0 | 0 | 1 | 2 | ••• | 0 | 51000 | 0 |

EVALMODE
TRIGG.-MODE
ANAMODE
HW-MODE
AVERAGE
⋮
µmSETPOINT-LO-WORD
µmSETPOINT-HI-WORD

The transmitted data frame is automatically echoed back by the L-LAS-TB-...-MA sensor!!

## SEND parameter-set = 1 to L-LAS-RAM  <order-word>=1
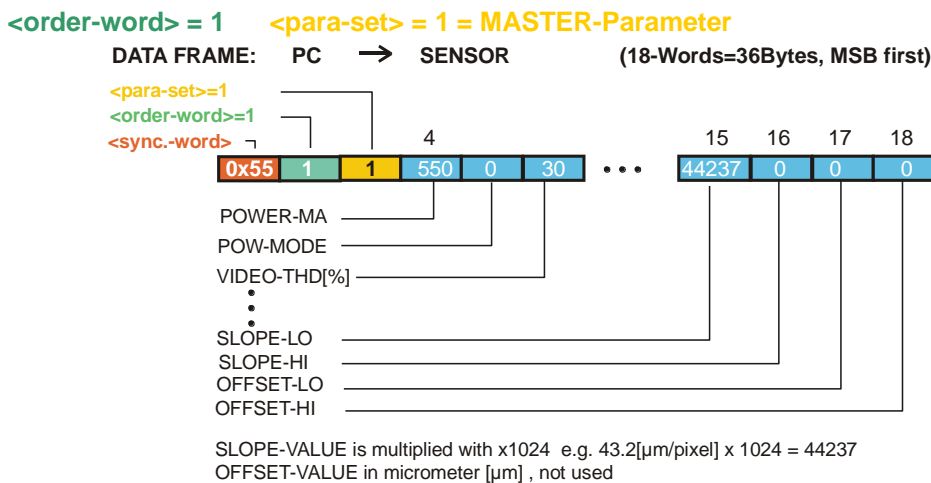
**<order-word> = 1    <para-set> = 1 = MASTER-Parameter**

DATA FRAME:    PC  →  SENSOR        (18-Words=36Bytes, MSB first)

<para-set>=1
<order-word>=1
<sync.-word>

|      |   |   | 4 |   |    |     | 15 | 16 | 17 | 18 |
|------|---|---|---|---|----|-----|-------|----|----|----|
| 0x55 | 1 | 1 | 550 | 0 | 30 | ••• | 44237 | 0 | 0 | 0 |

POWER-MA
POW-MODE
VIDEO-THD[%]
⋮
SLOPE-LO
SLOPE-HI
OFFSET-LO
OFFSET-HI

SLOPE-VALUE is multiplied with x1024  e.g. 43.2[µm/pixel] x 1024 = 44237
OFFSET-VALUE in micrometer [µm] , not used

The transmitted data frame is automatically echoed back by the L-LAS-TB-...-MA sensor!!

## SEND parameter-set = 2 to L-LAS-RAM  <order-word>=1

**<order-word> = 1    <para-set> = 2 = SLAVE-Parameter**

DATA FRAME:    PC  →  SENSOR        (18-Words=36Bytes, MSB first)

<para-set>=2
<order-word>=1
<sync.-word>

|      |   |   | 4 |   |    |     | 15 | 16 | 17 | 18 |
|------|---|---|---|---|----|-----|-------|----|----|----|
| 0x55 | 1 | 2 | 450 | 0 | 25 | ••• | 44237 | 0 | 0 | 0 |

POWER-SL
POW-MODE
VIDEO-THD [%]
⋮
SLOPE-LO
SLOPE-HI
OFFSET-LO
OFFSET-HI

SLOPE-VALUE is multiplied with x1024  e.g. 43.2[µm/pixel] x 1024 = 44237
OFFSET-VALUE in micrometer [µm] , not used
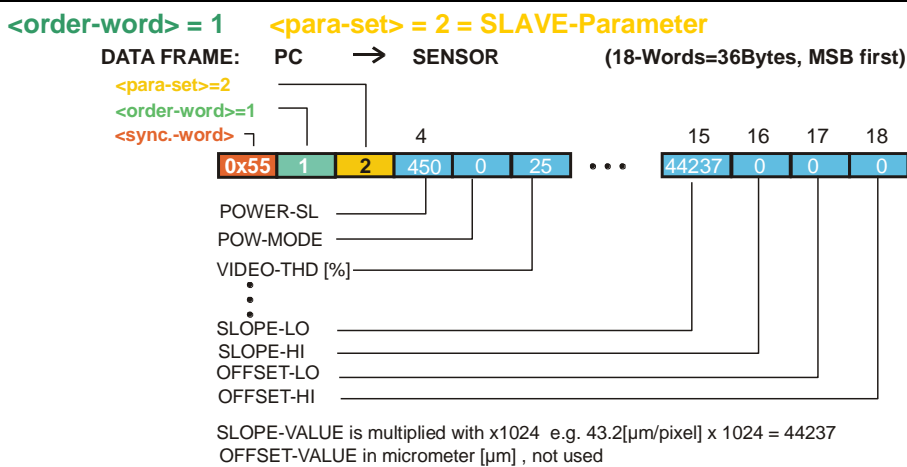
The transmitted data frame is automatically echoed back by the L-LAS-TB-...-MA sensor!!

## GET parameter-set = 0 of L-LAS-RAM  <order-word>=2

**<order-word> = 2     <para-set> = 0 = GENERAL-parameter**

DATA FRAME:   PC  → SENSOR     (18-Words=36Bytes, MSB first)

<para-set>=0
<order-word>=2
<sync.-word>

| 0x55 | 2 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 |

(columns 4 ... 15 16 17 18)

DATA FRAME:   SENSOR → PC     (18-Words=36Bytes, MSB first)

<para-set>=0
<order-word>=2
<sync.-word>

| 0x55 | 2 | 0 | 2 | 1 | 1 | ... | 0 | 51000 | 0 |

(columns 4 ... 16 17 18)

POWER
TRIGG-MODE
ANAMODE
:
PARA13
umSETPOINT-LO-WORD
umSETPOINT-HI-WORD
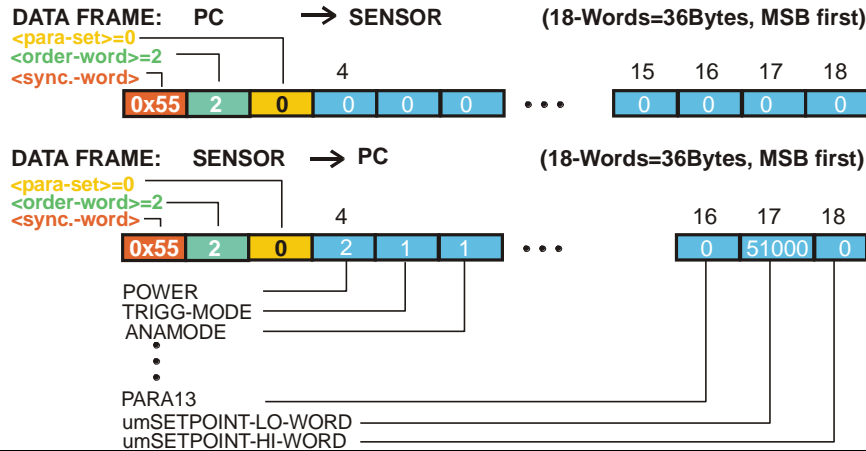
## GET parameter-set = 1 of L-LAS-RAM  <order-word>=2

**<order-word> = 2     <para-set> = 1 = MASTER- Parameter**

DATA FRAME:   PC  → SENSOR     (18-Words=36Bytes, MSB first)

<para-set>=1
<order-word>=2
<sync.-word>

| 0x55 | 2 | 1 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 |

(columns 4 ... 15 16 17 18)

DATA FRAME:   SENSOR → PC     (18-Words=36Bytes, MSB first)

<para-set>=1
<order-word>=2
<sync.-word>

| 0x55 | 2 | 1 | 550 | 0 | 30 | ... | 44237 | 0 | 0 | 0 |

(columns 4 ... 15 16 17 18)

POWER-MA
POW-MODE
VIDEO-THD [%]
:
SLOPE-LO
SLOPE-HI
OFFSET-LO
OFFSET-HI

SLOPE-VALUE is multiplied with x1024  e.g. 43.1[µm/pixel] x 1024 = 44237
OFFSET-VALUE in micrometer [µm], not used
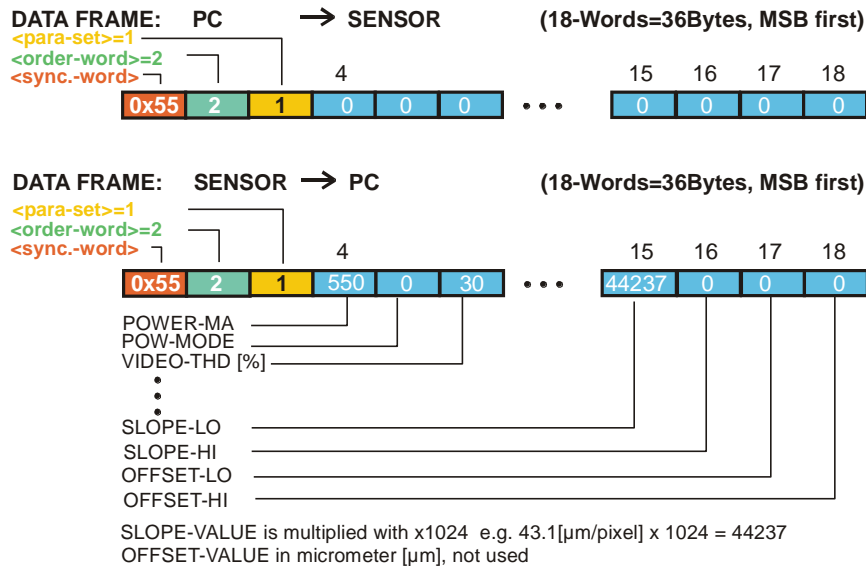
## GET parameter-set = 2 of L-LAS-RAM  <order-word>=2

**<order-word> = 2     <para-set> = 2 = MASTER- Parameter**

DATA FRAME:   PC  → SENSOR     (18-Words=36Bytes, MSB first)

<para-set>=2
<order-word>=2
<sync.-word>

| 0x55 | 2 | 2 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 |

(columns 4 ... 15 16 17 18)

DATA FRAME:   SENSOR → PC     (18-Words=36Bytes, MSB first)

<para-set> = 2
<order-word> = 2
<sync.-word>

| 0x55 | 2 | 2 | 550 | 0 | 30 | ... | 44237 | 0 | 0 | 0 |

(columns 4 ... 15 16 17 18)

POWER-MA
POW-MODE
VIDEO-THD [%]
:
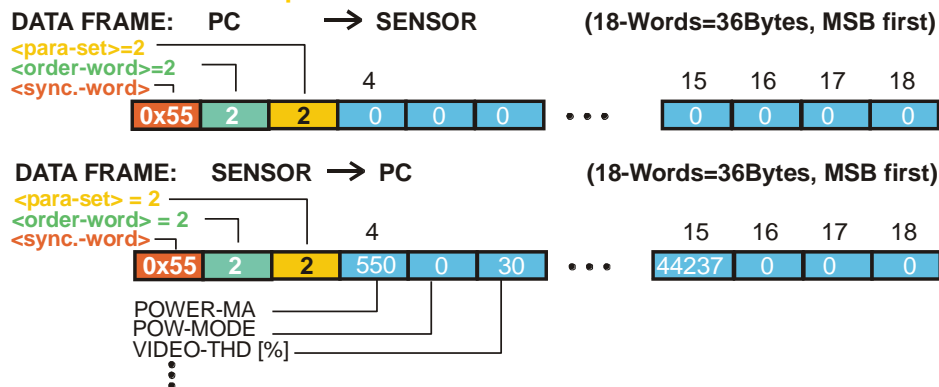
## TEACH FUNCTION at L-LAS <order-word>=6

<order-word> = 6    <para-set> = 0

DATA FRAME:    PC  →  SENSOR        (18-Words=36Bytes, MSB first)

<para-set>=0
<order-word>=6
<sync.-word>

| | | | | 4 | | | | 15 | 16 | 17 | 18 |

0x55 | 6 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0

The current data frame is automatically echoed back!

## RESET of minimum/maximum values at L-LAS <order-word>=6

<order-word> = 11    <para-set> = 0

DATA FRAME:    PC  →  SENSOR        (18-Words=36Bytes, MSB first)

<para-set>=0
<order-word>=11
<sync.-word>

| | | | | 4 | | | | 15 | 16 | 17 | 18 |

0x55 | 11 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0

The current data frame is automatically echoed back!

## GET measured value of L-LAS-RAM  <order-word>=8

<order-word> = 8    <para-set> = 0

DATA FRAME:    PC  →  SENSOR        (18-Words=36Bytes, MSB first)

<para-set>=0
<order-word>=8
<sync.-word>

| | | | | 4 | | | | 15 | 16 | 17 | 18 |

0x55 | 8 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0

DATA FRAME:    SENSOR → PC        (18-Words=36Bytes, MSB first)

<Para-set>= X
<order-word> = 8
<sync.-word>

| | | | | 4 | | | | | | | | | | | 15 | 16 | 17 | 18 |

0x55 | 8 | 1052 | 1278 | 1165 | 10049 | 1 | 422 | 2 | 2 | 20 | 30 | 2500 | 800 | 800 | 600 | 0 | 0

MVAL-MASTER
MVAL-SLAVE
M-VALUE
µm_VALUE (LowWord)
µm_VALUE (HighWord)
TOL-POTI-VALUE
NUMBER-OF-EDGE-MA
NUMBER-OF-EDGE-SL
WIDTH-MASTER-PEAK
WIDTH-SLAVE-PEAK
MAX-VALUE
MIN-VALUE
TEACH-VAL-MASTER
TEACH-VAL-SLAVE
FREE-USE
DIG-INPUT-STATE
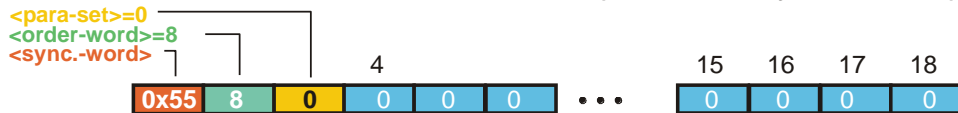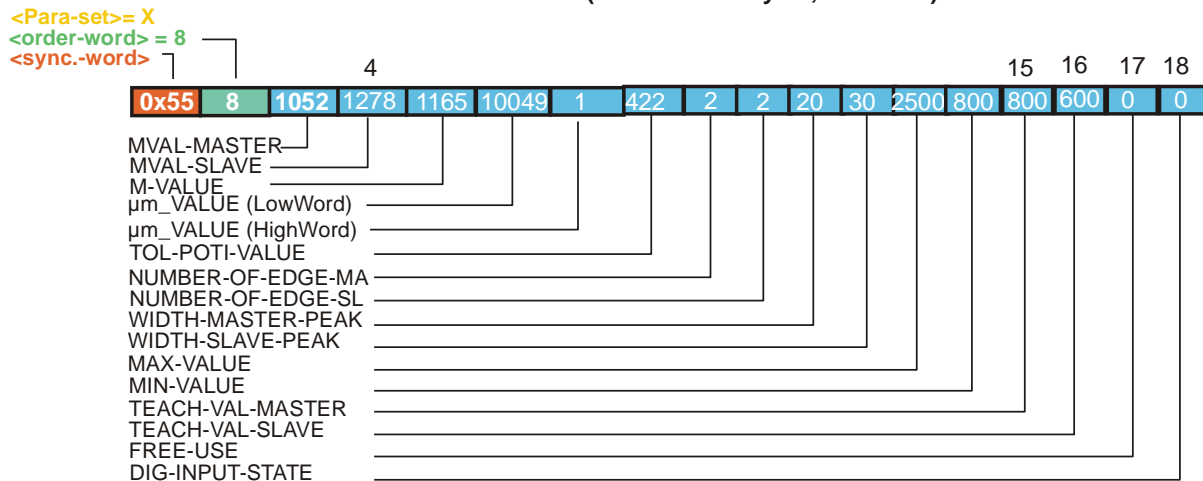
Example µm-VALUE: 75.584mm = 75584µm = LowWord (10049) + HighWord (1x65535)

## Get video data of L-LAS-RAM  <order-word> = 9

<order-word> = 9     <para-set> = 0 or 64,  <block-info> 0 or 1

**Step1: DATA FRAME:  PC  ⟶  L-LAS-sensor    (18-Words=36Bytes, MSB first)**

<order-word>=9
<sync.-word>
<index> = 0 (first-64-word-block)
<block> = 0 (MASTER-data)
18

| 0x55 | 9 | 0 | 0 | 0 | ••• | 0 | 0 | 0 |

**DATA FRAME:  L-LAS-sensor  ⟶  PC    (64-Words = 128Byte, MSB first)**

1   2   3                                                     64

| A1 | A2 | A3 | A4 | A5 | A6 | A7 | ••• | A62 | A62 | A63 | A64 |

First block of 64 words = the first half of the pixel at MASTER CCD.

Attention: Not every single pixel of the MASTER CCD is transmitted

**Step2: DATA FRAME:  PC  ⟶  L-LAS-sensor    (18-Words=36Bytes, MSB first)**

1
<block-index> = 64
18

| 0x55 | 9 | 64 | 0 | 0 | ••• | 0 | 0 | 0 |

**DATA FRAME:  L-LAS-sensor  ⟶  PC    (64-Words = 128Byte, MSB first)**

1   2   3                                                     64

| A65 | A66 | A67 | A68 | A69 | A70 | A71 | ••• | A127 | A128 |

2nd. block of 64 words: = second half of pixel at MASTER
Attention: Not every single pixel of the MASTER CCD is transmitted

**Step3: DATA FRAME:  PC  ⟶  L-LAS-sensor    (18-Words=36Bytes, MSB first)**

1
<index> = 0
18

| 0x55 | 9 | 0 | 1 | 0 | ••• | 0 | 0 | 0 |

<block> = 1 (SLAVE-data)

**DATA FRAME:  L-LAS-sensor  ⟶  PC    (64-Words = 128Byte, MSB first)**

1   2   3                                                     64

| B1 | B2 | B3 | B4 | ••• | B63 | B64 |

1st. block of 64 words = first half of the pixel at SLAVE CCD
Attention: Not every single pixel of the SLAVE CCD is transmitted !

**Step4: DATA FRAME:  PC  ⟶  L-LAS-sensor    (18-Words=36Bytes, MSB first)**

<index> = 64
18

| 0x55 | 9 | 64 | 1 | 0 | ••• | 0 | 0 | 0 |

<block> = 1 (SLAVE-data)

**DATA FRAME:  L-LAS-sensor  ⟶  PC    (64-Words = 128Byte, MSB first)**

1   2   3                                                     64

| B65 | B66 | B67 | B68 | ••• | B127 | B128 |

2nd. block of 64 words:= second half of pixel at SLAVE CCD
Attention: Not every single pixel of the SLAVE CCD is transmitted !