

Manual

Software L-LAS-LT-Scope V4.0

(PC software for Microsoft® Windows 7, Vista, XP)

for laser line sensors of L-LAS-LT series



STANDARD:

L-LAS-LT-37
L-LAS-LT-55
L-LAS-LT-80
L-LAS-LT-110
L-LAS-LT-135
L-LAS-LT-160
L-LAS-LT-200
L-LAS-LT-275
L-LAS-LT-450
L-LAS-LT-1000

COMPACT LINE (CL):

L-LAS-LT-20-CL
L-LAS-LT-38-CL
L-LAS-LT-50-CL
L-LAS-LT-120-CL
L-LAS-LT-157-CL
L-LAS-LT-165-CL
L-LAS-LT-250-CL

XL LINE (XL):

L-LAS-LT-800-XL
L-LAS-LT-1200-XL

0 Contents

| | | |
|----------|---|-----------|
| 0 | Contents | 2 |
| 1 | Functional principle: L-LAS-LT line sensors | 3 |
| 1.1 | Technical description | 3 |
| 2 | Installation of the L-LAS-LT-Scope software | 4 |
| 3 | Operation of the L-LAS-LT-Scope software | 5 |
| 3.1 | Control elements of the L-LAS-LT-Scope software: | 6 |
| 3.2 | Numeric and graphic display elements:..... | 15 |
| 3.3 | Serial RS232 data transfer:..... | 17 |
| 3.4 | Data transfer through the external RS232 to Ethernet adapter: | 19 |
| 3.5 | L-LAS-LT-Scope as an aid for sensor adjustment:..... | 20 |
| 3.6 | L-LAS-LT-Scope as an aid for transmitter power adjustment:..... | 21 |
| 4 | Evaluation modes | 22 |
| 4.1 | LEFT-EDGE | 22 |
| 4.2 | RIGHT-EDGE | 22 |
| 4.3 | CENTER | 22 |
| 4.4 | WIDTH | 23 |
| 5 | Data recorder function | 24 |
| 5.1 | Data format of the output file | 25 |
| 5.2 | 3-byte RS232 data transfer | 26 |
| 6 | CMOS calibration | 28 |
| 7 | Annex | 29 |
| 7.1 | Laser warning | 29 |
| 7.2 | Function of the TEACH/RESET button..... | 29 |
| 7.3 | Function of the TOLERANCE potentiometer | 29 |
| 7.4 | Function of digital inputs IN0 and IN1 | 30 |
| 7.5 | Connector assignment..... | 31 |
| 7.6 | RS232 interface protocol | 33 |

1 Functional principle: L-LAS-LT line sensors

1.1 Technical description

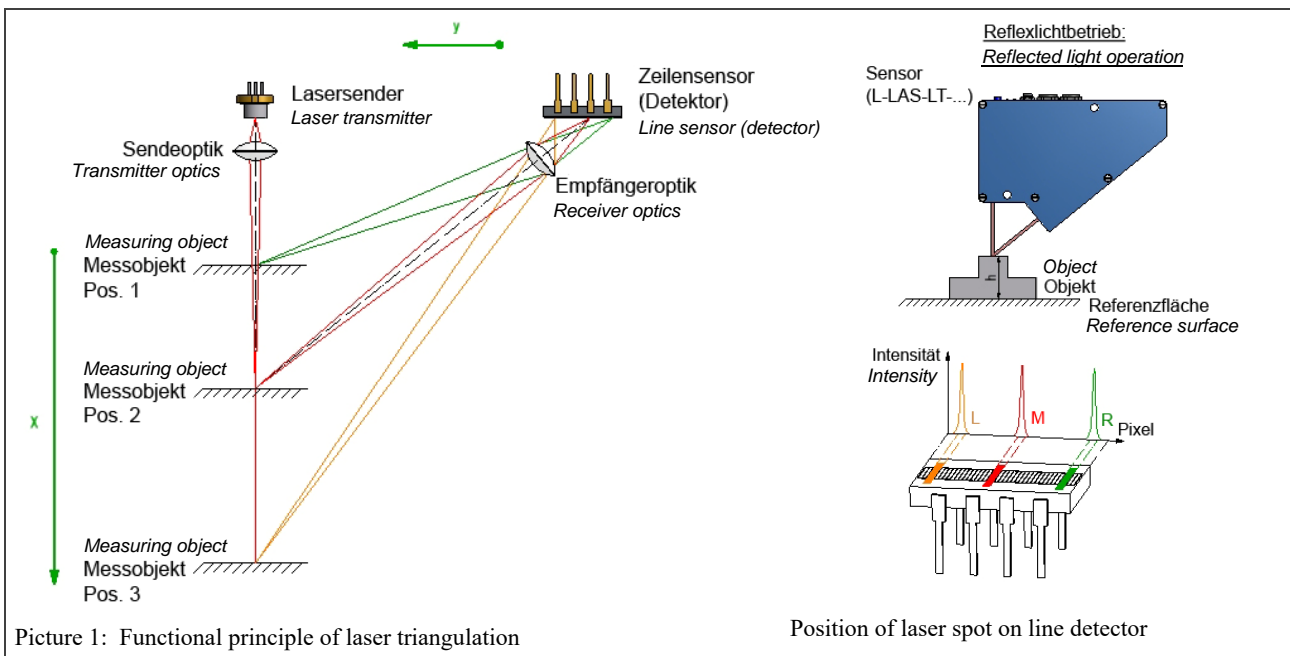
In the laser line sensors of the *L-LAS-LT* series the laser beam of a laser diode ($\lambda=670\text{nm}$, 1mW power, laser class 2) through suitable collimators and apertures is emitted from the optical transmitter unit as a parallel laser beam with homogeneous light distribution. After being reflected from the object surface, the laser light impinges on the CMOS line receiver of the optical receiver unit. This CMOS 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.

Depending on the object distance the laser light that is scattered back from the measuring object (triangulation principle) will only illuminate certain receiver elements (pixels) on the line. Compared to the non-illuminated pixels these pixels will output a considerably higher analog voltage (intensity maxima). By way of suitable software algorithms the areas of the illuminated zones can be determined from the previously stored data field. Since the distance of the pixels on the CMOS line is known, the position and distance of the measuring object can therefore be determined (cf. picture 1).

The micro-controller of the *L-LAS-LT* sensor can be parameterized through the serial RS232 interface by means of a Windows PC software. This allows the setting of various evaluation and operating modes. The housing of the control unit features a TEACH/RESET [1] 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-LT* sensor. The control unit that is integrated in the sensor has three digital outputs [2] (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.

[1] not available with all model ranges

[2] CL and XL types have two digital outputs OUT0, OUT1





2 Installation of the *L-LAS-LT-Scope* software

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

- 1 GHz Pentium-compatible processor or better.
- CD-ROM or DVD-ROM drive
- Approx. 25 MByte of free hard disk space
- SVGA graphics card with at least 800x600 pixel resolution and 256 colors or higher.
- Windows® XP, Windows® Vista, Windows® 7, or Windows® 8 operating system
- Free serial RS232 interface or USB port with USB-RS/232 adaptor at the PC

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

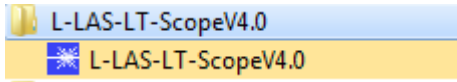
1.  CD-Laufwerk (D:) Insert the installation CD-ROM in your CD-ROM drive. In our example we suppose that this is drive "D".

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.

3. During the installation process a new program group for the software is created in the Windows Program Manager. In the program group an icon for starting the software is created automatically. When installation is successfully completed the installation program displays "Setup OK".

4. The *L-LAS-LT-Scope* software can then be started with a mouse click on the respective symbol in the new program group under:
Start >All Programs > L-LAS-LT-ScopeV4.0



Deinstallation of the *L-LAS-LT-Scope* software:

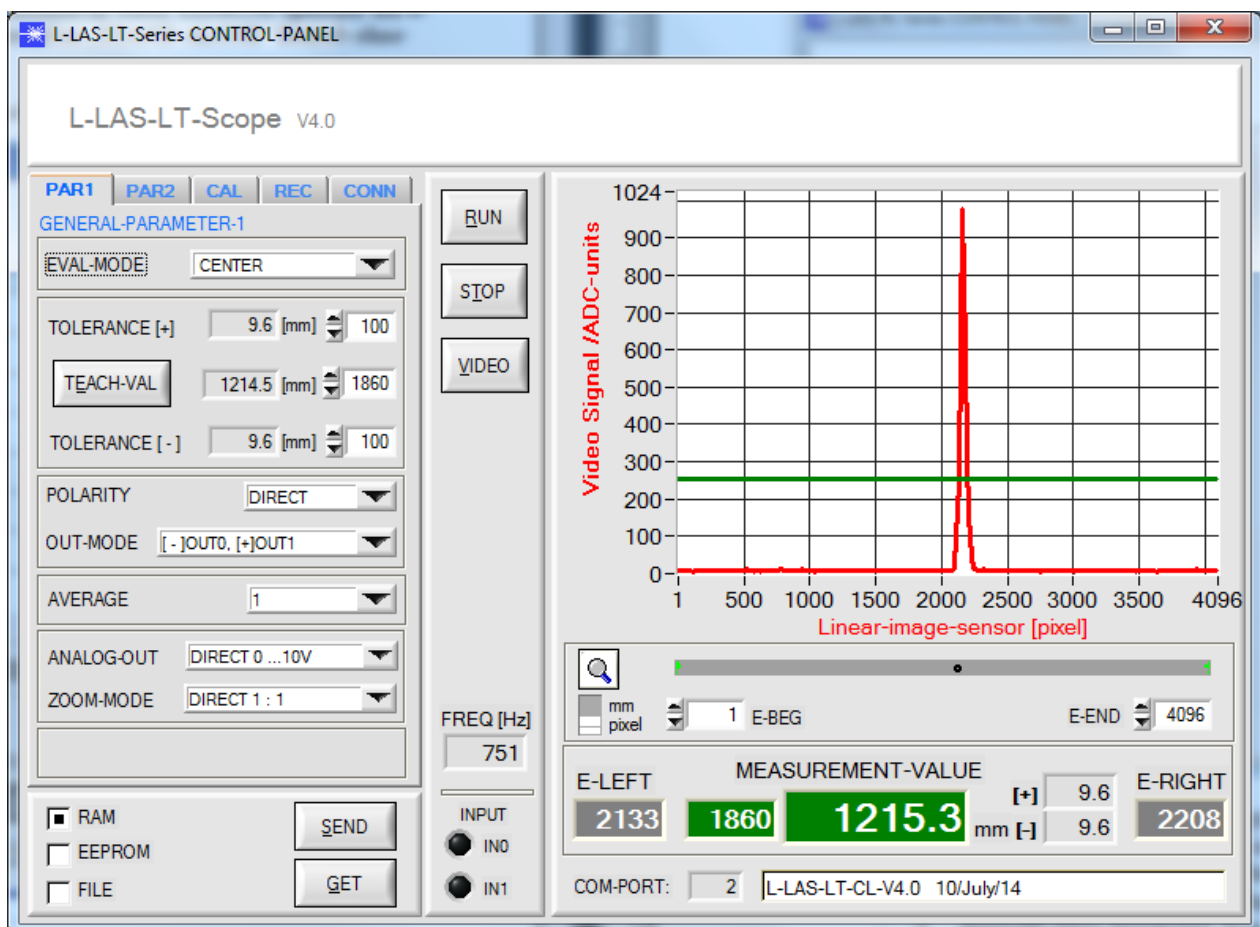
| | |
|--|---|
|  <div style="border: 1px solid lightblue; padding: 5px; display: inline-block;"> Programme und Funktionen </div> | <p>Please use the Windows® deinstallation tool to remove the software.</p> <p>The Windows deinstallation tool can be found under Start / Settings / Control Panel</p> |
|--|---|

3 Operation of the *L-LAS-LT-Scope* software

The *L-LAS-LT-Scope* software is used for parameterizing the electronic control unit of the *L-LAS-LT* line sensors through the serial interface. The measured values provided by the sensor 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-LT control unit*. The sensor system then continues to operate in "STAND-ALONE" mode without PC.

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

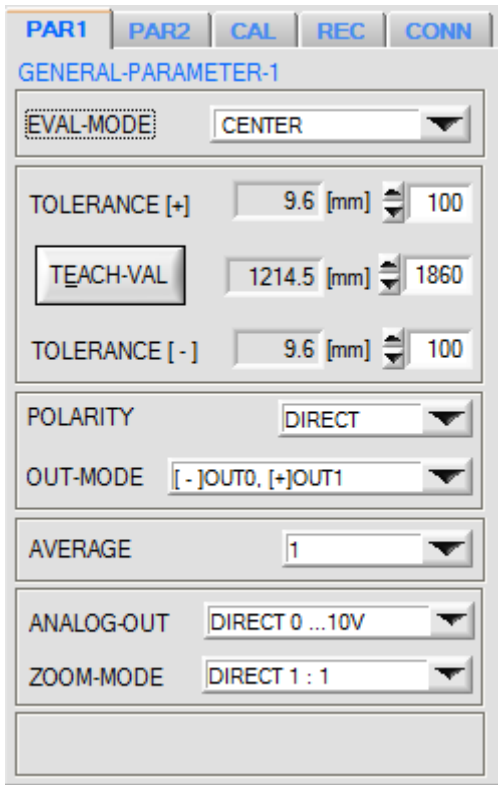


The *L-LAS-LT-Scope* CONTROL PANEL provides a great variety of functions:

- Visualization of measurement data 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. [3]
- [3] CL and XL types have two digital outputs OUT0, OUT1
- 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-LT-Scope* software.

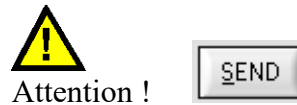
3.1 Control elements of the L-LAS-LT-Scope software:



PAR1 TAB:

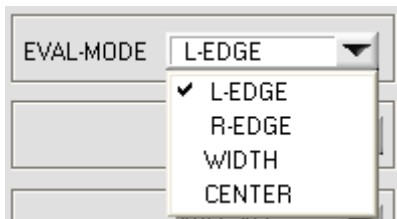
A click on the PAR1 button opens the PARAMETER-1 window on the user interface.

This window is used for setting various parameters at the control unit.



Attention !

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



EVAL-MODE:

This list selection field is used to set the evaluation mode at the *L-LAS-sensor*. Depending on the evaluation mode that is currently set the edges obtained from the video signal (intensity profile) of the CMOS line will be evaluated differently.

L-EDGE:

The first edge starting from the first pixel (left edge) of the intensity profile of the CMOS line is used as measurement value.

R-EDGE:

The first edge starting from the last pixel (right edge) of the intensity profile of the CMOS line is used as measurement value.

WIDTH:

The width of the intensity maximum occurring at the CMOS line is calculated from the video image with the help of the video threshold.

CENTER (recommended mode):

The average between the first and the last edge is used as measurement value: $CENTER = (L-EDGE + R-EDGE) / 2$

| | | |
|------------------|-------------|------|
| TOLERANCE [+] | 9.6 [mm] | 100 |
| TEACH-VAL | 1214.5 [mm] | 1860 |
| TOLERANCE [-] | 9.6 [mm] | 100 |

TOLERANCE-HIGH[+], TOLERANCE-LOW [-]:

In these input fields an upper and lower default value for the tolerance window (pixel values) can be set by entering numerical values or by clicking on the arrows. The tolerance window is applied around the setpoint value (TEACH-VALUE) and is framed by the upper and lower tolerance threshold.

The tolerance values in [mm] that are currently set at the *L-LAS-LT sensor* are displayed beside the pixel input elements.

| | |
|----------|--------|
| POLARITY | DIRECT |
|----------|--------|

POLARITY:

In this function field the output polarity at the *L-LAS-LT sensor* can be set with a mouse-click on the input field or by clicking on the arrow button. The L-LAS-LT sensors of -CL or -XL series has 2 digital outputs (OUT0, OUT1), the L-LAS-LT standard 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), (red LED on).

INVERSE:

In case of an error the respective digital output is set to the reference potential (GND,0V), (red LED on).

| | |
|----------|--|
| OUT-MODE | [-]OUT0, [+]OUT1 |
| | <input checked="" type="checkbox"/> [-]OUT0, [+]OUT1 <input type="checkbox"/> [-]OUT0, [OK]OUT1 <input type="checkbox"/> [OK]OUT0, [+]OUT1 |

DIGITAL-OUTPUT MODE:

This list function element is used to set the operating mode at the digital outputs.

With the L-LAS-LT-CL and -XL sensor types both digital outputs can thus be set to provide the "HIGH / LOW / GO" states.

| | |
|---------|---|
| AVERAGE | 2 |
|---------|---|

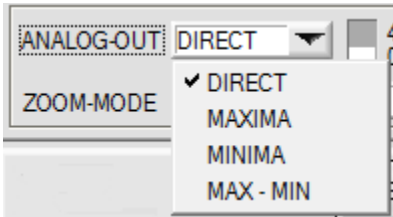
AVERAGE:

In this function field the averaging at the *L-LAS-LT sensor* can be activated 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 1024. The measurement value determined after averaging is provided at the analog output pin8/red/.

Averaging reduces the switching frequency at the *L-LAS-LT sensor* by a factor of 1/AVERAGE.

The current switching frequency is shown in a numeric display element.



ANALOG-OUT (Analog-Output-Mode):

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

DIRECT:

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

MAXIMA:

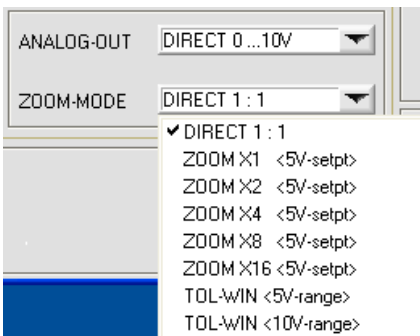
The current maximum value is provided at the analog output pin8/red/ (drag pointer principle, resetting by input IN1/pin4/yellow pulse of <750ms length, or by pressing the Teach/Reset button).

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).



ZOOM-MODE (Analog-Output):

Function element for setting various zoom modes at the analog output of the *L-LAS-LT* sensor.

DIRECT 1:1:

At the analog output pin8/red/ the total measuring range of the sensor is provided as a 0 to 10V voltage swing.

ZOOM X1, ZOOM X2 ... ZOOM X16:

At the analog output pin8/red/ the difference between the current measurement value (pixels) and the teach position (teach value in pixels) is provided. At the teach position a value of 5 V is provided at the analog output. If the current measurement value is lower than the teach position, a voltage < 5V is provided, if the current measurement value is higher than the teach value, a voltage > 5V is provided. The deviation from the 5V teach position can be amplified by a zoom factor of X2 to X16.

TOL-WIN <5V-range>:

At the analog output pin8/red/ a voltage swing of 5V is provided over the current tolerance window. At the lower tolerance limit the voltage value is 2.5V, at the upper tolerance limit 7.5V. A value of 5V is output at the teach position.

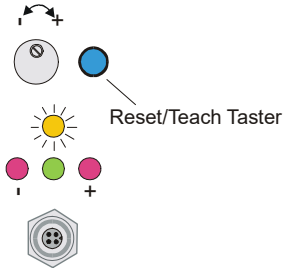
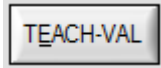
TOL-WIN <10V-range>:

At the analog output pin8/red/ a voltage swing of 10V is provided over the current tolerance window. A value of 5V is output at the teach position, at the lower tolerance limit the voltage value of the analog output is 0V, at the upper tolerance limit 10V.



TEACH-VAL:

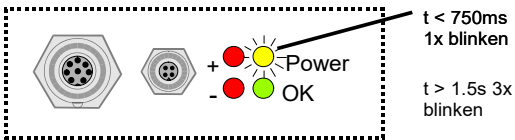
Numeric input field for setting the current teach value (setpoint value) in pixels. The teach value that is set here only is activated at the *L-LAS-LT* sensor when the SEND button is pressed. The teach value is set in pixels. Conversion into [mm] is performed by way of the SLOPE-VALUE (sensitivity – $\mu\text{m}/\text{pixel}$) and the OFFSET value from the sensor's calibration data.



After a click on the TEACH-VAL button the current edge information is written as teach value to the RAM memory of the *L-LAS-LT* sensor.

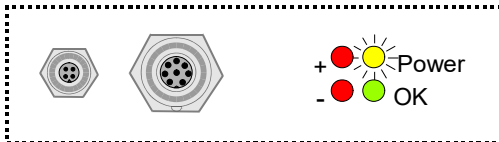
When the teach process is finished the yellow LED at the housing of the *L-LAS-LT* sensor shortly flashes 3 times.

The teach process also can be started by pressing the TEACH/RESET button at the housing (press for $t > 1.5\text{s}$) or by way of a high level at digital input IN1/yellow/pin4 ($t > 1.5\text{s}$).



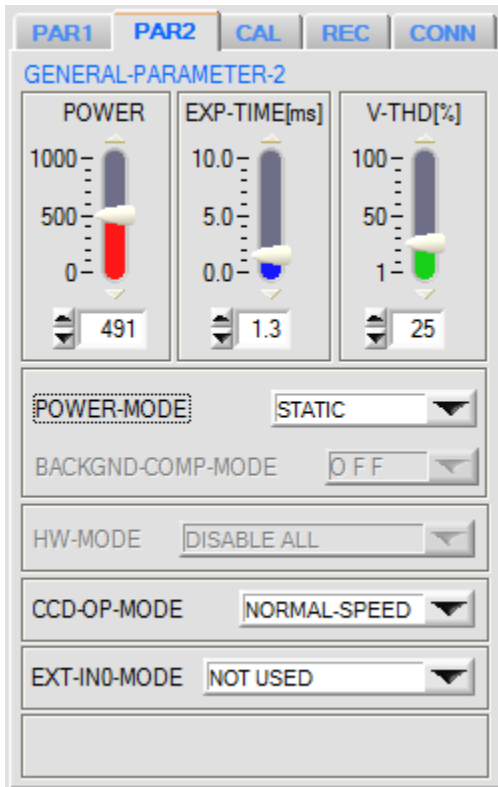
L-LAS-LT-CL housing type

PLC / PC /
POWER RS-232



L-LAS-LT-XL housing type

PC / PLC /
RS-232 POWER



PAR2 TAB:

A click on the PAR2 button opens the PARAMETER-2 window on the user interface.

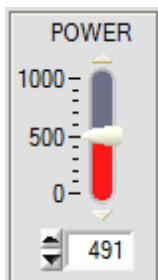
This window is used for setting additional parameters at the control unit.



Attention!

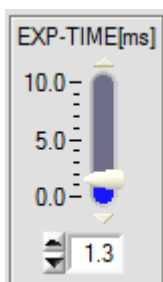


Changes that are made in the function fields described below only become active at the control unit of the L-LAS-LT sensor after a click on the SEND button!



POWER:

In this function field the laser power at the laser transmitter unit of the *L-LAS-LT* sensor can be set by using the arrows, the slider, or by entering a numerical value in the corresponding input field.

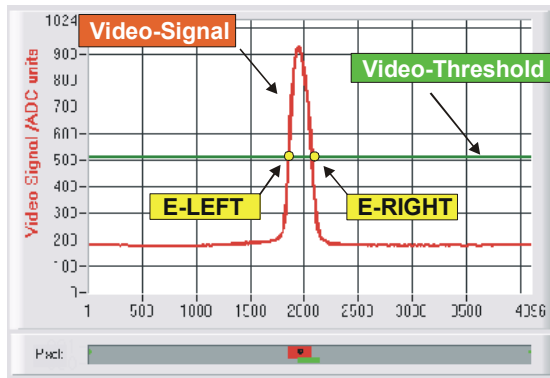
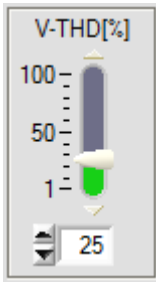


EXPOSURE-TIME[ms]:

In this function field the exposure time at the *L-LAS-LT sensor* can be set by using the arrows, the slider, or by entering a numeric value in the respective input field.

In case of particularly dark or matt surfaces an increase of the exposure time may mean that enough intensity still arrives at the CMOS line.

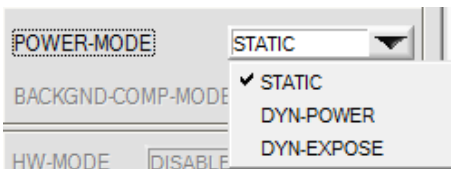
An increase of the exposure time reduces the scan frequency of the sensor. (e.g. 2ms=500Hz, 10ms=100Hz).



VIDEO-THRESHOLD[%]:

In this function field the video threshold at the *L-LAS-LT* 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 CMOS 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 CMOS line. The measurement value can be calculated from this information and from the known distances of the pixels on the CMOS line. The intersection points between intensity profile and video threshold that are provided by this method are hereinafter referred to as edges.



POWER-MODE:

In this list function field the power control mode for the laser transmitter unit of the *L-LAS-LT* sensor can be set.

STATIC:

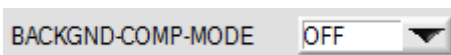
Static (constant) power of the laser transmitter unit.

DYN-POWER:

Laser power is adapted dynamically during operation. Power control attempts to keep the maximum value of the video profile in the range between 700 and 900 ADC units.

DYN-EXPOSE:

In this mode it is not the laser power at the transmitter unit that is controlled, but the exposure time at the CMOS line sensor is adapted dynamically. Dynamic exposure time control attempts to keep the maximum value of the video profile in the range between 700 and 900 ADC units.



BACKGND-COMP-MODE:

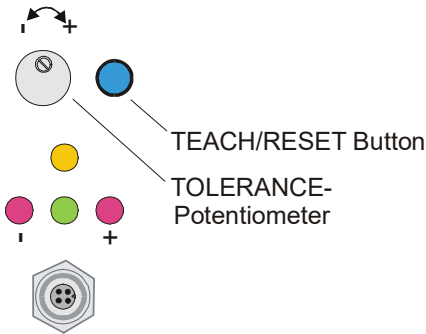
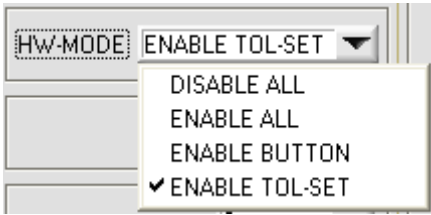
In this list function field the operating mode for background compensation at the *L-LAS-LT* sensor can be set.

OFF:

Background compensation is off.

ON:

The laser transmitter unit is cyclically turned on/off. In off state the "dark video image" is saved. When the laser diode is turned on, the previously saved "dark video image" is mathematically, pixel by pixel, subtracted from the current "bright video image". The resulting video image is evaluated.



HW-MODE (Hardware-Mode) [1]:

The TOLERANCE potentiometer and/or the TEACH/RESET button at the housing of the *L-LAS-LT* 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 TOL-SET, it is not possible to enter numerical values in the TOLERANCE-VALUE input field on the PC software user interface. The corresponding function fields are dimmed.

DISABLE ALL

Both the TEACH/RESET button and the TOLERANCE potentiometer at the sensor 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 ($t < 0.5s$) : RESET.
Button pressed for a longer time ($t > 1.5s$) : TEACH.

ENABLE BUTTON:

Only the TEACH/RESET button at the housing is activated.

ENABLE TOL-SET:

Only the TOLERANCE potentiometer at the housing is activated..

[1] not available with CL and XL models

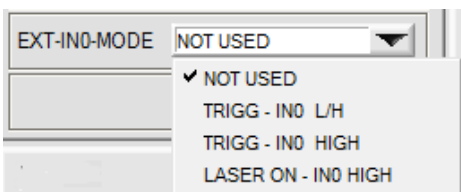


CMOS-OP-MODE:

List selection field for setting the operating mode at the CMOS pixel line sensor.

NORMAL-SPEED: Normal read frequency -> Full resolution

DOUBLE-SPEED: Double read frequency -> Half resolution



EXT-IN0-MODE:

List element for setting the operating mode at digital input IN0/pin3/green.

TRIGG-IN0 L/H:

External edge-controlled triggering of measurement value evaluation through digital input IN0/pin3/green. A new measurement value is generated with every new low/high edge.

TRIGG-IN0 HIGH:

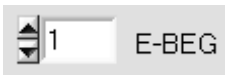
External triggering of measurement value evaluation through a high level (+Ub) at digital input IN0/pin3/green.

New measurement values are generated as long as digital input IN0 has a HIGH level.

LIGHT ON – IN0 HI

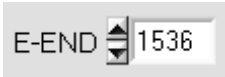
Activation of the laser transmitter unit by a HIGH level at IN0/pin3/green.

GENERAL control elements:



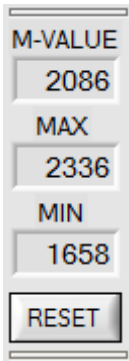
E-BEG:

Numeric input field for setting the evaluation beginning. The CMOS line is evaluated starting from the pixel that is entered here (evaluation-beginning). (Default value = 1).



E-END:

Numeric input field for setting the evaluation end. The CMOS line is evaluated up to this pixel. Pixels that lie on the right side of the pixel value specified here will not be evaluated.



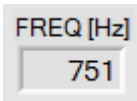
Reset button (maximum-minimum values):

A click on the RESET software button resets the current maximum and minimum values detected by the *L-LAS-LT sensor*. The respective current maximum and minimum values are shown in the numeric display fields. Resetting of the maximum and minimum values also can be triggered from the PLC by a short pulse (time $t < 750$ ms) at digital input IN1/yellow/pin4, and by pressing the hardware button at the housing of the *L-LAS-LT sensor*.



Attention:

This RESET function does not perform a hardware/software RESET at the *L-LAS-LT sensor*, it only resets the maximum and minimum values at the analog output pin8/red/!



FREQ [Hz]:

This field displays the current switching frequency of the sensor. The switching frequency depends on the currently set exposure time EXP-TIME[ms] and on the value of averaging AVERAGE. The switching frequency is reduced by a factor of 1/AVERAGE.



[MM] [PIXEL]:

This switch is used to select the measurement value output in the graphic display window.
mm := Display in [mm]
pixel := Display in [pixel].



Status display of digital inputs:

This LED display visualises the states of digital inputs IN0 and IN1.



Attention:

The LED display elements only are updated when RUN mode (data exchange through RS232) is active. IN0=HIGH< >LED(green), IN1=HIGH< >LED(yellow)



PARAMETER TRANSFER:

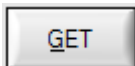
This group of function buttons is used for transferring parameters between the PC and the *L-LAS-LT control unit* through the serial RS232 interface.



SEND:

When the SEND button is clicked, the parameters currently set on the user interface are transferred to the *L-LAS-LT 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-LT 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-LT 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-LT control unit* is turned off.

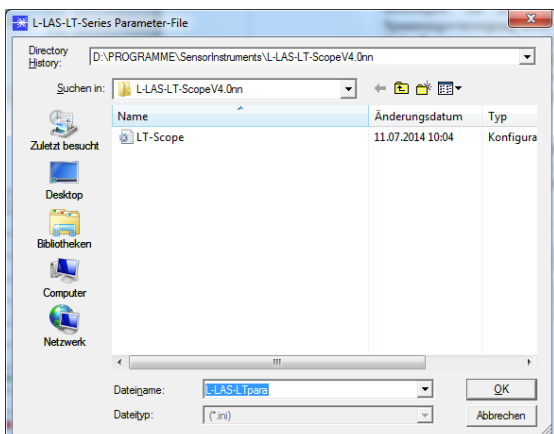
EEPROM:

The currently set parameters are written to the non-volatile EEPROM memory of the *L-LAS-LT 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-LT control unit*, these must be written to the RAM of the *L-LAS-LT control unit* by selecting the RAM button and then clicking on SEND. The *L-LAS-LT 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 name „L-LAS-LTpara.ini“.

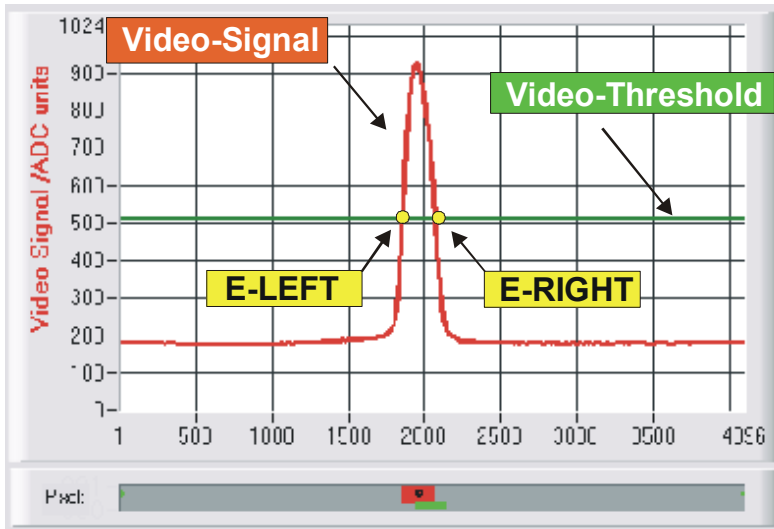
The output file can be opened e.g. with the standard Windows text editor program "EDITOR".

3.2 Numeric and graphic display elements:



VIDEO button:

After a click on the VIDEO button, the intensity profile measured at the CMOS receiver is transferred to the PC and shown as a red curve in the graphic display window.



The y-axis shows the analog signals of the individual pixels. The analog values (video signals) of the CMOS line are converted by means of an AD converter with 10-bit resolution, which results in a y-axis value range of 0 ... 1024. The currently set video threshold (V-THD) is shown as a green horizontal line in the graphic window.

The intensity maximum results from the optical representation of the laser light that is scattered back from the measuring object.

The edge values (pixels) are derived from the intersection points of the intensity profile (red curve) with the video threshold (green line). The x-axis shows the pixels of the CMOS line (e.g.: pixel: 1 ... 4096). Because of the limited data transfer rate of the serial interface (19200 baud/s) the graphic display window can only be updated every second.



Beneath the graphic display window there is another display element that shows the currently detected shadowed areas (gray) and the illuminated areas (red) of the CMOS line. Furthermore the currently detected edge position is indicated by way of a black point-shaped circle.



E-LEFT:

Numeric display field that shows the current pixel position of the left bright/dark transition that is calculated from the intensity profile (red curve) of the CMOS line.



E-RIGHT:

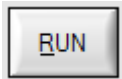
Numeric display field that shows the current pixel position of the right bright/dark transition that is calculated from the intensity profile (red curve) of the CMOS line.



MEASUREMENT-VALUE:

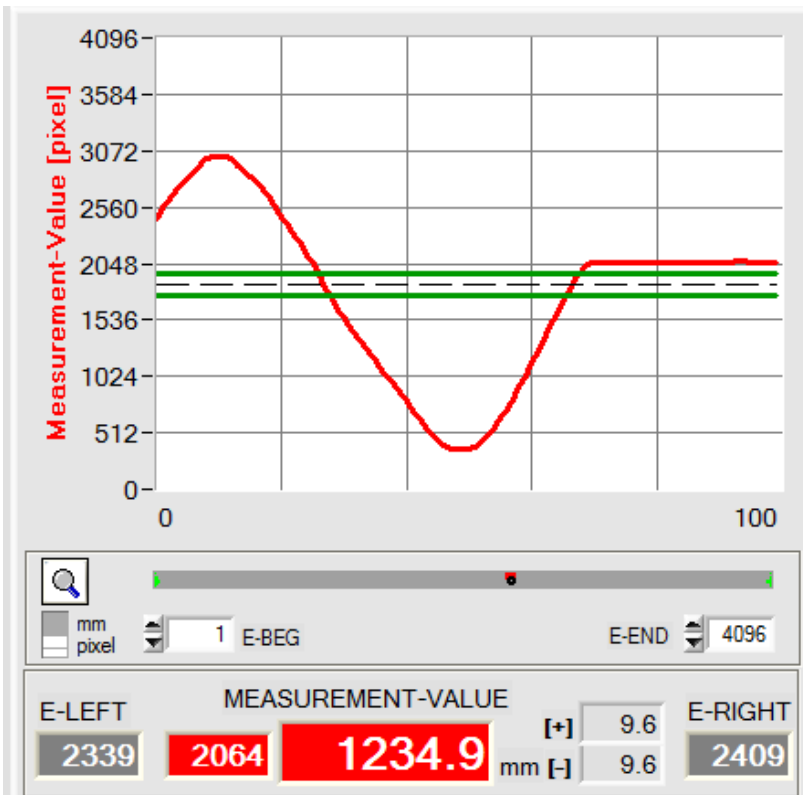
Numeric display field that shows the current measurement value (depending on the set evaluation mode). The left numeric display field shows the current measurement value in pixels, whereas the right display field shows the measurement value converted into millimetres.

If the current measurement value lies within the tolerance band around the teach value, the display fields are shown with a green background. If the measurement value lies outside the tolerance band, the display elements are shown with a red background. The measurement value in pixels or in [mm] does not directly result from the pixel edge values E-LEFT and E-RIGHT, it is rather the measurement values linearised by way of a conversion table that are output.



RUN button:

After a click on the RUN button, the current measurement data will be transferred from the L-LAS-LT sensor to the PC via the serial interface in "scroll mode".



In the form of a red curve the measurement values pass through the graphic display window from right to left.

The y-axis graduation corresponds with the pixels or sub-pixels on the CMOS line. The most recent measurement value is shown at the right end of the graphic display at x-value = 100.

The currently set setpoint value (TEACH value) is shown as a broken horizontal black line.

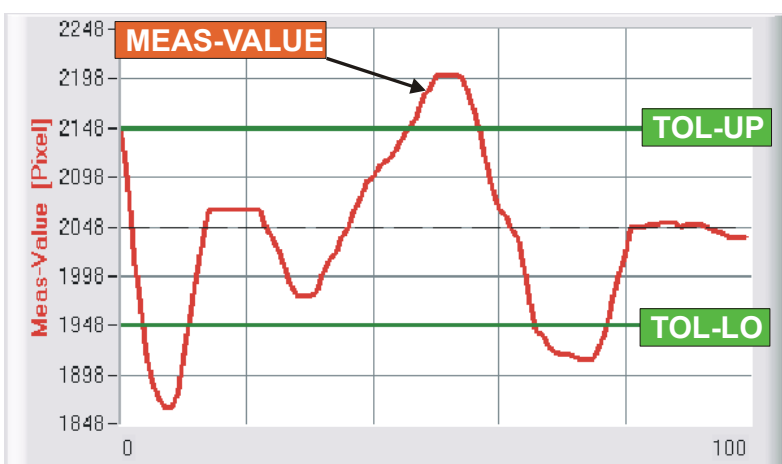
In addition, the current tolerance window is represented by two horizontal green lines that are applied around the setpoint value.



Graphic measurement value scaling can be selected with this binary switch [mm]-[pixel].

The length of the data frame in "RUN mode" is limited to 18 words (36 bytes), which allows faster updating of the numeric and graphic display elements.

Compared to "VIDEO mode", data transfer through the serial RS232 interface therefore does not take so much time (in VIDEO mode the intensity information for every pixel must be transferred).



ZOOM

A click on the ZOOM button automatically rescales the y-axis in the graphic display window, which means that the changes of the measurement value can be displayed more clearly.

The picture here shows the time characteristic of the measurement value change as a red curve, and the tolerance band as two green lines. The teach value is shown as a broken horizontal line.

3.3 Serial RS232 data transfer:

RS232 COMMUNICATION:

- Standard RS232 serial interface without hardware-handshake.
- 3-line-connection: GND, TXD, RXD.
- Speed: Adjustable from 9600 baud up to 115200 baud, 8 data-bits, no parity-bit, 1 stop-bit in binary mode, MSB first.

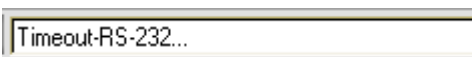
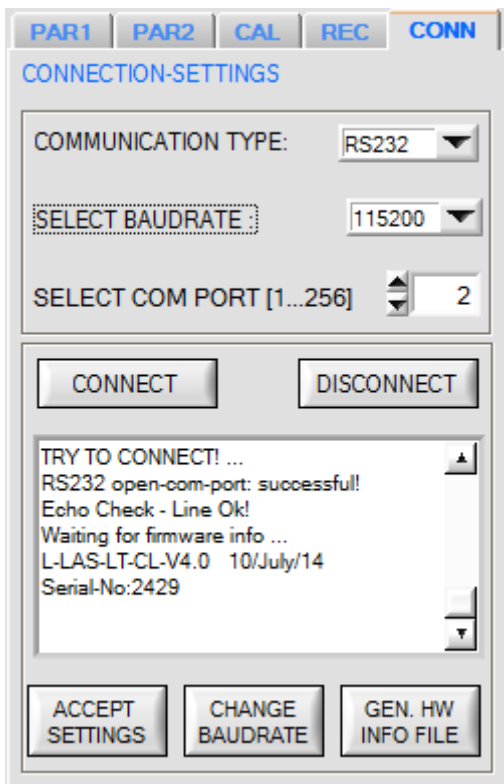


Attention !

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-LT 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-LT control unit* it is therefore necessary to stop the data transfer during the normal monitoring process (click on the STOP button).

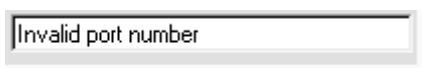
CONN:

When the software is started it attempts to establish a connection to the *L-LAS-LT sensor* through the COM interface that was last used. If connection could be established successfully, the current firmware version and the number of the COM port are displayed in the status line.



The serial connection between the PC and the *L-LAS-LT control unit* could not be established, or the connection is faulty.

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



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



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

COMMUNICATION TYPE:

COMMUNICATION TYPE:

The type of data communication can be set in this function field:

RS232:

Data communication through the standard RS232 interface.

TCP/IP:

Data communication through a RS232-TCP/IP Ethernet converter module.

SELECT BAUDRATE:

SELECT BAUDRATE:

The baud rate of the serial interface can be set in this function field:

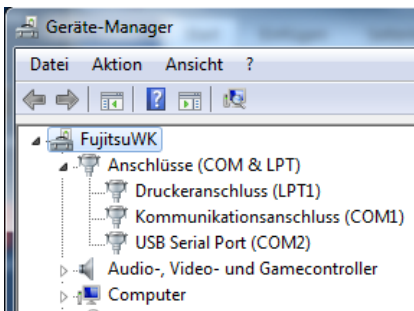
Possible values: 9600 baud, 19200 baud, 38400 baud, 57600 baud or 115200 baud (setting when delivered = 115200 baud).

SELECT COM PORT [1...256]

SELECT COM PORT [1...256]:

The number of the communication port can be set in this function field. Possible values are COM 1 to 255.

The communication port number can be found in the Windows® operating system under START/Control Panel/Device Manager.



CHANGE BAUDRATE  Attention!

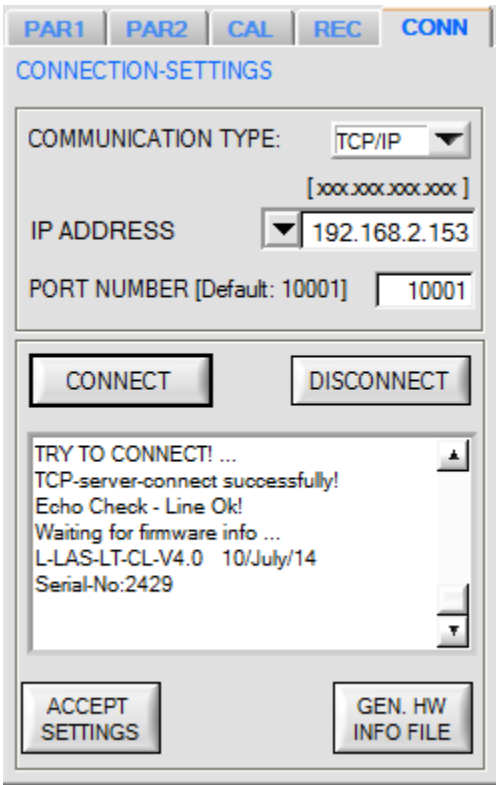
```
RS232 open-com-port: successful!
Try to change baudrate...
Baudrate-change OK!
RS232 open-com-port: successful!
```

CHANGE BAUDRATE:

With a click on this button the baud rate of the serial interface at the sensor hardware is changed to the value selected in the SELECT-BAUDRATE list field. A corresponding status message will be displayed when the change of baud rate at the sensor was successful.

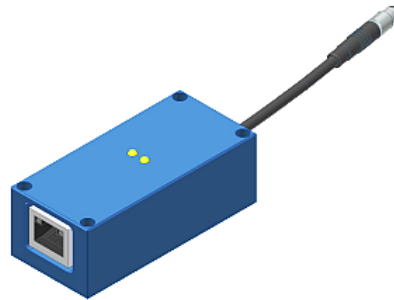
The baud rate change only is performed in the volatile RAM of the *L-LAS-LT sensor*. If the baud rate should be changed permanently, the new baud rate value must be saved to the EEPROM by clicking on the SEND + EE button!

3.4 Data transfer through the external RS232 to Ethernet adapter:



A RS232 to Ethernet adapter is necessary if the sensor should communicate through a local network. With this adapter a connection to the sensor can be established by way of the **TCP/IP** protocol.

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

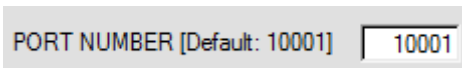


RS232/Ethernet Converter



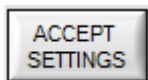
IP ADDRESS:

Input mask for entering the IP address.



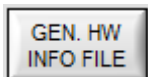
PORT NUMBER:

The **PORT NUMBER** for the network adapter based on *Lantronix-XPort* is set to 10001. This value must not be changed.



ACCEPT SETTINGS:

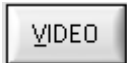
With a click on the ACCEPT SETTINGS button the current setting values of the *L-LAS-LT-Scope* PC software are saved in the LT-Scope.ini file. The popup window will then be closed. When the *L-LAS-LT-Scope* software is restarted, the parameters saved in the INI file will be loaded.



GEN. HW INFO FILE:

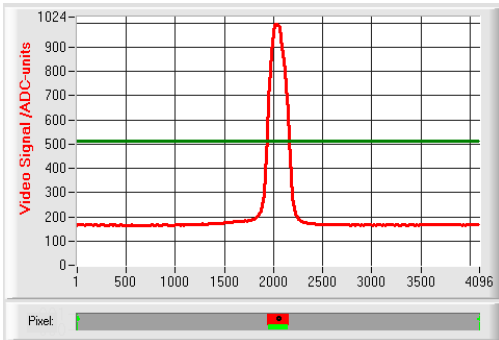
A click on this button generates a file in which all the important sensor data are stored in encrypted form. This file can be sent to the sensor manufacturer for diagnostic purposes.

3.5 L-LAS-LT-Scope as an aid for sensor adjustment:



VIDEO:

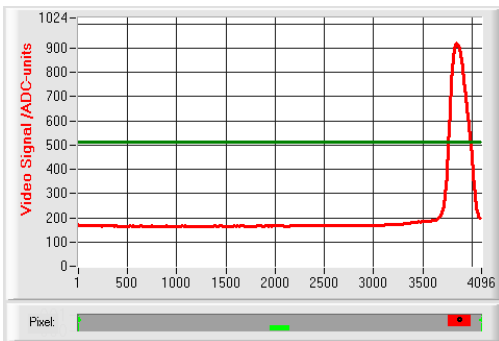
After a click on the VIDEO button, fine adjustment of the sensor relative to the measurement object can be observed in the graphic display window. Because of the limited data transfer rate of the RS232 interface the display window can only be updated every second.



Adjustment OK - centered

In the graphic display window the intensity profile is shown as a red curve. The numerical values 1...4096 on the x-axis represent the individual pixels of the CMOS line.

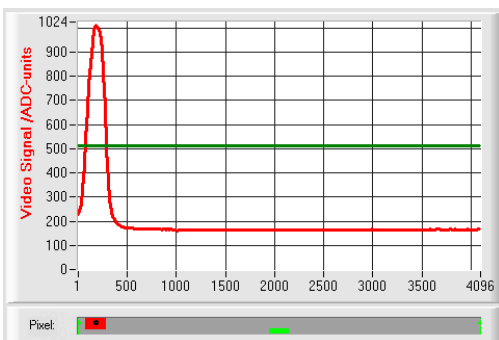
The intensity maximum approx. lies at pixel 2048. The *L-LAS-LT sensor* thus is optimally adjusted at the centre of the measuring range.



Upper measuring range limit reached:

The distance of the *L-LAS-LT sensor* from the measuring object almost is too large. The intensity maximum lies at pixel values close to 4000.

The distance between the *L-LAS-LT sensor* and the measuring object should be reduced.

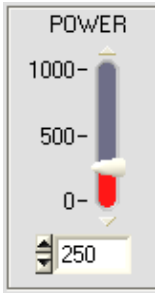


Lower measuring range limit reached

The distance of the *L-LAS-LT sensor* from the measuring object almost is too small. The intensity maximum lies at pixel values close to 1.

The distance between the *L-LAS-LT sensor* and the measuring object should be increased.

3.6 L-LAS-LT-Scope as an aid for transmitter power adjustment:



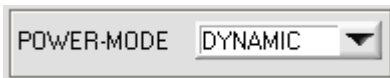
POWER:

The laser power at the laser transmitter unit of the *L-LAS-LT sensor* can be set by using the POWER slider or by entering a numerical value in the respective input field.



Attention !

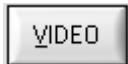
The laser power at the transmitter unit of the *L-LAS-LT sensor* is only updated when the SEND button is pressed.



DYNAMIC:

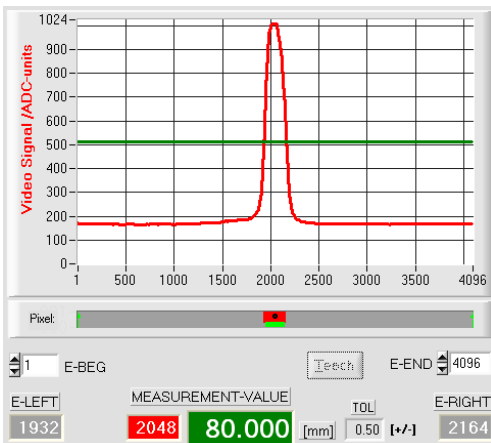
When the power mode is set to DYNAMIC, the laser power at the *L-LAS-LT sensor* is automatically regulated. This means that the laser power is regulated in such a way that the maximum values of the "intensity peaks" approx. lie at 80-90% of the analog dynamic range.

Settings at the POWER slider have no effect in this operating mode! --- This mode is recommended as the standard mode! ---



VIDEO:

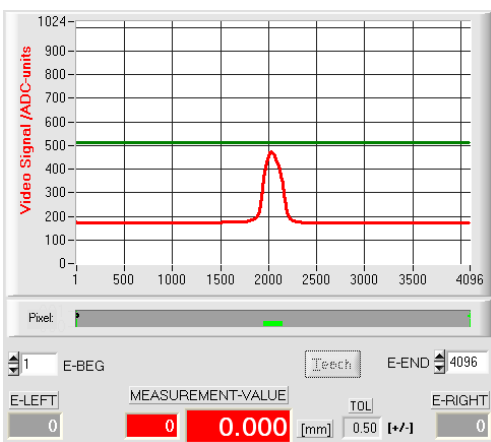
After a click on the VIDEO button, the current intensity profile is transferred from the *L-LAS-LT sensor* to the PC and is shown as a red curve in the graphic display window.



Optimum transmitter power:

In the whole measuring range (pixel 1...4096) the maximum of the intensity characteristic should be clearly above the video threshold (green line).

The measurement values can be calculated from the intersection points of the intensity profile with the video threshold:



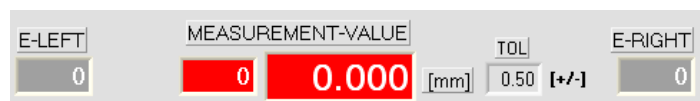
Transmitter power too low:

The intensity profile (red curve) at the CMOS receiver is too low.

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

No bright/dark transition (intersection point between red and green curve) can be detected.

The calculated measurement value therefore = 0!



4 Evaluation modes

4.1 LEFT-EDGE



The left intersection point (bright/dark transition) at the intensity maximum is used as the measurement value.

$$MVAL[pixel] = E_LEFT \quad \text{here: } 1052$$

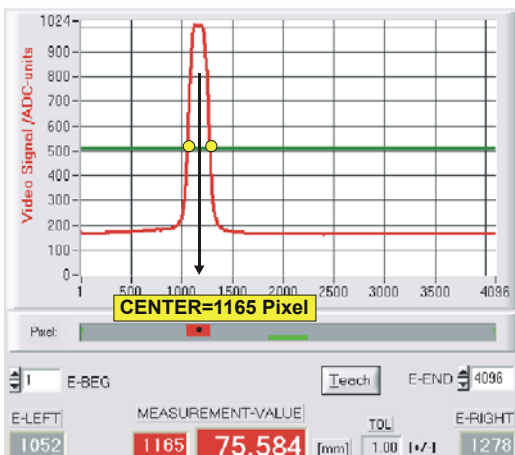
4.2 RIGHT-EDGE



The right intersection point (bright/dark transition) at the intensity maximum is used as the measurement value.

$$MVAL[pixel] = E_RIGHT \quad \text{here: } 1278$$

4.3 CENTER



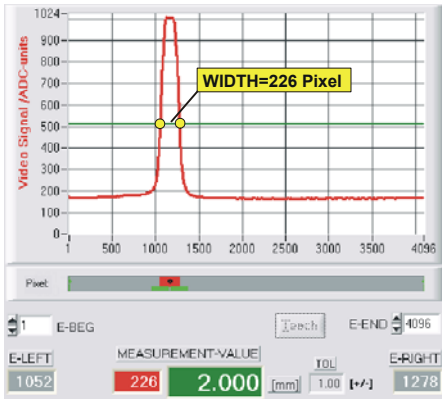
The center position of the intensity maximum is calculated from the intersection points of the intensity profile (red curve) with the video threshold (green line).

$$MVAL[pixel] = (E_RIGHT + E_LEFT) / 2$$

here: $MVAL = 1165 = (1278 + 1052) / 2$

EVAL-MODE CENTER should be set as the standard mode at the line sensor.

4.4 WIDTH

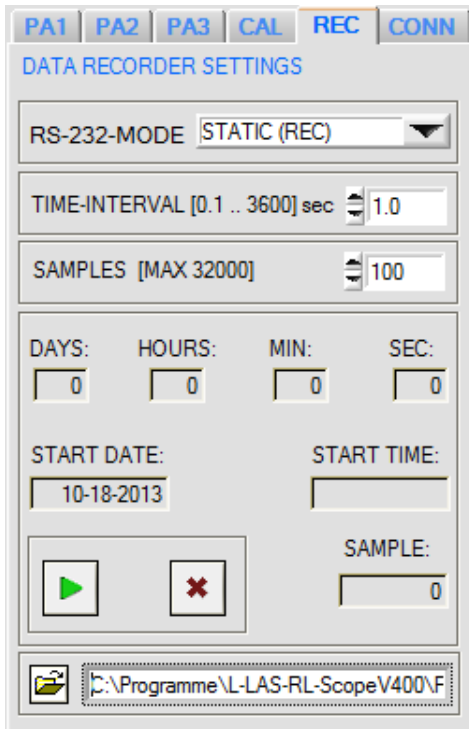


The width of the intensity maximum is calculated from the intersection points of the intensity profile (red curve) with the video threshold (green line).

$$MVAL[\text{pixel}] = E_RIGHT - E_LEFT$$

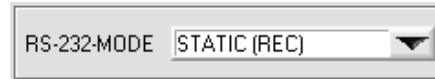
here: $MVAL = 226 = 1278 - 1052$

5 Data recorder function



REC: DATA RECORDER:

A click on the REC button opens the DATA-RECORDER window on the user interface.



RS232-MODE:

Drop-down function field for setting the data request at the *L-LAS-LT* sensor hardware.

STATIC(REC):

The sensor does not automatically send measurement data via the RS232 interface. Every individual data transfer is triggered by the PC/PLC by way of command no. 18. Upon this request the sensor sends a single data frame (36 byte) to the PC/PLC.

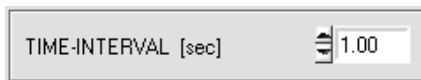
TRIG-IN0 L/H (REC):

A single data frame (36 byte) is sent to the PC/PLC with every LOW/HIGH edge at digital input IN0/pin3/green.

TRIG-IN0 L/H (3-BYTE), CONTINUOUS (3-BYTE):

Cannot be used with the data recorder!

High-speed 3-BYTE data transfer -> see chapter 5.2.



TIME-INTERVAL [sec]:

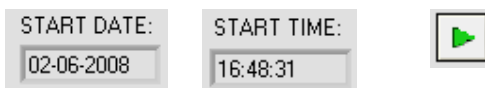
This numeric input field can be used to set a time interval in seconds. When this time interval is over, the PC software automatically requests measurement data from the sensor (command 18). The PC/PLC waits until the complete data frame (36 byte) from the sensor has arrived in the input buffer of the serial interface of the PC. Then the PC saves the new measurement data in an output file on the hard disk.

Minimum value: 0.1 [sec]. When the TIME-INTERVAL [sec] is over, the PC/PLC initiates a new transfer.

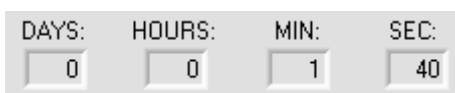


SAMPLES [MAX 32000]:

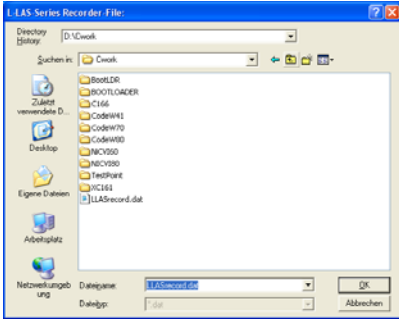
Numeric input field for setting the maximum number of measurement values that should be stored. The value range is from 10 to 32000.



Numeric display fields providing information about the start date and the start time. These displays will be updated when the START button is pressed.



Numeric display elements showing the time in seconds that has passed since the recorder function has been activated.



FILE button

A click on the File button opens a dialog for entering the file name and the target directory of the output file.

The currently selected target directory and file name of the output file are shown in the text display below.

d:\Programme\RECORD.DAT



START



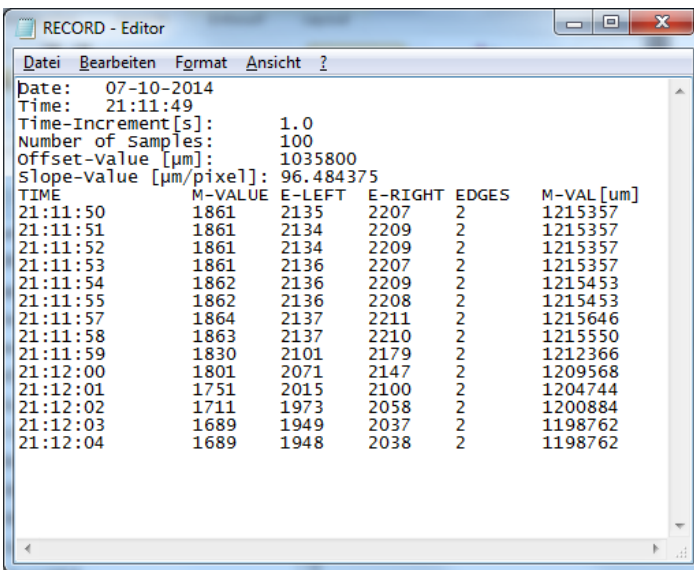
STOP

Automatic recording can be started by pressing the START button. With a click on the STOP button recording can be stopped before the maximum number set in SAMPLES is reached.

5.1 Data format of the output file

The output file of the data recorder consists of 7 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).



1st column =
Time of measurement value acquisition

2nd column =
Measurement value (pixel) M-VALUE

3rd column =
Measurement value (pixel) E-LEFT

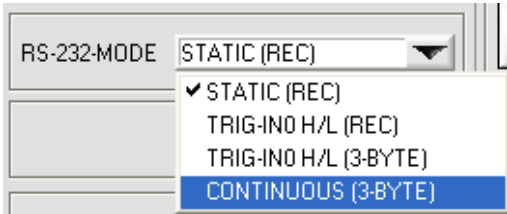
4th column =
Measurement value (pixel) E-RIGHT

5th column =
Number of edges (EDGES)

6th column =
Measurement value (micrometers) M-VAL[um]

5.2 3-byte RS232 data transfer

High-speed data transfer of digital values (pixel values) from the *L-LAS-LT sensor* to the PLC can be realised by way of two RS232-MODE (3-Byte) modes. With a baud rate of 19200 kBit/s the transfer of a 3-byte data frame takes approx. 1.0ms, with 115.2 kBit/s data transfer takes approx. 0.2ms.



3-byte data transfer:

EXT-IN0-L/H (3-BYTE):

3-byte data is activated by a Low/High or High/Low edge (hardware-specific) at IN0/pin3/green/ of the 8-pole PLC connector.

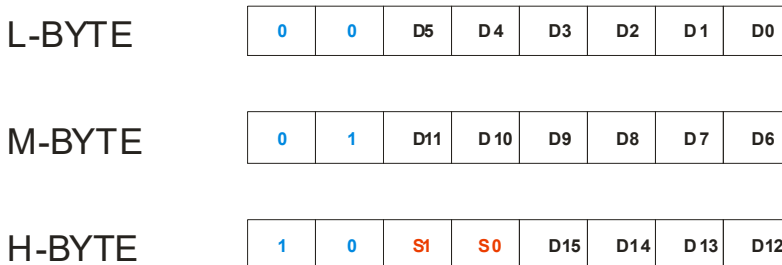
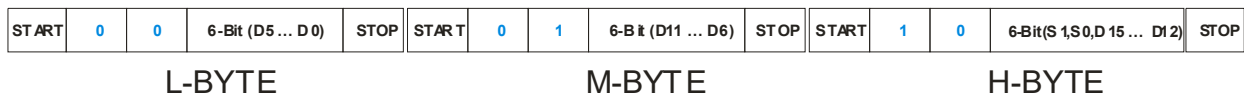
CONTINUOUS (3-BYTE):

Continuous 3-byte data transfer in the main program run.

Settings of the RS232 interface:

- Standard RS232 serial interface, no hardware handshake
- 3-wire-connection: GND, TXD, RXD
- Speed: 9600 baud, 19200 baud, 38400 baud, 57600 baud or 115200 baud
- 8 data-bits, NO parity-bit, 1 stop-bit, binary-mode.

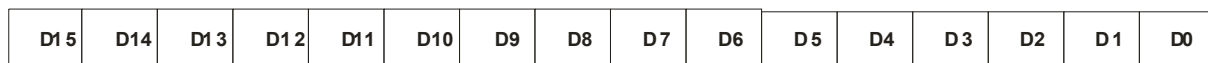
Send format of 3-byte data transfer:



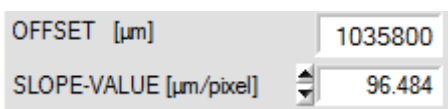
Extraction of the digital value (D0 – D15):

The first two bits are used to detect the low-byte (0|0), middle-byte (0|1) and high-byte (1|1). In the high-byte two status bits (S1|S0) are also transmitted.

Digital value DW = D0 ... D15



Conversion of the digital value into a mm value:



The millimetre value can be determined by way of the digital value **DW** (measurement value) and the two sensor-specific values SLOPE-VALUE and OFFSET:

Example: L-LAS-LT-1200-XL

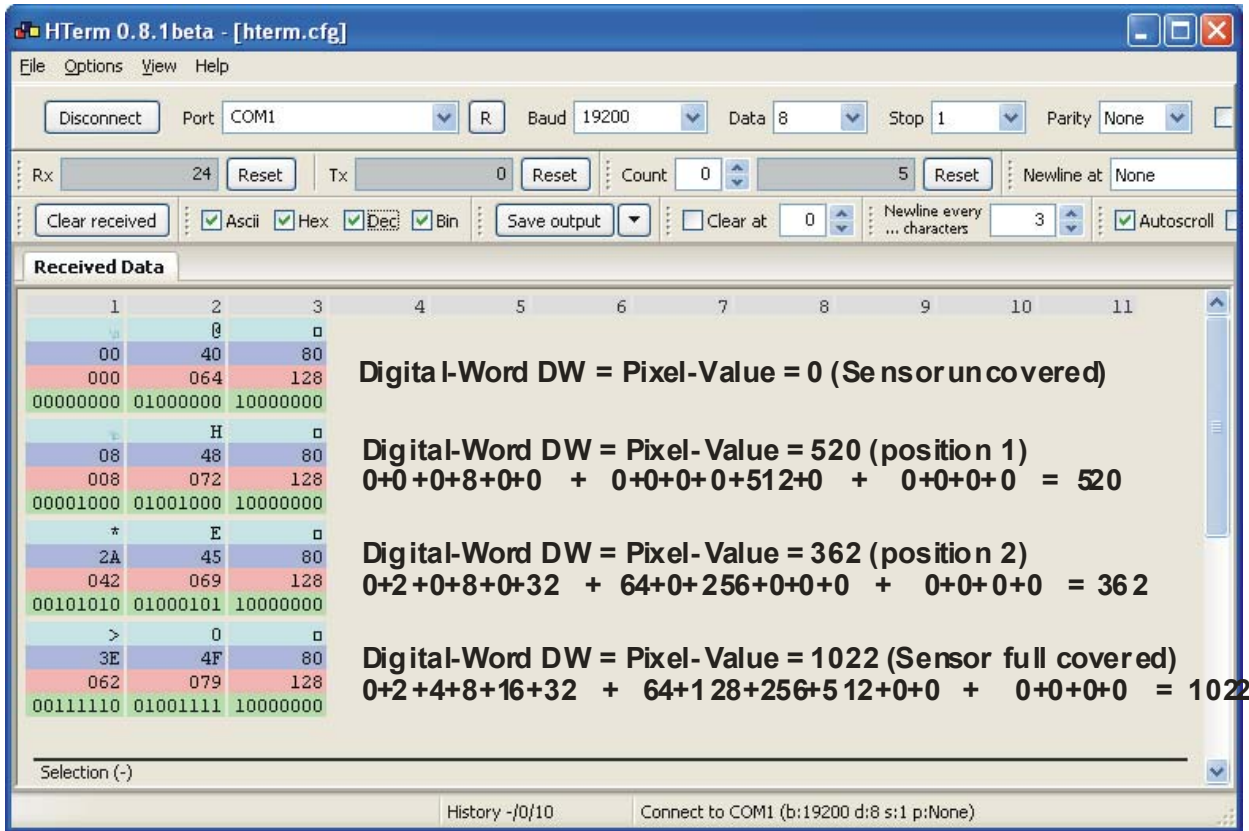
SLOPE [µm/pixel] = 96.5

OFFSET [µm]=103000:

$$\text{Measurement value [mm]} = \text{OFFSET}/1000 + \text{DW} * 0.0965\text{mm}$$

Examples for extracting the digital value:

Output of a typical Hyperterminal program – The object is placed at two different positions in the operating range:



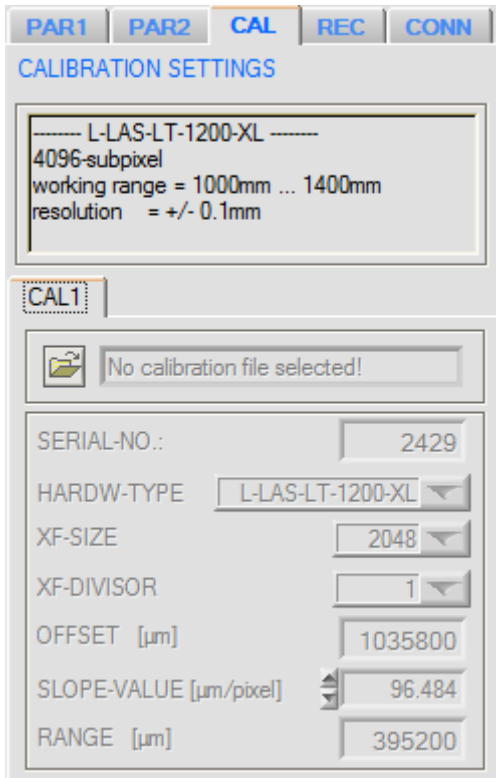
The screenshot shows the HTerm 0.8.1beta interface with the following configuration: Port COM1, Baud 19200, Data 8, Stop 1, Parity None. The received data is displayed in a table with columns 1-11. The data is as follows:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|----------|----------|----------|---|---|---|---|---|---|----|----|
| 00 | 40 | 80 | | | | | | | | |
| 000 | 064 | 128 | | | | | | | | |
| 00000000 | 01000000 | 10000000 | | | | | | | | |
| 08 | 48 | 80 | | | | | | | | |
| 008 | 072 | 128 | | | | | | | | |
| 00001000 | 01001000 | 10000000 | | | | | | | | |
| 2A | 45 | 80 | | | | | | | | |
| 042 | 069 | 128 | | | | | | | | |
| 00101010 | 01000101 | 10000000 | | | | | | | | |
| 3E | 4F | 80 | | | | | | | | |
| 062 | 079 | 128 | | | | | | | | |
| 00111110 | 01001111 | 10000000 | | | | | | | | |

The following calculations are shown in the software output:

- Digital-Word DW = Pixel-Value = 0 (Sensor uncovered)**
- Digital-Word DW = Pixel-Value = 520 (position 1)**
 $0+0+0+8+0+0 + 0+0+0+0+512+0 + 0+0+0+0 = 520$
- Digital-Word DW = Pixel-Value = 362 (position 2)**
 $0+2+0+8+0+32 + 64+0+256+0+0+0 + 0+0+0+0 = 362$
- Digital-Word DW = Pixel-Value = 1022 (Sensor full covered)**
 $0+2+4+8+16+32 + 64+128+256+512+0+0 + 0+0+0+0 = 1022$

6 CMOS calibration

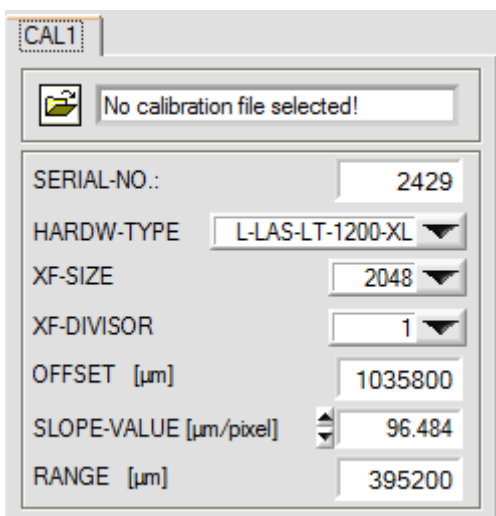


CMOS-CALIBRATION TAB:

Click on the CAL tab to open the CMOS-CALIBRATION window.

CMOS-INFO:

After a click on the CONNECT function field information about the currently detected sensor hardware is automatically exchanged through the serial RS232 interface. This hardware information is displayed in the CMOS-INFO text field.




CAL1:

This tab displays sensor-specific settings that can only be changed by the manufacturer.

- SERIAL-NO: 4-digit serial number
- HARDW-TYPE: Hardware designation of the sensor
- XF-SIZE: Size of the look-up table
- XF-DIVISOR: Divisor for converting the look-up values
- OFFSET [μm]: Measurement range start
- SLOPE-VALUE [μm/pixel]: Sensitivity
- RANGE [μm]: Measurement range

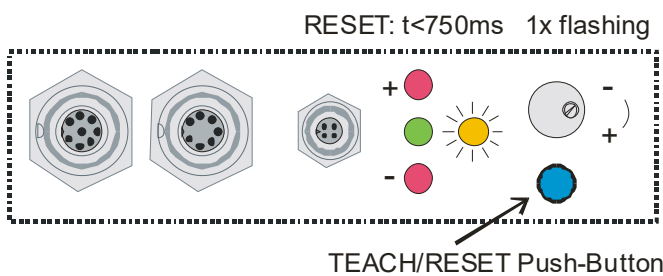
7 Annex

7.1 Laser warning

| LASER WARNING |
|--|
| <p>Solid-state laser, $\lambda=670$ nm, 1mW max. optical power, laser class 2 acc. to EN 60825-1</p> <p>Therefore no additional protective measures are required for the use of these laser transmitters.</p> <div style="display: flex; justify-content: space-around; align-items: center;">  <div style="border: 2px solid black; background-color: yellow; padding: 5px; text-align: center;"> <p style="margin: 0;">LASER RADIATION</p> <p style="margin: 0;">DO NOT STARE INTO THE BEAM</p> <p style="margin: 0;">CLASS II LASER PRODUCT</p> </div> </div> |

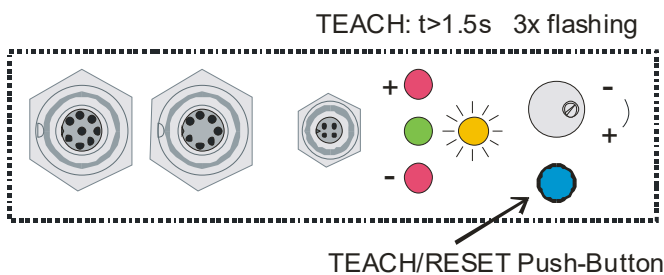
7.2 Function of the TEACH/RESET button

The housing of the *L-LAS-LT* sensor features a pushbutton with two functions [1].



RESET function:

When the button is pressed for a short time ($t < 750$ ms) the current maximum and minimum values (drag pointer values) are reset. This does not perform a hardware/software RESET!

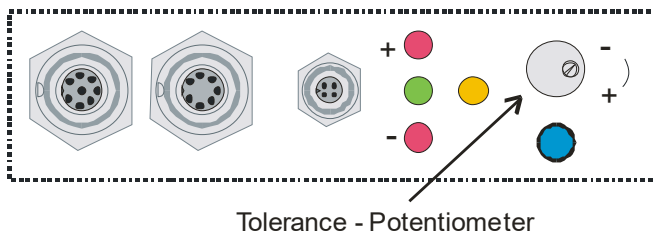


TEACH function:

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

7.3 Function of the TOLERANCE potentiometer

The housing of the *L-LAS-LT* sensor features a potentiometer for setting the tolerance band width [1].



TOLERANCE potentiometer:

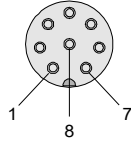
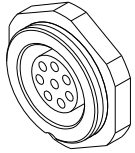
Turning the potentiometer clockwise increases the tolerance band width. Turning it counter-clockwise decreases the tolerance band width.

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

[1] Not available with CL or XL type

7.4 Function of digital inputs IN0 and IN1

The *L-LAS-LT sensor* has two digital inputs IN0 and IN1 that can be contacted through the 8-pole female connector (type Binder 712).



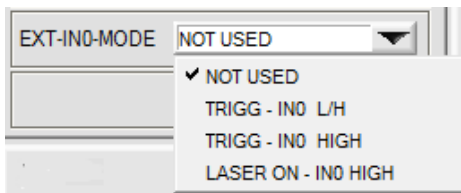
STANDARD and CL type / XL type

| Pin: | Color: | Assignment: |
|----------|---------------|--------------------------|
| 1 | white | 0V (GND) |
| 2 | brown | +15VDC ... +30VDC (+Ub) |
| 3 | green | IN0 (EXT TRIGGER) |
| 4 | yellow | IN1 (TEACH/RESET) |
| 5 | grey | OUT0 (-) |
| 6 | pink | OUT1 (+) |
| 7 | blue | OUT2 (OK) [1] |
| 8 | red | ANALOG (0 ... +10V) |

[1] Not available with CL or XL type

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

The operating mode of digital input IN0/pin3/green depends on the mode that is set in the EXT-IN0-MODE function field:



EXT-IN0-MODE:

NOT USED:

Digital input IN0/pin3/green is not used.

TRIGG-IN0 L/H:

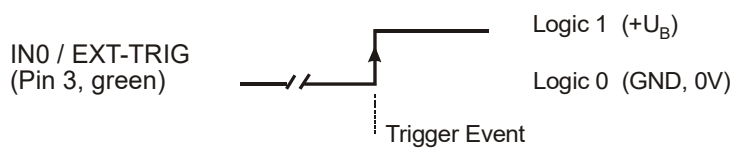
External edge-controlled triggering of measurement value evaluation through digital input IN0/pin3/green.

TRIGG-IN0 HIGH:

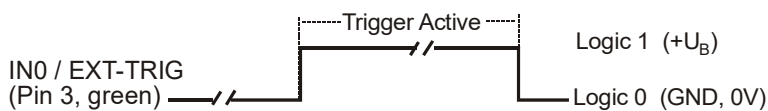
External triggering of measurement value evaluation by a high-level (+Ub) at digital input IN0/pin3/green.

LASER ON – IN0 HIGH:

The laser transmitter unit only is switched on when there is a high-level at digital input IN0/pin3/green.



External edge-controlled (LOW/HIGH) triggering of measurement value evaluation through digital input IN0.

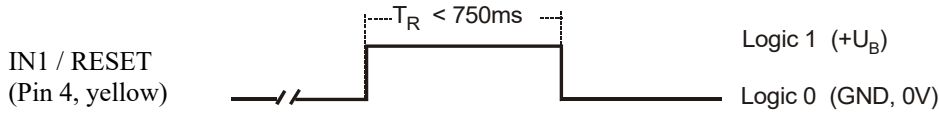


External triggering of measurement value evaluation through a HIGH level (+Ub) at digital input IN0.

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

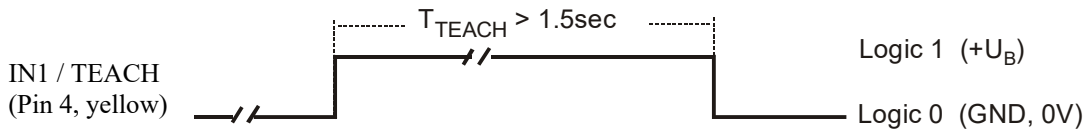
RESET function:

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

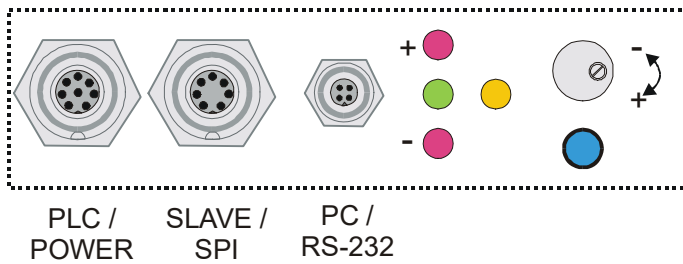


TEACH function:

When a HIGH pulse of more than **1.5s** duration is applied, the TEACH function is performed at the *L-LAS-LT sensor*. When a TEACH pulse has been detected, the green LED at the housing flashes shortly three times.

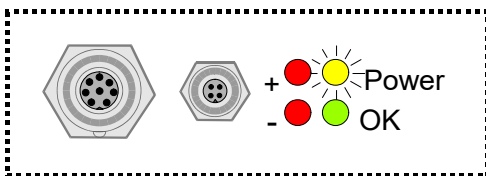


7.5 Connector assignment



L-LAS-LT type (standard)

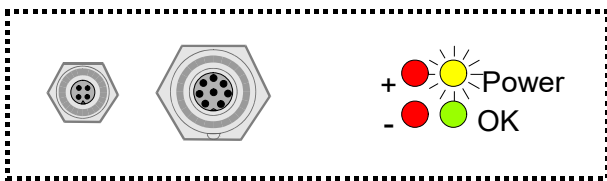
At the housing of the *L-LAS-LT sensor* there is a female connector for power supply connection (8-pole type Binder 712) as well as a second female connector for connecting a serial RS232 connecting cable (4-pole type M5 Binder 707). The third female connector (7-pole type Binder 712) is for data exchange between Master/Slave systems.



L-LAS-LT-CL type (Compact Line)

The housing of the *L-LAS-LT-...-CL sensor* features a female connector for power supply connection (8-pole type Binder 712) and a second female connector for connecting the serial RS232 connecting cable (4-pole M5 type Binder 707).

PLC / POWER PC / RS-232



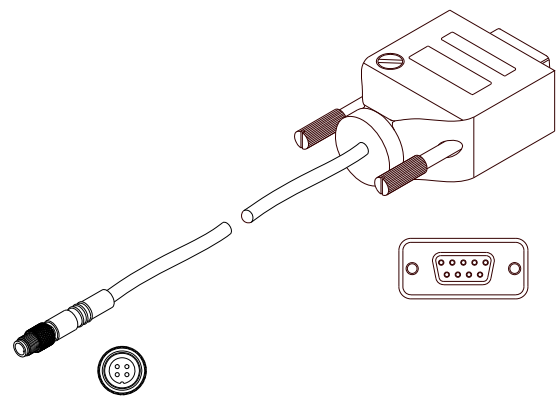
L-LAS-LT-XL type (XL Line)

The housing of the *L-LAS-LT-...-XL sensor* features a female connector for power supply connection (8-pole type Binder 712) and a second female connector for connecting the serial RS232 connecting cable (4-pole M5 type Binder 707).

PC / RS-232 PLC / POWER

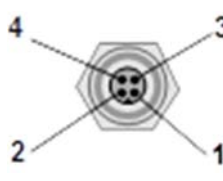
RS232 connection to PC:

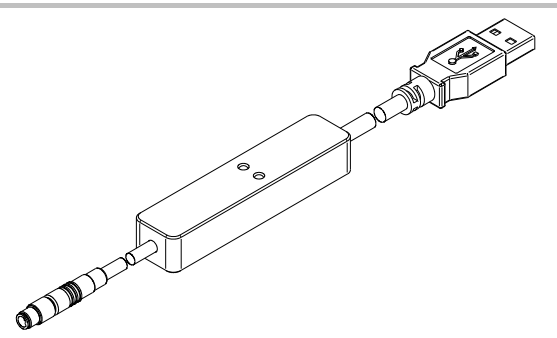
4-pole M5 female connector type Binder 707



cab-las4/PC

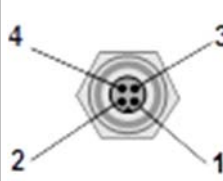
| Pin | Color | Assignment |
|-----|-------|---------------|
| 1 | brown | +24 VDC ± 10% |
| 2 | white | 0V (GND) |
| 3 | black | RxD |
| 4 | blue | TxD |





cab-4/USB

| Pin | Color | Assignment |
|-----|-------|---------------|
| 1 | brown | +24 VDC ± 10% |
| 2 | white | 0V (GND) |
| 3 | black | RxD |
| 4 | blue | TxD |

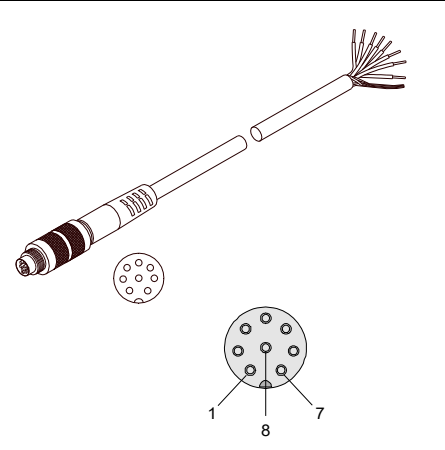


Connecting cable:

cab-las4/PC (length 2m or 5m, outer jacket: PUR) or
cab-4/USB (length 2m or 5m, outer jacket: PUR)

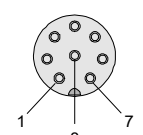
Interface to PLC / power supply:

8-pole female connector type Binder 712



cab-las8/SPS

| Pin | Color | Assignment L-LAS-LT Standard | Assignment L-LAS-LT-CL or L-LAS-LT-XL |
|-----|--------|---|--|
| 1 | white | 0V (GND) | 0V (GND) |
| 2 | brown | +24VDC ±10% | +24 VDC ± 10% |
| 3 | green | IN0 | IN1 |
| 4 | yellow | IN1 | IN1 |
| 5 | grey | OUT0 (-) | OUT0 (-) |
| 6 | pink | OUT1 (+) | OUT1 (+) |
| 7 | blue | OUT2 (OK) | 0V (GND) <i>optional with type 4/20: 4...20mA</i> |
| 8 | red | Analog (0...+10V) <i>optional with type 4/20: 4...20mA</i> | Analog (0...+10V) |



Connecting cable:

cab-las8/SPS (length 2m or 5m, cable jacket: PUR)

7.6 RS232 interface protocol

- Standard RS232 serial interface, no hardware handshake
- 3-line connection: GND, TX0, RX0
- Speed: 9600 Baud, 19200 Baud, 38400 Baud, 57600 Baud, or 115200 Baud
- 8 data-bits
- NO parity bit
- 1 stop-bit
- Binary mode.

METHOD:

The sensor control unit always behaves passively. Data exchange therefore is initiated by the PC (or PLC). The PC sends a data package ("frame") either with or without appended data, to which the sensor control unit responds with a frame that matches the request. The data package comprises a **HEADER** and the optional **DATA**.

HEADER

- 1. Byte** : Synchronisation byte <SYNC> (85_{dez} = 0x55_{hex})
- 2. Byte** : Order byte <ORDER>
- 3. Byte : Argument <ARG LO>
- 4. Byte : Argument <ARG HI>
- 5. Byte : Data length <LEN LO>
- 6. Byte : Data length <LEN HI>
- 7. Byte : Checksum header <CRC8 HEAD>
- 8. Byte : Checksum data <CRC8 DATA>

The first byte is a synchronisation byte and always is 85_{dez} (55_{hex}). The second byte is the so-called order byte <ORDER>, it determines the action that should be performed (send data, save data, etc.).

A 16-bit value <ARG> follows as the third and fourth byte. Depending on the order the argument is assigned a corresponding value. The fifth and sixth byte again form a 16-bit value <LEN>. This value states the number of appended data bytes. Without appended data <LEN=0>, the maximum data length is 512 bytes <LEN=512>. The seventh byte is formed with the CRC8 checksum over all data bytes.

The eighth byte is the CRC8 checksum for the header and is formed from bytes 0 up to and incl. 7.

The header always has a total length of 8 bytes. The complete frame may contain between 8 and 520 bytes.

| | | | | | | | | | | | | |
|-----------------|-----------------|--------------------|--------------------|--------------------|--------------------|-----------------|------------------|--------------------|--------------------|-----|-----------------------|-----------------------|
| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header | Byte9 Data | Byte10 Data | ... | Byte n+7 Data | Byte n+8 Data |
| 0x55 | <ORDER> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) | Data1 (lo byte) | Data1 (hi byte) | ... | Data n/2 (lo byte) | Data n/2 (hi byte) |

| <ORDER> | Meaning of the 2.nd byte <order>: | ORDER-TABLE |
|---------|---|--------------------------|
| 0 | NOP | no operation |
| 1 | Send parameter from PC to L-LAS-RAM | PC ⇒ L-LAS-RAM |
| 2 | Get parameter from L-LAS-RAM | L-LAS-RAM ⇒ PC |
| 3 | Send parameter from PC to EEPROM | PC ⇒ L-LAS-EEPROM |
| 4 | Get parameter from EEPROM of L-LAS | L-LAS-EEPROM ⇒ PC |
| 5 | Echo check: Get echo of L-LAS | first word=0x00AA=170dec |
| 6 | Activate teach at L-LAS, store in RAM | PC ⇒ L-LAS-RAM |
| 7 | Get software version info of L-LAS | L-LAS ⇒ PC |
| 8 | Get measured values from L-LAS-RAM | L-LAS-RAM ⇒ PC |
| 9 | Get video-buffer info from L-LAS | L-LAS-RAM ⇒ PC |
| 11 | Reset maximum/minimum values at analog-output | PC ⇒ L-LAS-RAM |
| 12* | Set laser power at L-LAS hardware | PC ⇒ L-LAS-RAM |
| 13* | Start/Stop 3-Byte-Data-Transfer | PC ⇒ L-LAS-RAM |
| 190 | Change RS232-baud-rate (L-LAS-RAM) | PC ⇒ L-LAS-RAM |

*) implemented as of firmware version V4.0.8

CRC8 checksum

The so-called "Cyclic Redundancy Check" or CRC is used to verify data integrity. This algorithm makes it possible to detect individual bit errors, missing bytes, and faulty frames. For this purpose a value - the so-called checksum - is calculated over the data (bytes) to be checked and is transmitted together with the data package. Calculation is performed according to an exactly specified method based on a generator polynomial. The length of the checksum is 8 bit (= 1 byte). The generator polynomial is:

$$X^8+X^5+X^4+X^0$$

To verify the data after they have been received, CRC calculation is performed once again. If the sent and the newly calculated CRC values are identical, the data are without error.

The following pseudo code can be used for checksum calculation:

```
calcCRC8 (data[ ], table[ ])
Input: data[ ], n data of unsigned 8bit
        table[ ], 256 table entries of unsigned 8bit
Output: crc8, unsigned 8bit

crc8 := AAhex
for I := 1 to n do
    idx := crc8 EXOR data[ i ]
    crc8 := table[ idx ]
endfor
return crc8
```

table[]

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 94 | 188 | 226 | 97 | 63 | 221 | 131 | 194 | 156 | 126 | 32 | 163 | 253 | 31 | 65 |
| 157 | 195 | 33 | 127 | 252 | 162 | 64 | 30 | 95 | 1 | 227 | 189 | 62 | 96 | 130 | 220 |
| 35 | 125 | 159 | 193 | 66 | 28 | 254 | 160 | 225 | 191 | 93 | 3 | 128 | 222 | 60 | 98 |
| 190 | 224 | 2 | 92 | 223 | 129 | 99 | 61 | 124 | 34 | 192 | 158 | 29 | 67 | 161 | 255 |
| 70 | 24 | 250 | 164 | 39 | 121 | 155 | 197 | 132 | 218 | 56 | 102 | 229 | 187 | 89 | 7 |
| 219 | 133 | 103 | 57 | 186 | 228 | 6 | 88 | 25 | 71 | 165 | 251 | 120 | 38 | 196 | 154 |
| 101 | 59 | 217 | 135 | 4 | 90 | 184 | 230 | 167 | 249 | 27 | 69 | 198 | 152 | 122 | 36 |
| 248 | 166 | 68 | 26 | 153 | 199 | 37 | 123 | 58 | 100 | 134 | 216 | 91 | 5 | 231 | 185 |
| 140 | 210 | 48 | 110 | 237 | 179 | 81 | 15 | 78 | 16 | 242 | 172 | 47 | 113 | 147 | 205 |
| 17 | 79 | 173 | 243 | 112 | 46 | 204 | 146 | 211 | 141 | 111 | 49 | 178 | 236 | 14 | 80 |
| 175 | 241 | 19 | 77 | 206 | 144 | 114 | 44 | 109 | 51 | 209 | 143 | 12 | 82 | 176 | 238 |
| 50 | 108 | 142 | 208 | 83 | 13 | 239 | 177 | 240 | 174 | 76 | 18 | 145 | 207 | 45 | 115 |
| 202 | 148 | 118 | 40 | 171 | 245 | 23 | 73 | 8 | 86 | 180 | 234 | 105 | 55 | 213 | 139 |
| 87 | 9 | 235 | 181 | 54 | 104 | 138 | 212 | 149 | 203 | 41 | 119 | 244 | 170 | 72 | 22 |
| 233 | 183 | 85 | 11 | 136 | 214 | 52 | 106 | 43 | 117 | 151 | 201 | 74 | 20 | 246 | 168 |
| 116 | 42 | 200 | 150 | 21 | 75 | 169 | 247 | 182 | 232 | 10 | 84 | 215 | 137 | 107 | 53 |

Appended data: Parameter set

The sensors of the *L-LAS-LT series* operate with the following parameters that are sent to the sensor or read from the sensor as appended data in the stated sequence:

| DATA-FRAME: <parameter-set> | | |
|-----------------------------|--------------------|--|
| Para | Meaning | Comment |
| 1 | POWER | Laser intensity (0 ... 1000) |
| 2 | POWER-MODE | Laser power mode: (0 = STATIC), (1=DYNAMIC), (2=DYN-EXPOSE) |
| 3 | BACKGND-MODE | Background mode (0=OFF, 1=ON) |
| 4 | INT-TIME | Exposure-time [ms] (0.3 .. 10) = 300 ... 10000 |
| 5 | VIDEO-THRESHOLD | Video-threshold (0 ... 100) |
| 6 | EVAL-MODE | Evaluation mode (0=L-EDGE, 1=R-EDGE, 2=WIDTH, 3=CENTER) |
| 7 | E-BEG | Evaluation start-pixel (1 ... E_END - 1) |
| 8 | E-END | Evaluation end -pixel (E_BEG+1 ... SUBPIXEL) |
| 9 | TEACH-VALUE | Teach-value (1 ... SUBPIXEL) |
| 10 | TOLERANCE-HI-VALUE | Upper-tolerance (0 ... SUBPIXEL/2) |
| 11 | TOLERANCE-LO-VALUE | Lower-tolerance (0 ... SUBPIXEL/2) |
| 12 | AVERAGE | Average-setting (1,2,4,5,16,32,64,128,256, 512 or 1024) |
| 13 | POLARITY | Polarität für OUT0, OUT1 und OUT2 (0=DIRECT, 1=INVERT) |
| 14 | EX-TRIGG-MODE | External-trigger-mode:(0=CONTINOUS, 1=IN0 L/H, 2=IN0 HI, 3=SAVE-VTHD, 4=OUTPUT-WIDTH, 5=LIGHT-ON) |
| 15 | ANA-MODE | Analog-mode (0=DIRECT,1=MAXIMA,2=MINIMA,3=MAX_MIN) |
| 16 | ANA-ZOOM | Analog-output-zoom-mode: output (0=DIRECT, 1=ZOOMx1, 2=ZOOMx2, 3=ZOOMx4, 4=ZOOMx8, 5=ZOOMx16, 6=WIN_5V, 7=WIN_10V) |
| 17 | OP-MODE | CMOS-operation-mode (0=FULL_RES, 1=HALF_RES/DOUBLE-SPEED) |
| 18 | HW-MODE | Enable/disable TOL-potentiometer and button at housing (DISABLE-ALL=0, ENABLE-ALL=1,ENABLE-BTN=2, ENABLE POTI=3) |
| 19 | OUT-MODE | Mode for digital outputs (0, 1 or 2) |
| 20 | VTHDMODE | Video-threshold-mode: (0=FIX, 1=AUTO) |
| 21 | RS232-MODE | RS232 mode: (0=STAT,1=IN0-L/H,2=IN0-HI[3-byte],3=CONT[3-byte]) |
| 22 | RS232-BAUDRATE | Baudrate: (0=9600,1=19200,2=38400,3=57600,4=115200) baud |
| 23 | FREE-USE | Free-use |
| 24 | FREE-USE | Free-use |

RS232 data-transfer-examples:

< ORDER = 5 > : READ CONNECTION OK from sensor.

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 | 5 | 0 | 0 | 0 | 0 | 170 | 60 |
| ARG=0 | | | | LEN=0 | | | |

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 | 5 | 170 | 0 | 0 | 0 | 170 | 178 |
| ARG=170 | | | | LEN=0 | | | |

Serial – number of sensor = <ARG> value

< ORDER = 7 > : Read FIRMWARE-STRING from sensor.

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 7 | 0 | 0 | 0 | 0 | 170 | 82 |
| ARG=0 | | | | LEN=0 | | | |

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header | Byte9 Data | Byte10 Data | Byte11 Data | Byte12 Data |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|------------|-------------|-------------|-------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) | ASCII | ASCII | ASCII | ASCII |
| 85 (dec) | 7 | 0 | 0 | 72 | 0 | 166 | 82 | L | - | L | A |
| ARG=0 | | | | LEN=72 | | | | | | | |

| Byte13 Data | Byte14 Data | Byte15 Data | Byte16 Data | Byte17 Data | Byte18 Data | Byte19 Data | Byte20 Data | Byte21 Data | Byte22 Data | Byte23 Data | Byte24 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII |
| S | - | L | T | - | C | L | - | V | 4 | . | 0 |

| Byte25 Data | Byte26 Data | Byte27 Data | Byte28 Data | Byte29 Data | Byte30 Data | Byte31 Data | Byte32 Data | Byte33 Data | Byte34 Data | Byte35 Data | Byte36 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII |
| . | 1 | | | 1 | 0 | / | J | u | l | y | / |

| Byte37 Data | Byte38 Data | Byte39 Data | Byte40 Data | Byte41 Data | Byte42 Data | Byte43 Data | Byte44 Data | Byte45 Data | Byte46 Data | Byte47 Data | Byte48 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII |
| 1 | 4 | | | | | | | | | | |

| Byte49 Data | Byte50 Data | Byte51 Data | Byte52 Data | Byte53 Data | Byte54 Data | Byte55 Data | Byte56 Data | Byte57 Data | Byte58 Data | Byte59 Data | Byte60 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII |
| | | | | | | | | | | | |

| Byte61 Data | Byte62 Data | Byte63 Data | Byte64 Data | Byte65 Data | Byte66 Data | Byte67 Data | Byte68 Data | Byte69 Data | Byte70 Data | Byte71 Data | Byte72 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII |
| | | | | | | | | | | | |

| Byte73 Data | Byte74 Data | Byte75 Data | Byte76 Data | Byte77 Data | Byte78 Data | Byte79 Data | Byte80 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII | ASCII |
| | | | | | | | |

< ORDER = 1 > : SEND PARAMETER-SET TO RAM of the sensor

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header | Byte9 Data | Byte10 Data | Byte11 Data | Byte12 Data |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|--------------------|--------------------|--------------------|--------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) | Para1 (lo byte) | Para1 (hi byte) | Para2 (lo byte) | Para2 (hi byte) |
| 85 (dec) | 1 | 0 | 0 | 46 | 0 | 0 | 81 | 144 | 1 | 0 | 0 |
| | | ARG=0 | | LEN=46 | | | | POWER=400 | | PMODE=0 | |

| Byte13 Data | Byte14 Data | Byte15 Data | Byte16 Data | Byte17 Data | Byte18 Data | Byte19 Data | Byte20 Data | Byte21 Data | Byte22 Data | Byte23 Data | Byte24 Data |
|-------------|-------------|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Para3 | Para3 | Para4 | Para4 | Para5 | Para5 | Para6 | Para6 | Para7 | Para7 | Para8 | Para8 |
| 0 | 0 | 53 | 5 | 25 | 0 | 3 | 0 | 1 | 0 | 0 | 16 |
| BGMODE=0 | | INT-TIME=1333 | | VTHD=25 | | EMODE=3 | | EBEG=1 | | EEND=4096 | |

| Byte25 Data | Byte26 Data | Byte27 Data | Byte28 Data | Byte29 Data | Byte30 Data | Byte31 Data | Byte32 Data | Byte33 Data | Byte34 Data | Byte35 Data | Byte36 Data |
|----------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Para9 | Para9 | Para10 | Para10 | Para11 | Para11 | Para12 | Para12 | Para13 | Para13 | Para14 | Para14 |
| 0 | 8 | 100 | 0 | 100 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| TEACH-VAL=2048 | | TOLHI=100 | | TOLLO=100 | | AVERAGE=2 | | POLARITY=1 | | TRIGMODE=0 | |

| Byte37 Data | Byte38 Data | Byte39 Data | Byte40 Data | Byte41 Data | Byte42 Data | Byte43 Data | Byte44 Data | Byte45 Data | Byte46 Data | Byte47 Data | Byte48 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Para15 | Para15 | Para16 | Para16 | Para17 | Para17 | Para18 | Para18 | Para19 | Para19 | Para20 | Para20 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ANAMODE=0 | | ANAZOOM=0 | | OPMODE=0 | | HWMODE=0 | | OUTMODE=0 | | RS232MODE=0 | |

| Byte49 Data | Byte50 Data | Byte51 Data | Byte52 Data | Byte53 Data | Byte54 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|
| Para21 | Para21 | Para22 | Para22 | Para23 | Para23 |
| 4 | 0 | 0 | 0 | 0 | 0 |
| RS232BAUD=4 | | FREEPARA=0 | | FREEPARA=0 | |

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 1 | 0 | 0 | 0 | 0 | 170 | 81 |
| | | ARG=0 | | LEN=0 | | | |

< ORDER = 2 > : READ PARAMETER-SET FROM RAM of the sensor

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header | |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|--|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) | |
| 85 (dec) | 2 | 0 | 0 | 0 | 0 | 170 | 185 | |
| ARG=0 | | | LEN=0 | | | | | |

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header | Byte9 Data | Byte10 Data | Byte11 Data | Byte12 Data |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|--------------------|--------------------|--------------------|--------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) | Para1 (lo byte) | Para1 (hi byte) | Para2 (lo byte) | Para2 (hi byte) |
| 85 (dec) | 2 | 0 | 0 | 46 | 0 | 240 | 185 | 144 | 1 | 0 | 0 |
| ARG=0 | | | LEN=46 | | | | POWER=400 | | PMODE=0 | | |

| Byte13 Data | Byte14 Data | Byte15 Data | Byte16 Data | Byte17 Data | Byte18 Data | Byte19 Data | Byte20 Data | Byte21 Data | Byte22 Data | Byte23 Data | Byte24 Data |
|-------------|-------------|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Para3 | Para3 | Para4 | Para4 | Para5 | Para5 | Para6 | Para6 | Para7 | Para7 | Para8 | Para8 |
| 0 | 0 | 53 | 5 | 25 | 0 | 3 | 0 | 1 | 0 | 0 | 16 |
| BGMODE=0 | | INT-TIME=1333 | | VTHD=25 | | EMODE=3 | | EBEG=1 | | EEND=4096 | |

| Byte25 Data | Byte26 Data | Byte27 Data | Byte28 Data | Byte29 Data | Byte30 Data | Byte31 Data | Byte32 Data | Byte33 Data | Byte34 Data | Byte35 Data | Byte36 Data |
|----------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Para9 | Para9 | Para10 | Para10 | Para11 | Para11 | Para12 | Para12 | Para13 | Para13 | Para14 | Para14 |
| 0 | 8 | 100 | 0 | 100 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| TEACH-VAL=2048 | | TOLHI=100 | | TOLLO=100 | | AVERAGE=2 | | POLARITY=0 | | TRIGMODE=0 | |

| Byte37 Data | Byte38 Data | Byte39 Data | Byte40 Data | Byte41 Data | Byte42 Data | Byte43 Data | Byte44 Data | Byte45 Data | Byte46 Data | Byte47 Data | Byte48 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Para15 | Para15 | Para16 | Para16 | Para17 | Para17 | Para18 | Para18 | Para19 | Para19 | Para20 | Para20 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ANAMODE=0 | | ANAZOOM=0 | | OPMODE=0 | | HWMODE=0 | | OUTMODE=0 | | RS232MODE=0 | |

| Byte49 Data | Byte50 Data | Byte51 Data | Byte52 Data | Byte53 Data | Byte54 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|
| Para21 | Para21 | Para22 | Para22 | Para23 | Para23 |
| 4 | 0 | 0 | 0 | 0 | 0 |
| RS232BAUD=4 | | FREEPARA=0 | | FREEPARA=0 | |

< ORDER = 8 > : READ MEASUREMENT DATA from sensor

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 8 | 0 | 0 | 0 | 0 | 170 | 118 |
| ARG=0 | | | | LEN=0 | | | |

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header | Byte9 Data | Byte10 Data | Byte11 Data | Byte12 Data |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|-------------------|-------------------|-------------------|-------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) | Raw1 (lo byte) | Raw1 (hi byte) | Raw2 (lo byte) | Raw2 (hi byte) |
| 85 (dec) | 8 | 0 | 0 | 40 | 0 | 36 | 118 | 155 | 8 | 64 | 9 |
| ARG=0 | | | | LEN=40 | | | | E_LEFT = 2203 | | E_RIGHT = 2368 | |

| Byte13 Data | Byte14 Data | Byte15 Data | Byte16 Data | Byte17 Data | Byte18 Data | Byte19 Data | Byte20 Data | Byte21 Data | Byte22 Data | Byte23 Data | Byte24 Data |
|--------------|-------------|--------------|-------------|--------------------|-------------|-------------|-------------|------------------|-------------|---------------|-------------|
| Raw3 | Raw3 | Raw4 | Raw4 | Raw5 | Raw5 | Raw6 | Raw6 | Raw7 | Raw7 | Raw8 | Raw8 |
| 180 | 7 | 2 | 0 | 83 | 181 | 18 | 0 | 0 | 8 | 11 | 0 |
| M_VAL = 1972 | | EDGE_CNT = 2 | | UM_VALUE = 1226067 | | | | TEACH_VAL = 2048 | | MV_FIRST = 11 | |

| Byte25 Data | Byte26 Data | Byte27 Data | Byte28 Data | Byte29 Data | Byte30 Data | Byte31 Data | Byte32 Data | Byte33 Data | Byte34 Data | Byte35 Data | Byte36 Data |
|-------------|-------------|----------------|-------------|----------------|-------------|--------------|-------------|------------------|-------------|-------------|-------------|
| Raw9 | Raw9 | Raw10 | Raw10 | Raw11 | Raw11 | Raw12 | Raw12 | Raw13 | Raw13 | Raw14 | Raw14 |
| 8 | 0 | 185 | 7 | 17 | 176 | 0 | 0 | 7 | 4 | 100 | 0 |
| MV_LAST = 8 | | ANA_MAX = 1977 | | ANA_MIN = 1968 | | IN_STATE = 0 | | VIDEO_MAX = 1017 | | DYNPOW=0 | |

| Byte37 Data | Byte38 Data | Byte39 Data | Byte40 Data | Byte41 Data | Byte42 Data | Byte43 Data | Byte44 Data | Byte45 Data | Byte46 Data | Byte47 Data | Byte48 Data |
|---------------|-------------|-------------|-------------|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Raw15 | Raw15 | Raw16 | Raw16 | Raw17 | Raw17 | Raw18 | Raw18 | Raw19 | Raw19 | Raw20 | Raw20 |
| 52 | 5 | 0 | 0 | 104 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| DYN_TIME=1332 | | RAW16=0 | | SCANTIME=2664 | | | | RAW19=0 | | RAW20 = 0 | |

< ORDER = 11 > : RESET MAX/MIN VALUE OF ANALOG-OUTPUT at sensor

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 11 | 0 | 0 | 0 | 0 | 170 | 47 |
| ARG=0 | | | | LEN=0 | | | |

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 190 | 0 | 0 | 0 | 0 | 170 | 47 |
| ARG=0 | | | | LEN=0 | | | |

< ORDER = 6 > : INITIATE TEACH-PROCEDURE at sensor (RAM)

The actual measurement value is set as new TEACH-IN value

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 | 6 | 0 | 0 | 0 | 0 | 170 | 101 |
| ARG=0 | | | | LEN=0 | | | |

DATA FRAME Sensor → PC

New TEACH-value is sent back

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header | Byte9 Data | Byte9 Data |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|--------------------|--------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) | Para1 (lo byte) | Para1 (hi byte) |
| 85 (dec) | 7 | 0 | 0 | 1 | 0 | 170 | 195 | 232 | 3 |
| ARG=0 | | | | LEN=1 | | | | TVAL=1000 | |

< ORDER = 11 > : RESET MAX/MIN VALUE OF ANALOG-OUTPUT at sensor

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 11 | 0 | 0 | 0 | 0 | 170 | 118 |
| ARG=0 | | | | LEN=0 | | | |

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 11 | 0 | 0 | 0 | 0 | 170 | 195 |
| ARG=0 | | | | LEN=0 | | | |

< ORDER = 12 > : SET LASER POWER at sensor

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 12 | 0 | 0 | 0 | 0 | 170 | 170 |
| | | ARG=0 | | LEN=0 | | | |

Laser intensity is set by <ARG> value:
 <ARG> = 0 = LASER OFF
 <ARG> = 1000 = MAX LASER POWER

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 12 | 0 | 0 | 0 | 0 | 170 | 170 |
| | | ARG=0 | | LEN=0 | | | |

< ORDER = 13 > : START/STOP 3-BYTE-OUTPUT at sensor

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 13 | 0 | 0 | 0 | 0 | 170 | 157 |
| | | ARG=0 | | LEN=0 | | | |

Function of 3-BYTE-OUTPUT is set by <ARG> value:
 Attention: Parameter 21 = RS-232-MODE must be set to CONT-3BYTE=3 in advance.

<ARG> = 0 = STOP 3-BYTE-OUTPUT
 <ARG> = 1 = START 3-BYTE-OUTPUT

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 13 | 0 | 0 | 0 | 0 | 170 | 157 |
| | | ARG=0 | | LEN=0 | | | |

< ORDER = 190 > : CHANGE BAUDRATE at sensor (RAM)

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 190 | 1 | 0 | 0 | 0 | 170 | 14 |
| | | ARG=1 | | LEN=0 | | | |

New baud rate is set by <ARG> value:

ARG=0: baud rate = 9600

ARG=1: baud rate = 19200

ARG=2: baud rate = 38400

ARG=3: baud rate = 57600

ARG=4: baud rate = 115200

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 190 | 0 | 0 | 0 | 0 | 170 | 195 |
| | | ARG=0 | | LEN=0 | | | |

< ORDER = 9 > : GET VIDEO-DATA INFORMATION of sensor

ATTENTION: Only 256 pixel of the CMOS line-sensor are transferred!

The <ARG> value determines the source of the VIDEO-DATA-INFORMATION

ARG = 0 : CMOS-VIDEO-RAM-DATA

DATA FRAME PC → Sensor

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) |
| 85 (dec) | 9 | 0 | 0 | 0 | 0 | 170 | 185 |
| ARG=0 | | | | LEN=0 | | | |

DATA FRAME Sensor → PC

| Byte1 Header | Byte2 Header | Byte3 Header | Byte4 Header | Byte5 Header | Byte6 Header | Byte7 Header | Byte8 Header | Byte9 Data | Byte10 Data | Byte11 Data | Byte12 Data |
|--------------|--------------|--------------------|--------------------|--------------------|--------------------|----------------|------------------|--------------------|--------------------|--------------------|--------------------|
| 0x55 | <order> | <ARG> (lo byte) | <ARG> (hi byte) | <LEN> (lo byte) | <LEN> (hi byte) | CRC8 (Data) | CRC8 (Header) | Para1 (lo byte) | Para1 (hi byte) | Para2 (lo byte) | Para2 (hi byte) |
| 85 (dec) | 9 | 0 | 0 | 0 | 1 | xxx | 185 | 200 | 0 | 220 | 0 |
| ARG=0 | | | | LEN=256 | | | | PIX1=200 | | PIX2=220 | |

| Byte13 Data | Byte14 Data | Byte15 Data | Byte16 Data | Byte17 Data | Byte18 Data | Byte19 Data | Byte20 Data | Byte21 Data | Byte22 Data | Byte23 Data | Byte24 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Para3 | Para3 | Para4 | Para4 | Para5 | Para5 | Para6 | Para6 | Para7 | Para7 | Para8 | Para8 |
| 240 | 0 | 0 | 1 | 44 | 1 | 124 | 1 | 0 | 2 | 88 | 2 |
| PIX3=240 | | PIX4=256 | | PIX5=300 | | PIX6=380 | | PIX7=512 | | PIX8=600 | |

| Byte25 Data | Byte26 Data | Byte27 Data | Byte28 Data | Byte29 Data | Byte30 Data | Byte31 Data | Byte32 Data | Byte33 Data | Byte34 Data | Byte35 Data | Byte36 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Para9 | Para9 | Para10 | Para10 | Para11 | Para11 | Para12 | Para12 | Para13 | Para13 | Para14 | Para14 |
| 168 | 2 | 170 | 2 | 188 | 2 | 188 | 2 | 198 | 2 | 208 | 2 |
| PIX9=680 | | PIX10=682 | | PIX11=700 | | PIX12=700 | | PIX13=710 | | PIX14=720 | |

| Byte37 Data | Byte38 Data | Byte39 Data | Byte40 Data | Byte41 Data | Byte42 Data | Byte43 Data | Byte44 Data | Byte45 Data | Byte46 Data | Byte47 Data | Byte48 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Para15 | Para15 | Para16 | Para16 | Para17 | Para17 | Para18 | Para18 | Para19 | Para19 | Para20 | Para20 |
| 34 | 3 | 32 | 3 | 32 | 3 | 22 | 3 | 19 | 3 | 20 | 3 |
| PIX15=802 | | PIX16=800 | | PIX17=800 | | PIX18=790 | | PIX19=787 | | PIX20=788 | |

●
●
●

| Byte49 Data | Byte50 Data | Byte51 Data | Byte52 Data | Byte53 Data | Byte54 Data | Byte55 Data | Byte56 Data | Byte57 Data | Byte58 Data | Byte59 Data | Byte60 Data |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Para251 | Para251 | Para252 | Para252 | Para253 | Para253 | Para254 | Para254 | Para255 | Para255 | Para256 | Para256 |
| 124 | 1 | 44 | 1 | 0 | 1 | 240 | 0 | 220 | 0 | 200 | 0 |
| PIX251=380 | | PIX252=300 | | PIX253=256 | | PIX254=240 | | PIX255=220 | | PIX256=200 | |