3D-Line Scan Camera 3DPIXA | Manual

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Support

Should you ever have problems with the 3DPIXA camera that you cannot solve by yourself, contact your local distributor or send us an email.

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Visit our website at http://www.chromasens.de which features detailed information on our company and products.

Table of contents

1 About this manual

1.1 Purpose of this manual

This manual describes the function, installation, setup and maintenance of 3DPIXA cameras whose article code starts with CP000470 or CP000520. For a description of the complete article code refer to chapter 2.2, p. 10.

CP000470 models:

- CP000470-D01-005-0035:   3DPIXA dual 5µm
- CP000470-C01-015-0040:   3DPIXA compact 15µm
- CP000470-C01-030-0105:   3DPIXA compact 30µm
- CP000470-D01-030-0210:   3DPIXA dual 30µm
- CP000470-D01-070-0500:   3DPIXA dual 70µm

CP000520 models:

- CP000520-D02-005-0035:   3DPIXA dual HR 5µm
- CP000520-D01-015-0105:   3DPIXA pro dual 15µm
- CP000520-D02-200-1400:   3DPIXA dual HR 200 µm

An overview of all available 3DPIXA camera models can be found on our homepage.

1.2 Associated documents

For certain operations the following manuals are useful for additional information:

Document	Description
Drawings and 3D CAD models	Technical drawings (see orange USB-stick) and CAD models
CS-3D-Viewer manual	User manual of the CD-3D-Viewer software for calculating the 3D information from the captured image(s).
allPIXA manual	Operating manual for the allPIXA cameras (CP000470 models)
allPIXA pro manual	Operating manual for the allPIXA pro cameras (CP000520 models)
Corona II + LED-Control Unit XLC4-1 Manual	User manual of the Corona II Illumination and the LED control unit XLC4
CS-3D-API manual	Software manual for CS-3D-API (C++ library)
CS-API manual	Software manual for Chromasens camera API
3DPIXA System Requirements	Specification of the hardware and software requirements

Tab. 1:   Associated documents

These documents are included in the scope of supply (see chapter 2.8, p. 17) and/or can be downloaded from our partner portal at http://www.chromasens.de/user.

1.3   Using this manual

▶ Read the manual carefully before installation, configuration and operation of the camera.
▶ Retain the manual throughout the entire working life of the camera.
▶ Keep the manual accessible to the operating personnel at all times.
▶ Pass the manual on to any subsequent owner or user of the camera.
▶ If the camera is installed in a machine or system, integrate the information contained in this manual into the machine or system documentation.

1.4   Firmware and software version in this manual

This document refers to the following version:
CS-3D-Software: v2.3e
Camera-FW: 1.69 (CP000470 models)
                         3.02 (CP000520 models)
CST version: 2.7.2 Build 11

Newer versions may have additional features. Contact our support for more details about new features.

1.5   List of abbreviations

Abbreviation	Explanation
API	Application Programming Interface
CST	Camera Setup Tool
FVAL	FrameValid Signal
GPU	Graphical Processing Unit
LVAL	LineValid Signal
LVDS	Low Voltage Differential Signaling
LVTTL	Low Voltage Transistor Transistor Logic
ROI	Region Of Interest
USB	Universal Serial Bus
PRNU	Photo Response Non Uniformity
AFE	Analog Front End

Tab. 2:   List of abbreviations

1.6 Symbols and markers

Symbol	Meaning
1. 2.	Requests for a multi-step action.
▶	Request for a single-step action.
✓	Pre-requirement for a requested action.
↪	Result of an action.

Tab. 3: Symbols and markers

⚠ **WARNING! Hazardous situation or task, which, if not avoided, may result in serious injury or death!**

▷ Measure for avoidance.

⚠ **CAUTION! Hazardous situation or task, which, if not avoided, may result in minor or moderate injury!**

▷ Measure for avoidance.

NOTICE! Hazardous situation or task, which, if not avoided, may result in damage to the product or the surrounding environment!

▷ Measure for avoidance.

ℹ Instructions for understanding or optimizing the operations.

2 Technical data

2.1 Intended use

The 3DPIXA is a stereo camera using line scan technology. It provides stereo images as a basis for the calculation of the 3D height data by one or multiple GPUs.

The 3DPIXA is designed for installation in machines and systems which are used for commercial and industrial applications, such as:

- Fast inline height measurement
- Completeness check in 2D and 3D
- Verification of 2D and 3D dimensions
- Identifying micron defects
- Combined 3D and 2D color inspection
- 3D web inspection

When using the 3DPIXA the following aspects must be recognized:

- The owner of the machine or system in which the 3DPIXA is installed is responsible for compliance with relevant safety regulations, standards and directives. Commissioning of the 3DPIXA is not permitted until it has been verified that the machine or system in which the 3DPIXA is installed complies with the safety regulations and standards of the country in which the 3DPIXA is run.
- The owner of the machine or system in which the 3DPIXA is installed must verify the suitability of the 3DPIXA for its intended use.
- The safety regulations of the country in which the device is used must be complied with.
- The 3DPIXA may only be connected or used as described in this manual.
- The 3DPIXA must be set up and installed in compliance with the instructions contained in this manual.

2.2 Definition of the camera identification

The article code of the 3DPIXA contains information on the camera model and is structured into 4 parts. Each part contains different information:
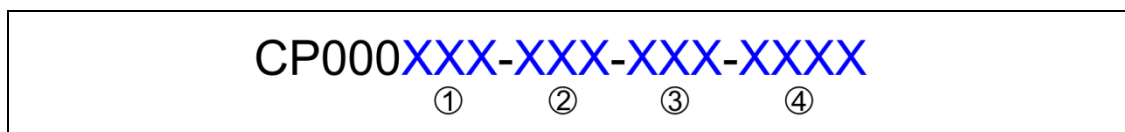
Fig. 1:   Structure of the article code

1   Type of electronics:
   – 470: allPIXA (classic)
   – 520: allPIXA pro
2   3DPIXA type
   – CXX: Compact
   – DXX: Dual
   – EXX: OEM
3   Resolution in µm
4   Field of view in mm

ℹ️ 3DPIXA cameras whose article code starts with CP000470 work with allPIXA electronics. For additional information, refer to the allPIXA manual.

3DPIXA cameras whose article code starts with CP000520 work with allPIXA pro electronics. For additional information, refer to the allPIXA pro manual.

An overview of all available 3DPIXA camera models can be found on our homepage.

2.3 Technical specifications

3DPIXA compact

	CP000470-C01-015-0040	CP000470-C01-030-0105
Optical resolution (µm/px)	15	30
Field of view (mm) (see Fig. 2, p. 13)	40	105
Number of pixels per line	2666	3500
Height resolution (µm)*	3	10
Height range (mm)* (see Fig. 2, p. 13)	2.6	8.2
Free working distance (mm) (see Fig. 2, p. 13)	99.6 ± 0.1	173.6 ± 0.1
Maximum speed for image acquisition (mm/s)	310	630
CameraLink configurations	Base/Medium	Base/Medium
Line frequency (kHz)	21.2	21.2
Dimensions L x W x H (mm) (see Fig. 2, p. 13)	167.65 x 102 x 100	151.04 x 102 x 100
Weight (kg)	2.7	2.15

Tab. 4: Technical specifications of the 3DPIXA compact models
* Height range and height resolution depend on object surface.
For well-structured surfaces the height range can exceed the specified values.

3DPIXA dual CP000470 models

	CP000470-D01-005-0035	CP000470-D01-030-0210	CP000470-D01-070-0500
Optical resolution (µm/px)	5	30	70
Field of view (mm) (see Fig. 2, p. 13)	35	210	500
Number of pixels per line	7000	7000	7142
Height resolution (µm)*	1	5	14
Height range (mm)* (see Fig. 2, p. 13)	0.7	11.2	52.3

	CP000470-D01-005-0035	CP000470-D01-030-0210	CP000470-D01-070-0500
Free working distance (mm) (see Fig. 2, p. 13)	71.9 ± 0.1	413.3 ± 0.1	796.9 ± 0.1
Maximum speed for image acquisition (mm/s)	100	630	1480
CameraLink configurations	Base/Medium	Base/Medium	Base/Medium
Line frequency (kHz)	21.2	21.2	21.2
Dimensions L x W x H (mm) (see Fig. 2, p. 13)	324 x 258 x 97	244 x 242 x 98.5	222 x 352 x 98.5
Weight (kg)	8.3	7.6	11.3

Tab. 5: Technical specifications of the 3DPIXA dual CP000470 models
* Height range and height resolution depend on object surface.
 For well-structured surfaces the height range can exceed the specified values.

3DPIXA dual CP000520 models

	CP000520-D02-005-0035	CP000520-D01-015-0105	CP000520-D02-200-1400
Optical resolution (µm/px)	5	15	200
Field of view (mm) (see Fig. 2, p. 13)	35	105	1400
Number of pixels per line	7000	7000	7000
Height resolution (µm)*	0.55	3	60
Height range (mm)* (see Fig. 2, p. 13)	0.5	3.5	400
Free working distance (mm) (see Fig. 2, p. 13)	77.9 ± 0.1	229 ± 0.1	1646.3
Maximum speed for image acquisition (mm/s)	106	440	4240
CameraLink configurations	Base/Medium	Base/Medium/ Full	Base/Medium
Line frequency (kHz)	21.2	29.7	21.2
Dimensions L x W x H (mm) (see Fig. 2, p. 13)	363 x 278 x 99	274 x 212.4 x 98.5	220.3 x 463 x 98.5
Weight (kg)	11.75	6.2	13.9

Tab. 6: Technical specifications of the 3DPIXA dual CP000520 models
* Height range and height resolution depend on object surface.
 For well-structured surfaces the height range can exceed the specified values.
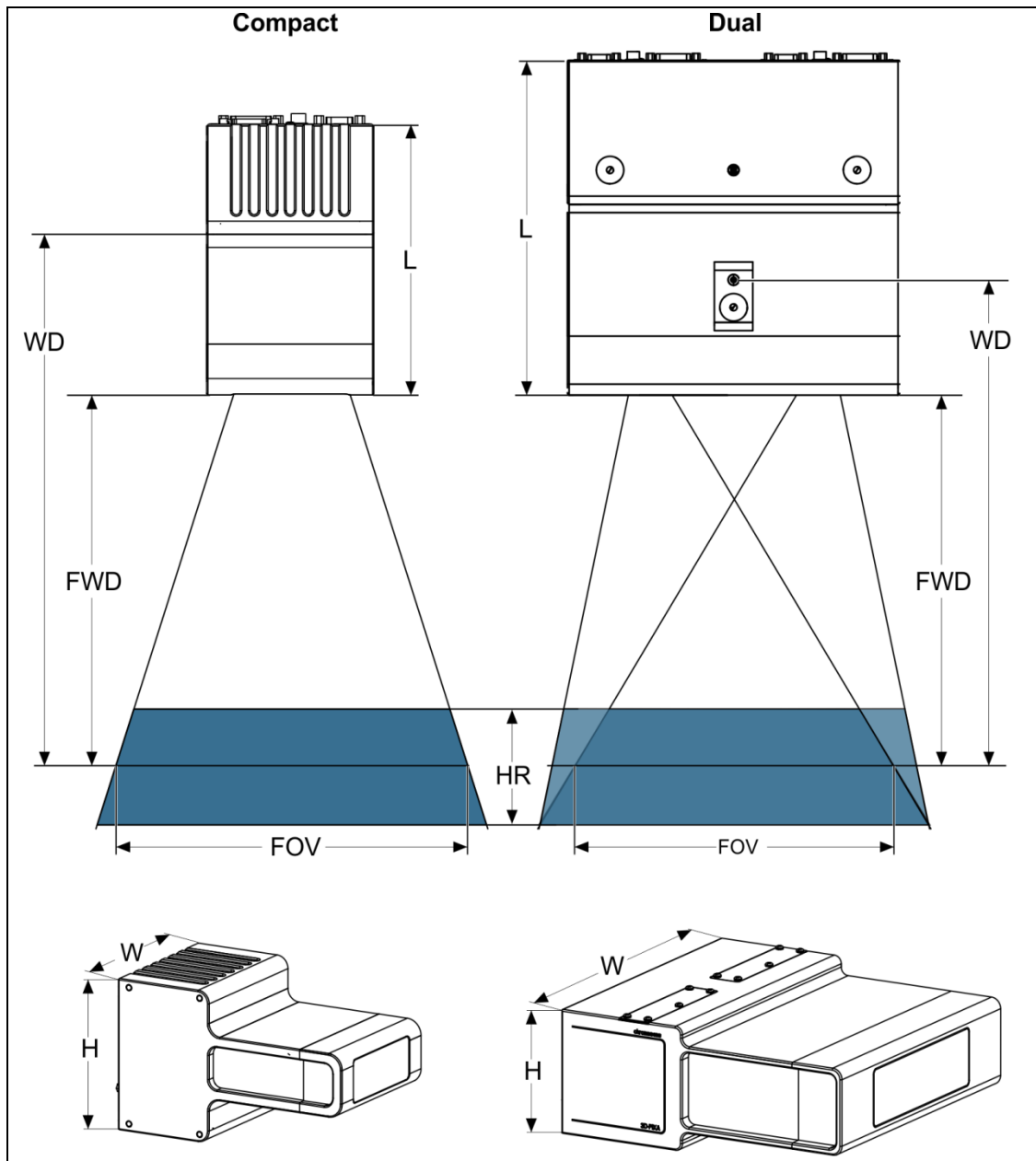
Fig. 2:   *Dimensions*

FOV	Field of view		HR	Height range
FWD	Free working distance		W	Width
L	Length		WD	Working distance
H	Height			

The reference positions of the used 3DPIXA model you will find in the corresponding technical drawing (see orange USB-stick).

2.4 Camera specifications

Camera	Stereo camera with lenses (factory calibrated)
Sensor	Tri-linear CCD line-sensor (RGB)
Active pixel size	10 µm x 10 µm
Interfaces	• CameraLink Base/Medium/Full • External I/O • Serial (RS232) • Power supply (Hirose) See chapter 10.2, p. 95.
Power supply	• Compact: 24 V DC ±10%; 1 A; 16 W • Dual CP000470: 24 V DC ±10%; 2 x 1 A; 32 W (2 x Hirose) • Dual CP000520: 24 V DC ±10%; 2 A; 38 W (1 x Hirose)
Trigger mode	Free run / external trigger
Operating temperature	0 °C to 60 °C, 32 °F to 140 °F (housing temperature)
Additional accessories	Chromasens Corona II illumination
Certifications	CE, FCC compliant, RoHS

Tab. 7:   Camera specifications

2.5 Software specifications

Software	• Chromasens 3D-API for fast 3D data calculation on NVIDIA GPU boards (Windows x64), see (see chapter 2.6.2, p. 16) • Chromasens 3D Viewer
Software output	• Rectified color image (3x8 Bit) • 3DPIXA compact: 1 raw image • 3DPIXA dual: 2 raw images • Height map (16 Bit) • 3D point cloud
Supported software libraries	• LabVIEW (National Instruments) • HALCON (MVtec) • MIL (Matrox) • Coake (SAC)

Tab. 8:   Software specifications

2.6 Compatibilities

2.6.1 CameraLink frame grabbers

The 3DPIXA camera is compatible with CameraLink frame grabbers which support the following configurations:

CP000470 models:

- CameraLink Base configuration:
  If a line frequency of 21.2 kHz is not required, the 3DPIXA can also be operated in base mode with a line frequency of 11.6 kHz.
  – Configuration: 1 tap with 24 bits   1X (1 pixel with 24 bits)
  – Bandwidth: 3 bytes @ 85 MHz pixel clock frequency = 255 MBytes/s
- CameraLink Medium configuration:
  High performance of the 3DPIXA is reached by using the medium configuration with a line frequency of 21.2 kHz.
  – Configuration: 2 taps with 24 bits   2XE (2 pixels with 24 bits)
  – Bandwidth: 6 bytes @ 85 MHz pixel clock frequency = 510 MBytes/s

CP000520 models:

- CameraLink Base configuration:
  If a line frequency of 23.1 kHz is not required, the 3DPIXA can also be operated in base mode with a line frequency of 12.4 kHz.
  – Configuration: 1 tap with 24 bits   1X (1 pixel with 24 bits)
  – Bandwidth: 3 bytes @ 85 MHz pixel clock frequency = 255 MBytes/s
- CameraLink Medium configuration:
  High performance of the 3DPIXA is reached by using the medium configuration with a line frequency of 23.1 kHz.
  – Configuration:
    2 taps with 24 bits   1X2 (2 pixels with 24 bits) (default setting)
    or
    2 taps with 24 bits   2XE (2 pixels with 24 bits)
  – Bandwidth: 6 bytes @ 85 MHz pixel clock frequency = 510 MBytes/s
- CameraLink Full configuration:
  Full performance of the 3DPIXA is reached by using the full configuration with a line frequency of 29.7 kHz.
  – Configurations:
    Full64: 8 taps with 8 bits   8Tx8b 1X8 raw
    Full80: 8 taps with 10 bits   8Tx10b 1X8 raw
              10 taps with 8 bits   10Tx8b 1X10 raw
  – Bandwidths:
    Full64: 8 bytes @ 85 MHz pixel clock frequency = 680 MBytes/s
    Full80: 10 bytes @ 85 MHz pixel clock frequency = 850 MBytes/s

Chromasens regularly tests frame grabbers for their compatibility with the 3DPIXA cameras. A list of frame grabbers tested can be found on our partner portal at http://www.chromasens.de/user (Downloads > System Requirements > 3DPIXA System Requirements).

2.6.2 GPUs

If the CS-3D-Viewer V2.3 and the CS-3D-API are used, CUDA 3.0 capable GPU is required. The calculation speed of the 3D data depends on the GPU used for the 3DPIXA application.

Chromasens regularly tests GPUs for their compatibility with the 3DPIXA cameras. A list of GPUs tested can be found on our partner portal at http://www.chromasens.de/user (Downloads > System Requirements > 3DPIXA System Requirements).

2.7 Ambient conditions

General ambient conditions

Life phase	Standard
Operation	IEC 721-3-3:IE33
Transport	IEC 721-3-1:IE11
Storage	IEC 721-3-2:IE21

Tab. 9:   General ambient conditions

Camera-specific ambient conditions

Condition	Value
Temperature during camera operation	0 °C to 60 °C, 32 °F to 140 °F (housing temperature)
Air humidity during camera operation	20 to 85% relative air humidity, noncondensing
Storage/transport temperature	–20 to +85 °C, –4 °F to 185 °F
Protection category	IP50

Tab. 10: Camera-specific ambient conditions

2.8   Scope of supply

- 3DPIXA stereo color line scan camera
- Master/Slave cable (3DPIXA dual CP000470 only, for 3DPIXA dual CP000520 not required)
- Software-protection dongle (silver USB-stick)
- Orange USB stick
  – 3D
      - CS-3DPIXA manual (this document)
      - Calibration files
      - CS-3D-Viewer and CS-3D-API software package
      - CS-3D-Viewer manual
      - CS-3D-API manual
      - Technical drawings
      - 3D camera models
  – Camera
      - CST (parameter programming software)
      - CS.-API / CS-API manual
      - allPIXA manual
      - allPIXA pro manual
  – Illumination
      - XLC4 commander / drivers
      - Corona II manual
      - Technical drawings
- Optional accessories (if ordered)

2.9   Optional accessories

The following optional accessories are available:

- Corona II Illumination: dark field, bright field, tube light (see current product catalog and Chromasens website)
- Power cable

3 Safety

3.1 Basic safety regulations

- ► Read all supplied documentation carefully and ensure that you have fully understood its contents before installing and operating the camera.
- ► Follow the instructions in this manual, especially with regard to transport, storage, installation, operation and maintenance.
- ► Operate the camera only under faultless and safe conditions.
- ► In the event of any fault or defect, stop the camera, the machine or the system in which the camera is installed, and immediately inform the responsible person.
- ► Modify or extend the camera only with the written consent of Chromasens GmbH. This applies in particular to modifications and extensions which can negatively affect the safety of the camera.
- ► Comply with the ambient conditions described in this manual.

3.2 Safety instructions for maintenance and cleaning

- ► Inform all personnel working on the system before carrying out service or maintenance work.
- ► Comply with deadlines and intervals for regular inspection work.
- ► Before starting maintenance work, disconnect the 3DPIXA from the power supply.
- ► Before starting maintenance work, let heat sources such as heaters, radiators or lighting equipment and the camera cool down to room temperature.
- ► Do not open or loosen screws or housing sections of the 3DPIXA.
- ► Do not carry out repair works.
- ► Transport the camera in its original packaging in order to prevent damage.

3.3 Residual risks

3.3.1 Hot surfaces

The body of the 3DPIXA will heat up during operation.
- ► Do not touch hot surfaces without suitable protective gloves.
- ► Allow hot surfaces to cool down before carrying out any work on the unit.

3.3.2 Electric voltage

The 3DPIXA runs with electric power.
- ► Before carrying out any work on the 3DPIXA, disconnect all mains cables.
- ► Make sure that the device is safely isolated from the power supply.

3.3.3 Electrostatic discharge

The 3DPIXA contains components and units which are sensitive to electrostatic charge.
- ► Observe all precautionary measures for handling electrostatically sensitive equipment.
- ► Make sure that the 3DPIXA, all tools and the person handling the equipment have the same electrical potential.

3.4 Personnel requirements

- The system owner must ensure that all persons working on the system are trained for the required work and have read and understood this manual. This applies in particular to personnel who only work occasionally with the 3DPIXA, for example during commissioning and maintenance work.
- Work on the electrical installations of the system may only be carried out by a qualified electrician or by persons who have undergone electrotechnical training under the supervision of a qualified electrician in compliance with applicable electrotechnical regulations.
- Only suitably trained and qualified persons are permitted to work with the 3DPIXA. Such persons are qualified to work with the 3DPIXA device if they are familiar with its assembly, installation and care as well as with all necessary precautionary measures.
- The assignments and responsibilities of personnel charged with operation, commissioning, maintenance and repair must be clearly defined. This definition must be specified by the owner of the machine or system in which the 3DPIXA is installed.

4 Design and function

4.1 Components of a 3D scanner system
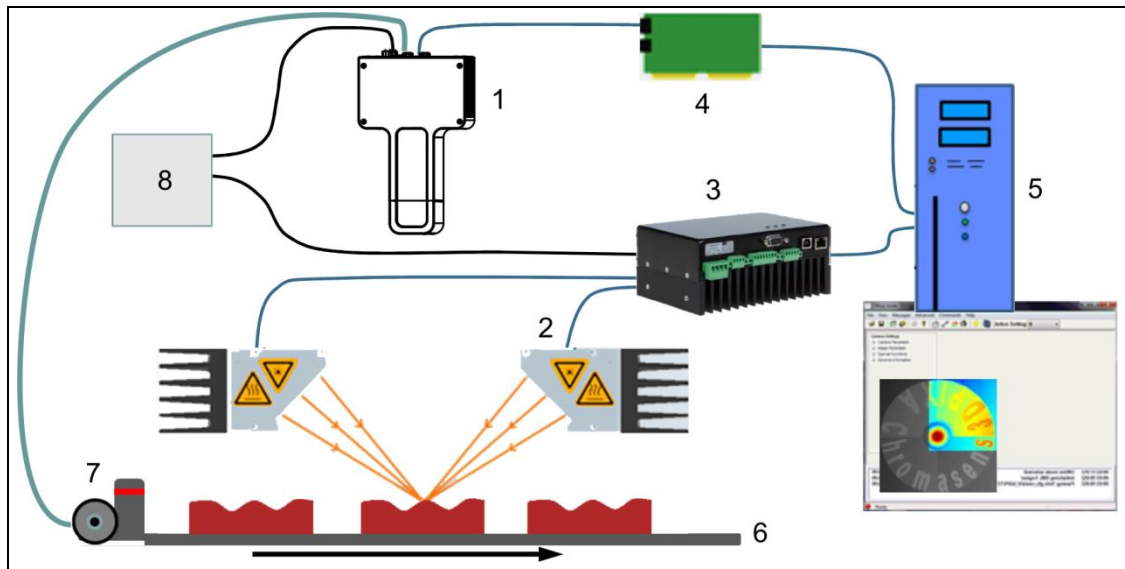
Fig. 3:   Design of a line scan camera application

The following components are necessary for a typical line scan camera application:

	Component	Function
1	Line scan camera	Scans the image line by line and communicates with the frame grabber.
2	Illumination	Lights up the information carrier/scan area on the passing object. The Chromasens Corona II illumination system is an ideal supplementary option for the 3DPIXA camera.
3	Illumination controller	Controls and monitors the illumination unit. The Chromasens Corona II illumination has integrated temperature/voltage sensors which can be read out with the XLC4 controller. By using the XLC4 controller, the illumination unit can be monitored and kept stable.
4	Frame grabber (PC plug-in card)	The image data are sent to a PC by means of a frame grabber with a CameraLink interface. The frame grabber establishes the necessary hardware connection to the PC.
5	PC with GPU and dongle	The PC serves for subsequent processing of the image data and can optionally control the illumination system.
6	Conveying unit	Moves the scanned object past the 3DPIXA camera.
7	Speed detection	The speed of the object / conveyor belt can be detected by means of an optional incremental encoder. The encoder can be connected either to the 3DPIXA camera or to the frame grabber.
8	Power supply	Both, the 3DPIXA camera and the illumination system, require a suitable power supply.

4.2 Principle design of the camera

4.2.1 Image acquisition

During operation an object is scanned by a CCD sensor.
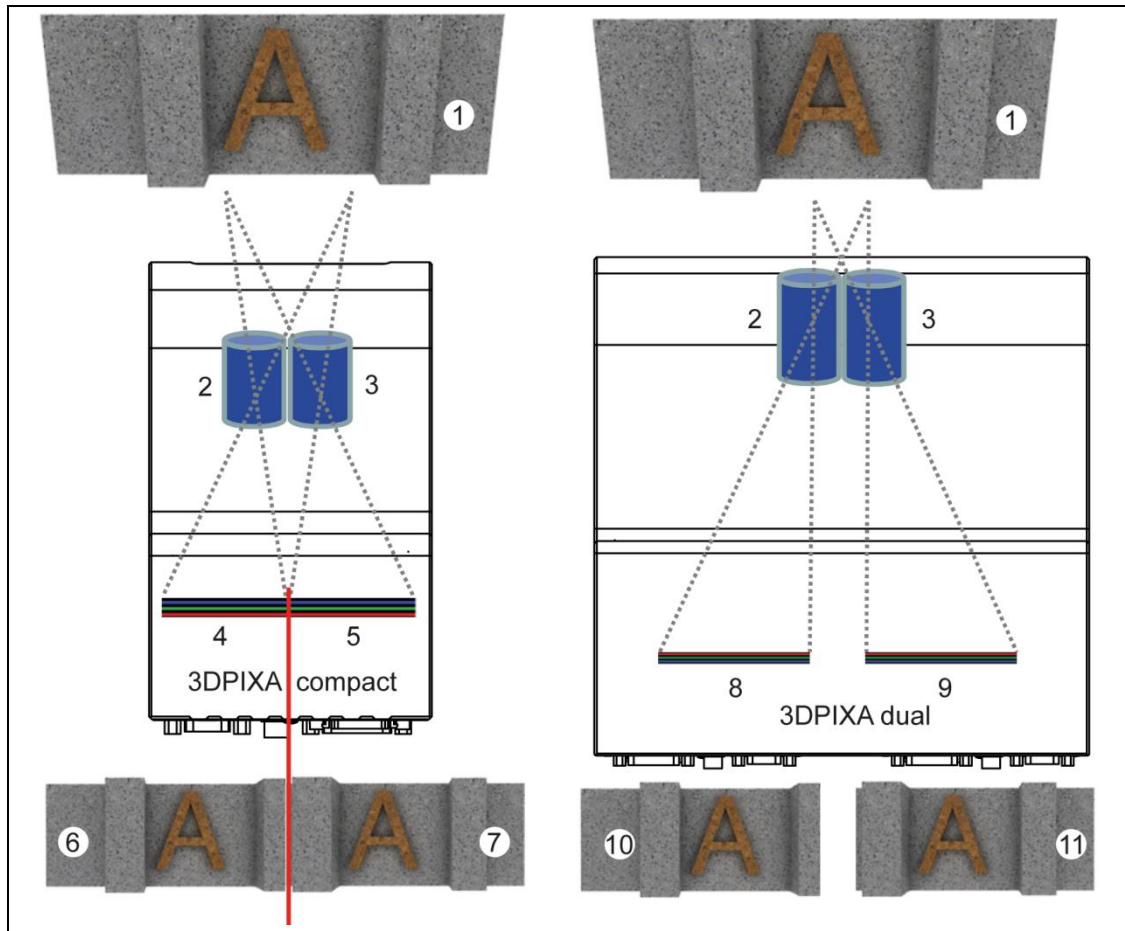
Fig. 4:   Comparison of the image acquisition by the 3DPIXA compact and 3DPIXA dual camera

1	Object	5	Front tab	9	Master sensor
2	Left lens	6	Rear tab image	10	Slave image
3	Right lens	7	Front tab image	11	Master image
4	Rear tab	8	Slave sensor		

In both camera types, 2 lenses (2, 3) at a defined distance create images of the object (1) on a CCD sensor.

- The CCD sensor of the 3DPIXA compact camera is divided into a front tab (5) and a rear tab (4) delivering a single stereo image (6, 7).
- The 3DPIXA dual camera is equipped with 2 physically separated sensors (8, 9) delivering master (11) and slave images (10).

The 2 images show slightly different perspective views of the object. These views are used for 3D calculation (see chapter 4.4, p. 24).

4.2.2 Restrictions on image pre-processing

Pre-processing in camera

Some of the functionalities that are, e.g., available for standard allPIXA cameras, are not available for 3DPIXA cameras. Some of the functions are available via the CS-3D-API (e.g. ROI) while others are making no sense for that specific camera type.

By selecting the compatible 3DPIXA camera in the CST, the unusable functions are greyed out. In this case the function cannot be set or changed.

General pre-process before 3D calculation

There could be applications where, e.g., a background segmentation could be helpful for the 3D data calculation. In this regard, please refer to our partner portal at http://www.chromasens.de/user (Downloads > Whitepapers) or contact our support.

4.3 Principle functionality of a line scan sensor

The 3DPIXA camera is equipped with trilinear CCD line scan sensors, each with 3 spatially separated lines. The lines are sensitive to the colors red, green and blue (RGB). In this way, each image point delivers 3-color information with 3 x 8 bit.
The square-shaped sensor pixels have sides of 10 µm length. The distance between the color sensor lines is 40 µm.
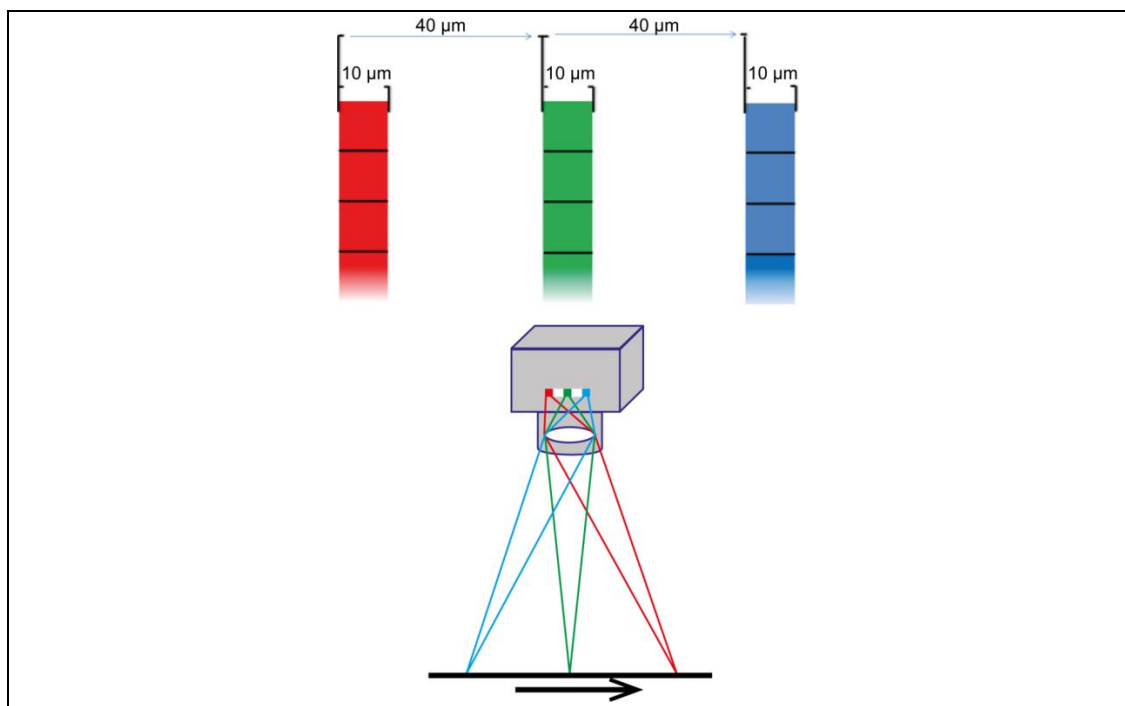
Fig. 5:   Sensor pixels of a line scan sensor

As a result of the object movement, an object point successively passes the 3 sensor lines. The 3DPIXA camera compensates the spatial separation of the sensor lines by taking into account the movement speed of the object. The 3 color channels are then combined into a complete color image. Continual scanning provides a color image which can theoretically be infinitely long.

4.3.1 Frame scan mode

The 3DPIXA camera is able to emulate a frame scan camera. Output data will be in real frames and the VSync signal (or FVAL) will be generated. The information on frame start and image size have to be supplied to the camera.

The trigger signal can be supplied as described in chapter 4.9, p. 31. The input connector of the external signals has to be configured by the IO-configurator via CST (see chapter 6.6, p. 57).

The image height (= number of scan lines per image) can be controlled by a fixed value or an external signal depending on the object size.

For 3DPIXA dual cameras the frame scan mode with FVAL is obligatory. This mode ensures the correct synchronization between the two separate cameras of the 3DPIXA dual camera and frame grabber.

4.3.2 Concept of image synchronization via frame mode

The 3DPIXA camera is able to emulate a frame scan camera as already described in chapter 4.3.1, p. 23. Output data will be in real frames and the VSync signal (or FVAL) will be generated.

Fig. 6 shows a simplified representation of the synchronization in the 3DPIXA dual between master camera and slave camera (left) and the processing in the frame grabber (right).
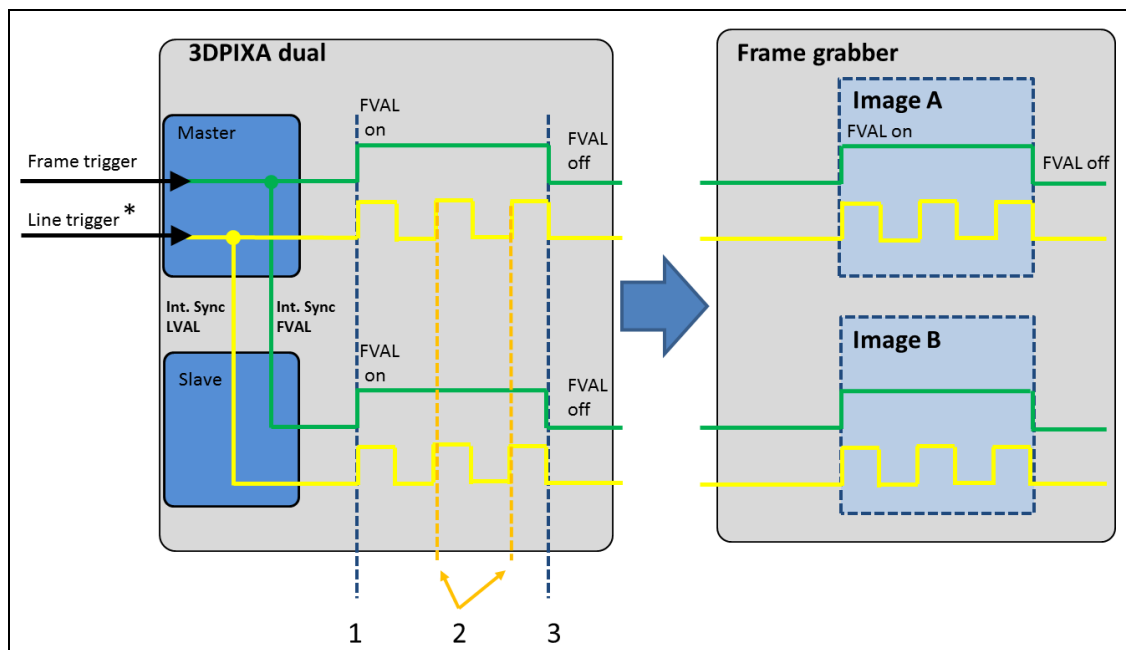
Fig. 6:   Synchronization 3DPIXA dual and processing in the Frame grabber
   * If no external line trigger signal is used, the master camera generates an internal line trigger signal that is determined by the integration time or the line period time (line free run).

1. The master camera uses the frame trigger signal to generate the FVAL. Due to the synchronization, the FVALs of the master camera and the slave camera are identical, which leads to a simultaneous image start of the master camera and the slave camera.
2. The master camera uses the line trigger signal to generate the LVAL. For one LVAL one image line is acquired in each camera. Due to synchronization, the LVALs of the master camera and the slave camera are identical, which leads to a synchronized recording of each image line between the master camera and the slave camera.
3. Due to the synchronized FVALs of the master camera and the slave camera, also the image ends of the master camera and the slave camera are identical.

> The frame/line trigger can be realized via I/O port of the camera or via frame grabber and CameraLink cable using CC bits (see chapter 5.5, p. 44).

4.4 Stereo imaging

Getting height information from stereo images is based on the triangulation principle. The same object is captured with 2 cameras providing a left and a right image (see chapter 4.2.1, p. 21). This means that one point on the object surface has 2 corresponding image points: one in the right and one in the left image.
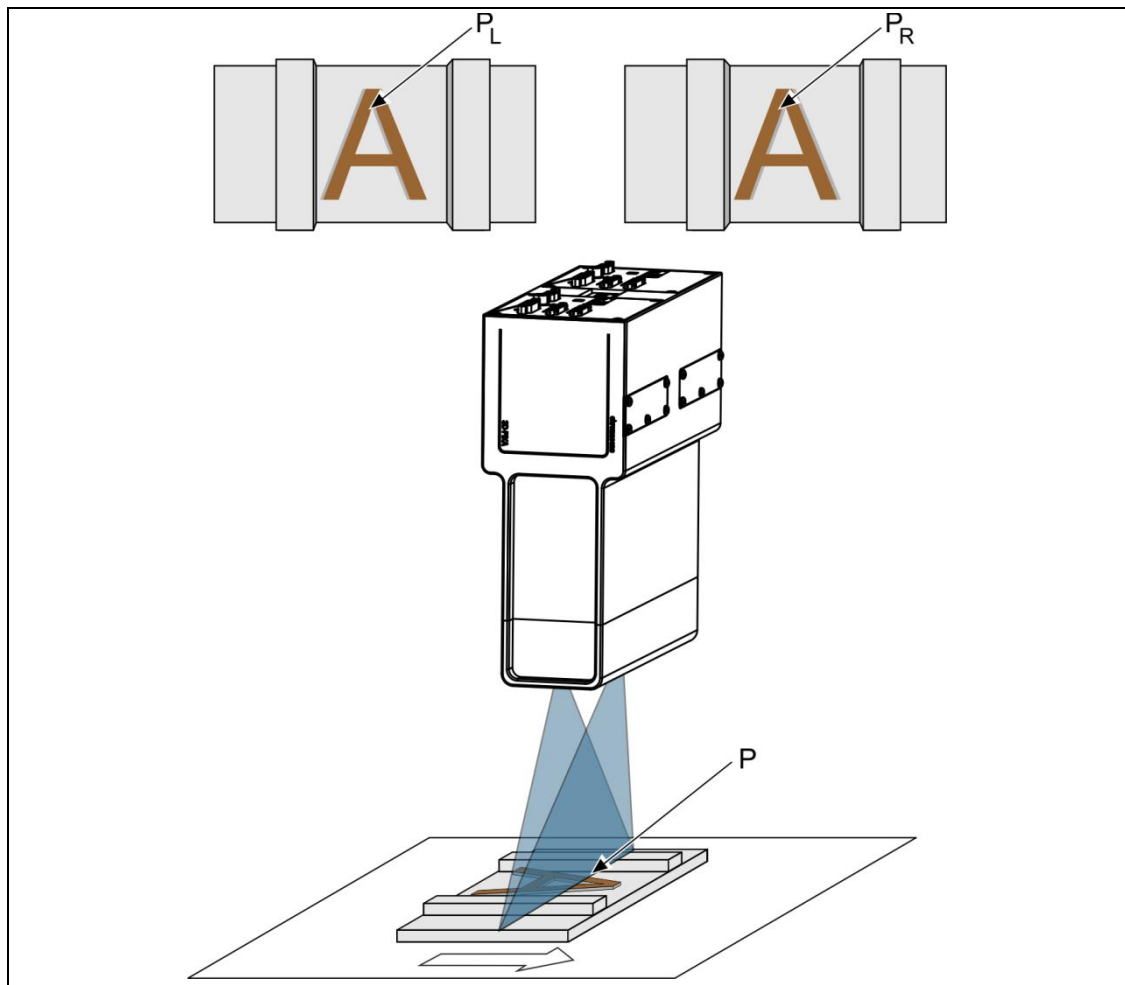
Fig. 7: Stereo imaging

Image point calculation:

- For calculating the height of an object point P, the corresponding 2 image points P_L and P_R have to be identified.
    - Differences of the 2 raw images (e.g., orientation, optical resolution) are rectified by calculation.
    - A pattern matching approach is applied to the rectified images to find the corresponding 2 image points (see chapter 4.4.1, p. 25).
- The distance (disparity) of the 2 corresponding image points is measured with subpixel accuracy. Each pair of corresponding image points results in a disparity value recorded in the height map image. The height map image consists of 16 bit grey values.
- The height in mm is determined from the height map image using the CS-3DAPI with calibration and configuration file.

4.4.1   Pattern matching

For pattern matching a correlation-based approach is used.
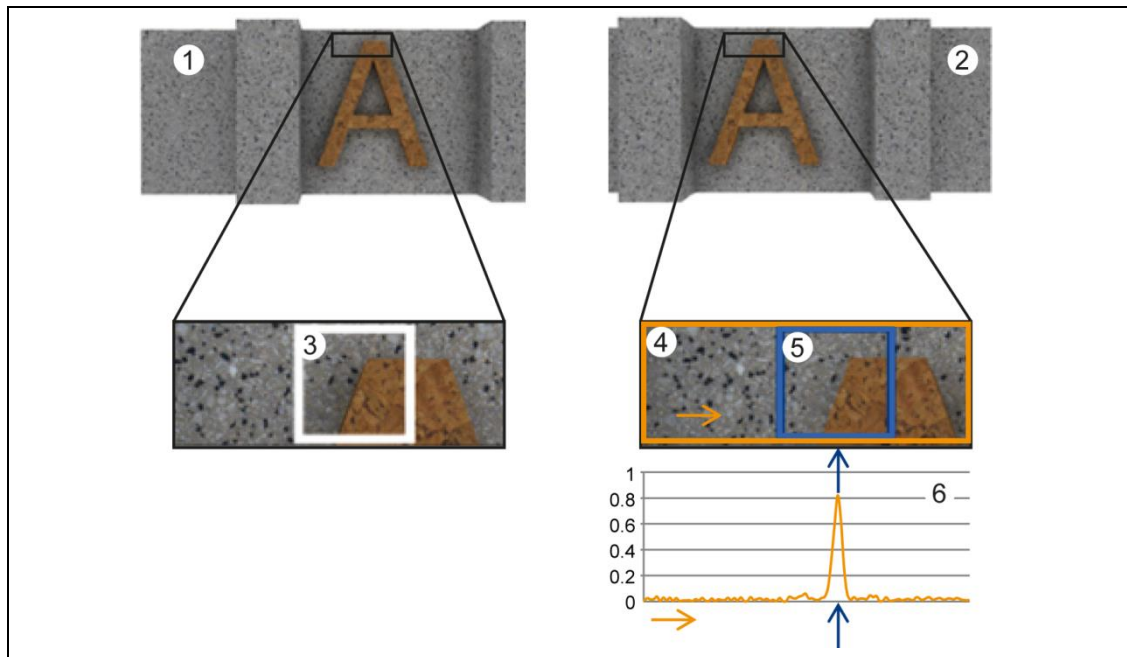
Fig. 8:   Pattern matching

1	Front tab / Master image	4	Search window
2	Rear tab / Slave image	5	Best match
3	Reference pattern	6	Correlation values

For each image point in the first image (e.g. slave image) a small window surrounding this point is taken as a reference pattern (3).

For this reference pattern the correlation values (6) are performed for all image points in the expected height range (determined by the minimum and maximum disparity setting) using a search window (4) in the second image (e.g. master image).

The highest correlation value gives the position of the best match (5). The position shift of the 2 image points is the disparity.

The pattern matching algorithm and the subsequent processing of the 3D data can be optimized with the following parameters:

- Window size
- Maximum and minimum disparity (corresponding to the expected height range)
- Minimum correlation factor
- Additional system parameters

For information on the parameter adjustment refer to the documentation of CS-3D-API and the CS-3D-Viewer.

> For pattern matching both images should be almost identical. To achieve this, evenly and homogeneously illuminated as well as perfectly focused images are very important.

4.5 Black offset and shading correction

The 3DPIXA camera supports black offset and shading (flat field) correction with the following properties:

- Both correction methods are based on pixel-by-pixel calculation, and the effects on the behavior of single pixels like PRNU (Photo Response Non Uniformity) and DSNU (Dark Signal Non Uniformity) will be eliminated.
- Both correction methods are carried out separately for every line (red, green, blue).
- The 3DPIXA camera offers 4 data sets for black offset correction and 4 data sets for shading correction. Therefore the user is able to utilize up to 4 different lighting systems by selecting the necessary data sets without transferring or generating new shading data.
- To measure height data with 3DPIXA dual, a valid offset and shading correction are both needed for the master and the slave camera.
- The 3DPIXA camera offers the possibility to generate black offset and shading correction internally or offline.
- For black offset correction the offline or internal calculation can be used without limitations. For a detailed description of the black offset correction refer to chapter 6.13, p. 76.
- For shading correction the offline calculation is recommended. For the offline calculation a scanned image that includes a moving homogeneous white object is needed. Scan the reference object and select the scanned image as reference image in the shading wizard. By averaging over a higher number of lines of a moving target, distortion by, e.g., dust will be eliminated. For a detailed description of the shading procedure refer to chapter 6.14, p. 77.
- Shading data calculated internally with a static white reference in front of a camera lead to vertical lines in the image, caused by spots of dust on the white reference or by the structure of the white reference material itself. These vertical lines in the image lead to incorrect or missing 3D height data which renders this method unusable.
- If no offline calculation of the shading correction is possible and shading correction has to be calculated internally, the target has to be slightly moved during the internal shading process. In this way, distortions by, e.g., dust may also be eliminated. In this case, it is very important to check the image quality while enabling the shading correction that no vertical lines are apparent.

> For shading correction the offline calculation is recommended.
>
> ▷   Use an image of a moving white object.
> ▷   Do **not** use a static white reference for shading correction.

- Generated data sets may be stored to the hard disc of the PC. The stored data can be transferred to the camera later on.

4.6 White balancing

In order to set the video values to optimal conditions, the 3DPIXA camera supports an automatic adjustment of the internal gain values. A closed loop can be established which enables an automatism of setting the white point stable in optimal conditions.
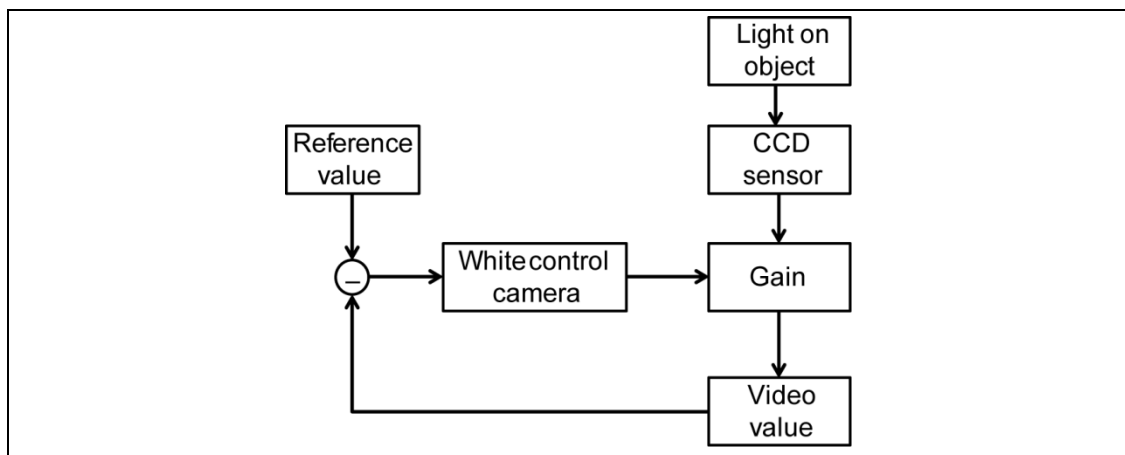
Fig. 9:   Closed loop control for white balancing

With the 3DPIXA camera, the area of an image can be defined as a reference, and the reference values (target values) can be set separately for each channel.

White balancing can be applied in 2 different ways:

- Single setup process:
  For 3DPIXA, white balancing is a single setup process with a static white reference in front of the camera during its installation (see chapter 6.12.1, p. 68).
  For 3DPIXA dual, white balancing has to be performed for the master and the slave camera separately.
- Adjusting the camera continuously:
  Adjusting the camera continuously during the scanning process in order to compensate variations of light is not necessary under normal operating conditions for 3DPIXA.

4.7   Illumination

Textures in the images are an important pre-condition for the passive stereo approach. To make the structures of the surface visible in the image, the interaction of the surface properties and illumination is crucial.
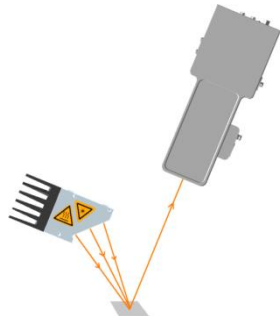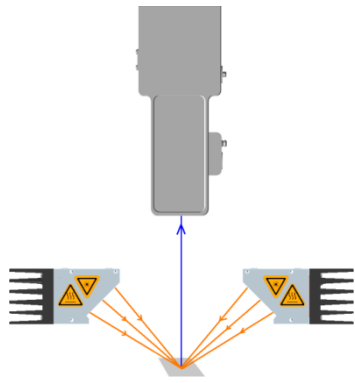
Illumination types
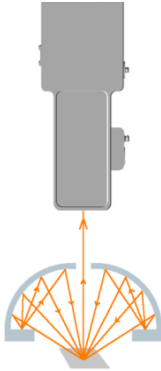
For each object surface there is an optimal illumination setting to minimize the specular reflections and to maximize the visibility of the structures of the surface.
Optimal illumination will ensure that the visible structures in the left and in the right image look almost identical. Thus pattern matching can be performed reliably and accurately.

The following table shows different illumination types and examples of use. For information on the illustrated illumination devices refer to the Corona II manual.

More details can be found on our partner portal at http://www.chromasens.de/user (Downloads > Whitepapers > Application Overview).

Illumination type	Properties	Examples of use
Bright-field illumination	• The reflecting portion of the incoming light goes directly into the camera. • Bright image • Good visibility of most structures	Diffuse bright field: • Plastic parts • Brushed aluminum • Flat surfaces
Dark-field illumination	• The bigger portion of the incoming light is reflected away from the camera. • Mainly the light scattered by the structure of the surface goes into the camera. • The brightness of the camera image highly depends on the structure of the surface.	Diffuse reflecting materials: • Leather • Wood • Food • Paper • Raw steel • Rubber

Illumination type	Properties	Examples of use
Tube light illumination	• Light beams illuminate the surface from many different angles. • Very diffuse and homogenous illumination • Reduces shadow casting • The contrast depends on the structure of the surface.	• Brushed aluminum • Electronic board • Solder paste • Connector pins
Coaxial illumination	• The object surface is illuminated with parallel light beams. • Reduced shadow casting • The semi-transparent mirror has a 50% reflectance. The irradiance on the camera sensor is 25%.	• Plugs/sockets • Plastic parts

Tab. 11: Illumination types

4.8 Image quality, image sharpness and height accuracy

For accurate height measurement the images taken with the 3DPIXA camera must show as much texture of the scanned object as possible. Textures in the images are an important pre-condition for the passive stereo approach. To make the structures of the surface visible in the image, observe the following:

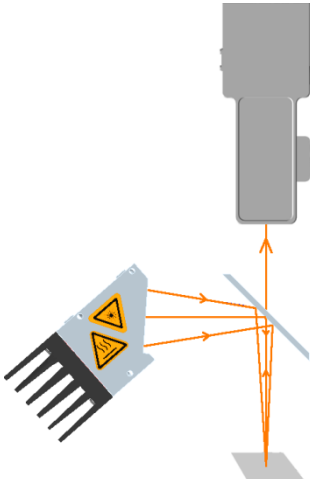• The interaction of the surface properties and illumination is crucial. The illumination type (see chapter 4.7, p. 28) and brightness of the illumination is important. Images should have as few dark and as few overexposed areas as possible.

• Acquiring a sharp image will ensure that the visible structures in the left and in the right image have the best contrast possible. Sharp images of suitable surfaces will show a visible difference in the color or brightness of neighboring pixels. Thus, pattern matching can be performed reliably and accurately (see Fig. 10, p. 30).
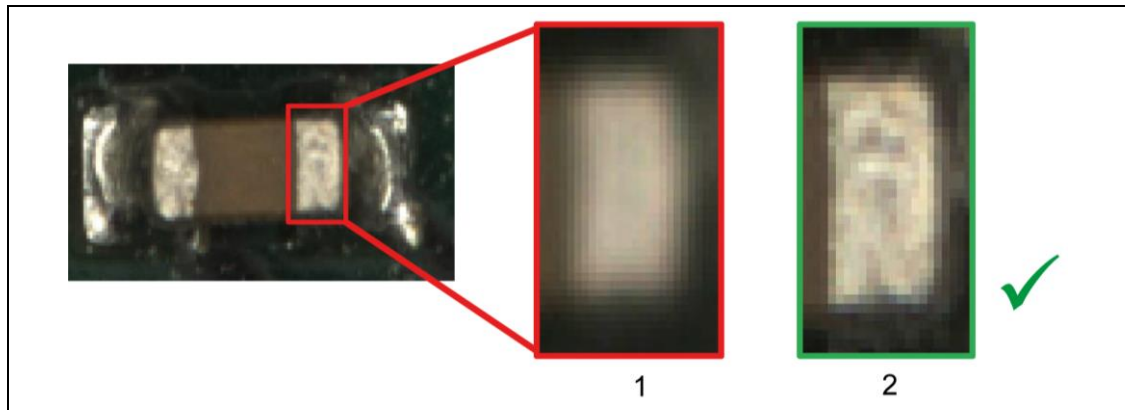
Fig. 10:   Example of a blurred image and a sharp image

1   Blurred image which results in less reliably height data
2   Sharp image which results in accurate height data

The relationship between sharpness and accuracy of a 3DPIXA can be illustrated as follows (see Fig. 11, p. 30):

The best focus point of the 3DPIXA is indicated by the working distance. At this point we have the best sharpness and the highest accuracy of the height measurement. If we move our object closer to or further away from the 3DPIXA image, sharpness and accuracy decrease with the distance to the focus point. For the best height measurement results, it is necessary to place the object always in the best focus point.
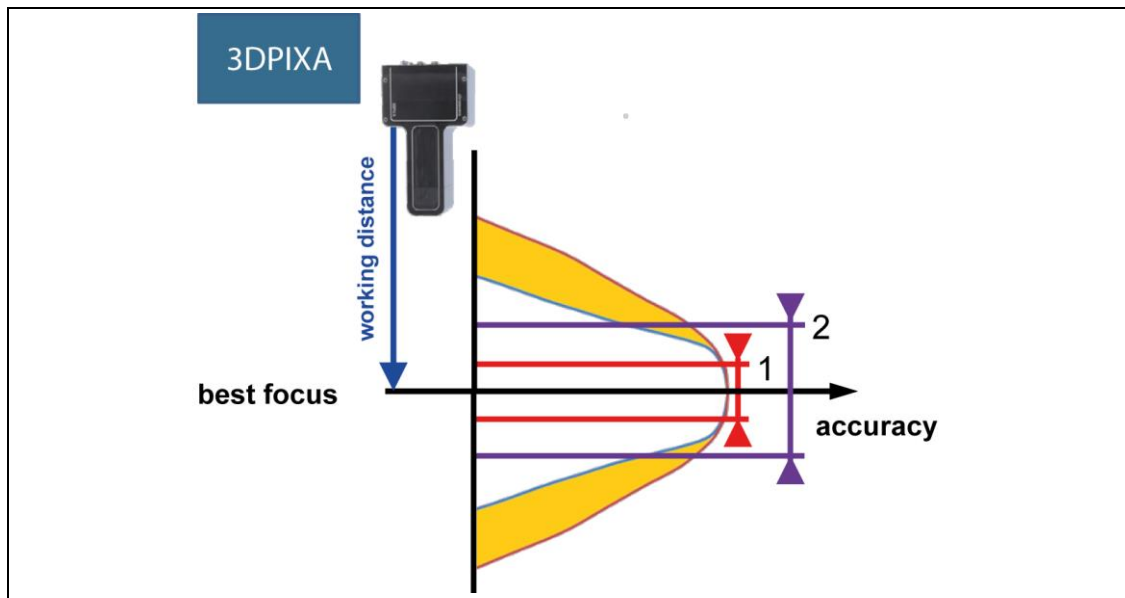
Fig. 11:   Dependency of best focus and measured height accuracy

1   Height range with best accuracy
2   Calibrated range of 3DPIXA (more information see CS-3D-Viewer Manual)

In the first step, the camera must be aligned to the best focus point over the indicated working distance in the technical drawing. It is also strongly recommended to evaluate the alignment of the camera using generated 3D data from the 3D-Viewer.

4.9 Image capture modes

The 3DPIXA can be operated in different frame and line trigger synchronization modes. The modes for setting up the camera and camera image acquisition are explained for 3DPIXA compact and dual models.

Frame grabber requirements:

For correct image acquisition, the frame grabber has to be set to area mode. The camera provides the frame grabber with the FrameValid (FVAL) signal. In this setup, the image capturing of the camera is synchronized with the frame grabber. Especially when using a 3DPIXA dual camera, this setup is obligatory for correct image synchronization between the master camera, the slave camera and the frame grabber.

4.9.1 3DPIXA in free running mode without frame and line trigger

For setting up the 3DPIXA, it is necessary to execute white balancing (see chapter 6.12, p. 68) and internal black referencing (see chapter 6.13, p. 76). To perform those steps, the 3DPIXA has to be set into free running mode without external frame trigger and without external line trigger (camera is in frame free run mode and line free run mode).

This configuration of the camera is not suitable for capturing images for 3D calculation, since there is no defined synchronization between the camera and the moving object.

3DPIXA compact

The free running mode without external frame trigger signal and without external line trigger signal is used to carry out white balancing and internal black (offset) referencing.

Camera parameter	Value	Comment
Integration time/ Line period time	Time in µs	Integration time / line period time has to be set.
Frame start (triggered frame scan)	free running	No external frame trigger signal is used. The camera is capturing lines all the time. The FVAL is generated in respect of the image height (number of scan lines per image) set in the camera.
Encoder / line trigger	disabled	No external encoder / line trigger signal is used. The camera is capturing lines all the time in respect of the set integration time / line period time.

3DPIXA dual

Free running mode without external frame trigger signal and without external line trigger signal. This mode is used to carry out white balancing and internal black (offset) referencing.

Camera parameter	Value		Comment
Integration time/ Line period time	master	Time in µs	Integration time / line period time has to be set only for the master camera.
	slave	ignored	
Frame start (triggered frame scan)	master	free running	No external frame trigger signal is used. Master camera and slave camera are capturing lines all the time. The FVAL is generated in respect of the image height (number of scan lines per image) set in the master camera and slave camera. The image heights have to be set identically for master camera and slave camera.
	slave	ignored	
Encoder / line trigger	master	disabled	No external encoder / line trigger signal is used. Master camera and slave camera are capturing lines all the time in respect of the set integration time / line period time set in the master camera.
	slave	ignored	

4.9.2 3DPIXA in frame trigger and line trigger mode

For correct image acquisition and height calculation of the 3DPIXA, the camera must be synchronized with the object movement. Therefore the external frame trigger signal and the external line trigger signal have to be used (see chapter 4.3.2, p. 23).

Image acquisition with external frame trigger signal and external line trigger signal is obligatory. This way the variations in transport speed (e.g. by acceleration of the object) can be compensated.

3DPIXA compact

Mode with external frame trigger and external line trigger signal. This mode is used for accurate synchronization of object movement with camera image capturing.

Camera parameter	Value	Comment
Integration time/ Line period time	Time in µs	Integration time / line period time has to be set.
Frame start (triggered frame scan)	triggered / use start condition	When the external frame trigger signal and external line trigger signals are received by the camera, it creates the FVAL and starting capturing lines in respect to the external line trigger / encoder signal (see chapter 0, p. 86). The line trigger signal must provide the required number of pulses corresponding to the image height (number of scan lines per image).
Encoder / line trigger	enabled	

3DPIXA dual

Mode with external frame trigger and external line trigger signal. This mode is used for accurate synchronization of object movement with camera image capturing. The external trigger signals are processed by the master camera. The behavior of the slave camera is determined by the master camera.

Camera parameter	Value		Comment
Integration time/ Line period time	master	Time in µs	Integration time / line period time has to be set only for the master camera.
	slave	ignored	
Frame start (triggered frame scan)	master	triggered / use start condition*	When the external frame trigger signal and external line trigger signals are received by the master camera, the master camera and the slave camera create the FVAL and starting capturing lines in respect to the external line trigger / encoder signal of the master camera (see chapter 0, p. 86). The line trigger signal must provide the required number of pulses corresponding to the image height (number of scan lines per image). The image heights have to be set identically for the master camera and the slave camera.
	slave	ignored	
Encoder / line trigger	master	enabled	
	slave	ignored	

* For frame start (triggered frame scan) using start and stop conditions refer to the allPIXA (pro) manual

4.9.3 Frame trigger and line trigger synchronization

The image acquisition of the 3DPIXA camera has to be synchronized with the transport speed in order to keep the data processing executable. For this purpose, the following trigger signals must be used.

Frame trigger

The frame trigger signal is typically generated by a light barrier or a hall sensor. These devices can be used as start and stop triggers and also to indicate the absolute position of the object and/or the scanning position.

Line trigger

The line trigger signal is typically generated by an encoder. Encoders provide consecutive pulses which indicate the relative position change of the object and/or the scanning position. Absolute positions cannot be determined by an encoder.

The pulse distances and the pulse widths give information on the movement speed and speed changes.

The following example illustrates the use of a frame trigger signal (light barrier) and a line trigger signal (encoder). The relation between the trigger signals and the line acquisition with constant integration time in line trigger mode is also shown.
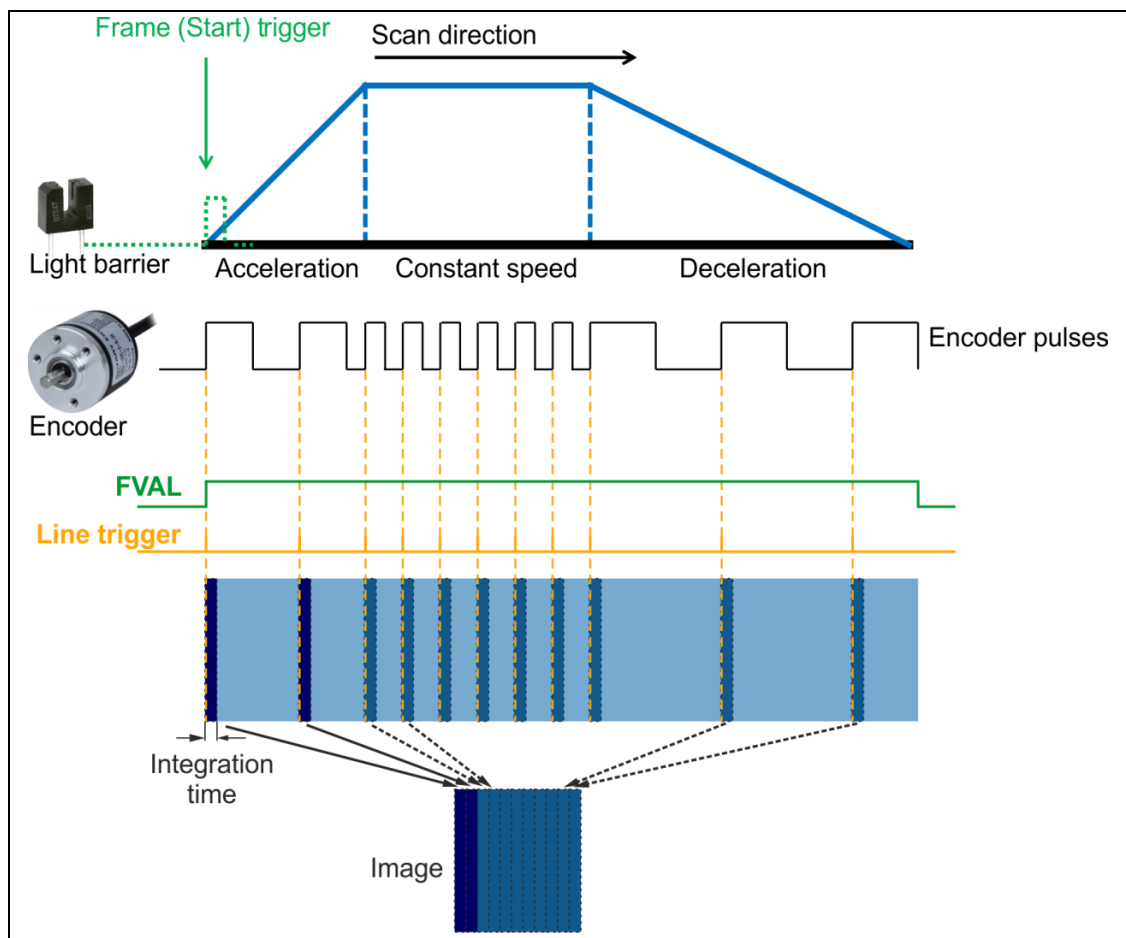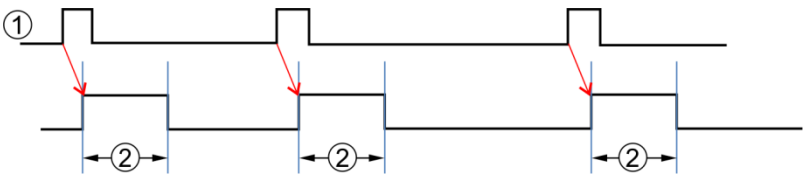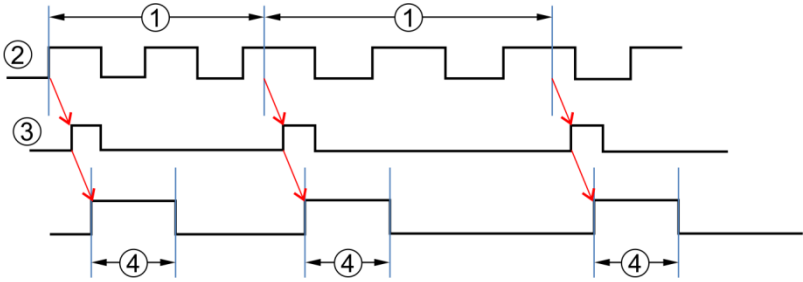
Fig. 12: Different uses of a light barrier and an encoder

The 3DPIXA camera can be operated with 2 different encoder modes (see chapter 0, p. 86):

Encoder mode	Description
Line trigger mode (classic mode)	In line trigger mode each encoder pulse (1) triggers one scanning line output: The pulse distances (2) must be larger than the integration time of the camera, i.e., they depend on the selected image resolution. If the line trigger reduction is used, the transport resolution is reduced by the line trigger reduction factor (see chapter 7.6.7, p. 90).
Encoder mode (advanced mode)	In encoder mode a defined number of encoder pulses (1) trigger one scanning line output: Even fractional numbers of encoder pulses are possible. If the line encoder reduction is used, the transport resolution is reduced by the encoder reduction factor (see chapter 0, p. 86).

Tab. 12: Encoder modes

4.10 Setting concept

The camera parameters are set, using the CST software supplied with the 3DPIXA cameras. For a CST software description refer to the following manuals:

- CP000470 models: allPIXA manual
- CP000520 models: allPIXA pro manual

18 different settings can be stored in the 3DPIXA camera and are selectable by short commands. This allows the user a quick change of the camera settings for different products. The camera starts up with setting no. 1.
The write-protected setting no. 19 is reserved for the factory settings. The factory settings may be used as a template for creating new settings.
Refer to the allPIXA (pro) manual for information on saving and loading settings.

4.11   Chromasens CS-API and CS-3D-API

This chapter gives a brief overview of the CS-API and 3D-API. Please use the corresponding manual for detailed information.
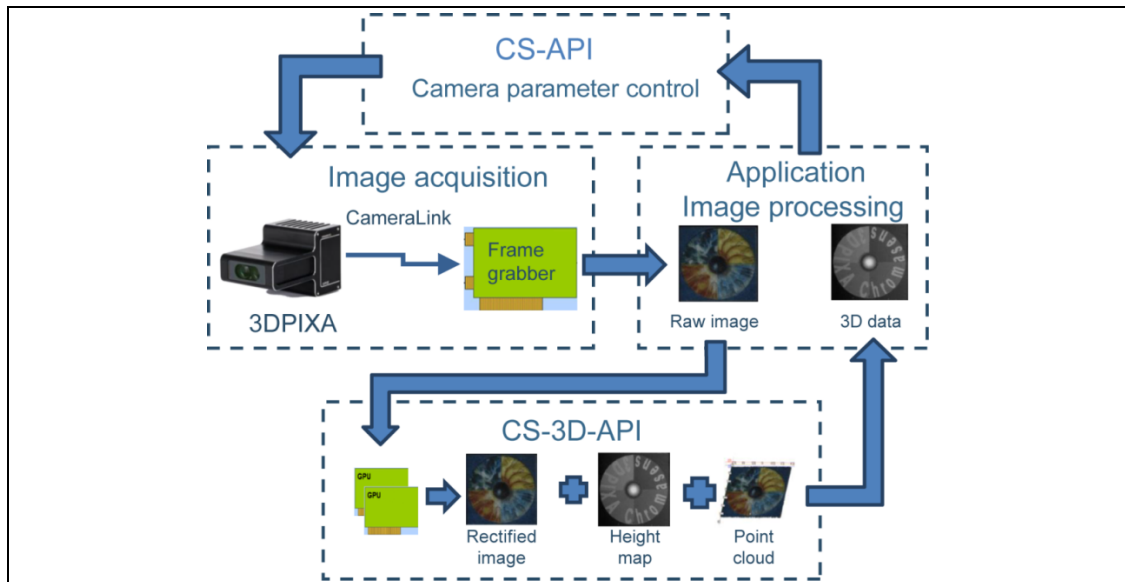
Fig. 13:   Overview CS-API and CS-3D-API

CS-API
For the use in an automated setup, the camera parameters can be set using the CS-API which provides a set of functions for easy communication with the 3DPIXA camera. With these functions the connection to the camera can be established via CameraLink or serial RS232 connection and internal working parameters of the camera can be read and modified. For more information see CS-API manual.

CST
User interface that makes CS-API functionalities available to the user in a comfortable way. It also provides wizards to generate a shading reference, to update the firmware, to check live values from the camera and access to all parameters.

CS-3D-API
The CS-3D-API is an SDK that provides you with functions to calculate 3D information in a fast and scalable manner. This SDK can be interfaced via native C++, but also via various wrappers for HALCON, LabVIEW and C#. Examples for different interfaces and wrappers are included for an easy start. For more information see the CS-3D-API manual on our homepage.

3D-Viewer
The 3D-Viewer is a GUI that uses the CS-3D-API for lab and testing environments to test the effect of different parameters and optimize them for a specific application. It also provides basic analysis functions like relative height measurements, pseudo-color and plane correction visualization. Export functions into VRML and STL models are also available.

We recommend to use the CST software for setting the camera parameters during initial setup. For getting familiar with the 3D calculation we propose to use the 3D-Viewer on the acquired images for parameter optimization.

5 Installing the 3D scanner system

5.1 Required and optional components

▶ Prior to installing the 3D scanner system ensure that the corresponding hardware and software components are available.

5.1.1 Hardware components

Component	Function/Requirements	Required
3DPIXA camera	See chapter 4, p. 20	✓
Moving stage/ conveyer	The moving stage must be of high quality in order to achieve high accurate 3D measurement results. The moving stage must have a stable and non-vibrating movement. Vibrating moving stages influence the measurement results.	✓
Lifting table	A fine scale lifting table might be needed if objects with different heights are measured. With the lifting table the object can be placed at the best focus plane of the camera. A lifting table is especially recommended, e.g., for a 3D demonstration scanner system, and in cases in which it is difficult to lift up and down the 3DPIXA camera.	–
CameraLink Frame grabber(s)	Depending on the required scanning speed, the 3DPIXA cameras can be operated in base or medium mode. Some 3DPIXA dual cameras can also be operated in full mode (see chapter 2.3, p. 11). • 3DPIXA compact camera: – 1 medium frame grabber or – 1 base frame grabber • 3DPIXA dual camera: – 2 medium frame grabbers or – 1 dual base frame grabber or – 2 base frame grabbers For more information on compatible frame grabbers, refer to chapter 2.6.1, p. 15.	✓
Line scan illumination	Chromasens manufactures its own high quality line scan illumination "Corona II" with extremely bright and homogeneous light. Especially the Chromasens tube light illumination is highly suitable for 3DPIXA applications as it reduces shadows on objects with its uniform light distribution. Contact Chromasens for further information on line scan illumination varieties.	✓

Component	Function/Requirements	Required

CameraLink cables	• 3DPIXA compact camera:
	   – Medium mode: 2 CameraLink cables
	   – Base mode: 1 CameraLink cable
	• 3DPIXA dual camera:
	   – Medium mode: 4 CameraLink cables
	   – Base mode: 2 CameraLink cables
	The 3DPIXA camera provides MDR connectors (26-pin MDR mini-D ribbon, female). Check the connectors of your frame grabber in order to decide if you need MDR-MDR or MDR-SDR CameraLink cables.
		✓

Power cable(s)	Hirose 6-pin plug "female" (HR10A-7P-6S) (can be ordered on request) • 3DPIXA compact camera: 1 power cable • 3DPIXA dual camera (CP000470): 2 power cables • 3DPIXA pro dual camera (CP000520): 1 power cable	✓
Encoder/ Light barrier	When using the 3DPIXA dual camera, a frame start signal has to be connected to the Master camera to ensure the acquisition of 2 images simultaneously. The frame start signal can be transmitted either directly via the I/O port of the Master camera or via the frame grabber using a CameraLink cable (see chapter 5.5.3, p. 47). • Encoder: Line trigger • Light barrier: Frame trigger	–
PC	System requirements: The latest system requirements can be found on our partner portal at http://www.chromasens.de/user (Downloads > System Requirements > 3DPIXA System Requirements).	✓
Software protection dongle	Required for 3D calculation with the 3D software. Dongle includes software license. (within scope of supply: silver USB stick)	✓
Chromasens 3D software USB-Stick	Includes necessary software, drivers, firmware, calibration files, technical drawings etc. (see chapter 5.1.2, p. 39). (within scope of supply: orange USB stick)	✓
Power supplies	Power supply for 3DPIXA camera (see chapter 2.4, p. 14), moving stage and line scan illumination	✓
2 gauge blocks	For adjusting the camera	–
Mounting plate	For fixing the camera	–
3DPIXA dual camera only:		
Master/Slave cable	See chapter 10.2.1, p. 95 (within scope of supply)	✓

Tab. 13: Required and optional hardware components

5.1.2 Software components

- 3D-Viewer and 3D API (included)
- CST (included)
- XLC4-Commander for Corona II illumination (included)
- 3DPIXA configuration and calibration file (included)
- Frame grabber software for image acquisition (must be delivered by the frame grabber manufacturer)

The included software components can be found on the orange USB stick.

5.2 Preconditions

Install the 3D scanner system in a temperature controlled environment (e.g. 21°C). The warming up of the components, the 3DPIXA, the light source and the translation stage may cause mechanical movements. It is therefore essential to control the temperature and allow the installed components to reach their thermal equilibrium.

The 3D scanner system components must fulfill the following preconditions for accurate measurements.

Camera holder

▶ Use a camera holder that protects the camera from uncontrolled movements:
  – Use a rigid material in order to avoid oscillations of the holder (thin plates are not suitable).
  – If necessary, use vibration dampers in order to avoid the transfer of vibrations from the environment.
  – Use a material with low thermal expansion and/or take measures for cooling.

Transport unit

▶ Use a vibration- and oscillation-free transport unit with precision guide. When using a conveyer:
  – Minimize vertical oscillations by adjusting the belt tension (see Fig. 14, p. 39).
  – Minimize lateral oscillations by adjusting the belt guide (see Fig. 15, p. 40).
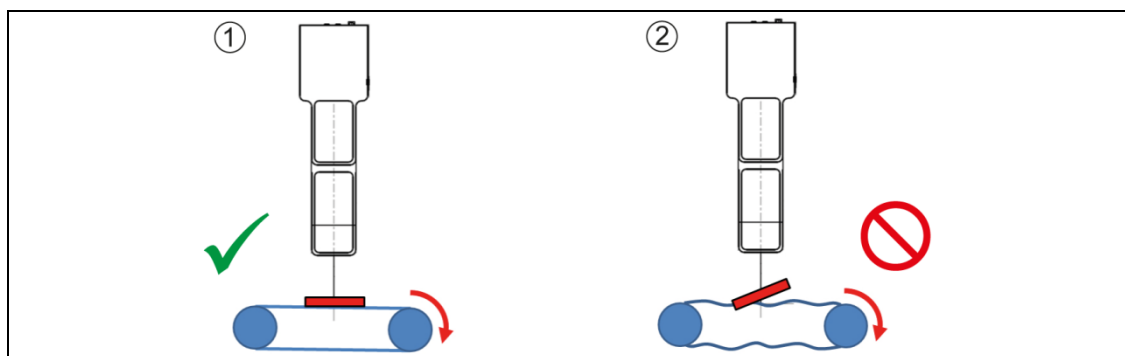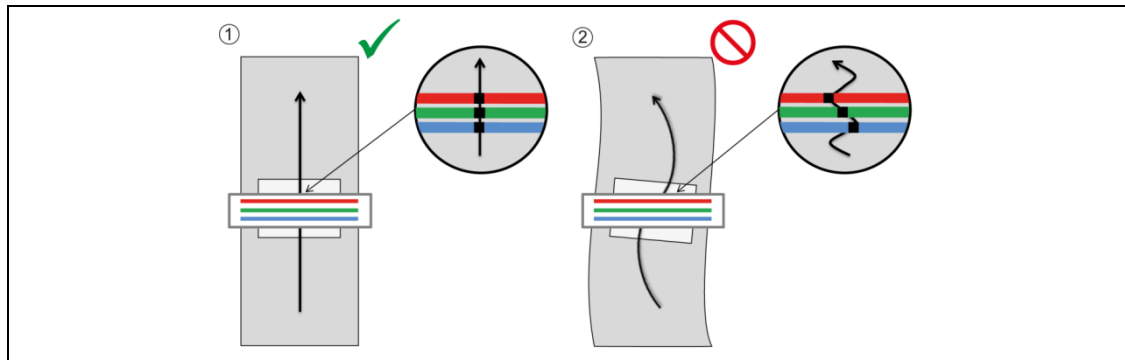

Fig. 14:   Conveyer belt adjustment: minimize vertical oscillations

1	Correct adjustment: Smooth transport	2	Incorrect adjustment: Wobbling target

Fig. 15:   Conveyer belt adjustment: minimize lateral oscillations

1	Correct adjustment: Smooth transport	2	Incorrect adjustment: Oscillating target

ℹ️ Not only conveyor belts but also linear stages show lateral and vertical oscillations.

▷ Make sure that the technical specifications of the linear stage match with the measuring task.

Lifting table

▶ Use a lifting table with precision guide and adequate height resolution:
– The lifting table must move without vibration and parallel to the camera view direction.
– The height resolution must be smaller than the height range of the used 3DPIXA camera type (see chapter 2.3, p. 11).

5.3   Mounting the camera

NOTICE! Damage by scratching the glass plate of the camera!

▷ Keep hard and sharp objects away from the glass plate of the camera.

ℹ️ Precise image capturing and 3D calculations are possible only if the camera is installed very precisely. Tilting of the camera leads to image artifacts and/or wrong calculation results.

✓ The preconditions for the 3D scanner components are fulfilled (see chapter 5.2, p. 39).

1. Prepare a mounting plate having regard to the following conditions:
– The attachment points in the mounting plate must match the mounting holes in the camera (see technical drawings).
– The camera can be installed at the correct working distance (see chapter 2.3, p. 11).
– The mounting plate can be fixed to a camera holder.
– The mounting plate efficiently dissipates the heat generated by the camera.
Heat conduction pads may be used between the camera and heat-conductive parts.
2. Mount the camera to the prepared mounting plate.
3. Place the camera at the correct free working distance.
For the product-specific free working distance see technical drawing for your 3DPIXA camera type. Take account of the object height.

Gauge blocks can be used to place and align the camera at the correct working distance. This is recommended especially for the alignment of the 3DPIXA dual camera.

4. Align the camera so that the following conditions are fulfilled:
   – The sensor line is adjusted perpendicular (90°) to the transport direction:
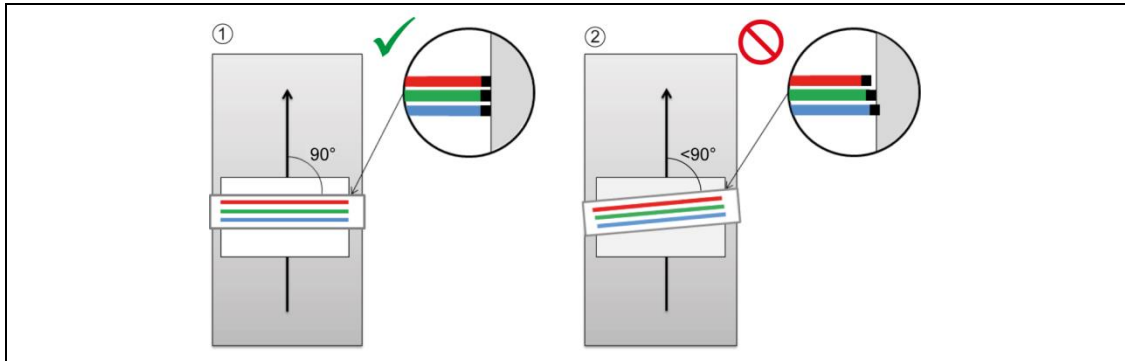
Fig. 16: Adjusting the sensor line

    1   Correct camera alignment: Camera is perpendicular to the transport direction
    2   Incorrect camera alignment

Misalignment of the sensor line would result in chromatic aberration on the image because the same point on the object will be imaged at different positions on the trilinear sensor (see right-hand side in Fig. 16, p. 41).

   – In the standard case, the longitudinal and transverse axes of the camera are adjusted perpendicular (90°) to the inspection plane (see Fig. 17, p. 41).
   – If the longitudinal alignment cannot be satisfactorily performed, for example using bright field illumination, the result is chromatic aberration in the image and different scaling of the 3 color lines. These effects in turn have an influence on the 2D image quality and the 3D measurement accuracy. In this case, special precautions must be carried out with the 3DPIXA. Please contact the Chromasens support.

Longitudinal misalignment would result in chromatic aberration in the image and different scaling of the 3 color lines:
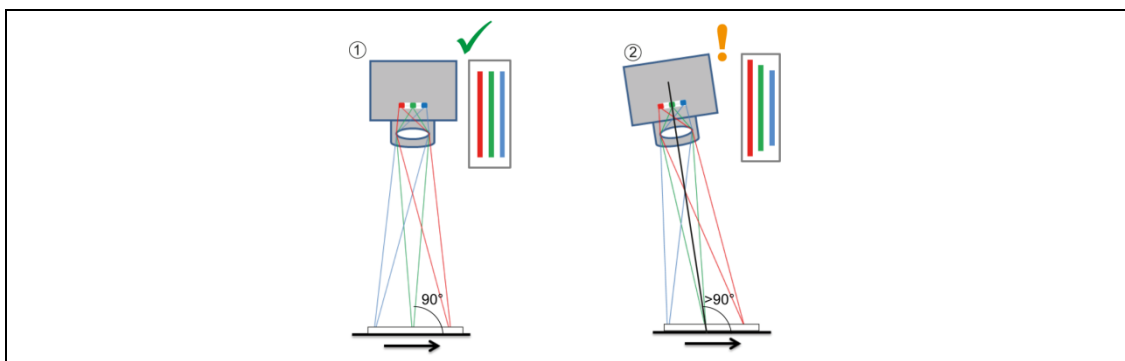
Fig. 17: Adjusting the longitudinal orientation of the camera

    1   Correct camera alignment: Camera axis is perpendicular to the transport plane and to the transport direction
    2   Special case requiring special precautions with the 3DPIXA

Transverse misalignment would result in chromatic aberration laterally to the transport direction, and the size and color would change in relation to the angle (see Fig. 18, p. 42).
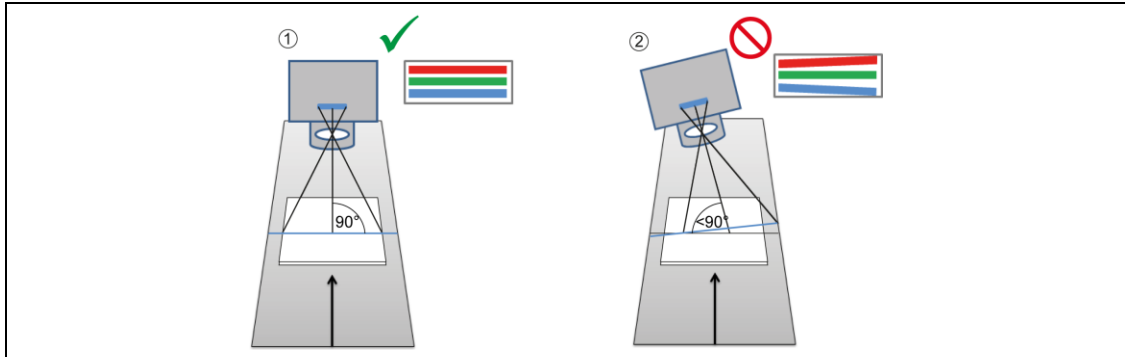
Fig. 18: Adjusting the transverse orientation of the camera

    1   Correct camera alignment: Camera axis is perpendicular to the transport plane
         and to the transverse direction
    2   Incorrect camera alignment
–   Depending on whether the target or the camera is moved for scanning, the forward
     scan direction is as shown in Fig. 19, p. 42.
     On the camera housing there is a marker (3) which indicates the forward direction
     over the movement of the object/target by means of an arrow.
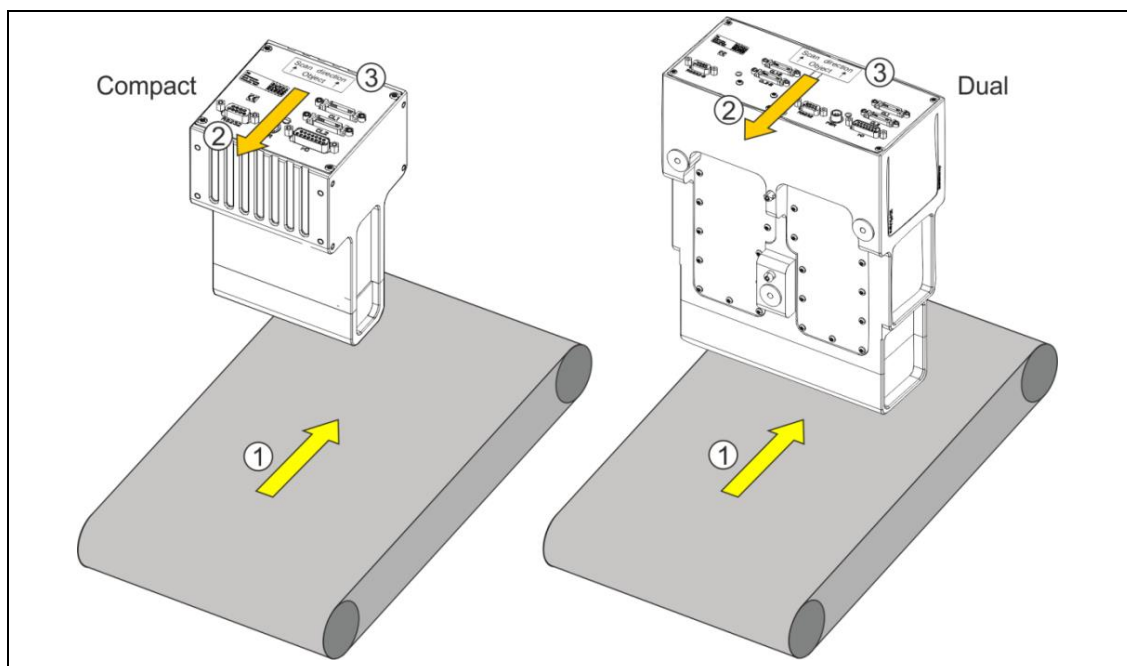
Fig. 19: Forward scan direction

    1   Target moving direction   3   Marker
    2   Camera moving direction

–   Moving the target (1), the direction of the marker (3) on the camera housing is
     identical to the target moving direction.

– Moving the camera (2), the direction of the marker (3) on the camera housing is contrary to the camera moving direction.

If forward scan direction cannot be implemented, the following steps must be performed:

– For correct image acquisition of the 3DPIXA, set the camera parameter *set scan direction* via CST or CS-API to backward.

– For correct 3D calculation, invert the parameter *invertTransportDirection* in the configuration file via 3D-Viewer or 3D-API.

For a more detailed description, refer to chapter 6.9, p. 65.

5. When the camera is aligned correctly, fix the mounting plate to the holder.
6. Check again the correct distance and alignment of the camera and correct it, if necessary.
7. If the thermal contact of the camera is low, install a fan and direct it at a large camera surface area.

5.4   Preparing the 3D scanner system components

For the installation of the Corona II Illumination refer to the Corona II manual.

1. Install the illumination:
   – Mount the illumination at the correct working distance.
   – Adjust the focusing point of the illumination.
   The camera should be looking at the brightest illuminated area.

2. Prepare the PC:
   – Install the GPU.
   – Install the frame grabber.
   – If Corona II Illumination is used: Install the RS232 port (see Corona II manual).
   – Turn on the PC.
   – Install the NVidia Driver.
   The newest version can be downloaded from
   http://www.nvidia.de/download/index.aspx
   A list of GPUs tested can be found on our partner portal at
   http://www.chromasens.de/user (Downloads > System Requirements > 3DPIXA
   System Requirements).

3. Install the optional trigger device (encoder and/or light barrier).
   For dual cameras, a frame start signal is required to ensure the acquisition of 2 images simultaneously (see chapter 4.9, p. 31).

5.5 Connecting the 3D scanner system components

5.5.1 Overview of the 3DPIXA connections, markers and status LED

On the back side of the camera you will find the following interfaces and information:
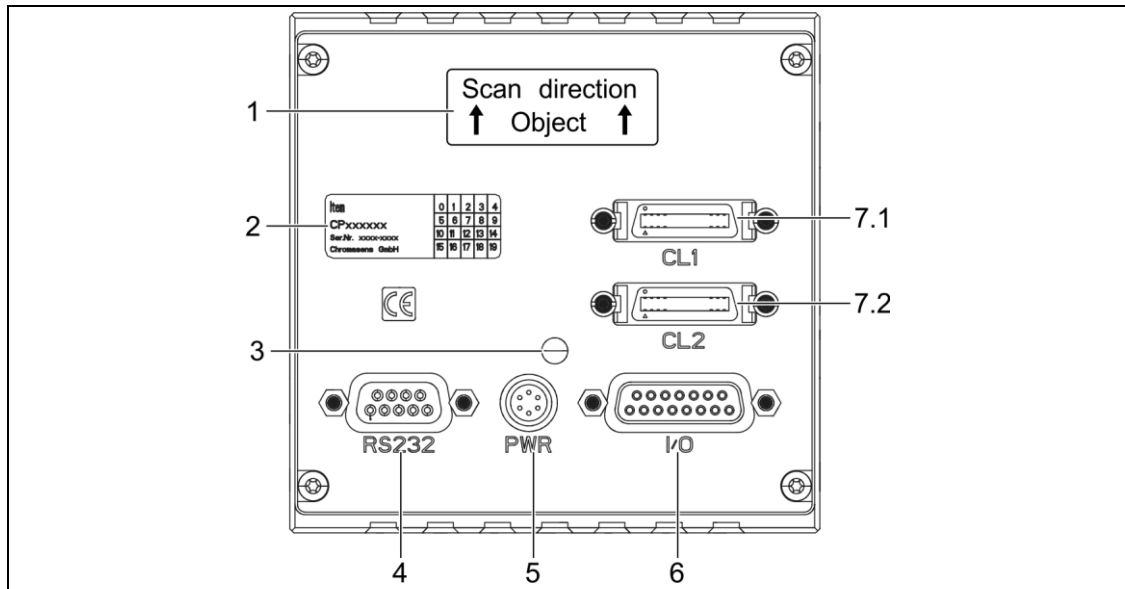
Fig. 20: 3DPIXA connections, markers and status LED

1	Marker which indicates the forward direction of the 3DPIXA
2	Type plate with serial number
3	Multi-color LED for indicating the allPIXA pro camera status
4	Serial port (serial RS 232 D-Sub 9 female, Config UART) for additional communication (e.g. configuration signals) between the allPIXA pro camera and the PC
5	Power connection (Hirose HR10A-7R-6P, male) for power supply
6	Digital port (IO interface D-Sub 15 female) for the incremental encoder signal, light barriers and other freely-programmable inputs and outputs. For Dual 3DPIXA cameras only the IO interface of the master camera has to be used.
7.1 7.2	Camera Link ports (port 1 and 2) for image signaling and for communication between the 3DPIXA pro camera and the PC

The procedure for connecting the CameraLink cables and connecting the power supply for 3DPIXA compact and 3DPIXA dual is described below.

ℹ️ If using a USB to Serial converter for the connection via RS232 it is recommended to use a converter with FTDI chipset (Prolifix chipsets may generate problems while connecting to the camera).

5.5.2 Connecting the camera

1. Connect the camera via CameraLink cables to the frame grabber:
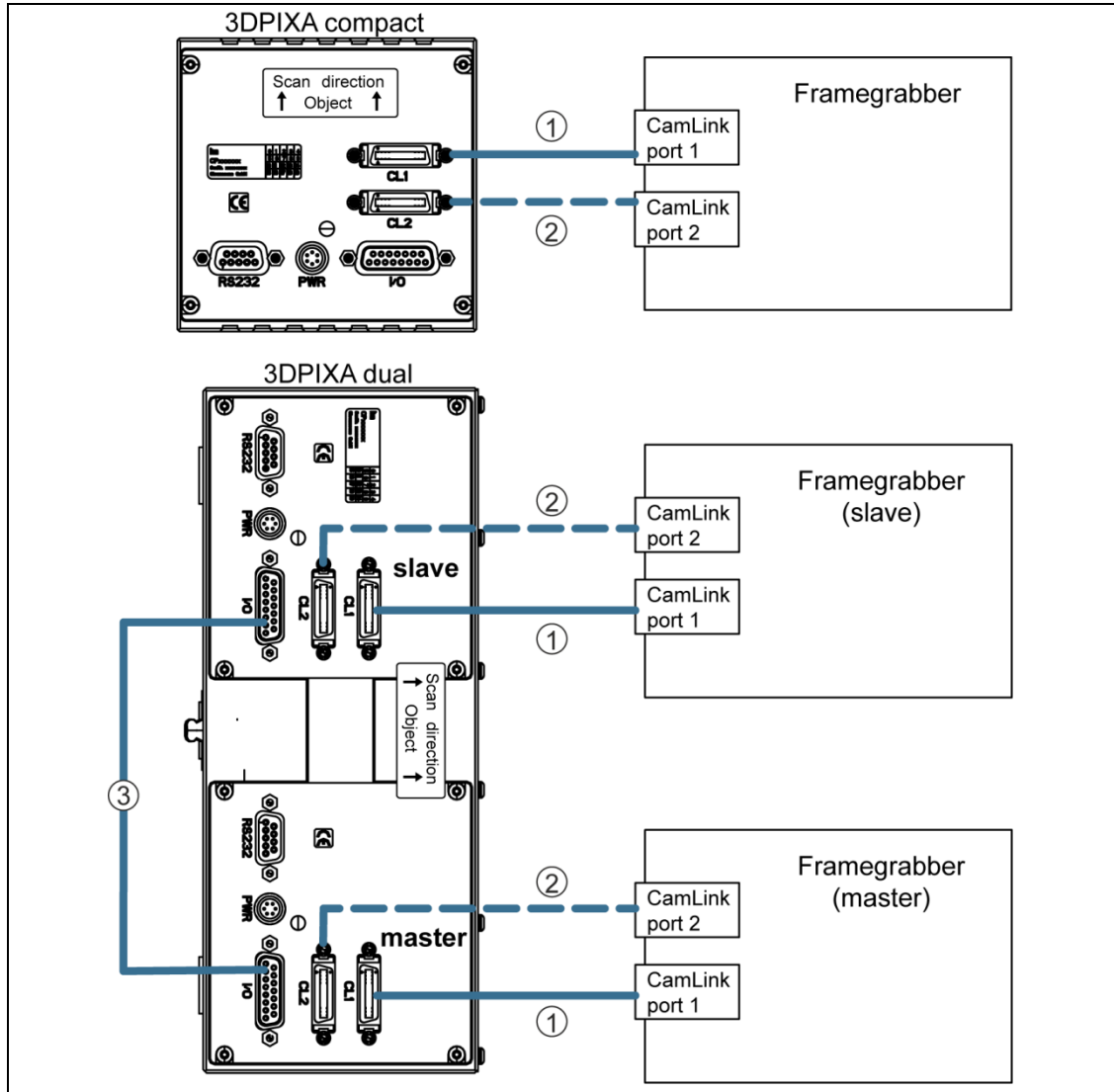
Fig. 21: Connecting the camera to the frame grabber

    1   CameraLink Port 1 (base mode)
    2   CameraLink Port 2 (additionally required for medium mode)
    3   Master/Slave synchronization

– Connect CL1 of the 3DPIXA camera to the first port of the frame grabber (1).
– If the camera will be operated in medium mode, connect CL2 of the 3DPIXA camera to the second port of the frame grabber (2).
– 3DPIXA dual: Synchronize the master and slave via the I/O ports (3).
  For the pin assignment of the master/slave synchronization cable, refer to chapter 10.2.1, p. 95.

i The master/slave synchronization via the I/O ports is necessary only for the CP000470 models. For these models a cable is included in the delivery (see chapter 2.8, p. 17). For the CP000520 models the synchronization is carried out internally.

2. Connect the camera to the power supply.
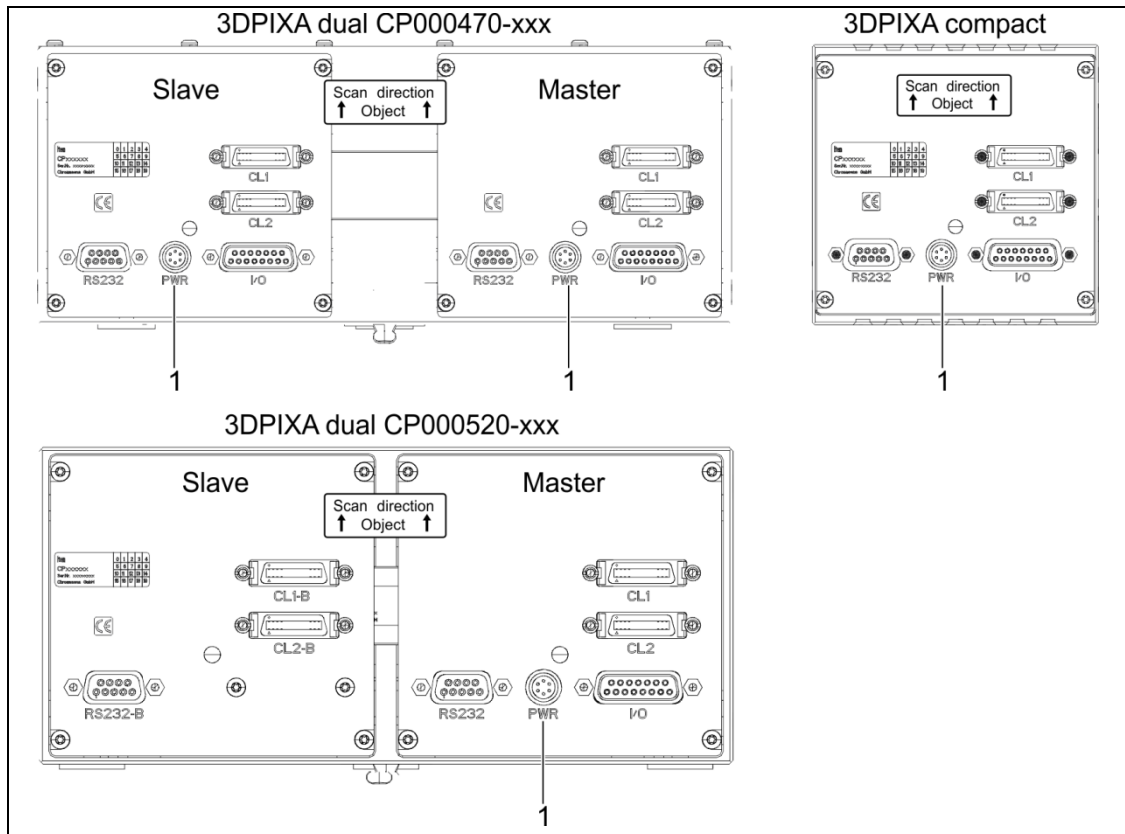
Fig. 22:   Power supply connection(s)

1   Power supply connection PWR

When connecting a 3DPIXA dual CP000470 model camera, both, master and slave have to be connected to the power supply.

5.5.3 Connecting the trigger device

Trigger devices may be connected via the I/O ports of the frame grabber or via the I/O port of the 3DPIXA camera.

Alternatively or additionally, the image acquisition can be triggered by the PC software.

Connecting the trigger devices via the I/O ports of the frame grabber
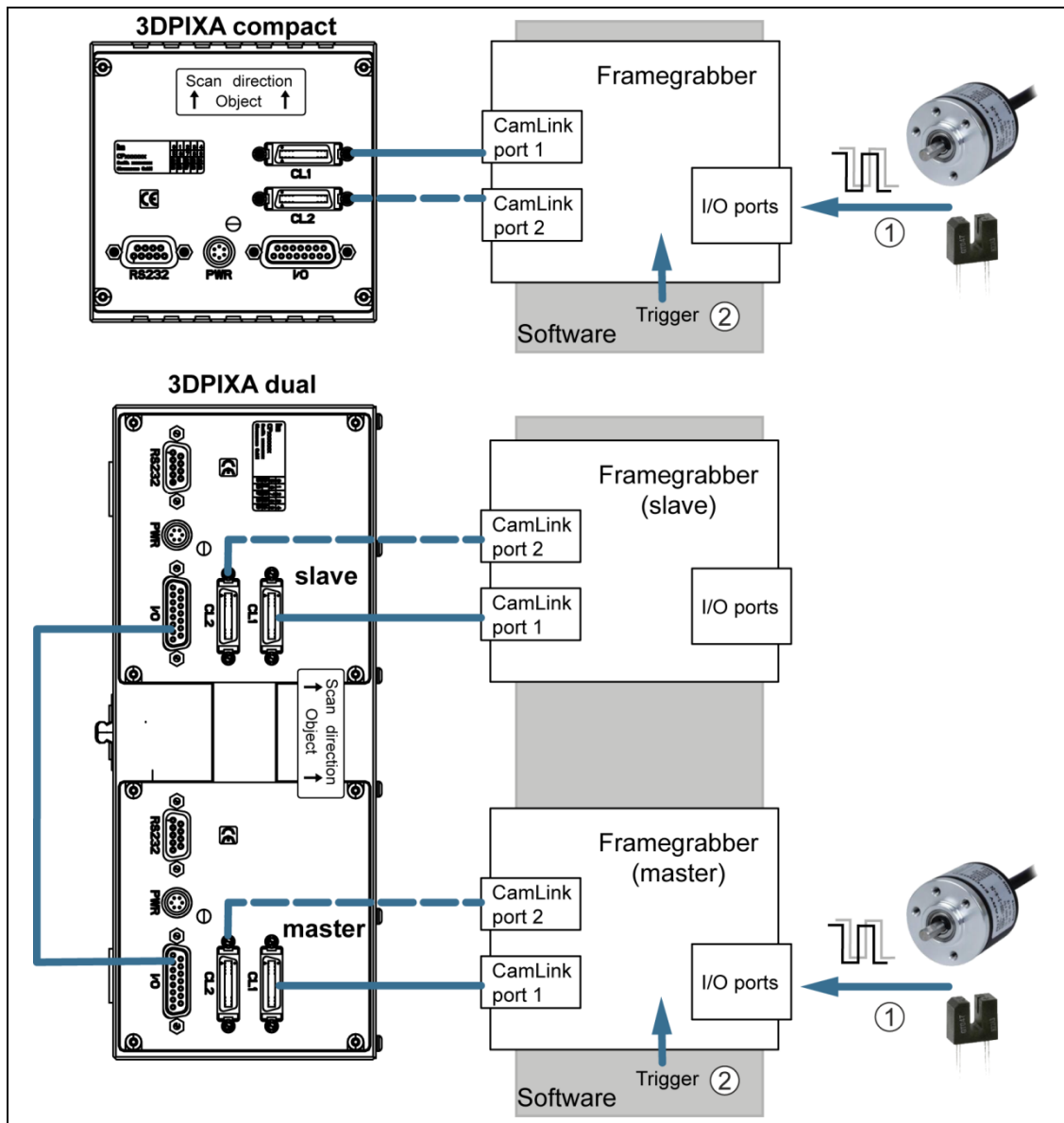
Fig. 23:   Trigger device connections via frame grabber

      1   Trigger device connection (hardware trigger)
      2   Software trigger

The trigger signals are transferred by CC bits (CC1 to CC4) via the CamLink connection CL1 to the camera.

Connecting the trigger devices via the I/O port of the camera
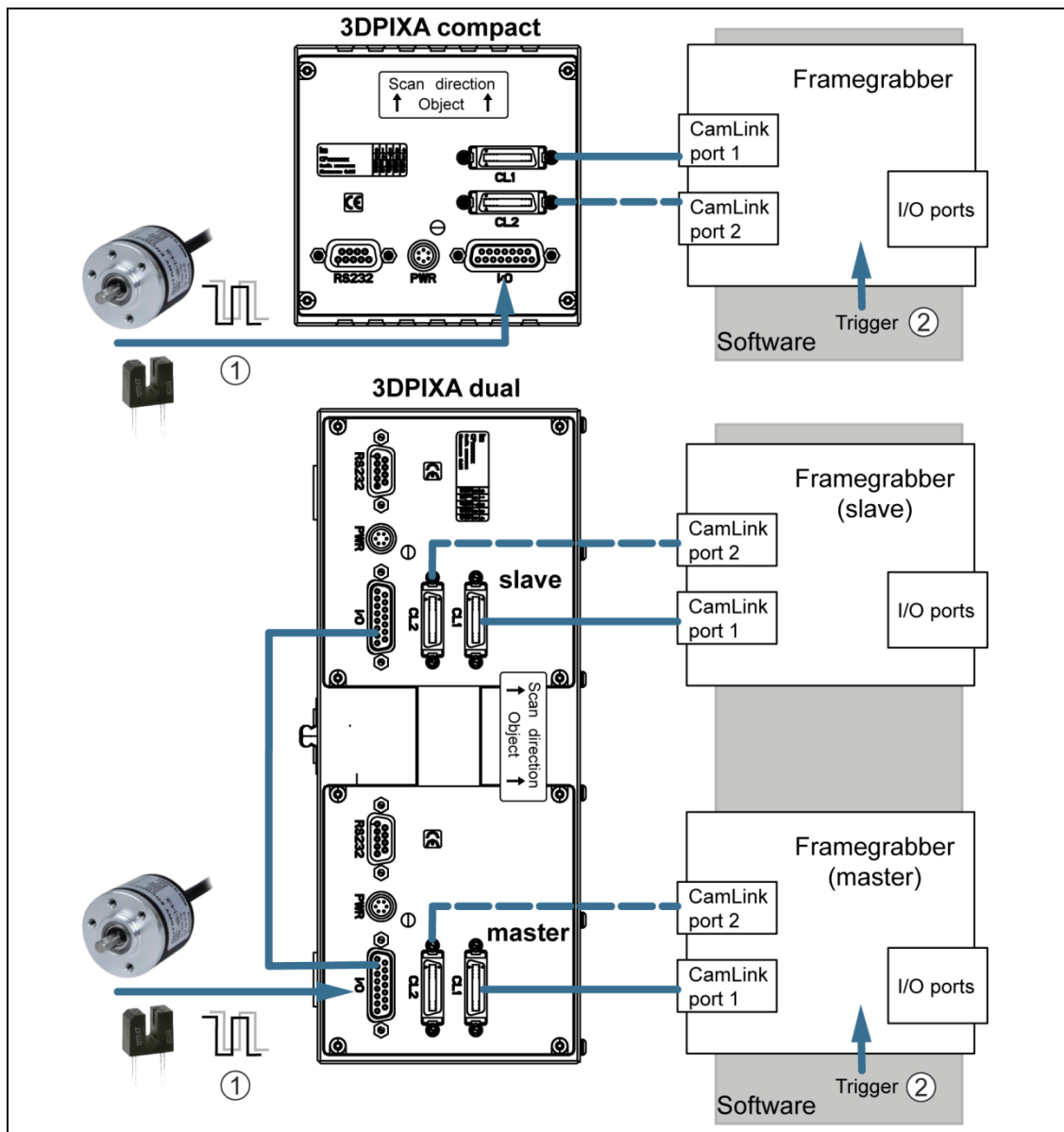
Fig. 24:   Trigger device connections via I/O port of the camera

1   Trigger device connection (hardware trigger)
2   Software trigger
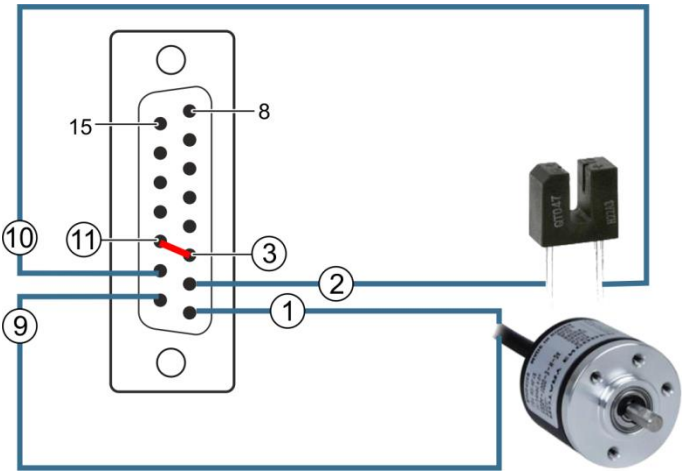
The hardware trigger signals are transferred via the I/O connection to the camera.

NOTICE! Maximum input levels of pins!

Non-compliance can result in irreparable damages to the 3DPIXA.

▷   Check the pin assignment of the I/O connector (see chapter 10.2.5, p. 97).

Pin	Master I/O
1	**Incremental encoder (high, optional)**
2	**Light barrier (high, optional)**
3	**nSelMaster (bridge to 0 V, closed by the supplied Master/Slave cable** (see chapter 10.2.1, p. 95**))**
4	–
5	Open
6	Master/Slave interface
7	0 V
8	Master/Slave interface
9	**Incremental encoder (low, optional)**
10	**Light barrier (low, optional)**
11	**0 V (bridge to nSelMaster , closed by the supplied Master/Slave cable** (see chapter 10.2.1, p. 95**))**
12	–
13	0 V
14	–
15	Open

Tab. 14: Pin assignment of the encoder and light barrier connections

6 Setting up the 3D scanner system

6.1 Commissioning the camera

ℹ The line frequency will be limited if using the 3DPIXA camera in base mode.

✓ The 3D scanner system is installed (see chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**, p. **Fehler! Textmarke nicht definiert.**).

Perform the following steps in the given order to commission the camera:

1. Set up the frame grabber (see chapter 6.2, p. 50).
2. Set up the illumination (see chapter 6.3, p. 51 for Corona II illumination setup).
3. Install the CST on the PC as described in the allPIXA (pro) manual (see chapter 1.2, p. 7)
4. Establish the communication between the camera and the PC as described in the allPIXA (pro) manual (see chapter 1.2, p. 7).
5. Set up the CameraLink interface (see chapter 6.4, p. 51).
6. Configure the camera with the simple setup tool (see chapter 6.5, p. 52).
7. Set up the trigger devices (if used) (see chapter 6.6, p. 57).

6.2 Setting up the frame grabber

ℹ The frame grabber setup has to be performed using the acquisition software recommended by the frame grabber manufacturer.

▷ For detailed information on the setting options, refer to the corresponding acquisition software documentation.

1. Open the image acquisition software.

ℹ For correct image acquisition, the frame grabber has to be set to area mode. The camera provides the frame grabber with the FrameValid (FVAL) signal. In this setup, the image capturing of the camera is synchronized with the frame grabber. Especially when using a 3DPIXA dual camera, this setup is obligatory for correct image synchronization between the master camera, the slave camera and the frame grabber.

2. Depending on the used CameraLink interface, set the following frame grabber settings:

CameraLink interface	Frame grabber settings			
	Tap configuration	Video output mode	Color space	Sensor length
Base mode	1 tap with 24 bits (1X)	3x8 bit = 24 bit/pixel, 1 pixel per cycle	RGB	7296
Medium mode	2 taps with 24 bits (2XE)	3x8 bit = 24 bit/pixel, 2 pixels per cycle	RGB	7296
Medium mode (CP000520 only)	2 taps with 24 bits (1X2 raw)	3x8 bit = 24 bit/pixel, 2 pixels per cycle	RGB	7296
Full64 mode	8 taps with 8 bits (1X8 raw)	3x8 bit = 24 bit/pixel, 2 2/3 pixels per cycle	RGB	7296
Full80 mode	10 taps with 8 bits (1X10 raw)	3x8 bit = 24 bit/pixel, 3 1/3 pixels per cycle	RGB	7296

Tab. 15: Frame grabber settings

3. If the trigger devices are connected via the I/O ports of the frame grabber (see chapter 5.5.3, p. 47), set the I/O port settings of the frame grabber correspondingly.

6.3 Setting up the Corona II Ilumination with XLC4

✓ The Corona II Illumination is installed (see Corona II manual).

1. Turn on the power supply of the Corona II Illumination.
2. Wait until the red LED of the XLC4 controller illuminates for about 4 s, and the green LED is blinking every 4 s.
   The XLC4 controller is ready for operation.
3. Connect the XLC4 controller to the PC.
   The XLC4 controller can be connected to the PC via the following interfaces (see Corona II manual):
   – RS232 (recommended)
   – USB
   – Ethernet
4. Configure the selected interface connection as described in the Corona II manual.

6.4 Setting up the CameraLink interface

The CameraLink interface can be set up with the Camera Setup Tool (CST) as described in the allPIXA (pro) manual (see chapter 1.2, p. 7). The Medium mode is set by default.

ℹ️ For the 3DPIXA dual camera the CameraLink interface has to be set up for both cameras separately. This can be done with two CST applications, which are opened at the same time.

1. Open the CST.
2. Select the CameraLink port where the camera is connected (CameraLink port of the frame grabber).
3. In the **Camera Settings** select **Output format** in the **Image parameter** folder.

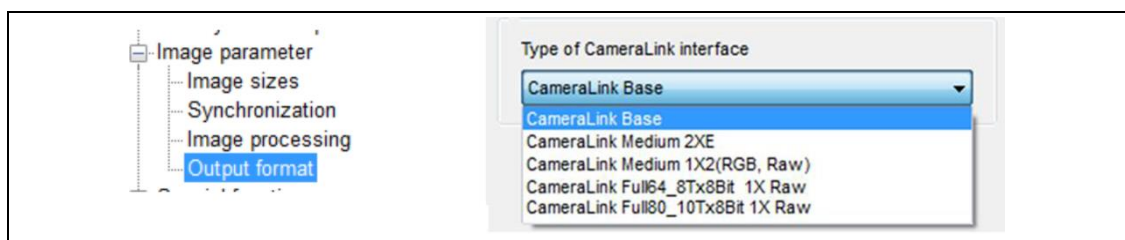*Fig. 25: Setting up the CameraLink interface*

4. In the **Type of CameraLink interface** dropdown list, select the desired CameraLink interface.
   For information on the CameraLink interface types refer to chapter 7.4.2, p. 84.
5. Select the *OK* button.
6. Save the settings to the non-volatile memory of the camera by selecting the corresponding icon in the toolbar or by pressing the F10 key on the PC keyboard.

6.5 Configuring the camera

6.5.1 Setting camera parameters for the 3DPIXA dual camera

For the 3DPIXA dual camera the timing and triggering parameters must be set only for the master camera. The behavior of the slave camera is determined by the timing and trigger parameters of the master camera. The set parameters for timing and triggering of the slave camera are ignored.

Overview of the settings which only have to be defined for the master camera:

- Simple setup view
  - Image parameters
    - Frame start (triggered frame scan)
  - Timing
    - Integration time
    - Line period
- Encoder setup
  - Enable encoder
- I/O configurator

ℹ The values for image start delay and image height must be set identically for the master camera and the slave camera.

ℹ White balancing (see chapter 6.12, p. 68) and shading reference (see chapter 6.13, p. 76 and chapter 6.14, p. 77) have to be performed separately.
The parameters not mentioned in this chapter have to be set identically for both cameras. This can be done with two CST applications, which are opened at the same time.

6.5.2 Configuring the camera with the simple setup tool

The simple setup tool is used to quickly configure the camera for the first image acquisitions.

1. Select the green smiley button in the toolbar of the CST.
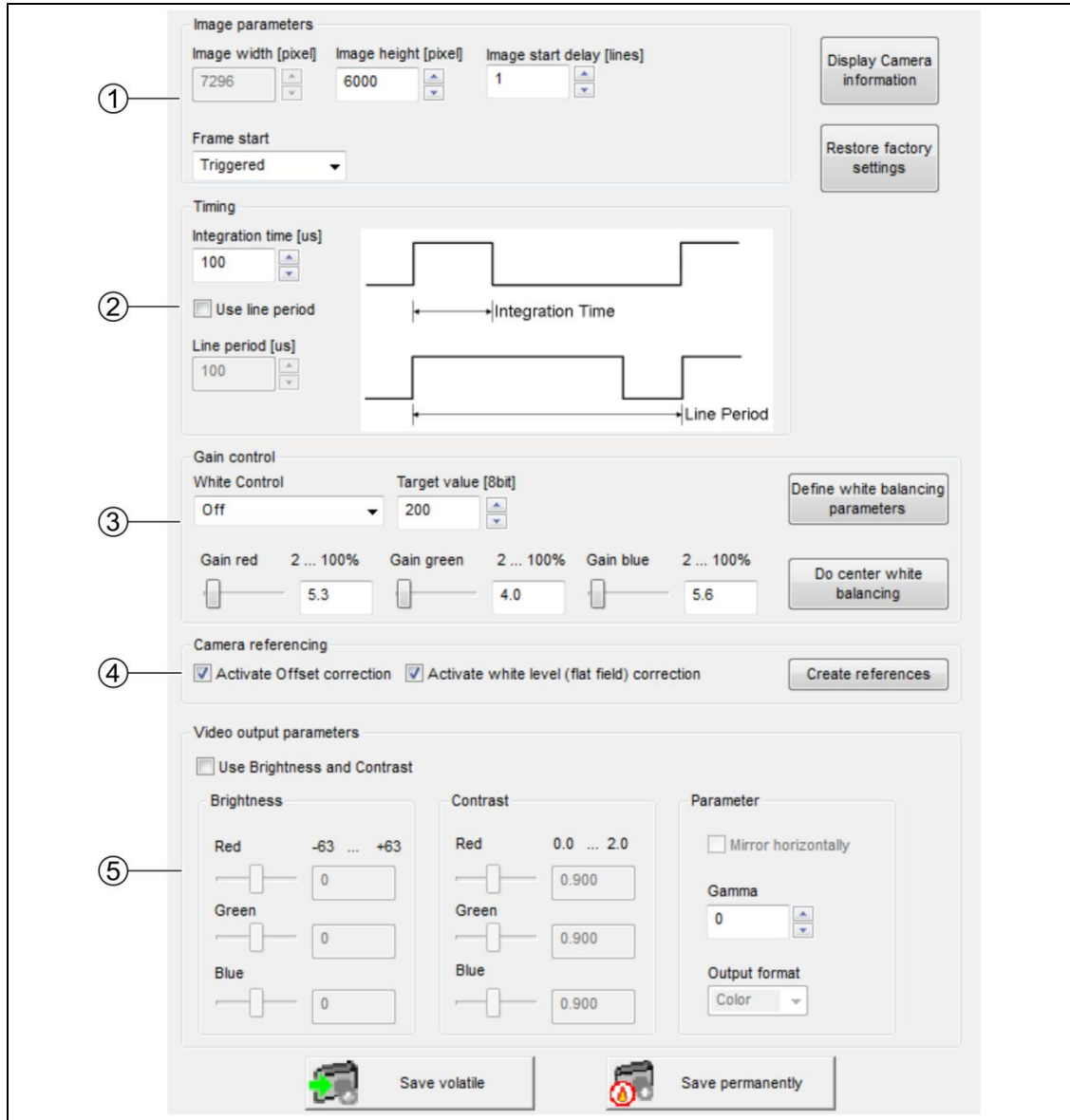   The simple setup tool is shown:

Fig. 26: Simple setup tool

1	Image parameters	4	Camera referencing
2	Timing parameters	5	Video output paramters
3	Gain control parameters		

2. Set the image parameters (1):
    –   Set the image height and the image start delay (image offset in moving direction).
        If using a 3DPIXA dual camera, the image height and the image start delay must be set identically for the master camera and the slave camera.
    –   Set the frame start:

        Triggered

        The camera starts to capture lines when the external frame trigger signal is created. This configuration of the camera in combination with the line trigger signal is mandatory for capturing images for 3D calculation. For more information see chapter 4.9, p. 31.

        Free running

        No external frame trigger signal is used. This configuration of the camera is obligatory to perform white balancing (step 4), tap balancing for 3DPIXA dual (step 5), or create a new black (offset) level reference (step 6).

3. Set the timing parameters (2):
    –   Set the integration time (see chapter 6.10, p. 66).
    –   If required, set the checkmark in the **Use line period** box and set the line period time. The line period determines the time between the acquisition of consecutive scan lines. The line period can be used only in free running mode, i.e., with the encoder disabled.
    –   When using a 3DPIXA dual camera, the integration time / line period is only set by the master camera (see chapter 6.5.1, p. 52).

ℹ The following steps are intended for image optimization. For first commissioning the factory settings can be used.

4. Set the gain control parameters (3):

Parameter	Function
White control	• Off: No white balancing (**use this setting for first commissioning**) • Continuous: White balancing is operated continuously, i.e., the camera gain values are adjusted continuously during the scanning process. • Once per frame: One frame is used for white balancing.
Target value [8 bit]	Target value for white balancing in 8 bit (0–255). The camera will try to adjust the analog camera gain values in order to reach the set target value.
Gain red/green/blue	Setting the gain control parameters manually by shifting the sliders or by entering the values in the input fields.

–   3DPIXA dual cameras only:
    Enable the encoder for the master camera and deactivate the offset and white level correction for the master camera and the slave camera. Select the ***Do center white balancing*** button for the master camera and the slave camera.
    The white control field is moved into the middle of the image, and white balancing is performed based on the target value. The new gain values are automatically set.

- 3DPIXA compact cameras only:
  Enable the encoder and deactivate the offset and white level correction for the camera. Select the **Do white balancing** button for the camera.
  A white control field is moved into the middle of each tab in the image, and white balancing is performed based on the target value. The new gain values are automatically set.
- The **Define white balancing parameters** button forwards the user to the full white balancing parameter set as described in chapter 6.12, p. 68.

5. 3DPIXA dual cameras only:
   Perform tap balancing by selecting the appropriate toolbar icon for both cameras.

6. Select the camera referencing settings (4):
   - Use the factory preset references for black level (offset) and white level (flat field) reference for first commissioning. Activate them by selecting the checkboxes.
   - After first commissioning, the references for black level (offset) and white level (flat field) correction have to be generated for your application. Select the **Create references** button.
     This starts the wizard for black (offset) referencing and shading (flat field) referencing (see chapter 0, p. 76 and chapter 6.14, p. 77).

7. Set the video output parameters in the simple setup tool in order to apply further digital image processing:

When using a 3DPIXA dual camera, these parameters must be set in both cameras.

Parameter	Function
Use Brightness and Contrast	When this checkbox is activated, the brightness and contrast settings are applied to the image.
Brightness	Adds an offset to the output values. The values are in the 8 bit range.
Contrast	Multiplies the output values with the set value. This is used to desaturate images after shading referencing.
Gamma	A gamma correction table will be applied to the image. • >0.4: $Video\_out\_level = video\_in\_level^{1/Gamma}$ • 0.1: A special table for sRGB conversion is used. • 0: Gamma correction is disabled The Gamma function must be disabled for the acquisition of the black (offset) and shading (flat field) reference and white balancing.

8. Save the settings either to the volatile or non-volatile memory of the camera. Data in volatile memory are lost after:
   - selecting a different setting,
   - resetting the camera,
   - doing a power cycle.

Restoring the factory settings

When selecting the **Restore factory settings** button, the currently active settings will be overwritten by the factory settings.

Displaying camera information

When selecting the **Display camera information** button, the following window is displayed:
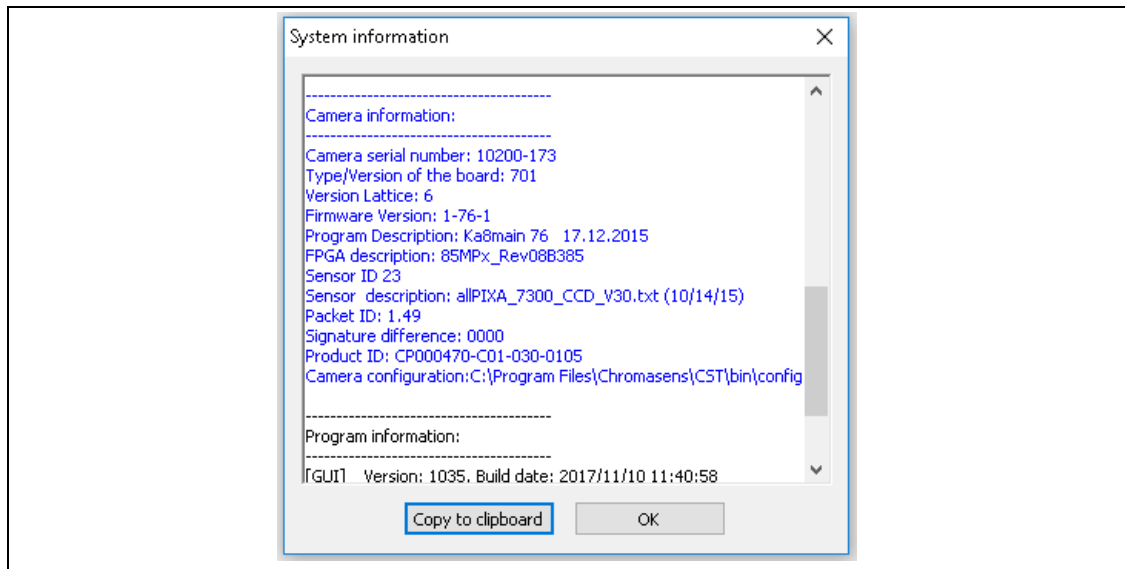

Fig. 27: **System information** *window*

The displayed information can be copied by selecting the **Copy to clipboard** button (e.g. in the event of a support request).

6.6   Setting up the trigger device and the synchronization

✓   The trigger device is installed (see chapter 5.5.3, p. 47).

1. Open the CST.
2. Select the *IO* button in the toolbar.
    The settings for the user-configurable inputs and outputs of the camera are shown.

ℹ   In order to be able to adjust the I/O settings, the user level *normal user* (default) has to be changed to *expert user* via the CST – system configuration.

ℹ   For the 3DPIXA dual camera the trigger inputs (1–4) have to be set only for the master camera.

	Name of IO function	Connector	Internal Function	IO-Standard	Bit Value	
01	Encoder Ch 0 / Incr0 / line trigger	CL1-CC1	Incr0/line trigger	LVDS	☒	1
02		X5-1/9	Incr0/line trigger	RS422	☐	
03		X5-4	Incr0/line trigger	LVTTL	☐	
04		---	Incr0/line trigger	---	☐	
05		---	Incr0/line trigger	---	☐	
06	Encoder Ch 1 / Incr1	CL1-CC2	Incr1	LVDS	☐	2
07		X5-2/10	Incr1	RS422	☐	
08		X5-12	Incr1	LVTTL	☐	
09		---	Incr1	---	☒	
10		---	Incr1	---	☐	
11	Enable Encoder	---	Enable Increments	---	☒	3
12		CL1-CC2	Enable Increments	LVDS	☐	
13		CL1-CC4	Enable Increments	LVDS	☐	
14	Invert Incr0 / line trigger	---	Inv. Incr0/line trigger	---	☐	
15	frame trigger / light barrier	CL1-CC3	LB0 + LB2 + LB3	LVDS	☒	4
16		CL1-CC4	LB1 + LB2	LVDS	☐	
17		X5-1/9	LB2	RS422	☐	
18		X5-2/10	LB3 + LB2	RS422	☐	
19		X5-3	LB3 + LB2	LVTTL	☐	
20	Select master camera	X5-3	nSelMaster	LVTTL	☐	5
21		CL1-CC4	nSelMaster	LVDS	☐	
22	Master / Slave interface	X5-4/12	MS_Interface	LVTTL	☐	
23		X5-6/8	MS_Interface	LVTTL	☐	
24		X9-1/8	MS_Interface	LVTTL	☐	
25	Test signals	X5-4	VSYNC	LVTTL	☐	6
26		X5-12	HSYNC	LVTTL	☐	

Fig. 28:   User-configurable inputs and outputs in the CST

1   Line trigger inputs Encoder Channel 0 (CC1)
2   Line trigger inputs Encoder Channel 1 (CC2)
3   Enabling line trigger inputs
4   Frame trigger inputs (CC3 or CC4)
5   Definition of master/slave assignment
    These I/O bits are factory preset for the 3DPIXA
6   These I/O bits can be set for putting out signals via the I/O for internal testing
    (Vsync FVAL Hsync LVAL)

3. Depending on the trigger device connection (see chapter 5.5.3, p. 47), select the following connectors in the **Bit Value** column:

Trigger device	Connection type	Connector
Line trigger	Frame grabber	CL1-CC1 CL1-CC2 (depending on the frame grabber settings)
	Camera I/O port	X5-1/9 X5-2/10 (depending on the I/O pin assignment)
Frame trigger	Frame grabber	CL1-CC3 CL1-CC4 (depending on the frame grabber settings)
	Camera I/O port	X5-1/9 X5-2/10 (depending on the I/O pin assignment)

Tab. 16: Trigger device setup

When the **Enable Encoder** function (3) is activated, the encoder can be enabled by using an external I/O port (CC2 or CC4 of the CameraLink interface).

> Internal functions may not be used twice.
> ▷ Make sure that the selected connectors have different internal functions.

4. When using an encoder:
   Open the **Encoder setup** page by selecting the corresponding toolbar icon.
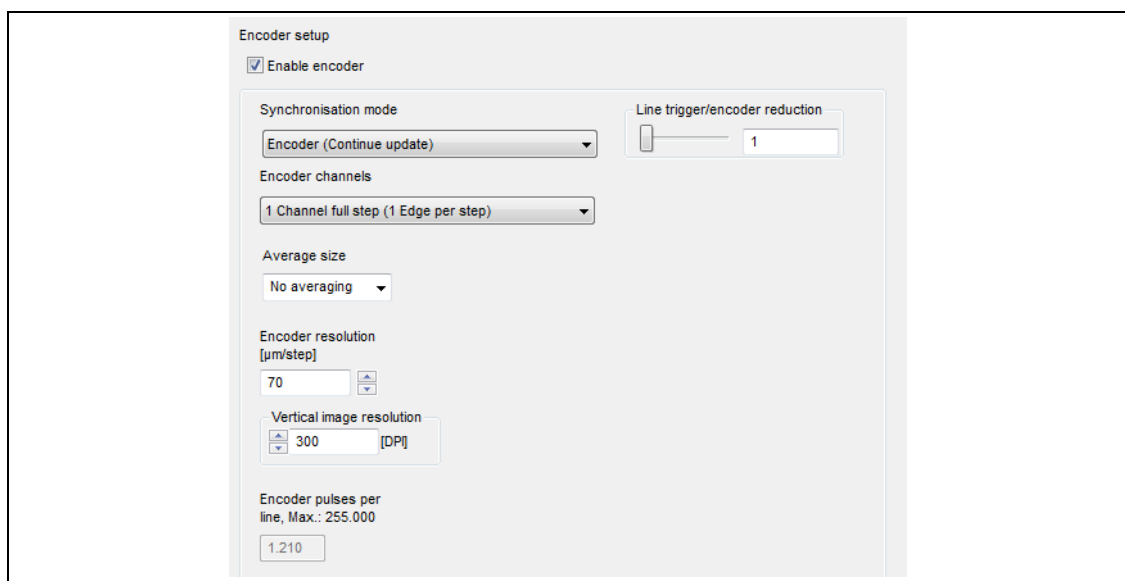

*Fig. 29: **Encoder setup** page*

5. Configure the encoder by setting the following parameters:

Parameter	Description
Synchronization mode	• Line trigger mode (Const. int time): The camera sends one line per number of pulses set in the **Line trigger/encoder reduction** field. • Encoder (Continue update): The internal intelligent encoder functionality is used. The camera measures the speed of the object and sends lines based on the defined encoder resolution and the vertical image resolution.
Encoder channels	Number of recognized edges per step of the encoder signal (see chapter 7.6.3, p. 88).
Line trigger/encoder reduction	• Line trigger mode: Number of trigger signals used for the triggering of one scanning line. • Encoder mode: Number of encoder pulses per line. If the number of encoder pulses per line exceeds 255, this factor has to be used to reduce the number below 255.
Average size	Number of encoder increments which are averaged for speed measurements.
Encoder resolution	Encoder resolution in μm/step. This is the distance the object moves during one encoder period.
Vertical image resolution	Physical resolution in transport direction. The vertical image resolution is calculated by dividing 1 inch (25 400 μm) through the optical resolution of the camera (see chapter 2.3, p. 11). Note: If the resolution and speed are too high and require a shorter integration time than defined in the camera setting, the camera will constantly output image data with the defined integration time until the speed drops below the required integration time.
Encoder pulses per line	Calculated from the defined encoder parameters. If the value exceeds 255, increase the line trigger/encoder reduction value in order to reduce the encoder pulses per line below 255.

Tab. 17: Encoder setup parameters

6.7   Determination of the maximum integration time

Relationship between the maximum line frequency and the minimum possible integration time:

$$\text{Minimum integration time (s)} = \frac{1}{\text{Maximum line frequency (Hz)}}$$

▶   Calculate the maximum possible integration time for your application using the following formula:

$$\text{Maximum integration time (s)} = \frac{\text{Desired transport resolution (mm/pixel)}}{\text{Nominal transport speed (mm/s)}}$$

> ⓘ If the transport resolution is stated in dpi and the speed in metric values, the values have to be converted (1 inch= 25.4 mm).

Example (3DPIXA camera CP000470-C01-015-0040)

- Line frequency of the camera: 21.2 kHz

$$\text{Minimum integration time} = \frac{1}{21200 \text{ Hz}} = 4.7 \times 10^{-5} \text{ s}$$

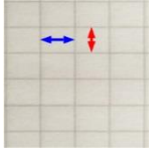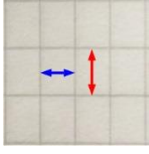- Nominal transport speed: 200 mm/s
- Transport resolution: 15 µm/pixel

$$\text{Maximum integration time} = \frac{0.015 \text{ (mm/pixel)}}{200 \text{ (mm/s)}} = 7.5 \times 10^{-5} \frac{\text{s}}{\text{pixel}}$$

> ⓘ Set the integration time minus 10 % of the maximum integration time to avoid a speed, which would be too high for the camera.

6.7.1 Checking the synchronization with target speed

Perform the following procedure to check the synchroniziation between the camera and the target speed:

1. Place a graph paper on a moving stage in the focus of the 3DPIXA camera.
2. Acquire an image of the moving graph paper.
3. Check the image for distortions of the graphic lines by counting pixels:

Image	Distortion	Cause
	No distortion	The moving speed and the integration time are suitable.
	Compression along the moving direction	The moving speed is too high or the integration time is too long.
	Stretching along the moving direction	The moving speed is too low or the integration time is too short.

Tab. 18: Examples for images

ℹ Count the pixels in the center of the image for an accurate determination.

4. If distortion exists, calculate the new moving speed and/or the integration time as follows:
   – Count the number of pixels along the blue and the red arrows.
     Example compression: 18 pixels along the blue arrow, 9 pixels along the red arrow
     Example stretching: 18 pixels along the blue arrow, 27 pixels along the red arrow
   – Multiply the current speed/time with the ratio of red arrow pixels to blue arrow pixels.
     Example compression:
     9/18 * current moving speed = 0.5 * current moving speed = new moving speed
     9/18 * current integration time = 0.5 * current integration time = new integration time
     Example stretching:
     27/18 * current moving speed = 1.5 * current moving speed = new moving speed
     27/18 * current integration time = 1.5 * current integration time = new integration time
5. Set the new moving speed and/or integration time (see chapter 6.10, p. 66).

6.8 Setting up the camera Master/Slave mode

For correct 3D calculation with a 3DPIXA dual camera, the image capture between the master and the slave camera must be synchronized. This is carried out via the master/slave mode (see chapter 4.3.2, p. 23). The Master/Slave mode is factory preset for the 3DPIXA dual cameras. It is therefore not necessary to make settings in Master/Slave mode for the first startup or standard operation.

> The implementation of the Master/Slave mode differs between the 3DPIXA dual (CP000470) and 3DPIXApro dual (CP000520) camera types.
> For the 3DPIXA dual and 3DPIXApro dual camera the Master/Slave mode has to be set up for both cameras separately. This can be done with two CST applications, which are opened at the same time.

6.8.1 Setting the Master/Slave mode for 3DPIXA dual (CP000470)

> The Master/Slave mode is factory preset for the 3DPIXA dual. It is therefore **not** necessary to make settings in Master/Slave mode for the first startup or standard operation.

For 3DPIXA dual, starting with the article code CP00470, an external Master/Slave synchronization cable is included in the delivery. The following description refers to the use with this external synchronization cable.

Setting the Master/Slave mode via the CST

1. Connect the master camera with the slave camera using the Master/Slave synchronization cable.
   The connector of the synchronization cable for the master camera is marked with the label "Master".
2. Open the CST for the master camera and for the slave camera and disable **Display only compatible cameras**.

> For adjusting the master/slave parameters, it is necessary to select the camera type allPIXA. If the CST is used with the compatible camera type 3DPIXA dual, no changes of the master/slave mode can be made.

3. In the **Camera Settings** select *Synchronization* in the **Image Parameter** folder.
4. In the **Set master-slave-mode** field select *Auto select by input* for the master camera and the slave camera.
5. In both CST for the master camera and the slave camera, select the *IO* button in the toolbar.

	X5-3	LD3 + LD2	LVTTL	☐
Select master camera	X5-3	nSelMaster	LVTTL	☒
	CL1-CC4	nSelMaster	LVDS	☐
Master / Slave interface	X5-4/12	MS_Interface	LVTTL	☐
	X5-6/8	MS_Interface	LVTTL	☒
	X9-1/8	MS_Interface	LVTTL	☐
Test signals	X5-4	VSYNC	LVTTL	☐

Fig. 30: Setting the IO-configuration for the Master/Slave mode of the 3DPIXA dual camera

6. In the IO-configuration, set the definition by selecting the corresponding checkboxes:
   – Select the IO-interface **X5-3** for the master camera and for the slave camera.
   – If the standard configuration is used, select **X5-6/8** for the Master/Slave interface.

6.8.2 Setting the Master/Slave mode for 3DPIXApro dual (CP000520)

> The Master/Slave mode is factory preset for the 3DPIXA dual. It is therefore **not** necessary to make settings in Master/Slave mode for the first startup or standard operation.

For the 3DPIXApro dual camera, starting with the article code CP00520, the master/slave synchronization is carried out via an internal synchronization cable in the camera housing.

Setting the Master/Slave mode via the CST

1. Open the CST for the master camera and for the slave camera and disable **Display only compatible cameras**.
   If no selection window is shown after opening the CST, select the *Set system settings* icon in the toolbar and disable **Display only compatible cameras** in the **Select camera type** field.

> For adjusting the master/slave parameters, it is necessary to select the camera type allPIXA. If the CST is used with the compatible camera type 3DPIXA dual, no changes of the master/slave mode can be made.

2. In the **Camera Settings** select *Synchronization* in the **Image Parameter** folder.
3. In the **Set master-slave-mode** field select *Camera acts as master* for the master camera and *Camera acts as slave* for the slave camera.
4. In both CST for the master camera and the slave camera, select the *IO* button in the toolbar.

Master / Slave interface	X5-6/8	MS_Interface	IO-Interface-6/8	☐
	X9-1/8	MS_Interface internal A	Internal Interface-A	☐
	X12-2/4	MS_Interface internal B	Internal Interface-B	☒
	X5-6/8-4/12	MS_Interface + Hub	IO-Interface-6/8 Ou	☐

Fig. 31: Setting the IO-configuration for the Master/Slave mode of the 3DPIXApro dual camera

5. In the IO-configuration, set the definition by selecting the IO-interface **X12-2/4** for the master camera and for the slave camera.

6.8.3 Checking the frame grabber image acquisition with the 3DPIXA dual camera

For correct 3D calculation with a 3DPIXA dual camera, the image capture between the master and the slave camera must be synchronized. In addition, the frame grabber acquisition must also be synchronized. This is ensured by the generated FVAL of the 3DPIXA camera.
The correct image capture of the frame grabber can be checked with the use of the first line info block in the images.

> The frame grabber must be configured in such a way that it uses the FVAL when capturing images.

1. In the **Camera Settings** select **Output format** in the **Image parameter** folder.
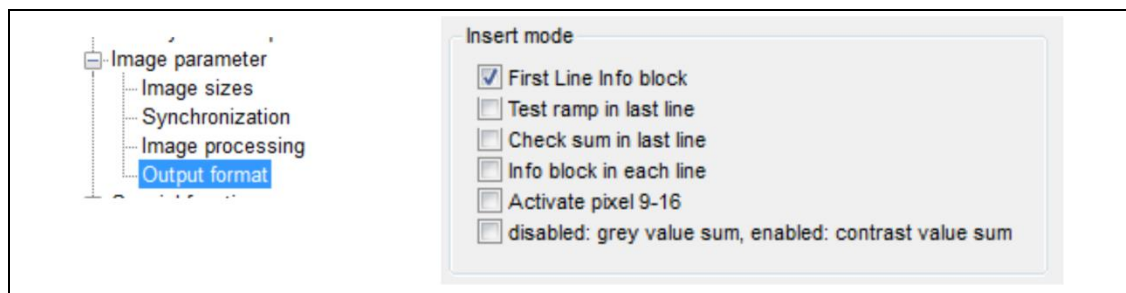
Fig. 32: Enabling First Line Info block

2. Activate **First Line Info block** in the CST for the master and for the slave camera.
    If the synchronization is correct, the first line info block is visible in the first line of the master image and the slave image. The beginning of the first line info block is in the upper left corner of the image.
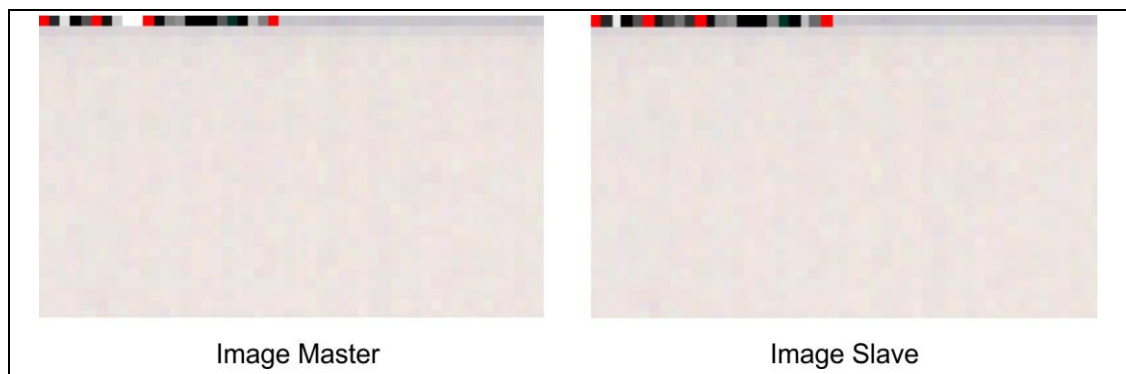
Fig. 33: First line info block of the master and slave images

> ▷ If the first line info blocks are not in the first line or if they are shifted to each other, check the frame grabber settings.
> ▷ If the beginnings of the first line info blocks are not in the upper left corner, check the settings of the readout direction of the frame grabber.

6.9 Setting the scan direction for the camera and 3D calculation

There is a dependency of the scan direction for the 3DPIXA camera and the 3D calibration. The relationship between the 3DPIXA alignment and the scan direction is described in chapter 5.3, p. 40.

In addition to the scan direction set in the camera, the scan direction must also be set for the 3D calibration.

The calibration of the 3DPIXA camera for measuring height information is implemented for the forward scan direction. To generate height information for the backward scan direction the calibration has to be switched to the inverted transport direction in the CS-3D-API. This is done by the parameter **invertTransportDirection** in the configuration file.

To set the scan direction for the camera and the 3D calibration perform the following steps:
1. Set the scan direction in the camera:
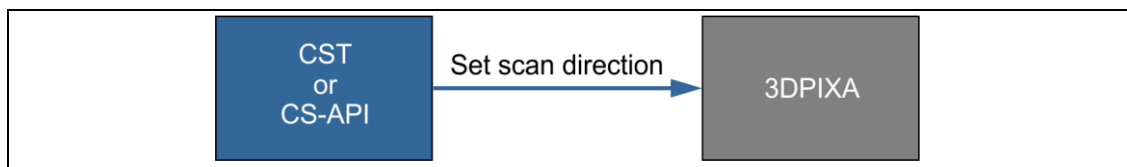
Fig. 34:   Setting the scan direction in the camera

If using a 3DPIXA dual camera, the scan direction has to be set for the master camera and the slave camera.

For setting the scan direction via the CST, proceed as follows:
–   In the **Camera Settings** select **Camera arrangement** in the **Camera parameter** folder.

Fig. 35:   Setting the scan direction via the CST

–   In the **Set scan direction** field, select the scan direction from the dropdown list.

For setting the scan direction via the CS-API, refer to the CS-API manual.

2. Set the scan direction for the 3D calibration via the configuration file:
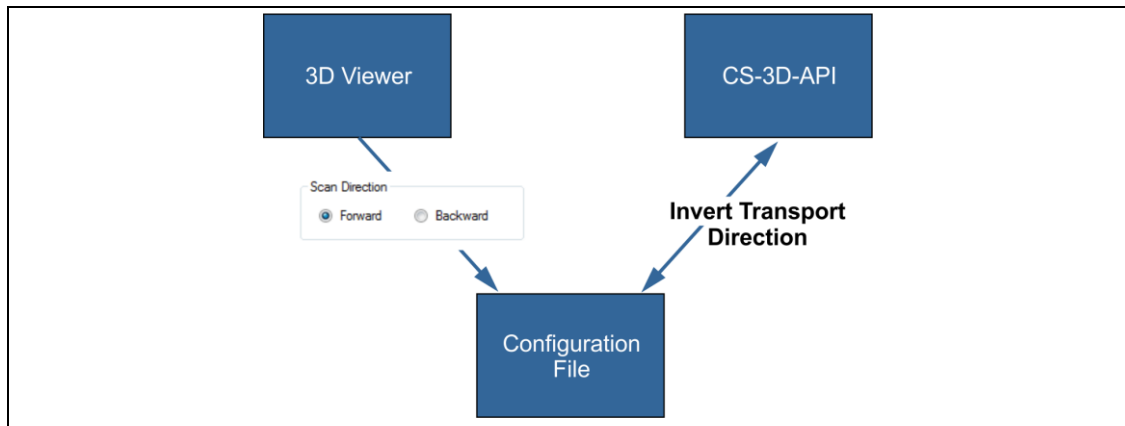
Fig. 36: Setting the scan direction for the 3D calibration

For setting the scan direction via the 3D-Viewer, select the menu items **Calculation > Options > Miscellaneous > Scan Direction**.
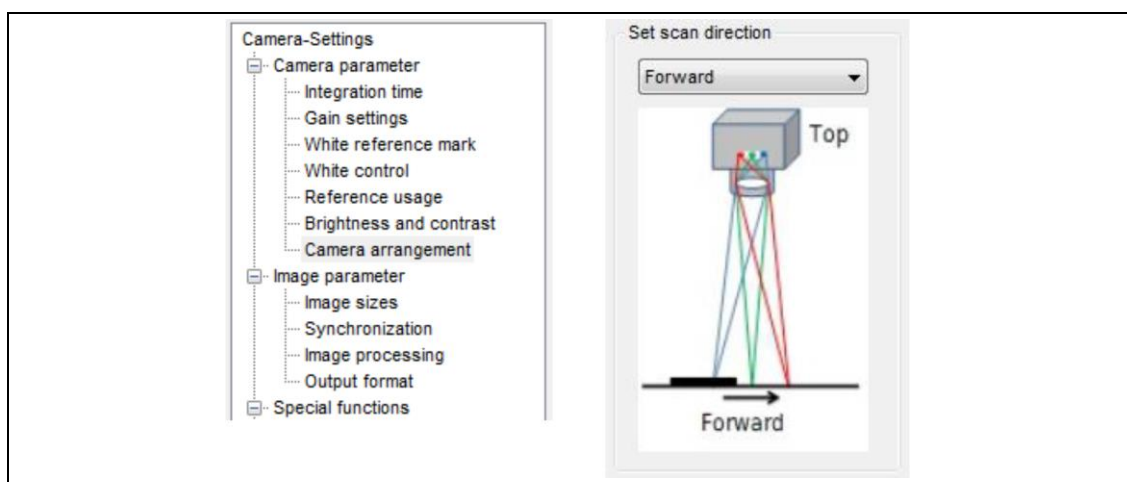
The **InvertTransportDirection** parameter in the configuration file has two states:

– **InvertTransportDirection** = 0: Forward scan direction (default)
– **InvertTransportDirection** = 1: Backward scan direction

For setting the scan direction via the CS-API, refer to the CS-API manual.

6.10 Adjusting the integration and line period times

1. Open the CST.
2. Select the COM port where the camera is connected (COM port of the frame grabber).
3. In the **Camera Settings** select **Integration time** in the **Camera Parameter** folder.
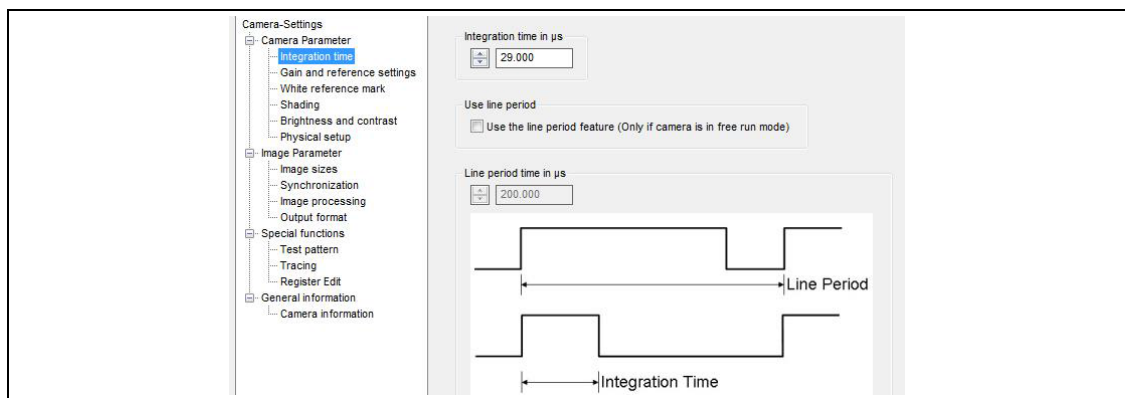
Fig. 37: Camera Parameter – Integration time

4. Enter the integration time and the line period time in the corresponding input fields. The input field for the line period time is only active if a checkmark is set in the **Use line period** field.
5. Save the settings to the non-volatile memory of the camera by selecting the corresponding icon in the toolbar or by pressing the F9 key on the PC keyboard.

If the 3DPIXA dual camera is used, the settings have to be done only in the master camera.

6.11 Preparing the camera for white balancing and black (offset) level correction

✓ A non-glossy white reference without texture and impurities (e.g., dust, scratches) on its surface is available.

1. Turn on the camera and the illumination.
2. Adjust the illumination brightness to the operating conditions.
3. Put the white reference into the FOV and in the correct working distance of the camera.
4. Open the CST.
5. Select the port where the camera is connected (port of the frame grabber).
6. In the **Camera Settings** make the following settings:
   If the 3DPIXA dual camera is used, the settings must be identical for both cameras. For this open the CST application for each camera.
   For the 3DPIXA dual camera the timing and trigger parameters have to be set only for the master camera.

Parameter	Setting	Value
Camera Parameter – Integration time	Use line period	Disabled
Camera Parameter – Shading	Activate black level correction	Disabled
	Activate white level (flat field) correction	Disabled
Camera Parameter – Brightness and contrast	Use brightness and contrast	Disabled
Image Parameter – Synchronization	Frame start/stop	Free running

Tab. 19: Initial settings for white balancing

7. Open the **Encoder setup** page (see Fig. 29, p. 58) by selecting the corresponding toolbar icon.
8. Make sure that the encoder is disabled (**no** checkmark in the **Enable encoder** box).
9. Save the settings in the volatile memory of the camera.

6.12 White balancing

6.12.1 3DPIXA compact camera

✓ The camera is prepared for white balancing (see chapter 6.11, p. 67).

1. Start the application software.
2. Observe a live image.
3. Identify the brightest areas in the images from the front tap and the rear tap.
   You may use a line profile to evaluate the brightness of the images. Check your frame grabber software whether a line profile is available.
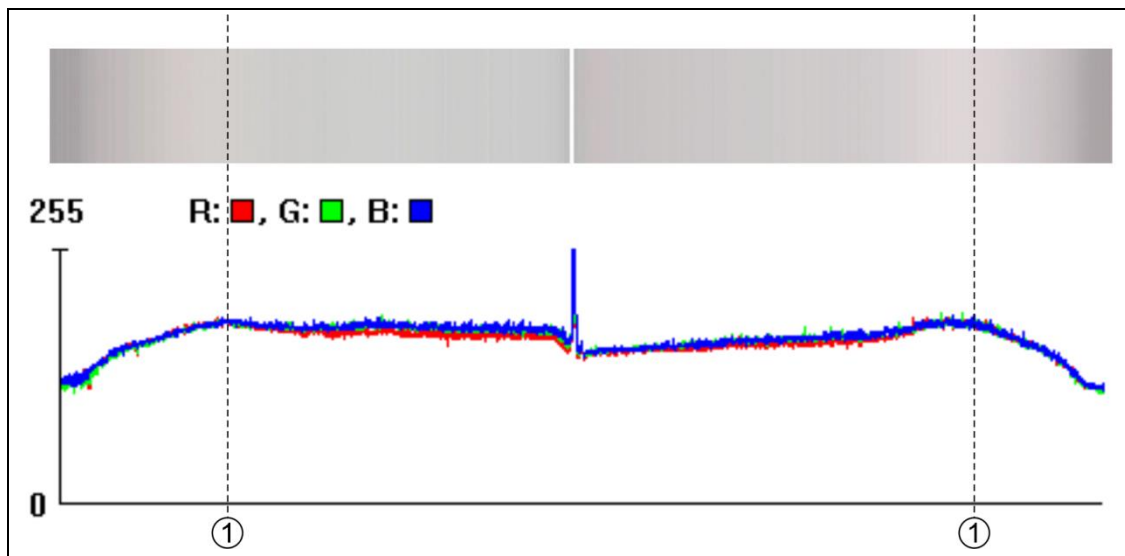
Fig. 38:   Identifying the brightest areas in the images

        1   Maximum brightness

4. In the **Camera Settings** select **White reference mark** in the **Camera Parameter** folder.
5. In the **Show white reference border** field enable *Display white reference borders in the image*.
6. Save the settings in the volatile memory of the camera by selecting the appropriate toolbar icon or by pressing the F9 key.
   The white reference marks are displayed in the images:

Fig. 39:   White reference marks

7. If the white reference marks are not displayed at the brightest areas of the images, move them accordingly:
   – In the **Camera Settings** select **White reference mark** in the **Camera parameter** folder.
   – In the **First relative pixel of white reference (A1)** field modify the value in order to move the white reference marks as shown in Fig. 40, p. 69.
     The new positions of the white reference marks will be shown after saving the new value in the volatile memory of the camera by selecting the appropriate toolbar icon or by pressing the F9 key.
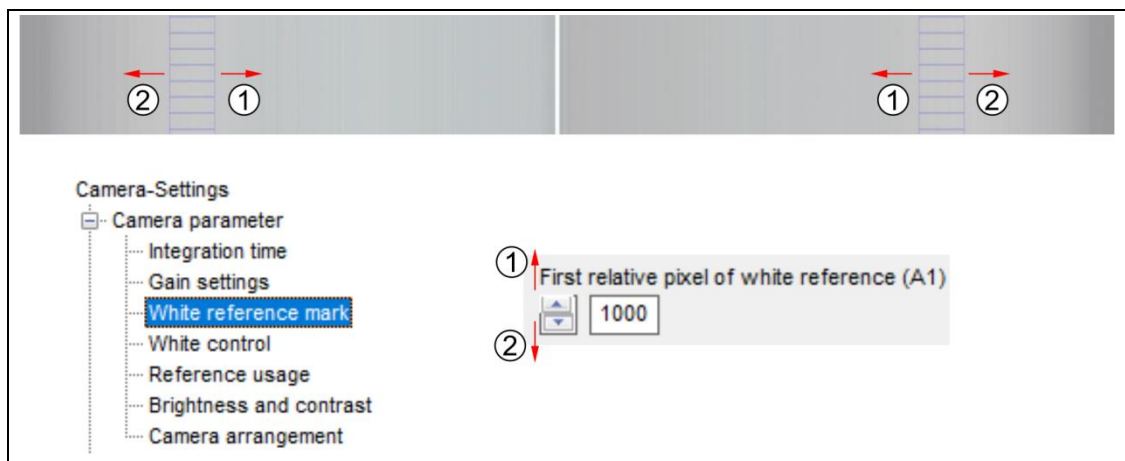
Fig. 40: Adjusting the white reference marks

       1   Moving the white reference marks inwards by increasing the value
       2   Moving the white reference marks outwards by decreasing the value

8. Hide the white reference marks:
   – Remove the checkmark in the **Display white reference borders in the image** box.
   – Save the setting in the non-volatile memory of the camera.
9. In the **Camera Settings** select **White control** in the **Camera parameter** folder.
10. Set the checkmark in the **Enable continuous white control** box.
11. Select the refresh icon in the toolbar.

12. In the **Camera Settings** select **Gain settings** in the **Camera parameter** folder.
    The actual camera gain values are read from the camera and displayed in the **Current camera gain values** field:
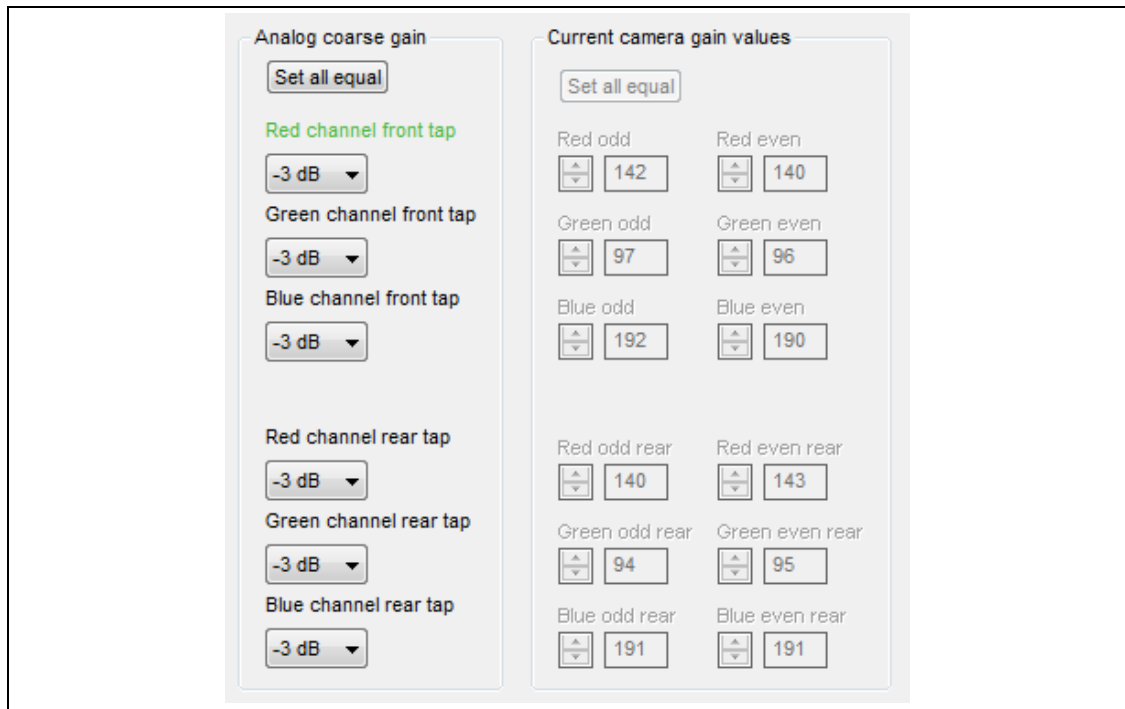
Fig. 41:   Current camera gain values

13. Check the displayed camera gain values.
    Values between 80 and 200 are recommended.
14. If the current camera gain values are outside this range:
    – Adjust the values by modifying the following parameters in the given order:

Camera gain value	Parameter modifications
>200	1. Increase the intensity of the illumination. 2. Increase the integration time. 3. Increase the analog coarse gain*.
<80	1. Decrease the analog coarse gain*. 2. Decrease the integration time. 3. Decrease the intensity of the illumination.

Tab. 20: Modifying the camera gain values
** 1 dB corresponds to 27.85 steps in the **Current camera gain values** field. The analog coarse gain can be set to the same value for all channels by setting the topmost value (red channel front tap), and then selecting the **Set all equal** button.*

– After each parameter modification, save the settings to the volatile memory of the camera, and select the refresh button.
– Check the values again and modify the parameters, if necessary.

15. In the **Camera Settings** select **White control** in the **Camera parameter** folder.
16. Check the values in the **Current White reference levels** field:
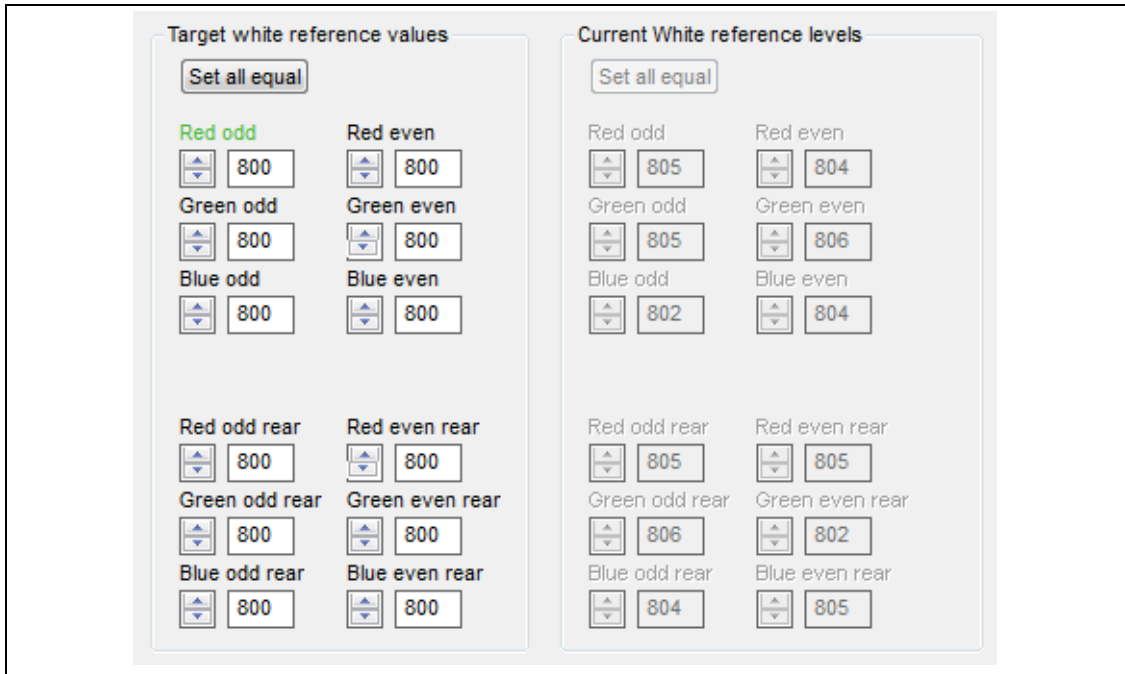
Fig. 42: White reference values

The current white reference levels should be between 780 and 820.

17. Make the following settings and save the settings in the volatile memory of the camera:

Parameter	Setting	Value
Camera Parameter – Gain and reference settings	Enable continuous white control	Disabled
	Update start gain with current gain values	Enabled

Tab. 21: Adjusting the start gain values

Now the values in the **Start gain values** field match with the values in the **Current camera gain values** field.

18. Save the settings in the non-volatile memory of the camera by selecting the appropriate toolbar icon or by pressing the F10 key.
    The camera will start with the start gain values.

Due to lens vignetting (shading), the image may have inhomogeneous light distribution. This will be improved with the shading (flat field) correction (see chapter 6.14, p. 77).

6.12.2   3DPIXA dual camera

i   White balancing has to be performed for both cameras separately.

✓   The camera is prepared for white balancing (see chapter 6.11, p. 67).

1.   Start the application software.
2.   Observe a live image.
3.   Identify the brightest area in the image.
      You may use a line profile to evaluate the brightness of the images. Check your frame
      grabber software whether a line profile is available.
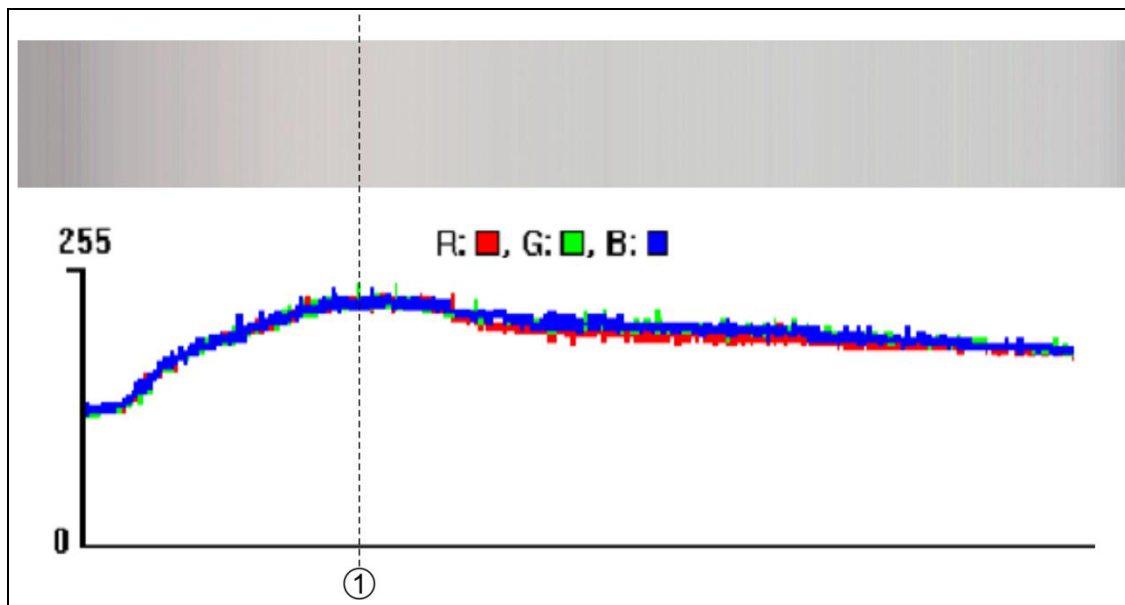
Fig. 43:   Identifying the brightest area in the image

1   Maximum brightness

4.   In the **Camera Settings** select **White reference mark** in the **Camera Parameter** folder.
5.   In the **Show white reference border** field enable ***Display white reference borders in
      the image***.
6.   Save the settings in the volatile memory of the camera by selecting the appropriate
      toolbar icon or by pressing the F9 key.
      The white reference mark is displayed in the image:

Fig. 44:   White reference marks

7. If the white reference mark is not displayed at the brightest area of the image, move it accordingly:
   – In the **Camera Settings** select **White reference mark** in the **Camera parameter** folder.
   – In the **First relative pixel of white reference (A1)** field modify the value in order to move the white reference mark as shown in Fig. 45, p. 73.
     The new position of the white reference mark will be shown after saving the new value in the volatile memory of the camera by selecting the appropriate toolbar icon or by pressing the F9 key.
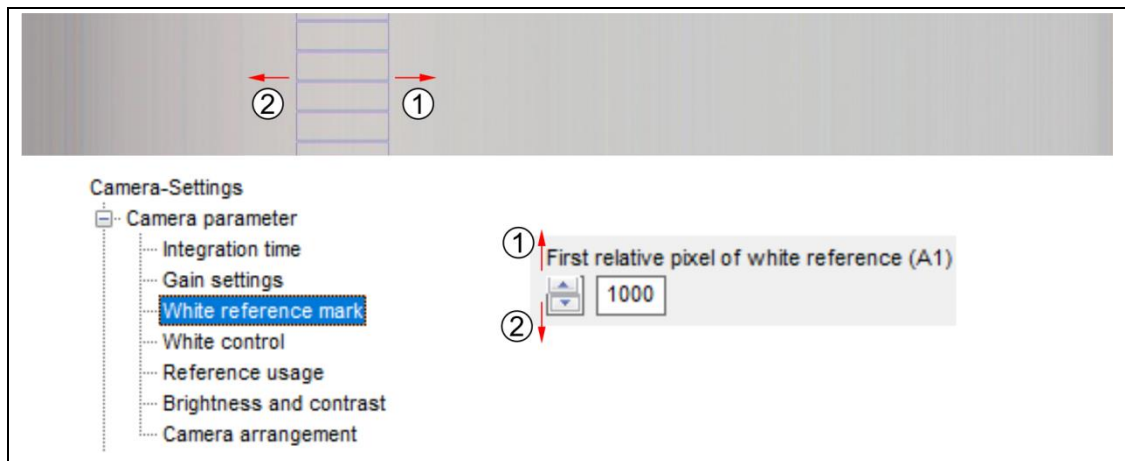
Fig. 45: Adjusting the white reference mark

       1   Moving the white reference mark rightwards by increasing the value
       2   Moving the white reference mark leftwards by decreasing the value

8. Hide the white reference mark:
   – Remove the checkmark in the **Display white reference borders in the image** box.
   – Save the setting in the non-volatile memory of the camera.
9. Repeat the previous steps for the second camera.
10. In the **Camera Settings** select **White control** in the **Camera parameter** folder.
11. Set the checkmark in the **Enable continuous white control** box.
12. Select the refresh icon in the toolbar.

13. In the **Camera Settings** select **Gain settings** in the **Camera parameter** folder.
    The actual camera gain values are read from the camera and displayed in the **Current camera gain values** field:
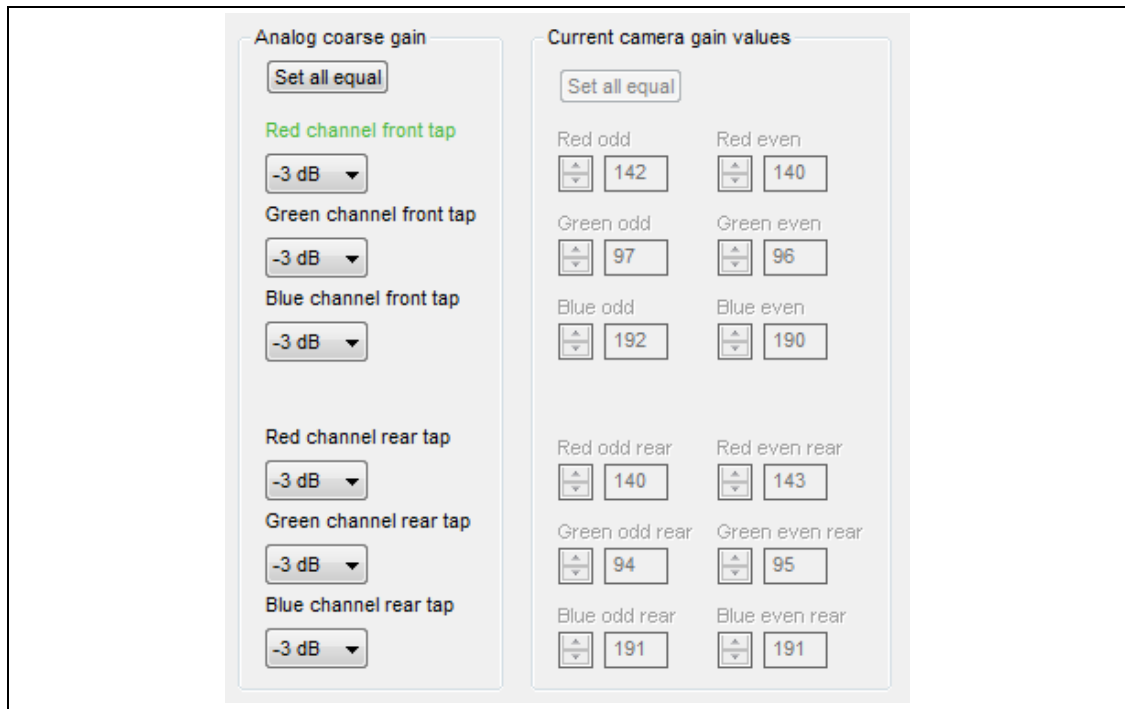
Fig. 46:   Current camera gain values

14. Check the displayed camera gain values.
    Values between 80 and 200 are recommended.
15. If the current camera gain values are outside this range:
    – Adjust the values by modifying the following parameters:

Camera gain value	Parameter modifications
>200	• Increase the intensity of the illumination. • Increase the integration time. • Increase the analog coarse gain*.
<80	• Decrease the intensity of the illumination. • Decrease the integration time. • Decrease the analog coarse gain*.

Tab. 22: Modifying the camera gain values
> ** 1 dB corresponds to 27.85 steps in the **Current camera gain values** field. The analog coarse gain can be set to the same value for all channels by setting the topmost value (red channel front tap), and then selecting the **Set all equal** button.*

    – After each parameter modification, save the settings to the volatile memory of the camera, and select the refresh button.
    – Check the values again and modify the parameters, if necessary.

16. In the **Camera Settings** select **White control** in the **Camera parameter** folder.
17. Check the values in the **Current White reference levels** field:
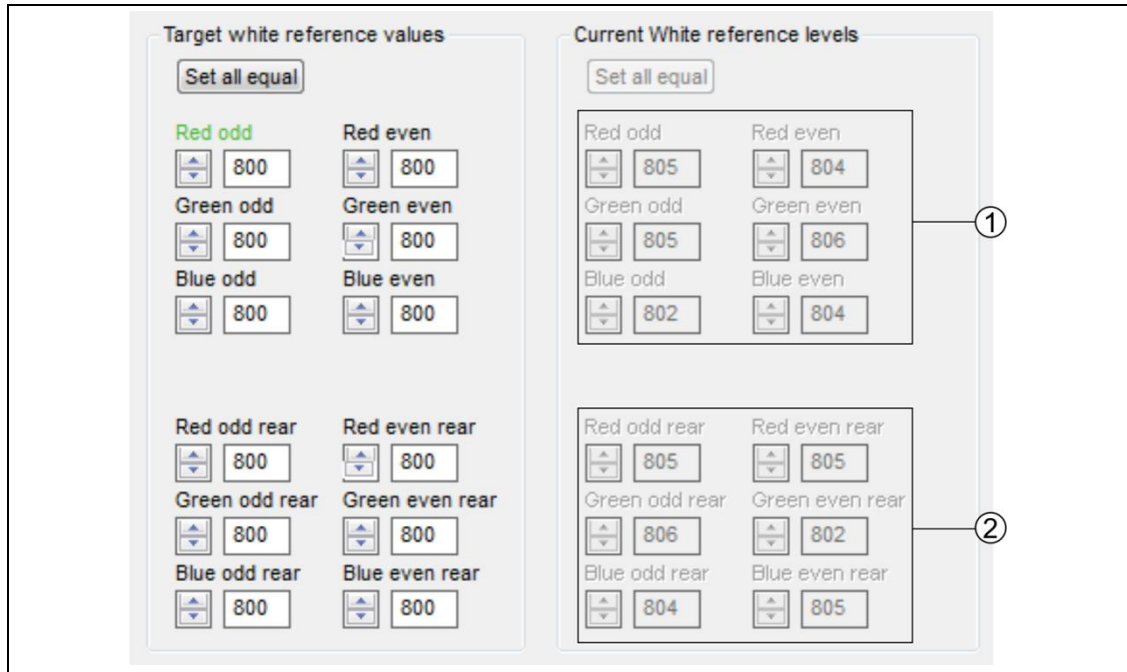
Fig. 47:   White reference values

    1   Values to be checked if the white reference mark is on the left side of the image
    2   Values to be checked if the white reference mark is on the right side of the image

The current white reference levels should be between 780 and 820.

18. Set the checkmark in the **Enable continuous white control** box.
19. Perform tap balancing by selecting the appropriate toolbar icon.
Now the values in the **Start gain values** field match with the values in the **Current camera gain values** field.
20. Save the settings in the non-volatile memory of the camera.
The camera will start with the start gain values.

Due to lens vignetting (shading), the image may have inhomogeneous light distribution. This will be improved with the shading correction (see chapter 6.14, p. 77).

6.13   Black (offset) level referencing

ℹ The camera gain values directly influence the black offset.

▷   Perform white balancing before starting the black referencing.
▷   If the camera gain values were changed, perform black referencing before operating the 3DPIXA camera.

✓   White balancing was performed (see chapter 6.12, p. 68).
✓   Triggered frame scan is set to **Free running**.
✓   The encoder is disabled.

For the 3DPIXA dual camera:

–   the trigger parameters has to be set only for the master camera,
–   the black (offset) level referencing has to be performed for the master camera and the slave camera.

1. Open the **Encoder setup** page (see Fig. 29, p. 58) by selecting the corresponding toolbar icon.
2. Make sure that the encoder is disabled (**no** checkmark in the **Enable encoder** box).
3. Open the **Reference generation wizard** by selecting the appropriate toolbar icon.
4. Select type of reference 1: **Black (offset) level reference**.
5. Select image source 2: **Create reference internally**.
6. Select the *Next* button.
7. Remove the checkmark from the **Perform white balancing** box.
    For the 3DPIXA camera, it is **not** recommended to perform white balancing using the **Reference generation wizard**.
8. Select the *Next* button.
9. Select the data set in which the offset reference shall be generated and stored.
10. Cover the lens so that the sensor is completely dark.
11. Select the *Next* button.
12. Wait until **Reference generation successful!** is displayed in the wizard window.
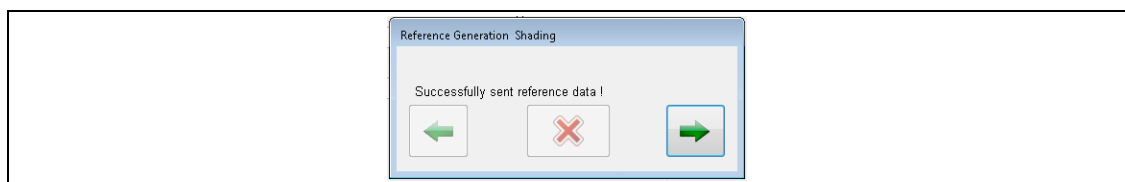
Fig. 48:   Reference generation successful

13. Select the *Next* button.
    The camera settings are restored.
14. In the **Camera Settings** select **Reference usage** in the **Camera parameter** folder.
15. Make sure that in the **Black reference data set field** the correct data set is selected.
16. Set the checkmark in the **Activate black level correction** box.
    At least a few pixels should be larger than 0 (e.g. 1 or 2) in the black image with activated black level correction and covered lens. Otherwise (if all pixels are 0), the image is over-compensated and black referencing must be repeated.
17. Save the settings in the non-volatile memory of the camera.

6.14 Shading white (flat field) referencing

ℹ Any features on the surface of the white reference (e.g. dust, scratches) will end up in the reference profile of the camera.

▷ Use a moving homogenous white reference target during the referencing process. The movement will result in an averaging process and the camera will diminish the effects on any small variation in the white reference.

✓ White balancing was performed (see chapter 6.12, p. 68)
✓ Black referencing was performed (see chapter 6.13, p. 76)

For the 3DPIXA dual camera, the shading white (flat field) referencing has to be performed for the master camera and the slave camera.

1. Make sure that the white reference is at the best focus plane of the camera.
2. Acquire an image.
   The image (= shading (flat field) reference) should have at least 500 lines.
3. Open the **Reference generation wizard** by selecting the appropriate toolbar icon.
4. Select the type of reference 1: **White (flat field) level reference**
5. Select the image source 2: **Load reference image from disk**
6. Select the *Next* (right arrow) button.

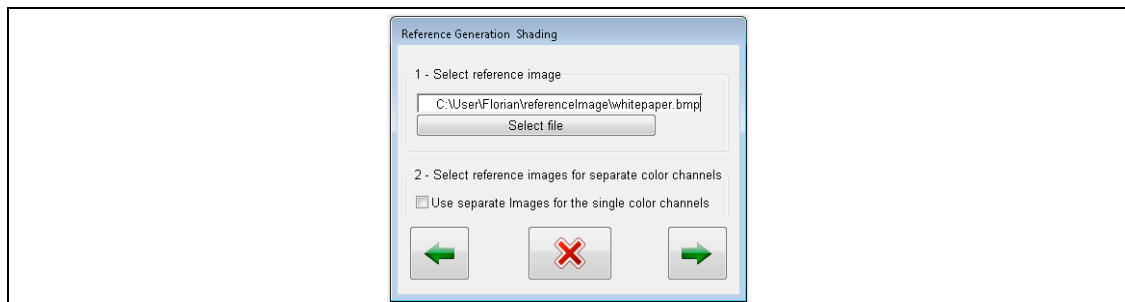Fig. 49: Selecting the shading reference file

7. Select the shading (flat field) reference file.
8. Select the *Next* button.
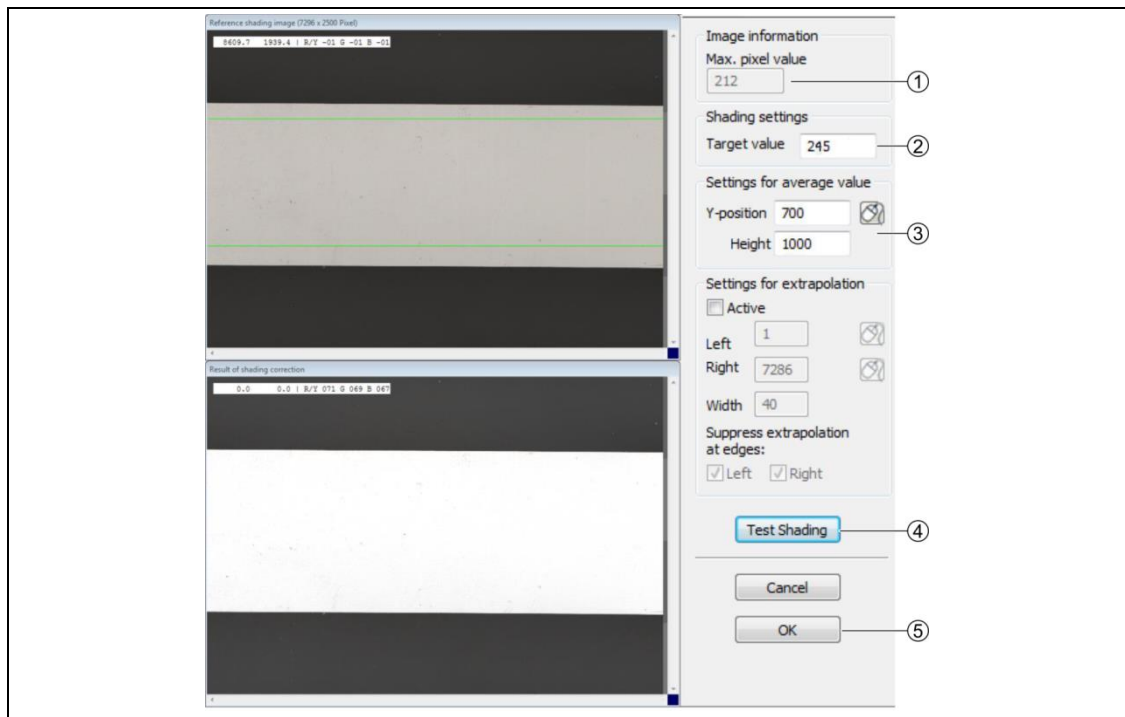   A shading (flat field) reference generation window opens.

Fig. 50:   Shading reference generation window

1	Image information with maximum pixel value	4	Test Shading button
2	Target value	5	OK button
3	Settings for average value		

9. In the **Image information** field (1), the maximum pixel value of the reference shading image is shown. Take care that the maximum pixel value is <245.

10. In the **Shading settings** field (2), set the target value to 245 in order to avoid image saturation.

11. In the **Settings for average value** field (3), specify the area where the reference values shall be calculated.
    Use at least 500 lines for calculating the reference values in order to eliminate noise.
    The values used for the reference will be calculated by averaging each column in the selected area.

12. Select the *Test Shading* button (4).

13. Make sure that no vertical lines are visible in the **Result of shading correction** window.

14. Select the *OK* button (5).

15. Select *Yes* to create the reference data.

16. Select the reference number and define the data set in which the reference data shall be generated and stored.
    Up to 4 data sets can be selected.

17. Select where to store the data.
    It is also possible to store the reference data to disk.

18. Set the checkmark in the **Send to camera** box.

19. Select the *Next* button.

20. Wait until **Successfully sent reference data!** is displayed in the wizard window.

21. Select the *Next* button.
22. In the **Camera Settings**, select **Reference usage** in the **Camera parameter** folder.
23. Set the checkmark in the **Activate white level correction** box.
24. Select the white reference data set (1 to 4).
25. Save the settings in the non-volatile memory of the camera.
    The shading (flat field) correction is now activated, and the video value of all pixels should be at approx. 245, like the target value.

6.15 Starting first 3D calculations

✓ The camera is commissioned (see chapter 6.1, p. 50).

1. Plug the software protection dongle (silver USB stick) into a USB slot of your PC.
2. Make sure the object is in the best focus plane of the camera.
3. Acquire a well illuminated raw image with texture.
   With the 3DPIXA dual camera 2 raw images are required.

   The image(s) should have the following properties:
   – 24 bit (bitmap format)
   – 7296 pixels image width

Do not start 3D calculations before you have acquired a good image.

4. Plug the orange USB stick into a USB slot of your PC.
5. Start the *cs-3d-setup-vX.X.exe* program in the 3D folder.
6. Install the 3D-Viewer software on the PC.
7. Open the 3D-Viewer.
8. Load the configuration from the camera.
   The configuration can be loaded either via the 3D-Viewer (see 3D-Viewer manual)
   or by copying the calibration files:
   – On the orange USB stick open the folder *3D > CalibrationFiles*.
   – Copy the calibration files *config.ini* and *calibration.ini* on the PC, preferably in the folder where the raw images will be saved.
9. Do the first 3D calculation as described in the *Getting started* chapter of the 3D-Viewer manual.

7 Camera parameters

7.1 Integration time

Function	Sets the minimum integration time (µs) for the camera
Step	0.001
Notes	These are the minimum integration times for the camera. The speed can additionally be throttled by CameraLink parameters.

	Camera	Value CST
Lower limit	CP000470 with 7.3k	47.00 µs
	CP000520 with 7.3k	33.65 µs
Upper limit	CP000470 with 7.3k	12.30 ms
	CP000520 with 7.3k	9.25 ms

For the minimum integration time for different camera types at different output pixel clocks, refer to chapter 7.4.2, p. 84.

7.2 Gain and reference

7.2.1 Target white reference values

Function	Video value for the desired value of the closed loop control for white balancing
Dependency	Only active when the "Enable White Control" option has been set into active mode.
Notes	• Refers to the white control mark. Inside this area the closed loop control tries to adjust gain to reach the desired values. • Internal value is a 14-bit video, GUI values are 10-bit video value, output range of the image at the CameraLink port is usually 8-bit range

	Camera	Value CST
Lower limit	All	0
Upper limit	All	1023 – dark reference value

This parameter refers to **Reference Value (1)** in Fig. 9, p. 27.

ⓘ Maximum reachable target value:

Target value = 1023 – max dark reference value (with active black level correction)

The typical dark reference values are about 4…16 (in 8 bit) in the raw image date.

ⓘ The level of the target value has to be adapted to the position of the white reference control zone (see Fig. 51, p. 81). For zone 1, the values have to be set to a lower value than for zone 2. If the target values for zone 1 are too high, the image center will be saturated.
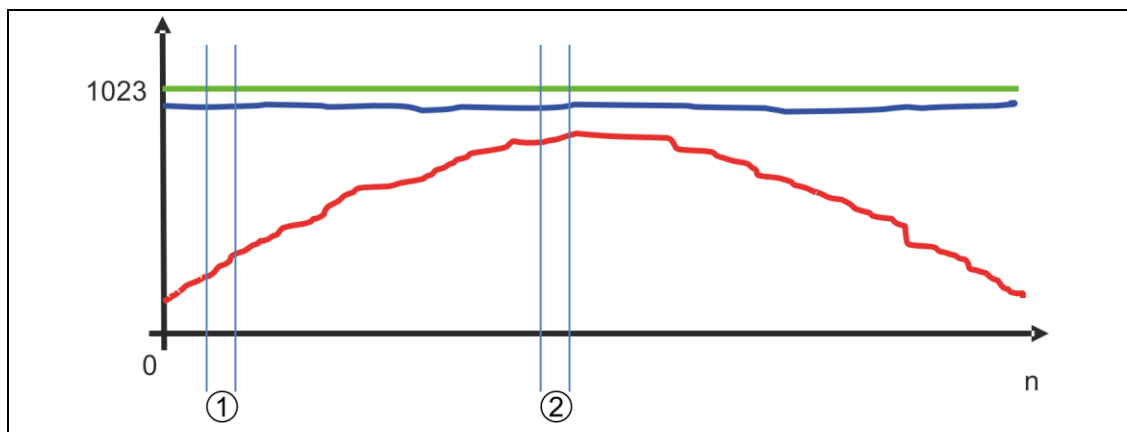
Fig. 51: Raw video values (red), theoretical maximum values (green) and dark reference values (blue) as a function of the number n of pixels (with 10 bit GUI value range)

| 1 | Control zone 1 | | 2 | Control zone 2 |

7.2.2 Analog Coarse Gain

This parameter describes the coarse gain parameter of the camera. Its operation will take place in the first step of analog image processing.

Function	Pre-amplification after CCD and before analog gaining
Channels	Red, Green, Blue Front; Rear
Type	–3 dB; 0 dB; +3 dB; +6 dB Logarithmic
Notes	Use this parameter for a rough adjustment of gaining at the first step.

	Camera	**Value CST**
Lower limit	All	–3 dB
		0 dB
		+3 dB
Upper limit	All	+6 dB

The Analog Coarse Gain is a pre-amplification factor (basically to adapt the output signal of the CCD to the input of the main analog amplifier). The output range of the CCD is higher than the input range of the AFE (analog front end). With this factor, the possible output range can be adjusted. With this "adjustable 2 step amplification", it is possible to adjust the 3DPIXA for a wide range of applications.

Usage

If the current gaining values are higher than about 200, the Analog Coarse Gain amplifier may be used (set to a higher amplification factor) to decrease gain values. Otherwise, the image pixel noise will be increased.

It is recommended to operate the camera with current gaining values in a range from 80…200 for best image quality by using the Analog Coarse Gain function to pre-adjust the actual gain range.

> If the output signal of the CCD is higher than the possible input signal of the AFE, this might cause saturation in the image with gaining values lower than 255. Therefore, Analog Coarse Gain has to be set to –3 dB.

7.2.3 Current camera gain values

This parameter describes the analog gaining parameter of the camera. Its operation will take place in the second step of analog image processing.

With active white control, this parameter refers to **Gain (3)** in Fig. 9, p. 27.

Function	Gaining values for the analog gaining of the camera.
Channels	Red, Green, Blue Odd; Even Front; Rear
Notes	1 step refers to 0.0359 dB, 27.85 steps refer to 1 dB. By increasing up to 168 steps, the signal will be doubled.

	Camera	Value CST
Lower limit	All	0
Upper limit	All	700

7.3   Image sizes

7.3.1   Image start delay

Function	Delay of image start after image trigger in lines. The image trigger can be taken internally or externally.
Channels	All
Type	Integer
Dependency	Only in frame scan mode
Notes	–

	Camera	Value CST
Lower limit	All	0
Upper limit	All	32767

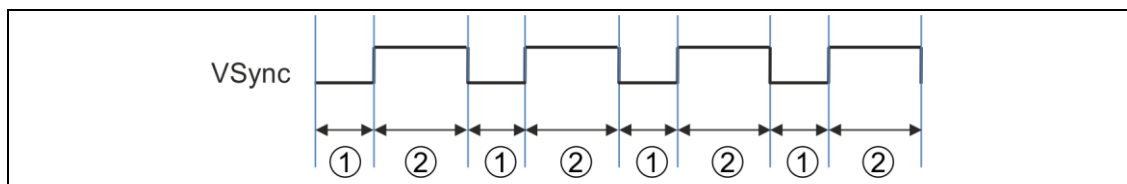*Fig. 52:   Vertical synchronization*

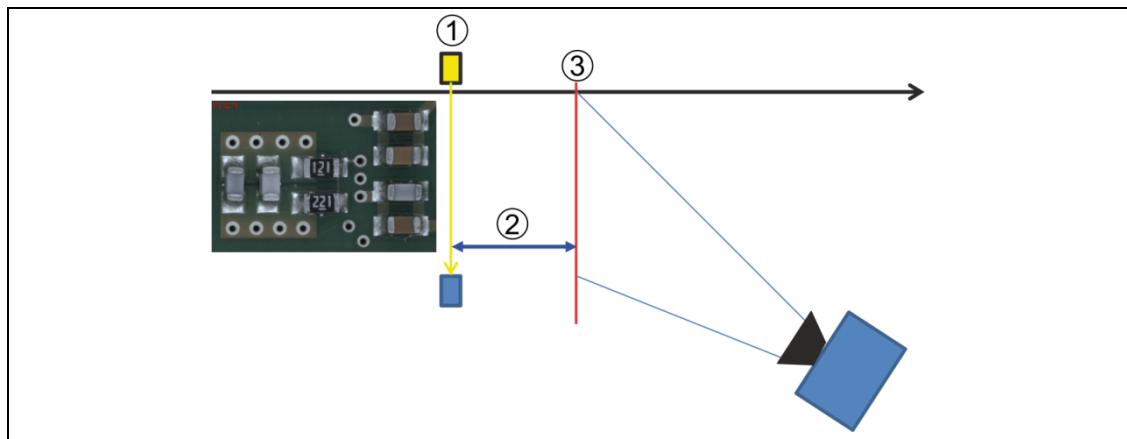1   Image start delay   2   Number of scan lines (image height)

Fig. 53:   Example for using the first valid scan line

1   Light barrier   3   Scanning position
2   Image start delay

7.4 Output format

7.4.1 Video output mode

ℹ️ The video output mode is preset and cannot be changed by the user. On customer's request changes are possible.

7.4.2 CameraLink interface type and minimum line time (integration time)

Function	Sets the output to Base, Medium, Full64 or Full80 mode.
Channels	All
Type	Integer
Dependency	None
Notes	• By using some modes, the line rates and integration time will be limited (see the tables below). • By using some modes, the scan line length must be a multiple of x (see the tables below). • For Base mode, the CameraLink connector 1 has to be used.

For an overview of the CameraLink interface types see chapter 2.6.1, p. 15.

Minimum line time (integration time) for different camera types at different CameraLink modes and frequencies

All output in regard with 16 clocks cycles gap between the CameraLink lines.

3DPIXA classic 7.3k (7300 pixel)		
CL-Definition	Base Mode	Medium Mode
85.00 MHz	86.1 µs	47.0 µs
72.86 MHz	100.4 µs	50.3 µs
63.75 MHz	114.8 µs	57.6 µs

3DPIXA pro 7.3k (7300 pixel)					
CL-Definition	Base Mode	Medium Mode	Full64 Mode	Full80 8Tap_10Bit	Full80 10Tap_8Bit
85.00 MHz	86.07 µs	43.13 µs	33.65 µs	33.65 µs	43.13 µs
75.56 MHz	96.83 µs	48.52 µs	36.44 µs	33.65 µs	48.52 µs
61.82 MHz	118.35 µs	59.30 µs	44.54 µs	35.69 µs	59.30 µs

7.4.3   Insert mode

Function	Enables different camera data displayed in the image (e.g. image counter or line counter).
Notes	The parameter inside the camera will be measured in bytes. In the CST the single bits can be set using the checkboxes.
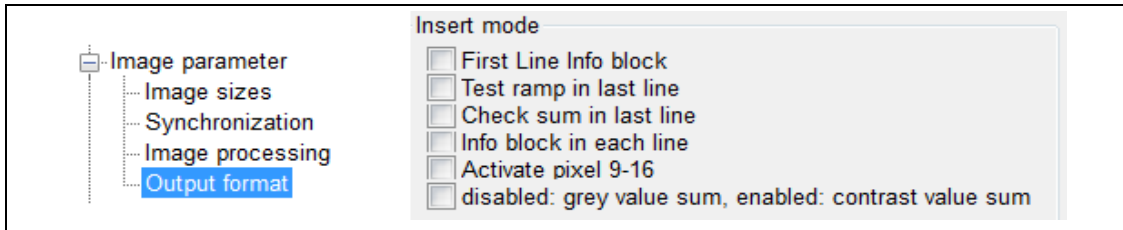
Single information will be displayed in the image as follows:

Information type	Description
First Line Info block	Image-related information is shown in the first 22 pixels of the first line. The image functionality is required.
Info block in each line	Line-related information is shown in the first 10 or 17 pixels of each line, depending on the selections for "Insert Mode".

For detailed information on the each line and last line information refer to the allPIXA(pro) manual.

7.5   Test pattern

In order to be able to check the system setup, it is helpful to generate exactly defined test images inside the camera.
This explicitly helps to check:
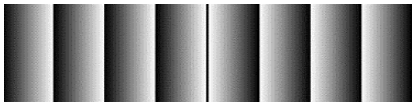
- the frame grabber connection,
- the frame grabber setting,
- the transmission quality over the CameraLink cable.

Function	Enables different test images in the camera.
Notes	The data is generated directly after the analog image processing. It will pass all the digital image processing steps.
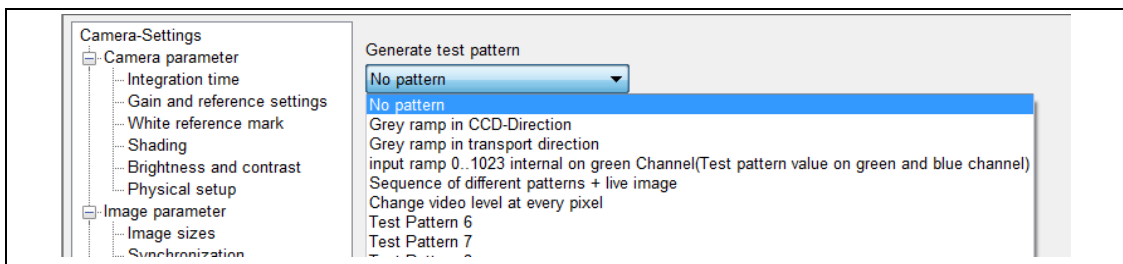
The following different test images are available:

Image	Name
	Test pattern 1: Grey ramp in CCD-Direction
	Test pattern 2: Grey ramp in transport direction **Scan direction:** forward backward
	Test pattern 3: Green ramp with parameter "Test pattern level"
	Test pattern 4: Sequence of different patterns + live image
	Test pattern 5: Change video level at every pixel

7.6 Line trigger and encoder setup (line synchronization)

> In case the camera is used in the "Triggered Frame Scan" with active line trigger or encoder, the linesync (encoder or line trigger) will have to fit some pulses before light barrier input.

7.6.1 Enable encoder

Function	Enables the line trigger or encoder mode in the camera and the main selection between internal and external line trigger.
Notes	For the use of this mode, the external ports have to be connected with the internal function by using the IO-Configurator of CST.
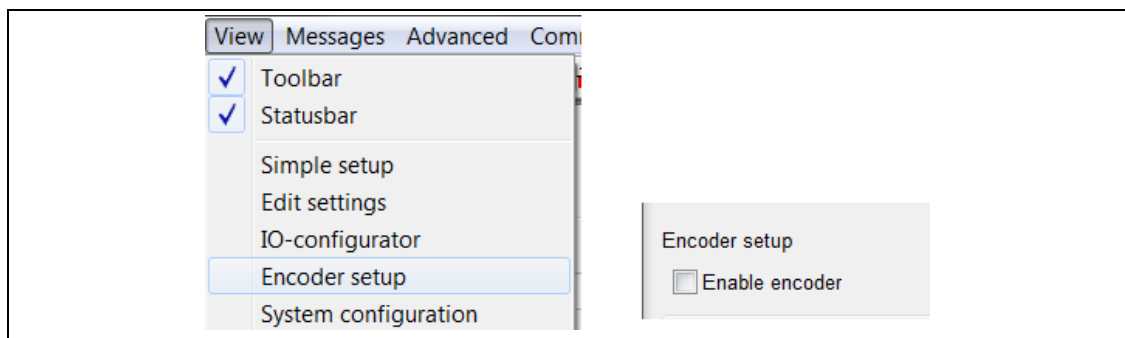
7.6.2 Synchronization mode

Function	Select "Line trigger" or "Encoder mode".
Dependency	Only active with active "Enable Encoder".
Notes	For the use of this mode, the external ports have to be connected to the internal function by using the IO-Configurator of CST.

Line trigger

With the line trigger the camera will send one line per pulse.
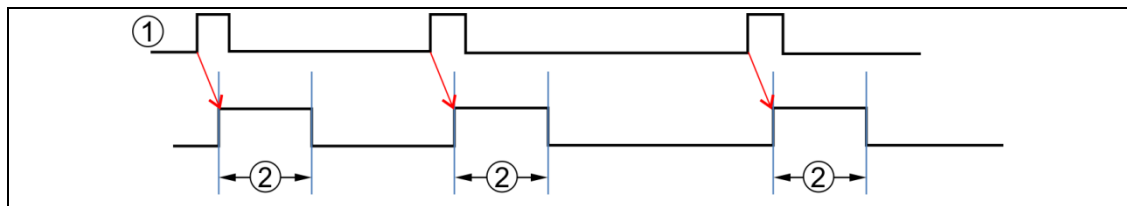
Fig. 54:   Line trigger and camera pulses

1   Line trigger   2   Integration time

Encoder mode

The camera measures the distance of the signals and will send lines with the requested resolution. An internal line trigger will be generated. The user has to set the desired transport and encoder resolution in the CST.
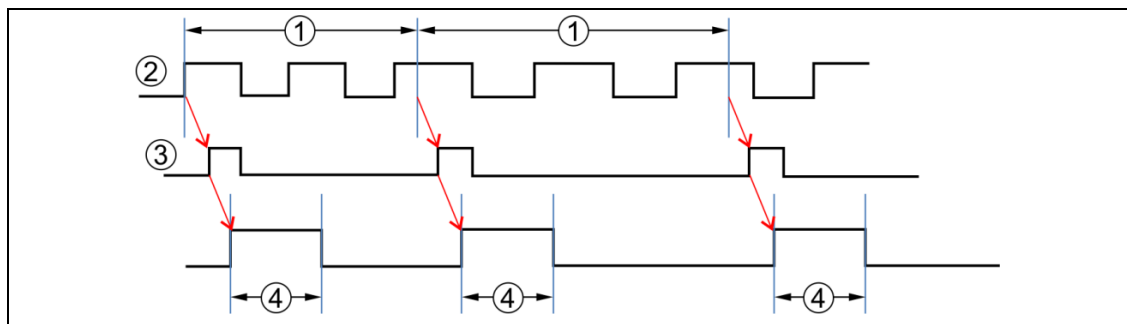
Fig. 55:   Encoder, line trigger and camera pulses

1   Encoder pulses per line trigger (e. g. 2.25)   3   Line trigger
2   Encoder pulses   4   Integration time

Minimum pulse duration:

- CP000520 models: 45 ns
- CP000470 models: 60 ns

Shorter pulses will be ignored.

Minimum speed with encoder mode: $V_{min} = \frac{mm/Encoder\ pulse}{0.59\ s}$

Example for the required minimum speed with encoder mode

Encoder has 12.5 pulses per mm

1 Encoder pulse is 1/12.5 mm = 0.08 mm

➥ V_{min} = 0.08 mm/0.59 s = 0.135 mm/s

7.6.3   Encoder channels

Function	Enables the line trigger or encoder mode in the camera and the main selection between internal and external line trigger.
Dependency	Only active with selected "Encoder mode" at the "Synchronization mode".
Notes	For the use of this mode, the external ports have to be connected to the internal function by using the IO-Configurator of CST.

One-Channel full step (1 edge per step)
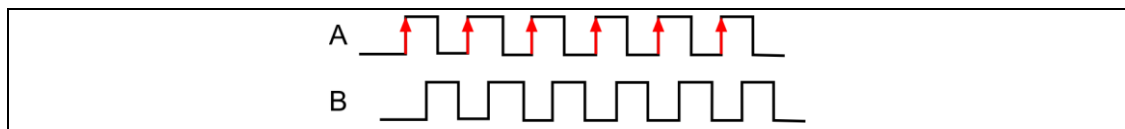
Fig. 56:   One-Channel full step, phase A and phase B

One-Channel encoder (2 edges per step)

Fig. 57:   One-Channel encoder, phase A and phase B

Two-channel encoder (4 edges per step)

Fig. 58:   Two-channel encoder, phase A and phase B

Best results will be reached with encoder mode 0 and without encoder averaging.

This mode will avoid errors due to tolerances in the duty factor of the pulses.

7.6.4 Average size for the encoder

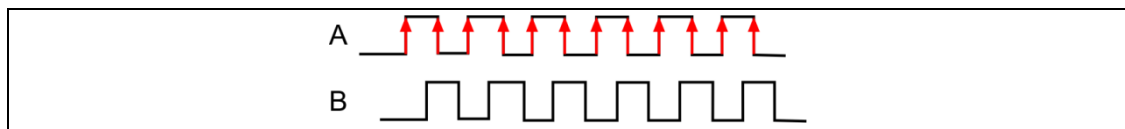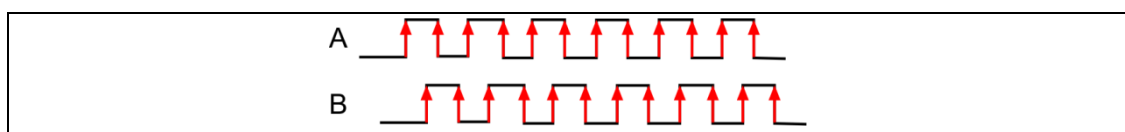|	
Function	Sets the number of increments taken for distance measurement to average the speed measurement
Channels	All
Type	Integer None; 2x; 4x; 8x; 16x
Dependency	Only active with selected "Encoder mode" at "Synchronization mode".
Notes	Best results will be reached with encoder mode 0 and without encoder averaging. This mode will avoid errors due to tolerances in the duty factor of the pulses.

7.6.5 Encoder resolution

Function	Sets the distance the transport might be moved by one increment of the encoder.
Step	0.001
Unit	µm per increment
Dependency	Only active with selected "Encoder mode" at "Synchronization mode".
Notes	Refers to a full increment of the encoder.

> ℹ The value "Encoder pulses per line" is internally calculated by the camera and may not exceed 255. Recommended values are between 0.5 and 255. Values <0.5 will cause a decrease in transport resolution accuracy (see chapter 7.6.6, p. 89).

7.6.6 Vertical image resolution

Function	Defines the desired transport (vertical) resolution for the encoder mode.
Step	0.01
Unit	DPI (dots per inch)
Dependency	Only active with selected "Encoder mode" at "Synchronization mode".
Notes	This parameter is needed for the calculation of internal parameters for the encoder mode.

	Camera	Value CST
Lower limit	All	0
Default	All	4.000 µm (*0.01 dpi)

> ℹ The value "Encoder pulses per line" is internally calculated by the camera and may not exceed 255. Recommended values are between 0.5 and 255. Values <0.5 will cause a decrease in transport resolution accuracy.

The value "Encoder pulses per line" is calculated with the following formula by the given values in the CST:

$$EncoderPulsePerLine = \frac{EncoderChannel \left(\frac{edges}{step}\right) \times 25.4 \left(\frac{mm}{inch}\right) \times 1000}{EncoderResolution \left(\frac{\mu m}{step}\right) \times VerticalImageResolution \left(\frac{dots}{inch}\right)}$$

The CST shows the result.

When using dots per inch (dpi) for the calculation, the following formula used:

$$EncoderPulsesPerLine = FullIncrementResolution \,(dpi) \times \frac{edges/step}{TransportResolution \,(dpi)}$$

The value "Encoder pulses per line" can also be calculated with the following formula:

$$EncoderPulsesPerLine = TransportResolution \left(\frac{\mu m}{pixel}\right) \times \frac{edges/step}{FullIncrementResolution \left(\frac{\mu m}{incr}\right)}$$

> "Vertical image resolution" and "Integration time" have to be suitable to the transport speed. The time for one line (speed divided by resolution) should be longer than the shortest possible integration time. In case of higher speed, the camera will switch to free running line mode.

7.6.7 Line trigger / encoder reduction

Function	Internal pre-counter for the line trigger or encoder signal, will output an internal line trigger after the set value of signals from external line trigger source.
Dependency	Only active with "Enable encoder".

When using the line trigger reduction, the vertical image resolution is reduced:

$$TransportResolution, reduced \,(dpi) = \frac{TransportResolution \,(dpi)}{Line\ trigger\ reduction\ factor}$$

$$TransportResolution, reduced\,(\mu m) = Line\ trigger\ reduction\ factor \times TransportResolution(\mu m)$$

8 Maintenance

8.1 Cleaning the camera

During operation of the camera, particles such as dust may be settled on the optical components (lens) of the camera. These deposits negatively affect the optical image and the function of the camera.

Cleaning intervals

The cleaning intervals depend on the environmental conditions. Regular inspection and cleaning intervals must be specified depending on the degree of soiling.

⚠ **CAUTION! Hot camera surfaces!**

The camera body heats up during operation. Touching the camera surface may cause burns.
  ▷ Switch off the camera and let the surfaces cool down to room temperature.

NOTICE! Damage by unsuitable cleaning agents!

  ▷ Do not use other liquid or cleaning agent than those stated in this manual.
  ▷ Never use hard or sharp tools for cleaning the camera.

Cleaning process

1. Wipe all surfaces requiring cleaning with a soft, lint-free cloth which may be moistened with Isopropanol.
2. Inspect the camera and make sure that the cleaning was effective. Repeat the cleaning, if necessary.
↪ If the contamination of a component cannot be removed by cleaning, it must be replaced.

9 Troubleshooting and support

9.1 Before contacting the Chromasens technical support

If you have a problem with the camera and decide to contact the Chromasens technical support, it is very important that you collect all relevant system information before.
This might guarantee a quick and efficient problem solving process together with the Chromasens technical support.
To collect the most important information of your issue, you can download the 3DPIXA support sheet from our website at

https://www.chromasens.de/en/distribution/support

  ▶ Fill out the form and provide the information including the requested files before you contact Chromasens technical support.

9.2 Return delivery (RMA number)

▶ Before returning material to Chromasens, request a RMA number (Return Material Authorization) from the Chromasens support:

Chromasens GmbH
Max-Stromeyer-Str. 116
78467 Konstanz
Germany

Phone:	+49 (0) 7531 / 876-0
Fax:	+49 (0) 7531 / 876-303
Email:	info@chromasens.de
Internet:	www.chromasens.de

This RMA number has to be stated in all of your delivery documents when material is returned to Chromasens. Returned material without RMA number might not be processed in time. Chromasens also reserves the right to reject material without RMA number.

9.3 Identifying the camera status

The camera status LED indicates the actual status of the camera. After booting is finished, the camera continuously performs self-checks. If an error is detected, the camera will indicate this by changing the LED color.

LED color	Meaning
Off	No power is present at the camera or the input voltage is out of the limits (see chapter 2.3, p. 11 for power rating and chapter 10.2.2, p. 96 for pin layout).
Green	The camera has power and is ok (FVAL inactive).
Red	The camera is in error state. You may check the detailed camera status using the CST.
Blue	The camera is ok and delivers image data (FVAL active).
Alternating green/blue	The camera is ok and delivers frequently image data based on a trigger signal.
Sequence of long green, short orange, green	This is the normal power up sequence. After this sequence, the camera will continue operation according to the definitions which have been made in setting 1.

Tab. 23: Meaning of the LED colors

9.4   Camera overheating protection

For safety reasons, the camera is equipped with an internal 3-step overheating protection.

Step 1: High temperature warning

The internal temperature of the camera exceeds the defined limits. This is indicated as follows:

- The status LED of the camera turns red.
- The camera returns the error state 0x3d or 0x3e.

▶ Let the camera cool down and check the environment.
▶ Improve the cooling of the camera, if necessary.

Step 2: Warning level 2

If the temperature is still increasing, the camera automatically turns into safety mode to protect the camera electronic from overheating. This status is indicated as follows:

- The status LED of the camera turns red.
- The camera returns the error state 0x40.
- The camera delivers the following image:

Fig. 59:   Image from the camera in safety mode

Step 3: Final safety shutdown

When the temperature is still exceeding the critical internal temperature, the camera hardware is shut down to protect and prevent damage to the camera. This status is indicated as follows:

- The camera does not send images any more.
- The status LED of the camera turns red.
- The camera returns the error state 0x40.

Bringing the camera back to normal operation

▶ Let the camera cool down.
▶ Check the environment and improve the cooling of the camera, if necessary.
▶ Restart the camera (power off/on).

9.5   Internal image storage of the camera

The hardware in the Chromasens 3DPIXA camera has an image flash memory. Thus, each of the cameras has a data storage function.
For access to the internal data memory, follow the instructions in the corresponding application note or follow the link to our homepage.
CP000470 models   https://www.chromasens.de/allpixa-downloads
CP000520 models   https://www.chromasens.de/allpixa-pro-downloads

10 Appendix

10.1 EC declaration of conformity

EC Declaration of Conformity

The manufacturer: **Chromasens GmbH**
Max-Stromeyer-Str. 116
D-78467 Konstanz
Germany

declares, that the following device and all corresponding variations

Device name:	3D PIXA
Product number:	CP000470

were developed in accordance to the Directive 2004/108/EC electromagnetic compatibility and corresponding to the following standards:

IEC 61000-6-2:2005:   Immunity for industrial environments
IEC 61000-6-4:2007:   Emission standard for industrial environments
FCC: Class B

The devices are linescan cameras, which are used for optical scanning. The nominal supply voltage is 24V and the integration of the devices into higher-level systems is documented.

The product specification and documentation is provided in the original versions.

The declaration of conformity becomes invalid if changes are made on the devices, or the use is not in accordance with the documentation.

2015/02/25 Konstanz

_____   _____   _____
date / location   signature CEO   signature Head of projekt
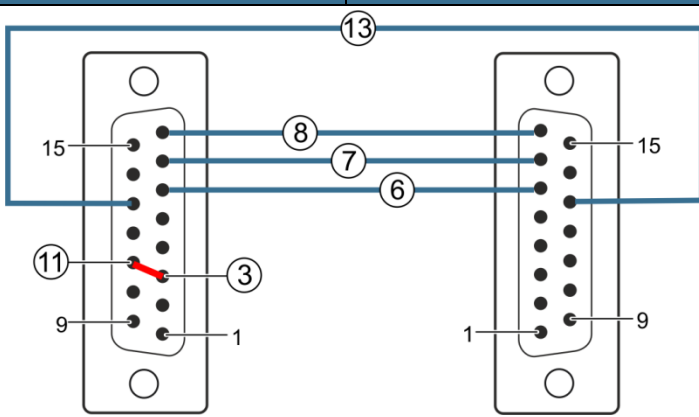
10.2 Connectors, cables and pin assignment

10.2.1 Master/Slave synchronization cable

NOTICE! Damage to the camera by wrong pin assignment!

> ▷ Make sure that the pins of the master/slave synchronization cable are assigned as described below.

The master/slave synchronization cable has to be equipped with 15-pin D-Sub connectors (male) at both ends.

Pin	Master I/O	Slave I/O
1	Incremental encoder (high, optional)	Open
2	Light barrier (high, optional)	Open
3	**nSelMaster (bridge to 0 V)**	Open, internal pull-up
4	–	–
5	Open	Open
6	**Master/Slave interface**	**Master/Slave interface**
7	**0 V**	**0 V**
8	**Master/Slave interface**	**Master/Slave interface**
9	Incremental encoder (low, optional)	Open
10	Light barrier (low, optional)	Open
11	**0 V (bridge to nSelMaster)**	–
12	–	–
13	0 V	0 V
14	–	–
15	Open	Open

Tab. 24: Pin assignment of the master/slave synchronization cable

> ℹ If pins 6 and 8 are already used for other applications, pin 4 and 12 can be used for the Master/Slave interface. As an alternative to pin 7, pin 13 can be used for the ground signal (0 V).

10.2.2 Power supply (PWR)

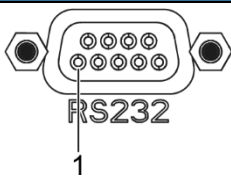The following connector is required for the power supply cable:

Manufacturer: Hirose

Article number: HR10A-7P-6S "female" (male connector is located on the camera)

	Pin	Description
	1	Power +24 V
	2	Power +24 V
	3	Not connected
	4	Not connected
	5	Ground
	6	Ground

Tab. 25: Pin assignment of the power supply connector

10.2.3 Config UART (serial RS232)

Serial connection to the PC can be established by using a 9-pin D-Sub connector (male) via the serial RS232 interface (V24).

	Pin	Name	Description (female)
	1	–	Not connected
	2	TxD	Transmit data
	3	RxD	Receive data
	4	–	Used for internal function, do not connect
	5	GND	Ground
	6	–	Not connected
	7	CST	Hardware Reset Input (should be left open if unused)
	8	–	Not connected
	9	–	Not connected

Tab. 26: Pin assignment of the RS232 connector
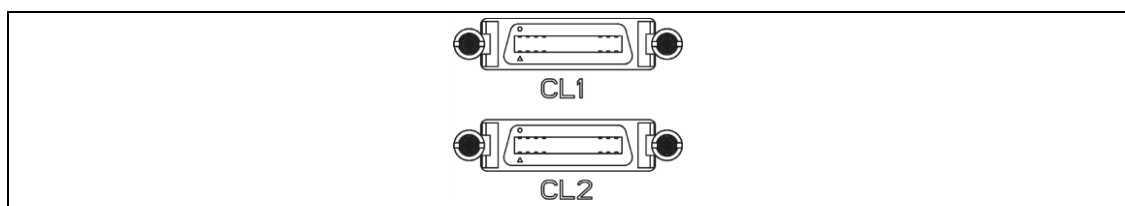
10.2.4 Video CameraLink ports 1 and 2

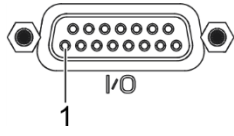*Fig. 60:   Video CameraLink ports 1 and 2*

CameraLink cables are ready-for-use supplied in different lengths varying from 1 m to 10 m. For connection to the camera, a 26-pin MDR mini-D ribbon (male) connector is required.

For long cable lengths (>6 m), high quality cables are recommended. Alternatively, the CameraLink transmission speed can be reduced using CST (see chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**, p. **Fehler! Textmarke nicht definiert.**). The setup of the frame grabber, the cable and the camera must be tested in advance to guarantee the required functionality.

10.2.5 Digital IO-port

The connection to the digital I/O interface (x5) of the 3DPIXA camera is established with a 15-pin D-Sub connector (male). Other functions are selectable at the IO-configurator in the CST.

	Pin	Level	Name	Default connection
I/O 1	1	RS422	GPIO_P0 (input)	Incremental encoder (high)
	2	RS422	GPIO_P1 (input)	Light barrier (high)
	3	LVCMOS	GPIO_P4	With CP000470 dual cameras this pin is used for the Master/Slave definition (bridge to pin 11, see chapter 10.2.1, p. 95). With other cameras this pin can be used for light barriers: • CP000470 models: $V_{in,\,max} = 3.6$ V • CP000520 models: $V_{in,\,max} = 5.0$ V
	4	LVCMOS	GPIO_P2	Reserved for customized applications
	5	3.3 V over 100 Ohm	Power	Output
	6	LVCMOS	GPIO_P3	Master/Slave interface
	7	0 V	Ground	–
	8	LVCMOS	GPIO_N4	Master/Slave interface
	9	RS422	GPIO_N0	Incremental encoder (low)
	10	RS422	GPIO_N1	Light barrier (low)
	11	0 V	Ground	–
	12	LVCMOS	GPIO_N2	Reserved for customized applications
	13	0 V	Ground	–
	14	LVCMOS	GPIO_N3	Reserved for customized applications
	15	5 V over 100 Ohm	Power supply	Output

Tab. 27: Pin assignment of the I/O connector

Power supply: With 100 Ohm series resistor
RS422:   RS422 standard
LVCMOS: With 10 Ohm series resistor

LVCMOS and RS422 levels

	V_{IL}		V_{IH}		V_{OL}	V_{OH}
I/O standard	V_{min}	V_{max}	V_{min}	V_{max}	V_{max}	V_{min}
LVCMOS	–0.5	0.7	1.7	3.6	0.4	2.1
RS422	–6.0	0.8	2.0	6.0	–	–

Tab. 28: LVCMOS and RS422 levels

> ℹ Maximum input level of the LVCMOS is 3.6 V (except pin 3 of CP000520 models with max. 5.0 V).
>
> Use a level converter, if necessary (e.g. 74 LVC14).
>
> Non-compliance can result in irreparable damages to the camera.

10.3   Glossary

Term	Explanation
Black (offset) level correction	Removes the dark offset from each pixel.
Disparity	Difference between the pixel position in the left and the right image, caused by projecting one object point through 2 different objectives.
Dongle	USB stick used for software copy protection.
RGB line distance	The tri-linear sensor has individual pixel lines for red, green and blue. Inside the camera the spatial differences of the pixel lines are corrected.
Shading (flat field) correction	Corrects the brightness inhomogeneity resulting from lens, illumination and non-uniformity of sensor pixels.
White balancing	Ensures that a reference white is kept stable in an image with color temperature or brightness changes in the illumination. This can be done in a one-time single setup process or continuously.
White reference	The white reference is a physical patch in the field of view of the camera that can be used for a camera-internal white balancing.

Tab. 29: Technical terms and definitions

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Max-Stromeyer-Straße 116
78467 Konstanz
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