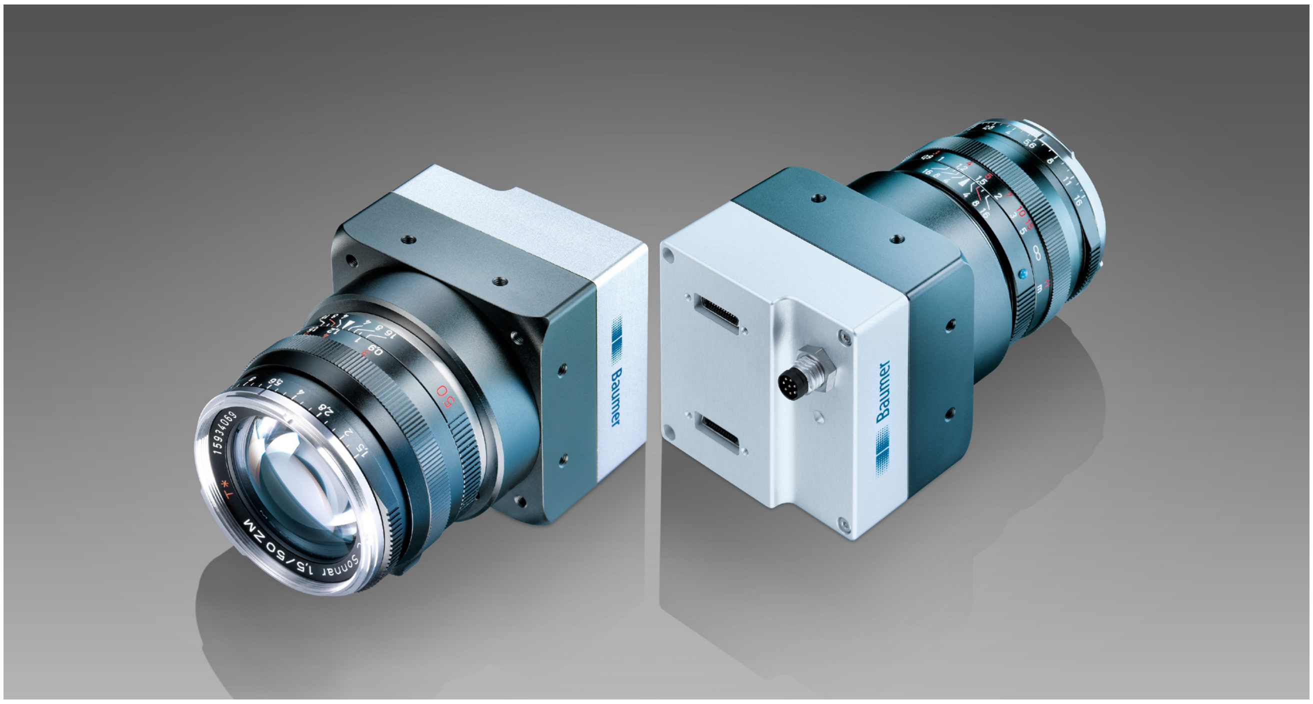


User´s Guide

LXC cameras (Camera Link®)

Document Version: v2.0
Release: 31.08.20
Document Number: 11160995

Table of Contents

1. General Information

Thanks for purchasing a camera of the Baumer family. This User´s Guide describes how to connect, set up and use the camera.

Read this manual carefully and observe the notes and safety instructions!

Target group for this User´s Guide

This User's Guide is aimed at experienced users, which want to integrate camera(s) into a vision system.

Copyright

Classification of the safety instructions

In the User´s Guide, the safety instructions are classified as follows:

Notice
Gives helpful notes on operation or other general recommendations.

	Caution
Pictogram	Indicates a possibly dangerous situation. If the situation is not avoided,slight or minor injury could result or the device may be damaged.

2. General safety instructions

Observe the the following safety instruction when using the camera to avoid any damage or injuries.

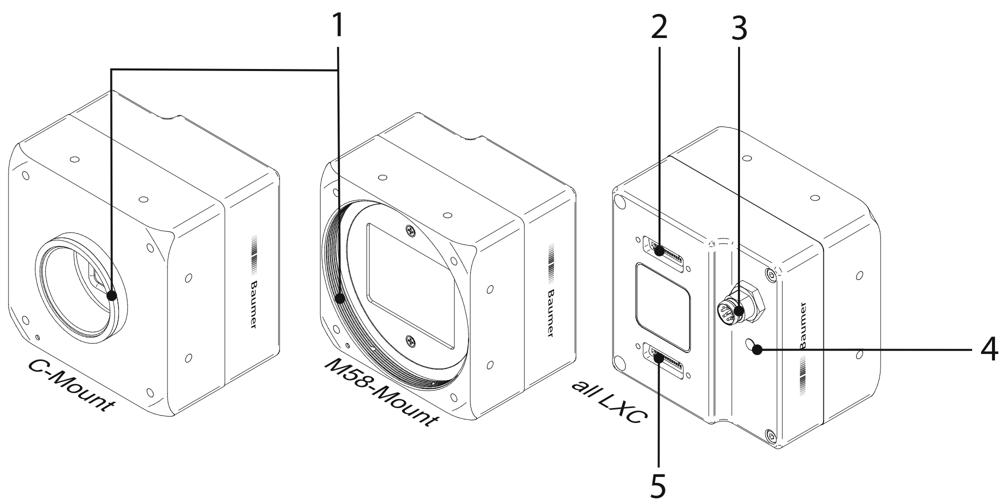
⚠	Caution
🌡	Provide adequate dissipation of heat, to ensure that the temperature does not exceed +50 °C (+122 °F). The surface of the camera may be hot during operation and immediately after use. Be careful when handling the camera and avoid contact over a longer period.

3. Intended Use

The camera is used to capture images that can be transferred over Camera Link® interfaces to a PC.

Notice
Use the camera only for its intended purpose! For any use that is not described in the technical documentation poses dangers and will void the warranty. The risk has to be borne solely by the unit´s owner.

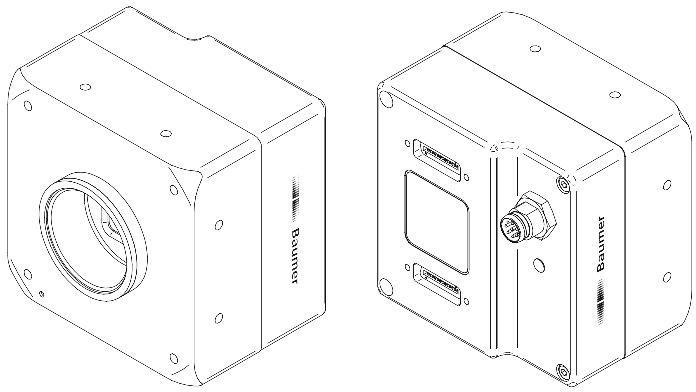
4. General Description



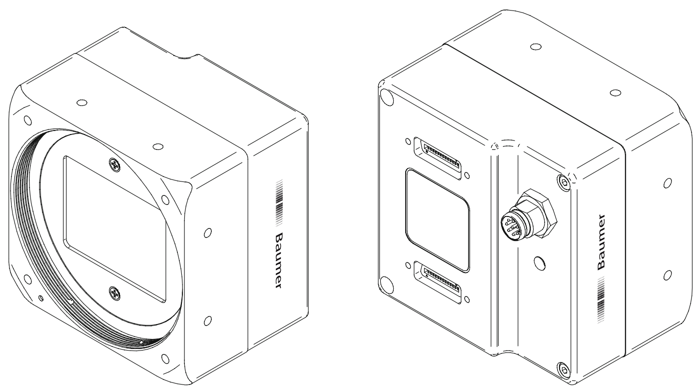
No.	Description	No.	Description
1	**LXC-20 / 40** C-mount only **LXC-120 / 200 / 250 / 500** lens mount (M58), adapter for other lens mounts available	4	Signaling LED
2	Camera Link® socket (Base)	5	Camera Link® socket (Medium / Full / EightyBit)
3	Power Suppy / Digital-IO		

5. Camera Models

5.1 LXC – Camera



LXC-20M / C
LXC-40M / C

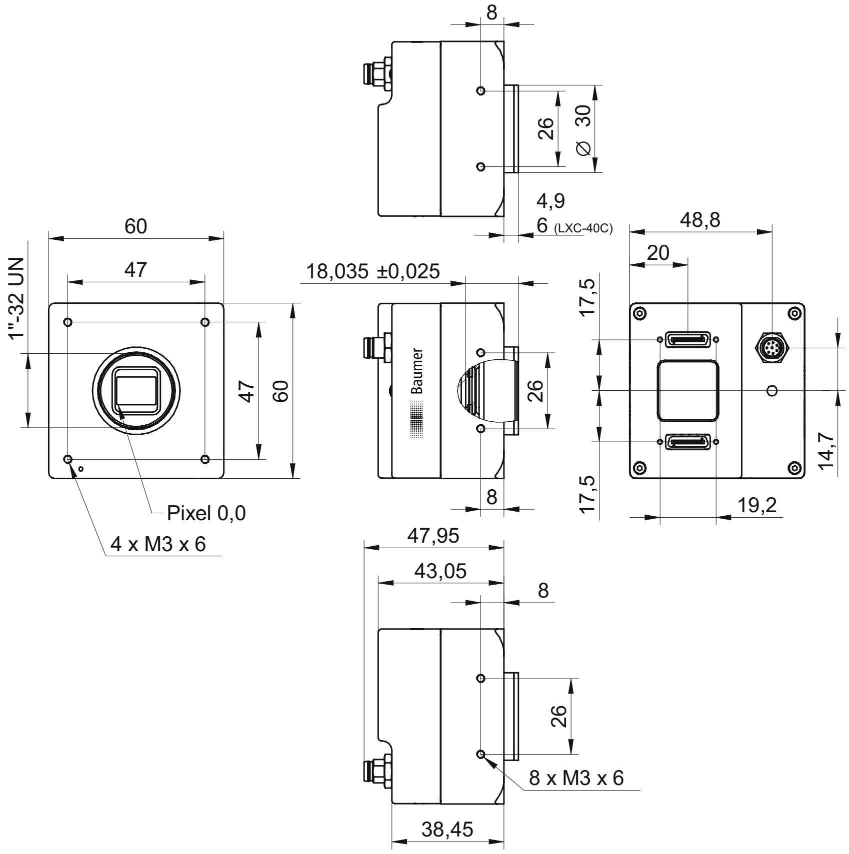


LXC-120M / C
LXC-200M / C
LXC-250M / C
LXC-500M / C

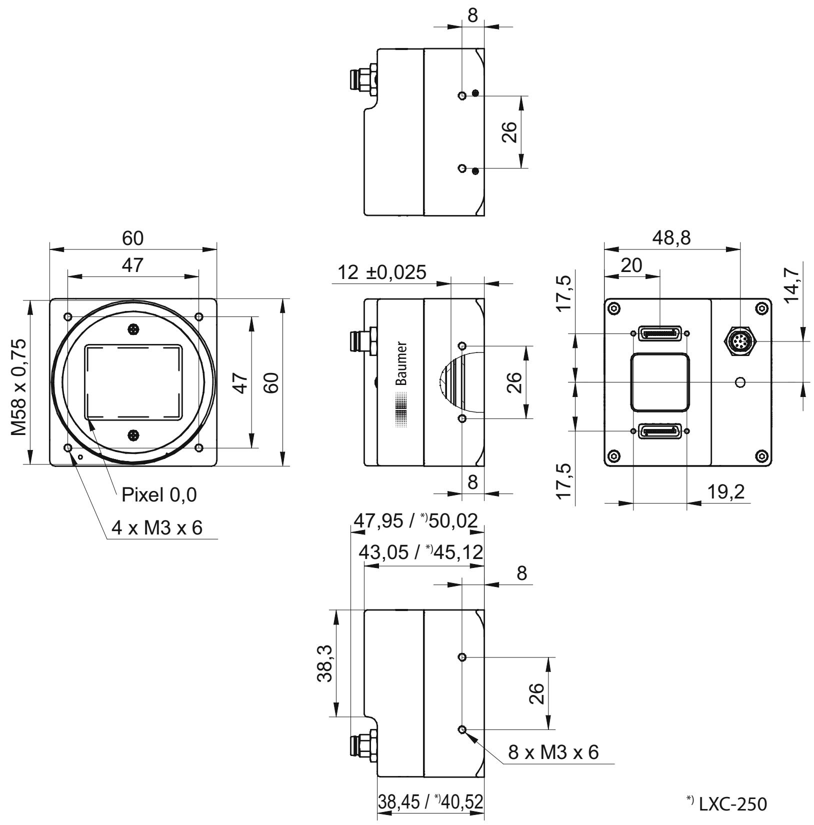
Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
Monochrome / Color			
LXC-20M / C	2/3"	2048 × 1088	337
LXC-40M / C	1"	2048 × 2048	180
LXC-120M / C	APS-C	4096 × 3072	63
LXC-200M / C	35 mm	5120 × 3840	32
LXC-250M / C	APS-H	5120 × 5120	32
LXC-500M / C	35 mm	7920 x 6004	15

5.2 Dimensions

LXC-20, LXC-40



LXC-120, LXC-200, LXC-250, LXC-500

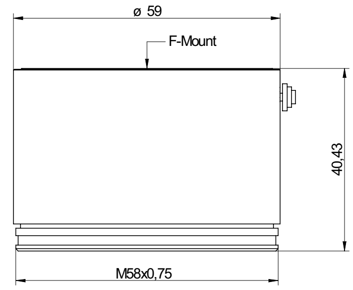


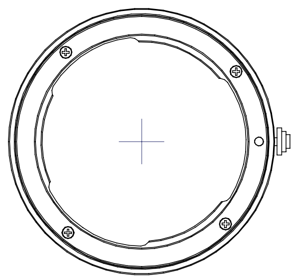
◄ **Figure 1**
Dimensions of the Baumer LXC cameras

5.3 Lens Mount Adapter

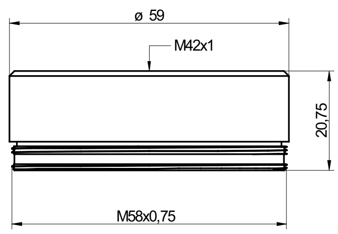
Notice
LXC-20 and LXC-40 have a C-Mount interface only.

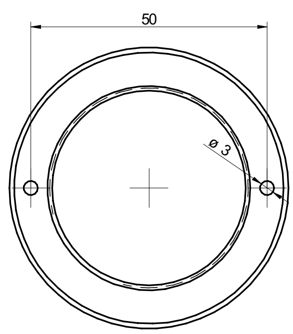
Adapter M58 / F-mount
(Art. No.: 11117852)





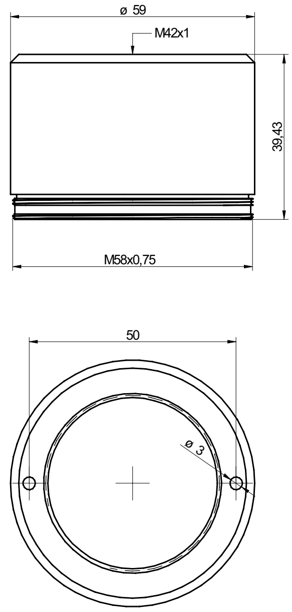
Adapter M58 / M42x1-mount (26.8mm)
(Art. No.: 11127232)





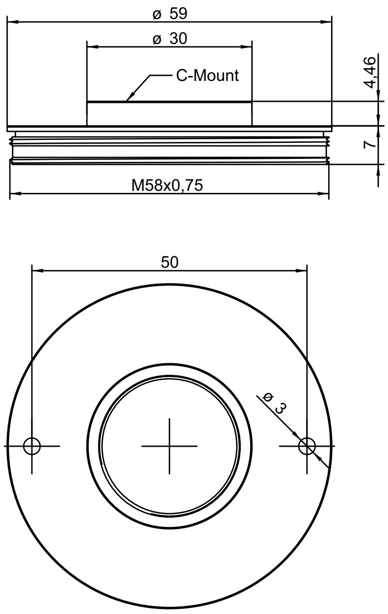
Notice
flange focal distance: 27 mm, ±0,25 mm
suitable for Zeiss M42 lenses (e.g. Biogon T* 2.8/21 Z-M42-I, Biogon T* 2/35 Z-M42-I, C Sonnar T* 1.5/50 Z-M42-I)

Adapter M58 / M42x1-mount (45.5 mm)
(Art. No: 11137781)

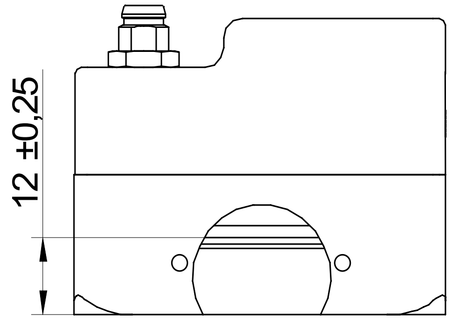


Notice
suitable for Zeiss (e.g. Distagon T* 2/25 Z-M42-I, Planar T* 1.4/50 Z-M42-I, Makro-Planar T* 2/50 Z-M42-I) and KOWA M42 lenses (e.g. LM28LF P-Mount, LM35LF P-Mount)

Adapter M58 / C-mount
(Art. No: 11115198)



5.4 Flange Focal Distance



6. Installation

Lens mounting

Notice
Avoid contamination of the sensor and the lens by dust and airborne particles when mounting the support or the lens to the device! Therefore the following points are very important: ▪ Install the camera in an environment that is as dust free as possible! ▪ Keep the dust cover (foil) on camera as long as possible! ▪ Hold the print with the sensor downwards with unprotected sensor. ▪ Avoid contact with any optical surface of the camera!

6.1 Environmental Requirements

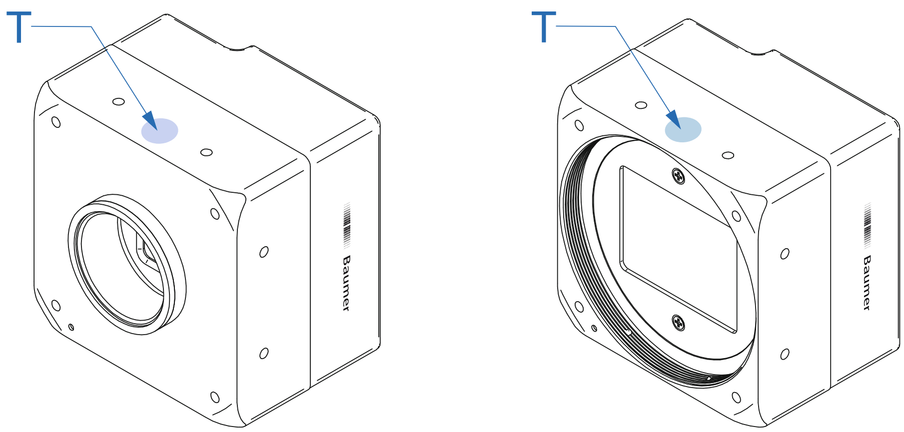
Temperature	
Storage temperature	-10 °C ... +70 °C (+14 °F ... +158 °F)
Operating temperature*	see Heat Transmission

* If the environmental temperature exceeds the values listed in the table below, the camera must be cooled. (see Heat Transmission)

Humidity	
Storage and Operating Humidity	10 % ... 90 % Non-condensing

6.2 Heat Transmission

⚠	Caution
🌡	Provide adequate dissipation of heat, to ensure that the temperature does not exceed +50 °C (+122 °F) at temperature measurment point T. The surface of the camera may be hot during operation and immediately after use. Be careful when handling the camera and avoid contact over a longer period. As there are numerous possibilities for installation, Baumer do not specifiy a specific method for proper heat dissipation, but suggest the following principles: ▪ operate the cameras only in mounted condition ▪ mounting in combination with forced convection may provide proper heat dissipation



◄ **Figure 2**
Temperature measurement points of Baumer LXC cameras

Measure Point	Maximal Temperature
T	50°C (122°F)

For remote temperature monitoring of the camera a temperature sensor is integrated.

Notice
The temperature sensor is able to deliver values of 0°C (32°F) to +85°C (185°F) Take care that the temperature of the camera does not exceed the specified case temperature +50°C (+122°F).

6.2.1 Emergency shutdown at Overtemperature

Notice
Feature only available on the LXC-250, LXC-500.

To prevent damage on the hardware due to high temperatures, the camera is equipped with an emergency shutdown. The *DeviceTemperatureStatusTransitionSelector* feature allows you to select different thresholds for temperatures:

NormalToHigh: freely programmable value

HighToExeeded: fixed value (camera shutdown if exceeded)

ExeededToNormal: freely programmable value, temperature for error-free re-ac tivation of the camera.

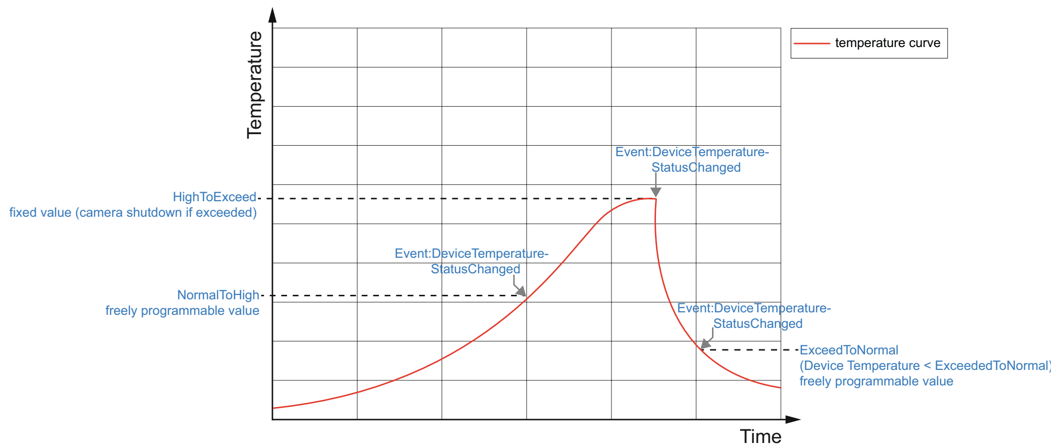
In the *DeviceTemperatureStatusTransition* feature, the temperatures for the programmable temperature transitions are set.

The *Event EventDeviceTemperatureStatusChanged* is always generated when *DeviceTemperatureStatus* changes.

If the temperature rises above the value set at *HighToExeeded*, the *DeviceTemperatureExceeded* feature is set to *True*, the image recording is stopped, and the LED is set to red.

For further use, the camera must disconnected from the power supply after cooling down or a device reset should be carried out.

The sufficient coolingis recognizable when the event *EvenDeviceTemperatureStatusChanged* (Device Temperature < *ExceededToNormal*) is output.



6.3 Mechanical Tests

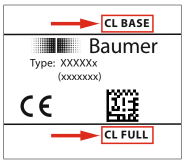
Tested with C-Mount adapter adapter and lens dummy.

Environmental Testing	Standard	Parameter	
Vibration, sinussodial	IEC 60068-2-6	Search for Resonance	10-2000 Hz
		Amplitude underneath cross-over frequencies	0,75 mm
		Acceleration	1 g
		Test duration	15 min (axis) 45 min (total)
Vibration, broad band	IEC 60068-2-64	Frequency range	10-1000 Hz
		Acceleration	10 g
		Test duration	300 min (axis) 15 h (total)
Shock	IEC 60068-2-27	Puls time	11 ms / 6 ms
		Acceleration	50 g / 100 g
Bump	IEC60068-2-29	Pulse Time	2 ms
		Acceleration	100 g

7. Process- and Data Interface

7.1 Pin-Assignment Interface

Notice



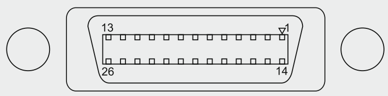
The camera has two Camera Link® sockets. To differentiate between Camera Link® socket, please look at the label.

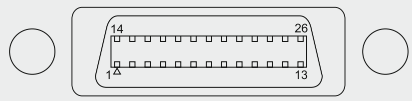
You can not use the Camera Link® (Medium / Full / EightyBit) socket alone!

Notice

To use Power over Camera Link® (PoCL, 12V DC ± 20%), both Camera Link® sockets must be used.

Camera Link® (Base)				Camera Link® (Medium / Full / EightyBit)			
Pin	**Signal**	**Pin**	**Signal**	**Pin**	**Signal**	**Pin**	**Signal**
1	GND	**14**	GND	**1**	GND	**14**	GND
2	X0-	**15**	X0+	**2**	Y0-	**15**	Y0+
3	X1-	**16**	X1+	**3**	Y1-	**16**	Y1+
4	X2-	**17**	X2+	**4**	Y2-	**17**	Y2+
5	XCLK-	**18**	XCLK+	**5**	YCLK-	**18**	YCLK+
6	X3-	**19**	X3+	**6**	Y3-	**19**	Y3+
7	SERTC+	**20**	SERTC-	**7**	100 Ω term.	**20**	100 Ω term.
8	SERTFG-	**21**	SERTFG+	**8**	Z0-	**21**	Z0+
9	CC1-	**22**	CC1+	**9**	Z1-	**22**	Z1+
10	CC2+	**23**	CC2-	**10**	Z2-	**23**	Z2+
11	CC3-	**24**	CC3+	**11**	ZCLK-	**24**	ZCLK+
12	CC4+	**25**	CC4-	**12**	Z3-	**25**	Z3+
13	GND	**26**	GND	**13**	GND	**26**	GND

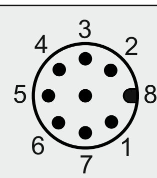




7.2 Pin-Assignment Power Supply and Digital-IOs

Power Supply / Digital-IOs

M8 / 8 pins (SACC-DSI-M8MS-8CON-M8-L180 SH)



1	(white)	not in use
2	(brown)	Power VCC +
3	(green)	IN 1 (line 0)
4	(yellow)	IO GND
5	(grey)	IO Power VCC
6	(pink)	OUT 1 (line 1)
7	(blue)	Power GND
8	(red)	not in use

Connecting cable (ordered separately):

5.0 m: (Art. No.: 11118810)
10.0 m: (Art. No.: 11138385)

Power Supply	
Power VCC	12 VDC ... 24 VDC

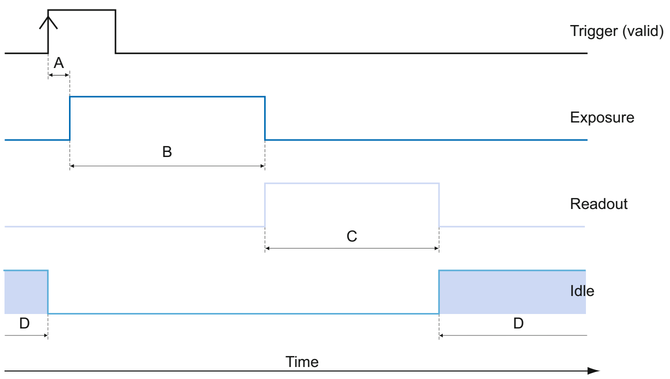
7.3 Power saving Mechanisms

The camera is equipped with various power saving mechanisms to reduce the power consumption and to prevent excessive heating.

1. Set the sensor into idle state (LXC 250 only)

If no frame is requested for a specific time (idle time), the sensor is set into idle state. This reduces the power consumption of the camera.

The sensor is not set into idle state:
- in Sequencer Mode
- in Burst Mode
- at set Acquisition Frame Rate

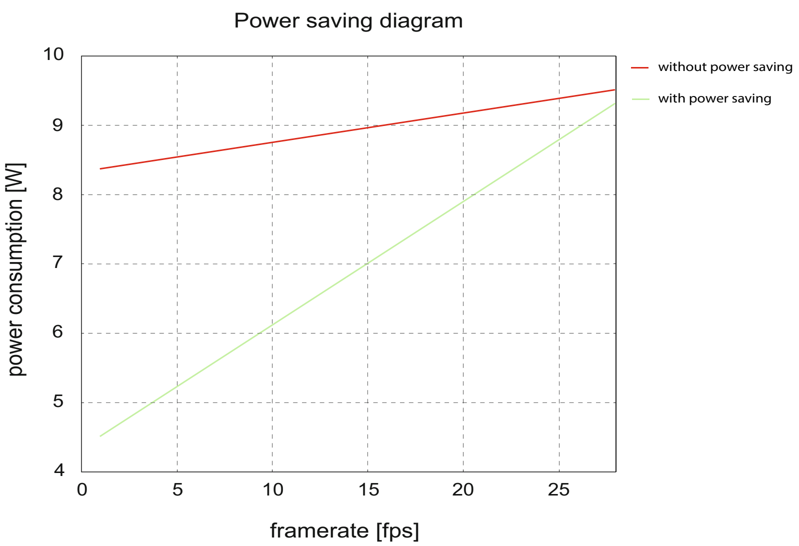


A - Trigger delay
B - Exposure time
C - Readout time
D - Idle time

2. Dynamic adjustment of the framerate (all models)

The frame rate is dynamically adjusted to the current situation. This means that only so many frames are recorded, as can be transferred via the interface with the current settings (e.g. resolution, binning and pixel format).

This dynamic adjustment only works when the feature *Acquisition Frame Rate* is deactivated, so the camera takes pictures at FreeRunning Mode.



Notice
The diagram applies for a low exposure time. As the exposure time increases, the power consumption of the camera increases even with small framerate.

7.4 LED Signaling

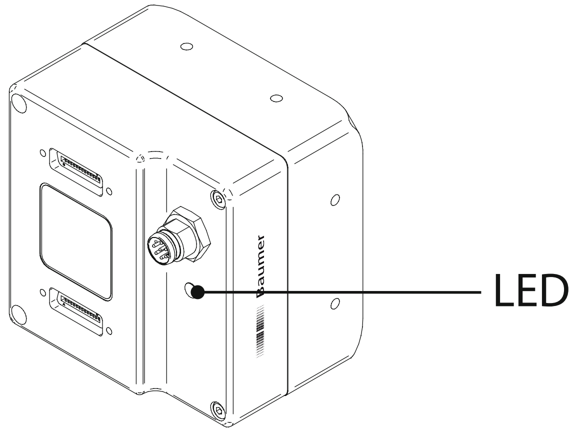


Figure 3 ► LED position

	Signal	Meaning
LED	green on	Power on, link good
	green blinking	Power on, no link
	red on	Error / Overtemperature
	red blinking	Boot process or Warning (update in progress, don't switch off)
	yellow	Readout active

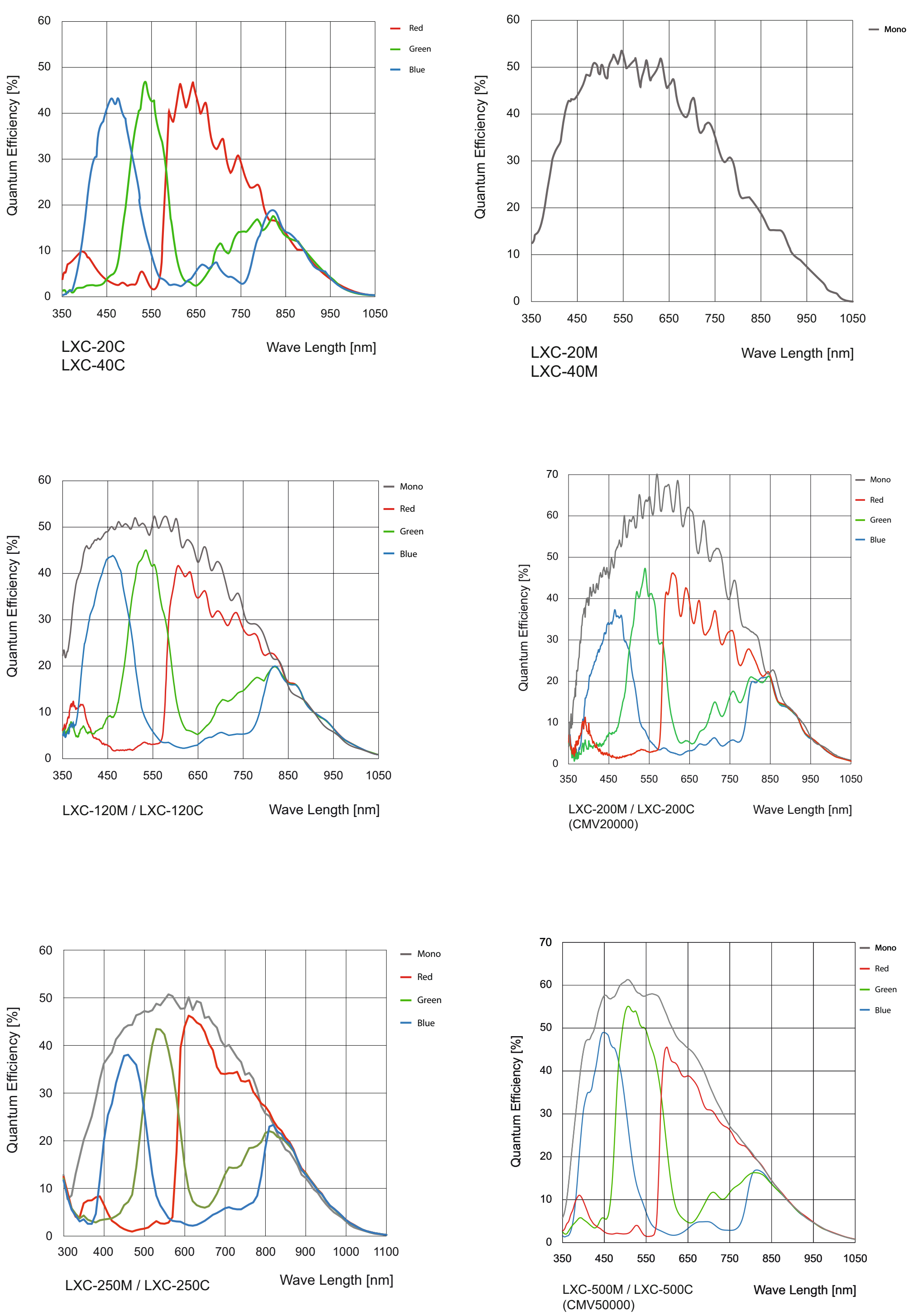
8. Product Specifications

8.1 Sensor Specifications

8.1.1 Quantum Efficiency of Baumer LXC Cameras

The quantum efficiency characteristics of monochrome and color matrix sensors for Baumer LXC cameras are displayed in the following graphs. The characteristic curves for the sensors do not take the characteristics of lenses and light sources without filters into consideration, but are measured with an AR coated cover glass.

Values relating to the respective technical data sheets of the sensors manufacturer.



◄ **Figure 4**
Quantum efficiency

8.1.2 Shutter

All cameras of the LXC series are equipped with a global shutter.

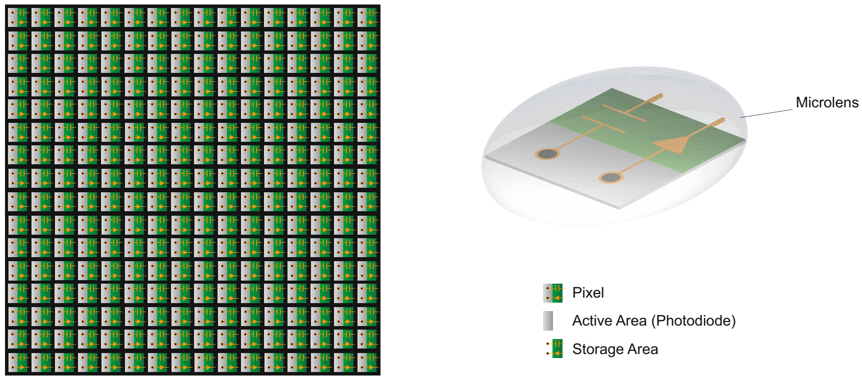


Figure 5 ▶
Structure of an imaging sensor with global shutter

Global shutter means that all pixels of the sensor are reset and afterwards exposed for a specified interval ($t_{exposure}$).

For each pixel an adjacent storage circuit exists. Once the exposure time elapsed, the information of a pixel is transferred immediately to its circuit and read out from there.

Due to the fact that photosensitive area gets "lost" by the implementation of the circuit area, the pixels are equipped with microlenses, which focus the light on the pixel.

8.1.3 Digitization Taps

The CMOSIS sensors, employed in Baumer LXC cameras are read out with 16 channels in parallel.

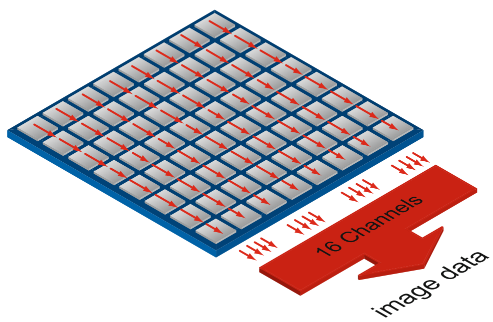
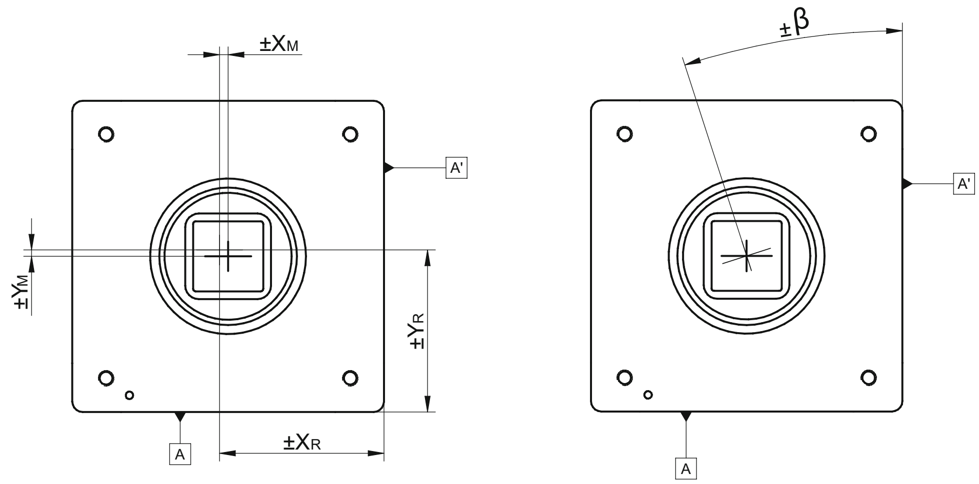


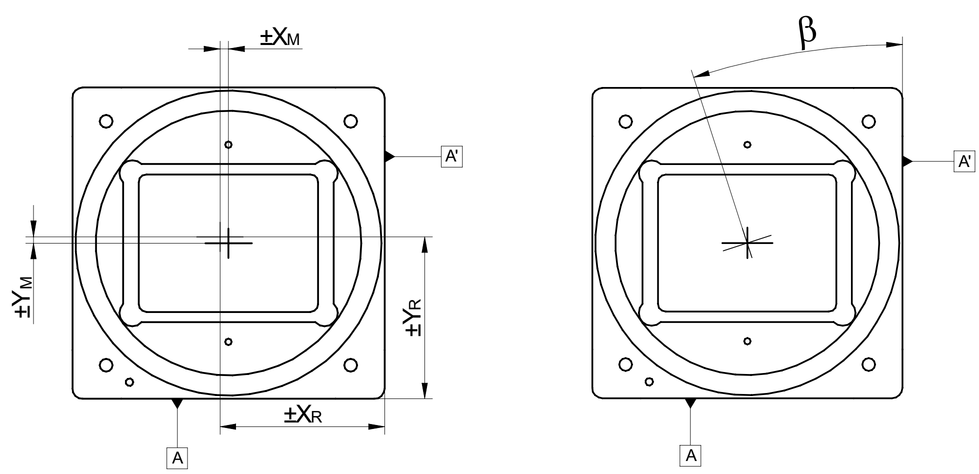
Figure 6 ▶
Digitization Tap of the Baumer LXC cameras Readout with 16 channel

8.1.4 Field of View Position

The typical accuracy by assumption of the root mean square value is displayed in the figures and the table below:



LXC-20, LXC-40



LXC-120, LXC-200, LXC-250, LXC-500

◄ **Figure 7**
Sensor accuracy of Baumer LXC cameras.

Camera Type	$\pm x_{M,typ}$ [mm]	$\pm y_{M,typ}$ [mm]	$\pm x_{R,typ}$ [mm]	$\pm y_{R,typ}$ [mm]	$\pm \beta_{typ}$ [°]
LXC-20	0.09	0.09	0.1	0.1	0.4
LXC-40	0.09	0.09	0.1	0.1	0.4
LXC-120	0.07	0.06	0.08	0.07	0.26
LXC-200	0.08	0.08	0.09	0.08	0.27
LXC-250	0.07	0.06	0.08	0.07	0.47
LXC-500	0.1	0.09	0.1	0.09	0.31

8.2 Timings

Notice

Overlapped mode can be switched off with setting the readout mode to *sequential shutter* instead of *overlapped shutter*.

The image acquisition consists of two separate, successively processed components.

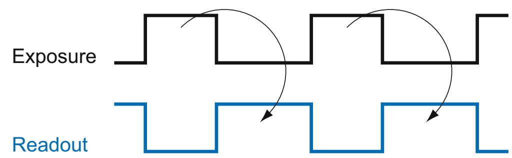
Exposing the pixels on the photosensitive surface of the sensor is only the first part of the image acquisition. After completion of the first step, the pixels are read out.

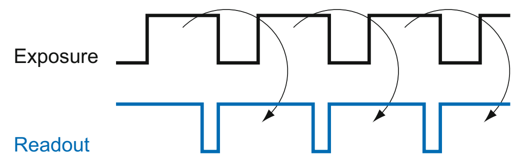
Thereby the exposure time ($t_{exposure}$) can be adjusted by the user, however, the time needed for the readout ($t_{readout}$) is given by the particular sensor and image format.

Baumer cameras can be operated with two modes, the Free Running Mode and the Trigger Mode.

The cameras can be operated non-overlapped[1)] or overlapped. Depending on the mode used, and the combination of exposure and readout time:

Non-overlapped Operation	Overlapped Operation
Here the time intervals are long enough to process exposure and readout successively.	In this operation the exposure of a frame (n+1) takes place during the readout of frame (n).





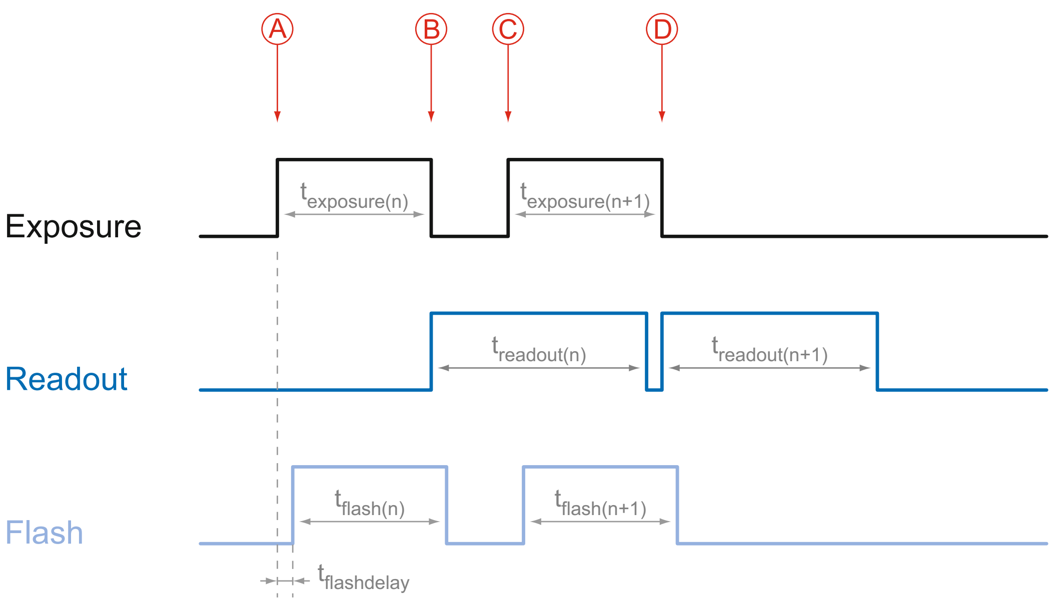
8.2.1 Free Running Mode

In the "Free Running" mode the camera records images permanently and sends them to the PC. In order to achieve an optimal (with regard to the adjusted exposure time $t_{exposure}$ and image format) the camera is operated overlapped.

In case of exposure times equal to / less than the readout time ($t_{exposure} \leq t_{readout}$), the maximum frame rate is provided for the image format used. For longer exposure times the frame rate of the camera is reduced.

Timings:
A - exposure time frame (n) effective
B - image parameters frame (n) effective
C - exposure time frame (n+1) effective
D - image parameters frame (n+1) effective

Image parameters:
Offset
Gain
Mode
Partial Scan



$t_{flash} = t_{exposure}$

1) Non-overlapped means the same as sequential.

8.2.2 Trigger Mode

After a specified external event (trigger) has occurred, image acquisition is started. Depending on the interval of triggers used, the camera operates non-overlapped or overlapped in this mode.

With regard to timings in the trigger mode, the following basic formulas need to be taken into consideration:

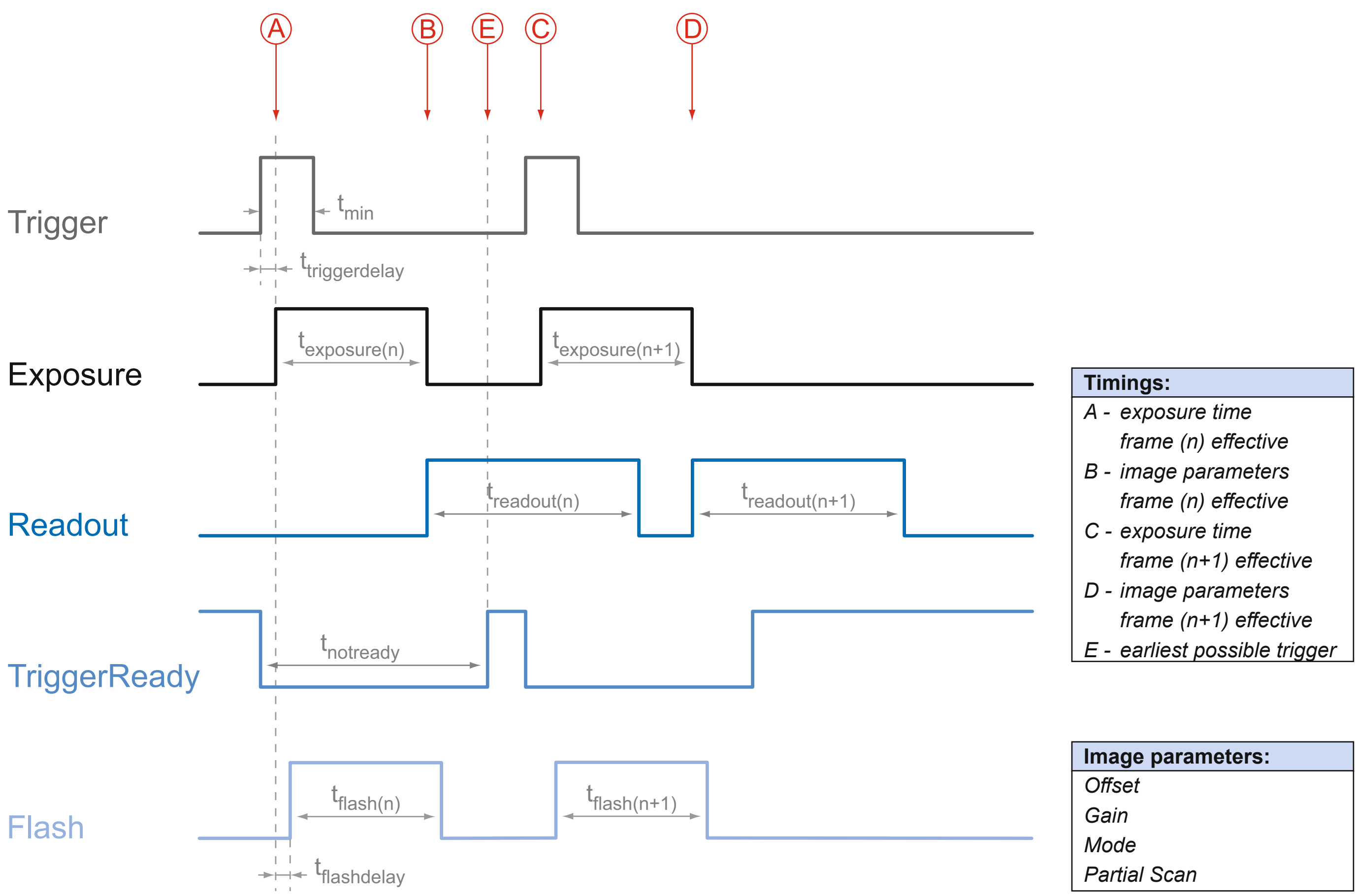
Case		Formula
$t_{exposure} < t_{readout}$	(1)	$t_{earliestpossibletrigger(n+1)} = t_{readout(n)} - t_{exposure(n+1)}$
	(2)	$t_{notready(n+1)} = t_{exposure(n)} + t_{readout(n)} - t_{exposure(n+1)}$
$t_{exposure} > t_{readout}$	(3)	$t_{earliestpossibletrigger(n+1)} = t_{exposure(n)}$
	(4)	$t_{notready(n+1)} = t_{exposure(n)}$

8.2.2.1 Overlapped Operation: $t_{exposure(n+2)} = t_{exposure(n+1)}$

In overlapped operation attention should be paid to the time interval where the camera is unable to process occuring trigger signals ($t_{notready}$). This interval is situated between two exposures. When this process time $t_{notready}$ has elapsed, the camera is able to react to external events again.

After $t_{notready}$ has elapsed, the timing of (E) depends on the readout time of the current image ($t_{readout(n)}$) and exposure time of the next image ($t_{exposure(n+1)}$). It can be determined by the formulas mentioned above (no. 1 or 3, as is the case).

In case of identical exposure times, $t_{notready}$ remains the same from acquisition to acquisition.



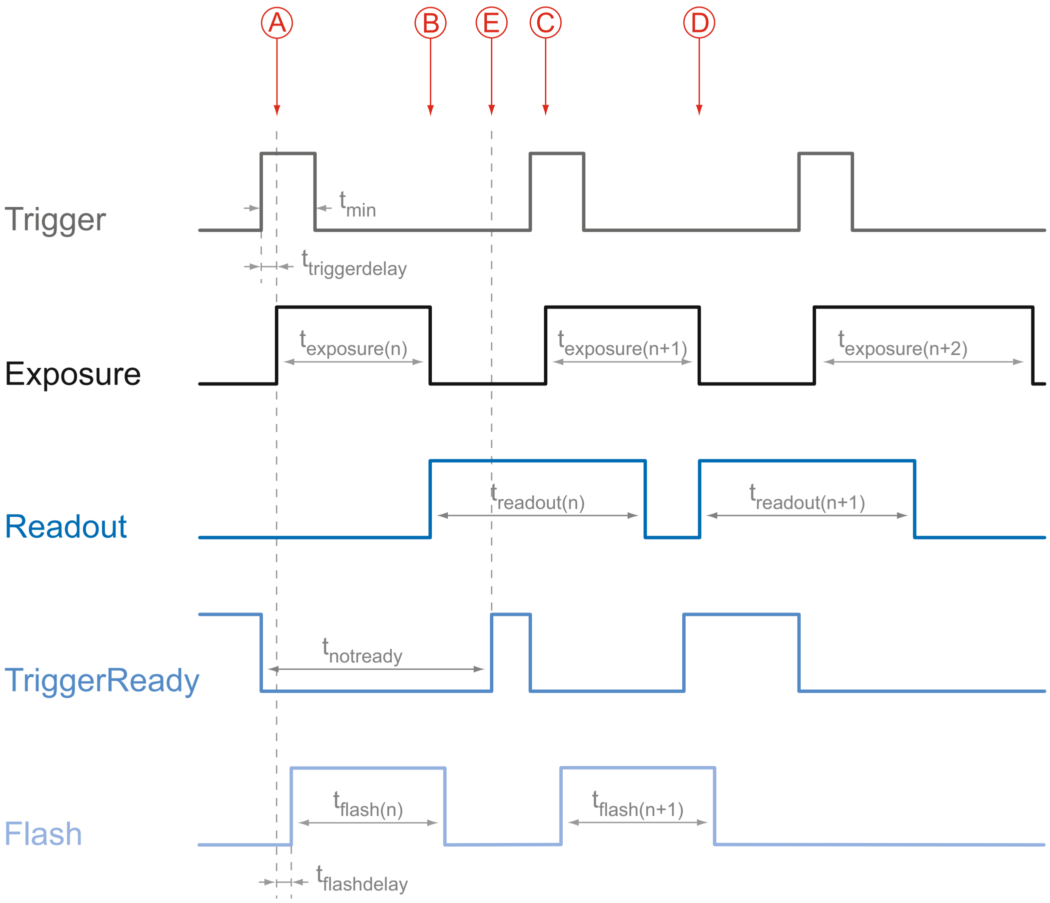
8.2.2.2 Overlapped Operation: $t_{exposure(n+2)} > t_{exposure(n+1)}$

If the exposure time ($t_{exposure}$) is increased from the current acquisition to the next acquisition, the time the camera is unable to process occuring trigger signals ($t_{notready}$) is scaled down.

This can be simulated with the formulas mentioned above (no. 2 or 4, as is the case).

Timings:
A - exposure time frame (n) effective
B - image parameters frame (n) effective
C - exposure time frame (n+1) effective
D - image parameters frame (n+1) effective
E - earliest possible trigger

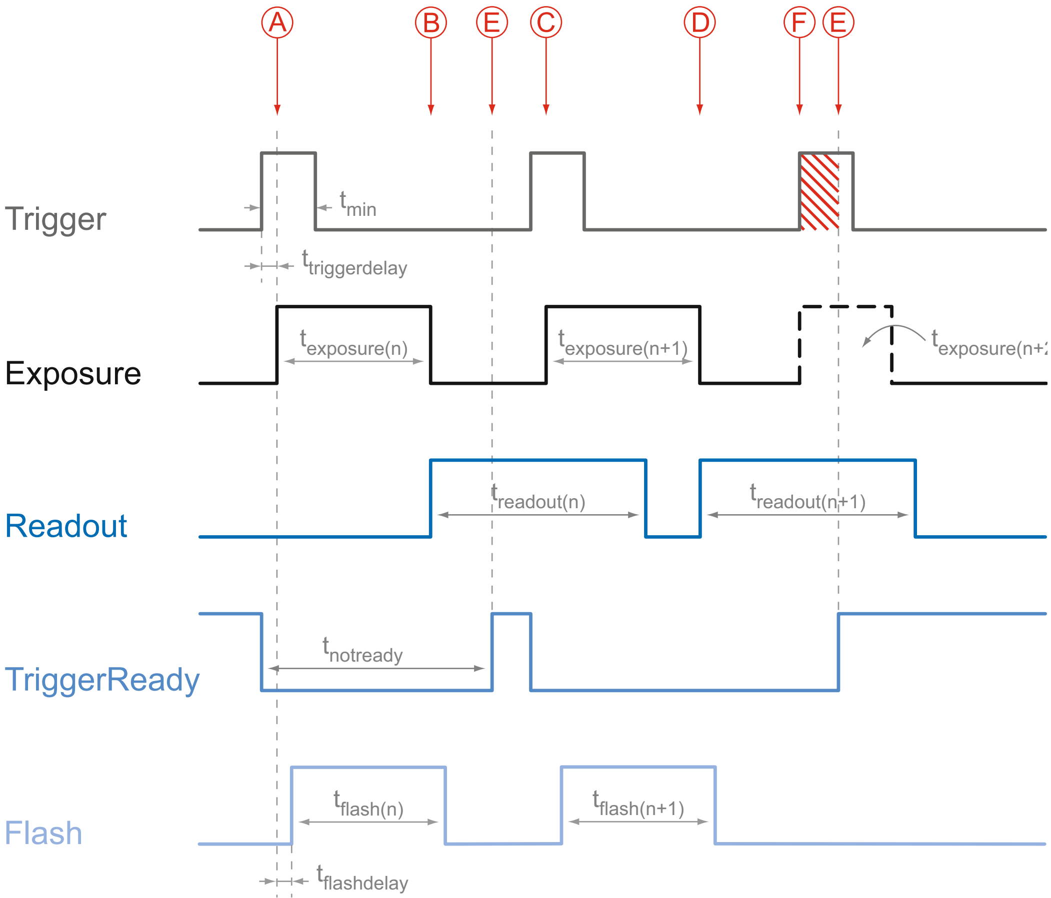
Image parameters:
Offset
Gain
Mode
Partial Scan



8.2.2.3 Overlapped Operation: $t_{exposure(n+2)} < t_{exposure(n+1)}$

If the exposure time ($t_{exposure}$) is decreased from the current acquisition to the next acquisition, the time the camera is unable to process occuring trigger signals ($t_{notready}$) is scaled up.

When decreasing the $t_{exposure}$ such, that $t_{notready}$ exceeds the pause between two incoming trigger signals, the camera is unable to process this trigger and the acquisition of the image will not start (the trigger will be skipped).



Timings:
A - exposure time frame (n) effective
B - image parameters frame (n) effective
C - exposure time frame (n+1) effective
D - image parameters frame (n+1) effective
E - earliest possible trigger
F - frame not started / trigger skipped

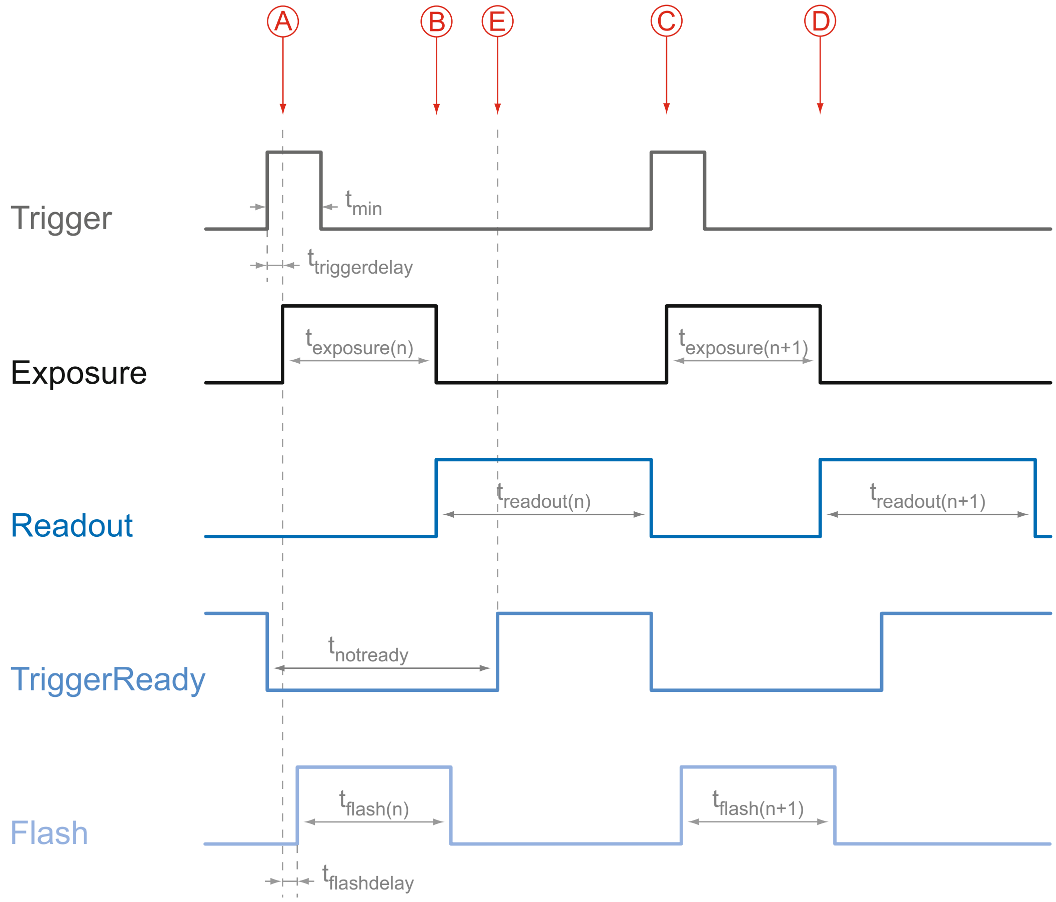
Image parameters:
Offset
Gain
Mode
Partial Scan

Notice

From a certain frequency of the trigger signal, skipping triggers is unavoidable. In general, this frequency depends on the combination of exposure and readout times.

8.2.2.4 Non-overlapped Operation

If the frequency of the trigger signal is selected for long enough, so that the image acquisitions ($t_{exposure}$ + $t_{readout}$) run successively, the camera operates non-overlapped.



Timings:
A - exposure time frame (n) effective
B - image parameters frame (n) effective
C - exposure time frame (n+1) effective
D - image parameters frame (n+1) effective
E - earliest possible trigger

Image parameters:
Offset
Gain
Mode
Partial Scan

9. Software

9.1 Frame grabber with GenCP support

The camera can be controlled via the GenCP/GenICam protocol. The SDK of some Camera Link frame grabber vendors directly supports this. Thus, only this SDK is required for image acquisition and camera configuration. See compliance list for details which frame grabbers support this.

9.2 Frame grabber without GenCP support

The camera can be controlled via the GenCP/GenICam protocol. If the SDK of the Camera Link frame grabber does not support the GenCP/GenICam protocol, the GenICam Reference implementation can be used for camera configuration.

Notice
Latest software version and technical documentation are available at: www.baumer.com/vision/login (registration required)

10. Camera Functionalities

10.1 Image Acquisition

10.1.1 Image Format

A digital camera usually delivers image data in at least one format - the native resolution of the sensor. Baumer cameras are able to provide several image formats (depending on the type of camera).

Compared with standard cameras, the image format on Baumer cameras not only includes resolution, but a set of predefined parameter.

These parameters are:
- Resolution (horizontal and vertical dimensions in pixels)
- Binning Mode
- Decimation

Camera Type	Full frame	Binning 2x2	Binning 1x2	Binning 2x1	Decimation 2x2	Decimation 1x2	Decimation 2x1
Mono							
LXC-20M	■	■	■	■	■	■	■
LXC-40M	■	■	■	■	■	■	■
LXC-120M	■	■	■	■	■	■	■
LXC-200M	■	■	■	■	■	■	■
LXC-250M	■	■	■	■	■	■	■
LXC-500M	■	■	■	■	■	■	■
Color							
LXC-20C	■	□	□	□	■	■	■
LXC-40C	■	□	□	□	■	■	■
LXC-120C	■	□	□	□	■	■	■
LXC-200C	■	□	□	□	■	■	■
LXC-250C	■	□	□	□	■	■	■
LXC-500C	■	□	□	□	■	■	■

10.1.2 Pixel Format

On Baumer digital cameras the pixel format depends on the selected image format.

10.1.2.1 Pixel Formats on Baumer LXC Cameras

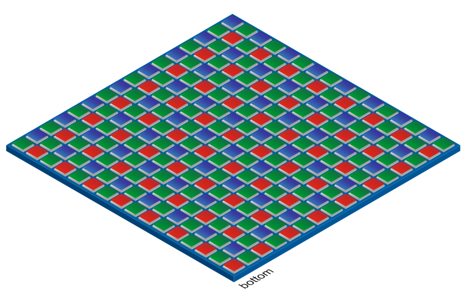
Camera Type	Mono8	Mono10	Mono12	BayerGB8	BayerBG8	BayerGB10	BayerBG10	Bayer RG8	Bayer RG10	Bayer RG12	Bayer BG12
Monochrome											
LXC-20M	■	■	□	□	□	□	□	□	□	□	□
LXC-40M	■	■	□	□	□	□	□	□	□	□	□
LXC-120M	■	■	□	□	□	□	□	□	□	□	□
LXC-200M	■	■	■	□	□	□	□	□	□	□	□
LXC-250M	■	■	□	□	□	□	□	□	□	□	□
LXC-500M	■	■	■	□	□	□	□	□	□	□	□
Color											
LXC-20C	□	□	□	■	□	■	□	□	□	□	□
LXC-40C	□	□	□	■	□	■	□	□	□	□	□
LXC-120C	□	□	□	■	□	■	□	□	□	□	□
LXC-200C	□	□	□	□	□	□	□	■	■	■	□
LXC-250C	□	□	□	■	□	■	□	□	□	□	□
LXC-500C	□	□	□	□	■	□	■	□	□	□	■

10.1.2.2 Definitions

Notice

Below is a general description of pixel formats. The table above shows, which camera support which formats.

Bayer: Raw data format of color sensors.
Color filters are placed on these sensors in a checkerboard pattern, generally in a 50% green, 25% red and 25% blue array.



◄ **Figure 8**
Sensor with Bayer Pattern.

Mono: Monochrome. The color range of mono images consists of shades of a single color. In general, shades of gray or black-and-white are synonyms for monochrome.

RGB: Color model, in which all detectable colors are defined by three coordinates, Red, Green and Blue.

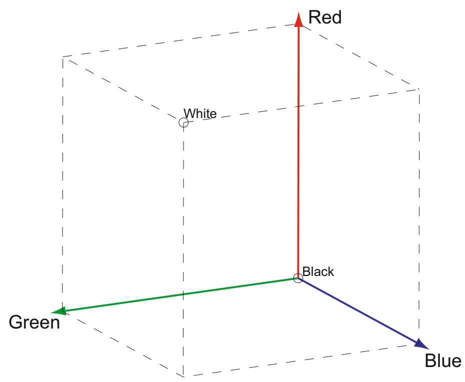


Figure 9 ▶
RBG color space displayed as color tube.

The three coordinates are displayed within the buffer in the order R, G, B.

BGR: Here the color alignment mirrors RGB.

YUV: Color model, which is used in the PAL TV standard and in image compression. In YUV, a high bandwidth luminance signal (Y: luma information) is transmitted together with two color difference signals with low bandwidth (U and V: chroma information). Thereby U represents the difference between blue and luminance (U = B - Y), V is the difference between red and luminance (V = R - Y). The third color, green, does not need to be transmitted, its value can be calculated from the other three values.

- YUV 4:4:4 Here each of the three components has the same sample rate. Therefore there is no subsampling here.
- YUV 4:2:2 The chroma components are sampled at half the sample rate. This reduces the necessary bandwidth to two-thirds (in relation to 4:4:4) and causes no, or low visual differences.
- YUV 4:1:1 Here the chroma components are sampled at a quarter of the sample rate.This decreases the necessary bandwith by half (in relation to 4:4:4).

Pixel depth: In general, pixel depth defines the number of possible different values for each color channel. Mostly this will be 8 bit, which means 2^8 different "colors".

For RGB or BGR these 8 bits per channel equal 24 bits overall.

8 bit:

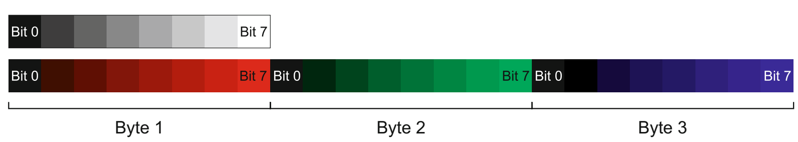


Figure 10 ▶
Bit string of Mono 8 bit and RGB 8 bit.

10 bit:

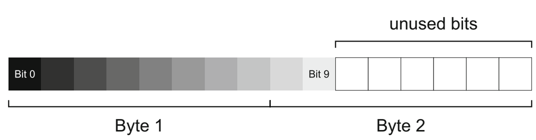


Figure 11 ▶
Spreading of Mono 10 bit over 2 bytes.

12 bit:

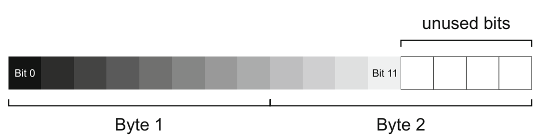
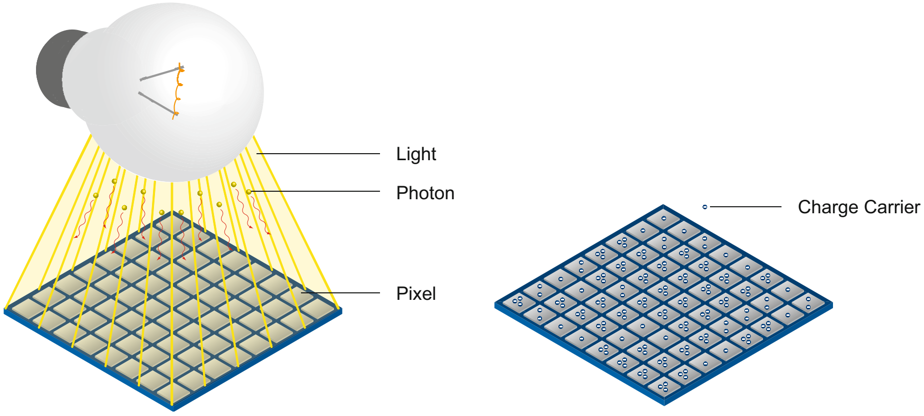


Figure 12 ▶
Spreading of Mono 12 bit over two bytes.

10.1.3 Exposure Time

On exposure of the sensor, the inclination of photons produces a charge separation on the semiconductors of the pixels. This results in a voltage difference, which is used for signal extraction.



◄ **Figure 13**
Incidence of light causes charge separation on the semiconductors of the sensor.

The signal strength is influenced by the incoming amount of photons. It can be increased by increasing the exposure time ($t_{exposure}$).

On Baumer LXC cameras, the exposure time can be set within the following ranges (step size 1µsec):

Camera Type	$t_{exposure}$ min	$t_{exposure}$ max
LXC-20M / C	30 µsec	1 sec
LXC-40M / C	30 µsec	1 sec
LXC-120M / C	16 µsec	1 sec
LXC-200M / C	200 µsec	1 sec
LXC-250M / C	27 µsec	1 sec
LXC-500M / C	95 µsec	1 sec

Notice

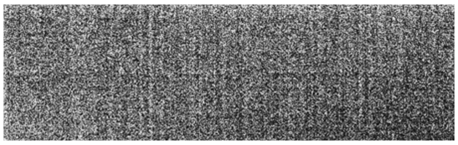
The exposure time can be programmed or controlled via trigger width.

However, the sensor needs additional time for the sampling operation during which the sensor is still light sensitive. As a consequence the real minimum exposure time is the respective **$t_{exposure}$ min** longer.

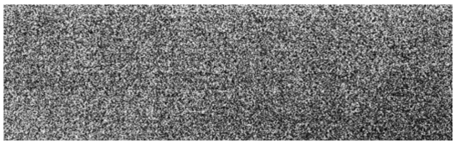
10.1.4 PRNU / DSNU Correction (FPN - Fixed Pattern Noise)

CMOS sensors exhibit nonuniformities that are often called fixed pattern noise (FPN). However it is no noise but a fixed variation from pixel to pixel that can be corrected. The advantage of using this correction is a more homogeneous picture which may simplify the image analysis. Variations from pixel to pixel of the dark signal are called dark signal non-uniformity (DSNU) whereas photo response nonuniformity (PRNU) describes variations of the sensitivity. DNSU is corrected via an offset while PRNU is corrected by a factor.

The correction is based on columns. It is important that the correction values are computed for the used sensor readout configuration. During camera production this is derived for the factory defaults. If other settings are used (e.g. different number of readout channels) using this correction with the default data set may degrade the image quality. In this case the user may derive a specific data set for the used setup.



PRNU / DSNU Correction Off



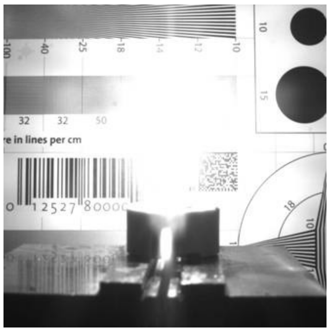
PRNU / DSNU Correction On

10.1.5 HDR

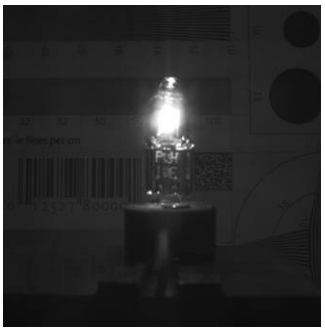
Beside the standard linear response the sensor supports a special high dynamic range mode (HDR) called piecewise linear response. With this mode illuminated pixels that reach a certain programmable voltage level will be clipped. Darker pixels that do not reach this threshold remain unchanged. The clipping can be adjusted two times within a single exposure by configuring the respective time slices and clipping voltage levels. See the figure below for details.

In this mode, the values for t_{Expo0}, t_{Expo1}, Pot_0 and Pot_1 can be edited.

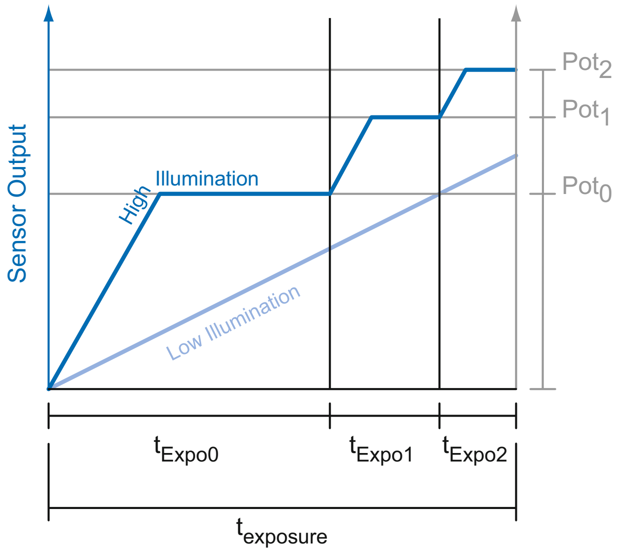
The value for t_{Expo2} will be calculated automatically in the camera. ($t_{Expo2} = t_{exposure} - t_{Expo0} - t_{Expo1}$)



HDR Off



HDR On



10.1.6 Look-Up-Table

The Look-Up-Table (LUT) is employed on Baumer monochrome cameras. It contains 2^{12} (4096) values for the available levels of gray. These values can be adjusted by the user.

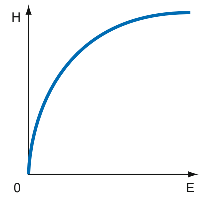
Notice
The LUT always calculates with 12 bit input and 12 bit output. In 8/10 bit mode, the lower bits of the input values are equal zero but can be spread to full 12 bit because of digital gain. Therefore, all values of the LUT have to be filled in.

10.1.7 Gamma Correction

With this feature, Baumer LXC cameras offer the possibility of compensating nonlinearity in the perception of light by the human eye.

For this correction, the corrected pixel intensity (Y') is calculated from the original intensity of the sensor's pixel ($Y_{original}$) and correction factor γ using the following formula (in over-simplified version):

$$Y' = Y_{original}^{\gamma}$$



▲ **Figure 14**
Non-linear perception of the human eye.
H - Perception of brightness
E - Energy of light

10.1.8 Region of Interest (ROI) and Multi ROI

With this functions it is possible to predefine a so-called Region of Interest (ROI) or Partial Scan. The ROI is an area of pixels of the sensor. After image acquisition, only the information of these pixels is sent to the PC.

This functions is turned on, when only a region of the field of view is of interest. It is coupled to a reduction in resolution and increases the frame rate.

The ROI is specified by following values:
- Region Selector Region 0 / Multi-ROI horizontal 1-8, Multi-ROI vertical 1-8
- Region Mode On/Off
- Offset X - x-coordinate of the first relevant pixel
- Offset Y - y-coordinate of the first relevant pixel
- Width - horizontal size of the ROI
- Height - vertical size of the ROI

Notice

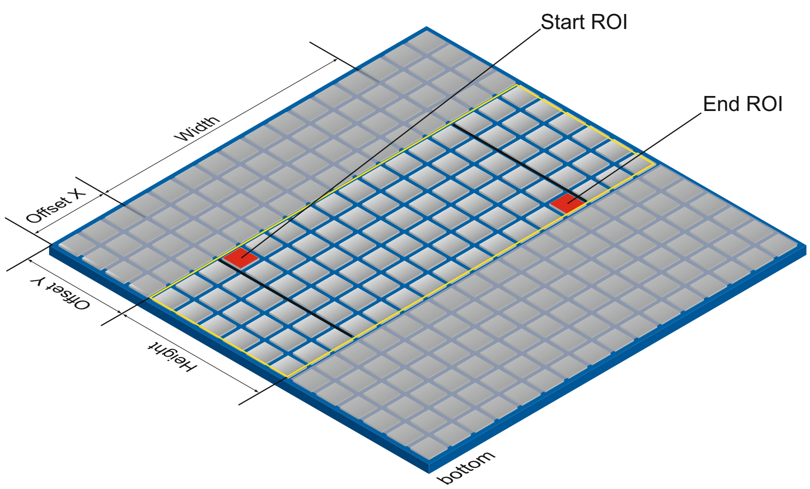
The values of the Offset X and Size X must be a multible of 32!

The step size in Y direction is 1 pixel at monochrome cameras and 2 pixel at color cameras.

Notice

If defect pixels should exist in the first (mono cameras) or in the first two (color cameras) rows or columns of a ROI, these cannot be corrected with the defect pixel correction. In this case you need to move or increase the ROI by a few pixels.

The coordinates of defect pixels can be read out with the Camera Explorer (Category: Control LUT).



◄ **Figure 15**
Parameters of the ROI.

10.1.8.1 Normal- ROI Readout (Region 0)

For the sensor readout time of the ROI, the horizontal subdivision of the sensor is unimportant – only the vertical subdivision is of importance.

Notice
The activation of ROI turns off all Multi-ROIs.

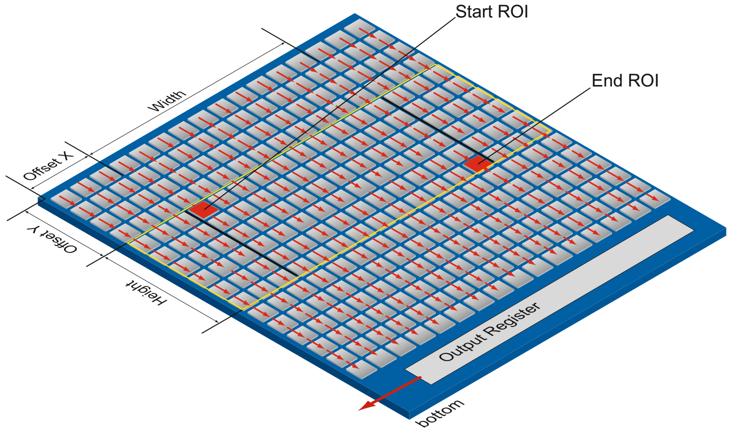


Figure 16 ►
ROI: Readout

The readout is line based, which means always a complete line of pixels needs to be read out and afterwards the irrelevant information is discarded.

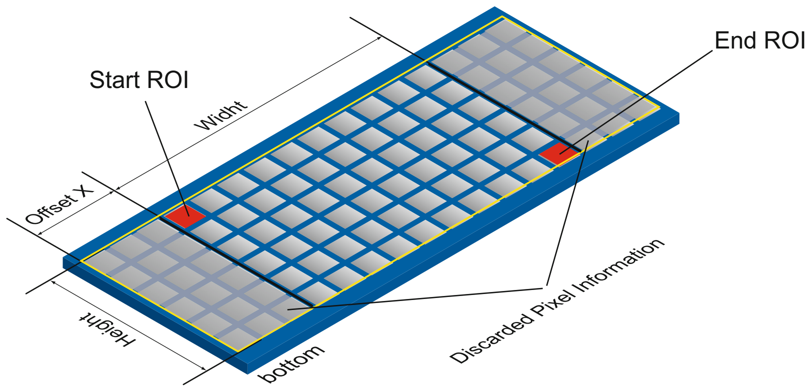


Figure 17 ►
ROI:
Discarded Information

10.1.9 Multi-ROI

With Multi-ROI it is possible to predefine several Region of Interests (ROIs). It can be specified up to 8 ROIs (Region 0 - Region 7), which must have the same size. Overlapped ROIs (in the figure Region 1 and Region 2) are possible.

The camera only reads out sensor parts that are within one of the active Multi Regions. Each defined ROI is sequentially transferred in a separate frame.

The activation of Multi-ROI turns off ROI.

Notice
Multi-ROI can not be used simultaneously with Binning.

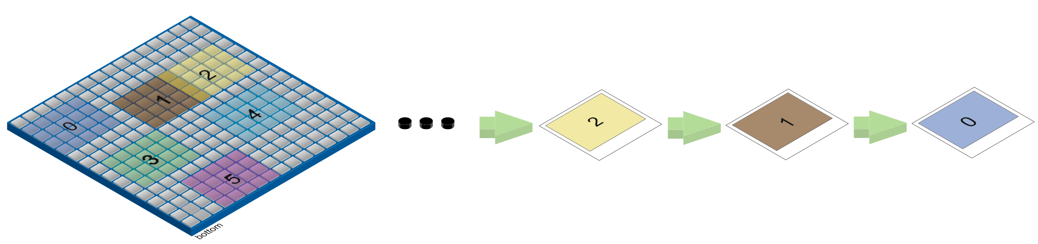


Figure 18 ►
Result frames generated by using Multi-ROI´s

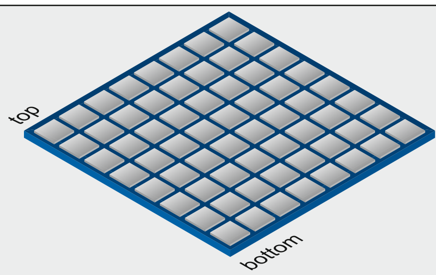
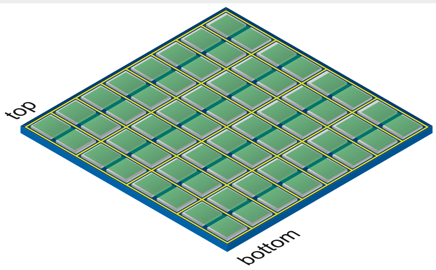
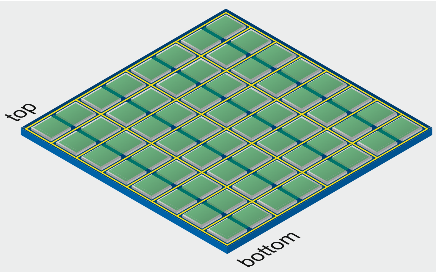
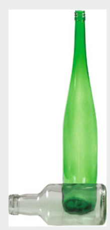
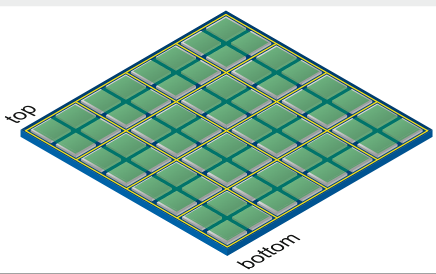
10.1.10 Binning

On digital cameras, you can find several operations for progressing sensitivity. One of them is the so-called "Binning". Here, the charge carriers of neighboring pixels are aggregated. Thus, the progression is greatly increased by the amount of binned pixels. By using this operation, the progression in sensitivity is coupled to a reduction in resolution.

Baumer cameras support three types of Binning – vertical, horizontal and bidirectional.

In unidirectional binning, vertically or horizontally neighboring pixels are aggregated and reported to the software as one single "superpixel".

In bidirectional binning, a square of neighboring pixels is aggregated.

Binning	Illustration	Example
without		
1x2		
2x1		
2x2		

◄ **Figure 19**
Full frame image, no binning of pixels.

◄ **Figure 20**
Vertical binning causes a vertically compressed image with doubled brightness.

◄ **Figure 21**
Horizontal binning causes a horizontally compressed image with doubled brightness.

◄ **Figure 22**
Bidirectional binning causes both a horizontally and vertically compressed image with quadruple brightness.

10.1.11 Decimation (sub-sampling)

In this mode, the sensor is read out partially. Thus the frame rate is increased and the amount of data transferred is reduced.

It is available for mono and color cameras. With color cameras, a color correct readout of the pixels takes place.

Notice
The camera must be stopped before decimation can be set.

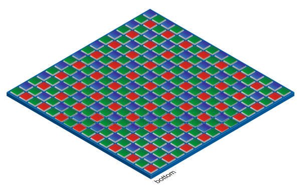
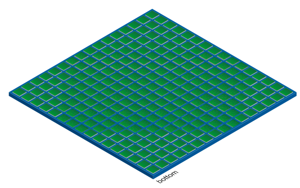
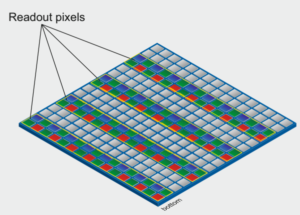
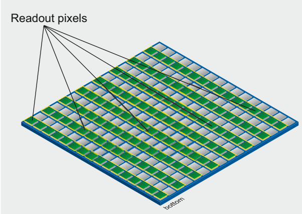
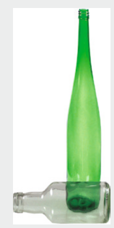
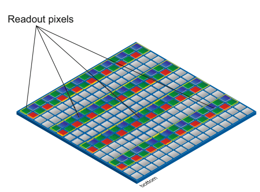
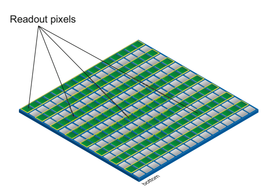
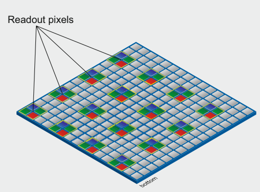
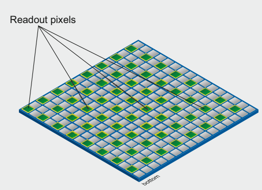
Decimation	Illustration color	Illustration mono	Example
without			
1x2			
2x1			
2x2			

Figure 23 ▶
Full frame image, no decimation of pixels.

Figure 24 ▶
Vertical decimation causes a vertically compressed image.

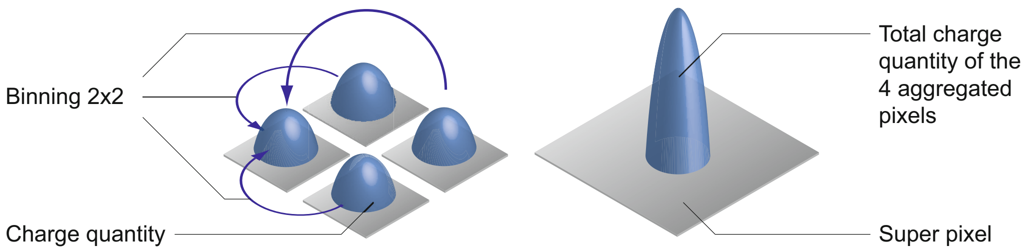
Figure 25 ▶
Horizontal decimation causes a horizontally compressed.

Figure 26 ▶
Bidirectional decimation causes both a horizontally and vertically compressed image.

10.1.12 Brightness Correction (Binning Correction)

The summation of pixel values may cause an overload. To prevent this, binning correction was introduced.

Binnig	Realization
1x2	1x2 binning is performed within the sensor, binning correction also takes place here. A possible overload is prevented by halving the exposure time.
2x1	2x1 binning takes place within the FPGA of the camera. The binning correction is realized by aggregating the charge quantities, and then halving this sum.
2x2	2x2 binning is a combination of the above versions.



◄ **Figure 27**
Aggregation of charge carriers from four pixels in bidirectional binning.

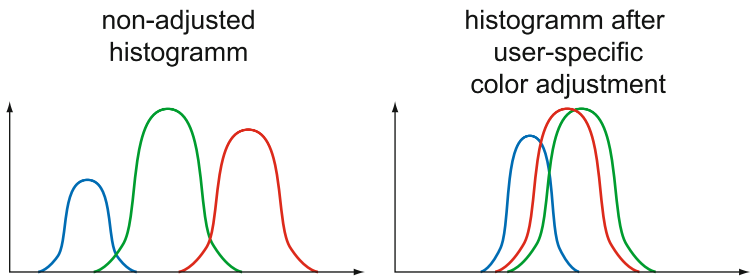
10.2 Color Adjustment – White Balance

This feature is available on all color Baumer LXC cameras and takes place within the Bayer processor.

White balance means independent adjustment of the three color channels, red, green and blue by employing of a correction factor for each channel.

10.2.1 User-specific Color Adjustment

The user-specific color adjustment in Baumer color cameras facilitates adjustment of the correction factors for each color gain. This way, the user is able to adjust the amplification of each color channel exactly to his needs. The correction factors for the color gains range from 1 to 4.

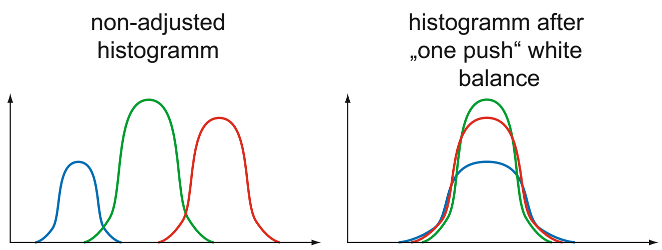


◄ **Figure 28**
Examples of histogramms for a non-adjusted image and for an image after user-specific white balance..

10.2.2 One Push White Balance

Notice
Due to the internal processing of the camera, One Push White Balance refers to the current ROI but always considers the entire row.

Here, the three color spectrums are balanced to a single white point. The correction factors of the color gains are determined by the camera (one time).



◄ **Figure 29**
Examples of histogramms for a non-adjusted image and for an image after "one push" white balance.

10.3 Analog Controls

10.3.1 Offset / Black Level

On Baumer LXC cameras the offset (or black level) is adjustable.

Camera Type	1 step = 4 LSB Relating to [bit]
Monochrome	
LXC-20M	0 ... 63 LSB	10 bit
LXC-40M	0 ... 63 LSB	10 bit
LXC-120M	0 ... 63 LSB	10 Bit
LXC-200M	0 ... 255 LSB	12 Bit
LXC-250M	0 ... 63 LSB	10 Bit
LXC-500M	0 ... 255 LSB	12 Bit
Color	
LXC-20C	0 ... 63 LSB	10 bit
LXC-40C	0 ... 63 LSB	10 bit
LXC-120C	0 ... 63 LSB	10 Bit
LXC-200C	0 ... 255 LSB	12 Bit
LXC-250C	0 ... 63 LSB	10 Bit
LXC-500C	0 ... 255 LSB	12 Bit

10.3.2 Gain

In industrial environments motion blur is unacceptable. Due to this fact exposure times are limited. However, this causes low output signals from the camera and results in dark images. To solve this issue, the signals can be amplified by user within the camera. This gain is adjustable from 0 to 12 db.

Notice
Increasing the gain factor causes an increase of image noise and leads to missing codes at Mono12, if the gain factor > 1.0.

10.4 Pixel Correction

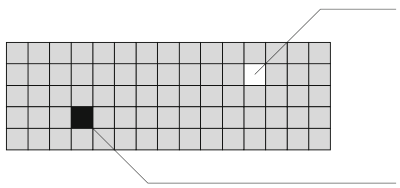
Notice
If defect pixels should exist in the first (mono cameras) or in the first two (color cameras) rows or columns of a ROI, these cannot be corrected with the defect pixel correction. In this case you need to move or increase the ROI by a few pixels. The coordinates of defect pixels can be read out with the Camera Explorer (Category: Control LUT).

10.4.1 General information

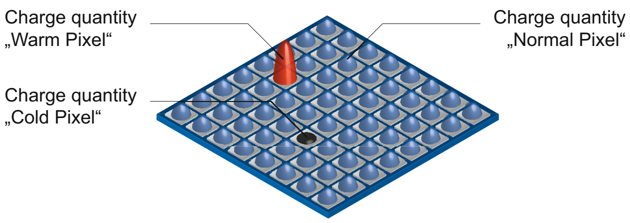
A certain probability for abnormal pixels - the so-called defect pixels - applies to the sensors of all manufacturers. The charge quantity on these pixels is not linear-dependent on the exposure time.

The occurrence of these defect pixels is unavoidable and intrinsic to the manufacturing and aging process of the sensors.

The operation of the camera is not affected by these pixels. They only appear as brighter (warm pixel) or darker (cold pixel) spot in the recorded image.



◄ **Figure 30**
Distinction of "hot" and "cold" pixels within the recorded image.



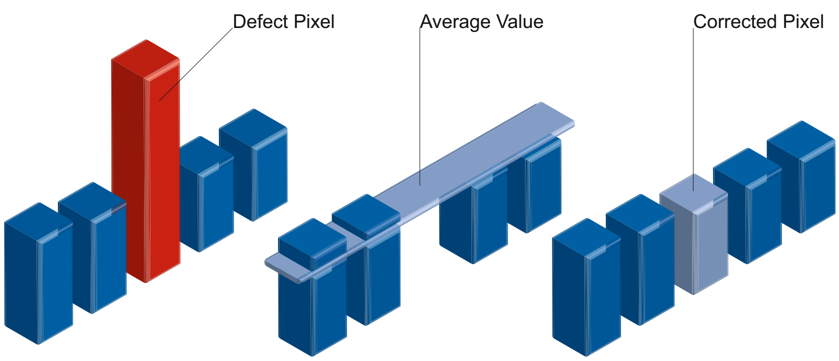
◄ **Figure 31**
Charge quantity of "hot" and "cold" pixels compared with "normal" pixels.

10.4.2 Correction Algorithm

On Baumer LXC cameras the problem of defect pixels is solved as follows:

- Possible defect pixels are identified during the production process of the camera.
- The coordinates of these pixels are stored in the factory settings of the camera.
  Once the sensor readout is completed, correction takes place:
  - Before any other processing, the values of the neighboring pixels with the same color on the left and the right side of the defect pixel, will be read out
  - Then the average value of these pixels is determined
  - Finally, the value of the defect pixel is substituted by the previously determined average value

This works horizontally and vertically. With this approach whole defect rows and defect columns can be corrected.



◄ **Figure 32**
Schematic diagram of the Baumer pixel correction.

10.4.3 Add Defect Pixel / Defect Columns / Defect Rows to Defect pixel list

As stated previously, this list is determined within the production process of Baumer cameras and stored in the factory settings. This list is editable.

Additional hot pixels, cold pixels, defect columns or defect rows can develop during the lifecycle of a camera. In this case Baumer offers the possibility of adding their coordinates to the defect pixel list.

The user can determine the coordinates[1)] of the affected pixels, columns and rows and add them to the list. Once the defect pixel list is stored in a user set, pixel correction is executed for all coordinates on the defect pixel list.

Notice
There are defect pixels, defect columns or defect rows, which occur only under certain environmental parameters. These include temperatures or exposure settings. Complete defect pixels, defect columns or defect rows that occur in your application.

Procedure

1. Start the *Camera Camera Link® ConfigTool v2*. Connect to the camera. Select the profile *GenICam Expert*.

2. Open the category *LUT Control*.

3. Select the to be corrected defect at *Defect Pixel List Selector* (Pixel, Column, Row).

4. Locate an empty *Defect Pixel List Index*.

An empty *Defect Pixel List Index* can be recognized by the fact that no entries are present at *Defect Pixel List Entry PosX* and *Defect Pixel List Entry PosY.*

Avoid using existing entries!

5. Determine the coordinates of the defect pixels, defect column or defect row. Keep the mouse pointer over the defect. The coordinates are displayed in the status bar.

For simplification, you can enlarge the image.

6. Enter the determined values of the defect.

<u>Pixel</u>
Enter the determined coordinates for X (*Defect Pixel List Entry PosX*).
Enter the determined coordinates for Y (*Defect Pixel List Entry PosY*).

<u>Column</u>
Enter the determined column (*Defect Pixel List Entry PosX*).

<u>Row</u>
Enter the determined row (*Defect Pixel List Entry PosY*).

7. Activate the registered *Defect Pixel List Index* (*Defect Pixel List Entry Active = True*).

8. Stop the camera and start them again to take over the updated entries.

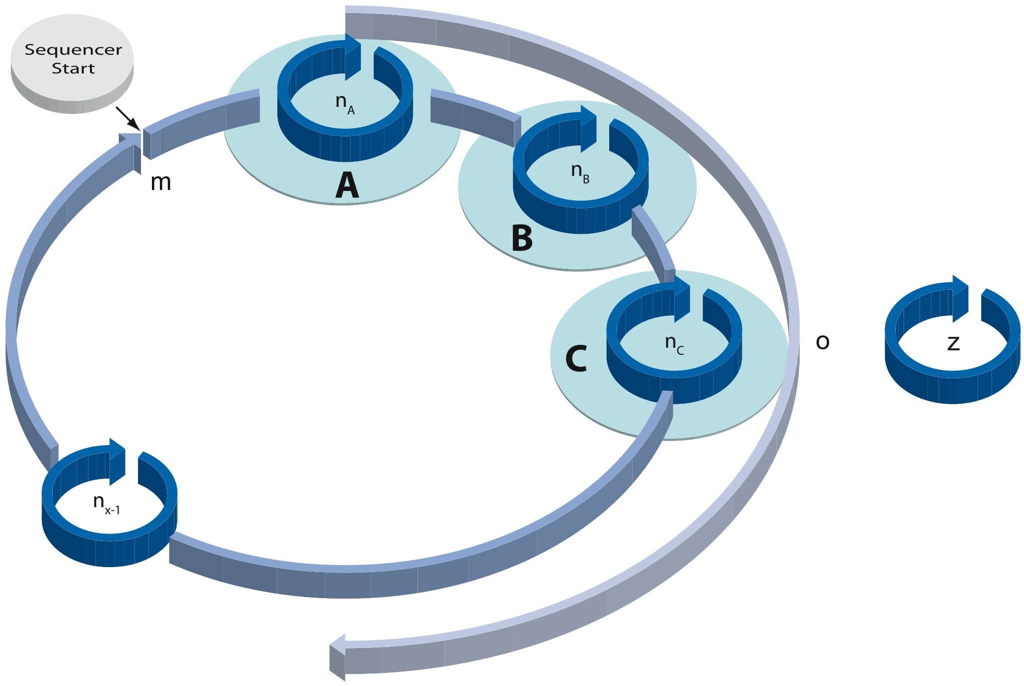
---

1) Position in relation to Full Frame Format (Raw Data Format / No flipping).

10.5 Sequencer

10.5.1 General Information

A sequencer is used for the automated control of series of images using different sets of parameters.



◄ **Figure 33**
Flow chart of sequencer.
m - number of loop passes
n - number of set repetitions
o - number of sets of parameters
z - number of frames per trigger

The figure above displays the fundamental structure of the sequencer module.

The loop counter (m) represents the number of sequence repetitions.

The repeat counter (n) is used to control the amount of images taken with the respective sets of parameters. For each set there is a separate n.

The start of the sequencer can be realized directly (free running) or via an external event (trigger). The source of the external event (trigger source) must be determined before.

The additional frame counter (z) is used to create a half-automated sequencer. It is absolutely independent from the other three counters, and used to determine the number of frames per external trigger event.

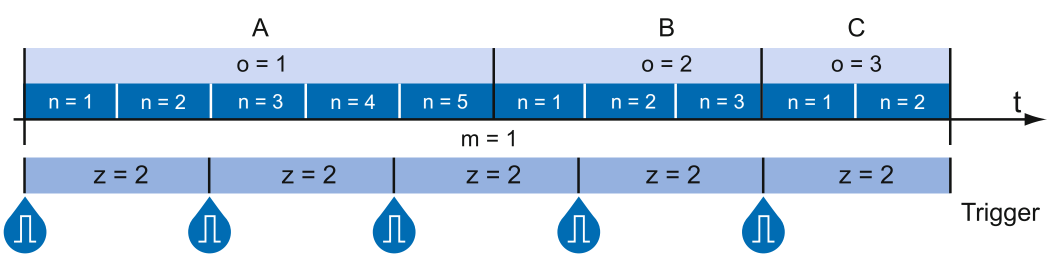
Sequencer Parameter:

The mentioned sets of parameter include the following:

- *Exposure time*
- *Gain factor*
- *Output line value*
- *Origin of ROI (Offset X, Y)*

The following timeline displays the temporal course of a sequence with:

- n = (A=5), (B=3), (C=2) repetitions per set of parameters
- o = 3 sets of parameters (A,B and C)
- m = 1 sequence and
- z = 2 frames per trigger



◄ **Figure 34**
Timeline for a single sequence

10.5.2 Baumer Optronic Sequencer in Camera xml-file

The Baumer Optronic seqencer is described in the category "BOSequencer" by the following features:

Static Sequencer Features These values are valid for all sets.	
BoSequencerEnable	Enable / Disable
BoSequencerFramesPerTrigger	Number of frames per trigger (z)
BoSequencerIsRunning	Check whether the sequencer is running
BoSequencerLoops	Number of sequences (m)
BoSequencerMode	Running mode of Sequencer
BoSequencerSetNumberOfSets	Number of sets - 1
BoSequencerStart	Start / Stop
BoSequencerSetActive	Returns the index of the active set of the running sequencer.
Set-specific Features These values can be set individually for each set.	
BoSequencerExposure	Parameter exposure
BoSequencerGain	Parameter gain
BoSequencerOffsetX	ROI Offset X
BoSequencerOffsetY	ROI Offset Y
BoSequencerIOSelector	Selected output lines
BoSequencerIOStatus	Status of all Sequencer outputs
BoSequencerSetRepeats	Number of repetitions (n)
BoSequencerSetSelector	Configure set of parameters

10.5.3 Examples

10.5.3.1 Sequencer without Machine Cycle

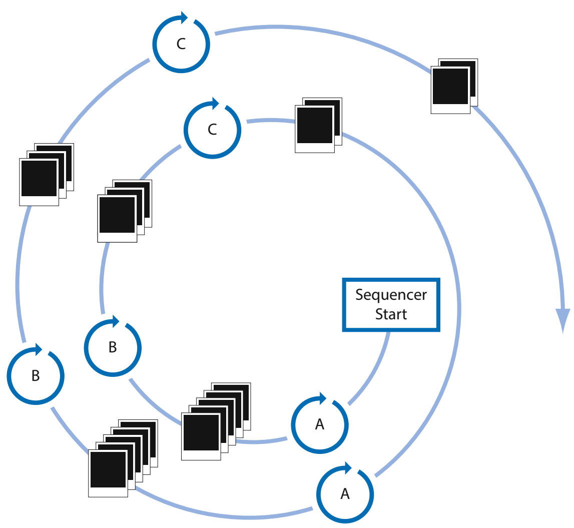


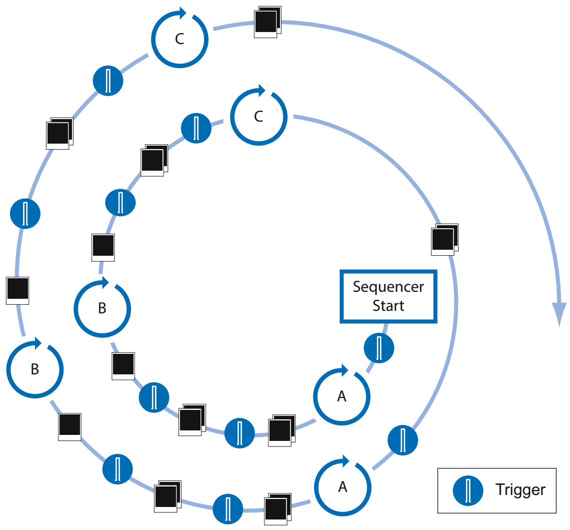
Figure 35 ▸
Example for a fully automated sequencer.

The figure above shows an example for a fully automated sequencer with three sets of parameters (A, B and C). Here the repeat counter (n) is set for (A=5), (B=3), (C=2) and the loop counter (m) has a value of 2.

When the sequencer is started, with or without an external event, the camera will record the pictures using the sets of parameters A, B and C (which constitutes a sequence).

After that, the sequence is started once again, followed by a stop of the sequencer - in this case the parameters are maintained.

10.5.3.2 Sequencer Controlled by Machine Steps (trigger)



◄ **Figure 36**
Example for a half-automated sequencer.

The figure above shows an example for a half-automated sequencer with three sets of parameters (A,B and C) from the previous example. The frame counter (z) is set to 2. This means the camera records two pictures after an incoming trigger signal.

10.5.4 Capability Characteristics of Baumer GAPI Sequencer Module

- up to 128 sets of parameters
- up to 2 billion loop passes
- up to 2 billion repetitions of sets of parameters
- up to 2 billion images per trigger event
- free running mode without initial trigger

10.5.5 Double Shutter

This feature offers the possibility of capturing two images in a very short interval. Depending on the application, this is performed in conjunction with a flash unit. Thereby the first exposure time ($t_{exposure}$) is arbitrary and accompanied by the first flash. The second exposure time must be equal to, or longer than the readout time ($t_{readout}$) of the sensor. Thus the pixels of the sensor are recepitve again shortly after the first exposure. In order to realize the second short exposure time without an overrun of the sensor, a second short flash must be employed, and any subsequent extraneous light prevented.

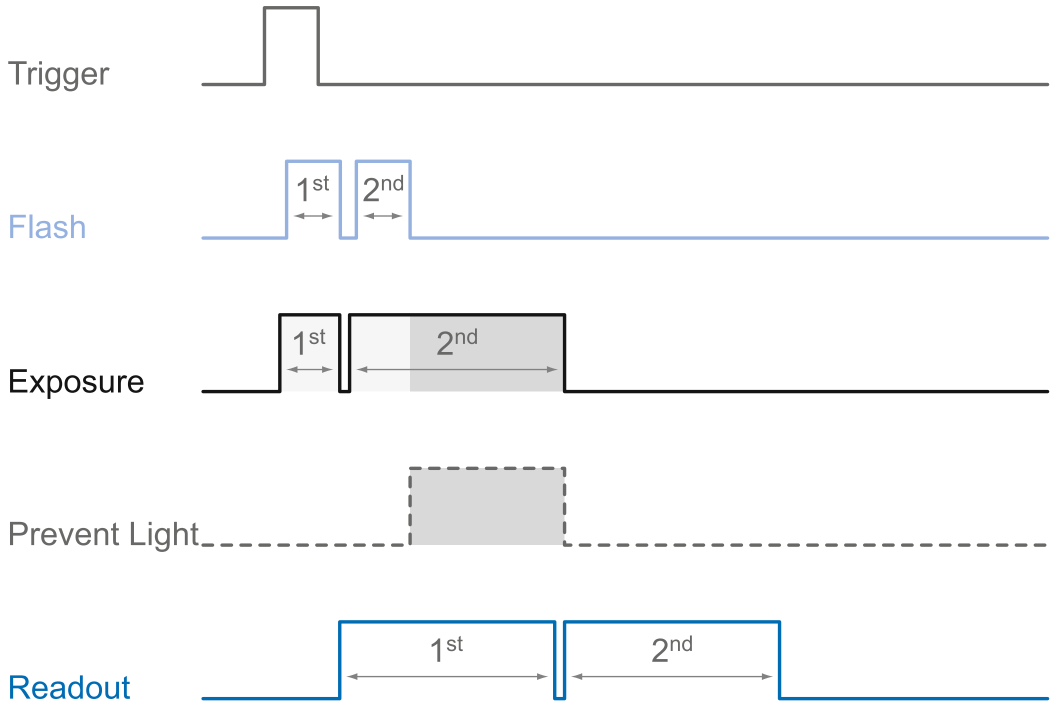


Figure 37 ►
Example of a double shutter.

On Baumer LXC cameras this feature is realized within the sequencer.

In order to generate this sequence, the sequencer must be configured as follows:

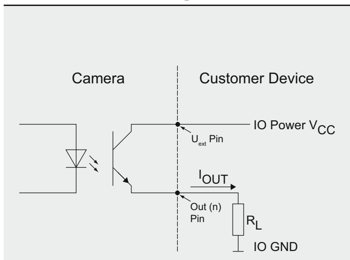
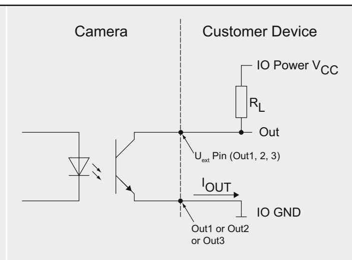
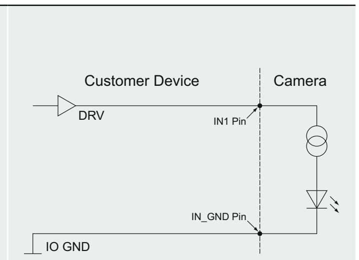
Parameter	Setting:
Sequencer Run Mode	Once by Trigger
Sets of parameters (o)	2
Loops (m)	1
Repeats (n)	1
Frames Per Trigger (z)	2

10.6 Process Interface

10.6.1 Digital I/O

All Baumer LXC cameras are equipped with one input line and one output lines.

10.6.1.1 I/O Circuits

Output high active	Output low active	Input
		

10.6.1.2 User Definable Inputs

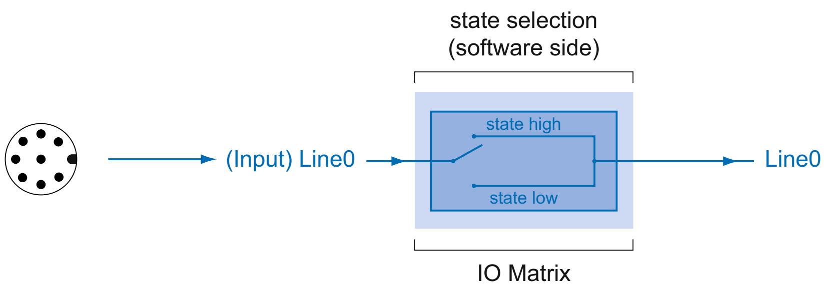
The wiring of the input connector is left to the user.

Sole exception is the compliance with predetermined high and low levels (0 .. 4,5V low, 11 .. 30V high).

The defined signals will have no direct effect, but can be analyzed and processed on the software side and used for controlling the camera.

The employment of a so called "IO matrix" offers the possibility of selecting the signal and the state to be processed.

On the software side the input signals are named "Line0".



◄ **Figure 38**
IO matrix of the Baumer LXC on input side.

10.6.1.3 Configurable Outputs

With this feature, Baumer offers the possibility of wiring the output connectors to internal signals, which are controlled on the software side.

Hereby on Baumer LXC cameras 17 signal sources – subdivided into three categories – can be applied to the output connectors.

The first category of output signals represents a loop through of signals on the input side, such as:

Signal Name	Explanation
Line0	Signal of input "Line0" is loopthroughed to this ouput

Within the second category you will find signals that are created on camera side:

Signal Name	Explanation
FrameActive	The camera processes a Frame consisting of exposure and readout
TriggerReady	Camera is able to process an incoming trigger signal
TriggerOverlapped	The camera operates in overlapped mode
TriggerSkipped	Camera rejected an incoming trigger signal
ExposureActive	Sensor exposure in progress
ReadoutActive	Read out in progress

Beside the signals mentioned above, each output can be wired to a user-defined signal ("UserOutput1", "SequencerOut 0" or disabled ("OFF").

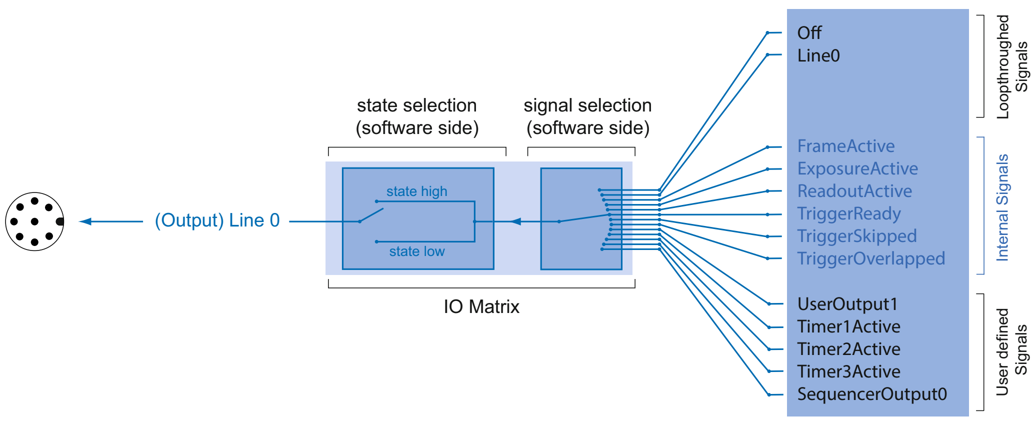


Figure 39 ►
IO matrix of the Baumer LXC on output side.

10.7 Trigger Input / Trigger Delay

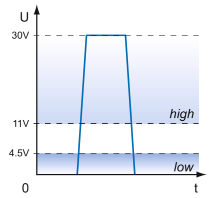


Figure 40 ▲
Trigger signal, valid for Baumer cameras.

Trigger signals are used to synchronize the camera exposure and a machine cycle or, in case of a software trigger, to take images at predefined time intervals.

Different trigger sources can be used here:

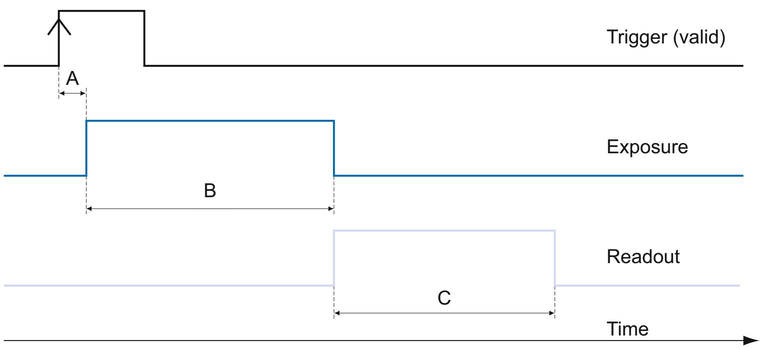
Off	Line0
All	CC 1
Software	

Possible settings of the Trigger Delay: :

Delay:	0-2 sec
Number of tracked Triggers:	512
Step:	1 µsec

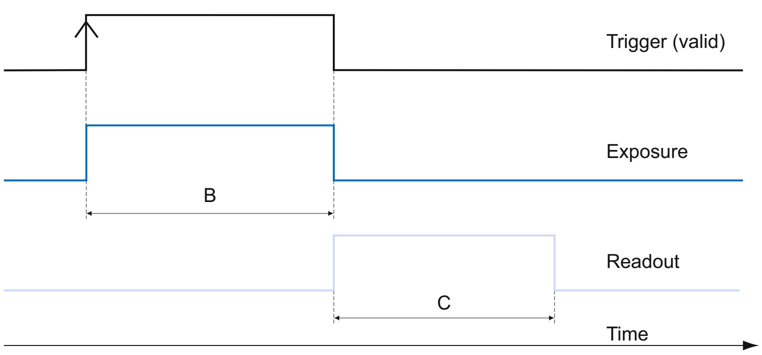
There are three types of modes. The timing diagrams for the three types you can see below.

Normal Trigger with adjusted Exposure



Camera in trigger mode:
A - Trigger delay
B - Exposure time
C - Readout time

Pulse Width controlled Exposure



10.7.1 Trigger Source

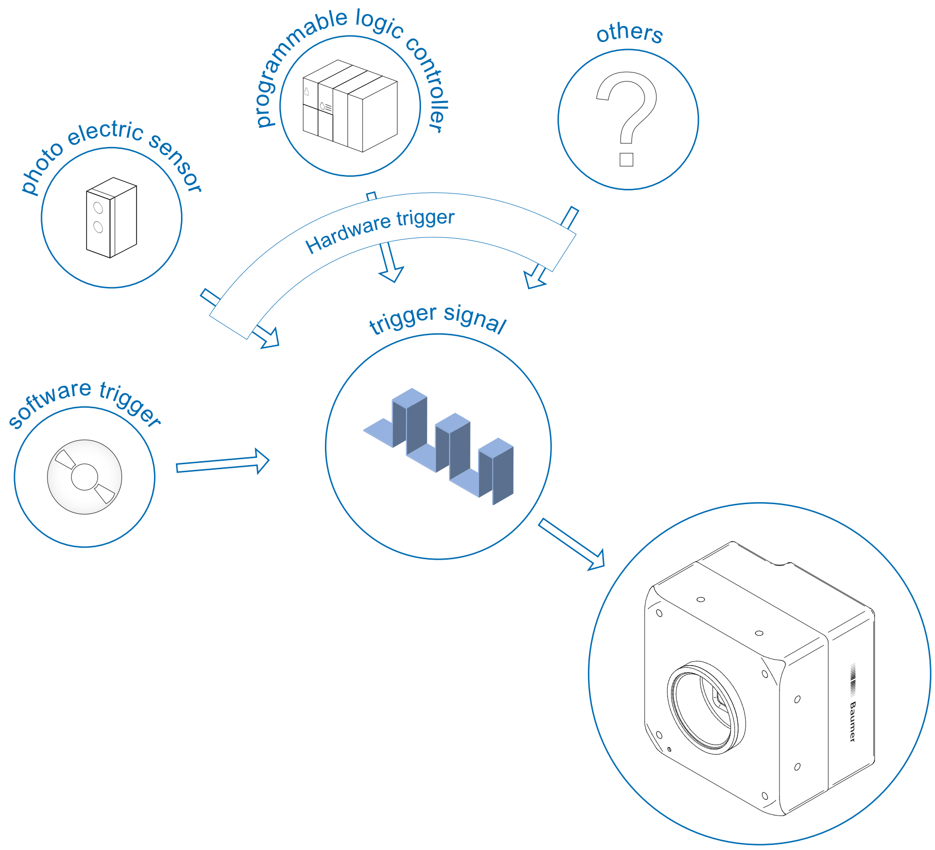


Figure 41 ►
Examples of possible trigger sources.

Each trigger source has to be activated separately. When the trigger mode is activated, the hardware trigger is activated by default.

10.7.2 Debouncer

The basic idea behind this feature was to seperate interfering signals (short peaks) from valid square wave signals, which can be important in industrial environments. Debouncing means that invalid signals are filtered out, and signals lasting longer than a user-defined testing time $t_{DebounceHigh}$ will be recognized, and routed to the camera to induce a trigger.

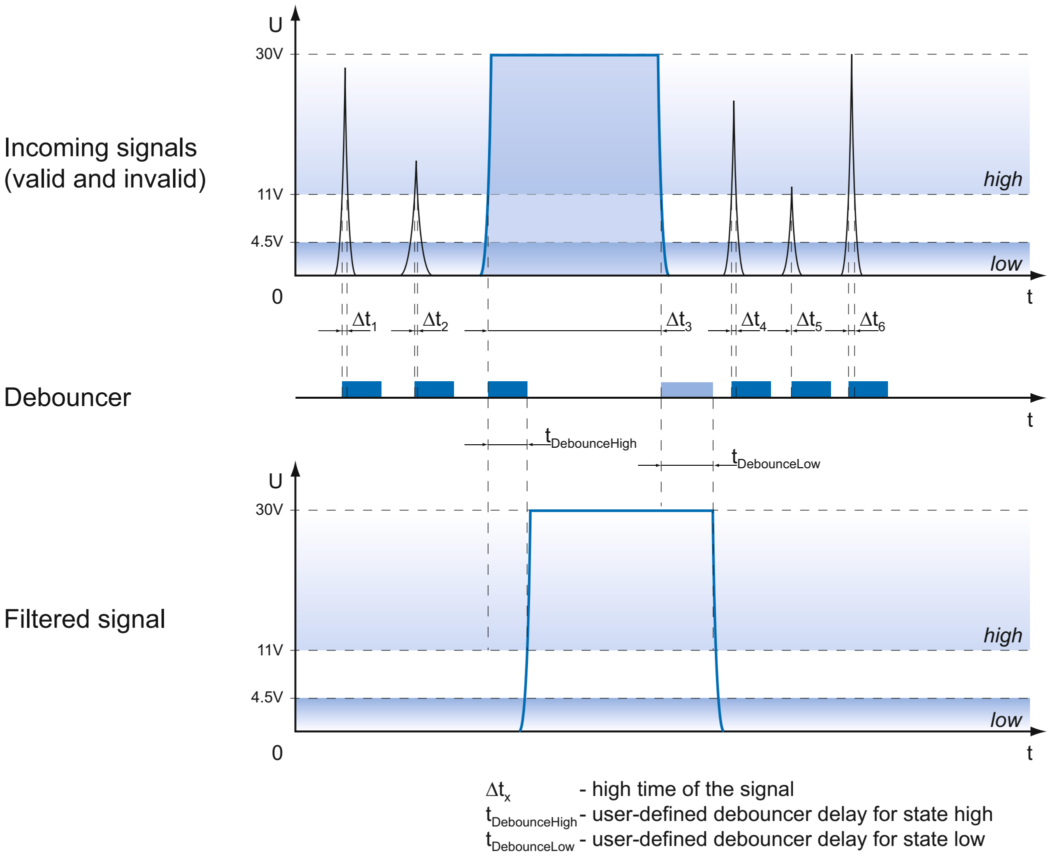
In order to detect the end of a valid signal and filter out possible jitters within the signal, a second testing time $t_{DebounceLow}$ was introduced. This timing is also adjustable by the user. If the signal value falls to state low and does not rise within $t_{DebounceLow}$, this is recognized as end of the signal.

The debouncing times $t_{DebounceHigh}$ and $t_{DebounceLow}$ are adjustable from 0 to 5 msec in steps of 1 µsec.

This feature is disabled by default.

Debouncer:

Please note that the edges of valid trigger signals are shifted by $t_{DebounceHigh}$ and $t_{DebounceLow}$!
Depending on these two timings, the trigger signal might be temporally stretched or compressed.



◄ **Figure 42**
Principle of the Baumer debouncer.

10.7.3 Flash Signal

On Baumer cameras, this feature is realized by the internal signal "ExposureActive", which can be wired to one of the digital outputs.

10.7.4 Timer

Timers were introduced for advanced control of internal camera signals.

On Baumer LXC cameras the timer configuration includes four components:

Setting	Description
TimeSelector	There are three timers. Own settings for each timer can be made. (Timer1, Timer2, Timer3)
TimerTriggerSource	This feature provides a source selection for each timer.
TimerTriggerActivation	This feature selects that part of the trigger signal (edges or states) that activates the timer.
TimerDelay	This feature represents the interval between incoming trigger signal and the start of the timer. (0 µsec .. 2 sec, step: 1 µsec)
TimerDuration	By this feature the activation time of the timer is adjustable. (10 µsec .. 2 sec, step: 1 µsec)

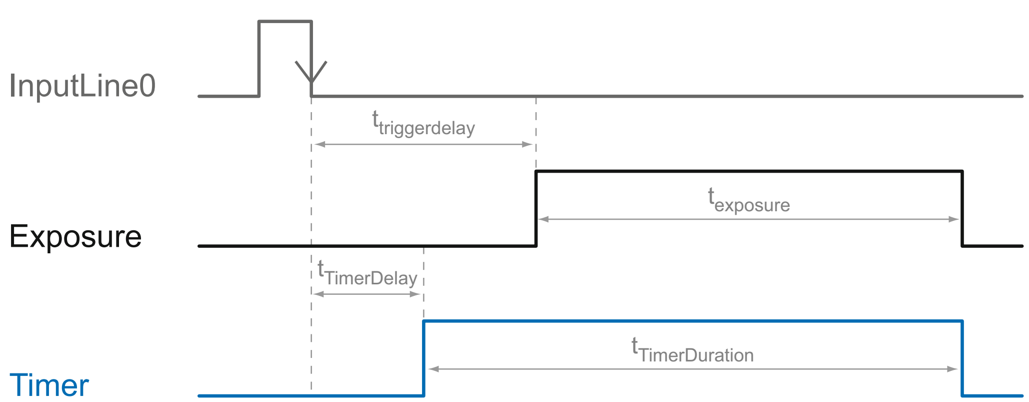
Different Timer sources can be used:

Off	Exposure Start
CC 1	Trigger Skipped
Software	Frame End
Line 0	Exposure End
Frame Start	

For example the using of a timer allows you to control the flash signal in that way, that the illumination does not start synchronized to the sensor exposure but a predefined interval earlier.

For this example you must set the following conditions:

Setting	Value
TriggerSource	Line0
TimerTriggerSource	Line0
Outputline1 (Source)	Timer1Active
TimerTriggerActivation	Falling Edge
Trigger Polarity	Falling Edge



10.8 User Sets

Three user sets (1-3) are available for the Baumer LXC cameras. The user sets can contain the following information:

Parameter	
AcquisitionFrameRate	ExposureTime
AcquisitionFrameRateEnable	FixedPatternNoiseCorrection
BinningHorizontal	FrameCounter
BinningVertical	Gain
BlackLevel	Gamma
BlackReferenceCorrectionEnable	HDREnable
BoSequencerEnable	Height
BoSequencerExposure	LUTEnable
BoSequencerFramesPerTrigger	LineDebouncerHighTimeAbs
BoSequencerGain	LineDebouncerLowTimeAbs
BoSequencerIOStatus	LineInverter
BoSequencerLoops	LineSource
BoSequencerMode	OffsetX
BoSequencerOffsetX	OffsetY
BoSequencerOffsetY	PixelFormat
BoSequencerSetNumberOfSets	ReadoutMode
BoSequencerSetRepeats	RegionMode
BoSequencerStart	ReverseX
BrightnessCorrection	ReverseY
CLFVALLowTime	SensorEffectCorrection
CLLVALLowTime	TestPattern
ChunkEnable	TimerDelay
ChunkModeActive	TimerDuration
DecimationHorizontal	TimerTriggerActivation
DecimationVertical	TimerTriggerSource
DefectPixelCorrection	TriggerActivation
DeviceClockFrequency	TriggerDelay
DeviceTapGeometry	TriggerMode
EventNotification	TriggerSource

These user sets are stored within the camera and and cannot be saved outside the device.

By employing a so-called "user set default selector", one of the three possible user sets can be selected as default, which means, the camera starts up with these adjusted parameters.

10.9 Factory Settings

The factory settings are stored in an additional parametrization set which is used by default. This settings are not editable.

11. Camera Link® Interface

The Camera Link® interface was specifically developed for cameras in machine vision applications and provides high transfer rates and low latency. Depending on the configuration (Base, Medium or Full) the transfer rate adds up to 850 MBytes/sec.

Cameras of the Baumer LXC series are equipped with a Camera Link® Full interface and therewith able to transmit up to 850 MBytes/sec.

11.1 Channel Link and LVDS Technology

Camera Link® bases upon the Channel Link® technology, but provides a specification, that is more beneficial for machine vision.

Channel Link® in turn is an advancement of the LDVS (Low Voltage Differential Signaling) standard – a low power, high speed interface standard.

The Channel Link® technology consists of a transmitter receiver pair with 21, 28 or 48 single-ended data signals and a single-ended clock signal can be wired on transmitter side. Within the transmitter the data is serialized with a ratio of 7:1. Afterwards the four resulting data streams and the clock signal are transferred via five LVDS pairs. On receiver side the four LVDS data streams and the LVDS clock are reordered to parallel signals and afterwards forwarded to further processing.

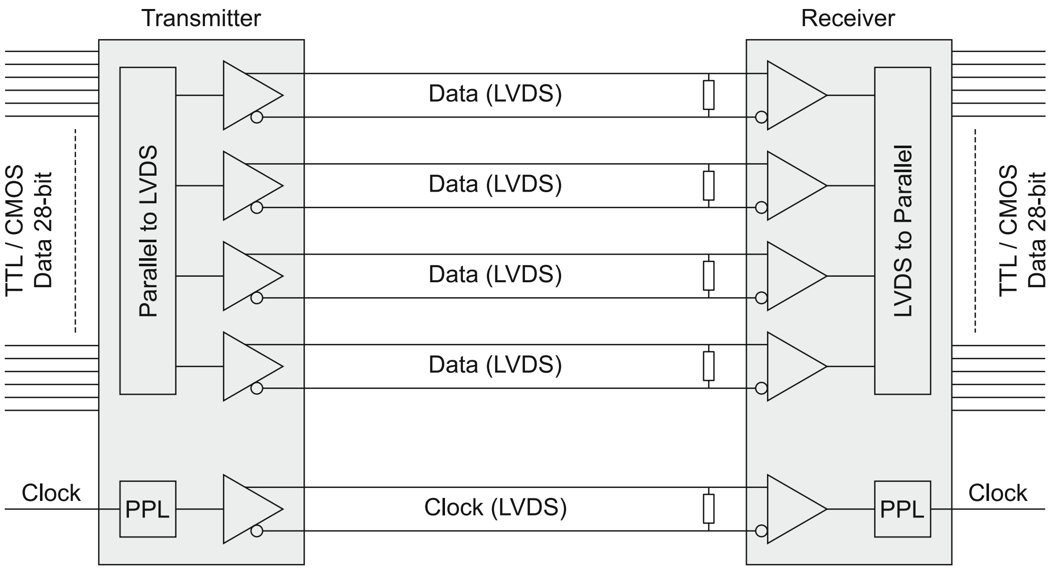


Figure 43 ▶ Channel Link® operation.

11.2 Camera Signals

The standard designates three different signal types, provided via standard Camera Link® cable:

11.2.1 Serial Communication

The standard regulates two LVDS pairs are allocated for asynchronous serial communication between the camera and the frame grabber. Cameras and frame grabbers should support at least 9600 baud serial communication.

Supported baud rates	
9600	115200
19200	230400
38400	460800
57600	921600

The following signals are designated:

Signal	Description
SerTFG	LVDS pair for serial communications to the frame grabber
SerTC	LVDS pair for serial communications to the camera

The serial interface must apply the following regulations:
- one start bit,
- one stop bit,
- no parity and
- no handshaking.

11.2.2 Camera Control

According to the Camera Link® standard four LVDS pairs have to be reserved for general-purpose camera control. They are defined as frame grabber outputs and camera inputs. The definition of these signals is left to the camera manufacturer.

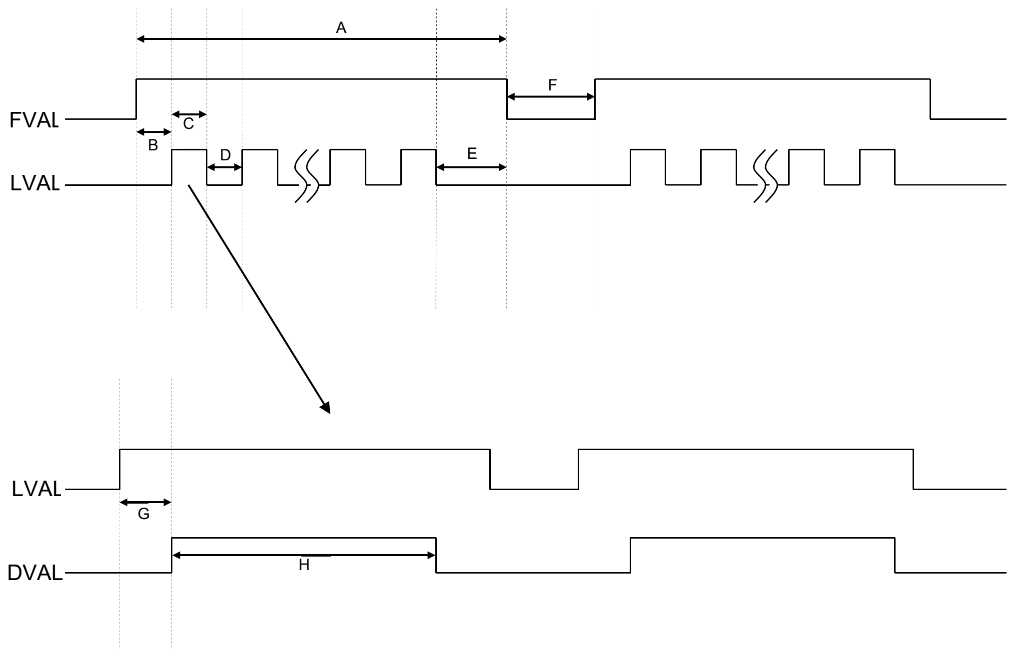
Signal	Baumer Naming	Employment
Camera Control 1 (CC1)	CC1	On Baumer LXC cameras, the wiring of these signals is arbitrary.
Camera Control 2 (CC2)	unused	
Camera Control 3 (CC3)	unused	
Camera Control 4 (CC4)	unused	

11.2.3 Video Data

The standard designates three signals (as well as the signal state) for the validation of transmitted image data:

Signal	Description
FVAL	Frame Valid is defined high for valid lines.
LVAL	Line Valid is defined high for valid pixels.
DVAL	Data Valid is defined high for valid data.

Signal Timing



	Description	Value
A	The time of FVAL High	depends on line numbers
B	The time from the rising edge of FVAL to the rising edge of LVAL	0
C	The time of LVAL High	depends on the CL TAP Format and pixel per line
D	The time of LVAL Low	4 * clock cycle
E	The time from the falling edge of LVAL to the falling edge of FVAL	0
F	The time of FVAL Low	64 * clock cycle
G	The time from the rising edge of LVAL to the rising edge of DVAL	0
H	The time of DVAL High	DVAL = LVAL

Notice

Depending on the used frame grabber, the frame may flicker if the values for the camera features *CLLVALLowTime* (**D**) and *CLFVALLowTime* (**F**) are set at an unfavorable level. Increase the values.

The change can cause a slight reduction in the frame rate. Ask the manufacturer of the frame grabber for the optimal values.

11.3 Camera Link® Taps

The standard defines a tap as "the data path carrying a stream of pixels". This means the number of taps equates to the number of simultaneously transferred pixel.

Notice

Please do not mix up sensor digitization taps and Camera Link® taps!

11.3.1 Tap Configuration

Within the subsequent sections, the transmission of images with different pixel formats (bit depth) linked to the employment of different numbers of taps is displayed.

The following table shows the adjustable tap configurations.

Configuration	Cables
CL Base (1T8, 2T8, 3T8, 1T10, 2T10, 1T12, 2T12)	1
CL Medium (3T10, 3T12, 4T8, 4T10 4T12)	2
CL Full (8T8)	2
CL Eighty Bit (10T8, 8T10)	2

Notice

nTx
n = number of pixels
x = bit depth

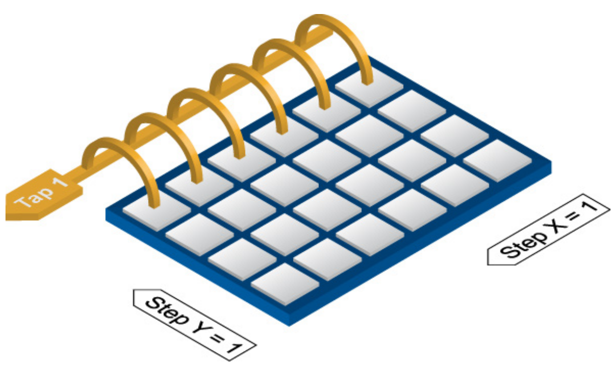
(e.g. 1T8=1 pixel, 8 bit)

11.3.2 Tap Geometry

Since frame grabbers possess the ability of image reconstruction from multi-tap cameras "on-the-fly", the Camera Link® standards demands the specification of the used / supported tap geometries from the manufacturers of both, cameras and frame grabbers.

11.3.2.1 Single Tap Geometry

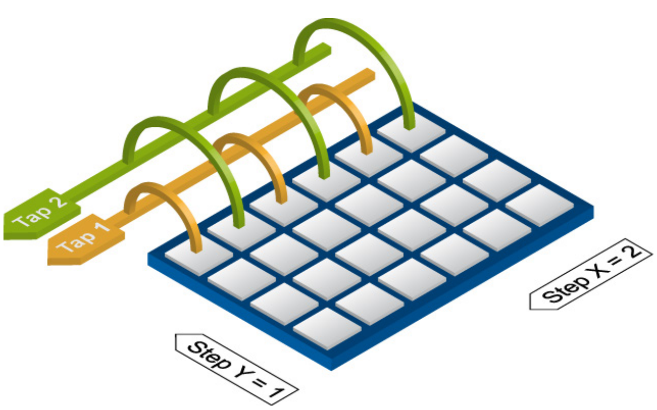
For single tap transmission the cameras of the Baumer LXC series employ the 1X-1Y tap geometry:



◄ **Figure 44**
Tap geometry 1X-1Y. The pixel information is transmitted pixel-by-pixel and line-by-line.

11.3.2.2 Dual Tap Geometry

For dual tap transmission the cameras of the Baumer LXC series employ the 1X2-1Y tap geometry:



◄ **Figure 45**
Tap geometry 1X2-1Y.

11.3.2.3 Triple Tap Geometry

For triple tap transmission the cameras of the Baumer LXC series employ the 1X3-1Y tap geometry:

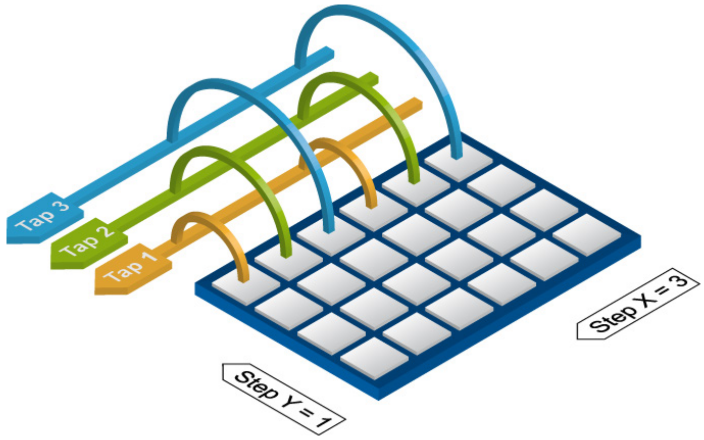


Figure 46 ▶
Tap geometry 1X3-1Y.

11.3.2.4 Quad, Eight and Ten Tap Geometry

For Quad, Eight and Ten tap transmission the cameras of the Baumer LXC series use the same system.

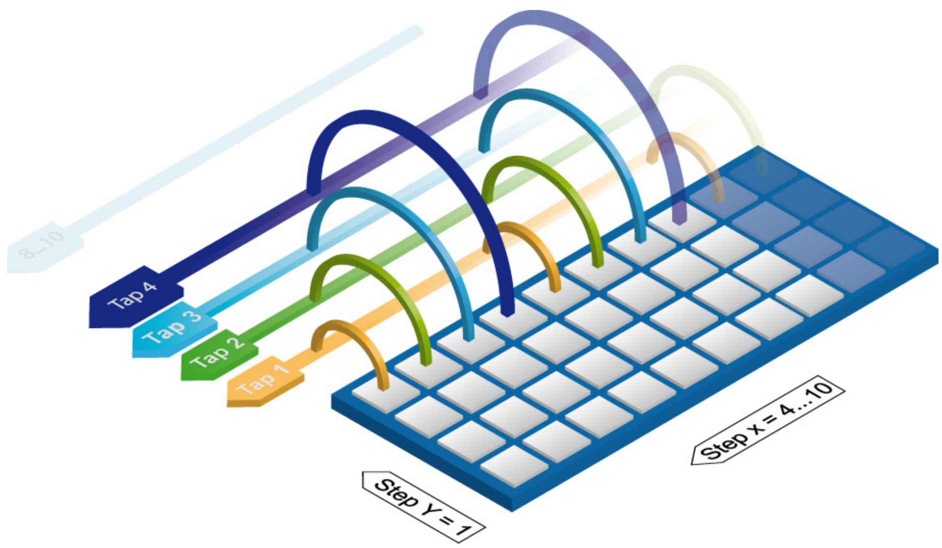


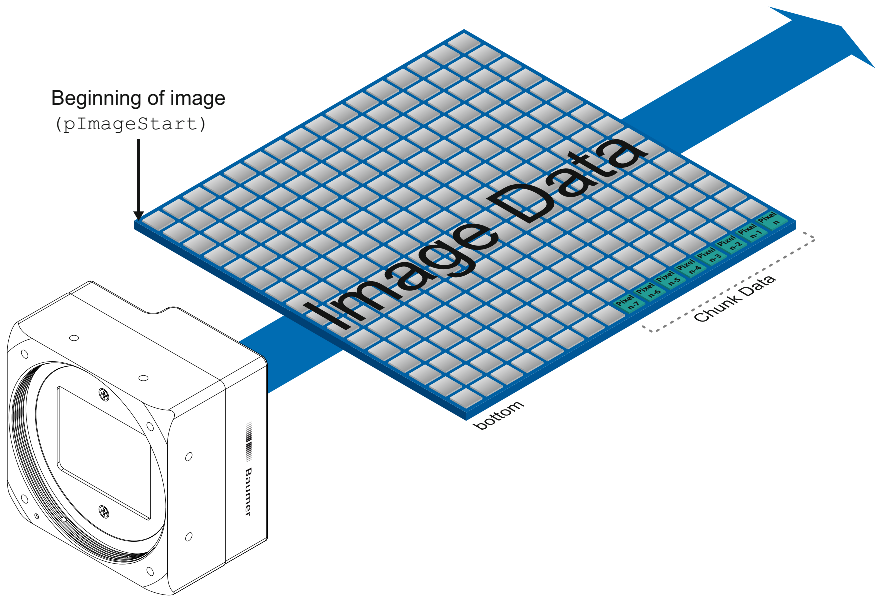
Figure 47 ▶
Tap geometry 1X4...10-1Y.

11.4 Chunk Data

The chunk provides additional information about the respective image (e.g. the time-stamp). When using Baumer LXC cameras, this information is encoded into the last eight pixels of the image.

This additional information can include:

Information	Description
CRC32	Delivers a checksum which ensures that the image is transmitted correctly.
RegionID	Delivers the ID of the Region (Multi-ROI)from which the image originates.
FrameID	Delivers a unique ID for the image in the form of a number.
Timestamp	Delivers a timestamp for each image.



The chunk data is assigned to the last 8 pixels as follows, depending on the settings:

<table>
<tr><th>Combination</th><th>Pixel n-7</th><th>Pixel n-6</th><th>Pixel n-5</th><th>Pixel n-4</th><th>Pixel n-3</th><th>Pixel n-2</th><th>Pixel n-1</th><th>Pixel n</th></tr>
<tr><td>1</td><td colspan="8">Bit 0 Timestamp Bit 63</td></tr>
<tr><td>2</td><td colspan="4">Bit 0 CRC32 Bit 31</td><td colspan="4">Bit 0 RegionID Bit 31</td></tr>
<tr><td>3</td><td colspan="4">Bit 0 CRC32 Bit 31</td><td colspan="4">Bit 0 FrameID Bit 31</td></tr>
<tr><td>4</td><td colspan="4">Bit 0 FrameID Bit 31</td><td colspan="4">Bit 0 RegionID Bit 31</td></tr>
<tr><td>5</td><td colspan="4">Bit 0 RegionID Bit 31</td><td colspan="4">Bit 0 0 Bit 31</td></tr>
<tr><td>6</td><td colspan="4">Bit 0 FrameID Bit 31</td><td colspan="4">Bit 0 0 Bit 31</td></tr>
<tr><td>7</td><td colspan="4">Bit 0 CRC32 Bit 31</td><td colspan="4">Bit 0 0 Bit 31</td></tr>
</table>

Notice

The programming of the chunk request is described in the document:

AN201517_Baumer_Application_Note_Chunk_LXC_EN.pdf

Latest software version and technical documentation are available at:
www.baumer.com/vision/login (Registration required.)

12. Cleaning

Avoid cleaning if possible. To prevent dust, follow the instructions under *Installation*.

Notice

Perform the cleaning in a dust-free room with clean tools. Use localized ionized air flow on to the glass during cleaning.

12.1 Sensor

Recommended Equipment

- Microscope
- Air gun
- Single drop bottle with pure alcohol
- Swab
- Phillips screwdriver

Procedure

1. Make sure that the contamination is not on the sensor glass (except LXC-20M, LXC-40M) or the installed lens.

2. Uninstall the lens mount adapter (except LXC-20M, LXC-40M). Uninstall the sensor glass (except LXC-20M, LXC-40M) using the phillips screw driver.

3. Blow away mobile contamination using the air gun.

4. Place the sensor under the microscope to determine the location of any remaining contamination.

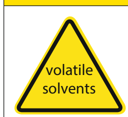
5. Clean the contamination on the sensor using one drop pure alcohol on a swab. Wipe the swab from left to right (or conversely, but only in one direction). Do this in an overlapping pattern, turning the swab after the first wipe and with each subsequent wipe. Avoid swiping back and forth with the same swab in order to ensure that particles are removed and not transferred to a new location on the sensor. Use several swabs for this procedure.

12.2 Cover glass

If you must clean it, use compressed air or a soft, lint free cloth dampened with a small quantity of pure alcohol.

12.3 Housing

⚠ Caution!



Volatile solvents for cleaning.
Volatile solvents damage the surface of the camera.
Never use volatile solvents (benzine, thinner) for cleaning!

To clean the surface of the camera housing, use a soft, dry cloth. To remove persistent stains, use a soft cloth dampened with a small quantity of neutral detergent, then wipe dry.

13. Transport / Storage

Notice

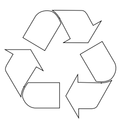
Transport the camera only in the original packaging. When the camera is not installed, then storage the camera in the original packaging.

Storage Environment	
Storage temperature	-10°C ... +70°C (+14°F ... +158°F)
Storage Humidy	10% ... 90% non condensing

14. Disposal

Dispose of outdated products with electrical or electronic circuits, not in the normal domestic waste, but rather according to your national law and the directives 2002/96/EC and 2006/66/EC for recycling within the competent collectors.

Through the proper disposal of obsolete equipment will help to save valuable resources and prevent possible adverse effects on human health and the environment.



The return of the packaging to the material cycle helps conserve raw materials an reduces the production of waste. When no longer required, dispose of the packaging materials in accordance with the local regulations in force.

Keep the original packaging during the warranty period in order to be able to pack the device in the event of a warranty claim.

15. Warranty Information

Notice

There are no adjustable parts inside the camera!

In order to avoid the loss of warranty do not open the housing!

Notice

If it is obvious that the device is / was dismantled, reworked or repaired by other than Baumer technicians, Baumer will not take any responsibility for the subsequent performance and quality of the device!

16. Conformity

Baumer LXC cameras comply with:
- CE
- RoHS

16.1 CE

We declare, under our sole responsibility, that the previously described Baumer LXC cameras conform with the directives of the CE (electromagnetic compatibility (EMC) 2004/108EC).

16.2 RoHS

All LXC cameras comply with the recommendation of the European Union concerning RoHS Rules.

16.3 Korean Conformity

Registration of Broadcasting and Communication Equipments

Several of the described Baumer LXC cameras conform with the directives of the Korean Conformity.

Product	Article No.	Registration No.	Date of Registration
LXC-200M	11148673	R-R-BkR--LXC-200M	2020-07-31
LXC-200C	11148674	R-R-BkR--LXC-200M	2020-07-31

17. Support

In the case of any questions please contact our Technical & Application Support Center.

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