

## User's Guide

### LXG cameras with *VisualApplets* (Gigabit Ethernet)

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# 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.

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## 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



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

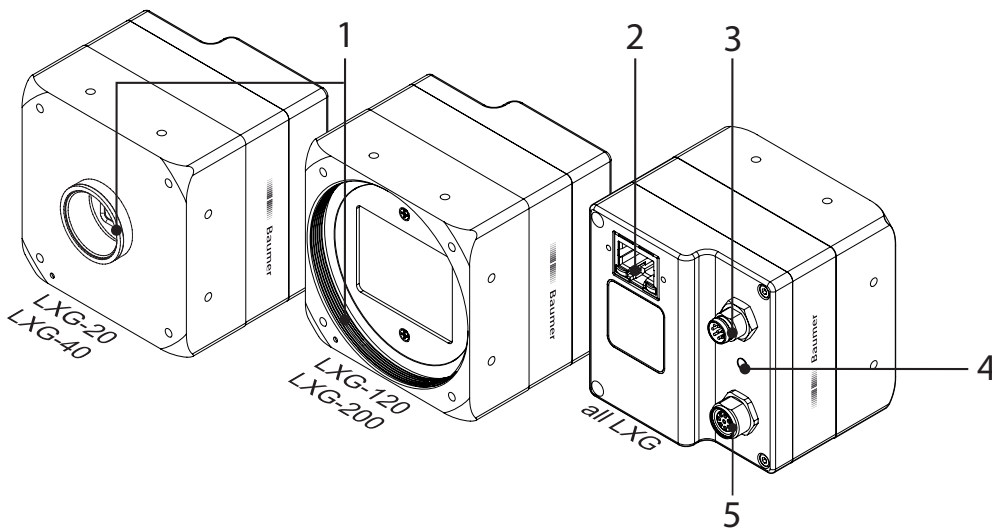
The camera is used to capture images that can be transferred over a GigE interface to a PC.

### 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

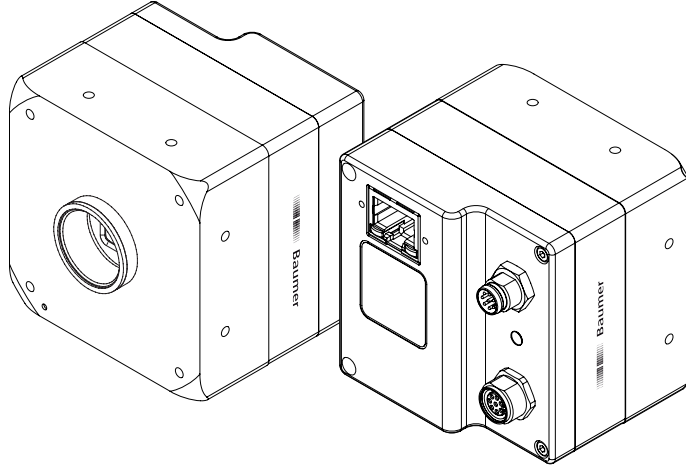


No.	Description	No.	Description
1	LXG-20 / 40 C-mount only.  LXG-120 / 200 lens mount (M58), adapter for other lens mounts available	4	Signaling LED
2	Data Port 1 (PoE)	5	Digital-I/O (RS485)
3	Power Supply / Digital-I/O		

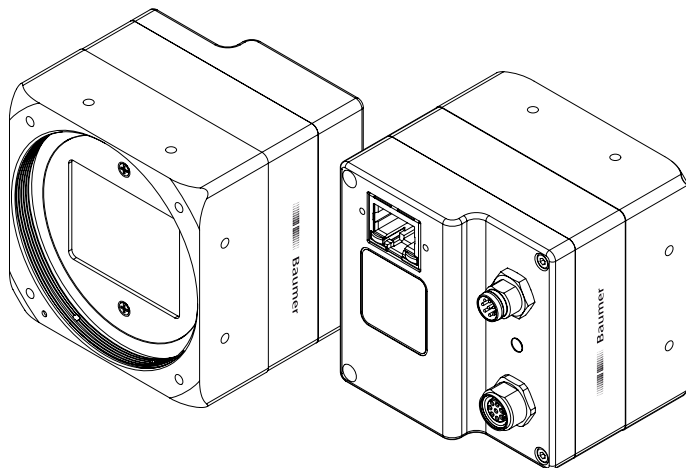
## 5. Camera Models

### 5.1 LXG – Cameras with *VisualApplets*

LXG-20M.PS / LXG-20C.P / LXG-40M.P



LXG-120M.PS / LXG-120M.P / LXG-200M.P



Camera Type	Sensor Size	Resolution	Full Frames <sup>1)</sup> [max. fps]
<b>Monochrome</b>			
LXG-20M.PS	2/3"	2018 × 1088	338
LXG-40M.P	1"	2048 × 2048	74
LXG-120M.PS	APS-C	4096 × 3072	60
LXG-120M.P	APS-C	4096 × 3072	25
LXG-200M.P	35 mm	5120 × 3840	16
<b>Color</b>			
LXG-20C.P	2/3"	2048 × 1088	140

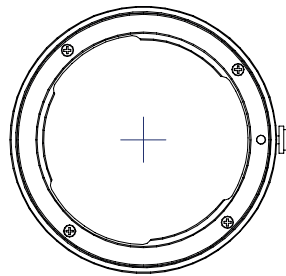
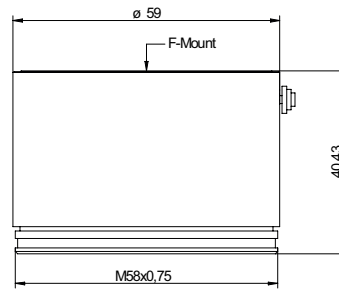
<sup>1)</sup> sensor frame rate





## 5.2 Lens mount Adapter

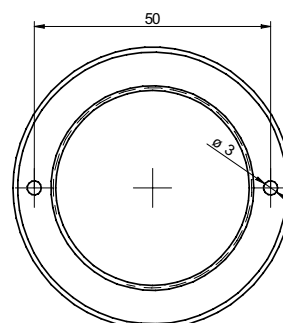
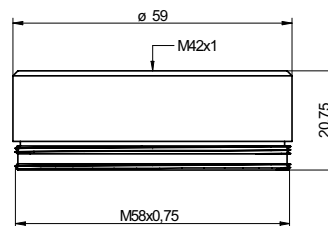
### Adapter M58 / F-mount (Art. No.: 11117852)



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

#### Notice

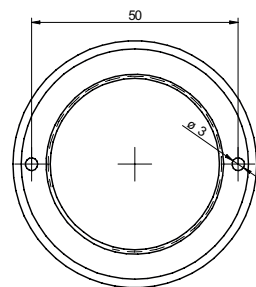
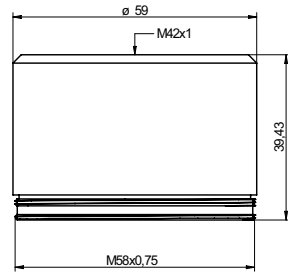
suitable for Zeiss M42 lenses (e.g. Biogon T\* 2.8/21 Z-M42-I, Biogon T\* 2/35 Z-M42-I, C Sonnar T\* 1.5/50 Z-M42-I)



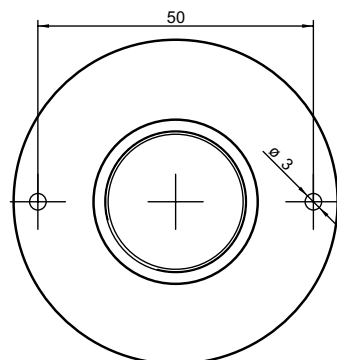
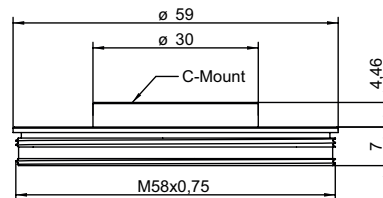
**Adapter M58 / M42x1-mount (45.5 mm) (Art. No: 11137781)**

**Notice**

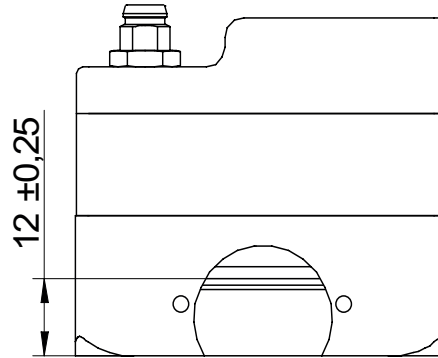
suitable for Zeiss (e.g. Distagon T\* 2/25 Z-M42-I, Planar T\* 1.4/50 Z-M42-I, Makro-Planar T\* 2/50 Z-M42-I) and KOWA M42 lenses (e.g. LM28LF P-mount, LM35LF P-mount)



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



## 5.3 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

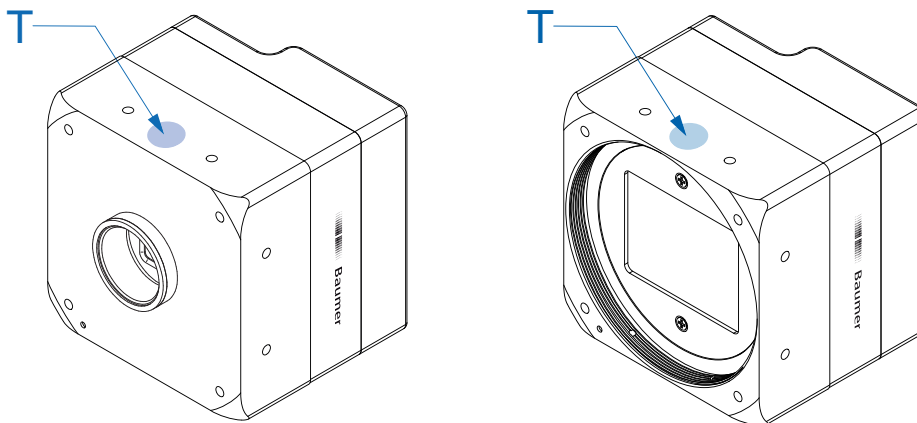
Provide adequate dissipation of heat, to ensure that the temperature does not exceed +50 °C (+122 °F) at temperature measurement point T.

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 specify 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 LXG cameras with VisualApplets.

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).

### 6.3 Mechanical Tests

Tested with C-Mount adapter adapter and lens dummy.

<b>Environmental Testing</b>	<b>Standard</b>	<b>Parameter</b>	
Vibration, sinussoidal	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

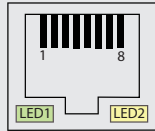
## 7. Process- and Data Interface

### 7.1 Pin-Assignment Interface

#### Notice

The Data Port supports Power over Ethernet (36 VDC .. 57 VDC).

#### Data / Control 1000 Base-T



1 MX1+ (green/white) (negative/positive $V_{port}$ )	5 MX3- (blue/white)
2 MX1- (green) (negative/positive $V_{port}$ )	6 MX2- (orange) (positive/negative $V_{port}$ )
3 MX2+ (orange/white) (positive/negative $V_{port}$ )	7 MX4+ (brown/white)
4 MX3+ (blue)	8 MX4- (brown)

### 7.2 Pin-Assignment Power Supply and Digital-IOs

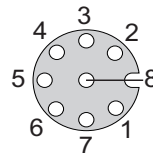
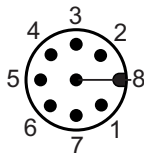
#### Power and Process Interface #1

(SACC-DSI-M8FS-8CON-M10-L180 SH)

#### Power and Process Interface #2

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

#### M8 / 8 pins wire colors of the connecting cable

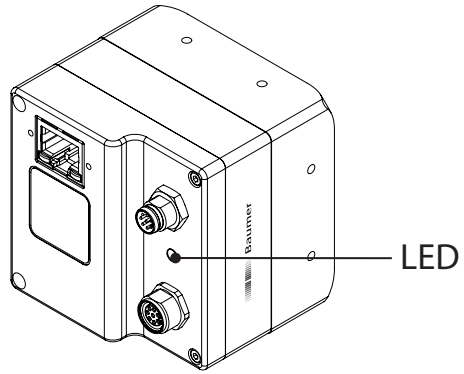


1	white	OUT 3 (line 3)	1	white	In2_RS485+ (line4)
2	brown	Power VCC+	2	brown	In2_RS485- (line4)
3	green	IN 1 (line 0)	3	green	In2_RS485+ (line5)
4	yellow	IO GND	4	yellow	In2_RS485- (line5)
5	grey	IO Power VCC	5	grey	OUT3_In2_RS485+ (line6)
6	pink	OUT 1 (line 1)	6	pink	OUT3_In2_RS485- (line6)
7	blue	Power GND	7	blue	external Power GND
8	red	OUT 2 (line 2)	8	red	external Power 5 V/200 mA

#### Power Supply

Power VCC	12 VDC ... 24 VDC
-----------	-------------------

## 7.3 LED Signaling



**Figure 3** ▶

LED positions on Baumer LXG cameras.

	Signal	Meaning
<b>Camera LED</b>	green on	Power on, link good
	green blinking	Power on, no link
	red on	Error
	red blinking	Warning (update in progress, don't switch off)
	yellow	Readout active



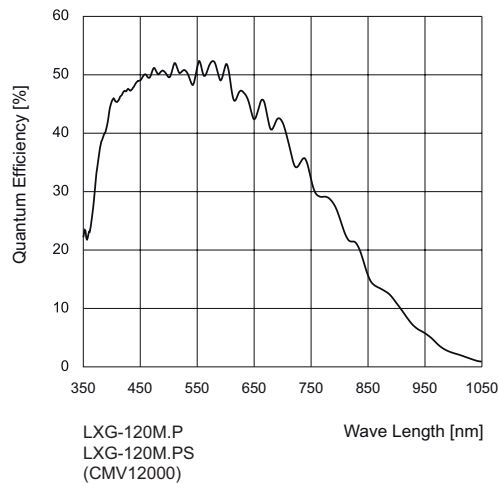
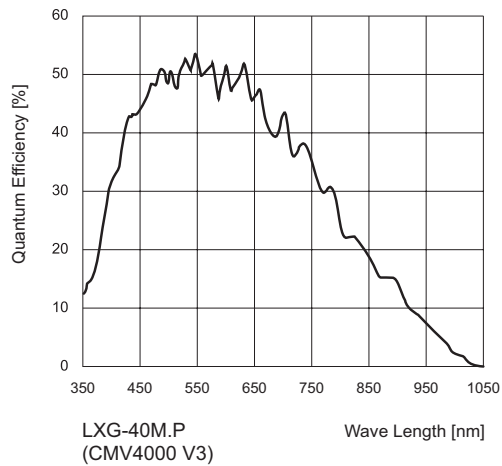
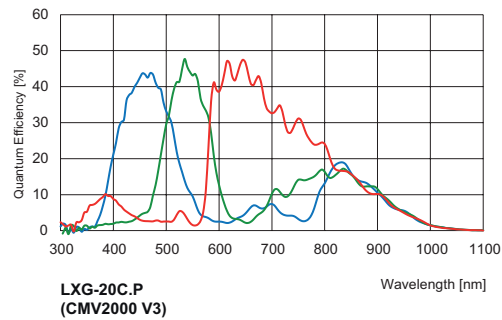
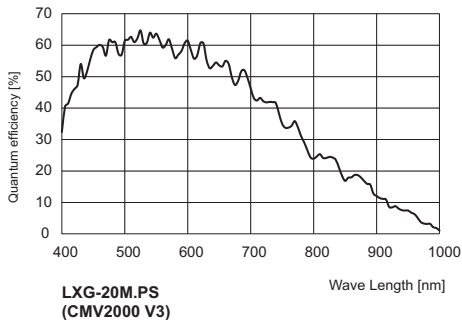
## 8. Product Specifications

### 8.1 Sensor Specifications

#### 8.1.1 Quantum Efficiency for Baumer LXG - Cameras with *VisualApplets*

The quantum efficiency characteristics of Baumer LXG - cameras with *VisualApplets* are displayed in the following graphs.

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



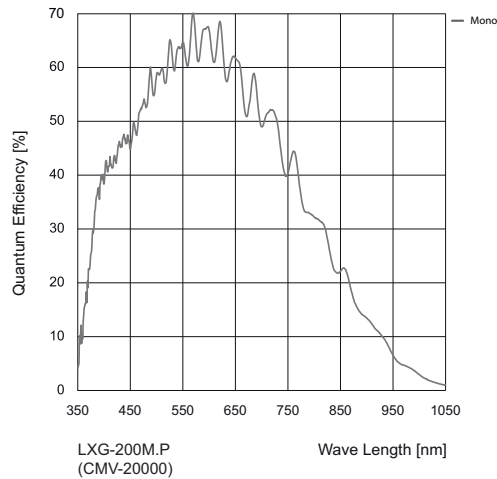


Figure 4 ▶

Quantum efficiency for Baumer LXG cameras with *VisualApplets*.

### 8.1.2 Shutter

All cameras of the LXG - camera with *VisualApplets* series are equipped with a global shutter.

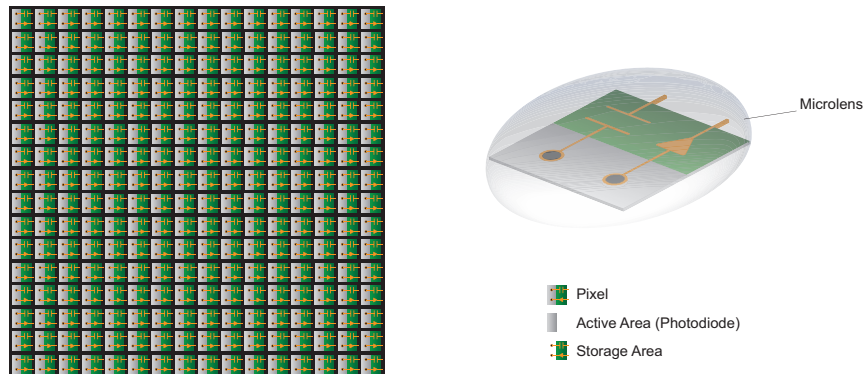


Figure 5 ▶

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 ( $t_{\text{exposure}}$ ).

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 are read out with 16 channels in parallel.

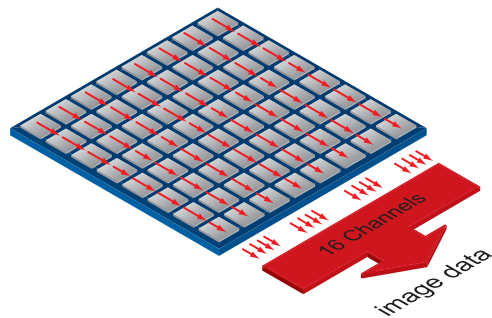
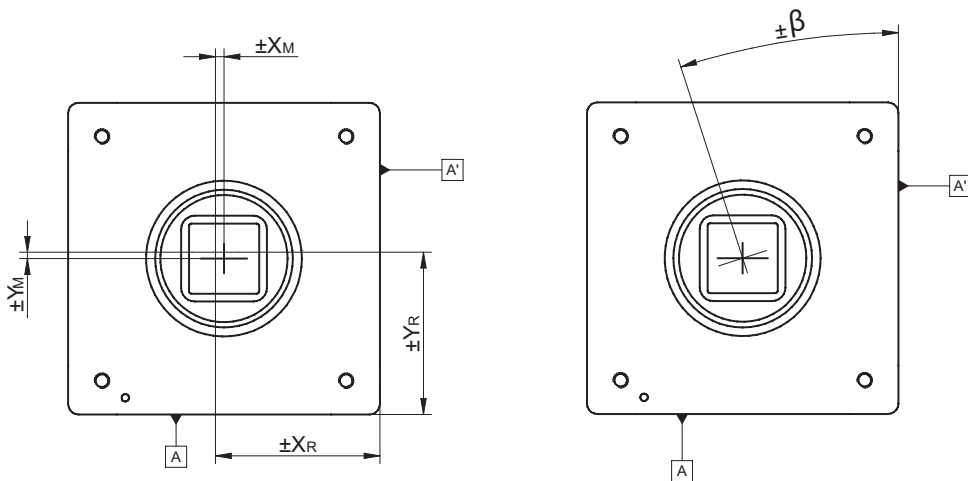


Figure 6 ▶

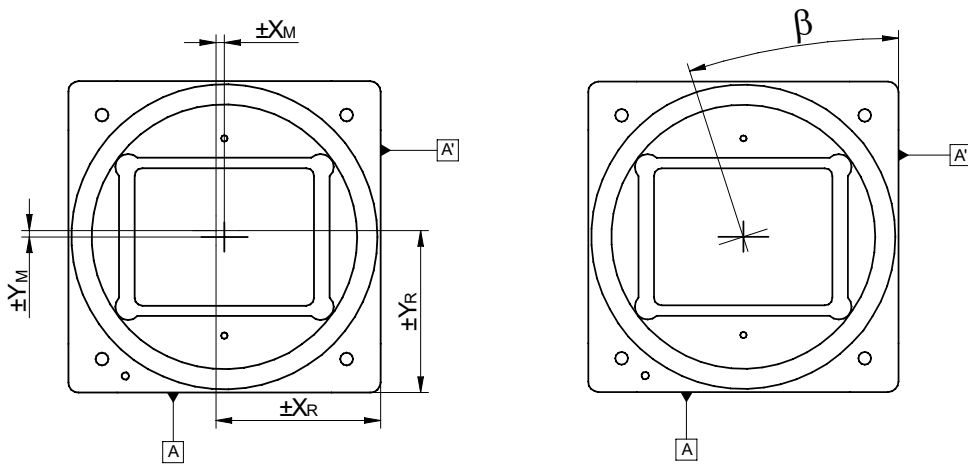
Digitization Tap of the Baumer LXG cameras with *VisualApplets* Readout with 16 channel

### 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:



LXG-20C.P / LXG-20M.P / LXG-40M.P



LXG-120M.PS / LXG-120M.P / LXG-200M.P

◀ **Figure 7**  
Sensor accuracy of  
Baumer LXG cameras  
with *VisualApplets*.

Camera Type	$\pm x_{M,typ}$ [mm]	$\pm y_{M,typ}$ [mm]	$\pm x_{R,typ}$ [mm]	$\pm y_{R,typ}$ [mm]	$\pm \beta_{typ}$ [°]
LXG-20C.P	0.09	0.09	0.1	0.1	0.4
LXG-20M.PS	0.09	0.09	0.1	0.1	0.4
LXG-40M.P	0.09	0.09	0.1	0.1	0.4
LXG-120M.PS	0.07	0.06	0.08	0.07	0.26
LXG-120M.P	0.07	0.06	0.08	0.07	0.26
LXG-200M.P	0.08	0.08	0.09	0.08	0.27

## 8.2 Timings

### Notice

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

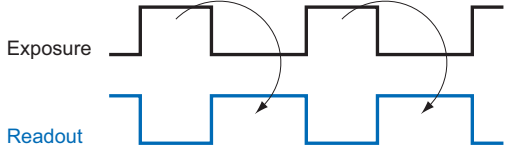
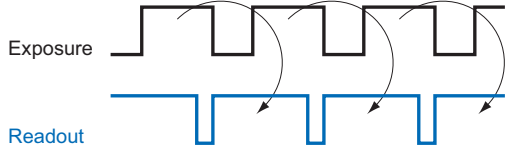
The image acquisition consists of two separate, successively processed components.

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 ( $t_{\text{exposure}}$ ) can be adjusted by the user, however, the time needed for the readout ( $t_{\text{readout}}$ ) 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<sup>1)</sup> or overlapped. Depending on the mode used, and the combination of exposure and readout time:

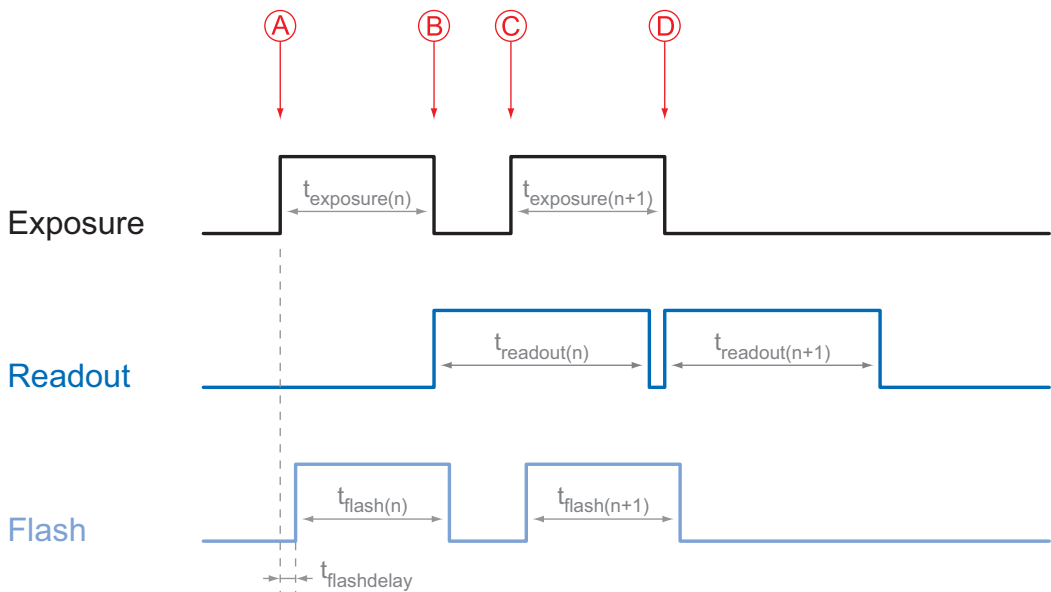
Non-overlapped Operation	Overlapped Operation
Here the time intervals are long enough to process exposure and readout successively.	In this operation the exposure of a frame (n+1) takes place during the readout of frame (n).
	

### 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  $t_{\text{exposure}}$  and image format) the camera is operated overlapped.

In case of exposure times equal to / less than the readout time ( $t_{\text{exposure}} \leq t_{\text{readout}}$ ), 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



$$t_{\text{flash}} = t_{\text{exposure}}$$

Image parameters:
Offset
Gain
Mode
Partial Scan

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:

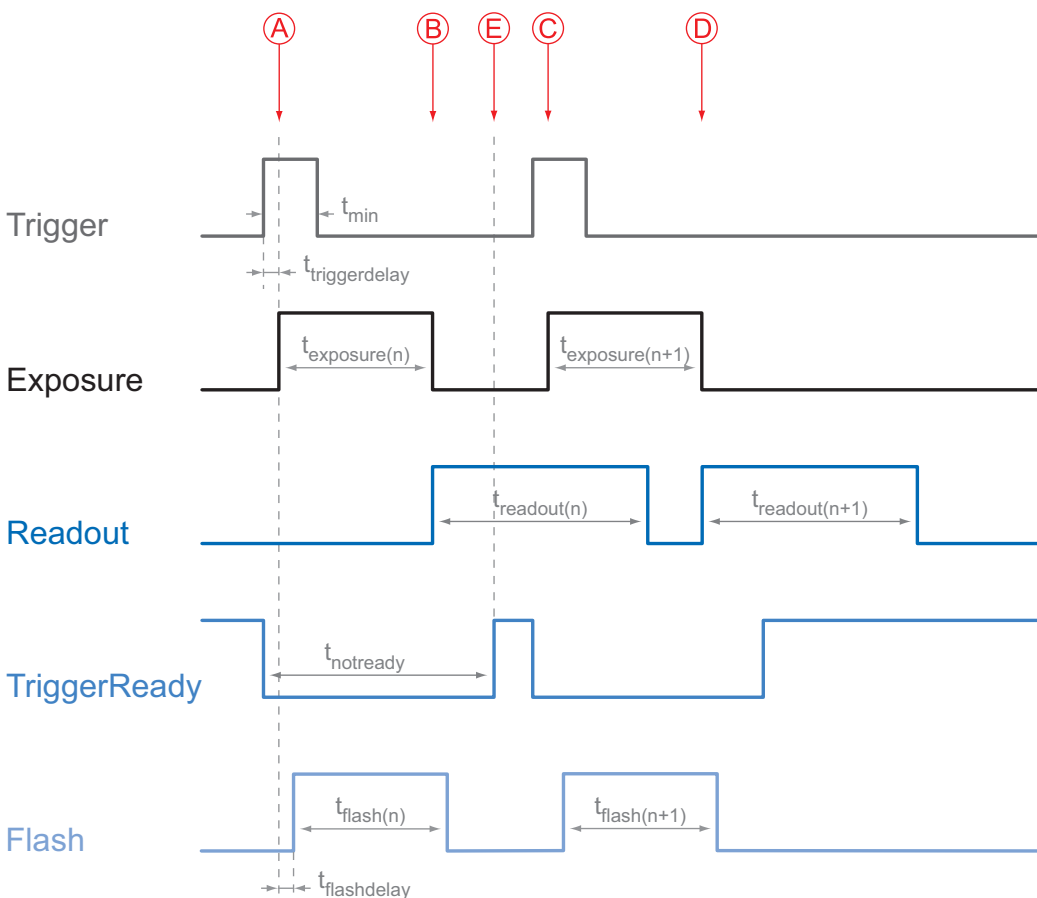
Case	Formula
$t_{\text{exposure}} < t_{\text{readout}}$	(1) $t_{\text{earliestpossibletrigger}(n+1)} = t_{\text{readout}(n)} - t_{\text{exposure}(n+1)}$
	(2) $t_{\text{notready}(n+1)} = t_{\text{exposure}(n)} + t_{\text{readout}(n)} - t_{\text{exposure}(n+1)}$
$t_{\text{exposure}} > t_{\text{readout}}$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

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

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

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

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



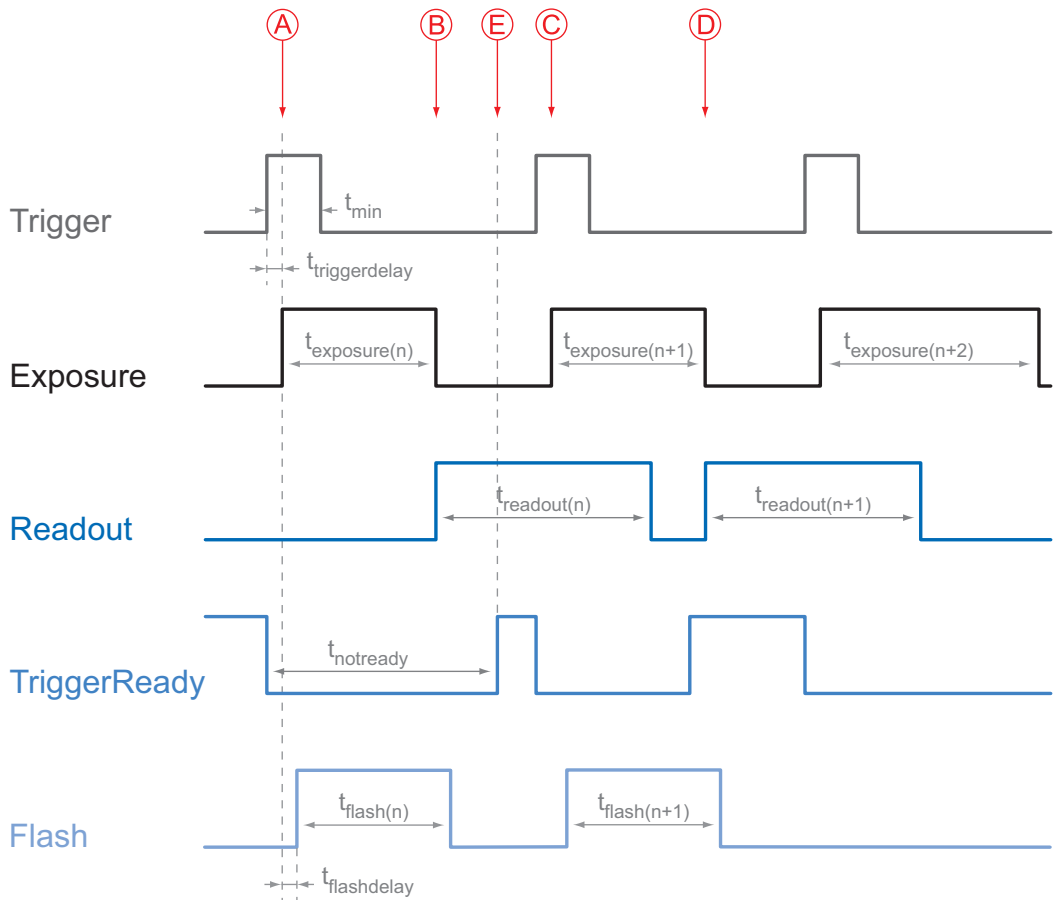
Timings:
A - exposure time frame (n) effective
B - image parameters frame (n) effective
C - exposure time frame (n+1) effective
D - image parameters frame (n+1) effective
E - earliest possible trigger

Image parameters:
Offset
Gain
Mode
Partial Scan

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

If the exposure time ( $t_{\text{exposure}}$ ) is increased from the current acquisition to the next acquisition, the time the camera is unable to process occurring trigger signals ( $t_{\text{notready}}$ ) 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

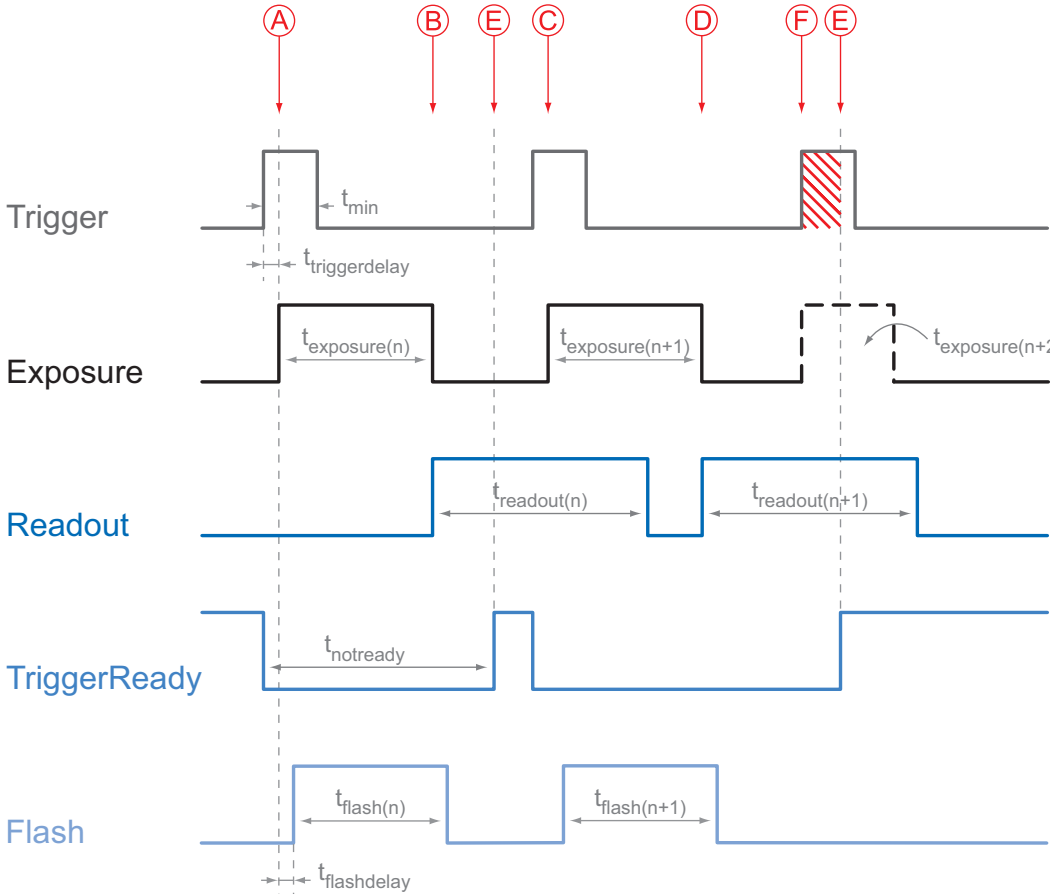
#### Image parameters:

- Offset
- Gain
- Mode
- Partial Scan

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

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

When decreasing the  $t_{\text{exposure}}$  such, that  $t_{\text{notready}}$  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

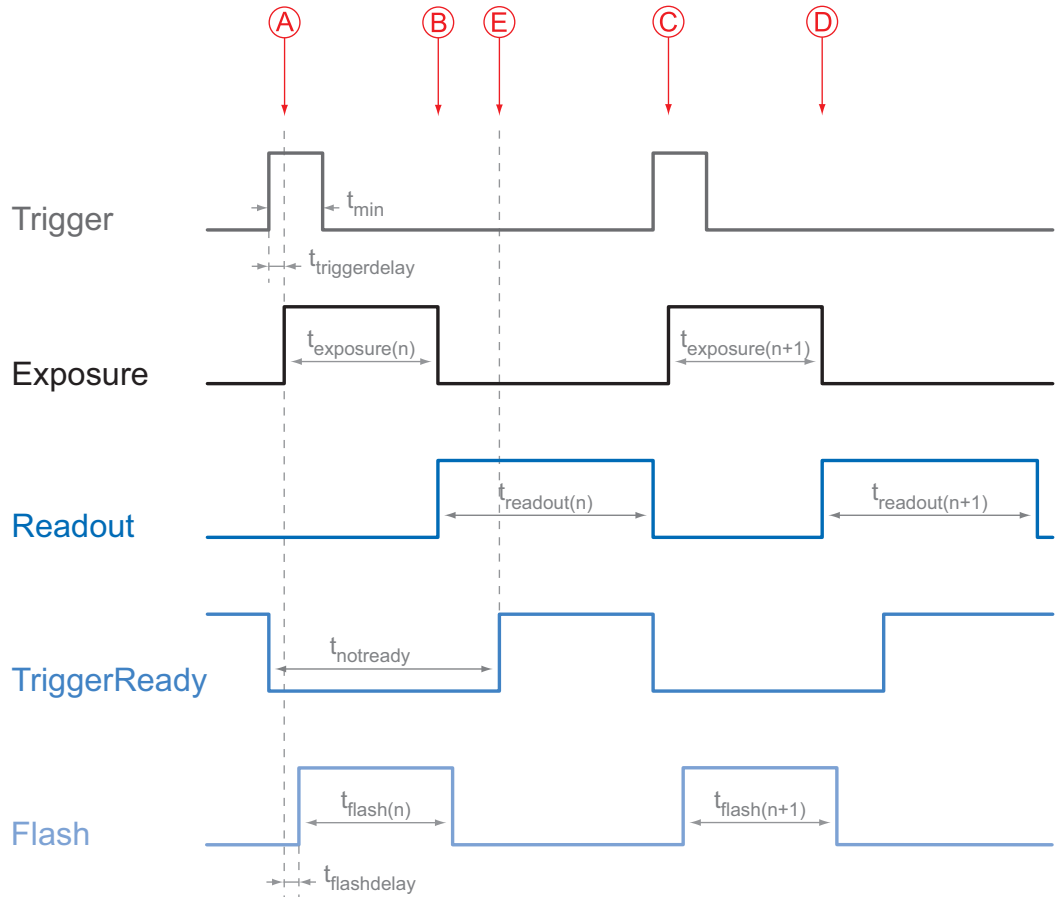
Image parameters:	
	Offset
	Gain
	Mode
	Partial Scan

#### 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 ( $t_{\text{exposure}} + t_{\text{readout}}$ ) 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 Baumer GAPI SDK

Baumer GAPI stands for **Baumer “Generic Application Programming Interface”**. With this API Baumer provides an interface for optimal integration and control of Baumer cameras. This software interface allows changing to other camera models.

It provides interfaces to several programming languages, such as C, C++ and the .NET™ Framework on Windows®, as well as Mono on Linux® operating systems, which offers the use of other languages, such as e.g. C# or VB.NET.

For LXG cameras with *VisualApplets* Baumer GAPI SDK v 2.3 SP1 and higher is required.

### 9.2 3<sup>rd</sup> Party Software

Strict compliance with the GenICam™ standard allows Baumer to offer the use of 3<sup>rd</sup> Party Software for operation with cameras.

You can find a current listing of 3<sup>rd</sup> Party Software, which was tested successfully in combination with Baumer cameras, at <http://www.baumer.com/?id=2851>

## 10. Camera Functionalities

### 10.1 Image Acquisition

#### 10.1.1 Image Format

The cameras support the native resolution of the sensor.

In ROI mode the resolution (horizontal and vertical dimensions in pixels) can be adjusted. Binning and Decimation are not available but can be implemented within *VisualApplets* if required.

## 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 LXG - Cameras with *VisualApplets*

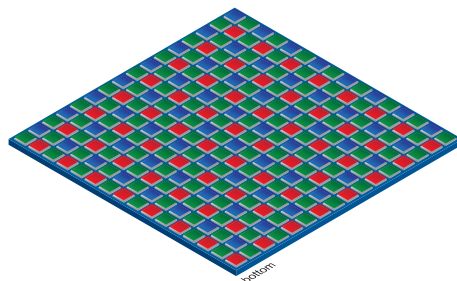
Camera Type	Mono8 (Interface)	Mono10 (Sensor)	Mono10p (Interface)	Mono12 (Sensor)	BayerGB8 (Interface)	BayerGB10 (Sensor)	BayerGB10Packed (Interface)
<b>Monochrome</b>							
LXG-20M.PS	■	■	■	□	□	□	□
LXG-40M.P	■	■	□	□	□	□	□
LXG-120M.PS	■	■	■	□	□	□	□
LXG-120M.P	■	□	□	■	□	□	□
LXG-200M.P	■	□	□	■	□	□	□
<b>Color</b>							
LXG-20C.P	□	□	□	□	■	■	■

### 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.

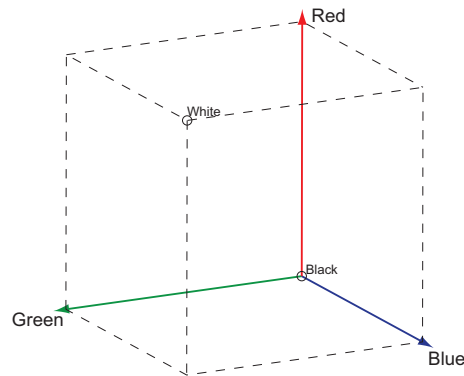


Figure 9 ►

RGB 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 bandwidth 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.

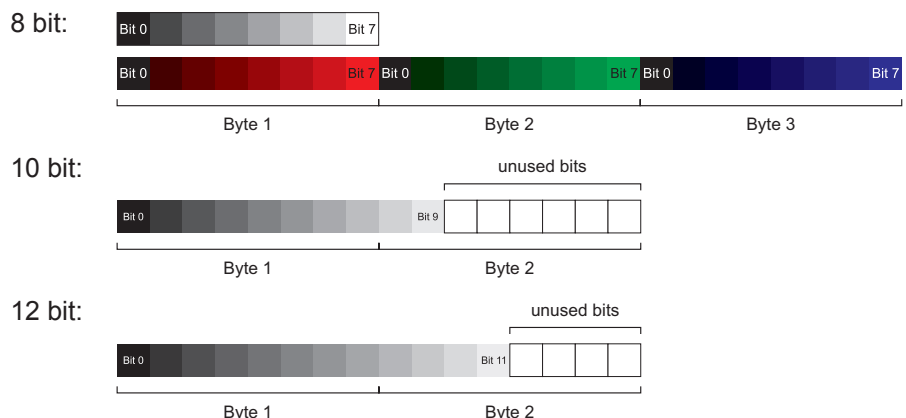


Figure 10 ►

Bit string of Mono 8 bit and RGB 8 bit.

Figure 11 ►

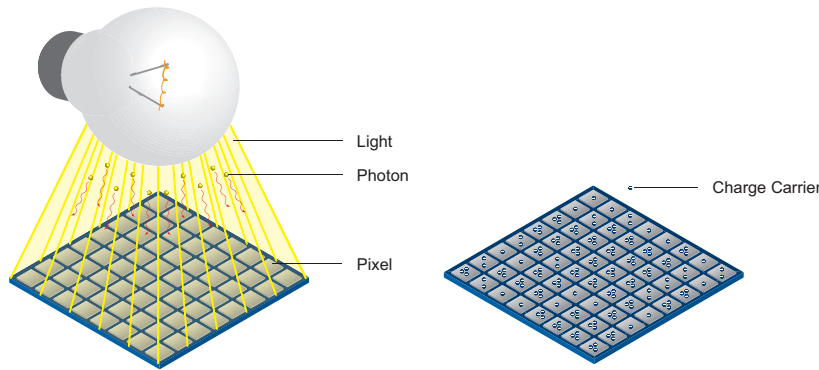
Spreading of Mono 10 bit over 2 bytes.

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 ( $t_{\text{exposure}}$ ).

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

Camera Type	$t_{\text{exposure min}}$	$t_{\text{exposure max}}$
LXG-20C.P	29 µsec	1 sec
LXG-20M.PS	30 µsec	1 sec
LXG-40M.P	57 µsec	1 sec
LXG-120M.PS	55 µsec	1 sec
LXG-120M.P	55 µsec	1 sec
LXG-200M.P	190 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  $t_{\text{exposure min}}$  longer.

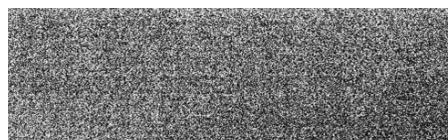
### 10.1.4 PRNU / DSNU Correction (FPN - Fixed Pattern Noise)

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. DSNU 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



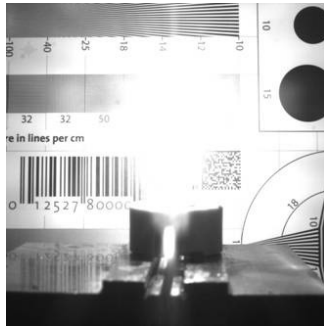
PRNU / DSNU Correction On

### 10.1.5 HDR

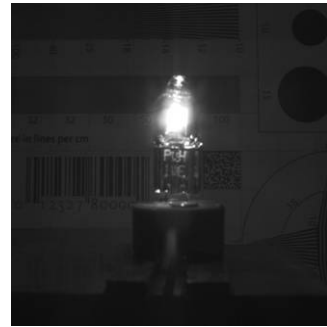
Beside the standard linear response the sensor supports a special high dynamic range mode (HDR) called piecewise linear response. With this mode illuminated pixels that reach a certain programmable voltage level will be clipped. Darker pixels that do not reach this threshold remain unchanged. The clipping 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.

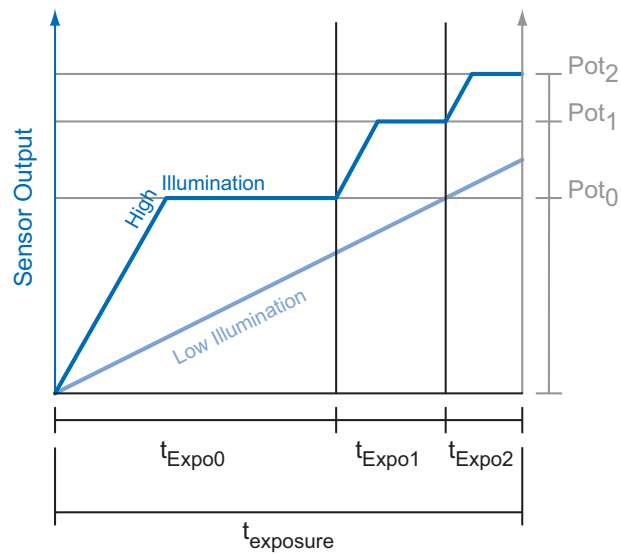
The value for  $t_{Expo2}$  will be calculated automatically in the camera. ( $t_{Expo2} = t_{exposure} - t_{Expo0} - t_{Expo1}$ )



HDR Off



HDR On



### 10.1.6 Region of Interest (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
- 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 value (Inc) of the Offset X must be a multiple of 8.

The value (Inc) of the Offset Y must be a multiple of 2 (LXG.P 120 = 4).

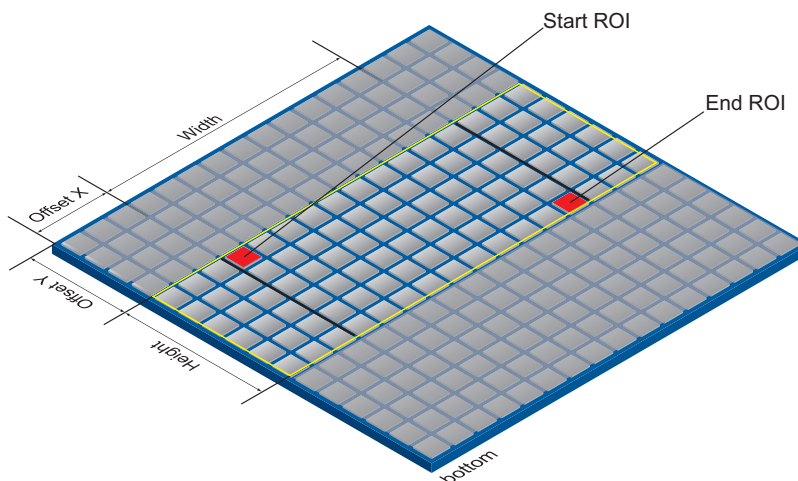
The value (Inc) of the Width must be a multiple of 8.

The value (Inc) of the Height must be a multiple of 2.

#### 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 14**  
Parameters of the ROI.

### 10.1.6.1 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.

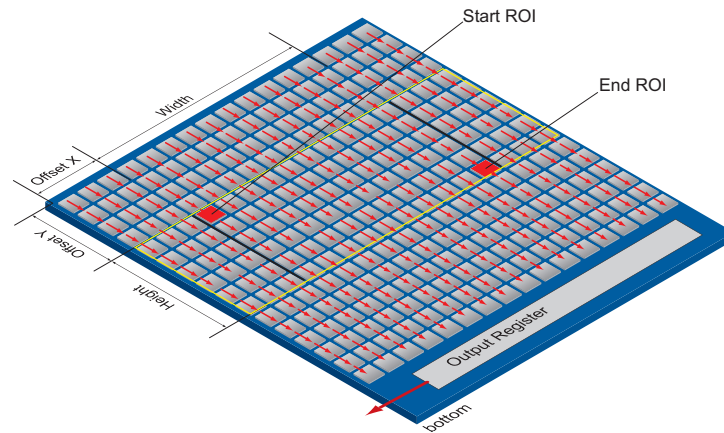
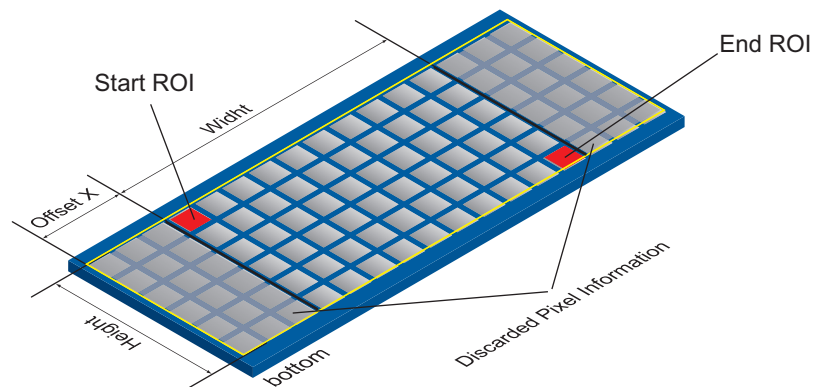


Figure 15 ►

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.





## 10.2 Analog Controls

### 10.2.1 Offset / Black Level

On Baumer LXG cameras with *VisualApplets* the offset (or black level) is adjustable.

Camera Type	1 step = 4 LSB Relating to [bit]
LXG-20C.P	0 ... 63 LSB   10 bit
LXG-20M.PS	0 ... 63 LSB   10 bit
LXG-40M.P	0 ... 63 LSB   10 bit
LXG-120M.PS	0 ... 63 LSB   10 bit
LXG-120M.P	0 .. 255 LSB   10 Bit
LXG-200M.P	0 .. 255 LSB   10 Bit

### 10.2.2 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.

## 10.3 Defect 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).

### 10.3.1 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.

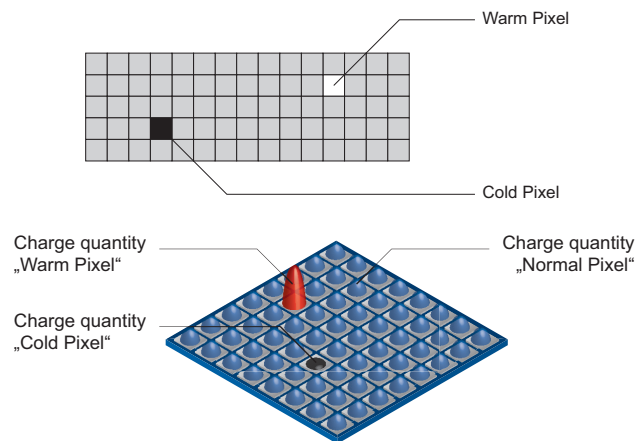


Figure 16 ►

Distinction of "hot" and "cold" pixels within the recorded image.

Figure 17 ►

Charge quantity of "hot" and "cold" pixels compared with "normal" pixels.

### 10.3.2 Correction Algorithm

On Baumer LXG cameras with *VisualApplets* 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.

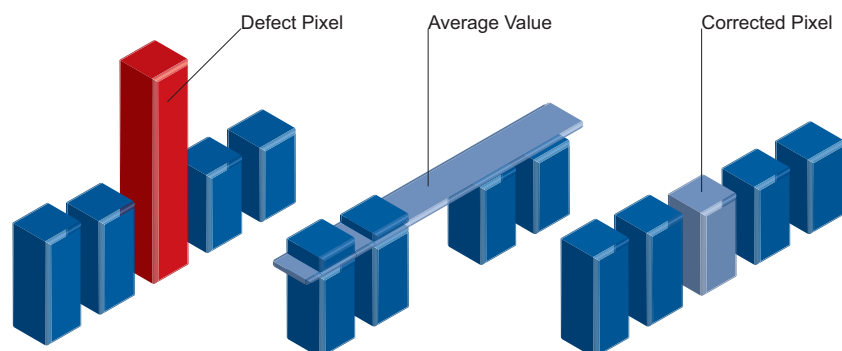


Figure 18 ►

Schematic diagram of the Baumer pixel correction.

### 10.3.3 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<sup>1)</sup> 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 Explorer*. 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.

#### Pixel

Enter the determined coordinates for X (*Defect Pixel List Entry PosX*).

Enter the determined coordinates for Y (*Defect Pixel List Entry PosY*).

#### Column

Enter the determined column (*Defect Pixel List Entry PosX*).

#### Row

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).

## 10.4 Sequencer

### 10.4.1 General Information

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

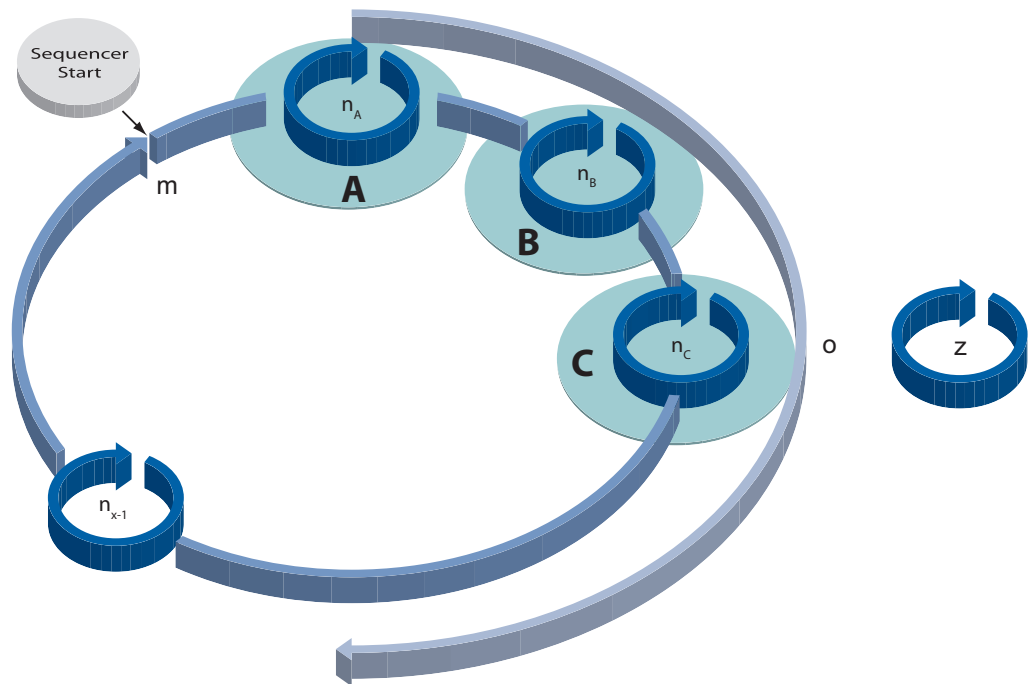


Figure 19 ►

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

#### Sequencer Parameter:

The mentioned sets of parameter include the following:

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

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.

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

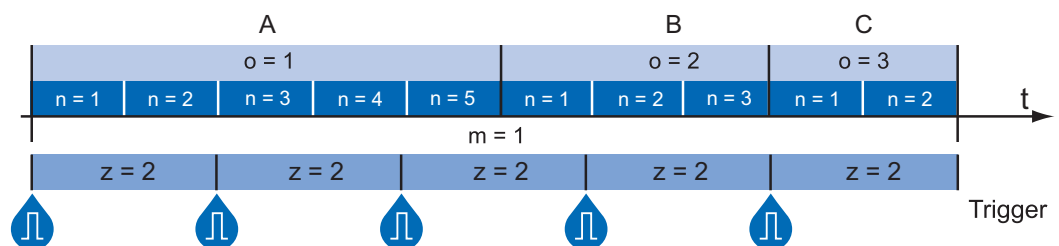


Figure 20 ►

Timeline for a single sequence

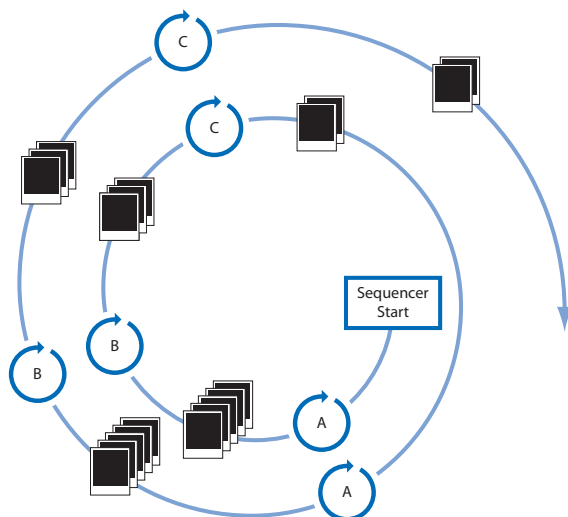
## 10.4.2 Baumer Optronic Sequencer in Camera xml-file

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

<b>Static Sequencer Features</b>	
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.
<b>Set-specific Features</b>	
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

## 10.4.3 Examples

### 10.4.3.1 Sequencer without Machine Cycle



◀ **Figure 21**  
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.

### 10.4.3.2 Sequencer Controlled by Machine Steps (Trigger)

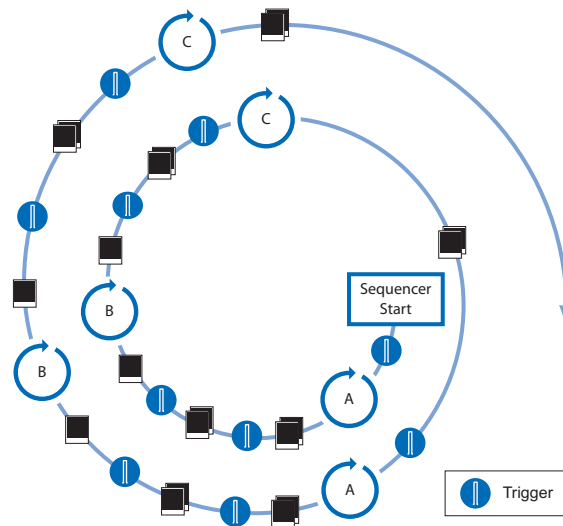


Figure 22 ▶

Example for a half-automated sequencer.

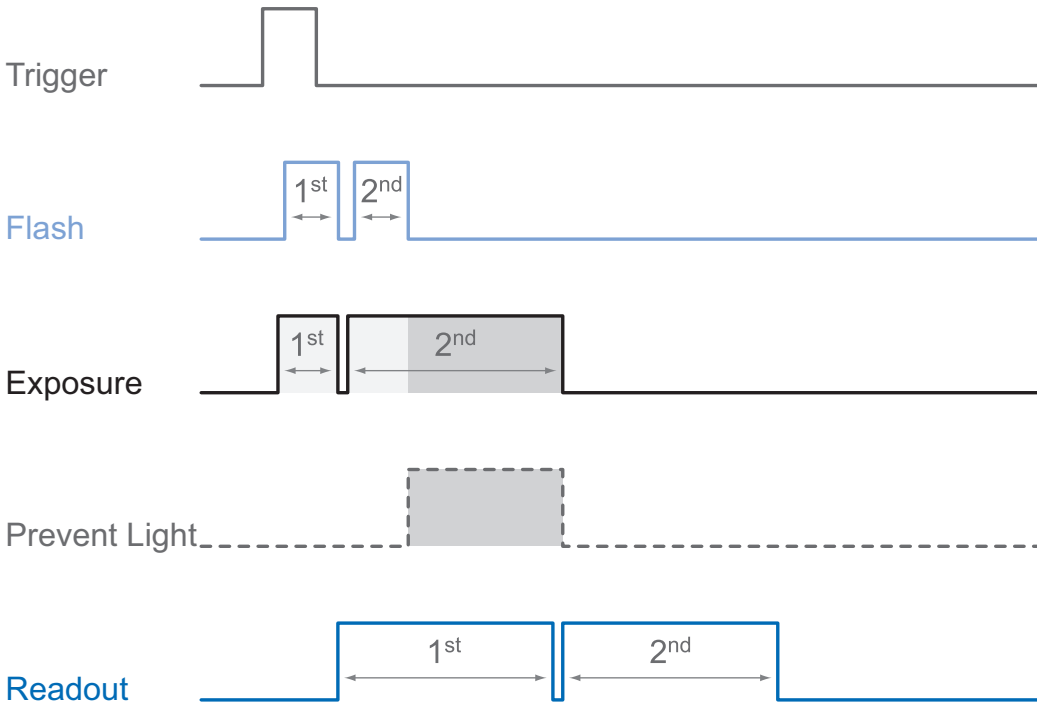
The figure above shows an example for a half-automated sequencer with three sets of parameters (A,B and C) from the previous example. The frame counter (z) is set to 2. This means the camera records two pictures after an incoming trigger signal.

### 10.4.4 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

### 10.4.5 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 ( $t_{\text{exposure}}$ ) is arbitrary and accompanied by the first flash. The second exposure time must be equal to, or longer than the readout time ( $t_{\text{readout}}$ ) of the sensor. Thus the pixels of the sensor are receptive 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 23**  
Example of a double shutter.

On Baumer LXG cameras with *VisualApplets* 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

## 10.5 Process Interface

### 10.5.1 Digital I/O

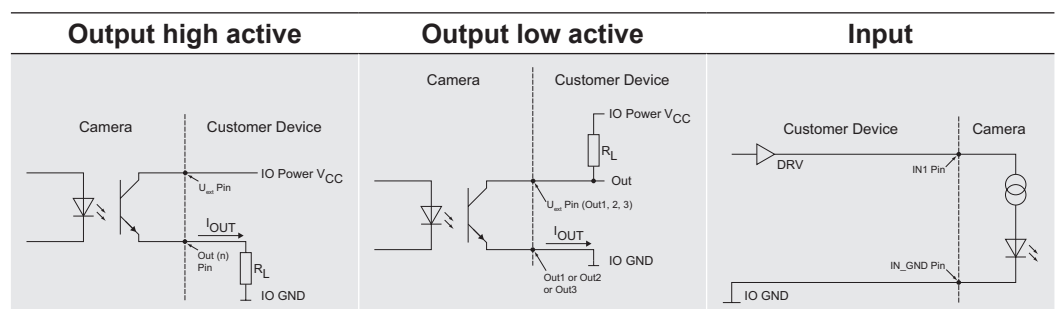
All Baumer LXG cameras with *VisualApplets* are equipped with one input line and three output lines.

#### 10.5.1.1 I/O Circuits

##### Notice

Low Active: At this wiring, only one consumer can be connected. When all Output pins (1, 2, 3) connected to I/O\_GND, then current flows through the resistor as soon as one Output is switched. If only one output connected to I/O\_GND, then this one is only usable.

The other two Outputs are not usable and may not be connected (e.g. I/O Power  $V_{CC}$ )!



#### 10.5.1.2 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).

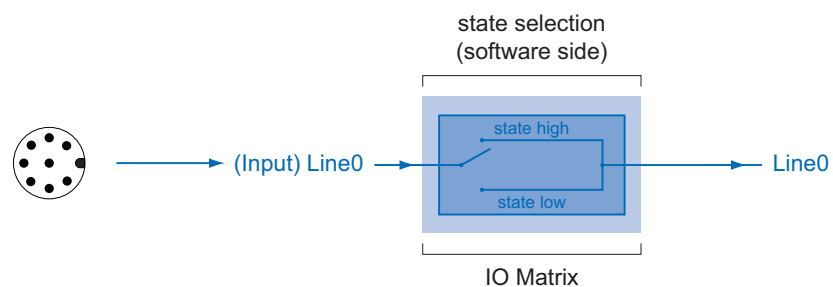
The defined signals will have no direct effect, but can be analyzed and processed on the software side and used for controlling the camera.

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 24 ►

IO matrix of the Baumer LXG cameras with *VisualApplets* on input side.





### 10.5.1.3 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 LXG cameras with *VisualApplets* 17 signal sources – subdivided into three categories – can be applied to the output connectors.

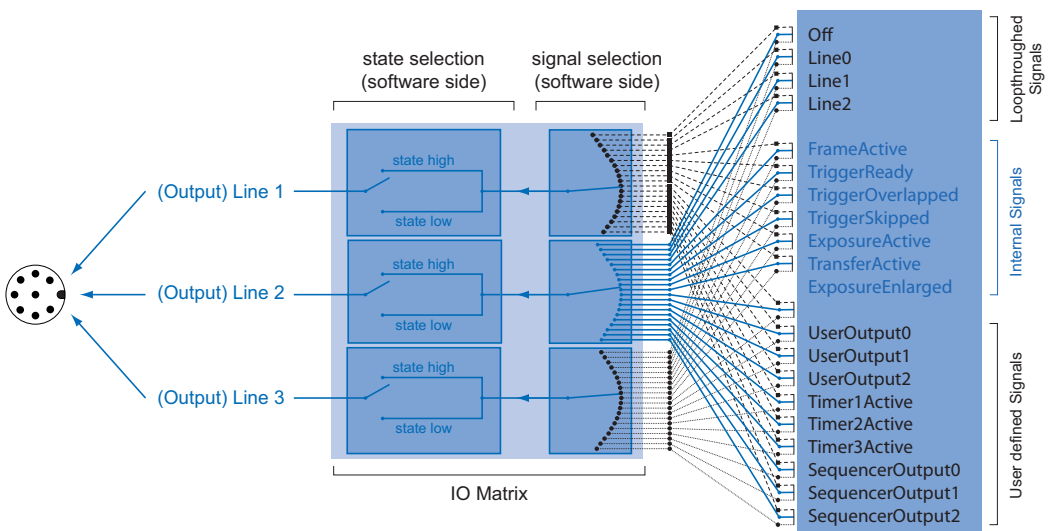
The first category of output signals represents a loop through of signals on the input side, such as:

Signal Name	Explanation
Line0	Signal of input "Line0" is loophroughed to this ouput
Line1	Signal of input "Line1" is loophroughed to this ouput
Line2	Signal of input "Line2" iys loophroughed 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
TransferActive	Image transfer via hardware interface in progress
ExposureEnlarged	This output marks the period of enlarged exposure time

Beside the 10 signals mentioned above, each output can be wired to a user-defined signal ("UserOutput0", "UserOutput1", "UserOutput2", "SequencerOut 0...2" or disabled ("OFF").



◀ **Figure 25**  
IO matrix of the Baumer LXG cameras with *VisualApplets* on output side.

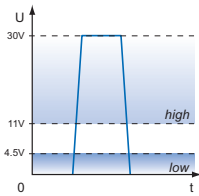


Figure 26 ▲

Trigger signal, valid for Baumer cameras.

## 10.6 Trigger Input / Trigger Delay

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:

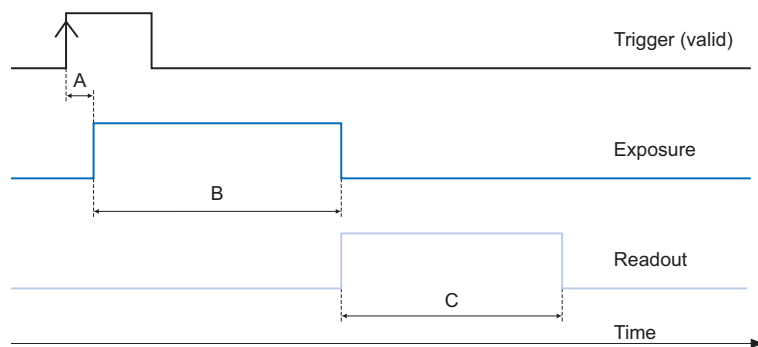
Line0	Actioncommand
Line1	Off
Line2	
SW-Trigger	

Possible settings of the Trigger Delay: :

Delay	0-2 sec
Number of tracked Triggers	512
Step	1 $\mu$ sec

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

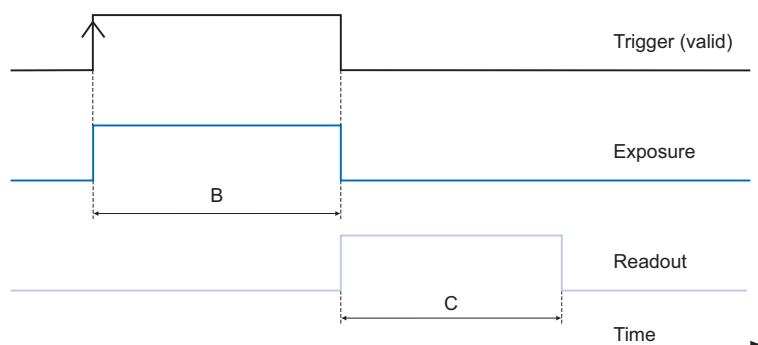
### Normal Trigger with adjusted Exposure



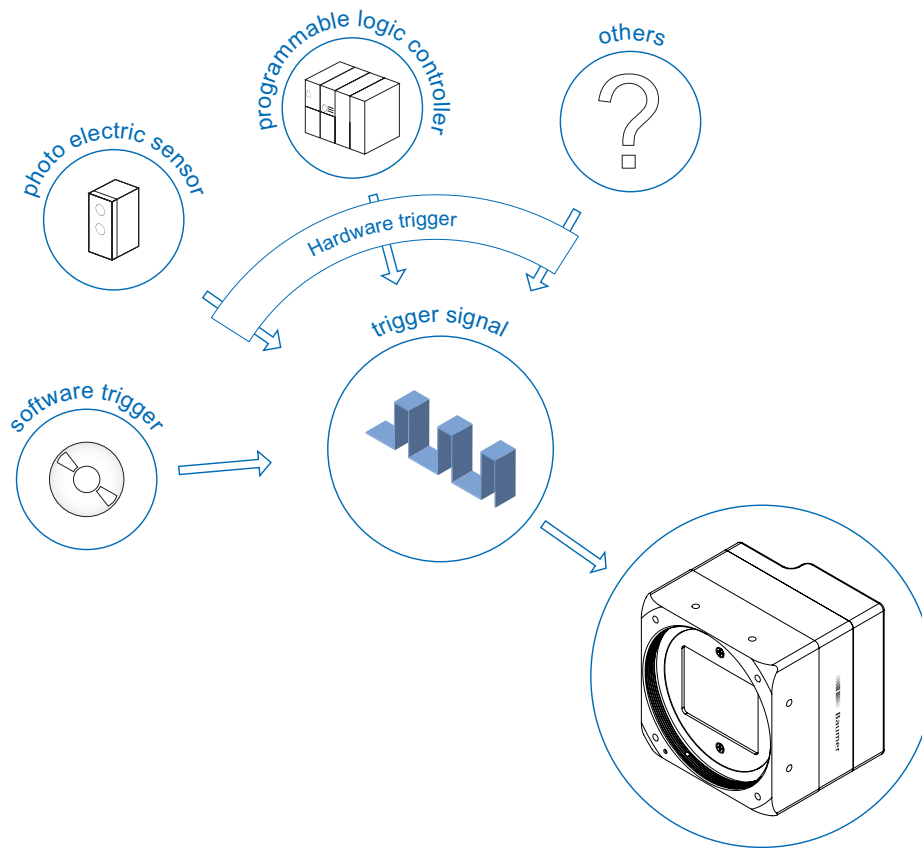
Camera in trigger mode:

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

### Pulse Width controlled Exposure



## 10.6.1 Trigger Source



◀ **Figure 27**  
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.

## 10.6.2 Debouncer

The basic idea behind this feature was to separate 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  $t_{\text{DebounceHigh}}$  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  $t_{\text{DebounceLow}}$  was introduced. This timing is also adjustable by the user. If the signal value falls to state low and does not rise within  $t_{\text{DebounceLow}}$ , this is recognized as end of the signal.

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

This feature is disabled by default.

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

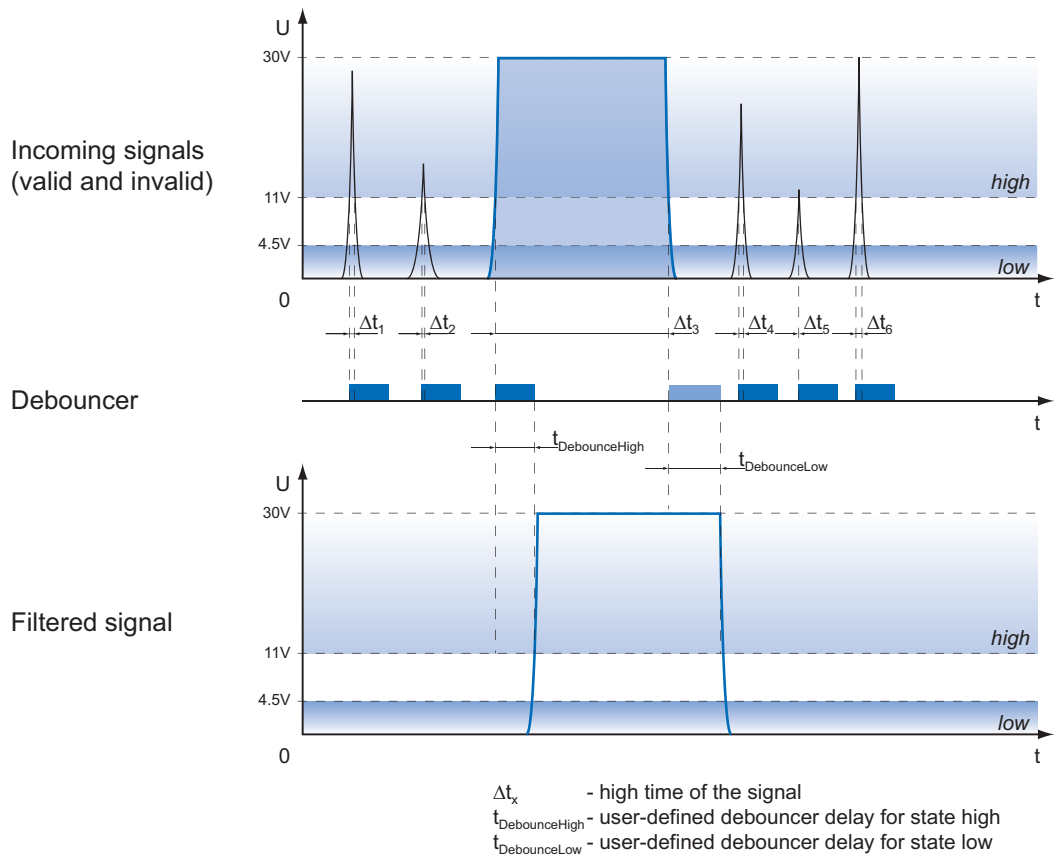


Figure 28 ►

Principle of the Baumer debouncer.

## 10.6.3 Flash Signal

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

### 10.6.4 Timer

Timers were introduced for advanced control of internal camera signals.

On Baumer LXG cameras with *VisualApplets* 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 $\mu$ sec .. 2 sec, step: 1 $\mu$ sec)
TimerDuration	By this feature the activation time of the timer is adjustable. (10 $\mu$ sec .. 2 sec, step: 1 $\mu$ sec)

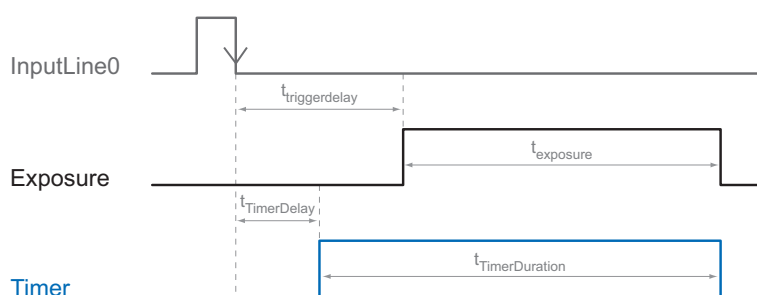
Different Timer sources can be used:

Input Line0	Frame Start
SW-Trigger	Frame End
ActionCommandTrigger	TriggerSkipped
Exposure Start	
Exposure End	

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	InputLine0
TimerTriggerSource	InputLine0
Outputline1 (Source)	Timer1Active
TimerTriggerActivation	Falling Edge
Trigger Polarity	Falling Edge



## 10.7 User Sets

### Notice

The *Visual Applet* design parameters are not stored in the user sets.

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

Parameter	
ChunkModeActive	Events
ChunkEnable	AcquisitionFrameRateEnable
DeviceTapGeometry	AcquisitionFrameRate
DeviceClockFrequency	PixelFormat
HDREnable	BlackLevel
BlackReferenceCorrectionEnable	Gain
FixedPatternNoiseCorrection	TestPattern
SensorEffectCorrection	ReverseX
ReadoutMode	ReverseY
BoSequencerEnable	LineMode
DefectPixelCorrection	LineStatus
ExposureTime	LineInverter
TriggerMode	LineSource
TriggerWidth	TimerDuration
TriggerSource	TimerDelay
TriggerDelay	TimerTriggerSource
PacketDelay	TimerTriggerActivation
TransmissionDelay	
ActionGroupKey	
ActionGroupMask	

These user sets are stored within the camera 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.

## 10.8 Factory Settings

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

# 11. Interface Functionalities

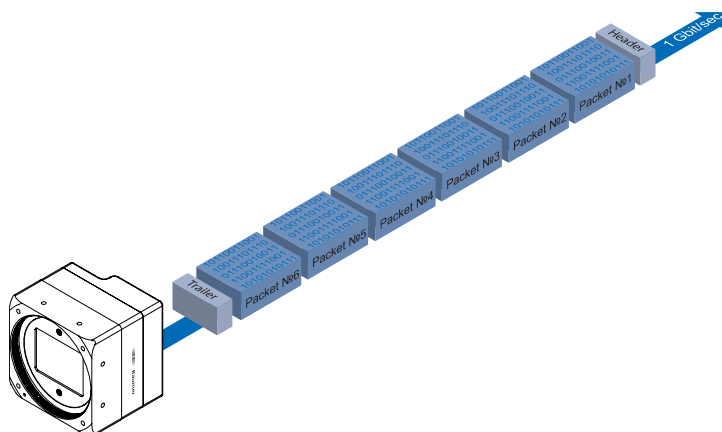
## 11.1 Device Information

This Gigabit Ethernet-specific information on the device is part of the Discovery-Acknowledge of the camera.

Included information:

- MAC address
- Current IP configuration (persistent IP / DHCP / LLA)
- Current IP parameters (IP address, subnet mask, gateway)
- Manufacturer's name
- Manufacturer-specific information
- Device version
- Serial number
- User-defined name (user programmable string)

At the beginning of a frame will transmitted a Leader and at the end will transmitted a Trailer.



◀ **Figure 29**  
Transmission of data packets

## 11.2 Baumer Image Info Header (Chunk Data)

The Baumer Chunk are data, which are generated by the camera.

These data include different settings for the respective image. Baumer GAPI can read this settings. Third Party Software, which supports the Chunk mode, can read the settings in the table below.

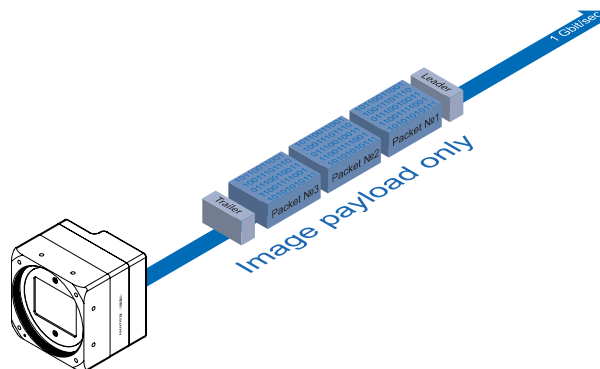
This settings may be for example (not completely):

Feature	Description
ChunkOffsetX	Horizontal offset from the origin to the area of interest (in pixels).
ChunkOffsetY	Vertical offset from the origin to the area of interest (in pixels).
ChunkWidth	Returns the Width of the image included in the payload.
ChunkHeight	Returns the Height of the image included in the payload.
ChunkPixelFormat	Returns the PixelFormat of the image included in the payload.
ChunkExposureTime	Returns the exposure time used to capture the image.
ChunkBlackLevelSelector	Selects which Black Level to retrieve data from.
ChunkBlackLevel	Returns the black level used to capture the image included in the payload.
ChunkFrameID	Returns the unique Identifier of the frame (or image) included in the payload.

There are three chunk modes:

### Image Data

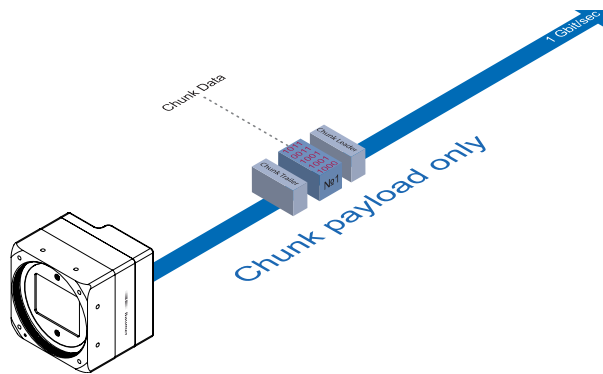
Only the image data are transferred, no chunk data.





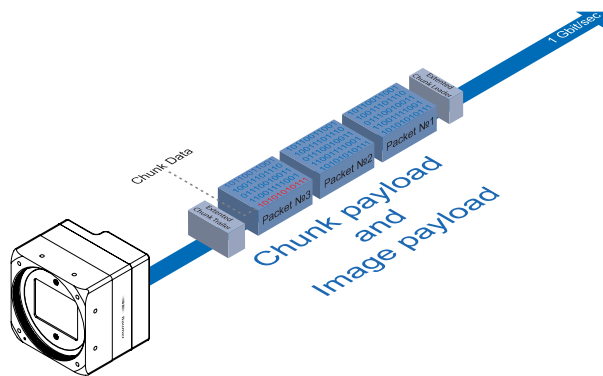
## Chunk Data

Only the chunk is transferred, no image data.



## Extended Chunk Data

Chunk data and image data are transferred. The chunk data are included in the last data packet.



## 11.3 Packet Size and Maximum Transmission Unit (MTU)

Network packets can be of different sizes. The size depends on the network components employed. When using GigE Vision®- compliant devices, it is generally recommended to use larger packets. On the one hand the overhead per packet is smaller, on the other hand larger packets cause less CPU load.

The packet size of UDP packets can differ from 576 Bytes up to the MTU.

The MTU describes the maximal packet size which can be handled by all network components involved.

In principle modern network hardware supports a packet size of 1518 Byte, which is specified in the network standard. However, so-called "Jumbo frames" are on the advance as Gigabit Ethernet continues to spread. "Jumbo frames" merely characterizes a packet size exceeding 1500 Bytes.

Baumer LXG cameras with *VisualApplets* can handle a MTU of up to 16384 Bytes.

## 11.4 "Inter Packet Gap" (IPG)

To achieve optimal results in image transfer, several Ethernet-specific factors need to be considered when using Baumer LXG cameras with *VisualApplets*.

Upon starting the image transfer of a camera, the data packets are transferred at maximum transfer speed (1 Gbit/sec). In accordance with the network standard, Baumer employs a minimal separation of 12 Bytes between two packets. This separation is called "Inter Packet Gap" (IPG). In addition to the minimal PD, the GigE Vision® standard stipulates that the PD be scalable (user-defined).

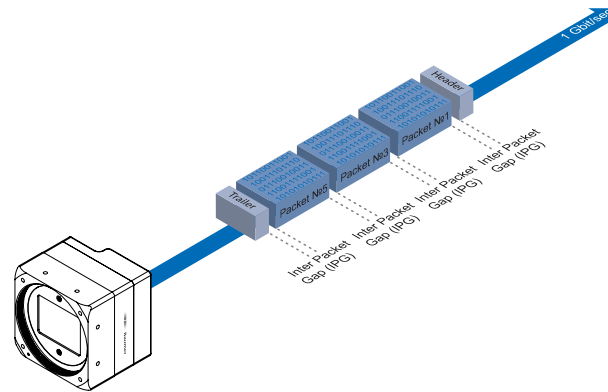


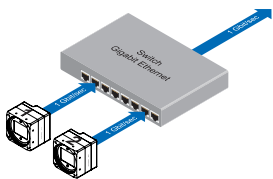
Figure 30 ▶

Packet Delay (PD) between the packets

### 11.4.1 Example 1: Multi Camera Operation – Minimal IPG

Setting the IPG to minimum means every image is transferred at maximum speed. Even by using a frame rate of 1 fps this results in full load on the network. Such "bursts" can lead to an overload of several network components and a loss of packets. This can occur, especially when using several cameras.

In the case of two cameras sending images at the same time, this would theoretically occur at a transfer rate of 2 Gbits/sec. The switch has to buffer this data and transfer it at a speed of 1 Gbit/sec afterwards. Depending on the internal buffer of the switch, this operates without any problems up to n cameras ( $n \geq 1$ ). More cameras would lead to a loss of packets. These lost packets can however be saved by employing an appropriate resend mechanism, but this leads to additional load on the network components.



▲ Figure 31

Operation of two cameras employing a Gigabit Ethernet switch. Data processing within the switch is displayed in the next two figures.

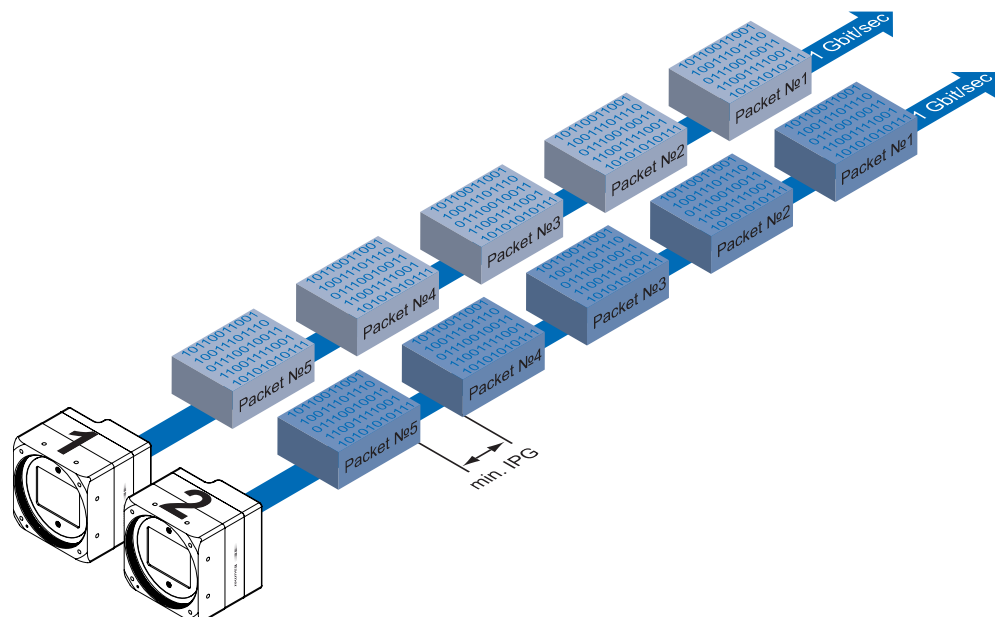


Figure 32 ▶

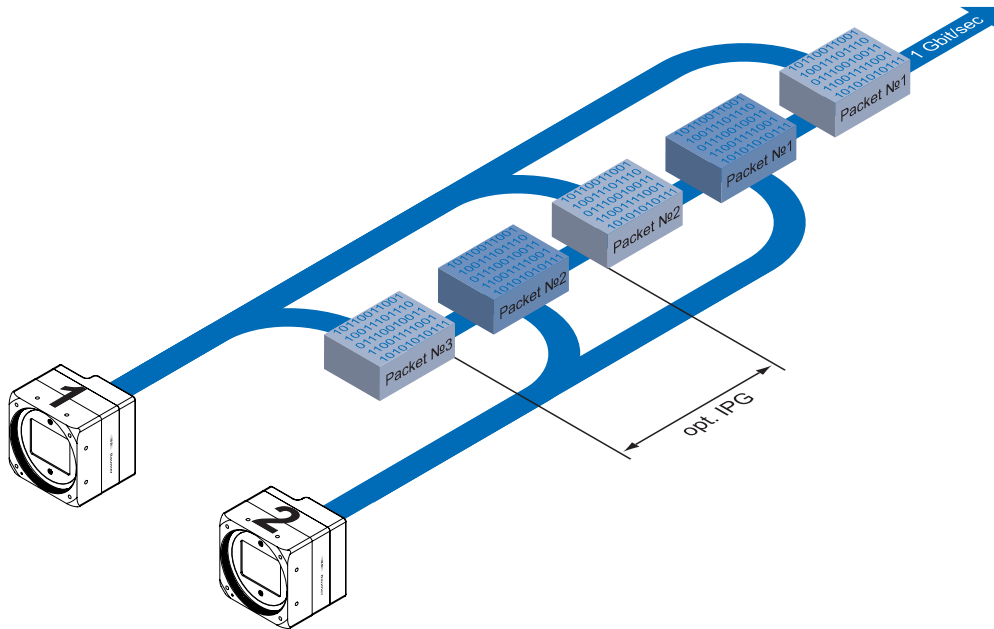
Operation of two cameras employing a minimal inter packet gap (IPG).

### 11.4.2 Example 2: Multi Camera Operation – Optimal IPG

A better method is to increase the IPG to a size of

$$\text{optimal IPG} = \text{packet size} + 2 \times \text{minimal IPG}$$

In this way both data packets can be transferred successively (zipper principle), and the switch does not need to buffer the packets.



**Max. IPG:**  
On the Gigabit Ethernet the max. IPG and the data packet must not exceed 1 Gbit. Otherwise data packets can be lost.

◀ **Figure 33**  
Operation of two cameras employing an optimal inter packet gap (IPG).

## 11.5 Frame Delay

Another approach for packet sorting in multi-camera operation is the so-called Frame Delay, which was introduced to Baumer Gigabit Ethernet cameras in hardware release 2.1.

Due to the fact, that the currently recorded image is stored within the camera and its transmission starts with a predefined delay, complete images can be transmitted to the PC at once.

The following figure should serve as an example:

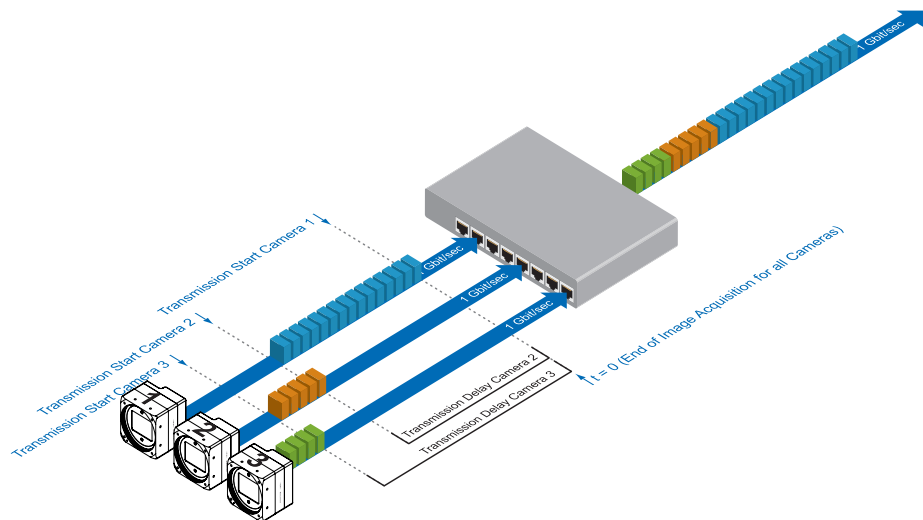


Figure 34 ▶

Principle of the Frame delay.

Due to process-related circumstances, the image acquisitions of all cameras end at the same time. Now the cameras are not trying to transmit their images simultaneously, but – according to the specified transmission delays – subsequently. Thereby the first camera starts the transmission immediately – with a transmission delay "0".

### 11.5.1 Time Saving in Multi-Camera Operation

As previously stated, the Frame delay feature was especially designed for multi-camera operation with employment of different camera models. Just here an significant acceleration of the image transmission can be achieved:

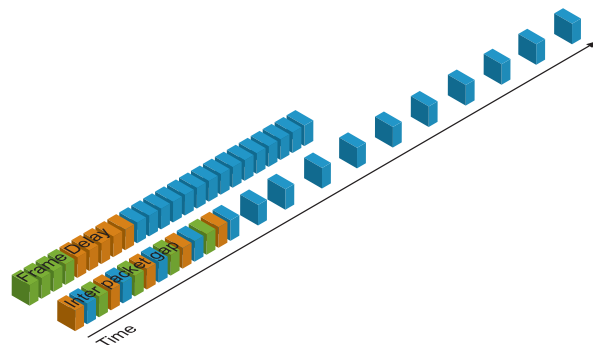


Figure 35 ▶

Comparison of frame delay and inter packet gap, employed for a multi-camera system with different camera models.

For the above mentioned example, the employment of the transmission delay feature results in a time saving – compared to the approach of using the inter packet gap – of approx. 45% (applied to the transmission of all three images).

### 11.5.2 Configuration Example

For the three used cameras the following data are known:

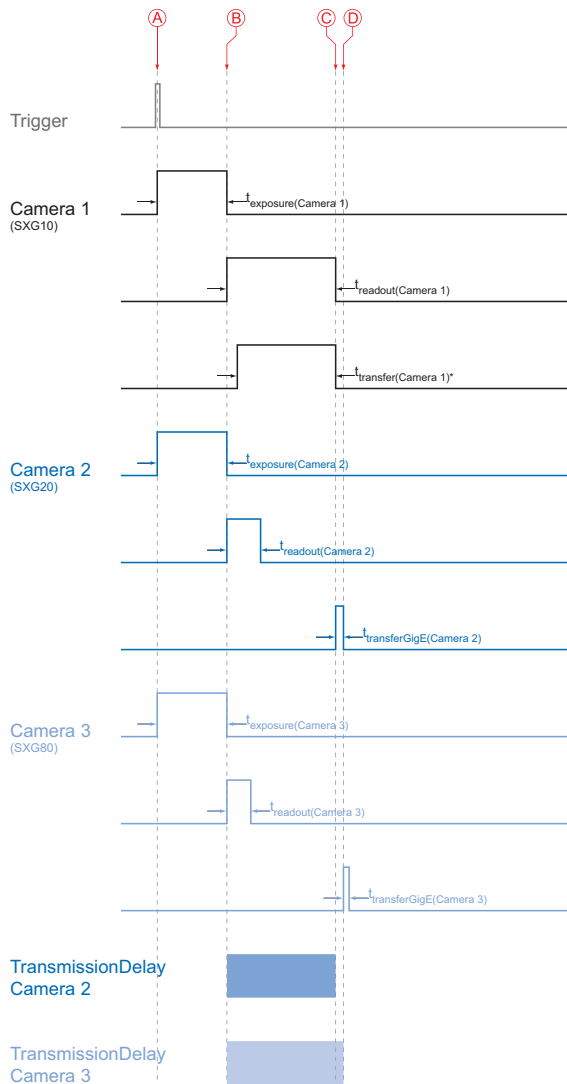
Camera Model	Sensor Resolution [Pixel]	Pixel Format (Pixel Depth) [bit]	Data Volume [bit]	Readout Time [msec]	Exposure Time [msec]	Transfer Time [msec]
LXG-200M.P	5120 x 3840	8	157286400	30.768	6	≈ 73.24
LXG-200M.P	5120 x 3840	8	157286400	30.768	6	≈ 73.24
LXG-200M.P	5120 x 3840	8	157286400	30.768	6	≈ 73.24

- The sensor resolution and the readout time ( $t_{readout}$ ) can be found in the respective Technical Data Sheet (TDS). For the example a full frame resolution is used.
- The exposure time ( $t_{exposure}$ ) is manually set to 6 msec.
- The resulting data volume is calculated as follows:  

$$\text{Resulting Data Volume} = \text{horizontal Pixels} \times \text{vertical Pixels} \times \text{Pixel Depth}$$

All the cameras are triggered simultaneously.

The transmission delay is realized as a counter, that is started immediately after the sensor readout is started.



**Timings:**

- A - exposure start for all cameras
- B - all cameras ready for transmission
- C - transmission start camera 2
- D - transmission start camera 3

◀ **Figure 36**  
 Timing diagram for the transmission delay of the three employed cameras, using even exposure times.

In general, the transmission delay is calculated as:

$$t_{\text{TransmissionDelay(Camera } n)} = t_{\text{exposure(Camera 1)}} + t_{\text{readout(Camera 1)}} - t_{\text{exposure(Camera } n)} + \sum_{n \geq 3}^n t_{\text{transferGigE(Camera } n-1)}$$

Therewith for the example, the transmission delays of camera 2 and 3 are calculated as follows:

$$t_{\text{TransmissionDelay(Camera 2)}} = t_{\text{exposure(Camera 1)}} + t_{\text{readout(Camera 1)}} - t_{\text{exposure(Camera 2)}}$$

$$t_{\text{TransmissionDelay(Camera 3)}} = t_{\text{exposure(Camera 1)}} + t_{\text{readout(Camera 1)}} - t_{\text{exposure(Camera 3)}} + t_{\text{transferGige(Camera 2)}}$$

Solving this equations leads to:

$$\begin{aligned} t_{\text{TransmissionDelay(Camera 2)}} &= 6 \text{ msec} + 30.768 \text{ msec} - 6 \text{ msec} \\ &= 30.768 \text{ msec} \\ &= 30768000 \text{ ticks} \end{aligned}$$

$$\begin{aligned} t_{\text{TransmissionDelay(Camera 3)}} &= 6 \text{ msec} + 30.768 \text{ msec} - 6 \text{ msec} + 73.27 \text{ msec} \\ &= 104.038 \text{ msec} \\ &= 10403800 \text{ ticks} \end{aligned}$$

### Notice

In Baumer GAPI the delay is specified in ticks. How do convert microseconds into ticks?

$$1 \text{ tick} = 1 \text{ ns}$$

$$1 \text{ msec} = 1000000 \text{ ns}$$

$$1 \text{ tick} = 0.000001 \text{ msec}$$

$$\text{ticks} = t_{\text{TransmissionDelay}} [\text{msec}] / 0.000001 = t_{\text{TransmissionDelay}} [\text{ticks}]$$

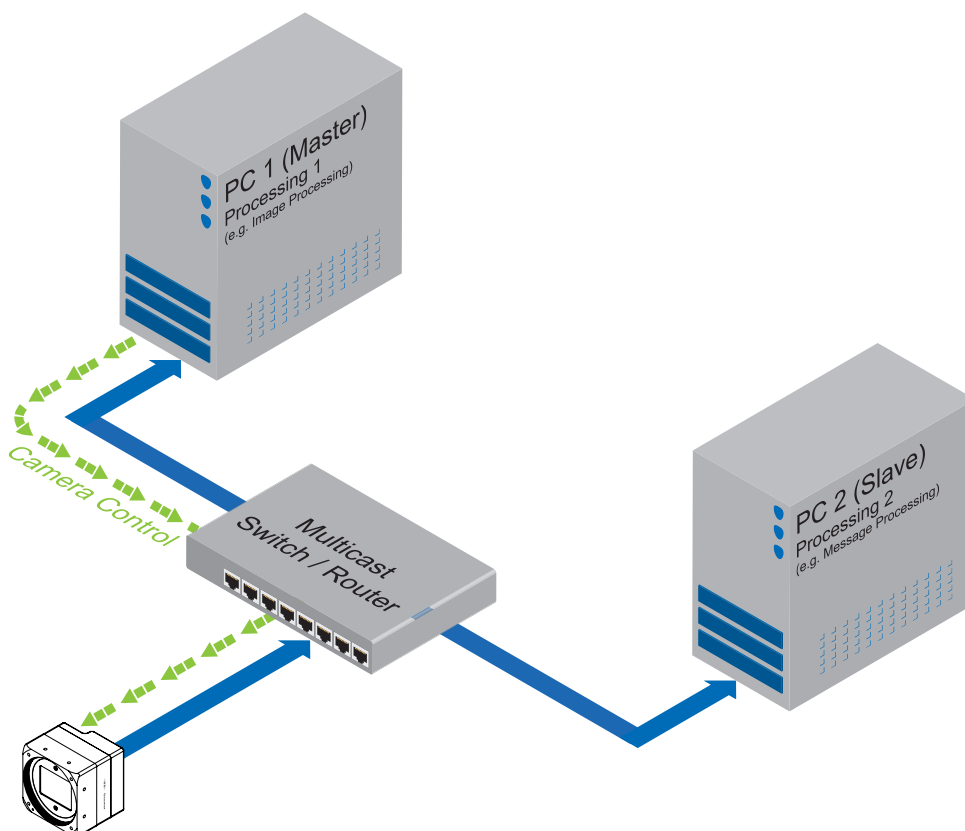
## 11.6 Multicast

Multicasting offers the possibility to send data packets to more than one destination address – without multiplying bandwidth between camera and Multicast device (e.g. Router or Switch).

The data is sent out to an intelligent network node, an IGMP (Internet Group Management Protocol) capable Switch or Router and distributed to the receiver group with the specific address range.

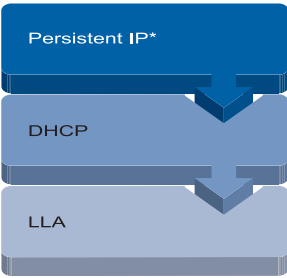
In the example on the figure below, multicast is used to process image and message data separately on two different PC's.

<b>Multicast Addresses:</b>
<i>For multicasting Baumer suggests an address range from 232.0.1.0 to 232.255.255.255.</i>



◀ **Figure 37**  
Principle of Multicast

**Internet Protocol:**  
On Baumer cameras IP v4 is employed.



**Figure 38** ▲

Connection pathway for Baumer Gigabit Ethernet cameras:  
The device connects step by step via the three described mechanisms.

**DHCP:**  
Please pay attention to the DHCP Lease Time.

**Figure 39** ►

DHCP Discovery (broadcast)

## 11.7 IP Configuration

### 11.7.1 Persistent IP

A persistent IP address is assigned permanently. Its validity is unlimited.

#### Notice

Please ensure a valid combination of IP address and subnet mask.

IP range:	Subnet mask:
0.0.0.0 – 127.255.255.255	255.0.0.0
128.0.0.0 – 191.255.255.255	255.255.0.0
192.0.0.0 – 223.255.255.255	255.255.255.0

These combinations are not checked by Baumer GAPI, Baumer GAPI Viewer or camera on the fly. This check is performed when restarting the camera, in case of an invalid IP - subnet combination the camera will start in LLA mode.

\* This feature is disabled by default.

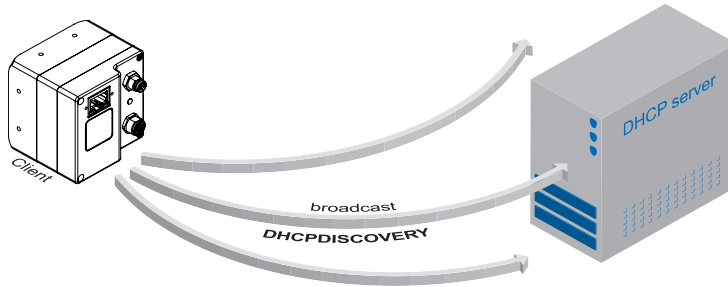
### 11.7.2 DHCP (Dynamic Host Configuration Protocol)

The DHCP automates the assignment of network parameters such as IP addresses, subnet masks and gateways. This process takes up to 12 sec.

Once the device (client) is connected to a DHCP-enabled network, four steps are processed:

#### ▪ DHCP Discovery

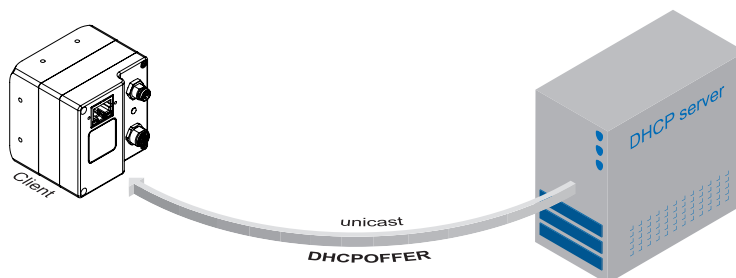
In order to find a DHCP server, the client sends a so called DHCPDISCOVER broadcast to the network.



#### ▪ DHCP Offer

After reception of this broadcast, the DHCP server will answer the request by a unicast, known as DHCPPOFFER. This message contains several items of information, such as:

Information for the client	MAC address
	offered IP address
Information on server	IP address
	subnet mask
	duration of the lease



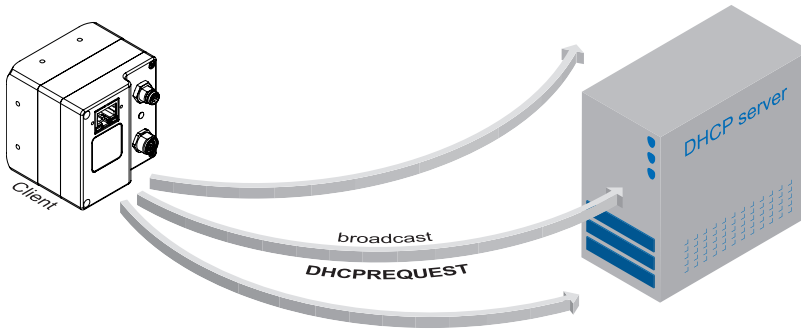
**Figure 40** ►

DHCP offer (unicast)



▪ **DHCP Request**

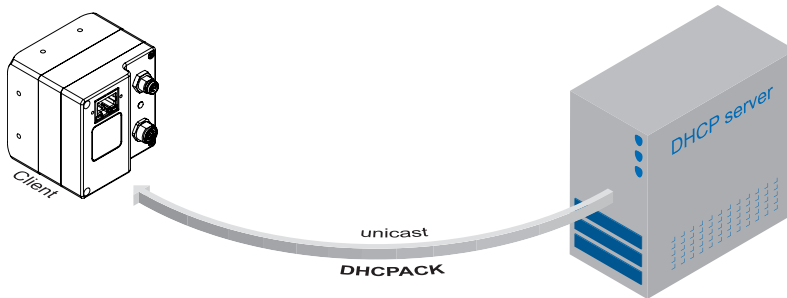
Once the client has received this DHCP OFFER, the transaction needs to be confirmed. For this purpose the client sends a so called DHCPREQUEST broadcast to the network. This message contains the IP address of the offering DHCP server and informs all other possible DHCP servers that the client has obtained all the necessary information, and there is therefore no need to issue IP information to the client.



◀ **Figure 41**  
DHCP Request  
(broadcast)

▪ **DHCP Acknowledgement**

Once the DHCP server obtains the DHCPREQUEST, a unicast containing all necessary information is sent to the client. This message is called DHCPACK. According to this information, the client will configure its IP parameters and the process is complete.



**DHCP Lease Time:**  
*The validity of DHCP IP addresses is limited by the lease time. When this time is elapsed, the IP configuration needs to be redone. This causes a connection abort.*

◀ **Figure 42**  
DHCP Acknowledgement (unicast)

**11.7.3 LLA**

LLA (Link-Local Address) refers to a local IP range from 169.254.0.1 to 169.254.254.254 and is used for the automated assignment of an IP address to a device when no other method for IP assignment is available.

The IP address is determined by the host, using a pseudo-random number generator, which operates in the IP range mentioned above.

Once an address is chosen, this is sent together with an ARP (Address Resolution Protocol) query to the network to check if it already exists. Depending on the response, the IP address will be assigned to the device (if not existing) or the process is repeated. This method may take some time - the GigE Vision® standard stipulates that establishing connection in the LLA should not take longer than 40 seconds, in the worst case it can take up to several minutes.

**LLA:**  
*Please ensure operation of the PC within the same subnet as the camera.*

**11.7.4 Force IP<sup>1)</sup>**

Inadvertent faulty operation may result in connection errors between the PC and the camera. In this case "Force IP" may be the last resort. The Force IP mechanism sends an IP address and a subnet mask to the MAC address of the camera. These settings are sent without verification and are adapted immediately by the client. They remain valid until the camera is de-energized.

1) In the GigE Vision® standard, this feature is defined as "Static IP".

## 11.8 Packet Resend

Due to the fact, that the GigE Vision® standard stipulates using a UDP – a stateless user datagram protocol – for data transfer, a mechanism for saving the "lost" data needs to be employed.

Here, a resend request is initiated if one or more packets are damaged during transfer and – due to an incorrect checksum – rejected afterwards.

On this topic one must distinguish between three cases:

### 11.8.1 Normal Case

In the case of unproblematic data transfer, all packets are transferred in their correct order from the camera to the PC. The probability of this happening is more than 99%.

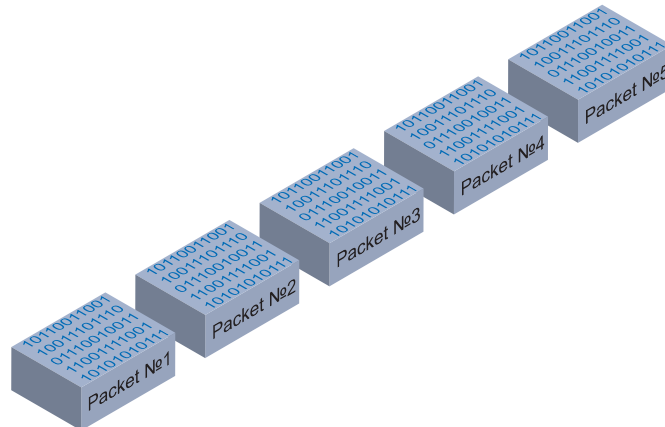


Figure 43 ▶

Data stream without damaged or lost packets.

### 11.8.2 Fault 1: Lost Packet within Data Stream

If one or more packets are lost within the data stream, this is detected by the fact, that packet number  $n$  is not followed by packet number  $(n+1)$ . In this case the application sends a resend request (A). Following this request, the camera sends the next packet and then resends (B) the lost packet.

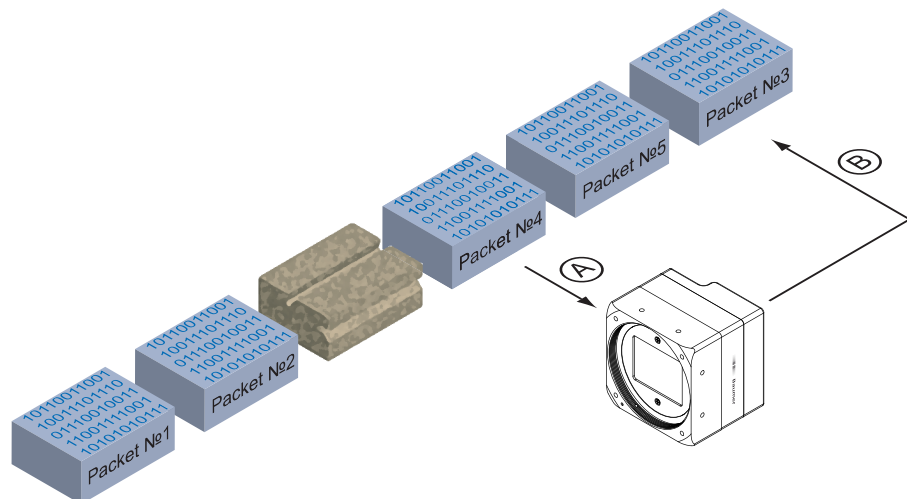


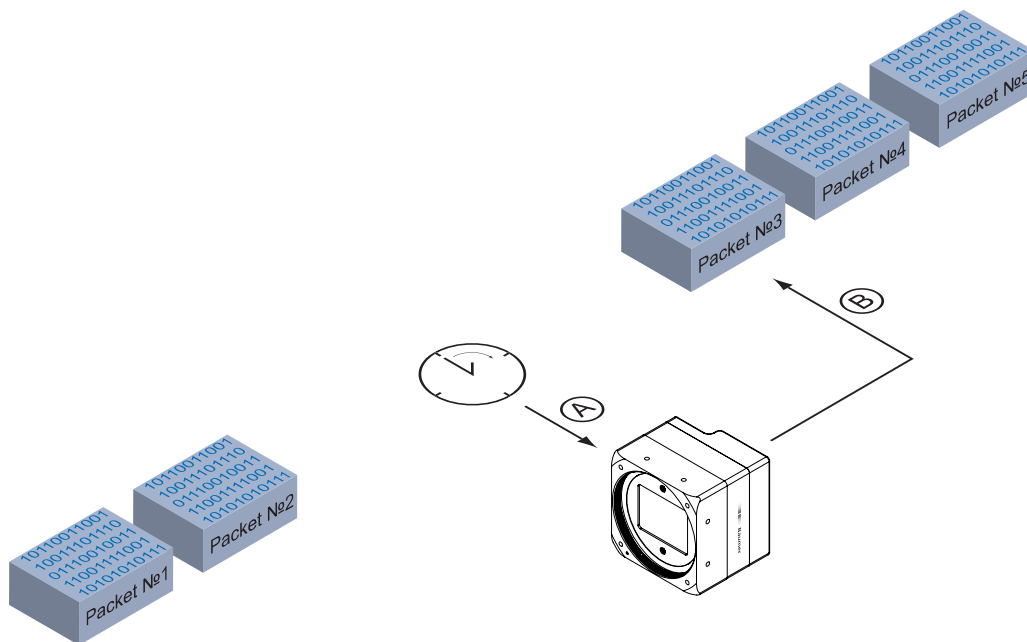
Figure 44 ▶

Resending lost packets within the data stream.

In our example packet no. 3 is lost. This fault is detected on packet no. 4, and the resend request triggered. Then the camera sends packet no. 5, followed by resending packet no. 3.

### 11.8.3 Fault 2: Lost Packet at the End of the Data Stream

In case of a fault at the end of the data stream, the application will wait for incoming packets for a predefined time. When this time has elapsed, the resend request is triggered and the "lost" packets will be resent.



◀ **Figure 45**  
Resending of lost packets at the end of the data stream.

In our example, packets from no. 3 to no. 5 are lost. This fault is detected after the predefined time has elapsed and the resend request (A) is triggered. The camera then resends packets no. 3 to no. 5 (B) to complete the image transfer.

### 11.8.4 Termination Conditions

The resend mechanism will continue until:

- all packets have reached the pc
- the maximum of resend repetitions is reached
- the resend timeout has occurred or
- the camera returns an error.

## 11.9 Message Channel

The asynchronous message channel is described in the GigE Vision® standard and offers the possibility of event signaling. There is a timestamp (64 bits) for each announced event, which contains the accurate time the event occurred. Each event can be activated and deactivated separately.

### EventMap LXG cameras with *VisualApplets*:

Bit	Edge	Event-ID	XML-Event-Description
<b>GigE Vision Standard Events</b>			
		0x0007	PrimaryApplicationSwitch
<b>Hardware-Events</b>			
0	rising	0x9000	Line0RisingEdge
1	falling	0x9001	Line0FallingEdge
2	rising	0x9002	Line1RisingEdge
3	falling	0x9003	Line1FallingEdge
4	rising	0x9004	Line2RisingEdge
5	falling	0x9005	Line2FallingEdge
6	rising	0x9006	Line3RisingEdge
7	falling	0x9007	Line3FallingEdge
12	rising	0x900C	ExposureStart
13	rising	0x900D	ExposureEnd
14	rising	0x900E	FrameStart
15	rising	0x900F	FrameEnd
16	rising	0x9010	TriggerReady
17	rising	0x9011	TriggerOverlapped
18	rising	0x9012	TriggerSkipped
20	rising	0x9014	Action1
<b>Software-Events</b>			
		0x9020	GigEVisionError
		0x9021	EventLost
		0x9022	EventDiscarded
		0x9023	GigEVisionHeartbeatTimeOut

## 11.10 Action Commands

The basic idea behind this feature was to achieve a simultaneous trigger for multiple cameras.

Action Command	Description
Action Command Trigger	used to send a trigger to all connected cameras.

Therefore a broadcast ethernet packet was implemented. This packet can be used to induce a trigger as well as other actions.

Due to the fact that different network components feature different latencies and jitters, the trigger over the Ethernet is not as synchronous as a hardware trigger. Nevertheless, applications can deal with these jitters in switched networks, and therefore this is a comfortable method for synchronizing cameras with software additions.

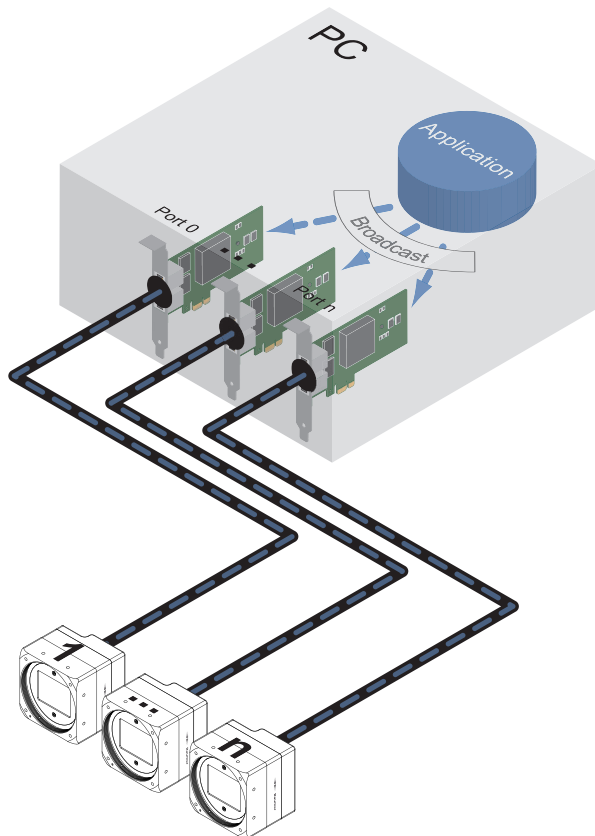
The action command is sent as a broadcast. In addition it is possible to group cameras, so that not all attached cameras respond to a broadcast action command.

Such an action command contains:

- a Device Key - for authorization of the action on this device
- a Group Key - for triggering actions on separated groups of devices
- a Group Mask - for extension of the range of separate device groups

### 11.10.1 Action Command Trigger

The figure below displays three cameras, which are triggered synchronously by a software application.



◀ **Figure 46**  
Triggering of multiple cameras via trigger over Ethernet (ToE).

Another application of action command is that a secondary application or PC or one of the attached cameras can actuate the trigger.

## 12. Start-Stop-Behaviour

### 12.1 Start / Stop Acquisition (Camera)

Once the image acquisition is started, three steps are processed within the camera:

- Determination of the current set of image parameters
- Exposure of the sensor
- Readout of the sensor.

Afterwards a repetition of this process takes place until the camera is stopped.

Stopping the acquisition means that the process mentioned above is aborted. If the stop signal occurs within a readout, the current readout will be finished before stopping the camera. If the stop signal arrives within an exposure, this will be aborted.

#### Special Case: Asynchronous Reset

The asynchronous reset represents a special case of stopping the current acquisition. Thereby exposure is aborted immediately. Thus the current image is not read out and the image is upcasted.

This feature was introduced to accelerate the changing of image parameters.

#### Asynchronous Reset:

For further information on the timings of this feature, please see the respective data sheets.

### 12.2 Start / Stop Interface

Without starting the interface, transmission of image data from the camera to the PC will not proceed. If the image acquisition is started before the interface is activated, the recorded images are lost.

If the interface is stopped during a transmission, this is aborted immediately.

### 12.3 Pause / Resume Interface

Pausing while the interface is operational, results in an interim storage of the recorded images within the internal buffer of the camera.

After resuming the interface, the buffered image data will be transferred to the PC.

### 12.4 Acquisition Modes

In general, three acquisition modes are available for LXG cameras with *VisualApplets*.

#### 12.4.1 Free Running

Free running means the camera records images continuously without external events.

#### 12.4.2 Trigger

The basic idea behind the trigger mode is the synchronization of cameras with machine cycles. Trigger mode means that image recording is not continuous, but triggered by external events.

#### 12.4.3 Sequencer

A sequencer is used for the automated control of series of images, using different settings for exposure time and gain.

## 13. 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.

### 13.1 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 LXG-40M.P) or the installed lens.
2. Uninstall the lens mount adapter ( LXG-40M.P). Uninstall the sensor glass (except LXG-40M.P) 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.

### 13.2 Cover glass

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

### 13.3 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.

## 14. 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

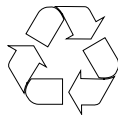
Storage temperature	-10 °C ... +70 °C ( +14 °F ... +158 °F)
Storage Humidity	10% ... 90% non condensing

## 15. 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 and 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.

## 16. 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!



## 17. Conformity



Baumer LXG cameras with *VisualApplets* comply with:

- CE
- RoHS

### 17.1 CE

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

## 18. Support

If you have any problems with the camera, then feel free to contact our support.

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