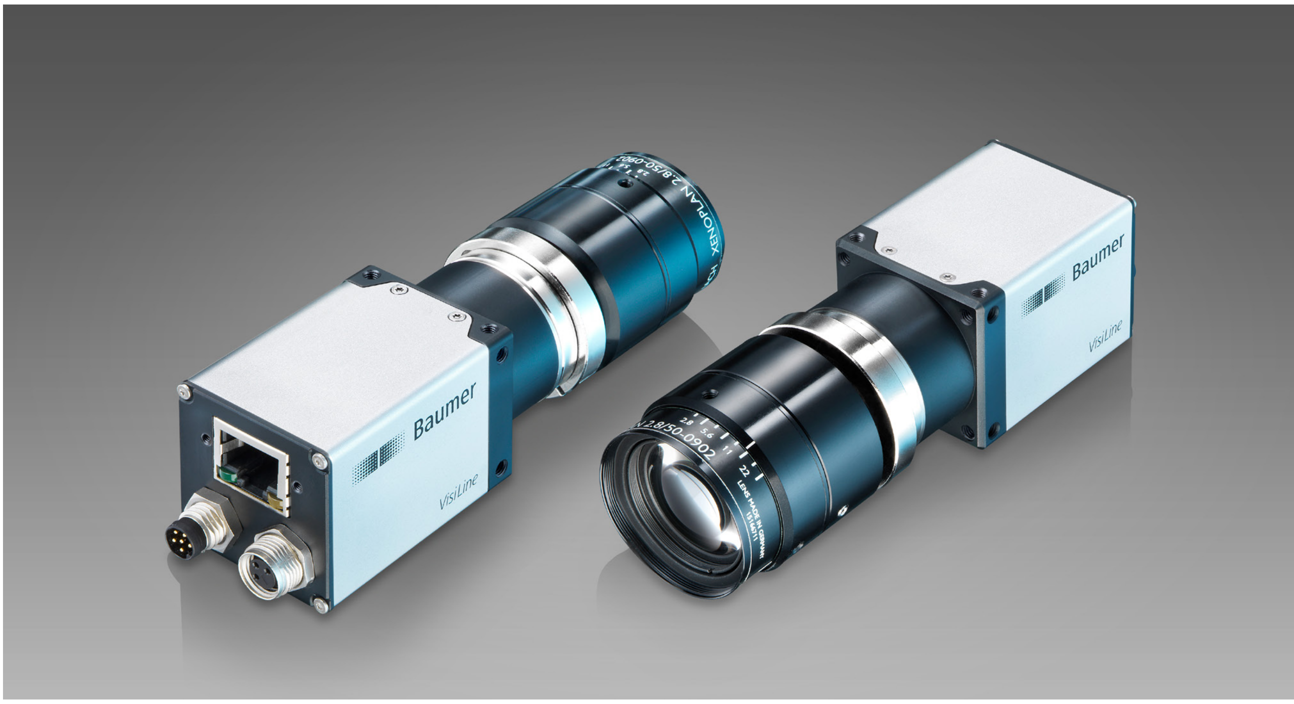


User´s Guide

VisiLine cameras (Gigabit Ethernet)

Document Version:	v2.5
Release:	29.09.2017
Document Number:	11107262

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

Caution

Heat can damage the camera. Provide adequate dissipation of heat, to ensure that the temperatures does not exceed the value (see Heat Transmission).

As there are numerous possibilities for installation, Baumer does not specify a specific method for proper heat dissipation.

Caution

Observe precautions for handling electrostatic sensitive devices!

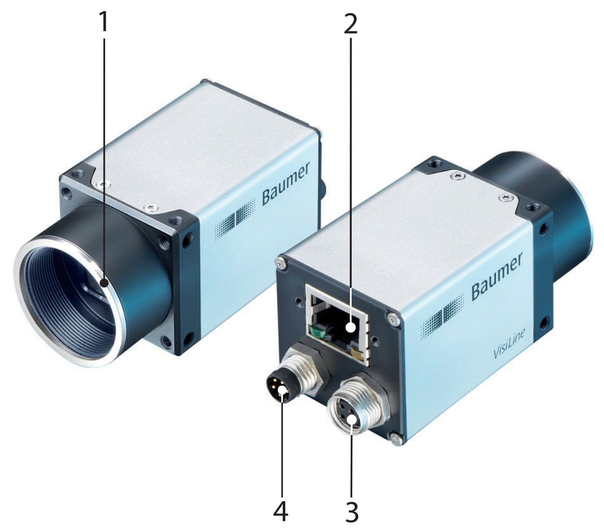
Caution

The camera is a class A device (DIN EN 55022:2011). It can cause radio interference in residential environments. Should this happen, you must take reasonable measures to eliminate the interference.

3. Intended Use

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

4. General Description

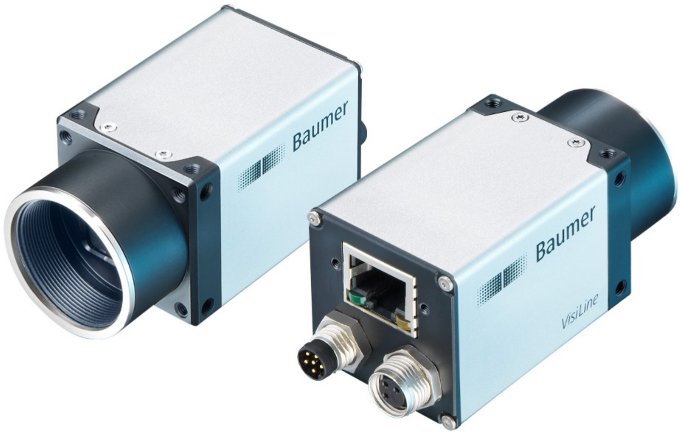


No.	Description	No.	Description
1	C-Mount lens connection	4	Power supply / Digital-IO
2	Ethernet Port		
3	Digital-IO		

All Baumer Gigabit Ethernet cameras of the *VisiLine*® family are characterized by:

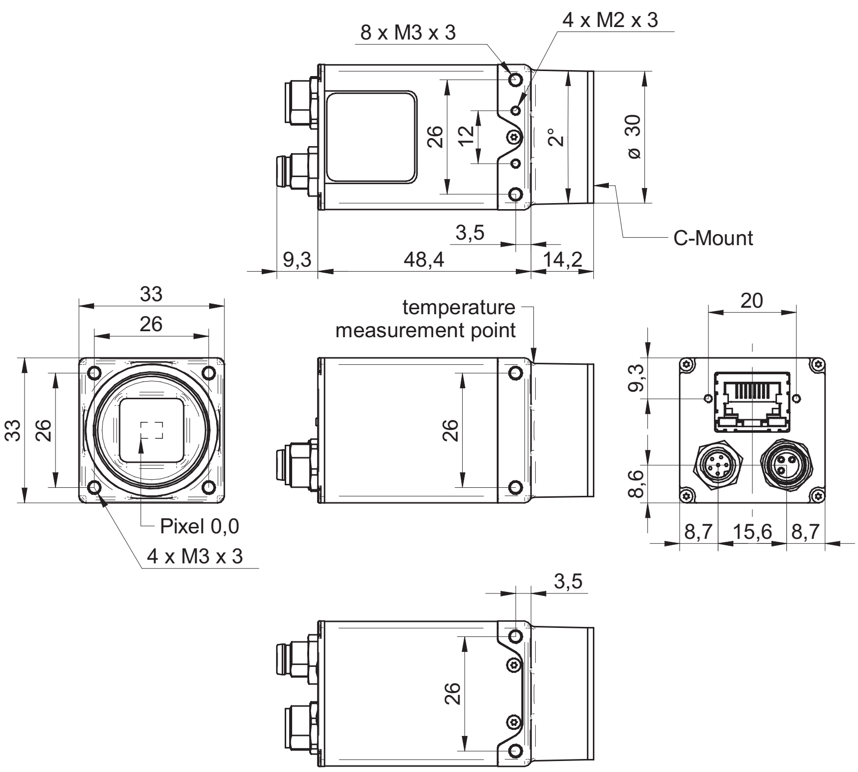
Best image quality	▪ Low noise and structure-free image information ▪ High quality mode with minimum noise
Flexible image acquisition	▪ Industrially compliant process interface with parameter setting capability (trigger and flash)
Fast image transfer	▪ Reliable transmission up to 1000 Mbit/sec according to IEEE802.3 ▪ Cable length up to 100 m ▪ PoE (Power over Ethernet) ▪ Baumer driver for high data volume with low CPU load ▪ High-speed multi-camera operation ▪ Gen<I>Cam™ and GigE Vision® compliant
Perfect integration	▪ Flexible generic programming interface (Baumer GAPI) for all Baumer cameras ▪ Powerful Software Development Kit (SDK) with sample codes and help files for simple integration ▪ Baumer viewer for all camera functions ▪ Gen<I>Cam™ compliant XML file to describe the camera functions ▪ Supplied with installation program with automatic camera recognition for simple commissioning
Compact design	▪ Light weight ▪ flexible assembly
Reliable operation	▪ State-of-the-art camera electronics and precision mechanics ▪ Low power consumption and minimal heat generation

5. Camera Models

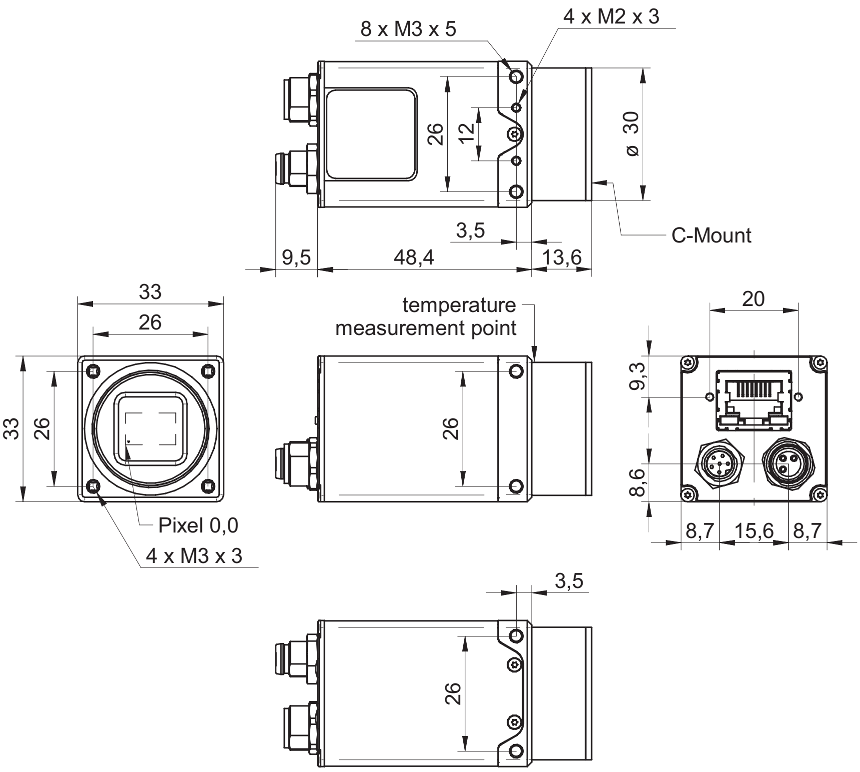


Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
CCD Sensor (monochrome / color)			
VLG-02M / VLG-02C	1/4"	656 x 490	160
VLG-12M / VLG-12C	1/3"	1288 x 960	42
VLG-20M / VLG-20C	1/1.8"	1624 x 1228	27
CMOS Sensor (monochrome / color)			
VLG-03M / VLG-03C	1/3"	640 x 480	376
VLG-22M / VLG-22C	2/3"	2044 x 1084	55
VLG-23M / VLG-23C	1/1.2"	1920 x 1200	53
VLG-24M / VLG-24C	1/1.2"	1920 x 1200	38.5
VLG-40M / VLG-40C	1"	2044 x 2044	29

Dimensions (except VLG-23M / VLG-23C, VLG-24M / VLG-24C)



Dimensions (VLG-23M / VLG-23C, VLG-24M / VLG-24C only)



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 (bag) 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

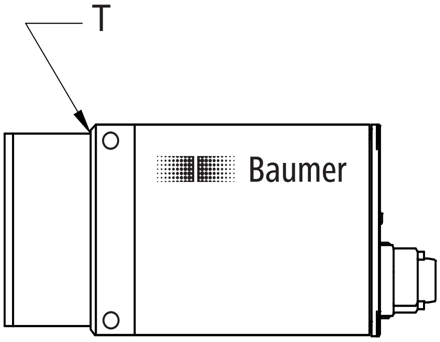
Temperature	
Storage temperature	-10°C ... +70°C (+14°F ... +158°F)
Operating temperature*	see Heat Transmission

* 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
	Heat can damage the camera. Provide adequate dissipation of heat, to ensure that the temperature does not exceed 50°C (122°F). As there are numerous possibilities for installation, Baumer does not specify a specific method for proper heat dissipation.



◄ **Figure 2**
Temperature measuring point

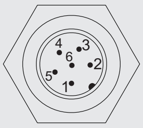
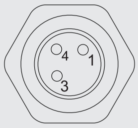
Measure Point	Maximal Temperature
T	50°C (122°F)

6.3 Mechanical Tests

Environmental Testing	Standard	Parameter	
Vibration, sinusodial	IEC 60068-2-6	Frequency Range	10-2000 Hz
		Amplitude underneath crossover frequencies	1.5 mm
		Acceleration	10 g
		Test duration / Axis	150 min
Vibration, broad band	IEC 60068-2-64	Frequency range	20-1000 Hz
		Acceleration RMS	10 g
		Test duration / Axis	300 min
Shock	IEC 60068-2-27	Puls time	11 ms
		Acceleration	50 g
Bump	IEC60068-2-29	Pulse Time	6 ms
		Acceleration	40 g

7. Pin-Assignment

7.1 Power Supply and Digital IOs

Power supply / Digital-IO (SACC-DSI-M 8MS-6CON-L180 SH / SACC-DSI-M8FS-3CON-M10-L180 SH) wire colors of the connecting cable					
					
1	Power V_{CC}	brown	1	not used	brown
2	IN 1	white	3	OUT 2	blue
3	GND	blue	4	OUT 3	black
4	OUT 1	black			
5	U_{ext} OUT	grey			
6	GND I/O	pink			

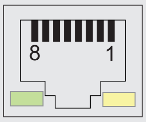
Notice

The electrical data are available in the respective data sheet.

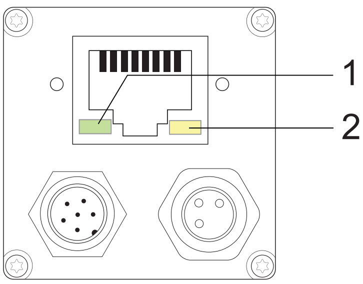
7.2 Ethernet Interface (PoE)

Notice

The *VisiLine*® supports PoE (Power over Ethernet) IEEE 802.3af Clause 33, 48V Power supply.

8P8C Modular Jack (RJ45) with LEDs			
			
1	green/white	MX1+	(negative / positive V_{port})
2	green	MX1-	(negative / positive V_{port})
3	orange/white	MX2+	(positive / negative V_{port})
4	blue	MX3+	
5	blue/white	MX3-	
6	orange	MX2-	(positive / negative V_{port})
7	brown/white	MX4+	
8	brown	MX4-	

7.2.1 LED Signaling



◄ **Figure 3**
LED positions on Baumer VisiLine cameras.

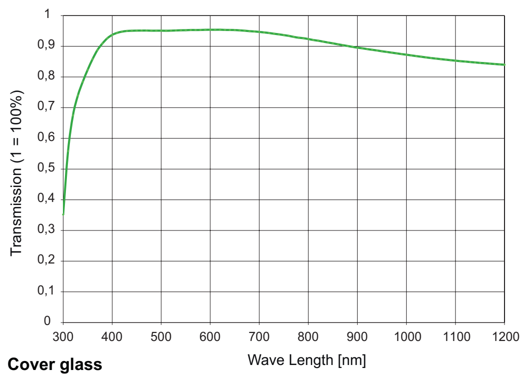
LED	Signal	Meaning
1	green	Link active
	green flash	Receiving
2	yellow	Transmitting

8. Product Specifications

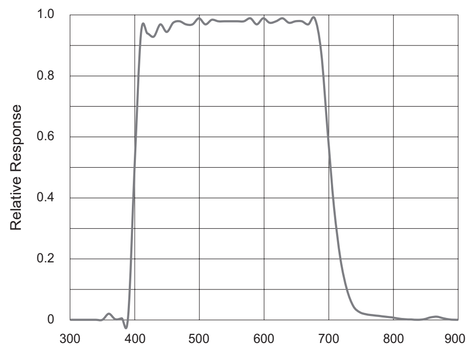
8.1 Spectral Sensitivity

The spectral sensitivity characteristics of monochrome and color matrix sensors for *Visi-Line*® 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.

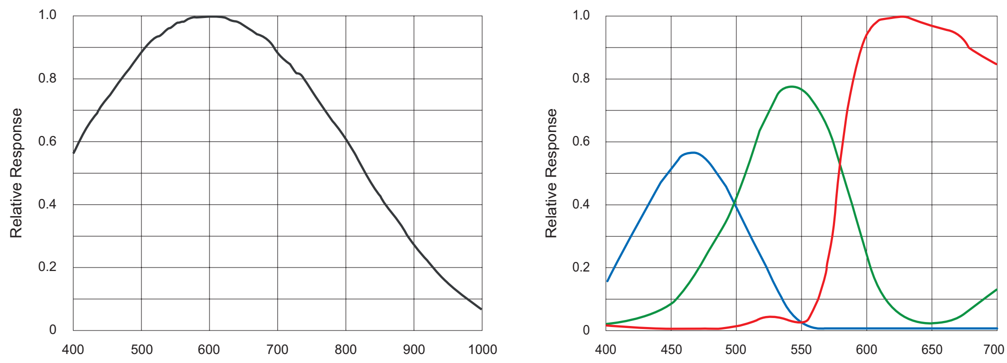
Values relating to the respective technical data sheets of the sensors.



Cover glass

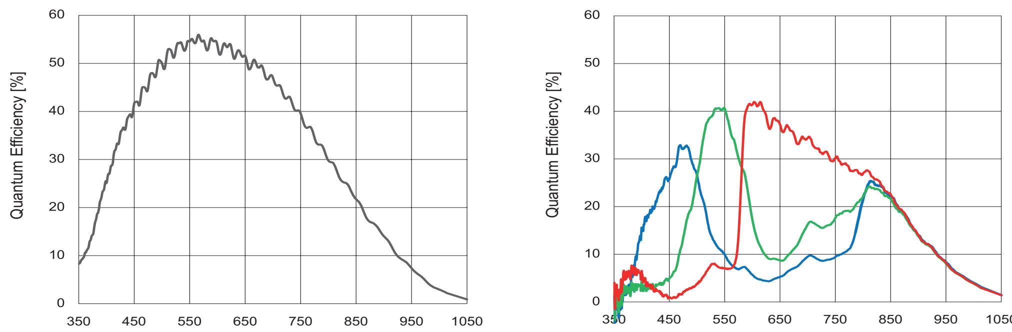


Filter glass



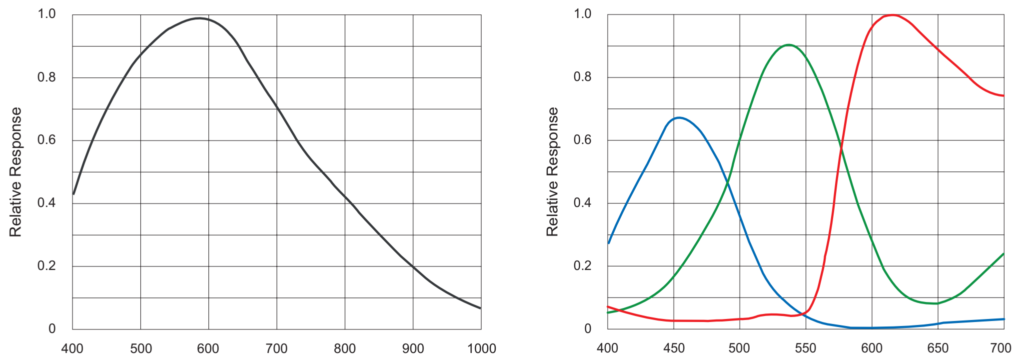
VLG-02M **VLG-02C**

Figure 5 ►
Spectral sensitivities for Baumer cameras with 0.2 MP CCD sensor.



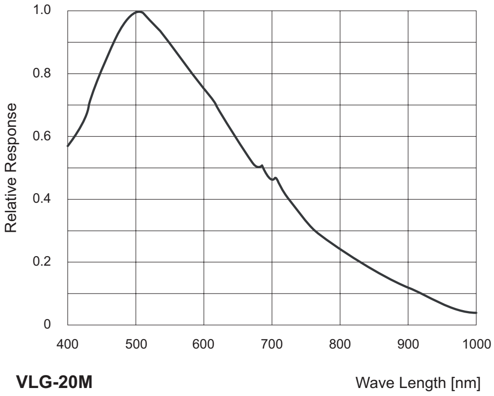
VLG-03M **VLG-03C**

Figure 4 ►
Spectral sensitivities for Baumer cameras with 0.3 MP CMOS sensor.

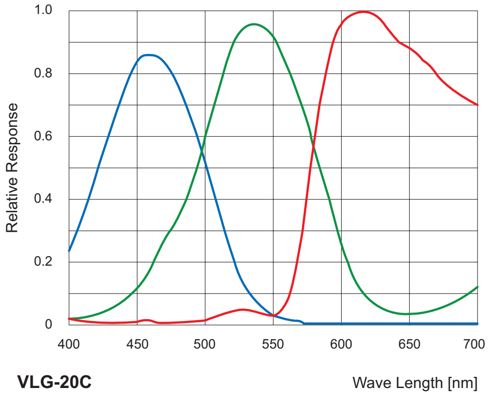


VLG-12M **VLG-12C**

Figure 6 ►
Spectral sensitivities for Baumer cameras with 1,2 MP CCD sensor.

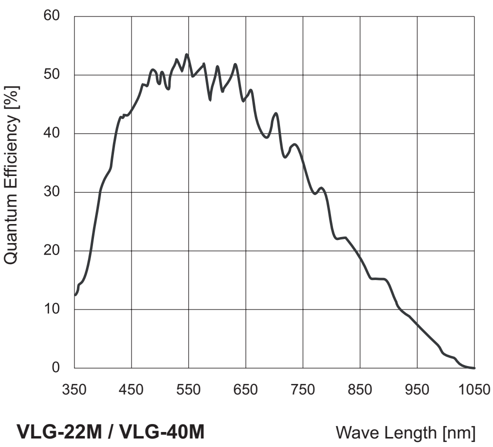


VLG-20M

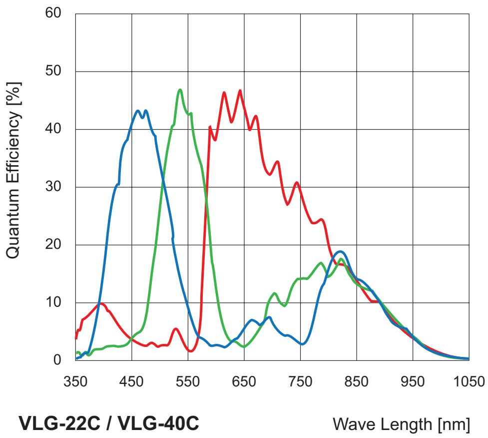


VLG-20C

◄ **Figure 7**
Spectral sensitivities for Baumer cameras with 2.0 MP CCD sensor.

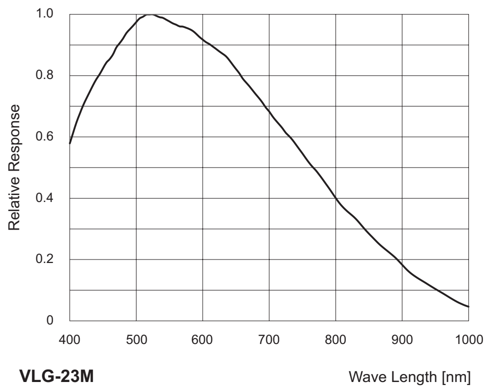


VLG-22M / VLG-40M

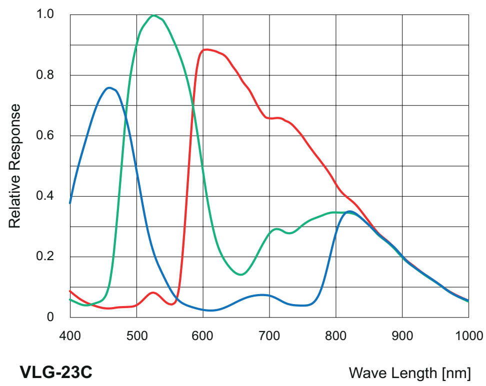


VLG-22C / VLG-40C

◄ **Figure 8**
Spectral sensitivities for Baumer cameras with 5.0, 4,0 MP CMOS sensor.

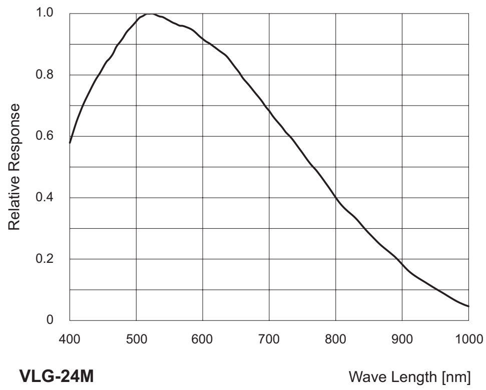


VLG-23M

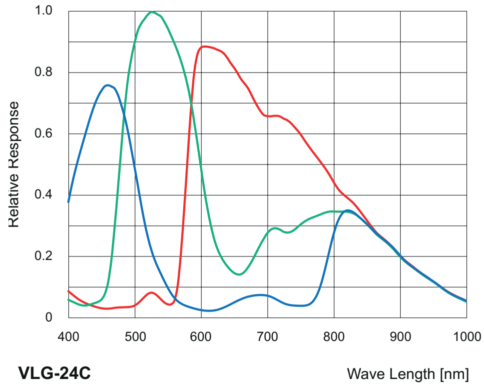


VLG-23C

◄ **Figure 8**
Spectral sensitivities for Baumer cameras with 2.3 MP CMOS sensor.



VLG-24M



VLG-24C

◄ **Figure 8**
Spectral sensitivities for Baumer cameras with 2.3 MP CMOS sensor.

8.2 Field of View Position

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

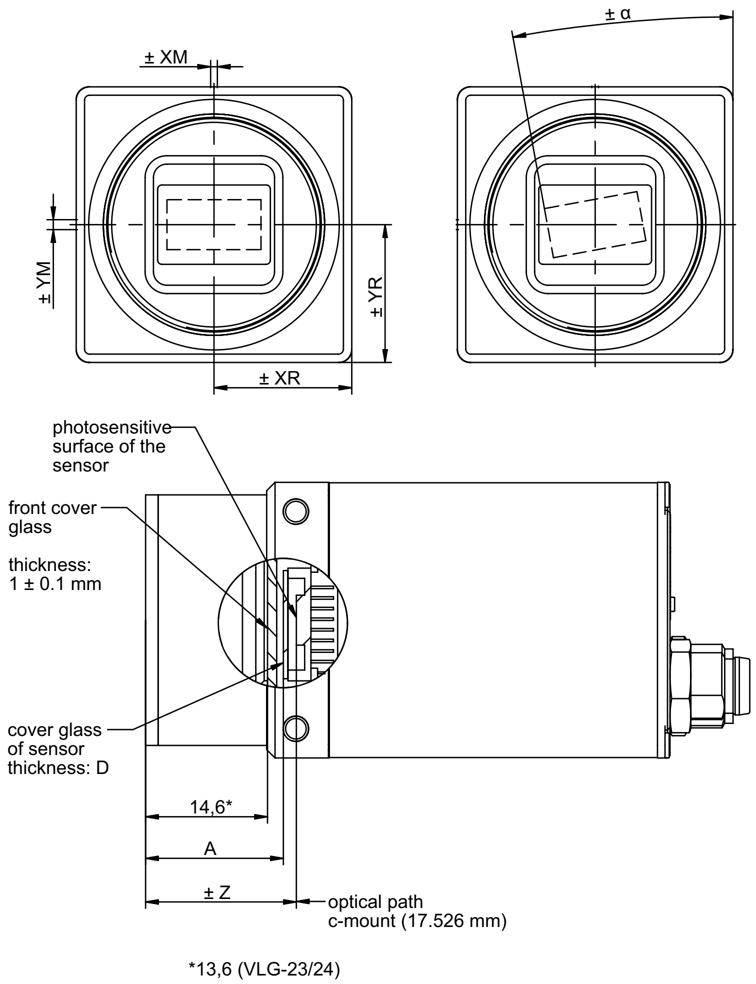


Figure 9 ►
Sensor accuracy of the Baumer VisiLine

Camera Type	± x_M [mm]	± y_M [mm]	± x_R [mm]	± Y_R [mm]	± z_{typ} [mm]	± α_{typ} [°]	A [mm]	D** [mm]
VLG-02*	0.09	0.09	0.09	0.09	0.025	0.7	16.1	0.75
VLG-03*	0.07	0.07	0.07	0.07	0.025	1.23	17.54	0.45
VLG-12*	0.06	0.06	0.06	0.06	0.025	0.7	16.6	0.5
VLG-20*	0.06	0.06	0.06	0.06	0.025	0.7	16.6	0.5
VLG-22*	0.07	0,07	0.07	0.07	0.025	0,5	16.2	0.55 ± 0.05
VLG-23*	0.06	0.06	0.06	0.06	0.025	0.47	16.2	0.5
VLG-24*	0.06	0.06	0.06	0.06	0.025	0.47	16.2	0.5
VLG-40*	0.07	0,07	0.07	0.07	0.025	0,5	16.2	0.55 ± 0.05

typical accuracy by assumption of the root mean square value
* C or M
** Dimension D in this table is from manufacturer datasheet

8.3 Acquisition Modes and Timings

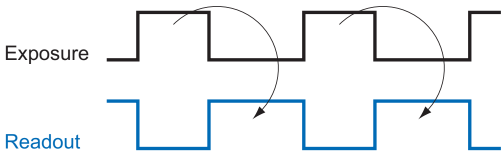
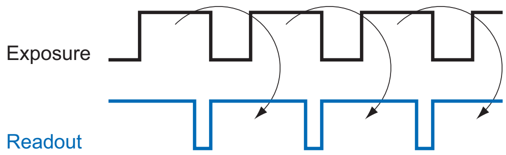
The image acquisition consists of two separate, successively processed components.

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 three modes, the *Free Running Mode*, the *Fixed-Frame-Rate Mode* and the *Trigger Mode*.

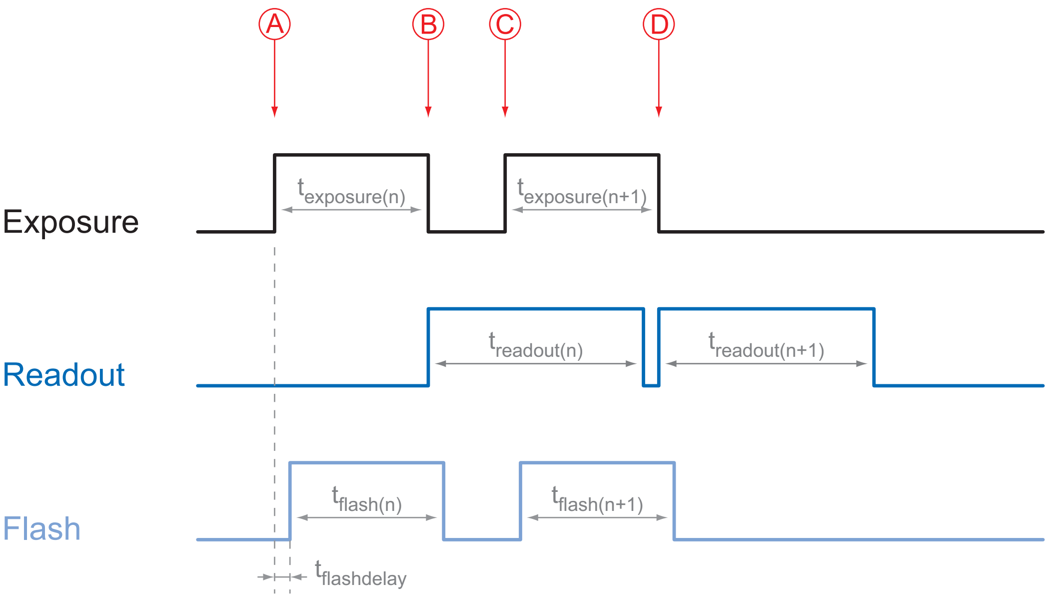
The cameras can be operated non-overlapped*) or overlapped. Depending on the mode used, and the combination of exposure and readout time:

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).
	

8.3.1 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 result (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.



$t_{flash} = t_{exposure}$

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

*) Non-overlapped means the same as sequential.

8.3.2 Fixed-Frame-Rate Mode

With this feature Baumer introduces a clever technique to the *VisiLine®* camera series, that enables the user to predefine a desired frame rate in continous mode.

For the employment of this mode the cameras are equipped with an internal clock generator that creates trigger pulses.

Notice
From a certain frame rate, skipping internal triggers is unavoidable. In general, this depends on the combination of adjusted frame rate, exposure and readout times.

8.3.3 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:

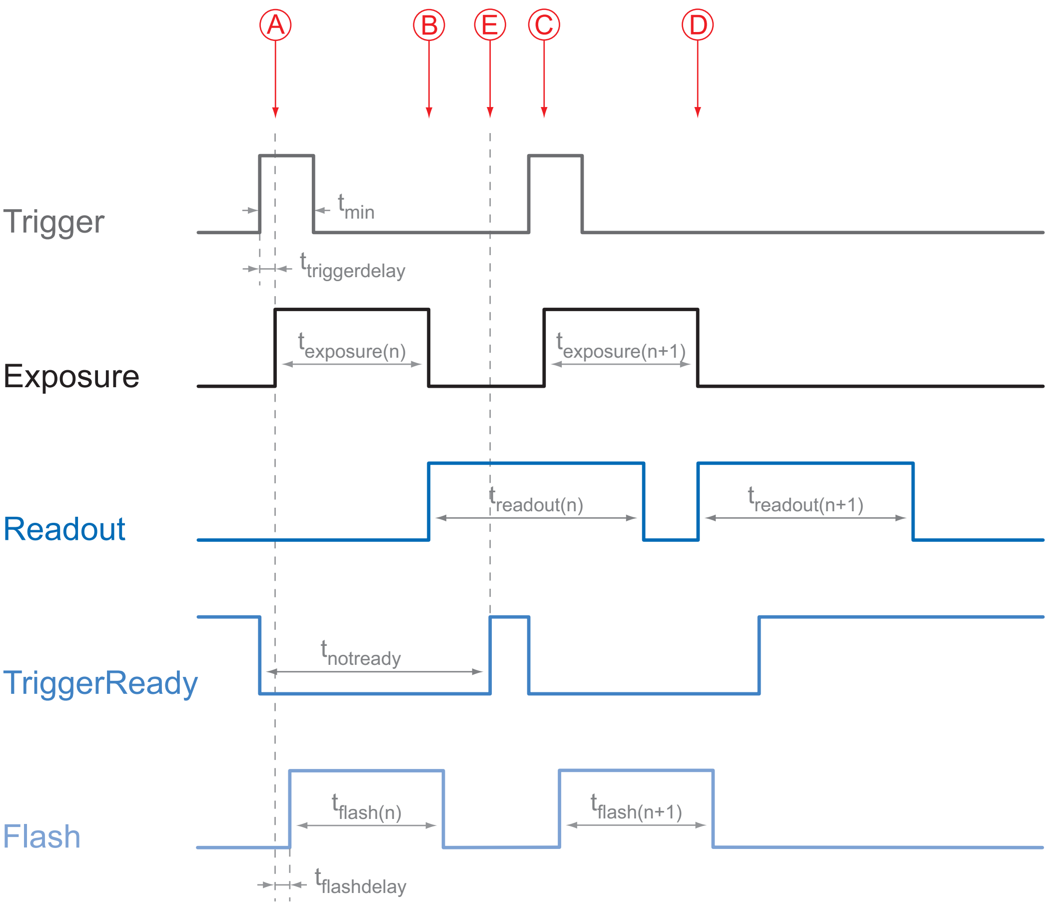
Case		Formula
$t_{exposure} < t_{readout}$	(1)	$t_{earliestpossibletrigger(n+1)} = t_{readout(n)} - t_{exposure(n+1)}$
	(2)	$t_{notready(n+1)} = t_{exposure(n)} + t_{readout(n)} - t_{exposure(n+1)}$
$t_{exposure} > t_{readout}$	(3)	$t_{earliestpossibletrigger(n+1)} = t_{exposure(n)}$
	(4)	$t_{notready(n+1)}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

8.3.3.1 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.



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

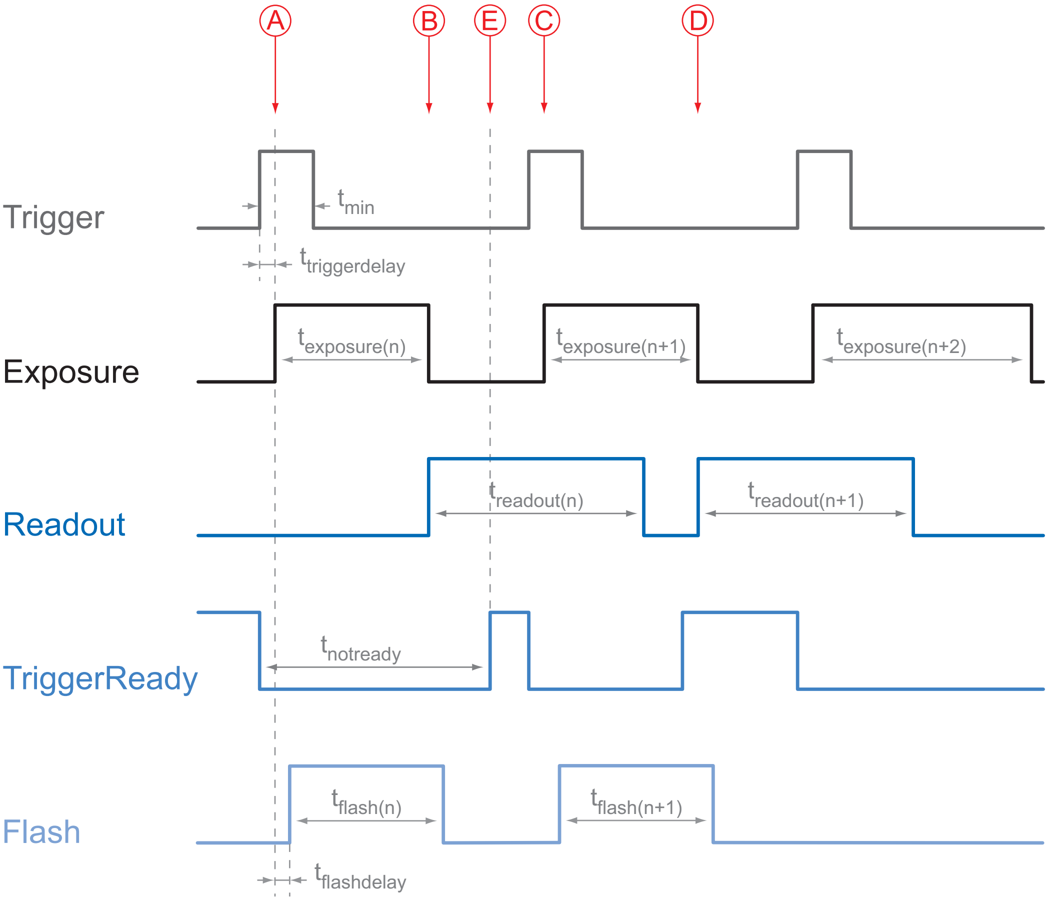
8.3.3.2 Overlapped Operation: $t_{exposure(n+2)} > t_{exposure(n+1)}$

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

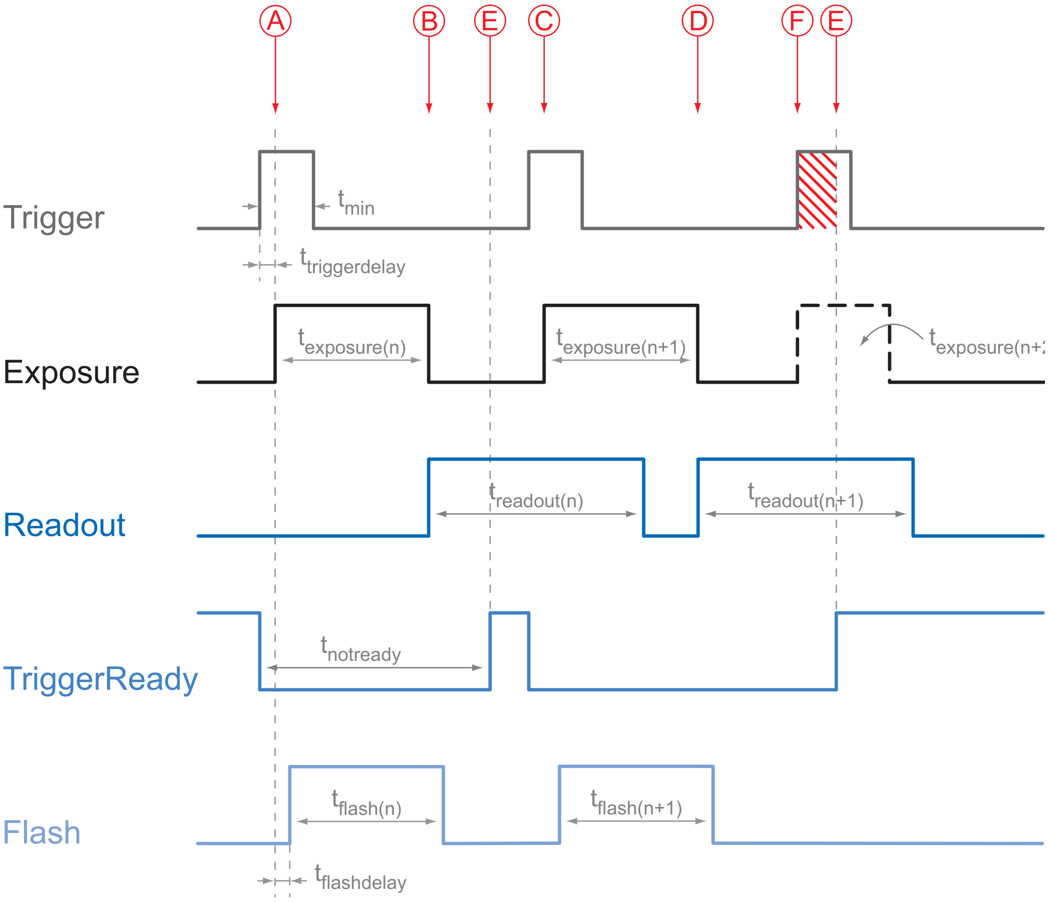
Image parameters:
Offset
Gain
Mode
Partial Scan



8.3.3.3 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 occurring 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

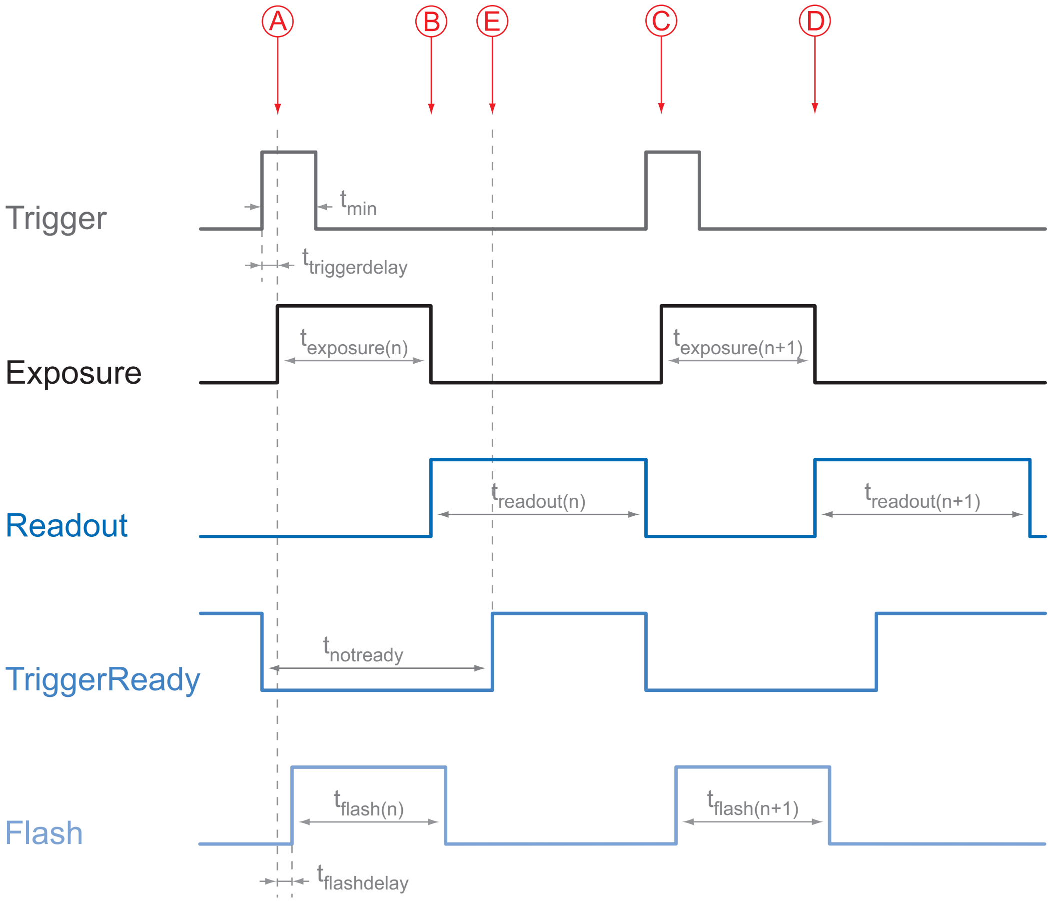
From a certain frequency of the trigger signal, skipping triggers is unavoidable. In general, this frequency depends on the combination of exposure and readout times.

8.3.3.4 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

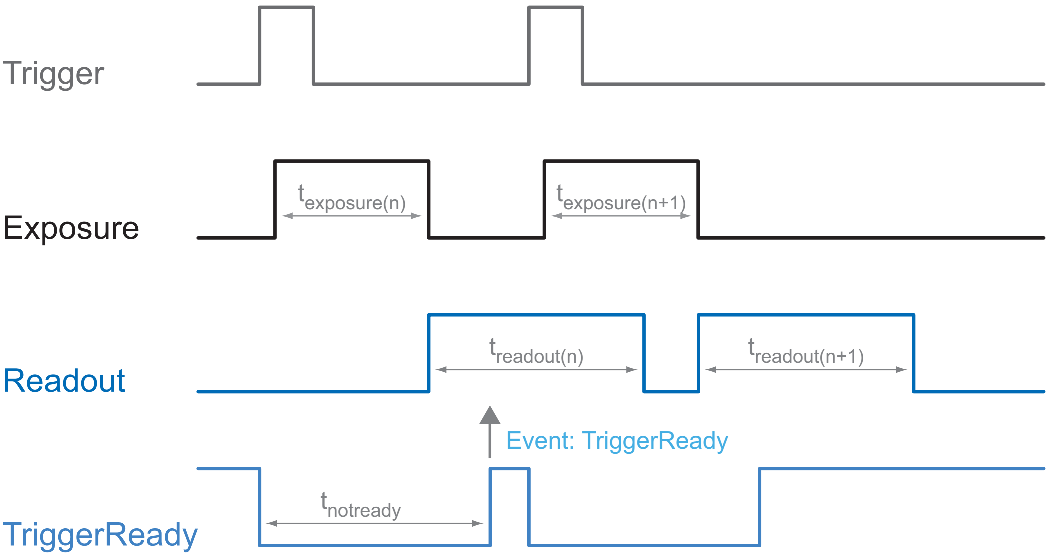


8.3.4 Advanced Timings for GigE Vision® Message Channel

The following charts show some timings for the event signaling by the asynchronous message channel. Vendor-specific events like "TriggerReady", "TriggerSkipped", "TriggerOverlapped" and "ReadoutActive" are explained.

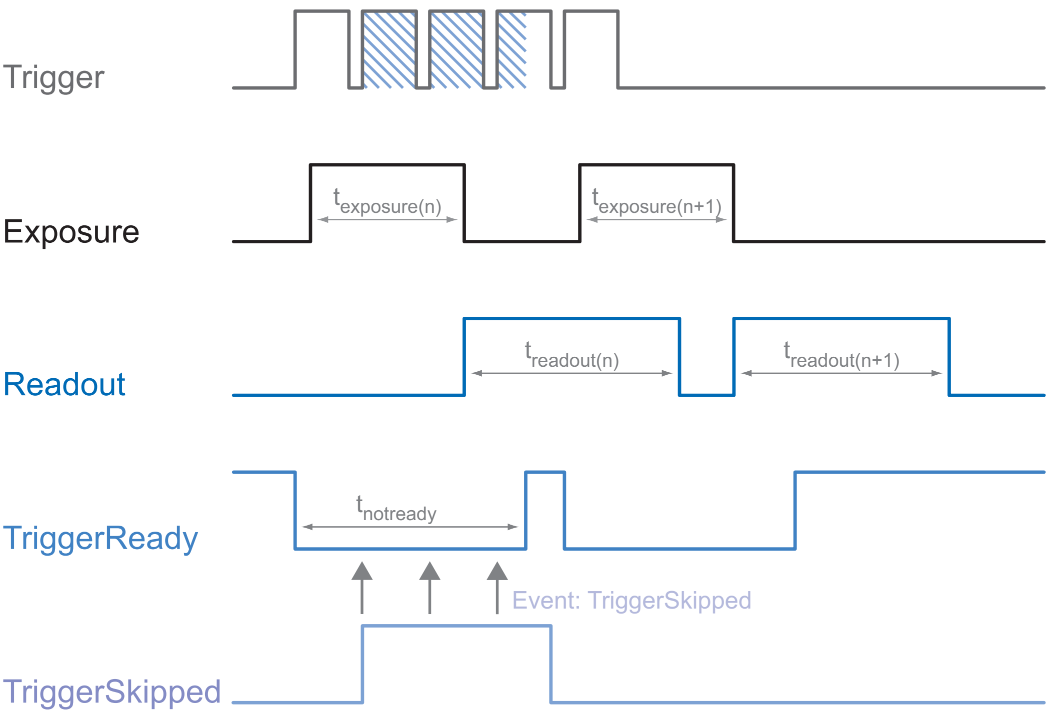
8.3.4.1 TriggerReady

This event signals whether the camera is able to process incoming trigger signals or not.



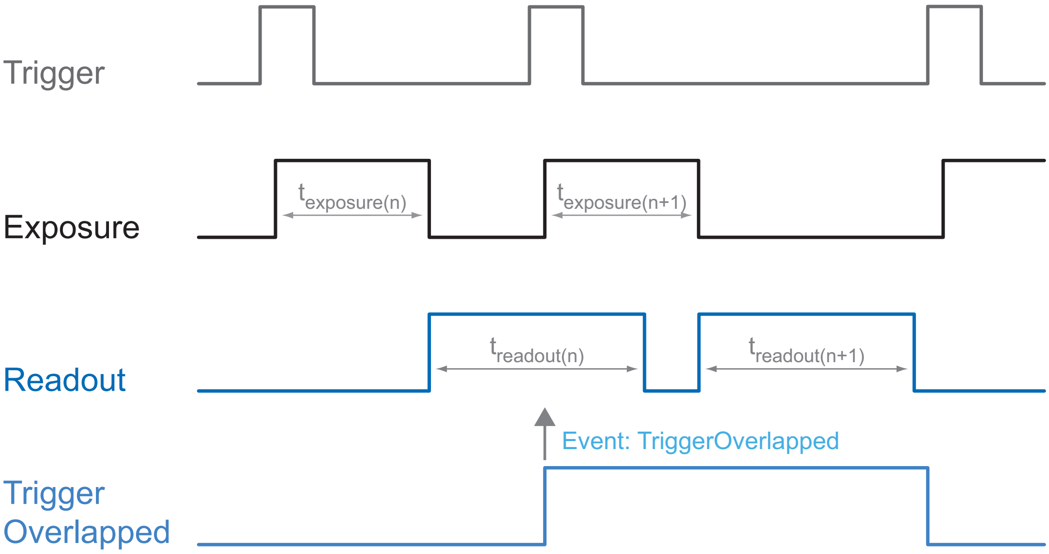
8.3.4.2 TriggerSkipped

If the camera is unable to process incoming trigger signals, which means the camera should be triggered within the interval $t_{notready}$, these triggers are skipped. On Baumer *VisiLine*® cameras the user will be informed about this fact by means of the event "TriggerSkipped".



8.3.4.3 TriggerOverlapped

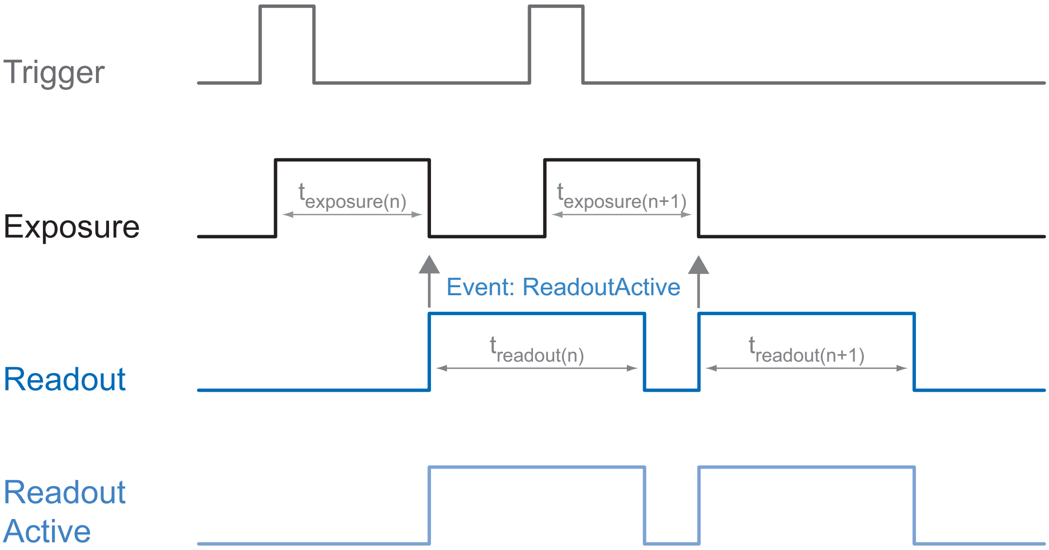
This signal is active, as long as the sensor is exposed and read out at the same time. which means the camera is operated overlapped.



Once a valid trigger signal occures not within a readout, the "TriggerOverlapped" signal changes to state low.

8.3.4.4 ReadoutActive

While the sensor is read out, the camera signals this by means of "ReadoutActive".



8.4 Software

8.4.1 Baumer GAPI

Baumer GAPI stands for **B**aumer "**G**eneric **A**pplication **P**rogramming **I**nterface". 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.

8.4.2 3rd Party Software

Strict compliance with the Gen<I>Cam™ standard allows Baumer to offer the use of 3rd Party Software for operation with cameras of the *VisiLine*® family.

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

9. Camera Functionalities

9.1 Image Acquisition

9.1.1 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

Camera Type	Full frame	Binning 2x2	Binning 1x2	Binning 2x1
Monochrome				
VLG-02M	■	■	■	■
VLG-03M	■	■	■	■
VLG-12M	■	■	■	■
VLG-20M	■	■	■	■
VLG-22M	■	■	■	■
VLG-23M	■	■	■	■
VLG-24M	■	■	■	■
VLG-40M	■	■	■	■
Color				
VLG-02C	■	■	■	■
VLG-03C	■	■	■	■
VLG-12C	■	■	■	■
VLG-20C	■	■	■	■
VLG-22C	■	■	■	■
VLG-23C	■	■	■	■
VLG-24C	■	■	■	■
VLG-40C	■	■	■	■

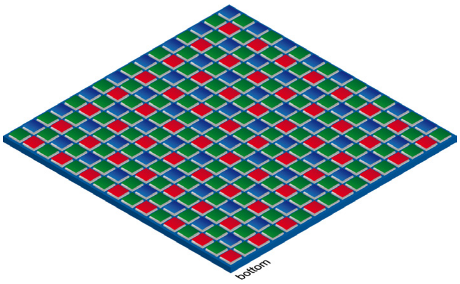
9.1.2 Pixel Format

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

9.1.2.1 Definitions

RAW: Raw data format. Here the data are stored without processing.

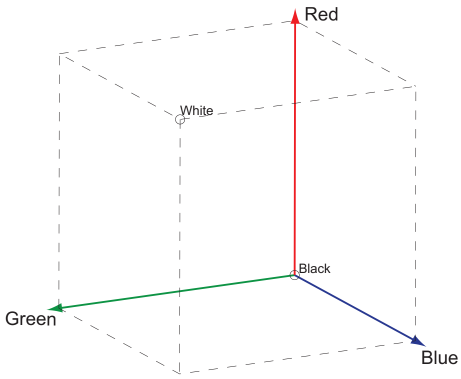
Bayer: Raw data format of color sensors.
Color filters are placed on these sensors in a checkerboard pattern, generally in a 50% green, 25% red and 25% blue array.



◄ **Figure 10**
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 11**
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.

Two bytes are needed for transmitting more than 8 bits per pixel - even if the second byte is not completely filled with data. In order to save bandwidth, the packed formats were introduced to Baumer *VisiLine*® cameras. In this formats, the unused bits of one pixel are filled with data from the next pixel.

Figure 12 ►
Bit string of Mono 8 bit and RGB 8 bit.

8 bit:

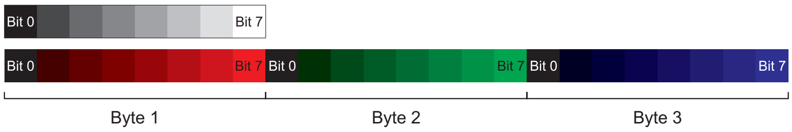


Figure 13 ►
Spreading of Mono 12 bit over two bytes.

12 bit:

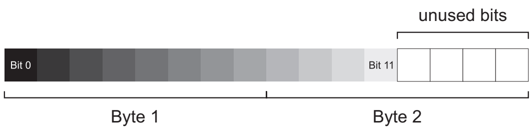
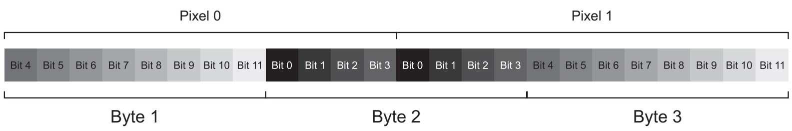


Figure 14 ►
Spreading of two pixels in Mono 12 bit over three bytes (packed mode).

Packed:

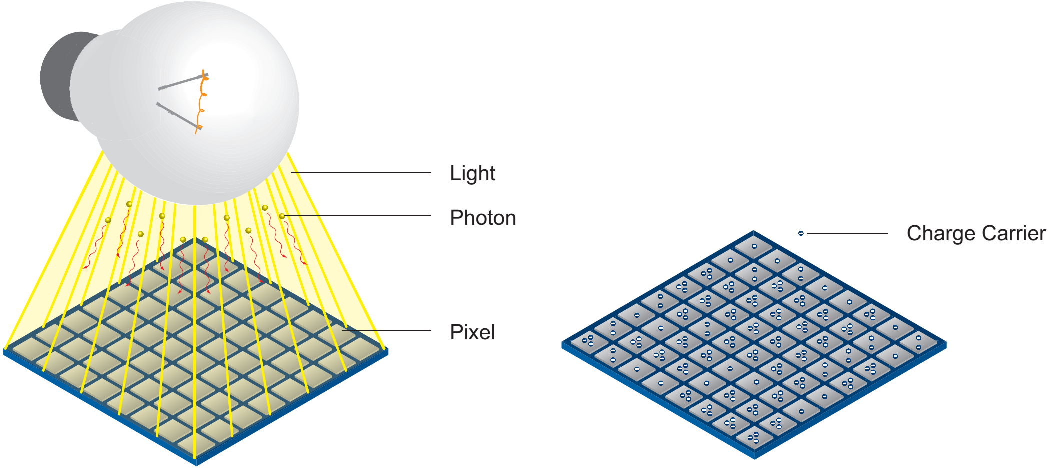


9.1.2.2 Pixel Formats on Baumer *VisiLine*® Cameras

Camera Type	Mono8	Mono12	Mono12Packed	Bayer RG8	Bayer RG12	RGB8Packed	BGR8Packed	YUV411Packed	YUV422Packed	YUV444Packed
Monochrome										
VLG-02M	■	■	■	□	□	□	□	□	□	□
VLG-03M	■	■	■	□	□	□	□	□	□	□
VLG-12M	■	■	■	□	□	□	□	□	□	□
VLG-20M	■	■	■	□	□	□	□	□	□	□
VLG-22M	■	■	■	□	□	□	□	□	□	□
VLG-23M	■	■	■	□	□	□	□	□	□	□
VLG-24M	■	■	■	□	□	□	□	□	□	□
VLG-40M	■	■	■	□	□	□	□	□	□	□
Color										
VLG-02C	■	□	□	■	■	■	■	■	■	■
VLG-03C	■	□	□	■	■	■	■	■	■	■
VLG-12C	■	□	□	■	■	■	■	■	■	■
VLG-20C	■	□	□	■	■	■	■	■	■	■
VLG-22C	■	□	□	■	■	■	■	■	■	■
VLG-23C	■	□	□	■	■	■	■	■	■	■
VLG-24C	■	□	□	■	■	■	■	■	■	■
VLG-40C	■	□	□	■	■	■	■	■	■	■

9.1.3 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 15**
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 *VisiLine*® cameras, the exposure time can be set within the following ranges (step size 1µsec):

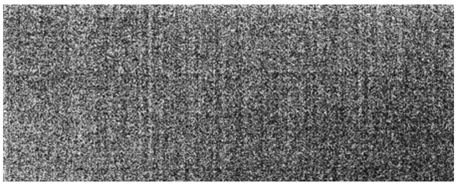
Camera Type	$t_{exposure}$ min	$t_{exposure}$ max
Monochrome		
VLG-02M	4 µsec	60 sec
VLG-03M	15 µsec	1 sec
VLG-12M	4 µsec	60 sec
VLG-20M	4 µsec	60 sec
VLG-22M	15 µsec	1 sec
VLG-23M	45 µsec	60 sec
VLG-24M	45 µsec	60 sec
VLG-40M	20 µsec	1 sec
Color		
VLG-02C	4 µsec	60 sec
VLG-03C	15 µsec	1 sec
VLG-12C	4 µsec	60 sec
VLG-20C	4 µsec	60 sec
VLG-22C	15 µsec	1 sec
VLG-23C	45 µsec	60 sec
VLG-24C	45 µsec	60 sec
VLG-40C	20 µsec	1 sec

9.1.4 Fixed Pattern Noise Correction (FPNC)

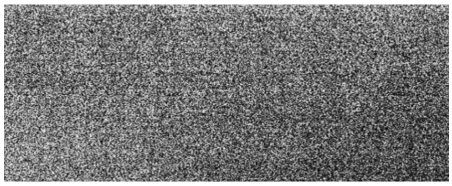
Camera Type	FPNC
CCD	
VLG-02M / VLG-02C	□
VLG-12M / VLG-12C	□
VLG-20M / VLG-20C	□
CMOS	
VLG-22M / VLG-22C	■
VLG-23M / VLG-23C	□
VLG-24M / VLG-24C	□
VLG-40M / VLG-40C	■

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.



FPN Correction Off



FPN Correction On

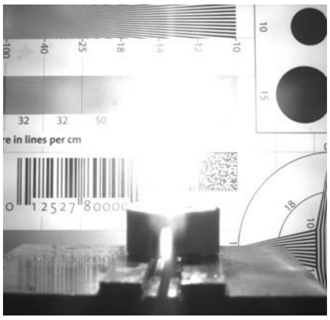
9.1.5 High Dynamic Range (HDR)

Camera Type	HDR
CCD	
VLG-02M / VLG-02C	□
VLG-12M / VLG-12C	□
VLG-20M / VLG-20C	□
CMOS	
VLG-22M / VLG-22C	■
VLG-23M / VLG-23C	□
VLG-24M / VLG-24C	□
VLG-40M / VLG-40C	■

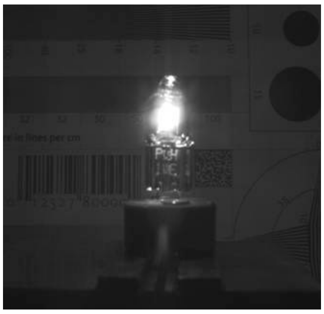
Beside the standard linear response the sensor supports a special high dynamic range mode (HDR) called piecewise linear response. With this mode illuminated pixels that reach a certain programmable voltage level will be clipped. Darker pixels that do not reach this threshold remain unchanged. The clipping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

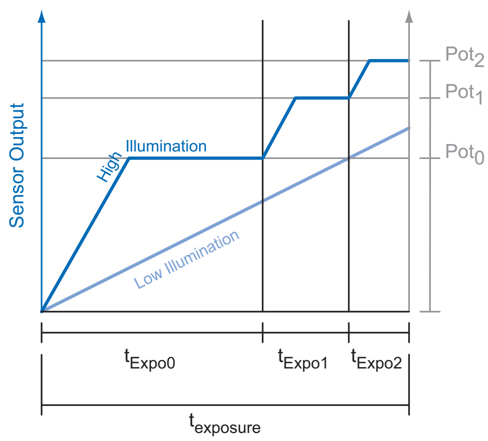
The value for t_{Expo2} will be calculated automatically in the camera. ($t_{Expo2} = t_{exposure} - t_{Expo0} - t_{Expo1}$)



HDR Off

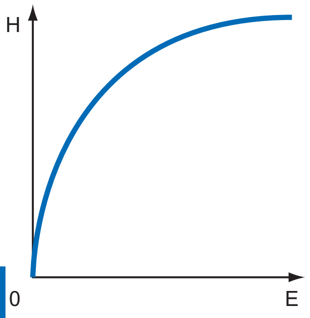


HDR On



9.1.6 Look-Up-Table

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



▲ **Figure 16**
Non-linear perception of the human eye.
H - Perception of brightness
E - Energy of light

9.1.7 Gamma Correction

With this feature, Baumer *VisiLine®* 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 oversimplified version):

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

On Baumer *VisiLine®* cameras the correction factor γ is adjustable from 0.1 to 2.

The values of the calculated intensities are entered into the Look-Up-Table. Thereby previously existing values within the LUT will be overwritten.

Notice
If the LUT feature is disabled on the software side, the gamma correction feature is disabled, too.

9.1.8 Region of Interest

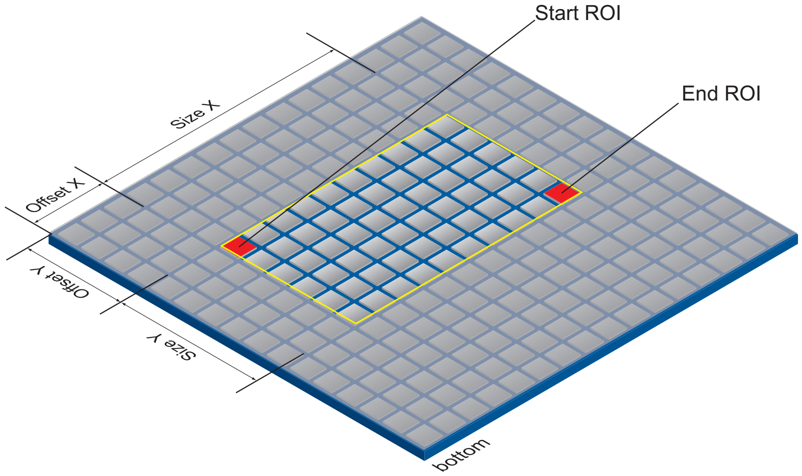
With the "Region of Interest" (ROI) function it is possible to predefine a so-called Region of Interest (ROI) or Partial Scan. This ROI is an area of pixels of the sensor. On image acquisition, only the information of these pixels is sent to the PC. Therefore, not all lines of the sensor are read out, which decreases the readout time ($t_{readout}$). This increases the frame rate (expect VLG-24M / VLG-24C).

This function is employed, when only a region of the field of view is of interest. It is coupled to a reduction in resolution.

The ROI is specified by four values:

- Offset X - x-coordinate of the first relevant pixel
- Offset Y - y-coordinate of the first relevant pixel
- Size X - horizontal size of the ROI
- Size Y - vertical size of the ROI

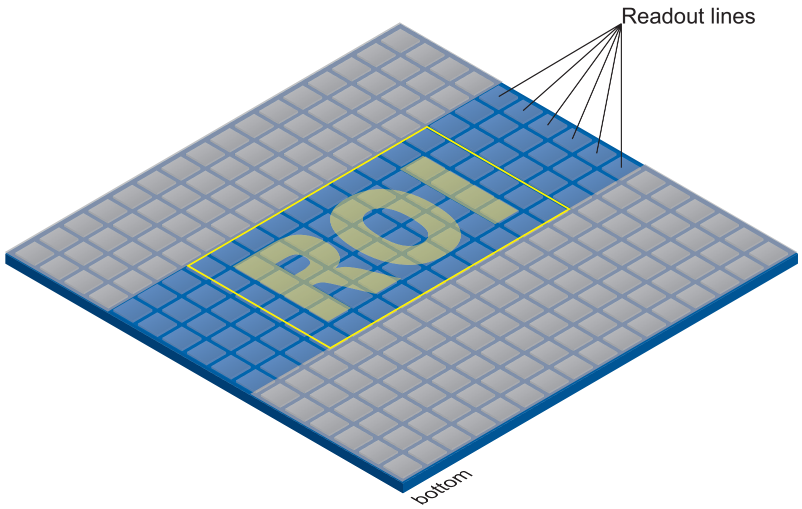
9.1.8.1 ROI



◄ **Figure 17**
ROI: Parameters

ROI Readout

In the illustration below, readout time would be decreased to 40%, compared to a full frame readout.



◄ **Figure 18**
Decrease in readout time by using partial scan.

9.1.9 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. Higher sensitivity enables shorter exposure times.

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.

Notice
Occuring deviations in brightness after binning can be corrected with *Brightness Correction* function.

9.1.9.1 Monochrome Binning

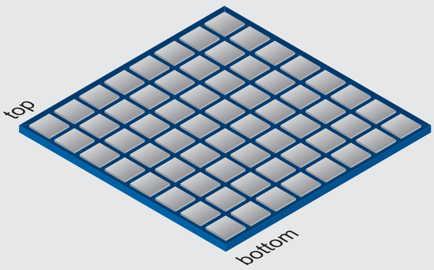
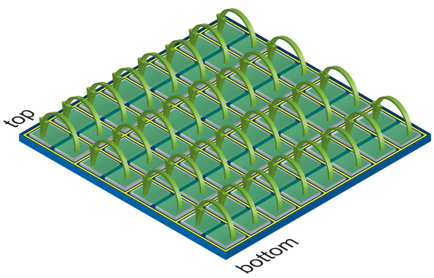
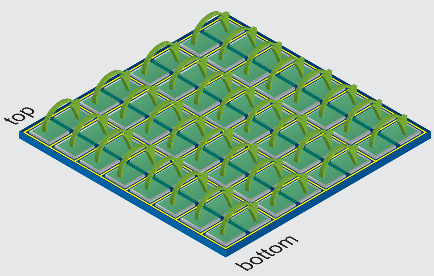
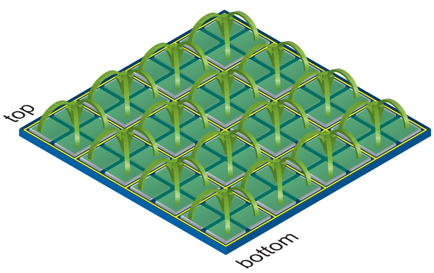
Binning	Illustration	Output
without		
1x2		
2x1		
2x2		

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.

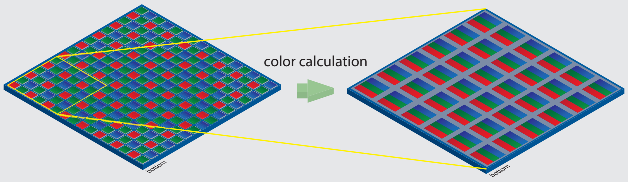
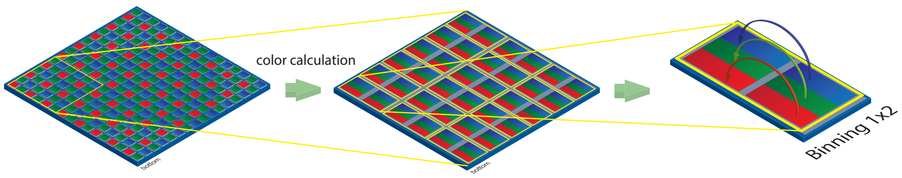
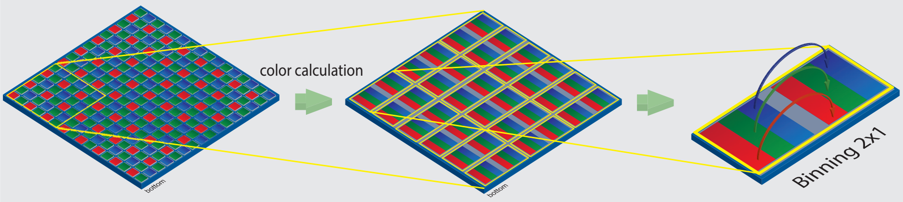
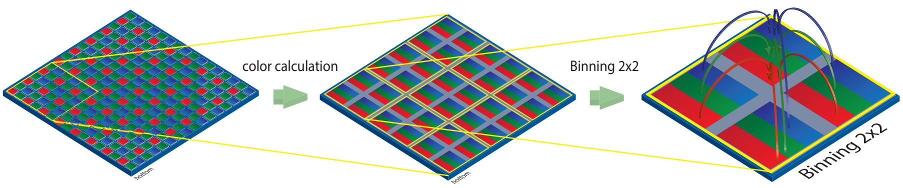
Figure 22 ▶
Bidirectional binning causes both a horizontally and vertically compressed image with quadruple brightness.

9.1.9.2 Color Binning

Color Binning is calculating on the camera (no higher frame rates) – The sensor does not support this binning operation.

Color calculated pixel formats

In pixel formats, which are not raw formats (e.g. RGB8Packed), the three calculated color values (R, G, B) of a pixel will be added with those of the corresponding neighbor pixel during binning.

Binning	Illustration
without	
1x2	
2x1	
2x2	

◀ **Figure 23**
Full frame image, no binning of pixels.

◀ **Figure 24**
Vertical binning causes a vertically compressed image with doubled brightness.

◀ **Figure 25**
Horizontal binning causes a horizontally compressed image with doubled brightness.

◀ **Figure 26**
Bidirectional binning causes both a horizontally and vertically compressed image with quadruple brightness.

RAW pixel formats

In the raw pixel formats (e.g. BayerRG8) the color values of neighboring pixels are combined.

> **Notice**
>
> The color information is lost in this process, because adjacent pixels with different colors are combined.

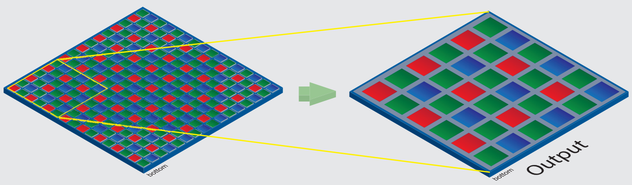
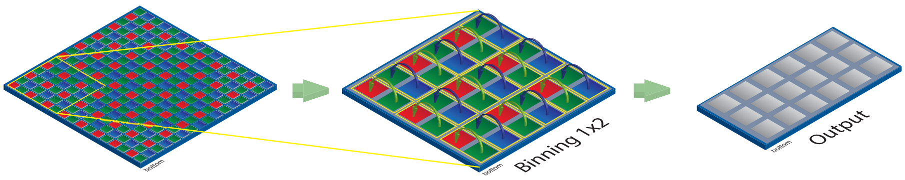
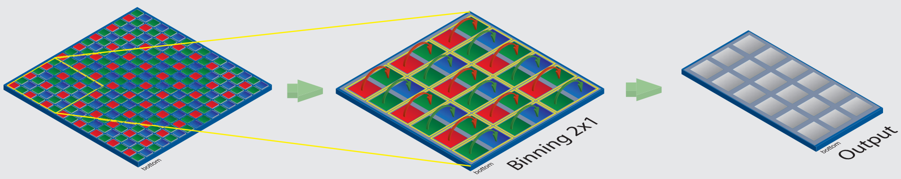
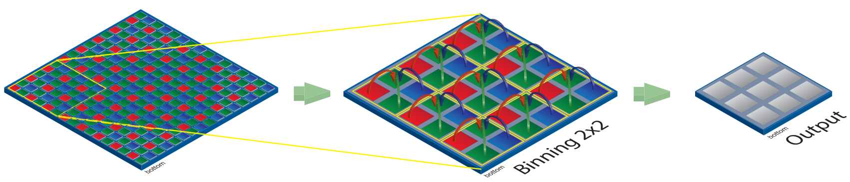
Binning	Illustration
without	
1x2	
2x1	
2x2	

Figure 27 ▶
Full frame image, no binning of pixels.

Figure 28 ▶
Vertical binning causes a vertically compressed image with doubled brightness.

Figure 29 ▶
Horizontal binning causes a horizontally compressed image with doubled brightness.

Figure 30 ▶
Bidirectional binning causes both a horizontally and vertically compressed image with quadruple brightness.

9.1.9.3 Binning Frame Rates [fps]

Full Frame

Camera Type	Mono8 [fps]	Mono 12	Mono12Packed	Bayer RG8	Bayer RG12	RGB8Packed	BGR8Packed	YUV411Packed	YUV422Packed	YUV444Packed
Monochrome										
VLG-02M	159	159	159	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-03M*	373	199	271	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-12M	42	42	42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-20M	27	27	27	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-22M*	55	27	37	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-23M*	53	26	35	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-24M*	38	26	35	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-40M*	29	14	19	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Color										
VLG-02C	159	n.a.	n.a.	159	159	127	127	159	159	127
VLG-03C*	371	n.a.	n.a.	373	199	135	135	270	198	135
VLG-12C	42	n.a.	n.a.	42	42	34	34	42	42	34
VLG-20C	27	n.a.	n.a.	27	27	20	20	27	27	20
VLG-22C*	55	n.a.	n.a.	55	27	18	18	37	27	18
VLG-23C*	53	n.a.	n.a.	53	26	17	17	35	26	17
VLG-24C*	38	n.a.	n.a.	38	26	17	17	35	26	17
VLG-40C*	29	n.a.	n.a.	29	14	9	9	19	14	9

Binning 1x2 (vertical)

Camera Type	Mono8	Mono 12	Mono12Packed	Bayer RG8	Bayer RG12	RGB8Packed	BGR8Packed	YUV411Packed	YUV422Packed	YUV444Packed
Monochrome										
VLG-02M	248	248	248	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-03M*	373	373	373	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-12M	72	72	72	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-20M	46	46	46	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-22M*	55	55	55	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-23M*	64	53	64	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-24M*	38	38	38	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-40M*	29	29	29	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Color										
VLG-02C	248	n.a.	n.a.	248**	248**	159	159	159	159	159
VLG-03C*	371	n.a.	n.a.	373**	373**	270	270	371	371	270
VLG-12C	72	n.a.	n.a.	72**	72**	42	42	42	42	42
VLG-20C	46	n.a.	n.a.	46**	46**	27	27	27	27	27
VLG-22C*	55	n.a.	n.a.	55**	55**	37	37	55	55	37
VLG-23C*	63	n.a.	n.a.	34**	53**	35	35	63	53	35
VLG-24C*	38	n.a.	n.a.	38**	38**	35	35	38	38	35
VLG-40C*	29	n.a.	n.a.	29**	29**	19	19	29	29	19

*) Exposure Time: 15µs (VLG-40: 20µs, VLG-23/24: 45µs), Readout Mode: overlapped

**) monochrome

Binning 2x1 (horizontal)

Camera Type	Mono8	Mono 12	Mono12Packed	Bayer RG8	Bayer RG12	RGB8Packed	BGR8Packed	YUV411Packed	YUV422Packed	YUV444Packed
Monochrome										
VLG-02M	159	159	159	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-03M*	373	373	373	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-12M	42	42	42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-20M	27	27	27	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-22M*	55	55	55	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-23M*	64	53	64	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-24M*	38	38	38	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-40M*	29	29	29	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Color										
VLG-02C	159	n.a.	n.a.	159**	159**	159	159	159	159	159
VLG-03C*	371	n.a.	n.a.	373**	373**	270	270	371	371	270
VLG-12C	42	n.a.	n.a.	42**	42**	42	42	42	42	42
VLG-20C	27	n.a.	n.a.	27**	27**	27	27	27	27	27
VLG-22C*	55	n.a.	n.a.	55**	55**	37	37	55	55	37
VLG-23C*	63	n.a.	n.a.	63**	53**	35	35	63	53	35
VLG-24C*	38	n.a.	n.a.	38**	38**	35	35	38	38	35
VLG-40C*	29	n.a.	n.a.	29**	29**	19	19	29	29	19

Binning 2x2

Camera Type	Mono8	Mono 12	Mono12Packed	Bayer RG8	Bayer RG12	RGB8Packed	BGR8Packed	YUV411Packed	YUV422Packed	YUV444Packed
Monochrome										
VLG-02M	248	248	248	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-03M*	373	373	373	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-12M	72	72	72	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-20M	46	46	46	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-22M*	55	55	55	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-23M*	64	64	64	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-24M*	38	38	38	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
VLG-40M*	29	29	29	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Color										
VLG-02C	248	n.a.	n.a.	248**	248**	159	159	159	159	159
VLG-03C*	371	n.a.	n.a.	373**	373**	371	371	371	371	371
VLG-12C	72	n.a.	n.a.	72**	72**	42	42	42	42	42
VLG-20C	46	n.a.	n.a.	46**	46**	27	27	27	27	27
VLG-22C*	55	n.a.	n.a.	55**	55**	55	55	55	55	55
VLG-23C*	63	n.a.	n.a.	63**	63	63	63	63	63	63
VLG-24C*	38	n.a.	n.a.	38**	38**	38	38	38	38	38
VLG-40C*	29	n.a.	n.a.	29**	29**	29	29	29	29	29

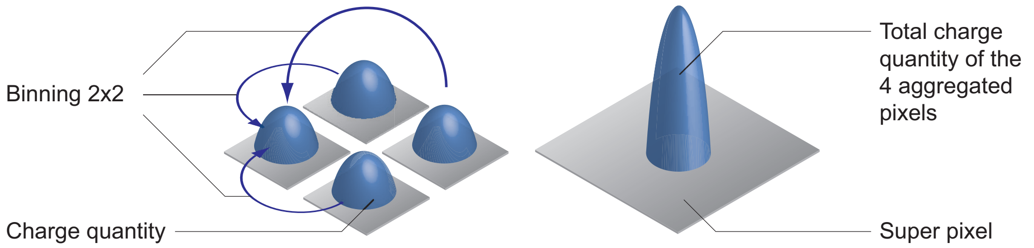
*) Exposure Time: 15µs (VLG-40: 20µs, VLG-23/24: 45µs), Readout Mode: overlapped

**) monochrome

9.1.10 Brightness Correction (Binning Correction)

The aggregation of charge carriers may cause an overload. To prevent this, binning correction was introduced. Here, three binning modes need to be considered separately:

Binninig	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 31**
Aggregation of charge carriers from four pixels in bidirectional binning.

9.1.11 Flip Image

The Flip Image function let you flip the captured images horizontal and/or vertical before they are transmitted from the camera.

Notice
A defined ROI will also flipped.

Camera Type	Horizontal	Vertical
VLG-02M / VLG-02C	■	□
VLG-03M / VLG-03C	■	■
VLG-12M / VLG-12C	■	□
VLG-20M / VLG-20C	■	□
VLG-22M / VLG-22C	■	■
VLG-23M / VLG-23C	■	■
VLG-24M / VLG-24C	■	■
VLG-40M / VLG-40C	■	■

Figure 32 ▶
Flip image vertical

Normal	Flip vertical
	

Figure 33 ▶
Flip image horiontal

Normal	Flip horizontal
	

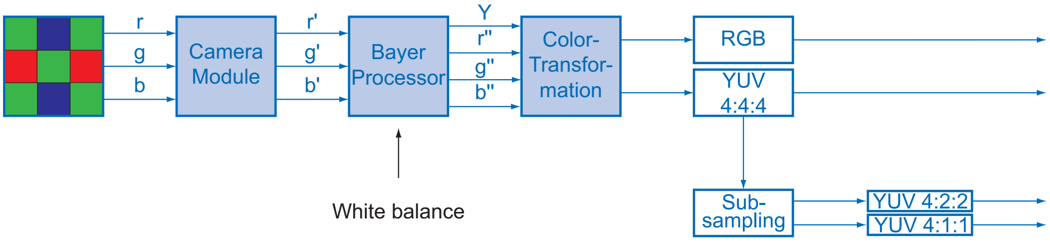
Figure 34 ▶
Flip image horiontal and vertical

Normal	Flip horizontal and vertical
	

9.2 Color Processing

Baumer color cameras are balanced to a color temperature of 5000 K.

Oversimplified, color processing is realized by 4 modules.



◄ **Figure 35**
Color processing modules of Baumer color cameras.

The color signals r (red), g (green) and b (blue) of the sensor are amplified in total and digitized within the camera module.

Within the Bayer processor, the raw signals r', g' and b' are amplified by using of independent factors for each color channel. Then the missing color values are interpolated, which results in new color values (r'', g'', b''). The luminance signal Y is also generated.

The next step is the color transformation. Here the previously generated color signals r'', g'' and b'' are converted to the chroma signals U and V, which conform to the standard. Afterwards theses signals are transformed into the desired output format. Thereby the following steps are processed simultaneously:

- Transformation to color space RGB or YUV
- External color adjustment
- Color adjustment as physical balance of the spectral sensitivities

In order to reduce the data rate of YUV signals, a subsampling of the chroma signals can be carried out. Here the following items can be customized to the desired output format:

- Order of data output
- Subsampling of the chroma components to YUV 4:2:2 or YUV 4:1:1
- Limitation of the data rate to 8 bits

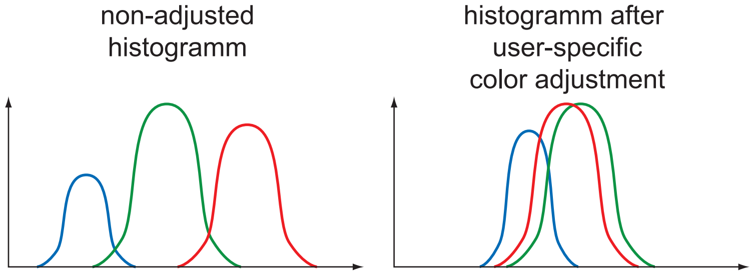
9.3 Color Adjustment – White Balance

This feature is available on all color cameras of the Baumer *VisiLine*® series 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.

9.3.1 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 36**
Examples of histogramms for a non-adjusted image and for an image after user-specific white balance..

9.3.2 One Push White Balance

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).

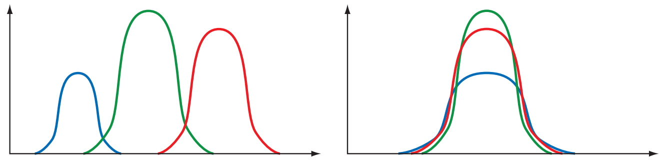


Figure 37 ►
Examples of histogramms for a non-adjusted image and for an image after "one push" white balance.

9.4 Analog Controls

9.4.1 Offset / Black Level

On Baumer *VisiLine*® cameras, the offset (or black level) is adjustable from 0 to 255 LSB (relating to 12 bit).

Camera Type	Step Size 1 LSB Relating to
Monochrome	
VLG-02M	14 bit
VLG-03M	12 bit
VLG-12M	14 bit
VLG-20M	14 bit
VLG-22M	12 bit
VLG-23M	12 bit
VLG-24M	12 bit
VLG-40M	12 bit
Color	
VLG-02C	14 bit
VLG-03C	12 bit
VLG-12C	14 bit
VLG-20C	14 bit
VLG-22C	12 bit
VLG-23C	12 bit
VLG-24C	12 bit
VLG-40C	12 bit

9.4.2 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 a user-defined gain factor within the camera. This gain factor is adjustable.

Notice
Increasing the gain factor causes an increase of image noise.

CCD Sensor

Camera Type	Gain [dB]
Monochrome	
VLG-02M	0...29
VLG-12M	0...29
VLG-20M	0...29
Color	
VLG-02C	0...29
VLG-12C	0...29
VLG-20C	0...29

CMOS Sensor

Camera Type	Gain [dB]
Monochrome	
VLG-03M	0...18
VLG-22M	0...18
VLG-23M	0...48
VLG-24M	0...48
VLG-40M	0...18
Color	
VLG-03C	0...18
VLG-22C	0...18
VLG-23C	0...48
VLG-24C	0...48
VLG-40C	0...18

9.5 Pixel Correction

9.5.1 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.

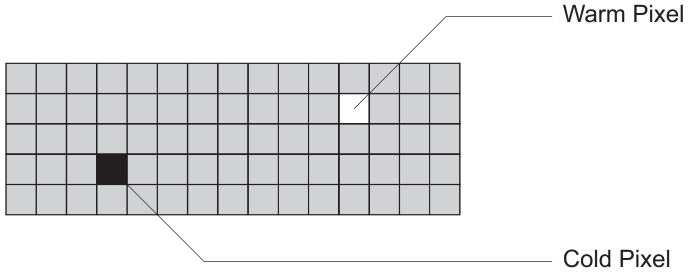


Figure 38 ▶
Distinction of "hot" and "cold" pixels within the recorded image.

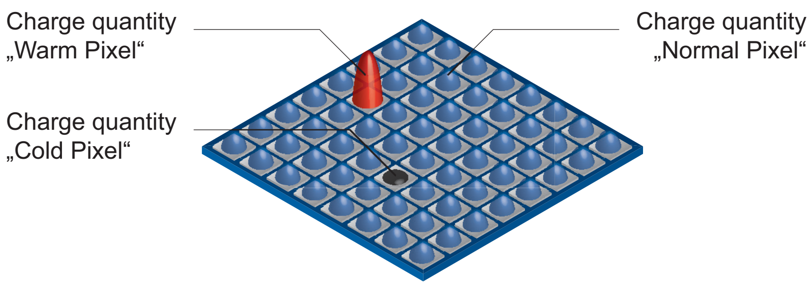


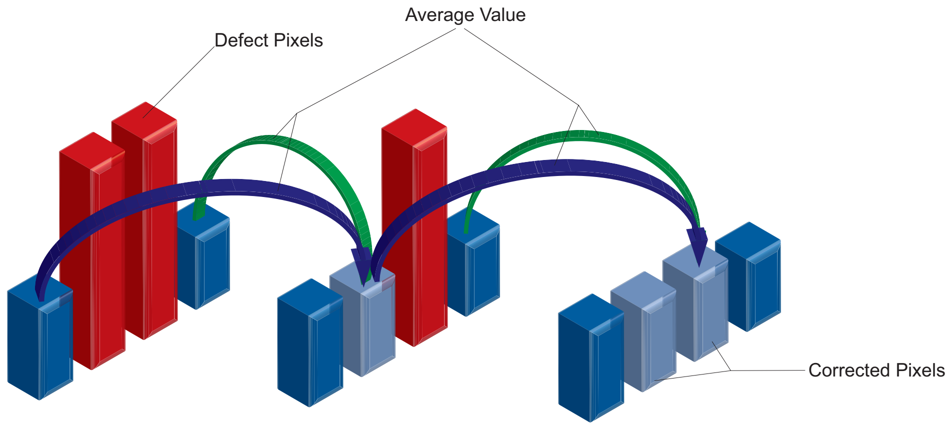
Figure 39 ▶
Charge quantity of "hot" and "cold" pixels compared with "normal" pixels.

9.5.2 Correction Algorithm

On cameras of the Baumer *VisiLine*® series, 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 on the left and the right side of the defect pixels, will be read out. (within the same bayer phase for color)
  - Then the average value of these 2 pixels is determined to correct the first defect pixel
  - Finally, the value of the second defect pixel is is corrected by using the previously corrected pixel and the pixel of the other side of the defect pixel.
  - The correction is able to correct up to two neighboring defect pixels.



9.5.3 Defectpixellist

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

Additional hot or cold pixels can develop during the lifecycle of a camera. In this case Baumer offers the possibility of adding their coordinates to the defectpixellist.

The user can determine the coordinates*) of the affected pixels 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 defectpixellist.

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

9.6 Process Interface

9.6.1 Digital IOs

9.6.1.1 User Definable Inputs

The wiring of these input connectors 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 "Trigger", "Timer" and "LineOut 1..3".

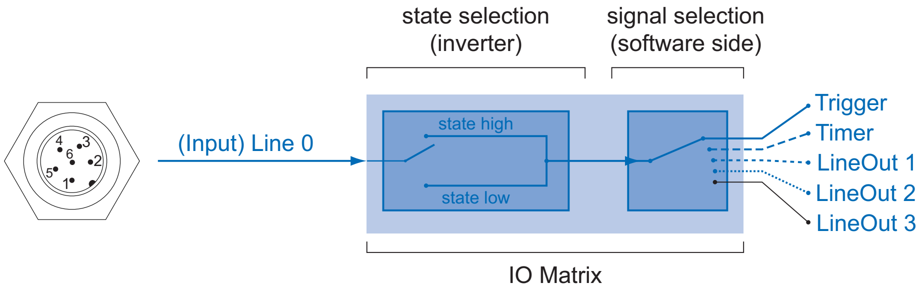
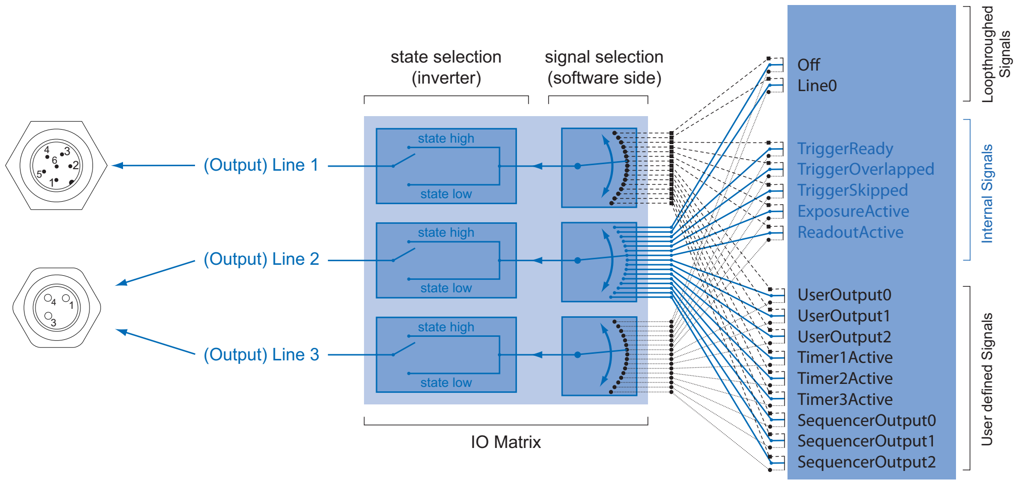


Figure 40 ►
IO matrix of the Baumer VisiLine on input side.

9.6.1.2 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 *VisiLine*® cameras, the output connector can be wired to one of provided internal signal: "Off", "ExposureActive", "Line 0", "Timer 1 … 3", "ReadoutActive", "User0 … 2", "TriggerReady", "TriggerOverlapped", "TriggerSkipped", "Sequencer Output 0 ... 2". Beside this, the output can be disabled.



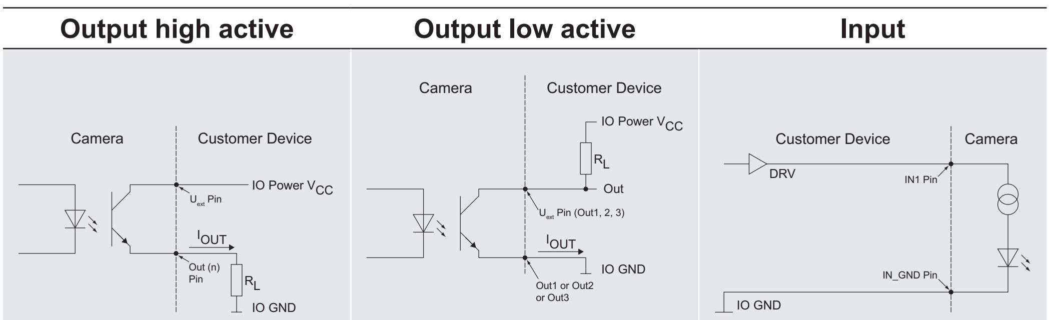
◄ **Figure 41**
IO matrix of the Baumer VisiLine on output side.

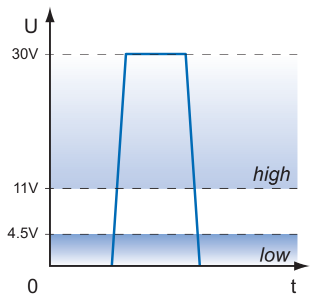
9.6.2 IO Circuits

Notice

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

The other two outputs are not usable and may not be connected (e.g. IO Power V_{CC})!





▲ **Figure 42**
Trigger signal, valid for Baumer cameras.

9.6.3 Trigger

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.

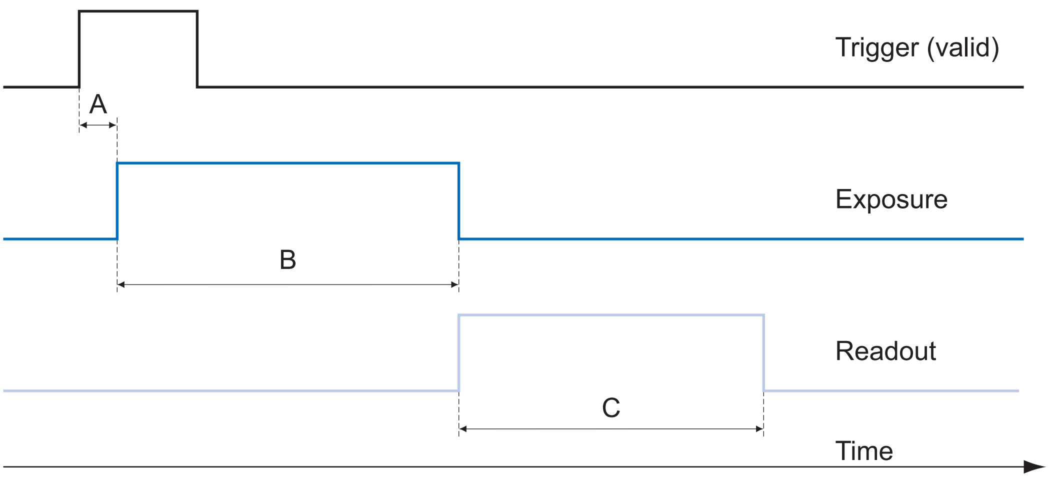


Figure 43 ►
Camera in trigger mode:
A - Trigger delay
B - Exposure time
C - Readout time

Different trigger sources can be used here.

Trigger Delay:

The trigger delay is a flexible user-defined delay between the given trigger impulse and the image capture. The delay time can be set between 0.0 µsec and 2.0 sec with a stepsize of 1 µsec. In the case of multiple triggers during the delay the triggers will be stored and delayed, too. The buffer is able to store up to 512 trigger signals during the delay.

Your benefits:

- *No need for a perfect alignment of an external trigger sensor*
- *Different objects can be captured without hardware changes*

9.6.4 Trigger Source

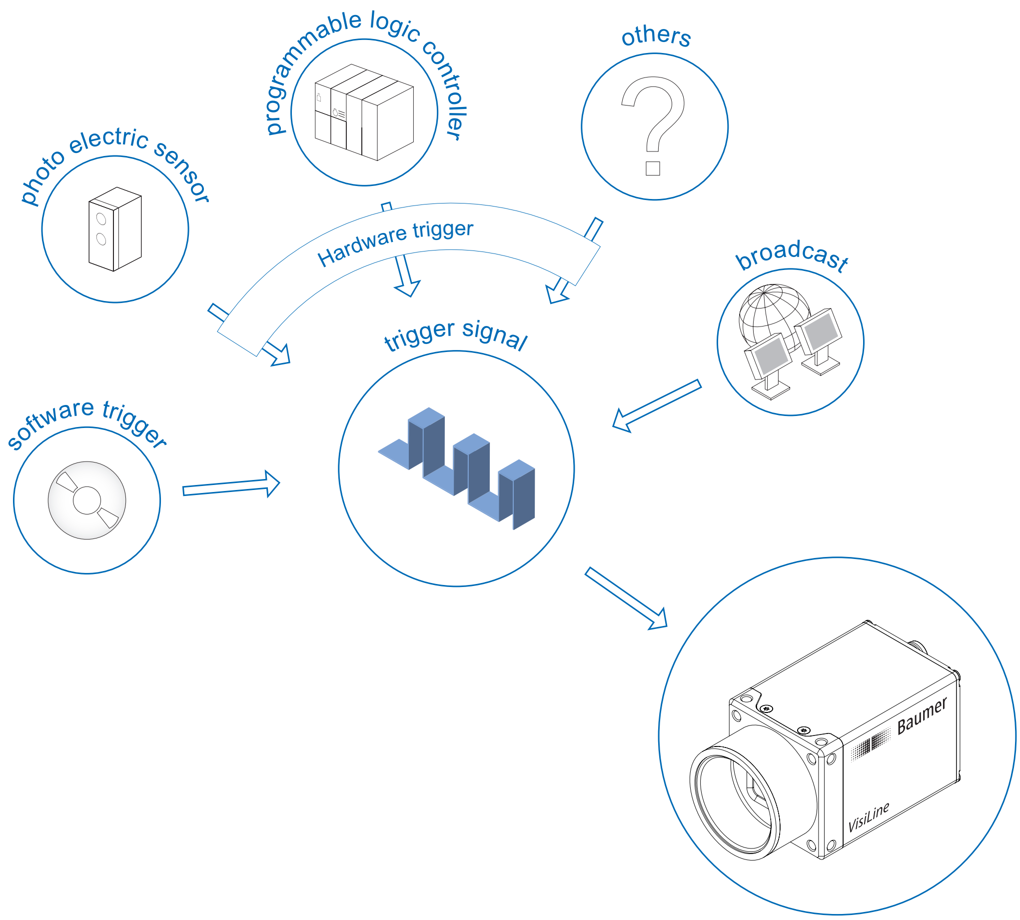


Figure 44 ►
Examples of possible trigger sources.

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

9.6.5 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.

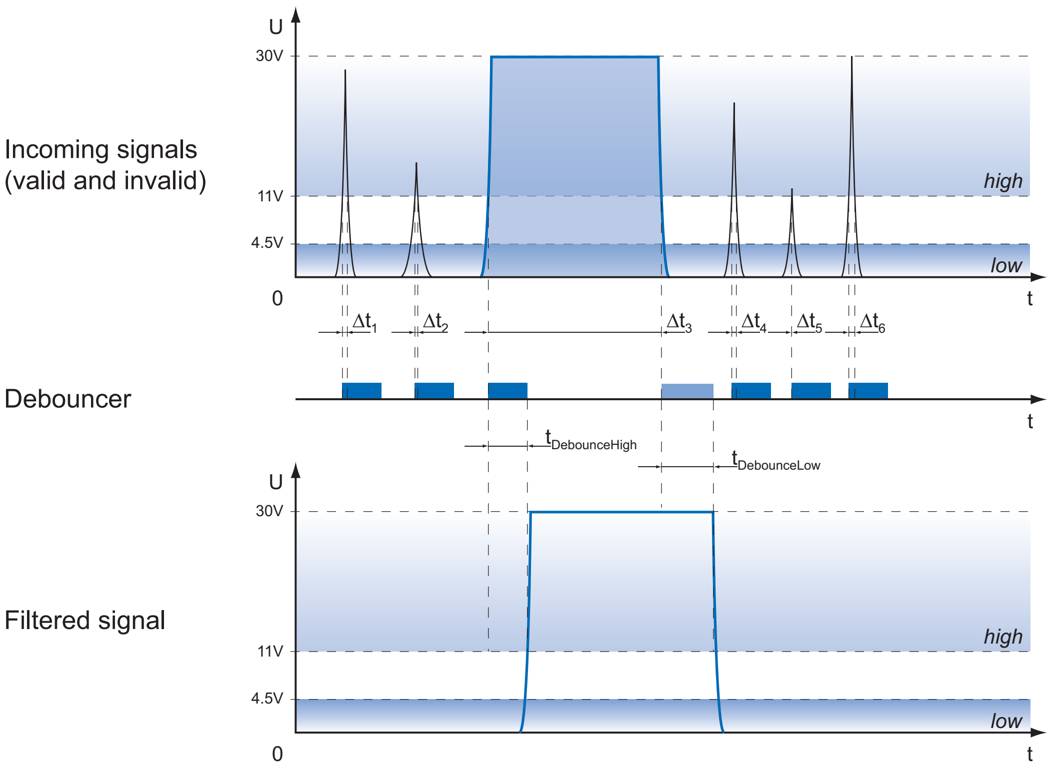
In order to detect the end of a valid signal and filter out possible jitters within the signal, a second testing time $t_{DebounceLow}$ was introduced. This timing is also adjustable by the user. If the signal value falls to state low and does not rise within $t_{DebounceLow}$, this is recognized as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

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

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.



Δt_x - high time of the signal
$t_{DebounceHigh}$ - user-defined debouncer delay for state high
$t_{DebounceLow}$ - user-defined debouncer delay for state low

9.6.6 Flash Signal

This signal is managed by exposure of the sensor.

Furthermore, the falling edge of the flash output signal can be used to trigger a movement of the inspected objects. Due to this fact, the span time used for the sensor readout $t_{readout}$ can be used optimally in industrial environments.

9.6.7 Timers

Timers were introduced for advanced control of internal camera signals.

For example the employment 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.

On Baumer *VisiLine*® cameras the timer configuration includes four components:

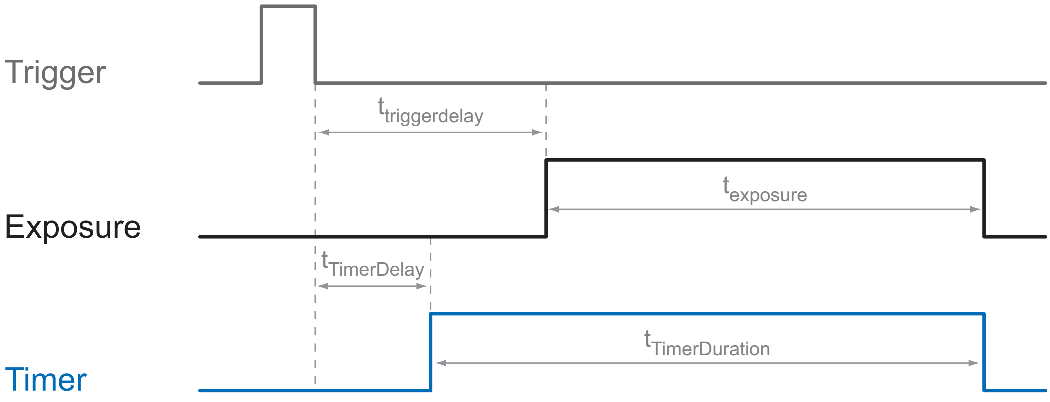


Figure 45 ▶
Possible Timer configuration on a Baumer VisiLine

Component	Description
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.
TimerDuration	By this feature the activation time of the timer is adjustable.

9.6.7.1 Flash Delay

As previously stated, the Timer feature can be used to start the connected illumination earlier than the sensor exposure.

This implies a timer configuration as follows:
- The flash output needs to be wired to the selected internal Timer signal.
- Trigger source and trigger activation for the Timer need to be the same as for the sensor exposure.
- The TimerDelay feature ($t_{TimerDelay}$) needs to be set to a lower value than the trigger delay ($t_{triggerdelay}$).
- The duration ($t_{TimerDuration}$) of the timer signal should last until the exposure of the sensor is completed. This can be realized by using the following formula:

$$t_{TimerDuration} = (t_{triggerdelay} - t_{TimerDelay}) + t_{exposure}$$

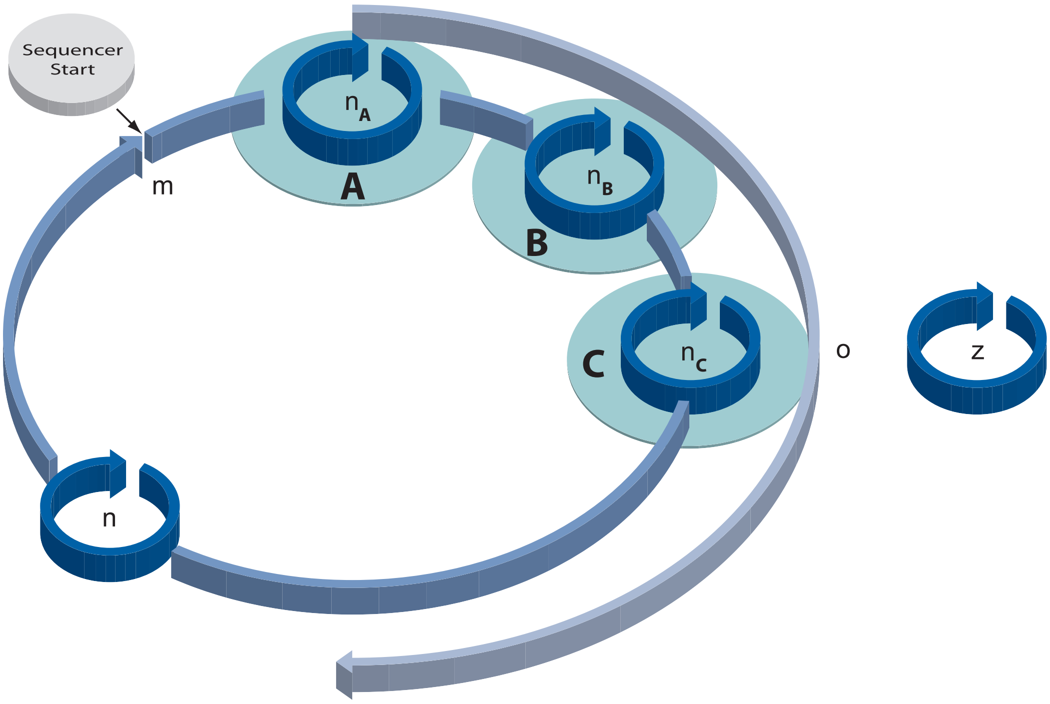
9.6.8 Frame Counter

The frame counter is part of the Baumer image infoheader and supplied with every image, if the chunkmode is activated. It is generated by hardware and can be used to verify that every image of the camera is transmitted to the PC and received in the right order.

9.7 Sequencer

9.7.1 General Information

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



◄ **Figure 38**
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.

A sequence (o) is defined as a complete pass through all sets of parameters.

The `SequencerLoops` (m) represents the number of sequence repetitions.

The `SequencerSetRepeats` (n) is used to control the amount of images taken with the respective sets of parameters.

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

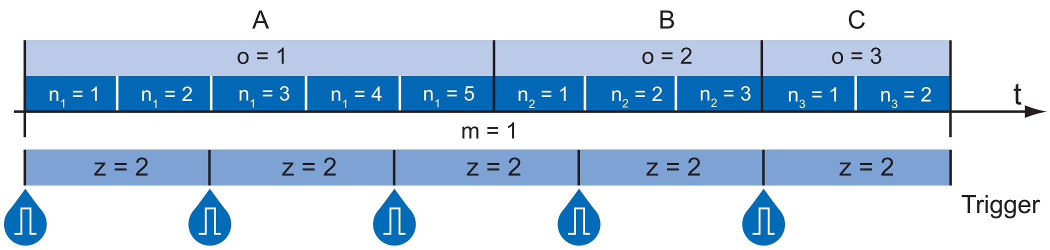
The additional `FramesPerTrigger` (z) is used to create a half-automated sequencer. It is absolutely independent from the other three counters, and used to determine the number of frames per external trigger event.

Sequencer Parameter:

The mentioned sets of parameter include the following:

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

The following timeline displays the temporal course of a sequence with:
- n_1 = 5 repetitions of parameters for set 1
- n_2 = 3 repetitions of parameters for set 2
- n_3 = 2 repetitions of parameters for set 3
- o = 3 sets of parameters (A,B and C)
- m = 1 sequence and
- z = 2 frames per trigger



◄ **Figure 46**
Timeline for a single sequence

9.7.2 Baumer Optronic Sequencer in Camera xml-file

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

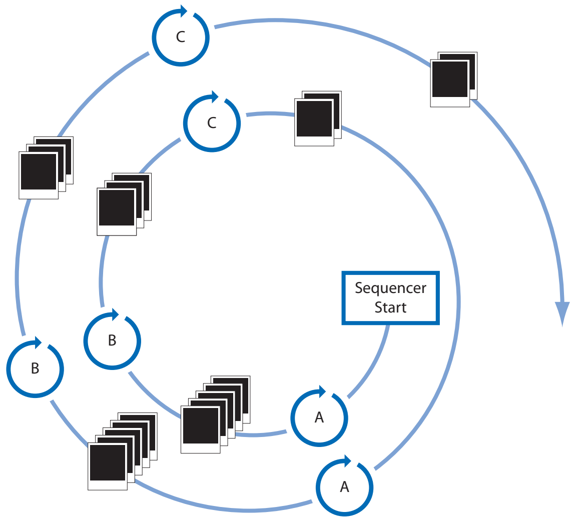
Static Sequencer Features These values are valid for all sets.	
BoSequencerEnable	Enable / Disable
BoSequencerFramesPerTrigger	Number of frames per trigger (z)
BoSequencerIsRunning	Check whether the sequencer is running
BoSequencerLoops	Number of sequences (m)
BoSequencerMode	Running mode of Sequencer
BoSequencerSetNumberOfSets	Number of sets - 1
BoSequencerStart	Start / Stop
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

Sequencer Running Modes

Mode	Description
SingleStepTrigger	On each trigger, the sequencer goes acquires Z images.Z is the count of freerunning images to take on one trigger event. When the end of the cycle is reached, the sequencer will restart automatically.
SingleStep-TriggerOnce	On each trigger, the sequencer goes acquires Z images. Z is the count of freerunning frames to take on one trigger event. When the end of the cycle is reached, the sequencer will **not** restart automatically.
FreeRunning (continuous)	The sequencer will not wait for an incoming event but starts immediatelly taking freerunning frames. When the end of the cycle is reached, the sequencer will restart automatically.
FreeRunningOnce	The sequencer will not wait for an incoming event but starts immediatelly taking freerunning frames. When the end of the cycle is reached, the sequencer will not restart automatically.
FreeRunningInit-Trigger	On the first incoming event, the sequencer will start with freerunning a full cycle. After completion, it will restart on the next incoming event automatically.
FreeRunningInit-TriggerOnce	On the first incoming event, the sequencer will start with freerunning a full cycle. After completion, it will not restart automatically.

9.7.3 Examples

9.7.3.1 Sequencer without Machine Cycle



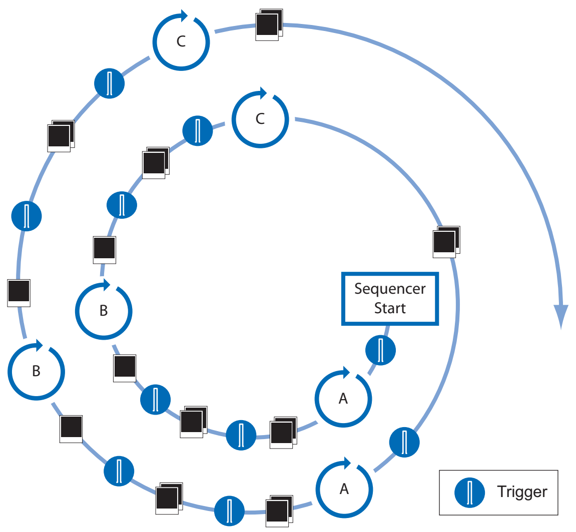
◄ **Figure 47**
Example for a fully automated sequencer.

The figure above shows an example for a fully automated sequencer with three sets of parameters (A, B and C). Here the `SequencerSetRepeats` (n) is set for (A=5), (B=3), (C=2) and the `SequencerLoops` (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.

9.7.3.2 Sequencer Controlled by Machine Steps (trigger)



◄ **Figure 48**
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. `FramesPerTrigger` (z) is set to 2. This means the camera records two pictures after an incoming trigger signal.

9.7.4 Capability Characteristics of Baumer GAPI Sequencer Module

- up to 128 sets of parameters
- up to 65536 loop passes
- up to 65536 repetitions of sets of parameters
- up to 65536 images per trigger event
- free running mode without initial trigger

9.7.5 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.

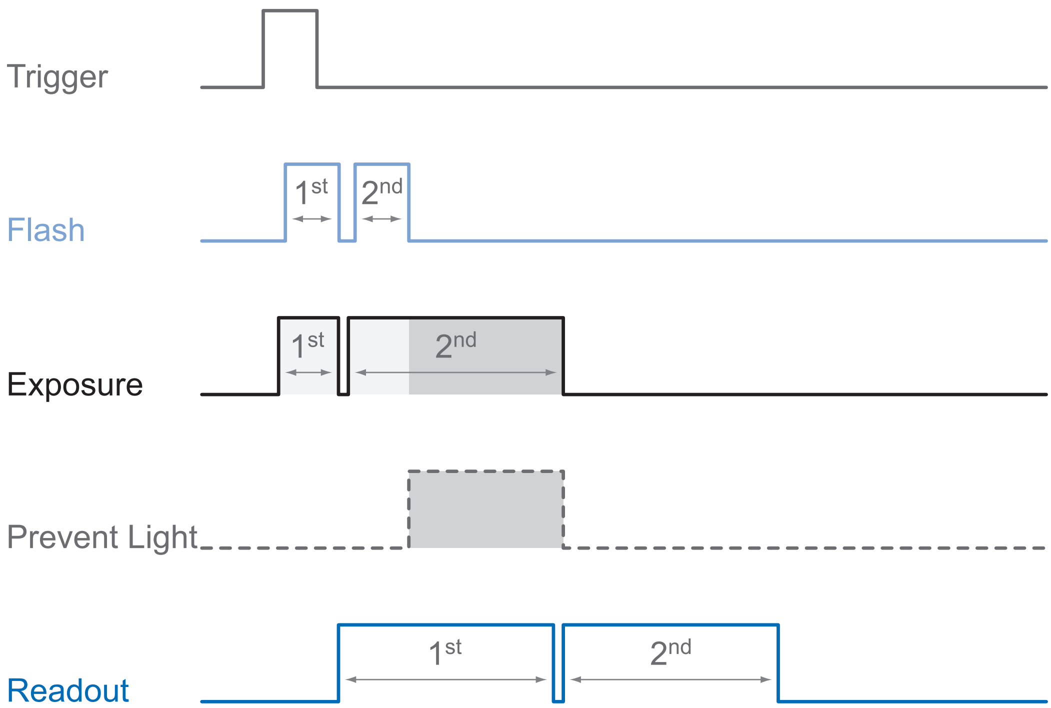


Figure 49 ▶
Example of a double shutter.

In order to generate this sequence, the sequencer can be configured, for example, as follows:

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

9.8 Device Reset

The feature Device Reset corresponds to the turn off and turn on of the camera. This is necessary after a parameterization (e.g. the network data) of the camera.

The interrupt of the power supply ist therefore no longer necessary.

9.9 User Sets

Four user sets (0-3) are available for the Baumer cameras of the *VisiLine®* series. User set 0 is the default set and contains the factory settings. User sets 1 to 3 are user-specific and can contain any user definable parameters.

These user sets are stored within the camera and can be loaded, saved and transferred to other cameras of the *VisiLine®* series.

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

Parameter	
AcquisitionStart	TimerDelay
AcquisitionStop	TimerTriggerSource
AcquisitionFrameRate	TimerTriggerActivation
TriggerMode	FrameCounter
TriggerSource	LineInverter
TriggerActivation	LineSource
TriggerDelay	UserOutputValue
ExposureMode	UserOutputValueAll
ExposureTime	LineDebouncerHighTimeAbs
AcquisitionFrameRateEnable	LineDebouncerLowTimeAbs
ReadoutMode	Width
Gain	Height
Gamma	OffsetX
BlackLevel	OffsetY
BrightnessCorrection	BinningHorizontal
BoSequencerEnable	BinningVertical
BoSequencerExposure	ReverseX
BoSequencerFramesPerTrigger	ReverseY
BoSequencerGain	PixelFormat
BoSequencerIOStatus	TestImageSelector
BoSequencerLoops	TestPattern
BoSequencerMode	LUTEnable
BoSequencerOffsetX	LUTValue
BoSequencerOffsetY	DefectPixelCorrection
BoSequencerSetNumberOfSets	ActionDeviceKey
BoSequencerSetRepeats	ActionGroupMask
BoSequencerStart	GEV SCPD
BoSequencerSetNumberOfSets	FixedPatternNoiseCorrection
BoSequencerSetRepeats	HDREnable
ChunkModeActive	
ChunkEnable	
TimerDuration	

9.10 Factory Settings

The factory settings are stored in "user set 0" which is the default user set. This is the only user set, that is not editable.

9.11 Timestamp

The timestamp is part of the GigE Vision® standard. It is 64 bits long and denoted in Ticks*). Any image or event includes its corresponding timestamp.

At power on or reset, the timestamp starts running from zero.

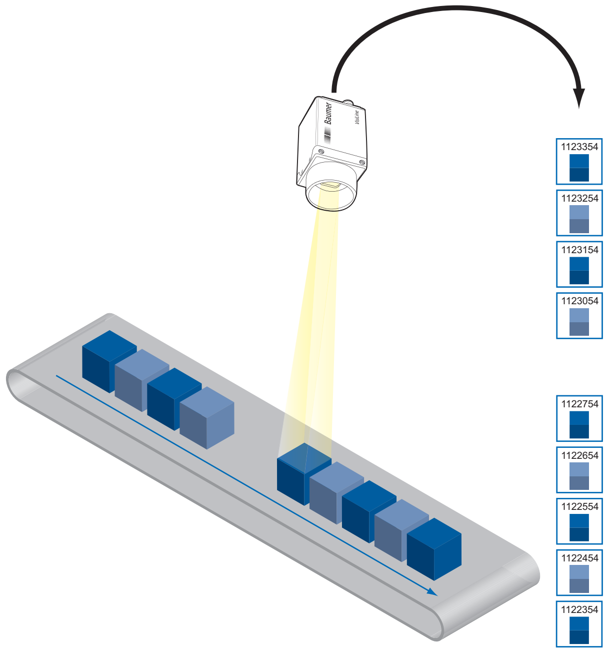


Figure 50 ▶
Timestamps of recorded images.

---

*) Tick is the internal time unit of the camera, it lasts 1 nsec.

10. Interface Functionalities

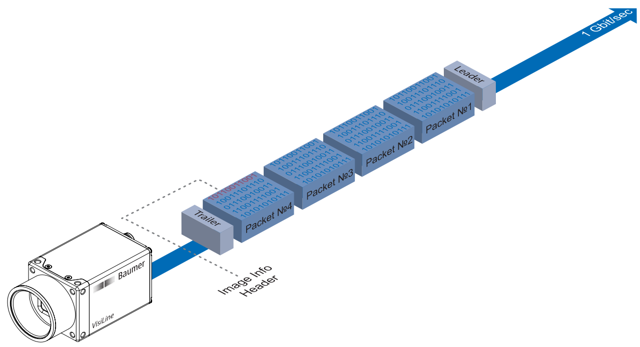
10.1 Device Information

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)

10.2 Baumer Image Info Header

The Baumer Image Info Header is a data packet, which is generated by the camera and integrated in the last data packet of every image, if chunk mode is activated.



◄ **Figure 51**
Location of the Baumer Image Info Header

In this integrated data packet are different settings for this image. Baumer GAPI can read the Image Info Header. Third Party Software, which supports the Chunk mode, can read the features in the table below. This settings are (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 pixel format of the image included in the payload.
ChunkTimestamp	Returns the Timestamp of the image included in the payload at the time of the FrameStart internal event.
ChunkExposureTime	Returns the exposure time used to capture the image.
ChunkGainSelector	Selects which Gain to retrieve data from.
ChunkGain	Returns the gain used to capture the image.
ChunkFrameID	Returns the unique Identifier of the frame (or image) included in the payload.
ChunkBinningHorizontal	Number of horizontal photo-sensitive cells to combine together.
ChunkBinningVertical	Number of vertical photo-sensitive cells to combine together.

10.3 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 1500 Byte, which is specified in the GigE network standard. "Jumboframes" merely characterizes a packet size exceeding 1500 Bytes.

Baumer *VisiLine*® cameras can handle a MTU of up to 65535 Bytes.

10.4 Inter Packet Gap (IPG)

IPG:

The IPG is measured in ticks.
An easy rule of thumb is:

1 Tick is equivalent to 1 Bit of data.
You should also not forget to add the various ethernet headers to your calculation.

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

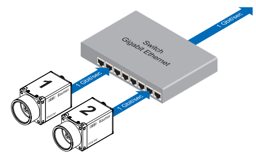
Upon starting the image transfer of a camera, the data packets are transferred at maximum transfer speed (1 Gbit/sec). In accordance with the network standard, Baumer employs a minimal separation of 12 Bytes between two packets. This separation is called "inter packet gap" (IPG). In addition to the minimal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

Notice
According to the Ethernet standard, IPG_{min} can not be lower than 12 Bytes.

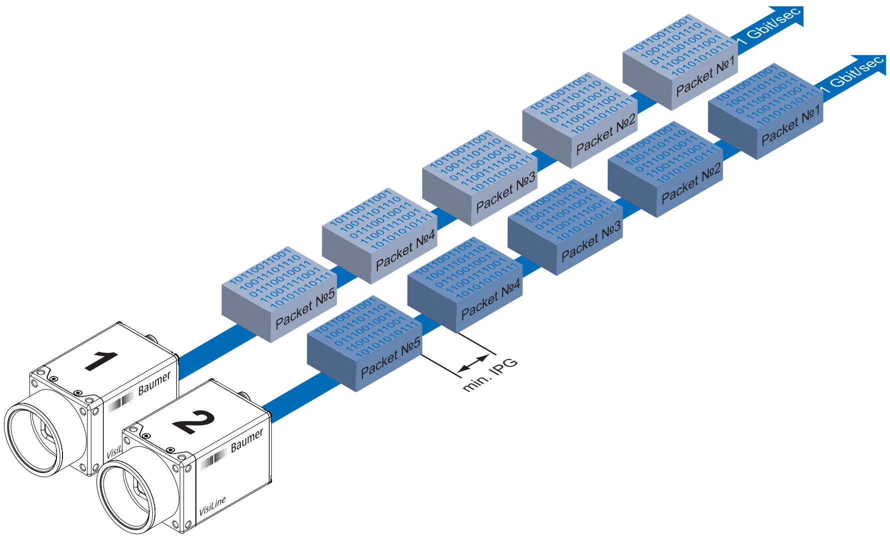
10.4.1 Example 1: Multi Camera Operation – Minimal IPG

Setting the IPG to minimum means every image is transfered 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 ≥ 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 52**
Operation of two cameras employing a Gigabit Ethernet switch.
Data processing within the switch is displayed in the next two figures.



◄ **Figure 53**
Operation of two cameras employing aminimal inter packet gap (IPG).

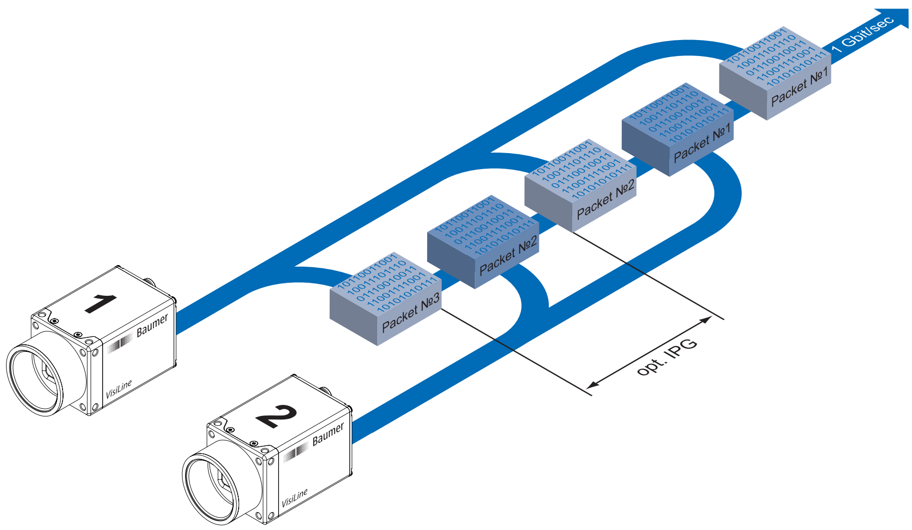
10.4.2 Example 2: Multi Camera Operation – Optimal IPG

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

*optimal IPG = (number of cameras-1)*packet size + 2 × 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 54**
Operation of two cameras employing an optimal inter packet gap (IPG).

10.5 Transmission Delay

Another approach for packet sorting in multi-camera operation is the so-called Transmission Delay.

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:

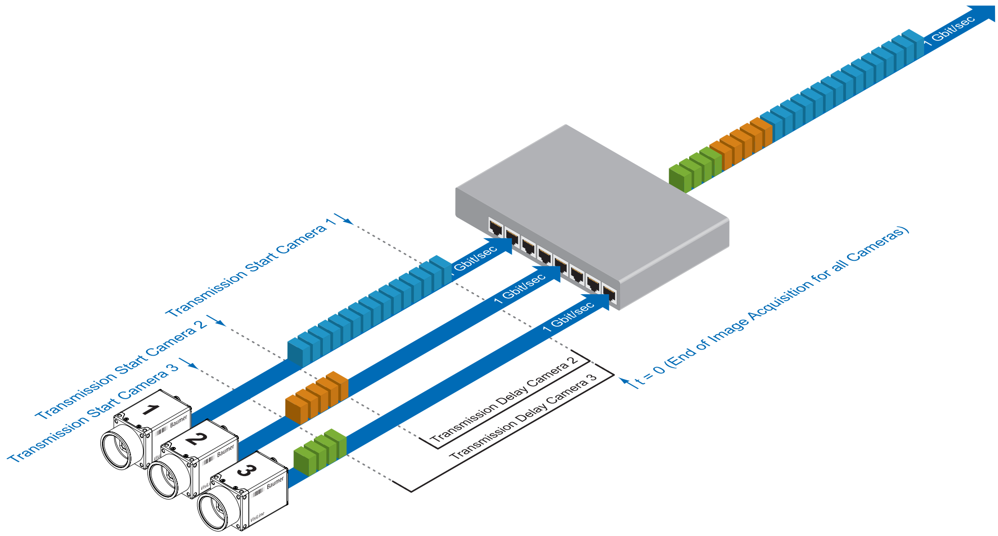


Figure 55 ►
Principle of the transmission delay.

For the image processing three cameras with different sensor resolutions are employed – for example camera 1: VLG-12M, camera 2: VLG-20M, camera 3: VLG-02M.

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 simultaniously, but – according to the specified transmission delays – subsequently. Thereby the first camera starts the transmission immediately – with a transmission delay "0".

10.5.1 Time Saving in Multi-Camera Operation

As previously stated, the transmission 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:

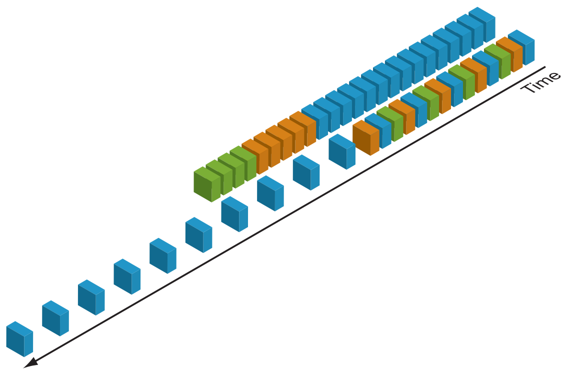


Figure 56 ►
Comparison of transmission delay and inter packet gap, employed for a multi-camera system with different camera models.

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).

10.5.2 Configuration Example

For the three employed cameras the following data are known:

Camera Model	Sensor Resolution	Pixel Format (Pixel Depth)	Resulting Data Volume	Readout Time	Exposure Time	Transfer Time (GigE)
	[Pixel]	[bit]	[bit]	[msec]	[msec]	[msec]
VLG-12M	1288 x 960	8	9891840	23.8	32	≈ 9.2
VLG-20M	1624 x 1228	8	15954176	37	32	≈ 14.9
VLG-02M	656 x 490	8	2571520	6.4	32	≈ 2.4

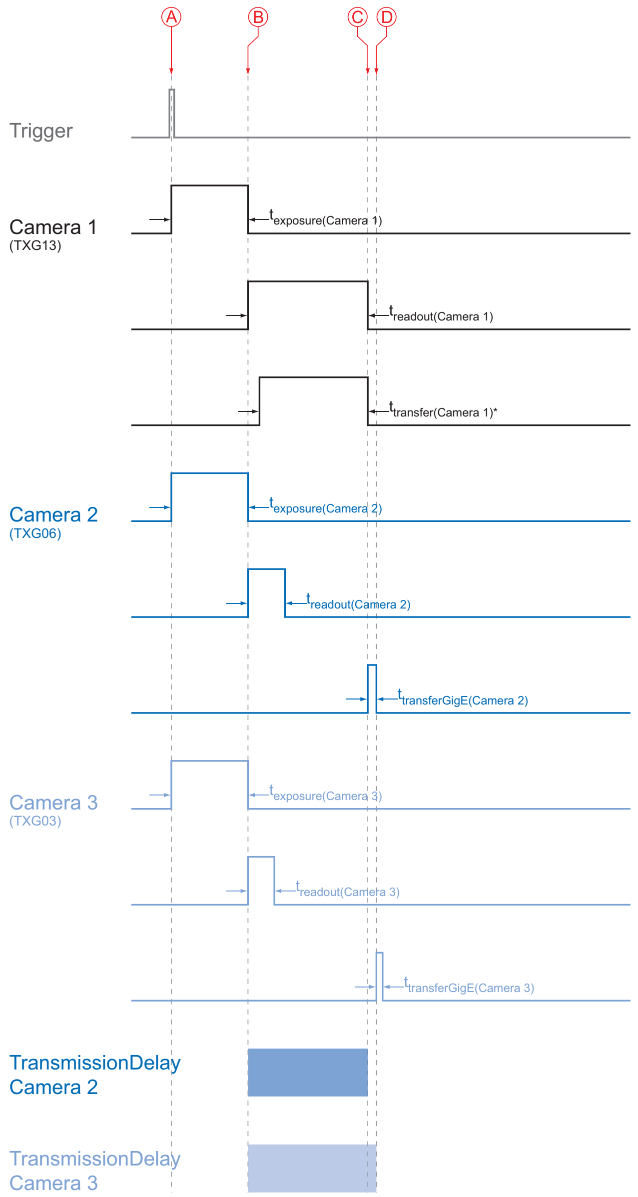
- The sensor resolution and the readout time ($t_{readout}$) can be found in the respective Technical Data Sheet (TDS). For the example a full frame resolution is used.
- The exposure time ($t_{exposure}$) is manually set to 32 msec.

- The resulting data volume is calculated as follows:
  Resulting Data Volume = horizontal Pixels × vertical Pixels × Pixel Depth

- The transfer time ($t_{transferGigE}$) for full GigE transfer rate is calculated as follows:
  Transfer Time (GigE) = Resulting Data Volume / 1024³ × 1000 [msec]

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

** Due to technical issues the data transfer of camera 1 does not take place with full GigE speed.*

◄ **Figure 57**
Timing diagram for the transmission delay of the three employed cameras, using even exposure times.

In general, the transmission delay is calculated as:

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

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

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

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

Solving this equations leads to:

$t_{TransmissionDelay(Camera\ 2)}$ $= 32\ msec + 23.8\ msec - 32\ msec$

$= 23.8\ msec$

$= 7437750\ ticks$

$t_{TransmissionDelay(Camera\ 3)}$ $= 32\ msec + 23.8\ msec - 32\ msec + 14.9\ msec$

$= 38{,}7\ msec$

$= 1209375\ ticks$

Notice

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

1 tick = 1 ns

1 msec = 1000000 ns

1 tick = 0,000001 msec

ticks= $t_{TransmissionDelay}$ *[msec] / 0,000001 =* $t_{TransmissionDelay}$*[ticks]*

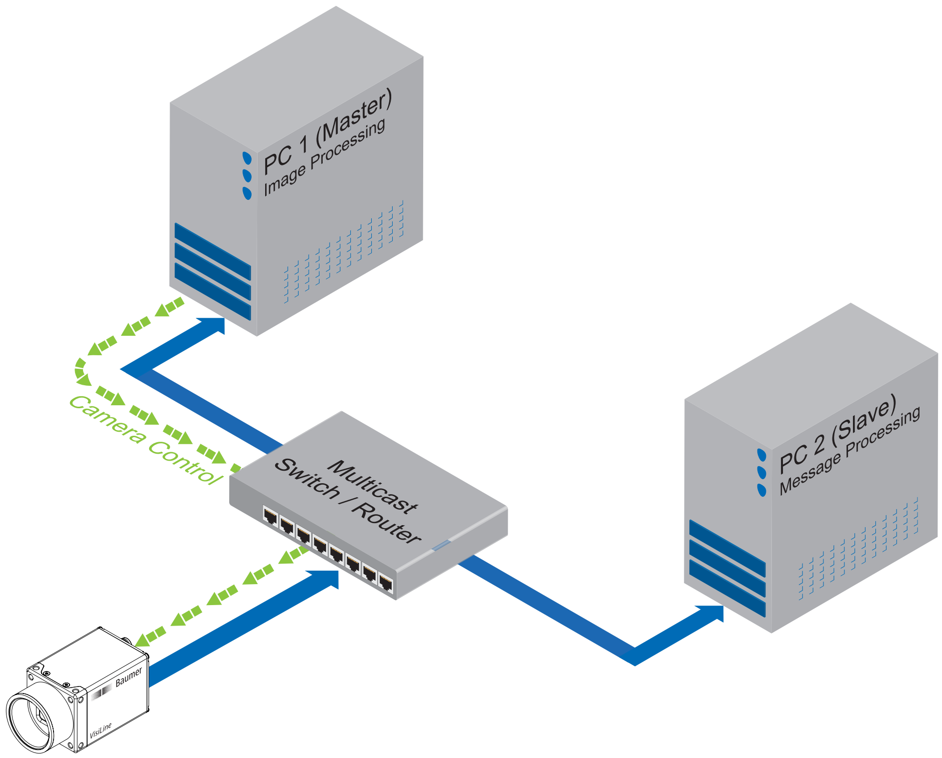
10.6 Multicast

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 differents PC's.

Multicast Addresses:
For multicasting Baumer suggests an adress range from 232.0.1.0 to 232.255.255.255.



◄ **Figure 58**
Principle of Multicast

Internet Protocol:
On Baumer cameras IP v4 is employed.

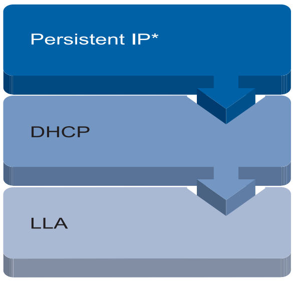


Figure 59 ▲
Connection pathway for Baumer Gigabit Ethernet cameras:
The device connects step by step via the three described mechanisms.

10.7 IP Configuration

10.7.1 Persistent IP

A persistent IP adress 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.

10.7.2 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:
Please pay attention to the DHCP Lease Time.

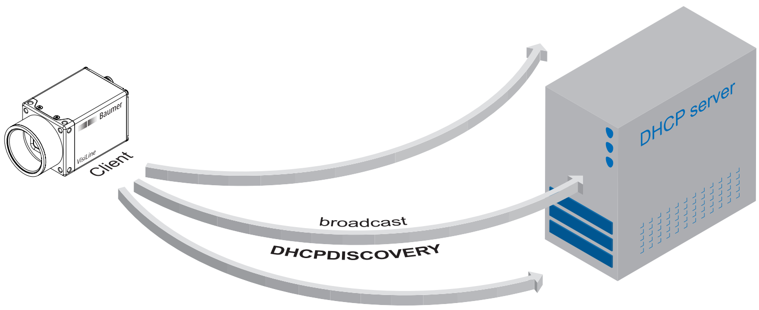


Figure 60 ►
DHCP Discovery (broadcast)

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

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

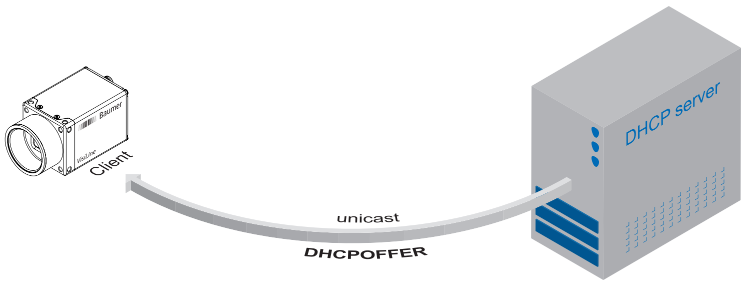
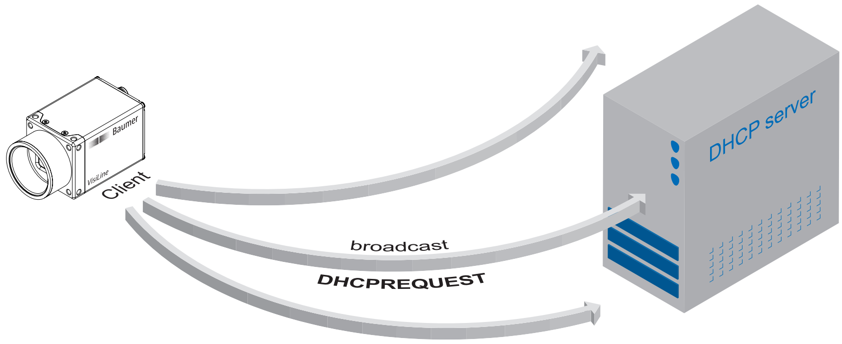


Figure 52 ►
DHCP offer (unicast)

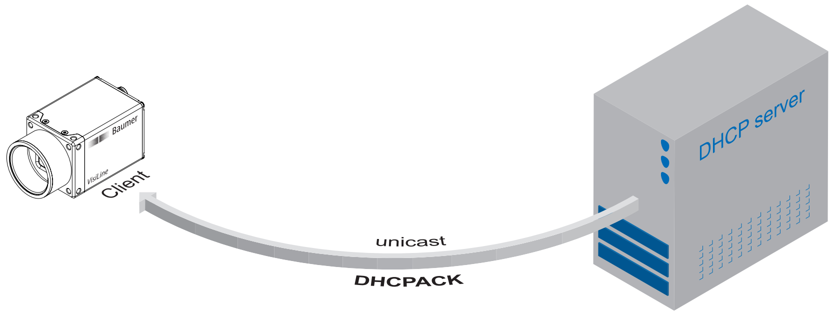
- DHCP Request
  Once the client has received this DHCPOFFER, the transaction needs to be confirmed. For this purpose the client sends a so called DHCPREQUEST broadcast to the network. This message contains the IP address of the offering DHCP server and informs all other possible DHCPservers that the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



◄ **Figure 61**
DHCP Request (broadcast)

- DHCP Acknowledgement
  Once the DHCP server obtains the DHCPREQUEST, an 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 62**
DHCP Acknowledgement (unicast)

10.7.3 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 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.

10.7.4 Force IP*)

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.

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

10.8 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:

10.8.1 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 then 99%.

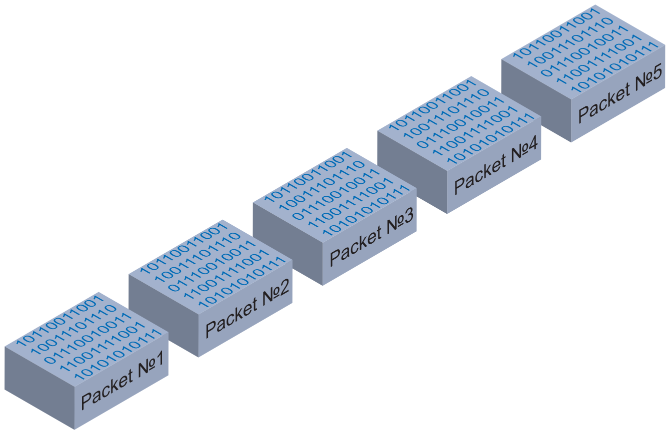


Figure 63 ►
Data stream without damaged or lost packets.

10.8.2 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.

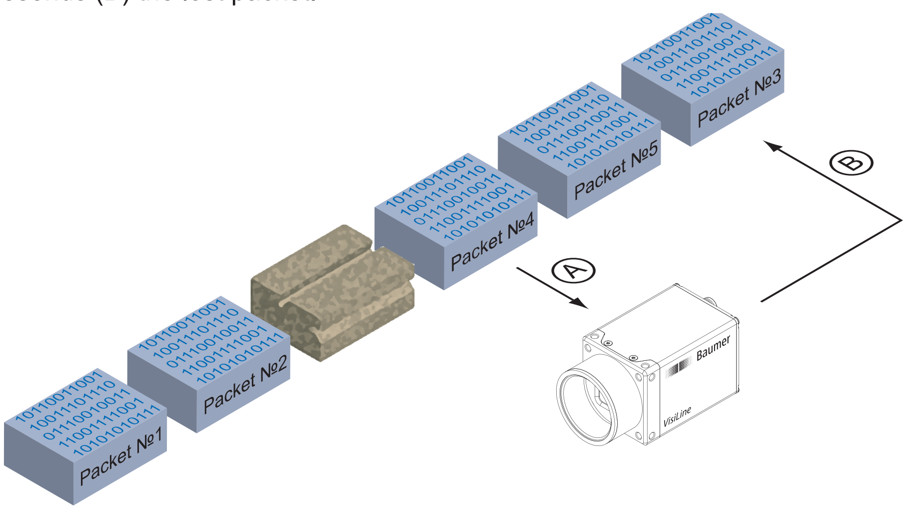
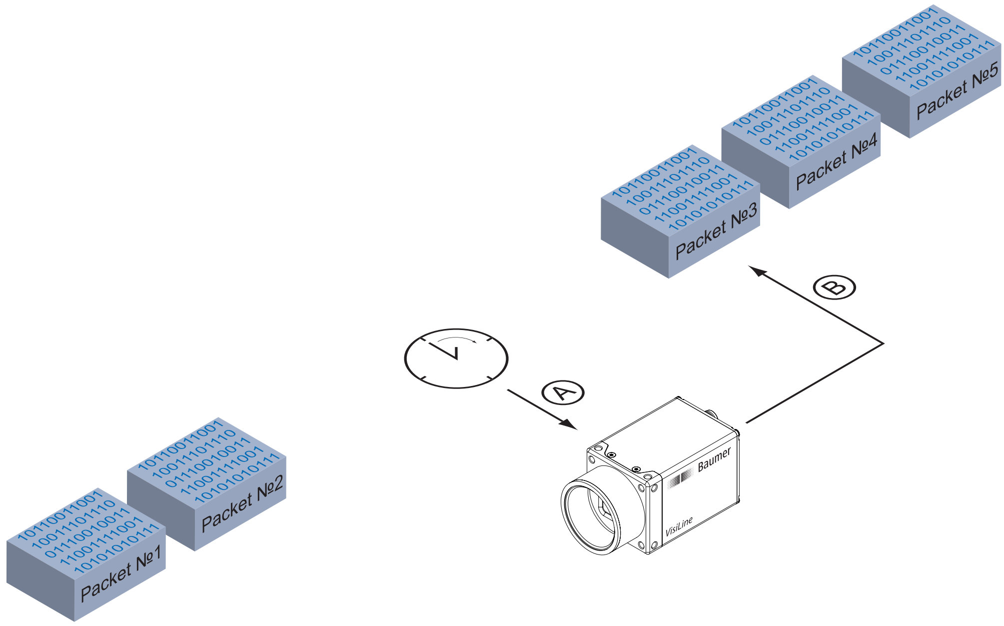


Figure 64 ►
Resending lost packets within the data stream.

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.

10.8.3 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 65**
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.

10.8.4 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 occured or
- the camera returns an error.

10.9 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.

10.9.1 Event Generation

Event	Description
Gen<i>Cam™	
ExposureStart	Exposure started
ExposureEnd	Exposure ended
FrameStart	Acquisition of a frame started
FrameEnd	Acquisition of a frame ended
Line0Rising	Rising edge detected on IO-Line 0
Line0Falling	Falling edge detected on IO-Line 0
Line1Rising	Rising edge detected on IO-Line 1
Line1Falling	Falling edge detected on IO-Line 1
Line2Rising	Rising edge detected on IO-Line 2
Line2Falling	Falling edge detected on IO-Line 2
Line3Rising	Rising edge detected on IO-Line 3
Line3Falling	Falling edge detected on IO-Line 3
Vendor-specific	
EventError	Error in event handling
EventLost	Occured event not analyzed
TriggerReady	$t_{notready}$ elapsed, camera is able to process incoming trigger
TriggerOverlapped	Overlapped Mode detected
TriggerSkipped	Camera overtriggered

10.10 Action Command / Trigger over Ethernet

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

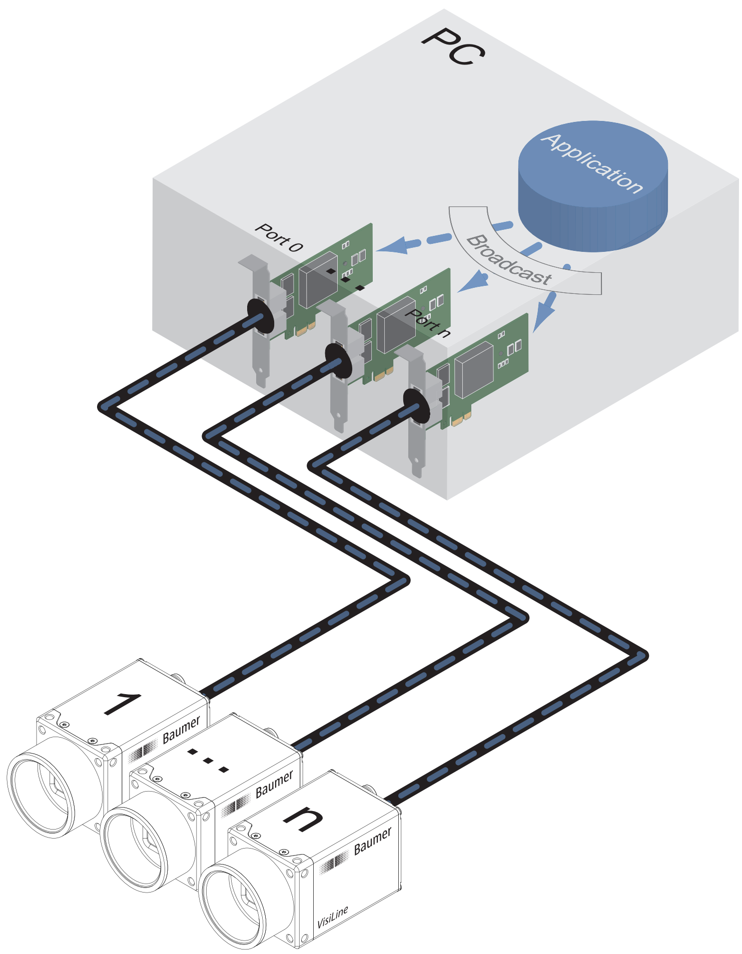
The action command is sent as a broadcast. In addition it is possible to group cameras, so that not all attached cameras respond to a broadcast action command.

Such an action command contains:
- a Device Key - for authorization of the action on this device
- an Action ID - for identification of the action signal
- a Group Key - for triggering actions on separated groups of devices
- a Group Mask - for extension of the range of separate device groups

Action Command:
Since hardware release 2.1 the implemetation of the Action Command follows the regulations of the GigE Vision® standard 1.2.

10.10.1 Example: Triggering Multiple Cameras

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



◄ **Figure 66**
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.

11. Start-Stop-Behaviour

11.1 Start / Stop / Abort 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.

Abort Acquisition

The acquisition abort represents a special case of stopping the current acquisition.

When an exposure is running, the exposure is aborted immediately and the image is not read out.

11.2 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.

11.3 Acquisition Modes

In general, three acquisition modes are available for the cameras in the Baumer *VisiLine*® series.

11.3.1 Free Running

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

11.3.2 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.

This feature is described in chapter 4.6. Process Interface.

11.3.3 Sequencer

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

12. Cleaning

Cover glass

Notice

The sensor is mounted dust-proof. Remove of the cover glass for cleaning is not necessary.

Avoid cleaning the cover glass of the sensor if possible. To prevent dust, follow the instructions under "Install lens".

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

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.

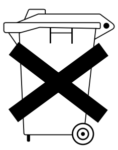
13. Transport / Storage

Notice

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

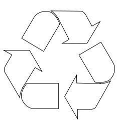
	Storage Environment
Storage temperature	-10°C ... +70°C (+14°F ... +158°F)
Storage Humidy	10% ... 90% non condensing

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 properly in the event of a warranty claim.

15. Warranty Notes

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

16. Support

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

Worldwide

Baumer Optronic GmbH
Badstrasse 30
DE-01454 Radeberg, Germany

Tel: +49 (0)3528 4386 845

Website: www.baumer.com

mail: support.cameras@baumer.com

17. Conformity

Cameras of the Baumer EXG family comply with:
- CE,
- RoHS
- KC

17.1 CE

We declare, under our sole responsibility, that the previously described Baumer cameras conform with the directives of the CE.

17.2 Korean Conformity

Registration of Broadcasting and Communication Equipments

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

Product	Article No.	Registration No.	Date of Registration
VLG-03M	11107138	MSIP-REI-BkR-VLG-03MCS	2017-09-15
VLG-03M.CS	11163336	MSIP-REI-BkR-VLG-03MCS	2017-09-15
VLG-03C	11118890	MSIP-REI-BkR-VLG-03MCS	2017-09-15

Baumer

Baumer Optronic GmbH
Badstrasse 30
DE-01454 Radeberg, Germany
Phone +49 (0)3528 4386 0 · Fax +49 (0)3528 4386 86
sales@baumeroptronic.com · www.baumer.com