User´s Guide

VEXG (Gigabit Ethernet) / VEXU (USB 3.0)

Document Version: v1.5
Release: 25.10.2018
Document Number: 11165414

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!

Support

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

Worlwide: **Baumer Optronic GmbH**
Badstrasse 30
DE-01454 Radeberg, Germany

Tel: +49 (0)3528 4386 845

Website: www.baumer.com

E-mail: support.cameras@baumer.com

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.

Intended Use

The camera is used to capture images that can be transferred over a GigE interface (VCXG) or a USB 3.0 interface (VCXU) to a PC.

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.

Transport / Storage

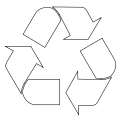
Transport the camera only in the original packaging. When the camera is not installed, then storage the camera in original packaging.

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

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Dispose of outdated products with electrical or electronic circuits, not in the normal domestic waste, but rather according to your national law and the directives 2002/96/EC and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

Warranty Notes

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!

Copyright

2. General safety instructions

Caution

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

As there are numerous possibilities for installation, Baumer recommends no specific method for proper heat dissipation, but suggest the following principles:

- operate the cameras only in mounted condition
- mounting in combination with forced convection may provide proper heat dissipation

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. General Description

All Baumer cameras of these families 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

Fast image transfer

VEXG
- Reliable transmission up to 1000 Mbit/sec according to IEEE802.3
- Cable length up to 100 m
- Baumer driver for high data volume with low CPU load
- High-speed multi-camera operation
- GenICam™ and GigE Vision® compliant

VEXU
- Reliable transmission at 5000 Mbit/sec according to USB 3.0 (v1.0.1) standard
- GenICam™ and USB3 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
- GenICam™ 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

Supported standards

VEXG
- v2.0 (v1.2 backward compatible)
- GenICam SFNC 2.1

VEXU
- USB3 Vision™ 1.0.1
- GenICam GenCP 1.1
- GenICam SFNC 2.1

Conformity

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

RoHS — All VCX cameras comply with the recommendation of the European Union concerning RoHS rules.

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

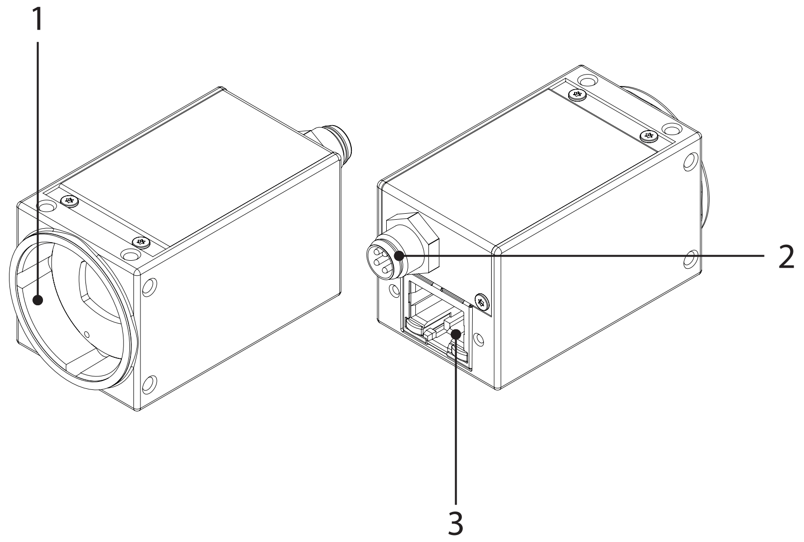
(see table on next page)

Korean Conformity (Registration of Broadcasting and Communication Equipments)

VEXG

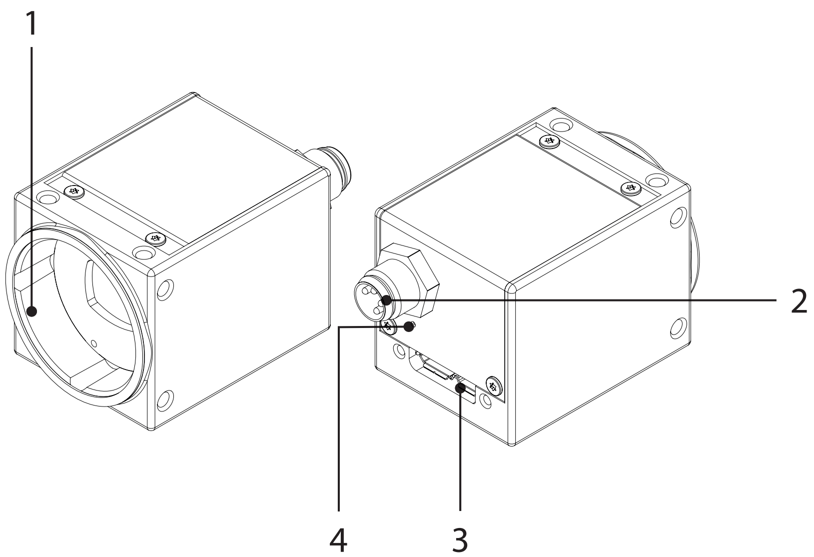
Product	Article No.	Registration No.	Date of Registration
Monochrome			
VEXG-52M.R	11185978	R-REI-BkR-VEXG-52MR	2018-07-10
VEXG-100M.R	11185979	R-REI-BkR-VEXG-100MR	2018-07-10
Color			
VEXG-52C.R	11185977	R-REI-BkR-VEXG-52MR	2018-07-10
VEXG-100C.R	11185990	R-REI-BkR-VEXG-100MR	2018-07-10

3.1 VEXG



No.	Description	No.	Description
1	Lens mount (CS-Mount)	**3**	Ethernet Port / Signaling LED´s
2	Power supply / Digital-IO		

3.2 VEXU



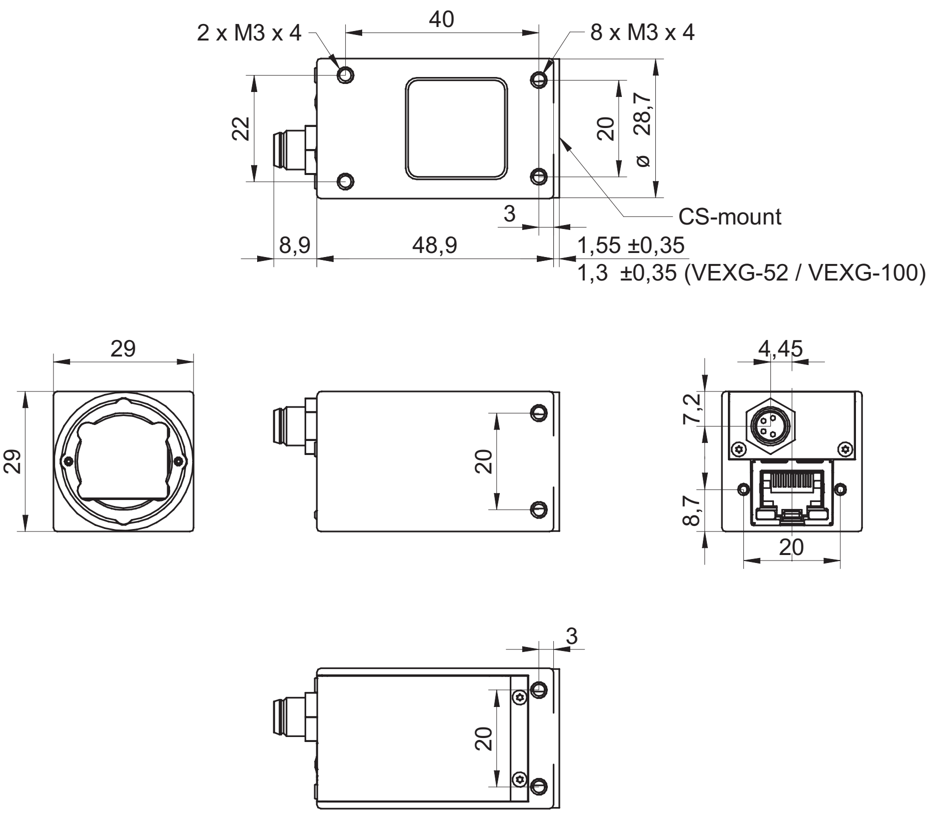
No.	Description	No.	Description
1	Lens mount (CS-Mount)	**3**	USB 3.0 port
2	Digital-IO	**4**	Signaling-LED

4. Camera Models

4.1 VEXG

Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
Monochrome			
VEXG-02M	1/4"	640 × 480	217
VEXG-13M	1/2"	1280 × 1024	61
VEXG-25M	2/3"	1920 × 1200	41
VEXG-52M.R	1/2.5"	2592 × 1944	14
VEXG-100M.R	1/2.3"	3856 × 2764	7
Color			
VEXG-02C	1/4"	640 × 480	217
VEXG-13C	1/2"	1280 × 1024	61
VEXG-25C	2/3"	1920 × 1200	41
VEXG-52C.R	1/2.5"	2592 × 1944	14
VEXG-100C.R	1/2.3"	3856 × 2764	7

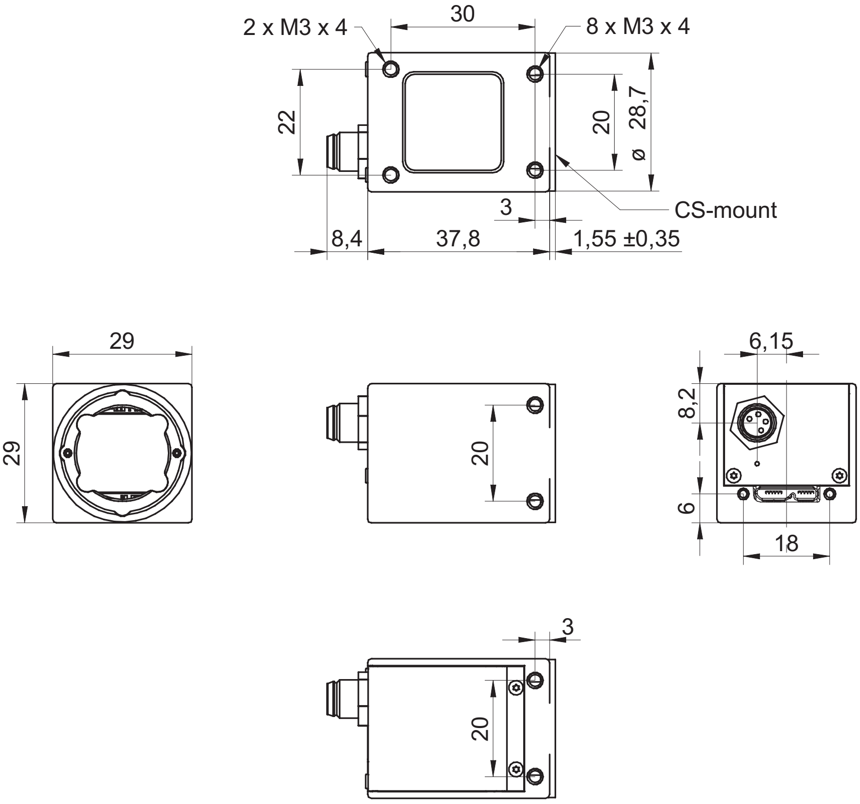
Dimensions



4.2 VEXU

Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
Monochrome			
VEXU-24M	1/1.2"	1920 × 1200	38
Color			
VEXU-24C	1/1.2"	1920 × 1200	38

Dimensions



5. Installation

5.1 Environmental Requirements

Temperature	
Storage temperature	-10 °C ... +70 °C (+14 °F ... +158 °F)
Operating temperature	+ 5 °C (+14 °F) ... see „Heat Transmission“

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

5.2 Heat Transmission

Caution

Device heats up during operation.

Skin irritation possible.

Do not touch the camera during operation.

Caution

Heat can damage the camera. Provide adequate dissipation of heat, to ensure that the temperatures does not exceed the values in the table below.

As there are num erous possibilities for installation, Baumer recommends no specific method for proper heat dissipation, but suggest the following principles:

- operate the cameras only in mounted condition
- mounting in combination with forced convection may provide proper heat dissipation

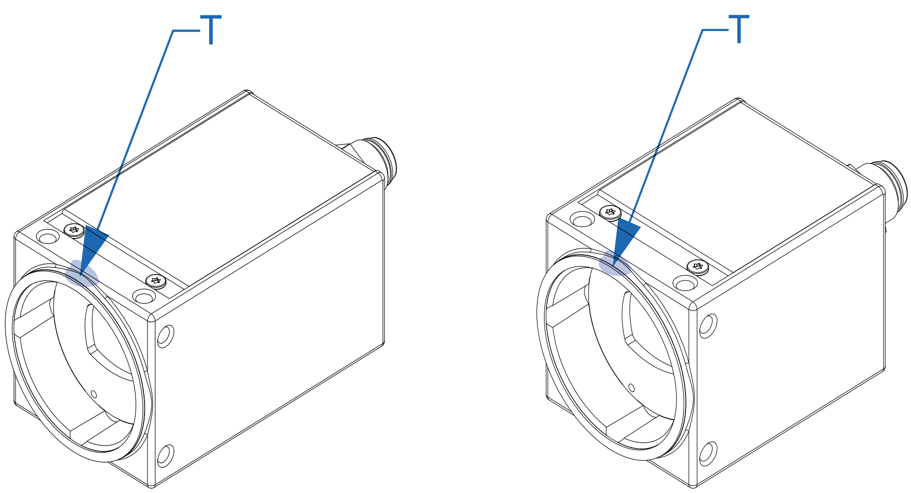


Figure 1 ►
Temperature measuring point

Measure Point (T) Maximal Temperature	
VEXG	**VEXU**
65 °C (149 °F) VEXG-100 / VEXG-52: 60 °C (140 °F)	65 °C (149 °F)

5.3 Lens mounting

Notice
Avoid contamination of the sensor and the lens by dust and airborne particles when mounting 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 camera downwards with unprotected sensor. ▪ Avoid contact with any optical surface of the camera!

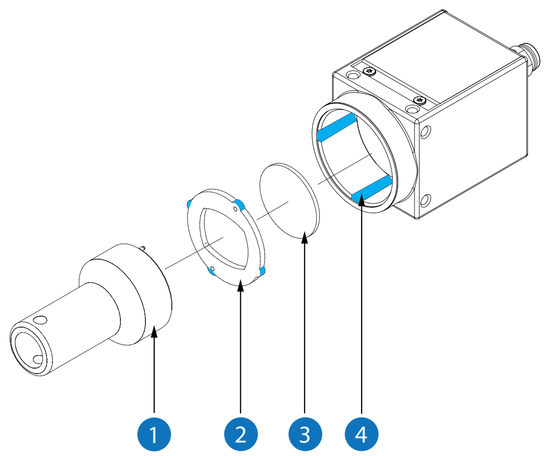
5.4 Filter replacement

A filter is installed in color cameras. This filter can lead to limitations in the applicability of the sensor for specific applications.

Proceed as follows to replace the filter.

Notice
Avoid contamination of the filter, sensor and the lens by dust and airborne particles! Perform the filter replacement in a dust-free room with clean tools!

Procedure



1. Insert the assembly tool (1) into the sensor opening. Place the two pins at the front end into the locator holes of the filter holder (2).
2. Turn the filter holder (2) until the guide tabs can be seen in the guide grooves (4).
3. Remove the filter holder (2).
4. Carefully remove the existing filter (3). Do not touch the sensor!
5. Insert the new filter into the sensor opening.
6. Put the filter holder (2) back in.
7. Turn the filter holder (2) until the guide tabs cannot be seen in the guide grooves (4).

5.5 Cleaning

Filter / 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.

5.6 Transport / Storage

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

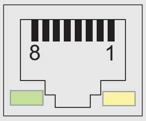
5.7 Mechanical Tests

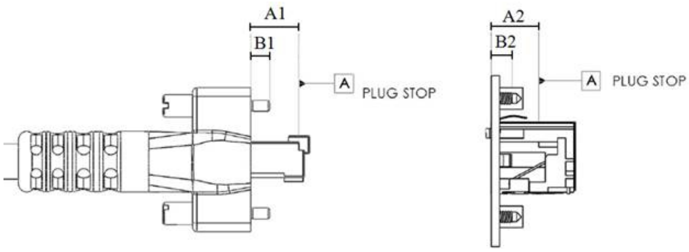
Environmental Testing	Standard	Parameter	
Vibration, sinusodial	IEC 60068-2-6	Frequency Range	10-2000 Hz
		Amplitude underneath crossover frequencies	1.5 mm
		Acceleration	10 g
		Test duration / Axis	150 min
Vibration, broad band	IEC 60068-2-64	Frequency range	20-1000 Hz
		Acceleration RMS	10 g
		Test duration / Axis	300 min
Shock	IEC 60068-2-27	Puls time	11 ms / 6 ms
		Acceleration	50 g / 100 g
Bump	IEC60068-2-29	Pulse Time	2 ms
		Acceleration	100 g

6. Pin-Assignment / LED-Signaling

6.1 VEXG

6.1.1 Ethernet Interface

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-	

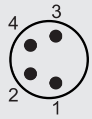


Free Connector (cable) Fixed Connector (camera)

Dimension - Free Connector (cable)	Type090
From overmold to plug stop (A1)	9.0mm (-0.50, +0.00)
From overmold to tip of thumbscrews (B1)	4.25mm (-1.00, +0.25)

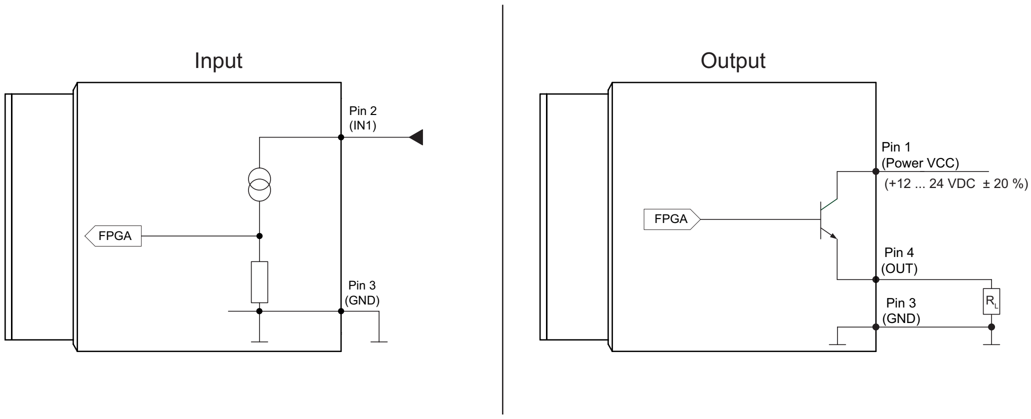
Dimension – Fixed Connector (camera)	Type090
From contact point to plug stop (A2)	9.0mm (-0.00, +1.00)
From contact point to bottom of thumbscrew thread (B2)	4.5mm (-0.00, +1)

6.1.2 Power Supply and Digital-IOs

Power Supply / Digital-IOs (on camera side) **wire colors on connecting cable (ordered separately)**					
					
1	Power VCC	brown	**3**	GND	blue
2	IN1 (Line0)	white	**4**	OUT1 (Line1)	black

Power Supply	
Power Supply	V_{CC}: 12 … 24 VDC ± 20%

6.1.3 Digital-IO



6.1.4 LED Signaling

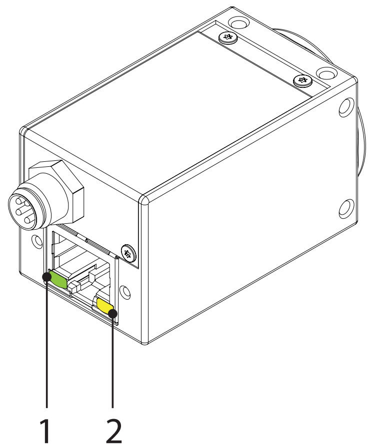


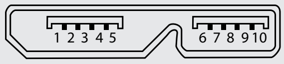
Figure 2 ►
LED positions on Baumer VEXG cameras.

LED	Signal	Meaning
1	green static	link active
	green flash	receiving
2	yellow static	error
	yellow flash	transmitting

6.2 VEXU

6.2.1 USB 3.0 Interface

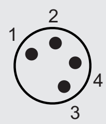
USB 3.0 Micro B



1	VBUS	**6**	MicB_SSTX-
2	D-	**7**	MicB_SSTX+
3	D+	**8**	GND_DRAIN
4	ID	**9**	MicB_SSRX-
5	GND	**10**	MicB_SSRX+

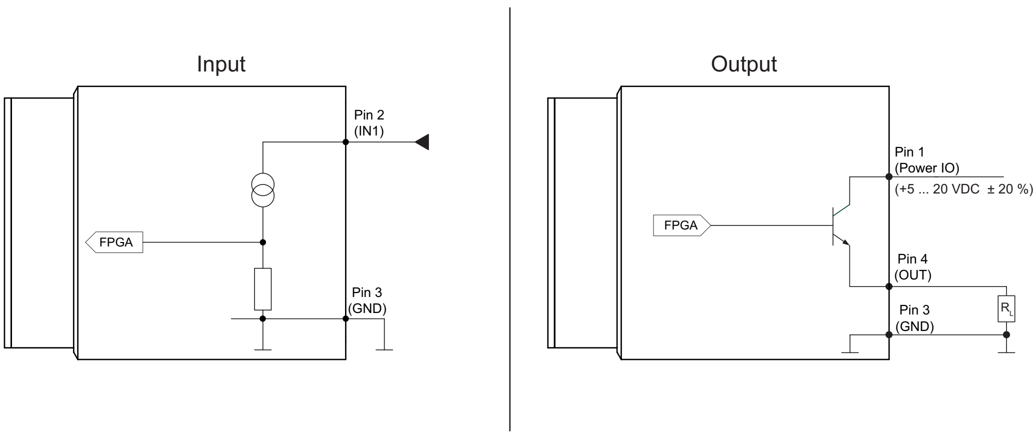
6.2.2 Digital-IOs

Power Supply / Digital-IOs (on camera side)
wire colors of the connecting cable (ordered separately)



1	Power IO	brown	**3**	GND	blue
2	IN1 (Line0)	white	**4**	OUT1 (Line1)	black

6.2.3 Digital-IO



6.2.4 LED Signaling

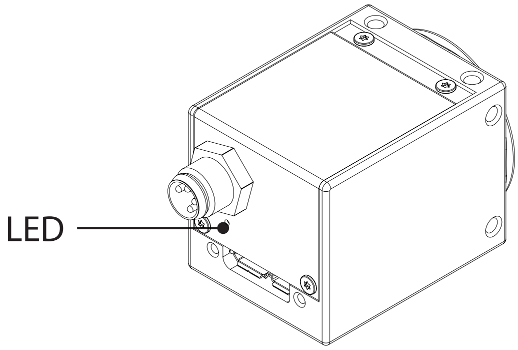


Figure 3 ►
LED position on Baumer VEXU camera.

	Signal	Meaning
LED	green flash	Power on
	green	USB 3.0 connection
	red	USB 2.0 connection
	yellow	Readout active
	red flash	Update

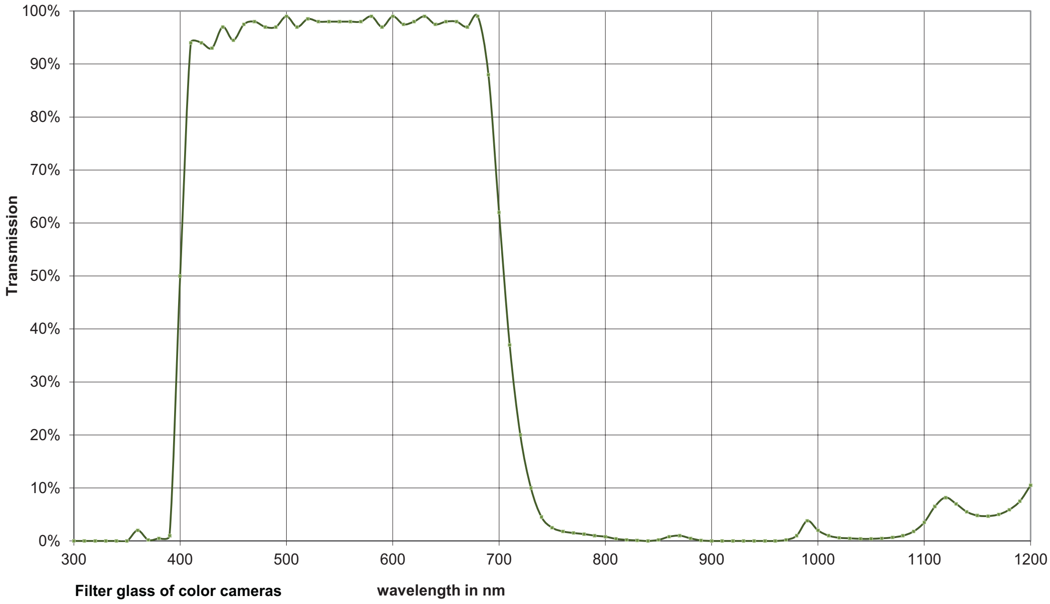
7. Product Specifications

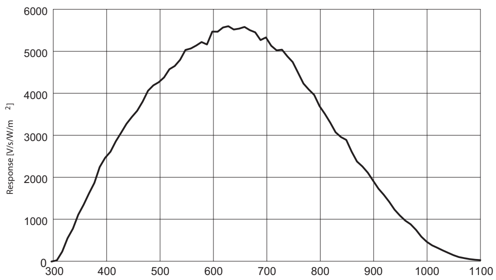
7.1 Sensor Specifications

7.1.1 Spectral Sensitivity

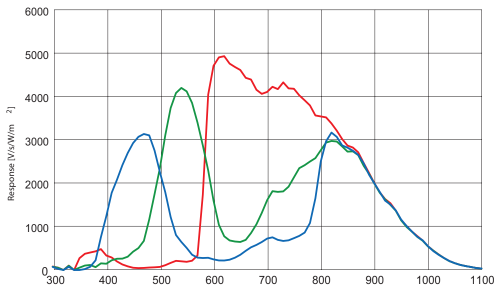
The spectral sensitivity characteristics of monochrome and color matrix sensors for cameras of this series are displayed in the following graphs. The characteristic curves for the sensors do not take the characteristics of lenses and light sources without filters into consideration.

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



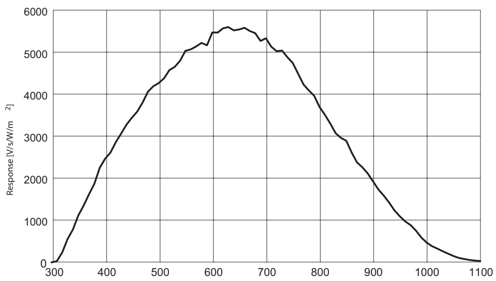


VEXG-02M (Python 300)

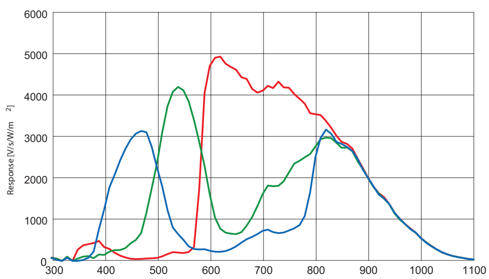


VEXG-02C (Python 300)

◄ **Figure 4**
Spectral sensitivities for Baumer cameras with 0.3 MP sensor.

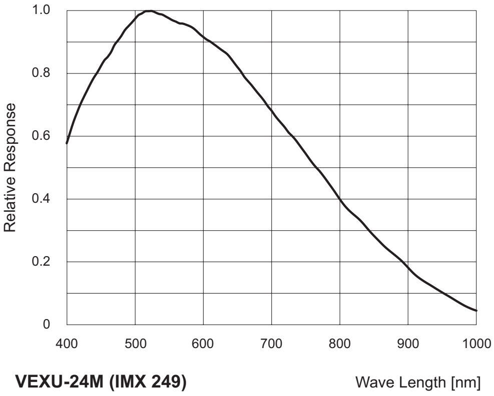


VEXG-13M (Python 1300)



VEXG-13C (Python 1300)

◄ **Figure 5**
Spectral sensitivities for Baumer cameras with 1.3 MP sensor.



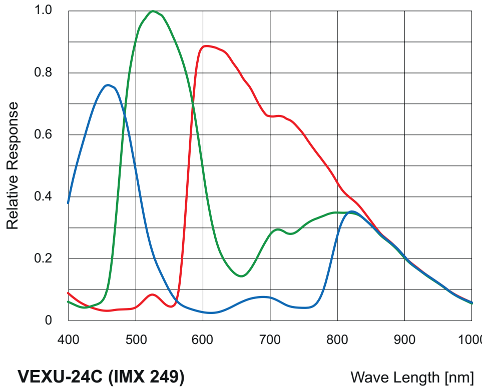
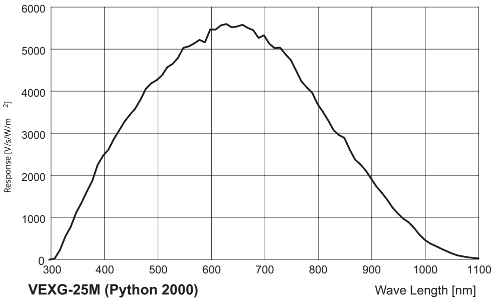


Figure 6 ▶
Spectral sensitivities for Baumer cameras with 2.3 MP sensor.



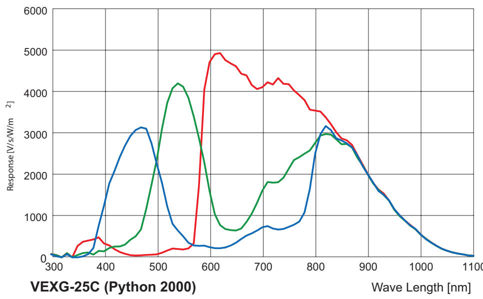
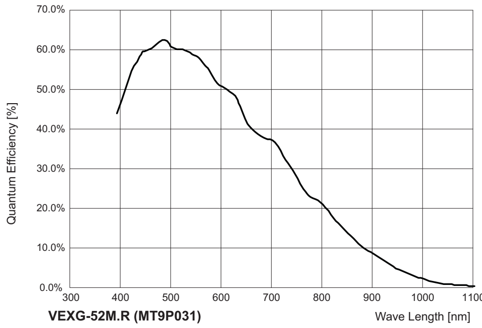


Figure 7 ▶
Spectral sensitivities for Baumer cameras with 2.3 MP sensor.



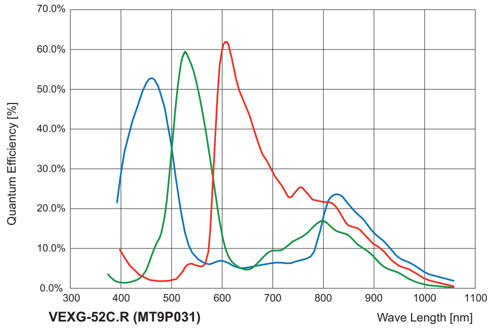
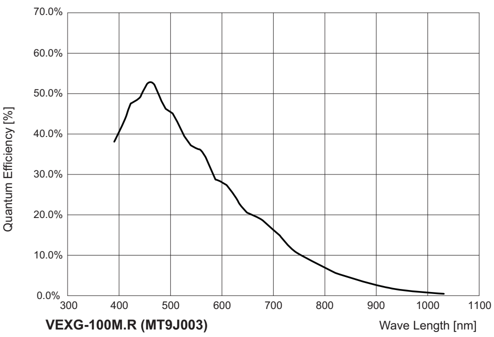


Figure 8 ▶
Spectral sensitivities for Baumer cameras with 5 MP sensor.



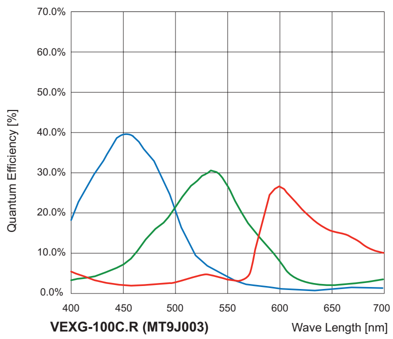


Figure 9 ▶
Spectral sensitivities for Baumer cameras with 10 MP sensor.

7.1.2 Sensor Shutter Mode (only cameras with Rolling Shutter sensors)

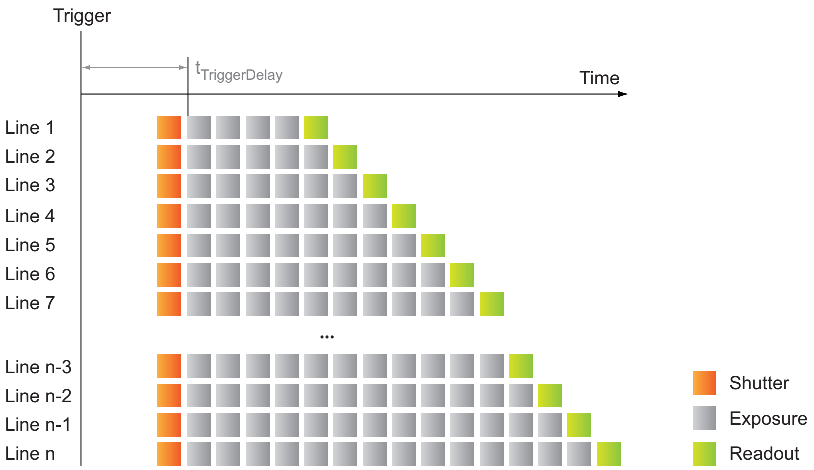
Sets the sensor shutter mode of the camera. The sensor shutter mode depends on the Trigger Mode.

An explanation of the various sensor shutter modes can be found in the next chapters.

VEXG (only cameras with rolling shutter sensors)

Camera Type (Sensor)				
	Trigger Mode = On		**Trigger Mode = Off**	
Monochrome				
	Shutter Mode	**Readout Mode**	**Shutter Mode**	**Readout Mode**
VEXG-52M.R	Global Reset	Non-overlapped	Rolling	Overlapped
	Rolling	Overlapped		
VEXG-100M.R	Global Reset	Non-overlapped	Rolling	Overlapped
Color				
VEXG-52C.R	Global Reset	Non-overlapped	Rolling	Overlapped
	Rolling	Overlapped		
VEXG-100C.R	Global Reset	Non-overlapped	Rolling	Overlapped

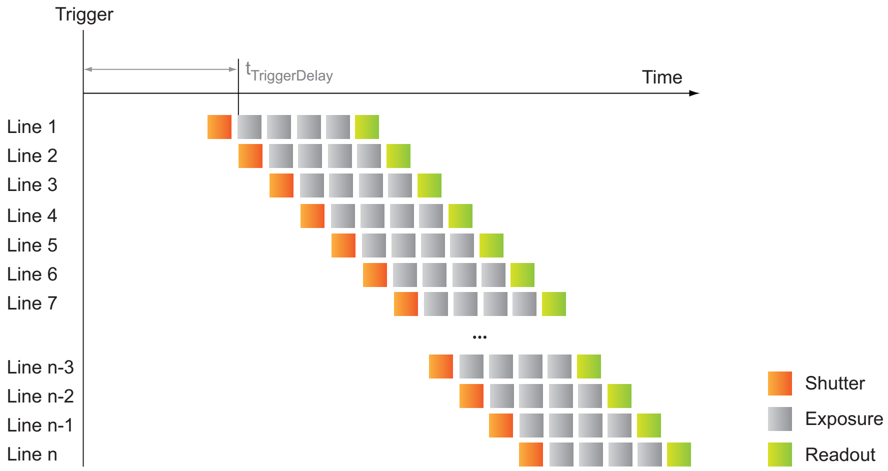
7.1.2.1 Global Reset



For cameras with rolling shutter sensor and set shutter mode Global Reset, for each frame all of the lines start exposure at the same time but the end of exposure is delayed by the offset of the previous line's readout. The exposure time for each line gradually lengthens. Data readout for each line begins immediately following the line's exposure. The readout time for each line is the same, but the start and end times are staggered.

An advantage of this shutter mode is a reduction in image artifacts typical of rolling shutters. However, because exposure lengthens throughout the frame, there may be a gradual increase in brightness from top to bottom of an image.

7.1.2.2 Rolling Shutter



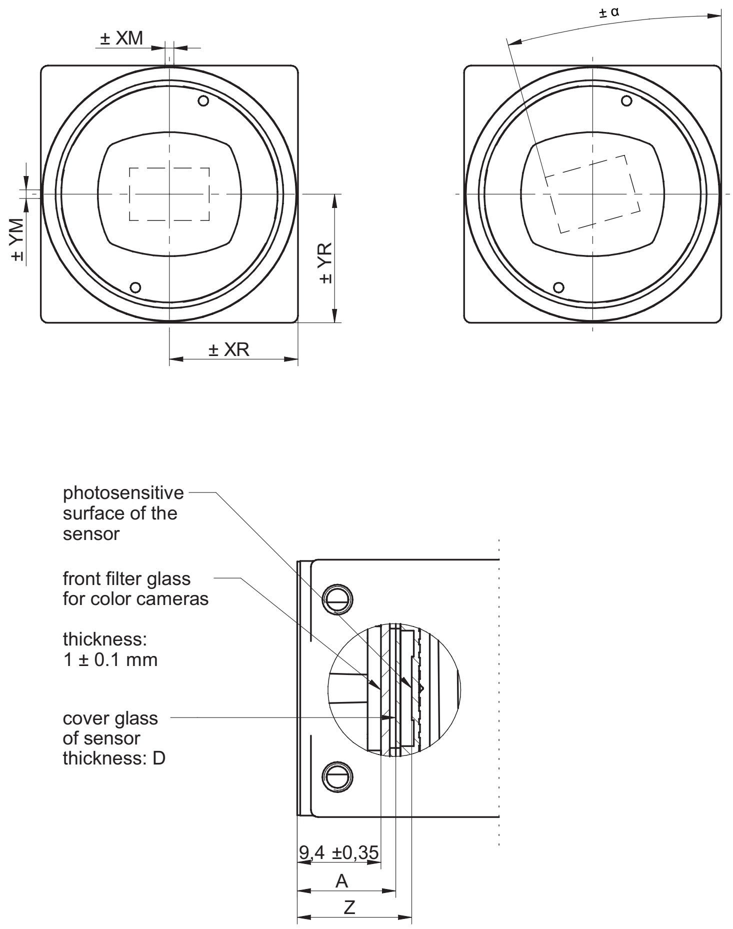
For cameras with rolling shutter sensor and set shutter mode Rolling, for each frame each line begins exposure at an offset equal to each line's readout time. The exposure time for each line is the same, but the start and end times are staggered. Data readout for each line begins immediately following the line's exposure. The readout time for each line is the same, but the start and end times are staggered.

One advantage of a Rolling Shutter is increased sensitivity. However, because exposure starts at different times throughout the frame, there are known artifacts such as skew, wobble, and partial exposure.

Notice
Due to technical issues of rolling shutter, a flash control depending on the exposure time does not make sense. Such cameras should be used in a continuously illuminated environment.

7.2 Field of View Position

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



◄ **Figure 10**
Sensor accuracy of the Baumer VEX series

7.2.1 VEXG

Camera Type	± x_M [mm]	± y_M [mm]	± x_R [mm]	± Y_R [mm]	± z_{typ} [mm]	± α_{typ} [°]	A [mm]	D** [mm]
VEXG-02*	0.04	0,04	0.04	0.04	12.50 ± 0.100	0.6	11.6	0.55
VEXG-13*	0.04	0,04	0.04	0.04	12.50 ± 0.100	0.6	11.6	0.55
VEXG-25*	0.05	0.05	0.05	0.05	17.65 ± 0.070	0.6	16.5	0.55
VEXG-52*	0.06	0.06	0.06	0.06	12.5 ± 0.100	0.6	12.35	0.4
VEXG-100*	0.06	0.06	0.06	0.06	12.5 ± 0.100	0.6	12.35	0.4

7.2.2 VEXU

Camera Type	± x_M [mm]	± y_M [mm]	± x_R [mm]	± Y_R [mm]	± z_{typ} [mm]	± α_{typ} [°]	A [mm]	D** [mm]
VEXU-24*	0.04	0,04	0.04	0.04	12.58 ± 0.065	0.4	10.8	0.50

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

7.3 Acquisition Modes and Timings

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

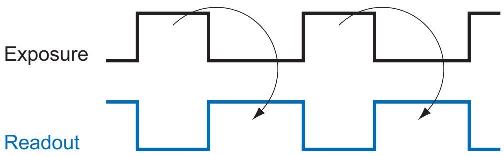
Exposing the pixels on the photosensitive surface of the sensor is only the first part of the image acquisition. After completion of the first step, the pixels are read out.

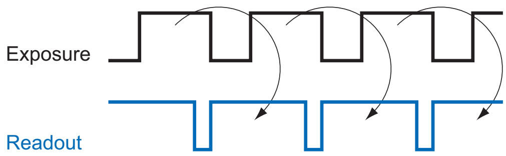
Thereby the exposure time ($t_{exposure}$) can be adjusted by the user, however, the time needed for the readout ($t_{readout}$) is given by the particular sensor and image format.

Baumer cameras can be operated with differtent acquisition modes, the *Continuous Mode (Free Running Mode)*, the *Acquisition Frame Rate Mode,* the *Single Frame Mode,* the *Multi Frame Mode* and the *Trigger Mode*.

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

Non-overlapped Operation	Overlapped Operation
Here the time intervals are long enough to process exposure and readout successively.	In this operation the exposure of a frame (n+1) takes place during the readout of frame (n).
Notice **Applies for cameras with Rolling Shutter sensor** The Acquisition Mode *Non-Overlapped Operation* is only available in Trigger Mode.	**Notice** **Applies for cameras with Rolling Shutter sensor** The Acquisition Mode *Overlapped Operation* is only available in Free Running Mode.





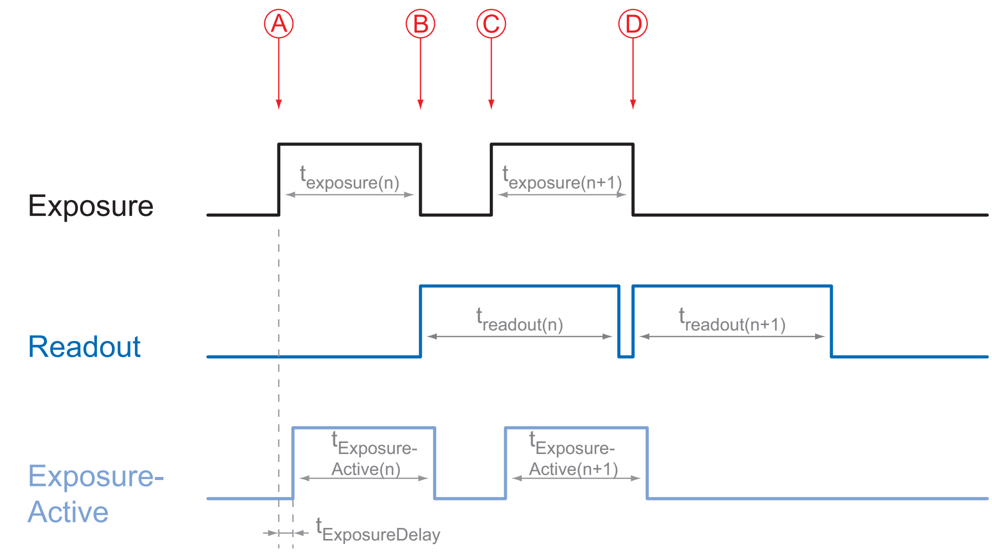
7.3.1 Continuous Mode (Free Running Mode)

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.

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

Image parameters:
Offset
Gain
Mode
Partial Scan



$t_{ExposureActive} = t_{exposure}$

1) Non-overlapped means the same as sequential.

7.3.2 Single Frame Mode

In this mode the camera is captured one frame after AcquisitionStart. Then the acquisition is stopped.

7.3.3 Multi Frame Mode

In this mode a predefined number of frames will be captured after AcquisitionStart. The AcquisitionFrameCount controls the number of captured frames. Then the acquisition is automatically stopped.

7.3.4 Acquisition Frame Rate (except cameras with Rolling Shutter sensors)

With this feature Baumer introduces a clever technique to the VEX camera series, that enables the user to predefine a desired frame rate in continuous 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.

7.3.5 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)	$t_{notready(n+1)} = t_{exposure(n)}$

VEXG (only cameras with Rolling Shutter sensor)

The sensor shutter mode depends on the Trigger Mode.

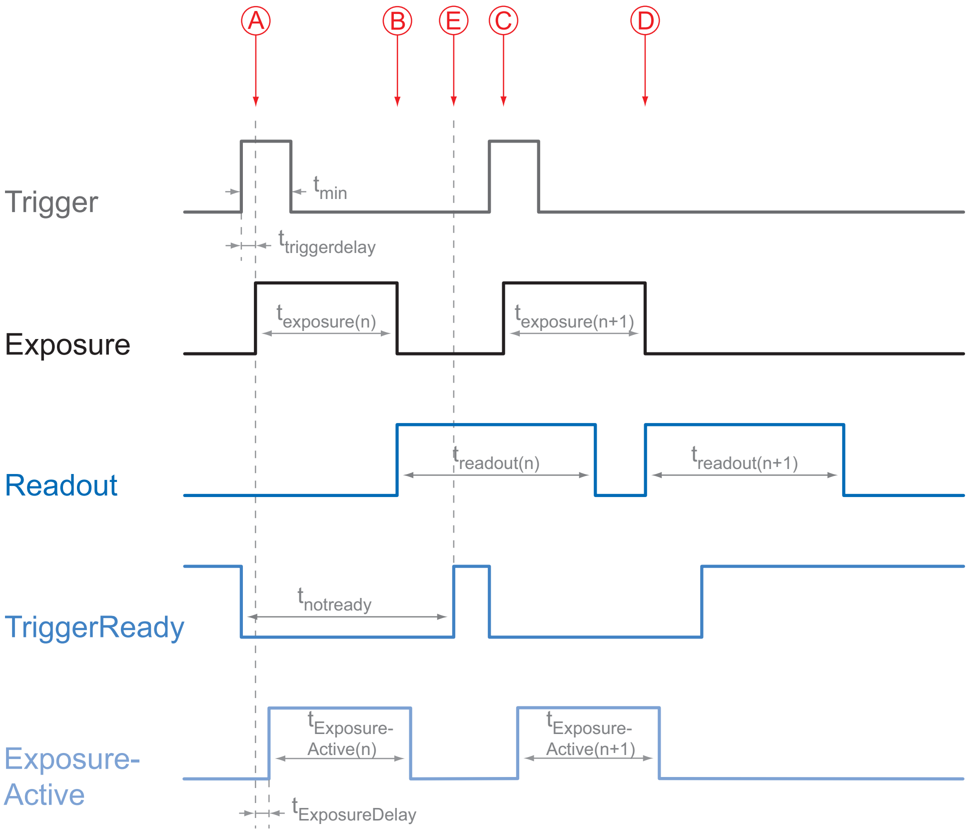
Camera Type (Sensor)				
	Trigger Mode = On		Trigger Mode = Off	
Monochrome				
	Shutter Mode	**Readout Mode**	**Shutter Mode**	**Readout Mode**
VEXG-52M.R	Global Reset	Non-overlapped	Rolling	Overlapped
	Rolling	Overlapped		
VEXG-100M.R	Global Reset	Non-overlapped	Rolling	Overlapped
Color				
VEXG-52C.R	Global Reset	Non-overlapped	Rolling	Overlapped
	Rolling	Overlapped		
VEXG-100C.R	Global Reset	Non-overlapped	Rolling	Overlapped

7.3.5.1 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

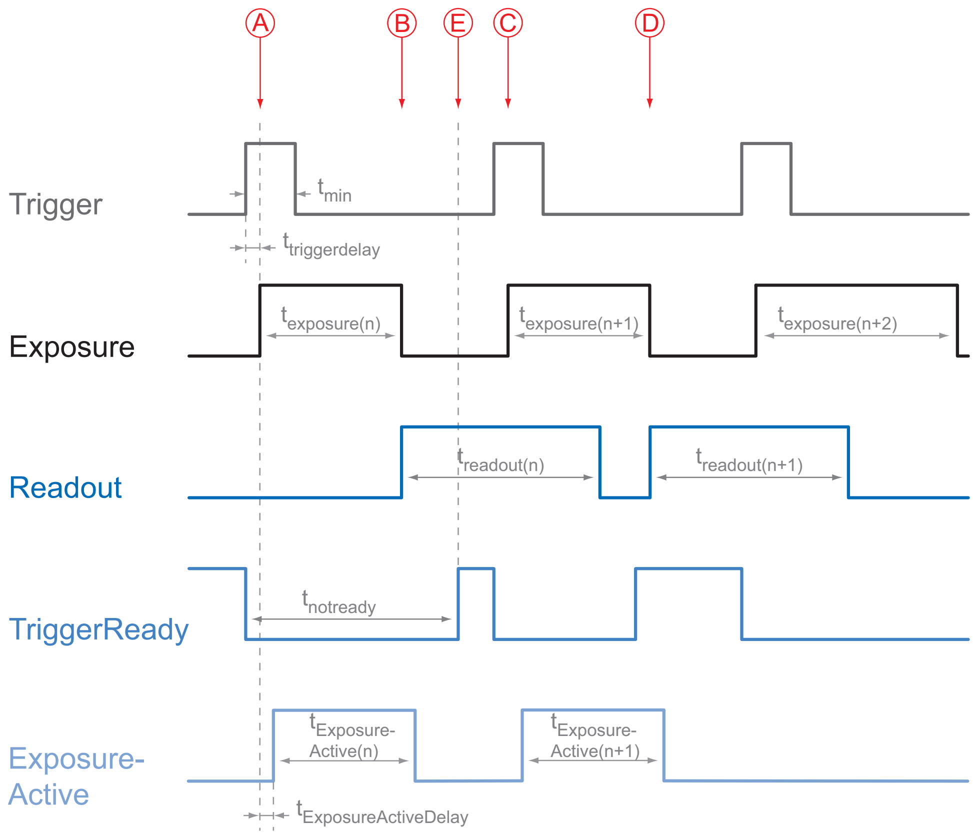
7.3.5.2 Overlapped Operation: $t_{exposure(n+2)}$ > $t_{exposure(n+1)}$

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

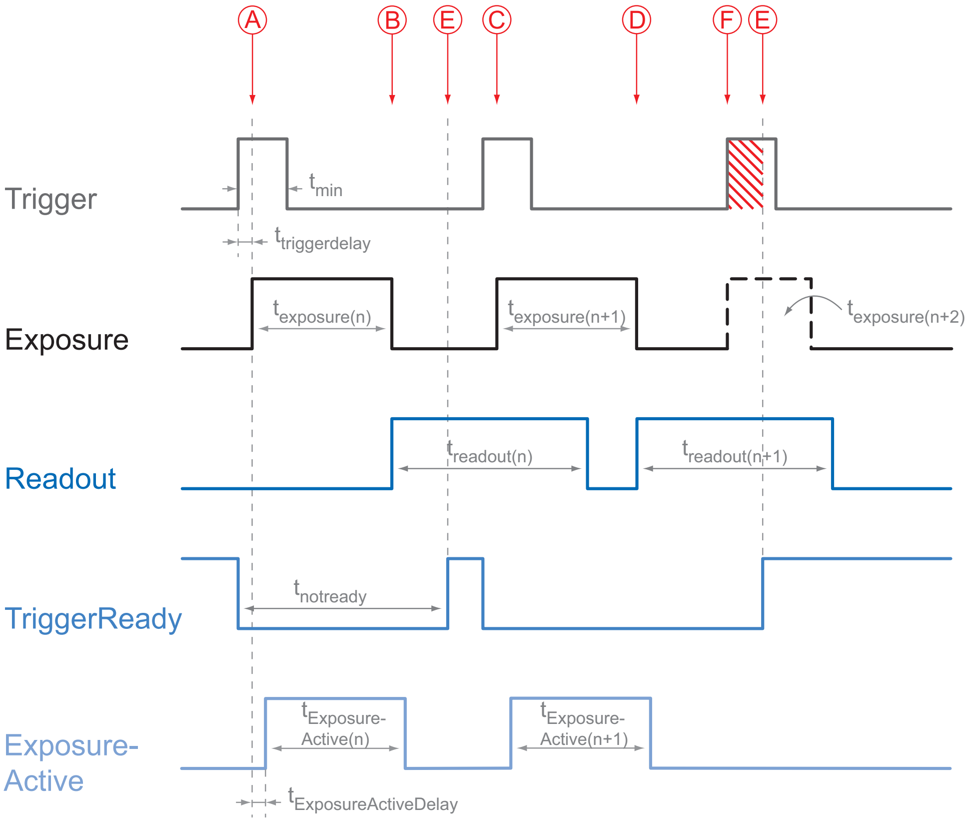
Image parameters:
Offset
Gain
Mode
Partial Scan



7.3.5.3 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*

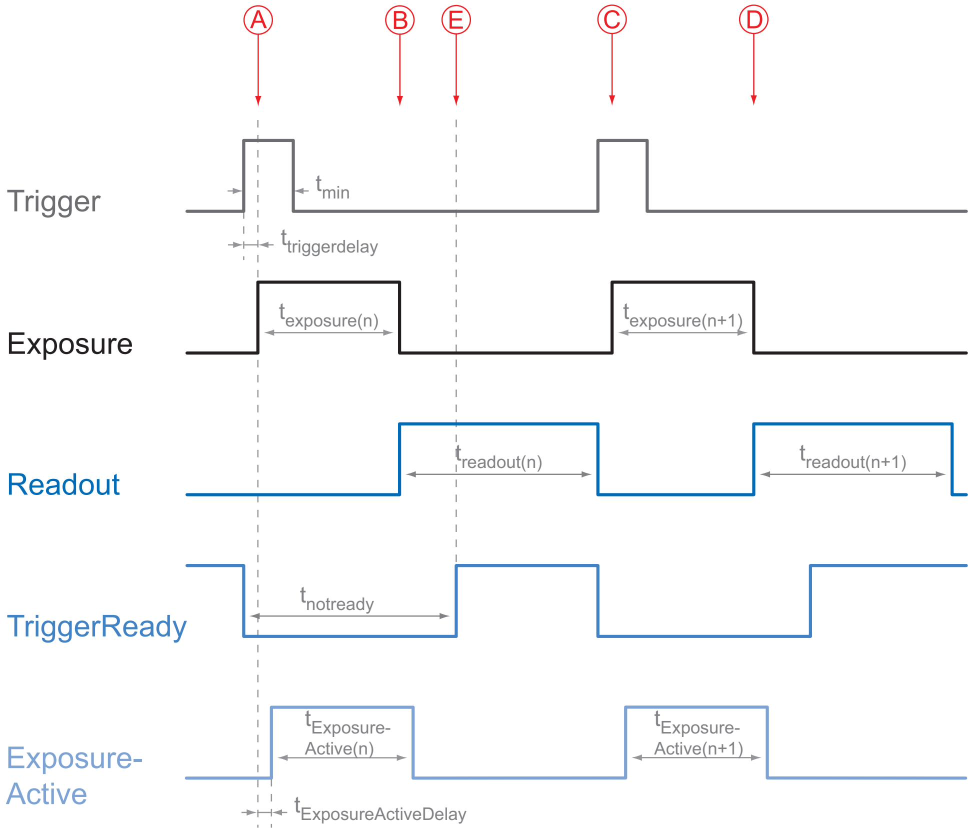
Image parameters:
Offset
Gain
Mode
Partial Scan

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.

7.3.5.4 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

7.4 Software

7.4.1 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.

More information can be found at: http://www.baumer.com/?id=8453

7.4.2 3rd Party Software

Strict compliance with the GenICam™ standard allows Baumer to offer the use of 3rd Party Software for operation with cameras of this series.

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

8. Camera Functionalities

8.1 Image Acquisition

8.1.1 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

8.1.1.1 VEXG

Camera Type	Full frame	Binning 2x2	Binning 2x1	Binning 1x2
Monochrome				
VEXG-02M	■	■	■	■
VEXG-13M	■	■	■	■
VEXG-25M	■	■	■	■
VEXG-52M.R	■	■	■	■
VEXG-100M.R	■	■	■	■
Color				
VEXG-02C	■	■	■	■
VEXG-13C	■	■	■	■
VEXG-25C	■	■	■	■
VEXG-52C.R	■	■	■	■
VEXG-100C.R	■	■	■	■

8.1.1.2 VEXU

Camera Type	Full frame	Binning 2x2	Binning 2x1	Binning 1x2
Monochrome				
VEXU-24M	■	■	■	■
Color				
VEXU-24C	■	■	■	■

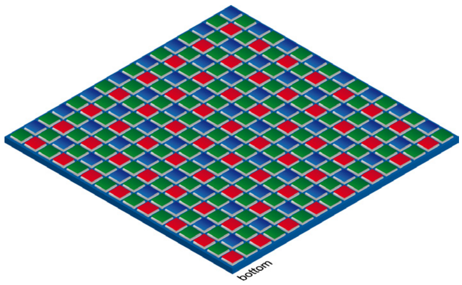
8.1.2 Pixel Format

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

8.1.2.1 General Definitions

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

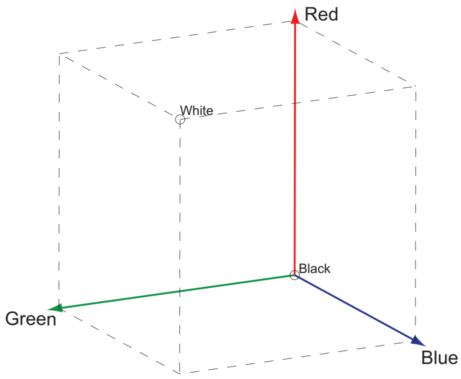
Bayer: Raw data format of color sensors.
Color filters are placed on these sensors in a checkerboard pattern, generally in a 50% green, 25% red and 25% blue array.



◄ **Figure 11**
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 12**
RBG color space displayed as color cube.

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

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 VEX cameras. In this formats, the unused bits of one pixel are filled with data from the next pixel.

8 bit:

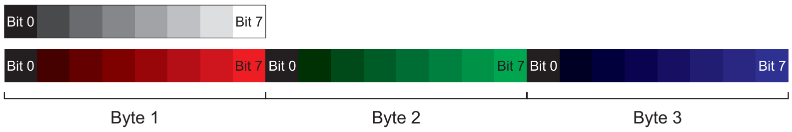


Figure 13 ▶ Bit string of Mono 8 bit and RGB 8 bit.

12 bit:

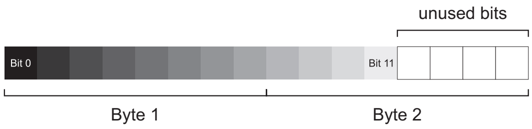


Figure 14 ▶ Spreading of Mono 12 bit over two bytes.

Packed:

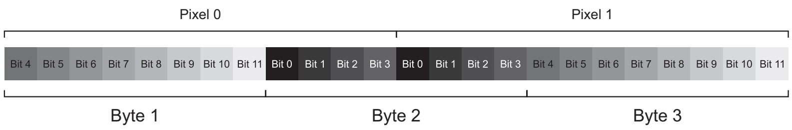


Figure 15 ▶ Spreading of two pixels in Mono 12 bit over three bytes (packed mode).

8.1.2.2 Pixel Formats VEXG

Camera Type	Mono8	Mono10	Mono12	Mono12p	Bayer RG8	Bayer RG10	Bayer RG12	Bayer RG129
Monochrome								
VEXG-02M	■	■	□	□	□	□	□	□
VEXG-13M	■	■	□	□	□	□	□	□
VEXG-25M	■	■	□	□	□	□	□	
VEXG-52M.R	■	□	■	■	□	□	□	□
VEXG-100M.R	■	□	■	■	□	□	□	□
Color								
VEXG-02C	□	□	□	□	■	■	□	□
VEXG-13C	□	□	□	□	■	■	□	□
VEXG-25C	□	□	□	□	■	■	□	□
VEXG-52C.R	□	□	□	□	■	□	■	■
VEXG-100C.R	□	□	□	□	■	□	■	■

8.1.2.3 Pixel Formats VEXU

Camera Type	Mono8	Mono12	Bayer RG8	Bayer RG12
Monochrome				
VEXU-24M	■	■	□	□
Color				
VEXU-24C	□	□	■	■

8.1.3 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.

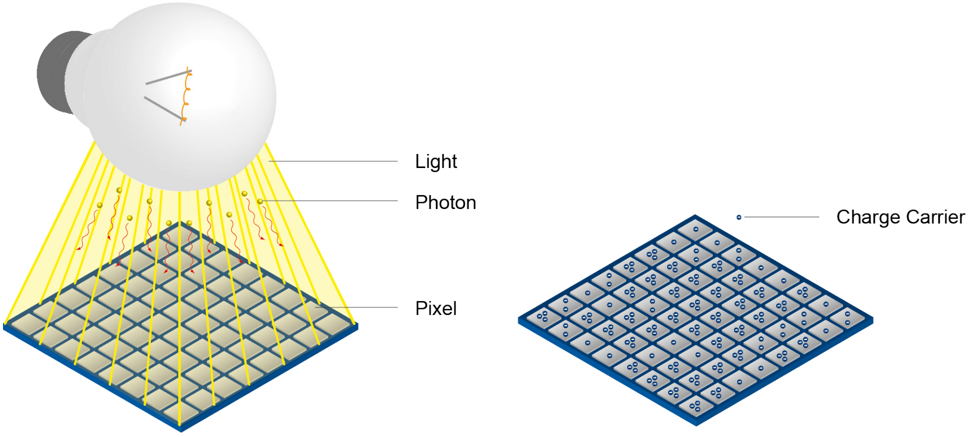


Figure 16 ▶
Incidence of light causes charge separation on the semiconductors of the sensor.

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

Notice

Due to the sensor, fixed pattern noise effects can occur at high exposure times. You can counteract this by setting the gain to a value of approximately 1.5 and reducing the exposure time accordingly.

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

Notice

Only for cameras with rolling shutter sensors!

The modification of the Exposure Time is done by reconfiguration of the sensor.

If the modification occurs during a sensor readout, the update will be delayed until the end of the current readout.

8.1.3.1 VEXG

Camera Type	$t_{exposure}$ min	$t_{exposure}$ max
Monochrome		
VEXG-02M	40 µsec	1 sec
VEXG-13M	40 µsec	1 sec
VEXG-25M	40 µsec	1 sec
VEXG-52M.R	20 µsec	1 sec
VEXG-100M.R	48 µsec	1 sec
Color		
VEXG-02C	40 µsec	1 sec
VEXG-13C	40 µsec	1 sec
VEXG-25C	40 µsec	1 sec
VEXG-52C.R	20 µsec	1 sec
VEXG-100C.R	48 µsec	1 sec

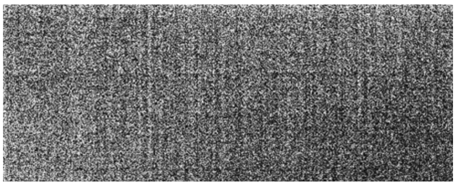
8.1.3.2 VEXU

Camera Type	$t_{exposure}$ min	$t_{exposure}$ max
Monochrome		
VEXU-24M	57 µsec	60 sec
Color		
VEXU-24C	57 µsec	60 sec

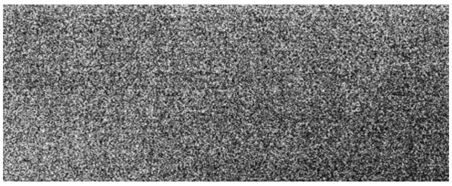
8.1.4 Fixed Pattern Noise Correction (FPNC)

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

8.1.4.1 VEXG

Camera Type	FPNC
Monochrome	
VEXG-02M	■
VEXG-13M	■
VEXG-25M	■
VEXG-52M.R	■
VEXG-100M.R	■
Color	
VEXG-02C	■
VEXG-13C	■
VEXG-25C	■
VEXG-52C.R	■
VEXG-100C.R	■

8.1.4.2 VEXU

Notice
On cameras with Sony sensors additional FPN correction is not necessary.

Camera Type	FPNC
Monochrome	
VEXU-24M	□
Color	
VEXU-24C	□

8.1.5 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.

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

Notice
For color binning and a defined region of interest, the setting of an odd number for the offset is possible. This would lead to a pixel offset and consequently to false colors.. This is prevented by performing the offset on an image without binning. Binning is then performed to this result.

8.1.5.1 ROI

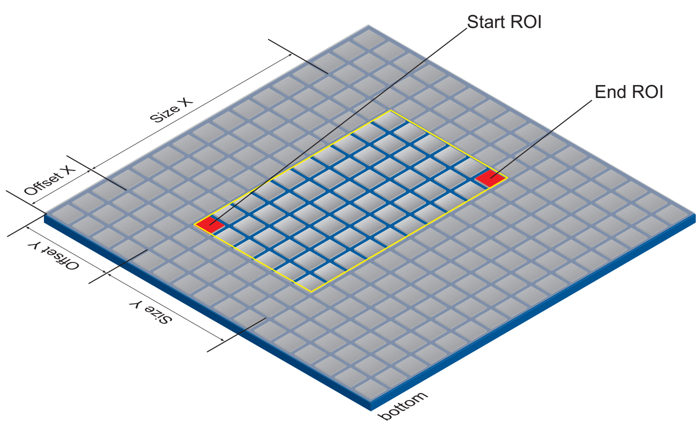


Figure 17 ▸
ROI: Parameters

ROI Readout

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

Notice
Applies for cameras with rolling shutter sensor The calculation of the ROI always takes place in FPGA. The speed does not increase.

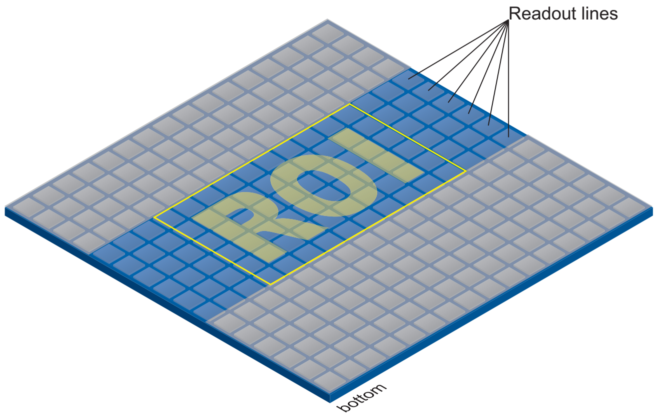


Figure 18 ▸
Decrease in readout time by using partial scan.

8.1.6 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.

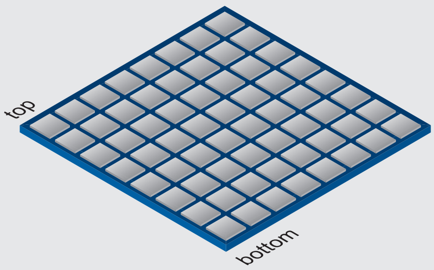
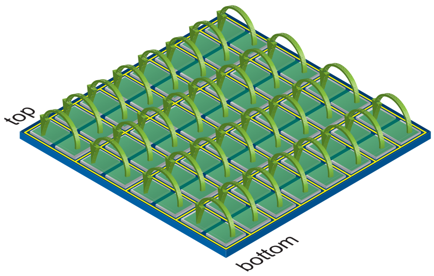
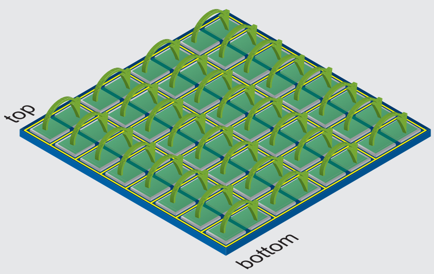
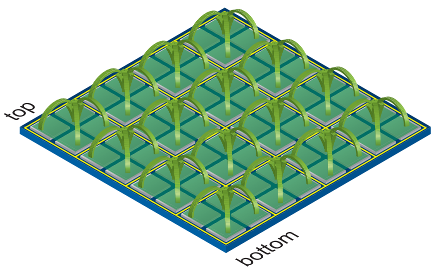
Baumer cameras support three types of Binning - vertical, horizontal and bidirectional.

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.

8.1.6.1 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.

8.1.6.2 Color Binning

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

At color binning the color values of neighboring pixels with the same color are combined.

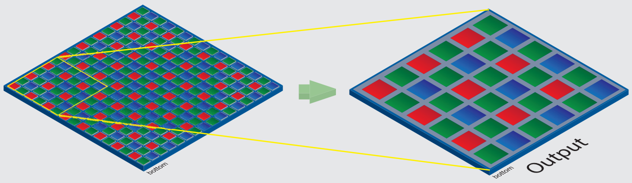
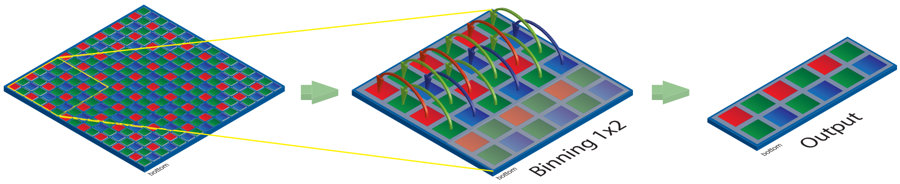
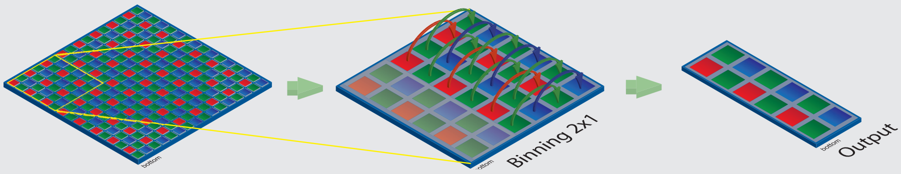
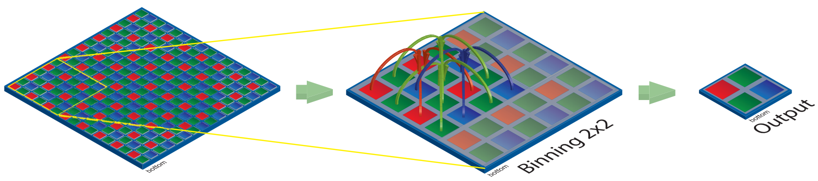
Binning	Illustration
without	
1x2	
2x1	
2x2	

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.

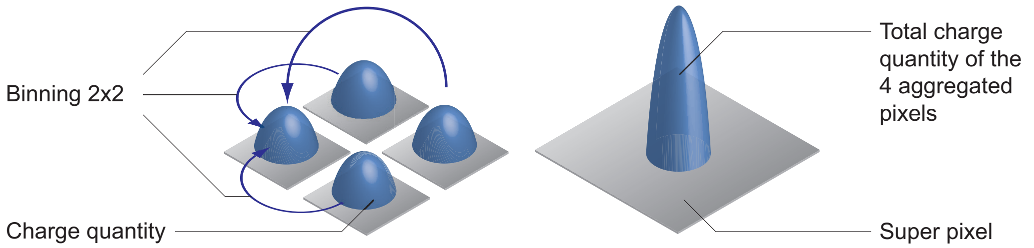
Figure 26 ▶
Bidirectional binning causes both a horizontally and vertically compressed image with quadruple brightness.

8.1.7 Brightness Correction

The aggregation of charge carriers may cause an overload. To prevent this, brightness correction was introduced. Brightness correction can be swiched on or off.

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

8.2 Analog Controls

8.2.1 Offset / Black Level

On Baumer VEX cameras, the offset (or black level) is adjustable from:

8.2.1.1 VEXG

Camera Type	Black Level
Monochrome	
VEXG-02M	0 ... 63 DN10
VEXG-13M	0 ... 63 DN10
VEXG-25M	0 ... 63 DN10
VEXG-52M.R	0 ... 255 DN12
VEXG-100M.R	0 ... 255 DN12
Color	
VEXG-02C	0 ... 63 DN10
VEXG-13C	0 ... 63 DN10
VEXG-25M	0 ... 63 DN10
VEXG-52C.R	0 ... 255 DN12
VEXG-100C.R	0 ... 255 DN12

8.2.1.2 VEXU

Camera Type	Black Level
Monochrome	
VEXU-24M	0 ... 255 DN12
Color	
VEXU-24C	0 ... 255 DN12

8.2.2 Gain

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

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

8.2.2.1 VEXG

Camera Type	Gain [dB]
Monochrome	
VEXG-02M	0...12
VEXG-13M	0...12
VEXG-25M	0...12
VEXG-52M.R	0...12
VEXG-100M.R	0...12
Color	
VEXG-02C	0...12
VEXG-13C	0...12
VEXG-25C	0...12
VEXG-52C.R	0...12
VEXG-100C.R	0...12

8.2.2.2 VEXU

Camera Type	Gain [dB]
Monochrome	
VEXU-24M	0...48
Color	
VEXU-24C	0...48

8.3 Pixel Correction

8.3.1 General information

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

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

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

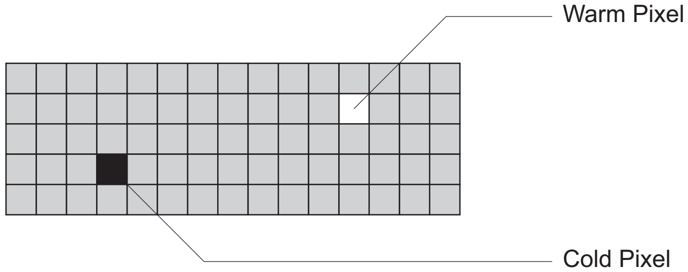


Figure 28 ▶ Distinction of "hot" and "cold" pixels within the recorded image.

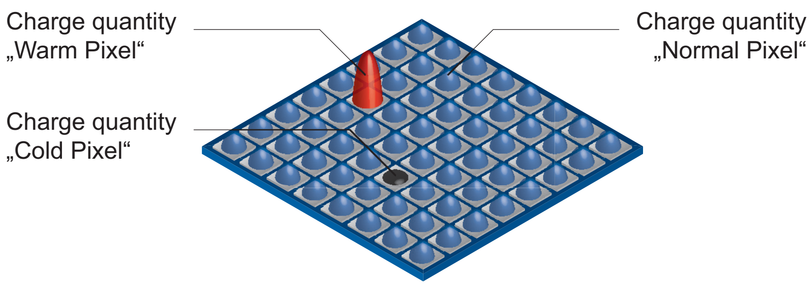


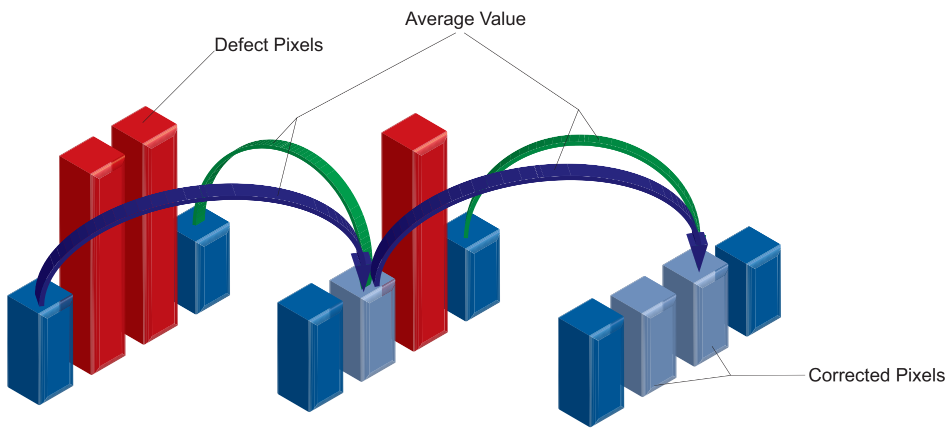
Figure 29 ▶ Charge quantity of "hot" and "cold" pixels compared with "normal" pixels.

8.3.2 Correction Algorithm

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

- Possible defect pixels are identified during the production process of the camera.
- The coordinates of these pixels are stored in the factory settings of the camera.

- Once the sensor readout is completed, correction takes place:
  - Before any other processing, the values of the neighboring pixels 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.



8.3.3 Add Defect Pixel to Defect pixel list

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 defect pixel list.

The user can determine the coordinates[1)] 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 defect pixel list.

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

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

Procedure (add Defect Pixel to defect pixel list)

1. Start the *Camera Explorer*. Connect to the camera. Select the profile *GenICam Expert*.
2. Open the category *LUT Control*.
3. Locate an empty *Defect Pixel List Index* (*Defect Pixel List Entry PosX* = 0 / *Defect Pixel List Entry PosY* = 0).

   Avoid using existing coordinates!
4. Determine the coordinates of the defect pixel. Keep the mouse pointer over the defect pixel. The coordinates of the defect pixel is displayed in the status bar.

   For simplification, you can enlarge the image.
5. Enter the determined coordinates for X (*Defect Pixel List Entry PosX*) and Y (*Defect Pixel List Entry PosY*).
6. Activate the registered *Defect Pixel List Index* (*Defect Pixel List Entry Active* = *True*).
7. Stop the camera and start them again to take over the updated coordinates.
8. Save your settings in a User Set (Category: *User Set Control*). Coordinates, which are not stored in an user set will be lost.

8.4 Process Interface

8.4.1 Digital-IOs

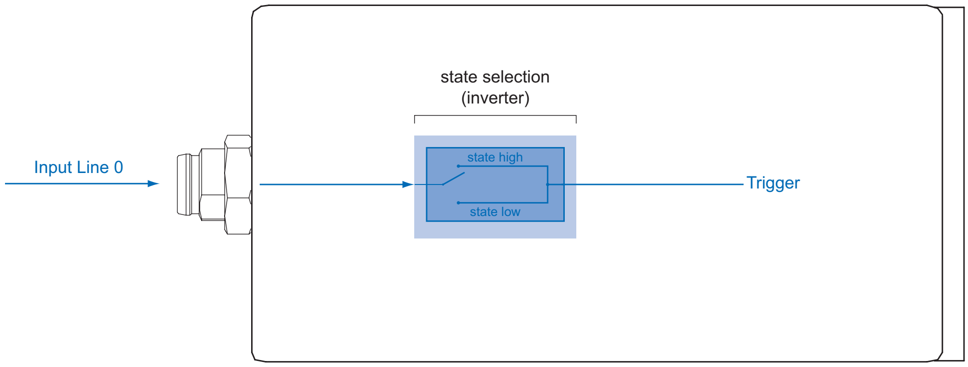
8.4.1.1 User Definable Inputs

The wiring of these input connectors is the responsibility of the user.

The sole exception to this is the compliance with predetermined high and low levels (only the optical input IN1; 0.0 ... 0.8V low, 3.3 ... 30V high).

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

On the software side, the signal is named "Trigger".



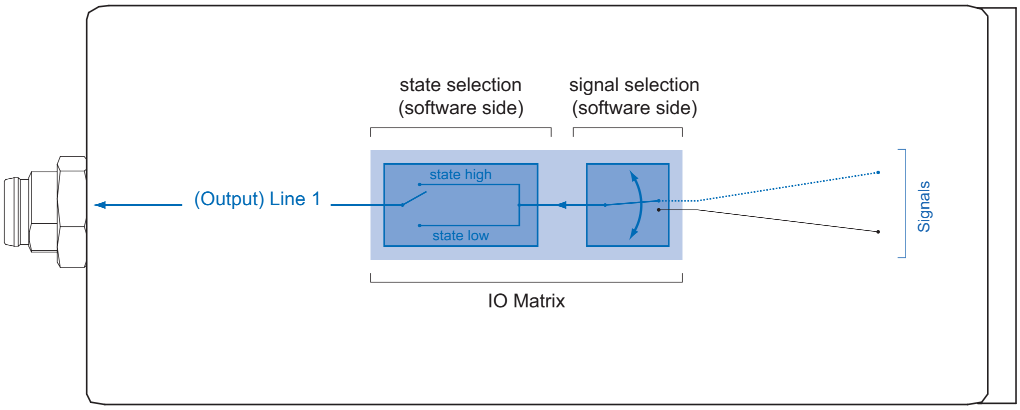
◀ **Figure 30**
Input Signal

8.4.1.2 Configurable Outputs

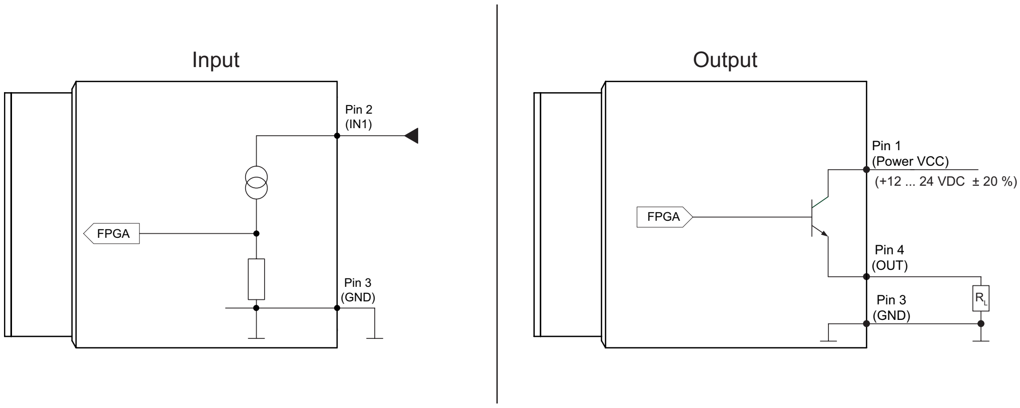
With this feature, Baumer gives you the option to wire the output connectors to internal signals that are controlled on the software side.

Signals	
Off	
ExposureActive	

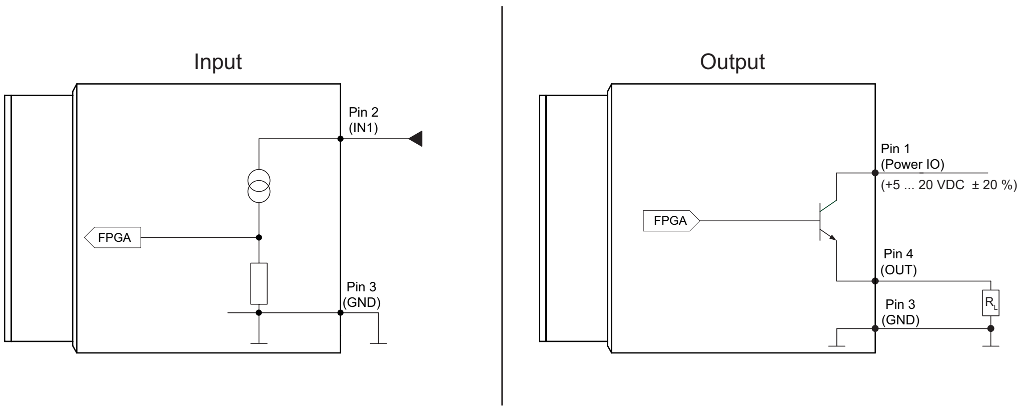
Figure 31 ▶
IO matrix



8.4.2 IO Circuits VEXG

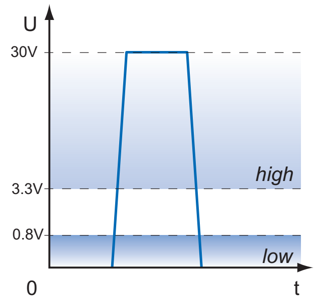


8.4.3 IO Circuits VEXU

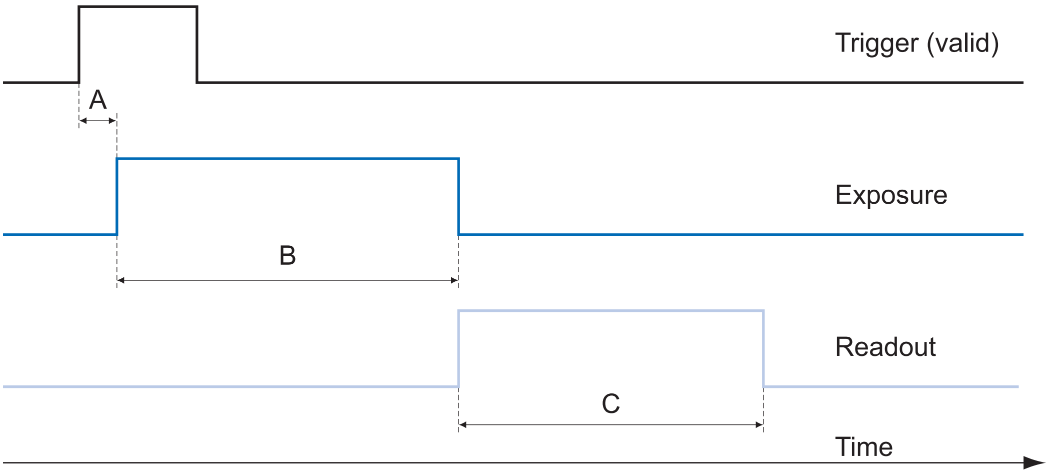


8.4.4 Trigger

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 32**
Trigger signal, valid for Baumer cameras.

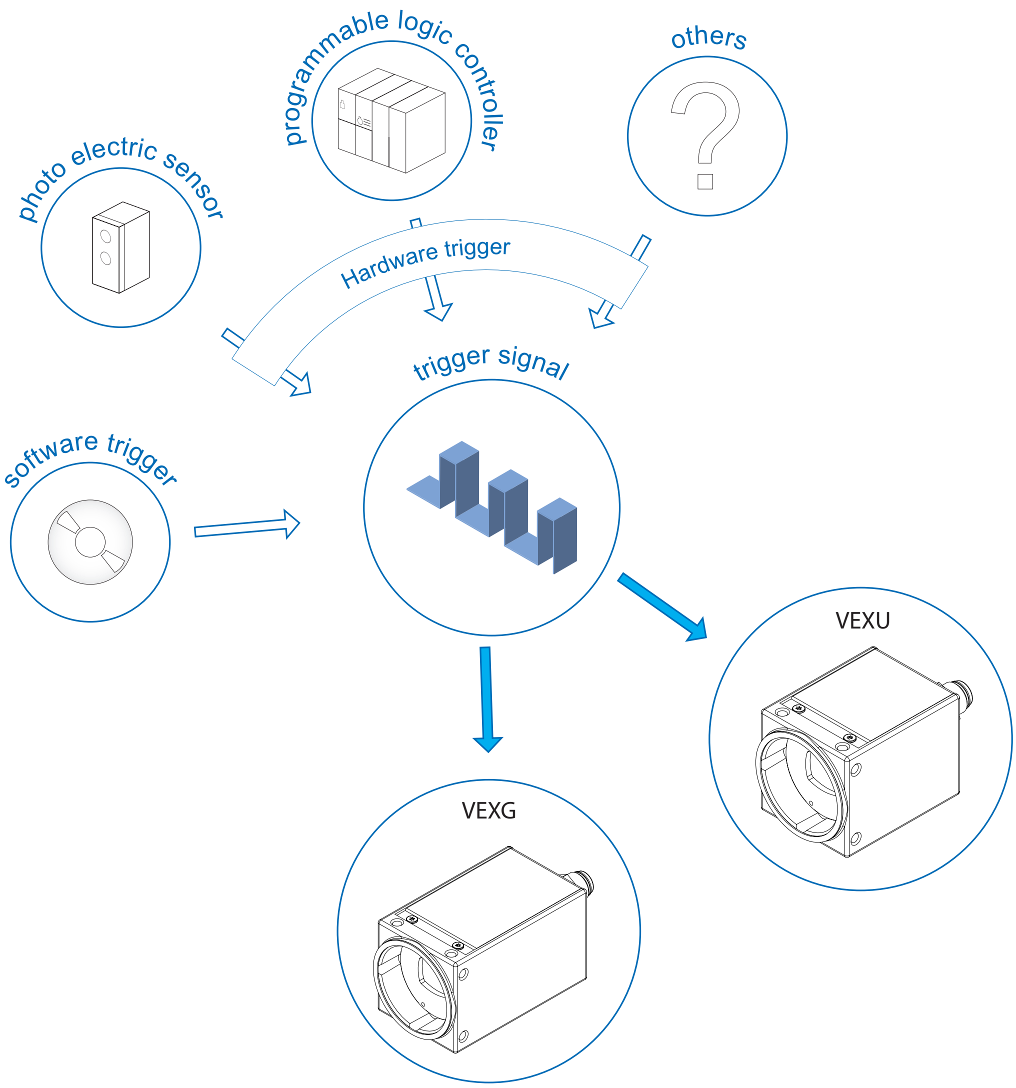


◄ **Figure 33**
Camera in trigger mode:
A - Trigger delay
B - Exposure time
C - Readout time

Different trigger sources can be used here.

8.4.5 Trigger Source

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.



◄ **Figure 34**
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.

8.4.6 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:

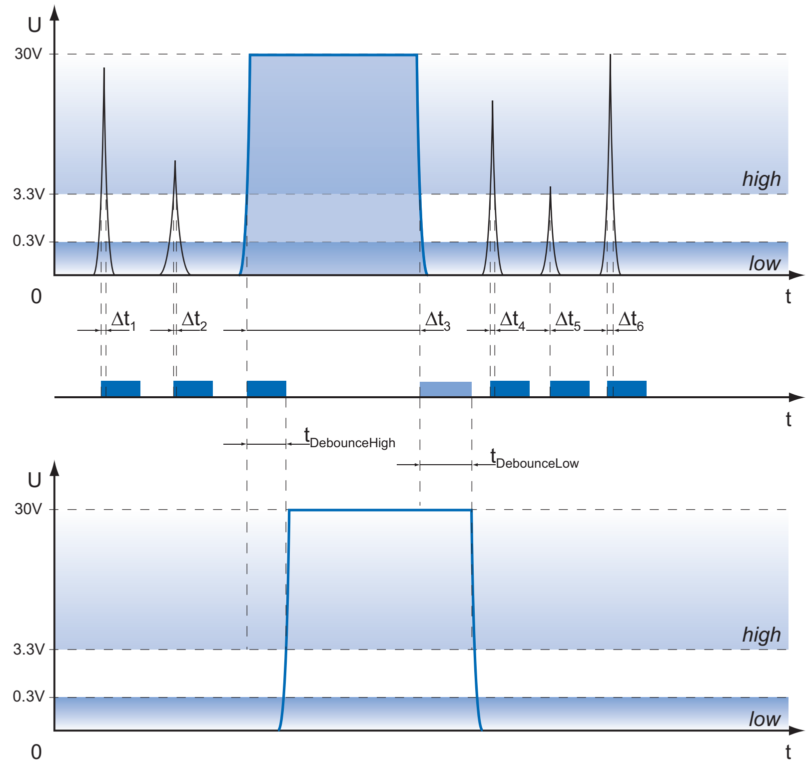
Please note that the edges of valid trigger signals are shifted by $t_{DebounceHigh}$ and $t_{DebounceLow}$!

Depending on these two timings, the trigger signal might be temporally stretched or compressed.

Incoming signals (valid and invalid)

Debouncer

Filtered signal



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

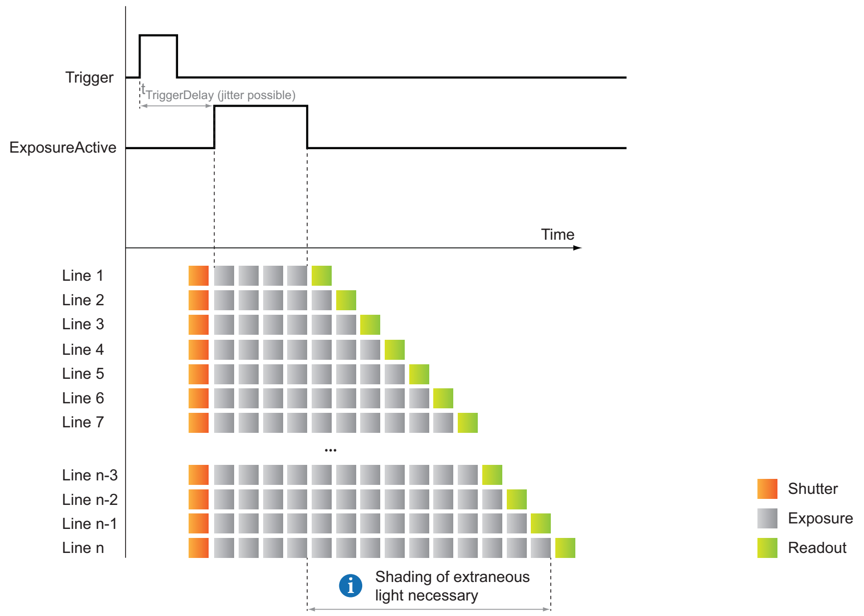
8.4.7 ExposureActive (Flash Signal)

This signal is managed by exposure of the sensor.

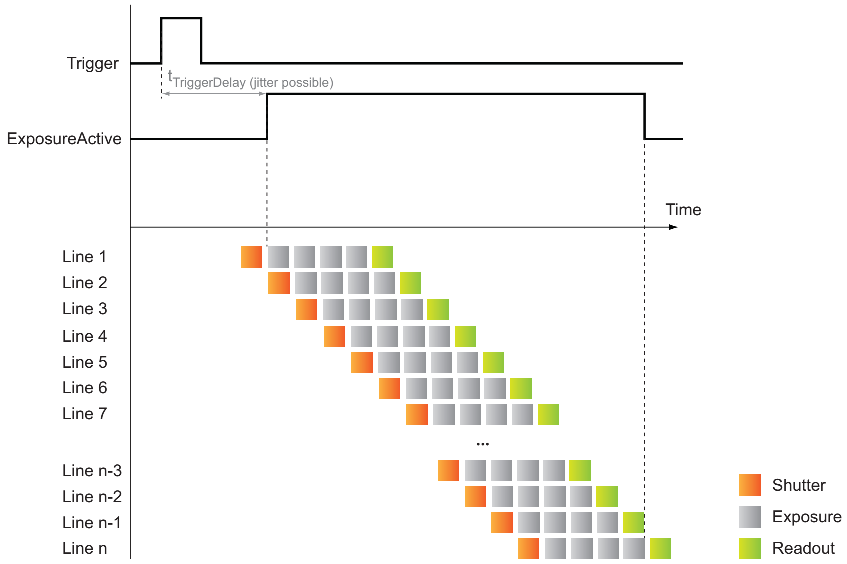
Furthermore, the falling edge of the ExposureActive output signal can be used to trigger a movement of the inspected objects. Due to this fact, the span time used for the sensor readout $t_{readout}$ can be used optimally in industrial environments.

Depending on Sensor Shutter Mode (only cameras with Rolling Shutter sensors), the ExposureActive signal is active at different times.

Sensor Shutter Mode: Global Reset



Sensor Shutter Mode: Rolling Shutter



8.4.8 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.

8.5 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.

8.6 User Sets

One user set (0-1) are available for the Baumer cameras of the EX series. User set 0 is the default set and contains the factory settings. User set 1 is user-specific and can contain any user definable parameters.

The user set are stored within the camera and can be loaded, saved and transferred to other cameras of the EX series.

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

8.6.1 VEXG

Parameter	
AcquisitionMode	LineDebouncerLowTimeAbs
AcquisitionFrameCount	Width
AcquisitionStart	Height
AcquisitionStop	OffsetX
AcquisitionFrameRate	OffsetY
TriggerMode	BinningHorizontal
TriggerSource	BinningVertical
TriggerActivation	PixelFormat
ExposureTime	TestPatternGeneratorSelector
AcquisitionFrameRateEnable	TestPattern
ReadoutMode	PixelFormat
Gain	TestPatternGeneratorSelector
BlackLevel	TestPattern
BrightnessCorrection	DefectPixelCorrection
FrameCounter	GEV SCPD
LineInverter	GEV SCFTD
LineSource	FixedPatternNoiseCorrection
LineDebouncerHighTimeAbs	

8.6.2 VEXU

Parameter	
AcquisitionMode	FrameCounter
AcquisitionFrameCount	ReadOutBuffering
AcquisitionStart	LineInverter
AcquisitionStop	LineSource
AcquisitionAbort	LineDebouncerHighTimeAbs
AcquisitionFrameRate	LineDebouncerLowTimeAbs
TriggerMode	EventNotification
TriggerSource	Width
TriggerActivation	Height
ExposureMode	OffsetX
ExposureTime	OffsetY
AcquisitionFrameRateEnable	BinningHorizontal
ReadoutMode	BinningVertical
Gain	PixelFormat
BalanceWhiteAuto	TestPatternGeneratorSelector
BlackLevel	TestPattern
BrightnessCorrection	DefectPixelCorrection

8.7 Factory Settings

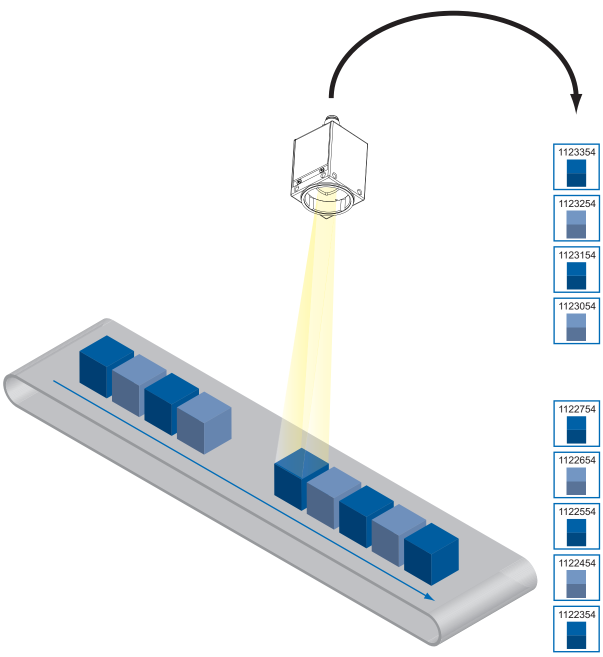
The factory settings are stored in "user set 0" which is the default user set. This is the only user set, that is not editable.

8.8 Timestamp

The Timestamp is 64 bits long and reports the current value of the device timestamp counter in nanoseconds. Any image or event includes its corresponding timestamp.

The resolution is at USB cameras 10 nanoseconds and at GigE cameras 8 nanoseconds.

At power on or reset (only GigE), the timestamp starts running from zero.



◄ **Figure 35**
Timestamps of recorded images.

8.9 Start-Stop-Behaviour

8.9.1 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.

8.9.2 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.

9. VEXG – Interface Functionalities

9.1 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)

9.2 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 EXG cameras can handle a MTU of up to 65535 Bytes.

9.3 Inter Packet Gap (IPG)

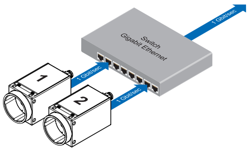
To achieve optimal results in image transfer, several Ethernet-specific factors need to be considered when using Baumer VEX cameras.

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.

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.*

9.3.1 Example 1: Multi Camera Operation – Minimal IPG



▲ **Figure 36**
Operation of two cameras employing a Gigabit Ethernet switch.
Data processing within the switch is displayed in the next two figures.

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.

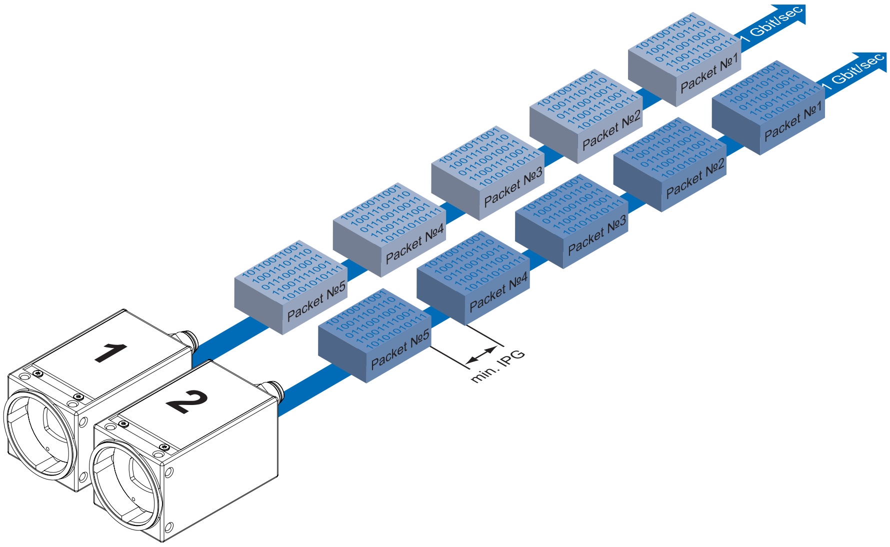


Figure 37 ►
Operation of two cameras employing aminimal inter packet gap (IPG).

9.3.2 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.

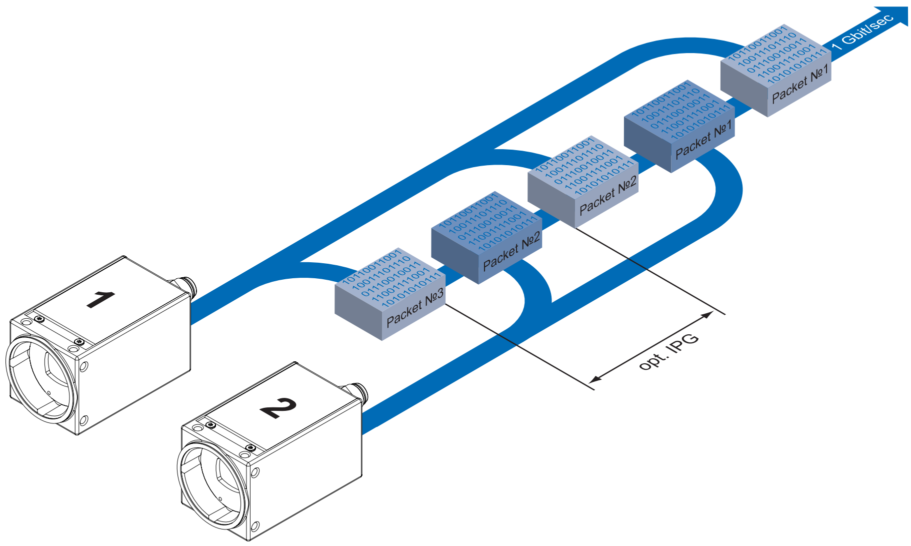


Figure 38 ►
Operation of two cameras employing an optimal inter packet gap (IPG).

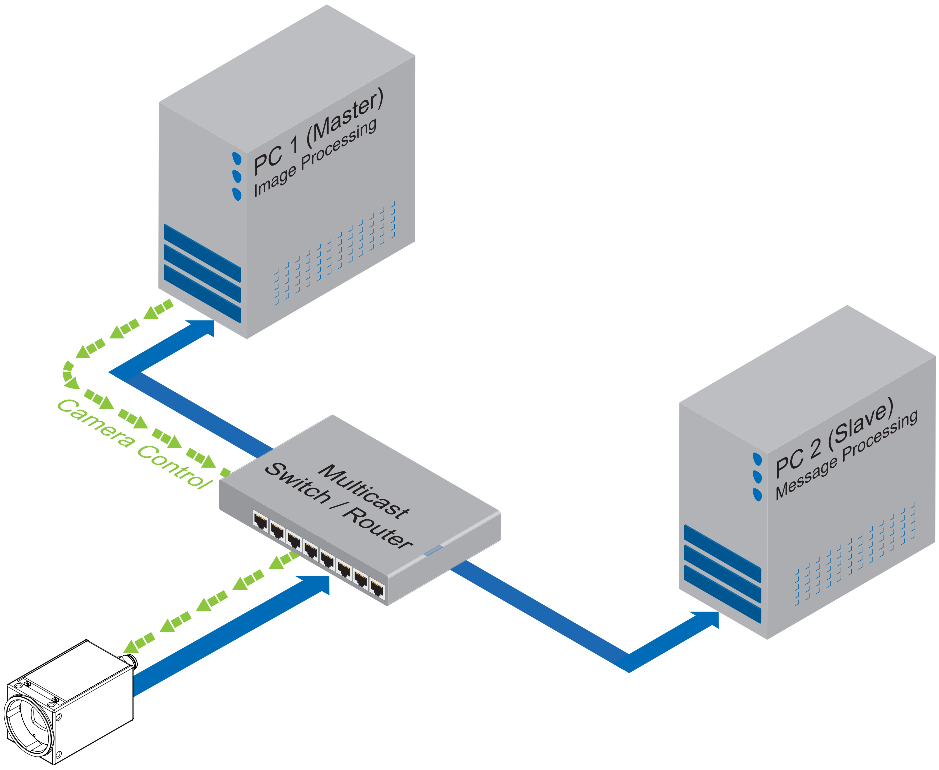
9.4 Multicast

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 39**
Principle of Multicast

9.5 IP Configuration

Internet Protocol:
On Baumer cameras IP v4 is employed.

9.5.1 Persistent IP

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

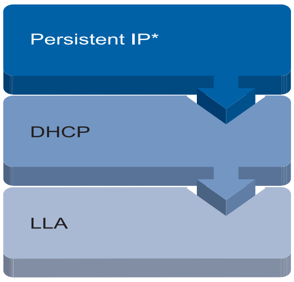


Figure 40 ▲
Connection pathway for Baumer Gigabit Ethernet cameras:
The device connects step by step via the three described mechanisms.

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 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.

9.5.2 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.

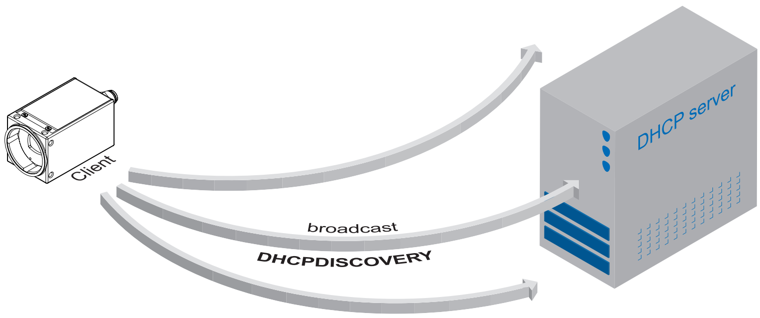


Figure 41 ►
DHCP Discovery (broadcast)

- 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

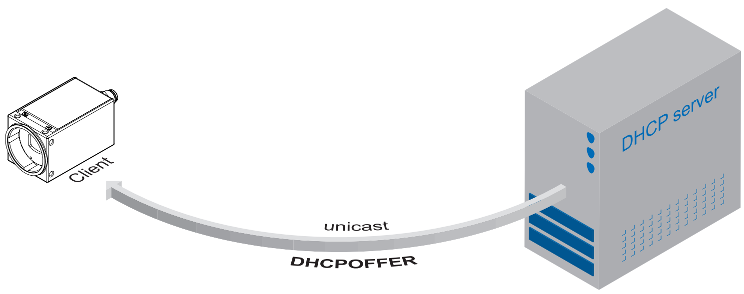
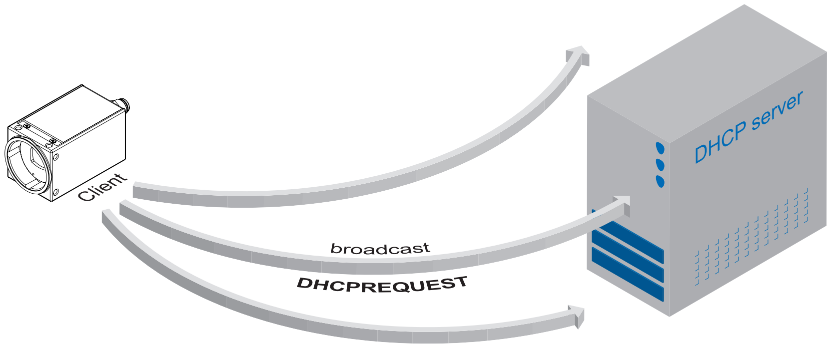


Figure 40 ►
DHCP offer (unicast)

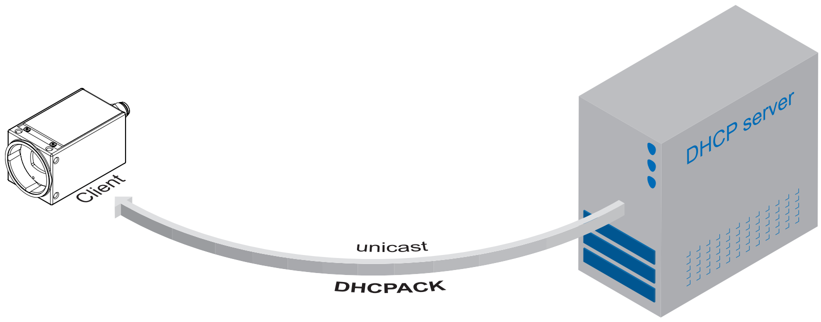
- DHCP Request
  Once the client has received this DHCPOFFER, the transaction needs to be confirmed. For this purpose the client sends a so called DHCPREQUEST broadcast to the network. This message contains the IP address of the offering DHCP server and informs all other possible DHCPservers that the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



◄ **Figure 42**
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 43**
DHCP Acknowledgement (unicast)

9.5.3 LLA

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

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.

9.5.4 Force IP[1)]

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

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

9.6 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:

9.6.1 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%.

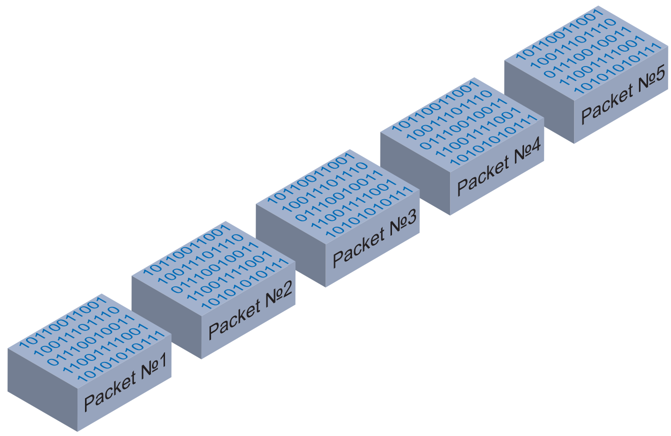


Figure 44 ►
Data stream without damaged or lost packets.

9.6.2 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.

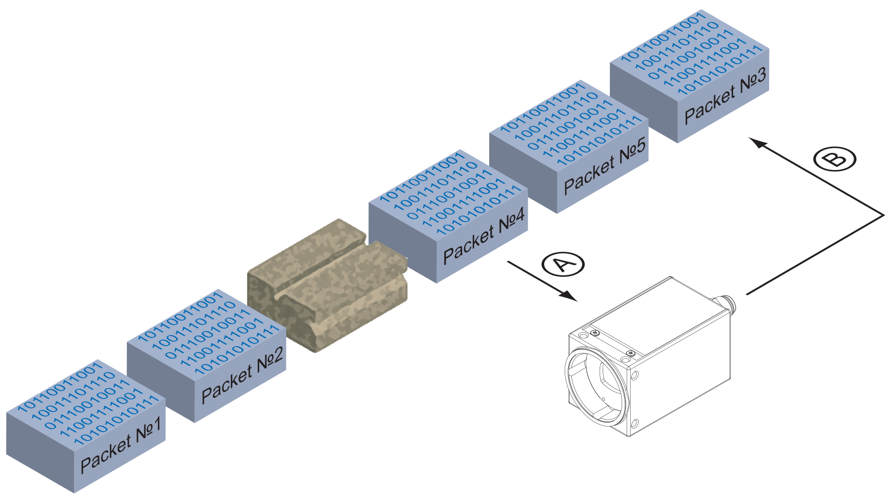
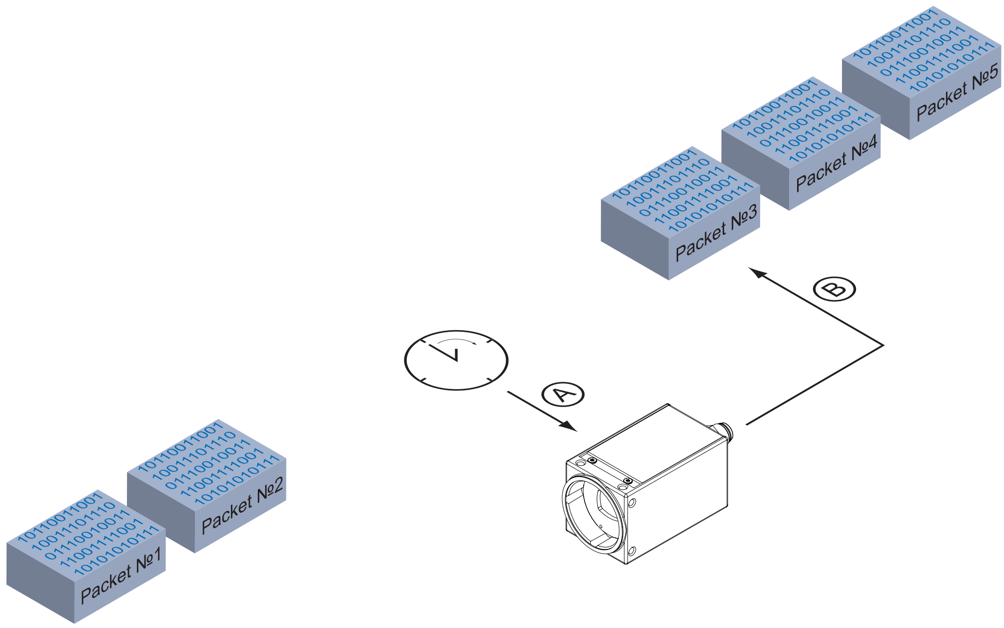


Figure 45 ►
Resending lost packets within the data stream.

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.

9.6.3 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 46**
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.

9.6.4 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. VEXU – Interface Functionalities

10.1 Device Information

This information on the device is part of the camera's USB descriptor.

Included information:

- Product ID (PID)
- Vendor ID (VID)

Model Name	Baumer USB Vendor ID [Hexadecimal]	Baumer USB Product ID [Hexadecimal]
VEXU-24M	2825	0126
VEXU-24C	2825	0127

- General Unique Identifier (GUID)
- Device vendor name (Manufacturer)
- Serial number (iSerialNumber)

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