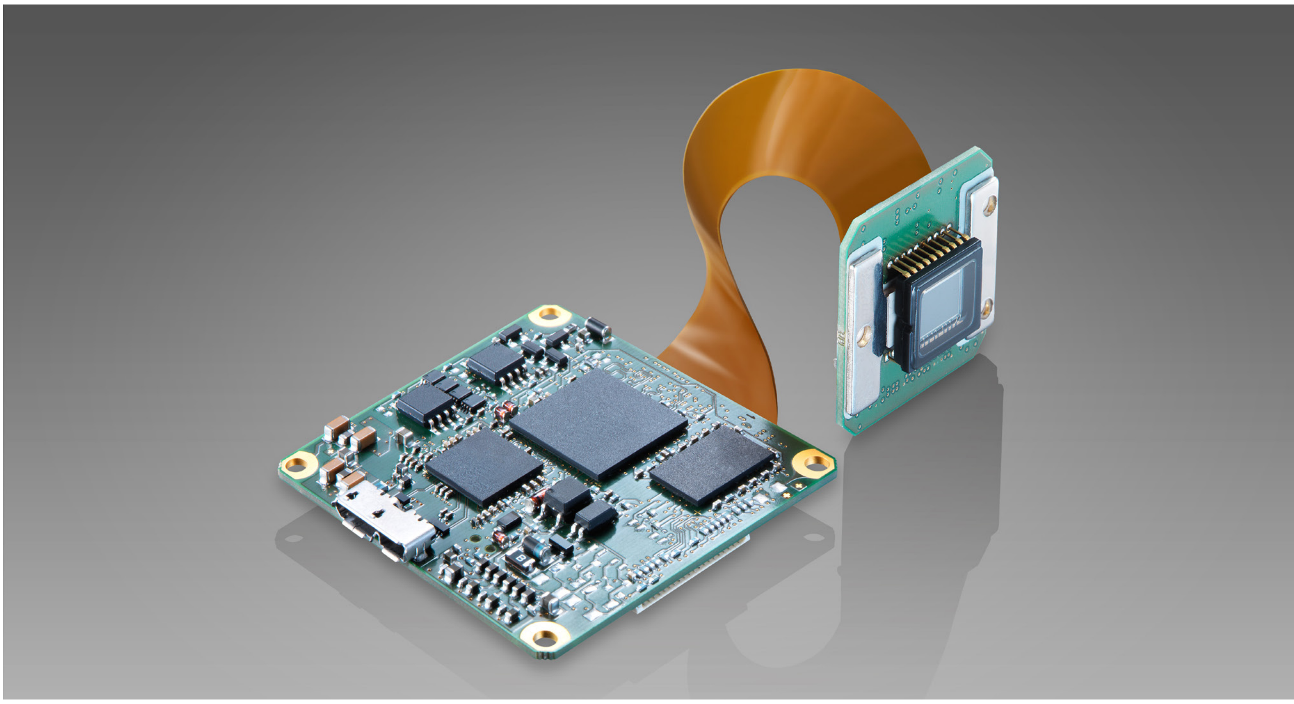
Baumer



User's Guide

Baumer MX Board Level Cameras (USB3 Vision™)

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1. General Information

Thank you for purchasing a camera from the Baumer range. 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 who 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 potentially 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. Heat must be dissipated adequately to ensure that the temperatures do not exceed the values (see Heat Transmission).

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

For applications with enough free space, the use of the Baumer heat sink (No. 11118288) is recommended.

Caution

Device heats up during operation.

Skin irritation possible.

Do not touch the camera and/or heat sink during operation.

Caution

Incorrect bending radius for the flexprint cable.

An incorrect bending radius can damage the flexprint cable.

Only bend the flexprint cable to a radius of up to 3 mm!

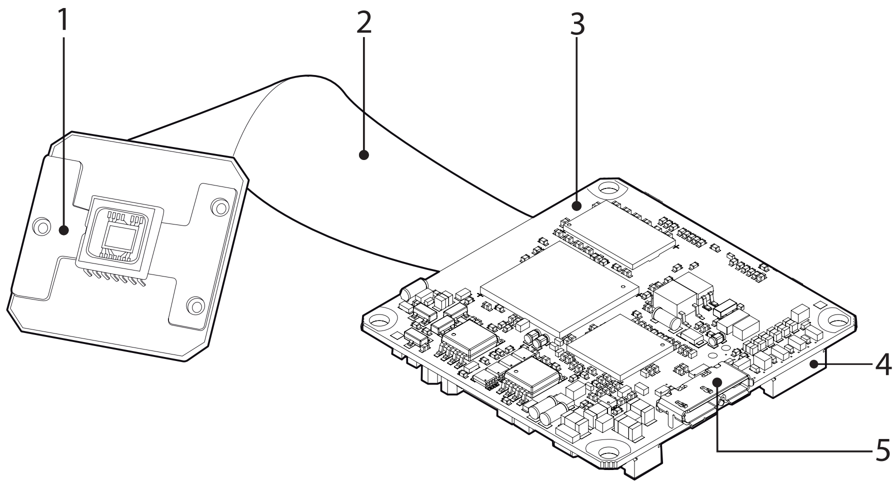
Caution

Observe precautions for handling electrostatically sensitive devices!

3. Intended Use

The camera is used to capture images that can then be transferred over a USB 3.0 interface to a PC.

4. General Description

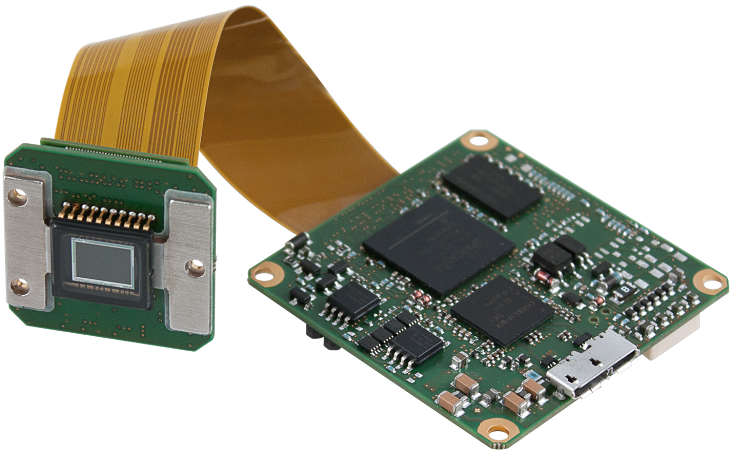


No.	Description	No.	Description
1	Print sensor	**4**	Digital IO
2	Flexprint cable	**5**	USB 3.0 port
3	System print		

All BaumerMX Board level cameras with a USB 3.0 interface have the following features:

Very high image quality	▪ Low noise and structure-free image information
Flexible image acquisition	▪ Industrially compliant process interface with parameter setting capability (trigger and flash)
Fast image transfer	▪ Reliable transmission at 5000 Mbit/sec according to USB 3.0 standard ▪ Baumer driver for high data volume with low CPU load ▪ Single cable solution for data and power ▪ 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 easy integration ▪ Baumer Camera Explorer Test Tool for all camera functions ▪ GenICam™ compliant XML file to show the camera functions ▪ Supplied with installation program including automatic camera recognition for easy 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

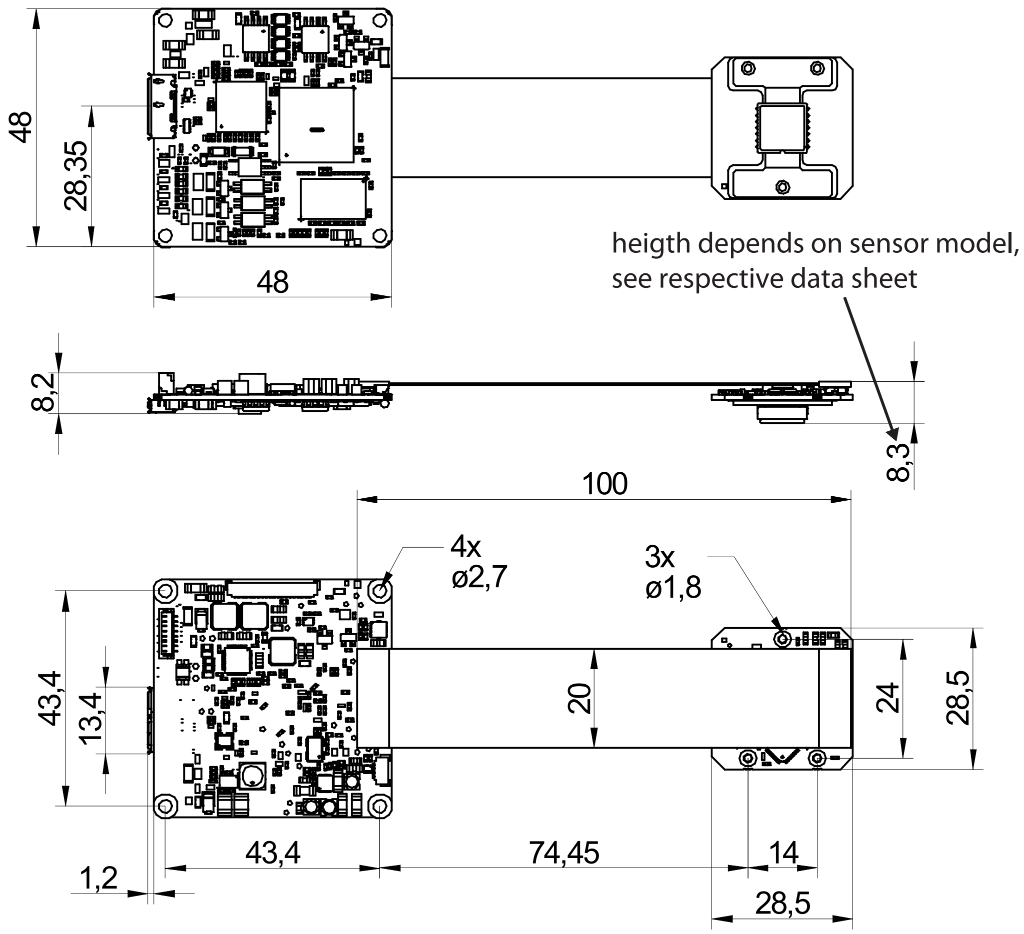
5. Camera Models



◄ **Figure 1**
Baumer MXU camera

Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
CCD Sensor (monochrome / color)			
MXU02 / MXU02c	1/4"	656 x 490	160
MXU12 / MXU12c	1/3"	1288 x 960	42
MXU20 / MXU20c	1/1.8"	1624 x 1228	27
CMOS Sensor (monochrome / color)			
MXUC20 / MXUC20c.2	2/3"	2044 x 1084	55
MXUC40.2 / MXUC40c.2	1"	2044 x 2044	29

Dimensions



◄ **Figure 2**
Dimensions of a Baumer MXU camera

6. Installation

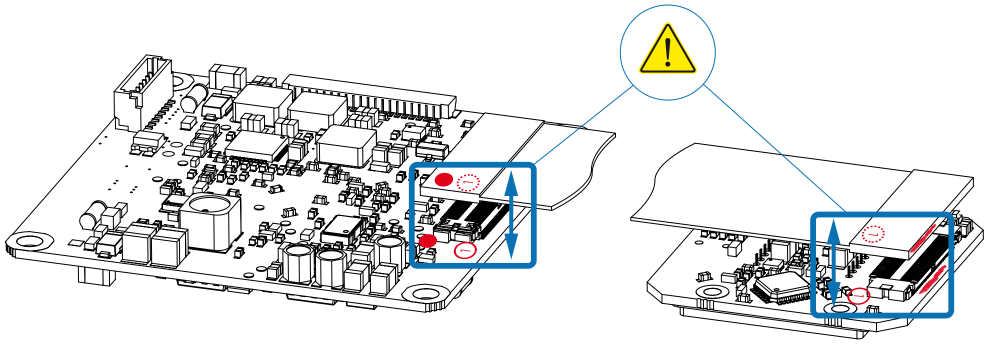
Caution

Observe precautions for handling electrostatically sensitive devices!

Connecting the flexprint cable

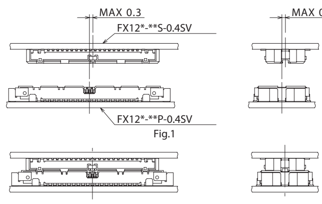
Notice

Observe the markings when connecting the flexprint cable.

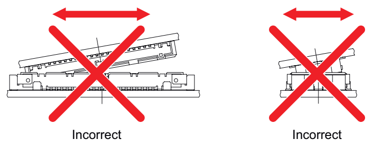


Handling Precautions when mating mounted connectors

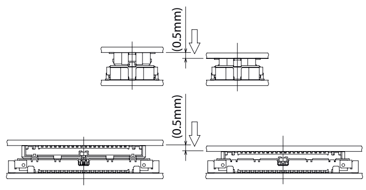
1. Start the engagement of the connector within the specified selfalignment range of 0.3 mm, while keeping the boards parallel to each other.



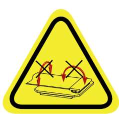
2. Do **NOT** start mating of the mounted connectors at an angle. Correctly position the connectors over each other an assure that both boards are parallel to each other.



3. When the connectors are correctly aligned (and both boards paralell to each other) apply even force until mating is confirmed by the "click" sensation.



Caution

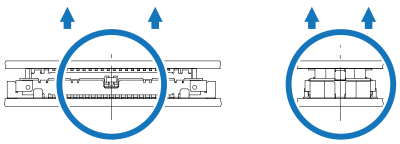


When the connectors are mounted on the FPC, care should taken to prevent the mated connectors from bending or twisting on the FPC.

The device case or cushioning material should be used to keep the connectors fully mated and supported.

Handling Precautions when un-mating

1. Keep the boards (with mounted connectors) parallel to each other.



2. If parallel disconnection is impossible, start un-mating at one end, exercising extreme caution to apply force at the center of the connector itself, away from the solder joint rows (Ref. Fig A and Fig. B).

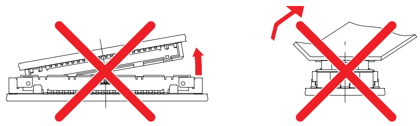
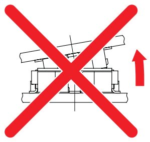
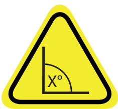


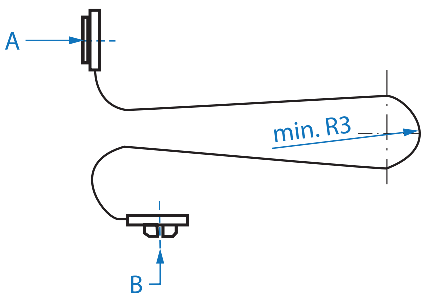
Fig. A Fig. B

3. Do **NOT** start disconnection at the sides as the connector can be damaged, voiding the warranty and making the re-engagement impossible.



6.1 Mechanical mounting

⚠	Caution
	Incorrect bending radius for the flexprint cable. An incorrect bending radius can damage the flexprint cable. Only bend the flexprint cable to a radius of up to 3 mm!



◀ **Figure 3**
Bending radius of the flexprint cable

6.2 Lens mounting

Notice

Ensure the sensor and lens are not contaminated with dust and airborne particles when mounting the support or the lens to the device!

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 the camera for as long as possible!
- Hold the print with the sensor downwards if the sensor is uncovered.
- Avoid contact with any of the camera's optical surfaces!

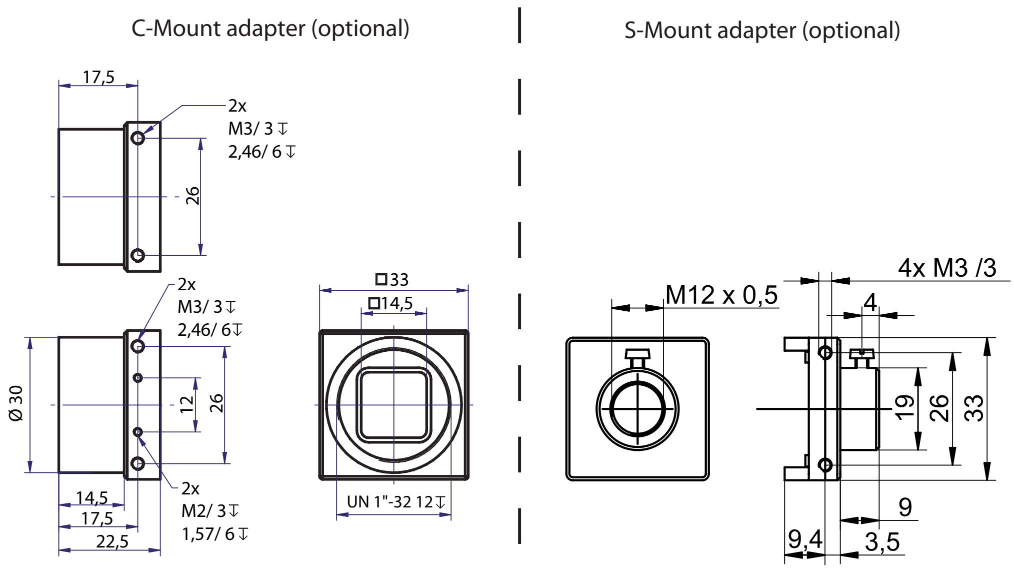


Figure 4 ►

Dimensions of C-Mount/S-Mount adapter (optional)

6.3 Environmental Requirements

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

* If the ambient 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

6.3.1 Heat Transmission

⚠ Caution

Heat can damage the camera. Heat must be dissipated adequately to ensure that the temperature does not exceed the values in the table below.

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

For applications with enough free space, the use of the Baumer heat sink (No. 11118288) is recommended.

⚠ Caution

Device heats up during operation.

Skin irritation possible.

Do not touch the camera and/or heat sink during operation.

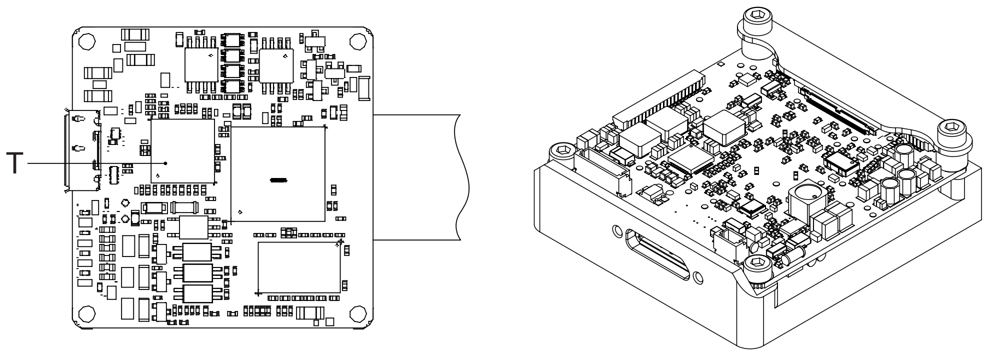


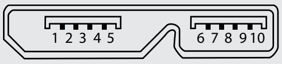
Figure 5 ►
Temperature measuring points / installed heat sink

Measurement Point	Maximum Temperature
T	80°C (176°F)

7. Pin Assignment

7.1 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+



7.2 Digital IOs

Caution

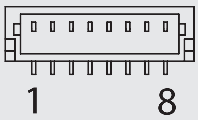
The General Purpose IOs (GPIOs) are not potential-free and do not have an overrun cut-off. Incorrect wiring (overvoltage, undervoltage or voltage reversal) can lead to defects within the electronics system.

GPIO Power V_{CC}: 3.3 V DC

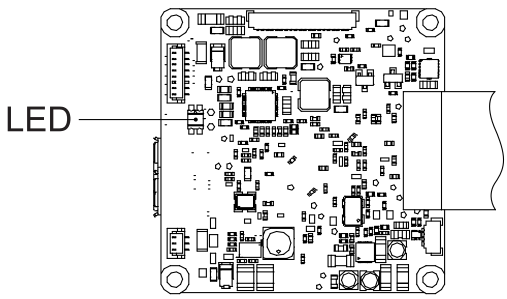
IOUT: max. 8 mA

The GPIOs are configured as an input through the default camera settings. They must be connected to GPIO_GND if not used or not configured as an output.

Digital IOs (JST BM08B-SRSS-TB)			
1	Shielding	5	GPIO1
2	IN1	6	GPIO2
3	IO GND	7	IOPower V_{CC}
4	OUT 1	8	GPIO_GND



7.2.1 LED Signalling



◄ **Figure 6**
LED position on Baumer MXU cameras.

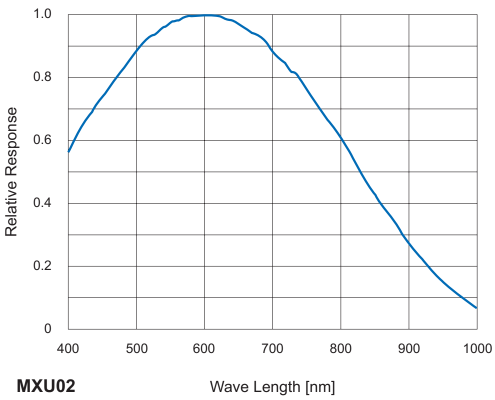
	Signal	Meaning
LED	green	USB 3.0 connection
	yellow	USB 2.0 connection (settings possible, no image)

8. Product Specifications

8.1 Spectral Sensitivity for Baumer MXU Cameras

The following graphs show the spectral sensitivity characteristics of monochrome and color matrix sensors for MXU cameras. The curves for the sensors do not take the characteristics of lenses and light sources without filters into account.

Values relate to the respective technical data sheets for the sensors.



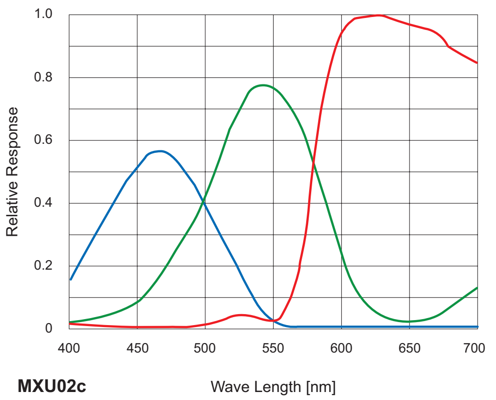
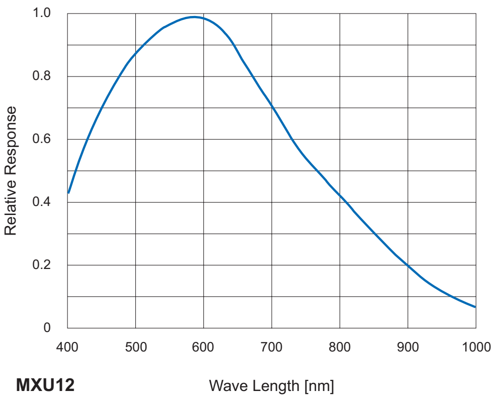


Figure 7 ▶
Spectral sensitivities for Baumer cameras with 0.3 MP CCD sensors.



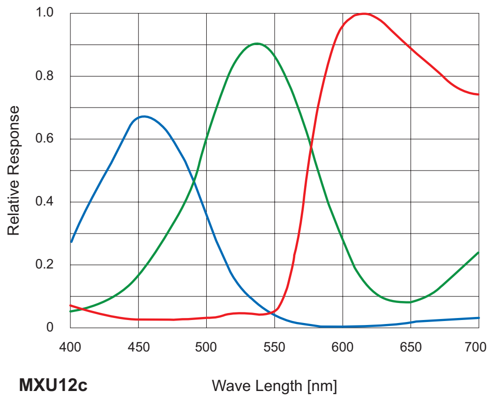
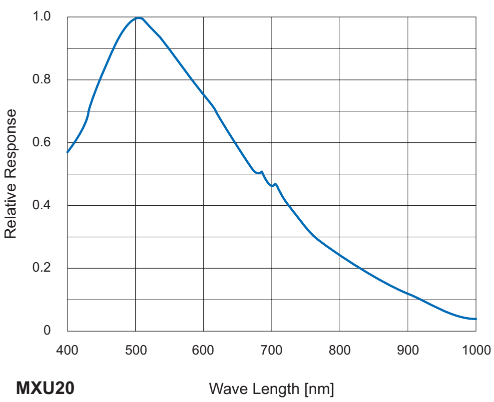


Figure 8 ▶
Spectral sensitivities for Baumer cameras with 1.2 MP CCD sensors.



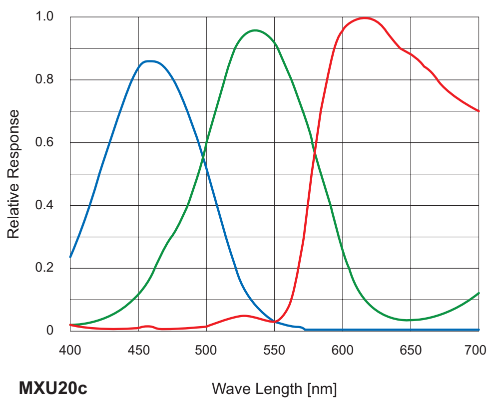
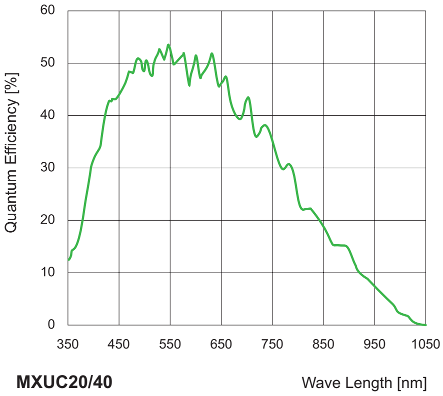
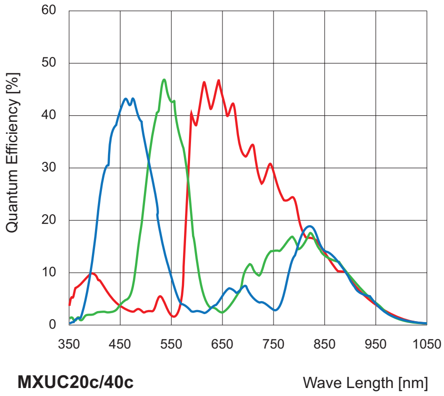


Figure 9 ▶
Spectral sensitivities for Baumer cameras with 2.0 MP CCD sensors.





◄ **Figure 10**
Spectral sensitivities for Baumer cameras with 2.0, 4.0 MP CMOS sensors.

8.2 Field of View Position

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

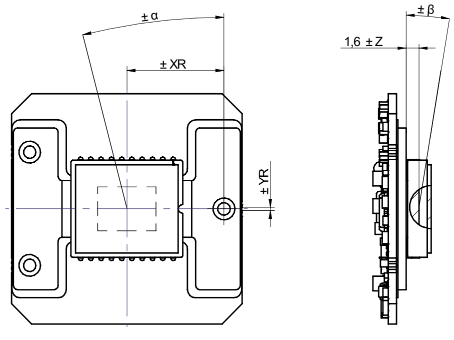


Figure 11 ▶
Sensor accuracy of Baumer MXU 02/12/20

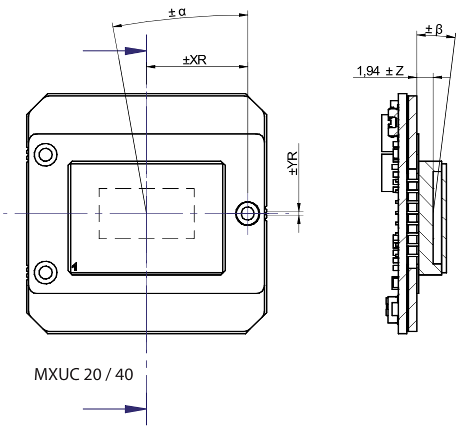


Figure 12 ▶
Sensor accuracy of Baumer MXUC 20/40

Camera Type	± $x_{R,typ}$ [mm]	± $y_{R,typ}$ [mm]	± α_{typ} [°]	± β_{typ} [°]	± z_{typ} [mm]
MXU02	0.25	0.25	1.50	0.32	0.10
MXU12	0.17	0.17	1.50	0.32	0.10
MXU20	0.17	0.17	1.50	0.34	0.10
MXUC20	0.07	0.07	0.5	0.05	0.09
MXUC40c.2	0.07	0.07	0.5	0.05	0.09

8.3 Acquisition Modes and Timings

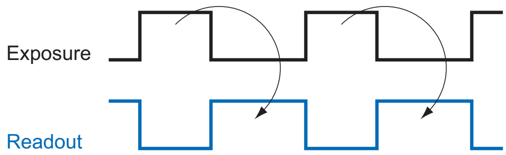
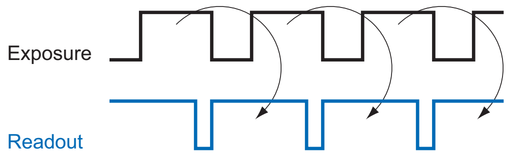
Image acquisition consists of two separate, successively processed components.

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

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

Baumer cameras can be operated in three different modes, Free Running Mode, Fixed-Frame-Rate Mode and Trigger Mode.

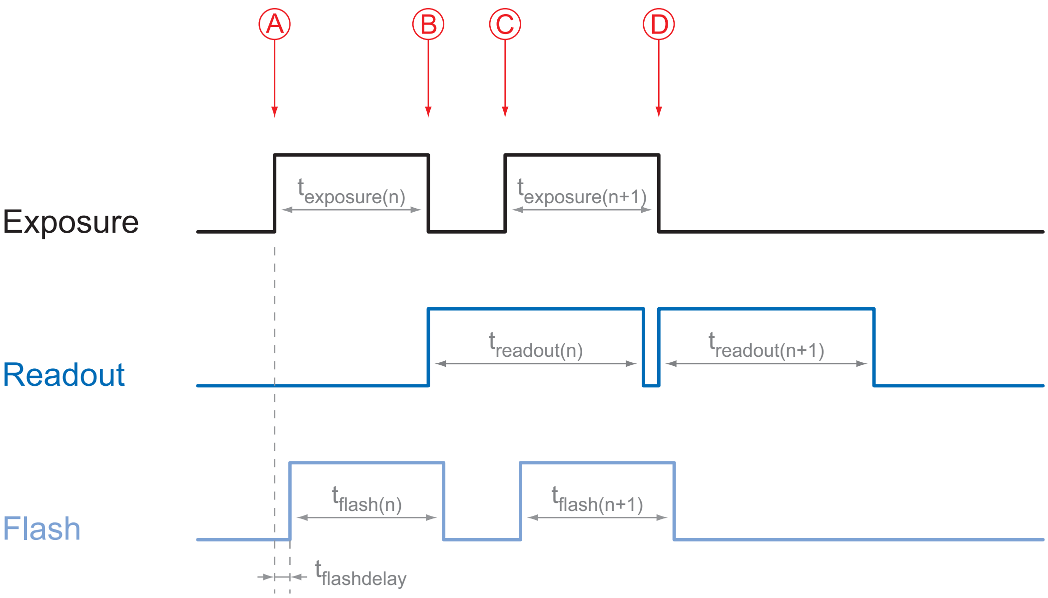
The cameras can be operated non-overlapped*) or overlapped, depending on the mode used and the combination of exposure and readout time:

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

8.3.1 Free Running Mode

In the "Free Running" mode, the camera records images permanently and transfers them to the PC. To achieve the best results (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 sequential.

8.3.2 Fixed-Frame-Rate Mode

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

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

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

8.3.3 Trigger Mode

Image acquisition begins after a specified external event (trigger) occurs. Depending on the interval of triggers used, the camera can operate either 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:

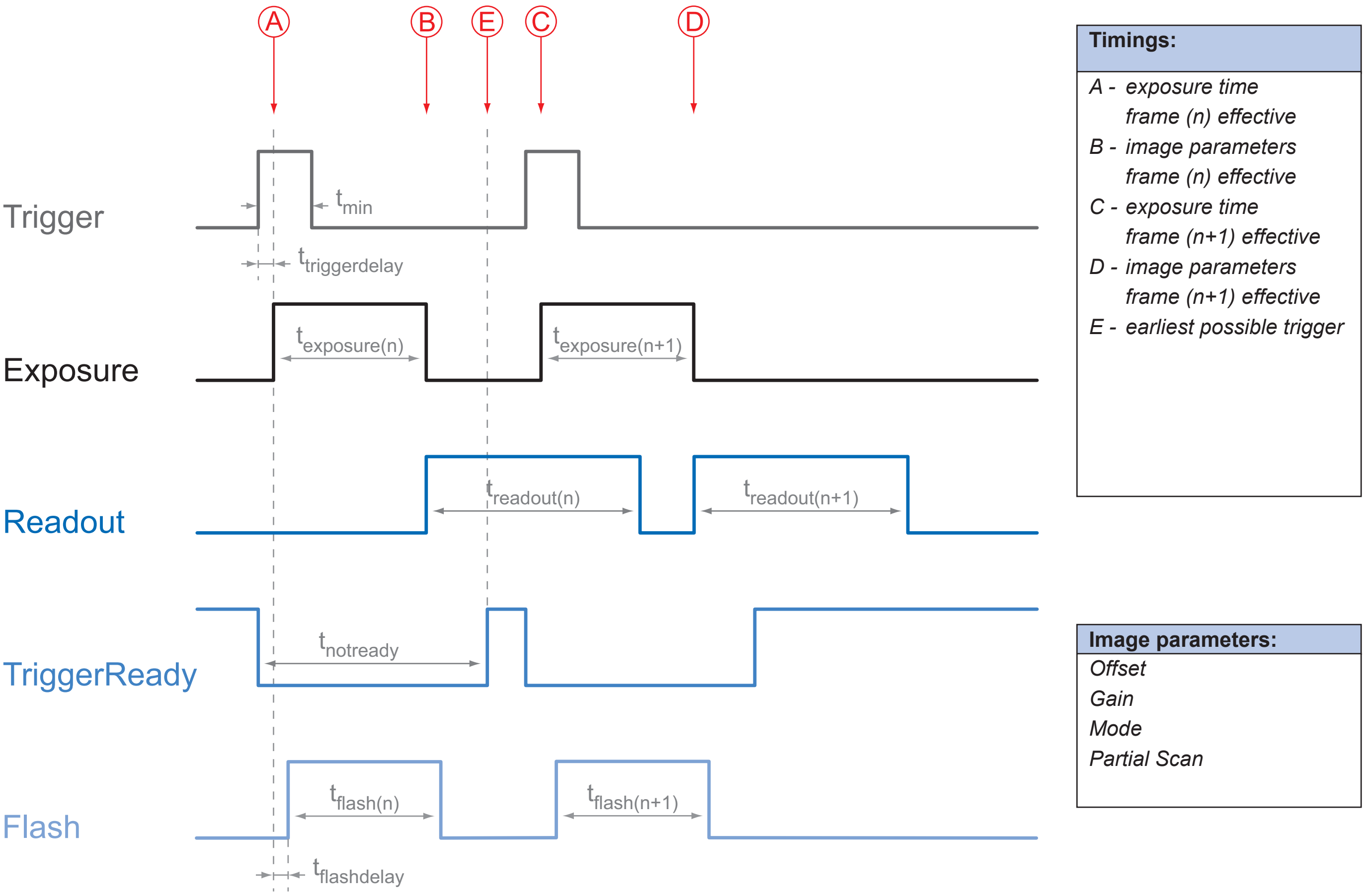
Case		Formula
$t_{exposure} < t_{readout}$	(1)	$t_{earliestpossibletrigger(n+1)} = t_{readout(n)} - t_{exposure(n+1)}$
	(2)	$t_{notready(n+1)} = t_{exposure(n)} + t_{readout(n)} - t_{exposure(n+1)}$
$t_{exposure} > t_{readout}$	(3)	$t_{earliestpossibletrigger(n+1)} = t_{exposure(n)}$
	(4)	$t_{notready(n+1)}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

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

During overlapped operation, be mindful of the time interval during which the camera is unable to process trigger signals ($t_{notready}$) that occur. This interval occurs between two exposures. When this processing time $t_{notready}$ has elapsed, the camera is able to react to external events again.

Once $t_{notready}$ 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, dependant on the case).

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



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 accordingly.

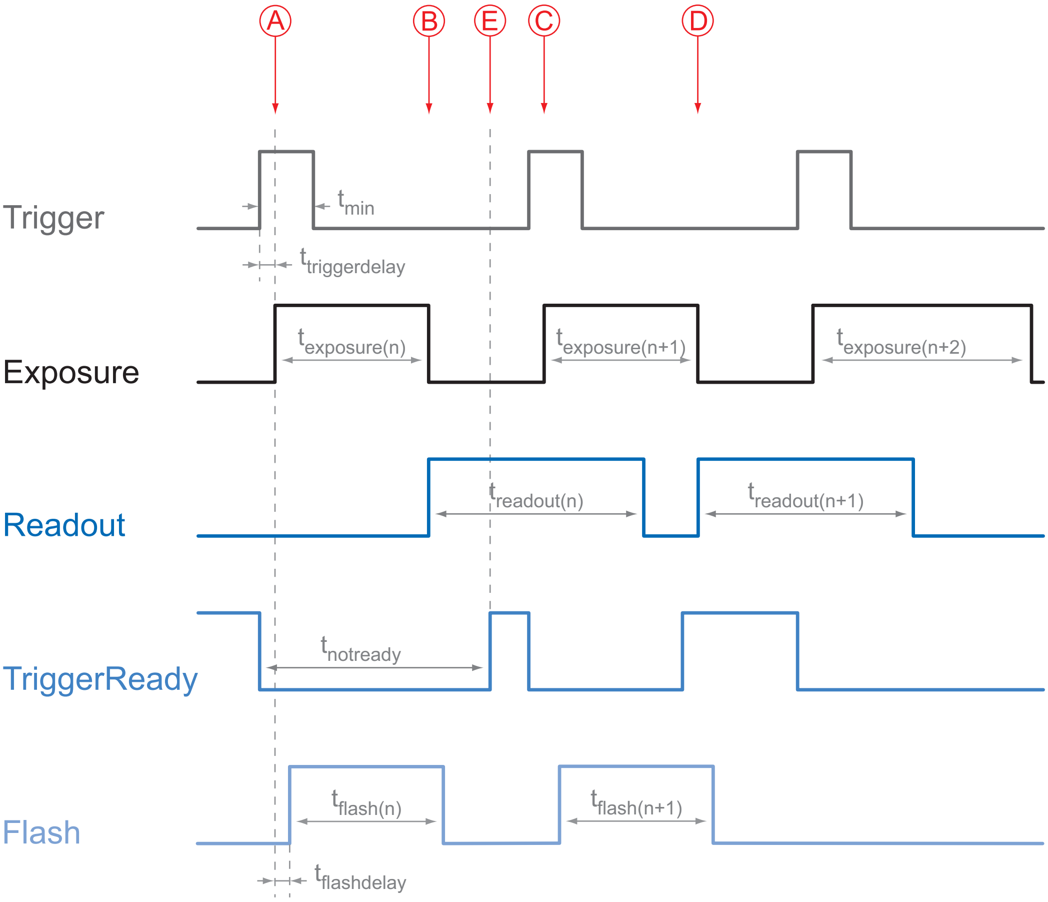
This can be simulated with the formulas mentioned above (no. 2 or 4, dependant on the case).

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:

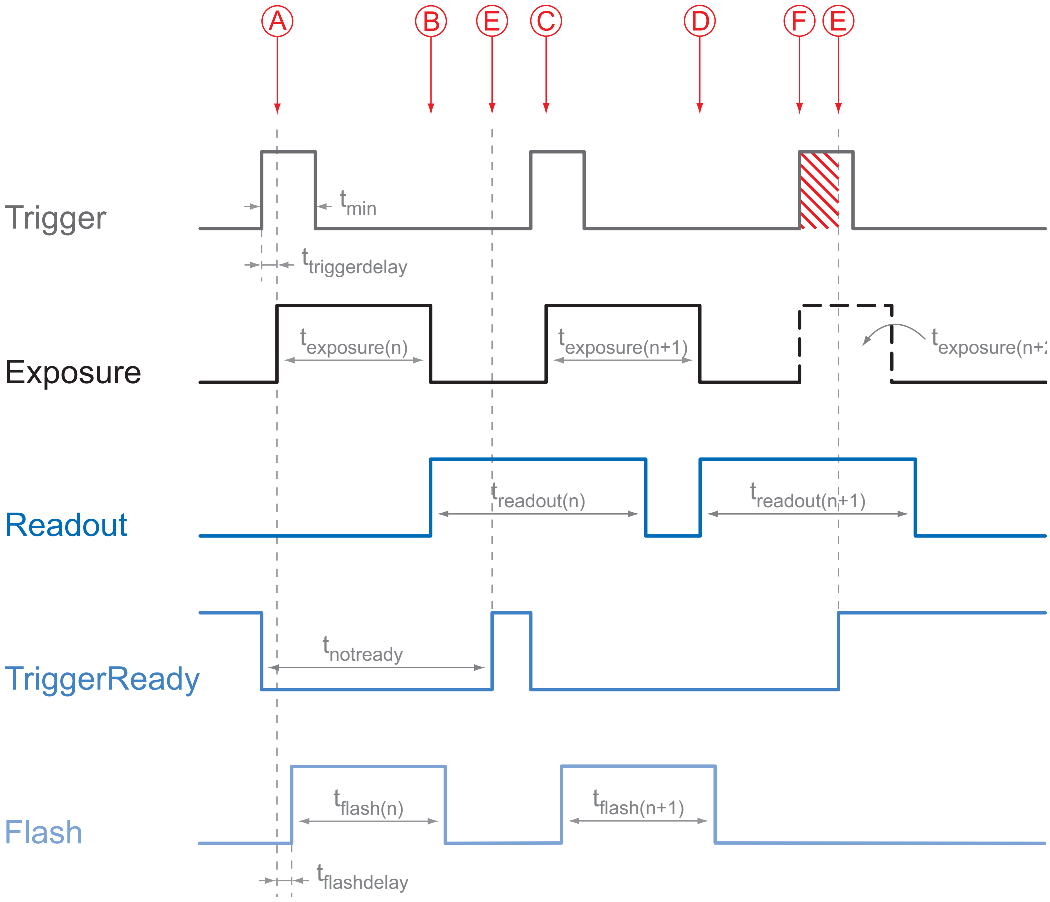
Offset
Gain
Mode
Partial Scan



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 accordingly.

If the $t_{exposure}$ is decreased to the extent that $t_{notready}$ exceeds the pause between two incoming trigger signals, the camera is unable to process this trigger and image acquisition 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
Above a certain frequency of trigger signal, skipping triggers becomes unavoidable. In general, this frequency depends on the combination of exposure and readout times.

8.3.3.4 Non-overlapped Operation

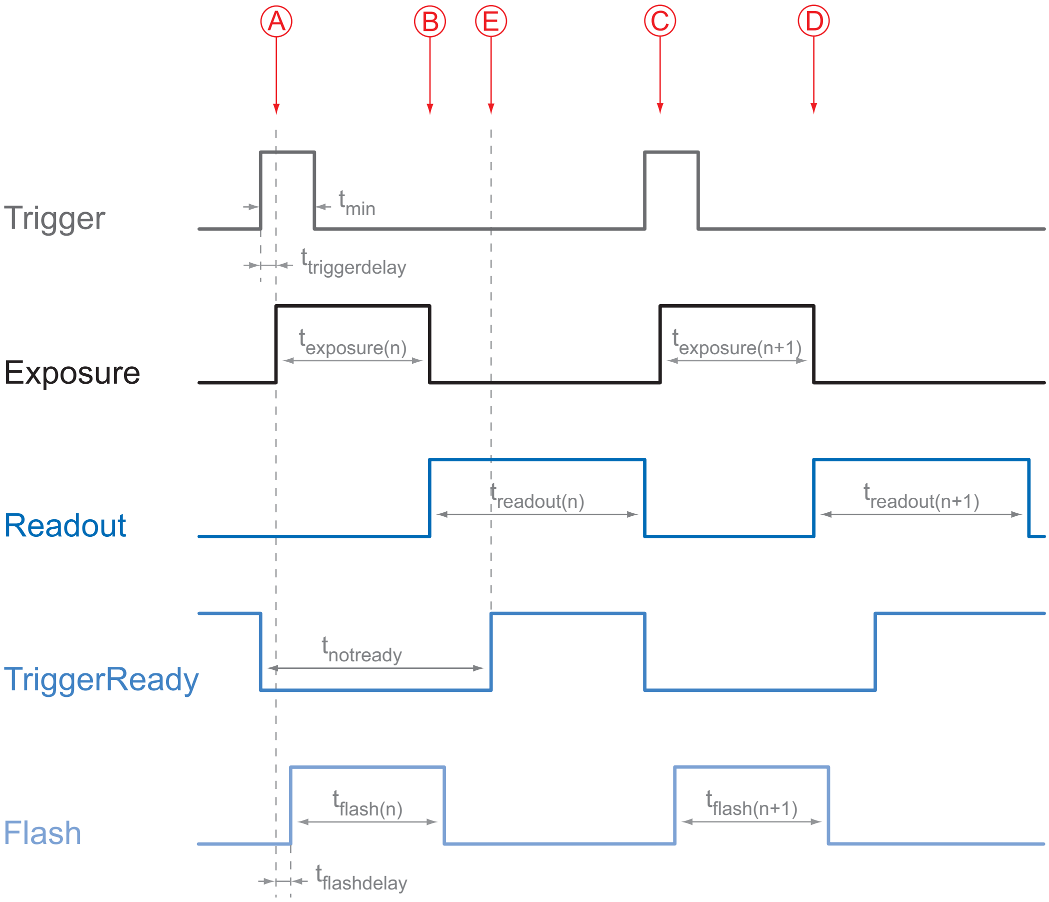
If the frequency of the trigger signal is set long enough that the image acquisitions ($t_{exposure}$ + $t_{readout}$) run successively, the camera operates non-overlapped.

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

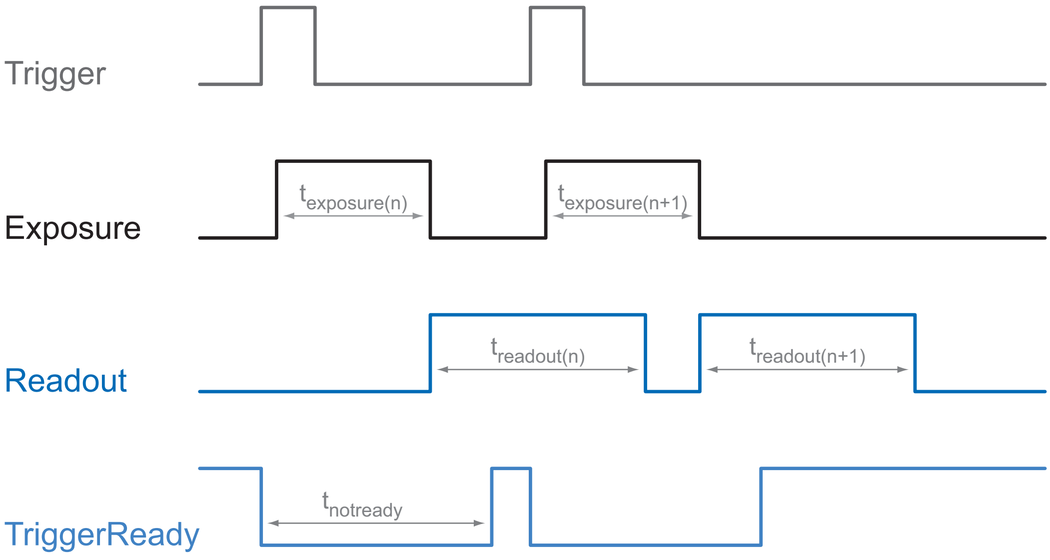


8.3.4 Advanced Timings for USB 3.0 Vision™ Message Channel

The following charts show some timings for event signalling by the asynchronous message channel. Explanations are provided for vendor-specific events such as "TriggerReady", "TriggerSkipped", "TriggerOverlapped" and "ReadoutActive".

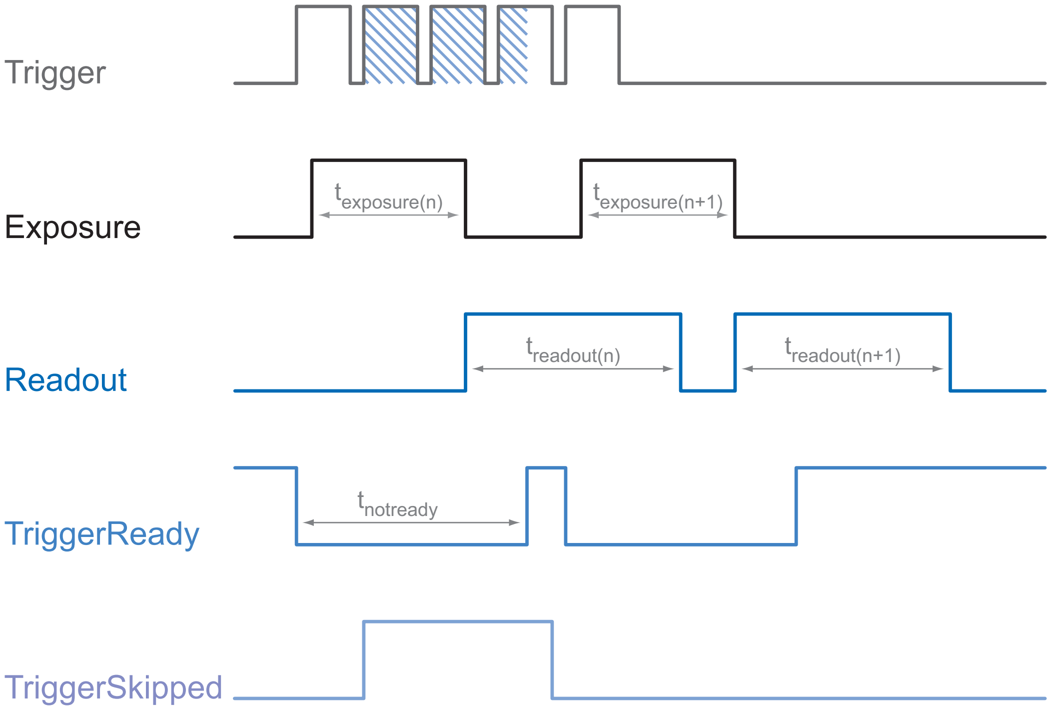
8.3.4.1 TriggerReady

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



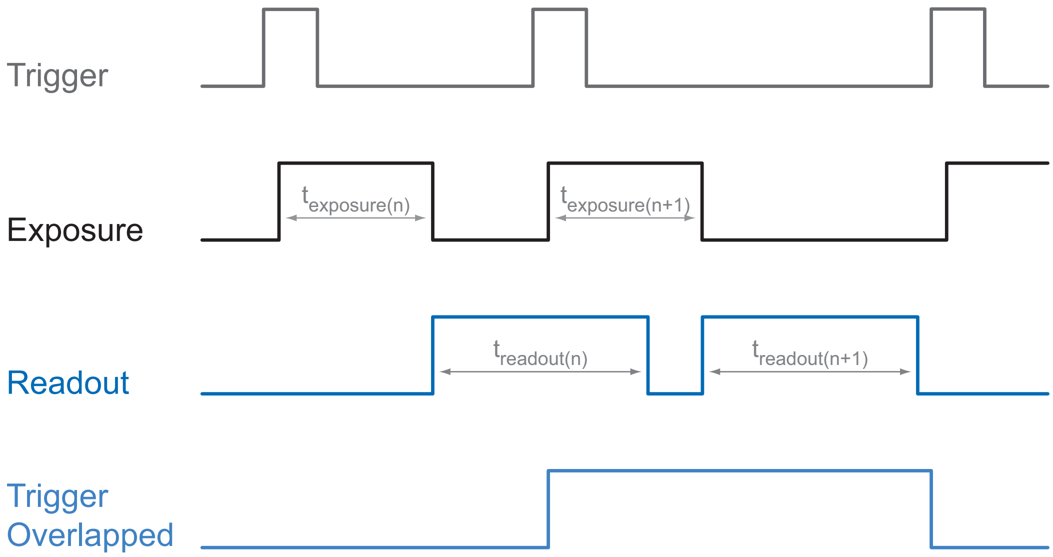
8.3.4.2 TriggerSkipped

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



8.3.4.3 TriggerOverlapped

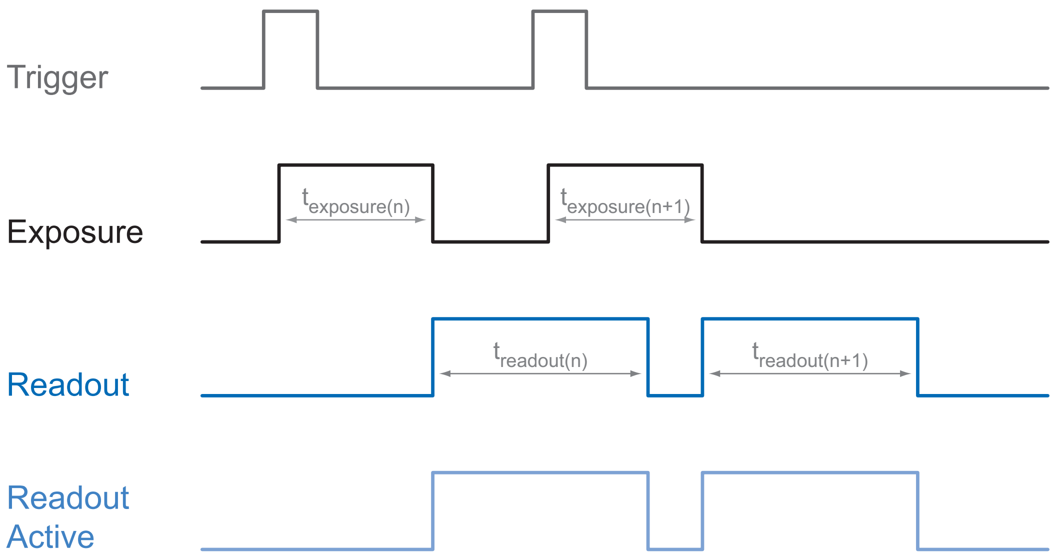
This signal is active for as long as the sensor is exposed and read out at the same time, meaning that the camera is operated overlapped.



Once a valid trigger signal occurs outside of a readout, the "TriggerOverlapped" signal changes to state low.

8.3.4.4 ReadoutActive

While the sensor is being read out, the camera signals this with "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.

It provides interfaces to several programming languages, such as C, C++ and the .NET™ Framework on Windows®, meaning that other languages, such as e.g. C# or VB.NET can also be used.

Baumer GAPI SDK v2.2 supports USB3 Vision™.

8.4.2 3rd Party Software

Strict compliance with the GenICam™ and USB3 Vision™ standards allows Baumer to offer the use of 3rd Party software.

You can find a current list of 3rd Party software that has been tested successfully in combination with Baumer cameras at http://www.baumer.com/de-en/products/identification-image-processing/software-and-starter-kits/third-party-software/

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 includes not only the resolution, but also a set of predefined parameters.

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

Camera Type	Full frame	Binning 2x2	Binning 1x2	Binning 2x1
Monochrome				
MXU02	■	■	■	■
MXU12	■	■	■	■
MXU20	■	■	■	■
MXUC20	■	■	□	□
MXUC40.2	■	■	□	□
Color				
MXU02c	■	■	■	■
MXU12c	■	■	■	■
MXU20c	■	■	■	■
MXUC20c	■	■	■	■
MXUC40c.2	■	■	■	■

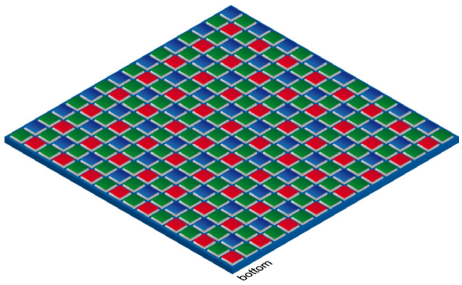
9.1.2 Pixel Format

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 is stored without being processed.

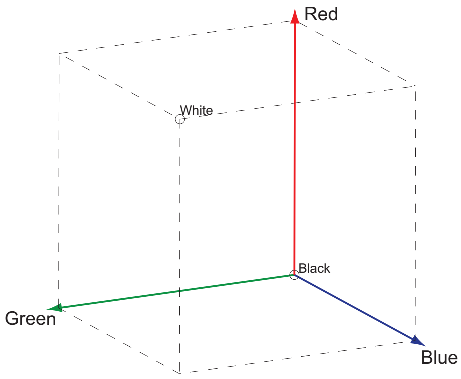
Bayer: Raw data format of color sensors.
Color filters are placed on these sensors in a checkerboard pattern, generally in a 50% green, 25% red and 25% blue array.



◄ **Figure 13**
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 synonymous with monochrome.

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



◄ **Figure 14**
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). 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 as 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. There is therefore no sub-sampling in this case.

YUV 4:2:2 The chroma components are sampled at half the sample rate. This reduces the necessary bandwidth to two-thirds (in relation to 4:4:4) and causes no, or low visual differences.

YUV 4:1:1 Here, the chroma components are sampled at a quarter of the sample rate. This decreases the necessary bandwidth by half (in relation to 4:4:4).

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

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

Two bytes are needed to transmit more than 8 bits per pixel - even if the second byte is not completely filled with data. In order to save bandwidth, packed formats have been added to Baumer MXU cameras. In these formats, the unused bits of one pixel are filled with data from the next pixel.

Figure 15 ►
Bit string of Mono 8 bit and RGB 8 bit.

8 bit:

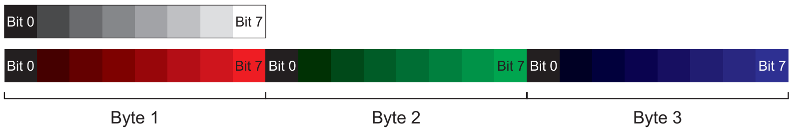


Figure 16 ►
Spreading of Mono 12 bit over two bytes.

12 bit:

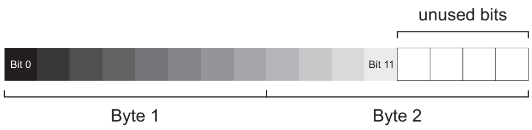
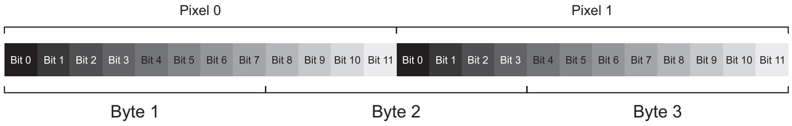


Figure 17 ►
Spreading of two pixels in Mono 12 bit over three bytes (packed mode).

Packed:

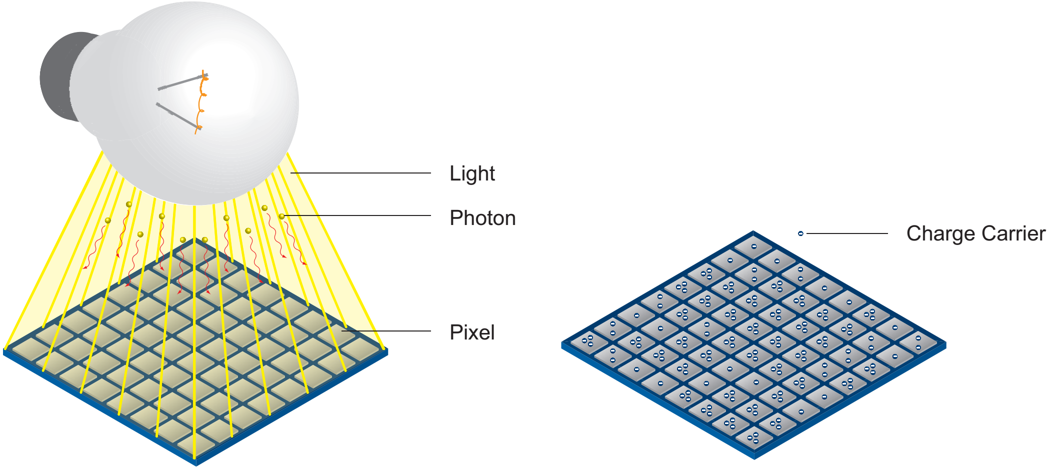


9.1.2.2 Pixel Formats on Baumer MXU Cameras

Camera Type	Mono 8	Mono 12	Mono 12 Packed	Bayer RG 8	Bayer RG 12	RGB 8	BGR 8	YUV8_UYV	YUV422_8_UYVY	YUV411_8_UYYVYY
Monochrome										
MXU02	■	■	■	□	□	□	□	□	□	□
MXU12	■	■	■	□	□	□	□	□	□	□
MXU20	■	■	■	□	□	□	□	□	□	□
MXUC20	■	■	■	□	□	□	□	□	□	□
MXUC40.2	■	■	■	□	□	□	□	□	□	□
Color										
MXU02c	■	□	□	■	■	■	■	■	■	■
MXU12c	■	□	□	■	■	■	■	■	■	■
MXU20c	■	□	□	■	■	■	■	■	■	■
MXUC20c	■	□	□	■	■	■	■	■	■	■
MXUC40c.2	■	□	□	■	■	■	■	■	■	■

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 18**
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 MXU cameras, the exposure time can be set within the following ranges (increments of 1µsec):

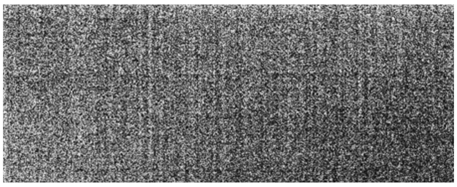
Camera Type	$t_{exposure}$ min	$t_{exposure}$ max
Monochrome		
MXU02	4 µsec	60 sec
MXU12	4 µsec	60 sec
MXU20	4 µsec	60 sec
MXUC20	15 µsec	1 sec
MXUC40.2	20 µsec	1 sec
Color		
MXU02c	4 µsec	60 sec
MXU12c	4 µsec	60 sec
MXU20c	4 µsec	60 sec
MXUC20c	15 µsec	1 sec
MXUC40c.2	20 µsec	1 sec

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

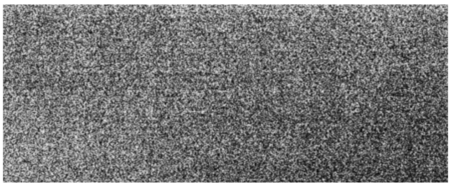
Camera Type	FPN
CCD (monochrome / color)	
MXU02 / MXU02c	□
MXU12 / MXU12c	□
MXU20 / MXU20c	□
CMOS (monochrome / color)	
MXUC20 / MXUC20c.2	■
MXUC40.2 / MXUC40c.2c	■

CMOS sensors exhibit non-uniformities that are often called fixed pattern noise (FPN). However, it is not actually noise, but rather 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 image analysis. Variations of the dark signal from pixel to pixel are called dark signal non-uniformity (DSNU) whereas photo response non-uniformity (PRNU) describes variations in sensitivity. DNSU is corrected via an offset while PRNU is corrected using a factor.

The correction is based on columns. It is important that the correction values are calculated for the sensor readout configuration used. During camera production, this is derived from 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 setup used.



PRNU / DSNU Correction Off



PRNU / DSNU Correction On

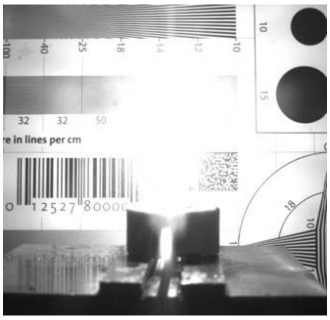
9.1.5 HDR (High Dynamic Range)

Camera Type	HDR
CCD (monochrome / color)	
MXU02 / MXU02c	□
MXU12 / MXU12c	□
MXU20 / MXU20c	□
CMOS (monochrome / color)	
MXUC20 / MXUC20c.2	■
MXUC40.2 / MXUC40c.2	■

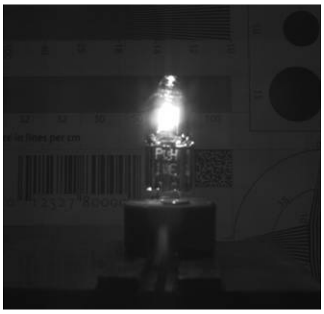
Alongside the standard linear response, the sensor also supports a special high dynamic range mode (HDR) called piecewise linear response. With this mode, illuminated pixels that reach a certain programmable voltage level are clipped. Darker pixels that do not reach this threshold remain unchanged. The clipping can be adjusted twice 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} is calculated automatically within the camera. ($t_{Expo2} = t_{exposure} - t_{Expo0} - t_{Expo1}$)



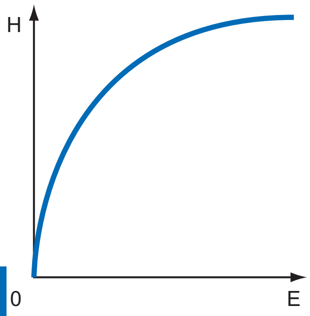
HDR Off



HDR On

9.1.6 Look-Up-Table

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



▲ Figure 19

Non-linear perception of the human eye.

H - Perception of brightness

E - Energy of light

9.1.7 Gamma Correction

With this feature, Baumer MXU cameras provide the option to compensate nonlinearity in the perception of light by the human eye.

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

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

On Baumer MXU cameras the correction factor γ is adjustable from 0.001 to 2.

The values of the calculated intensities are entered into the Look-Up-Table (see 9.1.5). 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 also disabled.

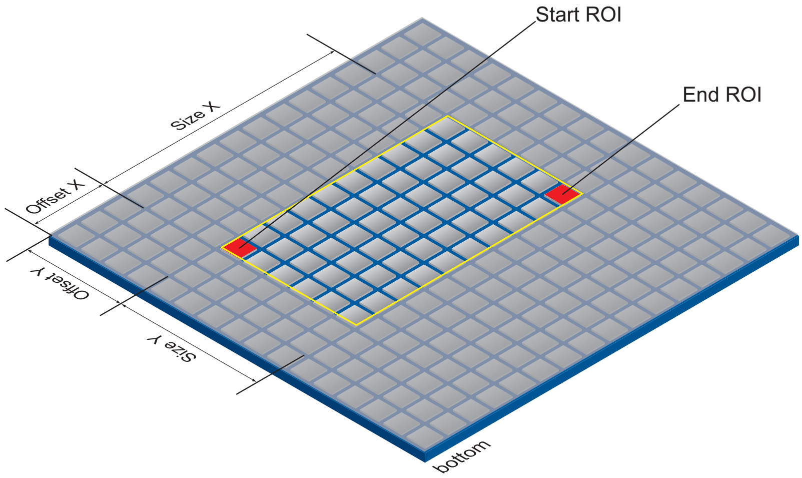
9.1.8 Region of Interest (ROI)

With the "Region of Interest" (ROI) function, you can predefine a so-called Region of Interest (ROI) or Partial Scan. This ROI is an area of pixels of the sensor. When an image is acquired, only the information about these pixels is transferred to the PC. Not all lines of the sensor are read out, which therefore decreases the readout time ($t_{readout}$). This increases the frame rate.

This function is used when only a particular region of the field of view is of interest. It is coupled with a reduction in resolution.

The ROI is specified by four values:

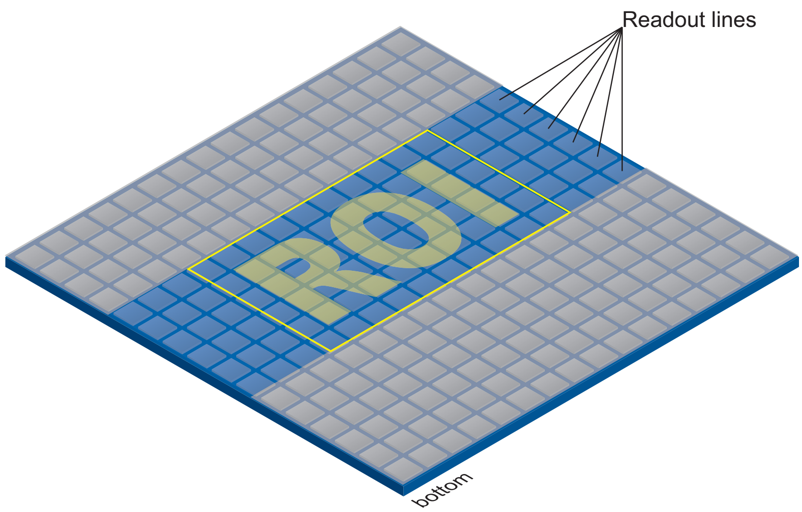
- Offset X - x-coordinate of the first relevant pixel
- Offset Y - y-coordinate of the first relevant pixel
- Size X - horizontal size of the ROI
- Size Y - vertical size of the ROI



◄ **Figure 20**
ROI: Parameters

ROI Readout

In the illustration below, readout time would decrease to 40% of a full frame readout.



◄ **Figure 21**
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

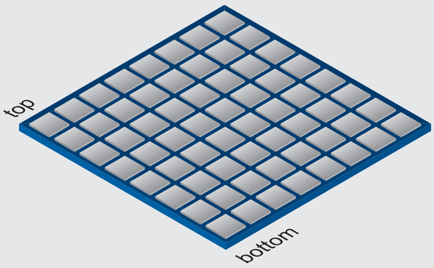
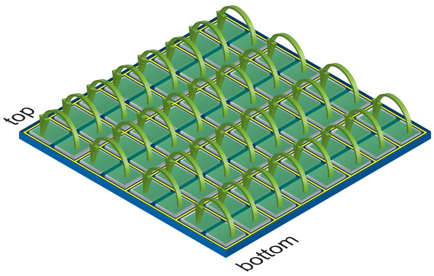
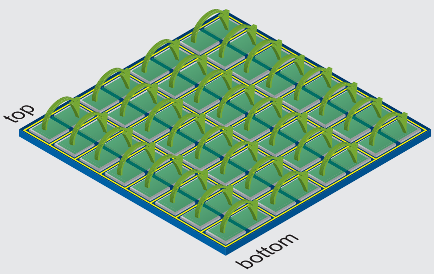
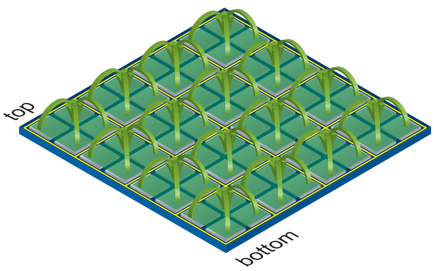
Binning	Illustration	Output
without		
1x2		
2x1		
2x2		

Figure 22 ▶ Full frame image, no binning of pixels.

Figure 23 ▶ Vertical binning causes a vertically compressed image with doubled brightness.

Figure 24 ▶ Horizontal binning causes a horizontally compressed image with doubled brightness.

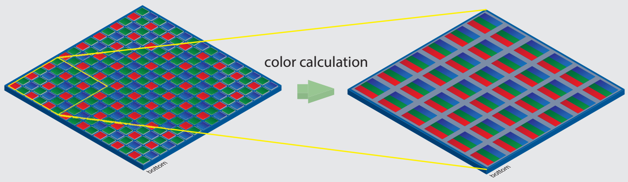
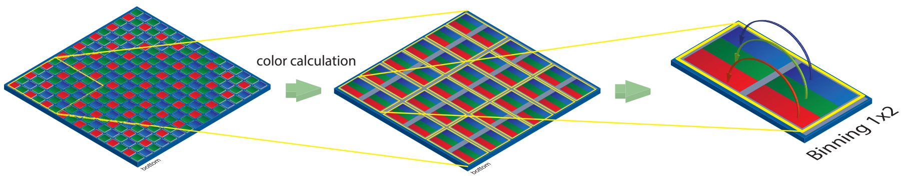
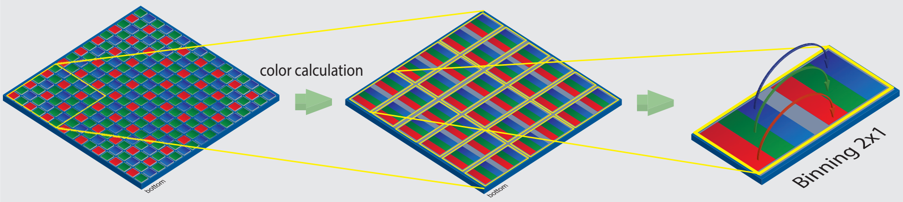
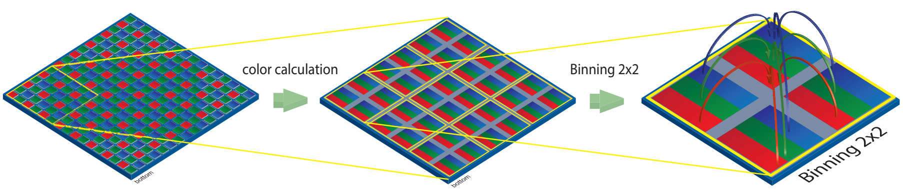
Figure 25 ▶ Bidirectional binning causes both a horizontally and vertically compressed image with quadruple brightness.

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 26**
Full frame image, no binning of pixels.

◀ **Figure 27**
Vertical binning causes a vertically compressed image with doubled brightness.

◀ **Figure 28**
Horizontal binning causes a horizontally compressed image with doubled brightness.

◀ **Figure 29**
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.

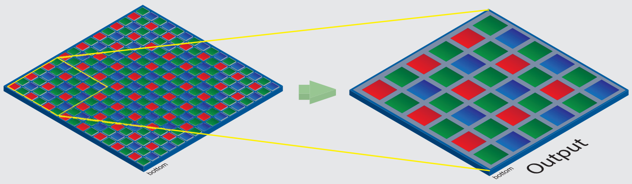
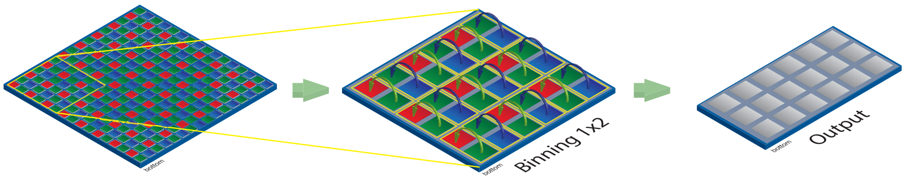
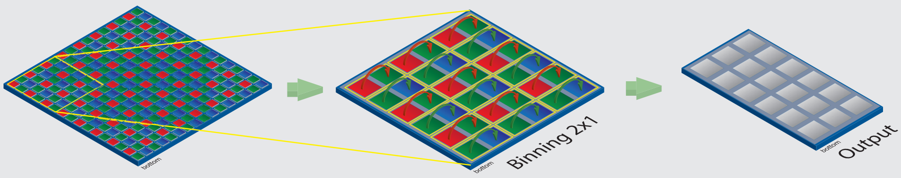
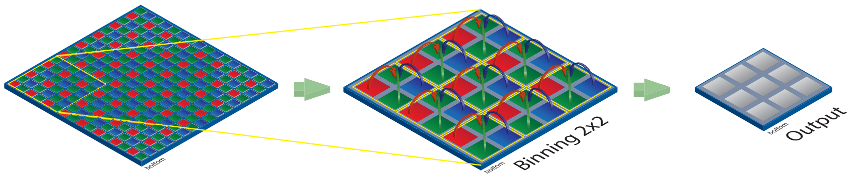
Notice
The color information is lost in this process, because adjacent pixels with different colors are combined.

Figure 30 ▶ Full frame image, no binning of pixels.

Figure 31 ▶ Vertical binning causes a vertically compressed image with doubled brightness.

Figure 32 ▶ Horizontal binning causes a horizontally compressed image with doubled brightness.

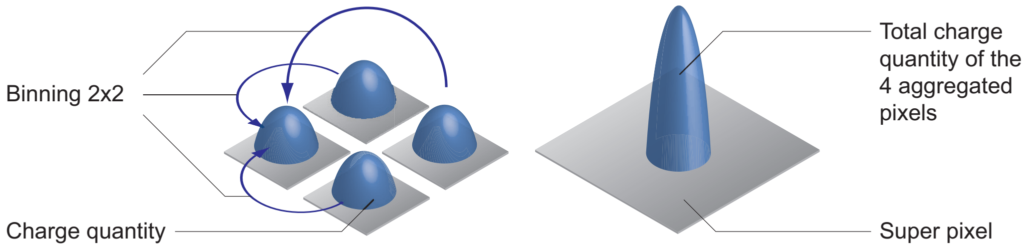
Figure 33 ▶ Bidirectional binning causes both a horizontally and vertically compressed image with quadruple brightness.

Binning	Illustration
without	
1x2	
2x1	
2x2	

9.1.10 Brightness Correction (Binning Correction)

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

Binning	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 34**
Aggregation of charge carriers from four pixels in bidirectional binning.

9.1.11 Flip Image

The Flip Image function lets you flip the captured images horizontally and/or vertically before they are transmitted from the camera.

Notice
Any defined ROI will also be flipped.

Camera Type	Horizontal	Vertical
MXU02 / MXU02c	■	□
MXU12 / MXU12c	■	□
MXU20 / MXU20c	■	□
MXUC20 / MXUC20c	■	■
MXUC40.2 / MXUC40c.2	■	■

Figure 35 ▶
Flip image vertically

Normal	Flip vertical
	

Figure 36 ▶
Flip image horizontally

Normal	Flip horizontal
	

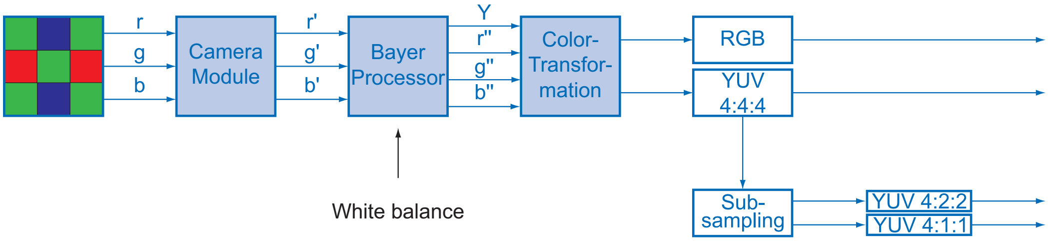
Figure 37 ▶
Flip image horizontally and vertically

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 38**
Color processing modules of Baumer color cameras.

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

Within the Bayer processor, the raw signals r', g' and b' are amplified using 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 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. Then, these signals are transformed into the desired output format. The following steps are then processed simultaneously:
- Transformation to RGB or YUV color space
- External color adjustment
- Color adjustment as a physical balance of the spectral sensitivities

A sub-sampling of the chroma signals can be carried out to reduce the data rate of YUV signals. Here, the following items can be customized to the desired output format:
- Order of data output
- Sub-sampling of the chroma components to YUV 4:2:2 or YUV 4:1:1
- Data rate is limited to 8 bits

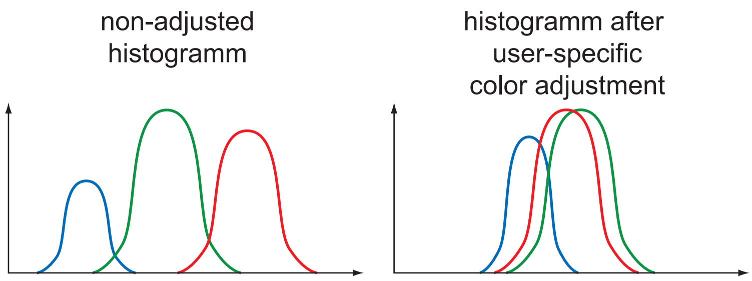
9.3 Color Adjustment – White Balance

This feature is available on all color cameras in the Baumer MXU series, and takes place within the Bayer processor.

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

9.3.1 User-specific Color Adjustment

The user-specific color adjustment in Baumer color cameras means you can adjust the correction factors for each color gain. This way, you can adjust the amplification of each color channel exactly to suit your needs. The correction factors for the color gains range from 1 to 4.



◄ **Figure 39**
Examples of histograms for a non-adjusted image and for an image after user-specific white balance adjustment.

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).

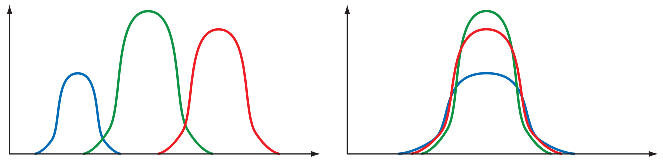


Figure 40 ▶
Examples of histograms for a non-adjusted image and for an image after "one push" white balance adjustment.

9.4 Analog Controls

9.4.1 Offset / Black Level

CCD Sensor

On Baumer MXU cameras with CCD sensors, the offset (or black level) is adjustable from 0 to 255 LSB (relating to 12 bit).

Camera Type	Increments of 1 LSB Relating to
Monochrome	
MXU02	12 bit
MXU12	12 bit
MXU20	12 bit
Color	
MXU02c	12 bit
MXU12c	12 bit
MXU20c	12 bit

CMOS Sensor

On Baumer MXU cameras with CMOS sensors, the offset (or black level) is adjustable from 0 to 255 LSB (relating to 12 bit).

Camera Type	Increments of 1 LSB Relating to
Monochrome	
MXUC20	12 bit
MXUC40.2	12 bit
Color	
MXUC20c	12 bit
MXUC40c.2	12 bit

9.4.2 Gain

In industrial environments, motion blur is unacceptable. Therefore, 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 in image noise.

CCD Sensor

Camera Type	Gain factor [db]
Monochrome	
MXU02	0...29.5
MXU12	0...29.5
MXU20	0...29.5
Color	
MXU02c	0...29.5
MXU12c	0...29.5
MXU20c	0...29.5

CMOS Sensor

Camera Type	Gain factor [db]
Monochrome	
MXUC20	0...18
MXUC40.2	0...18
Color	
MXUC20c	0...18
MXUC40c.2	0...18

9.5 Pixel Correction

9.5.1 General information

There is a certain probability of abnormal pixels - so-called defect pixels - occurring for sensors from all manufacturers. The charge quantity on these pixels is not linearly 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) spots on the recorded image.

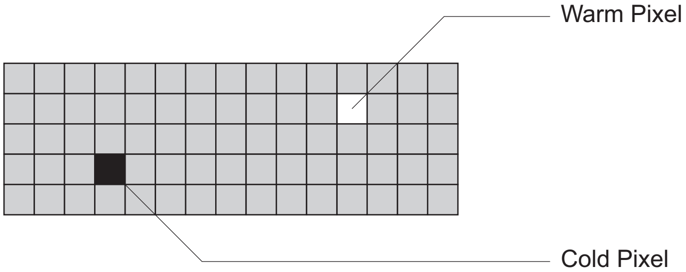


Figure 41 ►
Distinction of "hot" and "cold" pixels within the recorded image.

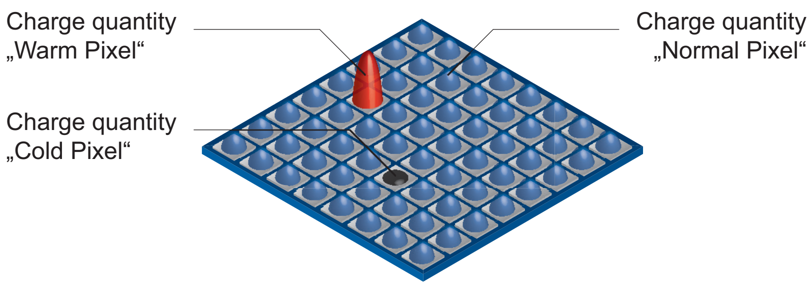


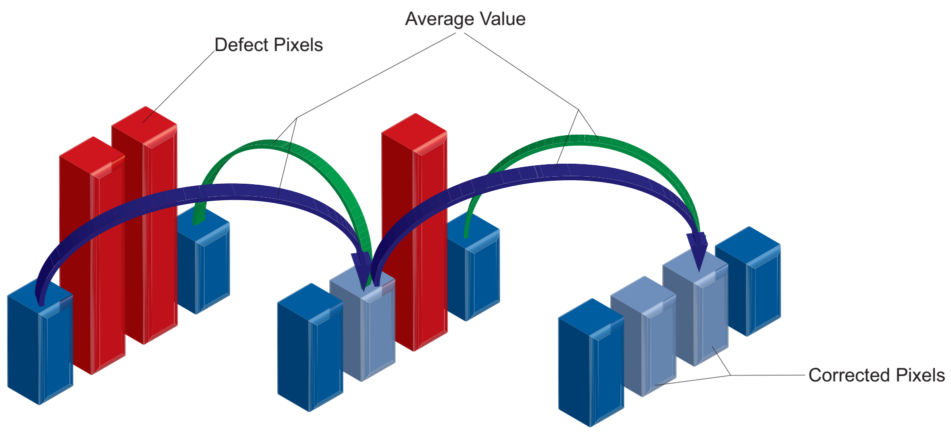
Figure 42 ►
Charge quantity of "hot" and "cold" pixels compared with "normal" pixels.

9.5.2 Correction Algorithm

On cameras in the Baumer MXU series, the problem of defect pixels is solved as follows:

- Possible defect pixels are identified during the camera's production process.
- 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 are 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 corrected by using the previously corrected pixel and the pixel on the other side of the defect pixel.
  - The correction process 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 gives you the option to add their coordinates to the defectpixellist.

You can determine the coordinates*) of the affected pixels and add them to the list. Once the defectpixellist is stored in a user set, pixel correction is carried out 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 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 ... 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 to control the camera.

Using a so called "IO matrix" allows you to select the signal and the state to be processed.

On the software side, the input signals are named "Trigger", "Timer" and "LineOut 1...3".

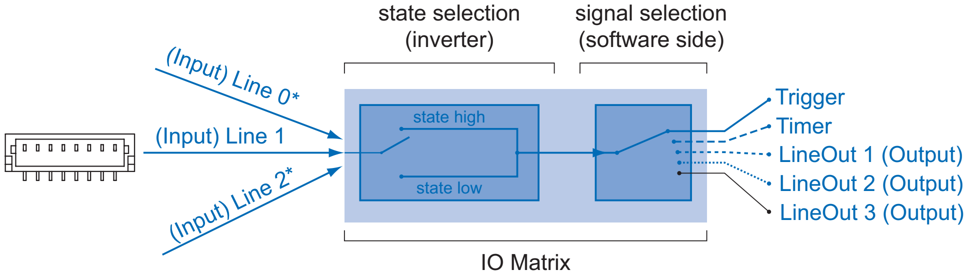


Figure 43 ▶ IO matrix of the Baumer MXU on the input side.

* Example, if the two GPIO's are used as input.

9.6.1.2 General Purpose Input/Output (GPIO)

Lines 1 and 2 are GPIOs and can be inputs and outputs.

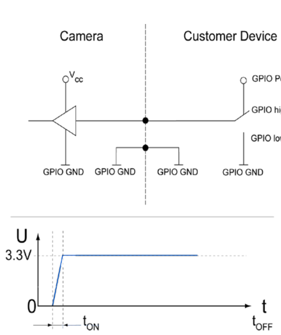
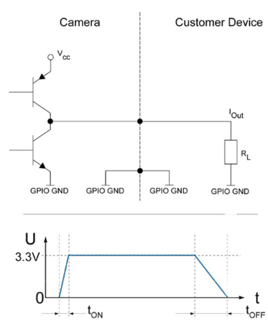
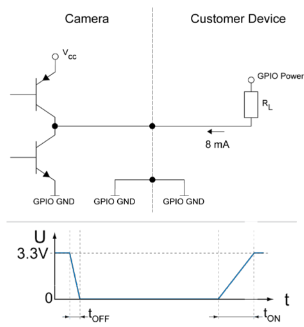
Used as an input: (0 ... .0.8 V low, 2.0 ... 4.1V high).
Used as an output (0 ... .0.4 V low, 2.9 ... 3.3V high)

⚠ Caution

The General Purpose IOs (GPIOs) are not potential-free and do not have an overrun cut-off. Incorrect wiring (overvoltage, undervoltage or voltage reversal) can lead to defects within the electronics system.

GPIO Power V_{CC}:	3.3 V DC
IOUT:	max. 8 mA
Load resistor:	approx. 470 Ohm (or higher)

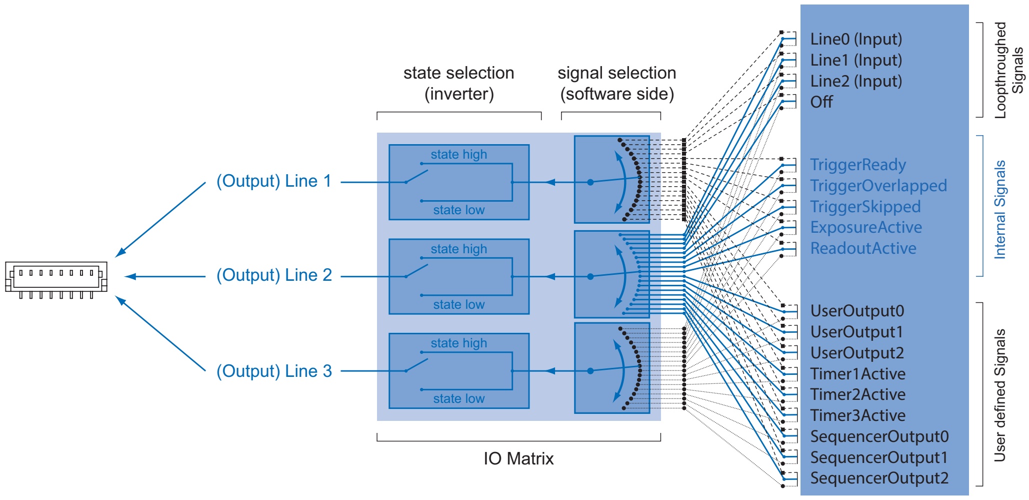
The GPIOs are configured as an input through the default camera settings. They must be connected to GPIO_GND if not used or not configured as an output.

GPIO IN	GPIO OUT High Active	GPIO OUT Low Active
		

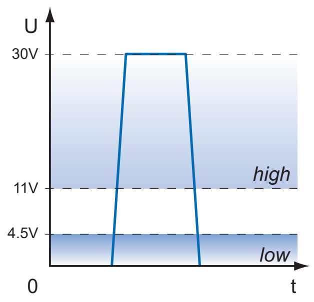
9.6.1.3 Configurable Outputs (opto / GPIO)

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

On MXU cameras, the output connector can be wired to one of the provided internal signals: "Off", "ExposureActive", "Line 0, 1, 2", "Timer 1 ... 3", "ReadoutActive", "User0 ... 2", "TriggerReady", "TriggerOverlapped", "TriggerSkipped", "Sequencer Output 0 ... 2". The output can also be disabled.



◄ **Figure 44**
IO matrix of the Baumer MXU on the output side.



▲ **Figure 45**
Trigger signal, valid for Baumer cameras.

9.6.2 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.

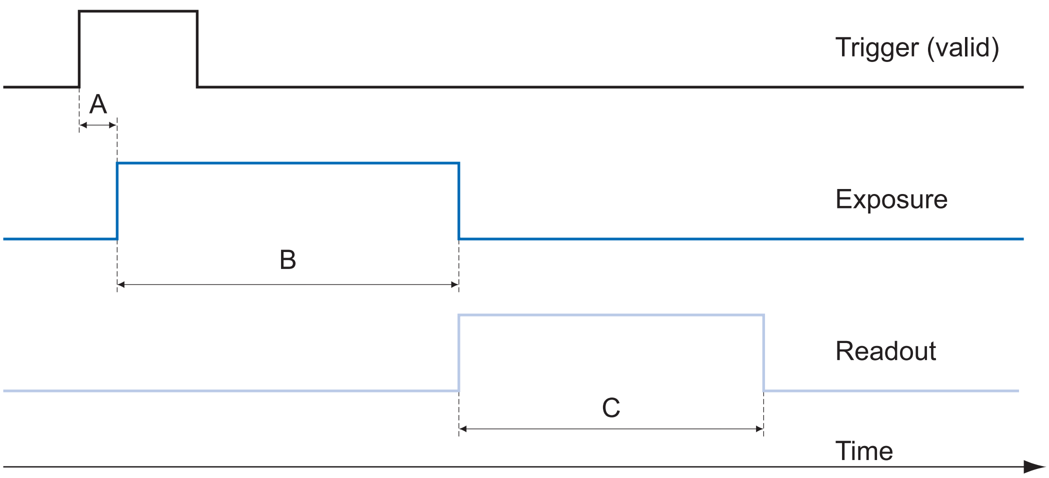


Figure 46 ►
Camera in trigger mode:
A - Trigger delay
B - Exposure time
C - Readout time

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 in increments of 1 µsec. Where there are multiple triggers during the delay, the triggers will also be stored and delayed. The buffer is able to store up to 512 trigger signals during the delay. *Your benefits:* ▪ *No need for an external trigger sensor to be perfectly aligned* ▪ *Different objects can be captured without hardware changes*

9.6.3 Trigger Source

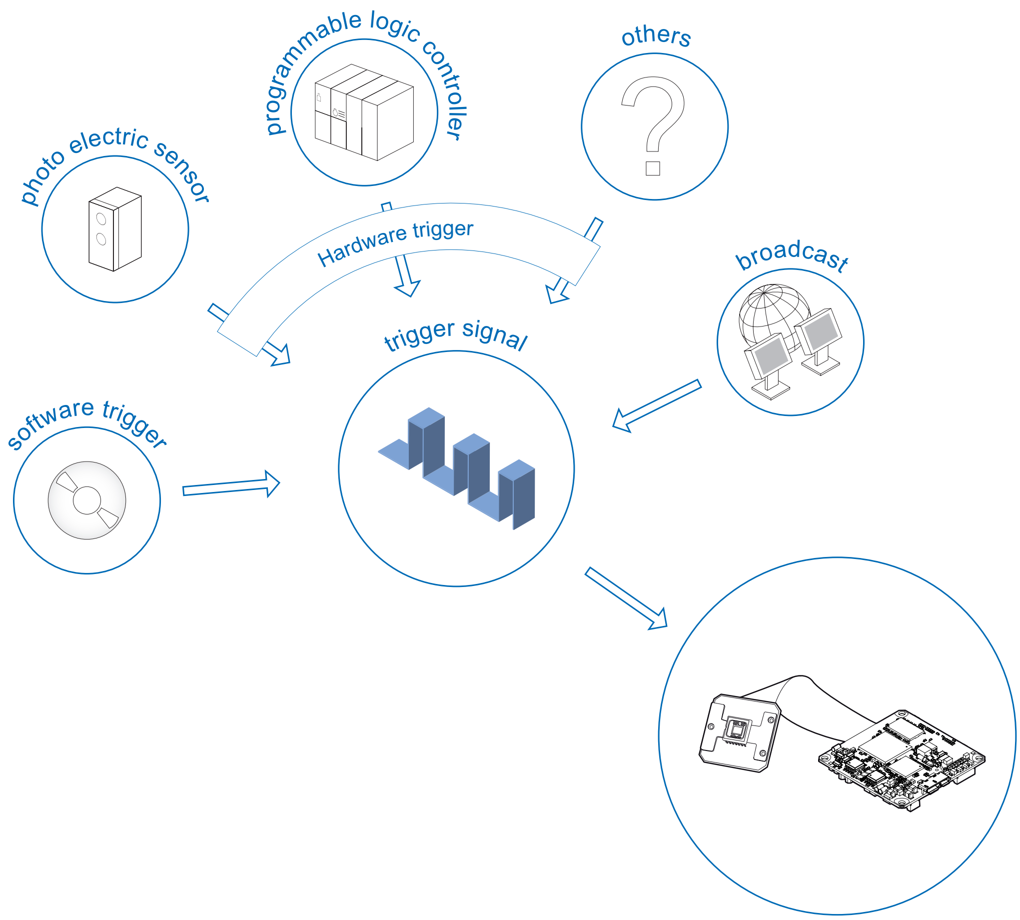


Figure 47 ►
Examples of possible trigger sources.

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

9.6.4 Debouncer

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

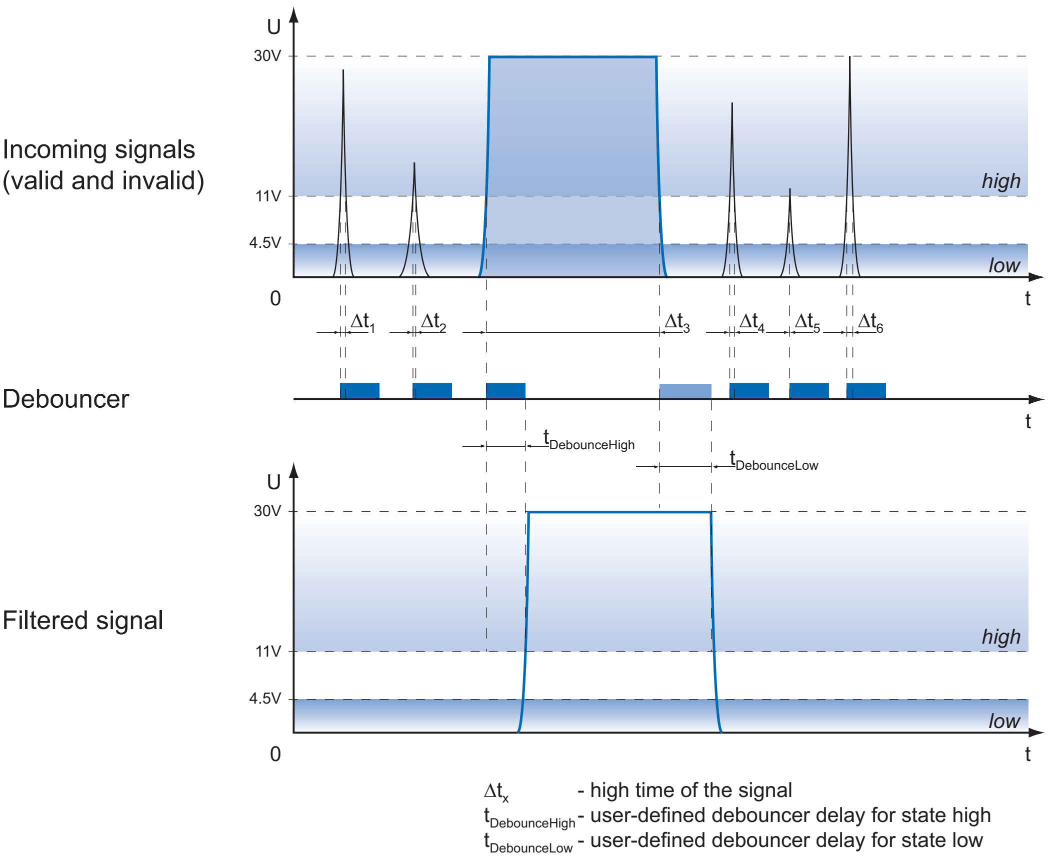
In order to detect the end of a valid signal and filter out possible jitters within the signal, a second testing time $t_{DebounceLow}$ was introduced. The timing for this can also be adjusted by the user. If the signal value falls to state low and does not rise within $t_{DebounceLow}$, this is recognized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

The debouncing times $t_{DebounceHigh}$ and $t_{DebounceLow}$ are adjustable from 0 to 5 msec in increments 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 may be temporally stretched or compressed.



9.6.5 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. For this reason, the span time used for the sensor readout $t_{readout}$ can be used in industrial environments.

9.6.6 Timers

Timers were introduced for advanced control of internal camera signals.

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

On Baumer MXU cameras, the timer configuration includes four components:

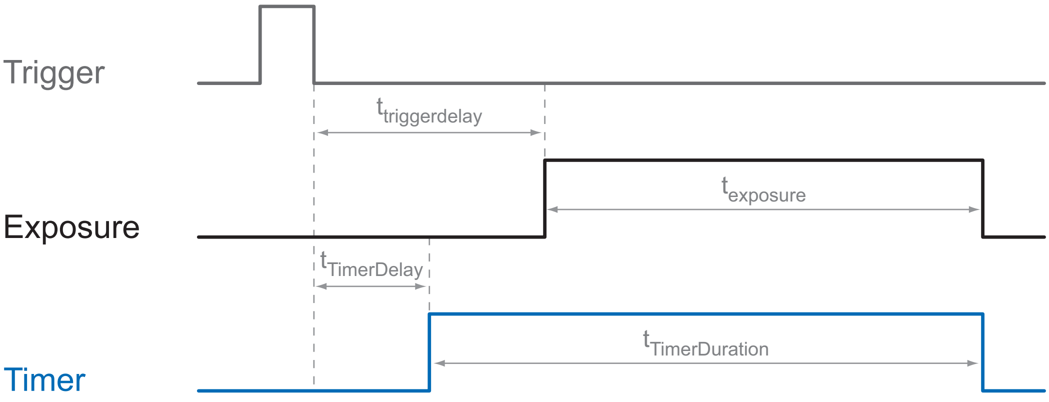


Figure 48 ▶ Possible timer configuration on a Baumer MXU.

Component	Description
TimerTriggerSource	This feature provides a source selection for each timer.
TimerTriggerActivation	This feature selects the part of the trigger signal (edges or states) that activates the timer.
TimerDelay	This feature represents the interval between the incoming trigger signal and the start of the timer.
TimerDuration	This feature is used to adjust the activation time of the timer.

9.6.6.1 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 must be wired to the selected internal timer signal.
- The 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 using the following formula:

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

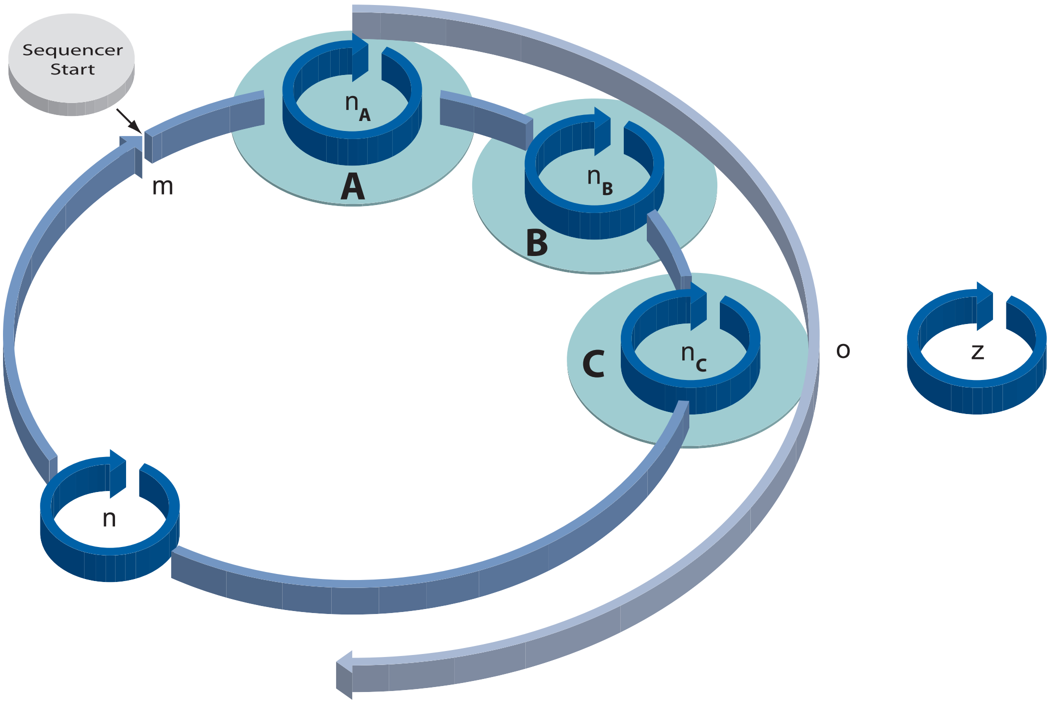
9.6.7 Frame counter

The frame counter is part of the Baumer Image Info Header and is supplied with every image, if chunk mode is activated. It is generated by hardware and can be used to verify that each of the camera's images 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 49**
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 shows the fundamental structure of the sequencer module.

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

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

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

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

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

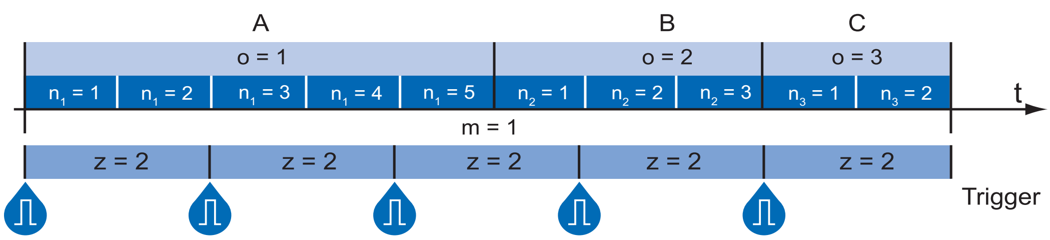
Sequencer Parameter:

The mentioned sets of parameters 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 50**
Timeline for a single sequence

9.7.2 Baumer Optronic Sequencer in Camera xml-file

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

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

9.7.3 Examples

9.7.3.1 Sequencer without Machine Cycle

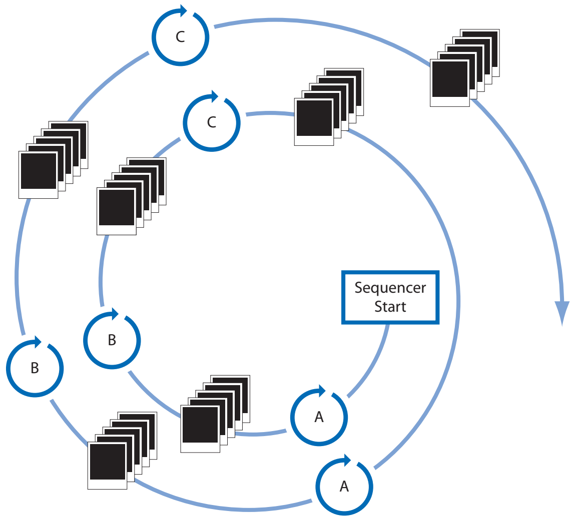
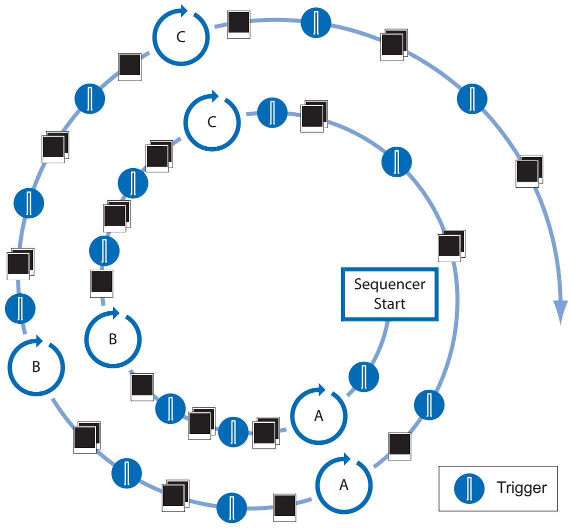


Figure 51 ▶
Example using a fully automated sequencer.

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

When the sequencer is started, with or without an external event, the camera will record 5 images successively in each case, using the sets of parameters A, B and C (which constitutes a sequence). After that, the sequence is started again, then the sequencer stops - in this case the parameters are maintained.

9.7.3.2 Sequencer Controlled by Machine Steps (trigger)



◀ **Figure 52**
Example using a semi-automated sequencer.

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

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 gives you the option to capture two images within a very short period of time. Depending on the application, this is performed in conjunction with a flash unit. 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. The pixels of the sensor are therefore receptive again shortly after the first exposure. In order to realize the second short exposure time without an overrun of the sensor, a second short flash must be used, and any subsequent extraneous light prevented.

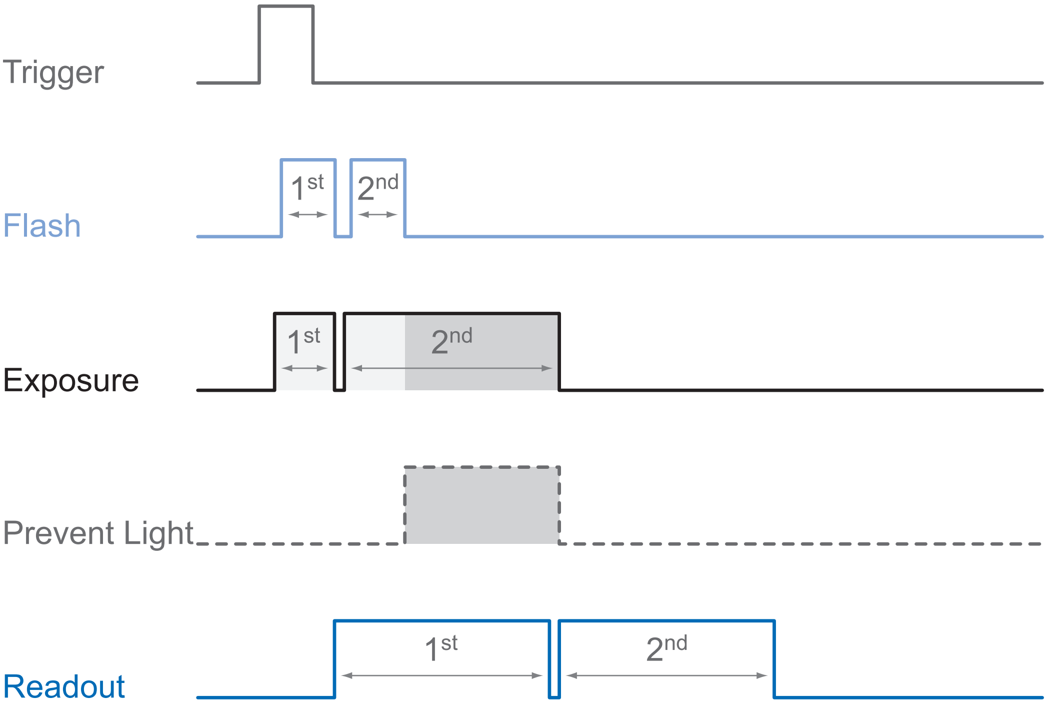


Figure 53 ▶
Example of a double shutter.

On Baumer MXU cameras, this feature is realized within the sequencer.

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

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

9.8 Device Reset

The Device Reset feature corresponds with the turn off and turn on of the camera. This must be done after a parameterization (e.g. the network data) of the camera.

It is therefore no longer necessary to interrupt the power supply.

9.9 User Sets

Four user sets (0-3) are available for the Baumer cameras in the MXU 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 in the MXU series.

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

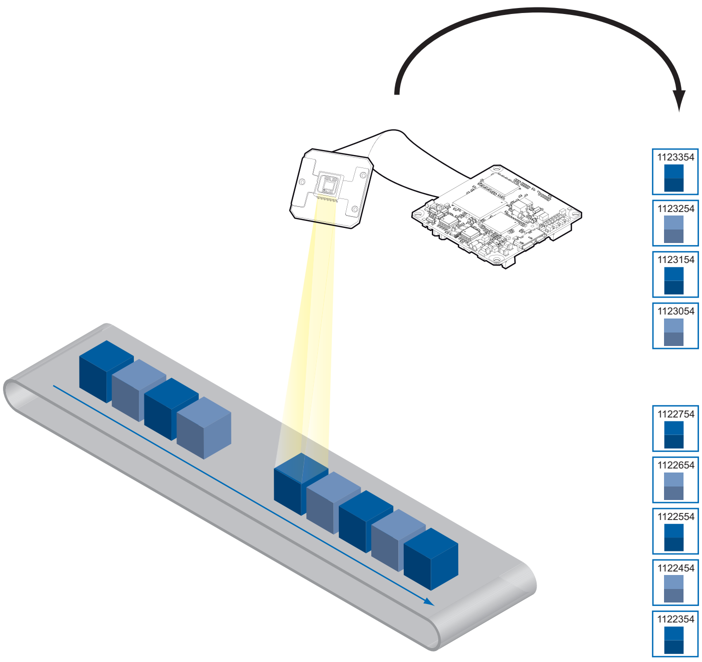
9.10 Factory Settings

The factory settings are stored in "user set 0", the default user set. This is the only user set that cannot be edited.

9.11 Timestamp

The timestamp is part of the USB 3.0 Vision™ standard. It is 64 bits long and denoted in nanoseconds. Any image or event includes its corresponding timestamp.

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



◄ **Figure 54**
Timestamps of recorded images.

10. Interface Functionalities

10.1 Device Information

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

Included information:

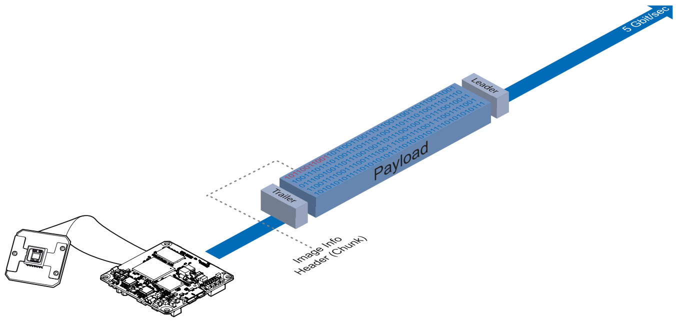
- Product ID (PID)
- Vendor ID (VID)

Model Name	Baumer USB Vendor ID [Hexadecimal]	Baumer USB Product ID [Hexadecimal]
MXU02	2825	0100
MXU02c	2825	0101
MXU12	2825	0102
MXU12c	2825	0103
MXU20	2825	0104
MXU20c	2825	0105
MXUC20	2825	0106
MXUC20c	2825	0107
MXUC40.2	2825	0108
MXUC40c.2	2825	0109

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

10.2 Baumer Image Info Header (Chunk)

The Baumer Image Info Header is a data packet that is generated by the camera and integrated into the Payload (every image), if chunk mode is activated.



◄ **Figure 55**
Location of the Baumer Image Info Header

This integrated data packet contains different settings for the image. Baumer GAPI can read the Image Info Header (Chunk). Third party software that supports chunk mode can read the features in the table below. These settings are (not exhaustive):

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 Message Channel

The asynchronous message channel is described in the USB 3.0 Vision™ standard and allows you to signal events. There is a timestamp (64 bits) for each announced event, which contains the accurate time at which the event occurred.

Each event can be activated and deactivated separately.

10.3.1 Event Generation

Event	Description
GenICam™	
ExposureStart	Exposure started
ExposureEnd	Exposure ended
FrameStart	Acquisition of a frame started
FrameEnd	Acquisition of a frame ended
Line0RisingEdge	Rising edge detected on IO-Line 0
Line0FallingEdge	Falling edge detected on IO-Line 0
Line1RisingEdge	Rising edge detected on IO-Line 1
Line1FallingEdge	Falling edge detected on IO-Line 1
Line2RisingEdge	Rising edge detected on IO-Line 2
Line2FallingEdge	Falling edge detected on IO-Line 2
Line3RisingEdge	Rising edge detected on IO-Line 3
Line3FallingEdge	Falling edge detected on IO-Line 3
Vendor-specific	
EventDiscarded	Event discarded
EventLost	Event occurred but not analyzed
TriggerReady	$t_{notready}$ elapsed, camera is able to process incoming trigger
TriggerOverlapped	Overlapped Mode detected
TriggerSkipped	Camera over-triggered

11. Start-Stop Behaviour

11.1 Start / Stop / Abort Acquisition (Camera)

Once 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, this process is repeated 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 completed before the camera is stopped. If the stop signal occurs during an exposure, this will be aborted.

Abort Acquisition

The acquisition abort process is a special case where the current acquisition is stopped.

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

11.2 Start / Stop Interface

Transmission of image data from the camera to the PC will not proceed until the interface is started. If 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 MXU 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 rather 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

⚠ Caution!

Do not try to clean the camera.

The camera could become damaged!

13. Transport / Storage

Notice

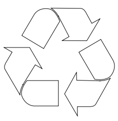
Transport the camera only in its original packaging. When the camera is not installed, store it in its original packaging.

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

14. Disposal

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

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



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

Keep the original packaging during the warranty period in order to be able to pack the device 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 anyone 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, feel free to contact our support.

Worldwide

Baumer Optronic GmbH
Badstrasse 30
DE-01454 Radeberg, Germany

Tel: +49 (0)3528 4386 845

Email: support.cameras@baumer.com

Website: www.baumer.com

17. Conformity

17.1 CE

Baumer MX Board Level Cameras (USB3 Vision™) are delivered without housing. The housing design is critical to a camera's electromagnetic interference characteristics.

For this reason, no CE certification tests regarding electromagnetic interference have been performed on MX Board Level Cameras (USB3 Vision™).

Users who design MX Board Level Cameras (USB3 Vision™) into their systems should perform appropriate tests for electromagnetic interference.

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