Basler scout

USER'S MANUAL

(for Scout-f Cameras Used with Basler's Pylon API)

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For customers in the U.S.A.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment.

The shielded interface cable recommended in this manual must be used with this equipment in order to comply with the limits for a computing device pursuant to Subpart J of Part 15 of FCC Rules.

For customers in Canada

This apparatus complies with the Class A limits for radio noise emissions set out in Radio Interference Regulations.

Pour utilisateurs au Canada

Cet appareil est conforme aux normes Classe A pour bruits radioélectriques, spécifiées dans le Règlement sur le brouillage radioélectrique.

Life Support Applications

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Basler customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Basler for any damages resulting from such improper use or sale.

Warranty Note

Do not open the housing of the camera. The warranty becomes void if the housing is opened.

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1 Specifications, Requirements, and Precautions

This section lists the camera models covered by the manual. It provides the general specifications for those models and the basic requirements for using them.

This section also includes specific precautions that you should keep in mind when using the cameras. We strongly recommend that you read and follow the precautions.

1.1 Models

The current Basler IEEE 1394 camera models are listed in the top row of the specification tables on the next pages of this manual. The camera models are differentiated by their sensor size, their maximum frame rate at full resolution, and whether the camera's sensor is mono or color.

The scout camera models are available in the following housing variants:

- standard housing
- 90° head housing

The housing variants other than the standard housing are appended to the camera's name, e.g. scA640-70fm/fc 90° head.

Unless otherwise noted, the material in this manual applies to all of the camera models listed in the tables. Material that only applies to a particular camera model or to a subset of models, such as to color cameras or a specific housing variant only, will be so designated.

1.2 General Specifications

Specification	scA640-70fm/fc	scA640-74fm/fc	scA640-120fm/fc
Sensor Size (H x V pixels)	fm: 659 x 494 fc: 658 x 492	fm: 659 x 494 fc: 658 x 492	fm: 659 x 494 fc: 658 x 492
Sensor Type	Sony ICX424 AL/AQ	Sony ICX414 AL/AQ	Sony ICX618 ALA/AQA
	Progressive scan CCD		
Optical Size	1/3"	1/2"	1/4"
Pixel Size	7.4 µm x 7.4 µm	9.9 µm x 9.9 µm	5.6 µm x 5.6 µm
Max. Frame Rate (at full resolution	71 fps	74 fps	120 fps
Mono/Color	All models available in mono or color		
Data Output Type	IEEE 1394b		
Pixel Data Formats	Mono Models:		
	Mono 8 (= DCAM Mono 8) Mono 16 (= DCAM Mono 16) Mono 12 Packed YUV 4:2:2 Packed (= DCAM YUV 4:2:2) YUV 4:2:2 (YUYV) Packed		
	Color Models		
	Mono 8 (= DCAM Mono 8) Bayer BG 8 (= DCAM Raw 8) Bayer BG 16 (= DCAM Raw 16) Bayer BG 12 Packed YUV 4:2:2 Packed (= DCAM YUV 4:2:2) YUV 4:2:2 (YUYV) Packed		
ADC Bit Depth	12 bits		
Synchronization	Via external trigger signal or via software		
Exposure Control	Programmable via the camera API		
Camera Power Requirements	+ 8 to + 36 VDC supplied via the IEEE 1394 cable < 1% ripple		
	2.5 W @ 12 V		3.0 W @ 12 V
I/O Ports	2 opto-isolated input ports and 4 opto-isolated output ports		
Lens Adapter	C-mount (CS-mount optional)		

Specification	scA640-70 fm/fc	scA640-74 fm/fc	scA640-120 fm/fc
Size (L x W x H)			
(standard housing)	73.7 mm x 44 mm x 29 mm (without lens adapter or connectors) 85.5 mm x 44 mm x 29 mm (with lens adapter and connectors)		
(90° head housing)	91.65 mm x 44 mm x 29 mm (without connectors and front module) 97 mm x 44 mm x 41.8 mm (with connectors and front module)		
Weight			
(standard housing)	160 g (typical)		
(90° head housing)	180 g (typical)		
Conformity	CE, FCC, GenICam, IP30		

Table 1: General Specifications

Specification	scA750-60fm/fc	scA780-54fm/fc	scA1000-20fm/fc
Sensor Size (H x V pixels)	fm: 752 x 480 fc: 750 x 480	fm: 782 x 582 fc: 780 x 580	fm: 1034 x 779 fc: 1032 x 778
Sensor Type	Aptina MT9V022 (formerly known as the Micron MT9V022)	Sony ICX415 AL/AQ	Sony ICX204 AL/AK
	Progressive Scan CMOS	Progressive scan CCD	
Optical Size	1/3"	1/2"	1/3"
Pixel Size	6.0 µm x 6.0 µm	8.3 µm x 8.3 µm	4.65 µm x 4.65 µm
Max. Frame Rate (at full resolution	64.9 fps	58 fps	21 fps
Mono/Color	All models available in mono or color		
Data Output Type	IEEE 1394b		
Pixel Data Formats	Mono Models:		
	Mono 8 (= DCAM Mono 8) YUV 4:2:2 Packed (= DCAM YUV 4:2:2) YUV 4:2:2 (YUYV) Packed	Mono 8 (= DCAM Mono 8) Mono 16 (= DCAM Mono 16) Mono 12 Packed YUV 4:2:2 Packed (= DCAM YUV 4:2:2) YUV 4:2:2 (YUYV) Packed	
	Color Models:		
	Mono 8 (= DCAM Mono 8) Bayer RG 8 (= DCAM Raw 8) YUV 4:2:2 Packed (= DCAM YUV 4:2:2) YUV 4:2:2 (YUYV) Packed	Mono 8 (= DCAM Mono 8) Bayer BG 8 (= DCAM Raw 8) Bayer BG 16 (= DCAM Raw 16) Bayer BG 12 Packed YUV 4:2:2 Packed (= DCAM YUV 4:2:2) YUV 4:2:2 (YUYV) Packed	
ADC Bit Depth	10 bits	12 bits	
Synchronization	Via external trigger signal or via software		
Exposure Control	Programmable via the camera API		
Camera Power Requirements	+ 8 to + 36 VDC supplied via the IEEE 1394 cable < 1% ripple		
	1.7 W @ 12 V	2.5 W @ 12 V	
I/O Ports	2 opto-isolated input ports and 4 opto-isolated output ports		
Lens Adapter	C-mount (CS-mount optional)		

Specification	scA750-60fm/fc	scA780-54fm/fc	scA1000-20fm/fc
Size (L x W x H) (standard housing)	73.7 mm x 44 mm x 29 mm (without lens adapter or connectors) 85.5 mm x 44 mm x 29 mm (with lens adapter and connectors)		
(90° head housing)	91.65 mm x 44 mm x 29 mm (without connectors and front module) 97 mm x 44 mm x 41.8 mm (with connectors and front module)		
Weight (standard housing)	160 g (typical)		
(90° head housing)	180 g (typical)		
Conformity	CE, FCC, GenICam, IP30		

Table 2: General Specifications

Specification	scA1000-30fm/fc	scA1300-32fm/fc	scA1390-17fm/fc
Sensor Size (H x V pixels)	fm: 1034 x 779 fc: 1032 x 778	fm: 1296 x 966 fc: 1294 x 964	fm: 1392 x 1040 fc: 1390 x 1038
Sensor Type	Sony ICX204 AL/AK	Sony ICX445 ALA/AQA	Sony ICX267 AL/AK
	Progressive scan CCD		
Optical Size	1/3"	1/3"	1/2"
Pixel Size	4.65 µm x 4.65 µm	3.75 µm x 3.75 µm	4.65 µm x 4.65 µm
Max. Frame Rate (at full resolution)	30 fps	33 fps	17 fps
Mono/Color	All models available in mono or color		
Data Output Type	IEEE 1394b		
Pixel Data Formats	Mono Models:		
	Mono 8 (= DCAM Mono 8) Mono 16 (= DCAM Mono 16) Mono 12 Packed YUV 4:2:2 Packed (= DCAM YUV 4:2:2) YUV 4:2:2 (YUYV) Packed		
	Color Models:		
	Mono 8 (= DCAM Mono 8) Bayer BG 8 (= DCAM Raw 8) Bayer BG 16 (= DCAM Raw 16) Bayer BG 12 Packed YUV 4:2:2 Packed (= DCAM YUV 4:2:2) YUV 4:2:2 (YUYV) Packed		
ADC Bit Depth	12 bits		
Synchronization	Via external trigger signal or via software		
Exposure Control	Programmable via the camera API		
Camera Power Requirements	+ 8 to + 36 VDC supplied via the IEEE 1394 cable < 1% ripple		
	2.5 W @ 12 V	3.0 W @ 12 V	2.75 W @ 12 V
I/O Ports	2 opto-isolated input ports and 4 opto-isolated output ports		
Lens Adapter	C-mount (CS-mount optional)		

Specification	scA1000-30 fm/fc	scA1300-32 fm/fc	scA1390-17 fm/fc
Size (L x W x H) (standard housing)	73.7 mm x 44 mm x 29 mm (without lens adapter or connectors) 85.5 mm x 44 mm x 29 mm (with lens adapter and connectors)		
(90° head housing)	91.65 mm x 44 mm x 29 mm (without connectors and front module) 97 mm x 44 mm x 41.8 mm (with connectors and front module)	Not applicable	91.65 mm x 44 mm x 29 mm (without connectors and front module) 97 mm x 44 mm x 41.8 mm (with connectors and front module)
Weight (standard housing)	160 g (typical)	160 g (typical)	160 g (typical)
(90° head housing)	180 g (typical)	Not applicable	180 g (typical)
Conformity	CE, FCC, GenICam, IP30		

Table 3: General Specifications

Specification	scA1400-17fm/fc	scA1400-30fm/fc	scA1600-14fm/fc
Sensor Size (H x V pixels)	fm: 1392 x 1040 fc: 1390 x 1038	fm: 1392 x 1040 fc: 1390 x 1038	fm: 1626 x 1236 fc: 1624 x 1234
Sensor Type	Sony ICX285 AL/AQ	Sony ICX285 AL/AQ	Sony ICX274 AL/AQ
	Progressive scan CCD		
Optical Size	2/3"	2/3"	1/1.8"
Pixel Size	6.45 µm x 6.45 µm	6.45 µm x 6.45 µm	4.4 µm x 4.4 µm
Max. Frame Rate (at full resolution)	17 fps	30 fps	14 fps
Mono/Color	All models available in mono or color		
Data Output Type	IEEE 1394b		
Pixel Data Formats	Mono Models:		
	Mono 8 (= DCAM Mono 8) Mono 16 (= DCAM Mono 16) Mono 12 Packed YUV 4:2:2 Packed (= DCAM YUV 4:2:2) YUV 4:2:2 (YUYV) Packed		
	Color Models:		
	Mono 8 (= DCAM Mono 8) Bayer BG 8 (= DCAM Raw 8) Bayer BG 16 (= DCAM Raw 16) Bayer BG 12 Packed YUV 4:2:2 Packed (= DCAM YUV 4:2:2) YUV 4:2:2 (YUYV) Packed		
ADC Bit Depth	12 bits		
Synchronization	Via external trigger signal or via software		
Exposure Control	Programmable via the camera API		
Camera Power Requirements	+ 8 to + 36 VDC supplied via the IEEE 1394 cable < 1% ripple		
	3.0 W @ 12 V	3.7 W @ 12 V	2.75 W @ 12 V
I/O Ports	2 opto-isolated input ports and 4 opto-isolated output ports		
Lens Adapter	C-mount (CS-mount optional)		

Specification	scA1400-17fm/fc	scA1400-30fm/fc	scA1600-14fm/fc
Size (L x W x H) (standard housing)	73.7 mm x 44 mm x 29 mm (without lens adapter or connectors) 85.5 mm x 44 mm x 29 mm (with lens adapter and connectors)		
(90° head housing)	91.65 mm x 44 mm x 29 mm (without connectors and front module) 97 mm x 44 mm x 41.8 mm (with connectors and front module)		
Weight (standard housing)	170 g (typical)	170 g (typical)	160 g (typical)
(90° head housing)	190 g (typical)	190 g (typical)	180 g (typical)
Conformity	CE, FCC, GenICam, IP30		

Table 4: General Specifications

1.3 Spectral Response for Mono Cameras

The following graphs show the spectral response for each available monochrome camera model.

Note

The spectral response curves excludes lens characteristics and light source characteristics.

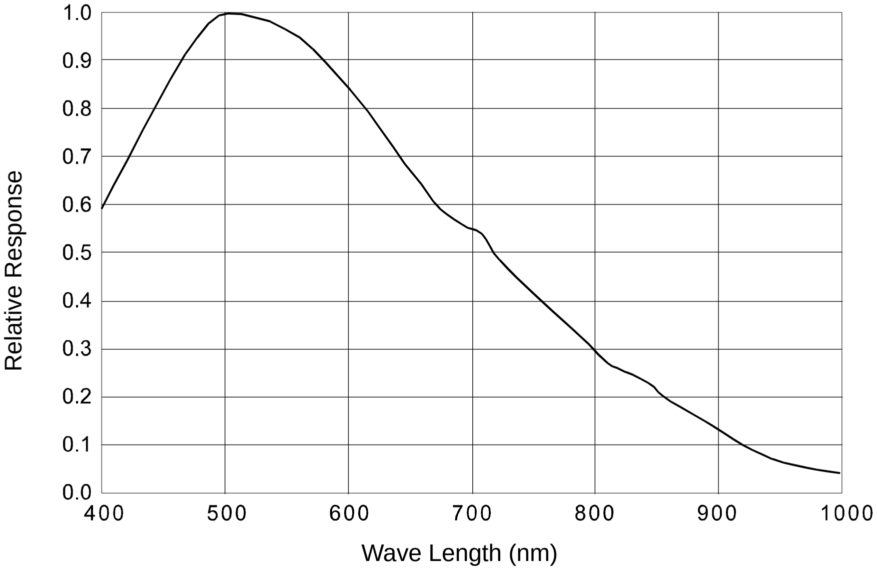


Fig. 1: scA640-70fm Spectral Response

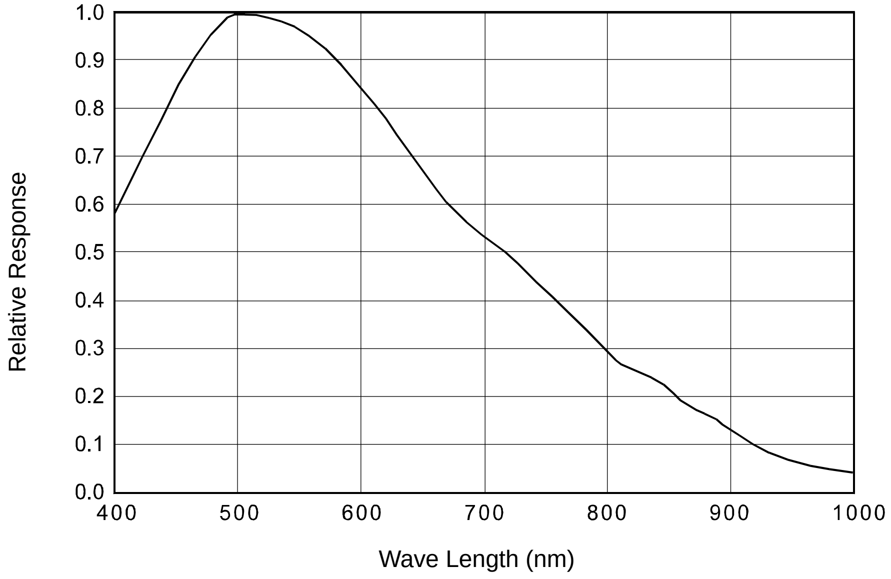


Fig. 2: scA640-74 fm Spectral Response

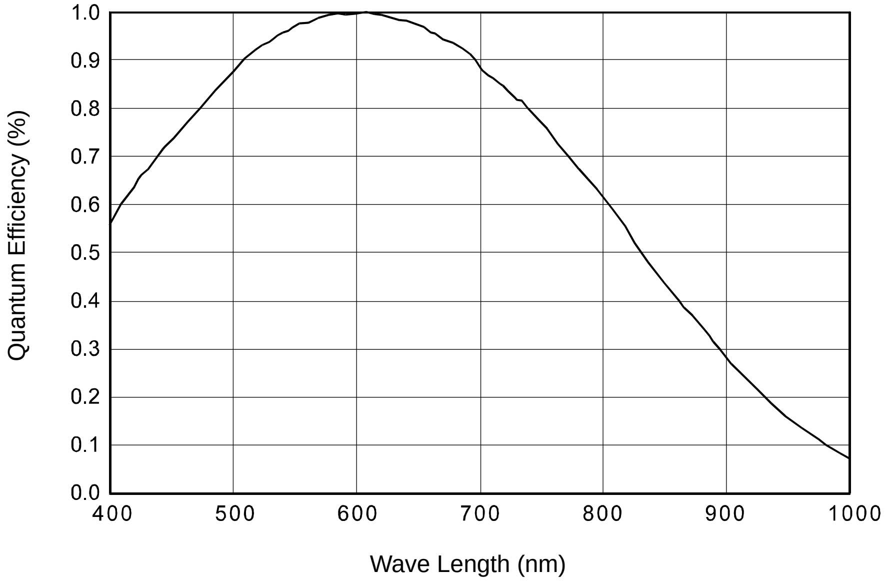


Fig. 3: scA640-120 fm Spectral Response

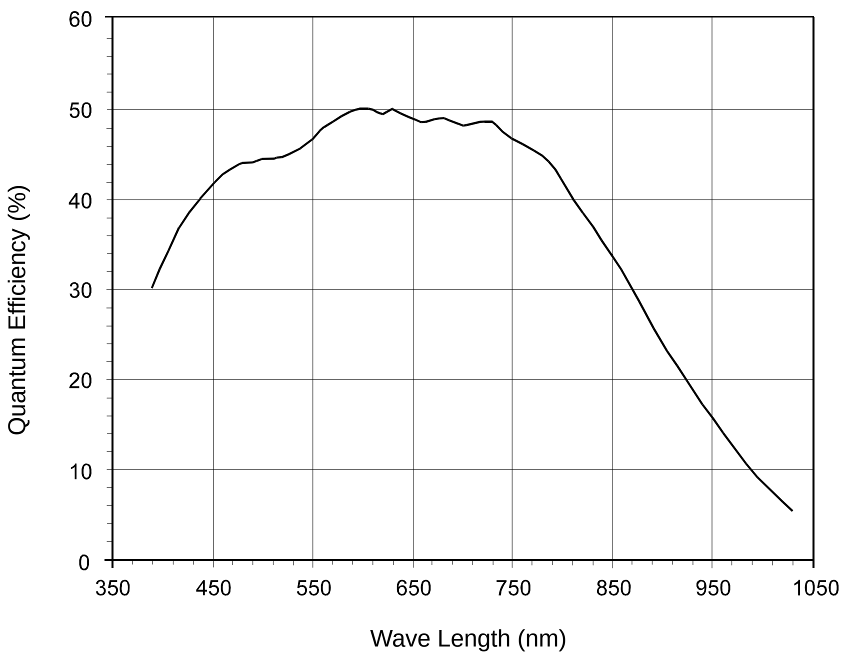


Fig. 4: scA750-60fm Spectral Response

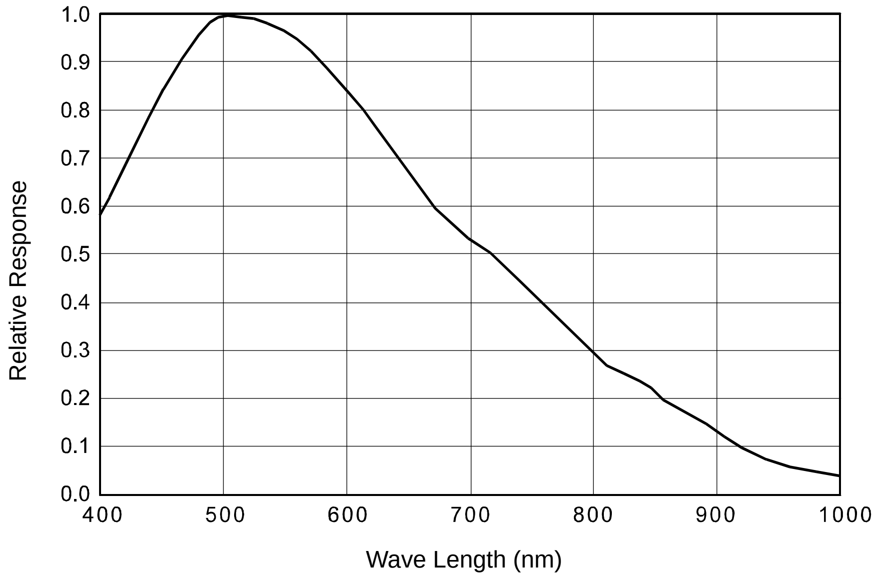


Fig. 5: scA780-54fm Spectral Response

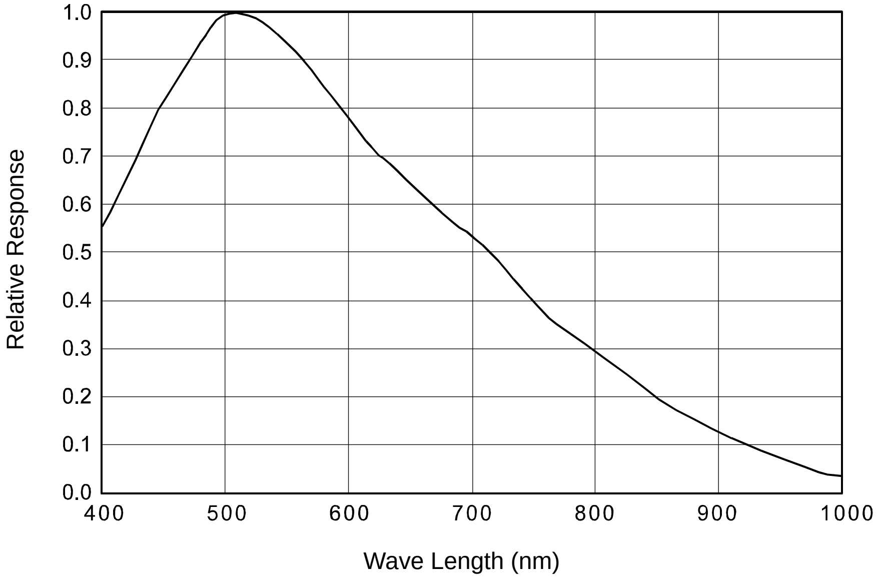


Fig. 6: scA1000-20fm and scA1000-30fm Spectral Response

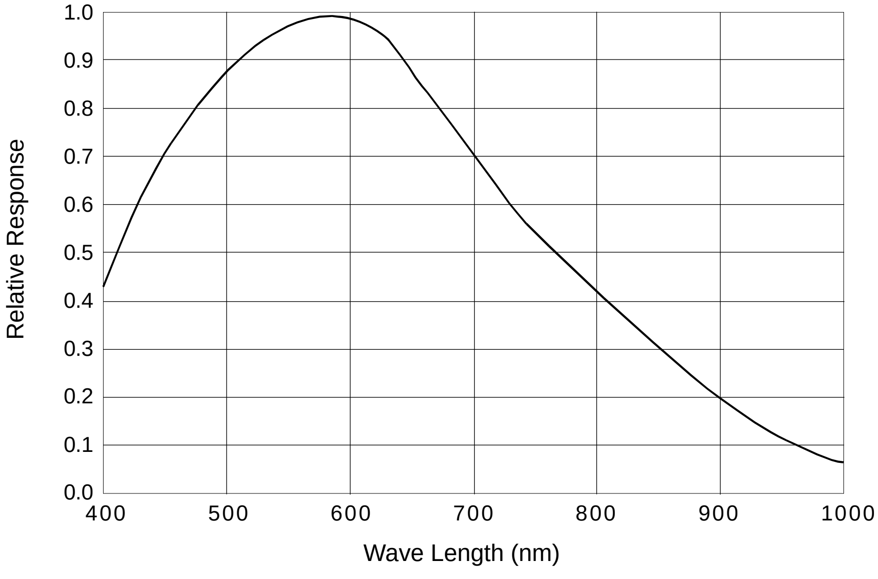


Fig. 7: scA1300-32fm Spectral Response

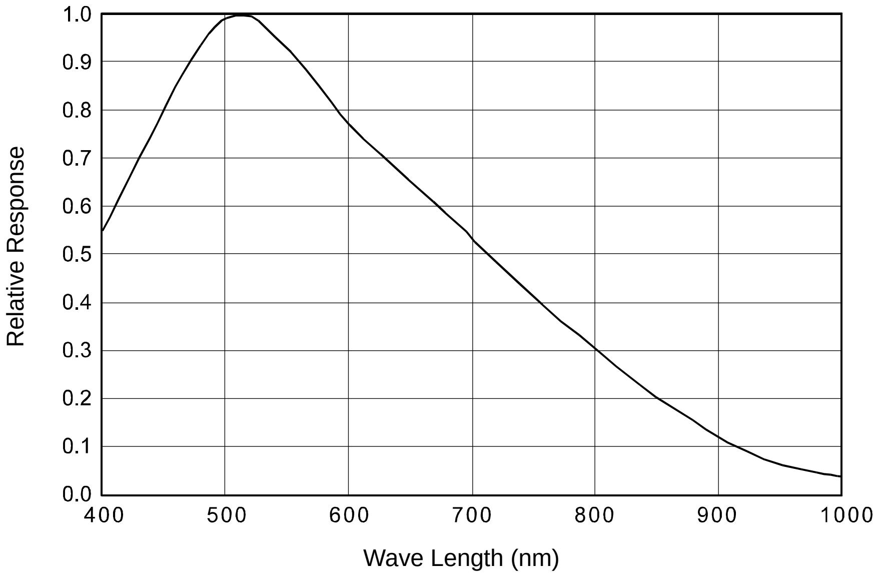


Fig. 8: scA1390-17fm Spectral Response

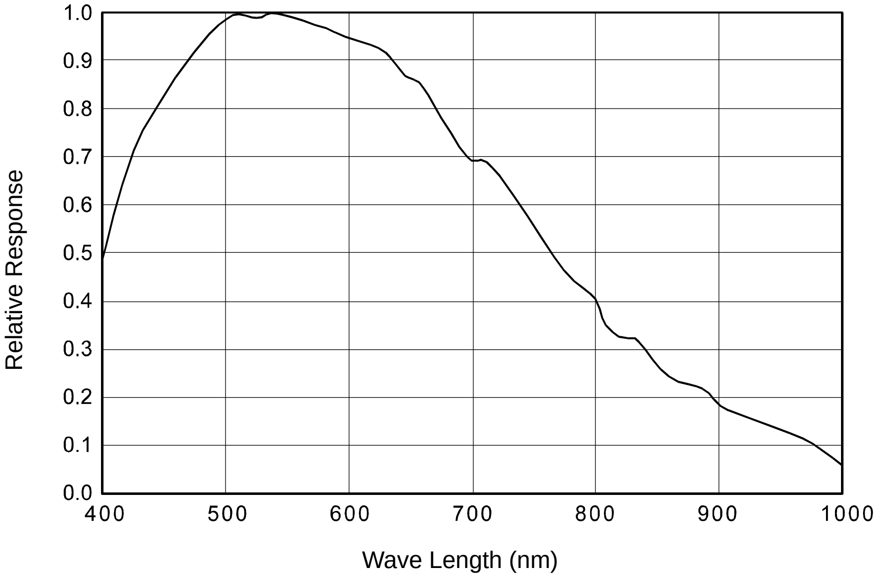


Fig. 9: scA1400-17fm and scA1400-30fm Spectral Response

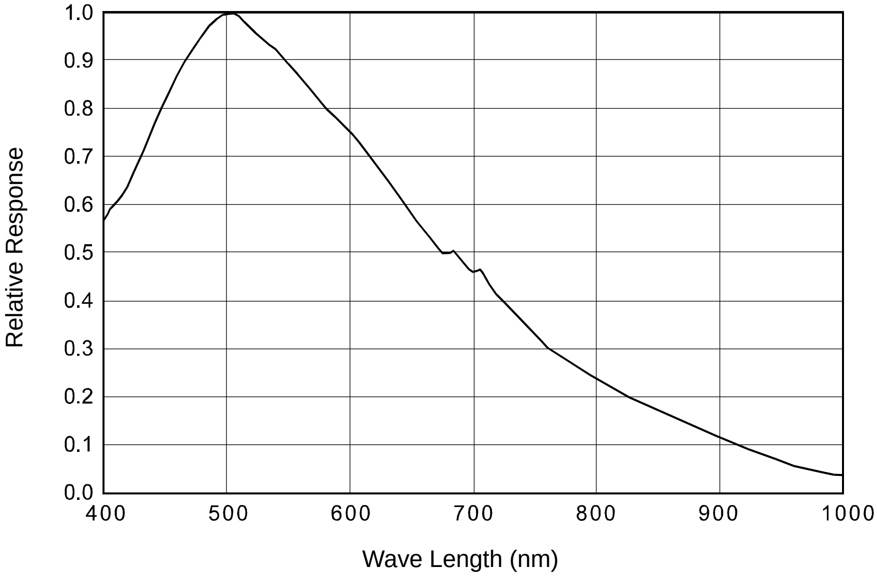


Fig. 10: scA1600-14fm Spectral Response

1.4 Spectral Response for Color Cameras

The following graphs show the spectral response for each available color camera model.

Note

The spectral response curves exclude lens characteristics, light source characteristics, and IR cut filter characteristics.

To obtain best performance from color models of the camera, use of a dielectric IR cut filter is recommended. The filter should transmit in a range from 400 nm to 700 ... 720 nm, and it should cut off from 700 ... 720 nm to 1100 nm.

A suitable IR cut filter is included in the standard C-mount lens adapter on color models of the camera. (An IR cut filter is not included in the optional CS-mount adapter.)

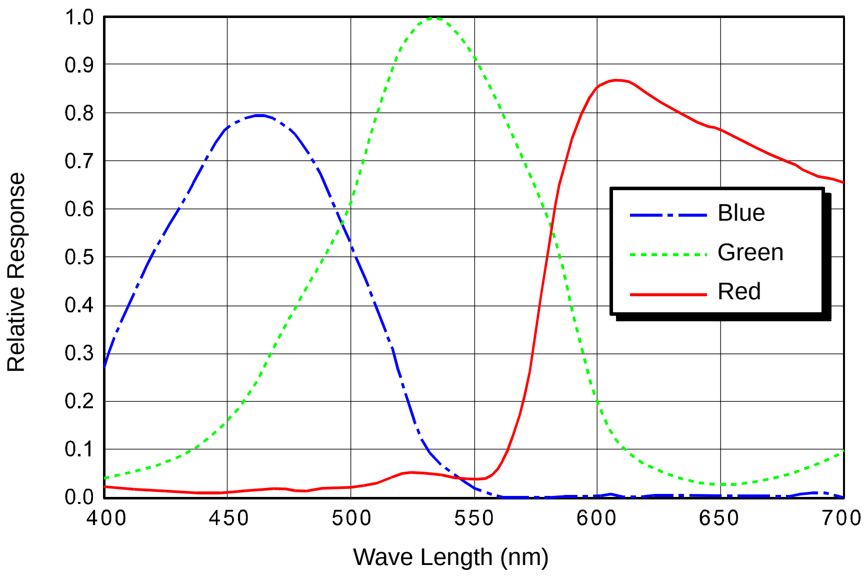


Fig. 11: scA640-70fc Spectral Response

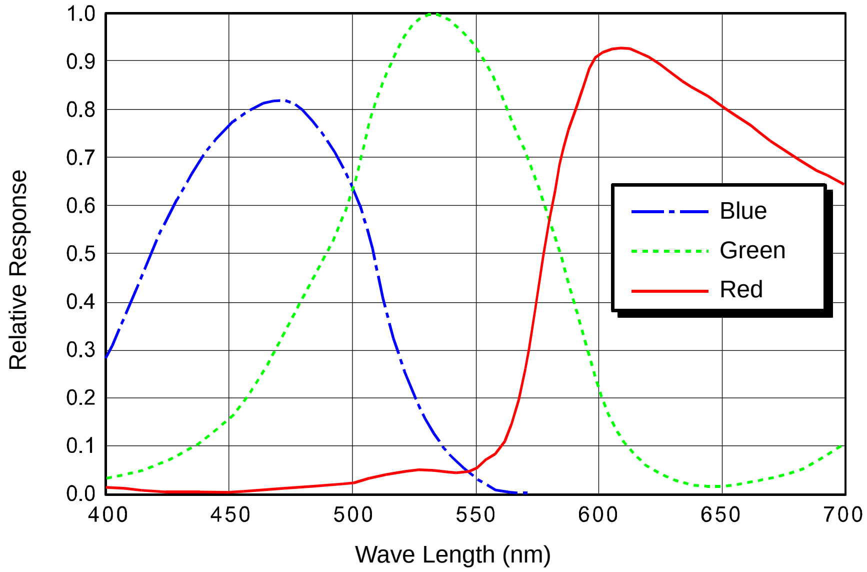


Fig. 12: scA640-74fc Spectral Response

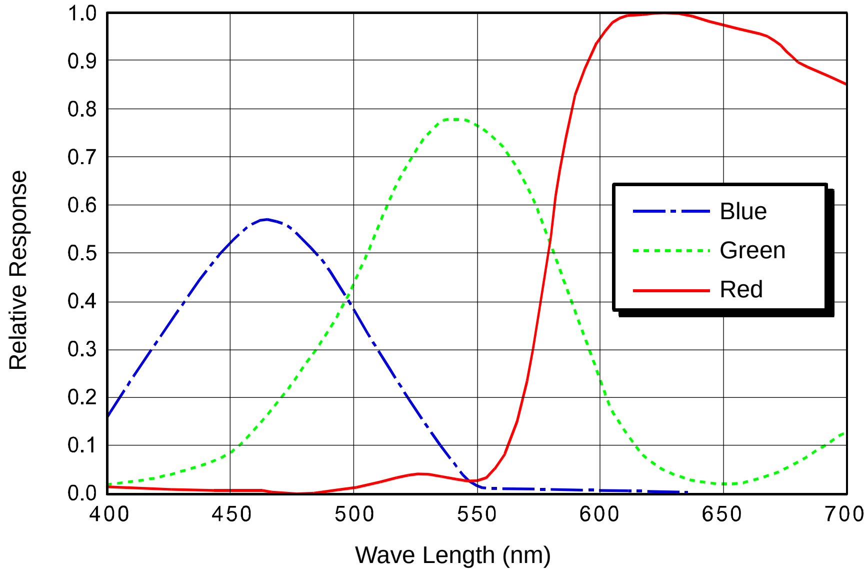


Fig. 13: scA640-120fc Spectral Response

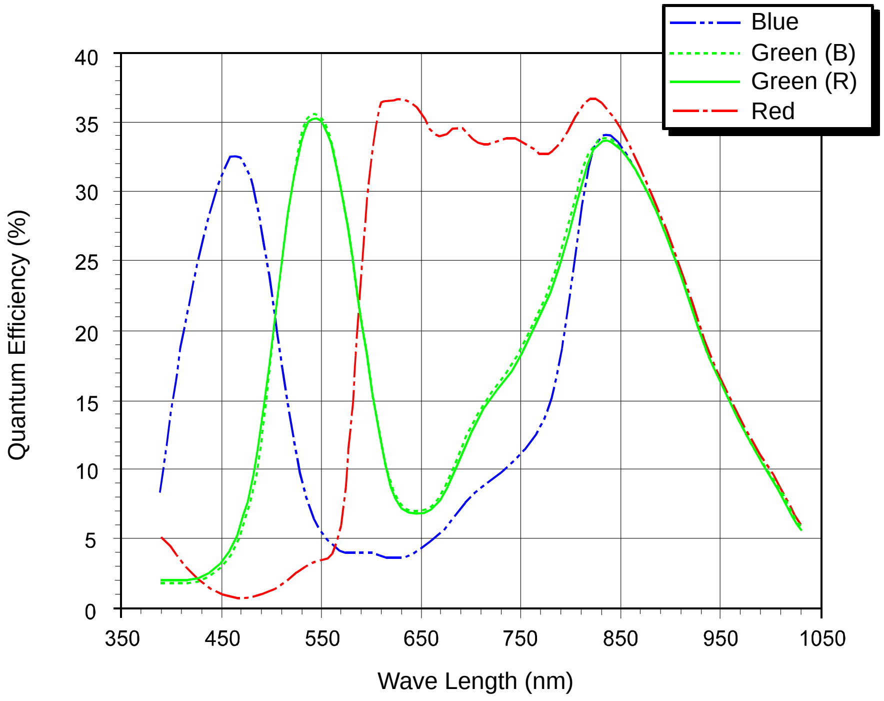


Fig. 14: scA750-60fc Spectral Response

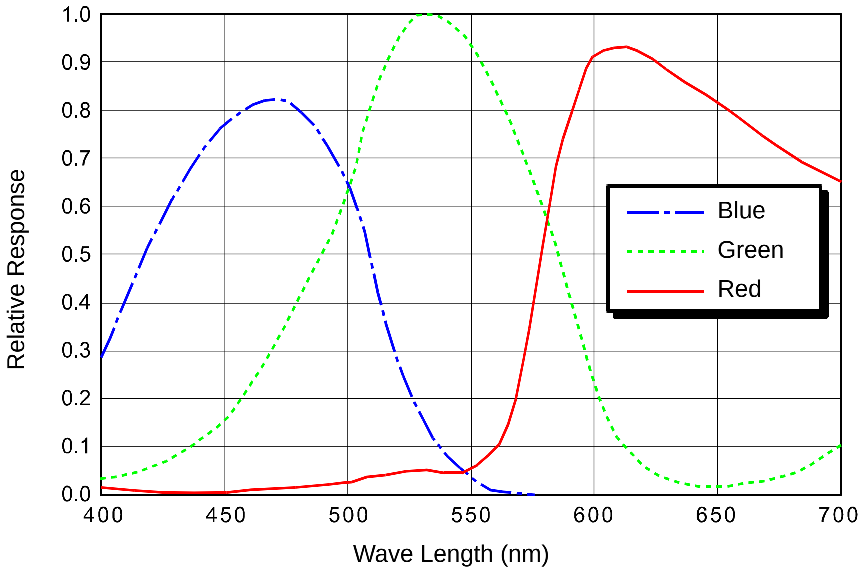


Fig. 15: scA780-54fc Spectral Response

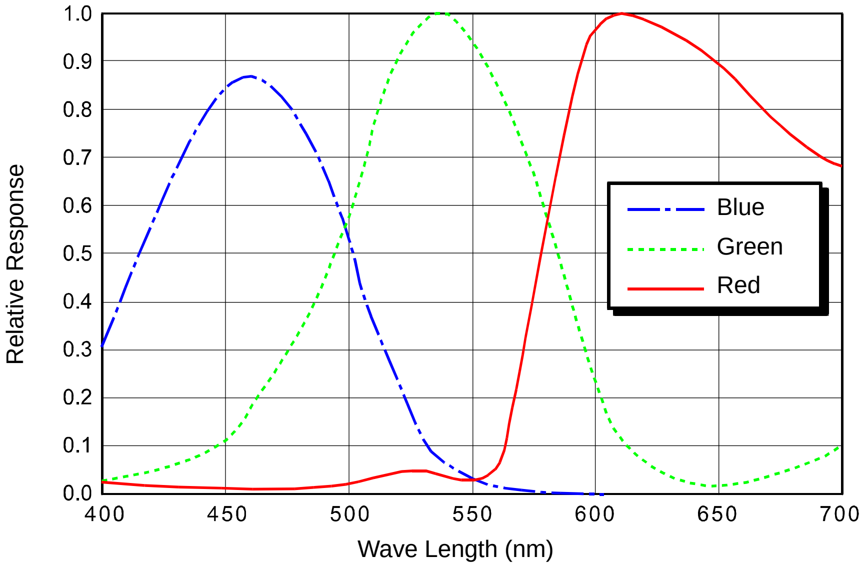


Fig. 16: scA1000-20fc and scA1000-30fc Spectral Response

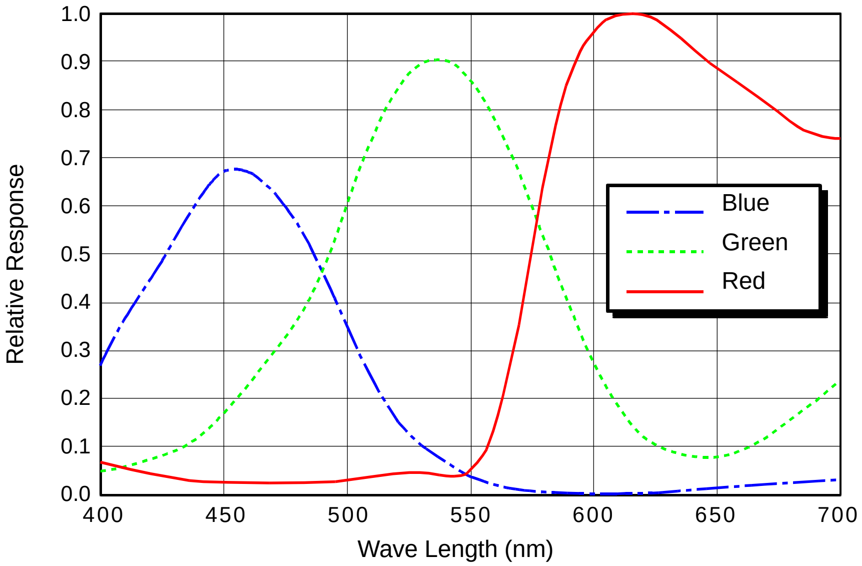


Fig. 17: scA1300-32fc Spectral Response

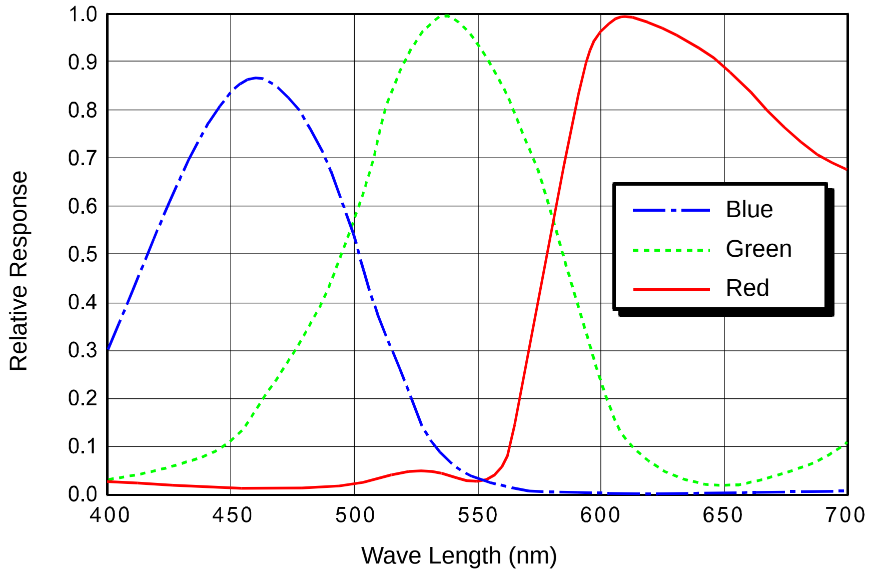


Fig. 18: scA1390-17fc Spectral Response

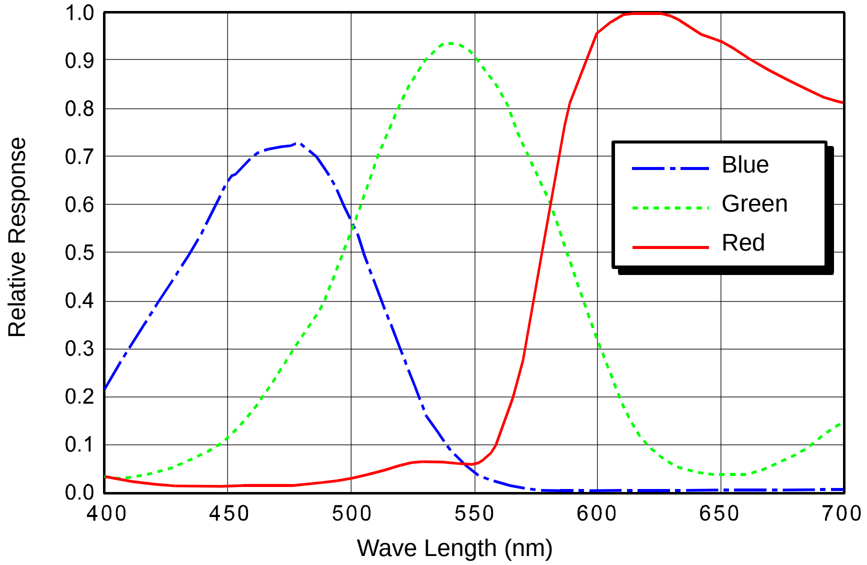


Fig. 19: scA1400-17fc and scA1400-30fc Spectral Response

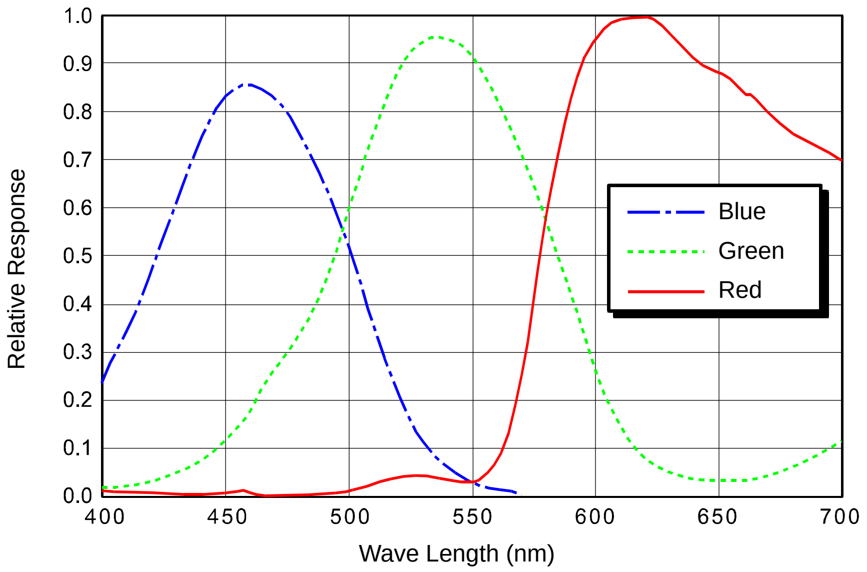


Fig. 20: scA1600-14fc Spectral Response

1.5 Mechanical Specifications

1.5.1 Standard Housing

The camera housing conforms to protection class IP30 provided the lens mount is covered by a lens or by the cap that is shipped with the camera.

1.5.1.1 Camera Dimensions and Mounting Points

The cameras are manufactured with high precision. Planar, parallel, and angular sides guarantee precise mounting with high repeatability.

The dimensions in millimeters for cameras equipped with a standard C-mount lens adapter are as shown in Figure 21. The dimensions for cameras equipped with an optional CS-mount lens adapter are shown in Figure 22 on page 24.

Camera housings are equipped with four mounting holes on the top and four mounting holes on the bottom as shown in the drawings.

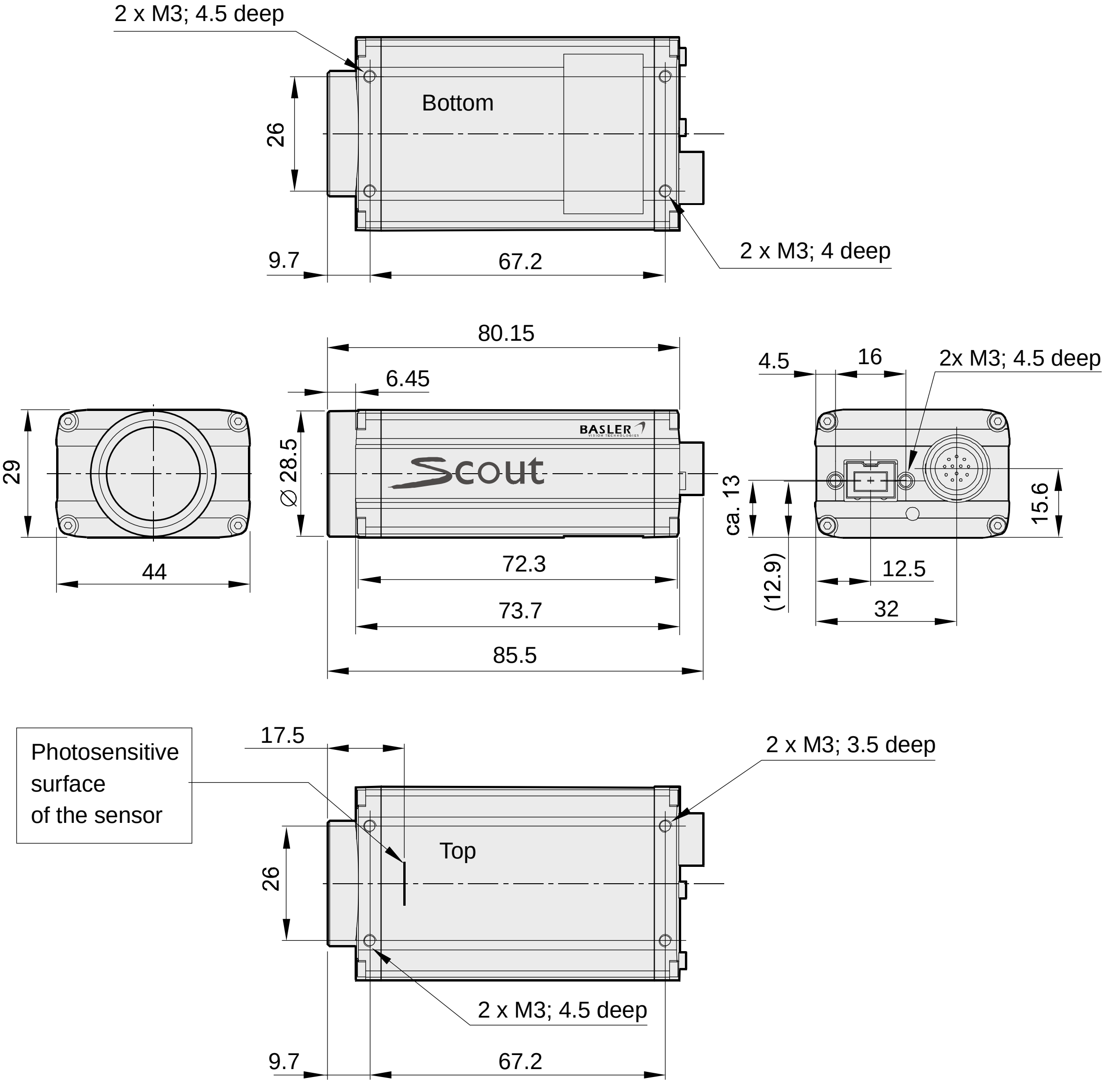


Fig. 21: Mechanical Dimensions (in mm) for Cameras with the Standard C-mount Lens Adapter

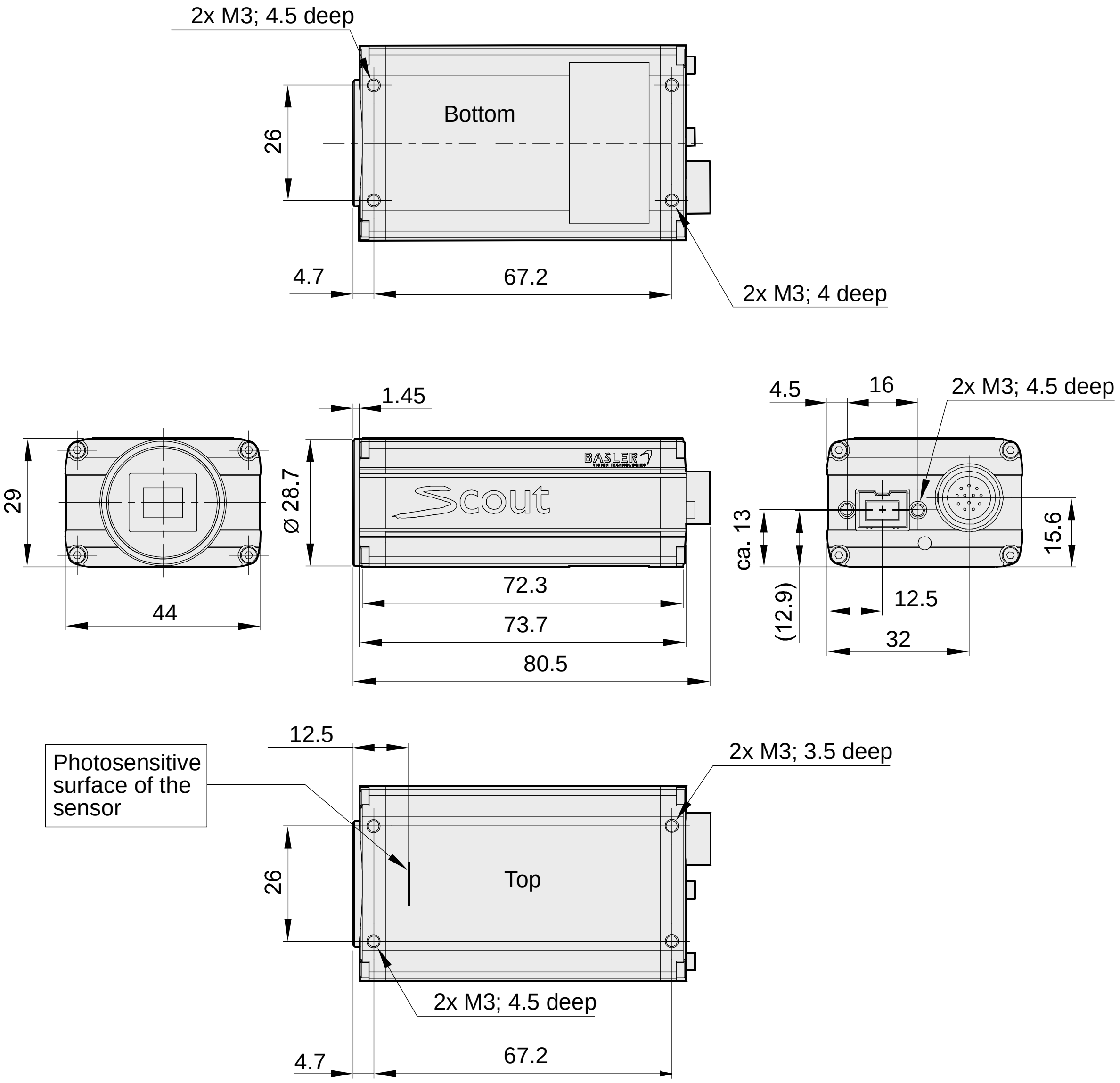
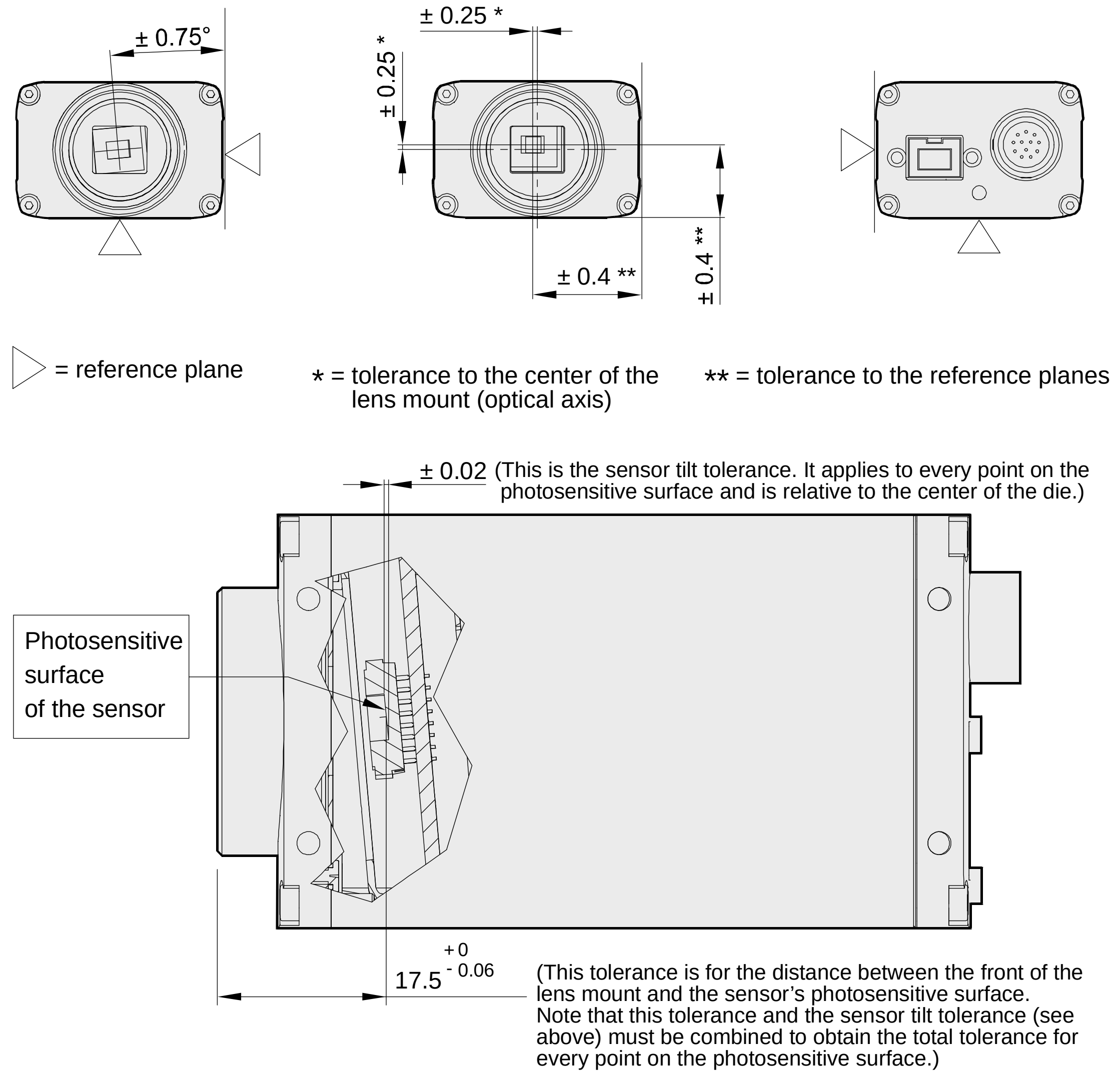


Fig. 22: Mechanical Dimensions (in mm) for Cameras with an Option CS-mount Lens Adapter

1.5.1.2 Sensor Positioning Accuracy

The sensor positioning accuracy for cameras equipped with a standard C-mount lens adapter is as shown in Figure 23. The sensor positioning accuracy for cameras equipped with an optional CS-mount lens adapter is as shown in Figure 24 on page 26.

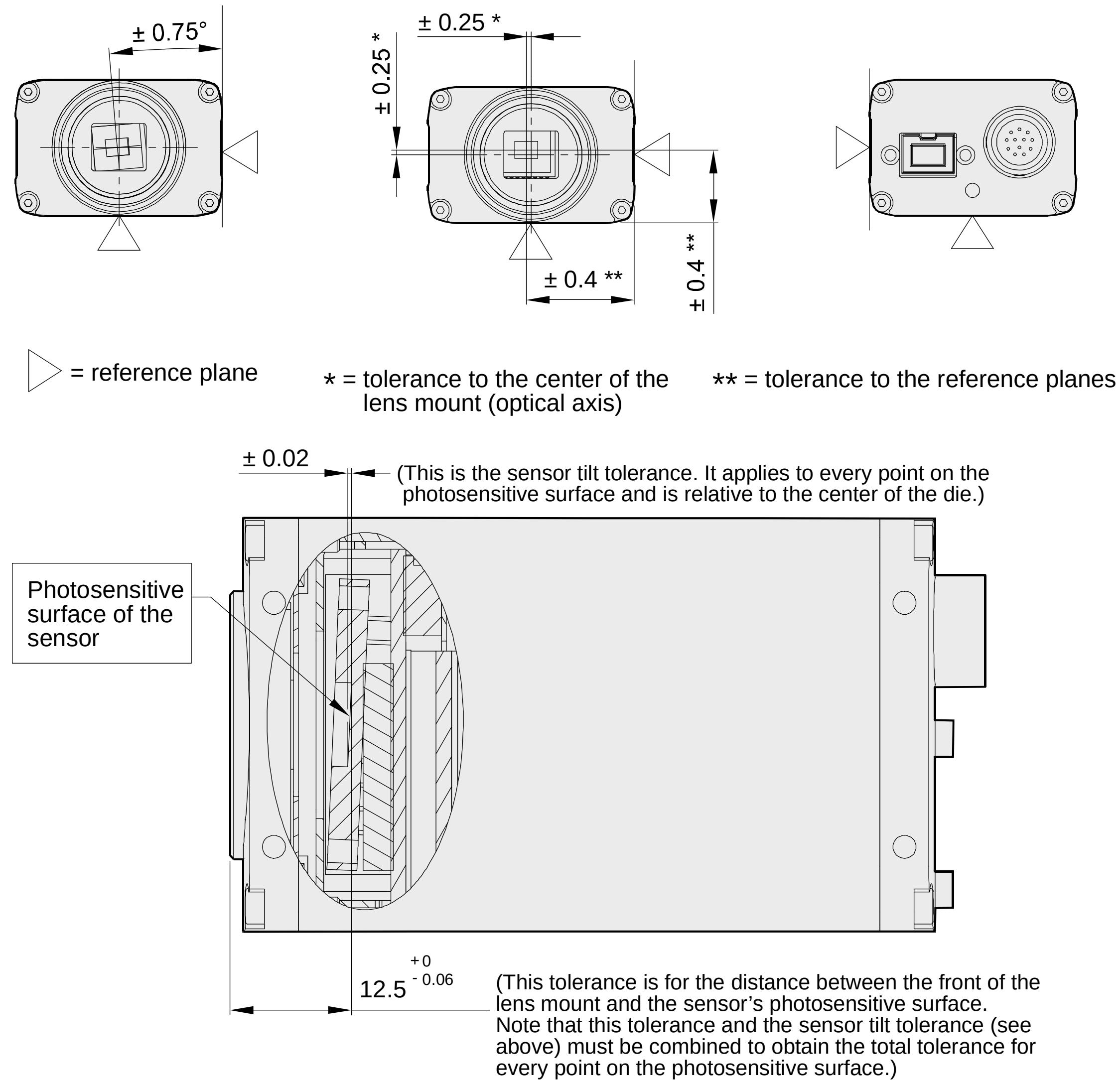

± 0.75°
± 0.25 *
± 0.25 *
± 0.4 **
± 0.4 **
▷ = reference plane
* = tolerance to the center of the lens mount (optical axis)
** = tolerance to the reference planes
± 0.02
Photosensitive surface of the sensor
$17.5^{+0}_{-0.06}$

(This is the sensor tilt tolerance. It applies to every point on the photosensitive surface and is relative to the center of the die.)

(This tolerance is for the distance between the front of the lens mount and the sensor's photosensitive surface. Note that this tolerance and the sensor tilt tolerance (see above) must be combined to obtain the total tolerance for every point on the photosensitive surface.)

Maximum Sensor Tilt Angle (Degrees)					
Camera Model	**Tilt X**	**Tilt Y**	**Camera model**	**Tilt X**	**Tilt Y**
scA640-70fm/fc	0.47	0.63	scA1000-30fm/fc	0.46	0.63
scA640-74fm/fc	0.35	0.47	scA1300-32fm/fc	0.47	0.63
scA640-120fm/fc	0.62	0.83	scA1390-17fm/fc	0.31	0.42
scA750-60fm/fc	0.51	0.80	scA1400-17fm/fc	0.25	0.34
scA780-54fm/fc	0.35	0.47	scA1400-30fm/fc	0.25	0.34
scA1000-20fm/fc	0.46	0.63	scA1600-14fm/fc	0.34	0.52

Fig. 23: Sensor Positioning Accuracy for Cameras with the Standard C-mount Lens Adapter (in mm unless otherwise noted)



▷ = reference plane

* = tolerance to the center of the lens mount (optical axis)

** = tolerance to the reference planes

(This is the sensor tilt tolerance. It applies to every point on the photosensitive surface and is relative to the center of the die.)

(This tolerance is for the distance between the front of the lens mount and the sensor’s photosensitive surface. Note that this tolerance and the sensor tilt tolerance (see above) must be combined to obtain the total tolerance for every point on the photosensitive surface.)

Maximum Sensor Tilt Angle (Degrees)					
Camera Model	**Tilt X**	**Tilt Y**	**Camera Model**	**Tilt X**	**Tilt Y**
scA640-70fm/fc	0.47	0.63	scA1000-30fm/fc	0.46	0.63
scA640-74fm/fc	0.35	0.47	scA1300-32m/fc	0.47	0.63
scA640-120fm/fc	0.62	0.83	scA1390-17fm/fc	0.31	0.42
scA750-60fm/fc	0.51	0.80	scA1400-17fm/fc	0.25	0.34
scA780-54fm/fc	0.35	0.47	scA1400-30fm/fc	0.25	0.34
scA1000-20fm/fc	0.46	0.63	scA1600-14fm/fc	0.34	0.52

Fig. 24: Sensor Positioning Accuracy for Cameras with an Optional CS-mount Lens Adapter (in mm unless otherwise noted)

1.5.2 90° Head Housing

The camera housing conforms to protection class IP30 provided the lens mount is covered by a lens or by the cap that is shipped with the camera.

1.5.2.1 Camera Dimensions and Mounting Points

In scout cameras with the 90° head housing the camera’s direction of view is at right angle to the direction of view of standard scout cameras.

The cameras are manufactured with high precision. Planar, parallel, and angular sides guarantee precise mounting with high repeatability.

The dimensions in millimeters for cameras equipped with a standard C-mount lens adapter are as shown in Figure 25.

Camera housings are equipped with four mounting holes on the top and four mounting holes on the bottom as shown in the drawings. In addition, there are four mounting holes in the front module (4x M3; 4.5 mm deep).

ⓘ **Note**

For optimum accuracy in the positioning of the camera's optical axis, we recommend using the front module reference plane (see the figure in the Sensor Positioning Accuracy section) as mounting surface.

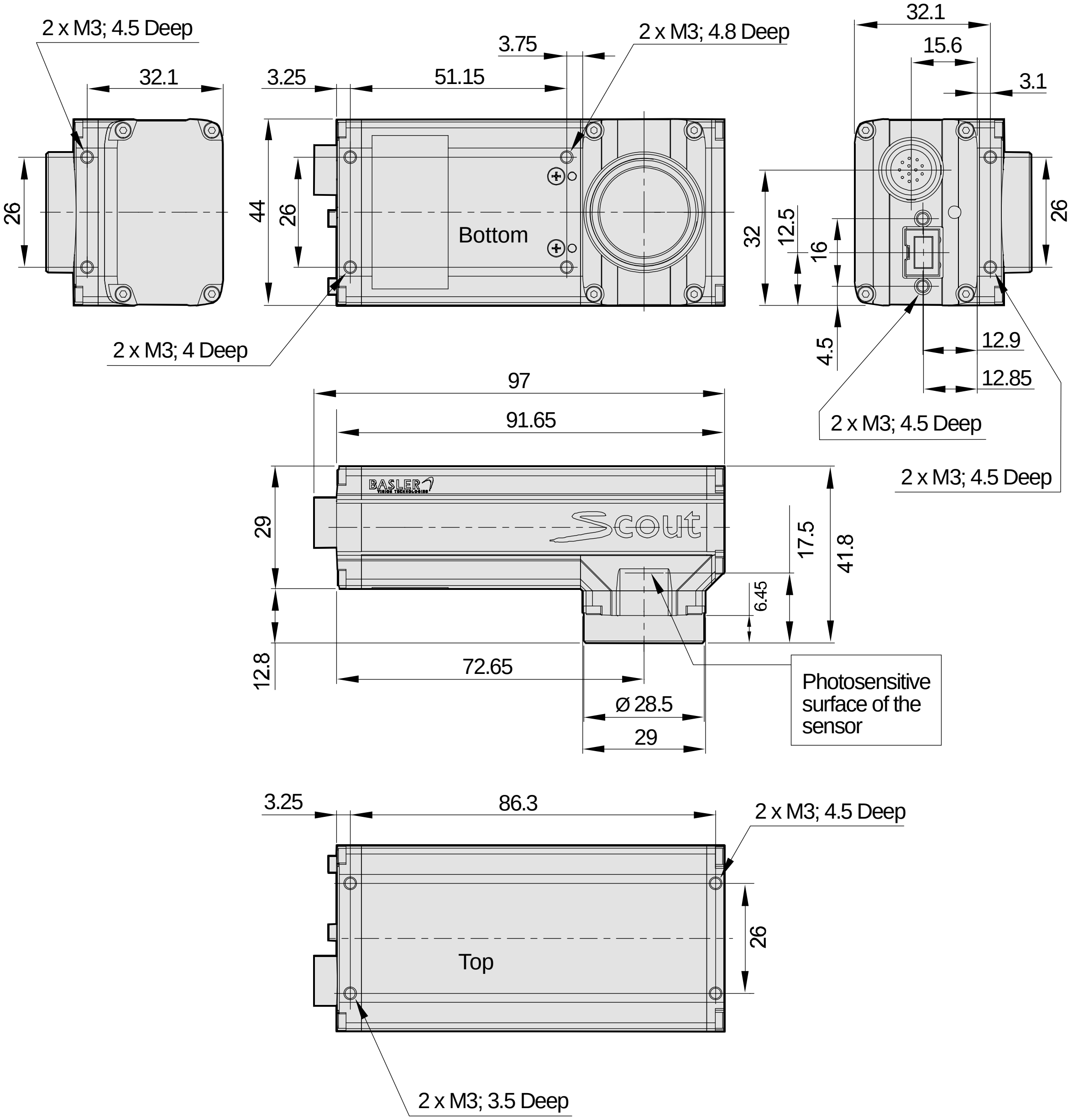
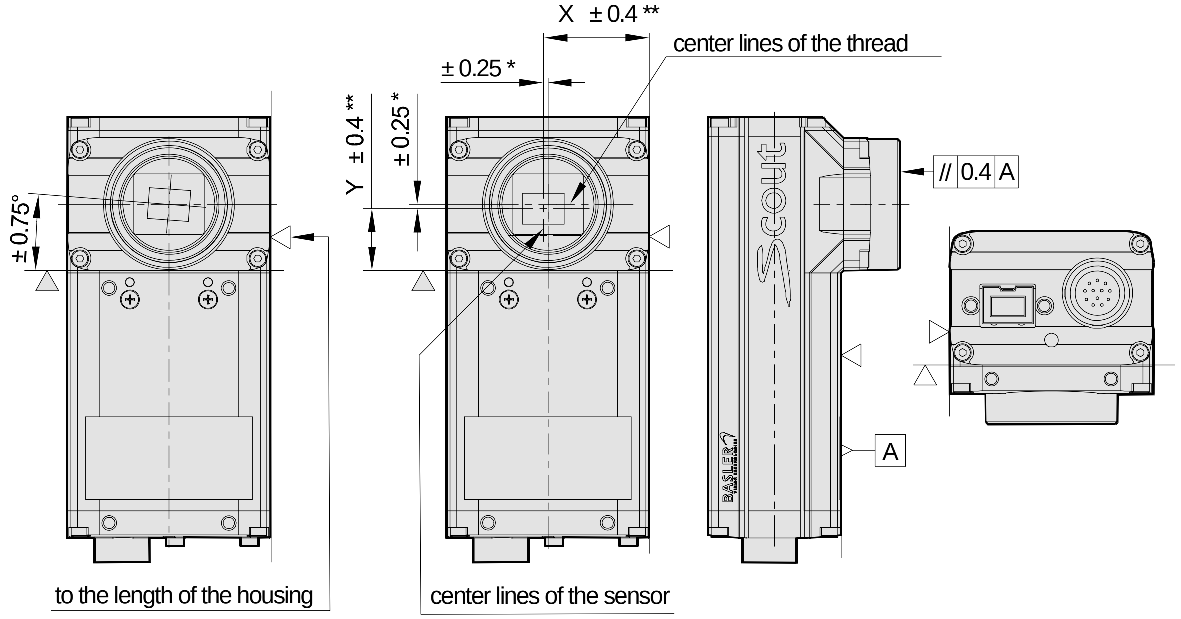


Fig. 25: Mechanical Dimensions (in mm) for Cameras (90° Head) with the Standard C-mount Lens Adapter

1.5.2.2 Sensor Positioning Accuracy

The sensor positioning accuracy for cameras equipped with a standard C-mount lens adapter is as shown in Figure 26.

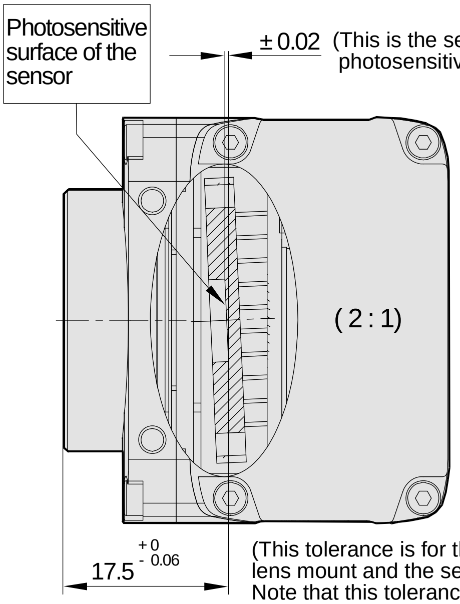

X ±0.4 **
±0.25 *
center lines of the thread
Y ±0.4 **
±0.25 *
±0.75°
// 0.4 A
A
to the length of the housing
center lines of the sensor

▷ = reference plane

▷ = front module reference plane

* = tolerance to the center of the lens mount (optical axis)

** = tolerance to the reference planes



(This is the sensor tilt tolerance. It applies to every point on the photosensitive surface and is relative to the center of the die)

Maximum Sensor Tilt Angle (Degrees)

Camera Model	Tilt X	Tilt Y	Camera Model	Tilt X	Tilt Y
scA640-70fm/fc	0.47	0.63	scA1000-30fm/fc	0.46	0.63
scA640-74fm/fc	0.35	0.47	scA1390-17fm/fc	0.31	0.42
scA640-120fm/fc	0.62	0.83	scA1400-17fm/fc	0.25	0.34
scA750-60fm/fc	0.51	0.80	scA1400-30fm/fc	0.25	0.34
scA780-54fm/fc	0.35	0.47	scA1600-14fm/fc	0.34	0.52
scA1000-20fm/fc	0.46	0.63			

(This tolerance is for the distance between the front of the lens mount and the sensor's photosensitive surface. Note that this tolerance and the sensor tilt tolerance (see above) must be combined to obtain the total tolerance for every point on the photosensitive surface.)

Fig. 26: Sensor Positioning Accuracy for Cameras (90° Head) with the Standard C-mount Lens Adapter (in mm unless otherwise noted)

1.5.3 Maximum Thread Length on Color Cameras

The C-mount lens adapter on color models of the camera is normally equipped with an internal IR cut filter. As shown below, the length of the threads on any lens you use with a color camera must be less than 8.0 mm. If a lens with a longer thread length is used, the IR cut filter will be damaged or destroyed and the camera will no longer operate.

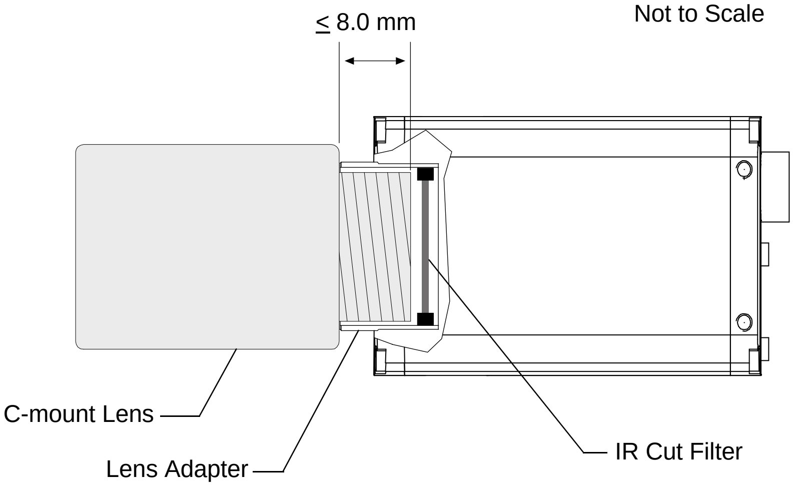


Fig. 27: Maximum Lens Thread Length on Color Cameras

Note

An internal IR cut filter is not included on color cameras equipped with the optional CS-mount adapter.

C-mount color cameras that do not include an internal IR cut filter are available on request.

Monochrome cameras are not normally equipped with an internal IR cut filter, however, they can be equipped with an internal filter on request.

1.5.4 Mechanical Stress Test Results

Scout cameras were submitted to an independent mechanical testing laboratory and subjected to the stress tests listed below. The mechanical stress tests were performed on selected camera models with standard housings. After mechanical testing, the cameras exhibited no detectable physical damage and produced normal images during standard operational testing.

Test	Standard	Conditions
Vibration (sinusoidal, each axis)	DIN EN 60068-2-6	10-58 Hz / 1.5 mm_58-500 Hz / 20 g_1 Octave/Minute 10 repetitions
Shock (each axis)	DIN EN 60068-2-27	20 g / 11 ms / 10 shocks positive 20 g / 11 ms / 10 shocks negative
Bump (each axis)	DIN EN 60068-2-29	20 g / 11 ms / 100 shocks positive 20 g / 11 ms / 100 shocks negative
Vibration (broad-band random, digital control, each axis)	DIN EN 60068-2-64	15-500 Hz / 0.05 PSD (ESS standard profile) / 00:30 h

Table 5: Mechanical Stress Tests

The mechanical stress tests were performed with a dummy lens connected to a C-mount. The dummy lens was 35 mm long and had a mass of 66 g. Using a heavier or longer lens requires an additional support for the lens.

1.6 Software Licensing Information

The software in the camera includes the LWIP TCP/IP implementation. The copyright information for this implementation is as follows:

Copyright (c) 2001, 2002 Swedish Institute of Computer Science. All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. The name of the author may not be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED.

IN NO EVENT SHALL THE AUTHOR BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

1.7 Avoiding EMI and ESD Problems

The cameras are frequently installed in industrial environments. These environments often include devices that generate electromagnetic interference (EMI) and they are prone to electrostatic discharge (ESD). Excessive EMI and ESD can cause problems with your camera such as false triggering or can cause the camera to suddenly stop capturing images. EMI and ESD can also have a negative impact on the quality of the image data transmitted by the camera.

To avoid problems with EMI and ESD, you should follow these general guidelines:

- Always use high quality shielded cables. The use of high quality cables is one of the best defenses against EMI and ESD.
- Try to use camera cables that are the correct length and try to run the camera cables and power cables parallel to each other. Avoid coiling camera cables. If the cables are too long, use a meandering path rather then coiling the cables.
- Avoid placing camera cables parallel to wires carrying high-current, switching voltages such as wires supplying stepper motors or electrical devices that employ switching technology. **Placing camera cables near to these types of devices may cause problems with the camera.**
- Attempt to connect all grounds to a single point, e.g., use a single power outlet for the entire system and connect all grounds to the single outlet. This will help to avoid large ground loops. (Large ground loops can be a primary cause of EMI problems.)
- Use a line filter on the main power supply.
- Install the camera and camera cables as far as possible from devices generating sparks. If necessary, use additional shielding.
- Decrease the risk of electrostatic discharge by taking the following measures:
  - Use conductive materials at the point of installation (e.g., floor, workplace).
  - Use suitable clothing (cotton) and shoes.
  - Control the humidity in your environment. Low humidity can cause ESD problems.

Note

The Basler application note called *Avoiding EMI and ESD in Basler Camera Installations* provides much more detail about avoiding EMI and ESD.
The application note can be downloaded at:
www.baslerweb.com/indizes/download_index_en_31412.html

1.8 Environmental Requirements

1.8.1 Temperature and Humidity

Housing temperature during operation:	0 °C ... +50 °C (+32 °F ... +122 °F)
Humidity during operation:	20 % ... 80 %, relative, non-condensing
Storage temperature:	-20 °C ... +80 °C (-4 °F ... +176 °F)
Storage humidity:	20 % ... 80 %, relative, non-condensing

1.8.2 Ventilation

Allow sufficient air circulation around the camera to prevent internal heat build-up in your system and to keep the camera's housing temperature below 50 °C. Additional cooling devices such as fans or heat sinks are not normally required, but should be provided if necessary.

1.9 Precautions

CAUTION

Avoid Dust on the Sensor

The camera is shipped with a cap on the lens mount. To avoid collecting dust on the camera's IR cut filter (color cameras) or sensor (mono cameras), make sure that you always put the cap in place when there is no lens mounted on the camera.

To further enhance dust protection, the internal space in the camera that contains the imaging sensor is sealed off from the camera's other internal spaces.

CAUTION

Lens Thread Length is Limited

Color models of the camera with a C-mount lens adapter are equipped with an IR cut filter mounted inside of the adapter. The location of this filter limits the length of the threads on any lens you use with the camera. If a lens with a very long thread length is used, the IR cut filter will be damaged or destroyed and the camera will no longer operate.

For more specific information about the lens thread length, see Section 1.5.3 on page 30.

CAUTION

Incorrect Power Can Cause Damage

The polarity of the power on the camera's IEEE 1394b socket must be as shown in the pin assignment table. **Do not** reverse the power polarity. Reversing the polarity will damage the camera.

If the voltage to the camera is greater than +36 VDC, damage to the camera can result. If the voltage is less than +8 VDC, the camera may operate erratically.

CAUTION

Inappropriate Code May Cause Unexpected Camera Behavior

The code snippets provided in this manual are included as sample code only. Inappropriate code may cause your camera to function differently than expected and may compromise your application.

To ensure that the snippets will work properly in your application, you must adjust them to meet your specific needs and must test them thoroughly prior to use.

Warranty Precautions

To ensure that your warranty remains in force:

Do not remove the camera’s serial number label

If the label is removed and the serial number can’t be read from the camera’s registers, the warranty is void.

Do not open the camera housing

Do not open the housing. Touching internal components may damage them.

Keep foreign matter outside of the camera

Be careful not to allow liquid, flammable, or metallic material inside of the camera housing. If operated with any foreign matter inside, the camera may fail or cause a fire.

Avoid Electromagnetic fields

Do not operate the camera in the vicinity of strong electromagnetic fields. Avoid electrostatic charging.

Transport Properly

Transport the camera in its original packaging only. Do not discard the packaging.

Clean Properly

Avoid cleaning the surface of the camera’s sensor if possible. If you must clean it, use a soft, lint free cloth dampened with a small quantity of high quality window cleaner. Because electrostatic discharge can damage the sensor, you must use a cloth that will not generate static during cleaning (cotton is a good choice).

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

Do not use solvents or thinners to clean the housing; they can damage the surface finish.

Read the manual

Read the manual carefully before using the camera!

2 Software and Hardware Installation

The information you will need to install and operate the camera is included in the Installation and Setup Guide for Cameras Used with Basler's pylon API, (AW000611xx000).

You can download the guide from the Basler website:
www.baslerweb.com/indizes/download_index_en_19627.html.

The guide includes information about both hardware and software and describes how to begin capturing images.

3 Tools for Changing Camera Parameters

This section explains the options available for changing the camera's parameters. The available options let you change parameters either by using stand-alone tools that access the camera via a GUI or by accessing the camera from within your software application.

3.1 The pylon Viewer

The Basler pylon Viewer is a standalone application that lets you view and change most of the camera's parameter settings via a GUI based interface. The viewer also lets you acquire images, display them, and save them. Using the pylon Viewer software is a very convenient way to get your camera up and running quickly when you are doing your initial camera evaluation or doing a camera design-in for a new project.

The pylon Viewer is included in Basler's pylon Driver Package. You can download the pylon package from the Basler website: www.baslerweb.com/beitraege/beitrag_en_71708.html.

For more information about using the viewer, see the Installation and Setup Guide for Cameras Used with Basler's pylon API, (AW000611xx000). You can download the guide from the Basler website: www.baslerweb.com/indizes/download_index_en_19627.html.

3.2 The pylon API

You can access all of the camera's parameters and can control the camera's full functionality from within your application software by using Basler's pylon API. The Basler pylon Programmer's Guide and API Reference contains an introduction to the API and includes information about all of the methods and objects included in the API.

The Basler pylon Software Development Kit (SDK) includes a set of sample programs that illustrate how to use the pylon API to parameterize and operate the camera. These samples include Microsoft® Visual Studio® solution and project files demonstrating how to set up the build environment to build applications based on the API.

The SDK is included in Basler's pylon Driver Package. You can download the pylon package from the Basler website: www.baslerweb.com/beitraege/beitrag_en_71708.html.

For more information about installing pylon software, see the installation and Setup Guide for Cameras Used with Basler’s pylon API (AW000611xx000). You can download the guide from the Basler website: www.baslerweb.com/indizes/download_index_en_19627.html.

4 Functional Description

This section provides an overview of the camera’s functionality from a system perspective. The overview will aid your understanding when you read the more detailed information included in the next chapters of the user’s manual.

4.1 Overview (All Models Except scA750-60)

Note

The information in this section applies to all camera models except the scA750-60 fm/fc. For information about scA750-60 cameras, see Section 4.2 on page 43.

Each camera provides features such as a full frame shutter and electronic exposure time control.

Exposure start, exposure time, and charge readout can be controlled by parameters transmitted to the camera via the Basler pylon API and the IEEE 1394b interface. There are also parameters available to set the camera for single frame acquisition or continuous frame acquisition.

Exposure start can also be controlled via an externally generated hardware trigger (ExTrig) signal. The ExTrig signal facilitates periodic or non-periodic acquisition start. Modes are available that allow the length of exposure time to be directly controlled by the ExTrig signal or to be set for a pre-programmed period of time.

Accumulated charges are read out of the sensor when exposure ends. At readout, accumulated charges are transported from the sensor’s light-sensitive elements (pixels) to the vertical shift registers (see Figure 28 on page 42). The charges from the bottom line of pixels in the array are then moved into a horizontal shift register. Next, the charges are shifted out of the horizontal register. As the charges move out of the horizontal shift register, they are converted to voltages proportional to the size of each charge. Each voltage is then amplified by a Variable Gain Control (VGC) and digitized by an Analog-to-Digital converter (ADC). After each voltage has been amplified and digitized, it passes through an FPGA and into an image buffer. All shifting is clocked according to the camera’s internal data rate. Shifting continues in a linewise fashion until all image data has been read out of the sensor.

The pixel data leaves the image buffer and passes back through the FPGA to an IEEE1394b link layer controller where it is assembled into data packets. The packets are passed to a 1394b physical layer controller which transmits them isochronously to an interface board in the host PC. The physical and link layer controllers also handle transmission and receipt of asynchronous control data such as changes to the camera’s parameters.

The image buffer between the sensor and the link layer controller allows data to be read out of the sensor at a rate that is independent of the data transmission rate between the camera and the host computer. This ensures that the data transmission rate has no influence on image quality.

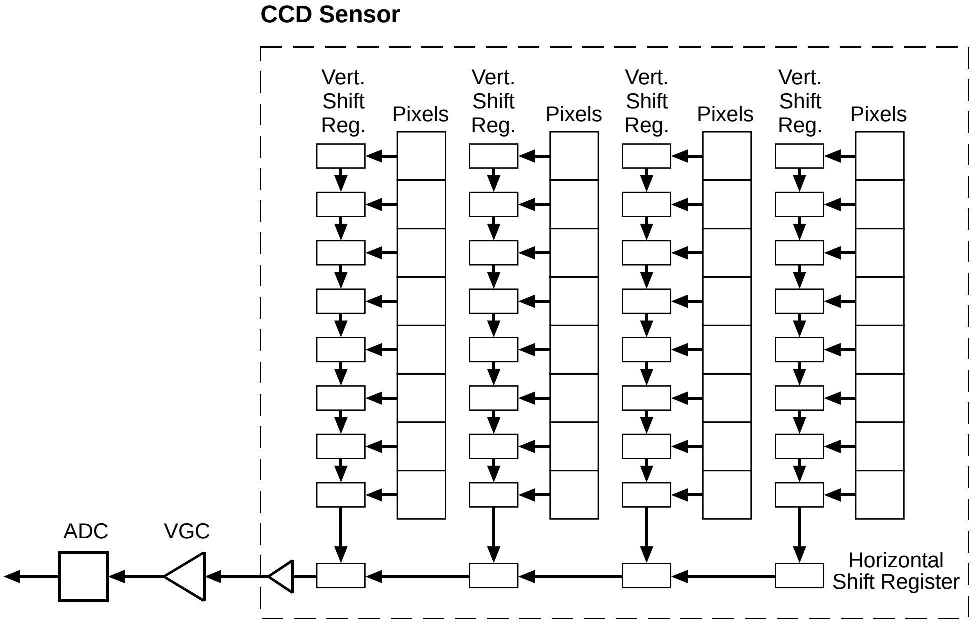


Fig. 28: CCD Sensor Architecture

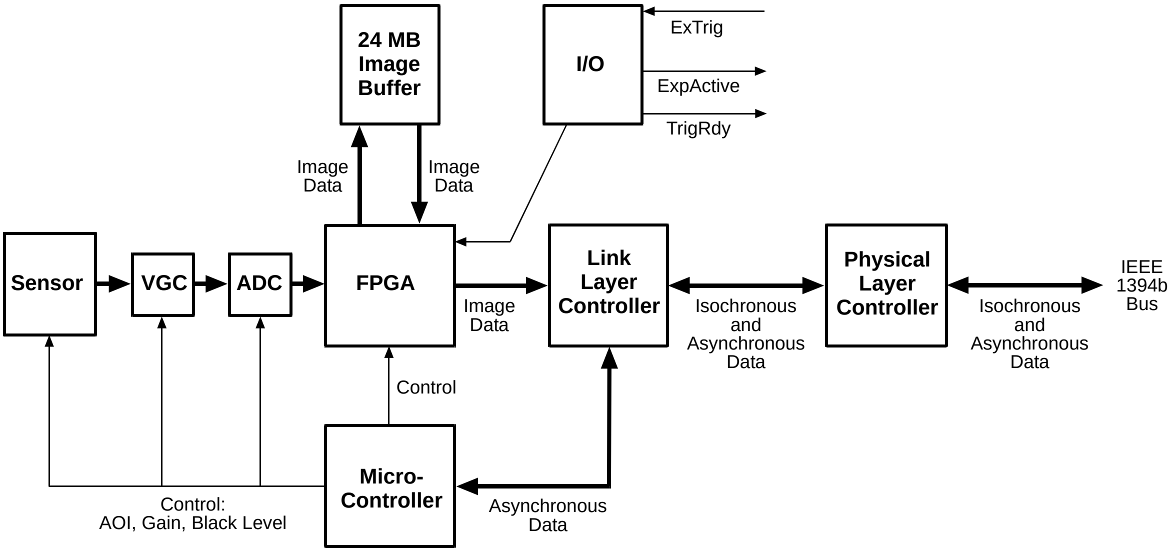


Fig. 29: Camera Block Diagram

4.2 Overview (scA750-60 Only)

Note

The information in this section only applies to scA750-60 fm/fc cameras. For information about the other camera models, see Section 4.1 on page 41.

Each camera provides features such as a full frame shutter and electronic exposure time control. The sensor chip includes gain controls, ADCs, and other digital devices.

Exposure start, exposure time, and charge readout can be controlled by parameters transmitted to the camera via the Basler pylon API and the GigE interface. There are also parameters available to set the camera for single frame acquisition or continuous frame acquisition.

Exposure start can also be controlled via an externally generated hardware trigger (ExTrig) signal. The ExTrig signal facilitates periodic or non-periodic acquisition start. Exposure can be set for a preprogrammed period of time.

Accumulated charges are read out when the programmed exposure time ends. At readout, the accumulated charges are transported from the sensor's light-sensitive elements (pixels) to the sensor's column buses (see Figure 28 on page 42). The charges from the bottom line of pixels in the array are then moved into the analog processing section of the sensor. As the charges move from the pixels to the analog processing section, they are converted to voltages proportional to the size of each charge. The voltages from the analog processing section are next passed to a bank of Analog-to-Digital converters (ADCs).

Finally, the voltages pass through a section of the sensor where they receive additional digital processing and then they are moved out of the sensor. As each voltage leaves the sensor, it passes through an FPGA and into an image buffer. All shifting is clocked according to the camera's internal data rate. Shifting continues in a linewise fashion until all image data has been read out of the sensor.

The pixel data leaves the image buffer and passes back through the FPGA to an IEEE1394b link layer controller where it is assembled into data packets. The packets are passed to a 1394b physical layer controller which transmits them isochronously to an interface board in the host PC. The physical and link layer controllers also handle transmission and receipt of asynchronous control data such as changes to the camera's parameters.

The image buffer between the sensor and the link layer controller allows data to be read out of the sensor at a rate that is independent of the data transmission rate between the camera and the host computer. This ensures that the data transmission rate has no influence on image quality.

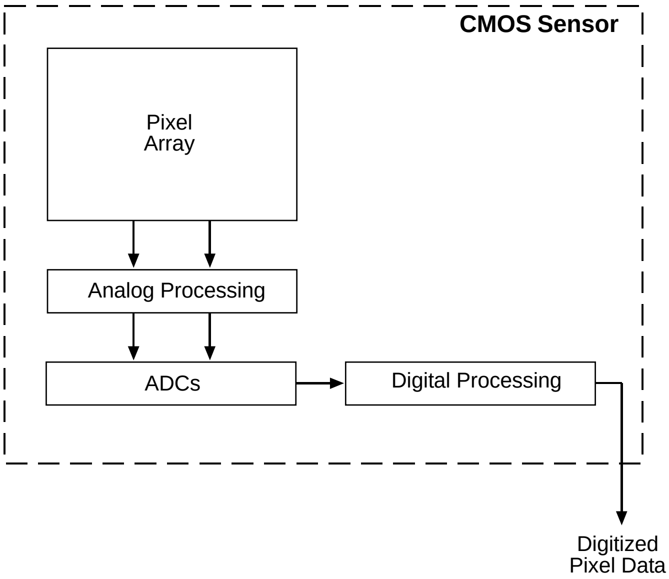


Fig. 30: CMOS Sensor Architecture

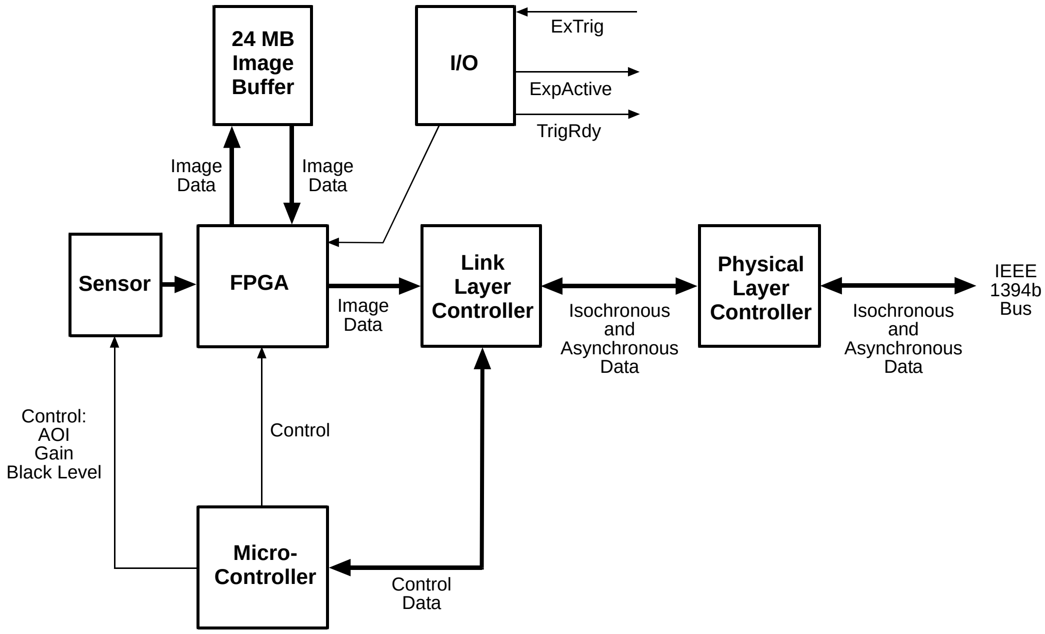


Fig. 31: Camera Block Diagram

5 Physical Interface

This section provides detailed information, such as pinouts and voltage requirements, for the physical interface on the camera. This information will be especially useful during your initial design-in process.

5.1 General Description of the Connections

The camera is interfaced to external circuity via connectors located on the back of the housing:

- an IEEE 1394b socket used to provide power and a bus connection to the camera.
- a 12-pin receptacle used to provide access to the camera’s I/O ports.

There is also an LED indicator on the back.

The drawing below shows the location of the two connectors and the LED.

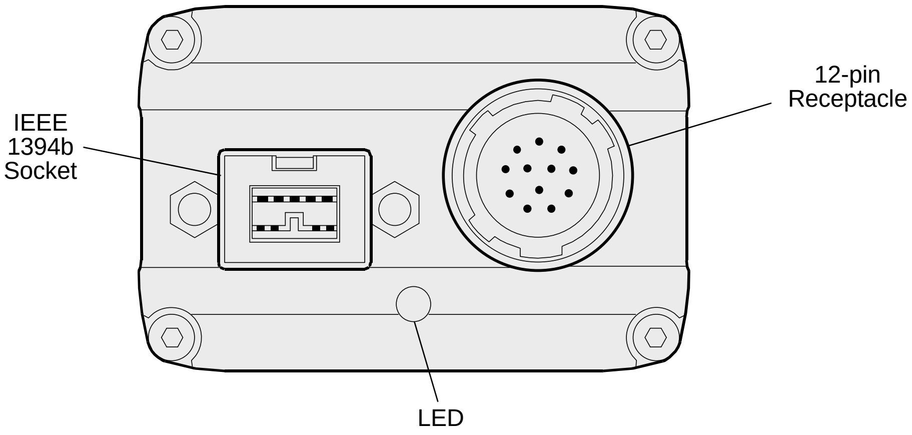


Fig. 32: Camera Connectors and LED

5.2 Connector Pin Assignments and Numbering

5.2.1 IEEE 1394b Socket Pin Assignments

The IEEE 1394b socket is used to supply power to the camera and to interface video data and control signals. The pin assignments for the socket are as shown in Table 6. Note that these are the standard pin assignments for IEEE 1394b sockets.

Pin	Signal	
1	TPB -	(twisted pair B minus)
2	TPB +	(twisted pair B plus)
3	TPA -	(twisted pair A minus)
4	TPA +	(twisted pair A plus)
5	TPA R	(twisted pair A ground)
6	VG	(power ground)
7	Not connected	
8	VP	(+8 to +36 VDC power)
9	TPB R	(twisted pair B ground)

Table 6: Pin Assignments for the IEEE 1394b Socket

Pin numbering for the IEEE 1394b socket is as shown in Section 5.2.3 on page 47.

5.2.2 12-pin Receptacle Pin Assignments

The 12 pin receptacle is used to access the two physical input lines and four physical output lines on the camera. The pin assignments for the receptacle are shown in Table 7.

Pin	Designation
1	Not connected
2	Not connected
3	I/O Input 1
4	I/O Input 2
5	I/O Input Gnd
6	I/O Output 1
7	I/O Output 2
8	Not connected
9	Not connected
10	I/O Output VCC
11	I/O Output 3
12	I/O Output 4

Table 7: Pin Assignments for the 12-pin Receptacle

Pin numbering for the 12-pin receptacle is as shown in Section 5.2.3 on page 47.

5.2.3 Pin Numbering

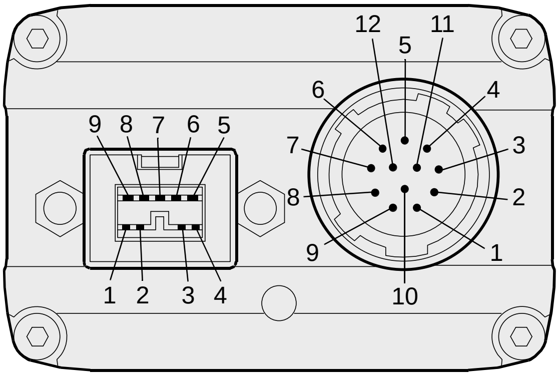


Fig. 33: Pin Numbering for the IEEE 1394b Socket and the 12-pin Receptacle

5.3 Connector Types

5.3.1 IEEE 1394b Connector

The 1394b socket on the camera is a standard, 9-pin IEEE 1394b bilingual socket.

The recommended mating connector is any standard, 9-pin IEEE 1394b plug.

5.3.2 12-pin Connector

The 12-pin connector on the camera is a Hirose micro receptacle (part number HR10A-10R-12P) or the equivalent.

The recommended mating connector is the Hirose micro plug (part number HR10A-10P-12S) or the equivalent.

5.4 Cabling Requirements

5.4.1 IEEE 1394b Cable

The maximum length of the IEEE 1394b cable used between the camera and the adapter in your PC or between the camera and a 1394b hub is 4.5 meters as specified in the IEEE 1394 standard.

Standard, 9-pin, shielded 1394b to 1394b cables should be used.

> **Note**
>
> The camera is backward compatible with IEEE 1394a devices. If you will be connecting the camera to an IEEE 1394a device, you must use a conversion cable. The cable should have a 9-pin IEEE 1394b plug on the end that connects to the camera and a 6-pin IEEE 1394a plug on the end that connects to the device.

5.4.2 Standard I/O Cable

> **Note**
>
> The standard I/O cable is intended for use if the camera is not connected to a PLC device. If the camera is connected to a PLC device, we recommend using a PLC I/O cable rather than the standard I/O cable.
>
> You can use a PLC I/O cable when the camera is not connected to a PLC device, if power for the I/O input is supplied with 24 VDC.
>
> See the following section for more information on PLC I/O cables.

The end of the standard I/O cable that connects to the camera must be terminated with a Hirose micro plug (part number HR10A-10P-12S) or the equivalent. The cable must be wired as shown in Figure 34.

The maximum length of the standard I/O cable is at least 10 meters. The cable must be shielded and must be constructed with twisted pair wire. Use of twisted pair wire is essential to ensure that input signals are correctly received.

Close proximity to strong magnetic fields should be avoided.

The required 12-pin Hirose plug is available from Basler. Basler also offers a standard I/O cable assembly that is terminated with a 12-pin Hirose plug on one end and unterminated on the other. Contact your Basler sales representative to order connectors or standard I/O cables.

CAUTION

An Incorrect Plug Can Damage the 12-pin Connector

The plug on the cable that you attach to the camera's 12-pin connector must have 12 pins. Use of a smaller plug, such as one with 10 pins or 8 pins, can damage the pins in the camera's 12-pin connector.

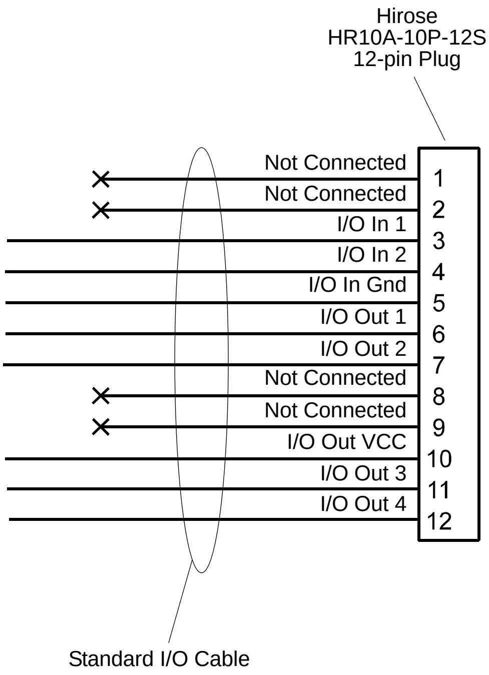


Fig. 34: Standard I/O Cable

5.4.3 PLC I/O Cable

As with the standard I/O cable described in the previous section, the PLC I/O cable is a single cable that connects to the camera’s I/O lines.

The PLC I/O cable adjusts the voltage levels of PLC devices to the voltage levels required by the camera, and it protects the camera against negative voltage and reverse polarity.

Close proximity to strong magnetic fields should be avoided.

Note

We recommend using a PLC I/O cable if the camera is connected to a PLC device.

If power for the I/O input is supplied at 24 VDC, you can also use a PLC I/O cable when the camera is not connected to a PLC device.

Basler offers PLC I/O cables with 3 meter and 10 meter lengths. Each cable is terminated with a 12-pin Hirose plug (HR10A-10P-12S) on the end that connects to the camera. The other end is unterminated. Contact your Basler sales representative to order the cables.

For information about the applicable voltage levels, see Section 5.7.1.1 on page 53.

5.5 IEEE 1394b Device Information

The camera uses an IEEE1394b - 2002 compliant physical layer device that can transmit at speeds up to 800 Mbit/s (S800). The device is backward compatible with IEEE 1394a - 2000 devices.

Detailed spec sheets for IEEE 1394b - 2002 compliant physical layer devices of the type used in the camera are available at the Texas Instruments website: www.ti.com.

5.6 Camera Power

Camera power must be supplied to the camera via the IEEE 1394b cable. Power consumption is as shown in the specification tables in Section 1 of this manual.

If your camera is connected to an IEEE 1394b adapter in a desktop computer, consult the instructions for the adapter and make sure that the adapter is properly configured to supply power to the camera.

If your camera is connected to a powered hub, consult the instructions for the hub and make sure that it is properly configured to supply power to the camera.

Many laptop computers have a connector for an IEEE 1394 device. In most cases, laptops **do not** supply power to the connected IEEE 1394 device. In this situation, you must use a powered hub between the laptop and the camera or you must install a PCMCIA IEEE 1394 adapter card that connects to an external power supply.

CAUTION

Incorrect Power Can Cause Damage

The polarity of the power on the camera's IEEE 1394b socket must be as shown in the pin assignment table. **Do not** reverse the power polarity. Reversing the polarity will damage the camera.

If the voltage supplied to the camera is greater than +36 VDC, damage to the camera can result. If the voltage is less than +8 VDC, the camera may operate erratically.

The following voltage requirements apply to the camera power (supplied via the IEEE 1394b cable):

Voltage	Significance
< +8 VDC	The camera may operate erratically.
+12 VDC	Recommended operating voltage; < 1 % ripple required.
+36 VDC	Absolute maximum; the camera may be damaged when the absolute maximum is exceeded.

Table 8: Voltage Requirements for the Camera Power

5.7 Input and Output Lines

5.7.1 Input Lines

5.7.1.1 Voltage Requirements

ⓘ **Note**

Different voltage levels apply depending on whether you are using a standard I/O cable or a PLC I/O cable (see below).

Voltage Levels When the Standard I/O Cable is Used

When a standard I/O cable is used, the following voltage requirements apply to the camera's I/O inputs (pins 3 and 4 of the 12-pin receptacle):

Voltage	Significance
+0 to +24 VDC	Recommended operating voltage.
+0 to +1.4 VDC	The voltage indicates a logical 0.
> +1.4 to +2.2 VDC	Region where the transition threshold occurs; the logical state is not defined in this region.
> +2.2 VDC	The voltage indicates a logical 1.
+30.0 VDC	Absolute maximum; the camera may be damaged if the absolute maximum is exceeded.

Table 9: Voltage Requirements for the I/O Input When Using the Standard I/O Cable

Voltage Levels When a PLC I/O Cable is Used

When a PLC I/O cable is used, the following voltage requirements apply to the inputs to the PLC I/O cable. The PLC I/O cable will adjust the voltages to the levels required at the camera's I/O input (see the previous table).

Voltage	Significance
+0 to +24 VDC	Recommended operating voltage.
+0 to +8.4 VDC	The voltage indicates a logical 0.
> +8.4 to +10.4 VDC	Region where the transition threshold occurs; the logical state is not defined in this region.
> +10.4 VDC	The voltage indicates a logical 1.
+30.0 VDC	Absolute maximum; the camera may be damaged if the absolute maximum is exceeded.

Table 10: Voltage Requirements for the I/O Input When Using a PLC I/O Cable

5.7.1.2 Line Schematic

The camera is equipped with two physical input lines designated as Input Line 1 and Input Line 2. The input lines are accessed via the 12-pin receptacle on the back of the camera.

As shown in the I/O line schematic, each input line is opto-isolated. See the previous section for input voltages and their significances. The absolute maximum input voltage is +30.0 VDC. The current draw for each input line is between 5 and 15 mA.

Figure 35 shows an example of a typical circuit you can use to input a signal into the camera.

By default, Input Line 1 is assigned to receive an external hardware trigger (ExTrig) signal that can be used to control the start of image acquisition.

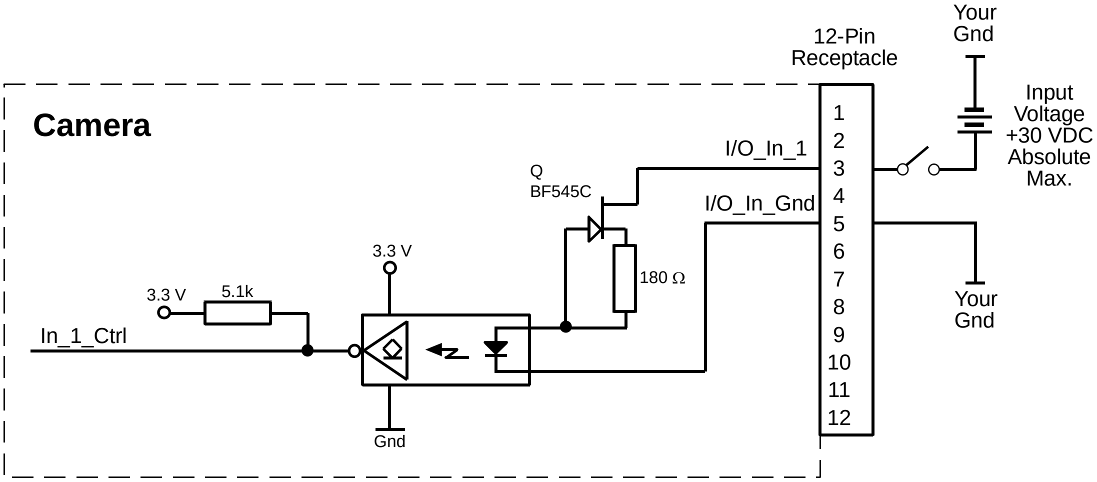


Fig. 35: Typical Input Circuit

For more information on input line pin assignments and pin numbering, see Section 5.2 on page 46.

For more information about how to use an ExTrig signal to control acquisition start, see Section 6.3 on page 68.

For more information about configuring the input lines, see Section 8.1 on page 127.

5.7.2 Output Lines

5.7.2.1 Voltage Requirements

The following voltage requirements apply to the I/O output VCC (pin 10 of the 12-pin receptacle):

Voltage	Significance
< +3.3 VDC	The I/O output may operate erratically.
+3.3 to +24 VDC	Recommended operating voltage.
+30.0 VDC	Absolute maximum; the camera may be damaged if the absolute maximum is exceeded.

Table 11: Voltage Requirements for the I/O Output VCC

5.7.2.2 Line Schematic

The camera is equipped with four physical output lines designated as Output Line 1, Output Line 2, Output Line 3, and Output Line 4. The output lines are accessed via the 12-pin receptacle on the back of the camera.

As shown in the I/O schematic, each output line is opto-isolated. See the previous section for the recommended operating voltage. The absolute maximum voltage is +30.0 VDC. The maximum current allowed through an output circuit is 100 mA.

A conducting transistor means a logical one and a non-conducting transistor means a logical zero.

Figure 36 shows a typical circuit you can use to monitor an output line with a voltage signal. The circuit in Figure 36 is monitoring output line 1.

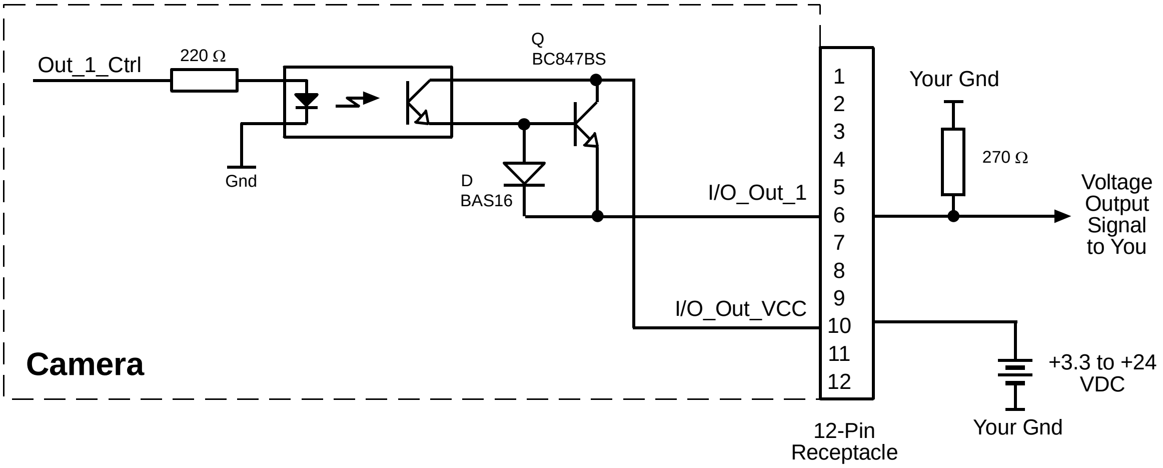


Fig. 36: Typical Voltage Output Circuit

Figure 37 shows a typical circuit you can use to monitor an output line with an LED or an opto-coupler. In this example, the voltage for the external circuit is +24 VDC. Current in the circuit is limited by an external resistor. The circuit in Figure 37 is monitoring output line 1.

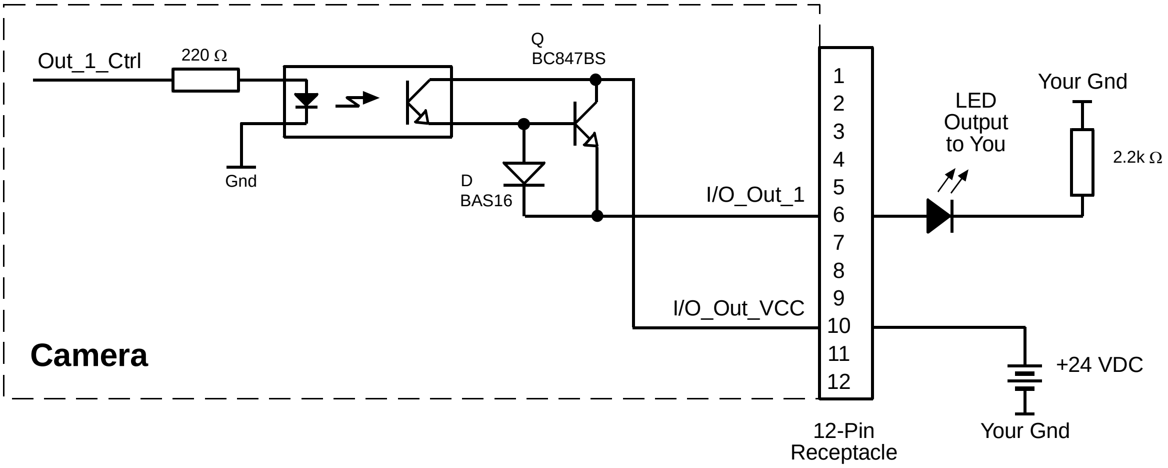


Fig. 37: Typical LED Output Signal at +24 VDC for the External Circuit (Example)

By default, the camera’s exposure active (ExpAc) signal is assigned to Output Line 1. The exposure active signal indicates when exposure is taking place.

By default, the camera’s trigger ready (TrigRdy) is assigned to Output Line 2. The trigger ready signal goes high to indicate the earliest point at which exposure start for the next frame can be triggered.

The assignment of camera output signals to physical output lines can be changed by the user.

For more information about output line pin assignments and pin numbering, see Section 5.2 on page 46.

For more information about the exposure active signal, see Section 6.8 on page 86.

For more information about the trigger ready signal, see Section 6.7 on page 82.

For more information about assigning camera output signals to physical output ports, see Section 8.2 on page 129.

5.7.3 Output Line Response Time

Response times for the output lines on the camera are as shown below.

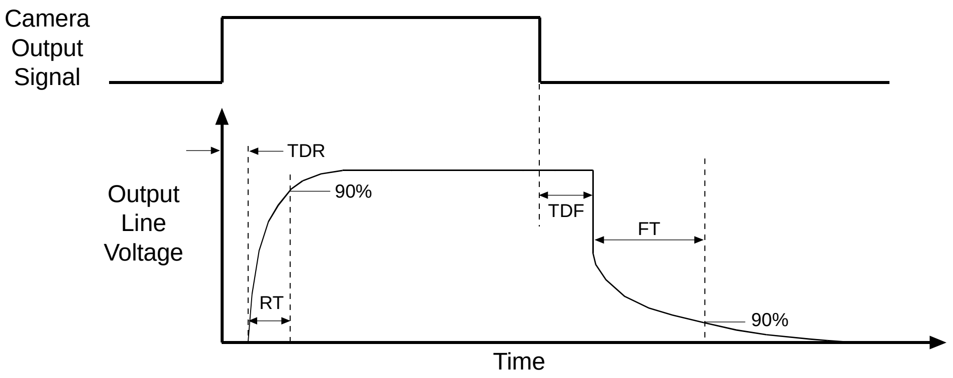


Fig. 38: Output Line Response Times

Time Delay Rise (TDR) = 1.5 µs

Rise Time (RT) = 1.3 - 5.0 µs

Time Delay Fall (TDF) = 1 - 20 µs

Fall Time (FT) = 1 - 5 µs

Note

The response times for the output lines on your camera will typically fall into the ranges specified above. The exact response time for your specific application will depend on the external resistor and the applied voltage you use.

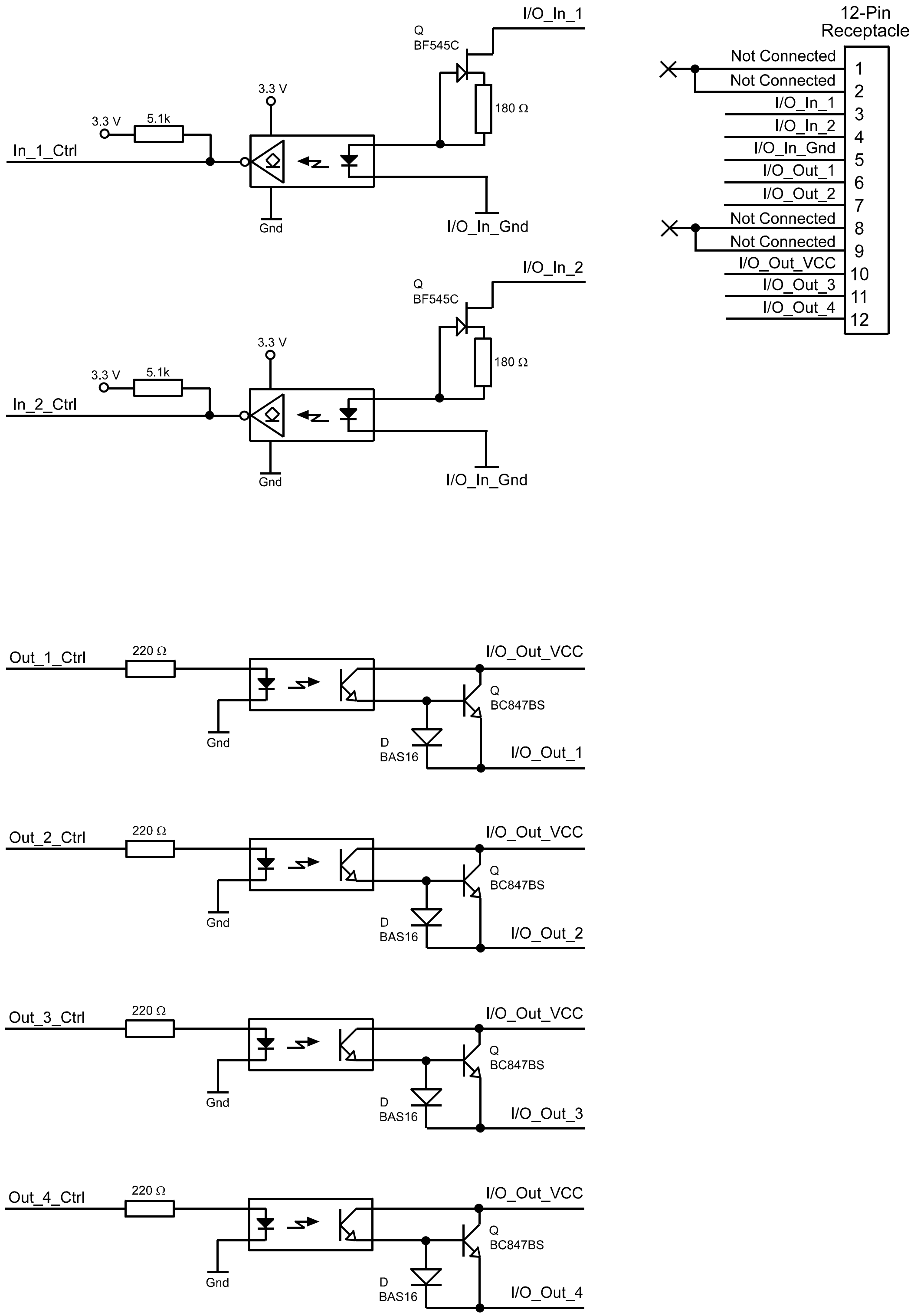


Fig. 39: I/O Line Schematic

6 Image Acquisition Control

This section provides detailed information about controlling image acquisition. You will find details about setting the exposure time for each acquired image and about how the camera's maximum allowed acquisition frame rate can vary depending on the current camera settings.

6.1 Controlling Image Acquisition with Parameters Only (No Triggering)

You can configure the camera so that image acquisition will be controlled by simply setting the value of several parameters via the camera's API. When the camera is configured to acquire images based on parameter values only, a software trigger or an external hardware trigger (ExTrig) signal is not required.

You can set the camera so that it will acquire images one at a time or so that it will acquire images continuously.

6.1.1 Switching Off Triggering

If you want to control image acquisition based on parameter settings alone, you must make sure that the camera's acquisition start trigger is set to off. Setting the acquisition start trigger is a two step process:

- First use the camera's Trigger Selector parameter to select the Acquisition Start trigger.
- Second use the camera's Trigger Mode parameter to set the selected trigger to Off.

You can set the Trigger Selector and the Trigger Mode parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
Camera.TriggerMode.SetValue( TriggerMode_Off );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

6.1.2 Acquiring One Image at a Time

In “single frame” operation, the camera acquires and transmits a single image. To select single frame operation, the camera’s Acquisition Mode parameter must be set to Single Frame.

To begin image acquisition, execute an Acquisition Start command. Exposure time is determined by the value of the camera’s exposure time parameter.

When using the single frame method to acquire images, you must not begin acquiring a new image until the previously captured image has been completely transmitted to the host PC.

You can set the Acquisition Mode parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
Camera.AcquisitionMode.SetValue( AcquisitionMode_SingleFrame );
```

You can also execute the Acquisition Start command by using the API.

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

For more information about the camera’s exposure time parameter, see Section 6.4 on page 75.

6.1.3 Acquiring Images Continuously (Free-run)

In “continuous frame” operation, the camera continuously acquires and transmits images. To select continuous frame operation, the camera’s Acquisition Mode parameter must be set to Continuous. (Note that operating the camera in continuous frame mode without the use of a trigger is also commonly called "free run".)

To begin acquiring images, issue an Acquisition Start command. The exposure time for each image is determined by the value of the camera’s exposure time parameter. Acquisition start for the second and subsequent images is automatically controlled by the camera. Image acquisition and transmission will stop when you execute an Acquisition Stop command.

When the camera is operating in continuous frame mode without triggering, the acquisition frame rate is determined by the Acquisition Frame Rate Abs parameter:

- If the parameter is enabled and set to a value less than the maximum allowed acquisition frame rate, the camera will acquire images at rate specified by the parameter setting.
- If the parameter is disabled or is set to a value greater than the maximum allowed acquisition frame rate, the camera will acquire images at the maximum allowed.

Note that before you can use the Acquisition Frame Rate Abs parameter to control the frame rate, the parameter must be enabled.

You can set the Acquisition Mode parameter value and you can enable and set the Acquisition Frame Rate Abs parameter from within your application software by using the pylon API. The following code snippets illustrate using the API to set the parameter values:

```
// set camera in continous mode
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );
// set a frame rate and getting the resulting frame rate
Camera.AcquisitionFrameRateEnable.SetValue( true );
Camera.AcquisitionFrameRateAbs.SetValue( 20.5 );
double resultingFrameRate = Camera.ResultingFrameRateAbs.GetValue();
```

You can also execute the Acquisition Start and Stop commands by using the API.

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

For more information about the camera’s exposure time parameter, see Section 6.4 on page 75.

For more information about determining the maximum allowed acquisition frame rate, see Section 6.10 on page 90.

Note

The explanations in Section 6.1.2 and Section 6.1.3 are intended to give you a basic idea of how parameters alone can be used to control image acquisition. For a more complete description, refer to the Basler pylon Programmer’s Guide and to the sample programs included in the Basler pylon Software Development Kit (SDK).

6.2 Controlling Image Acquisition with a Software Trigger

You can configure the camera so that image acquisition will be controlled by issuing a software trigger. The software trigger is issued by executing a Trigger Software command.

Image acquisition starts when the Trigger Software command is executed. The exposure time for each image is determined by the value of the camera’s exposure time parameter. Figure 40 illustrates image acquisition with a software trigger.

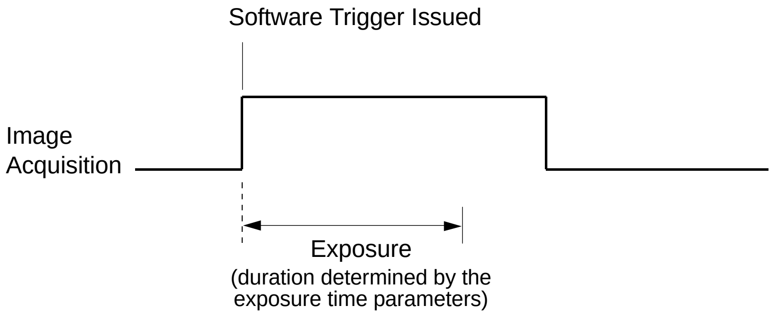


Fig. 40: Image Acquisition with a Software Trigger

When controlling image acquisition with a software trigger, you can set the camera so that it will react to a single software trigger or so that it will react to a continuous series of software triggers.

6.2.1 Enabling the Software Trigger Feature

To enable the software trigger feature:

- Use the camera’s Trigger Selector parameter to select the Acquisition Start trigger.
- Use the camera’s Trigger Mode parameter to set the mode to On.
- Use the camera’s Trigger Source parameter to set the trigger source to Software.
- Use the Exposure Mode parameter to set the exposure mode to timed.

You can set these parameter values from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter values:

```
Camera.TriggerSelector.SetValue(TriggerSelector_AcquisitionStart);
Camera.TriggerMode.SetValue( TriggerMode_On );
Camera.TriggerSource.SetValue( TriggerSource_Software );
Camera.ExposureMode.SetValue( ExposureMode_Timed );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

6.2.2 Acquiring a Single Image by Applying One Software Trigger

You can set the camera to react to a single software trigger and then issue a software trigger to begin image acquisition. To do so, follow this sequence:

1. Access the camera's API and set the exposure time parameter for your desired exposure time.
2. Set the value of the camera's Acquisition Mode parameter to Single Frame.
3. Execute an Acquisition Start command. This prepares the camera to react to a software trigger.
4. When you are ready to begin an image acquisition, execute a Trigger Software command.
5. Image acquisition will start and exposure will continue for the length of time you specified in step 1.
6. At the end of the specified exposure time, readout and transmission of the acquired image will take place.
7. At this point, the camera would ignore any additional software triggers. To acquire another image, you must:
   a. Repeat step 3 to prepare the camera to react to a software trigger.
   b. Repeat step 4 to issue a software trigger.

If you use the single image acquisition process repeatedly, you must not begin acquisition of a new image until transmission of the previously acquired image is complete.

You can set the exposure time and the Acquisition Mode parameter values from within your application software by using the pylon API. You can also execute the Acquisition Start and Trigger Software commands. The following code snippets illustrate using the API to set the parameter values and execute the commands:

```
Camera.ExposureTimeRaw.SetValue( 200 );
Camera.AcquisitionMode.SetValue( AcquisitionMode_SingleFrame );
// prepare for image capture
Camera.AcquisitionStart.Execute( );
Camera.TriggerSoftware.Execute( );
// retrieve the captured image
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

For more information about the camera's exposure time parameter, see Section 6.4 on page 75.

6.2.3 Acquiring Images by Applying a Series of Software Triggers

You can set the camera to react to multiple applications of the software trigger and then apply a series of software triggers to acquire images. To do so, follow this sequence:

1. Access the camera’s API and set the exposure time parameter for your desired exposure time.
2. Set the value of the camera’s Acquisition Mode parameter to Continuous.
3. Execute an Acquisition Start command. This prepares the camera to react to software triggers.
4. When you are ready to begin an image acquisition, execute a Trigger Software command.
5. Image acquisition will start and exposure will continue for the length of time you specified in step 1.
6. At the end of the specified exposure time, readout and transmission of the acquired image will take place.
7. To acquire another image, go to step 4.
8. Execute an Acquisition Stop command. The camera will no longer react to software triggers.

If you are acquiring images using a series of software triggers, you must avoid acquiring images at a rate that exceeds the maximum allowed with the current camera settings. You can use the Acquisition Status feature to determine when the camera is ready to be triggered for the next image acquisition.

You should also be aware that if the Acquisition Frame Rate Abs parameter is enabled, it will influence the rate at which the Trigger Software command can be applied:

- If the Acquisition Frame Rate Abs parameter is set to a value less than the maximum allowed, you can trigger acquisition at any rate up to the set value.
- If the Acquisition Frame Rate Abs parameter is set to a value greater than the maximum allowed, you can trigger acquisition at any rate up to the maximum allowed image acquisition rate with the current camera settings.

You can set the exposure time and the Acquisition Mode parameter values from within your application software by using the pylon API. You can also execute the Acquisition Start and Trigger Software commands. The following code snippets illustrate using the API to set the parameter values and execute the commands:

```
// issuing software trigger commands
Camera.ExposureTimeRaw.SetValue( 200 );
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );
// prepare for image acquisition here
     Camera.AcquisitionStart.Execute( );
     while ( ! finished )
     {
         Camera.TriggerSoftware.Execute( );
         // retrieve acquired image here
     }
     Camera.AcquisitionStop.Execute( );

// how to set and test the Acquisition Frame Rate
```

```
Camera.AcquisitionFrameRateAbs.SetValue( 60.0 );
double resultingFrameRate = Camera.ResultingFrameRateAbs.GetValue( );

// how to disable the FrameRateAbs parameter
Camera.AcquisitionFrameRateEnable.SetValue( false );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

For more information about the camera's exposure time parameter, see Section 6.4 on page 75.

For more information about determining the maximum allowed acquisition frame rate, see Section 6.10 on page 90.

For more information about the Acquisition Status feature, see Section 9.15 on page 190.

Note

The explanations in Section 6.2.2 and Section 6.2.3 are intended to give you a basic idea of how the use of a software trigger works. For a more complete description, refer to the Basler pylon Programmer's Guide and to the sample programs included in the Basler pylon Software Development Kit (SDK).

6.3 Controlling Image Acquisition with a Hardware Trigger

You can configure the camera so that an external hardware trigger (ExTrig) signal applied to one of the input lines will control image acquisition. A rising edge or a falling edge of the ExTrig signal can be used to trigger image acquisition.

The ExTrig signal can be periodic or non-periodic. When the camera is operating under control of an ExTrig signal, the period of the ExTrig signal will determine the rate at which the camera is acquiring images:

$$\frac{1}{\text{ExTrig period in seconds}} = \text{Acquisition Frame Rate}$$

For example, if you are operating a camera with an ExTrig signal period of 20 ms (0.020 s):

$$\frac{1}{0.020} = 50 \text{ fps}$$

So in this case, the acquisition frame rate is 50 fps.

The minimum high time for a rising edge trigger (or low time for a falling edge trigger) is 100 nanoseconds.

By default, input line 1 is assigned to receive an ExTrig signal.

When you are triggering image acquisition with an ExTrig signal, you must not acquire images at a rate that exceeds the maximum allowed for the current camera settings.

For more information about setting the camera for hardware triggering and selecting the input line to receive the ExTrig signal, see Section 6.3.2 on page 71.

For more information about determining the maximum allowed acquisition frame rate, see Section 6.10 on page 90.

6.3.1 Exposure Modes

If you are triggering exposure start with an ExTrig signal, two exposure modes are available, "timed" and "trigger width."

Timed Exposure Mode

When timed mode is selected, the exposure time for each image is determined by the value of the camera’s exposure time parameter. If the camera is set for rising edge triggering, the exposure time starts when the ExTrig signal rises. If the camera is set for falling edge triggering, the exposure time starts when the ExTrig signal falls. Figure 41 illustrates timed exposure with the camera set for rising edge triggering.

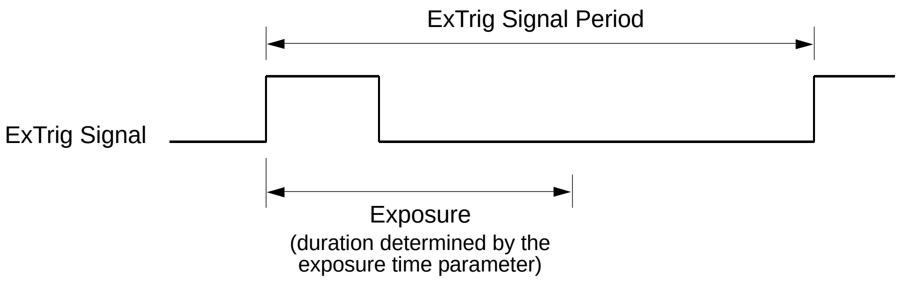


Fig. 41: Timed Exposure with Rising Edge Triggering

Trigger Width Exposure Mode

When trigger width exposure mode is selected, the length of the exposure will be directly controlled by the ExTrig signal. If the camera is set for rising edge triggering, the exposure time begins when the ExTrig signal rises and continues until the ExTrig signal falls. If the camera is set for falling edge triggering, the exposure time begins when the ExTrig signal falls and continues until the ExTrig signal rises. Figure 42 illustrates trigger width exposure with the camera set for rising edge triggering.

Trigger width exposure is especially useful if you intend to vary the length of the exposure time for each captured image.

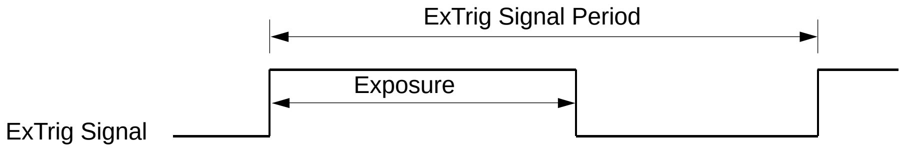


Fig. 42: Trigger Width Exposure with Rising Edge Triggering

Note

The trigger width exposure mode **is not** available on scA750-60 cameras. The trigger width exposure mode is available on all other camera models.

When you operate the camera in trigger width exposure mode, you must use the camera's exposure setting to set an exposure time. The exposure time setting will be used by the camera to operate the trigger ready signal.

You should adjust the exposure setting to represent the shortest exposure time you intend to use. For example, assume that you will be using trigger width exposure and that you intend to use the ExTrig signal to vary the exposure time in a range from 3000 µs to 5500 µs. In this case you would use the exposure setting to set the exposure time to 3000 µs.

If you are using the trigger width exposure mode and the camera is operating with overlapped exposures, there is something you must keep in mind. If the action of the ExTrig signal would end the current exposure while readout of the previously acquired image is still taking place, the camera will automatically continue the exposure until readout of the previous image is complete. This situation is illustrated Figure 41 for rising edge operation. On the first cycle of the ExTrig signal shown in the figure, the signal rises and falls while readout is taking place. Normally you would expect exposure to take place only when the ExTrig signal is high. But since the signal falls while the previous frame is still reading out, the camera automatically extends exposure until the readout is complete. On the second cycle of the ExTrig signal shown in the figure, the signal rises during previous frame readout, but falls after the readout is complete. This is a normal situation and exposure would be determined by the high time of the ExTrig signal as you would expect.

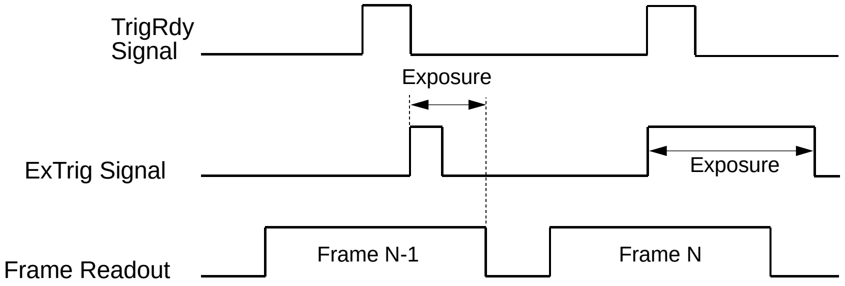


Fig. 43: Trigger Width Exposure Mode with Overlapped Exposure

Selecting an Exposure Mode

You can set the exposure time parameter value and select an exposure mode from within your application software by using the pylon API. The following code snippets illustrate using the API to set the exposure time parameter and select the exposure mode:

```
// set for the timed exposure mode, set exposure time to 3000 µs
Camera.ExposureMode.SetValue( ExposureMode_Timed );
Camera.ExposureTimeAbs.SetValue( 3000 );
// set for the width exposure mode, set minimum exposure time to 3000 µs
Camera.ExposureMode.SetValue( ExposureMode_TriggerWidth );
Camera.ExposureTimeAbs.SetValue( 3000 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon viewer, see Section 3.1 on page 39.

For more information about the camera's exposure time parameter, see Section 6.4 on page 75.

For more information about overlapped exposure, see Section 6.5 on page 79.

For more detailed information about using the trigger width exposure mode with overlapped exposure, refer to the application notes called "Using a Specific External Trigger Signal with Overlapped Exposure" (AW000565xx000). The application notes are available in the downloads section of the Basler website: www.baslerweb.com.

6.3.2 Setting the Camera for Hardware Triggering

To set the camera for hardware triggering:

- Use the Trigger Selector parameter to select the Acquisition Start trigger.
- Use the Trigger Mode parameter to set the trigger mode to On.
- Use the Trigger Source parameter to set the camera to accept the hardware trigger signal on input line 1 or on input line 2.
- Use the Trigger Activation parameter to set the camera for rising edge triggering or for falling edge triggering.

You can set these parameter values from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter values:

```
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
Camera.TriggerMode.SetValue( TriggerMode_On );
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

6.3.3 Acquiring a Single Image by Applying One Hardware Trigger Transition

You can set the camera to react to a single transition of an external hardware trigger (ExTrig) signal and then you can transition the ExTrig signal to begin image acquisition. When you are using an ExTrig signal to start image acquisition, you should monitor the camera's trigger ready (TrigRdy) output signal and you should base the use of your ExTrig signal on the state of the trigger ready signal.

To set the camera to react to a single ExTrig signal transition, follow the sequence below. The sequence assumes that you have set the camera for rising edge triggering and for the timed exposure mode.

1. Access the camera's API and set the exposure time parameter for your desired exposure time.
2. Set the value of the camera's Acquisition Mode parameter to Single Frame.
3. Execute an Acquisition Start command. This prepares the camera to react to a single trigger. (In single frame mode, executing the start command prepares the camera to react to a single trigger.)
4. Check the state of the camera's Trigger Ready signal:
    a. If the TrigRdy signal is high, you can transition the ExTrig signal when desired.
    b. If the TrigRdy signal is low, wait until TrigRdy goes high and then transition the ExTrig signal when desired.
5. When the ExTrig signal transitions from low to high, image acquisition will start. Exposure will continue for the length of time you specified in step 1.
6. At the end of the specified exposure time, readout and transmission of the acquired image will take place.
7. At this point, the camera would ignore any additional ExTrig signal transitions. To acquire another image, you must:
    a. Repeat step 3 to prepare the camera to react to a hardware trigger transition.
    b. Repeat step 4 to check if the camera is ready to acquire an image.
    c. Repeat step 5 to begin image acquisition

You can set the exposure time and the Acquisition Mode parameter values from within your application software by using the pylon API. You can also execute the Acquisition Start command. The following code snippet illustrates using the API to set the parameter values and execute the command:

```
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
Camera.ExposureMode.SetValue( ExposureMode_Timed );
Camera.ExposureTimeAbs.SetValue( 3000 );
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
Camera.AcquisitionMode.SetValue( AcquisitionMode_SingleFrame );
Camera.AcquisitionStart.Execute( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

For more information about the Trigger Ready signal, see Section 6.7 on page 82.

For more information about the camera's exposure time parameter, see Section 6.4 on page 75.

6.3.4 Acquiring Images by Applying a Series of Hardware Trigger Transitions

You can set the camera so that it will react to a continuous series of external hardware trigger (ExTrig) transitions and then you can cycle the ExTrig signal as desired to begin image acquisition. When you are using an ExTrig signal to start image acquisition, you should monitor the camera's trigger ready (TrigRdy) output signal and you should base the use of your ExTrig signal on the state of the trigger ready signal.

To set the camera to react continuously to ExTrig signal transitions, follow the sequence below. The sequence assumes that you have set the camera for rising edge triggering and for the timed exposure mode.

1. Access the camera's API and set the exposure time parameters for your desired exposure time.
2. Set the value of the camera's Acquisition Mode parameter to Continuous.
3. Execute an Acquisition Start command. This prepares the camera to react to the trigger signals.
4. Check the state of the camera's Trigger Ready signal:
   a. If the TrigRdy signal is high, you can transition the ExTrig signal when desired.
   b. If the TrigRdy signal is low, wait until TrigRdy goes high and then transition the ExTrig signal when desired.
5. When the ExTrig signal transitions from low to high, image acquisition will start. Exposure will continue for the length of time you specified in step 1.
6. At the end of the specified exposure time, readout and transmission of the acquired image will take place.
7. Repeat steps 4 and 5 each time you want to start another image acquisition.
8. Execute an Acquisition Stop command. The camera will no longer react to hardware triggers.

If you are acquiring images using a series of hardware trigger transitions, you must avoid acquiring images at a rate that exceeds the maximum allowed with the current camera settings. You can avoid triggering image acquistion at too high a rate by using the trigger ready signal as described above.

You should also be aware that if the Acquisition Frame Rate Abs parameter is enabled, it will influence the rate at which images can be acquired:

- If the Acquisition Frame Rate Abs parameter is set to a value less than the maximum allowed, you can trigger acquisition at any rate up to the set value.
- If the Acquisition Frame Rate Abs parameter is set to a value greater than the maximum allowed, you can trigger acquisition at any rate up to the maximum allowed image acquisition rate with the current camera settings.

You can set the exposure time and the Acquisition Mode parameter values from within your application software by using the pylon API. You can also execute the Acquisition Start and Stop commands. The following code snippet illustrates using the API to set the parameter values and execute the commands:

```
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
Camera.ExposureMode.SetValue( ExposureMode_Timed );
Camera.ExposureTimeAbs.SetValue( 3000 );
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );
Camera.AcquisitionStart.Execute( );
Camera.AcquisitionStop.Execute( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

For more information about the Trigger Ready signal, see Section 6.7 on page 82.

For more information about the camera's exposure time parameter, see Section 6.4 on page 75.

Note

The explanations in Section 6.3.3 and Section 6.3.4 are intended to give you a basic idea of how the use of a hardware trigger works. For a more complete description, refer to the Basler pylon Programmer's Guide and to the sample programs included in the Basler pylon Software Development Kit (SDK).

6.4 Exposure Time Parameters

Many of the camera’s image acquisition modes require you to specify an exposure time. There are two ways to set exposure time: by setting "raw" values or by setting an "absolute value". The two methods are described below. You can use whichever method you prefer to set the exposure time.

The exposure time must not be set below a minimum specified value. The minimum exposure time varies by camera model as shown in Table 12.

The maximum exposure time that can be set also varies by camera model as shown in Table 12.

Camera Model	Minimum Allowed Exposure Time	Maximum Possible Exposure Time
scA640-70fm/fc	24 µs	10000000 µs
scA640-74fm/fc	24 µs	10000000 µs
scA640-120fm/fc	16 µs	10000000 µs
scA750-60fm/fc	124 µs	126976 µs
scA780-54fm/fc	26 µs	10000000 µs
scA1000-20fm/fc	52 µs	10000000 µs
scA1000-30fm/fc	32 µs	10000000 µs
scA1300-32fm/fc	22 µs	10000000 µs
scA1390-17fm/fc	34 µs	10000000 µs
scA1400-17fm/fc	38 µs	10000000 µs
scA1400-30fm/fc	28 µs	10000000 µs
scA1600-14fm/fc	31 µs	10000000 µs

Table 12: Minimum Allowed Exposure Time and Maximum Possible Exposure Time

Note

Exposure time can not only be manually set (see below), but can also be automatically adjusted.

Exposure Auto is an auto function and the "automatic" counterpart to manually setting an "absolute" exposure time. The exposure auto function automatically adjusts the Auto Exposure Time Abs parameter value.

In contrast to the manually set "absolute" exposure time, the automatically adjusted "absolute" exposure time is not restricted to multiples of the current exposure time base. The automatic adjustment is not available when trigger width exposure mode is selected.

For more information about auto functions, see Section 9.11.1 on page 172.

For more information about the Exposure Auto function, see Section 9.11.3 on page 181.

For information on parameter settings for obtaining the maximum possible exposure time, see Section 6.4.1 on page 76.

6.4.1 Setting the Exposure Time Using "Raw" Settings

When exposure time is set using "raw" values, the exposure time will be determined by a combination of two elements. The first element is the value of the Exposure Time Raw parameter, and the second element is the Exposure Time Base. The exposure time is determined by the product of these two elements:

Exposure Time = (Exposure Time Raw Parameter Value) x (Exposure Time Base)

By default, the Exposure Time Base is fixed at 20 µs on all camera models except the scA750-60. On scA750-60 cameras, the default Exposure Time Base is 31 µs.

Typically, the exposure time is adjusted by setting only the Exposure Time Raw parameter. The Exposure Time Raw parameter value can range from 1 to 4095. So if the parameter value was set to 100 on an scA640-70 camera, for example, the exposure time will be 100 x 20 µs or 2000 µs.

Settings for Obtaining the Maximum Possible Exposure Time

On all camera models except the scA750-60, you can obtain the maximum possible exposure time (10000000 µs) by setting the Exposure Time Raw parameter value to 1 and the Exposure Time Base Abs value to 10000000 µs.

On scA750-60 cameras, you can obtain the maximum possible exposure time (126976 µs) by e.g. setting the exposure time raw parameter value to 2048 and the Exposure Time Base Abs value to 62 µs.

Changing the Exposure Time Base

Normally, the exposure time is adjusted by setting the value of the Exposure Time Raw parameter as explained above. However, if you require an exposure time that is longer than what you can achieve by changing the value of the Exposure Time Raw parameter alone, the Exposure Time Base Abs parameter can be used to change the exposure time base.

The Exposure Time Base Abs parameter value sets the exposure time base in µs and this parameter can be used to change the exposure time base.

On all camera models except the scA750-60, the default exposure time base is 20 µs and the time base can be changed in increments of 1 µs.

On scA750-60 cameras, the default exposure time base is 31 µs and the time base can be changed in increments of 31 µs.

You can set the Exposure Time Raw and Exposure Time Base Abs parameter values from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter values:

```
Camera.ExposureMode.SetValue( ExposureMode_Timed );
Camera.ExposureTimeRaw.SetValue( 100 );

Camera.ExposureTimeBaseAbs.SetValue( 186 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

6.4.2 Setting the Exposure Time Using "Absolute" Settings

You can also set the exposure time by using an "absolute" value. This is accomplished by setting the Exposure Time Abs parameter. The units for setting this parameter are µs and the value can be set in increments of 1 µs.

When you use the Exposure Time Abs parameter to set the exposure time, the camera accomplishes the setting change by automatically changing the Exposure Time Raw parameter to achieve the value specified by your Exposure Time Abs setting. This leads to a limitation that you must keep in mind if you use Exposure Time Abs parameter to set the exposure time. That is, you must set the Exposure Time Abs parameter to a value that is equivalent to a setting you could achieve by using the Exposure Time Raw parameter with the current Exposure Time Base parameter. For example, if the time base was currently set to 62 µs, you could use the Exposure Time Base Abs parameter to set the exposure to 62 µs, 124 µs, 186 µs, etc.

Note that if you set the Exposure Time Abs parameter to a value that you could not achieve by using the Exposure Time Raw and Exposure Time Base parameters, the camera will automatically change the setting for the Exposure Time Abs parameter to the nearest achieveable value.

You should also be aware that if you change the exposure time using the raw settings, the Exposure Time Abs parameter will automatically be updated to reflect the new exposure time.

Setting the Absolute Exposure Time Parameter

You can set the Exposure Time Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
Camera.ExposureTimeAbs.SetValue( 124 );
double resultingExpTime = Camera.ExposureTimeAbs.GetValue( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

6.5 Overlapping Exposure and Sensor Readout (All Models Except scA750-60)

Note

The information in this section applies to all camera models except the scA750-60 fm/fc. For information about scA750-60 cameras, see Section 6.6 on page 81.

The image acquisition process on the camera includes two distinct parts. The first part is the exposure of the pixels in the imaging sensor. Once exposure is complete, the second part of the process – readout of the pixel values from the sensor – takes place.

In regard to this image acquisition process, there are two common ways for the camera to operate: with "non-overlapped" exposure and with "overlapped" exposure. In the non-overlapped mode of operation, each time an image is acquired, the camera completes the entire exposure/readout process before acquisition of the next image is started. This situation is illustrated in Figure 44.

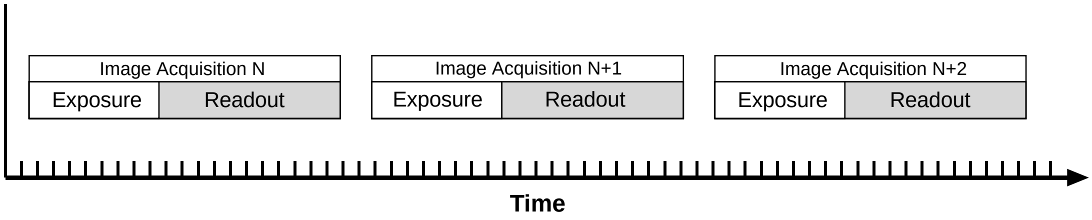


Fig. 44: Non-overlapped Exposure

While operating in a non-overlapped fashion is perfectly normal and is appropriate for many situations, it is not the most efficient way to operate the camera in terms of acquisition frame rate. On this camera, however, it is allowable to begin exposing a new image while a previously acquired image is being read out. This situation is illustrated in Figure 45 and is known as operating the camera with "overlapped" exposure.

As you can see, running the camera with readout and exposure overlapped can allow higher acquisition frame rates because the camera is performing two processes at once.

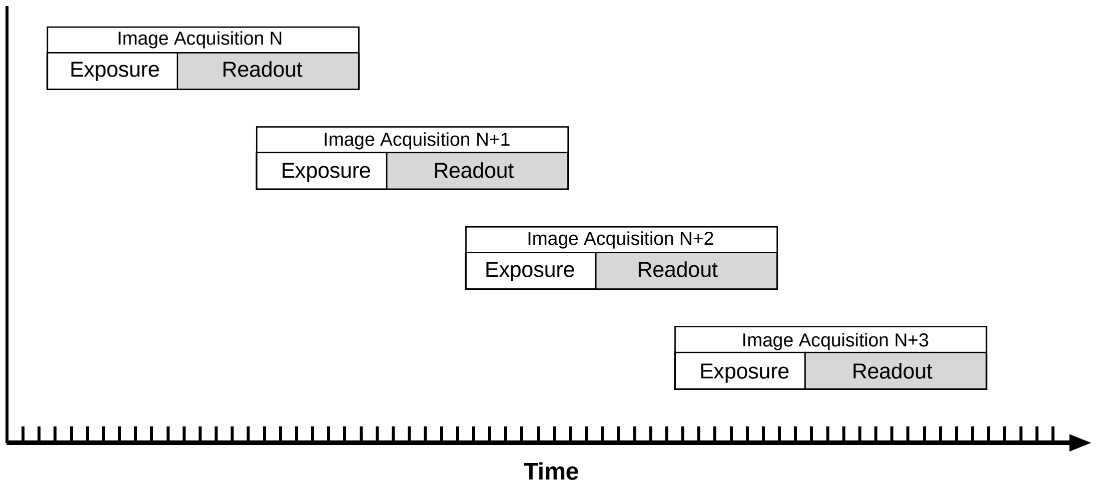


Fig. 45: Overlapped Exposure

Determining whether your camera is operating with overlapped or non-overlapped exposures is not a matter of issuing a command or switching a setting on or off. Rather the way that you operate the camera will determine whether the exposures are overlapped or not overlapped. If we define the “frame period” as the time from the start of exposure for one image acquisition to the start of exposure for the next image acquisition, then:

Exposure will overlap when:	Frame Period ≤ Exposure Time + Readout Time
Exposure will not overlap when:	Frame Period > Exposure Time + Readout Time

You can calculate the readout time for a captured image by using the formula on page 87.

6.5.1 Guidelines for Overlapped Operation

If you will be operating the camera with overlapped exposure, there are two important guidelines to keep in mind:

- You must not begin the exposure time for a new image acquisition while the exposure time of the previous acquisition is in progress.
- You must not end the exposure time of the current image acquisition until readout of the previously acquired image is complete.

The camera will ignore any trigger signals that violate these guidelines.

When you are operating a camera with overlapped exposure and using a hardware trigger signal to trigger image acquisition, you could use the camera’s exposure time parameter settings and timing formulas to calculate when it is safe to begin each new acquisition. However, there is a much more convenient way to know when it safe to begin each acquisition. The camera supplies a “trigger ready” signal that is specifically designed to let you trigger overlapped exposure safely and efficiently.

For more information about using the Trigger Ready signal with all camera models except the scA750-60 fm/fc, see Section 6.7.1 on page 82.

For more detailed guidelines about using an external trigger signal with the trigger width exposure mode and overlapped exposure, refer to the application notes called "Using a Specific External Trigger Signal with Overlapped Exposure" (AW000565xx000). The application notes are available in the downloads section of the Basler website: www.baslerweb.com.

6.6 Exposure Must Not Overlap Sensor Readout (scA750-60 Only)

Note

The information in this section only applies to scA750-60 fm/fc cameras. For information about the other camera models, see Section 6.5 on page 79.

The image acquisition process on the camera includes two distinct parts. The first part is the exposure of the pixels in the imaging sensor. Once exposure is complete, the second part of the process – readout of the pixel values from the sensor – takes place.

On these cameras, exposure for a new acquisition must not begin until readout of the previously acquired image is complete. This situation is illustrated in Figure 44.

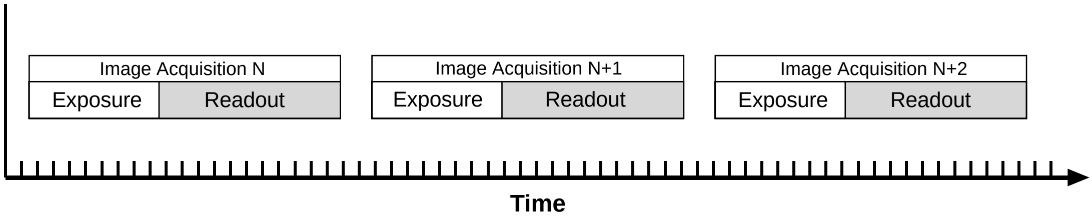


Fig. 46: Non-overlapped Readout and Exposure

A result of this characteristic is that the exposure time setting on the camera will have a direct effect on the camera’s maximum allowed frame rate. At longer exposure times, the maximum allowed frame rate will be lower.

When you are operating a camera and using a hardware trigger to trigger image acquisition, you could use the camera’s exposure time parameter settings and the timing formulas to calculate when it is safe to begin each new acquisition. However, there is a more convenient way to know when it safe to begin each acquisition. The camera supplies a “trigger ready” signal that is specifically designed to let you trigger acquisitions safely and efficiently.

For more information about using the Trigger Ready signal with scA750-60 fm/fc cameras, see Section 6.7.2 on page 84.

6.7 Trigger Ready Signal

6.7.1 Trigger Ready Signal (All Models Except scA750-60)

ⓘ **Note**

The information in this section applies to all camera models except the scA750-60 fm/fc. For information about scA750-60 cameras, see Section 6.7.2 on page 84.

As described in the previous section, the cameras can operate in an “overlapped” acquisition fashion. When the camera is operated in this manner, it is especially important that:

- the exposure time of a new image acquisition not start until exposure of the previously acquired image is complete, and
- the exposure time of a new image acquisition not end until readout of the previously acquired image is complete.

The camera supplies a “Trigger Ready” (TrigRdy) output signal you can use to ensure that these conditions are met when you are using a hardware trigger signal to trigger image acquisition. When you are acquiring images, the camera automatically calculates the earliest moment that it is safe to trigger each new acquisition. The trigger ready signal will go high when it is safe to trigger an acquisition, will go low when the acquisition has started, and will go high again when it is safe to trigger the next acquisition (see Figure 47). The camera calculates the rise of the trigger ready signal based on the current exposure time parameter setting, the current size of the area of interest, and the time it will take to readout the captured pixel values from the sensor.

The trigger ready signal is especially useful if you want to run the camera at the maximum acquisition frame capture rate for the current conditions. If you monitor the trigger ready signal and you trigger acquisition of each new image immediately after the signal goes high, you will be sure that the camera is operating at the maximum acquisition frame rate for the current conditions.

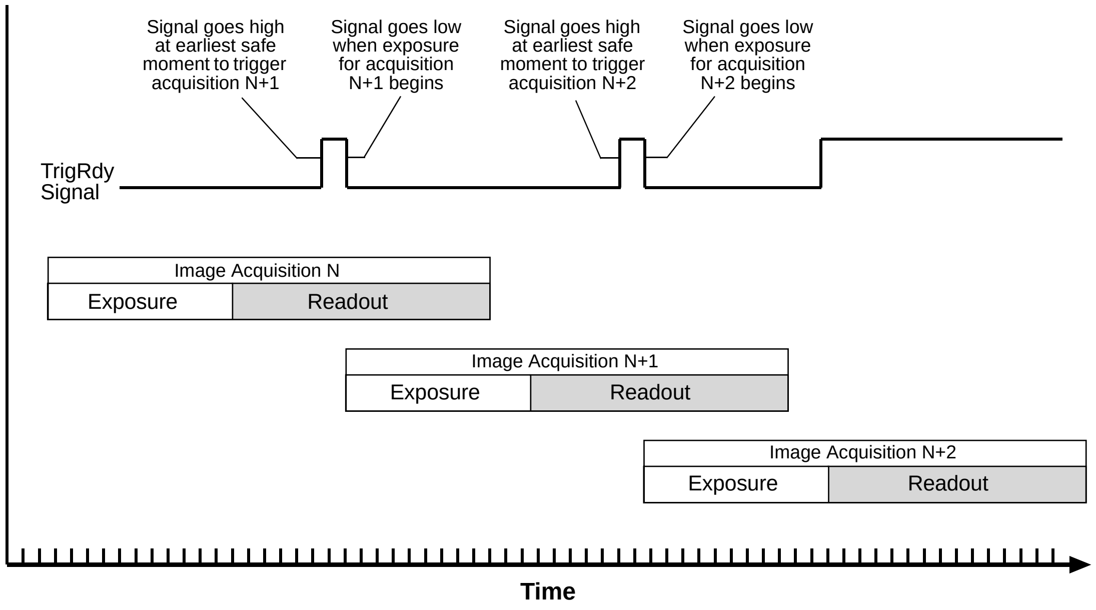

Signal goes high at earliest safe moment to trigger acquisition N+1
Signal goes low when exposure for acquisition N+1 begins
Signal goes high at earliest safe moment to trigger acquisition N+2
Signal goes low when exposure for acquisition N+2 begins
TrigRdy Signal
Image Acquisition N
Exposure
Readout
Image Acquisition N+1
Exposure
Readout
Image Acquisition N+2
Exposure
Readout
Time

Fig. 47: Trigger Ready Signal

You should be aware that if the Acquisition Frame Rate Abs parameter is enabled, the operation of the trigger ready signal will be influenced by the value of the parameter:

- If the value of the parameter is greater than zero but less than the maximum allowed, the trigger ready will go high at the rate specified by the parameter value. For example, if the parameter is set to 10, the trigger ready signal will go high 10 times per second.
- If the value of the parameter is greater than the maximum allowed acquisition frame rate with the current camera settings, the trigger ready signal will work as described above and will go high at a point that represents the maximum acquisition frame rate allowed.

Note

If you attempt to start an image acquisition when the trigger ready signal is low, the camera will simply ignore the attempt.

The trigger ready signal will only be available when hardware triggering is enabled.

By default, the trigger ready signal is assigned to physical output line 2 on the camera. However, the assignment of the trigger signal to a physical output line can be changed.

For more information about changing the assignment of camera output signals to physical output lines, see Section 8.2 on page 129.

For more information about the electrical characteristics of the camera’s output lines, see Section 5.7.2 on page 56.

6.7.2 Trigger Ready Signal (scA750-60 Only)

Note

The information in this section only applies to scA750-60 fm/fc cameras. For information about the other camera models, see Section 6.7.1 on page 82.

As described in an earlier section, on these cameras the exposure for an image acquisition must not begin until readout of the previously acquired image has ended. The camera supplies a "Trigger Ready" (TrigRdy) output signal you can use to ensure that these conditions are met when you are using a hardware trigger signal to trigger image acquisition. When you are acquiring images, the camera automatically calculates the earliest moment that it is safe to trigger each new acquisition. The trigger ready signal will go high when it is safe to trigger an acquisition, will go low when the acquisition has started, and will go high again when it is safe to trigger the next acquisition (see Figure 47). The camera calculates the rise of the trigger ready signal based on the current exposure time parameter setting, the current size of the area of interest, and the time it will take to readout the captured pixel values from the sensor.

The trigger ready signal is especially useful if you want to run the camera at the maximum acquisition frame capture rate for the current conditions. If you monitor the trigger ready signal and you begin acquisition of each new image immediately after the signal goes high, you will be sure that the camera is operating at the maximum acquisition frame rate for the current conditions.

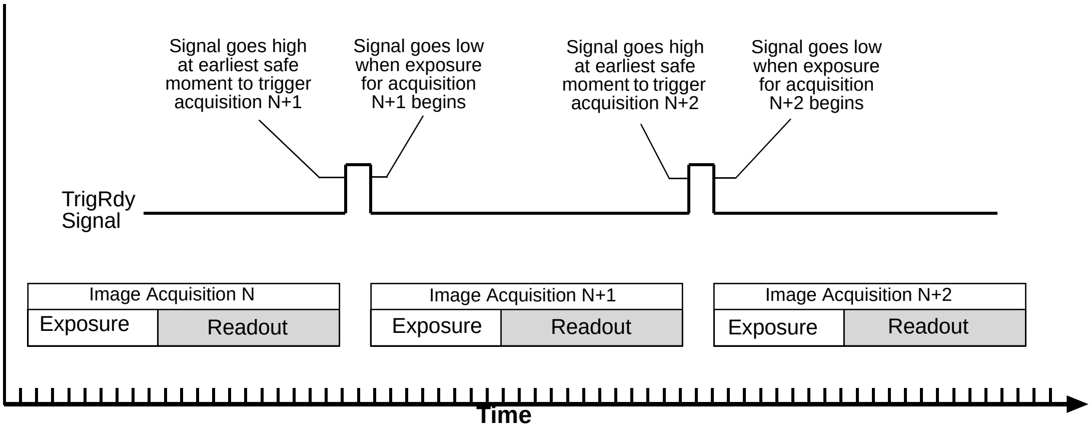

Signal goes high at earliest safe moment to trigger acquisition N+1
Signal goes low when exposure for acquisition N+1 begins
Signal goes high at earliest safe moment to trigger acquisition N+2
Signal goes low when exposure for acquisition N+2 begins
TrigRdy Signal
Image Acquisition N
Exposure
Readout
Image Acquisition N+1
Exposure
Readout
Image Acquisition N+2
Exposure
Readout
Time

Fig. 48: Trigger Ready Signal

You should be aware that if the Acquisition Frame Rate Abs parameter is enabled, the operation of the trigger ready signal will be influenced by the value of the parameter:

- If the value of the parameter is greater than zero but less than the maximum allowed, the trigger ready will go high at the rate specified by the parameter value. For example, if the parameter is set to 10, the trigger ready signal will go high 10 times per second.
- If the value of the parameter is greater than the maximum allowed acquisition frame rate with the current camera settings, the trigger ready signal will work as described above and will go high at a point that represents the maximum acquisition frame rate allowed.

Note

If you attempt to start an image acquisition when the trigger ready signal is low, the camera will simply ignore the attempt.

The trigger ready signal will only be available when hardware triggering is enabled.

By default, the trigger ready signal is assigned to physical output line 2 on the camera. However, the assignment of the trigger signal to a physical output line can be changed.

For more information about changing the assignment of camera output signals to physical output lines, see Section 8.2 on page 129.

For more information about the electrical characteristics of the camera's output lines, see Section 5.7.2 on page 56.

6.8 Exposure Active Signal

The camera's "exposure active" (ExpAc) signal goes high when the exposure time for each image acquisition begins and goes low when the exposure time ends as shown in Figure 49. This signal can be used as a flash trigger and is also useful when you are operating a system where either the camera or the object being imaged is movable. For example, assume that the camera is mounted on an arm mechanism and that the mechanism can move the camera to view different portions of a product assembly. Typically, you do not want the camera to move during exposure. In this case, you can monitor the ExpAc signal to know when exposure is taking place and thus know when to avoid moving the camera.

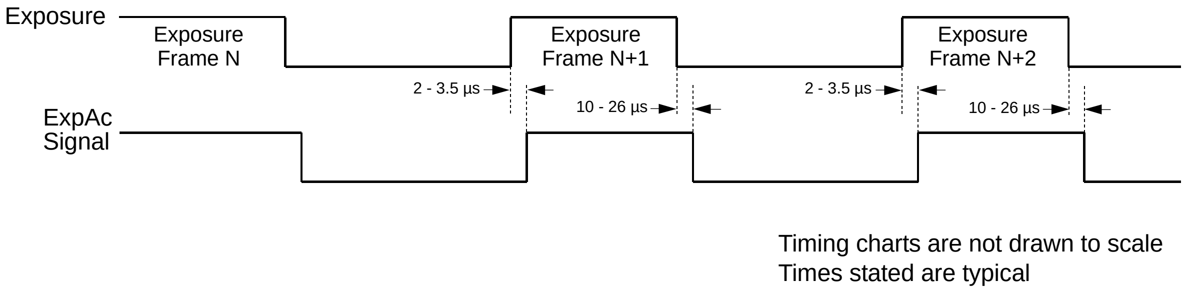


Fig. 49: Exposure Active Signal

Note

When you use the exposure active signal, be aware that there is a delay in the rise and the fall of the signal in relation to the start and the end of exposure. See Figure 49 for details.

By default, the ExpAc signal is assigned to physical output line 1 on the camera. However, the assignment of the ExpAc signal to a physical output line can be changed.

For more information about changing the assignment of camera output signals to physical output lines, see Section 8.2 on page 129.

For more information about the electrical characteristics of the camera's output lines, see Section 5.7.2 on page 56.

6.9 Acquisition Timing Chart

Figure 50 shows a timing chart for image acquisition and transmission. The chart assumes that exposure is triggered with an ExTrig signal with rising edge activation and that the camera is set for programmable exposure mode.

As Figure 50 shows, there is a slight delay between the rise of the ExTrig signal and the start of exposure. After the exposure time for an image capture is complete, the camera begins reading out the captured image data from the CCD sensor into a buffer in the camera. When the camera has determined that a sufficient amount of image data has accumulated in the buffer, it will begin transmitting the data from the camera to the host PC.

This buffering technique avoids the need to exactly synchronize the clock used for sensor readout with the clock used for data transmission over the IEEE 1394b bus. The camera will begin transmitting data when it has determined that it can safely do so without over-running or under-running the buffer. This buffering technique is also an important element in achieving the highest possible frame rate with the best image quality.

The **exposure start delay** is the amount of time between the point where the trigger signal transitions to the point where exposure actually begins.

The **frame readout time** is the amount of time it takes to read out the data for a captured image from the CCD sensor into the image buffer.

The **time to transmission end** is the amount of time between the point where the camera begins reading out the captured image data from the sensor to the point where it finishes transmitting the data for the captured image from the buffer to the host PC.

The exposure start delay varies from camera model to camera model. The table below shows the exposure start delay for each camera model:

Camera Model	Exposure Start Delay	Camera Model	Exposure Start Delay
scA640-70fm/fc	31.37 µs	scA1000-30fm/fc	45.33 µs
scA640-74fm/fc	29.87 µs	scA1300-32fm/fc	32.17 µs
scA640-120fm/fc	17.92 µs	scA1390-17fm/fc	58.90 µs
scA750-60fm/fc	180.0 µs	scA1400-17fm/fc	57.71 µs
scA780-54fm/fc	31.89 µs	scA1400-30fm/fc	33.40 µs
scA1000-20fm/fc	64.91 µs	scA1600-14fm/fc	60.52 µs

Table 13: Exposure Start Delays

Note that, if the debouncer feature is used, the debouncer setting for the input line must be added to the exposure start delays shown in Table 13 to determine the total start delay. For example, assume that you are using an scA640-70 camera and that you have set the cameras for hardware triggering. Also assume that you have selected input line 1 to accept the hardware trigger signal and that you have set the Line Debouncer Time Abs parameter for input line 1 to 5 µs. In this case:

Total Start Delay = Start Delay from Table 13+ Debouncer Setting

Total Start Delay = 31.37 µs+ 5 µs

Total Start Delay = 36.37 µs

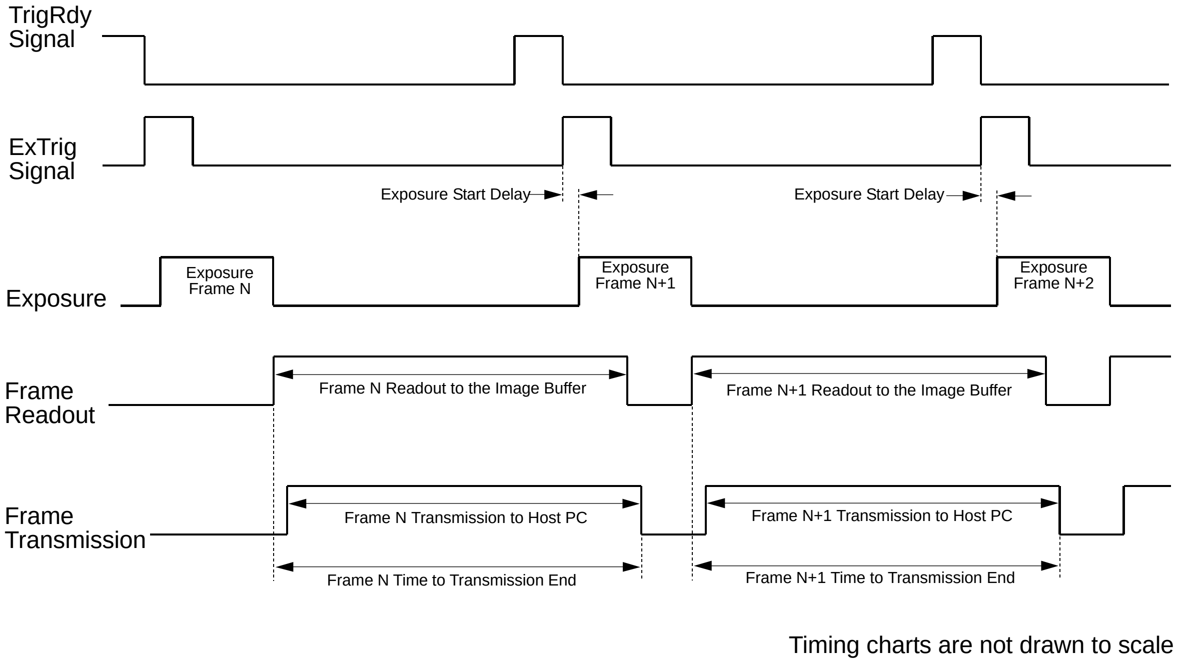

TrigRdy Signal
ExTrig Signal
Exposure Start Delay
Exposure Start Delay
Exposure
Exposure Frame N
Exposure Frame N+1
Exposure Frame N+2
Frame Readout
Frame N Readout to the Image Buffer
Frame N+1 Readout to the Image Buffer
Frame Transmission
Frame N Transmission to Host PC
Frame N+1 Transmission to Host PC
Frame N Time to Transmission End
Frame N+1 Time to Transmission End
Timing charts are not drawn to scale

Fig. 50: Exposure Start Controlled with an ExTrig Signal

You can calculate the frame readout time by using this formula:

Frame Readout Time = T_r = (AOI Height x C_1) + C_2

Where the values for the constants C_1 and C_2 are from the table in Section 6.10 on page 90 for all camera models except the scA750-60 or from the table in Section 6.11 on page 95 for scA750-60 cameras.

For more information about the frame height, see Section 9.6 on page 155.

You can calculate the time to transmission end (T_e) using these three steps:

1. Calculate the frame readout time (T_r) using the formula above.
2. Calculate the base transmission time (T_b) using these formulas:

$$\text{Packets per frame} = \frac{\text{Value of the Payload Size Parameter}}{\text{Value of the Packet Size Parameter}}$$

(round the result up to the nearest integer)

T_b = Packets per frame x 125 µs

3. Compare the results:

   If $T_b \leq T_r$, then $T_e = T_r + 250$ µs

   If $T_b > T_r$, then $T_e = T_b + 250$ µs

You can determine the value of the Payload Size and Packet Size parameters from within your application software by using the pylon API. The following code snippet illustrates using the API to work with the parameter values:

```
// Get payload size
int64_t payloadSize = Camera.PayloadSize.GetValue();

// Set packet size
Camera.PacketSizeSize.SetValue( 4096 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

6.10 Maximum Allowed Acquisition Frame Rate (All Models Except scA750-60)

Note

The information in this section applies to all camera models except the scA750-60 fm/fc. For information about scA750-60 cameras, see Section 6.11 on page 95.

In general, the maximum allowed acquisition frame rate can be limited by three factors:

- The amount of time it takes to read an acquired image out of the imaging sensor and into the camera's frame buffer (an acquired image is also known as a frame). This time varies depending on the height of the frame. Shorter frames take less time to read out of the sensor. The frame height is determined by the camera's AOI settings.
- The exposure time for acquired frames. If you use very long exposure times, you can acquire fewer frames per second.
- The number of packets needed to transfer an acquired frame from the camera to your PC.

To determine the maximum allowed acquisition frame rate with your current camera settings, you can read the value of the camera's Resulting Frame Rate parameter. This parameter indicates the camera's current maximum allowed frame rate taking the AOI, exposure time, and packet size settings into account.

You can read the current value of the Resulting Frame RateAbs parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to get the parameter values:

```
// Resulting Framerate
double resultingFps = Camera.ResultingFrameRateAbs.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

For more information about the AOI settings, see Section 9.6 on page 155.

Increasing the Maximum Allowed Frame Rate

You may find that you would like to acquire frames at a rate higher than the maximum allowed with the camera’s current settings. In this case, you must first use the three formulas described below to determine what factor is restricting the maximum frame rate the most. Next, you must try to make that factor less restrictive:

- You will often find that the sensor readout time is most restrictive factor. Decreasing the height of the acquired frames will decrease the sensor readout time and will make this factor less restrictive.
- If you find that the number of packets needed to transmit an image is restricting the frame rate, you may be able to decrease the number of packets needed to transmit a frame. The next section in this manual explains more about the effect of changing the packets per frame.
- If you are using normal exposure times and you are using the camera at it’s maximum resolution, your exposure time will not normally be the most restrictive factor on the frame rate. However, if you are using long exposure times or small areas of interest, it is quite possible to find that your exposure time is the most restrictive factor on the frame rate. In this case, you should lower your exposure time. (You may need to compensate for a lower exposure time by using a brighter light source or increasing the opening of your lens aperture.)

For more information about the AOI settings, see Section 9.6 on page 155.

Formula 1:

Calculates the maximum frame rate based on the sensor readout time:

$$\text{Max. Frames/s} = \frac{1}{(\text{AOI Height} \times C_1\ ) + C_2}$$

Where:

AOI Height = the height of the acquired frames as determined by the AOI settings.

The constants C_1 and C_2 depend on the camera model as shown in the table below:

Camera Model	C_1	C_2	Camera Model	C_1	C_2
scA640-70fm/fc	25.21 µs	1623 µs	scA1300-32fm/fc	27.83 µs	2758.63 µs
scA640-74fm/fc	24.01 µs	1546 µs	scA1390-17fm/fc	44.71 µs	12215 µs
scA640-120fm/fc	14.40 µs	1166.75 µs	scA1400-17fm/fc	44.37 µs	11465 µs
scA780-54fm/fc	25.70 µs	2231 µs	scA1400-30fm/fc	25.80 µs	52.37 µs
scA1000-20fm/fc	51.13 µs	7822 µs	scA1600-14fm/fc	6450 µs	6896 µs
scA1000-30fm/fc	36.57 µs	4699 µs			

Formula 2:

Calculates the maximum frame rate based on the exposure time for the acquired frames:

$$\text{Max. Frames/s} = \frac{1}{\text{Exposure time in µs} + C_3}$$

Where the constant C_3 depends on the camera model as shown in the table below:

Camera Model	C_3	Camera Model	C_3
scA640-70fm/fc	94.56 µs	scA1300-32fm/fc	52.91 µs
scA640-74fm/fc	90.06 µs	scA1390-17fm/fc	176.76 µs
scA640-120fm/fc	24.37 µs	scA1400-17fm/fc	173.83 µs
scA780-54fm/fc	95.70 µs	scA1400-30fm/fc	100.83 µs
scA1000-20fm/fc	194.82 µs	scA1600-14fm/fc	181.64 µs
scA1000-30fm/fc	136.47 µs		

Formula 3:

Calculates the maximum frame rate based on the number of packets needed to transmit a captured frame from the camera to your host PC via the IEEE 1394 bus:

$$\text{Packets per frame} = \frac{\text{Value of the Payload Size Parameter}}{\text{Value of the Packet Size Parameter}}$$

(round the result up to the nearest integer)

$$\text{Max. Frames/s} = \frac{1}{\text{Packets per frame} \times 125\ \text{µs}}$$

Example

Assume that you are using a monochrome scA640-70 camera set for an exposure time of 2000 µs and for 600 x 400 resolution. Also assume that you have checked the value of the Payload Size parameter and the Packet Size parameters and found them to be 327100 and 8192 respectively.

Formula 1:

$$\text{Max Frames/s} = \frac{1}{(400 \times 25.21\ \text{µs}) + 1623\ \text{µs}}$$

Max Frames/s = 85.4 frames/s

Formula 2:

$$\text{Max Frames/s} = \frac{1}{2000\ \mu s + 94.56\ \mu s}$$

Max Frames/s = 477.4 frames/s

Formula 3:

$$\text{Packets per frame} = \frac{327100}{8192}$$

Packets per frame = 39.9

(Round the result up to 40.)

$$\text{Max. Frames/s} = \frac{1}{40 \times 125\ \mu s}$$

Max Frames/s = 200 frames/s

Formula one returns the lowest value. So in this case, the limiting factor is the sensor readout time and the maximum allowed acquisition frame rate would be 85.4 frames per second.

6.10.1 Effect of the Packet Size Setting on the Maximum Allowed Frame Rate

After a camera acquires a frame, the image data is read out from the sensor into a buffer. Once the frame has been read out to the buffer, the data is packetized and transmitted across the IEEE 1394b bus to your host PC.

A parameter called Packet Size determines the number of bytes of data that will be included in each packet transferred across the bus. The minimum value for the Packet Size parameter is 1 and the maximum value is 8192. Normally, the value of the Packet Size parameter is set to the maximum and at maximum, the Packet Size parameter has no noticeable effect on the operation of the camera.

If you lower the value of the Packet Size parameter, the amount of image data included in each packet transmitted across the bus will be lower. This means that it will take more packets to transmit each frame and since the cycle time of the IEEE 1394b bus is fixed, it also means that it will take more time to transmit each frame. If you lower the Packet Size parameter enough, the slower data transfer rate can begin to affect the maximum allowed frame capture rate of your camera. If you look at the formulas the previous section, you will notice that one of the factors that can limit the maximum allowed frame rate is the number of packets needed to transmit a frame. The number of packets per frame is directly related to the Packet Size parameter setting.

You can see the effect of changing the Packet Size parameter by looking at the read only parameter called Resulting Frame Rate Abs. The Resulting Frame Rate Abs parameter indicates the maximum frame rate with the current camera settings. If you gradually decrease the setting for the Packet Size parameter, you will eventually find that the value of the Resulting Frame Rate Abs parameter will also decrease.

If you are operating a single camera on your IEEE 1394b bus, you would ordinarily leave the Packet Size parameter set at the maximum. However, if you are operating multiple cameras on a single IEEE 1394b bus, you will probably need to change the Packet Size parameter so that the cameras can effectively share the available bus bandwidth.

You can set the value of the Packet Size parameter and read the current value of the resulting Frame Rate parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to work withthe parameter values:

```
// Set packet size
Camera.PacketSize.SetValue( 4096 );

// Get resulting framerate
double resultingFps = Camera.ResultingFrameRateAbs.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about using multiple cameras on a single bus, see Section 11 on page 219.

6.11 Maximum Allowed Acquisition Frame Rate (scA750-60 Only)

Note

The information in this section only applies to scA750-60 fm/fc cameras. For information about the other camera models, see Section 6.10 on page 90.

In general, the maximum allowed acquisition frame rate can be limited by two factors:

- The sum of the exposure time plus the amount of time it takes to read the acquired image out of the imaging sensor and into the camera's frame buffer. (An acquired image is also known as a frame.)

  The exposure time is set by the user. If you use very long exposure times, you can acquire fewer frames per second.

  The readout time varies depending on the height of the frame. Shorter frames take less time to read out of the sensor. The frame height is determined by the camera's AOI Height settings.
- The number of packets needed to transfer an acquired frame from the camera to your PC.

To determine the maximum allowed acquisition frame rate with your current camera settings, you can read the value of the camera's Resulting Frame Rate parameter. This parameter indicates the camera's current maximum allowed frame rate taking the AOI, exposure time, and packet size settings into account.

You can read the current value of the Resulting Frame RateAbs parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to get the parameter values:

```
// Resulting Framerate
double resultingFps = Camera.ResultingFrameRateAbs.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

For more information about the AOI settings, see Section 9.6 on page 155.

Increasing the Maximum Allowed Frame Rate

You may find that you would like to acquire frames at a rate higher than the maximum allowed with the camera's current settings. In this case, you must first use the two formulas described below to determine what factor is restricting the maximum frame rate the most. Next, you must try to make that factor less restrictive:

- You will often find that the sum of the exposure time plus the sensor readout time is the most restrictive factor.

  Decreasing the AOI height for the acquired frames will decrease the sensor readout time and will make this factor less restrictive.

  If you are using long exposure times, it is quite possible to find that your exposure time is making this factor the most restrictive. In this case, you should lower your exposure time. (You may need to compensate for a lower exposure time by using a brighter light source or increasing the opening of your lens aperture.)
- If you find that the number of packets needed to transmit an image is restricting the frame rate, you may be able to decrease the number of packets needed to transmit a frame. The next section in this manual explains more about the effect of changing the packets per frame.

For more information about the AOI settings, see Section 9.6 on page 155.

Formula 1:

Calculates the maximum frame rate based on the sum of the exposure time plus the sensor readout time:

$$\text{Max. Frames/s} = \frac{1}{\text{Exposure Time in µs} + (\text{AOI Height} \times C_1) + C_2}$$

Where:

AOI Height = the height of the acquired frames as determined by the AOI settings.

The constants C_1 and C_2 depend on the camera model as shown in the table below:

	scA750-60 fm/fc
C_1	31.0 µs
C_2	397.0 µs

Formula 2:

Calculates the maximum frame rate based on the number of packets needed to transmit a captured frame from the camera to your host PC via the IEEE 1394 bus:

$$\text{Packets per frame} = \frac{\text{Value of the Payload Size Parameter}}{\text{Value of the Packet Size Parameter}}$$

(round the result up to the nearest integer)

$$\text{Max. Frames/s} = \frac{1}{\text{Packets per frame} \times 125\ \mu\text{s}}$$

Example

Assume that you are using a monochrome scA750-60 camera set for an exposure time of 2000 µs and for 600 x 400 resolution. Also assume that you have checked the value of the Payload Size parameter and the Packet Size parameters and found them to be 327100 and 8192 respectively.

Formula 1:

$$\text{Max. Frames/s} = \frac{1}{2000\ \mu\text{s} + (400 \times 31.0\ \mu\text{s}) + 397.0\ \mu\text{s}}$$

Max. Frames/s = 67.6 frames/s

Formula 2:

$$\text{Packets per frame} = \frac{327100}{8192}$$

Packets per frame = 39.9

(Round the result up to 40.)

$$\text{Max. Frames/s} = \frac{1}{40 \times 125\ \mu\text{s}}$$

Max Frames/s = 200 frames/s

Formula one returns the lowest value. So in this case, the limiting factor is the sum of the exposure time plus the sensor readout time and the maximum allowed acquisition frame rate would be 67.6 frames per second.

6.11.1 Effect of the Packet Size Setting on the Maximum Allowed Frame Rate

After a camera acquires a frame, the image data is read out from the sensor into a buffer. Once the frame has been read out to the buffer, the data is packetized and transmitted across the IEEE 1394b bus to your host PC.

A parameter called Packet Size determines the number of bytes of data that will be included in each packet transferred across the bus. The minimum value for the Packet Size parameter is 1 and the maximum value is 8192. Normally, the value of the Packet Size parameter is set to the maximum and at maximum, the Packet Size parameter has no noticeable effect on the operation of the camera.

If you lower the value of the Packet Size parameter, the amount of image data included in each packet transmitted across the bus will be lower. This means that it will take more packets to transmit each frame and since the cycle time of the IEEE 1394b bus is fixed, it also means that it will take more time to transmit each frame. If you lower the Packet Size parameter enough, the slower data transfer rate can begin to affect the maximum allowed frame capture rate of your camera. If you look at the formulas the previous section, you will notice that one of the factors that can limit the maximum allowed frame rate is the number of packets needed to transmit a frame. The number of packets per frame is directly related to the Packet Size parameter setting.

You can see the effect of changing the Packet Size parameter by looking at the read only parameter called Resulting Frame Rate Abs. The Resulting Frame Rate Abs parameter indicates the maximum frame rate with the current camera settings. If you gradually decrease the setting for the Packet Size parameter, you will eventually find that the value of the Resulting Frame Rate Abs parameter will also decrease.

If you are operating a single camera on your IEEE 1394b bus, you would ordinarily leave the Packet Size parameter set at the maximum. However, if you are operating multiple cameras on a single IEEE 1394b bus, you will probably need to change the Packet Size parameter so that the cameras can effectively share the available bus bandwidth.

You can set the value of the Packet Size parameter and read the current value of the resulting Frame Rate parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to work withthe parameter values:

```
// Set packet size
Camera.PacketSize.SetValue( 4096 );

// Get resulting framerate
double resultingFps = Camera.ResultingFrameRateAbs.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about using multiple cameras on a single bus, see Section 11 on page 219.

7 Pixel Data Formats

By selecting a pixel data format, you determine the format (layout) of the image data transmitted by the camera. This section provides detailed information about the available pixel data formats.

7.1 Setting the Pixel Data Format

The setting for the camera’s Pixel Format parameter determines the format of the pixel data that will be output from the camera. The available pixel formats depend on the camera model and whether the camera is monochrome or color. Table 14 lists the pixel formats available on each monochrome camera model and Table 15 lists the pixel formats available on each color camera model.

Mono Camera Model	Mono 8	Mono 16	Mono 12 Packed	YUV 4:2:2 Packed	YUV 4:2:2 (YUYV) Packed
scA640-70	●	●	●	●	●
scA640-74	●	●	●	●	●
scA640-120	●	●	●	●	●
scA750-60	●			●	●
scA780-54	●	●	●	●	●
scA1000-20	●	●	●	●	●
scA1000-30	●	●	●	●	●
scA1300-32	●	●	●	●	●
scA1390-17	●	●	●	●	●
scA1400-17	●	●	●	●	●
scA1400-30	●	●	●	●	●
scA1600-14	●	●	●	●	●

Table 14: Pixel Formats Available on Monochrome Cameras (• = format available)

Color Camera Model	Mono 8	Bayer RG 8	Bayer BG 8	Bayer BG 16	Bayer BG 12 Packed	YUV 4:2:2 Packed	YUV 4:2:2 (YUYV) Packed
scA640-70	●		●	●	●	●	●
scA640-74	●		●	●	●	●	●
scA640-120	●		●	●	●	●	●
scA750-60	●	●				●	●
scA780-54	●		●	●	●	●	●
scA1000-20	●		●	●	●	●	●
scA1000-30	●		●	●	●	●	●
scA1300-32	●		●	●	●	●	●
scA1390-17	●		●	●	●	●	●
scA1400-17	●		●	●	●	●	●
scA1400-30	●		●	●	●	●	●
scA1600-14	●		●	●	●	●	●

Table 15: Pixel Formats Available on Color Cameras (• = format available)

Details of the monochrome formats are described in Section 7.2 on page 101 and details of the color formats are described in Section 7.3 on page 108.

You can set the Pixel Format parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
Camera.PixelFormat.SetValue( PixelFormat_Mono8 );
Camera.PixelFormat.SetValue( PixelFormat_Mono12Packed );
Camera.PixelFormat.SetValue( PixelFormat_Mono16 );
Camera.PixelFormat.SetValue( PixelFormat_YUV422Packed );
Camera.PixelFormat.SetValue( PixelFormat_YUV422_YUYV_Packed );
Camera.PixelFormat.SetValue( PixelFormat_BayerBG8 );
Camera.PixelFormat.SetValue( PixelFormat_BayerBG16 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

7.2 Pixel Data Formats for Mono Cameras

7.2.1 Mono 8 Format (Equivalent to DCAM Mono 8)

When a monochrome camera is set for the Mono 8 pixel data format, it outputs 8 bits of brightness data per pixel.

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when the camera is set for Mono8 output.

The following standards are used in the table:

P_0 = the first pixel transmitted by the camera

P_n = the last pixel transmitted by the camera

B_0 = the first byte in the buffer

B_m = the last byte in the buffer

Byte	Data
B_0	Brightness value for P_0
B_1	Brightness value for P_1
B_2	Brightness value for P_2
B_3	Brightness value for P_3
B_4	Brightness value for P_4
B_5	Brightness value for P_5
B_6	Brightness value for P_6
B_7	Brightness value for P_7
•	•
•	•
•	•
B_{m-3}	Brightness value for P_{n-3}
B_{m-2}	Brightness value for P_{n-2}
B_{m-1}	Brightness value for P_{n-1}
B_m	Brightness value for P_n

With the camera set for Mono8, the pixel data output is 8 bit data of the “unsigned char” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

This Data Value (Hexadecimal)	**Indicates This Signal Level (Decimal)**
0xFF	255
0xFE	254
•	•
•	•
•	•
0x01	1
0x00	0

7.2.2 Mono 16 Format (Equivalent to DCAM Mono 16)

When a monochrome camera is set for the Mono16 pixel data format, it outputs 16 bits of brightness data per pixel with 12 bits effective. The 12 bits of effective pixel data fill from the least significant bit. The four unused most significant bits are filled with zeros.

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when the camera is set for Mono16 output. Note that the data is placed in the image buffer in **little endian format**.

The following standards are used in the table:

P_0 = the first pixel transmitted by the camera

P_n = the last pixel transmitted by the camera

B_0 = the first byte in the buffer

B_m = the last byte in the buffer

Byte	Data
B_0	Low byte of brightness value for P_0
B_1	High byte of brightness value for P_0
B_2	Low byte of brightness value for P_1
B_3	High byte of brightness value for P_1
B_4	Low byte of brightness value for P_2
B_5	High byte of brightness value for P_2
B_6	Low byte of brightness value for P_3
B_7	High byte of brightness value for P_3
B_8	Low byte of brightness value for P_4
B_9	High byte of brightness value for P_4
•	•
•	•
•	•
B_{m-7}	Low byte of brightness value for P_{n-3}
B_{m-6}	High byte of brightness value for P_{n-3}
B_{m-5}	Low byte of brightness value for P_{n-2}
B_{m-4}	High byte of brightness value for P_{n-2}
B_{m-3}	Low byte of brightness value for P_{n-1}
B_{m-2}	High byte of brightness value for P_{n-1}
B_{m-1}	Low byte of brightness value for P_n
B_m	High byte of brightness value for P_n

When the camera is set for Mono 16, the pixel data output is 16 bit data of the “unsigned short (little endian)” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below. Note that for 16 bit data, you might expect a value range from 0x0000 to 0xFFFF. However, with the camera set for Mono16 only 12 bits of the 16 bits transmitted are effective. Therefore, the highest data value you will see is 0x0FFF indicating a signal level of 4095.

This Data Value (Hexadecimal)	**Indicates This Signal Level (Decimal)**
0x0FFF	4095
0x0FFE	4094
•	•
•	•
•	•
0x0001	1
0x0000	0

Note

When a camera that is set for Mono 16 has only 12 bits effective, the leader of transmitted frames will indicate Mono 12 as the pixel format.

7.2.3 Mono 12 Packed Format

When a monochrome camera is set for the Mono 12 Packed pixel data format, it outputs 12 bits of brightness data per pixel. Every three bytes transmitted by the camera contain data for two pixels.

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when the camera is set for Mono 12 Packed output.

The following standards are used in the table:

P_0 = the first pixel transmitted by the camera

P_n = the last pixel transmitted by the camera

B_0 = the first byte in the buffer

B_m = the last byte in the buffer

Byte	**Data**	
B_0	P_0 bits 11 ... 4	
B_1	P_1 bits 3 ... 0	P_0 bits 3 ... 0
B_2	P_1 bits 11 ... 4	
B_3	P_2 bits 11 ... 4	
B_4	P_3 bits 3 ... 0	P_2 bits 3 ... 0
B_5	P_3 bits 11 ... 4	
B_6	P_4 bits 11 ... 4	
B_7	P_5 bits 3 ... 0	P_4 bits 3 ... 0
B_8	P_5 bits 11 ... 4	
B_9	P_6 bits 11 ... 4	
B_{10}	P_7 bits 3 ... 0	P_6 bits 3 ... 0
B_{11}	P_7 bits 11 ... 4	
•	•	
•	•	•
•	•	
B_{m-5}	P_{n-3} bits 11 ... 4	
B_{m-4}	P_{n-2} bits 3 ... 0	P_{n-3} bits 3 ... 0
B_{m-3}	P_{n-2} bits 11 ... 4	
B_{m-2}	P_{n-1} bits 11 ... 4	
B_{m-1}	P_n bits 3 ... 0	P_{n-1} bits 3 ... 0
B_m	P_n bits 11 ... 4	

When a monochrome camera is set for Mono 12 Packed, the pixel data output is 12 bit data of the “unsigned” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

This Data Value (Hexadecimal)	**Indicates This Signal Level (Decimal)**
0x0FFF	4095
0x0FFE	4094
•	•
•	•
•	•
0x0001	1
0x0000	0

7.2.4 YUV 4:2:2 Packed Format (Equivalent to DCAM YUV 4:2:2)

When a monochrome camera is set for the YUV 4:2:2 Packed pixel data format, the camera transmits Y, U, and V values in a fashion that mimics the output from a color camera set for YUV 4:2:2 Packed.

The Y value transmitted for each pixel is an actual 8 bit brightness value similar to the pixel data transmitted when a monochrome camera is set for Mono 8. The U and V values transmitted will always be zero. With this format, a Y value is transmitted for each pixel, but the U and V values are only transmitted for every second pixel.

The order of the pixel data for a received frame in the image buffer in your PC is similar to the order of YUV 4:2:2 Packed output from a color camera.

For more information about the YUV 4:2:2 Packed format on color cameras, see Section 7.3.6 on page 118.

7.2.5 YUV 4:2:2 (YUYV) Packed Format

When a monochrome camera is set for the YUV 4:2:2 (YUYV) Packed pixel data format, the camera transmits Y, U, and V values in a fashion that mimics the output from a color camera set for YUV 4:2:2 (YUYV) Packed.

The Y value transmitted for each pixel is an actual 8 bit brightness value similar to the pixel data transmitted when a monochrome camera is set for Mono 8. The U and V values transmitted will always be zero. With this format, a Y value is transmitted for each pixel, but the U and V values are only transmitted for every second pixel.

The order of the pixel data for a received frame in the image buffer in your PC is similar to the order of YUV 4:2:2 (YUYV) Packed output from a color camera.

For more information about the YUV 4:2:2 (YUYV) Packed format on color cameras, see Section 7.3.7 on page 121.

7.3 Pixel Data Output Formats for Color Cameras

7.3.1 The Bayer Color Filter

The sensor used in color models of the camera is equipped with an additive color separation filter known as a Bayer filter. The pixel data output formats available on color cameras are related to the Bayer pattern, so you need a basic knowledge of the Bayer filter to understand the pixel formats. With the Bayer filter, each individual pixel is covered by a micro-lens that allows light of only one color to strike the pixel. The pattern of the Bayer filter used on the camera is as shown in Figure 51 (the alignment of the Bayer filter with repect to the sensor is shown as an example only; the figure shows the "BG" filter alignment). As the figure illustrates, within each square of four pixels, one pixel sees only red light, one sees only blue light, and two pixels see only green light. (This combination mimics the human eye's sensitivity to color.)

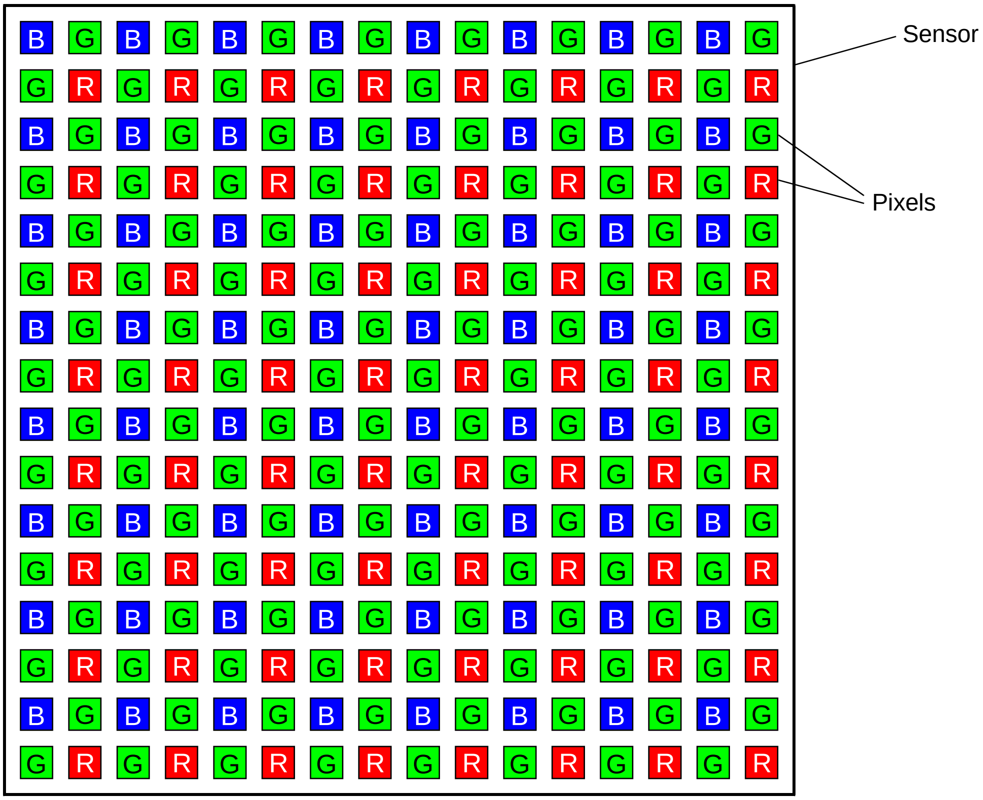


Fig. 51: Bayer Filter Pattern

7.3.1.1 Color Filter Alignment

The alignment of the Bayer filter to the pixels in the images acquired by color cameras is either Bayer BG or Bayer RG depending on the camera model. Table 16 shows the filter alignment for each available camera model.

Color Camera Model	Filter Alignment
scA640-70	BG
scA640-74	BG
scA640-120	BG
scA750-60	RG
scA780-54	BG
scA1000-20	BG
scA1000-30	BG
scA1300-32	BG
scA1390-17	BG
scA1400-17	BG
scA1400-30	BG
scA1600-14	BG

Table 16: Bayer Filter to Sensor Alignment

Bayer BG alignment means that pixel one and pixel two of the first line in each image transmitted will be blue and green respectively. And for the second line transmitted, pixel one and pixel two will be green and red respectively. Since the pattern of the Bayer filter is fixed, you can use this information to determine the color of all of the other pixels in the image.

Bayer RG alignment means that pixel one and pixel two of the first line in each image transmitted will be red and green respectively. And for the second line transmitted, pixel one and pixel two will be green and blue respectively. Since the pattern of the Bayer filter is fixed, you can use this information to determine the color of all of the other pixels in the image.

Because the size and position of the area of interest on color cameras must be adjusted in increments of 2, the color filter alignment will remain the same regardless of the camera's area of interest (AOI) settings.

The Pixel Color Filter parameter indicates the current alignment of the camera's Bayer filter to the pixels in the images captured by a color camera. You can tell how the current AOI is aligned to the Bayer filter by reading the value of the Pixel Color Filter parameter.

For more information about the camera's AOI feature, see Section 9.6 on page 155.

7.3.2 Bayer BG 8 Format (Equivalent to DCAM Raw 8)

When a color camera is set for the Bayer BG 8 pixel data format, it outputs 8 bits of data per pixel and the pixel data is not processed or interpolated in any way. So, for each pixel covered with a red lens, you get 8 bits of red data. For each pixel covered with a green lens, you get 8 bits of green data. And for each pixel covered with a blue lens, you get 8 bits of blue data. (This type of pixel data is sometimes referred to as "raw" output.)

The "BG" in the name Bayer BG 8 refers to the alignment of the colors in the Bayer filter to the pixels in the acquired images. For even lines in the images, pixel one will be blue, pixel two will be green, pixel three will be blue, pixel four will be green, etc. For odd lines in the images, pixel one will be green, pixel two will be red, pixel three will be green, pixel four will be red, etc.

For more information about the Bayer filter, see Section 7.3.1 on page 108.

The tables below describe how the data for the even lines and for the odd lines of a received frame will be ordered in the image buffer in your PC when the camera is set for Bayer BG 8 output.

The following standards are used in the tables:

P_0 = the first pixel transmitted by the camera for a line

P_n = the last pixel transmitted by the camera for a line

B_0 = the first byte of data for a line

B_m = the last byte of data for a line

Even Lines	
Byte	**Data**
B_0	Blue value for P_0
B_1	Green value for P_1
B_2	Blue value for P_2
B_3	Green value for P_3
B_4	Blue value for P_4
B_5	Green value for P_5
2	•
2	•
2	•
B_{m-5}	Blue value for P_{n-5}
B_{m-4}	Green value for P_{n-4}
B_{m-3}	Blue value for P_{n-3}
B_{m-2}	Green value for P_{n-2}
B_{m-1}	Blue value for P_{n-1}
B_m	Green value for P_n

Odd Lines	
Byte	**Data**
B_0	Green value for P_0
B_1	Red value for P_1
B_2	Green value for P_2
B_3	Red value for P_3
B_4	Green value for P_4
B_5	Red value for P_5
2	•
2	•
2	•
B_{m-5}	Green value for P_{n-5}
B_{m-4}	Red value for P_{n-4}
B_{m-3}	Green value for P_{n-3}
B_{m-2}	Red value for P_{n-2}
B_{m-1}	Green value for P_{n-1}
B_m	Red value for P_n

With the camera set for Bayer BG 8, the pixel data output is 8 bit data of the “unsigned char” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

This Data Value (Hexadecimal)	**Indicates This Signal Level (Decimal)**
0xFF	255
0xFE	254
•	•
•	•
•	•
0x01	1
0x00	0

7.3.3 Bayer RG 8 Format (Equivalent to DCAM Raw 8)

When a color camera is set for the Bayer RG 8 pixel data format, it outputs 8 bits of data per pixel and the pixel data is not processed or interpolated in any way. So, for each pixel covered with a red lens, you get 8 bits of red data. For each pixel covered with a green lens, you get 8 bits of green data. And for each pixel covered with a blue lens, you get 8 bits of blue data. (This type of pixel data is sometimes referred to as "raw" output.)

The "RG" in the name Bayer RG 8 refers to the alignment of the colors in the Bayer filter to the pixels in the acquired images. For even lines in the images, pixel one will be red, pixel two will be green, pixel three will be red, pixel four will be green, etc. For odd lines in the images, pixel one will be green, pixel two will be blue, pixel three will be green, pixel four will be blue, etc.

For more information about the Bayer filter, see Section 7.3.1 on page 108.

The tables below describe how the data for the even lines and for the odd lines of a received frame will be ordered in the image buffer in your PC when the camera is set for Bayer RG 8 output.

The following standards are used in the tables:

P_0 = the first pixel transmitted by the camera for a line

P_n = the last pixel transmitted by the camera a line

B_0 = the first byte of data for a line

B_m = the last byte of data for a line

Even Lines	
Byte	**Data**
B_0	Red value for P_0
B_1	Green value for P_1
B_2	Red value for P_2
B_3	Green value for P_3
B_4	Red value for P_4
B_5	Green value for P_5
2	•
2	•
2	•
B_{m-5}	Red value for P_{n-5}
B_{m-4}	Green value for P_{n-4}
B_{m-3}	Red value for P_{n-3}
B_{m-2}	Green value for P_{n-2}
B_{m-1}	Red value for P_{n-1}
B_m	Green value for P_n

Odd Lines	
Byte	**Data**
B_0	Green value for P_0
B_1	Blue value for P_1
B_2	Green value for P_2
B_3	Blue value for P_3
B_4	Green value for P_4
B_5	Blue value for P_5
2	•
2	•
2	•
B_{m-5}	Green value for P_{n-5}
B_{m-4}	Blue value for P_{n-4}
B_{m-3}	Green value for P_{n-3}
B_{m-2}	Blue value for P_{n-2}
B_{m-1}	Green value for P_{n-1}
B_m	Blue value for P_n

With the camera set for Bayer RG8, the pixel data output is 8 bit data of the “unsigned char” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

This Data Value (Hexadecimal)	**Indicates This Signal Level (Decimal)**
0xFF	255
0xFE	254
•	•
•	•
•	•
0x01	1
0x00	0

7.3.4 Bayer BG 16 Format (Equivalent to DCAM Raw 16)

When a color camera is set for the Bayer BG 16 pixel data format, it outputs 16 bits of data per pixel with 12 bits effective. The 12 bits of effective pixel data fill from the least significant bit. The four unused most significant bits are filled with zeros.

With the Bayer BG 16 the pixel data is not processed or interpolated in any way. So, for each pixel covered with a red lens, you get 12 effective bits of red data. For each pixel covered with a green lens, you get 12 effective bits of green data. And for each pixel covered with a blue lens, you get 12 effective bits of blue data. (This type of pixel data is sometimes referred to as "raw" output.)

The "BG" in the name Bayer BG 16 refers to the alignment of the colors in the Bayer filter to the pixels in the acquired images. For even lines in the images, pixel one will be blue, pixel two will be green, pixel three will be blue, pixel four will be green, etc. For odd lines in the images, pixel one will be green, pixel two will be red, pixel three will be green, pixel four will be red, etc.

For more information about the Bayer filter, see Section 7.3.1 on page 108.

The tables below describe how the data for the even lines and for the odd lines of a received frame will be ordered in the image buffer in your PC when the camera is set for Bayer BG 16 output. Note that the data is placed in the image buffer in **little endian format**.

The following standards are used in the tables:

P_0 = the first pixel transmitted by the camera for a line

P_n = the last pixel transmitted by the camera for a line

B_0 = the first byte of data for a line

B_m = the last byte of data for a line

Even Lines	
Byte	**Data**
B_0	Low byte of blue value for P_0
B_1	High byte of blue value for P_0
B_2	Low byte of green value for P_1
B_3	High byte of green value for P_1
B_4	Low byte of blue value for P_2
B_5	High byte of blue value for P_2
B_6	Low byte of green value for P_3
B_7	High byte of green value for P_3
•	•
•	•
•	•
B_{m-7}	Low byte of blue value for P_{n-3}
B_{m-6}	High byte of blue value for P_{n-3}

Odd Lines	
Byte	**Data**
B_0	Low byte of green value for P_0
B_1	High byte of green value for P_0
B_2	Low byte of red value for P_1
B_3	High byte of red value for P_1
B_4	Low byte of green value for P_2
B_5	High byte of green value for P_2
B_6	Low byte of red value for P_3
B_7	High byte of red value for P_3
•	•
•	•
•	•
B_{m-7}	Low byte of green value for P_{n-3}
B_{m-6}	High byte of green value for P_{n-3}

B_{m-5}	Low byte of green value for P_{n-2}
B_{m-4}	High byte of green value for P_{n-2}
B_{m-3}	Low byte of blue value for P_{n-1}
B_{m-2}	High byte of blue value for P_{n-1}
B_{m-1}	Low byte of green value for P_n
B_m	High byte of green value for P_n

B_{m-5}	Low byte of red value for P_{n-2}
B_{m-4}	High byte of red value for P_{n-2}
B_{m-3}	Low byte of green value for P_{n-1}
B_{m-2}	High byte of green value for P_{n-1}
B_{m-1}	Low byte of red value for P_n
B_m	High byte of red value for P_n

When the camera is set for Bayer BG 16, the pixel data output is 16 bit data of the “unsigned short (little endian)” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below. Note that for 16 bit data, you might expect a value range from 0x0000 to 0xFFFF. However, with the camera set for Bayer BG 16 only 12 bits of the 16 bits transmitted are effective. Therefore, the highest data value you will see is 0x0FFF indicating a signal level of 4095.

This Data Value (Hexadecimal)	**Indicates This Signal Level (Decimal)**
0x0FFF	4095
0x0FFE	4094
•	•
•	•
•	•
0x0001	1
0x0000	0

Note

When a camera that is set for Bayer BG 16 has only 12 bits effective, the leader of transmitted frames will indicate Bayer BG 12 as the pixel format.

7.3.5 Bayer BG 12 Packed Format

When a color camera is set for the Bayer BG 12 Packed pixel dataformat, it outputs 12 bits of data per pixel. Every three bytes transmitted by the camera contain data for two pixels.

With the Bayer BG 12 Packed coding, the pixel data is not processed or interpolated in any way. So, for each pixel covered with a red lens in the sensor's Bayer filter, you get 12 bits of red data. For each pixel covered with a green lens in the filter, you get 12 bits of green data. And for each pixel covered with a blue lens in the filter, you get 12 bits of blue data. (This type of pixel data is sometimes referred to as "raw" output.)

For more information about the Bayer filter, see Section 7.3.1 on page 108.

The tables below describe how the data for the even lines and for the odd lines of a received frame will be ordered in the image buffer in your PC when the camera is set for Bayer BG12 Packed output.

The following standards are used in the tables:

P_0 = the first pixel transmitted by the camera for a line

P_n = the last pixel transmitted by the camera for a line

B_0 = the first byte of data for a line

B_m = the last byte of data for a line

Even Lines		
Byte	**Data**	
B_0	Blue value for P_0 bits 11 ... 4	
B_1	Green value for P_1 bits 3 ... 0	Blue value for P_0 bits 3 ... 0
B_2	Green value for P_1 bits 11 ... 4	
B_3	Blue value for P_2 bits 11 ... 4	
B_4	Green value for P_3 bits 3 ... 0	Blue value for P_2 bits 3 ... 0
B_5	Green value for P_3 bits 11 ... 4	
B_6	Blue value for P_4 bits 11 ... 4	
B_7	Green value for P_5 bits 3 ... 0	Blue value for P_4 bits 3 ... 0
B_8	Green value for P_5 bits 11 ... 4	
•	•	
•	•	•
•	•	
B_{m-5}	Blue value for P_{n-3} bits 11 ... 4	
B_{m-4}	Green value for P_{n-2} bits 3 ... 0	Blue value for P_{n-3} bits 3 ... 0
B_{m-3}	Green value for P_{n-2} bits 11 ... 4	
B_{m-2}	Blue value for P_{n-1} bits 11 ... 4	
B_{m-1}	Green value for P_n bits 3 ... 0	Blue value for P_{n-1} bits 3 ... 0
B_m	Green value for P_n bits 11 ... 4	

Odd Lines		
Byte	**Data**	
B_0	Green value for P_0 bits 11 ... 4	
B_1	Red value for P_1 bits 3 ... 0	Green value for P_0 bits 3 ... 0
B_2	Red value for P_1 bits 11 ... 4	
B_3	Green value for P_2 bits 11 ... 4	
B_4	Red value for P_3 bits 3 ... 0	Green value for P_2 bits 3 ... 0
B_5	Red value for P_3 bits 11 ... 4	
B_6	Green value for P_4 bits 11 ... 4	
B_7	Red value for P_5 bits 3 ... 0	Green value for P_4 bits 3 ... 0
B_8	Red value for P_5 bits 11 ... 4	
•	•	
•	•	•
•	•	
•	•	
•	•	•
•	•	
B_{m-5}	Green value for P_{n-3} bits 11 ... 4	
B_{m-4}	Red value for P_{n-2} bits 3 ... 0	Green value for P_{n-3} bits 3 ... 0
B_{m-3}	Red value for P_{n-2} bits 11 ... 4	
B_{m-2}	Green value for P_{n-1} bits 11 ... 4	
B_{m-1}	Red value for P_n bits 3 ... 0	Green value for P_{n-1} bits 3 ... 0
B_m	Red value for P_n bits 11 ... 4	

When a color camera is set for Bayer BG 12 Packed, the pixel data output is 12 bit data of the “unsigned” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

This Data Value (Hexadecimal)	**Indicates This Signal Level (Decimal)**
0x0FFF	4095
0x0FFE	4094
•	•
•	•
•	•
0x0001	1
0x0000	0

7.3.6 YUV 4:2:2 Packed Format (Equivalent to DCAM YUV 4:2:2)

When a color camera is set for the YUV 422 Packed pixel data format, each pixel in the captured image goes through a two step conversion process as it exits the sensor and passes through the camera's electronics. This process yields Y, U, and V color information for each pixel.

In the first step of the process, an interpolation algorithm is performed to get full RGB data for each pixel. This is required because color cameras use a Bayer filter on the sensor and each individual pixel gathers information for only one color.

For more information on the Bayer filter, see Section 7.3.1 on page 108.

The second step of the process is to convert the RGB information to the YUV color model. The conversion algorithm uses the following formulas:

$$Y = 0.30\,R + 0.59\,G + 0.11\,B$$

$$U = -0.17\,R - 0.33\,G + 0.50\,B$$

$$V = 0.50\,R - 0.41\,G - 0.09\,B$$

Once the conversion to a YUV color model is complete, the pixel data is transmitted to the host PC.

Note

The values for U and for V normally range from -128 to +127. Because the camera transfers U values and V values with unsigned integers, 128 is added to each U value and to each V value before the values are transferred from the camera. This process allows the values to be transferred on a scale that ranges from 0 to 255.

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when the camera is set for YUV 4:2:2 Packed output.

The following standards are used in the table:

P_0 = the first pixel transmitted by the camera

P_n = the last pixel transmitted by the camera

B_0 = the first byte in the buffer

B_m = the last byte in the buffer

Byte	**Data**
B_0	U value for P_0
B_1	Y value for P_0
B_2	V Value for P_0
B_3	Y value for P_1
B_4	U value for P_2
B_5	Y value for P_2
B_6	V Value for P_2
B_7	Y value for P_3
B_8	U value for P_4
B_9	Y value for P_4
B_{10}	V Value for P_4
B_{11}	Y value for P_5
•	•
•	•
•	•
B_{m-7}	U value for P_{n-3}
B_{m-6}	Y value for P_{n-3}
B_{m-5}	V Value for P_{n-3}
B_{m-4}	Y value for P_{n-2}
B_{m-3}	U value for P_{n-1}
B_{m-2}	Y value for P_{n-1}
B_{m-1}	V Value for P_{n-1}
B_m	Y value for P_n

When the camera is set for YUV 4:2:2 Packed output, the pixel data output for the Y component is 8 bit data of the “unsigned char” type. The range of data values for the Y component and the corresponding indicated signal levels are shown below.

This Data Value (Hexadecimal)	**Indicates This Signal Level (Decimal)**
0xFF	255
0xFE	254
•	•
•	•
•	•
0x01	1
0x00	0

The pixel data output for the U component or the V component is 8 bit data of the “straight binary” type. The range of data values for a U or a V component and the corresponding indicated signal levels are shown below.

This Data Value (Hexadecimal)	**Indicates This Signal Level (Decimal)**
0xFF	127
0xFE	126
•	•
•	•
•	•
0x81	1
0x80	0
0x7F	-1
•	•
•	•
•	•
0x01	-127
0x00	-128

The signal level of a U component or a V component can range from -128 to +127 (decimal). Notice that the data values have been arranged to represent the full signal level range.

7.3.7 YUV 4:2:2 (YUYV) Packed Format

On color cameras, the YUV 4:2:2 (YUYV) packed pixel data format is similar to the YUV 4:2:2 pixel format described in the previous section. The only difference is the order of the bytes transmitted to the host PC. With the YUV 4:2:2 format, the bytes are ordered as specified in the DCAM standard issued by the 1394 Trade Association. With the YUV 4:2:2 (YUYV) format, the bytes are ordered to emulate the ordering normally associated with analog frame grabbers and Windows® frame buffers.

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when the camera is set for YUV 4:2:2 (YUYV) output.

With this format, the Y component is transmitted for each pixel, but the U and V components are only transmitted for every second pixel.

The following standards are used in the table:

P_0 = the first pixel transmitted by the camera

P_n = the last pixel transmitted by the camera

B_0 = the first byte in the buffer

B_m = the last byte in the buffer

Byte	**Data**
B_0	Y value for P_0
B_1	U value for P_0
B_2	Y value for P_1
B_3	V value for P_0
B_4	Y value for P_2
B_5	U value for P_2
B_6	Y value for P_3
B_7	V value for P_2
B_8	Y value for P_4
B_9	U value for P_4
B_{10}	Y value for P_5
B_{11}	V value for P_4
•	•
•	•
•	•
B_{m-7}	Y value for P_{n-3}
B_{m-6}	U value for P_{n-3}
B_{m-5}	Y value for P_{n-2}
B_{m-4}	V value for P_{n-3}
B_{m-3}	Y value for P_{n-1}
B_{m-2}	U value for P_{n-1}
B_{m-1}	Y value for P_n
B_m	V value for P_{n-1}

When a color camera is set for YUV 4:2:2 (YUYV) output, the pixel data output for the Y component is 8 bit data of the “unsigned char” type. The range of data values for the Y component and the corresponding indicated signal levels are shown below.

This Data Value (Hexadecimal)	Indicates This Signal Level (Decimal)
0xFF	255
0xFE	254
•	•
•	•
•	•
0x01	1
0x00	0

The pixel data output for the U component or the V component is 8 bit data of the “straight binary” type. The range of data values for a U or a V component and the corresponding indicated signal levels are shown below.

This Data Value (Hexadecimal)	Indicates This Signal Level (Decimal)
0xFF	127
0xFE	126
•	•
•	•
•	•
0x81	1
0x80	0
0x7F	-1
•	•
•	•
•	•
0x01	-127
0x00	-128

The signal level of a U component or a V component can range from -128 to +127 (decimal). Notice that the data values have been arranged to represent the full signal level range.

7.3.8 Mono 8 Format (Equivalent to DCAM Mono 8)

When a color camera is set for the Mono 8 pixel data format, the pixel values in each captured image are first interpolated and converted to the YUV color model as described for the YUV 4:2:2 Packed format. The camera then transmits the 8 bit Y value for each pixel to the host PC. In the YUV color model, the Y component for each pixel represents a brightness value. This brightness value can be considered as equivalent to the value that would be sent from a pixel in a monochrome camera. So in essence, when a color camera is set for Mono 8, it outputs an 8 bit monochrome image. (This type of output is sometimes referred to as "Y Mono 8".)

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when a color camera is set for Mono 8 output.

The following standards are used in the table:

P_0 = the first pixel transmitted by the camera

P_n = the last pixel transmitted by the camera

B_0 = the first byte in the buffer

B_m = the last byte in the buffer

Byte	Data
B_0	Y value for P_0
B_1	Y value for P_1
B_2	Y value for P_2
B_3	Y value for P_3
B_4	Y value for P_4
B_5	Y value for P_5
B_6	Y value for P_6
B_7	Y value for P_7
•	•
•	•
•	•
B_{m-3}	Y value for P_{n-3}
B_{m-2}	Y value for P_{n-2}
B_{m-1}	Y value for P_{n-1}
B_m	Y value for P_n

With the camera set for Mono 8, the pixel data output is 8 bit data of the “unsigned char” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

This Data Value (Hexadecimal)	**Indicates This Signal Level (Decimal)**
0xFF	255
0xFE	254
•	•
•	•
•	•
0x01	1
0x00	0

7.4 Pixel Transmission Sequence

For each captured image, pixel data is transmitted from the camera in the following sequence:

Row $_0$ Col $_0$,	Row $_0$ Col $_1$,	Row $_0$ Col $_2$	.. ..	Row $_0$ Col $_{m-2}$,	Row $_0$ Col $_{m-1}$,	Row $_0$ Col $_m$
Row $_1$ Col $_0$,	Row $_1$ Col $_1$,	Row $_1$ Col $_2$	.. ..	Row $_1$ Col $_{m-2}$,	Row $_1$ Col $_{m-1}$,	Row $_1$ Col $_m$
Row $_2$ Col $_0$,	Row $_2$ Col $_1$,	Row $_2$ Col $_2$	.. ..	Row $_2$ Col $_{m-2}$,	Row $_2$ Col $_{m-1}$,	Row $_2$ Col $_m$
:	:	:		:	:	:
:	:	:		:	:	:
Row $_{n-2}$ Col $_0$,	Row $_{n-2}$ Col $_1$,	Row $_{n-2}$ Col $_2$	.. ..	Row $_{n-2}$ Col $_{m-2}$,	Row $_{n-2}$ Col $_{m-1}$,	Row $_{n-2}$ Col $_m$
Row $_{n-1}$ Col $_0$,	Row $_{n-1}$ Col $_1$,	Row $_{n-1}$ Col $_2$	.. ..	Row $_{n-1}$ Col $_{m-2}$,	Row $_{n-1}$ Col $_{m-1}$,	Row $_{n-1}$ Col $_m$
Row $_n$ Col $_0$,	Row $_n$ Col $_1$,	Row $_n$ Col $_2$	.. ..	Row $_n$ Col $_{m-2}$,	Row $_n$ Col $_{m-1}$,	Row $_n$ Col $_m$

Where Row $_0$ Col $_0$ is the upper left corner of the sensor

The columns are numbered 0 through m from the left side to the right side of the sensor

The rows are numbered 0 through n from the top to the bottom of the sensor

The sequence assumes that the camera is set for full resolution.

8 I/O Control

This section describes how to configure the camera’s two physical input lines and four physical output lines. It also provides information about monitoring the state of the input and output lines.

For more detailed information about the physical and electrical characteristics of the input and output lines, see Section 5.4 on page 49.

8.1 Configuring Input Lines

8.1.1 Assigning an Input Line to Receive a Hardware Trigger Signal

You can assign one of the camera’s input lines to receive a external hardware trigger (ExTrig) signal. The incoming ExTrig signal can then be used to control image acquisition.

Section 6.3.2 on page 71 explains how to configure the camera to react to a hardware trigger signal and how to assign an input line to receive the hardware trigger signal.

Note

By default, physical input line 1 is assigned to receive the ExTrig signal. You can assign only one line to receive the ExTrig input signal.

8.1.2 Using an Unassigned Input Line to Receive a User Input Signal

You can use an unassigned input line to receive your own, user-generated input signal. The electrical characteristics of your input signal must meet the requirements shown in the Physical Interface section of this manual.

You can use the Line Status or Line Status All parameters to monitor the state of the input line that is receiving the user-defined signal.

Note

The line assigned to receive the ExTrig input signal can’t be used to receive a user-designed input signal.

For more information about using the Line Status and Line Status All parameters, see Section 8.3.1 on page 137 and Section 8.3.2 on page 137.

8.2 Configuring Output Lines

8.2.1 Assigning a Camera Output Signal to a Physical Output Line

You can use the camera's output signal assignment capability to assign one of the camera's standard output signals as the source signal for a physical output line. The camera has a variety of standard output signals available including:

- Exposure Active
- Trigger Ready
- Timer 1, Timer 2, Timer 3, Timer 4

You can also designate an output line as "user settable". If an output line is designated as a user settable, you can use the camera's API to set the state of the line as desired.

To assign an output signal to an output line or to designate the line as user settable:

- Use the Line Selector to select Output Line 1, Output Line 2, Output Line 3, or Output Line 4.
- Set the value of the Line Source Parameter to one of the available output signals or to user settable. This will set the source signal for the selected line.

Note

By default, the Exposure Active signal is assigned to Output Line 1 and the Trigger Ready Signal is assigned to Output Line 2.

You can set the Line Selector and the Line Source parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.LineSelector.SetValue( LineSelector_Out1 );
Camera.LineSource.SetValue( LineSource_ExposureActive );
Camera.LineSelector.SetValue( LineSelector_Out2 );
Camera.LineSource.SetValue( LineSource_TriggerReady );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

For more information about setting the state of user settable output signals, see Section 8.2.2 on page 130.

For more information about working with the timer output signals, see Section 8.2.4 on page 132

For more information about the exposure active signal, see Section 6.8 on page 86.

For more information about the trigger ready signal, see Section 6.7 on page 82.

8.2.2 Setting the State of User Settable Output Lines

As mentioned in the previous section, you can designate one or more of the user output lines as "user settable". Once you have designated an output line as user settable, you can use camera parameters to set the state of the line.

Setting the State of a Single User Settable Output Line

To set the state of a single user settable output line:

- Use the User Output Selector to select the output line you want to set. For example, if you have designated output line 3 as user settable, you would select user settable output 3.
- Set the value of the User Output Value parameter to true (high) or false (low). This will set the state of the selected line.

You can set the Output Selector and the User Output Value parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to designate output line 3 as user settable and setting the state of the output line:

```
Camera.LineSelector.SetValue( LineSelector_Out3 );
Camera.LineSource.SetValue( LineSource_UserOutput );
Camera.UserOutputSelector.SetValue( UserOutputSelector_UserOutput3 );
Camera.UserOutputValue.SetValue( true );
bool currentUserOutput3State = Camera.UserOutputValue.GetValue( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

Setting the State of Multiple User Settable Output Lines

The User Output Value All parameter is a 32 bit value. As shown in Figure 52, the lowest four bits of the parameter value will set the state of the user settable outputs. If a bit is 0, it will set the state of the associated output to low. If a bit is high, it will set the state of the associated port to high.

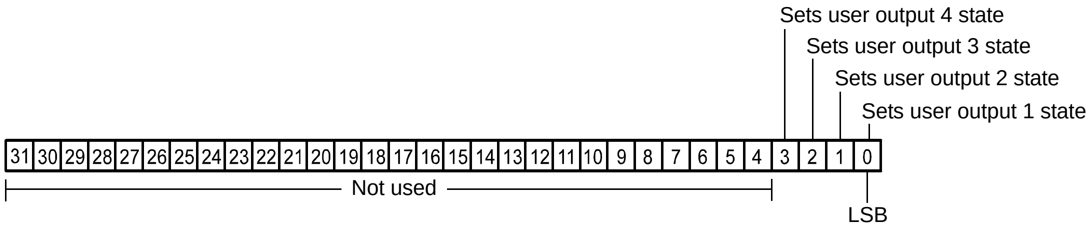


Fig. 52: User Output Value All Parameter Bits

To set the state of multiple user settable output lines:

- Use the User Output Value All parameter to set the state of multiple user settable outputs.

You can set the User Output Value All parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter:

```
Camera.UserOutputValueAll.SetValue( 0x3 );
int64_t currentOutputState = Camera.UserOutputValueAll.GetValue( );
```

Note

If you have the invert function enabled on an output line that is designated as user settable, the user setting sets the state of the line before the inverter.

8.2.3 Setting an Output Line for Invert

You can set each individual output line to invert or not to invert the outgoing signal. To set the invert function on an output line:

- Use the Line Selector to select an output line.
- Set the value of the Line Inverter parameter to true to enable inversion on the selected line and to false to disable inversion.

You can set the Line Selector and the Line Inverter parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
// Enable the inverter on output line 1
Camera.LineSelector.SetValue( LineSelector_Out1 );
Camera.LineInverter.SetValue( true );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

8.2.4 Working with Timers

The camera has four timer output signals available: Timer 1, Timer 2, Timer 3, and Timer 4. As shown in Figure 53, each timer works as follows:

- A trigger source event occurs that starts the timer.
- A delay period begins to expire.
- When the delay expires, the timer signal goes high and a duration period begins to expire.
- When the duration period expires, the timer signal goes low.

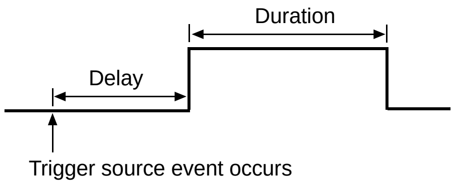


Fig. 53: Timer Signal

Currently, the only trigger source event available to start the timer is "exposure active". In other words, you can use exposure start to trigger the start of a timer.

Timer 1 can only be assigned to output line 1. Timer 2 can only be assigned to output line 2. Timer 3 can only be assigned to output line 3. Timer 4 can only be assigned to output line 4.

If you require the timer signal to be high when the timer is triggered and to go low when the delay expires, simply set the output line to invert.

8.2.4.1 Setting the Trigger Source for a Timer

To set the trigger source for a timer:

- Use the Timer Selector to select timer 1 or timer 2.
- Set the value of the Timer Trigger Source parameter to exposure active. This will set the selected timer to use the start of exposure to begin the timer.

You can set the Trigger Selector and the Timer Trigger Source parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TimerSelector.SetValue( TimerSelector_Timer1 );
Camera.TimerTriggerSource.SetValue( TimerTriggerSource_ExposureStart );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

8.2.4.2 Setting a Timer Delay Time

There are two ways to set the delay time for a timer: by setting "raw" values or by setting an "absolute value". You can use whichever method you prefer to set the delay time.

Setting the Delay with Raw Values

When the delay time for a timer is set using "raw" values, the delay time will be determined by a combination of two elements. The first element is the value of the Timer Delay Raw parameter, and the second element is the Timer Delay Time Base. The delay time is the product of these two elements:

Delay Time = (Timer Delay Raw Parameter Value) x (Timer Delay Time Base)

By default, the Timer Delay Time Base is fixed at 1 µs. Typically, the delay time is adjusted by setting the Timer Delay Raw parameter value.

The Timer Delay Raw parameter value can range from 0 to 4095. So if the value is set to 100, for example, the timer delay will be 100 x 1 µs or 100 µs.

To set the delay for a timer:

- Use the Timer Selector to select a timer.
- Set the value of the Timer Delay Raw parameter.

You can set the Timer Selector and the Timer Delay Raw parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TimerSelector.SetValue( TimerSelector_Timer1 );
Camera.TimerDelayRaw.SetValue( 100 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

Changing the Delay Time Base

By default, the Timer Delay Time Base is fixed at 1 µs (minimum value), and the timer delay is normally adjusted by setting the value of the Timer Delay Raw parameter. However, if you require a delay time that is longer than what you can achieve by changing the value of the Timer Delay Raw parameter alone, the Timer Delay Time Base Abs parameter can be used to change the delay time base.

The Timer Delay Time Base Abs parameter value sets the delay time base in µs. The default is 1 µs and it can be changed in 1 µs increments.

Note that there is only one timer delay time base and it is used by all four of the available timers.

You can set the Timer Delay Time Base Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
Camera.TimerDelayTimebaseAbs.SetValue( 5 );
```

Setting the Delay with an Absolute Value

You can also set the Timer delay by using an "absolute" value. This is accomplished by setting the Timer Delay Abs parameter. The units for setting this parameter are µs and the value can be set in increments of 1 µs.

To set the delay for a timer using an absolute value:

- Use the Timer Selector to select a timer.
- Set the value of the Timer Delay Abs parameter.

You can set the Timer Selector and the Timer Delay Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TimerSelector.SetValue( TimerSelector_Timer1 );
Camera.TimerDelayAbs.SetValue( 100 );
```

When you use the Timer Delay Abs parameter to set the delay time, the camera accomplishes the setting change by automatically changing the Timer Delay Raw parameter to achieve the value specified by the Timer Delay Abs setting. This leads to a limitation that you must keep in mind if you use Timer Delay Abs parameter to set the delay time. That is, you must set the Timer Delay Abs parameter to a value that is equivalent to a setting you could achieve by using the Timer Delay Raw and the current Timer Delay Base parameters. For example, if the time base was currently set to 50 µs, you could use the Timer Delay Abs parameter to set the delay to 50 µs, 100 µs, 150 µs, etc.

Note that if you set the Timer Delay Abs parameter to a value that you could not achieve by using the Timer Delay Raw and current Timer Delay Time Base parameters, the camera will automatically change the setting for the Timer Delay Abs parameter to the nearest achieveable value.

You should also be aware that if you change the delay time using the raw settings, the Timer Delay Abs parameter will automatically be updated to reflect the new delay time.

8.2.4.3 Setting a Timer Duration Time

There are two ways to set the duration time for a timer: by setting "raw" values or by setting an "absolute value". You can use whichever method you prefer to set the duration time.

Setting the Duration with Raw Values

When the duration time for a timer is set using "raw" values, the duration time will be determined by a combination of two elements. The first element is the value of the Timer Duration Raw parameter, and the second element is the Timer Duration Time Base. The duration time is the product of these two elements:

Duration Time = (Timer Duration Raw Parameter Value) x (Timer Duration Time Base)

By default, the Timer Duration Time Base is fixed at 1 µs. Typically, the duration time is adjusted by setting only the Timer Duration Raw parameter value.

The Timer Duration Raw parameter value can range from 1 to 4095. So if the value is set to 100, for example, the timer duration will be 100 x 1 µs or 100 µs.

To set the duration for a timer:

- Use the Timer Selector to select a timer.
- Set the value of the Timer Duration Raw parameter.

You can set the Timer Selector and the Timer Duration Raw parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TimerSelector.SetValue( TimerSelector_Timer1 );
Camera.TimerDurationRaw.SetValue( 100 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

Changing the Duration Time Base

By default, the Timer Duration Time Base is fixed at 1 µs, and the timer duration is normally adjusted by setting the value of the Timer Duration Raw parameter. However, if you require a duration time that is longer than what you can achieve by changing the value of the Timer Duration Raw parameter alone, the Timer Duration Time Base Abs parameter can be used to change the duration time base.

The Timer Duration Time Base Abs parameter value sets the duration time base in µs. The default is 1 µs and it can be changed in 1 µs increments.

Note that there is only one timer duration time base and it is used by all four of the available timers.

You can set the Timer Duration Time Base Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
Camera.TimerDurationTimebaseAbs.SetValue( 5 );
```

Setting the Duration with an Absolute Value

You can also set the Timer duration by using an "absolute" value. This is accomplished by setting the Timer Duration Abs parameter. The units for setting this parameter are µs and the value can be set in increments of 1 µs.

To set the duration for a timer using an absolute value:

- Use the Timer Selector to select a timer.
- Set the value of the Timer Duration Abs parameter.

You can set the Timer Selector and the Timer Duration Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TimerSelector.SetValue( TimerSelector_Timer1 );
Camera.TimerDurationAbs.SetValue( 100 );
```

When you use the Timer Duration Abs parameter to set the duration time, the camera accomplishes the setting change by automatically changing the Timer Duration Raw parameter to achieve the value specified by the Timer Duration Abs setting. This leads to a limitation that you must keep in mind if you use Timer Duration Abs parameter to set the duration time. That is, you must set the Timer Duration Abs parameter to a value that is equivalent to a setting you could achieve by using the Timer Duration Raw and the current Timer Duration Base parameters. For example, if the time base was currently set to 50 µs, you could use the Timer Duration Abs parameter to set the duration to 50 µs, 100 µs, 150 µs, etc.

If you read the current value of the Timer Duration Abs parameter, the value will indicate the product of the Timer Duration Raw parameter and the Timer Duration Time Base. In other words, the Timer Duration Abs parameter will indicate the current duration time setting.

You should also be aware that if you change the duration time using the raw settings, the Timer Duration Abs parameter will automatically be updated to reflect the new duration time.

8.3 Checking the State of the I/O Lines

8.3.1 Checking the State of a Single Output Line

You can determine the current state of an individual output line. To check the state of a line:

- Use the Line Selector parameter to select an output line.
- Read the value of the Line Status parameter to determine the current state of the selected line. A value of true means the line's state is currently high and a value of false means the line's state is currently low.

You can set the Line Selector and read the Line Status parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and read the parameter value:

```
// Select output line 2 and read the state
Camera.LineSelector.SetValue( LineSelector_Out2 );
bool outputLine2State = Camera.LineStatus.GetValue( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

8.3.2 Checking the State of All Lines

You can determine the current state of all input and output lines with a single operation. To check the state of all lines:

- Read the value of the Line Status All parameter.

You can read the Line Status All parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to read the parameter value:

```
int64_t lineState = Camera.LineStatusAll.GetValue( );
```

The Line Status All parameter is a 32 bit value. As shown in Figure 54, certain bits in the value are associated with each line and the bits will indicate the state of the lines. If a bit is 0, it indicates that the state of the associated line is currently low. If a bit is 1, it indicates that the state of the associated line is current high.

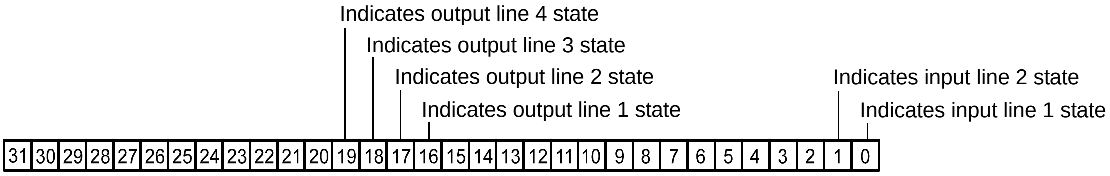

Indicates output line 4 state
Indicates output line 3 state
Indicates output line 2 state
Indicates output line 1 state
Indicates input line 2 state
Indicates input line 1 state
31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

Fig. 54: Line Status All Parameter Bits

9 Standard Features

This section provides detailed information about the standard features available on each camera. It also includes an explanation of their operation and the parameters associated with each feature.

9.1 Gain

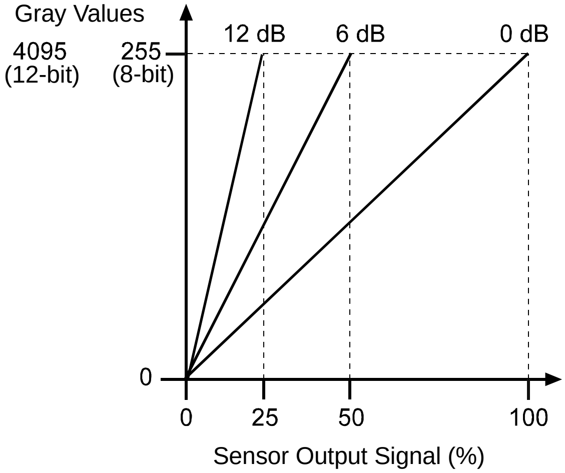


Fig. 55: Gain in dB

The camera's gain setting is adjustable. As shown in Figure 55, increasing the gain increases the slope of the response curve for the camera. This results in a higher gray value output from the camera for a given amount of output from the imaging sensor. Decreasing the gain decreases the slope of the response curve and results in a lower gray value for a given amount of sensor output.

Increasing the gain is useful when at your brightest exposure, a gray value lower than 255 (in modes that output 8 bits per pixel) or 4095 (in modes that output 12 bits per pixels) is reached. For example, if you found that at your brightest exposure the gray values output by the camera were no higher than 127 (in an 8 bit mode), you could increase the gain to 6 dB (an amplification factor of 2) and thus reach gray values of 254.

Setting the Gain (All Models Except scA750-60)

Note

The information in this section applies to all camera models except the scA750-60 fm/fc. For information about scA750-60 cameras, see the next section.

Note

Gain can not only be manually set (see below), but can also be automatically adjusted. The Gain Auto function is the "automatic" counterpart of the gain feature and adjusts the Gain Raw parameter value automatically.

For more information about auto fuctions, see Section 9.11.1 on page 172.

For more information about the Gain Auto function, see Section 9.11.2 on page 179.

The camera’s gain is determined by the value of the Gain Raw parameter. Gain Raw is adjusted on a decimal scale. The minimum decimal setting varies depending on the camera model and on whether vertical binning is enabled (see Table 17). The maximum setting depends on whether the camera is set for a pixel data format that yields 8 bit effective pixel depth (Mono 8, Bayer BG 8, YUV 4:2:2 Packed, YUV 4:2:2 (YUYV) Packed) or yields an effective pixel depth of 12 bits per pixel (Mono 16, Mono 12 Packed, Bayer BG 16, Bayer BG 12 Packed).

Camera Model	Min Setting	Min Setting with Vertical Binning	Max Setting (8 bit depth)	Max Setting (16 bit depth)
scA640-70	320	260	1023	511
scA640-74	280	200	1023	511
scA640-120	150	120	800	400
scA780-54	350	280	1023	511
scA1000-20	330	260	1023	511
scA1000-30	360	280	1023	511
scA1300-32	300	200	850	400
scA1390-17	360	280	1023	511
scA1400-17	192	110	1023	511
scA1400-30	150	0	850	400
scA1600-14	350	280	1023	511

Table 17: Minimum and Maximum Allowed Gain Raw Settings

To set the Gain Raw parameter value:

- Set the Gain Selector to Gain All.
- Set the Gain Raw parameter to your desired value.

You can set the Gain Selector and the Gain Raw parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.GainSelector.SetValue( GainSelector_All );
Camera.GainRaw.SetValue( 400 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

If you know the current decimal setting for the gain raw, you can use the formulas below to calculate the dB of gain that will result from that setting.

Formulas for All Models Listed on the Previous Page (except scA1400-30):

For gain raw settings from 110 to 511:

$$\text{Gain}_{\text{dB}} = 20 \times \log_{10}\left(\frac{658 + \text{Gain Raw Setting}}{658 - \text{Gain Raw Setting}}\right) - G_c$$

For gain raw settings from 512 to 1023:

$$\text{Gain}_{\text{dB}} = (0.0354 \times \text{Gain Raw Setting}) - G_c$$

Where:

$$G_c = 20 \times \log_{10}\left(\frac{658 + \text{Min Gain Raw Setting}}{658 - \text{Min Gain RawSetting}}\right)$$

Example:

Assume that you are working with a monochrome scA1400-17 camera that is set for the Mono 8 pixel format and has a gain raw setting of 500. Calculating the gain is a two step process:

Step 1:

$$G_c = 20 \times \log_{10}\left(\frac{658 + 192}{658 - 192}\right)$$

$$G_c = 5.22\text{ dB}$$

Step 2::

$$\text{Gain}_{dB} = 20 \times \log_{10}\left(\frac{658 + 500}{658 - 500}\right) - 5.22\text{ db}$$

$$\text{Gain}_{dB} = 12.1\text{ dB}$$

Calculation for the scA1400-30:

For the entire range of raw settings:

$$\text{Gain}_{dB} = (0.0359 \times \text{Gain Raw Setting}) - 5.385\text{ dB}$$

Table 18 shows the minimum and maximum gain in dB for each camera model.

Camera Model	dB Gain at Min Setting	dB Gain at Max Setting (8 bit depth)	dB Gain at Max Setting (16 bit depth)
scA640-70	0	27	8.8
scA640-74	0	28.3	10.1
scA640-120	0	24.3	8.2
scA780-54	0	25.9	7.7
scA1000-20	0	26.6	8.4
scA1000-30	0	25.5	7.3
scA1300-32	0	25.13	9.0
scA1390-17	0	25.5	7.3
scA1400-17	0	31.0	12.8
scA1400-30	0	25.13	9.0
scA1600-14	0	25.9	7.7

Table 18: Minimum and Maximum db of Gain

Setting the Gain (scA750-60 Only)

Note

The information in this section only applies to scA750-60 fm/fc cameras. For information about the other camera models, see the previous section.

Note

Gain can not only be manually set (see below), but can also be automatically adjusted. The Gain Auto function is the "automatic" counterpart of the gain feature and adjusts the Gain Raw parameter value automatically.

For more information about auto fuctions, see Section 9.11.1 on page 172.

For more information about the Gain Auto function, see Section 9.11.2 on page 179.

The camera's gain is determined by the value of the Gain Raw parameter. Gain Raw is adjusted on a decimal scale. The range for the Gain Raw parameter setting is from 0 to 22.

To set the Gain Raw parameter value:

- Set the Gain Selector to Gain All.
- Set the Gain Raw parameter to your desired value.

You can set the Gain Selector and the Gain Raw parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.GainSelector.SetValue( GainSelector_All );
Camera.GainRaw.SetValue( 20 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

If you know the current decimal setting for the gain raw, you can use the following formula to calculate the dB of gain that will result from that setting:

$$\text{Gain}_{\text{dB}} = 20 \times \log_{10}\left(1 + \frac{\text{Gain Raw Setting}}{6}\right)$$

Example:

Assume that you are working with an scA750-60 camera that has a gain raw setting of 18. The gain is calculated as follows:

$$\text{Gain}_{\text{dB}} = 20 \times \log_{10}\left(1 + \frac{18}{6}\right)$$

$$\text{Gain}_{\text{dB}} = 12.0\ \text{dB}$$

Table 19 shows the dB of gain that will be achieved at various Gain Raw settings.

Gain Setting	dB Gain
0	0
5	5.3
10	8.5
15	10.9
20	12.7
22	13.4

Table 19: dB of Gain at Various Settings

9.2 Black Level

Adjusting the camera’s black level will result in an offset to the pixel values output by the camera. Increasing the black level setting will result in a positive offset in the digital values output for the pixels. Decreasing the black level setting will result in a negative offset in the digital values output for the pixels.

Effect on All Camera Models Except the scA750-60, scA1300-32, and scA1400-30

If the camera is set for a pixel data format that yields 8 bit effective pixel depth (Mono 8, Bayer BG 8, Bayer RG 8, YUV 4:2:2 Packed, YUV 4:2:2 (YUYV) Packed), an increase of 16 in the black level parameter setting will result in a positive offset of 1 in the digital values output for the pixels. And a decrease of 16 in the setting will result in a negative offset of 1 in the digital values output for the pixels.

If the camera is set for a pixel data format that yields an effective pixel depth of 12 bits per pixel (Mono 16, Mono 12 Packed, Bayer BG 16, Bayer RG 16, Bayer BG 12 Packed), an increase of 1 in the black level parameter setting will result in a positive offset of 1 in the digital values output for the pixels. A decrease of 1 in the setting will result in a negative offset of 1 in the digital values output for the pixels.

Effect on scA750-60 Models

An increase of 4 in the black level parameter setting will result in a positive offset of 1 in the digital values output for the pixels. And a decrease of 4 in the setting will result in a negative offset of 1 in the digital values output for the pixels.

Effect on scA1300-32 and scA1400-30 Models

If the camera is set for a pixel data format that yields 8 bit effective pixel depth (Mono 8, Bayer BG 8, Bayer RG 8, YUV 4:2:2 Packed, YUV 4:2:2 (YUYV) Packed), an increase of 64 in the black level parameter setting will result in a positive offset of 1 in the digital values output for the pixels. And a decrease of 64 in the setting will result in a negative offset of 1 in the digital values output for the pixels.

If the camera is set for a pixel data format that yields an effective pixel depth of 12 bits per pixel (Mono 16, Mono 12 Packed, Bayer BG 16, Bayer RG 16, Bayer BG 12 Packed), an increase of 4 in the black level parameter setting will result in a positive offset of 1 in the digital values output for the pixels. A decrease of 4 in the setting will result in a negative offset of 1 in the digital values output for the pixels.

Setting the Black Level

The black level can be adjusted by changing the value of the Black Level Raw parameter. The Black Level Raw parameter value can range from 0 to 255 on all camera models except the scA750-60 fm/fc. On scA750-60 fm/fc cameras, the parameter value can range from 0 to 64. On scA1300-32 fm/fc and scA1400-30 fm/fc cameras, the parameter value can range from 0 to 1023.

To set the Black Level Raw parameter value:

- Set the Black Level Selector to Black Level All.
- Set the Black Level Raw parameter to your desired value.

You can set the Black Level Selector and the Black Level Raw parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.BlackLevelSelector.SetValue ( BlackLevelSelector_All );
Camera.BlackLevelRaw.SetValue( 32 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.3 White Balance (on Color Models)

White balance capability has been implemented on color models of the camera. White balancing can be used to adjust the color balance of the images transmitted from the camera.

Note

White balance can not only be manually set (see below), but can also be automatically adjusted. The Balance White Auto function is the "automatic" counterpart of the white balance feature and adjusts the white balance automatically.

For more information about auto fuctions, see Section 9.11.1 on page 172.

For more information about the Balance White Auto function, see Section 9.11.5 on page 184.

Setting the White Balance

With the white balancing scheme used on these cameras, the red intensity, green intensity, and blue intensity can each be adjusted. For each color, a Balance Ratio parameter is used to set the intensity of the color. If the Balance Ratio parameter for a color is set to a value of 1, the intensity of the color will be unaffected by the white balance mechanism. If the ratio is set to a value lower than 1, the intensity of the color will be reduced. If the ratio is set to a value greater than 1, the intensity of the color will be increased. The increase or decrease in intensity is proportional. For example, if the balance ratio for a color is set to 1.2, the intensity of that color will be increased by 20%.

The balance ratio value can range from 0.00 to 3.98. But you should be aware that if you set the balance ratio for a color to a value lower than 1, this will not only decrease the intensity of that color relative to the other two colors, but will also decrease the maximum intensity that the color can achieve. For this reason, we don't normally recommend setting a balance ratio less than 1 unless you want to correct for the strong predominance of one color.

To set the Balance Ratio parameter for a color:

- Set the Balance Ratio Selector to red, green, or blue.
- Set the Balance Ratio Abs parameter to the desired value for the selected color.

You can set the Balance Ratio Selector and the Balance Ratio Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.BalanceRatioSelector.SetValue( BalanceRatioSelector_Green );
Camera.BalanceRatioAbs.SetValue( 1.20 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.4 Digital Shift

Note

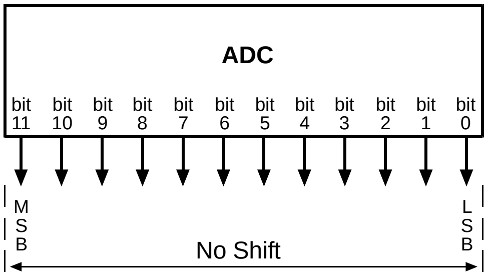
The information in this section applies to all camera models except the scA750-60 fm/fc.

The digital shift feature lets you change the group of bits that is output from the ADC in the camera. Using the digital shift feature will effectively multiply the output of the camera by 2 times, 4 times, 8 times, or 16 times. The next two sections describe how the digital shift works when the camera is set for a 12 bit pixel format and when it is set for a 8 bit pixel format. There is also a section describing precautions that you must observe when using the digital shift feature and a section that describes enabling and setting the digital shift feature.

9.4.1 Digital Shift with 12 Bit Pixel Formats

No Shift

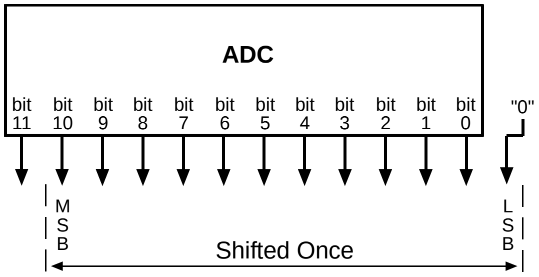
As mentioned in the Functional Description section of this manual, the camera uses a 12 bit ADC to digitize the output from the imaging sensor. When the camera is set for a pixel format that outputs pixel data at 12 bit effective depth, by default, the camera transmits the 12 bits that are output from the ADC.



Shift by 1

When the camera is set to shift by 1, the output from the camera will include bit 10 through bit 0 from the ADC along with a zero as an LSB.

The result of shifting once is that the output of the camera is effectively multiplied by 2. For example, assume that the camera is set for no shift, that it is viewing a uniform white target, and that under these conditions the reading for the brightest pixel is 100. If you changed the digital shift setting to shift by 1, the reading would increase to 200.

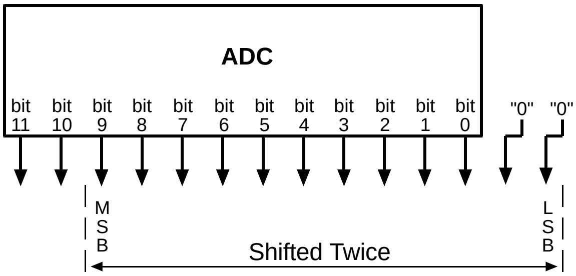


When the camera is set to shift by 1, the least significant bit output from the camera for each pixel value will be 0. This means that no odd gray values can be output and that the gray value scale will only include values of 2, 4, 6, 8, 10, and so on. This absence of some gray values is commonly referred to as "missing codes".

If the pixel values being output by the camera's sensor are high enough to set bit 11 to 1, we recommend not using shift by 1. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, you should only use the shift by 1 setting when your pixel readings with a 12 bit pixel format selected and with digital shift disabled are all less than 2048.

Shift by 2

When the camera is set to shift by 2, the output from the camera will include bit 9 through bit 0 from the ADC along with 2 zeros as LSBs.



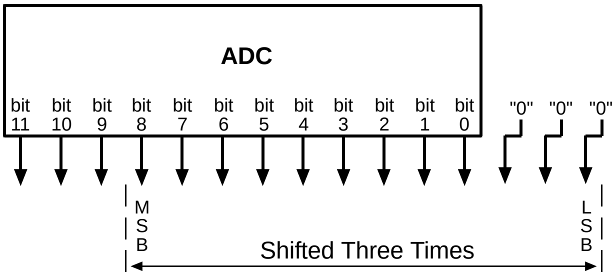
The result of shifting twice is that the output of the camera is effectively multiplied by 4.

When the camera is set to shift by 2, the 2 least significant bits output from the camera for each pixel value will be 0. This means that the gray value scale will only include every 4th value, for example, 4, 8, 16, 20, and so on.

If the pixel values being output by the camera's sensor are high enough to set bit 10 or bit 11 to 1, we recommend not using shift by 2. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, you should only use the shift by 2 setting when your pixel readings with a 12 bit pixel format selected and with digital shift disabled are all less than 1024.

Shift By 3

When the camera is set to shift by 3, the output from the camera will include bit 8 through bit 0 from the ADC along with 3 zeros as LSBs.

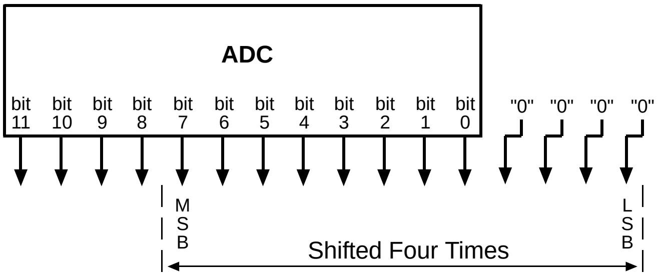


The result of shifting 3 times is that the output of the camera is effectively multiplied by 8.

When the camera is set to shift by 3, the 3 least significant bits output from the camera for each pixel value will be 0. This means that the gray value scale will only include every 8th gray value, for example, 8, 16, 24, 32, and so on.

If the pixel values being output by the camera's sensor are high enough to set bit 9, bit 10, or bit 11 to 1, we recommend not using shift by 3. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, you should only use the shift by 3 setting when your pixel readings with a 12 bit pixel format selected and with digital shift disabled are all less than 512.

Shift By 4



When the camera is set to shift by 4, the output from the camera will include bit 7 through bit 0 from the ADC along with 4 zeros as LSBs.

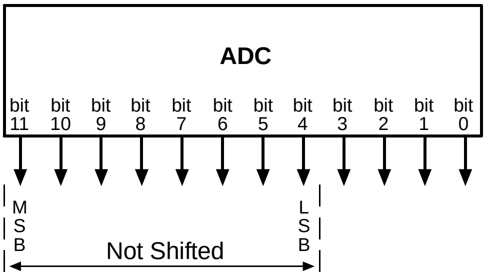
The result of shifting 4 times is that the output of the camera is effectively multiplied by 16.

When the camera is set to shift by 4, the 4 least significant bits output from the camera for each pixel value will be 0. This means that the gray value scale will only include every 16th gray value, for example, 16, 32, 48, 64, and so on.

If the pixel values being output by the camera's sensor are high enough to set bit 8, bit 9, bit 10, or bit 11 to 1, we recommend not using shift by 4. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, you should only use the shift by 4 setting when your pixel readings with a 12 bit pixel format selected and with digital shift disabled are all less than 256.

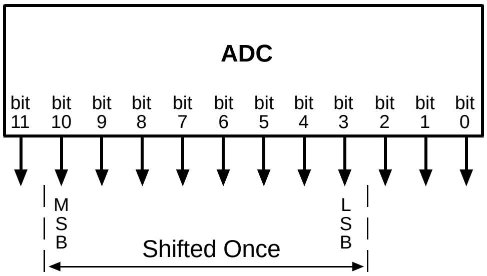
9.4.2 Digital Shift with 8 Bit Pixel Formats

No Shift



As mentioned in the Functional Description section of this manual, the camera uses a 12 bit ADC to digitize the output from the imaging sensor. When the camera is set for a pixel format that outputs pixel data at 8 bit effective depth, by default, the camera drops the 4 least significant bits from the ADC and transmits the 8 most significant bits (bit 11 through 4).

Shift by 1



When the camera is set to shift by 1, the output from the camera will include bit 10 through bit 3 from the ADC.

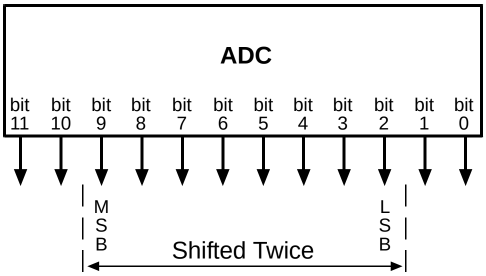
The result of shifting once is that the output of the camera is effectively multiplied by 2. For example, assume that the camera is set for no shift, that it is viewing a uniform white target, and that under these conditions the reading for the brightest pixel is 10. If you changed the digital shift setting to shift by 1, the reading would increase to 20.

If the pixel values being output by the camera's sensor are high enough to set bit 11 to 1, we recommend not using shift by 1. If you do nonetheless, all bits ouput from the camera will automatically be set to 1. Therefore, you should only use the shift by 1 setting when your pixel readings with an 8 bit pixel format selected and with digital shift disabled are all less than 128.

Shift by 2

When the camera is set to shift by 2, the output from the camera will include bit 9 through bit 2 from the ADC.

The result of shifting twice is that the output of the camera is effectively multiplied by 4.

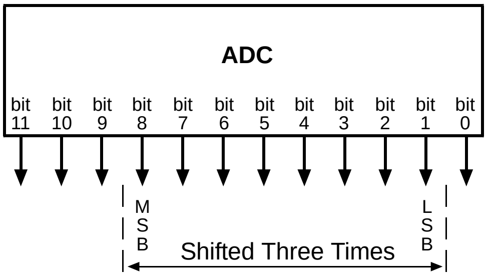


If the pixel values being output by the camera's sensor are high enough to set bit 10 or bit 11 to 1, we recommend not using shift by 2. If you do nonetheless, all bits ouput from the camera will automatically be set to 1. Therefore, you should only use the shift by 2 setting when your pixel readings with an 8 bit pixel format selected and with digital shift disabled are all less than 64.

Shift by 3

When the camera is set to shift by 3, the output from the camera will include bit 8 through bit 1 from the ADC.

The result of shifting three times is that the output of the camera is effectively multiplied by 8.

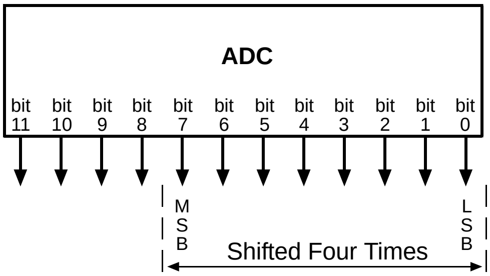


If the pixel values being output by the camera's sensor are high enough to set bit 9, bit 10, or bit 11 to 1, we recommend not using shift by 3. If you do nonetheless, all bits ouput from the camera will automatically be set to 1. Therefore, that you should only use the shift by 3 setting when your pixel readings with an 8 bit pixel format selected and with digital shift disabled are all less than 32.

Shift by 4

When the camera is set to shift by 4, the output from the camera will include bit 7 through bit 0 from the ADC.

The result of shifting four times is that the output of the camera is effectively multiplied by 16.



If the pixel values being output by the camera's sensor are high enough to set bit 8, bit 9, bit 10, or bit 11 to 1, we recommend not using shift by 4. If you do nonetheless, all bits ouput from the camera will automatically be set to 1. Therefore, you should only use the multiply by 4 setting when your pixel readings with an 8 bit pixel format selected and with digital shift disabled are all less than 16.

9.4.3 Precautions When Using Digital Shift

There are several checks and precautions that you must follow before using the digital shift feature. The checks and precautions differ depending on whether the camera will be set for a 12 bit pixel format or for an 8 bit pixel format in your application.

If you will be using a 12 bit pixel format, make this check:

Use the pylon Viewer or the pylon API to set the camera for a 12 bit pixel format and **no digital shift**.

Check the output of the camera under your normal lighting conditions and note the readings for the brightest pixels.

- If any of the readings are above 2048, do not use digital shift.
- If all of the readings are below 2048, you can safely use the shift by 1 setting.
- If all of the readings are below 1024, you can safely use the shift by 1 or 2 settings.
- If all of the readings are below 512, you can safely use the shift by 1, 2, or 3 settings.
- If all of the readings are below 256, you can safely use the shift by 1, 2, 3, or 4 settings.

If you will be using an 8 bit format, make this check:

Use the pylon Viewer or the pylon API to set the camera for a 8 bit pixel format and **no digital shift**.

Check the output of the camera under your normal lighting conditions and note the readings for the brightest pixels.

- If any of the readings are above 128, do not use digital shift.
- If all of the readings are below 128, you can safely use the shift by 1 setting.
- If all of the readings are below 64, you can safely use the shift by 1 or 2 settings.
- If all of the readings are below 32, you can safely use the shift by 1, 2, or 3 settings.
- If all of the readings are below 16, you can safely use the shift by 1, 2, 3, or 4 settings.

9.4.4 Enabling and Setting Digital Shift

You can enable or disable the digital shift feature by setting the value of the Digital Shift parameter. When the parameter is set to zero, digital shift will be disabled. When the parameter is set to 1, 2, 3, or 4, digital shift will be set to shift by 1, shift by 2, shift by 3, or shift by 4 respectively.

You can set the Digital Shift parameter values from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter values:

```
// Disable digital shift
Camera.DigitalShift.SetValue( 0 );
```

```
// Enable digital shift by 2
Camera.DigitalShift.SetValue( 2 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.5 Integrated IR Cut Filter (on Color Models)

Color models of the camera that have a C-mount lens adapter are equipped with an IR cut filter as standard equipment. The filter is mounted inside of the lens adapter. Cameras without an IR cut filter are available on request.

Color cameras that have the optional CS-mount lens adapter do not include an IR cut filter in the adapter.

Monochrome cameras do not include an IR cut filter in the lens adapter. Monochrome cameras with a C-mount lens adapter can be equipped with a filter on request.

CAUTION

Lens Thread Length is Limited

The location of the IR cut filter limits the length of the threads on any lens you use with the camera. If a lens with a very long thread length is used, the IR cut filter will be damaged or destroyed and the camera will no longer operate.

For more information about the location of the IR cut filter, see Section 1.5.3 on page 30.

9.6 Area of Interest (AOI)

The area of interest (AOI) feature lets you specify a portion of the sensor array and after each image is acquired, only the pixel information from the specified portion of the array is transmitted to the host PC.

The area of interest is referenced to the top left corner of the sensor array. The top left corner is designated as column 0 and row 0 as shown in Figure 56.

The location and size of the area of interest is defined by declaring an X offset (coordinate), a width, a Y offset (coordinate), and a height. For example, suppose that you specify the x offset as 10, the width as 16, the y offset as 6, and the height as 10. The area of the array that is bounded by these settings is shown in Figure 56.

The camera will only transfer pixel data from within the area defined by your settings. Information from the pixels outside of the area of interest is discarded.

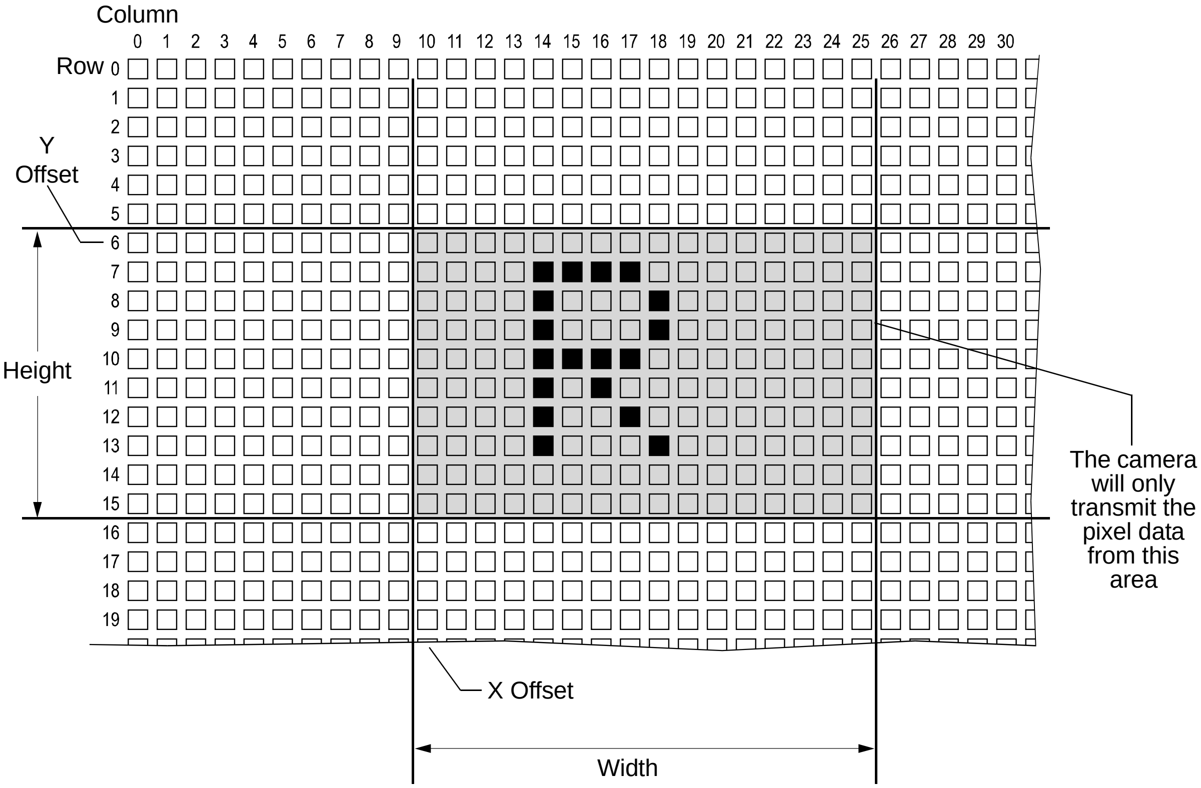


Fig. 56: Area of Interest

One of the main advantages of the AOI feature is that decreasing the height of the AOI can increase the camera's maximum allowed acquisition frame rate.

For more information about how changing the AOI height affects the maximum allowed frame rate, see Section 6.10 on page 90.

Setting the AOI

Except for the scA1300-32 camera, the AOI is set by default to use the full resolution of the camera's sensor. For the scA1300-32 cameras, the default resolution is set to 1280 x 960 pixels for mono models, and to 1278 x 958 pixels for color models.

You can change the size and the position of the AOI by changing the value of the camera's X Offset, Y Offset, Width, and Height parameters.

- The value of the X Offset parameter determines the starting column for the area of interest.
- The value of the Y Offset parameter determines the starting row for the area of interest.
- The value of the Width parameter determines the width of the area of interest.
- The value of the Height parameter determines the height of the area of interest.

When you are setting the camera's area of interest, you must follow these guidelines:

- The sum of the current X Offset setting plus the current Width setting must not exceed the width of the sensor in the camera model you are using. For example, on the monochrome version of the scA640-70, the sum of the current X Offset setting plus the current Width setting must not exceed 659.
- The sum of the current Y Offset setting plus the current Height setting must not exceed the height of the sensor in the camera model you are using. For example, on the monochrome version of the scA640-70, the sum of the current Y Offset setting plus the current Height setting must not exceed 494.

On monochrome cameras:

- The X Offset, Y Offset, Width, and Height parameters can be set in increments of 1.

On color cameras:

- The X Offset, Y Offset, Width, and Height parameters can be set in increments of 2 and they must be set to an even number. For example, the X Offset parameter can be set to 0, 2, 4, 6, 8, etc.

Note

Normally, the X Offset, Y Offset, Width, and Height parameter settings refer to the physical columns and lines in the sensor. But if binning is enabled, these parameters are set in terms of "virtual" columns and lines. For more information, see Section 9.6 on page 155.

You can set the X Offset, Y Offset, Width, and Height parameter values from within your application software by using the pylon API. The following code snippets illustrate using the API to get the maximum allowed settings and the increments for the Width and Height parameters. They also illustrate setting the X Offset, Y Offset, Width, and Height parameter values

```
int64_t widthMax = Camera.Width.GetMax( );
int64_t widhInc = Camera.Width.GetInc();
Camera.Width.SetValue( 200 );
Camera.OffsetX.SetValue( 100 );

int64_t heightMax = Camera.Height.GetMax( );
int64_t heightInc = Camera.Height.GetInc();
Camera.Height.SetValue( 200 );
Camera.OffsetY.SetValue( 100 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.6.1 Changing AOI Parameters "On-the-Fly"

Making AOI parameter changes “on-the-fly” means making the parameter changes while the camera is capturing images continuously. On-the-fly changes are only allowed for the parameters that determine the position of the AOI, i.e., the X Offset and Y Offset parameters. Changes to the AOI size are not allowed on-the-fly.

9.7 Binning (All Models Except scA750-60)

Note

- The binning feature is only available on the monochrome cameras.
- The binning feature is not available on scA750-60 cameras.

Binning increases the camera's response to light by summing the charges from adjacent pixels into one pixel. Two types of binning are available: vertical binning and horizontal binning.

With vertical binning, adjacent pixels from 2 lines, 3 lines, or a maximum of 4 lines in the imaging sensor array are summed and are reported out of the camera as a single pixel. Figure 57 illustrates vertical binning.

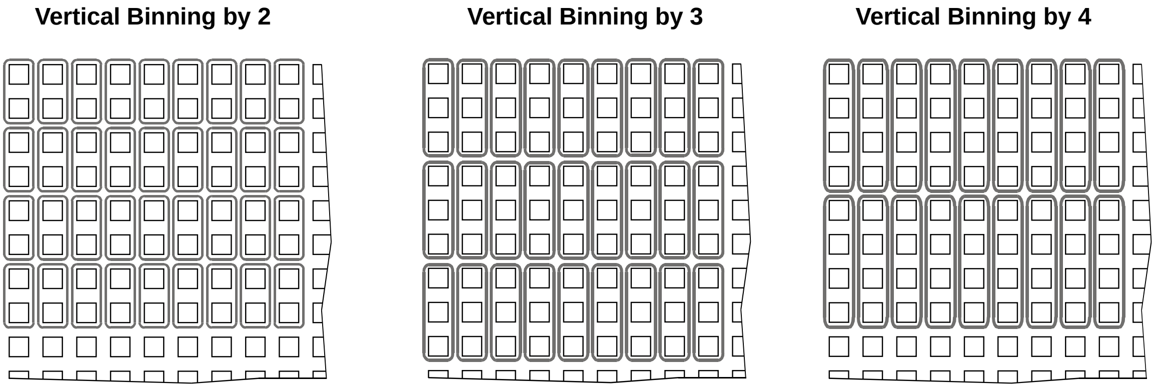


Fig. 57: Vertical Binning

With horizontal binning, adjacent pixels from 2 columns, 3 columns, or a maximum of 4 columns are summed and are reported out of the camera as a single pixel. Figure 58 illustrates horizontal binning.

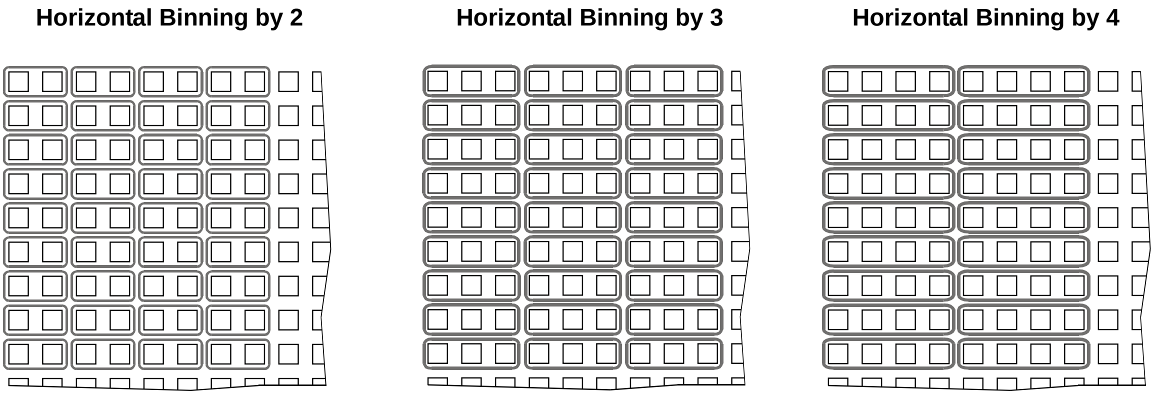


Fig. 58: Horizontal Binning

You can combine vertical and horizontal binning. This, however, may cause objects to appear distorted in the image. For more information on possible image distortion due to combined vertical and horizontal binning, see below.

Setting Binning

You can enable vertical binning by setting the Binning Vertical parameter. Setting the parameter's value to 2, 3, or 4 enables vertical binning by 2, vertical binning by 3, or vertical binning by 4 respectively. Setting the parameter's value to 1 disables vertical binning.

You can enable horizontal binning by setting the Binning Horizontal parameter. Setting the parameter's value to 2, 3, or 4 enables horizontal binning by 2, horizontal binning by 3, or horizontal binning by 4 respectively. Setting the parameter's value to 1 disables horizontal binning.

You can set the Binning Vertical or the Binning Horizontal parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter values:

```
// Enable vertical binning by 2
Camera.BinningVertical.SetValue( 2 );

// Enable horizontal binning by 4
Camera.BinningHorizontal.SetValue( 4 );

// Disable vertical and horizontal binning
Camera.BinningVertical.SetValue( 1 );
Camera.BinningHorizontal.SetValue( 1 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

9.7.1 Considerations When Using Binning

Increased Response to Light

Using binning can greatly increase the camera's response to light. When binning is enabled, acquired images may look overexposed. If this is the case, you can reduce the lens aperture, reduce the intensity of your illumination, reduce the camera's exposure time setting, or reduce the camera's gain setting.

When using vertical binning, the limits for the minimum gain settings are automatically lowered. This allows you to use lower gain settings than would otherwise be available.

For the lowered limits for the minimum gain settings, see Section 9.1 on page 139.

Reduced Resolution

Using binning effectively reduces the resolution of the camera's imaging sensor. For example, the sensor in the scA780-54gm camera normally has a resolution of 782 (H) x 582 (V). If you set this camera to use horizontal binning by 3 and vertical binning by 3, the effective resolution of the sensor is reduced to 260 (H) by 194 (V). (Note that the 782 pixel horizontal dimension of the sensor was not evenly divisible by 3, so we rounded down to the nearest whole number.)

Possible Image Distortion

Objects will only appear undistorted in the image if the numers of binned lines and columns are equal. With all other combinations, the imaged objects will appear distorted. If, for example, vertical binning by 2 is combined with horizontal binning by 4 the widths of the imaged objects will appear shrunk by a factor of 2 compared to the heights.

If you want to preserve the aspect ratios of imaged objects when using binning you must use vertical and horizontal binning where equal numbers of lines and columns are binned, e.g. vertical binning by 3 combined with horizontal binning by 3.

Binning's Effect on AOI Settings

When you have the camera set to use binning, keep in mind that the settings for your area of interest (AOI) will refer to the binned lines and columns in the sensor and not to the physical lines in the sensor as they normally would. Another way to think of this is by using the concept of a "virtual sensor." For example, assume that you are using a scA780-54gm camera set for 3 by 3 binning as described above. In this case, you would act as if you were actually working with a 260 column by 194 line sensor when setting your AOI parameters. The maximum AOI width would be 260 and the maximum AOI height would be 194. When you set the X Offset and the Width for the AOI, you will be setting these values in terms of virtual sensor columns. And when you set the Y Offset and the Height for the AOI, you will be setting these values in terms of virtual sensor lines.

For more information about the area of interest (AOI) feature, see Section 9.6 on page 155.

Binning’s Effect on the Sensor Readout and Frame Rate Formulas

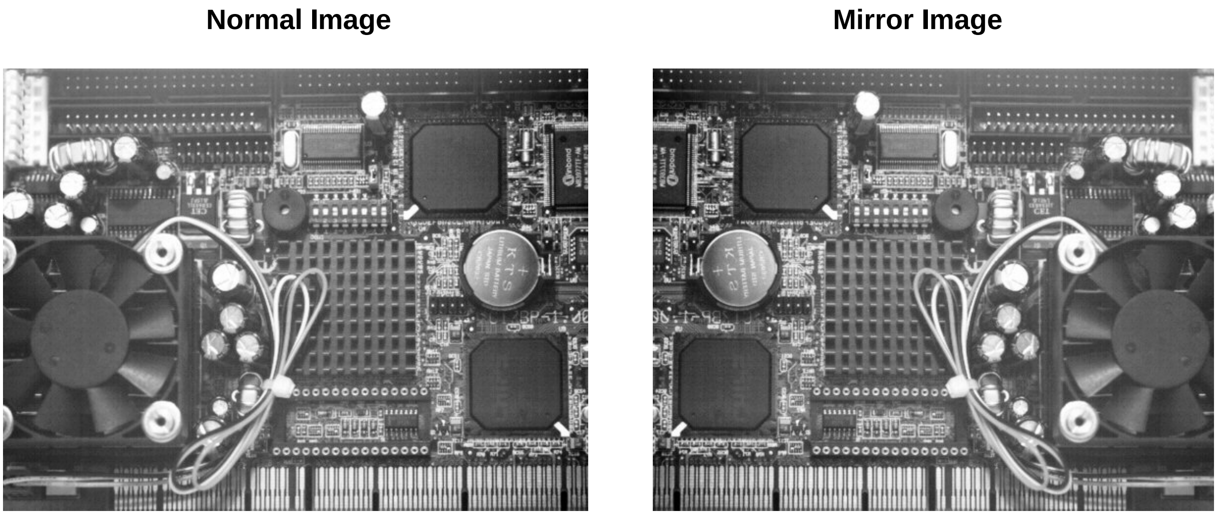
In several areas of the manual, formulas appear for sensor readout time and for calculating the maximum frame rate. In several of these formulas, you must enter the current height of the area of interest (AOI). If you are not using binning, you would enter the height of the AOI in physical sensor lines. If binning is enabled, however, you must use the concept of a "virtual" sensor as described above and the height of the AOI that you use in the formulas would be in terms of virtual sensor lines.

The affected formulas are on page 88, page 91.

9.8 Reverse X

The reverse X feature is a horizontal mirror image feature. When the reverse X feature is enabled, the pixel values for each line in a captured image will be swapped end-for-end about the line's center. This means that for each line, the value of the first pixel in the line will be swapped with the value of the last pixel, the value of the second pixel in the line will be swapped with the value of the next-to-last pixel, and so on.

Figure 59 shows a normal image on the left and an image captured with reverse X enabled on the right.


Normal Image

Mirror Image

Fig. 59: Reverse X Mirror Imaging

Using AOIs with Reverse X

You can use the AOI feature when using the reverse X feature. Note, however, that the position of an AOI relative to the sensor remains the same regardless of whether or not the reverse X feature is enabled.

As a consequence, an AOI will display different images depending on whether or not the reverse X feature is enabled.

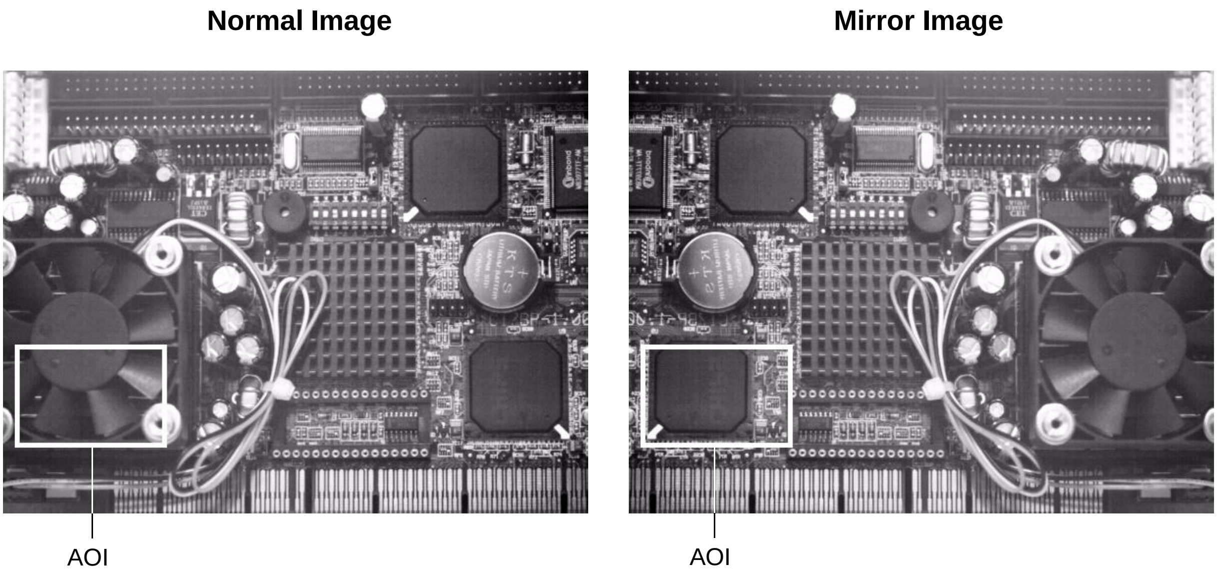


Fig. 60: Using an AOI with Reverse X Mirror Imaging

Note

For color cameras, provisions are made ensuring that the effective color filter alignment will be constant for both, normal and mirror images.

Note

AOIs used for the auto function feature will behave analogous to "standard" AOIs:

- Depending on whether or not the reverse X feature is enabled, an Image AOI will display different images and an Auto Function AOI will refer to different image contents.
- The positions of the AOIs relative to the sensor will not change.

For more information about auto functions, see Section 9.11 on page 172.

Setting Reverse X

You can enable or disable the reverse X feature by setting the ReverseX parameter value. You can set the parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
// Enable reverse X
Camera.ReverseX.SetValue(true);
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameter.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.9 Luminance Lookup Table

9.9.1 Lookup Table (All Models Except scA750-60)

Note

The information in this section applies to all camera models except the scA750-60 fm/fc. For information about scA750-60 cameras, see Section 9.9.2 on page 168.

On these cameras, pixel data is acquired at 12 bit depth. When a monochrome camera is set for the Mono 16 or Mono 12 packed pixel format or a color camera is set for the Bayer BG 16 or the Bayer BG 12 packed pixel format, the camera outputs pixel data with 12 effective bits. Normally, the effective 12 bits transmitted out of the camera for each pixel directly represent the 12 bits reported by the camera's ADC. The luminance lookup table feature lets you use a custom 12 bit to12 bit lookup table to map the 12 bits reported out of the ADC to 12 bits that will be transmitted by the camera.

The lookup table is essentially just a list of 4096 values, however, not every value in the table is actually used. If we number the values in the table from 0 through 4095, the table works like this:

- The number at location 0 in the table represents the effective 12 bits that will be transmitted out of the camera when the sensor reports that a pixel has a value of 0.
- The numbers at locations 1 through 7 are not used.
- The number at location 8 in the table represents the effective 12 bits that will be transmitted out of the camera when the sensor reports that a pixel has a value of 8.
- The numbers at locations 9 through 15 are not used.
- The number at location 16 in the table represents the effective 12 bits that will be transmitted out of the camera when the sensor reports that a pixel has a value of 16.
- The numbers at locations 17 through 23 are not used.
- The number at location 24 in the table represents the effective 12 bits that will be transmitted out of the camera when the sensor reports that a pixel has a value of 24.
- And so on.

As you can see, the table does not include a user defined 12 bit value for every pixel value that the sensor can report. So what does the camera do when the sensor reports a pixel value that is between two values that have a defined 12 bit output? In this case, the camera performs a straight line interpolation to determine the value that it should transmit. For example, assume that the sensor reports a pixel value of 12. In this case, the camera would perform a straight line interpolation between the values at location 8 and location 16 in the table. The result of the interpolation would be reported out of the camera as the 12 bit output.

Another thing to keep in mind about the table is that location 4088 is the last location that will have a defined 12 bit value associated with it. (Locations 4089 through 4095 are not used.) If the sensor reports a value above 4088, the camera will not be able to perform an interpolation. In cases where the sensor reports a value above 4088, the camera simply transmits the 12 bit value from location 4088 in the table.

The advantage of the luminance lookup table feature is that it allows a user to customize the response curve of the camera. The graphs below show the effect of two typical lookup tables. The first graph is for a lookup table where the values are arranged so that the output of the camera increases linearly as the sensor output increases. The second graph is for a lookup table where the values are arranged so that the camera output increases quickly as the sensor output moves from 0 through 2048 and increases gradually as the sensor output moves from 2049 through 4096.

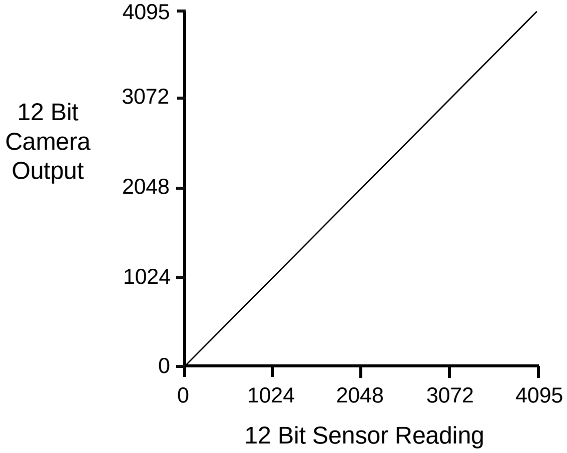


Fig. 61: Lookup Table with Values Mapped in a Linear Fashion

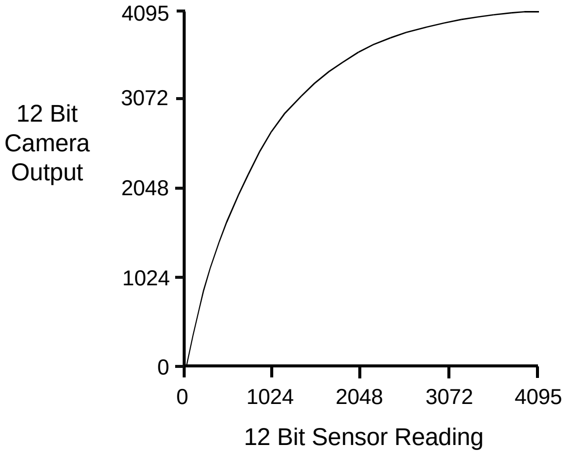


Fig. 62: Lookup Table with Values Mapped for Higher Camera Output at Low Sensor Readings

Using the Luminance Lookup Table to Get 8 Bit Output

As mentioned above, when the camera is set for a pixel format where it outputs 12 effective bits, the lookup table is used to perform a 12 bit to 12 bit conversion. But the lookup table can also be used in 12 bit to 8 bit fashion. To use the table in 12 bit to 8 bit fashion, you enter 12 bit values into the table and enable the table as you normally would. But instead of setting the camera for a pixel format that results in a camera output with 12 bits effective, you set the camera for a pixel format that results in 8 bit output (such as Mono 8, Bayer BG 8, or YUV 4:2:2 Packed). In this situation, the camera will first use the values in the table to do a 12 bit to 12 bit conversion. It will then drop the 4 least significant bits of the converted value and will transmit the 8 most significant bits.

Changing the Values in the Luminance Lookup Table and Enabling the Table

You can change the values in the luminance lookup table (LUT) and enable the use of the lookup table by doing the following:

- Use the LUT Selector to select a lookup table. (Currently there is only one lookup table available, i.e., the "luminance" lookup table described above.)
- Use the LUT Index parameter to select a value in the lookup table. The LUT Index parameter selects the value in the table to change. The index number for the first value in the table is 0, for the second value in the table is 1, for the third value in the table is 2, and so on.
- Use the LUT Value parameter to set the selected value in the lookup table.
- Use the LUT Index parameter and LUT value parameters to set other table values as desired.
- Use the LUT Enable parameter to enable the table.

You can set the LUT Selector, the LUT Index parameter and the LUT Value parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter values:

```
// Select the lookup table
Camera.LUTSelector.SetValue( LUTSelector_Luminance );

// Write a lookup table to the device.
// The following lookup table causes an inversion of the sensor values
// ( bright -> dark, dark -> bright )
for ( int i = 0; i < 4096; i += 8 )
{
   Camera.LUTIndex.SetValue( i );
   Camera.LUTValue.SetValue( 4095 - i );
}
// Enable the lookup table
Camera.LUTEnable.SetValue( true );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.9.2 Lookup Table (scA750-60 Only)

Note

The information in this section only applies to scA750-60 fm/fc cameras. For information about the other camera models, see Section 9.9.1 on page 165.

On these cameras, pixel data is acquired at 10 bit depth. Before the pixel values are transmitted out of the camera, the two least significant bits are dropped and the pixel data is transmitted at 8 bit depth.

Normally, the 10 bit pixel data reported by the sensor's ADCs is directly used to generate the 8 bit output transmitted by the camera. The luminance lookup table feature lets you use a custom 10 bit to 10 bit lookup table to map the 10 bit output reported by the ADCs to 10 bit values of your choice. The mapped 10 bit values will then be truncated and transmitted by the camera as 8 bit values.

The lookup table is essentially just a list of 1024 values, however, not every value in the table is actually used. If we number the values in the table from 0 through 1023, the table works like this:

- The number at location 0 in the table represents the mapped 10 bit value that will be used when the sensor reports that a pixel has a value of 0.
- The number at location 1 is not used.
- The number at location 2 in the table represents the mapped 10 bit value that will be used when the sensor reports that a pixel has a value of 2.
- The number at location 3 is not used.
- The number at location 4 in the table represents the mapped 10 bit value that will be used when the sensor reports that a pixel has a value of 4.
- The number at location 5 is not used.
- The number at location 6 in the table represents the mapped 10 bit value that will be used when the sensor reports that a pixel has a value of 6.
- And so on.

As you can see, the table does not include a mapped 10 bit output value for every pixel value that the sensor can report. So what does the camera do when the sensor reports a pixel value that is between two values that have a mapped 10 bit output? In this case, the camera performs a straight line interpolation between the two nearest neighbors to determine the value that it should use. For example, assume that the sensor reports a pixel value of 5. In this case, the camera would perform an interpolation between the values at location 4 and location 6 in the table. The result of the interpolation would be used as the mapped 10 bit value.

Another thing to keep in mind about the table is that location 1022 is the last location that will have a mapped 10 bit value associated with it. If the sensor reports a pixel value of 1023, the camera will not be able to perform an interpolation. In this case, the camera simply uses the mapped 10 bit value from location 1022 in the table.

The advantage of the luminance lookup table feature is that it allows a user to customize the response curve of the camera. The graphs on the next page show the effect of two typical lookup tables. The first graph is for a lookup table where the values are arranged so that the output of the camera increases linearly as the sensor output increases. The second graph is for a lookup table where the values are arranged so that the camera output increases quickly as the sensor output moves from 0 through 512 and increases gradually as the sensor output moves from 513 through 1023.

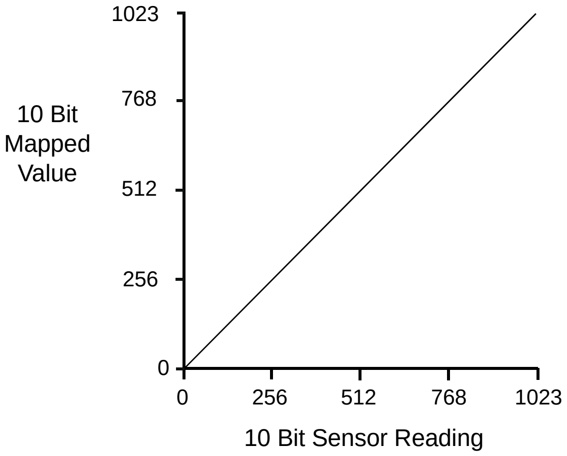


Fig. 63: Lookup Table with Values Mapped in a Linear Fashion

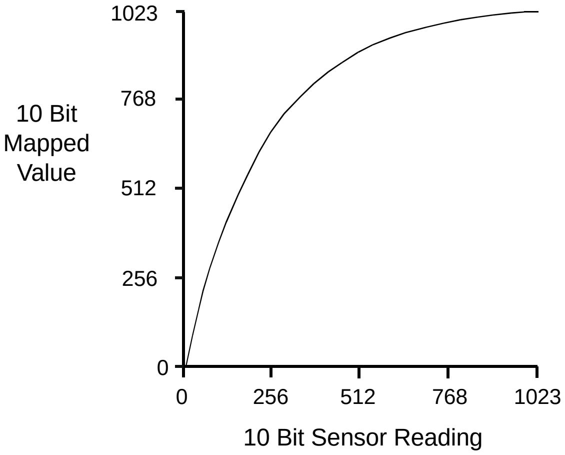


Fig. 64: Lookup Table with Values Mapped for Higher Camera Output at Low Sensor Readings

Changing the Values in the Luminance Lookup Table and Enabling the Table

You can change the values in the luminance lookup table (LUT) and enable the use of the lookup table by doing the following:

- Use the LUT Selector to select a lookup table. (Currently there is only one lookup table available, i.e., the "luminance" lookup table described above.)
- Use the LUT Index parameter to select a value in the lookup table. The LUT Index parameter selects the value in the table to change. The index number for the first value in the table is 0, for the second value in the table is 1, for the third value in the table is 2, and so on.
- Use the LUT Value parameter to set the selected value in the lookup table.
- Use the LUT Index parameter and LUT value parameters to set other table values as desired.
- Use the LUT Enable parameter to enable the table.

You can set the LUT Selector, the LUT Index parameter and the LUT Value parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter values:

```
// Select the lookup table
Camera.LUTSelector.SetValue( LUTSelector_Luminance );

// Write a lookup table to the device.
// The following lookup table causes an inversion of the sensor values
// ( bright -> dark, dark -> bright )
for ( int i = 0; i < 1024; i += 2 )
{
   Camera.LUTIndex.SetValue( i );
   Camera.LUTValue.SetValue( 1023 - i );
}
// Enable the lookup table
Camera.LUTEnable.SetValue( true );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.10 Gamma

The gamma correction feature lets you modify the brightness of the pixel values output by the camera's sensor to account for a non-linearity in the human perception of brightness. To accomplish the correction, a gamma correction factor (γ) is applied to the brightness value (Y) of each pixel according to the following formula:

$$Y_{corrected} = \left(\frac{Y_{uncorrected}}{Y_{max}}\right)^{\gamma} \times Y_{max}$$

The formula uses uncorrected and corrected pixel brightnesses that are normalized by the maximum pixel brightness. The maximum pixel brightness equals 255 for 8 bit output and 4095 for 12 bit output.

When the gamma correction factor is set to 1, the output pixel brightness will not be corrected.

A gamma correction factor between 0 and 1 will result in increased overall brightness, and a gamma correction factor greater than 1 will result in decreased overall brightness.

In all cases, black (output pixel brightness equals 0) and white (output pixel brightness equals 255 at 8 bit output and 4095 at 12 bit output) will not be corrected.

Setting the Gamma

You can enable or disable the gamma correction feature by setting the value of the Gamma Enable parameter.

When gamma correction is enabled, the correction factor is determined by the value of the Gamma parameter. The Gamma parameter can be set in a range from 0 to 3.99902. So if the Gamma parameter is set to 1.2, for example, the gamma correction factor will be 1.2.

You can set the Gamma Enable and Gamma parameter values from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter values:

```
// Enable the Gamma feature
Camera.GammaEnable.SetValue( true );

// Set the Gamma value to 1.2
Camera.Gamma.SetValue( 1.2 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.11 Auto Functions

9.11.1 Common Characteristics

Auto functions control image properties and are the "automatic" counterparts of certain features such as the gain feature or the white balance feature, which normally require "manually" setting the related parameter values. Auto functions are particularly useful when an image property must be adjusted quickly to achieve a specific target value and when a specific target value must be kept constant in a series of images.

An Auto Function Area of Interest (Auto Function AOI) lets you designate a specific part of the image as the base for adjusting an image property. Each auto function uses the pixel data from an Auto Function AOI for automatically adjusting a parameter value and, accordingly, for controlling the related image property. Some auto functions use their own individual Auto Function AOI and some auto functions share a single Auto Function AOI.

An auto function automatically adjusts a parameter value until the related image property reaches a target value. Note that the manual setting of the parameter value is not preserved. For example, when the Gain Auto function adjusts the gain parameter value, the manually set gain parameter value is not preserved.

For some auto functions, the target value is fixed. For other auto functions, the target value can be set, as can the limits between which the related parameter value will be automatically adjusted. For example, the gain auto function lets you set an average gray value for the image as a target value and also set a lower and an upper limit for the gain parameter value.

Generally, the different auto functions can operate at the same time. For more information, see the following sections describing the individual auto functions.

ⓘ	A target value for an image property can only be reached if it is in accord with all pertinent camera settings and with the general circumstances used for capturing images. Otherwise, the target value will only be approached. For example, with a short exposure time, insufficient illumination, and a low setting for the upper limit of the gain parameter value, the Gain Auto function may not be able to achieve the current target average gray value setting for the image.

ⓘ	You can use an auto function when binning is enabled (monochrome cameras only; not available on scA750-60 cameras). An auto function uses the binned pixel data and controls the image property of the binned image.

For more information about binning, see Section 9.7 on page 158.

9.11.1.1 Modes of Operation

The following auto function modes of operation are available:

- All auto functions provide the "once" mode of operation. When the "once" mode of operation is selected, the parameter values are automatically adjusted until the related image property reaches the target value. After the automatic parameter value adjustment is complete, the auto function will automatically be set to "off" and the new parameter value will be applied to the following images.

  The parameter value can be changed by using the "once" mode of operation again, by using the "continuous" mode of operation, or by manual adjustment.
- Some auto functions also provide a "continuous" mode of operation where the parameter value is adjusted repeatedly while images are acquired.

  Depending on the current frame rate, the automatic adjustments will usually be carried out for every or every other image, unless the camera’s microcontroller is kept busy by other tasks.

  The repeated automatic adjustment will proceed until the "once" mode of operation is used or until the auto function is set to "off", in which case the parameter value resulting from the latest automatic adjustment will operate unless it is manually adjusted.
- When an auto function is set to "off", the parameter value resulting from the latest automatic adjustment will operate unless it is manually adjusted.

ⓘ	You can enable auto functions and change their settings while the camera is capturing images ("on the fly").

ⓘ	After you have set an auto function to "once" or "continuous" operation mode, while the camera was continuously capturing images, the auto function will become effective with a short delay and the first few images may not be affected by the auto function.

ⓘ	If an auto function is set to "once" operation mode and if the circumstances will not allow reaching a target value for an image property, the auto function will try to reach the target value for a maximum of 30 images and will then be set to "off".

9.11.1.2 Auto Function AOI

An Auto Function AOI must be set separately from the AOI used to define the size of captured images (Image AOI). You can specify a portion of the sensor array and only the pixel data from the specified portion will be used for auto function control.

An Auto Function AOI is referenced to the top left corner of the sensor array. The top left corner is designated as column 0 and row 0 as shown in Figure 56.

The location and size of an Auto Function AOI is defined by declaring an X offset (coordinate), a width, a Y offset (coordinate), and a height. For example, suppose that you specify the X offset as 14, the width as 5, the Y offset as 7, and the height as 6. The area of the array that is bounded by these settings is shown in Figure 56.

Only the pixel data from within the area defined by your settings will be used by the related auto function.

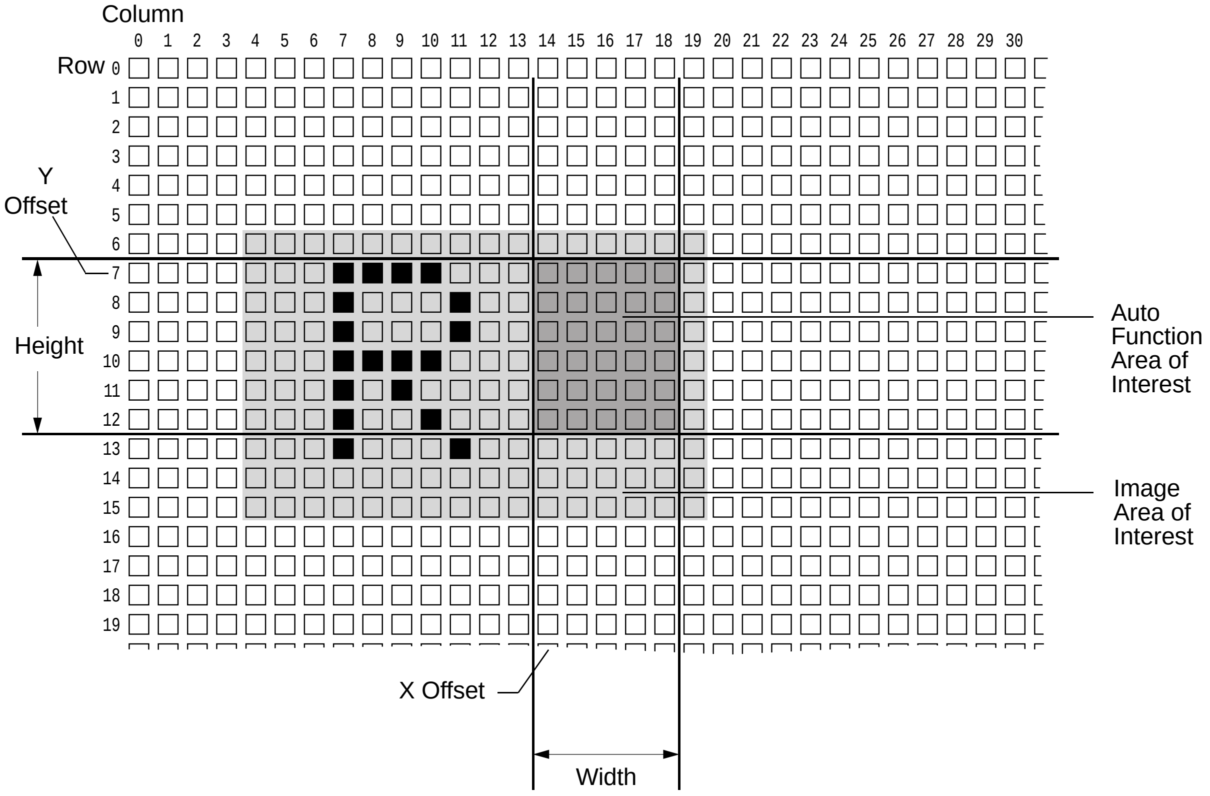


Fig. 65: Auto Function Area of Interest and Image Area of Interest

Relative Positioning of an Auto Function AOI

The size and position of an Auto Function AOI can be, but need not be, identical to the size and position of the Image AOI. Note that the overlap between Auto Function AOI and Image AOI determines whether and to what extent the auto function will control the related image property. Only the pixel data from the areas of overlap will be used by the auto function to control the image property of the entire image.

Different degrees of overlap are illustrated in Figure 66. The hatched areas in the figure indicate areas of overlap.

- If the Auto Function AOI is completely included in the Image AOI (see (a) in Figure 66), the pixel data from the Auto Function AOI will be used to control the image property.
- If the Image AOI is completely included in the Auto Function AOI (see (b) in Figure 66), only the pixel data from the Image AOI will be used to control the image property.
- If the Image AOI only partially overlaps the Auto Function AOI (see (c) in Figure 66), only the pixel data from the area of partial overlap will be used to control the image property.
- If the Auto Function AOI does not overlap the Image AOI (see (d) in Figure 66), the Auto Function will **not** or only to a **limited** degree control the image property. For details, see the sections below, describing the individual auto functions.

ⓘ	We strongly recommend completely including the Auto Function AOI in the Image AOI, or, depending on your needs, choosing identical positions and sizes for Auto Function AOI and Image AOI.

ⓘ	You can use auto functions when also using the reverse X feature. For information about the behavior and roles of Auto Function AOI and Image AOI when also using the reverse X feature, see the "Reverse X" section.

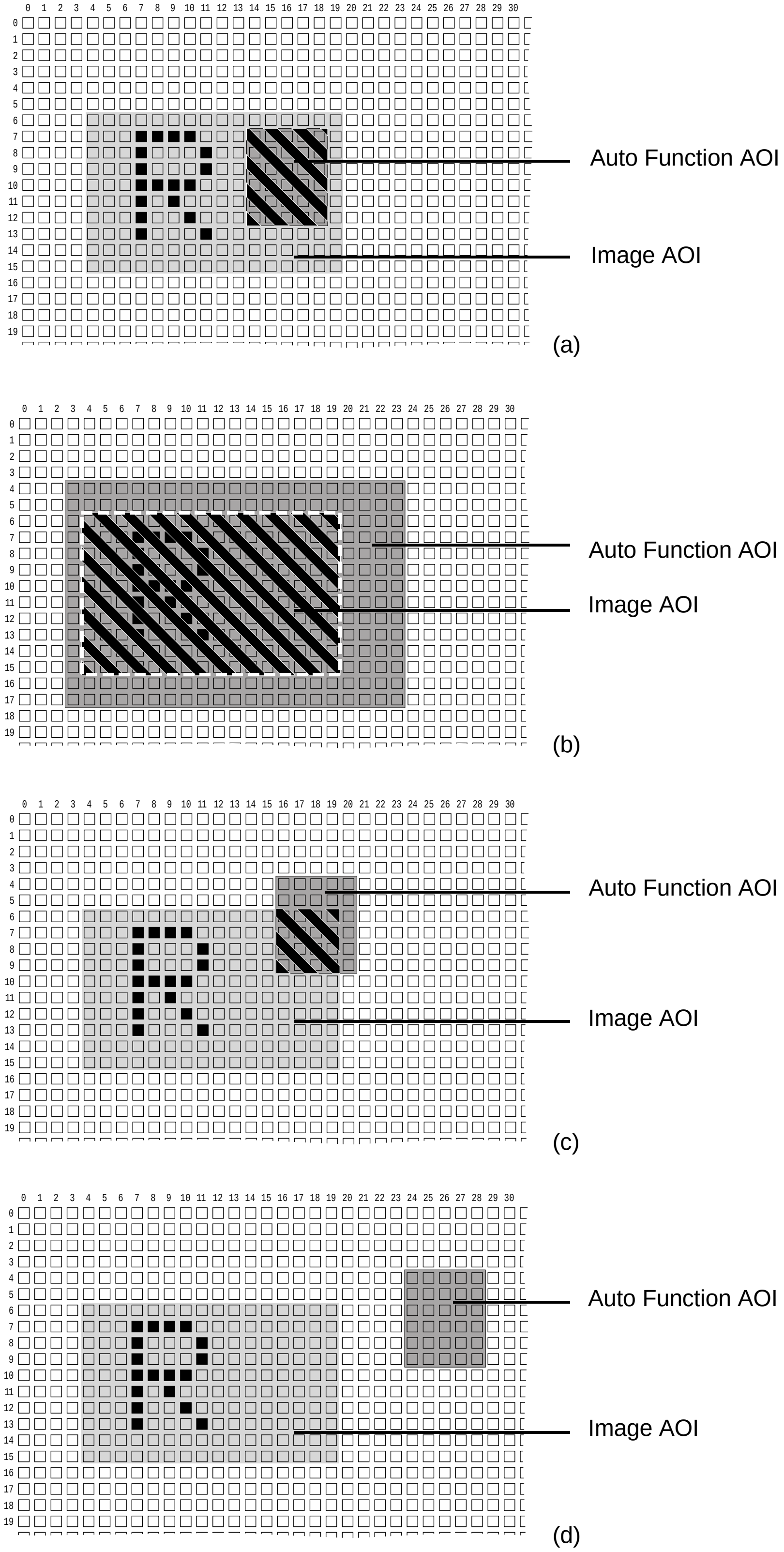


Fig. 66: Various Degrees of Overlap Between the Auto Function AOI and the Image AOI

Setting an Auto Function AOI

Setting an Auto Function AOI is a two-step process: You must first select the Auto Function AOI related to the auto function that you want to use and then set the size and the position of the Auto Function AOI.

By default, an Auto Function AOI is set to the full resolution of the camera’s sensor. You can change the size and the position of an Auto Function AOI by changing the value of the Auto Function AOI’s X Offset, Y Offset, Width, and Height parameters.

- The value of the X Offset parameter determines the starting column for the Auto Function AOI.
- The value of the Y Offset parameter determines the starting line for the Auto Function AOI.
- The value of the Width parameter determines the width of the Auto Function AOI.
- The value of the Height parameter determines the height of the Auto Function AOI.

When you are setting an Auto Function AOI, you must follow these guidelines:

- The sum of the X Offset setting plus the Width setting must not exceed the width of the camera’s sensor. For example, on the scA640-70, the sum of the X Offset setting plus the Width setting must not exceed 659.
- The sum of the Y Offset setting plus the Height setting must not exceed the height of the camera’s sensor. For example, on the scA640-70, the sum of the Y Offset setting plus the Height setting must not exceed 494.

The X Offset, Y Offset, Width, and Height parameters can be set in increments of 1.

ⓘ	On color cameras, we strongly recommend setting the X Offset, Y Offset, Width, and Height parameters for an Auto Function AOI in increments of 2 to make the Auto Function AOI match the Bayer filter pattern of the sensor. For example, you should set the X Offset parameter to 0, 2, 4, 6, 8, etc.

ⓘ	Normally, the X Offset, Y Offset, Width, and Height parameter settings for an Auto Function AOI refer to the physical columns and lines in the sensor. But if binning is enabled (monochrome cameras only; not available on scA750-60 cameras), these parameters are set in terms of "virtual" columns and lines, i.e. the settings for an Auto Function AOI will refer to the binned lines and columns in the sensor and not to the physical lines in the sensor as they normally would.

For more information about the concept of a "virtual sensor", see Section 9.7.1 on page 160.

You can select an Auto Function AOI and set the X Offset, Y Offset, Width, and Height parameter values for the Auto Function AOI from within your application software by using the pylon API. The following code snippets illustrate using the API to select an Auto Function AOI and to get the maximum allowed settings for the Width and Height parameters. The code snippets also illustrate setting the X Offset, Y Offset, Width, and Height parameter values. As an example, Auto Function AOI1 is selected:

```
// Select the appropriate auto function AOI for luminance statistics
// Currently AutoFunctionAOISelector_AOI1 is predefined to gather
// luminance statistics
// Set position and size of the auto function AOI
Camera.AutoFunctionAOISelector.SetValue( AutoFunctionAOISelector_AOI1 );
Camera.AutoFunctionAOIOffsetX.SetValue( 0 );
Camera.AutoFunctionAOIOffsetY.SetValue( 0 );
Camera.AutoFunctionAOIWidth.SetValue( Camera.AutoFunctionAOIWidth.GetMax() );
Camera.AutoFunctionAOIHeight.SetValue( Camera.AutoFunctionAOIHeight.GetMax() );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

9.11.1.3 Using an Auto Function

To use an auto function, carry out the following steps:

1. Select the Auto Function AOI that is related to the auto function you want to use.
2. Set the postion and size of the Auto Function AOI.
3. If necessary, set the lower and upper limits for the auto functions's parameter value.
4. If necessary, set the target value.
5. If necessary, set the auto function profile to define priorities between auto functions.
6. Enable the auto function by setting it to "once" or "continuous".

For more information the individual settings, see the sections below that describe the indvidual auto functions.

9.11.2 Gain Auto

Gain Auto is an auto function and the "automatic" counterpart of the manual gain feature. When the gain auto function is operational, the Gain Raw (All) parameter value is automatically adjusted within set limits, until a target average gray value for the pixel data from Auto Function AOI1 is reached.

The gain auto function uses Auto Function AOI1 and can be operated in the "once" and continuous" modes of operation.

If Auto Function AOI1 does not overlap the Image AOI (see the "Auto Function AOI" section) the pixel data from Auto Function AOI1 will not be used to control the image brightness. Instead, the current manual setting of the Gain Raw (All) parameter value will control the image brightness.

When the gain auto function is used, the exposure auto function can be used at the same time. In this case, however, you must also set the auto function profile feature.

For more information about gain, see Section 9.1 on page 139.

For more information about the auto function profile feature, see Section 9.11.4 on page 183.

To use the gain auto function, perform the following steps:

1. Select Auto Function AOI1.
2. Set the postion and size of Auto Function AOI1.
3. Set the lower and upper limits for the Gain Raw (All) parameter value.
4. Set the target average gray value.
5. If necessary, set the auto function profile.
6. Enable the gain auto function by setting it to "once" or "continuous". You must choose the "continuous" setting when using the auto function profile.

The currently settable limits for the Auto Gain Raw parameter value depend on the current pixel data format, on the current settings for binning, and on whether or not the Gain Raw parameter limits for the manually set gain feature are disabled.

The target average gray value may range from 0 (black) to 255 (white). Note that this range of numbers applies to 8 bit **and** to 16 bit (12 bit effective) output modes. Accordingly, also for 16 bit output modes, black is represented by 0 and white by 255.

You can carry out steps 1 to 6 from within your application software by using the pylon API. The following code snippets illustrate using the API to set the parameter values:

- Selecting and setting Auto Function AOI1
- Setting the limits for the Auto Gain Raw parameter value. The currently accessible minimum and maximum parameter values are chosen as examples
- Setting the target average gray value. A medium gray value is chosen as an example
- Enabling the gain auto function and selecting, for example, the "once" mode of operation

```
// Select the appropriate auto function AOI for luminance statistics
// Currently AutoFunctionAOISelector_AOI1 is predefined to gather
// luminance statistics
// Set position and size of the auto function AOI
Camera.AutoFunctionAOISelector.SetValue( AutoFunctionAOISelector_AOI1 );
Camera.AutoFunctionAOIOffsetX.SetValue( 0 );
Camera.AutoFunctionAOIOffsetY.SetValue( 0 );
Camera.AutoFunctionAOIWidth.SetValue( Camera.AutoFunctionAOIWidth.GetMax() );
Camera.AutoFunctionAOIHeight.SetValue( Camera.AutoFunctionAOIHeight.GetMax() );

// Select gain for automatic luminance control.
// Set gain limits for luminance control
Camera.GainSelector.SetValue( GainSelector_All );
Camera.AutoGainRawLowerLimit.SetValue( Camera.GainRaw.GetMin() );
Camera.AutoGainRawUpperLimit.SetValue( Camera.GainRaw.GetMax() );

// Set target value for luminance control. This is always expressed
// by an 8 bit value, regardless of the current pixel format
// i.e. 0 -> black, 255 -> white
Camera.AutoTargetValue.SetValue( 128 );

// Set mode of operation for gain auto function
Camera.GainAuto.SetValue( GainAuto_Once );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For general information about auto functions, see Section 9.11.1 on page 172.

For information about Auto Function AOIs and how to set them, see Section 9.11.1.2 on page 174.

9.11.3 Exposure Auto

Exposure Auto is an auto function and the "automatic" counterpart to manually setting an "absolute" exposure time. The exposure auto function automatically adjusts the Exposure Time Abs parameter value within set limits, until a target average gray value for the pixel data of the related Auto Function AOI is reached.

In contrast to the manually set "absolute" exposure time, the automatically adjusted "absolute" exposure time and the settable limits for parameter value adjustment are not restricted to multiples of the current exposure time base.

The exposure auto function uses Auto Function AOI1 and can be operated in the "once" and continuous" modes of operation.

If Auto Function AOI1 does not overlap the Image AOI (see the "Auto Function AOI" section) the pixel data from Auto Function AOI1 will not be used to control the image brightness. Instead, the current manual setting of the Exposure Time Abs parameter value will control the image brightness.

The exposure auto function is not available, when trigger width exposure mode is selected.

When the exposure auto function is used, the gain auto function can be used at the same time. In this case, however, you must also set the auto function profile feature.

ⓘ If the Auto Exposure Time Abs Upper Limit parameter is set to a sufficiently high value the camera's frame rate may be decreased.

For more information about "absolute" exposure time settings and related limitations, see Section 6.4.2 on page 78.

For more information about exposure modes and how to select them, see Section 6.2.1 on page 64 and Section 6.3.1 on page 69.

For more information about the auto function profile feature, see Section 9.11.4 on page 183.

To use the exposure auto function, carry out the following steps:

1. Make sure trigger width exposure mode is not selected.
2. Select Auto Function AOI1.
3. Set the postion and size of Auto Function AOI1.
4. Set the lower and upper limits for the Exposure Time Abs parameter value.
5. Set the target average gray value.
6. If necessary, set the auto function profile.
7. Enable the exposure auto function by setting it to "once" or "continuous". You must choose the "continuous" setting when using the auto function profile.

The settable limits for the Exposure Time Abs parameter value are limited by the minimum allowed and maximum possible exposure time of the camera model.

The target average gray value may range from 0 (black) to 255 (white). Note that this range of numbers applies to 8 bit **and** to 16 bit (12 bit effective) output modes. Accordingly, also for 16 bit output modes, black is represented by 0 and white by 255.

You can carry out steps 1 to 7 from within your application software by using the pylon API. The following code snippets illustrate using the API to set the parameter values:

- Selecting and setting Auto Function AOI1: See the "Auto Function AOI" section above.
- Setting the limits for the Exposure Time Abs parameter value (the set parameter values serve as examples):
- Setting the target average gray value. A medium gray value is selected as an example:
- Enabling the exposure auto function and selecting, for example, the "continuous" mode of operation:

```
 // Select the appropriate auto function AOI for luminance statistics
 // Currently AutoFunctionAOISelector_AOI1 is predefined to gather
 // luminance statistics
 // Set position and size of the auto function AOI
 Camera.AutoFunctionAOISelector.SetValue( AutoFunctionAOISelector_AOI1 );
 Camera.AutoFunctionAOIOffsetX.SetValue( 0 );
 Camera.AutoFunctionAOIOffsetY.SetValue( 0 );
 Camera.AutoFunctionAOIWidth.SetValue( Camera.AutoFunctionAOIWidth.GetMax() );
Camera.AutoFunctionAOIHeight.SetValue( Camera.AutoFunctionAOIHeight.GetMax() );

 // Set exposure time limits for luminance control
 Camera.AutoExposureTimeAbsLowerLimit.SetValue( 1000 );
 Camera.AutoExposureTimeAbsUpperLimit.SetValue( 1.0E6 );

 // Set target value for luminance control. This is always expressed
 // by an 8 bit value, regardless of the current pixel format
 // i.e. 0 -> black, 255 -> white
 Camera.AutoTargetValue.SetValue( 128 );

 // Set mode of operation for exposure auto function
 Camera.ExposureAuto.SetValue( ExposureAuto_Continuous );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For general information about auto functions, see Section 9.11.1 on page 172.

For information about Auto Function AOIs and how to set them, see Section 9.11.1.2 on page 174.

For information about minimum allowed and maximum possible exposure time, see Section Table 12: on page 75 in Section 6.4 on page 75.

9.11.4 Auto Function Profile

If you want to use the gain auto function and the exposure auto function at the same time, you must also set the auto function profile. The auto function profile assigns priorities between related auto functions: The auto function profile specifies whether gain or exposure time shall be kept as low as possible during adjustments until a target average gray value for the pixel data of the related Auto Function AOI is reached.

To use the gain auto function and the exposure auto function at the same time, carry out the following steps:

1. Set the auto function profile to specify whether gain or exposure time shall be minimized during adjustments.
2. Set the gain auto function to the "continuous" mode of operation.
3. Set the exposure auto function to the "continuous" mode of operation.

You can set the auto function profile from within your application software by using the pylon API. The following code snippets illustrate using the API to set the auto function profile. As an example, Gain Auto is set to be minimized during adjustments:

```
// Use GainAuto and ExposureAuto simultaneously
Camera.AutoFunctionProfile.SetValue( AutoFunctionProfile_GainMinimum );
Camera.GainAuto.SetValue( GainAuto_Continuous );
Camera.ExposureAuto.SetValue( ExposureAuto_Continuous );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

9.11.5 Balance White Auto

Balance White Auto is an auto function and the "automatic" counterpart of the manual white balance feature. The balance white auto function is only available on color models.

The automatic white balance is a two-step process. First, the Balance Ratio Abs parameter values for red, green, and blue are each set to 1.5. Then, assuming a "gray world" model, the Balance Ratio Abs parameter values are adjusted such that the average values for the "red" and "blue" pixels match the average value for the "green" pixels.

The balance white auto function uses Auto Function AOI2 and can only be operated in the "once" mode of operation.

If Auto Function AOI2 does not overlap the Image AOI (see the "Auto Function AOI" section) the pixel data from Auto Function AOI2 will not be used to control the white balance of the image. However, as soon as the Balance White Auto function is set to "once" operation mode, the Balance Ratio Abs parameter values for red, green, and blue are each set to 1.5. These settings will control the white balance of the image.

For information on the white balance feature, see Section 9.3 on page 147.

To use the balance white auto function, carry out the following steps:

1. Select Auto Function AOI2.
2. Set the postion and size of Auto Function AOI2.
3. Enable the balance white auto function by setting it to "once".

You can carry out steps 1 to 3 from within your application software by using the pylon API. The following code snippet illustrates using the API to use the auto function:

- Selecting and setting Auto Function AOI2: See the "Auto Function AOI" section above.
- Enabling the balance white auto function and selecting the "once" mode of operation:

```
// Set AOI for white balance statistics
// Currently AutoFunctionAOISelector_AOI2 is predefined to gather
// white balance statistics
// Set position and size of the auto function AOI
Camera.AutoFunctionAOISelector.SetValue( AutoFunctionAOISelector_AOI2 );
Camera.AutoFunctionAOIOffsetX.SetValue( 0 );
Camera.AutoFunctionAOIOffsetY.SetValue( 0 );
Camera.AutoFunctionAOIWidth.SetValue( Camera.AutoFunctionAOIWidth.GetMax() );
Camera.AutoFunctionAOIHeight.SetValue( Camera.AutoFunctionAOIHeight.GetMax() );

// Set mode of operation for balance white auto function
Camera.BalanceWhiteAuto.SetValue( BalanceWhiteAuto_Once );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For general information about auto functions, see Section 9.11.1 on page 172.

For information about Auto Function AOIs and how to set them, see Section 9.11.1.2 on page 174.

9.12 Disable Parameter Limits

For each camera parameter, the allowed range of parameter values normally is limited. The factory limits are designed to ensure optimum camera operation and, in particular, good image quality. For special camera uses, however, it may be helpful to set parameter values outside of the factory limits.

The disable parameter limits feature lets you disable the factory parameter limits for certain parameters. When the factory parameter limits are disabled, the parameter values can be set within extended limits. Typically, the range of the extended limits is dictated by the physical restrictions of the camera’s electronic devices, such as the absolute limits of the camera’s variable gain control.

The values for the extended limits can be seen using the Basler pylon Viewer or from within your application via the pylon API.

Note

Currently, the parameter limits can only be disabled on the Gain feature.

Disabling Parameter Limits

To disable the limits for a parameter:

- Use the Parameter Selector to select the parameter whose limits you wish to disable.
- Set the value of the Remove Limits parameter.

You can set the Parameter Selector and the value of the Remove Limits parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
// Select the feature whose factory limits will be disabled
Camera.ParameterSelector.SetValue( ParameterSelector_Gain );

// Disable the limits for the selected feature
Camera.RemoveLimits.SetValue( true );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters. Note that the disable parameter limits feature will only be available at the "guru" viewing level.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.13 Debouncer

The debouncer feature aids in discriminating between valid and invalid input signals and only lets valid signals pass to the camera. The debouncer value specifies the minimum time that an input signal must remain high or remain low in order to be considered a valid input signal.

ⓘ	We recommend setting the debouncer value so that it is slightly greater than the longest expected duration of an invalid signal. Setting the debouncer to a value that is too short will result in accepting invalid signals. Setting the debouncer to a value that is too long will result in rejecting valid signals.

Note that the debouncer delays a valid signal between its arrival at the camera and its transfer. The duration of the delay will be determined by the debouncer value.

The following diagram illustrates how the debouncer filters out invalid input signals, i.e. signals that are shorter than the debouncer value. The diagram also illustrates how the debouncer delays a valid signal.

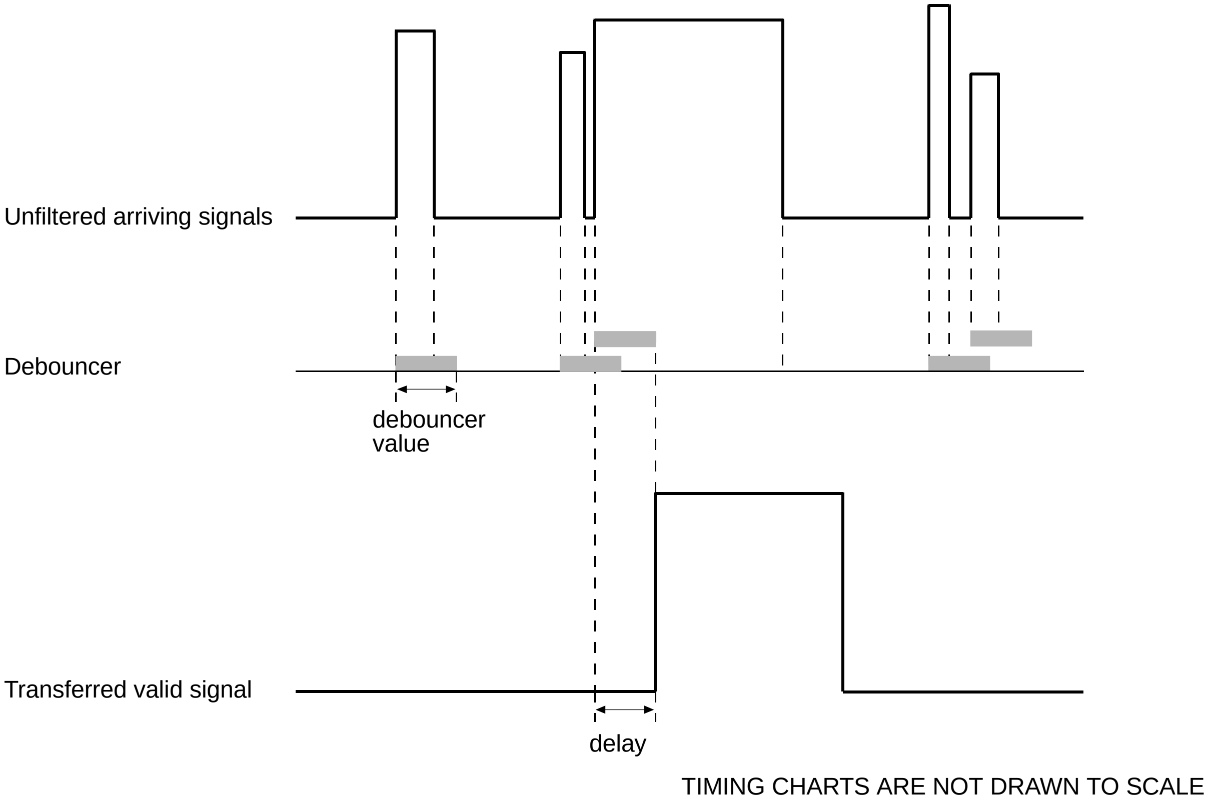

Unfiltered arriving signals
Debouncer
debouncer value
Transferred valid signal
delay
TIMING CHARTS ARE NOT DRAWN TO SCALE

Fig. 67: Filtering of Input Signals by the Debouncer

Setting the Debouncer

The debouncer value is determined by the value of the Line Debouncer Time Abs parameter value. The parameter is set in microseconds and can be set in a range from 0 to approximately 1 s.

To set a debouncer:

- Use the Line Selector to select the camera input line for which you want to set the debouncer (input line1 or 2).
- Set the value of the Line Debouncer Time Abs parameter.

You can set the Line Selector and the value of the Line Debouncer Abs parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
// Select the input line
Camera.LineSelector.SetValue( LineSelector_Line1 );

// Set the parameter value to 100 microseconds
Camera.LineDebouncerTimeAbs.SetValue( 100 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.14 Trigger Delay

The trigger delay feature lets you specify a delay (in microseconds) that will be applied between the receipt of a hardware trigger and it becoming effective.

The trigger delay may be specified in the range from 0 to 10000000l µs (equivalent to 10 s). When the delay is set to 0 µs, no delay will be applied.

The trigger delay will not operate when the camera is triggered by your application software and when the camera operates in continuous frame mode (free run).

Setting the Trigger Delay

You can set the Trigger Delay Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter values:

```
// Trigger delay
double TriggerDelay_us = 1000.0   // 1000us == 1ms == 0.001s;
Camera.TriggerDelayAbs.SetValue( TriggerDelay_us );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

9.15 Acquisition Status

When controlling image acquisition with a software trigger you can use the acquisition staus feature to detemine when the camera is ready to be triggered for an image acquisition. Using this feature, you can avoid triggering the camera at a rate that exceeds the maximum allowed with the current camera settings.

Note

It is not possible to monitor the status of the Acquisition Start command. Therefore, you can not use the status of the Acquisition Start command to determine when the camera is ready to be triggered for an image acquisition.

Determining the Acquisition Status

To determine the acquisition status of the camera:

- Use the Acquisition Status Selector to select the Frame Trigger Wait status.
- Read the value of the AcquisitionStatus parameter. If the value is set to "false", the camera is not ready to receive a software trigger, if the value is set to "true", the camera is ready to receive a software trigger.

You can set the Acquisition Status Selector and read the AcquisitionStatus parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to set and read the parameter values:

```
// Set the Acquisition Status Selector
Camera.AcquisitionStatusSelector.SetValue(
AcquisitionStatusSelector_FrameTriggerWait );

// Read the acquisition status
bool IsWaitingForFrameTrigger = Camera.AcquisitionStatus.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the Acquisition Status Selector.

9.16 Event Reporting

Event reporting is available on the camera. With event reporting, the camera can generate an "event" and transmit it to the PC whenever a specific situation has occurred.

Currently, the camera can generate and transmit an event for two types of situations:

- An end of an exposure has occurred
- An event overrun has occurred

An Example of Event Reporting

As an example of how event reporting works, assume that "end of exposure" event reporting has been enabled in the camera. Also assume that an end of exposure has just occurred in the camera. In this case:

1. An "end of exposure event" is created. The event contains:

   An *Event Type Identifier*. In this case, the identifier would show that an end of exposure type event has occurred.

   A *Stream Channel Identifier*. Currently this identifier is always 0.

   A *Frame ID*. This number indicates the frame count at the time that the event occurred.

   A *Timestamp*. This is a timestamp indicating when the event occurred. *
2. The event is placed in an internal queue in the camera.
3. As soon as bus transmission time is available, the camera will transmit an event message. If only one event is in the queue, the message will contain the single event. If more than one event is in the queue, the message will contain multiple events.

* The timestamp is a 32 bit value. The structure of this timestamp is similar to the timestamp described in Section 10.4 on page 210.

The Event Queue

As mentioned in the example above, the camera has an event queue. The intention of the queue is to handle short term delays in the camera’s ability to access the bus and send event messages. When event reporting is working "smoothly", a single event will be placed in the queue and this event will be sent to the PC in an event message before the next event is placed in queue. If there is an occasional short term delay in event message transmission, the queue can buffer several events and can send them within a single event message as soon as transmission time is available.

However if you are operating the camera at high frame rates with a small AOI, the camera may be able to generate and queue events faster than they can be transmitted and acknowledged. In this case:

1. The queue will fill and events will be dropped.
2. An event overrun will occur.
3. Assuming that you have event overrun reporting enabled, the camera will generate an "event overrun event" and place it in the queue.

4. As soon as transmission time is available, an event message containing the event overrun event will be transmitted to the PC.

The event overrun event is simply a warning that events are being dropped. The notification contains no specific information about how many or which events have been dropped.

Setting Your System for Event Reporting

To use event reporting, two conditions must be met:

- Event reporting must be enabled in the camera
- A pylon "event grabber" must be created within your application (assuming that you are using the pylon API)

The main purpose of the pylon event grabber is to receive incoming event messages.

An event adapter object of the event grabber can be used to parse the information contained within each event message.

You can enable event reporting, create a pylon event grabber, and use the event adapter object from within your application software by using the pylon API. The pylon software development kit includes a "Camera Events" code sample that illustrates the entire process.

For more detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

9.17 Test Images

All cameras include the ability to generate test images. Test images are used to check the camera's basic functionality and its ability to transmit an image to the host PC. Test images can be used for service purposes and for failure diagnostics. For test images, the image is generated internally by the camera's logic and does not use the optics, the imaging sensor, or the ADC. Six test images are available.

The Effect of Camera Settings on Test Images

When any of the test image is active, the camera's analog features such as gain, black level, and exposure time have no effect on the images transmitted by the camera. For test images 1, 2, 3 and 6, the cameras digital features, such as the luminance lookup table, will also have no effect on the transmitted images. But for test images 4 and 5, the cameras digital features will affect the images transmitted by the camera. This makes test images 4 and 5 as good way to check the effect of using a digital feature such as the luminance lookup table.

Enabling a Test Image

The Test Image Selector is used to set the camera to output a test image. You can set the value of the Test Image Selector to one of the test images or to "test image off".

You can set the Test Image Selector from within your application software by using the pylon API. The following code snippets illustrate using the API to set the selector:

```
// set for no test image
Camera.TestImageSelector.SetValue( TestImageSelector_Off );

// set for the first test image
Camera.TestImageSelector.SetValue( TestImageSelector_Testimage1 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

Test Image 1 - Fixed Diagonal Gray Gradient (8 bit)

The 8 bit fixed diagonal gray gradient test image is best suited for use when the camera is set for monochrome 8 bit output. The test image consists of fixed diagonal gray gradients ranging from 0 to 255.

If the camera is set for 8 bit output and is operating at full resolution, test image one will look similar to Figure 68.

The mathematical expression for this test image:

Gray Value = [column number + row number] MOD 256

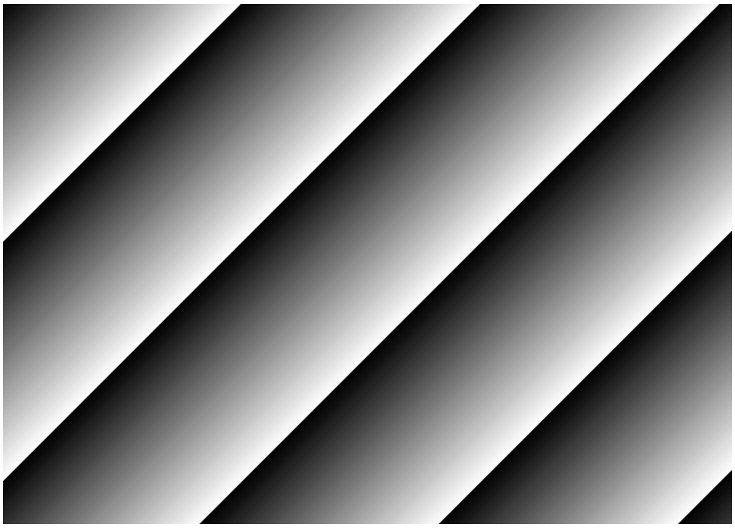


Fig. 68: Test Image One

Test Image 2 - Moving Diagonal Gray Gradient (8 bit)

The 8 bit moving diagonal gray gradient test image is similar to test image 1, but it is not stationary. The image moves by one pixel from right to left whenever a new image acquisition is initiated. The test pattern uses a counter that increments by one for each new image acquisition.

The mathematical expression for this test image is:

Gray Value = [column number + row number + counter] MOD 256

Test Image 3 - Moving Diagonal Gray Gradient (12 bit)

The 12 bit moving diagonal gray gradient test image is similar to test image 2, but it is a 12 bit pattern. The image moves by one pixel from right to left whenever a new image acquisition is initiated. The test pattern uses a counter that increments by one for each new image acquisition.

The mathematical expression for this test image is:

Gray Value = [column number + row number + counter] MOD 4096

Note

On scA750-60 cameras, test image 3 is a 10 bit pattern. Since these cameras do not have a 10 bit output mode available, use of test image 3 on scA750-60 cameras is not recommended.

Test Image 4 - Moving Diagonal Gray Gradient Feature Test (8 bit)

The basic appearance of test image 4 is similar to test image 2 (the 8 bit moving diagonal gray gradient image). The difference between test image 4 and test image 2 is this: if a camera feature that involves digital processing is enabled, test image 4 **will** show the effects of the feature while test image 2 **will not**. This makes test image 4 useful for checking the effects of digital features such as the luminance lookup table.

Test Image 5 - Moving Diagonal Gray Gradient Feature Test (12 bit)

The basic appearance of test image 5 is similar to test image 3 (the 12 bit moving diagonal gray gradient image). The difference between test image 5 and test image 3 is this: if a camera feature that involves digital processing is enabled, test image 5 **will** show the effects of the feature while test image 3 **will not**. This makes test image 5 useful for checking the effects of digital features such as the luminance lookup table.

Note

On scA750-60 cameras, test image 5 is a 10 bit pattern. Since these cameras do not have a 10 bit output mode available, use of test image 5 on scA750-60 cameras is not normally recommended. However, one situation where test image 5 is useful on scA750-60 cameras is to check the effect of the luminance lookup table.

Test Image 6 - Moving Diagonal Color Gradient

The moving diagonal color gradient test image is available on color cameras only and is designed for use when the camera is set for YUV output. As shown in Figure 69, test image six consists of diagonal color gradients. The image moves by one pixel from right to left whenever you signal the camera to capture a new image. To display this test pattern on a monitor, you must convert the YUV output from the camera to 8 bit RGB.

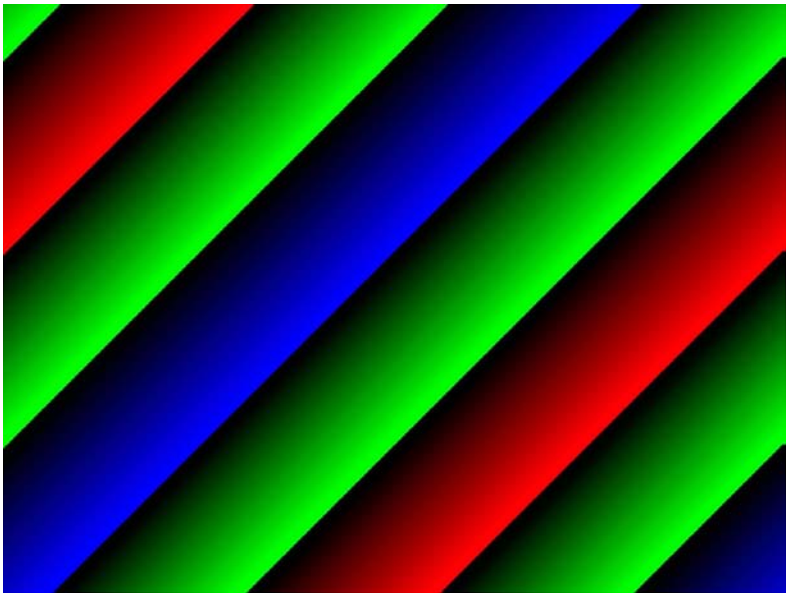


Fig. 69: Test Image Six

9.18 Device Information Parameters

Each camera includes a set of "device information" parameters. These parameters provide some basic information about the camera. The device information parameters include:

- Device Vendor Name (read only) - contains the name of the camera’s vendor. For scout cameras, this string will always indicate Basler as the vendor.
- Device Model Name (read only) - contains the model name of the camera, for example, scA640-70fm.
- Firmware Version (read only) - contains the version of the firmware in the camera.
- Device ID (read only) - contains the serial number of the camera.
- Device Scan Type (read only) - contains the scan type of the camera, for example, area scan.
- Sensor Width (read only) - contains the physical width of the sensor in pixels.
- Sensor Height (read only) - contains the physical height of the sensor.
- Max Width (read only) - Indicates the camera’s maximum area of interest (AOI) width setting.
- Max Height (read only) - Indicates the camera’s maximum area of interest (AOI) height setting.

You can read the values for all of the device information parameters or set the value of the Device ID parameter from within your application software by using the pylon API. The following code snippets illustrate using the API to read the parameters or write the Device ID:

```
// Read the Vendor Name parameter
Pylon::String_t vendorName = Camera.DeviceVendorName.GetValue();

// Read the Model Name parameter
Pylon::String_t modelName = Camera.DeviceModelName.GetValue();

// Read the Firmware Version parameter
Pylon::String_t firmwareVersion = Camera.DeviceFirmwareVersion.GetValue();

// Read the Device ID parameter
Pylon::String_t deviceID = Camera.DeviceID.GetValue();

// Read the Sensor Width parameter
int64_t sensorWidth = Camera.SensorWidth.GetValue();

// Read the Sensor Height parameter
int64_t sensorHeight = Camera.SensorHeight.GetValue();

// Read the Max Width parameter
int64_t maxWidth = Camera.WidthMax.GetValue();

// Read the Max Height parameter
int64_t maxHeight = Camera.HeightMax.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily read the parameters and to read or write the Device ID.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.19 Configuration Sets

A configuration set is a group of values that contains all of the parameter settings needed to control the camera. There are three basic types of configuration sets: the active configuration set, the default configuration set, and user configuration sets.

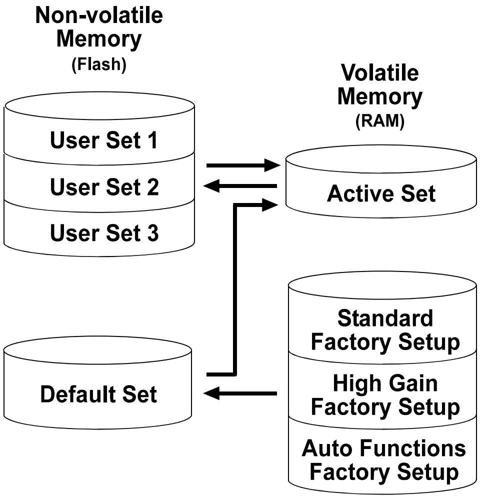


Fig. 70: Configuration Sets

Active Configuration Set

The active configuration set contains the camera’s current parameter settings and thus determines the camera’s performance, that is, what your image currently looks like. When you change parameter settings using the pylon API or the pylon Viewer, you are making changes to the active configuration set. The active configuration set is located in the camera’s volatile memory and the settings are lost if the camera is reset or if power is switched off. The active configuration set is usually called the "active set" for short.

Default Configuration Set

When a camera is manufactured, numerous tests are performed on the camera and three factory optimized setups are determined. The three factory optimized setups are:

- The Standard Factory Setup - is optimized for average conditions and will provide good camera performance in many common applications. In the standard factory setup, the gain is set to a low value, and all auto functions are set to off.
- The High Gain Factory Setup - is similar to the standard factory setup, but the gain ist set to + 6 dB.
- The Auto Fubnctions Factory Setup - is similar to the standard factory setup, but the Gain Auto and the Exposure Auto auto functions are both enabled and are set to the continuous mode of operation. During automatic parameter adjustment, gain will be kept to a minimum.

The factory setups are saved in permanent files in the camera’s non-volatile memory. They are not lost when the camera is reset or switched off and they cannot be changed.

You can select one of the three factory setups to be the camera’s "default configuration set". Instructions for selecting which factory setup will be used as the default set appear below. Note that your selection of which factory setup will serve as the default set will not be lost when the camera is reset or switched off.

The default configuration set can be loaded into the active set. The default configuration set can also be selected as the camera’s startup set. Instructions for loading the default set into the active set and for selecting the startup set appear below.

User Configuration Sets

As mentioned above, the active configuration set is stored in the camera’s volatile memory and the settings are lost if the camera is reset or if power is switched off. The camera can save most of the settings from the current active set to a reserved area in the camera’s non-volatile memory. A configuration set saved in the non-volatile memory is not lost when the camera is reset or switched off. There are three reserved areas in the camera’s non-volatile memory available for saving configuration sets. A configuration set saved in a reserved area is commonly referred to as a "user configuration set" or "user set" for short.

The three available user sets are called User Set 1, User Set 2, and User Set 3.

Note

The settings for the luminance lookup table are not saved in the user sets and are lost when the camera is reset or switched off. If used, these settings must be set again after each camera reset or restart.

Startup Set

You can select the default configuration set or one of the user configuration sets stored in the camera’s non-volatile memory to be the "startup set." The configuration set that you have selected as the startup set will automatically be loaded into the active set whenever the camera starts up at power on or after a reset. Instructions for selecting the startup set appear below.

For more information about auto functions, see Section 9.11 on page 172.

9.19.1 Saving User Sets

Saving the current active set into a user set in the camera’s non-volatile memory is a three step process:

- Make changes to the camera’s settings until the camera is operating in a manner that you would like to save.
- Set the User Set Selector to User Set 1, User Set 2, or User Set 3.
- Execute a User Set Save command to save the active set to the selected user set.

Saving an active set to a user set in the camera’s non-volatile memory will overwrite any parameters that were previously saved in that user set.

You can set the User Set Selector and execute the User Set Save command from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and execute the command:

```
Camera.UserSetSelector.SetValue( UserSetSelector_UserSet1 );
Camera.UserSetSave.Execute( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

9.19.2 Selecting a Factory Setup as the Default Set

When the camera is delivered, the Standard Factory Setup will be selected as the default configuration set. You can, however, select any one of the three factory setups to serve as the default set.

To select which factory setup to serve as the default set:

- Set the Default Set Selector to the Standard Factory Setup, High Gain Factory Setup or Auto Functions Factory Setup.

You can set the Default Set Selector from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector:

If you want to select the Standard Factory Setup:

```
Camera.DefaultSetSelector.SetValue(DefaultSetSelector_Standard);
```

If you want to select the High Gain Factory Setup:

```
Camera.DefaultSetSelector.SetValue(DefaultSetSelector_HighGain);
```

If you want to select the Auto Functions Factory Setup:

```
Camera.DefaultSetSelector.SetValue(DefaultSetSelector_AutoFunctions);
```

Note

Selecting which factory setup will serve as the default set is only allowed when the camera is idle, i.e. when it is not acquiring images continuously or does not have a single image acquisition pending.

Selecting the Standard Factory Setup as the default set and then loading the default set into the active set is a good course of action if you have grossly misadjusted the settings in the camera and you are not sure how to recover. The standard factory setup is optimized for use in typical situations and will provide good camera performance in most cases.

9.19.3 Loading a Saved Set or the Default Set into the Active Set

If you have saved a configuration set into the camera's non-volatile memory, you can load the saved set from the camera's non-volatile memory into the camera's active set. When you do this, the loaded set overwrites the parameters in the active set. Since the settings in the active set control the current operation of the camera, the settings from the loaded set will now be controlling the camera.

You can also load the default set into the camera's active set.

To load a saved configuration set or the default set from the camera's non-volatile memory into the active set:

- Set the User Set Selector to User Set 1, User Set 2, User Set 3 or Default.
- Execute a User Set Load command to load the selected set into the active set.

You can set the User Set Selector and execute the User Set Load command from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and execute the command:

```
Camera.UserSetSelector.SetValue( UserSetSelector_UserSet2 );
Camera.UserSetLoad.Execute( );
```

Note

Loading a user set or the default set into the active set is only allowed when the camera is idle, i.e. when it is not acquiring images continuously or does not have a single image acquisition pending.

Loading the Default Set with the Standard Factory Setup selected into the active set is a good course of action if you have grossly misadjusted the settings in the camera and you are not sure how to recover. The standard factory setup is optimized for use in typical situations and will provide good camera performance in most cases.

9.19.4 Selecting the Startup Set

You can select the default configuration set (i.e., whichever was selected as the default configuration set, either the Standard Factory Setup, the High Gain Factory Setup, or the Auto Functions Factory Setup) or one of the user configuration sets stored in the camera’s non-volatile memory to be the "startup set". The configuration set that you designate as the startup set will be loaded into the active set whenever the camera starts up at power on or after a reset.

The User Set Default Selector is used to select the startup set:

- Set the User Set Default Selector to User Set 1, User Set 2, User Set 3 or Default.

You can set the User Set Default Selector from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector:

```
Camera.UserSetDefaultSelector.SetValue( UserSetDefaultSelector_Default );
```

10 Chunk Features

This section provides detailed information about the chunk features available on each camera.

10.1 What are Chunk Features?

In most cases, enabling a camera feature will simply change the behavior of the camera. The Test Image feature is a good example of this type of camera feature. When the Test Image feature is enabled, the camera outputs a test image rather than a captured image. This type of feature is referred to as a "standard" feature.

When certain camera features are enabled, the camera actually develops some sort of information about each image that it acquires. In these cases, the information is added to each image as a trailing data "chunk" when the image is transferred to the host PC. Examples of this type of camera feature are the Frame Counter feature and the Time Stamp feature. When the Frame Counter feature is enabled, for example, after an image is captured, the camera checks a counter that tracks the number of images acquired and develops a frame counter stamp for the image. And if the Time Stamp feature is enabled, the camera creates a time stamp for the image. The frame counter stamp and the time stamp would be added as "chunks" of trailing data to each image as the image is transferred from the camera. The features that add chunks to the acquired images are referred to as “chunk” features.

Before you can use any of the features that add chunks to the image, you must make the chunk mode active. Making the chunk mode active is described in the next section.

10.2 Making the "Chunk Mode" Active

Before you can use any of the camera's "chunk" features, the "chunk mode" must be made active. To make the chunk mode active:

- Set the Chunk Mode Active parameter to true.

You can set the Chunk Mode Active parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
Camera.ChunkModeActive.SetValue( true );
```

Note that making the chunk mode inactive switches all chunk features off.

Also note that when you enable ChunkModeActive, the PayloadType for the camera changes from "Pylon::PayloadType_Image" to "Pylon::PayloadType_ChunkData".

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

10.3 Frame Counter

The Frame Counter feature numbers images sequentially as they are acquired. When the feature is enabled, a chunk is added to each image containing the value of the counter.

The frame counter is a 32 bit value. The counter starts at 0 and increments by 1 for each acquired image. The counter counts up to 4294967295 unless it is reset before (see below). After having reached the maximum value the counter will continue counting, starting at 0.

Be aware that if the camera is acquiring images continuously and continuous capture is stopped, several numbers in the counting sequence may be skipped. This happens due to the internal image buffering scheme used in the camera.

ⓘ **Note**

The chunk mode must be active before you can enable the frame counter feature or any of the other chunk feature. Making the chunk mode inactive disables all chunk features.

To enable the frame counter chunk:

- Use the Chunk Selector to select the Frame Counter chunk.
- Use the Chunk Enable parameter to set the value of the chunk to true.

Once the frame counter chunk is enabled, the camera will add a frame counter chunk to each acquired image.

To retrieve data from a chunk appended to an image that has been received by your PC, you must first run the image and its appended chunks through the chunk parser included in the pylon API. Once the chunk parser has been used, you can retrieve the frame counter information by doing the following:

- Read the value of the Chunk Frame Counter parameter.

You can set the Chunk Selector and Chunk Enable parameter value from within your application software by using the pylon API. You can also run the parser and retrieve the chunk data. The following code snippets illustrate using the API to activate the chunk mode, enable the frame counter chunk, run the parser, and retrieve the frame counter chunk data:

```
// make chunk mode active and enable Frame Counter chunk
Camera.ChunkModeActive.SetValue( true );
Camera.ChunkSelector.SetValue( ChunkSelector_Framecounter );
Camera.ChunkEnable.SetValue( true );

// retrieve date from the chunk
IChunkParser &ChunkParser = *Camera.CreateChunkParser();
GrabResult Result;
StreamGrabber.RetrieveResult( Result );
```

```
ChunkParser.AttachBuffer( (unsigned char*) Result.Buffer(),
  Result.GetPayloadSize() );
int64_t frameCounter = Camera.ChunkFramecounter.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

Comparing Counter Chunk Data

When comparing trigger input counter data and frame counter data related to the same image, be aware that the trigger input counter initially starts at 1 whereas the frame counter starts at 0. Therefore, the trigger input count will always be ahead of the matching frame count by one if both counters were started at the same time and if an image was acquired for every trigger.

Whenever the counters restart after having reached 4294967295 they will both start another counting cycle at 0. Accordingly, the difference between matching counts will always be one, regardless of the number of counting cycles.

Note that if both counters were started at the same time and not reset since and if the trigger input counter is ahead of the matching frame counter by more than one, the camera was overtriggered and not all external triggers resulted in image acquisitions.

Frame Counter Reset

Whenever the camera is powered off, the frame counter will reset to 0. During operation, you can reset the frame counter via I/O input 1, I/O input 2 or software, and you can disable the reset. By default, the frame counter reset is disabled.

To use the frame counter reset:

- Configure the frame counter reset by setting the counter selector to Counter2 and setting the counter event source to FrameStart.
- Set the counter reset source to Line1, Line2, Software or to Off.
- Execute the command if using software as the counter reset source.

You can set the frame counter reset parameter values from within your application software by using the pylon API. The following code snippets illustrate using the API to configure and set the frame counter reset and to execute a reset via software.

```
// configure reset of frame counter
Camera.CounterSelector.SetValue( CounterSelector_Counter2 );
Camera.CounterEventSource.SetValue( CounterEventSource_FrameStart );

// select reset by signal on input line 1
Camera.CounterResetSource.SetValue( CounterResetSource_Line1 );
```

```
// select reset by signal on input line 2
Camera.CounterResetSource.SetValue( CounterResetSource_Line2 );

// select reset by software
Camera.CounterResetSource.SetValue( CounterResetSource_Software );
// execute reset by software
Camera.CounterReset.Execute();

// disable reset
Camera.CounterResetSource.SetValue( CounterResetSource_Off );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

10.4 Time Stamp

The Time Stamp feature adds a chunk to each acquired image containing a time stamp that was generated when image acquisition was triggered.

The time stamp is a 32 bit value. The time stamp is based on the cycle timers for the IEEE 1394b bus. The counters start at camera reset or at power off/on. The table below how the cycle timers are assigned to the 32 bits in the chunk.

Bits	Description
0 ... 6	Seconds - counts in seconds. Wraps to zero after 127 seconds.
7 ... 19	Cycle Count - counts the number of 125 µs isochronous bus cycles. Wraps to zero after counting to 7999.
20 ... 31	Cycle Offset - counts at 24.576 MHz and wraps to zero after counting to 3071 (resulting in a 125 µs cycle)

Note

The chunk mode must be active before you can enable the time stamp feature or any of the other chunk feature. Making the chunk mode inactive disables all chunk features.

To enable the time stamp chunk:

- Use the Chunk Selector to select the Time Stamp chunk.
- Use the Chunk Enable parameter to set the value of the chunk to true.

Once the time stamp chunk is enabled, the camera will add a time stamp chunk to each acquired image.

To retrieve data from a chunk appended to the image you must first run the image and its appended chunks through the chunk parser that is included in the camera's API. Once the chunk parser has been used, you can retrieve the time stamp information by doing the following:

- Read the value of the Chunk Time Stamp parameter.

You can set the Chunk Selector and Chunk Enable parameter value from within your application software by using the pylon API. You can also run the parser and retrieve the chunk data. The following code snippets illustrate using the API to activate the chunk mode, enable the time stamp chunk, run the parser, and retrieve the frame counter chunk data:

```
// make chunk mode active and enable Time Stamp chunk
Camera.ChunkModeActive.SetValue( true );
Camera.ChunkSelector.SetValue( ChunkSelector_Timestamp );
Camera.ChunkEnable.SetValue( true );
```

```
// retrieve data from the chunk
IChunkParser &ChunkParser = *Camera.CreateChunkParser();
GrabResult Result;
StreamGrabber.RetrieveResult( Result );
ChunkParser.AttachBuffer( (unsigned char*) Result.Buffer(),
  Result.GetPayloadSize() );
int64_t timeStamp = Camera.ChunkTimestamp.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

10.5 Trigger Input Counter

The Trigger Input Counter feature numbers external image acquisition triggers sequentially as they are received. When the feature is enabled, a chunk is added to each image containing the related value of the trigger input counter.

The trigger input counter is a 32 bit value. On the first counting cycle, the counter starts at 1 and increments by 1 for each received trigger. The counter counts up to 4294967295 unless it is reset before (see below). After having reached the maximum value the counter will continue counting, starting at 0.

Be aware that if the camera is oparating in continuous frame mode (free run) the trigger input counter will not be available.

ⓘ **Note**

The chunk mode must be active before you can enable the trigger input counter feature or any of the other chunk feature. Making the chunk mode inactive disables all chunk features.

To enable the trigger input counter chunk:

- Use the Chunk Selector to select the Trigger Input Counter chunk.
- Use the Chunk Enable parameter to set the value of the chunk to true.

Once the trigger input counter chunk is enabled, the camera will add a trigger input counter chunk to each acquired image.

To retrieve data from a chunk appended to an image that has been received by your PC, you must first run the image and its appended chunks through the chunk parser included in the pylon API. Once the chunk parser has been used, you can retrieve the trigger input counter information by doing the following:

- Read the value of the Chunk Trigger Input Counter parameter.

You can set the Chunk Selector and Chunk Enable parameter value from within your application software by using the pylon API. You can also run the parser and retrieve the chunk data. The following code snippets illustrate using the API to activate the chunk mode, enable the trigger input counter chunk, run the parser, and retrieve the trigger input counter chunk data:

```
// make chunk mode active and enable Trigger Input Counter chunk
Camera.ChunkModeActive.SetValue( true );
Camera.ChunkSelector.SetValue( ChunkSelector_Triggerinputcounter );
Camera.ChunkEnable.SetValue( true );

// retrieve data from the chunk
IChunkParser &ChunkParser = *Camera.CreateChunkParser();
GrabResult Result;
```

```
StreamGrabber.RetrieveResult( Result );
ChunkParser.AttachBuffer( (unsigned char*) Result.Buffer(),
  Result.GetPayloadSize() );
int64_t triggerinputCounter = Camera.ChunkTriggerinputcounter.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

Comparing Counter Chunk Data

When comparing trigger input counter data and frame counter data related to the same image, be aware that the trigger input counter initially starts at 1 whereas the frame counter starts at 0. Therefore, the trigger input count will always be ahead of the matching frame count by one if both counters were started at the same time and if an image was acquired for every trigger.

Whenever the counters restart after having reached 4294967295 they will both start another counting cycle at 0. Accordingly, the difference between matching counts will always be one, regardless of the number of counting cycles.

Note that if both counters were started at the same time and not reset since and if the trigger input counter is ahead of the matching frame counter by more than one, the camera was overtriggered and not all external triggers resulted in image acquisitions.

Trigger Input Counter Reset

Whenever the camera is powered off, the trigger input counter will reset to 0. During operation, you can reset the trigger input counter via I/O input 1, I/O input 2 or software, and you can disable the reset. By default, the trigger input counter reset is disabled.

To use the trigger input counter reset:

- Configure the trigger input counter reset by setting the counter selector to Counter1 and setting the counter event source to FrameTrigger.
- Set the counter reset source to Line1, Line2, Software or to Off.
- Execute the command if using software as the counter reset source.

You can set the trigger input counter reset parameter values from within your application software by using the pylon API. The following code snippets illustrate using the API to configure and set the trigger input counter reset and to execute a reset via software.

```
// configure reset of trigger input counter
Camera.CounterSelector.SetValue( CounterSelector_Counter1 );
Camera.CounterEventSource.SetValue( CounterEventSource_FrameTrigger );

// select reset by signal on input line 1
Camera.CounterResetSource.SetValue( CounterResetSource_Line1 );

// select reset by signal on input line 2
```

```
Camera.CounterResetSource.SetValue( CounterResetSource_Line2 );

// select reset by software
Camera.CounterResetSource.SetValue( CounterResetSource_Software );
// execute reset by software
Camera.CounterReset.Execute();

// disable reset
Camera.CounterResetSource.SetValue( CounterResetSource_Off );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

10.6 Line Status All

The Line Status All feature samples the status of all of the camera's input lines and output lines each time an image acquisition is triggered. It then adds a chunk to each acquired image containing the line status information.

The line status all information is a 32 bit value. As shown in Figure 71, certain bits in the value are associated with each line and the bits will indicate the state of the lines. If a bit is 0, it indicates that the state of the associated line was low at the time of triggering. If a bit is 1, it indicates that the state of the associated line is was high at the time of triggering.

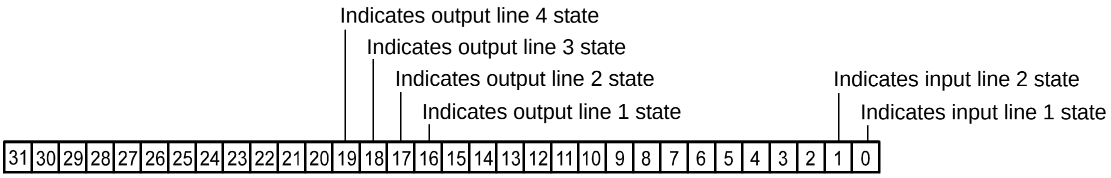

Indicates output line 4 state
Indicates output line 3 state
Indicates output line 2 state
Indicates output line 1 state
Indicates input line 2 state
Indicates input line 1 state
31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

Fig. 71: Line Status All Parameter Bits

Note

The chunk mode must be active before you can enable the line status all feature or any of the other chunk feature. Making the chunk mode inactive disables all chunk features.

To enable the line status all chunk:

- Use the Chunk Selector to select the Line Status All chunk.
- Use the Chunk Enable parameter to set the value of the chunk to true.

Once the line status all chunk is enabled, the camera will add a line status all chunk to each acquired image.

To retrieve data from a chunk appended to an image that has been received by your PC, you must first run the image and its appended chunks through the chunk parser included in the pylon API. Once the chunk parser has been used, you can retrieve the line status all information by doing the following:

- Read the value of the Chunk Line Status All parameter.

You can set the Chunk Selector and Chunk Enable parameter value from within your application software by using the pylon API. You can also run the parser and retrieve the chunk data. The following code snippets illustrate using the API to activate the chunk mode, enable the line status all chunk, run the parser, and retrieve the line status all chunk data:

```
// make chunk mode active and enable Line Status All chunk
Camera.ChunkModeActive.SetValue( true );
Camera.ChunkSelector.SetValue( ChunkSelector_LineStatusAll );
Camera.ChunkEnable.SetValue( true );

// retrieve data from the chunk
IChunkParser &ChunkParser = *Camera.CreateChunkParser();
GrabResult Result;
StreamGrabber.RetrieveResult( Result );
ChunkParser.AttachBuffer( (unsigned char*) Result.Buffer(),
  Result.GetPayloadSize() );
int64_t lineStatusAll = Camera.ChunkLineStatusAll.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

10.7 CRC Checksum

The CRC (Cyclic Redundancy Check) Checksum feature adds a chunk to each acquired image containing a CRC checksum calculated using the Z-modem method. As shown in Figure 6-2, the checksum is calculated using all of the image data and all of the appended chunks except for the checksum itself. The CRC chunk is always the last chunk appended to the image data.

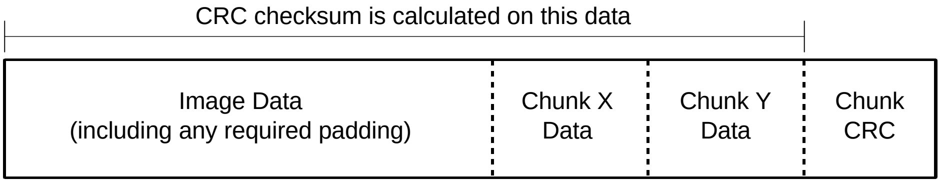

CRC checksum is calculated on this data
Image Data (including any required padding)
Chunk X Data
Chunk Y Data
Chunk CRC

Fig. 72: CRC Checksum

Note

The chunk mode must be active before you can enable the CRC feature or any of the other chunk feature. Making the chunk mode inactive disables all chunk features.

To enable the CRC checksum chunk:

- Use the Chunk Selector to select the CRC chunk.
- Use the Chunk Enable parameter to set the value of the chunk to true.

Once the CRC chunk is enabled, the camera will add a CRC chunk to each acquired image.

To retrieve CRC information from a chunk appended to an image that has been received by your PC, you must first run the image and its appended chunks through the chunk parser included in the pylon API. Once the chunk parser has been used, you can retrieve the CRC information. Note that the CRC information provided by the chunk parser is not the CRC checksum itself. Rather it is a true/false result. When the image and appended chunks pass through the parser, the parser calculates a CRC checksum based on the received image and chunk information. It then compares the calculated CRC checksum with the CRC checksum contained in the CRC checksum chunk. If the two match, the result will indicate that the image data is OK. If the two do not match, the result will indicate that the image is corrupted.

You can set the Chunk Selector and Chunk Enable parameter value from within your application software by using the pylon API. You can also run the parser and retrieve the chunk data. The following code snippets illustrate using the API to activate the chunk mode, enable the time stamp chunk, run the parser, and retrieve the frame counter chunk data:

```
// Make chunk mode active and enable CRC chunk
Camera.ChunkModeActive.SetValue( true );
Camera.ChunkSelector.SetValue( ChunkSelector_PayloadCRC16 );
Camera.ChunkEnable.SetValue( true );

// Check the CRC checksum of an grabbed image
IChunkParser &ChunkParser =
   *Camera.CreateChunkParser();
GrabResult Result;
StreamGrabber.RetrieveResult( Result );
ChunkParser.AttachBuffer( (unsigned char*) Result.Buffer(),
   Result.GetPayloadSize() );
if ( ChunkParser.HasCRC() && ! ChunkParser.CheckCRC() )
   cerr << "Image corrupted!" << endl;
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

11 Using Multiple Cameras on a Single Bus and Managing Bandwidth

This section includes information about using multiple cameras on a single IEEE 1394 bus.

11.1 Using Multiple Cameras Where All Devices are 1394b

Most of the information included in this manual assumes that you have a single camera attached to your IEEE 1394b bus. But is it also quite common to attach more than one camera to a single bus. One of the main advantages of the IEEE 1394 bus architecture is that it is designed to handle multiple devices (such as cameras) connected to a single bus. And the connected devices can share the available bandwidth on the bus.

One way you can manage two cameras on a single bus is to operate the cameras so that only on camera is transmitting an image at any given time. In this situation, the camera transmitting images can use 100% of the bus bandwidth. In many situations, however, you would like to have two (or more) cameras transmitting images at the same time. In this case, the cameras that are transmitting images simultaneously must share the available bus bandwidth.

To understand how bandwidth is shared on an IEEE 1394 bus, we need to look at a few bus architecture basics. The IEEE 1394b bus operates on a 125 microsecond cycle. During each cycle, the bus can carry a single packet from one device with a packet size up to 8192 bytes. As an alternative, the bus can carry several packets from different devices where the sum of the packet sizes is 8192 bytes or less. These two situations are illustrated in Figure 73.

In situation 1 shown in the figure, a single camera (camera A) is attached to the bus and we want that camera to use 100% of the bandwidth available during each bus cycle. In this case, we would set the camera so that it would put 8192 bytes into the packet that it sends on each cycle of the bus.

In situation 2, we have three cameras (cameras A, B, and C) attached to the bus and all three cameras will transmit image data simultaneously. We want camera A to use 25%, of the available bus bandwidth, camera B to use 25%, and camera 3 to use 50%. In this case, we would set camera A so that it would put 2048 bytes, i.e., 25% of the 8192 byte maximum, into each packet it sends. We would set camera B so that it would put 2048 bytes (25% of 8192) into each packet it sends. And we would set camera C so that it would put 4096 bytes (50% of the 8192) into each packet it sends. As shown in the figure, the bus carries the packets sequentially on each cycle. The total byte load in all of the packets combined is 8192 and is equal to the maximum allowed per cycle. Note that we could have made the packet sizes smaller and thus the total byte load per cycle would be less than the maximum allowed. It is OK to make the total byte load smaller than the maximum, but not larger.

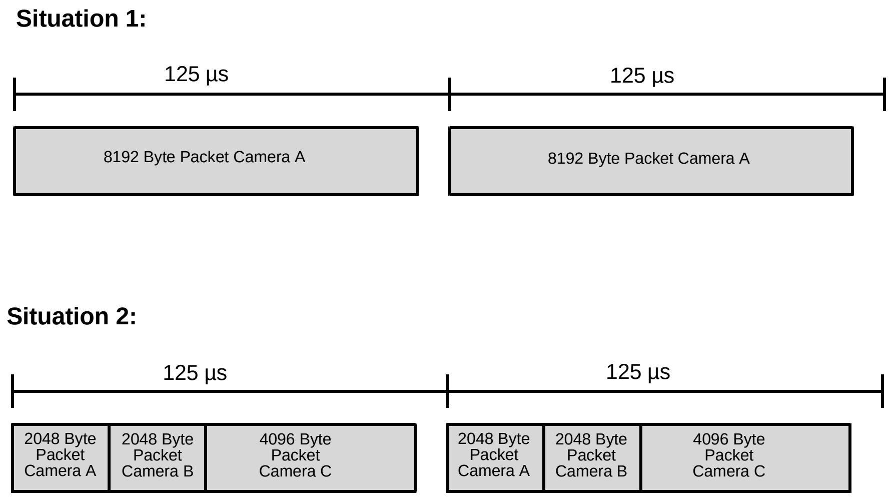

Situation 1:
125 µs
125 µs
8192 Byte Packet Camera A
8192 Byte Packet Camera A
Situation 2:
125 µs
125 µs
2048 Byte Packet Camera A
2048 Byte Packet Camera B
4096 Byte Packet Camera C
2048 Byte Packet Camera A
2048 Byte Packet Camera B
4096 Byte Packet Camera C

Fig. 73: Packet Transmission During Bus Cycles

A parameter called the Packet Size is used to set the size of the packet that the camera will transmit on each cycle of the bus. For an IEEE 1394b camera attached to an IEEE 1394b bus, the minimum value for this setting is 1 byte and the maximum is 8192 bytes. If you set the packet size to 8192, the camera will use 100% of the available bus bandwidth when it is transmitting images. If you set the bytes per packet to a lower value, the camera will use less of the bandwidth. For example, if you set the value to 5120 (62.5% of 8192), then the camera will send 5120 byte packets when it is transmitting image data and will use 62.5% of the available bus bandwidth.

You can set the value of the Packet Size parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
// Set packet size
Camera.PacketSize.SetValue( 4096 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameter.

For more information about the pylon Viewer, see Section 3.1 on page 39.

11.2 Using Multiple Cameras Where 1394a and 1394b Devices are Mixed

The descriptions in the previous section assume that all of the devices on the bus are IEEE 1394b devices. If the bus has mixed IEEE 1394a devices and IEEE 1394b devices, determining how to share bandwidth between devices is a bit more difficult. As a first step toward understanding the situation, consider the difference between 1394a devices and 1394b devices:

- A 1394a device can transmit at what is known as S400 speed (400 Mbit/s).
- During a single bus cycle, a device operating at S400 speed can transmit a single packet of up to 4096 bytes. Alternatively, several devices operating at S400 speed can transmit packets during a single bus cycle as long as the sum of the bytes in the packets is 4096 bytes or less.
- A 1394b device can transmit at what is known as S800 speed (800 Mbit/s).
- During a single bus cycle, a device operating at S800 speed can transmit a single packet of up to 8192 bytes. Alternatively, several devices operating at S800 speed can transmit packets during a single bus cycle as long as the sum of the bytes in the packets is 8192 bytes or less.

The next thing that we must consider in a bus that has mixed 1394a and 1394b devices is the speed at which each device will transmit:

- A 1394a device will always be capable of transmitting at S400 speed on a mixed 1394a / 1394b bus. (The 1394a device can transmit at slower speeds, but we are assuming that you always want to transmit at the fastest speed.)
- A 1394b device will transmit at S800 speed if all of the devices in its path to the host PC, including the adapter card in the PC, are 1394b devices. If the path to the PC passes through any 1394a device, then the 1394b device will transmit at S400 speed.

Figure 74 illustrates some situations where 1394a devices and 1394b devices are mixed on a single bus. If you look at the figure, you will notice:

- Camera 1 will transmit image data at S400 speed. This is simply because the camera itself is a 1394a device and S400 is the maximum speed for 1394a devices.
- Camera 2 will transmit image data at S400 speed. The camera is a 1394b device, which means that it is capable of S800 speed. But the camera's path to the host PC passes through a 1394a adapter, so this limits the camera's actual maximum speed to S400.
- Camera 3 will transmit image data at S800 speed. This is because the camera is a 1394b device and its path to the host PC passes through only 1394b devices.
- Camera 4 will transmit image data at S400 speed. This is simply because the camera itself is a 1394a device.
- Camera 5 will transmit image data at S400 speed. The camera is a 1394b device, but its path to the host PC passes through a 1394a hub, so this limits the camera's maximum speed to S400.
- Camera 6 will transmit image data at S400 speed. This is simply because the camera itself is a 1394a device.
- Camera 7 will transmit image data at S800 speed. This is because the camera is a 1394b device and its path to the host PC passes through only 1394b devices.

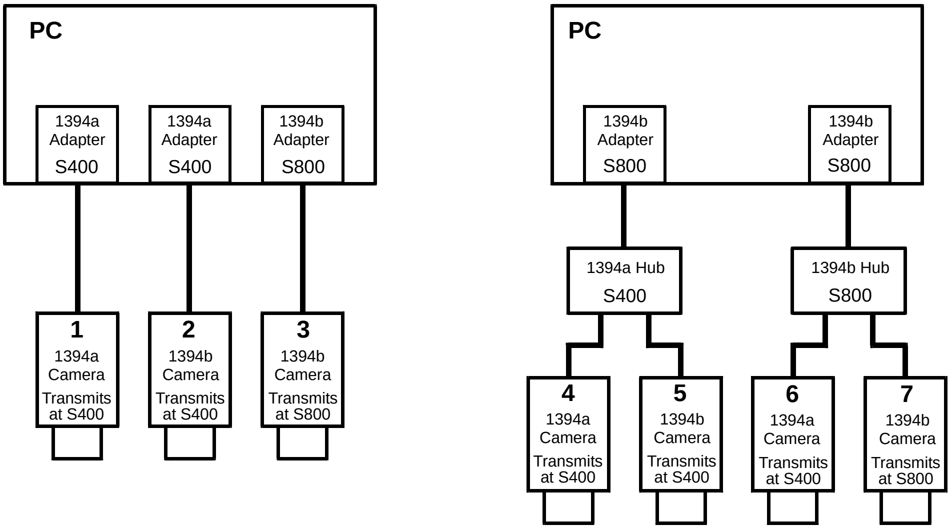

PC
1394a Adapter S400
1394a Adapter S400
1394b Adapter S800
1 1394a Camera Transmits at S400
2 1394b Camera Transmits at S400
3 1394b Camera Transmits at S800
PC
1394b Adapter S800
1394b Adapter S800
1394a Hub S400
1394b Hub S800
4 1394a Camera Transmits at S400
5 1394b Camera Transmits at S400
6 1394a Camera Transmits at S400
7 1394b Camera Transmits at S800

Fig. 74: Examples of Mixed Device Types

Note

The driver will always set each device to operate at the fastest possible speed for the current network configuration. This behavior of the driver can't be changed by the user.

So what does all of this mean when we are trying to share bandwidth between devices operating at different speeds on the same bus? Some examples will provide the best explanation.

Example 1: Assume that you have two cameras on the bus and that you want them to capture and transmit images simultaneously. Camera 1 is operating at S400 speed and the camera 2 is operating at S800 speed. Also assume that you want camera one to use 40% of the available bandwidth and camera 2 to use 60%. How would you set the packet size on the cameras so that each one would use the desired portion of the bandwidth available in each bus cycle?

For camera 1, the calculation would be:

0.40 x 4096 = 1638.4 bytes per packet

(the packet size must be set to a multiple of 4, so we would round the setting down to 1636)

For camera 2, the calculation would be:

0.60 x 8192 = 4915.2 bytes per packet

(the packet size must be set to a multiple of 4, so we would round the setting down to 4912)

So in this case, you would set the packet size for camera 1 to 1636 bytes and for camera 2 to 4912 bytes.

You may be asking why we multiply the percentage for camera 1 by 4096 and the percentage for camera 2 by 8192. The reason is:

> During the part of the bus cycle when the packet for camera 1 is transmitted, the bus will operate at S400 speed. At S400, the maximum number of bytes that can be transmitted in a bus cycle is 4096.
>
> During the part of the bus cycle when the packet for camera 2 is transmitted, the bus will operate at S800 speed. At S800, the maximum number of bytes that can be transmitted in a bus cycle is 8192.

Example 2: Assume that you have three cameras on the bus and that you want these camera to capture and transmit images simultaneously. Camera one is operating at S800 speed and is set for a packet size of 4200 bytes. Camera two is operating at S800 speed and is set for a packet size of 1800 bytes. Camera 3 is operating at S400 speed and is set for a packet size of 1000 bytes. How much of the available bandwidth would each camera use?

For camera 1, the calculation would be:

> 4200 / 8192 = 51.3%

For camera 2, the calculation would be:

> 1800 / 8192 = 22.0%

For camera 3, the calculation would be:

> 1000 / 4096 = 24.4%

If you add these three results together, you find that 97.7% of the available bandwidth is being used. Keep in mind that if the sum was greater than 100%, you would need to lower the packet size setting for one or more of the cameras.

11.2.1 Recommended Packet Size

When you change the value of the packet size setting on a camera, there is something that you must keep in mind. If you lower the packet size setting, the camera takes longer to transmit each acquired image. And if you lower the packet size enough, it will begin to restrict the maximum frame rate that the camera can achieve. A read only parameter called the Recommended Packet Size can help you avoid this problem.

The recommended packet size parameter indicates the lowest value you can use for the packet size setting without restricting the camera's maximum allowed frame rate. Assume, for example, that you checked the packet size parameter value and you found it to be 2400. This would mean that if you set the camera's packet size to 2400 bytes or more, the camera's maximum allowed frame rate would not be affected by the packet size setting. And if you set the packet size lower than 2400, the camera's maximum allowed frame rate would be affected. The farther below 2400 you set the packet size, the more restricted the maximum frame rate would be.

You read the value of the Recommended Packet Size parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to get the parameter values:

```
// RecommendedPacketSize
int64_t recommendedPacketSize = Camera.RecommendedPacketSize.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 39.

For more information about the camera's maximum allowed frame rate and how it can be restricted by the packet size setting, see Section 6.10 on page 90.

12 Troubleshooting and Support

This section outlines the resources available to you if you need help working with your camera. It also provides some basic troubleshooting information that you can use to solve problems.

12.1 Tech Support Resources

The troubleshooting resources in this section of the manual will help you to find the cause of many common problems. If you need more assistance, you can contact the Basler technical support team for your area. Basler technical support contact information is located in the front pages of this manual.

If you do decide to contact Basler technical support, please take a look at the form that appears on the last two pages of this section before you call. Filling out this form will help make sure that you have all of the information the Basler technical support team needs to help you with your problem.

You will also find helpful information such as frequently asked questions, downloads, and application notes on the Basler website at:
www.baslerweb.com/indizes/beitrag_index_en_22089.html

12.2 Obtaining an RMA Number

Whenever you want to return material to Basler, you must request a Return Material Authorization (RMA) number before sending it back. The RMA number **must** be stated in your delivery documents when you ship your material to us! Please be aware that if you return material without an RMA number, we reserve the right to reject the material.

You can find detailed information about how to obtain an RMA number on the Basler website at:
www.baslerweb.com/beitraege/beitrag_en_79701.html

12.3 Troubleshooting with the Camera LED

If the camera boots up successfully, the LED on the back of the camera will light and will remain green continuously.

If an error condition is detected, the LED will begin to flash. The number of flashes indicates the detected error as shown in Table 20.

LED State	Status Indication
Off	No power to the camera
Continuous green	The camera is OK.
Continuous red	Internal error. Contact Basler technical support.

Table 20: LED Indications

12.4 Troubleshooting Charts

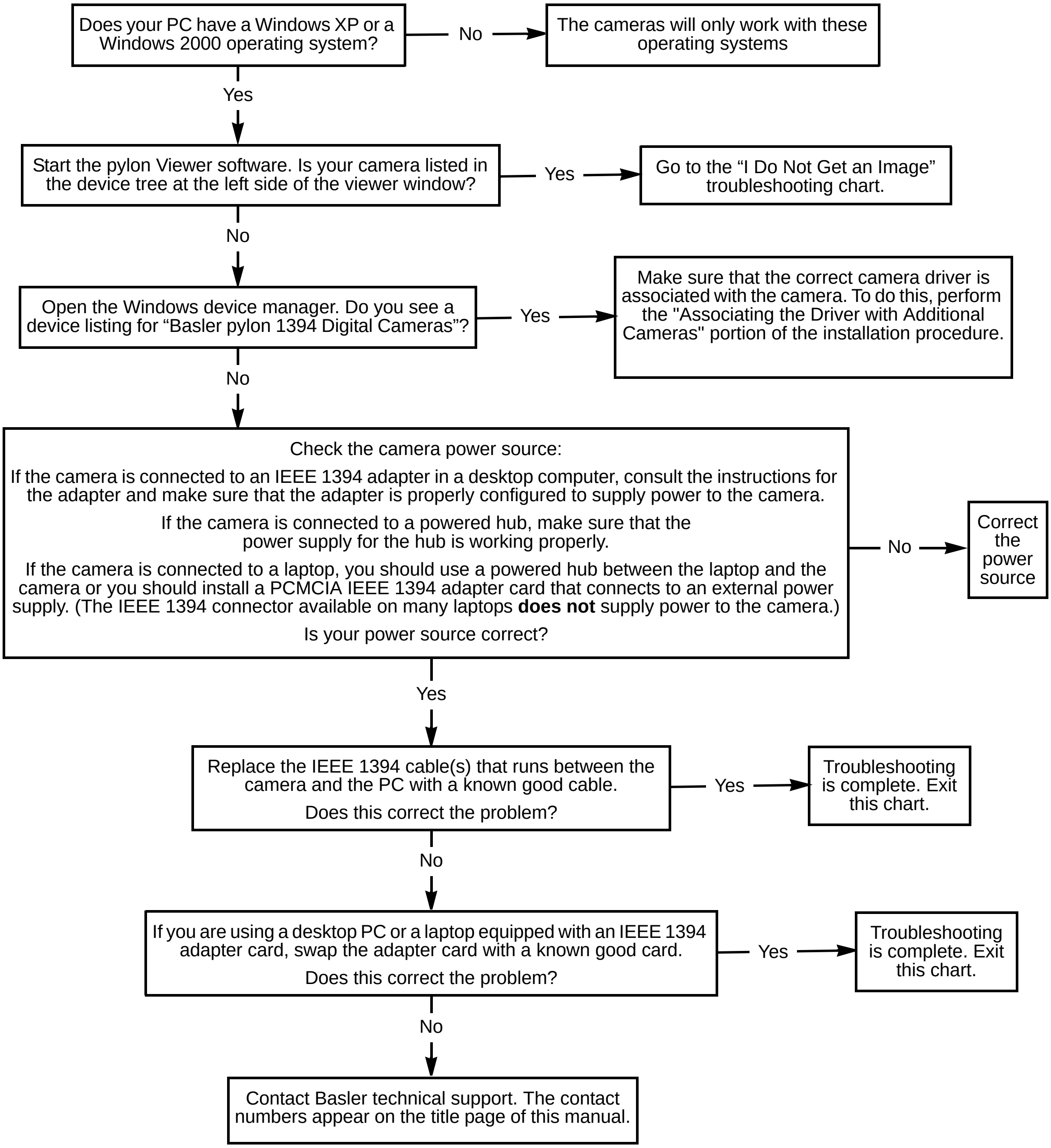
The following pages contain several troubleshooting charts that can help you find the cause of problems users sometimes encounter. The charts assume that you are familiar with the camera’s features and settings. If you are not, we suggest that you review the camera manual before you troubleshoot a problem.

The charts also assume that you have the pylon Viewer software installed on your host PC and that you are familiar with using the software.

For more information about the pylon Viewer, see Section 3.1 on page 39.

12.4.1 My Camera Is Not Being Recognized

Use this chart if your camera is connected to a PC, but is not being recognized by the PC.



Does your PC have a Windows XP or a Windows 2000 operating system?

The cameras will only work with these operating systems

Start the pylon Viewer software. Is your camera listed in the device tree at the left side of the viewer window?

Go to the “I Do Not Get an Image” troubleshooting chart.

Open the Windows device manager. Do you see a device listing for “Basler pylon 1394 Digital Cameras”?

Make sure that the correct camera driver is associated with the camera. To do this, perform the "Associating the Driver with Additional Cameras" portion of the installation procedure.

Check the camera power source:

If the camera is connected to an IEEE 1394 adapter in a desktop computer, consult the instructions for the adapter and make sure that the adapter is properly configured to supply power to the camera.

If the camera is connected to a powered hub, make sure that the power supply for the hub is working properly.

If the camera is connected to a laptop, you should use a powered hub between the laptop and the camera or you should install a PCMCIA IEEE 1394 adapter card that connects to an external power supply. (The IEEE 1394 connector available on many laptops **does not** supply power to the camera.)

Is your power source correct?

Correct the power source

Replace the IEEE 1394 cable(s) that runs between the camera and the PC with a known good cable.

Does this correct the problem?

Troubleshooting is complete. Exit this chart.

If you are using a desktop PC or a laptop equipped with an IEEE 1394 adapter card, swap the adapter card with a known good card.

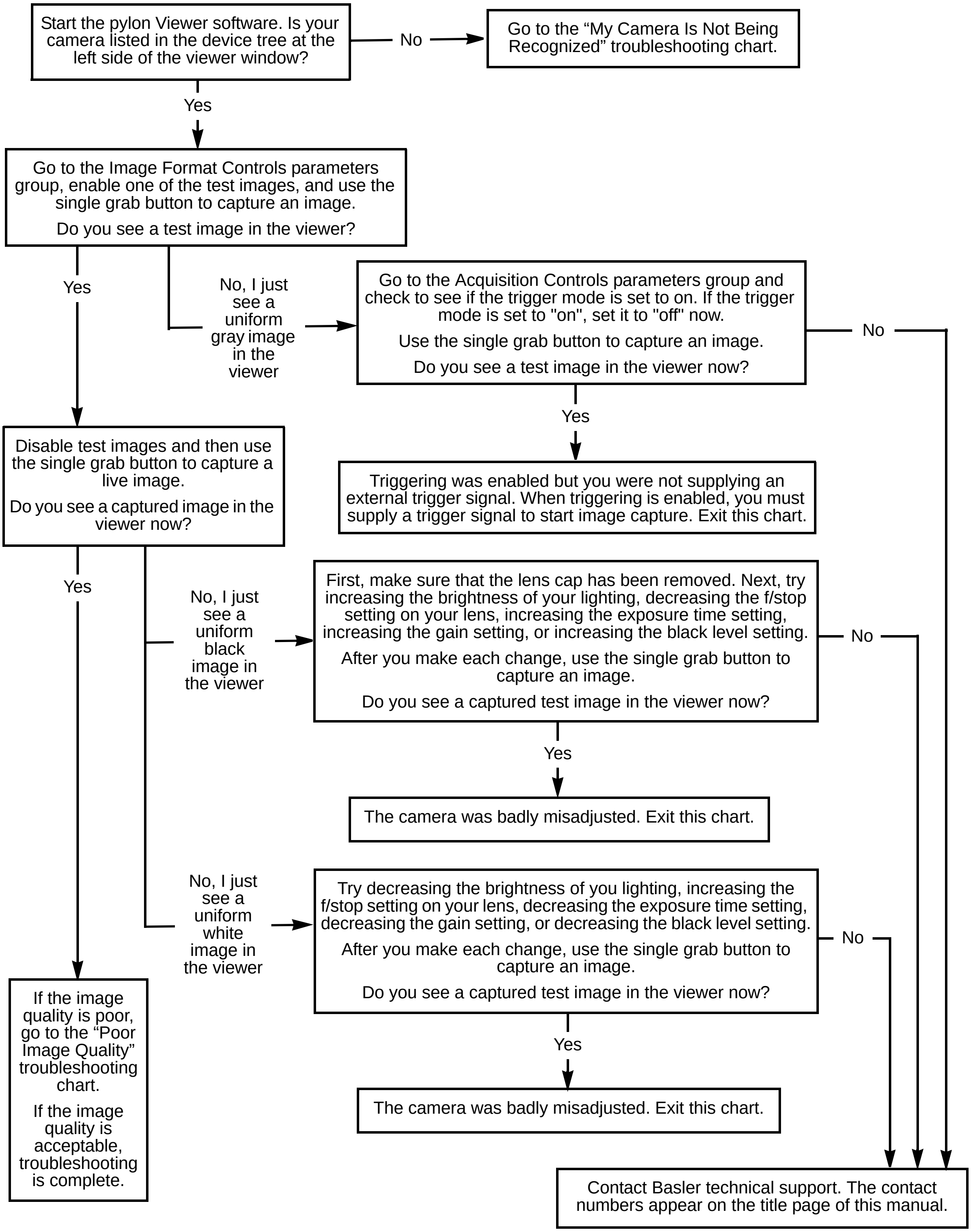
Does this correct the problem?

Troubleshooting is complete. Exit this chart.

Contact Basler technical support. The contact numbers appear on the title page of this manual.

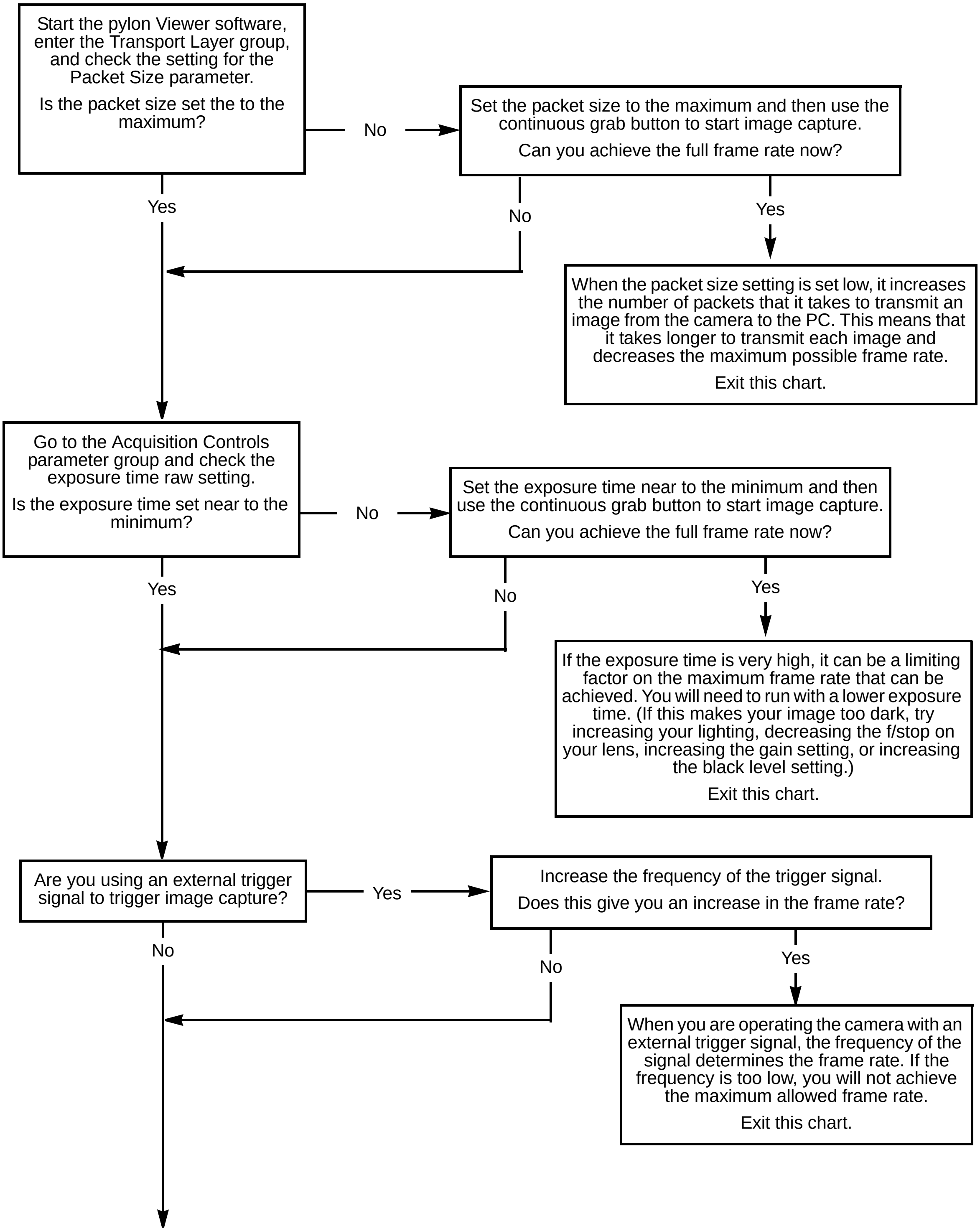
12.4.2 I Do Not Get an Image

Use this chart if you get no image at all when you attempt to capture an image. If you get a poor quality image, use the "Poor Image Quality" chart.


Start the pylon Viewer software. Is your camera listed in the device tree at the left side of the viewer window?
No
Go to the “My Camera Is Not Being Recognized” troubleshooting chart.
Yes
Go to the Image Format Controls parameters group, enable one of the test images, and use the single grab button to capture an image.
Do you see a test image in the viewer?
Yes
No, I just see a uniform gray image in the viewer
Go to the Acquisition Controls parameters group and check to see if the trigger mode is set to on. If the trigger mode is set to "on", set it to "off" now.
Use the single grab button to capture an image.
Do you see a test image in the viewer now?
No
Yes
Triggering was enabled but you were not supplying an external trigger signal. When triggering is enabled, you must supply a trigger signal to start image capture. Exit this chart.
Disable test images and then use the single grab button to capture a live image.
Do you see a captured image in the viewer now?
Yes
No, I just see a uniform black image in the viewer
First, make sure that the lens cap has been removed. Next, try increasing the brightness of your lighting, decreasing the f/stop setting on your lens, increasing the exposure time setting, increasing the gain setting, or increasing the black level setting.
After you make each change, use the single grab button to capture an image.
Do you see a captured test image in the viewer now?
No
Yes
The camera was badly misadjusted. Exit this chart.
No, I just see a uniform white image in the viewer
Try decreasing the brightness of you lighting, increasing the f/stop setting on your lens, decreasing the exposure time setting, decreasing the gain setting, or decreasing the black level setting.
After you make each change, use the single grab button to capture an image.
Do you see a captured test image in the viewer now?
No
Yes
The camera was badly misadjusted. Exit this chart.
If the image quality is poor, go to the “Poor Image Quality” troubleshooting chart.
If the image quality is acceptable, troubleshooting is complete.
Contact Basler technical support. The contact numbers appear on the title page of this manual.

12.4.3 I Can Not Get the Full Frame Rate

Use this troubleshooting chart if you are attempting to run the camera at its maximum stated frame rate and you are not able to do so.



Start the pylon Viewer software, enter the Transport Layer group, and check the setting for the Packet Size parameter.

Is the packet size set the to the maximum?

Set the packet size to the maximum and then use the continuous grab button to start image capture.

Can you achieve the full frame rate now?

When the packet size setting is set low, it increases the number of packets that it takes to transmit an image from the camera to the PC. This means that it takes longer to transmit each image and decreases the maximum possible frame rate.

Exit this chart.

Go to the Acquisition Controls parameter group and check the exposure time raw setting.

Is the exposure time set near to the minimum?

Set the exposure time near to the minimum and then use the continuous grab button to start image capture.

Can you achieve the full frame rate now?

If the exposure time is very high, it can be a limiting factor on the maximum frame rate that can be achieved. You will need to run with a lower exposure time. (If this makes your image too dark, try increasing your lighting, decreasing the f/stop on your lens, increasing the gain setting, or increasing the black level setting.)

Exit this chart.

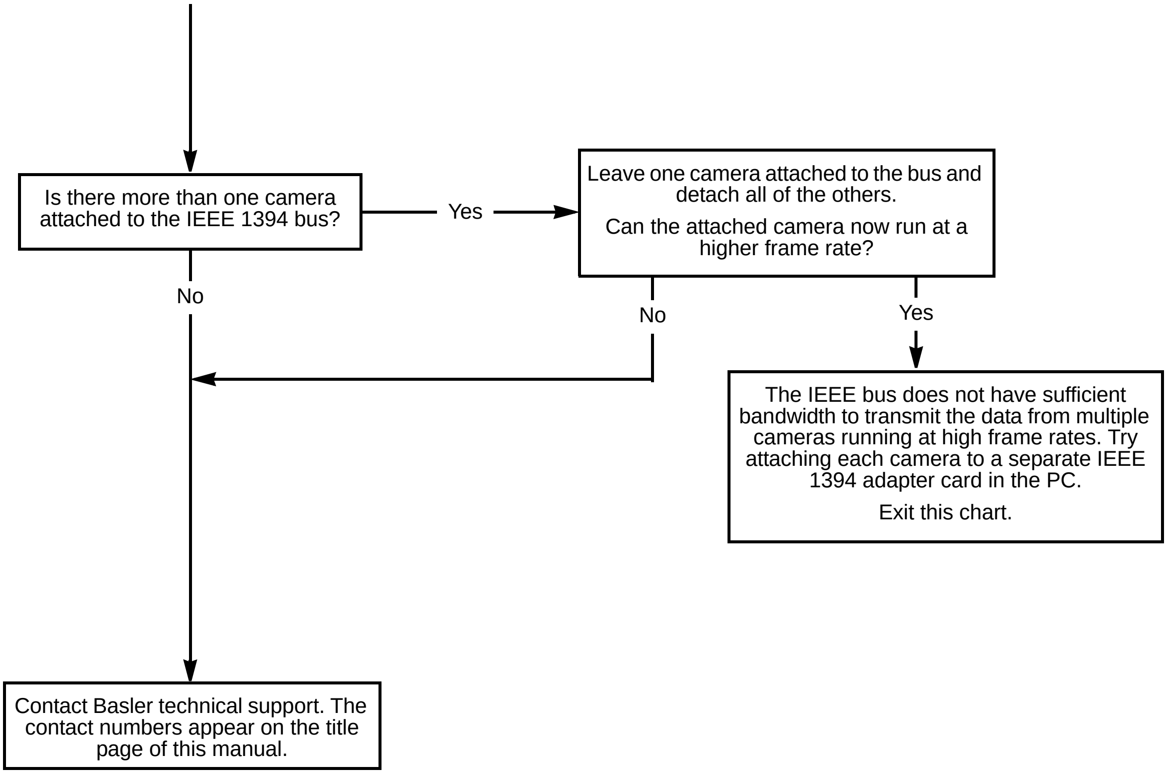
Are you using an external trigger signal to trigger image capture?

Increase the frequency of the trigger signal.

Does this give you an increase in the frame rate?

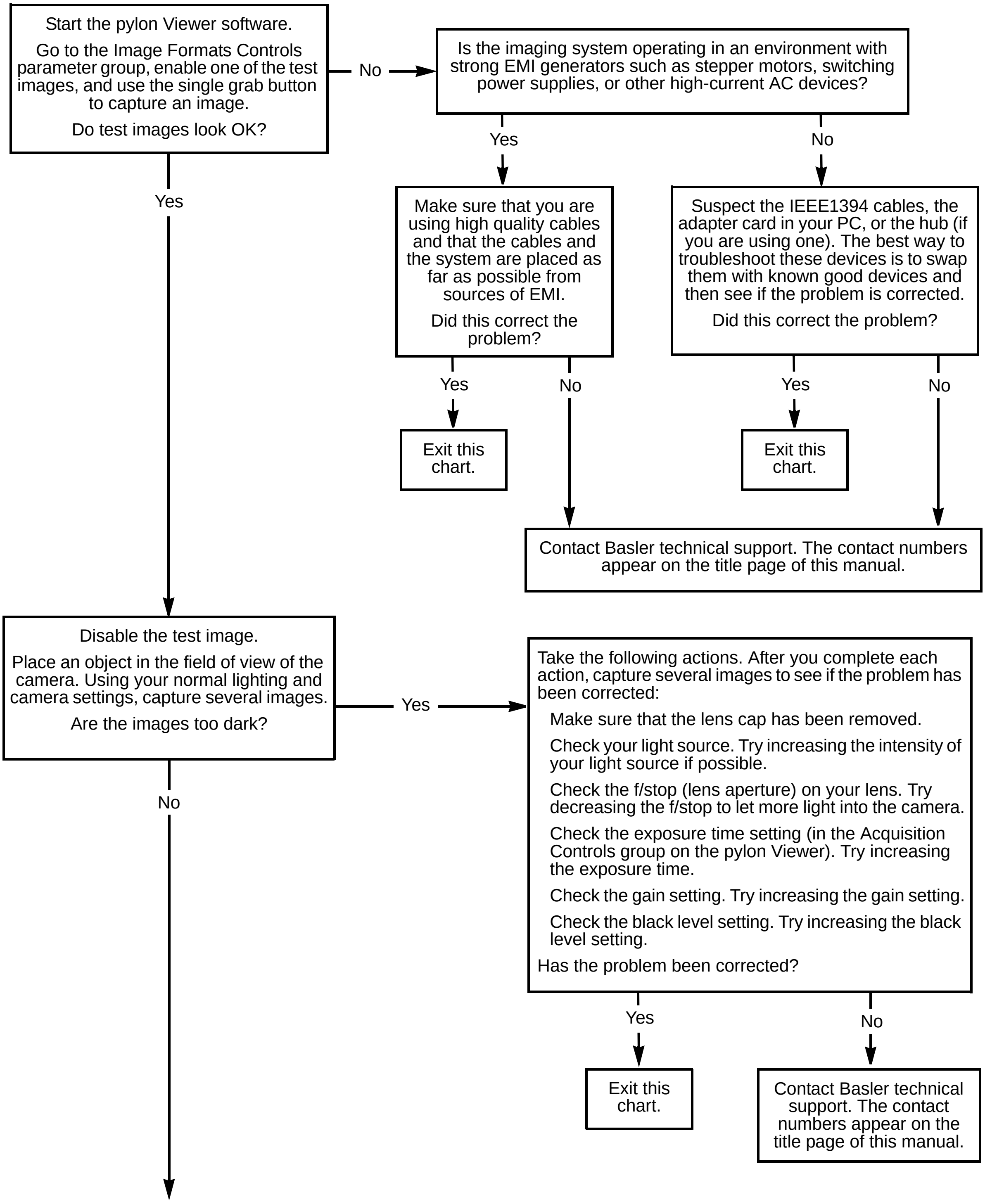
When you are operating the camera with an external trigger signal, the frequency of the signal determines the frame rate. If the frequency is too low, you will not achieve the maximum allowed frame rate.

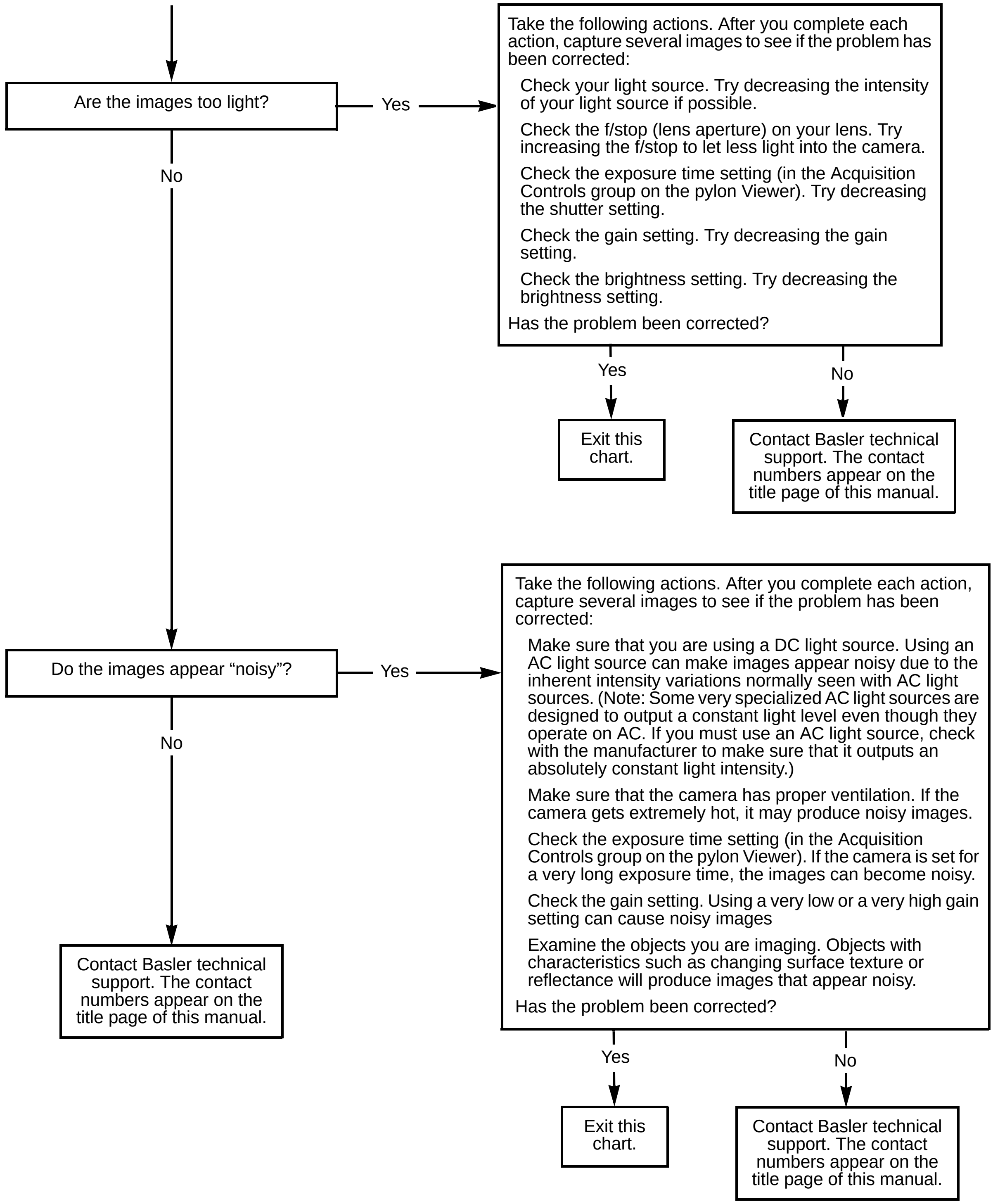
Exit this chart.


Is there more than one camera attached to the IEEE 1394 bus?
Yes
Leave one camera attached to the bus and detach all of the others.
Can the attached camera now run at a higher frame rate?
No
No
Yes
The IEEE bus does not have sufficient bandwidth to transmit the data from multiple cameras running at high frame rates. Try attaching each camera to a separate IEEE 1394 adapter card in the PC.
Exit this chart.
Contact Basler technical support. The contact numbers appear on the title page of this manual.

12.4.4 I Get Poor Image Quality

Use this chart if you can capture images, but they are poor quality. (If you can’t capture images at all, use the "I Do Not Get an Image" troubleshooting chart.)


Start the pylon Viewer software.
Go to the Image Formats Controls parameter group, enable one of the test images, and use the single grab button to capture an image.
Do test images look OK?
No
Is the imaging system operating in an environment with strong EMI generators such as stepper motors, switching power supplies, or other high-current AC devices?
Yes
No
Make sure that you are using high quality cables and that the cables and the system are placed as far as possible from sources of EMI.
Did this correct the problem?
Suspect the IEEE1394 cables, the adapter card in your PC, or the hub (if you are using one). The best way to troubleshoot these devices is to swap them with known good devices and then see if the problem is corrected.
Did this correct the problem?
Yes
Yes
No
Yes
No
Exit this chart.
Exit this chart.
Contact Basler technical support. The contact numbers appear on the title page of this manual.
Disable the test image.
Place an object in the field of view of the camera. Using your normal lighting and camera settings, capture several images.
Are the images too dark?
Yes
Take the following actions. After you complete each action, capture several images to see if the problem has been corrected:
Make sure that the lens cap has been removed.
Check your light source. Try increasing the intensity of your light source if possible.
Check the f/stop (lens aperture) on your lens. Try decreasing the f/stop to let more light into the camera.
Check the exposure time setting (in the Acquisition Controls group on the pylon Viewer). Try increasing the exposure time.
Check the gain setting. Try increasing the gain setting.
Check the black level setting. Try increasing the black level setting.
Has the problem been corrected?
No
Yes
No
Exit this chart.
Contact Basler technical support. The contact numbers appear on the title page of this manual.



Are the images too light?

Take the following actions. After you complete each action, capture several images to see if the problem has been corrected:

Check your light source. Try decreasing the intensity of your light source if possible.

Check the f/stop (lens aperture) on your lens. Try increasing the f/stop to let less light into the camera.

Check the exposure time setting (in the Acquisition Controls group on the pylon Viewer). Try decreasing the shutter setting.

Check the gain setting. Try decreasing the gain setting.

Check the brightness setting. Try decreasing the brightness setting.

Has the problem been corrected?

Exit this chart.

Contact Basler technical support. The contact numbers appear on the title page of this manual.

Do the images appear “noisy”?

Take the following actions. After you complete each action, capture several images to see if the problem has been corrected:

Make sure that you are using a DC light source. Using an AC light source can make images appear noisy due to the inherent intensity variations normally seen with AC light sources. (Note: Some very specialized AC light sources are designed to output a constant light level even though they operate on AC. If you must use an AC light source, check with the manufacturer to make sure that it outputs an absolutely constant light intensity.)

Make sure that the camera has proper ventilation. If the camera gets extremely hot, it may produce noisy images.

Check the exposure time setting (in the Acquisition Controls group on the pylon Viewer). If the camera is set for a very long exposure time, the images can become noisy.

Check the gain setting. Using a very low or a very high gain setting can cause noisy images

Examine the objects you are imaging. Objects with characteristics such as changing surface texture or reflectance will produce images that appear noisy.

Has the problem been corrected?

Exit this chart.

Contact Basler technical support. The contact numbers appear on the title page of this manual.

Contact Basler technical support. The contact numbers appear on the title page of this manual.

12.5 Before Contacting Basler Technical Support

To help you as quickly and efficiently as possible when you have a problem with a Basler camera, it is important that you collect several pieces of information before you contact Basler technical support.

Copy the form that appears on the next two pages, fill it out, and fax the pages to your local dealer or to your nearest Basler support center. Or, you can send an e-mail listing the requested pieces of information and with the requested files attached. Basler technical support contact information is shown in the title section of this manual.

1 The camera's product ID: ______________________________

2 The camera's serial number: ______________________________

3 1394 adapter that you use with the camera: ______________________________
____

4 Describe the problem in as much detail as possible: ______________________________
____
(If you need more space, use an extra sheet of paper.) ______________________________

5 If known, what's the cause of the problem? ______________________________
____
____

6 When did the problem occur? □ After start. □ While running.

□ After a certain action (e.g., a change of parameters):
____
____

□ ______________________________
____

7 How often did/does the problem occur?

□ Once. □ Every time.

□ Regularly when:

____

□ Occasionally when:

____

____

____

____

8 How severe is the problem?

□ Camera can still be used.

□ Camera can be used after I take this action:

____

____

□ Camera can no longer be used.

9 Did your application ever run without problems?

□ Yes □ No

10 Parameter set

It is very important for Basler technical support to get a copy of the exact camera parameters that you were using when the problem occurred.

To make a copy of the parameters, use the dump register tool. To get the tool, go to: www.baslerweb.com/beitraege/beitrag_en_19478.html (the tool is available for XP PCs only). Send the generated file to Basler technical support. Or, you can look up the settings with the pylon Viewer.

If you cannot access the camera, please try to state the following parameter settings:

□ Pixel format: ______________________________

□ Packet size: ______________________________

□ Exposure time: ______________________________

□ Frame rate: ______________________________

11 Live image/test image

If you are having an image problem, try to generate and save live images that show the problem. Also generate and save test images. Please save the images in BMP format, zip them, and send them to Basler technical support.

Revision History

Doc. ID Number	Date	Changes
AW00012501000	10 Jan 2007	Initial release of this document.
AW00012502000	20 Mar 2007	Updated the camera weights in the specification table in Section 1.2 on page 2. Added the dimensions for cameras equipped with CS-mount lens adaptors to Section 1.5 on page 22. Added Section 9.16 on page 191 to describe the new configuration sets feature. Corrected the description of the available device information parameters in Section 9.18 on page 197. Added Section 9.16 on page 191 to describe the new event reporting standard feature. Added Section 10.7 on page 217 to descrice the new CRC checksum chunk feature. Added information for the newly released scA750-60fm/fc camera. Updated all affected text and tables as appropriate.
AW00012503000	11 Jun 2007	Added information on IP30, Section 1.5.1.1 on page 22 and Section 1.5.2.1 on page 27. Added information (drawings inclusive) on the 90° head housing variant: Section 1.5.2 on page 27. Added Section 1.5.4 on page 31 with information on mechanical stress test results. Modified Section 2 for the installation of the Basler pylon software, version 1.0. Added information on the 8 bits effective pixel data: Section 7.2.1 on page 101, Section 7.2.4 on page 107, Section 7.2.5 on page 107, Section 7.3.3 on page 112, Section 7.3.6 on page 118, Section 7.3.7 on page 121 and Section 7.3.8 on page 123. Added minimum gain raw settings with vertical binning in Section 9.1 on page 139. Minor modifications througout the manual: modified frame height to AOI height.

Doc. ID Number	Date	Changes
AW00012504000	12 Oct 2007	Modified mechanical drawings in Section 1.5.1.1 on page 22 (dimensions), Section 1.5.2.1 on page 27 (dimensions), Section 1.5.2.2 on page 29 (front module reference planes), and deleted excess receptacle in Figure 22 in Section 1.5.1.1 on page 22. Added note on internal dust seal in Section 1.9 on page 35. Added warning not to remove the serial number in Section Section 1.9 on page 35. Updated times in Section 5.7.3 on page 59. Corrected receptable pin assignments in Fig 36 in Section 5.7.3 on page 59. Removed note on scA750-60 output in Sections 7.2.4, 7.2.5, 7.3.6, 7.3.7, 7.3.8. Corrected sequence of colors for Bayer BG 12 Packed format in Section 7.3.5 on page 116. Minor corrections throughout the manual.
AW00012505000	21 Dec 2007	Added guidelines for avoiding EMI and ESD problems in Section 2.1.1 on page 34. Corrected the voltage ranges relating to logic 0 and logic 1in Section 5.7.1 on page 53. Added references to Application Notes AW000565xx000 in Section 6.3.1 on page 69 and Section 6.5.1 on page 80. Added reference to binning in Section 9.6 on page 155. Added the binning feature in Section 9.7 on page 158. Added the Gamma feature in Section 9.10 on page 171. Added the Disable Parameter Limits feature in Section 9.12 on page 186. Added the Debouncer feature in Section 9.13 on page 187. Minor corrections throughout the manual.
AW00012506000	15 Feb 2008	Included the "Software Licensing Information" section on page 32. Moved the guidelines for avoiding EMI and ESD problems to Section 1.7 on page 33. Included the warning related to code snippes in Section 1.9 on page 35. Transferred the "Software and Hardware Installation" section to the "Installation and Setup Guide for Cameras Used with Basler's pylon API", (AW000611xx000). Added the reference to the "Installation and Setup Guide for Cameras Used with Basler's pylon API" in Section 2 on page 37. Corrected the minimum value for the Timer Delay Raw parameter and indicated the minimum value for the Timer Delay Time Base Abs parameter in Section 8.2.4.2 on page 133.

Doc. ID Number	Date	Changes
AW00012507000	5 Mar 2008	Integrated the scA1400-30fm/fc. Corrected the type of interface in the table in Section 1.5.2.2 on page 29. Added information on the lens to which the mechanical shock tests apply in Section 1.5.4 on page 31. Added information on the input line transition threshold in Table 7 on page 47. Added the maximum exposure times and related settings in Section 6.4.1 on page 76. Minor modifications and corrections throughout the manual.
AW00012508000	18 Jul 2008	Integrated information for the scA1300-32fm/fc. Updated the distances and related tolerances between the front of the lens mount and the sensor's photosensitive area in Section 1.5 on page 22. Indicated the applicability of the mechanical stress test to cameras with standard housing and an extended duration of the broad-band vibration test in Section 1.5.4 on page 31. Removed voltage information from Table 7 in Section 5.2.2 on page 47. Added Section 5.4.3 on page 51 and notes in Section 5.4.2 on page 49, introducing the PLC cable. Included detailed voltage information in Section 5.6 on page 52, Section 5.7.1.1 on page 53, and Section 5.7.2.1 on page 56. Modified the absolute maximum rating to +30 VDC in Section 5.7.1.2 on page 55, and Section 5.7.2.2 on page 56. Added a note relating to the debouncer in Section 6.9 on page 87. Updated the black level feature description and the Black Level Raw parameter range for the scA1400-30 in Section 9.2 on page 145. Corrected the minimum value for the white balance ratio in Section 9.3 on page 147. Corrected the name of the Gamma parameter in Section 9.10 on page 171. (The Gamma parameter was incorrectly referred to as the Gamma Raw parameter.) Included the "Auto Functions" section on page 172 and added related information in other parts of the manual. Extended the description of the debouncer in Section 9.13 on page 187. Minor modifications and corrections throughout the manual.
AW00012509000	22 Aug 2008	Updated contact addresses and phone numbers. Official release of the auto functions.

Doc. ID Number	Date	Changes
AW00012510000	18 Feb 2009	Integrated information for the scA640-120fm/fc. Added a note to Section 1.7 on page 33 indicating than an application note regarding EMI/ESD control is available. The text in sections Section 2 on page 37 and Section 3 on page 39 has been revised to reflect that the pylon driver package is now downloadable from the website. Removed the incorrect information about a Device User ID parameter in Section 9.18 on page 197 and replaced it with the correct information about the Device ID parameter. Added Section 12.2 on page 225 describing how to obtain an RMA number.
AW00012511000	17 June 2009	Updated sensor name "Micron MT9V022" to "Aptina MT9V022" in Section 1.2 on page 2. Removed the notes designating the information about the scA1300-32fm/fc cameras as preliminary in Section 1.2 on page 2. Updated minimum allowed exposure timens in Section 6.4 on page 75. Updated the constants C_1, C_2, and C_3 for scA1300-32fm/fc cameras in Section 6.10 on page 90. Added the digital shift feature in Section 9.4 on page 148. Corrected the indications of x offset and y offset in Figure 56 in Section 9.6 on page 155 and in Figure 65 in Section 9.11.1.2 on page 174. Added the reverse X feature in Section 9.8 on page 162. Removed the statement that auto functions have no effect on frame rate in Section 9.11.1 on page 172 and added a note that frame rate may be affected if exposure auto is used Section 9.11.3 on page 181. Added a reference to the reverse X feature in Section 9.11.1.2 on page 174. Replaced "Auto Gain Raw" by the correct "Gain Raw (All)" parameter name in Section 9.11.2 on page 179. Replaced "Auto Exposure Time Abs" by the correct "Exposure Time Abs" parameter name in Section 9.11.3 on page 181. Added the auto function profile feature in Section 9.11.4 on page 183 and adjusted Section 9.11.2 on page 179 and Section 9.11.3 on page 181 accordingly. Added the trigger delay feature in Section 9.14 on page 189. Added the acquisition status feature in Section 9.15 on page 190 and added a reference in Section 6.2.3 on page 66. Added the high gain and auto functions factory setups and the standard factory setup (formerly the "default set") in Section 9.19 on page 199. Added descriptions about resetting the frame counter and about relating frame and trigger input counter in Section 10.3 on page 207. Corrected the maximum value for the frame counter in Section 10.3 on page 207. Added the trigger input counter feature in Section 10.5 on page 212.

Feedback

Your feedback will help us improve our documentation. Please click the link below to access an online feedback form. Your input is greatly appreciated.

http://www.baslerweb.com/umfrage/survey.html

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