

Basler dart



USER'S MANUAL FOR USB 3.0 CAMERAS

Document Number: AW001305

Version: 04 Language: 000 (English)

Release Date: 8 July 2015

FCC and CE conformity

Basler dart cameras are OEM components. They are not intended for incorporation by end-users. Users who integrate dart cameras into their systems should perform appropriate testing regarding electromagnetic interference and apply CE and FCC conformity.

However, conformity tests have been performed using dart cameras with a metallic back installed on the rear side of the camera. This setup has been found to comply with the CE and FCC requirements pursuant to EN 55022 and FCC Part 15, Subpart B rules.

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

If you are using a dart S-mount or a dart CS-mount camera, do not remove the camera front. The warranty becomes void if the camera front is removed.

All material in this publication is subject to change without notice and is copyright Basler AG.

Contacting Basler Support Worldwide

Europe, Middle East, Africa

Basler AG

An der Strusbek 60–62

22926 Ahrensburg

Germany

Tel. +49 4102 463 515

Fax +49 4102 463 599

support.europe@baslerweb.com

The Americas

Basler, Inc.

855 Springdale Drive, Suite 203

Exton, PA 19341

USA

Tel. +1 610 280 0171

Fax +1 610 280 7608

support.usa@baslerweb.com

Asia-Pacific

Basler Asia Pte. Ltd.

35 Marsiling Industrial Estate Road 3

#05–06

Singapore 739257

Tel. +65 6367 1355

Fax +65 6367 1255

support.asia@baslerweb.com

www.baslerweb.com

Table of Contents

1	Specifications, Requirements, and Precautions	7
1.1	Models	7
1.2	General Specifications	8
1.3	Spectral Response	11
1.3.1	Mono Camera Spectral Response	11
1.3.2	Color Camera Spectral Response	13
1.4	Mechanical Specifications	15
1.4.1	Camera Dimensions and Mounting Points	15
1.4.2	Maximum Lens Dimensions	16
1.4.3	Mechanical Stress Test Results	18
1.5	Avoiding EMI and ESD Problems	19
1.6	Environmental Requirements	20
1.6.1	Temperature and Humidity	20
1.6.2	Heat Dissipation	21
1.7	USB 2.0 Compatibility	22
1.8	Precautions	23
2	Installation	27
3	Tools for Changing Camera Parameters	28
3.1	Basler pylon Camera Software Suite	28
3.1.1	pylon Viewer	28
3.1.2	pylon USB Configurator	29
3.1.3	pylon SDKs	29
4	Physical Interface	30
4.1	General Description of the Camera Connections	30
4.2	Camera Connector Types, Connection Numbering, and Assignments	31
4.2.1	I/O Connector	31
4.2.2	USB 3.0 Connector	32
4.3	LED Indicator	33
4.4	Camera Cabling Requirements	34
4.4.1	USB 3.0 Cable	34
4.4.2	I/O Cable	34
4.5	Camera Power	35
4.6	Direct-coupled General Purpose I/O (GPIO)	36
4.6.1	Operation as an Input Line	37
4.6.2	Operation as an Output Line	37
5	I/O Control	38
5.1	Configuring Input Lines and Signals	38
5.1.1	Selecting the Input Line as the Source Signal for a Camera Function	38

5.1.2	Input Line Debouncers	38
5.1.3	Input Line Inverter	40
5.2	Configuring Output Lines and Signals	41
5.2.1	Selecting a Source Signal for an Output Line	41
5.2.2	Setting the Status of a User Settable Output Line	42
5.2.3	Output Line Inverter	43
5.3	Checking the Status of the I/O Lines	44
5.3.1	Checking the Status of an I/O Line	44
5.3.2	Checking the Status of All Lines	45
6	Image Acquisition Control	47
6.1	Acquisition Start and Stop Commands and the Acquisition Mode	47
6.2	The Frame Start Trigger	49
6.2.1	Trigger Mode	49
6.2.1.1	Trigger Mode = Off (Free Run)	49
6.2.1.2	Trigger Mode = On (Software or Hardware Triggering)	51
6.2.2	Using a Software Frame Start Trigger	52
6.2.3	Using a Hardware Frame Start Trigger	53
6.3	Setting the Exposure Time	56
6.4	Electronic Shutter Operation	57
6.4.1	Global Shutter	58
6.4.2	Rolling Shutter	59
6.5	Overlapping Image Acquisitions	62
6.5.1	Automatic Overlapping of Image Acquisitions (All Cameras)	63
6.5.2	Manually Setting the Overlap Mode of Operation (daA1280-54um/uc only)	64
6.6	Acquisition Monitoring Tools	64
6.6.1	Exposure Active Signal	64
6.6.2	Flash Window Signal	66
6.7	Maximum Allowed Frame Rate	67
6.7.1	Using the Basler pylon API to Check the Maximum Allowed Frame Rate	68
6.7.2	Increasing the Maximum Allowed Frame Rate	68
7	Color Creation and Enhancement	70
7.1	Color Creation and Bayer Color Filter Alignment	70
7.2	Integrated IR Cut Filter	71
7.3	Color Enhancement Features	72
7.3.1	Light Source Presets	72
7.3.2	White Balance	73
7.3.3	Gamma Correction	74
7.3.4	A Procedure for Setting the Color Enhancements	75
8	Pixel Formats	77
8.1	Pixel Formats Available on Mono Cameras	77
8.2	Pixel Formats Available on Color Cameras	77

8.3	Details on Pixel Formats for Color Cameras	78
9	Features	79
9.1	Gain	79
9.2	Black Level	81
9.3	Contrast Enhancement	82
9.4	Sharpness Enhancement	83
9.5	Image Region of Interest (ROI)	84
9.6	Binning	87
9.6.1	Setting Binning	89
9.6.2	Setting the Binning Mode	90
9.6.3	Considerations When Using Binning	92
9.7	Mirror Imaging	93
9.7.1	Reverse X	93
9.7.2	Reverse Y	94
9.7.3	Enabling Reverse X and Reverse Y	96
9.8	Defect Pixel Correction	96
9.9	Auto Functions	97
9.9.1	Auto Function Operating Modes	98
9.9.2	Gain Auto	99
9.9.3	Exposure Auto	100
9.9.4	Balance White Auto	101
9.9.5	Auto Function Profile	102
9.10	Backlight Compensation	104
9.11	Test Patterns	105
9.12	Device Information Parameters	107
9.13	User Sets	109
9.13.1	Selecting a User Set	110
9.13.2	Saving a User Set	111
9.13.3	Loading a User Set into the Active User Set	112
9.13.4	Designating a User Set as the User Set Default	113
10	Troubleshooting and Support	114
10.1	Tech Support Resources	114
10.2	Obtaining an RMA Number	114
10.3	Before Contacting Basler Technical Support	115
	Index	118
	Revision History	121

1 Specifications, Requirements, and Precautions

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

This chapter 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 dart USB 3.0 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 resolution, their maximum frame rate at full resolution, and whether the camera's sensor is mono or color.

All dart camera models (except daA1920-15um, see below) are available in three variants:

- **Bare board:** This variant consists of a circuit board only.
- **S-mount:** This variant consists of a circuit board with a camera front attached. S-mount lenses can be attached to the lens mount on the camera front.
- **CS-mount:** This variant consists of a circuit board with a camera front attached. CS-mount lenses can be attached to the lens mount on the camera front.

The dart camera model daA1920-15um only is available as a bare board variant.

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, to a subset of models, or a variant, will be so designated.



The dart S-mount color cameras are not equipped with an IR cut filter. If you want to operate a dart S-mount color camera with an IR cut filter, you must attach a lens with an integrated IR cut filter to the camera.

1.2 General Specifications

Specification	daA1280-54um/uc	daA1920-15um
Resolution (H x V pixels)	1280 x 960	1920 x 1080
Sensor Type	Aptina AR0134 Progressive scan CMOS Global shutter	Aptina MT9P031 Progressive scan CMOS Rolling shutter
Optical Size	1/3"	1/3.7"
Effective Sensor Diagonal	6 mm	4.85 mm
Pixel Size (H x V)	3.75 μm x 3.75 μm	2.2 μm x 2.2 μm
Max. Frame Rate (at full resolution)	54 fps	15 fps
Mono/Color	Mono or color (color cameras include a Bayer pattern RGB filter on the sensor)	Mono
Data Output Type	USB 3.0, nominal max. 5 Gbit/s (SuperSpeed)	
Pixel Formats	Mono models: Mono 8 Mono 12 Color models: Bayer 8 Bayer 12 RGB 8 YCbCr422	Mono 8 Mono 12
Synchronization	Via hardware trigger, via software trigger, or free run	
Exposure Time Control	Via hardware trigger or programmable via the camera API	
Camera Power Requirements	Nominal +5 VDC, compliant with the Universal Serial Bus 3.0 specification, supplied via the camera's USB 3.0 port	
	≈ 1.3 W (typical) @ 5 VDC	≈ 1.2 W (typical) @ 5 VDC
I/O Lines	2 direct-coupled GPIO lines	
Lens Mount	S-mount, CS-mount, without mount (bare board)	Without mount (bare board)
Size (L x W x H)	S-mount and CS-mount model: 20 mm x 29 mm x 29 mm Bare board model: ≈ 7.2 mm x 27 mm x 27 mm	≈ 7.2 mm x 27 mm x 27 mm
Weight	S-mount and CS-mount model: < 15 g Bare board model: < 5 g	< 5 g

Table 1: General Specifications (daA1280-54um/uc, daA1920-15um)

Specification	daA1280-54um/uc	daA1920-15um
Conformity	CE (*), UL (in preparation), GenICam 2.4 (including PFNC 1.1 and SFNC 2.1), RoHS, USB3 Vision * The CE Conformity Declaration is available on the Basler website: www.baslerweb.com	
Software	Basler pylon Camera Software Suite (version 4.2 or higher) Available for Windows (x86, x64) and Linux (x86, x64, ARM).	

Table 1: General Specifications (daA1280-54um/uc, daA1920-15um)

Specification	daA1920-30um/uc	daA2500-14um/uc
Resolution (H x V pixels)	1920 x 1080	2592 x 1944
Sensor Type	Aptina MT9P031 Progressive scan CMOS Rolling shutter	
Optical Size	1/3.7"	1/2.5"
Effective Sensor Diagonal	4.85 mm	7.13 mm
Pixel Size (H x V)	2.2 μm x 2.2 μm	
Max. Frame Rate (at full resolution)	30 fps	14 fps
Mono/Color	Mono or color (color cameras include a Bayer pattern RGB filter on the sensor)	
Data Output Type	USB 3.0, nominal max. 5 Gbit/s (SuperSpeed)	
Pixel Formats	Mono models: Mono 8 Mono 12 Color models: Bayer 8 Bayer 12 RGB 8 YCbCr422	
Synchronization	Via hardware trigger, via software trigger, or free run	
Exposure Time Control	Via hardware trigger or programmable via the camera API	
Camera Power Requirements	Nominal +5 VDC, compliant with the Universal Serial Bus 3.0 specification, supplied via the camera's USB 3.0 port $\approx 1.3 \text{ W}$ (typical) @ 5 VDC	
I/O Lines	2 direct-coupled GPIO lines	
Lens Mount	S-mount, CS-mount, without mount (bare board)	
Size (L x W x H)	S-mount and CS-mount models: 20 mm x 29 mm x 29 mm Bare board model: $\approx 7.2 \text{ mm}$ x 27 mm x 27 mm	
Weight	S-mount and CS-mount models: < 15 g Bare board model: < 5 g	
Conformity	CE (*), UL (in preparation), GenICam 2.x (including PFNC 1.x and SFNC 2.x), RoHS, USB3 Vision * The CE Conformity Declaration is available on the Basler website: www.baslerweb.com	
Software	Basler pylon Camera Software Suite (version 4.2 or higher) Available for Windows (x86, x64) and Linux (x86, x64, ARM).	

Table 2: General Specifications (daA1920-30um/uc, daA2500-14um/uc)

1.3 Spectral Response

1.3.1 Mono Camera Spectral Response

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



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

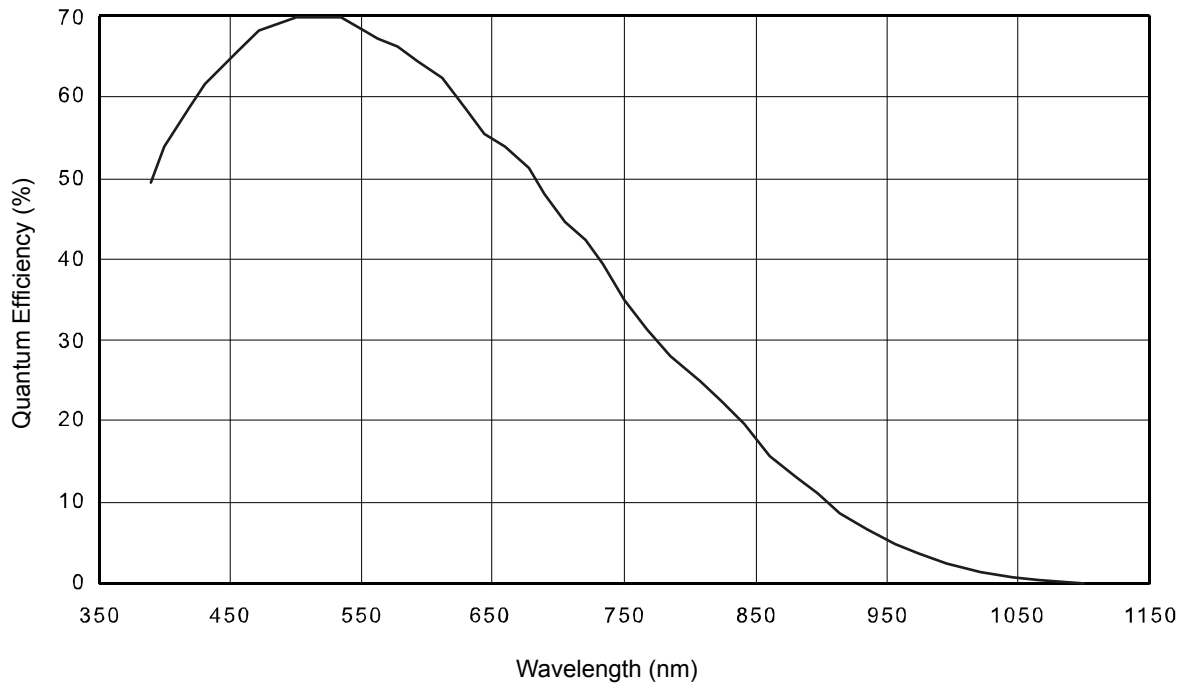


Fig. 1: daA1280-54um Spectral Response (From Sensor Data Sheet)

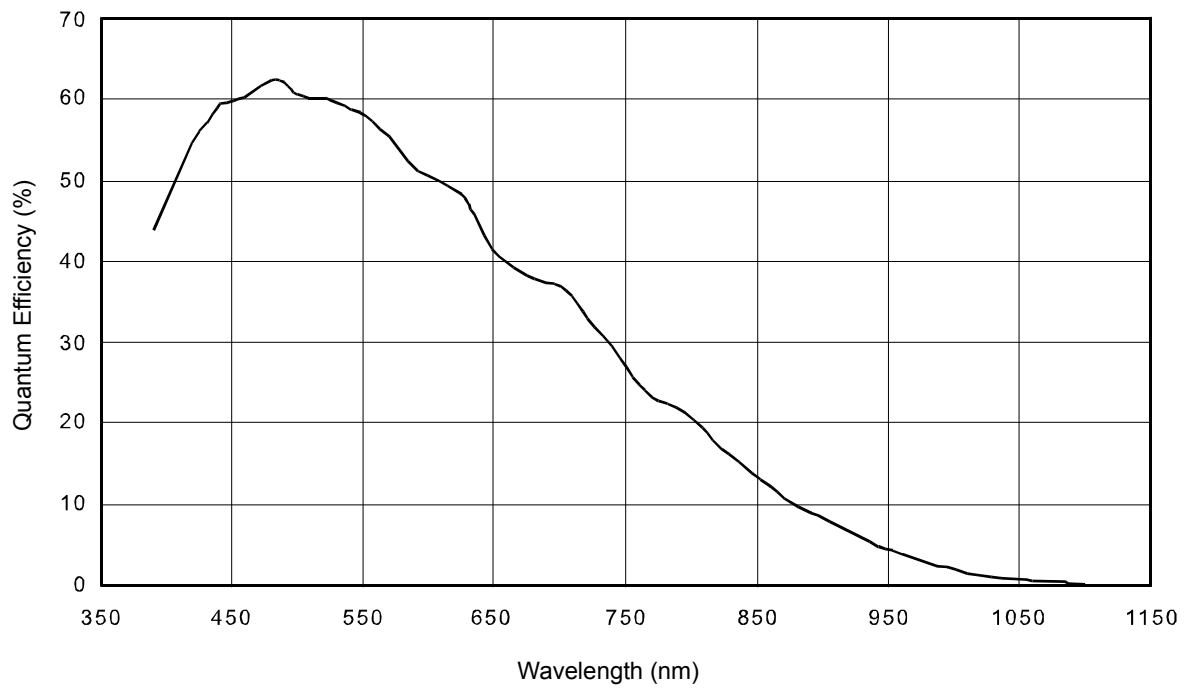


Fig. 2: daA1920-15um, daA1920-30um, and daA2500-14um Spectral Response (From Sensor Data Sheet)

1.3.2 Color Camera Spectral Response

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



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, we recommend using a dielectric IR cut filter. 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.

If you are using a

- dart **bare board** color camera, we recommend installing an IR cut filter or a lens with an integrated IR cut filter when integrating the camera into the system.
- dart **S-mount** color camera, we recommend attaching a lens with an integrated IR cut filter to the camera.
- dart **CS-mount** color camera, a suitable IR cut filter is already built into the lens adapter.

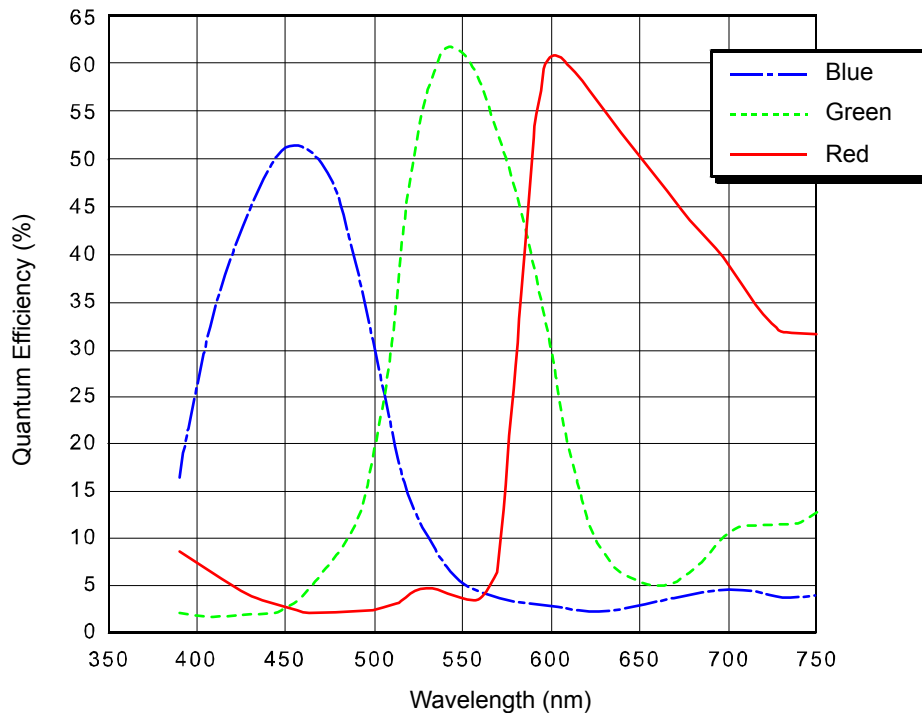


Fig. 3: daA1280-54uc Spectral Response (From Sensor Data Sheet)

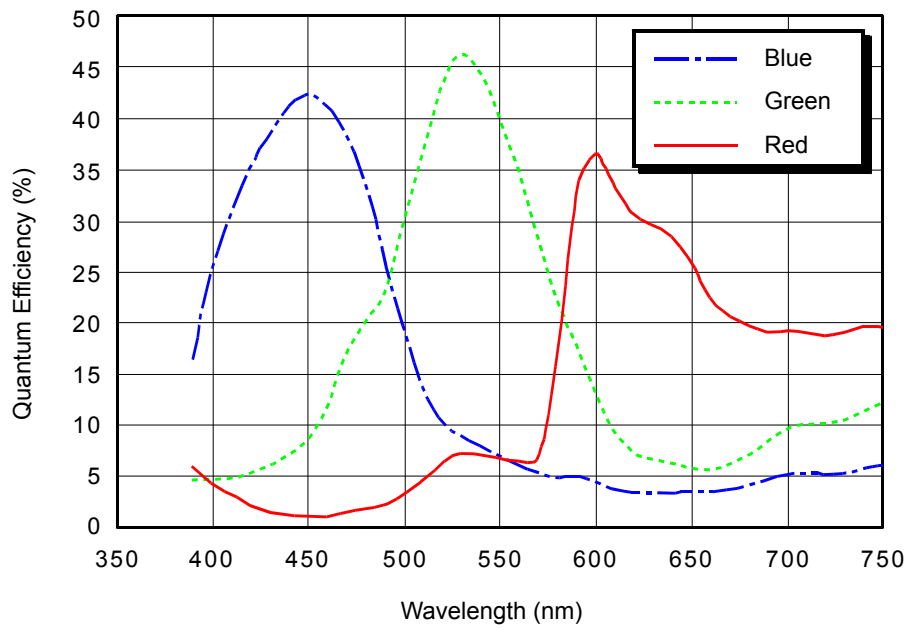


Fig. 4: daA1920-15uc, daA1920-30uc, and daA2500-14uc Spectral Response (From Sensor Data Sheet)

1.4 Mechanical Specifications

1.4.1 Camera Dimensions and Mounting Points

The dimensions in millimeters for

- dart bare board cameras are as shown in Figure 5.
- dart cameras equipped with an S-mount lens adapter are as shown in Figure 6.
- dart cameras equipped with a CS-mount lens adapter are as shown in Figure 7.

All dart cameras are equipped with mounting and heat dissipation holes on the bottom as shown in the drawings.

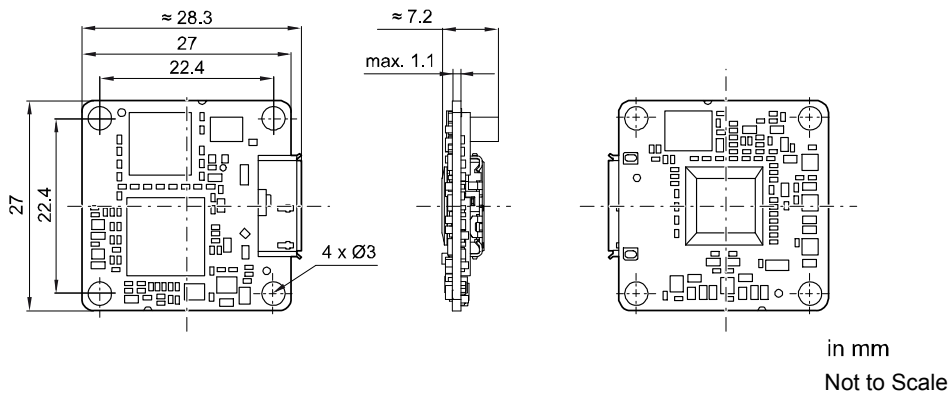


Fig. 5: Mechanical Dimensions (in mm) for Bare Board Cameras

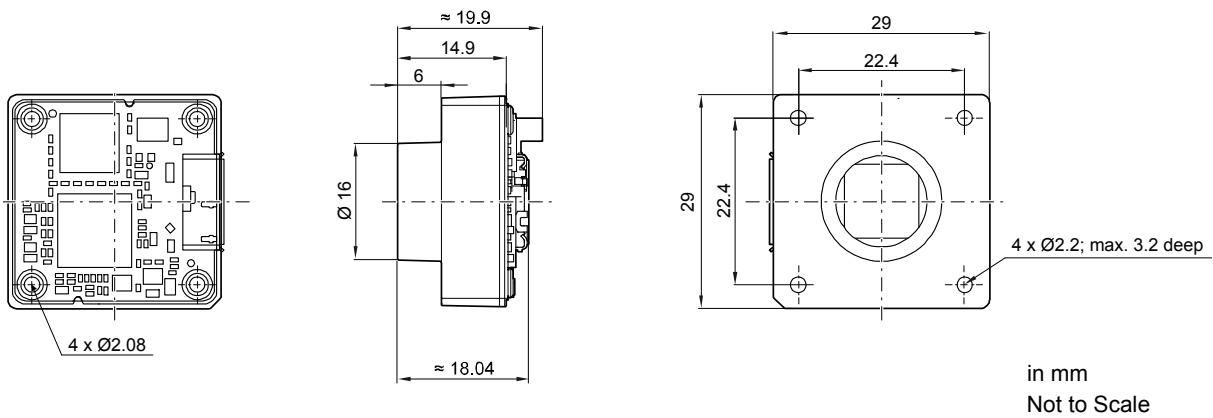


Fig. 6: Mechanical Dimensions (in mm) for Cameras with S-mount Lens Adapter

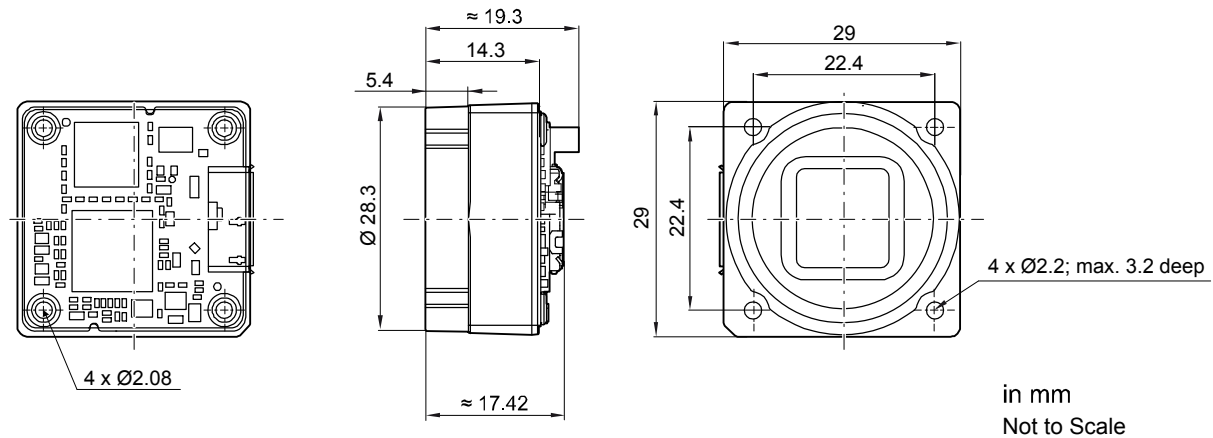


Fig. 7: Mechanical Dimensions (in mm) for Cameras with CS-mount Lens Adapter

1.4.2 Maximum Lens Dimensions

The maximum dimensions of the lens you use with the camera depend on the lens adapter type:

- Camera with **S-mount** lens adapter (see Figure 8):

The lens must not intrude into the camera body more than 11.7 mm. The length of the threads on the S-mount lens adapter is 7.5 mm.

NOTICE

Screwing in the lens too deep can damage camera components.

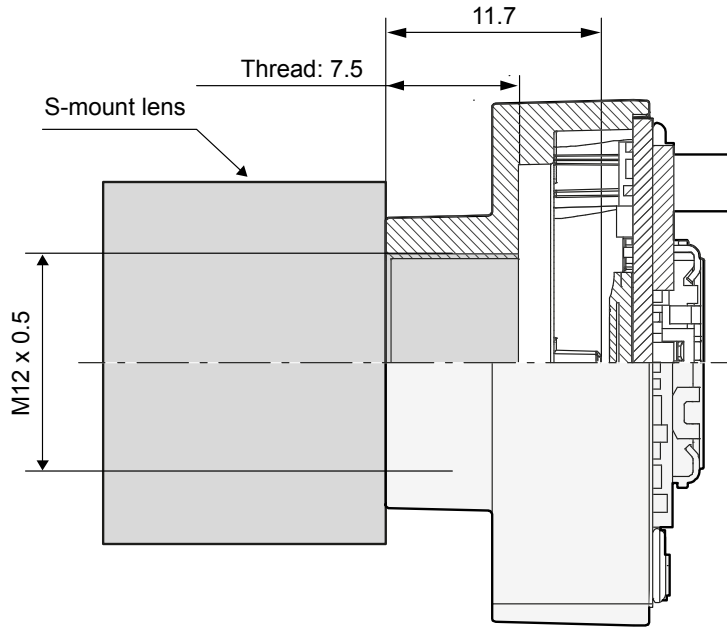
On S-mount cameras, the lens is screwed in and out to reach the desired level of focus. S-mount lenses do not have a defined flange and therefore will not stop before they touch (and possibly scratch or break) the sensor glass.

- Camera with **CS-mount** lens adapter (see Figure 9):
 - Color cameras: The lens must not intrude into the camera body more than 7 mm. The length of the threads on the CS-mount lens adapter is 5.6 mm.
 - Mono cameras: The lens must not intrude into the camera body more than 11 mm. The length of the threads on the CS-mount lens adapter is 5.6 mm.

NOTICE

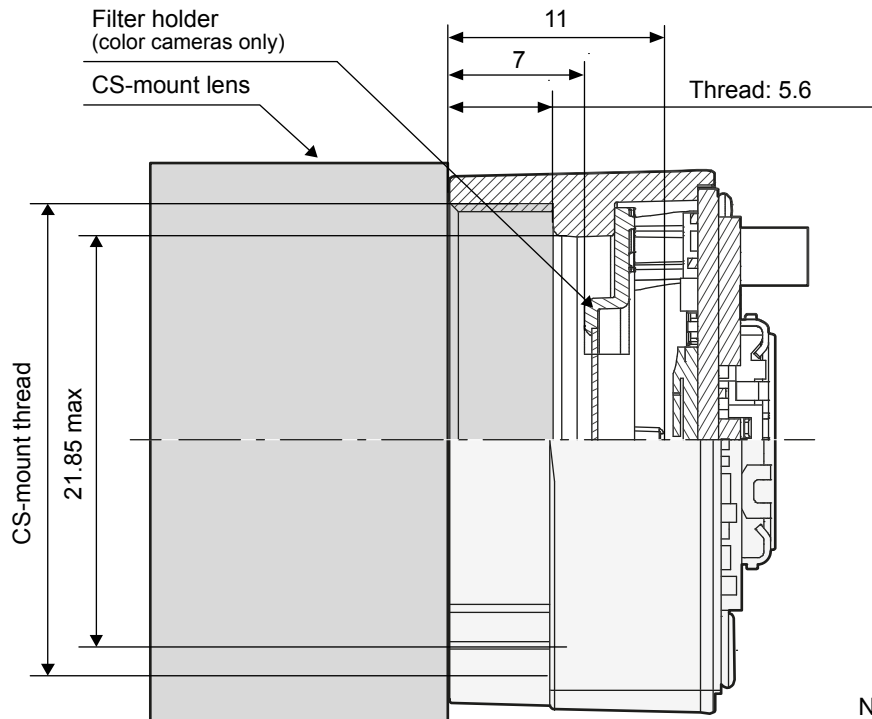
Incorrectly mounted C-mount lenses can damage camera components.

If you want to use C-mount lenses for dart CS-mount cameras, make sure that you attach a CS-mount adapter ring to the C-mount lens before mounting it on a dart CS-mount camera. Otherwise, the lens may reach too far into the camera and damage the IR cut filter (color cameras) or the sensor (mono cameras).



Not to Scale

Fig. 8: Maximum Lens Dimensions (in mm) for Cameras with S-mount Lens Adapter



Not to Scale

Fig. 9: Maximum Lens Dimensions (in mm) for Cameras with CS-mount Lens Adapter

1.4.3 Mechanical Stress Test Results

The following mechanical stress tests were performed on the Basler dart cameras:

- **dart bare board cameras:** See the stress tests for the dart S-mount camera. Because the circuit board of bare board models is the same as the circuit board of S-mount and CS-mount models, individual stress tests are not carried out for bare board cameras.
- **dart S-mount cameras:** The cameras were subjected to the stress tests listed in Table 3. After mechanical testing, the cameras exhibited no detectable physical damage and produced normal images during standard operational testing.
- **dart CS-mount cameras:** Stress tests are pending.

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 3: Mechanical Stress Tests for dart S-mount Cameras

The mechanical stress tests were performed with a dummy lens connected to an S-mount. The dummy lens had a mass of 30 g. Using a heavier lens requires an additional support for the lens.

1.5 Avoiding EMI and ESD Problems

The dart 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.
- Use camera cables that are the correct length. If there are multiple cameras installed, run the camera cables parallel to each other. Avoid coiling camera cables. If the cables are too long, use a meandering path rather than 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.
- 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.



For more information about avoiding EMI and ESD, see the application note *Avoiding EMI and ESD in Basler Camera Installations*. To download the application note, go to the Downloads section of the Basler website: www.baslerweb.com

1.6 Environmental Requirements

1.6.1 Temperature and Humidity

Requirements	dart S-mount and CS-mount Models	dart Bare Board Models
Device temperature during operation	0 °C ... +50 °C (+32 °F ... +122 °F)	0 °C ... +75 °C (*) (+32 °F ... +167 °F) (*)
Device temperature during storage	-20 °C ... +80 °C (-4 °F ... +176 °F)	
Humidity	20% ... 80%, relative, non-condensing	
Ambient temperature according to UL 60950-1	max. 40 °C (+104 °F)	
UL 60950-1 test conditions: no lens attached to the camera and without efficient heat dissipation; ambient temperature kept at 40 °C (+104 °F).		
* Temperature measured at the hottest point on the board. This point is significantly hotter than the other parts on the board. See temperature measurement point below.		

Table 4: Temperature and Humidity Requirements

Temperature Measurement Point

For

- S-mount and CS-mount variants, measure the temperature at the camera front.
- bare board variants, use the following temperature measurement point:

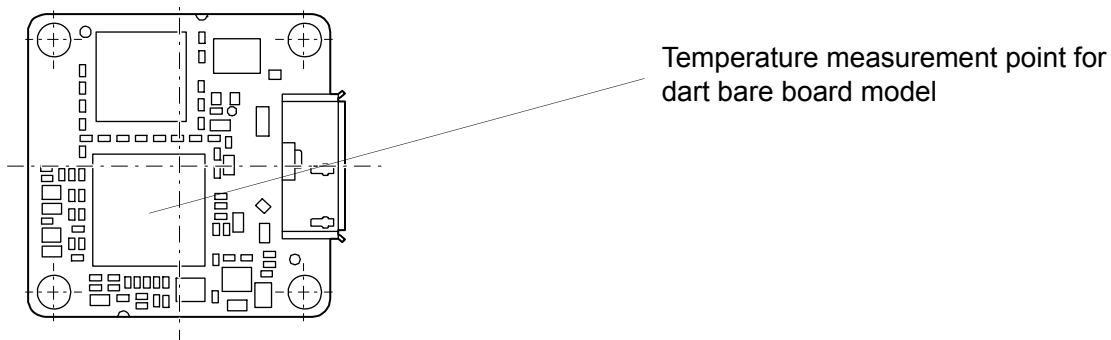


Fig. 10: Device Temperature Measurement Point (Bare Board Model)

1.6.2 Heat Dissipation

You must provide sufficient heat dissipation to keep the operation temperature of the Basler dart below the values indicated in Section 1.6.1 on [page 20](#).

Since each installation is unique, Basler does not supply a strictly required technique for proper heat dissipation. Instead, we provide the following general guidelines:

On all dart cameras, there are four holes at the corners of the camera board, designed for installing the camera. You can also use the holes to dissipate heat.

Depending on the dart variant, different components are used to dissipate heat:

- Basler bare board variants:
The metallic borders of the holes are designed to dissipate heat to connecting metallic components.
- Basler dart S-mount and CS-mount variants:
Rivets are placed in the four holes (see Figure 11). These rivets can be used to dissipate heat towards connected metallic components.



Fig. 11: Rivet at the Corner of the dart Camera Board

Usage of the holes or rivets depends on your system design. In all cases, make sure that the holes or rivets have contact to metallic components in your system. This way, the heat can dissipate towards the metallic components.

Three examples of how you can provide heat dissipation:

- Figure 12 (a): The camera front touches a mounting plate. Heat dissipates via the rivets, the camera front and the mounting plate.
- Figure 12 (b): The camera rear side touches a mounting plate. Heat dissipates via the rivets and the mounting plate.
- The use of a fan to provide air flow over the camera is an efficient method of heat dissipation.

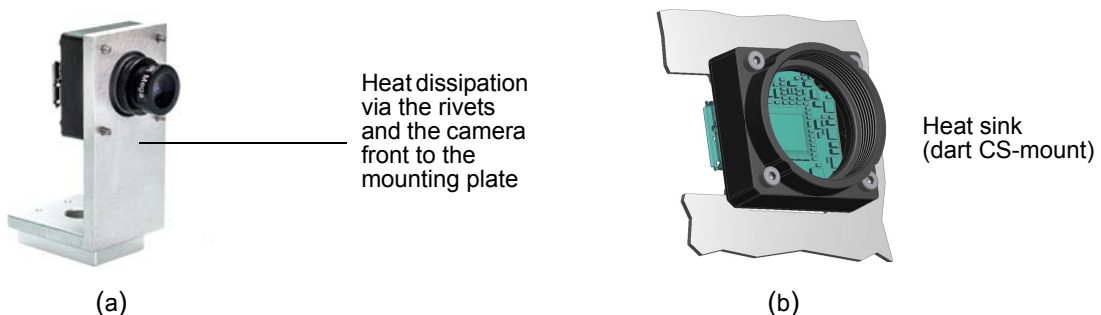


Fig. 12: Heat Sink Examples

1.7 USB 2.0 Compatibility

All Basler dart USB 3.0 cameras are USB 2.0 backward compatible. However, functionality and data transmission rate of the camera will be limited when connected to a USB 2.0 port.

For information about suitable USB 2.0 host controllers and about optimizing the USB 2.0 data transmission rate, see the application note *Recommended USB 2.0 Host Controllers for Basler dart and pulse Cameras* (AW001344).



If you operate a **daA1280-54um** or a **daA1280-54uc** camera on a USB 2.0 port, image noise may be increased. This is because the frame rate of the camera is usually lower when operated on a USB 2.0 port, and the image sensor of the daA1280-54um/uc produces more image noise at low frame rates.

To reduce image noise at low frame rates:

- Use a software or a hardware trigger to control image acquisition. For more information, see Section 6.2.2 on [page 52](#) and Section 6.2.3 on [page 53](#).
- Set the Overlap Mode parameter to Off. This puts the sensor in the "non-overlap" mode of operation with lower image noise at low frame rates. For more information, see Section 6.5.2 on [page 64](#).

1.8 Precautions



DANGER

Electric Shock Hazard

Non-approved power supplies may cause electric shock. Serious injury or death may occur.

- You must use a camera power supply which meets the Safety Extra Low Voltage (SELV) and Limited Power Source (LPS) requirements.
- If you use a powered hub as part of the USB 3.0 connection, you must use a powered hub that meets the SELV and LPS requirements.



WARNING

Fire Hazard

Non-approved power supplies may cause fire and burns.

- You must use a camera power supply which meets the Limited Power Source (LPS) requirements.
- If you use a powered hub as part of the USB 3.0 connection, you must use a powered hub that meets the LPS requirements.

NOTICE

Dust on the sensor can impair the camera's performance.

- Every time you handle the camera without a lens attached, make sure that the camera is pointing down so that no dust can reach the sensor.
- If the camera is not installed, store it in its original packaging.

NOTICE

Heat can damage the camera.

Make sure that you provide sufficient heat dissipation to keep the operation temperature of the device below the values indicated in Section 1.6.1 on [page 20](#). For more information about providing heat dissipation, see Section 1.6.2 on [page 21](#).

NOTICE**Incorrectly mounted lenses can damage camera components.**

- When mounting a lens on the camera, do not overtighten the lens. Otherwise, the screw threads of the lens mount can be damaged.
- For dart **CS-mount** variants:
 - Make sure that the lens does not intrude into the camera body more than 7 mm (color cameras) or 11 mm (mono cameras). Otherwise, the IR cut filter (color cameras) or the sensor (mono cameras) can be damaged.
 - If you want to use C-mount lenses for dart CS-mount cameras, make sure that you attach a CS-mount adapter ring to the C-mount lens before mounting it on a dart CS-mount camera. Otherwise, the lens may reach too far into the camera and damage the IR cut filter (color cameras) or the sensor (mono cameras).
- For dart **S-mount** variants:
 - On S-mount cameras, the lens is screwed in and out to reach the desired level of focus.
S-mount lenses do not have a defined flange and therefore will not stop before they touch (and possibly scratch or break) the sensor glass.
 - Do not screw in the lens deeper than 11.7 mm, especially during focusing.

For more information, see Section 1.4.2 on [page 16](#).

NOTICE**Voltage outside of the specified range can cause damage.**

- You must supply camera power that complies with the Universal Serial Bus 3.0 specification. The camera's nominal operating voltage is +5 VDC.
- The dart cameras must only be connected to other limited power sources (LPS) / Safety Extra Low Voltage (SELV) circuits that do not represent any energy hazards.

NOTICE**Electrostatic discharge (ESD) can damage the sensor and the circuit board.**

- Use anti-static clothes and materials, e.g. conductive shoes, anti-static gloves, and ESD protection wrist straps to decrease the risk of electrostatic discharge.
- Use conductive materials and install conductive mats at the point of installation (e.g. floor, workplace) to prevent the generation of static electricity.
- Control the humidity in your environment. Low humidity can cause ESD problems.

NOTICE**Incorrect cleaning can damage camera components.**

- Before cleaning, disconnect the camera from camera power by removing the USB 3.0 cable.
- After the cleaning procedure, make sure the cleaning material has evaporated before you reconnect the plugs.
- For dart **bare board**, dart **S-mount** and dart **CS-mount mono** variants, i.e. for dart cameras where the sensor is accessible:
 - Avoid cleaning the surface of the camera's sensor.
If you must clean it, use a soft, lint-free cloth dampened with a small quantity isopropanol.
 - Use a cloth that will not generate static charge during cleaning (cotton is a good choice). Electrostatic discharge might damage the sensor.
- For dart **CS-mount color** variants:
 - Try not to touch the IR cut filter and do not clean the IR cut filter mechanically. The glass of the IR cut filter can break if you apply too much pressure.
 - Use clean, oil-free compressed air to clean the IR cut filter. Be careful not to apply too much air pressure.
- Do not use solvents or thinners to clean the board or the camera front or both. They can damage the surface.

NOTICE**An incorrect plug can damage the connectors.**

- The plug on the cable that you attach to the camera's I/O connector must have 6 male pins and must be terminated with a 1.27 mm pitch dual row plug.
- The plug on the cable that you attach to the camera's USB 3.0 Micro-B connector must be designed for use with the USB 3.0 Micro-B connector.

Trying to use any other type of plug can destroy the connectors.

Warranty Precautions

To ensure that your warranty remains in force, adhere to the following guidelines:

Do not remove the camera's product label

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

Do not remove the camera front

If you are using a dart S-mount or a dart CS-mount camera, do not remove the camera front. The camera front and the circuit board are firmly riveted. Both parts can be damaged if you remove the camera front.

Prevent contact with foreign substances

Do not allow e.g. liquid, flammable or metallic material to get in contact with the board. Otherwise, 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 in original packaging

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

Clean with care

Follow the cleaning instructions in Section 1.8 on [page 23](#).

Read the manual

Read the manual carefully before using the camera!

2 Installation



Basler provides the dart camera as a component which is designed to be integrated into a system. Therefore, Basler dart cameras are delivered without housing.

The system designer or system integrator is responsible for the compliance of the final product to the local requirements and regulations valid in the country of use.



- Basler dart **S-mount** and **CS-mount** cameras are shipped with a plastic seal on the I/O connector.
- Basler dart **bare board** cameras are shipped with a plastic seal on the I/O connector and on the sensor.

Before installing the camera, carefully remove the plastic seal(s).

The information you will need to do a quick, simple installation of the camera and related software is included in the *dart Quick Installation Guide for USB 3.0 Cameras* (AW001304). The document also includes information about suitable USB 3.0 host controller chipsets.

You can download the document from the Downloads section of the Basler website:

www.baslerweb.com

3 Tools for Changing Camera Parameters

3.1 Basler pylon Camera Software Suite

The Basler pylon Camera Software Suite is designed to operate all Basler cameras that have an IEEE 1394a/b interface, a GigE interface, a Camera Link interface, or a USB 3.0 interface. The pylon camera drivers offer reliable, real-time image data transport into the memory of your PC at a very low CPU load.

The options available with the Basler pylon Camera Software Suite let you

- change parameters and control the camera by using a standalone GUI known as the Basler pylon Viewer.
- change parameters and control the camera from within your software application using the Basler pylon SDKs.
- obtain information about the USB camera device and other USB devices connected to your host PC by using the Basler pylon USB Configurator.

The remaining sections in this chapter provide an introduction to the tools.

The dart cameras require the Basler pylon Camera Software Suite 4.2 or a higher version. You can obtain the Basler pylon Camera Software Suite from the Basler website by using this link:

www.baslerweb.com

To help you install the software, you can also download the *Basler dart Quick Installation Guide for USB 3.0 Cameras* (AW001304) from the Basler website.

3.1.1 pylon Viewer

The pylon Viewer is included in the Basler pylon Camera Software Suite. It is a standalone application that lets you view and change most of the camera's parameter settings via a GUI-based interface. Using the pylon Viewer is a very convenient way to get your camera up and running quickly during your initial camera evaluation or a camera design-in for a new project.

For more information about using the pylon Viewer, see the *Installation and Setup Guide for Cameras Used with Basler pylon for Windows* (AW000611).

3.1.2 pylon USB Configurator

The pylon USB Configurator is included in the Basler pylon Camera Software Suite besides the Basler pylon IP Configurator and the Basler pylon Camera Link Configurator. The pylon USB Configurator is a standalone application. It allows you to

- obtain information about the architecture of the device tree to which your camera is connected and about the USB devices, including your camera
- automatically generate support information for Basler technical support.

For more information about generating support information, see Section 10.3 on [page 115](#).

For more information about using the pylon USB Configurator, see the *Installation and Setup Guide for Cameras Used with Basler pylon for Windows* (AW000611).

3.1.3 pylon SDKs

Three pylon SDKs are part of the Basler pylon Camera Software Suite:

- pylon SDK for C++ (Windows and Linux)
- pylon SDK for C (Windows)
- pylon SDK for .NET / C# (Windows)

Each SDK includes an application programming interface (API), a set of sample programs, and documentation:

- You can access all of the camera's parameters and control the camera's full functionality from within your application software by using the matching pylon API (C++, C, or .NET).
- The sample programs illustrate how to use the pylon API to parameterize and operate the camera.
- For each environment (C++, C, and .NET), a *Programmer's Guide and Reference Documentation* is available. The documentation gives an introduction to the pylon API and provides information about all methods and objects of the API.

4 Physical Interface

This chapter provides detailed information, such as voltage requirements and the I/O connector pinout, for the physical interface on the camera. The information in this chapter will be especially useful during your initial design-in process. The chapter also includes information about the required cables connecting to the camera.



Basler recommends specific external components - host adapters, cables, hubs - for use with Basler USB 3.0 cameras. For more information, see the document *Recommended Accessories for Basler USB 3.0 Cameras* (DG001115). You can download the document from the Basler website: www.baslerweb.com

Some of the recommended external components are available from Basler. Contact your Basler sales representative to order external components.

4.1 General Description of the Camera Connections

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

- A 6-pin socket connector used to provide access to the camera's I/O lines
- A USB 3.0 Micro-B connector used to provide a nominal 5 Gbit/s SuperSpeed data transfer connection.

There is also a LED indicator located on the back of the camera.

Figure 13 shows the location of the two connectors and the LED indicator.

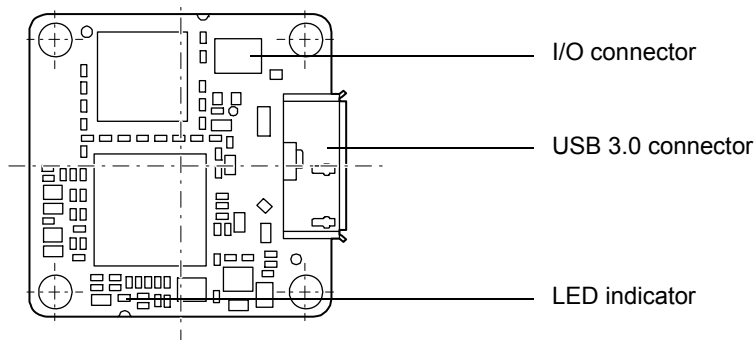


Fig. 13: Camera Connectors and LED Indicator

4.2 Camera Connector Types, Connection Numbering, and Assignments

4.2.1 I/O Connector

The I/O connector on the camera is a 6-pin socket connector with a 1.27-mm pitch dual-row receptacle. It is used to access the physical input and output lines on the camera. The pinout for the I/O connector is as shown in Figure 14.

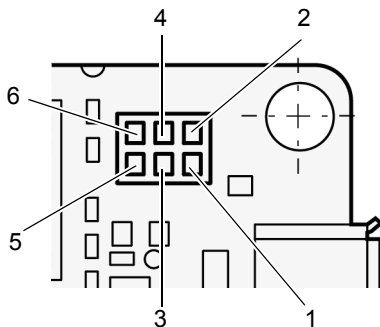


Fig. 14: Pinout for the I/O Connector

Contact	Designation	Function
1		3.3 VDC; max. 20 mA Power output. Do not apply any external voltage.
2		Ground
3	Line 1	Direct-coupled General Purpose I/O Preset: Input line
4	Line 2	Direct-coupled General Purpose I/O Preset: Input line
5	-	Reserved
6	-	Reserved

Table 5: Pinout for the I/O Connector and Related Designations

NOTICE

Using a wrong pin assignment can severely damage the camera.

- Make sure the cable and plug you connect to the I/O connector follow the correct pin assignment.
- Before you apply signals to the GPIO lines, connect the camera to a USB port and make sure the camera is turned on. Otherwise, electronic components in the camera could be damaged.



An I/O board is available from Basler. It has the following benefits:

- Offers additional I/O connectors instead of the single standard I/O connector.
- Increases the voltage allowed on the I/O input lines (TTL compatibility).
- Allows you to trigger multiple dart cameras simultaneously.
- Protects the dart camera against short circuits.

The board can be mounted to the back of the Basler dart circuit board. The connectors of the I/O board replace the standard I/O connector of the Basler dart.

Contact your Basler sales representative to order the dart I/O board.

For more information, see the *dart I/O board Technical Specification* (DG001439). You can download the document from the Basler website: www.baslerweb.com

4.2.2 USB 3.0 Connector

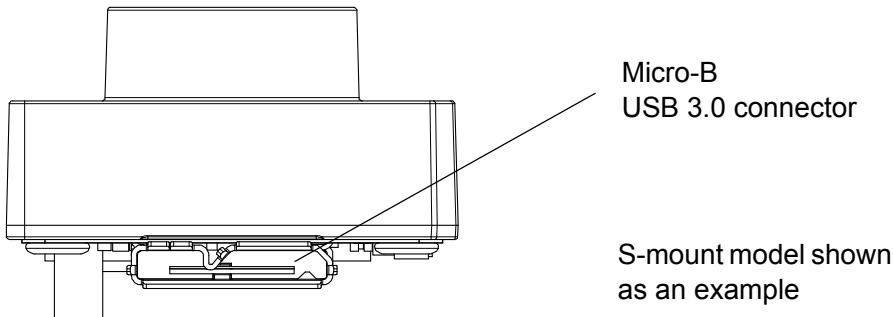


Fig. 15: Camera USB 3.0 Connector

The USB 3.0 connector for the camera's USB connection is a standard Micro-B USB 3.0 connector. It provides a USB 3.0 connection to supply power to the camera and to transmit video data and control signals.

Connection assignments and numbering adhere to the Universal Serial Bus 3.0 standard. The recommended mating connector is any standard Micro-B USB 3.0 plug.

Suitable cables are available from Basler. For more information, see Section 4.4 on [page 34](#).



Depending on how you integrate the Basler dart into your system, you must select a corresponding USB 3.0 connector that matches the orientation of the mounted dart USB 3.0 connector.

The orientation of the USB 3.0 connector is shown in Figure 15 (S-mount variant).

4.3 LED Indicator

There is an LED indicator on the back of the camera board (see Figure 13 on [page 30](#)).

Green LED is ...	Description
Dimming up/down	The camera is being configured.
Lit permanently	Camera is configured and operative.
Blinking rapidly	Internal error.
<p>The LED can be turned off permanently by setting the DeviceIndicatorMode parameter (see below). If the LED is turned off permanently, and if this setting is stored in a startup user set, the LED will light up for approximately 1 second. For more information about the startup user set, see Section 9.13 on page 109.</p>	

Table 6: LED Statuses

The following code snippet illustrates using the API to set the LED indicator mode:

```
// Turn off the LED indicator (LED is turned off permanently)
camera.DeviceIndicatorMode.SetValue(DeviceIndicatorMode_Inactive);

// Turn on the LED indicator (LED is on during camera operation)
camera.DeviceIndicatorMode.SetValue(DeviceIndicatorMode_Active);
```

You can also use the Basler pylon Viewer application to easily set the Indicator Mode parameter.

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).


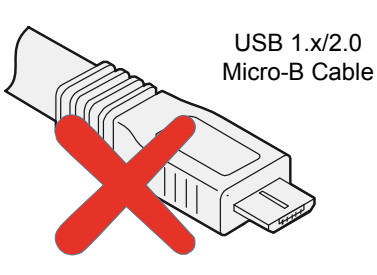
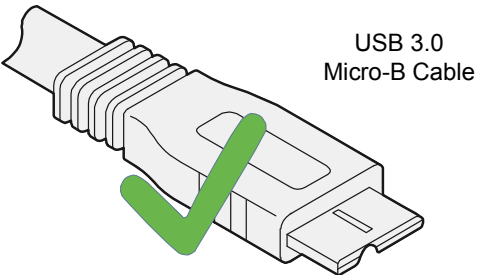
4.4 Camera Cabling Requirements

4.4.1 USB 3.0 Cable

Use a high-quality USB 3.0 cable. We highly recommend using USB 3.0 cables that are offered as Basler accessories. They were extensively tested for optimum performance.

For more information about recommended USB 3.0 cables, see the document *Recommended Accessories for Basler USB 3.0 Cameras* (DG001115). To download the document, go to the Basler website: www.baslerweb.com. Contact your Basler sales representative to order cable assemblies.

To avoid EMI, the cable must be shielded. Close proximity to strong high-frequency electromagnetic fields should be avoided in your installation.

	 <p>USB 1.x/2.0 Micro-B Cable</p>	 <p>USB 3.0 Micro-B Cable</p>
<p>Do not use cables with a USB 1.x/2.0 Micro-B cable plug.</p> <p>Use high-quality cables with a USB 3.0 Micro-B cable plug, even if you are connecting the camera to a USB 2.0 port. The camera may not work properly if you use a USB 1.x/2.0 Micro-B cable plug.</p>		

4.4.2 I/O Cable

A single I/O cable is used to connect to the camera's I/O lines. In your installation, close proximity to strong high-frequency electromagnetic fields should be avoided.

The end of the I/O cable that connects to the camera must be terminated with a 1.27 mm pitch dual row plug. The cable must be wired to conform with the pin assignments shown in the pin assignment table.

NOTICE

The GPIO lines are not protected against overcurrent or overvoltage. Applying incorrect electrical signals via the I/O cable may cause malfunction or damage to the camera.

You must supply power within the safe operating voltage range. For more information, see Section 4.6 on [page 36](#).

4.5 Camera Power

Power must be supplied to the camera via the USB 3.0 cable plugged into the camera's USB 3.0 Micro-B connector.

NOTICE

Voltage outside of the specified range can cause damage.

You must supply camera power that complies with the Universal Serial Bus 3.0 specification. The camera's nominal operating voltage is +5 VDC, effective at the camera's connector.

Power consumption is as shown in the specification tables in [Section 1.2 on page 8](#).

4.6 Direct-coupled General Purpose I/O (GPIO)

The camera has two direct-coupled GPIO lines that are accessed via contact 3 and 4 of the I/O connector on the back of the board (see [Figure 14](#)).

The GPIO lines

- can be set to operate as camera inputs or as camera outputs.
- are designated as Line 1 and Line 2 (see [Figure 14](#)).
- are compatible with low-voltage TTL (LVTTTL) signals. To make the camera compatible with standard TTL signals, attach the dart I/O board (optionally available) to the camera. For more information about the dart I/O board, see Section 4.2.1 on [page 31](#).

NOTICE

Applying incorrect electrical signals to the camera's GPIO lines can severely damage the camera.

- Before you apply signals to the GPIO lines, connect the camera to a USB port.
- The GPIO lines
 - **are not protected against overcurrent or overvoltage.**
 - are on the same electrical potential as the circuit board.
 - are protected against electrostatic discharge (ESD) strikes of up to 2 kV (contact discharge). The tests were performed according to the EN61000-4-2 standard.
- The GPIO lines Line 1 and Line 2 are configured to work as inputs during power up. Due to their high impedance, inputs are susceptible to noise and electromagnetic interference. For long cables or in harsh electromagnetic environments, use of active converter circuits may be necessary.
For more information about avoiding EMI problems, see Section 1.5 on [page 19](#).
- If you always require a defined output logic level, integrate a suitable pull-up or pull-down resistor. If you use a pull-down resistor, the resistor value should be 1.8 kOhm or greater so that the current limit is not exceeded.
- If the lines are configured as an output, never short-circuit the lines.

4.6.1 Operation as an Input Line

The following I/O supply voltage requirements apply to a direct-coupled GPIO line when the line is set as an input:

NOTICE

Voltage outside of the specified range can cause damage.

You must supply power within the specified voltage range.

Input Voltage	Significance
+4.2 VDC	Absolute maximum. The absolute maximum must never be exceeded. Otherwise, the camera can be damaged and the warranty becomes void.
+0 to +3.4 VDC	Safe operating I/O input voltage range.
+0 to + 0.7 VDC	The voltage indicates a logical 0.
+1.8 to 3.4 VDC	The voltage indicates a logical 1.
Note: The maximum input leakage current is 10 μ A.	

Table 7: Voltage Requirements for a Direct-coupled GPIO Line Set as an Input



To increase the voltage allowed on the I/O input lines, attach the dart I/O board (optionally available) to the camera. The I/O board makes the camera compatible with TTL input signals. For more information about the dart I/O board, see Section 4.2.1 on [page 31](#).

For more information about pin assignments and pin numbering, see Section 4.2.1 on [page 31](#).

4.6.2 Operation as an Output Line

The following I/O voltage levels apply to a direct-coupled GPIO line when the line is set as an output:

Output Voltage	Significance
+3.4 VDC	Maximum output voltage.
+0 to +0.5 VDC	The voltage indicates a logical 0.
+2.4 to +3.3 VDC	The voltage indicates a logical 1.
Note: The maximum current allowed through the output circuit is 2 mA.	

Table 8: Voltage Levels for a Direct-coupled GPIO Line Set as an Output

For more information about pin assignments and pin numbering, see Section 4.2.1 on [page 31](#).

5 I/O Control

5.1 Configuring Input Lines and Signals

5.1.1 Selecting the Input Line as the Source Signal for a Camera Function

You can select GPIO lines Line 1 and Line 2, if configured for input, to act as the source signal for the frame start trigger.

Whenever a proper electrical signal is applied to the selected line, the camera will recognize the signal as signal for the frame start trigger.

When you apply an electrical signal to the input line, the electrical signal must be appropriately timed for the function.

For detailed information about

- selecting an input line to act as the source signal for the frame start trigger and
- how the frame start trigger operates, see Section 6.2 on [page 49](#).

5.1.2 Input Line Debouncers

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.
- **too long** will result in rejecting valid signals.

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.

Figure 16 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.

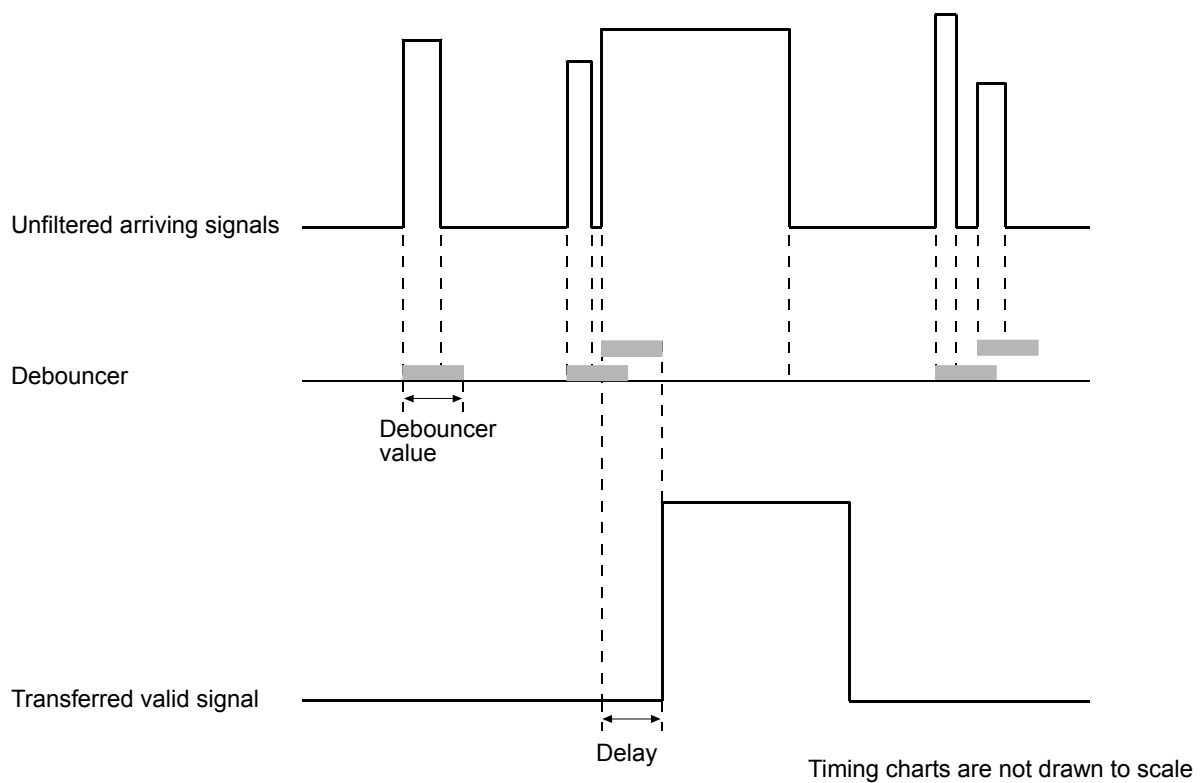


Fig. 16: Filtering of Input Signals by the Debouncer

Setting the Debouncer

You can set a debouncer value for GPIO lines Line 1 or Line 2. The line must be configured for input.

The debouncer value is determined by the value of the Line Debouncer Time parameter value. The parameter is set in microseconds and can be set in a range from 0 to 20,000 μ s.

To set the debouncer:

1. Use the Line Selector to select, for example, input line Line 1.
2. Set the value of the Line Debouncer Time parameter.

You can set the Line Selector and the value of the Line Debouncer Time parameter from within your application software by using the Basler 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 e.g. to 10 microseconds
camera.LineDebouncerTime.SetValue(10.0);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

5.1.3 Input Line Inverter

You can set GPIO lines Line 1 and Line 2, if configured for input, to invert or not to invert the incoming electrical signal.

To set the invert function for an input line:

1. Use the Line Selector to select the input line.
2. Set the value of the Line Inverter parameter to true to enable inversion on the selected line or 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 line 1
camera.LineSelector.SetValue(LineSelector_Line1);
camera.LineInverter.SetValue(true);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

5.2 Configuring Output Lines and Signals

5.2.1 Selecting a Source Signal for an Output Line

To make a physical output line useful, you must select a source signal for the line. You can select GPIO lines Line 1 or Line 2. The line must be configured for output.

The camera has several output signals available and any one of them can be selected to act as the source signal for an output line.

The camera has the following output signals available:

Output Signal	Valid for Camera Models
Flash Window	daA1920-15um, daA1920-30um/uc, daA2500-14um/uc
Exposure Active	daA1280-54um/uc
User Output 1	All models
User Output 2	All models

Table 9: Available Output Signals

For more information about the output signals User Output 1 and User Output 2, see Section 5.2.2 on [page 42](#).

To set a camera output signal as the source signal for an output line:

1. Use the Line Selector to select the output line.
2. 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 output line.

The following code snippet illustrates using the API to set the selector and the parameter value:

```
// Select the Flash Window signal as the source signal for Line 1
camera.LineSelector.SetValue(LineSelector_Line1);
camera.LineSource.SetValue(LineSource_FlashWindow);
```

You can set the Line Selector and the Line Source parameter values from within your application software by using the Basler pylon API.

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

For more information about

- the pylon API and the pylon Viewer, see Section 3.1 on [page 41](#).
- the flash window signal, see Section 6.6.2 on [page 66](#).
- setting the status of a user settable output line, see Section 5.2.2 on [page 42](#).
- the electrical characteristics of the output line, see Section 4.6.2 on [page 37](#).

5.2.2 Setting the Status of a User Settable Output Line

You can designate a camera's output line as "user settable" by means of the UserOutput parameters. If you have designated an output line as user settable, you can use the UserOutputValue parameter to set the status of the output line.

For each output line, a specific UserOutput parameter is available to set the line as "user settable":

If the corresponding line is configured for output,

- UserOutput 1 is available for GPIO line Line 1 and
- UserOutput 2 is available for GPIO line Line 2.

To set the status of a user settable output line:

1. Use the User Output Selector to select, for example, output line Line 1.
2. Set the value of the User Output Value parameter to true (1) or false (0). This will set the status of the output line.

You can set the Output Selector and the User Output Value parameters from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to designate an output line as user settable, set the status of the output line, and get informed about its current status:

```
// Set output line Line 1 to user settable
camera.LineSelector.SetValue(LineSelector_Line1);
camera.LineSource.SetValue(LineSource_UserOutput2);
// Set the status of output line Line 2
camera.UserOutputSelector.SetValue(UserOutputSelector_UserOutput2);
camera.UserOutputValue.SetValue(true);
// Get informed about the current user output value setting for output line Line 2
bool b = camera.UserOutputValue.GetValue();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 41](#).



If you have the line inverter enabled on an output line and if the line is designated as user settable, the user setting initially sets the status of the line which is then inverted by the line inverter.

5.2.3 Output Line Inverter

You can set GPIO lines Line 1 and Line 2, if configured for output, to invert or not to invert the electrical output signal.

To set the invert function for an output line:

1. Use the Line Selector to select the output line.
2. Set the value of the Line Inverter parameter
 - to true to enable inversion on the selected line
 - 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 line inverter on output line Line 1
camera.LineSelector.SetValue(LineSelector_Line1);
camera.LineInverter.SetValue(true);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 41](#).

5.3 Checking the Status of the I/O Lines

5.3.1 Checking the Status of an I/O Line

You can determine the current status of any I/O line that depends on whether an electrical signal is applied to the line and whether the line inverter is disabled or enabled.



The line status of a GPIO line (Line 1, Line 2) does not depend on the configuration of the GPIO line for input or output.

The signal levels and corresponding Line Status parameter values for all I/O lines are listed in Table 10.

Electrical Signal / Electrical Signal Level	Line Inverter Status	Logical Line Status Parameter Value	Binary Expression of the Line Status Parameter Value
Low	Disabled	False	0
Low	Enabled	True	1
High	Disabled	True	1
High	Enabled	False	0

Table 10: Signal Levels and Corresponding Line Status Parameter Values

To check the status of an I/O line:

1. Use the Line Selector parameter to select, for example, Line 1.
2. Read the value of the Line Status parameter to determine the current status of the line. A value of true means the line's status is currently high and a value of false means the line's status is currently low.

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

```
// Select output line Line 1 and read the status
camera.LineSelector.SetValue(LineSelector_Line1);
bool b = camera.LineStatus.GetValue();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 41](#).

5.3.2 Checking the Status of All Lines

The LineStatusAll parameter value

- is reported in bits 0 and 1 of a 32-bit word.
- indicates the line status of both I/O lines. As shown in [Figure 17](#), each bit in the value is associated with one I/O line and the bits will indicate the status of the lines.

If a bit is

- 0, it indicates that the line status of the associated line is currently low.
- 1, it indicates that the line status of the associated line is currently high.

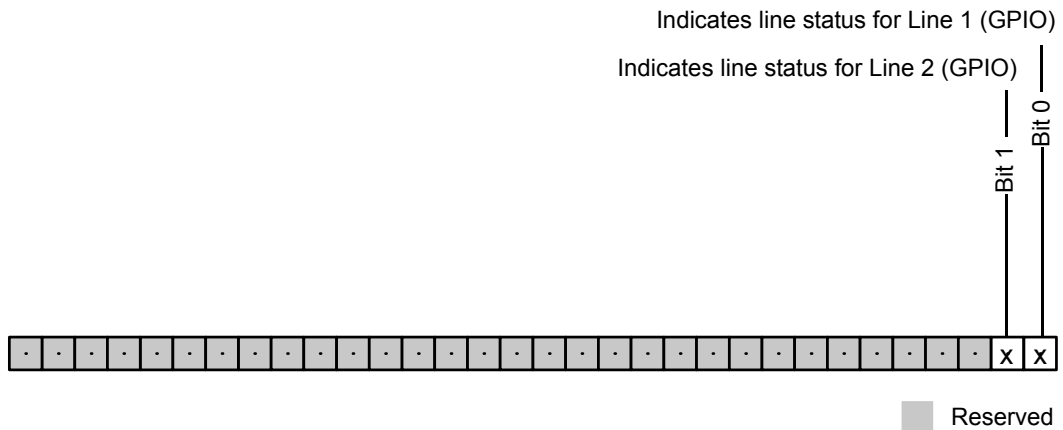


Fig. 17: Bit Field of the LineStatusAll Parameter: Bit Numbers and Assignment of I/O Lines

For more information about the relation between line status, electrical signal level, and line inverter setting, see Section 5.3.1 on [page 44](#).

You can determine the current status of both I/O lines with a single operation: Reading the hexadecimal number of the LineStatusAll parameter value allows you to check the current status of both I/O lines.

The following table refers to the bit field shown in [Figure 17](#) and lists all possible LineStatusAll parameter values (hexadecimal numbers) and related binary numbers.

LineStatusAll Parameter Value		Binary Expression of the LineStatusAll Parameter Value	
Hexadecimal Number	Binary Number	Line 2	Line 1
0x0	00	0	0
0x1	01	0	1
0x2	10	1	0
0x3	11	1	1

Table 1: LineStatusAll Parameter Values and Corresponding Binary Expressions

To check the status of all I/O lines with a single operation:

- Read the value of the LineStatusAll parameter to determine the current status of both I/O lines.

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

```
// Read the line status of both I/O lines
int64_t i = camera.LineStatusAll.GetValue();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 41](#).

6 Image Acquisition Control



The sample code included in this section represents "low level" code that is actually used by the camera.

Many tasks, however, can be programmed more conveniently with fewer lines of code when employing the Instant Camera classes, provided by the Basler pylon C++ API.

For information about the Instant Camera classes, see the *C++ Programmer's Guide and Reference Documentation* delivered with the Basler pylon Camera Software Suite.

6.1 Acquisition Start and Stop Commands and the Acquisition Mode

Executing an **Acquisition Start** command prepares the camera to acquire frames. You must execute an Acquisition Start command before you can begin acquiring frames.

Executing an **Acquisition Stop** command terminates the camera's ability to acquire frames. When the camera receives an Acquisition stop command and if the camera

- is currently not acquiring a frame, the camera stops acquiring frames immediately.
- is currently acquiring a frame, the frame acquisition process will be allowed to finish and the camera's ability to acquire new frames will be terminated.

The camera's **Acquisition Mode** parameter has two settings: single frame and continuous. The use of Acquisition Start and Acquisition Stop commands and the camera's Acquisition Mode parameter setting are related.

If the camera's Acquisition Mode parameter

- is set for **single frame**, after an Acquisition Start command has been executed, a single frame can be acquired. When acquisition of one frame is complete, the camera will execute an Acquisition Stop command internally and will no longer be able to acquire frames. To acquire another frame, you must execute a new Acquisition Start command.
- is set for **continuous frame**, after an Acquisition Start command has been executed, frame acquisition can be triggered as desired. Each time a frame trigger is applied while the camera is in a "waiting for frame trigger" acquisition status, the camera will acquire and transmit a frame. The camera will retain the ability to acquire frames until an Acquisition Stop command is executed. Once the Acquisition Stop command is received, the camera will no longer be able to acquire frames.



When the camera's acquisition mode is set to single frame, the maximum possible acquisition frame rate for a given ROI cannot be achieved. This is because the camera performs a complete internal setup cycle for each single frame and because it cannot be operated with overlapped exposure.

For more information about overlapped image acquisitions, see Section 6.5 on [page 62](#).

Setting the Acquisition Mode and Issuing Start/Stop Commands

You can set the Acquisition Mode parameter value and you can execute Acquisition Start or Acquisition Stop commands from within your application software by using the Basler pylon API. The code snippet below illustrates using the API to set the Acquisition Mode parameter value and to execute an Acquisition Start command, where Line 1 is taken as an example.

The snippet also illustrates setting several parameters regarding frame triggering. These parameters are discussed later in this chapter.

```
camera.AcquisitionMode.SetValue(AcquisitionMode_SingleFrame);  
camera.TriggerMode.SetValue(TriggerMode_On);  
camera.TriggerSource.SetValue(TriggerSource_Line1);  
camera.TriggerActivation.SetValue(TriggerActivation_RisingEdge);  
camera.ExposureMode.SetValue(ExposureMode_Timed);  
camera.ExposureTime.SetValue(3000.0);  
camera.AcquisitionStart.Execute();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

6.2 The Frame Start Trigger

The frame start trigger is used to begin frame acquisition. Assuming that the camera is in a "waiting for frame start trigger" acquisition status, it will begin a frame acquisition each time it receives a frame start trigger signal.

In order for the camera to be in a "waiting for frame start trigger" acquisition status:

- The Acquisition Mode parameter must be set correctly.
- A proper Acquisition Start command must be applied to the camera.

For more information about the Acquisition Mode parameter and about Acquisition Start and Acquisition Stop commands, see Section 6.1 on [page 47](#).

There are three ways to operate the camera using frame start trigger signals:

- Frame start trigger signals are generated internally by the camera, and frame acquisition will be done automatically. This is also known as the "**free run**". For more information, see Section 6.2.1.1 on [page 49](#).
- Frame start trigger signals are applied via **software**. Each time a Trigger Software command is executed via the pylon API on the host PC, the camera will begin a frame acquisition. For more information, see Section 6.2.2 on [page 52](#).
- Frame start trigger signals are applied via **hardware**. Each time a proper electrical signal is applied to the input line, the camera will begin a frame acquisition. For more information, see Section 6.2.3 on [page 53](#).

6.2.1 Trigger Mode

The main parameter associated with the frame start trigger is the Trigger Mode parameter. The Trigger Mode parameter for the frame start trigger has two available settings: Off and On.

6.2.1.1 Trigger Mode = Off (Free Run)

When the Trigger Mode parameter is set to Off, the camera will generate all required frame start trigger signals internally, and you do not need to apply frame start trigger signals to the camera. This status is also known as "free run".

With the trigger mode set to Off, the way the camera will operate the frame start trigger depends on the setting of the camera's Acquisition Mode parameter. If the Acquisition Mode parameter is set to

- **single frame**, the camera will automatically generate a single frame start trigger signal whenever it receives an Acquisition Start command.
- **continuous frame**, the camera will automatically begin generating frame start trigger signals when it receives an Acquisition Start command. The camera will continue to generate frame start trigger signals until it receives an Acquisition Stop command.

The rate at which the frame start trigger signals are generated in the continuous frame Acquisition Mode can be determined by the camera's Acquisition Frame Rate parameter:

Acquisition Frame Rate	Frame Start Trigger Rate
Acquisition frame rate < maximum allowed frame rate	Acquisition frame rate
Acquisition frame rate >=maximum allowed frame rate	Maximum allowed frame rate

Table 11: Frame Start Trigger Rates in the Continuous Frame Acquisition Mode

For more information about determining the maximum allowed frame rate, see Section 6.7 on [page 67](#).

Exposure Time Control with Trigger Mode Set to Off

When the Trigger Mode parameter for the frame start trigger is set to Off, the exposure time for each frame acquisition is determined by the value of the camera's Exposure Time parameter.

For more information about the camera's Exposure Time parameter, see Section 6.3 on [page 56](#).

Configuring and Enabling the Free Run Mode

The following code snippet illustrates using the API to set the Acquisition Mode to Continuous, the Trigger Mode to Off (free run), and the Acquisition Frame Rate to 60:

```
// Set the acquisition mode to Continuous
camera.AcquisitionMode.SetValue(AcquisitionMode_Continuous);
// Set the timed exposure mode
camera.ExposureMode.SetValue(ExposureMode_Timed);
// Set the exposure time
camera.ExposureTime.SetValue(3000.0);
// Set the frame rate
camera.AcquisitionFrameRate.SetValue(60.0);
// Enable free run mode by setting the trigger mode to Off
camera.TriggerMode.SetValue(TriggerMode_Off);
// Start frame capture
camera.AcquisitionStart.Execute();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

6.2.1.2 Trigger Mode = On (Software or Hardware Triggering)

When the Trigger Mode parameter for the frame start trigger is set to On, you must apply a frame start trigger signal to the camera each time you want to begin a frame acquisition.



Do not trigger frame acquisition at a rate that

- exceeds the maximum allowed for the current camera settings. If you apply frame start trigger signals to the camera when it is not ready to receive them, the signals will be ignored. For more information about determining the maximum allowed frame rate, see Section 6.7 on [page 67](#).
- exceeds the host computer's capacity limits for data transfer or storage or both. If you try to acquire more images than the host computer is able to process, frames may be dropped. For more information about bandwidth optimization, see the *Installation and Setup Guide for Cameras Used with Basler pylon for Windows* (AW000611).

The Trigger Source parameter specifies the source signal that will act as the frame start trigger signal. The available selections for the Trigger Source parameter are:

- **Software** - When the source signal is set to software, you apply a frame start trigger signal to the camera by executing a Trigger Software command for the frame start trigger on the host PC.
- **Line 1** -When the source signal is set to Line 1, you apply a frame start trigger signal to the camera by injecting a hardware trigger signal into Line 1. The GPIO line Line 1 must be configured for input.
- **Line 2** - Analogous to the Line 1 source signal. The GPIO line Line 2 must be configured for input.

If the Trigger Source parameter is set to Line 1 or Line 2, you must also set the Trigger Activation parameter. The available settings for the Trigger Activation parameter are:

- **Rising Edge** - specifies that the rising edge of the electrical signal will act as the frame start trigger.
- **Falling Edge** - specifies that the falling edge of the electrical signal will act as the frame start trigger.

For more information about

- using a software trigger to control frame acquisition start, see Section 6.2.2 on [page 52](#).
- using a hardware trigger to control frame acquisition start, see Section 6.2.3 on [page 53](#).

Exposure Time Control with Trigger Mode Set to On

If the Trigger Mode parameter for the frame start trigger is set to On and the Trigger Source parameter is

- set to **Software**, the exposure time for each frame acquisition is determined by the value of the camera's Exposure Time parameter.
- set to **Line 1 or Line 2**, the exposure time for each frame acquisition can be controlled with the Exposure Time parameter or it can be controlled by manipulating the hardware trigger signal.

For more information about

- controlling exposure time when using a software trigger, see Section 6.2.2 on [page 52](#).
- controlling exposure time when using a hardware trigger, see Section 6.2.3 on [page 53](#).

6.2.2 Using a Software Frame Start Trigger

If the Trigger Mode parameter for the frame start trigger is set to On and the Trigger Source parameter is set to Software,

- you must apply a software frame start trigger signal to the camera to begin each frame acquisition.
- the camera's Exposure Mode parameter must be set to Timed. The exposure time is set by the Exposure Time parameter.
- the frame rate will be determined by how often you apply a software trigger signal to the camera.

Configuring and Executing a Software Frame Start Trigger Command

The following code snippet illustrates using the API to set the parameter values and to execute the commands related to software frame start triggering with the camera set for continuous frame acquisition mode:

```
// Set the acquisition mode to Continuous
camera.AcquisitionMode.SetValue(AcquisitionMode_Continuous);
// Set the trigger mode to On
camera.TriggerMode.SetValue(TriggerMode_On);
// Set the timed exposure mode
camera.ExposureMode.SetValue(ExposureMode_Timed);
// Set the exposure time
camera.ExposureTime.SetValue(3000.0);
// Execute an acquisition start command to prepare for frame acquisition
camera.AcquisitionStart.Execute();
    while (!finished)
    {
        // Execute a Trigger Software command to apply a frame start
        // trigger signal to the camera
```

```
camera.TriggerSoftware.Execute();
    // Retrieve acquired frame here
}
camera.AcquisitionStop.Execute();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

6.2.3 Using a Hardware Frame Start Trigger

If the Trigger Mode parameter for the frame start trigger is set to On and the Trigger Source parameter is set to Line 1 or Line 2, an externally generated electrical signal injected into GPIO line Line 1 or Line 2 on the camera will act as the frame start trigger signal for the camera.

This type of trigger signal is generally referred to as a hardware trigger signal or as an external frame start trigger signal (ExFSTrig).

A rising edge or a falling edge of the ExFSTrig signal can be used to trigger frame acquisition. The Trigger Activation parameter is used to select rising edge or falling edge triggering.

When the camera is operating under control of an ExFSTrig signal, the period of the ExFSTrig signal will determine the rate at which the camera is acquiring frames:

$$\frac{1}{\text{ExFSTrig period in seconds}} = \text{frame rate}$$

For example, if you are operating a camera with an ExFSTrig signal period of 20 ms (= 0.02 s):

$$\frac{1}{0.02} = 50$$

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

For more information about determining the maximum allowed frame rate, see Section 6.7 on [page 67](#).

If you are triggering the start of a frame acquisition with an externally generated frame start trigger (ExFSTrig) signal, two exposure modes are available: **timed** and **trigger width**.

Timed Exposure Mode

When timed exposure mode is selected, the exposure time for each frame acquisition 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 ExFSTrig signal rises.
- **falling edge** triggering, the exposure time starts when the ExFSTrig signal falls.

Figure 18 illustrates timed exposure with the camera set for rising edge triggering.

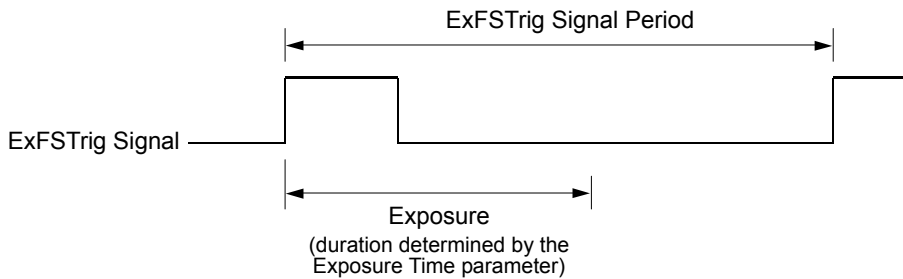


Fig. 18: Timed Exposure with Rising Edge Triggering

If you attempt to trigger a new exposure start while the previous exposure is still in progress, the trigger signal will be ignored. This situation is illustrated in Figure 19 for rising edge triggering.

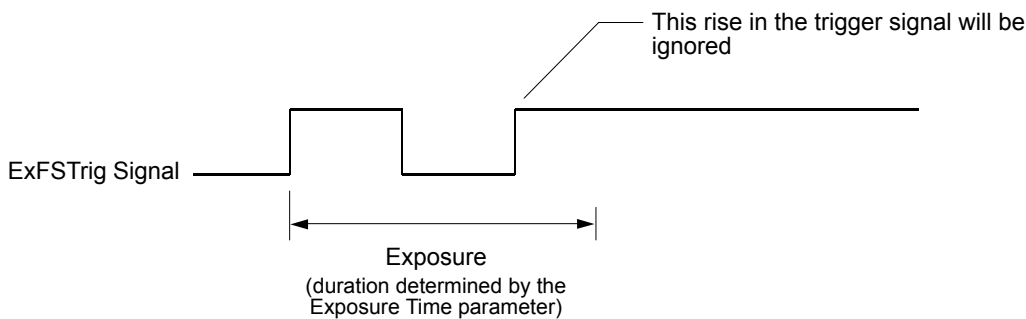


Fig. 19: Overtriggering with Timed Exposure

For more information about the camera's Exposure Time parameter, see Section 6.3 on [page 56](#).

Trigger Width Exposure Mode

When the trigger width exposure mode is selected, the length of the exposure for each frame acquisition will be directly controlled by the ExFSTrig signal. Trigger width exposure is especially useful if you intend to vary the length of the exposure time for each captured frame.

If the camera is set for

- **rising edge triggering**, the exposure time begins when the ExFSTrig signal rises and continues until the ExFSTrig signal falls.
- **falling edge triggering**, the exposure time begins when the ExFSTrig signal falls and continues until the ExFSTrig signal rises.

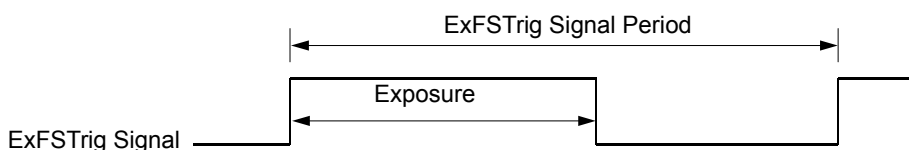


Fig. 20: Trigger Width Exposure with Rising Edge Triggering

Configuring and Executing a Hardware Frame Start Trigger Command

You can set all of the parameters needed to perform hardware frame start triggering from within your application by using the Basler pylon API. The following code snippet illustrates using the API to set the camera for single frame acquisition mode. In this example, the timed exposure mode will be used with GPIO line 1 as the trigger source and with rising edge triggering:

```
// Set the acquisition mode to Single Frame
camera.AcquisitionMode.SetValue(AcquisitionMode_SingleFrame);
// Set the trigger mode to On
camera.TriggerMode.SetValue(TriggerMode_On);
// Set the source for the selected trigger
camera.TriggerSource.SetValue(TriggerSource_Line1);
// Set the trigger activation mode to rising edge
camera.TriggerActivation.SetValue(TriggerActivation_RisingEdge);
// Set for the timed exposure mode
camera.ExposureMode.SetValue(ExposureMode_Timed);
// Set the exposure time
camera.ExposureTime.SetValue(3000.0);
// Execute an acquisition start command to prepare for frame acquisition
camera.AcquisitionStart.Execute();
// Frame acquisition will start when the externally generated
// frame start trigger signal (ExFSTrig signal) goes high
```

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

For more information about the pylon API and pylon Viewer, see Section 3.1 on [page 28](#).

6.3 Setting the Exposure Time

This section describes how the exposure time can be adjusted manually by setting the value of the exposure time parameter. The camera also has an Exposure Auto function that can automatically adjust the exposure time.



By default, the exposure auto function is enabled. Manual adjustment of the exposure time will not work.

Set the Exposure Auto parameter to "Off" before making any manual adjustments.

For more information about the exposure auto function, see Section 9.9.3 on [page 100](#).

Minimum Allowed Exposure Time	Maximum Possible Exposure Time	Increment
10 μ s	1000000 μ s	1 μ s

Table 12: Minimum and Maximum Allowed Exposure Time Setting and Increment



Depending on the camera's sensor and the frame rate, the effective exposure time may vary from the exposure time set. The variation is normally in the range of microseconds, but if a very low exposure time is set, this should be taken into account.

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

```
// Set the exposure time to 40.0  $\mu$ s
camera.ExposureTime.SetValue(40.0);
```

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

For more information about the pylon API and pylon Viewer, see Section 3.1 on [page 28](#).

6.4 Electronic Shutter Operation

All dart cameras are equipped with imaging sensors that have an electronic shutter. There are two types of electronic shutter modes used in the sensors: **global** and **rolling**. For rolling shutter, there are two sub-types: electronic rolling shutter (ERS) and global reset release mode (GRR).

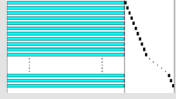
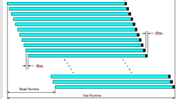
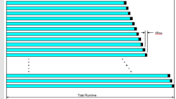
<p style="text-align: center;">Global Shutter</p> 	<p style="text-align: center;">Electronic Rolling Shutter (ERS)</p> 	<p style="text-align: center;">Global Reset Release Mode (GRR)</p> 
<p>For moving objects</p>	<ul style="list-style-type: none"> ■ For stationary objects/not moving objects ■ Lower ambient noise ■ If used for moving objects: Use of flash lighting and flash window recommended 	<ul style="list-style-type: none"> ■ For stationary objects/not moving objects ■ Use of flash lighting and flash window is a must.

Table 13: Overview of Shutter Modes

Camera Model	Shutter Type	Supported Shutter Modes
daA1280-54um/uc	Global Shutter	Global Shutter
daA1920-15um daA1920-30um/uc daA2500-14um/uc	Rolling Shutter	ERS, GRR

Table 14: Camera Models and Shutter Configuration

6.4.1 Global Shutter

Camera Model	Global Shutter Available?
daA1280-54um/uc	Yes
daA1920-15um daA1920-30um/uc daA2500-14um/uc	No

Table 15: Global Shutter Availability

A main characteristic of a global shutter is that for each frame acquisition, all of the pixels in the sensor start exposing at the same time and all stop exposing at the same time.

This means that image brightness tends to be more uniform over the entire area of each acquired image, and it helps to minimize problems with acquiring images of objects in motion.

Immediately after the end of exposure, pixel data readout begins and proceeds in a linewise fashion until all pixel data is read out of the sensor.

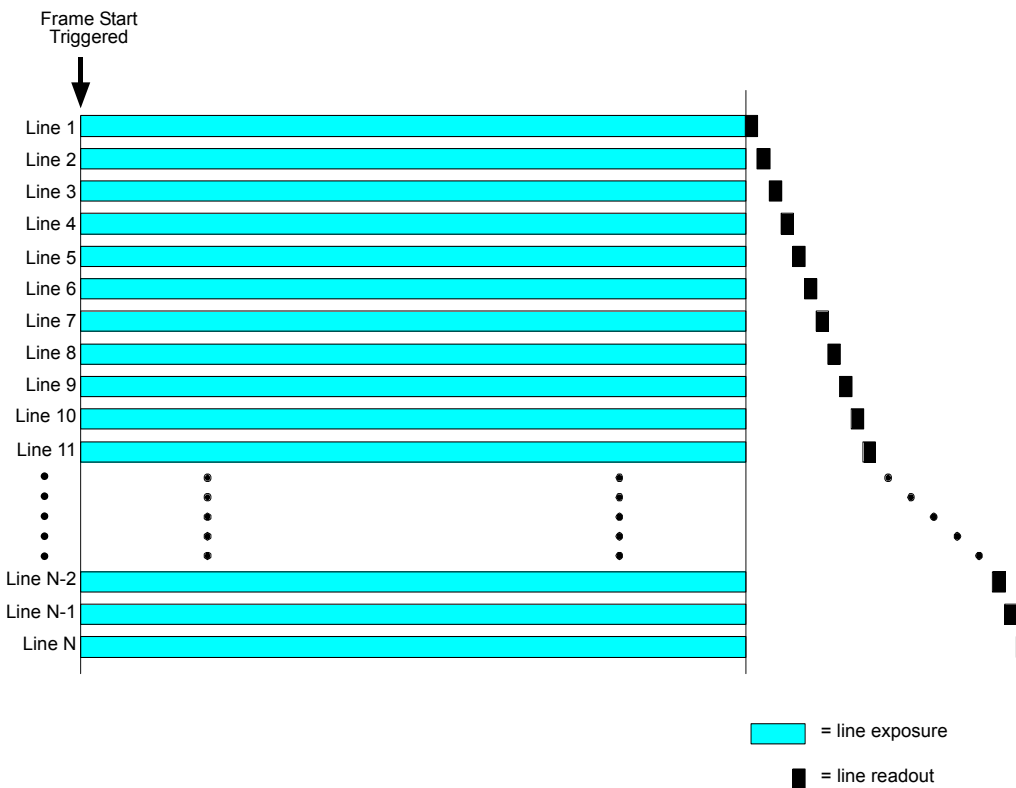


Fig. 21: Global Shutter

6.4.2 Rolling Shutter

Camera Model	Rolling Shutter Available?
daA1280-54um/uc	No
daA1920-15um daA1920-30um/uc daA2500-14um/uc	Yes

Table 16: Rolling Shutter Availability

The rolling shutter is used to control the start and stop of sensor exposure. The rolling shutter used in these cameras has two operating modes:

- electronic rolling shutter mode (ERS mode) and
- global reset release mode (GRR mode).

Electronic Rolling Shutter Mode (ERS)

When the shutter is in the electronic rolling shutter operating mode, it exposes and reads out the pixel lines with a temporal offset from one line to the next. When frame start is triggered, the camera

- resets line one of the ROI and begins exposing line one,
- resets line two a short time later (= temporal offset) and begins exposing line two,
- resets line three a short time later than line two (= additional temporal offset) and begins exposing line three.

And so on until the bottom line of pixels is reached (see Figure 22).

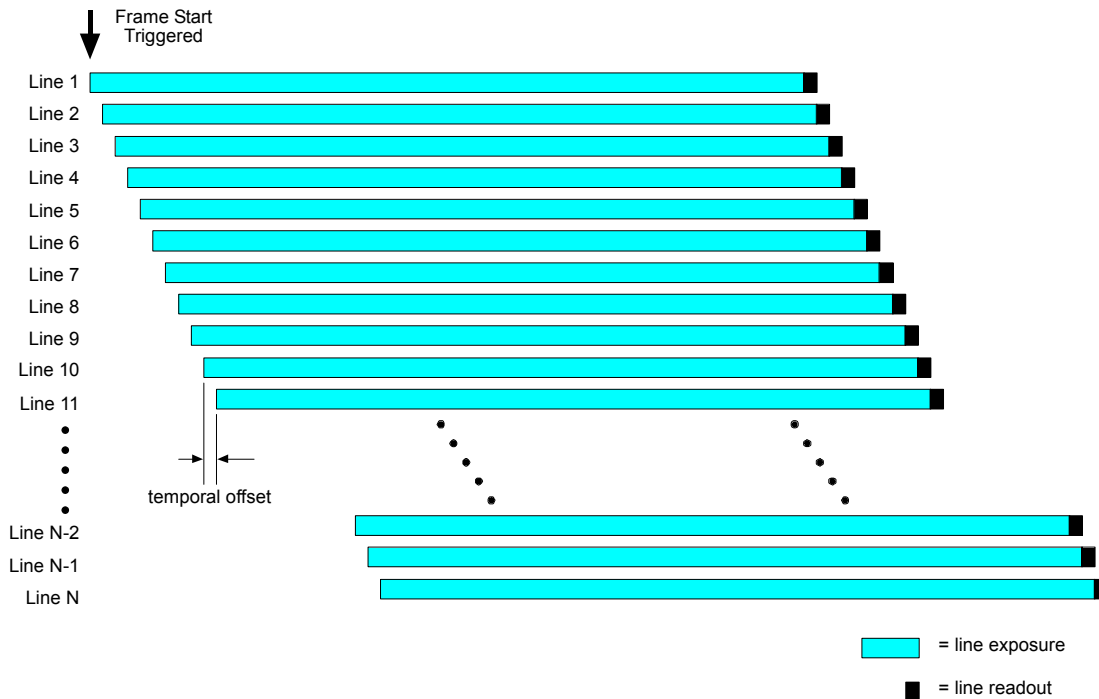


Fig. 22: Rolling Shutter in the ERS Mode

The pixel values for each line are read out at the end of exposure time for the line. The exposure time is the same for all lines and is determined by the Exposure Time parameter setting.

If the camera is operating with the rolling shutter in ERS mode and you are using the camera to capture images of moving objects, the use of flash lighting is most strongly recommended.

Global Reset Release Mode (GRR)

In the global reset release mode, all of the lines in the sensor reset and begin exposing when frame start is triggered. There is a temporal offset from one line to the next in the end of exposure. The exposure time

- for line one is determined by the Exposure Time parameter setting.
- for line two will end a short time (= temporal offset) after the exposure ends for line one.
- for line three will end another short time (= temporal offset) after the exposure ends for line two.

And so on until the bottom line of pixels is reached (see Figure 23).

The pixel values for each line are read out at the end of exposure time for the line.

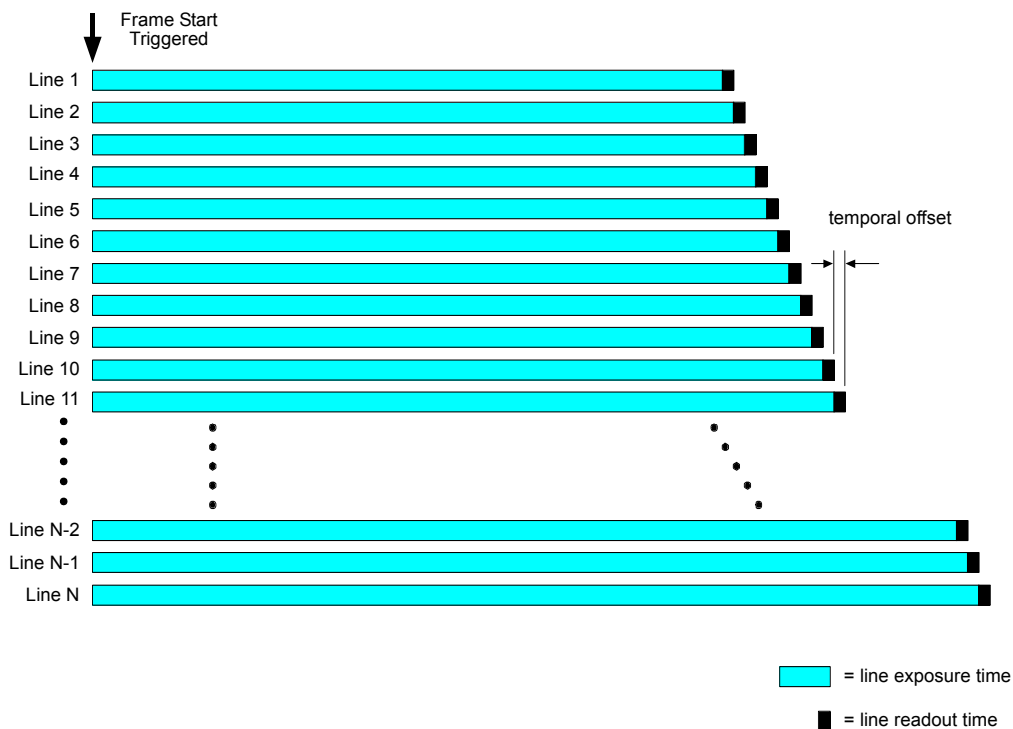


Fig. 23: Rolling Shutter in the Global Reset Release Mode

When the camera is operating with the rolling shutter in the global release mode, the use of flash lighting is most strongly recommended. For more information, see Section "Rolling Shutters and Flash Exposure" in this chapter.

Setting the Sensor Shutter Mode

You can set the sensor shutter mode (electronic rolling shutter or global reset release) from within your application software by using the Basler pylon API. The following code snippets illustrate using the API to set the sensor shutter modes:

```
// Set the electronic rolling shutter mode
camera.SensorShutterMode.SetValue(SensorShutterMode_Rolling);

// Set the global reset release shutter mode
camera.SensorShutterMode.SetValue(SensorShutterMode_GlobalReset);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

Rolling Shutters and Flash Exposure

If you are using

- the **electronic rolling shutter mode**, you should use flash exposure for capturing images of moving objects.
- the **global reset release mode**, you should use flash exposure for capturing images of both stationary and moving objects.

If you don't use flash exposure when capturing images of

- **stationary** objects, the brightness in each acquired image will vary significantly from top to bottom due to the differences in the exposure times of the lines.
- **moving** objects, the brightness in each acquired image will vary significantly from top to bottom due to the differences in the exposure times of the lines and the images will be distorted due to the temporal shift between the end of exposure for each line.

You can avoid these problems by using flash lighting and by applying the flash during the "flash window" for each frame. The flash window is the period of time during a frame acquisition when all of the lines in the sensor are open for exposure.

Cameras with a rolling shutter imaging sensor can provide a flash window output signal to aid you in the use of flash lighting. The flash window signal will go high when the flash window for each image acquisition opens and will go low when the flash window closes.



The flash window signal is also available on cameras with a global shutter imaging sensor. On global shutter cameras, the flash window signal is the equivalent of the exposure active signal.

For more information about the flash window signal, see Section 6.6.2 on [page 66](#).

6.5 Overlapping Image Acquisitions

There are two common ways for the camera to operate:

- with “non-overlapped” exposure and
- with “overlapped” exposure.

In the **non-overlap** mode of operation, each time a frame is acquired the camera completes the entire readout process (exposure of the pixels + readout of the pixel values from the sensor) before acquisition of the next frame is started. The exposure for a new frame does not overlap the sensor readout for the previous frame. This situation is illustrated in Figure 24 with the camera set for the trigger width exposure mode.

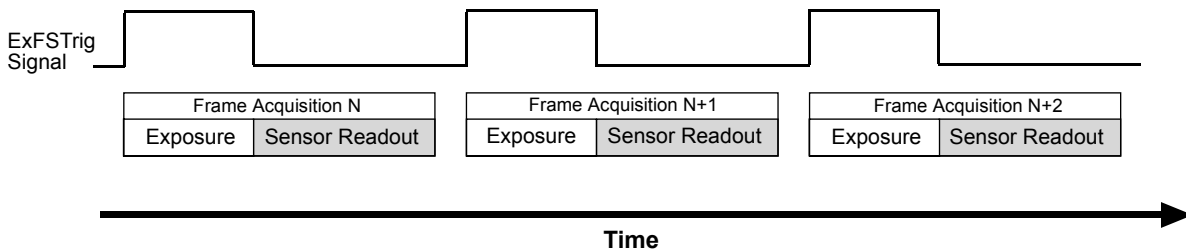


Fig. 24: Non-overlapped Exposure and Sensor Readout

In the **overlap** mode of operation, the exposure of a new frame begins while the camera is still reading out the sensor data for the previously acquired frame. This situation is illustrated in Figure 25 with the camera set for the trigger width exposure mode.

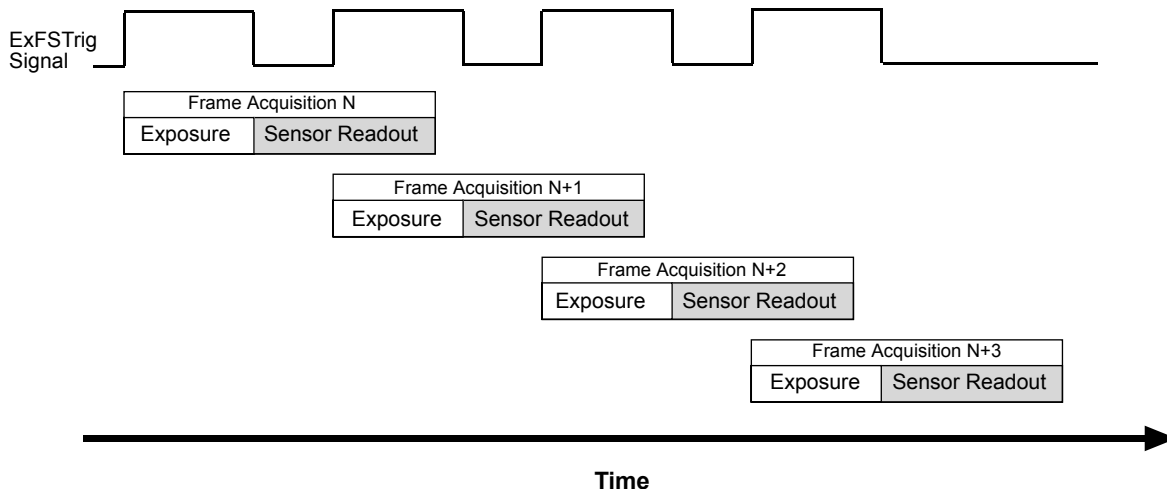


Fig. 25: Overlapped Exposure and Sensor Readout

6.5.1 Automatic Overlapping of Image Acquisitions (All Cameras)

If the camera allows overlapped image acquisitions (see Table 17), it will automatically overlap exposures and readouts to maximize the frame rate or to achieve a specific frame rate.

If the camera does not allow overlapped image acquisitions, the camera's maximum allowed frame rate will be limited by the duration of the frame acquisition process (exposure + readout).



To allow overlapping image acquisitions, the camera must be in the continuous acquisition mode. Overlapping image acquisition cannot be performed if the camera's acquisition mode is set to single frame.

For more information about the acquisition mode, see Section 6.1 on [page 47](#).

Camera Model	Rolling Shutter Mode	Trigger Mode	Overlapping Image Acquisitions allowed?
da1280-54um/uc	Not applicable (global shutter camera)	On (software / hardware)	No
		Off (free run)	Yes (*)
daA1920-15um daA1920-30um/uc daA2500-14um/uc	ERS	On (software / hardware)	Yes
	ERS	Off (free run)	Yes
	GRR	On (software / hardware)	No
	GRR	Off (free run)	No

(*) Overlapping image acquisitions are allowed unless you manually disable them using the Overlap Mode parameter. For more information, see Section 6.5.2 on [page 64](#).

Table 17: Conditions for Overlapping Image Acquisitions

For more information about

- rolling shutter modes, see Section 6.4.2 on [page 59](#).
- trigger modes, see Section 6.2.1 on [page 49](#).

6.5.2 Manually Setting the Overlap Mode of Operation (daA1280-54um/uc only)

On daA1280-54um and daA1280-54uc cameras, you can use the Overlap Mode parameter to manually disable or enable overlapping image acquisitions.

If the Overlap Mode parameter is set to

- **On**, the sensor is put in the **overlap** mode of operation. The camera will automatically overlap exposures and readouts in the free run mode.
- **Off**, the sensor is put in the **non-overlap** mode of operation. The camera will never overlap exposures and readouts. This can improve image quality, especially when you are operating the camera at low frame rates.

For more information about the overlap and non-overlap mode of operation, see Section 6.5 on [page 62](#).

The following code snippet illustrates using the pylon API to set the Overlap Mode parameter value:

```
// Set for the overlapping mode of operation
camera.OverlapMode.SetValue(OverlapMode_On);

// Set for the non-overlapping mode of operation
camera.OverlapMode.SetValue(OverlapMode_Off);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

6.6 Acquisition Monitoring Tools

6.6.1 Exposure Active Signal

Camera Model	Exposure Active Signal Available?
daA1280-54um/uc	Yes
daA1920-15um	No
daA1920-30um/uc	No
daA2500-14um/uc	No

Table 18: Exposure Active Availability

Cameras with a global shutter imaging sensor provide an "exposure active" (ExpAc) output signal.

The signal goes high when the exposure time for each frame acquisition begins and goes low when the exposure time ends as shown in Figure 26. 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.

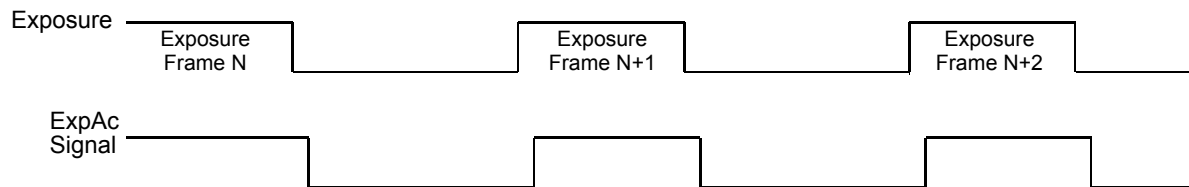


Fig. 26: Exposure Active Signal on Cameras with a Global Shutter



When you use the exposure active signal, be aware that there is a delay (in the range of microseconds) in the rise and the fall of the signal in relation to the start and the end of exposure.

To select the Exposure Active Signal as the source signal for an output line:

1. Use the Line Selector to select a GPIO line, e.g. Line 2. The line must be configured for output.
2. Set the value of the Line Source parameter to the exposure active output signal.

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

```
camera.LineSelector.SetValue(LineSelector_Line2);
camera.LineSource.SetValue(LineSource_ExposureActive);
```

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

For more information about

- the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).
- changing the selection of an output signal as the source signal for the output line, see Section 5.2.1 on [page 41](#).

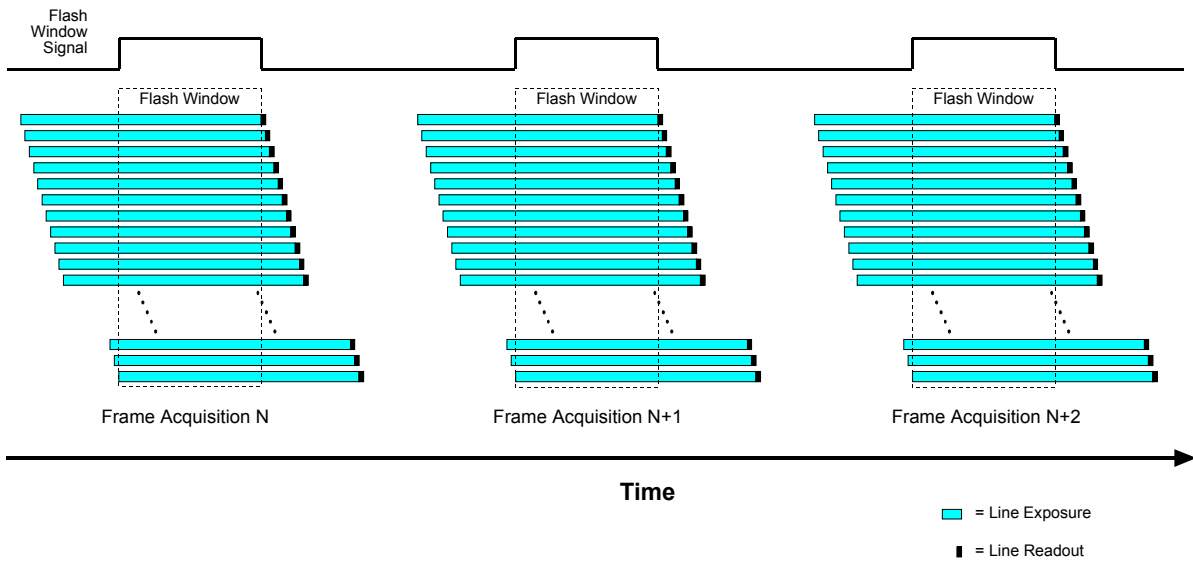


Fig. 27: Flash Window Signal on Cameras with a Rolling Shutter

6.6.2 Flash Window Signal

Camera Model	Flash Window Signal Available?
daA1280-54um/uc	No
daA1920-15um	Yes
daA1920-30um/uc	Yes
daA2500-14um/uc	Yes

Table 19: Flash Window Availability

Cameras with a rolling shutter imaging sensor provide a flash window output signal to aid you in the use of flash lighting.

The flash window signal will go high when the flash window for each image acquisition opens and will go low when the flash window closes. Figure 27 illustrates the flash window signal on a camera with the shutter operating in the electronic rolling shutter mode.



The flash window signal is also available on cameras with a global shutter imaging sensor. On global shutter cameras, the flash window signal is the equivalent of the exposure active signal.

For more information about the rolling shutter and the flash window, see Section 6.4.2 on [page 59](#).

To select the Flash Window Signal as the source signal for an output line:

1. Use the Line Selector to select a GPIO line, e.g. Line 2. The line must be configured for output.
2. Set the value of the Line Source parameter to the flash window signal.

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

```
camera.LineSelector.SetValue(LineSelector_Line2);  
camera.LineSource.SetValue(LineSource_FlashWindow);
```

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

For more information about

- the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).
- changing the selection of an output signal as the source signal for the output line, see Section 5.2.2 on [page 42](#).

6.7 Maximum Allowed Frame Rate

In general, the maximum allowed acquisition frame rate on any dart USB 3.0 camera can be limited by these factors:

- The exposure time for the acquisition of frames. If you use very long exposure times, you can acquire fewer frames per second.
- The amount of time it takes to read an acquired frame out of the imaging sensor and to prepare it for transmission out of the camera. The amount of time varies with the height of the frame. Frames with a smaller height take less time. The frame height is determined by the camera's ROI Height setting.
- The amount of time it takes to transmit an acquired frame from the camera to your host PC. The amount of time depends on the host computer's capacity limits for data transfer and the bandwidth assigned to the camera.
- Under certain conditions, overlapping image acquisition is not possible. This decreases the camera's maximum allowed frame rate. For more information about overlapping image acquisitions, see Section 6.5 on [page 62](#).

To determine the maximum allowed acquisition frame rate with your current camera settings, use the Basler pylon API to read the value of the camera's Resulting Frame Rate parameter. For more information, see Section 6.7.1 on [page 68](#).



When the camera's acquisition mode is set to single frame, the maximum possible acquisition frame rate cannot be achieved. This is because the camera performs a complete internal setup cycle for each single frame and because it cannot be operated with overlapped exposure.

For more information about overlapped image acquisitions, see Section 6.5 on [page 62](#).

6.7.1 Using the Basler pylon API to Check the Maximum Allowed Frame Rate

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

```
// Get the resulting frame rate
double d = camera.ResultingFrameRate.GetValue();
```

The Resulting Frame Rate parameter takes all camera settings into account that can influence the frame rate and indicates the maximum allowed frame rate given the current settings.

You can also use the Basler pylon Viewer application to easily read the parameter.

For more information about the pylon API and pylon Viewer, see Section 3.1 on [page 28](#).

6.7.2 Increasing the Maximum Allowed Frame Rate

If you want to acquire frames at a rate higher than the maximum allowed with the camera's current settings, you must adjust one or more of the factors that can influence the maximum allowed rate.

- Decreasing the height of the region of interest (ROI) can have a significant impact on the maximum allowed frame rate. If possible in your application, decrease the height of the ROI.
- Depending on the sensor, decreasing the width of the ROI may also increase the maximum allowed frame rate. The impact is lower than the impact of the ROI height, but may still be noticeable.
- If you are using long exposure times or small ROIs, your exposure time may limit the maximum allowed frame rate. Try using a shorter exposure time and see if the maximum allowed frame rate increases. 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 are using multiple cameras connected to one hub, the transmission time may restrict the maximum allowed rate. In this case, you could use a multiport host adapter in the PC instead of a hub.

- If your camera is equipped with a rolling shutter, use the electronic rolling shutter (ERS) mode rather than the global reset release shutter mode. The ERS mode allows overlapping frame acquisition while the global reset release mode does not. Overlapping frame acquisitions is, however, necessary for achieving the highest frame rates.



If you are working with exposure time, keep in mind that a very long exposure time can severely limit the camera's maximum allowed frame rate.

Example: Assume that your camera is set to use a 1/2 second exposure time. In this case, because each frame acquisition will take at least 1/2 second to be completed, the camera will only be able to acquire a maximum of two frames per second.

For more information about

- ROI settings, see Section 9.5 on [page 84](#).
- the ERS mode, see Section 6.4.2 on [page 59](#).
- overlapping image acquisitions, see Section 6.5 on [page 62](#).

7 Color Creation and Enhancement

This chapter provides information about how color images are created on different camera models and about the features available for adjusting the appearance of the colors.

7.1 Color Creation and Bayer Color Filter Alignment

The sensors in the color versions of the Basler dart USB 3.0 cameras are equipped with an additive color separation filter known as a Bayer filter. The pixel formats available on color cameras for pixel data output are related to the Bayer pattern.

With the Bayer filter, each individual pixel is covered by a part of the filter 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 28.

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.

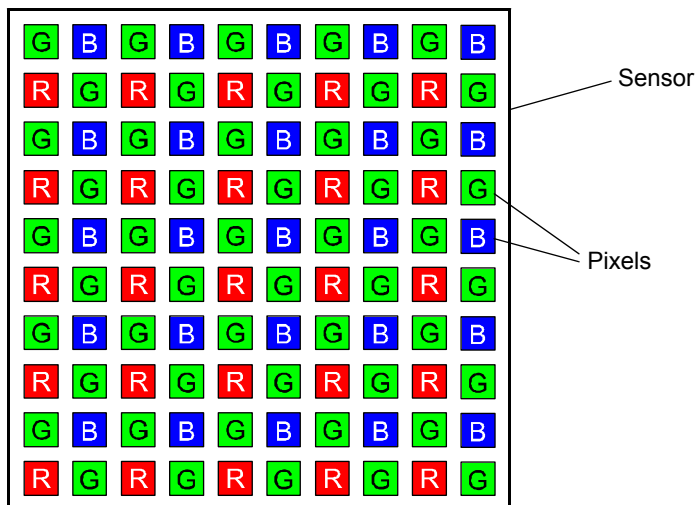


Fig. 28: Bayer Filter Pattern with "GB" Alignment

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



The standard alignment of the Bayer filter to the pixels in the images acquired by the dart color cameras is **GB**.

If you are using dart model daA1280-54uc, this alignment is fixed.

If you are using dart model daA1920-30uc or daA2500-14uc, the alignment will change if you enable image mirroring: If you use

- the reverse X feature to mirror the image horizontally, the effective Bayer color filter alignment will be BG.
- the reverse Y feature to mirror the image vertically, the effective Bayer color filter alignment will be RG.
- the reverse X and the reverse Y feature, the effective Bayer color filter alignment will be GR.

For more information about image mirroring, see Section 9.7.1 on [page 93](#) and Section 9.7.2 on [page 94](#).

7.2 Integrated IR Cut Filter

The dart CS-mount color cameras are equipped with an IR cut filter. The filter is mounted in a filter holder located in the lens mount.



The dart S-mount color cameras are not equipped with an IR cut filter. If you want to operate a dart S-mount color camera with an IR cut filter, you must attach a lens with an integrated IR cut filter to the camera.

NOTICE

Using a lens with a too long thread length can damage the IR cut filter or the filter holder.

Make sure that you do not damage the IR cut filter by using lenses with a too long lens thread. Otherwise, the IR cut filter or the filter holder will be damaged or destroyed and the camera will no longer operate.

For more information about the location of the IR cut filter in the camera, see Section 1.4.2 on [page 16](#).

7.3 Color Enhancement Features

7.3.1 Light Source Presets



For the light source presets to work properly, make sure that the pixel format is set to RGB 8 or YCbCr422. Light source presets cannot be selected if the pixel format is set to a Bayer 8 or Bayer 12 pixel format.

For more information about pixel formats, see Section 8 on [page 77](#).

CMOS image sensors do not accurately map object colors into the RGB color space, but the camera can apply a color transformation to correct most of the inaccuracy. The optimal setting depends on the spectral characteristics (“color temperature”) of the light source.

You can correct for the following kinds of light sources:

- **Off** - No light source preset is selected. Therefore, no alterations will be made to the pixel values according to a light source preset.
- **Tungsten 2800 K** - This setting will make appropriate corrections for images captured with tungsten lighting that has a color temperature of about 2800 K. When you select one of these settings, the camera will also adjust the white balance settings and the color adjustment settings so that they are appropriate for a tungsten incandescent light source with a color temperature of about 2800 K.
- **Daylight 5000 K / 6500 K** - These two settings will make appropriate corrections for images captured with daylight lighting that has a color temperature of about 5000 K / 6500 K. When you select one of these settings, the camera will also adjust the white balance settings and the color adjustment settings so that they are appropriate for a daylight light source with a color temperature of about 5000 K / 6500 K.



After camera power up or reset, the light source preset will be set to "Daylight 5000 K" unless you define a startup user set with a light source preset. For more information about user sets, see Section 9.13 on [page 109](#).

To set the Light Source Preset parameter value:

- Set the Light Source Preset parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
// Set the LightSourcePreset parameter value to "Off" (no correction)
camera.LightSourcePreset.SetValue(LightSourcePreset_Off);
```

```
//Set the LightSourcePreset parameter value to "Daylight5000K"
camera.LightSourcePreset.SetValue(LightSourcePreset_Daylight5000K);
```



```
// Set the LightSourcePreset parameter value to "Daylight6500K"
camera.LightSourcePreset.SetValue(LightSourcePreset_Daylight6500K);

// Set the LightSourcePreset parameter value to "Tungsten2800K"
camera.LightSourcePreset.SetValue(LightSourcePreset_Tungsten2800K);
```

7.3.2 White Balance

When looking at your acquired images, you might notice that the images come out with an e.g. orange, blue, or yellow look to them. The reason for this is that different sources of light have a different "color temperature". Fluorescent lighting adds a bluish cast to images whereas tungsten incandescent light adds a yellowish tinge.

The white balance feature allows you to correct these color shifts. A digital gain correction can be applied per color (red, green, blue) so that white objects in the camera's field of view appear white in the acquired images.

The white balance directly affects the "raw" pixel data. Therefore, it is effective on all pixel data output formats including "raw" pixel data formats (Bayer 8 and Bayer 12).

Setting the White Balance

This section describes how a color camera's white balance can be adjusted manually by setting the value of the Balance Ratio parameters for red, green, and blue. The camera also has a Balance White Auto function that can automatically adjust the white balance.



By default, the balance white auto function is enabled. Manual adjustment of the white balance will not work.

Set the Balance White Auto parameter to "Off" before making any manual adjustments.

For more information about the balance white auto function, see [Section 9.9.4 on page 101](#).

With the white balancing scheme used on the cameras, the red intensity, green intensity, and blue intensity can be individually 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.
- 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 1.25, the intensity of that color will be increased by 25 %.

The Balance Ratio parameter value can range from 1 to 7.984375.

To set the Balance Ratio parameter value for color :

1. Set the Balance Ratio Selector to red, green, or blue.
2. Set the Balance Ratio parameter to the desired value for the selected color.

You can set the Balance Ratio Selector and the Balance Ratio parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the selector and the parameter value for green as an example:

```
// Select the color for white balancing and set the related BalanceRatio value
camera.BalanceRatioSelector.SetValue(BalanceRatioSelector_Green);
camera.BalanceRatio.SetValue(1.25);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

7.3.3 Gamma Correction

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. Gamma correction is always performed in the RGB color space.

To accomplish gamma correction, a gamma correction value (γ) is applied to the pixel value of each red, green or blue pixel according to the following formula (shown for the red pixel value (R) as an example):

$$R_{\text{corrected}} = \left(\frac{R_{\text{uncorrected}}}{R_{\text{max}}} \right)^{\gamma} \times R_{\text{max}}$$

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.

The gamma correction value can be set in a range from 0 to 2.

When the gamma correction value is set to 1, the output pixel brightness will not be corrected (unless the pixel format is set to YCbCr422 or RGB8, see note below). The gamma correction value of 1 is the default value after camera reset or power up.

A gamma correction value between 0 and 1 will result in increased overall brightness, and a gamma correction value 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.



If the pixel format is set to **YCbCr422** or **RGB8**, an additional automatic gamma correction value of approximately 0.4 (sRGB gamma correction) is applied.

Note that this automatic gamma correction is independent from the Gamma parameter and will not be reflected in the Gamma parameter value.

Example: You set the pixel format to YCbCr422 and the Gamma parameter value to 1.2. First, an automatic gamma correction value of approximately 0.4 is applied to the pixel values. After that, a gamma correction value of 1.2 is applied to the resulting pixel values.

To set the Gamma parameter value:

- Set the Gamma parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter value to 1.2 as an example:

```
// Set the Gamma value to 1.2  
camera.Gamma.SetValue(1.2);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

7.3.4 A Procedure for Setting the Color Enhancements

When setting the color enhancements on the camera, we recommend using the procedure outlined below. Since it makes changing camera parameters quick and easy, we also recommend using the Basler pylon Viewer software when you are making adjustments.



The procedure aims at producing a color reproduction on a monitor that is optimized for human vision. The optimum for machine vision may require different color enhancement settings.

To set the color enhancements:

1. Arrange your camera so that it is viewing a scene similar to what it will view during actual operation. Make sure that the lighting for the scene is as close as possible to the actual lighting you will be using during normal operation. Using lighting that represents your normal operating conditions is extremely important.

We recommend including a standard color chart within your camera's field of view when you are adjusting the color enhancements. This will make it much easier to know when the colors are properly adjusted. One widely used chart is the ColorChecker® chart (also known as the Macbeth chart).

2. Set the exposure, gain, and white balance auto functions to "Off".
3. Make sure the settings for gain and black level are at their minimums.

4. Set the Light Source Preset parameter to the value that is most appropriate for your lighting. For example, if you use tungsten incandescent light, select the Tungsten2800K light source preset.
5. Begin capturing images and check the basic image appearance.
6. Set the exposure time, black level, and gain so that you are acquiring good quality images. It is important to make sure that the images are not overexposed. Overexposure can have a significant negative effect on the fidelity of the color in the acquired images. Generally, the settings for black level and gain should be as low as possible.
7. Adjust the white balance. Make sure a white or light gray object is imaged while white balance is carried out. An easy way to set the white balance is to use the "once" function on the camera's balance white auto feature.
8. If necessary, set the gamma value. When gamma is set correctly, there should be a smooth transition from the lightest to the darkest gray scale targets on your color chart or on a gray scale. If the camera is set to a light source preset and if the pixel format is set to a "raw" pixel format (Bayer 8 or Bayer 12), you may have to manually adjust the gamma parameter. For more information, see Section 7.3.1 on [page 72](#).
9. Examine the colors and see if they are satisfactory at this point.
10. If not, chose a different light source preset. Try each preset and determine which one gives you the best color results.



Certain conditions outside the camera, such as the lighting, the camera lens, filter or the monitor settings are relevant to the reproduction of color in the image. If you change any of these conditions you will have to repeat the above procedure to preserve optimum color reproduction.

8 Pixel Formats

8.1 Pixel Formats Available on Mono Cameras

For all dart **mono** cameras, the following pixel formats are available:

- Mono 8
- Mono 12

8.2 Pixel Formats Available on Color Cameras

For all dart **color** cameras, the following pixel formats are available:

- YCbCr422
- Bayer 8
- Bayer 12
- RGB 8



The standard alignment of the Bayer filter to the pixels in the images acquired by the dart color cameras is **GB**.

If you are using dart model daA1920-30uc or daA2500-14uc, the alignment will change if you enable image mirroring.

For more information about

- the color filter alignment, see Section 7.1 on [page 70](#).
- image mirroring, see Section 9.7.1 on [page 93](#) and Section 9.7.2 on [page 94](#).

You can find detailed information about the mono and color pixel formats in the Pixel Format Naming Convention, Version 1.1 and above. The document is available from the Automated Imaging Association (AIA).

You can set the Pixel Format parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the pixel format to Bayer GB 12:

```
// Set the pixel format to Bayer GB 12
camera.PixelFormat.SetValue(PixelFormat_BayerGB12);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

8.3 Details on Pixel Formats for Color Cameras

Bayer Formats

All dart color cameras can output color images based on the pixel formats Bayer 8 and Bayer 12.

When a color camera is set for one of these Bayer pixel formats, it outputs 8 or 12 bits of data per pixel and the pixel data is not processed or interpolated in any way, except for white balancing. Modifying the white balance will directly affect the "raw" pixel data.

For each pixel covered with a red, green, or blue filter, you get 8 or 12 bits of red, green, or blue data. This type of pixel data is sometimes referred to as "raw" output.

For more information about

- the Bayer filter, see Section 7.1 on [page 70](#).
- the white balance feature, see Section 7.3.2 on [page 73](#).

YUV Format

All dart color cameras can output color images based on pixel data in YUV format.

When a color camera is set for this format, each pixel value 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, Cb, and Cr color information for each pixel.

In the first step of the process, a demosaicing algorithm is performed to get RGB data for each pixel. This is required because color cameras with a Bayer filter on the sensor gather only one color of light for each individual pixel.

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

$$Y = 0.299 R + 0.587 G + 0.114 B$$

$$Cb = -0.16874 R - 0.33126 G + 0.5000 B + 128$$

$$Cr = 0.5000 R - 0.41869 G - 0.08131 B + 128$$

After conversion to the YCbCr color model is complete, the pixel data is transmitted to the host PC.

When a color camera is set for this format, each pixel value in the captured image goes through a 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 value.



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.

9 Features

9.1 Gain

The camera's gain feature is an analog feature allowing to adjust gain. As shown in Figure 29, 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.

This section describes how gain can be adjusted manually by setting the value of the Gain parameter. The camera also has a Gain Auto function that can automatically adjust the gain.

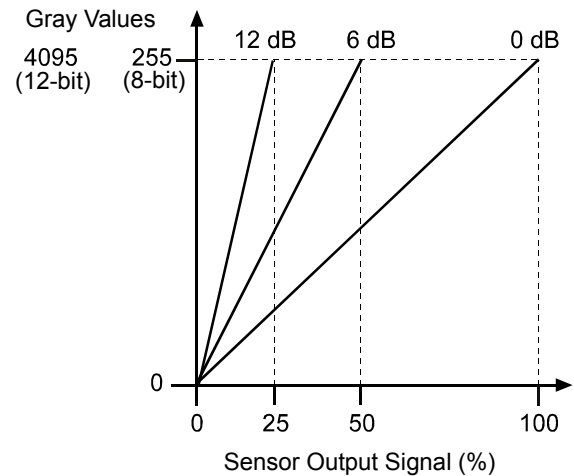


Fig. 29: Gain in dB



By default, the gain auto function is enabled. Manual adjustment of the Gain parameter will not work.

Set the Gain Auto parameter to "Off" before making any manual adjustments.

For more information about the gain auto function, see Section 9.9.2 on [page 99](#).

The camera's gain is determined by the value of the Gain parameter. The parameter is adjusted in dB. The maximum regular value varies by camera model (see Table 20).

Camera Model	Max Allowed Setting (in dB)
daA1280-54um/uc	18
daA1920-15um	24
daA1920-30um/uc	24
daA2500-14um/uc	24

Table 20: Maximum Allowed Gain Settings (in dB)

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

```
// Set the gain to 0.0359  
camera.Gain.SetValue(0.0359);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

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 (+1) in the pixel values output for the pixels. Decreasing the black level setting will result in a negative offset (-1) in the pixel values output for the pixels.

The black level can be adjusted by changing the value of the Black Level parameter.

The range of the allowed settings for the Black Level parameter value in DN varies by pixel format as shown in Table 21.

Min Allowed Black Level Setting	Max Allowed Black Level Setting (8 bit pixel format)	Max Allowed Black Level Setting (12 bit pixel format)
0	32	512

Table 21: Minimum and Maximum Black Level Settings [DN]

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

```
// Set the black level to 1.0  
camera.BlackLevel.SetValue(1.0);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.3 Contrast Enhancement

The contrast enhancement feature allows you to adjust the contrast of the captured images. The camera increases the contrast by setting the darkest regions of the image to black. A digital gain is applied to the remaining pixels to maintain the original saturation level.

This feature is available on both mono and color cameras.

You can adjust the contrast by setting the Contrast Enhancement parameter value. The parameter value can range from 0 (no enhancement applied) to 1 (maximum enhancement applied).

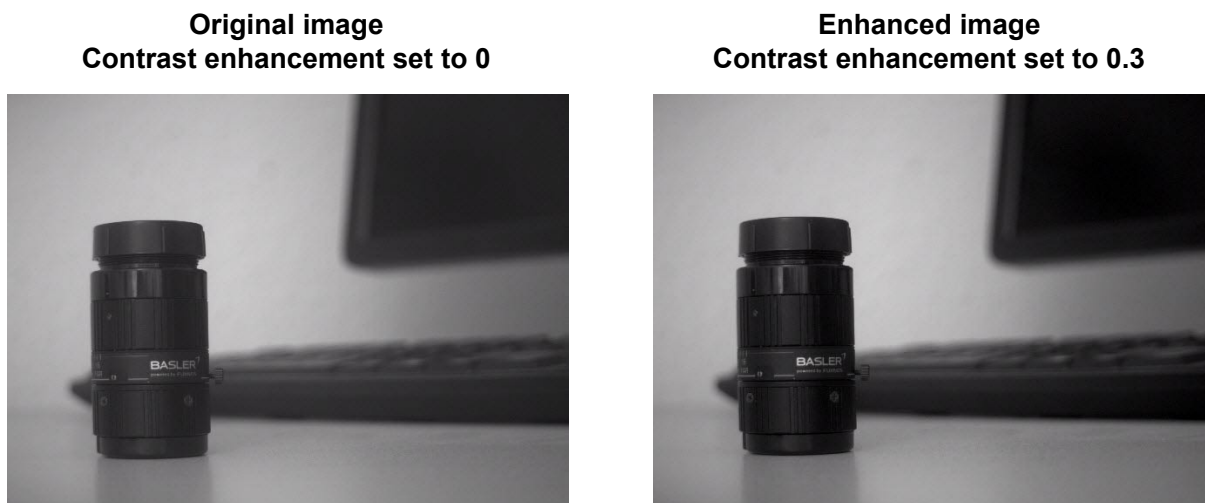


Fig. 30: Contrast Enhancement Comparison

You can set the contrast enhancement from within your application software by using the pylon API. The following code snippet illustrates using the API to set the Contrast Enhancement parameter value:

```
// Set the Contrast Enhancement parameter value to 0.3
camera.ContrastEnhancement.SetValue(0.3);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.4 Sharpness Enhancement



The sharpness enhancement feature is **not** available

- on dart mono cameras.
- on cameras that are set for a "raw" pixel format (Bayer 8 or Bayer 12). For more information about pixel formats, see Section 8 on [page 77](#).

The sharpness enhancement feature lets you increase the sharpness of the captured images. The higher the sharpness, the more distinct the image subject's contours will be.

You can adjust the amount of sharpness by setting the Sharpness Enhancement parameter value. The parameter value can range from 0 (no sharpening applied) to 1 (maximum sharpening applied).



If you use the gain and the sharpness enhancement feature at the same time, increasing the Gain parameter will reduce the amount of sharpening applied. The value of the Sharpness Enhancement parameter will remain the same, but the image will appear less sharpened. This adjustment is done automatically to keep image noise as low as possible.

You can set the sharpness enhancement from within your application software by using the pylon API. The following code snippet illustrates using the API to set the Sharpness Enhancement parameter value:

```
// Set the Sharpness Enhancement parameter value to 0.39
camera.SharpnessEnhancement.SetValue(0.39);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.5 Image Region of Interest (ROI)

The image region of interest (ROI) feature lets you specify a portion of the sensor array. After each image is acquired, only the pixel information from the specified portion of the array is transmitted out of the camera.

The region 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 31.

The location and size of the region of interest is defined by declaring an offset X (coordinate), a width, an offset Y (coordinate), and a height. For example, suppose that you specify the offset X as 10, the width as 16, the offset Y as 6, and the height as 10. The region of the array that is bounded by these settings is shown in Figure 31.

The camera will only transmit pixel data from within the region defined by your settings. Information from the pixels outside of the region of interest is discarded.

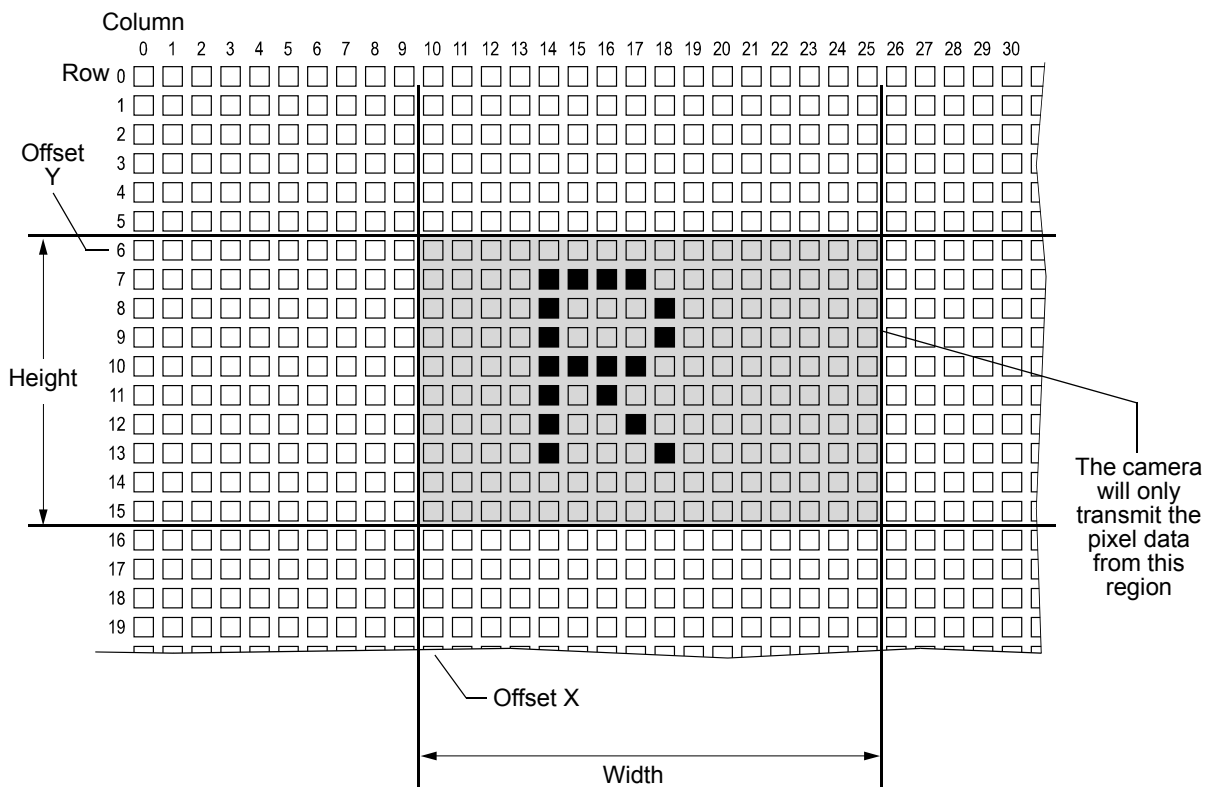


Fig. 31: Region of Interest

One of the main advantages of the image ROI feature is that decreasing the height of the ROI can increase the camera's maximum allowed acquisition frame rate.

For more information about how changing the ROI height affects the maximum allowed frame rate, see Section 6.7 on [page 67](#).

Guidelines for Setting the Image ROI

By default, the ROI is set to use the full resolution of the camera's sensor. You can change the size and the position of the ROI by changing the value of the camera's Offset X, Offset Y, Width, and Height parameters.

- Offset X: determines the starting column for the region of interest.
- Offset Y: determines the starting row for the region of interest.
- Width: determines the width of the region of interest.
- Height: determines the height of the region of interest.

When you are setting the camera's ROI, you must follow these guidelines:

Guideline	Example
Offset X + ROI width < Width of camera sensor	daA1280-54um: Offset X: 463, ROI width: 500 Width of camera sensor: 1280 $463 + 500 < 1280$
Offset Y + ROI height < Height of camera sensor	daA1280-54um: Offset Y: 351, ROI height: 200 Height of camera sensor: 960 $351 + 200 < 960$

Table 22: Guidelines for Setting the Camera's ROI

ROI Parameters	Camera Model	Parameter Range	Example
Offset X Offset Y	daA1280-54um/uc daA1920-15um daA1920-30um/uc daA2500-14um/uc	<ul style="list-style-type: none"> ■ Can be set in increments of 2 ■ Must be set to an even number 	0, 2, 4, 6, 8, etc.
Width	daA1280-54um/uc	<ul style="list-style-type: none"> ■ Can be set in increments of 2 ■ Minimum value is 16 	16, 18, 20, 22, 24, etc.
	daA1920-15um daA1920-30um/uc daA2500-14um/uc	<ul style="list-style-type: none"> ■ Can be set in increments of 2 ■ Minimum value is 4 	4, 6, 8, 10, 12, etc.
Height	daA1280-54um/uc	<ul style="list-style-type: none"> ■ Can be set in increments of 2 ■ Minimum value is 8 	8, 10, 12, 14, 16, etc.
	daA1920-15um daA1920-30um/uc daA2500-14um/uc	<ul style="list-style-type: none"> ■ Can be set in increments of 2 ■ Minimum value is 4 	4, 6, 8, 10, 12, etc.

Table 23: ROI Parameters and Parameter Ranges

You can set the Offset X, Offset Y, Width, and Height parameter values from within your application software by using the Basler pylon API. The following code snippets illustrate using the API to get the maximum allowed settings for the Width and Height parameters. They also illustrate setting the Offset X, Offset Y, Width, and Height parameter values:

```
int64_t i = camera.WidthMax.GetValue();  
int64_t i = camera.HeightMax.GetValue();  
  
camera.Width.SetValue(1294);  
camera.Height.SetValue(964);  
  
camera.OffsetY.SetValue(0);  
camera.OffsetX.SetValue(0);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

Changing ROI Parameters "On-the-Fly"

Making ROI 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 following parameters:

- Offset X
- Offset Y

Changes to the ROI size are not allowed on-the-fly.

9.6 Binning

With binning, multiple sensor pixels are combined and reported out of the camera as a single pixel.

Binning Directions

You can set binning in two directions: horizontal or vertical.

- With **vertical binning**, adjacent pixels from a specific number of **rows** in the imaging sensor array are combined and are reported out of the camera as a single pixel.
- With **horizontal binning**, adjacent pixels from a specific number of **columns** are combined and are reported out of the camera as a single pixel.

You can use both vertical and horizontal binning at the same time. However, if you use a different binning factor for vertical and horizontal binning, objects will appear distorted in the image. For more information about possible image distortion, see Section 9.6.3 on [page 92](#).

The number of binned pixels depends on the vertical binning and the horizontal binning settings. For more information about the binning settings, see Section 9.6.1 on [page 89](#).

Binning Modes

Two modes can be used to perform binning:

- **Sum**: The values of the affected pixels are summed. This increases the camera's response to light and the signal-to-noise ratio.
- **Average**: The values of the affected pixels are averaged. This increases the signal-to-noise ratio without changing the camera's response to light.

Both modes reduce the amount of image data to be transferred. This may result in higher camera frame rates.

The vertical binning mode and the horizontal binning mode can be set independently.

Usually, the binning modes used by the camera (vertical and horizontal) are preset and cannot be changed. However, on specific camera models and for specific binning directions, the binning mode can be set (see Table 24).

Camera Model	Vertical Binning Mode	Horizontal Binning Mode
daA1280-54um/uc	Average	Average
daA1920-15um daA1920-30um/uc daA2500-14um/uc	Sum	Average or Sum (settable)

Table 24: Camera Models and Supported Binning Modes

For more information about setting the binning mode, see Section 9.6.2 on [page 90](#).

Binning on Color and Monochrome Cameras

On monochrome cameras, the values of directly adjacent pixels are summed or averaged:

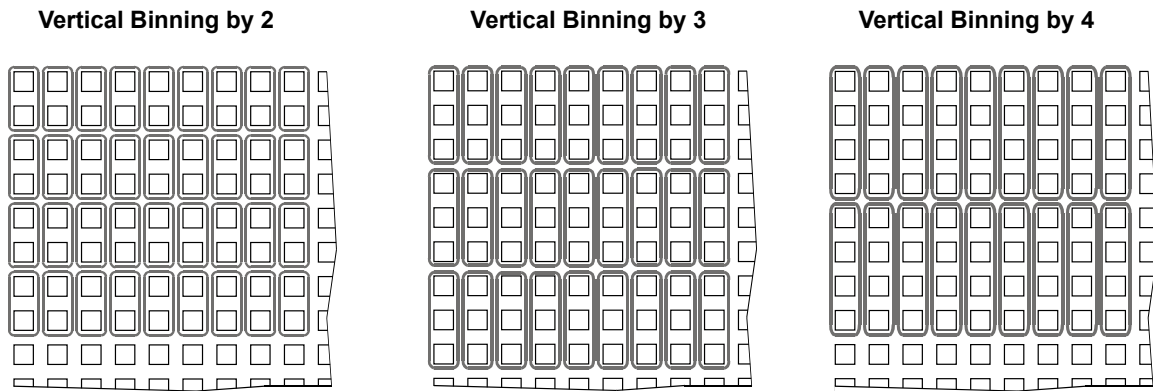


Fig. 32: Vertical Binning on Monochrome Cameras

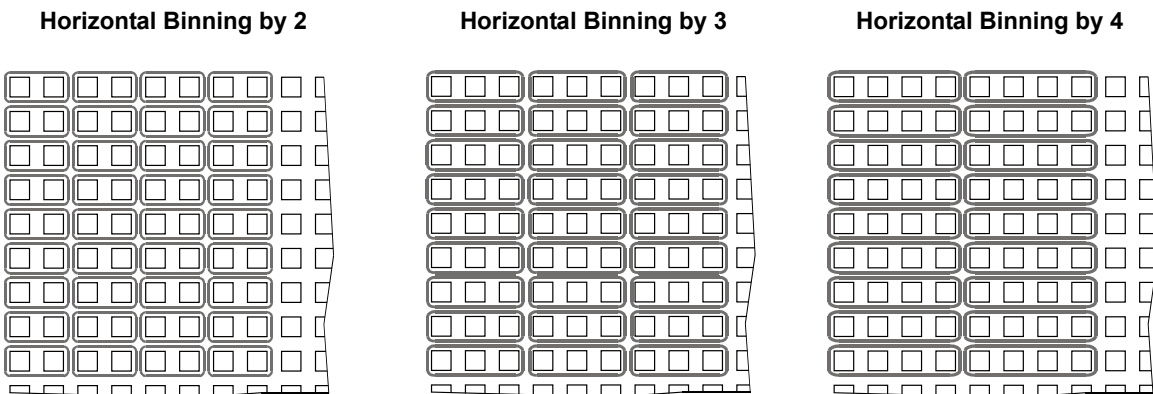


Fig. 33: Horizontal Binning on Monochrome Cameras

Horizontal and Vertical Binning by 2

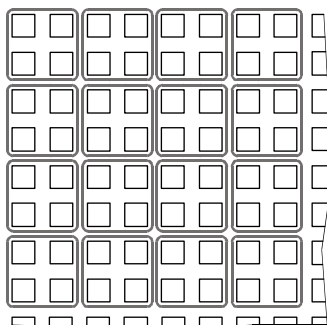


Fig. 34: Horizontal and Vertical Binning on Monochrome Cameras

On color cameras, the values of adjacent pixels of the same color are summed or averaged:

Vertical Color Binning by 2

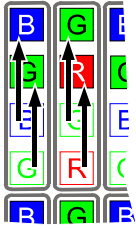


Fig. 35: Vertical Color Binning on Color Cameras

Horizontal Color Binning by 2

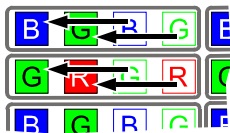


Fig. 36: Horizontal Color Binning on Color Cameras

Horizontal and Vertical Color Binning by 2

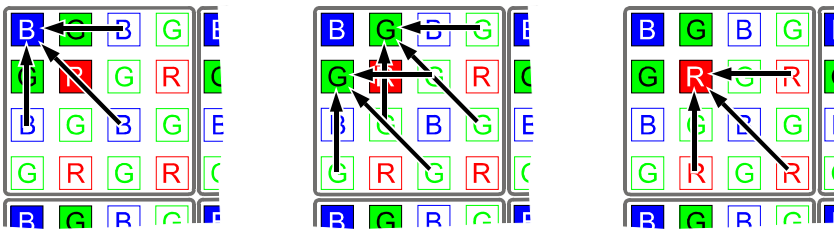


Fig. 37: Horizontal and Vertical Binning on Color Cameras

9.6.1 Setting Binning

You can enable

- **vertical binning** by setting the **Binning Vertical** parameter.
- **horizontal binning** by setting the **Binning Horizontal** parameter.

This applies to both color and mono cameras.

Setting the parameter's value to 2, 3, or 4 enables vertical or horizontal binning by 2, by 3, or by 4, respectively. Setting the parameter's value to 1 disables vertical or horizontal binning.

The range of allowed settings for the Binning Vertical and the Binning Horizontal parameter values varies by camera model as shown in Table 25.

Camera Model	Allowed Settings for the Binning Vertical Parameter	Allowed Settings for the Binning Horizontal Parameter	Notes
daA1280-54um/uc	1, 2 (*)	1, 2	* Vertical binning by 2 is only allowed if horizontal binning is also set to 2. To enable vertical binning by 2, set horizontal binning first, then set vertical binning.
daA1920-15um daA1920-30um/uc daA2500-14um/uc	1, 2, 3, 4	1, 2, 3 (**), 4	** Horizontal binning by 3 is not supported. Setting the parameter value to 3 is allowed, but will result in an effective horizontal binning by 2.

Table 25: Binning Vertical and Binning Horizontal Settings

You can set the Binning Vertical and the Binning Horizontal parameter values from within your application software by using the Basler 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);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.6.2 Setting the Binning Mode

Usually, the binning modes used by the camera (vertical and horizontal) are preset and cannot be changed. However, on specific camera models and for specific binning directions, the binning mode can be set.

If supported, you can set the

- **horizontal binning mode** by setting the **Binning Horizontal Mode** parameter
- **vertical binning mode** by setting the **Binning Vertical Mode** parameter.

For more information about the supported binning modes, see Section 9.6 on [page 87](#).



Basler dart cameras currently do not support setting the vertical binning mode. However, you can determine the current vertical binning mode by reading the Binning Vertical Mode parameter value.

You can set the Binning Vertical Mode and the Binning Horizontal Mode parameter values from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values:

```
// Set the horizontal binning mode to Average
camera.BinningHorizontalMode.SetValue(BinningHorizontalMode_Average);

// Determine the vertical binning mode
e = camera.BinningVerticalMode.GetValue();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.6.3 Considerations When Using Binning

Binning's Effect on ROI Settings

When you have the camera set to use binning, keep in mind that the settings for your image region of interest (ROI) will refer to the binned rows and columns in the sensor and not to the physical rows and columns 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 an daA1280-54um camera set for 2 by 2 binning as described above. In this case, you would act as if you were actually working with a 640 column by 480 row sensor when setting your ROI parameters. The maximum ROI width would be 640 and the maximum ROI height would be 480.

For more information about the image region of interest (ROI) feature, see Section 9.5 on [page 84](#).

Increased Response to Light

Using binning with summed pixel values (see "Binning Modes" in Section 9.6 on [page 87](#)) can greatly increase the camera's response to light. When pixel values are summed, the acquired images may look overexposed. If this is the case, you can reduce the lens aperture, the intensity of your illumination, the camera's exposure time setting, or the camera's gain setting.

Reduced Resolution

Using binning effectively reduces the resolution of the camera's imaging sensor. For example, the sensor in the daA1280-54um camera normally has a resolution of 1280 (H) x 960 (V). If you set this camera to use horizontal binning by 2 and vertical binning by 2, the effective resolution of the sensor is reduced to 640 (H) by 480 (V).

Possible Image Distortion

Objects will only appear undistorted in the image if the numbers 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.

9.7 Mirror Imaging

The camera's reverse X and reverse Y functions let you flip the captured images horizontally and/or vertically before they are transmitted from the camera.

The reverse X and reverse Y functions may both be enabled at the same time if so desired. This effectively rotates the image by 180 degrees.

9.7.1 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.

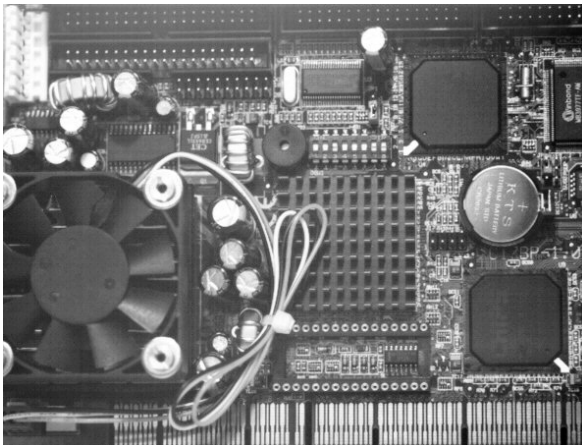


If you are using dart model daA1920-30uc or daA2500-14uc, the effective Bayer color pixel alignment will change from GB to BG if you enable reverse X.

For more information about color pixel alignments, see Section 7.1 on [page 70](#).

Figure 38 shows a normal image on the left and an image captured with reverse X enabled on the right.

Normal Image



Mirror Image

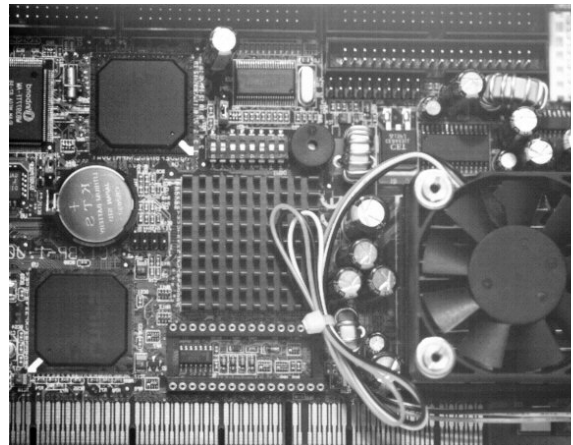


Fig. 38: Reverse X Mirror Imaging

Using ROIs with Reverse X

You can use the ROI feature when using the reverse X feature. The position of an ROI relative to the sensor remains the same regardless of whether or not the reverse X feature is enabled.

As a consequence, an ROI will display different images depending on whether or not the reverse X feature is enabled. See example in Figure 39.

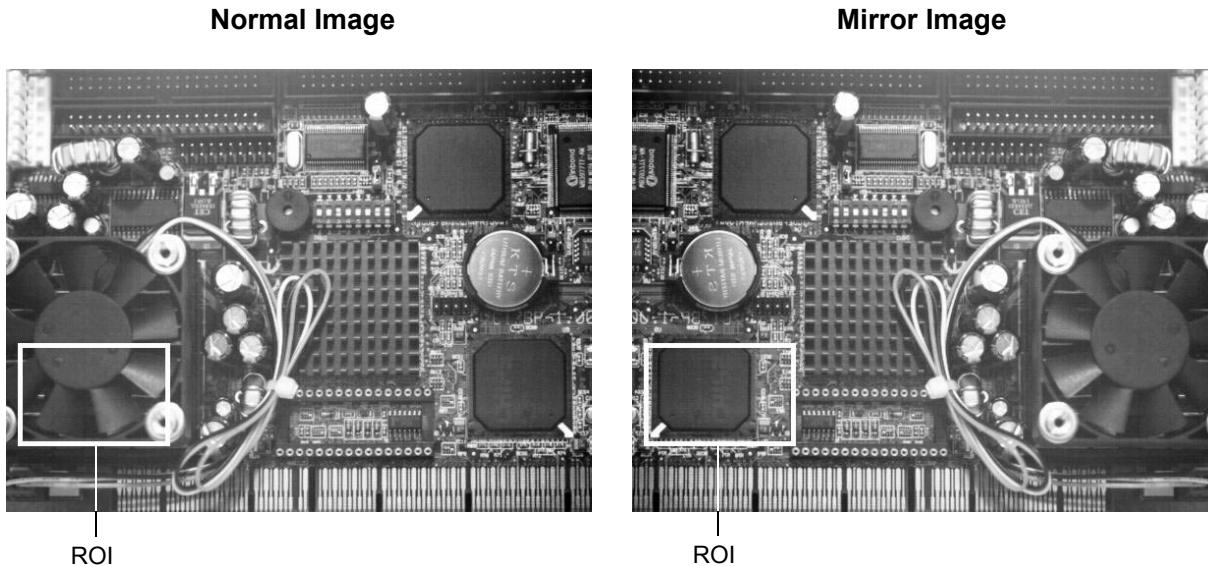


Fig. 39: Using an ROI with Reverse X Mirror Imaging

9.7.2 Reverse Y

The reverse Y feature is a vertical mirror image feature. When the reverse Y feature is enabled, the lines in a captured image will be swapped top-to-bottom. This means that the top line in the image will be swapped with the bottom line, the next-to-top line will be swapped with the next-to-bottom line, and so on.



If you are using dart model daA1920-30uc or daA2500-14uc, the effective Bayer color pixel alignment will change from GB to RG if you enable reverse Y.
For more information about color pixel alignments, see Section 7.1 on [page 70](#).

Figure 40 shows a normal image on the left and an image captured with reverse Y enabled on the right.

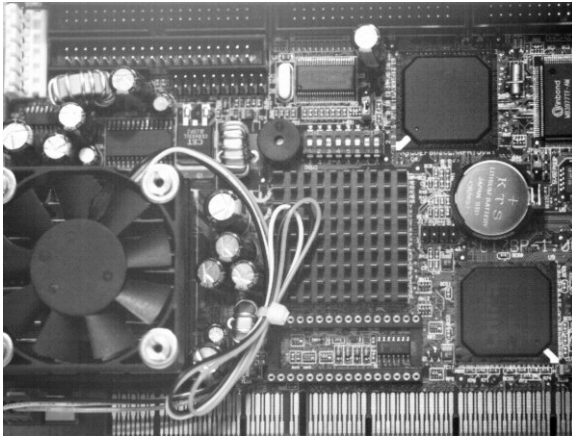
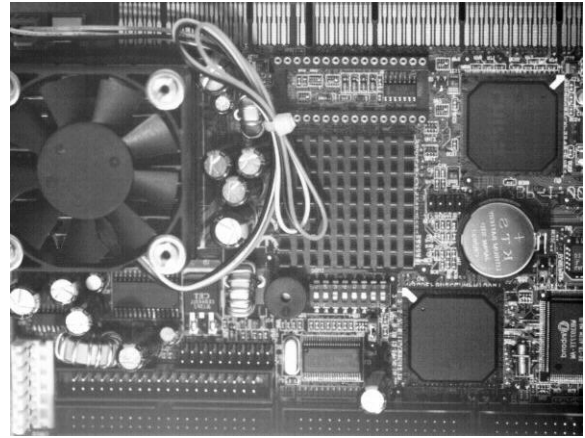
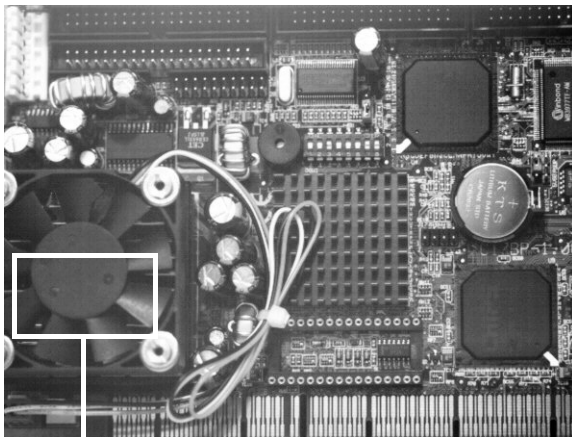
Normal Image**Reverse Y Mirror Image**

Fig. 40: Reverse Y Mirror Imaging

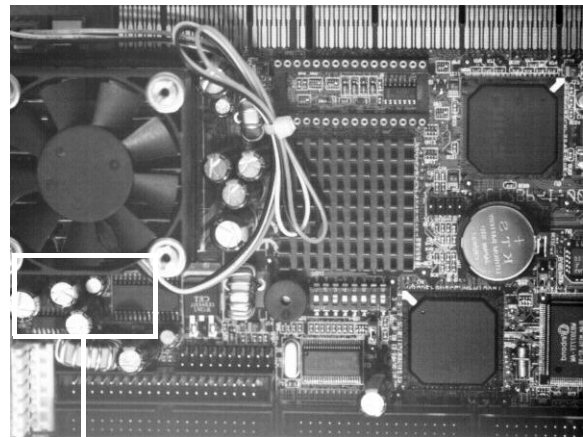
Using ROIs with Reverse Y

You can use the ROI feature when using the reverse Y feature. The position of an ROI relative to the sensor remains the same regardless of whether or not the reverse Y feature is enabled.

As a consequence, an ROI will display different images depending on whether or not the reverse Y feature is enabled. See example in Figure 41.

Normal Image

ROI

Reverse Y Mirror Image

ROI

Fig. 41: Using an ROI with Reverse Y Mirror Imaging

9.7.3 Enabling Reverse X and Reverse Y

You can enable the reverse X and reverse Y features by setting the Reverse X and the Reverse Y parameter values. You can use the pylon API to set the parameter values from within your application software. The following code snippet illustrates using the API to set the parameter values:

```
// Enable reverse X
camera.ReverseX.SetValue(true);

// Enable reverse Y
camera.ReverseY.SetValue(true);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.8 Defect Pixel Correction

When analyzing your acquired images, some pixels may appear significantly brighter or darker than the rest, even when uniform light is used. This problem arises from sensitivity differences among the pixels due to production tolerances.

The defect pixel correction minimizes the influence of these sensitivity differences.

The feature is enabled by default. When enabled, the camera identifies pixels that have a significantly greater or lesser intensity value than its neighboring pixels ("outlier pixels") and adjusts their intensity value.

You can enable or disable the defect pixel correction feature from within your application software by using the pylon API. The following code snippet illustrates using the API to disable the pixel correction:

```
// Disable pixel correction
camera.DefectPixelCorrectionMode.SetValue(DefectPixelCorrectionMode_Off);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.9 Auto Functions

Auto functions control image properties and are the "automatic" counterparts of certain features such as the gain feature or the white balance feature, which require manually setting the related parameter values.



By default, all auto functions (exposure auto, balance white auto, and gain auto) are enabled. They are set to the "continuous" mode of operation (see Section 9.9.1 on [page 98](#)).

If you want to manually set the parameter values for gain, exposure time, or white balance, you must first set the corresponding auto function parameter (Exposure Auto, Balance White Auto, or Gain Auto) to "Off".

After camera power up or reset, all auto functions will be re-enabled unless you define a startup user set with auto functions turned off. For more information about user sets, see Section 9.13 on [page 109](#).

Auto functions are particularly useful to keep good image quality under frequently changing conditions, e.g. unreliable light conditions.

An auto function automatically adjusts a parameter value until the related image property reaches a target value. Each auto function uses the pixel data of the full image as the base for adjusting.

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.

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.

9.9.1 Auto Function Operating Modes

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.



If an auto function is set to the "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 50 images and will then be set to "off".

- All auto functions also provide a **"continuous"** mode of operation where the parameter value is adjusted repeatedly while images are acquired. This is the default mode of operation.

Depending on the current frame rate, the automatic adjustments will usually be carried out for every or every other image.

The repeated automatic adjustment will proceed until the "once" mode of operation is used or until the auto function is set to "off".

- When an auto function is set to **"off"**, the parameter value resulting from the latest automatic adjustment will operate, unless the parameter is manually adjusted.



You can enable auto functions and change their settings while the camera is capturing images ("on the fly").



If 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.

9.9.2 Gain Auto

Gain Auto is the "automatic" counterpart to manually setting the gain parameter. When the gain auto function is operational, the camera will automatically adjust the gain parameter value within set limits until a target average gray value for the pixel data from the related Auto Function ROI is reached.

The gain auto function can be operated in the "once" and "continuous" modes of operation.

The gain auto function and 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

- setting the gain manually, see Section 9.1 on [page 79](#).
- the auto function profile feature, see Section 9.9.5 on [page 102](#).

The limits within which the camera will adjust the gain parameter are defined by the Auto Gain Upper Limit and the Auto Gain Lower Limit parameters.

The Auto Target Brightness parameter defines the target average gray value that the gain auto function will attempt to achieve when it is automatically adjusting the gain value. The target average gray value can range from 0 (black) to 255 (white) when the camera is set for an 8-bit pixel format or from 0 (black) to 4095 (white) when the camera is set for a 12-bit pixel format.

To set the gain auto function:

1. Set the value of the Auto Gain Lower Limit and Auto Gain Upper Limit parameters.
2. Set the value of the Auto Target Brightness parameter.
3. Set the value of the Gain Auto parameter for the "once" or the "continuous" mode of operation.

You can set the gain auto function from within your application software by using the pylon API. The following code snippets illustrate using the API to set the gain auto function:

```
// Set the upper and lower gain limits for
// the gain auto function
camera.AutoGainLowerLimit.SetValue(0.0);
camera.AutoGainUpperLimit.SetValue(19.745);

// Set the lowest possible lower limit and the highest possible
// upper limit for the gain auto function
camera.AutoGainLowerLimit.SetValue( camera.AutoGainLowerLimit.GetMin());
camera.AutoGainUpperLimit.SetValue(
camera.AutoGainUpperLimit.GetMax());

// Set the target gray value for the selected auto function
// The parameter value range refers to the theoretically maximum
// available range of gray values for the set pixel format.
// For example, if an 8 bit pixel format is set, a parameter value
// of 0.50196 will correspond to a gray value of 128.
camera.AutoTargetBrightness.SetValue(0.50196);
// Set the mode of operation for the gain auto function
```

```
camera.GainAuto.SetValue(GainAuto_Once);
```

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

For more information about

- the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).
- auto functions, see Section 9.9 on [page 97](#).

9.9.3 Exposure Auto



The exposure auto function will not work if the camera's exposure mode is set to trigger width. For more information about the trigger width exposure mode, see Section 6.2.3 on [page 53](#).

Exposure Auto is the "automatic" counterpart to manually setting the Exposure Time parameter. The exposure auto function automatically adjusts the Exposure Time parameter value within set limits until a target average gray value for the pixel data of the full image is reached.

The exposure auto function can be operated in the "once" and "continuous" modes of operation.

The exposure auto function and the gain 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 setting the exposure time manually, see Section 6.3 on [page 56](#).

For more information about the auto function profile feature, see Section 9.9.5 on [page 102](#).

The limits within which the camera will adjust the Auto Exposure Time parameter are defined by the Auto Exposure Time Upper Limit and the Auto Exposure Time Lower Limit parameters. The current minimum and the maximum allowed settings for the Auto Exposure Time Upper Limit parameter and the Auto Exposure Time Lower Limit parameters depend on the minimum allowed and maximum possible exposure time for your camera model.

The Auto Target Brightness parameter defines the target average gray value that the exposure auto function will attempt to achieve when it is automatically adjusting the Exposure Time value. The target average gray value may range from 0 (black) to 255 (white) when the camera is set for an 8-bit pixel format or from 0 (black) to 4095 (white) when the camera is set for a 12-bit pixel format.



If the Auto Exposure Time Upper Limit parameter is set to a sufficiently high value, the camera's frame rate can be decreased.

To set the exposure auto function:

1. Set the value of the Auto Exposure Time Lower Limit and Auto Exposure Time Upper Limit parameters.
2. Set the value of the Auto Target Brightness parameter.
3. Set the value of the Exposure Auto parameter for the "once" or the "continuous" mode of operation.

You can set the exposure auto function from within your application software by using the pylon API. The following code snippets illustrate using the API to set the exposure auto function:

```
// Set the exposure time limits for exposure auto control
camera.AutoExposureTimeLowerLimit.SetValue(1000.0);
camera.AutoExposureTimeUpperLimit.SetValue(500000.0);

// Set the target gray value for the selected auto function
// The parameter value range refers to the theoretically maximum
// available range of gray values for the set pixel format.
// For example, if an 8 bit pixel format is set, a parameter value
// of 0.50196 will correspond to a gray value of 128.
camera.AutoTargetBrightness.SetValue(0.50196);

// Set the mode of operation for the exposure auto function
camera.ExposureAuto.SetValue(ExposureAuto_Continuous);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

For general information about auto functions, see Section 9.9 on [page 97](#).

9.9.4 Balance White Auto

Balance White Auto is the "automatic" counterpart to manually setting the white balance. The balance white auto function is only available on color models.

For more information about white balance and setting the white balance manually, see Section 7.3.2 on [page 73](#).

To set the balance white auto function using the Basler pylon API, set the value of the Balance White Auto parameter for the "once" or the "continuous" mode of operation.

You can set the white balance auto functionality from within your application software by using the pylon API. The following code snippets illustrate using the API to set the balance auto functionality:

```
// Set mode of operation for balance white auto function to "once"
camera.BalanceWhiteAuto.SetValue(BalanceWhiteAuto_Once);
// Set mode of operation for balance white auto function to "continuous"
camera.BalanceWhiteAuto.SetValue(BalanceWhiteAuto_Continuous);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

For general information about auto functions, see Section 9.9 on [page 97](#).

9.9.5 Auto Function Profile



The auto function profile feature will only take effect if you use the gain auto function and the exposure auto function at the same time.

The auto function profile specifies how the gain and the exposure time will be balanced when the camera is making automatic adjustments.

If you want to use this feature, you must enable both the gain auto function and the exposure auto function and set both for the continuous mode of operation.

All Basler dart cameras support the following auto function profiles:

- **Minimize Gain:** Gain will be kept as low as possible during automatic adjustments.
- **Minimize Exposure:** Exposure time will be kept as low as possible during automatic adjustments.
- **Smart (default):** Gain will be kept as low as possible and the frame rate will be kept as high as possible during automatic adjustments. This is a four-step process:
 1. The camera will adjust the exposure time to achieve the target average gray value.
 2. If the exposure time must be increased to achieve the target average gray value, the camera increases the exposure time until a lowered frame rate is detected.
 3. If a lowered frame rate is detected, the camera stops increasing the exposure time and increases gain until the `AutoGainUpperLimit` value is reached.
 4. If the `AutoGainUpperLimit` is reached, the camera stops increasing gain and increases the exposure time until the target average gray value is reached. This will result in a lower frame rate.
- **Anti-Flicker 50 Hz / Anti-Flicker 60 Hz:** Gain and exposure time will be optimized to reduce flickering. If the camera is operating in an environment where the lighting flickers at a 50-Hz or a 60-Hz rate, the flickering lights can cause significant changes in brightness from image to image. Enabling the anti-flicker profile may reduce the effect of the flickering in the captured images.

Depending on your local power line frequency (e.g. North America: 60 Hz, Europe: 50 Hz), set the auto function profile to `AntiFlicker50Hz` or to `AntiFlicker60Hz`.

To set the auto function profile:

1. Set the value of the Auto Function Profile parameter to
 - AutoFunctionProfile_MinimizeGain,
 - AutoFunctionProfile_MinimizeExposureTime,
 - AutoFunctionProfile_Smart,
 - AutoFunctionProfile_AntiFlicker50Hz, or
 - AutoFunctionProfile_AntiFlicker60Hz.
2. Set the value of the Gain Auto parameter to the "continuous" mode of operation.
3. Set the value of the Exposure Auto parameter 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 snippet illustrates using the API to set the auto function profile. As an example, the MinimizeGain auto function profile is set:

```
// Keep gain as low as possible during automatic adjustments
camera.AutoFunctionProfile.SetValue(AutoFunctionProfile_MinimizeGain);
camera.GainAuto.SetValue(GainAuto_Continuous);
camera.ExposureAuto.SetValue(ExposureAuto_Continuous);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.10 Backlight Compensation



The backlight compensation feature will only take effect if you use the gain auto function or the exposure auto function or both. For more information about auto functions, see Section 9.9 on [page 97](#).

If a bright light comes from behind your image subject, the subject may be underexposed and appear silhouetted. The backlight compensation feature allows the camera to compensate for this underexposure.

You can adjust the backlight compensation by changing the value of the Auto Backlight Compensation parameter. The parameter value can range from 0 to 0.5.

When the Auto Backlight Compensation parameter value is set, a given percentage of the brightest pixels in the image (i.e. the pixels with the highest pixel values) will not be taken into account for the target average gray value calculations. These calculations are performed by the gain auto function and the exposure auto function (see Section 9.9.2 on [page 99](#) and Section 9.9.3 on [page 100](#)).

For example, if you set the parameter value to 0.3, then 30 % of the brightest pixels in the image will not be taken into account for the target average gray value calculations.

This allows the camera to properly expose the darker regions of the image.

You can set the backlight compensation from within your application software by using the pylon API. The following code snippets illustrate using the API to set the Auto Backlight Compensation parameter value:

```
// Set the Auto Backlight Compensation parameter value to 0.3  
camera.AutoBacklightCompensation.SetValue(0.3);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.11 Test Patterns

All cameras include the ability to generate test patterns. Test patterns are used to check the camera's basic functionality and its ability to transmit an image to the host PC.

Test patterns can be used for service purposes and for failure diagnostics.

Enabling a Test Pattern

The Test Pattern parameter is used to set the camera to output a test pattern. You can set the value of the Test Pattern parameter to one of the test patterns or to "test pattern off".

You can set the Test Pattern parameter from within your application software by using the Basler pylon API. The following code snippets illustrate using the API to set the parameter:

```
// Set for no test pattern
camera.TestPattern.SetValue(TestPattern_Off);
// Set for the first test pattern
camera.TestPattern.SetValue(TestPattern_GreyDiagonalSawtooth8);
// Set for the second test pattern
camera.TestPattern.SetValue(TestPattern_ColorDiagonalSawtooth8);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

Test Pattern 1: Gray Diagonal Sawtooth (8 bit)

The test pattern "Gray Diagonal Sawtooth" (8 bit) is best suited for use when the camera is set for monochrome 8-bit output. The test pattern 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 pattern 1 will look similar to Figure 42.

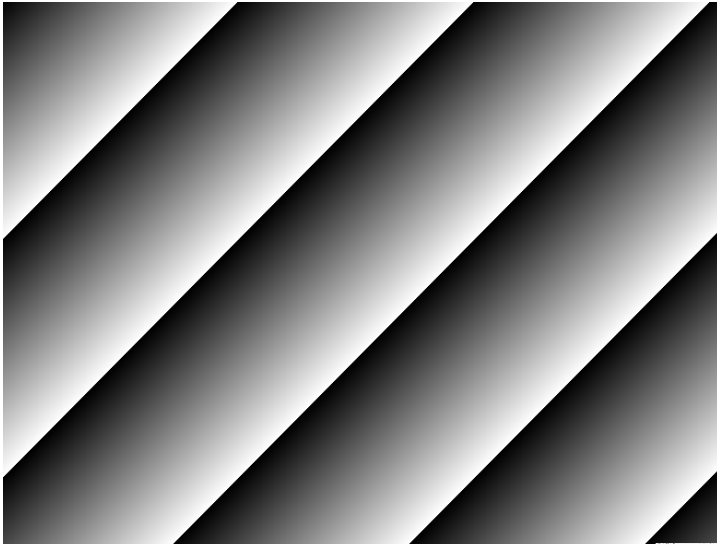


Fig. 42: Test Pattern 1

Test Pattern 2: Color Diagonal Sawtooth

The test pattern "Color Diagonal Sawtooth" is available on color cameras only. As shown in Figure 43, the test pattern consists of diagonal color gradients.

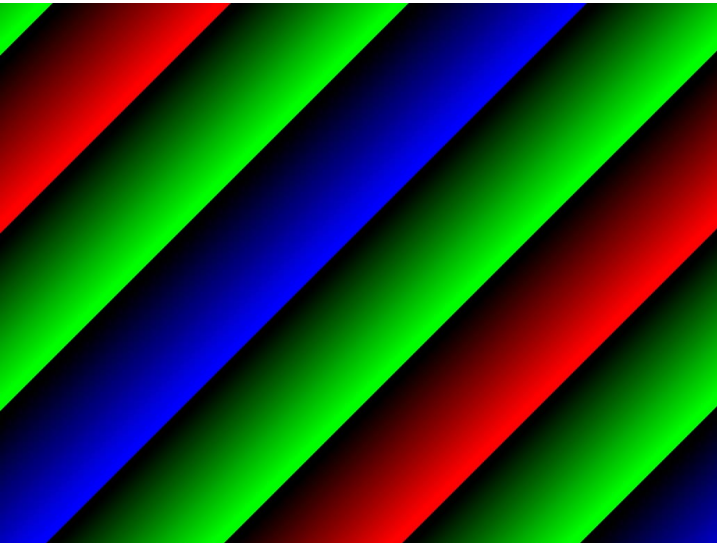


Fig. 43: Test Pattern 2

9.12 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 camera vendor's name.
- Device Model Name (read only) - contains the model name of the camera.
- Device Manufacturer Info (read only) - can contain some information about the camera manufacturer. This string usually indicates "none".
- Device Version (read only) - contains the device version number for the camera.
- Device Firmware Version (read only) - contains the version of the firmware in the camera.
- Device Serial Number (read only) - contains the serial number of the camera.
- Device User ID (read / write) - is used to assign a user-defined name to a device. This name will be displayed in the Basler pylon Viewer and the Basler pylon USB Configurator. The name will also be visible in the "friendly name" field of the device information objects returned by pylon's device enumeration procedure.
- 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 in pixels.
- Max Width (read only) - Indicates the camera's maximum region of interest (ROI) width setting for the current OffsetX settings.
- Max Height (read only) - Indicates the camera's maximum region of interest (ROI) height setting for the current OffsetY settings.

You can read the values for all of the device information parameters or set the value of the Device User ID parameter from within your application software by using the Basler pylon API. The following code snippets illustrate using the API to read the parameters or write the Device User ID:

```
// Read the Device Vendor Name parameter
GenICam::gcstring s = camera.DeviceVendorName.GetValue();

// Read the Device Model Name parameter
GenICam::gcstring s = camera.DeviceModelName.GetValue();

// Read the Device Manufacturer Info parameter
GenICam::gcstring s = camera.DeviceManufacturerInfo.GetValue();

// Read the Device Version parameter
GenICam::gcstring s = camera.DeviceVersion.GetValue();

// Read the Device Firmware Version parameter
GenICam::gcstring s = camera.DeviceFirmwareVersion.GetValue();

// Read the Device Serial Number parameter
GenICam::gcstring s = camera.DeviceSerialNumber.GetValue();
```

```
// Write and read the Device User ID parameter
camera.DeviceUserID.SetValue("CAM_1");
GenICam::gcstring s = camera.DeviceUserID.GetValue();

// Read the Device Scan Type parameter
DeviceScanTypeEnums e = camera.DeviceScanType.GetValue();

// Read the SensorWidth parameter
int64_t i = camera.SensorWidth.GetValue();

// Read the SensorHeight parameter
int64_t i = camera.SensorHeight.GetValue();

// Read the WidthMax parameter
int64_t i = camera.WidthMax.GetValue();

// Read the HeightMax parameter
int64_t i = camera.HeightMax.GetValue();
```

You can also use

- the Basler pylon Viewer application to easily read the parameters and to read or write the Device User ID.
- the Basler pylon USB Configurator to read the Device User ID.

For more information about the pylon API, the pylon Viewer, and the pylon USB Configurator, see Section 3.1 on [page 28](#).

9.13 User Sets

A user set is a group of parameter values with all the settings needed to control the camera.

There are four basic types of user sets:

- user sets that can be configured by the user (User Set 1, User Set 2, User Set 3)
- the user set with a factory setup that cannot be changed (Default User Set)
- the user set configured as the "startup" set (User Set Default).
- the active user set.

The Active User Set

The active user set contains most of the camera's current parameter settings. When you change parameter settings using the pylon API or the pylon Viewer, you are making changes to the active user set.

The active user 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.

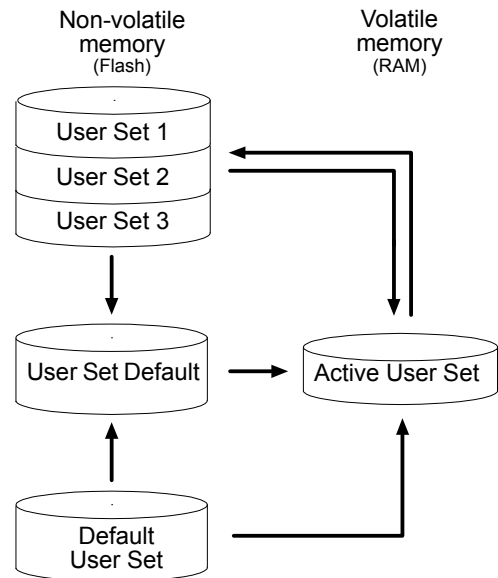


Fig. 44: User Sets

User Set 1, User Set 2, User Set 3

There are three reserved areas in the camera's non-volatile memory available for saving user sets that can be configured by the user. These user sets are not lost when the camera is reset or switched off. The three configurable user sets are called User Set 1, User Set 2, and User Set 3.

When the camera is running, a saved user set can be loaded into the active user set. A saved user set can also be designated as the User Set Default (the "startup" set) that will be loaded into the active set whenever the camera is powered on or reset.

Instructions for loading a saved user set into the active set and for designating which set will be the startup set appear in Section 9.13.3 on [page 112](#) and Section 9.13.1 on [page 110](#).

The Default User Set (Factory Setup)

When a camera is manufactured, numerous tests are performed on the camera and a factory optimized setup is determined. This factory setup is stored in the Default User Set. It is optimized for average conditions and will provide good camera performance in many common applications.

In the Default User Set,

- the gain auto, exposure auto, and white balance auto functions are set to the continuous mode of operation,
- the Smart auto function profile is set.

The Default User Set is saved in the camera's non-volatile memory. It is not lost when the camera is reset or switched off and it cannot be changed.

For more information about

- auto functions, see Section 9.9 on [page 97](#).
- the Smart auto function profile, see Section 9.9.5 on [page 102](#).

The User Set Default

You can designate one of the four user sets (the Default User Set, User Set 1, User Set 2, and User Set 3) as the User Set Default, i.e. as the startup user set. The startup user set will automatically be loaded into the active set whenever the camera starts up at power on or after a reset. Instructions for designating a user set as the User Set Default appear in Section 9.13.4 on [page 113](#).

9.13.1 Selecting a User Set

If you want to load any of the user sets into the Active User Set or if you want to configure User Set 1, User Set 2, or User Set 3, you must first select the desired user set.

To select a user set:

- Set the User Set Selector to the desired user set (Default User Set, User Set 1, User Set 2, or User Set 3).

You can set the User Set Selector from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to select User Set 1:

```
//Select User Set 1
camera.UserSetSelector.SetValue(UserSetSelector_UserSet1);
```

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

For more information about the Basler pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.13.2 Saving a User Set

After setting your camera parameter values, you can save most of the settings for further use into User Set 1, User Set 2, or User Set 3. These user sets are not lost when the camera is reset or switched off.

To save a user set:

1. Make changes to the camera's settings until the camera is operating in a manner that you would like to save.
2. Set the User Set Selector to User Set 1, User Set 2, or User Set 3.
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

- will overwrite any parameters that were previously saved in that user 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.

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 select User Set 1 and execute the save 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 Basler pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.13.3 Loading a User Set into the Active User Set

You can load any user set (Default User Set, User Set 1, User Set 2, or User Set 3) from the camera's non-volatile memory into the camera's active user set.

When you load a user set, the loaded set overwrites the parameter settings in the active set. The settings from the loaded set will now be controlling the camera.

To load a user set into the active user set:

1. Set the User Set Selector to the desired user set, e.g. User Set 2.
2. Execute a User Set Load command to load the selected user set into the active user 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 snippets illustrate using the API select User Set 2 and execute the load command:

```
//Load User Set 2  
camera.UserSetSelector.SetValue(UserSetSelector_UserSet2);  
camera.UserSetLoad.Execute();
```



Loading a user 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 User Set with the standard factory setup into the active set is recommended if you have 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.

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

For more information about the Basler pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

9.13.4 Designating a User Set as the User Set Default

You can designate any user set (Default User Set, User Set 1, User Set 2, or User Set 3) as the User Set Default.

The configuration set that you designate as the User Set Default will act as the **startup set** and will be loaded into the active user set whenever the camera starts up at power on or after a reset.

Selecting which user set will serve as the User Set Default 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.



If you have misadjusted the settings in the cameras and you are not sure how to recover, do the following:

1. Set the default user set as the startup set (User Set Default).
2. Restart the camera.

To designate a user set as the User Set Default:

- Set the User Set Default Selector to the desired User Set.

You can set the User Set Default Selector from within your application software by using the pylon API. The following code snippets illustrate using the API to set the selector:

```
//Designate User Set 1 as User Set Default  
camera.UserSetDefault.SetValue(UserSetDefault_UserSet1);
```

For more information about the Basler pylon API and the pylon Viewer, see Section 3.1 on [page 28](#).

10 Troubleshooting and Support

10.1 Tech Support Resources

If you need advice about your camera or if you need assistance troubleshooting a problem with your camera, 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.

You will also find helpful information such as frequently asked questions, downloads, and application notes in the Support and Downloads sections of the Basler website:
www.baslerweb.com

If you do decide to contact Basler technical support, please take a look at Section 10.3 on [page 115](#) before you call. The section gives information about assembling relevant data that will help the Basler technical support team to help you with your problem.

10.2 Obtaining an RMA Number

Whenever you want to return material to Basler, you must request a Return Material Authorization (RMA) number before sending the material 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 in the Support section of the Basler website: www.baslerweb.com

10.3 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. Basler technical support contact information is shown in the title section of this manual.

Three different methods are available of providing data to Basler technical support. The methods complement each other. We therefore recommend using them all for optimum assistance.

- Use the Basler pylon USB Configurator to automatically generate support information. A report is generated with information about the USB device tree displayed in the device pane and detailed information about each device.
- Send an e-mail to Basler technical support, already partially prepared by the Basler pylon USB Configurator.
- Use the form given below.

To automatically generate support information:

1. Click the question mark ? in the menu bar of the Basler pylon USB Configurator.
2. Click **Generate Support Information...** in the dropdown menu.
The **Support Information** window opens displaying a report.
3. Click the **Copy to Clipboard** button to keep the support information for inclusion in an e-mail to Basler technical support.

To use a prepared e-mail:

1. Click the question mark ? in the menu bar of the Basler pylon USB Configurator.
2. Click **Contact Basler Support...** in the dropdown menu.
A **pylon Support Request** window for an e-mail to Basler technical support opens. It includes information about the currently used versions of pylon and the PC's operating system.
3. Include the previously generated support information (see above).
4. If you are outside Europe replace **support.europe@baslerweb.com** by the address of your local Basler technical support.

To use the form:

1. Copy the form that appears below, fill it out, and send it - with sample images if appropriate - attached to your e-mail to Basler technical support
or
fax the completed form with the requested files attached to your local dealer or to Basler technical support.

1 The camera's product ID: _____

2 The camera's serial number: _____

3 Host adapter and chipset that you use with the camera: _____

Do you use a hub?

Yes

No

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 note of the parameters, use the Basler pylon Viewer.

If you cannot access the camera, please try to state the following parameter settings:

- Image Size (ROI): _____
- Pixel Format: _____
- Exposure Time: _____
- Frame Rate: _____

11 Live image/test pattern

If you are having an image problem, try to generate and save live images that show the problem. Also generate and save test patterns. Please save the images in BMP format, zip them, and send them to Basler technical support.

Index

A

acquisition frame rate
 see maximum allowed frame rate 67
 active set 109
 active user set 109
 AOI
 see image region of interest
 API 29
 area of interest
 see image region of interest
 auto function profile 102
 auto functions
 explained 97
 modes of operation 98
 target value 97

B

backlight compensation 104
 balance ratio 73
 balance white 73
 automatic adjustment 101
 balance ratio 73
 manual adjustment 73
 balance white auto 101
 Bayer filter 70
 Bayer filter alignment
 see color filter alignment
 binning
 image distortion 87, 92
 image ROI settings 92
 reduced resolution 92
 response to light 92

C

cable
 I/O 34
 USB 2.0 34
 USB 3.0 34
 camera power 35
 color creation 70
 color enhancement 72
 procedure 75
 color filter alignment 70, 71, 77, 93, 94
 color temperature 72, 73
 connector

 pin assignments 31
 pin numbering 31
 contrast enhancement 82

D

Default User Set 110
 default user set (factory setup) 110
 defect pixel correction 96
 device information parameters 107
 device version parameter 107
 dimensions 15

E

electronic rolling shutter mode 57, 59
 ERS mode
 see electronic rolling shutter mode
 exposure auto 100

F

factory setup 110
 filter alignment
 see color filter alignment
 firmware version parameter 107
 Frame rate
 see maximum allowed frame rate 67
 free run 49, 50, 63

G

gain 79
 maximum allowed setting 80
 gain auto 99
 gamma correction 74
 global reset release mode 57, 60
 GRR mode
 see global reset release mode

H

horizontal mirror image 93

- I**
- I/O
 - direct-coupled GPIO 36
 - I/O board 32
 - I/O cable
 - see cable
 - I/O connector 27, 31
 - image noise 22
 - image region of interest
 - height 84
 - offset X 84
 - offset Y 84
 - width 84
 - input line (direct coupled)
 - voltage requirements 37
 - inverter
 - see line inverter
 - IR cut filter 7, 13, 71
- L**
- LED indicator 33
 - light source
 - Daylight 5000 K 72
 - Daylight 6500 K 72
 - Off 72
 - preset 72
 - Tungsten 2800 K 72
 - line inverter
 - output line 43
 - line logic 44
 - line status
 - all I/O lines 45
- M**
- manufacturer info parameter 107
 - max height parameter 107
 - max width parameter 107
 - maximum allowed frame rate 67
 - mirror image 93
 - model name parameter 107
 - models 7
 - modes of operation (of auto functions) 98
- O**
- offset X 84
 - offset Y 84
- outlier pixels 96
 - output line (direct coupled)
 - voltage levels 37
 - overlap mode 22, 62, 64
- P**
- physical sensor 92
 - pin assignments 31
 - pin numbering 31
 - power
 - see camera power
 - power and I/O cable
 - voltage requirements 37
 - power supply
 - LPS 23, 24
 - SELV 23, 24
 - preset
 - see light source preset
 - pylon
 - Camera Software Suite 28
 - SDK 29
 - USB Configurator 28, 115
 - Viewer 28
- R**
- reduced resolution 92
 - region of interest
 - see image region of interest
 - reverse X 93
 - reverse Y 94
 - ROI
 - see image region of interest
- S**
- saving parameter value sets 111
 - saving user sets 109
 - scan type parameter 107
 - sensor
 - physical 92
 - virtual 92
 - sensor height parameter 107
 - sensor width parameter 107
 - serial number parameter 107
 - sets of parameter values, saving 111
 - sharpness enhancement 83
 - source signal
 - for input 38

for output.....41
spectral response..... 11, 13
standard factory setup 112
startup parameter set..... 113
startup user set 110, 113

T

temperature.....20
test images..... 105
test patterns 105

U

underexposure 104
USB 2.0.....22, 34
USB 3.0.....22, 32, 34
USB 3.0 connector 32
USB 3.0 powered hub
 LPS23
 SELV.....23
USB cable
 see cable
user ID parameter 107
user output42
user set 109
 default for startup 110
 explained..... 109
 saving..... 111
user set loaded at startup 113

V

vendor name parameter..... 107
virtual sensor.....92

W

white balance
 see balance white
white balance auto
 see balance white auto

Revision History

Doc. ID Number	Date	Changes
AW00130501000	28 Nov 2014	Initial release of the document.
AW00130502000	12 Mar 2015	Modifications and corrections related to the development of the camera from prototype to serial production.
AW00130503000	08 Apr 2015	Modifications and corrections related to the development of the camera from prototype to serial production.
AW00130504000	08 Jul 2015	Modifications and corrections related to the development of the camera from prototype to serial production.