

# Basler racer



## **USER'S MANUAL FOR CAMERA LINK CAMERAS**

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### **For customers in the USA**

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

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

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

### **For customers in Canada**

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

### **Pour utilisateurs au Canada**

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

### **Life support applications**

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

## **Observe the following items**

- Do not remove the camera's product label that contains the serial number.
- Do not open the housing and do not touch the internal components, you may damage them.
- Prevent ingress or insertion of foreign substances into the camera housing. If operated with any foreign substances inside, the camera may fail or cause a fire.
- Do not operate the camera in the vicinity of strong electromagnetic fields. Avoid electrostatic charging.
- Transport the camera in its original packaging only. Do not discard the packaging.

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# 1 Specifications, Requirements, and Precautions

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

This chapter also includes specific precautions that you should keep in mind when using the cameras. Basler strongly recommends that you read and follow the precautions.

## 1.1 Intended Use

Basler digital cameras for machine vision are designed exclusively for indoor professional image capture. Temperature and humidity requirements apply as detailed in Section 1.11 on [page 21](#). All relevant product documentation must be observed, including directions for correct camera use.

The cameras must not be used for the following:

- Purposes and installations requiring special camera certification other than mentioned in this documentation.
- Purposes and installations requiring specific design and precautions for use under harsh conditions.

If in doubt whether a specific camera is compatible with certain operating conditions and uses, contact your sales representative.

## 1.2 Authorized Users

Basler digital cameras for machine vision are designed for use by professionals only, concerned with the following tasks:

- Selection of cameras for use
- Camera integration and setup
- Everyday camera use

This documentation assumes the skills of electrical engineers, systems engineers, mechatronics engineers, technicians, and information technology engineers.

Camera use is not allowed for persons with insufficient skills or with impairments that prevent them from doing the following tasks:

- Using cameras correctly
- Adhering to the safety instructions
- Fully understanding all relevant camera documentation

## 1.3 Models

The current Basler racer Camera Link camera models are in the top row of the specification tables on the next pages of this manual. The camera models are differentiated by their resolution and their maximum line rate at full resolution.

Unless otherwise noted, the material in this manual applies to all of the camera models listed in the tables. Material that only applies to a particular camera model or to a subset of models are so designated.

## 1.4 General Specifications

Specification	raL2048-80km	raL4096-80km
Resolution	2048 pixels max. 2040 pixels available with 1X10 tap geometry	4096 pixels max. 4080 pixels available with 1X10 tap geometry
Sensor Type	Awaiba DR-2k-7 Monochrome Linear CMOS	Awaiba DR-4k-7 Monochrome Linear CMOS
Effective Sensor Diagonal	14.34 mm	28.67 mm
Pixel Size	7 $\mu\text{m}$ x 7 $\mu\text{m}$	
Max Line Rate	80 kHz	
Min Line Rate	No minimum when a hardware trigger signal is used 100 Hz when a hardware trigger signal is not used	
Mono/Color	Mono	
Sensor Bit Depth	12 bit	
Data Output Type	Camera Link base, medium or full configuration	
Connectors	One 6-pin Hirose micro-miniature receptacle Two Camera Link 26-pin SDR connectors (also known as Mini Camera Link connectors)	
Camera Link Pixel Clock Speed (Nominal)	32.5 MHz, 48 MHz, 65 MHz, 83.5 MHz (selectable; see Section 8.1 on <a href="#">page 100</a> for the difference between nominal and actual values)	
Camera Link Tap Geometry	1X, 1X2, 1X4, 1X8, 1X10	
Pixel Formats	Mono 8 Mono 10 Mono 12	
Synchronization	Via hardware trigger signal, via software trigger signal or free run	
Exposure Time Control	Programmable via the camera API	
Camera Power Requirements	PoCL (Power over Camera Link compliant) or +12 VDC (-10 %) to +24 VDC (+5 %), < 1 % ripple, supplied via the camera's 6-pin connector.	
Power Consumption (typical, at 12 VDC)	3 W	4 W
I/O Lines	4 input lines (CC1 to CC4) and 1 output line (via Camera Link spare bit)	

Table 1: General Specifications - 2k and 4k Mono Cameras

Specification	raL2048-80km	raL4096-80km
Lens Adapter	Universal camera front, suitable for lens mount adapters with the following lens mounts: C-mount (2k cameras), F-mount, M42x0.75-mount (FBD 16 mm), M42x1.0-mount (FBD 16 mm), M42x1.0-mount (FBD 45.56 mm), M58x0.75-mount (FBD 20 mm). Lens adapter must be ordered separately as an accessory. See Section 1.7.4 on <a href="#">page 17</a> for information about selecting a suitable lens adapter for your camera.	
Size (L x W x H)	33.77 mm x 56 mm x 62 mm (without lens adapter or connectors) 48.48 mm x 56 mm x 62 mm (with C-mount lens adapter and connectors) 77.57 mm x 56 mm x 62 mm (with F-mount lens adapter and connectors) 47.07 mm x 56 mm x 62 mm (with M42-mount lens adapter and connectors) 76.66 mm x 56 mm x 62 mm (with M42-mount FBD 45.56 mm lens adapter and connectors) 51.07 mm x 56 mm x 62 mm (with M58-mount lens adapter and connectors)	
Weight	≈ 210 g (typical) without lens adapter ≈ 240 g (typical) with C-mount lens adapter and connectors ≈ 300 g (typical) with F-mount lens adapter and connectors ≈ 230 g (typical) with M42-mount lens adapter and connectors ≈ 280 g (typical) with M42-mount FBD 45.56 lens adapter and connectors ≈ 240 g (typical) with M58-mount lens adapter and connectors	
Conformity	CE (includes RoHS), FCC, UL Listed, GenICam, Camera Link, IP30, REACH The CE Conformity Declaration is available on the Basler website: <a href="http://www.baslerweb.com">www.baslerweb.com</a>	
Software	Basler pylon Camera Software Suite (version 4.0 or higher) Available for Windows, Linux x86, Linux ARM, and OS X	

Table 1: General Specifications - 2k and 4k Mono Cameras

Specification	raL6144-80km	raL8192-80km
Resolution	6144 pixels max. 6120 pixels available with 1X10 tap geometry	8192 pixels max. 8160 pixels available with 1X10 tap geometry
Sensor Type	Awaiba DR-6k-7 Monochrome Linear CMOS	Awaiba DR-8k-3.5 Monochrome Linear CMOS
Effective Sensor Diagonal	43.01 mm	28.67 mm
Pixel Size	7 $\mu\text{m}$ x 7 $\mu\text{m}$	3.5 $\mu\text{m}$ x 3.5 $\mu\text{m}$
Max Line Rate	80 kHz	
Min Line Rate	No minimum when a hardware trigger signal is used 100 Hz when a hardware trigger signal is not used	
Mono/Color	Mono	
Sensor Bit Depth	12 bit	
Data Output Type	Camera Link base, medium or full configuration	
Connectors	One 6-pin Hirose micro-miniature receptacle Two Camera Link 26-pin SDR connectors (also known as Mini Camera Link connectors)	
Camera Link Pixel Clock Speed (Nominal)	32.5 MHz, 48 MHz, 65 MHz, 83.5 MHz (selectable; for the difference between nominal and actual values, see Section 8.1 on <a href="#">page 100</a> )	
Camera Link Tap Geometry	1X, 1X2, 1X4, 1X8, 1X10	
Pixel Formats	Mono 8 Mono 10 Mono 12	
Synchronization	Via hardware trigger signal, via software trigger signal or free run	
Exposure Time Control	Programmable via the camera API	
Camera Power Requirements	+12 VDC (-10 %) to +24 VDC (+5 %), < 1 % ripple, supplied via the camera's 6-pin connector.	
Power Consumption (typical, at 12 VDC)	4.5 W	5.5 W
I/O Lines	4 input lines (CC1 to CC4) and 1 output line (via Camera Link spare bit)	
Lens Adapter	Universal camera front, suitable for lens mount adapters with the following lens mounts: F-mount, M42x0.75-mount (FBD 16 mm), M42x1.0-mount (FBD 16 mm), M42x1.0-mount (FBD 45.56 mm), M58x0.75-mount (FBD 20 mm). Lens adapter must be ordered separately as an accessory. See Section 1.7.4 on <a href="#">page 17</a> for information about selecting a suitable lens adapter for your camera.	

Table 2: General Specifications - 6k and 8k Mono Cameras

Specification	raL6144-80km	raL8192-80km
Size (L x W x H)	33.77 mm x 56 mm x 62 mm (without lens adapter or connectors) 77.57 mm x 56 mm x 62 mm (with F-mount lens adapter and connectors) 47.07 mm x 56 mm x 62 mm (with M42-mount lens adapter and connectors) 76.66 mm x 56 mm x 62 mm (with M42-mount FBD 45.56 mm lens adapter and connectors) 51.07 mm x 56 mm x 62 mm (with M58-mount lens adapter and connectors)	
Weight	≈ 210 g (typical) without lens adapter ≈ 300 g (typical) with F-mount lens adapter and connectors ≈ 230 g (typical) with M42-mount lens adapter and connectors ≈ 280 g (typical) with M42-mount FBD 45.56 lens adapter and connectors ≈ 240 g (typical) with M58-mount lens adapter and connectors	
Conformity	CE (includes RoHS), FCC, UL Listed, GenICam, Camera Link, IP30, REACH The CE Conformity Declaration is available on the Basler website: <a href="http://www.baslerweb.com">www.baslerweb.com</a>	
Software	Basler pylon Camera Software Suite (version 4.0 or higher) Available for Windows, Linux x86, Linux ARM, and OS X	

Table 2: General Specifications - 6k and 8k Mono Cameras

Specification	raL12288-66km
Resolution	12288 pixels max. 12280 pixels available with 1X10 tap geometry
Sensor Type	Awaiba DR-12k-3.5 Monochrome Linear CMOS
Effective Sensor Diagonal	43.01 mm
Pixel Size	3.5 $\mu\text{m}$ x 3.5 $\mu\text{m}$
Max Line Rate	66 kHz
Min Line Rate	No minimum when a hardware trigger signal is used 100 Hz when a hardware trigger signal is not used
Mono/Color	Mono
Sensor Bit Depth	12 bit
Data Output Type	Camera Link base, medium or full configuration
Connectors	One 6-pin Hirose micro-miniature receptacle Two Camera Link 26-pin SDR connectors (also known as Mini Camera Link connectors)
Camera Link Pixel Clock Speed (Nominal)	32.5 MHz, 48 MHz, 65 MHz, 83.5 MHz (selectable; for the difference between nominal and actual values, see Section 8.1 on <a href="#">page 100</a> )
Camera Link Tap Geometry	1X, 1X2, 1X4, 1X8, 1X10
Pixel Formats	Mono 8 Mono 10 Mono 12
Synchronization	Via hardware trigger signal, via software trigger signal or free run
Exposure Time Control	Programmable via the camera API
Camera Power Requirements	+12 VDC (-10 %) to +24 VDC (+5 %), < 1 % ripple, supplied via the camera's 6-pin connector.
Power Consumption (typical, at 12 VDC)	6.5 W
I/O Lines	4 input lines (CC1 to CC4) and 1 output line (via Camera Link spare bit)
Lens Adapter	Universal camera front, suitable for lens mount adapters with the following lens mounts: F-mount, M42x0.75-mount (FBD 16 mm), M42x1.0-mount (FBD 16 mm), M42x1.0-mount (FBD 45.56 mm), M58x0.75-mount (FBD 20 mm). Lens adapter must be ordered separately as an accessory. See Section 1.7.4 on <a href="#">page 17</a> for information about selecting a suitable lens adapter for your camera.

Table 3: General Specifications - 12k Mono Cameras

Specification	raL12288-66km
Size (L x W x H)	33.77 mm x 56 mm x 62 mm (without lens adapter or connectors) 77.57 mm x 56 mm x 62 mm (with F-mount lens adapter and connectors) 47.07 mm x 56 mm x 62 mm (with M42-mount lens adapter and connectors) 76.66 mm x 56 mm x 62 mm (with M42-mount FBD 45.56 mm lens adapter and connectors) 51.07 mm x 56 mm x 62 mm (with M58-mount lens adapter and connectors)
Weight	≈ 210 g (typical) without lens adapter ≈ 300 g (typical) with F-mount lens adapter and connectors ≈ 230 g (typical) with M42-mount lens adapter and connectors ≈ 280 g (typical) with M42-mount FBD 45.56 lens adapter and connectors ≈ 240 g (typical) with M58-mount lens adapter and connectors
Conformity	CE (includes RoHS), FCC, UL Listed, GenICam, Camera Link, IP30, REACH The CE Conformity Declaration is available on the Basler website: <a href="http://www.baslerweb.com">www.baslerweb.com</a>
Software	Basler pylon Camera Software Suite (version 4.0 or higher) Available for Windows, Linux x86, Linux ARM, and OS X

Table 3: General Specifications - 12k Mono Cameras

## 1.5 Accessories



Fig. 1: Basler Accessories

Basler's cooperation with carefully selected suppliers means you get accessories you can trust which makes building a high-performance image processing system hassle-free.

### Key Reasons for Choosing Lenses, Cables, and Other Accessories from Basler

- Perfect match for Basler cameras
- One-stop-shopping for your image processing system
- Stable performance through highest quality standards
- Easy integration into existing systems
- Expert advice during selection process

See the Basler website for information about Basler's extensive accessories portfolio (e.g. cables, lenses, host adapter cards, switches): [www.baslerweb.com](http://www.baslerweb.com)

## 1.6 Spectral Response

The following graph shows the quantum efficiency curve for monochrome cameras.

	The quantum efficiency curve excludes lens characteristics and light source characteristics.
-----------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------

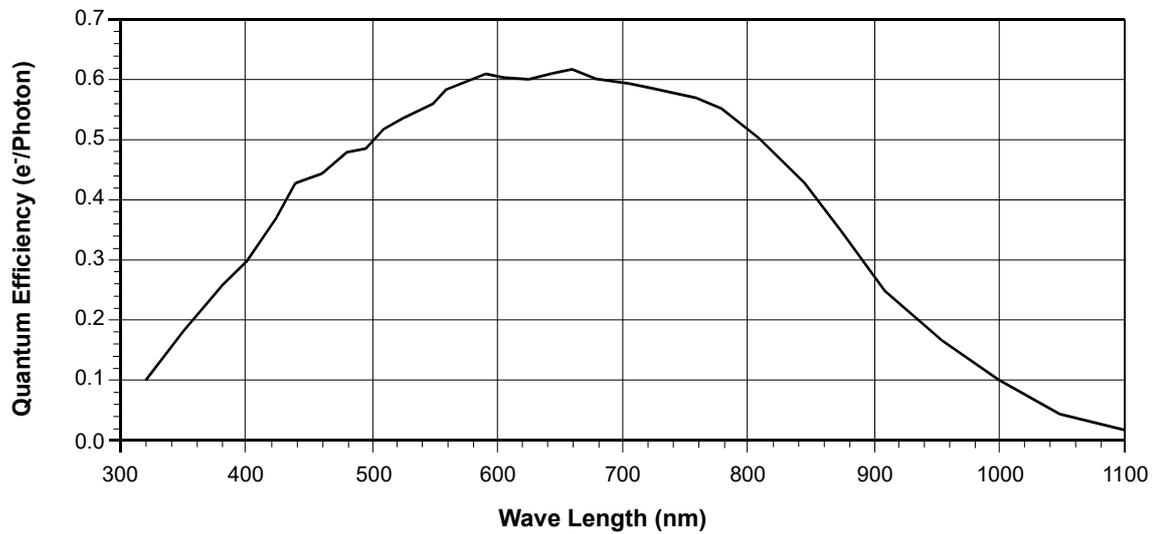


Fig. 2: Quantum Efficiency of the Monochrome Sensor in 12 Bit Depth Mode (Based on Sensor Vendor Information)

## 1.7 Mechanical Specifications

### 1.7.1 Camera Dimensions and Mounting Points

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

The camera housings conform to the IP30 protection class provided the camera front is covered by the protective plastic seal that is shipped with the camera.

The camera's dimensions in millimeters are as shown in the drawings below.

Camera housings are equipped with four mounting holes (4 x M4; 6.3 deep) on the front and two mounting holes (8 x M4; 6.3 deep) on each side as shown in the drawings. Four additional holes (4 x M2.5; 3.3 deep) are present on the camera front for mounting the lens adapter.

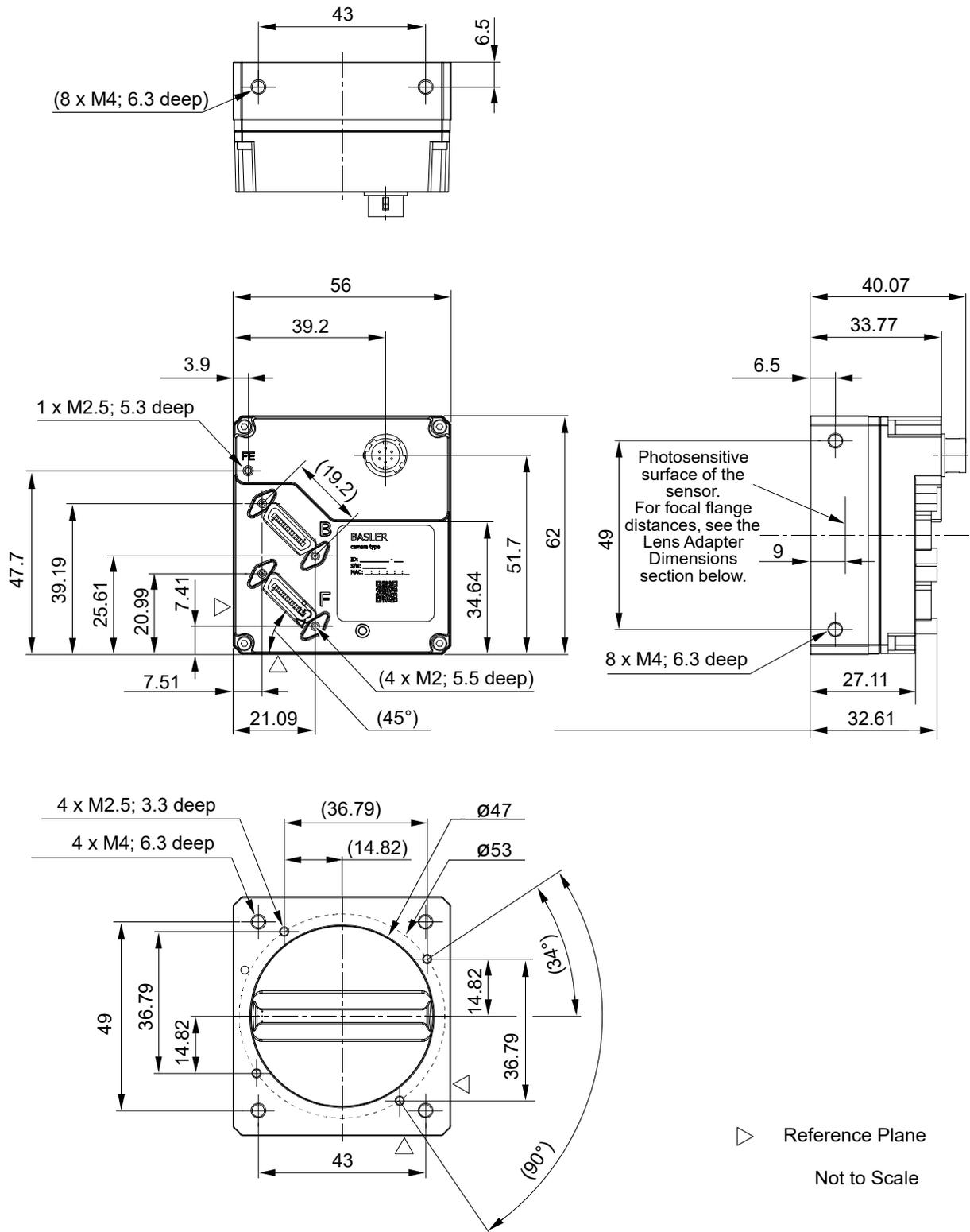


Fig. 3: Mechanical Dimensions (in mm)

## 1.7.2 Sensor Line Location

The location of the sensor line in the mono cameras is shown in Fig. 4. The sensor lines of different camera models vary in length, depending on maximum resolution and pixel size. As an example, a sensor line of maximum length, as applies to 6k and 12k cameras, is shown in Fig. 4.

A marker hole in the camera's front indicates the side of the camera where the pixel numbering for each sensor line starts. The first pixel is numbered one.

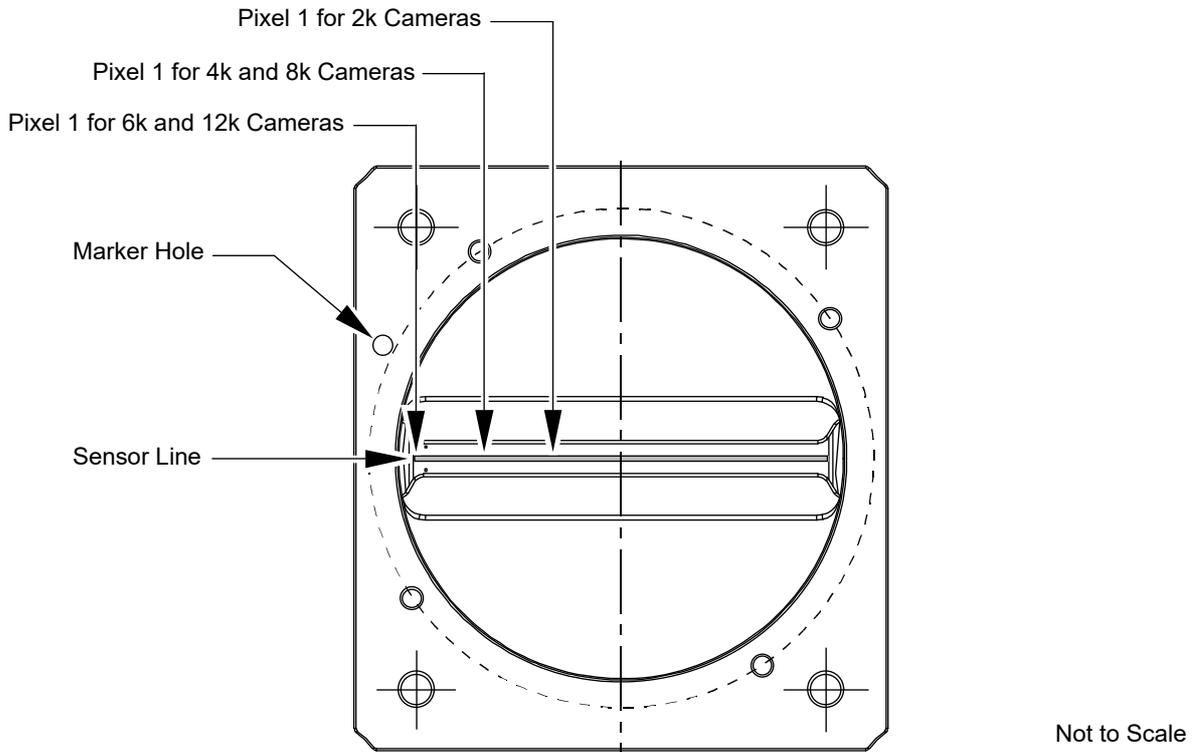


Fig. 4: Mono Sensor Line Location with Approximate Starting Points (Pixel 1) for Pixel Numbering

### 1.7.3 Lens Adapter Dimensions

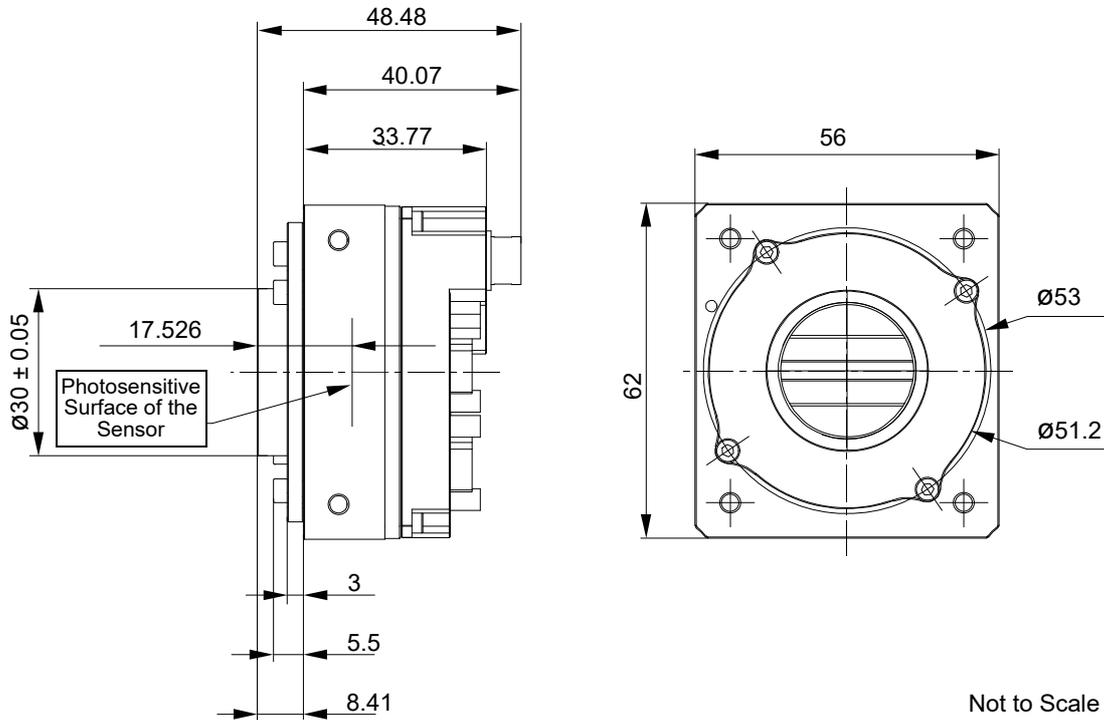


Fig. 5: C-mount Adapter on a racer Camera Link Camera; Dimensions in mm

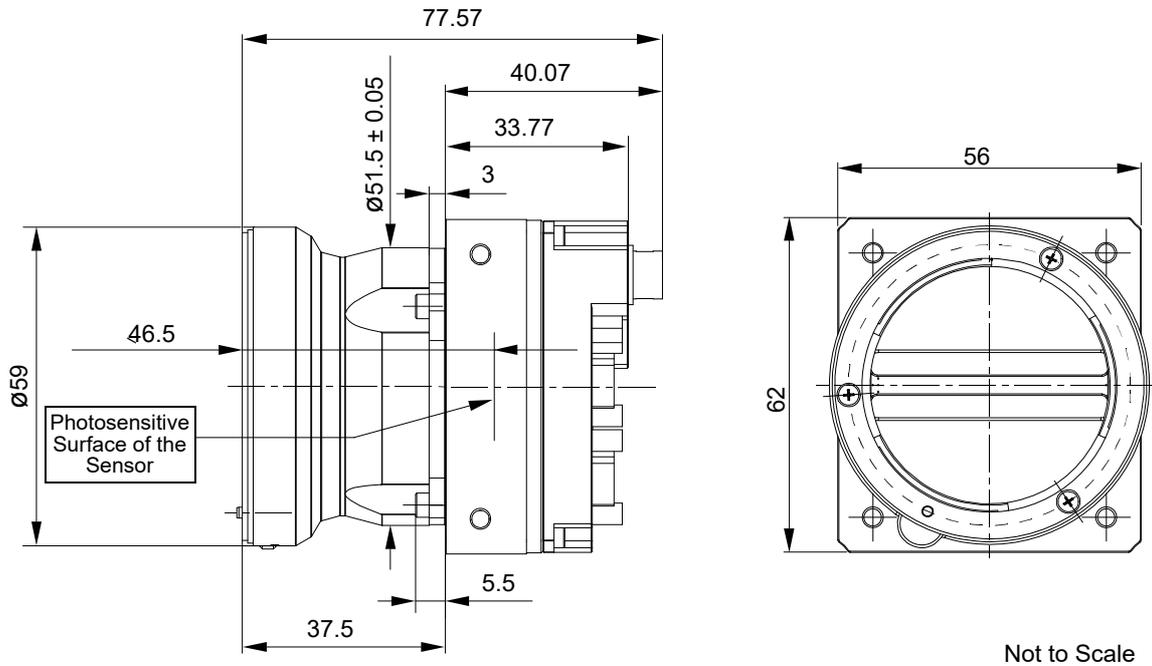


Fig. 6: F-Mount Adapter on a racer Camera Link Camera; Dimensions in mm

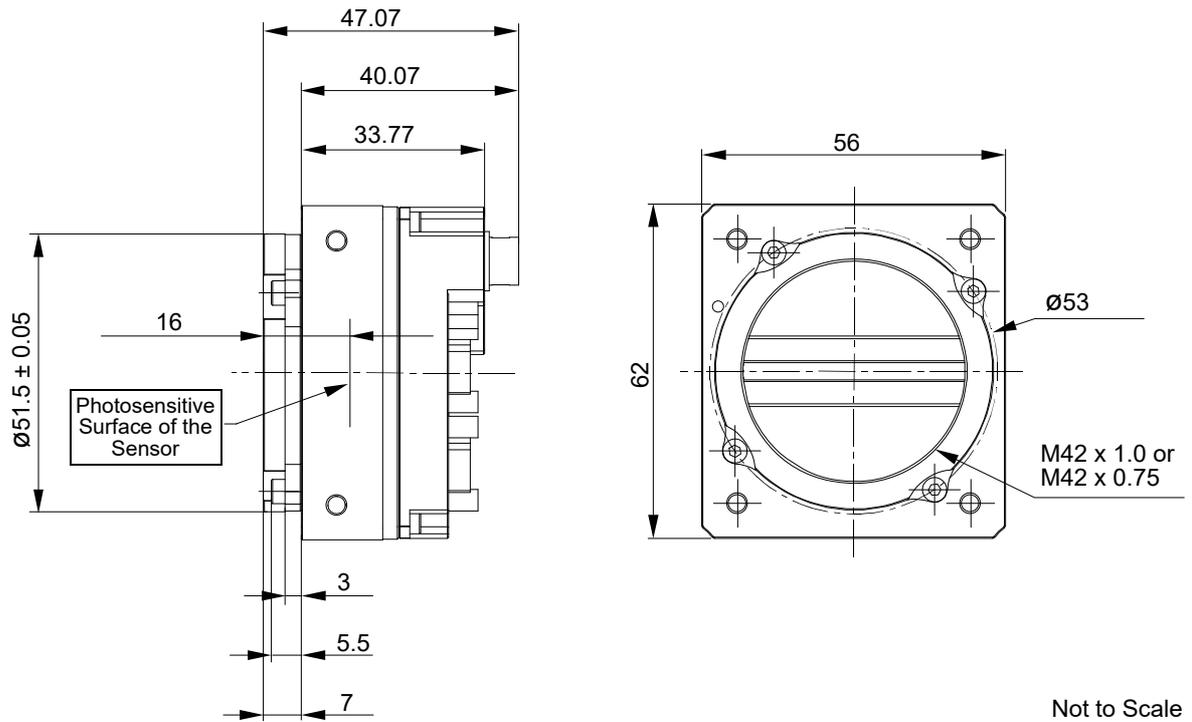


Fig. 7: M42 x 1.0 or M42 x 0.75 FBD 16 mm Mount Adapter on a racer Camera Link Camera; Dimensions in mm

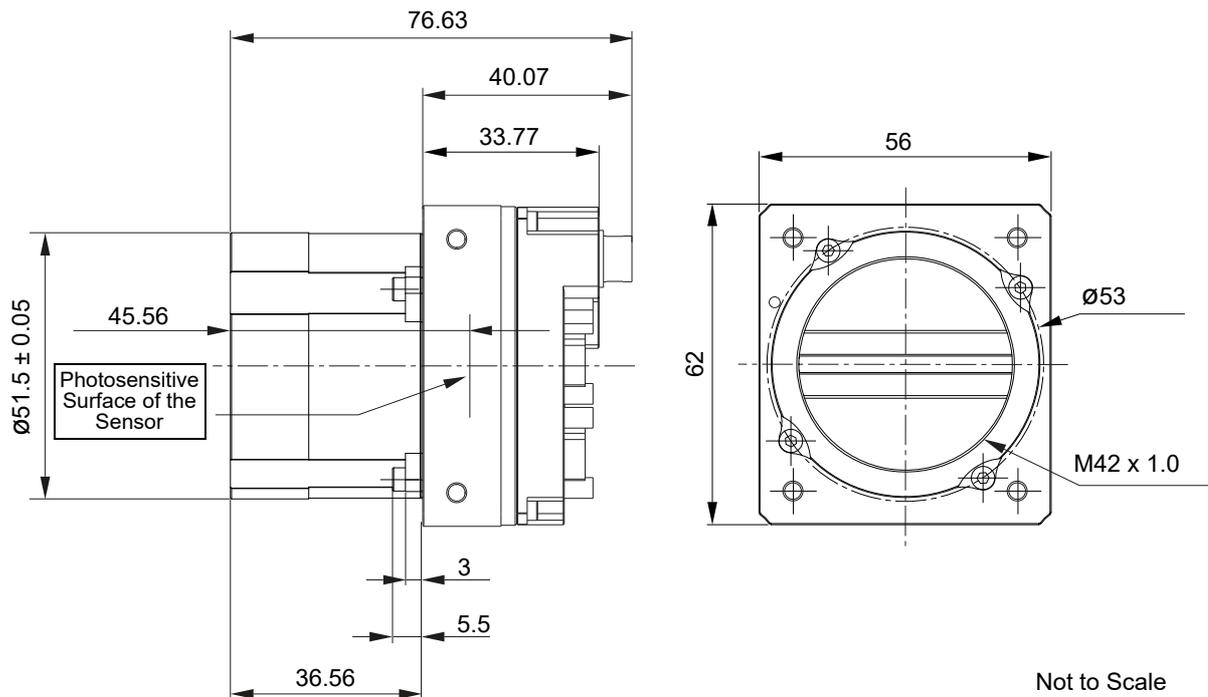


Fig. 8: M42 x 1.0 FBD 45.56 mm Mount Adapter on a racer Camera Link Camera; Dimensions in mm

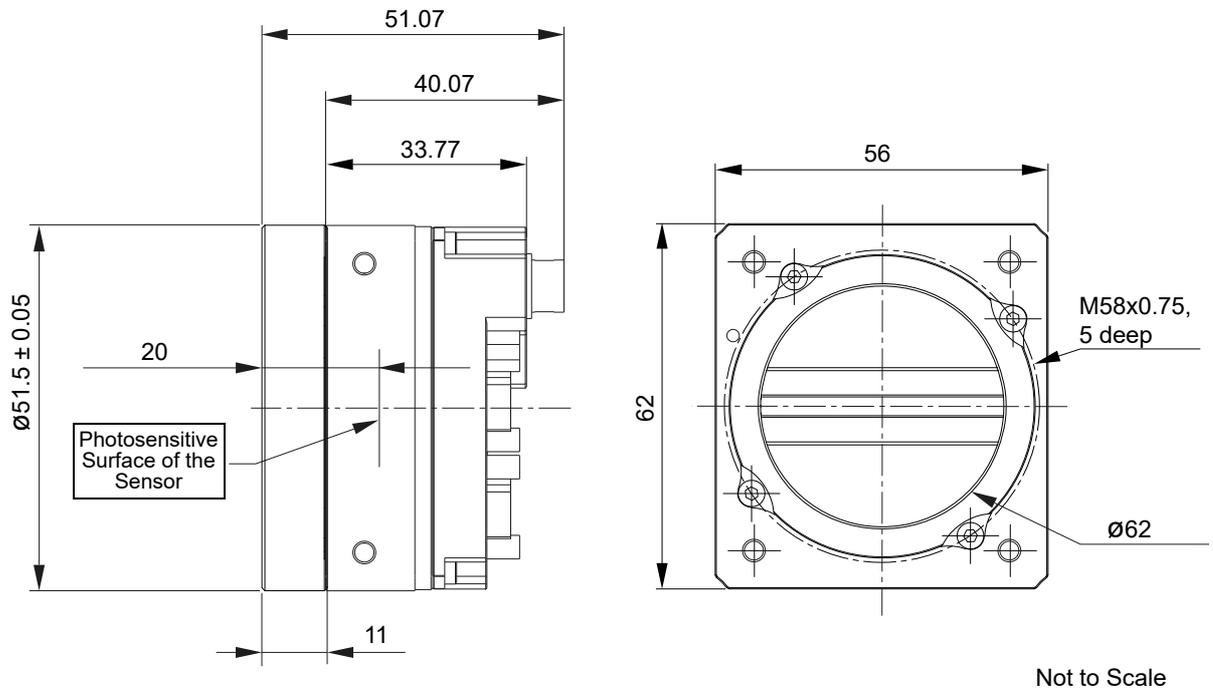


Fig. 9: M58 x 0.75 Mount FBD 20 mm Adapter on a racer Camera Link Camera; Dimensions in mm

## 1.7.4 Selecting the Optimum Lens Adapter

The camera's scope of delivery does not include a lens adapter. It is needed to attach a lens to a camera. You must order a lens adapter separately as an accessory.

The optimum choice of a lens mount adapter depends on the lens and on the resolution of the camera model. The recommended combinations of lens adapters and camera models are indicated in the following table:

Lens Adapter	Camera Model				
	raL2048	raL4096	raL6144	raL8192	raL12288
C-mount	•	-	-	-	-
F-mount	•	•	•	•	•
M42 x 1.0	•	•	•1)	•	•1)
M42 x 0.75	•	•	•1)	•	•1)
M42 x 1.0 FBD 45.56	•	•	•1)	•	•1)
M58	•	•	•1)	•	•1)

1) To ensure coverage of the entire sensor, contact Basler technical support for assistance when choosing a lens.

Table 4: Recommended Lens Adapters Depending on Camera Model (• = recommended, - = not recommended)

## 1.7.5 Attaching a Lens Adapter

Use the four M2.5 setscrews supplied with the lens adapter to lock the lens adapter to the camera. See [Fig. 3](#) for information where to place the M2.5 setscrews.

### NOTICE

**Screwing with excessive torque can damage the camera, lens adapter or setscrews.**

When screwing in the supplied M2.5 setscrews, make sure to never exceed a torque of 0.4 Nm.

## 1.8 Mechanical Stress Test Results

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

Test	Standard	Conditions
Vibration (sinusoidal, each axis)	DIN EN 60068-2-6	10-58 Hz / 1.5 mm <sub>rms</sub> / 58-500 Hz / 20 g <sub>rms</sub> / 1 Octave/Minute 10 repetitions
Shock (each axis)	DIN EN 60068-2-27	20 g / 11 ms / 100 shocks positive 20 g / 11 ms / 100 shocks negative
Vibration (broad-band random, digital control, each axis)	DIN EN 60068-2-64	15-500 Hz / 0.05 PSD (ESS standard profile) / 00:30 h

Table 5: Mechanical Stress Tests

## 1.9 Software Licensing Information

### 1.9.1 LZ4 Licensing

The software in the camera includes the LZ4 implementation. The copyright information for this implementation is as follows:

LZ4 - Fast LZ compression algorithm

Copyright (C) 2011-2013, Yann Collet.

BSD 2-Clause License (<http://www.opensource.org/licenses/bsd-license.php>)

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## 1.10 Avoiding EMI and ESD Problems

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

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

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

A functional earth connection on the back of the camera (labelled "FE", see Fig. 3 on [page 12](#)) allows to establish an electrically conducting connection to the camera housing if required by your application.



The Basler application note called *Avoiding EMI and ESD in Basler Camera Installations* provides much more detail about avoiding EMI and ESD. This application note can be obtained from the camera's Downloads section of our website: [www.baslerweb.com](http://www.baslerweb.com)

# 1.11 Environmental Requirements

## 1.11.1 Temperature and Humidity

Housing temperature during operation: 0 °C ... +60 °C (+32 °F ... +140 °F)

Housing temperature according to UL 60950-1:	max. 70 °C (+158 °F)
Ambient temperature according to UL 60950-1:	max. 50 °C (+122 °F)

**UL 60950-1 test conditions:** no lens attached to the camera and without efficient heat dissipation; ambient temperature kept at 50 °C (+122 °F).

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

## 1.11.2 Heat Dissipation

You must provide sufficient heat dissipation to maintain the temperature of the camera housing at 60 °C or less. Given the low power consumption of the camera its housing temperature during operation will generally stay within the specified limits. Overheating can only occur if heat dissipation is unusually restricted.

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

- In all cases, you should monitor the temperature of the camera housing and make sure that the temperature does not exceed 60 °C. Keep in mind that the camera will gradually become warmer during the first hour of operation. After one hour, the housing temperature will have stabilized and will no longer increase.
- If your camera is mounted on a substantial metal component in your system, this may provide sufficient heat dissipation.
- The use of a fan to provide air flow over the camera is an extremely efficient method of heat dissipation. The use of a fan provides the best heat dissipation.

### 1.11.3 Imaging Sensor Over Temperature Condition

The camera has imaging sensor over temperature protection. If the temperature of the camera's imaging sensor rises above 75° C, an over temperature condition will be detected and the circuitry for the imaging sensor will switch off. In this situation, you will still be able to communicate with the camera but the camera will no longer acquire images.

Provide the necessary cooling when this situation arises. After the imaging sensor circuitry has sufficiently cooled bring the camera back to normal operation by either action:

- Carry out a camera restart by switching power off and on again or
- Carry out a camera reset as described in Section 9.1 on [page 147](#).

## 1.12 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.



### **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.

### **NOTICE**

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

The camera is shipped with a protective plastic seal on the camera front. To avoid collecting dust on the camera's sensor, make sure that you always put the protective seal in place when there is no lens mounted on the camera.

Also, make sure to always point the camera downward when there is no protective seal on the camera front or no lens mounted.

Never apply compressed air to the camera. This can easily contaminate optical components, particularly the sensor.

### **NOTICE**

#### **Inappropriate code may cause unexpected camera behavior.**

- The code snippets provided in this manual are included as sample code only. Inappropriate code may cause your camera to function differently than expected and may compromise your application.
- To ensure that the snippets will work properly in your application, you must adjust them to meet your specific needs and must test them thoroughly prior to use.

**NOTICE****Applying incorrect power can severely damage the camera.**

- If you supply camera power as Power over Camera Link (PoCL; 2k and 4k cameras only):
  - You must supply camera power in accordance with the Power over Camera Link (PoCL) specifications in the Camera Link standard.
  - You must use a PoCL compliant frame grabber.
  - You must use Camera Link cables that are specifically designed for PoCL as specified in the Camera Link standard.
- If you supply camera power via the 6-pin receptacle:
  - You must supply camera power with the correct voltage: The camera's required operating voltage is +12 VDC (-10 %) to +24 VDC (+5 %), < 1 % ripple, effective on the camera's connector, with a nominal operating voltage of +12 VDC ( $\pm 10$  %).
  - You must supply camera power with the correct polarity.
  - You must avoid a voltage drop: If you supply camera power via a long cable a voltage drop can occur. Basler recommends that you provide +12 VDC to +24 VDC separately through the wires connecting to pins 1 and 2 of the receptacle. We also recommend that you provide ground separately to the wires connecting to pins 5 and 6.

**NOTICE****Making or breaking Camera Link connections incorrectly can severely damage the camera.**

- If you supply power to the camera via the Camera Link connection (PoCL; 2k and 4k cameras only), be sure that the power to the camera and to the frame grabber in your computer is switched off before you connect or disconnect the Camera Link cables.
- If you supply power to the camera via the 6-pin connector, switch off the power to the connector before you connect or disconnect the Camera Link cables.
- If you can't switch off the power, be sure that:
  - The plug for the 6-pin connector is the last plug that you plug into the camera when making connections.
  - The plug for the 6-pin connector is the first plug that you unplug from the camera when breaking connections.

**NOTICE****Incorrect plugs can damage the camera's connectors.**

The plug on the cable that you attach to the camera's 6-pin connector must have 6 female pins.

## 2 Software and Hardware Installation

The information you will need to install and operate the camera is included in the *Installation and Setup Guide for Cameras Used with pylon for Windows* (AW000611).

You can download the document from the Downloads section of the Basler website:  
[www.baslerweb.com](http://www.baslerweb.com)

# 3 Camera Drivers and Tools for Changing Camera Parameters

This chapter provides an overview of the options available for changing the camera's parameters:

- The options available with the Basler pylon Camera Software Suite let you change parameters and control the camera by using a stand-alone GUI (known as the pylon Viewer) or by accessing the camera from within your software application using the API.
- You can also control the camera and change parameters via direct access to the camera's register structure with the Basler Binary Protocol Library.

## 3.1 Basler pylon Camera Software Suite

The Basler pylon Camera Software Suite is available for Windows and Linux operating systems and is designed to operate all Basler cameras that have an IEEE 1394 interface, a GigE interface or a USB 3.0 interface. It will also operate some newer Basler camera models with a Camera Link interface. The pylon drivers offer reliable, real-time image data transport into the memory of your computer 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.

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

You can obtain the Basler pylon Camera Software Suite from the Basler website by using this link: [www.baslerweb.com](http://www.baslerweb.com)

To help you install the software, you can also download these documents from the Basler website:

- *pylon Deployment Guide (Software Version 5.x) – Installation Guide (AW001362)*
- *Installation and Setup Guide for Cameras Used with pylon for Windows (AW000611).*

### 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. 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 pylon for Windows* (AW000611).

### 3.1.2 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 and Linux)
- 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.

## 3.2 Basler Binary Protocol Library

Basler racer Camera Link cameras have blocks of mapped memory space known as registers. By reading values from the registers, you can determine basic information about the camera and information about the camera's current settings. By writing values to the registers, you can control how the camera's features will operate.

If you use the Basler pylon software described in the previous section, the camera's register structure is hidden. With pylon, a series of function calls allows you to change camera parameter settings without the need to know anything about the register that underlies each parameter.

If you desire, you can also change the camera parameter settings and control the camera by directly accessing the camera's register structure. The Basler Binary Protocol Library (BBPL) provides functions that allow you to read data from or write data to the camera's registers. The BBPL is an extension of the `clAllSerial/clSerial` API defined in Appendix B of the Camera Link Standard version 1.1 or higher. The BBPL adds convenience functions to this API that allow you to read from and write to the registers in Basler Camera Link cameras. The read and write requests are transmitted to the camera via a serial link between the camera and the frame grabber; the serial link is part of the standard Camera Link interface.

Sample code showing how to use the BBPL along with supporting documentation can be downloaded from the Basler website: [www.baslerweb.com](http://www.baslerweb.com)

When using the BBPL to change parameter values, you will need to know the details of the camera's register structure. For details of the register structure, refer to the racer-specific document *Register Structure and Access Methods for Camera Link Cameras* (AW001270). The document can be downloaded from the Basler website.



Note that if you are using an earlier Basler Camera Link camera that was originally designed to work with the Basler Binary Protocol II (e.g., the A400k, L400k, L800k, and the sprint), you can now use either the BBPL or the Binary Protocol II to access the camera's registers.

# 4 Camera Functional Description

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

Each camera employs a single-line CMOS sensor chip designed for monochrome imaging. For 2k cameras, the sensor includes 2048 pixels with a pixel size of  $7\ \mu\text{m} \times 7\ \mu\text{m}$ . For 4k/6k cameras, the sensor consists of two/three 2k sensor segments with a pixel size of  $7\ \mu\text{m} \times 7\ \mu\text{m}$ , resulting in a total of 4096/6144 pixels. For 8k/12k cameras, the sensor consists of 2/3 4k sensor segments with a pixel size of  $3.5\ \mu\text{m} \times 3.5\ \mu\text{m}$ , resulting in a total of 8192/12288 pixels. See Fig. 10 on [page 30](#) for an overview of the different sensor architectures.

Line start can be controlled by trigger signals transmitted to the camera via the Camera Link interface. Modes are available that allow the length of exposure time to be directly controlled by the line start signal or to be set for a pre-programmed period of time.

Accumulated charges are read out of the sensor when exposure ends. At readout, accumulated charges are moved from the sensor's light-sensitive elements (pixels) into the analog processing section of the sensor (Fig. 10 on [page 30](#)). As the charges move from the pixels to the analog processing section, they are converted to voltages proportional to the size of each charge. The voltages from the analog processing section are next passed to a bank of 12 Bit Analog-to-Digital converters (ADCs).

Finally, the gray values pass through a section of the sensor where they receive additional digital processing and then they are moved out of the sensor. As each gray value leaves the sensor, it passes into an FPGA (Fig. 11 on [page 31](#)). Up to this point, all shifting is clocked according to the camera's internal clock speed.

The gray values are then transmitted via the Camera Link interface to the frame grabber in your computer. Several different "Camera Link tap geometries" are available to determine how the pixel data will be transmitted over the Camera Link interface. The user can select the desired Camera Link tap geometry. See Section 7.2 on [page 98](#) for more detailed information about Camera Link tap geometries.

The user can also select from several available pixel clock speeds for the Camera Link interface. See Section 8.1 on [page 100](#) for more information about selecting the pixel clock speed.

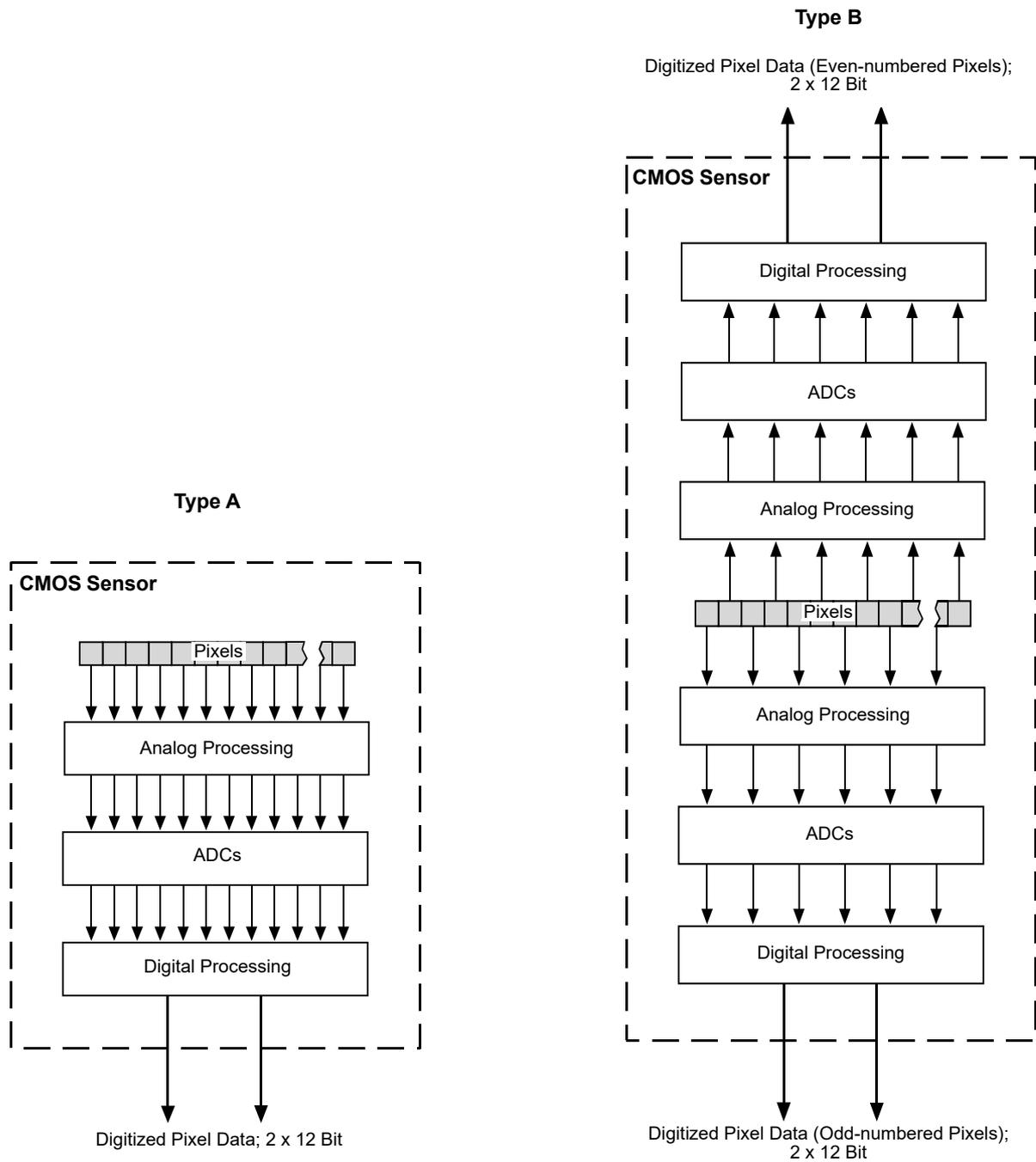


Fig. 10: CMOS Sensor Architecture. Type A is a 2k Sensor or 2k Sensor Segment with a Pixel Size of 7 μm x 7 μm and Type B is a 4k Sensor Segment with a Pixel Size of 3.5 μm x 3.5 μm.

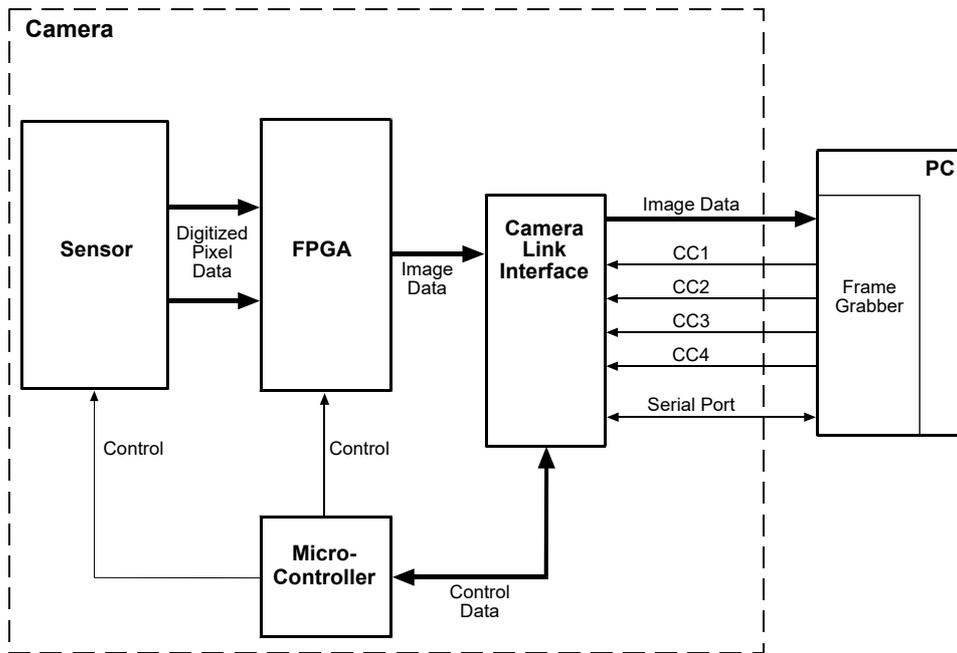


Fig. 11: Camera Block Diagram

# 5 Physical Interface

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



The sample code included in this chapter 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.

## 5.1 General Description of the Connections

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

- Two 26-pin, 0.03" pin spacing, Shrunk Delta Ribbon (SDR) female connectors used to transmit video data, control signals, and configuration commands. (This type of connector is also known as a Mini Camera Link connector). The SDR connectors as called for in the Camera Link specification as are the mating connectors.



The "SDR" (Shrunk Delta Ribbon) designation is the naming used by the 3M company. Other companies use different names for this type of connector. For example, Honda uses "HDR" as the connector name.

The **base** Camera Link connector can also be used to supply power to the camera in accordance with the Power over Camera Link (PoCL) specifications in the Camera Link standard (for 2k and 4k cameras only; for more information, see Section 5.4.3 on [page 42](#)).

- One 6-pin receptacle used to provide power to the camera if PoCL is not used. The receptacle is a Hirose micro connector (part number HR10A-7R-6PB) or the equivalent.

There are also a connection point for functional earth (FE) and a LED indicator located on the back of the camera as shown in the drawing.

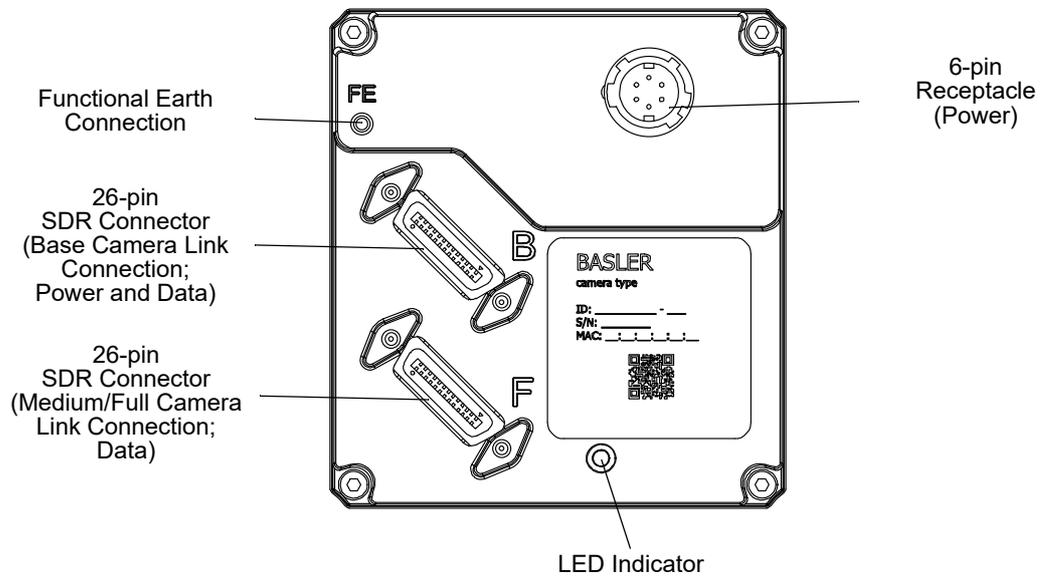


Fig. 12: Camera Connectors and LED Indicator

## 5.2 Camera Connector Pin Assignments and Numbering

### 5.2.1 6-pin Receptacle

The 6-pin receptacle is used to supply power to the camera. The pin assignments and pin numbering for the receptacle are as shown in Table 6.

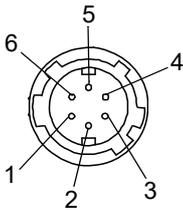
	Pin	Designation
	1	+12 VDC (-10 %) to +24 VDC (+5 %), < 1 % ripple, camera power *
	2	+12 VDC (-10 %) to +24 VDC (+5 %), < 1 % ripple, camera power *
	3	Not connected
	4	Not connected
	5	DC ground **
6	DC ground **	

Table 6: Pin Assignments and Numbering for the 6-pin Receptacle

\* Pins 1 and 2 are tied together inside of the camera.

\*\* Pins 5 and 6 are tied together inside of the camera.

#### NOTICE

##### Applying incorrect power can damage the camera.

- The camera's required operating voltage is +12 VDC (-10 %) to +24 VDC (+5 %), effective on the camera's connector.
- Applying power with the wrong polarity can severely damage the camera.
- Make sure that the polarity of the power applied to the camera is correct.

## 5.2.2 26-pin SDR Connectors

Two 26-pin, 0.03" pin spacing, Shrunk Delta Ribbon (SDR) female connectors are used to transmit video data, control signals, and configuration commands.

The **base** Camera Link SDR connector can also be used to supply power to the cameras in accordance with the Power over Camera Link (PoCL) specifications in the Camera Link standard. Note that only the 2k and 4k cameras can be fully operated using PoCL. For more information about correctly supplying power for full camera operation, see Section 5.4.3 on [page 42](#).

The pin assignments and pin numbering are shown in Table 7 on [page 36](#) for the base Camera Link SDR connector and in Table 8 on [page 37](#) for the medium/full Camera Link SDR connector.

A suitable cable is available from Basler. See the Basler website for information about cable characteristics. For voltage requirements of camera power, see Section 5.4 on [page 40](#).

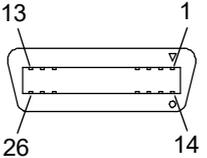
Pin Number	Signal Name	Direction	Level	Function
1, 26 *	Cam Pow.	In	+12 VDC	Camera power, +12 VDC nominal, < 1% ripple. For more details about PoCL power requirements see the Camera Link specifications v. 2.0 and above.
13, 14 **	Power Ret.		Return	Camera power return (Gnd)
2	X0-	Output	Camera Link LVDS	Data from transmitter circuit X
15	X0+			
3	X1-	Output	Camera Link LVDS	Data from transmitter circuit X
16	X1+			
4	X2-	Output	Camera Link LVDS	Data from transmitter circuit X
17	X2+			
6	X3-	Output	Camera Link LVDS	Data from transmitter circuit X
19	X3+			
5	XClk-	Output	Camera Link LVDS	Pixel clock from transmitter circuit X
18	XClk+			
7	SerTC+	Input	RS-644 LVDS	Serial communication data receive (SerTC = "serial to camera")
20	SerTC-			
8	SerTFG-	Output	RS-644 LVDS	Serial communication data transmit (SerTFG = "serial to frame grabber")
21	SerTFG+			
9	CC1-	Input	RS-644 LVDS	Configurable
22	CC1+			
10	CC2+	Input	RS-644 LVDS	Configurable
23	CC2-			
11	CC3-	Input	RS-644 LVDS	Configurable
24	CC3+			
12	CC4+	Input	RS-644 LVDS	Configurable
25	CC4-			
 <p>* Pins 1 and 26 are tied together in the camera. ** Pins 13 and 14 are tied together in the camera.</p>				

Table 7: Pin Assignments and Numbering for the Base Configuration 26-pin SDR Connector

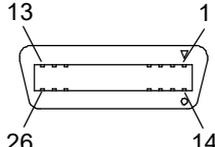
Pin Number	Signal Name	Direction	Level	Function
1, 26 *	Cam Pow.	In		Not used
13, 14 **	Power Ret.		Return	Gnd
2	Y0-	Output	Camera Link LVDS	Data from transmitter circuit Y
15	Y0+			
3	Y1-	Output	Camera Link LVDS	Data from transmitter circuit Y
16	Y1+			
4	Y2-	Output	Camera Link LVDS	Data from transmitter circuit Y
17	Y2+			
6	Y3-	Output	Camera Link LVDS	Data from transmitter circuit Y
19	Y3+			
5	YClk-	Output	Camera Link LVDS	Pixel clock from transmitter circuit Y
18	YClk+			
7	T+			Connected to T- with 100R; not used
20	T-			Connected to T+ with 100R; not used
8	Z0-	Output	Camera Link LVDS	Data from transmitter circuit Z
21	Z0+			
9	Z1-	Output	Camera Link LVDS	Data from transmitter circuit Z
22	Z1+			
10	Z2-	Output	Camera Link LVDS	Data from transmitter circuit Z
23	Z2+			
12	Z3-	Output	Camera Link LVDS	Data from transmitter circuit Z
25	Z3+			
11	ZClk-	Output	Camera Link LVDS	Pixel clock from transmitter circuit Z
24	ZClk+			
 <p>* Pins 1 and 26 are tied together in the camera. ** Pins 13 and 14 are tied together in the camera.</p>				

Table 8: Pin Assignments and Numbering for the Medium/Full Configuration 26-pin SDR Connector

## 5.3 Cabling Requirements

### 5.3.1 Camera Power Cable and Grounding

A single power cable is used to supply auxiliary power to the camera. For proper EMI protection, DC ground, the cable shield, and the camera housing must be connected and installed as shown in the figure below.

Close proximity to strong electromagnetic fields should be avoided. For more information about avoiding EMI and ESD, see Section 1.10 on [page 20](#).

Suitable cables are available from Basler. See the Basler website for information about cable characteristics, available Models and how to obtain them.

#### NOTICE

**An incorrect plug can damage the 6-pin connector.**

The plug on the cable that you attach to the camera's 6-pin connector must have 6 female pins.

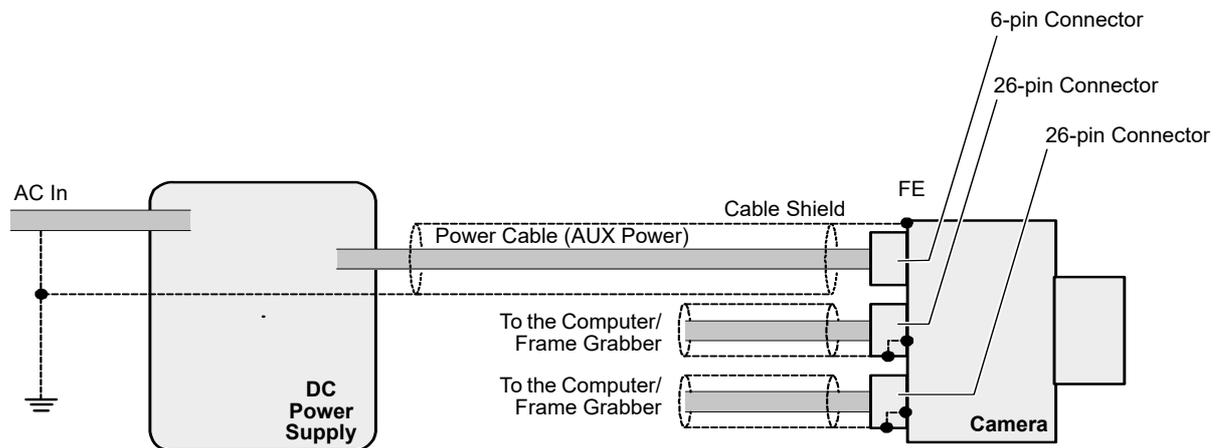


Fig. 13: Grounding Scheme for Power Supply, Power Cable, and Camera

## 5.3.2 Camera Link Cables

The Camera Link cables must meet the Mini Camera Link cable specifications given in the Camera Link Standard.

Close proximity to strong electromagnetic fields should be avoided and the cables used should be as short as possible.

Suitable cables are available from Basler. See the Basler website for information about cable characteristics, available Models and how to obtain them.

### Cable Length Limitations

Generally, Camera Link cables of up to 10 m length can be used for Camera Link cameras. However, when operating cameras at pixel clock speeds of 65 MHz and above, Basler strongly recommends to use shorter cables in accord with Fig. 14 to ensure the integrity of data transmission. For example, when operating the camera at 83.5 MHz (nominal) a Camera Link cable no longer than approximately 5 m should be used for reliable data transmission.

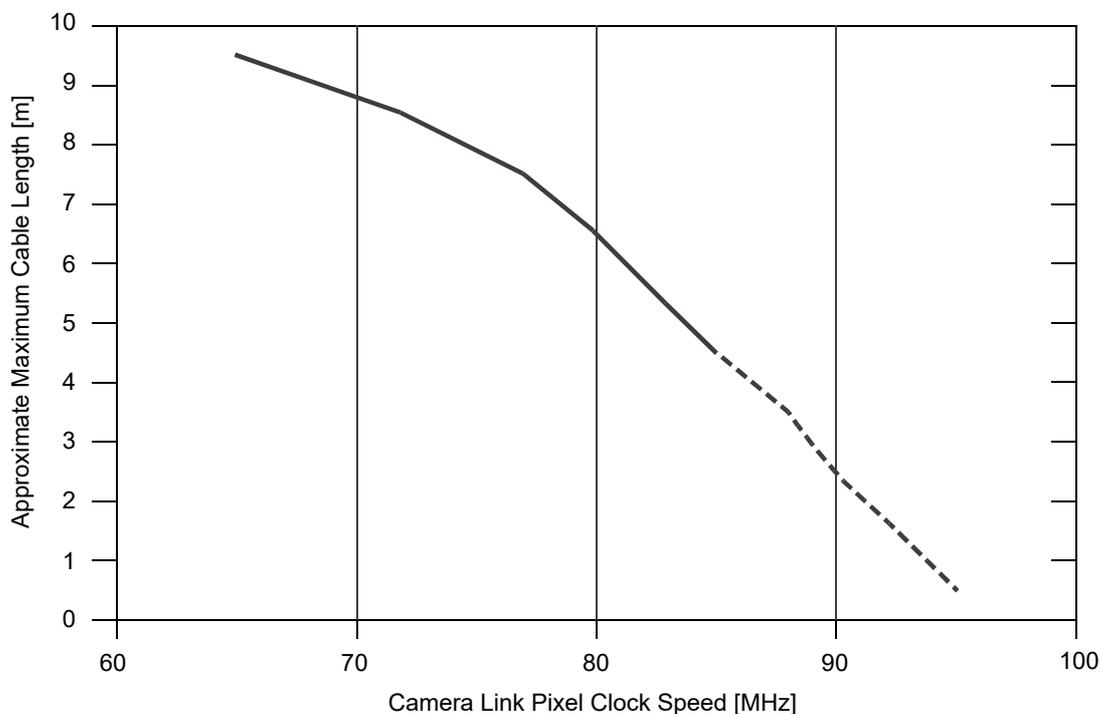


Fig. 14: Approximate Maximum Camera Link Cable Lengths for Reliable Data Transmission at Elevated Camera Link Pixel Clock Speeds.

Note that the maximum cable lengths indicated in Fig. 14 are only very approximate. For practical matters, the maximum cable length not only depends on Camera Link pixel clock speed but also on other factors e.g. on the quality of the frame grabber and on the harshness of the electromagnetic environment.

## 5.4 Camera Power

On camera models raL2048-80km and raL4096-80km, you can supply power to the camera in either one of two ways:

- Via the base Camera Link SDR connector (Power over Camera Link).
- Via the 6-pin connector (auxiliary power).

On camera models raL6144-80km, raL8192-80km, and raL12288-66km, you can supply power to the camera only via the 6-pin connector (auxiliary power).

### 5.4.1 Supplying Power Over Camera Link

On camera models raL2048-80km and raL4096-80km, you can supply power to the camera via a Camera Link cable as specified in the Camera Link standard v. 2.0 and above. This method of supplying power to the camera is known as Power over Camera Link or PoCL. PoCL camera power can **only** be supplied via the base Camera Link SDR connector.

The required nominal operating voltage for the camera is +12 VDC with less than one percent ripple. For more details about PoCL power requirements, see the Camera Link specifications v. 2.0 and above. Power consumption is as shown in the specification tables in Section 1 of this manual. Note that PoCL is specified for a maximum power consumption of only 4 W.

The power for the camera is supplied via the connection to your frame grabber. Therefore, if you are planning to use PoCL to power the camera, your frame grabber and the cables must be PoCL compliant.

#### NOTICE

##### **Incorrect power supply via Camera Link can cause damage.**

- The camera's required nominal operating voltage, effective on the camera's connector, is +12 VDC, < 1 % ripple, in accord with the Camera Link specifications.
- Failure to use a Power over Camera Link compliant frame grabber can result in severe damage to the camera.
- Failure to use a Camera Link cable that is specifically designed for PoCL (as specified in the Camera Link standard) can result in severe damage to the camera.

#### NOTICE

##### **Making or breaking Camera Link connections incorrectly can cause severe damage to the camera.**

If you are supplying power to the camera via the Camera Link connection (PoCL), be sure that the power to the camera and to the frame grabber in your computer is switched off before you connect or disconnect the Camera Link cables.

## 5.4.2 Supplying Auxiliary Power Via the 6-pin Connector

Auxiliary power can be supplied to the camera via the 6-pin connector on the back of the camera. The required operating voltage is +12 VDC (-10 %) to +24 VDC (+5 %) with a nominal operating voltage of +12 VDC ( $\pm 10\%$ ), effective on the camera's connector. Ripple must be less than one percent. Power consumption is as shown in the specification tables in Section 1 of this manual.

Close proximity to strong magnetic fields should be avoided.

See Section 5.2.1 on [page 34](#) for a description of the connector pinouts.

See Section 5.3.1 on [page 38](#) for a description of the power cable to be used with the 6-pin connector.

### NOTICE

#### Applying incorrect power can damage the camera.

- The camera's required nominal operating voltage is +12 VDC (-10 %) to +24 VDC (+5 %), < 1 % ripple, effective on the camera's connector.
- Applying power with the wrong polarity can severely damage the camera.
- Make sure that the polarity of the power applied to the camera is correct. Applying power with the wrong polarity can severely damage the camera.

### NOTICE

#### An incorrect plug can damage the 6-pin connector.

The plug on the cable that you attach to the camera's 6-pin connector must have 6 female pins.

### NOTICE

#### Making or breaking Camera Link connections incorrectly can severely damage the camera.

- If you supply power to the camera via the 6-pin connector, switch off the power to the connector before you connect or disconnect the Camera Link cables.
- If you can't switch off the power, be sure that:
  - The plug for the 6-pin connector is the last plug that you plug into the camera when making connections.
  - The plug for the 6-pin connector is the first plug that you unplug from the camera when breaking connections.

## 5.4.3 Power Intake Management

The requirements for supplying camera power via the base Camera Link SDR connector (Power over Camera Link; PoCL) or via the 6-pin connector (auxiliary power) differ between camera models.

### 5.4.3.1 Camera Models with 2k and 4k Pixels

Camera power can be supplied to 2k and 4k cameras via the base Camera Link SDR connector or via the 6-pin connector. If camera power is supplied via both connectors at the same time, the camera will switch off the internal circuitry for power supply via the Camera Link SDR connector and will only draw power via the 6-pin connector.

### 5.4.3.2 Camera Models with 6k, 8k, and 12k Pixels

For full camera operation of the 6k, 8k, and 12k cameras, camera power can only be supplied via the 6-pin connector. This is due to the fact that PoCL is specified for a maximum power consumption of only 4 W which is exceeded by the 6k, 8k, and 12k cameras.

## 5.4.4 LED Indicator

The LED indicator on the back of the camera signals whether power is present and also provides some basic error indications for the camera.

For more information, see Section 8.10 on [page 134](#).

## 5.5 I/O in the Camera Link Interface

### 5.5.1 Inputs

The camera is equipped with four input lines built into the Camera Link interface. These lines are designated as CC1, CC2, CC3, and CC4 as specified in the Camera Link standard. Typically, input signals are applied to these lines by the frame grabber board attached to the camera. The frame grabber board can typically be configured to supply different types of signals to these inputs as required by the camera user.

On the camera side, you can select these inputs to act as the source signal for the line start trigger signals.

For more information about using CC1, CC2, CC3, and CC4 on the specific type of frame grabber installed in your system, refer to the documentation for your frame grabber board.

You can also obtain some general information about how these lines are implemented in the Camera Link interface from the Basler document *racer Camera Link Information for Frame Grabber Designers* (AW001187). You can obtain the document from the Basler website: [www.baslerweb.com](http://www.baslerweb.com)

For more information about using CC1, CC2, CC3, and CC4 as the source signal for a camera function, see Section 6.1 on [page 55](#).

#### 5.5.1.1 Input Line Debouncers

Each individual input line is equipped with a debouncer. The debouncer 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.



Basler recommends setting the debouncer value so that it is slightly greater than the longest expected duration of an invalid signal.

Setting the debouncer to a value that is too short will result in accepting invalid signals. Setting the debouncer to a value that is too long will result in rejecting valid signals.

Note that the debouncer creates a delay between the arrival of a valid signal at the camera and its transfer to the camera's internal circuitry. The duration of the delay will be determined by the debouncer value.

Fig. 15 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.

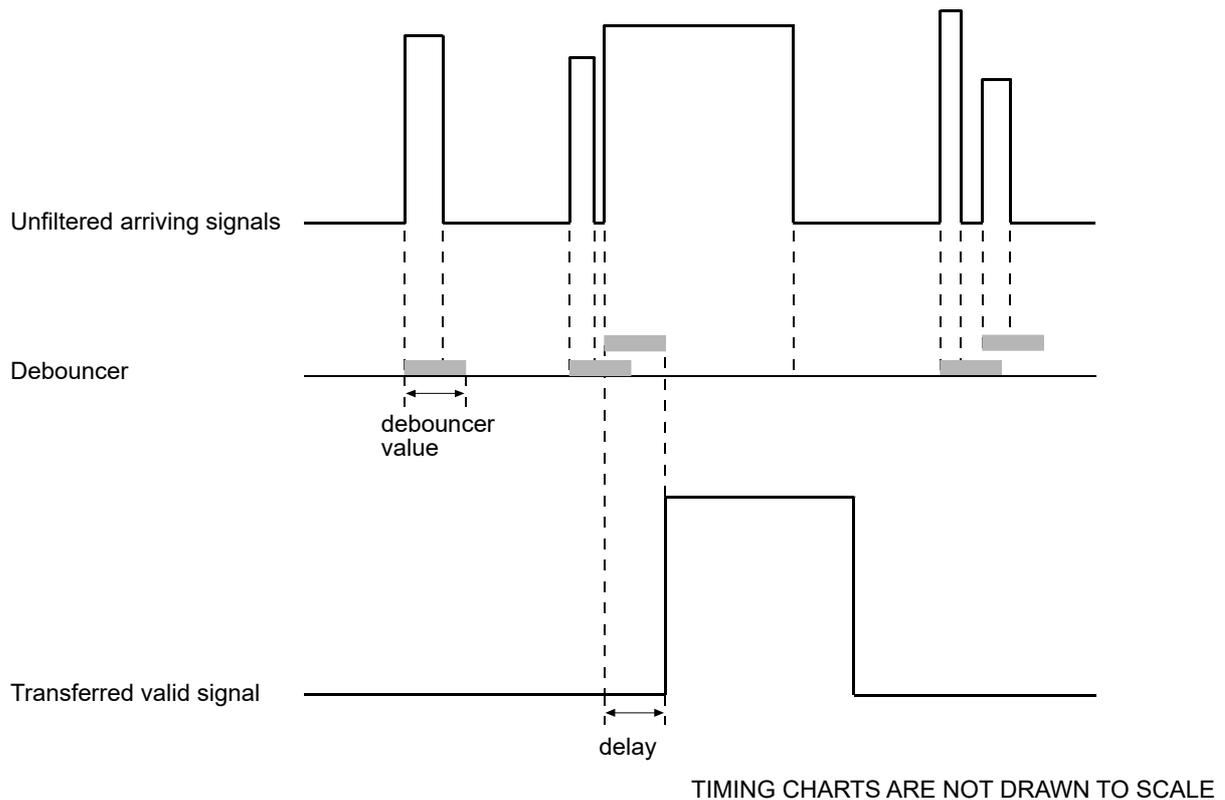


Fig. 15: Filtering of Input Signals by the Debouncer

## Setting the Debouncer

The debouncer value is determined by the value of the `LineDebouncerTimeAbs` parameter. The parameter is set in microseconds and can be set in a range from 0 to approximately 1 s.

### To set the debouncer using Basler pylon:

1. Set the `LineSelector` parameter to `CC1`, `CC2`, `CC3`, or `CC4`.
2. Set the value of the `LineDebouncerTimeAbs` parameter.

You can set the `LineSelector` and the `LineDebouncerTimeAbs` 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:

```
// Select the CC1 line
camera.LineSelector.SetValue(LineSelector_CC1);

// Set the parameter value to 150 microseconds
camera.LineDebouncerTimeAbs.SetValue(150);
```

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 26](#).

**To set the debouncer via direct register access:**

- For the CC1 line, set the value of the Input Debouncer Time CC1 register as desired (the value represents milliseconds).
- For the CC2 line, set the value of the Input Debouncer Time CC2 register.
- For the CC3 line, set the value of the Input Debouncer Time CC3 register.
- For the CC4 line, set the value of the Input Debouncer Time CC4 register.

For more information about direct register access, see Section 3.2 on [page 28](#).

### 5.5.1.2 Input Line Inverters

You can set CC1, CC2, CC3, and the CC4 line to invert or not to invert the input signal.

**To set the invert function on an input line using Basler pylon:**

1. Set the LineSelector parameter to CC1, CC2, CC3, or CC4.
2. Set the LineInverter parameter to True to enable inversion on the selected line or to False to disable inversion.

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

```
// Select the CC1 line
camera.LineSelector.SetValue(LineSelector_CC1);
// Disable the inverter on the selected line
camera.LineInverter.SetValue(false);
```

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 26](#).

**To set the invert function on an input line via direct register access:**

- For the CC1 line, set the value of the Line Inverter CC1 register to 0 (false) or 1 (true) as desired.
- For the CC2 line, set the value of the Line Inverter CC2 register.
- For the CC3 line, set the value of the Line Inverter CC3 register.
- For the CC4 line, set the value of the Line Inverter CC4 register.

For more information about direct register access, see Section 3.2 on [page 28](#).

### 5.5.1.3 Selecting an Input Line as a Source Signal for a Camera Function

You can select an input line as the source signal for the Line Start Trigger.

Note that to use an input line as the source signal for a camera function, you must apply a signal to the input line that is appropriately timed for the function.

For detailed information about selecting an input line as the source signal for the camera's Line Start Trigger function, see Section 6.1 on [page 55](#).

#### **Default Input Line Selection**

Line CC1 is selected as the source signal for the camera's Line Start Trigger function.

## 5.5.2 Outputs

As specified in the Camera Link standard, a "CL Spare" data bit is included in the Camera Link interface. On racer Camera Link cameras, the CL Spare data bit can be used as a camera output line.

You can select any one of the camera's standard output signals to act as the source signal for the CL Spare output line. The camera has these standard output signals available:

- Line Trigger Wait
- Exposure Active
- User Output
- Frequency Converter

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



The CL Spare data bit is not available when the camera is used with either of these Camera Link tap geometries:

- 1X8 Camera Link tap geometry used with the Mono 10 pixel format
- 1X10 Camera Link tap geometry.

The CL Spare data bit is not directly accessible by the camera user. The data bit must be accessed via the frame grabber attached to the camera. Not all frame grabbers provide users with direct access to this bit. Consult your frame grabber supplier for more information.

For more information about using the CL Spare bit on your specific type of frame grabber installed in your system, refer to the documentation for your frame grabber board.

You can also obtain some general information about how this bit is implemented in the Camera Link interface from the Basler document *racer Camera Link Information for Frame Grabber Designers* (AW001187). You can obtain the document from the Basler website: [www.baslerweb.com](http://www.baslerweb.com)

## 5.5.2.1 Minimum Output Pulse Width

You can use the minimum output pulse width feature to ensure that even very narrow camera output signals will reliably be detected by other devices. The feature allows you to set the output signal to a minimum width.

### Setting the Minimum Output Pulse Width

The `MinOutPulseWidthAbs` parameter sets the CL Spare output signals to a minimum width. The parameter is set in microseconds and can be set in a range from 0 to 100  $\mu$ s

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

```
// Select the output line
camera.LineSelector.SetValue(LineSelector_CLSpare);

// Set the parameter value to 10.0 microseconds
camera.MinOutPulseWidthAbs.SetValue(10.0);
```

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 selecting the source signal for an output line on the camera, see Section 5.5.2.3 on [page 49](#).

#### To set the value for the minimum output pulse width via direct register access:

- Set the value of the Min Out Pulse Width CL Spare register as desired (the value represents microseconds).

For more information about direct register access, see Section 3.2 on [page 28](#).

## 5.5.2.2 Output Line Inverters

You can set the CL Spare output line to invert or not to invert the input signal.

### Setting the CL Spare Output Line for Invert

#### To set the invert function on the CL Spare output line using Basler pylon:

1. Use the LineSelector parameter to select CL Spare.
2. Set the value of the LineInverter parameter to true to enable inversion on the selected line or to false to disable inversion.

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

```
// Select the CL Spare output line
camera.LineSelector.SetValue(LineSelector_CLSpare);
// Disable the inverter on the selected line
camera.LineInverter.SetValue(false);
```

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 26](#).

#### To set the invert function on the CL Spare output line via direct register access::

- For the CL Spare output line, set the value of the Line Inverter CL Spare register to 0 (false) or 1 (true) as desired.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 5.5.2.3 Selecting the Source Signal for an Output Line

To make an output line useful, you must select a source signal for the output line.

You can select any one of the camera's standard output signals to act as the source signal for the CL Spare output line. The camera has these standard output signals available:

- Line Trigger Wait
- Exposure Active

You can also select one of the following as the source signal for the output:

- the "User Output" signal (when you select "user output" as the source signal for the CL Spare output line, you can use the camera's API to set the state of the line as you desire)
- Off (when Off is selected as the source signal, the output is disabled.)

**To select the source signal for the output line using Basler pylon:**

1. Use the LineSelector parameter to select CL Spare as the output line.
2. Set the value of the LineSource parameter to LineTriggerWait, ExposureActive, UserOutput, or Off. This will select the source signal for the line.

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

```
// Select the line trigger wait signal for the CL Spare output line
camera.LineSelector.SetValue(LineSelector_CLSpare);
camera.LineSource.SetValue(LineSource_LineTriggerWait);

// Select the exposure active signal for the CL Spare output line
camera.LineSelector.SetValue(LineSelector_CLSpare);
camera.LineSource.SetValue(LineSource_ExposureActive);

// Select the CL Spare output line as a user output
camera.LineSelector.SetValue(LineSelector_CLSpare);
camera.LineSource.SetValue(LineSource_UserOutput);

// Disable the CL Spare output line
camera.LineSelector.SetValue(LineSelector_CLSpare);
camera.LineSource.SetValue(LineSource_Off);
```

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

For more information about the Line Trigger Wait signal, see Section 6.3.3 on [page 82](#).

For more information about the Exposure Active signal, see Section 6.3.1 on [page 80](#).

For more information about working with outputs that have "user settable" as the signal source, see Section 5.5.2.4 on [page 51](#).

**To select the source signal for the output line via direct register access:**

- Set the value of the Line Source CL Spare register to Line Trigger Wait, Exposure Active, or User as desired.

For more information about direct register access, see Section 3.2 on [page 28](#).

**Default Output Line Source Signal Selections**

By default, the camera's Exposure Active signal is selected as the source signal for the CL Spare output line.

## 5.5.2.4 Setting the State of a User Settable Output Line

As mentioned in the previous section, you can select "user output" as the signal source for the CL Spare output line. For the output line that has "user output" as the signal source, you can use camera parameters to set the state of the line.



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

### Setting the State of a User Output Line

#### To set the state of a single user output line using Basler pylon:

1. Use the UserOutputSelector parameter to select CL Spare as the output line you want to set.
2. Set the value of the UserOutputValue parameter to True (high) or False (low). This will set the state of the selected line.

You can set the UserOutputSelector and the UserOutputValue parameter values from within your application software by using the pylon API. The following code snippet illustrates using the API to select "user settable" as the source signal for output line 2 and how to set the state of the output line:

```
// Select "user output" as the signal source for the CL Spare output line
camera.LineSelector.SetValue(LineSelector_CLSpare);
camera.LineSource.SetValue(LineSource_UserOutput);

//Set the state of the CL Spare output line and then read the state
camera.UserOutputSelector.SetValue(UserOutputSelector_CLSpare);
camera.UserOutputValue.SetValue(true);
bool currentUserOutput2State = camera.UserOutputValue.GetValue();
```

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

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

#### To set the state of a single user output line via direct register access:

- Set the value of the User Output CL Spare register to 1 (True) or 0 (False) as desired.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 5.6 Checking the State of the I/O Lines

### 5.6.1 Checking the State of a Single Line

#### Checking the State of an I/O Line

**To check the state of a line using Basler pylon:**

1. Use the LineSelector parameter to select a line.
2. Read the value of the LineStatus parameter to determine the current state of the line. A value of True means the line's state is currently high and a value of False means the line's state is currently low.

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

```
// Select the CC1 line and read the state
camera.LineSelector.SetValue(LineSelector_CC1);
bool CC1 = camera.LineStatus.GetValue();

// Select the CLSpare line and read the state
camera.LineSelector.SetValue(LineSelector_CLSpare);
bool CLSpareState = camera.LineStatus.GetValue();
```

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

**To check the state of a line via direct register access:**

- For the CC1 line, read the value of the Line Status CC1 register. The value will indicate 1 (true) or 0 (false).
- For the CC2 line, read the value of the Line Status CC2 register.
- For the CC3 line, read the value of the Line Status CC3 register.
- For the CC4 line, read the value of the Line Status CC4 register.
- For the CL Spare line, read the value of the Line Status CL Spare register.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 5.6.2 Checking the State of All Lines

### Checking the State Using Basler pylon

You can determine the current state of all input and output lines by reading the value of the LineStatusAll parameter. You can read the LineStatusAll parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to read the parameter value:

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

The LineStatusAll parameter is a 32 bit value. As shown in Fig. 16, certain bits in the value are associated with each I/O line, and each of these bits will indicate the state of the associated line. If a bit is 0, it indicates that the state of the associated line is currently low. If a bit is 1, it indicates that the state of the associated line is currently high.

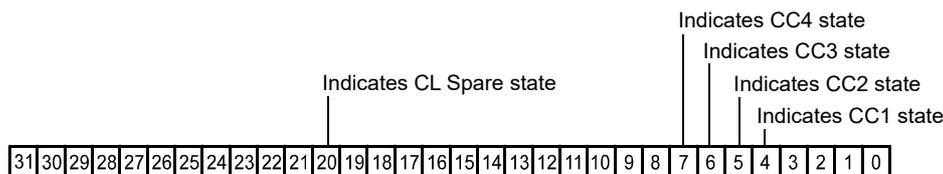


Fig. 16: Line Status All Parameter Bits

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

### Checking the State Using Direct Register Access

To check the current state of all I/O lines via direct register access, read the value of the Line Status All register. The register holds a 32 bit value that indicates the state of each I/O line. The mapping of the bits in the value to I/O lines is similar to the mapping described above for access via Basler pylon.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 5.7 Checking the Line Logic of the I/O Lines

### To determine the type of line logic for each I/O line using Basler pylon:

- Use the LineSelector parameter to select a line.
- Read the value of the LineLogic parameter to determine the type of line logic used by the line. The parameter will indicate whether the logic is positive or negative.

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

```
// Select the CC1 line and read the line logic type
camera.LineSelector.SetValue(LineSelector_CC1);
LineLogicEnums lineLogicCC1 = camera.LineLogic.GetValue();

// Select the CLSpare line and read line logic type
camera.LineSelector.SetValue(LineSelector_CLSpare);
LineLogicEnums lineLogicCLSpare = camera.LineLogic.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 26](#).

### To determine the type of line logic for each I/O line via direct register access:

- For the CC1 line, read the value of the Line Logic CC1 register. The value will indicate 1 (positive) or 0 (negative).
- For the CC2 line, read the value of the Line Logic CC2 register.
- For the CC3 line, read the value of the Line Logic CC3 register.
- For the CC4 line, read the value of the Line Logic CC4 register.
- For the CL Spare line, read the value of the Line Logic CL Spare register.

For more information about direct register access, see Section 3.2 on [page 28](#).

# 6 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.

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

The following elements are involved in controlling the acquisition of lines:

- the line start trigger
- exposure time control

## 6.1 Line Start Triggering

The line start trigger is used to start a line acquisition. Keep in mind that the camera will only react to a line start trigger when the line start trigger is valid. If the line start trigger is invalid, line start triggers will be ignored.

The first parameter associated with the line start trigger is the TriggerMode parameter. The TriggerMode parameter has two available settings: off and on.

### 6.1.1 Line Start with TriggerMode = Off

When the trigger mode is set to Off, selection of a source signal for the line start trigger is not required. With the trigger mode set to Off, the camera operates the line start trigger automatically and generates the line start triggers internally.

## Setting the Acquisition Line Rate

The rate at which the line start triggers are generated will be determined by the camera's AcquisitionLineRateAbs parameter:

- If AcquisitionLineRateAbs is set to a value less than the maximum allowed line acquisition rate, the parameter limits the line rate to the given value. This is useful if you want to limit the amount of data to be transferred from the camera to the computer.
- If AcquisitionLineRateAbs is set to a value greater than the maximum allowed line acquisition rate, the camera will generate line start triggers at the maximum allowed line rate.

For more information about setting the parameter, see Section 6.1.3 on [page 58](#).

For more information about the maximum allowed line rate, see Section 6.4 on [page 87](#).

## Exposure Time Control with TriggerMode = Off

When the trigger mode is set to Off, the exposure time for each line acquisition is determined by the value of the camera's ExposureTime parameter.

The minimum and the maximum allowed exposure time for each acquired line are as shown in Table 9.

	raL2048-80km	raL4096-80km	raL6144-80km	raL8192-80km	raL12288-66km
Min	2.0 $\mu$ s				
Max	10000 $\mu$ s				

Table 9: Minimum and Maximum Allowed Exposure Times



If you are using a GenICam compliant tool such as the Basler pylon Viewer and you attempt to set the exposure time to exactly the minimum allowed or to exactly the maximum allowed, you will see unusual error codes. This is an artifact of a rounding error in the GenICam interface architecture. As a workaround, you could set the exposure time slightly above the minimum or below the maximum. Values between the minimum and the maximum are not affected by the problem.

For more information about setting exposure time, see Section 6.1.3 on [page 58](#).

## 6.1.2 Line Start with TriggerMode = On

When the trigger mode is set to On, you must select a source signal for the line start trigger. TriggerSource specifies the source signal. The available selections for TriggerSource are:

- Software - When the line start trigger source is set to software, the user triggers line start by issuing a TriggerSoftware command to the camera from the host computer. Each time a TriggerSoftware command is received by the camera, the line start trigger will become valid. It will become invalid during line acquisition and will become valid again when the next TriggerSoftware command is received and when the camera is ready again for a new line acquisition.
- CC1 - When the source signal is set to CC1, CC2, CC3, or CC4, you apply a line start trigger signal to the camera by injecting an externally generated electrical signal (a "hardware trigger") into CC1, CC2, CC3, or CC4 in the Camera Link interface.

If TriggerSource is set to CC1, CC2, CC 3, or CC4, the user must also set the TriggerActivation parameter. The available settings for the TriggerActivation parameter are:

- RisingEdge - specifies that a rising edge of the source signal will start a line acquisition.
- FallingEdge - specifies that a falling edge of the source signal will start a line acquisition.



Typically, a frame grabber is used to supply an electrical line start signal to CC1, CC2, CC3, or CC4.

By default, CC1 is selected as the source signal for the line start trigger.

If the TriggerSource parameter is set to CC1, CC2, CC 3, or CC4, the externally generated electrical signal applied to the selected input line must be held high for a minimum period for the camera to detect a transition from low to high and must be held low for a minimum period for the camera to detect a transition from high to low:

- The minimum period is 100 ns if the debouncer is not used.
- The minimum period is equal to or larger than the debouncer value if the debouncer is used.

For more information about using a software trigger to control line acquisition start, see Section 6.1.4 on [page 60](#).

For more information about using a hardware trigger to control line acquisition start, see Section 6.1.5 on [page 64](#).



In all cases, the exposure time for each line must be within the minimum and the maximum stated in Table 11 on [page 65](#). This is true regardless of the method used to control exposure.

## Exposure Time Control with TriggerMode = On

When the trigger mode is set to On, the exposure time for each line acquisition is determined by the value of the camera's exposure time parameters.

For more information about setting exposure time, see Section 6.1.3 on [page 58](#).

### 6.1.3 Setting the Trigger Mode and Related Parameters

You can set the trigger mode and related parameter values from within your application software by using the pylon API. If your settings make it necessary, you can also set the TriggerSource parameter.

The following code snippet illustrates using the API to set the TriggerMode parameter for the line start trigger to On and the TriggerSource parameter to CC1:

```
// Select the line start trigger
camera.TriggerSelector.SetValue(TriggerSelector_LineStart);
// Set the mode for the selected trigger
camera.TriggerMode.SetValue(TriggerMode_On);
// Set the source for the selected trigger
camera.TriggerSource.SetValue (TriggerSource_CC1);
```

The following code snippet illustrates using the API to set the TriggerMode parameter for the line start trigger to Off and the AcquisitionLineRateAbs parameter to 60:

```
// Select the line start trigger
camera.TriggerSelector.SetValue(TriggerSelector_LineStart);
// Set the mode for the selected trigger
camera.TriggerMode.SetValue(TriggerMode_Off);
// Set the exposure time in (µs)
camera.ExposureTimeAbs.SetValue(300);
// Enable the acquisition line rate parameter and set the line rate. (Enabling
// the acquisition line rate parameter allows the camera to control the line
// rate internally.
camera.AcquisitionLineRateEnable.SetValue(true);
camera.AcquisitionLineRateAbs.SetValue(60.0);
```

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 26](#).

**To set the trigger mode to On and to select a trigger source via direct register access:**

1. Set the value of the Trigger Mode Line Start register to On.
2. Set the value of the Trigger Source Line Start register to Software, CC1, CC2, CC3, or CC4.
3. If the trigger source is set to CC1, CC2, CC3, or CC4, set the value of the Trigger Activation Line Start register to Rising Edge or Falling Edge.

**To set the trigger mode to Off, set the exposure time, and set the line acquisition rate via direct register access:**

1. Set the value of the Trigger Mode Line Start register to Off.
2. Set the value of the Exposure Time Raw register as desired.
3. A value in a raw register is simply an integer value with no units. To determine what the actual setting will be, you must multiply the value in the raw register by the camera's time base. The time base on racer cameras is 100 ns.
4. For example, if you set the Exposure Time Raw register to 1000, the exposure time would be 100  $\mu$ s (1000 x 100 ns = 100  $\mu$ s).
5. Set the value of the Acquisition Line Period Enable register to 1 (true).  
(This will enable the camera's ability to internally control the line period.)
6. Set the value of the Acquisition Line Period Raw register as desired.  
(Line Rate = 1 /Line Period.)

For more information about direct register access, see Section 3.2 on [page 28](#).

## 6.1.4 Using a Software Line Start Trigger Signal

### 6.1.4.1 Introduction

When the TriggerMode parameter is set to On and the TriggerSource parameter is set to Software, you must apply a software line start trigger signal to the camera to begin each line acquisition. Assuming that the camera is in a "waiting for line start trigger" acquisition status, line exposure will start when the software line start trigger signal is received by the camera. Fig. 17 illustrates line acquisition with a software line start trigger signal.

When the camera receives a software trigger signal and begins exposure, it will exit the "waiting for line start trigger" acquisition status because at that point, it cannot react to a new line start trigger signal. As soon as the camera is capable of reacting to a new line start trigger signal, it will automatically return to the "waiting for line start trigger" acquisition status.

### Timed Exposure Mode

When you are using a software trigger signal to start each line acquisition, the camera's ExposureMode parameter must be set to Timed. The exposure time for each acquired line will be determined by the value of the camera's ExposureTimeAbs parameter if you are parameterizing the camera with Basler pylon or by the Exposure Time Raw register if you are parameterizing the camera via direct register access.

The minimum and the maximum allowed exposure times for each acquired line are as shown in Table 10.

	raL2048-80km	raL4096-80km	raL6144-80km	raL8192-80km	raL12288-66km
Min	2.0 $\mu$ s				
Max	10000 $\mu$ s				

Table 10: Minimum and Maximum Allowed Exposure Times



If you are using a GenICam compliant tool such as the Basler pylon Viewer and you attempt to set the exposure time to exactly the minimum allowed or to exactly the maximum allowed, you will see unusual error codes. This is an artifact of a rounding error in the GenICam interface architecture. As a work around, you could set the exposure time slightly above the minimum or below the maximum. Values between the minimum and the maximum are not affected by the problem.

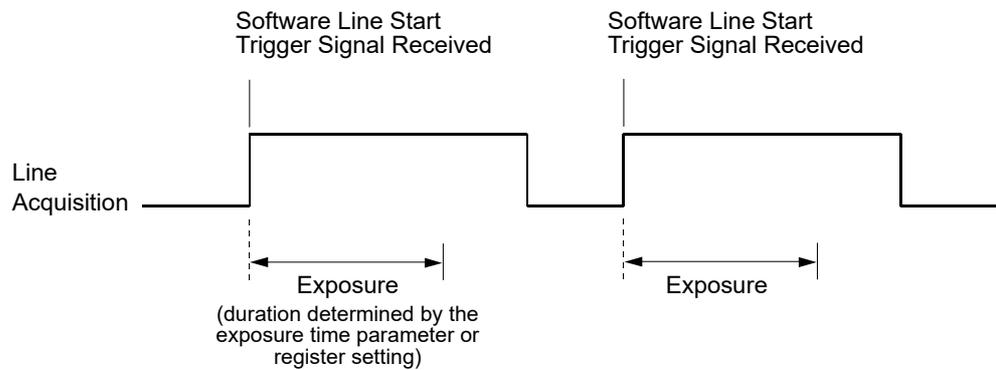


Fig. 17: Line Acquisition with a Software Line Start Trigger and Exposure Mode Set to Timed

When you are using a software trigger signal to start each line acquisition, the line rate will be determined by how often you apply a software trigger signal to the camera.



Do not trigger line acquisition at a rate that

- exceeds the maximum allowed for the current camera settings. If you apply line 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 line rate, see Section 6.4 on [page 87](#).
- exceeds the host computer's capacity limits for data transfer or storage or both. If you try to transfer more data than the host computer is able to process, lines may be dropped. For more information about bandwidth optimization, see the *Installation and Setup Guide for Cameras Used with Basler pylon for Windows* (AW000611).

Section 6.1.4.2 includes more detailed information about applying a software line start trigger signal to the camera using Basler pylon or via direct register access.

## 6.1.4.2 Setting the Parameters Related to Software Line Start Triggering and Applying a Software Trigger Signal

You can set all of the parameters needed to perform software line start triggering from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values and execute the commands related to software line start triggering.

```
// Disable the acquisition line rate parameter (this will disable the camera's
// internal line rate control and allow you to control the line rate with
// software line start trigger signals)
camera.AcquisitionLineRateEnable.SetValue(false);
// Select the line start trigger
camera.TriggerSelector.SetValue(TriggerSelector_LineStart);
// Set the mode for the selected trigger
camera.TriggerMode.SetValue(TriggerMode_On);
// Set the source for the selected trigger
camera.TriggerSource.SetValue (TriggerSource_Software);
// Set for the timed exposure mode
camera.ExposureMode.SetValue(ExposureMode_Timed);
// Set the exposure time
camera.ExposureTimeAbs.SetValue(300);
    while (! finished)
    {
        // Execute a trigger software command to apply a line start
        // trigger signal to the camera
        camera.TriggerSoftware.Execute();
        // Retrieve acquired line here
    }
// Note: as long as the Trigger Selector is set to LineStart, executing
// a Trigger Software command will apply a software line start trigger
// signal to the camera
```

The following code snippet illustrates using the API to check the acquisition status:

```
// Set the acquisition status selector
camera.AcquisitionStatusSelector.SetValue
(AcquisitionStatusSelector_LineTriggerWait);

// Read the acquisition status
bool IsWaitingForLineTrigger = camera.AcquisitionStatus.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 26](#).

**To set the parameters needed to perform software line start triggering via direct register access:**

1. Set the value of the Acquisition Line Period Enable register to 0 (false).  
(This will disable the camera's ability to internally control the line period and allow you to control the line rate with software trigger signals.)
2. Set the value of the Trigger Mode Line Start register to On.
3. Set the value of the Trigger Source Line Start register to Software.
4. Set the value of the Exposure Mode register to Timed.
5. Set the value of the Exposure Time Raw parameter as desired.  
A value in a raw register is simply an integer value with no units. To determine what the actual setting will be, you must multiply the value in the raw register by the camera's time base. The time base on racer cameras is 100 ns.  
For example, if you set the Exposure Time Raw register to 1000, the exposure time would be 100  $\mu$ s (1000 x 100 ns = 100  $\mu$ s).
6. Set the value of the Trigger Software Line Start register to 1.  
Setting the value of this register to 1 applies a software line start trigger to the camera. The register resets to 0 when execution is complete.

**To determine the acquisition status of the camera via direct register access:**

- Read the value of the Status Line Trigger Wait register.  
A value of 0 indicates that the camera is not ready to receive a line start trigger.  
A value of 1 indicates that the camera is ready to receive a line start trigger.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 6.1.5 Using a Hardware Line Start Trigger Signal

### 6.1.5.1 Introduction

If the TriggerMode parameter for the line start trigger is set to On and the TriggerSource parameter is set to CC1, CC2, CC3, or CC4, an externally generated electrical signal injected into the selected source will act as the line start trigger signal for the camera. This type of trigger signal is generally referred to as a hardware trigger signal or as an external line start trigger signal (ExLSTrig signal).

A rising edge or a falling edge of the ExLSTrig signal can be used to trigger line acquisition. The TriggerActivation parameter is used to select rising edge or falling edge triggering.

Assuming that the camera is in a "waiting for line start trigger" acquisition status, line acquisition will start when the hardware line start trigger signal is received by the camera.

When the camera receives a hardware trigger signal and begins exposure, it will exit the "waiting for line start trigger" acquisition status because at that point, it cannot react to a new line start trigger signal. As soon as the camera is capable of reacting to a new line start trigger signal, it will automatically return to the "waiting for line start trigger" acquisition status.

When the camera is operating under control of an ExLSTrig signal, the period of the ExLSTrig signal will determine the rate at which the camera will acquire lines:

$$\frac{1}{\text{ExLSTrig period in seconds}} = \text{Line Rate}$$

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

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

So in this case, the line rate is 50 lps.

If you have selected CC1, CC2, CC3, or CC4 as the trigger source, your frame grabber will typically apply the electrical signal to the selected input via the Camera Link cable. For more information about applying an ExLSTrig signal to CC1, CC2, CC3, or CC4, see the documentation for your frame grabber.



If you are triggering line acquisition with an ExLSTrig signal and you attempt to acquire lines at too high a rate, some of the line trigger signals that you apply will be received by the camera when it is not in a "waiting for line start trigger" acquisition status. The camera will ignore any line start trigger signals that it receives when it is not "waiting for line start trigger". (This situation is commonly referred to as "overtriggering" the camera.)

To avoid overtriggering, you should not attempt to acquire lines at a rate that exceeds the maximum allowed with the current camera settings.

For more information about determining the maximum allowed line rate with the current camera settings, see Section 6.4 on [page 87](#).

For more information about setting the camera for hardware triggering and selecting the source to receive the ExLSTrig signal, see Section 6.1.5 on [page 64](#).

For more information about CC1, CC2, CC3, and CC4, see Section 5.5.1 on [page 43](#).

## 6.1.5.2 Exposure Modes

If you are triggering the start of line acquisition with hardware line start trigger (ExLSTrig) signal, the following exposure modes are available:

- Timed exposure mode
- Trigger width exposure mode

### Timed Exposure Mode

When the timed exposure mode is selected, the exposure time for each line acquisition is determined by:

- the value of the camera's ExposureTimeAbs parameter if you are parameterizing the camera with Basler pylon.
- the value of the Exposure Time Raw register if you are parameterizing the camera via direct register access.

The minimum and the maximum allowed exposure time for each acquired line are as shown in Table 10.

	raL2048-80km	raL4096-80km	raL6144-80km	raL8192-80km	raL12288-66km
Min	2.0 $\mu$ s				
Max	10000 $\mu$ s				

Table 11: Minimum and Maximum Allowed Exposure Times



If you are using a GenICam compliant tool such as the Basler pylon Viewer and you attempt to set the exposure time to exactly the minimum allowed or to exactly the maximum allowed, you will see unusual error codes. This is an artifact of a rounding error in the GenICam interface architecture. As a work around, you could set the exposure time slightly above the minimum or below the maximum. Values between the minimum and the maximum are not affected by the problem.

If the camera is set for rising edge triggering, the exposure time starts when the ExLSTrig signal rises. If the camera is set for falling edge triggering, the exposure time starts when the ExLSTrig signal falls. Fig. 18 illustrates timed exposure with the camera set for rising edge triggering.

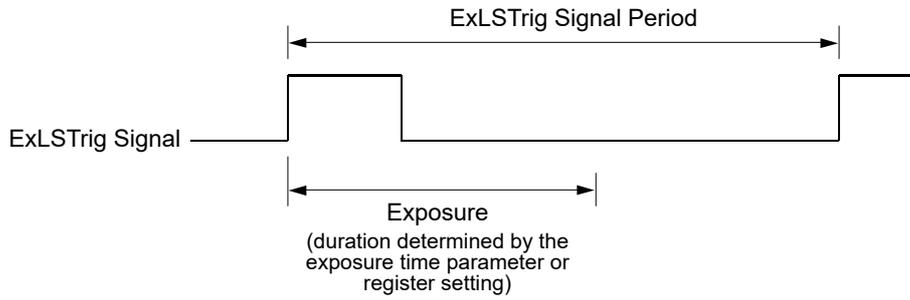


Fig. 18: Timed Exposure with Rising Edge Triggering

Note that if you attempt to trigger a new exposure start while the previous exposure is still in progress (overtriggering), the trigger signal will be ignored. This situation is illustrated in Fig. 19 for rising edge triggering.

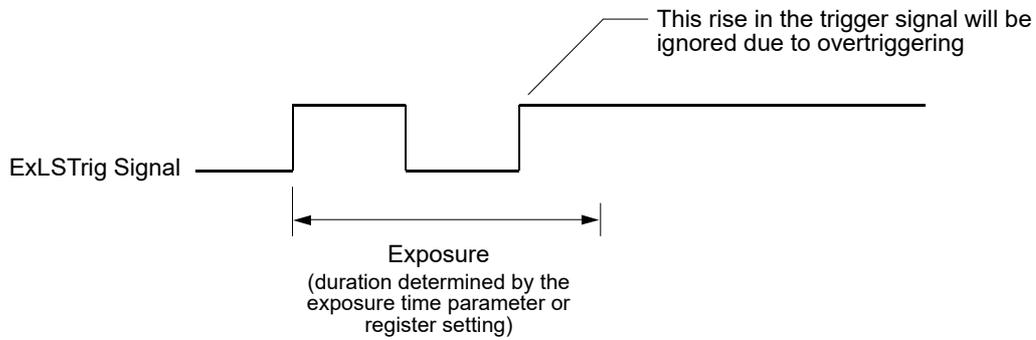


Fig. 19: Overtriggering with Timed Exposure

## Trigger Width Exposure Mode

When trigger width exposure mode is selected, the length of the exposure for each line acquisition will be directly controlled by the ExLSTrig signal. If the camera is set for rising edge triggering, the exposure time begins when the ExLSTrig signal rises and continues until the ExLSTrig signal falls. If the camera is set for falling edge triggering, the exposure time begins when the ExLSTrig signal falls and continues until the ExLSTrig signal rises.

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

The minimum allowed exposure time for each acquired line is as shown in Table 12 and there is no limit on the maximum exposure time. Keep in mind, however, that using a very long exposure time can lead to significant degradation of the image quality.

	raL2048-80km	raL4096-80km	raL6144-80km	raL8192-80km	raL12288-66km
Min	2.0 $\mu$ s				

Table 12: Minimum Allowed Exposure Times



If you are using a GenICam compliant tool such as the Basler pylon Viewer and you attempt to set the exposure time to exactly the minimum allowed or to exactly the maximum allowed, you will see unusual error codes. This is an artifact of a rounding error in the GenICam interface architecture. As a work around, you could set the exposure time slightly above the minimum or below the maximum. Values between the minimum and the maximum are not affected by the problem.

Fig. 20 illustrates trigger width exposure with the camera set for rising edge triggering.

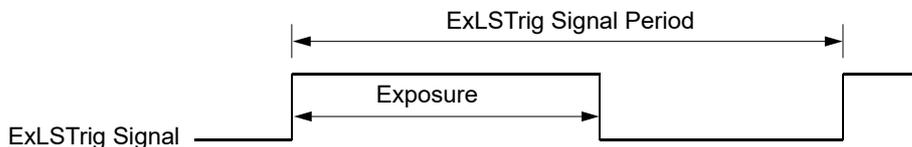


Fig. 20: Trigger Width Exposure with RisingEdge Triggering

When you use the trigger width exposure mode and want to monitor the Line Trigger Wait signal to avoid overtriggering you must also set an ExposureOverlapTimeMaxAbs value. This value allows the Line Trigger Wait signal to indicate when the camera becomes ready to receive a hardware line start trigger.



The joint use of the Line Trigger Wait signal and the ExposureOverlapTimeMaxAbs setting is particularly useful when overlapping exposure with sensor readout. For more information, see Section 6.2 on [page 71](#) and Section 6.3.3 on [page 82](#).

For more information about the Line Start Trigger Wait (ExLSTrig Wait) signal, see Section 6.3.3 on [page 82](#).

You can set an ExposureOverlapTimeMaxAbs value in two ways: If you are parameterizing the camera with Basler pylon you must set the ExposureOverlapTimeMaxAbs parameter and if you are parameterizing the camera via direct register access you must set the value of the Exposure Overlap Time Max Raw register.

The correct parameter values depend on the method that you choose to avoid overtriggering:

- If you want to monitor the Line Trigger Wait signal to avoid overtriggering you must set ExposureOverlapTimeMaxAbs to represent the **shortest** exposure time you intend to use. This will allow you to avoid the "illegal" situation shown in Fig. 24 on [page 74](#). For example, assume that you will be using trigger width exposure mode and that you intend to use the ExLSTrig signal to vary the exposure time in a range from 15  $\mu$ s to 20  $\mu$ s. In this case you would set the camera's ExposureOverlapTimeMaxAbs to 20  $\mu$ s.
- If you want to avoid overtriggering by obeying certain timing limits during line acquisition you must set the ExposureOverlapTimeMaxAbs to an appropriate value.

For more information about line acquisition while obeying certain timing limits and setting the ExposureOverlapTimeMaxAbs, see Section 6.2.1.2 on [page 75](#).

### 6.1.5.3 Setting the Parameters Related to Hardware Line Start Triggering and Applying a Hardware Trigger Signal

You can set all of the parameters needed to perform hardware line start triggering from within your application software by using the pylon API.

The following code snippet illustrates using the API to set the parameter values and execute the commands related to hardware line start triggering with the camera set for the timed exposure mode with rising edge triggering and CC1 as the trigger source.

```
// Disable the acquisition line rate parameter (this will disable the camera's
// internal line rate control and allow you to control the line rate with
// external line start trigger signals)
camera.AcquisitionLineRateEnable.SetValue(false);
// Select the line start trigger
camera.TriggerSelector.SetValue(TriggerSelector_LineStart);
// Set the mode for the selected trigger
camera.TriggerMode.SetValue(TriggerMode_On);
// Set the source for the selected trigger
camera.TriggerSource.SetValue (TriggerSource_CC1);
// 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.ExposureTimeAbs.SetValue(300);

// Line acquisition will start each time the externally generated
// line start trigger signal (ExLSTrig signal) goes high
```

The following code snippet illustrates using the API to set the parameter values and execute the commands related to hardware line start triggering with the camera set for the trigger width exposure mode with rising edge triggering and with line CC1 as the trigger source.

```
// Disable the acquisition line rate parameter (this will disable the camera's
// internal line rate control and allow you to control the line rate with
// external line start trigger signals)
camera.AcquisitionLineRateEnable.SetValue(false);
// Select the line start trigger
camera.TriggerSelector.SetValue(TriggerSelector_LineStart);
// Set the mode for the selected trigger
camera.TriggerMode.SetValue(TriggerMode_On);
// Set the source for the selected trigger to CC1
camera.TriggerSource.SetValue (TriggerSource_CC1);
// Set the trigger activation mode to rising edge
camera.TriggerActivation.SetValue(TriggerActivation_RisingEdge);
// Set for the trigger width exposure mode
camera.ExposureMode.SetValue(ExposureMode_TriggerWidth);

// Line acquisition will start each time the externally generated
// line start trigger signal (ExLSTrig signal) goes high
```

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

**To set the parameters needed to perform hardware line start triggering via direct register access:**

1. Set the value of the Acquisition Line Period Enable register to 0 (false). (This will disable the camera's ability to control the line period internally and allow you to control the line rate with an external signal.)
2. Set the value of the Trigger Mode Line Start register to On.
3. Set the value of the Trigger Source Line Start register to receive the hardware trigger signal on, CC1, CC2, CC3, or CC4.
4. Set the value of the Trigger Activation Line Start register to Rising Edge or Falling Edge as desired.
5. Set the value of the Exposure Mode register to Timed or to Trigger Width.
6. If the mode is set to Timed, set the value of the Exposure Time Raw register as desired. A value in a raw register is simply an integer value with no units. To determine what the actual setting will be, you must multiply the value in the raw register by the camera's time base. The time base on racer cameras is 100 ns. For example, if you set the Exposure Time Raw register to 1000, the exposure time would be 100  $\mu$ s (1000 x 100 ns = 100  $\mu$ s).
7. Apply the appropriate externally generated electrical signal (ExLSTrig signal) to the selected trigger source.

For more information about direct register access, see Section 3.2 on [page 28](#).

## Exposure Start and Exposure End Delays

When the trigger mode is set to On and an input line is selected as the source signal for the line start trigger, there is a delay between the transition of the line start signal and the actual start of exposure. For example, if you are using the timed exposure mode with rising edge triggering, there is a delay between the rise of the signal and the actual start of exposure.

There is also an exposure end delay, i.e., a delay between the point when exposure should end as explained in the diagrams on the previous page and when it actually does end.

The base exposure start and end delays are as shown in Table 13:

	raL2048-80km	raL4096-80km	raL6144-80km	raL8192-80km	raL12288-66km
Start Delay	1.5 $\mu$ s				
End Delay	1.2 $\mu$ s				

Table 13: Base Exposure Start and End Delays



If you are using a GenICam compliant tool such as the Basler pylon Viewer and you attempt to set the exposure time to exactly the minimum allowed or to exactly the maximum allowed, you will see unusual error codes. This is an artifact of a rounding error in the GenICam interface architecture. As a work around, you could set the exposure time slightly above the minimum or below the maximum. Values between the minimum and the maximum are not affected by the problem.



When using the frequency converter, the delay values may slightly differ from those given in [Table 13](#). For more information about the frequency converter, see [Section 6.3 on page 80](#).

There is also a second component to the start and end delays. This second component is the debouncer setting for the input line. The debouncer setting for the input line must be added to the base start and end delays shown in Table 13 to determine the total start delay and end delay. For example, assume that you are using an raL2048-80km camera and that you have set the trigger mode to On. Also assume that you have selected input line CC1 as the source signal for the line start trigger and that the debouncer parameter for line CC1 is set to 5  $\mu$ s. In this case:

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

Total Start Delay = 1.5  $\mu$ s + 5  $\mu$ s

Total Start Delay = 6.5  $\mu$ s

Total End Delay = End Delay Value from Table 13 + Debouncer Setting

Total End Delay = 1.2  $\mu$ s + 5  $\mu$ s

Total End Delay = 6.2  $\mu$ s

## 6.2 Overlapping Exposure with Sensor Readout

The line acquisition process on the camera includes two distinct parts. The first part is the exposure of the pixels in the imaging sensor. Once exposure is complete, the second part of the process – readout of the pixel values from the sensor – takes place. In regard to this line acquisition process, there are two common ways for the camera to operate: with “non-overlapped” exposure and with “overlapped” exposure.

For the examples shown in this section the Trigger Activation line start trigger signal is assumed to be set to RisingEdge.

In the non-overlapped mode of operation, each time a line is acquired the camera completes the entire exposure/readout process before acquisition of the next line is started. The exposure for a new line does not overlap the sensor readout for the previous line. This situation is illustrated in Fig. 21 here an hardware line start trigger is used with the camera set for the trigger width exposure mode.

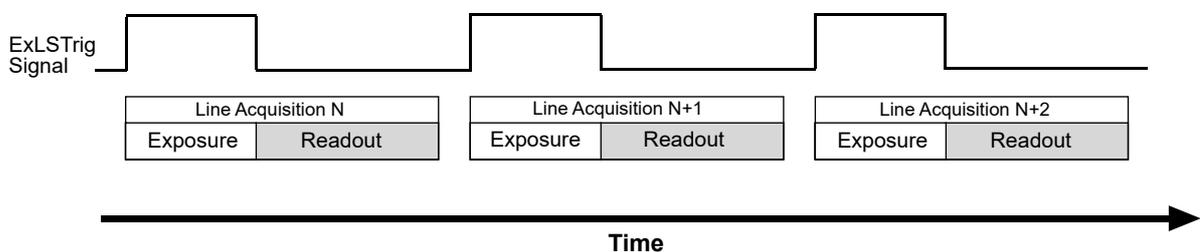


Fig. 21: Non-overlapped Exposure and Readout

In the overlapped mode of operation, the exposure of a new line begins while the camera is still reading out the sensor data for the previously acquired line. This situation is illustrated in Fig. 22 with the camera set for the trigger width exposure mode.

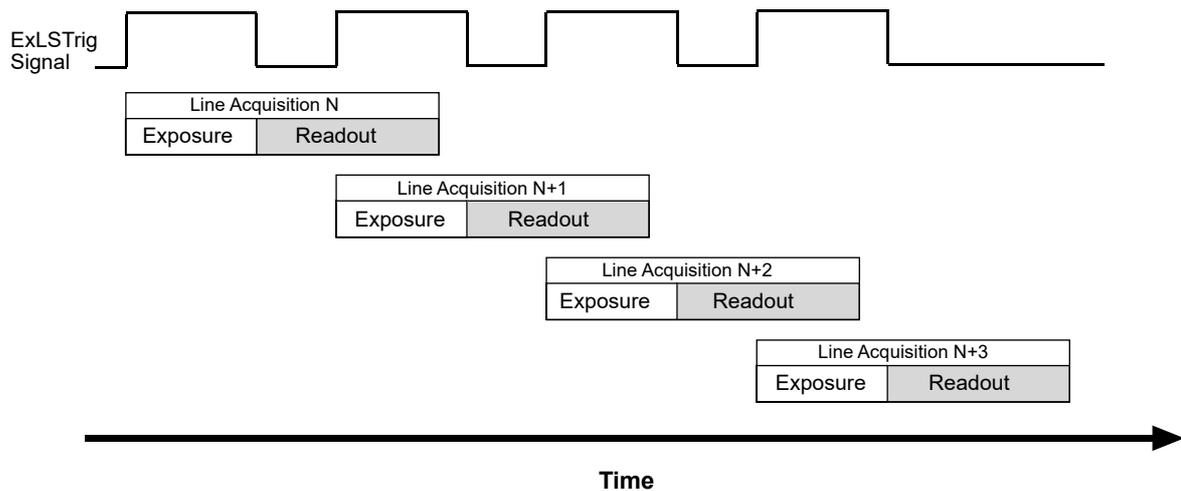


Fig. 22: Overlapped Exposure and Readout

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

- Exposure will not overlap when:  $\text{Line Period} > \text{Exposure Time} + \text{Readout Time}$
- Exposure will overlap when:  $\text{Line Period} \leq \text{Exposure Time} + \text{Readout Time}$

You can determine the readout time by reading the value of the `ReadoutTimeAbs` parameter. The parameter indicates what the readout time will be in microseconds given the camera's current settings. You can read the `ReadoutTimeAbs` parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to get the parameter value:

```
double ReadoutTime = camera.ReadoutTimeAbs.GetValue();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

You can also determine the readout time via direct register access by reading out the value of the Readout Time Raw register.

## 6.2.1 Guidelines for Overlapped Operation

To ensure smooth line acquisition and avoid overtriggering, you may only apply a line acquisition-related trigger when the camera is waiting for it. If the trigger is nonetheless applied, the trigger will be ignored and considered an overtrigger.

The risk of overtriggering exists particularly for overlapped operation where the sequence of line start triggers must be carefully coordinated both with the camera's exposure time and the sensor readout time.

The following examples use a non-inverted, rising edge hardware line start trigger signal (ExLSTrig).

### 6.2.1.1 Illegal Line Acquisition by Overtriggering

Certain attempts of triggering overlapped line acquisition are illegal and do not result in line acquisitions: When a line start trigger signal attempts an illegal line acquisition the trigger signal will be ignored and, accordingly, no line acquisition will be performed. In addition, the trigger signal will be reported as an overtrigger (see also Section 8.10.2 on [page 135](#)). Illegal triggering and impossible overlaps are shown in Fig. 23 on [page 74](#) and Fig. 24 on [page 74](#).

Illegal triggering when overlapping line acquisitions:

- The line start trigger goes high to start the exposure for line acquisition N+1 before the exposure or the exposure overhead for line acquisition N has ended (see Fig. 23 on [page 74](#)). This would result in the illegal overlap of exposures or of exposure and exposure overhead.



The exposure overhead (see Fig. 23 on [page 74](#)) is part of every exposure process. For simplicity, it is omitted from the other figures illustrating exposure and readout (see, for example, Fig. 24 on [page 74](#)).

The duration of the exposure overhead is expressed by constant  $C_1$  (see also Section 6.2.1.2 on [page 75](#) and Section 6.4.1 on [page 89](#)).

- The line start trigger goes low to end the exposure for line acquisition N+1 before readout for acquisition N has ended (premature exposure end; see Fig. 24 on [page 74](#)). This would result in the illegal overlap of two readouts (in trigger width exposure mode only).

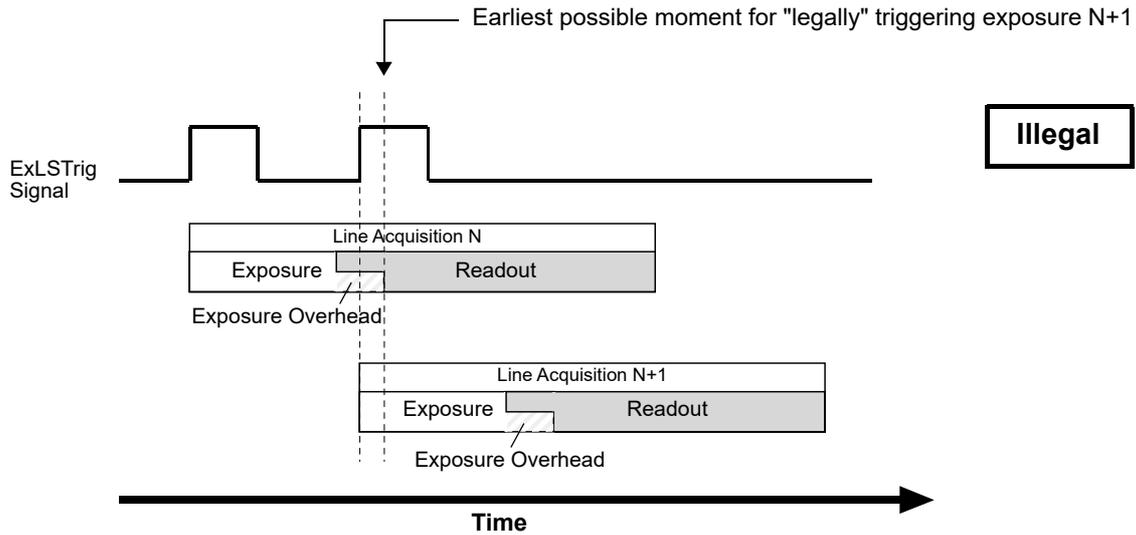


Fig. 23: Exposure N+1 Illegally Starts Before the Exposure Overhead for the Preceding Line Acquisition N Has Ended; the Shown Overlap of Readouts is Also Illegal; Timed Exposure Mode Used as an Example

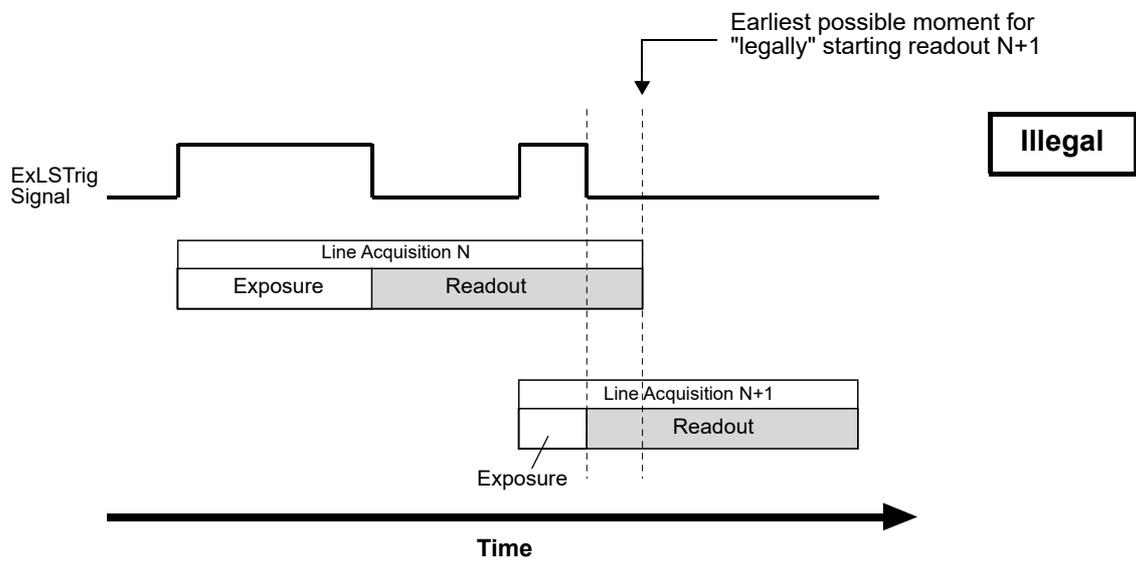


Fig. 24: Exposure N+1 Illegally Ends Before Readout of the Preceding Line Acquisition N Has Ended; Applies to Trigger Width Exposure Mode Only

When the line start trigger has illegally gone low to end the exposure for line acquisition N+1 before readout for acquisition N has ended (in trigger width exposure mode; see Fig. 24), the camera will behave as shown in Fig. 25: The camera will extend the exposure and end it when the next valid trigger for ending exposure occurs.

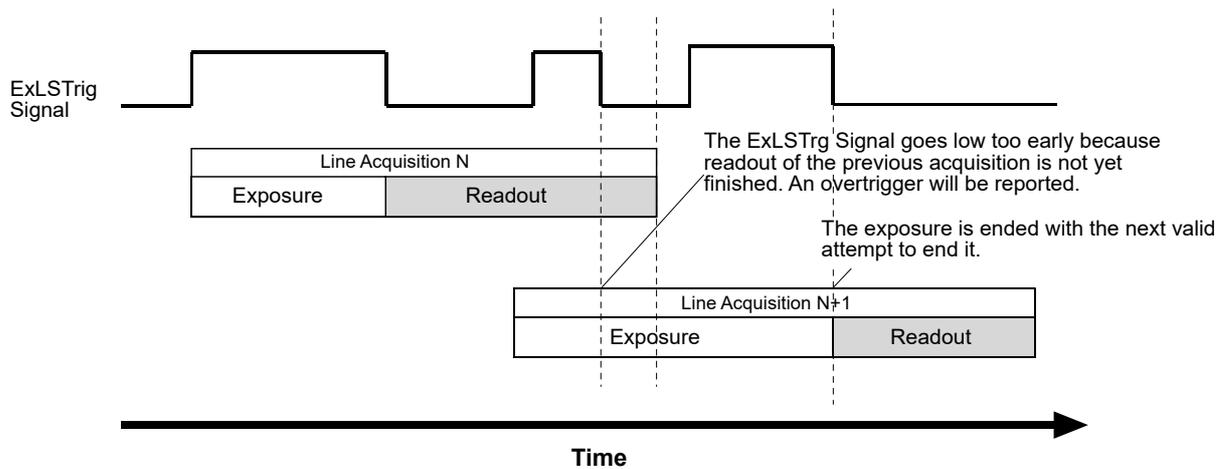


Fig. 25: Extension of Exposure N+1 After the Illegal Attempt of Ending It Too Early; Applies to Trigger Width Exposure Mode Only

### 6.2.1.2 Regular Line Acquisition Avoiding Overtriggering

As mentioned above, you can avoid overtriggering by applying an acquisition-related trigger **only** when the camera is waiting for it.

You can achieve this goal by

- making use of acquisition monitoring tools, i.e. monitoring the camera's acquisition status and triggering only when the camera indicates that it is in the "waiting status" for the trigger or by
- strictly obeying timing limits for exposure and triggering.

#### Using Acquisition Monitoring Tools

To get informed whether the camera is waiting for a trigger you can use the acquisition monitoring tools described in Section 6.3 on [page 80](#).

By applying an ExLSTrig signal as soon as the camera indicates that it is waiting for an ExLSTrig signal you can operate the camera in "overlapped mode" without overtriggering.

As an example, and in the context of overlapped exposure, the use of the line trigger wait signal is described in Section 6.3.3 on [page 82](#) for proper triggering with the line start trigger. Both timed and trigger width exposure mode are considered.

## Line Acquisition While Obeying Timing Limits

When strictly obeying the following timing limits you can avoid overtriggering in "overlapped mode" and "non-overlapped mode" without having to monitor the camera's acquisition status (see also Fig. 26 and Fig. 27 below). You must ensure that the following four conditions are fulfilled **at the same time**:

- **Condition one:** The exposure time  $E$  is  $\geq 2 \mu\text{s}$ .

This is the minimum allowed exposure time also given in Section 6.1.5.2 on [page 65](#).

- **Condition two:** Period  $F$  is  $\geq C_1$ ;  $F$  follows immediately after the exposure.

The constant  $C_1$  expresses the duration of exposure overhead. Exposure is not possible during this period. It is generally equal to  $5.4 \mu\text{s}$  as can be seen from Section 6.4.1 on [page 89](#), ("Factor 2"). However, when the parameter limit is removed from the ExposureOverhead parameter (see Section 8.3 on [page 106](#)), the constant is equal to  $3.4 \mu\text{s}$ . Accordingly,  $F$  must be  $\geq 5.4 \mu\text{s}$  in the general case, and  $\geq 3.4 \mu\text{s}$  when the parameter limit is removed from the ExposureOverhead parameter (see also [Table 14](#)).

- **Condition three:** ExLSTrig Signal Period  $\geq$  Minimum allowed line period.

- **Condition four:** Make sure the ExposureOverlapTimeMaxAbs is set to the appropriate value:

- When the parameter limit is not removed from the ExposureOverhead parameter the ExposureOverlapTimeMaxAbs parameter value must be set to  $7 \mu\text{s}$ .
- When the parameter limit is removed from the ExposureOverhead parameter the ExposureOverlapTimeMaxAbs parameter value must be set to  $9 \mu\text{s}$ .

The parameter values become obvious from the following relation:

Appropriate ExposureOverlapTimeMaxAbs parameter value =  
Minimum allowed line period of  $12.4 \mu\text{s}$  - duration of exposure overhead (being the minimum period after exposure when the next exposure is not yet possible, i.e. minimum  $F$  value).

For example, the following applies when operating the camera at the maximum allowed line rate (with conditions one through four fulfilled) and without having removed the parameter limit from the ExposureOverhead parameter.

$$7 \mu\text{s} = 12.4 \mu\text{s} - 5.4 \mu\text{s}.$$

- If you increase the ExposureOverlapTimeMaxAbs parameter value above  $7 \mu\text{s}$  while maintaining the line period the minimum value for the duration of the exposure overhead would be ignored and ExLSTrig signals can be considered overtriggers when in fact they are not.
- If you decrease the ExposureOverlapTimeMaxAbs parameter value below  $7 \mu\text{s}$  you would have to increase the duration of the exposure overhead and thereby increase the line rate.



When you want to operate the camera at the maximum allowed line rate and have set the ExposureOverlapTimeMaxAbs parameter value to the appropriate value (see above) you can vary the exposure time  $E$  within the ranges indicated in [Table 14](#) without having to adjust the ExposureOverlapTimeMaxAbs parameter value.

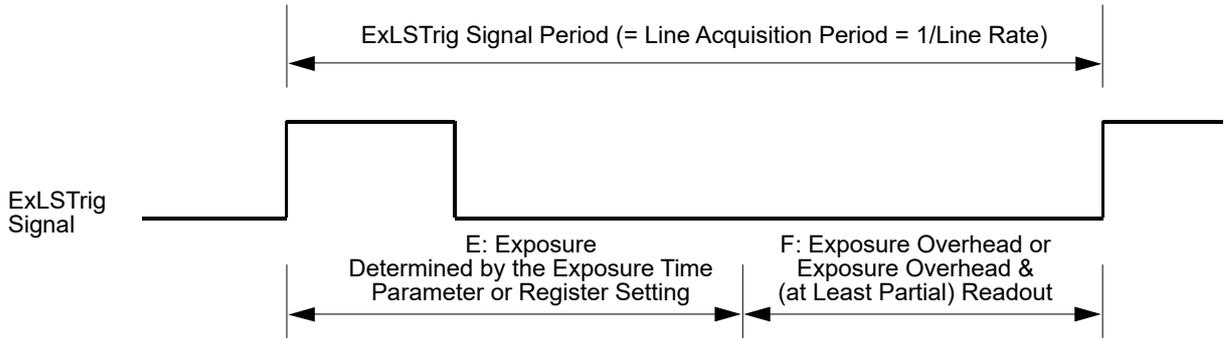


Fig. 26: Relation of the ExLSTrig Signal Period and Periods E and F for Regular Line Acquisition in Timed Exposure Mode

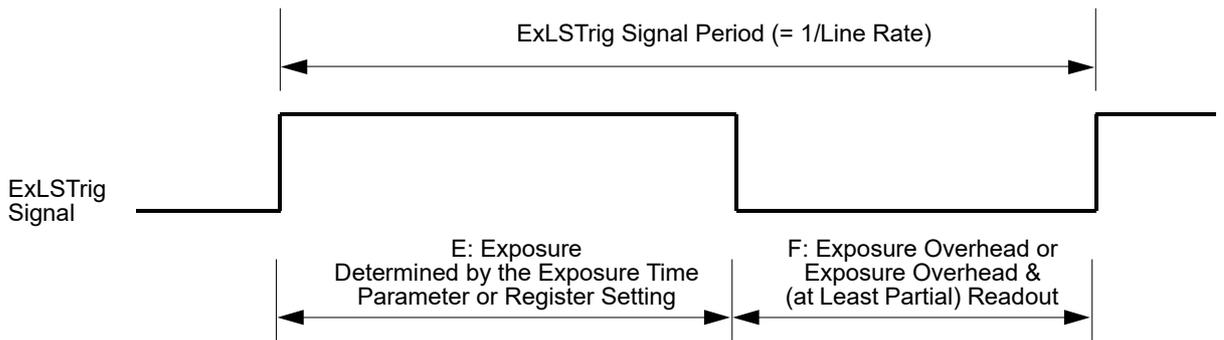


Fig. 27: Relation of the ExLSTrig Signal Period and Periods E and F for Regular Line Acquisition in Trigger Width Exposure Mode

From the above conditions, one can readily calculate the allowed values for E and F for regularly operating the camera at the maximum allowed line rate. This operation will also involve the maximum possible overlap between consecutive line acquisitions.

	raL2048-80km	raL4096-80km	raL6144-80km	raL8192-80km	raL12288-66km
Nominal Maximum Allowed Line Acquisition Rate	80000 lines/s	80000 lines/s	80000 lines/s	80000 lines/s	66000 lines/s
Actual Maximum Allowed Line Acquisition Rate (approx. values)	80600 lines/s	80600 lines/s	80600 lines/s	80600 lines/s	66000 lines/s
Actual Minimum Allowed Line Acquisition Period	12.4 $\mu$ s	12.4 $\mu$ s	12.4 $\mu$ s	12.4 $\mu$ s	15.1 $\mu$ s
E, for $F \geq 5.4$ (This Applies When the Parameter Limit is Not Removed from the ExposureOverhead Parameter)	2.0 $\mu$ s to 7.0 $\mu$ s	2.0 $\mu$ s to 9.7 $\mu$ s			
E, for $F \geq 3.4$ (This Applies When the Parameter Limit is Removed from the ExposureOverhead Parameter)	2.0 $\mu$ s to 9.0 $\mu$ s	2.0 $\mu$ s to 11.7 $\mu$ s			

Table 14: Minimum and Maximum Allowed Exposure Times at Maximum Allowed Line Acquisition Rate and Optimum ExposureOverlapTimeMaxAbs Parameter Value Settings

## Example

Assume that you are using an raL2048-80km camera at full resolution (2048 pixels), assume that you want to use the maximum allowed line acquisition rate (equivalent to the minimum allowed line acquisition period), and the default value for  $C_1$ .

Also assume that the other relevant settings (e.g. Camera Link clock speed and Camera Link tap geometry) are in accord with operation at 80.6 kHz.

The camera is nominally capable of 80000 line acquisitions per second (80 kHz) at full resolution. Actually, however, it is capable of up to approximately 80600 line acquisitions per second.

Accordingly, the corresponding minimum allowed ExLSTrig signal period where overtriggering is avoided is calculated as:

$$\text{ExLSTrig signal period} = 1/80600 \text{ [lines/s]} = 12.4 \mu\text{s}.$$

Note that this ExLSTrig signal period equals the actual minimum allowed line acquisition period.

From condition number three follows the maximum possible exposure time that is compatible with maximum overlap:

$$E = \min. \text{ ExLSTrig Signal Period} - F$$

$$E = 12.4 \mu\text{s} - 5.4 \mu\text{s} = 7 \mu\text{s}$$

Therefore, when operating the camera at a line acquisition rate of 80.6 kHz (involving maximum overlap) and using the default value for  $C_1$ , the maximum possible exposure time is 7  $\mu$ s. When also considering the above condition number one, it follows that the exposure time can range between 2  $\mu$ s and 7  $\mu$ s to be in accord with camera operation at a line rate of 80.6 kHz.



If you increase exposure times given in [Table 14](#) beyond their upper limits the related extent of overlap and the acquisition line rate will decrease. When extending exposure time even further, consecutive line acquisitions will eventually not overlap at all.

## 6.3 Acquisition Monitoring Tools

The camera includes the acquisition status feature and generates these output signals that you can use to monitor the progress of line acquisition by the camera:

- the exposure active signal
- the line trigger wait signal.

The camera also allows selecting the output of the frequency converter module as output signals. In addition, you can check the camera's acquisition status (see below).

### 6.3.1 Exposure Active Signal

The camera's Exposure Active output signal will go high when the exposure time for each line acquisition begins and goes low when the exposure time ends. The signal can for example be used as a flash trigger.

An example of the Exposure Active signal's behavior on a camera using a rising edge hardware line start trigger signal (ExLSTrig) and the timed exposure mode is shown in Fig. 28.

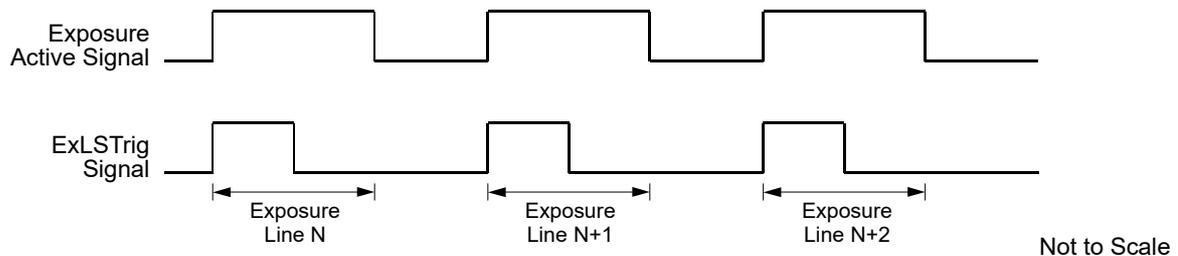


Fig. 28: Exposure Active Signal

### Selecting the Exposure Active Signal as the Source Signal for the CL Spare Output Line

**To select the exposure active signal as the source signal for the CL Spare output line using Basler pylon:**

You can select the exposure active signal as the source signal for the CL Spare output line:

1. Set the LineSelector parameter to the CLSpare line.
2. Set the value of the LineSource parameter to the exposure active output signal.

You can set the LineSelector and the LineSource 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:

```
//Select the CL Spare line
camera.LineSelector.SetValue(LineSelector_ClSpare);
//Set the source signal for the selected line
camera.LineSource.SetValue(LineSource_ExposureActive);
```

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

**To select the exposure active signal as the source signal for the CL Spare line via direct register access:**

- Set the value of the Line Source CL Spare register to Exposure Active.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 6.3.2 Acquisition Status

If a camera receives a software line start trigger signal when it is not in a "waiting for line start trigger" acquisition status, it will simply ignore the trigger signal.

The camera's acquisition status indicator gives you the ability to check whether the camera is in a "waiting for line start trigger" acquisition status. If you check the acquisition status before you apply each software line start trigger signal, you can avoid applying trigger signals to the camera that will be ignored.

The acquisition status indicator is designed for use when you are using host control of image acquisition, i.e., when you are using software line start trigger signals.

### Checking the Acquisition Status

**To determine the acquisition status of the camera using Basler pylon API:**

1. Set the AcquisitionStatusSelector parameter to LineTriggerWait.
2. Read the value of the AcquisitionStatus parameter.

If the value is set to False, the camera is not waiting for the trigger signal.

If the value is set to True, the camera is waiting for the trigger signal.

You can check the acquisition status from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to check the acquisition status:

```
// Check the line start trigger acquisition status
// Set the acquisition status selector
camera.AcquisitionStatusSelector.SetValue
(AcquisitionStatusSelector_LineTriggerWait);
// Read the acquisition status
bool IsWaitingForLineTrigger = camera.AcquisitionStatus.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 26](#).

**To determine the line start trigger status via direct register access:**

- Read the value of the Status Line Trigger Wait register.  
If the value is set to 0, the camera is not waiting for the trigger signal.  
If the value is set to 1, the camera is waiting for the trigger signal.

For more information about direct register access, see Section 3.2 on [page 28](#).

### 6.3.3 Line Trigger Wait Signal

As you are acquiring lines, the camera automatically monitors the line start trigger status and supplies a signal that indicates the current status.

The Line Trigger Wait signal will go high whenever the camera enters a "waiting for line start trigger" status. The signal will go low when an hardware line start trigger (ExLSTrig) signal is applied to the camera and the camera exits the "waiting for line start trigger status". The signal will go high again when the camera again enters a "waiting for line trigger" status and it is safe to apply the next line start trigger signal.

If you base your use of the ExLSTrig signal on the state of the line trigger wait signal, you can avoid "line start overtriggering", i.e., applying a line start trigger signal to the camera when it is not in a "waiting for line start trigger" acquisition status. If you do apply a line start trigger signal to the camera when it is not ready to receive the signal, it will be ignored.

The line trigger wait signal can be selected as the source signal for the CL spare bit on the camera.

For more information about selecting the source signal for the CL spare bit on the camera, see Section 5.5.2 on [page 47](#).

Fig. 29 and Fig. 30 illustrate the Line Trigger Wait signal with exposure and readout overlapped. The figures assume raising edge triggering.

### Using the Line Trigger Wait Signal with the Timed Exposure Mode

When the camera is set for the timed exposure mode, the rise of the line trigger wait signal is based on the current exposure time setting and on when readout of the current line will end. This functionality is illustrated in Fig. 29.

If you are operating the camera in the timed exposure mode, you can avoid overtriggering by always making sure that the line trigger wait signal is high before you trigger the start of line capture.

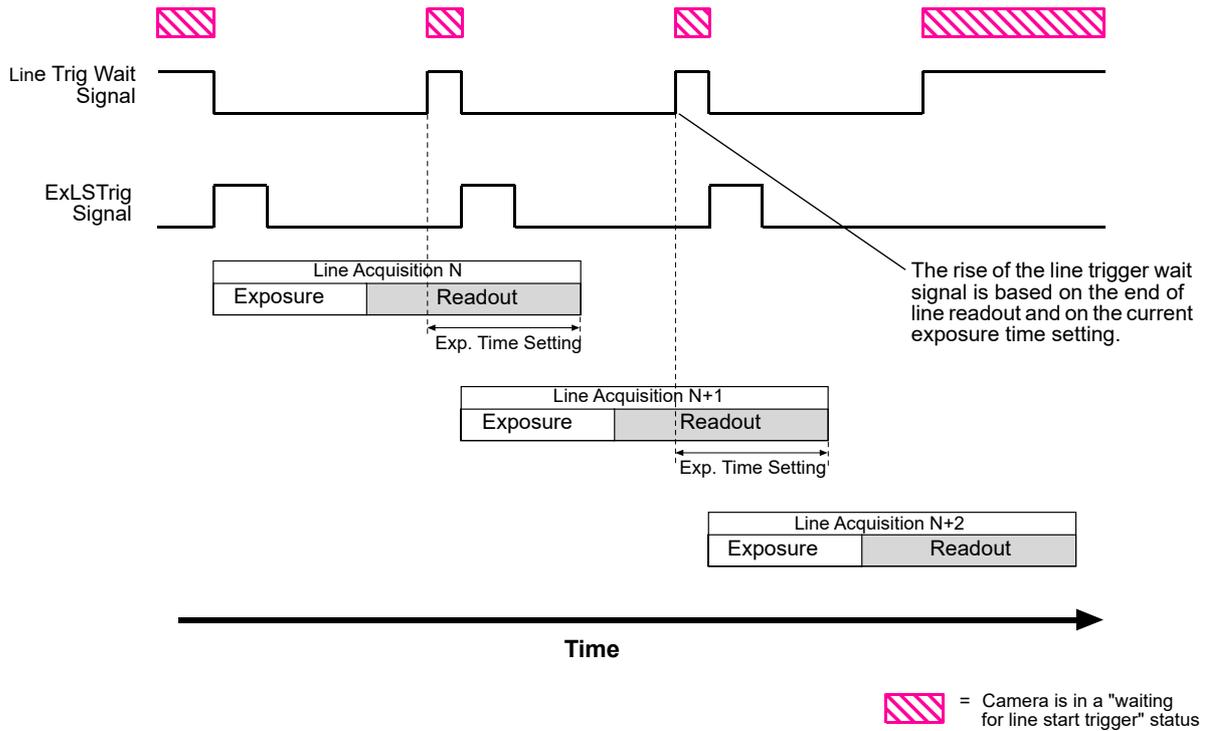


Fig. 29: Line Trigger Wait Signal with the Timed Exposure Mode

## Using the Line Trigger Wait Signal with the Trigger Width Exposure Mode

When the camera is set for the trigger width exposure mode, the rise of the line trigger wait signal is based on the `ExposureOverlapTimeMaxAbs` parameter setting and on the end of readout for the current line acquisition. This functionality is illustrated in Fig. 30.

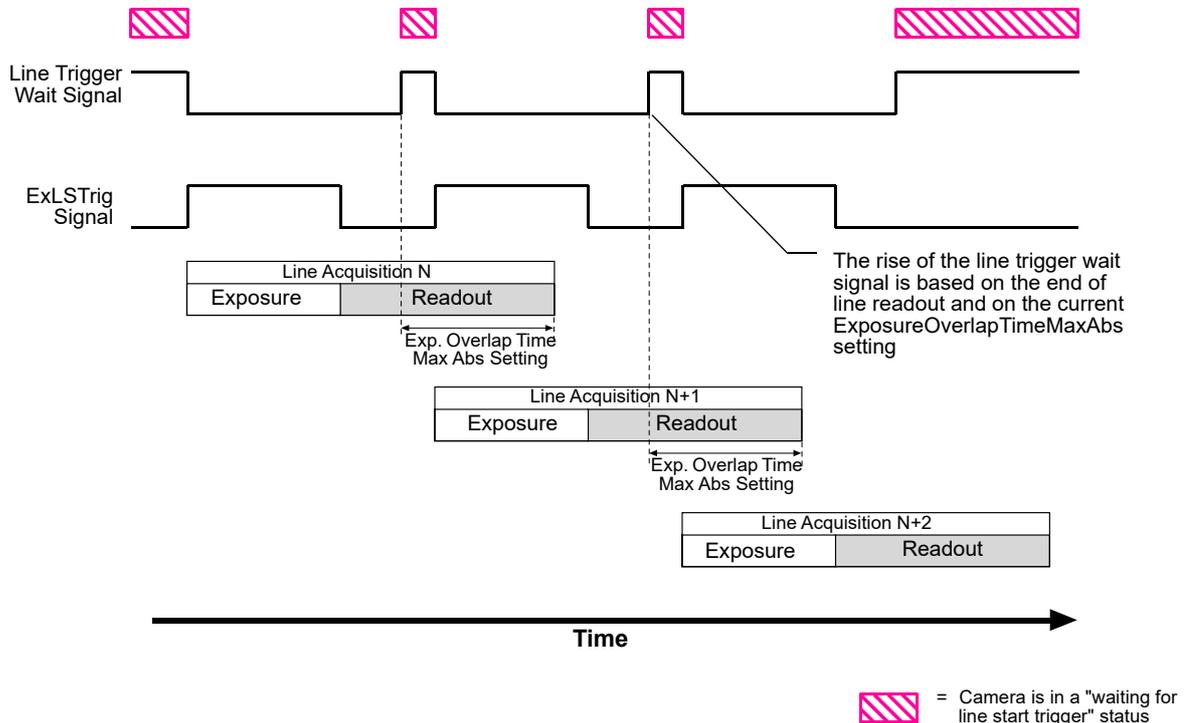


Fig. 30: Line Trigger Wait Signal with the Trigger Width Exposure Mode

If you are operating the camera in the trigger width exposure mode, you must set an `ExposureOverlapTimeMaxAbs` value in order to control the Line Trigger Wait signal. You can do this in either of two ways: If you are parameterizing the camera with Basler pylon you must set the `ExposureOverlapTimeMaxAbs` parameter and if you are parameterizing the camera via direct register access you must set the value of the Exposure Overlap Time Max Raw register.

The correct parameter values depend on the method that you choose to avoid overtriggering:

You can avoid overtriggering the camera by always doing the following:

- Monitoring the camera's line trigger wait signal and using the ExLSTrig signal to start exposure only when the Line Trigger Wait signal is high. You must set `ExposureOverlapTimeMaxAbs` to represent the **shortest** exposure time you intend to use. Using the shortest time helps you to avoid the "illegal" situation shown in Fig. 24 on [page 74](#). For example, assume that you will be using trigger width exposure mode and that you intend to use the ExLSTrig signal to vary the exposure time in a range from 15  $\mu\text{s}$  to 20  $\mu\text{s}$ . In this case you would set the camera's `ExposureOverlapTimeMaxAbs` to 15  $\mu\text{s}$ .

If your shortest intended exposure time is longer than the maximum settable `ExposureOverlapTimeMaxAbs` parameter value, you can remove the parameter's upper parameter limits (see Section 8.3 on [page 106](#)) to extend the overlap and achieve a higher line

acquisition rate. Make sure not to set the ExposureOverlapTimeMaxAbs to a too high parameter value in order to avoid the "illegal" situation shown in Fig. 23 on [page 74](#).

- Obeying certain timing limits during line acquisition and setting the camera's ExposureOverlapTimeMaxAbs to an appropriate value (see Section 6.2.1.2 on [page 75](#)).

For more information about avoiding overtriggering, see Section 6.2.1.2 on [page 75](#).

## Setting the ExposureOverlapTimeMaxAbs Parameter

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

```
// Set to 15 µs
camera.ExposureOverlapTimeMaxAbs.SetValue(15);
```

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

### To set the ExposureOverlapTimeMaxAbs parameter value via direct register access:

- Set the value of the Exposure Overlap Time Max Raw register. For conversion from Abs to Raw, you must multiply the value by 10. For example, an absolute value of 15 (15 µs) corresponds to a raw value of 150.

For more information about direct register access, see Section 3.2 on [page 28](#).

## Selecting the Line Trigger Wait Signal as the Source Signal for the CL Spare Output Line

### To select the line trigger wait signal as the source signal for the CL Spare line using Basler pylon:

1. Set the LineSelector parameter to the CL Spare output line.
2. Set the value of the LineSource parameter to the line trigger wait signal.

You can set the LineSelector and the LineSource 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:

```
//Select the CL Spare line
camera.LineSelector.SetValue(LineSelector_ClSpare);
//Set the source for the selected line
camera.LineSource.SetValue(LineSource_LineTriggerWait);
```

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 26](#).

For more information about selecting the source signal for the CL spare bit on the camera, see Section 5.5.2 on [page 47](#).

**To select the line trigger wait signal as the source signal for the CL Spare line via direct register access:**

- Set the value of the Line Source CL Spare register to Line Trg Ready.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 6.3.4 Input Related Signals as Output Signals

The camera allows selecting the output signal of the frequency converter module and assigning it to the camera's CL Spare output line. In this fashion input signals can be passed through a camera to trigger additional cameras.

In this case, setting a minimum output pulse width may be necessary to ensure output signal detection.

For more information about selecting the source signal for the CL Spare output line on the camera, see Section 5.5.2.3 on [page 49](#).

For more information about the minimum output pulse width feature, see Section 5.5.2.1 on [page 48](#).

## 6.4 Maximum Allowed Line Acquisition Rate

The maximum allowed line acquisition rate for your camera is not static. It can vary depending on how certain camera features are set. In general, the following factors can affect the maximum allowed line rate:

- The Camera Link pixel clock speed and the Camera Link tap geometry settings.  
When the pixel clock speed is set to a high value, it will take less time to transfer captured images from the camera to the frame grabber in your host computer.  
When the camera is set for a tap geometry that uses more taps (e.g., the 1X4 geometry uses four taps and the 1X8 geometry uses eight taps), it can typically transfer data out of the camera faster.  
So if the camera is set for a high pixel clock speed and a high number of taps, it typically will have a much higher maximum allowed line rate than when it is set for a low pixel clock speed and a low number of taps.
- Whether binning is enabled. Enabling horizontal binning may yield a significant increase in the maximum allowed line rate, but this will only be true if the camera is not already reading out image data at a rate that is near to the current data carrying capacity of the Camera Link interface.
- The exposure time for acquired lines. If you use very long exposure times, you can acquire fewer lines per second.

There are several ways that you can determine the maximum allowed acquisition line rate with your current camera settings:

- You can go to the Support section of the Basler website and use the online frame rate calculator: [www.baslerweb.com](http://www.baslerweb.com)
- You can use Basler pylon to read the value of the camera's ResultingLineRateAbs parameter (see below).
- You can use direct register access to read the value of the Resulting Line Period Raw register (see below).

For more information about selectable Camera Link pixel clock speeds, see Section 8.1 on [page 100](#).

For more information about Camera Link tap geometries, see Section 7.2 on [page 98](#).

## Checking the Maximum Allowed Line Rate

You can use the Basler pylon API to read the current value of the `ResultingLineRateAbs` 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 line rate
double resultingLps = camera.ResultingLineRateAbs.GetValue();
```

The `ResultingLineRateAbs` parameter takes all camera settings that can influence the line rate into account and indicates the maximum allowed line 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 the pylon Viewer, see Section 3.1 on [page 26](#).

When using direct register access, you work with the "resulting line period" rather than the line acquisition rate. Once the resulting line period is known, the maximum allowed line acquisition rate can be determined by:

$$\text{Max Line Acquisition Rate} = \frac{1}{\text{Resulting Line Period in Seconds}}$$

### To determine the resulting line period via direct register access:

- Check the value of the Resulting Line Period Raw register.

The Resulting Line Period Raw register takes all of camera settings that can influence the line period into account and indicates the minimum allowed line period given the current settings.

A value in a raw register is simply an integer value with no units. To determine what the actual line period will be, you must multiply the value in the raw register by the camera's time base. The time base on racer cameras is 100 ns.

For example, if you read the Resulting Line Period Raw register and find that its value is 10000, the resulting line period would be 1 ms (10000 x 100 ns = 1 ms).

For more information about direct register access, see Section 3.2 on [page 28](#).

## 6.4.1 Increasing the Maximum Allowed Line Rate

You may find that you would like to acquire lines at a rate higher than the maximum allowed with the camera's current settings. In this case, you must first determine what factor is most restricting the maximum line rate. The descriptions of the three factors that appear below will let you determine which factor is restricting the rate.

### Factor 1:

Factor 1 is the sensor readout time. The readout time for a particular sensor is a fixed value. Therefore, the related maximum line acquisition rate is also fixed. Note that this line acquisition rate is the absolute maximum for a camera model and that it does not increase when smaller image AOIs are used. The table below shows the nominal maximum line rate (in lines per second) for each camera model. The line rates are based on sensor readout time. For the actual maximum line rates, see Section 6.2.1.2 on [page 75](#).

Max Lines/s (nominal; based on sensor readout)				
raL2048-80km	raL4096-80km	raL6144-80km	raL8192-80km	raL12288-66km
80000	80000	80000	80000	80000

### Factor 2:

Factor 2 is the exposure time. You can use the formula below to calculate the maximum line rate based on the exposure time for each acquired line:

$$\text{Max Lines/s} = \frac{1}{\text{Exposure time in } \mu\text{s} + C_1}$$

Where the constant  $C_1$  takes account of the exposure overhead (see also Section 6.2.1.1 on [page 73](#)). The constant depends on whether the parameter limit is removed from the ExposureOverhead parameter, as shown in the table below:

	raL2048-80km	raL4096-80km	raL6144-80km	raL8192-80km	raL12288-66km
$C_1$ (Default Value)	5.4 $\mu\text{s}$				
$C_1$ (Limit Removed From ExposureOverhead Parameter)	3.4 $\mu\text{s}$				

For more information about setting the exposure time, see Section 6.1.5.3 on [page 68](#). For information about how to increase the exposure time see Section 6.4.2 on [page 91](#).

**Formula 3** calculates the maximum line rate based on the amount of time it takes to transmit the pixel data for an acquired line from the camera to the host computer:

$$\text{Max Lines / s} = \frac{\text{CL Clk} \times \text{Taps}}{\text{AOI Width} + (7 \times \text{Taps})}$$

Where: *CL Clk* is the Camera Link pixel clock speed for your camera model (see Section 8.1 on [page 100](#))

*Taps* is the number of Camera Link taps being used as determined by the current Camera Link tap geometry setting (see Section 7.2 on [page 98](#))

*AOI Width* is the width of the AOI based on the current AOI width setting (see Section 8.4 on [page 107](#))

Once you have determined the maximum allowed line rate, you can easily determine the minimum allowed line period:

$$\text{Min Line Period} = \frac{1}{\text{Max Line Rate}}$$

### Example

Assume that you are using an raL2048-80km camera set for an exposure time of 190  $\mu\text{s}$ . Also assume that you are using full resolution (2048 pixels), the default value for  $C_1$ , a Camera Link clock speed of 32.5 MHz, and the 1X4 Camera Link tap geometry that provides 4 taps.

**Factor 1 (sensor readout, nominal value):**

$$\text{Max Lines/s} = 80000$$

**Factor 2 (exposure time):**

$$\text{Max Lines/s} = \frac{1}{190 \mu\text{s} + 5.4 \mu\text{s}}$$

$$\text{Max Lines/s} = 5117$$

**Formula 3 (data transmission):**

$$\text{Max Lines/s} = \frac{32500000 \times 4}{2048 + (7 \times 4)}$$

$$\text{Max Lines/s} = 62620$$

Factor 2, the exposure time, is the most restrictive factor. In this case, the exposure time setting is limiting the maximum allowed line rate to 5117 lines per second. If you wanted to operate the camera at a higher line rate, you would need to lower the exposure time.

Because the exposure time is the most restrictive factor, you could also remove the limit from the ExposureOverhead parameter to increase the line rate. In this case  $C_1 = 3.4 \mu\text{s}$  would apply and the formula for Factor 2 a maximum allowed line rate of 5170 lines per second would result.

For more information about removing the limit from the ExposureOverhead parameter and the resulting side effects, see [Section 6.4.2](#).

## 6.4.2 Removing the Parameter Limits for the Exposure Overhead Parameter

By removing the parameter limits for the ExposureOverhead parameter you can improve the line acquisition with respect to either of the following two goals:

- You can extend the exposure time: When operating a camera at a maximum allowed line rate, the interval between two consecutive line start triggers will consist of the exposure time and the time needed to prepare the sensor for the next acquisition.

In this situation, the time available for exposure will sometimes, despite bright illumination, be too short for obtaining a sufficiently bright image. To brighten of the image at a given high line rate, you can remove the parameter limits for the ExposureOverhead parameter. As a consequence, the exposure time can be somewhat extended at the expense of the sensor's "preparation time" that will be shortened accordingly. Note that the image quality will somewhat decrease.

- You can increase the maximum allowed line rate: If you remove the parameter limits for the ExposureOverhead parameter, if you do not extend the exposure time accordingly, and if the exposure time is the determining factor for the maximum allowed line rate (Factor 2), you will be able to increase the maximum allowed line rate to some extent (see [Section 6.4.1](#)). Note that the image quality will somewhat decrease.

If you chose to extend the exposure time you can use the timed and trigger width exposure modes (see [Section 6.1.4.2 on page 62](#) and [Section 6.1.5.2 on page 65](#) for information about the timed exposure mode and [Section 6.1.5.2 on page 65](#) for information about the trigger width exposure mode):

- When the camera is set for the timed exposure mode, the upper limit of the ExposureTime parameters increases according to the decrease of the "preparation time".
- When the camera is set for the trigger width exposure mode, you can extend the ExLSTrig signal period according to the decrease of the exposure overhead time. To maintain the line rate, increase the ExposureOverlapTimeMaxAbs parameter value by the amount of time that was gained for exposure time.

**To remove the limits for the ExposureOverhead parameter using Basler pylon:**

1. Set the ParameterSelector parameter to ExposureOverhead.
2. Set the RemoveLimits parameter to True.

You can set the ParameterSelector and the RemoveLimits 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:

```
// Select the parameter whose factory limits will be removed.
camera.ParameterSelector.SetValue(ParameterSelector_ExposureOverhead);
// Remove the limits for the selected parameter.
camera.RemoveLimits.SetValue(true);
```

You can also use the Basler pylon Viewer application to easily set the parameters. Note that the remove parameter limits feature will only be available at the "guru" viewing level.

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

**To remove the limits for the ExposureOverhead parameter using direct register access:**

- Set the value of the Remove Param Limits Exposure Time register to enabled.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 6.5 Frequency Converter

The camera is equipped with a frequency converter module that allows triggering the camera at a frequency that differs from the frequency of the input signals received.

The frequency converter module includes three sub-modules acting in sequence on the original signals:

- The pre-divider module receives the input signals. The module allows employing an integer factor, the pre-divider, to decrease the original frequencies and passes the signals on to the next module, the multiplier module.

If for example a pre-divider of 2 is selected only every other input signal is passed out unchanged to the multiplier module and, accordingly, the frequency is halved. If a pre-divider of 1 is selected every input signal is passed out unchanged to the multiplier module.

Employing the pre-divider may be advisable for decreasing periodic jitter of the input signals and will be required if the input signal frequency is higher than 100 kHz. The signal frequency of the signals passed on to the multiplier module must be within the range of 10 Hz to 100 kHz.

Basler recommends to only use low values for the pre-divider. The original signal frequency should be changed as little as possible to facilitate frequency adjustment by the multiplier module.

- The multiplier module receives the signals from the pre-divider module. The signal frequency must be within the range of 10 Hz to 100 kHz. The multiplier module allows applying an integer factor, the multiplier, to generate signals at increased frequencies and passes the signals on to the next module, the post-divider module.

If, for example, a multiplier of 2 is selected signals are generated at double the frequency of the signals received from the pre-divider module and are passed on to the divider module. If a multiplier of 1 is selected every signal received from the pre-divider module is passed unchanged on to the divider module.

The Align parameter can be set to RisingEdge and FallingEdge. If RisingEdge is selected there will be for the rising edge of each signal received from the pre-divider module a phase-locked, matching rising edge among the signals generated. If FallingEdge is selected there will be for the falling edge of each signal received from the pre-divider module a phase-locked, matching falling edge among the signals generated.

Make sure to select a multiplier that will not too much increase the frequency such that the camera will be overtriggered. Temporarily, a too high frequency can occur during frequency adjustment causing overtriggering even if a relatively low multiplier was selected. Basler recommends to use one of the safeguards against overtriggering the camera:

- Set the PreventOvertrigger parameter to True if you use Basler pylon for camera configuration.
- Set the Frequency Converter Prevent Overtrigger register to 1 if you use direct register access for camera configuration.

The PreventOvertrigger parameter provides a safeguard against overtriggering the camera. Basler recommends setting the PreventOvertrigger parameter to True to prevent overtriggering.

- The post-divider module receives the signals from the multiplier module. The post-divider module allows employing an integer factor, the post-divider, to generate signals at decreased frequencies and provides these signals to be used as camera trigger signals, e.g. as line start triggers.

If for example a post-divider of 2 is selected only every other signal received from the multiplier module is passed out from the divider module and, accordingly, the frequency is halved. If a post-divider of 1 is selected every signal received from the multiplier module is passed out unchanged from the divider module.



You can use the frequency converter to multiply the original signal frequency by a fractional value. Basler recommends multiplying the frequency by the enumerator value using the multiplier module and dividing the resulting frequency by the denominator value using the post-divider module.

## Setting the Frequency Converter

You can configure the frequency converter module from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values:

```
// Values for FrequencyConverterInputSource that might be available
// (from _Basler***CameraParams.h where *** == 'GigE' or *** == 'CameraLink'
//
//enum FrequencyConverterInputSourceEnums
//{
//    FrequencyConverterInputSource_CC1,
//    FrequencyConverterInputSource_CC2,
//    FrequencyConverterInputSource_CC3,
//    FrequencyConverterInputSource_CC4,
//};

cam.FrequencyConverterInputSource.SetValue(FrequencyConverterInputSource_CC1);
cam.FrequencyConverterPreDivider.SetValue(4);
cam.FrequencyConverterMultiplier.SetValue(17);
cam.FrequencyConverterPostDivider.SetValue(1);
cam.FrequencyConverterPreventOvertrigger.SetValue(false);

// Values for FrequencyConverterSignalAlignment that might be available
// (from _Basler***CameraParams.h where *** == 'GigE' or *** == 'CameraLink'
//
//enum FrequencyConverterSignalAlignmentEnums
//{
//    FrequencyConverterSignalAlignment_RisingEdge,
//    FrequencyConverterSignalAlignment_FallingEdge
//};

cam.FrequencyConverterSignalAlignment.SetValue(FrequencyConverterSignalAlignment_RisingEdge);
```

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

**To set the parameters needed to configure the frequency converter module via direct register access:**

1. Select the source signal for frequency conversion by setting the related value of the Frequency Converter Signal Source register.
2. Set the desired frequency value of the Frequency Converter Pre Divider register.
3. If you want to perform signal alignment (see above) you can set the value of the Frequency Converter Signal Alignment register.
4. To avoid overtriggering, Basler recommends to set the Frequency Converter Prevent Overtrigger register to 1.
5. Set the desired frequency value of the Frequency Converter Multiplier register.
6. Set the desired frequency value of the Frequency Converter Post Divider register.

For more information about direct register access, see Section 3.2 on [page 28](#).

# 7 Pixel Formats and Tap Geometries

This chapter provides information about the sensor bit depths and pixel formats available on the camera.



For a description of tap geometries and complete details regarding the way that pixel data is handled by the camera, refer to the Basler document named *racer Camera Link Information for Frame Grabber Designers* (AW001187). You can obtain the document from the camera's Downloads section of the Basler website: [www.baslerweb.com](http://www.baslerweb.com)

## 7.1 Pixel Formats

### Pixel Formats for Monochrome Cameras

The choice of a pixel format determines the bit depth of the data transmitted from the camera for each pixel in the acquired lines. The pixel formats available on the mono cameras depend on the currently selected Camera Link tap geometry as shown in Table 15.

Camera Link Tap Geometry	Available Pixel Formats		
	Mono 8	Mono 10	Mono 12
1X	•	•	•
1X2	•	•	•
1X4	•	•	•
1X8	•	•	
1X10	•		

Table 15: Selected Camera Link Tap Geometry and Available Mono Pixel Formats (• = format available)

## Pixel Format Interaction with the Sensor Bit Depth

The camera's sensor can capture image data at 12 bit depth. There is an interaction between the Sensor Bit Depth setting and the Pixel Format setting as described in Table 16.

Sensor Bit Depth	Pixel Format Setting		
	Mono 8	Mono 10	Mono 12
12 bits	8 most significant bits of data from the sensor are transmitted.	10 most significant bits of data from the sensor are transmitted.	All 12 bits of data from the sensor are transmitted.

Table 16: Interaction Between the Sensor Bit Depth and the Pixel Format

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

## Setting the Pixel Format

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

```
// Set pixel format to Mono 8
camera.PixelFormat.SetValue(PixelFormat_Mono8);
// Set pixel format to Mono 10
camera.PixelFormat.SetValue(PixelFormat_Mono10);
// Set pixel format to Mono 12
camera.PixelFormat.SetValue(PixelFormat_Mono12);
```

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 26](#).

### To set the sensor pixel format via direct register access:

- Set the value of the Pixel Format register to Mono 8, Mono 10, or Mono 12 as desired.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 7.2 Camera Link Tap Geometry

The Camera Link tap geometry determines how the data that is read out of the imaging sensor will be transmitted from the camera to the frame grabber in your host computer via the Camera Link interface. The selection of a camera link tap geometry also determines whether your camera will be operating in the base, medium, or full Camera Link configuration and which Camera Link connectors on the camera will be used to transmit pixel data. Table 17 indicates how the Camera Link interface will operate with each available tap geometry setting.

The e.g. X2, X4, or X8 in the tap geometry names indicates the number of Camera Link taps that will be used for a given configuration (e.g., X2 means 2 taps, 1X uses one tap). As a general rule of thumb, a camera will have a higher maximum allowed line rate when it is operating with a tap geometry that uses more Camera Link taps.

Tap Geometry Setting	Camera Link Configuration	Camera Link Connectors Used to Transmit Data
1X	Base	Base Only
1X2	Base	Base Only
1X4	Medium	Base and Medium/Full
1X8	Full	Base and Medium/Full
1X10	Full	Base and Medium/Full

Table 17: Camera Link Operation at Various Tap Geometry Settings

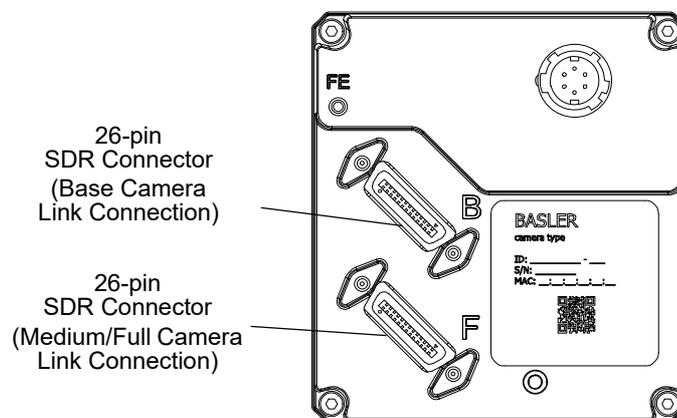


Fig. 31: Camera Link Connections

For a description of tap geometries refer to the Basler document named *racer Camera Link Information for Frame Grabber Designers* (AW001187). You can obtain the document from the camera's Downloads section of the Basler website: [www.baslerweb.com](http://www.baslerweb.com)

## 7.2.1 Setting the Tap Geometry

You can use the pylon API to set the Camera Link tap geometry from within your application software. The following code snippet illustrates using the API to set the tap geometry:

```
// Set the tap geometry to 1X
camera.ClTapGeometry.SetValue(ClTapGeometry_Geometry1X);

// Set the tap geometry to 1X2
camera.ClTapGeometry.SetValue(ClTapGeometry_Geometry1X2);

// Set the tap geometry to 1X4
camera.ClTapGeometry.SetValue(ClTapGeometry_Geometry1X4);

// Set the tap geometry to 1X8
camera.ClTapGeometry.SetValue(ClTapGeometry_Geometry1X8);

// Set the tap geometry to 1X10
camera.ClTapGeometry.SetValue(ClTapGeometry_Geometry1X10);
```

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 26](#).

### To set the Camera Link tap geometry via direct register access:

- Set the value of the CL Tap Geometry register for 1X, 1X2, 1X4, 1X8 or 1X10 as desired.

For more information about direct register access, see Section 3.2 on [page 28](#).

# 8 Features

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

## 8.1 Camera Link Pixel Clock Speed

The camera provides selectable Camera Link pixel clock speeds. The pixel clock speed determines the rate at which pixel data will be transmitted from the camera to the frame grabber in your computer via the Camera Link interface. The following nominal pixel clock speeds are available: 32.5 MHz, 48 MHz, and 65 MHz, and 83.5 MHz. The default clock speed is 83.5 MHz (nominal).



For technical reasons, pixel clock speeds must be set as **nominal** pixel clock speeds. However, an actual pixel clock speed of a camera can slightly differ from its nominal value (see below).

Unless noted otherwise, the descriptions in this manual use the nominal pixel clock speeds.

The following pixel clock speeds are available:

Nominal Pixel Clock Speed	Actual Pixel Clock Speed
32.5 MHz	32.500000 MHz
48 MHz	48.000000 MHz
65 MHz	65.000000 MHz
83.5 MHz	83.214286 MHz

Table 18: Nominal and Actual Camera Link Pixel Clock Speeds

The rate at which image data is transferred from the camera to the frame grabber depends on the set pixel clock speed. Setting the camera for a higher pixel clock speed will increase the transfer rate. Some frame grabbers, however, cannot operate at the higher clock speeds. So it is important that you determine the maximum clock speed that your frame grabber can handle and that you set the camera's pixel clock speed no higher than the frame grabber's maximum.

Keep in mind that if you set the camera for one of the lower pixel clock speeds, it may limit the camera's maximum allowed line acquisition rate.

If you change the clock speed while the camera is in the process of acquiring images:

- Triggering and image acquisition will stop.
- Any acquired image that is being transmitted will be delivered.
- The camera's clock speed will be changed internally.
- Once the change is complete, triggering and image acquisition will resume.

The Camera Link clock speed setting will be stored in the camera's configuration sets. This means, for example, that if you have a different clock speed setting stored in user set 1 and user set 2 and you change the active set from user set 1 to user set 2, the clock speed will change.

For more information about the maximum allowed line acquisition rate, see Section 6.4 on [page 87](#).

For more information about configuration sets, see Section 8.14 on [page 143](#).

## Setting the Camera Link Pixel Clock

You can use the pylon API to set the Camera Link pixel clock speed from within your application software. The following code snippet illustrates using the API to set the clock speed:

```
// Set the Camera Link pixel clock speed 32.5
camera.ClPixelClock.SetValue(ClPixelClock_PixelClock32_5);

// Set the Camera Link pixel clock speed to 48
camera.ClPixelClock.SetValue(ClPixelClock_PixelClock48);
```



You can use the pylon API to set the pixel clock speed to 32.5, 48, 65, or 83.5 MHz. These are the only valid values for the pixel clock speed. If you attempt to use the API to set the clock speed to a value other than these, the camera will automatically round the setting down to the nearest valid speed.

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 26](#).

### To set the Camera Link pixel clock speed via direct register access:

- Set the value of the CI Pixel Clock register for 32.5, 48, 65, or 83.5 MHz.

For more information about changing settings via direct register access, see Section 3.2 on [page 28](#).

## 8.2 Gain and Black Level

### 8.2.1 Gain

The camera's gain is adjustable. As shown in Fig. 32, increasing the gain increases the slope of the response curve for the camera. This results in an increase in the gray values 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 lower gray values for a given amount of sensor output.

Increasing the gain is useful when at your brightest exposure, the highest gray values achieved are lower than 255 (for pixel formats with 8 bit depth) or 4095 (for pixel formats with 12 bit depth). 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 format), you could increase the gain to 6 dB (an amplification factor of 2) and thus reach gray values of 254.

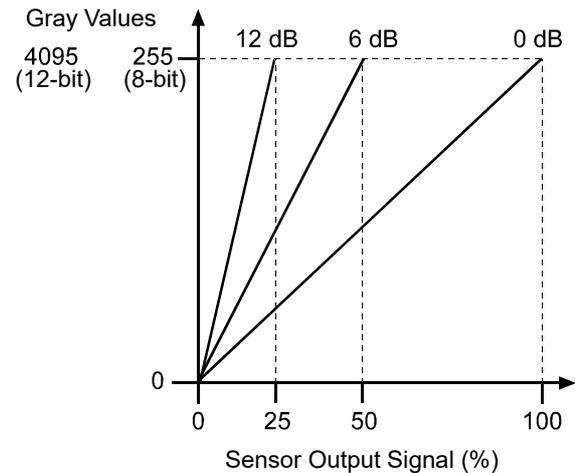


Fig. 32: Gain in dB

You can use the analog gain for coarsely setting gain and the digital gain for finer adjustment.

#### 8.2.1.1 Analog Gain

The camera's analog gain is determined by the Gain parameter with the gain selector set to Analog All. All pixels in the sensor are affected by this setting.

The allowed parameter values are 1 and 4. A parameter value of 1 corresponds to 0 dB and gain will not be modified. A parameter value of 4 corresponds to 12 dB and an amplification factor of 4.

#### To set the analog gain using Basler pylon:

1. Set the GainSelector parameter to AnalogAll.
2. Set the Gain parameter to 1 or 4, as desired.

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

```
// Set Gain Analog All
camera.GainSelector.SetValue(GainSelector_AnalogAll);
camera.GainRaw.SetValue(4);
```

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

#### To set the analog gain via direct register access:

- Set the value of the Gain Analog All register.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.2.1.2 Digital Gain

Adjusting the camera's digital gain will digitally shift the group of bits that is output for the pixel values from each ADC in the camera.

Increasing the digital gain parameter value will result in an amplified gain and therefore in higher pixel values. Decreasing the digital gain setting will result in a decreased gain and therefore in lower pixel values.

The digital gain parameter values can be set on an integer scale ranging from 256 to 2047. This range of settings is linearly related to a range of amplification factors where a parameter value of 256 corresponds to 0 dB and gain will not be modified and a parameter value of 2047 corresponds to 18.057 dB and an amplification factor of approximately 8.00.

You can use the formula below to calculate the dB of gain that will result from the GainRaw parameter values:

$$\text{Gain[dB]} = 20 \times \log_{10} \left( \frac{\text{Gain Raw}}{256} \right)$$

$$\text{Gain[dB]} = 20 \times \log_{10} (\text{Gain Raw}) - 48.165$$

Note that due to the nature of digital gain certain gray values will be absent in the image ("missing codes") if digital gain is set to a value larger than 256.

You can use the remove parameter limits feature to remove to lower limit for digital gain parameter values. When you use the remove parameter limits feature you can also set digital gain parameter values in the range from 0 to 256. This corresponds to a range of amplification factors from 0 to approximately 0.99.

For more information about the remove parameter limits feature, see Section 8.3 on [page 106](#).



If the digital gain parameter value is set below 256 using the remove parameter limits feature: In this case, regardless of the brightness of illumination, the camera will not be able to reach the maximum gray values that otherwise could be reached. For example, if the camera is set to a 12 bit pixel format, the maximum gray value of 4095 can not be reached if the digital gain parameter value is set below 256.

**To set the digital gain using Basler pylon:**

1. Set the GainSelector parameter to DigitalAll.
2. Set the Gain parameter to your desired value.

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

```
// Set Gain Digital All
camera.GainSelector.SetValue(GainSelector_DigitalAll);
camera.GainRaw.SetValue(256);
```

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

**To set the digital gain via direct register access:**

- Set the value of the Gain Digital All register.

For more information about direct register access, see Section 3.2 on [page 28](#).

### 8.2.1.3 Using Both Analog Gain and Digital Gain

You can use analog gain and digital gain at the same time. In this case, the amplification factors will multiply. For example, if you set analog gain to an amplification factor of 4 and use an amplification factor of 1.2 for digital gain the total amplification factor will be 4.8. This corresponds to adding 12 dB and 1.6 dB to give a total gain of 13.6 dB.

For optimum image quality, Basler recommends to set the total amplification as low as possible. If you need an amplification factor larger than Basler recommends to set analog gain to 4 and then digital gain to reach the desired total amplification.



If you use analog gain and digital gain at the same time and also use the remove parameter limits for digital gain with digital gain parameter values below 256: Note also that the amplification factor for total gain will be 0 if the digital gain setting is 0.

## 8.2.2 Black Level

Adjusting the camera's black level will result in an offset to the pixel values output from the camera.

The camera's black level is determined by the `BlackLevelRaw` parameter with the black Level selector set to `All`. All pixels in the sensor are affected by this setting.

If the camera is set for a pixel format with an 8 bit depth, an increase of 16 in a black level setting will result in a positive offset of 1 in the pixel values output from the camera. And a decrease of 16 in a black level setting will result in a negative offset of 1 in the pixel values output from the camera.

If the camera is set for a pixel format with a 12 bit depth, an increase of 1 in a black level setting will result in a positive offset of 1 in the pixel values output from the camera. A decrease of 1 in a black level setting will result in a negative offset of 1 in the pixel values output from the camera.

### To set the black level using Basler pylon:

1. Set the `BlackLevelSelector` parameter to `All`.
2. Set the `BlackLevelRaw` parameter to your desired value.

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

```
// Set BlackLevelRaw All
camera.BlackLevelSelector.SetValue(BlackLevelSelector_All);
camera.BlackLevelRaw.SetValue(64);
```

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

### To set the black level via direct register access:

- Set the value of the Black Level All register.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.3 Remove Parameter Limits

For each camera feature, the allowed range of any associated parameter values is normally limited. The factory limits are designed to ensure optimum camera operation and, in particular, good image quality. For special camera uses, however, it may be helpful to set parameter values outside of the factory limits.

The remove parameter limits feature lets you remove the factory limits for parameters associated with certain camera features. When the factory limits are removed, the parameter values can be set within extended limits. Typically, the range of the extended limits is dictated by the physical restrictions of the camera's electronic devices, such as the absolute limits of the camera's variable gain control.

The values for any extended limits can be determined by using the Basler pylon Viewer or from within your application via the pylon API.

Currently, the following limits can be removed:

- **Gain:** Removing this parameter limit reduces the lower limit for the Gain parameter to 0. For more information, see Section 8.2.1 on [page 102](#).
- **Target Gray Value:** Removing this parameter limit increases the lower and upper limits of the TargetGrayValue parameter used for auto functions. For more information, see Section 8.5 on [page 110](#).
- **Exposure Overhead:** Removing this parameter limit allows you to improve line acquisition. Also, it slightly increases the upper limit of the ExposureOverlapTimeMaxAbs parameter. For more information, see Section 6.3.3 on [page 82](#), and Section 6.4.2 on [page 91](#).
- **Exposure Overlap Time Max:** Removing this parameter limit greatly increases the upper limit of the ExposureOverlapTimeMaxAbs parameter. For more information, see Section 6.1.5.2 on [page 65](#), Section 6.2.1.2 on [page 75](#), and Section 6.3.3 on [page 82](#).

### To remove the limits for a parameter using Basler pylon:

1. Use the ParameterSelector parameter to select the parameter whose limits you want to remove.
2. Set the RemoveLimits parameter to True.

You can set the ParameterSelector and the RemoveLimits 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:

```
// Select the parameter whose factory limits will be removed.
camera.ParameterSelector.SetValue(ParameterSelector_Gain);
// Remove the limits for the selected feature.
camera.RemoveLimits.SetValue(true);
```

You can also use the Basler pylon Viewer application to easily set the parameters. Note that the remove parameter limits feature will only be available at the "guru" viewing level.

### To remove e.g. the limits for the Gain parameter using direct register access:

- Set the value of the Remove Param Limits Gain register to enabled.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.4 Image Area of Interest (AOI)

The image area of interest feature lets you specify a portion of the sensor line. During operation, only the pixel information from the specified portion of the line is read out of the sensor and transmitted from the camera to the frame grabber. One of the main advantages of the AOI feature is that decreasing the size of the AOI will increase the camera's maximum allowed acquisition line rate if it is limited by the time it takes to transmit the pixel data from the camera to the computer. For more information about how changing the AOI size affects the maximum allowed line rate, see Section 6.4 on [page 87](#).

The area of interest is referenced to the left end of the sensor array. The outer left pixel is designated as pixel 0 (see Fig. 33).

The location and size of the area of interest is defined by declaring an offset X and a width. For example, suppose that you specify the offset X as 16 and the width as 24. The area of the array that is defined by these settings is shown in Figure 33. With these settings, the camera will read out and transmit pixel values for pixels 16 through 39..

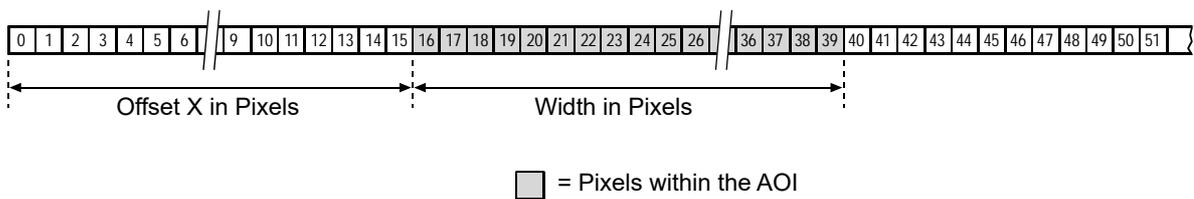


Fig. 33: Image Area of Interest

### 8.4.1 Setting the Image AOI

By default, the AOI is set to use the full resolution of the camera's sensor. You can change the size and the position of the AOI by changing the values of the camera's OffsetX and Width parameters.

When you are setting the camera's area of interest, you must follow these guidelines:

- The sum of the Offset X setting plus the Width setting must not exceed the width of the camera's sensor. For example, on the raL2048-80km, the sum of the Offset X setting plus the Width setting must not exceed 2048.
- Depending on the selected Camera Link tap geometry, the following increments apply to offset X and width if horizontal binning is not enabled:

Camera Link Tap Geometry	Offset X Increment	Width Increment
1X	8	8
1X2	8	8
1X4	8	8
1X8	8	8
1X10	8	40

Table 19: Camera Link Tap Geometry and Related Increments for AOI Offset X and Width

For example, if you are working with a camera that has a sensor with 2048 pixels and if you have selected the 1X4 Camera Link tap geometry:

$$\text{Offset X} + \text{AOI Width} \leq 2048$$

The AOI offset X can be set to 0, 8, 16, 24, etc.

The AOI width can be set to 8, 16, 24, 32, etc.

For more information about Camera Link tap geometries, see Section 7.2 on [page 98](#).



The 1X10 tap geometry constraints the AOI width increment to 40 pixels (see Table 19). As a result, the accessible maximum resolution of a sensor is somewhat smaller than the full resolution of a sensor. For example, for raL2048-80km cameras, the full resolution is 2048 pixels, of which only 2040 pixels can be used with 1X10 tap geometry. The other tap geometries can use the full resolution of a sensor.

For more information, see the "Resolution" entries in Section 1.4 on [page 3](#).



Your frame grabber may place additional restrictions on how the AOI position and size must be set. Check the documentation included with your frame grabber to determine its AOI requirements.

Normally, the OffsetX and Width parameter settings refer to the physical line of the sensor. But if binning is enabled, these parameters are set in terms of a "virtual" line. For more information about using an image AOI with binning, see Section 8.7 on [page 124](#).

You can set the OffsetX and Width 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 and the increments for the OffsetX and Width parameters. They also illustrate setting the OffsetX and Width parameter values.

```
int64_t offsetXMax = camera.OffsetX.GetMax();
int64_t offsetXInc = camera.OffsetX.GetInc();
camera.OffsetX.SetValue(16);
int64_t widthMax = camera.Width.GetMax();
int64_t widthInc = camera.Width.GetInc();
camera.Width.SetValue(24);
```

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 26](#).

#### **To set the AOI Offset X and Width parameter values via direct register access:**

1. Set the value of the Offset X register.
2. Set the value of the Width register.

### **Using the Image AOI Feature with Horizontal Binning Enabled**

If the camera's horizontal binning feature (see Section 8.7 on [page 124](#)) is enabled, it will have an effect on the way that you set up the area of interest. With horizontal binning enabled, pairs of adjacent pixel in a line are binned together into a single pixel. When you set an AOI with horizontal binning enabled, the AOI settings are based on "binned" pixels rather than the actual physical pixels in the sensor lines.

#### **Examples:**

- If you are working with a camera that has sensor lines with 2048 physical pixels and you enable horizontal binning by 2, you effectively reduce the resolution to 1024 "binned" pixels. In this case, you would set the AOI as if you were working with a sensor that actually has 1024 pixels.
- If you are working with a camera that has sensor lines with 4096 physical pixels and you enable horizontal binning by 2, you effectively reduce the resolution to 2048 "binned" pixels. In this case, you would set the AOI as if you were working with a sensor that actually has 2048 pixels.
- If you are using binning by 3, make sure to set up an area of interest where the Width parameter value is evenly divisible by 3.

## 8.5 Auto Functions

### 8.5.1 Common Characteristics

Auto functions control image properties and are the "automatic" counterparts of certain features which normally require "manually" setting the related parameter values. Auto functions are particularly useful when an image property must be adjusted quickly towards a specific target value and when an image property must be kept constant during acquisition.

On racer cameras, two auto functions are available: Gain Auto and Exposure Auto.

By specifying a portion of the sensor line and a specific number of consecutive lines to be acquired, you can define an auto function area of interest (auto function AOI). Each auto function uses the pixel data from the auto function AOI to automatically adjust a parameter value towards a set target value and, accordingly, to control the related image property.

The auto functions automatically adjust a parameter value until the related image property reaches a target value. The manual setting of the parameter value is not preserved. For example, when the gain auto function adjusts the gain parameter value, the manually set gain parameter value is not preserved.

For both auto functions, the target value can be set. Also, the limits between which the related parameter value will be automatically adjusted can be set. For example, the gain auto function lets you set an average gray value as a target value and also set a lower and an upper limit for the gain parameter value.

Both 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 acquisition. 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 target average gray value setting.



You can use an auto function when binning is enabled. An auto function uses the binned pixel data and controls the image property of the binned line.

For more information about binning, see Section 8.7 on [page 124](#).

## 8.5.2 Auto Function Operating Modes

The following auto function modes of operation are available:

- **"Once"** mode of operation: When this 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.

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 up to 30 times and will then be set to Off.

- **"Continuous"** mode of operation: When this mode of operation is selected, the parameter value is adjusted repeatedly while lines are acquired.

The repeated automatic adjustment will proceed until the "once" mode of operation is used or until the auto function is set to Off, in which case the parameter value resulting from the latest automatic adjustment will operate, unless the parameter is manually adjusted.

- **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 acquiring lines ("on the fly").



If you have set an auto function to "once" or "continuous" operation mode while the camera was continuously acquiring lines, the auto function will become effective with a short delay and the first few lines may not be affected by the auto function.

## 8.5.3 Auto Function AOI

The auto function AOI is used by the auto functions to automatically adjust a parameter value (gain or exposure time), and accordingly, to control the related image property (brightness).

To set the auto function AOI, you must specify

- the desired portion of the sensor line using the AutoFunctionAOIWidth and AutoFunctionAOIOffsetX parameters. Setting these parameters is similar to setting the Width and OffsetX parameters of the image AOI (see Section 8.4 on [page 107](#)). The outer left pixel of the sensor is designated as pixel 0.
- the desired number of lines to be acquired, using the AutoFunctionAOIHeight parameter.

When these parameters are set, the camera will accumulate pixel data from the specific portion of the sensor line until the set number of lines has been acquired.

**Example:** You set the AutoFunctionAOIOffsetX parameter to 11, the AutoFunctionAOIWidth parameter to 10, and the AutoFunctionAOIHeight parameter to 15. The camera will accumulate the pixel data from pixels 11 through 20 each from 15 consecutive line acquisitions.

The resulting auto function AOI is shown in Fig. 34. The accumulated pixel data will be used for image property control.

For more information about setting the parameters, see Section 8.5.3.2 on [page 115](#).

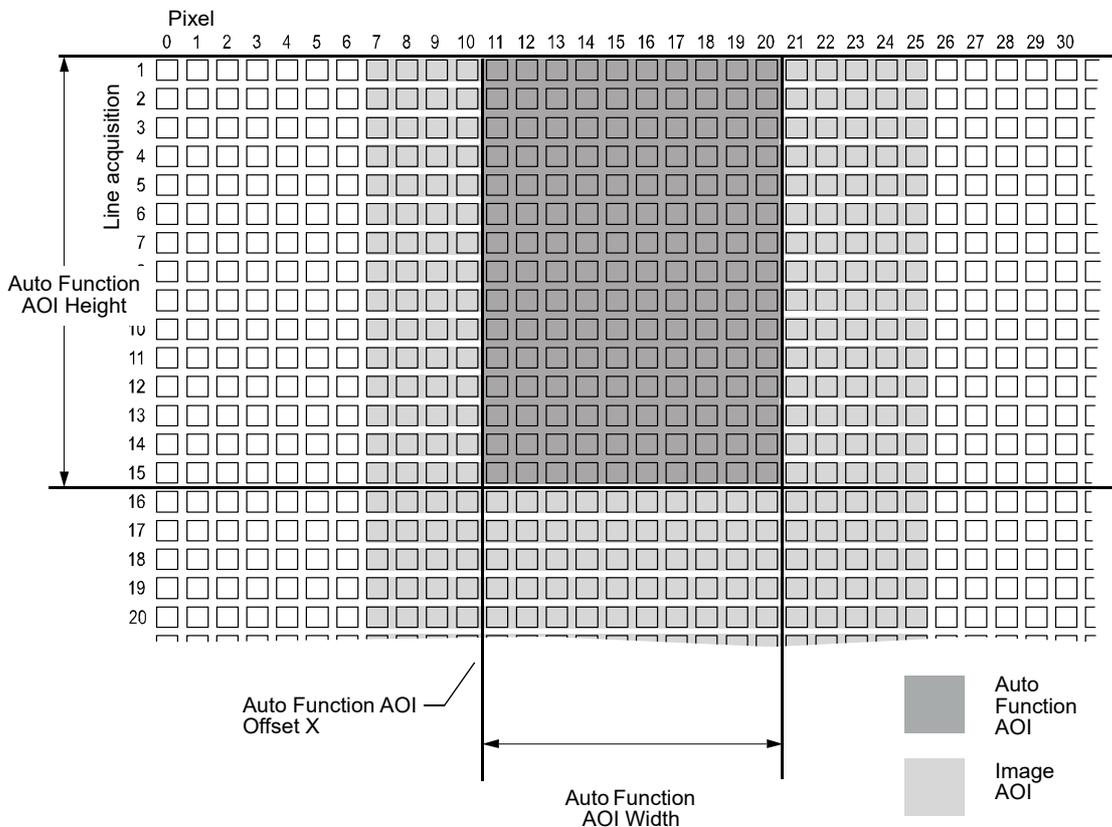


Fig. 34: Example Auto Function Area of Interest



If the operation mode of an auto function is set to "continuous", there will be a short delay between each auto function AOI cycle. This is because the accumulated pixel data of the auto function AOI has to be processed by the camera's FPGA. During this delay, the camera will keep acquiring lines. This means that not all acquired lines may be used for auto function control. However, this should only affect a few lines. Also, the delay does not increase with larger auto function AOIs.

### 8.5.3.1 Positioning of the Auto Function AOI Relative to the Image AOIs

The offsetsX and widths of auto function AOI and image AOIs can, but need not be identical.

The overlap between auto function AOI and image AOI determines whether and to what extent the auto function will control the related image property. Only the pixel data from the areas of overlap will be used by the auto function to control the image property.

Different degrees of overlap are illustrated in [Fig. 35](#). The hatched areas in the figure indicate areas of overlap.

- If the auto function AOI is completely included in the image AOIs (see (a) in [Fig. 35](#)), the pixel data from the auto function AOI will be used to control the image property.
- If the image AOIs are completely included in the auto function AOI (see (b) in [Fig. 35](#)), only the pixel data from the image AOIs will be used to control the image property.
- If the image AOIs only partially overlap the auto function AOI (see (c) in [Fig. 35](#)), only the pixel data from the area of partial overlap will be used to control the image property.
- If the auto function AOI does not overlap the image AOIs (see (d) in [Fig. 35](#)), the Auto Function will **not** or only to a **limited** degree control the image property. For details, see the sections below, describing the individual auto functions.



Basler strongly recommends completely including the auto function AOI within the image AOIs, or, depending on your needs, choosing identical offsetsX and widths for auto function AOI and image AOIs.

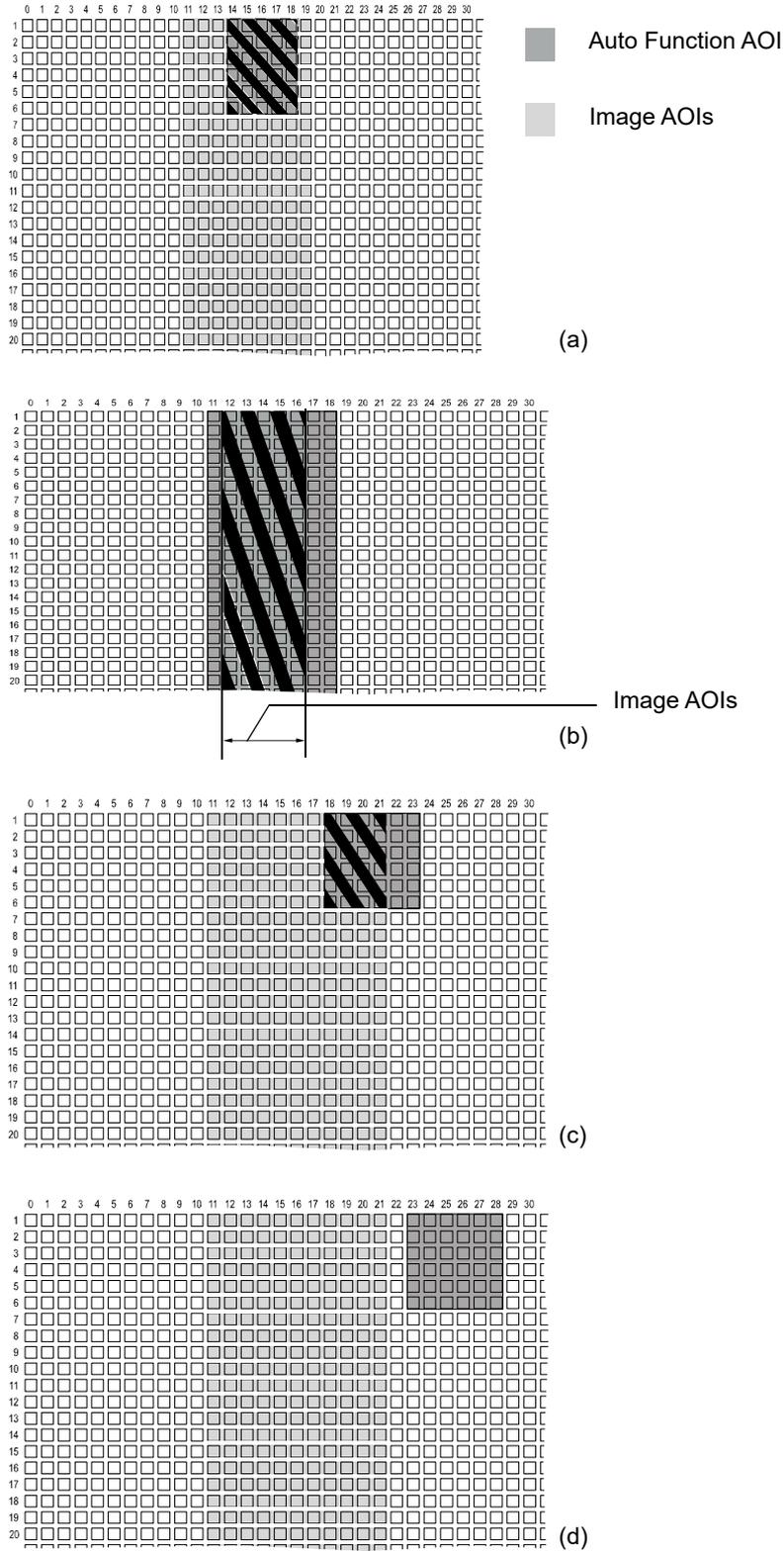


Fig. 35: Various Degrees of Overlap Between the Auto Function AOI and the Image AOIs

### 8.5.3.2 Setting the Auto Function AOI

By default, the auto function AOI is set to the full width of the sensor line and to a height of 128 lines. You can change the size and the position of the auto function AOI by changing the value of the following parameters:

- `AutoFunctionAOIOffsetX`: determines the starting pixel (in horizontal direction) for the auto function AOI. The outer left pixel is designated as pixel 0.
- `AutoFunctionAOIWidth`: determines the width of the auto function AOI.
- `AutoFunctionAOIHeight`: determines the number of lines that must be acquired for auto function control.

All parameters can be set in increments of 1.

For general information about the parameters, see Section 8.5.1 on [page 110](#).

When you are setting the auto function AOI, you must follow these guidelines:

Guideline	Notes
<code>AutoFunctionAOIOffsetX + AutoFunctionAOIWidth</code> < width of camera sensor	<b>Example:</b> raL4096-80km <code>AutoFunctionAOIOffsetX + AutoFunctionAOIWidth</code> < 4096.
<code>AutoFunctionAOIHeight</code> ≤ number of line acquisitions	If <code>AutoFunctionAOIHeight</code> > number of line acquisitions, the effective auto function AOI height will be equal to the actual number of line acquisitions. <b>Example:</b> If you set <code>AutoFunctionAOIHeight</code> to 400, and acquire only 100 lines, the effective auto function AOI height will be 100.



Normally, the `AutoFunctionAOIOffsetX` and the `AutoFunctionAOIWidth` parameter settings refer to the physical line of the sensor. But if binning is enabled, these parameters are set in terms of a "virtual" line. For more information about binning, see Section 8.7 on [page 124](#).



Depending on your firmware version, you may be able to choose from multiple auto function AOIs (AOI 1, AOI 2, ...) using the `AutoFunctionAOISelector`. However, leave the Auto Function AOI 1 selected at all times and do not use the other auto function AOIs.

You can set the parameter values for the auto function AOI from within your application software by using the Basler pylon API:

```
// Select Auto Function AOI 1
camera.AutoFunctionAOISelector.SetValue(AutoFunctionAOISelector_AOI1);
// Set the position and size of the auto function AOI (sample values)
camera.AutoFunctionAOIOffsetX.SetValue(20);
```

```
camera.AutoFunctionAOIWidth.SetValue(500);  
camera.AutoFunctionAOIHeight.SetValue(300);
```

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 26](#).

## 8.5.4 Gain Auto

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

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

If the auto function AOI does not overlap the image AOI (see Section 8.5.3.1 on [page 113](#)), the pixel data from the auto function AOI will not be used to control the gain. Instead, the current manual setting for the GainRaw parameter value will control the gain.

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 8.2 on [page 102](#).
- the auto function profile feature, see Section 8.5.7 on [page 120](#).

The limits within which the camera will adjust the GainRaw parameter are defined by the AutoGainRawUpperLimit and the AutoGainRawLowerLimit parameters. The minimum and maximum allowed settings for the AutoGainRawUpperLimit and AutoGainRawLowerLimit parameters depend on the current pixel format, on the current settings for binning, and on whether or not the parameter limits for manually setting the gain feature are disabled.

The AutoTargetValue parameter defines the target average gray value that the gain auto function will attempt to achieve when it is automatically adjusting the GainRaw value. The target average gray value can range from 50 (near-black) to 205 (near-white) when the camera is set for an 8-bit pixel format or from 800 (near-black) to 3280 (near-white) when the camera is set for a 12-bit pixel format.

### To set the gain auto functionality:

1. Set the value of the AutoFunctionAOIOffsetX, AutoFunctionAOIWidth, and AutoFunctionAOIHeight parameters.
2. Set the GainSelector parameter to DigitalAll.
3. Set the value of the AutoGainRawLowerLimit and AutoGainRawUpperLimit parameters.
4. Set the value of the AutoTargetValue parameter.
5. Set the value of the GainAuto parameter for the "once" or the "continuous" mode of operation.

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

```
// Set the position and size of the auto function AOI (sample values)
camera.AutoFunctionAOIOffsetX.SetValue(20);
camera.AutoFunctionAOIWidth.SetValue(500);
camera.AutoFunctionAOIHeight.SetValue(300);

// Select gain all and set the upper and lower gain limits for the
// gain auto function
camera.GainSelector.SetValue(GainSelector_DigitalAll);
camera.AutoGainRawLowerLimit.SetValue(camera.GainRaw.GetMin());
camera.AutoGainRawUpperLimit.SetValue(camera.GainRaw.GetMax());

// Set the target gray value for the gain auto function
// (If exposure auto is enabled, this target is also used for
// exposure auto control.)
camera.AutoTargetValue.SetValue(128);

// Set the mode of operation for the gain auto function
camera.GainAuto.SetValue(GainAuto_Continuous);
```

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

For general information about auto functions, see Section 8.5.1 on [page 110](#).

For more information about

- the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).
- the auto function AOI and how to set it, see Section 8.5.3 on [page 112](#).

## 8.5.5 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 6.1.5.2 on [page 65](#).

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

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

If the auto function AOI does not overlap the image AOI (see Section 8.5.3.1 on [page 113](#)), the pixel data from the auto function AOI will not be used to control the exposure time. Instead, the current manual setting of the ExposureTimeAbs parameter value will control the exposure time.

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 6.1.3 on [page 58](#).
- the auto function profile feature, see Section 8.5.7 on [page 120](#).

The limits within which the camera will adjust the ExposureTimeAbs parameter are defined by the AutoExposureTimeAbsUpperLimit and the AutoExposureTimeAbsLowerLimit parameters. The current minimum and the maximum allowed settings for the AutoExposureTimeAbsUpperLimit parameter and the AutoExposureTimeAbsLowerLimit parameters depend on the minimum allowed and maximum possible exposure time for your camera model.

The AutoTargetValue parameter defines the target average gray value that the exposure auto function will attempt to achieve when it is automatically adjusting the ExposureTimeAbs value. The target average gray value can range from 50 (near-black) to 205 (near-white) when the camera is set for an 8-bit pixel format or from 800 (near-black) to 3280 (near-white) when the camera is set for a 12-bit pixel format.



If the AutoExposureTimeAbsUpperLimit parameter is set to a sufficiently high value, the camera's line rate may be decreased.

#### To set the exposure auto functionality:

1. Set the value of the AutoFunctionAOIOffsetX, AutoFunctionAOIWidth, and AutoFunctionAOIHeight parameters.
2. Set the value of the AutoExposureTimeAbsLowerLimit and AutoExposureTimeAbsUpperLimit parameters.
3. Set the value of the AutoTargetValue parameter.
4. Set the value of the Exposure Auto parameter for the "once" or the "continuous" mode of operation.

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

```
// Set the position and size of the auto function AOI (sample values)
camera.AutoFunctionAOIOffsetX.SetValue(20);
camera.AutoFunctionAOIWidth.SetValue(500);
camera.AutoFunctionAOIHeight.SetValue(300);

// Set the exposure time limits for exposure auto control
camera.AutoExposureTimeAbsLowerLimit.SetValue(1000);
camera.AutoExposureTimeAbsUpperLimit.SetValue(5000);

// Set the target gray value for the exposure auto function
// (If gain auto is enabled, this target is also used for
// gain auto control.)
```

```
camera.AutoTargetValue.SetValue(128);

// 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 information about

- the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#)
- the auto function AOI and how to set it, see Section 8.5.3 on [page 112](#)
- minimum allowed and maximum possible exposure time, see Section 6.1.1 on [page 55](#).

For general information about auto functions, see Section 8.5.1 on [page 110](#).

## 8.5.6 Gray Value Adjustment Damping

The gray value adjustment damping controls the rate by which pixel gray values are changed when Exposure Auto or Gain Auto or both are enabled.

If an adjustment damping factor is used, the gray value target value is not immediately reached, but after a certain delay. This can be useful, for example, when objects move into the camera's view area and where the light conditions are gradually changing due to the moving objects.

By default, the gray value adjustment damping is set to 0.75. This is a setting where the damping control is as stable and quick as possible.

### Setting the Adjustment Damping

The adjustment damping is determined by the value of the `GrayValueAdjustmentDampingAbs` parameter.

The higher the value, the lower the adjustment damping is, i.e.

- the sooner the target value will be reached,
- the adaptation is realized over a smaller number of line acquisitions.

You can set the gray value adjustment damping from within your application software by using the pylon API. The following code snippets illustrate using the API to set the gray value adjustment damping:

```
camera.GrayValueAdjustmentDampingAbs.SetValue(0.5);
```

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

## 8.5.7 Auto Function Profile

If you want to use the gain auto function and the exposure auto function at the same time,

- the auto function profile feature also takes effect.  
The auto function profile specifies whether the gain or the exposure time will be kept as low as possible when the camera is making automatic adjustments to achieve a target average gray value for the pixel data. By default, the auto function profile feature minimizes exposure time.
- you should set both functions for the continuous mode of operation.

### To use the gain auto function and the exposure auto function at the same time:

1. Set the value of the `AutoFunctionProfile` parameter to specify whether gain or exposure time will be minimized during automatic adjustments.
2. Set the value of the `GainAuto` parameter to the "continuous" mode of operation.
3. Set the value of the `ExposureAuto` 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, Gain is set to be minimized during adjustments:

```
// Use Gain Auto and Exposure Auto simultaneously
camera.AutoFunctionProfile.SetValue(AutoFunctionProfile_GainMinimum);
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 26](#).

## 8.6 Luminance Lookup Table

The type of electronics used on the camera allow the camera's sensor to acquire pixel values at a 12 bit depth. Normally, when a camera is set for a 12 bit pixel format, the camera uses the actual 12 bit pixel values reported by the sensor.

The luminance lookup table feature lets you create a custom 12 bit to 12 bit lookup table that maps the actual 12 bit values output from the sensor to substitute 12 bit values of your choice. When the lookup table is enabled, the camera will replace the actual pixel values output from the sensor with the substitute values from the table.

The lookup table has 4096 indexed locations with a 12 bit value stored at each index. The values stored in the table are used like this:

- When the sensor reports that a pixel has an actual 12 bit value of 0, the substitute 12 bit value stored at index 0 will replace the actual pixel value.
- The numbers stored at indices 1 through 7 are not used.
- When the sensor reports that a pixel has an actual 12 bit value of 8, the substitute 12 bit value stored at index 8 will replace the actual pixel value.
- The numbers stored at indices 9 through 15 are not used.
- When the sensor reports that a pixel has an actual 12 bit value of 16, the substitute 12 bit value stored at index 16 will replace the actual pixel value.
- The numbers stored at indices 17 through 23 are not used.
- When the sensor reports that a pixel has an actual 12 bit value of 24, the substitute 12 bit value stored at index 24 will replace the actual pixel value.
- And so on.

As you can see, the table does not include a defined 12 bit substitute value for every actual pixel value that the sensor can report. If the sensor reports an actual pixel value that is between two values that have a defined substitute, the camera performs a straight line interpolation to determine the substitute value that it should use. For example, assume that the sensor reports an actual pixel value of 12. In this case, the camera would perform a straight line interpolation between the substitute values at index 8 and index 16 in the table. The result of the interpolation would be used by the camera as the substitute.

Another thing to keep in mind about the table is that index 4088 is the last index that will have a defined substitute value associated with it (the values at indices 4089 through 4095 are not used.) If the sensor reports an actual value greater than 4088, the camera will not be able to perform an interpolation. In cases where the sensor reports an actual value greater than 4088, the camera simply uses the 12 bit substitute value from index 4088 in the table.

The advantage of the luminance lookup table feature is that it lets a user customize the response curve of the camera. The graphs below represent the contents of two typical lookup tables. The first graph is for a lookup table where the values are arranged so that the output of the camera increases linearly as the actual sensor output increases. The second graph is for a lookup table where the values are arranged so that the camera output increases quickly as the actual sensor output moves from 0 through 2048 and increases gradually as the actual sensor output moves from 2049 through 4096.

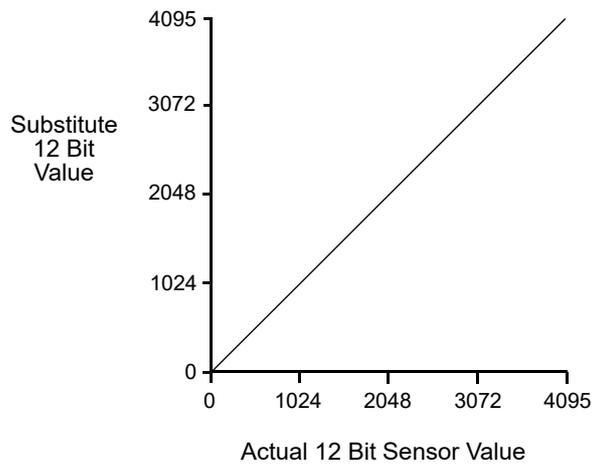


Fig. 36: Lookup Table with Values Mapped in a Linear Fashion

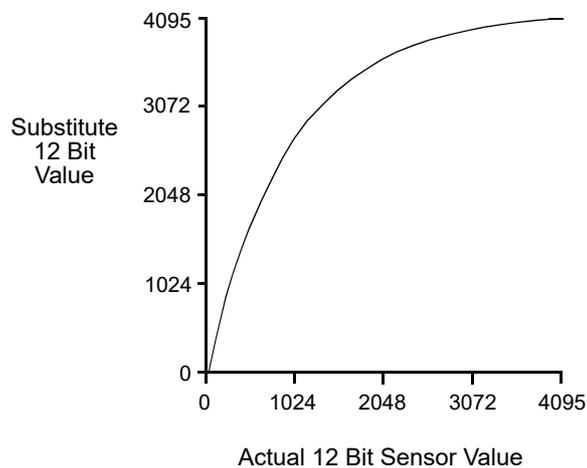


Fig. 37: Lookup Table with Values Mapped for Higher Camera Output at Low Sensor Readings

## Using the Luminance Lookup Table to Get 8 Bit Output

As mentioned above, when the camera is set for a 12 bit pixel format, the lookup table can be used to perform a 12 bit to 12 bit substitution. The lookup table can also be used in 12 bit to 8 bit fashion. To use the table in 12 bit to 8 bit fashion, you enter 12 bit substitution values into the table and enable the table as you normally would. But instead of setting the camera for a 12 bit pixel format, you set the camera for an 8 bit format (such as Mono 8). In this situation, the camera will first use the values in the table to do a 12 bit to 12 bit substitution. It will then truncate the lowest 4 bits of the substitute value and will transmit the remaining 8 highest bits.

## Changing the Values in the Luminance Lookup Table and Enabling the Table Using Basler pylon

You can change the values in the luminance lookup table (LUT) and enable the use of the lookup table by doing the following:

1. Use the LUTSelector parameter to select a lookup table. (Currently there is only one lookup table available, i.e., the "luminance" lookup table described above.)
2. Use the LUTIndex parameter to select an index number.
3. Use the LUTValue parameter to enter the substitute value that will be stored at the index number that you selected in step 2.
4. Repeat steps 2 and 3 to enter other substitute values into the table as desired.
5. Use the LUTEnable parameter to enable the table.

You can set the LUTSelector, the LUTIndex, and the LUTValue parameters from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter values:

```
// Select the lookup table
camera.LUTSelector.SetValue(LUTSelector_Luminance);

// Write a lookup table to the device.
// The following lookup table causes an inversion of the sensor values
// (bright -> dark, dark -> bright)
for (int i = 0; i < 4096; i += 8)
{
    camera.LUTIndex.SetValue(i);
    camera.LUTValue.SetValue(4095 - i);
}
// Enable the lookup table
camera.LUTEnable.SetValue(true);
```

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

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

## Changing the Values in the Luminance Lookup Table and Enabling the Table Using Direct Register Access

When setting up the luminance lookup table via direct register access, two registers are involved: the LUT register and the LUT Enable register.

- The LUT register is simply an array register that holds the 4096 12 bit values described earlier in this section. As a first step to using the lookup table feature. You must populate this register with 12 bit values.
- Once the LUT register has been populated, you can enable the use of the lookup table by setting the value of the LUT Enable register to 1 (enabled).

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.7 Binning

Binning increases the camera's response to light by summing the charges from adjacent pixels into one pixel.

With horizontal binning, the charges of 2, 3, or a maximum of 4 adjacent pixels are summed and are reported out of the camera as a single pixel. Fig. 38 illustrates horizontal binning.



Fig. 38: Horizontal Binning

For information about using binning with the Image Area of Interest feature enabled, see Section 8.4 on [page 107](#).

### Setting Binning

You can enable horizontal binning by setting the `BinningHorizontal` parameter. Setting the parameter's value to 2, 3, or 4 enables horizontal binning by 2, horizontal binning by 3, or horizontal binning by 4 respectively. Setting the parameter's value to 1 disables horizontal binning.

You can set the `BinningHorizontal` 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:

```
// Enable horizontal binning by 4
camera.BinningHorizontal.SetValue(4);

// Disable horizontal binning
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 26](#).

#### To enable horizontal binning via direct register access:

- Set the value of the Binning Horizontal register.

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

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.8 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. To accomplish the correction, a gamma correction factor ( $\gamma$ ) is applied to the brightness value ( $Y$ ) of each pixel according to the following formula:

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

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.

When the gamma correction factor is set to 1, the output pixel brightness will not be corrected.

A gamma correction factor between 0 and 1 will result in increased overall brightness, and a gamma correction factor greater than 1 will result in decreased overall brightness.

In all cases, black (output pixel brightness equals 0) and white (output pixel brightness equals 255 at 8 bit output and 4095 at 12 bit output) will not be corrected.

### Enabling Gamma Correction and Setting the Gamma

You can enable or disable the gamma correction feature by setting the value of the `GammaEnable` parameter.

When gamma correction is enabled, the correction factor is determined by the value of the `Gamma` parameter. The `Gamma` parameter can be set in a range from 0 to 3.99902. So if the `Gamma` parameter is set to 1.2, for example, the gamma correction factor will be 1.2.

You can set the `GammaEnable` and `Gamma` 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 the Gamma feature
camera.GammaEnable.SetValue(true);

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

**To enable gamma correction and to set the gamma value via direct register access:**

1. Set the value of the GammaEnable register to Enabled.
2. Set the value of the Gamma Selector register to User.
3. If the Gamma Selector is set to User, set the value in the Gamma register to the desired gamma value.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.9 Shading Correction

Two types of shading correction are available on the camera, offset shading correction and gain shading correction. You can set the camera to only perform offset shading correction, to only perform gain shading correction, or to perform both types of shading correction.

### 8.9.1 Offset Shading Correction

When a line scan camera with a digital sensor captures a line in complete darkness, all of the pixel values in the line should be near zero and they should be equal. In practice, slight variations in the performance of the pixels in the sensor will cause some variation in the pixel values output from the camera when the camera is capturing lines in darkness. Offset shading correction (also known as dark signal non-uniformity (DSNU) correction) corrects for this type of variation.

Offset shading correction works by adding an individual gray value to each pixel value in the acquired lines. The gray values used for correction are included in a "shading file", commonly also referred to as a "shading set".

In order to use offset shading correction, the user must enable offset shading correction and activate the related defaultshading file or the previously created usershading file (see below).

### 8.9.2 Gain Shading Correction

When a line scan camera with a digital sensor captures a line with the camera viewing a uniform light-colored target in bright light, all of the pixel values in the line should be near their maximum gray value and they should be equal. In practice, slight variations in the performance of the pixels in the sensor, variations in the optics, and variations in the lighting will cause some variation in the pixel values output from the camera. Gain shading correction (also known as photo response non-uniformity (PRNU) correction) corrects for this type of variation.

Gain shading correction works by applying an individual multiplier to each pixel value in the acquired lines. The multipliers used for correction are included in a "shading file", commonly also referred to as a "shading set". In order to use gain shading correction, the user must enable gain shading correction and activate the related defaultshading file or the previously created usershading file (see below).

## 8.9.3 Default Shading Set File and User Shading Set File

For each type of shading correction, two types of shading set files are available in the camera's nonvolatile memory:

- The first type of shading set file is called the "defaultshading" file. One "defaultshading" file is available for offset shading correction and another one for gain shading correction.

A "defaultshading" file contains a complete collection of the values needed to perform either offset shading or gain shading correction. The values in the files are generated during the camera's factory setup procedure and they essentially serve as default shading correction values. The values are optimized for performing shading correction with "standard" optics and lighting. Using the factory values will give you reasonable shading correction performance in most situations. One advantage of the factory values is that they serve as a good default. The "defaultshading" files are in a protected area of the camera's memory and can't be changed.

- The second type of shading set file is called the "usershading" file. One "usershading" file is available for offset shading correction and another one for gain shading correction.

Like a "defaultshading" file, a "usershading" file also holds a complete collection of the values needed to perform either offset shading or gain shading correction. The values stored in the files must, however, be generated by the camera user. When the values are generated the camera must operate under its real world conditions. The "usershading" files contain the shading correction values that will normally be used for day-to-day camera operation. A procedure describing how to generate the values in the files appears below.



"Defaultshading" files are always enabled. When "usershading" files are also enabled, they will supplement the default shading correction by modifying the default correction values.

### 8.9.3.1 Creating a "Usershading" File

To create a "usershading" file and enable it, you must take the steps listed below. Basler strongly recommends that you read through all of the steps and read all of the other information in this section before you attempt to do shading correction.

When you create a "usershading" file you must make sure to create correction values for all of the pixels in the sensor's line regardless of how you plan to use the camera during normal operation.

## Creating a "Usershading" File for Offset Shading Correction



Creating a "usershading" file for offset shading correction will overwrite any "usershading" file for offset shading correction that is already in the camera's memory.

If you want to preserve the previous "usershading" file save it to your computer before creating the new "usershading" file.

For information about saving a "usershading" file to the computer, see Section 8.9.3.2 on [page 132](#).

The generation of a "usershading" file requires a certain minimum number of line acquisitions. Higher line rates require larger numbers of line acquisitions to reach the minimum number.

When the minimum number is reached, the "usershading" file is automatically created. It is stored in the camera's non-volatile memory and is not lost if the camera power is switched off.

The Create value and the value of the Offset Shading Create register (see below) change to Off when the minimum number of line acquisitions is reached.

**Hint:** To ease acquisition of the required number of lines Basler recommends to set the line start trigger mode to Off for automatic line start triggering.

Example: At a line acquisition rate of 100 Hz or less, a new "usershading" file will generally have been generated by the time approximately 2300 line acquisitions have occurred.

### To create a "usershading" file for offset shading correction:

1. Adjust the optics, line rate, exposure time control mode, exposure time, gain, and camera temperature as you would for normal operation.
2. Make sure Exposure Auto and Gain Auto are disabled.
3. Prevent light from striking the camera's sensor: Cover the camera lens, close the iris in the camera lens, or darken the room so that the camera will be capturing lines in complete darkness.
4. Set the camera's OffsetX and Width parameters so that the entire width of the sensor will be used during line acquisition.  
Note: You can create a "usershading" file for an AOI that is narrower than the entire width of the sensor. In this case, however, the "usershading" file will only apply to the narrower AOI or to smaller included AOIs. Basler recommends using the entire width of the sensor.
5. If you use Basler pylon, select Offset Shading in the Basler pylon Viewer or via the Basler pylon API.
6. If you use Basler pylon, select the "usershading" file in the Basler pylon Viewer or via the Basler pylon API.  
If you use direct register access, set the value of the Offset Shading Set Selector register to the desired user set, e.g. User Shading Set 1.
7. If you use Basler pylon, go to the **Create** enumeration in the Basler pylon Viewer and select **Once** or send a create command via the Basler pylon API.

If you use direct register access, set the value of the Offset Shading Create register to OnePush.

8. Perform line acquisitions until the Create value changes to Off or until the Offset Shading Create register value changes to Off.

The "usershading" file is automatically created. It is stored in the camera's non-volatile memory.



Any time you make a change to the line rate, exposure time control mode, exposure time, gain, or camera temperature, you must create a new "usershading" file for offset shading correction. Using an out of date "usershading" file can result in poor image quality.

### Creating a "Usershading" File for Gain Shading Correction



Creating a "usershading" file for gain shading correction will overwrite any "usershading" file for gain shading correction that is already in the camera's memory.

If you want to preserve the previous "usershading" file save it to your computer before creating the new "usershading" file.

For information about saving a "usershading" file to the computer, see Section 8.9.3.2 on [page 132](#).

The generation of a "usershading" file requires a certain minimum number of line acquisitions. Higher line rates require larger numbers of line acquisitions to reach the minimum number.

When the minimum number is reached, the "usershading" file is automatically created. It is stored in the camera's non-volatile memory and is not lost if the camera power is switched off.

The Create value and the value of the Gain Shading Create register (see below) change to Off when the minimum number of line acquisitions is reached.

**Hint:** To ease acquisition of the required number of lines Basler recommends to set the line start trigger mode to Off for automatic line start triggering.

Example: At a line acquisition rate of 100 Hz or less, a new "usershading" file will generally have been generated by the time approximately 2300 line acquisitions have occurred.

#### To create a "usershading" file for gain shading correction:

1. Adjust the lighting, optics, line rate, exposure time control mode, exposure time, gain, and camera temperature as you would for normal operation.
2. Make sure Exposure Auto and Gain Auto are disabled.
3. Place a uniform white target in the field of view of the camera. Make sure the target covers the entire field of view.
4. Set the camera's OffsetX and Width parameters so that the entire width of the sensor lines will be used during line acquisition.

5. Perform several line acquisitions and examine the pixel values returned from the camera. The pixel values for the brightest pixels in each line should be about 90 to 95 % of maximum (i.e., if the camera is set for 8 bit output, the pixels should be from 90 to 95 % of 255).
  - a. If the values for the brightest pixels are at 90 to 95 % of maximum, go on to step 6.
  - b. If the values for the brightest pixels are not at 90 to 95 % of the maximum, adjust your lighting and/or lens aperture to achieve 90 to 95 %.
6. Perform several line acquisitions and examine the pixel values returned from the camera. In each line, the values for the darkest pixels must be greater than 1/4 of the values for the brightest pixels. (If the values for the darkest pixels are less than 1/4 of the values for the brightest, the camera will not be able to fully correct for shading variations.)
  - a. If the values for the darkest pixels are greater than 1/4 of the values for the brightest, go on to step 7.
  - b. If the values for the darkest pixels are less than 1/4 of the values for the brightest pixels, it usually indicates extreme variations in lighting or poor quality optics. Make corrections as required.
7. If you use Basler pylon, select Gain Shading in the Basler pylon Viewer or via the Basler pylon API.
8. If you use Basler pylon, select "usershading" file in the Basler pylon Viewer or via the Basler pylon API.

If you use direct register access, set the value of the Gain Shading Set Selector register to the desired user set, e.g. User Shading Set 1
9. If you use Basler pylon, go to the **Create** enumeration in the Basler pylon Viewer and select **Once** or send a create command via the Basler pylon API.

If you use direct register access, set the value of the Gain Shading Create register to OnePush
10. Perform line acquisitions until the Create value changes to Off or until the Gain Shading Create register value changes to Off.



Any time you make a change to the optics or lighting or if you change the camera's gain settings or exposure mode, you must create a new "usershading" file for gain shading correction. Using an out of date "usershading" file can result in poor image quality.

### 8.9.3.2 Working with Shading Sets Using Basler pylon

Once you have created shading set files, you can use the following pylon API functions to work with the shading sets:

**Shading Selector** - is used to select the type of shading correction to configure, i.e. offset shading correction or gain shading correction.

**Shading Create** - is used to create a "usershading" file. The enumeration allows selecting the settings Off and Once.

**Shading Enable** - is used to enable and disable the selected type of shading correction.

**Shading Set Selector** - is used to select the shading set to which the activate and the create enumeration commands will be applied.

**Shading Set Activate** - is used to activate the selected shading set. "Activate" means that the shading set will be copied from the camera's non-volatile memory into its volatile memory. When the shading correction feature is enabled, the shading set in the volatile memory will be used to perform shading correction.

**Shading Set Default Selector** - is used to select the shading set that will be loaded into the camera's volatile memory during camera bootup.

**Shading Status** - is used to determine the error status of operations such as Shading Set Activate. The following error statuses may be indicated:

No error - the last operation performed was successful.

Startup Set error - there was a problem with the default shading set.

Activate error - the selected shading set could not be loaded into the volatile memory.

Create error - an error occurred during the attempt of creating a "usershading" file.

You can use the functions listed above from within your application software by using the Basler pylon API.

You can also use the Shading parameters group in the Basler pylon Viewer application to access these functions.

And you can use the File Access selection in the Camera menu of the Viewer to save a shading set file to a computer and to upload a shading set file from the computer to the camera.

### 8.9.3.3 Working with Shading Sets Using Direct Register Access

Once you have created shading set files, you can use the following registers to work with the shading sets:

**Offset Shading Enable/Gain Shading Enable** - is used to enable and disable offset or gain shading correction.

**Offset Shading Set Selector/Gain Shading Set Selector** - is used to select the shading set to which the activate and the create commands will be applied.

**Offset Shading Create/Gain Shading Create** - is used to create a "usershading" file. The enumeration allows selecting the settings Off and OnePush.

**Offset Shading Activate/Gain Shading Activate** - is used to activate the selected shading set. "Activate" means that the shading set will be copied from the camera's non-volatile memory into its volatile memory. When the shading correction feature is enabled, the shading set in the volatile memory will be used to perform shading correction.

**Offset Shading Startup Set/Gain Shading Startup Set** - is used to select the shading set that will be loaded into the camera's volatile memory during camera bootup.

**Offset Shading Status/Gain Shading Status** - is used to determine the error status of operations such as Offset Shading Activate. The following error statuses may be indicated:

No error - the last operation performed was successful.

Startup Set error - there was a problem with the default shading set.

Activate error - the selected shading set could not be loaded into the volatile memory.

Create error - an error occurred during the attempt of creating a "usershading" file.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.10 Error Detection

### 8.10.1 LED Indicator

The LED indicator on the back of the camera includes both a small red LED and a small green LED. The LED indicator signals the camera's current condition as shown in Table 20.

LED State	Status Indication
Red and Green Both Off	No power to the camera
Continuous Green	The camera has booted up successfully and is OK.
Flashing Green	The camera is set to expect a hardware trigger signal on an input, but no trigger signal is present.
Green and Red Both Flashing Alternately	An error condition has been detected that may be correctable with user intervention. (See Section 8.10.2 on <a href="#">page 135</a> for more information).
Flashing Red	Internal error. Contact Basler technical support.

Table 20: LED Indications



During the camera bootup process, the red and the green LED will simultaneously be lit.

## 8.10.2 Error Codes

The camera can detect several user correctable errors. If one of these errors is present, the camera will set an error code and will flash alternately both the red and green LEDs in the LED indicator.

The following table indicates the available error codes:

Code	Condition	Meaning
0	No Error	The camera has not detected any errors since the last time that the error memory was cleared.
1	Overtrigger	An overtrigger has occurred. The user has applied a line start trigger to the camera when the camera was not in a waiting for line start trigger condition.
2	User Set Load	An error occurred when attempting to load a user set. Typically, this means that the user set contains an invalid value. Try loading a different user set.
3	Invalid Parameter	A parameter is set out of range or in an otherwise invalid manner. (Typically, this error only occurs when the user is setting parameters via direct register access.)
4	Over Temperature	The camera has stopped image acquisition due to overheating. Provide adequate cooling to the camera.
5	Power Failure	Power is erroneously supplied via the base Camera Link SDR connector (PoCL) to a 6k, 8k, or 12k camera. Supply power via the 6-pin connector.

Table 21: Error Codes

When the camera detects a user correctable error, it sets the appropriate error code in an error memory. If two or three different detectable errors have occurred, the camera will store the code for each type of error that it has detected (the camera will store one occurrence of each code no matter how many times it has detected the corresponding error).

You can use the following procedure to check the error codes:

- Read the value of the LastError parameter. The LastError parameter will indicate the last error code stored in the memory.
- Execute the ClearLastError command to clear the last error code from the memory.
- Continue reading and clearing the last error until the parameter indicates a No Error code.

## Reading and Clearing the Error Codes Using Basler pylon

You can use the pylon API to read the value of the LastError parameter and to execute a ClearLastError command from within your application software. The following code snippets illustrate using the API to read the parameter value and execute the command:

```
// Read the value of the last error code in the memory
LastErrorEnums lasterror = camera.LastError.GetValue();

// Clear the value of the last error code in the memory
camera.ClearLastError.Execute();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

## Reading and Clearing the Error Codes Using Direct Register Access

To get the value of the last error code in the memory via direct register access, read the value of the Last User Error register.

To clear the value of the last error code in the memory via direct register access, set the value of the Clear Last User Error register to 1.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.11 Test Images

All cameras include the ability to generate test images. Test images are used to check the camera's basic functionality and its ability to transmit an image to the host computer. Test images can be used for service purposes and for failure diagnostics.

When the camera is in test image mode, the optics and the imaging sensor are not used. The lines that make up each test image are generated internally by the camera's logic and are transmitted to the host computer line by line.



If the camera is set to use an electrical signal applied to input line CC1, CC2, CC3 or CC4 as the source signal for the line trigger, these signals must be provided to the camera in order to generate test images.

### The Effect of Camera Settings on Test Images

When any test image is active, the camera's analog features such as analog gain, black level, and exposure time have no effect on the images transmitted by the camera. For test images 1, 2, and 3, the camera's digital features, will also have no effect on the transmitted images. But for test images 4 and 5, the camera's digital features will affect the images transmitted by the camera.

Make sure to disable shading correction before generating test images.

### Enabling a Test Image Using Basler pylon

The Test Image Selector is used to set the camera to output a test image. You can set the value of the TestImageSelector parameter to one of the test images or to Off.

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

```
// set for no test image
camera.TestImageSelector.SetValue(TestImageSelector_Off);
// set for the first test image
camera.TestImageSelector.SetValue(TestImageSelector_Testimage1);
```

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 26](#).

### Enabling a Test Image Using Direct Register Access

To enable a test image via direct register access, set the value of the Test Image Selector register to Test Image 1, 2, 3, 4, or 5 as desired.

To disable test images, set the value of the Test image Selector Register to Off.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.11.1 Test Images in Detail

### Test Image 1 - Fixed Horizontal Gray Gradient (8 bit)

The 8 bit fixed horizontal gray gradient test image is best suited for use when the camera is set for monochrome 8 bit output. The test image consists of fixed horizontal gray gradients ranging from 0 to 255.

The mathematical expression for this test image is:

$$\text{Gray Value} = [\text{column number}] \text{ MOD } 256$$

### Test Image 2 - Moving Diagonal Gray Gradient (8 bit)

The 8 bit moving diagonal gray gradient test image is similar to test image 1, but it is not stationary. The image moves by one pixel from right to left whenever a new line acquisition is initiated. The test pattern uses a counter that increments by one for each new line acquisition.

The mathematical expression for this test image is:

$$\text{Gray Value} = [\text{column number} + \text{counter}] \text{ MOD } 256$$

### Test Image 3 - Moving Diagonal Gray Gradient (12 bit)

The 12 bit moving diagonal gray gradient test image is similar to test image 2, but it is a 12 bit pattern. The image moves by one pixel from right to left whenever a new line acquisition is initiated. The test pattern uses a counter that increments by one for each new line acquisition.

The mathematical expression for this test image is:

$$\text{Gray Value} = [\text{column number} + \text{counter}] \text{ MOD } 4096$$

### Test Image 4 - Moving Diagonal Gray Gradient Feature Test (8 bit)

The basic appearance of test image 4 is similar to test image 2 (the 8 bit moving diagonal gray gradient image). The difference between test image 4 and test image 2 is this: if a camera feature that involves digital processing is enabled, test image 4 **will** show the effects of the feature while test image 2 **will not**. This makes test image 4 useful for checking the effects of digital features such as digital gain.

### Test Image 5 - Moving Diagonal Gray Gradient Feature Test (12 bit)

The basic appearance of test image 5 is similar to test image 3 (the 12 bit moving diagonal gray gradient image). The difference between test image 5 and test image 3 is this: if a camera feature that involves digital processing is enabled, test image 5 **will** show the effects of the feature while test image 3 **will not**. This makes test image 5 useful for checking the effects of digital features.

## 8.12 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:

- DeviceVendorName (read only) - indicates the name of the camera's vendor. This string will always indicate Basler as the vendor.
- DeviceModelName (read only) - indicates the model name of the camera, for example, raL2048-80km.
- DeviceManufacturerInfo (read only) - can indicate some information about the camera manufacturer. This string usually indicates "none".
- DeviceVersion (read only) - indicates the device version number for the camera.
- FirmwareVersion (read only) - indicates the version of the firmware in the camera.
- DeviceID (read only) - indicates the serial number of the camera.
- DeviceUserID (read / write) - is used to assign a user defined name to a device. This name will be displayed in the Basler pylon Viewer. The name will also be visible in the "friendly name" field of the device information objects returned by pylon's device enumeration procedure.
- DeviceScanType (read only) - indicates the scan type of the camera (line scan).
- SensorWidth (read only) - indicates the physical width of the sensor in pixels. The parameter value is identical with the camera's maximum possible resolution.
- SensorHeight (read only) - indicates the physical height of the sensor in pixels.
- MaxWidth (read only) - indicates the camera's maximum possible width setting for an image AOI.
- TemperatureAbs (read only) - Indicates the current temperature of the camera's sensor board in degrees centigrade.

### Working with Device Information Parameters Using Basler pylon

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

```
// Read the Vendor Name parameter
Pylon::String_t vendorName = camera.DeviceVendorName.GetValue();

// Read the Model Name parameter
Pylon::String_t modelName = camera.DeviceModelName.GetValue();

// Read the Manufacturer Info parameter
Pylon::String_t manufacturerInfo = camera.DeviceManufacturerInfo.GetValue();

// Read the Device Version parameter
Pylon::String_t deviceVersion = camera.DeviceVersion.GetValue();
```

```
// Read the Firmware Version parameter
Pylon::String_t firmwareVersion = camera.DeviceFirmwareVersion.GetValue();

// Read the Device ID parameter
Pylon::String_t deviceID = camera.DeviceID.GetValue();

// Write and read the Device User ID
camera.DeviceUserID = "custom name";
Pylon::String_t deviceUserID = camera.DeviceUserID.GetValue();

// Read the Sensor Width parameter
int64_t sensorWidth = camera.SensorWidth.GetValue();

// Read the Sensor Height parameter
int64_t sensorHeight = camera.SensorHeight.GetValue();

// Read the Max Width parameter
int64_t maxWidth = camera.WidthMax.GetValue();

// Read the Temperature Abs parameter
camera.TemperatureSelector.SetValue(TemperatureSelector_Sensorboard);
double temperature = camera.TemperatureAbs.GetValue();
```

You can also use the Basler pylon Viewer application to easily read the parameters and to read or write the Device User ID.

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

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

## Working with Device Information Parameters Using Direct Register Access

When working with the camera via direct register access, you can do the following:

Register Name	Read the Value	Write the Value
Device Vendor Name	•	
Device Model Name	•	
Device Manufacturer Info	•	
Device Version	•	
Device Firmware Version	•	
Device ID	•	
Device User ID	•	•
Device Scan Type	•	
Sensor Width	•	
Sensor Height	•	
Width Max	•	
Height Max	•	

Table 22: Working with Registers Related to Device Information Parameters

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.13 User Defined Values

The camera can store two "user defined values". These two values are 32 bit signed integer values that you can set and read as desired. They simply serve as convenient storage locations for the camera user and have no impact on the operation of the camera.

The two values are designated as Value 1 and Value 2.

### Setting User Defined Values

Setting a user defined value using Basler pylon is a two step process:

- Set the `UserDefinedValueSelector` parameter to Value 1 or Value 2.
- Set the `UserDefinedValue` parameter to the desired value for the selected value.

You can use the pylon API to set the `UserDefinedValueSelector` and the `UserDefinedValue` parameter values from within your application software. The following code snippet illustrates using the API to set the parameter values:

```
// Set user defined value 1
camera.UserDefinedValueSelector.SetValue(UserDefinedValueSelector_Value1);
camera.UserDefinedValue.SetValue(1000);

// Set user defined value 2
camera.UserDefinedValueSelector.SetValue(UserDefinedValueSelector_Value2);
camera.UserDefinedValue.SetValue(2000);

// Get the value of user defined value 1
camera.UserDefinedValueSelector.SetValue(UserDefinedValueSelector_Value1);
int64_t UserValue1 = camera.UserDefinedValue.GetValue();
```

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 3.1.1 on [page 27](#).

#### To set the user defined values via direct register access:

- Set the value of the User Defined Value 1 register or the User Defined Value 2 register as desired.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.14 Configuration Sets

A configuration set is a group of values that contains all of the parameter settings needed to control the camera. There are three basic types of configuration sets: the active configuration set, the default configuration set, and user configuration sets.

### Active Configuration Set

The active configuration set contains the camera's current parameter settings and thus determines the camera's performance, that is, what your image currently looks like. When you change parameter settings using the pylon API or the pylon Viewer, you are making changes to the active configuration set.

The active configuration set is located in the camera's volatile memory and the settings are lost if the camera is reset or if power is switched off. The active configuration set is usually called the "active set" for short.

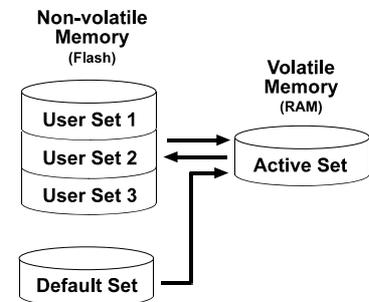


Fig. 39: Configuration Sets

### Default Configuration Set

When a camera is manufactured, a test setup is performed on the camera and an optimized configuration is determined. The default configuration set contains the camera's factory optimized configuration. The default configuration set is saved in a permanent file in the camera's non-volatile memory. It is not lost when the camera is reset or switched off and it cannot be changed. The default configuration set is usually just called the "default set" for short.

### User Configuration Sets

As mentioned above, the active configuration set is stored in the camera's volatile memory and the settings are lost if the camera is reset or if power is switched off. The camera can save most of the settings from the current active set to a reserved area in the camera's non-volatile memory. A configuration set saved in the non-volatile memory is not lost when the camera is reset or switched off. There are three reserved areas in the camera's non-volatile memory available for saving configuration sets. A configuration set saved in a reserved area is commonly referred to as a "user configuration set" or "user set" for short.

The three available user sets are called User Set 1, User Set 2, and User Set 3.



The settings for the luminance lookup table are not saved in the user sets and are lost when the camera is reset or switched off. If used, these settings must be set again after each camera reset or restart.

## Default Startup Set

You can select the default configuration set or one of the user configuration sets stored in the camera's non-volatile memory to be the "default startup set." The configuration set that you designate as the default startup set will be loaded into the active set whenever the camera starts up at power on or after a reset. Instructions for selecting the default startup set appear in Section 8.14.3 on [page 146](#).

## 8.14.1 Saving Configuration Sets

Saving the current active set into a user set in the camera's non-volatile memory is a three step process:

- Make changes to the camera's settings until the camera is operating in a manner that you would like to save.
- Set the UserSetSelector parameter to UserSet1, UserSet2, or UserSet3.
- Execute a UserSetSave command to save the active set to the selected user set.

Saving an active set to a user set in the camera's non-volatile memory will overwrite any parameters that were previously saved in that user set.

You can set the UserSetSelector parameter and execute the UserSetSave command from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter and execute the command:

```
camera.UserSetSelector.SetValue(UserSetSelector_UserSet1);  
camera.UserSetSave.Execute();
```

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

### **To save the current active set to a user set in the camera's non-volatile memory via direct register access:**

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 value of the User Set Selector register to User Set 1, 2, or 3 as desired.
3. Set the value of the User Set Save register to 1.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.14.2 Loading a Saved Set or the Default Set into the Active Set

If you have saved a configuration set into the camera's non-volatile memory, you can load the saved set from the camera's non-volatile memory into the camera's active set. When you do this, the loaded set overwrites the parameters in the active set. Since the settings in the active set control the current operation of the camera, the settings from the loaded set will now be controlling the camera.

You can also load the default set into the camera's active set.

### To load a saved configuration set or the default set from the camera's non-volatile memory into the active set using Basler pylon:

1. Set the `UserSetSelector` parameter to `UserSet1`, `UserSet2`, `UserSet3`, or `Default`.
2. Execute a `UserSetLoad` command to load the selected set into the active set.

You can set the `UserSetSelector` parameter and execute the `UserSetLoad` command from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter and execute the command:

```
camera.UserSetSelector.SetValue(UserSetSelector_UserSet2);  
camera.UserSetLoad.Execute();
```



Loading a user set or the default set into the active set is only allowed when the camera is idle, i.e. when it is not acquiring lines.

Loading the default set into the active set is a good course of action if you have grossly misadjusted the settings in the camera and you are not sure how to recover. The default settings are optimized for use in typical situations and will provide good camera performance in most cases.

### To load a saved user set or the default set from the camera's non-volatile memory into the active set via direct register access:

1. Set the value of the User Set Selector register to User Set 1, 2, or 3, or to the Default set as desired.
2. Set the value of the User Set Load register to 1.

For more information about direct register access, see Section 3.2 on [page 28](#).

## 8.14.3 Selecting the Default Startup Set

You can select the default configuration set or one of the user configuration sets stored in the camera's non-volatile memory to be the "default startup set". The configuration set that you designate as the default startup set will be loaded into the active set whenever the camera starts up at power on or after a reset.

The `UserSetDefaultSelector` parameter is used to select the default startup set:

- Set the `UserSetDefaultSelector` parameter to `UserSet1`, `UserSet2`, `UserSet3`, or `Default`.

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

```
// Designate user set 1 as the startup set
camera.UserSetDefaultSelector.SetValue(UserSetDefaultSelector_UserSet1);

// Designate the default set as the startup set
camera.UserSetDefaultSelector.SetValue(UserSetDefaultSelector_Default);
```

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 26](#).

### To select the Default Startup Set via direct register access:

- Set the value of the User Set Default Selector register for User Set 1, User Set 2, User Set 3, or Default as desired.

For more information about direct register access, see Section 3.2 on [page 28](#).

# 9 Troubleshooting and Support

This chapter explains camera reset and outlines the resources available to you if you need help working with your camera.

## 9.1 Camera Reset

Some situations may require a camera reset. It is executed using the DeviceReset command parameter via the pylon API and is therefore also referred to as a "software reset".

During camera reset, camera power stays on. This is in contrast to camera restart where camera power is switched off and on again.

From the perspective of the Basler pylon software and the operating system, camera reset and camera restart both appear as a "surprise device removal" and must be handled accordingly.



When camera reset is carried out, all settings stored in the camera's volatile memory are lost.

If you want to preserve settings stored in the camera's volatile memory, save them as a user set before carrying out camera reset. Note that some settings can not be saved in a user set, for example the settings for the luminance lookup table.

### Resetting the camera

After having issued the camera reset command perform the subsequently necessary steps, e.g. some cleanup on the computer, in accord with the DeviceRemovalHandling sample code that is included in the pylon SDK documentation.

After camera reset was carried out, allow some time to elapse until the camera is detected again.

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 26](#).

## 9.2 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 Downloads and the Support sections of the Basler website: [www.baslerweb.com](http://www.baslerweb.com)

If you do decide to contact Basler technical support, please take a look at the form that appears on the last two pages of this section before you call. Filling out this form will help make sure that you have all of the information the Basler technical support team needs to help you with your problem.

## 9.3 Obtaining an RMA Number

Whenever you want to return material to Basler, you must request a Return Material Authorization (RMA) number before sending it back. The RMA number **must** be stated in your delivery documents when you ship your material to us! Please be aware that if you return material without an RMA number, we reserve the right to reject the material.

You can find detailed information about how to obtain an RMA number in the Support section of the Basler website: [www.baslerweb.com](http://www.baslerweb.com)

## 9.4 Before Contacting Basler Technical Support

To help you as quickly and efficiently as possible when you have a problem with a Basler camera, it is important that you collect several pieces of information before you contact Basler technical support.

Copy the form that appears on the next two pages, fill it out, and fax the pages to your local dealer or to your nearest Basler support center. Or, you can send an e-mail listing the requested pieces of information and with the requested files attached. Basler technical support contact information is shown in the title section of this manual.

- 1 The camera's product ID: \_\_\_\_\_
- 2 The camera's serial number: \_\_\_\_\_
- 3 Frame grabber that you use with the camera: \_\_\_\_\_  
\_\_\_\_\_
- 4 Describe the problem in as much detail as possible:  
(If you need more space, use an extra sheet of paper.) \_\_\_\_\_  
\_\_\_\_\_
- 5 If known, what's the cause of the problem? \_\_\_\_\_  
\_\_\_\_\_
- 6 When did the problem occur?  After start.  While running.  
 After a certain action (e.g., a change of parameters): \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- 7 How often did/does the problem occur?  Once.  Every time.  
 Regularly when:  
\_\_\_\_\_  
 Occasionally when:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- 8 How severe is the problem?  Camera can still be used.  
 Camera can be used after I take this action:  
\_\_\_\_\_  
\_\_\_\_\_  
 Camera can no longer be used.

- 9 Did your application ever run without problems?  Yes  No

10 Parameter set

It is very important for Basler technical support to get a copy of the exact camera parameters that you were using when the problem occurred.

To make note of the parameters, use the Basler pylon Viewer.

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

- Frame Size: \_\_\_\_\_  
 Pixel Format: \_\_\_\_\_  
 Exposure Time: \_\_\_\_\_  
 Line rate: \_\_\_\_\_

11 Live image/test image

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

## Revision History

Doc. ID Number	Date	Changes
AW00118501000	13 Jun 2012	Preliminary release of this document. Applies to prototype cameras only.
AW00118502000	01 Feb 2013	Second preliminary release of this document for prototype cameras.
AW00118503000	25 Jun 2013	First release of this document for series cameras.
AW00118504000	13 Sep 2013	<p>Updated the contact information for Asia.</p> <p>Added bit depth to Fig. 1 in Section 1.3 on page 8.</p> <p>Added dimension values to Fig. 2 in Section 1.4.1 on page 9.</p> <p>Modified dimension values in Fig. 4 on page 12 and Fig. 5 on page 12.</p> <p>Updated the LZ4 licensing text in Section 1.5.2 on page 17.</p> <p>Replaced the reference to a racer Camera Link-specific installation and setup guide by a reference to document AW000611 in Section 2 on page 24 and Section 3 on page 25.</p> <p>Included a reference to the racer-specific document about register structure and access methods (AW001270) in Section 3.2 on page 27.</p>
AW00118505000	01 Oct 2015	<p>Minor corrections and modifications throughout the manual.</p> <p>Updated the contact information on the back of the front page.</p> <p>Corrected subpart J to subpart B in the FCC section at the back of the front page.</p> <p>Added references to CE Conformity Declaration in Section 1.2 on page 2.</p> <p>Updated the dimensions of the F-mount lens adapter in Section 1.2 on page 2 and Section 1.4.3 on page 12.</p> <p>Added environmental requirements according to UL 60950-1 in Section 1.7.1 on page 19.</p> <p>Changed maximum housing temperature during operation from 50 °C to 60 °C in Section 1.7.1 on page 19 and Section 1.7.2 on page 19.</p> <p>Added precautions related to SELV and LPS in Section 1.8 on page 21.</p> <p>Updated Section 3.1 on page 25 to reflect software update to Basler pylon Camera Software Suite.</p> <p>Updated the power cable drawing in Section 5.4.1 on page 37.</p> <p>Added information about "low level" code and the Instant Camera classes in Chapter 6 on page 55.</p> <p>Added information about the AcquisitionLineRateAbs parameter in Section 6.1.1 on page 55.</p>
AW00118506000	08 Sep 2016	<p>Added the M42-mount FBD 45.46 and M58-mount adapters to the specification tables in Section 1.2 on page 2, to the lens adapter drawings in Section 1.5.3 on page 13, and to the table in Section 1.5.4 on page 16.</p> <p>Added Section 1.3 on page 8 ("Accessories").</p> <p>Added the ExposureOverlapTimeMaxAbs and the TargetGrayValue parameters to the list of parameters whose limits can be removed in Section 8.3 on page 106.</p> <p>Added the Auto Functions feature in Section 8.5 on page 110.</p>

Doc. ID Number	Date	Changes
AW00118507000	27 Jul 2017	<p>Modified wording for the warranty information and moved warranty information to the beginning of the document.</p> <p>Replaced "external trigger" by "hardware trigger" throughout the manual.</p> <p>Changed "Max Power Consumption" to "Power Consumption (typical)" in Section 1.4 on <a href="#">page 3</a>.</p> <p>Indicated the inclusion of RoHS conformity with CE conformity and added REACH conformity in Section 1.4 on <a href="#">page 3</a>.</p> <p>Added the precaution not to apply compressed air in Section 1.12 on <a href="#">page 23</a>.</p> <p>Added introductory text to Chapter 3 on <a href="#">page 26</a>.</p> <p>Added Linux support for the pylon SDK for C in Section 3.1.2 on <a href="#">page 27</a>.</p> <p>Removed the "Connector Types" section from Chapter 5 and transferred contents to Section 5.1 on <a href="#">page 32</a>.</p> <p>Removed wiring information from Section 5.3.1 on <a href="#">page 38</a> and modified Fig. 13 for grounding information.</p> <p>Expanded explanations related to ExposureOverlapTimeMaxAbs in Section 6.3.3 on <a href="#">page 82</a>.</p>
AW00118508000	29 April 2019	<p>Removed reference to warranty.</p> <p>Added the sections "Intended Use" on <a href="#">page 1</a>, "Authorized Users" on <a href="#">page 2</a>, and "Mechanical Stress Test Results" on <a href="#">page 18</a>.</p> <p>Added effective sensor diagonals in Section 1.4 on <a href="#">page 3</a>.</p> <p>Removed software licensing information about LWIP TCP/IP licensing in Section 1.9 on <a href="#">page 19</a>.</p> <p>Replaced reference to further documents in Section 3.1 on <a href="#">page 26</a>.</p> <p>Corrected Section 8.5.3 on <a href="#">page 112</a> to take account of (height of image AOI) = const. = 1</p> <p>Creation of user shading files in Section 8.9.3.1 on <a href="#">page 128</a>:</p> <p>Added indication for reaching a sufficient number of acquisitions. Added instructions for disabling auto functions when creating usershading files.</p> <p>Minor changes throughout the manual.</p>

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