

# Basler pulse



## **USER'S MANUAL FOR USB 3.0 CAMERAS**

Document Number: AW001345

Version: 04 Language: 000 (English)

Release Date: 07 September 2016

### **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 USB 3.0 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.

### **Life support applications**

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

## **Warranty Information**

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

### **Do not remove the camera's serial number label**

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

### **Do not open the camera housing**

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

### **Prevent ingress or insertion of foreign substances into the camera housing**

Prevent liquid, flammable, or metallic substances from entering the camera housing. If operated with any foreign substances inside, the camera may fail or cause a fire.

### **Avoid electromagnetic fields**

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

### **Transport in original packaging**

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

### **Clean with care**

Follow the cleaning instructions in Section 1.8 on [page 22](#).

### **Read the manual**

Read the manual carefully before using the camera!

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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. We strongly recommend that you read and follow the precautions.

## 1.1 Models

The current Basler pulse USB 3.0 camera models are listed in the top row of the specification tables on the next pages of this manual. The camera models are differentiated by their resolution, their maximum frame rate at full resolution, and whether the camera's sensor is mono or color.

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



## 1.2 General Specifications

Specification	puA1280-54um/uc	puA1600-60um/uc
Resolution (H x V pixels)	1280 x 960	1600 x 1200
Sensor Type	Aptina AR0134 Progressive scan CMOS Global shutter	e2v EV76C570 Progressive scan CMOS Global shutter
Optical Size	1/3"	1/1.8"
Effective Sensor Diagonal	6 mm	9 mm
Pixel Size (H x V)	3.75 $\mu\text{m}$ x 3.75 $\mu\text{m}$	4.5 $\mu\text{m}$ x 4.5 $\mu\text{m}$
Max. Frame Rate (at full resolution)	54 fps	60 fps
Mono/Color	Mono or color (color cameras include a Bayer pattern RGB filter on the sensor)	
Data Output Type	USB 3.0, nominal max. 5 Gbit/s (SuperSpeed)	
Pixel Formats	Mono models: Mono 8 Mono 12  Color models: Bayer 8RGB 8 Bayer 12YCbCr422	Mono models: Mono 8 Mono 12 (*)  Color models: Bayer 8 Bayer 12 (*) RGB 8 YCbCr422  (*) 12-bit image data based on 10-bit sensor data. See Section 6.1 on <a href="#">page 47</a> .
Synchronization	Via software trigger or free run	
Exposure Time Control	Programmable via the camera API	
Camera Power Requirements	Nominal +5 VDC, compliant with the Universal Serial Bus 3.0 specification, supplied via the camera's USB 3.0 port	
	$\approx 1.3$ W (typical) @ 5 VDC	
Lens Mount	CS-mount	
Size (D x L)	38.8 mm x 28.2 mm	
Weight	< 60 g	

Table 1: General Specifications (puA1280-54um/uc, puA1600-60um/uc)

---

Specification	puA1280-54um/uc	puA1600-60um/uc
Conformity	CE, UL, GenICam 2.4 (including PFNC 1.1 and SFNC 2.1), RoHS, USB3 Vision 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 4.2.2 or higher) Available for Windows (x86, x64) and Linux (x86, x64, ARM).	

Table 1: General Specifications (puA1280-54um/uc, puA1600-60um/uc)

Specification	puA1920-30um/uc	puA2500-14um/uc
Resolution (H x V pixels)	1920 x 1080	2592 x 1944
Sensor Type	Aptina MT9P031 Progressive scan CMOS Rolling shutter	
Optical Size	1/3.7"	1/2.5"
Effective Sensor Diagonal	4.85 mm	7.13 mm
Pixel Size (H x V)	2.2 µm x 2.2 µm	
Max. Frame Rate (at full resolution)	30 fps	14 fps
Mono/Color	Mono or color (color cameras include a Bayer pattern RGB filter on the sensor)	
Data Output Type	USB 3.0, nominal max. 5 Gbit/s (SuperSpeed)	
Pixel Formats	Mono models: Mono 8 Mono 12  Color models: Bayer 8 Bayer 12 RGB 8 YCbCr422	
Synchronization	Via software trigger or free run	
Exposure Time Control	Programmable via the camera API	
Camera Power Requirements	Nominal +5 VDC, compliant with the Universal Serial Bus 3.0 specification, supplied via the camera's USB 3.0 port  ≈ 1.3 W (typical) @ 5 VDC	
Lens Mount	CS-mount	
Size (D x L)	38.8 mm x 28.2 mm	
Weight	< 60 g	
Conformity	CE, UL, GenICam 2.4 (including PFNC 1.1 and SFNC 2.1), RoHS, USB3 Vision 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 4.2.2 or higher) Available for Windows (x86, x64) and Linux (x86, x64, ARM).	

Table 2: General Specifications (puA1920-30um/uc, puA2500-14um/uc)

## 1.3 Spectral Response

### 1.3.1 Mono Camera Spectral Response

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



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

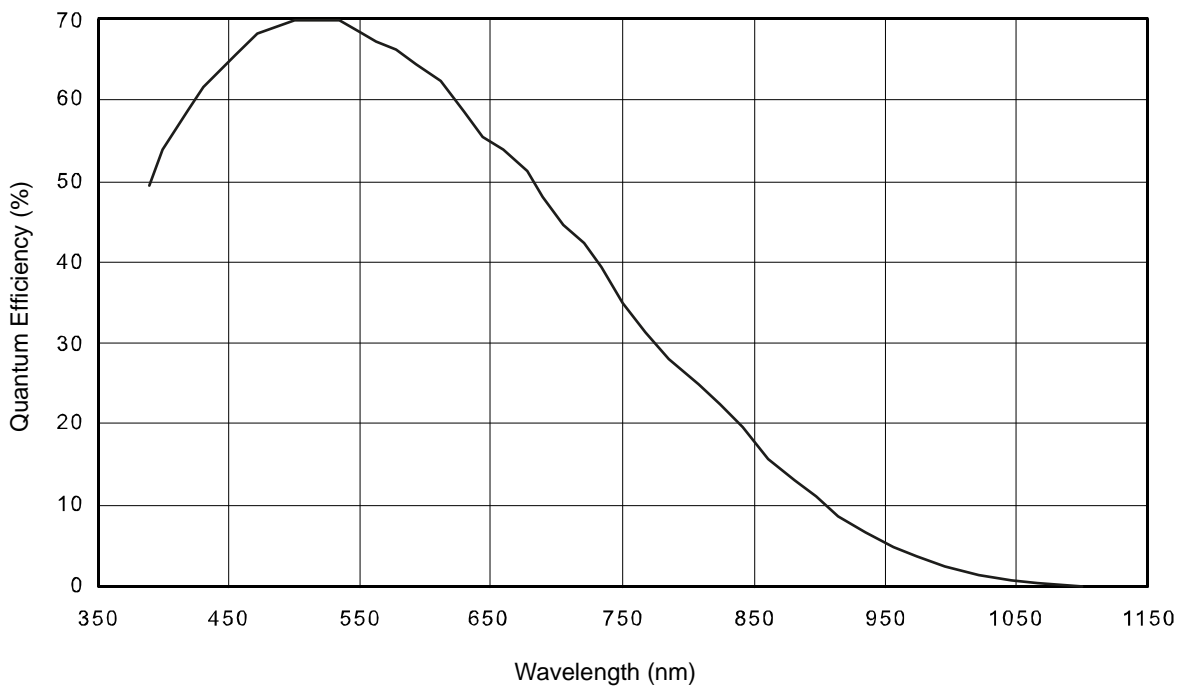


Fig. 1: puA1280-54um Spectral Response (From Sensor Data Sheet)

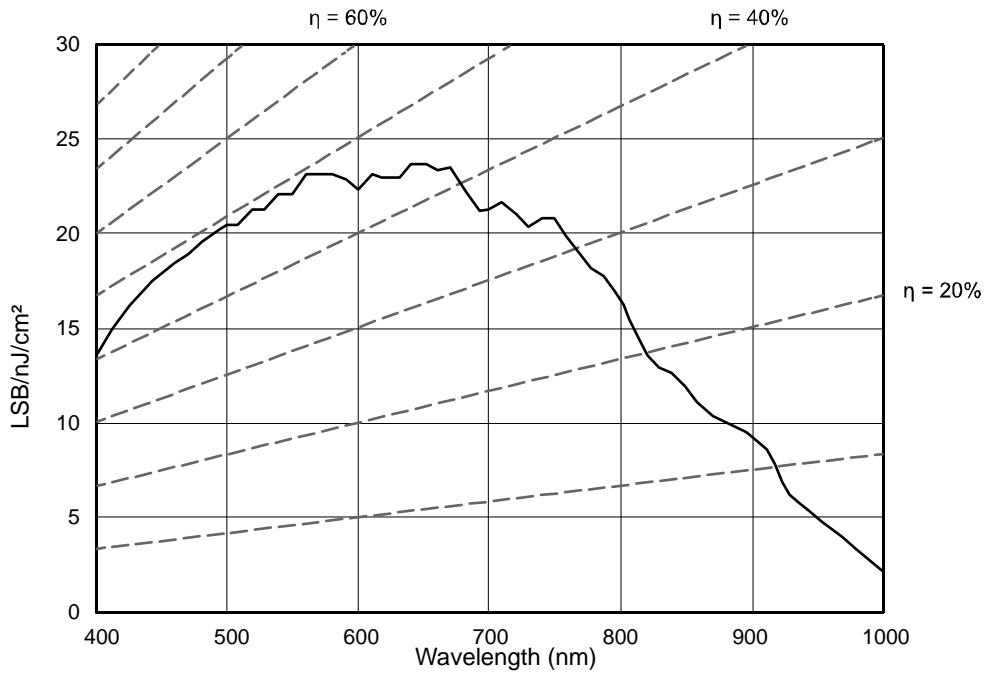


Fig. 2: puA1600-60um Spectral Response (From Sensor Data Sheet)

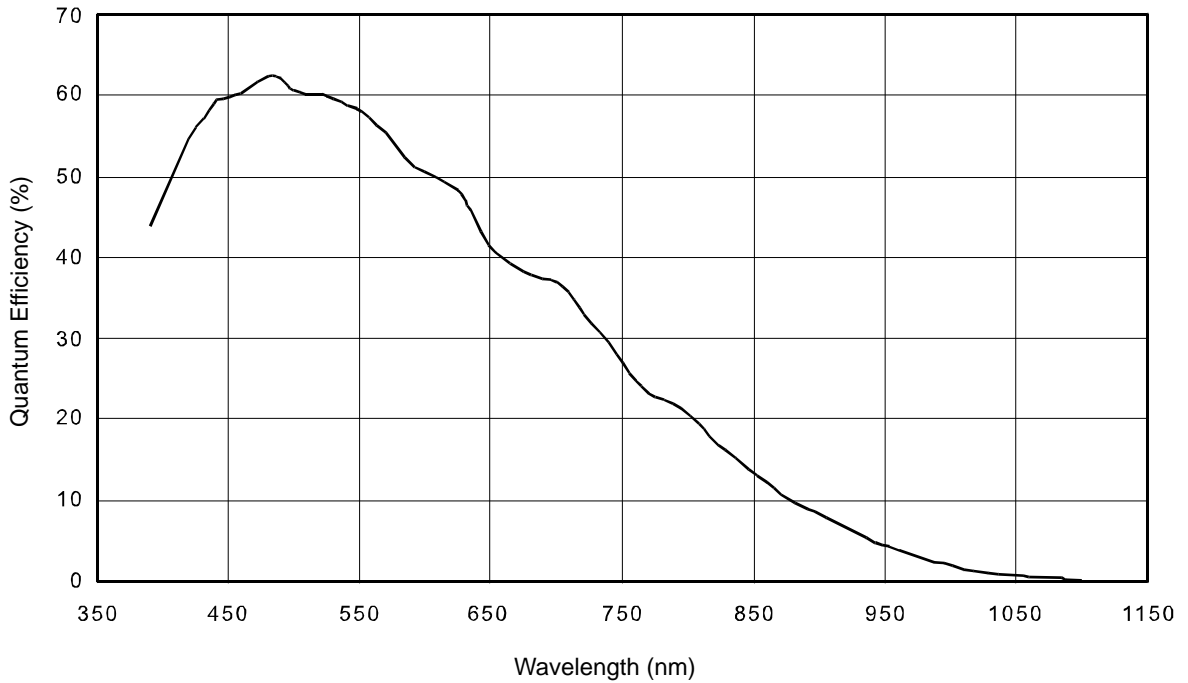



Fig. 3: puA1920-30um and puA2500-14um Spectral Response (From Sensor Data Sheet)

### 1.3.2 Color Camera Spectral Response

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

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

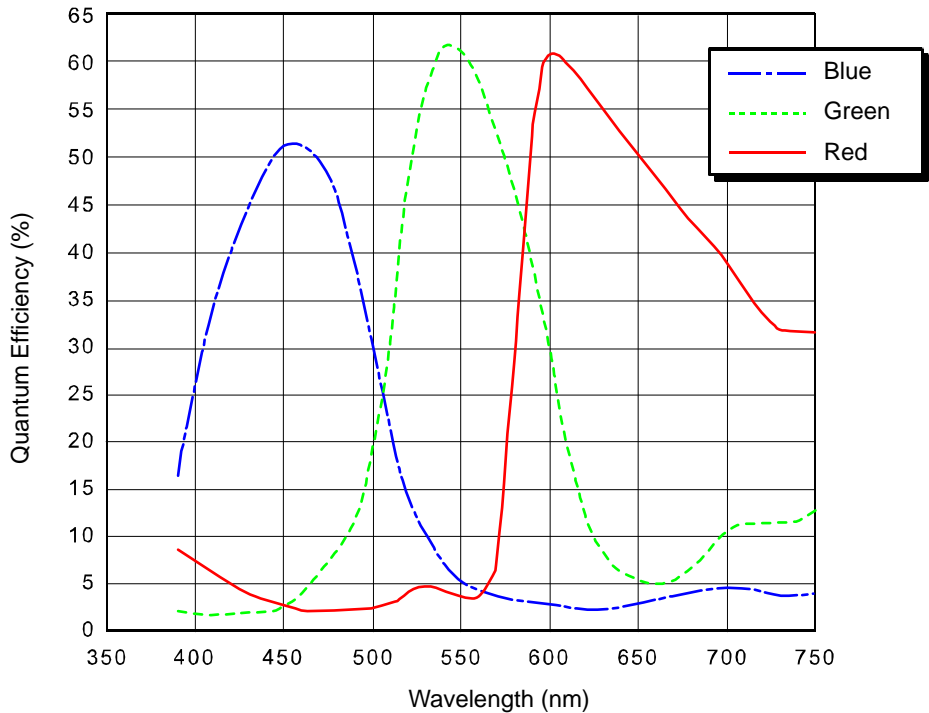


Fig. 4: puA1280-54uc Spectral Response (From Sensor Data Sheet)

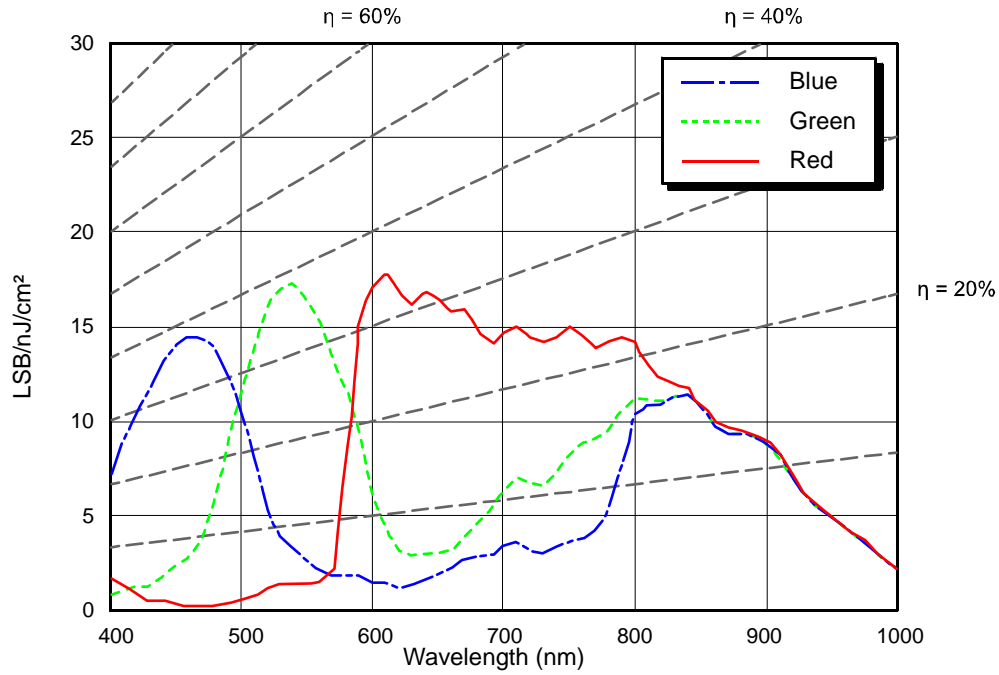


Fig. 5: puA1600-60um Spectral Response (From Sensor Data Sheet)

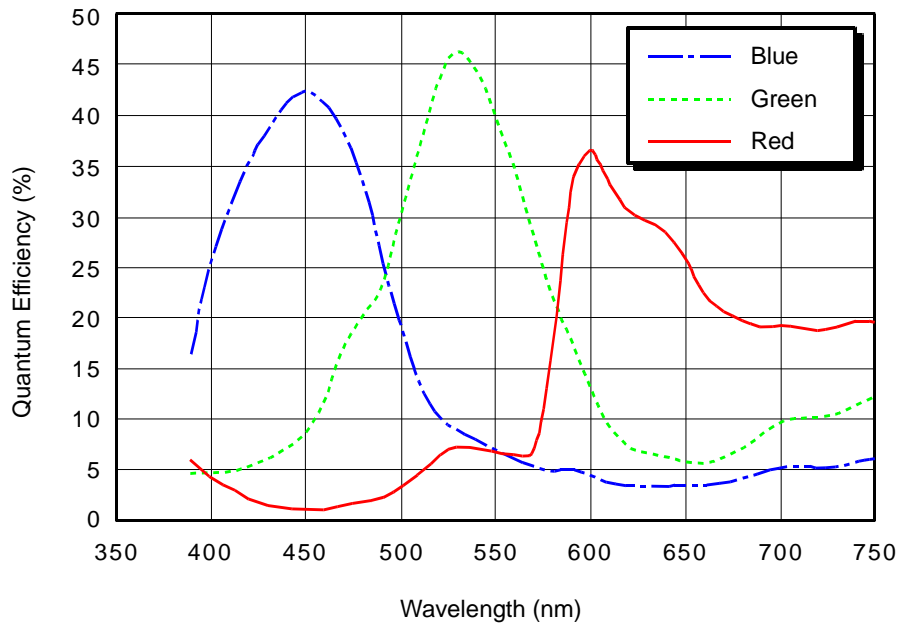


Fig. 6: puA1920-15uc, puA1920-30uc, and puA2500-14uc Spectral Response (From Sensor Data Sheet)

# 1.4 Mechanical Specifications

## 1.4.1 Camera Dimensions and Mounting Points

The dimensions in millimeters for pulse cameras are as shown in Figure 7.

All pulse cameras are equipped with a tripod socket on the bottom as shown in the drawings. For more information about the tripod socket, see Section 4.4 on [page 29](#).

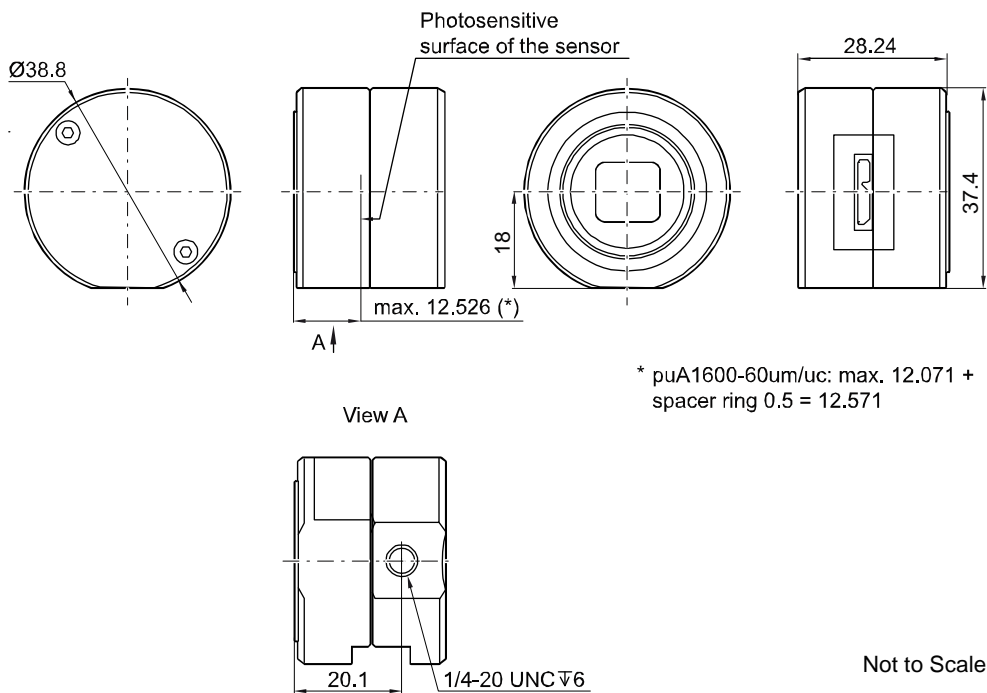


Fig. 7: Mechanical Dimensions (in mm) for pulse Cameras



## 1.4.2 Maximum Lens Dimensions

When mounting a lens on the pulse camera, observe the following:

- The lens must not intrude into the camera body more than the values given below.

Camera Model	Maximum Allowed Lens Intrusion (in mm)
puA1280-54um puA1920-30um puA2500-14um	11
puA1600-60um	10
puA1280-54uc puA1600-60uc puA1920-30uc puA2500-14uc	7

Table 3: Maximum Allowed Lens Intrusion for pulse Camera Models

- The length of the threads on the CS-mount lens adapter is 5.6 mm.
- The puA1600-60um/uc cameras are shipped with a 0.5 mm spacer ring. The spacer ring optimizes the flange focal distance of these cameras. When mounting a lens on the camera, attach the spacer ring to the lens.

The maximum lens dimensions are also shown in Fig. 8 on [page 17](#).

If the lens intrudes too deep into the camera, the IR cut filter (color cameras) or the circuit board (mono cameras) may be damaged or destroyed and the camera will no longer operate properly.

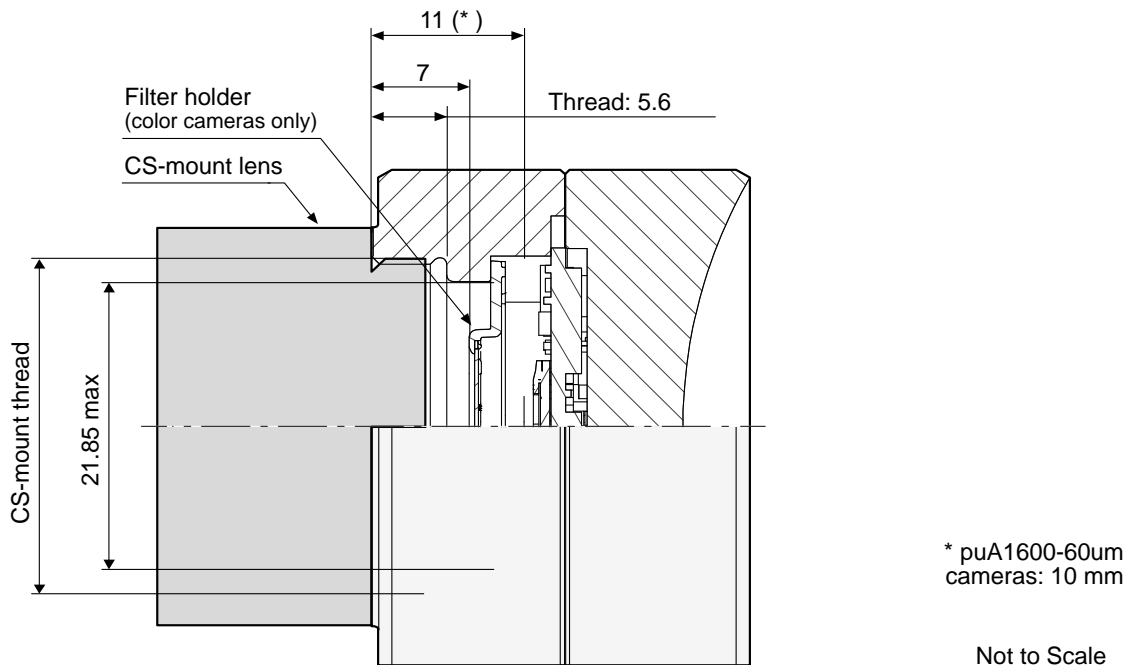


Fig. 8: Maximum Lens Dimensions (in mm) for pulse Cameras

### 1.4.3 Mechanical Stress Test Results

Cameras were subjected to the stress tests listed in Table 4. After mechanical testing, the cameras exhibited no detectable physical damage and produced normal images during standard operational testing.

Test	Standard	Conditions
Vibration (sinusoidal, each axis)	DIN EN 60068-2-6	10-58 Hz / 1.5 mm_58-500 Hz / 20 g_1 Octave/Minute 10 repetitions
Shock (each axis)	DIN EN 60068-2-27	20 g / 11 ms / 10 shocks positive 20 g / 11 ms / 10 shocks negative
Bump (each axis)	DIN EN 60068-2-27	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 4: Mechanical Stress Tests for pulse Cameras

The mechanical stress tests were performed with a dummy lens attached. The dummy lens had a mass of 66 g.

Using a heavier lens requires an additional support for the lens.

## 1.5 Avoiding EMI and ESD Problems

Excessive electromagnetic interference (EMI) and electrostatic discharge (ESD) can cause problems with your camera or can cause the camera to suddenly stop capturing images. EMI and ESD can also have a negative impact on the quality of the image data transmitted by the camera.

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

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



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

## 1.6 Environmental Requirements

### 1.6.1 Temperature and Humidity

Category	Requirements
Housing temperature during <b>operation</b>	0 °C ... +50 °C (+32 °F ... +122 °F)
Housing temperature during <b>storage</b>	-20 °C ... +80 °C (-4 °F ... +176 °F)
Humidity	20% ... 80%, relative, non-condensing
Housing temperature according to UL 60950-1	max. 70 °C (+158 °F)
Ambient temperature according to UL 60950-1	max. 30 °C (+86 °F)
UL 60950-1 test conditions: no lens attached to the camera and without efficient heat dissipation; ambient temperature kept at 30 °C (+86 °F).	

Table 5: Temperature and Humidity Requirements

If the camera is attached to a metallic component (e.g. a suitable lens or mounting plate), the camera can be operated at higher ambient temperatures. However, always make sure that the operation temperature of the camera does not exceed the maximum specified value indicated above.

Keep in mind that the camera will gradually become warmer during the first hour of operation. After one hour, the housing temperature should stabilize and no longer increase.



To ensure good image quality, we recommend not to operate the camera at elevated temperatures.

## 1.7 USB 2.0 Compatibility

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

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



If you operate a **puA1280-54um** or a **puA1280-54uc** camera on a USB 2.0 port, image noise may be increased. This is because the frame rate of the camera is usually lower when operated on a USB 2.0 port, and the image sensor of the puA1280-54um/uc produces more image noise at low frame rates.

To reduce image noise at low frame rates:

- Use a software trigger to control image acquisition. For more information about using a software trigger, see Section 5.2.1.2 on [page 34](#).
- Set the `OverlapMode` parameter to `Off`. This puts the sensor in the "non-overlap" mode of operation with lower image noise at low frame rates. For more information, see Section 5.5.2 on [page 44](#).

## 1.8 Precautions



### **DANGER**

#### **Electric Shock Hazard**

Unapproved power supplies may cause electric shock. Serious injury or death may occur.

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



### **WARNING**

#### **Fire Hazard**

Unapproved power supplies may cause fire and burns.

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

### **NOTICE**

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

The camera is shipped with a protective seal on the lens mount. To avoid collecting dust on the camera's IR cut filter (color cameras) or sensor (mono cameras), make sure to observe the following:

- Always put the protective seal in place when there is no lens mounted on the camera.
- Make sure that the camera is pointing down every time you remove or replace the protective seal or a lens.
- If the camera is not installed, store it in its original packaging.

### **NOTICE**

#### **An incorrect plug can damage the connector.**

The plug on the cable that you attach to the camera's USB 3.0 Micro-B connector must be designed for use with the USB 3.0 Micro-B connector.

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

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

- Make sure that the lens does not reach too far into the camera body. Otherwise, the IR cut filter (color cameras) or the sensor (mono cameras) can be damaged. For more information about the maximum lens dimensions, see Section 1.4.2 on [page 17](#).
- If you want to use C-mount lenses, make sure that you attach a CS-mount adapter ring to the C-mount lens before mounting it on the camera. Otherwise, the lens may reach too far into the camera and damage camera components.

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

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

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

- Before cleaning, disconnect the camera from camera power by removing the USB 3.0 cable.
- After the cleaning procedure, make sure the cleaning material has evaporated before you reconnect the plugs.
- For pulse **mono** cameras:
  - Avoid cleaning the surface of the camera's sensor.  
If you must clean it, use a soft, lint-free cloth dampened with a small quantity isopropanol.
  - Use a cloth that will not generate static charge during cleaning (cotton is a good choice).  
Electrostatic discharge might damage the sensor.
- For pulse **color** cameras:
  - Try not to touch the IR cut filter and do not clean the IR cut filter mechanically. The glass of the IR cut filter can break if you apply too much pressure.
  - Use clean, oil-free compressed air to clean the IR cut filter. Be careful not to apply too much air pressure.
- To clean the surface of the camera housing, use a soft, dry cloth. To remove severe stains, use a soft cloth dampened with a small quantity of neutral detergent, then wipe dry.
- Do not use solvents or thinners to clean the housing. They can damage the surface finish.

## 2 Installation

The information you will need to install 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 Basler website: [www.baslerweb.com](http://www.baslerweb.com).



# 3 Tools for Changing Camera Parameters

## 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.
- obtain information about the USB camera device and other USB devices connected to your computer by using the Basler pylon USB Configurator.

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

The pulse cameras require the Basler pylon Camera Software Suite 4.2.2 or a higher version. You can obtain the Basler pylon Camera Software Suite from the Basler website: [www.baslerweb.com](http://www.baslerweb.com).

To help you install the software, you can also download the *Installation and Setup Guide for Cameras Used with Basler pylon for Windows* (AW000611) from the Basler website.

### 3.1.1 pylon Viewer

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

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

## 3.1.2 pylon USB Configurator

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

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

For more information about generating support information, see Section 8.3 on [page 97](#).

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

## 3.1.3 pylon SDKs

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

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

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

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

# 4 Physical Interface

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



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

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

## 4.1 USB 3.0 Connector



Micro-B  
USB 3.0 connector

Fig. 9: Camera USB 3.0 Connector

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

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


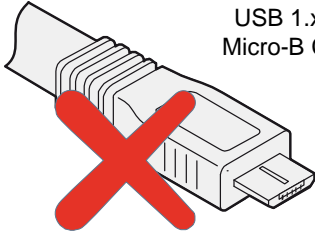
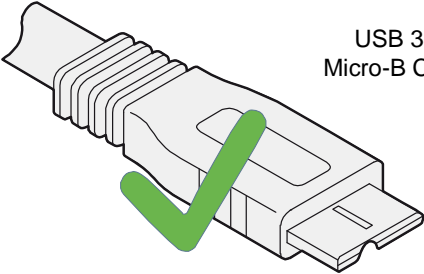
Suitable cables are available from Basler. For more information, see Section 4.2 on [page 28](#).

## 4.2 USB 3.0 Cabling Requirements

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

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

To avoid EMI, the cable must be shielded, as specified by the USB 3.0 standard. Close proximity to strong high-frequency electromagnetic fields should be avoided.

	 <p data-bbox="571 653 727 709">USB 1.x/2.0 Micro-B Cable</p>	 <p data-bbox="1098 653 1254 709">USB 3.0 Micro-B Cable</p>
	<p data-bbox="347 940 1062 972">Do not use cables with a USB 1.x/2.0 Micro-B cable plug.</p> <p data-bbox="347 989 1337 1087">Use high-quality cables with a USB 3.0 Micro-B cable plug, even if you are connecting the camera to a USB 2.0 port. The camera may not work properly if you use a USB 1.x/2.0 Micro-B cable plug.</p>	

## 4.3 Camera Power

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

### NOTICE

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

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

Power consumption is as shown in the specification tables in [Section 1.2 on page 9](#).

## 4.4 Tripod Socket

All pulse cameras are equipped with a tripod socket to attach the camera to a tripod. The socket has a standard 1/4-20 UNC thread.

The tripod socket is located at the bottom of the camera as shown in Figure 10.

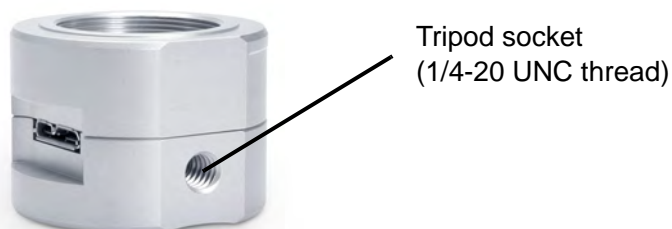


Fig. 10: Camera Tripod Socket

## 4.5 IR Cut Filter

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

The filter on pulse color cameras has the following spectral characteristics:

Wavelength (nm)	Transmittance
420 – 600	$T_{\min} \geq 90\%$ $T_{\text{avg}} \geq 92\%$
$650 \pm 10$	$T = 50\%$
700 – 1000	$T_{\text{avg}} \leq 1\%$
1000 – 1100	$T_{\text{avg}} \leq 5\%$

Table 6: IR Cut Filter Spectral Characteristics

### NOTICE

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

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

For more information about the location of the IR cut filter in the camera, see Section 1.4.2 on [page 17](#).

# 5 Image Acquisition Control



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

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

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

## 5.1 Acquisition Start and Stop Commands and the Acquisition Mode

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

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

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

The camera's **AcquisitionMode parameter** has two settings: single frame and continuous. The use of AcquisitionStart and AcquisitionStop commands and the camera's AcquisitionMode parameter setting are related.

If the camera's AcquisitionMode parameter

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



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

For more information about overlapped image acquisitions, see Section 5.5 on [page 42](#).

## Setting the Acquisition Mode and Issuing Start/Stop Commands

The code snippet below illustrates using the API to set the `AcquisitionMode` parameter value and to execute an `AcquisitionStart` command:

```
camera.AcquisitionMode.SetValue(AcquisitionMode_SingleFrame);  
camera.AcquisitionStart.Execute();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 5.2 The Frame Start Trigger

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

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

- The `AcquisitionMode` parameter must be set correctly.
- A proper `AcquisitionStart` command must be applied to the camera.

For more information about the `AcquisitionMode` parameter and about `AcquisitionStart` and `AcquisitionStop` commands, see Section 5.1 on [page 31](#).

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

- Frame start trigger signals are generated internally by the camera, and frame acquisition will be done automatically. This is also known as the "**free run**". For more information, see Section 5.2.1.1 on [page 33](#).
- Frame start trigger signals are applied via **software**. Each time a `TriggerSoftware` command is executed via the pylon API, the camera will begin a frame acquisition. For more information, see Section 5.2.1.2 on [page 34](#).

The exposure time for each frame acquisition is determined by the value of the camera's `ExposureTime` parameter.

For more information about the camera's `ExposureTime` parameter, see Section 5.3 on [page 36](#).



## 5.2.1 Trigger Mode

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

### 5.2.1.1 Trigger Mode = Off (Free Run)

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

The way the camera will operate the frame start trigger depends on the setting of the camera's AcquisitionMode parameter. If the AcquisitionMode parameter is set to

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

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

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

Table 7: Frame Start Trigger Rates in the Continuous Frame Acquisition Mode

For more information about determining the maximum allowed frame rate, see Section 5.6 on [page 45](#).

### Configuring and Enabling the Free Run Mode

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

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

```
camera.TriggerMode.SetValue(TriggerMode_Off);
// Start frame capture
camera.AcquisitionStart.Execute();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

### 5.2.1.2 TriggerMode = On (Software Triggering)

If the TriggerMode parameter is set to On,

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



Do not trigger frame acquisition at a rate that

- exceeds the maximum allowed for the current camera settings. If you apply frame start trigger signals to the camera when it is not ready to receive them, the signals will be ignored. For more information about determining the maximum allowed frame rate, see Section 5.6 on [page 45](#).
- exceeds the host computer's capacity limits for data transfer or storage or both. If you try to acquire more images than the host computer is able to process, frames may be dropped. For more information about bandwidth optimization, see the *Installation and Setup Guide for Cameras Used with Basler pylon for Windows* (AW000611).

### Immediate Trigger Mode

Available for ...

puA1280-54um/uc, puA1920-15um,  
puA1920-30um/uc, puA2500-14um/uc

If the TriggerMode parameter is set to On, the immediate trigger mode setting also takes effect.

You can enable or disable the immediate trigger mode by setting the ImmediateTriggerMode parameter to one of the following values:

- **On:** Exposure starts immediately after triggering, but changes to image parameters become effective with a short delay, i.e., after one or more images have been acquired. This is useful if

you want to minimize the exposure start delay, i.e., if you want to start image acquisition as soon as possible, and if your imaging conditions are stable.

- **Off:** Changes to image parameters become effective immediately, but exposure starts with a short delay after triggering.

By default, the parameter is set to Off.

## Configuring and Executing a Software Trigger Command

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

```
// Set the acquisition mode to Continuous
camera.AcquisitionMode.SetValue(AcquisitionMode_Continuous);
// Set the trigger mode to On
camera.TriggerMode.SetValue(TriggerMode_On);
// Set the immediate trigger mode to Off
camera.ImmediateTriggerMode.SetValue(ImmediateTriggerMode_Off);
// Set the timed exposure mode
camera.ExposureMode.SetValue(ExposureMode_Timed);
// Set the exposure time
camera.ExposureTime.SetValue(3000.0);
// Execute an AcquisitionStart command to prepare for frame acquisition
camera.AcquisitionStart.Execute();
    while (!finished)
    {
        // Execute a TriggerSoftware command to apply a frame start
        // trigger signal to the camera
        camera.TriggerSoftware.Execute();
        // Retrieve acquired frame here
    }
camera.AcquisitionStop.Execute();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 5.3 Setting the Exposure Time

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



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

Set the ExposureAuto parameter to Off before making any manual adjustments.

For more information about the exposure auto function, see Section 7.11.4 on [page 83](#).

The minimum and maximum possible exposure time that can be set is shown in Table 8.

Minimum Allowed Exposure Time	Maximum Possible Exposure Time	Increment
10 $\mu\text{s}$	1000000 $\mu\text{s}$	1 $\mu\text{s}$

Table 8: Minimum and Maximum Allowed Exposure Time Setting and Increment



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

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

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

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

For more information about the pylon API and pylon Viewer, see Section 3.1 on [page 25](#).

## 5.4 Electronic Shutter Operation

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

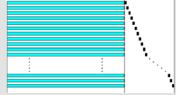

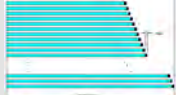
<b>Global Shutter</b> 	<b>Electronic Rolling Shutter (ERS)</b> 	<b>Global Reset Release Mode (GRR)</b> 
For moving objects	<ul style="list-style-type: none"> <li>■ For stationary objects/<b>not</b> moving objects</li> <li>■ Lower ambient noise</li> <li>■ If used for moving objects: Use of flash lighting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

Table 9: Overview of Shutter Modes

<b>Camera Model</b>	<b>Shutter Type</b>	<b>Supported Shutter Modes</b>
puA1280-54um/uc puA1600-60um/uc	Global Shutter	Global Shutter
puA1920-30um/uc puA2500-14um/uc	Rolling Shutter	Electronic Rolling Shutter (ERS) Global Reset Release Mode (GRR)

Table 10: Camera Models and Shutter Configuration

## 5.4.1 Global Shutter

Camera Model	Global Shutter Available?
puA1280-54um/uc puA1600-60um/uc	Yes
puA1920-30um/uc puA2500-14um/uc	No

Table 11: Global Shutter Availability

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

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

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

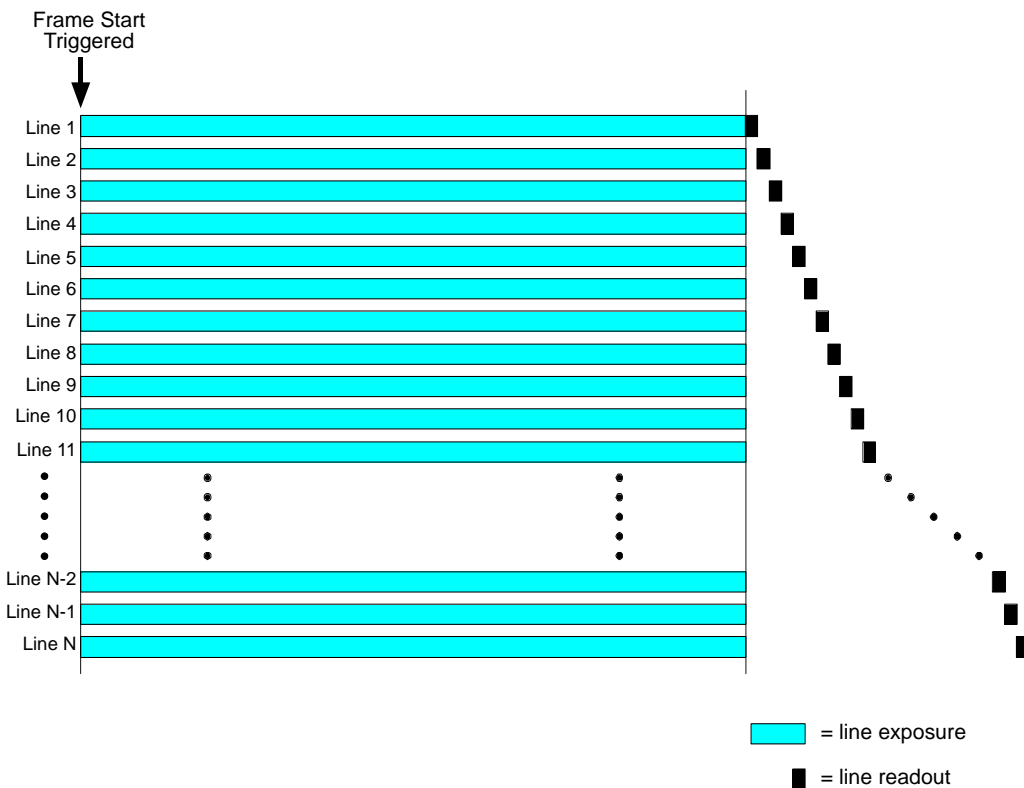


Fig. 11: Global Shutter

## 5.4.2 Rolling Shutter

Camera Model	Rolling Shutter Available?
puA1280-54um/uc puA1600-60um/uc	No
puA1920-30um/uc puA2500-14um/uc	Yes

Table 12: Rolling Shutter Availability

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

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

### Electronic Rolling Shutter Mode (ERS)

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

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

And so on until the bottom line of pixels is reached (see Figure 12).

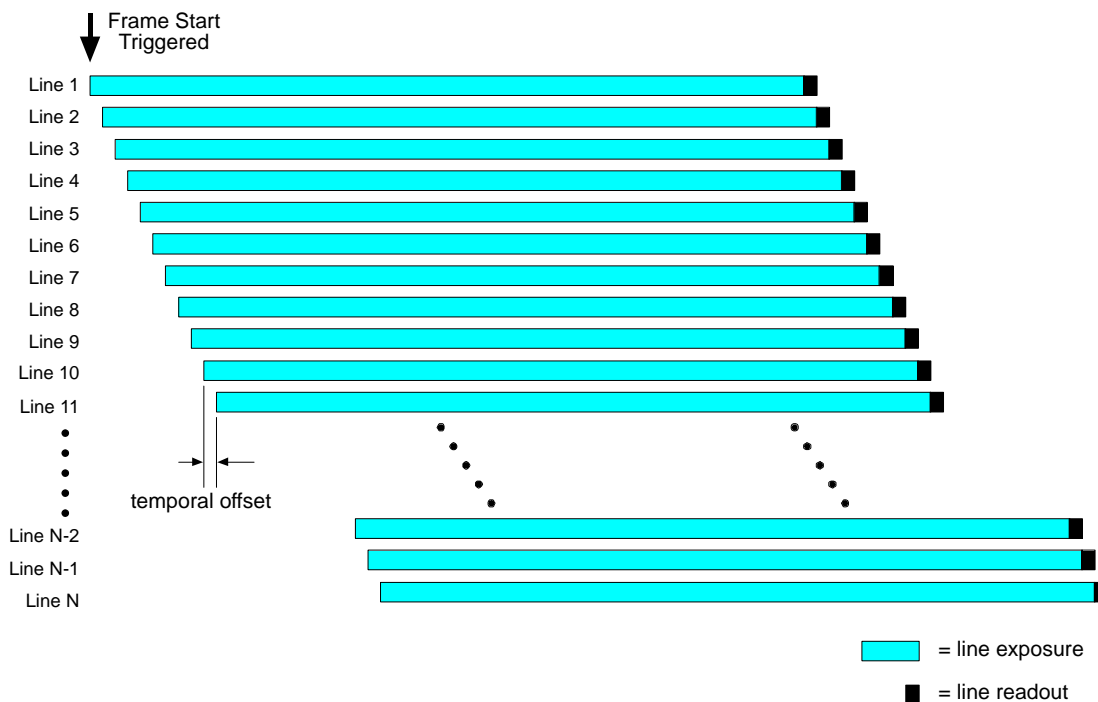


Fig. 12: Rolling Shutter in the ERS Mode

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

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

## Global Reset Release Mode (GRR)

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

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

And so on until the bottom line of pixels is reached (see Figure 13).

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

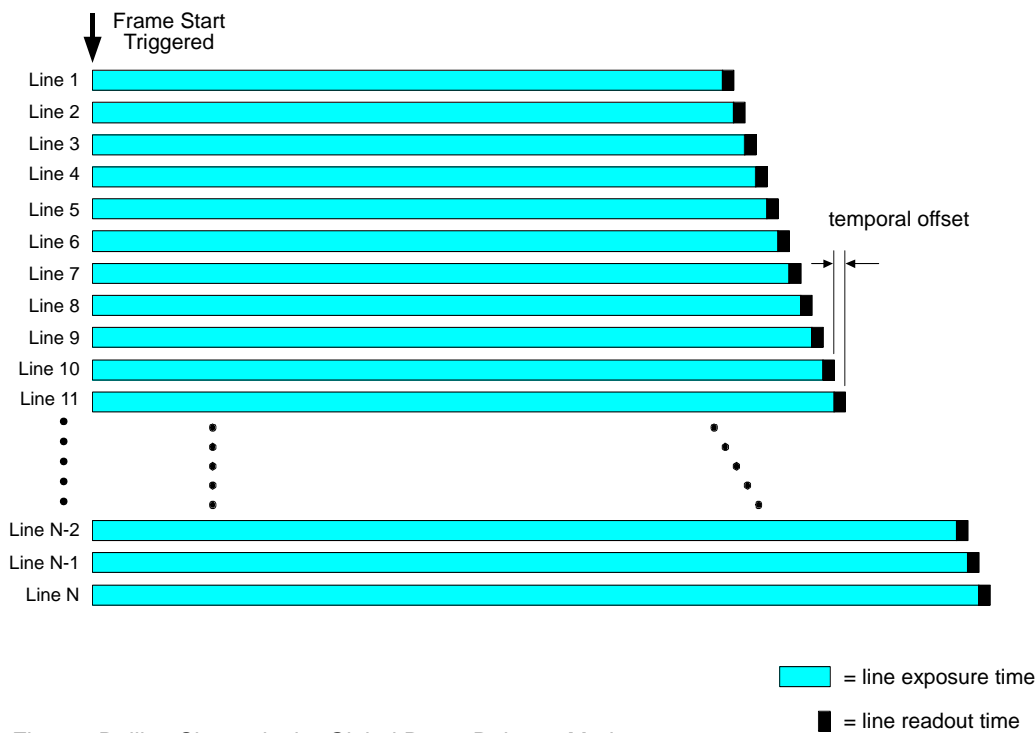


Fig. 13: Rolling Shutter in the Global Reset Release Mode

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



## Setting the Sensor Shutter Mode

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

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## Rolling Shutters and Flash Exposure

If you are using

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

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

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

## 5.5 Overlapping Image Acquisitions

There are two common ways for the camera to operate:

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

In the **non-overlap** mode of operation, each time a frame is acquired the camera completes the entire readout process (exposure of the pixels + readout of the pixel values from the sensor) before acquisition of the next frame is started. The exposure for a new frame does not overlap the sensor readout for the previous frame. This situation is illustrated in Figure 14.

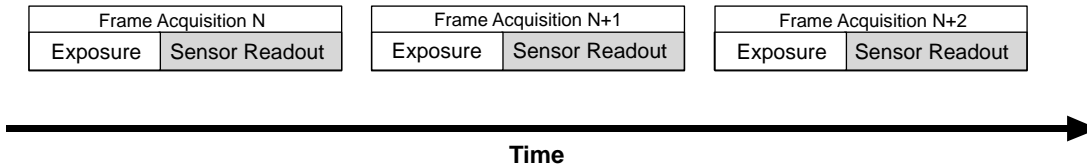


Fig. 14: Non-overlapped Exposure and Sensor Readout

In the **overlap** mode of operation, the exposure of a new frame begins while the camera is still reading out the sensor data for the previously acquired frame. This situation is illustrated in Figure 15.

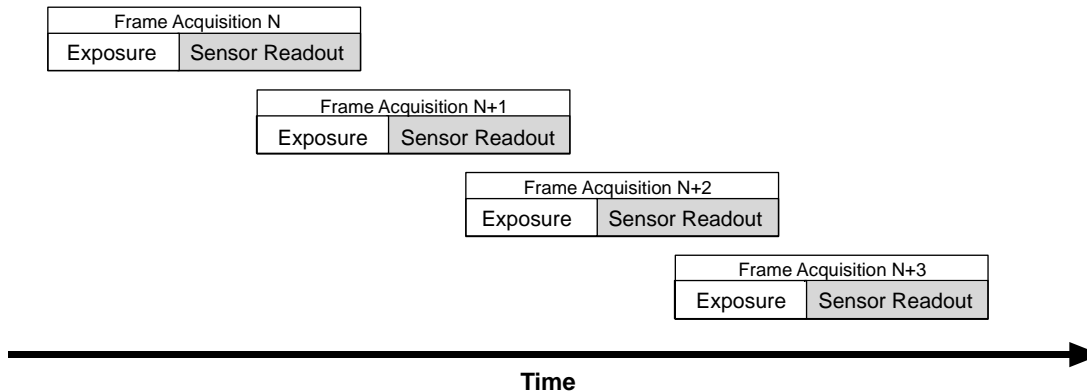


Fig. 15: Overlapped Exposure and Sensor Readout

## 5.5.1 Automatic Overlapping of Image Acquisitions (All Cameras)

If the camera allows overlapped image acquisitions (see Table 13), it will automatically overlap exposures and readouts to maximize the frame rate or to achieve a specific frame rate.

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



To allow overlapping image acquisitions, the camera must be in the continuous acquisition mode. Overlapping image acquisition cannot be performed if the camera's acquisition mode is set to single frame.  
For more information about the acquisition mode, see Section 5.1 on [page 31](#).

Camera Model	Rolling Shutter Mode	Frame Start Trigger Mode	Overlapping Image Acquisitions allowed?
pu1280-54um/uc puA1600-60um/uc	Not applicable (global shutter camera)	On (software trigger)	<b>No</b>
		Off (free run)	<b>Yes (*)</b>
puA1920-30um/uc puA2500-14um/uc	ERS	On (software trigger)	<b>Yes</b>
	ERS	Off (free run)	<b>Yes</b>
	GRR	On (software trigger)	<b>No</b>
	GRR	Off (free run)	<b>No</b>

(\*) Overlapping image acquisitions are allowed unless you manually disable them using the `OverlapMode` parameter. For more information, see Section 5.5.2 on [page 44](#).

Table 13: Conditions for Overlapping Image Acquisitions

For more information about

- rolling shutter modes, see Section 5.4.2 on [page 39](#).
- frame start trigger modes, see Section 5.2.1 on [page 33](#).

## 5.5.2 Manually Setting the Overlap Mode of Operation (puA1280-54um/uc, puA1600-60um/uc)

On puA1280-54um/uc and puA1600-60um/uc cameras, you can use the `OverlapMode` parameter to manually disable or enable overlapping image acquisitions.

If the `OverlapMode` parameter is set to

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

For more information about the overlap and non-overlap mode of operation, see Section 5.5 on [page 42](#).

The following code snippet illustrates using the pylon API to set the `OverlapMode` parameter value:

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 5.6 Maximum Allowed Frame Rate

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

- The exposure time for the acquisition of frames. If you use very long exposure times, you can acquire fewer frames per second.
- The amount of time it takes to read an acquired frame out of the imaging sensor and to prepare it for transmission out of the camera. The amount of time varies with the height of the frame. Frames with a smaller height take less time. The frame height is determined by the camera's ROI Height setting.
- The amount of time it takes to transmit an acquired frame from the camera to your computer. The amount of time depends on the host computer's capacity limits for data transfer and the bandwidth assigned to the camera.
- Under certain conditions, overlapping image acquisition is not possible. This decreases the camera's maximum allowed frame rate. For more information about overlapping image acquisitions, see Section 5.5 on [page 42](#).

To determine the maximum allowed acquisition frame rate with your current camera settings, you can do the following:

- Use the Frame Rate Calculator that can be found in the Support section of the Basler website: [www.baslerweb.com](http://www.baslerweb.com) > Support > Tools > Frame Rate Calculator
- Use the Basler pylon API to read the value of the camera's ResultingFrameRate parameter. For more information, see Section 5.6.1 on [page 45](#).

### 5.6.1 Using the Basler pylon API to Check the Maximum Allowed Frame Rate

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

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

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

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

For more information about the pylon API and pylon Viewer, see Section 3.1 on [page 25](#).

## 5.6.2 Increasing the Maximum Allowed Frame Rate

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

- Decreasing the height of the region of interest (ROI) can have a significant impact on the maximum allowed frame rate. If possible in your application, decrease the height of the ROI.
- Depending on the sensor, decreasing the width of the ROI may also increase the maximum allowed frame rate. The impact is lower than the impact of the ROI height, but may still be noticeable.
- If you are using long exposure times or small ROIs, your exposure time may limit the maximum allowed frame rate. Try using a shorter exposure time and see if the maximum allowed frame rate increases. You may need to compensate for a lower exposure time by using a brighter light source or increasing the opening of your lens aperture.
- If you are using multiple cameras connected to one hub, the transmission time may restrict the maximum allowed rate. In this case, you could use a multiport host adapter in the computer instead of a hub.
- If your camera is equipped with a rolling shutter, use the electronic rolling shutter (ERS) mode rather than the global reset release shutter mode. The ERS mode allows overlapping frame acquisition while the global reset release mode does not. Overlapping frame acquisitions is, however, necessary for achieving the highest frame rates.

For more information about

- ROI settings, see Section 7.7 on [page 64](#).
- the ERS mode, see Section 5.4.2 on [page 39](#).
- overlapping image acquisitions, see Section 5.5 on [page 42](#).



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

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

# 6 Pixel Formats

## 6.1 Available Pixel Formats

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

- Mono 8
- Mono 12

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

- YCbCr422
- Bayer 8
- Bayer 12
- RGB 8



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

If you are using pulse model puA1600-60uc, puA1920-30uc, or puA2500-14uc, the alignment will change if you enable image mirroring.

For more information about

- the color filter alignment, see Section 7.6.1 on [page 56](#).
- image mirroring, see Section 7.9 on [page 72](#).



The image sensor of the puA1600-60uc/um delivers 10 bits of data per pixel. If you set the puA1600-60uc/um for a 12-bit pixel format (Mono 12 or Bayer 12), the camera will output 12-bit image data based on 10-bit sensor data.

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

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 6.2 Details on Pixel Formats for Color Cameras

### YCbCr422 Format

All pulse color cameras can output color images based on pixel data in YCbCr422 format. This is the default pixel format.

When a color camera is set for this format, each pixel value in the captured image goes through a two step conversion process as it exits the sensor and passes through the camera's electronics. This process yields Y, Cb, and Cr color information for each pixel.

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

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

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

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

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

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



By default, when the pixel format is set to YCbCr422 or RGB 8, images are acquired in sRGB color space.

You can use the `BslColorSpaceMode` parameter to change the color space to RGB. For more information, see Section 7.4 on [page 52](#).

### Bayer Formats

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

When a color camera is set for one of these Bayer pixel formats, it outputs 8 or 12 bits of data per pixel. For each pixel covered with a red, green, or blue filter, you get 8 or 12 bits of red, green, or blue data. This type of pixel data is sometimes referred to as "raw" output.

For more information about

- the Bayer filter, see Section 7.6.1 on [page 56](#).
- the Balance White feature, see Section 7.6.3 on [page 59](#).



# 7 Features

## 7.1 Feature Sequence

Most of the camera features described in this chapter modify the pixel data output by the image sensor. These features are processed in a specific sequence. Knowing the sequence is especially useful if you are configuring multiple features and want to avoid side effects.

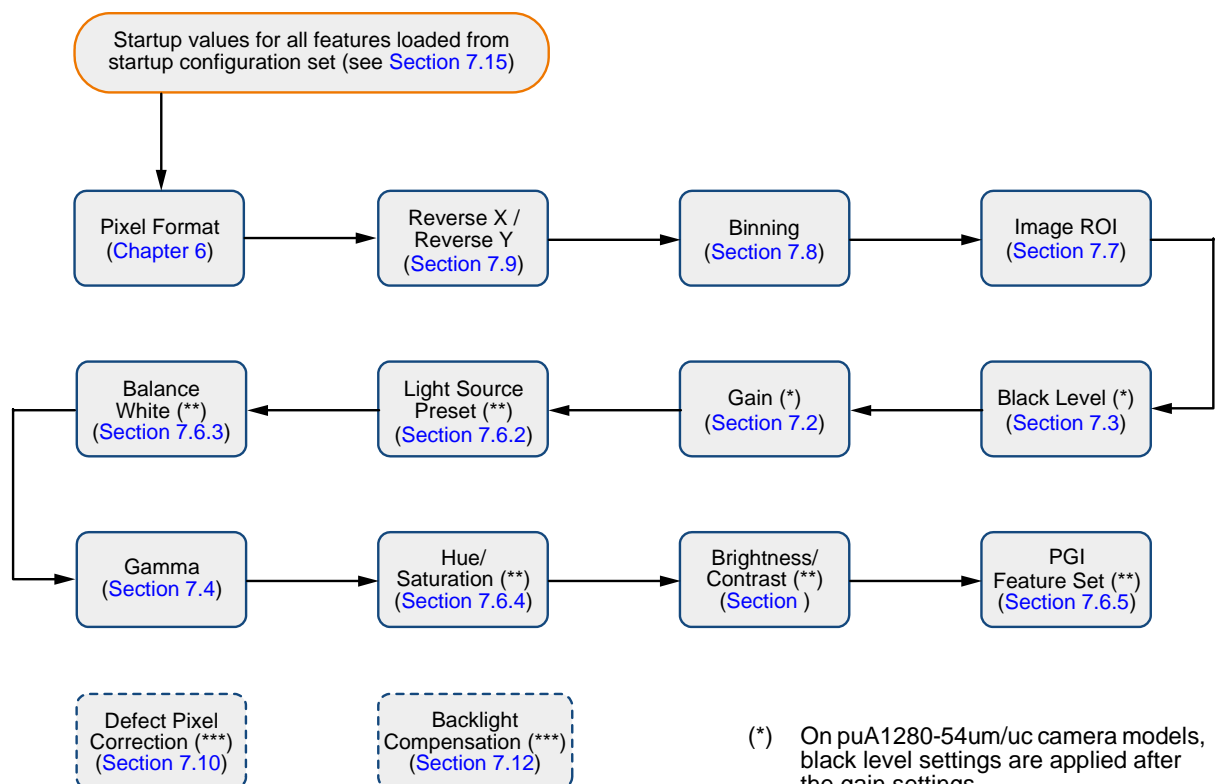


Fig. 16: Feature Sequence

# 7.2 Gain



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

Set the GainAuto parameter to Off before making any manual adjustments.

For more information about the gain auto function, see Section 7.11.3 on [page 82](#).

The camera's Gain feature is an analog feature allowing you to adjust gain. As shown in Figure 17, increasing the gain increases the slope of the response curve for the camera. This results in a higher gray value output from the camera for a given amount of output from the imaging sensor. Decreasing the gain decreases the slope of the response curve and results in a lower gray value for a given amount of sensor output.

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

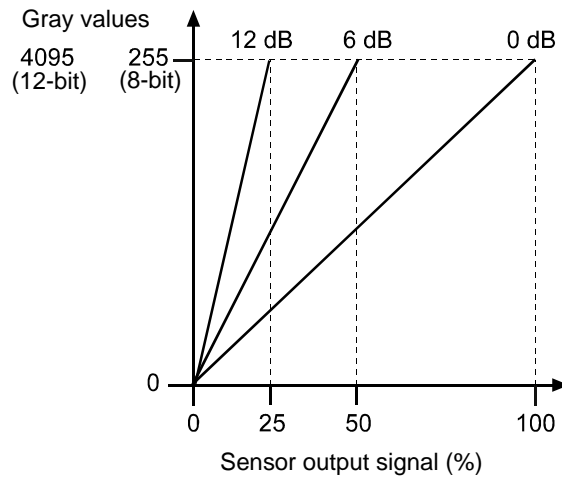


Fig. 17: Gain in dB

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

The camera's gain is determined by the value of the Gain parameter. The parameter is adjusted in dB. The maximum regular value varies by camera model (see Table 14).

Camera Model	Max Allowed Setting (in dB)
puA1280-54um/uc	18
puA1600-60um/uc puA1920-15um puA1920-30um/uc puA2500-14um/uc	24

Table 14: Maximum Allowed Gain Settings (in dB)

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.3 Black Level



On puA1280-54um/uc cameras, the black level settings are applied to the pixel data **after** the gain settings have been applied.

On all other pulse cameras, the black level settings are applied **before** the gain settings.

Adjusting the camera's black level will result in an offset to the pixel values output by the camera. Increasing the black level setting will result in a positive offset (+1) in the pixel values output for the pixels. Decreasing the black level setting will result in a negative offset (-1) in the pixel values output for the pixels.

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

The range of the allowed settings for the BlackLevel parameter value in DN varies by pixel format as shown in Table 15.

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

Table 15: Minimum and Maximum Black Level Settings [DN]

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.4 Gamma

The Gamma feature lets you modify the brightness of acquired images to account for a non-linearity in the human perception of brightness.

The gamma correction can be set manually as desired using the Gamma parameter:

- Gamma = 1: The overall brightness is **not corrected** (unless the pixel format is set to YCbCr422 or RGB8, see section below).
- Gamma < 1: The overall brightness is **increased**.
- Gamma > 1: The overall brightness is **decreased**.

In all cases, black pixels (brightness = 0) and white pixels (brightness = maximum) will not be adjusted. The maximum pixel brightness equals 255 for 8-bit output and 4095 for 12-bit output.

To accomplish gamma correction, a gamma correction value ( $\gamma$ ) is applied to the pixel value of each pixel according to the following formula:

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

### sRGB Gamma Correction and Color Space Mode

If the pixel format is set to YCbCr422 or RGB 8, you can use the BslColorSpaceMode parameter to change the color space for image acquisition. This will enable or disable the application of an additional sRGB gamma correction value.

You can set the BslColorSpaceMode parameter to the following values:

- **sRGB:** The image brightness is optimized for display on an sRGB monitor. An additional gamma correction value of approximately 0.4 is applied. This is the default setting.

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

**Example:** You set the BslColorSpaceMode parameter to sRGB and the Gamma parameter value to 1.2. First, an sRGB gamma correction value of approximately 0.4 is applied to the pixel values. Then, a gamma correction value of 1.2 is applied to the resulting pixel values.

- **RGB:** No additional sRGB gamma correction value is applied.

If the pixel format is set to Bayer 8 or Bayer 12, the BslColorSpaceMode parameter is not available, and gamma correction is always performed in RGB color space.

You can set the parameter values from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the color space to sRGB and the gamma correction 1.2 as an example:

```
// Set the color space to sRGB
camera.BslColorSpaceMode.SetValue(BslColorSpaceMode_sRGB);
// Set the Gamma value to 1.2
camera.Gamma.SetValue(1.2);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.5 Brightness/Contrast

The Brightness/Contrast feature lets you make adjustments to the tonal values of your images.

You can adjust brightness and contrast by setting the BslBrightness, BslContrast, and BslContrastMode parameters.

The BslBrightness and BslContrast parameter values are always processed together as two parts of a common Brightness/Contrast function, as described in the following sections.

### 7.5.1 Contrast

Adjusting the contrast changes the degree of difference between light and dark areas in the image. The more contrast you apply, the more defined the difference will be.

You can adjust the contrast by setting the BslContrast parameter. The parameter value can range from -1 to 1. By default, the parameter is set to 0, and no contrast adjustment is performed.

How the BslContrast parameter works depends on the **contrast mode** set. You can select the contrast mode by setting the BslContrastMode parameter to one of the following values:

- **Linear:** This is the default contrast mode. When this contrast mode is set, a linear function is used to adjust the contrast. Increasing or decreasing the BslContrast parameter increases or decreases the slope of the linear function.

8-bit pixel values shown  
as an example

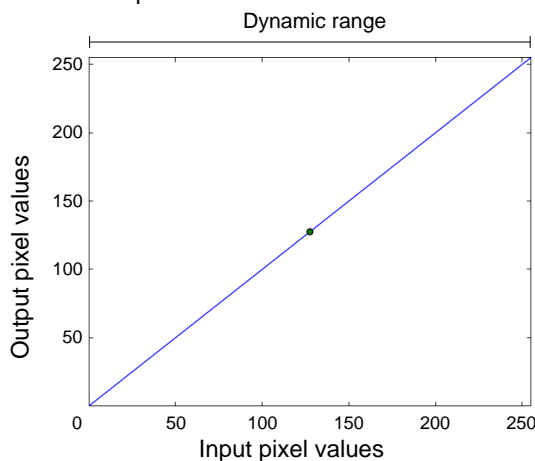


Fig. 18: Contrast = 0, Brightness = 0, Linear Contrast Mode

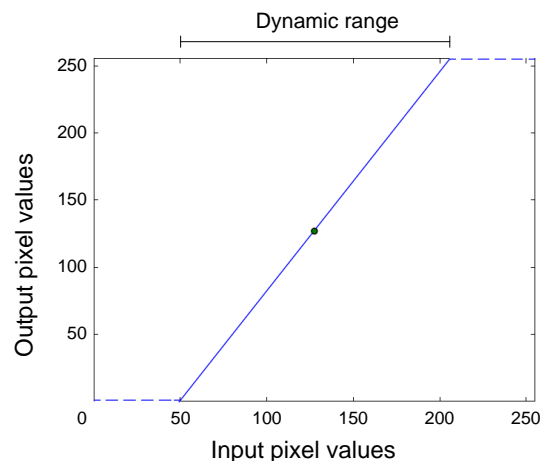


Fig. 19: Contrast = 0.3, Brightness = 0, Linear Contrast Mode

The higher the slope of the linear function, the more output pixel values will be set to completely black (0) or completely white (maximum pixel value). In the example shown in Figure 19, input values from 0 to approximately 50 are set to completely black, and input values from approximately 205 to 255 are set to completely white.

This means that the overall range of tonal values, i.e., the dynamic range of the image, is decreased. The darkest and lightest regions of the image will appear completely black or

completely white, but the other areas will appear more defined.

Decreasing the contrast has the opposite effect.

- **S-Curve:** When this contrast mode is set, an S-curve function is applied to adjust the contrast. This allows you to improve perceived contrast while preserving the dynamic range of the image.

When the contrast mode is set to S-Curve and both BslContrast and BslBrightness are set to 0, the Brightness/Contrast function looks as shown in Figure 18. If you increase the contrast, however, the graph of the function will be shaped like an "S":

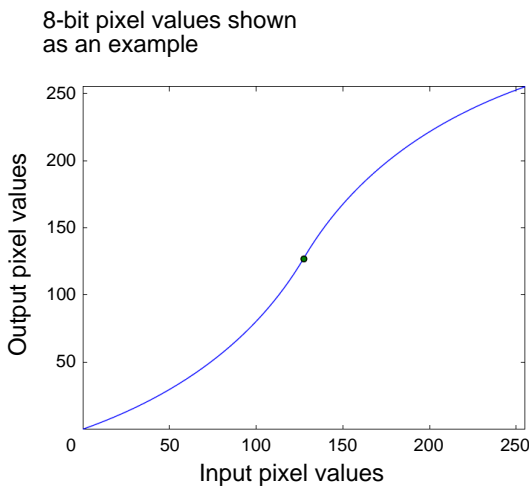


Fig. 20: Contrast = 0.3, Brightness = 0,  
S-Curve Contrast Mode

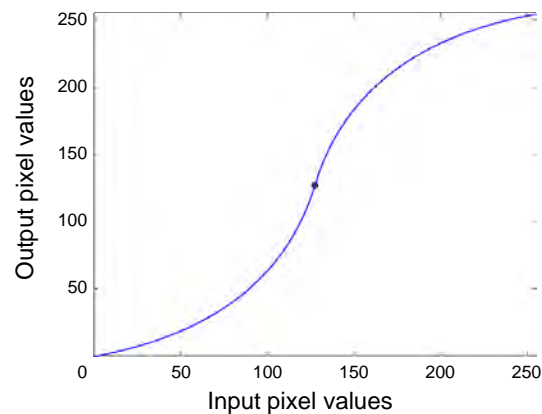


Fig. 21: Contrast = 0.5, Brightness = 0,  
S-Curve Contrast Mode

As shown in Figure 20 and Figure 21, increasing the contrast in S-Curve mode has the following effects:

- The S-curve gets flatter around its starting and end points and steeper around the center. As a result, contrast in light and dark areas of the image is reduced, and contrast in mid tones is increased.
- Low input pixel values are lowered and high input pixel values are increased. As a result, extreme dark and light areas of your image are compressed, which further improves the perceived contrast.
- As the curve always starts at  $(0,0)$  and ends at  $(X_{\max}, Y_{\max})$ , the dynamic range of the image is always preserved.

Setting contrast below 0 in S-Curve mode results in an inverted S-curve with opposite effects.

## 7.5.2 Brightness

Adjusting the brightness allows you to lighten or darken the image by increasing or decreasing its tonal values.

You can adjust the brightness by setting the BslBrightness parameter. The parameter value can range from -1 to 1. By default, the parameter is set to 0, and no brightness adjustment is performed.

Adjusting the brightness moves the pivot point of the Brightness/Contrast function.

Increasing the brightness moves the pivot point towards the upper left. As a result, the image will appear lighter. Decreasing the brightness moves the pivot point to the lower right, and the image will appear darker.

Figure 22 shows an example for the S-Curve contrast mode set. For more information about contrast and contrast modes, see Section 7.5.1 on [page 53](#).

8-bit pixel values shown as an example

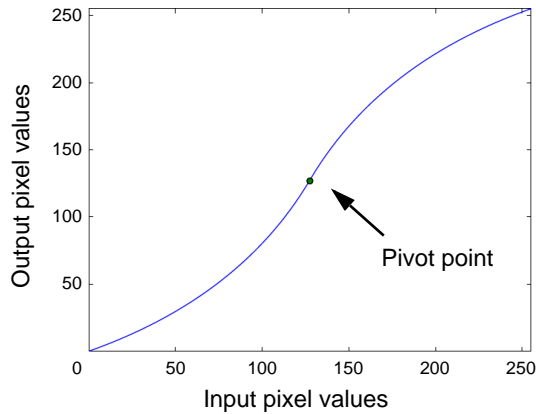


Fig. 22: Contrast = 0.3, Brightness = 0, S-Curve Contrast Mode

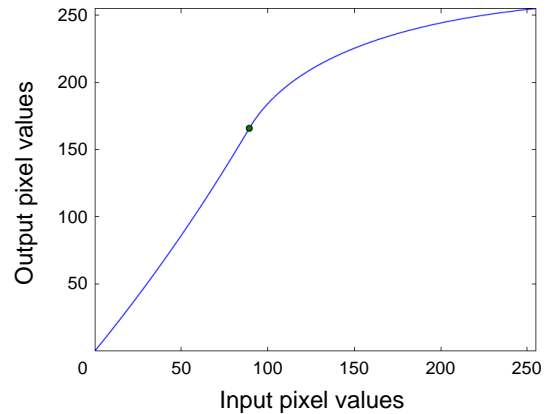


Fig. 23: Contrast = 0.3, Brightness = 0.3, S-Curve Contrast Mode

## 7.5.3 Setting Brightness and Contrast

You can set brightness and contrast within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameters:

```
// Set the Brightness parameter value to 0.5
camera.BslBrightness.SetValue(0.5);
// Set the contrast mode to Linear
camera.BslContrastMode.SetValue(BslContrastMode_Linear);
// Set the Contrast parameter value to 1.2
camera.BslContrast.SetValue(1.2);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.6 Color Enhancement Features

### 7.6.1 General Considerations

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

With the Bayer filter, each individual pixel is covered by a part of the filter that allows light of only one color to strike the pixel. The pattern of the Bayer filter used on the camera is as shown in Figure 24.

As the figure illustrates, within each square of four pixels, one pixel sees only red light, one sees only blue light, and two pixels see only green light. This combination mimics the human eye's sensitivity to color.

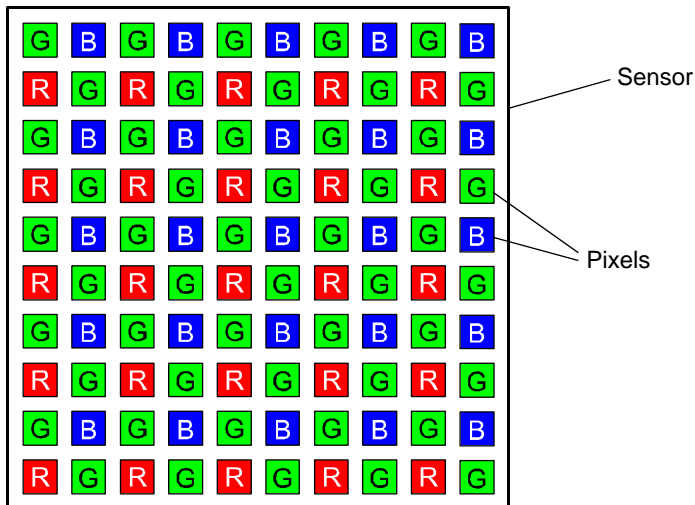


Fig. 24: Bayer Filter Pattern with "GB" Alignment

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





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

If you are using pulse model puA1280-54uc, this alignment is fixed.

If you are using pulse model puA1600-60uc, puA1920-30uc, or puA2500-14uc, the alignment will change if you enable image mirroring: If you use

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

For more information about image mirroring, see Section 7.9.1 on [page 72](#) and Section 7.9.2 on [page 73](#).

## 7.6.2 Light Source Preset



- The Light Source Preset feature is only available when the pixel format is set to YCbCr422 or RGB 8. For more information about pixel formats, see Chapter 6 on [page 47](#).
- If the balance white auto function is set to Off, you must reset the white balance before changing the light source preset, as described below.

By using a light source preset, you can correct color shifts caused by a specific light source. This also corrects color inaccuracies caused by the image sensor.

You can set the following light source presets:

- **Off** - No alterations will be made to the pixel values. This also means that the camera does not correct color inaccuracies caused by the image sensor. Therefore, Basler does not recommend using this setting.
- **Tungsten 2800 K** - The camera corrects color shifts caused by tungsten lighting that has a color temperature of about 2800 K. The camera will also optimize the white balance settings for a tungsten light source and correct color inaccuracies caused by the image sensor.
- **Daylight 5000 K / 6500 K** - The camera corrects for color shifts caused by daylight lighting that has a color temperature of about 5000 K / 6500 K. The camera will also optimize the white balance settings for a daylight light source and correct color inaccuracies caused by the image sensor.



After camera power up or reset, the light source preset is set to "Daylight 5000 K" unless you define a startup set with a different light source preset. For more information about the startup set, see Section 7.15 on [page 92](#).

**To set a light source preset:**

1. If the BalanceWhiteAuto parameter is set to Off, reset the white balance by setting the BalanceRatio parameter value for all color channels (red, green, and blue) to 1. For more information about the BalanceRatio parameter, see Section 7.6.3 on [page 59](#).
2. Set the LightSourcePreset parameter to the desired light source preset.

You can set the parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to configure white balancing and set a light source preset:

```
// When the balance white auto function is disabled,  
// white balance must be reset before changing the preset  
camera.BalanceWhiteAuto.SetValue(BalanceWhiteAuto_Off);  
camera.BalanceRatioSelector.SetValue(BalanceRatioSelector_Red);  
camera.BalanceRatio.SetValue(1);  
camera.BalanceRatioSelector.SetValue(BalanceRatioSelector_Green);  
camera.BalanceRatio.SetValue(1);  
camera.BalanceRatioSelector.SetValue(BalanceRatioSelector_Blue);  
camera.BalanceRatio.SetValue(1);  
// Set the light source preset to "Tungsten 2800 K"  
camera.LightSourcePreset.SetValue(LightSourcePreset_Tungsten2800K);  
  
// When the balance white auto function is enabled,  
// the preset can be changed right away  
camera.BalanceWhiteAuto.SetValue(BalanceWhiteAuto_Continuous);  
camera.LightSourcePreset.SetValue(LightSourcePreset_Daylight5000K);
```

## 7.6.3 Balance White



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

Set the BalanceWhiteAuto parameter to Off before making any manual adjustments.

For more information about the balance white auto function, see Section 7.11.5 on [page 85](#).

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

While the Light Source Preset feature is useful to preconfigure the white balance based on fixed preset values (see Section 7.6.2 on [page 57](#)), the Balance White feature lets you fine-tune the white balance for your specific imaging conditions.

The white balance is effective on all pixel data output formats including "raw" pixel formats (Bayer 8 and Bayer 12).

### Setting the White Balance

You can perform white balancing by adjusting the intensity of the colors red, green, and blue in your images. Each color can be individually adjusted using the BalanceRatio parameter.

#### To set the white balance:

1. Set the BalanceRatioSelector parameter to Red, Green, or Blue.
2. Set the BalanceRatio parameter to the desired value for the selected color channel.

The BalanceRatio parameter value can range from 1 to 7.984375:

- BalanceRatio = 1: The intensity of the color is **unaffected** by the white balance mechanism.
- Balance ratio > 1: The intensity of the color is **increased** relative to the other two colors.
- Balance ratio < 1: The intensity of the color is **decreased** relative to the other two colors.

The increase or decrease in intensity is proportional. For example, if the balance ratio for a color is set to 1.25, the intensity of that color is increased by 25 %.

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

```
// Select the green color channel and set its intensity to 125%
camera.BalanceRatioSelector.SetValue(BalanceRatioSelector_Green);
camera.BalanceRatio.SetValue(1.25);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.6.4 Hue/Saturation



The Hue/Saturation feature is only available when the pixel format is set to YCbCr422 or RGB 8. For more information about pixel formats, see Chapter 6 on [page 47](#).

The Hue/Saturation feature lets you adjust the color appearance in your images.

### Hue

Adjusting the **hue** shifts the colors of the image. This can be useful, e.g., for correcting minor color shifts or creating false-color images.

You can adjust the hue by setting the BslHue parameter. The parameter can be set in a range from -180° to 180°. The parameter value refers to a rotation of the RGB color cube. By default, the parameter is set to 0° (no color shift).

### Saturation

Adjusting the **saturation** changes the colorfulness (intensity) of the colors. A higher saturation, for example, will make colors easier to distinguish.

You can adjust the saturation by setting the BslSaturation parameter. By default, the parameter is set to 1 (normal saturation). Lower parameter values result in more muted colors that are closer to gray. Higher parameter values result in more vivid, vibrant colors.

### Setting Hue and Saturation

You can set hue and saturation within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameters:

```
// Set the Hue parameter value to 5 degrees
camera.BslHue.SetValue(5);
// Set the Saturation parameter value to 1.4
camera.BslSaturation.SetValue(1.4);
```

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 25](#).

## 7.6.5 PGI Feature Set



The PGI feature set is only available when the pixel format is set to YCbCr422 or RGB 8. For more information about pixel formats, see Chapter 6 on [page 47](#).

The Basler PGI feature set is integrated into all Basler pulse color cameras. It consists of four image optimization features:

- Denoising
- 5 × 5 Debayering
- Color Anti-Aliasing
- Sharpness Enhancement



On puA1280-54uc camera models, the PGI feature set consists only of Denoising, 5 × 5 Debayering, and Color Anti-Aliasing. The Sharpness Enhancement feature is not available.

With the exception of the Sharpness Enhancement feature, these optimizations are done **automatically** and can't be controlled by the user.

The PGI image optimizations take effect whenever the pixel format is set to YCbCr422 or RGB 8. To disable PGI image optimizations, set the pixel format to Bayer 8 or Bayer 12.

For more information about

- pixel formats, see Chapter 6 on [page 47](#).
- the Sharpness Enhancement feature, see Section 7.6.6 on [page 62](#).
- the PGI image optimizations, see the white paper "Better Image Quality with Basler PGI". You can find the white paper in the "Documents" section of the Basler website: [www.baslerweb.com](http://www.baslerweb.com).

## 7.6.6 Sharpness Enhancement



- The Sharpness Enhancement feature is not available on puA1280-54uc camera models.
- The Sharpness Enhancement feature is only available when the pixel format is set to YCbCr422 or RGB 8. For more information about pixel formats, see Chapter 6 on [page 47](#).

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

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



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

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.6.7 A Procedure for Setting the Color Enhancements

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



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

### To set the color enhancements:

1. Arrange your camera so that it is viewing a scene similar to what it will view during actual operation. Make sure that the lighting for the scene is as close as possible to the actual lighting you will be using during normal operation. Using lighting that represents your normal operating conditions is extremely important.  
  
We recommend including a standard color chart within your camera's field of view when you are adjusting the color enhancements. One widely used chart is the ColorChecker® chart (also known as the Macbeth chart).
2. Set the exposure auto, gain auto, and balance white auto functions to Off.
3. Reset the white balance by setting all BalanceRatio parameter values to 1.
4. Make sure the settings for gain and black level are at their minimums.
5. Set the LightSourcePreset parameter to the value that is most appropriate for your lighting. For example, if you use tungsten incandescent light, select the Tungsten2800K light source preset.
6. Begin capturing images and check the basic image appearance.
7. Set the exposure time, black level, and gain so that you are acquiring good quality images. It is important to make sure that the images are not overexposed. Overexposure can have a significant negative effect on the fidelity of the color in the acquired images. Generally, the settings for black level and gain should be as low as possible.
8. Adjust the white balance. Make sure a white or light gray object is imaged while white balance is carried out. An easy way to set the white balance is to use the Once mode of operation on the camera's Balance White Auto feature.
9. If necessary, set the gamma value. When gamma is set correctly, there should be a smooth transition from the lightest to the darkest gray scale targets on your color chart or on a gray scale.
10. If necessary, fine-tune the colors and tonal values by adjusting brightness, contrast, hue, and saturation.
11. Examine the colors and see if they are satisfactory at this point. If not, restart from step 3.



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

## 7.7 Image ROI

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

The region of interest is referenced to the top left corner of the sensor array. The top left corner is designated as column 0 and row 0 as shown in Figure 25.

The location and size of the region of interest is defined by declaring an offset X (coordinate), a width, an offset Y (coordinate), and a height. For example, suppose that you specify the offset X as 10, the width as 16, the offset Y as 6, and the height as 10. The region of the array that is bounded by these settings is shown in Figure 25.

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

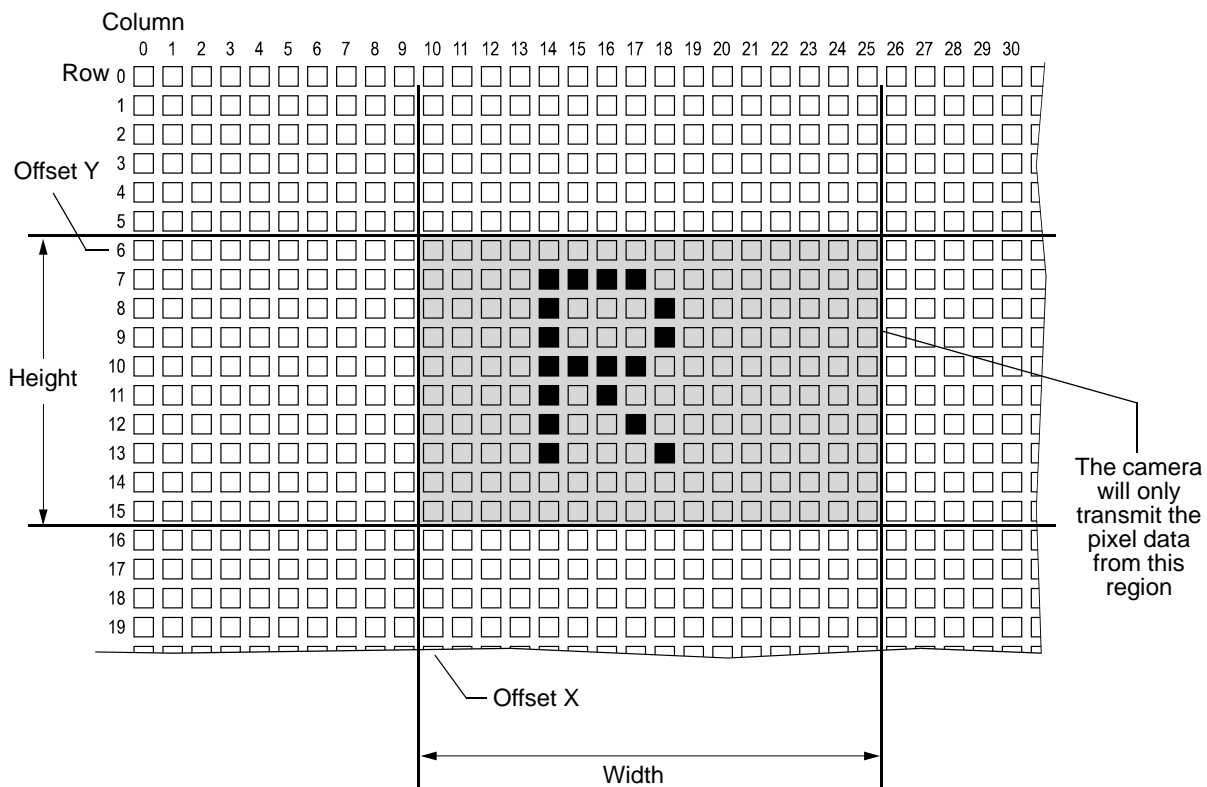


Fig. 25: Region of Interest

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

For more information about how changing the ROI height affects the maximum allowed frame rate, see Section 5.6 on [page 45](#).



## Guidelines for Setting the Image ROI

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

- OffsetX: determines the starting column for the region of interest.
- OffsetY: determines the starting row for the region of interest.
- Width: determines the width of the region of interest.
- Height: determines the height of the region of interest.

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

Guideline	Example
Offset X + ROI width < Width of camera sensor	puA1280-54um: Offset X: 463, ROI width: 500 Width of camera sensor: 1280 463 + 500 < 1280
Offset Y + ROI height < Height of camera sensor	puA1280-54um: Offset Y: 351, ROI height: 200 Height of camera sensor: 960 351 + 200 < 960

Table 16: Guidelines for Setting the Camera's ROI

ROI Parameters	Camera Model	Parameter Range	Example
OffsetX OffsetY	puA1280-54um/uc puA1600-60um/uc puA1920-15um puA1920-30um/uc puA2500-14um/uc	<ul style="list-style-type: none"> <li>■ Can be set in increments of 2</li> <li>■ Must be set to an even number</li> </ul>	0, 2, 4, 6, 8, etc.
Width	puA1280-54um/uc puA1600-60um/uc	<ul style="list-style-type: none"> <li>■ Can be set in increments of 2</li> <li>■ Minimum value is 16</li> </ul>	16, 18, 20, 22, 24, etc.
	puA1920-15um puA1920-30um/uc puA2500-14um/uc	<ul style="list-style-type: none"> <li>■ Can be set in increments of 2</li> <li>■ Minimum value is 4</li> </ul>	4, 6, 8, 10, 12, etc.
Height	puA1280-54um/uc puA1600-60um/uc	<ul style="list-style-type: none"> <li>■ Can be set in increments of 2</li> <li>■ Minimum value is 8</li> </ul>	8, 10, 12, 14, 16, etc.
	puA1920-15um puA1920-30um/uc puA2500-14um/uc	<ul style="list-style-type: none"> <li>■ Can be set in increments of 2</li> <li>■ Minimum value is 4</li> </ul>	4, 6, 8, 10, 12, etc.

Table 17: ROI Parameters and Parameter Ranges

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

```
int64_t i = camera.WidthMax.GetValue();
int64_t i = camera.HeightMax.GetValue();

camera.Width.SetValue(1294);
camera.Height.SetValue(964);

camera.OffsetY.SetValue(0);
camera.OffsetX.SetValue(0);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## Changing ROI Parameters "On-the-Fly"

Making ROI parameter changes "on-the-fly" means making the parameter changes while the camera is capturing images continuously.

On-the-fly changes are only allowed for the following parameters:

- OffsetX
- OffsetY

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

## 7.8 Binning

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

### Binning Directions

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

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

You can use both horizontal and vertical binning at the same time. However, if you use a different binning factor for horizontal and vertical binning, objects will appear distorted in the image. For more information about possible image distortion, see Section 7.8.3 on [page 71](#).

The number of binned pixels depends on the horizontal binning and the vertical binning settings. For more information about the binning settings, see Section 7.8.1 on [page 68](#).

### Binning Modes

Two modes can be used to perform binning:

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

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

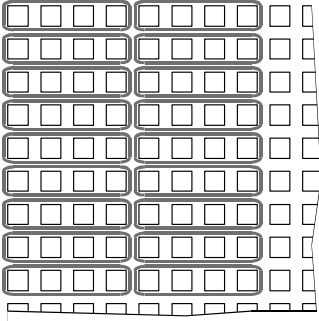
On some camera models, the binning modes used by the camera are preset and can't be changed.

On other camera models, the binning modes can be set. For more information, see Section 7.8.2 on [page 70](#).

## Binning on Color and Monochrome Cameras

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

**Horizontal Binning by 4**



**Vertical Binning by 2**

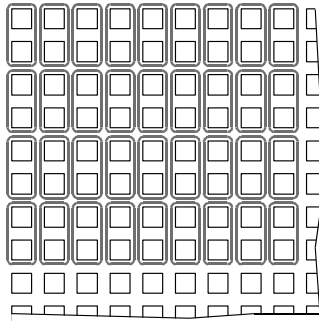
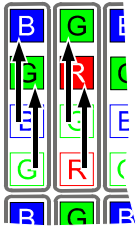


Fig. 26: Binning on Monochrome Cameras

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

**Vertical Color Binning by 2**



**Horizontal Color Binning by 2**

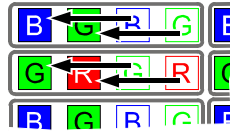


Fig. 27: Binning on Color Cameras

## 7.8.1 Setting Binning

You can enable

- **horizontal binning** by setting the **BinningHorizontal** parameter.
- **vertical binning** by setting the **BinningVertical** parameter.

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



**Always set the BinningHorizontal parameter first, then set the BinningVertical parameter.**

If the BinningHorizontal parameter is not set first, some combinations of vertical binning and horizontal binning can't be achieved.

For a list of allowed combinations, see Table 18.

**Example:** On puA1280-54um/uc cameras, you can't set the BinningVertical parameter to 2 when the BinningHorizontal parameter is set to 1. Set the BinningHorizontal parameter to 2 first, then set the BinningVertical parameter to 2.

The range of allowed settings for the BinningHorizontal and the BinningVertical parameter values varies by camera model as shown in Table 18.

Camera Model	Allowed Settings BinningHorizontal	Allowed Settings BinningVertical	Allowed Combinations (H x V Binning)	Notes
puA1280-54um/uc	1, 2	1, 2	1 x 1 2 x 1 2 x 2	
puA1600-60um/uc	1, 2	1, 2	1 x 1 2 x 2	
puA1920-15um puA1920-30um/uc puA2500-14um/uc	1, 2, 3 (*), 4	1, 2, 3, 4	All	* Horizontal binning by 3 is not supported. Setting the parameter value to 3 is allowed, but will result in an effective horizontal binning by 2.

Table 18: Binning Horizontal and Binning Vertical Settings

You can set the Binning Horizontal and the BinningVertical 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 horizontal binning by 4
camera.BinningHorizontal.SetValue(4);
// Enable vertical binning by 2
camera.BinningVertical.SetValue(2);
// Disable horizontal and vertical binning
camera.BinningVertical.SetValue(1);
camera.BinningHorizontal.SetValue(1);
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.8.2 Setting the Binning Mode

If supported, you can set the

- **horizontal binning mode** by setting the **BinningHorizontalMode** parameter.
- **vertical binning mode** by setting the **BinningVerticalMode** parameter.



**Always set the BinningHorizontalMode parameter first, then set the BinningVerticalMode parameter.**

If the BinningHorizontalMode parameter is not set first, some combinations of the binning horizontal mode and the binning vertical mode can't be achieved.

For a list of allowed combinations, see Table 19.

**Example:** On puA1600-60um/uc cameras, you can't set the BinningVerticalMode parameter to Sum when the BinningHorizontalMode parameter is set to Average. Set the BinningHorizontalMode parameter to Sum first, then set the BinningVerticalMode parameter to Sum.

The range of allowed settings for the BinningHorizontalMode and the BinningVerticalMode parameter values varies by camera model as shown in Table 19.

Camera Model	Allowed Settings BinningHorizontalMode Parameter	Allowed Settings BinningVerticalMode Parameter	Allowed Combinations (H x V Binning Mode)
puA1280-54um/uc	Average	Average	Average x Average
puA1600-60um/uc	Average, Sum	Average, Sum	Average x Average Sum x Sum
puA1920-15um puA1920-30um/uc puA2500-14um/uc	Average, Sum	Average	Average x Average Sum x Average

Table 19: Binning Mode Horizontal and Binning Mode Vertical Settings

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

```
// Set the horizontal binning mode to Average
camera.BinningHorizontalMode.SetValue(BinningHorizontalMode_Average);
// Set the vertical binning mode to Sum
camera.BinningVerticalMode.SetValue(BinningVerticalMode_Sum);
// Determine the vertical binning mode
e = camera.BinningVerticalMode.GetValue();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.8.3 Considerations When Using Binning

### Binning's Effect on ROI Settings

When you have the camera set to use binning, keep in mind that the settings for your image region of interest (ROI) will refer to the binned rows and columns in the sensor and not to the physical rows and columns in the sensor as they normally would.

For example, assume that you are using an puA1280-54um camera set for 2 by 2 binning as described above. In this case, you would act as if you were actually working with a 640 column by 480 row sensor when setting your ROI parameters.

For more information about the Image Region of Interest (ROI) feature, see Section 7.7 on [page 64](#).

### Increased Response to Light

Using binning with summed pixel values (see "Binning Modes" in Section 7.8 on [page 67](#)) can greatly increase the camera's response to light. When pixel values are summed, the acquired images may look overexposed. If this is the case, you can reduce the lens aperture, the intensity of your illumination, the camera's exposure time setting, or the camera's gain setting.

### Reduced Resolution

Using binning effectively reduces the resolution of the camera's imaging sensor. For example, the sensor in the puA1280-54um camera normally has a resolution of 1280 (H) x 960 (V). If you set this camera to use horizontal binning by 2 and vertical binning by 2, the effective resolution of the sensor is reduced to 640 (H) by 480 (V).

### Possible Image Distortion

Objects will only appear undistorted in the image if the numbers of binned lines and columns are equal. With all other combinations, the imaged objects will appear distorted. If, for example, vertical binning by 2 is combined with horizontal binning by 4, the widths of the imaged objects will appear shrunk by a factor of 2 compared to the heights.

## 7.9 Reverse X and Reverse Y

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

Reverse X and Reverse Y can be enabled at the same time. This effectively rotates the image by 180 degrees.

### 7.9.1 Reverse X

The Reverse X feature is a horizontal mirror image feature. When Reverse X is enabled, the pixel values for each line in a captured image will be swapped end-for-end about the line's center. This means that for each line, the value of the first pixel in the line will be swapped with the value of the last pixel, the value of the second pixel in the line will be swapped with the value of the next-to-last pixel, and so on.

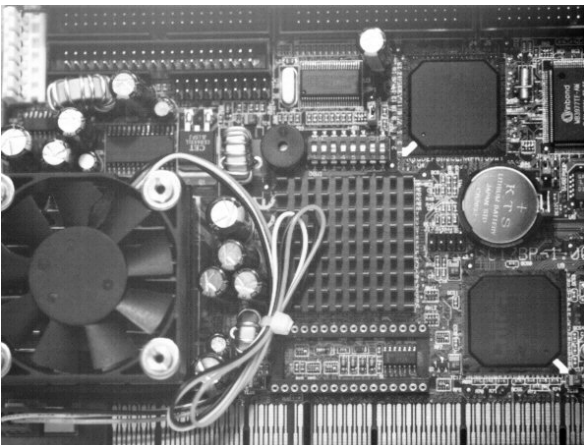


If you are using pulse model puA1600-60uc, puA1920-30uc, or puA2500-14uc, the effective Bayer color pixel alignment will change from GB to BG if you enable reverse X.

For more information about color pixel alignments, see Section 7.6 on [page 56](#).

Figure 28 shows a normal image on the left and an image captured with reverse X enabled on the right.

**Normal Image**



**Mirror Image**

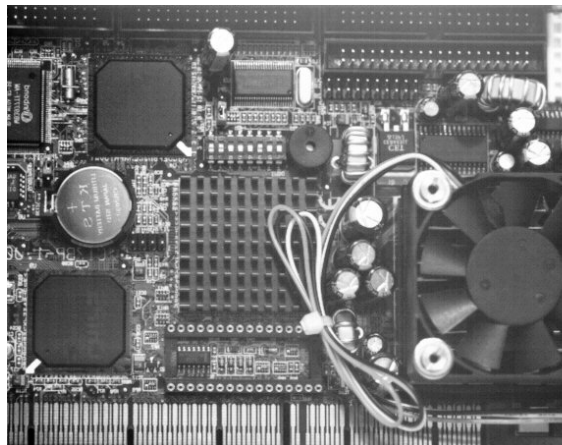


Fig. 28: Reverse X Mirror Imaging



## Using ROIs with Reverse X

You can use the Image ROI and Auto Function ROI features when using the Reverse X feature. The position of an ROI relative to the sensor remains the same regardless of whether or not the Reverse X feature is enabled.

As a consequence, different regions of the image will be controlled or displayed depending on whether or not the Reverse X feature is enabled. See example in [Figure 29](#).

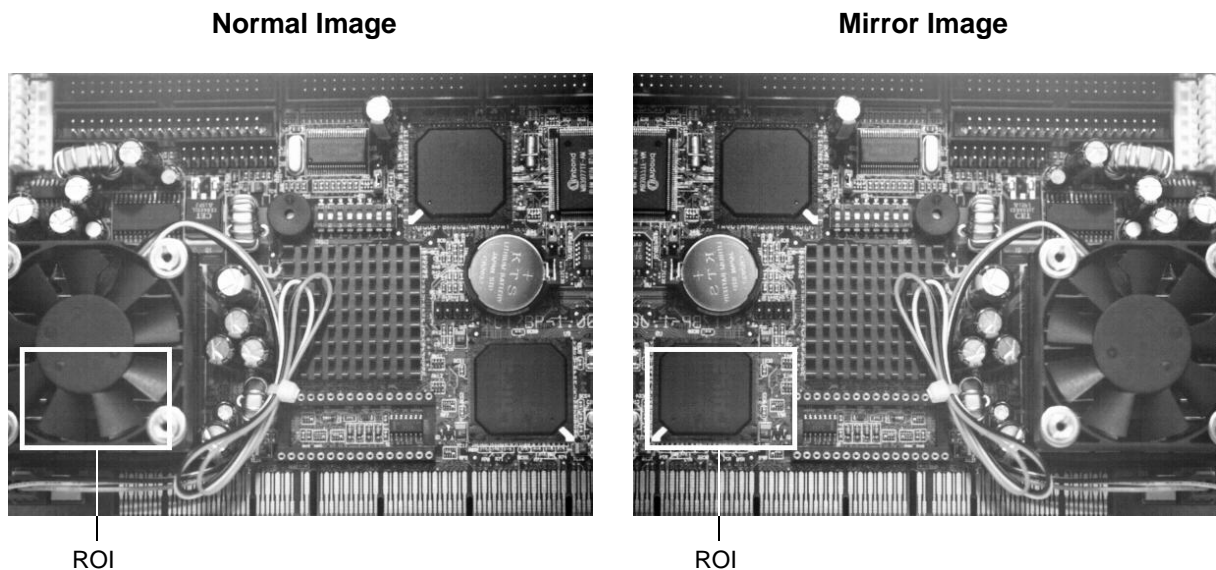


Fig. 29: Using an ROI with Reverse X Mirror Imaging

## 7.9.2 Reverse Y

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



If you are using pulse model puA1600-60uc, puA1920-30uc, or puA2500-14uc, the effective Bayer color pixel alignment will change from GB to RG if you enable reverse Y.

For more information about color pixel alignments, see [Section 7.6 on page 56](#).

Figure 30 shows a normal image on the left and an image captured with reverse Y enabled on the right.

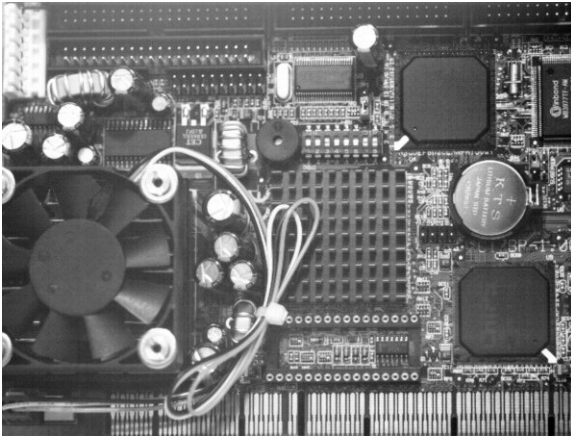
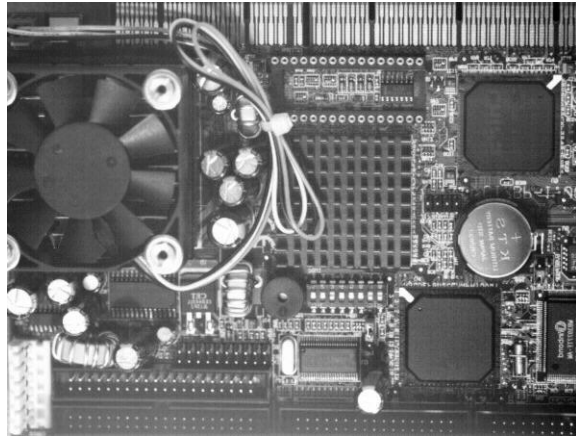
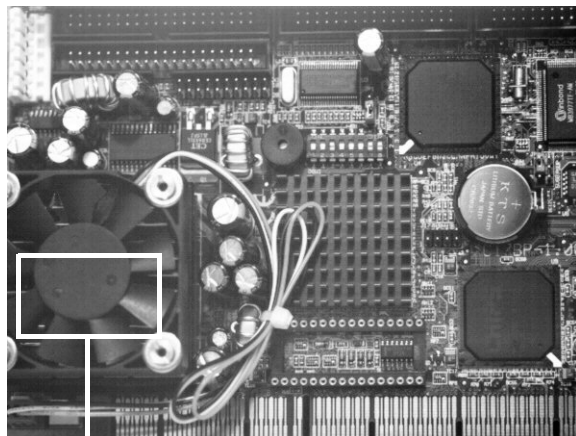
**Normal Image****Reverse Y Mirror Image**

Fig. 30: Reverse Y Mirror Imaging

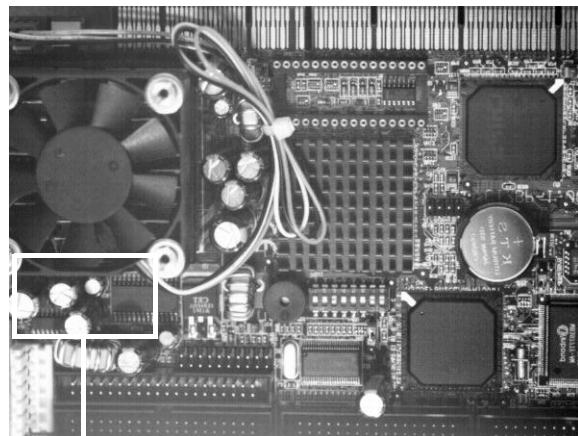
## Using ROIs with Reverse Y

You can use the Image ROI and Auto Function ROI features when using the Reverse Y feature. The position of an ROI relative to the sensor remains the same regardless of whether or not the Reverse Y feature is enabled.

As a consequence, different regions of the image will be controlled or displayed depending on whether or not the Reverse Y feature is enabled. See example in [Figure 31](#).

**Normal Image**

ROI

**Reverse Y Mirror Image**

ROI

Fig. 31: Using an ROI with Reverse Y Mirror Imaging

## 7.9.3 Enabling Reverse X and Reverse Y

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

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.10 Defect Pixel Correction

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

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

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

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.11 Auto Functions

Auto functions control image properties and are the automatic counterparts of certain features such as the Gain feature or the Balance White feature, which require manually setting the related parameter values.



**By default, all auto functions (exposure auto, balance white auto, and gain auto) are enabled.** They are set to the continuous mode of operation (see Section 7.11.1 on [page 77](#)).

If you want to manually set the parameter values for gain, exposure time, or white balance, you must first set the corresponding auto function parameter (ExposureAuto, BalanceWhiteAuto, or GainAuto) to Off.

After camera power up or reset, all auto functions will be re-enabled unless you define a startup set with auto functions turned off. For more information about the startup set, see Section 7.15 on [page 92](#).

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

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

The manual setting of the parameter value is not preserved. For example, when the gain auto function adjusts the Gain parameter value, the manually set Gain parameter value is not preserved.

Generally, the different auto functions can operate at the same time. For more information, see the following sections describing the individual auto functions.



A target value for an image property can only be reached if it is in accord with all pertinent camera settings and with the general circumstances used for capturing images. Otherwise, the target value will only be approached.

For example, with a short exposure time, insufficient illumination, and a low setting for the upper limit of the Gain parameter value, the gain auto function may not be able to achieve the current target value setting for the image.

## 7.11.1 Auto Function Operating Modes

The following auto function modes of operation are available:

- All auto functions provide the **Once** mode of operation. When the Once mode of operation is selected, the parameter values are automatically adjusted until the related image property reaches the target value. After the automatic parameter value adjustment is complete, the auto function will automatically be set to Off and the new parameter value will be applied to the following images.

The parameter value can be changed by using the Once mode of operation again, by using the Continuous mode of operation, or by manual adjustment.



If an auto function is set to the Once operation mode and if the circumstances will not allow reaching a target value for an image property, the auto function will try to reach the target value for a maximum of 50 images and will then be set to Off.

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

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

The repeated automatic adjustment will proceed until the Once mode of operation is used or until the auto function is set to Off.

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



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



If you have set an auto function to Once or Continuous operation mode while the camera was continuously capturing images, the auto function will become effective with a short delay and the first few images may not be affected by the auto function.

## 7.11.2 Auto Function ROI

The Auto Function Region of Interest (ROI) feature lets you specify a part of the sensor array that will be used for auto function control.

The settings for the Auto Function ROI feature are not tied to the settings for the Image ROI feature. For more information about the Image ROI feature, see Section 7.7 on [page 64](#).

All pulse cameras provide two Auto Function ROIs. For both Auto Function ROIs, you can specify a separate part of the sensor array.

Each Auto Function ROI serves as the base for specific auto functions:

- The pixel data from **Auto Function ROI 1** serves as the base for **Exposure Auto** and **Gain Auto**. The Auto Function ROI settings are always identical for both auto functions. This does not imply, however, that Gain Auto and Exposure Auto must always be used at the same time.
- The pixel data from **Auto Function ROI 2** serves as the base for **Balance White Auto**.

These presets are fixed and can't be changed.

The location and size of an Auto Function ROI is defined by declaring an X offset, a Y offset, a width, and a height. Auto Function ROIs are referenced to the top left corner of the sensor array (column 0, row 0).

For example, suppose that you specify the X offset as 14, the width as 5, the Y offset as 7, and the height as 6. This sets the following Auto Function ROI:

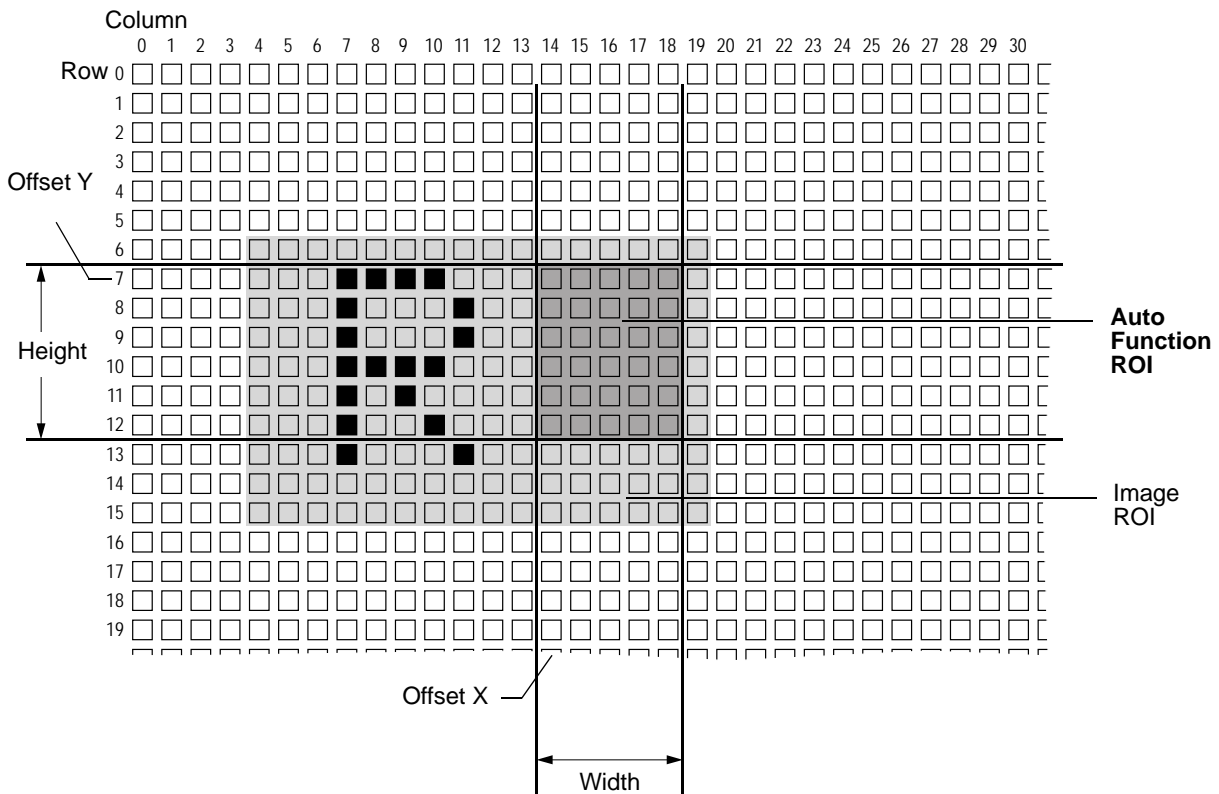


Fig. 32: Auto Function Region of Interest and Image Region of Interest

## 7.11.2.1 Setting an Auto Function ROI

By default, all Auto Function ROIs are set to the full resolution of the camera's sensor. However, you can change their positions and sizes as desired.

### To set an Auto Function ROI:

1. Select the Auto Function ROI that you want to configure. You can do this by setting the `AutoFunctionROISelector` parameter to `ROI1` or `ROI2`.
2. Set the position and size of the selected Auto Function ROI by changing the following parameters:
  - `AutoFunctionROIOffsetX`
  - `AutoFunctionROIOffsetY`
  - `AutoFunctionROIWidth`
  - `AutoFunctionROIHeight`

When you are setting an Auto Function ROI, you must follow these guidelines:

Guideline	Example
$\text{AutoFunctionROIOffsetX} + \text{AutoFunctionROIWidth} \leq \text{Width of camera sensor}$	puA1600-60um: $\text{AutoFunctionROIOffsetX} + \text{AutoFunctionROIWidth} \leq 1600$
$\text{AutoFunctionROIOffsetY} + \text{AutoFunctionROIHeight} \leq \text{Height of camera sensor}$	puA1600-60um: $\text{AutoFunctionROIOffsetY} + \text{AutoFunctionROIHeight} \leq 1200$

You can configure an Auto Function ROI from within your application software by using the Basler pylon API. The following code snippets illustrate using the API to select an Auto Function ROI and set its size and position:

```
// Select Auto Function ROI 1
camera.AutoFunctionROISelector.SetValue(AutoFunctionROISelector_ROI1);
// Set position and size for the selected Auto Function ROI
camera.AutoFunctionROIOffsetX.SetValue(10);
camera.AutoFunctionROIOffsetY.SetValue(10);
camera.AutoFunctionROIWidth.SetValue(500);
camera.AutoFunctionROIHeight.SetValue(400);
```

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 25](#).



- On color cameras, you must set the parameters for position and size to even values (divisible by 2). This matches the Auto Function ROI with the color filter pattern of the sensor.
- If the Binning feature is enabled, the Auto Function ROI settings refer to the binned lines and columns and not to the physical lines in the sensor as they normally would. For more information about the Binning feature, see Section 7.8 on [page 67](#).
- If the Reverse X or the Reverse Y feature or both are enabled, the position of the Auto Function ROI relative to the sensor remains the same. As a consequence, different regions of the image will be controlled depending on whether or not Reverse X or Reverse Y or both are enabled. For more information about the Reverse X and Reverse Y features, see Section 7.9 on [page 72](#).

### 7.11.2.2 Overlap Between Auto Function ROI and Image ROI

The size and position of an Auto Function ROI can be, but need not be, identical to the size and position of the Image ROI.

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

Different degrees of overlap are illustrated in [Figure 33](#). The hatched areas in the figure indicate areas of overlap.

- If the Auto Function ROI is completely included in the Image ROI (see (a) in [Figure 33](#)), the pixel data from the Auto Function ROI will be used to control the image property.
- If the Image ROI is completely included in the Auto Function ROI (see (b) in [Figure 33](#)), only the pixel data from the Image ROI will be used to control the image property.
- If the Image ROI only partially overlaps the Auto Function ROI (see (c) in [Figure 33](#)), only the pixel data from the area of partial overlap will be used to control the image property.
- If the Auto Function ROI does not overlap the Image ROI (see (d) in [Figure 33](#)), the auto function will **not work**.



- The minimum overlap between Auto Function ROI and Image ROI is  $4 \times 4$  pixels. If a lower overlap is set (e.g.  $4 \times 2$  pixels), the related auto function will **not work**.
- Basler strongly recommends completely including the Auto Function ROI within the Image ROI or choosing identical positions and sizes for Auto Function ROI and Image ROI.



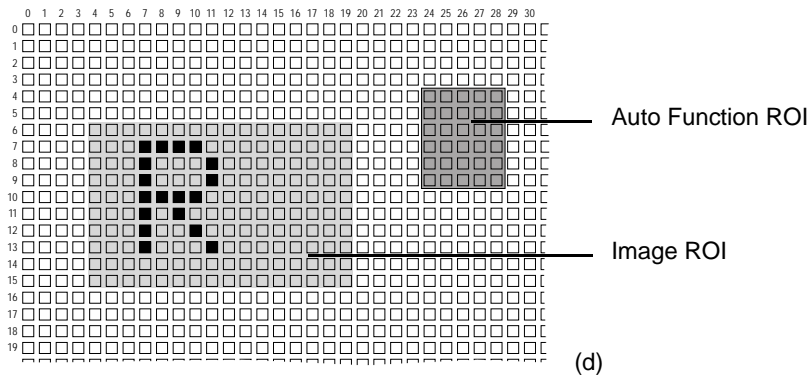
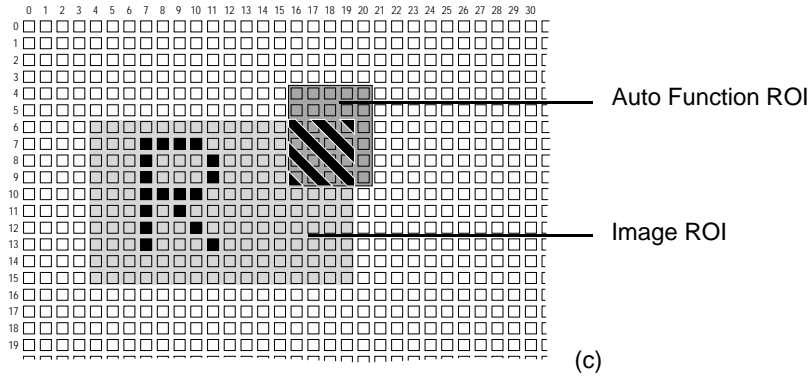
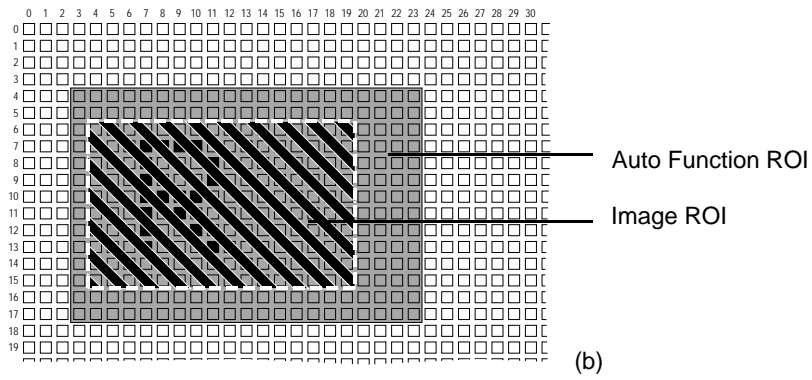
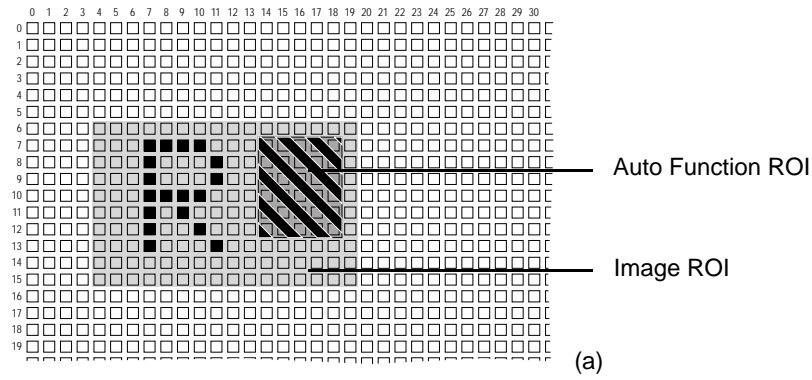


Fig. 33: Various Degrees of Overlap Between the Auto Function ROI and the Image ROI

## 7.11.3 Gain Auto

Gain Auto is the automatic counterpart to manually setting the Gain parameter. The gain auto function automatically adjusts the Gain parameter value within set limits until a target brightness value for the pixel data is reached.

The gain auto function can be operated in the Once and Continuous modes of operation.

The gain auto function and the exposure auto function can be used at the same time. In this case, however, you must also set the Auto Function Profile feature.

For more information about

- setting the gain manually, see Section 7.2 on [page 50](#).
- the Auto Function Profile feature, see Section 7.11.6 on [page 85](#).

### Lower and Upper Limits

The limits within which the camera will adjust the Gain parameter are defined by the AutoGainUpperLimit and the AutoGainLowerLimit parameters.

**Example:** You set AutoGainLowerLimit to 2 and AutoGainUpperLimit to 6. During automatic adjustments, the Gain parameter value will never be lower than 2 and never be higher than 6.

### Target Value

When the gain auto function is enabled, it adjusts the gain until a target brightness, i.e., an average gray value, is reached. You can set the target value using the AutoTargetBrightness parameter.

The parameter value range refers to the theoretically maximum available range of gray values for the set pixel format.

**Example:** If an 8-bit pixel format is set, the maximum gray value is 256. Therefore, a parameter value of 0.5 corresponds to a gray value of 128.



The target value calculation does not include gamma correction. Depending on the gamma correction value set, images output by the camera may have a significantly lower or higher average gray value than indicated by the AutoTargetBrightness parameter value.

For example, if you set the pixel format to YCbCr422 and AutoTargetBrightness to 0.5, images output by the camera will have a higher average gray value than 128. This is because an additional sRGB gamma correction value is applied after the target value calculation has been performed.

For more information about gamma correction, see Section 7.4 on [page 52](#).

**To set the gain auto function:**

1. Set the value of the AutoGainLowerLimit and AutoGainUpperLimit parameters.
2. Set the value of the AutoTargetBrightness parameter.
3. Set the value of the GainAuto parameter for the Once or the Continuous mode of operation.

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

```
// Set the lowest possible lower limit and the highest possible
// upper limit for the gain auto function
camera.AutoGainLowerLimit.SetValue(camera.AutoGainLowerLimit.GetMin());
camera.AutoGainUpperLimit.SetValue(camera.AutoGainUpperLimit.GetMax());
// Set the target average gray value to 60% of the maximum gray value
camera.AutoTargetBrightness.SetValue(0.6);
// Enable Gain Auto by setting the operation mode to Continuous
camera.GainAuto.SetValue(GainAuto_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 25](#).
- auto functions, see Section 7.11 on [page 76](#).

## 7.11.4 Exposure Auto

Exposure Auto is the automatic counterpart to manually setting the ExposureTime parameter. The exposure auto function automatically adjusts the ExposureTime parameter value within set limits until a target brightness value for the pixel data is reached.

The exposure auto function can be operated in the Once and Continuous modes of operation.

The exposure auto function and the gain auto function can be used at the same time. In this case, however, you must also set the Auto Function Profile feature.

For more information about setting the exposure time manually, see Section 5.3 on [page 36](#).

For more information about the Auto Function Profile feature, see Section 7.11.6 on [page 85](#).

## Lower and Upper Limits

The limits within which the camera will adjust the `AutoExposureTime` parameter are defined by the `AutoExposureTimeUpperLimit` and the `AutoExposureTimeLowerLimit` parameters.

**Example:** You set `AutoExposureTimeLowerLimit` to 100 and `AutoExposureTimeUpperLimit` to 5000. During automatic adjustments, the exposure time will never be lower than 100 ms and never be higher than 5000 ms.



If the `AutoExposureTimeUpperLimit` parameter is set to a sufficiently high value, the camera's frame rate can be decreased.

## Target Value

When the exposure auto function is enabled, it adjusts the exposure time until a target brightness, i.e., an average gray value, is reached. You can set the target value using the `AutoTargetBrightness` parameter.

The parameter value range refers to the theoretically maximum available range of gray values for the set pixel format.

For example, if an 8-bit pixel format is set, the maximum gray value is 256. Therefore, a parameter value of 0.5 corresponds to a gray value of 128.



The target value calculation does not include gamma correction. Depending on the gamma correction value set, images output by the camera may have a significantly lower or higher average gray value than indicated by the `AutoTargetBrightness` parameter value.

For example, if you set the pixel format to `YCbCr422` and `AutoTargetBrightness` to 0.5, images output by the camera will have a higher average gray value than 128. This is because an additional sRGB gamma correction value is applied after the target value calculation has been performed.

For more information about gamma correction, see Section 7.4 on [page 52](#).

### To set the exposure auto function:

1. Set the value of the `AutoExposureTimeLowerLimit` and `AutoExposureTimeUpperLimit` parameters.
2. Set the value of the `AutoTargetBrightness` parameter.
3. Set the value of the `ExposureAuto` parameter for the Once or the Continuous mode of operation.

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

```
// Set the lowest possible lower limit and the highest possible
// upper limit for the exposure auto function
```

```
camera.AutoExposureTimeLowerLimit.SetValue(camera.AutoExposureTimeLowerLimit.GetMin());
camera.AutoExposureTimeUpperLimit.SetValue(camera.AutoExposureTimeUpperLimit.GetMax());
// Set the target average gray value to 60% of the maximum gray value
camera.AutoTargetBrightness.SetValue(0.6);
// Enable Exposure Auto by setting the operation mode to 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 25](#).

For general information about auto functions, see Section 7.11 on [page 76](#).

## 7.11.5 Balance White Auto

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

For more information about white balance and setting the white balance manually, see Section 7.6.3 on [page 59](#).

To set the balance white auto function using the Basler pylon API, set the value of the BalanceWhiteAuto parameter for the Once or the Continuous mode of operation.

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

For general information about auto functions, see Section 7.11 on [page 76](#).

## 7.11.6 Auto Function Profile



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

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

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

All Basler pulse cameras support the following auto function profiles:

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

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

#### To set the auto function profile:

1. Set the value of the `AutoFunctionProfile` parameter to
  - `AutoFunctionProfile_MinimizeGain`,
  - `AutoFunctionProfile_MinimizeExposureTime`,
  - `AutoFunctionProfile_Smart`,
  - `AutoFunctionProfile_AntiFlicker50Hz`, or
  - `AutoFunctionProfile_AntiFlicker60Hz`.
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, the `MinimizeGain` auto function profile is set:

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.12 Backlight Compensation



The Backlight Compensation feature will only take effect if the gain auto function or the exposure auto function or both are enabled. For more information about auto functions, see Section 7.11 on [page 76](#).

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

You can adjust the backlight compensation by setting the value of the `AutoBacklightCompensation` parameter. The parameter value can range from 0 to 0.5.

When the `AutoBacklightCompensation` parameter value is set, a given percentage of the brightest pixels in the image (i.e. the pixels with the highest pixel values) will not be taken into account for the target value calculations. These calculations are performed by the gain auto function and the exposure auto function (see Section 7.11.3 on [page 82](#) and Section 7.11.4 on [page 83](#)).

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

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

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.13 Test Patterns

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

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

### Enabling a Test Pattern

The TestPattern parameter is used to set the camera to output a test pattern. You can set the value of the TestPattern parameter to one of the test patterns or to Off.

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

### Test Pattern 1: Gray Diagonal Sawtooth (8 bit)

The test pattern "Gray Diagonal Sawtooth" (8 bit) is best suited for use when the camera is set for monochrome 8-bit output. The test pattern consists of fixed diagonal gray gradients ranging from 0 to 255.

If the camera is set for 8-bit output and is operating at full resolution, test pattern 1 will look similar to Figure 34.



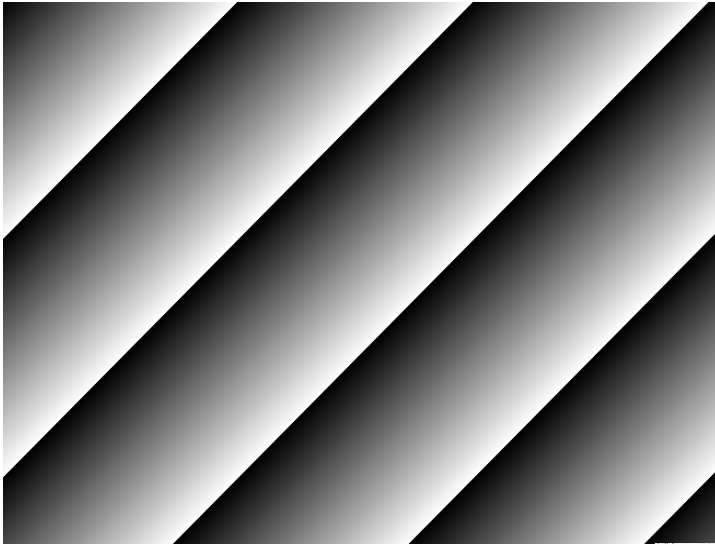


Fig. 34: Test Pattern 1

### Test Pattern 2: Color Diagonal Sawtooth

The test pattern "Color Diagonal Sawtooth" is available on color cameras only. As shown in Figure 35, the test pattern consists of diagonal color gradients.

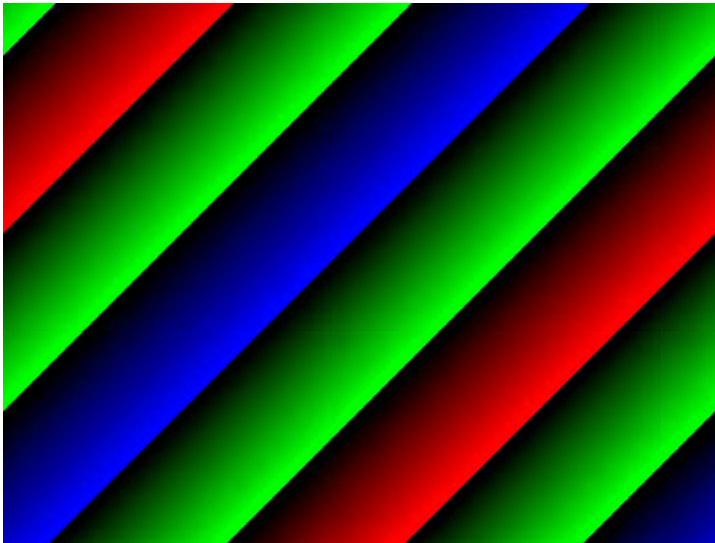


Fig. 35: Test Pattern 2

## 7.14 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) - contains the camera vendor's name.
- DeviceModelName (read only) - contains the model name of the camera.
- DeviceManufacturerInfo (read only) - can contain some information about the camera manufacturer. This string is usually empty.
- DeviceVersion (read only) - contains the device version number for the camera.
- DeviceFirmwareVersion (read only) - contains the version of the firmware in the camera.
- DeviceSerialNumber (read only) - contains 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 and the Basler pylon USB Configurator. The name will also be visible in the "friendly name" field of the device information objects returned by pylon's device enumeration procedure.
- DeviceScanType (read only) - contains the scan type of the camera, for example, area scan.
- SensorWidth (read only) - contains the physical width of the sensor in pixels.
- SensorHeight (read only) - contains the physical height of the sensor in pixels.
- MaxWidth (read only) - Indicates the camera's maximum region of interest (ROI) width setting for the current OffsetX settings.
- MaxHeight (read only) - Indicates the camera's maximum region of interest (ROI) height setting for the current OffsetY settings.

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

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

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

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

// Read the DeviceVersionparameter
GenICam::gcstring s = camera.DeviceVersion.GetValue();

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

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

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

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

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

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

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

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

You can also use

- the Basler pylon Viewer application to easily read the parameters and to read or set the DeviceUserID parameter.
- the Basler pylon USB Configurator to set the DeviceUserID parameter.

For more information about the pylon API, the pylon Viewer, and the pylon USB Configurator, see Section 3.1 on [page 25](#).

## 7.15 Configuration Sets and User Sets

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

There are three basic types of configuration sets: the active set, the factory set, and user sets. In addition, you can designate a startup set.

### Active Set

The active 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 direct register access, you are making changes to the active set. The active set is located in the camera's volatile memory and the settings are lost, if the camera is reset or if power is switched off.

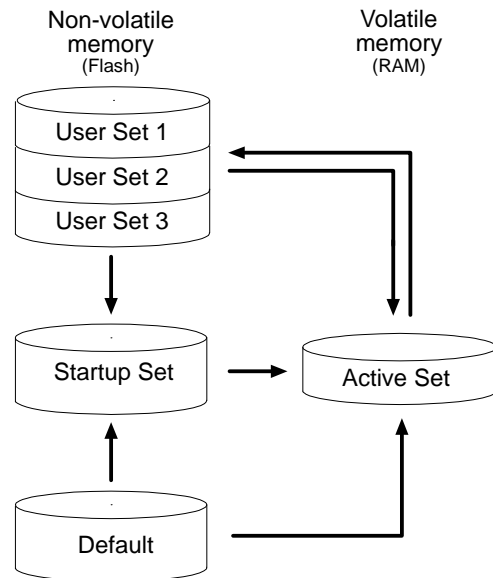


Fig. 36: Configuration Sets

### Factory Set (Default)

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

In the Default set,

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

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

For more information about

- auto functions, see Section 7.11 on [page 76](#).
- the Smart auto function profile, see Section 7.11.6 on [page 85](#).

## User Sets

There are three reserved areas in the camera's non-volatile memory available for saving configuration sets that can be customized by the user. These sets are not lost when the camera is reset or switched off. They are commonly referred to as "user sets".

The three available user sets are called User Set 1, User Set 2, and User Set 3.

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

## Startup Set

You can designate the factory set or one of the user sets as the "startup" set. The designated startup set will automatically be loaded into the active set whenever the camera starts up at power on or after a reset.

For more information about designating the startup set, see Section 7.15.3 on [page 95](#).

## 7.15.1 Saving a User Set

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

### To save the currently active set into a user set:

1. Make changes to the camera's settings until the camera is operating in a manner that you would like to save.
2. Set the `UserSetSelector` parameter to `UserSet1`, `UserSet2`, or `UserSet3`.
3. Execute a `UserSetSave` command to save the active set to the selected user set.



#### Saving an active set to a user set

- will overwrite any parameters that were previously saved in that user set.
- is only allowed when the camera is idle, i.e. when it is not acquiring images continuously or does not have a single image acquisition pending.

You can save a user set from within your application software by using the pylon API. The following code snippet illustrates using the API to select User Set 1 and to execute the save command:

```
camera.UserSetSelector.SetValue(UserSetSelector_UserSet1);
camera.UserSetSave.Execute();
```

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

For more information about the Basler pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.15.2 Loading a User Set or the Factory Set into the Active Set

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

The loaded set overwrites the parameter settings in the active set. The settings from the loaded set will now be controlling the camera.

### To load a user set or the factory set into the active set:

1. Set the UserSetSelector to UserSet1, UserSet2, UserSet3, or to Default.
2. Execute a UserSetLoad command to load the selected set into the active set.

You can set the UserSetSelector and execute the UserSetLoad command from within your application software by using the pylon API. The following code snippets illustrate using the API select User Set 2 and execute the load command:

```
camera.UserSetSelector.SetValue(UserSetSelector_UserSet2);  
camera.UserSetLoad.Execute();
```



Loading a user set or the factory set into the active set is only allowed when the camera is idle, i.e. when it is not acquiring images continuously or does not have a single image acquisition pending.

Loading the Default set with the standard factory setup into the active set is recommended if you have misadjusted the settings in the camera and you are not sure how to recover. The standard factory setup is optimized for use in typical situations and will provide good camera performance in most cases.

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

For more information about the Basler pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).

## 7.15.3 Designating the Startup Set

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

The configuration set that you designate as the startup set will be loaded into the active set whenever the camera starts up at power on or after a reset.

Designating a startup set is only allowed when the camera is idle, i.e. when it is not acquiring images continuously or does not have a single image acquisition pending.

### To designate a user set or the factory set as the startup set:

1. Set the UserSetDefault parameter to UserSet1, UserSet2, UserSet3, or to Default.

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

```
camera.UserSetDefault.SetValue(UserSetDefault_UserSet1);
```

For more information about the Basler pylon API and the pylon Viewer, see Section 3.1 on [page 25](#).



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

1. Set the UserSetDefault parameter to Default.
2. Restart the camera.

# 8 Troubleshooting and Support

## 8.1 Tech Support Resources

If you need advice about your camera or if you need assistance troubleshooting a problem with your camera, you can contact the Basler technical support team for your area. Basler technical support contact information is located in the front pages of this manual.

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

If you do decide to contact Basler technical support, please take a look at Section 8.3 on [page 97](#) before you call. The section gives information about assembling relevant data that will help the Basler technical support team to help you with your problem.

## 8.2 Obtaining an RMA Number

Whenever you want to return material to Basler, you must request a Return Material Authorization (RMA) number before sending the material back. The RMA number **must** be stated in your delivery documents when you ship your material to us! Please be aware that, if you return material without an RMA number, we reserve the right to reject the material.

You can find detailed information about how to obtain an RMA number in the Support section of the Basler website: [www.baslerweb.com](http://www.baslerweb.com)



## 8.3 Before Contacting Basler Technical Support

To help you as quickly and efficiently as possible when you have a problem with a Basler camera, it is important that you collect several pieces of information before you contact Basler technical support. Basler technical support contact information is shown in the title section of this manual.

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

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

### To automatically generate support information:

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

### To use a prepared e-mail:

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

### To use the form:

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

1 The camera's product ID: \_\_\_\_\_

2 The camera's serial number: \_\_\_\_\_

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

Do you use a hub?

 Yes No

4 Describe the problem in as much detail as possible:  
(If you need more space, use an extra sheet of paper.)  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

5 If known, what's the cause of the problem?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

6 When did the problem occur?  After start.  While running.

After a certain action (e.g., a change of parameters):

7 How often did/does the problem occur?  Once.  Every time.

Regularly when:  
\_\_\_\_\_  
\_\_\_\_\_

Occasionally when:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- 8 How severe is the problem?
- Camera can still be used.
- Camera can be used after I take this action:  
\_\_\_\_\_  
\_\_\_\_\_
- Camera can no longer be used.

- 9 Did your application ever run without problems?  Yes  No

10 Parameter set

It is very important for Basler technical support to get a copy of the exact camera parameters that you were using when the problem occurred.

To make note of the parameters, use the Basler pylon Viewer.

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

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

11 Live image/test 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.

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## Revision History

Doc. ID Number	Date	Changes
AW00134501000	08 Jul 2015	Initial release of the document.
AW00134502000	13 Oct 2015	<p>Added information for the new puA1600-60um/uc cameras throughout the manual.</p> <p>Changed camera parameter names to camel case (e.g. Binning Vertical to BinningVertical) throughout the manual.</p> <p>Removed "Image Acquisition Triggering" entry in Table 1 and Table 2 in Section 1.2 on page 8.</p> <p>Rearranged information about the maximum lens intrusion and added Table 3 in Section 1.4.2 on page 16.</p> <p>Removed information related to the trigger width exposure mode in Section 5.5 on page 39.</p> <p>Moved Table 17 ("Binning Mode Horizontal and Binning Mode Vertical Settings", former Table 15) to Section 8.6.2 on page 65.</p> <p>Reduced the number of illustrations to explain binning in Section 8.6 on page 62.</p> <p>Rearranged Table 16 and Table 17 in Section 8.6.1 on page 64 and Section 8.6.2 on page 65.</p> <p>Renamed "target average gray" to "target brightness" throughout Section 8.9 on page 71 for consistency with the AutoTargetBrightness parameter name.</p> <p>Rephrased Section 8.13 on page 83 for consistent terminology (user sets, factory set, active set, startup set).</p> <p>Corrected the description of the gain auto function (removed auto function ROI reference) in Section 8.9.2 on page 73.</p>

Doc. ID Number	Date	Changes
AW00134503000	12 Apr 2016	<p>Minor modifications and corrections throughout the manual.</p> <p>Updated information about UL conformity in Section 1.2 on page 9.</p> <p>Moved warranty precautions from Section 1.8 on page 21 to the title pages.</p> <p>Added information about the spectral characteristics of the IR cut filter in Section 4.5 on page 29.</p> <p>Added information about the Immediate Trigger Mode feature in Section 5.2.1.2 on page 33.</p> <p>Removed Chapter 6 ("Color Creation and Enhancement"). Content of this chapter can now be found in Section 4.5 on page 29 ("IR Cut Filter") and Section 7.6 on page 55 ("Color Enhancement Features").</p> <p>Added Section 7.1 on page 48 ("Feature Sequence").</p> <p>Added information about black level and gain settings in Section 7.3 on page 50.</p> <p>Added information about sRGB gamma correction and the ColorSpaceMode parameter in Section 7.4 on page 51.</p> <p>Added the Brightness/Contrast feature in Section 7.5 on page 52.</p> <p>Added information about resetting the white balance settings before setting a light source preset in Section 7.6.2 on page 56.</p> <p>Added the Hue/Saturation feature in Section 7.6.4 on page 59.</p> <p>Added the PGI Feature Set in Section 7.6.5 on page 60.</p> <p>Updated information about the availability of the Sharpness Enhancement feature in Section 7.6.6 on page 61.</p> <p>Added the Auto Function ROI feature in Section 7.11.2 on page 77.</p> <p>Revised and shortened Section 7.11.3 on page 81 ("Gain Auto") and Section 7.11.4 on page 82 ("Exposure Auto").</p> <p>Removed Section 8.3 ("Contrast Enhancement"). The Contrast Enhancement feature is no longer available.</p> <p>Moved Section 8.4 ("Sharpness Enhancement") to the color enhancement features (now Section 7.6.6 on page 61).</p>
AW00134504000	07 Sep 2016	<p>Added Section 1.4.3 on <a href="#">page 18</a> ("Mechanical Stress Test Results").</p> <p>Revised Section 4.2 on <a href="#">page 28</a> ("USB 3.0 Cabling Requirements").</p> <p>Added reference to the frame rate calculator in Section 5.6 on <a href="#">page 45</a>.</p> <p>Corrected available binning modes for puA1920-15 and puA2500-14 camera models in Section 7.8.2 on <a href="#">page 70</a>.</p> <p>Corrected parameter names in Section 7.15.3 on <a href="#">page 95</a>.</p>