Basler ace

USER'S MANUAL FOR CAMERA LINK CAMERAS

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Preliminary

The information in this document is preliminary and all content is subject to change.

Applies to prototype cameras only.

BASLER VISION TECHNOLOGIES

For customers in the U.S.A.

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

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

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

For customers in Canada

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

Pour utilisateurs au Canada

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

Life Support Applications

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

Warranty Note

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

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Table of Contents

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 ace Camera Link® camera models are listed in the top row of the specification table on the next page of this manual. The camera models are differentiated by the sensor size 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 specification table. Material that only applies to a particular camera model or to a subset of models, such as to color cameras only, will be so designated.

1.2 General Specifications

Specification	acA2000-140km	acA2000-140kc	acA2000-340km	aca2000-340kc
Sensor Resolution (H x V pixels)	2048 x 1088	2046 x 1086	2048 x 1088	2046 x 1086
Sensor Type	CMOSIS CMV 2000 Progressive scan CMOS			
Optical Size	2/3"			
Pixel Size	5.5 µm x 5.5 µm			
Max Frame Rate (at full resolution and 10 bit sensor depth)	140 fps		340 fps	
Mono/Color	Mono	Color	Mono	Color
Sensor Bit Depth	12 bits or 10 bits (selectable)			
Data Output Type	Camera Link base or medium configuration		Camera Link base, mdeium, or full configuration	
Camera Link Connectors	Two 26-pin SDR connectors (also known as Mini Camera Link connectors)			
Camera Link Clock Speed	32.5 MHz, 48 MHz, 65 Mhz, or 82 MHz (selectable)			
Camera Link Tap Geometry	1X2-1Y, 1X3-1Y, or 1X4-1Y		1X2-1Y, 1X3-1Y, 1X4-1Y, 1X6-1Y, 1X8-1Y or 1X10-1Y	
Pixel Data Formats	Mono 12, Mono10, or Mono 8	Bayer GB 12, Bayer GB 10, or Bayer GB 8	Mono 12, Mono10, or Mono 8	Bayer GB 12, Bayer GB 10, or Bayer GB 8
Synchronization	Via external trigger signal, software trigger signal, or free run			
Exposure Control	Trigger width or timed			
Power Requirements	PoCL (Power over Camera Link compliant) or +12 VDC (± 10%), < 1% ripple, supplied via the camera's 4-pin connector			
Max Power Consumption	3.0 W @ 12 VDC			
I/O Lines	1 GPIO (can be set to operate as an input or an output)			
Lens Adapter	C-mount			
Size (L x W x H)	43.5 mm x 29.0 mm x 29.0 mm (without lens adapter or connectors) 58.9 mm x 29.0 mm x 29.0 mm (with lens adapter and connectors)			
Weight	< 90 g (typical)			
Conformity	CE, FCC, GenICam, RoHS, Camera Link, IP30			
Driver	Basler pylon (release 2.3 or newer)			
API for Configuration	Register-based API for C or VB6 Basler pylon C++ API			

Table 1: General Specifications

Specification	acA2040-70km	acA2040-70kc	acA2040-180km	aca2040-180kc
Sensor Resolution (H x V pixels)	2048 x 2048	2046 x 2046	2048 x 2048	2046 x 2046
Sensor Type	CMOSIS CMV 4000 Progressive scan CMOS			
Optical Size	1"			
Pixel Size	5.5 µm x 5.5 µm			
Max Frame Rate (at full resolution and 10 bit sensor depth)	70 fps		180 fps	
Mono/Color	Mono	Color	Mono	Color
Sensor Bit Depth	12 bits or 10 bits (selectable)			
Data Output Type	Camera Link base or medium configuration		Camera Link base, medium, or full configuration	
Camera Link Connectors	Two 26-pin SDR connectors (also known as Mini Camera Link connectors)			
Camera Link Clock Speed	32.5 MHz, 48 MHz, 65 Mhz, or 82 MHz (selectable)			
Camera Link Tap Geometry	1X2-1Y, 1X3-1Y, or 1X4-1Y		1X2-1Y, 1X3-1Y, 1X4-1Y, 1X6-1Y, 1X8-1Y or 1X10-1Y	
Pixel Data Formats	Mono 12, Mono10, or Mono 8	Bayer GB 12, Bayer GB 10, or Bayer GB 8	Mono 12, Mono10, or Mono 8	Bayer GB 12, Bayer GB 10, or Bayer GB 8
Synchronization	Via external trigger signal, software trigger signal, or free run			
Exposure Control	Trigger width or timed			
Power Requirements	PoCL (Power over Camera Link compliant) or +12 VDC (± 10%), < 1% ripple, supplied via the camera's 4-pin connector			
Max Power Consumption	3.0 W @ 12 VDC			
I/O Lines	1 GPIO (can be set to operate as an input or an output)			
Lens Adapter	C-mount			
Size (L x W x H)	43.5 mm x 29.0 mm x 29.0 mm (without lens adapter or connectors) 58.9 mm x 29.0 mm x 29.0 mm (with lens adapter and connectors)			
Weight	< 90 g (typical)			
Conformity	CE, FCC, GenICam, RoHS, Camera Link, IP30			
Driver	Basler pylon (release 2.3 or newer)			
API for Configuration	Register-based API for C or VB6 Basler pylon C++ API			

Table 2: General Specifications

1.3 Spectral Response

1.3.1 Monochrome Cameras

The following graph shows the spectral response for all monochrome cameras.

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

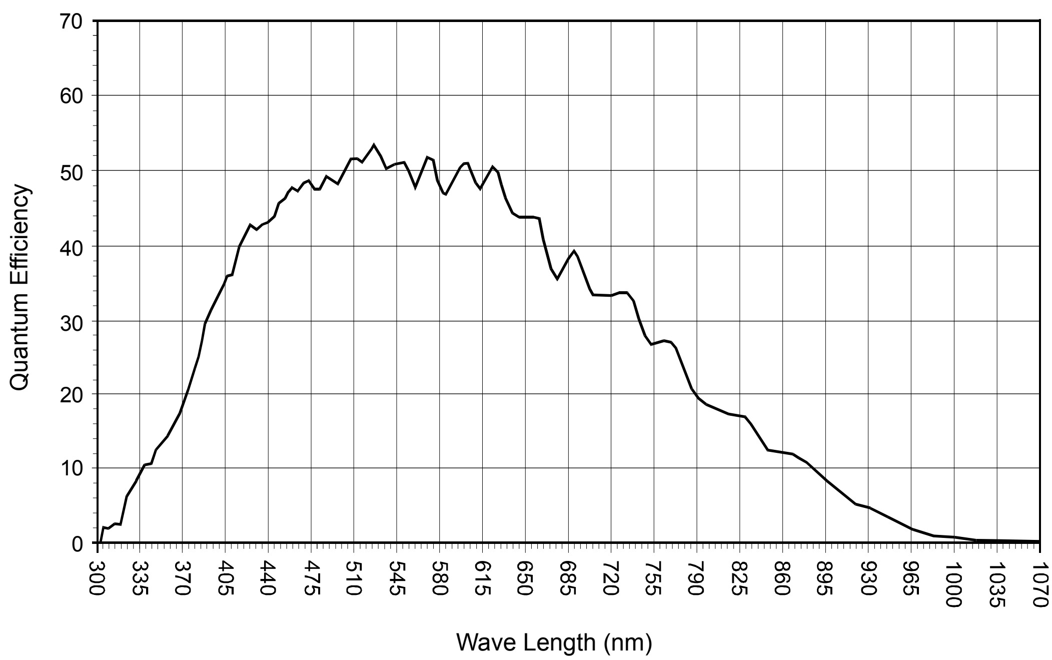


Fig. 1: Mono Camera Spectral Response

1.3.2 Color Cameras

The following graph shows the spectral response for all color cameras.

ⓘ	The spectral response curves excludes lens characteristics, light source characteristics, and IR cut filter characteristics. To obtain best performance from color models of the camera, use of a dielectric IR cut filter is recommended. The filter should transmit in a range from 400 nm to 700 ... 720 nm, and it should cut off from 700 ... 720 nm to 1100 nm. A suitable IR cut filter is included in the standard C-mount lens adapter on color models of the camera.

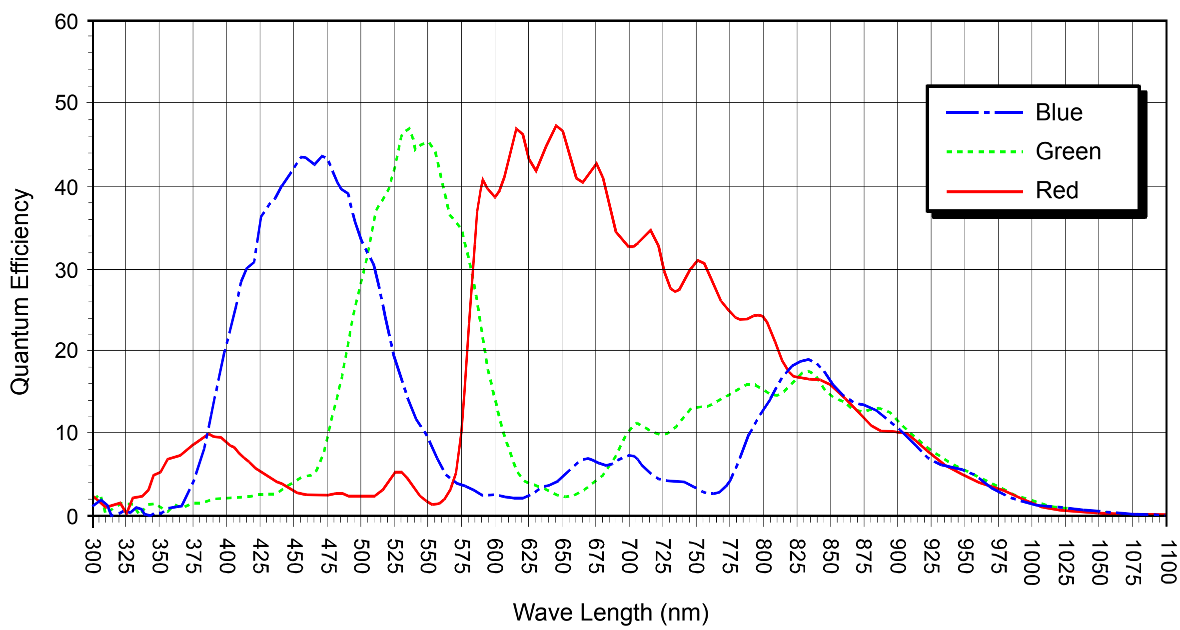


Fig. 2: Color Camera Spectral Response

1.4 Mechanical Specifications

The camera housing conforms to protection class IP30 assuming that the lens mount is covered by a lens or by the protective plastic seal that is shipped with the camera.

1.4.1 Camera Dimensions and Mounting Points

The camera dimensions in millimeters are as shown in Figure 3.

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

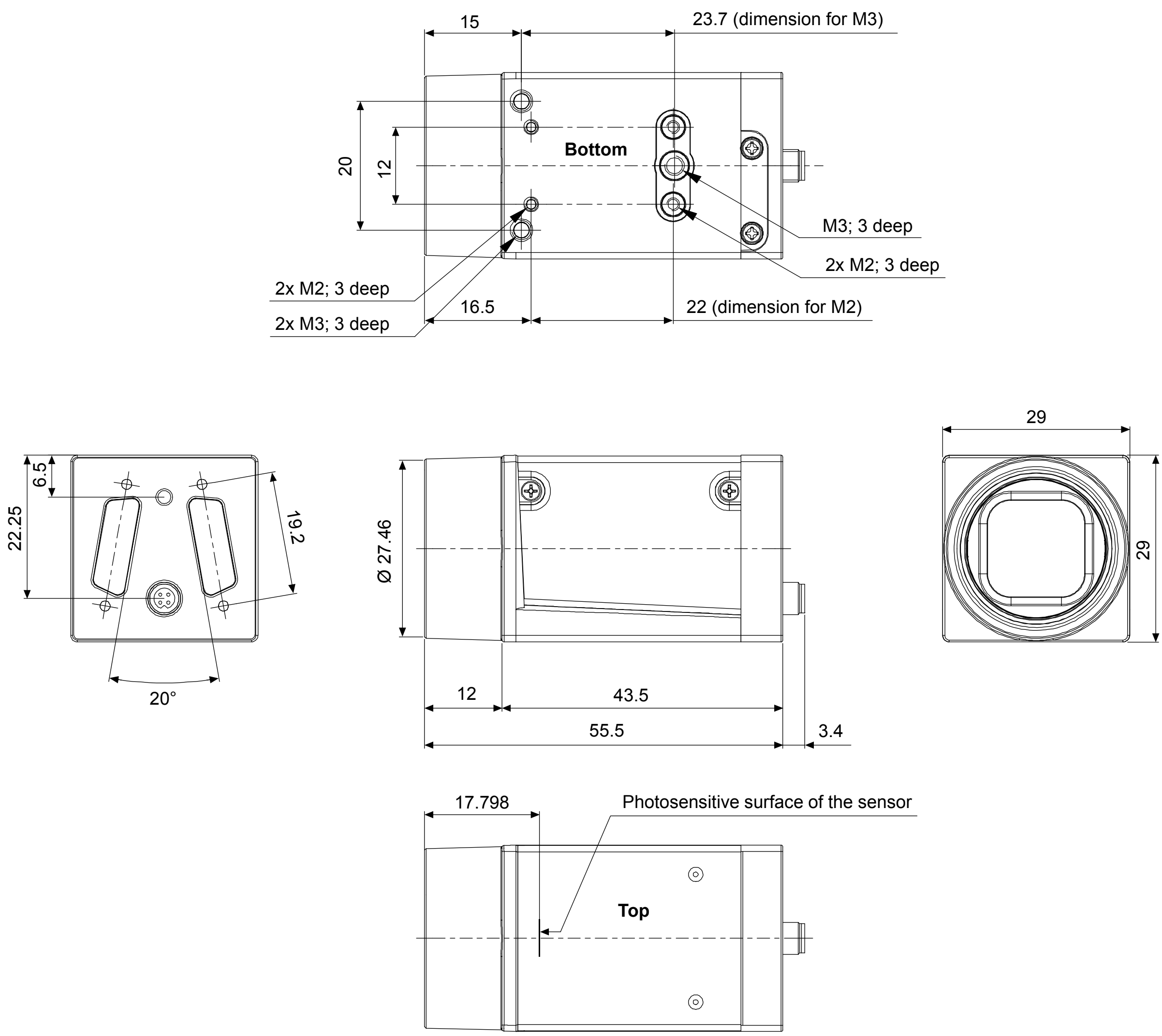


Fig. 3: Mechanical Dimensions (in mm)

1.4.2 Maximum Allowed Lens Thread Length

The C-mount lens mount on all cameras is normally equipped with a plastic filter holder. As shown in Figure 4, the length of the threads on any lens you use with the camera can be a maximum of 9.6 mm, and the lens can intrude into the camera body a maximum of 10.8 mm. If either of these limits is exceeded, the lens mount or the filter holder will be damaged or destroyed and the camera will no longer operate properly.

Note that on color cameras, the filter holder will be populated with an IR-cut filter. On monochrome cameras, the filter holder will be present, but will not be populated with a filter.

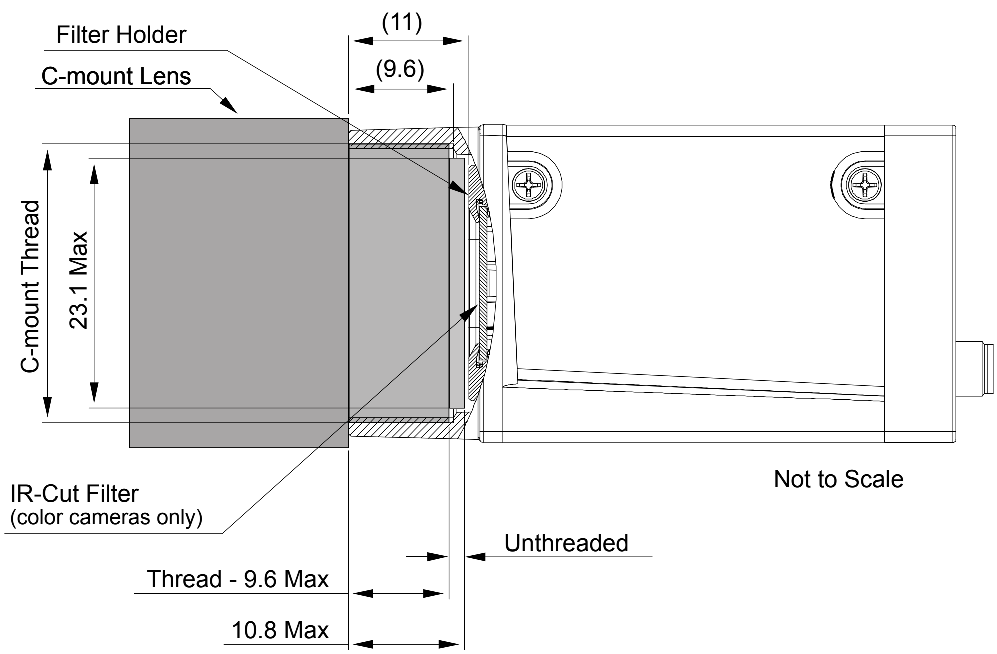


Fig. 4: Maximum Lens Thread Length (dimensions in mm)

1.5 Avoiding EMI and ESD Problems

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

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

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

ⓘ	The Basler application note called *Avoiding EMI and ESD in Basler Camera Installations* provides much more detail about avoiding EMI and ESD. This application note can be obtained from the Downloads section of our website: www.baslerweb.com

1.6 Environmental Requirements

1.6.1 Temperature and Humidity

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

1.6.2 Heat Dissipation

You must provide sufficient heat dissipation to maintain the temperature of the camera housing at 50 °C or less. Since each installation is unique, Basler does not supply a strictly required technique for proper heat dissipation. Instead, we provide the following general guidelines:

- In all cases, you should monitor the temperature of the camera housing and make sure that the temperature does not exceed 50 °C. 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.
- If your camera is mounted on a substantial metal component in your system, this may provide sufficient heat dissipation.
- The use of a fan to provide air flow over the camera is an extremely efficient method of heat dissipation. The use of a fan provides the best heat dissipation.

1.7 Precautions

NOTICE

Avoid dust on the sensor.

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

NOTICE

On all cameras, the lens thread length is limited.

All cameras (mono and color) are equipped with a plastic filter holder located in the lens mount. The location of the filter holder limits the length of the threads on any lens you use with the camera. If a lens with a very long thread length is used, the filter holder or the lens mount will be damaged or destroyed and the camera will no longer operate properly.

For more specific information about the lens thread length, see Section 1.4.2 on page 7.

NOTICE

If you are supplying power to the camera via Power over Camera Link (PoCL), you must use a PoCL compliant frame grabber and you must use Camera Link cables that are specifically designed for PoCL as specified in the Camera Link standard. Failure to use a PoCL compliant frame grabber or the correct cables can result in severe damage to the camera.

If you are supplying power to the camera via the 4-pin M5 connector, the voltage of the power to the camera must be between +10.8 VDC and +13.2 VDC.

1. If the voltage is greater than +13.2 VDC, severe damage to the camera can result.
2. If the voltage is less than +10.8 VDC, the camera may operate erratically.

Applying power with the wrong polarity can result in severe damage to the camera.

For more information about camera power, see Section 5.5 on page 30.

NOTICE

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

1. If you are supplying power to the camera via the Camera Link connection (PoCL), be sure that the power to the frame grabber is switched off before you connect or disconnect the Camera Link cables.
2. If you are supplying power to the camera via the 4-pin M5 connector, switch off the power to the connector before you connect or disconnect the Camera Link cables.

NOTICE

The camera's GPIO line can be set to operate as an input or as an output. Applying incorrect electrical signals to the camera's GPIO line can severely damage the camera.

1. Before you connect any external circuitry to the GPIO line, we strongly recommend that you set the GPIO line to operate as an input or as an output (according to your needs).
2. Once the line is set, make sure that you only apply electrical signals to the line that are appropriate for the line's current setting.

For more information about setting the GPIO line operation, see Section 6.1 on page 47.

For more information about the electrical requirements for the GPIO line, see Section 5.7 on page 33.

NOTICE

An incorrect plug can damage the 4-pin connector.

The plug on the cable that you attach to the camera's 4-pin connector must have 4 female pins. Using a plug designed for a smaller or a larger number of pins can damage the connector.

NOTICE

Inappropriate code may cause unexpected camera behavior.

1. The code snippets provided in this manual are included as sample code only. Inappropriate code may cause your camera to function differently than expected and may compromise your application.
2. To ensure that the snippets will work properly in your application, you must adjust them to meet your specific needs and must test them thoroughly prior to use.
3. The code snippets in this manual are written in C++. Other programming languages can also be used to write code for use with Basler pylon. When writing code, you should use a programming language that is both compatible with pylon and appropriate for your application. For more information about the programming languages that can be used with Basler pylon, see the documentation included with the pylon package.

Warranty Precautions

To ensure that your warranty remains in force:

Do not remove the camera's serial number label

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

Do not open the camera housing

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

Keep foreign matter outside of the camera

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

Avoid Electromagnetic fields

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

Transport Properly

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

Clean Properly

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

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

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

Read the manual

Read the manual carefully before using the camera!

2 Installation

The information you will need to do a quick, simple installation of the camera is included in the *Installation and Setup Guide for Ace Camera Link Cameras* (AW000996xx000). You can download the Quick Installation Guide from the Downloads section of our website:
www.baslerweb.com

3 Camera Drivers and Tools for Changing Camera Parameters

This chapter provides an overview of the camera drivers and the options available for changing the camera's parameters.

The options available with the Basler pylon Driver Package let you change parameters and control the camera by using a stand-alone GUI (known as the pylon Viewer) or by accessing the camera from within your software application using the driver API.

You can also control the camera and change parameters via direct access to the camera's register structure.

3.1 The Pylon Driver Package

The Basler pylon Driver Package is designed to operate all Basler cameras that have an IEEE 1394a interface, an IEEE 1394b interface, or a GigE 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 PC at a very low CPU load.

Features in the pylon driver package include:

- The Basler GigE Vision filter driver
- The Basler GigE Vision performance driver
- IEEE 1394a/b drivers
- A Camera Link configuration driver for some newer camera models
- A pylon camera API for use with a variety of programming languages
- A pylon DirectShow driver
- A pylon TWAIN driver
- A variety of adapters for third party software imaging processing libraries
- The Basler pylon Viewer
- Source code samples
- A programming guide and API reference.

You can obtain the Basler pylon Driver Package from the Downloads section of our website:

www.baslerweb.com

To help you install the driver for use with ace Camera Link cameras, you can use the *Installation and Setup Guide for Ace Camera Link Cameras* (AW000996xx000). You can obtain the guide from the Downloads section of the website.

The pylon package includes several tools that you can use to change the parameters on your camera, including the pylon Viewer and the pylon API. The remaining sections in this chapter provide an introduction to these tools.

3.1.1 The pylon Viewer

The pylon Viewer is included in Basler's pylon Driver Package. The Viewer 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 software is a very convenient way to get your camera up and running quickly when you are doing your initial camera evaluation or doing a camera design-in for a new project.

For more information about using the viewer, see the *Installation and Setup Guide for Ace Camera Link Cameras* (AW000996xx000).

3.1.2 The pylon API

After the pylon Driver Package has been installed on your PC, you can access all of the camera's parameters and can control the camera's full functionality from within your application software by using the pylon API. The pylon Programmer's Guide and the pylon API Reference contain an introduction to the API and include information about all of the methods and objects included in the API. The programmer's guide and API reference are included in the pylon SDK.

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

3.2 The Basler Binary Protocol Library

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

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

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

Sample code showing how to use the BBPL along with supporting documentation can be downloaded from the Basler website:

www.baslerweb.com

When using the BBPL to change parameter values, you will need to know the details of the camera's register structure. For details of the register structure, refer to the document called *Ace and Aviator Register Structure and Access Methods* (AW000997xx000). The document can also be downloaded from the Basler website.

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

4 Camera Functional Description

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

4.1 Overview

Each camera provides features such as a full frame shutter and electronic exposure time control. Exposure start, exposure time, and charge readout can be controlled by parameters transmitted to the camera via the Camera Link interface.

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

Accumulated charges are read out of the sensor when exposure ends. The accumulated charges are read out of the sensor sequentially, row-by-row. As shown in Figure 5 on page 22, each row passes through an "analog front end" where the charges are transformed to voltages, gain and black level are adjusted, and an analog to digital conversion is performed. The A to D conversion can be performed at 10 bit or at 12 bit depth.

As shown in Figure 6 on page 22, the digitized values from each row are passed to an LVDS block where they are transmitted to the camera's FPGA. The Image data is then transmitted via the Camera Link interface to the frame grabber in your PC. Several different "tap geometries" are available to determine how the pixel data will be transmitted over the Camera Link interface. The user can select the desired tap geometry. See Figure 9.3 on page 144 for more detailed information about tap geometries.

The user can also select from several available pixel clock speeds for the Camera Link interface. See Section 10.1 on page 155 for more information about selecting the pixel clock speed.

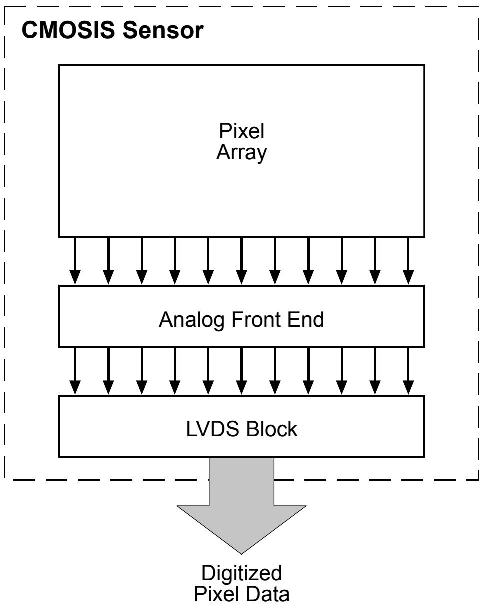


Fig. 5: CMOSIS Sensor Architecture

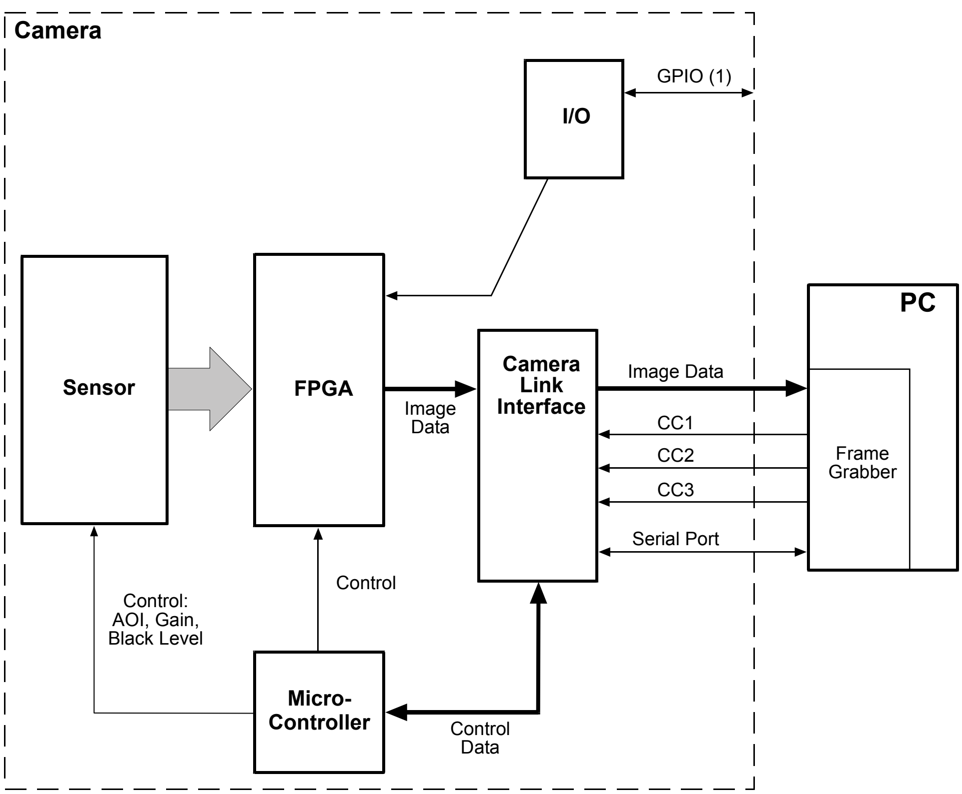


Fig. 6: Camera Block Diagram

5 Physical Interface

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

5.1 General Description of the Camera Connections

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

- Two 26-pin, 0.03” pin spacing, Shrunk Delta Ribbon (SDR) female connectors used to transmit video data, control signals, and configuration commands. (This type of connector is also known as a Mini Camera Link connector.)

  These connectors can also be used to supply power to the camera in accordance with the Power over Camera Link (PoCL) specifications in the Camera Link standard.
- One 4-pin, M5 receptacle used to connect to the camera’s GPIO line.

  This connector can also be used to provide power to the camera if PoCL is not used.

The drawing below shows the location of the three connectors.

There is also an LED indicator located on the back of the camera as shown in the drawing.

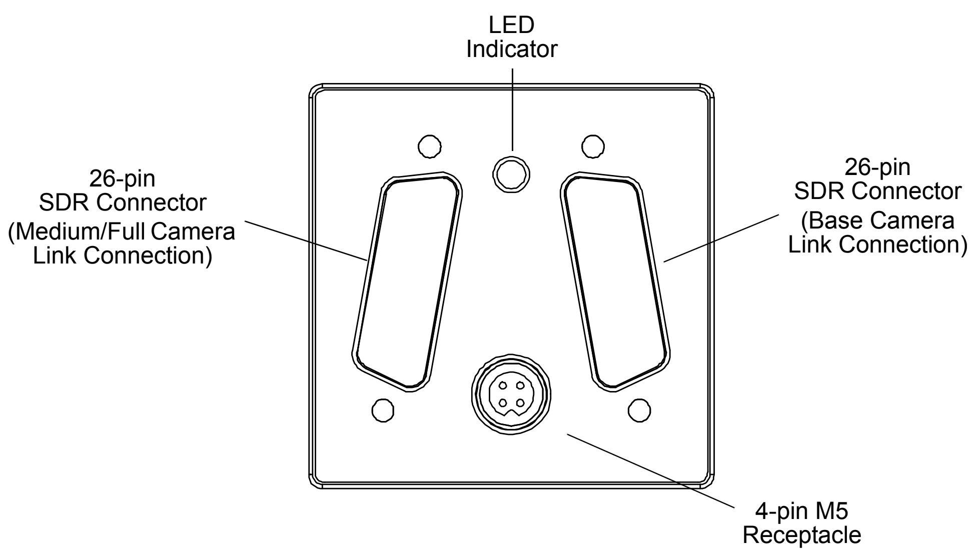
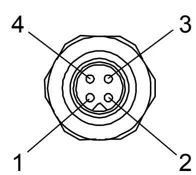


Fig. 7: Camera Connections

5.2 Camera Connector Pin Assignments and Numbering

5.2.1 4-Pin Receptacle

The 4-pin receptacle is used to supply power to the camera and to access the camera's GPIO line. The pin assignments and pin numbering for the receptacle are as shown in Table 1.



Pin	Designation
1	+12 VDC Camera Power (+12 VDC ± 10%)
2	General Purpose I/O (GPIO)
3	Camera Power Ground
4	GPIO Ground

Table 1: Pin Assignments and Numbering for the 4-pin Receptacle

5.2.2 26-Pin SDR Connectors

Two 26-pin, 0.03” pin spacing, Shrunk Delta Ribbon (SDR) female connectors are used to transmit video data, control signals, and configuration commands. The pin assignments and pin numbering for the base Camera Link SDR connector are as shown in Table 2 for the medium Camera Link SDR connector are as shown in Table 3 on page 26.

Pin Number	Signal Name	Direction	Level	Function
1, 26 *	Cam Pow.	In	+12 VDC	Camera power, +12 VDC (±10%, < 1% ripple)
13, 14 **	Power Ret.		Return	Camera power return (Gnd)
2	X0-	Output	Camera Link LVDS	Data from transmitter circuit X
15	X0+			
3	X1-	Output	Camera Link LVDS	Data from transmitter circuit X
16	X1+			
4	X2-	Output	Camera Link LVDS	Data from transmitter circuit X
17	X2+			
6	X3-	Output	Camera Link LVDS	Data from transmitter circuit X
19	X3+			
5	XClk-	Output	Camera Link LVDS	Pixel clock from transmitter circuit X
18	XClk+			
7	SerTC+	Input	RS-644 LVDS	Serial communication data receive (SerTC = "serial to camera")
20	SerTC-			
8	SerTFG-	Output	RS-644 LVDS	Serial communication data transmit (SerTFG = "serial to frame grabber")
21	SerTFG+			
9	CC1-	Input	RS-644 LVDS	Configurable
22	CC1+			
10	CC2+	Input	RS-644 LVDS	Configurable
23	CC2-			
11	CC3-	Input	RS-644 LVDS	Configurable
24	CC3+			
12	None	None	None	None
25	None-			

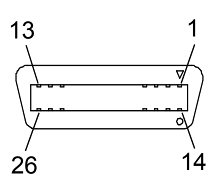


Table 2: Pin Assignments and Numbering for the Base Configuration 26-pin SDR Connector

* Pins 1 and 26 are tied together in the camera.

** Pins 13 and 14 are tied together in the camera.

Pin Number	Signal Name	Direction	Level	Function
1, 26 *	Cam Pow.	In	+12 VDC	Camera power, +12 VDC (±10%, < 1% ripple)
13, 14 **	Power Ret.		Return	Camera power return (Gnd)
2	Y0-	Output	Camera Link LVDS	Data from transmitter circuit Y
15	Y0+			
3	Y1-	Output	Camera Link LVDS	Data from transmitter circuit Y
16	Y1+			
4	Y2-	Output	Camera Link LVDS	Data from transmitter circuit Y
17	Y2+			
6	Y3-	Output	Camera Link LVDS	Data from transmitter circuit Y
19	Y3+			
5	YClk-	Output	Camera Link LVDS	Pixel clock from transmitter circuit Y
18	YClk+			

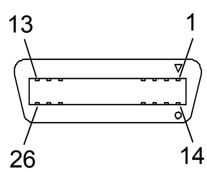


Table 3: Pin Assignments and Numbering for the Medium/Full Configuration 26-pin SDR Connector

* Pins 1 and 26 are tied together in the camera.
** Pins 13 and 14 are tied together in the camera.

5.3 Camera Connector Types

5.3.1 4-Pin Receptacle

The 4-pin connector on the camera is a Binder M5 receptacle (part number 09-3111-86-04) or the equivalent.

A recommended mating connector is the Binder M5 plug (part number 79-3108-52-04) or the equivalent. Several other mating connectors in a variety of different form factors are also available from Binder.

5.3.2 26-Pin SDR Connectors

The 26-pin connectors on the camera are female, 0.03 inch pin spacing, SDR connector as called for in the Camera Link specification.

The recommended mating connector is also defined in the Camera Link Specification.

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

5.4 Cabling Requirements

5.4.1 Camera Link Cables

The Camera Link cables must meet the Mini Camera Link cable specifications specified in Appendix D of the Camera Link Standard.

5.4.2 Standard Power and I/O Cable

ⓘ	The standard power and I/O cable is intended for use when the camera is not connected to a PLC device. If the camera is connected to a PLC device, we recommend using a PLC power and I/O cable rather than the standard power and I/O cable. See the following section for more information about PLC power and I/O cables.

A "standard power and I/O cable" is used to connect to the 4-pin connector on the camera. This cable can be used both to supply power to the camera (when Power over Camera Link is not used) and to connect to the camera's GPIO line as shown in Figure 8.

The end of the standard power and I/O cable that connects to the camera must be terminated with a Binder M5 plug or the equivalent (the Binder part number for one possible mating plug is 79-3108-52-04; Binder makes mating plugs in a variety of form factors). The cable must be wired to conform with the pin assignments shown in the pin assignment table.

The maximum length of the standard power and I/O cable is at least 10 meters. Close proximity to strong magnetic fields should be avoided.

The required 4-pin Binder plug is available from Basler. Basler also offers pre-made standard power and I/O cable assemblies that are terminated with a 4-pin Binder plug on one end and unterminated on the other. Contact your Basler sales representative to order connectors or cables.

NOTICE
An incorrect plug can damage the 4-pin connector. The plug on the cable that you attach to the camera's 4-pin connector must have 4 female pins. Using a plug designed for a smaller or a larger number of pins can damage the connector.

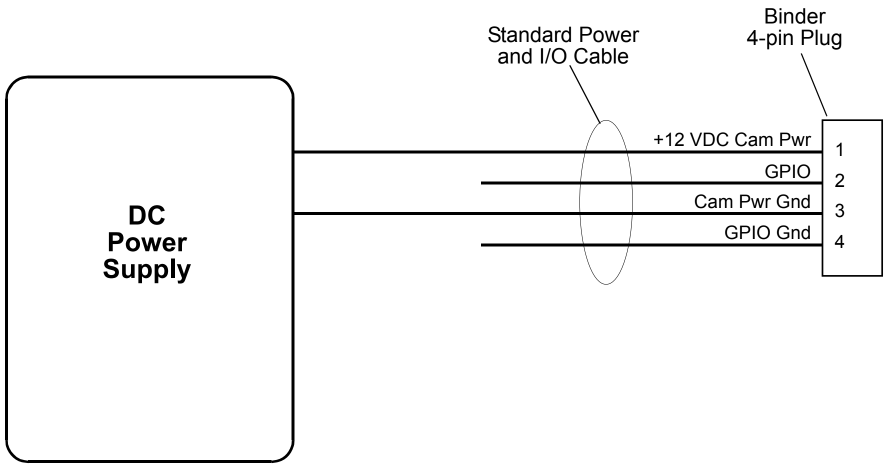


Fig. 8: Standard Power and I/O Cable

5.4.3 PLC Power and I/O Cable

ⓘ	We recommend using a PLC power and I/O cable when the camera is connected to a PLC device. If the GPIO is set to function as an input and power is supplied to the input at 24 VDC, you can use a PLC power and I/O cable even if the camera is not connected to a PLC device. If the GPIO is set to function as an output, you can use a standard power and I/O cable.

As with the standard power and I/O cable described in the previous section, the PLC power and I/O cable is a single cable that can be used both to supply power to the camera (when Power over Camera Link is not used) and to connect to the camera's GPIO line. The PLC power and I/O cable adjusts the voltage levels of PLC devices to the voltage levels required by the camera's GPIO line and it protects the camera against negative voltage and reverse polarity.

Close proximity to strong magnetic fields should be avoided.

Basler offers a PLC power and I/O cable that is terminated with a 4-pin Binder plug on the end that connects to the camera. The other end is unterminated. Contact your Basler sales representative to order the cable.

5.5 Camera Power

Power can be supplied to the camera in either one of two ways:

- Via the Camera Link cables. This is commonly known as Power over Camera Link or PoCL.
- Via the 4-pin M5 connector.

5.5.1 Supplying Power Over Camera Link

Power can be supplied to the camera via the Camera Link cables as specified in Appendix E of the Camera Link standard. This method of supplying power to the camera is known as Power over Camera Link or PoCL.

Nominal operating voltage for the camera is +12 VDC (± 10%) with less than one percent ripple. Power consumption is as shown in the specification tables in Section 1 of this manual.

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

NOTICE

If you are supplying power to the camera using PoCL:

1. Failure to use a Power over Camera Link compliant frame grabber can result in severe damage to the camera.
2. Failure to use Camera Link cables that are specifically designed for PoCL (as specified in the Camera Link standard) can result in severe damage to the camera.

NOTICE

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

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

5.5.2 Supplying Power Via the 4-Pin M5 Connector

Power can be supplied to the camera via the 4-pin M5 connector on the back of the camera. Nominal operating voltage is +12 VDC (± 10%) with less than one percent ripple. Power consumption is as shown in the specification tables in Section 1 of this manual.

Close proximity to strong magnetic fields should be avoided.

See Section 5.2.1 on page 24 for a description of the connector pinouts.

See Section 5.4.2 on page 28 for a description of the cable to be used with the 4-pin connector.

NOTICE

If the voltage of the power to the camera is greater than +13.2 VDC, damage to the camera can result. If the voltage is less than +10.8 VDC, the camera may operate erratically.

Applying power with the wrong polarity can result in severe damage to the camera.

1. Always make sure that the voltage of the power to the camera is within the specified range.
2. Always make sure that the polarity of the applied voltage is correct.

NOTICE

An incorrect plug can damage the 4-pin connector.

The plug on the cable that you attach to the camera's 4-pin connector must have 4 female pins. Use of a plug with a different number of pins, can damage the pins in the camera's 4-pin connector.

NOTICE

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

If you are supplying power to the camera via the 4-pin M5 connector, switch off the power to the connector before you connect or disconnect the Camera Link cables.

5.6 LED Indicator

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

For more information, see Section 10.10 on page 206.

5.7 General Purpose I/O (GPIO)

5.7.1 Introduction

The camera has one GPIO line that is accessed via pins 2 and 4 in the 4-pin M5 connector on the back of the camera. The GPIO line can be set to operate as an input to the camera or to operate as a camera output. The GPIO line is designated as line 1.

The next sections describe the differences in the GPIO electrical functionality when the line is set to operate as an input and when it is set to operate as an output.

NOTICE

The camera's GPIO line can be set to operate as an input or as an output. Applying incorrect electrical signals to the camera's GPIO line can severely damage the camera.

1. Before you connect any external circuitry to the GPIO line, we strongly recommend that you set the GPIO line to operate as an input or as an output (according to your needs).
2. Once the line is properly set, make sure that you only apply electrical signals to the line that are appropriate for the line's current setting.

For more information about setting the GPIO line operation, see Section 6.1 on page 47.

For more information about the 4-pin connector, see Section 5.2.1 on page 24.

5.7.2 Operation as an Input

This section describes the electrical operation of the GPIO line when the line has been set to operate as an input.

5.7.2.1 Voltage Requirements

Different voltage levels apply, depending on whether the standard power and I/O cable or a PLC power and I/O cable is used (see below).

Voltage Levels When the Standard Power and I/O Cable is Used

The following voltage requirements apply to the camera's GPIO line when the line is set to act as an input and a standard power and I/O cable is used:

Voltage	Significance
+0 to +20 VDC	Recommended signal voltage.
+0 to +1.4 VDC	The voltage indicates a logical 0.
> +1.4 to +2.2 VDC	Region where the transition threshold occurs; the logical state is not defined in this region.
> +2.2 VDC	The voltage indicates a logical 1.
+24.0 VDC	Absolute maximum; the camera may be damaged when the absolute maximum is exceeded.

Table 4: Voltage Requirements with the GPIO Set as an Input and Using the Standard Power and I/O Cable

Voltage Levels When a PLC Power and I/O Cable is Used

The following requirements apply to the camera's GPIO line when the line is set to act as an input and a PLC power and I/O cable is used. The PLC power and I/O cable will adjust the voltages to the levels required by the camera's GPIO line (see Table 4).

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

Table 5: Voltage Requirements with the GPIO Set as an Input and Using a PLC Power and I/O Cable

5.7.2.2 Electrical Characteristics

As shown in Figure 9, when the GPIO line is set to operate as an input, the line is opto-isolated. See the previous section for input voltages and their significances. The absolute maximum input voltage is +24.0 VDC. The current draw for each input line is between 5 mA and 15 mA.

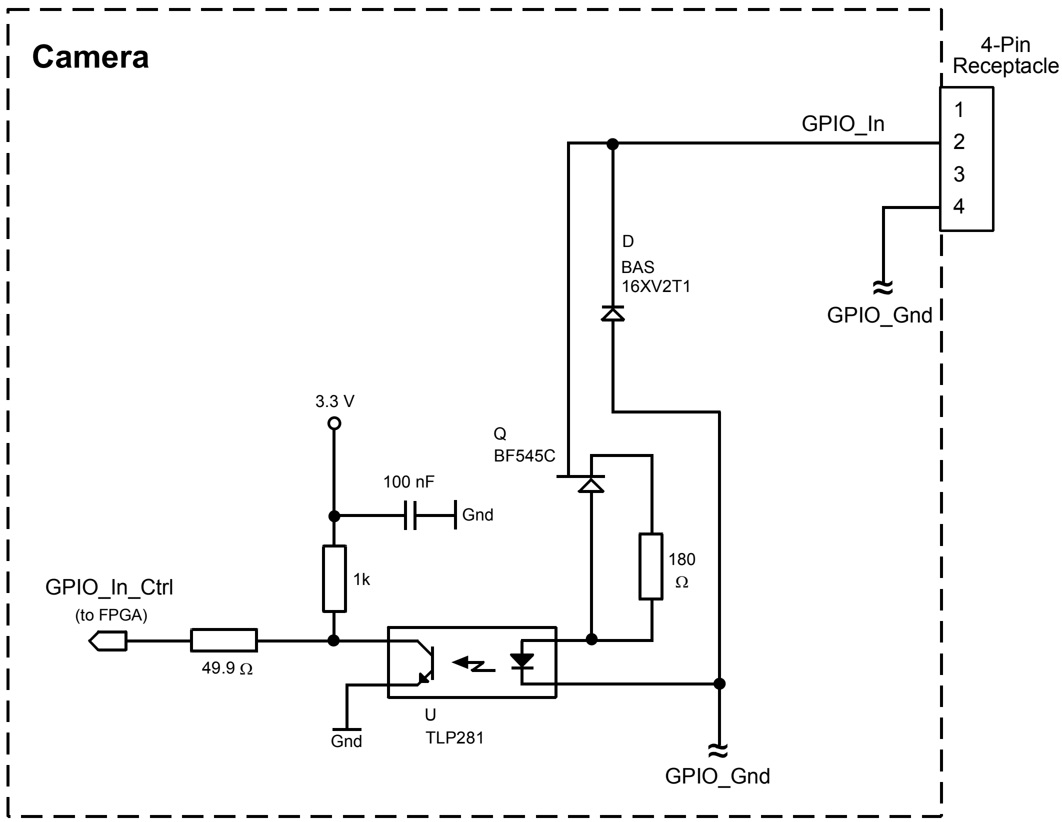


Fig. 9: Schematic with GPIO Set as an Input

Figure 10 shows an example of a typical circuit you can use to input a signal into the camera.

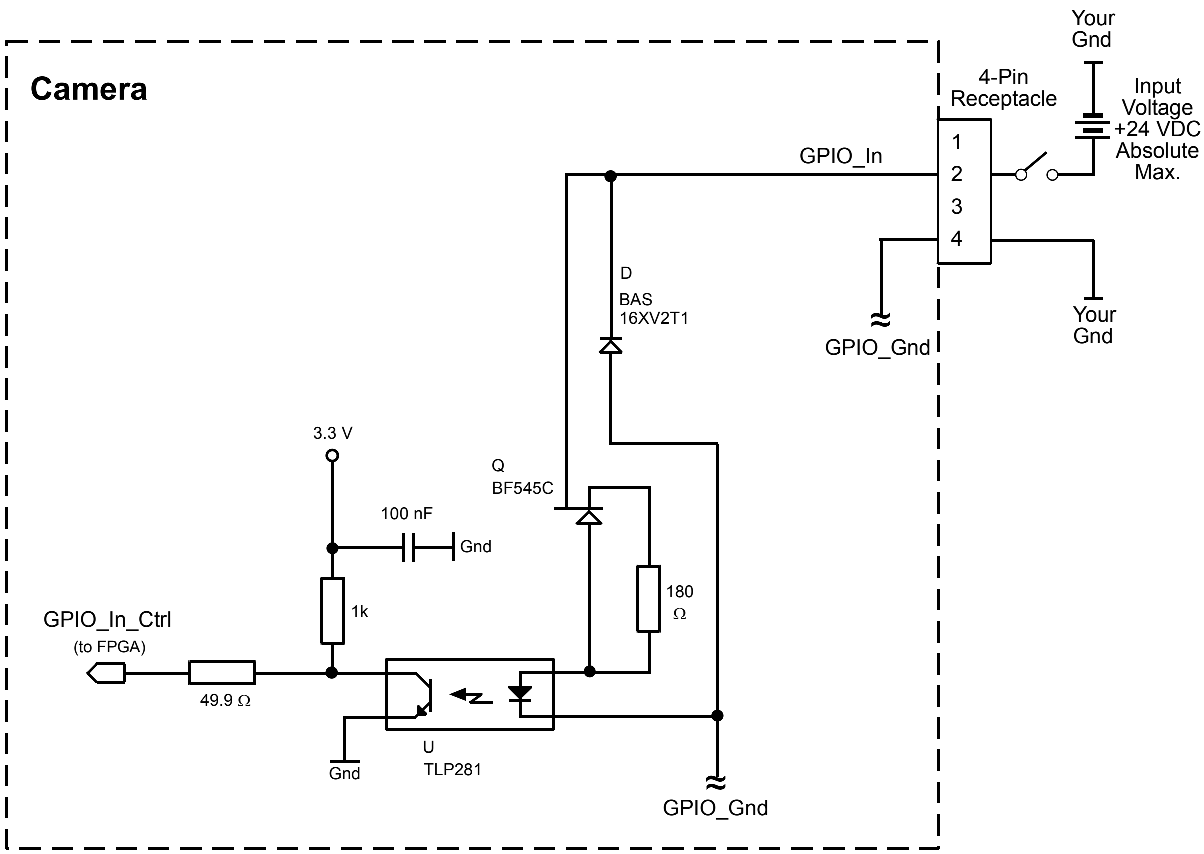


Fig. 10: Typical Input Circuit

For more information about GPIO pin assignments and pin numbering, see Section 5.2 on page 24.

For more information about setting the GPIO line operation, see Section 6.1 on page 47.

5.7.2.3 Response Time

The response times for the GPIO line on the camera when the line is set to operate as an input are as shown in Figure 11.

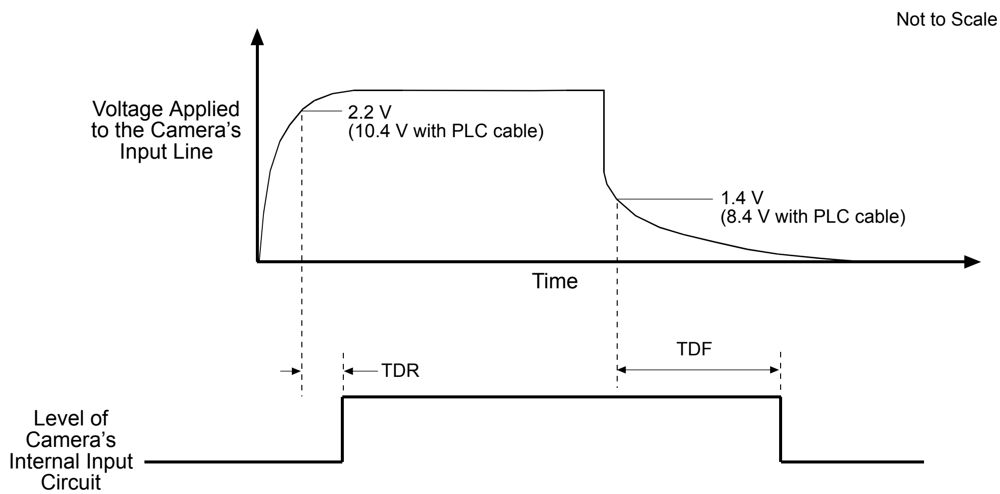


Fig. 11: GPIO Line Input Response Times

Time Delay Rise (TDR) = 1.3 µs to 1.6 µs

Time Delay Fall (TDF) = 40 µs to 60 µs

5.7.3 Selecting the Input as the Source Signal for a Camera Function

When the GPIO line is set to operate as an input, you can select the input to act as the source signal for the following camera functions:

- the acquisition start trigger
- the frame start trigger

Note that when the input has been selected as the source signal for a camera function, you must apply an electrical signal to the input that is appropriately timed for the function.

For more information about using the input line as the source signal for a camera function, see Section 6.1.3 on page 48.

5.7.4 Operation as an Output

This section describes the electrical operation of the GPIO line when the line has been set to operate as an output.

5.7.4.1 Voltage Requirements

The following voltage requirements apply to the camera's GPIO line when it is set to opertae as an output:

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

Table 6: Voltage Requirements with the GPIO Set as an Output

5.7.4.2 Electrical Characteristics

As shown in Figure 12, when the GPIO line is set to operate as an output, the line is opto-isolated. See the previous section for the recommended operating voltages. The absolute maximum voltage is +30.0 VDC. The maximum current allowed through the output circuit is 50 mA.

If the GPIO line is not set to invert:

- A low output signal from the camera results in a non-conducting Q1 transistor in the output circuit.
- A high output signal from the camera results in a conducting Q1 transistor in the output circuit.

If the GPIO line is set to invert:

- A low output signal from the camera results in a conducting Q1 transistor in the output circuit.
- A high output signal from the camera results in a non-conducting Q1 transistor in the output circuit.

ⓘ	When the GPIO is set to operate as an output, you should use a standard power and I/O cable, **not a PLC power and I/O cable** (see Section 5.4 on page 28.)

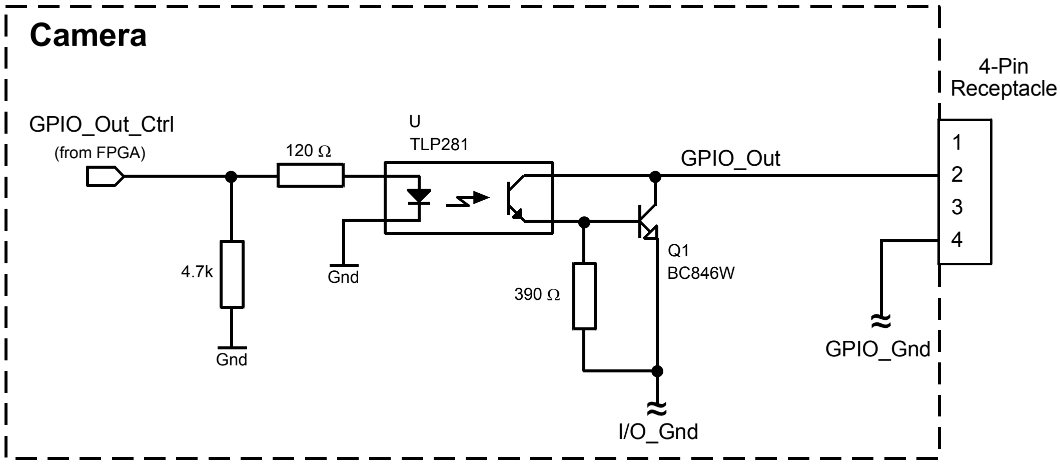


Fig. 12: Schematic with GPIO Set as an Output

Figure 13 shows a typical circuit you can use to monitor the output line with a voltage signal.

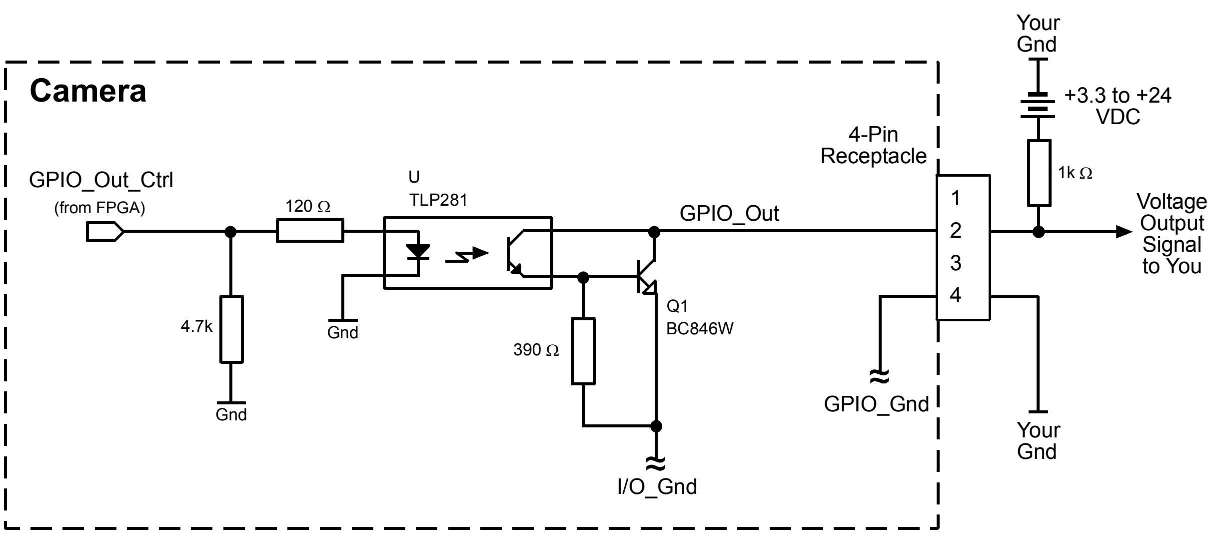


Fig. 13: Typical Voltage Output Circuit

Figure 14 shows a typical circuit you can use to monitor the output line with an LED or an opto-coupler. In this example, the voltage for the external circuit is +24 VDC. Current in the circuit is limited by an external resistor.

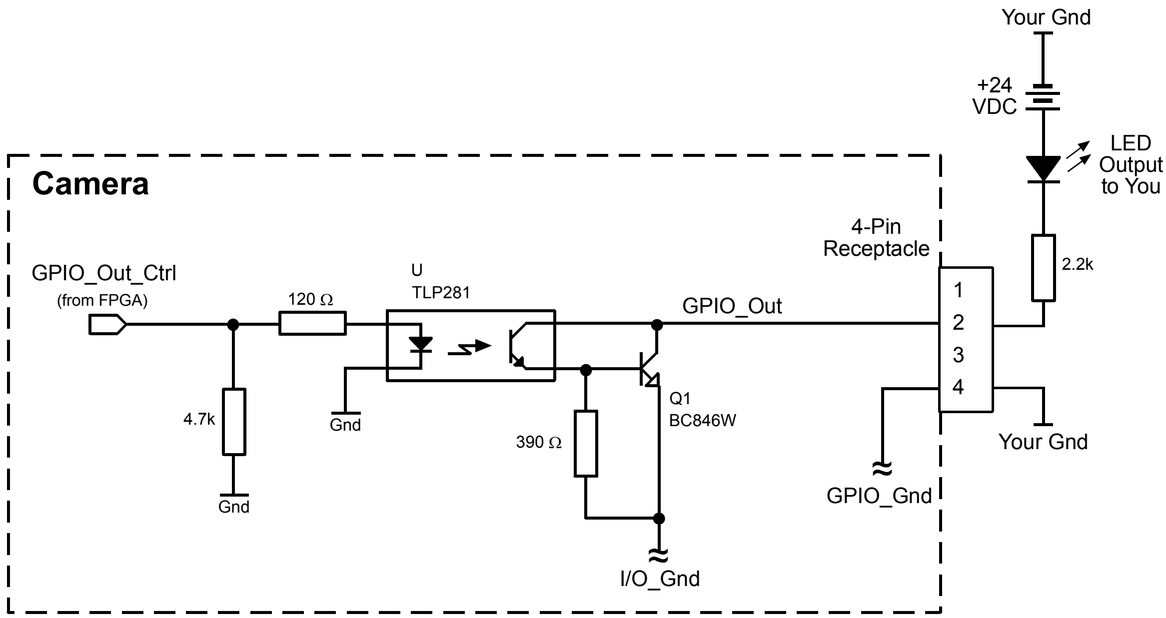


Fig. 14: Typical LED Output Signal at +24 VDC for the External Circuit (Example)

For more information about GPIO pin assignments and pin numbering, see Section 5.2 on page 24.

For more information about setting the GPIO line operation, see Section 6.1 on page 47.

5.7.4.3 Response Time

ⓘ	The information in this section assumes that the output circuit on your camera is designed as in the typical voltage output circuit shown in Section 5.7.4.2. The response times for the output lines on your camera will typically fall into the ranges specified below. The exact response time for your specific application will depend on the external resistor and the applied voltage you use.

The response times for the GPIO line on the camera when the line is set to operate as an output are as shown in Figure 15.

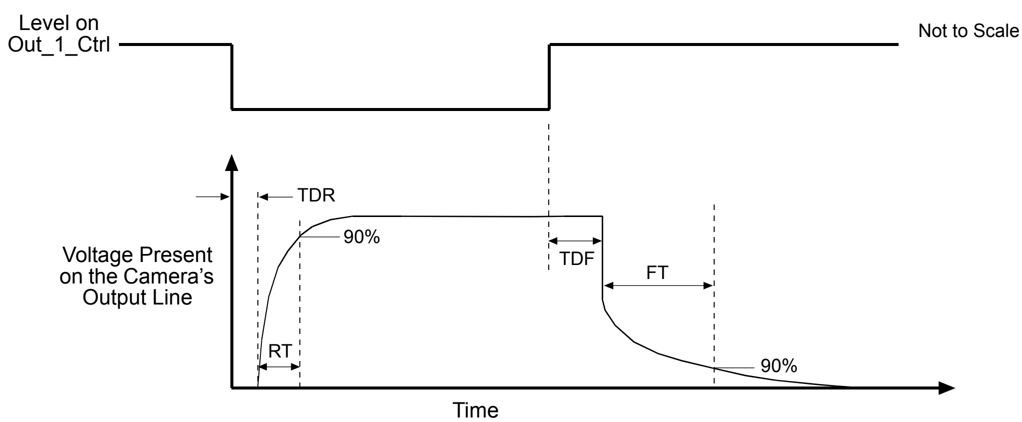


Fig. 15: GPIO Line Output Response Times

Time Delay Rise (TDR) = 40 µs

Rise Time (RT) = 20 µs to 70 µs

Time Delay Fall (TDF) = 0.6 µs

Fall Time (FT) = 0.7 µs to 1.4 µs

5.7.4.4 Selecting a Source Signal for the Output Line

When the GPIO line is configured to act as an output line, you must select a source signal for the line to make the line useful. The camera has several standard output signals available and any one of them can be selected to act as the source signal for the output line.

For more information about selecting a source signal for the output line, see Section 6.2.3 on page 53.

5.8 I/O in the Camera Link Interface

5.8.1 Inputs

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

On the camera side, you can select these inputs to act as the source signal for the following camera functions:

- the acquisition start trigger
- the frame start trigger

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

You can also obtain some general information about how these lines are implemented in the Camera Link interface from the Basler document named *Ace Camera Link Information for Frame Grabber Designers* (AW000990xx000). You can obtain the document from the Downloads section of the Basler website:

www.baslerweb.com

For more information about using CC1, CC2, and CC3 as the source signal for a camera function, see Section 6.1 on page 47.

5.8.2 Outputs

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

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

- Acquisition Trigger Wait
- Frame Trigger Wait
- Exposure Active
- Frame Cycle

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

ⓘ	The CL Spare data bit is not available when the camera is set for the 1X8-1Y or the 1X10-1Y tap geometry. The CL Spare data bit is not directly accessible by the camera user. The data bit must be accessed via the frame grabber attached to the camera. Not all frame grabbers provide users with direct access to this bit. Consult your frame grabber supplier for more information.

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

You can also obtain some general information about how this bit is implemented in the Camera Link interface from the Basler document named *Ace Camera Link Information for Frame Grabber Designers* (AW000990xx000). You can obtain the document from the Downloads section of the Basler website:

www.baslerweb.com

For more information about selecting a camera output signal to act as the source signal for the CL Spare bit, see Section 6.2 on page 52.

6 I/O Control

This section describes how to set the camera's input and output lines. It also provides information about monitoring the state of the input and output lines.

6.1 Input Lines

6.1.1 Available Input Lines

The camera is equipped with one GPIO line designated as line 1. The GPIO line can be accessed through the four pin connector on the back of the camera as described in the "Physical Interface" chapter. The GPIO line can be set to operate as either as an input line or an output line. This section describes using the GPIO when it is set to operate as an input line.

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

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

You can also get some general information about how these lines are implemented in the Camera Link interface from the Basler document called *Ace Camera Link Information for Frame Grabber Designers* (AW000990xx000). You can obtain the document from the Downloads section of the Basler website:

www.baslerweb.com

6.1.2 Setting the GPIO Line to Operate as an Input

The Line Mode parameter is used to set the camera's GPIO line to operate as an input.

NOTICE

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

1. Before you connect any external circuitry to the GPIO line, we strongly recommend that you set the GPIO line mode so that the line will operate as an input.
2. Once the line mode is set, make sure that you only apply electrical signals to the line that are appropriate for the line's current mode.

For more information about the electrical characteristics of the GPIO line, see Section 5.7 on page 33.

Setting the Line Mode Using Basler Pylon

You can set the Line Mode parameter value from within your application software by using the pylon API.

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

```
// Configure the GPIO line as an input
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineMode.SetValue( LineMode_Input );
```

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 17.

Setting the Line Mode Using Direct Register Access

To configure the GPIO line as an input via direct register access:

- Set the value of the Line Mode Line 1 register to Input.

For more information about direct register access, see Section 3.2 on page 19.

6.1.3 Selecting an Input Line as the Source Signal for a Camera Function

You can set the GPIO line (assuming it is set as an input), CC1, CC2, or CC3 to act as the source signal for one of the following camera functions:

- Acquisition Start Trigger - If an input line is selected as the source signal for the acquisition start trigger, whenever a proper electrical signal is applied to the line, the camera will recognize the signal as an acquisition start trigger signal.
- Frame Start Trigger - If an input line is selected as the source signal for the frame start trigger, whenever a proper electrical signal is applied to the line, the camera will recognize the signal as an frame start trigger signal.

For detailed information about selecting an input line to act as the source signal for the acquisition start trigger and for details about how the acquisition start trigger operates, see Section 7.2.5 on page 73.

For detailed information about selecting an input line to act as the source signal for the frame start trigger and for details about how the frame start trigger operates, see Section 7.3.3 on page 84.

6.1.4 Input Line Debouncer

When the GPIO line is set to operate as an input, it is equipped with a debouncer feature on the line. CC1, CC2, and CC3 are also equipped with debouncers.

The debouncer feature aids in discriminating between valid and invalid input signals and only lets valid signals pass to the camera. The debouncer value specifies the minimum time that an input signal must remain high or remain low in order to be considered a valid input signal.

ⓘ	We recommend setting the debouncer value so that it is slightly greater than the longest expected duration of an invalid signal. Setting the debouncer to a value that is too short will result in accepting invalid signals. Setting the debouncer to a value that is too long will result in rejecting valid signals.

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

Figure 16 illustrates how the debouncer filters out invalid input signals, i.e. signals that are shorter than the debouncer value. The diagram also illustrates how the debouncer delays a valid signal.

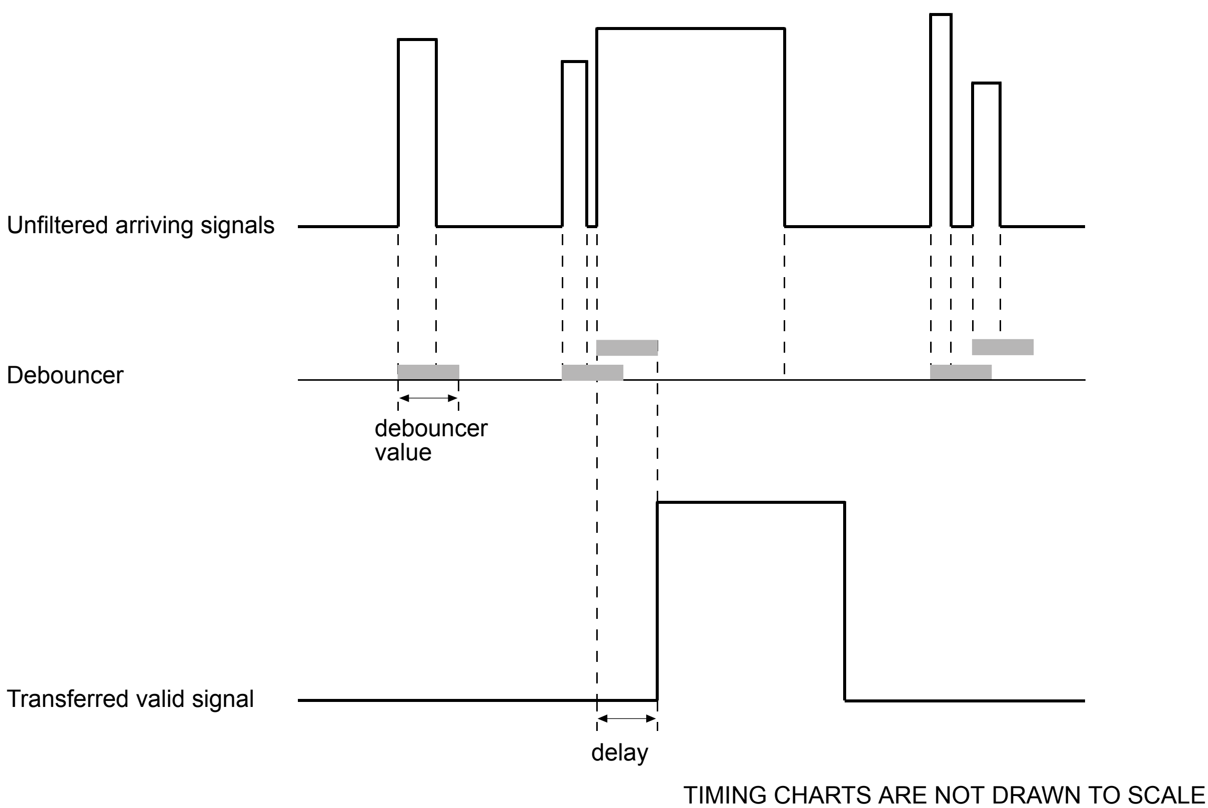


Fig. 16: Filtering of Input Signals by the Debouncer

Setting the Debouncer Using Basler Pylon

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

To set the debouncer:

- Use the Line Selector to select CC1, CC2, CC3, or Line1 (Line1 designates the GPIO line).
- Set the value of the Line Debouncer Time Abs parameter.

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

```
// Select the GPIO line
Camera.LineSelector.SetValue( LineSelector_Line1 );

// Set the parameter value to 100 microseconds
Camera.LineDebouncerTimeAbs.SetValue( 100 );

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting the Debouncer Using Direct Register Access

To set the value of the input line debouncers via direct register access:

- For the GPIO line, set the value of the Input Debouncer Time Line 1 register as desired (the value represents milliseconds).
- For the CC1 line, set the value of the Input Debouncer Time CC1 register.
- For the CC2 line, set the value of the Input Debouncer Time CC2 register.
- For the CC3 line, set the value of the Input Debouncer Time CC3 register.

For more information about direct register access, see Section 3.2 on page 19.

6.1.5 Setting an Input Line for Invert

You can set CC1, CC2, CC3, and the GPIO line to invert or not to invert the incoming electrical signal.

Setting an Input Line for Invert Using Basler Pylon

To set the invert function on an input line:

- Use the Line Selector to select CC1, CC2, CC3, or Line1 (Line1 designates the GPIO line).
- Set the value of the Line Inverter parameter to true to enable inversion on the selected line or to false to disable inversion.

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

```
// Select the GPIO line
Camera.LineSelector.SetValue( LineSelector_Line1 );
// Enable the inverter on the selected line
Camera.LineInverter.SetValue( true );

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting an Input Line for Invert Using Direct Register Access

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

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

For more information about direct register access, see Section 3.2 on page 19.

6.2 Output Lines

6.2.1 Available Output Lines

The camera is equipped with one GPIO line designated as line 1. The GPIO line can be accessed through the four pin connector on the back of the camera as described in the "Physical Interface" chapter. The GPIO line can be set to operate as either as an input line or an output line. This section describes using the GPIO when it is set to operate as an output line.

The camera is also equipped with a CL Spare data bit built into the Camera Link interface as specified in the Camera Link standard. On ace Camera Link cameras, the CL Spare data bit can be used as a camera output line.

> The CL Spare data bit is not available when the camera is set for the 1X8-1Y or the 1X10-1Y tap geometry.
>
> The CL Spare data bit is not directly accessible by the camera user. The data bit must be accessed via the frame grabber attached to the camera. Not all frame grabbers provide users with direct access to this bit. Consult your frame grabber supplier for more information.

You can get some general information about how this bit is implemented from the Basler document called *Ace Camera Link Information for Frame Grabber Designers* (AW000990xx000). You can obtain the document from the Downloads section of the Basler website:

www.baslerweb.com

6.2.2 Setting the GPIO Line to Operate as an Output

The Line Mode parameter is used to set the camera's GPIO line to operate as an output.

NOTICE

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

1. Before you connect any external circuitry to the GPIO line, we strongly recommend that you set the GPIO line mode so that the line will operate as an output .
2. Once the line mode is set, make sure that you only apply electrical signals to the line that are appropriate for the line's current mode.

For more information about the electrical characteristics of the GPIO line, see Section 5.7 on page 33.

Setting the Line Mode Using Basler Pylon

You can set the Line Mode parameter value from within your application software by using the pylon API.

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

```
// Configure the GPIO line as an output
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineMode.SetValue( LineMode_Output );
```

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 17.

Setting the Line Mode Using Direct Register Access

To configure the GPIO line as an output via direct register access:

- Set the value of the Line Mode Line 1 register to Output.

For more information about direct register access, see Section 3.2 on page 19.

6.2.3 Selecting the Source Signal for an Output Line

You can select any one of the camera's standard output signals to act as the source signal for the GPIO line (assuming it is set as an output) or for the CL Spare line. The camera has four standard output signals available:

- Acquisition Trigger Wait
- Frame Trigger Wait
- Exposure Active
- Frame Cycle

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

For more information about the acquisition trigger and frame trigger wait signals, see Section 7.1 on page 63.

For more information about the exposure active signal, see Section 7.6.1 on page 97.

For more information about the frame cycle signal, see Section 7.6.4 on page 110.

For more information about setting the state of a user settable output line, see Section 6.2.4 on page 55.

For more information about the electrical characteristics of the GPIO line when it is set as an output, see Section 5.7.4 on page 39.

Selecting the Source Signal Using Basler Pylon

To select a camera output signal as the source signal for the GPIO line (assuming it is set as an output) or for the CL Spare line, or to designate a line as user settable:

- Use the Line Selector to select the line.
- Set the value of the Line Source Parameter to one of the available output signals or to user settable. This will set the source signal for the output line.

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

```
// Select the GPIO line
Camera.LineSelector.SetValue( LineSelector_Line1 );
// Set the source signal for the selected line
Camera.LineSource.SetValue( LineSource_ExposureActive );

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

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 17.

Selecting the Source Signal Using Direct Register Access

To select a camera output signal as the source signal for the GPIO line (assuming that it is set as an output) or to designate the line as user settable via direct register access:

- Set the value of the Line Source Line 1 register to Acquisition Trigger Wait, Frame Trigger Wait, Exposure Active, Frame Cycle, or User as desired.

To select a camera output signal as the source signal for the CL Spare line or to designate the line as user settable via direct register access:

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

For more information about direct register access, see Section 3.2 on page 19.

6.2.4 Setting the State of a User Settable Output Line

As mentioned in the previous section, the GPIO line (assuming it is set as an output) or the CL Spare line can each be designated as "user settable". If you have designated a line as user settable, you can use camera parameters to set the state of the line.

Setting the State Using Basler Pylon

To set the state of a user settable output line:

- Use the User Output Selector to select the GPIO line or the CL Spare line.
- Set the value of the User Output Value parameter to true (1) or false (0). This will set the state of the output line.

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

```
// Set the GPIO line to be user settable
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineSource.SetValue( LineSource_UserOutput );
// Select the user settable line and set the state
Camera.UserOutputSelector.SetValue( UserOutputSelector_UserOutputLine1 );
Camera.UserOutputValue.SetValue( true );
bool currentUserOutput1State = Camera.UserOutputValue.GetValue( );

// Set the CL Spare line to be user settable
Camera.LineSelector.SetValue( LineSelector_ClSpare );
Camera.LineSource.SetValue( LineSource_UserOutput );
// Select the user settable line and set the state
Camera.UserOutputSelector.SetValue( UserOutputSelector_UserOutputClSpare );
Camera.UserOutputValue.SetValue( false );
bool currentUserOutput1State = Camera.UserOutputValue.GetValue( );
```

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting the State Using Direct Register Access

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

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

For more information about direct register access, see Section 3.2 on page 19.

6.2.5 Setting an Output Line for Invert

You can set the output lines to not invert or to invert.

For the GPIO Line

If the GPIO line is not set to invert:

- A low output signal from the camera results in a non-conducting Q1 transistor in the output circuit (see Figure 17).
- A high output signal from the camera results in a conducting Q1 transistor in the output circuit.

If the GPIO line is set to invert:

- A low output signal from the camera results in a conducting Q1 transistor in the output circuit.
- A high output signal from the camera results in a non-conducting Q1 transistor in the output circuit.

For the CL Spare Line

If the CL Spare line is not set to invert:

- When the source camera signal assigned to the line is high, the CL Spare line will transmit a 1. And when the source signal is low, the CL Spare line will transmit a 0.

If the CL Spare line is set to invert:

- When the source camera signal assigned to the line is high, the CL Spare line will transmit a 0. And when the source signal is low, the CL Spare line will transmit a 1.

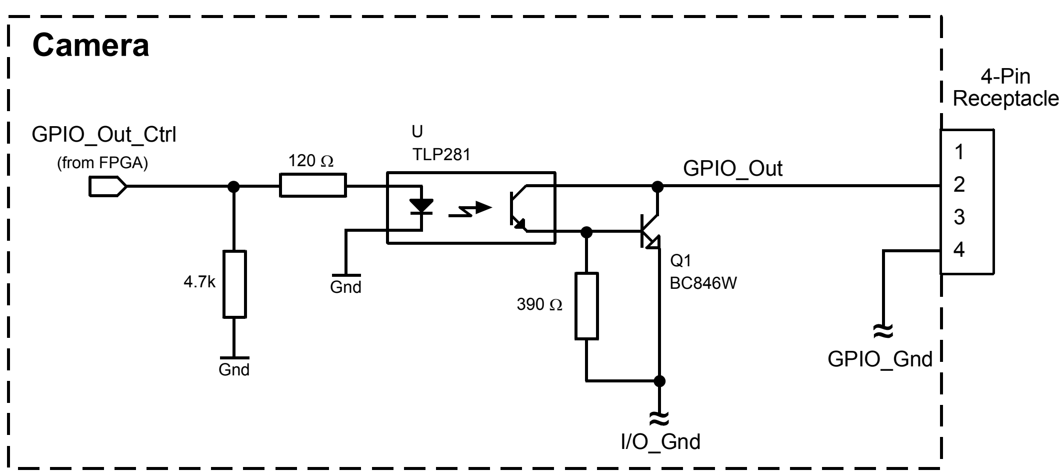


Fig. 17: GPIO Line Schematic (GPIO Line Set as an Output)

Setting an Output Line for Invert Using Pylon

To set the invert function on an output line:

- Use the Line Selector to select the GPIO line or the CL Spare line.
- Set the value of the Line Inverter parameter to true to enable inversion on the selected line or to false to disable inversion.

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

```
// Select the GPIO line
Camera.LineSelector.SetValue( LineSelector_Line1 );
// Enable the inverter on the selected line
Camera.LineInverter.SetValue( true );

// Select the CL Spare line
Camera.LineSelector.SetValue( LineSelector_ClSpare );
// Disable the inverter on the selected line
Camera.LineInverter.SetValue( false );
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting an Output Line for Invert Using Direct Register Access

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

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

For more information about direct register access, see Section 3.2 on page 19.

6.3 Checking the State of the I/O Lines

6.3.1 Checking the State of a Single Line

Checking the State Using Basler Pylon

You can determine the current state of each I/O line using Basler Pylon:

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

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

```
// Select the GPIO line and read the state
Camera.LineSelector.SetValue( LineSelector_Line1 );
bool Line1State = Camera.LineStatus.GetValue( );

// Select the CLSpare line and read the state
Camera.LineSelector.SetValue( LineSelector_ClSpare );
bool ClSpareState = Camera.LineStatus.GetValue( );

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Checking the State Using Direct Register Access

To check the current state of an I/O line via direct register access:

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

For more information about direct register access, see Section 3.2 on page 19.

6.3.2 Checking the State of All Lines

Checking the State Using Basler Pylon

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

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

The Line Status All parameter is a 32 bit value. As shown in Figure 18, certain bits in the value are associated with each I/O line, and each of these bits will indicate the state of the assocaited line. If a bit is 0, it indicates that the state of the associated line is currently low. If a bit is 1, it indicates that the state of the associated line is currently high.

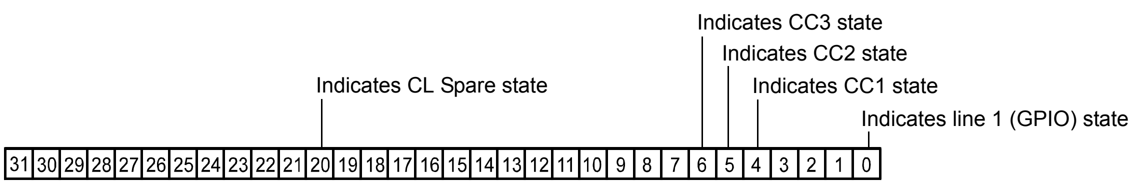


Fig. 18: Line Status All Parameter Bits

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Checking the State Using Direct Register Access

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

For more information about direct register access, see Section 3.2 on page 19.

6.4 Checking the Line Logic

Checking the Line Logic Using Basler Pylon

You can determine the type of line logic for each I/O line using Basler Pylon:

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

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

```
// Select the GPIO line and read the line logic type
Camera.LineSelector.SetValue( LineSelector_Line1 );
LineLogicEnums lineLogicLine1 = Camera.LineLogic.GetValue( );

// Select the CLSpare line and read line logic type
Camera.LineSelector.SetValue( LineSelector_ClSpare );
LineLogicEnums lineLogicClSpare = Camera.LineLogic.GetValue( );

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Checking the Line Logic Using Direct Register Access

To check the Line Logic of an I/O line via direct register access:

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

For more information about direct register access, see Section 3.2 on page 19.

7 Image Acquisition Control

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

7.1 Overview

This section presents an overview of the elements involved with controlling the acquisition of images. Reading this section will give you an idea about how these elements fit together and will make it easier to understand the detailed information in the sections that follow.

Three major elements are involved in controlling the acquisition of images:

- The acquisition start trigger
- The frame start trigger
- Exposure time control

When reading the explanations in the overview and in this entire chapter, keep in mind that the term "frame" is typically used to mean a single acquired image.

When reading the material in this chapter, it is helpful to refer to Figure 19 on page 65 and to the use case diagrams in Section 7.9 on page 119. These diagrams present the material related to the acquisition start trigger and the frame start trigger in a graphical format.

Acquisition Start Trigger

The acquisition start trigger is essentially an enabler for the frame start trigger.

The acquisition start trigger has two modes of operation: off and on.

If the Trigger Mode parameter for the acquisition start trigger is set to off, the camera will generate all required acquisition start trigger signals internally, and you do not need to apply acquisition start trigger signals to the camera.

If the Trigger Mode parameter for the acquisition start trigger is set to on, the initial acquisition status of the camera will be "waiting for acquisition start trigger" (see Figure 19 on page 65). When the camera is in this acquisition status, it cannot react to frame start trigger signals. When an acquisition start trigger signal is applied to the camera, the camera will exit the "waiting for acquisition start trigger" acquisition status and enter a "waiting for frame start trigger" acquisition status. The camera can then react to frame start trigger signals. The camera will continue to react to frame start trigger signals until the number of frame start trigger signals it has received is equal to an integer parameter setting called the Acquisition Frame Count. At that point, the camera will return to the "waiting for acquisition start trigger" acquisition status and will remain in that status until a new acquisition start trigger signal is applied.

As an example, assume that the Acquisition Frame Count parameter is set to three and that the camera is in a "waiting for acquisition start trigger" acquisition status. When an acquisition start trigger signal is applied to the camera, it will exit the "waiting for acquisition start trigger" acquisition status and enter the "waiting for frame start trigger" acquisition status. Once the camera has received three frame start trigger signals, it will return to the "waiting for acquisition start trigger" acquisition status. At that point, you must apply a new acquisition start trigger signal to the camera to make it exit "waiting for acquisition start trigger".

Frame Start Trigger

Assuming that an acquisition start trigger signal has just been applied to the camera, the camera will exit from the "waiting for acquisition start trigger" acquisition status and enter a "waiting for frame start trigger" acquisition status. Applying a frame start trigger signal to the camera at this point will exit the camera from the "waiting for frame start trigger" acquisition status and will begin the process of exposing and reading out a frame (see Figure 19 on page 65). As soon as the camera is ready to accept another frame start trigger signal, it will return to the "waiting for frame start trigger" acquisition status. A new frame start trigger signal can then be applied to the camera to begin another frame exposure.

The frame start trigger has two modes: off and on.

If the Trigger Mode parameter for the frame start trigger 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. The rate at which the camera will generate the signals and acquire frames will be determined by the way that you set several frame rate related parameters.

If the Trigger Mode parameter for the frame start trigger is set to on, you must trigger frame start by applying frame start trigger signals to the camera. Each time a trigger signal is applied, the camera will begin a frame exposure. When frame start is being triggered in this manner, it is important that you do not attempt to trigger frames at a rate that is greater than the maximum allowed. (There is a detailed explanation about the maximum allowed frame rate at the end of this chapter.) Frame start trigger signals that are applied to the camera when it is not in a "waiting for frame start trigger" acquisition status will be ignored.

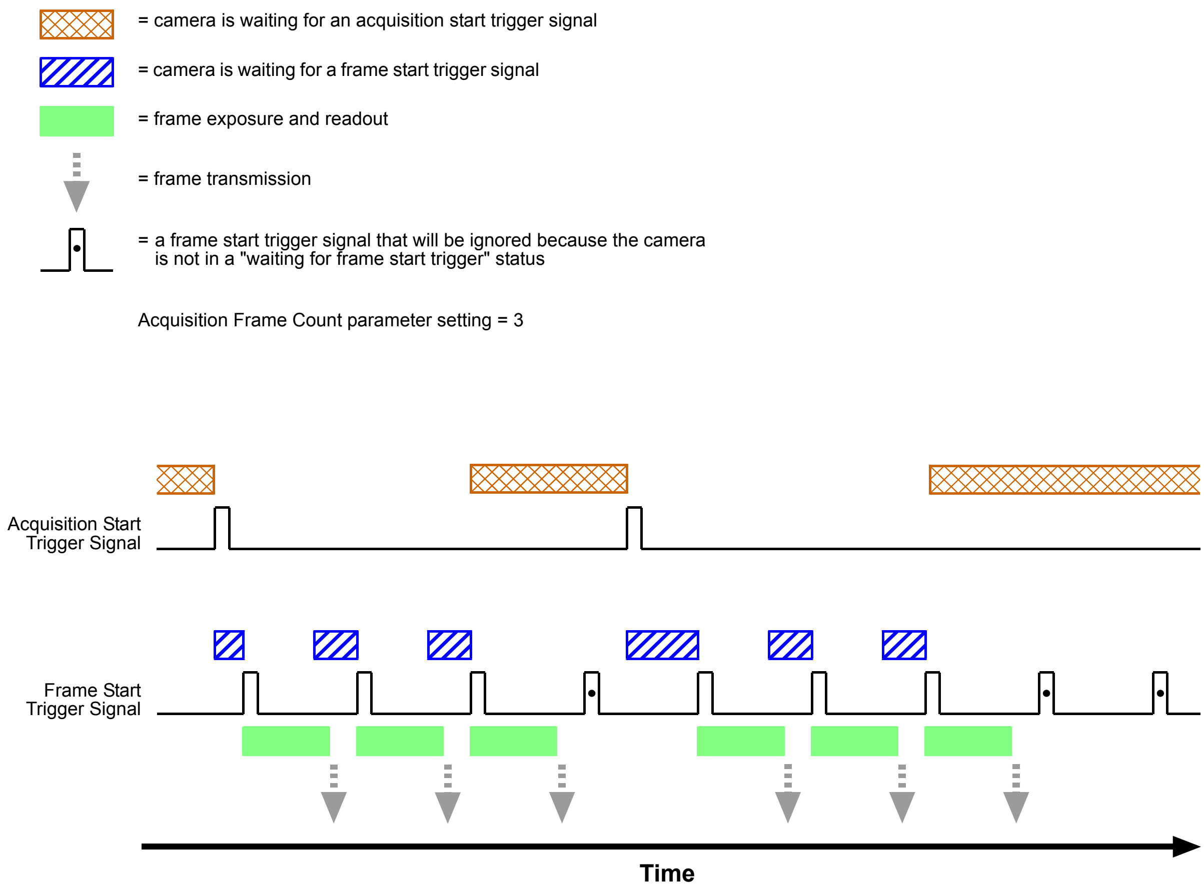


Fig. 19: Acquisition Start and Frame Start Triggering

Applying Trigger Signals

The paragraphs above mention "applying a trigger signal". There are two ways to apply an acquisition start or a frame start trigger signal to the camera: via software or via hardware.

To apply trigger signals via software, you must first select the acquisition start or the frame start trigger and then indicate that software will be used as the source for the selected trigger signal. At that point, the Basler pylon API or direct camera register access can be used to apply a software trigger signal to the camera for the selected trigger.

To apply trigger signals via hardware, you must first select the acquisition start or the frame start trigger. You then configure the camera's GPIO as an input and select the input to be used as the source for the selected trigger. At that point, each time the proper electrical signal is applied to the selected input, an occurrence of the selected trigger signal will be recognized by the camera.

The Trigger Selector (This Only Applies When You Are Using Basler pylon)

If you are using the Basler pylon API to parameterize the camera, the concept of the "trigger selector" is very important to understand when working with the acquisition start and frame start triggers. Many of the parameter settings and the commands that apply to the triggers have names that are not specific to a particular type of trigger, for example, the acquisition start trigger has a mode setting and The frame start trigger has a mode setting. But in Basler pylon there is a single parameter, the Trigger Mode parameter, that is used to set the mode for both of these triggers. Also, the Trigger Software command mentioned earlier can be executed for either the acquisition start trigger or the frame start trigger. So if you want to set the Trigger Mode or execute a Trigger Software command for the acquisition start trigger rather than the frame start trigger, how do you do it? The answer is, by using the Trigger Selector parameter. Whenever you want to work with a specific type of trigger, your first step is to set the Trigger Selector parameter to the trigger you want to work with (either the acquisition start trigger or the frame start trigger). At that point, the changes you make to the Trigger Mode, Trigger Source, etc., will be applied to the selected trigger only.

Exposure Time Control

As mentioned earlier, when a frame start trigger signal is applied to the camera, the camera will begin to acquire a frame. A critical aspect of frame acquisition is how long the pixels in the camera’s sensor will be exposed to light during the frame acquisition.

If the camera is set for software frame start triggering, the camera’s Exposure Time parameter will determine the exposure time for each frame.

If the camera is set for hardware frame start triggering, there are two modes of operation: "timed" and "trigger width". With the "timed" mode, the Exposure Time parameter will determine the exposure time for each frame. With the "trigger width" mode, the way that you manipulate the rise and fall of the hardware signal will determine the exposure time. The "trigger width" mode is especially useful if you want to change the exposure time from frame to frame.

7.2 The Acquisition Start Trigger

(When reading this section, it is helpful to refer to Figure 19 on page 65.)

The acquisition start trigger is used in conjunction with the frame start trigger to control the acquisition of frames. In essence, the acquisition start trigger is used as an enabler for the frame start trigger. Acquisition start trigger signals can be generated within the camera or may be applied externally as software or hardware acquisition start trigger signals.

When the acquisition start trigger is enabled, the camera's initial acquisition status is "waiting for acquisition start trigger". When the camera is in this acquisition status, it will ignore any frame start trigger signals it receives. If an acquisition start trigger signal is applied to the camera, it will exit the "waiting for acquisition start trigger" acquisition status and enter the "waiting for frame start trigger" acquisition status. In this acquisition status, the camera can react to frame start trigger signals and will begin to expose a frame each time a proper frame start trigger signal is applied.

A primary feature of the acquisition start trigger is that after an acquisition start trigger signal has been applied to the camera and the camera has entered the "waiting for frame start trigger" acquisition status, the camera will return to the "waiting for acquisition start trigger" acquisition status once a specified number of frame start triggers has been received. Before more frames can be acquired, a new acquisition start trigger signal must be applied to the camera to exit it from "waiting for acquisition start trigger" status. Note that this feature only applies when the Trigger Mode parameter for the acquisition start trigger is set to on. This feature is explained in greater detail in the following sections.

7.2.1 Acquisition Start Trigger Mode

The main parameter associated with the acquisition start trigger is the Trigger Mode parameter. The Trigger Mode parameter for the acquisition start trigger has two available settings: off and on.

7.2.1.1 Acquisition Start Trigger Mode = Off

When the Trigger Mode parameter for the acquisition start trigger is set to off, the camera will generate all required acquisition start trigger signals internally, and you do not need to apply acquisition start trigger signals to the camera.

7.2.1.2 Acquisition Start Trigger Mode = On

When the Trigger Mode parameter for the acquisition start trigger is set to on, the camera will initially be in a "waiting for acquisition start trigger" acquisition status and cannot react to frame start trigger signals. You must apply an acquisition start trigger signal to the camera to exit the camera from the "waiting for acquisition start trigger" acquisition status and enter the "waiting for frame start trigger" acquisition status. The camera can then react to frame start trigger signals and will continue to do so until the number of frame start trigger signals it has received is equal to the current Acquisition

Frame Count parameter setting. The camera will then return to the "waiting for acquisition start trigger" acquisition status. In order to acquire more frames, you must apply a new acquisition start trigger signal to the camera to exit it from the "waiting for acquisition start trigger" acquisition status.

When the Trigger Mode parameter for the acquisition start trigger is set to on, you must select a source signal to act as the acquisition start trigger. The Trigger Source parameter specifies the source signal. The available selections for the Trigger Source parameter are:

- Software - When the source signal is set to software, you apply an acquisition start trigger signal to the camera by executing a Trigger Software command for the acquisition start trigger on the host PC.
- Line 1 - When the source signal is set to line 1, you apply an acquisition start trigger signal to the camera by injecting an externally generated electrical signal (commonly referred to as a hardware trigger signal) into the GPIO line on the camera. This assumes that the GPIO line on the camera has been properly set to operate as an input line.
- CC1 - When the source signal is set to CC1, you apply an acquisition start trigger signal to the camera by injecting an externally generated electrical signal into CC1 in the Camera Link interface.
- CC2 - When the source signal is set to CC2, you apply an acquisition start trigger signal to the camera by injecting an externally generated electrical signal into CC2 in the Camera Link interface.
- CC3 - When the source signal is set to CC3, you apply an acquisition start trigger signal to the camera by injecting an externally generated electrical signal into CC3 in the Camera Link interface.

If the Trigger Source parameter for the acquisition start trigger is set to line 1, CC1, CC2, or CC3, you must also set the Trigger Activation parameter. The available settings for the Trigger Activation parameter are:

- Rising Edge - specifies that a rising edge of the hardware trigger signal will act as the acquisition start trigger.
- Falling Edge - specifies that a falling edge of the hardware trigger signal will act as the acquisition start trigger.

ⓘ	Typically, a frame grabber is used to supply the electrical frame start trigger signal to CC1, CC2, or CC3.

For more detailed information about the GPIO line on the camera, see Section 5.7 on page 33.

For more detailed information about the CC1, CC2, and CC3 inputs in the Camera Link interface, refer to the document called *Ace Camera Link Information for Frame Grabber Designers* (AW000990xx000). You can obtain the document from the Downloads section of the Basler website:

www.baslerweb.com

7.2.2 Acquisition Frame Count

When the Trigger Mode parameter for the acquisition start trigger is set to on, you must set the value of the camera's Acquisition Frame Count parameter. The value of the Acquisition Frame Count can range from 1 to 255.

With acquisition start triggering on, the camera will initially be in a "waiting for acquisition start trigger" acquisition status. When in this acquisition status, the camera cannot react to frame start trigger signals. If an acquisition start trigger signal is applied to the camera, the camera will exit the "waiting for acquisition start trigger" acquisition status and will enter the "waiting for frame start trigger" acquisition status. It can then react to frame start trigger signals. When the camera has received a number of frame start trigger signals equal to the current Acquisition Frame Count parameter setting, it will return to the "waiting for acquisition start trigger" acquisition status. At that point, you must apply a new acquisition start trigger signal to exit the camera from the "waiting for acquisition start trigger" acquisition status.

7.2.3 Setting The Acquisition Start Trigger Mode and Related Parameters

Setting the Parameters Using Basler pylon

You can set theTrigger Mode and Trigger Source parameter values for the acquisition start trigger and the Acquisition Frame Count parameter value from within your application software by using the pylon API.

The following code snippet illustrates using the API to set the acquisition start Trigger Mode to on, the Trigger Source to software, and the Acquisition Frame Count to 5:

```
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Software );
// Set the acquisition frame count
Camera.AcquisitionFrameCount.SetValue( 5 );
```

The following code snippet illustrates using the API to set the Trigger Mode to on, the Trigger Source to line 1, the Trigger Activation to rising edge, and the Acquisition Frame Count to 5:

```
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Configure the GPIO line as an input
```

```
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineMode.SetValue( LineMode_Input );
// Set the source for the selected trigger to line 1
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
// Set the activation mode for the selected trigger to rising edge
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
// Set the acquisition frame count
Camera.AcquisitionFrameCount.SetValue( 5 );
```

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 17.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

Setting the Parameters Using Direct Register Access

To set the parameters related to the acquisition start trigger via direct register access:

- Set the value of the Trigger Mode Acquisition Start register to On.
- Set the value of the Trigger Source Acquisition Start register to Software, Line 1, CC1, CC2, or CC3.
- If the trigger source is set to line 1, set the GPIO line to operate as an input by setting the value of the LineModeLine1 register to Input.
- If the trigger source is set to line 1, CC1, CC2, or CC3, set the value of the Trigger Activation Acquisition Start register to Rising Edge or Falling Edge.
- Set the value of the Acquisition Frame Count register as desired.

For more information about direct register access, see Section 3.2 on page 19.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

7.2.4 Using a Software Acquisition Start Trigger Signal

7.2.4.1 Introduction

If the camera's Trigger Mode parameter for the acquisition start trigger is set to on and the Trigger Source parameter is set to software, you must apply a software acquisition start trigger signal to the camera before you can begin frame acquisition.

The camera will initially be in a "waiting for acquisition start trigger" acquisition status. It cannot react to frame trigger signals when in this acquisition status. When a software acquisition start trigger signal is received by the camera, it will exit the "waiting for acquisition start trigger" acquisition status and will enter the "waiting for frame start trigger" acquisition status. It can then react to frame start trigger signals. When the number of frame start trigger signals received by the camera is equal to the current Acquisition Frame Count parameter setting, the camera will return to the "waiting for acquisition start trigger" acquisition status. When a new software acquisition start trigger signal is applied to the camera, it will again exit from the "waiting for acquisition start trigger" acquisition status and enter the "waiting for frame start trigger" acquisition status.

Section 7.2.4.2 includes more detailed information about applying a software acquisition start trigger to the camera using Basler pylon or via direct register access.

7.2.4.2 Setting the Parameters Related to Software Acquisition Start Triggering and Applying a Software Trigger Signal

Setting the Parameters and Applying the Signal Using Basler pylon

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

```
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Software );
// Set the acquisition frame count
Camera.AcquisitionFrameCount.SetValue( 5 );
// Execute a trigger software command to apply a software acquisition start trigger
// signal to the camera
Camera.TriggerSoftware.Execute( );

// Note: as long as the Trigger Selector is set to Acquisition Start, executing
// a Trigger Software command will apply an acquisition start software trigger
// signal to the camera
```

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 17.

Setting the Parameters and Applying the Signal Using Direct Register Access

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

- Set the value of the Trigger Mode Acquisition Start register to On.
- Set the value of the Trigger Source Acquisition Start register to Software.
- Set the value of the Acquisition Frame Count register as desired.
- Set the value of the Trigger Software Acquisition Start register to 1.
  Setting the value of this register to 1 applies a software acquisition start trigger signal to the camera. The register resets to 0 when execution is complete.

For more information about direct register access, see Section 3.2 on page 19.

7.2.5 Using a Hardware Acquisition Start Trigger Signal

7.2.5.1 Introduction

If the Trigger Mode parameter for the acquisition start trigger is set to on and the Trigger Source parameter is set to line 1, CC1, CC2, or CC3, an externally generated electrical signal injected into the selected source will be will act as the acquisition start trigger signal for the camera. This type of trigger signal is generally referred to as a hardware trigger signal or as an external acquisition start trigger signal (ExASTrig).

If the Trigger Source is set to line 1, the GPIO line must be properly set to operate as an input in order to accept the trigger signal.

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

When the Trigger Mode parameter is set to on, the camera will initially be in a "waiting for acquisition start trigger" acquisition status. It cannot react to frame start trigger signals when in this acquisition status. When the appropriate ExASTrig signal is applied to the selected source (e.g, a rising edge of the signal for rising edge triggering), the camera will exit the "waiting for acquisition start trigger" acquisition status and will enter the "waiting for frame start trigger" acquisition status. It can then react to frame start trigger signals. When the number of frame start trigger signals received by the camera is equal to the current Acquisition Frame Count parameter setting, the camera will return to the "waiting for acquisition start trigger" acquisition status. When a new ExASTrig signal is applied to the selected source, the camera will again exit from the "waiting for acquisition start trigger" acquisition status and enter the "waiting for frame start trigger" acquisition status.

For more information about setting the camera for hardware acquisition start triggering and selecting the source to receive the ExASTrig signal, see Section 7.2.5.3 on page 74.

For more information about the electrical requirements for the GPIO line when it is set to operate as an input, see Section 5.7.2 on page 33.

For more information about CC1, CC2, and CC3, see Section 6.1 on page 47.

7.2.5.2 Acquisition Start Trigger Delay

The acquisition start trigger delay feature lets you specify a delay (in microseconds) that will be applied between the receipt of each hardware acquisition start trigger signal by the camera and when the trigger signal will become effective.

The acquisition start trigger delay may be specified in the range from 0 to 10000000 µs (equivalent to 10 s). When the delay is set to 0 µs, no delay will be applied.

If you are parameterizing the camera with Basler pylon, the Trigger Delay Abs parameter will determine the length of the delay.

If you are parameterizing the camera via direct register access, the Trigger Delay Raw Acquisition Start register will determine the length of the delay.

ⓘ	The acquisition start trigger delay will not operate if the Acquisition Start Trigger Mode parameter is set to off or if you are using a software acquisition start trigger.

7.2.5.3 Setting the Parameters Related to Hardware Acquisition Start Triggering and Applying a Hardware Trigger Signal

Setting the Parameters Using Basler pylon and Applying a Signal

You can set all of the parameters needed to perform hardware acquisition start triggering from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter values required to enable rising edge hardware acquisition start triggering with line 1 as the trigger source:

```
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Configure the GPIO line as an input
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineMode.SetValue( LineMode_Input );
// Set the source for the selected trigger to line 1
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
// Set the activation mode for the selected trigger to rising edge
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
// Set the acquisition frame count
Camera.AcquisitionFrameCount.SetValue( 5 );

// Apply a rising edge of the externally generated electrical signal
// (ExASTrig signal) to line 1 on the camera
```

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 17.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

Setting the Parameters Using Direct Register Access and Applying a Signal

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

- Set the value of the Trigger Mode Acquisition Start register to On.
- Set the value of the Trigger Source Acquisition Start register to Line 1, CC1, CC2, or CC3.
- If the trigger source is set to line 1, set the GPIO line to operate as an input by setting the value of the LineModeLine1 register to Input.
- Set the value of the Trigger Activation Acquisition Start register to Rising Edge or Falling Edge.
- Set the value of the Acquisition Frame Count register as desired.

Apply the appropriate externally generated electrical signal (ExASTrig signal) to the selected trigger source.

For more information about direct register access, see Section 3.2 on page 19.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

7.3 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.

(For a quick overview of acquisition start triggering and frame start triggering, see Section 7.1 on page 63.)

When reading this section, it is helpful to refer to Figure 19 on page 65 and the use case diagrams that appear in Section 7.9 on page 119.

7.3.1 Frame Start Trigger Mode

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

7.3.1.1 Frame Start Trigger Mode = Off

When the Trigger Mode parameter for the frame start trigger 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.

If you are using Basler pylon to parameterize the camera, the rate at which the frame start trigger signals will be generated is determined by the camera’s Acquisition Frame Rate Abs parameter:

- If the parameter is not enabled, the camera will generate frame start trigger signals at the maximum rate allowed given the current camera settings.
- If the parameter is enabled and is set to a value less than the maximum allowed frame rate, the camera will generate frame start trigger signals at the rate specified by the parameter setting.
- If the parameter is enabled and is set to a value greater than the maximum allowed frame rate, the camera will generate frame start trigger signals at the maximum allowed frame rate.

If you are using direct register access to parameterize the camera, the rate at which the frame start trigger signals will be generated is determined by the camera’s Acquisition Frame Period Raw parameter (Frame Rate = 1/ Frame Period):

- If the parameter is not enabled, the camera will generate frame start trigger signals at the maximum rate allowed given the current camera settings.
- If the parameter is enabled and is set to a value that would result in a frame rate less than the maximum allowed, the camera will generate frame start trigger signals at the rate that results from the parameter setting.
- If the parameter is enabled and is set to a value that would result in a frame rate greater than the maximum allowed given the current camera settings, the camera will generate frame start trigger signals at the maximum allowed frame rate.

Exposure Time Control with the Frame Start Trigger Off

When the Trigger Mode parameter for the frame start trigger is set to off, the exposure time for each frame acquisition is determined by:

- the value of the camera's Exposure Time Abs parameter if you are parameterizing the camera using Basler pylon.
- the value in the camera's Exposure Time Raw register if you are parameterizing the camera using direct register access.

For more information about setting the Exposure Time Abs parameter or the Exposure Time Raw register, see Section 7.4 on page 92.

7.3.1.2 Frame Start Trigger Mode = On

When the Trigger Mode parameter for the frame start trigger is set to on, you must apply a frame start trigger signal to the camera each time that you want to begin a frame acquisition. The Trigger Source parameter specifies the source signal that will act as the frame start trigger. The available selections for the Trigger Source parameter are:

- Software - When the source signal is set to software, you apply a frame start trigger signal to the camera by executing a Trigger Software command for the frame start trigger on the host PC.
- Line 1 - When the source signal is set to line 1, you apply a frame start trigger signal to the camera by injecting an externally generated electrical signal (commonly referred to as a hardware trigger signal) into the GPIO line on the camera. This assumes that the GPIO line on the camera has been properly set to operate as an input line.
- CC1 - When the source signal is set to CC1, you apply a frame start trigger signal to the camera by injecting an externally generated electrical signal into CC1 in the Camera Link interface.
- CC2 - When the source signal is set to CC2, you apply a frame start trigger signal to the camera by injecting an externally generated electrical signal into CC2 in the Camera Link interface.
- CC3 - When the source signal is set to CC3, you apply a frame start trigger signal to the camera by injecting an externally generated electrical signal into CC3 in the Camera Link interface.

If the Trigger Source parameter is set to line 1, line 2, CC1, CC2, or CC3, you must also set the Trigger Activation parameter. The available settings for the Trigger Activation parameter are:

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

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

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

For more information about using a software trigger to control frame acquisition start, see Section 7.3.2 on page 81.

For more information about using a hardware trigger to control frame acquisition start, see Section 7.3.3 on page 84.

Exposure Time Control with the Frame Start Trigger On

When the Trigger Mode parameter for the frame start trigger is set to on and the Trigger Source parameter is set to software, the exposure time for each frame acquisition is determined by:

- the value of the camera's Exposure Time Abs parameter if you are parameterizing the camera using Basler pylon.
- the value in the camera's Exposure Time Raw register if you are parameterizing the camera using direct register access.

When the Trigger Mode parameter is set to on and the Trigger Source parameter is set to line 1, CC1, CC2, or CC3, the exposure time for each frame acquisition can be controlled using one of the values mentioned in the two bullet points above or it can be controlled by manipulating the hardware trigger signal.

For more information about controlling exposure time when using a software trigger, see Section 7.3.2 on page 81.

For more information about controlling exposure time when using a hardware trigger, see Section 7.3.3 on page 84.

7.3.1.3 Setting the Frame Start Trigger Mode and Related Parameters

Setting the Parameters Using Basler pylon

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

The following code snippet illustrates using the API to set the Trigger Mode parameter for the frame start trigger to on and the Trigger Source parameter to CC1:

```
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_CC1 );
```

The following code snippet illustrates using the API to set the Trigger Mode parameter for the frame start trigger to on and the Trigger Source parameter to line 1:

```
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Configure the GPIO line as an input
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineMode.SetValue( LineMode_Input );
// Set the source for the selected trigger to line 1
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
```

The following code snippet illustrates using the API to set the Trigger Mode parameter for the frame start trigger to off and the Acquisition Frame Rate Abs parameter to 60:

```
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_Off );
// Set the exposure time
Camera.ExposureTimeAbs.SetValue( 3000 );
// Enable the acquisition frame rate parameter and set the frame rate. (Enabling
// the acquisition frame rate parameter allows the camera to control the frame
// rate internally.
Camera.AcquisitionFrameRateEnable.SetValue( true );
Camera.AcquisitionFrameRateAbs.SetValue( 60.0 );
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

For more detailed information about the camera’s GPIO line, see Section 5.7 on page 33.

Setting the Parameters Using Direct Register Access

To set the trigger mode for the frame start trigger to on and to select a trigger source via direct register access:

- Set the value of the Trigger Mode Frame Start register to On.
- Set the value of the Trigger Source Frame Start register to Software, Line 1, CC1, CC2, or CC3.
- If the trigger source is set to Line 1, set the GPIO line to operate as an input by setting the value of the Line Mode Line 1 register to Input.
- If the trigger source is set to line 1, CC1, CC2, or CC3, set the value of the Trigger Activation Frame Start register to Rising Edge or Falling Edge.

To set the trigger mode for the frame start trigger to off, set the exposure time, and set the frame acquisition rate via direct register access:

- Set the value of the Trigger Mode Frame Start register to Off.
- Set the value of the Exposure Time Raw register as desired.

  A value in a raw register is simply an integer value with no units. To determine what the actual setting will be, you must multiply the value in the raw register by the camera's time base. The time base on ace cameras is 1 µs.

  For example, if you set the Exposure Time Raw register to 1000, the exposure time would be 1000 µs (1000 x 1 µs = 1000 µs).
- Set the value of the Acquisition Frame Period Enable register to 1 (true).
  (This will enable the camera's ability to internally control the frame period.)
- Set the value of the Acquisition Frame Period Raw register as desired.
  (Frame Rate = 1 /Frame Period.)

For more information about direct register access, see Section 3.2 on page 19.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

7.3.2 Using a Software Frame Start Trigger Signal

7.3.2.1 Introduction

If the Trigger Mode parameter for the frame start trigger is set to on and the Trigger Source parameter is set to software, you must apply a software frame start trigger signal to the camera to begin each frame acquisition. Assuming that the camera is in a "waiting for frame start trigger" acquisition status, frame exposure will start when the software frame start trigger signal is received by the camera. Figure 20 illustrates frame acquisition with a software frame start trigger signal.

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

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

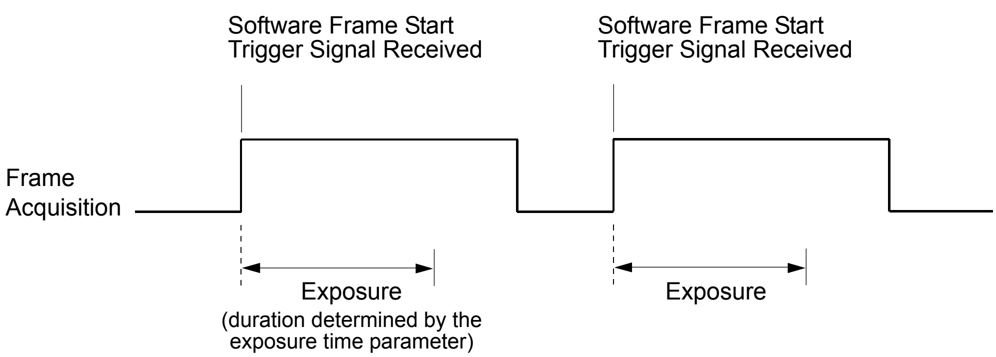


Fig. 20: Frame Acquisition with a Software Frame Start Trigger

When you are using a software trigger signal to start each frame acquisition, the frame rate will be determined by how often you apply a software trigger signal to the camera, and you should not attempt to trigger frame acquisition at a rate that exceeds the maximum allowed with the current camera settings. (There is a detailed explanation about the maximum allowed frame rate at the end of this chapter.) Software frame start trigger signals that are applied to the camera when it is not ready to receive them will be ignored.

Section 7.3.2.2 includes more detailed information about applying a software frame start trigger signal to the camera using Basler pylon or via direct register access.

For more information about determining the maximum allowed frame rate with the current camera settings, see Section 7.8 on page 115.

7.3.2.2 Setting the Parameters Related to Software Frame Start Triggering and Applying a Software Trigger Signal

Setting the Parameters and Applying the Signal Using Basler pylon

You can set all of the parameters needed to perform software frame start triggering from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values and execute the commands related to software frame start triggering. In this example, the acquisition start trigger mode will be set to off:

```
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_Off );
// Disable the acquisition frame rate parameter (this will disable the camera's
// internal frame rate control and allow you to control the frame rate with
// software frame start trigger signals)
Camera.AcquisitionFrameRateEnable.SetValue( false );
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Software );
// Set for the timed exposure mode
Camera.ExposureMode.SetValue( ExposureMode_Timed );
// Set the exposure time
Camera.ExposureTimeAbs.SetValue( 3000 );

     while ( ! finished )
     {
         // Execute a trigger software command to apply a frame start
         // trigger signal to the camera
         Camera.TriggerSoftware.Execute( );
         // Retrieve acquired frame here
     }

// Note: as long as the Trigger Selector is set to FrameStart, executing
// a Trigger Software command will apply a software frame start trigger
// signal to the camera
```

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

```
// Set the acquisition status selector
Camera.AcquisitionStatusSelector.SetValue
( AcquisitionStatusSelector_FrameTriggerWait );

// Read the acquisition status
bool IsWaitingForFrameTrigger = Camera.AcquisitionStatus.GetValue();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting the Parameters and Applying the Signal Using Direct Register Access

To set the parameters needed to perform software frame start triggering via direct register access (with the acquisition start trigger mode set to off):

- Set the value of the Trigger Mode Acquisition Start register to Off.
- Set the value of the Acquisition Frame Period Enable register to 0 (false).
  (This will disable the camera's ability to internally control the frame period and allow you to control the frame rate with a software trigger signals.)
- Set the value of the Trigger Mode Frame Start register to On.
- Set the value of the Trigger Source Frame Start register to Software.
- Set the value of the Exposure Mode register to Timed.
- Set the value of the Exposure Time Raw parameter as desired.

  A value in a raw register is simply an integer value with no units. To determine what the actual setting will be, you must multiply the value in the raw register by the camera's time base. The time base on ace cameras is 1 µs.

  For example, if you set the Exposure Time Raw register to 1000, the exposure time would be 1000 µs (1000 x 1 µs = 1000 µs).
- Set the value of the Trigger Software Frame Start register to 1.
  Setting the value of this register to 1 applies a software frame start trigger to the camera. The register resets to 0 when execution is complete.

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

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

For more information about direct register access, see Section 3.2 on page 19.

7.3.3 Using a Hardware Frame Start Trigger Signal

7.3.3.1 Introduction

If the Trigger Mode parameter for the frame start trigger is set to on and the Trigger Source parameter is set to line 1, CC1, CC2, or CC3, an externally generated electrical signal injected into the selected source will act as the frame start trigger signal for the camera. This type of trigger signal is generally referred to as a hardware trigger signal or as an external frame start trigger signal (ExFSTrig signal).

If the Trigger Source is set to line 1, the GPIO line must be properly set to operate as an input in order to accept the trigger signal.

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

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

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

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

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

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

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

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

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

If you have selected line 1 as the trigger source, some other kind of external electrical device will be used to apply the electrical signal to the selected input.

ⓘ	If you are triggering frame acquisition with an ExFSTrig signal and you attempt to acquire frames at too high a rate, some of the frame trigger signals that you apply will be received by the camera when it is not in a "waiting for frame start trigger" acquisition status. The camera will ignore any frame start trigger signals that it receives when it is not "waiting for frame start trigger". (This situation is commonly referred to as "overtriggering" the camera. To avoid overtriggering, you should not attempt to acquire frames at a rate that exceeds the maximum allowed with the current camera settings.

For more information about determining the maximum allowed frame rate with the current camera settings, see Section 7.8 on page 115.

For more information about setting the camera for hardware triggering and selecting the source to receive the ExFSTrig signal, see Section 7.3.3.4 on page 89.

For more information about the electrical requirements for the GPIO line when it is set to operate as an input, see Section 5.7.2 on page 33.

For more information about CC1, CC2, and CC3, see Section 6.1 on page 47.

7.3.3.2 Exposure Modes

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

Timed Exposure Mode

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

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

If the camera is set for rising edge triggering, the exposure time starts when the ExFSTrig signal rises. If the camera is set for falling edge triggering, the exposure time starts when the ExFSTrig signal falls. Figure 21 illustrates timed exposure with the camera set for rising edge triggering.

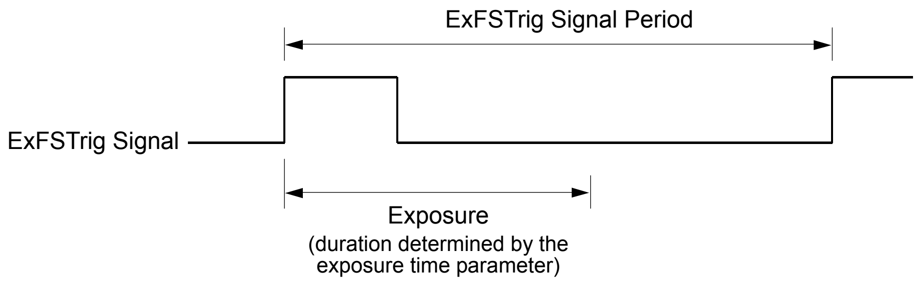


Fig. 21: Timed Exposure with Rising Edge Triggering

Note that if you attempt to trigger a new exposure start while the previous exposure is still in progress, the trigger signal will be ignored, and an over trigger error will be generated. This situation is illustrated in Figure 22 for rising edge triggering.

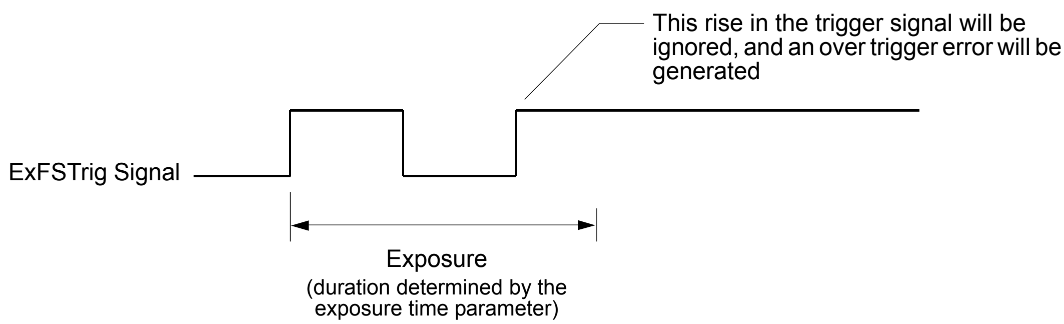


Fig. 22: Overtriggering with Timed Exposure

For more information about setting the exposure time, see Section 7.3.3.4 on page 89.

For more information about the over trigger error, see Section 10.10 on page 206.

Trigger Width Exposure Mode

When trigger width exposure mode is selected, the length of the exposure for each frame acquisition will be directly controlled by the ExFSTrig signal. If the camera is set for rising edge triggering, the exposure time begins when the ExFSTrig signal rises and continues until the ExFSTrig signal falls. If the camera is set for falling edge triggering, the exposure time begins when the ExFSTrig signal falls and continues until the ExFSTrig signal rises. Figure 23 illustrates trigger width exposure with the camera set for rising edge triggering.

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

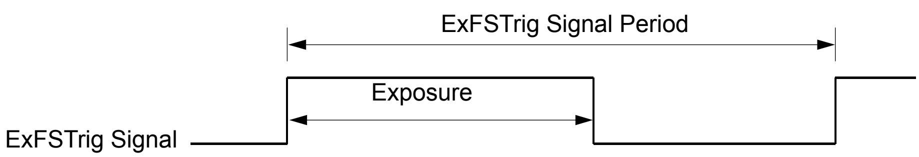


Fig. 23: Trigger Width Exposure with Rising Edge Triggering

When you operate the camera in trigger width exposure mode, you must also set the camera's Exposure Overlap Time Max Abs parameter. This parameter setting will be used by the camera to operate the Frame Trigger Wait signal.

You should set the Exposure Overlap Time Max Abs parameter value to represent the shortest exposure time you intend to use. For example, assume that you will be using trigger width exposure mode and that you intend to use the ExFSTrig signal to vary the exposure time in a range from 3000 µs to 5500 µs. In this case you would set the camera's Exposure Overlap Time Max Abs parameter to 3000 µs.

For more information about the Frame Trigger Wait signal and the Exposure Overlap Time Max Abs parameter, see Section 7.6.2.2 on page 102.

7.3.3.3 Frame Start Trigger Delay

The frame start trigger delay feature lets you specify a delay (in microseconds) that will be applied between the receipt of each hardware frame start trigger signal and when the trigger signal will become effective.

The frame start trigger delay may be specified in the range from 0 to 10000000 µs (equivalent to 10 s). When the delay is set to 0 µs, no delay will be applied.

If you are parameterizing the camera with Basler pylon, the Trigger Delay Abs parameter will determine the length of the delay.

If you are parameterizing the camera via direct register access, the Trigger Delay Raw Frame Start register will determine the length of the delay.

The frame start trigger delay will not operate if the Frame Start Trigger Mode is set to off or if you are using a software frame start trigger.

7.3.3.4 Setting the Parameters Related to Hardware Frame Start Triggering and Applying a Hardware Trigger Signal

Setting the Parameters Using Basler pylon and Applying the Signal

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

The following code snippet illustrates using the API to set the parameter values and execute the commands related to hardware frame start triggering with the camera set for the timed exposure mode with rising edge triggering and CC1 as the trigger source. In this example, the trigger mode for the acquisition start trigger will be set to off:

```
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_Off );
// Disable the acquisition frame rate parameter (this will disable the camera's
// internal frame rate control and allow you to control the frame rate with
// external frame start trigger signals)
Camera.AcquisitionFrameRateEnable.SetValue( false );
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_CC1 );
// Set the trigger activation mode to rising edge
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
// Set for the timed exposure mode
Camera.ExposureMode.SetValue( ExposureMode_Timed );
// Set the exposure time
Camera.ExposureTimeAbs.SetValue( 3000 );

// Frame acquisition will start each time the externally generated
// frame start trigger signal (ExFSTrig signal)goes high
```

The following code snippet illustrates using the API to set the parameter values and execute the commands related to hardware frame start triggering with the camera set for the trigger width exposure mode with rising edge triggering, with line 1 as the trigger source, and with a trigger delay. In this example, the trigger mode for the acquisition start trigger will be set to off:

```
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_Off );
// Disable the acquisition frame rate parameter (this will disable the camera's
```

```
// internal frame rate control and allow you to control the frame rate with
// external frame start signals)
Camera.AcquisitionFrameRateEnable.SetValue( false );
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Configure the GPIO line as an input
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineMode.SetValue( LineMode_Input );
// Set the source for the selected trigger to line 1
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
// Set the trigger activation mode to rising edge
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
// Set for the trigger width exposure mode
Camera.ExposureMode.SetValue( ExposureMode_TriggerWidth );
// Set the trigger delay for one millisecond (1000us == 1ms == 0.001s)
double TriggerDelay_us = 1000.0;
Camera.TriggerDelayAbs.SetValue( TriggerDelay_us );

// Frame acquisition will start each time the externally generated
// frame start trigger signal (ExFSTrig signal)goes high
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

Setting the Parameters Using Direct Register Access and Applying the Signal

To set the parameters needed to perform hardware frame start triggering via direct register access (with the trigger mode for the acquisition start trigger set to off):

- Set the value of the Trigger Mode Acquisition Start register to Off.
- Set the value of the Acquisition Frame Period Enable register to 0 (false).
  (This will disable the camera's ability to control the frame period internally and allow you to control the frame rate with an external signal.)
- Set the value of the Trigger Mode Frame Start register to On.
- Set the value of the Trigger Source Frame Start register to receive the external trigger signal on Line 1, CC1, CC2, or CC3.
- If the trigger source is set to line 1, set the GPIO line to operate as an input by setting the value of the Line Mode Line 1 register to Input.
- Set the value of the Trigger Activation Frame Start register to Rising Edge or Falling Edge as desired.
- Set the value of the Exposure Mode register to Timed or to Trigger Width.

  If the mode is set to timed, set the value of the Exposure Time Raw register as desired.

A value in a raw register is simply an integer value with no units. To determine what the actual setting will be, you must multiply the value in the raw register by the camera's time base. The time base on ace cameras is 1 µs.

For example, if you set the Exposure Time Raw register to 1000, the exposure time would be 1000 µs (1000 x 1 µs = 1000 µs).

Apply the appropriate externally generated electrical signal (ExFSTrig signal) to the selected trigger source.

For more information about direct register access, see Section 3.2 on page 19.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

7.4 Setting the Exposure Time

ⓘ	This section (Section 7.4) describes how the exposure time can be adjusted "manually", i.e., by setting the value of the exposure time parameter. The camera also has an Exposure Auto function that can automatically adjust the exposure time. **Manual adjustment of the exposure time parameter will only work correctly if the Exposure Auto function is disabled.** For more information about auto functions in general, see Section 10.9 on page 187. For more information about the Exposure Auto function in particular, see Section 10.9.5 on page 200.

If you are operating the camera in any one of the following ways, you must use the camera's Exposure Time parameter to set the exposure time:

- the frame start trigger mode is set to off
- the frame start trigger mode is set to on and the trigger source is set to software
- the frame start trigger mode is set to on, the trigger source is set to line 1, CC1, CC2, or CC3, and the exposure mode is set to timed

The minimum allowed exposure time for all camera models is 24 µs.

The maximum allowed exposure time for all camera models is 2500000 µs.

Setting the Exposure Time Using Basler pylon

If you are parameterizing the camera with Basler pylon, the exposure time is determined by the setting of the Exposure Time Abs parameter. The Exposure Time Abs parameter sets the exposure time in µs. The exposure time should be set in increments of 1 µs.

You can use the pylon API to set the Exposure Time Abs 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 1000 µs
Camera.ExposureTimeAbs.SetValue( 1000 );
```

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 17.

Setting the Exposure Time Using Direct Register Access

If you are parameterizing the camera via direct register access, the Exposure Time Raw register sets the exposure time.

To set the exposure time via direct register access:

- Set the value of the Exposure Time Raw register.

A value in a raw register is simply an integer value with no units. To determine what the actual exposure time will be, you must multiply the value in the raw register by the camera’s time base. The time base on ace cameras is 1 µs.

For example, if you set the Exposure Time Raw register to 1000, the exposure time would be 1000 µs (1000 x 1 µs = 1000 µs).

For more information about direct register access, see Section 3.2 on page 19.

7.5 Overlapping Exposure with Sensor Readout

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

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

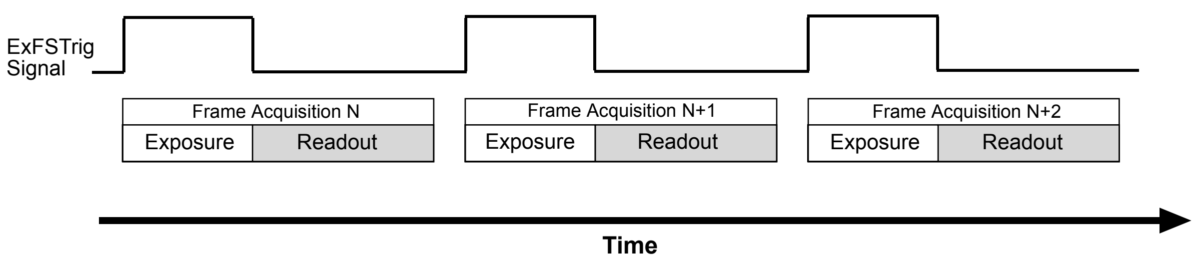


Fig. 24: Non-overlapped Exposure and Readout

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

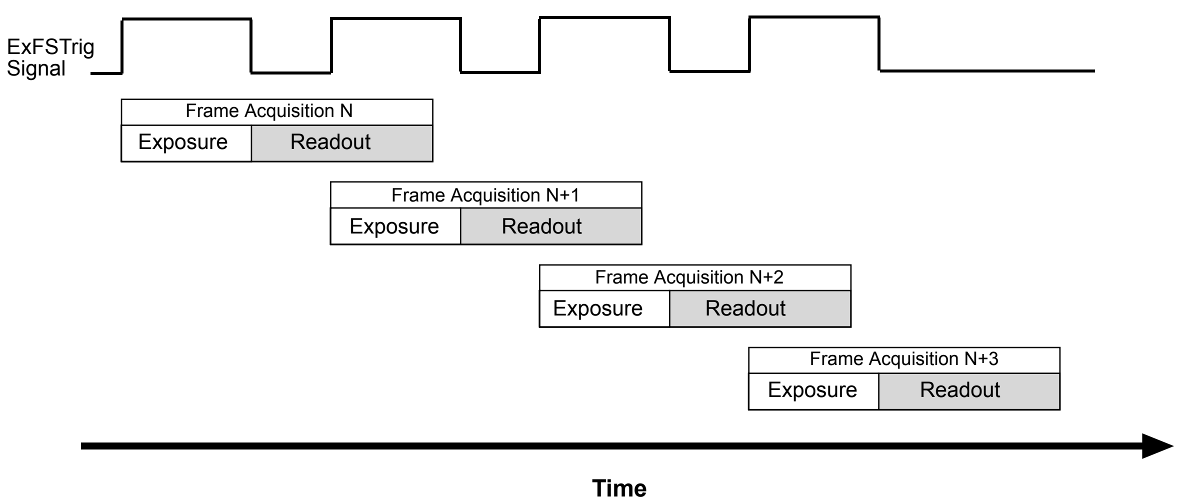


Fig. 25: Overlapped Exposure and Readout

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

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

For more information about determining the frame readout time, see Section 7.7 on page 113.

Guideline for Overlapped Operation with Trigger Width Exposure

If the camera is set for the trigger width exposure mode and you are operating the camera in a way that readout and exposure will be overlapped, there is an important guideline you must keep in mind:

- You must not end the exposure time of the current frame acquisition until readout of the previously acquired frame is complete.

If this guideline is violated, the camera will drop the frame for which the exposure was just ended and will declare an over trigger error. This situation is illustrated in Figure 26 with the camera set for the trigger width exposure mode with rising edge triggering.

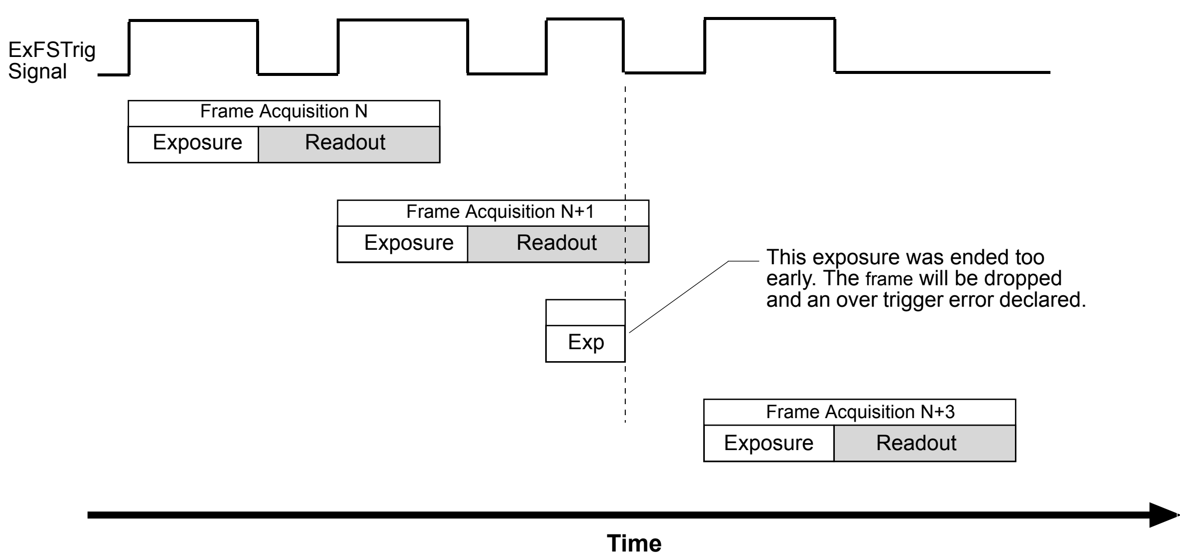


Fig. 26: Overtriggering Caused by an Early End of Exposure

You can avoid violating this guideline by using the camera’s Frame Trigger Wait signal to determine when exposure can safely begin and by properly setting the camera’s Exposure Overlap Time Max Abs parameter.

For more information about the Frame Trigger Wait signal and the Exposure Overlap Time Max Abs parameter, see Section 7.6.2.2 on page 102.

For more information about trigger width exposure, see Section 7.3.3.2 on page 85.

For more information about the over trigger error, see Section 10.10 on page 206.

7.6 Acquisition Monitoring Tools

7.6.1 Acquisition Status Indicator

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

If a camera receives a software frame start trigger signal when it is not in a "waiting for frame start trigger" acquisition status, it will simply ignore the trigger signal and will generate an overtrigger error.

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

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

For more information about the overtrigger error, see Section 10.10.2 on page 207.

Checking the Acquisition Status Using Basler Pylon

To determine the acquisition status of the camera via the Basler pylon API:

- Use the Acquisition Status Selector to select the Acquisition Trigger Wait status or the Frame Trigger Wait status.
- Read the value of the Acquisition Status parameter.

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

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

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

```
// Check the acquisition start trigger acquisition status
// Set the acquisition status selector
Camera.AcquisitionStatusSelector.SetValue
( AcquisitionStatusSelector_AcquisitionTriggerWait );
// Read the acquisition status
bool IsWaitingForAcquisitionTrigger = Camera.AcquisitionStatus.GetValue();

// Check the frame start trigger acquisition status
// Set the acquisition status selector
Camera.AcquisitionStatusSelector.SetValue
( AcquisitionStatusSelector_FrameTriggerWait );
// Read the acquisition status
```

```
bool IsWaitingForFrameTrigger = Camera.AcquisitionStatus.GetValue();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Checking the Acquisition Status Using Direct Register Access

To determine the acquisition start trigger status via the direct register access:

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

To determine the frame start trigger status via the direct register access:

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

For more information about direct register access, see Section 3.2 on page 19.

7.6.2 Trigger Wait Signals

If a camera receives a hardware acquisition start trigger signal when it is not in a "waiting for acquisition start trigger" acquisition status, it will simply ignore the trigger signal and will generate an overtrigger error.

If a camera receives a hardware frame start trigger signal when it is not in a "waiting for frame start trigger" acquisition status, it will simply ignore the trigger signal and will generate anovertrigger error.

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

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

These signals are designed to be used when you are triggering acquisition start or frame start via a hardware trigger signal.

For more information about the overtrigger error, see Section 10.10.2 on page 207.

7.6.2.1 Acquisition Trigger Wait Signal

As you are acquiring frames, the camera automatically monitors the acquisition start trigger status and supplies a signal that indicates the current status. The Acquisition Trigger Wait signal will go high whenever the camera enters a "waiting for acquisition start trigger" status. The signal will go low when an external acquisition start trigger (ExASTrig) signal is applied to the camera and the camera exits the "waiting for acquisition start trigger status". The signal will go high again when the camera again enters a "waiting for acquisition trigger" status and it is safe to apply the next acquisition start trigger signal.

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

Figure 27 illustrates the Acquisition Trigger Wait signal with the Acquisition Frame Count parameter set to 3 and with exposure and readout overlapped. The figure assumes that the trigger mode for the frame start trigger is set to off, so the camera is internally generating frame start trigger signals.

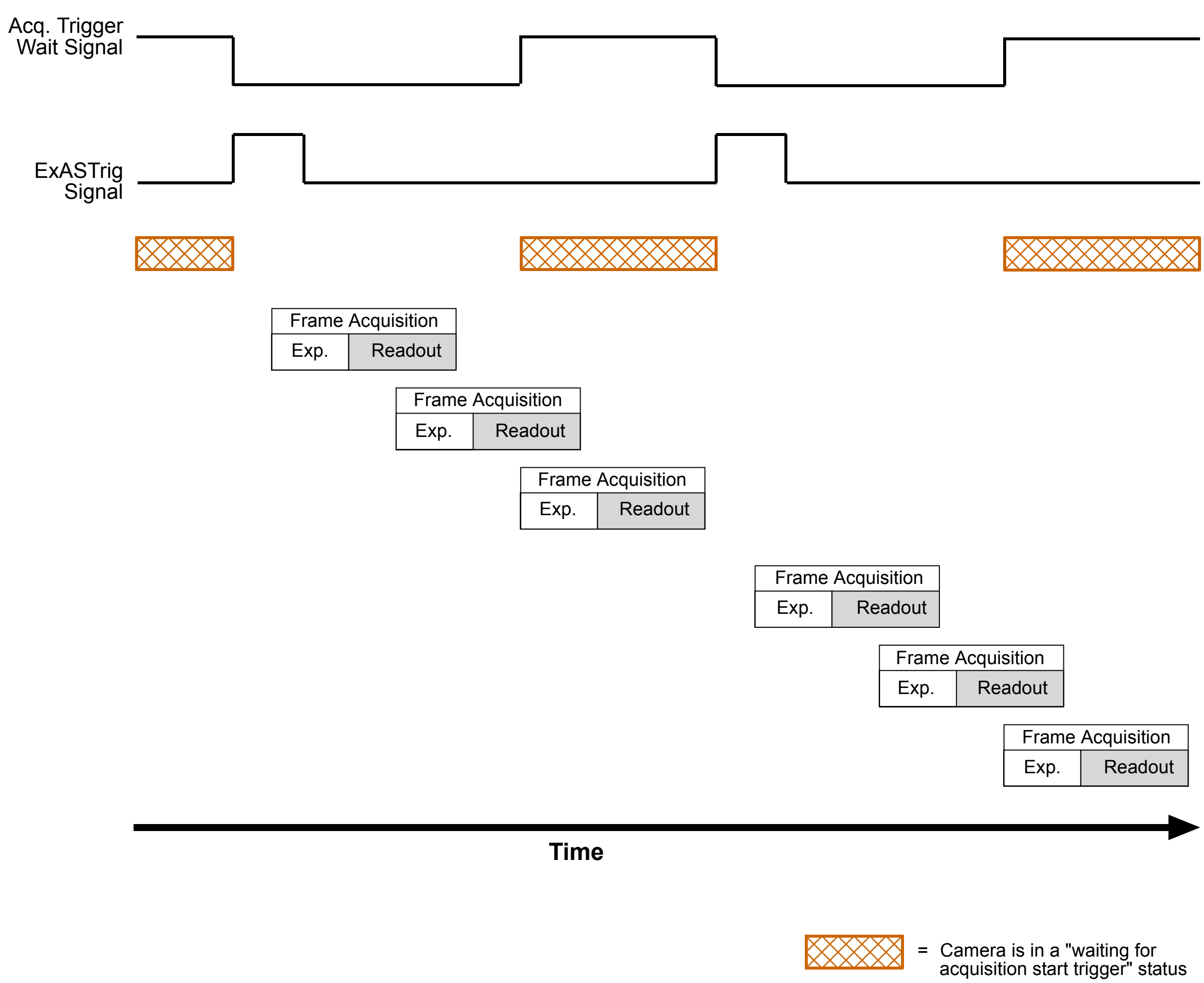


Fig. 27: Acquisition Trigger Wait Signal

ⓘ	The acquisition trigger wait signal will only be available when hardware acquisition start triggering is enabled.

For more information about the overtrigger error, see Section 10.10.2 on page 207.

Selecting the Acquisition Trigger Wait Signal as the Source Signal for an Output Line Using Basler Pylon

You can select the acquisition trigger wait signal as the source signal for the camera's GPIO line (assuming it is set as an output) or the CL Spare output line. Selecting a source signal for the output line is a three step process:

- Configure the GPIO line as an output (if you want to use the GPIO line).
- Use the Line Selector to the desired line.
- Set the value of the Line Source Parameter to the acquisition trigger wait signal.

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

```
// Configure the GPIO line as an output
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineMode.SetValue( LineMode_Output );
//Select the GPIO line
Camera.LineSelector.SetValue( LineSelector_Line1 );
//Set the source for the selected line
Camera.LineSource.SetValue( LineSource_AcquisitionTriggerWait );

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

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 17.

Selecting the Acquisition Trigger Wait Signal as the Source Signal for an Output Line Using Direct Register Access

You can select the acquisition trigger wait signal as the source signal for the camera's GPIO line (assuming it is set as an output) or the CL Spare output line.

To select the acquisition trigger wait signal as the source signal for the GPIO line via direct register access:

- Set the GPIO line to operate as an output by setting the value of the Line Mode Line 1 register to Output.
- Set the value of the Line Source Line 1 register to Acquisition Trigger Wait.

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

- Set the value of the Line Source CL Spare register to Acquisition Trigger Wait.

For more information about direct register access, see Section 3.2 on page 19.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

7.6.2.2 Frame Trigger Wait Signal

Overview

As you are acquiring frames, the camera automatically monitors the frame start trigger status and supplies a signal that indicates the current status. The Frame Trigger Wait signal will go high whenever the camera enters a "waiting for frame start trigger" status. The signal will go low when an external frame start trigger (ExFSTrig) signal is applied to the camera and the camera exits the "waiting for frame start trigger status". The signal will go high again when the camera again enters a "waiting for frame trigger" status and it is safe to apply the next frame start trigger signal.

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

Figure 28 illustrates the Frame Trigger Wait signal. The camera is set for the trigger width exposure mode with rising edge triggering and with exposure and readout overlapped.

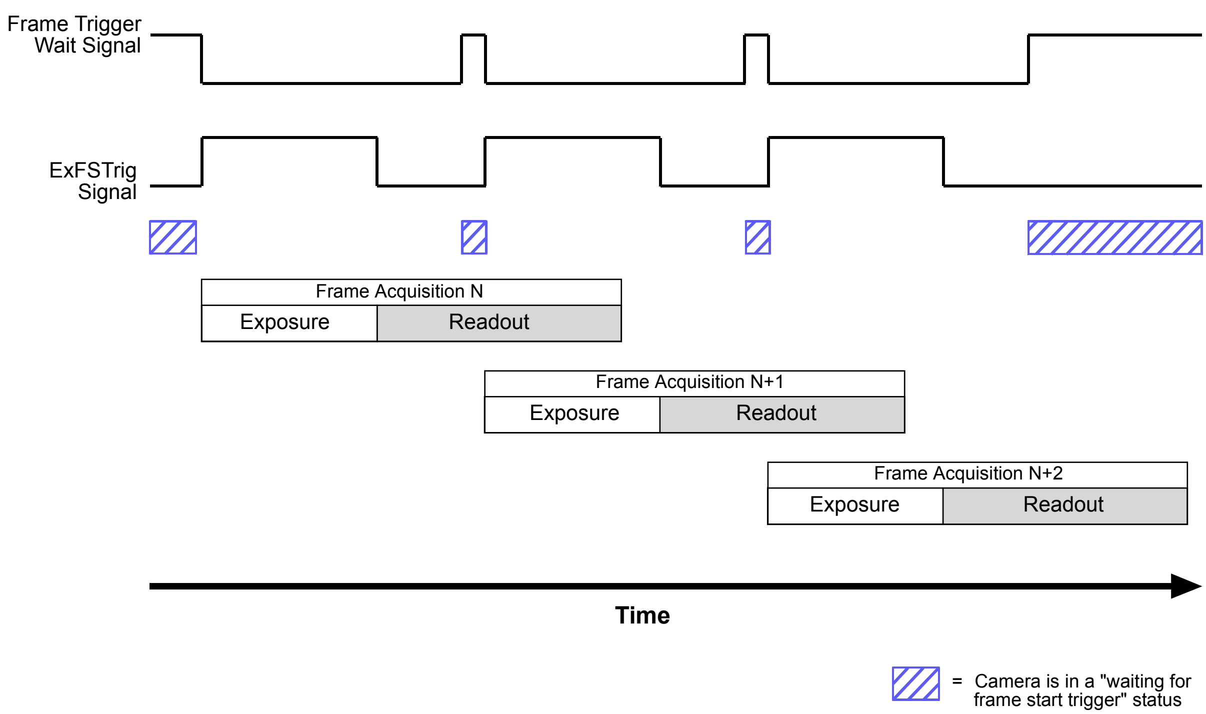


Fig. 28: Frame Trigger Wait Signal

ⓘ	The frame trigger wait signal will only be available when hardware frame start triggering is enabled.

For more information about the over trigger error, see Section 10.10 on page 206.

Frame Trigger Wait Signal Details

When the camera is set for the timed exposure mode, the rise of the Frame Trigger Wait signal is based on the current exposure time parameter setting and on when readout of the current frame will end. This functionality is illustrated in Figure 29.

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

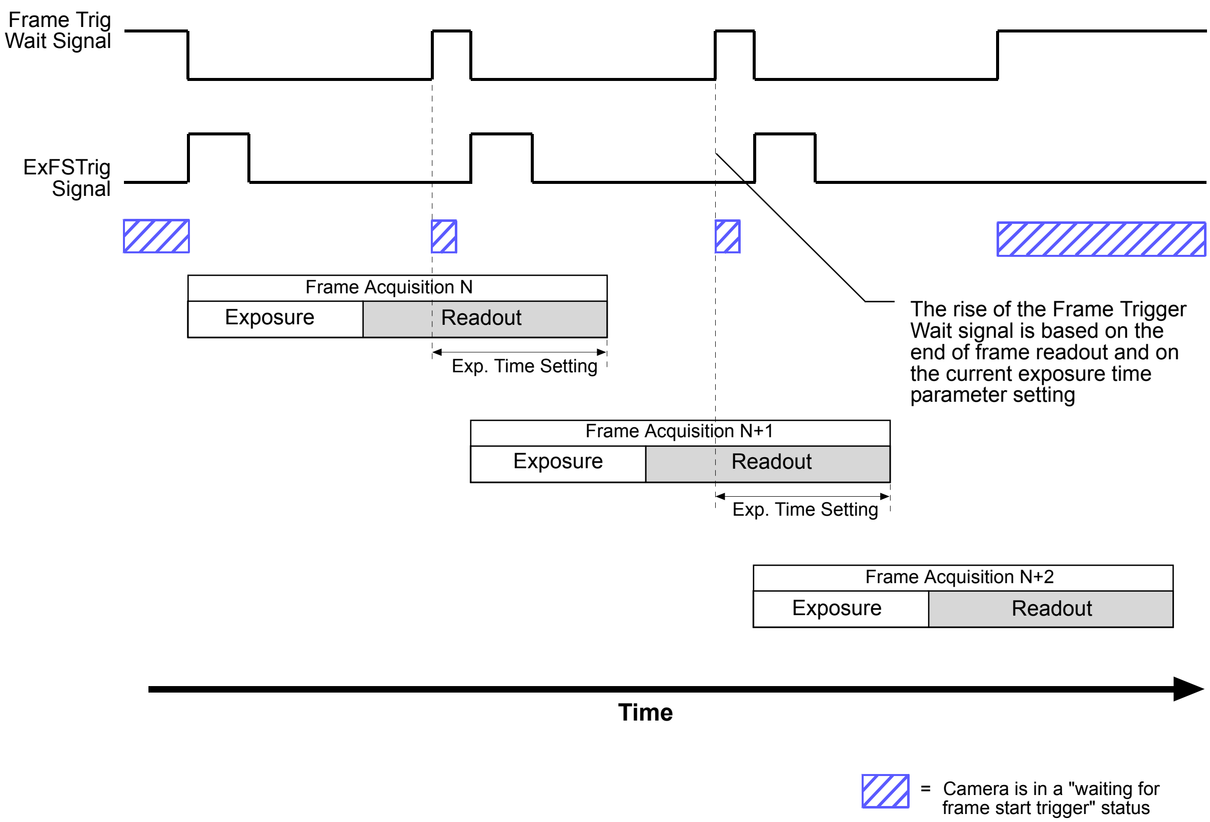


Fig. 29: Frame Trigger Wait Signal with the Timed Exposure Mode

When the camera is set for the trigger width exposure mode, the rise of the Frame Trigger Wait signal is based on the Exposure Overlap Time Max parameter setting and on when readout of the current frame will end. This functionality is illustrated in Figure 30.

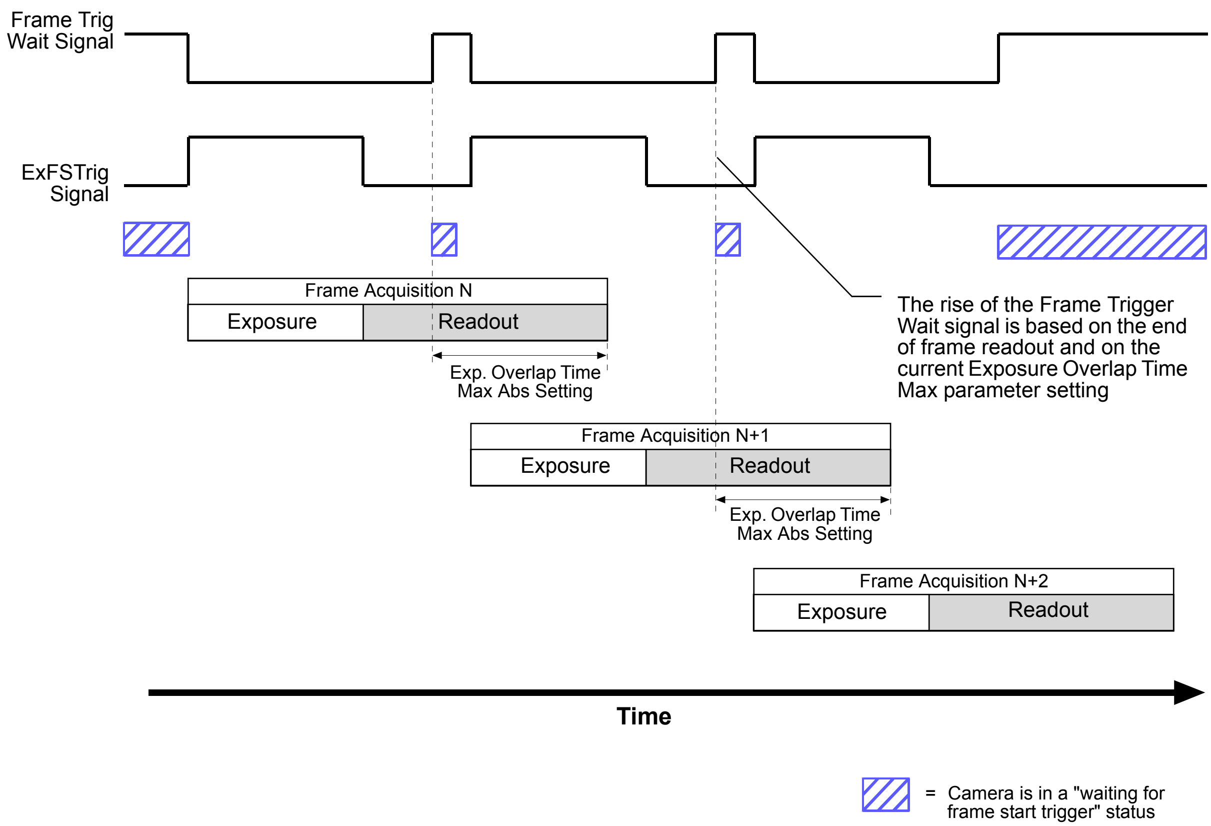


Fig. 30: Frame Trigger Wait Signal with the Trigger Width Exposure Mode

If you are operating the camera in the trigger width exposure mode, you can avoid overtriggering the camera by always doing the following:

- Setting the camera’s Exposure Overlap Time Max parameter so that it represents the smallest exposure time you intend to use.
- Making sure that your exposure time is always equal to or greater than the setting for the Exposure Overlap Time Max Abs parameter.
- Monitoring the camera’s Frame Trigger Wait signal and only using the ExFSTrig signal to start exposure when the Frame Trigger Wait signal is high.

You should set the Exposure Overlap Time Max parameter value to represent the shortest exposure time you intend to use. For example, assume that you will be using trigger width exposure mode and that you intend to use the ExFSTrig signal to vary the exposure time in a range from 3000 µs to 5500 µs. In this case you would set the camera’s Exposure Overlap Time Max parameter to 3000 µs.

Setting the Exposure Overlap Time Max Using Basler Pylon

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

```
// Set the Exposure Overlap Time Max to 3000 µs
Camera.ExposureOverlapTimeMaxAbs.SetValue( 3000 );
```

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

Setting the Exposure Overlap Time Max Using Direct Register Access

If you are parameterizing the camera via direct register access, the Exposure Overlap Time Max Raw register sets the exposure overlap time max.

To set the exposure overlap time max via direct register access:

- Set the value of the Exposure Overlap Time Max Raw register.

A value in a raw register is simply an integer value with no units. To determine what the actual exposure time will be, you must multiply the value in the raw register by the camera's time base. The time base on ace cameras is 1 µs.

For example, if you set the Exposure Overlap Time Max Raw register to 3000, the exposure overlap time max would be 3000 µs (3000 x 1 µs = 3000 µs).

Selecting the Frame Trigger Wait Signal as the Source Signal for an Output Line Using Basler Pylon

You can select the frame trigger wait signal as the source signal for the camera's GPIO line (assuming it is set as an output) or the CL Spare output line. Selecting a source signal for the output line is a three step process:

- Configure the GPIO line as an output (if you want to use the GPIO line).
- Use the Line Selector to select the desired line.
- Set the value of the Line Source Parameter to the frame trigger wait signal.

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

```
// Configure the GPIO line as an output
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineMode.SetValue( LineMode_Output );
//Select the GPIO line
Camera.LineSelector.SetValue( LineSelector_Line1 );
```

```
//Set the source for the selected line
Camera.LineSource.SetValue( LineSource_FrameTriggerWait );

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

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 17.

Selecting the Frame Trigger Wait Signal as the Source Signal for an Output Line Using Direct Register Access

You can select the frame trigger wait signal as the source signal for the camera's GPIO line (assuming it is set as an output) or the CL Spare output line.

To select the frame trigger wait signal as the source signal for the GPIO line via direct register access:

- Set the GPIO line to operate as an output by setting the value of the Line Mode Line 1 register to Output.
- Set the value of the Line Source Line 1 register to Frame Trigger Wait.

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

- Set the value of the Line Source CL Spare register to Frame Trigger Wait.

For more information about direct register access, see Section 3.2 on page 19.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

7.6.3 Exposure Active Signal

The camera can provide an "exposure active" (ExpAc) output signal. The signal goes high when the exposure time for each frame acquisition begins and goes low when the exposure time ends as shown in Figure 31. (In this example,the camera is operating in the timed exposure mode.)

This signal can be used as a flash trigger and is also useful when you are operating a system where either the camera or the object being imaged is movable. For example, assume that the camera is mounted on an arm mechanism and that the mechanism can move the camera to view different portions of a product assembly. Typically, you do not want the camera to move during exposure. In this case, you can monitor the ExpAc signal to know when exposure is taking place and thus know when to avoid moving the camera.

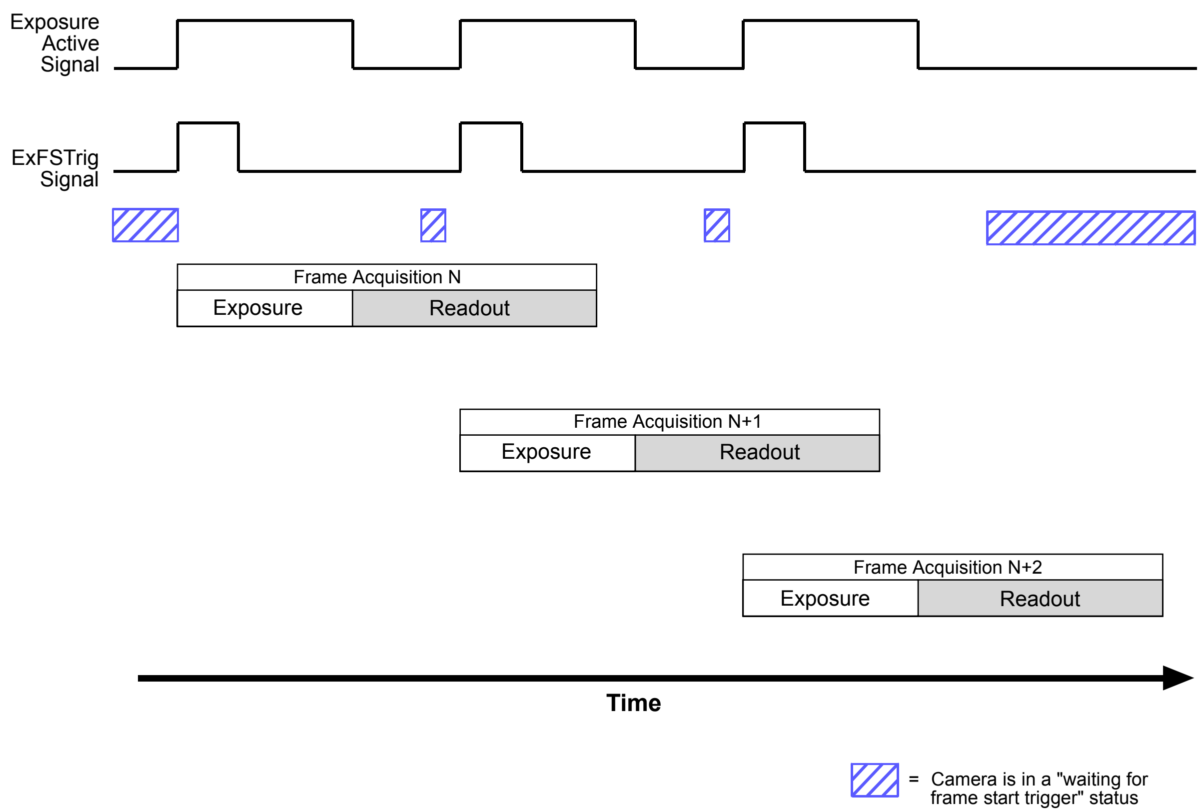


Fig. 31: Exposure Active Signal

Selecting the Exposure Active Signal as the Source Signal for an Output Line Using Basler Pylon

You can select the exposure active signal as the source signal for the GPIO line (assuming it is set as an output) or the CL Spare output line. Selecting a source signal for the output line is a three step process:

- Configure the GPIO line as an output (if you want to use the GPIO line).
- Use the Line Selector to select the desired line.
- Set the value of the Line Source Parameter to the exposure active output signal.

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

```
// Configure the GPIO line as an output
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineMode.SetValue( LineMode_Output );
//Select the GPIO line
Camera.LineSelector.SetValue( LineSelector_Line1 );
//Set the source signal for the selected line
Camera.LineSource.SetValue( LineSource_ExposureActive );

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

Selecting the Exposure Active Signal as the Source Signal for an Output Line Using Direct Register Access

You can select the exposure active signal as the source signal for the camera's GPIO line (assuming it is set as an output) or the CL Spare output line.

To select the exposure active signal as the source signal for the GPIO line via direct register access:

- Set the GPIO line to operate as an output by setting the value of the Line Mode Line 1 register to Output.
- Set the value of the Line Source Line 1 register to Exposure Active.

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

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

For more information about direct register access, see Section 3.2 on page 19.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

7.6.4 Frame Cycle Signal

The camera can provide a "Frame Cycle" (FrmCyc) output signal. The signal goes high when the camera enters a waiting for frame trigger condition and goes low when the exposure time for the next triggered image ends as shown in Figure 32. (In this example, the camera is operating in the timed exposure mode.)

The intention of this signal is to let you monitor these two important points in the acquisition process with a single output signal..

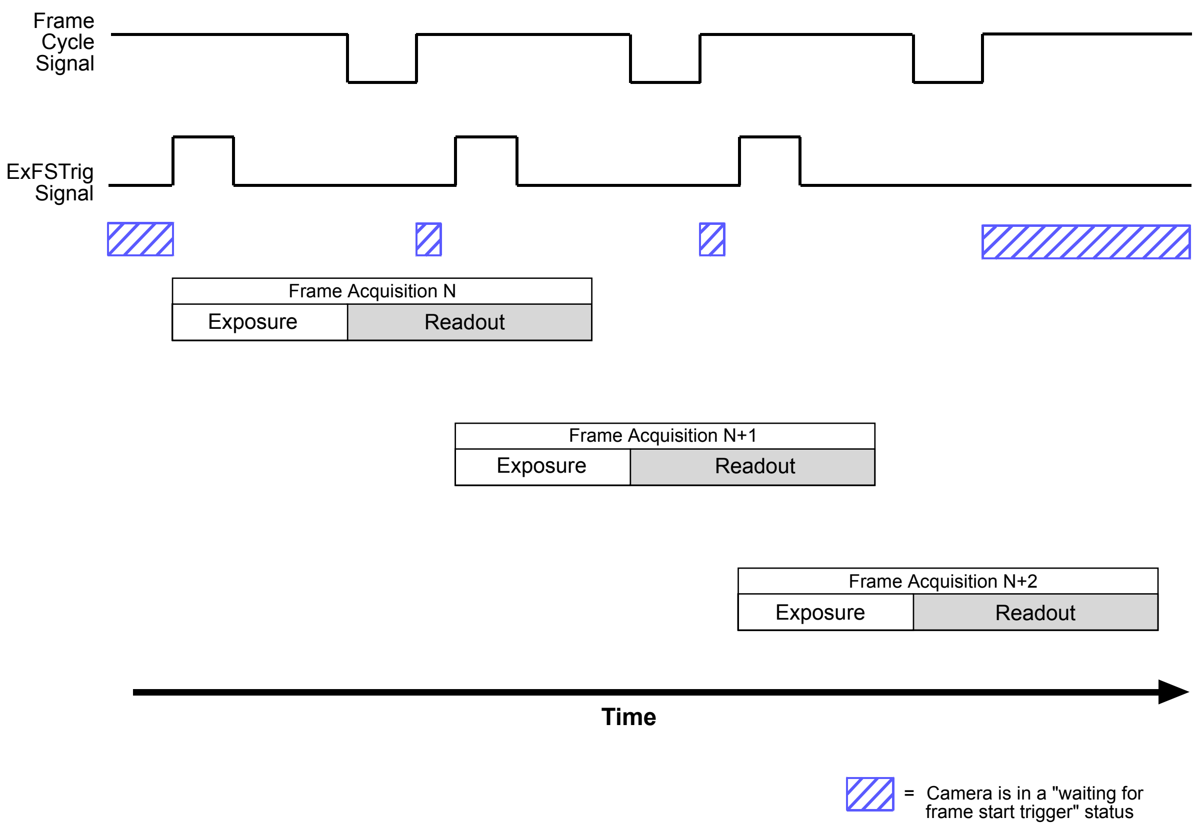


Fig. 32: Frame Cycle Signal

Selecting the Frame Cycle Signal as the Source Signal for an Output Line Using Basler Pylon

You can select the frame cycle signal as the source signal for the camera's GPIO line (assuming it is set as an output) or the CL Spare output line. Selecting a source signal for the output line is a three step process:

- Configure the GPIO line as an output (if you want to use the GPIO line).
- Use the Line Selector to select the desired line.
- Set the value of the Line Source Parameter to the frame cycle output signal.

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

```
// Configure the GPIO line as an output
Camera.LineSelector.SetValue( LineSelector_Line1 );
Camera.LineMode.SetValue( LineMode_Output );

//Select the GPIO line
Camera.LineSelector.SetValue( LineSelector_Line1 );
//Set the source signal for the selected line
Camera.LineSource.SetValue( LineSource_FrameCycle );

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

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 17.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

Selecting the Frame Cycle Signal as the Source Signal for an Output Line Using Direct Register Access

You can select the frame cycle signal as the source signal for the camera's GPIO line (assuming it is set as an output) or the CL Spare output line.

To select the frame cycle signal as the source signal for the GPIO line via direct register access:

- Set the GPIO line to operate as an output by setting the value of the Line Mode Line 1 register to Output.
- Set the value of the Line Source Line 1 register to Frame Cycle.

To select the frame cycle signal as the source signal for the CL Spare line via direct register access:

- Set the value of the Line Source CL Spare register to Frame Cycle.

For more information about direct register access, see Section 3.2 on page 19.

For more detailed information about the camera's GPIO line, see Section 5.7 on page 33.

7.7 Acquisition Timing Chart

Figure 33 shows a timing chart for frame acquisition and transmission. The chart assumes that exposure is triggered by an externally generated frame start trigger (ExFSTrig) signal with rising edge activation and that the camera is set for the timed exposure mode.

As Figure 33 shows, there is a slight delay between the rise of the ExFSTrig signal and the start of exposure. After the exposure time for a frame acquisition is complete, the camera begins reading out the acquired image data from the imaging sensor. After a short delay, the camera will begin transmitting image data from the camera to the host PC.

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

Note that, if the debouncer feature is used, the debouncer setting for the input line must be added to the exposure start delay shown in Figure 33 to determine the total start delay.

The **frame readout time** is the amount of time it takes to read out the data for an acquired frame from the imaging sensor. This time period will vary depending on several camera settings such as the image AOI, the Camera Link tap geometry, the Camera Link pixel clock speed, and others. As explained below, you can read the value of the Readout Time parameter to determine the sensor readout time given the current camera settings.

The **frame transmission time** is the amount of time it takes to transmit an acquired frame from the buffer in the camera to the host PC via the network. The frame transmission time will always be equal to the frame readout time.

The **transmission start delay** is the amount of time between the point where the camera begins reading out the acquired frame data from the sensor to the point where it begins transmitting the data for the acquired frame from the buffer to the host PC.

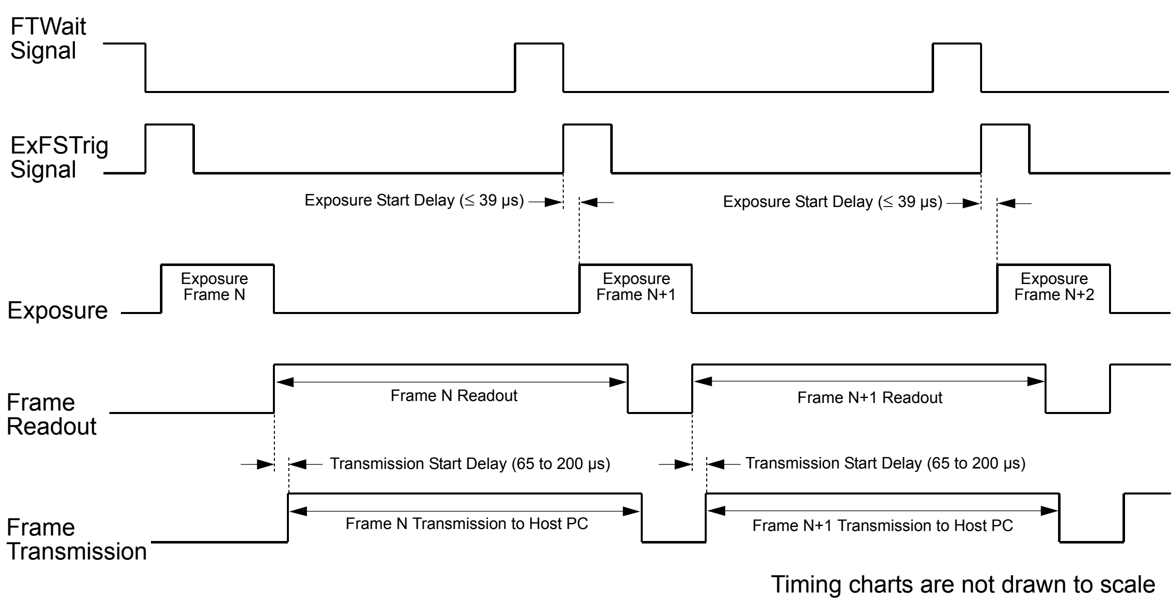


Fig. 33: Exposure Start Controlled with an ExFSTrig Signal

Determining the Frame Readout Time Using Basler Pylon

You can determine the frame readout time by reading the value of the Readout Time Abs parameter. The parameter indicates what the readout time will be in microseconds given the camera's current settings. You can read the Readout Time Abs parameter value from within your application software by using the Basler pylon API.

The following code snippet illustrates using the API to get the parameter value:

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Determining the Frame Readout Time Using Direct Register Access

To determine the frame readout time via direct register access:

- Read the value of the Readout Time Raw register.

A value in a raw register is simply an integer value with no units. To determine what the actual exposure time will be, you must multiply the value in the raw register by the camera's time base. The time base on ace cameras is 1 µs.

For example, if you read the Readout Time Raw register value as 18000, the frame readout time would be 18000 µs (18000 x 1 µs = 18000 µs).

Note that the frame transmission time is always equal to the frame readout time.

7.8 Maximum Allowed Frame Acquisition Rate

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

- The Camera Link pixel clock speed and the Camera Link tap geometry settings.

  When the pixel clock speed is set to a high value, it will take less time to transfer captured images from the camera to the frame grabber in your host PC.

  When the camera is set for a tap geometry that uses more taps (e.g., the 1X2-1Y geometry uses two taps and the 1X3-1Y geometry uses three taps), it can typically transfer data out of the camera faster.

  So if the camera is set for a high pixel clock speed and a high number of taps, it typically will have a much higher maximum allowed frame rate than when it is set for a low pixel clock speed and a low number of taps.
- The sensor bit depth setting. The sensor can capture pixel data at 12 bit or at 10 bit depth. When the sensor is set for 12 bit depth, it operates slower than at 10 bit depth. If you have the sensor set for 10 bit depth, you can acquire images at a significantly higher maximum allowed rate.
- The amount of time it takes to read the data for an acquired image (known as a frame) out of the imaging sensor. This time varies depending on the height of the frame. The frame height is determined by the camera's AOI settings. If you use shorter AOIs (i.e., AOIs that include fewer lines), it takes less time to read an acquired frame out of the sensor and you can acquire more frames per second.

  Decreasing the width of the AOI can also yield a significant increase in the maximum allowed frame rate, but this is only true when the width is lowered in increments of 50% of the sensor width (e.g., from 2048 to 1024 or from 1024 to 512).
- Whether binning is enabled. Enabling either horizontal or vertical binning may yield a significant increase in the maximum allowed frame rate, but this will only be true if the camera is not already reading out image data at a rate that is near to the current data carrying capacity of the Camera Link interface.
- The exposure time for acquired frames. If you use very long exposure times, you can acquire fewer frames per second.

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

- You can go to the Support section of the Basler website and use the online frame rate calculator:

  www.baslerweb.com
- You can use Basler pylon to read the value of the camera's Resulting Frame Rate Abs parameter (see below).
- You can use direct register access to read the value of the Resulting Frame Period register (see below).

For more information about the image AOI settings, see Section 10.3 on page 158.

For more information about selectable pixel clock speeds, see Section 10.1 on page 155.

For more information about the sensor bit depth, see Section 10.1 on page 155.

For more information about Camera Link tap geometries, see Section 9.3 on page 144.

Using Basler pylon to Check the Maximum Allowed Frame Rate

You can use the Basler pylon API to read the current value of the Resulting Frame Rate Abs 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 resultingFps = Camera.ResultingFrameRateAbs.GetValue();
```

The Resulting Frame Rate Abs parameter takes all camera settings that can influence the frame rate into account 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 the pylon Viewer, see Section 3.1 on page 17.

Using Direct Register Access to Check the Maximum Allowed Rate

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

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

To determine the resulting frame period:

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

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

A value in a raw register is simply an integer value with no units. To determine what the actual frame period will be, you must multiply the value in the raw register by the camera’s time base. The time base on ace cameras is 1 µs.

For example, if you read the Resulting Frame Period Raw register and find that its value is 10000, the resulting frame period would be 10000 µs (10000 x 1 µs = 10000 µs).

For more information about direct register access, see Section 3.2 on page 19.

7.8.1 Increasing the Maximum Allowed Frame Rate

You may find that you would like to acquire frames at a rate higher than the maximum allowed with the camera's current settings. In this case, you must adjust one or more of the factors that can influence the maximum allowed rate and then check to see if the maximum allowed rate has increased:

- If you have the Camera Link pixel clock speed on your camera set to a low value, consider setting it to a higher value. Be aware, however, that some frame grabbers cannot handle higher pixel clock speeds. Before you increase the setting for the camera's pixel clock, make sure that your frame grabber is compatible with the higher setting.
- If you are using a Camera Link configuration with a low number of taps, consider using a configuration with a higher number.
- If you have the sensor bit depth set to 12 bits, consider changing the value to 10 bits. This will typically yield a significant increase in the maximum allowed frame rate.
- Decreasing the height of the AOI can have a significant impact on the maximum allowed frame rate. If possible in your application, decrease the height of the AOI.

  Decreasing the width of the AOI can also yield a significant increase in the maximum allowed frame rate, but this is only true when the width is lowered in increments of 50% of the sensor width (e.g., from 2048 to 1024 or from 1024 to 512).
- If possible in your application, enable either horizontal or vertical binning (or both). This may yield a significant increase in the maximum allowed frame rate, but this will only be true if the camera is not already reading out image data at a rate that is near to the current data carrying capacity of the Camera Link interface.

Decreasing the sensor bit depth, decreasing the AOI height, decreasing the AOI width, and enabling binning can each result in an increase in the maximum allowed frame rate because they decrease the time that it takes to read out pixel data from the imaging sensor. But in order to actually see an increase in the maximum allowed frame rate, you must have the pixel clock speed and the number of taps set high enough so that the Camera Link interface can transfer the larger amount of image data that will be generated when the camera is operated at a higher frame rate.

If you decrease the bit depth, decrease the AOI Height, decrease the AOI Width, or enable binning and you have the pixel clock speed and the number of taps set to low values, you will see no increase in the maximum allowed frame rate.

- If you are using normal exposure times and you are using the camera at it's maximum resolution, your exposure time will not normally restrict the frame rate. However, if you are using long exposure times or a small area of interest, it is possible that your exposure time is limiting the maximum allowed frame rate. If you are using a long exposure time or a small AOI, try using a shorter exposure time and see if the maximum allowed frame rate increases. (You may need to compensate for a shorter exposure time by using a brighter light source or increasing the opening of your lens aperture.)

ⓘ	An important thing to keep in mind is a common mistake new camera users frequently make when they are working with exposure time. They will often use a very long exposure time without realizing that this can severely limit the camera's maximum allowed frame rate. As an 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. Even if the camera's nominal maximum frame rate is, for example, 100 frames per second, it will only be able to acquire two frames per second because the exposure time is set much higher than normal.

For more information about the sensor bit depth feature, see Section 10.1 on page 155.

For more information about the image AOI settings, see Section 10.3 on page 158.

For more information about selectable pixel clock speeds, see Section 10.1 on page 155.

For information about Camera Link tap geometries, see Section 9.3 on page 144.

For more information about the exposure time, see Section 7.4 on page 92.

7.9 Use Case Descriptions and Diagrams

The following pages contain a series of use case descriptions and diagrams. The descriptions and diagrams are designed to illustrate how acquisition start triggering and frame start triggering work in some common situations and with some common combinations of parameter settings.

These use cases do not represent every possible combination of the parameters associated with acquisition start and frame start triggering. They are simply intended to aid you in developing an initial understanding of how these two triggers interact.

In each use case diagram, the black box in the upper left corner indicates how the parameters are set.

ⓘ	The use case diagrams are representational. They are not drawn to scale and are not designed to accurately describe precise camera timings.

Use Case 1 - Acquisition and Frame Start Triggers Both Off (Free Run)

Use case one is illustrated on page 120.

In this use case, the Trigger Mode parameter for the acquisition start trigger and the Trigger Mode parameter for the frame start trigger are both set to off. The camera will generate all required acquisition start and frame start trigger signals internally. When the camera is set this way, it will constantly acquire images without the need for any type of triggering by the user. This use case is commonly referred to as "free run".

The rate at which the camera will acquire images will normally be determined by the camera's Acquisition Frame Rate Abs parameter when the camera is parameterized via Basler pylon or by the Acquisition Frame Period Raw register when the camera is parameterized via direct register access. If the Acquisition Frame Rate Abs parameter or the Acquisition Frame Period Raw register (respectively) is disabled, the camera will acquire frames at the maximum allowed frame rate.

In the real world, cameras are used in free run for many applications. One example is for aerial photography. A camera set for free run is used to capture a continuous series of images as an aircraft overflies an area. The images can then be used for a variety of purposes including vegetation coverage estimates, archaeological site identification, etc.

For more information about the Acquisition Frame Rate Abs parameter and the Acquisition Frame Period Raw register, see Section 7.3.1.1 on page 76 and Section 7.3.1.3 on page 79.

Use Case: "Free Run" (Acquisition Start Trigger Off and Frame Start Trigger Off)

The acquisition start trigger is off. The camera will generate acquisition start trigger signals internally with no action by the user.

The frame start trigger is off. The camera will generate frame start trigger signals internally with no action by the user.

Settings: Trigger Mode for the acquisition start trigger = Off
Trigger Mode for the frame start trigger = Off

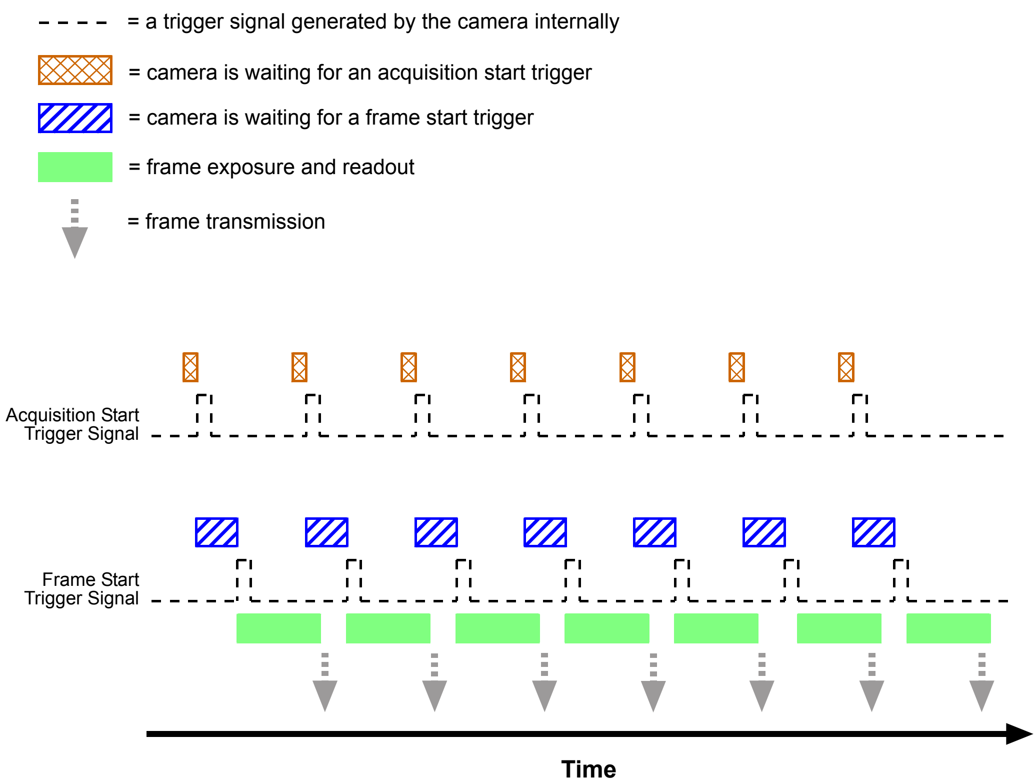


Fig. 34: Use Case 1 - Acquisition Start Trigger Off and Frame Start Trigger Off

Use Case 2 - Acquisition Start Trigger Off - Frame Start Trigger On

Use case two is illustrated on page 122.

In this use case, the Trigger Mode parameter for the acquisition start trigger is set to off and the Trigger Mode parameter for the frame start trigger is set to on.

Because the acquisition start trigger is set to off, the user does not need to apply acquisition start trigger signals to the camera. The camera will generate all required acquisition start trigger signals internally.

Because the frame start trigger is set to on, the user must apply a frame start trigger signal to the camera in order to begin each frame exposure. In this case, we have set the frame start trigger signal source to line 1 and the activation to rising edge. So, the rising edge of an externally generated electrical signal applied to line 1 will serve as the frame start trigger signal.

(Note that the GPIO line is designated as line 1 and in this case it has been set to act as in input line.)

This type of camera setup is used frequently in industrial applications. One example might be a wood products inspection system used to inspect the surface of pieces of plywood on a conveyor belt as they pass by a camera. In this situation, a sensing device is usually used to determine when a piece of plywood on the conveyor is properly positioned in front of the camera. When the plywood is in the correct position, the sensing device transmits an electrical signal to line 1 on the camera. When the electrical signal is received on line 1, it serves as a frame start trigger signal and initiates a frame acquisition. The frame acquired by the camera is transmitted to an image processing system that will inspect the image and determine if there are any defects in the plywood's surface.

Use Case:	Acquisition Start Trigger Off and Frame Start Trigger On The acquisition start trigger is off. The camera will generate acquisition start trigger signals internally with no action by the user. The frame start trigger is on, and the frame start trigger source is set to line 1. The user must apply a frame start trigger signal to line 1 to start each frame exposure.
Settings:	Trigger Mode for the acquisition start trigger = Off Trigger Mode for the frame start trigger = On Trigger Source for the frame start trigger = Line 1 Trigger Activation for the frame start trigger = Rising Edge

- - - - = a trigger signal generated by the camera internally

——— = a trigger signal applied by the user

= camera is waiting for an acquisition start trigger signal

= camera is waiting for a frame start trigger signal

= frame exposure and readout

= frame transmission

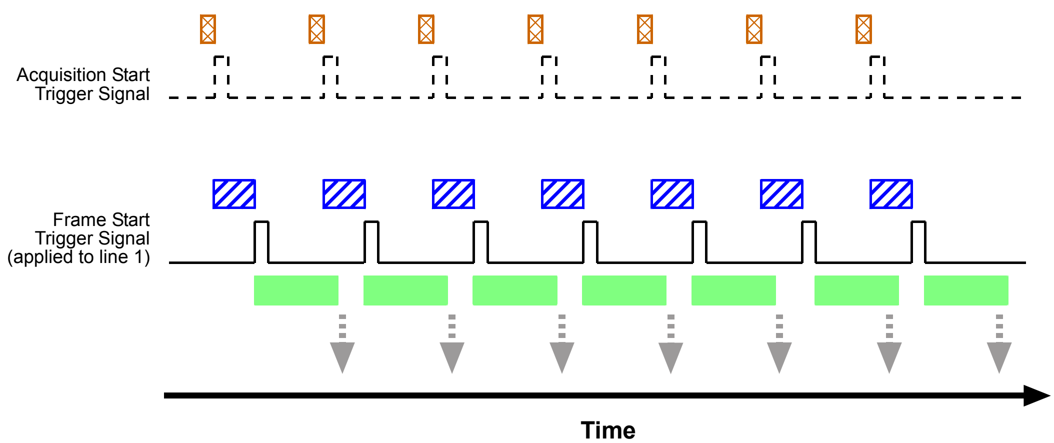


Fig. 35: Use Case 2 - Acquisition Start Trigger Off and Frame Start Trigger On

Use Case 3 - Acquisition Start Trigger On - Frame Start Trigger Off

Use case three is illustrated on page 124.

In this use case, the Trigger Mode parameter for the acquisition start trigger is set to on and the Trigger Mode parameter for the frame start trigger is set to off.

Because the acquisition start trigger mode is set to on, the user must apply an acquisition start trigger signal to the camera. In this case, we have set the acquisition start trigger signal source to line 1 and the activation to rising edge, so an externally generated electrical signal applied to line 1 will serve as the acquisition start trigger signal. The Acquisition Frame Count parameter has been set to 3.

(Note that the GPIO line is designated as line 1 and in this case it has been set to act as in input line.)

When a rising edge of the electrical signal is applied to line 1, the camera will exit the "waiting for acquisition start trigger" acquisition status and enter a "waiting for frame start trigger" acquisition status. Once the camera has acquired 3 frames, it will re-enter the "waiting for acquisition start trigger" acquisition status. Before any more frames can be acquired, a new rising edge must be applied to line 1 to make the camera exit the "waiting for acquisition start trigger" acquisition status.

Because the frame start trigger is set to off, the user does not need to apply frame start trigger signals to the camera. The camera will generate all required frame start trigger signals internally. The rate at which the frame start trigger signals will be generated is normally determined by the camera's Acquisition Frame Rate Abs parameter when the camera is parameterized via Basler pylon or by the Acquisition Frame Period Raw register the camera is parameterized via direct register access. If the Acquisition Frame Rate Abs parameter or the Acquisition Frame Period Raw register (respectively) is disabled, the camera will acquire frames at the maximum allowed frame rate.

This type of camera setup is used frequently in "intelligent traffic systems." With these systems, a typical goal is to acquire several images of a car as it passes through a toll booth. A sensing device is usually placed at the start of the toll booth area. When a car enters the area, the sensing device applies an electrical signal to line 1 on the camera. When the electrical signal is received on line 1, it serves as an acquisition start trigger signal and the camera exits from the "waiting for acquisition start trigger" acquisition status and enters a "waiting for frame trigger" acquisition status. In our example, the next 3 frame start trigger signals internally generated by the camera would result in frame acquisitions. At that point, the number of frames acquired would be equal to the setting for the Acquisition Frame Count parameter. The camera would return to the "waiting for acquisition start trigger" acquisition status and would no longer react to frame start trigger signals. It would remain in this condition until the next car enters the booth area and activates the sensing device.

This sort of setup is very useful for traffic system applications because multiple frames can be acquired with only a single acquisition start trigger signal pulse and because frames will not be acquired when there are no cars passing through the booth (this avoids the need to store images of an empty toll both area.)

For more information about the Acquisition Frame Rate Abs parameter and the Acquisition Frame Period Raw register, see Section 7.3.1.1 on page 76 and Section 7.3.1.3 on page 79.

Use Case:	Acquisition Start Trigger On and Frame Start Trigger Off The acquisition start trigger is on, and the acquisition start trigger source is set to line 1. The user must apply an acquisition start trigger signal to line 1 to make the camera exit the "waiting for acquisition start trigger" acquisition status. Because the acquisition frame count is set to 3, the camera will re-enter the "waiting for acquisition start trigger" acquisition status after 3 frames have been acquired. The frame start trigger is off. The camera will generate frame start trigger signals internally with no action by the user.
Settings:	Trigger Mode for the acquisition start trigger = On Trigger Source for the acquisition start trigger = Line 1 Trigger Activation for the acquisition start trigger = Rising Edge Acquisition Frame Count = 3 Trigger Mode for the frame start trigger = Off

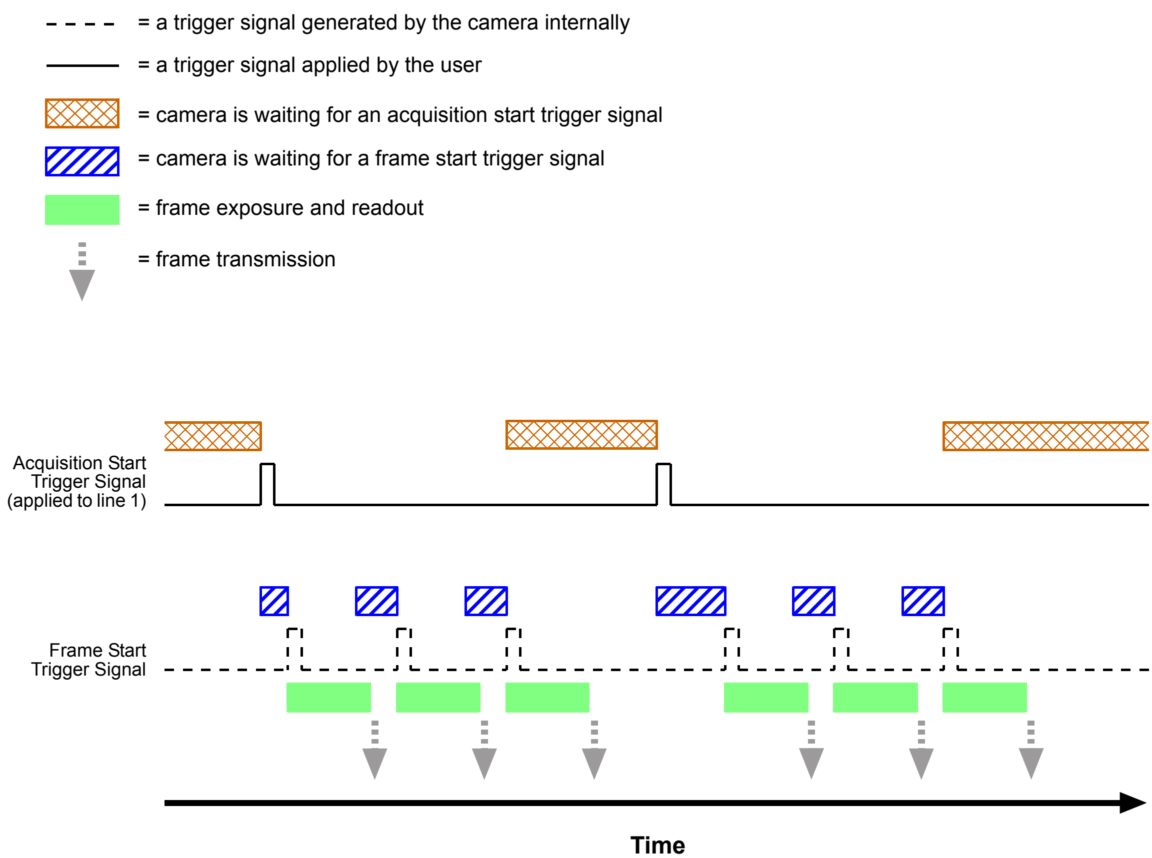


Fig. 36: Use Case 3 - Acquisition Start Trigger On and Frame Start Trigger Off

Use Case 4 - Acquisition Start and Frame Start Triggers On

Use case four is illustrated on page 126.

In this use case, the Trigger Mode parameter for the acquisition start trigger is set to on and the Trigger Mode parameter for the frame start trigger is set to on.

Because the acquisition start trigger mode is set to on, the user must apply an acquisition start trigger signal to the camera. In this case, we have set the acquisition start trigger signal source to software, so the execution of an acquisition trigger software command will serve as the acquisition start trigger signal. The Acquisition Frame Count parameter is set to 3.

When an acquisition trigger software command is executed, the camera will exit the "waiting for acquisition start trigger" acquisition status and enter a "waiting for frame start trigger" acquisition status. Once the camera has acquired 3 frames, it will re-enter the "waiting for acquisition start trigger" acquisition status. Before any more frames can be acquired, a new acquisition trigger software command must be executed to make the camera exit the "waiting for acquisition start trigger" acquisition status.

Because the frame start trigger is set to on, the user must apply a frame start trigger signal to the camera in order to begin each frame acquisition. In this case, we have set the frame start trigger signal source to line 1 and the activation to rising edge, so the rising edge of an externally generated electrical signal applied to line 1 will serve as the frame start trigger signal. Keep in mind that the camera will only react to a frame start trigger signal when it is in a "waiting for frame start trigger" acquisition status.

(Note that the GPIO line is designated as line 1 and in this case it has been set to act as in input line.)

A possible use for this type of setup is a conveyor system that moves objects past an inspection camera. Assume that the system operators want to acquire images of 3 specific areas on each object, that the conveyor speed varies, and that they do not want to acquire images when there is no object in front of the camera. A sensing device on the conveyor could be used in conjunction with a PC to determine when an object is starting to pass the camera. When an object is starting to pass, the PC will execute an acquisition start trigger software command, causing the camera to exit the "waiting for acquisition start trigger" acquisition status and enter a "waiting for frame start trigger" acquisition status.

An electrical device attached to the conveyor could be used to generate frame start trigger signals and to apply them to line 1 on the camera. Assuming that this electrical device was based on a position encoder, it could account for the speed changes in the conveyor and ensure that frame trigger signals are generated and applied when specific areas of the object are in front of the camera. Once 3 frame start trigger signals have been received by the camera, the number of frames acquired would be equal to the setting for the Acquisition Frame Count parameter, and the camera would return to the "waiting for acquisition start trigger" acquisition status. Any frame start trigger signals generated at that point would be ignored.

This sort of setup is useful because it will only acquire frames when there is an object in front of the camera and it will ensure that the desired areas on the object are imaged. (Transmitting images of the "space" between the objects would be a waste of bandwidth and processing them would be a waste of processor resources.)

Use Case: Acquisition Start Trigger On and Frame Start Trigger On

The acquisition start trigger is on, and the acquisition start trigger source is set to software. The user must execute an acquisition start trigger software command to make the camera exit the "waiting for acquisition start trigger" acquisition status. Because the acquisition frame count is set to 3, the camera will re-enter the "waiting for acquisition start trigger" acquisition status after 3 frame trigger signals have been applied.

The frame start trigger is on, and the frame start trigger source is set to line 1. The user must apply a frame start trigger signal to line 1 to start each frame exposure.

Settings: Trigger Mode for the acquisition start trigger = On
Trigger Source for the acquisition start trigger = Software
Acquisition Frame Count = 3
Trigger Mode for the frame start trigger = On
Trigger Source for the frame start trigger = Line 1
Trigger Activation for the frame start trigger = Rising Edge

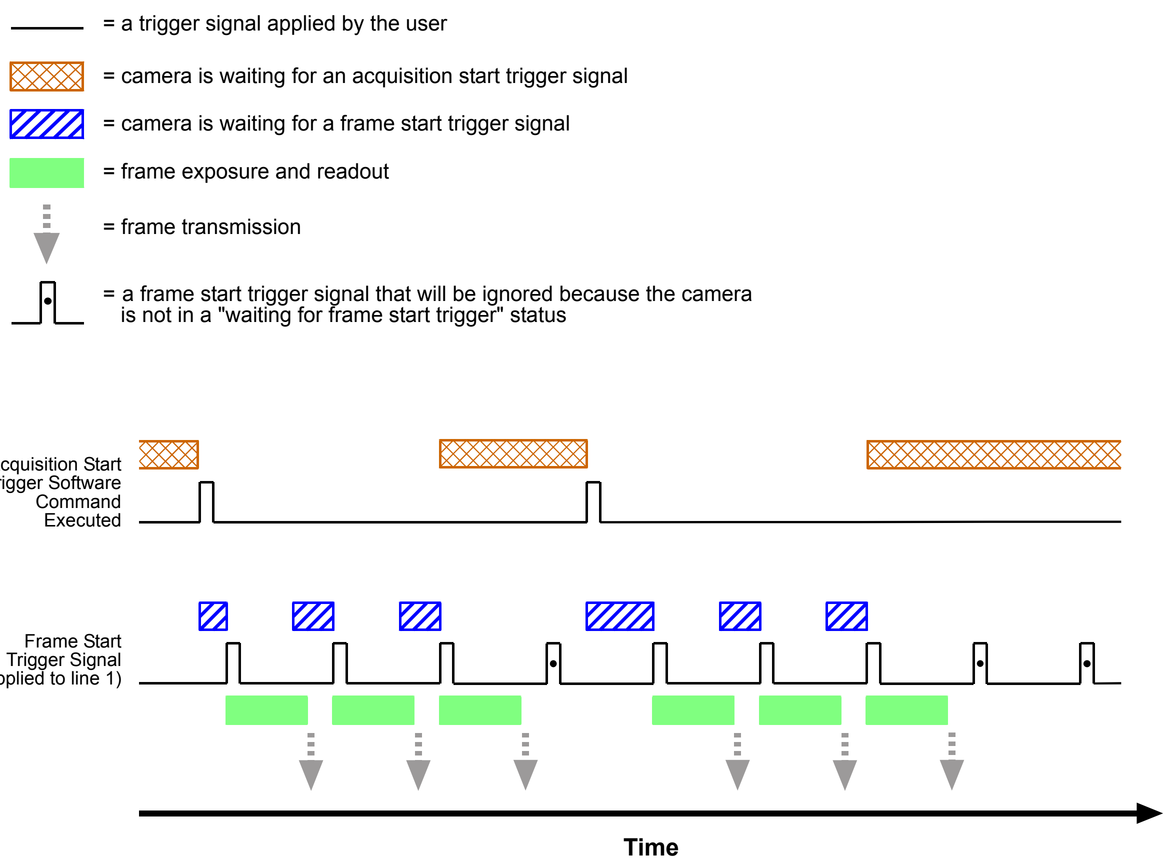


Fig. 37: Use Case 4 - Acquisition Start Trigger On and Frame Start Trigger On

8 Color Creation and Enhancement

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

8.1 Color Creation

The sensor used in the cameras is equipped with an additive color separation filter known as a Bayer filter. The pixel data output formats available on color cameras are related to the Bayer pattern, so you need a basic knowledge of the Bayer filter to understand the pixel formats. With the Bayer filter, each individual pixel is covered by a 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 38 (the alignment of the Bayer filter with repect to the sensor is shown as an example only; the figure shows the "GB" filter alignment). As the figure illustrates, within each square of four pixels, one pixel sees only red light, one sees only blue light, and two pixels see only green light. (This combination mimics the human eye’s sensitivity to color.)

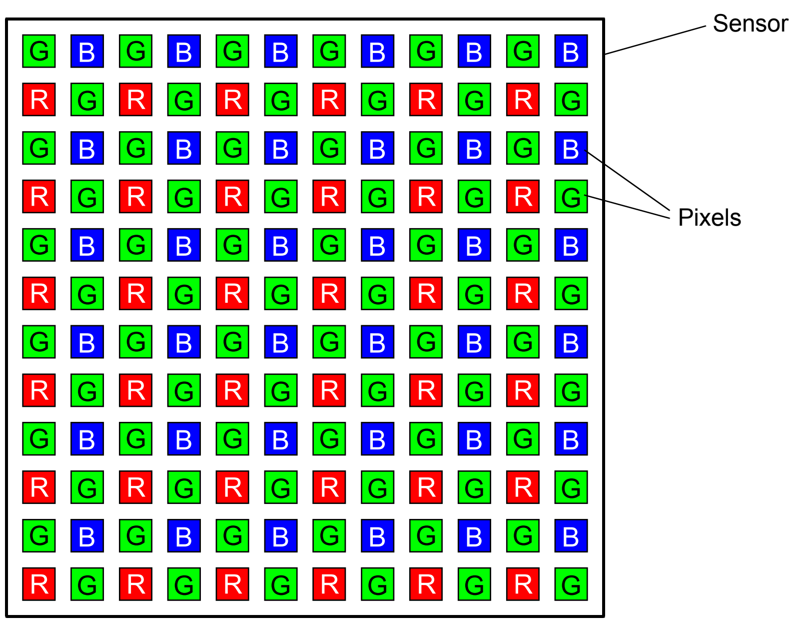


Fig. 38: Bayer Filter Pattern

8.1.1 Bayer Color Filter Alignment

On all color camera models, the alignment of the filter to the pixels in the acquired images is Bayer GB. Bayer GB alignment 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 fixed, you can use this information to determine the color of all of the other pixels in the image.

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

The image area of interest (AOI) parameters can only be changed in certain defined increments. The increments are designed so that the alignment of the Bayer filter to the pixels in the transmitted images will stay the same regardless of the size of the image AOI.

When either the reverse X feature or the reverse Y feature or both are used, the alignment of the color filter to the image remains Bayer GB. The camera includes a mechanism that keeps the filter alignment constant when these features are used.

For more information about the camera's AOI feature, see Section 10.3 on page 158.

For more information about the reverse X and reverse Y features, see Section 10.7 on page 177.

8.1.2 Pixel Data Formats Available on Color Cameras

Bayer Formats

Cameras equipped with a Bayer pattern color filter can output pixel data in the Bayer GB 8, the Bayer GB 10, or the Bayer GB 12 pixel data format. When a color camera is set for one of these three pixel data output formats, the pixel data is not processed or interpolated in any way. So, for each pixel covered with a red lens, you get 8, 10, or 12 bits of red data. For each pixel covered with a green lens, you get 8, 10, or 12 bits of green data. And for each pixel covered with a blue lens, you get 8, 10, or 12 bits of blue data. (This type of pixel data is sometimes referred to as "raw" output.)

8.2 Integrated IR Cut Filter (All Color Models)

All color camera models are equipped with an IR-cut filter as standard equipment. The filter is mounted in a filter holder located in the lens mount.

Monochrome cameras include a filter holder in the lens mount, but the holder is not populated with an IR-cut filter.

NOTICE
On all cameras, the lens thread length is limited. All cameras (mono and color) are equipped with a plastic filter holder located in the lens mount. The location of the filter holder limits the length of the threads on any lens you use with the camera. If a lens with a very long thread length is used, the filter holder or the lens mount will be damaged or destroyed and the camera will no longer operate.

For more information about the location of the IR cut filter, see Section 1.4.2 on page 7.

8.3 Color Enhancement Features

8.3.1 White Balance

This section (Section 8.3) describes how a color camera's white balance can be adjusted "manually", i.e., by setting the value of the Balance Ratio Abs parameters for red, green, and blue.

The camera also has a White Balance Auto function that can automatically adjust the white balance. **Manual adjustment of the Balance Ratio Abs parameters for red, green, and blue will only work correctly if the Balance White Auto function is disabled.**

For more information about auto functions in general, see Section 10.9 on page 187.

For more information about the Balance White Auto function, see Section 10.9.7 on page 204.

White balance capability has been implemented on color models of the camera. White balancing can be used to adjust the color balance of the images transmitted from the camera.

With the white balancing scheme used on these cameras, the red intensity, green intensity, and blue intensity can each be adjusted. For each color, a Balance Ratio parameter is used to set the intensity of the color. If the Balance Ratio parameter for a color is set to a value of 1, the intensity of the color will be unaffected by the white balance mechanism. If the ratio is set to a value lower than 1, the intensity of the color will be reduced. If the ratio is set to a value greater than 1, the intensity of the color will be increased. The increase or decrease in intensity is proportional. For example, if the balance ratio for a color is set to 1.2, the intensity of that color will be increased by 20%.

The balance ratio value can range from 0.00 to 15.984. But you should be aware that if you set the balance ratio for a color to a value lower than 1, this will not only decrease the intensity of that color relative to the other two colors, but will also decrease the maximum intensity that the color can achieve. For this reason, we don't normally recommend setting a balance ratio less than 1 unless you want to correct for the strong predominance of one color.

Setting the White Balance Using Basler pylon

Setting the Balance Ratio parameter for a color using Basler pylon is a two step process:

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

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

```
// Set the red balance ratio
```

```
Camera.BalanceRatioSelector.SetValue( BalanceRatioSelector_Red );
Camera.BalanceRatioAbs.SetValue( 1.20 );

// Set the green balance ratio
Camera.BalanceRatioSelector.SetValue( BalanceRatioSelector_Green );
Camera.BalanceRatioAbs.SetValue( 1.20 );
```

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 17.

Setting the White Balance Using Direct Register Access

To set the balance ratio parameters via direct register access:

- Set the value of White Balance Red register to adjust the red ratio.
- Set the value of the White Balance Green register to adjust the green ratio.
- Set the value of the White Balance Blue register to adjust the blue ratio.

For more information about direct register access, see Section 3.2 on page 19.

8.3.2 Gamma Correction

The gamma correction feature lets you modify the brightness of the pixel values output by the camera's sensor to account for a non-linearity in the human perception of brightness. There are two modes of gamma correction available on the camera: sRGB and User.

sRGB Gamma

When the camera is set for sRGB gamma correction, it automatically sets the gamma correction to adjust the pixel values so that they are suitable for display on an sRGB monitor. If you will be displaying the images on an sRGB monitor, using this type of gamma correction is appropriate.

User Gamma

With User type gamma correction, you can set the gamma correction value as desired.

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

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

The formula uses uncorrected and corrected pixel brightnesses that are normalized by the maximum pixel brightness. The maximum pixel brightness equals 255 for 8 bit output, 1023 for 10 bit output, and 4095 for 12 bit output.

The gamma correction value can be set in a range from 0 to 3.99998.

When the gamma correction value is set to 1, the output pixel brightness will not be corrected.

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

In all cases, black (output pixel brightness equals 0) and white (output pixel brightness equals 255 at 8 bit output, 1023 at 10 bit output, and 4095 at 12 bit output) will not be corrected.

Enabling and Setting Gamma Correction Using Basler Pylon

You can enable or disable the gamma correction feature by setting the value of the Gamma Enable parameter.

You can use the Gamma Selector to select either sRGB or user gamma correction.

If you select user gamma correction, you can use the Gamma parameter to set the gamma correction value.

You can set the Gamma Enable parameter, use the Gamma Selector, and set Gamma parameter values from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values for sRGB type correction:

```
// Enable the Gamma feature
Camera.GammaEnable.SetValue( true );
// Set the gamma type to sRGB
Camera.GammaSelector.SetValue ( GammaSelector_sRGB );
```

The following code snippet illustrates using the API to set the parameter values for user type correction:

```
// Enable the Gamma feature
Camera.GammaEnable.SetValue( true );
// Set the gamma type to User
Camera.GammaSelector.SetValue ( GammaSelector_User );
// 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 17.

Enabling and Setting Gamma Correction Using Direct Register Access

To enable gamma correction and to set the gamma value via direct register access:

- Set the value of the Gamma Enable register to Enabled.
- Set the value of the Gamma Selector register to SRGB or User.
- If the Gamma Selector is set to User, eet the value in the Gamma register to the desired gamma value.

For more information about direct register access, see Section 3.2 on page 19.

8.3.3 Matrix Color Transformation

With the matrix type of color transformation, a vector consisting of the R, G, or B component for each pixel in the image is multiplied by a matrix containing a set of correction values. The main objectives of this matrix multiplication process are to make corrections to the color information that will account for the type of lighting used during image acquisition and to compensate for any imperfections in the sensor's color generation process.

The first camera parameter associated with matrix color transformation is the Color Transformation Selector parameter. This parameter is used to select the type of transformation that will be performed. For ace Camera Link cameras, RGB to RGB is the only setting available. This setting simply means that the camera will not transform the red, green, and blue pixel values from the sensor into a different color space (such as YUV).

The second parameter associated with matrix color transformation is the Light Source Selector parameter. The following settings are available for this parameter:

- Off - No alterations will be made to the pixel values.
- Daylight - This setting will automatically populate the matrix with a pre-selected set of values that will make appropriate corrections for images captured with daylight lighting that has a color temperature of about 5000K.
- Tungsten - This setting will automatically populate the matrix with a pre-selected set of values that will make appropriate corrections for images captured with tungsten lighting that has a color temperature of about 2500K to 3000K.
- Daylight 6500K - This setting will automatically populate the matrix with a pre-selected set of values that will make appropriate corrections for images captured with daylight lighting that has a color temperature of about 6500K.
- Custom - The user can set the values in the matrix as desired.

In almost all cases, selecting one of the settings that populate the matrix with pre-selected values will give you excellent results with regard to correcting the colors for the light source you are using.

The custom setting should only be used by someone who is thoroughly familiar with matrix color transformations. Instructions for using the custom setting appear in the next section.

The third parameter associated with matrix color transformation is the Color Transformation Matrix Factor parameter. This parameter determines how strong an effect the matrix correction function will have on the colors output by the camera. The parameter setting is a floating point value that can range from 0 to 1. When the parameter value is set to 0, matrix correction will have no effect. When the value is set to 1, matrix correction will have its maxumum effect.

Setting Matrix Color Transformation Using Basler Pylon

You can set the Color Transformation Selector and Light Source Selector parameters from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values:

```
// Select the color transformation type
Camera.ColorTransformationSelector.SetValue
     ( ColorTransformationSelector_RGBtoRGB );

// Set the light source selector so that no correction will be done
Camera.LightSourceSelector.SetValue
     ( LightSourceSelector_Off );
// Set the light source selector for daylight (at about 5000K)
Camera.LightSourceSelector.SetValue
     ( LightSourceSelector_Daylight );
// Set the light source selector for tungsten lighting
Camera.LightSourceSelector.SetValue
     ( LightSourceSelector_Tungsten );
// Set the light source selector for daylight (at about 6500K)
Camera.LightSourceSelector.SetValue
     ( LightSourceSelector_Daylight6500K );

// Set the matrix correction factor
Camera.ColorTransformationMatrixFactor.SetValue( 0.50 );
```

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 17.

Setting Matrix Color Transformation Using Direct Register Access

To set matrix color transformation via direct register access:

- Set the value of the Light Source Selector register to Off, Daylight, Tungsten, Daylight 6500K, or Custom as desired.
- Set the value of the Color Matrix Factor register as desired.

For more information about direct register access, see Section 3.2 on page 19.

8.3.3.1 "Custom" Light Source Setting

ⓘ	The "Custom" setting for the Light Source Selector parameter is intended for use by someone who is thoroughly familiar with matrix color transformations. **It is nearly impossible to enter correct values in the conversion matrix by trial and error.**

The RGB to RGB color matrix conversion for each pixel is performed by multiplying a 1 x 3 matrix containing R, G, and B color values with a 3 x 3 matrix containing correction values. Each column in the 3 x 3 matrix can be populated with values of your choice. In other words:

$$\begin{bmatrix} Gain00 & Gain01 & Gain02 \\ Gain10 & Gain11 & Gain12 \\ Gain20 & Gain21 & Gain22 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Where Gain00, Gain01, etc. are settable values.

Keep in mind that ace Camera Link cameras use sensors with a Bayer pattern filter and that they do not interpolate the pixel values. This means that when the camera is a doing matrix correction for a particular pixel, only one actual color value will be available for that pixel. To fill in the other two color values in the 1 x 3 matrix, the camera uses values from neighboring pixels. After making the correction calculations, the camera only transmits the result for the actual pixel color and discards the other two calculated values. For example, if the camera is correcting the value for a red pixel, it will populate the 1 x 3 matrix with the actual value for the red pixel. It will then populate the green and blue positions in the matrix with values from a neighboring green and a neighboring blue pixel. After making the matrix correction calculations, the camera will discard the green and blue values from the result and only transmit the red value.

Each GainXY position can each be populated with a floating point value ranging from -8.0 to +7.96875 by using the Color Transformation Value Selector to select one of the GainXX positions in the matrix and using the Color transformation Value parameter to enter a value for that position.

As an alternative the Gain XY values can each be entered as an integer value on a scale ranging from -256 to +255. This integer range maps linearly to the floating point range with -256 being equivalent to -8.0, 32 being equivalent to 1.0, and +255 being equivalent to +7.96875. The integer values can be entered using the Color transformation Value Raw parameter.

A reference article that explains the basics of color matrix transformation for video data can be found at:
http://www.its.bldrdoc.gov/pub/ntia-rpt/04-406/index.php

Setting Custom Matrix Values Using Basler Pylon

You can set the Color Transformation Value Selector, Color Transformation Value, and Color Transformation Value Raw parameters from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the values in the matrix. Note that the values in this example are just randomly selected numbers and do not represent values that you should actually use.

```
// Set the light source selector for custom
Camera.LightSourceSelector.SetValue ( LightSourceSelector_Custom );

// Select a position in the matrix
Camera.ColorTransformationValueSelector.SetValue
      ( ColorTransformationValueSelector_Gain10 );
// Set the value for the selected position as a floating point value
Camera.ColorTransformationValue.SetValue( 2.11 );

// Select a position in the matrix
Camera.ColorTransformationValueSelector.SetValue
      ( ColorTransformationValueSelector_Gain10 );
// Set the value for the selected position as an integer value
Camera.ColorTransformationValueRaw.SetValue( 135 );
```

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 17.

Setting Custom Matrix Values Using Direct Register Access

To set Gain XY values in the matrix via direct register access:

- Set the value of the Light Source Selector register to Custom.
- Set the value of the following registers as desired:

  Color Matrix RGB 2 RGB 00

  Color Matrix RGB 2 RGB 01

  Color Matrix RGB 2 RGB 02

  Color Matrix RGB 2 RGB 10

  Color Matrix RGB 2 RGB 11

  Color Matrix RGB 2 RGB 12

  Color Matrix RGB 2 RGB 20

  Color Matrix RGB 2 RGB 21

  Color Matrix RGB 2 RGB 22

For more information about direct register access, see Section 3.2 on page 19.

9 Sensor Bit Depth, Pixel Formats, Tap Geometries, and Clock Speeds

This chapter provides information about the sensor bit depths, pixel formats, Camera Link tap geometries and pixel clock speeds available on the camera.

ⓘ	If you plan to design your own frame grabber, or if you would like complete details regarding the way that pixel data is handled by the camera, refer to the Basler document named *Ace Camera Link Information for Frame Grabber Designers* (AW000990xx000). You can obtain the document from the Downloads section of the Basler website: www.baslerweb.com

9.1 Sensor Bit Depth

As mentioned in the "Functional Description" section of this manual, the camera’s imaging sensor can be set to acquire image data at either 10 bit or 12 bit depth.

When the sensor is operating at 10 bit depth, it operates significantly faster than at 12 bit depth. So when the sensor is set for 10 bit acquisition, the camera can be operated at a higher maximum frame rate.

Keep in mind that the data depth of the pixel values actually reported out of the camera will depend on the camera’s current pixel format setting.

For more information about pixel formats, see Section 9.2 on page 141.

Setting the Sensor Bit Depth Using Basler pylon

You can use the pylon API to set the sensor bit depth from within your application software. The following code snippet illustrates using the API to set the exposure mode:

```
// Set the sensor bit depth to 10
Camera.SensorBitDepth.SetValue( SensorBitDepth_BitDepth10 );

// Set the sensor bit depth to 12
Camera.SensorBitDepth.SetValue( SensorBitDepth_BitDepth12 );
```

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 17.

Setting the Sensor Bit Depth Using Direct Register Access

To set the sensor bit depth via direct register access:

- Set the value of the Sensor Bit Depth register to 10 Bit Depth or 12 Bit Depth.

For more information about direct register access, see Section 3.2 on page 19.

9.2 Pixel Formats

Pixel Formats for Monochrome Cameras

The choice of a pixel format determines the bit depth of the data transmitted from the camera for each pixel in the acquired frames. The pixel formats available on the mono cameras depend on the current setting of the Camera Link Geometry parameter as shown in Table 7.

Camera Link Geometry Setting	Available Pixel Formats		
	Mono 8	Mono 10	Mono 12
1X2-1Y	●	●	●
1X3-1Y	●		
1X4-1Y	●	●	●
1X6-1Y	●		
1X8-1Y	●	●	
1X10-1Y	●		

Table 7: Mono Pixel Formats Available for Each Geometry (● = format available)

Pixel Formats for Color Cameras

The choice of a pixel format determines the bit depth of the data transmitted from the camera for each pixel in the acquired frames. The pixel formats available on the color cameras depend on the current setting of the Camera Link Geometry parameter as shown in Table 7.

Camera Link Geometry Setting	Available Pixel Formats		
	Bayer GB 8	Bayer GB 10	Bayer GB 12
1X2-1Y	●	●	●
1X3-1Y	●		
1X4-1Y	●	●	●
1X6-1Y	●		
1X8-1Y	●	●	
1X10-1Y	●		

Table 8: Pixel Formats Available for Each Geometry (● = format available)

The pixels output from the color camera are not interpolated in any way; they are output as "raw" data. This means that for each pixel, there is only one color value (i.e., for each red pixel there is only a red value, for each green pixel there is only a green value, and for each blue pixel there is only a blue value).

Color cameras do not output interpolated RGB values for each pixel, even when they are set for a multiple tap Camera Link geometry such as 1X3-1Y or 1X6-1Y.

Pixel Format Interaction with the Sensor Bit Depth Setting

The camera's sensor can capture image data at 12 bit depth or at 10 bit depth (depending on the Sensor Bit Depth setting). There is an interaction between the Sensor Bit Depth setting and the Pixel Format setting as described in Table 9.

Sensor Bit Depth Setting	Pixel Format Setting		
	Mono 8 or Bayer GB 8	**Mono 10 or Bayer GB 10**	**Mono 12 or Bayer GB 12**
12 bits	8 most significant bits of data from the sensor are transmitted	10 most significant bits of data from the sensor are transmitted	All 12 bits of data from the sensor are transmitted
10 bits	8 most significant bits of data from the sensor are transmitted	All 10 bits of data from the sensor are transmitted	All 10 bits of data from the sensor are transmitted and 2 zero-packed least significant bits are added

Table 9: Interaction Between the Sensor Bit Depth and the Pixel Format

For more information about the sensor bit depth, see Section 9.1 on page 140.

Setting the Pixel Format Using Basler Pylon

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

Mono cameras

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

Color Cameras:

```
// Set pixel format to Bayer GB 8
Camera.PixelFormat.SetValue( PixelFormat_BayerGB8 );
// Set pixel format to Bayer GB 10
Camera.PixelFormat.SetValue( PixelFormat_BayerGB10 );
// Set pixel format to Bayer GB 12
Camera.PixelFormat.SetValue( PixelFormat_BayerGB12 );
```

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 17.

Setting the Pixel Format Using Direct Register Access

To set the sensor pixel format via direct register access:

- On mono cameras, set the value of the Pixel Format register to Mono 8, Mono 10, or Mono 12 as desired.
- On color cameras, set the value of the Pixel Format register to Bayer GB 8, Bayer GB 10, or Bayer GB 12 as desired.

For more information about direct register access, see Section 3.2 on page 19.

9.3 Camera Link Tap Geometry

9.3.1 Overview

The Camera Link tap geometry determines how the data that is read out of the imaging sensor will be transmitted from the camera to the frame grabber in your host PC via the Camera Link interface. The selection of a camera link tap geometry also determines whether your camera will be operating in the base, medium, or full Camera Link configuration and which Camera Link connectors on the camera will be used to transmit pixel data. Table 10 indicates how the Camera Link interface will operate with each available tap geometry setting.

The X2, X3, X4, X6, X8, or X10 in the tap geometry names indicates the number of Camera Link taps that will be used for a given configuration (i.e., X2 means 2 taps, X3 means 3 taps, etc.). As a general rule of thumb, a camera will have a higher maximum allowed frame rate when it is operating with a tap geometry that uses Camera Link taps.

Tap Geometry Setting	Camera Link Configuration	Camera Link Connectors Used to Transmit Data
1X2-1Y	Base	Base Only
1X3-1Y	Base	Base Only
1X4-1Y	Medium	Base and Medium/Full
1X6-1Y	Medium	Base and Medium/Full
1X8-1Y	Full	Base and Medium/Full
1X10-1Y	Full	Base and Medium/Full

Table 10: Camera Link Operation at Various Tap Geometry Settings

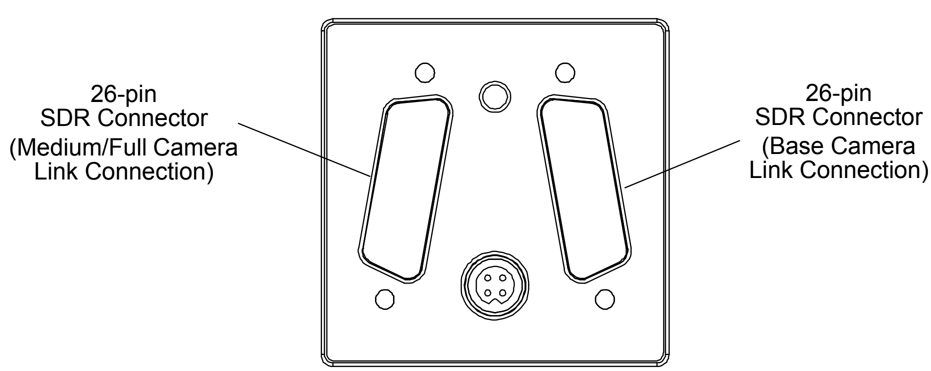


Fig. 39: Camera Link Connections

The tap geometries available vary by model as shown in Table 11.

Tap Geometry Setting	Camera Model			
	acA2000-140km/kc	acA2000-340km/kc	acA2040-70km/kc	acA2040-180km/kc
1X2-1Y	●	●	●	●
1X3-1Y	●	●	●	●
1X4-1Y	●	●	●	●
1X6-1Y		●		●
1X8-1Y		●		●
1X10-1Y		●		●

Table 11: Available Tap Geometries by Model (● = geometry available)

For more information about the camera's maximum allowed frame rate, see Section 7.8 on page 115.

This section describes the basics of Camera Link tap geometry. For more complete tap geometry details, refer to the Basler document named *Ace Camera Link Information for Frame Grabber Designers* (AW000990xx000) You can obtain the document from the Downloads section of the Basler website:
www.baslerweb.com

9.3.2 1X2-1Y Tap Geometry Description

The characteristics of the 1X2-1Y tap geometry are:

- On each cycle of the Camera Link pixel clock, the data for two pixels are transmitted via the Camera Link interface. This is commonly referred to as a "two tap" Camera Link configuration.
- The camera will begin transmitting data from line one. It will transmit the data for the first two pixels in line one on the first Camera Link pixel clock cycle, the next two pixels in line one on the second pixel clock cycle, the next two pixels in line one on the third clock cycle, and so on until the line is complete.
- When line one is complete, transmission of line two will begin and will proceed in a similar fashion. Data transmission will continue line-by-line until all of the data for the image have been transmitted.

When the camera is set for the 1X2-1y tap geometry, it uses the base Camera Link configuration.

The 1X2-1Y transmission scheme is shown graphically in Figure 40.

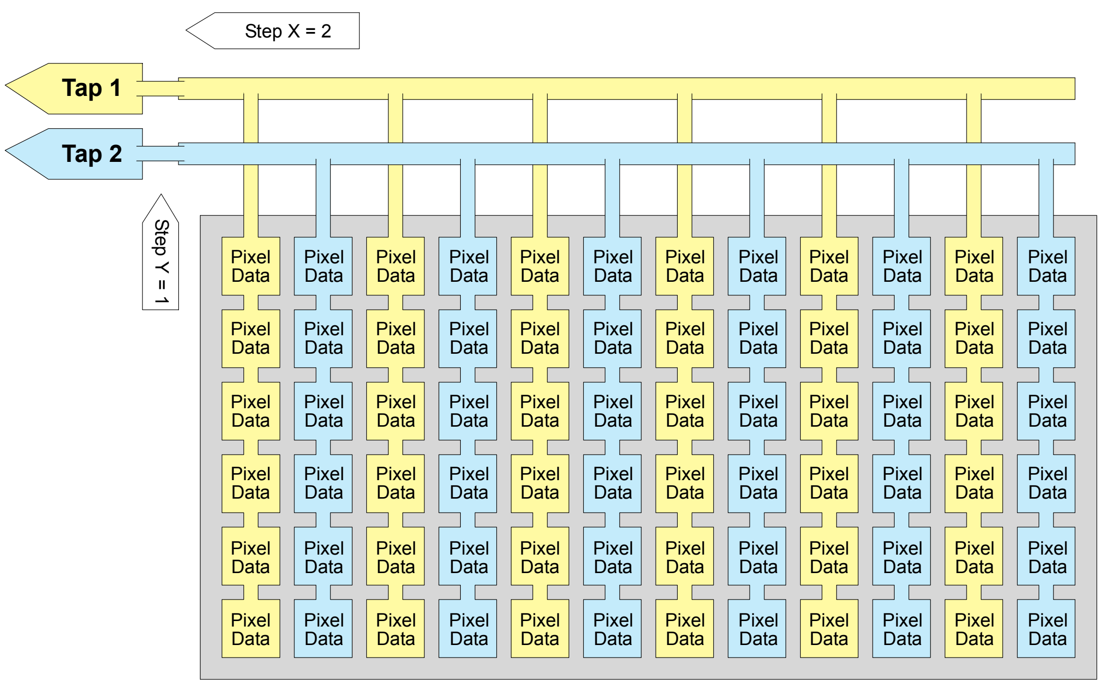


Fig. 40: 1X2-1Y Tap Geometry

9.3.3 1X3-1Y Tap Geometry Description

The characteristics of the 1X3-1Y tap geometry are:

- On each cycle of the Camera Link pixel clock, the data for three pixels are transmitted via the Camera Link interface. This is commonly referred to as a "three tap" Camera Link configuration.
- The camera will begin transmitting data from line one. It will transmit the data for the first three pixels in line one on the first Camera Link pixel clock cycle, the next three pixels in line one on the second pixel clock cycle, the next three pixels in line one on the third clock cycle, and so on until the line is complete.
- When line one is complete, transmission of line two will begin and will proceed in a similar fashion. Data transmission will continue line-by-line until all of the data for the image have been transmitted.

When the camera is set for the 1X3-1y tap geometry, it uses the base Camera Link configuration.

The 1X3-1Y transmission scheme is shown graphically in Figure 40.

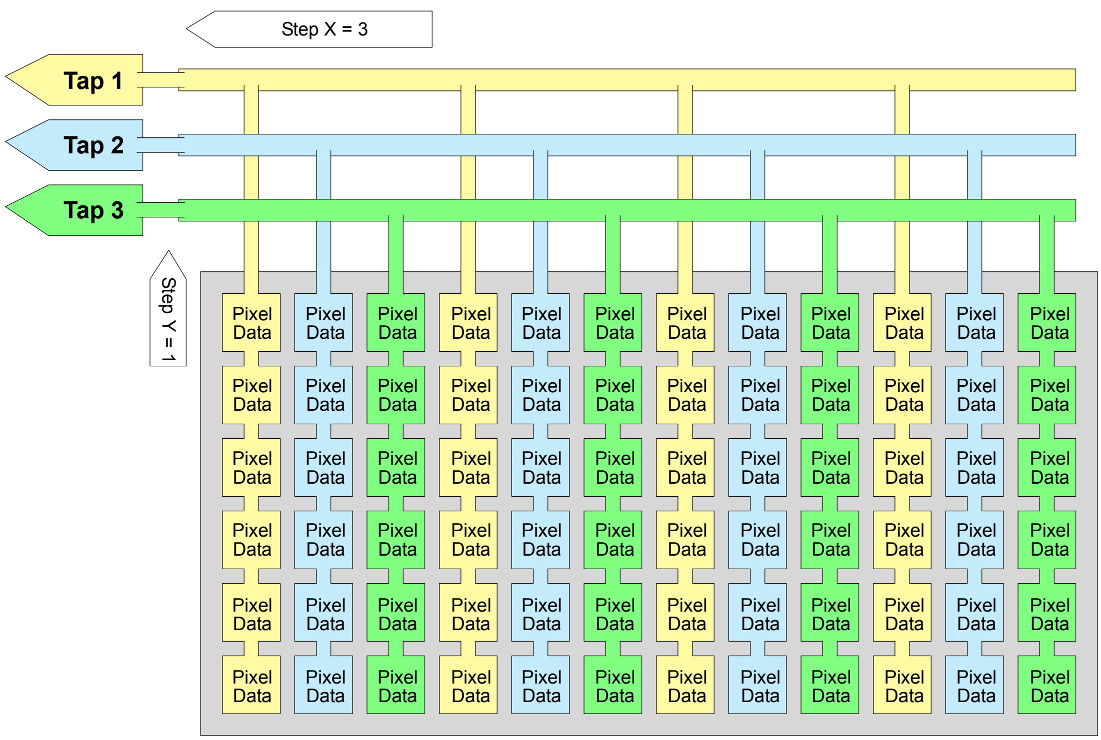


Fig. 41: 1X3-1Y Tap Geometry

9.3.4 1X4-1Y Tap Geometry Description

The characteristics of the 1X4-1Y tap geometry are:

- On each cycle of the Camera Link pixel clock, the data for four pixels are transmitted via the Camera Link interface. This is commonly referred to as a "four tap" Camera Link configuration.
- The camera will begin transmitting data from line one. It will transmit the data for the first four pixels in line one on the first Camera Link pixel clock cycle, the next four pixels in line one on the second pixel clock cycle, the next four pixels in line one on the third clock cycle, and so on until the line is complete.
- When line one is complete, transmission of line two will begin and will proceed in a similar fashion. Data transmission will continue line-by-line until all of the data for the image have been transmitted.

When the camera is set for the 1X4-1y tap geometry, it uses the medium Camera Link configuration.

The 1X4-1Y transmission scheme is shown graphically in Figure 40.

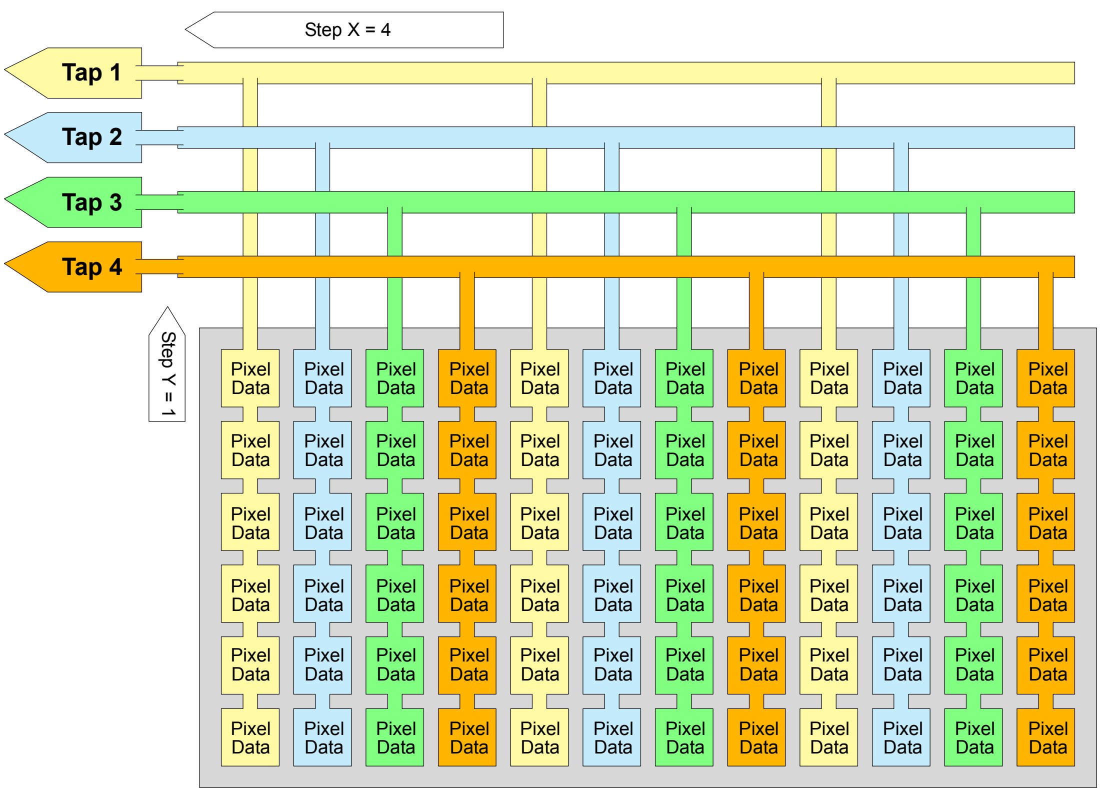


Fig. 42: 1X4-1Y Tap Geometry

9.3.5 1X6-1Y Tap Geometry Description

The characteristics of the 1X6-1Y tap geometry are:

- On each cycle of the Camera Link pixel clock, the data for six pixels are transmitted via the Camera Link interface. This is commonly referred to as a "six tap" Camera Link configuration.
- The camera will begin transmitting data from line one. It will transmit the data for the first six pixels in line one on the first Camera Link pixel clock cycle, the next six pixels in line one on the second pixel clock cycle, the next six pixels in line one on the third clock cycle, and so on until the line is complete.
- When line one is complete, transmission of line two will begin and will proceed in a similar fashion. Data transmission will continue line-by-line until all of the data for the image have been transmitted.

When the camera is set for the 1X6-1y tap geometry, it uses the medium Camera Link configuration.

The 1X6-1Y transmission scheme is shown graphically in Figure 40.

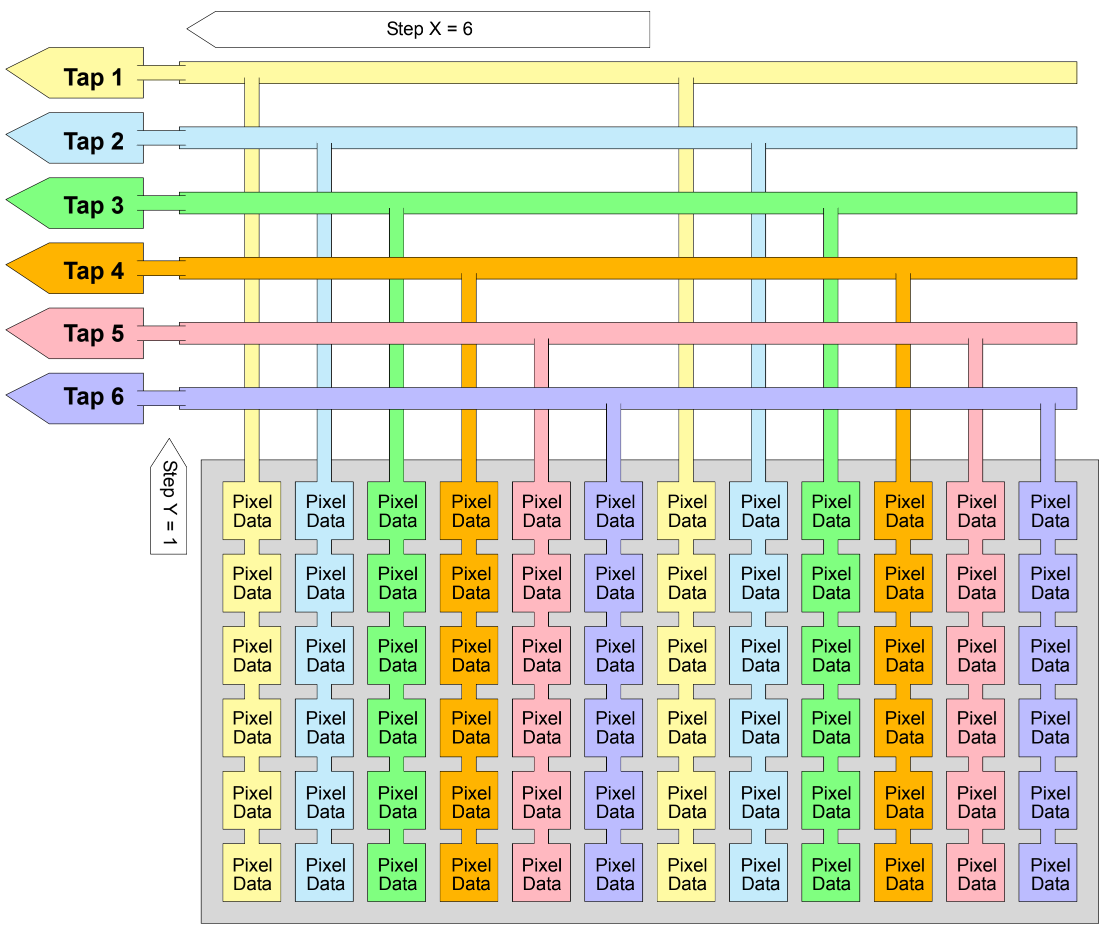


Fig. 43: 1X6-1Y Tap Geometry

9.3.6 1X8-1Y Tap Geometry Description

The characteristics of the 1X8-1Y tap geometry are:

- On each cycle of the Camera Link pixel clock, the data for eight pixels are transmitted via the Camera Link interface. This is commonly referred to as an "eight tap" Camera Link configuration.
- The camera will begin transmitting data from line one. It will transmit the data for the first eight pixels in line one on the first Camera Link pixel clock cycle, the next eight pixels in line one on the second pixel clock cycle, the next eight pixels in line one on the third clock cycle, and so on until the line is complete.
- When line one is complete, transmission of line two will begin and will proceed in a similar fashion. Data transmission will continue line-by-line until all of the data for the image have been transmitted.

When the camera is set for the 1X8-1y tap geometry, it uses the full Camera Link configuration.

The 1X8-1Y transmission scheme is shown graphically in Figure 40.

Fig. 44: 1X8-1Y Tap Geometry

9.3.7 1X10-1Y Tap Geometry Description

The characteristics of the 1X10-1Y tap geometry are:

- On each cycle of the Camera Link pixel clock, the data for ten pixels are transmitted via the Camera Link interface. This is commonly referred to as an "ten tap" Camera Link configuration.
- The camera will begin transmitting data from line one. It will transmit the data for the first ten pixels in line one on the first Camera Link pixel clock cycle, the next ten pixels in line one on the second pixel clock cycle, the next ten pixels in line one on the third clock cycle, and so on until the line is complete.
- When line one is complete, transmission of line two will begin and will proceed in a similar fashion. Data transmission will continue line-by-line until all of the data for the image have been transmitted.

When the camera is set for the 1X10-1y tap geometry, it uses the full Camera Link configuration.

The 1X10-1Y transmission scheme is shown graphically in Figure 40.

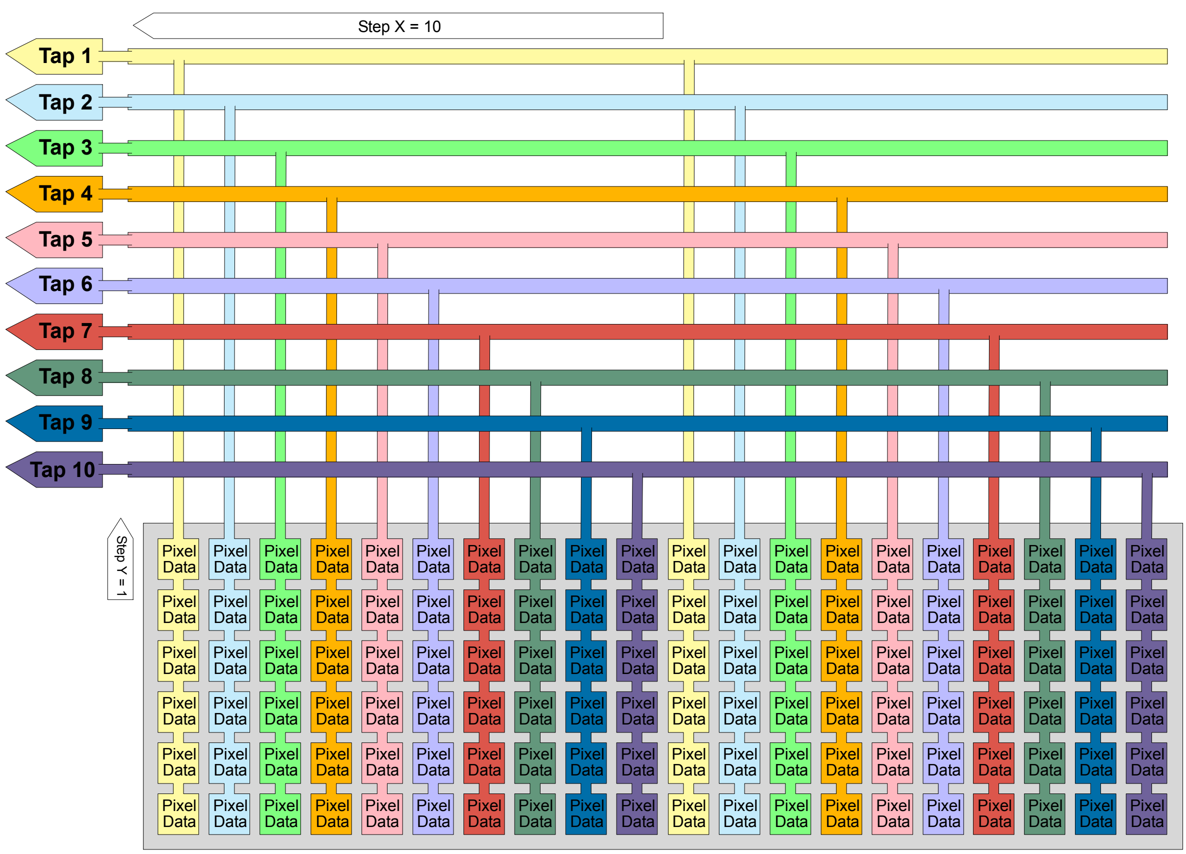


Fig. 45: 1X10-1Y Tap Geometry

9.3.8 Setting the Tap Geometry

Setting the Tap Geometry Using Basler Pylon

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

```
// Set the tap geometry to 1X2-1Y
Camera.ClTapGeometry.SetValue( ClTapGeometry_Geometry1X2_1Y );

// Set the tap geometry to 1X3-1Y
Camera.ClTapGeometry.SetValue( ClTapGeometry_Geometry1X3_1Y );
```

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 17.

Setting the Tap Geometry Direct Register Access

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

- Set the value of the CL Tap Geometry register for 1X2-1Y, 1X3-1Y, 1X4-1Y, 1X6-1Y, 1X8-1Y or 1X10-1Y as desired.

For more information about direct register access, see Section 3.2 on page 19.

9.4 Camera Link Pixel Clock Speed

The camera features selectable Camera Link pixel clock speeds. The pixel clock speed determines the rate at which pixel data will be transmitted from the camera to the frame grabber in your PC via the Camera Link interface. The four available pixel clock speeds are: 32.5 MHz, 48 MHz, 65 MHz, and 82 MHz. The default clock speed is 82 MHz.

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

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

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

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

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

For more information about the maximum allowed frame acquisition rate, see Section 7.8 on page 115.

For more information about configuration sets, see Section 10.14 on page 215.

Setting the Camera Link Pixel Clock Using Basler pylon

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

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

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

ⓘ	You can use the pylon API to set the pixel clock speed to 32.5, 48, 65, or 82 MHz. These are the only valid values for the pixel clock speed. If you attempt to use the API to set the clock speed to a value other than these, the camera will automatically move the setting to the nearest lower valid speed.

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting the Camera Link Pixel Clock Using Direct Register Access

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

- Set the value of the CL Pixel Clock register to 32.5 MHz, 48 MHz, 65 MHz, or 82 MHz.

For more information about direct register access, see Section 3.2 on page 19.

10 Features

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

10.1 Gain

ⓘ	This section (Section 10.1) describes the basic theory of gain and how gain can be adjusted "manually", i.e., by setting the value of the gain raw parameter. The camera also has a Gain Auto function that can automatically adjust the gain. **Manual adjustment of the gain parameters will only work correctly if the Gain Auto function is disabled.** For more information about auto functions in general, see Section 10.9 on page 187. For more information about the Gain Auto function in particular, see Section 10.9.4 on page 197.

The camera's gain setting is adjustable. As shown in Figure 46, 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.

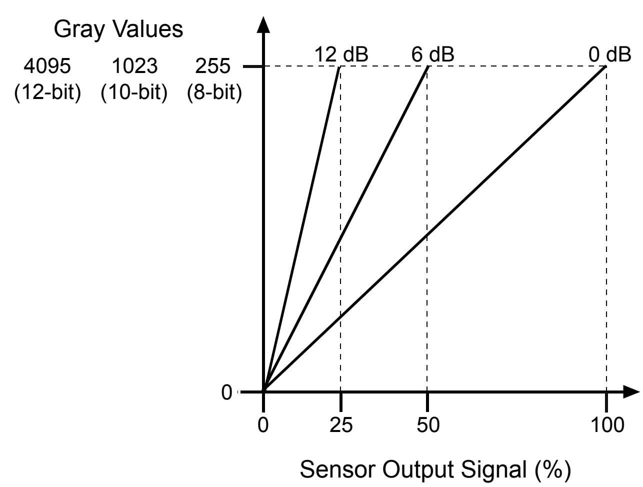


Fig. 46: Gain in dB

Increasing the gain is useful when at your brightest exposure, a gray value lower than 255 (in modes that output 8 bits per pixel), 1023 (in modes that output 10 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.

The camera’s gain is determined by the value of the Gain Raw parameter. Raw gain is adjusted on an integer scale. The minimum setting is 33 and the maximum setting is 511. If you know the current setting for the Gain Raw parameter, you can calculate the camera’s gain in dB using the following formula:

$$\text{Gain in dB} = 20 \log_{10} (\text{Gain Raw Setting} / 32)$$

For example, if the current Gain Raw setting is 128, then:

$$\text{Gain in dB} = 20 \log_{10} (128 / 32)$$

$$\text{Gain in dB} = 12.0$$

Setting the Gain Using Basler pylon

To set the Gain Raw parameter value:

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

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

```
// Set the gain
Camera.GainSelector.SetValue( GainSelector_All );
Camera.GainRaw.SetValue( 128 );
```

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 17.

Setting the Gain Using Direct Register Access

To set the gain via direct register access:

- Set the value of the Gain All register.

For more information about direct register access, see Section 3.2 on page 19.

10.2 Black Level

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

The black level can be set on an integer scale ranging from 0 to 255.

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

If the camera is set for a pixel format that yields a 10 bit pixel depth, an increase of 4 in the black level parameter setting will result in a positive offset of 1 in the digital values output for the pixels. A decrease of 4 in the setting will result in a negative offset of 1 in the digital values output for the pixels.

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

Setting the Black Level Using Basler pylon

To set the black level:

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

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

```
// Set the black level
Camera.BlackLevelSelector.SetValue ( BlackLevelSelector_All );
```

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 17.

Setting the Black Level Using Direct Register Access

To the black level via direct register access:

- Set the value of the Black Level All register.

For more information about direct register access, see Section 3.2 on page 19.

10.3 Image Area of Interest (AOI)

The image area of interest (Image AOI or AOI for short) feature lets you specify a portion of the sensor array and after each image is acquired, only the pixel information from the specified portion of the array will be read out of the sensor and transmitted from the camera.

The area of interest is referenced to the top left corner of the sensor array. The top left corner is designated as column 0 and row 0 as shown in Figure 47.

The location and size of the area of interest is defined by declaring an offset X, a width, an offset Y, 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 area of the array that is bounded by these settings is shown in Figure 47.

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

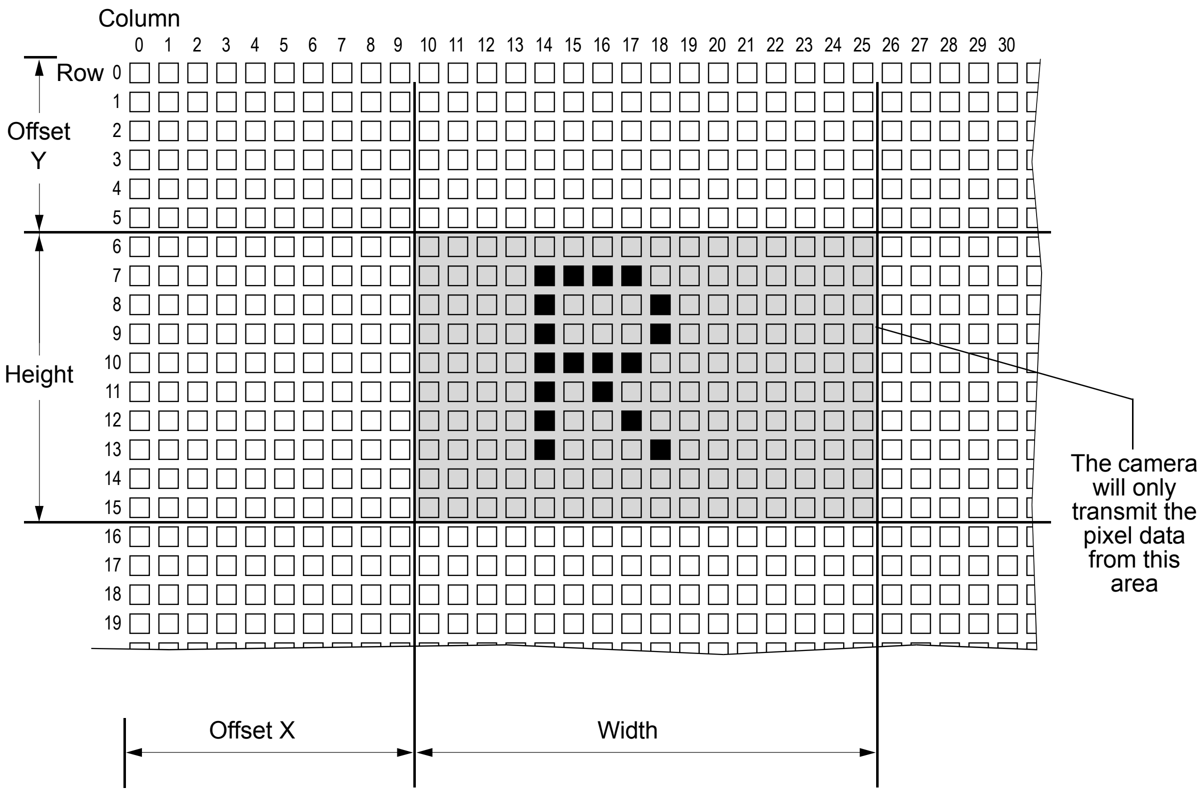


Fig. 47: Area of Interest

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

The AOI feature also includes Center X and a Center Y capabilities. When Center X is enabled, the camera will automatically center the AOI along the sensor's X axis (and will disable the Offset X setting). When Center Y is enabled, the camera will automatically center the AOI along the sensor's Y axis (and will disable the Offset Y setting).

For more information about how changing the AOI size affects the maximum allowed frame rate, see Section 7.8 on page 115.

10.3.1 Setting the Image AOI

By default, the AOI is set to use the full resolution of the camera's sensor. You can change the size and the position of the AOI by changing the value of the camera's Offset X, Offset Y, Width, and Height parameters. You can also enable automatic centering using the Center X and Center Y parameters.

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

On all camera models:

- The sum of the Offset X setting plus the Width setting must not exceed the width of the camera's sensor. For example, on the acA2000-140gm, the sum of the Offset X setting plus the Width setting must not exceed 2048.
- The sum of the Offset Y setting plus the Height setting must not exceed the height of the camera's sensor. For example, on the acA2000-140gm, the sum of the Offset Y setting plus the Height setting must not exceed 1088.

On monochrome camera models:

- The Offset Y and Height parameters can each be set in increments of 1.
- The Offset X and Width parameters can be set in increments of:

  2 on a camera set for the 1X2-1Y Camera Link tap geometry

  3 on a camera set for the 1X3-1Y Camera Link tap geometry

  4 on a camera set for the 1X4-1Y Camera Link tap geometry

  6 on a camera set for the 1X6-1Y Camera Link tap geometry

  8 on a camera set for the 1X6-1Y Camera Link tap geometry

  10 on a camera set for the 1X10-1Y Camera Link tap geometry

On color camera models:

- The Offset Y and Height parameters can each be set in increments of 2.
- The Offset X and Width parameters can be set in increments of:

  2 on a camera set for the 1X2-1Y Camera Link tap geometry

  6 on a camera set for the 1X3-1Y Camera Link tap geometry

  4 on a camera set for the 1X4-1Y Camera Link tap geometry

  6 on a camera set for the 1X6-1Y Camera Link tap geometry

  8 on a camera set for the 1X6-1Y Camera Link tap geometry

  10 on a camera set for the 1X10-1Y Camera Link tap geometry

For more information about Camera Link tap geometries, see Section 9.3 on page 144.

ⓘ	Your frame grabber may place additional restrictions on how the AOI size must be set. Check the documentation included with your frame grabber to determine its AOI requirements. Normally the X Offset, Y Offset, Width, and Height parameter settings refer to the physical columns and lines in the sensor. But if binning is enabled, these parameters are set in terms of "virtual" columns and lines. For more information about binning, see Section 10.8 on page 182.

Setting the Image AOI Using Basler pylon

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

```
int64_t widthMax = Camera.Width.GetMax( );
int64_t widthInc = Camera.Width.GetInc();
Camera.Width.SetValue( 200 );
Camera.OffsetX.SetValue( 100 );

int64_t heightMax = Camera.Height.GetMax( );
int64_t heightInc = Camera.Height.GetInc();
Camera.Height.SetValue( 200 );
Camera.OffsetY.SetValue( 100 );

// Enable automatic X and Y centering
Camera.CenterX.SetValue( true );
Camera.CenterY.SetValue( true );
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting the Image AOI Using Direct Register Access

To set the AOI Offset X, Offset Y, Width, and Height parameters via direct register access:

- Set the value of the Offset X register.
- Set the value of the Offset Y register.
- Set the value of the Width register.
- Set the value of the Height register.

To enable Center X and Center Y via direct register access:

- Set the value of the Center X register.
- Set the value of the Center Y register.

For more information about direct register access, see Section 3.2 on page 19

10.4 Stacked Zone Imaging

The stacked zone imaging feature lets you define up to eight zones on the sensor array. When an image is acquired, only the pixel information from the areas within the defined zones will be read out of the sensor. The lines read out of the zones will then be stacked together and will be transmitted from the camera as a single image.

The Stacked Zone Imaging Enable parameter is used to enable or disable stacked zone imaging. When the parameter is set to true, stacked zone imaging is enabled.

The Offset X and Width parameters are used to begin the process of setting up stacked zone imaging. Since all of the zones must be the same width and all of the zones must be vertically aligned, these two parameters define the left and right borders for all of the zones as shown in Figure 48 on page 163. In the figure, Offset X is set to 10 and the Width is set to 16.

The next step in the setup process is to define each individual zone. Up to 8 zones can be set up, with zone index numbers ranging from 1 through 8. Each zone can be enabled or disabled individually by first using the Stacked Zone Imaging Index parameter to select a zone number and then using the Stacked Zone Imaging Zone Enable parameter to enable the selected zone.

Once a zone has been enabled, you must use the Stacked Zone Imaging Zone Offset Y parameter to set the offset (in pixels) between the top of the sensor and the top of the zone. And you can use the Stacked Zone Imaging Zone Height parameter to set the height of the zone.

In Figure 48, for example, three zones have been enabled - zone 1, zone 2, and zone 3.

- The Offset X is set to 10 and the Width is set to 16. These settings apply to all zones.

For zone 1:

- The Stacked Zone Imaging Zone Offset Y parameter is set to 6
- The Stacked Zone Imaging Zone Height parameter is set to 6.

For zone 2:

- The Stacked Zone Imaging Zone Offset Y parameter is set to 20
- The Stacked Zone Imaging Zone Height parameter is set to 10.

For zone 3:

- The Stacked Zone Imaging Zone Offset Y parameter is set to 38.
- The Stacked Zone Imaging Zone Height parameter is set to 8.

With these settings, the camera would output an image that is 16 pixels wide and 24 lines (the total height of the three zones) high.

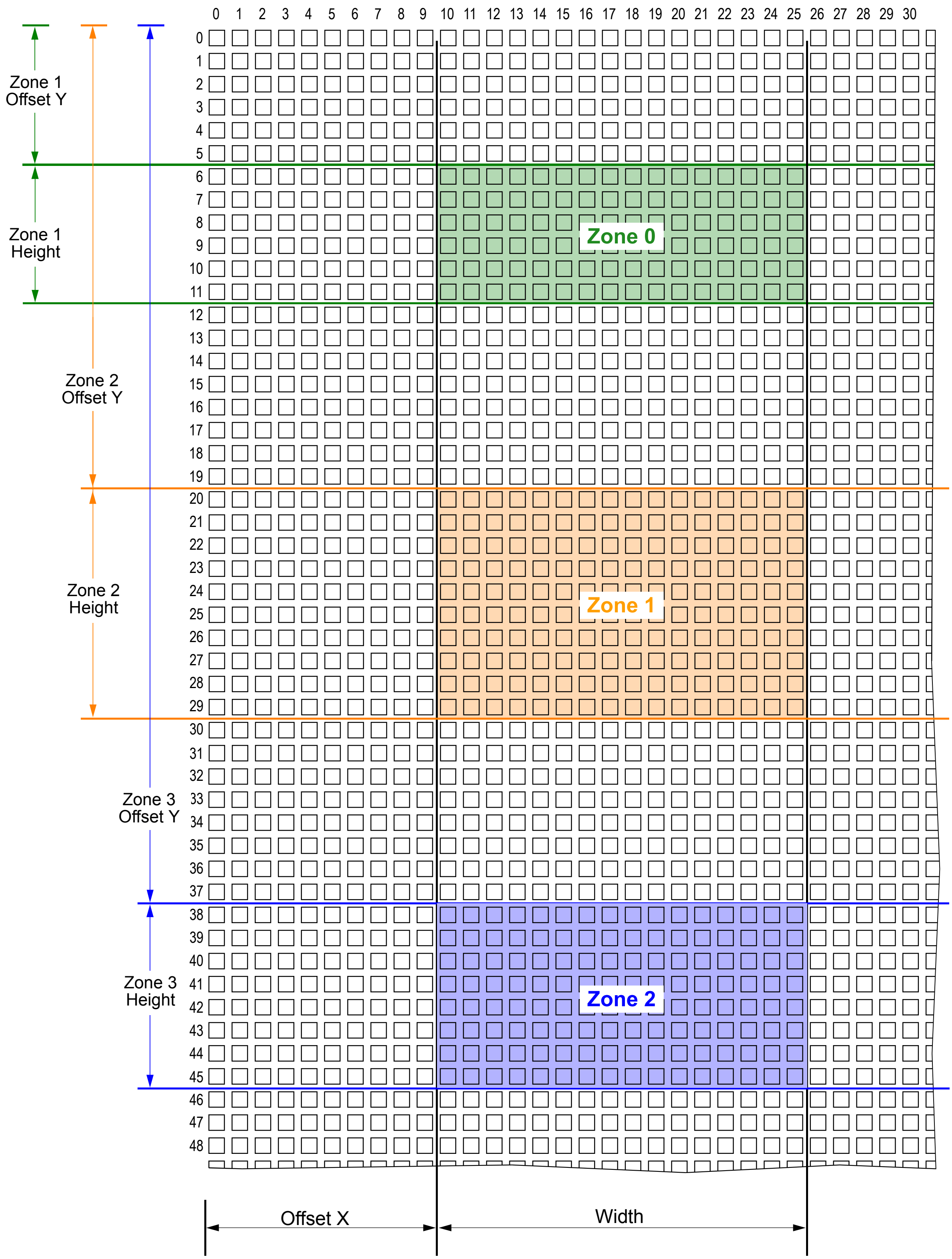


Fig. 48: Stacked Zone Imaging

There are several things to keep in mind when setting up zoned imaging:

- You are not required to enable the zones in sequence. For example, you can enable zones 2, 4, and 6 and not enable zones 1, 3, and 5.
- You do not need to order the zones from top to bottom on the sensor. For example, you could place zone 1 near the bottom of the sensor, zone 3 near the top, and zone 2 in the middle.

  But note that the camera always reads out and transmits the zones starting from the top of the sensor and going to the bottom, regardless of how the zone numbers are ordered. So the lines in the transmitted images will always be ordered from top to bottom in relation to the sensor.
- The zones can be set so that they overlap. When this happens, the camera will internally transform the overlapped zones into a single large zone that will be read out and transmitted as if it were simply a single large zone. (The lines included in the overlapping area will only be read out and transmitted once.)

When stacked zone imaging is enabled, the camera's Offset Y parameter becomes read only, and this parameter indicates the Y offset for the zone nearest to the top of the sensor.

When stacked zone imaging is enabled, the Height parameter becomes read only, and this parameter indicates the total height of the image that will be transmitted from the camera (i.e., the sum of the heights of all zones).

10.4.1 Setting Stacked Zone Imaging

Guidelines

When you are setting the stacked zones, you must follow these guidelines:

On all camera models:

- The sum of the Offset X setting plus the Width setting must not exceed the width of the camera's sensor. For example, on the acA2000-140gm, the sum of the Offset X setting plus the Width setting must not exceed 2048.
- For any given zone, The sum of the Stacked Zone Imaging Zone Offset Y setting plus the Stacked Zone Imaging Zone Height setting must not exceed the height of the camera's sensor. For example, on the acA2000-140gm, the sum of the Stacked Zone Imaging Zone Offset Y setting plus the Stacked Zone Imaging Zone Height setting must not exceed 1088.

On monochrome camera models:

- The Stacked Zone Imaging Zone Offset Y and Stacked Zone Imaging Zone Height parameters for any given zone can each be set in increments of 1.
- The Offset X and Width parameters can be set in increments of:

  2 on a camera set for the 1X2-1Y Camera Link tap geometry

  3 on a camera set for the 1X3-1Y Camera Link tap geometry

  4 on a camera set for the 1X4-1Y Camera Link tap geometry

  6 on a camera set for the 1X6-1Y Camera Link tap geometry

  8 on a camera set for the 1X6-1Y Camera Link tap geometry

  10 on a camera set for the 1X10-1Y Camera Link tap geometry

On color camera models:

- The Stacked Zone Imaging Zone Offset Y and Stacked Zone Imaging Zone Height parameters for any given zone can each be set in increments of 2.
- The Offset X and Width parameters can be set in increments of:

  2 on a camera set for the 1X2-1Y Camera Link tap geometry

  6 on a camera set for the 1X3-1Y Camera Link tap geometry

  4 on a camera set for the 1X4-1Y Camera Link tap geometry

  6 on a camera set for the 1X6-1Y Camera Link tap geometry

  8 on a camera set for the 1X6-1Y Camera Link tap geometry

  10 on a camera set for the 1X10-1Y Camera Link tap geometry

Setting Stacked Zone ImagingUsing Basler pylon

You can set the parameter values associated with stacked zone imaging from within your application software by using the Basler pylon API. The following code snippets illustrate using the API to set up two zones.

```
// Enable stacked zone imaging
Camera.StackedZoneImagingEnable.SetValue( true );

// Set the width and offset X for the zones
Camera.Width.SetValue( 200 );
Camera.OffsetX.SetValue( 100 );

// Set zone 1

// Select the zone
Camera.StackedZoneImagingIndex.SetValue( 1 );
// Enable the selected zone
Camera.StackedZoneImagingZoneEnable.SetValue( true );
// Set the offset Y for the selected zone
Camera.StackedZoneImagingZoneOffsetY.SetValue( 100 );
// Set the height for the selected zone
Camera.StackedZoneImagingZoneHeight.SetValue( 100 );

// Set zone 2

// Select the zone
Camera.StackedZoneImagingIndex.SetValue( 2 );
// Enable the selected zone
Camera.StackedZoneImagingZoneEnable.SetValue( true );
// Set the offset Y for the selected zone
Camera.StackedZoneImagingZoneOffsetY.SetValue( 250 );
// Set the height for the selected zone
Camera.StackedZoneImagingZoneHeight.SetValue( 200 );
```

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 17.

Setting Stacked Zone Imaging Using Direct Register Access

To enable stacked zone imaging via direct register access:

- Set the value of the Stacked Zone Imaging Enable register to 1 (true).

To set the Offset X and Width, parameters for the zones:

- Set the value of the Offset X register.
- Set the value of the Width register.

To set up zone 1:

- Enable zone 1 by setting the value of the Stacked Zone Imaging Zone 1 Enable register to 1 (true).
- Set the Y offset for zone 1 by setting the value of the Stacked Zone Imaging Zone 1 Offset Y register.
- Set the height for zone 1 by setting the value of the Stacked Zone Imaging Zone 1 Height register.

Zones 2 through 8 are set up in similar fashion.

For more information about direct register access, see Section 3.2 on page 19

10.5 Sequencer

Overview

During normal operation, the camera is controlled by a set of configuration parameters that reside in the camera's volatile memory. This set of parameters is known as the "active parameter set". When you use the pylon API or direct register access to make a change to a camera parameter such as the Gain, you are making a change to the active parameter set. And since the active parameter set controls camera operation, you will see a change in camera operation when you change a parameter in the active set.

From the point of view of the sequence feature, the parameters in the active set can be divided into two types: "non-sequenceable" and "sequenceable" parameters (as shown in Figure 49 on page 168). The non-sequence parameters are those that cannot be changed using the sequencer feature and the sequence parameters are those that can be changed using the sequencer feature.

With the sequencer feature, you can define up to four different "sequence sets". Each sequence set includes a set of values for all of the sequenceable parameters. As you are acquiring images, you can replace the sequenceable values in the active set with the values from any one of the sequence sets at will. So, for example, you could define four sequence sets, with each one being appropriate for a different type of lighting conditions. As you are operating your system and the lighting conditions change, you could replace the sequenceable values in the active set with the values from any one of the sequence sets at will. One of the main advantages of the sequence sets is that because they reside in the camera's FPGA, you can replace the values in the active set with values from one of the sequence sets almost instantaneously.

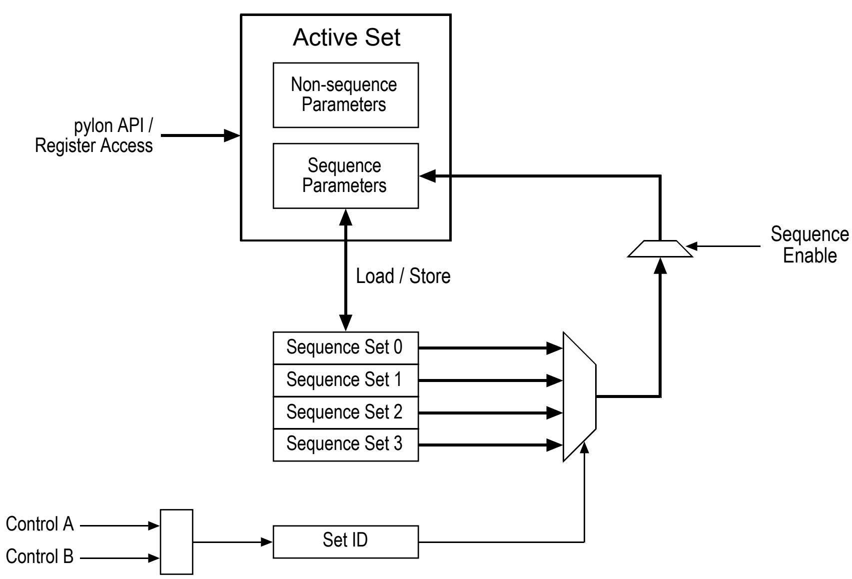


Fig. 49: Sequence Feature Block Diagram

The four sequence sets are stored in the camera's memory and they do not actively control the operation of the camera. They are simply sets of stored parameter values that are available for use by the sequencer feature. The four sequence parameter sets are designated as Sequence Set 0, Set 1, Set 2, and Set 3.

The parameters included in each sequence set are:

Exposure Time
Enable Acquisition Frame Rate
Acquisition Frame Rate
Width
Height
X Offset
Y Offset
Binning
Pixel Format
Test Image
Gain
Black Level
Digital Shift
LUT Enable
Light Source Selector
Color Transformation Value
Color Transformation Matrix Factor
Stacked Zone Enable
Zone Enable
Zone Top
Zone Height

Sequencer Feature Operation

The software module that operates the sequencer feature has two controls designated as Control A and Control B. Each control can be set to a zero or to a one. As shown below, the state of the two controls selects a "set ID", which acts as a pointer to one of the four sequence sets.

Control B	Control A	Selects
0	0	Set ID 0 (Sequence Set 0)
0	1	Set ID 1 (Sequence Set 1)
1	0	Set ID 2 (Sequence Set 2)
1	1	Set ID 3 (Sequence Set 3)

Table 12: Controls A and B

The Sequence Enable parameter is used to enable the sequencer feature. Assuming that the camera is in the process of continuously capturing images, the sequencer feature operates as follows:

- When the sequencer feature becomes enabled, the camera checks the state of Control A and Control B and determines which sequence set is currently pointed to. The camera immediately replaces the sequenceable parameter values in the active set with the values from that sequence set.

  When the next image is acquired, the modified active set will be used to control the image acquisition.

- After each image is acquired, the camera checks the state of Control A and Control B:

  If there has been no change in the state, the camera will take no action regarding the active set.

  If the state has changed, the camera will determine which sequence parameter set is now being pointed to and will immediately replace the sequenceable parameter values in the active set with the values from that sequence set.
- When the sequencer feature becomes disabled, the parameter values in the active set will return to what they were before the feature was enabled.

ⓘ	When the sequencer feature is enabled, the values of the sequenceable parameters in the active set cannot be accurately read using the pylon API or direct register access. We recommend that you do not attempt to read or change any of the sequenceable parameters when the sequencer feature is enabled.

Setting the State of Control A and Control B

Before using the sequencer feature, the user must assign a source signal to Control A and a source signal to Control B. The user then sets the state of Control A and Control B by manipulating the source signals. The source input signals available for Control A or Control B are:

- Line 1 - When the source signal for a control is set to line 1, you set the state of the control by applying the appropriate electrical signal to the GPIO line on the camera. (This assumes that the GPIO line on the camera has been properly set to operate as an input line.)
- CC1 - When the source signal for a control is set to CC1, you set the state of the control by applying the appropriate electrical signal to CC1 in the Camera Link interface.
- CC2 - When the source signal for a control is set to CC2, you set the state of the control by applying the appropriate electrical signal to CC2 in the Camera Link interface.
- CC3 - When the source signal for a control is set to CC3, you set the state of the control by applying the appropriate electrical signal to CC3 in the Camera Link interface.

You can also set Control A or Control B to "Disabled". When a control is set to disabled, its value will always be zero.

To assign a source signal to control:

- Use the Sequence Control Selector parameter to select either Control A or Control B.
- Use the Sequence Control Source parameter to set the source signal for the selected control to Line 1, CC1, CC2, CC3, or to Disabled.

The disabled setting is useful if you only want to use one source signal to select between two of the available sequence parameter sets. For example, you could set Control A to use CC1 as its source signal and set Control B as disabled. In this case, you could point to sequence parameter set 0 or sequence parameter set 1 by simply using CC1 to set the state of Control A.

Populating the Sequence Parameter Sets

Before you begin using the sequencer feature, you must populate the sequence parameter sets with values that will be useful for your particular situation. You should use the following procedure to populate the sequence parameter sets:

- Make sure that the sequencer feature is disabled.
- Set up your first acquisition scenario (i.e., lighting, object positioning, etc.)
- Adjust the camera parameters to get the best image quality with this scenario (you are adjusting the parameters in the active parameter set).
- Use the Sequence Set Selector to select sequence parameter set 0, 1, 2, or 3.
- Execute the Sequence Set Store command to copy the sequenceable parameter values currently in the active parameter set into the selected sequence set. (Any existing parameter values in the sequence parameter set will be overwritten.)
- Repeat the above steps for the other sequence parameter sets.

There is also a command called Sequence Set Load that can be useful when working with the sequence parameter sets. If you use the Sequence Set Selector parameter to select a sequence parameter set and then you execute the Sequence Set Load command, the sequenceable parameter values in the active set will be replaced by the values stored in the selected sequence set. This ability can be useful in two situations. First, if you simply want to see how the parameters currently stored in one of the sequence parameter sets will affect camera operation, you can load the parameters from that sequence parameter set into the active parameter set and see what happens. Second, if you want to prepare a new sequence parameter set and you know that an existing set is already close to what you will need, you can load the existing sequence set into the active set, make some small changes to the active set, and then save the active set to one of the other sequence parameter sets.

ⓘ	Because the sequence parameter sets reside in volatile memory, they are not retained if camera power is switched off.

Setting the Sequencer Using Basler Pylon

You can use the pylon API to set the parameters associated with the sequencer feature from within your application software.

The following code snippet illustrates using the API to populate sequence parameter set 0 and sequence parameter set 1 by storing the sequenceable parameter values from the active set in the sequence sets:

```
// Disable the sequencer feature
Camera.SequenceEnable.SetValue( false );

// Set up the first acquisition scenario (lighting, object position, etc.) and
// adjust the camera parameters for the best image quality.

// Select sequence parameter set 0
Camera.SequenceSetSelector.SetValue( 0 );
// Store the sequenceable parameters from the active set in the selected sequence
// set
Camera.SequenceSetStore.Execute( );

// Set up the second acquisition scenario (lighting, object position, etc.) and
// adjust the camera parameters for the best image quality.

// Select sequence parameter set 1
Camera.SequenceSetSelector.SetValue( 1 );
// Store the sequenceable parameters from the active set in the selected sequence
// set
Camera.SequenceSetStore.Execute( );
```

The following code snippet illustrates using the API to set the source signal for Control A and Control B to CC1 and CC2 respectively:

```
// Select Control A
Camera.SequenceControlSelector.SetValue( SequenceControlSelector_ControlA );
// Set the signal source for the selected input
Camera.SequenceControlSource.SetValue( SequenceControlSource_CC1 );

// Select Control B
Camera.SequenceControlSelector.SetValue( SequenceControlSelector_ControlB );
// Set the signal source for the selected input
Camera.SequenceControlSource.SetValue( SequenceControlSource_CC2 );
```

The following code snippet illustrates using the API to load the sequenceable parameter values from sequence set 0 into the active set:

```
// Select sequence parameter set 0
Camera.SequenceSetSelector.SetValue( 0 );
```

```
// Load the sequenceable parameters from the sequence set into the active set
Camera.SequenceSetLoad.Execute( );
```

The following code snippet illustrates using the API to enable the sequencer feature:

```
// Enable the sequencer feature
Camera.SequenceEnable.SetValue( true );
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting the Sequencer Feature Using Direct Register Access

To populate the sequencer parameter sets via direct register access:

- Disable the sequencer feature by setting the value of the Sequence Enable register to 0 (false).
- Set up the first acquisition scenario (lighting, object position, etc.) and adjust camera parameters for best image quality

  Select sequence parameter set 0 by setting the value of the Sequence Step Selector register to 0.

  Store the sequenceable parameters from the active set in the selected sequence parameter set by setting the value of the Sequence Step Store register to 1.
- Follow a similar process to populate sequence parameters set 1, 2, or 3.

To select the source signal for Control A:

- Set the value of the Sequence Control Source 0 to Line 1, CC1, CC2, CC3, or Disabled as desired.

To select the source signal for Control B:

- Set the value of the Sequence Control Source 1 to Line 1, CC1, CC2, CC3, or Disabled as desired.

To load the sequenceable parameters values from sequence set 0 into the active set via direct register access:

- Select sequence parameter set 0 by setting the value of the Sequence Step Selector register to 0.
- Load the sequenceable parameters from the selected sequence parameter set into the active set by setting the value of the Sequence Step Load register to 1.
- Follow a similar process to load the sequenceable parameters from set 1, 2, or 3.

To enable the sequencer feature:

- Set the value of the Sequence Enable register to 1 (true).

For more information about direct register access, see Section 3.2 on page 19

10.6 Binning

> The binning feature is only available on the monochrome cameras.

Binning increases the camera’s response to light by summing the charges from adjacent pixels into one pixel. Two types of binning are available: vertical binning and horizontal binning.

With vertical binning, adjacent pixels from 2 lines, 3 lines, or a maximum of 4 lines in the imaging sensor array are summed and are reported out of the camera as a single pixel. Figure 50 illustrates vertical binning.

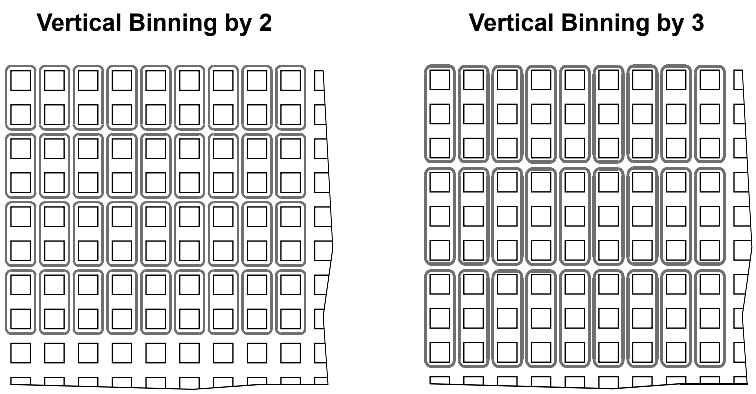


Fig. 50: Vertical Binning

With horizontal binning, adjacent pixels from 2 columns, 3 columns, or a maximum of 4 columns are summed and are reported out of the camera as a single pixel. Figure 51 illustrates horizontal binning.

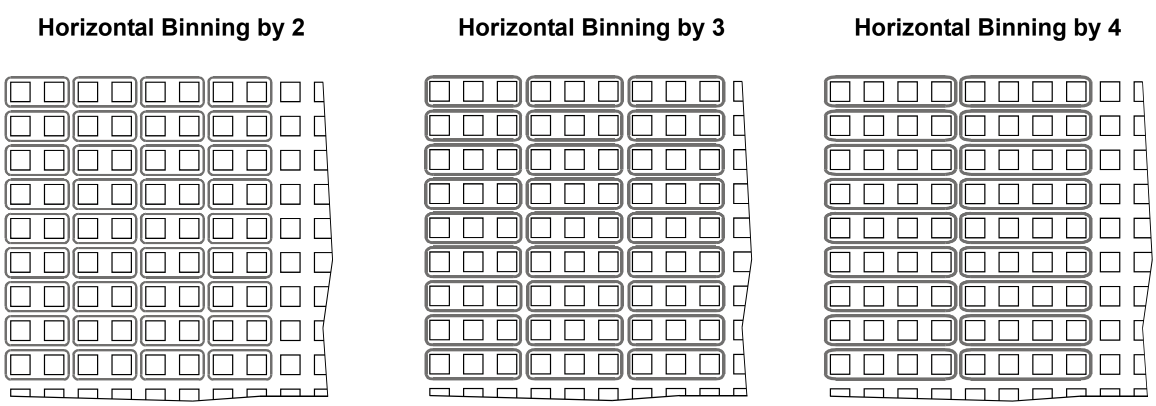


Fig. 51: Horizontal Binning

You can combine vertical and horizontal binning. This, however, may cause objects to appear distorted in the image. For more information on possible image distortion due to combined vertical and horizontal binning, see the next section.

Setting Binning Using Basler pylon

You can enable vertical binning by setting the Binning Vertical parameter. Setting the parameter's value to 2, 3, or 4 enables vertical binning by 2, vertical binning by 3, or vertical binning by 4 respectively. Setting the parameter's value to 1 disables vertical binning.

You can enable horizontal binning by setting the Binning Horizontal parameter. Setting the parameter's value to 2, 3, or 4 enables horizontal binning by 2, horizontal binning by 3, or horizontal binning by 4 respectively. Setting the parameter's value to 1 disables horizontal binning.

You can use the pylon API to set the Binning Vertical or the Binning Horizontal parameter value from within your application software. The following code snippet illustrates using the API to set the parameter values:

```
// Enable vertical binning by 2
Camera.BinningVertical.SetValue( 2 );

// Enable horizontal binning by 4
Camera.BinningHorizontal.SetValue( 4 );

// Disable vertical and horizontal binning
Camera.BinningVertical.SetValue( 1 );
Camera.BinningHorizontal.SetValue( 1 );
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting Binning Using Direct Register Access

To enable vertical binning via direct register access:

- Set the value of the Binning Vertical register.

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

To enable horizontal binning via direct register access:

- Set the value of the Binning Horizontal register.

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

For more information about direct register access, see Section 3.2 on page 19.

10.6.1 Considerations When Using Binning

Increased Response to Light

Using binning can greatly increase the camera's response to light. When binning is enabled, acquired images may look overexposed. If this is the case, you can reduce the lens aperture, reduce the intensity of your illumination, reduce the camera's exposure time setting, or reduce the camera's gain setting.

Reduced Resolution

Using binning effectively reduces the resolution of the camera's imaging sensor. For example, the sensor in the acA2000-140km camera normally has a maximum resolution of 2048 (H) x 1088 (V) pixels. If you set this camera to use horizontal binning by 3 and vertical binning by 3, the effective maximum resolution of the sensor is reduced to 682 (H) by 362 (V). (Note that the dimensions of the sensor are not evenly divisible by 3, so we rounded down to the nearest whole number.)

Possible Image Distortion

Objects will only appear undistorted in the image if the 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 shrunken by a factor of 2 compared to the heights.

If you want to preserve the aspect ratios of imaged objects when using binning, you must use vertical and horizontal binning where equal numbers of lines and columns are binned, e.g. vertical binning by 3 combined with horizontal binning by 3.

Binning's Effect on AOI Settings

When you have the camera set to use binning, keep in mind that the settings for your area of interest (AOI) will refer to the binned lines and columns in the sensor and not to the physical lines in the sensor as they normally would. Another way to think of this is by using the concept of a "virtual sensor." For example, assume that you are using an acA2000-140km camera set for 3 by 3 binning as described above. In this case, you would act as if you were actually working with a 682 column by 362 line sensor when setting your AOI parameters. The maximum AOI width would be 682 and the maximum AOI height would be 362. When you set the Width for the AOI, you will be setting this value in terms of virtual sensor columns. And when you set the Height for the AOI, you will be setting this value in terms of virtual sensor lines.

For more information about the imaging area of interest (AOI) feature, see Section 10.3 on page 158.

10.7 Mirror Imaging

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

Note that the reverse X and reverse Y functions may both be enabled at the same time if so desired.

10.7.1 Reverse X

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

Figure 52 shows a normal image on the left and an image captured with reverse X enabled on the right.

Normal Image **Reverse X Mirror Image**

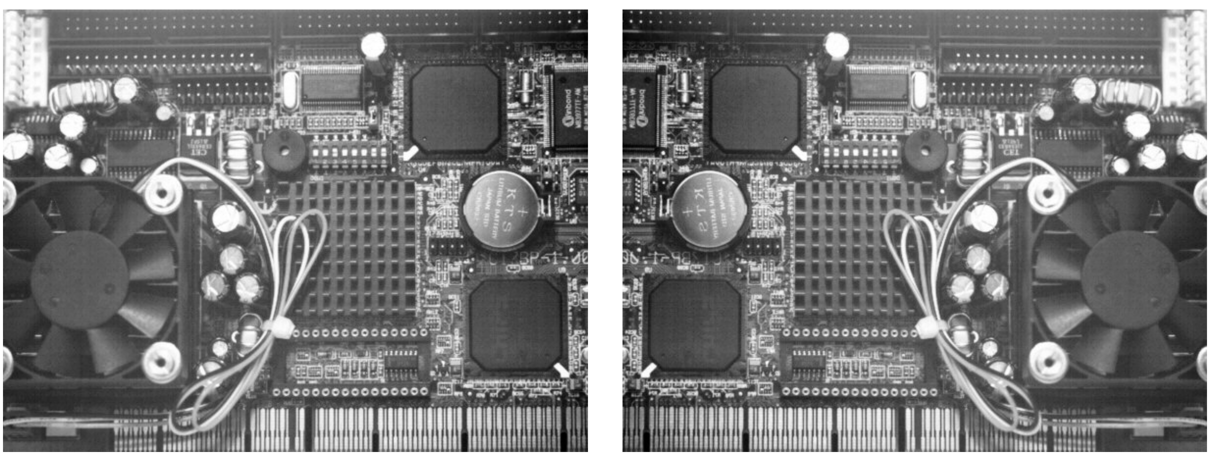


Fig. 52: Reverse X Mirror Imaging

The Effect of Reverse X on the Auto Function AOIs

If you are using the camera’s auto functions, you should be aware of the effect that using the reverse X feature will have on the auto function AOIs. When reverse X is used, the position of the auto function AOIs relative to the sensor remains the same. As a consequence, each auto function AOI will include a different portion of the captured image depending on whether or not the reverse X feature is enabled. Figure 53 shows the effect of that reverse X mirroring will have on the auto function AOIs.

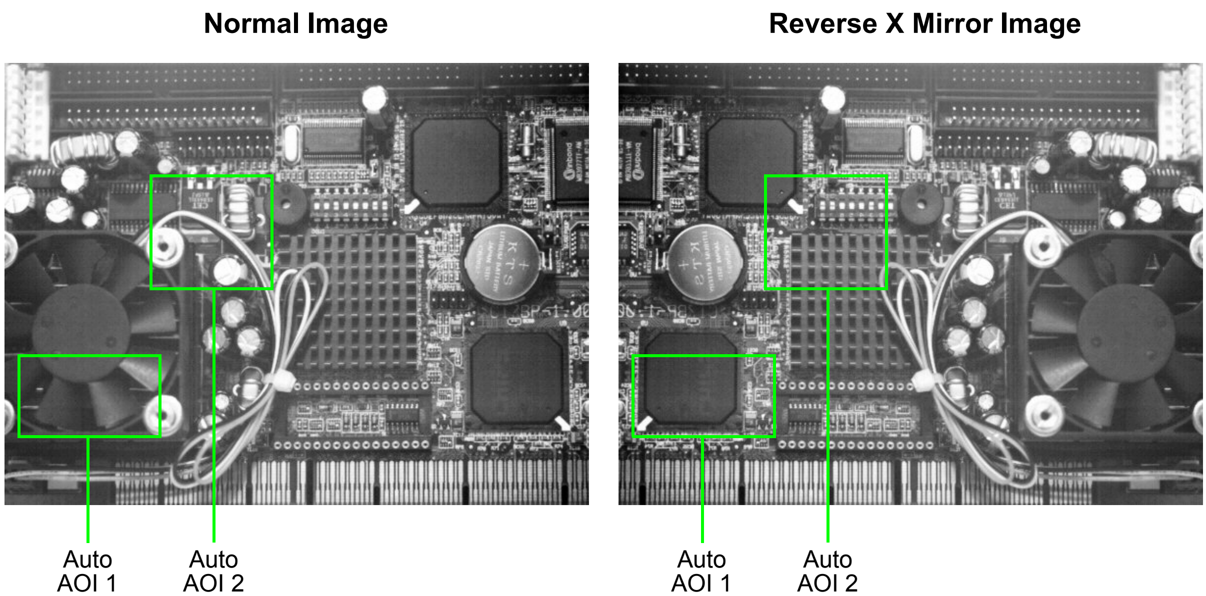


Fig. 53: Using Reverse X Mirror Imaging with Auto Functions Enabled

For more information about auto functions and auto function AOIs, see Section 10.9 on page 187.

10.7.2 Reverse Y

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

Figure 52 shows a normal image on the left and an image captured with reverse Y enabled on the right.

Normal Image **Reverse Y Mirror Image**

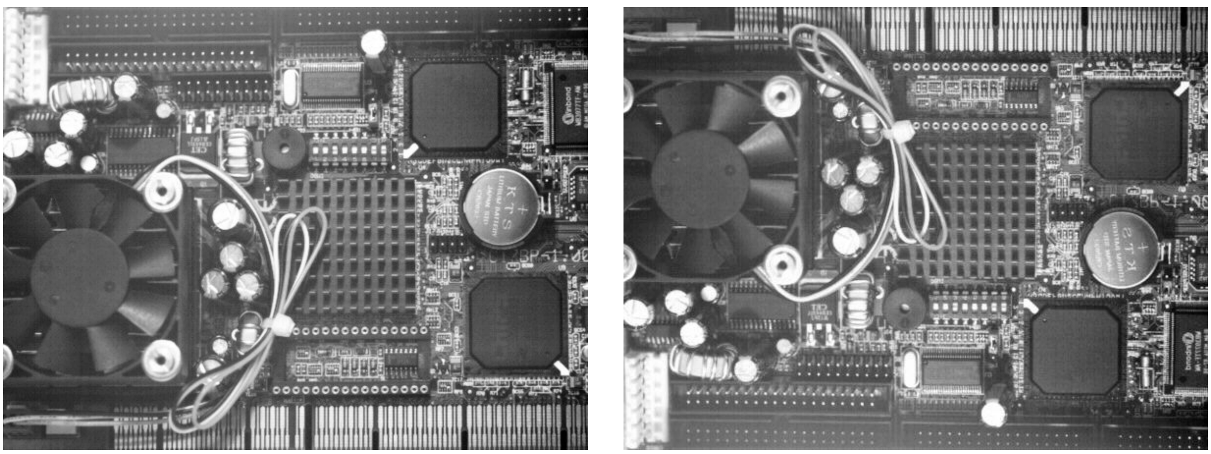


Fig. 54: Reverse Y Mirror Imaging

The Effect of Reverse Y on the Auto Function AOIs

If you are using the camera's auto functions, you should be aware of the effect that using the reverse Y feature will have on the auto function AOIs. When reverse Y is used, the position of the auto function AOIs relative to the sensor remains the same. As a consequence, each auto function AOI will include a different portion of the captured image depending on whether or not the reverse Y feature is enabled. Figure 55 shows the effect of that reverse Y mirroring will have on the auto function AOIs.

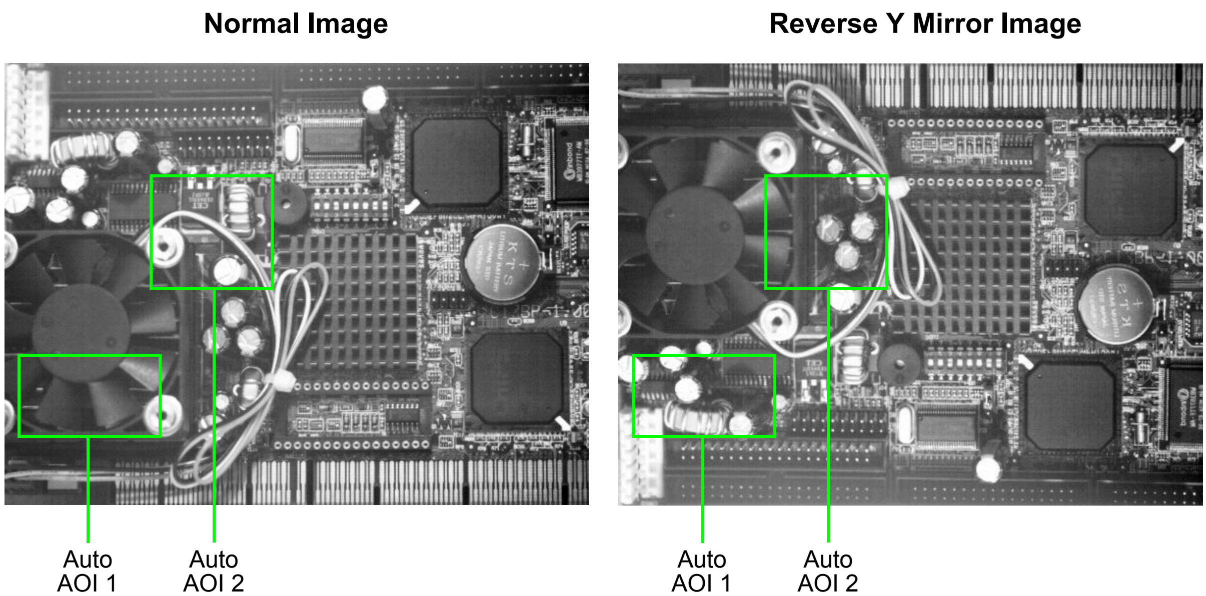


Fig. 55: Using Reverse Y Mirror Imaging with Auto Functions Enabled

For more information about auto functions and auto function AOIs, see Section 10.9 on page 187.

10.7.3 Enabling Reverse X and Reverse Y

Enabling Reverse X and Y Using Basler Pylon

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

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

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Enabling Reverse X and Y Using Direct Register Access

To enable reverse X via direct register access:

- Set the value of the Reverse X register to 1 (enabled).

To enable reverse Y via direct register access:

- Set the value of the Reverse Y register to 1 (enabled).

For more information about direct register access, see Section 3.2 on page 19.

10.8 Luminance Lookup Table

The type of electronics used on the camera allows the camera's sensor to acquire pixel values at a 12 bit depth. Normally, when a camera is set for a 12 bit pixel data format, the camera transmits the actual 12 bit pixel values reported by the sensor.

The luminance lookup table feature lets you create a custom 12 bit to 12 bit lookup table that maps the actual 12 bit values output from the sensor to substitute 12 bit values of your choice. When the lookup table is enabled, the camera will replace the actual pixel values output from the sensor with the substitute values from the table.

The lookup table has 4096 indexed locations with a 12 bit value stored at each index. The values stored in the table are used like this:

- When the sensor reports that a pixel has an actual 12 bit value of 0, the substitute 12 bit value stored at index 0 will replace the actual pixel value.
- The numbers stored at indices 1 through 7 are not used.
- When the sensor reports that a pixel has an actual 12 bit value of 8, the substitute 12 bit value stored at index 8 will replace the actual pixel value.
- The numbers stored at indices 9 through 15 are not used.
- When the sensor reports that a pixel has an actual 12 bit value of 16, the substitute 12 bit value stored at index 16 will replace the actual pixel value.
- The numbers stored at indices 17 through 23 are not used.
- When the sensor reports that a pixel has an actual 12 bit value of 24, the substitute 12 bit value stored at index 24 will replace the actual pixel value.
- And so on.

As you can see, the table does not include a defined 12 bit substitute value for every actual pixel value that the sensor can report. If the sensor reports an actual pixel value that is between two values that have a defined substitute, the camera performs a straight line interpolation to determine the substitute value that it should use. For example, assume that the sensor reports an actual pixel value of 12. In this case, the camera would perform a straight line interpolation between the substitute values at index 8 and index 16 in the table. The result of the interpolation would be used by the camera as the substitute.

Another thing to keep in mind about the table is that index 4088 is the last index that will have a defined substitute value associated with it (the values at indices 4089 through 4095 are not used.) If the sensor reports an actual value greater than 4088, the camera will not be able to perform an interpolation. In cases where the sensor reports an actual value greater than 4088, the camera simply uses the 12 bit substitute value from index 4088 in the table.

	If the imaging sensor bit depth is set to 10 bits, the sensor will only capture pixel data at 10 bit depth. In this case, the pixel values output from the sensor wil be converted to 12 bit depth by padding the 10 bit values with two zeros as least significant bits. These converted 12 bit values will then be used as input to the lookup table. There is only one lookup table. When the lookup table is enabled on color cameras, the single table is used for red, green, and blue pixel values. The values for the luminance lookup table are not saved in the user sets and are lost when the camera is reset or switched off. If you are using the lookup table feature, you must reenter the lookup table values after each camera startup or reset.

The advantage of the luminance lookup table feature is that it lets a user customize the response curve of the camera. The graphs below represent the contents of two typical lookup tables. The first graph is for a lookup table where the substitute values are designed so that the output of the camera increases linearly as the actual sensor output increases. The second graph is for a lookup table where the substitute values are designed so that the camera output increases quickly as the actual sensor output moves from 0 through 2048 and increases gradually as the actual sensor output moves from 2049 through 4096.

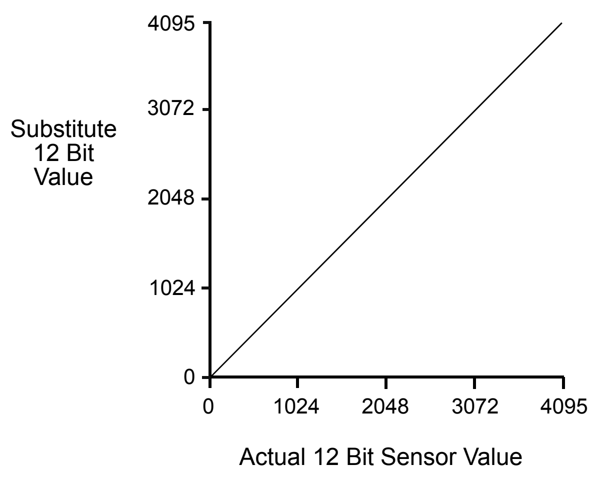


Fig. 56: Lookup Table with Values Mapped in a Linear Fashion

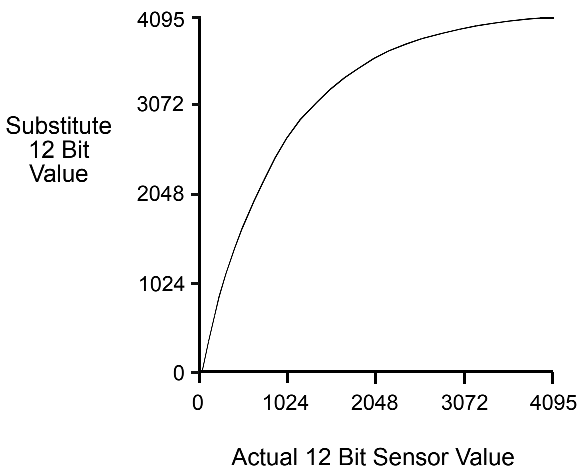


Fig. 57: Lookup Table with Values Mapped for Higher Camera Output at Low Sensor Readings

Using the Luminance Lookup Table to Get 10 Bit or 8 Bit Output

As mentioned above, when the camera is set for a 12 bit pixel data format, the lookup table can be used to perform a 12 bit to 12 bit substitution. The lookup table can also be used in 12 bit to 10 bit or 12 bit to 8 bit fashion.

To use the table in 12 bit to 10 bit fashion, you enter 12 bit substitution values into the table and enable the table as you normally would. But instead of setting the camera for a 12 bit pixel data format, you set the camera for a 10 bit format (such as Mono 10). In this situation, the camera will first use the values in the table to do a 12 bit to 12 bit substitution. It will then truncate the least significant 2 bits of the substitute value and will transmit the remaining 10 most significant bits.

To use the table in 12 bit to 8 bit fashion, you enter 12 bit substitution values into the table and enable the table as you normally would. But instead of setting the camera for a 12 bit pixel data format, you set the camera for an 8 bit format (such as Mono 8). In this situation, the camera will first use the values in the table to do a 12 bit to 12 bit substitution. It will then truncate the least significant 4 bits of the substitute value and will transmit the remaining 8 most significant bits.

10.8.1 Entering LUT Values and Enabling the LUT

Entering Values and Enabling the LUT Using Basler pylon

You can enter values into the luminance lookup table (LUT) and enable the use of the lookup table by doing the following:

- Use the LUT Selector to select a lookup table. (Currently there is only one lookup table available, i.e., the "luminance" lookup table described above.)
- Use the LUT Index parameter to select an index number.
- Use the LUT Value parameter to enter the substitute value that will be stored at the index number that you selected in step 2.
- Repeat steps 2 and 3 to enter other substitute values into the table as desired.
- Use the LUT Enable parameter to enable the table.

You can use the pylon API to set the LUT Selector, the LUT Index parameter, and the LUT Value parameter from within your application software. The following code snippet illustrates using the API to set the selector and the parameter values:

```
// Select the lookup table
Camera.LUTSelector.SetValue( LUTSelector_Luminance );

// Write a lookup table to the device.
// The following lookup table causes an inversion of the sensor values
// ( bright -> dark, dark -> bright )
for ( int i = 0; i < 4096; i += 8 )
{
   Camera.LUTIndex.SetValue( i );
   Camera.LUTValue.SetValue( 4095 - i );
}
// Enable the lookup table
Camera.LUTEnable.SetValue( true );
```

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 17.

Entering Values and Enabling the LUT Using Direct Register Access

When setting up the luminance lookup table via direct register access, two registers are involved: the LUT register and the LUT Enable register.

The LUT register is simply an array register that holds the 4096 12 bit values described earlier in this section. As a first step to using the lookup table feature. You must populate this register with 12 bit values.

Once the LUT register has been populated, you can enable the use of the lookup table by setting the value of the LUT Enable register to 1 (enabled).

For more information about direct register access, see Section 3.2 on page 19.

10.9 Auto Functions

Auto functions control image properties and are the "automatic" counterparts of certain features, such as the gain feature or the white balance feature, which normally require "manually" setting the related parameter values. Auto functions are particularly useful when an image property must be adjusted quickly to achieve a specific target value and when a specific target value must be kept constant in a series of images.

An Auto Function Area of Interest (Auto Function AOI) lets you designate a specific part of the image as the base for adjusting an image property. Each auto function uses the pixel data from an Auto Function AOI for automatically adjusting a parameter value and, accordingly, for controlling the related image property. Some auto functions always share an Auto Function AOI.

An auto function automatically adjusts a parameter value until the related image property reaches a target value, and the parameter value cannot be manually set.

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

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

ⓘ	A target value for an image property can only be reached if it is in accord with all pertinent camera settings and with the general circumstances used for capturing images. Otherwise, the target value will only be approached. For example, with a short exposure time, insufficient illumination, and a low setting for the upper limit of the gain parameter value, the Gain Auto function may not be able to achieve the current target average gray value setting for the image.

ⓘ	You can use an auto function when binning is enabled (monochrome cameras only). An auto function uses the binned pixel data and controls the image property of the binned image.

For more information about binning, see Section 10.6 on page 174.

10.9.1 Auto Function Operating Modes

The following auto function modes of operation are available:

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

  The parameter value can be changed by using the "once" mode of operation again, by using the "continuous" mode of operation, or by manual adjustment.

ⓘ	If an auto function is set to the "once" operation mode and if the circumstances will not allow reaching a target value for an image property, the auto function will try to reach the target value for a maximum of 30 images and will then be set to "off".

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

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

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

10.9.2 Auto Function AOIs

Each auto function uses the pixel data from an Auto Function AOI for automatically adjusting a parameter value, and accordingly, for controlling the related image property. Some auto functions always share an Auto Function AOI and some auto functions can use their own individual Auto Function AOIs. Within these limitations, auto functions can be assigned to Auto Function AOIs as desired.

Each Auto Function AOI has its own specific set of parameter settings, and the parameter settings for the Auto Function AOIs are not tied to the settings for the AOI that is used to define the size of captured images (Image AOI). For each Auto Function AOI, you can specify a portion of the sensor array and only the pixel data from the specified portion will be used for auto function control. Note that an Auto Function AOI can be positioned anywhere on the sensor array.

An Auto Function AOI is referenced to the top left corner of the sensor array. The top left corner of the sensor array is designated as column 0 and row 0 as shown in Figure 58.

The location and size of an Auto Function AOI is defined by declaring an X offset (coordinate), a width, a Y offset (coordinate), and a height. For example, suppose that you specify the X offset as 14, the width as 5, the Y offset as 7, and the height as 6. The area of the array that is bounded by these settings is shown in Figure 58.

Only the pixel data from the area of overlap between the Auto Function AOI defined by your settings and the Image AOI will be used by the related auto function.

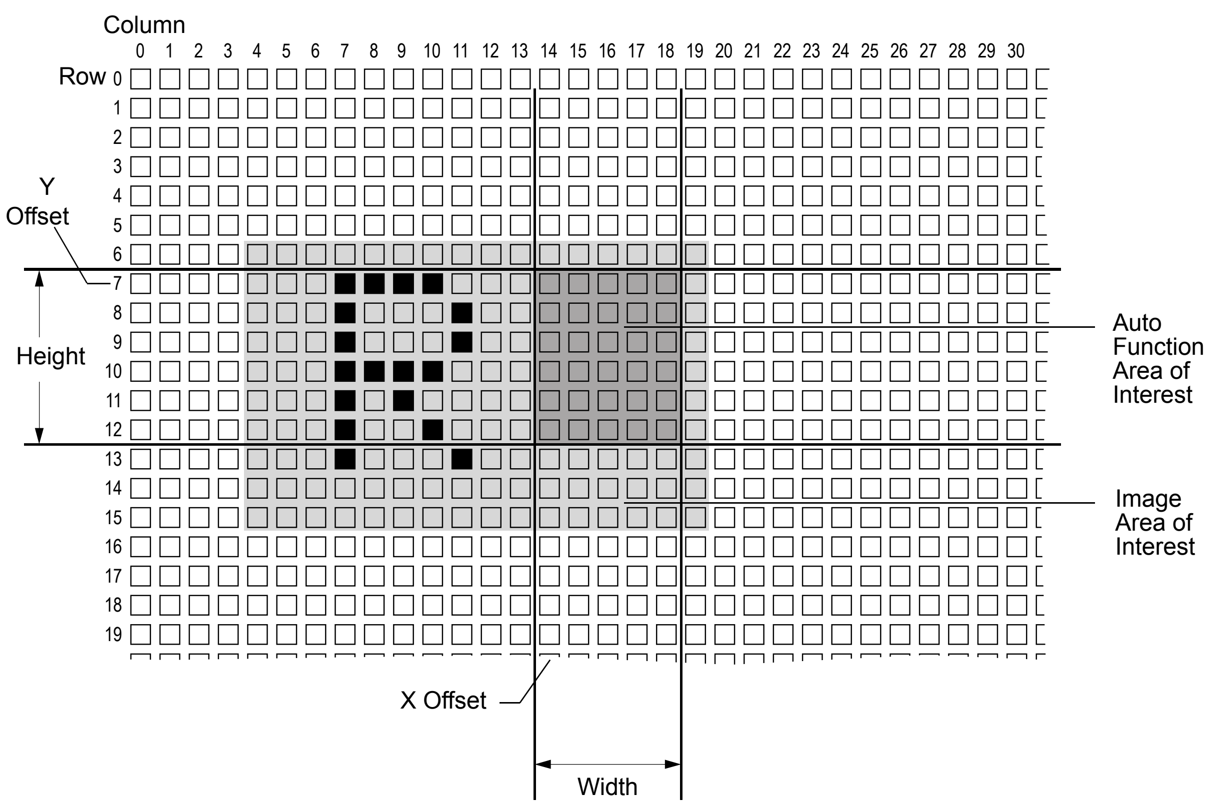


Fig. 58: Auto Function Area of Interest and Image Area of Interest

10.9.2.1 Assignment of an Auto Function to an Auto Function AOI

By default, the Gain Auto and the Exposure Auto auto functions are assigned to Auto Function AOI 1 and the Balance White Auto auto function is assigned to Auto Function AOI 2. The assignments can, however, be set as desired. For example, the Balance White Auto auto function can be assigned to Auto Function AOI 1 or all auto functions can be assigned to the same Auto Function AOI.

ⓘ	We strongly recommend that you do not assign an auto function to more than one Auto Function AOI even though this can be done.

One limitation must be kept in mind: For the purpose of making assignments, the Gain Auto and the Exposure Auto auto functions are always considered as a single "Intensity" auto function and therefore the Auto Function AOI assignment is always identical for both auto functions. For example, if you assign the "Intensity" auto function to Auto Function AOI 2 the Gain Auto and the Exposure Auto auto functions are both assigned to Auto Function AOI 2. This does not imply, however, that the Gain Auto and the Exposure Auto auto functions must always be used at the same time.

Assigning an Auto Function to an Auto Function AOI Using Basler Pylon

You can assign auto functions to Auto Function AOIs from within your application software by using the pylon API.

As an example, the following code snippet illustrates using the API to assign the Gain Auto and Exposure Auto auto function - considered as a single "Intensity" auto function - and the Exposure Auto auto function to Auto Function AOI 1.

The snippet also illustrates disabling the unused Auto Function AOI 2 to avoid assigning any auto function to more than one Auto Function AOI.

```
// Select Auto Function AOI 1
// Assign auto functions to the selected Auto Function AOI
Camera.AutoFunctionAOISelector.SetValue( AutoFunctionAOISelector_AOI1 );
Camera.AutoFunctionAOIUsageIntensity.SetValue( true );
Camera.AutoFunctionAOIUsageWhiteBalance.SetValue( true );

// Select the unused Auto Function AOI 2
// Disable the unused Auto Function AOI
Camera.AutoFunctionAOISelector.SetValue( AutoFunctionAOISelector_AOI2 );
Camera.AutoFunctionAOIUsageIntensity.SetValue( false );
Camera.AutoFunctionAOIUsageWhiteBalance.SetValue( false );
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Assigning an Auto Function to an Auto Function AOI Using Direct Register Access

To assign an auto function to Auto Function AOI 1 via direct register access:

- Set the value of the Auto AOI 1 Usage register.

To assign an auto function to Auto Function AOI 2 via direct register access:

- Set the value of the Auto AOI 2 Usage register.

For more information about direct register access, see Section 3.2 on page 19

10.9.2.2 Relative Positioning of an Auto Function AOI

The size and position of an Auto Function AOI can be, but need not be, identical to the size and position of the Image AOI. Note that the overlap between an Auto Function AOI and the Image AOI determines whether and to what extent the auto function will control the related image property. Only the pixel data from the areas of overlap of an Auto Function AOI and the Image AOI will be used by the auto function to control the image property of the entire image.

Different degrees of overlap are illustrated in Figure 59. The hatched areas in the figure indicate areas of overlap.

- If the Auto Function AOI is completely included in the Image AOI (see (a) in Figure 59), all pixel data from the Auto Function AOI will be used to control the image property.
- If the Image AOI is completely included in the Auto Function AOI (see (b) in Figure 59), only the pixel data from the Image AOI will be used to control the image property.
- If the Image AOI only partially overlaps the Auto Function AOI (see (c) in Figure 59), only the pixel data from the area of partial overlap will be used to control the image property.
- If the Auto Function AOI does not overlap the Image AOI (see (d) in Figure 59), the Auto Function will **not** control the image property. For details, see the sections below, describing the individual auto functions.

ⓘ	We strongly recommend completely including the Auto Function AOI within the Image AOI, or, depending on your needs, setting identical positions and sizes for the Auto Function AOIs and the Image AOI.

ⓘ	You can use auto functions when also using the reverse X and reverse Y mirroring features. For information about the behavior of Auto Function AOIs when also using the reverse X or reverse Y mirroring feature, see the "Mirror Image" section.

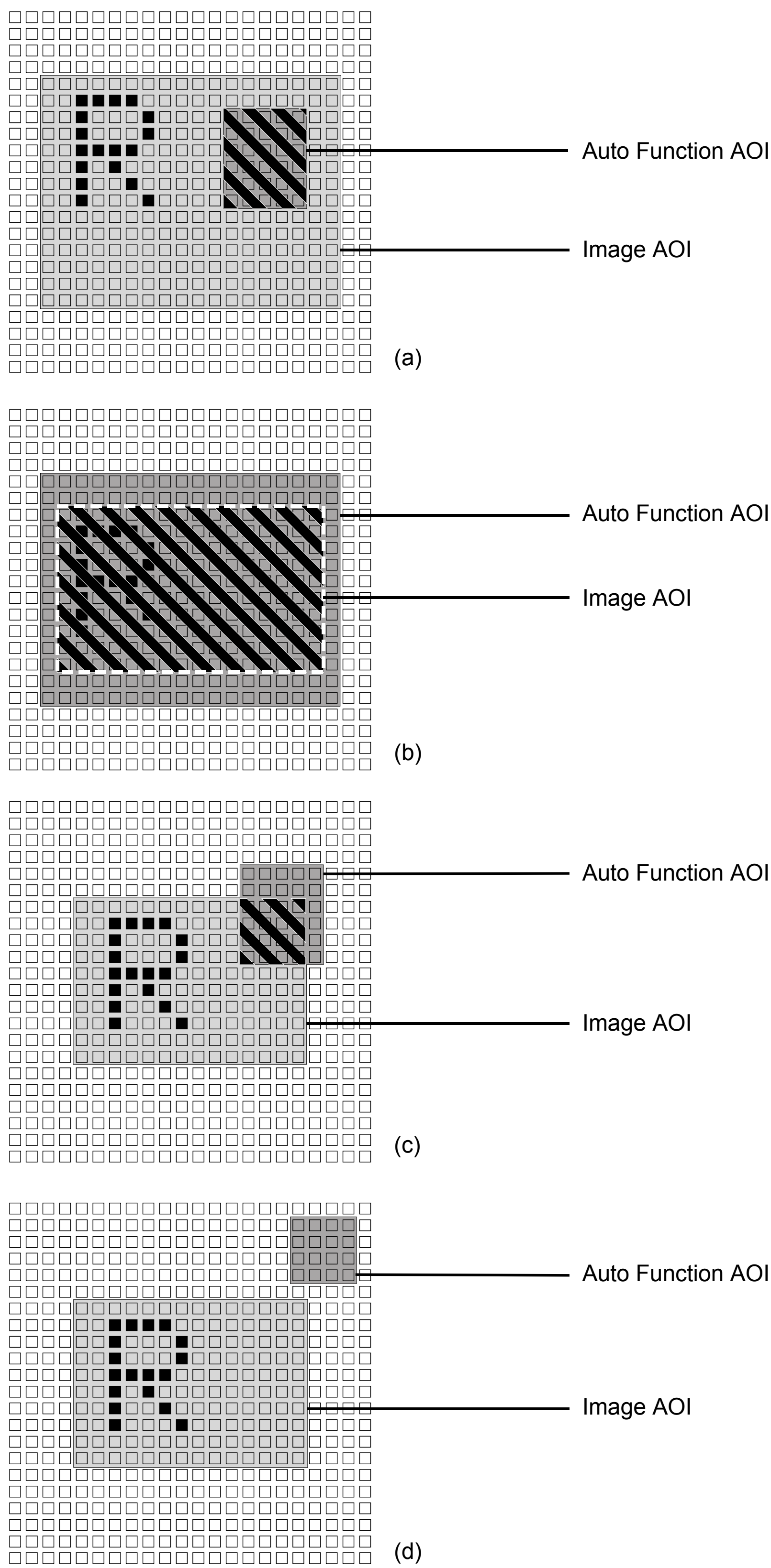


Fig. 59: Various Degrees of Overlap Between the Auto Function AOI and the Image AOI

10.9.2.3 Setting an Auto Function AOI Position and Size

Setting an Auto Function AOI position and size is a two-step process: You must first select the Auto Function AOI related to the auto function that you want to use and then set the position and the size of the Auto Function AOI.

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

- The value of the X Offset parameter determines the starting column for the Auto Function AOI.
- The value of the Y Offset parameter determines the starting line for the Auto Function AOI.
- The value of the Width parameter determines the width of the Auto Function AOI.
- The value of the Height parameter determines the height of the Auto Function AOI.

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

- The sum of the X Offset setting plus the Width setting must not exceed the width of the camera's sensor. For example, on the acA2000-140km, the sum of the X Offset setting plus the Width setting must not exceed 2048.
- The sum of the Y Offset setting plus the Height setting must not exceed the height of the camera's sensor. For example, on the acA2000-140km, the sum of the X Offset setting plus the Width setting must not exceed 1088.

ⓘ	Normally, the X Offset, Y Offset, Width, and Height parameter settings for an Auto Function AOI refer to the physical columns and lines in the sensor. But if binning is enabled (monochrome cameras only), these parameters are set in terms of "virtual" columns and lines, i.e., the settings for an Auto Function AOI will refer to the binned lines and columns in the sensor and not to the physical lines in the sensor as they normally would.

For more information about the concept of a "virtual" sensor, see Section 10.8 on page 182.

Setting an Auto Function AOI Position and Size Using Basler pylon

You can select an Auto Function AOI and set the X Offset, Y Offset, Width, and Height parameter values for the Auto Function AOI from within your application software by using the pylon API. The following code snippet illustrates using the API to select Auto Function AOI one and to get the maximum allowed settings for the Width and Height parameters. The snippet also illustrates setting the X Offset, Y Offset, Width, and Height parameter values.

```
// Select auto function AOI 1
// Set position and size of the selected auto function AOI
Camera.AutoFunctionAOISelector.SetValue( AutoFunctionAOISelector_AOI1 );
Camera.AutoFunctionAOIOffsetX.SetValue( 0 );
Camera.AutoFunctionAOIOffsetY.SetValue( 0 );
Camera.AutoFunctionAOIWidth.SetValue( Camera.AutoFunctionAOIWidth.GetMax() );
Camera.AutoFunctionAOIHeight.SetValue( Camera.AutoFunctionAOIHeight.GetMax() );
```

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 17.

Setting an Auto Function AOI Position and Size Using Direct Register Access

To set the X Offset, Y Offset, Width, and Height for Auto Function 1 via direct register access:

- Set the value of the Auto AOI 1 Left register to set the X offset.
- Set the value of the Auto AOI 1 Top register to set the Y offset.
- Set the value of the Auto AOI 1 Width register to set the width.
- Set the value of the Auto AOI 1 Height register to set the height.

To set the X Offset, Y Offset, Width, and Height for Auto Function 2 via direct register access:

- Set the value of the Auto AOI 2 Left register to set the X offset.
- Set the value of the Auto AOI 2 Top register to set the Y offset.
- Set the value of the Auto AOI 2 Width register to set the width.
- Set the value of the Auto AOI 2 Height register to set the height.

For more information about direct register access, see Section 3.2 on page 19.

10.9.3 Using an Auto Function

To use an auto function, carry out the following steps:

1. Select an Auto Function AOI.
2. Assign the auto function you want to use to the selected Auto Function AOI.
3. Unassign the auto function you want to use from the other Auto Function AOI.
4. Set the position and size of the Auto Function AOI.
5. If necessary, set the lower and upper limits for the auto functions's parameter value.
6. If necessary, set the target value.
7. If necessary, set the auto function profile to define priorities between auto functions.
8. Enable the auto function by setting it to "once" or "continuous".

For more information about the individual settings, see the next sections that describe the individual auto functions.

10.9.4 Gain Auto

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

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

If the related Auto Function AOI does not overlap the Image AOI (see the "Auto Function AOI" section) the pixel data from the Auto Function AOI will not be used to control the gain. Instead, the current manual setting for the Gain Raw parameter value will control the gain.

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

For more information about the "manual" gain settings, see Section 10.1 on page 155.

For more information about the auto function profile Section 10.9.6 on page 203.

The limits within which the camera will adjust the Gain Raw parameter are defined by the Auto Gain Raw Upper Limit and the Auto Gain Raw Lower Limit parameters. The minimum and maximum allowed settings for the Auto Gain Raw Upper Limit and Auto Gain Raw Lower Limit parameters depend on the current pixel data format, on the current settings for binning, and on whether or not the parameter limits for manually setting the gain feature are disabled.

The Auto Target Value parameter defines the target average gray value that the gain auto function will attempt to achieve when it is automatically adjusting the Gain Raw value. The target average gray value can range from 0 (black) to 255 (white) when the camera is set for an 8 bit pixel format, from 0 (black) to 1023 (white) when the camera is set for a 10 bit pixel format, or from 0 (black) to 4095 (white) when the camera is set for a 12 bit pixel format.

Setting the Gain Auto Function Using Basler pylon

Setting the gain auto functionality using Basler pylon is a several step process:

- Select the Auto Function AOI to which the Gain Auto function is assigned.
- Set the value of the Offset X, Offset Y, Width, and Height parameters for the AOI.
- Set the Gain Selector to All.
- Set the value of the Auto Gain Raw Lower Limit and Auto Gain Raw Upper Limit parameters.
- Set the value of the Auto Target Value parameter.
- Set the value of the Gain Auto parameter for the "once" or the "continuous" mode of operation.

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

```
// Select Auto Function AOI to which the Gain Auto function is assigned
// For this example, assume that the Gain Auto function is assigned
// to Auto AOI 1
Camera.AutoFunctionAOISelector.SetValue( AutoFunctionAOISelector_AOI1 );

// Set the position and size of selected auto function AOI. In this example, we set
// auto function AOI to cover the entire sensor.
Camera.AutoFunctionAOIOffsetX.SetValue( 0 );
Camera.AutoFunctionAOIOffsetY.SetValue( 0 );
Camera.AutoFunctionAOIWidth.SetValue( Camera.AutoFunctionAOIWidth.GetMax() );
Camera.AutoFunctionAOIHeight.SetValue( Camera.AutoFunctionAOIHeight.GetMax() );

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

// Set target gray value for the gain auto function.
Camera.AutoTargetValue.SetValue( 16 );

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting the Gain Auto Function Using Direct Register Access

Setting the gain auto functionality via direct register access is a several step process:

- Set the position and size of Auto Function AOI 1 by setting the value of the Auto AOI 1 Left register, the value of the Auto AOI 1 Top register, the value of the Auto AOI 1 Width register, and the value of the Auto AOI 1 Height register.

  (**Note:** This step assumes that the Gain Auto function is assigned to Auto Function AOI 1. If the Gain Auto function is assigned to Auto Function AOI 2, you would set the Auto Function AOI 2 registers.)
- Set the value of the Auto Gain Lower Limit register and the Auto Gain Upper Limit register.
- Set the value of the Auto Target Value register.
- Enable the gain auto function by selecting the value of the Gain Auto register to the Once or the Continuous mode of operation as desired.

For more information about direct register access, see Section 3.2 on page 19.

10.9.5 Exposure Auto

ⓘ	The exposure auto function will not work if the camera's exposure mode is set to trigger width. For more information about the trigger width exposure mode, see Section 7.3.3.2 on page 85.

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

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

If the related Auto Function AOI does not overlap the Image AOI (see the "Auto Function AOI" section), the pixel data from the Auto Function AOI will not be used to control the exposure time. Instead, the current manual setting for the Exposure Time Abs parameter will control the exposure time.

The exposure auto function and the gain auto function can be used at the same time. In this case, the auto function profile feature also takes effect. By default, the auto function profile feature minimizes gain.

When trigger width exposure mode is selected, the exposure auto function is not available.

For more information about the "manual" exposure time setting, see Section 7.4 on page 92.

For more information about the trigger width exposure mode, see Section 7.3.3.2 on page 85.

For more information about the auto function profile Section 10.9.6 on page 203.

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

The Auto Target Value parameter defines the target average gray value that the exposure auto function will attempt to achieve when it is automatically adjusting the Exposure Time Abs value. The target average gray value can range from 0 (black) to 255 (white) when the camera is set for an 8 bit pixel format, from 0 to 1023 when the camera is set for a 10 bit pixel format, and from 0 to 4095 when the camera is set for a 12 bit pixel format.

ⓘ	If the Exposure Time Abs Upper Limit Parameter is set to a sufficiently high value, the camera's maximum allowed frame rate may be decreased.

Setting the Exposure Auto Function Using Basler pylon

Setting the exposure auto functionality using Basler pylon is a several step process:

- Select the Auto Function AOI to which the Exposure Auto function is assigned.
- Set the value of the Offset X, Offset Y, Width, and Height parameters for the AOI.
- Set the value of the Auto Exposure Time Abs Lower Limit and Auto Exposure Time Abs Upper Limit parameters.
- Set the value of the Auto Target Value parameter.
- Set the value of the Exposure Auto parameter for the "once" or the "continuous" mode of operation.

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

```
// Select Auto Function AOI to which the Exposure Auto function is assigned
// For this example, assume that the Exposure Auto function is
// assigned to Auto AOI 1
Camera.AutoFunctionAOISelector.SetValue( AutoFunctionAOISelector_AOI1 );

// Set the position and size of selected auto function AOI. In this example, we set
// auto function AOI to cover the entire sensor.
Camera.AutoFunctionAOIOffsetX.SetValue( 0 );
Camera.AutoFunctionAOIOffsetY.SetValue( 0 );
Camera.AutoFunctionAOIWidth.SetValue( Camera.AutoFunctionAOIWidth.GetMax() );
Camera.AutoFunctionAOIHeight.SetValue( Camera.AutoFunctionAOIHeight.GetMax() );

// Set the exposure time limits for the exposure auto function
Camera.AutoExposureTimeAbsLowerLimit.SetValue( 1000 );
Camera.AutoExposureTimeAbsUpperLimit.SetValue( 1.0E6 );

// Set target gray value for the exposure auto function
// (If gain auto is enabled, this target is also used for gain auto control)
Camera.AutoTargetValue.SetValue( 32 );

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

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting the Exposure Auto Function Using Direct Register Access

Setting the exposure auto functionality via direct register access is a several step process:

- Set the position and size of Auto Function AOI 1 by setting the value of the Auto AOI 1 Left register, the value of the Auto AOI 1 Top register, the value of the Auto AOI 1 Width register, and the value of the Auto AOI 1 Height register.

  (**Note:** This step assumes that the Exposure Auto function has been assigned to Auto Function AOI 1. If the Exposure Auto function is assigned to Auto Function AOI 2, you would set the Auto Function AOI 2 registers.)
- Set the value of the Auto Exposure Lower Limit register and the Auto Exposure Upper Limit register.
- Set the value of the Auto Target Value register.
- Enable the gain auto function by selecting the value of the Exposure Auto register to the Once or the Continuous mode of operation as desired.

For more information about direct register access, see Section 3.2 on page 19.

10.9.6 Auto Function Profile

If you want to use the gain auto function and the exposure auto function at the same time, the auto function profile feature also takes effect. The auto function profile specifies whether the gain or the exposure time will be kept as low as possible when the camera is making automatic adjustments to achieve a target average gray value for the pixel data from the Auto Function AOI that was related to the gain auto and the exposure auto function. By default, the auto function profile feature minimizes gain.

If you want to use the gain auto and the exposure auto functions at the same time, you should set both functions for the continuous mode of operation.

Setting the Auto Function Profile Using Basler pylon

Setting the camera with Basler pylon to use the gain auto function and the exposure auto function at the same time is a several step process:

- Set the value of the Auto Function Profile parameter to specify whether gain or exposure time will be minimized during automatic adjustments.
- Set the value of the Gain Auto parameter to the "continuous" mode of operation.
- Set the value of the Exposure Auto parameter to the "continuous" mode of operation.

You can set the auto function profile from within your application software by using the pylon API. The following code snippet illustrates using the API to set the auto function profile. As an example, Gain Auto is set to be minimized during adjustments:

```
// Use GainAuto and ExposureAuto simultaneously
Camera.AutoFunctionProfile.SetValue( AutoFunctionProfile_GainMinimum );
Camera.GainAuto.SetValue( GainAuto_Continuous );
Camera.ExposureAuto.SetValue( ExposureAuto_Continuous );
```

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 17.

Setting the Auto Function Profile Using Direct Register Access

Setting the camera to use the gain auto function and the exposure auto function at the same time via direct register access is a several step process:

- Set the value of the Auto Function Profile register to specify whether gain or exposure time will be minimized during automatic adjustments.
- Set the value of the Gain Auto register for the Continuous" mode of operation.
- Set the value of the Exposure Auto register for the Continuous mode of operation.

For more information about direct register access, see Section 3.2 on page 19.

10.9.7 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.

Automatic white balancing is a two-step process. First, the Balance Ratio Abs parameter values for red, green, and blue are each set to 1.0. Next, the Balance Ratio Abs parameter values are automatically adjusted such that the average values for the "red", "green", and "blue" pixels are all the same. During this process, the color that needs the smallest amount of gain will be adjusted to a value of 1.0.

The balance white auto function uses the Auto Function AOI that was related to the Balance White Auto function and can only be operated in the "once" mode of operation.

If the related Auto Function AOI does not overlap the Image AOI (see the "Auto Function AOI" section) the pixel data from the Auto Function AOI will not be used to control the white balance of the image. However, as soon as the Balance White Auto function is set to "once" operation mode, the Balance Ratio parameter values for red, green, and blue are each set to 1.5. These settings will then control the white balance of the image.

For more information about the "manual" white balance settings, see Section 8.3.1 on page 130.

Setting the Balance White Auto Function Using Basler pylon

Setting the balance white auto functionality using Basler pylon is a several step process:

- Select the Auto Function AOI to which the Balance White Auto is assigned.
- Set the value of the Offset X, Offset Y, Width, and Height parameters for the AOI.
- Set the value of the Exposure Auto parameter for the "once" or the "continuous" mode of operation.

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

```
// Select Auto Function AOI to which the Balance White Auto function is assigned
// For this example, assume that the Balance White Auto function is
// assigned to Auto AOI 2
Camera.AutoFunctionAOISelector.SetValue( AutoFunctionAOISelector_AOI2 );

// Set the position and size of selected auto function AOI. In this example, we set
// auto function AOI to cover the entire sensor.
Camera.AutoFunctionAOIOffsetX.SetValue( 0 );
Camera.AutoFunctionAOIOffsetY.SetValue( 0 );
Camera.AutoFunctionAOIWidth.SetValue( Camera.AutoFunctionAOIWidth.GetMax() );
Camera.AutoFunctionAOIHeight.SetValue( Camera.AutoFunctionAOIHeight.GetMax() );

// Set mode of operation for balance white auto function
Camera.BalanceWhiteAuto.SetValue( BalanceWhiteAuto_Once );
```

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 17.

Setting the Balance White Auto Function Using Direct Register Access

Setting the balance white auto functionality via direct register access is a several step process:

- Set the position and size of Auto Function AOI 2 by setting the value of the Auto AOI 2 Left register, the value of the Auto AOI 2 Top register, the value of the Auto AOI 2 Width register, and the value of the Auto AOI 2 Height register.

  (**Note:** This step assumes that the Balance White Auto function has been assigned to Auto Function AOI 2. If the Exposure Auto function is assigned to Auto Function AOI 1, you would set the Auto Function AOI 1 registers.)
- Enable the balance white auto function in the once mode of operation by selecting the value of the Balance White Auto register to Once.

For more information about direct register access, see Section 3.2 on page 19.

10.10 Error Detection

10.10.1 LED Indicator

The LED indicator on the back of the camera includes both a small red LED and a small green LED. The LED indicator signals the camera's current condition as shown in Table 13.

LED State	Status Indication
Red and Greeen Both Off	No power to the camera
Continuous Green / Red Off	The camera has booted up successfully and is OK.
Flashing Green / Red Off	The camera is set to expect an external trigger signal on an input, but no trigger signal is present.
Green and Red Both Flasing	An error condition has been detected that may be correctable with user intervention. (See the next section for more information).
Flashing Red / Green Off	Internal error. Contact Basler technical support.

Table 13: LED Indications

During the camera bootup process, both the red and the green LEDs will be lit.

10.10.2 Error Codes

The camera can detect several user correctable errors. If one of these errors is present, the camera will set an error code and will flash both the red and green LEDs in the LED indicator.

The following table indicates the available error codes:

Code	Condition	Meaning
0	No Error	The camera has not detetcted any errors since the last time that the error memory was cleared.
1	Overtrigger	An overtrigger has occurred. The user has applied an acquisition start trigger to the camera when the camera was not in a waiting for acquisition start condition. Or, the user has applied a frame start trigger to the camera when the camera was not in a waiting for frame start condition.
2	User set load	An error occured when attempting to load a user set. Typically, this means that the user set contains an invalid value. Try loading a different user set .
3	Invalid Parameter	A parameter is set out of range or in an otherwise invalid manner. (Typically, this error only occurs when the user is setting parameters via direct register access.)

Table 14: Error Codes

When the camera detects a user correctable error, it sets the appropriate error code in an error memory. If two or three different detectable errors have occured, the camera will store the code for each type of error that it has detected (it will store one occurance of the each code no matter how many times it has detected the corresponding error).

You can use the following procedure to check the error codes:

- Read the value of the Last Error parameter. The Last Error parameter will indicate the last error code stored in the memory.
- Execute the Clear Last Error Command to clear the last error code from the memory.
- Continue reading and clearing the last error until the parameter indicates a No Error code.

Reading and Clearing the Error Codes Using Basler Pylon

You can use the pylon API to read the value of the Last Error parameter and to execute a Clear Last Error command from within your application software. The following code snippets illustrate using the API to read the parameter value and execute the command:

```
// Read the value of the last error code in the memory
LastErrorEnums lasterror = Camera.LastError.GetValue();

// Clear the value of the last error code in the memory
Camera.ClearLastError.Execute( );
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Reading and Clearing the Error Codes Using Direct Register Access

To get the value of the last error code in the memory via direct register access:

- Read the value of the Last User Error register.

To clear the value of the last error code in the memory via direct register access:

- Set the value of the Clear Last User Error register to 1.

For more information about direct register access, see Section 3.2 on page 19

10.11 Test Images

All cameras include the ability to generate test images. Test images are used to check the camera's basic functionality and its ability to transmit an image to the host PC. Test images can be used for service purposes and for failure diagnostics. For test images, the image is generated internally by the camera's logic and does not use the optics, the imaging sensor, or the ADCs. Five test images are available.

The Effect of Camera Settings on Test Images

When any of the test image is active, the camera's analog features such as gain, black level, and exposure time have no effect on the images transmitted by the camera. For test images 1, 2, and 3, the camera's digital features, such as the luminance lookup table, will also have no effect on the transmitted images. But for test images 4 and 5, the cameras digital features will affect the images transmitted by the camera. This makes test images 4 and 5 as good way to check the effect of using a digital feature such as the luminance lookup table.

Enabling a Test Image Using Basler pylon

With Basler pylon, the Test Image Selector is used to set the camera to output a test image. You can set the value of the Test Image Selector to enable one of the test images or to "test image off".

You can use the pylon API to set the Test Image Selector from within your application software. The following code snippets illustrate using the API to set the selector:

```
// Set for no test image
Camera.TestImageSelector.SetValue( TestImageSelector_Off );

// Set for test image 1
Camera.TestImageSelector.SetValue( TestImageSelector_Testimage1 );
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Enabling a Test Image Using Direct Register Access

To enable a test image via direct register access:

- Set the value of the Test image Selector Register to Test Image 1, 2, 3, 4, or 5 as desired.

To disable test images:

- Set the value of the Test image Selector Register to Off.

For more information about direct register access, see Section 3.2 on page 19.

10.11.1 Test Image Descriptions

Test Image 1 - Fixed Diagonal Gray Gradient (8 bit)

The 8 bit fixed diagonal gray gradient test image is best suited for use when the camera is set for monochrome 8 bit output. The test image consists of fixed diagonal gray gradients ranging from 0 to 255.

If the camera is set for 8 bit output and is operating at full resolution, test image one will look similar to Figure 60.

The mathematical expression for this test image:

Gray Value = [column number + row number] MOD 256

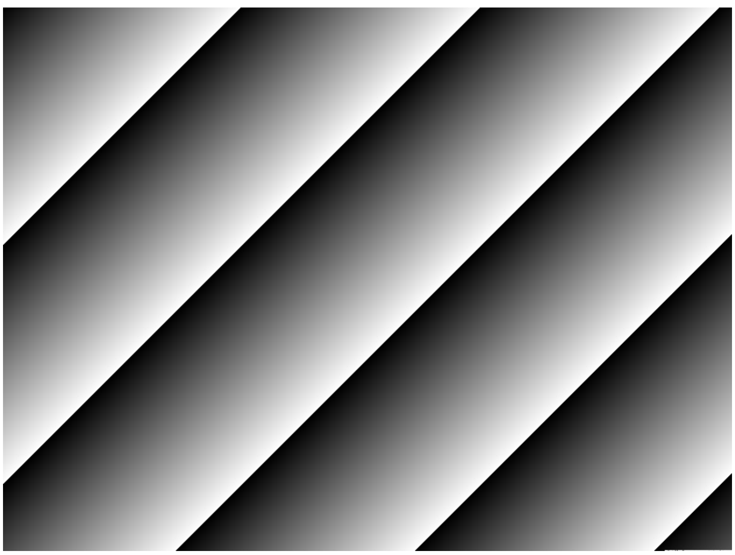


Fig. 60: Test Image One

Test Image 2 - Moving Diagonal Gray Gradient (8 bit)

The 8 bit moving diagonal gray gradient test image is similar to test image 1, but it is not stationary. The image moves by one pixel from right to left whenever a new image acquisition is initiated. The test pattern uses a counter that increments by one for each new image acquisition.

The mathematical expression for this test image is:

Gray Value = [column number + row number + counter] MOD 256

Test Image 3 - Moving Diagonal Gray Gradient (12 bit)

The 12 bit moving diagonal gray gradient test image is similar to test image 2, but it is a 12 bit pattern. The image moves by one pixel from right to left whenever a new image acquisition is initiated. The test pattern uses a counter that increments by one for each new image acquisition.

The mathematical expression for this test image is:

Gray Value = [column number + row number + counter] MOD 4096

Test Image 4 - Moving Diagonal Gray Gradient Feature Test (8 bit)

The basic appearance of test image 4 is similar to test image 2 (the 8 bit moving diagonal gray gradient image). The difference between test image 4 and test image 2 is this: if a camera feature that involves digital processing is enabled, test image 4 **will** show the effects of the feature while test image 2 **will not**. This makes test image 4 useful for checking the effects of digital features such as the luminance lookup table.

Test Image 5 - Moving Diagonal Gray Gradient Feature Test (12 bit)

The basic appearance of test image 5 is similar to test image 3 (the 12 bit moving diagonal gray gradient image). The difference between test image 5 and test image 3 is this: if a camera feature that involves digital processing is enabled, test image 5 **will** show the effects of the feature while test image 3 **will not**. This makes test image 5 useful for checking the effects of digital features such as the luminance lookup table.

10.12 Device Information Parameters

Each camera includes a set of "device information" parameters. These parameters provide some basic information about the camera. The device information parameters include:

- Device Vendor Name (read only) - contains the name of the camera's vendor. This string will always indicate Basler as the vendor.
- Device Model Name (read only) - contains the model name of the camera, for example, acA2000-140km.
- Device Manufacturer Info (read only) - can contain some information about the camera manufacturer. This string usually indicates "none".
- Device Version (read only) - contains the device version number for the camera. This is usually the material number of the device.
- Device Firmware Version (read only) - contains the version of the firmware the camera.
- Device ID (read only) - typically contains the serial number of the camera.
- Device User ID (read / write) - is used to assign a user defined name to a device. This name will be displayed in the Basler pylon Viewer. The name will also be visible in the "friendly name" field of the device information objects returned by pylon's device enumeration procedure.
- Device Scan Type (read only) - contains the scan type of the camera, for example, line scan or area scan. The aviator will always indicate area scan.
- Sensor Width (read only) - contains the physical width of the sensor in pixels.
- Sensor Height (read only) - contains the physical height of the sensor.
- Max Width (read only) - Indicates the camera's maximum area of interest (AOI) width setting.
- Max Height (read only) - Indicates the camera's maximum area of interest (AOI) height setting.

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Working with Device Information Parameters Using Basler pylon

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

```
// Read the Vendor Name parameter
Pylon::String_t vendorName = Camera.DeviceVendorName.GetValue();

// Read the Model Name parameter
Pylon::String_t modelName = Camera.DeviceModelName.GetValue();

// Read the Manufacturer Info parameter
Pylon::String_t manufacturerInfo = Camera.DeviceManufacturerInfo.GetValue();

// Read the Device Version parameter
Pylon::String_t deviceVersion = Camera.DeviceVersion.GetValue();
```

```
// Read the Firmware Version parameter
Pylon::String_t firmwareVersion = Camera.DeviceFirmwareVersion.GetValue();

// Read the Device ID parameter
Pylon::String_t deviceID = Camera.DeviceFirmwareVersion.GetValue();

// Write and read the Device User ID
Camera.DeviceUserID = "custom name";
Pylon::String_t deviceUserID = Camera.DeviceUserID.GetValue();

// Read the Sensor Width parameter
int64_t sensorWidth = Camera.SensorWidth.GetValue();

// Read the Sensor Height parameter
int64_t sensorHeight = Camera.SensorHeight.GetValue();

// Read the Max Width parameter
int64_t maxWidth = Camera.WidthMax.GetValue();

// Read the Max Height parameter
int64_t maxHeight = Camera.HeightMax.GetValue();
```

You can also use the Basler pylon Viewer application to easily read the parameters and to read or write the Device User ID.

For more information about the pylon API and the pylon Viewer, see Section 3.2 on page 19.

Working with Device Information Parameters Using Direct Register Access

When working with the camera via direct register access, you can do the following:

- Read the value in the Device Vendor Name register.
- Read the value in the Device Model Name register.
- Read the value in the Device Manufacturer Info register.
- Read the value in the Device Version register.
- Read the value of the Device Firmware Version register.
- Read the value in the Device ID register.
- Read the value in or set the value of the Device User ID register.
- Read the value in the Device Scan Type register.
- Read the value in the Sensor Width register.
- Read the value in the Sensor Height register.
- Read the value in the Width Max register.
- Read the value in the Height Max register.

For more information about via direct register access, see Section 3.2 on page 19.

10.13 User Defined Values

The camera can store five "user defined values". These five values are 32 bit signed integer values that you can set and read as desired. They simply serve as convenient storage locations for the camera user and have no impact on the operation of the camera.

The five values are designated as Value 1, Value 2, Value 3, Value 4, and Value 5.

Setting User Defined Values Using Basler Pylon

Setting a user defined value using Basler pylon is a two step process:

- Set the User Defined Value Selector to Value 1, Value 2, Value 3, Value 4, or Value 5.
- Set the User Defined Value parameter to the desired value for the selected value.

You can use the pylon API to set the User Defined Value Selector and the User Defined Value parameter value from within your application software. The following code snippet illustrates using the API to set the selector and the parameter value:

```
// Set user defined value 1
Camera.UserDefinedValueSelector.SetValue( UserDefinedValueSelector_Value1 );
Camera.UserDefinedValue.SetValue( 1000 );

// Set user defined value 2
Camera.UserDefinedValueSelector.SetValue( UserDefinedValueSelector_Value2 );
Camera.UserDefinedValue.SetValue( 2000 );

// Get the value of user defined value 1
Camera.UserDefinedValueSelector.SetValue( UserDefinedValueSelector_Value1 );
int64_t UserValue1 = Camera.UserDefinedValue.GetValue();
```

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

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Setting User Defined Values Using Direct Register Access

To set the user defined values via direct register access:

- Set the value of the User Defined Value 1 register, the User Defined Value 2 register, the User Defined Value 3 register, the User Defined Value 4 register or the User Defined Value 5 register as desired.

For more information about direct register access, see Section 3.2 on page 19.

10.14 Configuration Sets

A configuration set is a group of values that contains all of the parameter settings needed to control the camera. There are three basic types of configuration sets: the active set, the default set, and user sets.

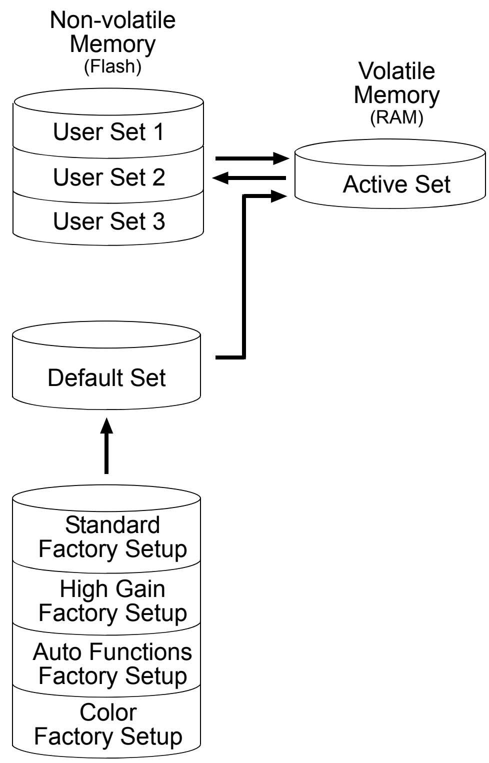


Fig. 61: Configuration Sets

The 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.

The Default Set

When a camera is manufactured, numerous tests are performed on the camera and four factory optimized setups are determined. The four factory optimized setups are:

- The Standard Factory Setup - is optimized for average conditions and will provide good camera performance in many common applications. In the standard factory setup, the gain is set to a low value, and all auto functions are set to off.
- The High Gain Factory Setup - is similar to the standard factory setup, but the gain is set to + 6 dB.
- The Auto Functions Factory Setup - is similar to the standard factory setup, but the Gain Auto and the Exposure Auto auto functions are both enabled and are set to the continuous mode of operation. During automatic parameter adjustment, gain will be kept to a minimum.
- The Color Factory Setup - is optimized to yield the best color fidelity over a range of the most common lighting conditions.

The factory setups are saved in permanent files in the camera's non-volatile memory. They are not lost when the camera is reset or switched off and they cannot be changed.

You can select one of the four factory setups to be the camera's "default set". Instructions for selecting which factory setup will be used as the default set appear later in the Configuration Sets section. Note that your selection of which factory setup will serve as the default set will not be lost when the camera is reset or switched off.

When the camera is running, the default set can be loaded into the active set. The default 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. Instructions for loading the default set into the active set and for designating which set will be the startup set appear later in the Configuration Sets section.

User Sets

As mentioned above, the active configuration set is stored in the camera's volatile memory and the settings are lost if the camera is reset or if power is switched off. The camera can save most of the settings from the current active set to a reserved area in the camera's non-volatile memory. A configuration set that has been saved in the non-volatile memory is not lost when the camera is reset or switched off. There are three reserved areas in the camera's non-volatile memory available for saving configuration sets. A configuration set saved in a reserved area is commonly referred to as a "user set".

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. Instructions for loading a saved user set into the active set and for designating which set will be the startup set appear later in the Configuration Sets section.

The values for the luminance lookup table are not saved in the user sets and are lost when the camera is reset or switched off. If you are using the lookup table feature, you must reenter the lookup table values after each camera startup or reset.

Designating a Startup Set

You can designate the default 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. Instructions for designating the startup set appear below.

10.14.1 Selecting a Factory Setup as the Default Set

When the camera is delivered, the Auto Functions Factory Setup will be selected as the default set. You can, however, select any one of the three factory setups to serve as the default set.

ⓘ	Selecting which factory setup will serve as the default set is only allowed when the camera is idle, i.e. when it is not acquiring images continuously or does not have a single image acquisition pending. Selecting the standard factory setup as the default set and then loading the default set into the active set is a good course of action if you have grossly misadjusted the settings in the camera and you are not sure how to recover. The standard factory setup is optimized for use in typical situations and will provide good camera performance in most cases.

Selecting a Factory Setup Using pylon

To select which factory setup will serve as the default set using Basler pylon:

- Set the Default Set Selector to the Standard Factory Setup, High Gain Factory Setup or Auto Functions Factory Setup.

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

If you want to select the Standard Factory Setup:

```
Camera.DefaultSetSelector.SetValue(DefaultSetSelector_Standard);
```

If you want to select the High Gain Factory Setup:

```
Camera.DefaultSetSelector.SetValue(DefaultSetSelector_HighGain);
```

If you want to select the Auto Functions Factory Setup:

```
Camera.DefaultSetSelector.SetValue(DefaultSetSelector_AutoFunctions);
```

If you want to select the Color Factory Setup:

```
Camera.DefaultSetSelector.SetValue(DefaultSetSelector_Color);
```

Selecting a Factory Setup Using Direct Register Access

To select which factory setup will serve as the default set via direct register access:

- Set the Default Set Selector register to the Standard Factory Setup, High Gain Factory Setup, Auto Functions Factory Setup, or Color setup.

10.14.2 Saving User Sets

You can save the current parameter set being used by the camera (i.e., the "active" set in the camera's volatile memory) to user set 1, user set 2, or user set 3. The user sets are stored in the camera's non-volatile memory and will be retained when the camera power is switched off or the camera is reset. When you save the active set to a user set, any parameter data already in that user set will be overwritten.

Saving User Sets Using Basler Pylon

Using Basler pylon to save the current active set to a user set in the camera's non-volatile memory is a several step process:

- Make changes to the camera's settings until the camera is operating in a manner that you would like to save.
- Set the User Set Selector to User Set 1, User Set 2, or User Set 3 as desired.
- Execute a User Set Save command to save the active set to the selected user set.

Saving an active set to a user set in the camera's non-volatile memory will overwrite any parameters that were previously saved in that user set.

You can use the pylon API to set the User Set Selector and to execute the User Set Save command from within your application software. The following code snippet illustrates using the API to set the selector and execute the 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 pylon API and the pylon Viewer, see Section 3.1 on page 17.

Saving User Sets Using Direct Register Access

To save the current active set to a user set in the camera's non-volatile memory via direct register access:

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

For more information about direct register access, see Section 3.2 on page 19.

10.14.3 Loading a Saved User Set or the Default Set into the Active Set

If you have saved a configuration set into one of the user sets in the camera's non-volatile memory, you can load the saved user set into the camera's active set. When you do this, the parameters stored in the user set overwrite the parameters in the active set. Since the settings in the active set control the current operation of the camera, the settings from the loaded user set will now be controlling the camera.

You can also load the default set into the camera's active set.

ⓘ	Loading a user set or the default set into the active set is only allowed when the camera is idle, i.e. when it is not acquiring an image. Assuming that you have selected the standard factory setup as the default set, loading the default set into the active set is a good course of action if you have grossly misadjusted the settings in the camera and you are not sure how to recover. The standard factory setup is optimized for use in typical situations and will provide good camera performance in most cases.

Loading a Set Using Basler Pylon

Loading a saved user set or the default set from the camera's non-volatile memory into the active set using Basler pylon is a two step process:

- Set the User Set Selector to User Set 1, User Set 2, User Set 3, or Default as desired.
- Execute a User Set Load command to load the selected set into the active set.

You can use the pylon API to set the User Set Selector and to execute the User Set Load command from within your application software. The following code snippet illustrates using the API to set the selector and execute the command:

```
// Load user set 2 into the active set
Camera.UserSetSelector.SetValue( UserSetSelector_UserSet2 );
Camera.UserSetLoad.Execute( );

// Load the default set into the active set
Camera.UserSetSelector.SetValue( UserSetSelector_Default );
Camera.UserSetLoad.Execute( );
```

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Loading a Set Using Direct Register Access

To load a saved user set or the default set from the camera's non-volatile memory into the active set via direct register access:

- Set the value of the User Set Selector register to User Set 1, 2, or 3, or to the Default set as desired.
- Set the value of the User Set Load register to 1.

For more information about direct register access, see Section 3.2 on page 19.

10.14.4 Selecting a "Startup" Set

You can select the default set or one of the user sets stored in the camera's non-volatile memory to be the "startup" set. The configuration set that you select as the startup set will be loaded into the active set whenever the camera starts up at power on or after a reset.

Selecting the Startup Set Using Basler Pylon

With Basler pylon, the User Set Default Selector parameter is used to select User Set 1, User Set 2, User Set 3, or the Default Set as the startup set.

You can use the pylon API to set the User Set Default Selector parameter from within your application software. The following code snippet illustrates using the API to set the selector:

```
// Designate user set 1 as the startup set
Camera.UserSetDefaultSelector.SetValue( UserSetDefaultSelector_UserSet1 );

// Designate the default set as the startup set
Camera.UserSetDefaultSelector.SetValue( UserSetDefaultSelector_Default );
```

For more information about the pylon API and the pylon Viewer, see Section 3.1 on page 17.

Selecting the Startup Set Using Direct Register Access

When using direct register access, the User Set Default Selector register is used to select the startup set:

- Set the value of the User Set Default Selector register for User Set 1, User Set 2, User Set 3, or Default as desired.

For more information about direct register access, see Section 3.2 on page 19.

11 Technical Support

This chapter outlines the resources available to you if you need help working with your camera.

11.1 Technical Support Resources

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

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

If you do decide to contact Basler technical support, please take a look at the form that appears on the last two pages of this section before you call. Filling out this form will help make sure that you have all of the information the Basler technical support team needs to help you with your problem.

11.2 Obtaining an RMA Number

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

You can find detailed information about how to obtain an RMA number in the Support section of our website: www.baslerweb.com

11.3 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.

Copy the form that appears on the next two pages, fill it out, and fax the pages to your local dealer or to your nearest Basler support center. Or, you can send an e-mail listing the requested pieces of information and with the requested files attached. Basler technical support contact information is shown in the title section of this manual.

1. The camera's product ID: ______________________________

2. The camera's serial number: ______________________________

3. Your operating system: ______________________________

4. Frame grabber that you use with the camera: ______________________________

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

6. If known, what's the cause of the problem?
   ____
   ____
   ____

7. When did/does the problem occur?
   - ☐ At startup.
   - ☐ While running.
   - ☐ After a certain action (e.g., a change of parameters):
   ____
   ____
   ____
   ____

8. How often did/does the problem occur?
   - ☐ Once.
   - ☐ Every time.
   - ☐ Regularly when:
   ____
   - ☐ Occasionally when:
   ____
   ____
   ____
   ____

9. 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.

10. Did your application ever run without problems?

- ☐ Yes
- ☐ No

11. 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 Basler's pylon Viewer tool.

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

- ☐ Pixel Data Format: ______________________
- ☐ Image Size (AOI): ______________________
- ☐ Exposure Time Control Mode ______________________
- ☐ Exposure Time: ______________________
- ☐ Gain: ______________________
- ☐ Black Level: ______________________
- ☐ Frame Rate: ______________________

12. Live image/test image

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

Revision History

Doc. ID Number	Date	Changes
AW00098501000	16 Feb 2011	Preliminary release of this document. Applies to prototype cameras only.
AW00098502000	1 Apr 2011	Second preliminary release. Added information for the acA2000-340km/kc, acA2040-70km/kc, and acA2040-180km/kc models. Added information for the new stacked zone imaging, sequencer, and error detection features. Applies to prototype cameras only.
AW00098503000	6 Jun 2011	Third preliminary release. Applies to prototype cameras only. Updated all specifications and feature descriptions.

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