user manual

pco.edge 10 bi CLHS
pco.edge 10 bi LT CLHS

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Excelitas PCO GmbH asks you to carefully read and follow the instructions in this document.
For any questions or comments, please feel free to contact us at any time.

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pco.edge 10 bi CLHS user manual 1.0.0

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Contents

1 Safety

This camera system is scientific measuring equipment designed to capture images for analysis. It is intended to be used by technicians, engineers, and scientists. Before using the camera system, read this manual carefully and keep a copy accessible for future reference. The camera system may only be used indoors and according to the instructions in this manual. Provisions, limitations, and operating conditions stated herein must be observed. For safety reasons, unauthorized modifications and alterations of the system are prohibited. Opening the camera voids the warranty.

DANGER
POWER SUPPLY, CABLE OR PLUG: Risk of electric shock, which can cause death or serious injury. Before each use, inspect the power supply, cable, and plug for damage. Do not use if damaged.

WARNING
VOLTAGE-CARRYING PARTS INSIDE: Risk of electric shock or injury. Do not insert any objects into the camera through its openings.

WARNING
MOISTURE ENTERS CAMERA: Risk of electric shock or injury. Keep the camera dry and protect it from extreme ambient temperature changes to prevent water condensation and damage. Operate and store the camera only within the specified temperature and humidity ranges.

CAUTION
CABLES: Risk of injury from tripping over loose cables. Keep cables organized and out of the way to prevent tripping hazards.

NOTICE
HUMIDITY, DUST, OR RADIATION: Humidity, dust, or X-rays may damage the camera. Do not operate the camera in humid or dusty environments or areas with high levels of X-ray radiation.

NOTICE
LIQUIDS: If liquids have penetrated the camera, damage may occur. Switch off the camera immediately, disconnect it from power, and contact customer support.

NOTICE
SHOCK AND VIBRATIONS: Falling, dropping, or exposure to vibrations may cause damage or affect device performance over time. Always place the camera on a flat, stable surface or mount it securely using the mounting threads.

NOTICE
HOUSING DAMAGE: If the camera has been dropped or the housing is damaged, switch off the camera immediately, disconnect it from power, and contact customer support.

NOTICE
LENS (ADAPTER) MOUNTING: Forcing lens mount adapters or lenses onto the camera may damage the threads. Always screw them gently onto the camera flange.

2 Introduction

Thank you for choosing our high-performance sCMOS camera, designed for advanced microscopy and low-light imaging applications. Engineered for precision, speed, and sensitivity, it delivers exceptional image quality across a wide range of scientific and industrial environments.

Key features[1]

- **Back illuminated sensor** with microlenses and full pixel-height deep trench isolation to reduce crosstalk and ensure a high modulation transfer function (MTF).
- **Selectable scan rates** to ensure the best image quality for a variety of applications and configurations.
- **Line scanning mode** provides even more precise timing options for sensor exposure.
- **Optimized mechanics** protect the sensor from vibrations while enabling cooling either through optimized internal airflow or via liquid cooling.
- **Camera Link HS**, renowned for its exceptional speed, reliability, and bandwidth, is combined with a fiber-optic link (FOL) for high-speed data transmission.

INFO This user manual covers the setup, configuration, and operation of the **pco.edge 10 bi CLHS** and the **pco.edge 10 bi LT CLHS**. For technical specifications, refer to the respective camera datasheets on our website.
The following icons are used to highlight information throughout the manual:

Icon	Meaning
	Difference between the two cameras.
	Important information to protect the camera system.
	Helpful tips on how to use the camera system.
	Additional equipment required to use the described function.
	Brief instructions on how to use pco.camware.

[1] Some are only available in the pco.edge 10 bi CLHS.

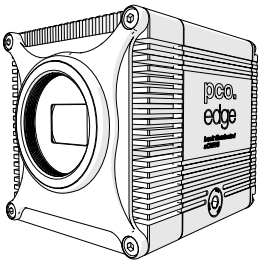
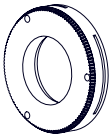
3 Package contents

Standard camera system

Ordering information	Camera system
85108076021	pco.edge 10 bi CLHS
85108076025	pco.edge 10 bi LT CLHS

When unpacking, ensure all items are present and in good condition. If anything is missing or damaged, immediately contact our customer support.
Retain the packaging box and any protective covers for future transport or storage of the system.

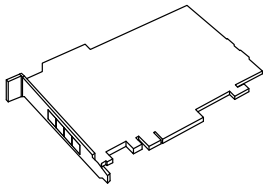
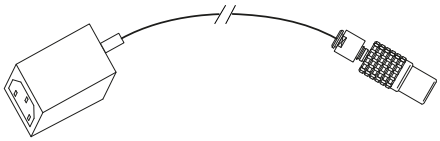
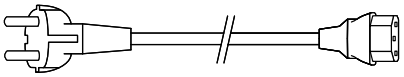
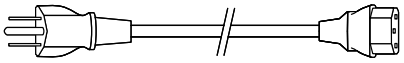
The following items are included in standard delivery[2]:

Item	Illustration
Camera pco.edge 10 bi CLHS or pco.edge 10 bi LT CLHS	
Lens mount adapter **(on camera installed)** F-mount	
Lens mount adapter **(on camera installed)** F-mount cover	
Lens mount adapter C-mount	
Lens mount adapter C-mount cover	

Continued on next page

[2]The illustrations are provided to assist in identifying the items. They are not to scale.

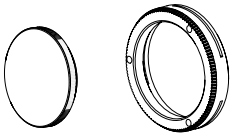
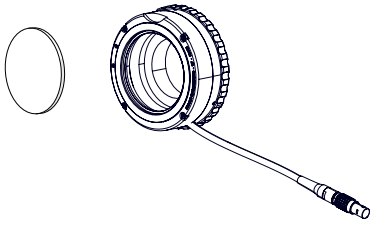
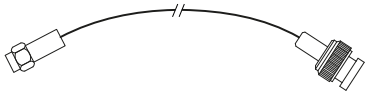
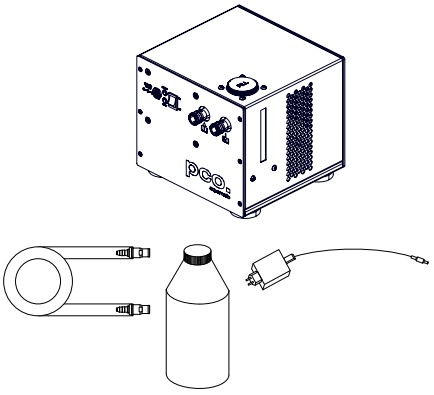
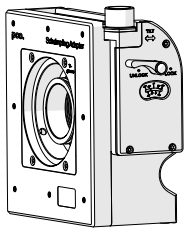
Continued from previous page

Item	Illustration
Frame grabber card Kaya CLHS compatible (SFP+ modules included)	
Data cable FOL cable (pink, 5 m)	
Power supply 24V / 65W	
Power cable EU	
Power cable USA	
QR code card camera control software interface driver web support form	Links to: pco.camware pco.driver customer support

Download all pco.software products from our website free of charge.

Optional Accessories

The following accessories are compatible with the system and can be purchased separately:

Item	Illustration	Article number
Lens mount adapter TFL-mount + cover		30109000070
Lens mount adapter EF-mount + cover		30108025020
Coaxial cable SMA - BNC		10307000116
Data cable FOL cable (pink, 10 m)		20307500842
Data cable FOL cable (pink, 20 m)		20307500845
Liquid cooling system pco.aquamatic III includes: cooler unit flexible tube (2x) coolant power supply		85108000245
Camera adapter pco.scheimpflug		30109000500

If you have any questions or special requests, visit our website and feel free to contact us.

4 Quick Start Guide

For your first images, choose a compatible lens and an object that is visible under normal light conditions as well as easy to focus on.

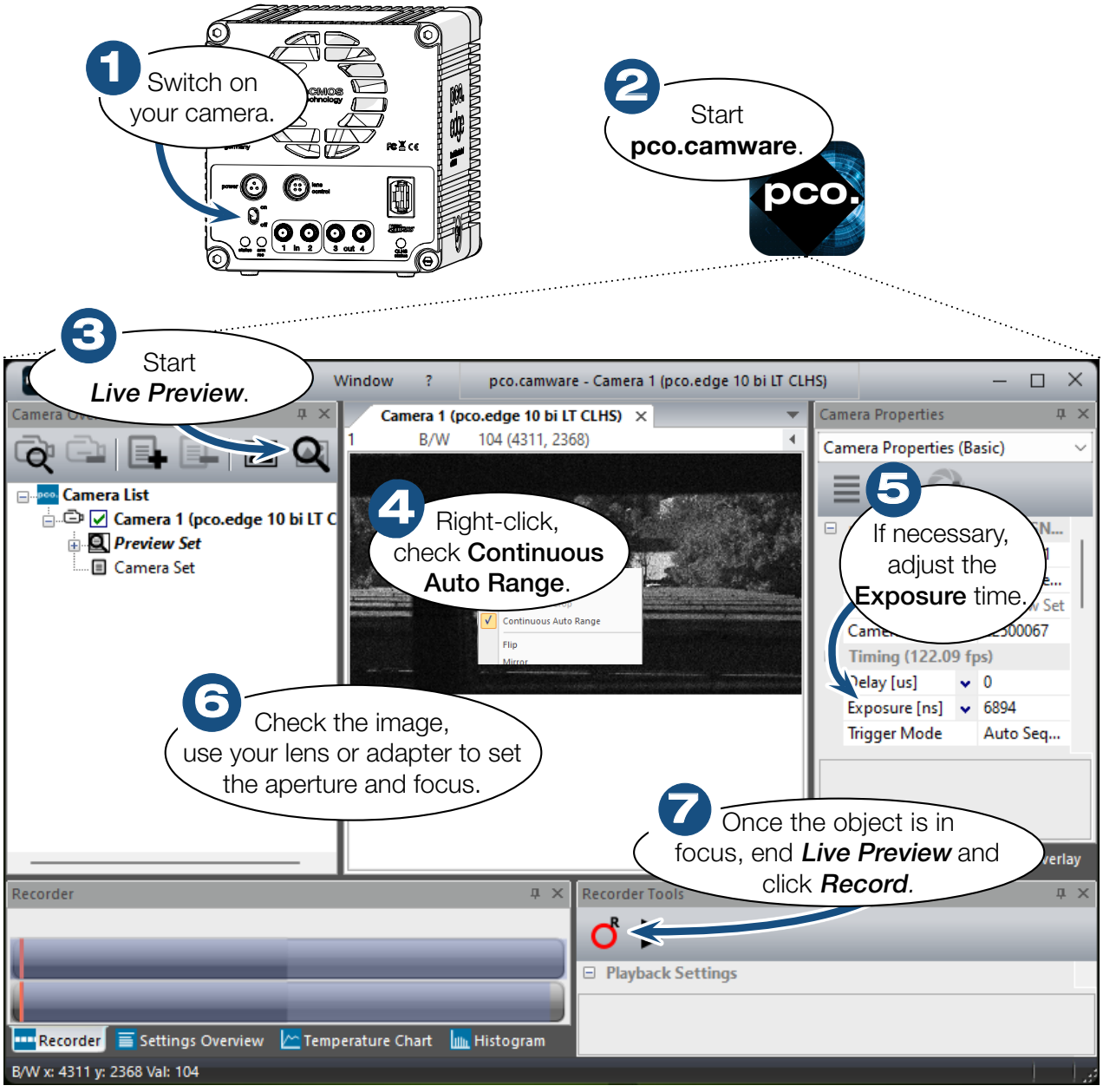
Required setup

Your computer:

- is equipped with the provided **frame grabber** (CLHS interface),
- has the latest version of **pco.camware**, and
- the latest version of **pco.driver KAYA** installed.

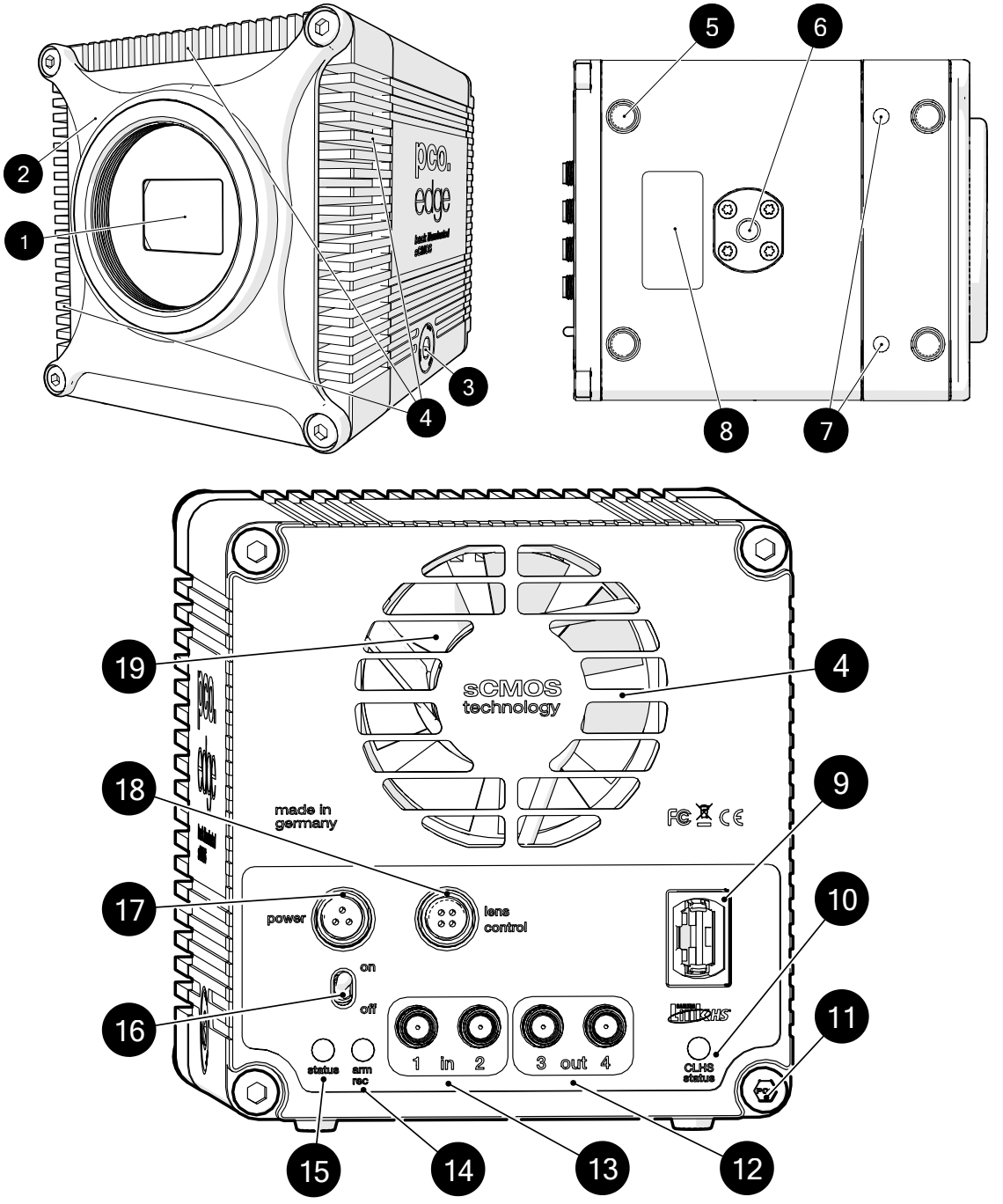
Your camera:

- is powered by the provided power supply and power cable and
- is connected to the computer via the provided FOL cable.



5 Camera overview

5.1 Camera components



1 input window
2 camera flange
3 coolant port
4 air vents
5 rubber foot
6 tripod mount
7 mounting threads
8 serial number label
9 data port (CLHS)
10 LED ”CLHS status”
11 tamper seal
12 SMA output connectors
13 SMA input connectors
14 LED ”arm/rec”
15 LED ”status”
16 on/off switch
17 power port
18 lens control port
19 cooling fan

5.2 Ports, connectors and cables

Ports and connectors:

All electrical ports and connectors are located on the rear panel of the camera, the cooling ports are hidden threads located at the sides of the housing.

Type	Description
Data	Camera Link HS (F3, 4x4, S10)
Power	LEMO EGG.0B.303 (3-pin)
SMA (input/output)	jack, 50 Ω, straight panel mount, DC-6 GHz, gold-plated
Lens control[3]	LEMO EGG.0B.304 (4-pin)
Coolant	G 1/8 thread (6H, 7 mm depth)

Cables:

The standard camera system includes a power supply, two power cables, and an FOL cable for data transfer.
Optionally, add one to four coaxial cables for status or trigger functionality, depending on the setup.

Type of cable	Length	Description
Data cable	5.0 m	FOL MTP/LC (Female B/4X) BREAKOUT OM4
Power supply	1.0 m	IEC 60320 C14 to LEMO FGG.0B.303 (3-pin) Input: 100 - 240 VAC Output: 24 VDC, 2.71 A, 65 W
Power cable (EU)	2.0 m	Type F (Schuko) to IEC 60320 C13
Power cable (US)	2.0 m	Type B (NEMA 5-15 P) to IEC 60320 C13
Coaxial cable	0.3 m	SMA (plug, 50 Ω, straight connector, DC-6 GHz, gold-plated) to BNC (jack, 50 Ω, straight connector, DC-6 GHz, nickel-plated)

NOTICE: Note that other cables may not be suitable for the camera system. If other cables are used, full functionality and regulatory compliance cannot be guaranteed.

5.3 Input/Output signal specifications

The camera is equipped with four SMA connectors, two of them designated for input signals and two for output signals:

Connector	Input/Output	Signal	Sensitivity type
SMA 1	input	exposure trigger	edge
SMA 2	input	acquire enable	level
SMA 3	output	status	level
SMA 4	output	status	level

[3] To be used with the pco.lens adapter EF-mount.

The input signals need to meet the following electrical requirements:

Input	Requirements
Type	digital
Level	3.3 V LVTTL (5 V tolerance)
Coupling	DC
Impedance	1 kΩ
Slew rate	>1 V/ms

The output signals have the following electrical properties:

Output	Properties
Type	digital
Level	3.3 V LVTTL
Coupling	DC

5.4 Lens mount adapter system

Our cameras are equipped with the camera flange as interchangeable lens mount adapter system. With the camera flange and our lens mount adapters the cameras can be used with a wide range of standard lenses.

NOTICE: Dust particles can damage the camera sensor's input window. When changing lens mount adapters, work in a clean environment and ensure not to touch the input window.

Use our free lens selector tool **MachVis OnLine** to find a suitable lens for your camera system.

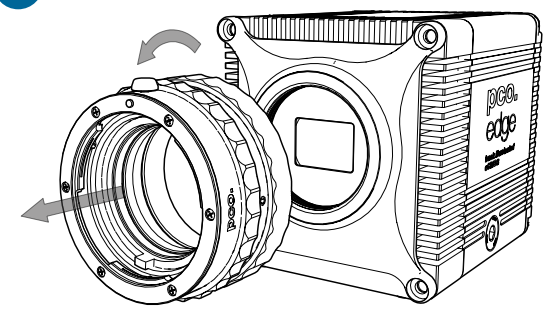
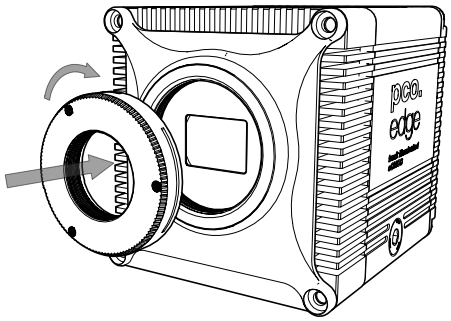
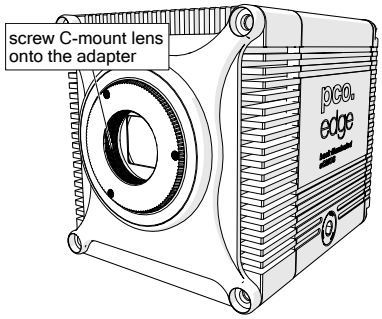
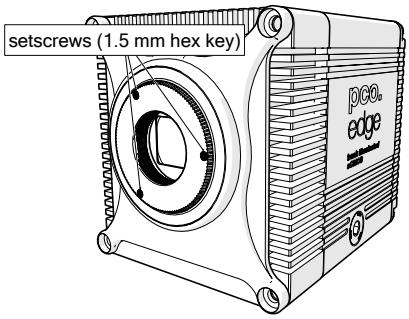
5.4.1 How to switch to C-mount/TFL-mount

For standard delivery the camera is equipped with an F-mount adapter. To attach a C-mount lens, observe the following steps to switch from the F-mount adapter to the C-mount adapter.

For TFL-mount lenses follow the same steps to switch to the TFL-mount adapter.

NOTICE: Dust particles can damage the camera sensor's input window. When changing lens mount adapters, work in a clean environment and ensure not to touch the input window.

NOTICE: Using too much force may damage the setscrews. To secure the adapter, apply a maximum torque of 0.8 Nm. Keep the front of the camera turned sideways or down when securing the adapter to prevent dust particles from falling onto the input window.

1  Turn the F-mount adapter counterclockwise to loosen it.	2  Turn the C-mount adapter clockwise and screw it in gently until it sits snugly.
3  Screw a C-mount lens onto the adapter and perform the **fine focal adjustment** to set the flange focal distance to 17.526 mm.	4  Hold the adapter in place and secure it with the three setscrews and a 1.5 mm hex key.

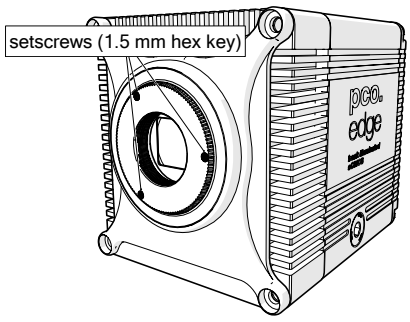
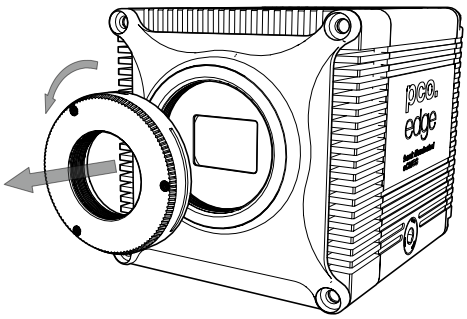
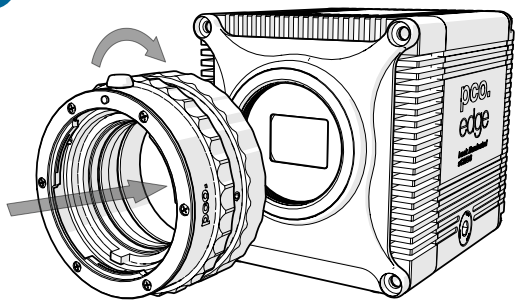
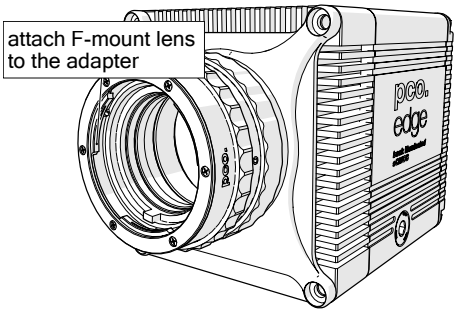
Keep in mind that C-mount lenses might cause vignetting in full-resolution images because this camera system has a large sensor diagonal and wide field of view. To avoid vignetting with a C-mount lens, use the **Region of Interest (ROI)** function to limit the resolution.

5.4.2 How to switch to F-mount/EF-mount

To use an F-mount lens, observe the following steps to switch from the C-mount/TFL-mount adapter to the F-mount adapter.

Follow the same steps to switch to the EF-mount adapter.

NOTICE: Dust particles can damage the camera sensor's input window. When changing lens mount adapters, work in a clean environment and ensure not to touch the input window.

1  Use a 1.5 mm hex key to loosen the setscrews.	2  Turn the C-mount adapter counterclockwise to take it off.
3  Turn the F-mount adapter clockwise and screw it in gently until it sits snugly.	4  Attach an F-mount lens to the adapter and perform the **fine focal adjustment** to set the flange focal distance to 46.5 mm.

Our F-mount adapter supports lenses with automatic diaphragm, allowing you to set the aperture using the adapter's aperture ring. F-mount lenses without an automatic diaphragm can still be mounted, but their aperture cannot be controlled via the adapter and must be set manually on the lens.

5.4.3 How to perform fine focal adjustment

For the fine focal adjustment of any of the lens mount adapters, use compatible lenses with a large aperture.

To adjust the **EF-mount adapter**, connect the cable to the lens control port and follow along via software using the **Lens Control** option.

Follow these steps:

1. Screw a lens with a large aperture onto the adapter, turning it clockwise.
2. Follow the **Quick Start Guide** to see an image.
3. Set the lens focus to infinity.
4. Point the camera at a distant object.

   Rule of thumb: The distance to the object must be at least 200 times the focal length of the lens. The further away, the better.
5. Adjust the adapter until the object is in focus.
6. Set the lens focus to minimum working distance (opposite to infinity).
7. Point the camera at an object placed at the minimum working distance.
8. Adjust the adapter until the object is in focus.
9. Repeat steps 3 - 8 until the focus is consistently sharp in both positions.

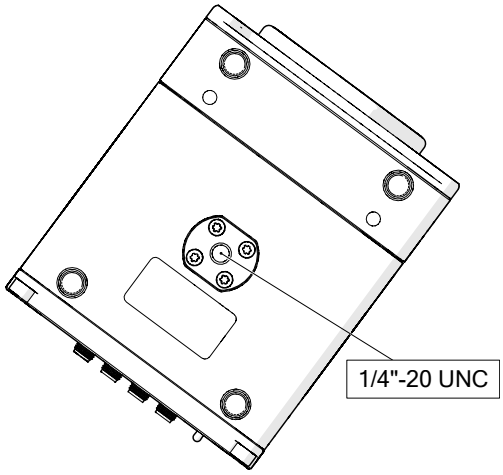
5.5 Camera mounting

To reduce vibrations when placed on a flat surface, the camera is equipped with rubber feet. Additionally, there are several options to mount the camera. Ensure the camera is mounted firmly to prevent vibrations from affecting image quality. Choose liquid cooling to further minimize vibrations.

NOTICE: Dropping the camera may damage the camera housing and/or parts inside. When mounting the camera, make sure it is mounted securely. If the camera has been dropped, cut off the power supply and contact customer support.

5.5.1 Tripod mounting

The camera can be mounted on a tripod via the tripod mount located in the center of the bottom of the housing. To ensure the camera's compatibility with most conventional tripods, this mount is equipped with a 1/4"-20 UNC thread.



NOTICE: Do not overtighten, as this might damage the mounting stud or thread. For the 1/4"-20 UNC thread the maximum recommended torque is 7 nm.

5.5.2 Custom mounting

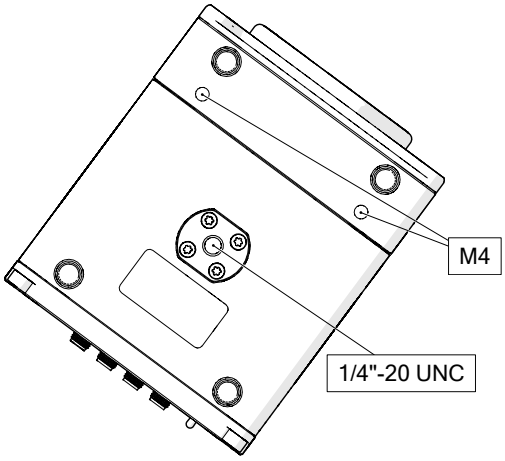
The camera housing includes several attachment points on the bottom and front, offering flexibility for accommodating customer-designed mounting solutions. It is recommended to use more than one attachment point to stabilize the camera.

When designing a mounting device, keep the camera's weight and dimensions in mind. For more information, refer to the camera's datasheet and download the supporting drawings from MachVis OnLine.

NOTICE: Overtightening the screws when mounting the camera may cause damage. The maximum recommended torque for the M4 threads is 2.2 Nm. For the 1/4”-20 UNC thread do not exceed a torque of 7 Nm.

Bottom mounting:

There are two M4 threads located at the bottom toward the front. In addition, feel free to use the tripod mount in the center.

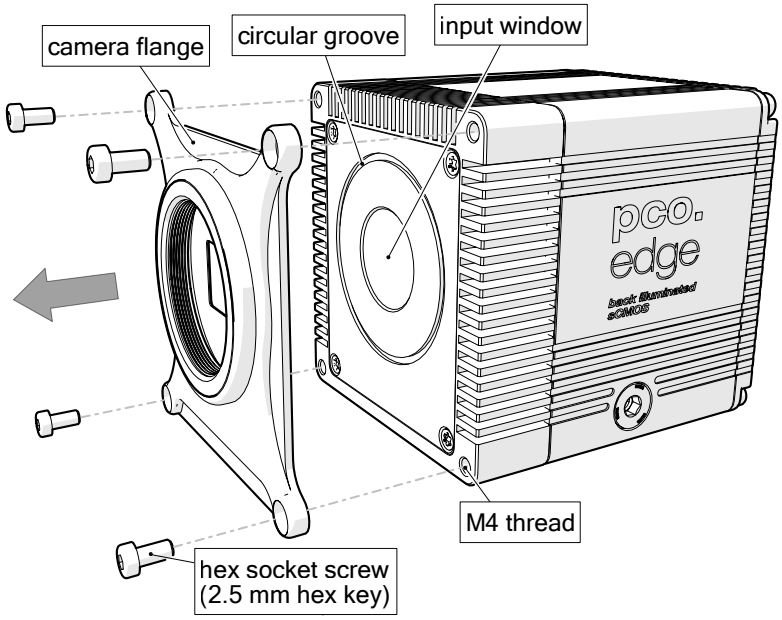


Front (Direct) mounting:

There are four M4 threads located at the front of the housing, usually used to attach the camera flange to the camera. The camera flange is detachable and the four threads may be used to secure the camera directly (without a lens or lens mount adapter) to a mounting device.

By direct mounting you can make use of the minimum distance between the camera’s housing and its focal plane.

NOTICE: Dust particles can damage the camera sensor’s input window. When taking off the camera flange, work in a clean environment and make sure not to touch the input window.



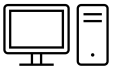
Follow these steps:

1. Remove the lens, lens mount adapter and camera flange.
2. Seal the circular groove with an O-ring or design the mounting device to block any parasitic light.
3. Secure the camera to the mounting device by using the M4 threads.

6 Setup and configuration

This chapter explains the minimum requirements for a computer to operate the camera, how to setup the hardware, and the available software options for camera control.

6.1 System requirements



These are the minimum requirements for a computer to facilitate installation, smooth operation, and performance of the camera system:

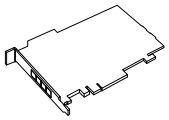
System components	Minimum requirements
OS (64-bit)[a]	Windows 10 or later Ubuntu 20.04 or 22.04 Debian 11 or 12 RHEL 8 or 9 Rocky Linux 8 or 9
CPU	i7 or XEON > 2.8 GHz
RAM	16 GB
Storage	500 MB (SSD; NVMe)
GPU	Nvidia (CC $\geq$ 8; VRAM $\geq$ 2 GB)
Display	Full-HD resolution display
PCIe slot	Gen 3 x8

[a] Not all products in our software suite are compatible with every operating system listed.

We recommend to use only currently supported operating systems.

Download the latest versions of our pco.software and camera drivers from our website.

6.2 Frame grabber



A CLHS-compatible frame grabber card is included on delivery as part of the camera system. This card is to be used to establish the CLHS connection for data transfer between the computer and the camera. Download and install the PCO CLHS driver from our website to use the frame grabber with the camera.

Follow the installation guidance in our pco.driver manual and any information given by the manufacturer.

6.3 Cooling system

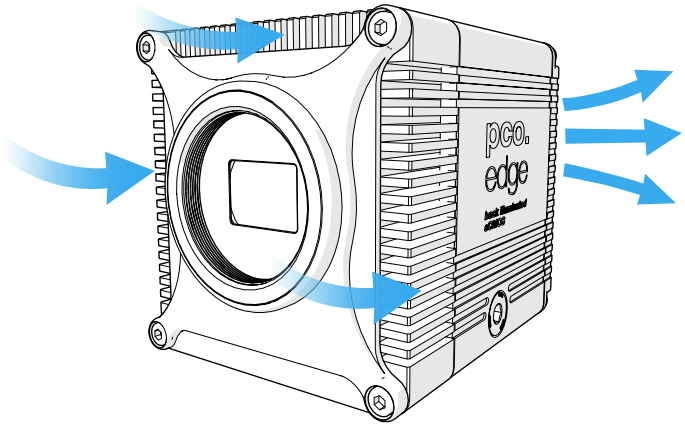
The camera's cooling system supports two cooling methods. Choose between forced air and liquid cooling by adding an external liquid cooling system.

Keep ambient temperature stable for optimal performance.

6.3.1 Forced air cooling

Air cooling by fan is the default mode.

The fan turns on automatically when the camera is powered on. Air vents are located at the front, top and both sides of the camera, enabling airflow to the fan at the rear. To ensure a constant operating temperature, the camera needs a sufficient supply of fresh air.



NOTICE: Do not obstruct the air vents or the fan of the camera. To ensure adequate airflow, allow sufficient clearance around all the air vents. Prolonged exposure to excessive heat or inadequate ventilation can wear out components, leading to more frequent repairs or even replacement.

6.3.2 Liquid cooling

Additional equipment required:
To use this option, an external liquid cooling system is required. We recommend the use of the pco.aquamatic III, on which our cameras have been tested.

NOTICE: Using coolant below the ambient dew point temperature may cause water condensation, risking damage to electronics and image quality. Always maintain coolant temperatures as specified by the manufacturer and consider ambient conditions to prevent condensation.

Set up and connect the liquid cooling system before powering up the camera.

Follow these steps:

1. Set up the liquid cooling system according to the instructions in its manual.
2. Remove the protective covers (5.0 mm hex key, counterclockwise) from the coolant ports on the sides of the camera.
3. Attach the coolant connectors to the camera housing by turning them clockwise.
4. Connect the tubes to the coolant connectors.

There is no need to disconnect the liquid cooling system after every use. For longer storage periods or when removing the external cooling system, leave the coolant connectors attached to the camera housing to prevent any residual coolant from leaking.

6.4 Hardware setup

This section explains the hardware setup to use the camera system, including the most common optional components.

NOTICE: Do not bend, kink, or sharply twist the FOL cable at any time to avoid damage and signal loss. The minimum bend radius is 7.5 mm.

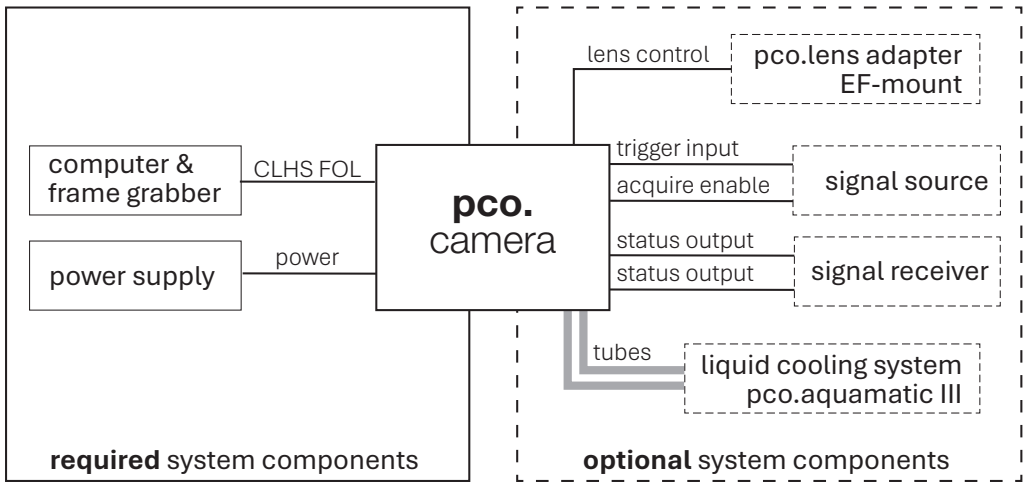
These components are essential:

1. Install the **frame grabber**.
2. Power the camera via the included power supply and cable.
3. Take off any plastic covers and connect the FOL cable to the camera and the computer for data transfer. Make sure to use all four connectors on the multi-connector end.

These components are optional, adjust the order depending on the individual setup:

4. Connect the camera to an external liquid cooling system.
5. Attach a coaxial cable for signal input to one or both SMA input connectors.
6. Attach a coaxial cable for status signal output to one or both SMA output connectors.
7. Connect the pco.lens adapter EF-mount to the lens control port for remote lens control.

Example setup:



6.5 Software options

This section provides an overview over the available software needed to control the camera. In addition to our main camera control software **pco.camware**, we offer both **software development kits** as well as third-party **application integrations** to address the full range of user needs.

All pco.software products are available on our website free of charge.

Unless otherwise stated, all software-related instructions and explanations in this manual pertain to the GUI software **pco.camware**, which is used for demonstration purposes due to its broad applicability and ease of use.

6.5.1 PCO user interface software

Our graphical user interface (GUI) camera control software **pco.camware** is a Windows application suitable for all our camera systems. We recommend using this software for initial setup and to get acquainted with the camera.

This application enables control of most camera settings and facilitates image acquisition and storage. You can customize it exactly to your needs using different layouts, styles and features.

Download the latest version from our website and follow the installation guide in the pco.camware Manual.
⟶ During installation, when the window **Choose Components** appears, make sure **Camera Link HS DLL (CLHS)** is checked.

6.5.2 PCO software development kits

PCO offers software development kits (SDK) for a wide range of different programming languages to be used for customized applications. They are compatible with Windows and Linux platforms.

We feature the high-level SDKs **pco.cpp**, **pco.python**, and **pco.csharp** for C++, Python, and C# applications, respectively. To control the camera in MATLAB, LabVIEW, and Java, use **pco.matlab**, **pco.labview**, and **pco.java**.
For users requiring a low-level C interface, we also provide the general SDKs, **pco.sdk** and **pco.recorder**.

More detailed information can be found on our website.
Visit our GitHub repositories for example projects.

6.5.3 Application integrations

In case you are already used to a different software, PCO cameras are also integrated in a variety of widely used third-party applications.

We provide and manage the **PCO µManager Integration**, which allows for camera control directly in µManager.

Other integrations are developed and maintained by third-party software providers. For microscopy this includes applications such as **NIS-Elements** and **VisiView**.

7 Operation modes

This chapter provides a detailed overview of the camera's functions and features, outlining the various operational modes.

If not stated otherwise, all settings are available in **pco.camware**. The pco.camware logo indicates short instructions on how to use the respective settings in pco.camware. For detailed instructions, refer to the pco.camware user manual.

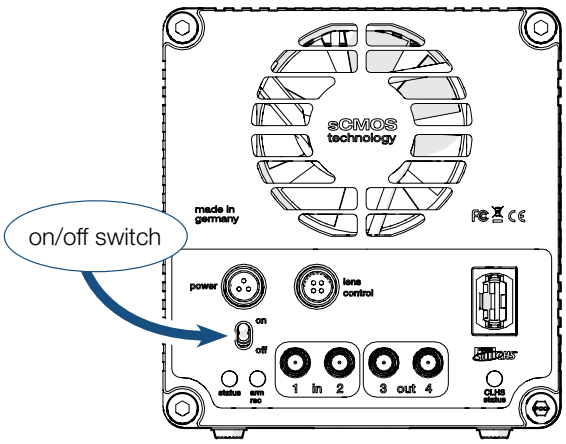
7.1 Basic operation

This section covers the basic operation of the camera, including switching it on or off, understanding the provided LED signals, and how to set the exposure time for image acquisition.

Follow the **Quick Start Guide** to capture your first images.

7.1.1 Switching the camera on/off

After the hardware setup is finished and the camera is powered up, the camera is ready for use. The on/off switch is located at the rear panel of the camera.



1. To turn on the camera, move the on/off switch upward.
2. To turn off the camera, return the on/off switch downward.

7.1.2 LED signals and their meanings

The camera is equipped with three LEDs, labeled ”status”, ”arm/rec” and ”CLHS status”. These LEDs are located on the rear panel of the camera and provide information about the state of the camera.

For light-sensitive environments the LED lights can be switched off via software. However, as these signals give important information, they should be switched on to check the state of the camera if issues arise.

LED ”status”

This LED indicates the general state of the camera. It displays three colors, which have the following meanings:

Color	Meaning
(off)	camera is without power / switched off
orange	camera is booting
green	camera is ready for use
red	error (see the **Troubleshooting chapter**)

LED ”arm/rec”

This LED only lights up when the status of the camera is ”ready for use” (green light LED ”status”). When the status is different, the LED ”arm/rec” is off. It is capable of displaying orange, either solid or blinking, with the following meanings:

Signal	Meaning
(off)	camera is disarmed
solid orange	camera is armed/ready to record
blinking orange	camera is recording

LED ”CLHS status”

This LED provides information about the status of the camera’s CLHS connection. It is capable of displaying green, with the meaning:

Signal	Meaning
(off)	camera is without power / switched off
solid green	camera is waiting for CLHS connection CLHS connection is established

7.1.3 Setting the exposure time

Set the exposure time via software. If the image is too bright, decrease it. If the image is too dark, increase it.

Keep in mind that longer exposure times may affect the frame rate.

Because of the sensor's line-by-line readout, the exposure time can only be set in whole multiples of the line time. The exposure time range and line time depend on the **scan rate**[4]:

Scan rate	Exposure time range	Line time
fast scan	6.895 µs - 10 s	6.895 µs
medium scan	13.789 µs - 10 s	13.789 µs
slow scan	1 ms - 10 s	27.578 µs

Adding delay:

For precise synchronization with external devices, there is the option to add delay before the exposure of each frame. Delay may be added in steps of the line time up to a maximum of 1 s. Adding delay will reduce the frame rate.

pco.camware:
Set the exposure time in nanoseconds, microseconds or milliseconds. The software automatically adjusts the time to the nearest line time multiple. It may be adjusted during recording.

7.2 Defining Regions of Interest (ROI)

A Region of Interest (ROI) limits readout to a specific part of the sensor, reducing image resolution and possibly affecting the frame rate. This saves processing time and resources by focusing only on the relevant area. Using an ROI improves efficiency and accuracy in tasks like detection, measurement, and monitoring.

The ROI can be adjusted vertically, horizontally, or in both directions, using predefined step sizes:

Vertical ROI (step size 4 rows)**:**
Setting a vertical ROI speeds up frame rate and reduces the amount of image data.

[4] The pco.edge 10 bi LT CLHS is limited to using fast scan.

Horizontal ROI (step size 32 columns)**:**
Setting a horizontal ROI reduces the amount of image data, it does not affect frame rate.

pco.camware:
Select the intended values for each side (Left, Right, Top, and Bottom) of the sensor in the ROI section.

7.3 Applying binning

Binning combines adjacent pixels (horizontally, vertically, or both) to form super-pixels. This process improves the signal-to-noise ratio (SNR) by increasing the overall signal, which is useful to enhance image quality in low-light conditions. At the same time the image's spatial resolution is reduced. Note that since binning is performed digitally after signal readout, readout noise will not be reduced.

This camera supports binning for 2 or 4 pixels horizontally, vertically, or in both directions. The two most common types can be applied:

Sum binning:
The process of combining the values of the adjacent pixels by adding them together.

Average binning:
The process of combining adjacent pixels by calculating their average value.

pco.camware:
Select the intended binning mode Sum or Average and specify the number of pixels to combine horizontally and/or vertically in the Binning section.

7.4 Using lens control

Requires optional accessory:
The lens control function requires the pco.lens adapter EF-mount and a compatible lens.

If access to the camera is difficult, this camera supports remote lens control for electronic lenses when using the pco.lens adapter EF-mount.

Follow these steps:

1. Attach the pco.lens adapter EF-mount and a compatible lens to the camera.
2. Connect the cable of the pco.lens adapter EF-mount to the lens control port at the rear of the camera.
3. Adjust aperture and focus via software.

pco.camware:
Open the Lens Control Dialog and adjust aperture and focus by using the sliders.

7.5 Adjusting the cooling setpoint

The sensor temperature can be adjusted within a specified range to optimize performance based on your application needs.

Lowering the sensor temperature generally reduces thermal noise, improving image clarity. Higher temperature setpoints may be preferable to reduce power consumption or to prevent moisture buildup in humid environments.

After adjusting the temperature, always monitor image quality and allow the camera sufficient time to stabilize. Maintaining a stable ambient temperature will help ensure consistent performance.

Keep in mind that the camera is calibrated at a default temperature setpoint, designed to deliver optimal image quality and noise performance under typical conditions. Significant deviations from the calibrated temperature may affect noise characteristics and overall image quality.

pco.camware:
Adjust the sensor temperature by changing the Cooling Setpoint in the Sensor Control section.

7.6 Selecting a scan rate

Note:
Only the **pco.edge 10 bi CLHS** allows selecting between the three scan rates.
The **pco.edge 10 bi LT CLHS** is limited to using fast scan.

The scan rate refers to the speed at which the sensor reads out image data. This camera offers three selectable scan rate configurations designed to optimize performance based on specific application requirements by balancing key parameters for image quality.

- **Fast scan (275 MHz):** enables high frame rates essential for capturing rapid events.
- **Medium scan (137 MHz):** provides an intermediate setting, balancing high frame rates with improved noise performance.
- **Slow scan (68 MHz):** minimizes readout noise, making it well-suited for low-light imaging and high-precision applications.

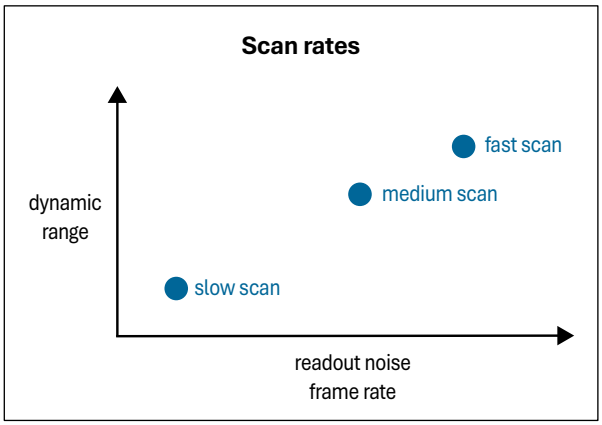


Diagram is not to scale and is intended for reference only.

The diagram above illustrates the relationship between the three scan rate configurations and three key performance parameters: dynamic range, readout noise, and frame rate.

pco.camware:
Select the scan rate by choosing the corresponding value for Pixelrate [MHz] in the Sensor Control section.

7.7 Choosing a shutter mode

The camera is equipped with a rolling shutter sensor. In standard rolling shutter mode, the exposure time is set directly. Additionally, the line scanning mode is available, offering enhanced control over exposure timing by adjusting two parameters: the line time and the number of sensor lines exposed simultaneously.

For simplicity, the sensor size, indicated by the number of lines, has been limited in the timing diagrams in this chapter. For details on how a line is defined, see the Dual-row readout section.

7.7.1 Rolling shutter

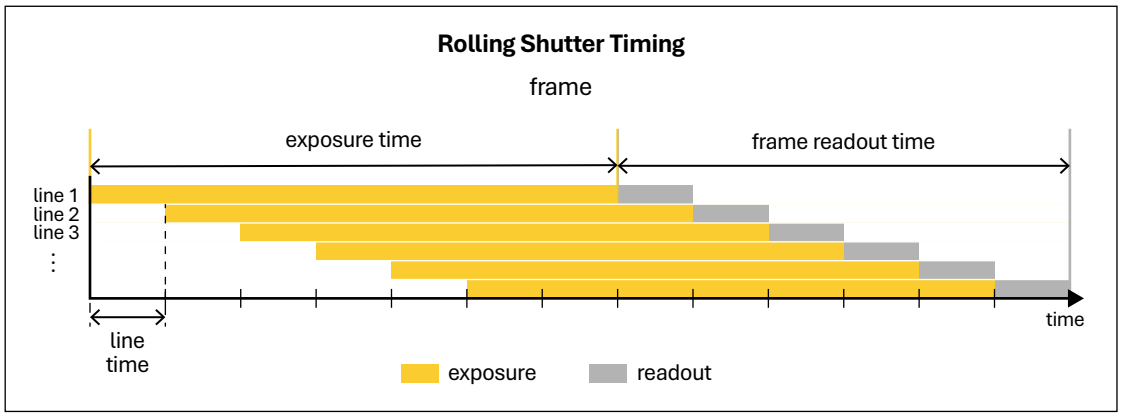
This is the default shutter mode of the camera.

In general, a rolling shutter captures an image sequentially, line by line, from top to bottom.

Each line has the same exposure time, but the exposure starts and ends at different times for each line, resulting in a staggered capture across the frame. After a line's exposure ends, it is read out immediately. Within each line, all pixels are exposed simultaneously and then read out in parallel.

While multiple lines may be exposed at the same time, readout occurs strictly sequentially, one line after another. Since the timing is controlled by the sensor, readout can begin only at regular intervals, called the line time. This means that exposure can start and stop only at specific times, with each line beginning its exposure exactly one line time after the previous one.

The diagram below depicts the timing characteristics of a single frame captured using the rolling shutter:



In rolling shutter mode the line time is fixed and, like the exposure time range, depends on the scan rate[5]:

Scan rate	Line time	Exposure time range
fast scan	6.895 µs	6.895 µs - 10 s
medium scan	13.789 µs	13.789 µs - 10 s
slow scan	27.578 µs	1 ms - 10 s

Dual-row readout

This camera is equipped with a sensor that utilizes a fixed dual-row readout. Instead of processing a single pixel row at a time, two adjacent pixel rows — one even-numbered and one odd-numbered — are exposed and read out simultaneously. For the purposes of rolling shutter mode, these two pixel rows together constitute one line.

$$\textit{1 line} = \textit{2 pixel rows}$$

This effectively halves the frame readout time, which enables higher frame rates and reduces rolling shutter artifacts.

Overlapping exposure and readout

This camera supports overlapping exposure and readout, which means that while frame (n) is still being exposed and read out, the camera can already begin exposing the next frame (n+1). This enables higher frame rates and more efficient data acquisition without compromising image quality, which is especially relevant during continuous image acquisition.

Note that while exposure can overlap both within a frame and between consecutive frames, the readout process is still strictly sequential. As a result, the frame readout time defines the minimum possible frame time. Depending on the configuration, the highest achievable frame rate may be limited by either the frame readout time or the exposure time.

While the exposure time is set directly, the frame readout time is calculated as follows:

$$\textit{frame readout time} = \textit{line time} \times \textit{number of lines}$$

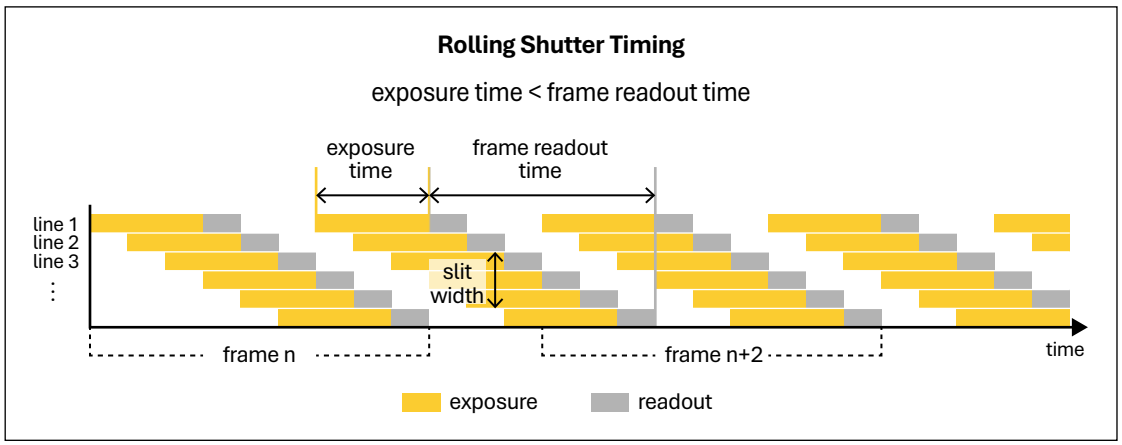
Keep in mind that setting a Region of Interest (ROI) might affect the number of lines.

[5] The pco.edge 10 bi LT CLHS is limited to using fast scan.

The following diagrams depict the limiting factors during continuous acquisition, illustrating image capture timing at the highest achievable frame rate.

Exposure time < frame readout time

When the exposure time is shorter than the frame readout time, the readout time becomes the bottleneck. The frame rate does not increase even if the exposure is shortened further.
In this scenario, the image is captured by a moving exposure slit that sequentially progresses from the top to the bottom of the sensor. At no point during the frame is the entire sensor exposed at the same time.



To calculate the slit width, which is the number of simultaneously exposed lines, divide the intended exposure time by the respective line time:

$$\textit{slit width (in lines)} = \frac{\textit{exposure time}}{\textit{line time}}$$

Example:
The slit width at an intended exposure time of 25 µs in fast scan (line time = 6.895 µs):

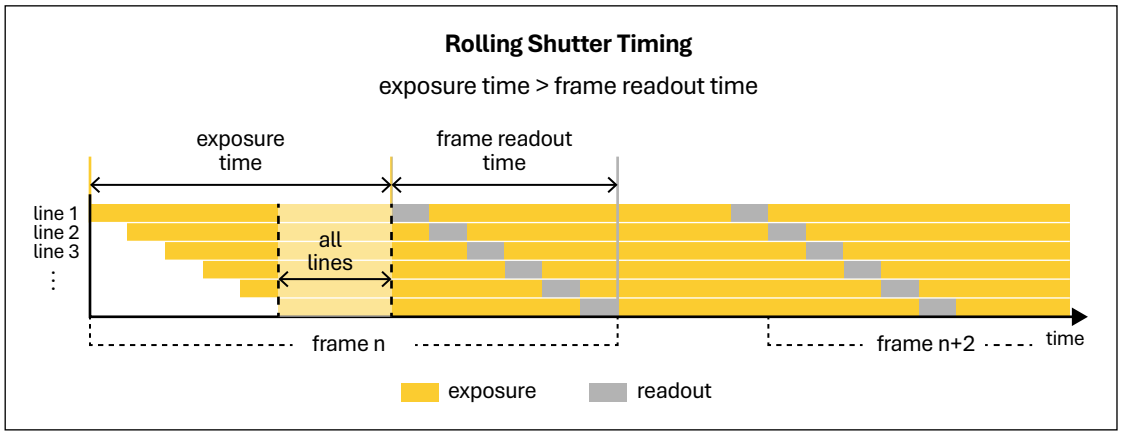
$$\textit{slit width (in lines)} = \frac{25\,\mu s}{6.895\,\mu s} \approx 3.63$$

As only entire lines can be exposed, adjust the exposure time to 3 or 4 lines.
When converting the slit width into micrometers, keep in mind: *1 line = 2 pixel rows*.

For even more precise control over exposure timing during short exposure durations, consider using line scanning mode instead of the standard rolling shutter mode.

Exposure time > frame readout time

However, when the exposure time is longer than the frame readout time, the exposure time becomes the limiting factor. Shortening it will directly increase the frame rate.
In this scenario, the entire sensor is fully exposed for a period.



When using triggered flash illumination to eliminate rolling shutter artifacts, the period when all lines are exposed simultaneously is the optimal moment to illuminate the sensor. Use the output signal Status Exposure for precise synchronization with an external light source.

Output signal for exposure timing

As exposure in rolling shutter mode is staggered across the frame, the camera provides an output signal, Status Exposure, which offers several timing options to convey information about specific phases of the exposure process.
For detailed information about this signal and its timing characteristics, please refer to the chapter **Understanding status signals** and the section **Status Exposure**.

Adding delay

For precise synchronization with external devices, there is the option to add delay before the exposure of each frame. Delay may be added in steps of the line time up to a maximum of 1 s. Adding delay will reduce the frame rate.

7.7.2 Line scanning mode

Note:
only available in the ***pco.edge 10 bi CLHS***

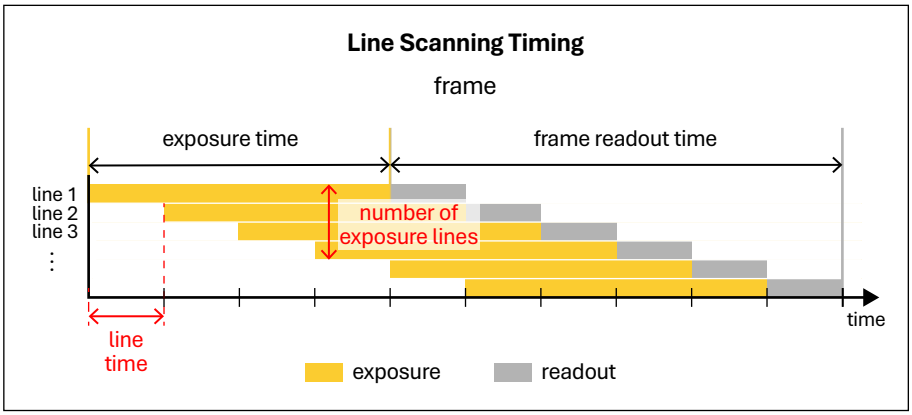
The line scanning mode is a special readout mode dedicated to lightsheet fluorescence microscopy (LSFM). Built on the rolling shutter mode, this feature enables optimized synchronization of the camera and the microscope system.

For best synchronization with external devices, choose an external trigger mode and make use of the camera's status signals.

Unlike the standard rolling shutter mode, in which the exposure time is set directly, line scanning mode allows adjustment of two key parameters: the **number of exposure lines** and the **line time**, setting the exposure time according to the relation:

$$\textit{exposure time} = \textit{number of exposure lines} \times \textit{line time}$$

Together, these two parameters control the slit characteristics — with the slit referring to the area of the sensor exposed at any given time. While the number of exposure lines defines the slit width, which corresponds to the height of the moving exposure window, the line time determines the slit speed.



Setting the line time

Specific line times are calculated by adding multiples of the step size to the minimum line time. The maximum line time defines the upper limit.

The minimum and maximum line times and the step size[6] differ for the scan rates, as shown in the following table:

Scan rate	Min. line time	Step size	Max. line time
fast scan	6.895 µs	22 ns	238.3 µs
medium scan	13.789 µs	22 ns	238.3 µs
slow scan	27.578 µs	87 ns	953.2 µs

Selecting the number of exposure lines

As this camera is equipped with a dual-row readout sensor, one exposure line is composed of two pixel rows, which are exposed and read out simultaneously:

1 exposure line = 2 pixel rows

The minimum and maximum number of exposure lines possible depend on the chosen line time, since exposure is restricted by the camera's exposure time range.

Scan rate	Exposure time range
fast scan	6.895 µs - 10 s
medium scan	13.789 µs - 10 s
slow scan	1 ms - 10 s

[6] Values are rounded to the nearest nanosecond.

Example:
In slow scan, when the minimum line time is chosen, the minimum number of exposure lines possible is 37:

$37 \times 27.578\,\mu s = 1\,020.386\,\mu s$ > min. exposure time
$36 \times 27.578\,\mu s = 992.808\,\mu s$ < min. exposure time

Adding delay

It is possible to add delay by setting a number of delay lines. The delay time is calculated, similar to the exposure time, by multiplying the line time with the number of delay lines:

$$\textit{delay time} = \textit{number of delay lines} \times \textit{line time}$$

That time is then added before each frame is exposed.
The minimum number of delay lines is 0 (no delay), while the maximum number of delay lines possible depends on the line time settings.

pco.camware:
In Camera Properties (Expert) in the Timing section set Line Scanning Mode to On. The parameters Line Time and Exposure Lines appear. Enter the intended values for both parameters.

7.8 Understanding status signals

Additional equipment required:
The status signal feature requires a compatible signal receiver and a connecting cable.

The camera can output three real-time status signals, **Status Line**, **Status Busy**, and **Status Exposure**, which may be used for synchronization purposes.

Use output ports SMA 3 and SMA 4 to measure the signals. With two cables connected, the camera can send two status signals simultaneously.

Via software you can:

- configure the signal-to-port assignment,
- switch the signals on and off,
- select the signal polarity.

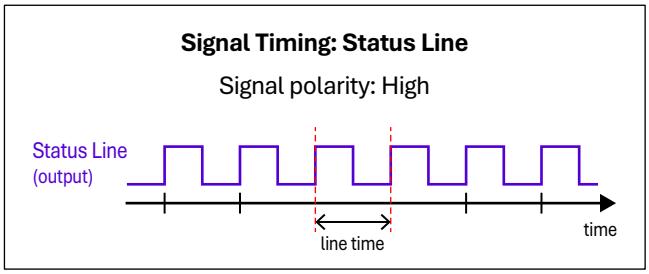
7.8.1 Status Line

This signal indicates the timing of the readout of the camera. Each line time interval is signaled by a complete period with a 50 % duty cycle (equal high and low durations). It is provided continuously by the sensor, independent of recording state or trigger events. As the signal timing corresponds to the line time, the duration of one period changes depending on the selected scan rate.

Parameter	Value
Assigned port	SMA 3 SMA 4
Status	Off On
Signal polarity	High Low

Description for signal polarity 'High':

The rising edge of Status Line indicates the beginning of a line readout. To optimize synchronization with external devices, use the rising edge of this signal.



7.8.2 Status Busy

This status signal indicates whether the camera is ready to accept a trigger. The active state of Status Busy shows that the camera is unable to process new trigger events.

Parameter	Value
Assigned port	SMA 3
Status	Off On
Signal polarity	High Low

Description for signal polarity 'High':

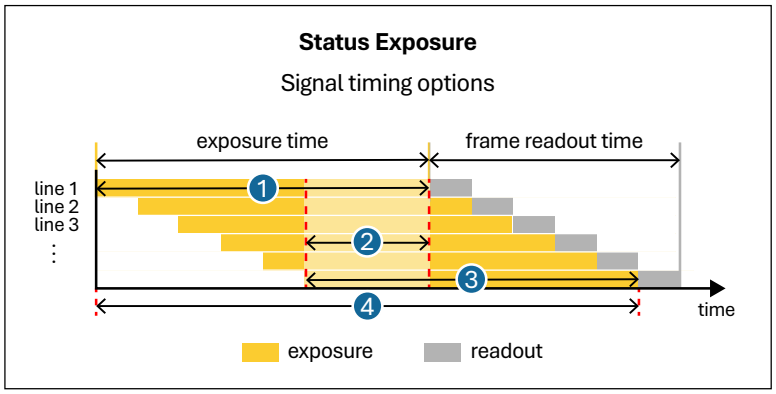
A high signal on Status Busy means no trigger can be accepted (the camera is busy), while a low signal shows that the camera can accept a new trigger.

Timing diagrams of Status Busy in combination with different trigger modes are included in the chapter **Configuring trigger modes**.

7.8.3 Status Exposure

This signal indicates the exposure phase of the sensor. Since this camera employs the rolling shutter mode, specific signal timing may be selected to show different stages in the exposure process, as illustrated in the diagram below.

Parameter	Value
Assigned port	SMA 3 SMA 4
Status	Off On
Signal polarity	High Low
Signal timing	1 Show time of 'First Line' 2 Show common time of 'All Lines' 3 Show time of 'Last Line' 4 Show overall time of 'All Lines'



Choosing suitable signal timing:

1. The duration of the signal for *Show time of 'First Line'* corresponds to the user-defined exposure time, representing the start of exposure for each frame.

2. The signal *Show common time of 'All Lines'* represents the period during which all sensor lines are exposed simultaneously. This signal is intended for precise synchronization with an external light source used for triggered flash illumination.
   To use this signal timing, ensure that the configured exposure time exceeds the frame readout time. Otherwise, there will be no interval during which all lines are exposed simultaneously and the signal will not be generated.

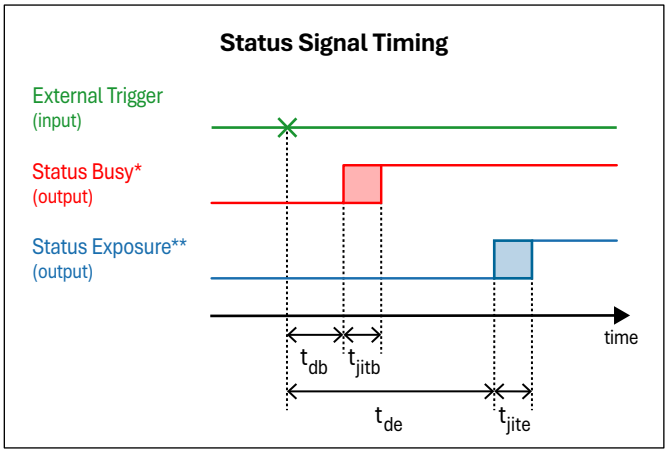
3. The duration of the signal for *Show time of 'Last Line'* corresponds to the user-defined exposure time, representing the end of exposure for each frame.

4. The signal *Show overall time of 'All Lines'* indicates the period during which any line of the sensor is being exposed. Without overlap between frames, this signal marks the beginning and end of exposure for each frame. With exposure overlapping between frames, the signal may remain active continuously.

Timing diagrams of Status Exposure in combination with different trigger modes are included in the chapter **Configuring trigger modes**.

7.8.4 Timing characteristics

After the camera receives a trigger signal, there is a short processing delay before the signals for Status Busy and Status Exposure are updated. The following timing diagram illustrates these delays, followed by a table presenting precise delay measurements[7] for each scan rate[8].



*Status Busy is shown with signal polarity: High.
**Status Exposure is shown with signal polarity: High and signal timing: Show time of 'First Line'.

Parameter	Fast scan	Medium scan	Slow scan
t_{db} (delay Status Busy)	53 ns	53 ns	112 ns
t_{jitb} (jitter Status Busy)	7 ns	7 ns	29 ns
t_{de} (delay Status Exposure) Standard rolling shutter:	4 line times -1.3 µs 26.3 µs	4 line times -1.3 µs 53.9 µs	4 line times +12.3 µs 122.7 µs
t_{jite} (jitter Status Exposure) Standard rolling shutter:	≤1 line time ≤6.9 µs	≤1 line time ≤13.8 µs	≤1 line time ≤27.6 µs

7.9 Configuring trigger modes

The camera supports several trigger modes. You can choose between Auto Sequence, Software Trigger, External Exposure Start and External Exposure Control. Select the trigger mode via software. The signal for external triggering is received via input port SMA 1.

Adding delay

For precise synchronization with external devices, there is the option to add delay via software before the exposure of each frame in all trigger modes but External Exposure Control. Delay may be added in steps of the line time up to a maximum of 1 s.
Adding delay will reduce the frame rate.

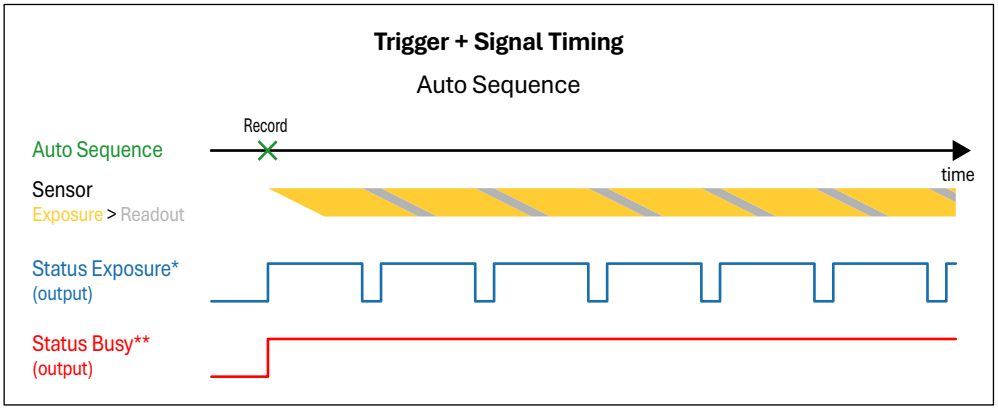
[7] Values are rounded to the nearest nanosecond and to one decimal place for microseconds.
[8] The pco.edge 10 bi LT CLHS is limited to using fast scan.

The diagrams shown in this chapter do not include any system delay or jitter times for either trigger or status signals, unless explicitly stated.

7.9.1 Auto Sequence

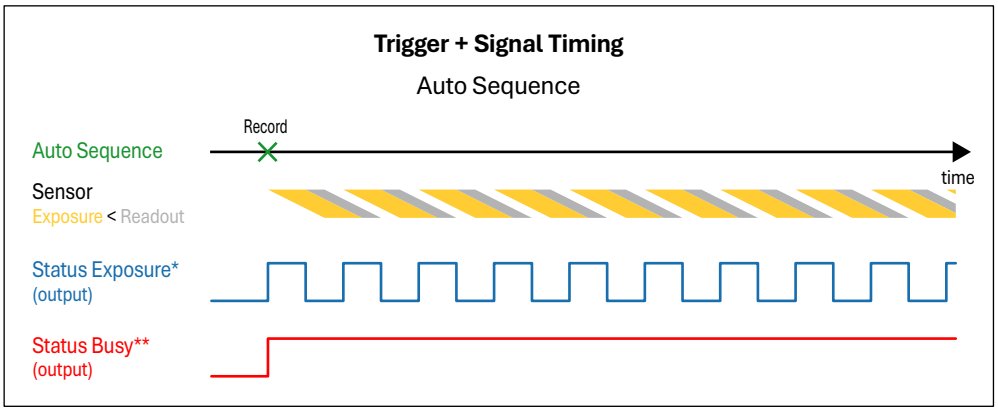
This is the default trigger mode. In this mode, image acquisition runs continuously between a start command and a stop command.
Use this mode when the focus is on capturing the maximum number of frames per second.

The camera optimizes image acquisition by computing the highest achievable frame rate based on the current configuration. When the exposure time is longer than the frame readout time, the next frame begins exposure immediately after the first line of the previous frame has been read out. In this case the exposure duration is the limiting factor for achieving a high frame rate, as shown in the diagram below.



*Status Exposure is shown with signal polarity: High and signal timing: Show time of 'First Line'.
**Status Busy is shown with signal polarity: High.

When the exposure time is shorter than the frame readout time, the camera schedules the next exposure of the first line based on the readout timing. It is timed so precisely that when the readout of the last line of one frame finishes, it immediately continues with the readout of the first line of the next frame. The result is a seamless transition between the readout of two consecutive frames, making the frame readout time the limiting factor for a high frame rate, as illustrated in the following diagram.

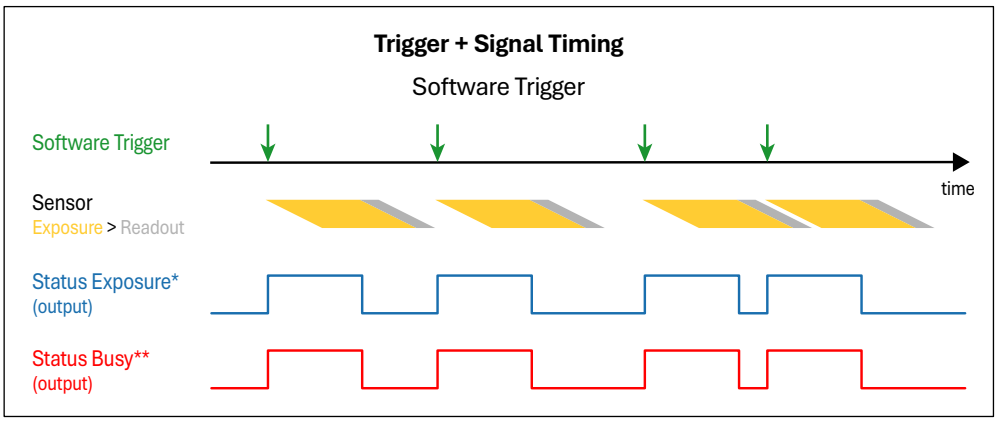


*Status Exposure is shown with signal polarity: High and signal timing: Show time of 'First Line'.
**Status Busy is shown with signal polarity: High.

pco.camware:
Choose Trigger Mode **Auto Sequence**.
Click 'Record' and continuous image acquisition starts.

7.9.2 Software Trigger

This trigger mode is for the acquisition of single images via software command. Its focus is on capturing a specific event on demand.
Use this mode for low-frequency image acquisition of static objects, where precise timing is not critical.



*Status Exposure is shown with signal polarity: High and signal timing: Show time of 'First Line'.
**Status Busy is shown with signal polarity: High.

pco.camware:
Select Trigger Mode **Soft Trigger**.
Click 'Record' and the 'Trigger' button appears next to it.
With every click on 'Trigger' a single image is captured.

7.9.3 External Exposure Start

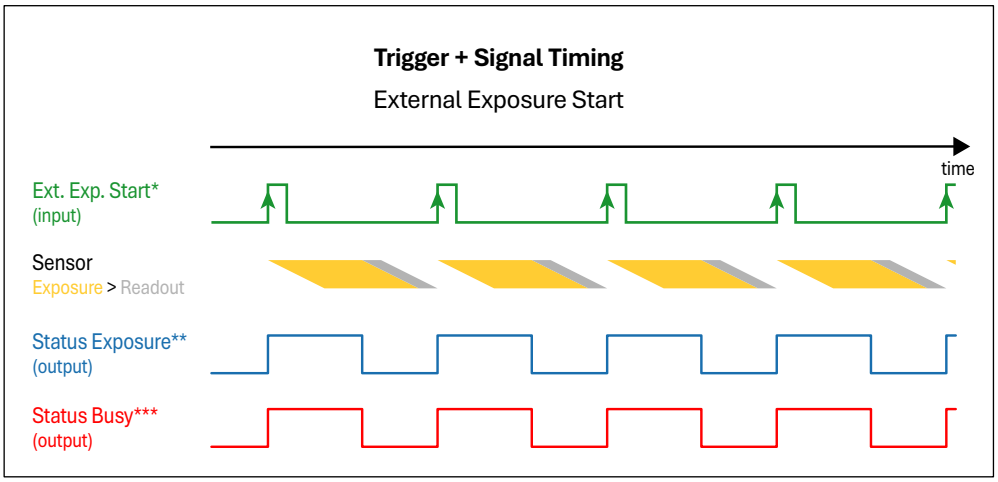
Additional equipment required:
This mode requires an external trigger source and a connecting cable.

In External Exposure Start, each exposure is initiated by an external trigger signal.
Use this mode for precise timing of image capture and to synchronize the camera with external devices.

Parameter	Value
Assigned port	SMA 1 (CLHS trigger card)
Status	Off On
Signal polarity	Rising Falling

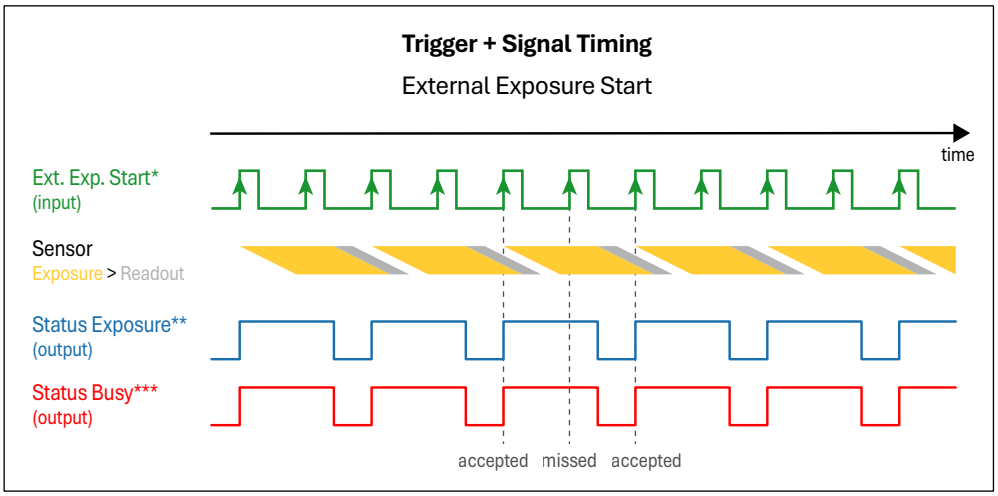
Due to the **rolling shutter design** of the sensor, exposure can only start at specific times determined by line timing. The exact timing is explained in the section Timing characteristics below.

By default, each rising edge of the signal triggers the capture of a single image. The signal frequency directly determines the frame rate. Without a trigger, no image is acquired.



*Ext. Exp. Start is shown with signal polarity: Rising.
**Status Exposure is shown with signal polarity: High and signal timing: Show time of 'First Line'.
***Status Busy is shown with signal polarity: High.

The possible frame rate is limited by sensor exposure, readout, and processing time, depending on the current configuration. In the External Exposure Start trigger mode, trigger events can be accepted during readout, as indicated by the Status Busy signal. If trigger pulses exceed the camera's capacity, some may be missed, resulting in fewer images captured than expected from the signal frequency.

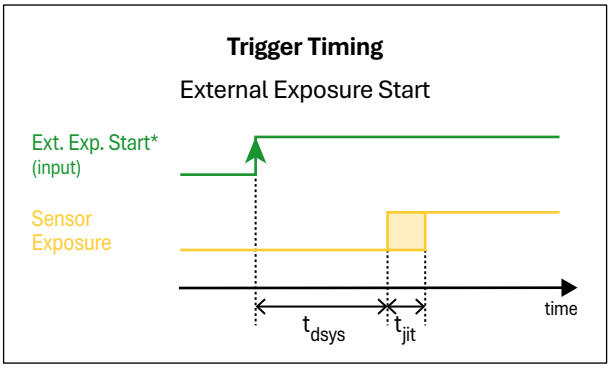


*Ext. Exp. Start is shown with signal polarity: Rising.
**Status Exposure is shown with signal polarity: High and signal timing: Show time of 'First Line'.
***Status Busy is shown with signal polarity: High.

If the external trigger input rate is too close to the maximum frame rate, it becomes unpredictable whether a trigger is accepted or missed. Check the Status Busy signal to confirm that the camera can accept a new trigger.

Timing characteristics

After the camera receives the external trigger signal, there is a short processing delay before the sensor is exposed. The following timing diagram illustrates this delay, followed by a table presenting precise delay measurements[9] for each scan rate[10].



*Ext. Exp. Start is shown with signal polarity: Rising.

Parameter	Fast scan	Medium scan	Slow scan
t_{dsys} (system delay) Standard rolling shutter:	4 line times -1.3 µs 26.3 µs	4 line times -1.3 µs 53.9 µs	4 line times +12.3 µs 122.7 µs
t_{jit} (jitter) Standard rolling shutter:	≤1 line time ≤6.9 µs	≤1 line time ≤13.8 µs	≤1 line time ≤27.6 µs

[9]Values are rounded to one decimal place.
[10]The pco.edge 10 bi LT CLHS is limited to using fast scan.

pco.camware:
In Camera Properties (Expert) -> Hardware I/O Control -> Exposure Trigger choose ”On”.
Select Trigger Mode **Ext. Exp. Start**.
Click ’Record’ and trigger from external source.

7.9.4 External Exposure Control

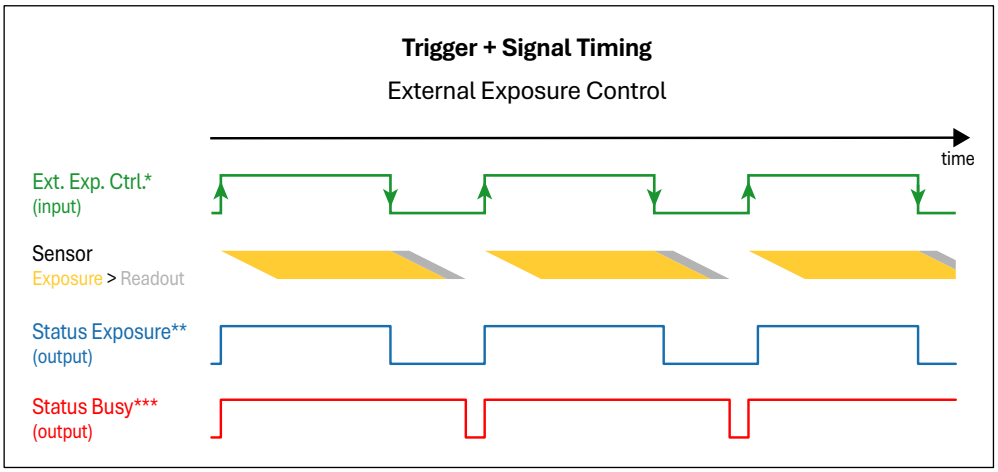
Additional equipment required:
This mode requires an external trigger source and a connecting cable.

In External Exposure Control, both the start and duration of each exposure are defined by an external trigger signal.
Use this mode for precise timing of image capture and to synchronize the camera with external devices.

Parameter	Value
Assigned port	SMA 1 (CLHS trigger card)
Status	Off On
Signal polarity	Rising Falling

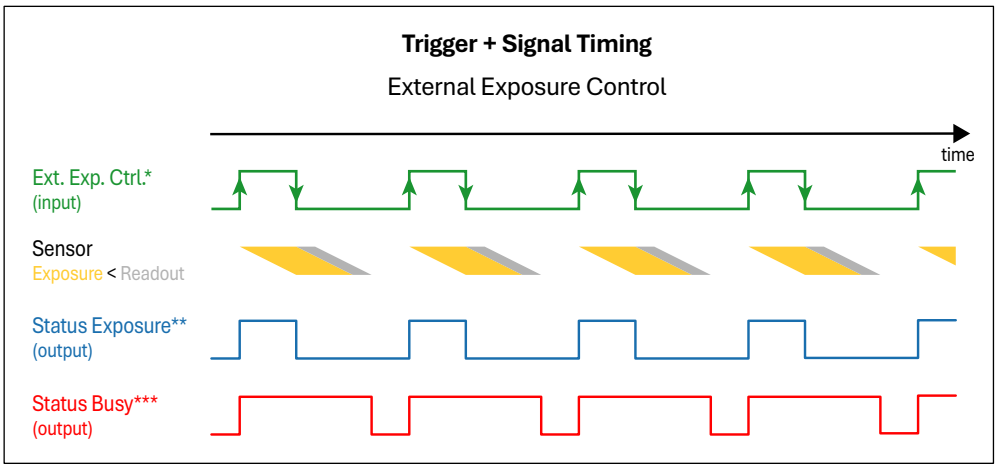
Due to the **rolling shutter design** of the sensor, exposure can only start and end at specific times determined by line timing. As a result, once the trigger is received, exposure will begin or end at the next available line time. Since the camera’s exposure time is limited, exposure stops automatically once the maximum exposure time is reached.

By default, exposure begins by the rising edge of the trigger signal and ends when the falling edge is detected. The signal frequency directly determines the frame rate as well as the duration of exposure. Without a trigger, no image is acquired.



*Ext. Exp. Ctrl. is shown with signal polarity: Rising.
**Status Exposure is shown with signal polarity: High and signal timing: Show time of ‘First Line’.
***Status Busy is shown with signal polarity: High.

The possible frame rate is limited by sensor readout and processing time, depending on the current configuration. In the External Exposure Control trigger mode, trigger events cannot be accepted during readout, as indicated by the Status Busy signal.



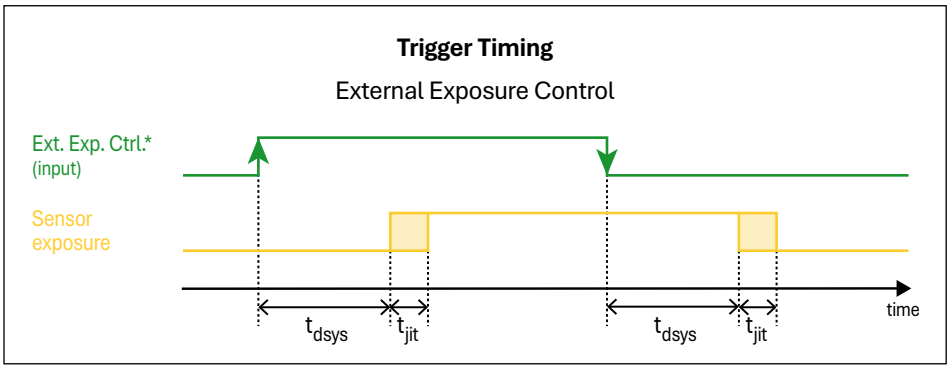
*Ext. Exp. Ctrl. is shown with signal polarity: Rising.
**Status Exposure is shown with signal polarity: High and signal timing: Show time of 'First Line'.
***Status Busy is shown with signal polarity: High.

If trigger pulses exceed the camera's capacity, some may be missed, resulting in fewer images captured than expected from the signal frequency.

If the external trigger input rate is too close to the maximum frame rate it becomes unpredictable whether a trigger is accepted or missed. Check the Status Busy signal to confirm that the camera can accept a new trigger.

Timing characteristics

After the camera receives the external trigger signal, there is a short processing delay before the start and end of sensor exposure. The following timing diagram illustrates this delay, followed by a table presenting precise delay measurements[11] for each scan rate[12].



*Ext. Exp. Ctrl. is shown with signal polarity: Rising.

[11] Values are rounded to one decimal place.
[12] The pco.edge 10 bi LT CLHS is limited to using fast scan.

Parameter	Fast scan	Medium scan	Slow scan
t_{dsys} (system delay) Standard rolling shutter:	4 line times -1.3 µs 26.3 µs	4 line times -1.3 µs 53.9 µs	4 line times +12.3 µs 122.7 µs
t_{jit} (jitter) Standard rolling shutter:	≤1 line time ≤6.9 µs	≤1 line time ≤13.8 µs	≤1 line time ≤27.6 µs

pco.camware:
In Camera Properties (Expert) -> Hardware I/O Control -> Exposure Trigger choose ”On”.
Select Trigger Mode **Ext. Exp. Ctrl.**
Click ’Record’ and trigger from external source.

7.10 Utilizing Acquire Enable

Additional equipment required:
The Acquire Enable feature requires an external signal source and a connecting cable.

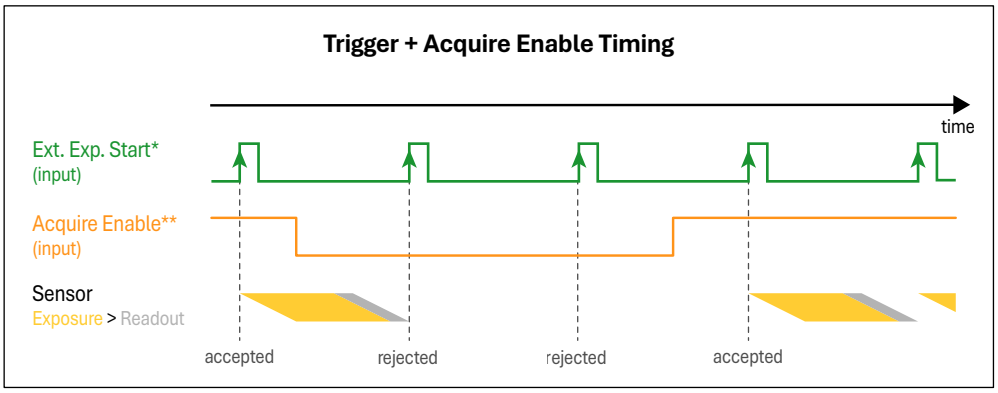
This feature is an additional option to control image acquisition by administering an external signal.

Acquire Enable can be used with the trigger modes Auto Sequence, External Exposure Start, and External Exposure Control. The Software Trigger is not affected by this signal.

Parameter	Value
Assigned port	SMA 2
Status	Off On
Signal polarity	High Low

As gate signal, Acquire Enable enables or disables image capture by permitting or rejecting trigger events. When the signal is active, the camera is allowed to capture images based on the selected trigger mode. When it is changed to inactive, image capture is blocked.

The signal polarity ’High’ means a high-level signal input enables image acquisition while a low-level signal input disables it. For the signal polarity ’Low’, the opposite applies.



*Ext. Exp. Start is shown with signal polarity: Rising.
**Acquire Enable is shown with signal polarity: High.

Description for signal polarity 'High':

While the Acquire Enable signal is high, images are captured based on the settings of the trigger mode. Once the Acquire Enable signal changes to low, new trigger signals are rejected and image acquisition is paused. As soon as the Acquire Enable signal returns to high, image acquisition resumes.

pco.camware:
In Camera Properties (Expert):
1. Hardware I/O Control -> Acquire Enable choose 'On' and desired signal polarity.
2. Recording Control -> Acquire Mode select 'External'.

8 Maintenance

8.1 Cleaning

CAUTION
Risk of injury due to electric shock. Before cleaning any component unplug the camera.

8.1.1 General cleaning

Camera housing:
Use a soft, dry cloth to dust off the camera housing.

Data port/FOL connectors:
Use specialized MTP/MPO cleaners to clean the data port or any FOL connectors.

Power port, lens control port and SMA connectors:
Use compressed air or a soft, anti-static brush to remove dust.

Lens:
Refer to the manual of the respective lens for information.

8.1.2 Input window cleaning

NOTICE: Only clean the sensor's input window if absolutely necessary. Do not touch the input window, as this may scratch and damage the glass.

How to be sure the dust is on the input window:

- Capture a uniform image, e.g. of a white sheet of paper.
- Rotate the camera lens.
- Capture another image, are the dark spots in the same position?

  ⇒ NO: Dust is not on the input window, no need to clean it.

  ⇒ YES: Dust is on the input window.

Clean with compressed air:

- Disconnect from power and any cables.
- Remove the lens and lens mount adapter.
- Blow out the input window with clean compressed air.

8.2 Storage

Read this section to learn about the proper storage conditions to protect the camera system.

Dust-free environment:
Store the camera system in a dust-free environment to keep dust from entering the camera housing.

Dry environment:
Store the camera in a non-condensing environment within the specified humidity range to keep moisture from entering the camera housing.

Temperature:
Store the camera within the specified temperature range.

Secure location:
Make sure to keep the camera in a secure location so it does not fall down or get damaged.

Protect input window:
Always store the camera with the protective cover or a lens attached to avoid dust and dirt on the input window.

Protect FOL cable:
Do not bend the FOL cable for storage to avoid breaking the fibers.

Protect FOL connectors:
Always store the camera with the protective covers on the data port and the FOL cable to avoid dust and dirt on the connectors.

Disconnect liquid cooling system:
Disconnect the camera from the liquid cooling system, but leave the coolant connectors attached to prevent any residual coolant from leaking.
For adequate storage of the liquid cooling system refer to the respective manual.

9 Troubleshooting

Issue	Solution
Status LED red, indicating error	Check camera health status or contact our customer support.
Software does not recognize camera	• Check FOL cable for kinks. • Clean all connectors with an MTP/MPO cleaner. • Reattach all connectors: The single connector on the camera needs to lock in with a noticable click, while the four multi-connectors slide in with light resistance. • Check frame grabber. • Update/Reinstall software.
Camera shuts off by itself	Check if the camera is overheating.
Issues with frame grabber	Refer to the troubleshooting guide for frame grabbers (CLHS interface).

Where to find the camera's serial number:

- Camera housing: The serial number is on a label on the bottom of the camera.
- pco.camware: In the Camera Properties menu in the Camera section at the top.

Where to find the installed firmware version:

- pco.camware: In the Camera Properties menu in the Camera section at the top.

For any other questions or problems, feel free to use the following options:

- Read the pco.troubleshooting manual for help with a PCO software product.
- Fill out the support ticket on our website.

10 Recycling

The camera and its accessories include electronic devices, which contain materials harmful to the environment. These electronic devices must be recycled.
To safely dispose of your camera, take it to your local recycling center or return it to Excelitas PCO GmbH.

11 Warranty

Please be advised that all quotations and sales of products by Excelitas PCO GmbH are subject to the General Terms and Conditions of Sale. Within these terms, we stipulate a 12-month warranty period commencing from the date of shipment to the buyer.

In the event of a claim under this guarantee, the equipment is to be sent, including a description of the fault, to Excelitas PCO GmbH. Returned equipment will not be accepted without a ticket number issued by the support team, which is available under the email address pco@excelitas.com.

Follow shipping instructions provided by the service technician. The unit should be returned in its original packaging if possible. In the case of damage caused by wear and tear, careless handling, neglect, by the use of force or in the case of interventions and repairs not carried out by Excelitas PCO GmbH, the guarantee ceases to be valid. This guarantee may not form the basis for any claims for damages, in particular not for compensation of consequential damages. The warranty is not transferable.

12 About Excelitas PCO

Pioneering in Cameras and Optoelectronics (PCO) has been our shared philosophy since our establishment in 1987. Starting with image-intensified cameras, followed by the co-invention of the groundbreaking sCMOS sensor technology, PCO greatly surpassed the imaging performance standards of the day. Acquired by Excelitas in 2021, our PCO camera portfolio continues to forge ahead as a leader in digital imaging innovation across diverse applications such as scientific and industrial research, automotive testing, quality control, and metrology.

With sophisticated mechanical design, extensive software support, and a broad range of accessories, we deliver adaptable solutions for all demands. This adaptability extends to tailor-made firmware and custom image sensors, which allow us to develop highly specialized solutions for all our customers. PCO represents a world-renowned brand of high-performance camera systems that complement Excelitas' expansive range of illumination, optical, and sensor technologies and extend the bounds of our end-to-end photonic solutions capabilities.

Our comprehensive camera portfolio covers the entire spectrum - from deep ultraviolet (DUV) to shortwave infrared (SWIR), from long exposure to high-speed, from line scan to high-resolution area scan. Our camera systems are controlled and processed through an intuitive and powerful software suite addressing an extensive range of platforms and architectures.

pco.®

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