user manual

pco.edge

pco.edge GOLD

pco.edge 4.2
pco.edge 5.5

pco.edge GOLD 4.2
pco.edge GOLD 5.5

pco.
imaging

In this manual you find instructions for the pco.edge scientific CMOS (sCMOS) camera series.

Target Audience: The pco.edge is designed for use by technicians, engineers and scientists.

In case of any questions or comments, please contact us at PCO.

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The cover photo shows exemplary PCO camera systems.

Lenses are sold separately.

Updated April 2014 © PCO AG

Table of Contents

1 Introduction

The new imaging standard.

Features

The pco.edge is a breakthrough in scientific imaging cameras, due to its distinctive ability to simultaneously deliver extremely low noise, fast frame rates, wide dynamic range, high quantum efficiency, high resolution and a large field of view - all in one image.

The camera series' main features are:

- low noise: 0.9 electrons med (pco.edge 4.2, slow scan)
- high resolution: 5.5 megapixel (pco.edge 5.5)
- high dynamic range: 33000:1 (pco.edge 4.2, slow scan)
- high speed: 100 fps @ full resolution (pco.edge 4.2 & 5.5, Camera Link)
- deep cooling: - 30 °C (pco.edge GOLD, water cooling)

- flexibility: user selectable choice of shutter mode
- free of drift: stabilized Peltier cooling in order to avoid any drift phenomena in image sequences

Overview – Available Camera Models

This table shows an overview over all available camera models.

Type	Interface	Shutter	Read Out Frequency	Sensor
pco.edge 4.2	USB 3.0	Rolling (RS)	110 MHz	mono
pco.edge 4.2	Camera Link	Rolling (RS)	95.3 MHz (slow scan)	mono
			272.3 MHz (fast scan)	mono
pco.edge GOLD 4.2	USB 3.0	Rolling (RS)	110 MHz	mono
pco.edge 5.5	USB 3.0	Rolling (RS)	86 MHz	mono & color
		Global (GS)	(under development)	
pco.edge 5.5	Camera Link	Rolling (RS)	95.3 MHz (slow scan)	mono & color
			286 MHz (fast scan)	
		Global (GS)	slow scan, not available*	
			286 MHz (fast scan)	
		Global Reset (GR)	95.3 MHz (slow scan)	
			286 MHz (fast scan)	
pco.edge GOLD 5.5	USB 3.0	Rolling (RS)	86 MHz	mono & color
		Global (GS)	(under development)	

*since the image quality in Global Shutter Mode decreases with slower readout frequency, the slow scan mode is disabled.

Areas of Application

live cell microscopy
single molecule detection
localization microscopy
lightsheet microscopy
selective plane illumination microscopy
SPIM
structured illumination microscopy
SIM
TIRF microscopy / waveguides
spinning disk confocal microscopy
genome sequencing (2nd and 3rd gen)
FRET
FRAP
lucky astronomy / imaging
adaptive optics
solar astronomy
fluorescence spectroscopy
bio- & chemi-luminescence
high content screening
photovoltaic inspection
x-ray tomography
ophtalmology
flow cytometry
biochip reading
machine vision
TV / broadcasting
spectral (hyperspectral) imaging
laser induced breakdown-spectroscopy (LIBS)

2 Safety Instructions

Never operate the camera in humid or dusty environments or in places with high amounts of X-ray radiation. **Humidity**, **dust** or **X-rays** could damage the camera.

To avoid the risk of water condensation, protect the camera against extreme changes of ambient temperature. If **condensation** enters the camera, there is the risk of electric shock.

To prevent damage to the camera, the system must be kept stable and protected against **strong jolts or vibrations**. The socket at the bottom of the camera is to be used for mounting purposes only.

The slits in the camera case (side & back planes) are designed for heat dissipation by the camera fan. To prevent **overheating** of the camera, do not block these slits. Do not leave the camera system in direct sunlight to avoid the risk of overheating.

Electric shock warning – Never slide any items through the **slits** into the camera because of the risk of electric shock if the voltage parts inside are touched.

Each time the camera is used, check the **power cable** for any damage.

Never position the cable in a way that it could become a **tripping hazard**.

Do not force the lens onto the camera. To protect the lens connector thread from damage, use minimal force when attaching a lens to the camera.

If any of the following conditions apply, immediately switch off the camera, separate it from the power line and contact our customer support:

- If the power cable or the power plug seems to be worn or damaged.
- If liquids have penetrated the device.
- If, after thoroughly reviewing the instruction manual, the device is still not operating properly.
- If the camera has been dropped or the casing is damaged.

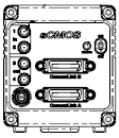
3 System Components

A camera system includes all parts which are necessary to install and run your camera. If you purchased a water cooling system with your camera, please see Appendix 7.

Camera Head

F-mount optical connection (standard)
For standard F-mount/SLR lenses and adapters.

C-mount ring provided (see appendix A3)
For standard C-mount and microscopy connectors.



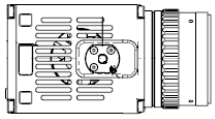
LED indicates camera status

- green continuos: camera is booting
- green blinking: camera is ready for operation
- yellow blinking: recording on
- red blinking: error

Input/Output 4x SMA connectors
2x input - 2x output

Interface (user selectable)
- Dual Camera Link 'full' or
- USB 3.0

1/4-20 UNC mounting thread
Serial Number tag



Power Supply

Your system will be equipped with either a 24 V or a 12 V power supply, depending on the model you selected. (connector: Lemo FGG.0B)

Power Cord (optional)

Standard IEC7 connector (please refer to your local dealer)

Camera Link Grabber Card / USB 3.0 PCI Interface Card

PCI Express x4 Card (Camera Link "full") or
PCI Express x1 Card (2 x USB 3.0 connections)

Note: A PCI Card with 4 x USB 3.0 connections is also available, contact PCO for further details. A PCIe x4 slot is necessary for this card.

Cables

2x Camera Link cables (3m) or
1x USB 3.0 cable (3m)

Note: If a longer cable length is required, contact PCO for available solutions.

Digital Camera Tools (USB storage device)

The accompanying USB storage device contains:
- Camware: software for camera control & image acquisition
- camera & grabber board drivers

4 Installation

You will find all necessary files on the accompanying USB storage device.
You may also **download the newest versions** of our software, camera drivers and third party software drivers from our website (support section).

Minimum computer system requirements:

- Clock speed: 2.4 GHz
- DDR3-RAM 4GB (1066 MHz)
- Windows 7 64-bit (for full performance, see appendix A8)
- 1280 x 1024 pixel resolution display
- nVIDIA CUDA GPU

4.1 Frame Grabber (Camera Link) / PCI Board Installation (USB 3.0)

When operating the camera with Camera Link Interface: Please run the appropriate grabber driver installation (provided with the accompanying USB stick) with default settings.

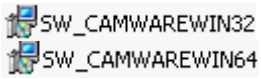
After the installation, shut down the computer and install grabber card hardware. For further information please see appendix A9 (ME4 Grabber Instruction).

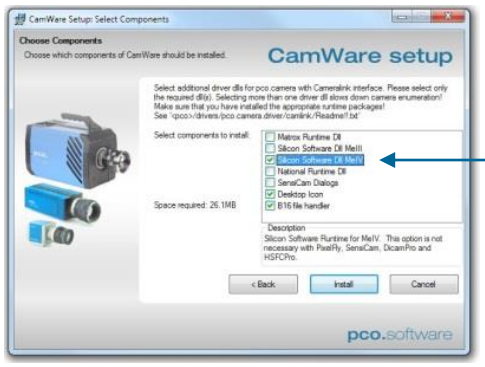
When USB 3.0 is used to interface the camera, it is recommended to use the PCI Interface card which is provided by PCO. For an installation instruction or further hardware recommendations, see appendix A10.

4.2 Camware

The pco.camware 32-bit/64-bit Windows application software enables you to control every camera parameter or setting. Images can be displayed on a monitor and may be downloaded and stored.

Please run the respective software installation provided on the USB storage device:





Select the required runtime libraries! “Dll MeIV” when you use Camera Link Interface.

After a successful installation, you will find the program folder ’Digital Camera Toolbox’ in your program directory. (It may also appear in the folder: User/AppData/Roaming)

5 Quick Start

Note: In order to get familiar with your new camera & software it might be helpful, if you first aim at an object that is easy to focus and that can be seen at standard light conditions**.**

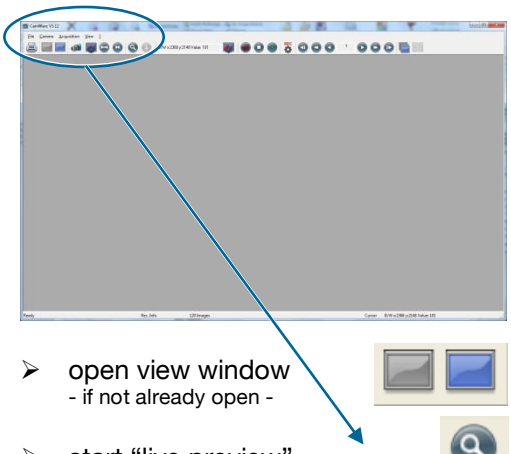
5.1 Preparation

- ✓ installation is finished (see chapter 4)
- ✓ an appropriate lens is attached (remove cap!)
  or the camera is attached properly to the microscope, spectrograph or other scientific device
- ✓ camera is connected to the power supply
- ✓ camera is connected to the PC (connect cable "A" with connectors "A" on PC and "A" on camera, cable "B" respectively)

- ✓ computer is on
- ✓ camera is on and ready (green blinking LED)

5.2 Start

- ➢ start Camware



- ➢ open view window
  - if not already open -

- ➢ start "live preview"

- ➢ apply "auto range peak"

- ➢ you may adjust aperture and focus

You should now clearly see the object in the window.

- ➢ If you need to change exposure time (e.g. the image is still either too dark or too bright), please go to chapter 6!

- ➢ If you want to record and save images, please see chapter 6 and chapter 7 for detailed information!

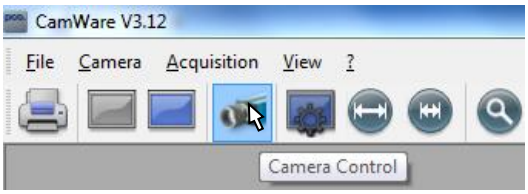
6 Camera Control for the pco.edge

The 'Camera Control' window in Camware is the main interface for all camera settings.

For further Camware features please see chapter 7!

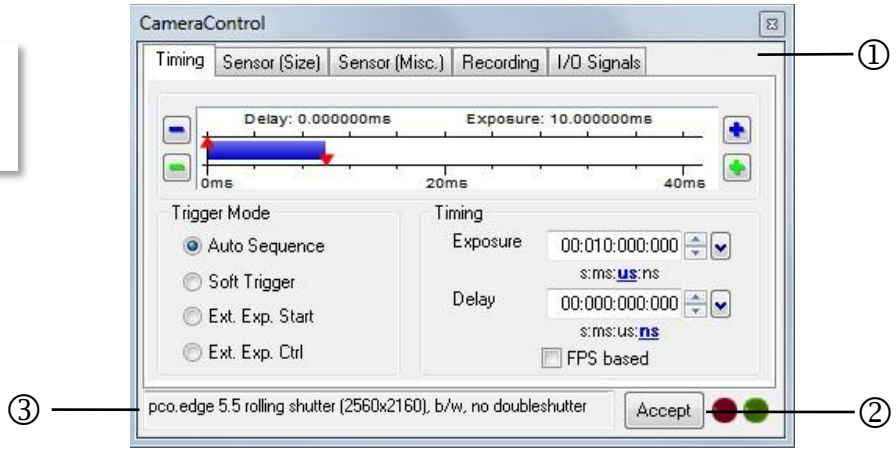
6.1 The “Camera Control” window

The camera control window can be opened by selecting the proper command in the "Camera"-Menu or by the corresponding button in the toolbar:



The camera control dialog always adapts to the camera type connected. For the pco.edge the camera control settings are spread over five **property tabs** ①, which will be explained below.

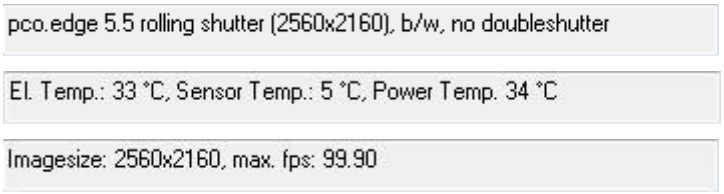
The camera control dialog automatically adjusts settings in case they are out of limits.



Changes to the camera control tabs must be completed by pressing the **“Accept” button** ②.

If the "Accept" button is not pressed, these changes will be ignored and lost. The camera control dialog automatically adjusts settings in case they are out of limits. When the ‘Accept’ button is pressed the settings will be transferred to and validated by the camera. If the camera accepts the settings the green LED will be highlighted.
The red LED will be highlighted in case a record is started.

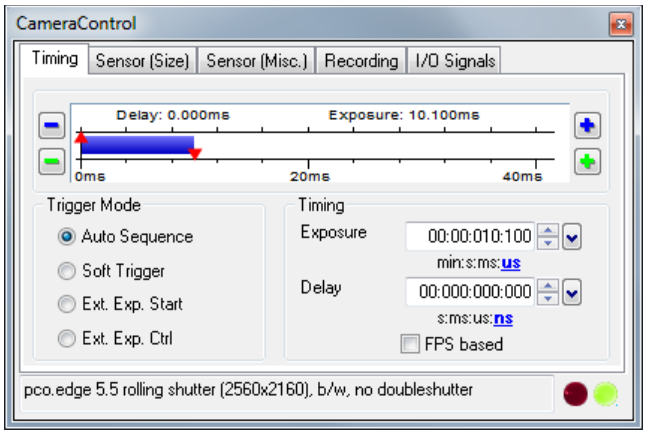
In the **information field** ③ you can view some information about the camera. Click into the info field in order to scroll through the values.



Power Temp.: temperature hotspot close to FPGA

6.2 The “Timing” tab

In this context trigger means exposure trigger, i.e. the trigger signal controls the exposure of a single image (light integration time).



Trigger Mode

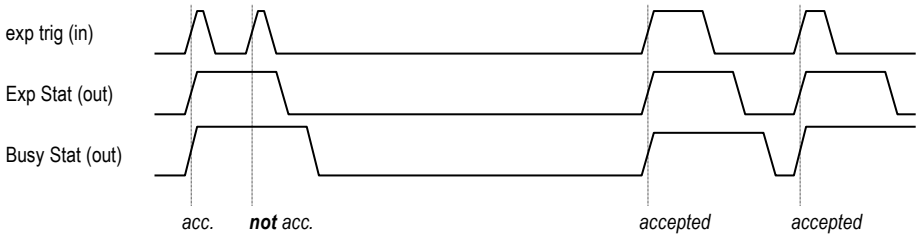
[Auto Sequence] The camera will optimize the image recording depending on the adjusted exposure time and the required readout time to achieve the best possible frame rate (“free running”).

[Soft Trigger] Single images can be recorded with Camware control. A single image can be acquired by pressing the "Single Trigger" button (7.2). Other signals cannot influence this operating mode - for test purposes only.

[External Exp. Start] The image acquisition is triggered by an external signal. It is also possible to force a software trigger for a test image with the "Single Trigger" button.

In the [External Exp. Start] exposure control mode, single image recording is started by the falling or rising edge of the voltage signal at the BNC input #1 (6.6). The frame rate cannot be set, as the frame rate is defined by the frequency of the external signal. However the predefined exposure time and ROI settings affect the maximum possible frame rate.

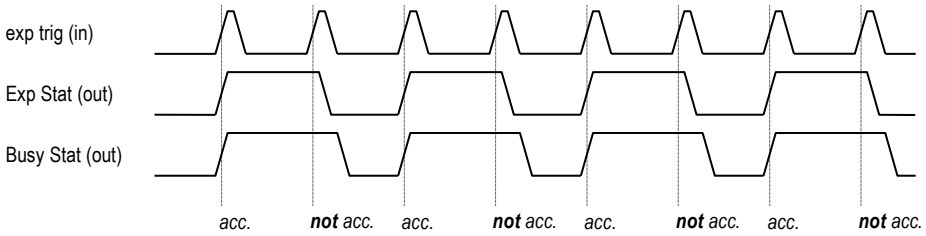
The Busy Status signal at BNC #3 (6.6) will indicate if a new trigger is accepted.



The maximum achievable frame rate in external trigger mode is negligibly less (about 0.1%) than operating the camera in [Auto Sequence] mode.

Note: If the trigger rate of the external signal is quite near the maximum possible frame rate (difference < 1/1000), then it will be random, whether or not a trigger is accepted!

If the trigger rate of the external signal is higher than the maximum possible frame rate, then every second trigger pulse is ignored. Therefore the actual frame rate drops to ½ of the external trigger rate. If the trigger rate is increased further, then only every 3rd, every 4th etc. trigger edge will be accepted.



In order to avoid trade-offs at maximum frame rate use either the Busy Status signal or make sure that the external trigger rate follows this condition:

External Trigger Rate ≤ fmax / 1.001

[External Exp. Ctrl] An external signal applied at BNC #1 (6.6), controls the start and the duration of the exposure.

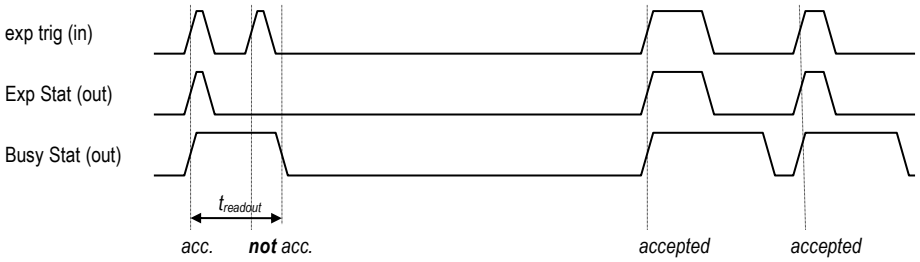
A new exposure is started by the falling or rising edge of the voltage signal at the BNC input. The exposure is finished when the opposite edge is detected. Thus in this mode, the start as well as the length of the exposure time can be controlled.

No further settings can be made, as the image timing is completely controlled by the external trigger signal.

Be aware, that the externally controlled exposure time is limited. The integration will be stopped automatically if the maximum exposure time is achieved.

Camera	Interface	Shutter Mode	max. exposure time
pco.edge 4.2 pco.edge GOLD 4.2	Camera Link & USB 3.0	Rolling Shutter	10s
pco.edge 5.5 pco.edge GOLD 5.5	Camera Link & USB 3.0	Global Shutter	5s
		Rolling Shutter Global Reset	8s

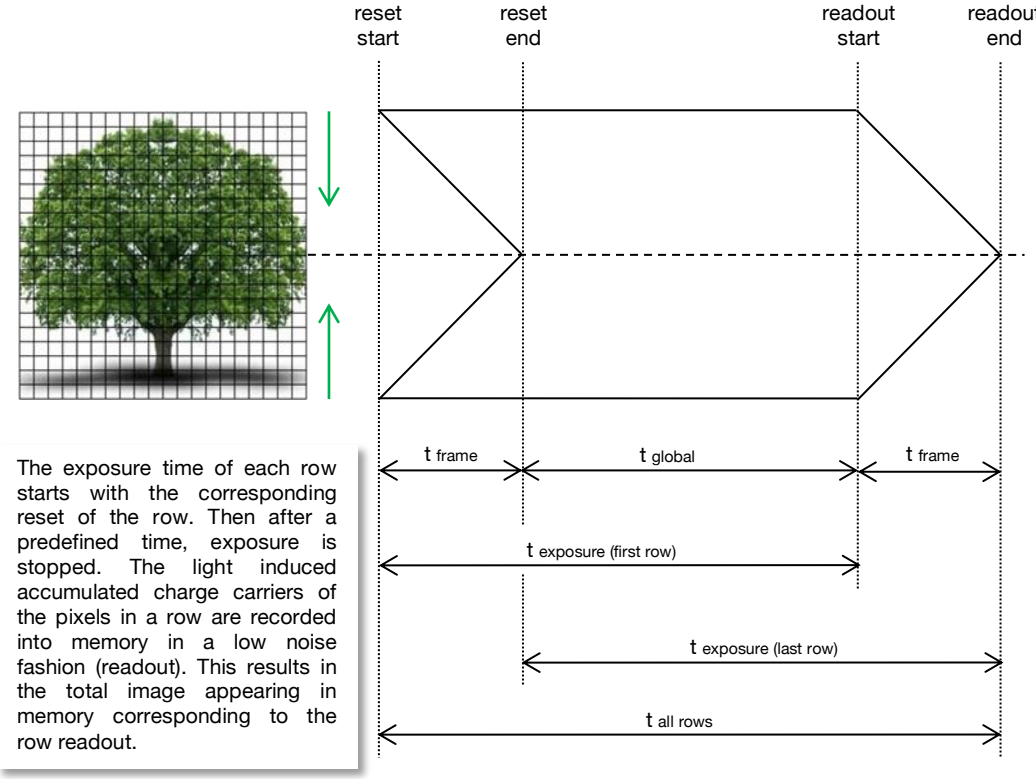
The Busy Status signal at BNC #3 (6.6) indicates if a new trigger will be accepted.



6.2.1 Rolling Shutter – Timing Details

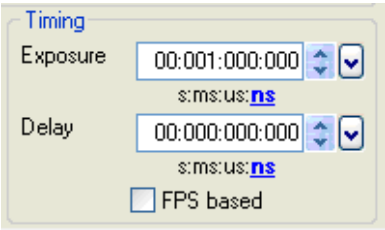
In rolling shutter mode the pixel reset and exposure start is carried out row by row. Each row has the same exposure time, but a different start of exposure. The pco.edge image sensor consists of two discrete halves, which are exposed and read out simultaneously, i.e. from the outside to the center. Within one row, the exposure starts simultaneously for all pixels.

General Timing Diagram



The exposure time of each row starts with the corresponding reset of the row. Then after a predefined time, exposure is stopped. The light induced accumulated charge carriers of the pixels in a row are recorded into memory in a low noise fashion (readout). This results in the total image appearing in memory corresponding to the row readout.

Timing

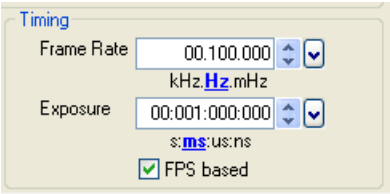


The exposure and delay time can be adjusted in steps of 10µs.

Camera (RS only)	Interface	exposure time	delay time
pco.edge 4.2	Camera Link & USB 3.0	500µs … 10s	0µs … 1s
pco.edge GOLD 4.2	USB 3.0	500µs ... 60s	0µs … 1s
pco.edge 5.5	Camera Link & USB 3.0	500µs … 2s	0µs … 1s
pco.edge GOLD 5.5	USB 3.0	500µs ... 60s	0µs … 1s

[FPS based] The camera will optimize the image recording to achieve the selected frame rate with chosen exposure time as close as possible.

Note:
- Only for [Auto Sequence] trigger mode
- "FPS based" mode only available with Camera Link Interface



First the frame rate is set. If the time required for readout of the image is longer than 1 / frame rate, then the frame rate will be reduced to 1 / $t_{readout}$.

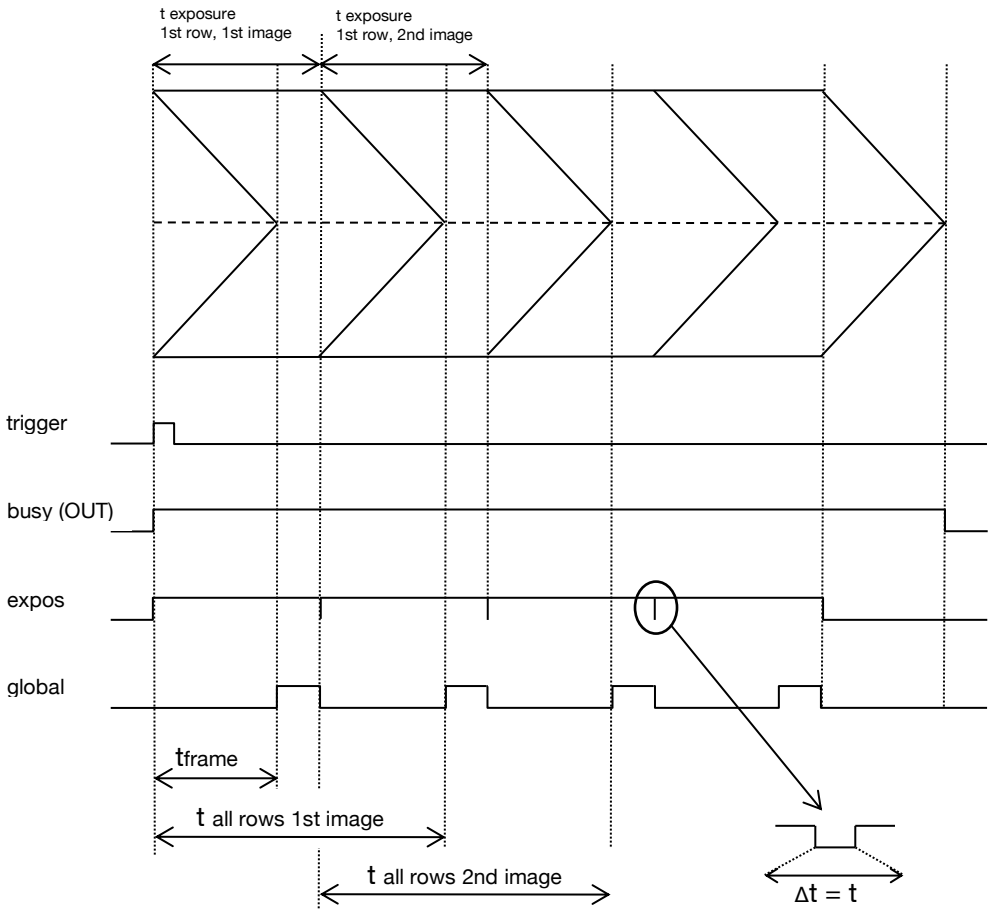
The frame rate can be adjusted in steps of 100 mHz (rolling shutter).

If the selected exposure time would require a lower frame rate, the exposure time is cut to the maximum possible time at that frame rate.

Camera (RS only)	Interface	Frame rate (FPS Based)	exposure time
pco.edge 4.2 (@ full resol.)	Camera Link	0.1 … 35 Hz @ 95.3 MHz	500µs … 10s
		0.1 … 100 Hz @ 272.3 MHz	
pco.edge 5.5 (@ full resol.)	Camera Link	0.5 … 33.3 Hz @ 95.3 MHz	500µs … 2s
		0.5 … 100 Hz @ 286 MHz	

Exposure time > Sensor frame readout time (Auto Sequence)

In case the required exposure is longer than the frame readout time, the image sensor is completely exposed to light for some time (tglobal). In case of a triggered flash illumination, this would be the best moment to illuminate the image sensor.



The hardware signal for the time tglobal is available on connector #4 (Global OUT). Setting can be made through SDK (not available in Camware).

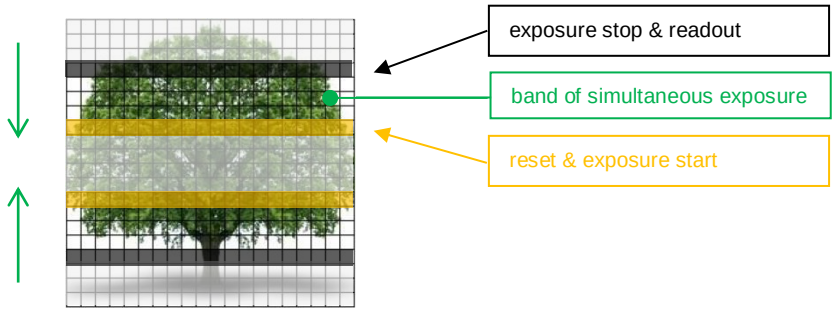
Obviously, if during exposure and readout, parts of the viewed image are moving horizontally, this would result in image distortion. This is why the global shutter mode may be a prerequisite for some applications.

However, most dynamic events can be captured in 1 ms, which is a common integration time with SLR cameras set at 1/1000 exposure. The time shift from one row to another is only about 10 µs (fast scan). The resulting maximum readout time of 10 ms (@ full resolution) seems to be sufficient for a broad spectrum of dynamic events.

The 10ms is also faster than the image shift process of most frame transfer emCCD image sensors previously used for low light applications. If this does not influence the image recording and processing, then rolling shutter mode will not affect it either.

Exposure time < Sensor frame readout time (Auto Sequence)

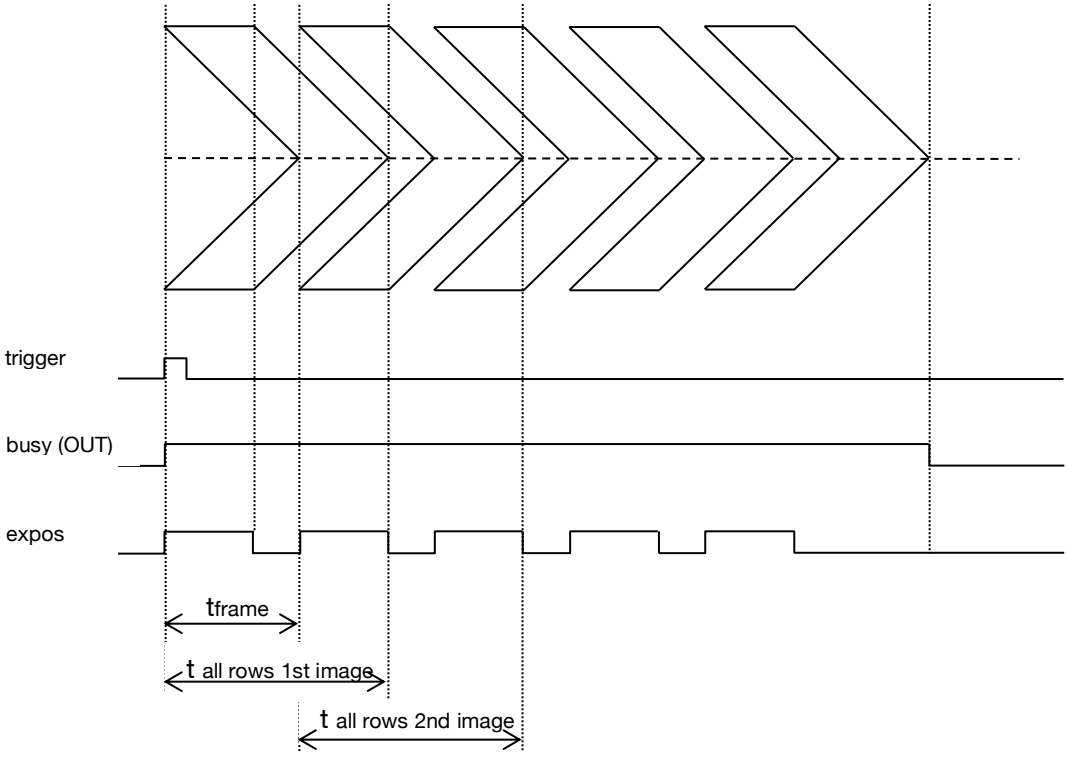
In case the required exposure is shorter than the frame readout time, the image is composed of two exposure bands moving from the outside to the center of the sensor.



For example, the shortest exposure time in RS is 500µs. The band of simultaneous exposure is in this case (smallest possible height):

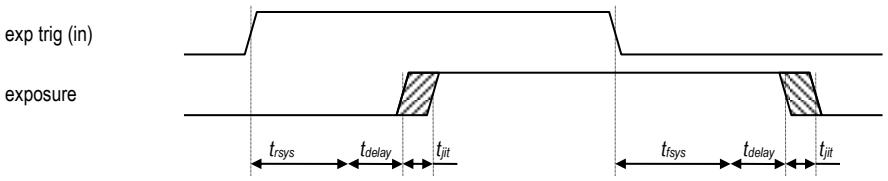
Camera (RS only)	Interface	MHz	time per row	min. number of simult. rows
pco.edge 4.2 pco.edge GOLD 4.2	USB 3.0	110	24.10 µs	20
pco.edge 4.2	Camera Link	95.3	27.60 µs	18
		272.3	9.65 µs	51
pco.edge 5.5 pco.edge GOLD 5.5	USB 3.0	86	30.50 µs	16
pco.edge 5.5	Camera Link	95.3	27.52 µs	18
		286	9.17 µs	54

Previous comments on image distortion (also known as “Rolling Shutter Effect”) apply here as well.



Details for [External Exp. Start] and [External Exp. Ctrl]

The detailed timing for external trigger includes system delay times, an adjustable additional delay time, and the jitter.

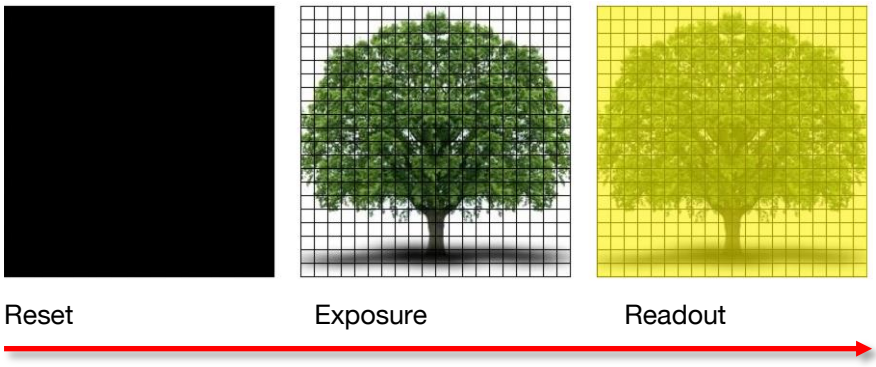


Camera (RS only)	Interface	internal system clock	tsys	tjit (jitter) ≙1 row time	tdelay (delay)
pco.edge 4.2 pco.edge GOLD 4.2	USB 3.0	100 MHz	50 ns	0 ... 24.10 µs	0 … 1s
pco.edge 4.2	Camera Link	72 MHz	70 ns	0 ... 27.60 µs (slow scan)	0 … 1s
				0 … 9.65 µs (fast scan)	0 … 1s
pco.edge 5.5 pco.edge GOLD 5.5	USB 3.0	100 MHz	50 ns	0 … 30.50 µs	0 … 1s
pco.edge 5.5	Camera Link	72 MHz	70 ns	0 ... 27.52 µs (slow scan)	0 … 1s
				0 … 9.17 µs (fast scan)	0 … 1s

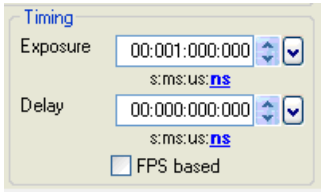
For optimized synchronization (minimized jitter time) use the falling edge of the line signal at the status output (see SDK description).

6.2.2 Global Shutter – Timing Details

First, all pixels are globally reset and these reset values are shifted into so-called diffusion nodes. From there, they are non-destructively read out into memory as reset dark images. The exposure starts after transfer of the reset dark image to the diffusion nodes, where they are stored on the chip. The exposure is stopped by global charge transfer to the diffusion nodes. Then, the exposure image is read out to the memory, where the former reset dark image is subtracted to perform an external correlated double sampling, which reduces the noise. Since two images have to be read out to receive one resulting image, the sCMOS image sensor's global shutter mode has only half of the frame rate of the rolling shutter mode.



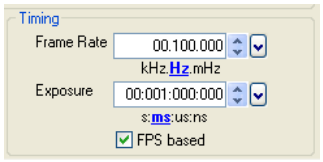
Timing



The exposure and delay time can be adjusted in steps of 10µs.

Camera (GS only)	exposure time	delay time
pco.edge 5.5	10 µs .. 100 ms	0 µs … 1s

[FPS based] The camera will optimize the image recording to achieve the selected frame rate with chosen exposure time as close as possible.
Note: • Only for [Auto Sequence] trigger mode
• "FPS based" mode only available with Camera Link Interface



First the frame rate is set. If the time required for readout of the image is longer than 1 / frame rate, then the frame rate will be reduced to 1 / $t_{readout}$.

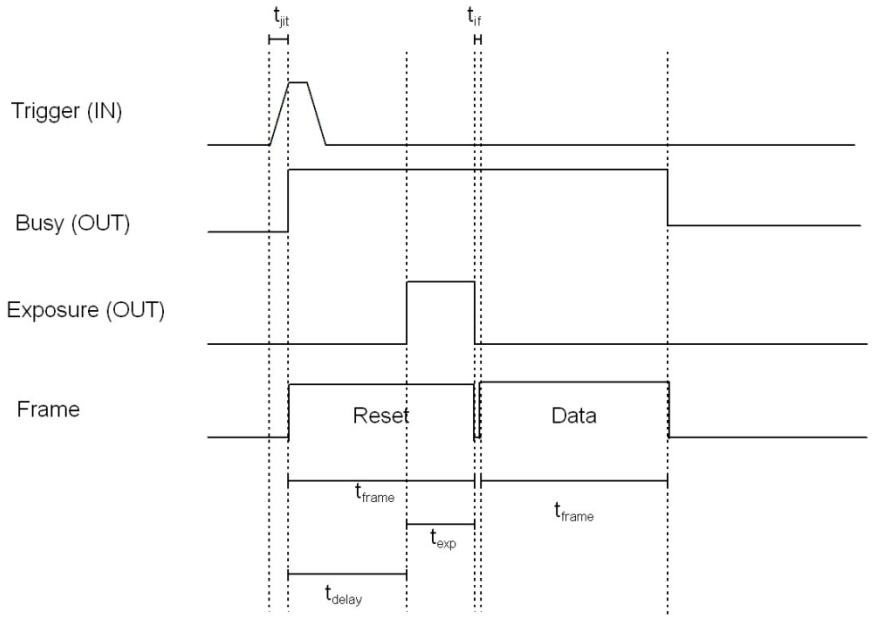
The frame rate can be adjusted in steps of 1 mHz (global shutter).

If the selected exposure time would require a lower frame rate, the exposure time is cut to the maximum possible time at that frame rate.

Camera (GS only)	Interface	Frame rate (FPS Based)	exposure time
pco.edge 5.5	Camera Link	10 … 16.7 Hz @ 95.3 MHz	10µs … 100ms
		10 … 50 Hz @ 286 MHz	

External Exposure Start

(Auto Sequence respectively)

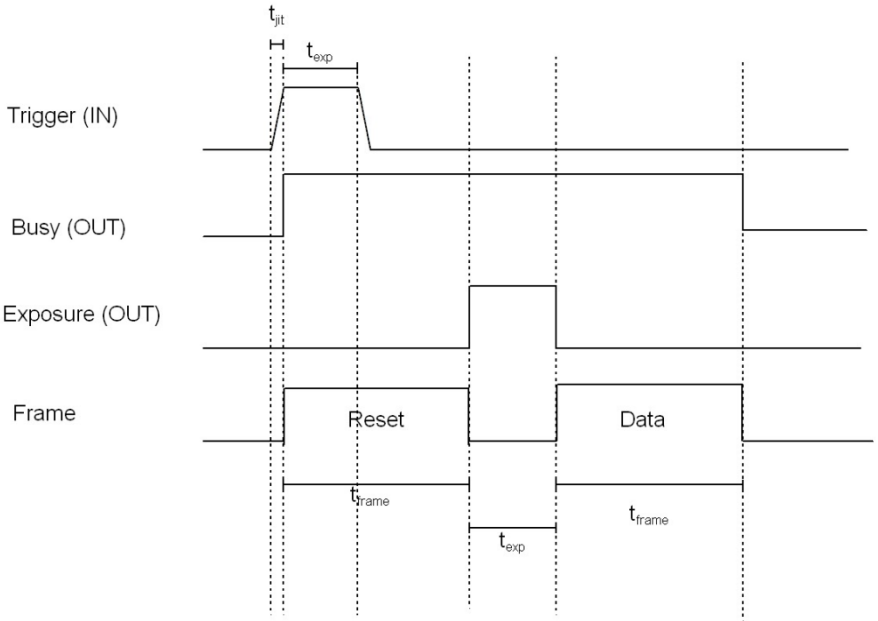


if $t_{exp} < t_{frame}$

system delay (t_{delay}) is added before exposure starts

	# of lines	95.3 MHz (slow scan)	286 MHz (fast scan)
tjit	1	0 … 27.52 µs	0 … 9.17 µs
tframe	ROI (y)	29.76 ms (max)	10.00 ms (max)
texp	programmable	10 µs … 100 ms	10 µs … 100 ms
tdelay (system)	(tframe – texp)		
tif	1	27.52 µs	9.17 µs

External Exposure Control



	# of lines	95.3 MHz (slow scan)	286 MHz (fast scan)
tjit	1	0 … 27.52 µs	0 … 9.17 µs
tframe	ROI (y)	29.76 ms (max)	10.00 ms (max)
texp	counted		

In [External Exposure Control] trigger mode the external signal controls start of image acquisition and duration of the exposure. First, all pixels are globally reset and these reset values are shifted into so-called diffusion nodes. From there, they are non-destructively read out into memory as reset dark images.

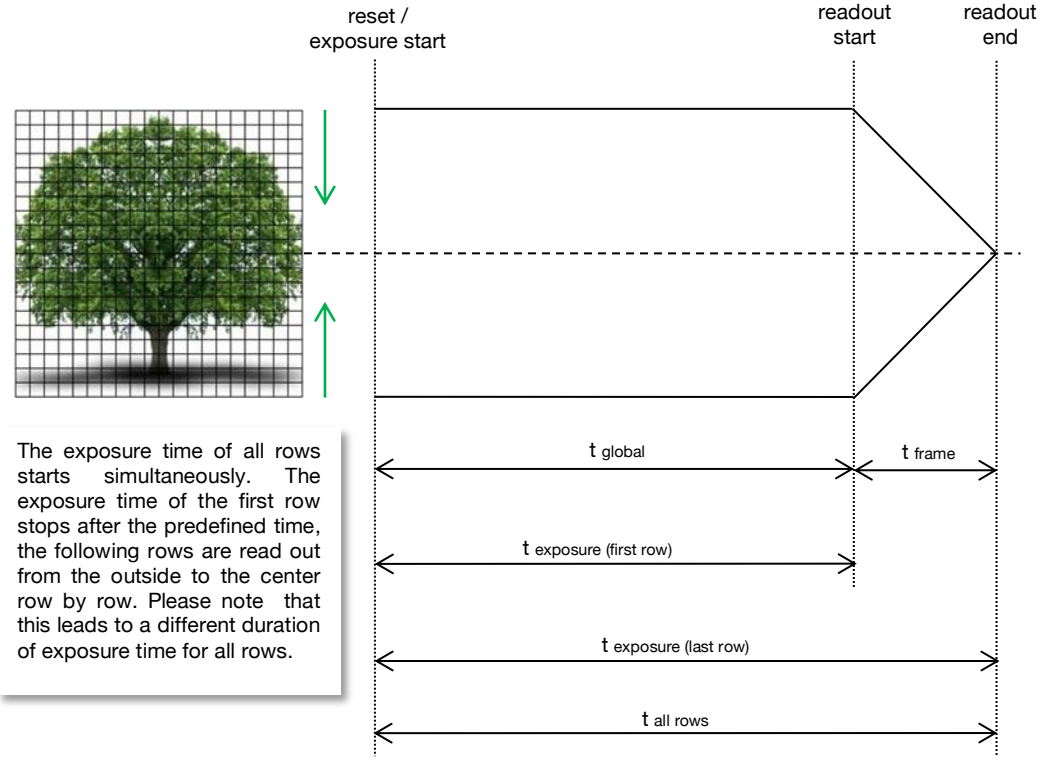
In this mode, the exposure starts always after the readout of the dark image is completed. The length of the exposure has been detected by the sensor from the trigger input. The exposure is stopped by global charge transfer to the diffusion nodes after the respective time. Then, the exposure image is read out to the memory, where the former reset dark image is subtracted to perform an external correlated double sampling, which reduces the noise.

Since two images have to be read out to receive one resulting image and the exposure cannot start during readout time of the dark image, this specific global shutter mode provides less than half of the frame rate of the rolling shutter mode.

6.2.3 Global Reset – Timing Details

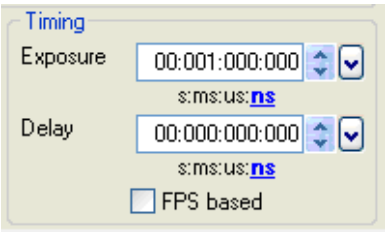
All pixels are globally reset, and the exposure starts for all rows at the same time. The exposure stop is carried out row by row, therefore the duration of the exposure is not the same for all pixels. The rolling readout improves the image quality, but due to the difference in exposure time, a flash illumination is recommended. The readout (exposure stop) is done from the outside to the center.

General Timing Diagram



The exposure time of all rows starts simultaneously. The exposure time of the first row stops after the predefined time, the following rows are read out from the outside to the center row by row. Please note that this leads to a different duration of exposure time for all rows.

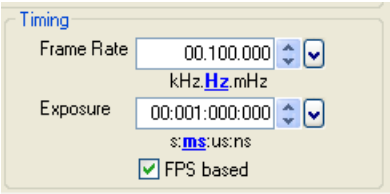
Timing



The exposure and delay time can be adjusted in steps of 10µs.

Camera (GR only)	exposure time	delay time
pco.edge 5.5 (global reset)	10 µs – 2 s	0 µs … 1s

[FPS based] The camera will optimize the image recording to achieve the selected frame rate with chosen exposure time as close as possible.
Note: • Only for [Auto Sequence] trigger mode
• "FPS based" mode only available with Camera Link Interface



First the frame rate is set. If the time required for readout of the image is longer than 1 / frame rate, then the frame rate will be reduced to 1 / $t_{readout}$.

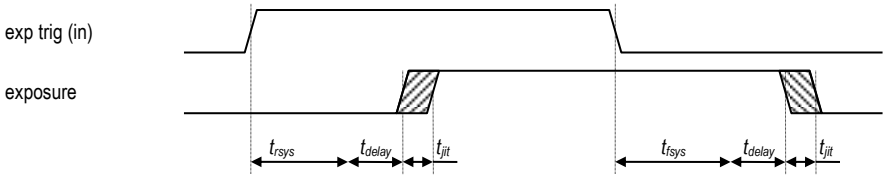
The frame rate can be adjusted in steps of 1 mHz (global reset).

If the selected exposure time would require a lower frame rate, the exposure time is cut to the maximum possible time at that frame rate.

Camera (GR only)	Interface	Frame rate (FPS Based)	exposure time
pco.edge 5.5 (Global Reset)	Camera Link	1 … 33.3 Hz @ 95.3 MHz	10µs … 2s
		1 … 100 Hz @ 286 MHz	

Details for [External Exp. Start] and [External Exp. Ctrl]

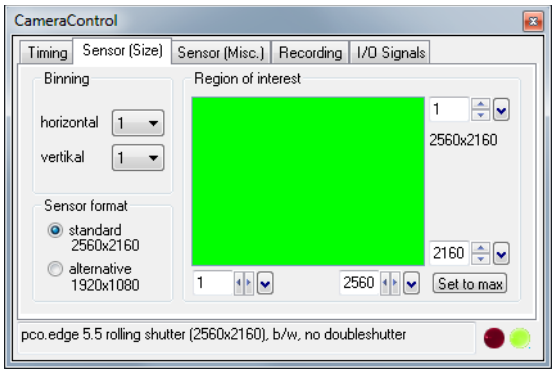
The detailed timing for external trigger includes system delay times, an adjustable additional delay time and the jitter.



Camera (GR only)	Interface	tsys	tjit (jitter)	tdelay (delay)
pco.edge 5.5	Camera Link	70 ns	0 … 27.52 µs (slow scan)	0 … 1s
			0 … 9.17 µs (fast scan)	0 … 1s

For optimized synchronization (minimized jitter time) use the falling edge of the line signal at the status output (see SDK description).

6.3 The “Sensor (Size)” tab



Binning

H1xV1, H1xV2, H1xV4, H2xV1, H2xV2, H2xV4, H4xV1, H4xV2, H4xV4
For further information on binning in CMOS sensors see appendix A11.

Region of Interest

The ROI (region of interest) selects only a part of the sensor to be read out. Please be aware, that in order to speed up the frame rate and to reduce the amount of image data, the selected ROI needs to be placed symmetrical to the horizontal center line. The decreased image size you see within Camware is a combination of reduced sensor resolution and software downsizing (“Soft-ROI”). Please be aware, that in some cases, especially for cameras with Camera Link interface, small changes in resolution will not influence the frame rate.

Examples of achievable frame rates at a specific ROI can be found in the datasheets of the cameras, see appendix A1.

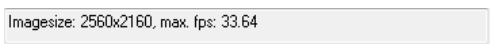
Camera	Interface	ROI, horizont. increments	ROI, vertical increments	min. ROI	vert. symm. ROI
pco.edge 4.2	Cam.Link	1	1	40x8	no
pco.edge 4.2 pco.edge GOLD 4.2	USB 3.0	4	1	64 x16	no
pco.edge 5.5	Cam.Link	4	1	160 x 8	no
pco.edge 5.5 pco.edge GOLD 5.5	USB 3.0	4	1	64 x16	no

Note: “Soft-ROI” is enabled within Camware by default. Due to this functionality, the resolution of pco.edge cameras with Camera Link interface can be adjusted in steps of 1 – 4 pixels. Since the readout architecture of these cameras is not able to address single pixels, this downsizing is done by software. If you work with Device Adapters (µManager, Labview, etc.) or with our SDK, the Soft-ROI is disabled by default. For Further information, please see the SDK description.

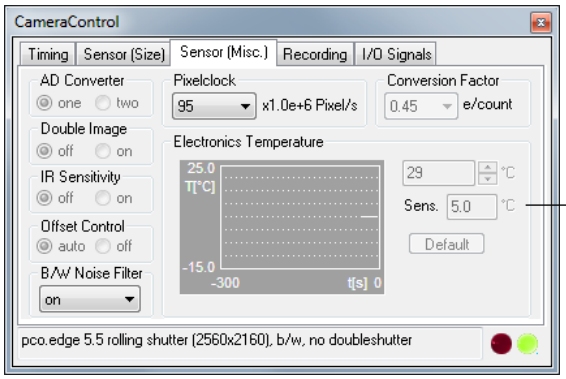
Sensor Format

Camera	Interface	Preselected Sensor Format
pco.edge 4.2	Camera Link	2048 x 2048
pco.edge 4.2 pco.edge GOLD 4.2	USB 3.0	2048 x 2048
pco.edge 5.5	Camera Link	2560 x 2160 1920 x 1080
pco.edge 5.5 pco.edge GOLD 5.5	USB 3.0	2560 x 2160

Camware will show the actual frame rate, corresponding to the selected image size, in the information box:



6.4 The “Sensor (Misc.)” tab



If a pco.edge GOLD camera is connected, a drop-down menu with selectable sensor temperatures will appear.

Pixelclock

The pixel clock sets the clock frequency and therefore the image sensor readout speed. (See table on page 6 for available readout frequencies.)

A/D Converter

Feature not applicable for pco.edge

Double Image

This feature is widely used for particle image velocimetry (PIV) measurements, but not available for the standard pco.edge cameras.

IR Sensitivity

Feature not applicable for pco.edge

Offset Control

Offset control is done automatically for optimal results. User control is disabled.

B/W Noise Filter

In addition to the integrated hot pixel calibration, a spurious noise filter can be activated here in order to remove so-called “blinkers”. If you encounter unexpected aliasing effects, turn this filter off.

Conversion Factor

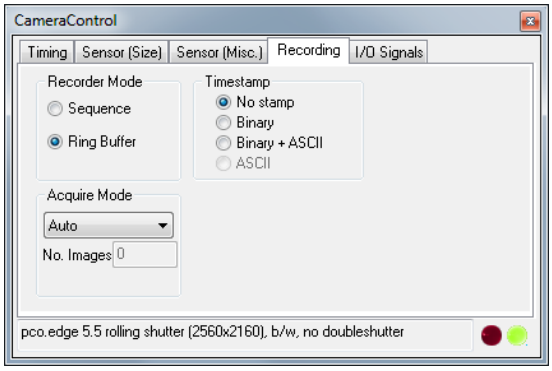
The conversion factor defines how many charge carriers (electrons), which have been generated by light in the image sensor in each pixel, are necessary to generate one count (one intensity level) in the digital image. Therefore, the conversion factor describes the gain that is applied to the signal before it is converted into a digital value. The conversion is optimized for the pco.edge @ 0.46 e^-/count.

Cooling Setpoint

Display of sensor temperature. A peltier cooling unit is used to to keep the sensor's dark current to an acceptable minimum and in order to allow for a continuous operation free of any drift phenomena in image sequences. Either an internal fan or an external water cooling system assures proper heat transfer from the peltier element to regulate the temperature of the cameras.

Camera	Interface	Sensor Temperature
pco.edge 4.2 pco.edge 5.5	Camera Link	5 °C
pco.edge 4.2 pco.edge 5.5	USB 3.0	0 °C
pco.edge GOLD 4.2 pco.edge GOLD 5.5	USB 3.0	- 15 °C - 30 °C (water cooling only)

6.5 The “Recording" tab



Recorder Mode

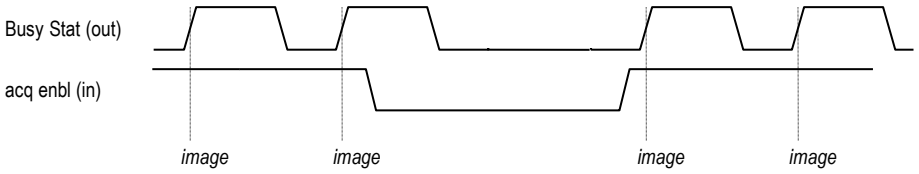
The Camware will use free RAM space on your computer. The recorded images will be temporally saved as 16bit multi TIFF. In [Sequence] mode the recording stops when RAM space is full. In [Ring Buffer] mode the camera will stop only by a stop command, hence overwriting previous images. For longer recording periods an appropriate RAID system is necessary, see also the 'Direct Record To File' option on page 36.

Acquire Mode

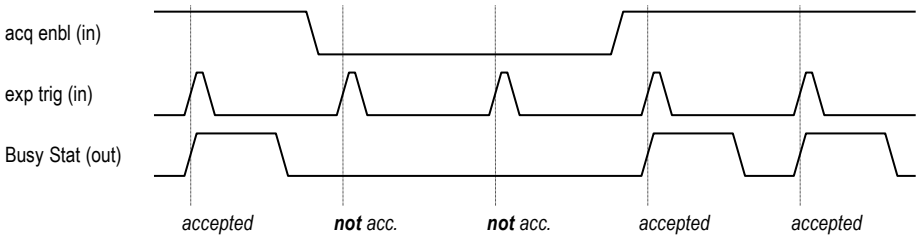
The acquire mode gives you the ability to enable or disable the recording by an external signal. If set to **[Auto]** all images are accepted and all images taken are saved. A signal at the acq enbl input (see chapter 6.6) is ignored for this function.

If set to **[External]**, the camera will only record images, if the external signal enables recording.

This sensor timing scheme is paused by the signal at the acq enbl input. The acq enbl input is sampled at the beginning of the image generation, which can be seen at the rising edge of the busy stat output. If the acq enbl input is high (low, when inverted) when an image is acquired, it causes an idle state until the acq enbl input is low (high, when inverted).



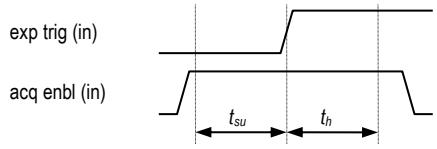
In trigger mode [External Exp. Start], the acq enbl input works like a gate for the trigger signal. A trigger edge (rising, falling when exp trig is inverted) is accepted only when the acq enbl signal is high (low, when inverted).



In trigger mode [External Exp. Ctrl], the acq enbl input works very similar to the mode [External Exp. Start]. However, the acq enbl input is ignored for the edge which is closing the exposure time (started exposure will be finished accordingly).

When using acq enbl in external trigger modes, the following timing specification should be met:

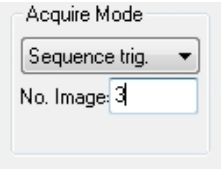
tsu = 70 ns
th = 70 ns



If the acq enbl signal changes within the window of tsu (set up) to th (hold), the behavior is random. The trigger may be accepted or ignored.

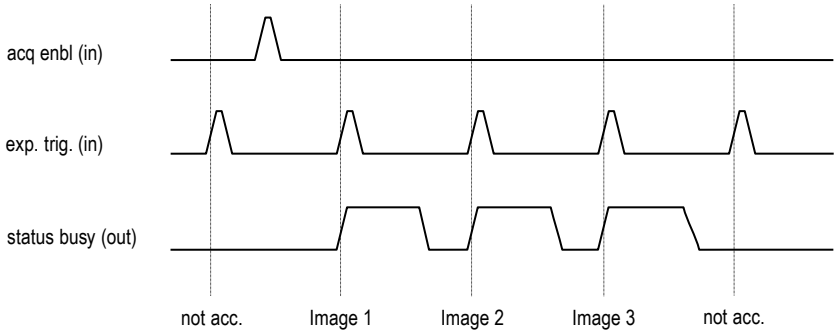
[Sequence Trig.]

Once, a falling or rising edge at the “acquire enable” trigger input (see chapter 6.6) is recognized, an internal image counter starts to run. It will count all acquired images and will stop the recording when the predefined number of images is reached.



Example Timing Diagram

Trigger Mode: External Exposure Start
Acquire Mode: Sequence Trigger
Image Counter: 3



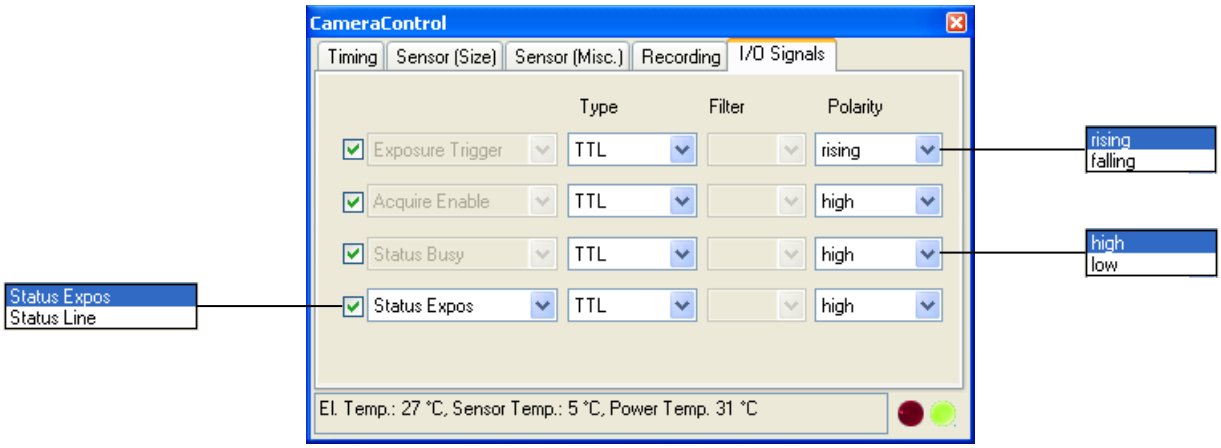
Time Stamp

A time stamp can be placed into the upper left corner of the image. It can be either off, binary, or binary with text. The time resolution is 1µs.

In binary mode the first 16 pixels will be filled with the time stamp information (binary code). The numbers are coded in BCD with one byte per pixel, which means that every pixel can hold 2 digits. If the pixels have more resolution as 8 bits, then the BCD digits are right bound adjusted and the upper bits are zero. For further information please refer to the SDK.

In binary and ASCII mode text will be placed into the image replacing the content of the image (271x 8 pixels).

6.6 The “I/O Signals” tab



Exposure Trigger

If checked, a signal for [External Exp. Start] or [External Exp. Ctrl] trigger mode (see chapter 6.2) is accepted at the exp trig input.

Acquire Enable

If checked, a signal for Acquire Mode (see chapter 6.5) is accepted at the acq enbl input.

Status Busy

If checked, a signal indicating busy status is given at the status busy output. Once an acceptable trigger edge is received, busy will go high. As soon as busy goes low again, a new trigger edge is accepted.

Status Expos

If checked, a signal indicating exposure status is given at the status output. Status Expos indicates the actual exposure window for one frame.

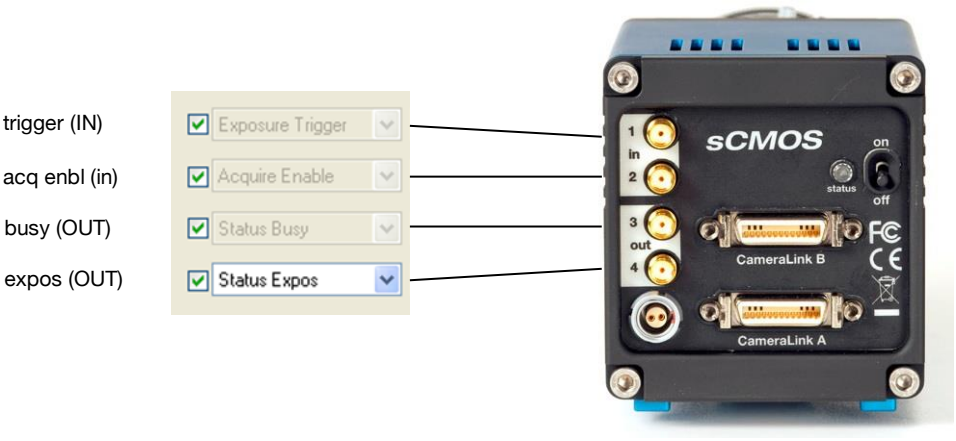
Status Line

If checked, a signal indicating line status is given at the status output. Use the falling line edge for optimized synchronization (minimized jitter time; see page 18).

[Filter] electrical interference filters

[Polarity] active for high/low signal or rising/falling edge
Maximum low level: 0.8V
Minimum high level: 2V
Slew Rate >1ms/V

[Type] TTL
Electrically grounded, no opt coupler.
3,3Volt LVTTL out , short time short-circuit-proof
Continuous overvoltage withstand: +10V and -5V.
1ms pulse overvoltage withstand: +33V and -33V
ESD pulse: +- 4kV


trigger (IN)
acq enbl (in)
busy (OUT)
expos (OUT)
Exposure Trigger
Acquire Enable
Status Busy
Status Expos
1
in
2
3
out
4
sCMOS
on
status
off
CameraLink B
CameraLink A

7 Camware Features

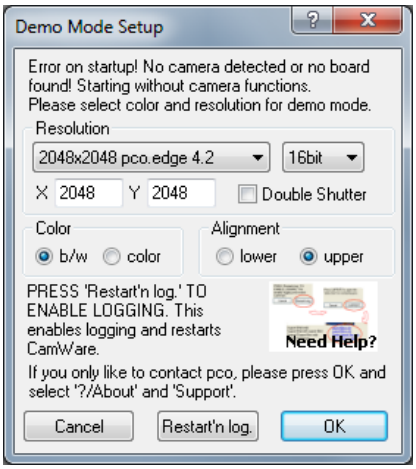
PCO's renowned software for camera control, image acquisition, and archiving of images in various file formats.

You will find an **online help** under the common Help menu.

Note: There are some features explained in the online help that are not applicable for this camera version.

7.1 If no camera is connected

When Camware is started, it automatically recognizes the camera type of the connected and running cameras.



If Camware is started with no camera connected to the PC or with cameras switched off, it starts in demo mode.

In this mode all **image processing** features are available. The user only has to tell Camware which type of images will be opened. For that purpose, the "Demo Mode Setup" window opens and asks for the corresponding input.

Need Help? If this window pops up because you have trouble running the camera, please see instructions in appendix A6.

Resolution

The drop down list offers the existing image sensor spatial resolutions of all PCO camera systems. Please select the specific resolution and bit depth of the images to be opened! If double shutter images have been recorded and should be opened, "Double Shutter Mode" should be checked.

Color

With the radio buttons, the user can specify whether the image type is monochrome (b/w) or color.

Alignment

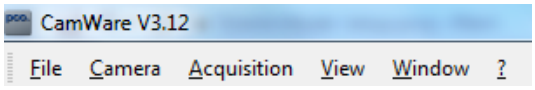
These two radio buttons adjust whether MSB aligned ("upper") or LSB aligned ("lower") images have been stored (see page 34, "File Settings").

Example settings to view the b16 files of the pco.edge:

Camera	Resolution	bit	DoubleShutter	Color	Alignment
pco.edge 5.5 color	2560x2160	16	<no>	color	-
pco.edge 4.2 mono	2048x2048	16	<no>	mono	-

7.2 Overview

Menu Bar

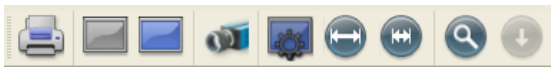


See chapter 7.3 - 7.8.

Local Menu

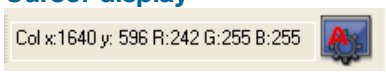
The “mouse right-click” is explained in chapter 7.9.

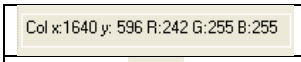
Toolbar



	prints the currently displayed image or comment window
	opens a b/w | color display window
	opens the camera control window
	opens the convert control
	auto range peak/crop (see chapter 7.6 under “Convert Control BW”)
	live preview: useful for fast and easy camera adjustment and focusing This command disables the camera control window if it is opened!
	soft trigger: captures a single image (see chapter 6.2)

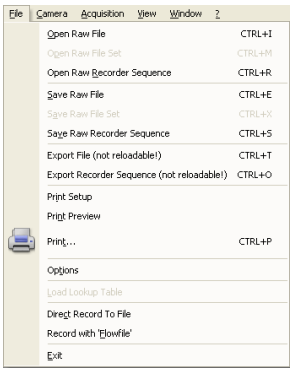
Cursor display



	cursor: pixel position and intensity value
	continuous “auto range crop" scaling

Recorder

	record START / STOP / PLAY
	opens the recorder settings window
	replay navigation
 	The 'Recorder Browser' gives an overview of the recorded images. A click on the desired image makes it the current image in the Black/White or Color window. ‘Skip #images’ allows for convenient overview at large numbers of images.
	With the "Multi Frame Window" it is possible to view all active camera images in one window. The user might select between "time" oriented or "camera number" oriented order.



7.3 The File Menu

Open RAW File (single image only)

This command should be used to import a single image into the currently active image window. Only files with the extension and format of "*.b16" (PCO proprietary binary image format) and "*.tif" (TIFF image format) can be imported. If the recorder is enabled, each imported image will be transferred to the buffer shown in the picture number. The image itself will be fitted to the current image size. If the recorder is disabled, the current image sizes will be set to the parameters of the imported image.

Open RAW File Set (for hsfc pro camera)

This command is used to open a set of images, previously saved with the 'Save Raw File Set' command. The corresponding windows will be opened automatically. Additionally a comment window will be opened, which shows the settings of the channel and a comment. This option is not accessible in case of the recorder is switched on.

Open RAW Recorder Sequence (image sequence from one camera)

This command is used to import a sequence of images. If more than one camera is connected and an image window is currently open, the sequence will be loaded to the active window. If no image window is open, the images will be loaded to camera #1. This command opens the "Open file" dialog box. Only files with the extension and the format of "*.b16" and "*.tif" (TIFF16) can be imported.

Save RAW File (single image only)

The "Save" command should be used to save the image, which is displayed in the active window. The command opens the "Save file" dialog box. The image file can be saved in 16bit "*.b16" and ".tif" format.
If more than one camera is connected, it is possible to save all current images by selecting "Export all images" in the "Save file" dialog box. With this feature it is possible to save one image of each active camera within one process step (it is not necessary to repeat the save process for each camera). The "Save" command will not be available, if there is no image window open. See 6.5 for further information!

Save RAW Set (for hsfc pro camera)

To save one image of each active camera within one single b16 file.

Save RAW Recorder Sequence (image sequence from one camera)

The "Save Recorder" command should be used to save or export image records. If more than one camera is connected and an image window is currently open, the record of the active window will be saved. The command opens the "Save file" dialog box. The "Save Recorder" command will not be available, if there is no image window open. See 6.5 for further information!

Export File (not reloadable!)

Use this command to export the image in the active image window. This command will open the Save file dialog box. Files with the extensions "fts", "tif", "bmp", "asc", "jpg", and "jp2" can be exported. This item will be not visible, if there is no image window open.

Note: be aware of the different storage abilities of the formats, for example "*.bmp" - the bitmap format only allows for 8bit values to be stored and therefore the image content of a 16 bit image is reduced, if stored as bitmap.

Export Recorder Sequence (not reloadable!)

Use this command to export a sequence of images. If more than one channel is connected and an image window is currently open the record of the window which has got the input focus will be saved. If no image window is open the images of channel 1 will be saved. This command will open the Export image dialog box. Files with the extensions "fts", "tif", "bmp", "asc", "avi", "mpg", “jpg”, “jp2”, and “wmv” can be exported.

If you export recorder files you will not be able to reload them into CamWare!

Print Setup

The "Print Setup" command opens the Windows "Print Setup" dialog box for adjustments and settings of the connected printer(s).

Print Preview

The "Print Preview" command opens a "Print Preview" window.

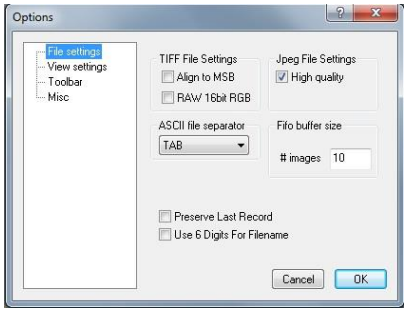
Print

Opens the Windows "Print" dialog box for the currently displayed image or comment display.

Options

This command opens the "Options" dialog, allowing special settings.

Options: File Settings



Tiff Bit Alignment

Here you can select the alignment of the pixel value, if the pixel depth is less than 16bit (e.g. MSB: each pixel value is shifted from bit 12-1 to bit 16-5 in case of 12bit). This removes the 'dark image effect' inside other image applications. Not applicable for pco.edge camera.

Tiff RAW

Here you can select whether the 16bit RGB tif file is saved with 16bit raw or white balanced data. If this item is checked, each 16bit RGB pixel value is saved as raw 16bit RGB (48bit) value, without white balancing. Saving to 16bit RGB can be done by selecting the color display window, export recorder, selecting 8bit-tif (!) and checking 'Save 16bit RGB'.

ASCII file separator

Here you can select an appropriate separator for the ASCII file format.

Jpeg High Quality

Here you can select the quality of the saved jpeg/jp2 files. High quality saves images with 100% quality (otherwise 85% quality).

Preserve Last Record

If checked, a message box will pop up in case the user may overwrite or loose data.

Options: View Settings

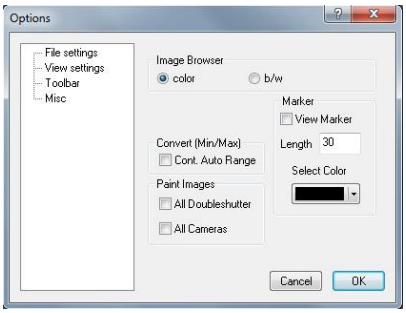


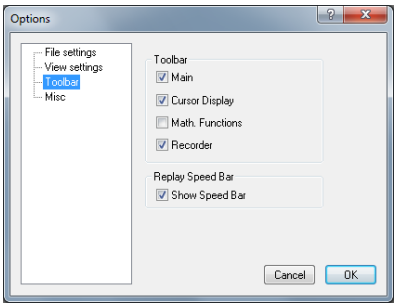
Image Browser
Here you can select between showing all image tiles inside the browser window either b/w or color. Setting b/w will result in a faster refresh. (valid only for color CCD).

Marker
Use this command to display a cross in the centre or elsewhere in the image (see "Set Crosshair" page 44).

Convert (Min/Max) (“Continuous Auto Range Crop”, see chapter 7.6 under “Convert Control BW”)
This option enables the automatic min/max function during record and replay. Disable this feature if the application stops responding during this mode (due to operating system capacity problems).

Paint Images:
This option enables the update of (both double shutter images or) multiple cameras images during record and replay. Disable this feature if the application stops responding during this mode (due to operating system performance problems).

Options: Toolbar



Toolbar
Opens the corresponding toolbars (see 7.2)

Math. Functions 

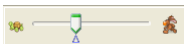
With the math window you have the ability to build the difference between a reference image and the actual image. If you activate math every new image acquired will be subtracted from the reference image or vice versa.

 last acquired image will be copied to reference buffer

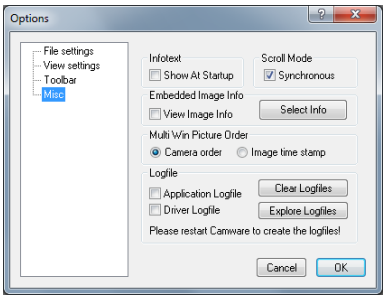
 a reference picture will be acquired and copied to reference buffer

add offset here to avoid negative values, which would not be visible

 enable / disable math function

Replay Speed Bar 
The faster replay speed is useful if large sets of image data need to be scanned.

Options: Misc



Infotext
Use this command to show or hide the start-up information dialog box.

Synchronous Scrolling
If this item is checked all opened image windows will be scrolled at the same time and in the same manner.

View Embedded Image Info (for pixelfly and sensicam models)
If this item is checked an embedded text will be shown inside the image. See chapter 7.6.

Multi Win Picture Order
With the 'Multi Window' you have the ability to view the images of all active cameras in one window. You can select between 'time' oriented or 'camera number' oriented order. 'Time' oriented means that the sequence of images depends on the individual time stamp of each image. 'Camera number' oriented means that the first image shown is from camera 1, then camera 2 and so on. Not recommended for pco.edge.

Logfile
This option enables the logging of errors and system info. Enable this feature in order to create a support file, which can help to find out troubles with the cameras (see A6 “Customer Service and Trouble Shooting”).

Load lookup Table (for monochrome cameras)
With the Pseudo LUT feature you can load any LUT with one of four different formats and you can view the result in the color view window.

Use one of the attached predefined LUTs or define your own.

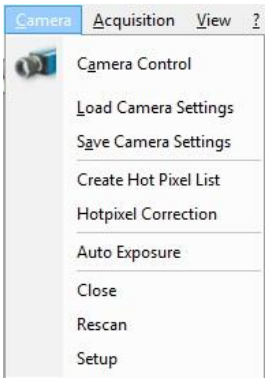
Direct Record to File
With this command you can pre-set a certain number of images to be stored directly onto hard disk. If the camera captures images faster than the computer can save to disk, then you will lose images. The displaying of the images doesn't interfere with the record process. See also 'Recorder Mode' on page 26 and PC recommendations in appendix A8 (Image Data Flow).

Use this command to write data to your RAID system.

Record with ‘Flowfile’ (for pixelfly and sensicam models)

Exit
This command exits the program and closes all channel dialog windows.

Window positions, settings and sizes are stored in the windows registry and will be loaded again at next start-up.



7.4 The Camera Menu

Camera Control
Use this command to open the camera control window (see 6.1).

Load Camera Settings
With this command you can reload camera settings which have been previously saved. You can reload only a file which has been made with the same camera configuration as it was found by the application at start-up.

Save Camera Settings
This command saves the actual camera settings of all existing cameras.

Create Hot Pixel List (for long exposure only)
This feature applies for cameras with exposure times longer than 5s and is not applicable for the pco.edge camera.

Hotpixel Correction (for long exposure only)
Sophisticated hot pixel correction is already implemented in the pco.edge camera.

Auto Exposure
Starts some exposures and tries to find an exposure time that captures images with grey values between 1400 and 1500. It re-adjusts the lookup tables in order to display the images with the new settings best. For low light conditions only.

Close
Disconnects camera and switches Camware to Demo Mode. In case of multiple cameras, all cameras must be closed in order for Camware to switch to Demo Mode.

Rescan
Disconnect and reconnect camera.

Setup
Switch between Rolling Shutter, Global Shutter and Global Reset Mode.
Automatic restart of the camera.

7.5 The Acquisition Menu

Live Preview

The 'Live Preview' is useful for fast and easy adjusting and focusing of the camera. The active window will be updated. To see another window, simply click on the window. This option is not available in double shutter mode.

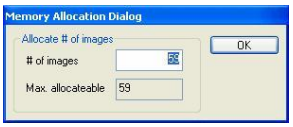
Acquire Picture

Records single images in case of pixelfly and sensicam cameras. (legacy)

Acquire Sequence

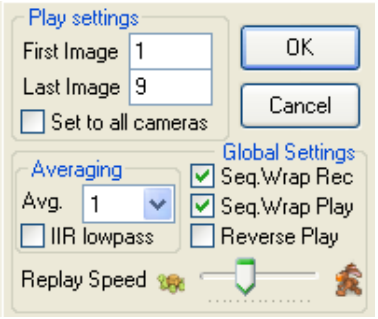
Starts recording images into the system memory according to Trigger Mode selection (see 6.2). During the recording, the camera controls are locked.

Rec. Memory Settings



Predefine the number of images in the allocated RAM segment here.

Recorder Settings



This command opens the Recorder Settings dialog window.

The **Play Settings** are referred to the camera. If more than one camera is connected, the camera number is retrieved from the image window that has received the input focus (is active). If no image window is opened, the dialog is referred to camera 1. If the 'Set to all' checkbox is checked the settings apply to all connected cameras.

The **Global Settings** are valid for all connected cameras.

Averaging

If in the "Avg." dropdown list a value not equal to 1 is selected, the corresponding number of images is averaged in the buffer, reducing the statistically independent noise.
Another option to reduce the noise is the activation of the "IIR lowpass" IIR-filter: Image(act) = Image(act - 1) * 0.9 + Image(new) * 0.1

Replay Speed Slider

The slider can be used to adjust the sequence replay speed, from slow (turtle) to fast (rabbit).

Seq. Wrap Rec

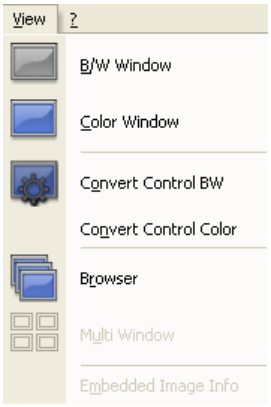
Sequential Wrap Recording sets Recorder Mode (6.6) to “Ring Buffer”.

Seq. Wrap Play

The play button starts the display for a sequence as defined by the first image/last image fields and will loop until the stop button is pressed.

Reverse Play

If the "Reverse Play" box is checked, it is possible to play the recorded images in reverse.



7.6 The View Menu

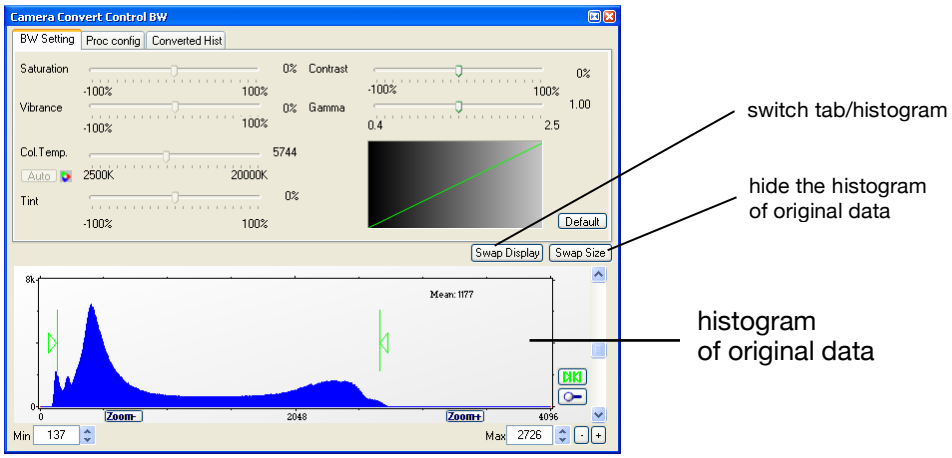
B/W Window

Use this command to open a b/w display window.

Color Window

Use this command to open a color display window.

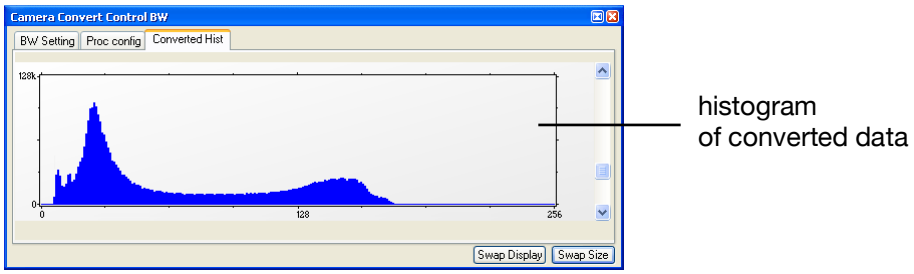
Convert Control BW



The user can influence how the 16 bit intensity values (x-axis) of the original image are converted into 8 bit values (y-axis) in different ways.

Green sliders in histogram
- left slider = 'Min' controller (corresponds to value "0" of the 8 bit display)
  Values below that mark are set to "0", i.e. displayed as black.
- right slider = 'Max' controller (corresponds to value "255")
  Values above that mark are set to "255", i.e. displayed as white.

The values in-between are converted into a value between "0" and "255" according to Contrast and Gamma settings. See the small graph, which reflects the calculation.



How the Auto Range applies:

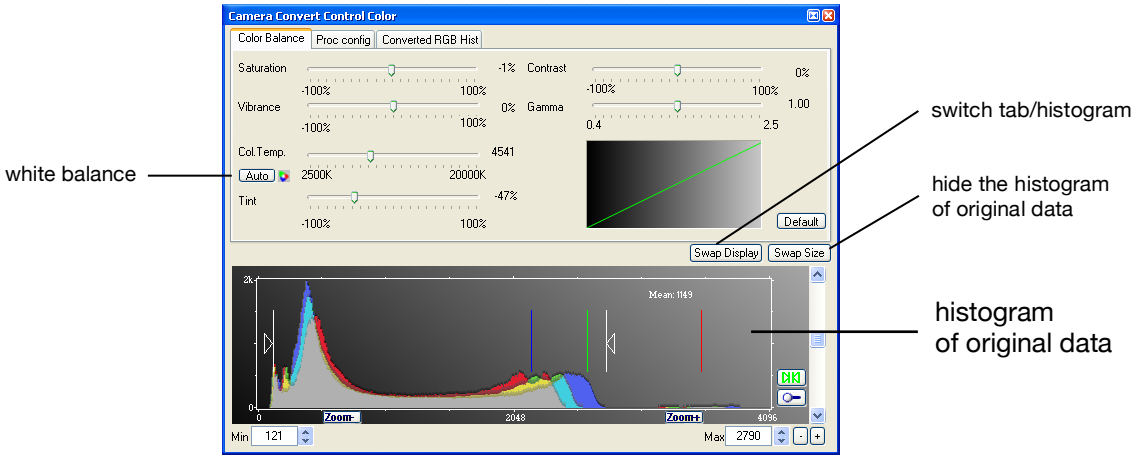
 Auto Range Peak searches for the minimum and maximum 16 bit intensity values of the image. Given these number the converter scales the 8 bit display (256) within these two values.

 Auto Range Crop sets the converter to ignore the extreme intensity values of the image and scales the display in a smaller range. Thus dark or bright light spots, reflections, etc. are cut off.

 Min/Max (Automatic) = Continuous Auto Range Crop

'Proc config' tab: please see under 'Convert Control Color'

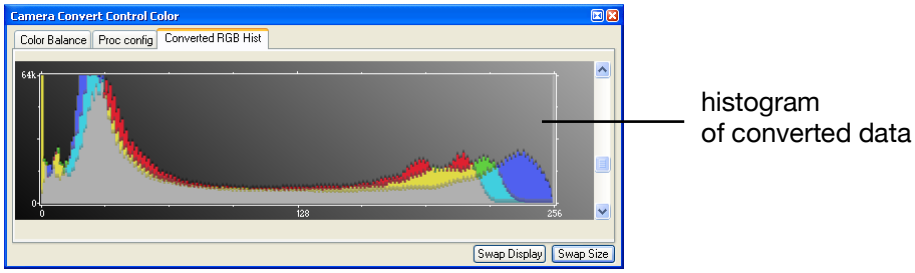
Convert Control Color



The user can influence how the 16 bit intensity values (x-axis) of the original image are converted into 8 bit values (y-axis) in different ways.

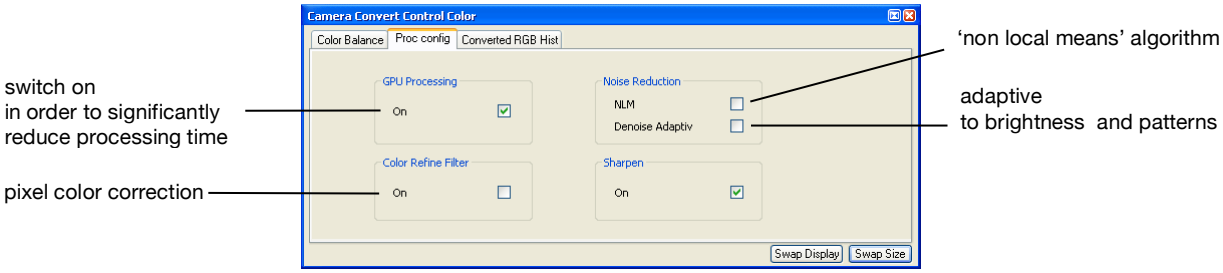
White sliders in histogram
- left slider = 'Min' controller (corresponds to value "0" of the 8 bit display)
  Values below that mark are set to "0", i.e. displayed as 'no color'.
- right slider = 'Max' controller (corresponds to value "255")
  Values above that mark are set to "255", i.e. displayed as 'full color'.

The values in-between are converted into a value between "0" and "255" according to Contrast and Gamma settings. See the small graph, which reflects the calculation.



The balancing of RGB can be controlled by Col.Temp and Tint.
Press the Auto button to set the white balance.

Intensity of single color can be controlled by Saturation and Vibrance.



Due to proprietary high-end algorithms used for these image processing features, no detailed description is given here.

AMD's ATI graphics processing units are not recommended.

GPU Processing

In order to benefit from all of Camware's advanced processing features, we highly recommend a NVIDIA CUDA-enabled graphics processing unit (GPU), e.g. NVIDIA GeForce 9600 GT or better.

Find a list of CUDA-enabled products here:
http://www.nvidia.com/object/cuda_learn_products.html
Get the CUDA driver here:
http://www.nvidia.com/object/cuda_get.html

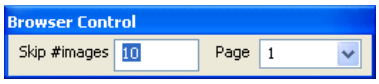
Make sure:
- that the CUDA driver is successfully installed.
- that the GPU has at least 512MB memory.

Camware Image Processing

	color	monochrome
Pre Processing		
Noise Reduction	✓	✓
Bayer Processing		
Bayer Demosaicing	✓	
Sharpen	✓	
Refine Process	✓	
Chroma Blurr	✓	
Post Processing		
Offset, Gain (Min/Max)	✓	✓
Color Correction	✓	
Saturation, Vibrance	✓	
Color Temperature, Tint, White Balance	✓	
Gamma, Contrast	✓	✓

Browser

The 'Recorder Browser' gives an overview of the images in the Recorder, and helps you in an easy way to select a new current image. Simply click on the desired image to make it the current image. It may then be viewed in the Black/White and Color Window.
The Browser window can show up to 40 pictures per page, thus enabling easy printing of the Browser window. You can switch between the single pages by double clicking inside the Browser window or with the local menu (right mouse button).

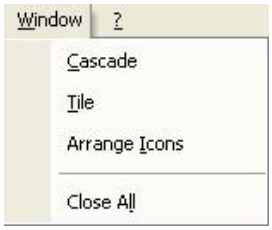


'Skip #images' allows for convenient overview at large numbers of images.

Multi Window

View the images of all active cameras in consecutive order in one window. 'Time' oriented means that the sequence of images depends on the individual time stamp of each image. 'Camera number' oriented means that the first image shown is from camera 1, then camera 2 and so on.

Embedded Image Info (only for pixelfly and sensicam models)
see Timestamp feature in chapter 6.6



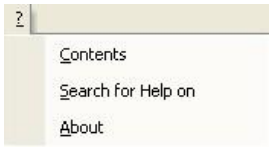
7.7 The Window Menu

Cascade
Show all windows overlapped.

Tile
Tile windows vertically or horizontally.

Arrange Icons
Rearranges all minimized topic icons on the desktop.

Close All
Close all windows.

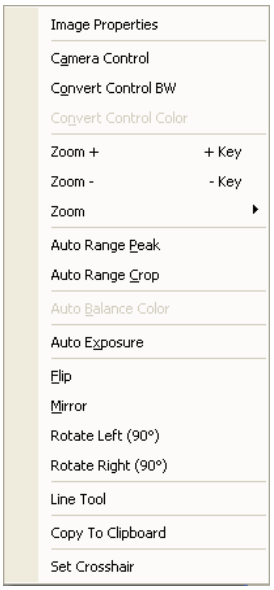


7.8 The Help Menu

Contents
Opens the main page of the online program help.

Search for Help on
Opens an index list for help.

About
This window shows program information and contains helpful support links. In case of a camera problem, support files (see 7.3 Options/Misc/Logfile) may be generated, which can be automatically attached to the email. The support files contain relevant hardware information, the log files and the PCO related registry entries. These files are moved into a zip-archive called “CWSupport.zip”, which can be found in the application folder.



7.9 The Local Menu

The local menu is opened by clicking the right mouse button inside the client area of an image window.

Image Properties

Opens an information bubble with main image properties and activates 'in image' display. The 'in image' display does not overwrite image data. All camera link cameras generate the image properties out of Camware ("Camera Description", see SDK manual for further information) and the PC system time. In case a pco.edge with USB 3.0 interface is connected, the image properties and other meta data is transferred from the camera directly. One additional "line", which contains all image properties, will be sent from the camera after the image data is transferred.

Camera Control

Opens the Camera Control window (see chapter 6).

Convert Control BW/Color

Opens the corresponding Convert Control windows (see 7.6).

Zoom

Changes the zoom used to display the image.

Auto Range Peak/Crop

Displays the image in a predefined scaling (see 7.6).

Auto Balance Color

The white balance feature, which corresponds to the white balance button in the 'Convert Control Color' (see 7.6).

Auto Exposure

Auto Exposure feature (see 7.4)

Flip

The image will be flipped before display.

Mirror

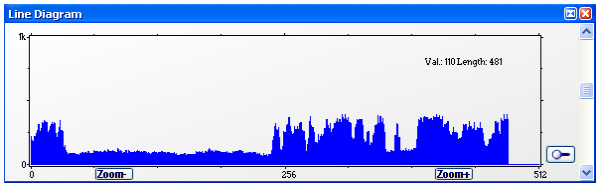
The selected image will be mirrored before display.

Rotate

The image will be rotated by 90° clockwise (right) or counterclockwise (left) before it is shown in the image window.

Line Tool

Select 'Line Tool' to show a graph, which shows the intensity of the pixels under the red line shown in the image window. The selection of this menu item determines the location of the first point. After this you can move the mouse to the second point, which can be selected by a 'left click'. Now a 'Line Diagram' opens and the length of the line (unit: pixel) is shown in a bubble and displayed in the window.



Copy To Clipboard

Copies the active image to clipboard.

Set Crosshair

Move the marker to any point in the image.

7.10 Additional Features

Setting Contrast Area by Mouse

You can control the minimum and maximum values used for the conversion from 16 bit to 8 bit with the mouse. Move the mouse cursor into a region which should be shown with maximum contrast. Press the shift and the left mouse button. Hold down the mouse button while increasing the size of the rubber band window with mouse moves. After releasing of the mouse button the coordinates of the rubber band window act as a border for calculating the minimum and maximum values.

Setting a new ROI by Mouse

In the same manner you can setup a new region of interest (see ROI in Camera control) for the camera. You only have to press the CTRL (Strg) button instead of the shift button. The coordinates of the rubber band window are used for calculating a new region of interest, which will be adapted to the camera capabilities automatically. You can reset the ROI to maximum by pressing the CTRL (Strg) button and the right mouse button.

White Balance by Mouse

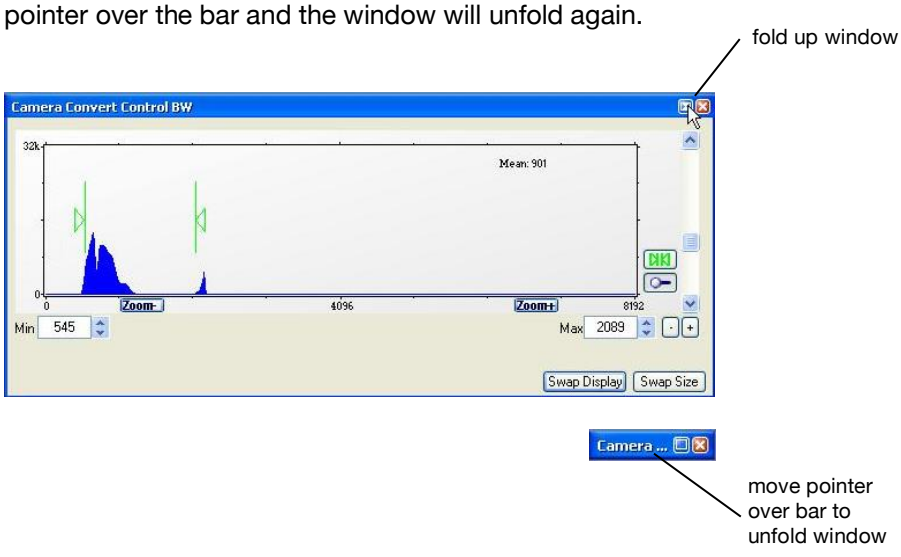
In the same manner you can change the 'white balance'. You only have to press the CTRL (Strg) and the shift button at the same time. The pixel values within the coordinates of the rubber band window are used for calculating a new 'white balance'.

For best results we recommend to use the white balance button in the 'Convert Control Color' (see 7.6) or the 'Auto Balance Color' in the Local Menu (see 7.9) respectively.

Fold Up Window

The Convert Control windows can be minimized/folded up. Just move the pointer over the bar and the window will unfold again.

Fold Up Window not available yet for W7/64-bit systems.



Appendix

A1 Technical Data

pco.edge 4.2 | scientific CMOS camera

technical data USB 3.0

image sensor

type of sensor	scientific CMOS (sCMOS)
image sensor	CIS2020
resolution (h x v)	2048 x 2048 active pixel
pixel size (h x v)	6.5 µm x 6.5 µm
sensor format / diagonal	13.3 mm x 13.3 mm / 18.8 mm
shutter mode	rolling shutter
MTF	76.9 lp/mm (theoretical)
fullwell capacity	30 000 e⁻
readout noise[1]	0.9med / 1.4rms e-
dynamic range	33 000 : 1 (90.4 dB)
quantum efficiency	> 70 %
spectral range	370 nm .. 1100 nm
dark current[2]	< 0.3 e⁻/pixel/s @ 0 °C
DSNU	< 0.3 e⁻ rms
PRNU	< 0.2 %
anti blooming factor	1 : 10 000

camera

frame rate	40 fps @ 2048 x 2048 pixel
exposure / shutter time	500 µs .. 10 s
dynamic range A/D[3]	16 bit
A/D conversion factor	0.46 e⁻/count
pixel scan rate	110.0 MHz
pixel data rate	220.0 Mpixel/s
binning horizontal	x1, x2, x4
binning vertical	x1, x2, x4
region of interest (ROI)	horizontal: steps of 4 pixels vertical: steps of 1 pixel
non linearity	< 0.6 %
cooling method	0 °C stabilized, peltier with forced air (fan) / water cooling (up to 30°C ambient)
trigger input signals	frame trigger, programmable input (SMA connectors)
trigger output signals	exposure, busy, line, programmable output (SMA connectors)
data interface	USB 3.0
time stamp	in image (1 µs resolution)

frame rate table

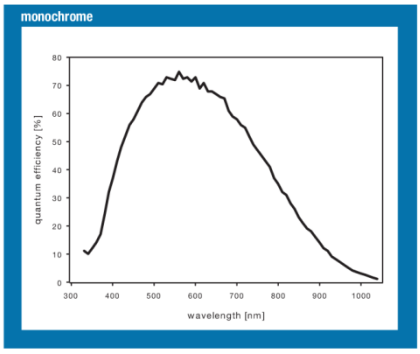
typical example	
2048 x 2048	40 fps

general

power supply	12 .. 24 VDC (+/- 10 %)
power consumption	21 W max. (typ. 12 W @ 20 °C)
weight	930 g
operating temperature	+ 10 °C .. + 40 °C
operating humidity range	10 % .. 80 % (non-condensing)
storage temperature range	- 10 °C .. + 60 °C
optical interface	F-mount & C-mount
CE / FCC certified	yes

[1] The readout noise values are given as median (med) and root mean square (rms) values, due to the different noise models, which can be used for evaluation. All values are raw data without any filtering.
[2] Measurements with dark current compensation.
[3] The high dynamic signal is simultaneously converted at high and low gain by two 11 bit A/D converters and the two 11 bit values are sophistically merged into one 16 bit value.

quantum efficiency



pco.

Subject to change, please refer to current data sheet available on our website.

pco.edge 4.2 | scientific CMOS camera

technical data Camera Link

image sensor

type of sensor	scientific CMOS (sCMOS)
image sensor	CIS2020
resolution (h x v)	2048 x 2048 active pixel
pixel size (h x v)	6.5 µm x 6.5 µm
sensor format / diagonal	13.3 mm x 13.3 mm / 18.8 mm
shutter mode	rolling shutter with free selectable readouts
MTF	76.9 lp/mm (theoretical)
fullwell capacity	30 000 e⁻
readout noise[1]	0.9_{med} / 1.4_{rms} e- @ slow scan 1.0_{med} / 1.5_{rms} e- @ fast scan
dynamic range	33 000 : 1 (90.4 dB) slow scan
quantum efficiency	> 70 %
spectral range	370 nm .. 1100 nm
dark current[2]	< 0.3 e⁻/pixel/s @ 5 °C
DSNU	< 1.0 e⁻ rms
PRNU	< 0.5 %
anti blooming factor	1 : 10000

camera

frame rate	100 fps @ 2048 x 2048 pixel, fast scan
exposure / shutter time	500 µs .. 10 s
dynamic range A/D[4]	16 bit
A/D conversion factor	0.46 e⁻/count
pixel scan rate	272.3 MHz fast scan 95.3 MHz slow scan
pixel data rate	544.6 Mpixel/s 190.7 Mpixel/s
binning horizontal	x1, x2, x4
binning vertical	x1, x2, x4
region of interest (ROI)	horizontal: steps of 1 pixel vertical: steps of 2 pixels
non linearity	< 1 %
cooling method	+ 5 °C stabilized, peltier with forced air (fan) / water cooling (up to 30°C ambient)
trigger input signals	frame trigger, sequence trigger, programmable input (SMA connectors)
trigger output signals	exposure, busy, line, programmable output (SMA connectors)
data interface	Camera Link Full (10 taps, 85 MHz)
time stamp	in image (1 µs resolution)

frame rate table

typical examples	fast scan	slow scan
2048 x 2048	100 fps	35 fps
2048 x 1024	200 fps	70 fps
2048 x 512	400 fps	140 fps
2048 x 256	800 fps	281 fps
2048 x 128	1600 fps	562 fps
1920 x 1080	189 fps	66 fps
1600 x 1200	170 fps	60 fps
1280 x 1024	200 fps	70 fps
640 x 480	426 fps	150 fps
320 x 240	853 fps	300 fps

general

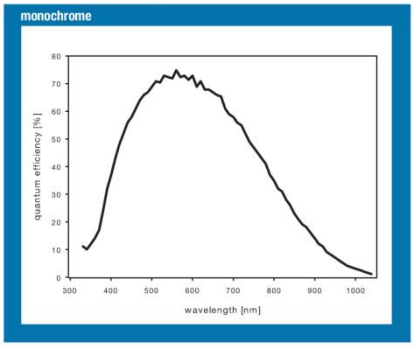
power supply	12 .. 24 VDC (+/- 10 %)
power consumption	20 W max. (typ. 10 W @ 20 °C)
weight	700 g
operating temperature	+ 10 °C .. + 40 °C
operating humidity range	10 % .. 80 % (non-condensing)
storage temperature range	- 10 °C .. + 60 °C
optical interface	F-mount & C-mount
CE / FCC certified	yes

frame rate table extended readout mode[3]

typical examples	fast scan	slow scan
2048 + 12 x 2048	100 fps	35 fps
2048 + 12 x 1024	200 fps	70 fps

[1] The readout noise values are given as median (med) and root mean square (rms) values, due to the different noise models, which can be used for evaluation. All values are raw data without any filtering.
[2] Measurements with dark current compensation.
[3] Extended readout mode with 12 columns of black reference pixel.
[4] The high dynamic signal is simultaneously converted at high and low gain by two 11 bit A/D converters and the two 11 bit values are sophistically merged into one 16 bit value.

quantum efficiency



pco.

Subject to change, please refer to current data sheet available on our website.

pco.edge 5.5 | scientific CMOS camera

technical data USB 3.0

image sensor

type of sensor	scientific CMOS (sCMOS)
image sensor	CIS2521
resolution (h x v)	2560 x 2160 pixel
pixel size (h x v)	6.5 µm x 6.5 µm
sensor format / diagonal	16.6 mm x 14.0 mm / 21.8 mm
shutter modes	rolling shutter (RS)
MTF	76.9 lp/mm (theoretical)
fullwell capacity	30 000 e-
readout noise[1]	1.1med /1.5rms e-
dynamic range	27 000 : 1 (88.6 dB)
quantum efficiency	> 60 %
spectral range	370 nm .. 1100 nm
dark current[2]	< 0.3 e-/pixel/s @ 0 °C
DSNU	< 0.3 e- rms
PRNU	< 0.2 %
anti blooming factor	1 : 10 000

camera

frame rate	32 fps @ 2560 x 2160 pixel
exposure / shutter time	500 µs .. 2 s
dynamic range A/D[3]	16 bit
A/D conversion factor	0.46 e-/count
pixel scan rate	86.0 MHz
pixel data rate	172.0 Mpixel/s
binning horizontal	x1, x2, x4
binning vertical	x1, x2, x4
region of interest (ROI)	horizontal: steps of 4 pixels vertical: steps of 1 pixel
non linearity	< 0.6 %
cooling method	0 °C stabilized, peltier with forced air (fan) / water cooling (up to 30°C ambient)
trigger input signals	frame trigger, programmable input (SMA connectors)
trigger output signals	exposure, busy, line, programmable output (SMA connectors)
data interface	USB 3.0
time stamp	in image (1 µs resolution)

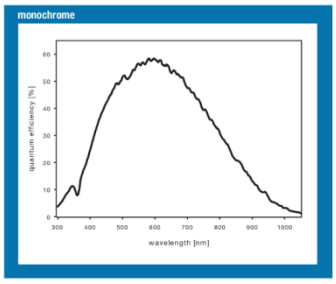
frame rate table

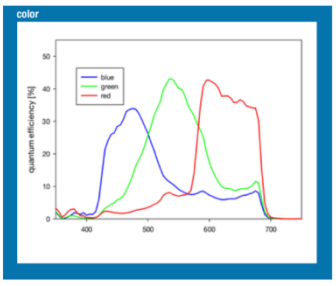
typical example	
2560 x 2160	32 fps

general

power supply	12 .. 24 VDC (+/- 10 %)
power consumption	21 W max. (typ. 12 W @ 20 °C)
weight	930 g
operating temperature	+ 10 °C .. + 40 °C
operating humidity range	10 % .. 80 % (non-condensing)
storage temperature range	- 10 °C .. + 60 °C
optical interface	F-mount & C-mount
CE / FCC certified	yes

[1] The readout noise values are given as median (med) and root mean square (rms) values, due to the different noise models, which can be used for evaluation. All values are raw data without any filtering.
[2] Measurements with dark current compensation.
[3] The high dynamic signal is simultaneously converted at high and low gain by two 11 bit A/D converters and the two 11 bit values are sophistically merged into one 16 bit value.





Subject to change, please refer to current data sheet available on our website.

pco.edge 5.5 | scientific CMOS camera

technical data Camera Link

image sensor

type of sensor	scientific CMOS (sCMOS)
image sensor	CIS2521
resolution (h x v)	2560 x 2160 pixel
pixel size (h x v)	6.5 µm x 6.5 µm
sensor format / diagonal	16.6 mm x 14.0 mm / 21.8 mm
shutter modes	rolling shutter (RS) with free selectable readouts, global/snapshot shutter (GS), global reset - rolling readout (GR)
MTF	76.9 lp/mm (theoretical)
fullwell capacity	30 000 e⁻
readout noise[1]	1.1med /1.5rms e- @ RS, slow scan 1.5med /1.7rms e- @ RS, fast scan 2.2med /2.5rms e- @ GS, fast scan
dynamic range	27 000 : 1 (88.6 dB) RS, slow scan
quantum efficiency	> 60 %
spectral range	370 nm .. 1100 nm
dark current[2]	< 0.3 e⁻/pixel/s RS @ 5 °C < 0.5 e⁻/pixel/s GS @ 5 °C
DSNU	< 1.0 e⁻ rms
PRNU	< 0.5 %
anti blooming factor	1 : 10000

frame rate table

typical examples	RS	GS fast scan	RS slow scan
2560 x 2160	100 fps	50 fps	33 fps
2560 x 1024	212 fps	105 fps	70 fps
2560 x 512	422 fps	208 fps	140 fps
2560 x 256	838 fps	409 fps	279 fps
2560 x 128	1651 fps	789 fps	550 fps
1920 x 1080	201 fps	100 fps	67 fps
1600 x 1200	181 fps	90 fps	60 fps
1280 x 1024	212 fps	105 fps	70 fps
640 x 480	450 fps	222 fps	150 fps
320 x 240	893 fps	436 fps	297 fps

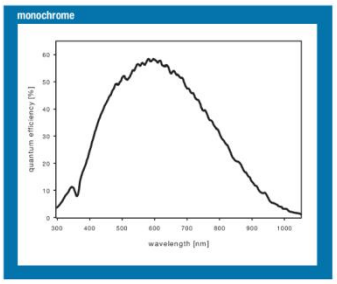
[1] The readout noise values are given as median (med) and root mean square (rms) values, due to the different noise models, which can be used for evaluation. All values are raw data without any filtering.
[2] Measurements with dark current compensation.
[3] The high dynamic signal is simultaneously converted at high and low gain by two 11 bit A/D converters and the two 11 bit values are sophistically merged into one 16 bit value.
[4] Visually lossless compression / decompression for data transfer in fast scan mode and horizontal resolution greater than 1920 pixel (due to Camera Link limitations).

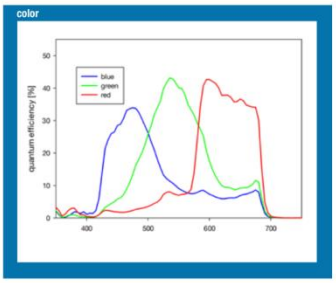
camera

frame rate @ 2560 x 2160 pixel	100 fps @ RS, fast scan 50 fps @ GS, fast scan
exposure / shutter time	500 µs .. 2 s RS 10 µs .. 100 ms GS 10 µs .. 2 s GR
dynamic range A/D[3,4]	16 bit
A/D conversion factor	0.46 e⁻/count
pixel scan rate	286.0 MHz fast scan 95.3 MHz slow scan
pixel data rate	572.0 Mpixel/s 190.7 Mpixel/s
binning horizontal	x1, x2, x4
binning vertical	x1, x2, x4
region of interest (ROI)	horizontal: steps of 4 pixels vertical: steps of 2 pixels
non linearity	< 1 %
cooling method	+ 5 °C stabilized, peltier with forced air (fan) / water cooling (up to 30°C ambient)
trigger input signals	frame trigger, sequence trigger, programmable input (SMA connectors)
trigger output signals	exposure, busy, line, programmable output (SMA connectors)
data interface	Camera Link Full (10 taps, 85 MHz)
time stamp	in image (1 µs resolution)

general

power supply	12 .. 24 VDC (+/- 10 %)
power consumption	20 W max. (typ. 10 W @ 20 °C)
weight	700 g
operating temperature	+ 10 °C .. + 40 °C
operating humidity range	10 % .. 80 % (non-condensing)
storage temperature range	- 10 °C .. + 60 °C
optical interface	F-mount & C-mount
CE / FCC certified	yes





Subject to change, please refer to current data sheet available on our website.

pco.edge gold 5.5 | deep cooled scientific CMOS camera

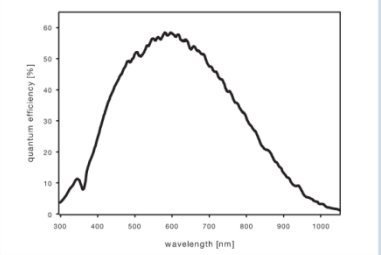
technical data

image sensor

type of sensor	scientific CMOS (sCMOS)
image sensor	CIS2521
resolution (h x v)	2560 x 2160 pixel
pixel size (h x v)	6.5 µm x 6.5 µm
sensor format / diagonal	16.6 mm x 14.0 mm / 21.8 mm
shutter modes	rolling shutter (RS)
MTF	76.9 lp/mm (theoretical)
fullwell capacity	30 000 e⁻
readout noise[1]	0.8_{med} /1.3_{rms} e-
dynamic range	37 000 : 1 (91.4 dB)
quantum efficiency	> 60 %
spectral range	370 nm .. 1100 nm
dark current[2]	< 0.08 e⁻/pixel/s @ -30 °C
DSNU	< 0.3 e⁻ rms
PRNU	< 0.2 %
anti blooming factor	1 : 10 000

quantum efficiency

monochrome



camera

frame rate	32 fps @ 2560 x 2160 pixel
exposure / shutter time	500 µs .. 60 s
dynamic range A/D[3]	16 bit
A/D conversion factor	0.46 e⁻/count
pixel scan rate	86.0 MHz
pixel data rate	172.0 Mpixel/s
binning horizontal	x1, x2, x4
binning vertical	x1, x2, x4
region of interest (ROI)	horizontal: steps of 4 pixels vertical: steps of 1 pixel
non linearity	< 0.6 %
cooling method	-30 °C water cooling, up to 25 °C ambient temperature -15 °C peltier with forced air (fan), up to 30 °C ambient temp.
trigger input signals	frame trigger, programmable input (SMA connectors)
trigger output signals	exposure, busy, line, programmable output (SMA connectors)
data interface	USB 3.0
time stamp	in image (1 µs resolution)

general

power supply	24 VDC (+/- 10 %)
power consumption	36 W max.
weight	1800 g
operating temperature	+ 10 °C .. + 40 °C
operating humidity range	10 % .. 80 % (non-condensing)
storage temperature range	- 10 °C .. + 60 °C
optical interface	F-mount & C-mount
CE / FCC certified	yes

frame rate table

typical example	
2560 x 2160	32 fps

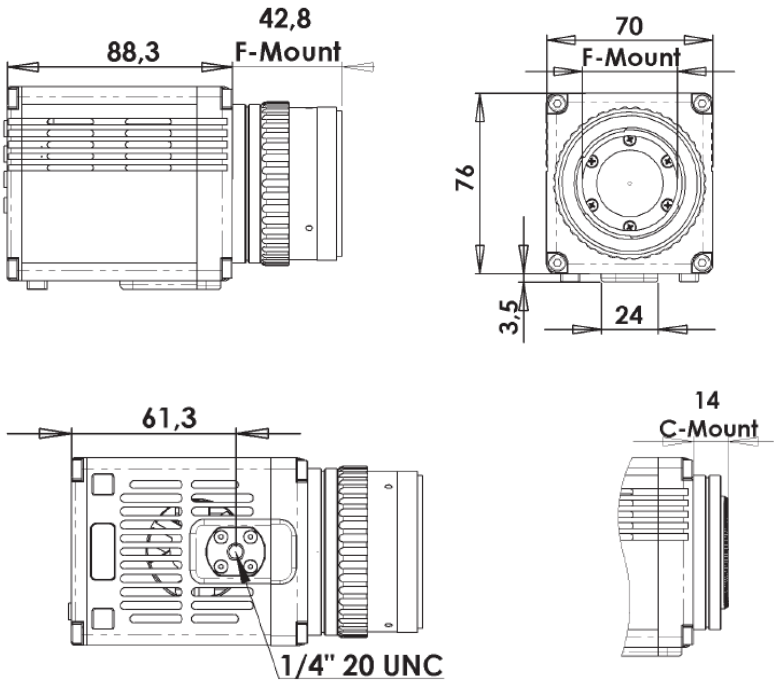
[1] The readout noise values are given as median (med) and root mean square (rms) values, due to the different noise models, which can be used for evaluation. All values are raw data without any filtering.
[2] Measurements with dark current compensation.
[3] The high dynamic signal is simultaneously converted at high and low gain by two 11 bit A/D converters and the two 11 bit values are sophistically merged into one 16 bit value.

Subject to change, please refer to current data sheet available on our website.

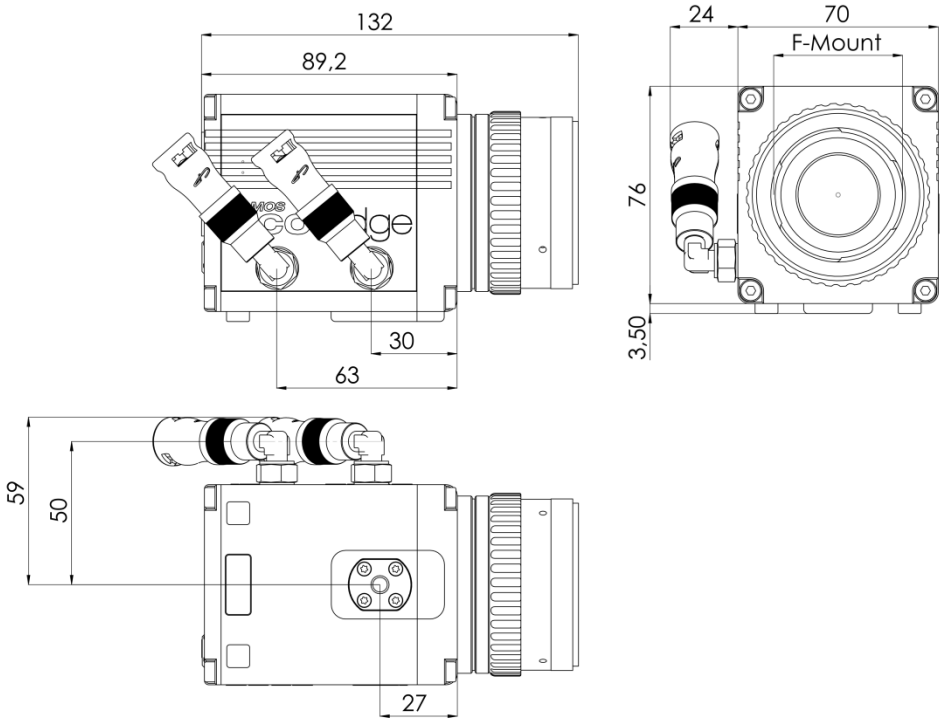
A2 Mechanical Dimensions

All dimensions given in millimeter.

Standard Version (pco.edge 4.2 / 5.5, Camera Link or USB 3.0)

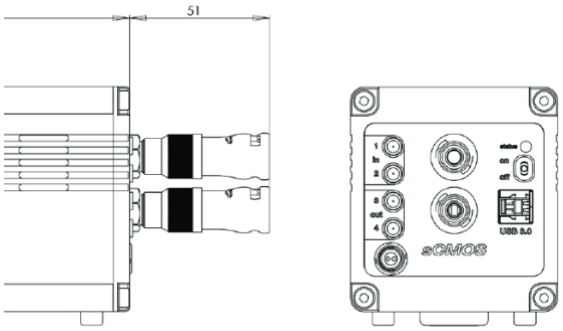


Water Cooled Standard Version (pco.edge 4.2 / 5.5, Camera Link)

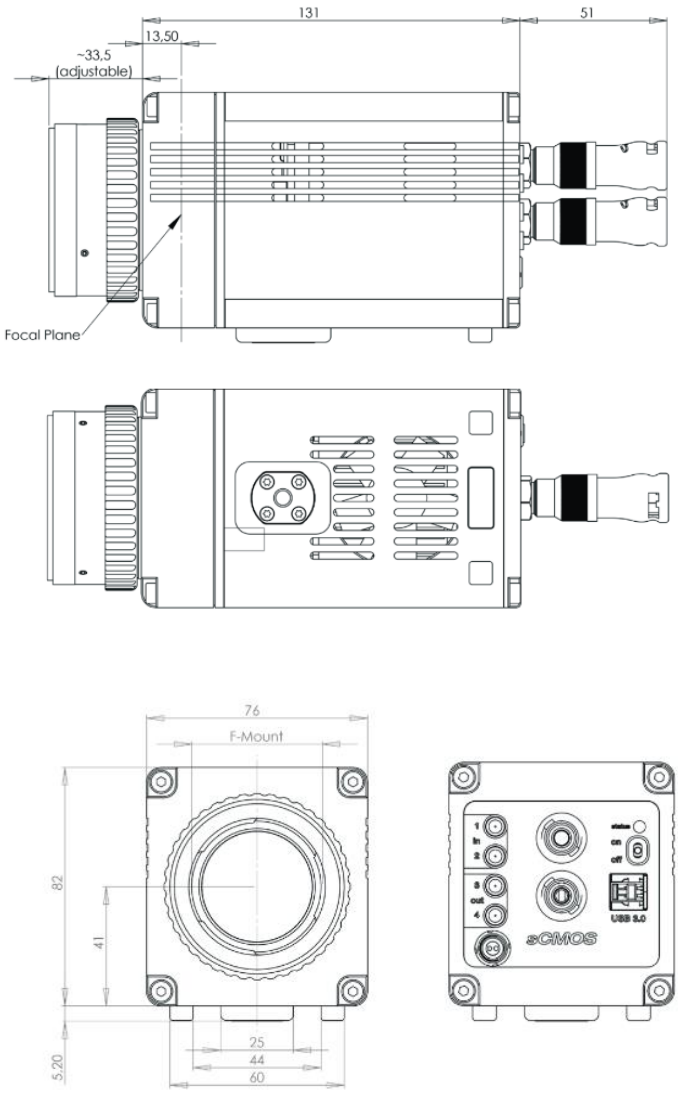


Water Cooled Standard Version (pco.edge 4.2 / 5.5, USB 3.0)

The housing size is similar to the dimensions of the Standard Version, except the camera design with USB 3.0 interface allows to locate the water connectors at the back of the camera.



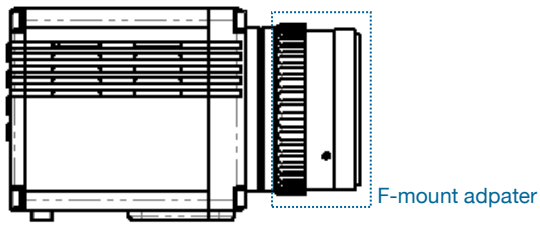
pco.edge GOLD series



A3 How to change optical input F-mount to C-mount

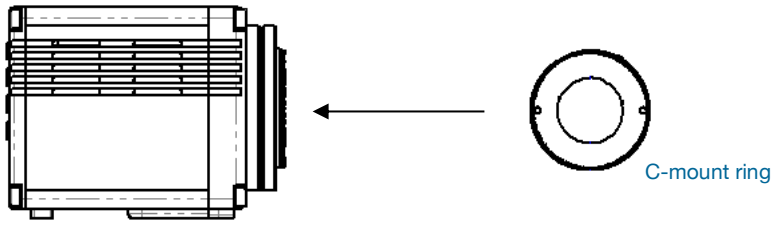
Step #1: Remove F-mount Adapter

Grasp the F-mount adapter at the blue ring (counter ring) and turn counterclockwise.



Step #2: Insert C-mount Ring

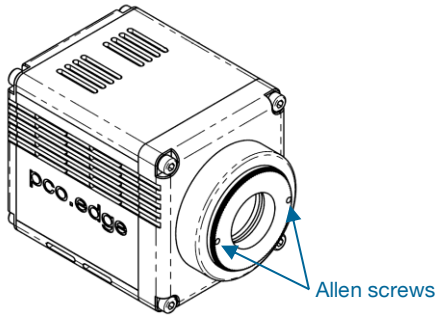
Carefully screw the ring completely in and tighten the two Allen screws.



Adjust Back Focal Length

First step, attach a lens to your c-mount adapter. Then set the focus of your lens to infinity. After that, look for a point in infinity* and generate a sharp image by turning the smaller ring of the adapter. Then fix this position with the two small indented screws.

*rule of thumb: object should be away about 2000 times the focal length in mm



Limitations of c-mount lenses

Keep in mind that c-mount lenses could cause shadings at the edges of big sized sensors. Most c-mount lenses are able to illuminate a maximum image circle of 16 mm diameter only.

A4 Image File Formats

There are different file formats available for saving camera images with Camware.

b16

The “b16” 16 bit format is similar to the bmp format. However, 16 bit pixel values are used instead of 8 bit pixel values.

The file format consists either of a "Basic Header" (6 Long-parameter) or of an "Extended Header" (32 Long-parameter), the latter of which is optionally for additional information. There might follow a variable comment field (ASCII code). Finally, there is the actual data set that is saved linearly (as in the case of BMP files).

With the exception of the first value, all parameters are "Long Integers" (4 Byte). The first 6 parameters must always exist. The rest of the parameters, as well as the comment field, are optional.

	Parameter	Function
1	“PCO-“	the first 4 byte are the characters “PCO-“
2	file size	file size in byte
3	header length	header size + comment filed in byte
4	image width	image width in pixel
5	image height	image height in pixel
6	extended header	-1 (true), extended header follows
7	color mode	0 = black/with camera, 1 = color camera
8	b/w min	black/white LUT-setting, minimum value
9	b/w max	black/white LUT-setting, maximum value
10	b/w linlog	black/white LUT-setting, 0 = linear, 1 = logarithmic
11	red min	red LUT-setting, minimum value
12	red max	red LUT-setting, maximum value
13	green min	green LUT-setting, minimum value
14	green max	green LUT-setting, maximum value
15	blue min	blue LUT-setting, minimum value
16	blue max	blue LUT-setting, maximum value
17	color linlog	color LUT-setting, 0 = linear, 1 = logarithmic
18 … 266	internal use	
Comment file in ASCII characters with variable length of 0…XX. The length of the comment filed must be documented in the “header length” field.		
	16 bit pixel data	
line 1, pixel 1		value of the first pixel
line 1, pixel 2		value of the second pixel
…		…

We recommend that all images should be saved first in the b16 or TIFF format. The advantage is to have the b16 or tiff images available all the time. You will always have the maximum 16 bit information. Please note that not all image analysis programs can accommodate 16 bit data. The 8 bit format saves only the information displayed on the monitor screen. The 16 bit information will be lost and cannot be displayed later.

pcoraw

This 16 bit PCO file format is based on the new BigTIFF format, thus allowing for file size > 4GB. A new PCO proprietary compression scheme is added in case it is necessary.

TIFF

Tag Image File Format, version 6.0 and lower. There is a 16bit monochrome and color image format.

BMP
Windows Bitmap Format, b/w or color 8 bit format-images, which have been saved in BMP format can be loaded later only as 8 bit images, i.e. part of the original information (16 bit) is lost.

FTS
Flexible Image Transport System, Version 3.1. There is a 16 bit image format. The NASA/Science Office of Standards and Technology (NOST) has defined this format. Some programs use the FIT extension for this format.

ASCII
16 bit format, some mathematical programs prefer ASCII data.

JPG
JPEG (named after the Joint Photographic Experts Group who created the standard) is a commonly used method of lossy compression for photographic images. The degree of compression can be adjusted, allowing a selectable tradeoff between storage size and image quality.

JP2
JPEG 2000 is a wavelet-based image compression standard and coding system. It was created by the Joint Photographic Experts Group committee in the year 2000 with the intention of superseding their original discrete cosine transform-based JPEG standard (created 1992).

AVI
Audio Video Interleave is a multimedia container format introduced by Microsoft in November 1992 as part of its Video for Windows technology.

MPG
MPEG-1, similar to JPEG, is a standard for lossy compression of video and audio developed by the Moving Picture Experts Group (MPEG).

WMV
Windows Media Video (WMV) is a compressed video compression format for several proprietary codecs developed by Microsoft. The original video format, known as WMV, was originally designed for Internet streaming applications, as a competitor to RealVideo.

A5 Service and Maintenance

Service

The camera is designed to operate with no need of special adjustments or periodic inspections.

Maintenance

Unplug the camera from any power supply before cleaning it.

Use a soft, dry cloth for cleaning the camera.
Do not use liquid cleaners or sprays.

The lens is best cleaned with pressurized air or with liquid cleaners such as pure alcohol or with special optical cleaners that are available at high quality photo stores.

Never use aggressive cleaning liquids such as gasoline, acetone, spirits or nitro cleanser.

Every time the input window is cleaned, there is the possibility of surface damage. Do not clean the input window unless it is absolutely necessary. Be careful and avoid scratches and damage to the input window surface.

Use a cotton swab dipped in pure alcohol or optical cleaning liquid and wipe only on the glass surface. Do not get any cleaning liquid on the metallic parts such as the lens thread, because tiny detached particles may scratch the surface.

Always store the camera with the protective cap or with a lens mounted to avoid dust and dirt on the input window!

Camera Disposal

The camera includes electronic devices, which can contain materials harmful to the environment. If the camera is to be discarded, please dispose of it in an environmentally responsible manner and use recycling facilities, where available.

A6 Customer Service and Trouble Shooting

If you have a question, which is not adequately addressed in this manual, please contact PCO or your local dealer.

To speed your request, we need the following information:

- Short description of the problem
- Description of your application
- Camera settings
- Type and version of camera software being used
- Camera serial number
- Operating system (PC)
- Processor type (PC)
- Memory
- Graphic card
- Graphic card setup

Please use the email options under the Help menu (see 7.8)
or go to our website: http://www.pco.de/support-request/

Repair

Before sending the camera for repair, first contact your local dealer or PCO respectively.

When shipping the camera for repair, be certain to carefully pack the camera with proper shipping materials. If possible use the original packaging. Use the protection cap to protect the camera on the lens thread.

Firmware, Software and Driver Update

You will find all necessary software and drivers on the accompanying USB storage device.

For the latest versions please check our website:
http://www.pco.de/de/software/pcoedge/

A7 Water Cooling Option pco.aquamatic II

This is the re-cooling unit for pco.edge cameras with water-cooling.

System Components

Material No.	Description	#
30108000211	pco.aquamatic II	1
50402000055	Power Supply ETC 70-12 1.2m	2
10307000130	EDGE WAT camera cable 5m FGG-RG58- NC3MX	3
10305000190	Innovatec Protect IP 1L	4
20307500024	Power Cable	5
30108000212	Connection Tube 5m PVC 3541-01 PCO (with fittings)	6

3

2 5

4

The operation of the pco.aquamatic is simple and uncomplicated. Normally no maintenance and nearly no attention are needed. Only the liquid level of the reservoir (tank) should be controlled from time to time.

Only use *Innovatec Protect IP* for the pco.aquamatic! Do not use or add any other cooling liquid or water! If you need to add cooling liquid in order to maintain level in the tank, please contact PCO for additional supply.

The recommended service interval for the change of the cooling liquid is 4 years.

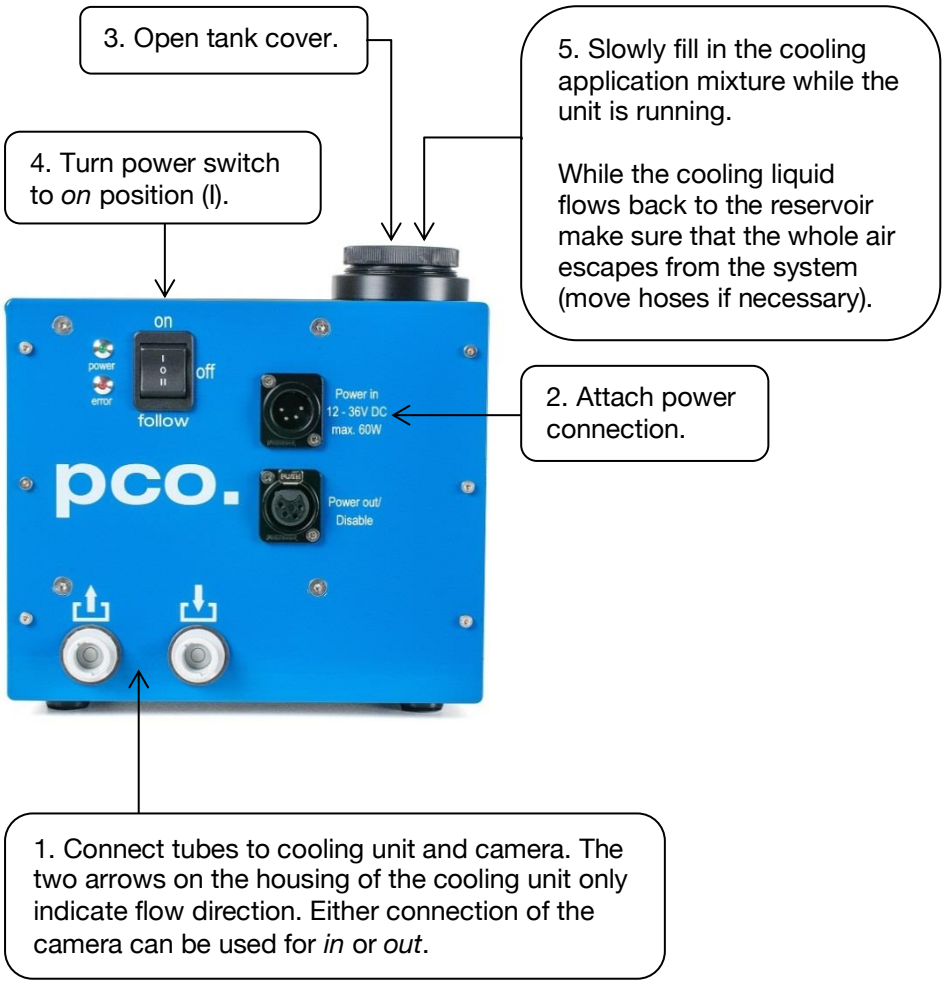
The cooling liquid will turn yellow after some hours of operation. This is normal and no sign of malfunction. The optimum pH-value is between 8 and 9 (please check this value if you are concerned about the cooling liquid quality).

First Time Installation

Please take care to situate the unit on a flat and firm surface. Do not cover the air intakes of the unit. Please ensure free airflow around the pco.aquamatic to ensure maximum cooling performance. All tubes and power cords need to run kink-free.

Before installation of the unit carefully read the accompanying *Innovatek Protect IP* safety datasheet!

Please follow steps 1 – 6.



 outlet flow  inlet flow

The cooling liquid reservoir (tank) is filled when liquid level is approximately 1-2 cm from the top edge of the tank (see inside mark). The integrated pump only works when the pump chamber is completely filled. To ensure this please move hoses or remove air by evacuating. Reservoir capacity is approximately 500 ml.

After steps 1 – 6 are completed successfully the system is ready for operation.

Operation

First connect power out of cooling unit with power in of camera with the *PCO WAT camera cable*.

The cooling unit provides two operation modes. Please select.

Operation Mode “on”: the cooling unit is on permanently and provides power to the camera. Camera can be switch on and off as necessary.

Operation mode “follow”: the cooling unit turns on when the camera is switched on and vice versa.

Error Codes

The cooling liquid temperature sensor is located in the reservoir (tank).

27°C	fan turns off
36°C	fan turns on
55°C	warning message
60°C	error message

If a **warning level** is passed, the Power LED blinks slowly and the Error LED displays the error code. If a **failure level** is passed, the Power LED blinks fast and the Error LED shows the error code.

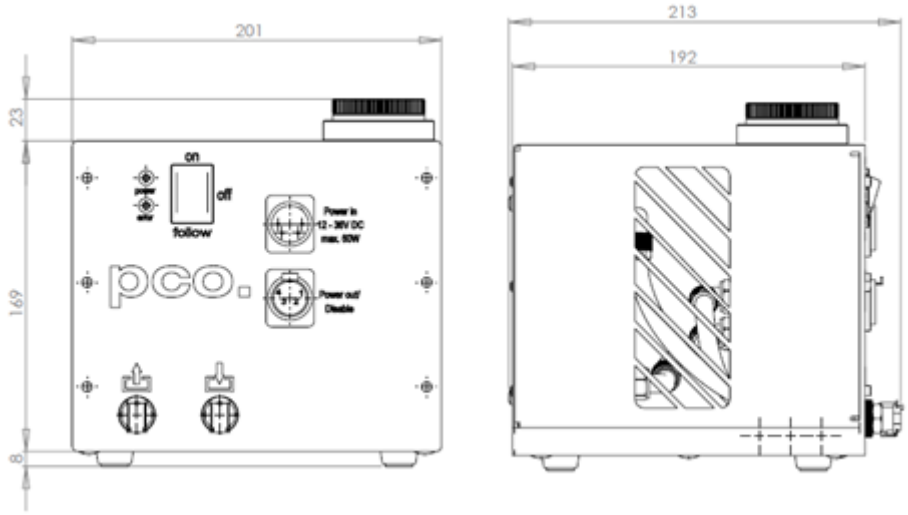
power	error	Error / Failure
on	off	**none**
1Hz flash	one short flash	Warning when temperature at 55 °C (also if sensor is defect or missing)
2Hz flash	one short flash	Failure when temperature at 60 °C
1Hz flash	two short flashes	Fan speed (also if a high deviation of the standard value is reached)

Note: the camera has its own protection circuit and will shut down automatically when the electronics temperature exceeds safety level.

Dimensions

All dimensions are given in millimeter.

Weight: 4kg (completely filled cooler liquid tank)



General Information

You are not restriced to purchase the pco.aquamatic system. A separate power supply will be provided to every pco.edge camera with water connectors in case you want to use an own water cooling solution. The hardware of pco.edge cameras with USB 3.0 Interface is designed to work with or without a water cooling system since a fan to provide proper heat transfer is inside the camera anyways. Please note, that the minimum sensor temperature of the pco.edge GOLD series is depending on the cooling system.

In case you use an own water cooling system, please make sure that the liquid you use to cool your camera is NEVER below the dew point of the ambient temperature at all times! In order to avoid any appearance of condensation, use a cooling liquid at room temperature. A liquid flow rate of 1 – 2 litres per minute is sufficient.

A8 Image Data Flow – PC Recommendations

New sCMOS image sensors provide an extremely high frame rate compared to other scientific image sensors. The high frame rate, along with the high dynamic, creates a large amount of data that must be handled and stored. The maximum data rate of the sCMOS image sensor is given by:

pco.edge 5.5, Camera Link:

[2560 * 2160 (pixel in 1 frame) * 2 Byte (= 16bit dynamic)] * 100 [frames/s] = 1.1 GB/s (pco.edge 5.5, Camera Link)

To handle this considerable amount of data, there are two options available.

Option 1: Real-time Recording to Computer

The pco.edge sCMOS camera series uses this option. For this purpose, the interface must be capable of transmitting data at the required speed. Interfaces such as GigE, USB 3.0 and Camera Link are not fast enough to transmit this data, which is delivered by the largest sCMOS image sensor. Nevertheless, there is a sophisticated solution that uses the Camera Link interface, which is integrated into the pco.edge camera. It is a fact of nature that light, itself, has its own noise component called “photon or shot noise”, which increases with light signal. In this approach, no compression is made in small signals, while for large signals a suitable compression is applied. Since the introduced compression error is always smaller than the photon noise induced error, it is not seen and a so called **“visual lossless” compression** has been performed.

It can be shown that this is possible without any significant loss of information. Therefore, the calculation for the pco.edge camera at full speed and full frame has to be re-written:

[2560 * 2160 (pixel in 1 frame) * 1.5 Byte (= 12bit dynamic)] * 100 [frames/s] = 0.829 GB/s

The Camera Link interface can transmit this in real-time. In the future, recently-introduced machine vision interfaces including CoaXPress and Camera Link HS are capable of transmitting sCMOS image data without any compression. A network type interface, 10GigE, is similar with respect to hardware to Camera Link HS, but incorporates all of the known GigE advantages and disadvantages. Here, the usual protocols are not favorable for image data transmission, and any network traffic can dramatically reduce available transmission speed. **The real-time data transmission into the computer allows for a variety of applications, since it is free from camera memory limitations.** Image data can be stored directly in the computer’s random access memory (RAM) up to more than 64 gigabyte. With an appropriate RAID system, the data can be stored directly to hard disks and there is no delay involved.

Option 2: Recording in the Camera

For high-speed imaging applications where data transfer rates are in the range of several GB/s it is accepted that the primary image memory (camRAM) must be located in the camera. Two examples of such high-speed cameras are the pco.dimax with 36 GB of camRAM and the pco.dimax HD with 18 GB of camRAM memory. This allows for fast recording, but just up to the integrated memory limit. Before a second sequence can be recorded, one must endure the wait time until data is downloaded to computer storage. Therefore, this option can only be used for recording short sequences with enough time between each event to download the image data. This option is not necessary for the pco.edge as

either with USB 3.0 or Camera Link interface, the image data will be recorded to the computer in real-time.

Memory Structure / Organization

As the memory is software-controlled in both options, it does not matter how the data are stored. The memory can be organized for ring buffer or FIFO recording, or for a specified number of images like a “burst” mode. The pco.edge camera enables all of these possibilities with the integrated dynamic link libraries and proprietary pco.camware application software. This allows the customer to select the memory structure and organization that is optimized for the application at hand.

Recommendations

In the following you can find two exemplary systems for RAID and RAM storage options that have been successfully tested by PCO for high performance.

RAID 0	11x Seagate 2TB Constellation ES.2 SATA 6Gb/s 16 GB DDR3 RAM LSI MegaRAID SAS 9280 16+4 Port 6Gb/s PCI 2.0 x8 Intel® DX79SI motherboard Intel® Core™ i7-3820 processor 3.6 GHz 500 GB Western Digital RE4 64MB GeForce GTS 640 2GB (NVIDIA CUDA) Windows 7 Professional 64 bit
RAM	64 GB DDR3 RAM Intel® DX79SI motherboard Intel® Core™ i7-3820 processor 3.6 GHz GeForce GTS 640 2GB (NVIDIA CUDA) 500 GB Western Digital RE4 64MB Windows 7 Professional 64 bit

Note: items are exemplary and subject to change. Please contact PCO for current systems.

ASUS mainboards seem to fail generally during the HS-mode test (see appendix A9) and are not recommended. Other appropriate mainboards, tested at PCO:

Intel Siler X79
Intel DX58SO2
Gigabyte GA-X58A-UD3R
Supermicro X8DTH-iF (S5520 chipset)

Recommended minimum configuration:

CPU >= 2.4GHz

RAM >= 1066MHz

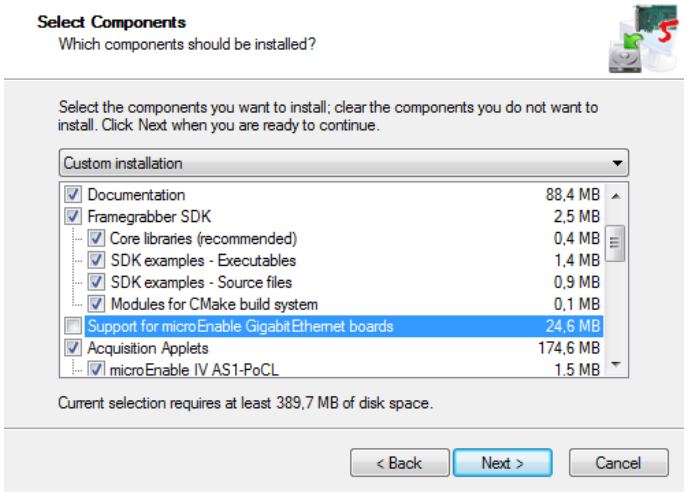
A9 ME4 Grabber Instructions

Install and test SILICONSOFTWARE microEnable IV (ME4) Camera Link grabber for pco.edge camera.

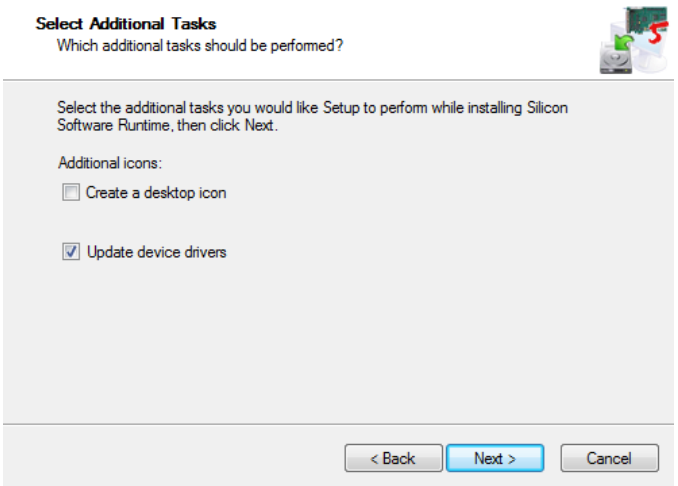
Please install the latest silicon software runtime package before installing the hardware.

Note: When working on a 64bit operating system, please make sure to install the proper (64bit) runtime when also a 64bit application will be operated. If the application is 32bit, you need to install the 32 bit runtime as well.

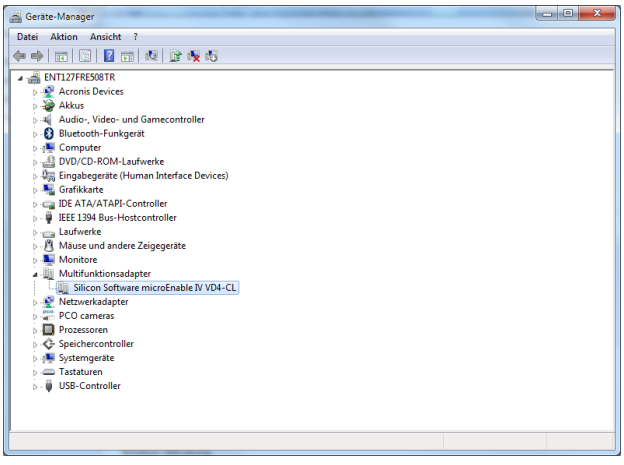
If there is no ME GigE board installed, please deselect ‚Support for…‘



Let the program also update device drivers.

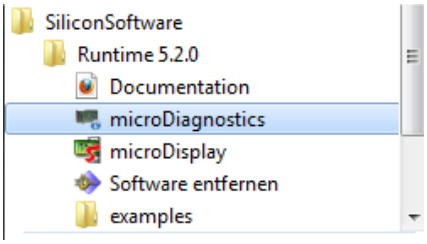


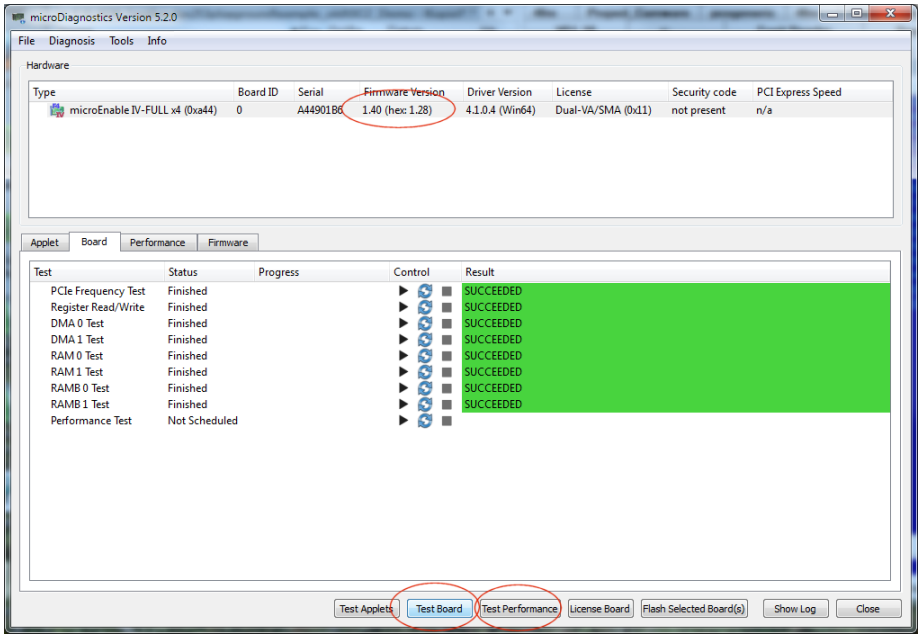
The grabber card should be displayed within the device manager.



If the device is not shown this way, please reinstall the SiliconSoftware device driver. The driver is located in the following directory: C:\Program Files< (x86)>\SiliconSoftware\RuntimeX.X.X\drivers\me4.

After the installation, please start the program microDiagnostics:





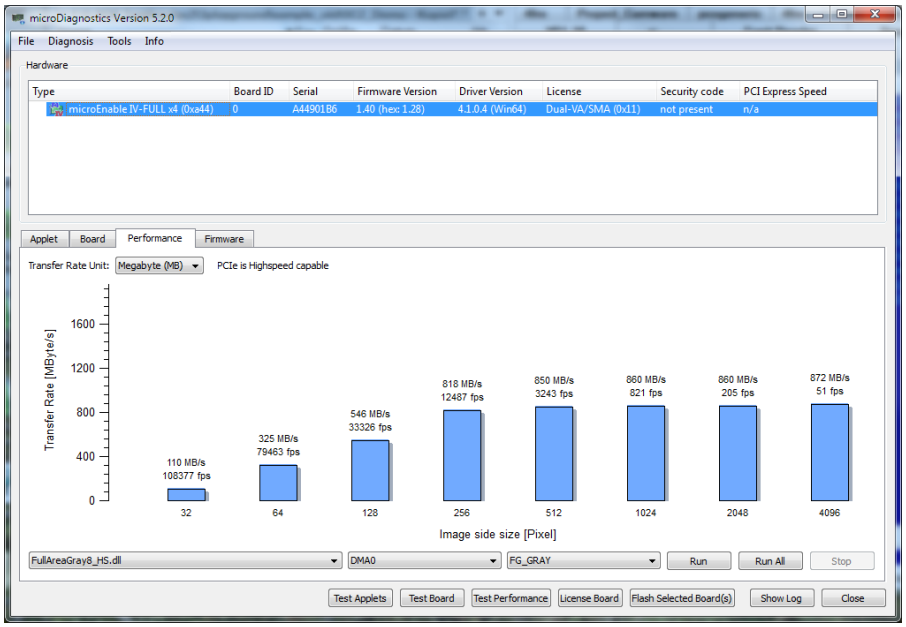
Please verify the firmware version, which must be 1.40 (1.28 in hex) or above.

To test the board, select the board in 'hardware' and click 'Test Board'.

If the firmware is not 1.40 (1.28 in hex), please upgrade to the latest firmware. Select 'Flash Board(s)', then select the grabber in the dialog and open the appropriate hap file, e.g. firmware_me4Fullx4_a44-01-28.hap.

Then click on 'Yes' when you're asked to proceed. You must power cycle your computer after the upgrade.

In case the firmware version is ok, please click on 'Test Performance'.



It is mandatory that 'PCIe is Highspeed Capable' is shown. Otherwise the board is probably not able to transfer the necessary data rate.

The transfer rates as shown should be displayed.

If you have a board, which is not member of the following list and the above test did run with success (Highspeed capable!), please report it to PCO and/or Silicon software.

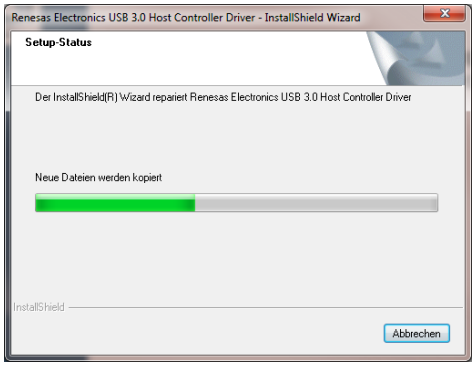
- Supermicro X8ST3
- GigaByte GA-X58A-UD3R
- Intel S5520
- Intel DX58SO2
- Intel DX79SI
- EVGA X79
- Supermicro X8DTH-iF

A10 USB 3.0 – Installation & Hardware Recommendations

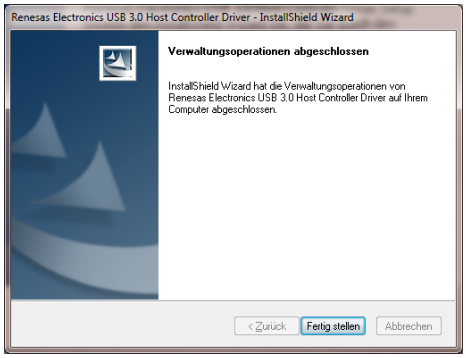
Driver Installation Instruction

- Within the provided installation files “USB_HBA”, open the folder “U3X4-PCIE4XE101, U3X4-PCIE1XE101, U3-PCIE1XG202.
- Open the subfolder “Driver” and run “RENESAS-USB3-Host-Driver-30230-setup.exe”.
- If your current OS is Win7/8 and the User Account Control is enabled, a Dialog could occur asking, if you wish to launch the setup. Accept with “Yes”.
- At first the installation is prepared.

- Secondly the software components are copied.



- Finally the installation is completed and the Delock USB 3.0 extension card can be used.



PC & Hardware Recommendations

The PCO USB 3.0 interface is based on the Cypress EZ-USB FX31 device and it is compatible to PCO software such as the pco.camware and PCO SDK. To run a PCO USB 3.0 camera successfully the user should consider a number of important issues that are discussed in the following Chapters.

Motherboard And Chipset Configuration

It is recommended to use a Motherboard with a state of-the-art USB 3.0 host controller for the onboard USB 3.0 ports. The latest generation of the USB 3.0 xHCI host controllers manufactured by Intel, Renesas (NEC), Fresco, Via Labs, ASMedia and Texas InstrumentInc. (TI) are tested by Cypress Semiconductor Corporation. (see Cypress EZ-USB® FX3TM SDK Release Notes, Version 1.2.3, (Chapter 1.3). CurrentlyPCO recommends only motherboards with the following onboard xHCI host controllers:

- Renesas/NEC µPD720202 host controller
- Intel® USB 3.0 eXtensible Host Controller

If the Motherboard does not have an onboard USB 3.0 port or the onboard USB 3.0 port does not work properly with a PCO USB 3.0 camera, please use an independent PCIe USB 3.0 extension card. In this case, PCO recommends the following:

- DELOCK 89348 (U3-PCIE1XG202-10)
  PCIe 1x (µPD720202 host controller)
  (This board is sent with your pco.edge USB 3.0 camera system as standard)
- DELOCK 89325 (U3X4-PCIE4XE101)
  PCIe 4x (µPD720202 host controller)

USB 3.0 extension card with xHCI4 host controller

The following companies manufacture USB 3.0 xHCI host controller:

- Renesas Electronics America Inc. (earlier NEC),
- Texas Instrument Inc.,
- VIA Labs Inc (Diamond),
- Fresco Logic Inc.,
- Intel Inc.,
- AMD Inc. and
- Etron Technology, Inc.

Note: To determine suitable manufacturers of the xHCI controller, please use the Windows Device Manager. For example, in Windows 7 drop down the “USBController” entry and find the USB 3.0 host xHCI controller of the USB 3.0 device in the sub-tree. Then right-click to open the properties dialog, click the ‘details’ tab, and choose ‘Vendor’ in the properties pull-down box.

NOTE: USB3.0 interface cards with controllers from Etron Technology, Inc. have not yet been tested.

The following table gives an overview about tested and recommended system configurations or hardware components.

Component	Recommendation
Motherboard	There is no recommendation for a manufacturer. But if an onboard USB 3.0 port is used, the Renesas´s xHCI host controller µPD720202 is recommended.
USB 3.0 extension card	• DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x (µPD720202 host controller), • DELOCK 89325 (U3X4-PCIE4XE101) PCIe 4x (µPD720202 host controller)
PCIe Slot	A PCIe 4x, 8x or 16x slot is recommended.
USB 3.0 Cable	USB 3.0 cable included in the packaging of your PCO USB 3.0 camera
USB 3.0 Hub	Not recommended
Operating System	Windows XP 32 Bit, Win7 32 Bit / 64 Bit, Win8 32 Bit / 64 Bit
Multiple PCO USB 3.0 cameras connected to a PC	A separate DELOCK 89348 (U3-PCIE1XG202-10) extension card for each camera should be used to guaranty maximum data throughput of each camera.
FOL adapter	Please visit our homepage (www.pco.de) for latest information.

Recommended Software Components

The PCO USB 3.0 driver supports Windows 7/8 (x86 or x64) and Windows XP x86 operating systems. Microsoft does not support USB 3.0 natively for Win 7 or older Windows versions. Therefore use the manufacturers' supplied xHCI host controller driver. By contrast, in Windows 8 Microsoft does provide a native generic xHCI Driver but PCO recommends using the driver from the corresponding manufacturer of the xHCI host controller. Currently there are seven different vendors producing USB 3.0 host controllers:

- Renesas Electronics America Inc. (earlier NEC),
- Texas Instrument Inc.,
- VIA Labs Inc (Diamond),
- Fresco Logic Inc.,
- Intel Inc.,
- AMD Inc and
- Etron Technology, Inc.

Please make sure that the most recent driver from the manufacturer is installed before a PCO USB 3.0 camera is connected to a USB 3.0 port of the PC. The appropriate driver for the PC´s USB 3.0 port could be loaded from the homepage of the manufacturer of the USB 3.0 host xHCI controller; or, from the homepage of the USB 3.0 extension card vendor. The current driver of the extension card included in the packaging of your PCO USB 3.0 camera is added to the PCO USB Stick delivered with the PCO USB 3.0 camera.

Note: To determine the driver currently in use for the xHCI controller, use the Windows Device Manager. For example in Windows 7, drop down the "USB-Controller" entry and find the USB 3.0 host xHCI controller of the USB 3.0 device in the sub-tree. Then right-click to open the Properties dialog, click the 'driver' tab and choose 'driver details'.

If the PCO USB 3.0 camera is turned on and is connected to the USB 3.0 port of the PC, the OS will automatically try to recognize the device and will try to install the correct PCO USB 3.0 driver.

Please visit the support section of our homepage (www.pco.de/support) to get further information about USB 3.0 and the most recent recommendation for USB 3.0 components.

A11 Binning in CMOS sensors

Binning describes the summation of single pixels to form larger pixels and thereby improving the signal-to-noise ratio (SNR).

Binning in CCD image sensors

The term binning comes from scientific CCD image sensors. The prominent feature of charge-coupled-devices (CCD) is the lossless transport or shifting of charge packages until an amplifier circuit converts them into a voltage at the output, where the main readout noise contribution occurs.

If charge packages from two or more pixels are added before they are read out (past the output amplifier) because of very low light signals, this process is called binning. Since the signal is increased before it is read out, and the image sensor's readout characteristics remain unchanged, binning improves the SNR, and the image sensor's resolution is reduced. The lossless transport feature of CCD image sensors makes binning possible.

Binning in CMOS image sensors

In general, there is no binning possible in CMOS image sensors because there are voltages processed instead of charges transported. In each pixel, the light generated charges are converted into voltages with the readout noise contribution of these amplifiers. Therefore, as opposed to CCD image sensors, if these voltages were combined, the readout noise would also be combined, which would not have the same positive effect on the SNR.

Nevertheless, such a summation or even an averaging would be beneficial for the SNR, but with a smaller impact compared to CCD image sensors. Since such "CMOS binning" cannot be done within the image sensor, it either has to be done in the camera or it has to be done in the computer.

There are two options for "CMOS binning":

"CMOS binning" – accumulation

Pixel values can accumulate, causing an effective dynamic reduction or larger number formats, because the result might exceed the original format -- two times maximum 8 bit values will result in a 9 bit value. This will not be a problem if 12 bit values are accumulated and transported as 16 bit images. However, in the case of scientific CMOS, if 16 bit values are transmitted in 16 bit images, only two times 15 bit maximum values are allowed. The signal of the binned pixels will be accumulated, due to the properties of readout noise, the increase of the noise itself will only be as big as the square root of the number of binned pixels. The SNR will improve and in addition, a reduction of the stored image data is achieved.

"CMOS binning" - averaging

The current default binning mode is "accumulation". Averaging is not available within Camware.

Pixel values can be averaged, which has the same effect on the SNR as accumulation due to the properties of noise. This would keep the image output format the same and would reduce the amount of image data that can be stored. When this type of "CMOS binning" is processed in the camera it is called "hardware binning". This should not be confused with real binning in CCD image sensors, because the "hardware" that processes this binning is not much different from the "hardware" in computer processing. Therefore, the term "hardware binning" may be misleading.

PCO AG was founded in 1987. The company headquarters in Kelheim employs more than 70 specialists in the development and production of optimized, fast, sensitive camera systems for scientific applications. PCO's range of products includes digital camera systems featuring high dynamics, extremely high sensitivity, high resolution, high speed, and extremely low noise, which are sold in industrial and scientific markets all over the world.

Cameras for every point of view.

The systems produced by PCO AG are cameras and scientific measuring instruments at the same time. Our high-tech systems are mostly the result of manual labor: over 70 highly specialized employees handle development and production at the Kelheim site. We deliver roughly 4.000 cameras a year to customers all over the world. As in every cutting edge technology, dialogue with the user is the main focus of PCO's approach. Worldwide representatives, in cooperation with the in-house marketing division and technical support team, ensure that PCO camera systems are developed in step with the individual requirements of our customers.

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