

pco.edge 4.2 LT

scientific CMOS camera

high resolution

2048 x 2048 pixel

low noise

0.8 electrons



USB 3.0

**small
form factor**

high dynamic range

37 500:1

high speed

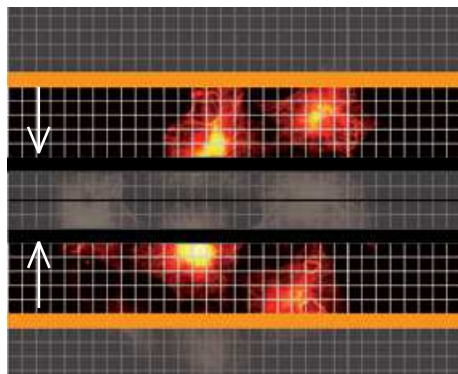
40 fps

high quantum efficiency

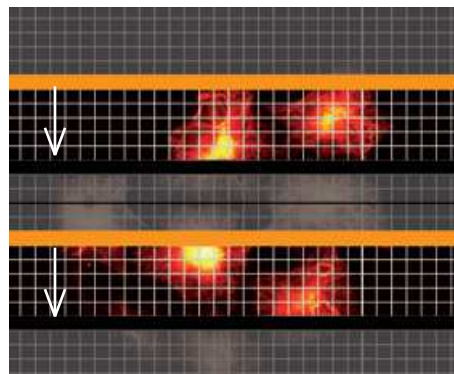
up to 82 %

features

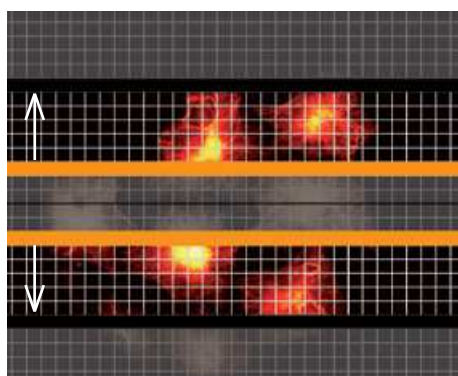
Selectable rolling shutter operation modes of pco.edge cameras.



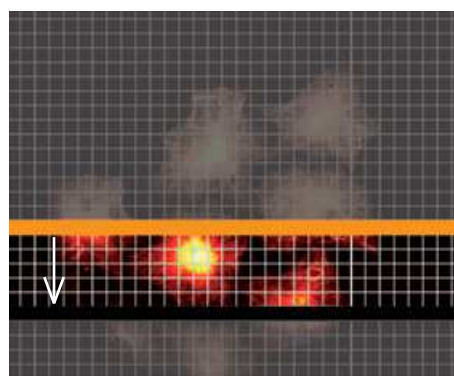
dual outside in



dual top down



dual inside out



single top down

rolling shutter readout modes – optimized for synchronization of microscopes and scanning applications

All pco.edge sCMOS cameras from the beginning feature a variety of precise synchronization modes, which are optimized for advanced microscopy imaging and scanning. The flexible frame and line triggers with very low latency in combination with the free selectable readout modes can easily be combined to cover every modern microscopy situation to name a few:

- lightsheet microscopy
- selective plane imaging microscopy (SPIM)
- structured illumination microscopy
- localizations microscopy (GSD, PALM, STORM, dSTORM)
- spinning disk confocal microscopy
- RESOLFT

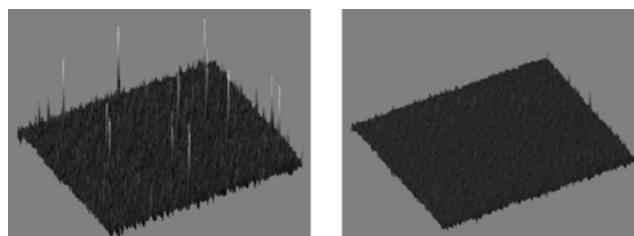
For example, one mode is used in a lightsheet or SPIM application, the lower right rolling shutter operational mode “single top down” operation is convenient to properly synchronize the camera exposure with the scanner. On the other hand, if speed is required and a flash like exposure is applied the upper left mode “dual outside in” is used for localization microscopy techniques like GSD, PALM or STORM.

features

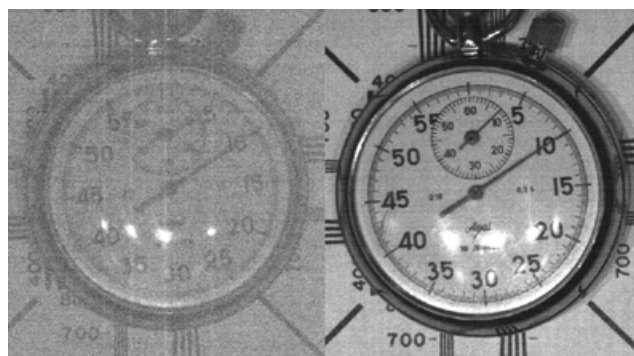
superior image quality

The pco.edge sCMOS camera features outstanding low read out noise. Even at maximum speed of 40 frames/s at full resolution of 2048 x 2048 pixel the noise is $0.8 e^-$ med. Moreover the pco.edge provides an excellent homogeneous pixel response to light (PRNU, photo response non-uniformity) and an excellent homogeneous dark signal pixel behaviour (DSNU, dark signal non-uniformity), which is achieved by a sophisticated electronic circuit technology and firmware algorithms.

The lower figure shows a comparison of a scientific grade CCD and the new pco.sCMOS image sensor under similar weak illumination conditions. This demonstrates the superiority of sCMOS over CCD with regards to read out noise and dynamic, without any smear (the vertical lines in the CCD image).



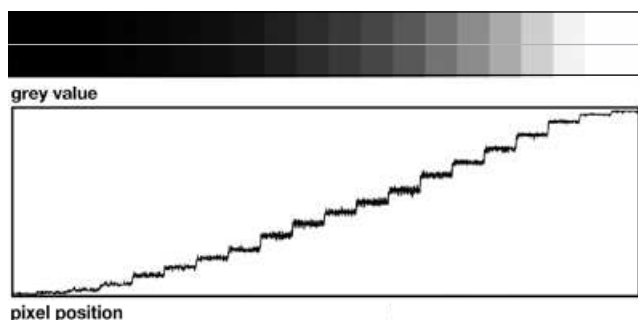
Dark image comparison with the measured distribution of “hot blinking” pixels at typical cooled down operating temperature of the image sensor. The left image gives a 3D view with the sophisticated “blinker filter” algorithm off and the right image shows the result with the filter switched on.



The left image was recorded by a scientific CCD camera while the right image was recorded by a pco.edge under identical conditions.

flexibility and free of latency

User selectable choice of rolling shutter modes for exposure provides flexibility for a wide range of applications. The advantages of rolling shutter are high frame rates and low read out noise. Due to realtime transmission of the image data to the PC, there is no latency between recording and access or storage of the data.



The top image shows an extract of a typical pco.edge recording of a grey scale with a 1 : 10 000 dynamic in 20 steps. The bottom image is a plot of the grey values profile along the centered line through the top image (with gamma 2.2).

37 500:1 dynamic range

Due to the excellent low noise and the high fullwell capacity of the sCMOS image sensor an intra scene dynamic range of better than 37 500 : 1 is achieved. A unique architecture of dual column level amplifiers and dual 11 bit ADCs is designed to maximize dynamic range and to minimize read out noise simultaneously. Both ADC values are analyzed and merged into one high dynamic 16 bit value.

technical data USB 3.0

image sensor

| | |
|----------------------------|--|
| type of sensor | scientific CMOS (sCMOS) |
| image sensor | CIS2020A |
| 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 modes | rolling shutter (RS) with free selectable readout modes, global reset - rolling readout (GR) |
| MTF | 76.9 lp/mm (theoretical) |
| fullwell capacity (typ.) | 30 000 e ⁻ |
| readout noise ¹ | 0.8 _{med} / 1.3 _{rms} e ⁻ |
| dynamic range (typ.) | 37 500 : 1 (91.5 dB) |
| quantum efficiency | up to 82 % @ peak |
| spectral range | 370 nm .. 1100 nm |
| dark current (typ.) | < 0.8 e ⁻ /pixel/s @ 10 °C |
| DSNU | < 0.3 e ⁻ rms |
| PRNU | < 0.2 % |
| anti blooming factor | > 10 000 |

frame rate table²

| typical examples | |
|------------------|---------|
| 2048 x 2048 | 40 fps |
| 2048 x 1024 | 80 fps |
| 2048 x 512 | 160 fps |
| 2048 x 256 | 315 fps |
| 2048 x 128 | 610 fps |
| 1920 x 1080 | 76 fps |
| 1600 x 1200 | 69 fps |
| 1280 x 1024 | 80 fps |
| 640 x 480 | 170 fps |
| 320 x 240 | 335 fps |

camera

| | |
|--------------------------------|---|
| frame rate | 40 fps @ 2048 x 2048 pixel |
| exposure / shutter time | 100 µs .. 10 s RS 30 µs .. 2 s GR |
| 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 | +10 °C stabilized, peltier with forced air (fan) (up to 27°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) |

general

| | |
|---------------------------|-------------------------------|
| power supply | 12 .. 24 VDC (+/- 10 %) |
| power consumption | 21 W max. (typ. 12 W @ 20 °C) |
| weight | 900 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.

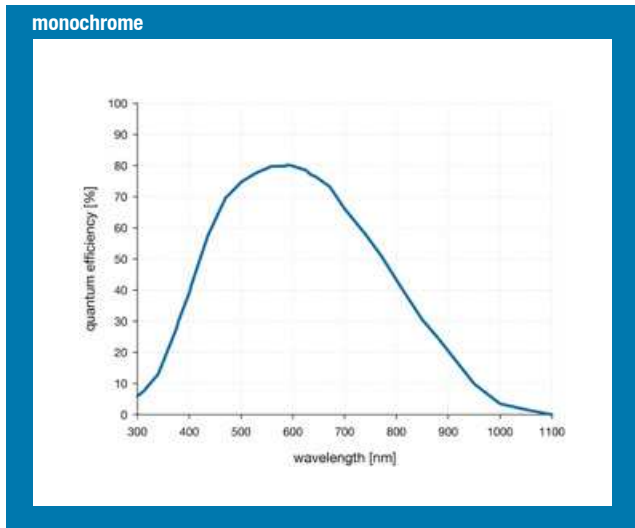
² Max. fps with centered ROI.

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.



technical data

quantum efficiency

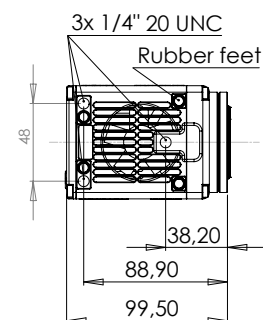
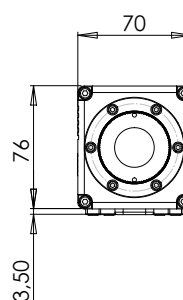
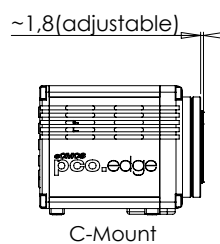
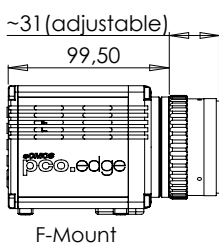


camera views



dimensions

F-mount and C-mount lens changeable adapter.



All dimensions are given in millimeter.

technical data

software

For camera control, image acquisition and archiving of images in various file formats PCO provides the software application Camware (Windows 7, 8 and later).

A camera SDK (software development kit) including a 32 / 64 bit dynamic link library for user customization and integration on PC platforms is available for free.

For camera interface drivers and a list of supported third party software please visit www.pco.de.

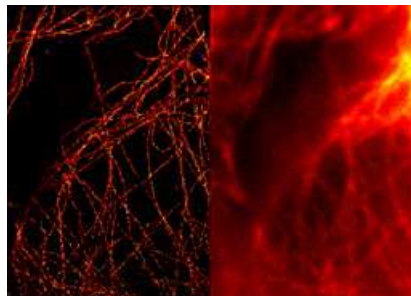
third party integrations

software drivers



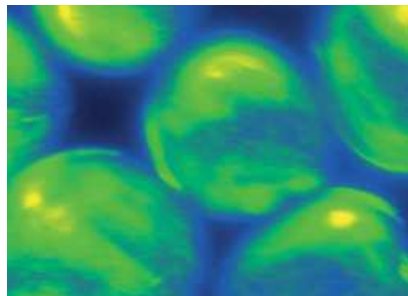
applications

life science



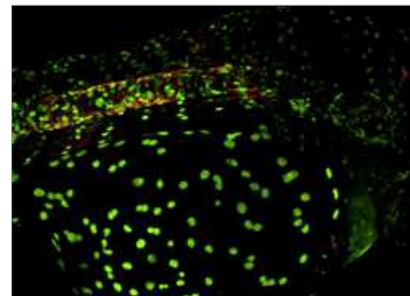
A widefield (right) and a GSDIM super-resolution (left) microscopy image of tubulin fibers obtained with a pco.edge, courtesy of Leica Microsystems, Germany

physical science



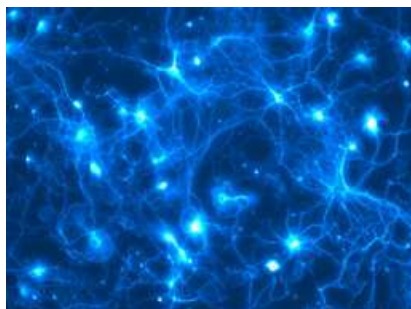
A single image of fluorescence labeled protein networks in water drops in an oil phase, which moved fast. One pixel corresponds to 0.1625 μm in reality, courtesy of Prof. Dr. Sarah Köster, Institute for X-Ray Physics, Göttingen, Germany

life science



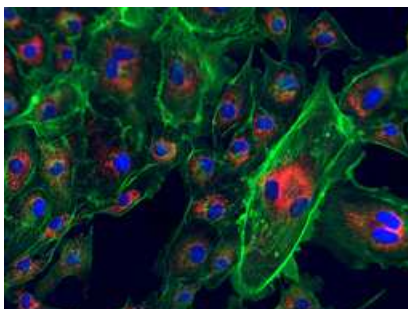
Zebrafish with two fluorescent labels, collected with a VisiScope Confocal based on the Yokogawa CSU-W1 wide head and a pco.edge camera, courtesy of Visitron Systems GmbH, Germany

life science



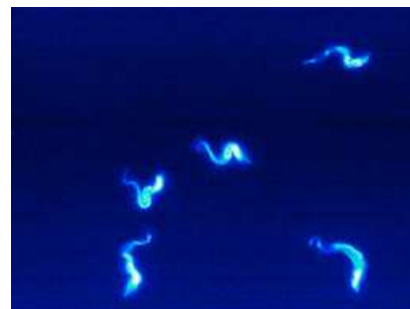
Neuronal network marked with a fluorophore (false color rendering) and recorded with a pco.edge.

life science



Extract of a fluorescent slide which was scanned by a pco.edge camera in a Panoramic 250 Flash scanner for digital pathology, courtesy of 3DHitech, Hungary

life science



An image of a sequence, which was recorded with a pco.edge at 400 frame/s. The maximum signal was about 100 photons, courtesy of Prof. Engstler, University of Würzburg, Germany

application areas

■ Widefield microscopy ■ Fluorescent microscopy ■ Digital pathology ■ PALM ■ STORM ■ GSDIM ■ dSTORM ■ Superresolution microscopy ■ Lightsheet microscopy ■ Selective plane imaging microscopy (SPIM) ■ Calcium imaging ■ FRET ■ FRAP ■ 3D structured illumination microscopy ■ High speed bright field ratio imaging ■ High throughput screening ■ High content screening ■ Biochip reading ■ TIRF ■ TIRF microscopy / waveguides ■ Spinning disk confocal microscopy ■ Live cell microscopy ■ 3D metrology ■ TV / broadcasting ■ Ophthalmology ■ Electro physiology ■ Lucky astronomy ■ Photovoltaic inspection