pco.edge 3.1
scientific CMOS camera

- high resolution: 2048 x 1536 pixel
- low noise: < 1.1 electrons
- high speed: 50 fps
- high dynamic range: 27 000:1
- high quantum efficiency: > 60 %

USB 3.0
small form factor
global shutter
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.
superior image quality

The new pco.edge camera (with scientific CMOS image sensor) features outstanding low read out noise of 1.1 electrons (e\(^-\)) med. Even at maximum speed of 50 frames/s at full resolution of 2048 x 1536 pixel the noise is 1.1 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 pco.sCMOS over CCD with regards to read out noise and dynamic, without any smear (the vertical lines in the CCD image).

flexibility and free of latency

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

27000:1 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 27 000 : 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.
image sensor
- type of sensor: scientific CMOS (sCMOS)
- image sensor: based on CIS2521
- resolution (h x v): 2048 x 1536 pixel
- pixel size (h x v): 6.5 µm x 6.5 µm
- sensor format / diagonal: 13.3 mm x 10.0 mm / 16.6 mm
- shutter modes: rolling shutter (RS)
  - with free selectable readout modes,
  - global/snapshot shutter (GS),
  - global reset - rolling readout (GR)
- MTF: 76.9 lp/mm (theoretical)
- fullwell capacity (typ.): 30 000 e-
- readout noise\(^1\): 1.1\(_{\text{med}}\)/1.5\(_{\text{rms}}\) e- @ RS
  - 3.3\(_{\text{med}}\)/3.5\(_{\text{rms}}\) e- @ GS
- dynamic range (typ.): 2 000 : 1 (88.6 dB)
- quantum efficiency: > 60 % @ peak
- spectral range: 370 nm .. 1100 nm
- dark current (typ.): < 0.5 e-/pixel/s RS @ 5 °C
  - < 0.8 e-/pixel/s GS @ 5 °C
- DSNU: < 0.3 e- rms
- PRNU: < 0.2 %
- anti blooming factor: > 10 000

camera
- frame rate: 50 fps
  - @ 2048 x 1536 pixel
- exposure / shutter time:
  - 500 µs .. 2 s RS
  - 20 µs .. 100ms GS
  - 30 µs .. 2 s GR
- dynamic range A/D\(^2\): 16 bit
- A/D conversion factor: 0.46 e-/count
- pixel scan rate:
  - 204.0 MHz GS
  - 105.0 MHz RS
- pixel data rate:
  - 408.0 Mpixel/s GS
  - 210.0 Mpixel/s RS
- 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: +5 °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)

maximum examples
<table>
<thead>
<tr>
<th>GS</th>
<th>RS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2048 x 1536</td>
<td>50 fps</td>
</tr>
<tr>
<td>1920 x 1080</td>
<td>72 fps</td>
</tr>
<tr>
<td>1280 x 1024</td>
<td>75 fps</td>
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<tr>
<td>640 x 480</td>
<td>160 fps</td>
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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

monochrome

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Quantum Efficiency (%)</th>
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<tbody>
<tr>
<td>400</td>
<td>80</td>
</tr>
<tr>
<td>500</td>
<td>60</td>
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<tr>
<td>600</td>
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<td>800</td>
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<tr>
<td>900</td>
<td>5</td>
</tr>
<tr>
<td>1000</td>
<td>3</td>
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</table>

Color

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Blue</th>
<th>Green</th>
<th>Red</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>80</td>
<td>60</td>
<td>40</td>
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</tr>
<tr>
<td>700</td>
<td>20</td>
<td>10</td>
<td>5</td>
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</table>

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

![LeVIEW](image)
![MathWorks](image)
![u-Manager](image)
![VisiView®](image)
![Molecular Devices](image)
sCMOS solutions

Deep Cooled Version – pco.edge Gold

The new pco.edge gold cameras are designed to offer long exposure times and best performance data especially in terms of read out noise and intra-scene dynamic. The scientific CMOS sensor is adjustable via air cooling to -15°C and with water cooling down to -30°C. This ensures optimized dark current noise performance even during long exposure times.

Pco.edge Board Level

PCO offers board level pco.edge series camera modules for OEM customization. The modules can be equipped with different sCMOS sensors, different interfaces and various features such as special read out modes. PCO also offers custom designed circuit boards with various form factors and sizes to meet special customer needs. Please contact us directly to discuss additional details.
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
- Neuronal network marked with a fluorophore (false color rendering) and recorded with a pco.edge.

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

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
- 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

Europe

PCO AG
Donaupark 11
93309 Kelheim, Germany

fon +49 (0)9441 2005 50
fax +49 (0)9441 2005 20
info@pco.de
www.pco.de

America

PCO-TECH Inc.
6930 Metroplex Drive
Romulus, Michigan 48174, USA

fon +1 (248) 276 8820
fax +1 (248) 276 8825
info@pco-tech.com
www.pco-tech.com

Asia

PCO Imaging Asia Pte.
3 Temasek Ave
Centennial Tower, Level 34
Singapore, 039190

fon +65-6549-7054
fax +65-6549-7001
info@pco-imaging.de
www.pco-imaging.de