

pco.1600 / 2000 / 4000

cooled 14 bit CCD cameras

excellent
low readout noise

ultra
stable offset



interframing time
120 ns

high resolution
1600 x 1200 pixel
2048 x 2048 pixel
4008 x 2672 pixel

technical data

image sensor

type of sensor	CCD (interline transfer)
image sensor	KAI-2001
resolution (h x v)	1600 x 1200 pixel (normal mode) 1648 x 1214 pixel (ext. mode)
pixel size (h x v)	7.4 µm x 7.4 µm
sensor format / diagonal	11.8 x 8.9 mm ² /14.8 mm @ normal mode 12.2 x 9.0 mm ² /15.2 mm @ ext. mode
shutter mode	global (snapshot)
MTF	67.6 lp/mm
fullwell capacity	40 000 e ⁻
readout noise	10 e ⁻ rms @ 10 MHz (typ.) 17 e ⁻ rms @ 40 MHz (typ.)
dynamic range	4 000 : 1 (72 dB)
quantum efficiency	55 % peak
spectral range	320 nm .. 1000 nm (normal) 200 nm .. 1000 nm (UV sensitive)
dark current	0.01 e ⁻ /pixel/s @ -20 °C (typ.)
DSNU ¹	< 20 e ⁻ rms
PRNU ²	2 %
region of interest (ROI)	1, 2, 3, 4 .. n

camera pco.1600

max. frame rate	30 fps @ full frame	
exposure/shutter time	500 ns .. 49 days	
dynamic range A/D	14 bit	
A/D conversion factor	2.1 e ⁻ /count	
pixel scan rate	2 x 10 MHz / 2 x 40 MHz	
binning (hor x ver)	1 x 1 .. 2 x 8	
non linearity	< 1 %	
smear	< 0.01 %	
anti-blooming factor	> 300 (@ 100 ms exposure)	
interframing time ³	120 ns	
trigger input signals	acquire enable, exposure trigger (jitter <13 ns)	
trigger output signals	exposure, busy	
data interface	USB 3.0, CameraLink, GigE/USB 2.0, IEEE1394a	
cooled CCD	Δ-50 °C versus ambient temp.	
cooling method	Peltier cooler	
max. modulation frequency	50 kHz	optional
max. exposures in one image	500 000	optional
single exposure time	500 ns...1 ms	optional

camera pco.1600 s

max. frame rate	17 fps @ full frame
exposure/shutter time	5 µs .. 60 s
pixel scan rate	1 x 10 MHz / 1 x 40 MHz
extended mode	not available
spectral range	UV sensitive not available
dark current	0.07 e ⁻ /pixel/s @ 0 °C (typ.)
cooled CCD	0 °C
interframing time	not available
max. modulation frequency	not available
max. exposures in one image	not available
single exposure time	not available

general

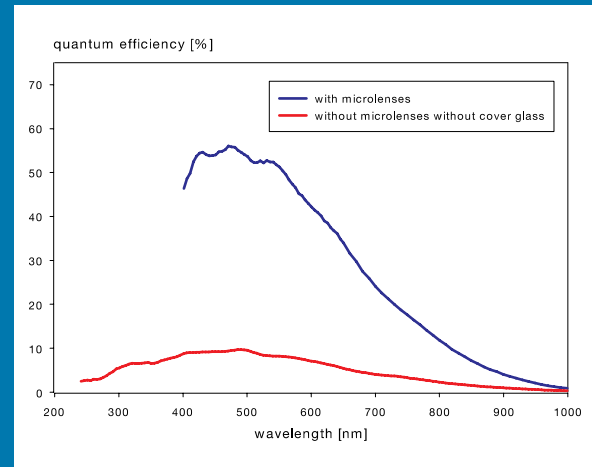
power supply	90 .. 260 VDC (12 VDC optional)
power consumption	24 W typical 40 W maximum
mechanical dimensions	135 x 51 x 195 mm ³
power supply (w x h x l)	
weight	1.8 kg
operating temperature	+ 5 °C .. + 40 °C
operating humidity range	10 % .. 90 % (non-condensing)
storage temperature range	- 20 °C .. + 70 °C
optical interface	C-mount, Nikon F-mount
CE certified	yes

frame rate table

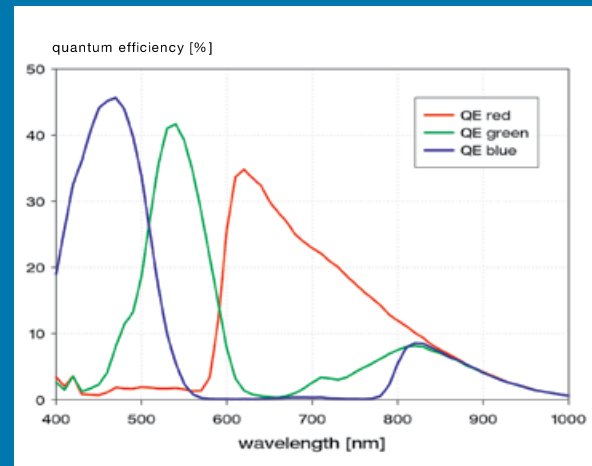
pixelclock used A/D converters	10 MHz		40 MHz	
	1	2	1	2
full frame	4.8 fps	9.2 fps	17.3 fps	29.8 fps
2 x 2 binning	9.4 fps	17.7 fps	32.4 fps	53.4 fps
2 x 8 binning	33.1 fps	57.3 fps	92.9 fps	130.5 fps

quantum efficiency

monochrome



color



¹ dark signal non-uniformity measured in a 90 % center zone of the image sensor

² photo response non-uniformity

³ time between two consecutive images for particle image velocimetry (PIV) applications

technical data

image sensor

type of sensor	CCD (interline transfer)
image sensor	KAI-4022
resolution (h x v)	2048 x 2048 pixel (normal mode) 2112 x 2072 pixel (ext. mode)
pixel size (h x v)	7.4 µm x 7.4 µm
sensor format / diagonal	15.2 x 15.2 mm ² /21.4 mm @ normal mode 15.6 x 15.3 mm ² /21.9 mm @ ext. mode
shutter mode	global (snapshot)
MTF	67.6 lp/mm
fullwell capacity	40 000 e ⁻ (21000 e ⁻ @ 40 MHz)
readout noise	6 e ⁻ rms @ 10 MHz (typ.) 7 e ⁻ rms @ 40 MHz (typ.)
dynamic range	6 667 : 1 (76.5 dB)
quantum efficiency	55 % peak
spectral range	320 nm .. 1000 nm (normal) 200 nm .. 1000 nm (UV sensitive)
dark current	0.01 e ⁻ /pixel/s @ -20 °C (typ.)
DSNU ¹	< 20 e ⁻ rms
PRNU ²	2 %
region of interest (ROI)	1, 2, 3, 4 .. n

camera pco.2000

max. frame rate	14.7 fps @ full frame	
exposure/shutter time	500 ns .. 49 days	
dynamic range A/D	14 bit	
A/D conversion factor	2.1 e ⁻ /count	
pixel scan rate	2 x 10 MHz / 2 x 40 MHz	
binning (hor x ver)	1 x 1 .. 2 x 8	
non linearity	< 1 %	
smear	< 0.01 %	
anti-blooming factor	> 300 (@ 100 ms exposure)	
interframing time ³	180 ns	
trigger input signals	acquire enable, exposure trigger (jitter < 13ns)	
trigger output signals	exposure, busy	
data interface	USB 3.0, CameraLink, GigE/USB 2.0, IEEE1394a	
cooled CCD	Δ-50 °C versus ambient temp.	
cooling method	Peltier cooler	
max. modulation frequency	40 kHz	optional
max. exposures in one image	100 000	optional
single exposure time	500 ns...1 ms	optional

camera pco.2000 s

max. frame rate	8.2 fps @ full frame
exposure/shutter time	5 µs .. 60 s
pixel scan rate	1 x 10 MHz / 1 x 40 MHz
extended mode	not available
spectral range	UV sensitive not available
dark current	0.07 e ⁻ /pixel/s @ 0 °C (typ.)
cooled CCD	0 °C
interframing time	not available
max. modulation frequency	not available
max. exposures in one image	not available
single exposure time	not available

general

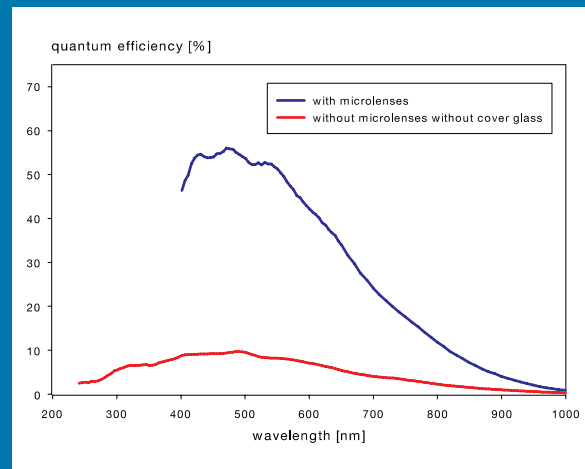
power supply	90 .. 260 VDC (12 VDC optional)
power consumption	24 W typical 40 W maximum
mechanical dimensions	135 x 51 x 195 mm ³
power supply (w x h x l)	
weight	1.8 kg
operating temperature	+ 5 °C .. + 40 °C
operating humidity range	10 % .. 90 % (non-condensing)
storage temperature range	- 20 °C .. + 70 °C
optical interface	C-mount, Nikon F-mount
CE certified	yes

frame rate table

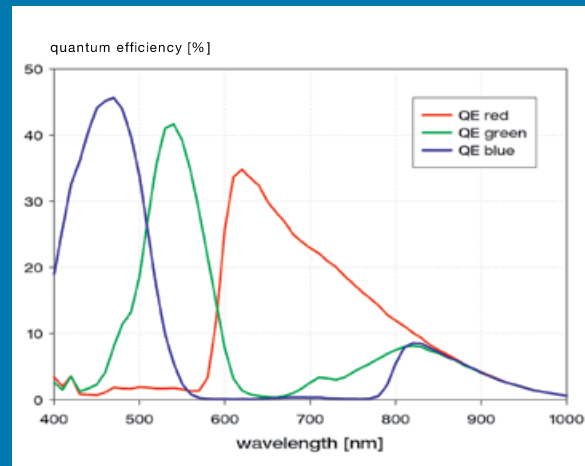
pixelclock used A/D converters	10 MHz		40 MHz	
	1	2	1	2
full frame	2.2 fps	4.3 fps	8.2 fps	14.7 fps
2 x 2 binning	4.3 fps	8.3 fps	15.5 fps	26.7 fps
2 x 8 binning	15.5 fps	27.8 fps	46.8 fps	69.7 fps

quantum efficiency

monochrome



color



¹ dark signal non-uniformity measured in a 90 % center zone of the image sensor

² photo response non-uniformity

³ time between two consecutive images for particle image velocimetry (PIV) applications

technical data

image sensor

type of sensor	CCD (interline transfer)
image sensor	KAI-11002
resolution (h x v)	4008 x 2672 pixel (normal mode) 4072 x 2720 pixel (ext. mode)
pixel size (h x v)	9.0 μm x 9.0 μm
sensor format / diagonal	36.0 x 24.0 mm ² /43.4 mm @ normal mode 36.6 x 24.5 mm ² /44.0 mm @ ext. mode
shutter mode	global (snapshot)
MTF	55.6 lp/mm
fullwell capacity	60 000 e ⁻
readout noise	11 e ⁻ rms @ 8 MHz (typ.) 14 e ⁻ rms @ 32 MHz (typ.)
dynamic range	5 455 : 1 (74.7 dB)
quantum efficiency	50 % peak
spectral range	320 nm .. 1000 nm
dark current	0.02 e ⁻ /pixel/s @ -20 °C (typ.)
DSNU ¹	< 20 e ⁻ rms
PRNU ²	2 %
region of interest (ROI)	1, 2, 3, 4 .. n

camera pco.4000

max. frame rate	5.0 fps @ full frame	
exposure/shutter time	5 μs .. 49 days	
dynamic range A/D	14 bit	
A/D conversion factor	3.3 e ⁻ /count	
pixel scan rate	2 x 8 MHz / 2 x 32 MHz	
binning (hor x ver)	1 x 1 .. 2 x 8	
non linearity	< 1 %	
smear	< 0.01 %	
anti-blooming factor	> 300 (@ 100 ms exposure)	
interframing time ³	250 ns	
trigger input signals	acquire enable, exposure trigger (jitter < 13 ns)	
trigger output signals	exposure, busy	
data interface	USB 3.0, CameraLink, GigE/USB 2.0, IEEE1394a	
cooled CCD	Δ-45 °C versus ambient temp.	
cooling method	Peltier cooler	
max. modulation frequency	20 kHz	optional
max. exposures in one image	100 000	optional
single exposure time	500 ns...1 ms	optional

camera pco.4000 s

max. frame rate	2.7 fps @ full frame
exposure/shutter time	5 μs .. 60 s
pixel scan rate	1 x 8 MHz / 1 x 32 MHz
extended mode	not available
dark current	0.1 e ⁻ /pixel/s @ 0 °C (typ.)
cooled CCD	0 °C
interframing time	not available
max. modulation frequency	not available
max. exposures in one image	not available
single exposure time	not available

general

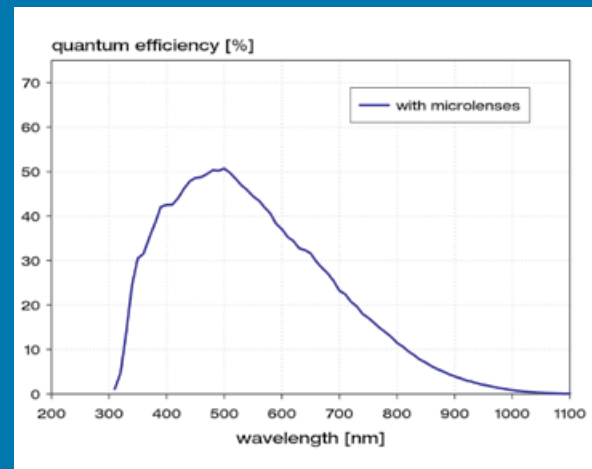
power supply	90 .. 260 VAC
power consumption	25 W typical 50 W maximum
mechanical dimensions	135 x 51 x 195 mm ³
power supply (w x h x l)	
weight	1.9 kg
operating temperature	+ 5 °C .. + 40 °C
operating humidity range	10 % .. 90 % (non-condensing)
storage temperature range	- 20 °C .. + 70 °C
optical interface	F-mount Nikon
CE certified	yes

frame rate table

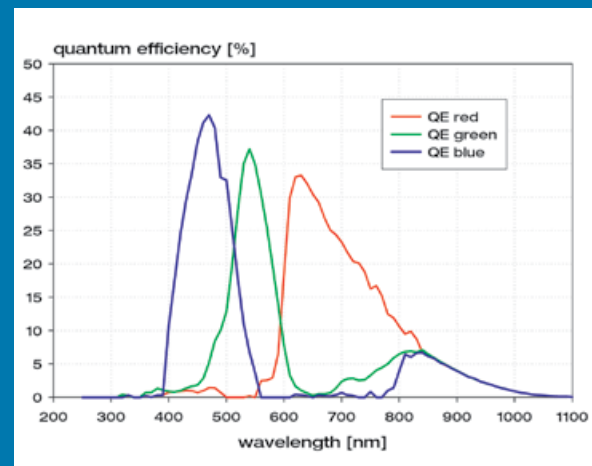
pixelclock used A/D converters	8 MHz		32 MHz	
	1	2	1	2
full frame	0.7 fps	1.4 fps	2.7 fps	5.0 fps
2 x 2 binning	1.4 fps	2.7 fps	5.2 fps	9.2 fps
2 x 8 binning	5.0 fps	9.2 fps	15.7 fps	24.0 fps

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technical data

software

For camera control, image acquisition and archiving of images in various file formats PCO provides the software 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.

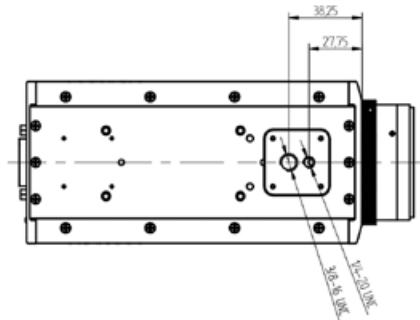
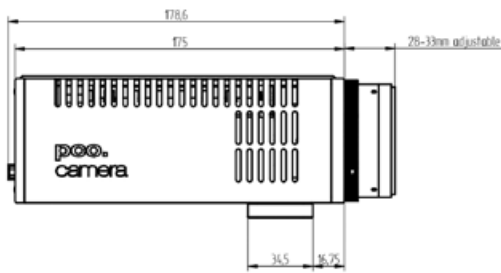
For camera interface drivers and a list of supported third party software please visit www.pco.de

options

UV & color versions available; custom made versions, modulation mode, external fan cooler

dimensions

F-mount lens adapter



All dimensions are given in millimeter.



third party integrations

software drivers



MathWorks®



applications

bio marker



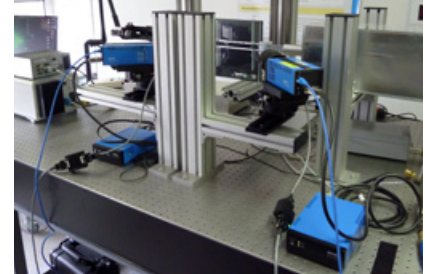
Fluorescence labelled leukocyte/endothelial cell interactions in the brain microcirculation of a mouse (pco.1600). Courtesy of Temple University School of Medicine - Microvascular Research Lab, Dr. Ronald Tum

aerial photography



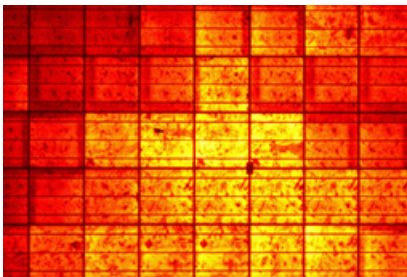
Aerial photograph out of a sequence recorded in a height of 3000 feet with a pco.4000 setup. One pixel corresponds to 14 cm in reality. Courtesy of DLR Optical Informationssysteme at Inst. for Robotics and Mechatronics

stereo particle image velocimetry



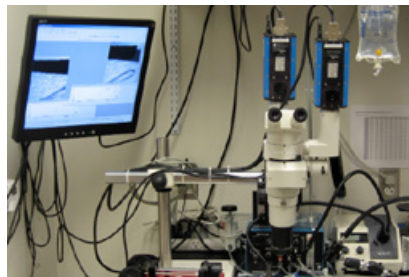
Stereo particle image velocimetry with two pco.2000 cameras. Courtesy of Intelligent Laser Applications, Jülich and Friedrich-Alexander University, Erlangen, Institute for processing machines and systems engineering (IPAT)

quality control in solar panels



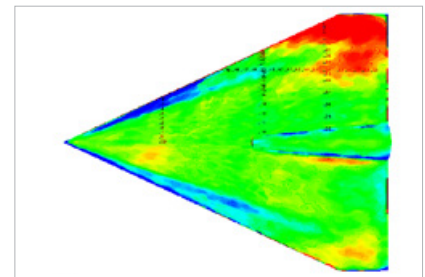
Electroluminescence image of a solar panel with poly-crystalline solar cells. Darker areas indicate areas or crystal layers, which do not contribute to the solar current generation. It was recorded with a pco.4000.

stereo microscopy



Stereo microscopic imaging set-up with two pco.1600 cameras to characterize the 3D geometry of a mouse aortic arch. Courtesy of Department of Biomedical Engineering, Duke University, Durham, Dr. M. H. Friedman,

pressure sensitive paint



Results of the pressure sensitive paint (PSP) measured partial pressure distribution on a 60° delta wing model in a low speed channel (measured by 2 pco.4000). Courtesy of DLR Göttingen

application areas

- laser induced fluorescence ■ high resolution microscopy ■ luminescence microscopy ■ electron microscopy
- fluorescence spectroscopy (up to NIR) ■ bioluminescence chemoluminescence ■ low light level imaging
- imaging of bio markers (e.g. green fluorescent protein, GFP) ■ time resolved spectroscopy
- spray analysis ■ hydrodynamics ■ electrophoresis ■ absorption & luminescence spectroscopy
- imaging of potential sensitive dyes (Neuroscience) ■ security ■ astronomy ■ combustion process analysis
- gel imaging ■ fuel injection ■ scientific imaging ■ combustion imaging ■ spray imaging ■ PIV imaging

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