

# 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 <sup>2</sup> /14.8 mm @ normal mode 12.2 x 9.0 mm <sup>2</sup> /15.2 mm @ ext. mode
shutter mode	global (snapshot)
MTF	67.6 lp/mm
fullwell capacity	40 000 e <sup>-</sup>
readout noise	10 e <sup>-</sup> rms @ 10 MHz (typ.) 17 e <sup>-</sup> 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 <sup>-</sup> /pixel/s @ -20 °C (typ.)
DSNU <sup>1</sup>	< 20 e <sup>-</sup> rms
PRNU <sup>2</sup>	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 <sup>-</sup> /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 <sup>3</sup>	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 <sup>-</sup> /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

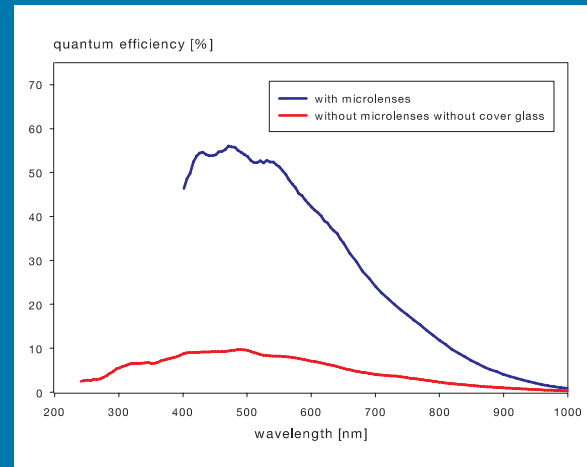
power supply	90 .. 260 VDC (12 VDC optional)
power consumption	24 W typical 40 W maximum
mechanical dimensions	135 x 51 x 195 mm <sup>3</sup>
power supply (w x h x l)	
weight	1.8 kg
operating temperature	+ 5 °C .. + 40 °C
operating humidity range	10 % .. 90 % (non-condensing)
storage temperature range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

## frame rate table

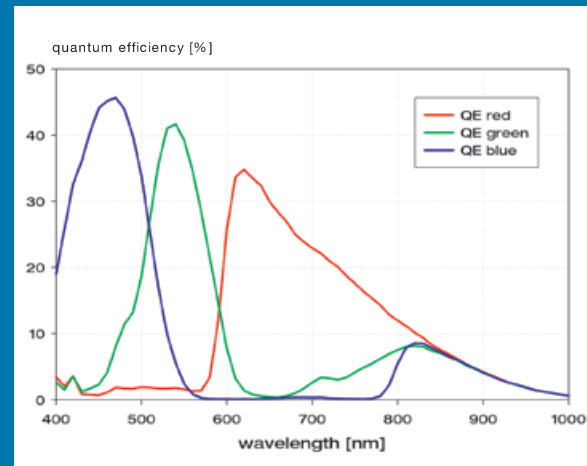
pixelclock used A/D converters	10 MHz		40 MHz	
	1	2	1	2
full frame	4.8 fps	9.2 fps	17.3 fps	29.8 fps
2 x 2 binning	9.4 fps	17.7 fps	32.4 fps	53.4 fps
2 x 8 binning	33.1 fps	57.3 fps	92.9 fps	130.5 fps

## quantum efficiency

### monochrome



### color



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

<sup>2</sup> photo response non-uniformity

<sup>3</sup> 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 <sup>2</sup> /21.4 mm @ normal mode 15.6 x 15.3 mm <sup>2</sup> /21.9 mm @ ext. mode
shutter mode	global (snapshot)
MTF	67.6 lp/mm
fullwell capacity	40 000 e <sup>-</sup> (21000 e <sup>-</sup> @ 40 MHz)
readout noise	6 e <sup>-</sup> rms @ 10 MHz (typ.) 7 e <sup>-</sup> 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 <sup>-</sup> /pixel/s @ -20 °C (typ.)
DSNU <sup>1</sup>	< 20 e <sup>-</sup> rms
PRNU <sup>2</sup>	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 <sup>-</sup> /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 <sup>3</sup>	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 <sup>-</sup> /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

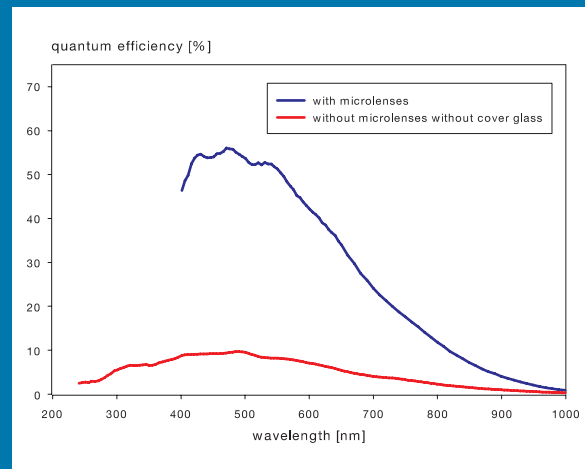
power supply	90 .. 260 VDC (12 VDC optional)
power consumption	24 W typical 40 W maximum
mechanical dimensions	135 x 51 x 195 mm <sup>3</sup>
power supply (w x h x l)	
weight	1.8 kg
operating temperature	+ 5 °C .. + 40 °C
operating humidity range	10 % .. 90 % (non-condensing)
storage temperature range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

## frame rate table

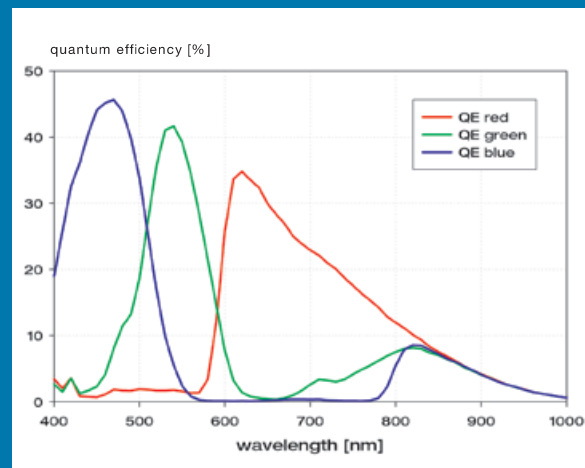
pixelclock used A/D converters	10 MHz		40 MHz	
	1	2	1	2
full frame	2.2 fps	4.3 fps	8.2 fps	14.7 fps
2 x 2 binning	4.3 fps	8.3 fps	15.5 fps	26.7 fps
2 x 8 binning	15.5 fps	27.8 fps	46.8 fps	69.7 fps

## quantum efficiency

### monochrome



### color



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

<sup>2</sup> photo response non-uniformity

<sup>3</sup> 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 <sup>2</sup> /43.4 mm @ normal mode 36.6 x 24.5 mm <sup>2</sup> /44.0 mm @ ext. mode
shutter mode	global (snapshot)
MTF	55.6 lp/mm
fullwell capacity	60 000 e <sup>-</sup>
readout noise	11 e <sup>-</sup> rms @ 8 MHz (typ.) 14 e <sup>-</sup> 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 <sup>-</sup> /pixel/s @ -20 °C (typ.)
DSNU <sup>1</sup>	< 20 e <sup>-</sup> rms
PRNU <sup>2</sup>	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 <sup>-</sup> /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 <sup>3</sup>	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 <sup>-</sup> /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

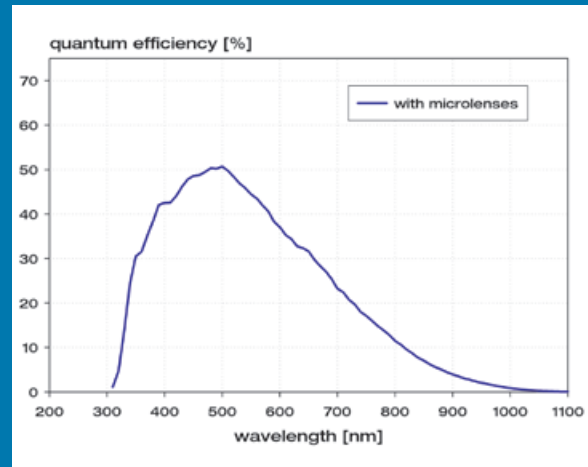
power supply	90 .. 260 VAC
power consumption	25 W typical 50 W maximum
mechanical dimensions	135 x 51 x 195 mm <sup>3</sup>
power supply (w x h x l)	
weight	1.9 kg
operating temperature	+ 5 °C .. + 40 °C
operating humidity range	10 % .. 90 % (non-condensing)
storage temperature range	- 20 °C .. + 70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

## frame rate table

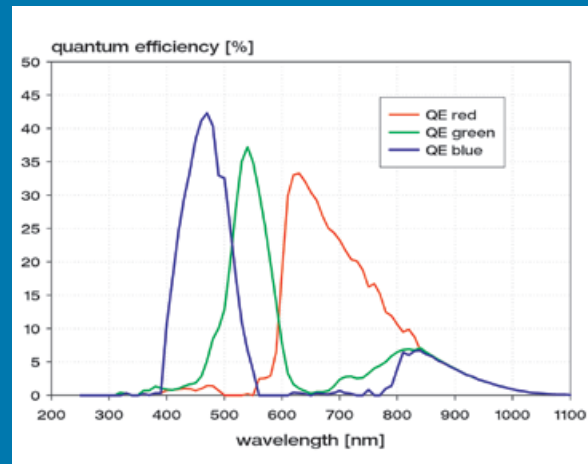
pixelclock used A/D converters	8 MHz		32 MHz	
	1	2	1	2
full frame	0.7 fps	1.4 fps	2.7 fps	5.0 fps
2 x 2 binning	1.4 fps	2.7 fps	5.2 fps	9.2 fps
2 x 8 binning	5.0 fps	9.2 fps	15.7 fps	24.0 fps

## quantum efficiency

### monochrome



### color



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

<sup>2</sup> photo response non-uniformity

<sup>3</sup> time between two consecutive images for particle image velocimetry (PIV) applications

# 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.

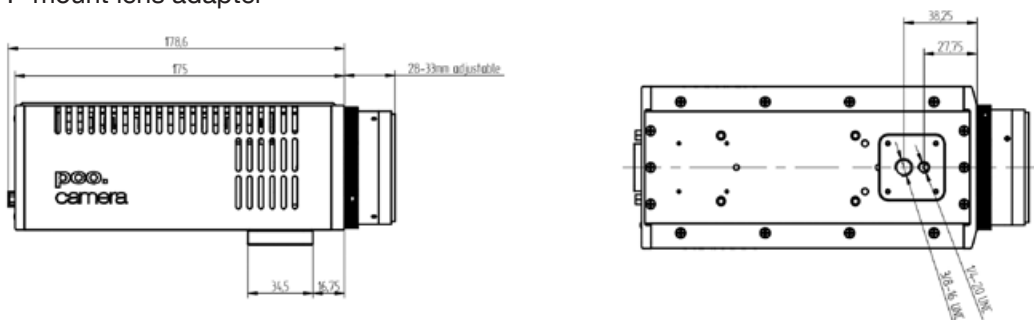
For camera interface drivers and a list of supported third party software please visit [www.pco.de](http://www.pco.de)

## options

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

## dimensions

F-mount lens adapter

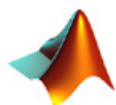


All dimensions are given in millimeter.



# third party integrations

## software drivers



MathWorks®



VisiView®



# applications

## bio marker



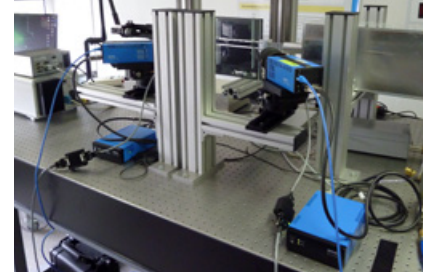
Fluorescence labelled leukocyte/endothelial cell interactions in the brain microcirculation of a mouse (pco.1600). Courtesy of Temple University School of Medicine - Microvascular Research Lab, Dr. Ronald Tum

## aerial photography



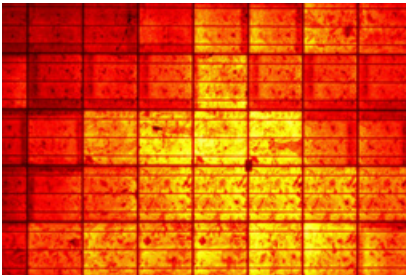
Aerial photograph out of a sequence recorded in a height of 3000 feet with a pco.4000 setup. One pixel corresponds to 14 cm in reality. Courtesy of DLR Optical Informationssysteme at Inst. for Robotics and Mechatronics

## stereo particle image velocimetry



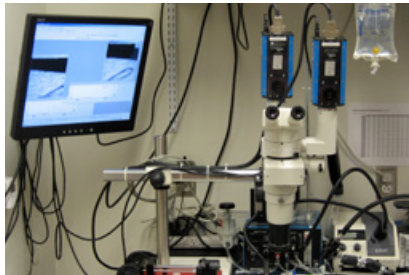
Stereo particle image velocimetry with two pco.2000 cameras. Courtesy of Intelligent Laser Applications, Jülich and Friedrich-Alexander University, Erlangen, Institute for processing machines and systems engineering (IPAT)

## quality control in solar panels



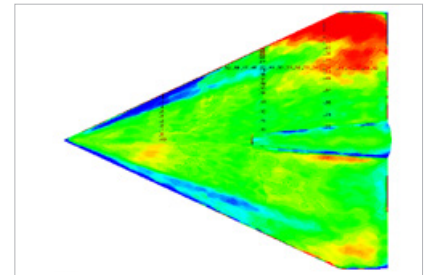
Electroluminescence image of a solar panel with poly-crystalline solar cells. Darker areas indicate areas or crystal layers, which do not contribute to the solar current generation. It was recorded with a pco.4000.

## 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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