pco.4000
cooled digital 14bit CCD camera system

- superior resolution (4008 × 2672 pixel)
- 14 bit dynamic range
- frame rate of 5 fps at full resolution
- image memory in camera (camRAM up to 4 GB)
- excellent low noise of 11e⁻ rms @ 8 MHz
- thermo-electrical cooling of -45 °C vs. ambient
- standard interfaces (IEEE 1394, camera link, GigE Vision)
- UV sensitive & color CCD image sensor available
- double shutter and modulate versions available

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1288
EMVA Standard Compliant

data available on www.pco.de

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This high resolution 14 bit cooled CCD camera system comprises advanced CCD and electronics technology. With the new approach to integrate the image memory (camRAM) into the camera itself, it enables unmatched fast image recording with 128 MB/s. The system features thermo-electrical cooling (down to –45 °C vs. ambient), an excellent high resolution (4008 × 2672 pixel) and low noise (down to 11e^- rms). It consists of a compact camera with an external intelligent power supply. The image data are transferred via customer selectable standard data interfaces to a computer (IEEE 1394 (“firewire”), camera link, GigE Vision). The available exposure times range from 5 µs to 49 days. This digital CCD camera system is perfectly suited for low light and high resolution camera applications, like microscopy, aerial photography or quality control.

The camera is available as high performance pco.4000 comprising the double shutter function for PIV or as advanced scientific grade pco.4000s. A modulation version pco.4000mod allows in addition to accumulate multiple exposures into one image.

technical data

	unit	setpoint	pco.4000	pco.4000s
resolution (hor × ver) [1]	pixel	@ normal @ extended mode	4008 × 2672 4072× 2720	4008 × 2672 -
pixel size (hor × ver)	µm²		9.0 × 9.0	9.0 × 9.0
sensor format / diagonal	mm² / mm		36.6 × 24.5 / 44.0 @ ext. mode	36.0 × 24.0 / 43.4 @ normal mode
peak quantum efficiency	%	@ 500 nm typical	50	50
full well capacity of CCD	e^-		60 000	60 000
image sensor			KAI-11002	KAI-11002
maximum dynamic range	dB		75	74
dynamic range A/D [2]	bit		14	14
readout noise	e^- rms	@ 8 / 32 MHz	11 / 22	12 / 25
imaging frequency, frame rate	fps	@ full frame	5.0	2.7
pixel scan rate	MHz		2 × 8 / 2 × 32	1 × 8 / 1 × 32
A/D conversion factor	e^- / count		3.3	3.3
spectral range	nm	normal UV sensitive	320..1000 200..1000	320..1000 -
exposure time	s		5 µs..49 days	5 µs..60 s
anti-blooming factor		typical	> 300	> 300
smear	%		0.01	0.01
binning horizontal	pixel		1, 2	1, 2
binning vertical	pixel		1, 2, 4, 8	1, 2, 4, 8
dark current	e^- / pixel·s	@ 20 °C typical @ –20 °C typical	0.7 0.02	0.1 @ 0 °C -
region of interest (ROI)	pixel	hor & ver	1, 2, 3, 4...n	1, 2, 3, 4...n

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technical data

non linearity	%	full temperature range @ 8 MHz	< 2	< 2
uniformity darkness DSNU [3]	e^- rms	@ 90% center zone	< 20	< 20
uniformity brightness PRNU [4]	%	typical	2	2
trigger, auxiliary signals		internal external	software TTL level	software TTL level
power consumption	W	typical maximum	25 50	22 50
power supply	VAC		90...260	90...260
mechanical dimensions camera (w × h × l)	mm^3		84 × 66 × 175	84 × 66 × 175
mechanical dimensions power supply (w × h × l)	mm^3		135 × 51 × 195	135 × 51 × 195
weight	kg		1.9	1.9
operating temperature range	°C		+5..+40	+5..+40
operating humidity range	%		10..90	10..90
storage temperature range	°C		–20..+70	–20..+70
optical input			Nikon f-mount	Nikon f-mount
optical input window			fused silica	fused silica
data interface			IEEE 1394, camera link, GigE Vision	IEEE 1394, camera link, GigE Vision
CE certified			yes	yes
cooled CCD	°C		Δ–45 versus ambient temp.	0
cooling method			2 stage Peltier cooler with forced air cooling	2 stage Peltier cooler with forced air cooling
interframing time (PIV mode)	ns	double shutter version only	250	not available
max. modulation frequency	kHz	modulate version only	20	not available
max. exposures in one image		modulate version only	100.000	not available
single exposure time	s	modulate version only	500 ns...1 ms	not available

[1] horizontal versus vertical
[2] Analog-to-Digital-converter
[3] dark signal non-uniformity
[4] photo response non-uniformity

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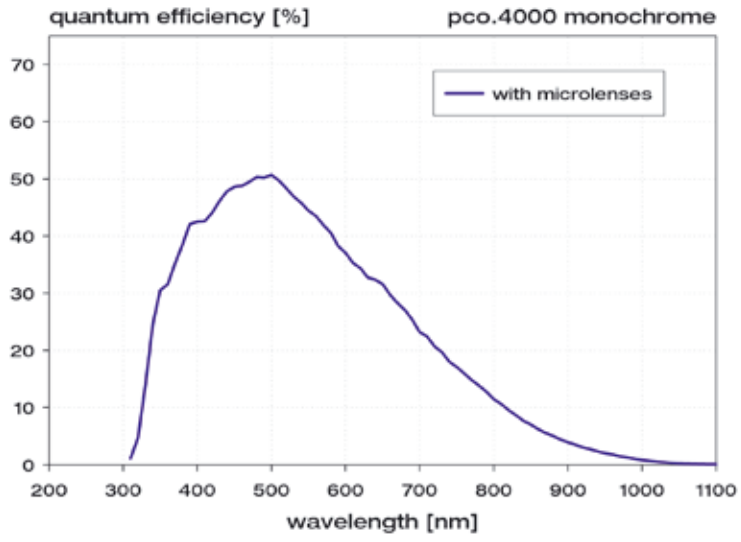
software	Camware software for camera control, image acquisition and archiving of images in various file formats, WindowsXP, Vista and later, 32 bit-dynamic link library (DLL) is available for user customisation and integration on PC platforms (software development kit - SDK), software is operational in either single mode or with built-in recorder functions, drivers for popular third party software packages are available (see website)
options	CCD image sensor in color & UV sensitive version custom-made versions camRAM available in: 512 MB, 1 GB, 2 GB & 4 GB external fan cooling, DC version

frame rate table [frames per second]

The given resolutions are selected for the frame rate calculations in the tables only, they are not mandatory. For ROIs see „technical data“ table on page 2.

pixelclock	8 MHz		32 MHz	
used A/D converters	1	2	1	2
full frame	0.7	1.4	2.7	5.0
2 × 2 binning	1.4	2.7	5.2	9.2
2 × 8 binning	5.0	9.2	15.7	24.0
ROI 2048 × 2048 pixel	0.9	1.8	3.4	6.0
ROI 1600 × 1200 pixel	1.5	2.8	5.1	8.4
ROI 1280 × 1024 pixel	1.7	3.2	5.7	9.2
ROI 640 × 480 pixel	3.4	5.8	9.1	12.7

quantum efficiency



(KAI-11002 monochrome qe curve as measured by Kodak)

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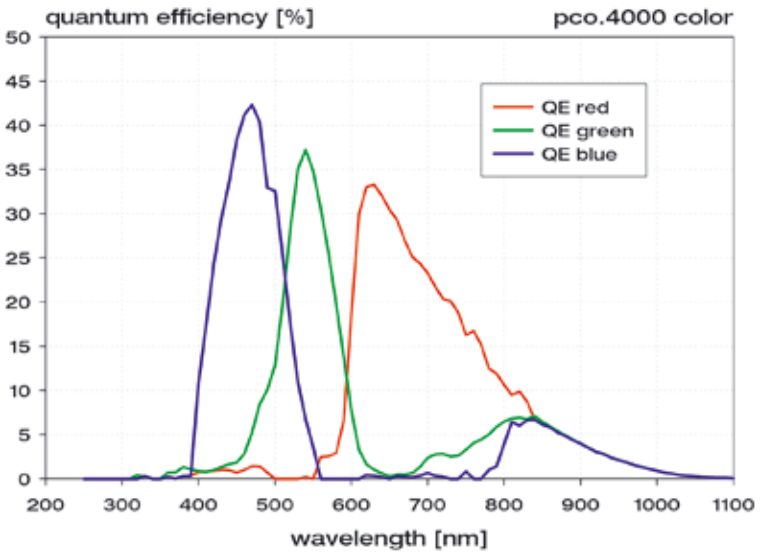
quantum efficiency



(KAI-11002 color qe curves as measured by Kodak)

areas of application

■ 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 ■ PIV imaging ■ fluorescence imaging ■ semiconductor quality control ■ aerial photography ■ flow visualization ■ traffic control and surveillance ■ pressure sensitive paint (PSP)

Full resolution image (4008 x 2672 pixel) of a pco.4000, recorded with a Nikon lens (focal length = 200 mm, aperture = 16). It corresponds to 8 images of a sensicam camera with SVGA resolution.

Sub-image (251 x 167 pixel) of image above, illustrating the huge amount of information comprised in one full resolution image of the pco.4000. Even the license plate of the car could be read.

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