pco.dimax

high speed CMOS camera

high
color fidelity

excellent
ISO speed

high resolution
4 megapixel

high speed
1279 fps

The new pco.dimax is a breakthrough in high speed camera image quality, due to its distinctive ability to simultaneously deliver extremely high color fidelity, fast frame rates, high resolution and a variety of operational and trigger modes - all with a superb image quality.

pco.

1288
EMVA Standard Compliant

features

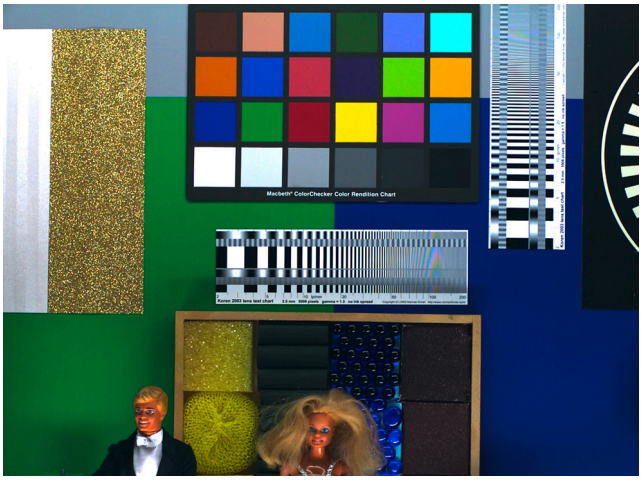
free of session referencing

With innovative use of on chip information, the pco.dimax offers an operation free from session referencing, which does not require any additional mechanical shutter for dark referencing. The pco.dimax incorporates an internal fully automatic referencing feature that does not require additional operator intervention. Therefore it is possible to change frame rates “on the fly” (during recording).

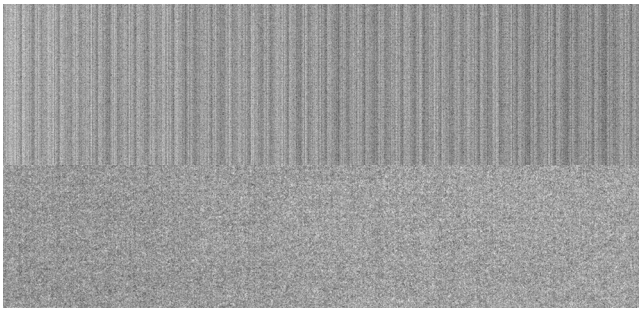
color image quality

The pco.dimax incorporates sophisticated techniques to achieve its high color image quality, proven and recommended by broadcast experts and camera men. This quality applies for high speed frame rates to shoot slow motion clips as well as for standard broadcast frame rates (such as 50 to 60 fps for HDTV 1080p).

A combination of special optical filters and an optimized color-calibration achieves an excellent sRGB image quality. According to ISO Standard 17321 the pco.dimax reaches quality grades of 83 SMI (matching high end digital cameras with typical 75 to 90 SMI). This can be seen by the typical test image sample in the figure, which shows a demanding scene for a correct Bayer pattern color conversion.



A typical test image with color checker, MTF test charts and challenging structures obtained with a color pco.dimax.



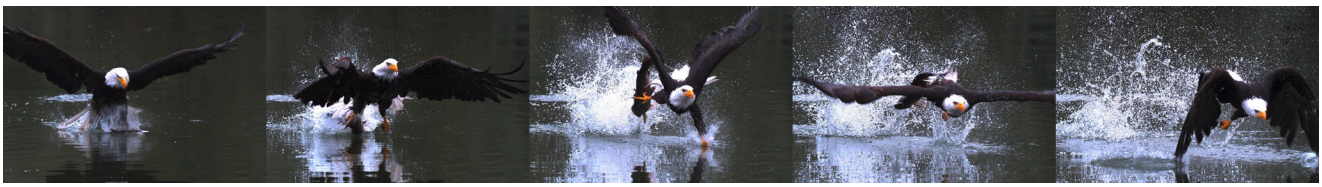
The top image shows the typical fixed pattern structures in the dark image of high speed CMOS image sensors, while the lower image shows the lower and more homogeneous noise in the dark image of a pco.dimax.

low light performance

The customized CMOS image sensor in combination with proprietary algorithms achieves a very low dark signal non-uniformity (DSNU), which can be seen in the figure in a comparison of the dark image of a standard high speed CMOS image sensor and a dark image of the pco.dimax. Hence high quality images can also be recorded at low light sceneries. The low light performance is even further improved by the CDI mode, which is explained in the next section.

CDI

If structural information in the dark side of the histogram of the images is of major importance, the pco.dimax with its correlated double image (CDI) mode offers to record images with increased dynamic range and a 30% better performance on the weak signal side of the images (at the expense of half of the usual frame rate).



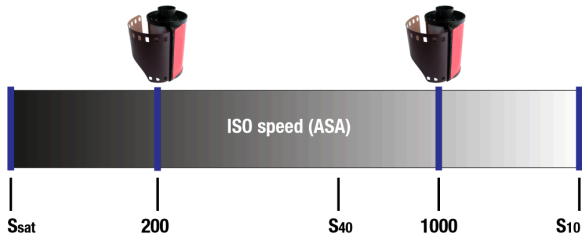
A bald eagle catches its prey - original resolution 1920 x 1080 @ 500 frames/s (color version)

features

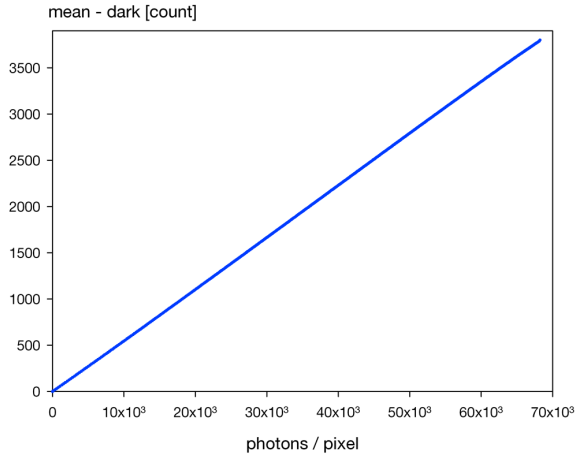
Crashtest, single extracted images of sequence - original resolution 2016 x 2016 @ 1102 frames/s (color version)

light sensitivity & ISO speed

Compared to analog photographic films, which are limited to one light sensitivity value, the pco.dimax offers a range of sensitivities (displayed as a band in the figure) called ISO speeds, specified by the ISO Standard 12232. It defines the parameters s_{sat}, $s_{noise40}$ and $s_{noise10}$ for digital camera characterization.
S_{sat} gives the maximum amount of light the sensor can process. $S_{noise40}$ defines "excellent" and $s_{noise10}$ "acceptable image quality". Both $s_{noise40}$ and $s_{noise10}$ are based on noise and quality image comparisons. Qualitatively speaking, the broader the band from s_{sat} to $s_{noise10}$ (see figure), the better the camera performance becomes. The pco.dimax provides image recording from ISO Speed 160, for highest quality, up to 16,000 and more at high frame rates.



The graph shows the ISO 12232 values s_{sat}, s_{40} and s_{10} relative to the formerly used sensitivity values for negative film (examples give ASA 200 and ASA 1000) along a virtual sensitivity scale.



EMVA 1288 linearity measuements of a pco.dimax.

linearity

For quantitative image measurements and analysis the linearity of the camera is a prerequisite. The EMVA 1288 linearity measurement results, as shown in the graph next to this text, demonstrate the scientific grade linearity that is a feature of the pco.dimax.

synchronization & trigger

A precise camera to camera synchronization for pco.dimax cameras is integrated by a master-slave mode with a remarkable low jitter (< 50 ns). Further a variety of trigger signals can be used for sequence as well as for single image triggering, allowing for low level, high level, differential and passive signals at the optically isolated inputs. Time code can be added by an IRIG-B signal (modulated or unmodulated). These features are extremely useful for stereo camera applications for 3D motion analysis and 3D particle image velocimetry (3D PIV) measurements.

technical data

image sensor

type of sensor	CMOS
image sensor	proprietary
resolution (h x v)	2016 x 2016 pixel
pixel size (h x v)	11 µm x 11 µm
sensor format / diagonal	22.18 mm x 22.18 mm / 31.36 mm
shutter mode	global (snapshot)
MTF	45.5 lp/mm (theoretical)
fullwell capacity	36 000 e⁻
readout noise	23 e⁻ rms @ 62.5 MHz (typ.) 18 e⁻ rms @ 62.5 MHz (CDI, typ.)
dynamic range	1 600 : 1 (64 dB) 2 000 : 1 (66 dB, CDI[1])
quantum efficiency	50 % @ peak
spectral range	290 nm .. 1100 nm
dark current	530 e⁻/pixel/s @ 20 °C
DSNU	< 0.6 cnts. rms @ 90 % center zone
PRNU	< 1 % @ 80 % signal

camera

max. frame rate (full frame)	1279 fps (monochrome) 1102 fps (color)
exposure/shutter time	1.5 µs .. 40 ms
dynamic range A/D	12 bit
A/D conversion factor	8.8 e⁻/count
pixel scan rate	62.5 MHz (mono) / 55 MHz (color)
pixel data rate	5198 (mono) / 4479 (color) Mpixel/s
region of interest	steps of 48 x 4 pixel
non linearity	< 0.5 % (diff.) / < 0.2 (integr.)
primary image memory (camRAM)	18 GB / 36 GB
trigger input signals	frame trigger, sequence trigger, stop trigger[2]
trigger output signals	exposure, busy
data interface	GigE & USB2.0; CamLink / HD-SDI
time stamp	in image (1 µs resolution)
time code input	IRIG-B (modulated & unmodulated)
interframing time[3]	3.15 µs (mono[3]) / 3.58 µs (color[3])
operational shock	30 g @ 11 ms, half sine wave, all axes
operational vibration	25 g @ 1 - 150 Hz, all axes

[1] in correlated double image mode (CDI) the readout noise is reduced and therefore the intrascene dynamic is improved.
[2] all trigger input signals are optically isolated and various signal conditions can be selected like: low level TTL, high level TTL, differential (RS486) and passive (contact closure).
[3] time between two consecutive images for particle image velocimetry (PIV) applications, mono = monochrome camera, color = color camera.
[4] the given resolutions are selected for the frame rate calculations only, they are not mandatory. For region of interest conditions see table above.

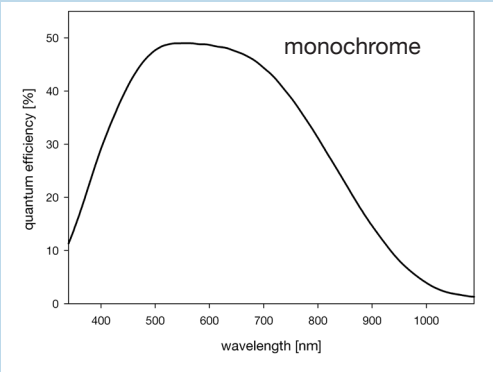
general

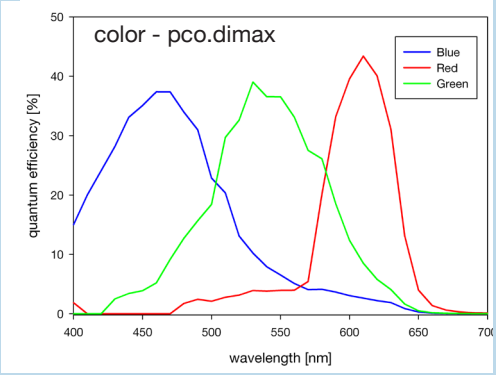
power supply	90 .. 260 VAC (12 VDC opt.)
power consumption	80 W
battery operation time	> 6 h (data preservation) > 50 min (full operation)
weight	7 kg
operating temperature	+ 5 °C .. + 40 °C
operating humidity range	10 % .. 90 % (non-condensing)
storage temperature range	- 20 °C .. + 70 °C
optical interface	F-mount (std.) / C-mount (opt.)
CE / FCC certified	yes

frame rate table[4]

typical examples [pixel]	frame rate monochrome (color)	images camRAM 36GB
2016 x 2016	1 279 (1 102) fps	6 307
1920 x 1080	2 470 (2 128) fps	12 362
1296 x 720	5 085 (4 346) fps	27 471
1008 x 1000	4 501 (3 822) fps	25 430
480 x 240	27 642 (23 061) fps	222 518
240 x 16	152 811 (130 650) fps	6 675 542

quantum efficiency





pco.

technical data

software

Camware is provided for camera control, image acquisition and archiving of images in various file formats (WindowsXP and later). A free software development kit (SDK) including a 32 / 64 bit dynamic link library, for user customization, integration on PC platforms is available. Drivers for popular third party software packages are also available.
(Please visit www.pco.de for more information)

options

monochrome & color versions available; rechargable battery packs; custom made versions

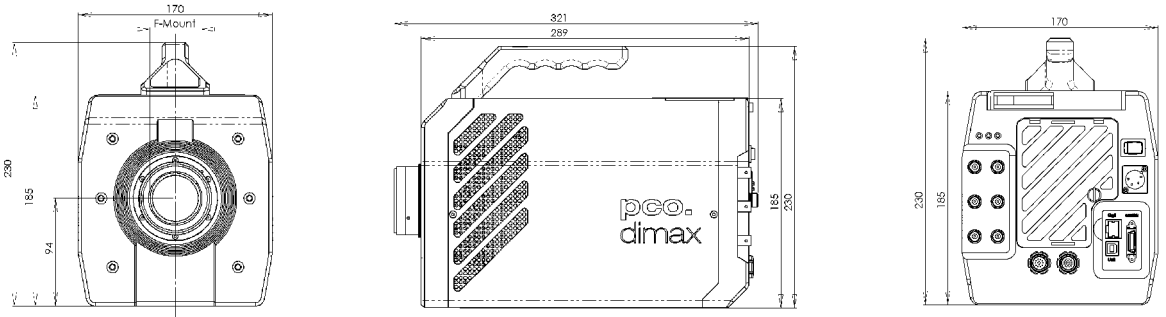
ISO speed rating[1,2]		
color (raw)	s_{sat}	160
	$s_{noise, 40}$	500
	$s_{noise, 10}$	3 200
color (NLM noise filtered)	s_{sat}	160
	$s_{noise,40}$	1 250
	$s_{noise,10}$	6 400
monochrome (raw)	s_{sat}	1 250
	$s_{noise, 40}$	2 500
	$s_{noise, 10}$	16 000
monochrome (raw & NLM noise filtered)	s_{sat}	1 250
	$s_{noise, 40}$	> 10 000
	$s_{noise, 10}$	> 50 000

Color		
CIELab ΔE^3	average	< 2.4
SMI[4]	ISO 17321	> 83
color space	sRGB / ITU-R	BT.709

1 ISO 12232: Photography - Electronic still-picture cameras - Determination of ISO speed
2 measured with daylight 6000 K
3 using a Macbeth Colorchecker - 24 patches color
4 Sensitivity metamersim index (SMI) is defined in the ISO Standard 17321 and describes the ability of a camera to reproduce accurate colors using a Macbeth Colorchecker - 18 patches color

dimensions

F-mount lens changeable adapter.



All dimensions are given in millimeter.

camera views

Further information can be found on www.pco.de

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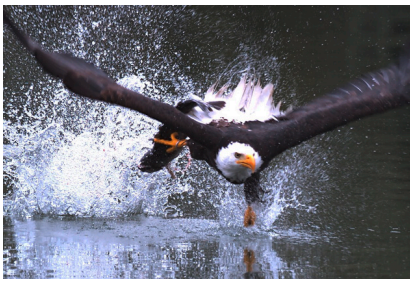
applications

automobile safety tests

The recording of safety tests with automobiles is a requirement for car manufacturers. More and more also 3D information are required for a proper modelling.

motion analysis

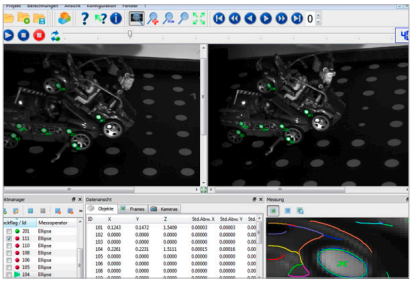


Motion analysis and super slow motion recordings are important means to learn from nature. The bald eagle catch sequence was recorded by a pco.dimax together with the Bavarian TV channel, PCO, Germany

physical science

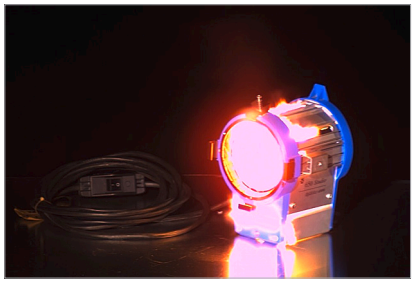
Documentation and motion analysis are important tools to improve space technology as well. The shuttle start was recorded by a pco.dimax, The Cooke Corporation, USA.

3D motion analysis



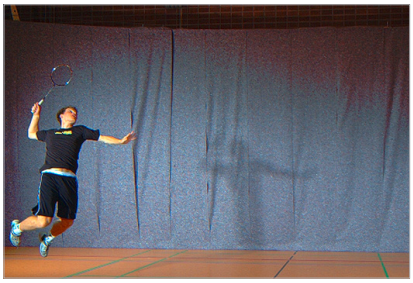
Within a stereo camera set-up it is possible to follow markers and receive 3D information about the event, which is recorded, courtesy of SOLVing3D, Germany

material testing



A lamp head was tested and recorded by a pco.dimax with respect to material behaviour for safety reasons, courtesy of ARRI, Munich, Germany

TV / Broadcasting



A full HD high speed image of a badminton player, who jumped off the ground to smash. The 2128 fps together with the supreme image quality are useful features for slow motion applications, courtesy of Signum Bildtechnik, Munich, Germany

application areas

■ automobile safety tests ■ high speed particle image velocimetry (PIV) ■ material testing ■ tensile testing ■ airbag inflation ■ short time physics ■ hydrodynamics ■ spray analysis ■ motion analysis ■ TV / Broadcasting ■ combustion imaging ■ fast events in nature and machine vision ■ high speed inspection ■ hyper velocity impact studies ■ fast flow visualization ■ ballistics ■ fuel injection ■ slow motion in sports ■ 3D analyis of fast events ■ sparks in electronical switches ■ machine vision ■ ignition & injection research ■ high speed photogrammetry

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