pco.dimax HS

high speed CMOS cameras

high speed
> 7000 fps
@ 1 Mpixel

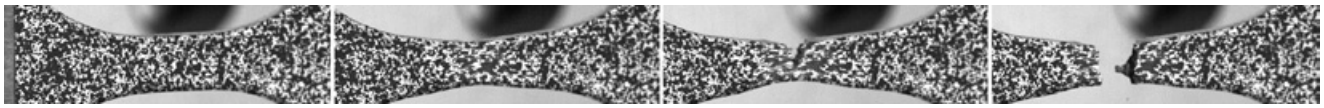
excellent
light sensitivity

high resolution
1000 x 1000 pixel HS1
1400 x 1050 pixel HS2
2000 x 2000 pixel HS4

1288
EMVA Standard Compliant

pco.

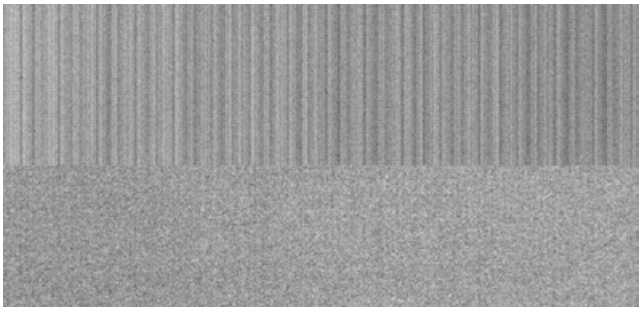
features



Different images of a high speed sequence of a 3D material test, which was recorded with two high speed cameras. The images show how the material was lenghtened and torn into two parts. The pattern was sprayed onto the sample to improve the 3D calculations.

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 need additional operator intervention. Therefore it is possible to change frame rates “on the fly” (during recording).



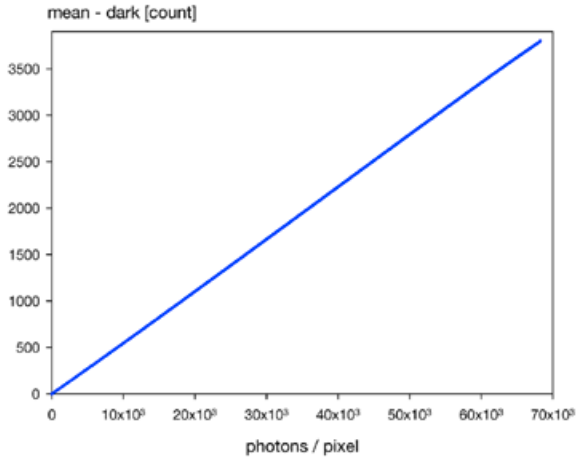
The top image shows the typical fixed pattern structures in the dark image of high speed CMOS image sensors, while the lower image shows less and more homogeneous noise in the dark image of a pco.dimax.

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 on the next page.

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.



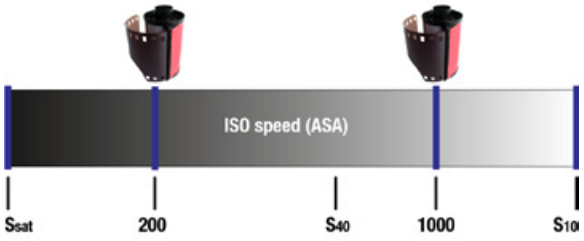
EMVA 1288 linearity measurement of a pco.dimax camera.

Different images of a highspeed sequence that was recorded for a music video, showing a woman jumping on a trampoline and performing a back salto.

features

light sensitivity & ISO speed

Compared to analog photographic films, which are limited to one light sensitivity value, the pco.dimax HS 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 1250, for highest quality, up to 16,000 and more at high frame rates.



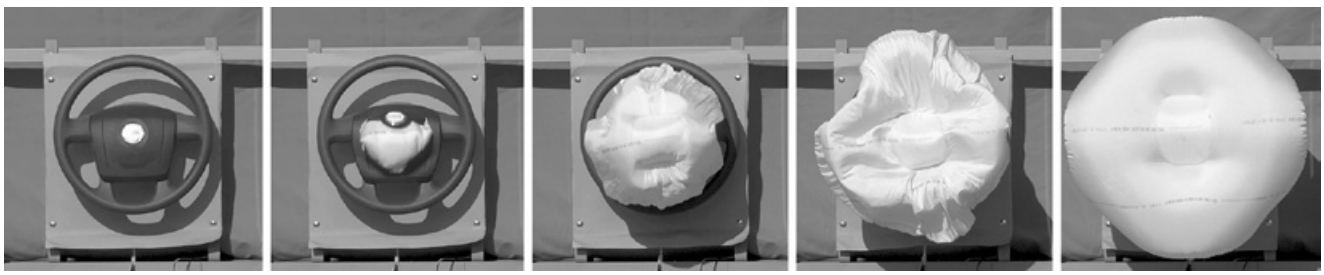
The graph shows the ISO 12232 values s_{sat}, s_{40} and s_{10} relative to the formerly used sensitivity values for negative film (examples give ASA 200 and ASA 1000) along a virtual sensitivity scale.

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.

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).



Different images of a highspeed sequence of an airbag inflation, which was recorded with two highspeed cameras. With the stereo setup it was possible to analyze the airbag inflation in three dimensions without any marker on the airbag.

technical data

image sensor HS1/HS2/HS4

type of sensor	CMOS
image sensor	proprietary
resolution (h x v)	1000 x 1000 pixel HS1 1400 x 1050 pixel HS2 2000 x 2000 pixel HS4
pixel size (h x v)	11 µm x 11 µm
sensor format / diagonal	11.0 x 11.0 mm² / 15.6 mm HS1 15.4 x 11.6 mm² / 19.3 mm HS2 22.0 x 22.0 mm² / 31.1 mm HS4
shutter mode	global (snapshot)
fullwell capacity	36000 e⁻
readout noise	23 e⁻ rms (typ.) 18 e⁻ rms (CDI, typ.)
dynamic range	1600 : 1 (64 dB) 2000 : 1 (65 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 HS1/HS2/HS4

max. frame rate (full frame)	7039 fps HS1 5469 fps HS2 2277 fps HS4
exposure/shutter time	1.5 µs .. 40 ms
dynamic range A/D	12 bit
A/D conversion factor	8.34 e⁻/count
region of interest	steps of 2 x 2 pixel (centered)
non linearity	< 0.5 % (diff.) / < 0.2 (integr.)
primary image memory (camRAM)	9 GB / 18 GB / 36 GB
trigger input signals	frame trigger, sequence trigger, stop trigger[2]
trigger output signals	exposure, busy
data interface	USB 3.0, GigE/USB 2.0, CameraLink
time stamp	in image (1 µs resolution)
time code input	IRIG-B (optional)
interframing time[4]	3.15 µs
operational shock	30 g @ 11 ms, half sine wave, all axes
operational vibration	25 g @ 1 - 150 Hz, all axes

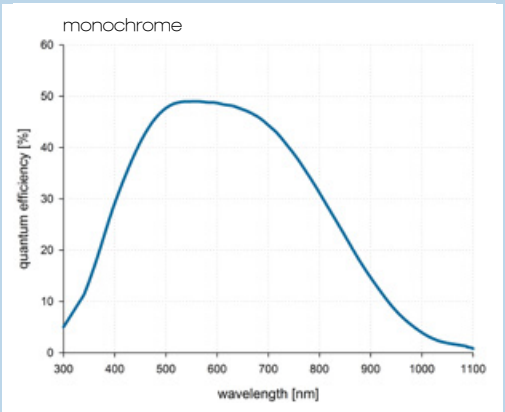
general HS1/HS2/HS4

power supply	90 .. 260 VAC (12 VDC opt.)
power consumption	90 W (130 W with battery[5])
weight	7.9 kg
ambient 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[3]

typical examples [pixel]	frame rate	recording time (36 GB)	images in memory (36 GB)
pco.dimax HS1			
1000 x 1000	7039 fps	6.9 s	48497
800 x 600	12841 fps	7.7 s	98491
640 x 480	17985 fps	8.8 s	157958
320 x 200	46746 fps	14.0 s	653411
pco.dimax HS2			
1400 x 1050	5469 fps	6.2 s	33943
1280 x 720	8226 fps	6.4 s	52839
1000 x 1000	7039 fps	6.9 s	48497
800 x 600	12841 fps	7.7 s	98491
640 x 480	17985 fps	8.8 s	157958
320 x 200	46746 fps	14.0 s	653411
pco.dimax HS4			
2000 x 2000	2277 fps	5.6 s	12729
1400 x 1050	5469 fps	6.2 s	33943
1280 x 720	8226 fps	6.4 s	52839
1000 x 1000	7039 fps	6.9 s	48497
800 x 600	12841 fps	7.7 s	98491
640 x 480	17985 fps	8.8 s	157958
320 x 200	46746 fps	14.0 s	653411

quantum efficiency



[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 (RS-485) and passive (contact closure).
[3] the given resolutions are selected for the frame rate calculations only, they are not mandatory. For region of interest conditions see table "camera".
[4] time between two consecutive images for particle image velocimetry (PIV) applications
[5] includes charging current

technical data

software

For camera control, image acquisition and archiving of images in various file formats PCO provides the software application Camware (Windows XP, 7 and 8).

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 a list of third party software supported, please visit www.pco.de

ISO speed rating[1]		
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

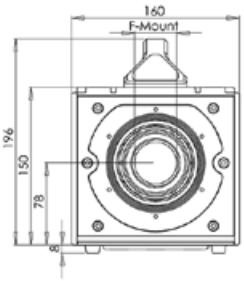
[1] ISO 12232: Photography - Electronic still-picture cameras - Determination of ISO speed

options

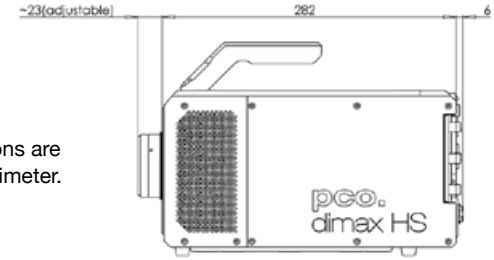
custom made versions; rechargable battery packs

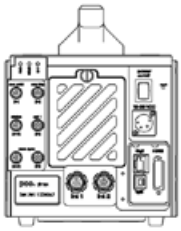
dimensions

F-mount lens changeable adapter.



All dimensions are given in millimeter.



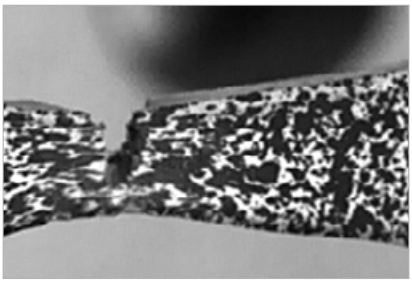


camera views

Further information can be found on www.pco.de

applications

material testing

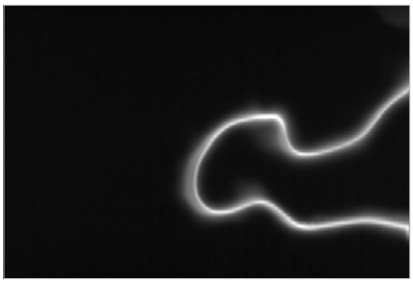


Material tests like rupture tests or tensile tests can be observed and evaluated.

deformation fields

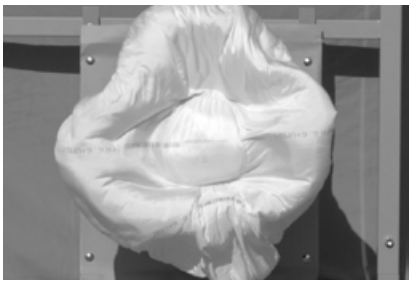
Deformation of metals that are cut can be investigated and optimized.

ignition research



Ignition sparks within the combustion process can be observed to optimize the process.

airbag inflation



Airbag inflation can be recorded with more than 7000 frames/s at 1k x 1k resolution or with more than 5000 stereo images/s at 1k x 1k resolution (both images in one readout image with mirror set-up).

industrial quality control

In fast machines like the shown SMD placing malfunctions can be investigated and resolved.

super slow motion videos

Super slow motion sequences like the image from a music video can be recorded with a high monochrome image quality.

application areas

■ material testing ■ airbag inflation ■ high speed particle image velocimetry (PIV) ■ tensile testing ■ short time physics ■ hydrodynamics ■ spray analysis ■ combustion analysis ■ deformation ■ machine vision ■ industrial quality control ■ hypervelocity impact studies ■ fuel injection ■ ballistics ■ abrasive material research ■ sparks in electronical switches ■ research in ignition ■ high speed photogrammetry

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