

# pco.dicam C1

intensified 16 bit **sCMOS** camera

intensified  
**sCMOS**



enhanced  
extinction ratio gating

intensified  
**sCMOS** technology  
2048 x 2048 pixel

106 fps  
@ full resolution

10G fibre optic  
data interface

double image mode  
with 300 ns interframing time

exposure time 4 ns  
with 25 mm intensifier

# pco.



## pco.dicam C1

After more than 30 years of experience with image intensified cameras, we are proud to introduce the new pco.dicam C1 to you. The pco.dicam C1 is the first intensified camera system which exploits the full performance inherent to **scientific CMOS** sensor technology.

It is the optical coupling of 25 mm high resolution image intensifiers with an outstanding high efficiency tandem lens system to a 16 bit 4 Mpixel **sCMOS** sensor which makes the camera so unique. The 10G fibre optic based data interface guarantees you uncompressed and robust 16 bit data transfer of 106 full frames per second via optical fiber over virtually any distance.

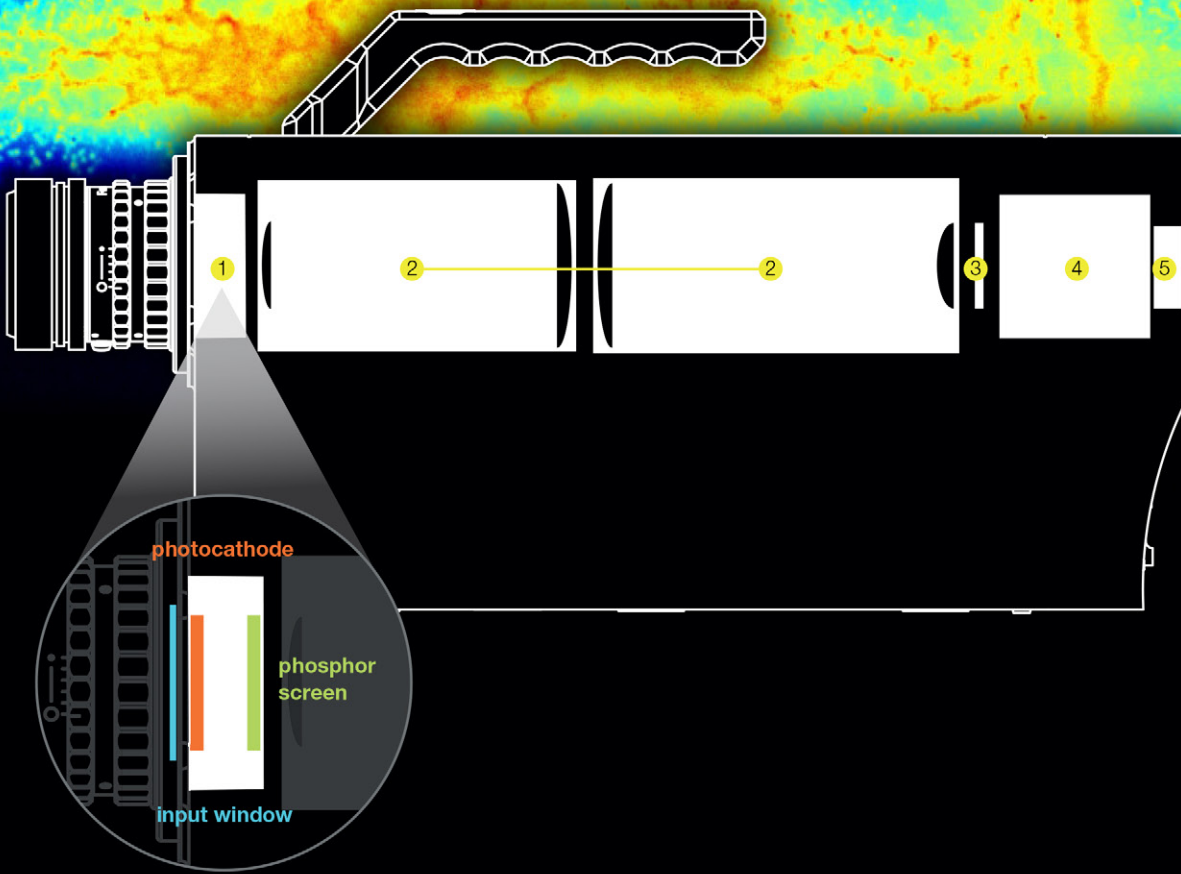
## & feature benefit

<b>106 frames/s @ full 4.2 Mpixel resolution</b>	high frame rates at high resolution for imaging of dynamic processes
<b>&gt; 7000 frames/s @ reduced resolution</b>	kHz scan rates for spectroscopic applications
<b>1.1 e<sup>-</sup> readout noise</b>	lowest readout noise of any gated intensified camera system
<b>16 bit digitization</b>	taking advantage of the higher dynamic range possible from high end image intensifiers
<b>25 mm high resolution image intensifier</b>	doubles the optical resolution of conventional 18 mm image intensifiers
<b>optical coupling via ultra-speed tandem lens</b>	outstanding image quality with high transmission efficiency and no artifacts
<b>tandem lens with 0.53 : 1 image scaling</b>	full 25 mm diameter of intensifier output is lossless imaged onto sCMOS sensor
<b>10G fibre optic based data interface</b>	fiber optical interface virtually covers any distance without deploying additional interface converters or signal amplifiers with immunity to EMI
<b>880 MByte/s image data rate</b>	highest sustained image data rate of any intensified camera system on the market; no limitations for recording duration
<b>double image mode with 300 ns interframing time</b>	two consecutive full resolution images with a configurable minimum interframing time of 300 ns
<b>4.2 MPix sCMOS sensor</b>	overcomes CCD limitations in terms of speed and sensitivity
<b>enhanced extinction ratio gating</b>	fast MCP gating for improved extinction ratio for the blue and uv part of the spectrum
<b>additional optical trigger input</b>	robust trigger transmission over long distance in EMC critical environments
<b>EF lens control -optional-</b>	convenient remote lens control for camera systems inaccessible during an experiment
<b>selected highly homogeneous image intensifiers</b>	integrated best image intensifier quality available on the market
<b>&lt; 50 ns trigger to exposure start delay</b>	ultra fast camera reaction to trigger event
<b>4 ns gating with 25 mm intensifier</b>	captures fast transient phenomena
<b>extensive and highly precise IN/OUT signaling</b>	allows for perfect synchronization in any experimental set-up as timing master or slave
<b>configurable delay in steps of 1 ns</b>	flexible adaptation to synchronization needs

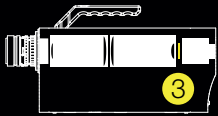
» applications

laser induced incandescence (LII) | shock wave physics | laser induced breakdown spectroscopy (LIBS) | particle image velocimetry (PIV) | time resolved spectroscopy | plasmaphysics | laser induced fluorescence (LIF) | ballistics | combustion

# camera modules

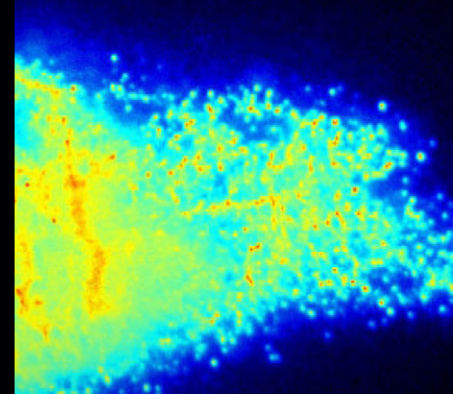
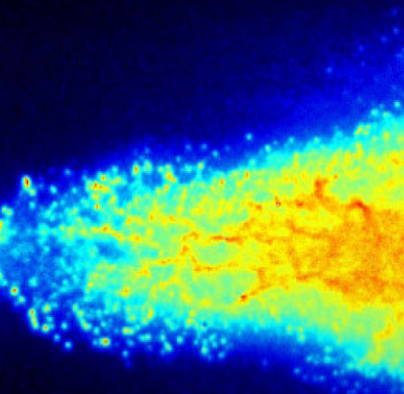


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» sCMOS image sensor

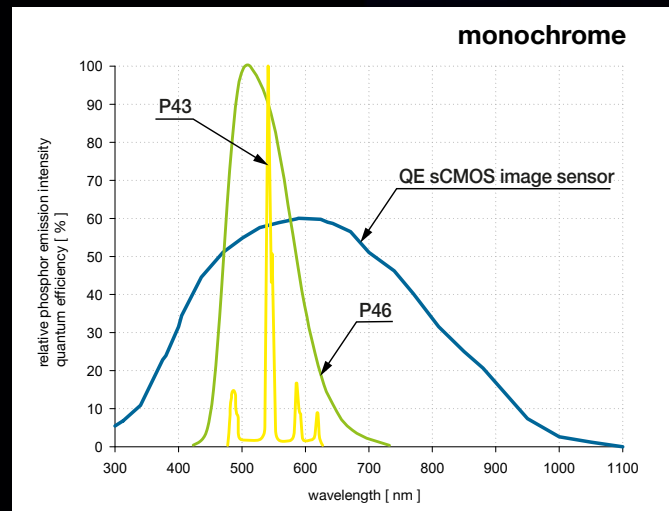
<b>type of sensor</b>	scientific CMOS (sCMOS)
<b>resolution (h x v)</b>	2048 x 2048 active pixel
<b>pixel size (h x v)</b>	6.5 $\mu\text{m}$ x 6.5 $\mu\text{m}$
<b>sensor format / diagonal</b>	13.3 mm x 13.3 mm / 18.8 mm
<b>shutter mode</b>	single image double image
<b>MTF<sup>1</sup></b>	76.9 lp/mm (theoretical)
<b>fullwell capacity</b>	15 000 e <sup>-</sup> for P46 phosphor 30 000 e <sup>-</sup> for P43 phosphor
<b>readout noise<sup>2</sup></b>	1.1 <sub>med</sub> / 1.5 <sub>rms</sub> e <sup>-</sup> single image 2.2 <sub>med</sub> / 2.5 <sub>rms</sub> e <sup>-</sup> double image
<b>dynamic range</b>	13 600 : 1 (82.7 dB) for P46 phosphor 27 200 : 1 (88.7 dB) for P43 phosphor
<b>quantum efficiency</b>	58 % for P43 peak emission @ 545 nm 57 % for P46 peak emission @ 530 nm
<b>spectral range</b>	300 nm ... 1000 nm
<b>dark current<sup>3</sup></b>	< 0.6 e <sup>-</sup> /pixel/s @ 7 °C
<b>DSNU</b>	1.0 <sub>rms</sub> e <sup>-</sup>
<b>PRNU</b>	< 0.6 %
<b>anti blooming factor</b>	1 : 10 000



» frame rate table<sup>4</sup>

2048 x 2048	106 fps
2048 x 1024	210 fps
2048 x 512	414 fps
2048 x 256	807 fps
2048 x 128	1535 fps
2048 x 64	2795 fps
2048 x 32	4739 fps
2048 x 16	7266 fps
1920 x 1080	199 fps
1600 x 1200	180 fps
1280 x 1024	210 fps
640 x 480	441 fps
320 x 240	858 fps

» quantum efficiency



<sup>1</sup> Modulation transfer function

<sup>2</sup> The readout noise values are given as median (med) and root mean square (rms) values due to the different noise models, which can be used for evaluation. All values are raw data without any filtering.

<sup>3</sup> Measurements with dark current compensation

<sup>4</sup> Exposure time < 1  $\mu\text{s}$



» camera system

<b>frame rate</b>	up to 106 fps @ 2048 x 2048 pixel
<b>dynamic range A/D<sup>5</sup></b>	16 bit
<b>pixel scan rate</b>	286.0 MHz
<b>binning horizontal</b>	x1, x2, x4
<b>binning vertical</b>	x1, x2, x4
<b>region of interest (ROI)</b>	horizontal: steps of 4 pixels vertical: steps of 1 pixel
<b>non-linearity</b>	< 1 %
<b>cooling method</b>	+7 °C stabilized, 1 stage peltier with forced air (fan)
<b>input signals</b>	optical trigger (FOL), electrical trigger, arm input (TTL level, BNC connectors), gate disable (high-speed TTL input, BNC connectors)
<b>output signals</b>	gate/expos out monitor, user monitor output (TTL level, BNC connectors)
<b>time stamp</b>	in image (1 μs resolution)

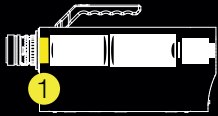
» exposure modes

<b>single image mode</b>	
exposure times	4, 10 ns fixed, 20 ns ... 250 ns (1 ns steps), 250 ns ... 1 s (10 ns steps)
delay times	0 ns ... 250 ns (1 ns steps), 250 ns ... 1 s (10 ns steps)
maximum repetition... ...with external gating	200 kHz sustained, 3.3 MHz burst
insertion delay	
trigger input to exposure out	19 ns
trigger input to optical open	49 ns
jitter	
trigger input to exposure out	35 ps rms
trigger input to optical open	150 ps rms
<b>double image mode</b>	
exposure times	20 ns ... 1 ms (in 10 ns steps)
delay settings	0 ns ... 10 ms (in 10 ns steps)
interframing time	300 ns ... 10 ms (in 10 ns steps)

» general

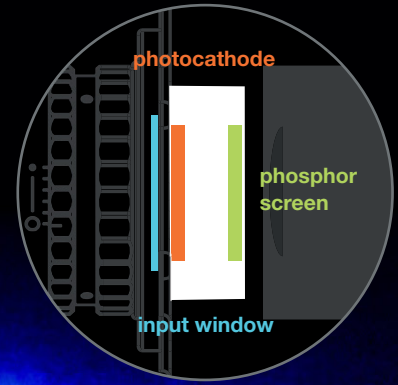
<b>power supply</b>	18 ... 28 VDC
<b>power consumption</b>	35 ... 40 W
<b>weight</b>	7 kg
<b>operating temperature</b>	+ 10 °C ... + 40 °C
<b>operating humidity range</b>	10 % ... 80 % (non-condensing)
<b>storage temperature range</b>	- 10 °C ... + 60 °C
<b>optical interface</b>	F-mount optional: C-mount, Canon mount
<b>lens remote controller</b>	electronic control for Canon EF lenses
<b>CE / FCC certified</b>	yes

<sup>5</sup> The high dynamic signal is simultaneously converted at high and low gain by two 11 bit A/D converters and the two 11 bit values are sophisticatedly merged into one 16 bit value.

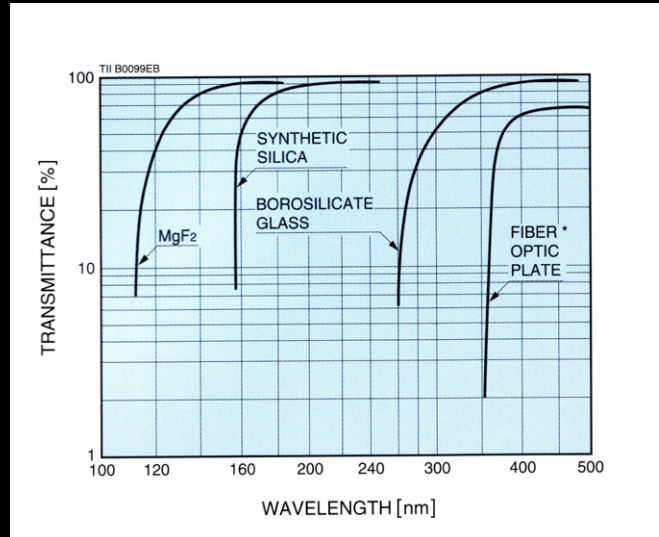


» image intensifier

<b>type</b>	HighRes MCP <sup>6</sup> (6 μm channel)
<b>input window</b>	synthetic silica, borosilicate (MgF <sub>2</sub> optional)
<b>photocathode material</b>	S20, GaAs, GaAsP (others on request)
<b>image intensifier</b>	6 μm
<b>pitch distance</b>	
<b>image intensifier MCP type</b>	single stage low resistance MCP for high strip current
<b>MCP operational modes</b>	continuous gated for enhanced extinction ratio
<b>image intensifier diameter</b>	25 mm (18 mm optional on request)
<b>phosphor screen material</b>	P43, P46
<b>output window</b>	glass
<b>image intensifier system resolution</b>	> 50 lp/mm @ 5 % MTF typical (depends on phosphor)
<b>shortest gating time</b>	4 ns



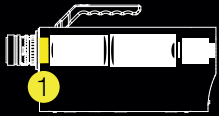
» image intensifier input window



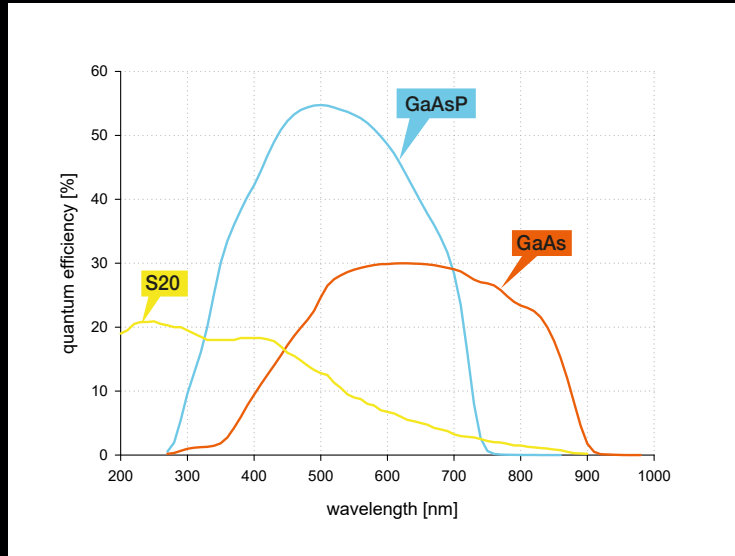
Typical transmittance of image intensifier input window materials

To make use of the good UV-sensitivity of S20 photocathode material the standard input window is made of synthetic silica for transmission down to 180 nm.

GaAs and GaAsP photocathodes are deposited on borosilicate glass.



» image intensifier photocathode characteristics



Spectral sensitivities of different photocathode materials: S20 (multialkali), GaAs, GaAsP

data courtesy of Hamamatsu Photonics

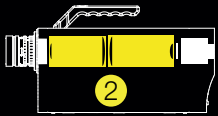
photocathode material	peak wavelength [nm]	typical quantum efficiency at peak wavelength [%]	dark counts [s <sup>-1</sup> /cm <sup>2</sup> ]
S20 (multialkali)	250	20	1500
GaAs	650	30	30 000
GaAsP	500	55	10 000

data courtesy of Hamamatsu Photonics

» image intensifier phosphor

phosphor	phosphor decay (typ.) to..		peak emission	typical efficiency
	.. 10 %	.. 1 %		
P43	1 ms	4 ms	545 nm	100 %
P46	0.2 - 0.4 μs	2 μs	530 nm	30 %

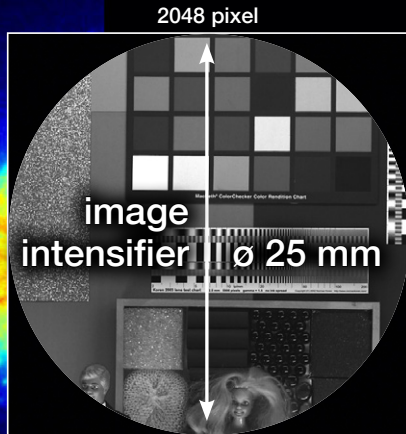
You can combine all photocathode materials with P43 or P46 phosphor. Whereas the P43 phosphor has a much brighter emission than the P46 phosphor, it has a rather long decay time, i.e. the time required till the phosphor emission fades out after the excitation by electron bombardement has been stopped. This decay time is therefore critical for fast image repetition rates primarily in double image application or when operating the camera in spectroscopic mode with line rates in the kHz range.



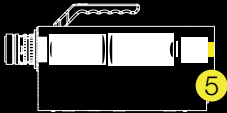
» optical coupling lens system

“ultra-speed tandem lens” between image intensifier & sCMOS

transmission efficiency	> 30 %
vignetting	< 3 %
resolution	> 60 lp/mm
scaling rates	$\beta=0.53$ for 25 mm intensifier



The projected image circle is completely covered by 2048 x 2048 6.5  $\mu\text{m}$  pixels of the sCMOS detector – cf. image left. There is no “waste” of valuable intensifier area. As a consequence the four corners of the sCMOS sensor remain black. For a fast scan of just a few vertically centered lines – the camera module allows you to achieve more than 7.000 fps for such a ROI – the full line length of 2048 pixels is available.



» camera interface

data transfer	Camera Link HS, FOL cable, frame grabber (Single F2,1X1, S10)
input signals	optical trigger (FOL), electrical trigger, arm input (TTL level, BNC connectors), gate disable (high-speed TTL input, BNC connectors)
output signals	gate/expos out monitor, user monitor output (TTL level, BNC connectors)



» software

With pco.camware you control camera settings as well as image acquisition. Also, you can chose various formats for your files (Windows 7 and later).

Visit [www.pco.de](http://www.pco.de) for a free software development kit (SDK). It includes a dynamic link library for user customization and integration on PC platforms. Drivers for popular third party software packages are also available.



# pco.dicam C1

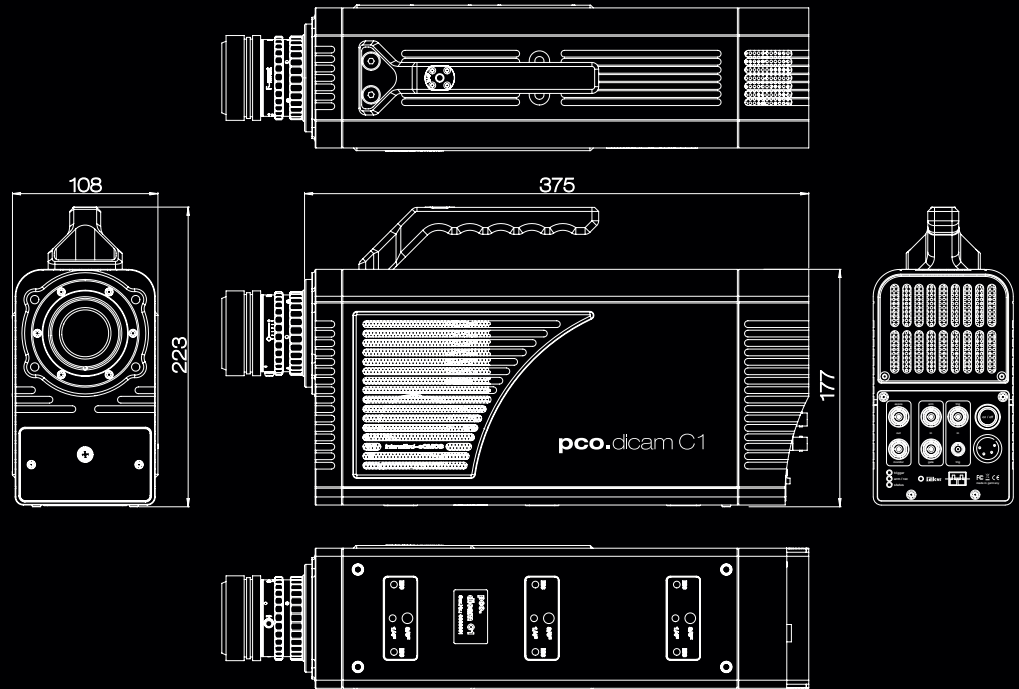
## » lens remote controller

The optional Canon lens control adapter enables you to connect electronic EF- and EF-S Canon lenses allowing to remote control focus and aperture of those lenses.



## » dimensions

F-mount and C-mount lens changeable adapter.



All dimensions are given in millimeter.

## » camera view



» possible combinations

photocathode	input window	phosphor	order code
S20 selected*	synthetic silica	P46	70108001003
		P43	70108001002
GaAs standard*	borosilicate	P46	70108001006
		P43	70108001004
GaAs selected*	borosilicate	P46	70108001007
		P43	70108001005
GaAsP standard*	borosilicate	P46	70108001010
		P43	70108001008
GaAsP selected*	borosilicate	P46	70108001011
		P43	70108001009

\* Image intensifiers with GaAs and GaAsP photocathode are available in two quality grades:

Standard: quality specified for central 16 mm x 16 mm square region corresponding to 1300 x 1300 pixel sCMOS sensor resolution

Selected: quality specified for 24.9 mm diameter area corresponding to full 2048 x 2048 pixel sCMOS sensor resolution, extinction ratio 10 times higher than standard grade, image intensifiers with S20 photocathode exclusively come in selected grade quality, contact our technical sales team for further details on the two quality grades

» select optical interface

C-mount
F-mount
EF lens control

» select FOL

type of data interface FOL module in camera and frame grabber

SM SFP+ up to 10 km
MM SFP+ up to 300 m

FOL cable length default: 10 m

**Need more help?**

**Get in touch with our experts, tell us what you want to achieve and let us help you find the best customization for your application!**

**find us**

**europe**

PCO AG  
Donaupark 11  
93309 Kelheim, Germany

+49 9441 2005 50  
info@pco.de  
pco.de



**america**

PCO-TECH Inc.  
6930 Metroplex Drive  
Romulus, Michigan 48174, USA

+1 248 276 8820  
info@pco-tech.com  
pco-tech.com

**asia**

PCO Imaging Asia Pte.  
3 Temasek Ave  
Centennial Tower, Level 34  
Singapore, 039190

+65 6549 7054  
info@pco-imaging.com  
pco-imaging.com



**china**

Suzhou PCO Imaging Technology Co., Ltd.  
Room A10, 4th Floor, Building 4  
Ascendas Xinsu Square, No. 5 Xingnan Street  
Suzhou Industrial Park, China 215021

+86 512 67634643  
info@pco.cn  
pco.cn



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