



xiX-XL

[ksi-eks'el:] or [sai-eks'el:]

- Hi-res PCIe cameras with larger format sensors

Ximea cameras •
Technical Manual •
Version v240108 •

Introduction

About this manual

Dear customer,

Thank you for purchasing a product from XIMEA.

We hope that this manual can answer your questions, but should you have any further questions or if you wish to claim a service or warranty case, please contact your local dealer or refer to the XIMEA Support on our website:

www.ximea.com/support

The purpose of this document is to provide a description of the Ximea cameras and to describe the correct way to install related software and drivers and run it successfully. Please read this manual thoroughly before operating your new Ximea cameras for the first time. Please follow all instructions and observe the warnings.

This document is subject to change without notice.

About XIMEA

XIMEA is one of the worldwide leaders for innovative camera solutions with a 30-year history of research, development and production of digital image acquisition systems. Based in Slovakia, Germany and the US and with a global distributor network, XIMEA offers their cameras worldwide. In close collaboration with customers XIMEA has developed a broad spectrum of technologies and cutting-edge, highly competitive products.

XIMEA's camera centric technology portfolio comprises a broad spectrum of digital technologies, from data interfaces such as USB 2.0, USB 3.1 and PCIe to cooled digital cameras with CCD, CMOS and sCMOS sensors, as well as X-ray cameras.

XIMEA has three divisions – generic machine vision and integrated vision systems, scientific imaging and OEM/custom.

XIMEA cameras find use in many industrial applications, such as motion control, robotics, or quality control in manufacturing. The broad spectrum of cameras also includes thermally stabilized X-ray cameras, and specialty cameras for medical applications, research, surveillance and defense.

Contact XIMEA

XIMEA is a worldwide operating company

Headquarters, Sales worldwide

XIMEA GmbH
Am Mittelhafen 16
48155 Münster
Germany

Tel: +49 (251) 202 408-0
Fax: +49 (251) 202 408-99

Web www.ximea.com
General inquiries info@ximea.com
Sales sales@ximea.com
Support [XIMEA Support](#)

Sales America

XIMEA Corp.
12600 W Colfax Ave., Suite A-130
Lakewood, CO 80215
USA

Tel: +1 (303) 389-9838
Fax: +1 (303) 202-6350

R&D, Production

XIMEA s.r.o.
Lesná 52
900 33 Marianka
Slovakia

Tel: +421 (2) 205 104 26
Fax: +421 (2) 205 104 27

Standard conformity

The cameras have been tested using the following equipment:

TBD

Warning: Changes or modifications to the product or the environment may render it ineligible for operation under CE, FCC or other jurisdictions. XIMEA recommends using the above configuration to ensure compliance with the following standards.

CE conformity



Note: TBD Models have not been certified, yet.

For customers in the US: FCC conformity



Note: TBD Models have not been certified, yet.

For customers in Canada

Note: TBD - Models have not been certified, yet.

RoHS conformity



The xiX-XL cameras comply with the requirements of the RoHS (Restriction of Hazardous Substances) Directive 2015/863/EU.

WEEE conformity



The xiX-XL cameras comply with the requirements of the WEEE (waste electrical and electronic equipment) Directive 2012/19/EU.

GenlCam GenTL API



GenlCam standard transport layer interface, grabbing images. **GenlCam/GenTL** provides an agnostic transport layer interface to acquire images or other data and to communicate with a device. Each XIMEA camera can be GenTL Producer.

Helpful links

XIMEA Homepage	http://www.ximea.com/
XIMEA Registration	http://www.ximea.com/en/products/register
XIMEA Support	https://www.ximea.com/support/wiki/allprod/Contact_Support
Frequently Asked Questions	http://www.ximea.com/support/wiki/allprod/Frequently_Asked_Questions
Knowledge Base	http://www.ximea.com/support/wiki/allprod/Knowledge_Base
XIMEA Software Package	https://www.ximea.com/support/wiki/apis/APIs#Software-packages
Vision Libraries	http://www.ximea.com/support/projects/vision-libraries/wiki
XIMEA General Terms & Conditions	http://www.ximea.com/en/corporate/generaltc

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1 xiX-XL camera series

1.1 What is xiX-XL



xiX-XL is the high-resolution camera family with PCI express Interface and detachable sensor heads:

- xiX-XL is the high-resolution camera family with PCI express Interface
- BSI sensors: Sony CMOS sensors: 61 Mpx, 101 Mpx, and 151 Mpx
- Full frame 35 mm and Medium format sensor sizes
- Backside illumination technology for high quantum efficiency of up to 90 %
- Impressive speed - 61 Mpx at 17 fps, 101 Mpx at 8 fps, 151 Mpx at 6 fps, and more with binning

The new xiX-XL cameras as part of the xiX-camera series are based on sensors with backside-illuminated technology from Sony and deliver resolutions starting from 61 Mpx and going up to 151 Mpx. With a very high quantum efficiency, reaching 90 % sensitivity, each sensor offers a high dynamic range of 80 dB, resulting in high-quality 16-bit RGB or black-and-white images. Even though these sensors have a small pixel size of 3.76 μm , the saturation capacity is well above 40 000 e⁻.

The small pixel size also allows the individual cameras (with a resolution of over 150 Mpx) to be condensed in space-restricted applications. The separation of the sensor head from the camera body can further assist with building various multicamera systems. All this is combined with the PCI-Express interface allowing data throughputs up to 32 Gbit/s.

1.2 Advantages

Industry standard interface	PCI Express
Compact	compared to sensor size the cameras are relatively small with the possibility to separate sensor head and camera electronics
Powerful	32 Gbit/s interface using standard PCI express hardware (X8G3 models)
High resolutions	high resolution, high frame rate: 61 Mpx at 17 fps, 101 Mpx at 8 fps, 151 Mpx at 6 fps
Robust	full metal semi-housed
Compatibility	support for Windows, Linux and MacOS, various image processing libraries
Connectivity	programmable opto-isolated I/O, and non-isolated digital input and output
Software interfaces	GenICam / GenTL and highly optimized xiAPI SDK
Economical	excellent value and price, low TCO and fast ROI
Low latency	computer CPU not involved in data transfer, latency from camera to memory is low
Optimized transfer	GPU-direct (Linux only) ideal for setup using GPU for image processing

1.3 Camera applications

- 360 panorama (360° spherical, cyclorama imaging), photogrammetry, videogrammetry
- 3D mapping, GIS (Geographical Information Systems)
- aerial or city/street mapping (UAV / UAS - drones)
- astronomy

1.4 Common features

Sensor technology CMOS	rolling shutter, backside illuminated (BSI)
Acquisition modes	continuous, software and hardware trigger, fps limiting, triggered exposure and burst
Partial image readout ROI	decimation and binning modes supported (model specific)
Image data formats	8, 10, 12, 14 or 16 bit RAW pixel data
Color image processing	host based de-bayering, sharpening, gamma, color matrix, true color CMS
Hot/blemish pixels correction	on camera storage of up to 5000 px coordinates, host assisted correction
Auto adjustments	Auto white balance, auto gain, auto exposure
Flat field corrections	host assisted pixel level shading and lens corrections
Image data and control interface	TBD
General purpose I/O	1x opto-isolated input, 1x opto-isolated output, and 4x non-isolated bidirectional I/O, 4x user configurable LEDs
Synchronization	hardware trigger input, software trigger, exposure strobe output, busy output
Housing and lens mount	M72 - stand, optional hasselblad mount, EF-mount
Power requirements	external power supply required of 12 to 24 V DC
Environment	operating 0 to 50 °C on housing, RH 80 % non-condensing, -25 to 60 °C storage
Operating systems	Windows, Linux Ubuntu, MacOS
Software support	xiAPI SDK, adapters and drivers for various image processing packages
Firmware updates	xiAPI SDK, field firmware updatable

1.5 Model nomenclature

xiX-XL MX(x)xyT-zz-X4G3-FF

MX xiX family name

xxx: (x)xxx: resolution in 0.1 Mpx. E.g. 2.3 Mpx resolution: xxx = 23 or 101.8 Mpx Resolution: (x)xxx = 1018

y: Color sensing

C: color model

M: black & white model

T: Sensor technology

R: Rolling shutter

G: Global shutter

zz: Vendor of the sensor

SY: Sony

X4G3: Number of PCIe lanes used, 4 for these cameras
PCIe generation, currently at Gen 3 for these cameras

FF: FireFly cable connection

1.6 Models and sensors overview



Model	Resolution	Pixel size	Bits	Dynamic range	Sensor diagonal	FPS ¹	
MX610MR-SY-X4G3-FF	B/W	9568 × 6380	3.76 μm	12/14/16	75.4/80/81 dB	43.17 mm	17.9/9.9/3.9
MX610CR-SY-X4G3-FF	Color						
MX1018MR-SY-X4G3-FF	B/W	11 648 × 8742	3.76 μm	12/14/16	75.8/80.4/81.4 dB	54.78 mm	8.74/6/2.7
MX1018CR-SY-X4G3-FF	Color						
MX1510MR-SY-X4G3-FF	B/W	14 176 × 10 640	3.76 μm	12/14/16	75.8/80.4/81.1 dB	66.68 mm	6.2/4.6/2
MX1510CR-SY-X4G3-FF	Color						

¹transport frame rate at full resolution

Table 1: xiX-XL models overview

1.7 Accessories overview

The following accessories are available:

Item P/N	Description
CBL-PB4-PWR-0M15	Power cable with barrel connector 15 cm long
CBL-PB6-IO-0M10	IO pig tail cable 10 cm long
CBL-ECUE-X4G3-0M30	Cable Micro Assembly, Low-Profile FireFly, 30 cm
CBL-ECUE-X4G3-1M0	Cable Micro Assembly, Low-Profile FireFly, 100 cm
CBL-ECUE-X4G3-2M0	Cable Micro Assembly, Low-Profile FireFly, 200 cm
HA-1/2P-X4G3-MTP/FF-X8G3	Ximea PCIe Dual FireFly x4 Gen 3 Host Adapter Card
ADPT-1/2/4P-X4G3-FF-X4/8G3-MTP	PCIe Adapter FireFly to MTP
ADPT-MX-X4G3-FF-X4G3-MTP	MTP Adapter for MX-X4G3-FF camera
CB-X8G3-FAN-COOLER-KIT	Heatsink Fan Cooler for X8G3 cameras with screws Kit
CB-X8G3-WAT-COOLER-KIT	Heatsink Water Cooler for X8G3 cameras with screws Kit
CBL-HQCD-0M15	Highspeed Coaxial HQCD cable, 15 cm length
CBL-HQCD-0M50	Highspeed Coaxial HQCD cable, 50 cm length
CBL-HQCD-1M0	Highspeed Coaxial HQCD cable, 100 cm length
CBL-HQCD-2M0	Highspeed Coaxial HQCD cable, 200 cm length
MECH-60MM-BRACKET-T-KIT	MECH Tripod Bracket 60 mm with Screws Kit
MECH-60MM-EF-ADAPTER-KIT	Canon EF Lens Mount Adapter Kit
ME-LA-80MM-M72-L-KIT	M72 lens adapter with screws Kit

Table 2: accessories overview

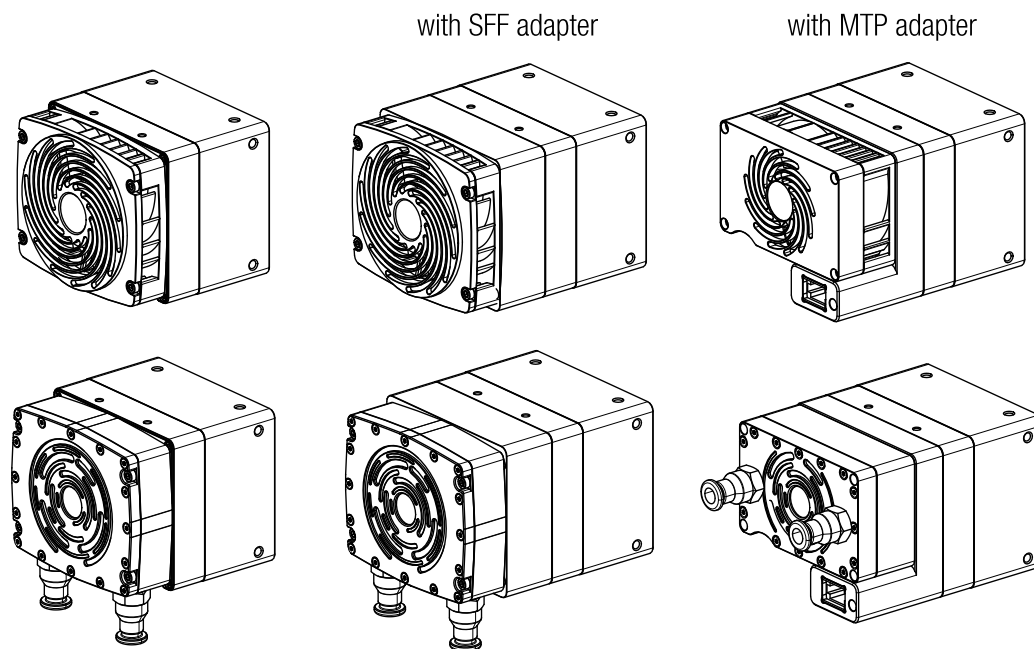


Figure 1: camera with accessory/cooling options

2 Hardware specification

2.1 Power supply

Depending on the used accessories cameras can be powered either by their respective sync cable or the FireFly connector.
See section [Camera interface](#)

2.2 General specification

2.2.1 Environment

Description	Symbol	Value
Optimal ambient temperature operation	T_{opt}	10 to 25 °C
Ambient temperature operation	T_{max}	0 to 50 °C
Ambient temperature for storage and transportation	$T_{storage}$	-25 to 60 °C
Relative Humidity, non-condensing	RH	80 %

Table 3: environment

Housing temperature must not exceed 65 °C.

Note: The following parameters are not guaranteed if the cameras are operated outside the optimum range:

- Dark current
- Dynamic Range
- Linearity
- Acquisition
- Readout noise
- S/N ratio
- Durability

2.3 Lens mount

Different types of lens mounts can help with offsetting the rolling shutter, specifically in photogrammetry applications.

2.3.1 EF mount

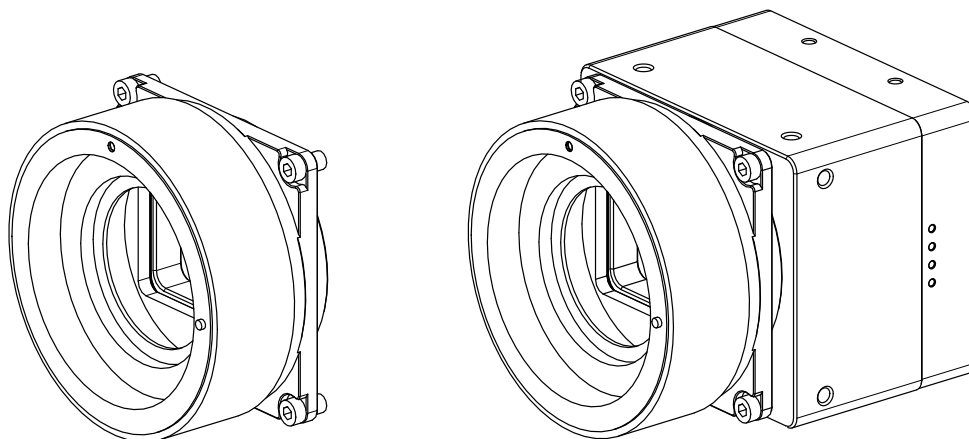


Figure 2: camera with the optional EF-Mount adapter

EF mount supported by MX610xR-SY-X4G3-FF model.

The active EF-mount for example allows remote control of aperture, focus and image stabilization. The adapter is mounted to the camera using 4 M4x10 screws.

Note: The distance between the outer EF-Mount Adapter and the active sensor surface is 44 mm and when no EF-Mount adapter is included it is 13.78 mm. Refer to [MECH-60MM-EF-ADAPTER](#) for more information.

2.3.2 M72 mount

M72 mount supported by MX1018xR-SY-X4G3-FF and MX1510xR-SY-X4G3-FF models

M72 Lens Adapter for 80 × 80 mm front camera element. The adapter is mounted to the camera using 4 M4x10 screws. Please see [ME-LA-80MM-M72-L-KIT](#) for more information.

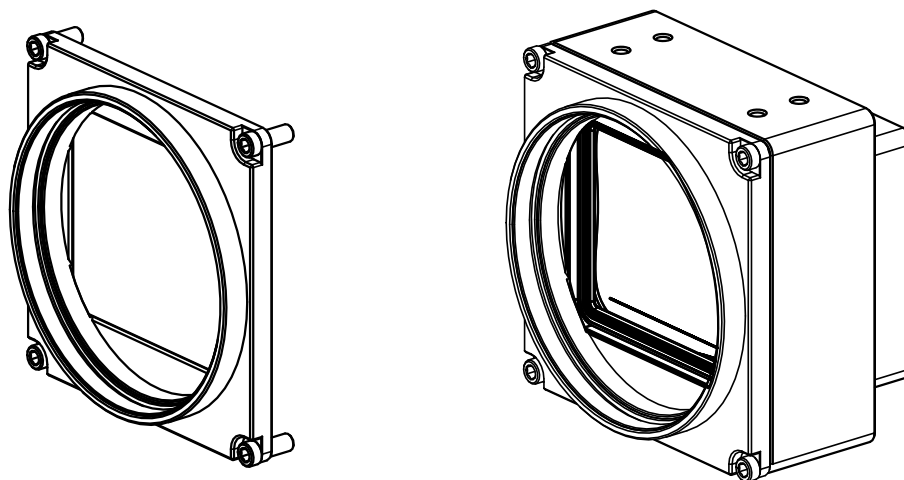


Figure 3: camera with the optional M72-Mount adapter

2.4 Mounting points

Mounting points available to the customer are shown below. All are M4 thread. Four mounting points at the front panel are used for the EF-mount and M72-mount adapters when installed.

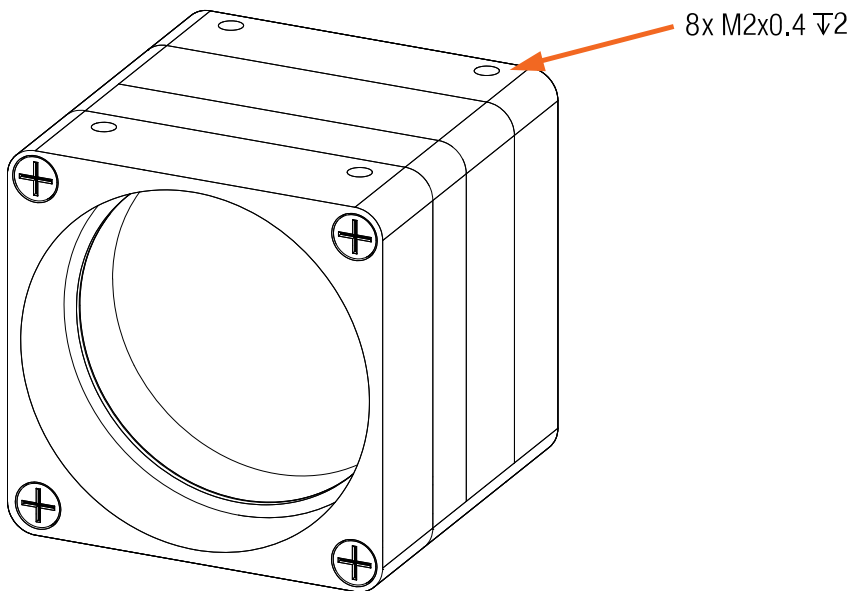


Figure 4: mounting points

All mounting screws are customized M4 screws

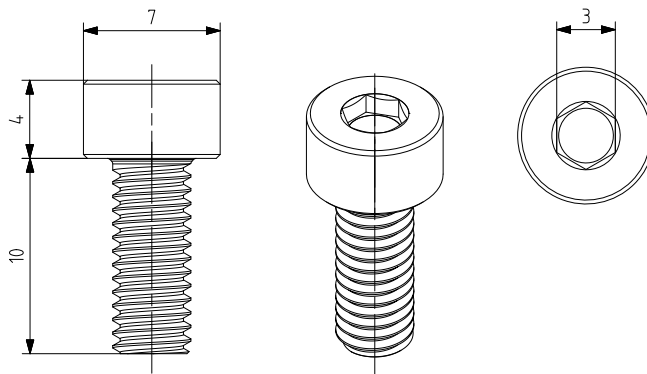


Figure 5: M4 mounting screws

Material	Stainless steel
Surface	Polished
Thread	M4 Full thread
Driver	IMBUS 3.0
Avail. lengths	6 to 40 mm

Table 4: M4 screw description

2.5 Optical path

No filter glass is added by Ximea. All windows are applied by the sensor vendor. Do not use compressed air to clean the camera as this could damage (e.g. scratch) the filter glass.

Distance from the flange to sensor is designed so that the optical distance depends on camera model (see image below).

* FDD is flange focal distance between the front flange surface and the sensor active surface.

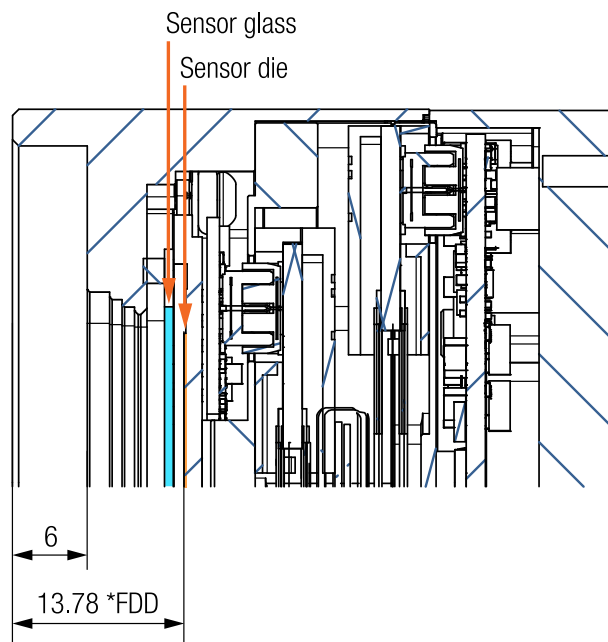


Figure 6: Optical path - cross section of MX610-FF

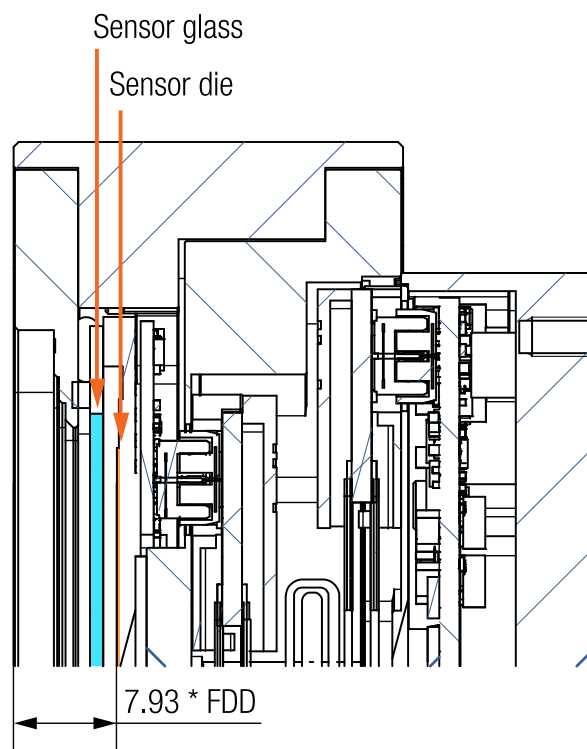


Figure 7: Optical path - cross section of MX1018-FF

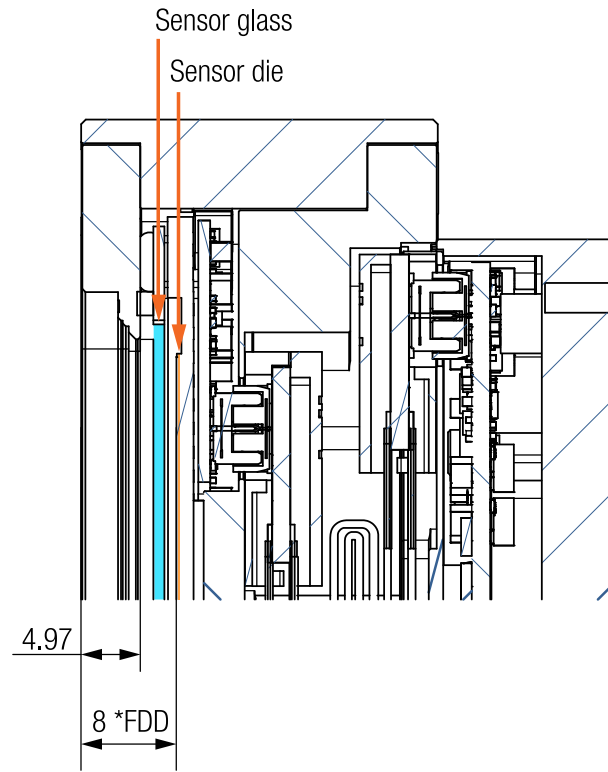


Figure 8: Optical path - cross section of MX1510-FF

2.6 Sensor and camera characteristics

2.6.1 List of used sensors and filters

Table below details which sensor models and filters are fitted to each camera model.

Camera model	Sensor model	Sensor type	Filter
MX610CR-SY-X4G3-FF	Sony IMX455	Color	BayerRG
MX610MR-SY-X4G3-FF	Sony IMX455	Monochrome	None
MX1018CR-SY-X4G3-FF	Sony IMX461	Color	BayerRG
MX1018MR-SY-X4G3-FF	Sony IMX461	Monochrome	None
MX1510CR-SY-X4G3-FF	Sony IMX411	Color	BayerRG
MX1510MR-SY-X4G3-FF	Sony IMX411	Monochrome	None

Table 5: list of camera models and their respective sensor models and filters

2.6.2 Sensor and camera parameters of particular models

Sensor and camera characteristics of models:

MX610CR-SY-X4G3-FF and MX610MR-SY-X4G3-FF

Sensor and camera parameters		
Technology	CMOS BSI	
Pixel resolution (H x V)	[px]	9568 × 6380
Active area size (H X V)	[mm]	35.98 × 23.86
Sensor diagonal	[mm]	43.17
Pixel size (H x V)	[μm]	3.76 × 3.76
Pwr. consumption	[W]	10.5
Pwr. consumption max	[W]	15.4

Table 6: sensor and camera parameters

Mode	Low noise	High dynamic range	High sat. capacity
Binning	-	1 × 1	3 × 3
Sensor bitdepth	[bit]	16	12
Paralell ADC	-	enabled	enabled
High conversion gain mode	-	enabled	disabled
Shutter type	-	rolling	rolling
Analog gain	[dB]	6	0
Parameters			
Saturation capacity	[ke.]	7.5	371.9
Dynamic range	[dB]	72.4	82
SNR _{max}	[dB]	38.7	46.6
System gain 1/K	[e./DN]	0.13	0.78
Dark noise	[e.]	1.3	3.2
Dark current @ 40 °C	[e./s]	0.6	1.2
Abs. sensitivity thresh.	[e.]	1.8	3.7
DSNU	[e.]	0.3	0.6
PRNU	[%]	1	0.7
Linearity error	[%]	0.4	0.5

Table 7: image quality parameters

Sensor and camera characteristics of models:

MX1018CR-SY-X4G3-FF and MX1018MR-SY-X4G3-FF

Sensor and camera parameters		
	Technology	CMOS BSI
Pixel resolution (H x V)	[px]	11 656 × 8742
Active area size (H X V)	[mm]	43.83 × 32.87
Sensor diagonal	[mm]	55
Pixel size (H x V)	[μm]	3.76 × 3.76
Power consumption	[W]	10.75
Power consumption max	[W]	15.6

Table 8: sensor and camera parameters

Mode		Low noise	High dynamic range	High sat. capacity
Binning	-	1 × 1	1 × 1	3 × 3
Sensor bitdepth	[bit]	16	16	12
Paralell ADC	-	enabled	enabled	enabled
High conversion gain mode	-	enabled	disabled	disabled
Shutter type	-	rolling	rolling	rolling
Analog gain	[dB]	6	0	0
Parameters				
Saturation capacity	[ke.]	7.4	46.4	361.1
Dynamic range	[dB]	72.8	82.3	76.9
SNR _{max}	[dB]	38.7	46.7	55.6
System gain 1/K	[e./DN]	7.95	0.78	97.14
Dark noise	[e.]	1.2	3.1	51
Dark current @ 40 °C	[e./s]	0.6	1.2	8.5
Abs. sensitivity thresh.	[e.]	1.7	3.6	51.5
DSNU	[e.]	0.2	0.4	5.7
PRNU	[%]	1.7	1.2	1.2
Linearity error	[%]	0.4	0.3	0.1

Table 9: image quality parameters

Sensor and camera characteristics of models:

MX1510CR-SY-X4G3-FF and MX1510MR-SY-X4G3-FF

Sensor and camera parameters		
	Technology	CMOS BSI
Pixel resolution (H x V)	[px]	14 176 × 10 640
Active area size (H X V)	[mm]	53.36 × 40.00
Sensor diagonal	[mm]	66.68
Pixel size (H x V)	[μm]	3.76 × 3.76
Pwr. consumption	[W]	10.5
Pwr. consumption max	[W]	16.0

Table 10: sensor and camera parameters

Mode		Low noise	High dynamic range	High sat. capacity
Binning	-	1 × 1	1 × 1	3 × 3
Sensor bitdepth	[bit]	16	16	12
Paralell ADC	-	enabled	enabled	enabled
High conversion gain mode	-	enabled	disabled	disabled
Shutter type	-	rolling	rolling	rolling
Analog gain	[dB]	6	0	0
Parameters				
Saturation capacity	[ke.]	7.45	45.7	369.4
Dynamic range	[dB]	72.8	81.8	76.9
SNR _{max}	[dB]	38.7	46.6	55.7
System gain 1/K	[e./DN]	7.84	0.78	98.28
Dark noise	[e.]	1.3	3.2	52.5
Dark current @ 40 °C	[e./s]	0.6	1.2	8.5
Abs. sensitivity thresh.	[e.]	1.8	3.7	53
DSNU	[e.]	0.2	0.5	5.1
PRNU	[%]	2.5	1.1	1.1
Linearity error	[%]	0.6	0.9	0.3

Table 11: image quality parameters

2.6.3 Sensor Read-out Modes

MX610CR-SY-X4G3-FF and MX610MR-SY-X4G3-FF

Parallel ADC	Shutter type	Downsampling (H x V)	Resolution (W x H)	Bits/pix	Maximum frame rate	Band.limit Mbytes/s
False	Rolling	1 x 1	9568 x 6380	12	17.9	3500.0
False	Rolling	Bin.2 x 2	4768 x 3190	12	38.5	3500.0
False	Rolling	Bin.3 x 3	3168 x 2124	12	57.5	3500.0
False	Rolling	1 x 1	9568 x 6380	14	10.0	3500.0
False	Rolling	1 x 1	9568 x 6380	16	4.0	3500.0
True	Rolling	1 x 1	9568 x 6380	12	9.4	3500.0
True	Rolling	1 x 1	9568 x 6380	14	5.0	3500.0
True	Rolling	1 x 1	9568 x 6380	16	2.0	3500.0

Table 12: sensor modes

MX1018CR-SY-X4G3-FF and MX1018MR-SY-X4G3-FF

Parallel ADC	Shutter type	Downsampling (H x V)	Resolution (W x H)	Bits/pix	Maximum frame rate	Band.limit Mbytes/s
False	Rolling	1 x 1	11648 x 8742	12	8.7	3500.0
False	Rolling	Bin.2 x 2	5824 x 4370	12	8.7	3500.0
False	Rolling	Bin.3 x 3	3872 x 2912	12	27.8	3500.0
False	Rolling	1 x 1	11648 x 8742	14	6.0	3500.0
False	Rolling	Bin.2 x 2	5824 x 4370	14	6.0	3500.0
False	Rolling	1 x 1	11648 x 8742	16	2.8	3500.0
False	Rolling	Bin.2 x 2	5824 x 4370	16	2.8	3500.0
True	Rolling	1 x 1	11648 x 8742	12	4.4	3500.0
True	Rolling	1 x 1	11648 x 8742	14	3.0	3500.0
True	Rolling	1 x 1	11648 x 8742	16	1.4	3500.0

Table 13: sensor modes

MX1510CR-SY-X4G3-FF and MX1510MR-SY-X4G3-FF

Parallel ADC	Shutter type	Downsampling (H x V)	Resolution (W x H)	Bits/pix	Maximum frame rate	Band.limit Mbytes/s
False	Rolling	1 x 1	14176 x 10640	12	6.2	3500.0
False	Rolling	Bin.2 x 2	7072 x 5320	12	7.0	3500.0
False	Rolling	Bin.3 x 3	4704 x 3544	12	20.8	3500.0
False	Rolling	1 x 1	14176 x 10640	14	4.6	3500.0
False	Rolling	Bin.2 x 2	7072 x 5320	14	4.6	3500.0
False	Rolling	1 x 1	14176 x 10640	16	2.0	3500.0
False	Rolling	Bin.2 x 2	7072 x 5320	16	2.0	3500.0
True	Rolling	1 x 1	14176 x 10640	12	3.1	3500.0
True	Rolling	1 x 1	14176 x 10640	14	2.3	3500.0
True	Rolling	1 x 1	14176 x 10640	16	1.0	3500.0

Table 14: sensor modes

2.6.4 Quantum efficiency curves

Quantum efficiency curves for models:

MX610CR-SY-X4G3-FF and MX610MR-SY-X4G3-FF

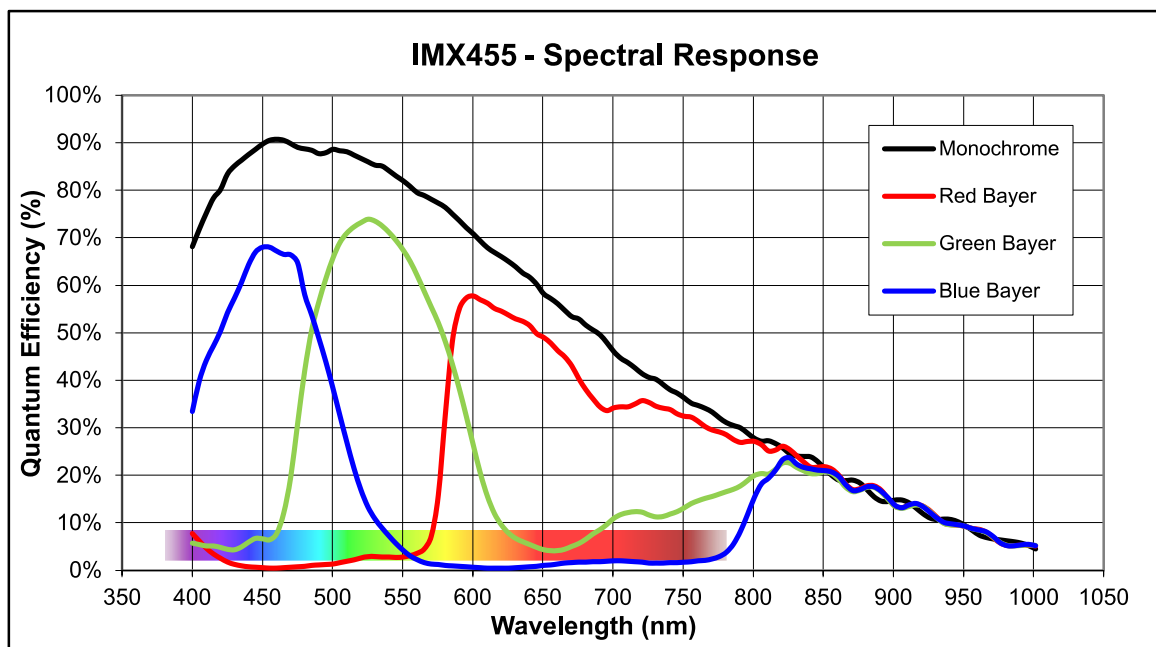


Figure 9: quantum efficiency curves of MX610CR-SY-X4G3-FF

Quantum efficiency curves for models:

MX1018CR-SY-X4G3-FF and MX1018MR-SY-X4G3-FF

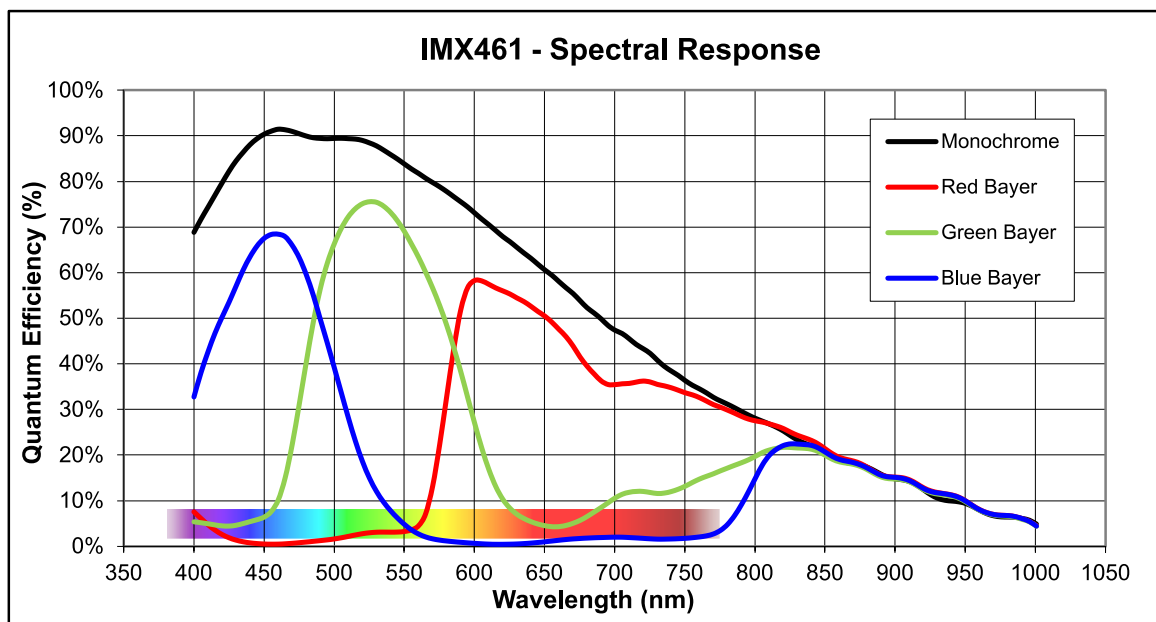


Figure 10: quantum efficiency curves of MX1018CR-SY-X4G3-FF

Quantum efficiency curves for models:

MX1510CR-SY-X4G3-FF and MX1510MR-SY-X4G3-FF

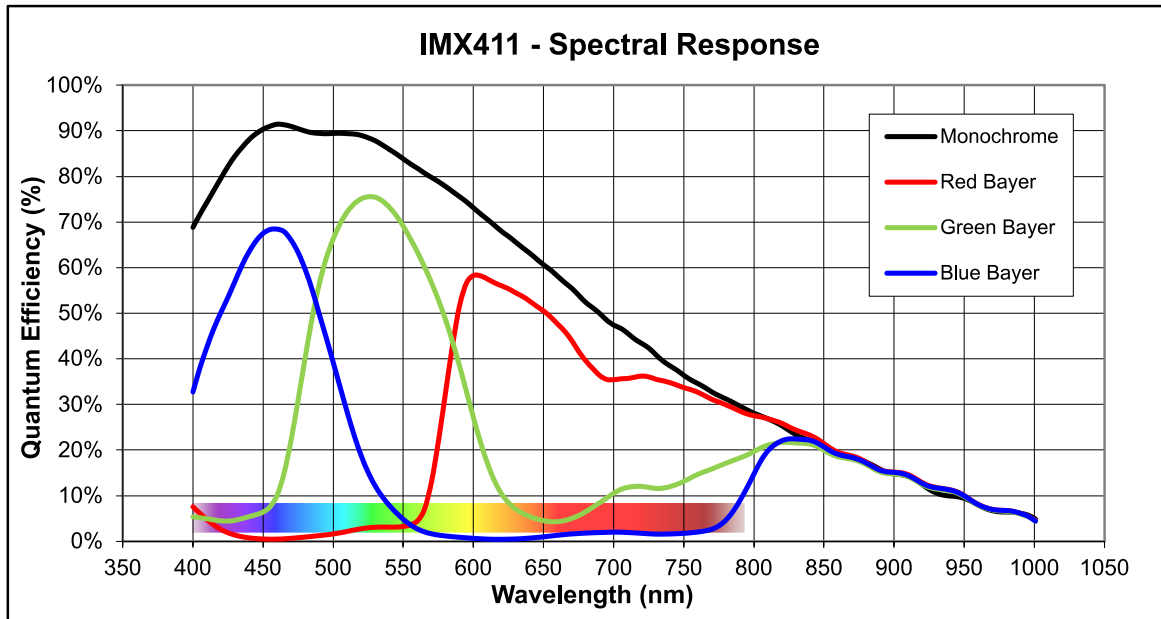


Figure 11: quantum efficiency curves of MX1510CR-SY-X4G3-FF

2.7 Mechanical characteristics

2.7.1 Dimensions and mass

Dimensions and mass for models:

MX610CR-SY-X4G3-FF and MX610MR-SY-X4G3-FF

Width [W]	Height [H]	Depth ¹ [D]	Mass ¹ [M]
70 mm	60 mm	48.6 mm	345 g

¹without adapters

Table 15: camera parameters

Dimensions and mass for models:

MX1018CR-SY-X4G3-FF and MX1018MR-SY-X4G3-FF

Width [W]	Height [H]	Depth ¹ [D]	Mass ¹ [M]
80 mm	80 mm	45.1 mm	490 g

¹without adapters

Table 16: camera parameters

Dimensions and mass for models:

MX1510CR-SY-X4G3-FF and MX1510MR-SY-X4G3-FF

Width [W]	Height [H]	Depth ¹ [D]	Mass ¹ [M]
80 mm	80 mm	45.1 mm	455 g

¹without adapters

Table 17: camera parameters

2.7.2 Dimensional drawings

Dimensional drawings for models:

MX610CR-SY-X4G3-FF

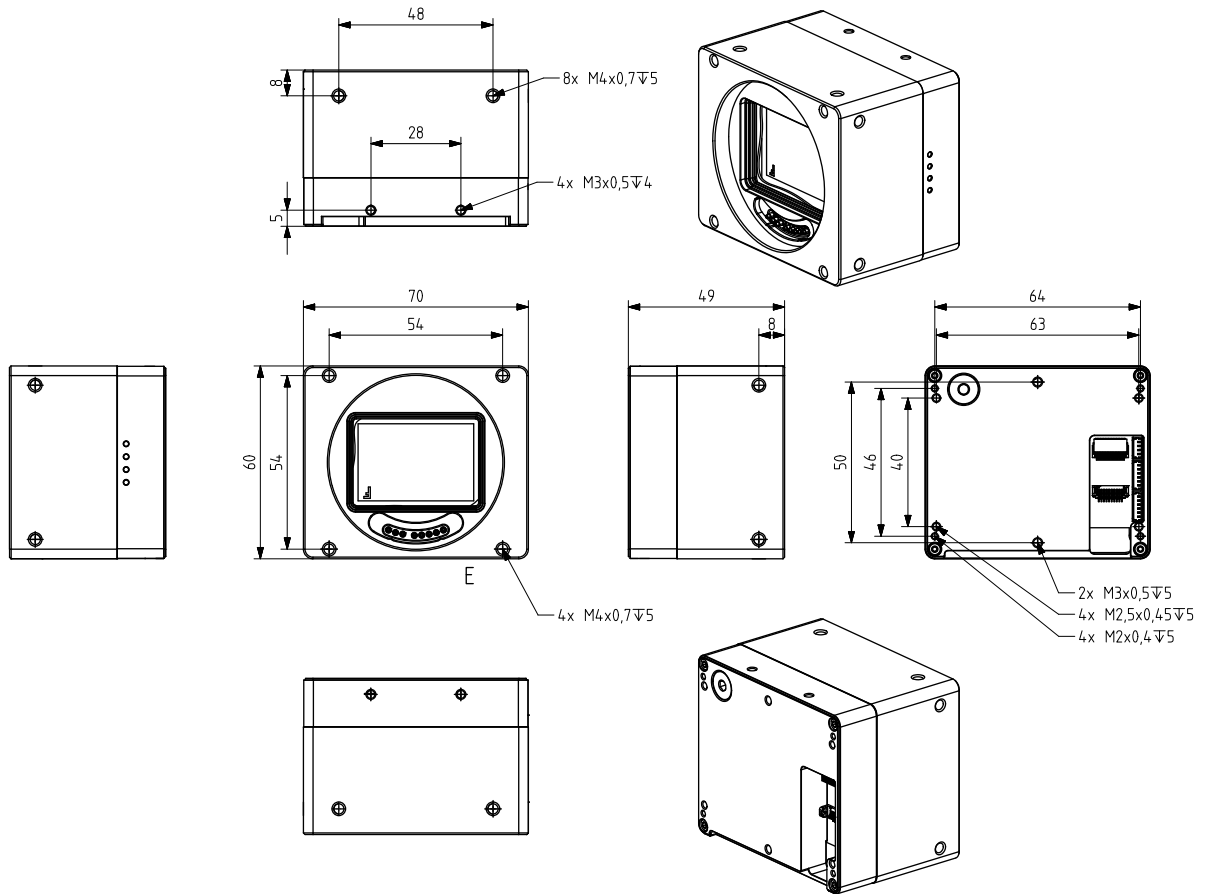


Figure 12: MX610xR-SY-X4G3-FF dimensional drawings

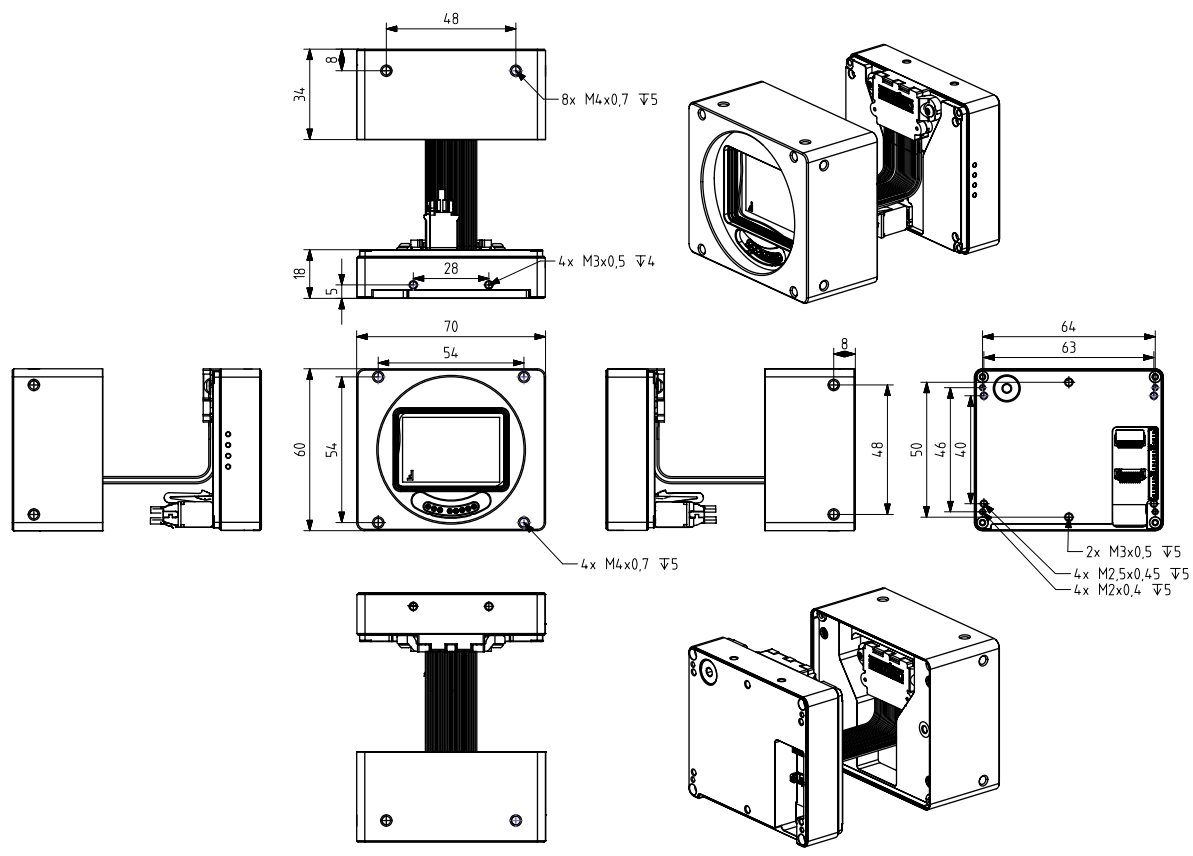


Figure 13: MX610xR-SY-X4G3-FF with detached sensor sub-assembly

Dimensional drawings for models:

MX610MR-SY-X4G3-FF

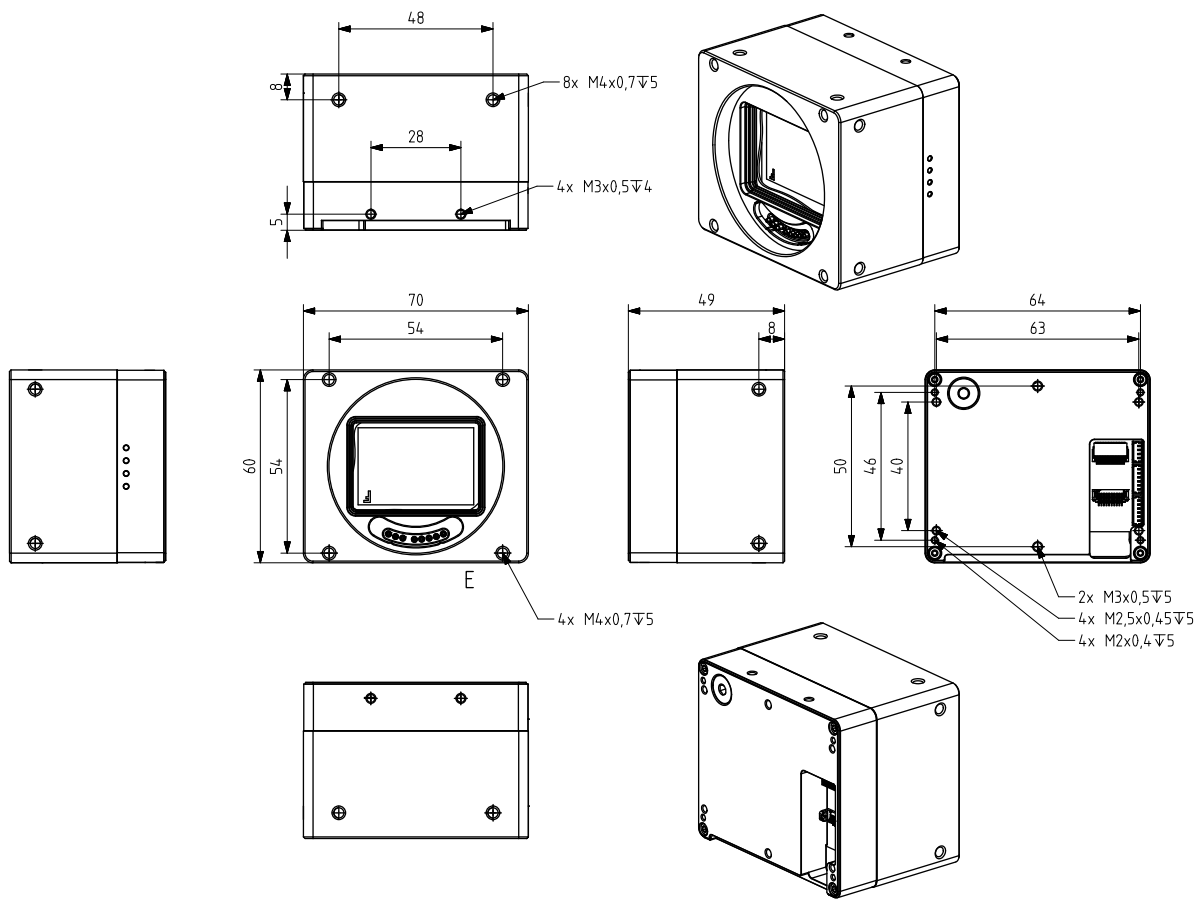


Figure 14: MX610xR-SY-X4G3-FF dimensional drawings

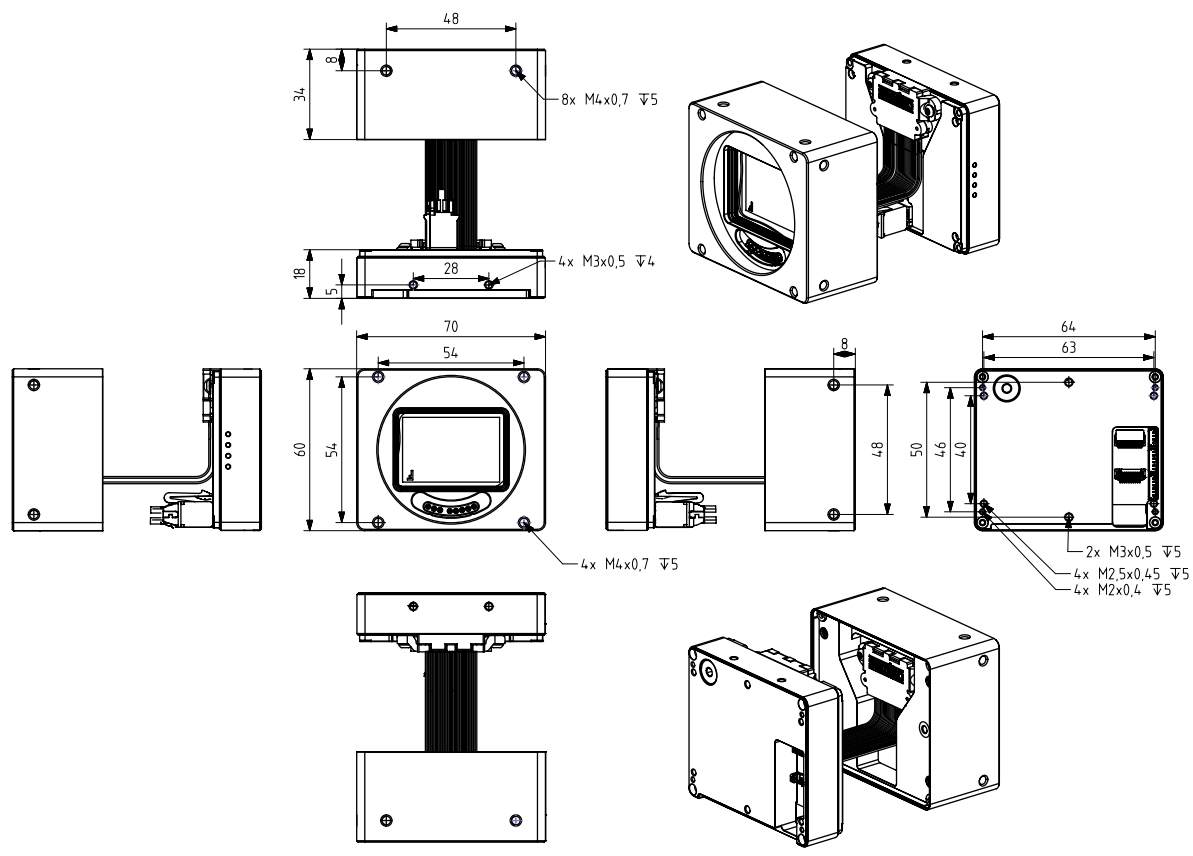


Figure 15: MX610xR-SY-X4G3-FF with detached sensor sub-assembly

Dimensional drawings for models:

MX1018CR-SY-X4G3-FF

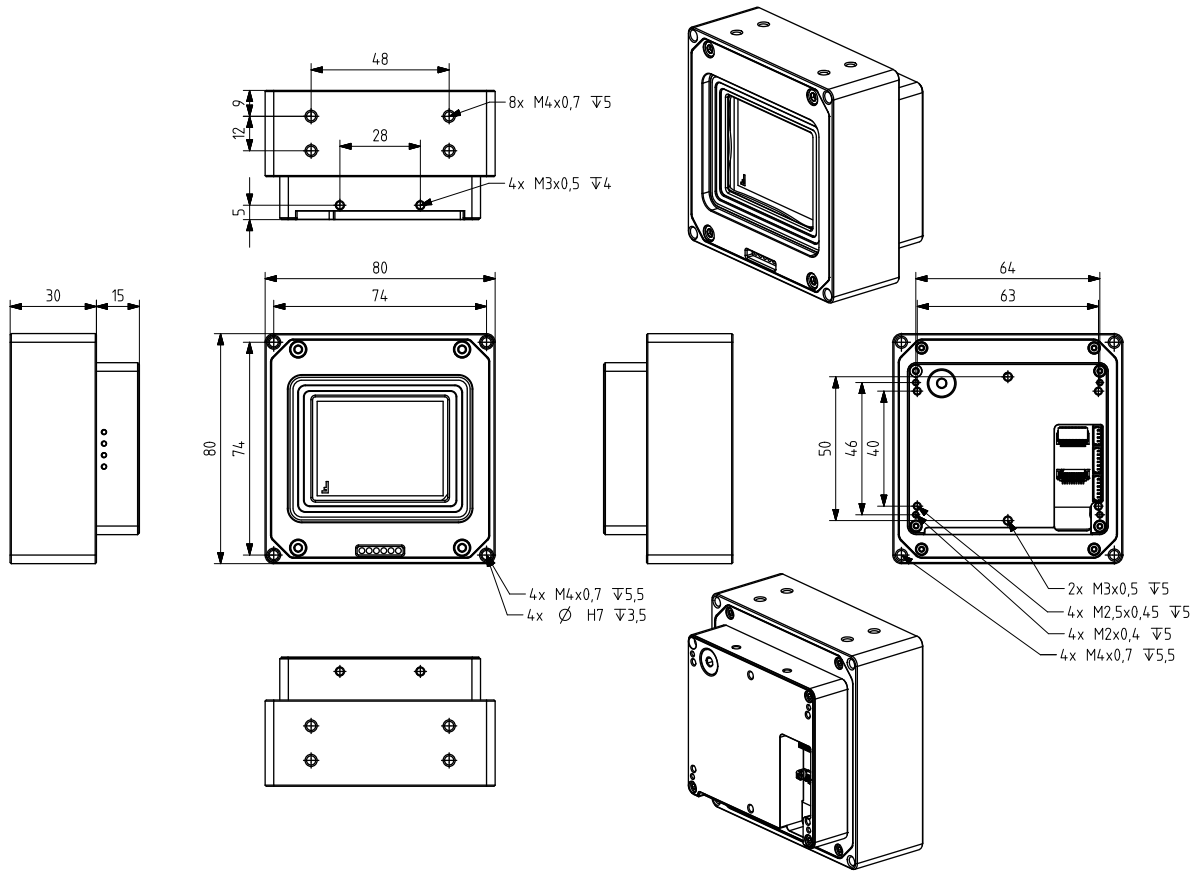


Figure 16: MX1018xR-SY-X4G3-FF dimensional drawings

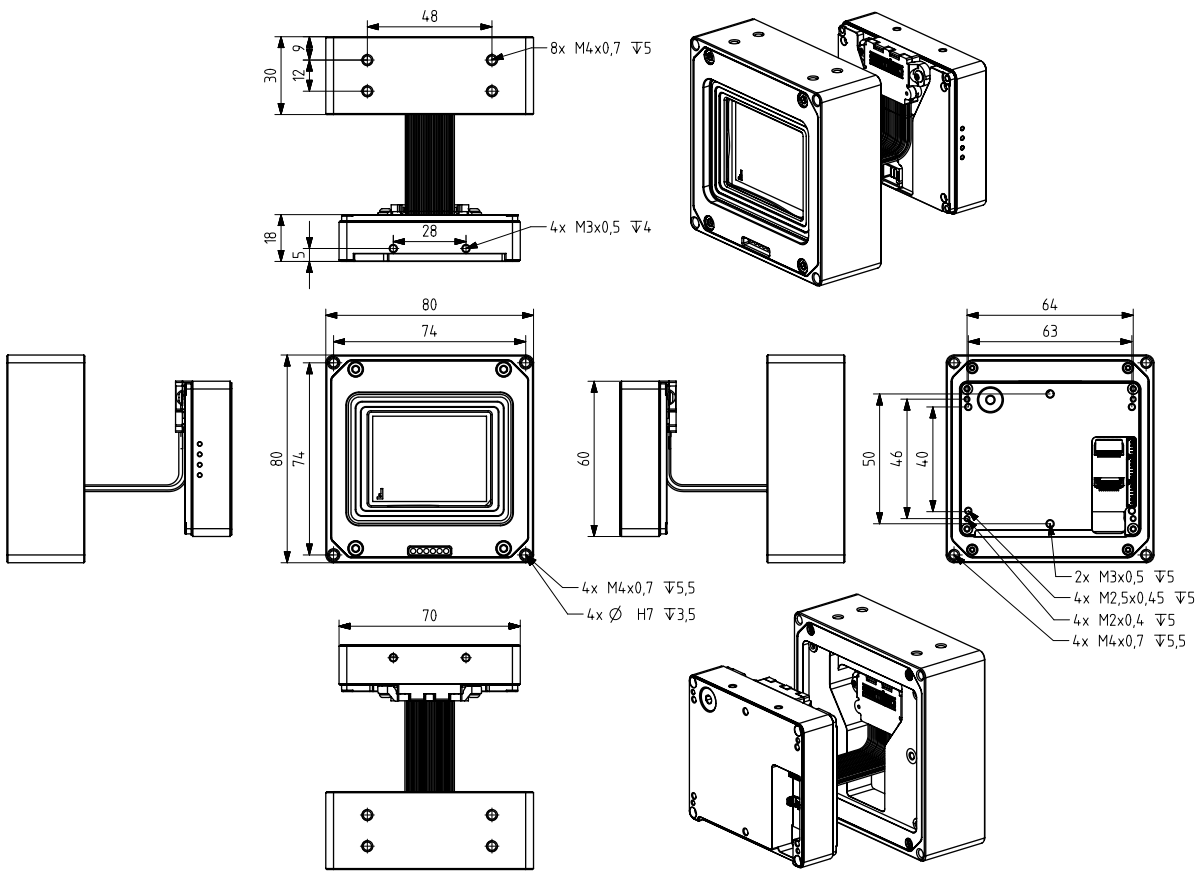


Figure 17: MX1018xR-SY-X4G3-FF with detached sensor sub-assembly

Dimensional drawings for models:

MX1018MR-SY-X4G3-FF

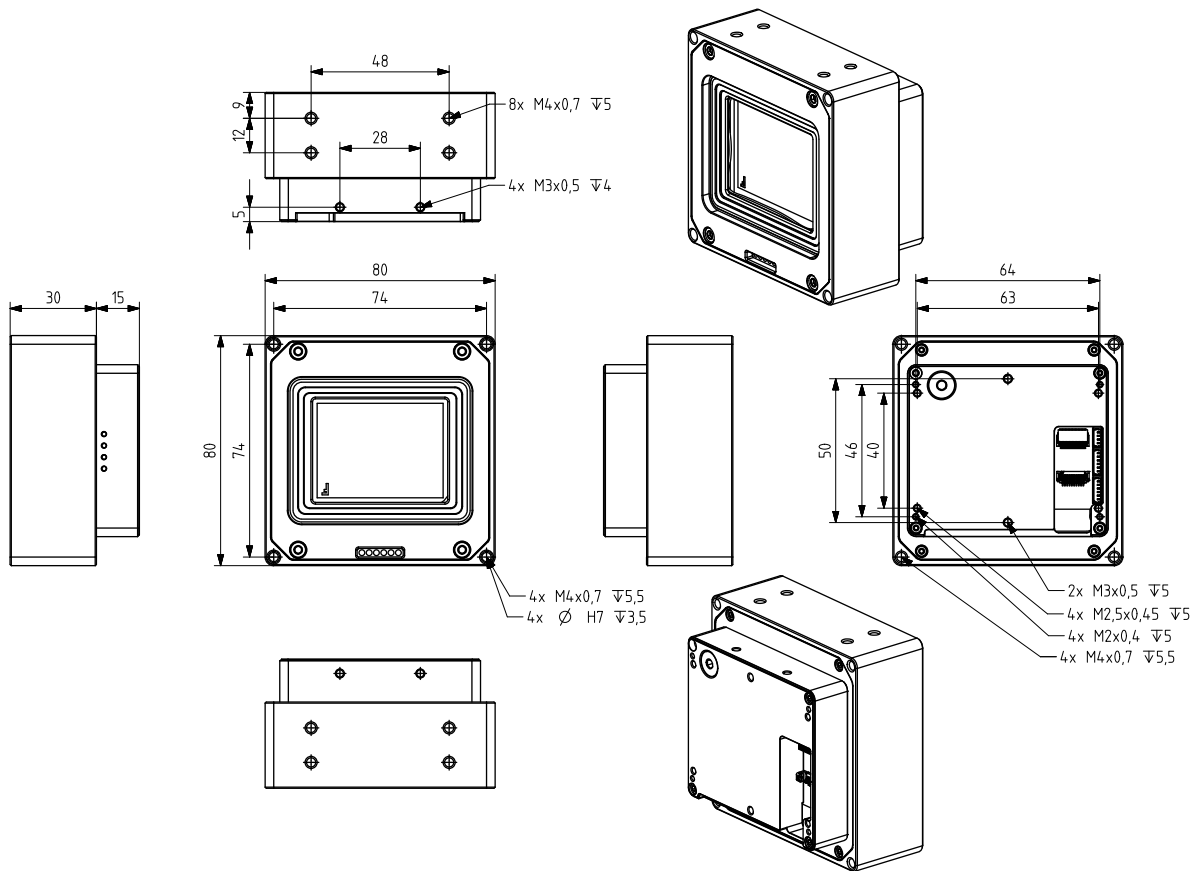


Figure 18: MX1018xR-SY-X4G3-FF dimensional drawings

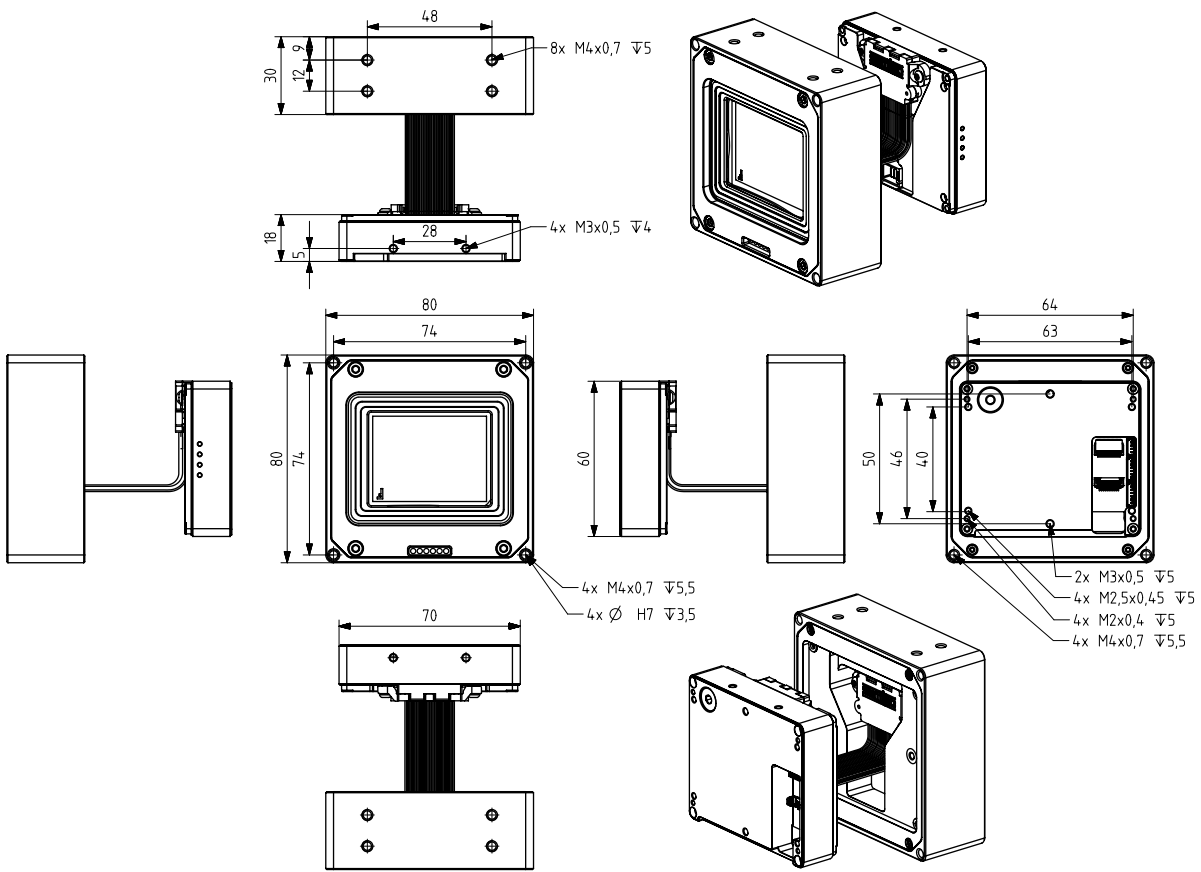


Figure 19: MX1018xR-SY-X4G3-FF with detached sensor sub-assembly

Dimensional drawings for models:

MX1510CR-SY-X4G3-FF

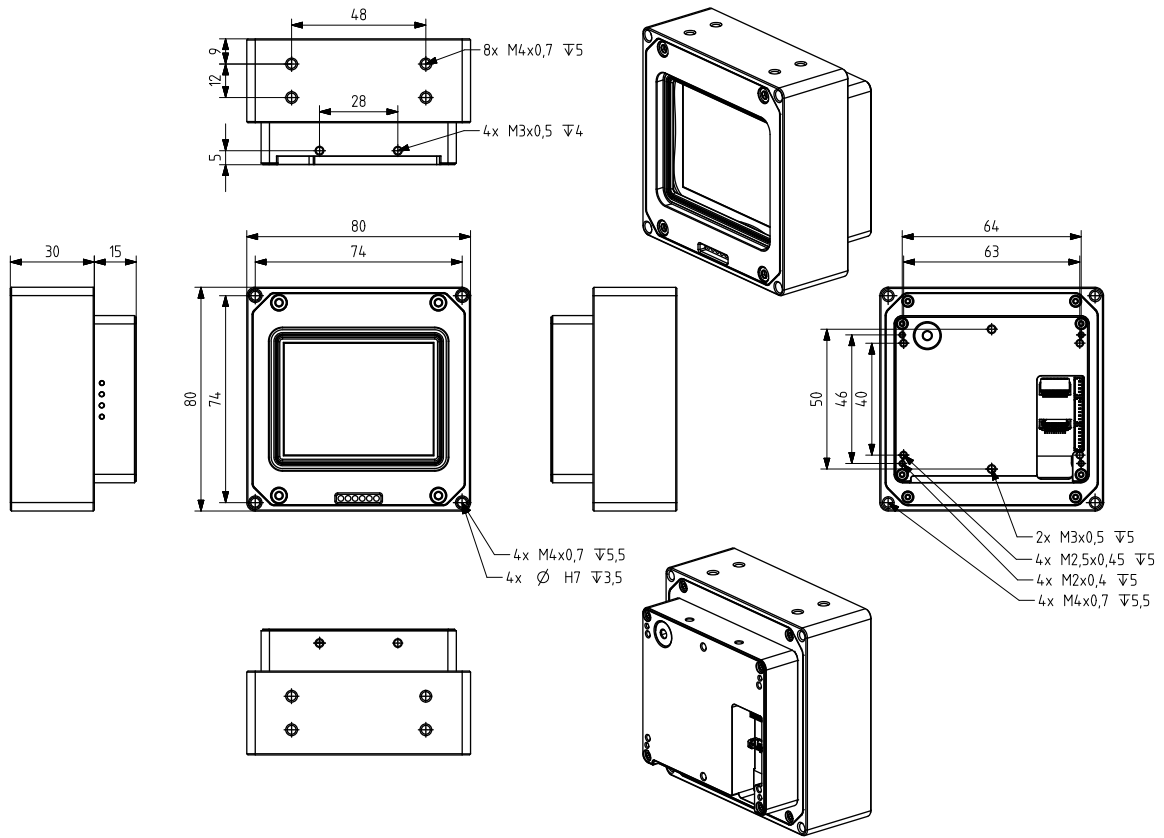


Figure 20: MX1510xR-SY-X4G3-FF dimensional drawings

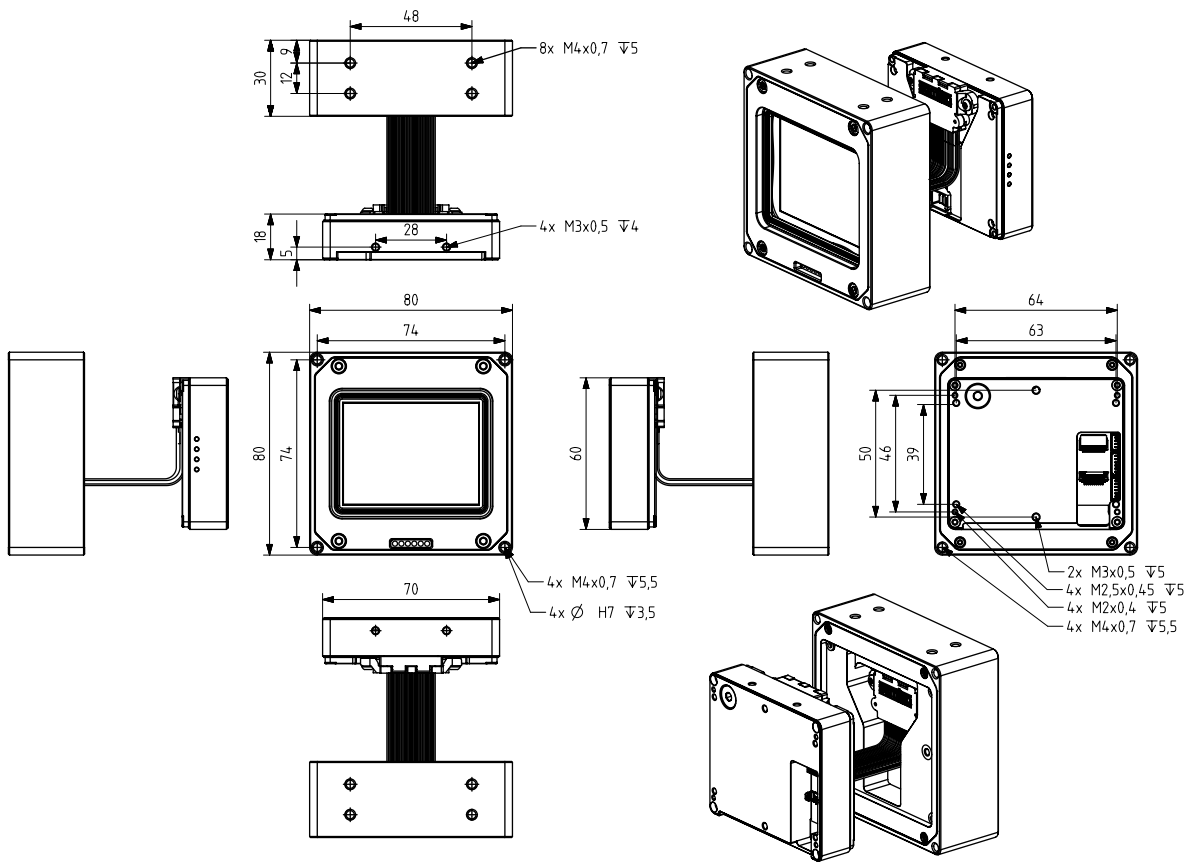


Figure 21: MX1510xR-SY-X4G3-FF with detached sensor sub-assembly

Dimensional drawings for models:

MX1510MR-SY-X4G3-FF

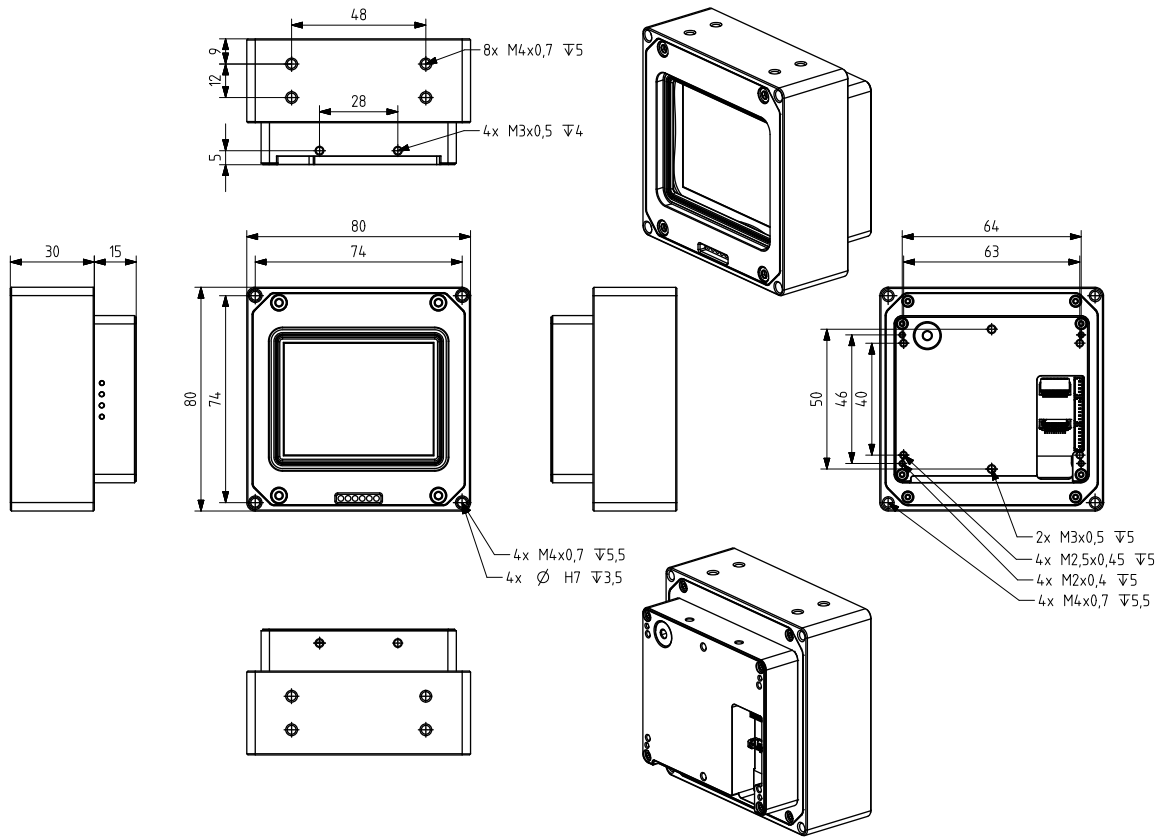


Figure 22: MX1510xR-SY-X4G3-FF dimensional drawings

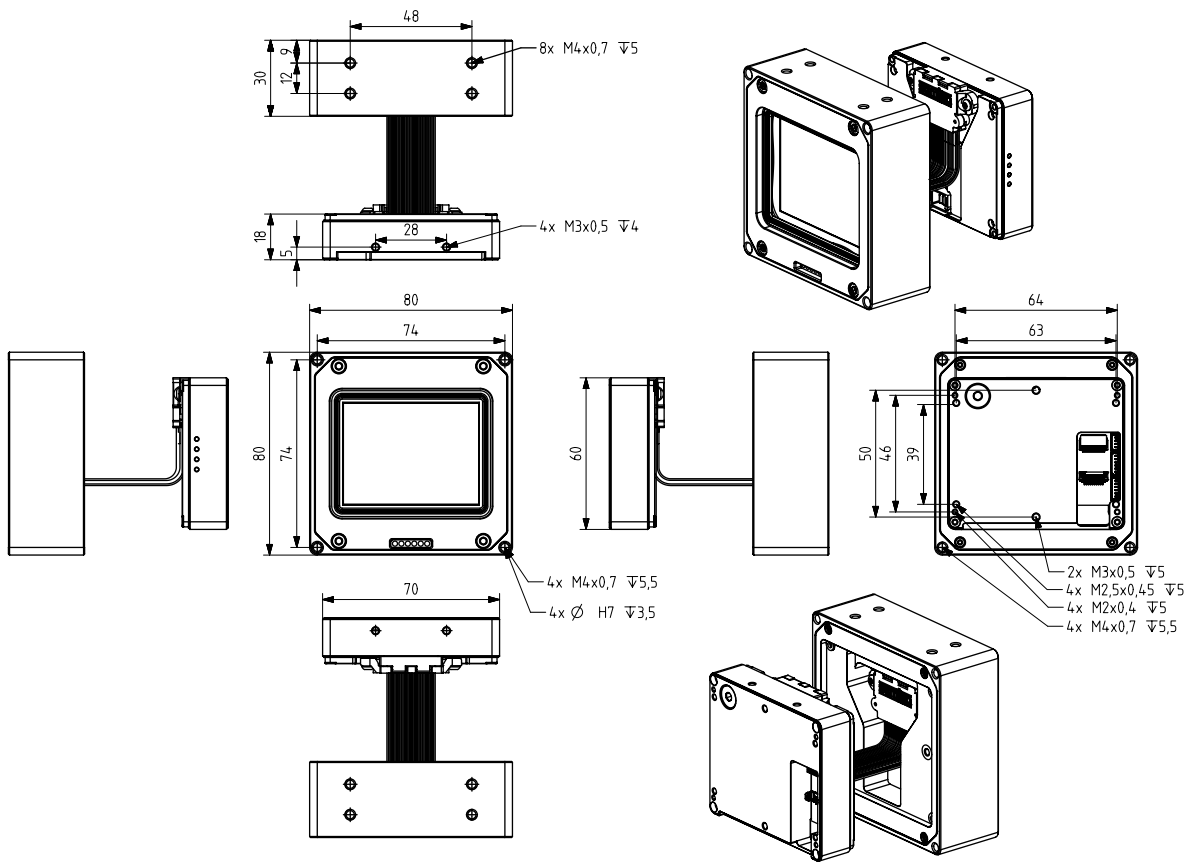


Figure 23: MX1510xR-SY-X4G3-FF with detached sensor sub-assembly

2.8 User interface – LEDs

LED	Color	Defaults	Note
1	Green	PCIe Lanes	User configurable
2	Red	PCIe Clock Present	User configurable
3	Blue	PCIe Clock Present	User configurable
4	Orange	PCIe Link Speed	User configurable

Table 18: LED output description during camera power up

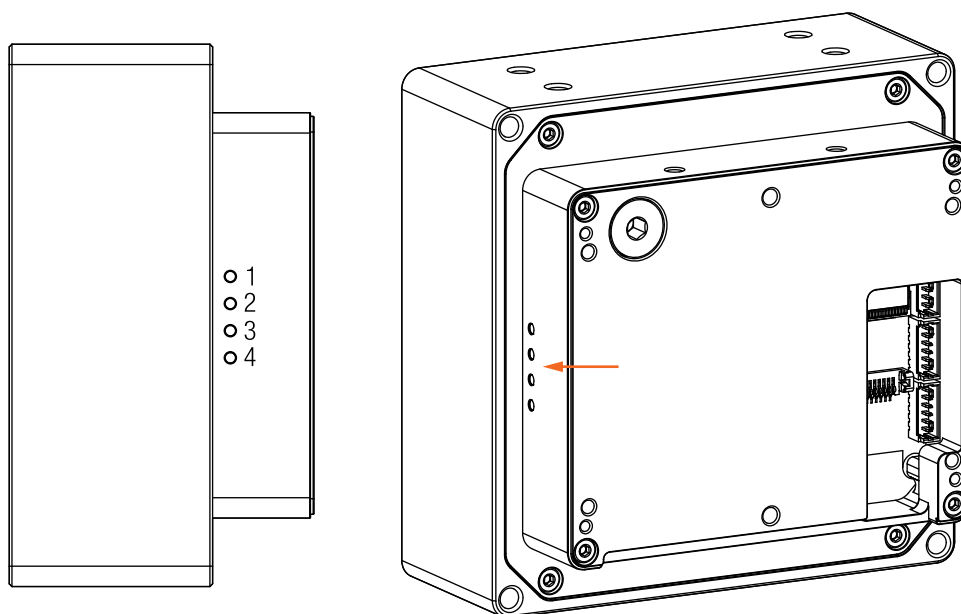


Figure 24: LEDs position

LED statuses during boot sequence

Status	LED 1	LED 2	LED 3	LED 4
Off	Off	Off	Off	Off
Power	On	Off	Off	Off
Camera booted, no PCIe connection	Off	Off	On	On
Recovery firmware loaded ¹	flash	flash	flash	flash
PCIe connected X4 Gen3	On	flash	flash	On
PCIe connected (X2 or X1) Gen3	flash	flash	flash	On

¹To identify, if the recovery firmware is loaded, please start xiCOP. See [XIMEA control panel](#)

Table 19: LED output description during camera power up

2.9 Camera interface

NOTE: It is important that the power is turned off when inserting/detaching the cable. General **ESD** precautions need to be applied. Failing this requirement may lead to camera damage.

2.9.1 PCIe / FireFly interface

The interface connector is used for data transmission, camera control, power and IO (see section **Digital inputs / outputs (GPIO) interface** for connector pinout description).

Note: It is important that the power is turned off when inserting/detaching the cable. Connecting camera to powered host can cause destruction of camera. For cameras with ADPT-MX-X4G3-FF-X4G3-MTP and ADPT-MX-X4G3-FF-X4G3-SFF adapters please refer to section **ADPT-MX-X4G3-FF-X4G3-SFF** and **ADPT-MX-X4G3-FF-X4G3-MTP**

Item	Value
Connector	Samtec (UEC5-019-1-H-D-RA-1-A + UCC8-010-1-H-S-1-A)
Signals	PCIe 4 Gen3; Power input; Optoisolated IO
Mating Connectors	Samtec ECUE, PCUO

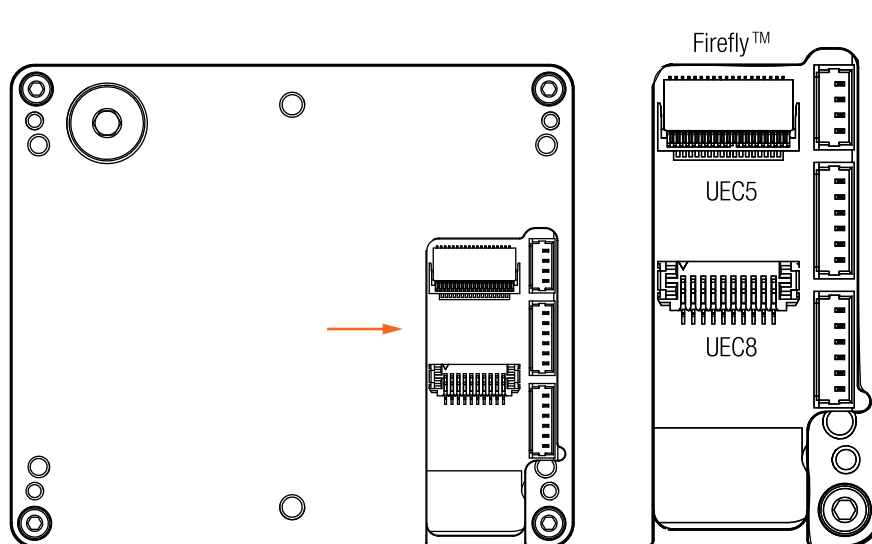


Figure 25: xiX-X4G3-FF connector location

This section is usable for these cameras: MX1510CR-SY-X4G3-FF, MX1018CR-SY-X4G3-FF, MX610CR-SY-X4G3-FF, MX610MR-SY-X4G3-FF, MX1018MR-SY-X4G3-FF and MX1510MR-SY-X4G3-FF.

2.10 Digital inputs / outputs (GPIO) interface

GPIO interface for models:

MX1510CR-SY-X4G3-FF, MX1018CR-SY-X4G3-FF, MX610CR-SY-X4G3-FF, MX610MR-SY-X4G3-FF, MX1018MR-SY-X4G3-FF and MX1510MR-SY-X4G3-FF

Item	Value
Connector	Samtec (UEC5-019-1-H-D-RA-1-A + UCC8-010-1-H-S-1-A)
Signals	PCIe 4 Gen3; Power input; Optoisolated IO
Mating Connectors	Samtec ECUE, PCUO

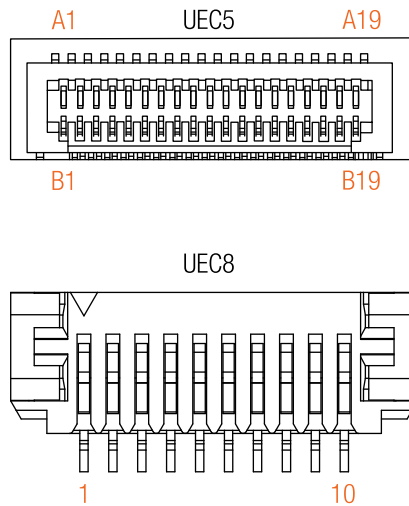


Figure 26: FireFly connector pinning

Pinout FireFly UCC8 connector

Pin	Name	GPI/GPO index API	Type
1	VCC_TX	None	Power output
2	GND	None	Ground
3	NC	None	None
4	NC	None	None
5	PCIe_RST0_N_IN	None	PCIe reset
6	NC	None	None
7	NC	None	None
8	NC	None	None
9	OUT1	-/1	Optically isolated Digital Output (OUT)
10	VCC_RX	None	Power output

Pin	Name	GPI/GPO index API	Type
A1	GND	None	Signal and power ground
A2	PCle_PETN_2	None	PCle TX differential pair 2
A3	PCle_PETP_2	None	PCle TX differential pair 2
A4	GND	None	Signal
A5	PCle_PETN_1	None	PCle TX differential pair 1
A6	PCle_PETP_1	None	PCle TX differential pair 1
A7	GND	None	Signal and power ground
A8	IN1	1/-	Optically isolated Digital Input (IN)
A9	IN1_GND	None	Ground for opto-isolated Input 1
A10	GND	None	Signal and power ground
A11	PCle_RSTO_N_IN	None	PCle reset
A12	NC	None	None
A13	GND	None	Signal and power ground
A14	PCle_PERP_2	None	PCle RX differential pair 2
A15	PCle_PERN_2	None	PCle RX differential pair 2
A16	GND	None	Signal and power ground
A17	PCle_PERP_1	None	PCle RX differential pair 1
A18	PCle_PERN_1	None	PCle RX differential pair 1
A19	GND	None	Signal and power ground
B1	GND	None	Signal and power ground
B2	PCle_PETN_3	None	PCle TX differential pair 3
B3	PCle_PETP_3	None	PCle TX differential pair 3
B4	GND	None	Signal and power ground
B5	PCle_PETN_0	None	PCle TX differential pair 0
B6	PCle_PETP_0	None	PCle TX differential pair 0
B7	GND	None	Signal and power ground
B8	OUT1	-/1	Optically isolated Digital Output (OUT)
B9	OUT1_GND	None	Ground for opto-isolated Output 1
B10	GND	None	Signal and power ground
B11	PWR	None	Power input
B12	PWR	None	Power input
B13	GND	None	Signal and power ground
B14	PCle_PERN_3	None	PCle RX differential pair 3
B15	PCle_PERP_3	None	PCle RX differential pair 3
B16	GND	None	Signal and power ground
B17	PCle_PERN_0	None	PCle RX differential pair 0
B18	PCle_PERP_0	None	PCle RX differential pair 0
B19	GND	None	Signal and power ground

Connector	Signals	Mating Connectors
4 pin Pico Blade	AUX power input	Molex 0510210400
6 pin Pico Blade	Optically isolated IO	Molex 0510210600
6 pin Pico Blade	Non isolated IO	Molex 0510210600

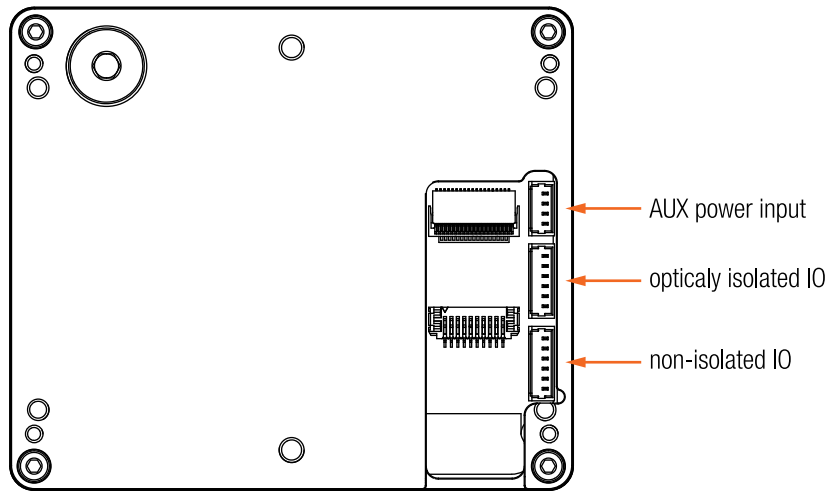


Figure 27: xiX-X4G3-FF IO connector location

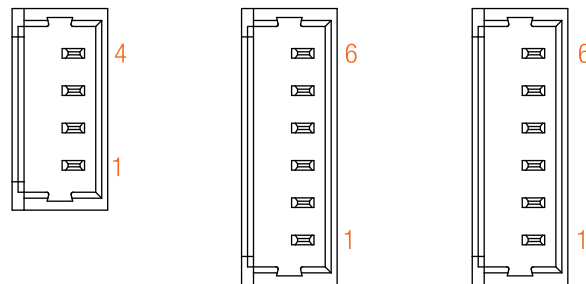


Figure 28: xiX-X4G3-FF IO connector pinning

AUX power input pin assignment

Pin	Name	Signal
1	GND	Power ground
2	PWR_IN	Power input
3	PWR_IN	Power input
4	GND	Power ground

Optically isolated IO pin assignment

Pin	Name	GPI/GPO index API	Signal
1	IN1	1/-	Optically isolated Digital Input (IN)
2	IN_GND	None	Common pole for optically isolated inputs
3	IN2	2/-	Optically isolated Digital Input (IN)
4	OUT1	-/1	Optically isolated Digital Output (OUT)
5	OUT_GND	None	Common pole for optically isolated outputs
6	OUT2	-/2	Optically isolated Digital Output (OUT)

Non-isolated IO pin assignment

Pin	Name	GPI/GPO index API	Signal
1	INOUT1	3/3	Non-isolated digital lines - Digital Input-Output (INOUT)
2	GND	None	Common pole for non-isolated IO (same as power GND)
3	INOUT2	4/4	Non-isolated digital lines - Digital Input-Output (INOUT)
4	INOUT3	5/5	Non-isolated digital lines - Digital Input-Output (INOUT)
5	GND	None	Common pole for non-isolated IO (same as power GND)
6	INOUT4	6/6	Non-isolated digital lines - Digital Input-Output (INOUT)

2.10.1 Optically isolated digital inputs

General info

Item	Parameter / Note
Maximal input voltage	24 V DC
Common pole	Yes, IN GND
Effect of incorrect input terminal connection	Reverse voltage polarity protected
Effects when withdrawing/inserting input module under power	No damage, no lost data
Maximal recommended cable length	10 m
Input level for logical 0	Voltage < 1.2 V / current 0.3 mA
Input level for logical 1	Voltage < 3.3 V / current 1 mA
Input debounce filter	No / Current > 1 mA
Input delay - rising edge	0.1 μ s ($V_{INPUT} = 10$ V, $T_{AMBIENT} = 25$ °C)
Input delay - falling edge	5 μ s ($V_{INPUT} = 10$ V, $T_{AMBIENT} = 25$ °C)
External trigger mapping	Yes
Input functions	Trigger - rising or falling edge are supported for trigger

Table 20: optically isolated digital input, general info

Digital input – Internal schematic

The internal scheme of Digital Input signal flow inside the camera is below.

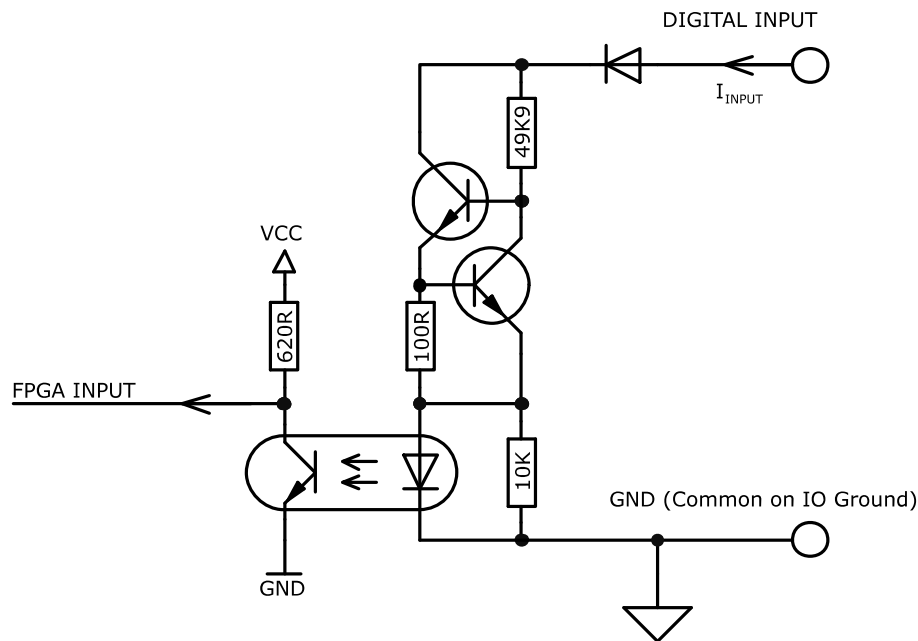


Figure 29: digital input, interface schematic

Digital input – Wiring

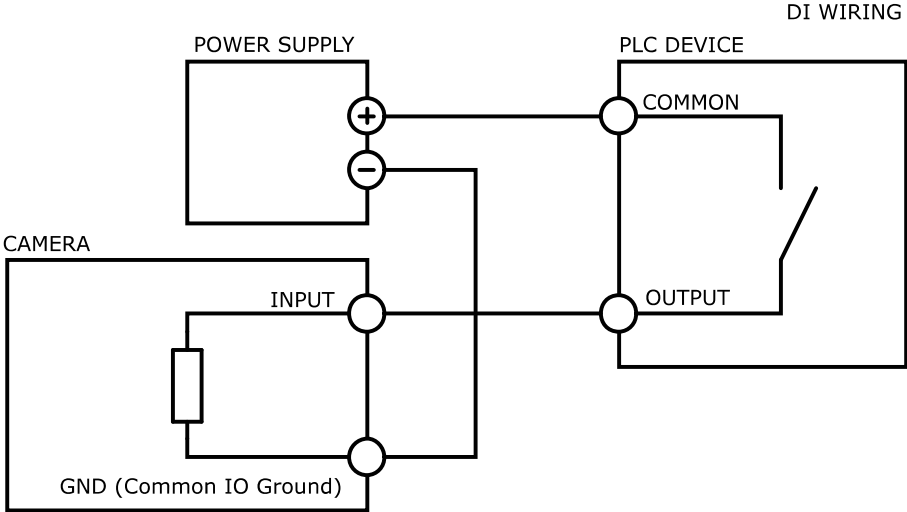


Figure 30: digital input, interface wiring

2.10.2 Optically isolated digital outputs

General info

Item	Parameter / Note
Maximal open circuit voltage	24 V DC
Output port type	Open collector NPN
Common pole	Yes, OUT GND
Protection	Short-circuit / over-current / reverse voltage
Protection circuit	PTC resettable fuse
Maximal sink current	36 mA
Trip current	71 mA, self-restarting when failure mode current disconnected
Inductive loads	False
Effect of incorrect output terminal connection	Protected against reverse voltage connection
Maximal output dropout	1 V sink current 25 mA
Output delay - ON -> OFF	14.4 μ s, $V_{PULL-UP} = 12$ V $R_{PULL-UP} = 5$ k, $T_{AMBIENT} = 25$ °C
Output delay - OFF -> ON	2.68 μ s, $V_{PULL-UP} = 12$ V $R_{PULL-UP} = 5$ k, $T_{AMBIENT} = 25$ °C
Number of outputs	1
Strobe output mapping	Yes

Table 21: optically isolated digital output, general info

Optically isolated digital output – Internal schematic

Following scheme is the internal scheme of the Digital Output signal flow inside the camera.

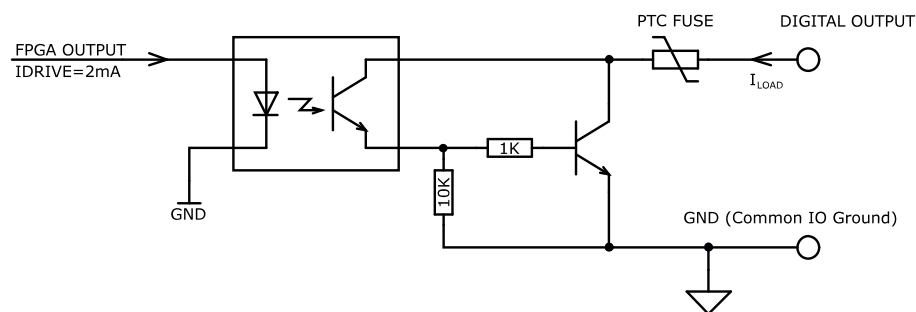


Figure 31: digital output, interface schematic

Digital output – Wiring

Digital output has an open collector switching transistor with common IO Ground. In most cases a power source for external device must be provided.

Connecting digital output to an NPN-compatible PLC device input (biased)

Output state	Output switch state	Input state
ON	Sourcing current	Pull up (energized)
OFF	Relaxing	Not energized

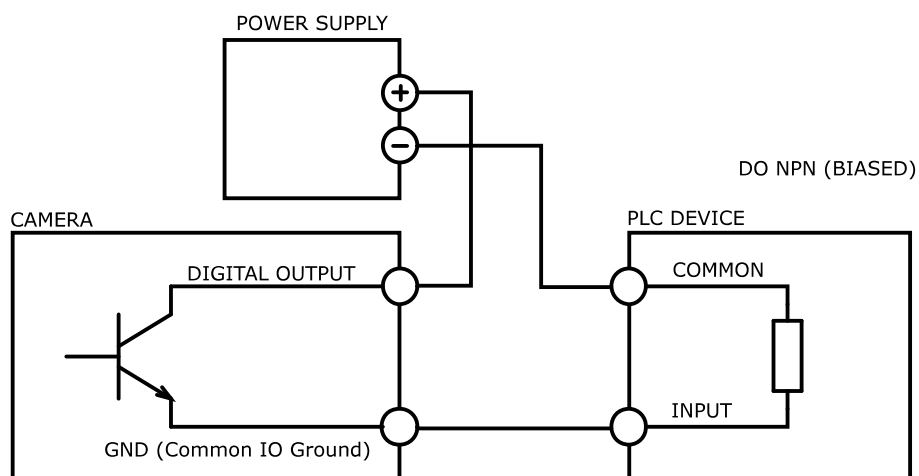


Figure 32: connecting digital output to a NPN-compatible PLC device input (biased)

Note: If using this configuration, take into account that Common Ground connection may be biased by power supply for Digital Input!

Connecting digital output to an NPN-compatible PLC device input

This type of connection is possible only when opto-isolated input is used (bidirectional in some cases) or when only one general opto-isolated input is used.

Output state	Output switch state	Input state
ON	Sourcing current	Pull down (energized)
OFF	Relaxing	Not energized

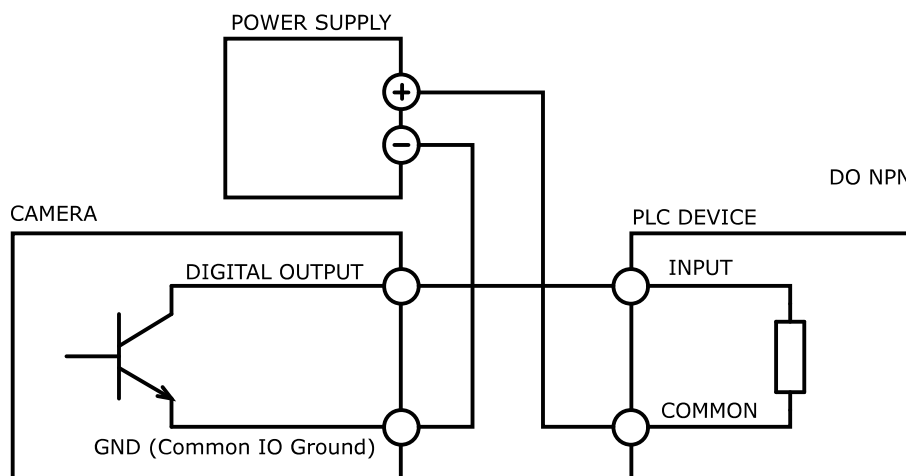


Figure 33: connecting digital output to a NPN-compatible PLC device input - more bidirectional inputs

Note: In this case a bidirectional opto-isolated input must be used.

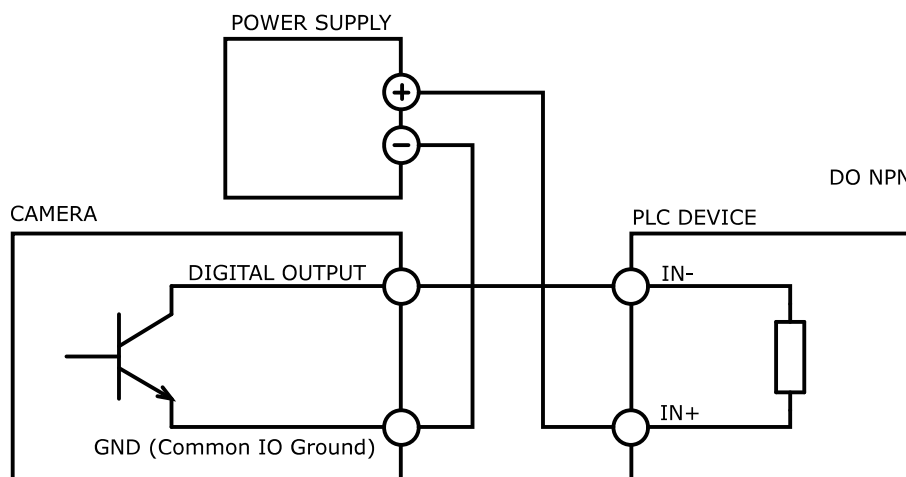


Figure 34: connecting digital output to a NPN-compatible PLC device input - single input

Connecting digital output to a PNP-compatible device

Output state	Output switch state	Input state
ON	Sinking current	Not energized
OFF	Relaxing	Pull up (energized)

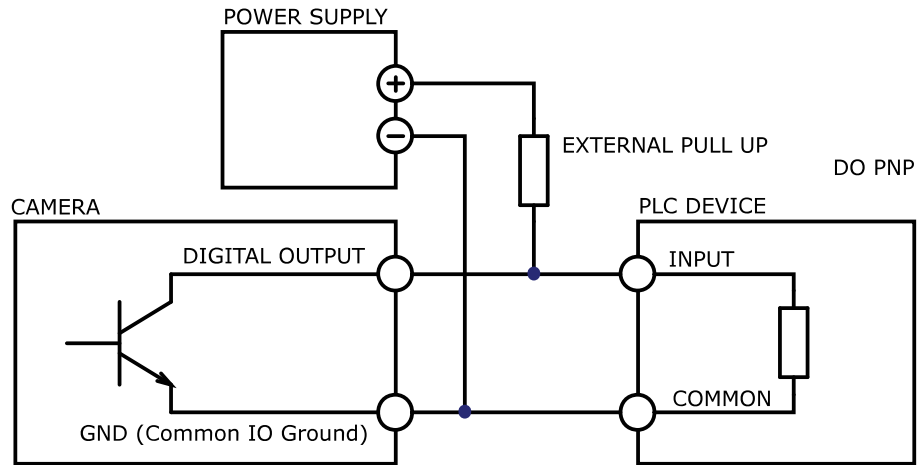


Figure 35: connecting digital output to a PNP-compatible device

Pull up resistor can be calculated as follows:

$$R = \frac{V_{PSU} - V_{input}}{I_{input}},$$

where:

V_{PSU} is power supply voltage. Must be higher than required input amplitude,

V_{input} is required input amplitude,

I_{input} is input driving current (corresponding to input amplitude).

Remember to use the appropriate resistor power rating:

$$P(R) > (V_{PSU} - V_{output}) \times I_{input}$$

Output wiring example: LED Driving

LED can be driven directly by camera digital output. A series resistor must be used to limit LED current.

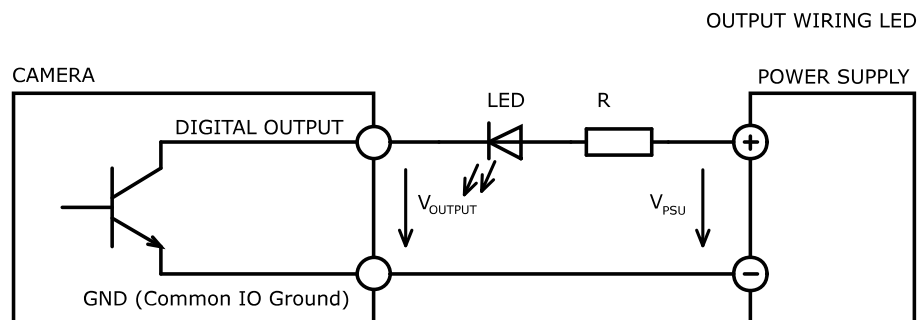


Figure 36: LED driving

LED series resistor can be calculated by the following equation:

$$R = \frac{V_{PSU} - V_{output} - V_{LED}}{I_{LED}}$$

where:

V_{PSU} is power supply voltage (5 V to 24 V),

V_{output} is voltage across digital output pins (see. [Optically isolated digital outputs](#)),

V_{LED} is LED forward voltage (see table below),

I_{LED} is LED current.

Remember to use the appropriate resistor power rating:

$$P(RES) = I_{LED}^2 \times R = (V_{PSU} - V_{LED}) \times I_{LED}$$

Typical LED forward voltage:

LED Colour	V_{LED} (typ.)	V_{LED} (max.)	Note
Standard Red	1.7 V	2.1 V	-
Super Bright Red	1.85 V	2.5 V	-
Low power Red	1.7 V	2.0 V	-
Orange	2.0 V	2.1 V	-
Yellow	2.1 V	2.2 V	-
Green	1.9 V	2.5 V	-
Emerald Green	2.1 V	2.7 V	-
Blue	2.5 V	3.7 V	-
White	2.8 V	3.8 V	-
Infra-Red	1.3 V	1.8 V	Opto coupler

Table 22: digital output, LED driving

Output wiring example: Inductive load (Relay) driving

Do not connect inductive load RL directly to camera digital output. A transistor must be used to prevent damage of the output. See image below for possible inductive load driving. Resistor R can be connected to digital outputs and power supply to provide the necessary bias current for transistor. You should also use an external diode to protect the transistor from over voltage while disconnecting an inductive load. Keep in mind that this connection has an inverted logic. Current will flow through the load at the start of the camera.

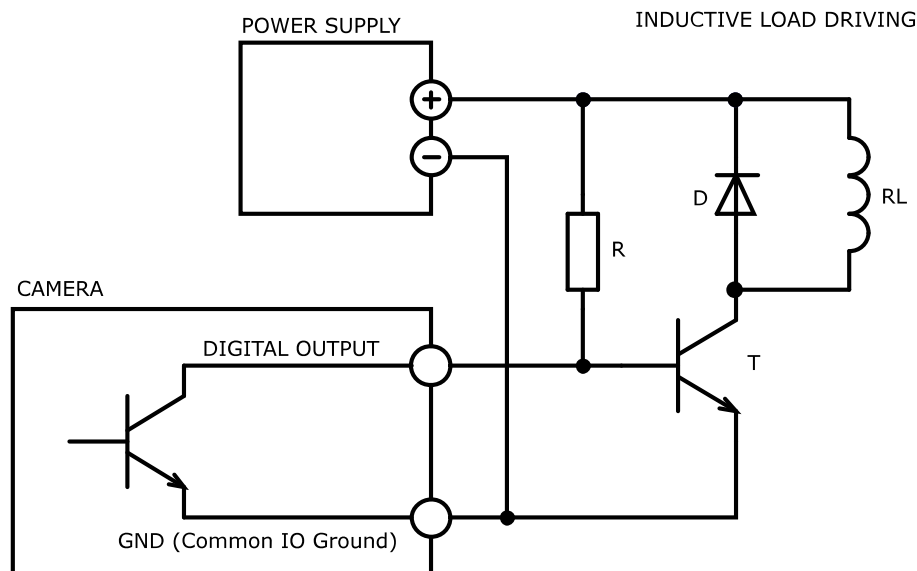


Figure 37: inductive load (Relay) driving (inverted logic)

For positive logic you can use a second bipolar transistor.

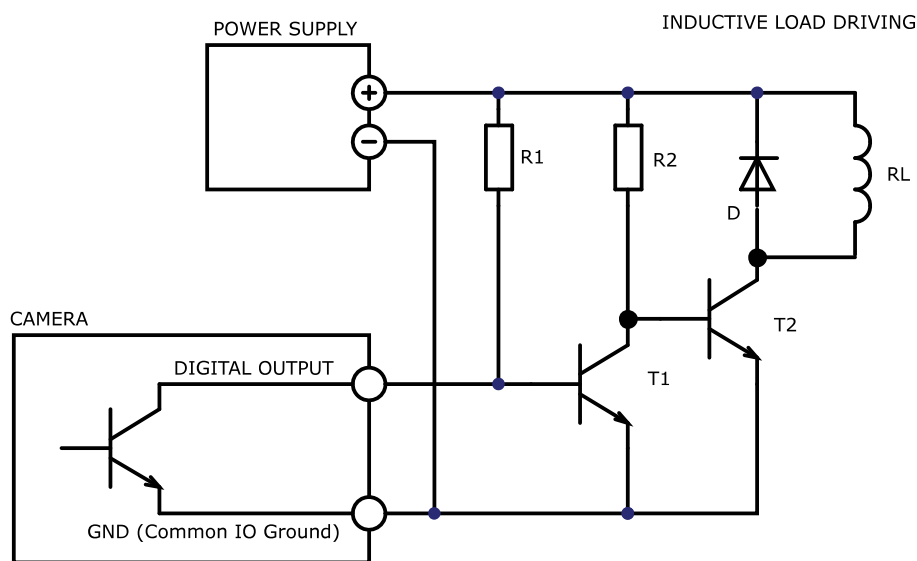


Figure 38: inductive load (Relay) driving (non-inverted logic)

2.10.3 Non-isolated digital lines

Item	Parameter / Note
Number of digital lines	4 , each line can be configured by application separately as input or output
Maximal input voltage	24 V DC
Common pole	YES
Effect of incorrect input terminal connection	Reverse voltage polarity protected
Effects when withdrawing/inserting input module under power	No damage, no lost data
Protection	Short-circuit / over-current / reverse voltage
Maximal output sink current	30 μ A Maximal advised load = 60 k Ω
Inductive loads	False
Output Level logical 0	< 0.4 V Load 100 k Ω
Output Level logical 1	> 2.5 V Load 100 k Ω
Output delay - rising edge	400 ns Load 100 k Ω threshold 2 V
Output delay - falling edge	450 ns Load 100 k Ω threshold 0.5 V
Input impedance- minimum	15 k Ω
Input level for logical 0	< 0.7 V
Input level for logical 1	> 2.4 V
Input debounce filter	No
Input delay - rising edge	750 ns $V_{INPUT} = 5$ V
Input delay - falling edge	1200 ns $V_{INPUT} = 5$ V
Input functions	Trigger, rising or falling edge are supported for trigger
Output functions	False, signal inversion supported

Table 23: non isolated digital lines - digital input/output (INOUT)

Non isolated Digital lines can be used as inputs or outputs compatible with TTL logic. These are high impedance pins so when used as output high impedance slave input has to be used.

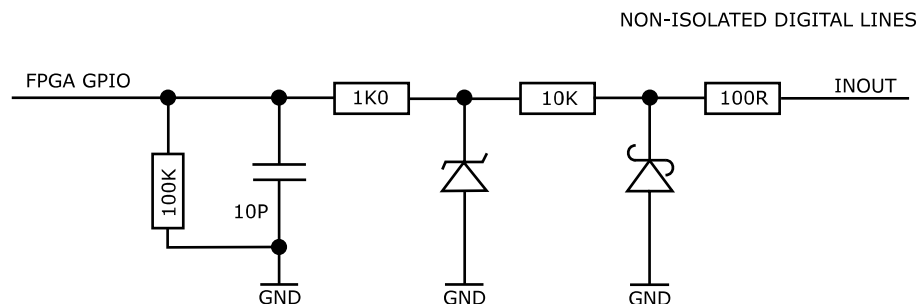


Figure 39: non isolated input/output, interface schematic

2.11 Accessories

2.11.1 CBL-PB4-PWR-0M15



Figure 40: CBL-PB4-PWR-0M15

Power cable with barrel connector 15 cm long

Manufacturer	Model	Description
Molex	86053120	4 pin Pico Blade connector
NINIGI	PC-GP2.1N	Barrel connector 5.5/2.1

Table 24: connectors CBL-PB4-PWR-0M15

2.11.2 CBL-PB6-IO-xM



Figure 41: CBL-PB6-IO-xM

IO pig tail cable 10 cm long

Manufacturer	Model	Description
Molex	86053248	6 pin Pico Blade connector

Table 25: connectors CBL-PB6-IO-0M10

2.11.3 CBL-ECUE-X4G3-xM

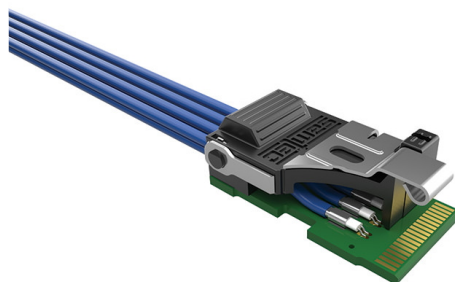


Figure 42: CBL-ECUE-X4G3-xM

BL-ECUE-X4G3-xM Cable Micro Assembly, Low-Profile FireFly, 30 cm, 100 cm, 200 cm. FireFly copper cables - Bidirectional and flexible. PCIe Gen3 x4 lanes with 14 Gbps Both sides are equipped with locking mechanism.

MX X4G3 cameras can be connected to host via cable with FireFly connector. The EMI/EMC performance should be evaluated by customer. For connecting to different host via vast range of adapters. Please see website [Cameras Adapters](#)

2.11.4 CBL-HQCD-xM

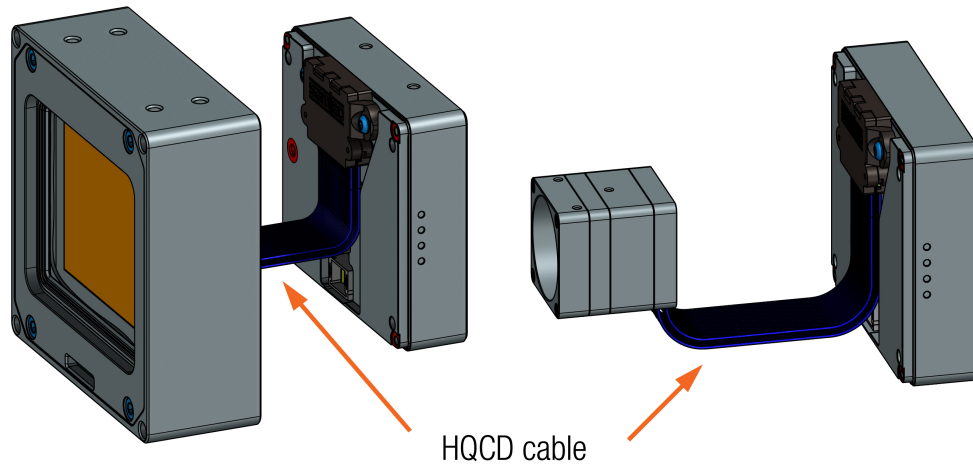


Figure 43: HQCD cable (e.g. MX1510MR-SY-X4G3-FF, MX245MR-SY-X4G3-FF)

All xiX-XL cameras in the manual have front and rear sub-assembly detached option. Please check the [Accessories overview](#) for supported lengths of the HQCD cables.

2.11.5 CB-X8G3-FAN-COOLER-KIT

The camera needs to have proper cooling to ensure optimal performance. A fan cooling element can be included with the camera. This fan module is designed to provide air cooling for the camera and can be mounted on the backside of the camera.

To attach or detach the fan module, you will need a hex 2.0 screwdriver and four M2.5x14 screws. When removing or inserting the fan assembly, it's important to be careful not to damage the spring pins that connect the cooling unit to the camera electronics.

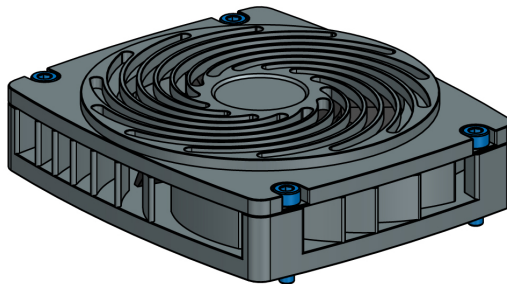
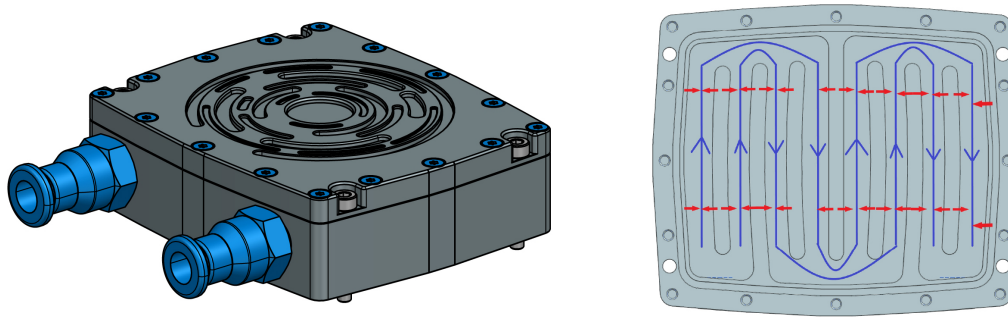


Figure 44: mounting fan cooling element CB-X8G3-FAN-COOLER

Width [W]	Height [H]	Depth [D]	Mass [M]
60 mm	70 mm	17 mm	20 g

Table 26: mechanical parameters

2.11.6 CB-X8G3-WAT-COOLER-KIT



A heatsink water cooler from anodized aluminum with a screws kit is available for X8G3/X4G3 cameras. This water cooling option is designed to prevent vibrations and can be conveniently mounted on the backside of the camera.

- 1 SSC6 - M5 quick coupler with airtight washer for 6mm tubes (water rated)
- 2 6061 aluminum housing with optimized water flow and cooling abilities
- 3 airtight sealing (tested at 10 bars)
- 4 M 2.5 x 18 screws for mounting cooler

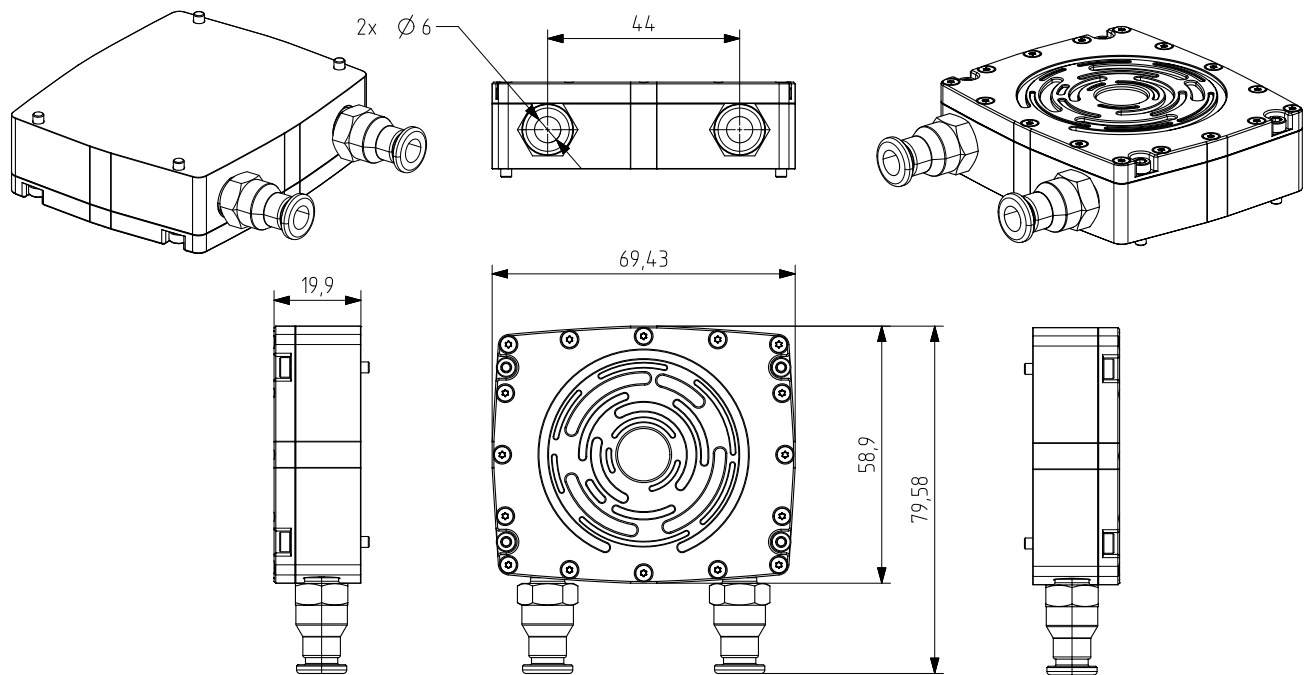


Figure 45: CB-X8G3-WAT-COOLER-KIT drawing

2.11.7 MECH-60MM-BRACKET-T

Bracket is made of solid high quality anodized aluminum. All threads are milled and all edges chamfered. Use 4x M4 screws provided with bracket as a kit for mounting. Bracket can be mounted on the bottom or side of the camera (depending on the camera model).

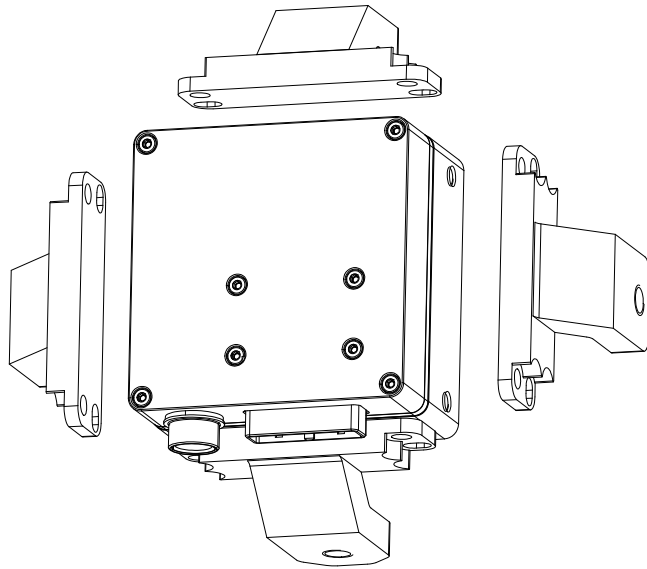


Figure 46: MECH-60MM-BRACKET-T

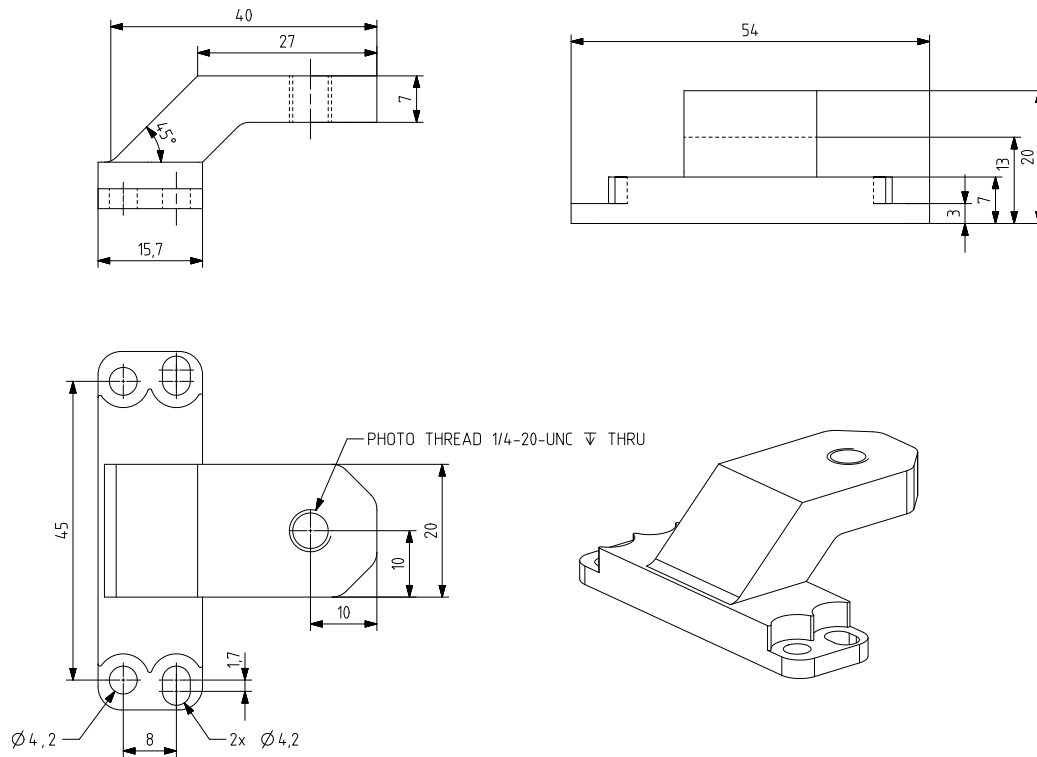


Figure 47: MECH-60MM-BRACKET-T drawing

Width [W]	Height [H]	Depth [D]	Mass [M]
54 mm	20 mm	40 mm	20 g

Table 27: parameters of MECH-60MM-BRACKET-T

2.11.8 MECH-60MM-EF-ADAPTER

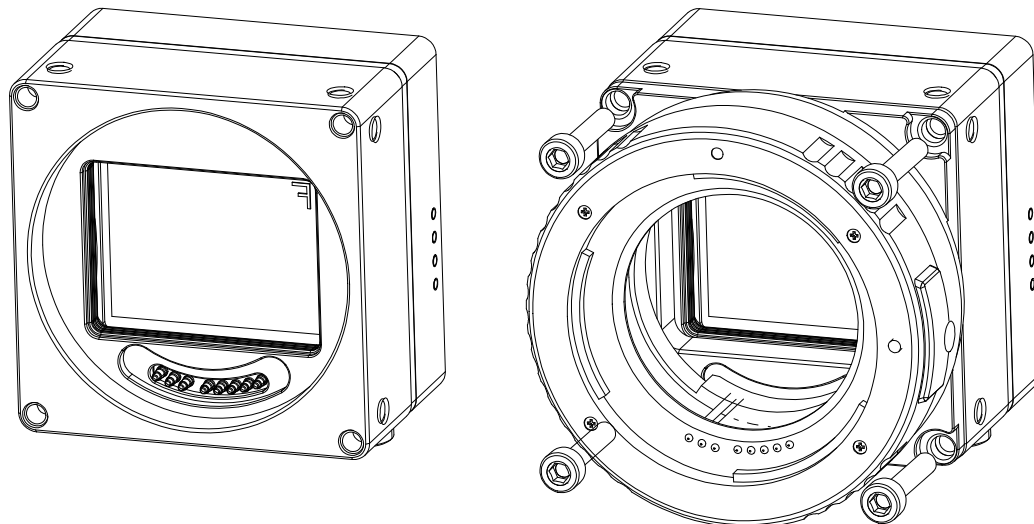


Figure 48: mounting lens adapter with CANON EF-mount MECH-60MM-EF-ADAPTER

Canon EF Lens Mount Adapter Kit

Camera features active control interface for lenses with CANON EF-mount. For attaching such lens MECH-60MMEF-ADAPTER is required. Adapter is mounted using 4 front mount holes. Screws are included in MECH-60MM-EF-ADAPTER-KIT which can be purchased from XIMEA. Optionally camera can be assembled in production when the operation has been ordered along with camera.

Note: To be used with standart Canon Mount Lenses. Use 4x M4x6 or standard M4 screws for attaching camera. Nominal flange focal distance from the front of adapter to active area ins sensor is 44.00 mm + 0 - 0.2 mm.

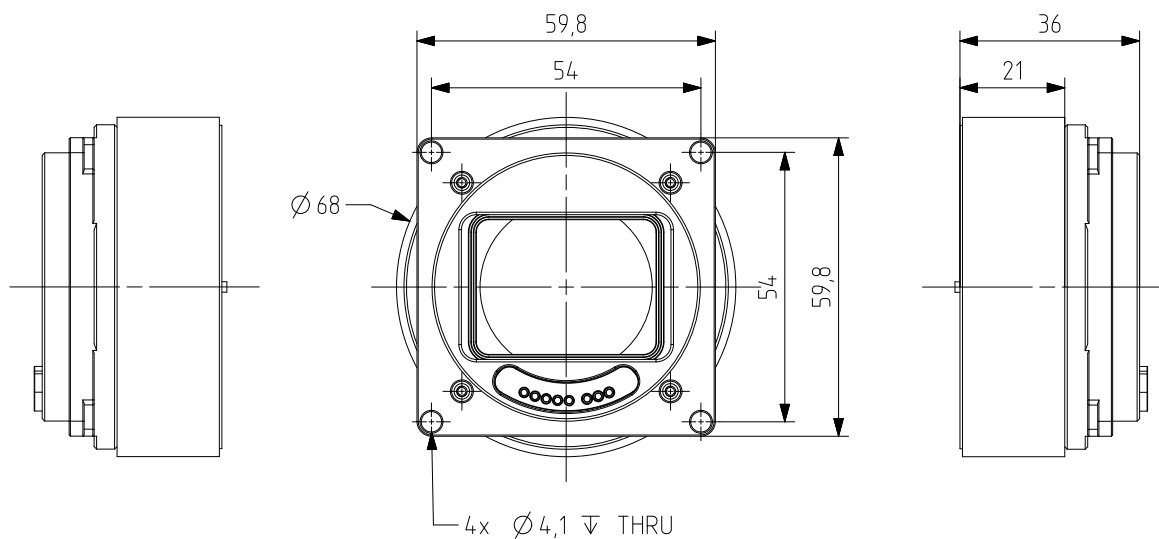


Figure 49: MECH-60MM-EF-ADAPTER drawing

Width [W]	Height [H]	Depth [D]	Mass [M]	Material
80 mm	80 mm	12.25 mm	30 g	Machined aluminum alloy ¹

¹anodized to black color

Table 28: mechanical parameters of MECH-60MM-EF-ADAPTER

2.11.9 ME-LA-80MM-M72-L-KIT

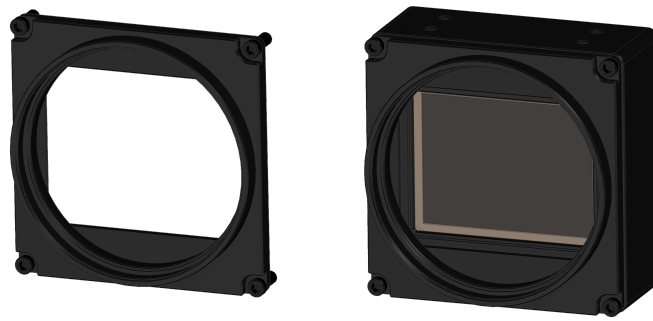


Figure 50: ME-LA-80MM-M72-L-KIT

M72 Lens Adapter for 80×80 mm front camera element. The adapter is mounted to the camera using 4 M4x10 screws.

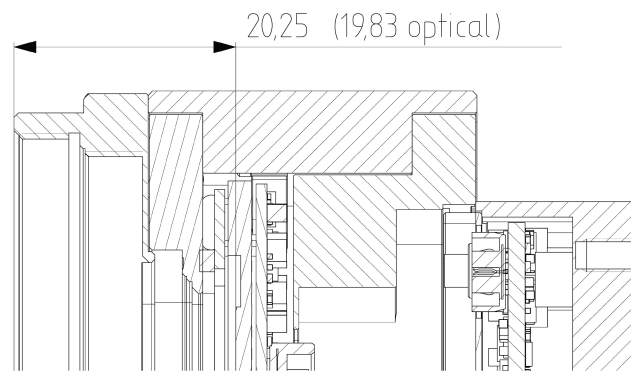


Figure 51: ME-LA-80MM-M72-L optical path

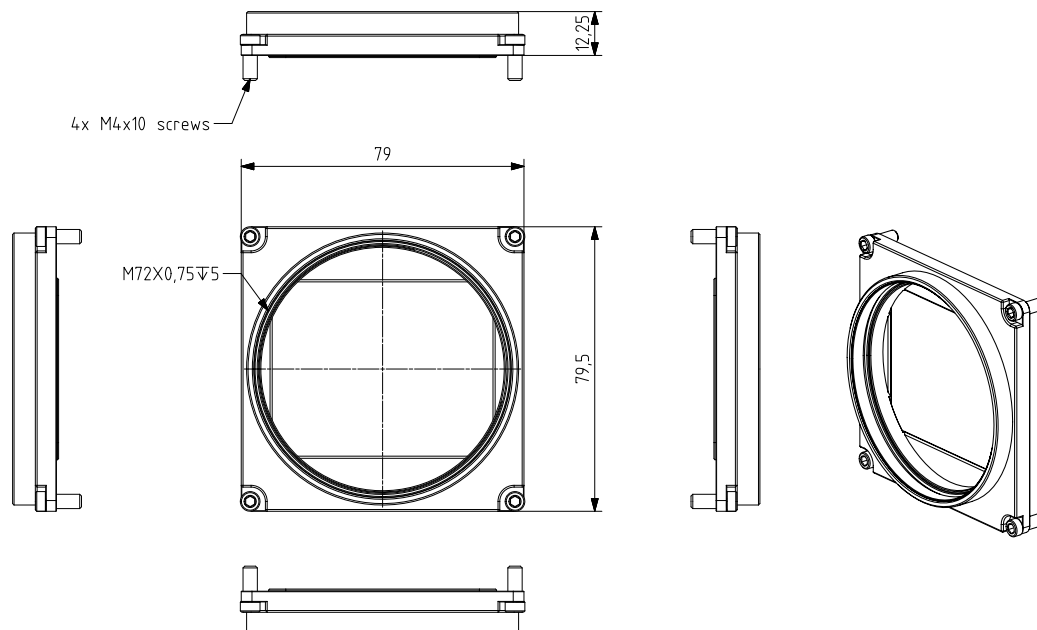


Figure 52: ME-LA-80MM-M72-L drawing

2.11.10 ADPT-MX-X4G3-FF-X4G3-MTP



Back part attachment to connect XIMEA Firefly cameras to MTP cable. Converts 1x PCIe Gen3 x4 camera. The camera adapter also offers power and IO connectors for synchronization and triggering.

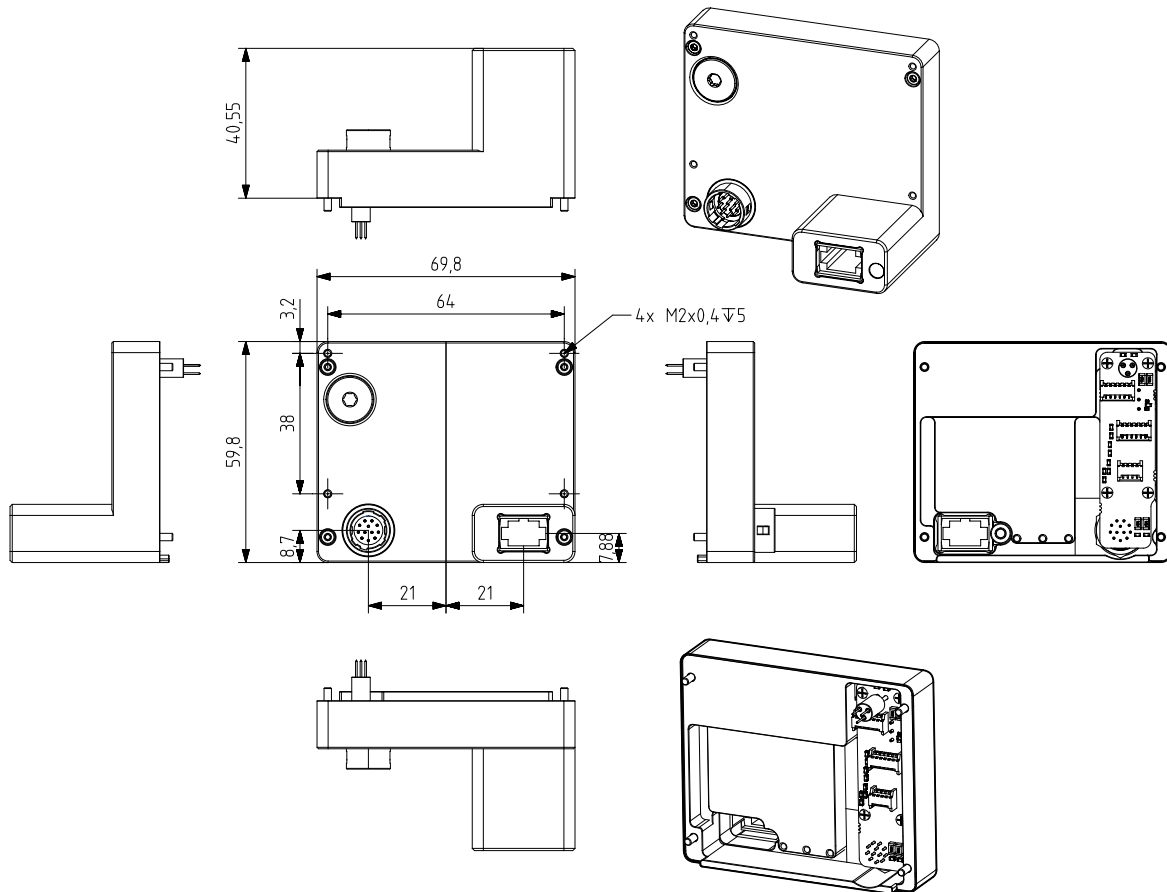


Figure 53: ADPT-MX-X4G3-FF-X4G3-MTP dimensional drawing

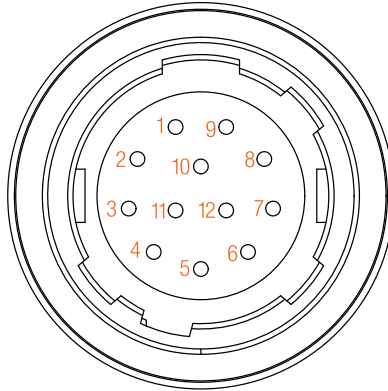


Figure 54: ADPT-MX-X4G3-FF-X4G3-MTP IO connector

The IO pins of the adapter are connected to the corresponding IO pins on the FireFly camera, based on their names

Pin	Name	Signal
1	IN2	Opto-isolated Input 2
2	IN1	Opto-isolated Input 1
3	OUT2	Opto-isolated Output 2
4	OUT1	Opto-isolated Output 1
5	AUX PWR	Power supply input
6	GND	External grounds for power and non-isolated I/O
7	INOUT1	Non-isolated I/O
8	INOUT3	Non-isolated I/O
9	INOUT2	Non-isolated I/O
10	IN GND	Ground for Opto-Isolated Inputs (IN1, IN2)
11	OUT GND	Ground for Opto-Isolated Out (OUT1, OUT2)
12	INOUT4	Non-isolated I/O

Table 29: ADPT-MX-X4G3-FF-X4G3-MTP IO pin assignment

ADPT-MX-MTP-FAN-COOLER

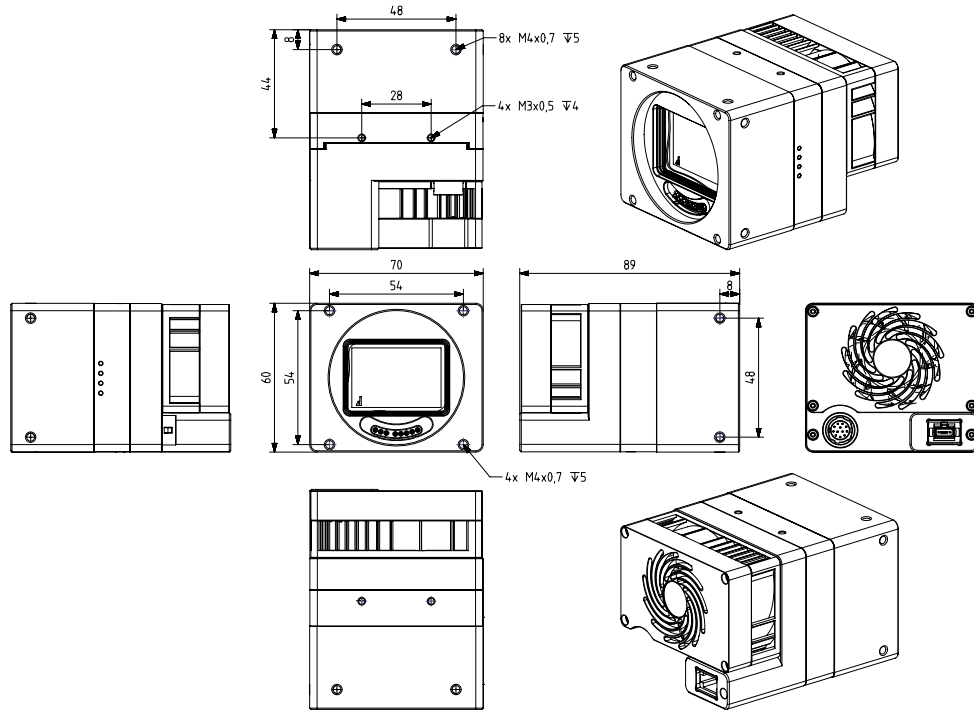


Figure 55: MX610xR-SY-X4G3-FF with MTP adapter and fan cooling

ADPT-MX-MTP-WAT-COOLER

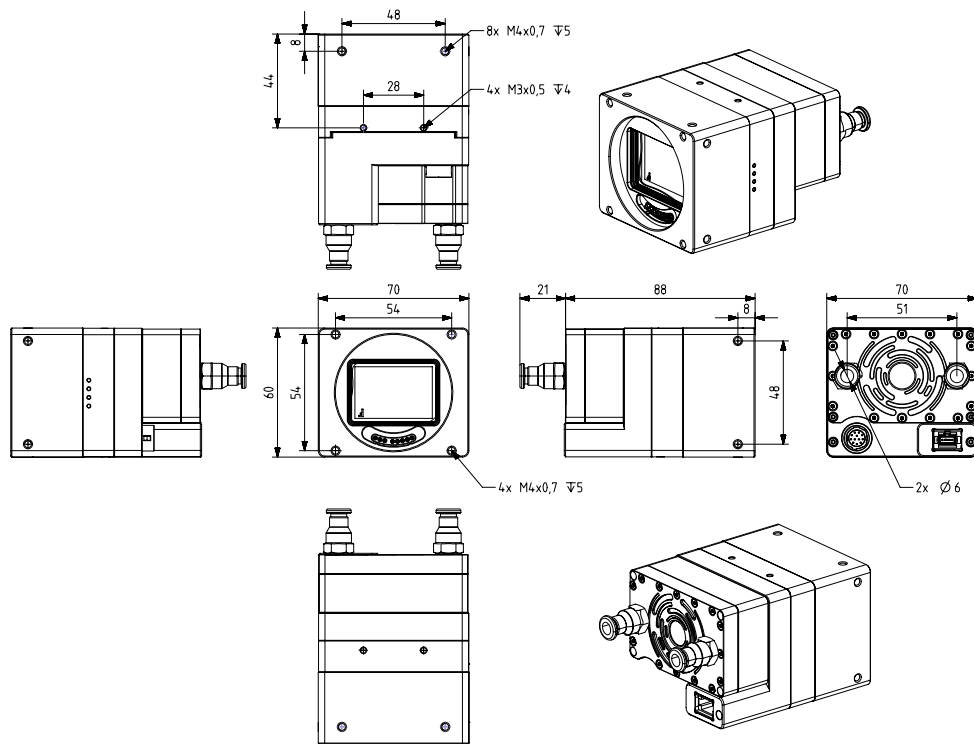
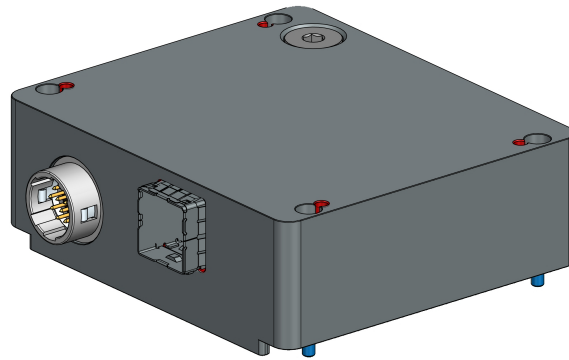


Figure 56: MX610xR-SY-X4G3-FF with MTP adapter and water cooling

2.11.11 ADPT-MX-X4G3-FF-X4G3-SFF



Back part attachment to connect XIMEA Firefly cameras to SFF-8644 cable. Converts 1x PCIe Gen3 x4 camera.

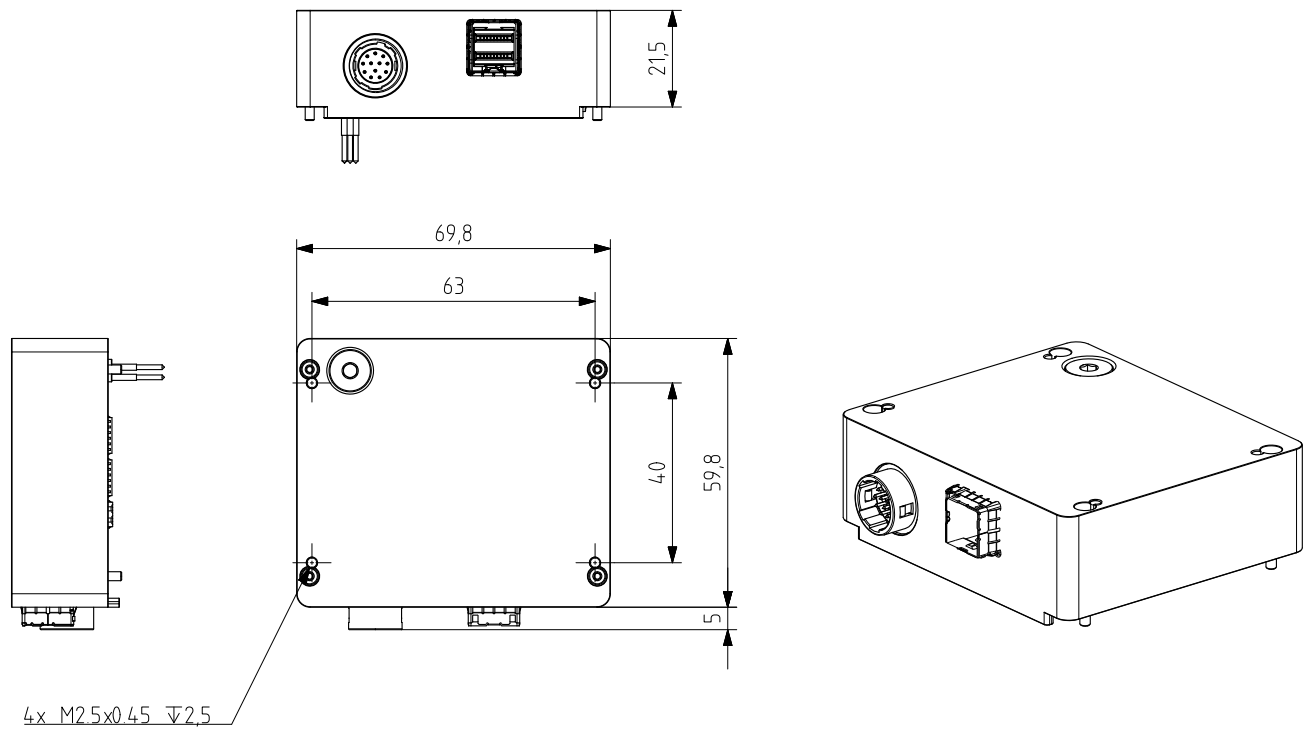


Figure 57: ADPT-MX-X4G3-FF-X4G3-SFF dimensional drawing

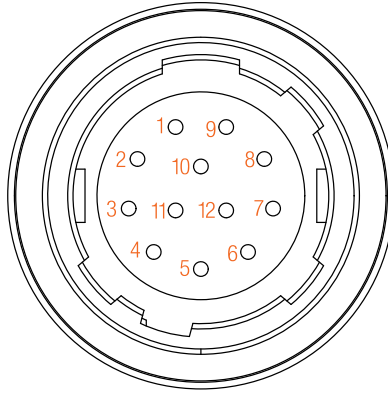


Figure 58: ADPT-MX-X4G3-FF-X4G3-SFF IO connector

The IO pins of the adapter are connected to the corresponding IO pins on the FireFly camera, based on their names

Pin	Name	Signal
1	IN2	Opto-isolated Input 2
2	IN1	Opto-isolated Input 1
3	OUT2	Opto-isolated Output 2
4	OUT1	Opto-isolated Output 1
5	AUX PWR	Power supply input
6	GND	External grounds for power and non-isolated I/O
7	INOUT1	Non-isolated I/O
8	INOUT3	Non-isolated I/O
9	INOUT2	Non-isolated I/O
10	IN GND	Ground for Opto-Isolated Inputs (IN1, IN2)
11	OUT GND	Ground for Opto-Isolated Out (OUT1, OUT2)
12	INOUT4	Non-isolated I/O

Table 30: ADPT-MX-X4G3-FF-X4G3-SFF IO pin assignment

ADPT-MX-SFF-FAN-COOLER

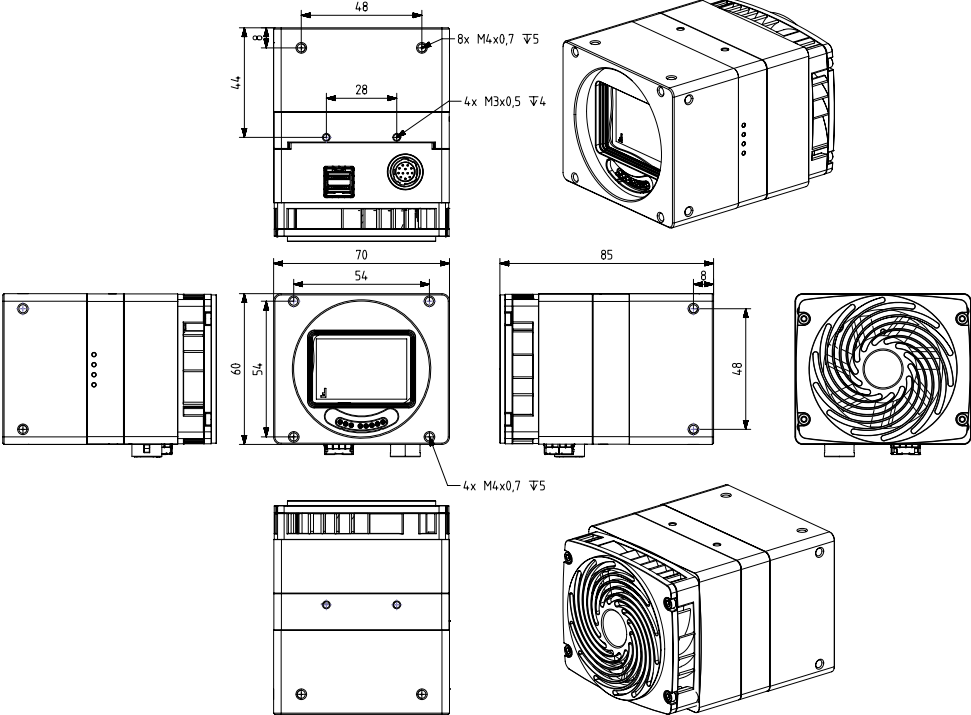


Figure 59: MX610xR-SY-X4G3-FF with SFF adapter and fan cooling

ADPT-MX-SFF-WAT-COOLER

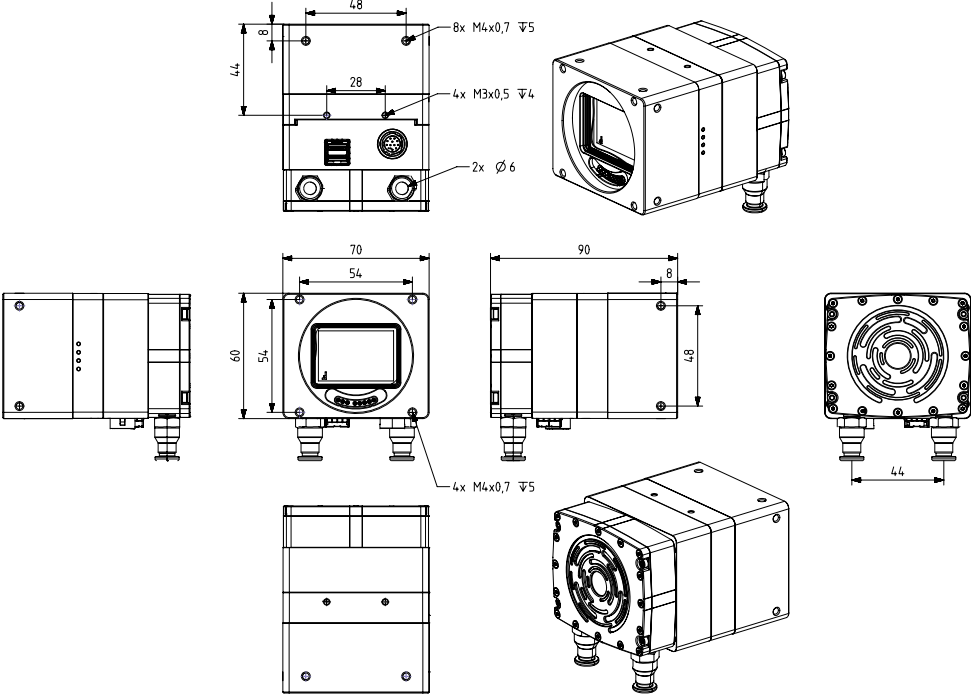
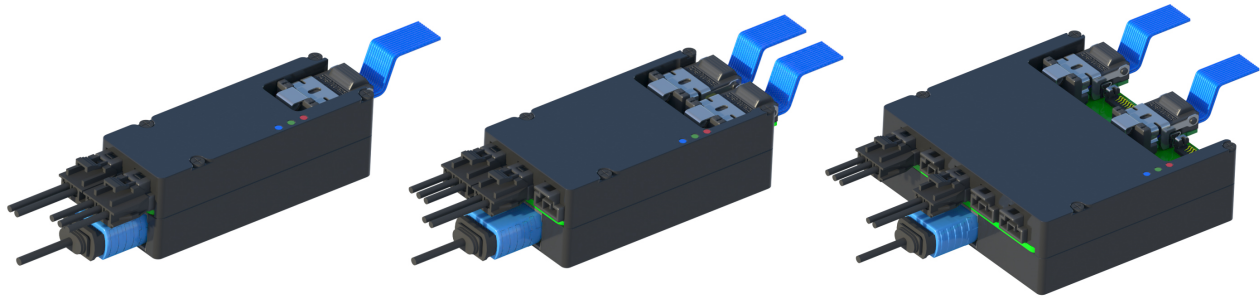


Figure 60: MX610xR-SY-X4G3-FF with SFF adapter and water cooling

2.11.12 FireFly MTP adapters



Adapter to connect XIMEA FireFly cameras to MTP cable.

The camera/s should be connected to these adapters over a FireFly ECUE copper cable (e.g. 10 cm - 3 m). The adapter has an integrated PCUI module, which allows connection to PC over optical MTP cable (e.g. 10 m). Adapters contain also connectors for power and GPI/GPO from the camera. The power cable is going to be bundled with the adapter delivery and sync cable is optional.

ADPT-1P-X4G3-FF-X4G3-MTP

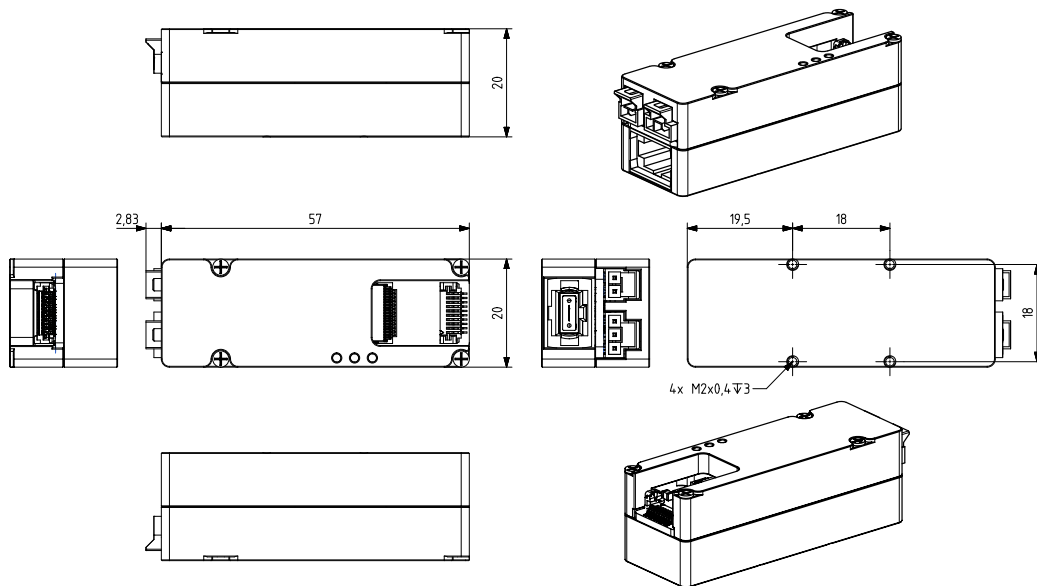


Figure 61: ADPT-1P-X4G3-FF-X4G3-MTP dimensional drawings

ADPT-1P-X8G3-FF-X8G3-MTP / ADPT-2P-X2G3-FF-X4G3-MTP

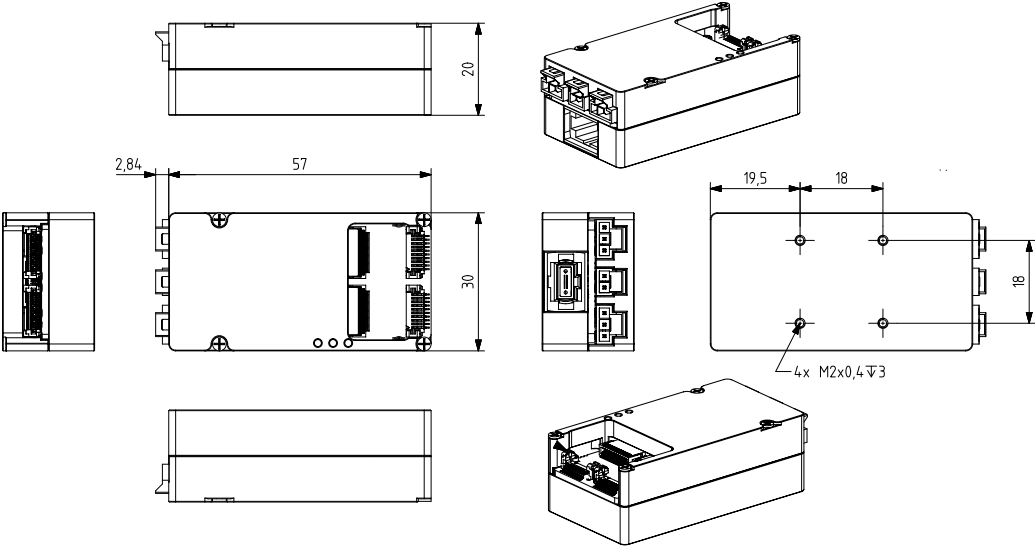


Figure 62: ADPT-1P-X8G3-FF-X8G3-MTP and ADPT-2P-X2G3-FF-X4G3-MTP dimensional drawings

ADPT-4P-X2G3-FF-X8G3-MTP

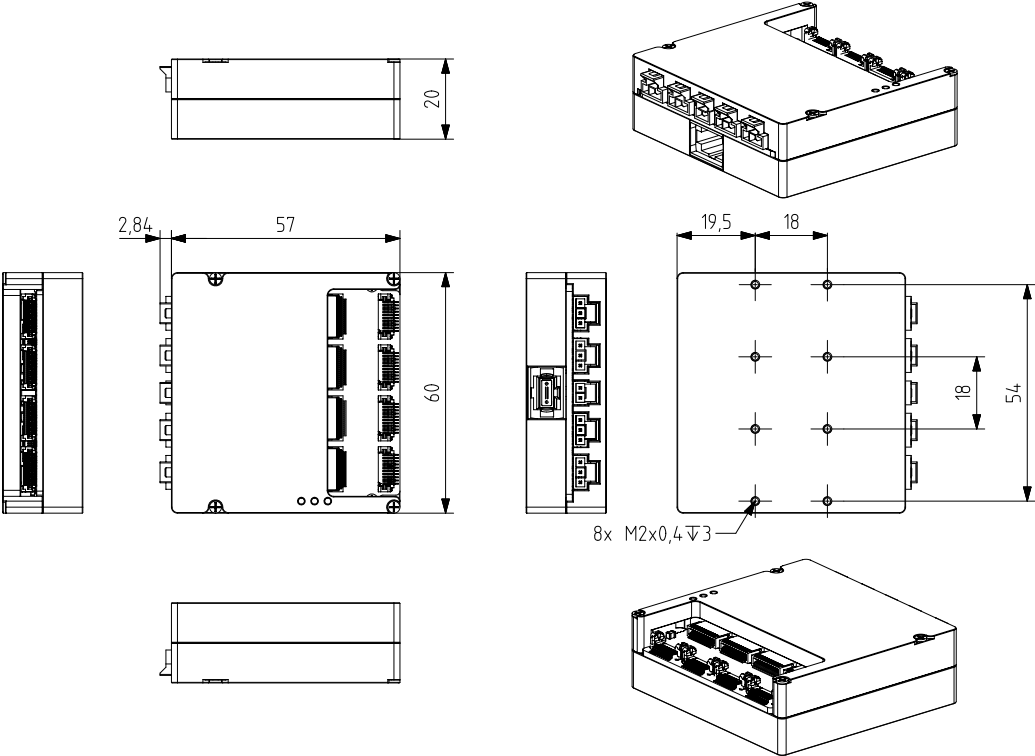
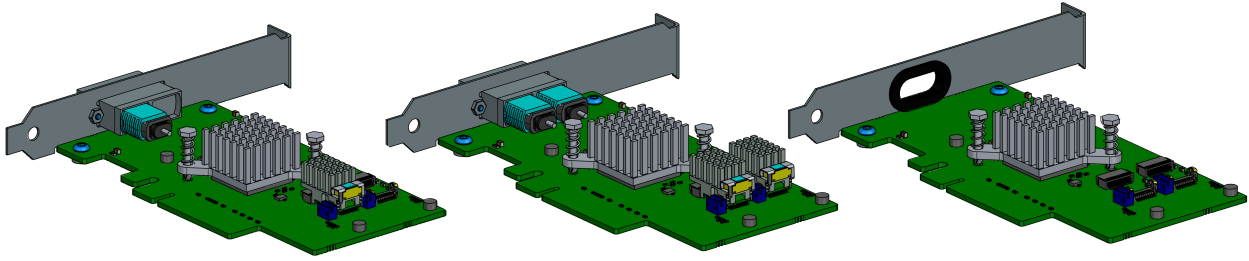


Figure 63: ADPT-4P-X2G3-FF-X8G3-MTP dimensional drawings

2.11.13 PCIe host adapters

Supports PCIe Gen3 x4 lines and requires PCIe Gen.3 x8 slot on the computer side. Bandwidth of 32 Gbps. Cable lengths of up to 100 m.



HA-1P-X4G3-MTP-X8G3 / HA-2P-X4G3-MTP-X8G3

PCIe MTP Gen3 x4 Host Adapter - single or dual port for MTP fiber optic cables.

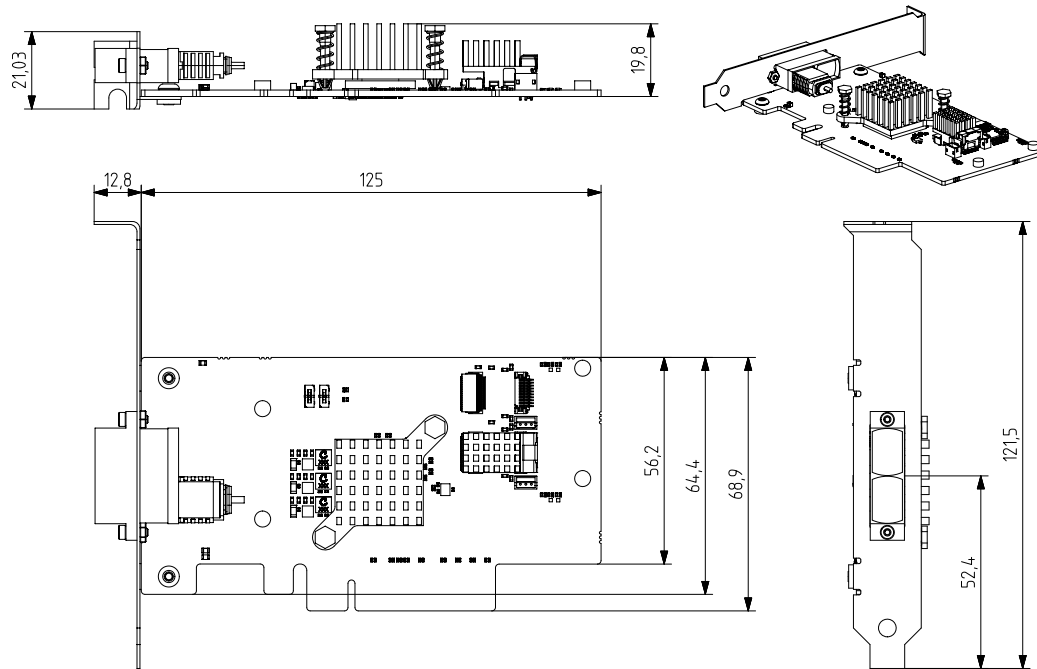


Figure 64: dimensions of host adapter HA-1P-X4G3-MTP-X8G3

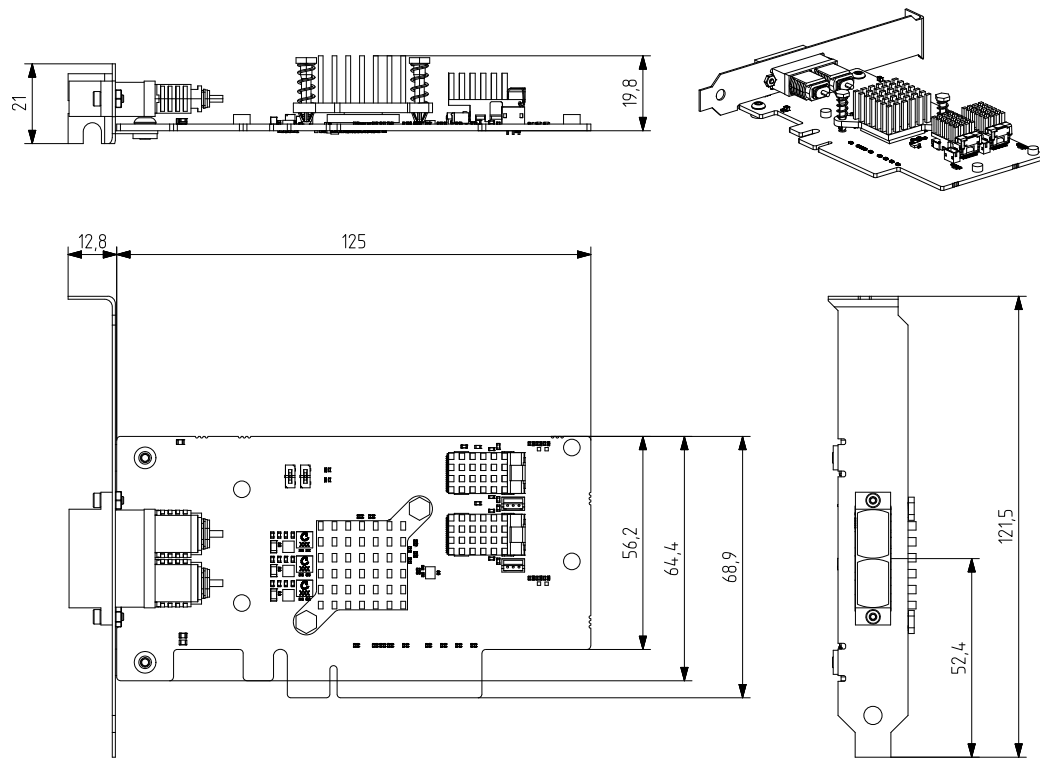


Figure 65: dimensions of host adapter HA-2P-X4G3-MTP-X8G3

HA-2P-X4G3-FF-X8G3

PCIe FireFly Host Adapter Dual - dual ports for Firefly cables.

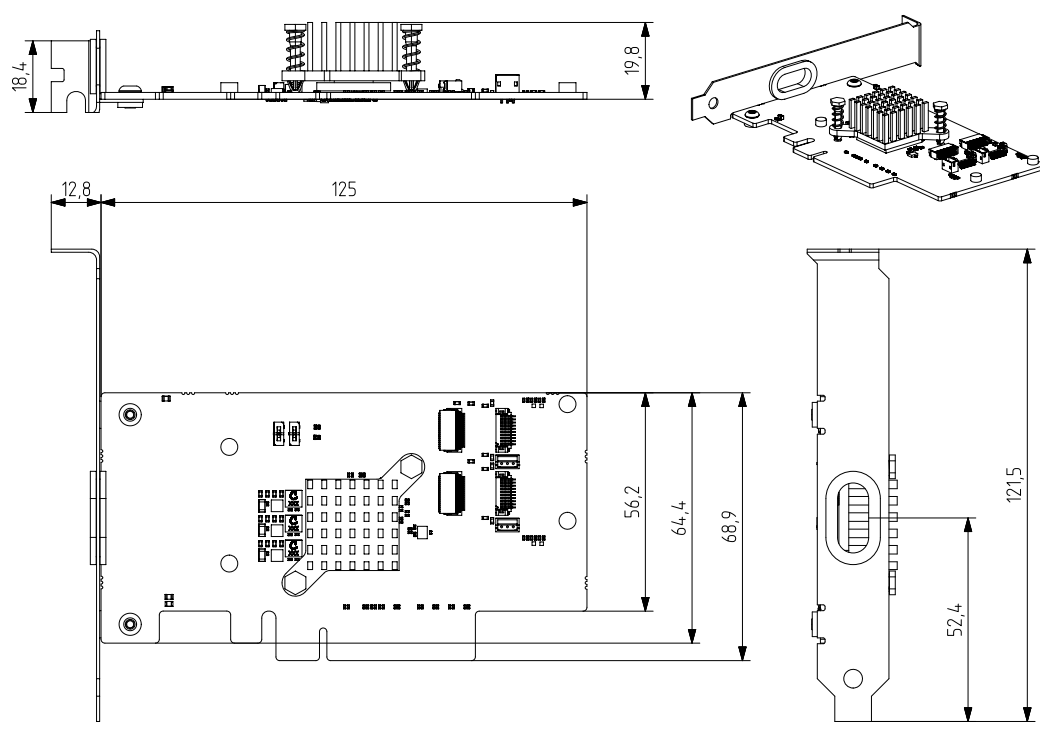


Figure 66: dimensions of host adapter HA-2P-X4G3-FF-X8G3

3 General features

3.1 Camera features

3.1.1 ROIs – Region of interest

ROI, also called area-of-interest (AOI) or windowing, allows the user to specify a sub-area of the original sensor size for read-out. ROI can be set by specifying the size (width and height) as well as the position (based on upper left corner) of the sub-area.

3.1.2 Downsampling modes

Downsampling describes the possibility of reducing the image resolution without affecting the sensors physical size, i.e. without reducing the physical size of the sensing area. This feature is useful when optics are used, that are particularly fitted to a certain sensor size and if it is necessary to maintain the full image circle on the sensor.

Downsampling can be achieved in two ways: binning and decimation.

Binning/decimation selector selects which binning/decimation engine is used (Sensor, FPGA, CPU). After setting of selector, multiple parameters could be get or set for the selected unit.

They can be divided into:

Patterns define the horizontal/vertical pattern how photo-sensitive cells are combined (mono or bayer)

Values reduce the horizontal or vertical resolution of the image by the specified horizontal/vertical downsampling factor

Modes in case of binning set the mode used to combine horizontal/vertical photo-sensitive cells together (sum or average)

Binning

When binning is applied, the image is divided into cluster of $k \times l$ pixels, where all pixels in each cluster are interpolated and result in the value of one output pixel. For example, a 2×2 binning produces 2×2 -pixel clusters and results in images with $\frac{1}{4}$ of the original resolution.

Decimation – Skipping

When decimation is chosen, only every n -th pixel is used to create the output image. For example, with a 2×1 vertical skipping, every odd number line is used and every even number line is skipped, resulting in an image with half its original vertical resolution. Skipping is a faster downsampling mode, but also introduces more aliasing effects.

3.1.3 Image data output formats

All modes are provided by the xiAPI or standard interfaces using the xiAPI (please see [Programming](#)).

Each camera supports several Image Data Output Formats:

Mode	Description
XI_RAW8	8 bits per pixel raw data from sensor. [pixel byte] raw data from transport (camera output)
XI_RAW16	16 bits per pixel raw data from sensor. [pixel byte low] [pixel byte high] 16 bits (depacked) raw data
XI_MONO8	8 bits per pixel. [Intensity] ^{1,2}
XI_MONO16	16 bits per pixel. [Intensity LSB] [Intensity MSB] ^{1,2}
xl_RGB24	RGB data format. [Blue][Green][Red] ²
xl_RGB32	RGBA data format. [Blue][Green][Red][0] ²
xl_RGB48	RGB data format. [Blue low byte][Blue high byte][Green low][Green high][Red low][Red high] ¹
xl_RGB64	RGBA data format. [Blue low byte][Blue high byte][Green low][Green high][Red low][Red high][0][0] ¹
xl_RGB_PLANAR	RGB planar data format. [Red][Red]...[Green][Green]...[Blue][Blue]... ²
xl_RGB16_PLANAR	RGB16 planar data format
xl_FRM_TRANSPORT_DATA	Data from transport layer (e.g. packed). Depends on data on the transport layer ³

¹Higher CPU processing is required when this mode is selected because color filter array processing is implemented on PC. This processing is serialized when multiple cameras is used at once. The most effective way to get data from camera is to use XI_RAW8, where no additional processing is done in API.

²On monochromatic cameras the black level is not subtracted in XI_MONO8 and XI_MONO16 formats by Image Processing in xiAPI, so black level remains the same as in RAW format.

³When using Transport Data Format, the Image Processing block from XiAPI Image Data Flow is skipped and therefore the Transport format is the most effective data format in terms of CPU and RAM usage.

Table 31: image formats - MX1510CR-SY-X4G3-FF

3.2 Acquisition modes

3.2.1 Free-Run

Also known as continuous acquisition. In this mode the sensor delivers a constant stream of image data at the maximum speed available by the current bandwidth, without any external trigger. Each image exposure is sequentially started automatically when possible.

For all sensors the exposure of the next frame overlaps with the data readout of the previous frame. This Overlap mode gives the highest number of frames per second (FPS).

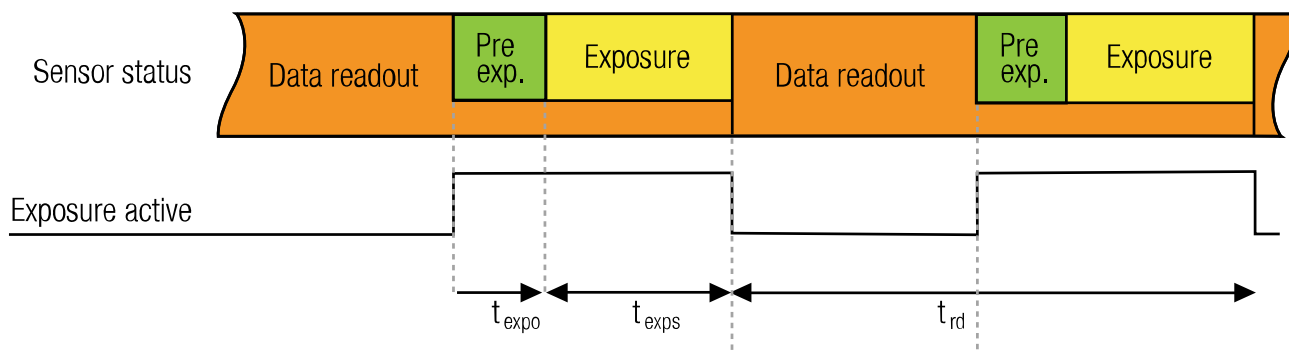


Figure 67: acquisition mode - free run

The frame rate in free run mode depends inversely on the frame time. In general the frame time roughly equals to the readout time or to the exposure time, depending on which one of the two is larger. This means that when exposure time is larger than the readout time, the frame rate gradually decreases with increasing exposure time ($frame_rate \sim 1/t_{exp}$).

This is however not true for the IMX455, IMX461 and IMX461 sensors where the frame time is always a multiple of the readout time and its value equals $n \cdot t_{readout}$ where n is the integer part of division of exposure time by readout time ($n = t_{exp} // t_{readout}$).

In this mode the timing depends on the Exposure Time and Data Readout Time. In situation when the exposure time is comparable or longer than readout time, the exposure active signal might have constant active level during acquisition. This might be caused also by different propagation delay for rising and falling edge of opto isolated outputs, see [Optically isolated digital outputs](#). Polarity inversion might help to make visible the separated exposure pulses. Some camera models support limiting of FPS. When set the camera will limit the frame rate so it does not exceed the set value. Please see: [Frame_Rate_Control](#). This is also applicable in case of triggered acquisition.

3.2.2 Trigger controlled acquisition/exposure

Unlike in the free-run, each image exposure can also be triggered with an input trigger signal. In this mode, the sensor waits in stage until the trigger signal arrives. Only then, the exposure of first frame is started, which is followed by the data readout. XIMEA cameras supports several triggered modes along with single image exposure after one trigger. The trigger signal can be either edge sensitive or level sensitive. In the case of “level sensitive”, it can be used to control length of exposure or acquisition itself. Generally trigger sources can be divided into two groups:

Software trigger

The trigger signal can be sent to the sensor using a software command. In this case, common system related latencies and jitter apply.

Hardware trigger

A hardware trigger can be sent to the sensor using the digital input described in [Optically isolated digital inputss](#). Triggering by hardware is usually used to reduce latencies and jitter in applications that require the most accurate timing. In this case rising edge of input signal is suggested as the delay of opto coupler is smaller as well as introduced jitter. Triggering by hardware is usually used to reduce latencies and jitter in applications that require the most accurate timing.

Triggered mode - Burst of frames

For more information please see: [Frame Burst Modes](#)

Frame Burst Start

In this mode each trigger pulse triggers defined number of exposed frames.

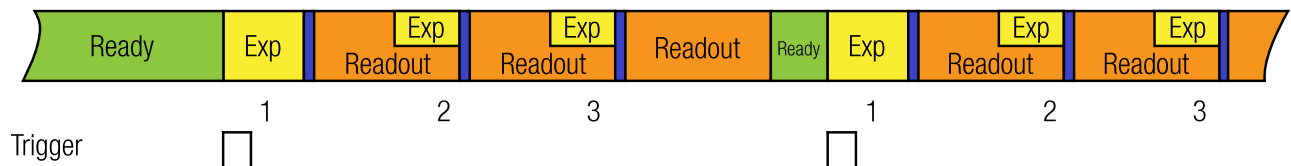


Figure 68: triggered burst of frames – frame burst start

Frame Burst Active

If trigger is level-sensitive, it can be used to control image acquisition.

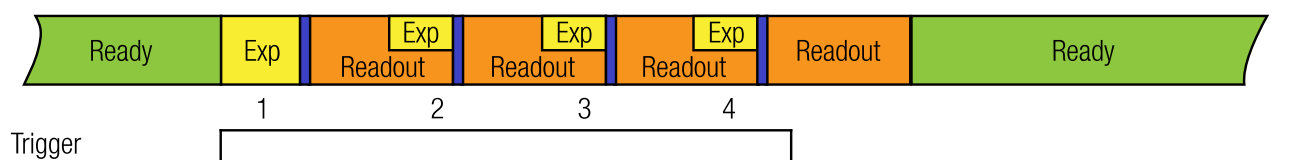


Figure 69: triggered burst of frames – frame burst active

Triggered mode - Exposure defined by trigger pulse length

In this mode the exposure is defined by trigger pulse length. This can be used to achieve longer exposure than allowed by API. Also, it can be used to trigger several images in sequence with different exposure time. Exposure time is measured and reported in image metadata. Please see: [Exposure Defined by Trigger Pulse Length](#)

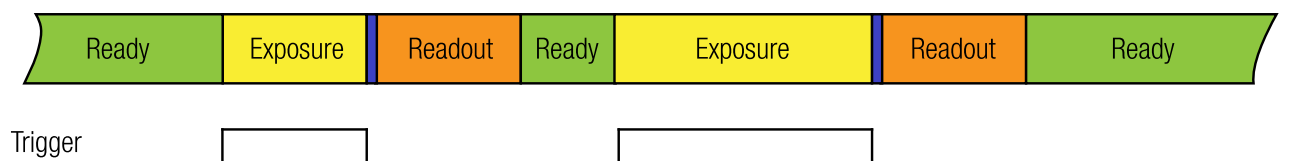


Figure 70: exposure defined by trigger pulse length

3.3 Exposure time

Also known as shutter speed. This parameter defines the length of the integration period for each frame. Most CMOS sensors generate the exposure interval internally. For some it is possible to control it by external signaling. The sensor internal timing depends on the provided system clock. Most sensors use dividers to generate slower clocks for internal usage.

The minimum exposure time is defined mostly by row times, where the row time (T_R) is dependent on various internal settings. Very few sensors support exposure times equal to zero. There is a defined minimum exposure time as well as minimum steps between possible exposure times. There is also a maximum exposure time, defined by sensor architecture.

3.4 Gain

The gain value influences the analog-to-digital conversion process of the image sensor pipeline and acts as a multiplier of the output signal. Using gain values greater than 0 will increase the pixel intensities but may also increase the overall noise level. For some camera models the gain can be set in discrete steps only.

3.4.1 Parallel ADC readout mode

Enabling this feature activates the parallel ADC readout process for all pixels, effectively halving the maximum frame rate while improving the noise performance and signal to noise ratio in low light scenes.

3.4.2 High conversion gain mode

Enables high conversion gain feature which applies additional gain to the signal at the pixel level which leads to a reduction in read noise, a boost in sensitivity and signal-to-noise ratio, particularly in low-light situations. Consequently, the camera exhibits superior performance in dark environments, capturing images with minimal noise and enhanced detail.

3.4.3 Programmable gain - north

First of two channels of programmable gain control (PGC) function - Gain setting of R, B pixels (North column analog gain). This is available only on some cameras.

3.4.4 Programmable gain - south

Second of two channels of programmable gain control (PGC) function - Gain setting of Gr, Gb pixels (South column analog gain). This is available only on some cameras.

3.5 Sensor Shutter Modes

Cameras can be operated in two shutter modes, Rolling Shutter or Global Reset Release. The Rolling Shutter mode is used if the camera is operated in free-run mode. If the camera is triggered, either by hardware trigger or through software, the sensor uses the Global Reset Release mode.

3.5.1 Global Reset Release Mode

- Global reset of all photo diodes
- Integration stage

Transfer, conversion and readout line by line starts at the end of the integration of the first line. Not transferred line stays in integration stage until readout of particular line starts. This leads to different exposure time for individual lines. Each next line has exposure longer by readout of one line.

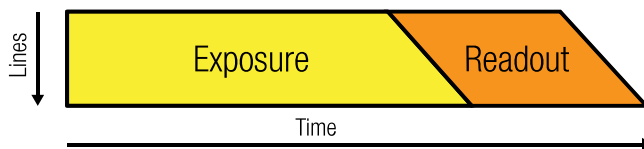


Figure 71: global reset release mode - schematic

Because of the longer exposure of the lower lines they may be show increased blurring if the object moves. To freeze the motion, a flash may be used. In contrast to rolling shutter mode the flash strobe does not need to be delayed.



Figure 72: global reset release mode - image horizontally moved object

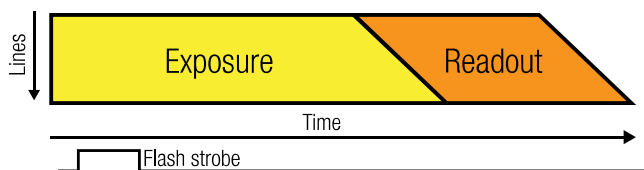


Figure 73: global reset release mode with flash - schematic

3.5.2 Rolling Shutter Mode

- Line by line integration state
- Line by line transfer and readout

Integration of next line is delayed by readout time of one line

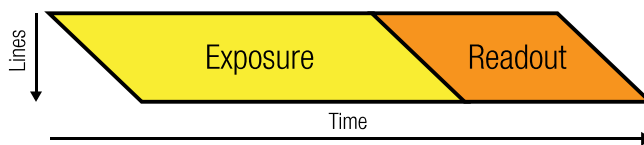


Figure 74: rolling shutter mode - schematic

Because of the sequential start of the exposure, the rolling shutter mode may introduce artifacts effect if objects move. In the direction of the lines (horizontal) the image will be sheared. When moving in vertical direction, the object may appear longer or shorter. When the exposure is longer also motion blur may occur



Figure 75: rolling shutter mode image of a horizontally moved object



Figure 76: rolling shutter mode image of a horizontally moved object, long exposure time

Rolling shutter artifacts may be prevented by using a flash or stroboscopic light. The flash or strobe must occur when all lines are exposed simultaneously. The exact timing depends on sensor type and readout timing. In Rolling shutter mode all lines are triggered consecutively, and a strobe must be timed so that it does not start before all lines are open. The delay can be calculated from the highest frame rate and is $1/fps$. The strobe must also end before the first lines are closed again for exposure, which sets a lower limit for the exposure time, as can be seen in the figure above.

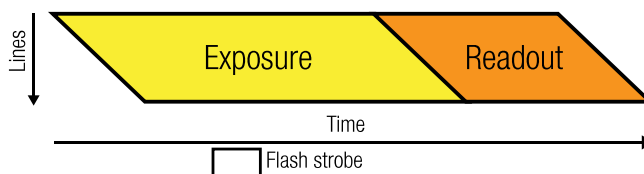


Figure 77: rolling shutter mode with flash - schematic

3.5.3 How to Freeze the Motion

When a moving object (e.g. on a conveyor belt) is imaged with a longer exposure time, the resulting image will show Motion Blur. To avoid Motion Blur the short exposure times or flash illumination should be used.

Example of a setup with MU9 camera:

```
Sensor width (W) 0.0057m
2520 pixel horizontally (PX)
Field of view (FOV) 0.2m
Conveyor speed (CS) 0.1m/s
```

To contain Motion Blur to within one image pixel the following calculation for the flash light duration may be used:

```
Pixel distance (PD) W/PX -> 0.0057m/2592pixels = 2.2um.
Pixel distance recalculated FOVPD = FOV/PX = 0.2m/2592 = 77.2um
During exposure the object should not move more than 77.2um
Flash Time (FT) should be less than FOVPD/CS = 77.2um/0.1m/s = 0.772ms
```

3.6 API Features

Host-assisted image processing features available in xiAPI

3.6.1 Exposure – Auto gain

When AEAG is used, every captured image is evaluated for its mean intensity. Based on the result, the exposure and gain values are modified with the objective to achieve a target intensity level for the following image. Further, the maximum applicable exposure and gain values can be defined. Since both, exposure and gain, have an influence on the intensity, the ratio between those two parameters in their contribution to the algorithm can also be set (exposure priority).

3.6.2 White balance

Only for color models: The white balance can be adjusted with three coefficients kR, kG and kB, one for each color channel. These coefficients can be set individually in order to increase or decrease each channel's contribution and therefore allow the user to control the color tint of the image.

Assisted manual white balance

This feature measures the white balance a single time and sets the white balance coefficient to achieve a mean grey (neutral) tint. The measurement is performed on the central rectangle of the image, with 1/8th of its width and height. The function expects a white sheet of paper exposed to 50% of the intensity values (8 Bit RGB values should be around 128) to be visible.

Auto White Balance

The white balance is measured across the full image for every 4th image that is acquired, and the white balance coefficients are set to achieve a neutral colour tint.

3.6.3 Gamma

Only for color models: As a part of the color filtering process, it is possible to adjust the gamma level of the image. The adjustment can be set separately for the luminosity and the chromaticity.

3.6.4 Sharpness

Only for color models: As a part of the color filtering process, it is possible to adjust the sharpness of the image.

3.6.5 Color correction matrix

The color correction matrix is a 4x4-matrix which is applied on each pixel of an image in a host-assisted port-processing step. This Matrix can be used for example to adjust the brightness, contrast, and saturation.

3.6.6 Sensor defect correction

During the manufacturing process, every camera is tested for various type of defects and a list of the measured defect pixels is created and stored in the camera's non-volatile memory. This list is then used for the correction of acquired images during operation. The correction is inactive by default, but can be turned on by the user if a non-processed output is required.

4 Operation

For a proper operation of your camera there are certain requirements that have to be met. You can read more about these requirements as well as about the correct usage of camera in the following sections.

4.1 System requirements

4.1.1 Software requirements

Cameras are compatible with the following operating systems:

- Windows 10, 11
- Linux Ubuntu
- MacOS 10.8 or newer



All XIMEA cameras are compatible with the most advanced Vision and Image Processing Libraries. See chapter [XIMEA Software Packages](#) for more information about the options to access cameras, as well as a list of currently supported libraries and frameworks supported in Windows. For more information visit page: [API - Application Programming Interfaces](#)

4.1.2 Hardware requirements

The XIMEA cameras are compatible with PCI express Generation 2 & 3.
Please note details and the most recent info at: [PCI Express cameras](#)

System configuration

Recommended system configuration:

For best processing performance and bandwidth, we recommend using the following system configuration. This is essential when using the higher resolution models for achieving maximum frame rate.

CPU: Intel i7

RAM: 4GB RAM or more

Disc Space: 200 MB of free disc space

Video: NVIDIA or Radeon graphics card 128MB or integrated on CPU

Ports: TBD

4.2 XIMEA software packages

4.2.1 XIMEA Windows software package

XIMEA API Software Package can be installed on: Microsoft Windows 10, 11.

Contents

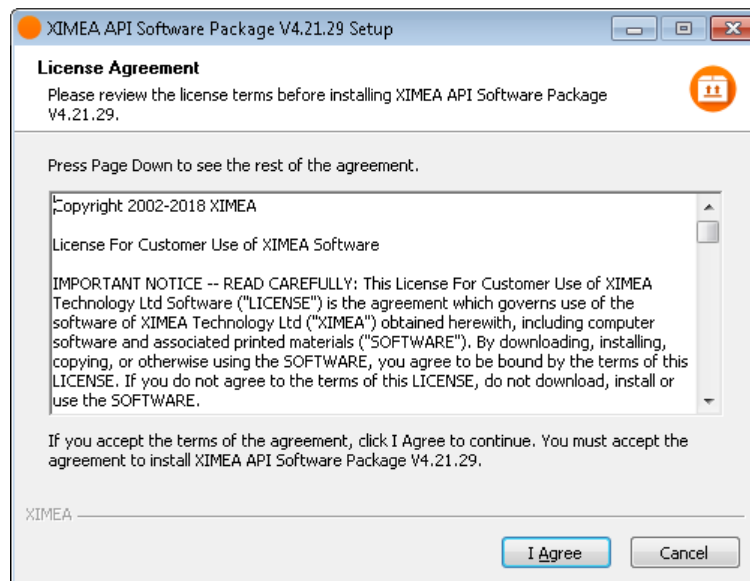
The package contains:

- OS Drivers of all XIMEA camera types for OS Microsoft Windows, Windows Server 2008 R2 x86-64, Windows 10 32/64 bit
- APIs (*xiAPI*, *xiAPI.NET*, *xiApiPython*)
- Examples
- CamTool
- xiCOP
- GenTL Producer - for connection of GenTL Consumer applications
- *Vision Libraries* integration demonstrations:
 - NI LabView interface - xiLib

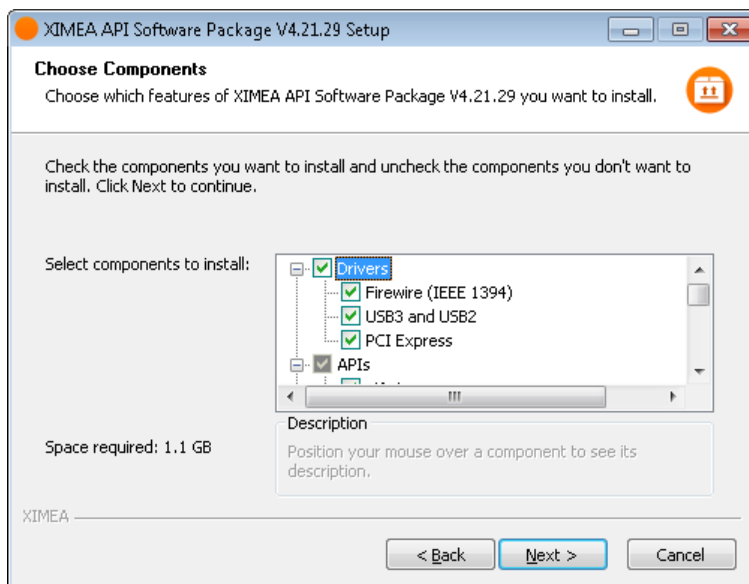
Installation

- Download and execute the XIMEA API Software Package installer (EXE-file, approximate size 100 MB): http://www.ximea.com/downloads/recent/XIMEA_Installer.exe
- Read the License Agreement
- Start the installer

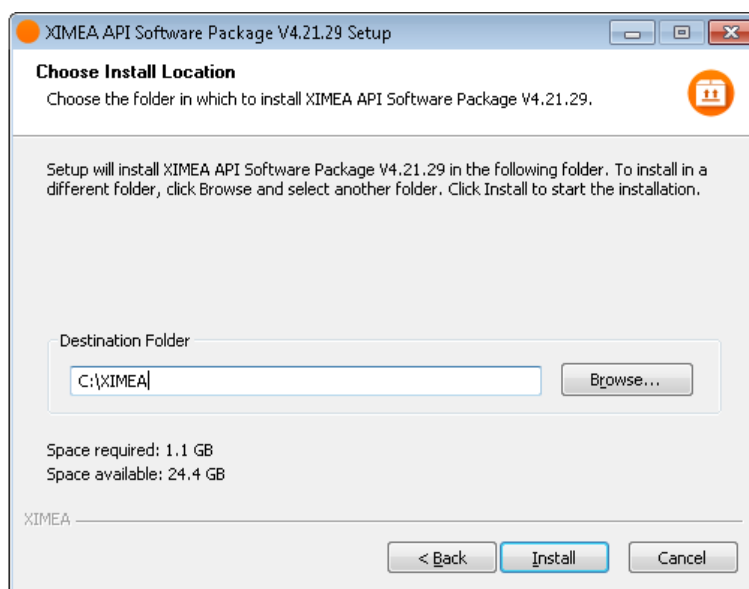
Be sure that you have administrator privileges or start the Installer with administrator rights (right click and select “run as administrator”):



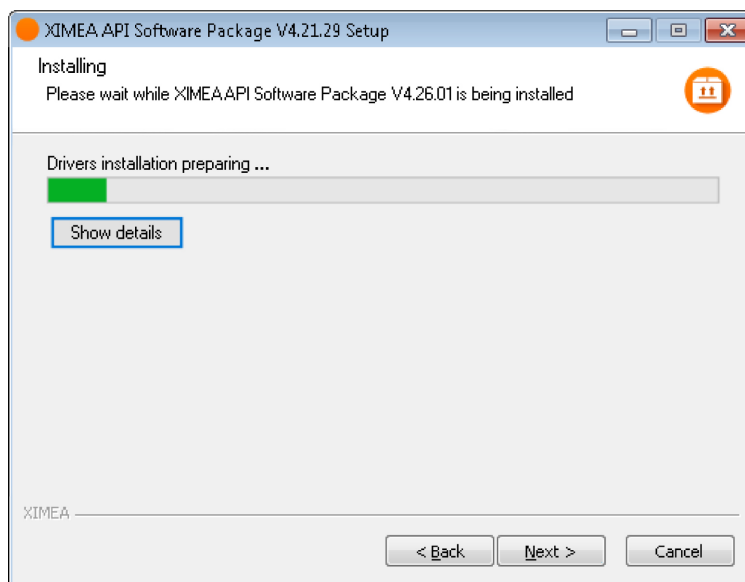
- Select the Software components you want to install. You can uncheck the components you don't want to install, but it is recommended to leave them all checked



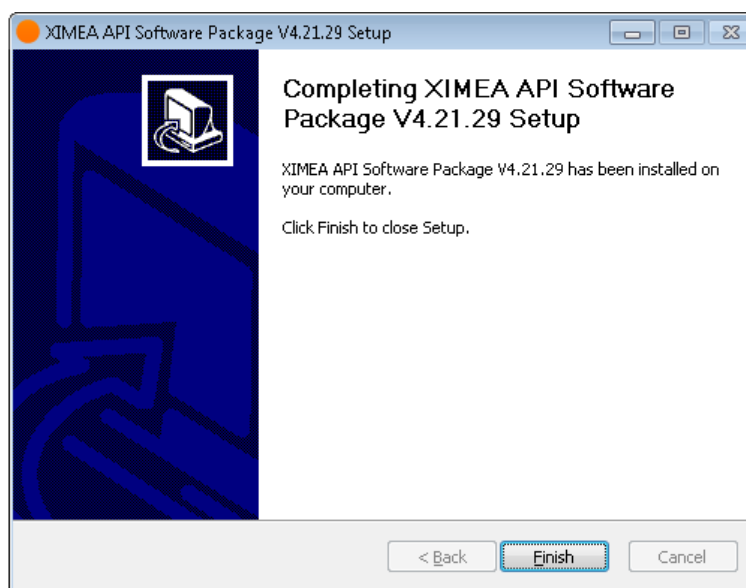
- Specify the install location - you can leave the default location or change it to your desired location



- Now the XIMEA API Software Package should start copying files, updating System Variables and installing drivers if necessary



- Installation is completed
- Finish



4.2.2 XIMEA Linux software package

XIMEA Linux Software Package is tarred installer with files that can be run on Linux Ubuntu 14.04 and 16.04 (32 and 64 Bit) and newer releases.

Contents

The package contains:

- Driver for XIMEA USB2 and USB3 cameras
- xiAPI
- XIMEA CamTool
- Examples:
 - xiSample - sample showing basic image acquisition in xiAPI

Installation

- Download XIMEA Linux Software Package:

http://www.ximea.com/downloads/recent/XIMEA_Linux_SP.tgz

```
wget http://www.ximea.com/downloads/recent/XIMEA_Linux_SP.tgz
```



```
ximea@ximea-Linux64: ~
ximea@ximea-Linux64:~$ wget http://www.ximea.com/downloads/recent/XIMEA_Linux_SP.tgz
--2013-06-05 17:06:29-- http://www.ximea.com/downloads/recent/XIMEA_Linux_SP.tgz
Resolving www.ximea.com (www.ximea.com)... 91.143.80.251
Connecting to www.ximea.com (www.ximea.com)[91.143.80.251]:80... connected.
HTTP request sent, awaiting response... 301 Moved Permanently
Location: http://www.ximea.com/support/attachments/271/XIMEA_Linux_SP.tgz [following]
--2013-06-05 17:06:30-- http://www.ximea.com/support/attachments/271/XIMEA_Linux_SP.tgz
Connecting to www.ximea.com (www.ximea.com)[91.143.80.251]:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 3885021 (3.7M) [application/octet-stream]
Saving to: 'XIMEA_Linux_SP.tgz'

100%[=====] 3,885,021  2.09M/s  in 1.8s

2013-06-05 17:06:31 (2.09 MB/s) - 'XIMEA_Linux_SP.tgz' saved [3885021/3885021]

ximea@ximea-Linux64:~$
```

- Untar

```
tar xzf XIMEA_Linux_SP.tgz
```

```
cd package
```

- Start installation script
`./install`

```
ximea@ximea-Linux64: ~/package
ximea@ximea-Linux64:~$ tar xzf XIMEA_Linux_SP.tgz
ximea@ximea-Linux64:~$ cd package
ximea@ximea-Linux64:~/package$ ./install -cam_usb30
This will install XIMEA Linux Package after 5 seconds
To abort installation - press Ctrl-C
Installing x64 bit version
[sudo] password for ximea:
This is installation of package for platform -x64
Checking if user is super user
OK
-----
WARNING!!!
You have enabled experimental USB3 support! It may affect USB2 support too.
DO NOT downgrade the kernel to versions older than 3.4!!!!
Advised way of enabling USB3 support is upgrading kernel to version at least as new as 3.6.
If you decide to do it in the future, rerun this installation script after rebooting into new k
rnel.
-----
Installing libusb
OK
Installing Firewire support -- libraw1394
OK
Checking Firewire stack
Installing API library
OK
OK
OK
Rebuilding linker cache
Installing XIMEA-GenTL library
OK
Installing vaViewer
OK
Installing streamViewer
OK
Installing xiSample
OK
Creating desktop link for vaViewer
Creating desktop link for streamViewer
Installing udev rules for USB and Firewire cameras
OK
-----
Note:
You may need to reconnect your USB and/or Firewire cameras
Also check that you are in the "plugdev" group
More info:
http://www.ximea.com/support/wiki/apis/Linux_USB20_Support
-----
For GenICam - please add GENICAM_GENTL64_PATH=/opt/XIMEA/lib/libXIMEA_GenTL.so to Your .bashrc
o enable GenTL
Now applications can be started. E.g. /opt/XIMEA/bin/xiSample
-----
Done OK
ximea@ximea-Linux64:~/package$
```

Note: If logged in user is not root, you will be asked for your password to get root access, because the installation runs with root account using sudo.

4.2.3 XIMEA macOS software package

XIMEA macOS Software Package is native DMG installer that can be run on macOS 10.8 (Mountain Lion) or newer.

Contents

The package contains:

- Driver (beta version) for XIMEA USB2 and USB3 cameras
- xiAPI
- XIMEA CamTool
- Examples:
 - xiSample - sample showing basic image acquisition in xiAPI

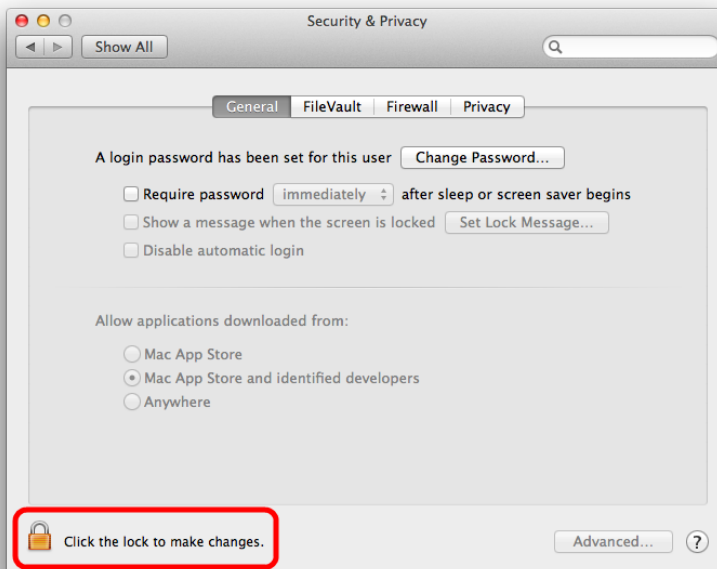
Installation

Before installing XIMEA macOS Software Package it may be necessary to modify security settings on your computer. The new feature of OS X 10.8 called GateKeeper can prevent you from using our macOS Software Package due to the fact that the current version is unsigned.

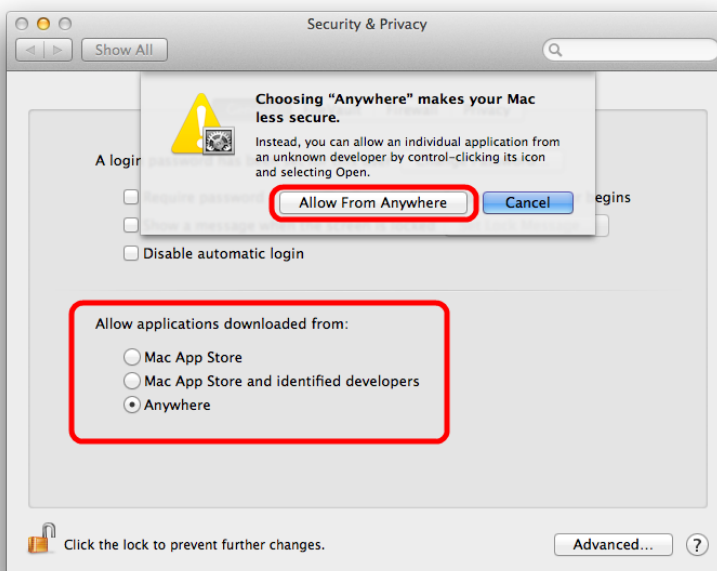
- Open System Preferences application and click on Security & Privacy



- Click on the lock to allow changes to be made



- On the General Tab select the option Anywhere under Allow applications downloaded from:



- Download XIMEA macOS Software:
http://www.ximea.com/downloads/recent/XIMEA_OSX_SP.dmg
- Mount it by double-clicking this file in Finder
- Run the install script to install XiAPI on your macOS system
- A window with package contents will open

Start XIMEA CamTool

- Connect camera
- Start Applications / XIMEA CamTool
- Start acquisition by clicking on orange triangle at upper left corner of CamTool



Short description

The CamTool is a cross-platform application showcasing the features of all XIMEA camera families. It runs on Windows, Linux, macOS systems offering a substantial imaging tool set, which can be further extended with custom modules using a plugin infrastructure. CamTool is based on Qt for the UI and xiAPI for the camera control. Its camera settings menu resembles the parameter set of the xiAPI.

4.3 XIMEA CamTool

CamTool allows to operate all connected cameras simultaneously. In this case all controls are layered for the cameras. Basic controls are placed as tabs in upper part of the window. Image window can be detached from application if needed. Amount of visible camera controls depend on visibility level which can be set in Edit → Options. For more information, please, refer to: [CamTool](#)

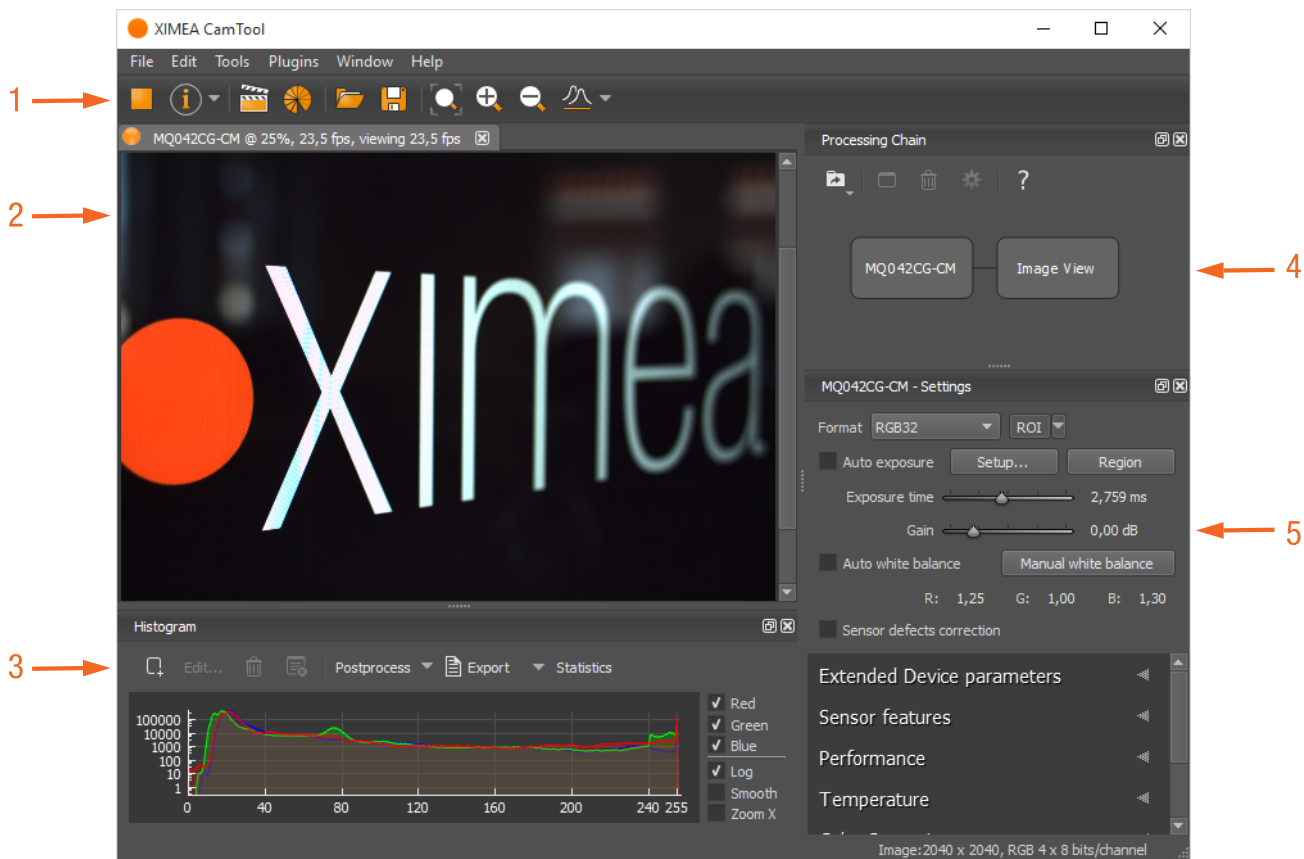


Figure 78: Camtool

Number	1	2	3	4	5
Description	Control panel	Image window	Analytics tools	Processing chain	Camera control

Functions

- To see live image from multiple XIMEA cameras connected
- Control the camera parameters
- Store of camera image and video
- Analyze the image properties
- Histogram and line profile
- Image averaging, image flip/mirror
- Software trigger timer, save/load camera and program settings
- LUT (Look up table)
- Lua scripting

4.4 XIMEA control panel

The XIMEA Control Panel (xiCOP), is a diagnostics and management tool for all XIMEA cameras. xiCOP is available for Windows (32, 64-bit) and Linux (64-bit) operating system.

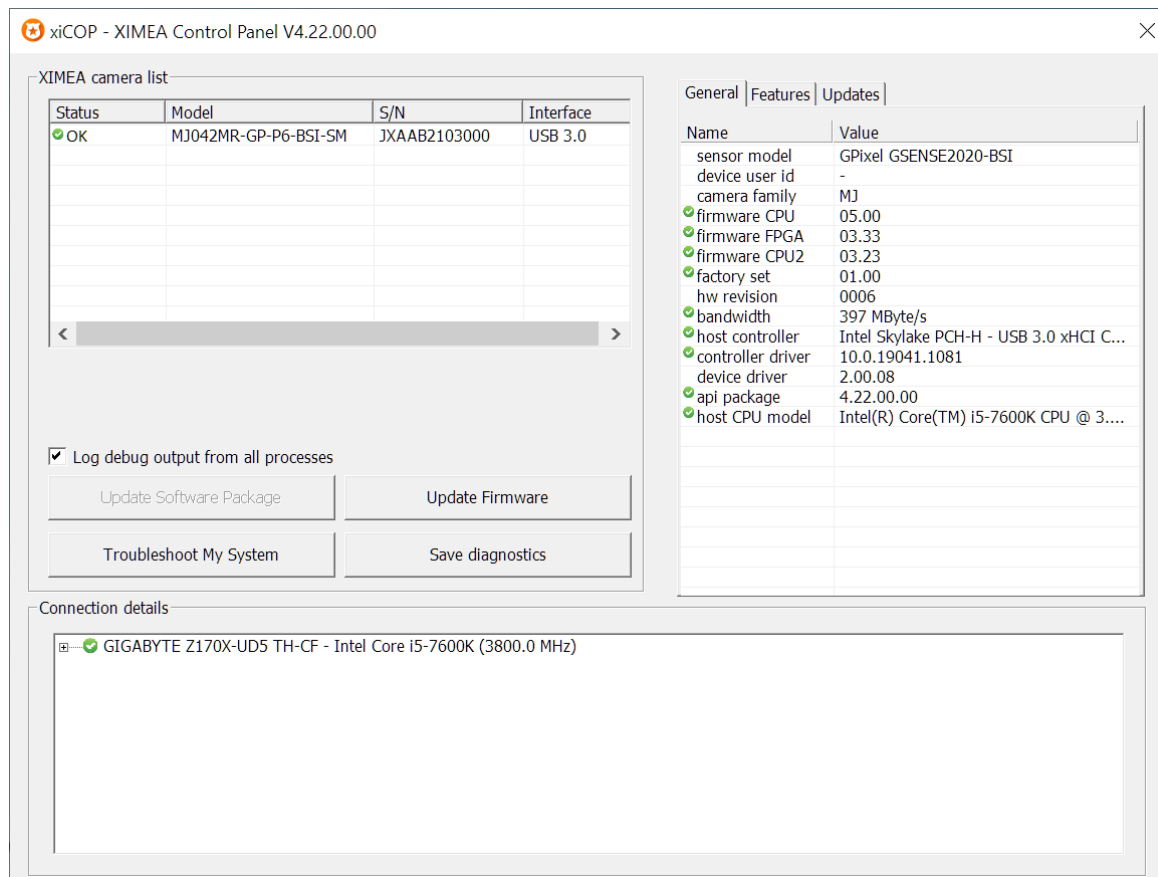


Figure 79: xiCOP example

Features

- Facilitates diagnostics of system performance bottlenecks
xiCOP is capable of retrieving the system's hardware tree, thus problematic hardware configurations can be identified
- Diagnosis of firmware and software compatibility
xiCOP checks relevant firmware and software versions and warns if a component is not up-to-date
- Lists all currently attached XIMEA devices and their features.
- Saves a diagnostic log and debug output which can be reviewed by technical support
- Suggests solution for diagnosed issues
- Allows setting of User IDs to XIMEA cameras
- One click to switch selected XIMEA cameras to USB3 Vision standard and back to XIMEA API
- One click update to the latest XIMEA API Software Package
- One click update of firmware in selected cameras

4.5 Supported vision libraries

All XIMEA cameras are compatible with the most advanced vision and image processing libraries. For GUI based software packages, the cameras can be directly accessed without the need of programming. Code libraries are generally used in conjunction with one of our APIs, in order to add additional functionality (e.g. image processing, communication, data storage).

For an up-to-date listing of the supported vision libraries and software packages, visit our web site:

<http://www.ximea.com/support/projects/vision-libraries/wiki>.

4.5.1 MathWorks MATLAB



MathWorks® is the leading developer and supplier of software for technical computing and Model-Based Design. More: <http://www.mathworks.de/>

https://www.ximea.com/support/wiki/vision-libraries/MathWorks_Matlab

4.5.2 MVTec HALCON



HALCON is the comprehensive standard software for machine vision with an integrated development environment (IDE) that is used world-wide. More: <http://www.mvtec.com/halcon/>

https://www.ximea.com/support/wiki/vision-libraries/MVTec_HALCON

4.5.3 National Instruments LabVIEW vision library



LabVIEW is a graphical programming environment. More: <http://www.ni.com/labview/>

https://www.ximea.com/support/wiki/vision-libraries/National_Instruments_LabVIEW

4.5.4 OpenCV



OpenCV is an open-source library of programming functions mainly aimed at real time computer vision. More: <https://opencv.org/>

<https://www.ximea.com/support/wiki/vision-libraries/OpenCV>

4.6 Programming

Depending on the target application, the user can choose between several ways of accessing and controlling the camera. These can be divided into two categories: a programmatic approach, through programming code, or an integrated approach, through a supported, GUI based software package. The programmatic approach is generally used for the development of a custom application or image processing pipeline. The integrated approach is favored, if the specific toolset of a certain software package is sufficient and the camera serves as an integrated capture device.

4.6.1 Standard interface

As an alternative to the proprietary API, the camera can be accessed through a set of standard interfaces. These interfaces decouple a specific hardware design (e.g. physical interface) of a camera from its control in software. Therefore, multiple camera classes and types can be used in a unified way.

GenICam/GenTL

GenICam/GenTL provides a camera-agnostic transport layer interface to acquire images or other data and to communicate with a device. Each camera serves as a GenTL Producer which can be accessed in all software packages that are compatible with the GenICam standard, as well as through custom developments which implement this standard interface. For more information on programming according the GenICam standard, please visit the standard's website at <http://www.emva.org/standards-technology/genicam/>

4.6.2 xiAPI

xiAPI stands for XIMEA Application Programming Interface. It is a common interface for all XIMEA cameras.

Architecture

API is a software interface between the camera system driver and application.

- On Windows: xiAPI is compiled into xiapi32.dll or xiapi64.dll
- On Linux: xiAPI is compiled into /usr/lib/libm3api.so

Installation

xiAPI is part of all current XIMEA software packages for Windows, Linux and MacOS. For information on the software packages, see [XIMEA Software Packages](#).

xiAPI functions description

The core of xiAPI consists of the following functions, which allow controlling of the camera functionality.

```
// get the number of discovered devices.
XI_RETURN xiGetNumberDevices(OUT DWORD *pNumberDevices);

// open interface
XI_RETURN xiOpenDevice(IN DWORD DevId, OUT PHANDLE hDevice);

// get parameter
XI_RETURN xiGetParam(IN HANDLE hDevice, const char* prm, void* val,
    DWORD * size, XI_PRM_TYPE * type);

// set parameter
XI_RETURN xiSetParam(IN HANDLE hDevice, const char* prm, void* val,
    DWORD size, XI_PRM_TYPE type);
```

```
// start the data acquisition
XI_RETURN xiStartAcquisition(IN HANDLE hDevice);

// acquire image and return image information
XI_RETURN xiGetImage(IN HANDLE hDevice, IN DWORD TimeOut, INOUT XI_IMG * img);

// stop the data acquisition
XI_RETURN xiStopAcquisition(IN HANDLE hDevice);

// close interface
XI_RETURN xiCloseDevice(IN HANDLE hDevice);
```

xiAPI parameters description

For a complete list of available parameters, please visit the xiAPI online manual at http://www.ximea.com/support/wiki/apis/XiAPI_Manual. All functions in xiAPI return status values in form of the XI_RETURN structure which is defined in xiApi.h. If a parameter is not supported by a certain camera, the return value will represent a respective error code (e.g. 106 - Parameter not supported).

Note: Since xiAPI is a unified programming interface for all of XIMEA's cameras, not all of the described parameters apply for every camera and sensor model.

xiAPI examples

Connect device

This example shows the enumeration of available devices. If any device was found the first device (with index 0) is opened.

```
HANDLE xiH = NULL;

// Get number of camera devices
DWORD dwNumberOfDevices = 0;
xiGetNumberDevices(&dwNumberOfDevices);

if (!dwNumberOfDevices)
{
    printf("No camera found\n");
}
else
{
    // Retrieving a handle to the camera device
    xiOpenDevice(0, &xiH);
}
```

Parameterize device

This example shows how an exposure time is set. Next, the maximum possible downsampling rate is retrieved and the result is set as new downsampling rate.

```
// Setting "exposure" parameter (10ms)
int time_us = 10000;
xiSetParam(xiH, XI_PRM_EXPOSURE, &time_us, sizeof(time_us), xiTypeInteger);

// Getting maximum possible downsampling rate
int dspl_max = 1;
xiGetParamInt(xiH, XI_PRM_DOWNSAMPLING XI_PRM_INFO_MAX, &dspl_max);

// Setting maximum possible downsampling rate
xiSetParamInt(xiH, XI_PRM_DOWNSAMPLING, dspl_max);
```

Acquire images

This example shows how the acquisition is started on the device with the handle xiH, ten images are acquired in a row and the acquisition is stopped.

```

        xiStartAcquisition(xiH);

#define EXPECTED_IMAGES 10
for (int images=0;images < EXPECTED_IMAGES;images++)
{
    // getting image from camera
    xiGetImage(xiH, 5000, &image);
    printf("Image %d (%dx%d) received from camera\n", images,
        (int)image.width, (int)image.height);
}
    xiStopAcquisition(xiH);

```

Hardware trigger and exposure active output

In this setup each image is triggered by a Digital Input Trigger. After the image is triggered, it can be transferred using xiGetImage. This setup ensures a low latency between the trigger signal and image Exposure start.

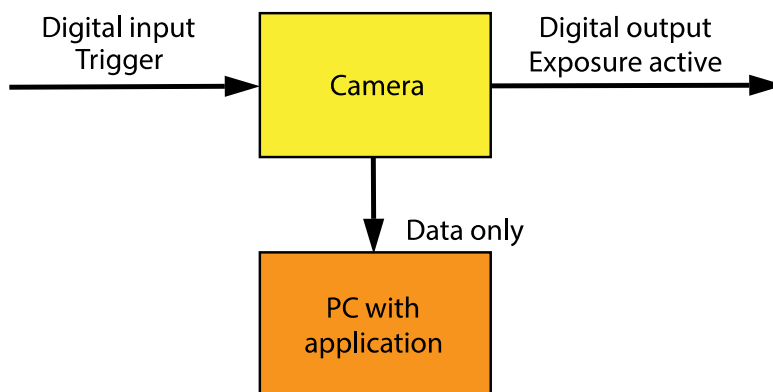


Figure 80: GPIO schematic

```

        HANDLE xiH;
    xiOpenDevice(0, & xiH);

    // select trigger source
    xiSetParamInt(xiH, XI_PRM_TRG_SOURCE, XI_TRG_EDGE_RISING);

    // select input pin 1 mode
    xiSetParamInt(xiH, XI_PRM_GPI_SELECTOR, 1);
    xiSetParamInt(xiH, XI_PRM_GPI_MODE, XI_GPI_TRIGGER)

    // set digital output 1 mode
    xiSetParamInt(xiH, XI_PRM_GPO_SELECTOR, 1);
    xiSetParamInt(xiH, XI_PRM_GPO_MODE, XI_GPO_EXPOSURE_ACTIVE);

    xiStartAcquisition(handle1);

    // Trigger signal should start image exposure within timeout
#define TIMEOUT_IMAGE_WAITING_MS 10000
    xiGetImage(handle, TIMEOUT_IMAGE_WAITING_MS, &image);
    // process image here...

```

xiAPI Auto Bandwidth Calculation

xiAPI uses Auto Bandwidth Calculation (ABC) before the opening of each camera by default. After the measurement, 90% of the measured value is used as the maximum allowed transfer speed of the camera to ensure the stability of transfer.

It is important to set this parameter to XI_OFF to ensure highest possible data transfer speed.

To disable ABC, the application should set parameter XI_PRM_AUTO_BANDWIDTH_CALCULATION to XI_OFF before the first xiOpenDevice is used. This setting disabled ABC and the camera stream is not limited.

xiAPI.NET

XIMEA Application Programming Interface for Dot Net - Microsoft Visual C#. **xiAPI.NET** is designed as a wrapper around xiAPI and therefore shares most of its functionality.

xiApiPython

Applications in Python can access XIMEA cameras using **xiApiPython** interface. It is a wrapper around xiAPI, which integrates camera features and capabilities into PYTHON.

5 Appendix

5.1 Troubleshooting and support

This chapter explains how to proceed, if you have issues in bringing your camera to proper operation.

At first, please make sure that you have installed the latest version of the following XIMEA software package, based on your OS:

- XIMEA Windows Software Package
https://www.ximea.com/support/wiki/apis/XIMEA_Windows_Software_Package
- XIMEA Linux Software Package
https://www.ximea.com/support/wiki/apis/XIMEA_Linux_Software_Package
- XIMEA macOS Software Package
https://www.ximea.com/support/wiki/apis/XIMEA_macOS_Software_Package

Please make sure, that you have connected your camera with the appropriate XIMEA cable to an appropriate port. Ensure that the connections are carefully locked. Follow the instructions described in section 4.3 (run the camera with the Ximea CamTool). In case that you still have issues, please read the following chapters.

5.1.1 Worldwide support

We offer worldwide first level support to you by our partners. Please refer to your local dealer if you need technical support for your camera.

5.1.2 Before contacting technical support

There are several steps to take before contacting your local dealer for technical support. In case you cannot display images from your camera, please open the XIMEA xiCOP software (please see section 4.4). It will immediately start searching for connected cameras. Your camera will appear in the XIMEA camera list on the upper left side of the xiCOP window if it is connected properly and your USB interface meets the minimum system requirements described in section 4.1. If the camera does not appear, please proceed with the following steps:

- Step 1** Click on the button “Troubleshoot My System” and follow the instructions that are suggested.
- Step 2** If step 1 does not lead to a positive result, please click the button “Save diagnostics”. Keep the diagnostic file ready for providing it to support.
- Step 3** Contact your local dealer where you bought the camera either by phone or by email for first level support. They will decide if they can help you immediately or if more information is necessary for initiating the next steps.

5.2 Frequently Asked Questions

- Frequently Asked Questions
http://www.ximea.com/support/wiki/allprod/Frequently_Asked_Questions
- Knowledge Base
http://www.ximea.com/support/wiki/allprod/Knowledge_Base

5.3 Product service request (PSR)

If you experienced any unexpected behavior of your camera, please, follow the steps described below:

5.3.1 Step 1 – Contact support

If your camera is not working as expected, please, contact your local dealer for troubleshooting the product and determine the eligibility of a Product Service Request (PSR).

In case you were asked to create a PSR by your local contact, please continue to [Step 2](#).

NOTE: Your product must be UNDER WARRANTY in order to qualify for a free repair or replacement.

5.3.2 Step 2 – Create product service request (PSR)

- Read the XIMEA General Terms & Conditions at: <http://www.ximea.com/en/corporate/generaltc>
- Open the XIMEA Helpdesk at: <https://desk.ximea.com/new-ticket>
- Set field Department to “Service”
- Fill in all fields
- Confirm with the button “Submit”

5.3.3 Step 3 – Wait for PSR approval

Our support personnel will verify the PSR for validity.

If your PSR is valid and no further information is required, the PSR will be approved within 3 business days. After that you will get a notification email contains the shipping instructions.

When you received the PSR Approval email – please continue to [Step 4](#).

In case your PSR was rejected – please do not send the product to XIMEA.

5.3.4 Step 4 – Sending the camera to XIMEA

If possible, send the camera back in the original package. If not possible, please pack the camera in a way that it cannot be damaged during shipment and send it back as described in the PSR Approval email that you have received.

5.3.5 Step 5 – Waiting for service conclusion

Once we have received the camera, we will send you a notification. The XIMEA Service will then check the status of the camera that you have sent for a possible repair. Depending on warranty conditions, product status and agreement one of the following operations will be performed:

	Operation	Repair costs paid by	Return delivery costs paid by
	repaired in warranty	XIMEA	XIMEA
	replaced in warranty	XIMEA	XIMEA
	repaired for cost	Customer	Customer
	not repaired and returned	—	Customer
	not repaired and discarded if requested by customer	—	—

Table 32: service operations overview

If the camera will be returned, you will receive the tracking number. In this case, please continue to [Step 6](#).

5.3.6 Step 6 – Waiting for return delivery

After you have received the return shipment, please confirm it by changing the status of the PSR to “Received by customer”.

5.4 Safety instructions and precautions

This chapter describes safety instructions and precautions valid for cameras. In order to avoid harm or damage your camera, please handle it as described in this manual, paying special attention to the following warnings:

5.4.1 Disassembly

There are no switches or parts inside the cameras that requires any kind of mechanical adjustment. Please note that the warranty is voided by opening the camera housing.

Do not disassemble the camera except removing lens mount (or removing cooling element if camera has one), see [Lens mount](#).

5.4.2 Mounting / Screws

Use only the designated threaded holes for mounting the camera. Please note the camera / bracket drawings in chapter [Mechanical characteristics](#).

Use only the specified screws and torques when fastening, see [Mounting points](#).

5.4.3 Connections

Use only recommended connectors and cables. Please check the system requirements described in chapter [System requirements](#).

5.4.4 Power supply

Use only the recommended electrical power supply. Camera can be bus powered or powered from external power supply, for detailed information see section [Power supply](#) .

5.4.5 Environment / protection against water

Use camera in acceptable environment only, please note the descriptions in section [Environment](#). Protect the camera against contact with water. Do not let camera get wet.

Damage may be caused by:

- Overheating
- Contact with water
- Operation in an environment with condensing humidity
- Mechanical shock

5.4.6 Recommended light conditions

Do not expose the camera to light sources with intense energy, e.g. laser beams or X-ray.

Light intensity or exposure time exceeding the saturation of the sensor may damage the sensor irreparably. This may occur e.g. in the following situations:

- High-energy laser light hitting the sensor directly
- Bright light sources hitting the sensor directly (burn-in)
- Camera is exposed to X-rays

The warranty does not cover damaged cameras caused by X-ray applications or very high intensity light / laser light.

5.4.7 Protection of optical components

- Do not touch the optical components with hard or abrasive objects,
- when handling the camera, avoid touching the lenses and filter glasses,
- fingerprints or other impurities may affect the image quality and may damage the surfaces,
- mount / dismount lenses and additional filters only in a dust free environment.
- do not use compressed air as this could push dust into the camera (and lenses).

5.4.8 Mechanical loads

Avoid excessive shaking, throwing, dropping or any kind of mishandling of the device.

5.4.9 Camera / lens cleaning

- Use only optical quality tissue / cloth (dry cotton) a standard camera lens cleaning kit, if you must clean a lens or filter. Do not apply excessive force.
- Use only optics cleaner (e.g. 60 % ethyl alcohol, 40 % ether). Never use aggressive cleaners like gasoline or spirits. Such cleaners may destroy the surface.
- Do not use compressed air.

5.4.10 Protect against static discharge (ESD)

Image sensors and the PCB are easily damaged by static discharge (ESD).

- Please use anti-static gloves, clothes and materials. Also use conductive shoes.
- Wear an ESD protection wrist strap.
- Install a conductive mat on the floor and/or working table to prevent the generation of static electricity.

5.4.11 Safety instruction for board level cameras

Abuse or misapplication of the board level camera may result in limited warranty or cancelation of warranty. Due to the exposed electronics, special rules apply:

- Only qualified personnel are allowed to handle, install and operate the board level cameras.
- Board level cameras are delivered without housing. Handle the PCB and the sensor with care. Do not bend the boards. Do not touch the components or contacts on a board. Hold the board by its edges only.
- Protect the board level camera against static discharge (see [Protect against static discharge \(ESD\)](#) discharge (ESD)).
- Do not hold any components of your board level cameras against your clothing, even if you are wearing a wrist strap.
- Do not remove the board level camera from its anti-static packaging unless your body is grounded.
- To protect the boards from radiation of other modules or devices a housing or shielding may be required.
- Be sure that the board level camera has no contact to any electrical source before mounting or making connections to the board level camera.
- Do not connect or disconnect any cables or use the board level camera during an electrical storm.
- Avoid any mechanical forces to the board level cameras, especially torsional, tensile and compressive forces. Any of these forces may result in damage of the board level cameras.
- Always use clean boards.
- To protect the boards from dirt like dust or liquids always use the board level cameras in clean room environment or use a protective housing.

5.5 Warranty

In addition to the provisions of Article VIII of the Standard Terms & Conditions of XIMEA GmbH (see [Standard Terms & Conditions of XIMEA GmbH](#)) the following additions and specifications apply:

XIMEA warrants to the Original Purchaser that the Camera provided is guaranteed to be free from material and manufacturing defects for a period of two years. Should a unit fail during this period, XIMEA will, at its option, repair or replace the damaged unit. Repaired or replaced Products are covered for the remainder of the original Product warranty period.

Warranty is void if any proprietary labeling is removed. This warranty does not apply to units that, after being examined by XIMEA, have been found to have failed due to customer abuse, mishandling, alteration, improper installation or negligence. If the original camera module is housed within a case, removing the case for any purpose voids this warranty. This warranty does not apply to damage to any part of the optical path resulting from removal or replacement of the protective glass or filter over the camera, such as scratched glass or sensor damage. If the camera is disassembled, reworked or repaired by anyone other than a recommended service person, XIMEA or its suppliers will take no responsibility for the subsequent performance or quality of the camera.

XIMEA expressly disclaims and excludes all other warranties, express, implied and statutory, including, but without limitation, warranty of merchantability and fitness for a particular application or purpose. In no event shall XIMEA be liable to the Original Purchaser or any third party for direct, indirect, incidental, consequential, special or accidental damages, including without limitation damages for business interruption, loss of profits, revenue, data or bodily injury or death except in case of willful misconduct by XIMEA or employees of XIMEA.

5.5.1 Disclaimer of Warranty

In addition to the provisions of Article XII of the Standard Terms & Conditions of XIMEA GmbH (see [Standard Terms & Conditions of XIMEA GmbH](#)) the following apply:

Although XIMEA has taken care to ensure the accuracy of the information contained herein it accepts no responsibility for the consequences of any use thereof and also reserves the right to change the specification of goods without notice.

XIMEA does not assume any liability for damage that is the result of improper use of its products or failure to comply with the operating manuals or the applicable rules and regulations.

5.6 Standard Terms & Conditions of XIMEA GmbH

Printed here for your information is the version from May 2021. Please check the most current version at

[XIMEA General Terms and Conditions](#)

General Conditions

for the Supply of Products and Services of the Electrical and Electronics Industry (“Grüne Lieferbedingungen” – GL)*
for commercial transactions between businesses

recommended by ZVEI-Zentralverband Elektrotechnik- und Elektronikindustrie e. V.

as of January 2022 (with 24 months warranty period), and listed below

Article I: General Provisions

1. Legal relations between Supplier and Purchaser in connection with supplies and/or services of the Supplier (hereinafter referred to as “Supplies”) shall be solely governed by the present GL. The Purchaser’s general terms and conditions shall apply only if expressly accepted by the Supplier in writing. The scope of delivery shall be determined by the congruent mutual written declarations.
2. The Supplier herewith reserves any industrial property rights and/or copyrights and rights of use pertaining to its cost estimates, drawings and other documents (hereinafter referred to as “Documents”). The Documents shall not be made accessible to third parties without the Supplier’s prior consent and shall, upon request, be returned without undue delay to the Supplier if the contract is not awarded to the Supplier. Sentences 1 and 2 shall apply mutatis mutandis to the Purchaser’s Documents; these may, however, be made accessible to those third parties to whom the Supplier has rightfully subcontracted Supplies.
3. The Purchaser has the non-exclusive right to use standard software and firmware, provided that it remains unchanged, is used within the agreed performance parameters, and on the agreed equipment. Without express agreement the Purchaser may make one back-up copy of standard software.
4. Partial deliveries are allowed, unless they are unreasonable to accept for the Purchaser.
5. The term “claim for damages” used in the present GL also includes claims for indemnification for useless expenditure.

Article II: Prices, Terms of Payment, and Set-Off

1. Prices are ex works and excluding packaging; value added tax shall be added at the then applicable rate.
2. If the Supplier is also responsible for assembly or erection and unless otherwise agreed, the Purchaser shall pay the agreed remuneration and any incidental costs required, e. g. for traveling and transport as well as allowances.
3. Payments shall be made free Supplier’s paying office.
4. The Purchaser may set off only those claims which are undisputed or non-appealable.

Article III: Retention of Title

1. The items pertaining to the Supplies (“Retained Goods”) for which the purchase price claim is due immediately or for which a payment period of up to and including 30 days after delivery, delivery with installation/assembly or receipt of invoice has been agreed for the due date of the purchase price claim shall remain the property of the Supplier until payment has been made in total.
2. In all other cases, the items pertaining to the Supplies (“Retained Goods”) shall remain the Supplier’s property until each and every claim the Supplier has against the Purchaser on account of the business relationship has been fulfilled. If the combined value of the Supplier’s security interests exceeds the value of all secured claims by more than 20 %, the Supplier shall release a corresponding part of the security interest if so requested by the Purchaser; the Supplier shall be entitled to choose which security interest it wishes to release.
3. For the duration of the retention of title, the Purchaser may not pledge the Retained Goods or use them as security, and resale shall be possible only for resellers in the ordinary course of their business and only on condition that the reseller receives payment from its customer or makes the transfer of property to the customer dependent upon the customer fulfilling its obligation to effect payment.
4. Should Purchaser resell Retained Goods, it assigns to the Supplier, already today, all claims it will have against its customers out of the resale, including any collateral rights and all balance claims, as security, without any subsequent declarations to this effect being necessary. If the Retained Goods are sold on together with other items and no individual price has been agreed with respect to the Retained Goods,

Purchaser shall assign to the Supplier such fraction of the total price claim as is attributable to the price of the Retained Goods invoiced by Supplier.

5. (a) Purchaser may process, amalgamate or combine Retained Goods with other items. Processing is made for Supplier. Purchaser shall store the new item thus created for Supplier, exercising the due care of a diligent business person. The new items are considered as Retained Goods.

(b) Already today, Supplier and Purchaser agree that if Retained Goods are combined or amalgamated with other items that are not the property of Supplier, Supplier shall acquire co-ownership in the new item in proportion of the value of the Retained Goods combined or amalgamated to the other items at the time of combination or amalgamation. In this respect, the new items are considered as Retained Goods.

(c) The provisions on the assignment of claims according to No. 4 above shall also apply to the new item. The assignment, however, shall only apply to the amount corresponding to the value invoiced by Supplier for the Retained Goods that have been processed, combined or amalgamated.

(d) Where Purchaser combines Retained Goods with real estate or movable goods, it shall, without any further declaration being necessary to this effect, also assign to Supplier as security its claim to consideration for the combination, including all collateral rights for the prorate amount of the value the combined Retained Goods have on the other combined items at the time of the combination.

6. Until further notice, Purchaser may collect assigned claims relating to the resale. Supplier is entitled to withdraw Purchaser's permission to collect funds for good reason, including, but not limited to delayed payment, suspension of payments, start of insolvency proceedings, protest or justified indications for overindebtedness or pending insolvency of Purchaser. In addition, Supplier may, upon expiry of an adequate period of notice disclose the assignment, realize the claims assigned and demand that Purchaser informs its customer of the assignment.

7. The Purchaser shall inform the Supplier forthwith of any seizure or other act of intervention by third parties. If a reasonable interest can be proven, Purchaser shall, without undue delay, provide Supplier with the information and/or Documents necessary to assert the claims it has against its customers.

8. Where the Purchaser fails to fulfill its duties, fails to make payment due, or otherwise violates its obligations the Supplier shall be entitled to rescind the contract and take back the Retained Goods in the case of continued failure following expiry of a reasonable remedy period set by the Supplier; the statutory provisions providing that a remedy period is not needed shall be unaffected. The Purchaser shall be obliged to return the Retained Goods. The fact that the Supplier takes back Retained Goods and/or exercises the retention of title, or has the Retained Goods seized, shall not be construed to constitute a rescission of the contract, unless the Supplier so expressly declares.

Article IV: Time for Supplies; Delay

1. Times set for Supplies shall only be binding if all Documents to be furnished by the Purchaser, necessary permits and approvals, especially concerning plans, are received in time and if agreed terms of payment and other obligations of the Purchaser are fulfilled. If these conditions are not fulfilled in time, times set shall be extended reasonably; this shall not apply if the Supplier is responsible for the delay.

2. If non-observance of the times set is due to:

(a) force majeure, such as mobilization, war, terror attacks, rebellion or similar events (e. g. strike or lockout);

(b) virus attacks or other attacks on the Supplier's IT systems occurring despite protective measures were in place that complied with the principles of proper care;

(c) hindrances attributable to German, US or otherwise applicable national, EU or international rules of foreign trade law or to other circumstances for which Supplier is not responsible; or

(d) the fact that Supplier does not receive its own supplies in due time or in due form such times shall be extended accordingly.

3. If the Supplier is responsible for the delay (hereinafter referred to as "Delay") and the Purchaser has demonstrably suffered a loss therefrom, the Purchaser may claim a compensation as liquidated damages of 0.5 % for every completed week of Delay, but in no case more than a total of 5 % of the price of that part of the Supplies which due to the Delay could not be put to the intended use.

4. Purchaser's claims for damages due to delayed Supplies as well as claims for damages in lieu of performance exceeding the limits specified in No. 3 above are excluded in all cases of delayed Supplies, even upon expiry of a time set to the Supplier to effect the Supplies. This shall not apply in cases of liability based on intent, gross negligence, or due to loss of life, bodily injury or damage to health. Rescission of the contract by the Purchaser based on statute is limited to cases where the Supplier is responsible for the delay. The above provisions do not imply a change in the burden of proof to the detriment of the Purchaser.

5. At the Supplier's request, the Purchaser shall declare within a reasonable period of time whether it, due to the delayed Supplies, rescinds the contract or insists on the delivery of the Supplies.

6. If dispatch or delivery, due to Purchaser's request, is delayed by more than one month after notification of the readiness for dispatch was given, the Purchaser may be charged, for every additional month commenced, storage costs of 0.5 % of the price of the items of the Supplies, but in no case more than a total of 5 %. The parties to the contract may prove that higher or, as the case may be, lower storage costs have been incurred.

Article V: Passing of Risk

1. Even where delivery has been agreed freight free, the risk shall pass to the Purchaser as follows:

(a) if the delivery does not include assembly or erection, at the time when it is shipped or picked up by the carrier. Upon the Purchaser's request, the Supplier shall insure the delivery against the usual risks of transport at the Purchaser's expense;

(b) if the delivery includes assembly or erection, at the day of taking over in the Purchaser's own works or, if so agreed, after a successful trial run.

2. The risk shall pass to the Purchaser if dispatch, delivery, the start or performance of assembly or erection, the taking over in the Purchaser's own works, or the trial run is delayed for reasons for which the Purchaser is responsible or if the Purchaser has otherwise failed to accept the Supplies.

Article VI: Assembly and Erection

Unless otherwise agreed in written form, assembly and erection shall be subject to the following provisions:

1. Purchaser shall provide at its own expense and in due time:

(a) all earth and construction work and other ancillary work outside the Supplier's scope, including the necessary skilled and unskilled labor, construction materials and tools;

(b) the equipment and materials necessary for assembly and commissioning such as scaffolds, lifting equipment and other devices as well as fuels and lubricants;

(c) energy and water at the point of use including connections, heating and lighting;

(d) suitable dry and lockable rooms of sufficient size adjacent to the site for the storage of machine parts, apparatus, materials, tools, etc. and adequate working and recreation rooms for the erection personnel, including sanitary facilities as are appropriate in the specific circumstances; furthermore, the Purchaser shall take all measures it would take for the protection of its own possessions to protect the possessions of the Supplier and of the erection personnel at the site;

(e) protective clothing and protective devices needed due to particular conditions prevailing on the specific site.

2. Before the erection work starts, the Purchaser shall unsolicitedly make available any information required concerning the location of concealed electric power, gas and water lines or of similar installations as well as the necessary structural data.

3. Prior to assembly or erection, the materials and equipment necessary for the work to start must be available on the site of assembly or erection and any preparatory work must have advanced to such a degree that assembly or erection can be started as agreed and carried out without interruption. Access roads and the site of assembly or erection must be level and clear.

4. If assembly, erection or commissioning is delayed due to circumstances for which the Supplier is not responsible, the Purchaser shall bear the reasonable costs incurred for idle times and any additional traveling expenditure of the Supplier or the erection personnel.

5. The Purchaser shall attest to the hours worked by the erection personnel towards the Supplier at weekly intervals and the Purchaser shall immediately confirm in written form if assembly, erection or commissioning has been completed.

6. If, after completion, the Supplier demands acceptance of the Supplies, the Purchaser shall comply therewith within a period of two weeks. The same consequences as upon acceptance arise if and when the Purchaser lets the two-week period expire or the Supplies are put to use after completion of agreed test phases, if any.

Article VII: Receiving Supplies

The Purchaser shall not refuse to receive Supplies due to minor defects.

Article VIII: Defects as to Quality

The Supplier shall be liable for defects as to quality (“Sachmängel”, hereinafter referred to as “Defects”), as follows:

1. The Supplies are free from Defects if upon the passing of the risk they comply with the subjective requirements, the objective requirements and the installation requirements pursuant to Sec. 434 German Civil Code (“Bürgerliches Gesetzbuch”). 2 If the parties have agreed on the quality of the Supplies (“Beschaffensvereinbarung”), the question whether the Supplies meet the objective requirements shall be determined exclusively by such agreement. 3 Sentence 2 shall not apply if the last contract in the supply chain is a sale of consumer goods.

2. Defective parts or defective services shall be, at the Supplier’s discretion, repaired, replaced or provided again free of charge, provided that the reason for the Defect had already existed at the time when the risk passed.

3. Claims for repair or replacement are subject to a statute of limitations of 24 months calculated from the start of the statutory statute of limitations; the same shall apply mutatis mutandis in the case of rescission and reduction. This shall not apply: - where longer periods are prescribed by law according to Sec. 438 para. 1 No. 2 (buildings and things used for a building), and Sec. 634a para. 1 No. 2 (defects of a building) German Civil Code (“Bürgerliches Gesetzbuch”),

- in the case of intent,
- in the case of fraudulent concealment of the Defect or
- non-compliance with guaranteed characteristic (“Beschaffensgarantie”).

Claims for the reimbursement of expenses on the part of the Purchaser in accordance with Sec. 445a BGB (entrepreneur’s right of recourse) shall likewise be subject to a statute of limitations of 24 months from the start of the statutory statute of limitations, provided the last contract in the supply chain is not a sale of consumer goods.

4. The legal provisions regarding suspension of the statute of limitations (“Ablaufhemmung”, “Hemmung”) and recommencement of limitation periods shall be unaffected. The suspension of the statute of limitations according to Sec. 445b para. 2 BGB (limitation of right of recourse) shall in any case end no later than 5 years after the date on which the Supplier delivered the concerned item to the seller. This shall not apply if the last contract in the supply chain is a sale of consumer goods or in cases that are according to No. 3 Sentence 2 above.

5. Notifications of Defect by the Purchaser shall be given in written form without undue delay.

6. In the case of claims for Defects, the Purchaser may withhold payments to an amount that is in a reasonable proportion to the Defect. The Purchaser has no right to withhold payments to the extent that its claim of a Defect is time-barred. Unjustified notifications of Defect shall entitle the Supplier to demand reimbursement of its expenses by the Purchaser.

7. The Supplier shall be given the opportunity to repair or to replace the defective good (“Nacherfüllung”) within a reasonable period of time.

8. If repair or replacement is unsuccessful, the Purchaser is entitled to rescind the contract or reduce the remuneration; any claims for damages the Purchaser may have according to No. 10 shall be unaffected.

9. There shall be no claims based on Defect in cases of insignificant deviations from the agreed quality, of only minor impairment of usability, of natural wear and tear, or damage arising after the passing of risk from faulty or negligent handling, excessive strain, unsuitable equipment, defective civil works, inappropriate foundation soil, or claims based on particular external influences not assumed under the contract, or from non-reproducible software errors. Claims based on defects attributable to improper modifications, installation/ removal, or repair work carried out by the Purchaser or third parties and the consequences thereof are likewise excluded.

10. The Purchaser shall have no claim with respect to expenses incurred in the course of supplementary performance, to the extent that expenses are increased because the subjectmatter of the Supplies has subsequently been brought to another location than the Purchaser’s branch office, unless doing so complies with the normal use of the Supplies. This applies accordingly to claims for the reimbursement of expenses on the part of the Purchaser in accordance with Sec. 445a BGB (entrepreneur’s right of recourse), provided the last contract in the supply chain is not a sale of consumer goods.

11. The Purchaser’s right of recourse against the Supplier pursuant Sec. 445a BGB (entrepreneur’s right of recourse) is limited to cases where the Purchaser has not concluded an agreement with its customers exceeding the scope of the statutory provisions governing claims based on Defects.

12. The Purchaser shall have no claim for damages based on Defects. This shall not apply to the extent that a Defect has been fraudulently concealed, the guaranteed characteristics are not complied with, in the case of loss of life, bodily injury or damage to health, and/or intentionally or grossly negligent breach of contract on the part of the Supplier. The above provisions do not imply a change in the burden of proof to the detriment of the Purchaser. Any other or additional claims of the Purchaser exceeding the claims provided for in this Article VIII, based on a Defect, are excluded.

Article IX: Industrial Property Rights and Copyrights; Defects in Title

1. Unless otherwise agreed, the Supplier shall provide the Supplies in the country of the place of delivery only, without infringing any third-party industrial property rights and copyrights (hereinafter referred to as "IPR"). If a third party asserts a justified claim against the Purchaser based on an infringement of an IPR by the Supplies made by the Supplier and used in conformity with the contract, the Supplier shall be liable to the Purchaser within the time period stipulated in Article VIII No. 2 as follows:

(a) The Supplier shall choose whether to acquire, at its own expense, the right to use the IPR with respect to the Supplies concerned or whether to modify the Supplies such that they no longer infringe the IPR or replace them. If this would be impossible for the Supplier under reasonable conditions, the Purchaser may rescind the contract or reduce the remuneration pursuant to the applicable statutory provisions;

(b) The Supplier's liability to pay damages is governed by Article XII;

(c) The above obligations of the Supplier shall apply only if the Purchaser (i) immediately notifies the Supplier of any such claim asserted by the third party in written form, (ii) does not concede the existence of an infringement and (iii) leaves any protective measures and settlement negotiations to the Supplier's discretion. If the Purchaser stops using the Supplies in order to reduce the damage or for other good reason, it shall be obliged to point out to the third party that no acknowledgement of the alleged infringement may be inferred from the fact that the use has been discontinued.

2. Claims of the Purchaser shall be excluded if it is responsible for the infringement of an IPR.

3. Claims of the Purchaser are also excluded if the infringement of the IPR is caused by specifications made by the Purchaser, by a type of use not foreseeable by the Supplier or by the Supplies being modified by the Purchaser or being used together with products not provided by the Supplier.

4. In addition, with respect to claims by the Purchaser pursuant to No. 1 a) above, Article VIII Nos. 4, 5, 8, and 9 shall apply *mutatis mutandis* in the event of an infringement of an IPR.

5. Where other defects in title occur, Article VIII shall apply *mutatis mutandis*.

6. Any other claims of the Purchaser against the Supplier or its agents or any such claims exceeding the claims provided for in this Article IX, based on a defect in title, are excluded.

Article X: Conditional Performance

1. The performance of this contract is conditional upon that no hindrances attributable to German, US or otherwise applicable national, EU or international rules of foreign trade law or any embargos or other sanctions exist.

2. The Purchaser shall provide any information and Documents required for export, transport and import purposes.

Article XI: Impossibility of Performance; Adaptation of Contract

1. To the extent that delivery is impossible, the Purchaser is entitled to claim damages, unless the Supplier is not responsible for the impossibility. The Purchaser's claim for damages is, however, limited to an amount of 10 % of the value of the part of the Supplies which, owing to the impossibility, cannot be put to the intended use. This limitation shall not apply in the case of liability based on intent, gross negligence or loss of life, bodily injury or damage to health; this does not imply a change in the burden of proof to the detriment of the Purchaser. The Purchaser's right to rescind the contract shall be unaffected.

2. Where events within the meaning of Article IV No. 2 (a) to (c) substantially change the economic importance or the contents of the Supplies or considerably affect the Supplier's business, the contract shall be adapted taking into account the principles of reasonableness and good faith. To the extent this is not justifiable for economic reasons, the Supplier shall have the right to rescind the contract. The same applies if required export permits are not granted or cannot be used. If the Supplier intends to exercise its right to rescind the contract, it shall notify the Purchaser thereof without undue delay after having realized the repercussions of the event; this shall also apply even where an extension of the delivery period has previously been agreed with the Purchaser.

Article XII: Other Claims for Damages

1. Unless otherwise provided for in the present GL, the Purchaser has no claim for damages based on whatever legal reason, including infringement of duties arising in connection with the contract or tort.

2. This does not apply if liability is based on:

- (a) the German Product Liability Act (“Produkthaftungsgesetz”);
- (b) intent;
- (c) gross negligence on the part of the owners, legal representatives or executives;
- (d) fraud;
- (e) failure to comply with a guarantee granted;
- (f) negligent injury to life, limb or health; or
- (g) negligent breach of a fundamental condition of contract (“wesentliche Vertragspflichten”).

However, claims for damages arising from a breach of a fundamental condition of contract shall be limited to the foreseeable damage which is intrinsic to the contract, provided that no other of the above case applies.

3. The above provision does not imply a change in the burden of proof to the detriment of the Purchaser.

Article XIII: Venue and Applicable law

1. If the Purchaser is a businessman, sole venue for all disputes arising directly or indirectly out of the contract shall be the Supplier’s place of business. However, the Supplier may also bring an action at the Purchaser’s place of business.
2. This contract and its interpretation shall be governed by German law, to the exclusion of the United Nations Convention on contracts for the International Sale of Goods (CISG).

Article XIV: Severability Clause

The legal invalidity of one or more provisions of this Agreement in no way affects the validity of the remaining provisions. This shall not apply if it would be unreasonably onerous for one of the parties to be obligated to continue the contract.

5.7 List of Trademarks

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5.8 Copyright

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Glossary

- API** Application Programming Interface 66
- CMOS** Complementary Metal-Oxide-Semiconductor 67
- ESD** Electrostatic discharge vi, 33, 91
- FPGA** Field Programmable Gate Array 63
- FPS** Frame Per Second 65
- PCB** Printed Circuit Board (same as PWB) 91
- PSR** Product Service Request v, 89
- ROI** Region Of Interest 63
- SDK** Software Development Kit 3
- TBD** To Be Determined – some parameters require further characterization ii, 3, 72

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