xiRay

[ksi-ɹeɪ] or [sai-ɹeɪ]

USB 3.1 scientific X-ray camera series

XIMEA Cameras
Technical Manual
Version v250923

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 queries or if you wish to claim a service or warranty case, please contact your local dealer or refer to XIMEA Support on our website: www.ximea.com/support

The purpose of this document is to provide a description of XIMEA Cameras and to describe the correct way to install related software, 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, 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.

Our broad portfolio of cameras includes thermally stabilized astronomy and x-ray cameras, as well as specialty cameras for medical applications, research, surveillance and defense.

Contact XIMEA

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Standard conformity

CE conformity

Figure 1: Standard conformity CE logo

The camera models listed below comply with the requirements of the EC EMC Directive 2014/30/EU regarding the electromagnetic compatibility of equipment.

Certified camera models include
all models in this manual (refer to the table Models and sensors overview)

UKCA conformity

Figure 2: Standard conformity UKCA logo

We declare that the products listed below comply with the requirements of Directive 2014/35/EU (Low Voltage Directive) and Directive 2014/30/EU (Electromagnetic Compatibility).

All tests are based on EU rules and standards valid before January 1, 2021 (Brexit). The harmonized EU product standards were converted into UK designated standards on exit day. Based on that, these products are UKCA compliant.

Certified camera models include
all models in this manual (refer to the table Models and sensors overview)

FCC conformity

Figure 3: Standard conformity FCC logo

The camera models listed below have been tested and found to comply with Part 15 of the FCC rules, which states that:

Operation is subject to the following two conditions:

1. This device may not cause harmful interference.

2. This device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the users will be required to correct the interference at their own expense.

You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment under the above jurisdictions. The shielded interface cable recommended in this manual must be used with this equipment to comply with the limits for a computing device pursuant to Subpart J of Part 15 of FCC Rules.

Certified camera models include
all models in this manual (refer to the table Models and sensors overview)

RoHS conformity

Figure 4: Standard conformity RoHS logo

The products described in this technical manual comply with the RoHS-3 (Restriction of Hazardous Substances) Directive 2015/863/EU.

WEEE conformity

Figure 5: Standard conformity WEEE logo

The products described in this technical manual comply with the WEEE (Waste Electrical and Electronic Equipment) Directive 2012/19/EU.

GenICam GenTL API

The GenICam/GenTL standard offers a device-agnostic interface for the acquisition of images and other data types, as well as for communication with devices. This enables each XIMEA camera to function as a GenTL Producer, facilitating the capture of images through a standardized transport layer interface.

Disclaimer

This document and the technical data contained herein are for descriptive purposes only and not binding. They are not to be construed as warranted characteristics or guarantees of properties, quality or durability in the legal sense. Specifications are subject to change without notice. The information contained in this document is provided “as is” without warranty of any kind.

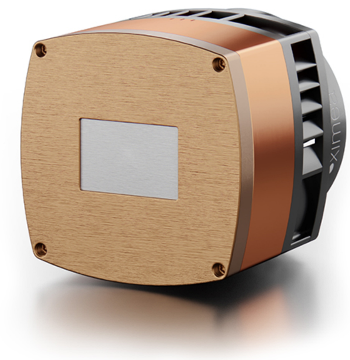
Helpful links

XIMEA Homepage	http://www.ximea.com/
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

Contents

1 xiRay camera series

1.1 What is xiRay



Scientific grade 5K, compact camera for Material and life sciences. The scientific grade sCMOS cameras are equipped with a USB3 interface and Thermoelectric Peltier cooler module. The xiRay cameras are integrated devices - meaning that the Scintillator is part of the camera. Instead of a lens, the camera has a fiber-optic plate bonded to the sensor. Some models are available with a Taper which can increase the FoV (field of view) of the camera 2:1 or higher.

- 15 Mpx, APS-C
- sCMOS sensor - Gpixel GSENSE5130
- Ultra compact Scientific CMOS camera with Peltier TEC Cooling
- Incredible speed with USB3 interface
- High Dynamic range and extremely Low noise
- 0.5 mm berylium plate, radiation hardened glass

1.2 Advantages

Precise	Built with the latest sCMOS sensors from Gpixel for sensitivity and speed
Small	Ultra-precision, machined copper, aluminum alloy, CNC milled housing
Low consumption	Energy range 5 keV - 100 keV
Fast	Fast data rate trough USB3 interface
Scientific	Suppressed dark current and noise during long exposures and low-light
Optimized	Low and high gain modes for best results in Full Well Capacity (FWC) and Dynamic Range (DR)
Cool	Thermoelectric Peltier TE Cooling enhanced with air
Stable	Built into a full metal housing that guarantees stability and longevity
Connective	Programmable opto-isolated I/O digital input and output, 3 status LEDs
Compatible	Support for Windows, Linux and MacOS, ARM, various Image Processing Libraries
Software interfaces	GenICam / GenTL and highly optimized xiAPI SDK

1.3 Camera applications

- micro CT (Computed Tomography)
- soft X-Ray microscopy
- X-Ray spectroscopy
- coherent X-Ray diffraction
- crystallography
- non-destructive testing
- fluoroscopy
- plasma diagnostics
- radiography
- industrial CT scanning

1.4 Common features

Sensor technology	scientific sCMOS
Acquisition modes	rolling shutter, Global Reset Release
Sensor versions	backside illuminated (BSI)
Scintillator	phosphor composition GadOx: Eu, thickness 10 nm or 22 nm, grain 2.5 nm
Image data formats	2 × 10, 2 × 12 bit RAW pixel data
SDK / API	programmable with C++ and C#, Python
Partial image readout	ROI / AOI (region / area), decimation and binning modes supported
Interface default	USB 3.1 Gen1 standard Type C compliant to USB3 vision standard
General purpose I/O	1x opto-isolated input, 1x opto-isolated output, 3x LED software programmable
Synchronization	hardware and software trigger input, frame active output, busy output, overlapped
Cooling	thermoelectric peltier cooling and fan
Power consumption	4.2 W (21.8 W with cooling ON) supplied via USB3 interface with PD - power delivery for cooling
Environment	operating 0 to 50 °C on housing, RH 80 % non-condensing, –25 to 60 °C storage
Conformity	CE, FCC, RoHS, GenICam/GenTL, USB 3.0 SuperSpeed
Operating systems	Windows, Linux Ubuntu, macOS
Software support	API / SDK, adapters and drivers for various image processing Libraries
Firmware updates	Field firmware update through xiCOP tool
Viewer program	CamTool viewer

1.5 Model nomenclature

xiRay	MJxxxyT-zz-ooo
MJ:	xiRay family name
xxx:	resolution in 0.1 Mpx. e.g. 1.3 Mpx Resolution: xxx = 013
y:	Color sensing
X:	x-ray
T:	Sensor technology
R:	Rolling
zz:	Vendor of the sensor
GP:	Gpixel
ooo:	
ooo: = GO:	GadOx scintillator (typically on XRAY cameras)
ooo: = TP2:1:	fiber optic, taper with magnification ratio 2:1
ooo: = FA:	fiber optic, Plate 1:1

1.6 Models and sensors overview

Camera model	Sensor model	Sensor type	Filter	Resolution [px]	Pixel size [µm]
MJ150XR-GP-FA-GO	GPixel GSENSE5130	X-Ray	None	5120 × 2968	4.25
MJ150XR-GP-TP2:1-GO	GPixel GSENSE5130	X-Ray	None	5120 × 2968	8.5

Table 1: List of camera models and their respective sensor models and filters

1.7 Accessories overview

The following accessories are available:

Item P/N	Description
ADPT-PWR-INJ-TC	USB type C power injector adapter
CBL-U3-3M0	USB3 cable, Type-A to Micro-B, 3 m
CBL-U3-P-TC-1M0	USB3 cable, Type-C to Type-C, 1 m
CBL-U3-P-TC-2M0	USB3 cable, Type-C to Type-C, 2 m
CBL-MJ-PWR-2M0	2 m Power cable
CBL-MJ-SYNC-3M0	3 m Trigger/Sync I/O cable
ME-ADPT-MJ-T	Tripod bracket mount

Table 2: List of accessories available for xiRay cameras

2 Hardware specification

2.1 Power supply

The power consumption table can consist of several values:

Supply voltage: Voltage used for measuring the power consumption.

Idle: The average power consumption when the camera is powered, but not opened/initialized in software.

Typical: The average power consumption during streaming in the most power-intensive mode, (typically the one with the highest frame rate).

Maximum: The highest power consumption peak recorded during streaming in the most power-intensive mode, (measured using a current probe).

Power consumption of:
all models in this manual (refer to the table Models and sensors overview)

Supply Voltage	Consumption idle[1]	Consumption typical[1]	Consumption maximum[2]
20 V	4.0 W	4.2 W	21.8 W

[1]Supported voltage 5 - 24 V
[2]Cooling active −15 °C

Table 3: Power consumption of the specific models

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 4: Environment

Housing temperature must not exceed 60 °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 Mounting points

The mounting points available to the customer are shown below. Use only the designated threaded holes for mounting the camera. Utilize only the specified screws and torques when fastening.

Specific mounting information can be found in the dimensional drawings of the camera models located in section Dimensional drawings.

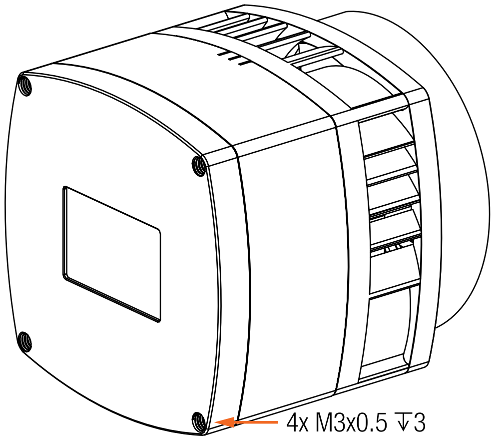


Figure 6: MJ150XR-GP-FA-GO camera mounting points

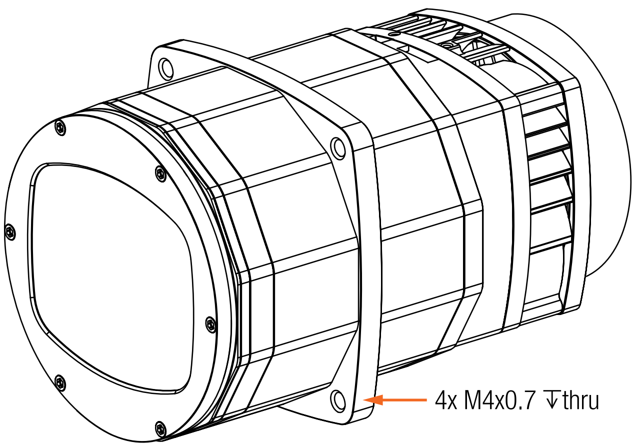


Figure 7: MJ150XR-GP-TP2:1-GO camera mounting points

2.4 X-ray imaging path

Focal Object Distance (FOD) and Focus Detector Distance (FDD)

The relationship between FOD (Focal Object Distance) and FDD (Focus Detector Distance) influences image sharpness and magnification.

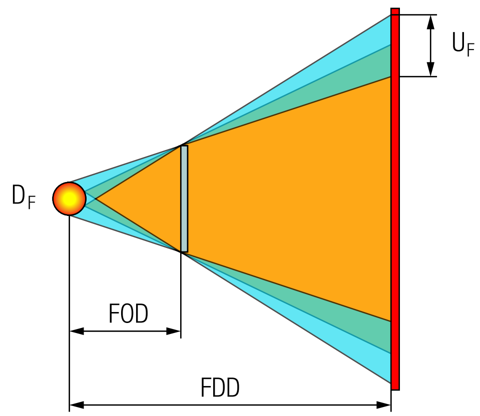


Figure 8: Geometric magnification and image blur

The image above illustrates how X-rays or light rays diverge from a focal point, creating an enlarged projection of an object. The magnification (M) is determined by the ratio:

$$M = \frac{FDD}{FOD}$$

where:

FOD is the distance from the focal source to the object

FDD is the distance from the focal source to the detector

As the magnification increases, the focal spot size introduces a penumbra (blurred edges), calculated as:

$$U_F = D_F \times (M - 1)$$

where:

D_F is the focal spot size - a larger focal spot or an increased magnification results in greater blur

Note: Increasing FDD enhances magnification but also increases blur. Minimizing Df and optimizing FOD can improve image clarity. Understanding these principles is essential for achieving high-resolution imaging.

Cross-section corresponding to:
MJ150XR-GP-FA-GO

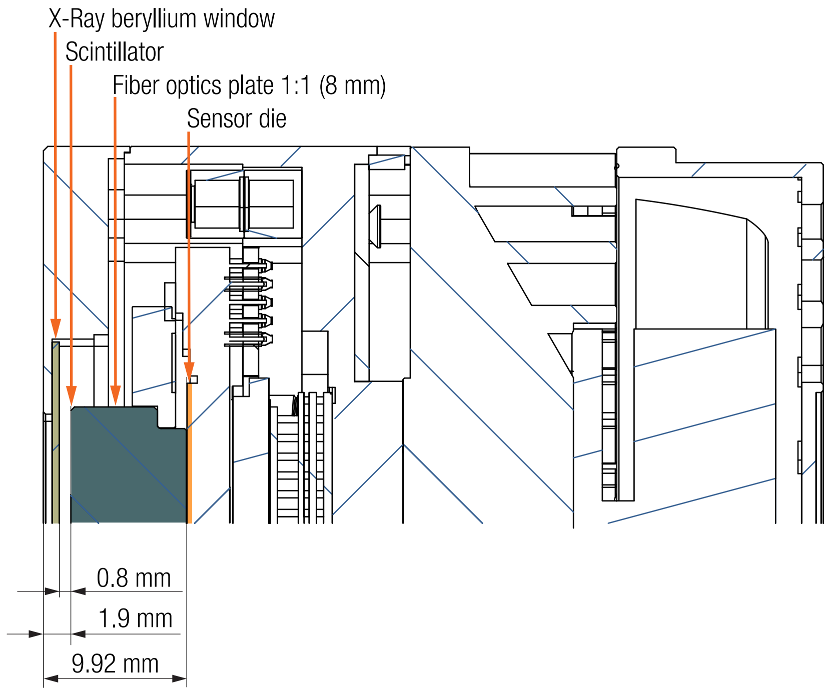


Figure 9: Cross section of MJ150XR-GP-FA-GO

Parameter	Value
Scintillator	GadOx:Eu, 10 µm, 5 mg/cm^2, 2.5 µm grain
FO Material	BYD61-4, 8 mm, 4 µm
FO Dimensions	FOP - 24 × 16 × 8 mm
Filter type	X-Ray Berilium window, 0.5 mm

Table 5: Additional information

Cross-section corresponding to:
MJ150XR-GP-TP2:1-GO

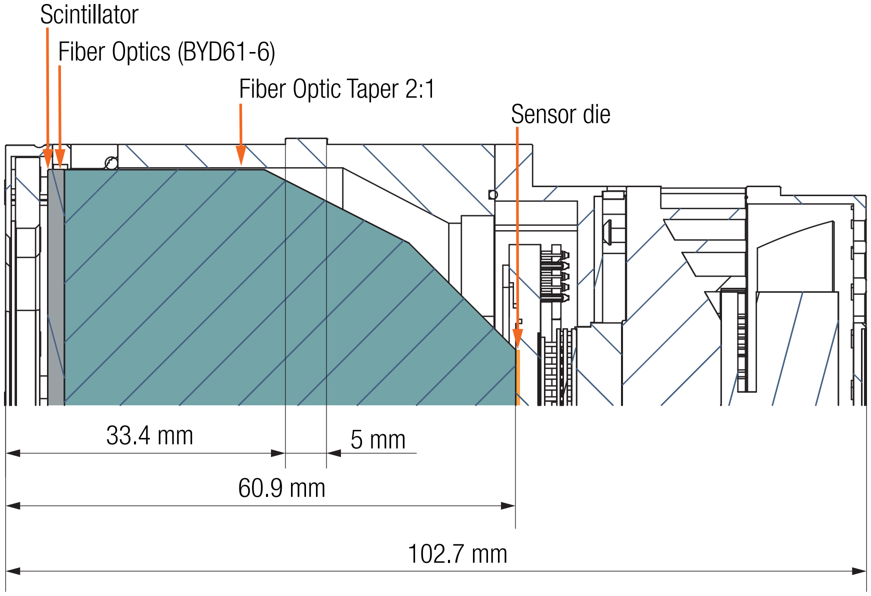


Figure 10: Cross section of MJ150XR-GP-TP2:1-GO

Parameter	Value
Scintillator	GadOx:Eu, 22 µm, 10 mg/cm^2, 2.5 µm grain
FO Material	BLI58-6 + BYD61-6
FO Dimensions	TP2:1 - Diameter 56 mm, Thickness 53.85 + 2 mm

Table 6: Additional information

2.5 Sensor and camera characteristics

2.5.1 Sensor and camera parameters

Sensor parameters of:
MJ150XR-GP-FA-GO

Description	Value	Unit
Technology	sCMOS	None
Pixel resolution (H x V)	5120 x 2968	[px]
Active area size (H X V)	21.49 x 12.61	[mm]
Sensor diagonal	25.2	[mm]
Pixel size (H x V)	4.25 x 4.25	[µm]

Table 7: Sensor parameters of the specific models

Sensor parameters of:
MJ150XR-GP-TP2:1-GO

Description	Value	Unit
Technology	sCMOS	None
Pixel resolution (H x V)	5120 x 2968	[px]
Active area size (H X V)	42.98 x 25.12	[mm]
Sensor diagonal	50.3	[mm]
Pixel size (H x V)	8.5 x 8.5	[µm]

Table 8: Sensor parameters of the specific models

2.5.2 Image quality parameters

The image quality parameters listed below represent typical values for these camera models.
Minor variations may occur between different units of the same model.

Image quality parameters of:
all models in this manual (refer to the table Models and sensors overview)

Mode		12 bit CMS2 Low gain	12 bit CMS2 High gain
User set	-	2-12-CMS-L	2-12-CMS-H
Analog gain	[dB]	0.0	19.0
Parameters			
Median temporal dark noise	[e_-]	4.95	1.18
Overall system gain	[e_-/DN]	0.24	0.02
Dark current	[e_-/s]	2.49	2.1
Dark current meas. temp.	[°C]	0.0	0.0
DSNU	[e_-]	2.69	1.65

Table 9: Image quality parameters of the specific models

2.5.3 Sensor read-out modes

Note: Since the minimum and maximum exposure times depend on the sensor read-out mode used, we recommend checking the exposure range in the Camera Model Frame Rate Calculator of the specific model.

Sensor Read-out modes of:
all models in this manual (refer to the table Models and sensors overview)

User set	Shutter type	Downsampling (Hor.x Ver.)	Sensor bit/px	Resolution (Wid x Hei)	Transport bit/px	Frame rate[1]
2-12-CMS-L/H	Rolling / GRR	1 x 1	12	5056 x 2968	16	13.1
4-12-CMS-L/H	Rolling / GRR	1 x 1	12	5056 x 2968	16	8.7
2-12-HDR-HL	Rolling / GRR	1 x 1	12	5056 x 2968	16	13.1
2-12-CMS-A-L/H	Rolling / GRR	1 x 1	12	5056 x 2968	12	17.4

[1]Frame rate was measured using the transport format at bandwidth limit 380.0 MB/s

Table 10: Sensor read-out modes of the specific models

2.6 Mechanical characteristics

2.6.1 Dimensions and mass

Dimensions and mass of:
MJ150XR-GP-FA-GO

Width [W]	Height [H]	Depth [D]	Mass[1] [M]
52.1 mm	52.1 mm	54 mm	405 g

[1] without adapters

Table 11: Camera parameters of the specific models

Dimensions and mass of:
MJ150XR-GP-TP2:1-GO

Width [W]	Height [H]	Depth [D]	Mass[1] [M]
63.5 mm	63.5 mm	102.7 mm	300 g

[1] without adapters

Table 12: Camera parameters of the specific models

2.6.2 Dimensional drawings

Dimensional drawings of:

MJ150XR-GP-FA-GO

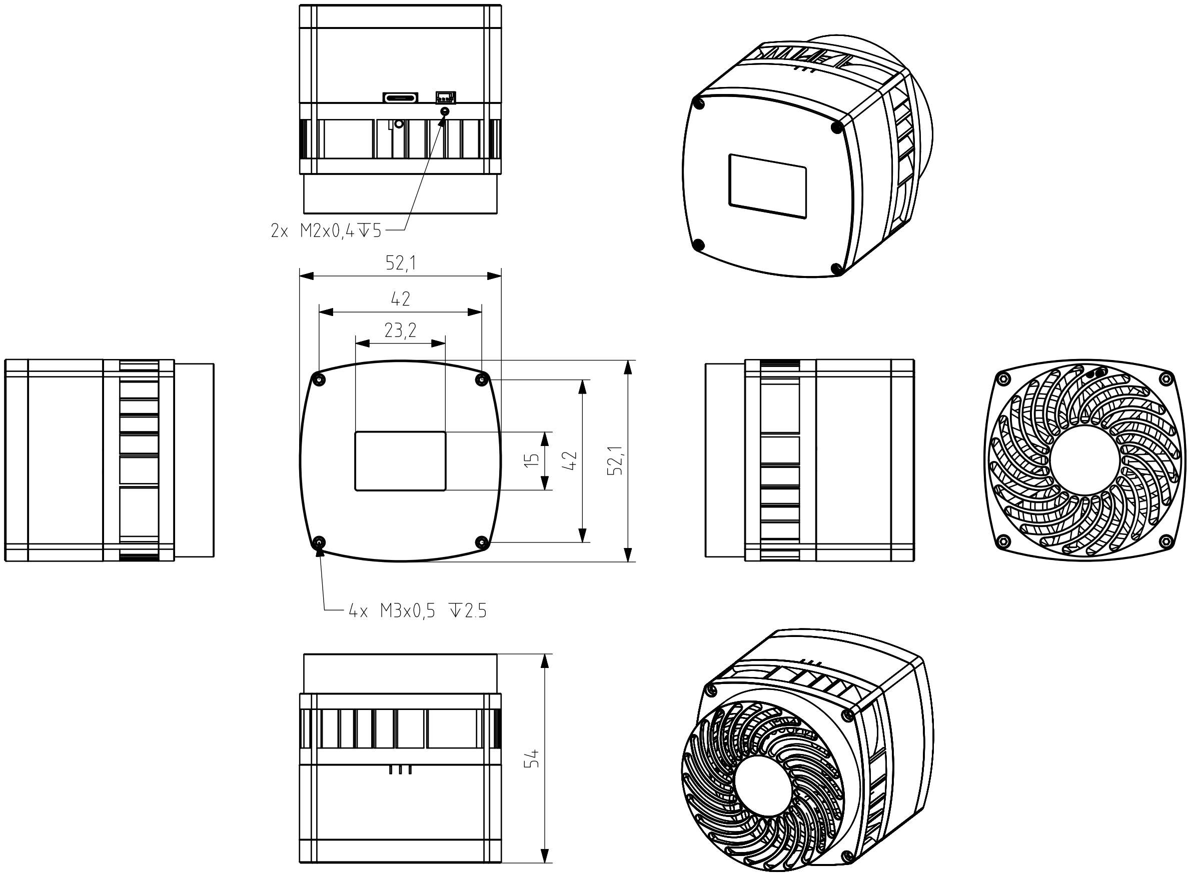


Figure 11: Dimensional drawing of MJ150XR-GP-FA-GO

Dimensional drawings of:
MJ150XR-GP-TP2:1-GO

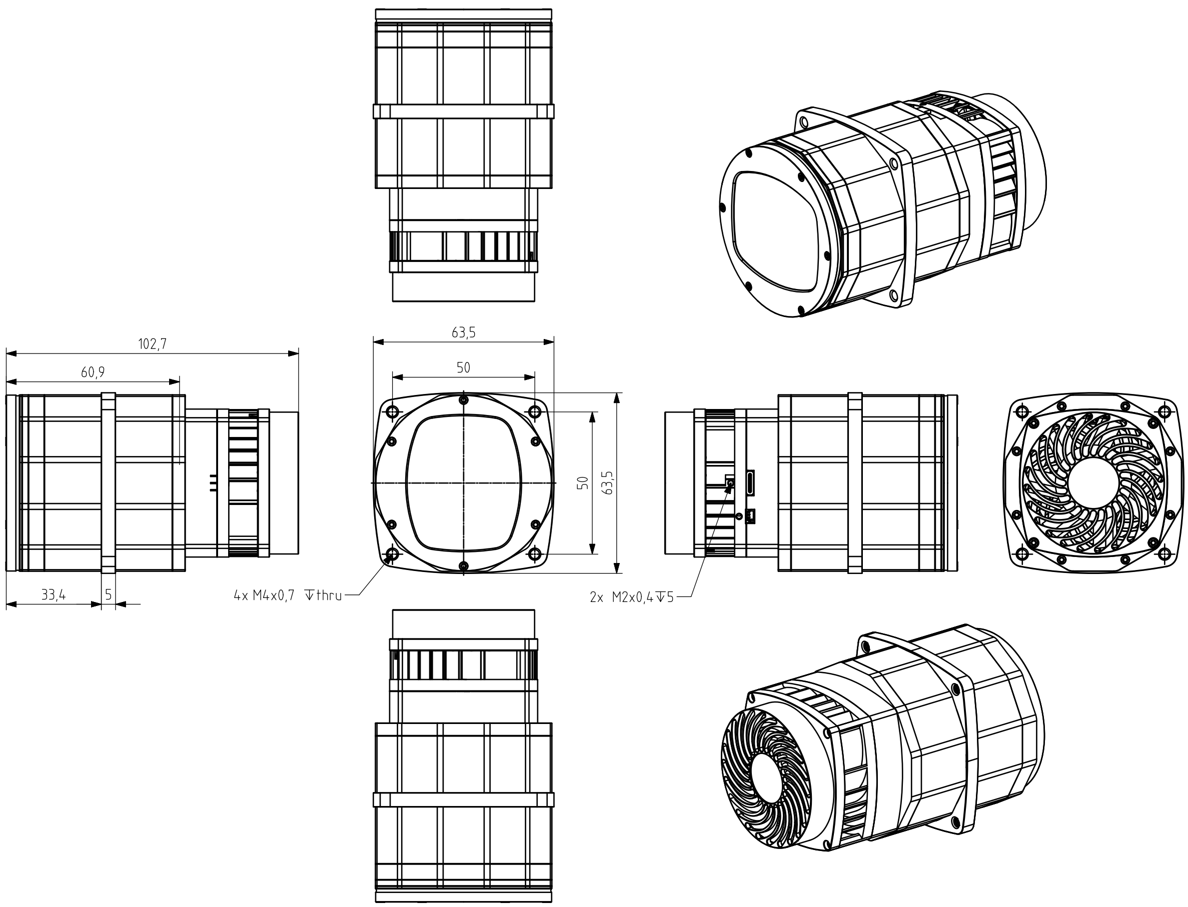


Figure 12: Dimensional drawing of MJ150XR-GP-TP2:1-GO

2.7 User interface – LEDs

LED	Color	Defaults	Note
1	Red	ON	User configurable
2	Yellow	ON	User configurable
3	Green	ON	User configurable

Table 13: LED output description during camera power up

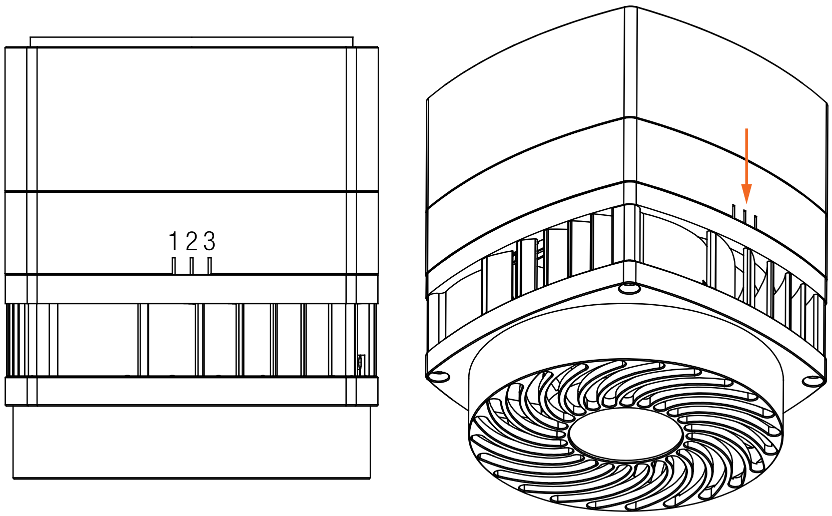


Figure 13: Position of LEDs on xiRay camera

LED statuses during boot sequence of:
all models in this manual (refer to the table Models and sensors overview)

Status	LED 1	LED 2	LED 3
Off	Off	Off	Off
Power	On	Off	Off
Booting	Off	flash 2 Hz	Off
Boot up finished	On	Off	On
USB init - wait for enumeration	flash 1 Hz	Off	Off
Enumeration finished USB2	Off	Off	flash 2 Hz
Enumeration finished USB3	Off	Off	On
Device stop	flash 2 Hz	Off	flash 2 Hz
Error	flash 2 Hz	Off	flash async.

Table 14: LED statuses during boot sequence

2.8 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.

The following section applies to:
all models in this manual (refer to the table Models and sensors overview)

2.8.1 USB 3.1 Gen1 Type-C

The USB 3.1 Type-C connector is used for data transmission, camera control and power.

Item	Value
Connector	USB 3.1
Signals	Standard USB 3.1 Gen1 Type-C Connector
Mating Connectors	Standard USB 3.1 Type C Connector with thumbscrews[1]

[1] Screw thread M2, thread distance 15.0 mm

Table 15: USB 3.1 Gen1 Type-C connector general info

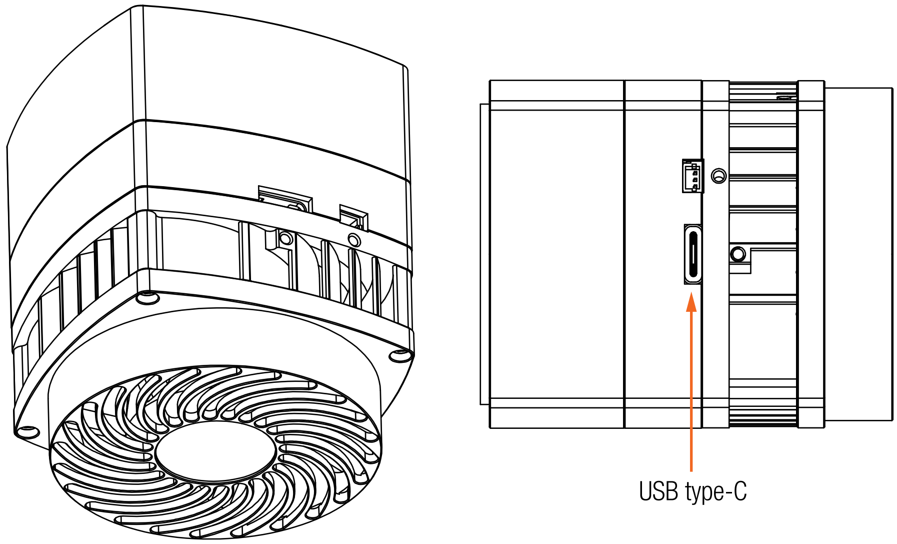


Figure 14: USB 3.1 Type-C connector location

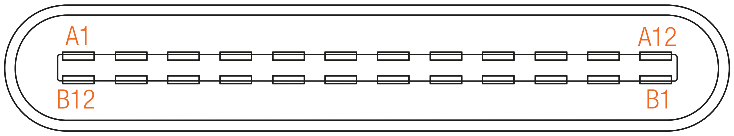


Figure 15: USB 3.1 Type-C connector pinout

Pin	Signal	Description	Pin	Signal	Description
A1	GND	Ground return	B12	GND	Ground return
A2	SSTXp1	SuperSpeed differential pair #1, TX, pos.	B11	SSRXp1	SuperSpeed differential pair #2, RX, pos.
A3	SSTXn1	SuperSpeed differential pair #1, TX, neg.	B10	SSRXn1	SuperSpeed differential pair #2, RX, neg.
A4	V-BUS	Bus power	B9	VBUS	Bus power
A5	CC1	Configuration channel	B8	SBU2	Sideband use (SBU)
A6	Dp1	Non-SuperSpeed diff. pair, position 1, pos.	B7	Dn2	Non-SuperSpeed diff. pair, position 2, neg.
A7	Dn1	Non-SuperSpeed diff. pair, position 1, neg.	B6	Dp2	Non-SuperSpeed diff. pair, position 2, pos.
A8	SBU1	Sideband use (SBU)	B5	CC2	Configuration channel
A9	VBUS	Bus power	B4	VBUS	Bus power
A10	SSRXn2	SuperSpeed differential pair #4, RX, neg.	B3	SSTXn2	SuperSpeed differential pair #3, TX, neg.
A11	SSRXp2	SuperSpeed differential pair #4, RX, pos.	B2	SSTXp2	SuperSpeed differential pair #3, TX, pos.
A12	GND	Ground return	B1	GND	Ground return

Table 16: USB 3.1 Gen1 Type-C pin assignment

2.9 Digital inputs / outputs (GPIO) interface

The description of the GPIO interface below applies to:
all models in this manual (refer to the table Models and sensors overview)

Item	Value
Connector	I/O & Sync 3-pin
Signals	Opto-isolated input and output
Mating Connectors	JST - SHR-03V-S, 03SR-3S

Table 17: IO connector general info

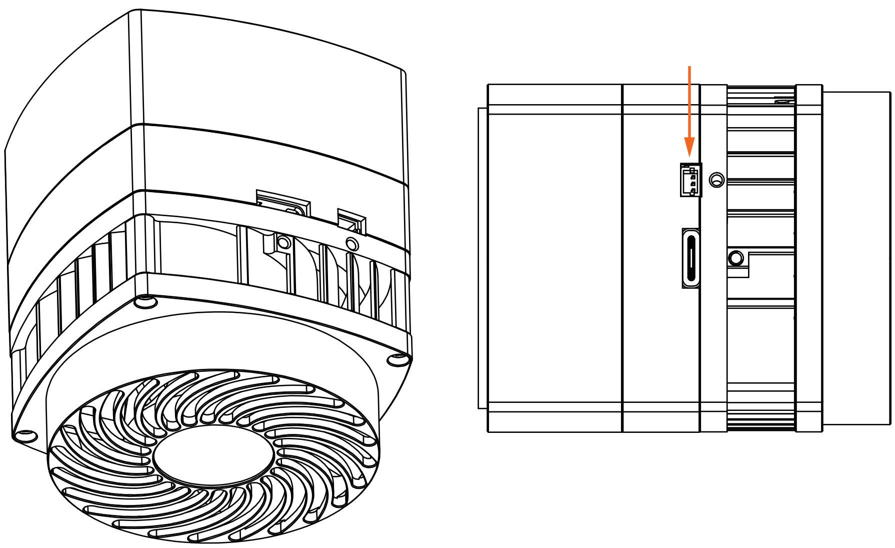


Figure 16: IO connector location

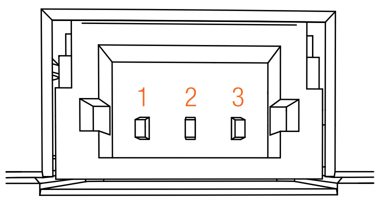


Figure 17: IO connector pinout

Pin	Name	GPI/GPO index API	Type
1	OUT1	-/1	Optically isolated Digital Output (OUT)
2	IO GND	None	Common ground for Input/Output
3	IN1	1/-	Optically isolated Digital Input (IN)

Table 18: USB IO connector pin assignment

2.9.1 Optically isolated Digital Input (IN)

The description of optically isolated digital input below applies to:
all models in this manual (refer to the table Models and sensors overview)

Item	Parameter	Note
Maximal input voltage	24 V DC	None
Common pole	YES	IN GND
Effect of incorrect input terminal connection	Reverse voltage polarity protected	None
Effects when withdrawing/inserting input module under power	no damage, no lost data	None
Maximal recommended cable length	10m	None
Input Level for logical 0	Voltage < 1.2 V / Current < 0.3 mA	None
Input Level for logical 1	Voltage > 3.3 V / Current > 1 mA	None
Input debounce filter	No	None
Input delay - rising edge	0.1 µs	VINPUT=10 V,TAMBIENT=25 °C
Input delay - falling edge	5 µs	VINPUT=10 V,TAMBIENT=25 °C
External trigger mapping	YES	None
Input functions	Trigger	Rising or falling edge are supported for trigger

Table 19: General info for optically isolated digital input

2.9.2 Optically isolated Digital Output (OUT)

The description of optically isolated digital output below applies to:
all models in this manual (refer to the table Models and sensors overview)

Item	Parameter	Note
Maximal open circuit voltage	24 V DC	None
Output port type	Open collector NPN	None
Common pole	True	OUT GND
Protection	short-circuit / over-current / Reverse voltage	None
Protection circuit	PTC Resettable Fuse	None
Maximal sink current	36 mA	None
Trip current	71 mA	Self-restarting when failure mode current disconnected
Inductive loads	false	None
Effect of incorrect output terminal connection	Protected against reverse voltage connection	None
Maximal output dropout	1 V	Sink current 25 mA
Output delay - ON -> OFF	26 µs	VOUTPUT=10 V,TAMBIENT=25 °C
Output delay - OFF -> ON	1.5 µs	VOUTPUT=10 V,TAMBIENT=25 °C
Strobe output mapping	True	None

Table 20: General info for optically isolated digital output

2.10 Accessories

2.10.1 Sync trigger cable CBL-MJ-SYNC-3M0

3.0 m trigger and synchronization cable with 4 poles and digital I/O circular. Allows to externally trigger and synchronize the cameras.

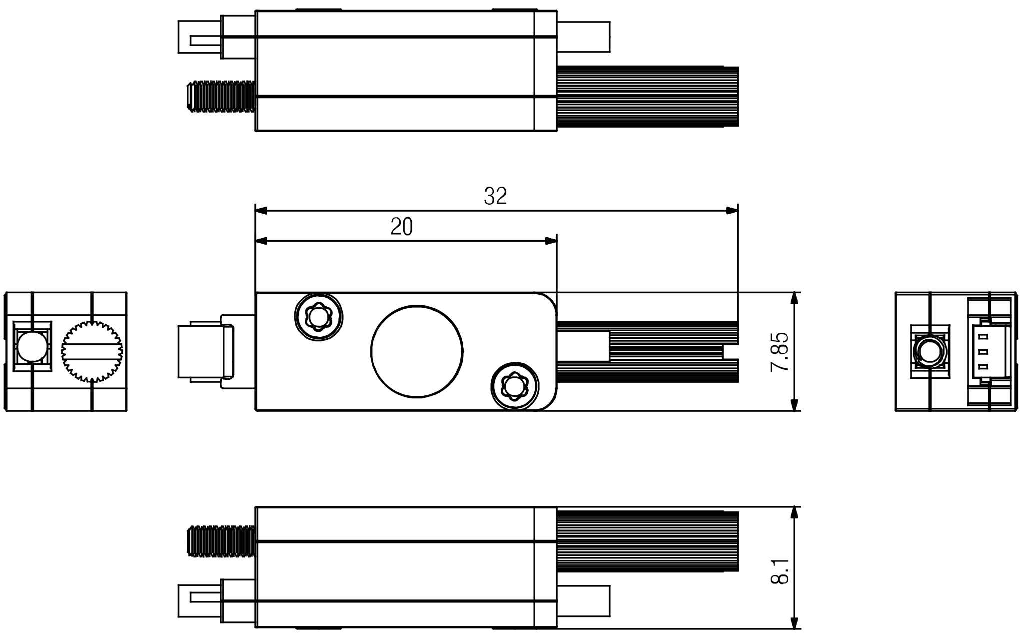


Figure 18: Sync cable CBL-MJ-SYNC-3M0 dimensional drawing

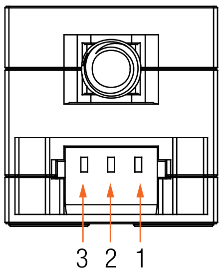


Figure 19: Sync cable CBL-MJ-SYNC-3M0 pin numbering

Pin	Color	Signal
1	White	OUT1 - Opto-isolated Output
2	Black	OUT_GND Opto-Isolated output ground pole
3	Red	IN1 - Opto-isolated Input
(Shell)	Black	Chassis ground

Table 21: Sync cable CBL-MJ-SYNC-3M0 pin assignment

2.10.2 AUX CBL-MJ-PWR-2M0

2.0 m AUX power cable for use with power injector (see Power injector ADPT-PWR-INJ-TC) CBL-MJ-PWR-2M0 cable ends with barrel connector - pigtail allows easy extension in length. Recommended voltage for cable use is 20 V with range 12 to 24 V

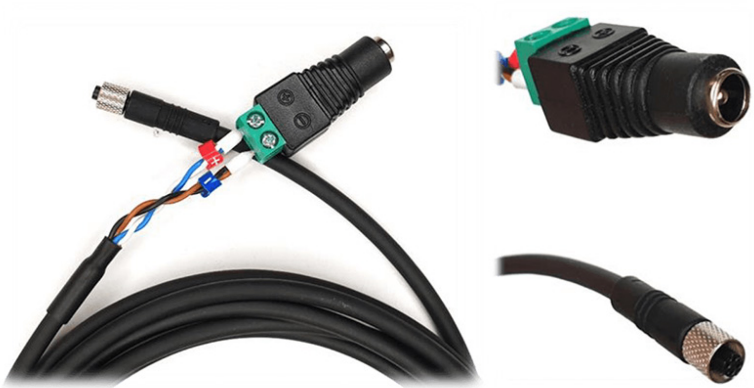


Figure 20: CBL-MJ-PWR-2M0

2.10.3 CBL-U3-P-TC-xM

USB 3.2 Gen 1 black cable with Type-C to Type-C connectors and vertical locking screw. Cables are vailable in two length - 1.0 m or 2.0 m length with part number: CBL-U3-P-TC-1M0 or CBL-U3-P-TC-2M0

Figure 21: CBL-U3-P-TC-xM

2.10.4 CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M

1.0 m / 3.0 m / 5.0 m USB 3.0 cable.

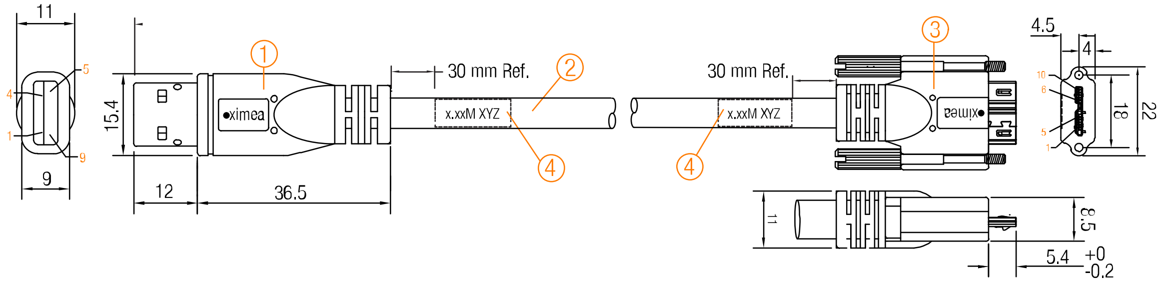


Figure 22: CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M cable components

1 USB A 3.0 9 pin Molded Plug <BLK>

2 MCD-USB-211 [OD = 7.3 mm] <BLK>

3 3 USB MicB 3.0 sl 10 pin Molded Plug with Screw Locking <BLK>

4 Cable Label

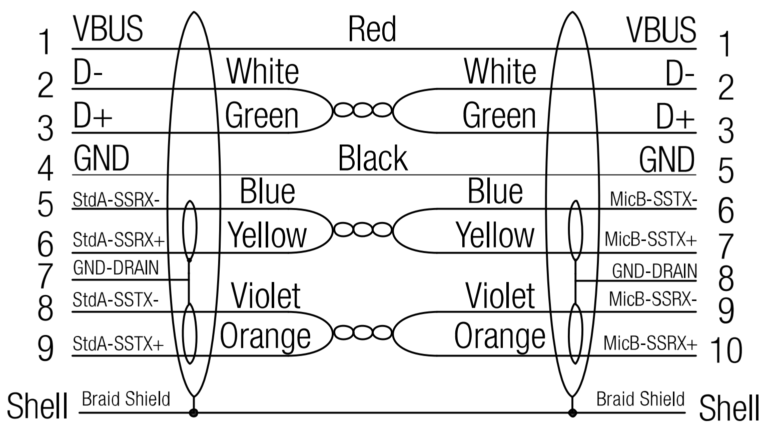


Figure 23: Wiring of CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M

Pin	Signal	Description
1	VBUS	Power
2	D-	USB 2.0 signal pair
3	D+	
4	ID	OTG Identification
5	GND	Power Ground
6	MicB_SSTX-	USB 3.0 SuperSpeed transmitter signal pair
7	MicB_SSTX+	
8	GND_DRAIN	USB 3.0 signal Ground
9	MicB_SSRX-	USB 3.0 SuperSpeed receiver signal pair
10	MicB_SSRX+	

Table 22: CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M pin assignment

2.10.5 Power injector ADPT-PWR-INJ-TC

Figure 24: ADPT-PWR-INJ-TC

Injector for power delivery to sCMOS cameras. Adapter has Micro-B connector for standard USB3 to the computer host, Type-C connector for standard USB3 connection to the camera target, power GPIO for AUX power delivery 20 V.

LED	Color	Description
1	Blue	Orientation of Type-C connected cable
2	Red	Type-C Power EN#
3	Green	Adapter power

Table 23: ADPT-PWR-INJ-TC LED description

Dimensional drawings

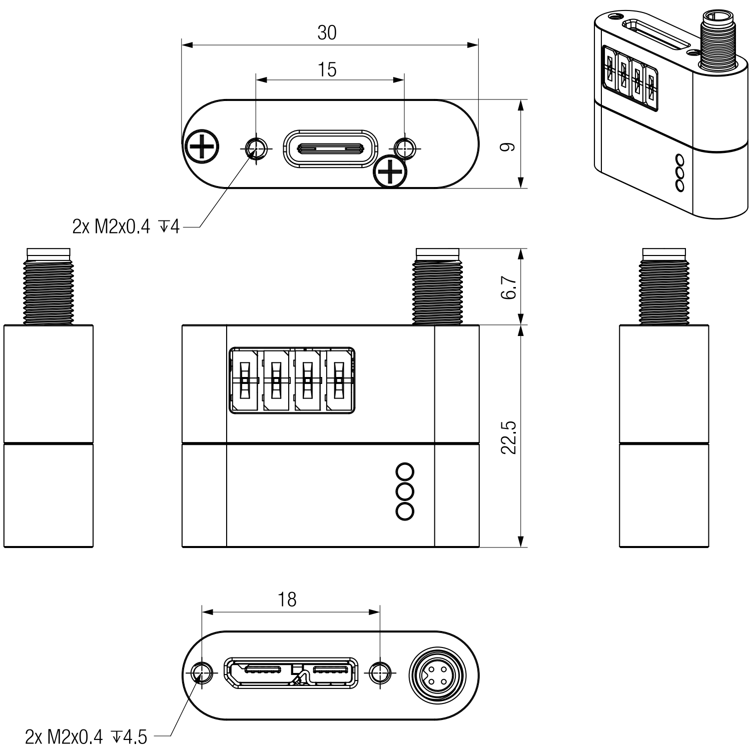


Figure 25: ADPT-PWR-INJ-TC dimensional drawing

Configuration

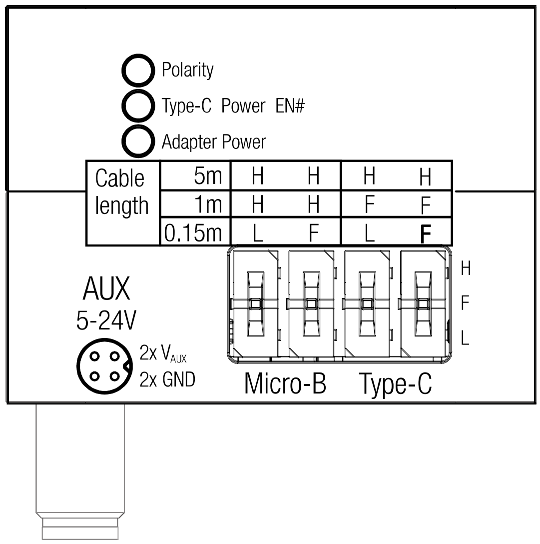


Figure 26: Laser markings and position of dip switches on power injector

Cable lenght	Switch configuration			
	Micro-B		Type-C	
5 m	H	H	H	H
1 m	H	H	F	F
0.15 m	L	F	L	F

Table 24: Dip switches configuration

Example for 5 m Micro-B cable and 0.15 m Type-C cable with dipswitches in correct position:

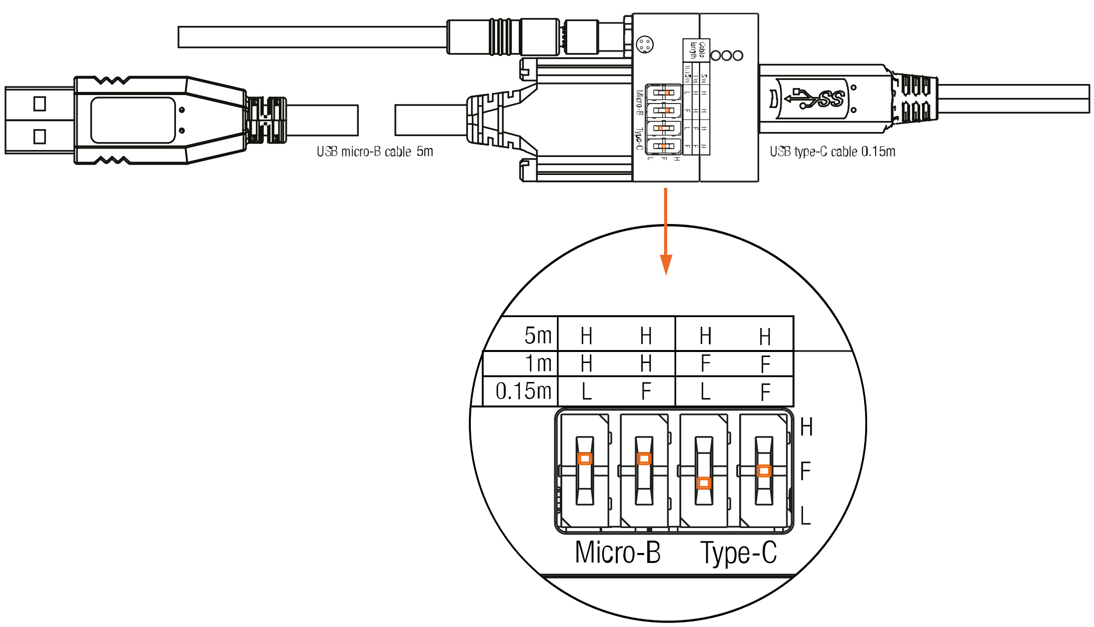


Figure 27: Example of dip switches position

Connecting the camera

The camera was tested using two setups with accessories described in Accessories section. These setups are the recommended configurations where full functionality is guaranteed. Using the camera with other controllers or cables may lead to suboptimal performance.

The first setup involves a direct connection using a 1 m USB 3.0 cable with power delivery (CBL-U3-P-TC-xM) to a USB 3.0 host adapter, see USB 3 host adapters.

The second setup includes the use of a power injector. To correctly connect the camera with the power injector, follow the steps below:

Step 1. Connect USB micro-B cable (CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M0) to power injector (ADPT-PWR-INJ-TC)

Step 2. Connect USB A (CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M0) to PC

Step 3. Connect power cable (Power cable AUX – CBL-MJ-PWR-2M0) and power on

Step 4. Connect USB type-C cable (CBL-U3-P-TC-xM) to power adapter

Step 5. Connect USB type-C cable to the camera

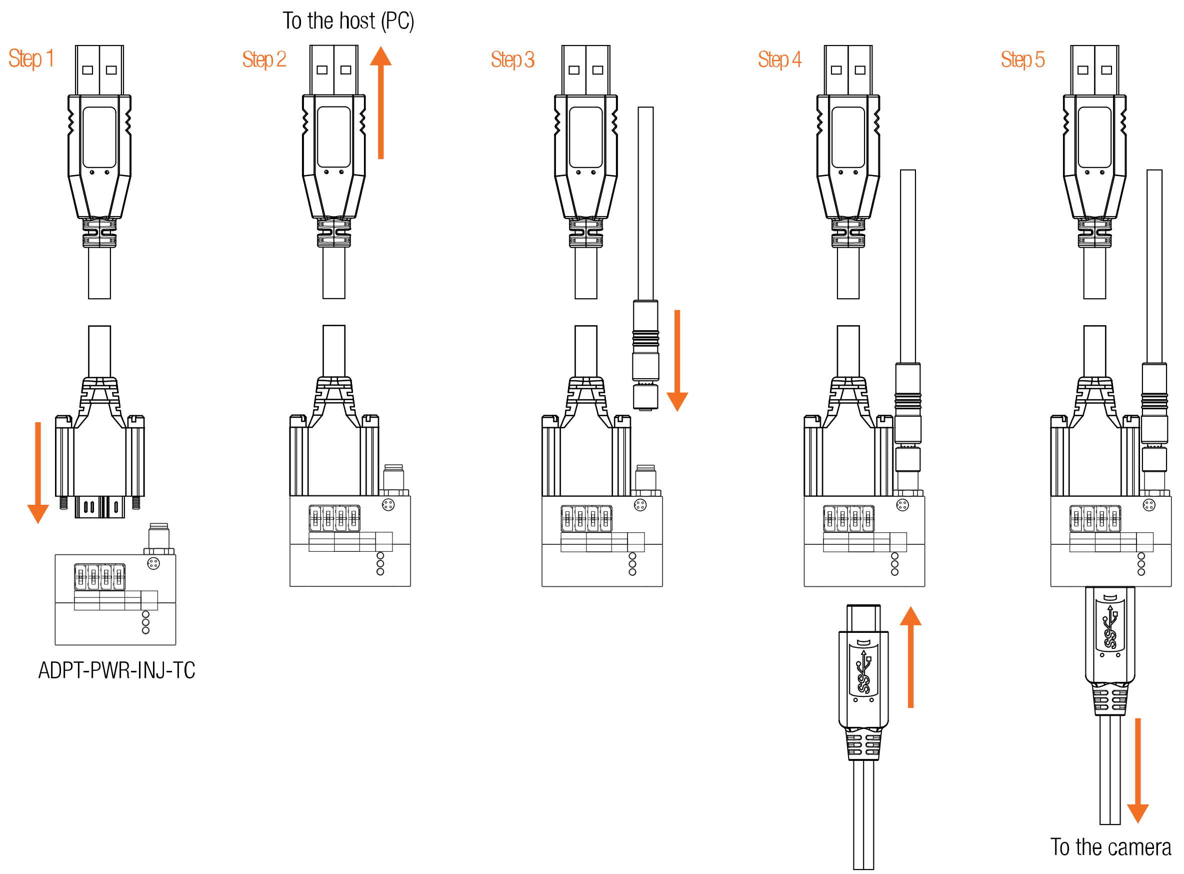


Figure 28: ADPT-PWR-INJ-TC - connecting the components

2.10.6 Tripod Adapter ME-ADPT-MJ-T

Figure 29: ME-ADPT-MJ-T

ME-ADPT-MJ-T tripod mounting bracket with M4 and M6 threads at the bottom and 1/4” thread in the middle. Bracket can be mounted on the front side of the camera. All threads of tripod adapter are milled and all edges chamfered. Solid high quality anodized aluminum.

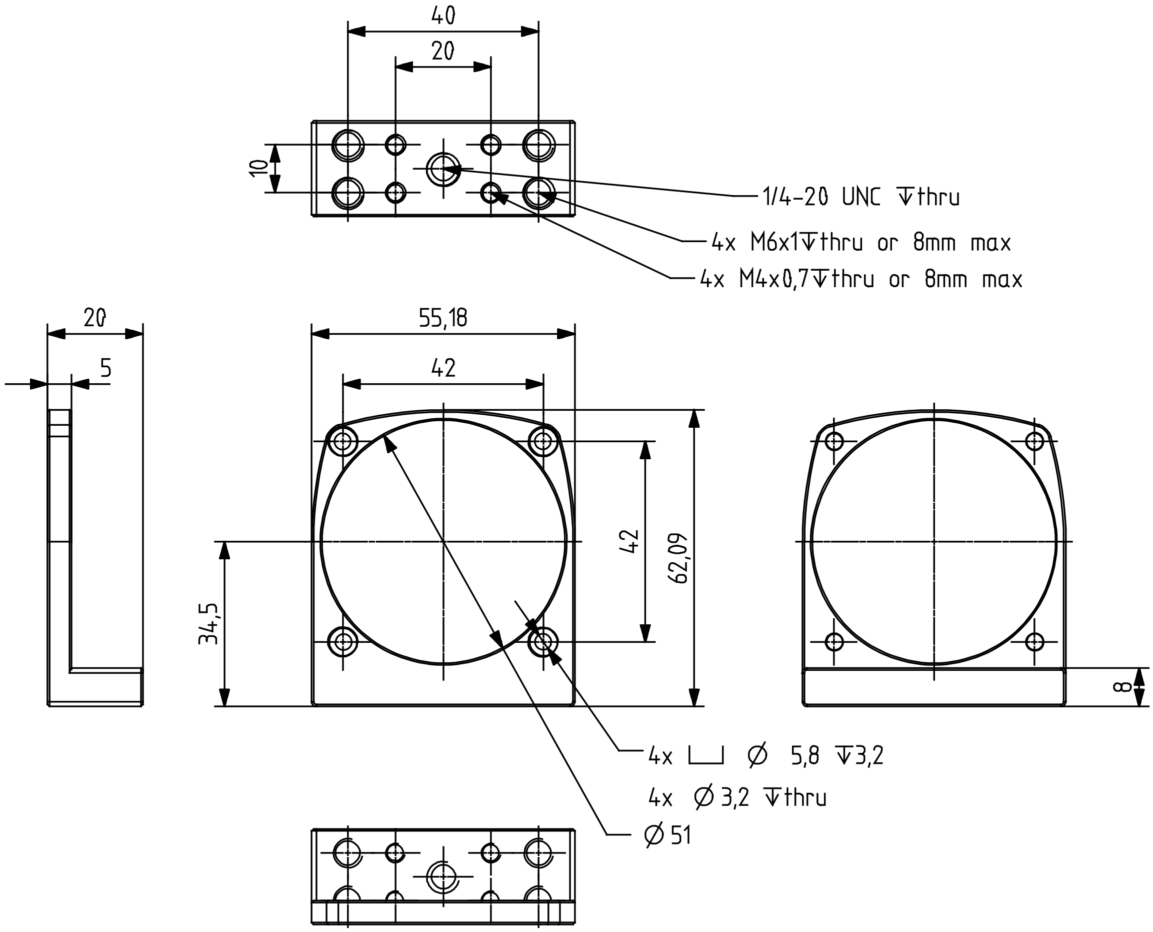


Figure 30: ME-ADPT-MJ-T dimensional drawing

Width [W]	Height [H]	Depth [D]	Material
55.18 mm	62.09 mm	20 mm	anodized aluminum

Table 25: ME-ADPT-MJ-T dimensions

2.10.7 USB 3 host adapters

USB 3.0 to PCI Express x1 Gen2 Host Card

Please refer to following page USB 3 Host Adapters for more information.

USB 3.1 Host Adapter

For a stable operation of your camera and achieving the maximum possible system performance with the highest frame rate it is important to choose an appropriate USB 3.1 host adapter chipset. Please have a look at the following link to our webpage: USB3 Hardware Compatibility

XIMEA maintains a regularly updated overview of compatible USB 3.0 and USB 3.1 host adapters together with the available bandwidth USB 3 Host Adapters

The maximum data transfer rate depends on different conditions (motherboard, chipset, driver version, operating system, etc.).

To achieve maximum performance of USB3 cameras - USB 3.1 host adapter must be connected to the PCIe slot/port/hub and running at 5 GT/s in case of PCIe Gen2 host adapters. For cards requiring Gen3 the speed needs to be 8 GT/s.

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 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*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 ¼ 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 2x1 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 model supports several Image Data Output Formats.

This table is applicable to:
all models in this manual (refer to the table Models and sensors overview)

Mode	Description
XI_MONO8	8 bits per pixel. [Intensity][1,2]
XI_MONO16	16 bits per pixel. [Intensity LSB] [Intensity MSB][1,2]
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_FRM_TRANSPORT	Data from transport layer (e.g. packed). Depends on data on the transport layer[3]

[1] Higher 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.
[2] On 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.
[3] When 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 26: Image data output formats

3.1.4 Camera readout modes

STD modes

In all standard modes the top gain channel is connected to the odd rows of the sensor and the bottom channel to the even rows. The frame rate is higher in these modes because two image rows are read in parallel. Both channels use the same gain value which can be controlled by the API parameter XI_PRM_GAIN.

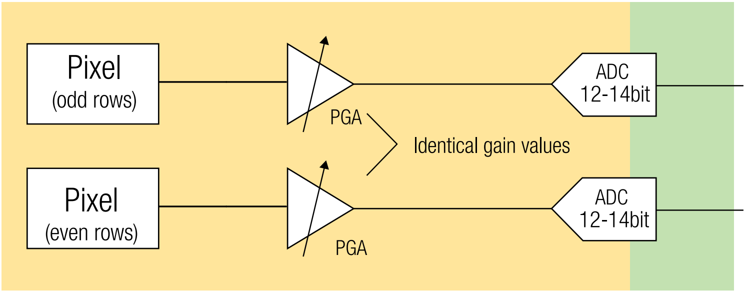


Figure 31: STD mode

ADC depth	HG/LG readout	MJ042 mode
12	LG	STD mode 1: 12-STD-L
12	HG	STD mode 2: 12-STD-H

Table 27: Supported combinations of ADC width and LG/HG readout

Note: The sensor data is transferred within the camera to the FPGA, where it is sequenced and transmitted via the PCIe interface.

STD mode: 12-bit, LG (12-STD-L)

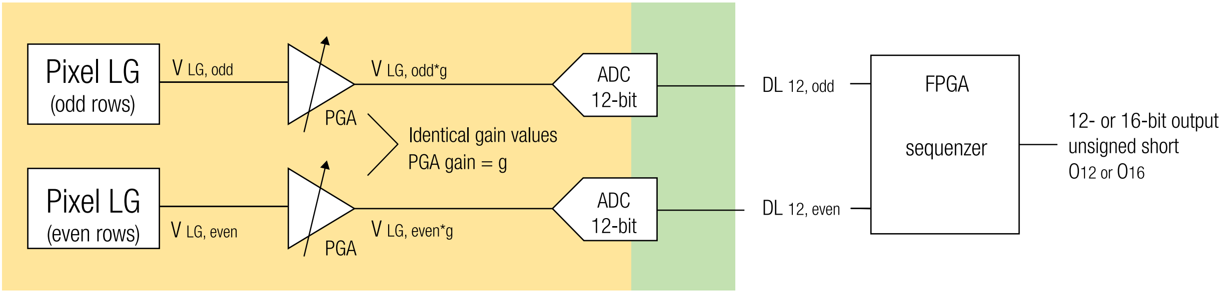


Figure 32: STD mode 12-bit, LG

V_{LG} : analog LG values from pixel

$V_{LG}*g$: analog LG values amplified by PGA gain g

DL_{12} : digital 12-bit LG values

The sequencer in the FPGA sorts the lines correctly.

Note: If a 12-bit camera readout is used, the DL_{12} values are transferred as O_{12}.

STD mode: 12-bit, HG (12-STD-H)

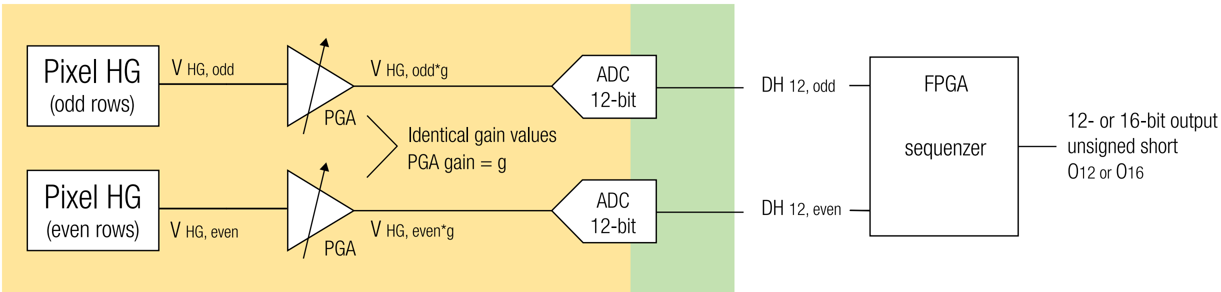


Figure 33: STD mode 12-bit, HG

V_{HG} : analog HG values from pixel

V_{HG}*g : analog HG values amplified by PGA gain g

DH_{12} : digital 12-bit HG values

The sequencer in the FPGA sorts the lines correctly.

Note: If a 12-bit camera readout is used, the DL_{12} values are transferred as O_{12}.

CMS modes

In CMS mode, the reset and pixel output are sampled multiple times and summed up for pixel-related noise suppression. Both channels use the same gain value which can be controlled by the API parameter XI_PRM_GAIN.

In 2-CMS mode the pixel data is sampled twice, using both gain channels in parallel. The identical image is therefore sampled and read out two times, one time via top and a second time via bottom readout channel.

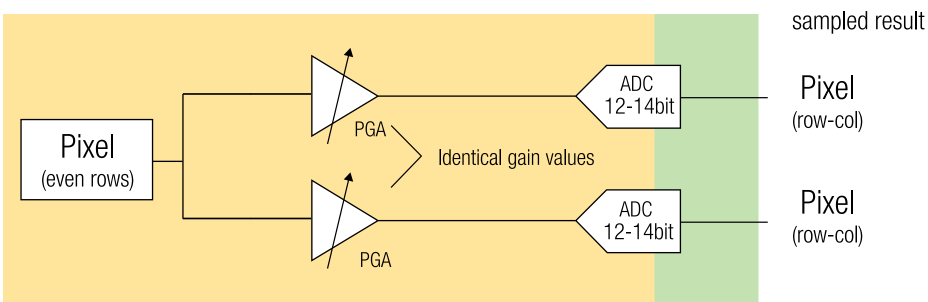


Figure 34: CMS mode

Samplings	ADC depth	HG/LG readout	MJ042 mode
2-CMS	12	LG	CMS mode 1: 2-12-CMS-S-L
2-CMS	12	HG	CMS mode 2: 2-12-CMS-S-H

Table 28: Supported combinations of ADC width and LG/HG readout

The image data is transferred within the camera twice to the FPGA, where it is summed (and effectively averaged) and transmitted via the PCIe interface.

CMS mode: 2-CMS, 12-bit, LG (2-12-CMS-S-L)

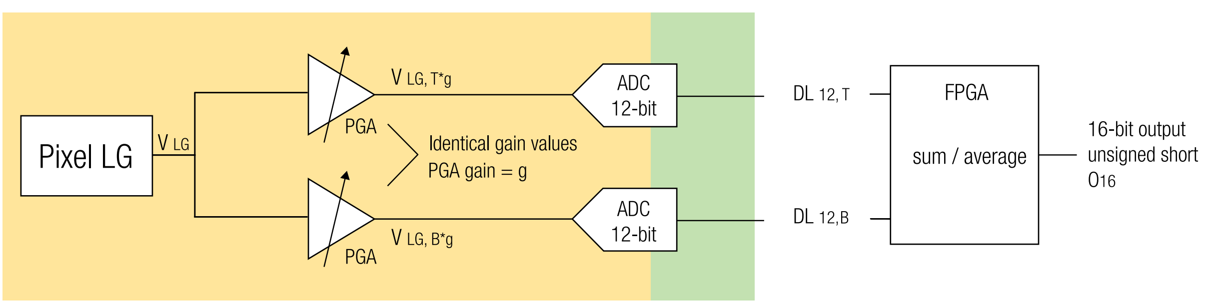


Figure 35: CMS mode 2-CMS, 12-bit, LG

V_{LG} : analog LG values from pixel

$V_{LG,T}*g$: analog LG values amplified by PGA gain g, top gain channel

$V_{LG,B}*g$: analog LG values amplified by PGA gain g, bottom gain channel

$DL_{12,T}$: digital 12-bit LG values, top gain channel

$DL_{12,B}$: digital 12-bit LG values, bottom gain channel

The FPGA adds both pictures.

The 16-bit output result is calculated as:

$O16 = (DL_{12,T} + DL_{12,B}) \times 8$

CMS mode: 2-CMS, 12-bit, HG (2-12-CMS-S-H)

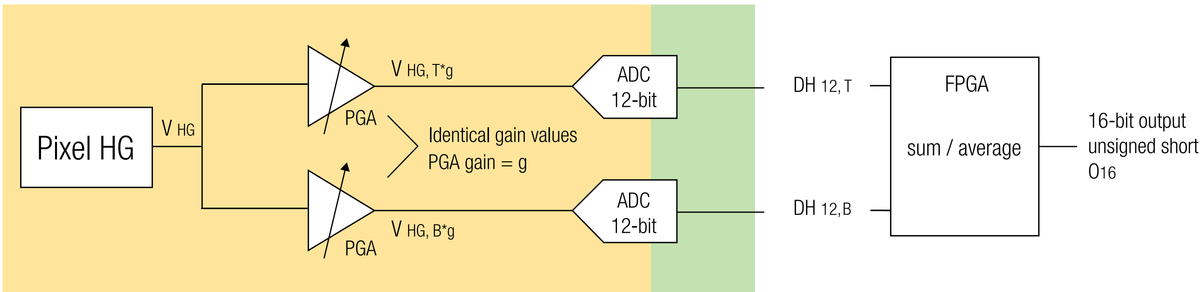


Figure 36: CMS mode 2-CMS, 12-bit, HG

V_{HG} : analog HG values from pixel

$V_{HG,T}*g$: analog HG values amplified by PGA gain g, top gain channel

$V_{HG,B}*g$: analog HG values amplified by PGA gain g, bottom gain channel

$DH_{12,T}$: digital 12-bit HG values, top gain channel

$DH_{12,B}$: digital 12-bit HG values, bottom gain channel

The FPGA adds both pictures.

The 16-bit output result is calculated as:

$O16 = (DH_{12,T} + DH_{12,B}) \times 8$

HDR mode

The HDR modes work significantly different than the STD and CMS modes. The gain values of the two PGA-ADC readout channels are different. The gain values cannot be influenced by the user through API settings.

HDR mode: 12-bit, HG + LG (2-12-HDR-HL)

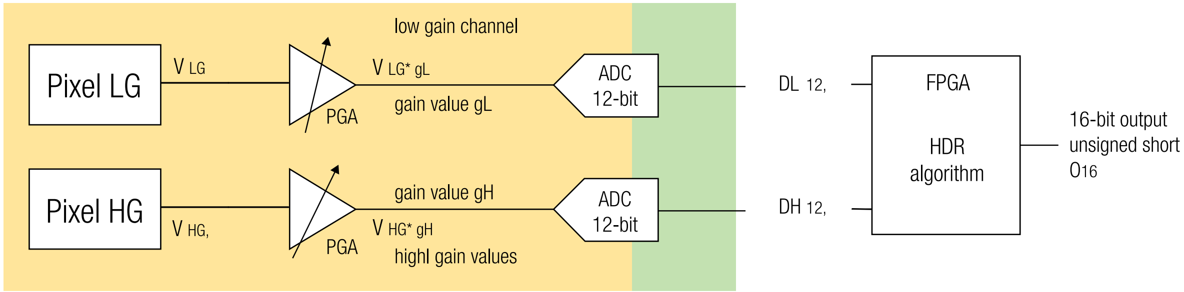


Figure 37: HDR mode 12-bit, HG + LG

V_{LG} : analog LG values from pixel

V_{HG} : analog HG values from pixel

g_L : analog PGA gain of low gain channel

g_H : analog PGA gain of high gain channel

$V_{LG}*g_L$: analog LG values amplified by PGA gain gL, low gain channel

$V_{HG}*g_H$: analog HG values amplified by PGA gain gH, high gain channel

DL_{12} : digital 12-bit LG values

DH_{12} : digital 12-bit HG values

The FPGA merges the values to an HDR image. The 16-bit output result is calculated as:

$$O_{16} = \text{(unsigned short)}\left(\left(DL_{12}\frac{DH_{12}}{4095.0} + DH_{12}\left(1 - \frac{DH_{12}}{4095.0}\right)\frac{g_L}{g_H}\right) \times 16.0\right)$$

Mode settings – factory presets (API)

To simplify the use of the camera modes in the API, presets can be used instead of setting all individual parameters.
Please have a look at XI_PRM_USER_SET_SELECTOR for additional info.

The desired mode can be used as preset by selecting and setting:

```
xiSetParamInt(handle, XI_PRM_USER_SET_SELECTOR, value); // from table above
xiSetParamInt(handle, XI_PRM_USER_SET_LOAD, XI_ON);
```

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).

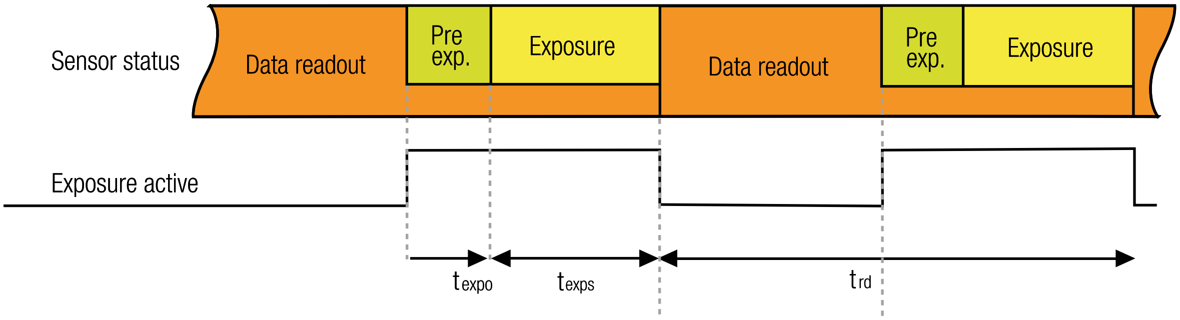


Figure 38: Acquisition mode - free run

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).

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. 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. 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.

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.

3.5 Control cooling

The scientific grade sCMOS cameras from XIMEA are equipped with Thermoelectric Peltier cooler module, which allows to cool the sensor to low temperatures minimizing dark current and the related dark current shot noise. Below measurement was performed on the conditions.

Accuracy was defined as a difference between the maximum and the minimum recorded temperature for 10 minutes after the sensor temperature reached the target cooling temperature. As it was not measured with an independent thermometer, these values show only control loop deviations. Power consumption is the maximum power value recorded during the measurement procedure for a selected mode. All values have been measured on Technical Sample. They are typical and not guaranteed.

Mode	Ambient temp.	Exposure	Min. temp.	Accuracy	Max. power consumption
All suported user set selectors	23 °C	100 µs - 5 s	0 °C	0.05 °C	25 W

Table 29: Cooling performance measurements

3.6 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.

3.6.1 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.

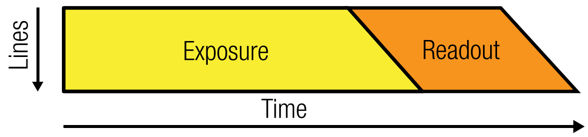


Figure 39: Global reset release mode - schematic

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 40: Global reset release mode - image horizontally moved object

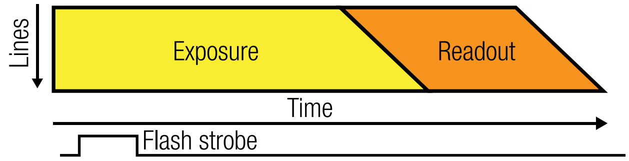


Figure 41: Global reset release mode with flash - schematic

3.6.2 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

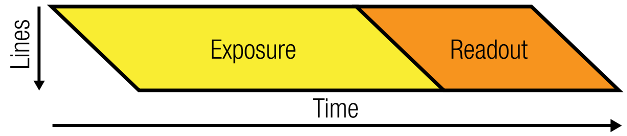


Figure 42: Rolling shutter mode - schematic

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 43: Rolling shutter mode image of a horizontally moved object

Figure 44: 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.

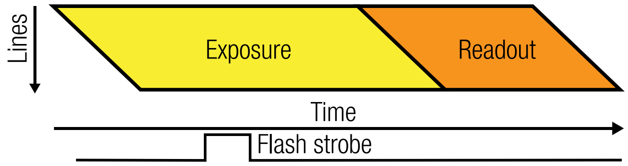


Figure 45: Rolling shutter mode with flash - schematic

3.7 API Features

Host-assisted image processing features available in xiAPI

3.7.1 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).

3.7.2 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.

3.7.3 Flat field correction

Flat field correction (FFC or shading correction) is a method to remove non-uniformities in the image caused by different sensitivities of the pixels and by distortions caused by optics. For XIMEA cameras this correction is applied in the image processing part of the image data flow diagram (it is performed on the host computer thus depending on the image size and CPU performance enabling it may cause increased processing time).

In order for the xiapi to calculate the gain and offset coefficients for each individual pixel, it is necessary to load calibration images (1 dark image and 1 mid-saturated image) before applying FFC in RAW8 or RAW16 format depending on desired output bit depth. To obtain optimal results, camera should be in the same setup (lens, device output bit depth, gain, ROI, downsampling, Zero ROT, light conditions...) during acquisition of calibration images and while using FFC.

Compare of camera output with shading (left) and after FFC enabled (right):

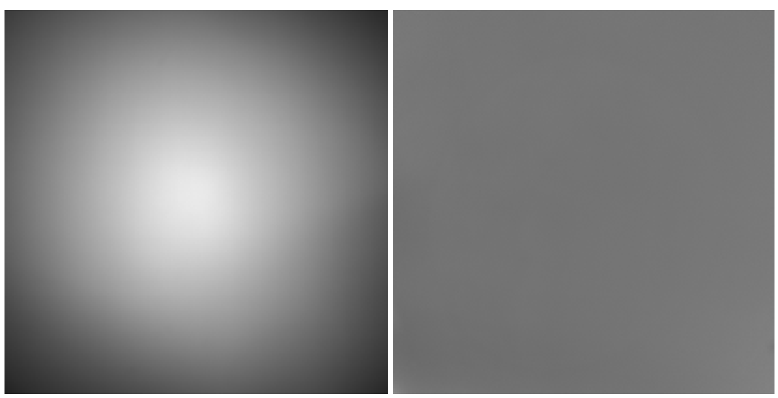


Figure 46: Flat field correction - images comparison

Acquisition of calibration images

The easiest way to acquire calibration images is by using **CamTool** guide:

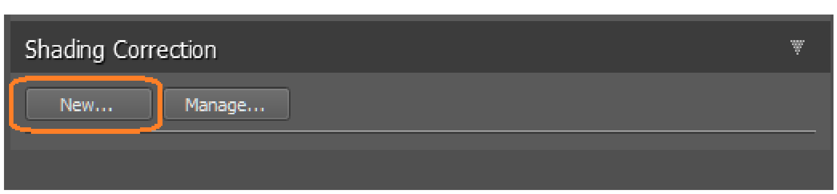


Figure 47: Flat field correction - new FFC

Dark Image

Close camera lens with a cap (make it dark) and click button Capture. Average the image from set number of frames to suppress dynamic noise.

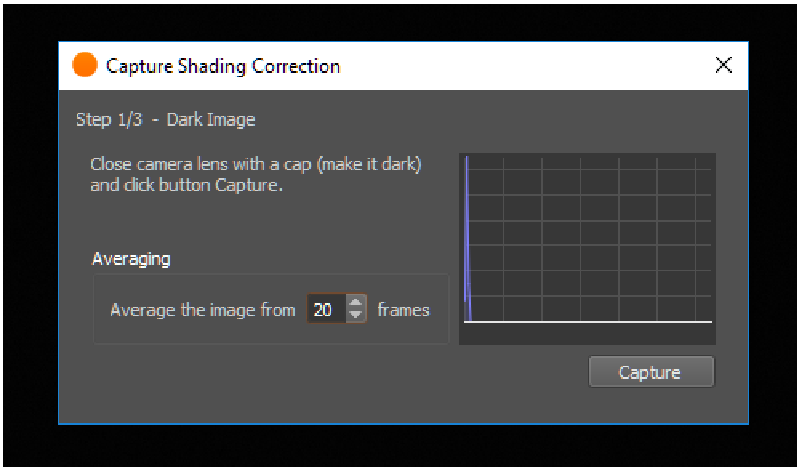


Figure 48: Flat field correction - Dark image

Mid-saturated image

Open camera lens and aim the camera into paper illuminated at 30-70% and click button Capture. Average the image from set number of frames. Image should be focused out of captured plane to reduce dust or other details in the scene.

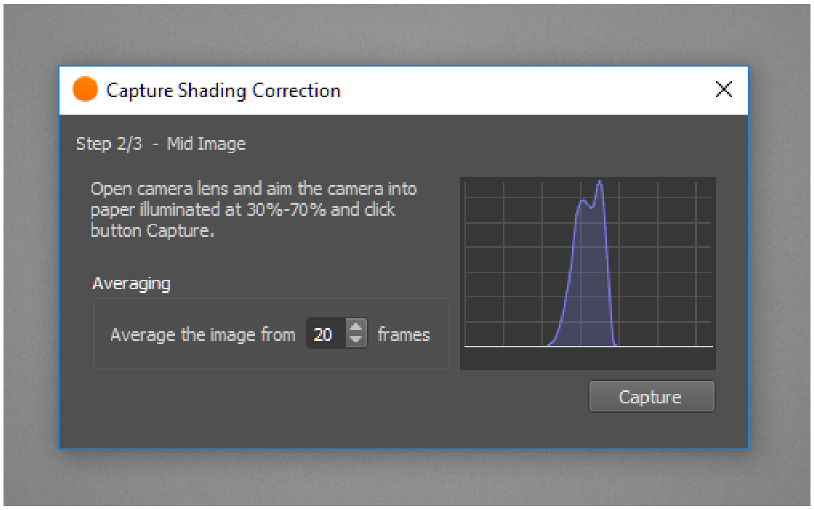


Figure 49: Flat field correction - Mid- saturated image

Save TIFF files

Save the new preset how it be displayed in CamTool.

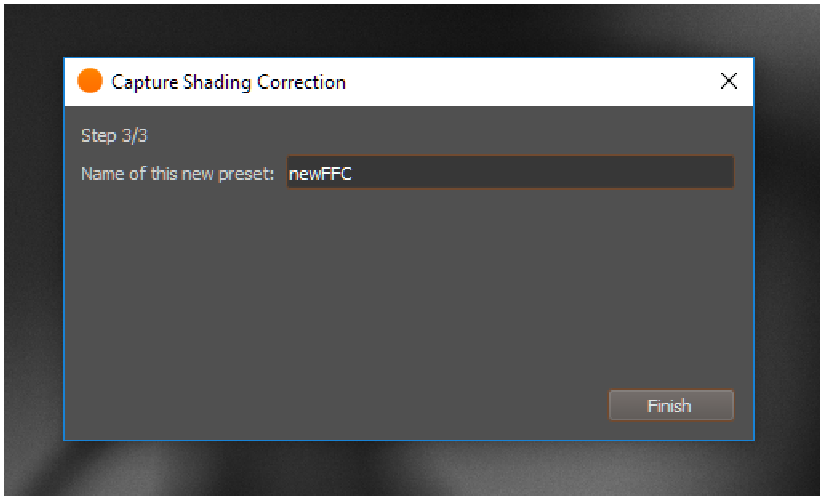


Figure 50: Flat field correction - new preset

To verify calibration, FFC can be also enabled in CamTool by clicking on created preset

Figure 51: Flat field correction - Enabling FFC

In case of any issue, please double check that all dependent camera parameters (device output bit depth, ROI, downsampling, Zero ROT, exposure, gain...) are in the same setup as during acquisition of calibration images

To see calibration images and be able to save them, click on Manage, then choose preset from list. Camera parameters for that particular preset will be displayed. Click on show dark/mid image

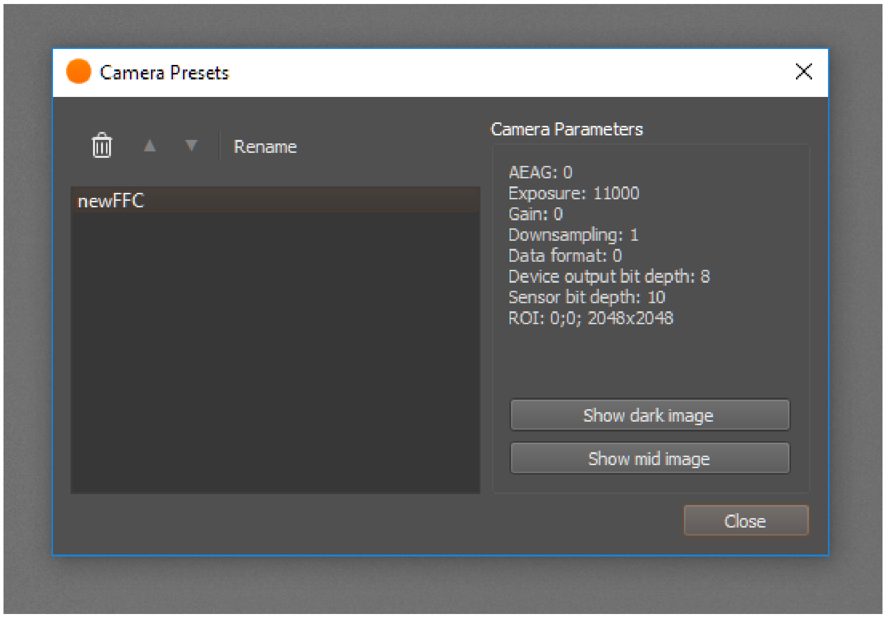


Figure 52: Flat field correction - FFC management

When images are shown in CamTool it is possible to save them by clicking on save icon in top toolbar. Images should be saved in uncompressed TIFF format to use in API.

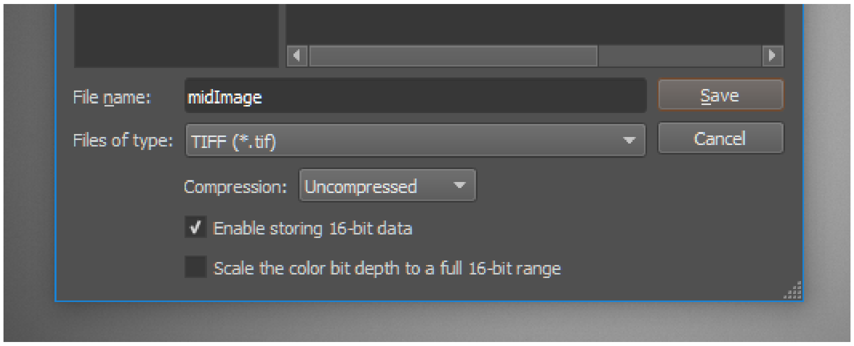


Figure 53: Flat field correction - Safe TIFF

Otherwise, calibration images from CamTool are stored in hidden AppData folder. It can be opened in Windows Run application by command:

`%LOCALAPPDATA%\xiCamTool\shading`

Calibration images might be also acquired in any other tool as long as the output is in TIFF format and with the same camera setup.

Applying FFC in xiAPI

xiAPI command sequence:

- Set all dependent camera parameters (device output bit depth, ROI, downsampling, Zero ROT, exposure, gain...) to be in the same setup as during acquisition of calibration images.
- Load dark image - XI_PRM_FFC_DARK_FIELD_FILE_NAME
  `size` - size of the file name - `strlen(file\_name)`.
- Load mid-saturated image - XI_PRM_FFC_FLAT_FIELD_FILE_NAME
  `size` - size of the file name - `strlen(file\_name)` (place both image files into project folder).

  Note: Use the same image file for this parameter as for XI_PRM_FFC_DARK_FIELD_FILE_NAME for dark-field correction only. Processing will subtract the dark image only while using the unity (1.00) gain for correction.
- Enable XI_PRM_FFC.

Sample code:

```
xiSetParamInt(0, XI_PRM_NEW_PROCESS_CHAIN_ENABLE, XI_ON); // MU,MQ,MD camera families

xiOpenDevice(0, &xiH);
// set dependent camera params to same values as during calibration

xiSetParamString(xiH, XI_PRM_FFC_DARK_FIELD_FILE_NAME, "darkImage.tif", strlen("darkImage.tif"));
xiSetParamString(xiH, XI_PRM_FFC_FLAT_FIELD_FILE_NAME, "midImage.tif", strlen("midImage.tif"));
xiSetParamInt(xiH, XI_PRM_FFC, 1);
```

In FFCdemoWithOpenCV.cpp is FFC demonstrated in OpenCV+xiAPI example. FFC might be enabled or disabled by pressing any key while program is running.

4 Operation

For a proper operation of your camera there are certain requirements that have to be met. You can read more about these requirement 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 API - Application Programming Interfaces.

4.1.2 Hardware requirements

The XIMEA USB3 cameras are compatible with USB 3.1, USB 3.0 and USB 2.0. Please note, that the highest performance can only be achieved by using high performance USB 3.1 or USB 3.0 ports. Using a USB 2.0 port will lead to a limited frame rate.

Please note details and the most recent info on our website: USB3 Hardware Compatibility.

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

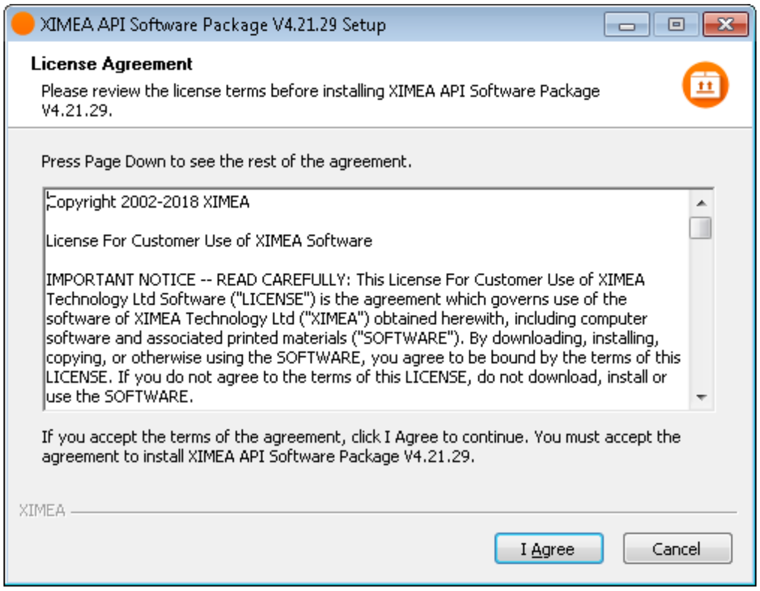
The package contains:

- 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

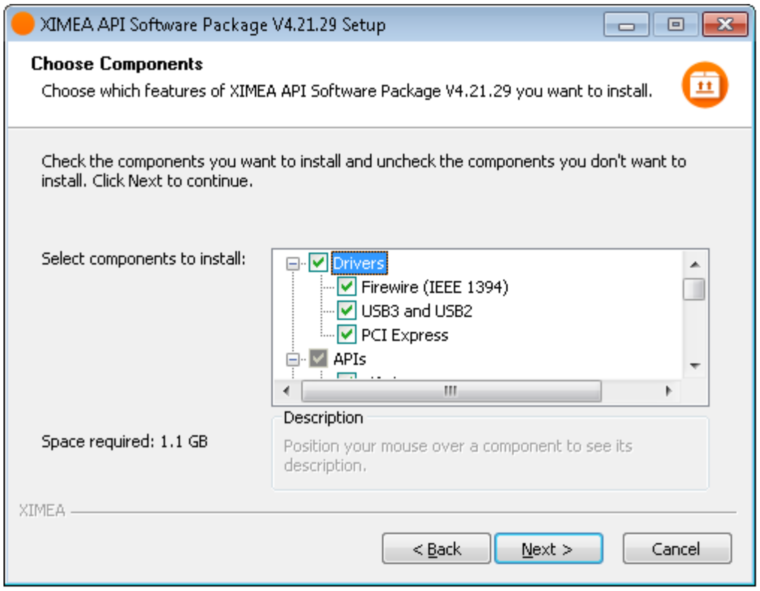
Installation

- 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

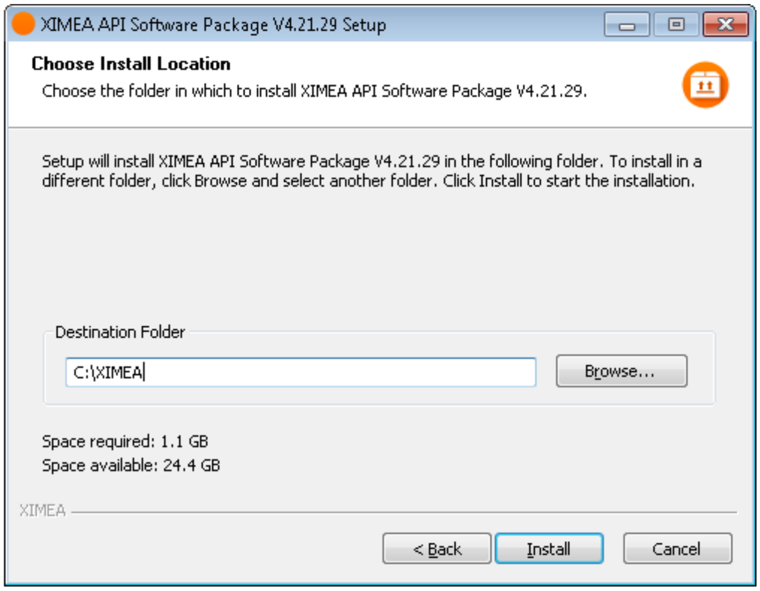
  Be sure that you have administrator privileges or start the Installer with administrator rights (right click and select “run as administrator”):



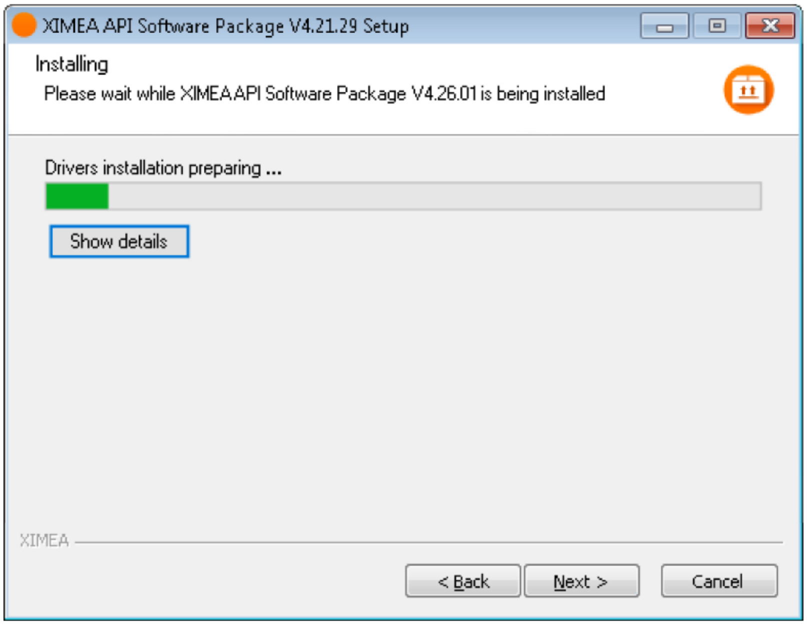
- Select the Software components you want to install. You can uncheck the components you don't want to install, but it is recommended to leave them all checked



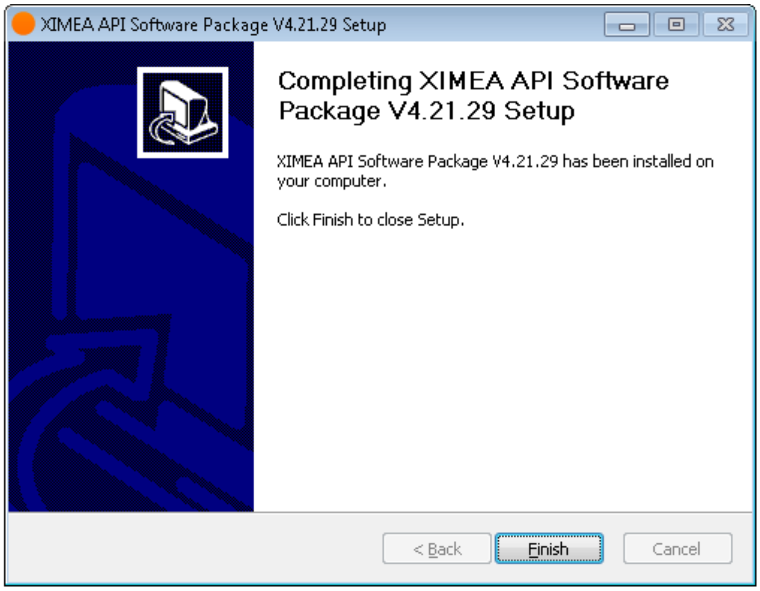
- Specify the install location - you can leave the default location or change it to your desired location



- 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

Instalation

- Download XIMEA Linux Software Package:

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

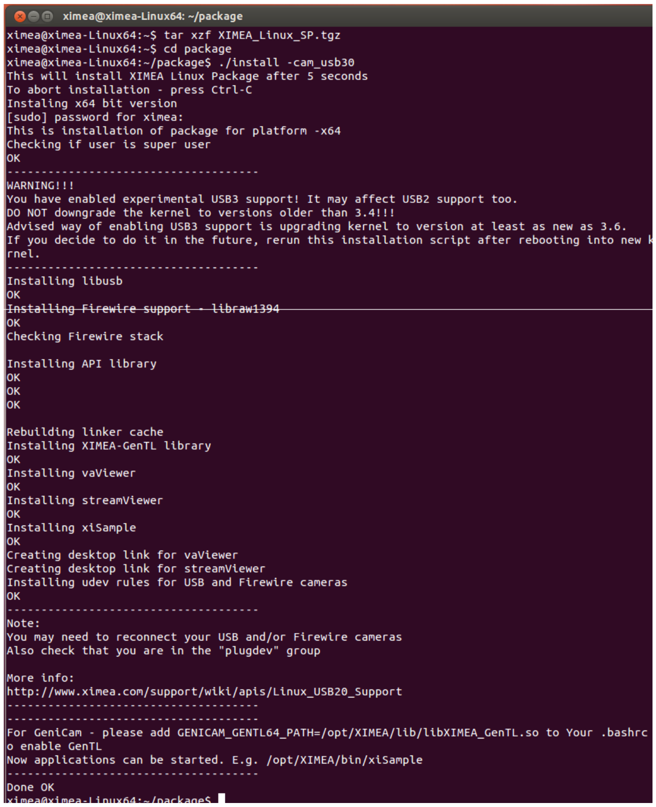
  ```
  wget http://www.ximea.com/downloads/recent/XIMEA_Linux_SP.tgz
  ```

- Untar

  ```
  tar xzf XIMEA_Linux_SP.tgz
  cd package
  ```

- Start installation script

  `./install`



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:

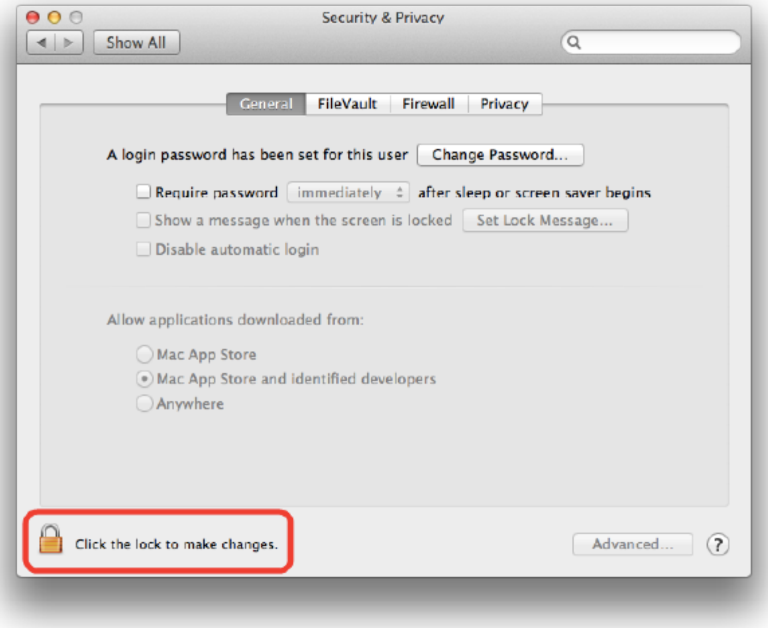
- Driver (beta version) for XIMEA USB2 and USB3 cameras
- xiAPI
- XIMEA CamTool
- Examples:
  - xiSample - sample showing basic image acquisition in xiAPI

Installation

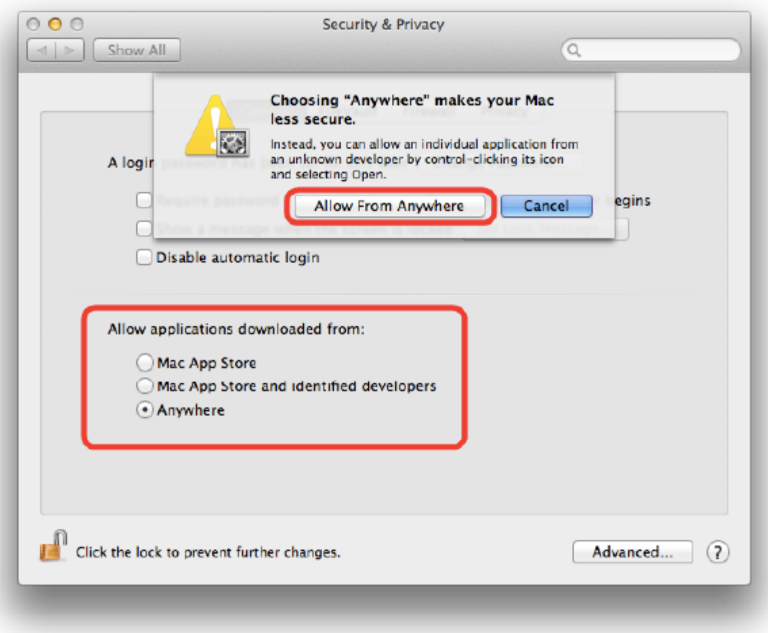
Before installing XIMEA macOS Software Package it may be necessary to modify security settings on your computer. The new feature of OS X 10.8 called GateKeeper can prevent you from using our macOS Software Package due to the fact that the current version is unsigned.

- 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 Finde
- 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, visit our website page: CamTool.

Figure 54: CamTool preview

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

Table 30: CamTool layout

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

4.3.1 Control cooling

The Temperature control is part of the “Camera Settings” panel, which is displayed on the right side by default. More complex temperature monitoring can be displayed in Tools > Temperature Graph.

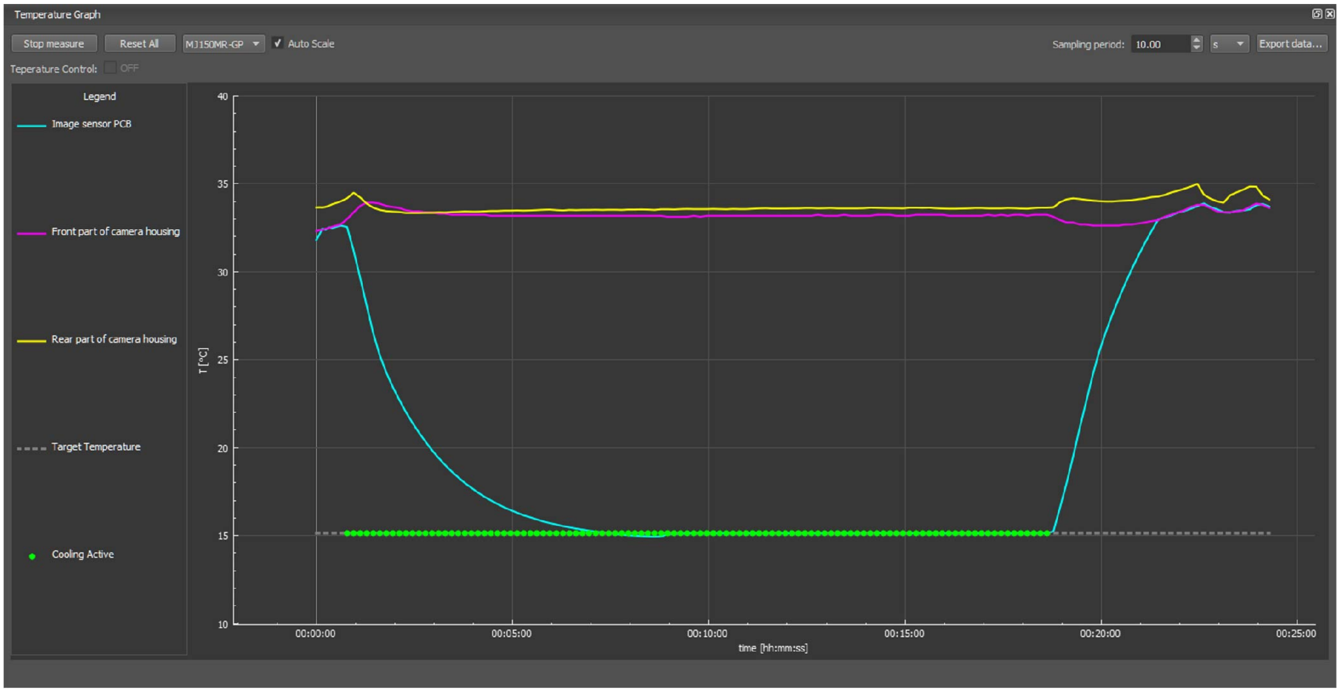


Figure 55: Temperature graph layout

4.3.2 Mode settings

In CamTool you can directly access the camera modes with the presets. The UserSetControl is part of the ”Camera Settings” panel, which is displayed on the right side by default. When a User Set is loaded, all parameters specified in it are always set. For example, the gain value is also reset. This also applies if the already selected mode is set again.

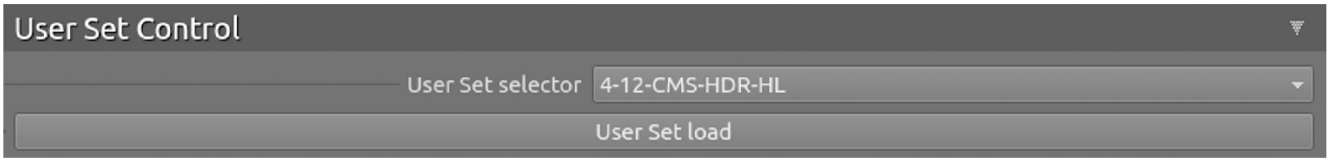


Figure 56: User set control in CamTool

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.

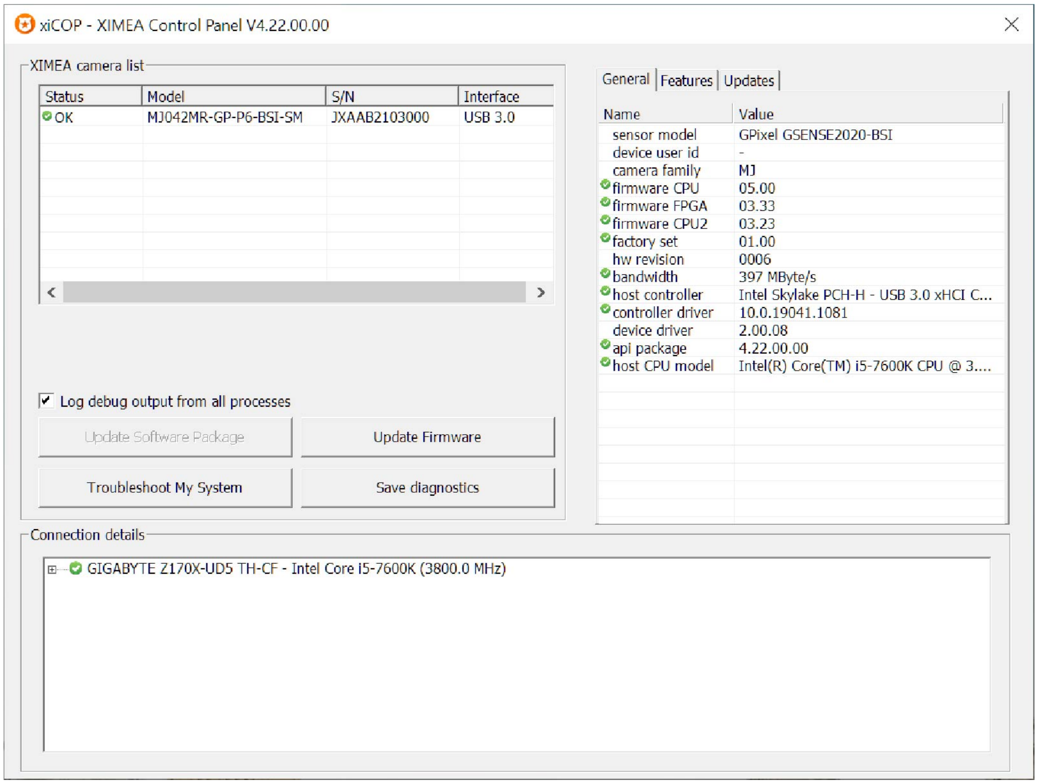


Figure 57: xiCOP example

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 website page: Vision Libraries.

4.5.1 MathWorks MATLAB

MathWorks® is the leading developer and supplier of software for technical computing and Model-Based Design. More on our website page: 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 on our website page: MVTec HALCON.

4.5.3 National Instruments LabVIEW vision library

LabVIEW is a graphical programming environment. More on our website page: National Instruments LabVIEW Vision Library.

4.5.4 OpenCV

OpenCV is an open-source library of programming functions mainly aimed at real time computer vision. More on our website page: 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 programing according the GenICam standard, please visit the standard's website at www.emva.org.

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

// Setting maxium 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.

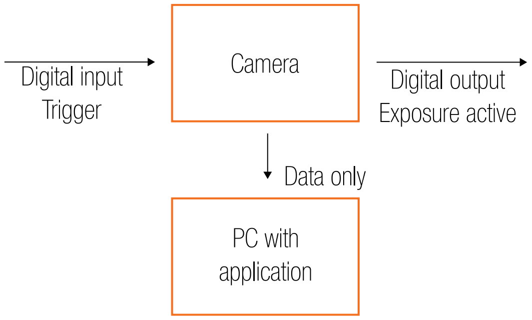


Figure 58: GPIO scheme

```
        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
- XIMEA Linux Software Package
- 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
- Knowledge Base

5.3 Product service request (PSR)

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

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 (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.

Step 2 – Create product service request (PSR)

- Read the XIMEA General Terms & Conditions
- Open the XIMEA Helpdesk
- Set field Department to "Service"
- Fill in all fields
- Confirm with the button "Submit"

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.

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.

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 31: Service operations overview

If the camera will be returned, you will receive the tracking number. In this case, please continue to Step 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".

NOTE: If you have any problems accessing the links below, please contact our Support Team at www.ximea.com.

5.4 Safety instructions and precautions

Safety instructions and precautions are available at the following XIMEA webpage: Safety instructions and precautions.

5.5 Warranty

Information about warranty is available at the following XIMEA webpage: Warranty.

5.6 Standard Terms & Conditions of XIMEA GmbH

The Standard Terms and Conditions are available at the following XIMEA webpage: General Terms and Conditions.

5.7 List of Trademarks

List of Trademarks is available at the following XIMEA webpage: List of Trademarks.

5.8 Copyright

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Glossary

CMOS	Complementary Metal-Oxide-Semiconductor 47
DR	Dynamic Range 8
ESD	Electrostatic discharge 26
FPGA	Field Programmable Gate Array 39
FPS	Frame Per Second 46
FWC	Full Well Capacity 8
PSR	Product Service Request 72
ROI	Region Of Interest 39
sCMOS	Scientific Complementary Metal-Oxide-Semiconductor 8

List of Figures

List of Tables

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