ximea

xiJ

[ksi-dʒeɪ or sai- dʒeɪ]

- USB 3.1 scientific cameras

Technical Manual

Version 0.06, November, 2022

1. Introduction

1.1. About This Manual

Dear customer,

Thank you for purchasing a product from XIMEA.

The purpose of this document is to provide a description of the XIMEA xiJ-Series 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 camera for the first time. Please follow all instructions and observe the warnings.

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 section of our website: www.ximea.com/support

This document is subject to change without notice.

1.2. About XIMEA

We develop, manufacture and market innovative camera solutions and imaging systems for integrators, OEMs, and the global markets in general. Our history in research, development, and production dates back to 1992. From our locations in Slovakia, Germany, and the US, and with a global distributor network, we offer our solutions to all types of companies and institutions across every imaginable application field.

Industrial cameras, scientific cameras, custom engineering, imaging ecosystems as well as software and tools form the portfolio.

A 50/50 mix of custom projects and series production guarantees innovative, technology-driven developments, as well as reliable supply and support.

We utilize the latest CMOS and sCMOS sensors combined with the fastest and highly efficient interfaces such as USB3, Thunderbolt, and PCIe.

The robust camera packages are the smallest and lightest in class. The mechanical and electrical design aims for a high degree of flexibility that facilitates all sorts of integrations.

Innovative cooling concepts and deep knowledge in sensor tuning, elevate the imaging performance.

The extensive software support spans across various platforms, operating systems, and programming environments. In addition, we support generic camera interfaces and a multitude of vision libraries.

Technology-driven and always seeking innovative solutions, our creations are already solving future problems today.

We don‘t just make imaging systems - we invent them.

1.2.1. Contact XIMEA

XIMEA is a worldwide operating company

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Support	https://www.ximea.com/support/wiki/allprod/Contact_Support

1.3. Standard Conformity

The xiJ cameras have been tested using the following equipment:

- Host adapter card, connector Type-A, ref. Asmedia ASM3142 - PCIe USB card U31-PCIE2XG321
- Shielded USB 3.0 Type-A to micro-B cable ref. CBL-U3-3M0 (3m)
- USB type C power injector adapter ref. ADPT-PWR-INJ-TC
- Shielded USB 3.1 Type-C to Type-C cable ref. CBL-U31TC-3M0 (3m)
- Power cable ref. CBL-MJ-PWR-2M0
- Power supply 5-24V DC

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:

1.3.1. CE Conformity

The xiJ cameras described in this manual comply with the requirements of the

- EC EMC Directive 2014/30/EU electromagnetic compatibility of equipment

1.3.2. For customers in the US: FCC Conformity

The xiJ cameras described in this manual 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:

- This device may not cause harmful interference, and
- 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 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 above jurisdictions. The shielded interface cable recommended in this manual must be used with this equipment in order to comply with the limits for a computing device pursuant to Subpart J of Part 15 of FCC Rules.

1.3.3. For customers in Canada

The xiJ cameras comply with the Class A limits for radio noise emissions set out in Radio Interference Regulations.

1.3.4. RoHS Conformity

The xiJ cameras comply with the requirements of the RoHS (Restriction of Hazardous Substances) Directive 2011/65/EU.

1.3.5. WEEE Conformity

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

1.3.6. GenICam GenTL API

GenICam standard transport layer interface, grabbing images. GenICam/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.

1.4. Helpful Links

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

1.5. Table of Contents

2. xiJ Camera Series

2.1. What is xiJ

xiJ [ksi-dʒeɪ or saɪ-dʒeɪ] is a compact sCMOS Cameras with scientific grade parameters:

- Scientific grade family of sCMOS sensors from Gpixel
- Resolutions 4.2 Mpix
- Includes versions with Backside Illuminated sensors
- Crystal clear 12 and 16 bit/pixel images from Dual ADC pixel design
- Extremely low readout noise architecture, down to 1.2 e^-
- Dynamic range up to 90 dB
- Quantum Efficiency up to 95%
- Variety of sensor readout options
- Partial readout and binning modes for enhanced sensitivity and speed
- Framerates up to 61 fps trough USB3 interface
- Power delivery via USB-C cable using USB PD protocol 2.0
- Compact dimensions down to 52 x 52 x 62 mm
- Thermoelectric Peltier cooling down to -20°C (with stability of ±0.1°C).
- External triggering and synchronization functionality

2.2. Advantages

Precise	Built with the latest sCMOS sensors from Gpixel for sensitivity and speed.
Small	Compact housings with C-mount. Smallest cooled camera around any given sensor.
Fast	Fast data rate through USB3 interface.
Robust	Combination of stainless steel, machined copper and aluminum alloy housing materials with Indium seals to achieve long life and optimal cooling performance.
Scientific	Suppressed dark current and noise during long exposures and low-light.
Optimized	Low and high gain modes for best results in FWC and dynamic range.
Cool	Thermoelectric Peltier cooling backed by a fan.
Stable	Sensor chamber is filled with inert gas for sustained temperature conditions and protection.
Connectivity	Programmable opto-isolated I/O digital input and output. Programmable status LEDs.
Compatibility	Support for various host platforms and software environments.

table 2-1, advantages

2.3. Scientific Camera Applications

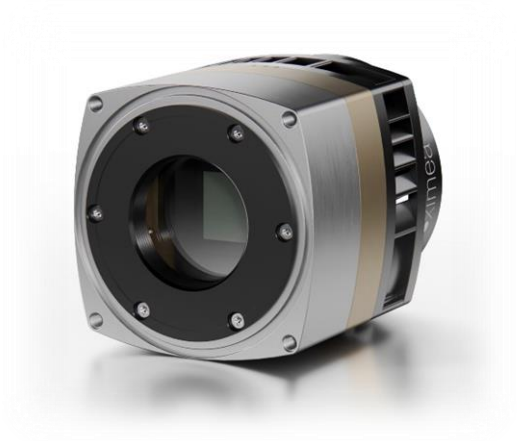
- Fluorescence Resonance Energy Transfer
- Fluorescence recovery after photobleaching
- Fluorescence in situ hybridization
- Total internal reflection fluorescence
- Fluorescence correlation spectroscopy
- Near Earth object detection
- Astronomy
- Photoactivated localization microscopy
- Stochastic Optical Reconstruction Microscopy
- Single Plane Illumination Microscopy
- Optical coherence tomography
- Coherent Anti-Stokes Raman Scattering
- Bose-Einstein condensates

2.4. Common features

Sensor technology	Scientific CMOS (sCMOS)
Acquisition modes	Rolling shutter, Global Reset Release
Sensor versions	Backside illuminated (BSI)
Image data formats	12, 16 bit RAW pixel data
Interface default	USB 3.1 Gen1 standard Type C compliant to USB3 Vision standard The xiJ camera line comes with type-C interface to the host computer. At the time of writing, the USB cameras utilize USB 3.1 gen1 definitions and yield a bandwidth of about 400 Mbyte/s.
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
Lens mount	C-mount or T-mount (M42 x 0.75mm)
Cooling	Thermoelectric Peltier cooling and fan
Power consumption	3.4 Watt (16.8 W with Cooling ON) supplied via USB3 interface with PD - Power delivery for Cooling
Size dimensions	52 x 52 x 62 mm (depends on version)
Weight	336 grams (depends on version)
Environment	Operating 0°C to 40°C on housing; RH 80% non-condensing; -30°C to 60°C storage
Conformity	CE, FCC, RoHS, GenICam/GenTL, USB 3.0 SuperSpeed
Operating systems	Windows 7 SP1 (x86 and x64) and 10, Linux Ubuntu, macOS
Host hardware	Support for x86/x64 and ARM platforms. Minimum Requirements: Intel i3 3.0GHz, +2GB RAM physical memory, NVIDIA or Radeon 128MB, Motherboard with PCIe x1 Gen 2 slot, USB 3.0 host adapter with Power delivery
Software support	GenICam / GenTL and highly optimized xiAPI SDK (C/C++, C#, Python). Support various image processing libraries (LabView, Matlab, MicroManager, …)
Firmware updates	Field firmware update through xiCOP tool
Viewer program	CamTool viewer

table 2-2, common features

2.5. Models Overview, sensor and models



Model	Resolution	Pixel size	Bits	Dynamic range	Sensor size	FPS[1]
MJ042MR-GP-P6-BSI	4.1 MP	6.5 µm	12	90 dB	1.2”	61.6

table 2-3, models overview

Note: 1) Full resolution, 12-bit, transport format.

2.6. Accessories

The following accessories are available (short list):

Item P/N	Description
ADPT-PWR-INJ-TC	USB type C power injector adapter
CBL-U3-3M0	USB3 cable, Type-A to Micro-B, 3m
CBL-U31TC-3M0	USB3 cable, Type-C to Type-C, 3m
CBL-MJ-PWR-2M0	Power cable
CBL-MJ-SYNC-3M0	3.0m Trigger/Sync I/O cable

table 2-4, accessories

3. Hardware Specification

3.1. Power Supply

The xiJ cameras support power delivery via USB Type-C connector. The camera can be powered via power injector (see *3.12 Power injector ADPT-PWR-INJ-TC*) if a power delivery enabled host is not available.

Power supply, via USB system connector:

- 20 V (nominal)
- 5 V to 24 V (at the camera connector)

Note: For proper cooling, the supplied voltage needs to be at least 12V. With lower voltage level, the cooling performance is limited.

Power consumption:

- 3.4 W (nominal, no cooling)
- 2.5 W (stand-by, no streaming)
- 16.8 W (max, cooling active -15°C)

Note: ADPT-PWR-INJ-TC will add 0.8 to 0.9 W to the power consumption.

3.2. General Specification

3.2.1. Environment

Description	Symbol	Value
Optimal ambient temperature operation	T_{opt}	+10 to +25 °C
Ambient temperature operation	T_{max}	0 to +40 °C
Ambient temperature for storage and transportation	$T_{storage}$	-30 to +70 °C
Relative Humidity, non-condensing	RH	80 %

table 3-1, environment

Housing temperature must not exceed +50°C. The following parameters are not guaranteed if the camera is operated outside the optimum range:

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

3.3. Lens Mount

The xiJ cameras are compatible with C-mount and T-mount lenses.

3.3.1. C-mount

Note: The maximum distance between flange focal distance and back focal distance for C-mount lenses must not exceed 6mm. Otherwise the protective sapphire glass may be damaged or the capability to focus to infinity could be limited.

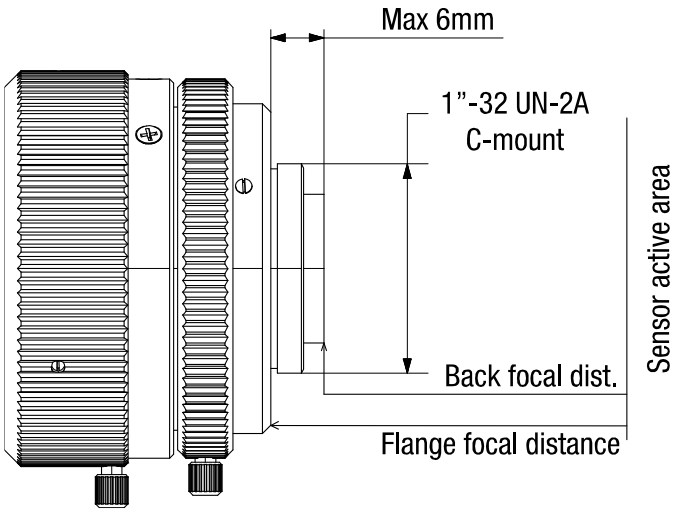


figure 3-1, distance between flange focal distance and back focal distance

3.3.2. T-mount (M42 x 0.75mm)

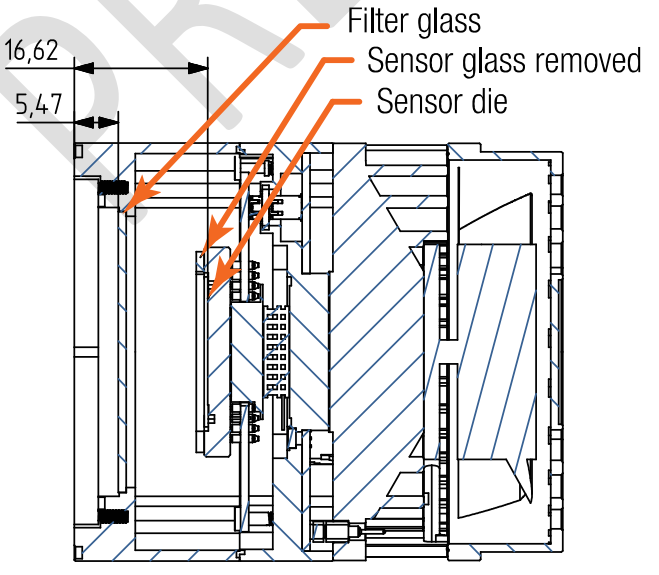
The camera can be coupled with additional lens adapters and extensions to further expand the range of compatible lenses:

- Standard T-mount: Flange focal distance is 55mm (can be achieved with purchased T-mount extension rings: 20mm in camera + 25mm extension ring + 10mm extension ring).
- Canon EF mount: Flange focal distance is 44mm (20mm in camera + 5mm extension ring + 19mm T2 to Canon EF mount adapter)
- Nikon F mount: Flange focal distance is 46.5mm (20mm in camera + 5mm extension ring + 0.5mm spacer + 21mm T2 to Nikon mount adapter)

3.4. Optical path

3.4.1. Filter glasses

A filter glass is part of the optical path of the camera. The window is cold welded using indium wire, to keep contaminants out of the camera and to keep the filler gases intact. The camera can operate without a lens mount. 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 is 16.62mm - 0.2mm (tolerance). Additionally, C-mount or T-mount lens accessories can be installed on the camera providing various lens mounting options.



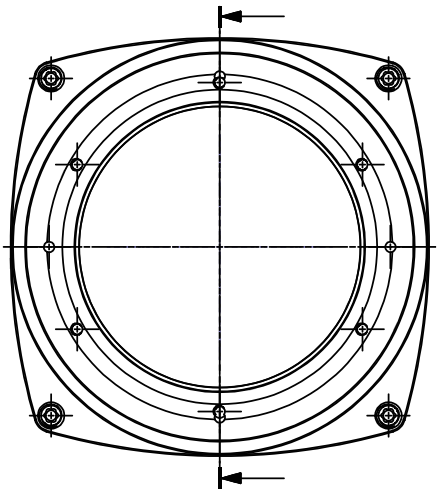


figure 3-2, optical path section

3.4.2. Monochrome camera models

Used filter material	Sapphire
Thickness	1.0±0.1 mm
Coating	Anti-reflex, both sides

table 3-2, monochrome camera - filter glass parameter

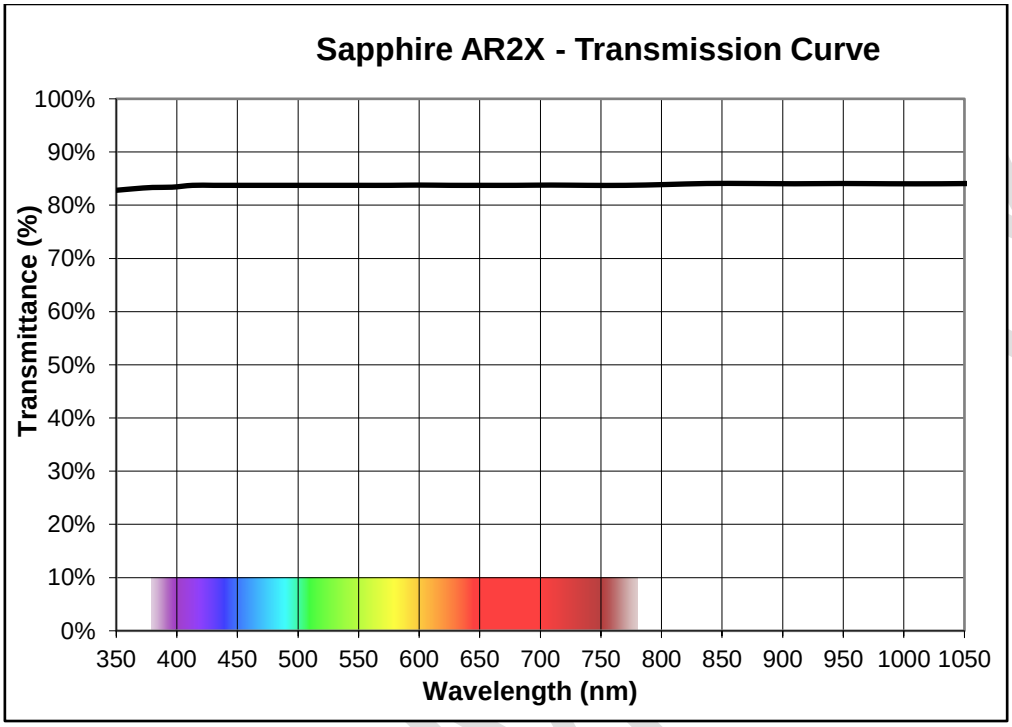


figure 3-3, monochrome camera - filter glass transmission curve

3.5. Model Specific Characteristics

3.5.1. MJ042MR-GP-P6-BSI

3.5.1.1. Sensor and camera parameters

xiJ model		MJ042MR-GP-P6-BSI
Sensor parameters		
Model name		GSENSE2020BSI-ABM-NUN-AR1[1]
Technology		sCMOS
Color filter		None
Shutter type		Rolling shutter, Global reset release
Pixel Resolution (H × V)	[pixel]	2048 x 2048
Active area size (H × V)	[mm]	13.3 x 13.3
Sensor diagonal	[mm]	18.8
Optical format	[inch]	1.1
Pixel Size (H × V)	[µm]	6.5 x 6.5
ADC resolution	[bit]	2x12 [2]
Image quality parameters[3]		
Saturation capacity	[ke-]	57.8 [4]
Dynamic range	[dB]	90
SNR Max	[dB]	48.6
Conversion gain	[e-/LSB_{16}]	1.19
Median read noise	[e-]	1.82
Dark current	[e-/s]	20
DSNU	[e-]	0.7
PRNU	%	1.3
Linearity	[%]	TBD
Camera parameters		
Exposure time (EXP)		24µs to 2147.483 sec, in steps of 10.5µs [5]
Analog Gain Range	[dB]	0-25 [6]
Refresh rate (MRR)	[fps]	61.6
Power consumption		
typical	[W]	3.4
Maximum	[W]	18 [7]
Dimensions/Mass		
Height	[mm]	52.1
Width	[mm]	52.1
Depth	[mm]	61.75
Weight	[g]	336

table 3-3, MJ042MR-GP-P6-BSI, sensor and camera parameters

Notes:

1) No micro-lenses, no sensor cover glass
2) Parallel readout of two 12bit channels merged into 16bit data
3) Measured in HDR mode, at 20°C
4) Measured according to EMVA1288 Standard
5) Defined for maximal bandwidth. Minimal Exposure and exposure step (Line Period) could be calculated in: Camera performance calculator https://www.ximea.com/support/tools/camcalc/#/camera/MJ042MR-GP-P6-BSI

6) Value is dependent on the readout mode

7) Measured on air-cooled cameras with cooling set to -20°C

Supported standard readout modes	Binning / decimation	Output resolution	fps	Sensor Bit/px	Transport Bit/px
12-STD-L	1x1	2048 x 2048	62.0	12	12
	2x2 / 1x1	1024 x 1024	62.1	12	12
	4x4 / 1x1	512 x 512	62.1	12	12
	2x1 / 1x2	1024 x 1024	62.1	12	12
	4x1 / 1x4	512 x 512	122.2	12	12
12-STD-H	1x1	2048 x 2048	62.0	12	12
2-12-CMS-S-L	1x1	2048 x 2048	46.9	12	16
	2x2 / 1x1	1024 x 1024	47.3	12	16
	4x4 / 1x1	512 x 512	47.3	12	16
	2x1 / 1x2	1024 x 1024	93.9	12	16
	4x1 / 1x4	512 x 512	184.7	12	16
2-12-CMS-S-H	1x1	2048 x 2048	46.9	12	16
2-12-HDR-HL	1x1	2048 x 2048	46.8	12	16
	2x2 / 1x1	1024 x 1024	46.8	12	16
	4x4 / 1x1	512 x 512	46.8	12	16
	2x1 / 1x2	1024 x 1024	93.9	12	16
	4x1 / 1x4	512 x 512	184.8	12	16

table 3-4, MJ042MR-GP-P6-BSI, supported standard readout modes

3.5.1.2. Quantum efficiency curves [%]

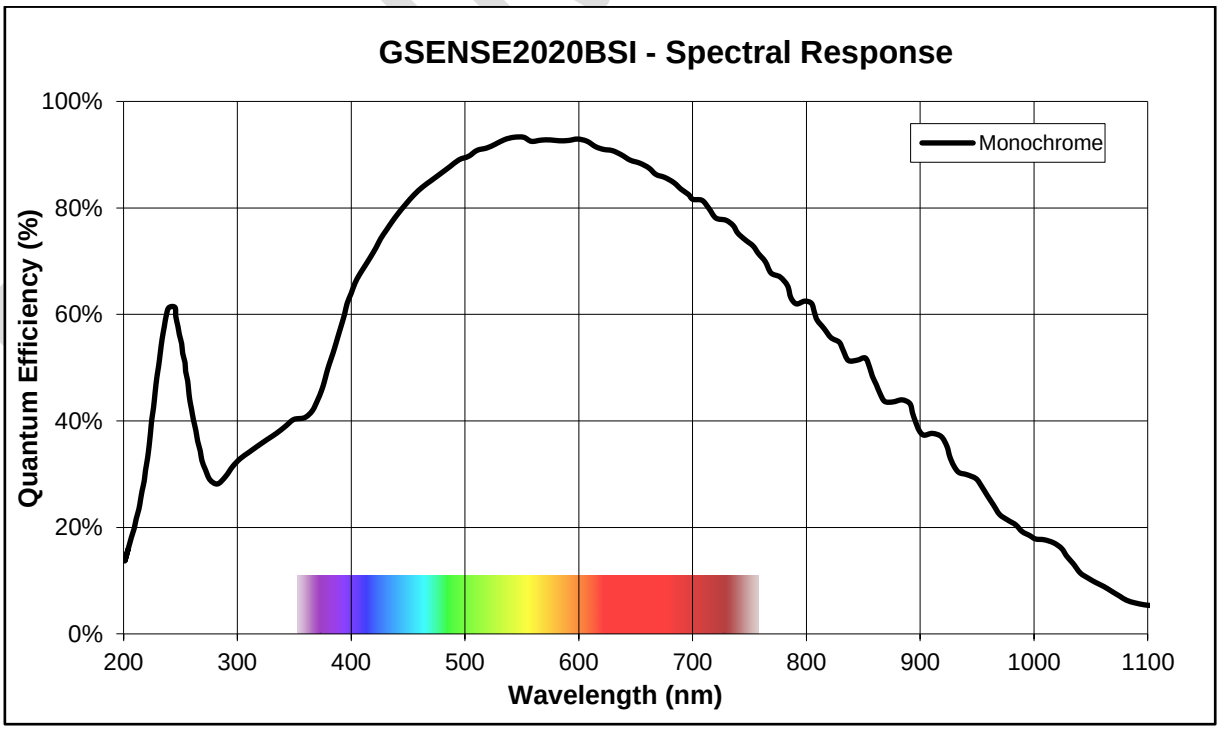


figure 3-4, GSENSE2020BSI, quantum efficiency curve, ©GSENSE

3.5.1.3. Dimensional drawings MJ042MR-GP-P6-BSI (C-mount)

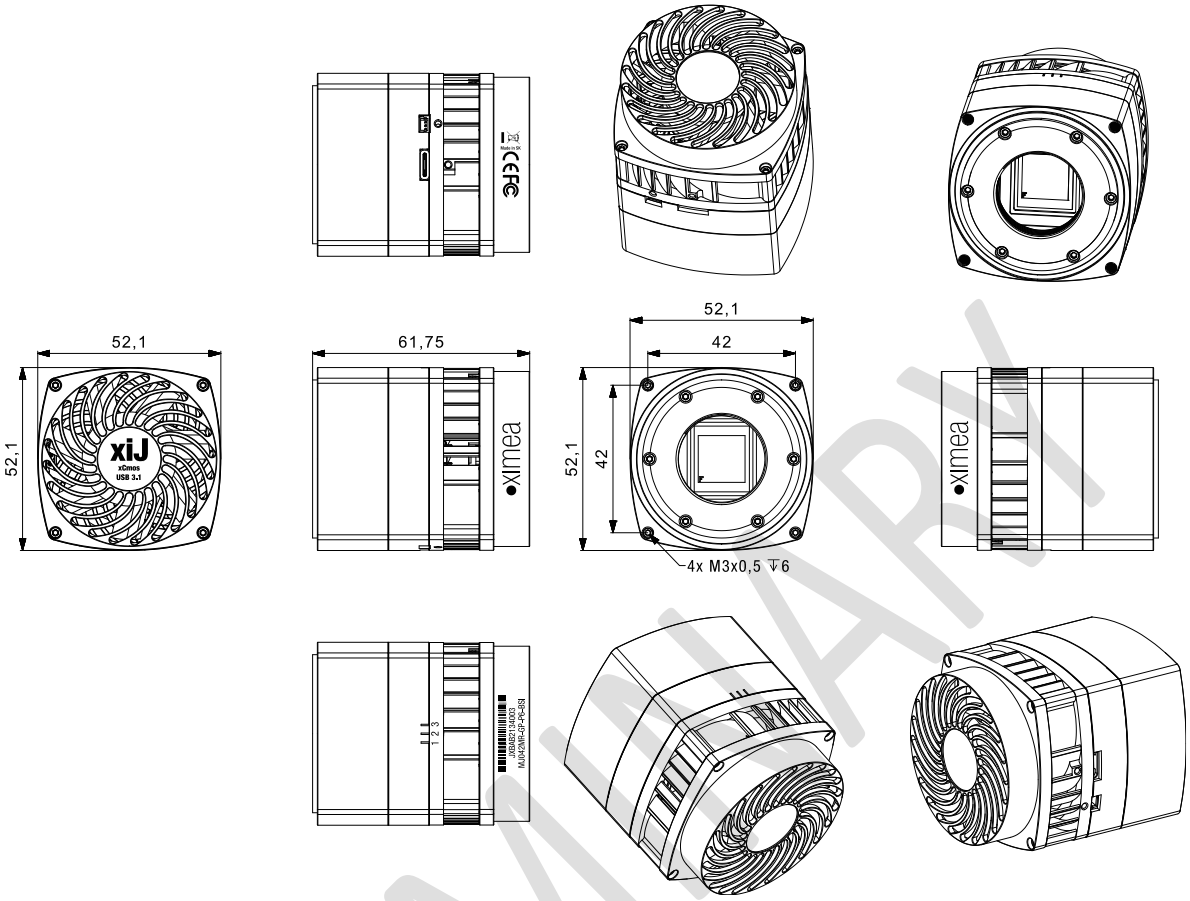


figure 3-5, dimensional drawing MJ042MR-GP-P6-BSI, C-Mount housing

3.5.1.4. Sensor features

feature	Note
Binning	Yes, vertical 1-4, horizontal 1-4
Skipping	Yes, vertical 1-4
ROI	Vertical cropping results in increased read speed, horizontal reduces data transfer
HW Trigger	Trigger supported (see *4.1.5.2 Trigger controlled Acquisition*/Exposure)
HDR	Yes, Dual ADC channel merging

table 3-5, sensor features available

3.6. User interface – LEDs

Three status LEDs are located on the back of the cameras, please see below.

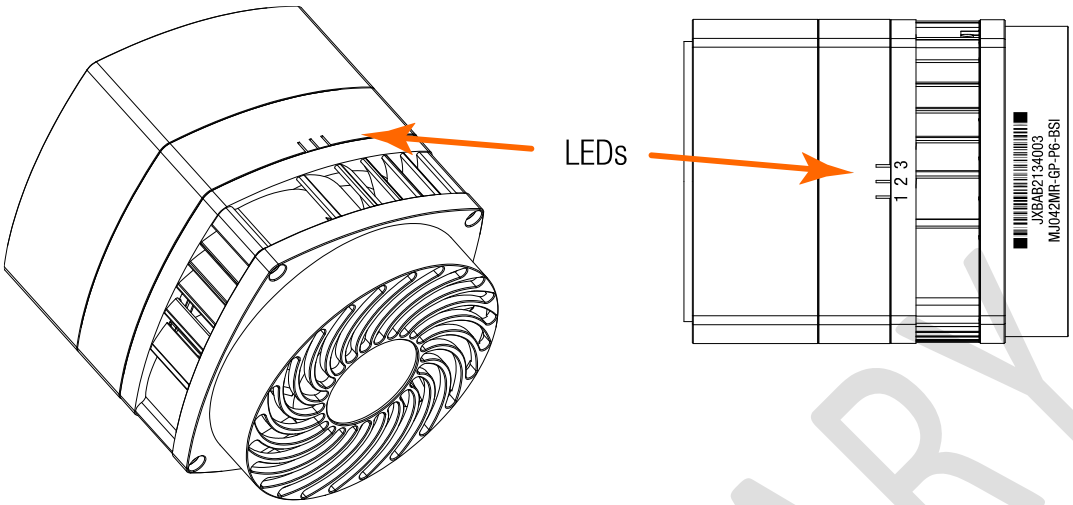


figure 3-6, position status LEDs

All LEDs can be configured similar to standard input and output lines.

Default LED function after power on

LED	Color	Power-on defaults	Note
1	Red	On	User configurable
2	Green	On	User configurable
3	Orange	On	User configurable

table 3-6, LED output description

LED statuses during boot sequence

Status	LED1 (Red)	LED2 (Green)	LED3 (Orange)
Off	Off	Off	Off
Power	On	Off	Off
Booting	Off	flash ~2Hz	Off
Boot up finished	On	Off	On
USB init – wait for enumeration	flash ~1Hz	Off	Off
Enumeration finished USB2	Off	Off	flash ~2Hz
Enumeration finished USB3	Off	Off	On
Device stop	flash ~2Hz	Off	flash ~2Hz
Error	flash ~2Hz	Off	flash async.

Table 3-7 LED status during boot

3.7. xiJ USB 3.1 Gen1 Type-C Interface

Connector	Signals	Mating Connectors
USB 3.1	Standard USB 3.1 Gen1 Type-C Connector	Standard USB 3.1 Type C Connector with thumbscrews Screw thread M2, thread distance 15.0mm

table 3-8, USB 3.1 mating connector description

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

3.7.1. Type-C connector location

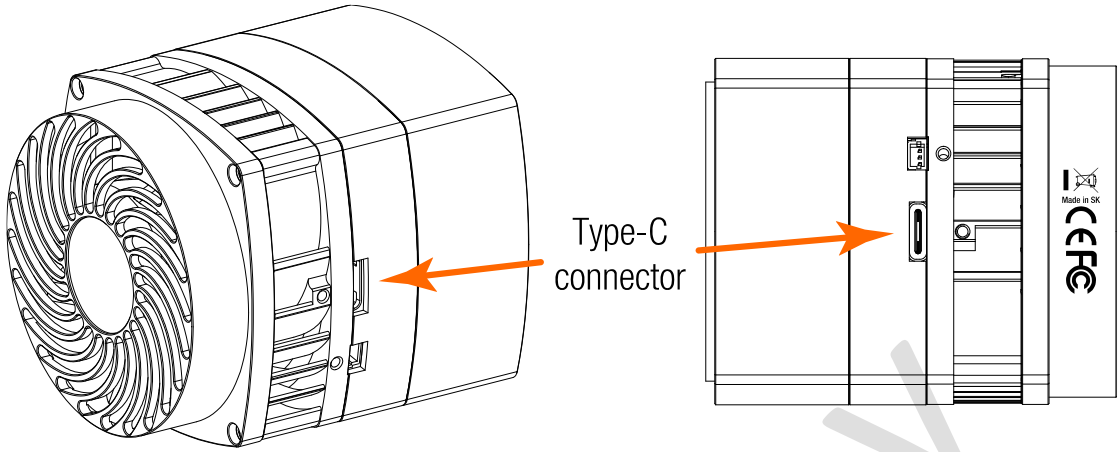


figure 3-7, position of Type-C connector

3.7.2. Pinning

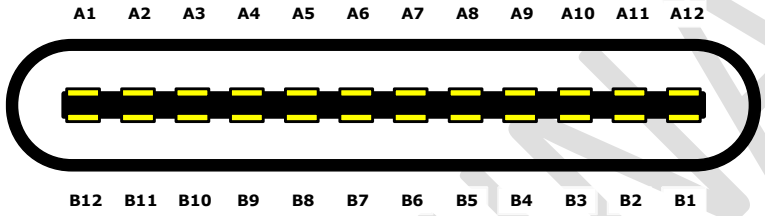


figure 3-8 pinning of Type-C connector

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	VBUS	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 3-9 USB type C connector pin assignment

3.8. xiJ Digital Input / Output (GPIO) Interface

USB XiJ cameras use a 3-pin connector for the GPIO interface and have one input and one output.

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

table 3-10, GPIO mating connector description

3.8.1. Location

IO interface receptacle is located on the side of the camera:

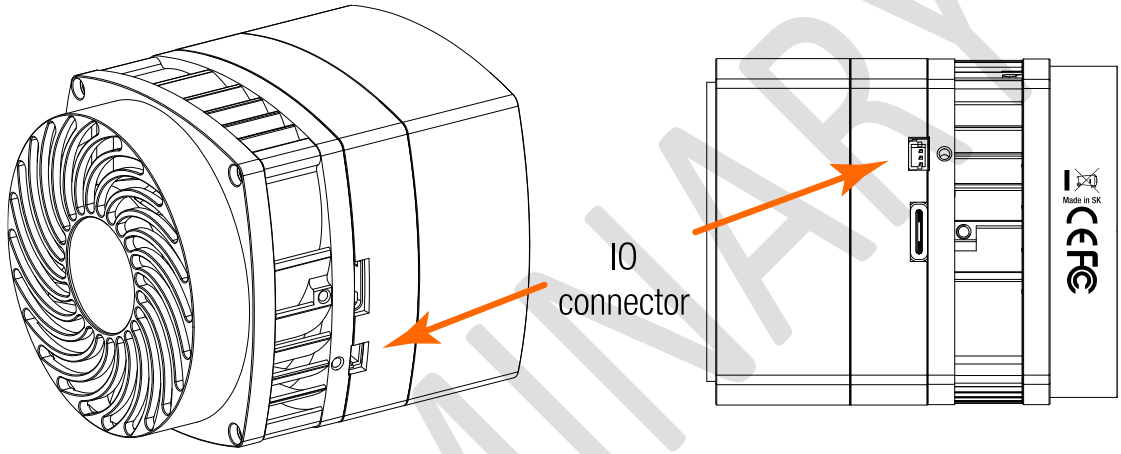


figure 3-9, position GPIO connector

3.8.2. IO Connector Pinning

Pinning of the IO connector (camera):

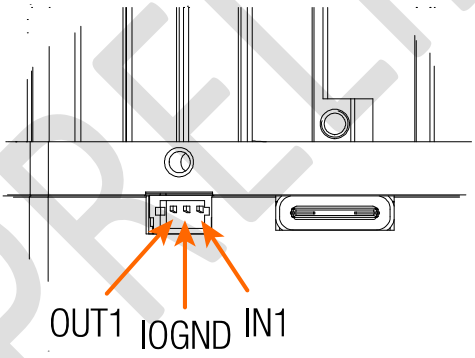


figure 3-10, pinning GPIO connector

I/O connector Pin Assignment:

Pin	Name	Signal	Technical description
1	OUT1	Opto-isolated Output	(<0.8 Low; 3.3-24 High) [1]
2	IO GND	Common (IO Ground)	-
3	IN1	Opto-isolated Input	(<0.8 Low; 3.3-24 High) [1]

table 3-11, I/O connector Pin Assignment

Note: – 1) Values differ for rev.5 and lower

3.8.3. Optically isolated Digital Input

3.8.3.1. Optically isolated Digital Input – General info

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

table 3-12, Optically isolated digital input, general info

Note: Applies to the current revision (Rev6). Values and maximal voltage for Rev4 and Rev5 differ.

3.8.3.2. Digital Input – signal levels

V-in-min [V]	V-in-max [V]	State	I-max [mA]
-24.0	1.2	Off (0)	0.0 – 0.3 mA (0mA nominal)
1.2	3.3	Transient	-
3.3	24.0	On (1)	1 – 6 mA (5mA nominal)

table 3-13, digital info, signal levels

Note:

- Input level **Vin** represents amplitude of the input signal.
- Voltage levels referenced to common ground GND

3.8.3.3. Digital Input – Internal Schematic

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

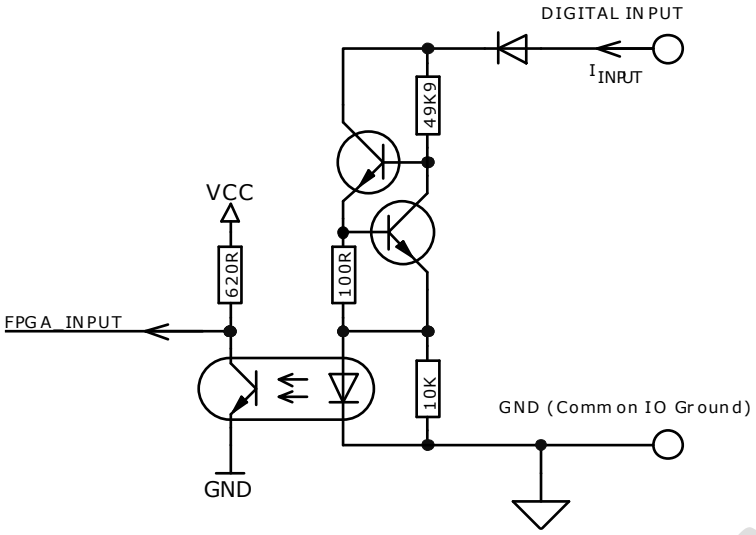


figure 3-11, digital input, interface schematic

3.8.3.4. Digital Input – Wiring

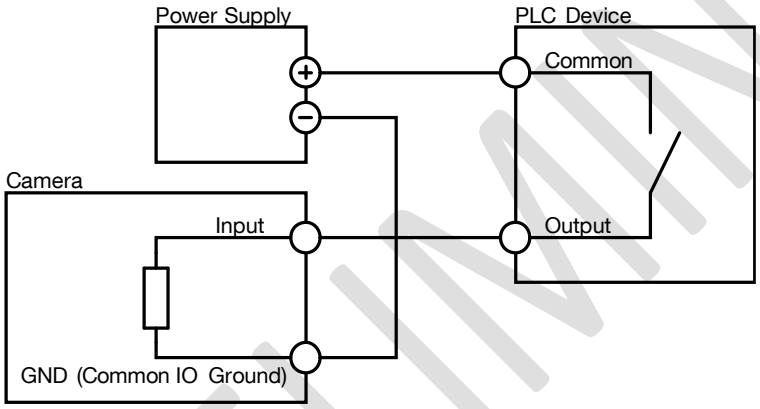


figure 3-12, digital input, interface wiring

3.8.3.5. Digital Input – Timing

Typical measured input delay between Digital Input to FPGA Input

Measurements of input delays:

Edge Type	Input Voltage [V]	Typ. Delay [µs]
Rising	3.3	0.74
Rising	5	0.26
Rising	10	0.1
Rising	24	0.1
Falling	3.3	4.4
Falling	5	4.64
Falling	10	4.93
Falling	24	5.08

table 3-14, digital input, timing

Note:

- Measured at: Ambient Temperature 25°C

3.8.4. Optically isolated Digital Output

3.8.4.1. Optically isolated Digital Output – General info

Item	Parameter / note
Maximal open circuit voltage	24V
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	36mA
Trip current	71mA – self restarting when failure mode current disconnected
Inductive loads	No
Effect of incorrect output terminal connection	Protected against reverse voltage connection
Maximal output dropout	1V, sink current 25mA
Output delay ON->OFF	14.4µs ($V_{PULL-UP}$=12V, $R_{PULL-UP}$=5kOhm, $T_{AMBIENT}$=25°C)
Output delay OFF->ON	2.68µs ($V_{PULL-UP}$=12V, $R_{PULL-UP}$=5kOhm, $T_{AMBIENT}$=25°C)
Number of outputs	1
Strobe output mapping	Yes

table 3-15, Optically isolated digital output, general info

3.8.4.2. Optically isolated Digital Output Delay

Output current	OFF -> ON	ON -> OFF	Note
1mA	1.4 µs	14.1 µs	V_{OUTPUT}=5V, $T_{AMBIENT}$=25°C
1mA	1.9 µs	25.3 µs	V_{OUTPUT}=10V, $T_{AMBIENT}$=25°C
5mA	2.2 µs	9.2 µs	V_{OUTPUT}=5V, $T_{AMBIENT}$=25°C
10mA	3.3 µs	11.5 µs	V_{OUTPUT}=10V, $T_{AMBIENT}$=25°C
10mA	3.8 µs	12.8 µs	V_{OUTPUT}=12V, $T_{AMBIENT}$=25°C

table 3-16, Optically isolated digital output delays

Note: Delays might be longer for higher voltage.

3.8.4.3. Optically isolated Digital Output – Internal schematic

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

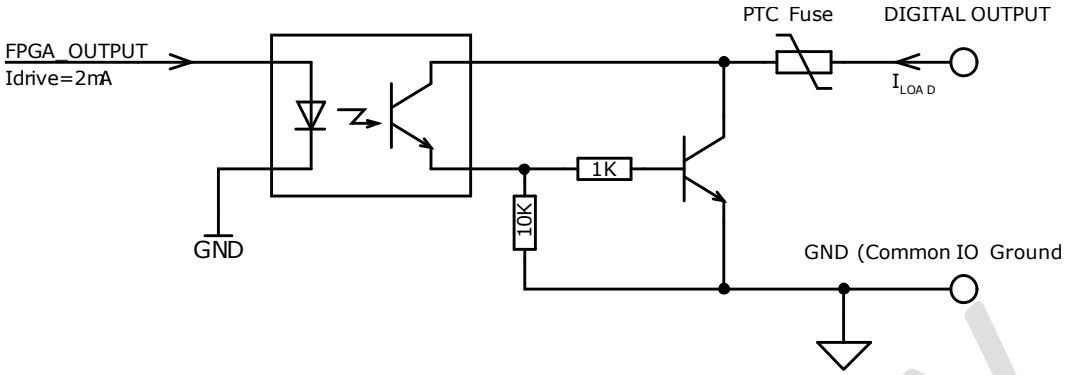


figure 3-13, digital output, interface schematic

Output Transfer Characteristic

When Output is in **On** state – typical transfer characteristic of output is as on following figure:

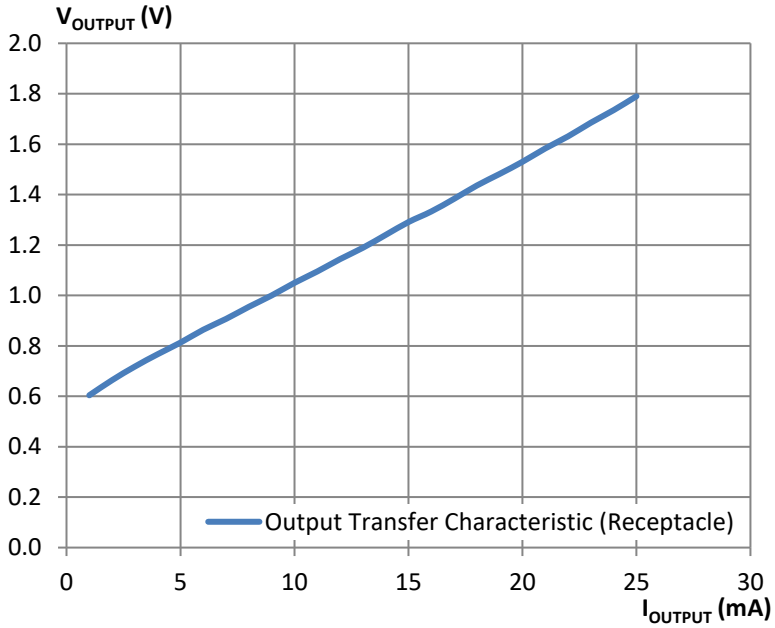


figure 3-14, digital output transfer characteristics

3.8.4.4. 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.

3.8.4.4.1. 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

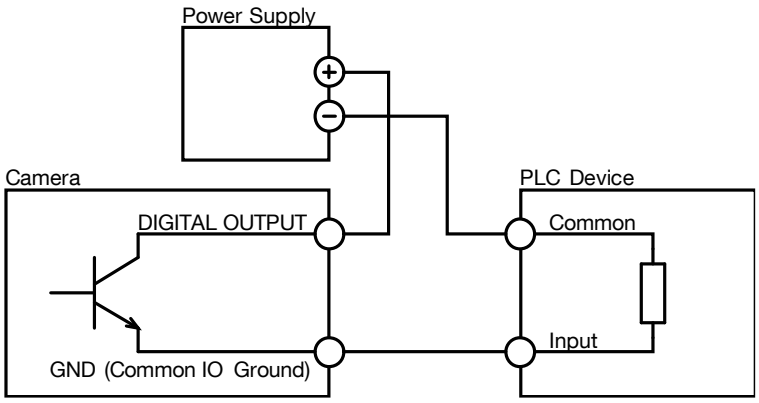


figure 3-15, Connecting Digital OUTPUT to a NPN-compatible PLC device input (biased)

Important note:

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

3.8.4.4.2. 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

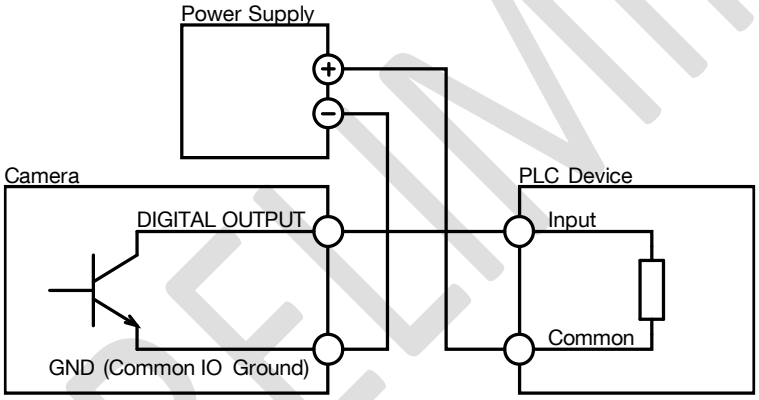


figure 3-16, Connecting Digital OUTPUT to an NPN-compatible PLC device input – more bidirectional inputs used

Note:

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

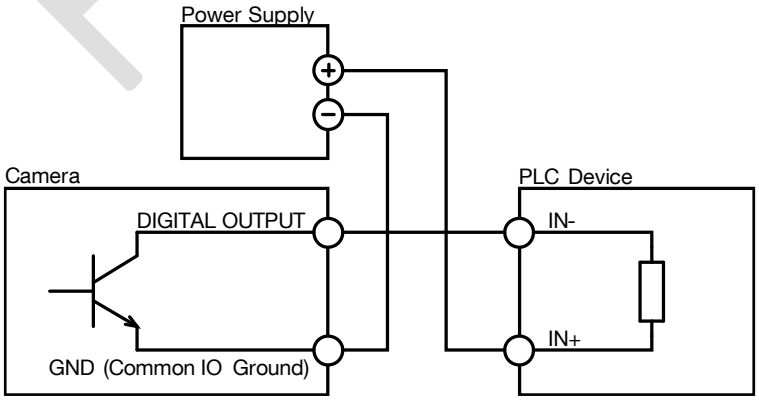


figure 3-17, Connecting Digital OUTPUT to an NPN-compatible PLC device – single input

3.8.4.4.3. 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)

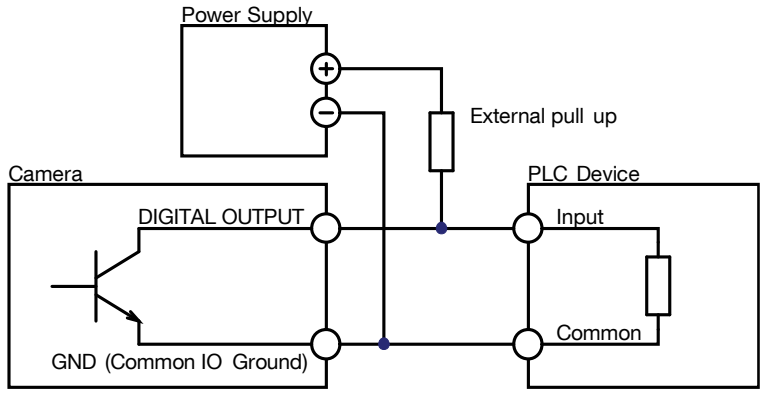


figure 3-18, Connecting Digital OUTPUT to a PNP-compatible device

Pull up resistor can be calculated as follows: $R = \frac{V_{psu} - V_{input}}{I_{input}}$

Where:

V_{psu} power supply voltage. Must be higher than required input amplitude

V_{input} required input amplitude

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

Remember to use the appropriate resistor power rating $P(R) > (V_{psu} - V_{input}) * I_{input}$

3.8.4.4.4. Output Wiring Example: LED Driving

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

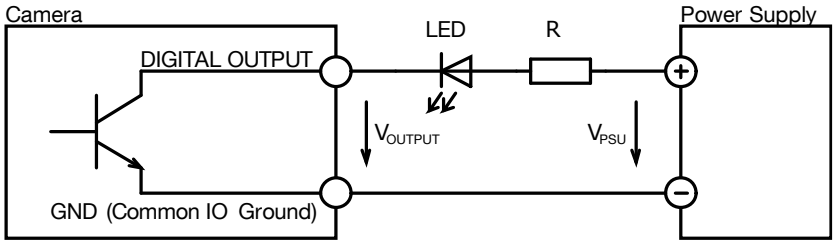


figure 3-19, LED Driving

LED series resistor can be calculated by the following equation: $R = \frac{V_{psu} - V_{output} - V_{led}}{I_{led}}$

Where:

V_{psu} power supply voltage (5V to 24V)

V_{output} voltage across digital output pins (see. *3.8.4.1 Optically isolated Digital Output – General info*)

V_{led} LED forward voltage (see table below)

I_{led} LED current

Note:

- 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	1.7V	2.1V	
Super Bright Red	1.85V	2.5V	
Low power Red	1.7V	2.0V	
Orange	2.0V	2.1V	
Yellow	2.1V	2.2V	
Green	1.9V	2.5V	
Emerald Green	2.1V	2.7V	
Blue	2.5V	3.7V	
White	2.8V	3.8V	
Infra-Red	1.3V	1.8V	Opto coupler

table 3-17, digital output, LED driving

3.8.4.4.5. 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.

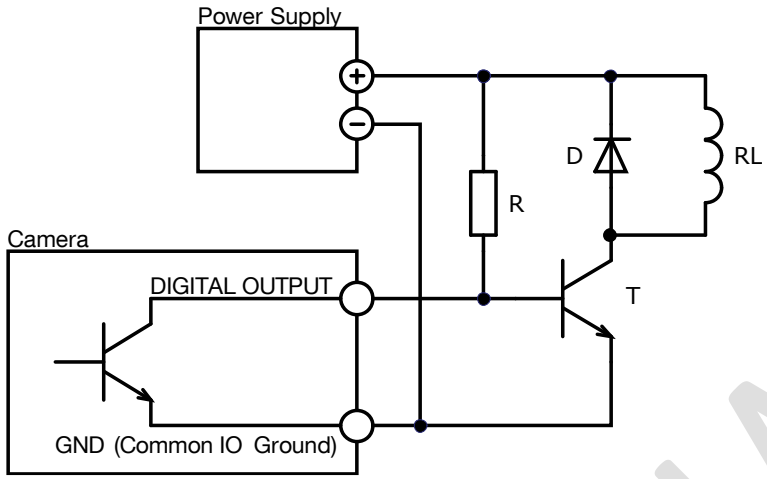


figure 3-20, Inductive load (Relay) Driving (inverted logic)

For positive logic you can use a second bipolar transistor.

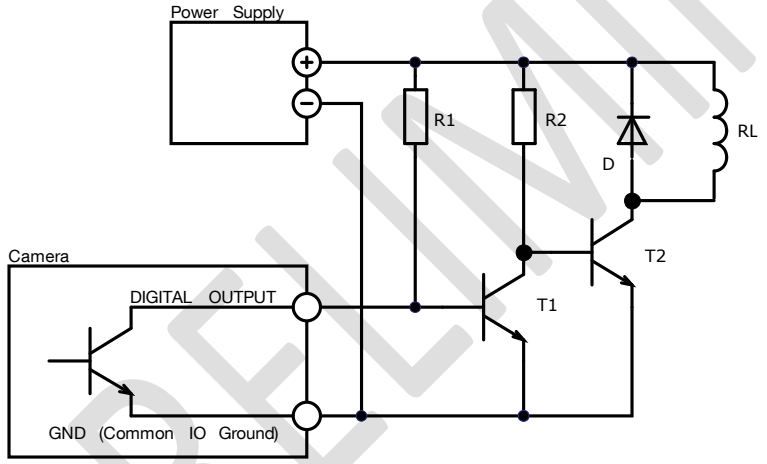


figure 3-21, Inductive load (Relay) Driving (non-inverted logic)

3.9. CBL-U3-P-TC-1M0

1.0m USB3.1 Type-C cable with high power rating.

figure 3-22, USB type-C cable

3.10. CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M0

1.0m / 3.0m / 5.0m USB 3.0 cable. Needed when camera is used with the power injector (see *3.12 Power injector ADPT-PWR-INJ-TC*).

figure 3-23, USB 3.0 cable

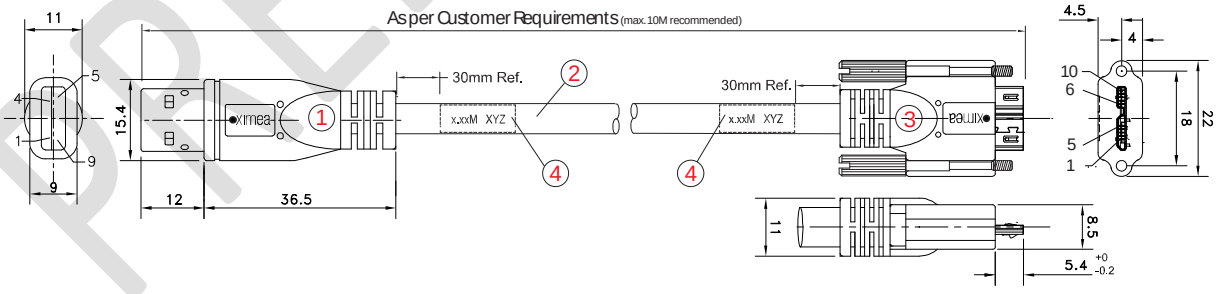


figure 3-24, drawing USB 3.0 cable

Item	Description
1	USB A 3.0 9 pin Molded Plug <BLK>
2	MCD-USB-211 [OD= 7.3mm] <BLK>
3	3 USB MicB 3.0 sl 10 pin Molded Plug with Screw Locking <BLK>
4	Cable Label

table 3-18, USB3 cable, components

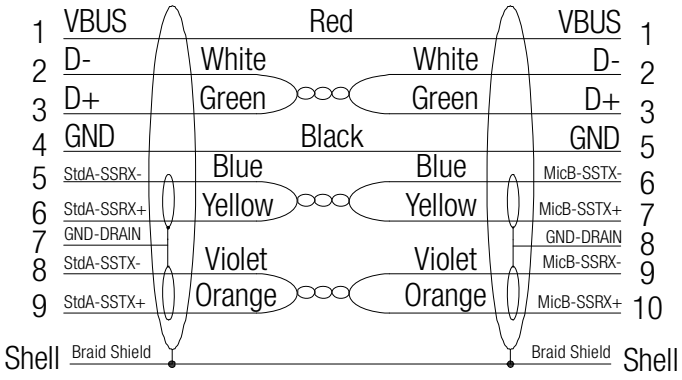


figure 3-25, wiring USB3 cable

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 3-19, USB3 connector, pin assignment

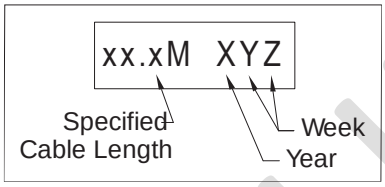


figure 3-26, label details USB3 cable

3.11. Sync trigger cable CBL-MJ-SYNC-3M0

3.0m trigger and synchronization cable, 4 poles, digital I/O circular

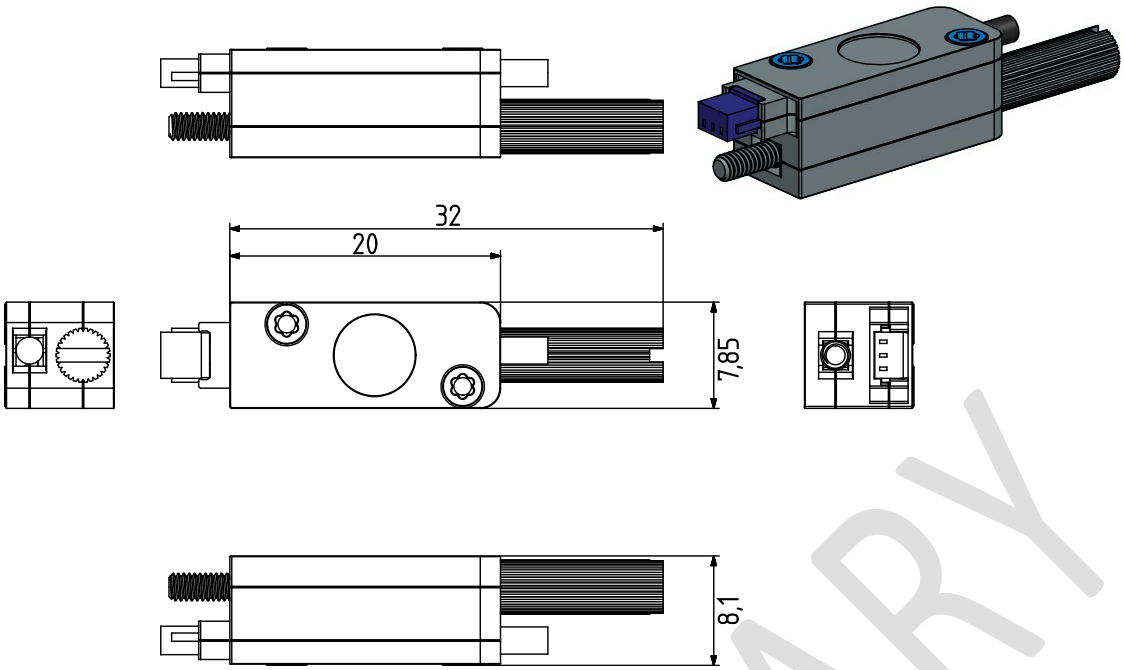


figure 3-27, sync cable dimensional drawing

Sync cable wiring

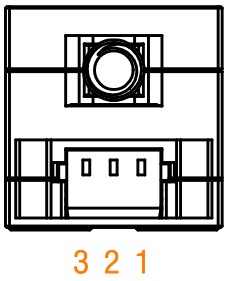


figure 3-28, sync cable pin numbering

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

table 3-20, IO/AUX cable, pin assignment

3.12. Power injector ADPT-PWR-INJ-TC

Injector for power delivery to sCMOS cameras.

figure 3-29, power injector

It 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 20V.

LED description

LED	Color	Description
1	Blue	Polarity
2	Red	Type-C Power EN#
3	Green	Adapter power

table 3-21, LED description

3.12.1. Dimensional drawings

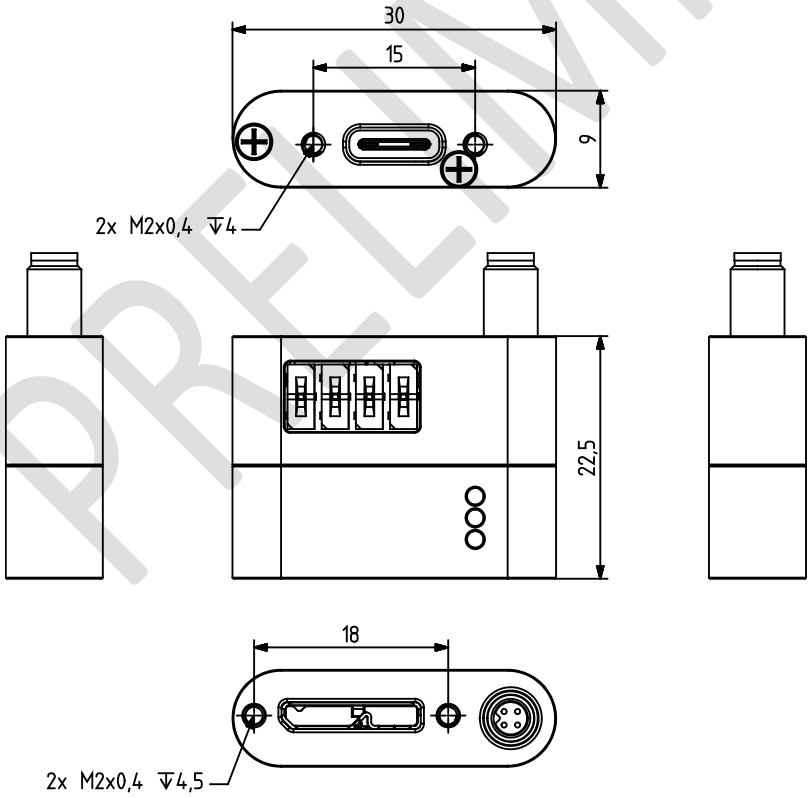


figure 3-30, dimensions of power injector

3.12.2. Configuration

Cable length	Dip switch configuration	
	Micro-B	Type-C
5m	H H	H H
1m	H H	F F
0.15m	L F	L F

table 3-22, power injector dip switch configuration

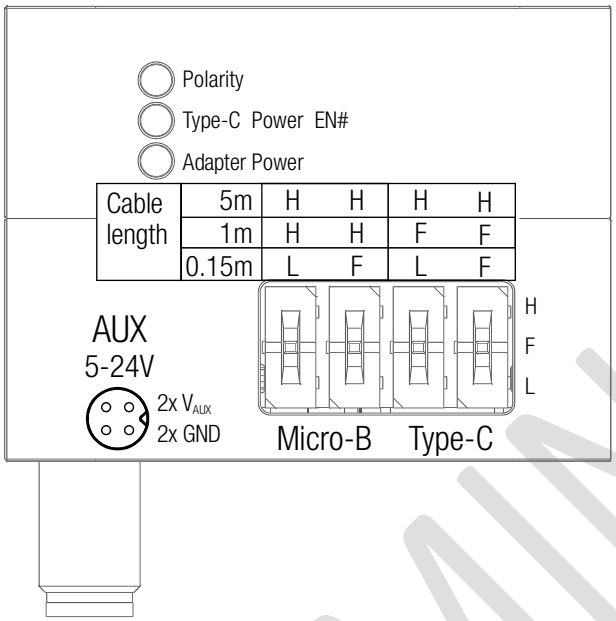


figure 3-31, laser markings and position of dip switches on power injector

3.13. Power cable AUX – CBL-MJ-PWR-2M0

2.0m AUX power cable for use with power injector (see *3.12 Power injector ADPT-PWR-INJ-TC*)

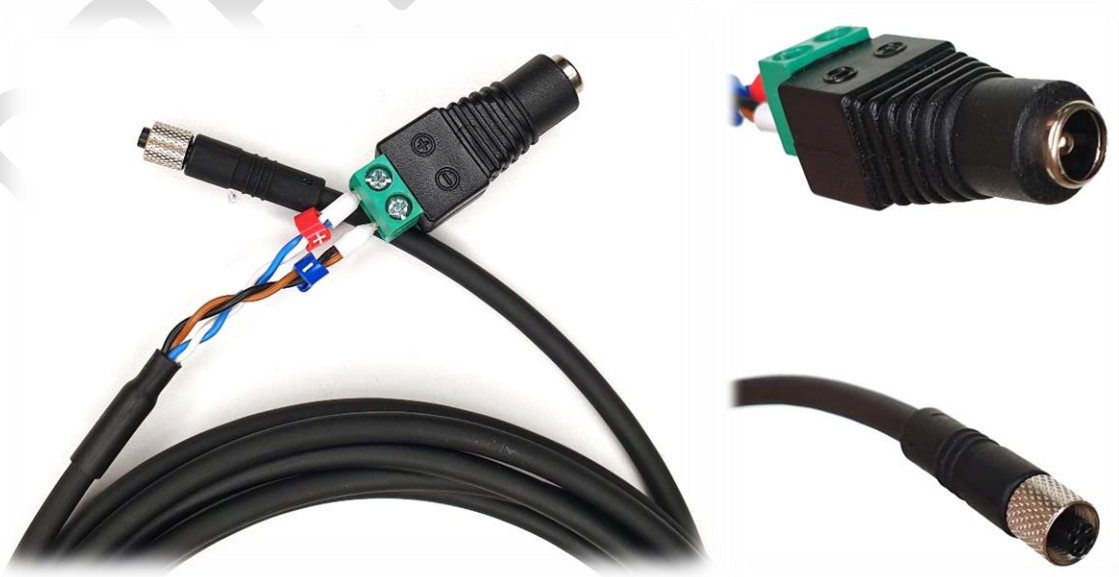


figure 3-32, AUX power cable and its connectors

3.14. Tripod Adapter – ME-ADPT-MJ-T

xiJ series tripod mounting bracket

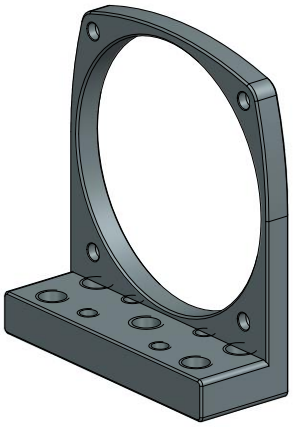


figure 3-33, mounting tripod adapter

xiJ series tripod mounting bracket with M4 and M6 threads at the bottom and ¼" thread in the middle.
Bracket can be mounted on the front side of the camera.

3.14.1. Dimensional drawings

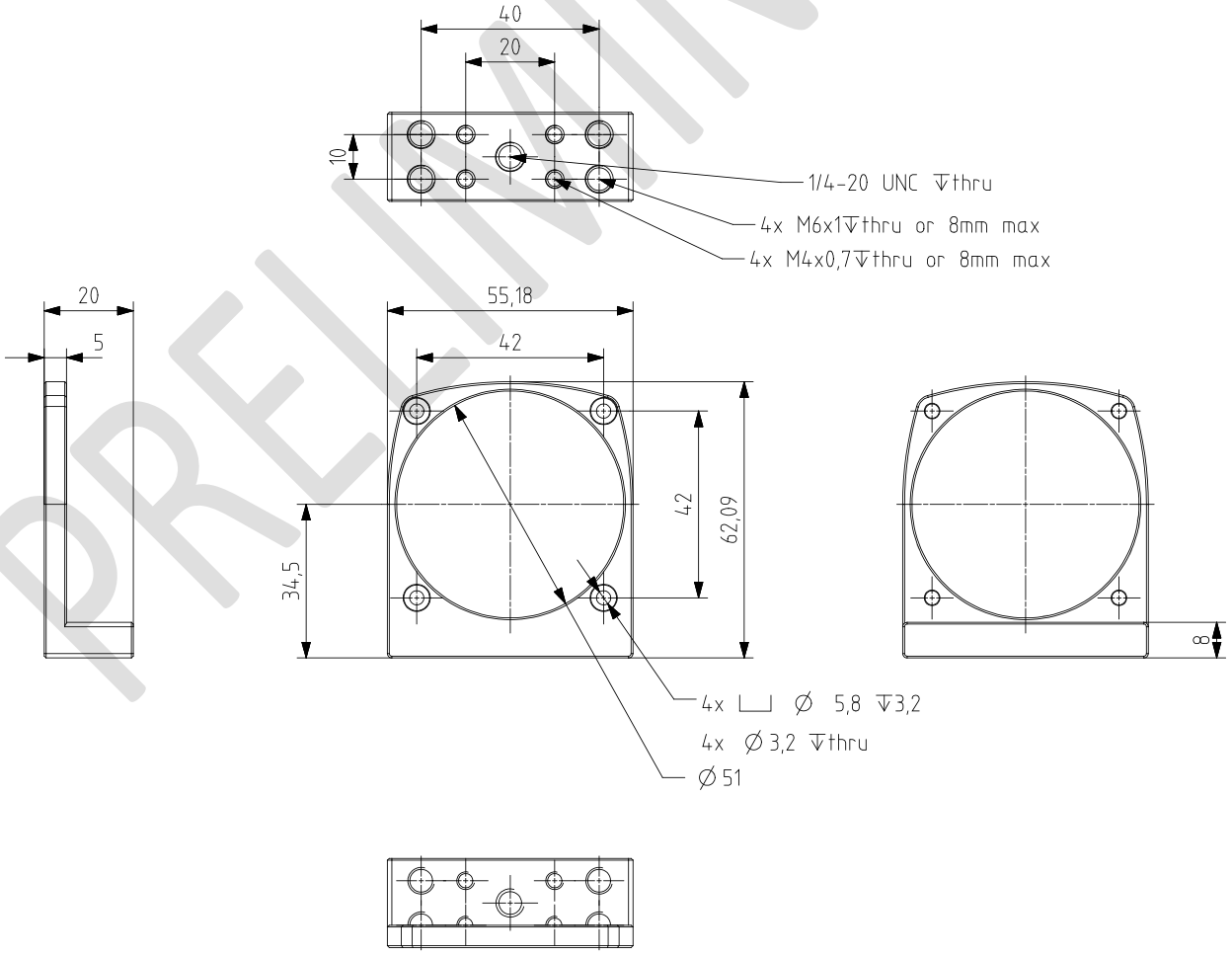


figure 3-34, dimensional drawing tripod adapter

Mass without screws: 30g ±0.5g.

3.15. USB 3 host adapters

Camera has been fully tested on HA-1P-USB3-TC-X4G3-AS, HA-2P-USB3-TA-X4G3-AS adapters (with ASM3142, USB 3.1 Host Controller). Testing on other controllers pending. Host adapter requires special firmware, so we recommend to order it from XIMEA.

figure 3-35, 2-port USB 3.1 Host Controller HA-2P-USB3-TA-X4G3-AS

4. General Features

4.1. Camera Features

4.1.1. ROIs – Region Of Interest

ROI, also called area-of-interest (AOI) or windowing, which 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.

Please note *3.5 Model Specific Characteristics*

4.1.2. Downsampling Modes

Downsampling describes the possibility of reducing the image resolution without affecting the sensors physical size, ie. 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)

4.1.2.1. 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, 2*2 binning sums 4 pixels and results in images with ¼ of the original resolution.

4.1.2.2. Decimation

When skipping 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 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.

4.1.3. Image Data Output Formats

All modes are provided by the xiAPI or standard interfaces using the xiAPI (please note *5.7. Programming*).

Each xiJ camera supports several Image Data Output Formats.

Mode	Description
RAW8	Raw sensor data, 8 Bit per pixel, single channel
RAW16	Raw sensor data, 16 Bit per pixel, single channel 12 Bit sensor output (LSB) with bit-shift up to 16 Bit
MONO8	Intensity output, 8 Bit per pixel, single channel
MONO16	Intensity output, 16 Bit per pixel, single channel
RAW32	Raw sensor data in integer format, 32 Bit per pixel, single channel 4 bytes (LSB first) pixel (depacked)
RAW32FLOAT	Raw sensor data in single-precision floating point format, 32 Bit per pixel, single channel 4 bytes per pixel (depacked)
FRM_TRANSPORT_DATA	Data from transport layer (e.g. packed). This format is optimal when an efficient storage and later (offline) processing is required. Format is defined by XI_PRM_TRANSPORT_PIXEL_FORMAT

table 4-1, image formats

Note1: For most formats the transport data can be packed. 12-bit pixel bit depth transfers only 12bit per pixel compared to 16bit per pixel when the data are not packed. In case of packed format the CPU load is higher due to unpacking of the image data. Available bandwidth is however used optimally.

4.1.4. Camera readout modes

4.1.4.1. 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.

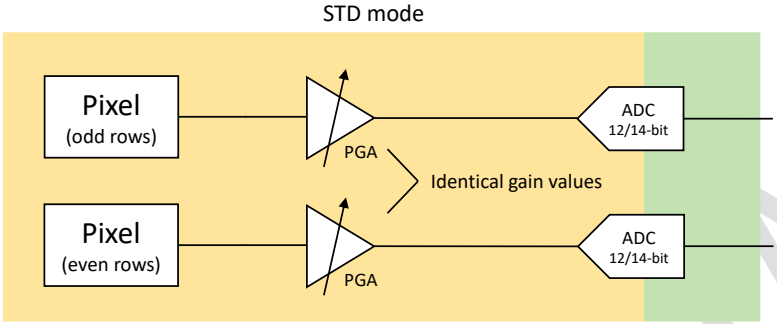


figure 4-1, STD mode

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

table 4-2, 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.

4.1.4.1.1. STD mode 1: 12-bit, LG (12-STD-L)

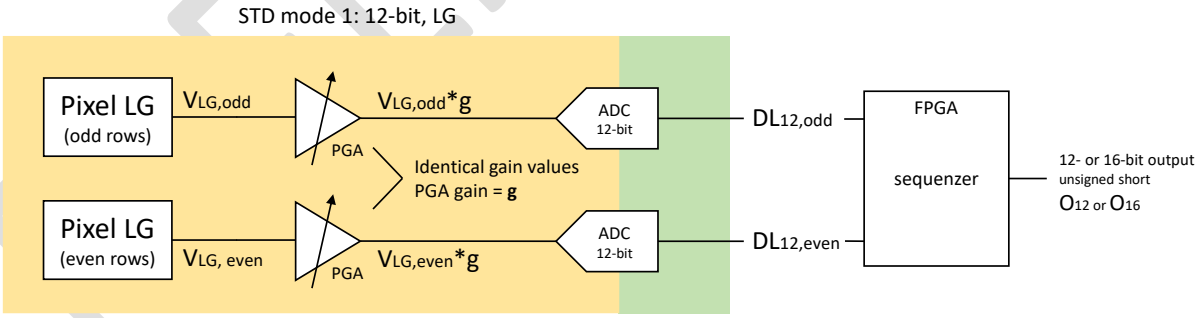


figure 4-2, 12-STD-L mode

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}.

4.1.4.1.2. STD mode 2: 12-bit, HG (12-STD-H)

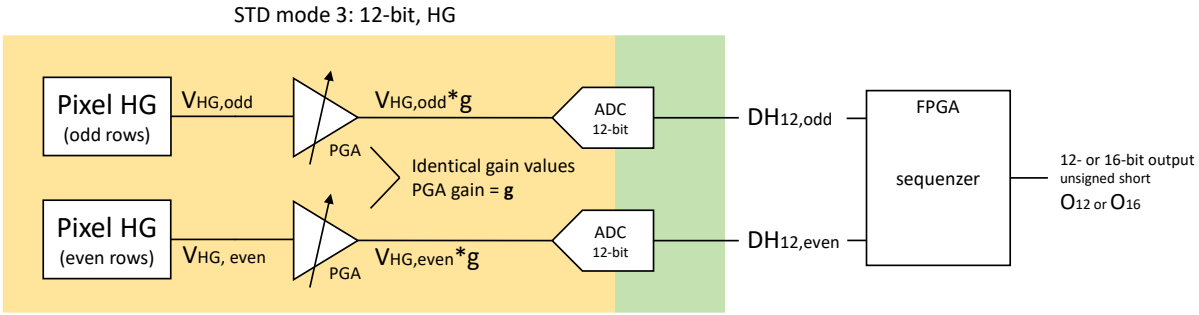


figure 4-3, 12-STD-H mode

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}.

4.1.4.2. 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.

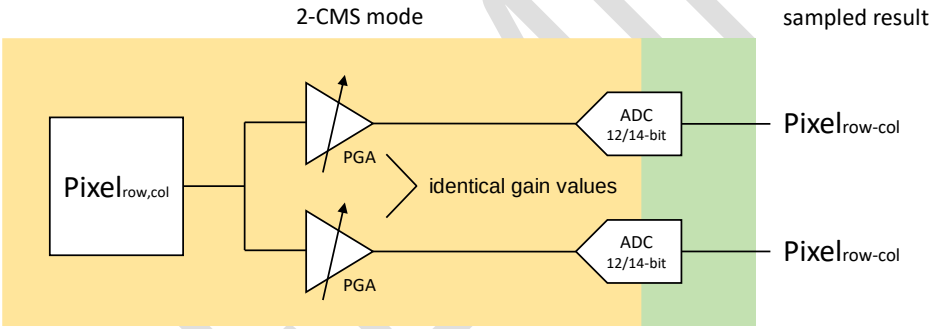


figure 4-4, CMS mode

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 4-3, 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.

4.1.4.2.1. CMS mode 1: 2-CMS, 12-bit, LG (CMS mode 1: 2-12-CMS-S-L)

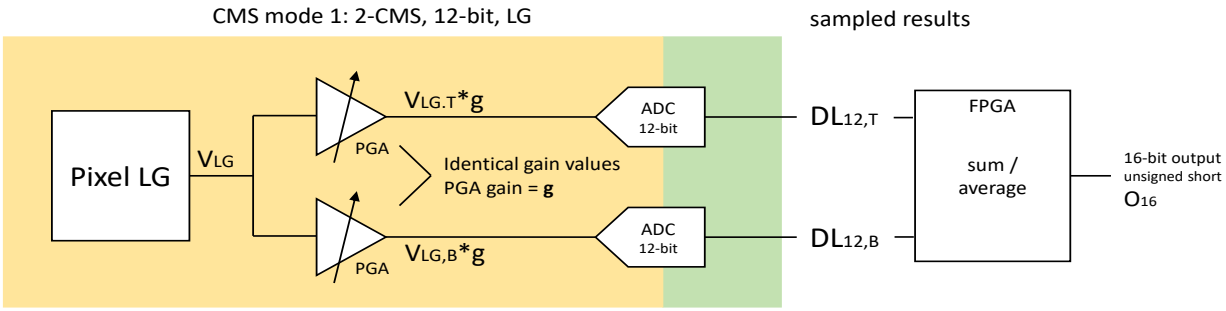


figure 4-5, CMS mode 2-12-CMS-S-L

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

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

4.1.4.2.2. CMS mode 3: 2-CMS, 12-bit, HG (CMS mode 1: 2-12-CMS-S-H)

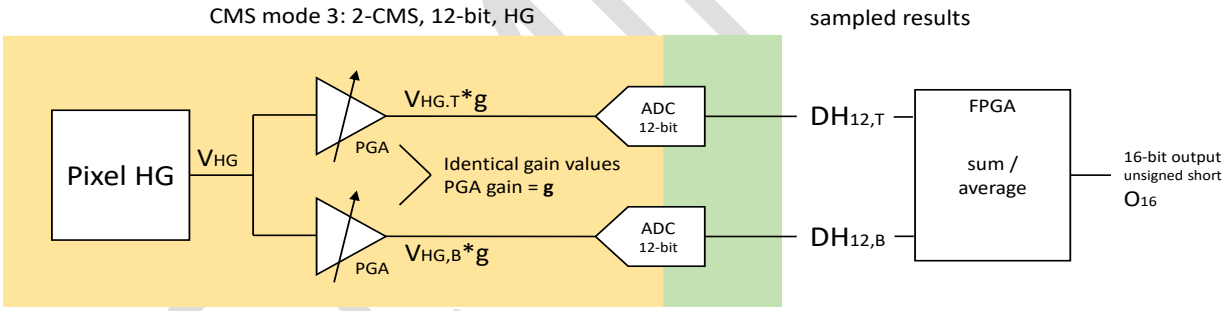


figure 4-6, CMS mode 2-12-CMS-S-H

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

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

4.1.4.3. 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.

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

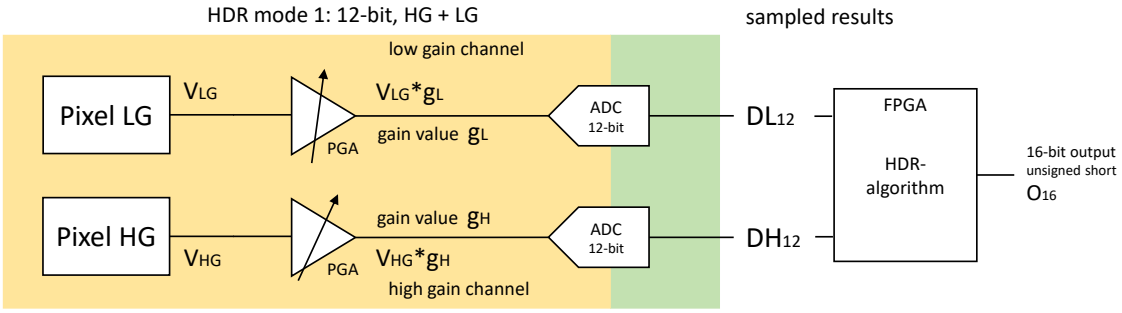


figure 4-7, HDR mode 2-12-HDR-HL

VLG : analog LG values from pixel
VHG : analog HG values from pixel
gL : analog PGA gain of low gain channel
gH : analog PGA gain of high gain channel
VLG*gL : analog LG values amplified by PGA gain gL, low gain channel
VHG*gH : analog HG values amplified by PGA gain gH, high gain channel
DL12 : digital 12-bit LG values
DH12 : digital 12-bit HG values

The FPGA merges the values to an HDR image.

The 16-bit output result is calculated as

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

4.1.4.4. 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.

Mode	Parameter setting (enum)	Related numeric value
12-STD-L	XI_US_12_STD_L	10
12-STD-H	XI_US_12_STD_H	11
2-12-CMS-S-L	XI_US_2_12_CMS_L	14
2-12-CMS-S-H	XI_US_2_12_CMS_H	15
2-12-HDR-HL	XI_US_2_12_HDR_HL	22

table 4-4, supported modes in xiAPI

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);
```

Please have a look at https://www.ximea.com/support/wiki/apis/XiAPI_Manual#XI_PRM_USER_SET_SELECTOR-or-user_set_selector for additional info.

4.1.5. Acquisition modes

4.1.5.1. 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 Overlapped mode gives the highest number of frames per second (FPS).

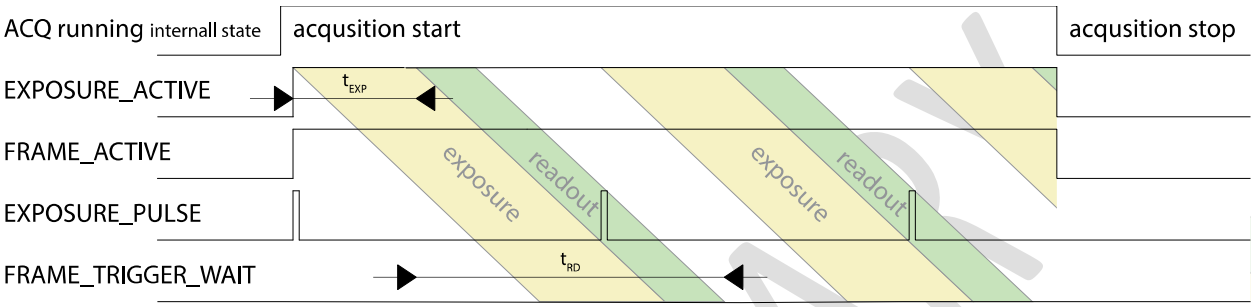


figure 4-8, acquisition mode - free run

In this mode the timing depends on the Exposure Time and Data Readout Time.

4.1.5.2. 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.

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 *3.8.3 Optically isolated Digital Input*. Triggering by hardware is usually used to reduce latencies and jitter in applications that require the most accurate timing.

4.1.5.2.1. Triggered mode

This mode gives lower FPS compared to *Free-Run* mode. Sensor support two modes of exposure which have impact on camera signaling.

Sensor timing in global reset release mode

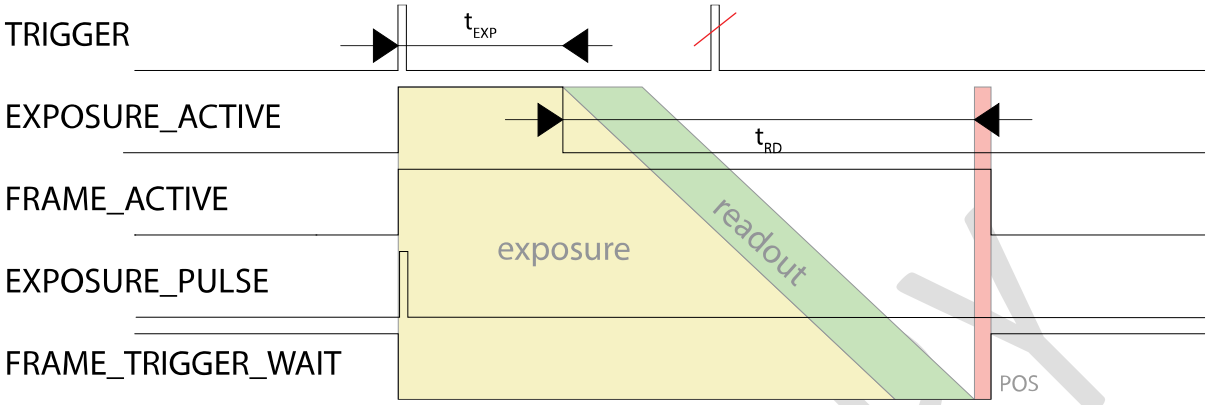


figure 4-9, acquisition mode – triggered global reset release

In this mode the timing depends on sum of:

- Input transition time (t_{itr}), depends on:
  - Digital Input Delay - time for changing internal circuit to active state. It is constant for each camera model. For this camera it is negligible.
  - Trigger delay (t_{delay}) – delay set in camera to postpone trigger to sensor.
- Exposure time (t_{exps}) – Exposure time.
- Data Readout time (t_{rd}) – Depends on mode of operation, no direct calculation possible.
- Post image timeout (t_{pos}) – time after image readout need by sensor to be ready for next exposure.

The timing strongly depends on camera settings. Most of the times can be calculated using Camera performance calculator https://www.ximea.com/support/tools/camcalc/#/camera/MJ042MR-GP-P6-BSI.

Trigger to exposure delay

Mode	TRG voltage [V]	Trigger to exposure delay [ns]
All modes	5	500
All modes	10	315

table 4-5, delay in global reset release mode

Sensor timing in rolling shutter mode

Similar to global reset release mode, except exposure is done in rolling shutter mode

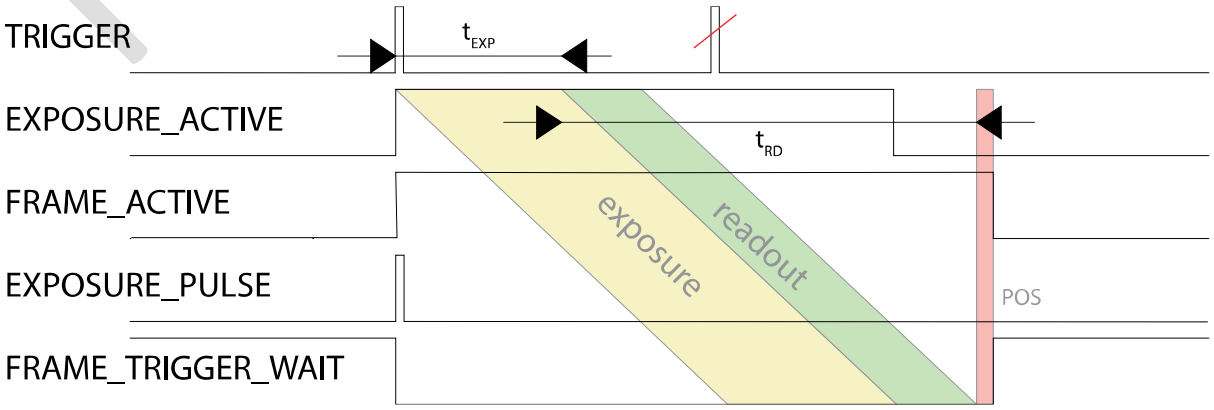


figure 4-10, acquisition mode – triggered rolling shutter mode

For description please see previous page.

Trigger to exposure delay

Mode	TRG voltage [V]	Trigger to exposure delay [us]
XI_US_12_STD_H	5	27.21
XI_US_12_STD_L	5	28.04
XI_US_2_12_CMS_S_H	5	32.05
XI_US_2_12_CMS_S_L	5	32.38
XI_US_2_12_HDR_HL	5	32.38

table 4-6, delay in rolling shutter mode

4.1.6. 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.

4.1.7. 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.

4.1.8. 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.

Cooling performance measurements

Mode	Ambient Temp. [°C]	Exposure [s]	Minimum Temp. [°C]	Accuracy [°C]	Max. Power consumption [W]
XI_US_2_12_CMS_S_H	22	5	-20	0.05	18

table 4-7, cooling performance

4.2. API Features

Host-assisted image processing features available in xiAPI.

4.2.1. Auto 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).

4.2.2. 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.

5. Operation

For a proper operation of your xiJ 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 xiJ camera in the following sections.

5.1. System Requirements

5.1.1. Software Requirements

The xiJ cameras are compatible with the following operating systems:

- Windows 10
- Windows 7 SP1
- Linux Ubuntu
- MacOS 10.8 or newer

macOS

All XIMEA cameras are compatible with the most advanced Vision and Image Processing Libraries.

See chapter *5.2 Connecting the camera*

The camera was tested on 2 setups with accessories described in chapter *3. Hardware Specification.* That is recommended setups, where functionality is guaranteed. Using cameras with other controllers and cables may result in suboptimal performance.

The first one is the direct connection with 1m USB3 cable with power delivery (e.g. *3.9. CBL-U3-P-TC-1M0*) to the host adapter (*3.15. USB 3 host adapters*).

The second one is using power injector. In order to correctly connect the camera with the power injector, the below order of steps must be followed:

1. Connect USB micro-B cable (*3.10. CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M0*) to power injector (*3.12. Power* injector ADPT-PWR-INJ-TC).
2. Connect USB A (*3.10. CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M0*) to PC.
3. Connect power cable (*3.13. Power* cable AUX – CBL-MJ-PWR-2M0) and power on.
4. Connect USB type-C cable (*3.9. CBL-U3-P-TC-1M0*) to power adapter.
5. Connect USB type-C cable to the camera.

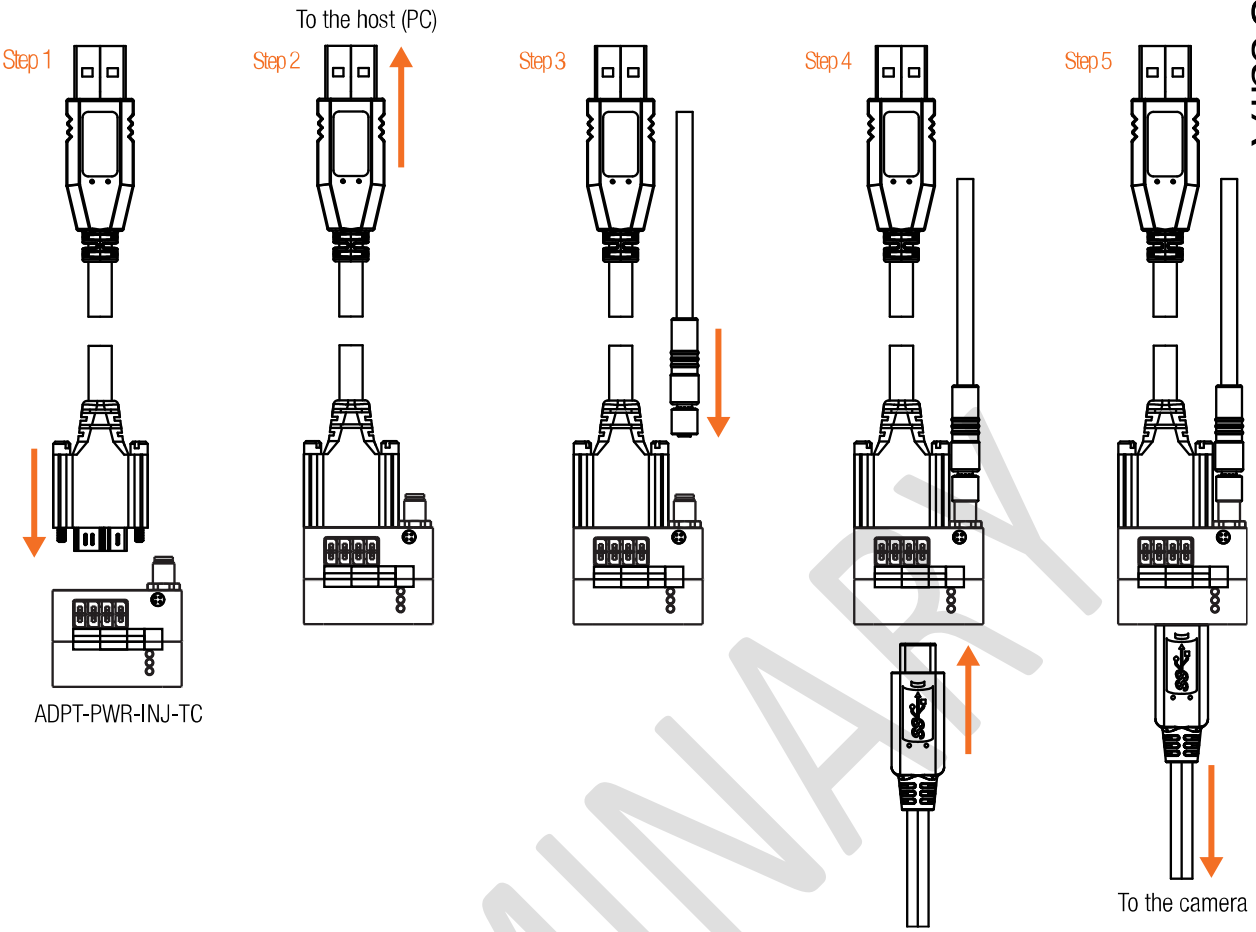


figure 5-1, connecting the components

XIMEA Software Packages for more information about the options to access a xiJ cameras, as well as a list of currently supported libraries and frameworks supported in Windows.

For more information visit page: https://www.ximea.com/support/wiki/apis/APIs

5.1.2. Hardware Requirements

The XIMEA xiJ cameras are compatible with USB 3.1 and USB 3.0. Please note, that the highest performance can only be achieved by using high performance USB 3.1 or USB 3.0 ports.

5.1.2.1. System Configuration

Minimum system configuration:

For a basic operation of your xiJ camera with a PC the following minimum system configuration is required. Please note that bandwidth and processing performance are tied to the hardware configuration and the minimum hardware configuration could lead to a reduced bandwidth and limited frame rate.

CPU:	Intel i3 or better
RAM:	2GB RAM or more
Disc Space:	200 MB of free disc space
Video:	NVIDIA or Radeon graphics card 128MB or integrated on CPU
Ports:	Motherboard with USB 3.0 port or PCIe x1-16 Gen 2 slot for compatible USB 3.0 host adapter

Recommended system configuration:

For best processing performance and bandwidth we recommend to use 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:	Asmedia ASM3142 host adapter card purchased from XIMEA (see *3.15 USB 3 host adapters*)

5.1.2.2. USB 3.1 Host Adapter

For a stable operation of your xiJ 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.

The maximum data transfer rate depends on different conditions (motherboard, chipset, driver version, operating system...). Camera has been fully tested on host adapters with ASM3142, USB 3.1 Host Controller (see *3.15 USB 3 host adapters*).

5.1.2.3. Cables

The USB 3.1 Gen1 cable that you use with the xiJ camera is responsible for the data transfer to the PC and can also deliver power. It is required to use an industrial USB 3.1 Gen1 cable with a proper wiring and shielding. We recommend using XIMEA industrial USB 3.1 Gen1 cables in order to achieve the maximum possible performance of the camera.

XIMEA offers several passive USB 3.1 Gen1 cables and sync cables, please see *3.9 CBL-U3-P-TC-1M0* , *3.10 CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M0*

5.2. Connecting the camera

The camera was tested on 2 setups with accessories described in chapter *3. Hardware Specification.* That is recommended setups, where functionality is guaranteed. Using cameras with other controllers and cables may result in suboptimal performance.

The first one is the direct connection with 1m USB3 cable with power delivery (e.g. *3.9. CBL-U3-P-TC-1M0*) to the host adapter (*3.15. USB 3 host adapters*).

The second one is using power injector. In order to correctly connect the camera with the power injector, the below order of steps must be followed:

6. Connect USB micro-B cable (*3.10. CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M0*) to power injector (*3.12. Power* injector ADPT-PWR-INJ-TC).
7. Connect USB A (*3.10. CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M0*) to PC.
8. Connect power cable (*3.13. Power* cable AUX – CBL-MJ-PWR-2M0) and power on.
9. Connect USB type-C cable (*3.9. CBL-U3-P-TC-1M0*) to power adapter.
10. Connect USB type-C cable to the camera.

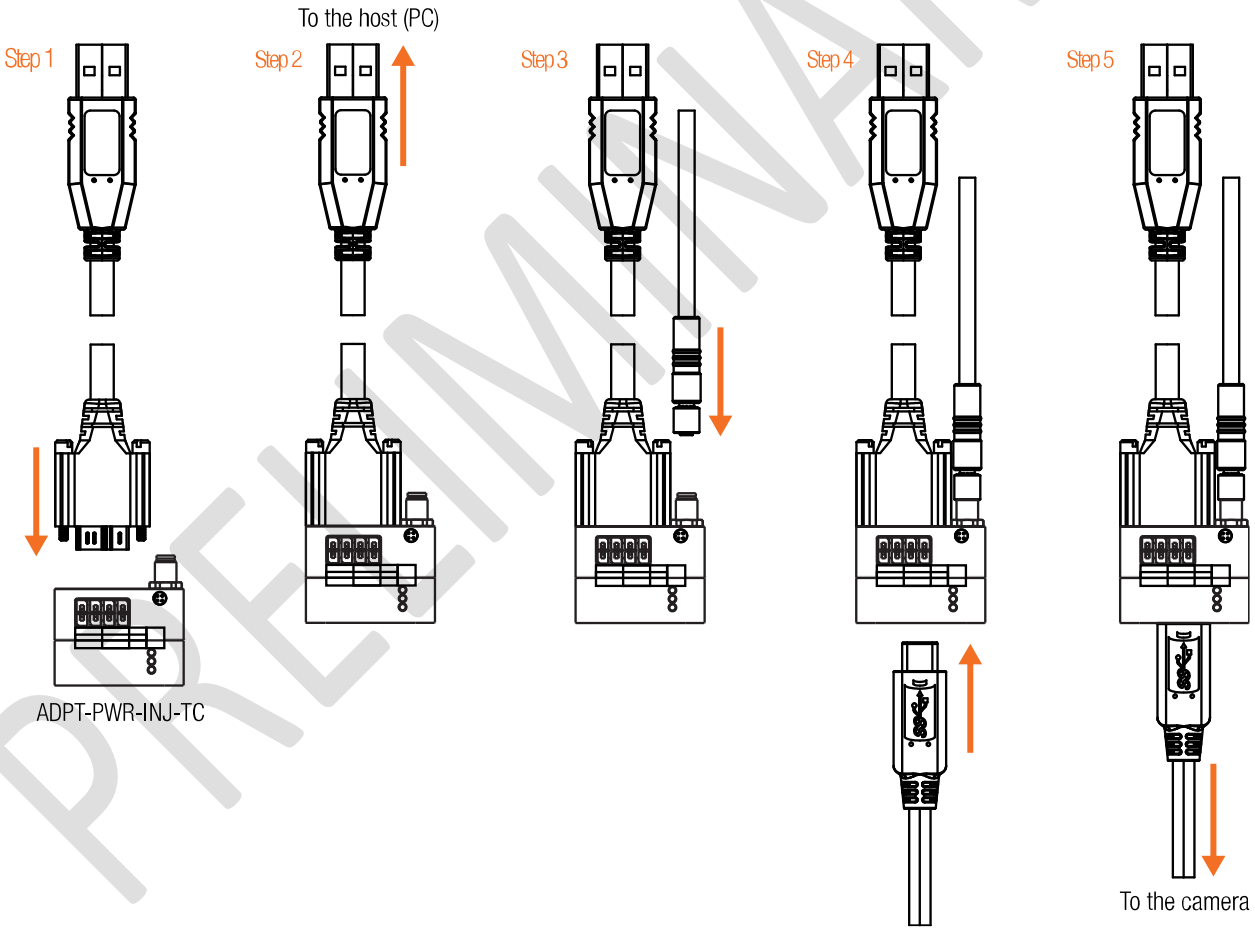


figure 5-1, connecting the components

5.3. XIMEA Software Packages

5.3.1. XIMEA Windows Software Package

XIMEA API Software Package can be installed on: Microsoft Windows 10, Microsoft Windows 8, Microsoft Windows 7 (and Microsoft Windows 7 Embedded), Microsoft Windows Server 2008 R2.

5.3.1.1. Contents

The package contains:

- OS Drivers of all XIMEA camera types for OS Microsoft Windows 10 32/64 bit, Windows 7 SP1 32/64 bit, 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

5.3.1.2. 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):

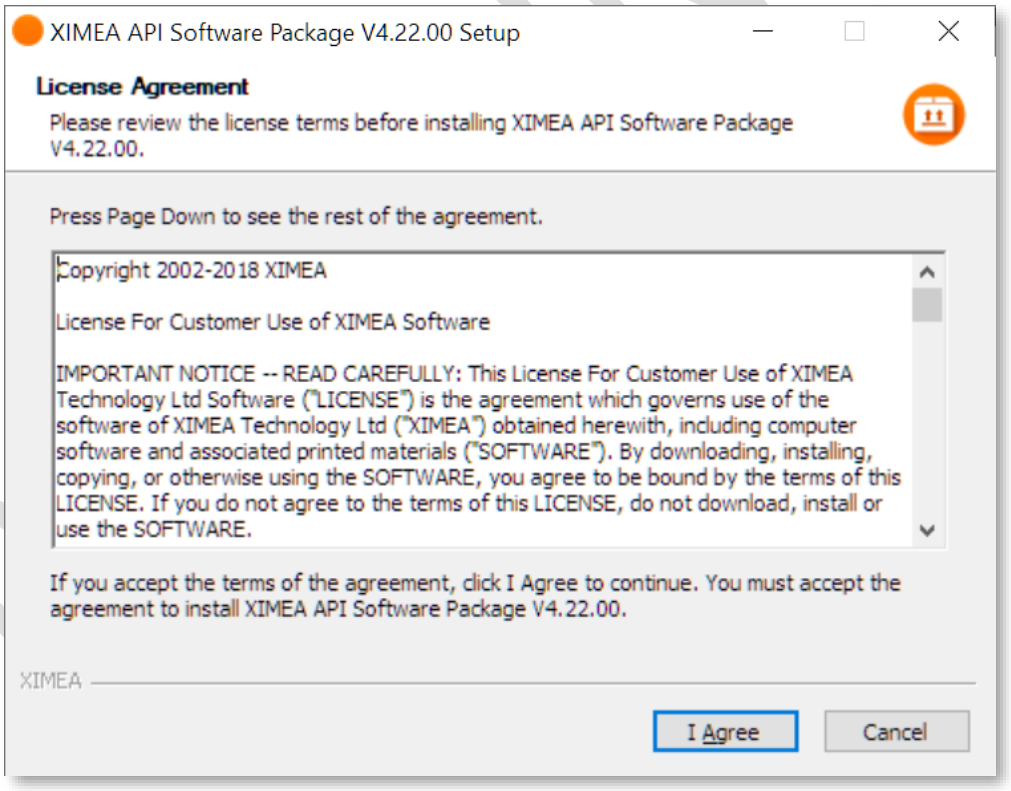


figure 5-2, XIMEA Windows Software Package installation - 1

- 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.

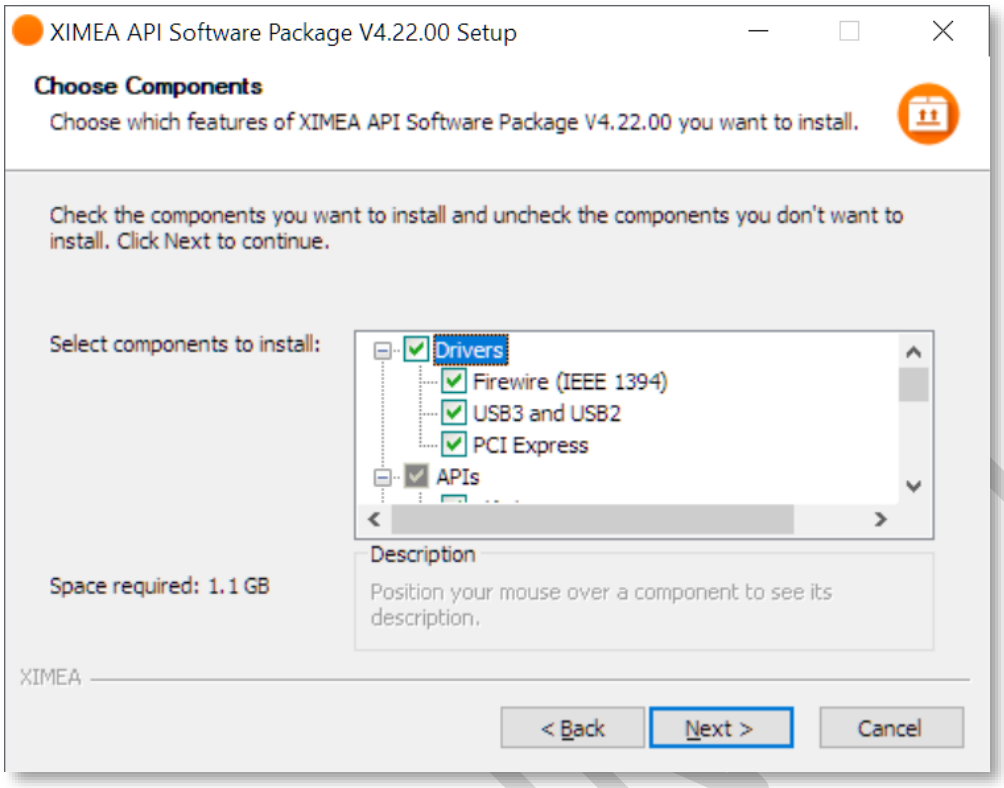


figure 5-3, XIMEA Windows Software Package installation - 2

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

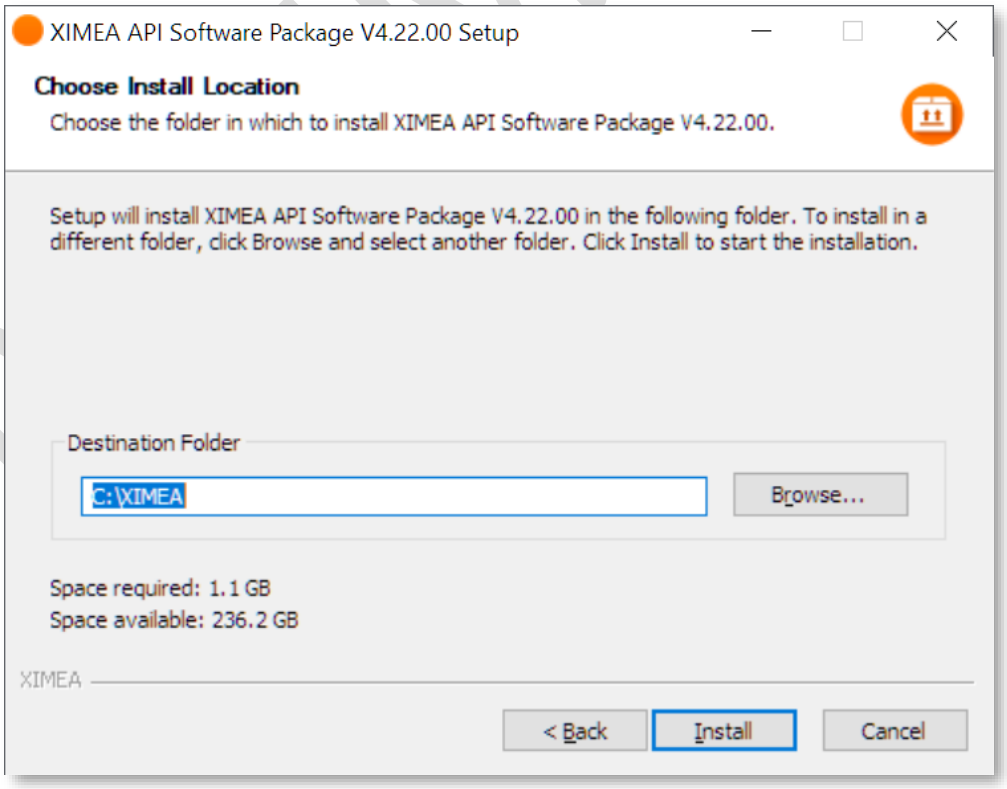


figure 5-4, XIMEA Windows Software Package installation - 3

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

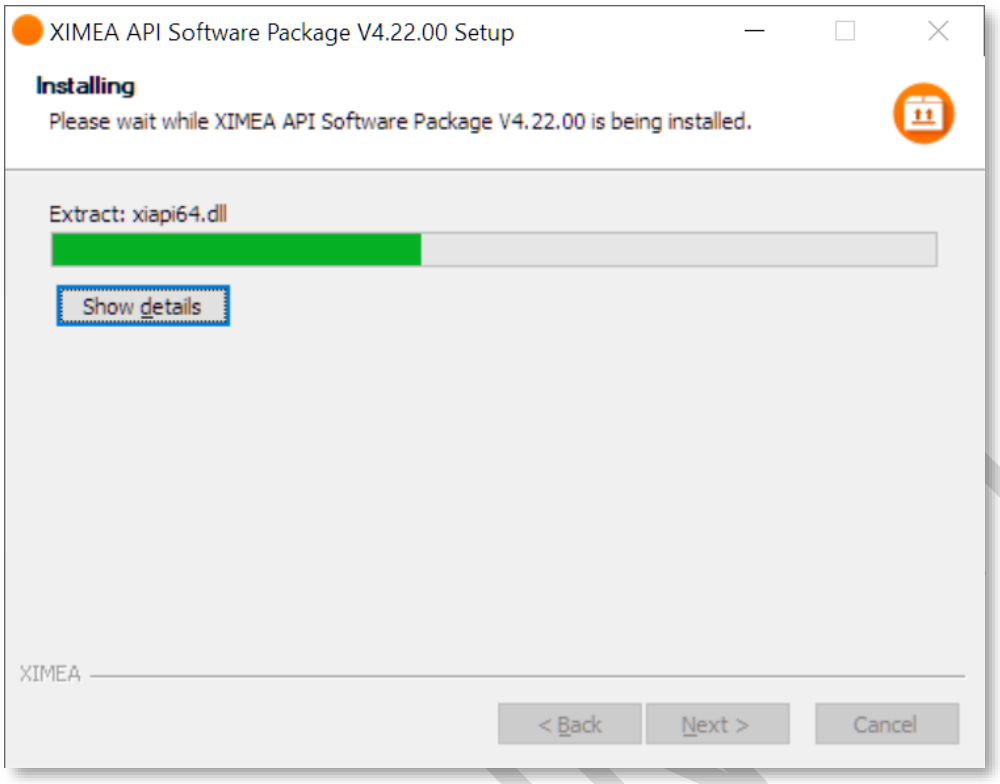


figure 5-5, xiAPI installation, Windows - 4

- Installation is completed.

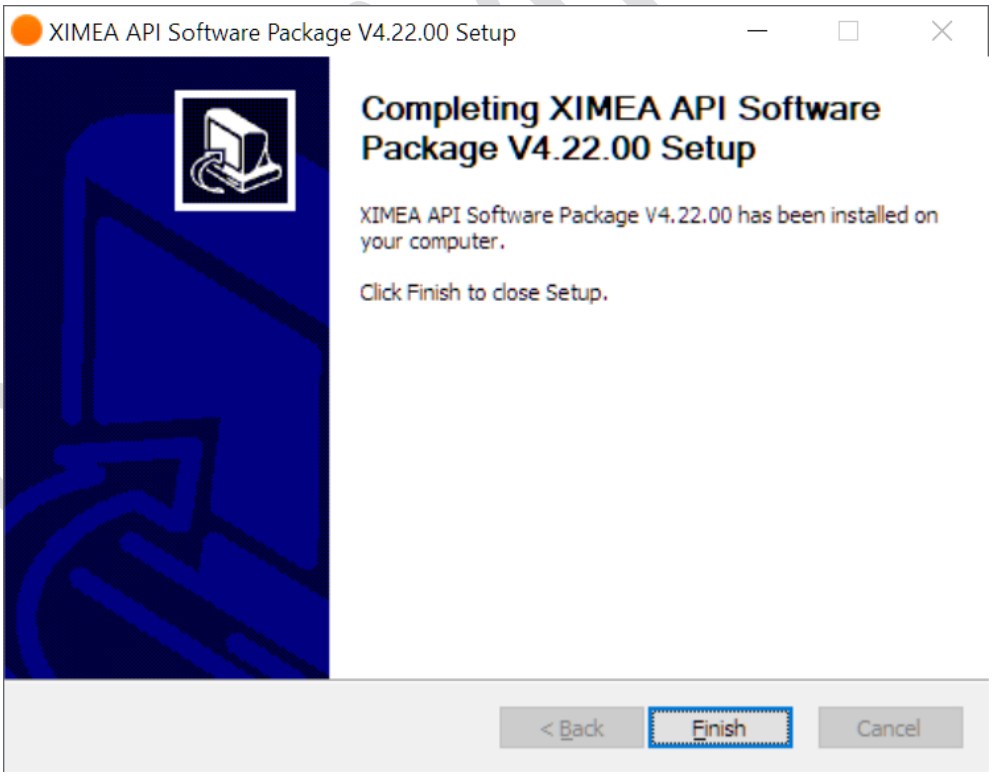


figure 5-6, xiAPI installation, Windows - 5

- Finish.

5.3.2. 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.

5.3.2.1. 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

5.3.2.2. Installation

- Download XIMEA Linux Software Package
  `wget http://www.ximea.com/downloads/recent/XIMEA_Linux_SP.tgz`

figure 5-7, XIMEA Linux Software Package installation - 1

- Untar
  `tar xzf XIMEA_Linux_SP.tgz`
  `cd package`
- Start installation script
  `./install`

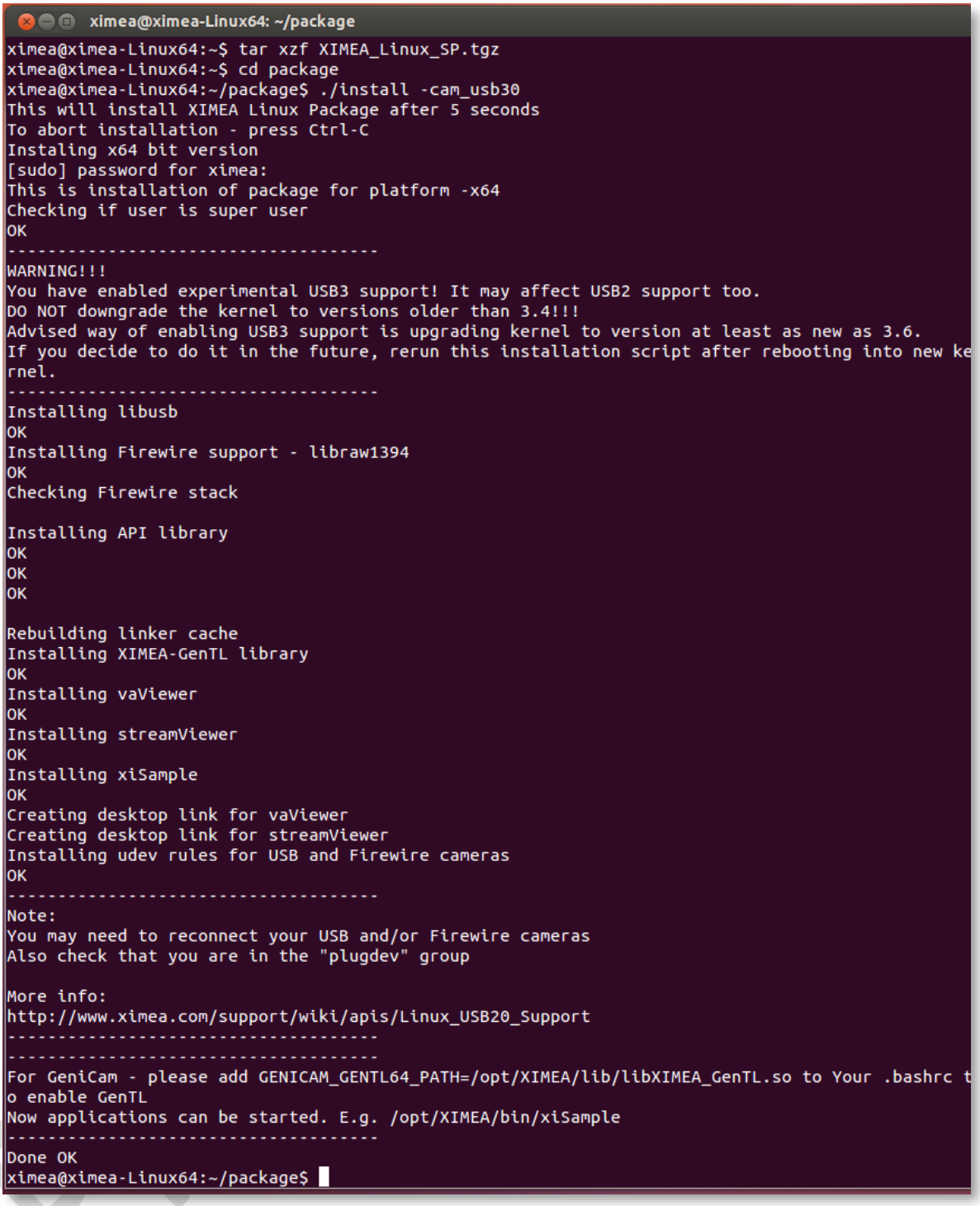


figure 5-8, XIMEA Linux Software Package installation - 2

1) **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*.

5.3.3. XIMEA macOS Software Package

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

5.3.3.1. 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

5.3.3.2. 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.

figure 5-9, XIMEA macOS Software Package installation - 1

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

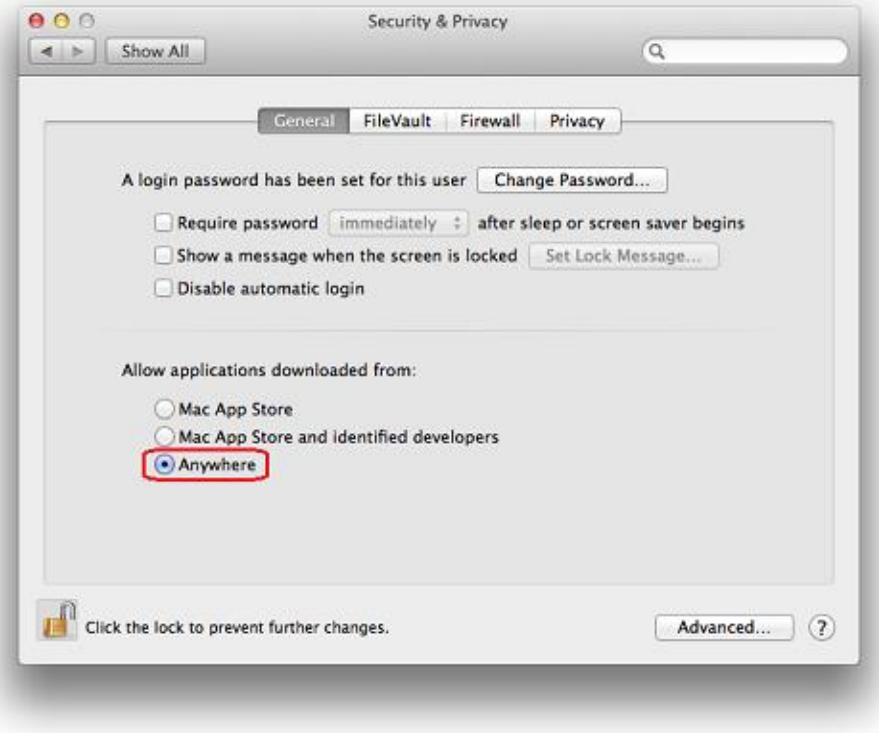


figure 5-10, xiAPI installation, MacOS - 2

- Download XIMEA macOS Software. Package: 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.

5.3.3.3. Start XIMEA CamTool

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

5.4. XIMEA CamTool

The CamTool is a cross-platform application showcasing the features of all XIMEA camera families.

Short description

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

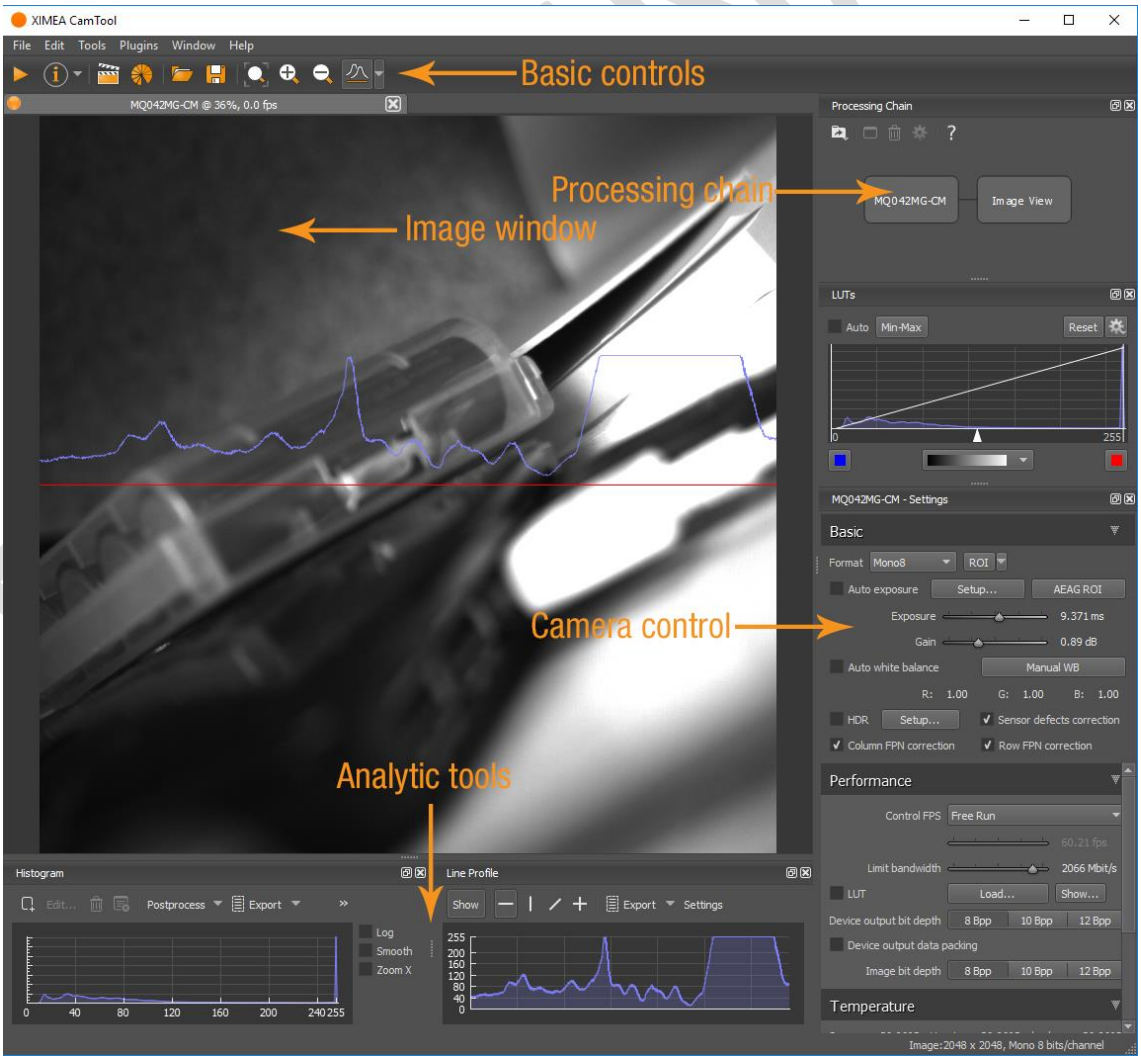


figure 5-11, CamTool Layout

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

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: https://www.ximea.com/support/wiki/allprod/XIMEA_CamTool

5.4.1. 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.

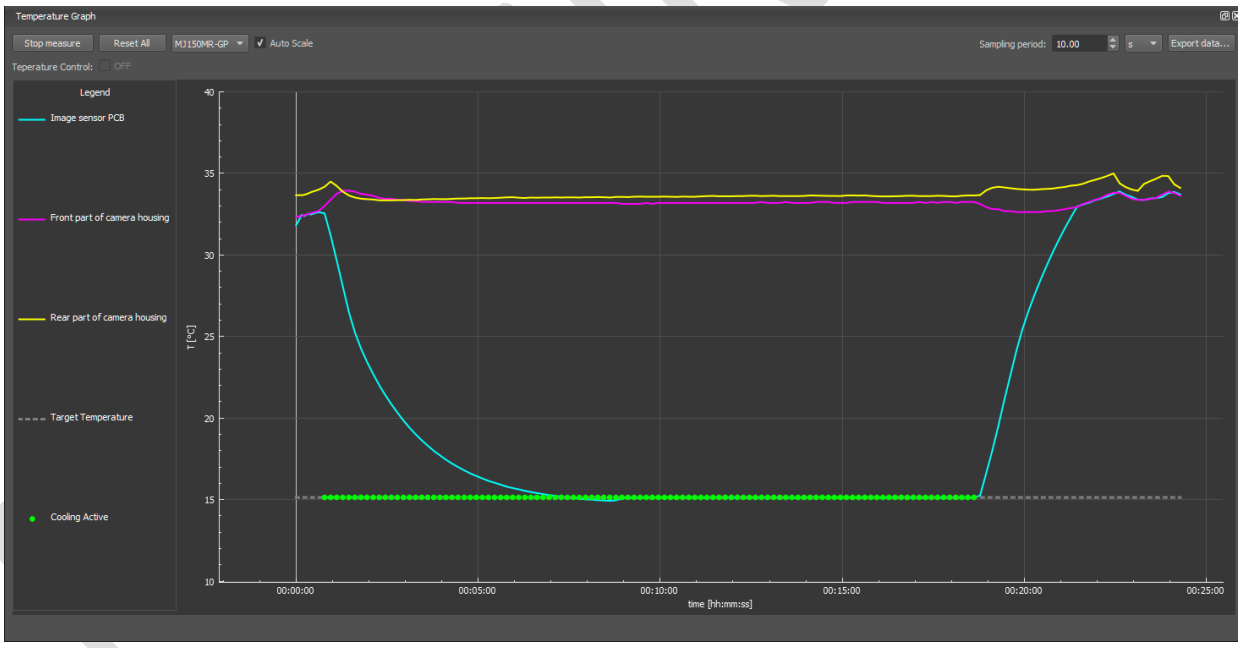


figure 5-12, Temperature Graph Layout

5.4.2. 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.

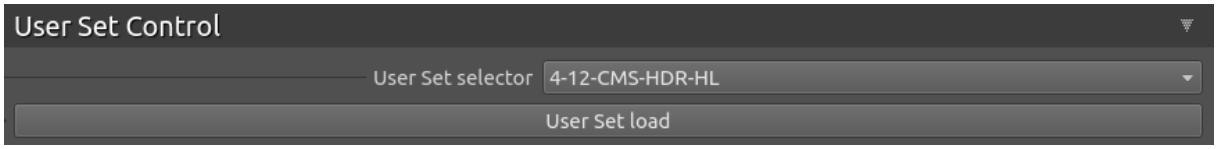


figure 5-13, User Set Control in CamTool

5.5. 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.

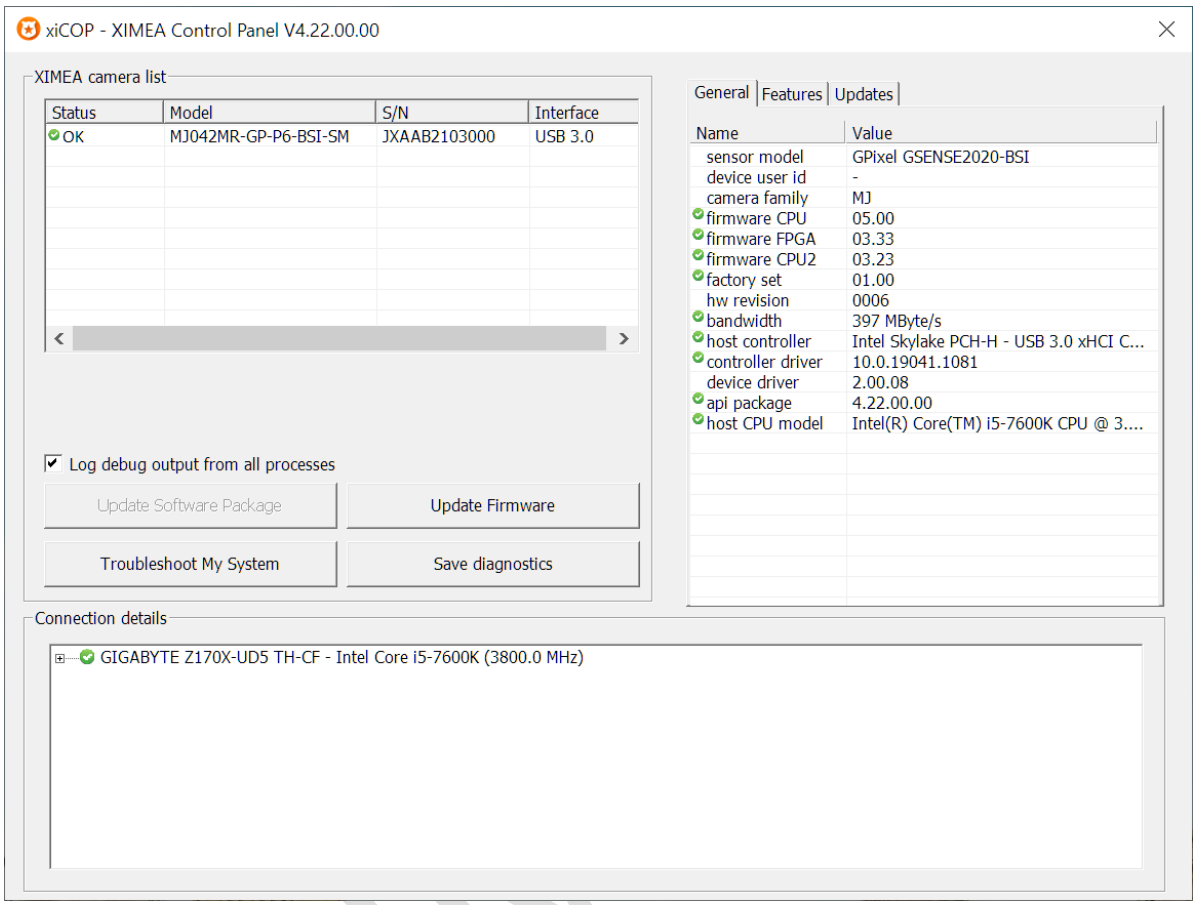


figure 5-14, xiCOP

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.

5.6. 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.

5.6.1. MathWorks MATLAB

MathWorks® is the leading developer and supplier of software for technical computing and Model-Based Design.

More: http://www.mathworks.de/ or https://www.ximea.com/support/wiki/vision-libraries/MathWorks_Matlab

5.6.2. MVTec HALCON

HALCON is the comprehensive standard software for machine vision with an integrated development environment (IDE) that is used worldwide.

More: http://www.mvtec.com/halcon/ or https://www.ximea.com/support/wiki/vision-libraries/MVTec_HALCON

5.6.3. 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

5.6.4. 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

5.7. 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.

5.7.1. 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.

5.7.1.1. GenICam

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 http://www.emva.org/standards-technology/genicam/

5.7.2. 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 *5.2 Connecting the camera*

The camera was tested on 2 setups with accessories described in chapter *3. Hardware Specification.* That is recommended setups, where functionality is guaranteed. Using cameras with other controllers and cables may result in suboptimal performance.

The first one is the direct connection with 1m USB3 cable with power delivery (e.g. *3.9. CBL-U3-P-TC-1M0*) to the host adapter (*3.15. USB 3 host adapters*).

The second one is using power injector. In order to correctly connect the camera with the power injector, the below order of steps must be followed:

11. Connect USB micro-B cable (*3.10. CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M0*) to power injector (*3.12. Power* injector ADPT-PWR-INJ-TC).
12. Connect USB A (*3.10. CBL-U3-1M0 / CBL-U3-3M0 / CBL-U3-5M0*) to PC.
13. Connect power cable (*3.13. Power* cable AUX – CBL-MJ-PWR-2M0) and power on.
14. Connect USB type-C cable (*3.9. CBL-U3-P-TC-1M0*) to power adapter.
15. Connect USB type-C cable to the camera.

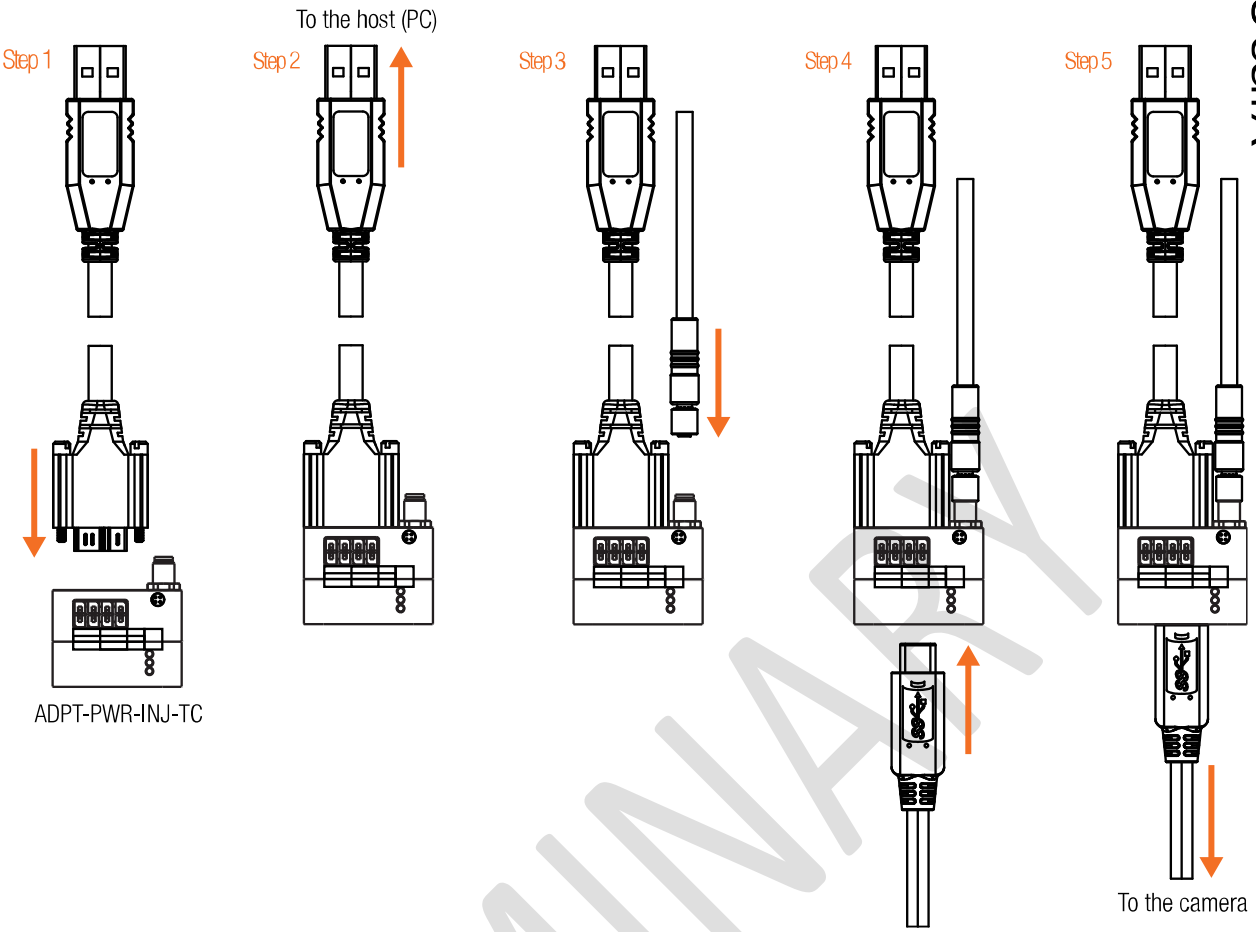


figure 5-1, connecting the components

XIMEA Software Packages.

5.7.2.1. 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);
```

5.7.2.2. 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

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.

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).*

5.7.2.3. 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.

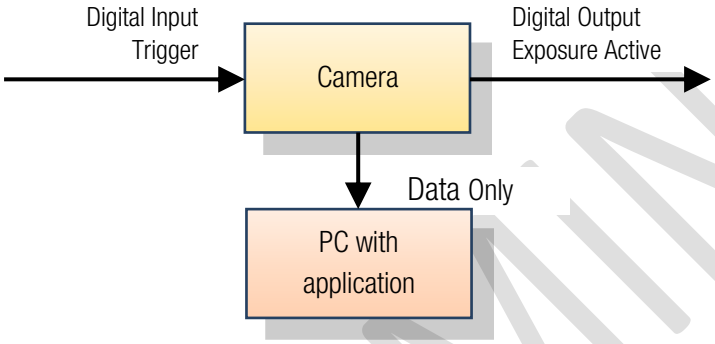


figure 5-15, GPIO - schematic

```
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.

5.7.3. 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.

5.7.4. 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. It is a part of the XIMEA Software Package.

6. Appendix

6.1. Troubleshooting and Support

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

At first, please make sure, that you have installed the latest version of the 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 xiJ camera with the XIMEA USB 3.0 cable to an appropriate USB 3.0 port. Ensure that the connections are carefully locked. Follow the instructions described in chapter *5.4 XIMEA CamTool* (run the xiJ camera with the Ximea CamTool). In case that you still have issues, please read the following chapters.

6.1.1. 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 xiJ camera.

6.1.2. Before Contacting Technical Support

There are a few steps to take before contacting your local dealer for technical support. In case you cannot display images from your xiJ camera, please open the XIMEA xiCOP software (please see *5.5 XIMEA Control Panel*). 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 *5.1 System Requirements*. If the camera does not appear, please proceed with the following steps:

Step no:	Description
1	Click on the button “Troubleshoot My System” and follow the instructions that are suggested.
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.
3	Contact your local dealer where you bought the camera either by phone or by email for first level support. He will decide if he can help you immediately or if more information is necessary for initiating the next steps.

table 6-1, use xiCOP before contacting technical support

6.1.3. Frequently Asked Questions

In this manual, we can list only a few FAQ. For more and updated information, please also note:

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

6.1.3.1. Can the fan part of the Cooling be removed?

Yes, but besides voiding the warranty, this will automatically turn off the cooling completely including the temperature sensor in the camera so even the Peltier will stop working. Thus, the image quality can get considerably reduced.

6.1.3.2. How is the ADC for bit readout set up?

Gpixel sensors offer 3 operation modes: HDR, STD and CMS.

These sensors support 12-bit readout modes and have 2 different on-pixel gain modes:

- High gain (HG), optimized for low readout noise.
- Low gain (LG), optimized for high full well capacity.

You can read more about CMS, HDR and STD modes in section *4.1.4 Camera readout modes* or HERE.

6.1.3.3. How does the HDR mode work?

In the case of HDR mode, two 12bit ADC samples are gathered from each pixel through two readout channels called Low gain and High gain. These readout channels use different floating diffusions (with different capacities) and apply different analog gains to the signal resulting in different conversion gains (e-/LSB12), sampling noise and sampling range. The High gain channel ensures that at very low levels of saturation (when the signal and the image noise are low) the readout process does not add a lot of extra noise to the statistical uncertainty. At higher levels of saturation, when the High gain channel is saturated, the Low gain channel with the higher measurement range is used. The Low gain channel readout circuit also has a higher readout noise than the High gain channel, but it still is sufficiently low when compared to the image noise at higher signal levels and therefore does not influence much the measurement uncertainty which is dominated by the image noise. The actual merging algorithm of Low and High gains is described in the section *4.1.4.3 HDR mode*.

6.1.3.4. What does the 2x 12 bit definition mean?

The models from xiJ camera family are based on scientific CMOS (sCMOS) sensors. Such cameras use two images with High and Low gain to produce the final image. That is why it's specified with 2x 12 bit. The resulting image will have a combined 16 bits.

By default, the cameras are set to High Dynamic Range (HDR) mode. In this mode, the value for each pixel is calculated on the camera's FPGA through merging of the data from the high and low gain channels of the sensor.

6.2. Product service request (PSR)

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

6.2.1. Step 1 - Contact Support

If your xiJ 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.

6.2.2. Step 2 - Create Product Service Request (PSR)

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

6.2.3. 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.

6.2.4. 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.

6.2.5. 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 6-2, service operations overview

If the camera will be returned, you will receive a tracking number. In this case, please continue to step 6

6.2.6. 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".

6.3. Safety instructions and precautions

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

6.3.1. Disassembling

Do not disassemble the camera.

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.

6.3.2. Mounting / Screwing

Use only the designated threaded holes for mounting the camera. Please note the camera / bracket drawings in chapter *3.5 Model Specific Characteristics* and *3.14.Tripod Adapter – ME-ADPT-MJ-T*

Use only the specified screws and torques when fastening.

6.3.3. Connections

Use only recommended connectors and cables. Please check the system requirements described in *5.1 System Requirements*.

6.3.4. Power supply

xiJ camera can be bus powered or powered from external power supply using power injector ADPT-PWR-INJ-TC, described in *3.12 Power injector ADPT-PWR-INJ-TC*. For more information see *3.1 Power Supply*

6.3.5. Environment / protect against water

Use camera in acceptable environment only, please note the descriptions in *3.2.1 Environment*.

Protect the camera against contact with water. Do not let camera get wet.

Damages may be caused by:

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

6.3.6. 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.

6.3.7. Protect the 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 will 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).

6.3.8. Mechanical loads

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

6.3.9. Camera / lens cleaning

Please follow instructions described below.

- 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.

6.3.10. 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.

6.4. Warranty

In addition to the provisions of Article VIII of the Standard Terms & Conditions of XIMEA GmbH (see *6.7 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.

6.5. Disclaimer of Warranty

In addition to the provisions of Article XII of the Standard Terms & Conditions of XIMEA GmbH (see *6.7 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.

6.6. List Of Trademarks

XIMEA, xiC, xiQ, xiMU, xiB, xiB-64, xiX, xSWITCH, xPLATFORM, xEC, xEC2, xiCool, xiRAY, xiCe, xiSpec, xiFLY, xiD, xiJ, xiLAB, xiAPI, xiCamTool, xiCOP and CURRERA are trademarks or registered trademarks of XIMEA GmbH in Germany, Slovakia, USA and other countries.

Microsoft, Windows, Windows 10, Windows 8, Windows 7, Windows Vista, and Windows XP are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries. Apple, the Apple logo, Macintosh, MacOS, OS X, Bonjour, the Bonjour logo and the Bonjour symbol are trademarks of Apple Computer, Inc. Linux is a trademark of Linus Torvalds. The USB3 Vision is trademark owned by the AIA.

All other brands, service provision brands and logos referred to are brands, service provision brands and logos belonging to their respective owners.

6.7. Standard Terms & Conditions of XIMEA GmbH

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 June 2011

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 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") 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.

2. 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.

3. 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.

4. (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. 3 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.

5. 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.

6. 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.

7. 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. 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.

2. Claims for repair or replacement are subject to a statute of limitations of 12 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), Sec. 479 para. 1 (right of recourse), and Sec. 634a para. 1 No. 2 (defects of a building) German Civil Code ("Bürgerliches Gesetzbuch"), in the case of intent, fraudulent concealment of the Defect or non-compliance with guaranteed characteristics (“Beschaffenheitsgarantie”). The legal provisions regarding suspension of the statute of limitations ("Ablaufhemmung", "Hemmung") and recommencement of limitation periods shall be unaffected.

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

4. In the case of notification of a Defect, the Purchaser may withhold payments to an amount that is in a reasonable proportion to the Defect. The Purchaser, however, may withhold payments only if the subject-matter of the notification of the Defect involved is justified and incontestable. 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.

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

6. 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.

7. 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 or repair work carried out by the Purchaser or third parties and the consequences thereof are likewise excluded.

8. The Purchaser shall have no claim with respect to expenses incurred in the course of supplementary performance, including costs of travel, transport, labor, and material, to the extent that expenses are increased because the subject matter 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.

9. The Purchaser's right of recourse against the Supplier pursuant to Sec. 478 BGB 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. Moreover, No. 8 above shall apply mutatis mutandis to the scope of the right of recourse the Purchaser has against the Supplier pursuant to Sec. 478 para. 2 BGB.

10. 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 free from third parties' industrial property rights and copyrights (hereinafter referred to as "IPR") with respect to the country of the place of delivery only. 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, 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.

6.8. Copyright

All texts, pictures and graphics are protected by copyright and other laws protecting intellectual property. It is not permitted to copy or modify them for trade use or transfer, nor may they be used on websites.

6.9. Revision History

Version	Date	Notes
0.00	08/01/2021	Initial version
0.06	11/21/2022	Preliminary release

7. Glossary

Term /Abbreviation	Definition
ADC	Analog to Digital Converter
API	Application Programming Interface
AR (coating)	Anti-Reflex
B/W or B&W	Black and White
CCD	Charge-Coupled Device
CDS	Correlated double sampling
CMOS	Complementary Metal Oxide Semiconductor
DNC	Do not connect
DSNU	Dark Signal non-Uniformity
DR	Dynamic Range
EMC	Electro Magnetic Compatibility
ERS	Electronic rolling shutter
FPN	Fixed pattern noise
FPS	Frame per second
FWC	Full Well Capacity
GR	Global reset
GS	Global shutter
IR	Infra-Red
JTAG	Joint Test Action Group
LSB	Least Significant Bit
MIMR	Multiple integration multiple ROI
MSB	Most significant bit
MSL	Moisture sensitivity level
NA	Not Available
PCB	Printed Circuit Board (same as PWB)
PGA	Programmable gain amplifier
PRNU	Photo response non-uniformity
PWB	Printed Wiring Board (same as PCB)
RGB	Red Green Blue
ROI	Region of interest
Sat	Saturation value
SDK	Software Development Kit
SIMR	Single integration multiple ROI
SNR	Signal To Noise (ratio)
SPI	Serial peripheral interface
SW	Software
TBD	To be determined – some parameters require characterization
T_{int}	Integration time

8. list of figures

9. list of tables

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