# xiQ

[ksi-kju: or sai-kju:]

● USB 3.0 camera series

# 1. Introduction

## 1.1. About This Manual

Dear customer,

Thank you for purchasing  a product from XIMEA.

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

The purpose of this document is to provide a description of the XIMEA xiQ-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.

This document is subject to change without notice.

## 1.2. About XIMEA

XIMEA is one of the worldwide leaders for innovative camera solutions with a 20-year history of research, development and production of digital image acquisition systems. Based in Slovakia, Germany and the US and with a global distributor network, XIMEA offers their cameras worldwide. In close collaboration with customers XIMEA has developed a broad spectrum of technologies and cutting-edge, highly competitive products.

XIMEA's camera centric technology portfolio comprises a broad spectrum of digital technologies, from data interfaces such as FireWire, USB 2.0 and USB 3.0, to cooled digital cameras with CCD and CMOS sensors, as well as smart cameras with embedded PCs, and X-ray cameras. XIMEA has three divisions – generic machine vision and integrated vision systems, scientific imaging and OEM/custom.

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

### 1.2.1. Contact XIMEA

XIMEA is a worldwide operating Company

| Headquarter Sales worldwide | Sales America, Australia, New Zealand | R&D, Production |
|---|---|---|
| XIMEA GmbH Hansestraße 81 48165 Münster Germany | XIMEA Corp. 2102 Beech Court Golden, CO 80401 USA | XIMEA s.r.o. Lesna 52 900 33 Marianka Slovakia |
| Tel: +49 (2501) 964 555-0 Fax: +49 (2501) 964 555-99 | Tel: +1 (303) 389-9838 Fax: +1 (303) 202-6350 | |

| | |
|---|---|
| Internet | www.ximea.com |
| General inquiries | info@ximea.com |
| Sales | sales@ximea.com |
| Support | support@ximea.com |

## 1.3. Standard Conformity

The xiQ cameras have been tested using the following equipment:

- A shielded USB 3.0 cable ref. CBL-U3-3M0 (3m)
- A shielded I/O Sync cable ref. CBL-MQSYNC-3M0 (3m)

**Warning**: Changes or modifications to the product 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 xiQ cameras described in this manual comply with the requirements of the

- EC EMC Directive 2004/108/EEC
    electromagnetic compatibility of equipment

Used harmonized European standards and technical specifications:

- EN 55022:2006 + A2:2010)
    Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement
- EN 55024:2010
    Information technology equipment - Immunity characteristics - Limits and methods of measurement
- EN 61000-6-2:2005        Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments
- EN 61000-6-3:2007 + A1:2011
    Generic standards – Emission standard for residential, commercial and light-industrial environments
- EN 61000-6-4:2007 + A1:2011
    Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
- EN 61000-4-2:2009        Electrostatic discharge immunity test
- EN 61000-4-3:2006 + A2:2010
    Radiated, radio-frequency electromagnetic field immunity test
- EN 61000-4-4:2012        Electrical fast transient/burst immunity test
- EN 61000-4-6:2009        Immunity to conducted disturbances, induced by radio frequency fields
- EN 61000-6-1:2007        Generic standards – Immunity for residential, commercial and light-industrial environments

### 1.3.2. For customers in the US: FCC Conformity

The xiQ 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 xiQ cameras comply with the Class A limit s for radio noise emissions set out in Radio Interference Regulations.

### 1.3.4. RoHS Conformity



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

### 1.3.5. WEEE Conformity



The xiQ cameras comply with the requirements of the WEEE (waste electrical and electronic equipment) Directive 2003/108/EC.

### 1.3.6. AIA standard USB3 Vision



The xiQ cameras are compliant with the USB 3.0 SuperSpeed specification and are designed to be compliant with the AIA USB3 Vision standard.

### 1.3.7. 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

- XIMEAHomepage                               http://www.ximea.com/
- xiQ USB3 Vision Camera Zone       http://www.ximea.com/usb3zone
- USB3 Hardware Compatibility          http://www.ximea.com/support/wiki/usb3/Compatible_hardware
- xiAPI stable versions download        https://www.ximea.com/support/documents/4
- xiAPI beta versions download           https://www.ximea.com/support/documents/14
- 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 Live Support                         http://www.ximea.com/support/wiki/allprod/XIMEA_Live_Support
- XIMEA General Terms & Conditions    http://www.ximea.com/en/corporate/generaltc

## 1.4.1. Table of Contents

# 2.    xiQ Camera Series



## 2.1.    What is xiQ

xiQ [ksi-kju: or sai-kju:] is an ultra-compact USB 3.0 Industrial camera family with outstanding features:

• Extremely small  footprint
• Lowe thermal dissipation
• Single PC board electronics
• USB3 Vision Standard compatible
• sensors: VGA, 1.3 MP, 2 MP, 2.2 MP and 4.2 MP, b/w, color and NIR extended
• frame rates: VGA @ >500 fps to 4.2 MP @ 90 fps

## 2.2.    Advantages

| | |
|---|---|
| Industry standard interface | Compliant with USB 3.0 SuperSpeed specification |
| AIA standard compatibility | USB3 Vision standard |
| small | fits into places where no other camera can fit |
| Cool | low power consumption, 1.0 to 1.8 W |
| Powerful | 5Gb/s interface up to 450Mpix/s data throughput |
| Fast | high speed, high frame rate: >500fps at VGA and 90fps at 4Mpix resolutions |
| Robust | full metal housing, no sheet metal covers |
| Lightweight | facilitates increased performance of robotic arms and gimbals |
| Connectivity | Programmable opto-isolated input and output, 3 status LEDs |
| Compatibility | support for Windows, Linux and MacOS, various Image Processing Libraries |
| Software interfaces | GenICam / GenTL and highly optimized xiAPI SDK |
| Economical | excellent value and price, low TCO and fast ROI |

*table 2-1, advantages*

## 2.3. USB3 Vision Camera Applications

- Automation
- Ultra-fast 3D scanning
- Miniature and fast robotic arms
- Mobile devices
- In-situ optical inspection camera
- Material and Life science microscopy
- Ophthalmology and Retinal imaging
- Broadcasting
- Fast process capture, e.g. golf club swings
- Intelligent Transportations Systems (ITS) and traffic monitoring

## 2.4. Common features

| | |
|---|---|
| Sensor Technology | CMOS, Global shutter |
| Acquisition Modes | Continuous, software and hardware trigger, defined fps, triggered exposure (*1) and burst |
| Partial Image Readout | ROI, Skipping and Binning modes supported (model specific) |
| Image data formats | 8, 10 or 12 bit RAW pixel data |
| Color image processing | Host based de-Bayering, sharpening, Gamma, color matrix, true color CMS |
| Hot/blemish pixels correction | On camera storage of up to 5000 pixel coordinates, host assisted correction |
| Auto adjustments | Auto white balance, auto gain, auto exposure |
| Flat field corrections | Host assisted pixel level shading and lens corrections |
| Image Data and Control Interface | USB 3.0 standard Micro B with screw lock threads compliant to USB3 Vision standard |
| General Purpose I/O | 1x opto-isolated input, 1x opto-isolated output, power LED, 2x LED software programmable |
| Signal conditioning | Programmable debouncing time |
| Synchronization | Hardware trigger input, software trigger, exposure strobe output, busy output |
| Housing and lens mount | Standard C-mount. Available options are CS mount, and board level |
| Power requirements | 1 to 1.8W, supplied via USB 3.0 interface |
| Environment | Operating 0°C to 50°C on housing, RH 80% non-condensing, -30°C to 60°C storage Ingress Protection: IP40 |
| Operating systems | Windows 7 SP1 (x86 and x64), Linux Ubuntu, MacOS 10.8 |
| Software support | xiAPI SDK, adapters and drivers for various image processing packages |
| Firmware updates | Field firmware updatable |

*table 2-2, common features*

Notes:

(*1):     triggered exposure not available for models MQ013xG-E2

## 2.5. Model Nomenclature

Order numbers name conventions for the different models:

MQxxxyG-zz[-OPT]$_n$

MQ: xiQ family name

xxx: Resolution in 0.1 MPixel. E.g. 1.3 MPixel Resolution: xxx = 013

y:      y=C: color model
        y=M: black & white model
        y=R: black & white, Infrared-extended model

zz: Vendor of the sensor

        zz = E2: E2V
        zz = CM: CMOSIS
        zz = ON: Onsemi

[-OPT]: Options

        OPT = TP: sensor with taped sensor glass
        OPT = BRD: board level camera

## 2.6. Models Overview, sensor and models
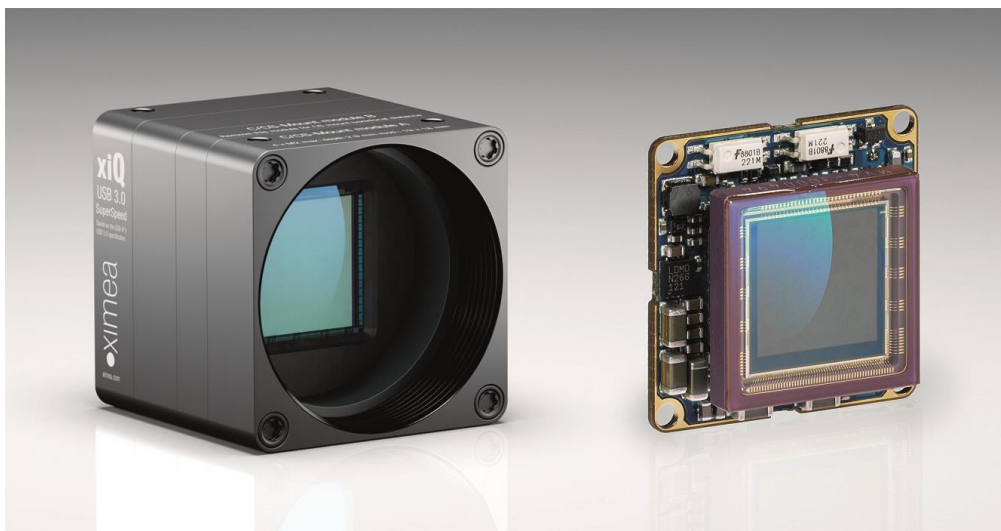


| Model | | Resolution | Pixel size | ADC [bit] | DR | Optical size | Sensor diagonal | FPS |
|---|---|---|---|---|---|---|---|---|
| MQ003MG-CM | b/w | 648x488 | 7.4 µm | 10/12 | 66 dB | 1/3" | 6.0 mm | >500 |
| MQ003CG-CM | Color | | | | | | | |
| MQ013MG-E2 | b/w | 1280x1024 | 5.3 µm | 10 | 66 dB | 1/1.8" | 8.7 mm | 60 |
| MQ013CG-E2 | Color | | | | | | | |
| MQ013RG-E2 | b/w NIR | | | | | | | |
| MQ013MG-ON | b/w | 1280x1024 | 4.8 µm | 10 | 60 dB | 1/2" | 7.9 mm | 150 |
| MQ013CG-ON | Color | | | | | | | |
| MQ022MG-CM | b/w | 2048*1088 | 5.5 µm | 10/12 | 60 dB | 2/3" | 12.8 mm | 180 |
| MQ022CG-CM | Color | | | | | | | |
| MQ022RG-CM | b/w NIR | | | | | | | |
| MQ042MG-CM | b/w | 2048x2048 | 5.5 µm | 10/12 | 60 dB | 1" | 15.9 mm | 90 |
| MQ042CG-CM | Color | | | | | | | |
| MQ042RG-CM | b/w NIR | | | | | | | |

*table 2-3, models overview*

Note: Maximum frame rate measured at 8 bits per pixel

## 2.7. Options

All models are available in board level version

The models MQ042MG-CM and MQ042CG-CM can be ordered with taped sensor glass.

## 2.8. Accessories

The following accessories are available:

| Item P/N | Description |
|---|---|
| CBL-U3-3M0 | 3.0m USB 3.0 cable |
| CBL-U3-3M0-ANG | 3.0m USB 3.0 cable, angled micro USB3 connector |
| CBL-U3-5M0 | 5.0m USB 3.0 cable |
| CBL-U3-8M0 | 8.0m USB 3.0 cable |
| CBL-MQSYNC-3M0 | 3.0m xiQ series I/O sync cable, pig tail |
| MQ-BRACKET-T | xiQ series tripod mounting bracket |
| U3PE-FL1009 | PCI express adapter, 2x USB 3.0 ports |
| U3PE-D720202-X4 | PCI express adapter, 4x USB 3.0 ports, PCIe x4 slot |

*table 2-4, accessories*

# 3. Hardware Specification

## 3.1. Power Supply

The xiQ cameras are powered via the USB 3.0 Micro-B connector. The input voltage is 5 V DC. The power consumption is 1.0 - 1.8W depending on the xiQ model.

Power supply, via USB 3.0 system connector:

- 5 V (nominal)
- 4.45 V to 5.25 V (at the connector of hub or root port)

## 3.2. General Specification

### 3.2.1. Environment

| Description | Symbol | Value |
|---|---|---|
| Optimal ambient temperature operation | $T_{opt}$ | +10 to +25 °C |
| Ambient temperature operation | $T_{max}$ | -10 - +55 °C |
| Ambient temperature for storage and transportation | $T_{storage}$ | -25 - +70 °C |
| Relative Humidity, non-condensing | RH | 80 % |

*table 3-1, environment*

Housing temperature must not exceed +65°C. The following parameters are not guaranteed if the camera is operated outside the optimum range:

- Dark current
- Dynamic Range
- Linearity
- Acquisition and readout noise
- S/N ratio, durability

### 3.2.2. Firmware / Host driver / API features

| Description | Value |
|---|---|
| Interpolation methods | 9331, SHT_advanced |
| White balance coefficients ranges | 0.0 to 3.9 |
| Sharpness filter | 0 to 100 % |
| Gamma | 0.3 to 1.0 |
| Full color correction matrix (3+1)x3 coefficients ranges | -3.9 to 3.9 |

*table 3-2, firmware / API features*

More details on API/SDK features are available at XIMEA support pages: http://www.ximea.com/support

## 3.3. Lens Mount

The xiQ cameras are compatible with C-mount and CS-mount lenses.



front view                    side view
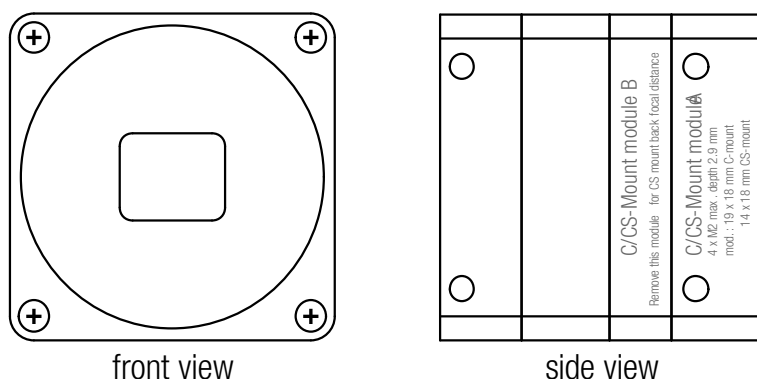
*figure 3-1, position C/CS-Mount module B*

The cameras are delivered with C-mount back focal length. By removing the "C/CS-Mount module B" (see the figure above) the camera can be rebuilt to CS-mount compatibility. The required M2x8mm special screws are part of the camera delivery.
The length of the lens thread is 6.5 mm.

**Note:** The distance between the threaded flange and the surface of the filter glass is 11.9 mm in case of C-Mount and 6.9 mm in case of CS-Mount. To avoid damaging of the filter glass, nothing may extend deeper into the housing.

Lens mount adapter configuration:

- C-Mount    (with C/CS Mount module B)
- CS-Mount  (without C/CS Mount module B)

## 3.3.1. Screws

All mounting screws are customized M2 screws with different lengths.

Technical details:

| Material | Steel |
|---|---|
| Surface | Black zinc |
| Thread | M2 |
| Driver | PH 00 |
| Avail. Lengths | 2mm – 24 mm |

*table 3-3, custom screws, technical details*

Drawings, e.g. with 10mm length:
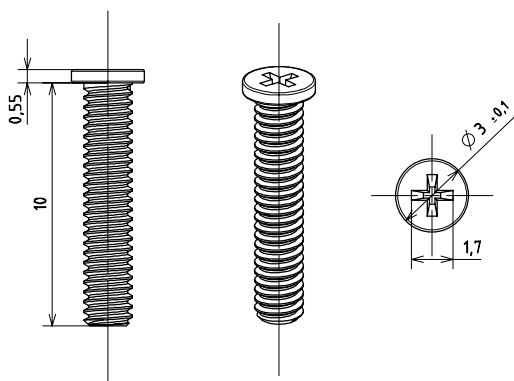


*figure 3-2, xiQ mounting screws*

**Note:** Never exceed a maximum torque of 0.3Nm when fastening the M2 mounting screws.

## 3.4. Optical path

### 3.4.1. Monochrome and near infrared extended camera models

| Used filter brand | BK7 AR2x |
|---|---|
| Thickness | 1.0±0.1 mm |
| Coating | Anti-reflex both sides |

*table 3-4, monochrome camera - filter glass parameter*
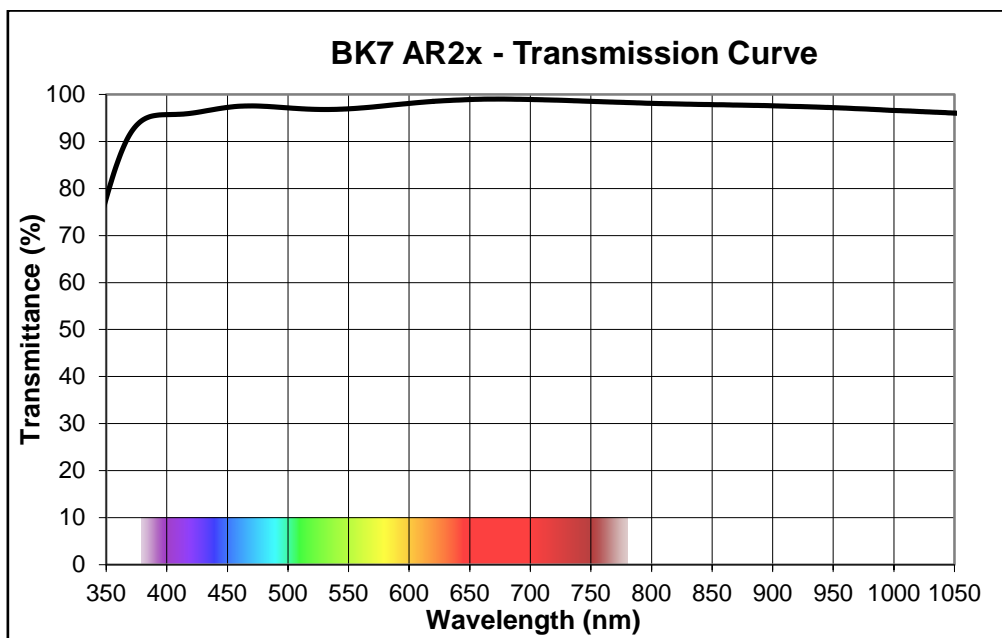


*figure 3-3, monochrome camera - filter glass transmission curve*

### 3.4.2. Color camera models

| Used filter brand | ICR650 |
|---|---|
| Thickness | 1.0±0.1 mm |
| Coating | NA |

*table 3-5, color camera - filter glass parameter*
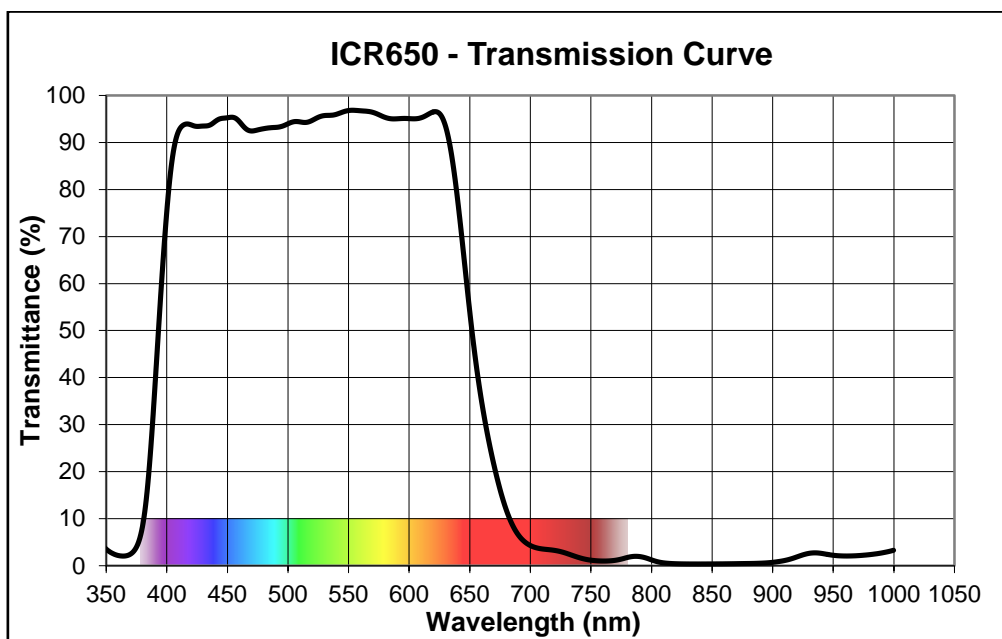


*figure 3-4, color camera - filter glass transmission curve*

## 3.5. Model Specific Characteristics

### 3.5.1. MQ003xG-CM

#### 3.5.1.1. Sensor and camera parameters

| xiQ model | | MQ003CG-CM | MQ003MG-CM |
|---|---|---|---|
| **Sensor parameter (*1)** | | | |
| Brand | | CMV300ES-3E7C1WP | CMV300ES-3E7M1WP |
| Color filter | | RGB Bayer mosaic | None |
| Type | | Global shutter, overlap mode | |
| Pixel Resolution (H × V) | [pixel] | 648 × 488 | |
| Active area size (H × V) | [mm] | 4.8 × 3.6 | |
| Sensor diagonal | [mm] | 5.9 | |
| Optical format | [inch] | 1/3 | |
| Pixel Size (H × V) | [µm] | 7.4 × 7.4 | |
| ADC resolution | [bit] | 10, (12 TBD) | |
| FWC | [ke-] | 20 | |
| Dynamic range | [dB] | 60 | |
| SNR Max | [dB] | >40 (TBD) | |
| Dark noise | [e-] | 20 (RMS) | |
| Dark current | [e-/s] | 125 (25°C) | |
| DSNU | [$LSB_{10}$/s] | 3 | |
| Sensitivity | [V/(Lux s)] | 6 | |
| **Camera parameters** | | | |
| Digitization | [bit] | 12 | |
| Supported bit resolutions | [bit/pixel] | 8, 10, (12) | |
| Exposure time (EXP) | | 7.4µs to 10sec, in steps of 7.4µs (*1) | |
| Variable Gain Range (VGA) | [dB] | 8.4 | |
| Refresh rate (MRR) | [fps] | 90 | |

| **Supported standard readout modes** | | Binning/skipping | pixels | fps (*2) | Bit/px |
|---|---|---|---|---|---|
| | 0 | 1x1 | 648 × 488 | 548 | 8 |
| | 1 | 1x1 | 648 × 488 | 548 | 10 |

| **Power consumption** | | | |
|---|---|---|---|
| typical | [W] | 1.2 | |
| Maximum | [W] | 1.3 | |
| **Mechanical** | | | |
| height | [mm] | 26.4 | |
| width | [mm] | 26.4 | |
| depth | [mm] | 24.6 (with C/CS Mount module B) 19.6 (without C/CS Mount module B) | |
| weight | [g] | 26.4 (with C/CS Mount module B) 22.4 (without C/CS Mount module B) 3.4 (board level camera) | |

*table 3-6, MQ003xG-CM, sensor and camera parameters*

Notes:

(*1)    defined for max. bandwidth. By decreasing bandwidth the minimum exposure time and exposure step will increase

(*2)    the maximum frame rate depends on the temperature of the sensor. The sensor manufacturer guarantees only 480 fps at higher sensor temperatures (e.g. 50-70 °C).

### 3.5.1.2. Quantum efficiency curves [%]



*figure 3-5, CMV300-mono, quantum efficiency curve, ©CMOSIS*

### 3.5.1.3. Mechanical drawings (C-mount [with C/CS mount module B])



*figure 3-6, mechanical drawing MQ003xG-CM, C-Mount housing*

### 3.5.1.4. Mechanical drawings (CS-mount [without C/CS mount module B])
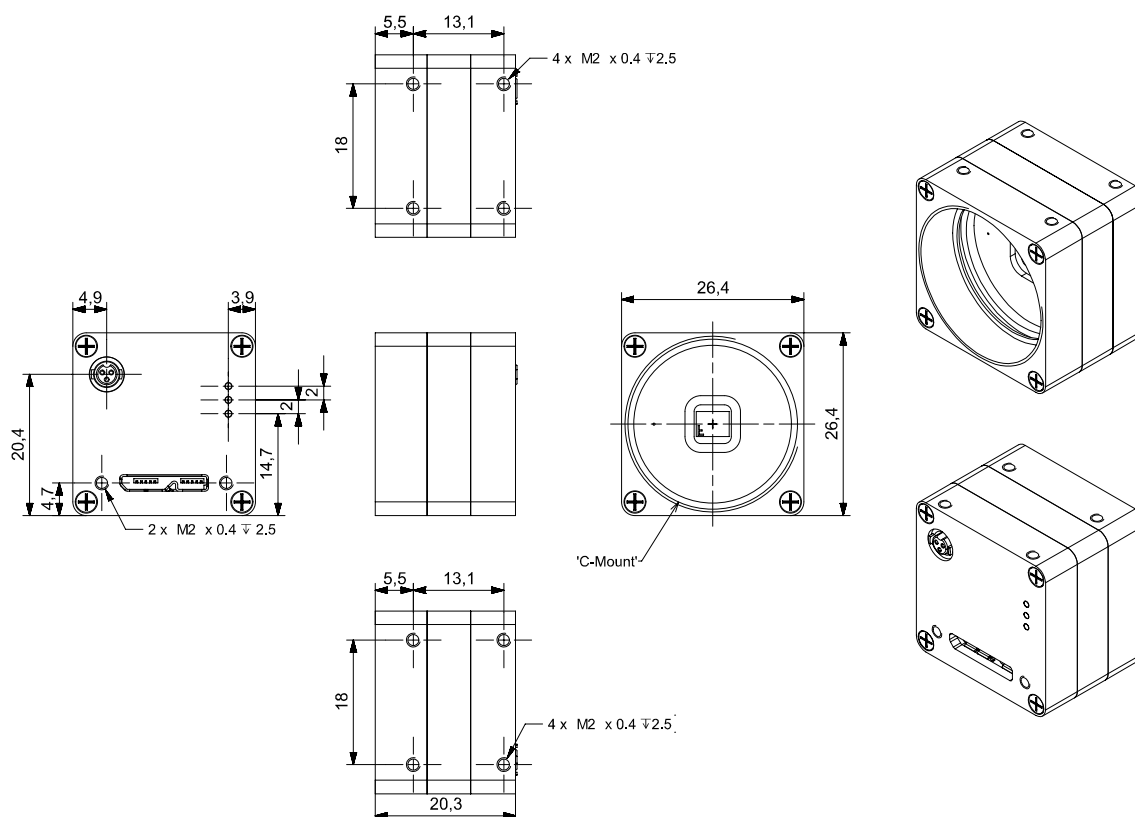


*figure 3-7, mechanical drawing MQ003xG-CM, CS-Mount housing*

### 3.5.1.5. Referenced documents

CMOSIS Datasheet CMV300-datasheet-v2.0 (05/06/13)

### 3.5.1.6. Sensor features

| feature | Note |
|---|---|
| Binning | No |
| Skipping | Not supported, yet |
| ROI | Single window in y direction supported, (cropping in X by xiAPI planned) |
| HW Trigger | Trigger with overlap (see *4.3.2.4 Triggered mode with overlap*) |
| HDR | Knee point based HDR (beta stage), see *4.4.9 HDR* |

*table 3-7, sensor features available*

## 3.5.2. MQ013xG-E2

### 3.5.2.1. Sensor and camera parameters

| xiQ model | | MQ013CG-E2 | MQ013MG-E2 | MQ013RG-E2 |
|---|---|---|---|---|
| **Sensor parameter** | | | | |
| Brand | | EV76C560ACT-EQV | EV76C560ABT-EQV | EV76C661ABT-EQTR |
| Color filter | | RGB Bayer mosaic | None | None |
| Type | | Global shutter, overlap mode | | |
| Pixel Resolution (H × V) | [pixel] | 1280 × 1024 | | |
| Active area size (H × V) | [mm] | 6.9 × 5.5 | | |
| Sensor diagonal | [mm] | 8.7 | | |
| Optical format | [inch] | 1/1.8 | | |
| Pixel Size (H × V) | [µm] | 5.3 × 5.3 | | |
| ADC resolution | [bit] | 10 | | |
| FWC | [ke-] | 12 | | |
| Dynamic range | [dB] | >60 | | >63 (25°C) / >60 (65°C) |
| SNR Max | [dB] | 40 | | 39 |
| Dark signal (*1) | [$LSB_{10}$/s] | 24 (25°C) / 420 (65°C) | | 38 (25°C) / 830 (65°C) |
| DSNU (*1) | [$LSB_{10}$/s] | 6 (25°C) / 116 (65°C) | | 21 (25°C) / 220 (65°C) |
| Sensitivity (*2) | [$LSB_{10}$/(Lux s)] | 6600 | | 13000 |
| **Camera parameters** | | | | |
| Digitization | [bit] | 10 | | |
| Supported bit resolutions | [bit/pixel] | 8, 10 | | |
| Exposure time (EXP) | | 15.625µs to 10sec, in steps of 15.625µs | | |
| Variable Gain Range (VGA) | [dB] | 24 | | |
| Refresh rate (MRR) | [fps] | 61 | | |

| **Supported standard readout modes** | Binning/skipping | pixels | fps | Bit/px |
|---|---|---|---|---|
| 0 | 1x1 | 1280 x 1024 | 61 | 8 |
| 1 | 2x2 bin | 640 x 512 | 61 | 8 |
| 2 | 1x1 | 1280 x 1024 | 61 | 12 (*3) |
| 3 | 2x2 bin | 640 x 512 | 61 | 12 (*3) |

| **Power consumption** | | |
|---|---|---|
| typical | [W] | 0.75 |
| Maximum | [W] | 0.9 |
| **Mechanical** | | |
| height | [mm] | 26.4 |
| width | [mm] | 26.4 |
| depth | [mm] | 26.2 (with C/CS Mount module B) <br> 21.2 (without C/CS Mount module B) |
| weight | [g] | 26.6 (with C/CS Mount module B) <br> 22.6 (without C/CS Mount module B) <br> 4 (board level camera) |

*table 3-8, MQ013xG-E2, sensor and camera parameters*

Notes:

(*1) Min gain, 10 bits.

(*2) Measurement conditions: 3200K, window without AR coating, IR cut off filter BG38 2 mm

(*3) the sensor has 10 bit output, 12 bit are shifted

### 3.5.2.2.  Quantum efficiency curves [%]
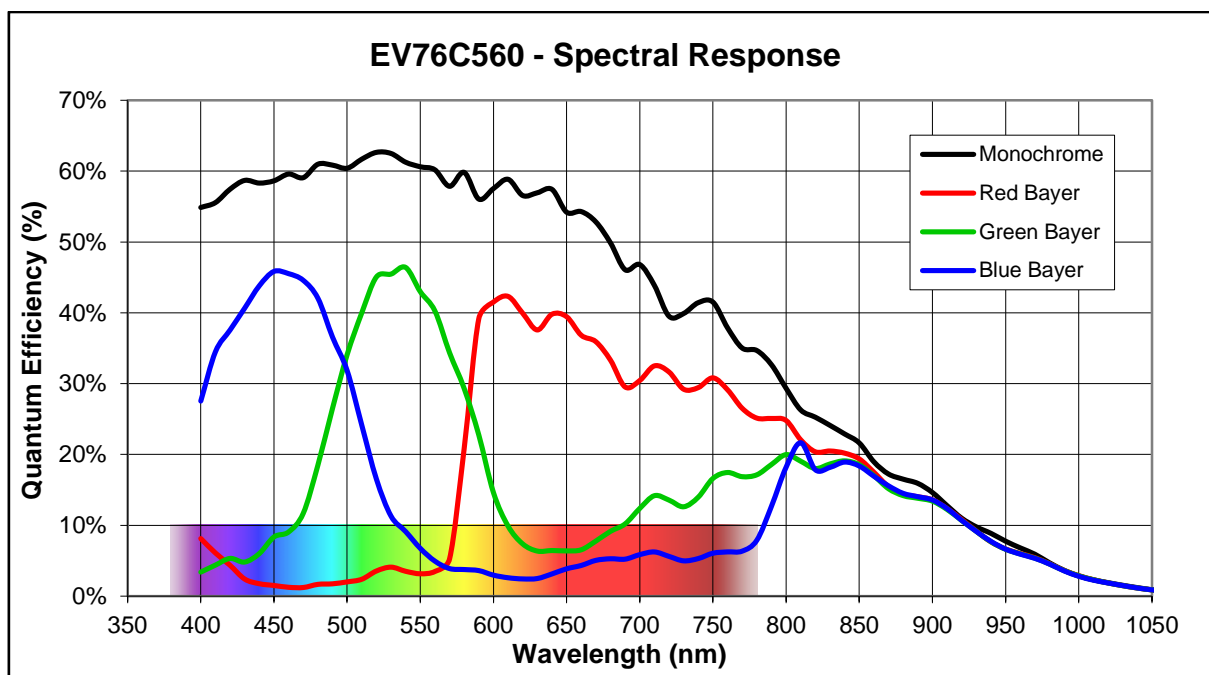


*figure 3-8, EV76C560-mono and color, quantum efficiency curves, ©E2V*
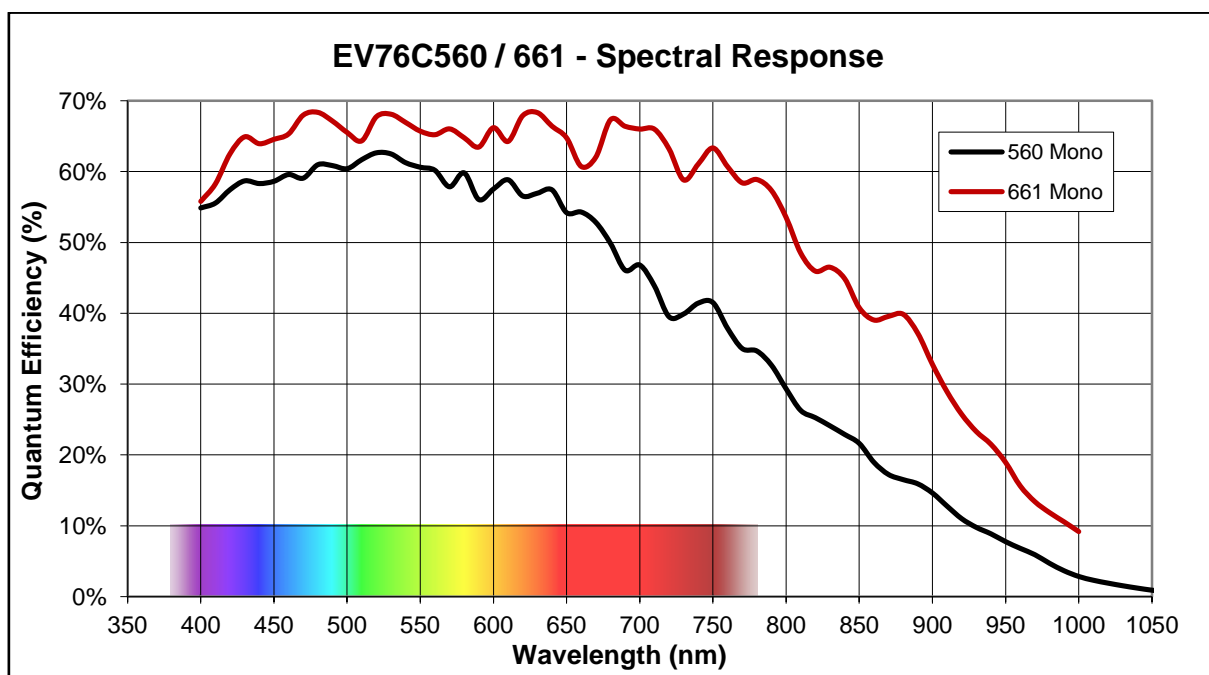


*figure 3-9, EV76C560-mono and EV76C661-NIR, quantum efficiency curves, ©E2V*

### 3.5.2.3. Mechanical drawings (C-mount [with C/CS mount module B])



*figure 3-10, mechanical drawing MQ013xG-E2, C-Mount housing*

### 3.5.2.4. Mechanical drawings (CS-mount [without C/CS mount module B])
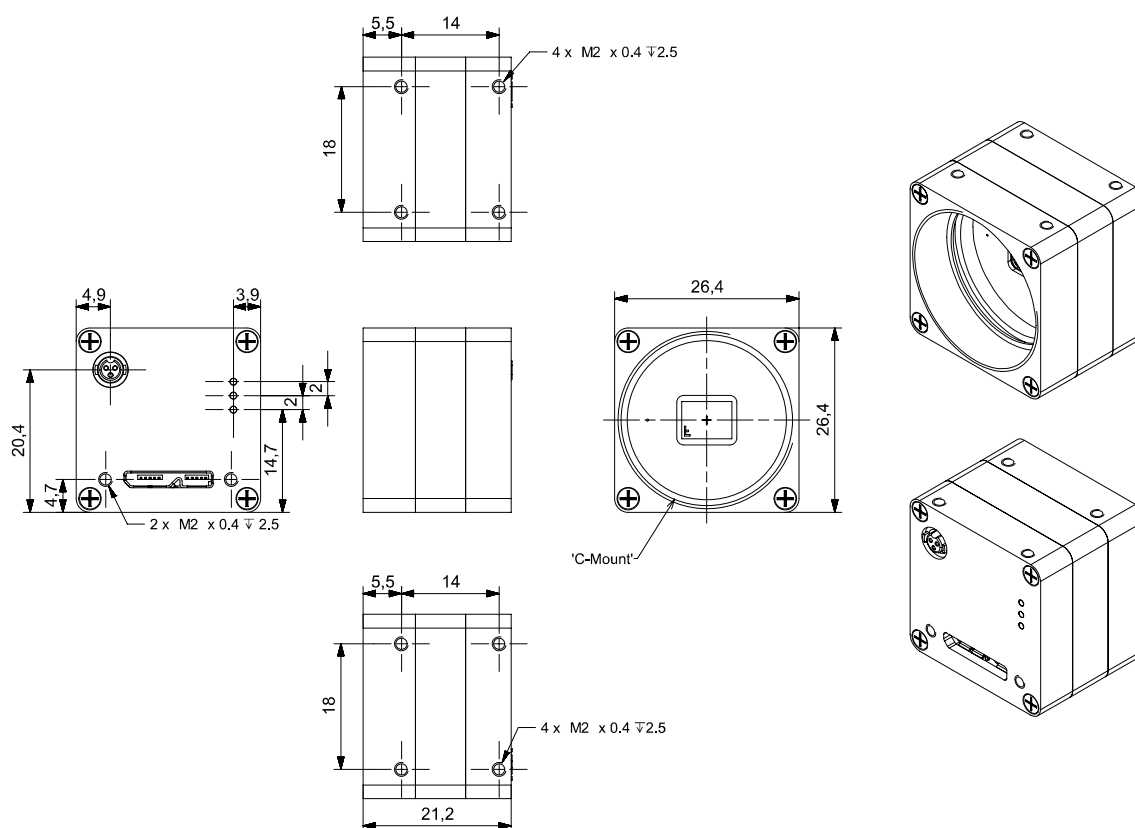


*figure 3-11, mechanical drawing MQ013xG-E2, CS-Mount housing*

### 3.5.2.5. Referenced documents

E2V Datasheet EV76C56 1005A–IMAGE–29/06/09

### 3.5.2.6. Sensor features

| feature | Note |
|---------|------|
| Binning | Yes, 2x2 binning supported |
| Skipping | Not supported yet |
| ROI | 1 ROI with free parameters supported |
| HW Trigger | Trigger without overlap usable (see *4.3.2.3 Triggered mode without overlap*) |
| HDR | Currently not supported |

*table 3-9, sensor features available*

### 3.5.2.7. Note: horizontal image lines (MQ013CG-E2, MQ013MG-E2)

Running the cameras in overlap mode (live mode) with exposure times between 300µs and 16ms may cause a horizontal line in the image. This is a known issue of the used sensors and is caused by pixel readout or sensor reset during acquisition.

### 3.5.2.8. Note: triggered exposure

The feature triggered exposure is not supported by the sensors.

### 3.5.2.9. Frame rate examples

Following table lists examples for the maximum frame rate - Frames Per Second (FPS) that can be achieved with active region of interest (ROI), free run mode (no trigger), RAW8 data format, exposure time 200µs.

Tested with: Intel i7-3770, 4GB DDR3, GA-Z77M-D3H, Windows 7 x64, API_INST_V3_19_06. Measured without further data processing.

| Camera model | USB3-Controller | FPS | ROI |
|--------------|-----------------|-----|-----|
| MQ013MG-E2 | Intel Z77 | 2100 | 1280 x 12 |
| MQ013MG-E2 | Fresco Logic FL1009 | 860 | 1280 x 56 |

*Table 3-10, MQ013MG-E2, frame rate examples with ROI*

### 3.5.3. MQ013xG-ON

#### 3.5.3.1. Sensor and camera parameters

| xiQ model | | MQ013CG-ON | | MQ013MG-ON | |
|---|---|---|---|---|---|
| **Sensor parameter (*1)** | | | | | |
| Brand | | NOIV1SE1300A-QDC | | NOIV1SN1300A-QDC | |
| Color filter | | RGB Bayer mosaic | | None | |
| Type | | Global shutter, overlap mode | | | |
| Pixel Resolution (H × V) | [pixel] | $1280 \times 1024$ | | | |
| Active area size (H × V) | [mm] | $4.8 \times 3.6$ | | | |
| Sensor diagonal | [mm] | 7.9 | | | |
| Optical format | [inch] | 1/2 | | | |
| Pixel Size (H × V) | [µm] | $4.8 \times 4.8$ | | | |
| ADC resolution | [bit] | 10, 8 | | | |
| FWC | [ke-] | 13.7 | | | |
| Dynamic range | [dB] | 53 | | | |
| SNR Max | [dB] | 41 | | | |
| Dark noise | [e-] | 30: 2.2 $LSB_{10}$ | | | |
| Dark current | [e-/s] | 4.5 (25°C) | | | |
| DSNU | [$LSB_{10}$/s] | 0.33 | | | |
| Sensitivity | [V/(Lux s)] | 4.6 | | | |
| **Camera parameters** | | | | | |
| Digitization | [bit] | 10 | | | |
| Supported bit resolutions | [bit/pixel] | 8, 10 | | | |
| Exposure time (EXP) | | 1µs to 1sec (TBD) in steps of 1µs if exp < 65.54ms; 4µs if exp<262.1ms; 16µs otherwise | | | |
| Variable Gain Range (VGA) | [dB] | 8.4 | | | |
| Refresh rate (MRR) | [fps] | 150 | | | |
| **Supported standard readout modes** | | Binning/skipping | pixels | fps | Bit/px |
| | 0 | 1x1 | $1280 \times 1024$ | 150 | 8 |
| | 1 | 1x1 | $1280 \times 1024$ | 145 | 10 |
| | 2 | 2x2 | 640 x 512 | 500 | 8 |
| | 3 | 2x2 | 640 x 512 | 288 | 10 |
| **Power consumption** | | | | | |
| typical | [W] | 1.3 | | | |
| Maximum | [W] | 1.4 | | | |
| **Mechanical** | | | | | |
| height | [mm] | 26.4 | | | |
| width | [mm] | 26.4 | | | |
| depth | [mm] | 24.6 (with C/CS Mount module B) 19.6 (without C/CS Mount module B) | | | |
| weight | [g] | 26.9 (with C/CS Mount module B) 22.9 (without C/CS Mount module B) 4.3 (board level camera) | | | |

*table 3-11, MQ013xG-ON, sensor and camera parameters*

### 3.5.3.2. Quantum efficiency curves [%]
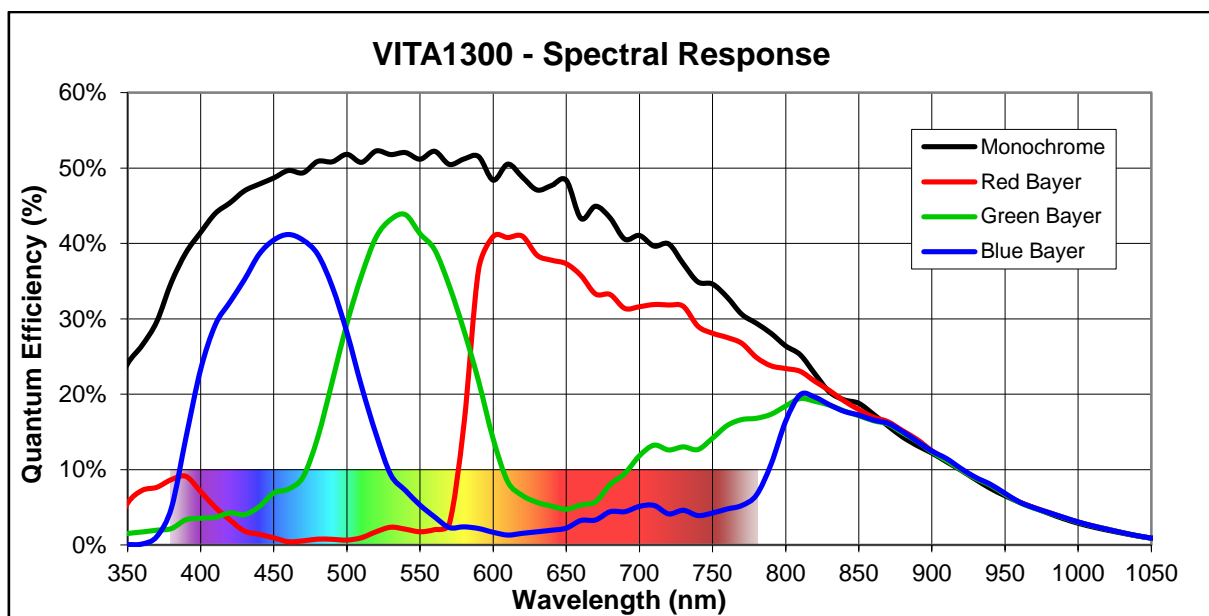


*figure 3-12 VITA1300 mono and color, quantum efficiency curves, ©Onsemi*

### 3.5.3.3. Mechanical drawings (C-mount [with C/CS mount module B])
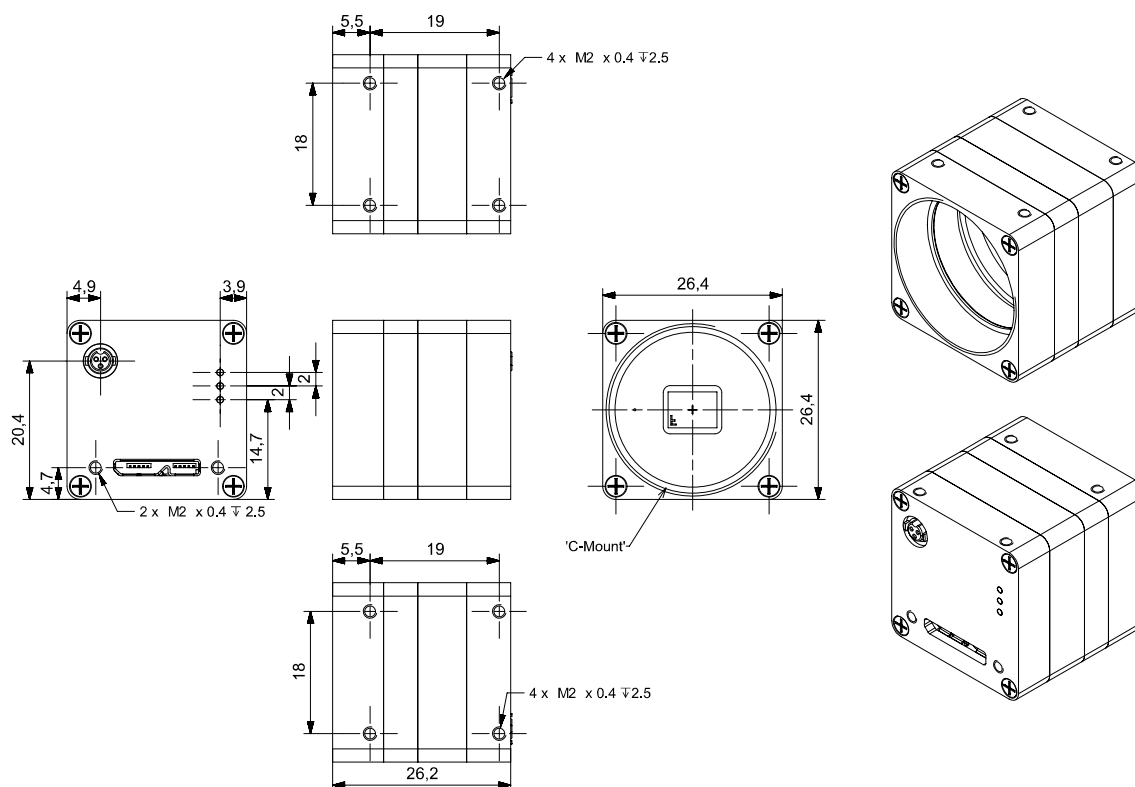


*figure 3-13, mechanical drawing MQ013xG-ON, C-Mount housing*

### 3.5.3.4. Mechanical drawings (CS-mount [without C/CS mount module B])
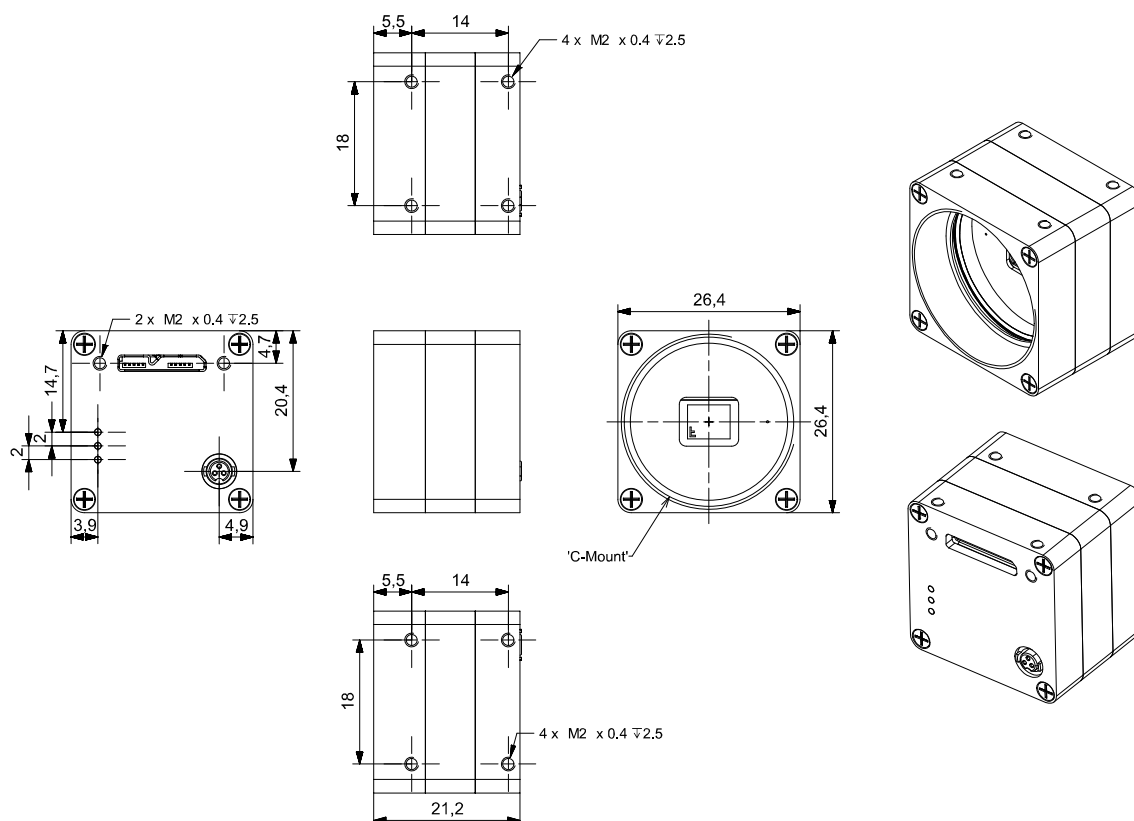


*figure 3-14, mechanical drawing MQ013xG-ON, CS-Mount housing*

### 3.5.3.5. Camera orientation

Please note that the camera orientation of the MQ013xG-ON models are different. The USB 3.0 connector is at the upper side of the camera. Please see the next figure:
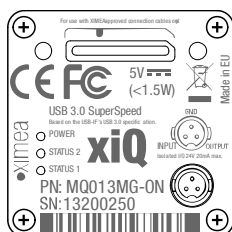


*Figure 3-15, MQ013xG-ON, camera orientation*

### 3.5.3.6. Referenced documents

Onsemi Datasheet VITA1300-datasheet-Rev. 8 (July 2012)

### 3.5.3.7. Sensor features

| feature | Note |
|---|---|
| Binning | Not implemented |
| Skipping | Yes, 2x2 binning supported |
| ROI | 1 ROI with free parameters supported (x coordinates multiple of 16, y coordinates multiple of 2) |
| HW Trigger | Trigger with overlap usable (see *4.3.2.4 Triggered mode with overlap*) |
| HDR | Knee point based HDR (beta stage), see *4.4.9 HDR – Not implemented, yet* |

*table 3-12, sensor features available*

## 3.5.4. MQ022xG-CM

### 3.5.4.1. Sensor and camera parameters

| xiQ model | MQ022CG-CM | MQ022MG-CM | MQ022RG-CM |
|---|---|---|---|
| **Sensor parameter (*1)** | | | Coming soon |
| Brand | CMV2000ES-3E5C1PP | CMV2000ES-3E5M1PP | CMV2000ES-3E12M1PP |
| Color filter | RGB Bayer mosaic | None | None |
| Type | Global shutter, overlap mode | | |
| Pixel Resolution (H × V) [pixel] | 2048 × 1088 | | |
| Active area size (H × V) [mm] | 11.27 × 6 | | |
| Sensor diagonal [mm] | 12.8 | | |
| Optical format [inch] | 2/3 | | |
| Pixel Size (H × V) [µm] | 5.5 × 5.5 | | |
| ADC resolution [bit] | 10, (12 TBD) | | |
| FWC [ke-] | 13.5 | | |
| Dynamic range [dB] | 60 | | |
| SNR Max [dB] | 41.3 | | |
| Dark noise [e-] | 13 (RMS) | | |
| Dark current [e-/s] | 125 (25°C) | | |
| DSNU [$LSB_{10}$/s] | 3 | | |
| Sensitivity [V/(Lux s)] | 4.64 | | |
| **Camera parameters** | | | |
| Digitization [bit] | 10 | | |
| Supported bit resolutions [bit/pixel] | 8, 10, (12) | | |
| Exposure time (EXP) | 15.32µs to 1sec, in steps of 2.69µs (*1) | | |
| Variable Gain Range (VGA) [dB] | 8.4 | | |
| Refresh rate (MRR) [fps] | 180 | | |

| **Supported standard readout modes** | Binning/skipping | pixels | fps | Bit/px |
|---|---|---|---|---|
| 0 | 1x1 | 2048 × 1088 | 180 | 8 |
| 1 | 1x1 | 2048 × 1088 | 90 | 10 |

| **Power consumption** | |
|---|---|
| typical [W] | 1.5 |
| Maximum [W] | 1.75 |

| **Mechanical** | |
|---|---|
| height [mm] | 26.4 |
| width [mm] | 26.4 |
| depth [mm] | 30.2 (with C/CS Mount module B) <br> 25.2 (without C/CS Mount module B) |
| weight [g] | 31.8 (with C/CS Mount module B) <br> 27.8 (without C/CS Mount module B) <br> 7.2 (board level camera) |

*table 3-13, MQ022xG-CM, sensor and camera parameters*

Notes:

(*1)     defined for max. bandwidth and 8bit per pixel. Higher dynamic range (i.e. 10 or 12 bit/pixel) will reduce available frame rate. By decreasing bandwidth the minimal exposure time and exposure step will increase.

## 3.5.4.2. Quantum efficiency curves [%]



figure 3-16, CMV2000 mono and color, quantum efficiency curve, ©CMOSIS



figure 3-17, CMV2000-mono and NIR (E12), quantum efficiency curves, ©CMOSIS

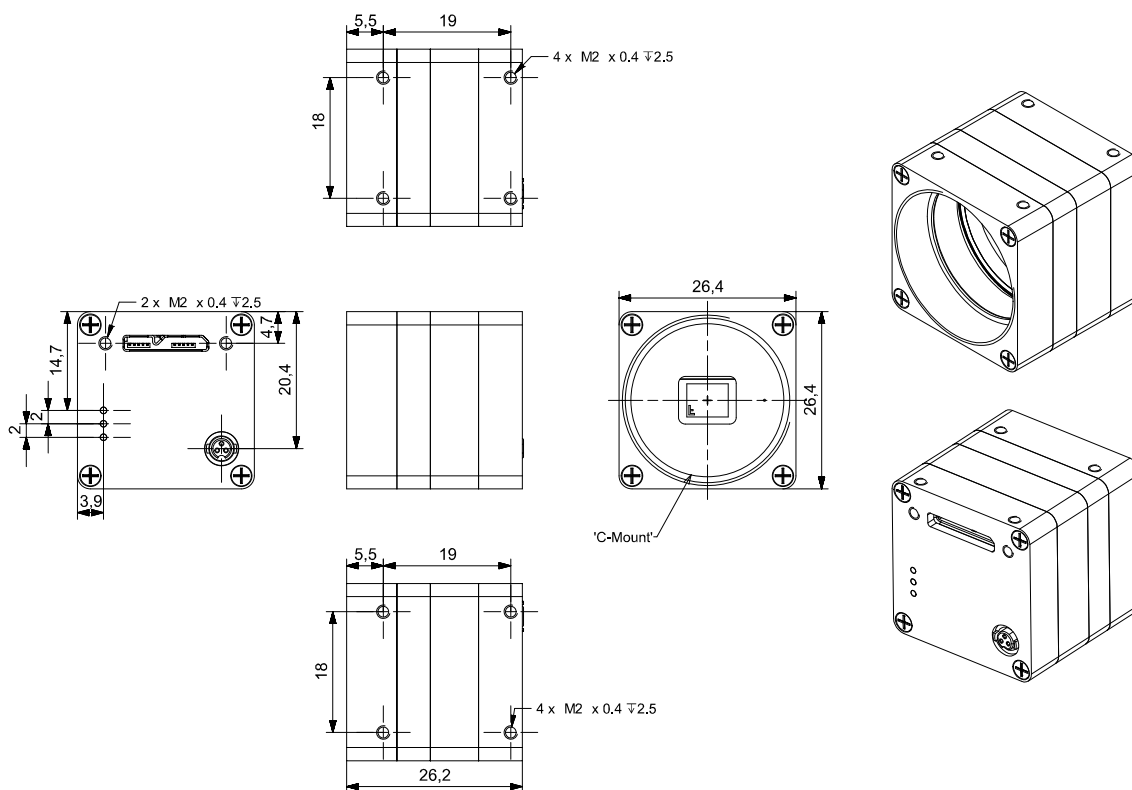### 3.5.4.3. Mechanical drawings (C-mount [with C/CS mount module B])



*figure 3-18, mechanical drawing MQ022xG-CM, C-Mount housing*

### 3.5.4.4. Mechanical drawings (CS-mount [without C/CS mount module B])
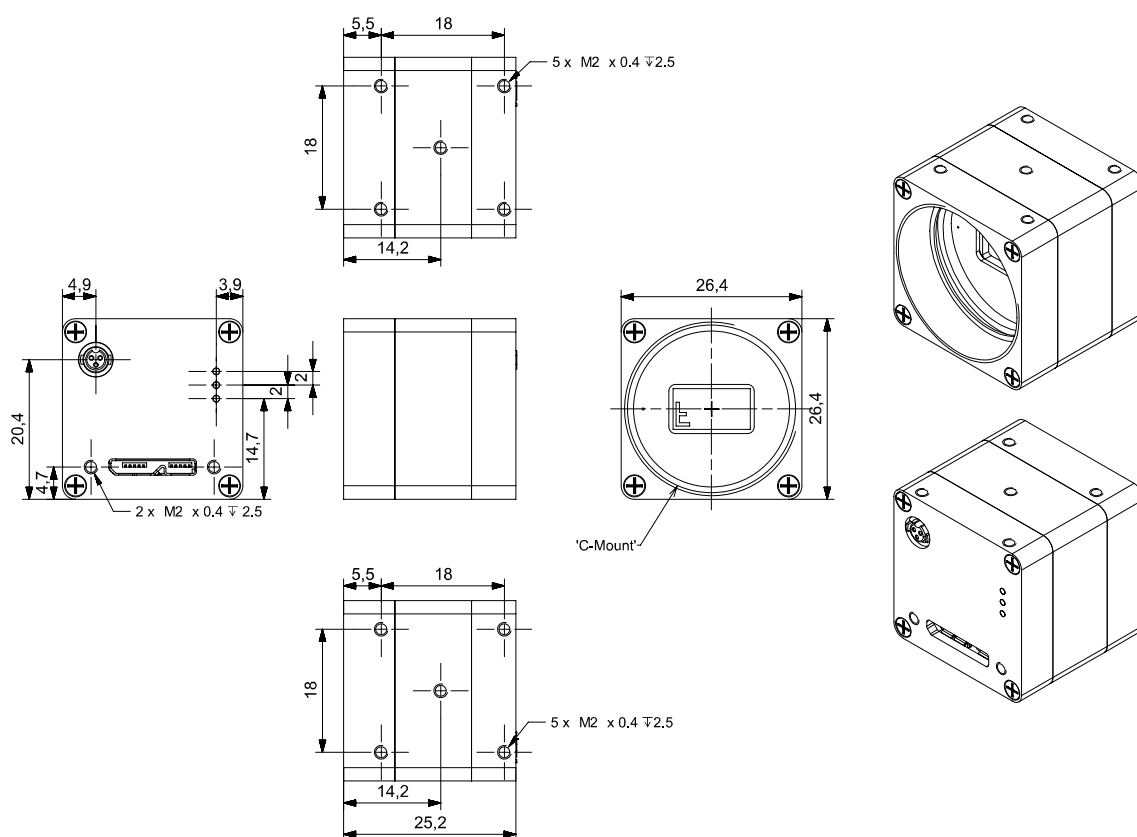


*figure 3-19, mechanical drawing MQ022xG-CM, CS-Mount housing*

### 3.5.4.5. Referenced documents

CMOSIS Datasheet CM2000-datasheet-v3.2 (30/07/12)

### 3.5.4.6. Sensor features

| feature | Note |
|---|---|
| Binning | No |
| Skipping | Not supported, yet |
| ROI | Single window in y direction supported |
| HW Trigger | Trigger with overlap usable (see *4.3.2.4 Triggered mode with overlap*) |
| HDR | Knee point based HDR (beta stage), see *4.4.9 HDR* |

*table 3-14, sensor features available*

## 3.5.5. MQ042xG-CM

### 3.5.5.1. Sensor and camera parameters

| xiQ model | | MQ042CG-CM | MQ042MG-CM | MQ042RG-CM |
|---|---|---|---|---|
| **Sensor parameter (*1)** | | | | |
| Brand | | CMV4000ES-3E5C1PP | CMV4000ES-3E5M1PP | CMV4000ES-3E12M1PP |
| Color filter | | RGB Bayer mosaic | None | None |
| Type | | Global shutter, overlap mode | | |
| Pixel Resolution (H × V) | [pixel] | 2048 × 2048 | | |
| Active area size (H × V) | [mm] | 11.27 × 11.27 | | |
| Sensor diagonal | [mm] | 15.9 | | |
| Optical format | [inch] | 1 | | |
| Pixel Size (H × V) | [µm] | 5.5 × 5.5 | | |
| ADC resolution | [bit] | 10, (12 TBD) | | |
| FWC | [ke-] | 13.5 | | |
| Dynamic range | [dB] | 60 | | |
| SNR Max | [dB] | 41 | | |
| Dark noise | [e-] | 13 (RMS) | | |
| Dark current | [e-/s] | 125 (25°C) | | |
| DSNU | [$LSB_{10}$/s] | 3 | | |
| Sensitivity | [V/(Lux s)] | 5.56 | | |
| **Camera parameters** | | | | |
| Digitization | [bit] | 10 | | |
| Supported bit resolutions | [bit/pixel] | 8, 10, (12) | | |
| Exposure time (EXP) | | 25.8µs to 1sec, in steps of 2.69µs (*1) | | |
| Variable Gain Range (VGA) | [dB] | 8.4 | | |
| Refresh rate (MRR) | [fps] | 90 | | |
| **Supported standard readout modes** | | Binning/skipping | pixels | fps | Bit/px |
| | 0 | 1x1 | 2048 × 2048 | 90 | 8 |
| | 1 | 1x1 | 2048 × 2048 | 45 | 10 |
| **Power consumption** | | | | |
| typical | [W] | 1.5 | | |
| Maximum | [W] | 1.75 | | |
| **Mechanical** | | | | |
| height | [mm] | 26.4 | | |
| width | [mm] | 26.4 | | |
| depth | [mm] | 30.25 (with C/CS Mount module B) 25.2 (without C/CS Mount module B) | | |
| weight | [g] | 32.1 (with C/CS Mount module B) 28.1 (without C/CS Mount module B) 8 (board level camera) | | |

*table 3-15, MQ042xG-CM, sensor and camera parameters*

Notes:

(*1)    defined for max. bandwidth and 8bit per pixel. Higher dynamic range (i.e. 10 or 12 bit/pixel) will reduce available frame rate. By decreasing bandwidth the minimal exposure time and exposure step will increase.
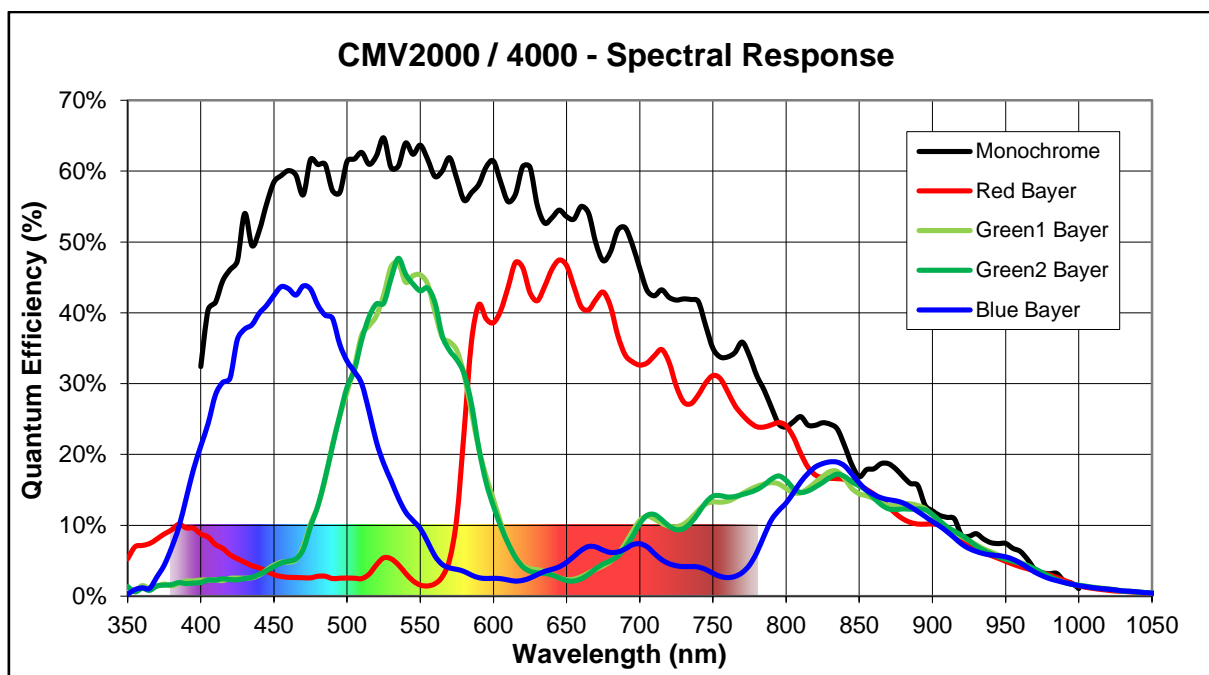
## 3.5.5.2. Quantum efficiency curves [%]
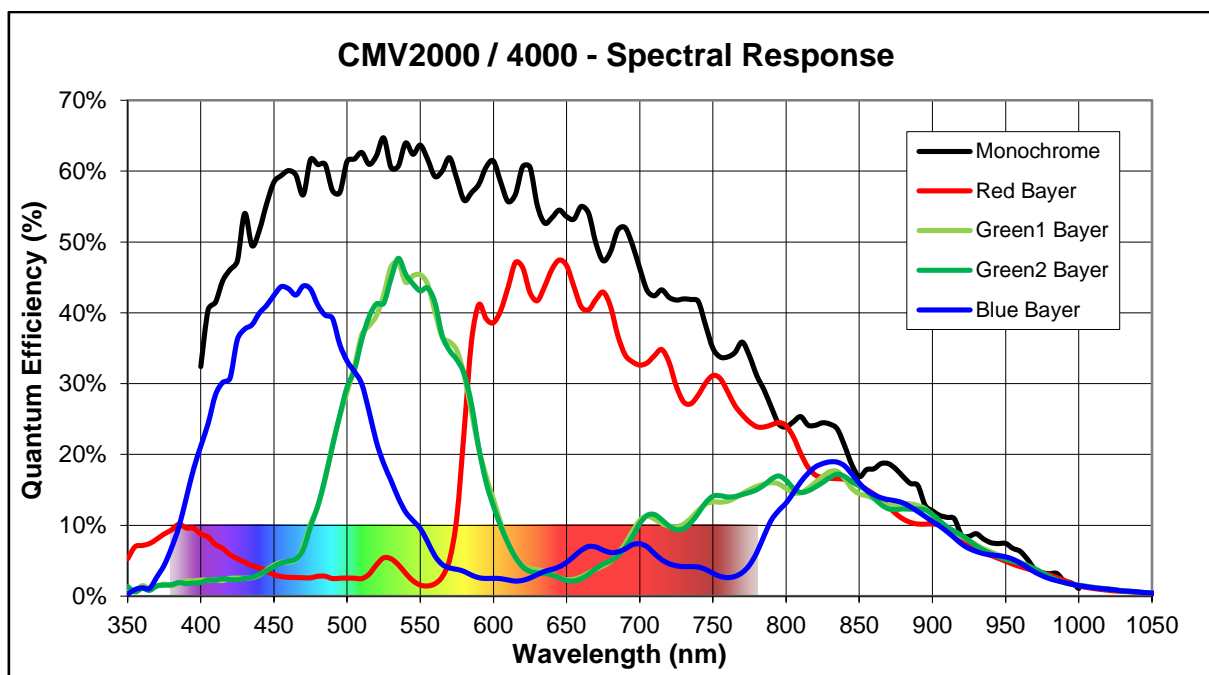


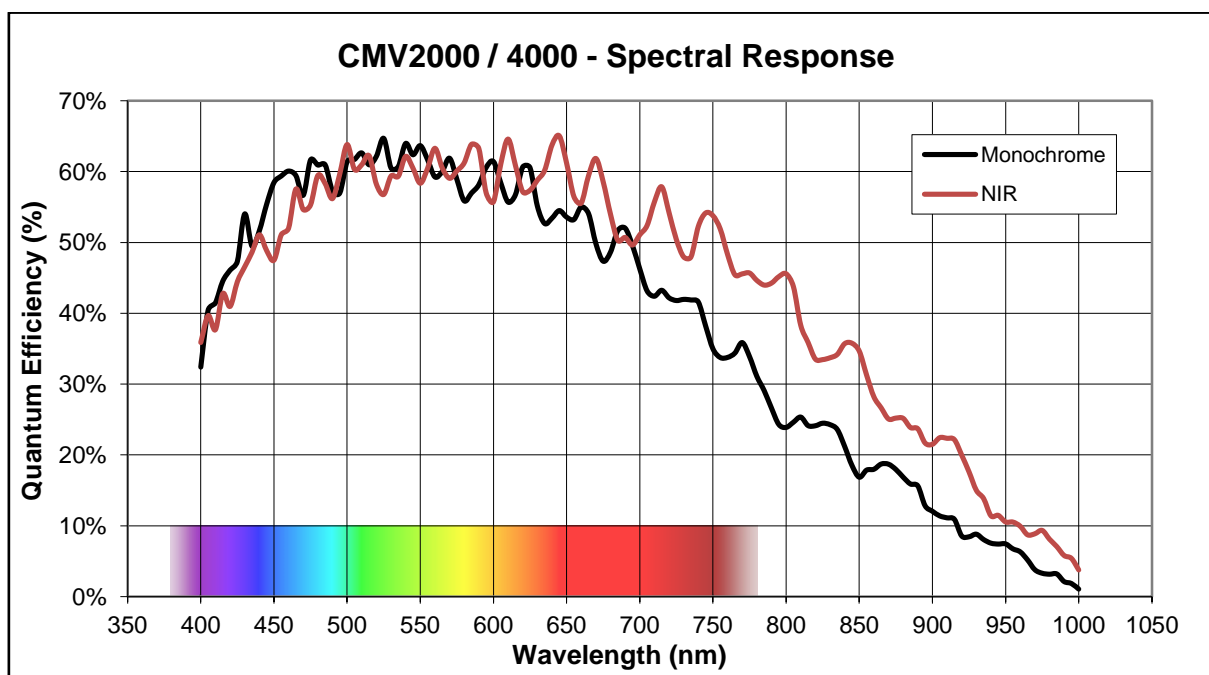*figure 3-20, CMV4000 mono and color, quantum efficiency curve, ©CMOSIS*
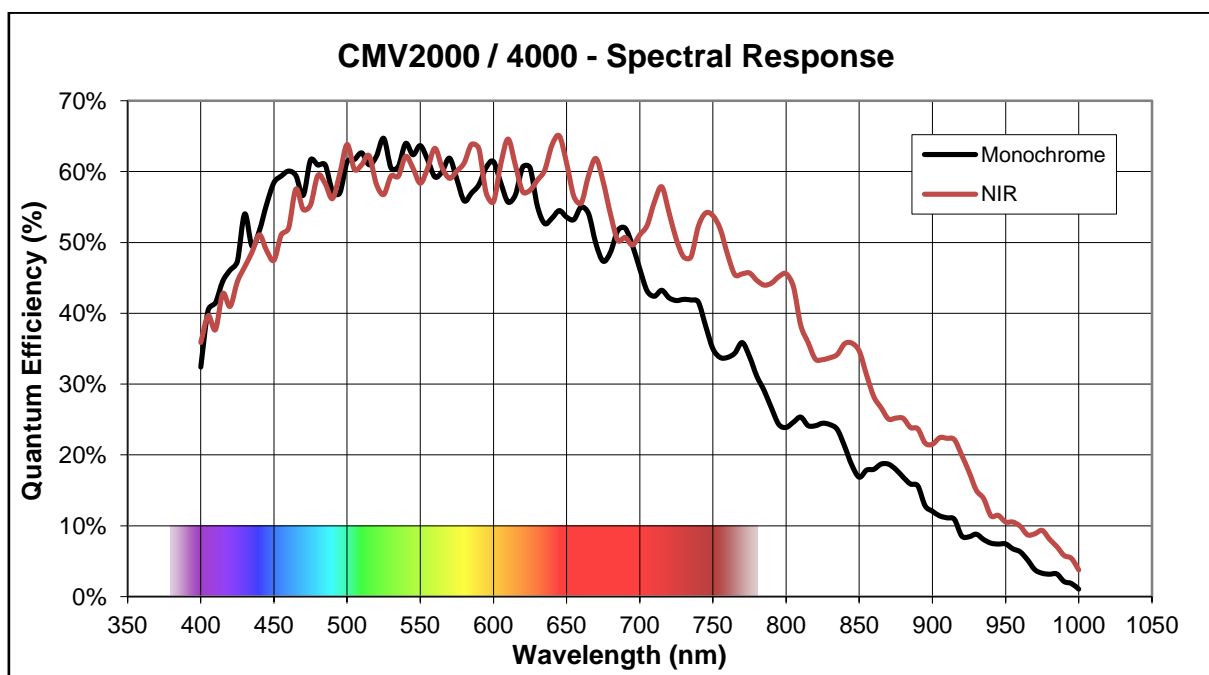


*figure 3-21, CMV4000-mono and NIR (E12), quantum efficiency curves, ©CMOSIS*

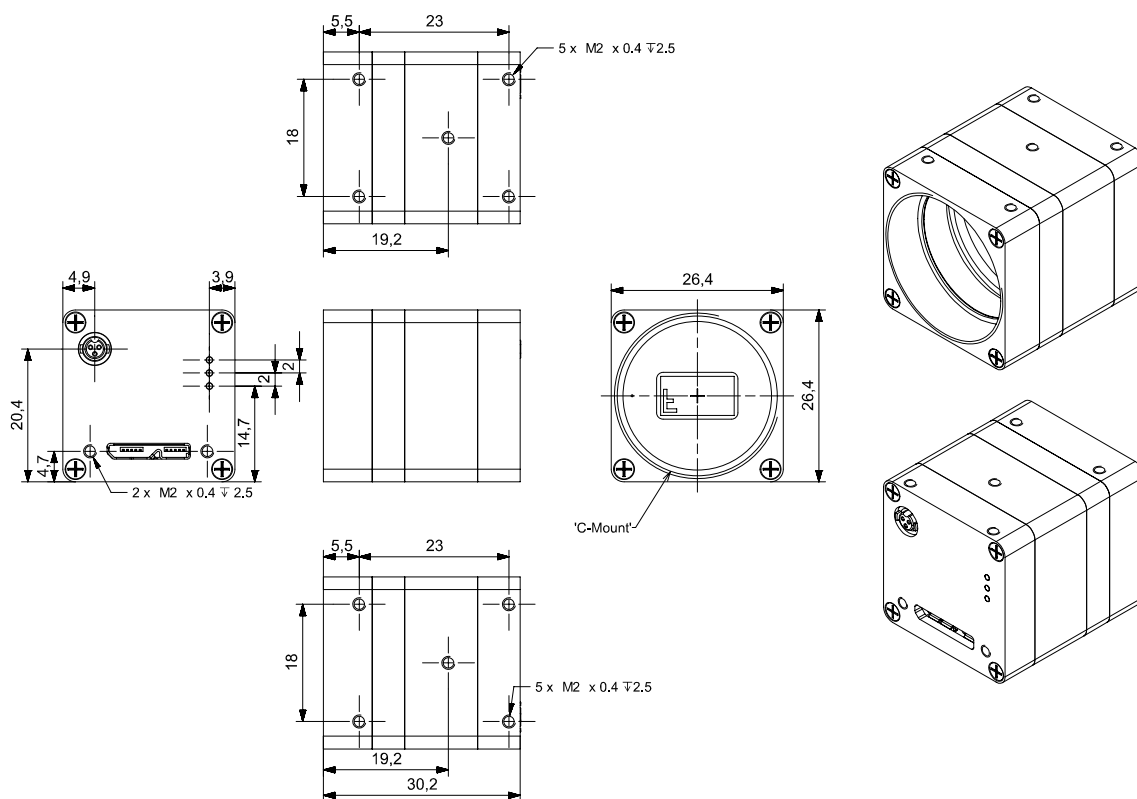### 3.5.5.3. Mechanical drawings (C-mount [with C/CS mount module B])



*figure 3-22, mechanical drawing MQ042xG-CM, C-Mount housing*

### 3.5.5.4. Mechanical drawings (CS-mount [without C/CS mount module B])



*figure 3-23, mechanical drawing MQ042xG-CM, CS-Mount housing*

### 3.5.5.5.  Referenced documents

CMOSIS Datasheet CMV4000-datasheet-v3.2 (30/07/12)

### 3.5.5.6.  Sensor features

| feature | Note |
|---|---|
| Binning | No |
| Skipping | Not supported, yet |
| ROI | Single window in y direction supported |
| HW Trigger | Trigger with overlap usable (see *4.3.2.4 Triggered mode with overlap*) |
| HDR | Knee point based HDR (beta stage), see *4.4.9 HDR* |

*table 3-16, sensor features available*

### 3.5.5.7.  Frame rate examples

Following table lists examples for the maximum frame rate - Frames Per Second (FPS) that can be achieved with active region of interest (ROI), free run mode (no trigger), RAW8 data format, exposure time 200µs.

Tested with: Intel i7-3770, 4GB DDR3, GA-Z77M-D3H, Windows 7 x64, API_INST_V3_19_06. Measured without further data processing.

| Camera model | USB3-Controller | FPS | ROI |
|---|---|---|---|
| MQ042MG-CM | Intel Z77 | 970 | 2048 x 180 |
| MQ042MG-CM | Fresco Logic FL1009 | 500 | 2048 x 300 |

*Table 3-17, MQ042MG-CM, frame rate examples with ROI*

## 3.6.    User interface – LEDs

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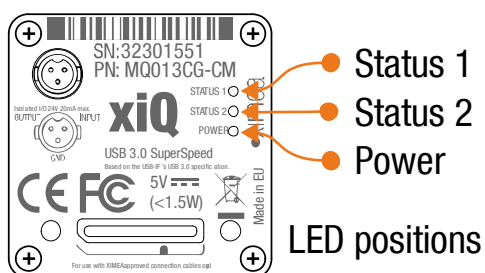


figure 3-24, position status LEDs

The LEDs Status1 and Status2 are programmable. Please note the following description:

| LED | Color | Description |
|---|---|---|
| Power | Orange | Power indication: LED is on if the power is on (USB 3.0 cable connected) |
| Status 2 | Green | USB 3.0 Enumeration<br>USB 2.0 Enumeration (default),<br><br>User configurable:<br>register (set value)<br>strobe<br>busy<br>streaming<br>trigger<br>　　　level<br>　　　edge<br>digital input<br>slow blink<br>fast blink |
| Status 1 | Red | Streaming (default),<br><br>User configurable:<br>register (set value)<br>strobe<br>busy<br>streaming<br>trigger<br>　　　level<br>　　　edge<br>digital output<br>slow blink<br>fast blink |

table 3-18, LED output description

## 3.7.    xiQ USB 3.0 Interface

| Connector | Signals | Mating Connectors |
|---|---|---|
| USB 3.0 | Standard USB 3.0 Micro-B Female Connector | Standard USB 3.0 Micro-B Connector with thumbscrews Screw thread M2, thread distance 18.0mm |

*table 3-19, USB 3.0 mating connector description*

The USB 3.0 Micro-B connector is used for data transmission, camera control and power.

### 3.7.1.  Location

The USB 3.0 connector is located on the back side of the camera:
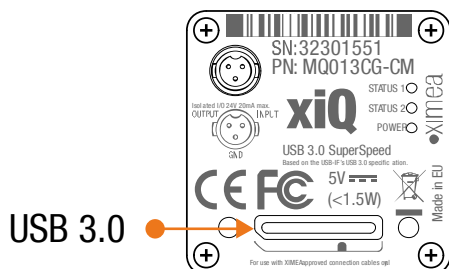


*figure 3-25, position USB 3.0 interface*

### 3.7.2.  Pinning
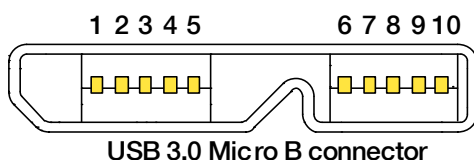


*figure 3-26, pinning USB 3.0 connector*

USB 3.0 Micro B connector (powered) Pin Assignment

| 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 3-20, USB 3.0 connector, pin assignment*

The USB 3.0 standard is backward compatible with the USB 2.0 interface.

## 3.8. xiQ Digital Input / Output (GPIO) Interface

| Connector | Signals | Mating Connectors |
|---|---|---|
| I/O & Sync | Opto-isolated trigger input and illuminator sync output | HIROSE SR38-4R-3S(71)) with optional locking nut |

*table 3-21, GPIO mating connector description*

### 3.8.1. Location

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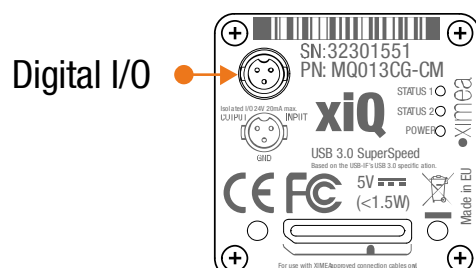


*figure 3-27, position GPIO connector*

### 3.8.2. IO Connector Pinning

Pinning of the IO connector (camera):
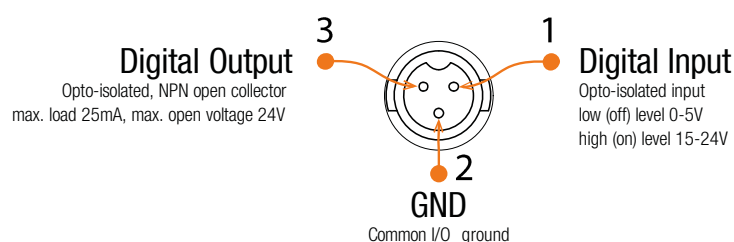


*figure 3-28, pinning GPIO connector*

I/O connector Pin Assignment:

| Pin | Signal | Technical description |
|---|---|---|
| 1 | Trigger/sync digital Input (VDI) | IEC 61131-2 specification |
| 2 | Common (IO Ground) | |
| 3 | Trigger/sync digital Output (VDO) | Open collector NPN |
| ( Shell ) | Common (IO Ground) | |

*table 3-22, I/O connector Pin Assignment*

### 3.8.3. Digital Input

#### 3.8.3.1. Digital Input - General info

| Item | Parameter / note |
|---|---|
| Indicator | Yes, must be configured by user to Status 2 LED |
| Effect of incorrect input terminal connection | Reverse voltage polarity protected |
| Effects when withdrawing/inserting input module under power | no damage, no lost data |
| Maximal recommended cable length | 10m |
| Input debounce filter | yes, (rising and/or falling), 10µs step, max time 81.92ms |

*table 3-23, digital input, general info*

### 3.8.3.2.    Digital Input – signal levels

Input levels according IEC 61131-2, Type 1

| V-in-min [V] | V-in-max [V] | State | I-max [mA] |
|---|---|---|---|
| -3 | 5 | Off (0) | 0.004 |
| 5 | 15 | Transient | 4 |
| 15 | 24 | On (1) | 12 |

*table 3-24, 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

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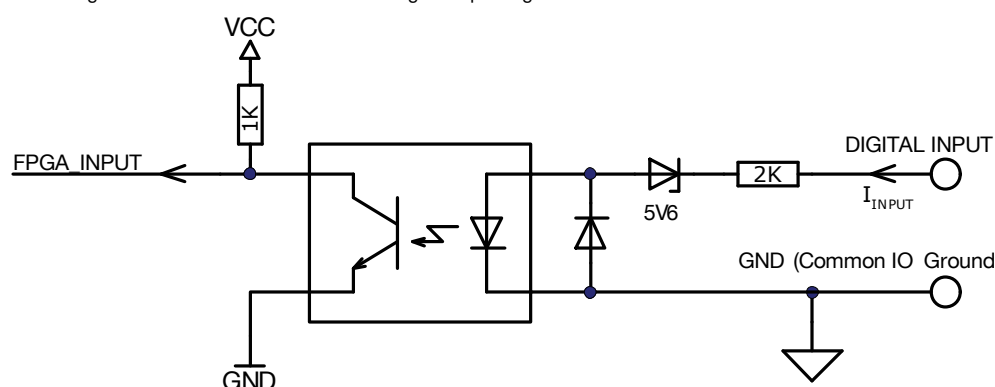


*figure 3-29, digital input, interface schematic*

### 3.8.3.4.    Digital Input – Wiring
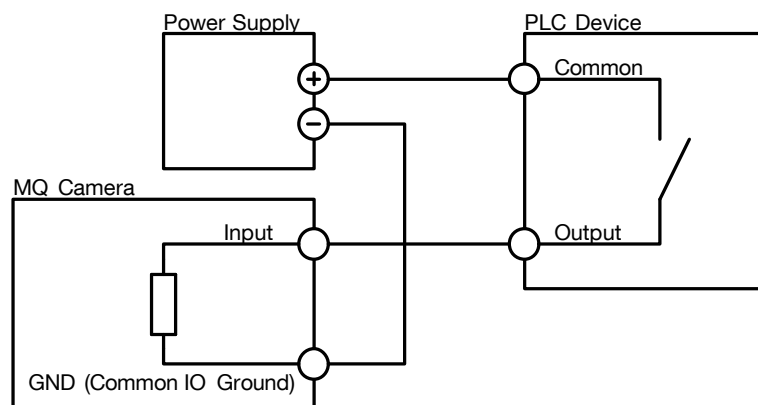


*figure 3-30, digital input, interface wiring*

### 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 | 15 | 1.4 |
| Rising | 20 | 0.6 |
| Falling | 15 | 5.3 |
| Falling | 20 | 7.8 |

*table 3-25, digital input, timing*

*Note:*

- Measured at: Ambient Temperature 25°C

## 3.8.4. Digital Output

### 3.8.4.1. Digital Output - General info

| Item | Parameter / note |
|---|---|
| Indicator | Yes, must be configured by user to Status 1 LED |
| Output port type | Open collector NPN |
| Protection | short-circuit / over-current / Reverse voltage |
| Protection circuit | PTC Resettable Fuse |
| Effect of incorrect output terminal connection | **Not protected against reverse voltage connection** |
| Inductive loads | no |
| Maximal output dropout | 1.8V, Sink current 25mA |

*table 3-26, digital output, general info*

### 3.8.4.2. Digital Output – signal levels

Output levels definition

| State | Open Collector Switch State | R [Ohm] | Conditions |
|---|---|---|---|
| On (1) | ON - Transistor is conducting | max. 160 | For output > 5mA |
| Off (0) | OFF - Transistor is not conducting | min 100 k | |

*table 3-27, digital output, signal levels*

Maximum sink current:  25 mA

Maximum open circuit voltage: 24V

### 3.8.4.3. Digital Output – Internal schematic

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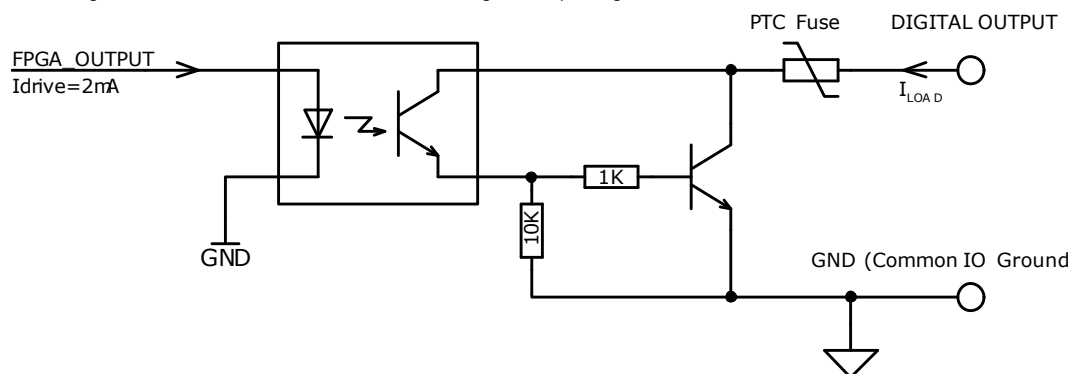


*figure 3-31, digital output, interface schematic*

Output Transfer Characteristic

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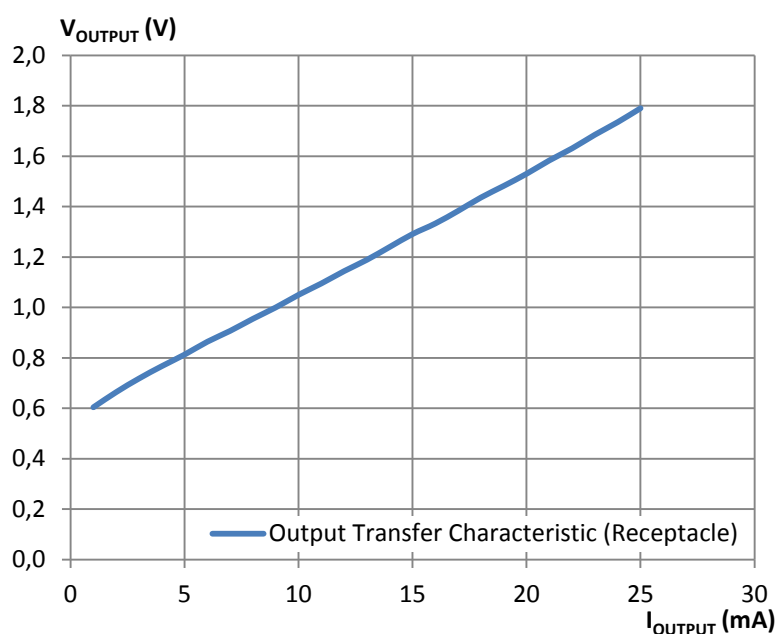


*figure 3-32, digital output transfer characteristics*

### 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 a NPN-compatible PLC device input (biased)

| Output state | Output switch state | Input state |
|---|---|---|
| ON | Sourcing current | Pull up (energized) |
| OFF | Relaxing | Not energized |
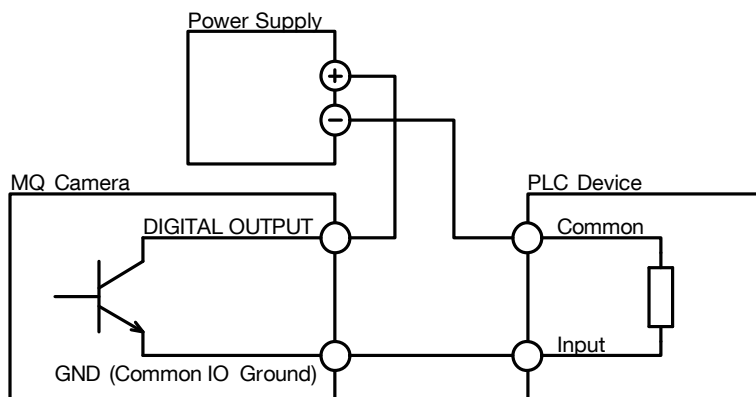
*figure 3-33, Connecting Digital OUTPUT to a NPN-compatible PLC device input (biased)*

**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 a 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 |
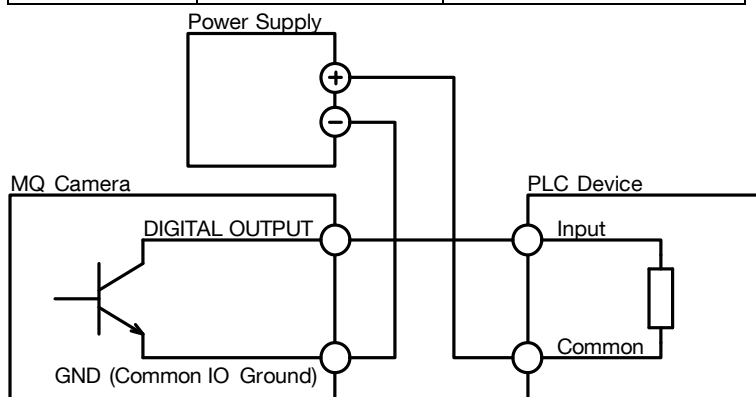


*figure 3-34, Connecting Digital OUTPUT to a NPN-compatible PLC device input - more bidirectional inputs used*

**Note:**

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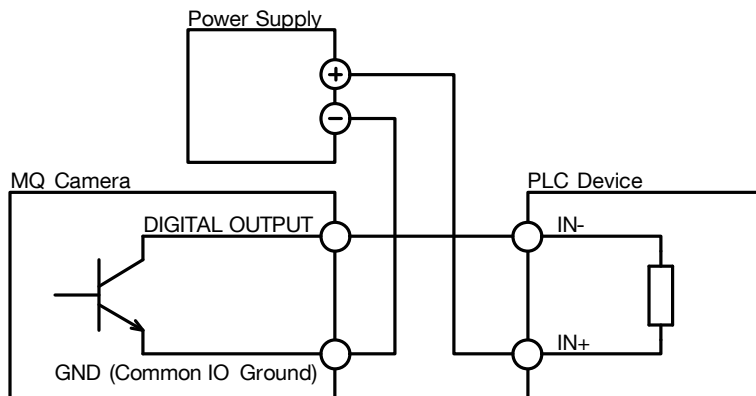


*figure 3-35, Connecting Digital OUTPUT to a NPN-compatible PLC device - single input*

### 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) |
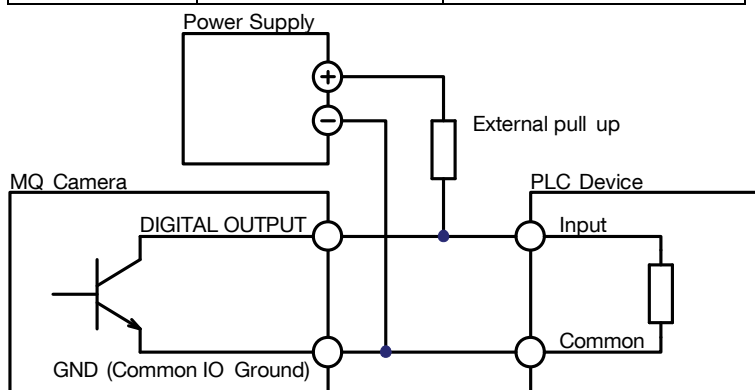


*figure 3-36, Connecting Digital OUTPUT to a PNP-compatible device*

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

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.
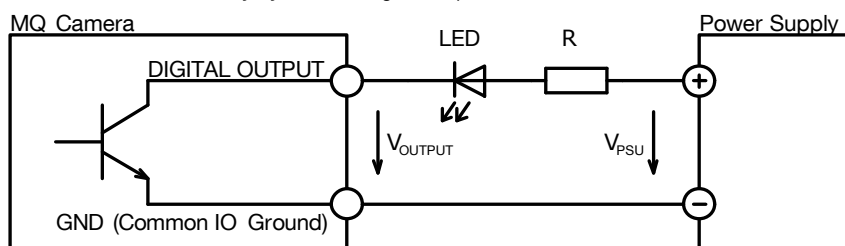


*figure 3-37, LED Driving*

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

Where:

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

$V_{output}$    voltage across digital output pins (see.*3.8.4.3 Digital Output – Internal schematic*)

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

$I_{led}$    LED current

**Note:**

- Remember to use the appropriate resistor power rating $P(RES) = I_{led} * I_{led} * R$

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 | |
| Emeralded Green | 2.1V | 2.7V | |
| Blue | 2.5V | 3.7V | |
| White | 2.8V | 3.8V | |
| Infra Red | 1.3V | 1.8V | Opto coupler |

*table 3-28, 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.
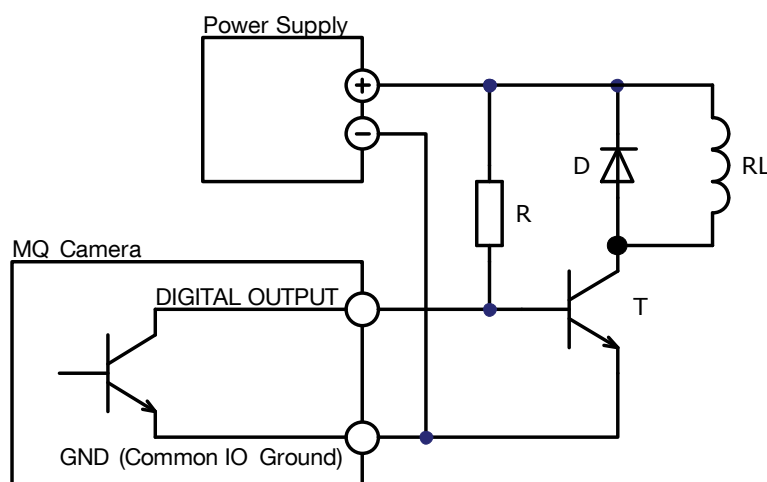


*figure 3-38, Inductive load (Relay) Driving (inverted logic)*

For positive logic you can use a second bipolar transistor.
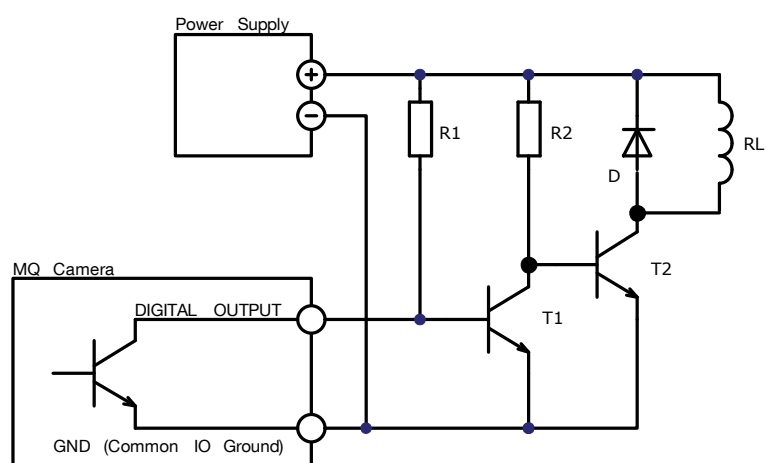


*figure 3-39, Inductive load (Relay) Driving (non-inverted logic)*

### 3.8.4.4.6. Output Wiring Example: Driving the trigger input of a strobe controller

The digital output can be used to drive a strobe controller according to the table below.

Driving the trigger input of a strobe controller

| Trigger polarity | Opto-isolated controller input | Output delay | Wiring | Description |
|---|---|---|---|---|
| Positive edge | Yes | 0.5µs | figure 3-33 | |
| Negative edge | Yes | 0.5µs | figure 3-35 | |
| Positive edge | No | 155µs | figure 3-36 | Not recommended in cases when short delay time is required. Output delay is much longer than in other wiring examples. Use external pull up in case that no pull up at controller input is used. |
| Negative edge | No | 0.5µs | figure 3-36 | Note that external pull up is not used in this case. Assume that internal pull up at the controller input is used. |

*table 3-29, digital output, wiring examples*

### 3.8.4.5. Digital Output – Timing

Typical input delay between FPGA_Output to Digital Output

| Edge Type | Typ. delay [µs] |
|---|---|
| Off -> On | 0.5 |
| On -> Off | 155 |

*table 3-30, digital output, typical timing*

Note: Measured at conditions: $V_{OUTPUT}$=18V, $T_{AMBIENT}$=27°C

Output delay depending on output current:

| Output current | OFF->ON | ON->OFF |
|---|---|---|
| 2mA | 0.55µs | 184µs |
| 5mA | 0.55µs | 182µs |
| 10mA | 0.55µs | 133µs |
| 25mA | 0.55µs | 113µs |

*table 3-31, digital output, current depending timing*

Note: Measured at conditions: $V_{OUTPUT}$=11V, $T_{AMBIENT}$=25°C

## 3.9. CBL-U3-3M0 / CBL-U3-5M0 / CBL-U3-8M0

3.0m / 5.0m / 8.0 USB 3.0 cables

### Cable drawing
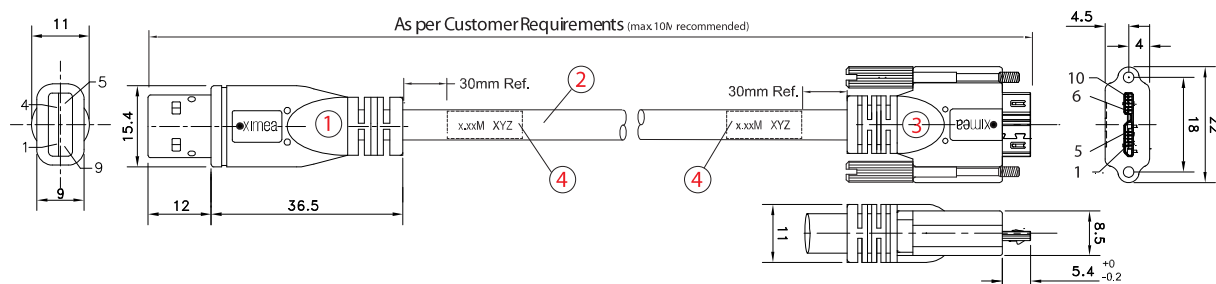


*figure 3-40, drawing USB3 cable*

### Cable components

| 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 3-32, USB3 cable, components*

### USB 3.0 cable wiring
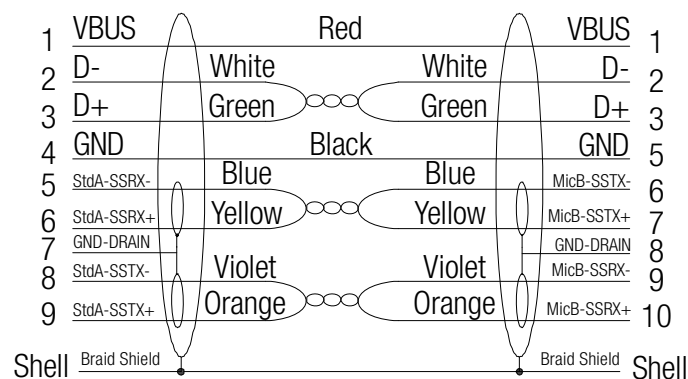


*figure 3-41, wiring USB3 cable*

### Pin Assignment micro USB3 connector:

| 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 3-33, USB3 connector, pin assignment*

**Cable label details**



xx.xM  X Y Z

Specified
Cable Length

Week
Year
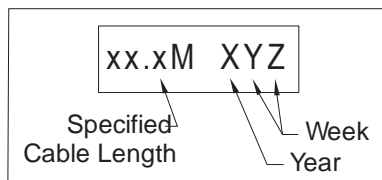
*figure 3-42, label details USB3 cable*

## 3.10. CBL-U3-3M0-ANG

3.0m USB 3.0 cable, angled micro USB3 connector

**Cable drawing**



As per Customer Requirements (max.3M recommended)
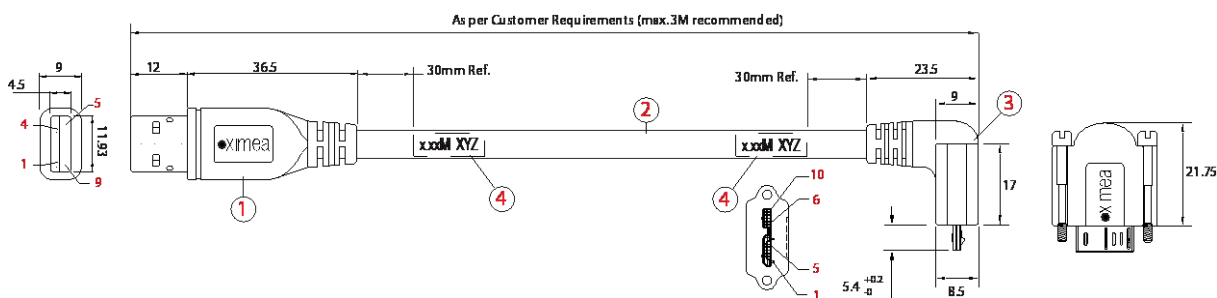
*figure 3-43, drawing USB3 cable angled*

**Cable components**

| Item | Description |
|------|-------------|
| 1 | USB A 3.0 9 pin Molded Plug <BLK> |
| 2 | A12-7143 [OD=5.9mm] <BLK><br>UL20726 2STP#30 + 1UTP#28 + 2C#26 |
| 3 | USB MicB 3.0 sl 90D A1(10 pin Molded Plug) <BLK> |
| 4 | Cable Label |

*table 3-34, USB3 cable angled, components*

**USB 3.0 cable wiring**



| | | | | | |
|--|--|--|--|--|--|
| 1 | VBUS | Red | VBUS | 1 | |
| 2 | D- | White | White | D- | 2 |
| 3 | D+ | Green | Green | D+ | 3 |
| 4 | GND | Black | GND | 5 | |
| 5 | StdA-SSRX- | Blue | Blue | MicB-SSTX- | 6 |
| 6 | StdA-SSRX+ | Yellow | Yellow | MicB-SSTX+ | 7 |
| 7 | GND-DRAIN | | GND-DRAIN | 8 | |
| 8 | StdA-SSTX- | Violet | Violet | MicB-SSRX- | 9 |
| 9 | StdA-SSTX+ | Orange | Orange | MicB-SSRX+ | 10 |
| Shell | Braid Shield | | Braid Shield | Shell | |
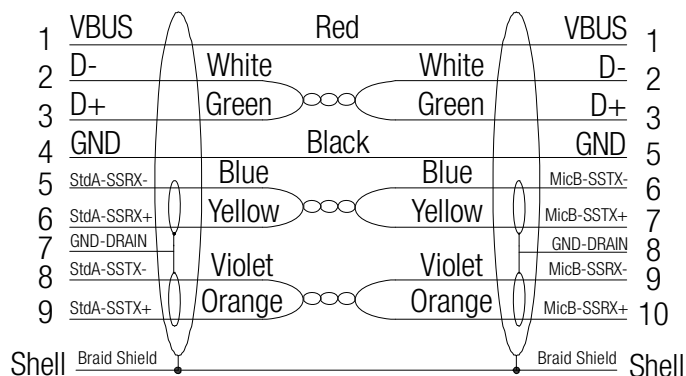
*figure 3-44, wiring USB3 cable angled*

Pin Assignment micro USB3 connector:

| 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 3-35, USB3 connector, pin assignment*

Cable label details
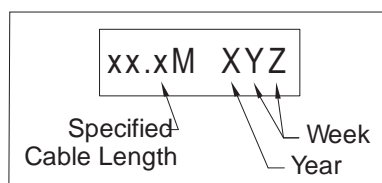


*figure 3-45, label details USB3 cable angled*

## 3.11. CBL-MQSYNC-3M0

3.0m xiQ series I/O sync cable, pig tail

### Cable drawing
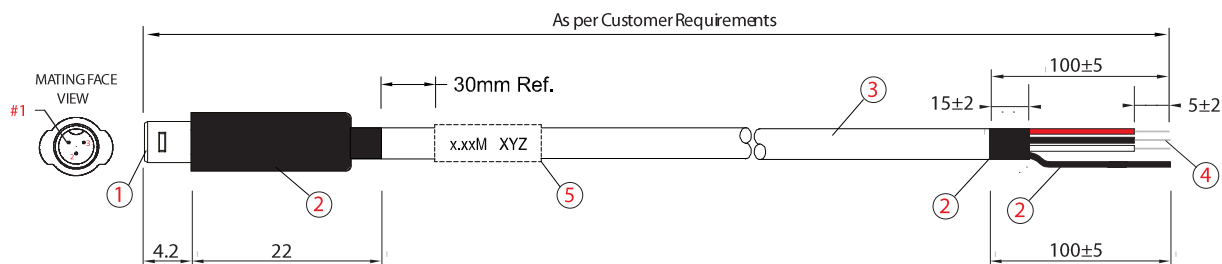


*figure 3-46, drawing sync cable*

### Cable components

| Item | Description |
|------|-------------|
| 1 | HRS SR38-4P-3P (71) <br> Hirose SR38 Series Male Connector |
| 2 | Heat Shrink Tube |
| 3 | A12-1709 [OD=3.30mm] <BLK> <br> (10/0.120x3C) + 32/0.120 27AWG 3Core Line Cord |
| 4 | Process end with wire end Striped and tin plated soldering |
| 5 | Cable Label |

*table 3-36, sync cable, components*

### Sync cable wiring
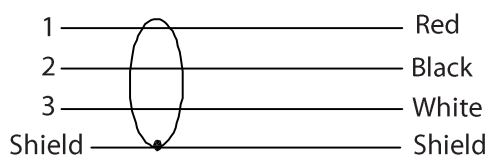


*figure 3-47, wiring sync cable*

### Pin Assignment:

| Pin | color | Signal |
|-----|-------|--------|
| 1 | Red | Trigger/sync digital Input (VDI) |
| 2 | Black | Common (IO Ground) |
| 3 | White | Trigger/sync digital Output (VDO) |

*table 3-37, sync cable, pin assignment*

### Cable label details
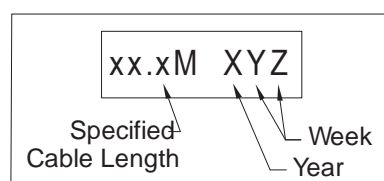


*figure 3-48, label details sync cable*

## 3.12. Tripod Adapter – MQ-BRACKET-T

xiQ series tripod mounting bracket
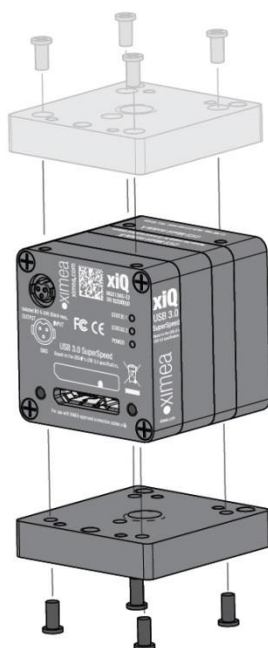


*figure 3-49, mounting tripod adapter*

xiQ series tripod mounting bracket with 1/4-20 thread.

Use 4x SROB-M2x4-CUST screws for mounting. Bracket can be mounted on the bottom or top side of the camera.

### 3.12.1. Mechanical drawings (Brackets for MQ013xG-yy and MQ042xG-CM)
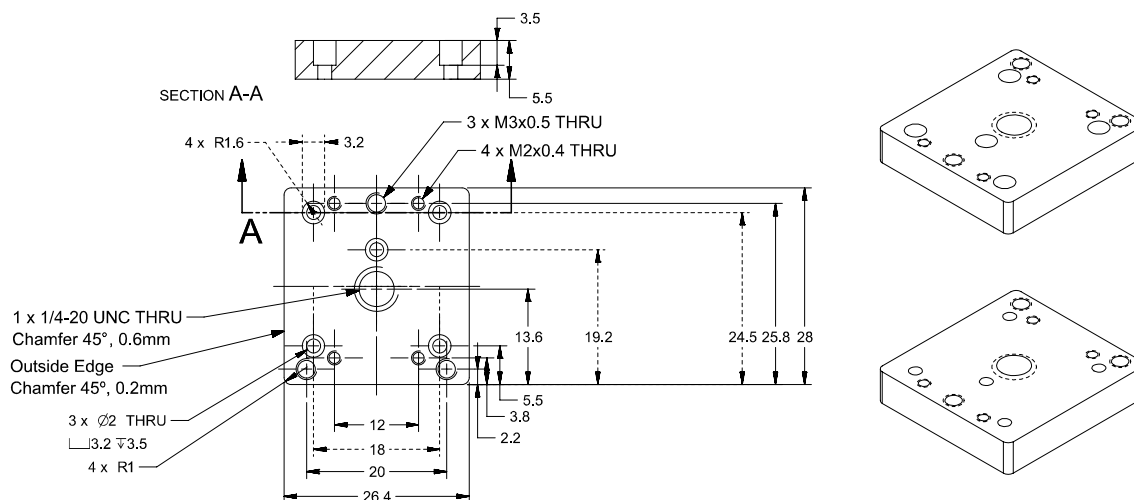


*figure 3-50, mechanical drawing tripod adapter (MQ013xG-yy and MQ042xG-CM)*

Weight without screws: 9.8 g.

## 3.12.2. Mechanical drawings (universal)
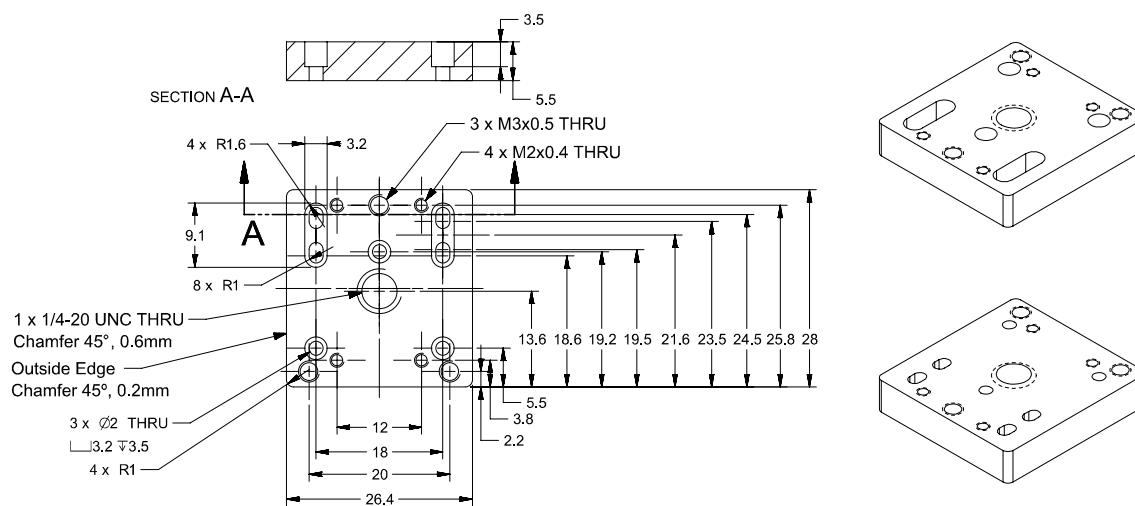


*figure 3-51, , mechanical drawing tripod adapter (universal)*

Weight without screws: 9.3 g.

## 3.13. U3PE-FL1009

2-port USB 3.0 to PCI Express x1 Gen2 Host Card



*figure 3-52, picture U3PE-FL1009*

Technical Specifications

| Controller | PCI Express to USB 3.0 Single Chip Host Controller Fresco FL1009 |
|---|---|
| PCIe Host Bus | Single (x1) PCI Express Lane<br>Supports PCI Express Specification Revision 2.1 at 5GT/s<br>Supports PCI Bus Power Management Interface Specification revision 1.2 |
| USB Features | Compliant with USB 3.0 Specification Revision 1.0<br>Compliant with Extensible Host Controller Interface (xHCI) Specification revision 1.0<br>2 downstream USB ports support SS/HS/FS/LS data rates (5Gbps/480Mbps/12Mbps/1.5Mbps) |
| Advanced Power Saving | Support all USB 3.0 Power States: U0, U1, U2 and U3<br>Support USB 2.0 Link Power management (LPM)<br>USB-IF LPM PDK Standard<br>PCIe Active State Power Management (ASPM) L0s and L1 |
| USB3 cable lock mechanism | Provides the threaded holes for the jack-screws of USB 3.0 A Plug w/Jackscrew lock Cable<br>Distance between the hole midpoints: 19mm, threads: M2 x 0.4 |

*table 3-38, technical specification, U3PE-FL1009*

Computer Platform

- Computer with PCI Express slot (x1, x4, x8, x16)
  Note:
    - U3PE-FL1009 needs PCI Express 25W slot (x1, x4, x8, x16)
    - For the best performance (5.0 Gbps), U3PE-FL1009 should be installed in a PCIe Gen 2 compliant slot in the host computer.  Most computers have PCIe Gen 2 (5.0 Gbps) throughput on x8 or x16 slots.
      A PCIe Gen 1 compliant slot reaches up to 2.5 Gbps throughput

Operating System Requirements

- Windows XP, Windows Vista, Windows 7, Windows 8
  USB 3.0 Host Drivers for x86 (32-bit) and x64 (64-bit) for Windows XP, Windows Vista, Windows 7

## 3.14. U3PE-D720202-X4

Quad Channel 4-port USB 3.0 to PCI Express x4 Gen 2 Host Card, 8-Lane, 8-Port PCI Express Switch



*figure 3-53, picture U3PE-D720202-X4*

**Technical Specifications**

| Controller | PCI Express to USB 3.0 Single Chip Host Controller Renesas uPD720202 |
|---|---|
| Primary PCI Express | Standards compliant<br>• PCI Express Base Specification r2.0 (Backwards compatible with PCIe r1.0a/1.1)<br>• PCI Power Management Spec r1.2<br>• Supports Access Control Services<br>• Dynamic Link-width control<br>• Dynamic SerDes speed control<br>High Performance<br>• Non-Blocking Internal architecture<br>• Full line rate on all Ports<br>• Cut-Thru latency: 130ns<br>• 2KB max payload size<br>PCI Express Power Management<br>• Link power management states: L0, L0s, L1, L2/L3 Ready, and L3<br>• Device states: D0 and D3hot<br>Quality of Service (QoS) support<br>• Two Virtual Channels (VC) per Port<br>• Eight Traffic Classes per Port<br>• Weighted Round-Robin Port & VC Arbitration |
| Secondary PCI Express | Four Single (x1) PCI Express Lane<br>Compliant with PCI Express Base Specification Revision 2.0<br>Supports PCI Express Card Electromechanical Specification Revision 2.0<br>Supports PCI Bus Power Management Interface Specification Revision 1.2 |
| USB Features | Compliant with USB 3.0 Specification Revision 1.0<br>Compliant with Extensible Host Controller Interface (xHCI) Specification revision 1.0<br>4 downstream USB ports support SS/HS/FS/LS data rates (5Gbps/480Mbps/12Mbps/1.5Mbps) |

*table 3-39, technical specification, U3PE-D720202-X4*

**Computer Platform**

- Computer with PCI Express slot (x4, x8, x16)
  **Note:**

    o For the best performance (5.0 Gbps), U3PE-D720202-X4 should be installed in a PCIe Gen 2 compliant slot in the host computer.  Most computers have PCIe Gen 2 (5.0 Gbps) throughput on x8 or x16 slots.
    A PCIe Gen 1 compliant slot reaches up to 2.5 Gbps throughput


**Operating System Requirements**

- Windows XP, Windows Vista, Windows 7, Windows 8

    o USB 3.0 Host Drivers
    x86 (32-bit) and x64 (64-bit) for Windows XP, Windows Vista, Windows 7

# 4. Operation

For a proper operation of your xiQ camera there are certain requirements that have to be met. You will read more about these requirements in the following chapters, as well as a description of how to use a xiQ camera.

## 4.1. System Requirements

### 4.1.1. Software Requirements

The xiQ cameras are compatible with the following operating systems:

- Windows 7 SP1
- Windows 8
- Linux Ubuntu
- MacOS 10.8
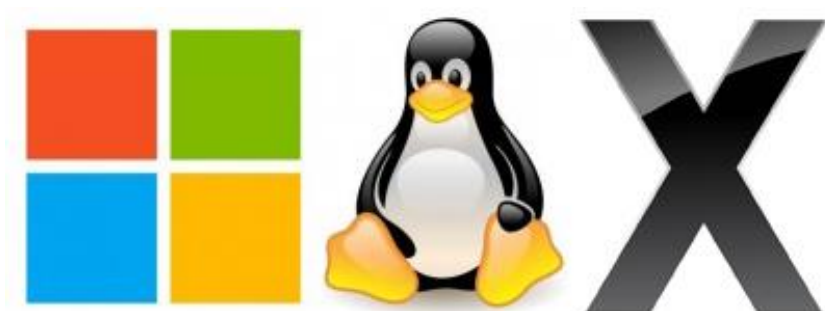


All XIMEA cameras are compatible with the most advanced Vision and Image Processing Libraries.

See chapter *5 Software* for more information about the options to access a xiQ cameras, as well as a list of currently supported libraries and frameworks supported in Windows.

### 4.1.2. Hardware Requirements

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

Please note details and the most recent info at:

Recommended hardware    http://www.ximea.com/support/wiki/usb3/Compatible_hardware

#### 4.1.2.1. System Configuration

**Minimum system configuration:**

For a basic operation of your xiQ 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 |
| Ports: | Motherboard with USB 2.0 or 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: | 2GB RAM or more |
| Disc Space: | 200 MB of free disc space |
| Video: | NVIDIA or Radeon graphics card 128MB |
| Ports: | Motherboard with a USB 3.0 port connected to a high performance chipset (e.g. Intel QM77 or Z77) and/or PCIe x1-16 Gen 2 slot for compatible USB 3.0 host adapter (see next chapter for more details) |

## 4.1.2.2. USB 3.0 Host Adapter

For a stable operation of your xiQ camera and achieving the maximum possible system performance with the highest frame rate it is important to choose an appropriate USB 3.0 host adapter chipset.

Please have a look at the following link to our webpage: http://www.ximea.com/support/wiki/usb3/Compatible_hardware

XIMEA maintains a regularly updated overview of compatible USB 3.0 host adapter chipsets together with the available bandwidth (e.g. see *3.13 U3PE-FL1009* and *3.14 U3PE-D720202-X4*).

The maximum data transfer rate depends on different conditions (motherboard, chipset, driver version, operating system, ..). The Following table lists the maximum data transfer speed achieved using the selected controller on Windows 7 x64 with CPU Intel i7-3770.

| USB3-Controller | Driver version | Data [MB/s] |
|---|---|---|
| Fresco Logic FL1009 | 3.5.24.0 | 395 |
| Fresco Logic FL1100 | 3.5.24.0 | 400 |
| Intel QM77 | 1.0.4.220 | 450 |
| Intel Z77 | 1.0.4.220 | 450 |
| Renesas D720202 | 3.0.12.0 | 365 |

*Table 4-1, USB3 maximum data transfer rates*

**PCI Express (PCIe) bus speed requirement**: To achieve maximum performance of USB3 cameras - USB 3.0 host adapter must be connected to the PCIe slot/port/hub supporting Gen 2 (or higher) and running at 5Gb/s.

## 4.1.2.3. Cables

The USB 3.0 cable that you use with the xiQ camera is responsible for the power supply and the data transfer to the PC. It is required to use an industrial USB 3.0 cable with a proper wiring and shielding. We recommend using XIMEA industrial USB 3.0 cables in order to achieve the maximum possible performance of the camera.

XIMEA offers several passive USB 3.0 cables and a sync cables, please see *3.9 CBL-U3-3M0 / CBL-U3-5M0 / CBL-U3-8M0*, *3.10 CBL-U3-3M0-ANG* and *3.11 CBL-MQSYNC-3M0*.

## 4.2. Video Formats

## 4.2.1. Full Resolution

By default, each camera outputs a full resolution image based on its sensor specification.

However, on some sensors, the actual output resolution can deviate from the specification if a color mode is used (see. *4.2.4 Color and Mono Modes*).

## 4.2.2. ROIs – Region Of Interest

ROI, also called area-of-interest (AOI) or windowing, allows the user to specify a sub-area of the original sensor size for read-out.

Depending on the sensor xiQ cameras support the definition of one single ROI by specifying the size (width and height) as well as the position (based on upper left corner) of the of the sub-area. Since the utilized CMOS sensors rely on the output of full lines, only the decrease of lines, i.e. the vertical resolution, results in an increase of frame rate.

Please note *3.5 Model Specific Characteristics.*

## 4.2.3. Downsampling Modes

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

### 4.2.3.1. Binning

When binning is applied, the image is divided into cluster of k*k pixels, where all pixels in each cluster are interpolated and result in the value of one output pixel. For example, a 2*2 binning produces 2*2 pixel clusters and results in images with ¼ of the original resolution.

### 4.2.3.2. Skipping

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.

## 4.2.4. Color and Mono Modes

All modes are provided by the xiAPI or standard interfaces using the xiAPI (please note *5.1 Accessing the Camera*).

Each xiQ cameras supports several mono (black-and-white) output modes.

| Mode | Description |
|------|-------------|
| RAW8 | Raw sensor data, 8 Bit per pixel, single channel |
| RAW16 | Raw sensor data, 16 Bit per pixel, single channel<br>10 or 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 |

*table 4-2, image formats, mono*

Color camera models (MQxxxCG-xx) also support additional color modes.

| Mode | Description |
|------|-------------|
| RGB24 | RGB filtered output, 24 Bit per pixel, 3 channels<br>Sequence: [Blue][Green][Red] |
| RGB32 | RGBA filtered output, 32 Bit per pixel, 4 channels, Alpha channel<br>equals 0. Sequence: [Blue][Green][Red][0] |
| RGB_PLANAR | RGB filtered output with planar-oriented channels.<br>Format: [R][R]...[G][G]...[B][B]... |

*table 4-3, image formats, color*

Note1: For color modes **RGB32** and **RGB24** the image from sensor needs to be pre-processed (de-bayering). CPU load is higher in these modes. Setting this parameter will reset current region of interest. **RGB24** is being processed from the **RGB32** by removing the unused Alpha channel creating a slightly higher CPU load then the **RGB32** format.

Note2: The color filtering (de-bayering) relies on the interpolation of adjacent pixels in order to create pixel in the target image. Pixels on the edges of the image are missing adjacent pixels and therefore cannot be used for the interpolation process. The result is a target image that is smaller than the source image (4 pixels on all sides).

## 4.3. Acquisition modes

### 4.3.1. 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 exposition is 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).
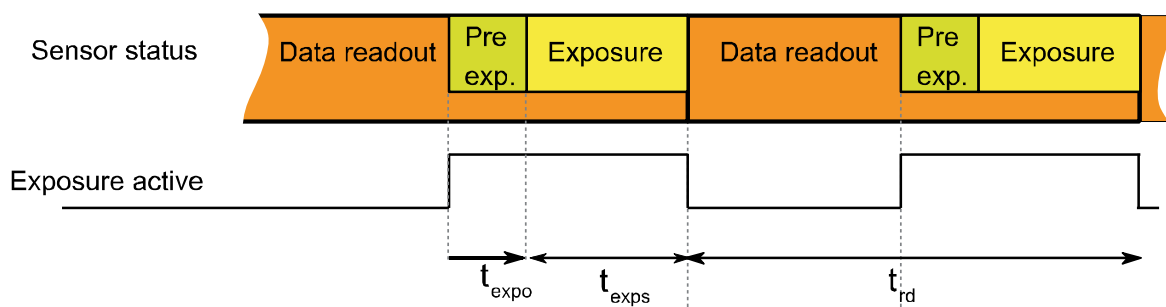


*figure 4-1, acquisition mode - free run*

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

### 4.3.2. Triggered Acquisition

Unlike in the free-run, each image exposition 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 is started, which is followed by the data readout.

#### 4.3.2.1. Software Trigger

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

#### 4.3.2.2. Hardware Trigger

A hardware trigger can be send to the sensor using the digital input described in *3.8.3 Digital Input*. Triggering by hardware is usually used to reduce latencies as well as jitter in applications that require the most accurate timing.

## 4.3.2.3.    Triggered mode without overlap

This mode gives lower FPS compared to *Free-Run* mode and lower FPS than *Exposure Overlapped with Data Readout* mode.

**Sensor timing in Exposure Overlapped with Data Readout Mode**
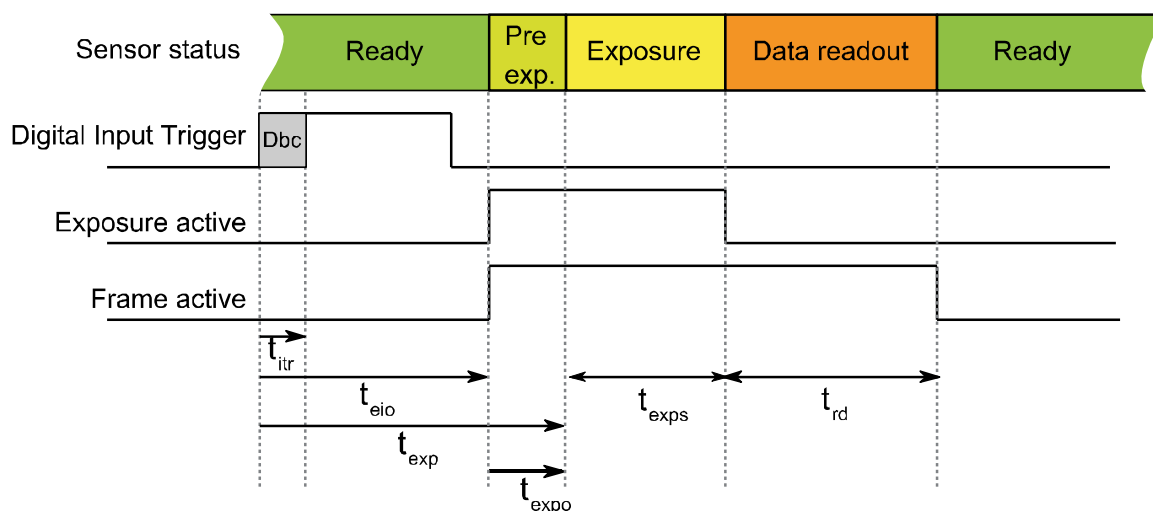


*figure 4-2, acquisition mode – triggered without overlap*

In this mode the timing depends on sum of:

- Input transition time ($t_{itr}$), depends on:

  o   Digital Input Delay - time for changing internal circuit to active state. It is constant for each camera model.

  o   Input Debouncing Time - time for stabilizing uneven input signals (e.g. from mechanical switches). This time can be can be set using xiAPI with parameters XI_PRM_DEBOUNCE_EN and XI_PRM_DEBOUNCE_T0 on some cameras. Default 0.

- Exposure time (see ET above).

- Data Readout time (see $t_{rd}$ above)

**Typical times for selected camera models**

| Camera Model | DownS | $t_{itr}$ [µs] | $t_{exp}$ [µs] | $t_{eio}$ [µs] | $t_{expo}$ [µs] | $t_{rd}$ [µs] | Notes |
|---|---|---|---|---|---|---|---|
| MQ013xG-E2 | any | 1.4 | 29 | 19/238 | -10 | 400+16.6*BWF*LC | N1, N2 |

*table 4-4, trigger mode w/o overlap, timing*

Notes:

- N1: V(Input)=15V

- N2:**x** in model name means all available models (M, C, R)


Description:

DownS  = Current camera DownSampling (XI_PRM_DOWNSAMPLING)

$t_{eio}$     = Trigger (Digital Input) to Strobe (Digital Output) (on some models is listed: Off->On change / On->Off change)

$t_{exp}$     = Strobe (Sensor) to Digital Output (on some models is listed: Off->On change / On->Off change)

$t_{expo}$    = Start of exposition to Exposure Active Digital Output

LC       = Current Line Count (XI_PRM_ HEIGHT)

BW       = Bandwidth Factor for maximum bandwidth this is 1 when the bandwidth will be lower BWF will rise (TBD)

$t_{exps}$    = Current Exposure Time set (XI_PRM_EXPOSURE)

Conditions: XI_PRM_DEBOUNCE_EN=0 (off).


**Minimum trigger period ($T_{trig\_min}$)**

Minimum trigger period can be calculated using the following formula:

$$t_{trig\_min} = t_{exp} + t_{exps} + t_{rd}$$

Example for MQ013MG-E2, Exposure time = 500µs, image = 500 pixels width x 200 pixels height:

$$t_{trig\_min} = 29µs + 500µs + 400µs + 16.6µs * 200lines = 4.249µs$$

## 4.3.2.4.   Triggered mode with overlap

Several sensors are capable to trigger exposure in overlap mode, so it is capable to reach the same frame rate as in free run mode.

When the trigger period is longer than the exposure and readout time, the signal wave form will look similar to *Triggered mode without overlap*. However when the trigger period is decreased, the sensor will expose the images in overlap mode. In this case, the frame active signal will be constantly active.

### Sensor timing in Exposure Overlapped with Data Readout Mode
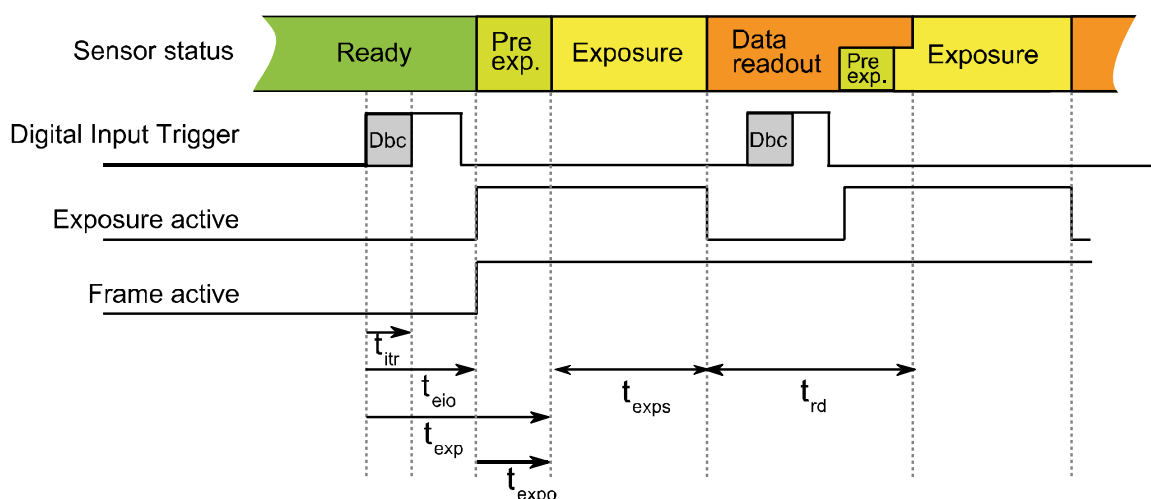


*figure 4-3, acquisition mode – triggered with overlap*

For timing description please see previous paragraph

### Typical times for selected camera models

| Camera Model | DownS | $t_{itr}$ [µS] | $t_{exp}$ [µS] | $t_{eio}$ [µS] | $t_{expo}$ [µS] | $t_{rd}$ [µS] | Notes |
|---|---|---|---|---|---|---|---|
| MQ042xG-CM | any | 1.4 | 10 | 11/224 | 0 | (64.5+5.375*LC)*BWF | N1,N2 |
| MQ022xG-CM | any | 1.4 | 10 | 11/224 | 0 | (37.625+5.375*LC)*BWF | N1,N2 |
| MQ003xG-CM | any | 1.4 | 10 | 11/224 | 0 | (40.625+6.771*LC)*BWF | N1,N2,N3 |

*table 4-5, trigger mode with overlap, timing*

Notes:

- N1: V(Input)=15V
- N2: 8bit per pixel maximum bandwidth (TBD)
- N3: $t_{exps} > t_{rd}$ for $t_{exps} < t_{rd}$ , $t_{eio}$ and $t_{exp}$ will plus ($t_{rd}$ - $t_{exp}$)

**Description:**

DownS = Current camera DownSampling (XI_PRM_DOWNSAMPLING)

$t_{eio}$ = Trigger (Digital Input) to Strobe (Digital Output) (on some models is listed: Off->On change / On->Off change)

$t_{exp}$ = Strobe (Sensor) to Digital Output (on some models is listed: Off->On change / On->Off change)

$t_{expo}$ = Start of exposition to Exposure Active Digital Output

LC = Current Line Count (XI_PRM_ HEIGHT)

BWF = Bandwidth Factor see table below

$t_{exps}$ = Current Exposure Time set (XI_PRM_EXPOSURE)

Conditions: XI_PRM_DEBOUNCE_EN=0 (off).

## Bandwidth factor

Bandwidth factor is a number reflecting the ratio between the maximum sensor frequency and the current sensor frequency, calculated from the Bandwidth Limit.

$BWF = F_{max} / F_{limit}$

Where $F_{max}$ is maximum possible clock for used sensor in MHz and $F_{limit}$ is used clock depending on Bandwidth Limit parameter set in API (XI_PRM_LIMIT_BANDWIDTH). $F_{limit}$ is set in 1MHz steps and cannot go lower than $F_{min}$.

MQ003xG-CM

$F_{max}$ = 24MHz

$F_{min}$ = 10MHz

$$F_{limit} = \frac{325 * BWL}{10368 * BPP} * \frac{6 + LC}{LC} [MHz]$$

$t_{fot}$ = 40.625*BWF [µs]

BPP    number of bytes per pixel

BWL    bandwith limit in Mbit/s

MQ042xG-CM and MQ022xG-CM

$F_{max}$ = 48MHz

$F_{min}$ = 5Mhz

$$F_{limit} = \frac{129 * BW}{8192 * BPP} * \frac{12 + LC}{LC} [MHz]$$

$t_{fot}$ = 64.5 * BWF [µs]

BPP    number of bytes per pixel

BW    bandwidth in Mbit/s

## Minimum trigger period ($t_{trig\_min}$)

Minimum trigger period can be calculated using the following formula:

$t_{trig\_min} = t_{exp} + t_{exps}$ (When exposure time is longer than readout time)

$t_{trig\_min} = t_{rd}$ (When exposure time is significantly shorter then readout time)

$t_{trig\_min} = t_{exps} + t_{fot}$ (When exposure is smaller than readout time but the difference is less than $t_{fot}$)

Example for MQ022MG-CM, Exposure time = 500µs, image = 2048 pixels width x 1088 pixels height with maximum bandwidth and 1 byte per pixel:

$t_{trig\_min}$ = 10µs + (37.625 + 5.375 * 1088 lines) * 1 = 5895µs

## 4.4. Camera Parameters and Features

### 4.4.1. Exposure

Also known as shutter speed. This parameter defines the length of the integration period for each frame.

Most of 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 are using dividers to generate slower clocks for internal usage.

The exposure time is mostly defined by number row times, where the row time is dependent on various internal settings. Very few sensors support exposure times equal to zero. There is defined minimal exposure time as well as steps between possible exposure times.

### 4.4.2. 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.

### 4.4.3. 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).

### 4.4.4. White Balance

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

#### 4.4.4.1. Assisted Manual White Balance

This feature measures the white balance a single time and sets the white balance coefficient to achieve a mean grey (neutral) tint.

The measurement is performed on the central rectangle of the image, with $1/8^{th}$ of its width and height. The function expects a white sheet of paper exposed to 50% of the intensity values (8 Bit RGB values should be around 128) to be visible.

#### 4.4.4.2. Auto White Balance

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

### 4.4.5. Gamma

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

### 4.4.6. Sharpness

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

### 4.4.7. Color Correction Matrix

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

### 4.4.8. Bad pixel Correction

During manufacturing, every camera is going through a testing procedure where hot pixels are measured based on dark field images. The measured hot pixels are stored inside the camera and are used for the correction of the acquired images during operation. The correction is active by default, but can be turned off by the user if a non-processed output is required.

## 4.4.9. HDR

Some sensors offer the ability to acquire images with a higher dynamic range than the value presented in the specification.

The high dynamic range can be achieved by several means as part of the sensor output. The feature that is used on xiQ cameras is a piecewise linear response, a so-called multiple slope integration.

The dynamic range of a linear image sensor is limited by the saturation of the pixel. Different light intensities are shown in the figure below. All blue marked light intensities cause different signal levels and can be separated without saturation. All red marked intensities cause an overexposure and the info about the different light intensity above 100% is lost.
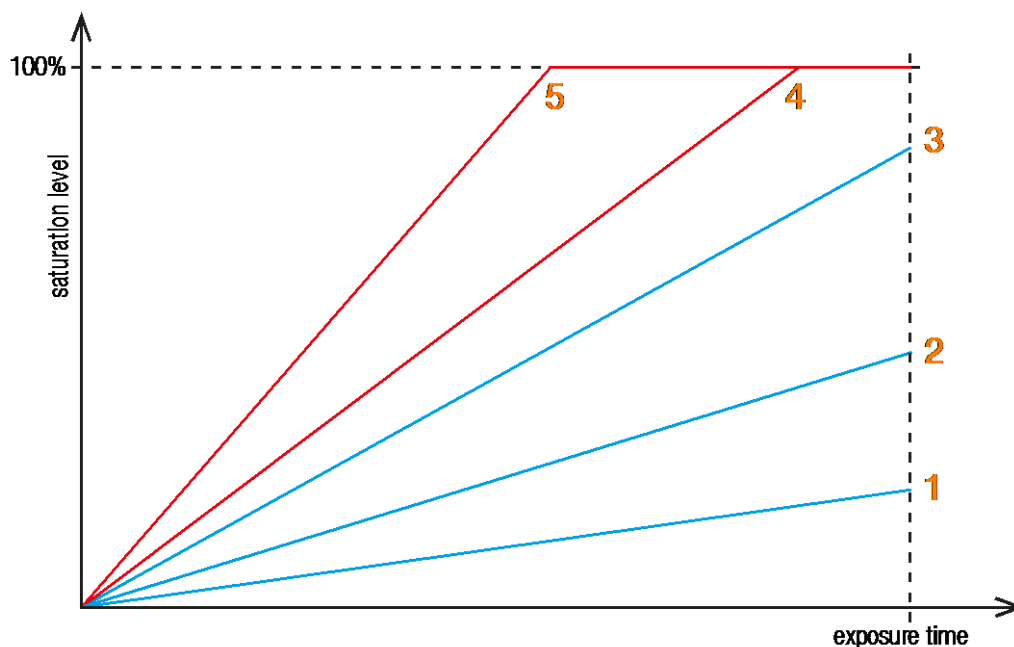


*figure 4-4, image saturation example without HDR*

Please note the exemplary corresponding positions 1 – 5 in the image with standard dynamic range:



*figure 4-5, image example without HDR*

The dynamic range can be increased by dividing the integration (exposure time) in two or three phases (slopes), with different maximum saturation levels. The xiQ cameras support the dividing in three slopes.

To use this kind of HDR method the user has to define two pairs of parameters: (T1, SL1) and (T2, SL2).

- T1 and T2 define portions of the total exposure time and the length of the three timing phases.
- SL1 and SL2 define portions of the sensor saturation, so called kneepoint1 and kneepoint2.
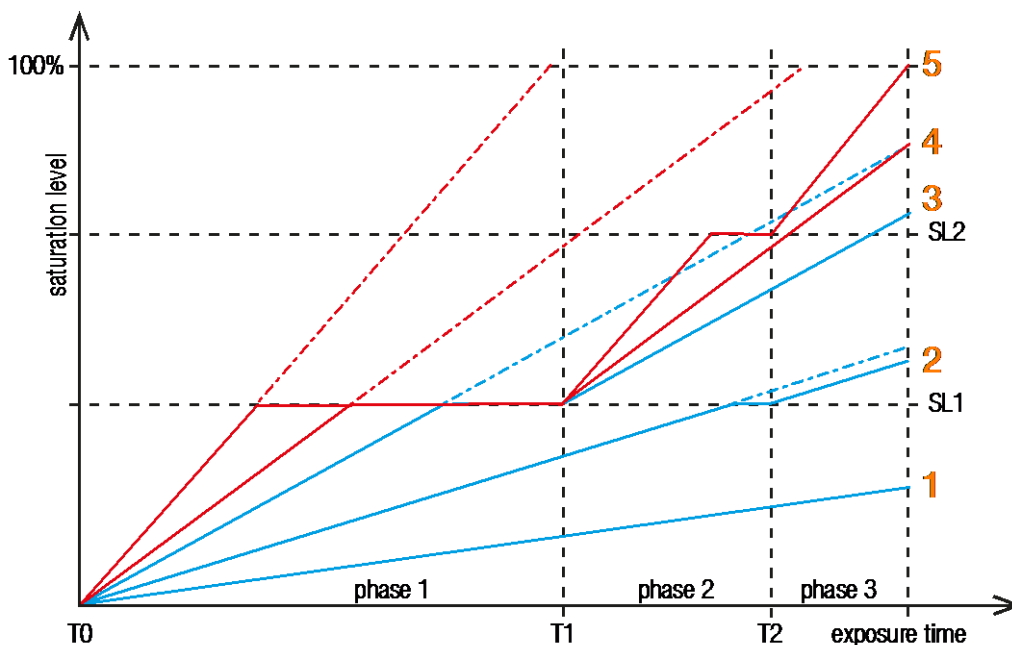
Please note the figure below:



figure 4-6, image saturation example with HDR

Please note the exemplary corresponding positions 1 – 5 in the image with high dynamic range:



figure 4-7, image example with HDR

Description of the multiple slope integration:

Phase 1

- All pixels are integrated until they reach the defined saturation level of kneepoint1 (SL1).
- If the saturation level of kneepoint1 is reached, the integration stops. SL1 is the maximum saturation level for all pixels in this phase.

Phase 2

- All pixels are integrated until they reach the defined saturation level of kneepoint2 (SL2).
- If the saturation level of kneepoint2 is reached, the integration stops. SL2 is the maximum saturation level for all pixels in this phase.

Phase 3

- All pixels are integrated until the exposure time is reached. The pixel saturation may reach the maximum saturation level.

The main idea of this method is to reach an approx. logarithmic saturation curve. In order to achieve this goal phase2 always has a smaller slope than phase1 and phase3 smaller than phase 2. Thus, the signal response during phase1 is higher as during phase2. And the signal increase during phase2 is higher than during phase3.

As a result, darker pixels can be integrated during the complete integration time and the full sensor sensitivity can be exploited. Brighter pixels are limited at the knee points and lose a part of their integration time.
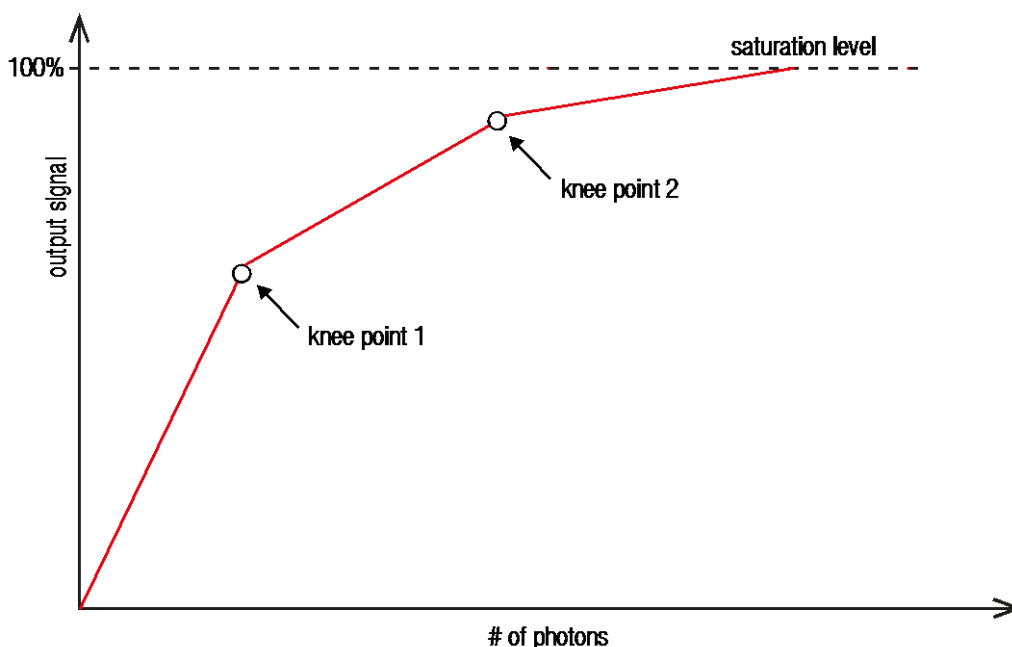


*figure 4-8, HDR - approx. logarithmic saturation curve*

# 5. Software

## 5.1. Accessing the Camera

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.

### 5.1.1. Proprietary API

All XIMEA cameras are supported by the same unified APIs (application programming interface). The API is a software interface between the camera system driver and the application. Different APIs are available for different programming environments, e.g. *xiAPI* (see *5.6.1  XIMEA APIs*) for C/C++ developments and *xiAPI.Net* for C#/.Net based developments

### 5.1.2. 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.

#### 5.1.2.1.    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.

#### 5.1.2.2.    USB3 Vision

The USB3 Vision standard not only defines hardware specifications and communication protocols, but also enables a library vendor or application developer to set up a software stack including their own drivers and the GenICam programming interface. This allows the usage of any USB3 Vision compliant device while relying on mechanisms for device discovery and identification, control, and image streaming which are defined by the standard.

#### 5.1.2.3.    DirectShow

DirectShow is a universal camera interface for the Windows operating systems. This interface provides the option to use the camera in application developments based on the DirectX SDK, as well as all third-party software packages and tools which implement DirectShow for video capture.

### 5.1.3. Vision Library Integration

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).

## 5.2. Supported Vision Libraries

For an up-to-date lasting of the supported vision libraries and software packages, visit our web site http://www.ximea.com/support/projects/vision-libraries/wiki.

### 5.2.1. 3DExpress



**3DExpress**, developed by **AQSENSE S.L**, is a 3D preprocessing software for machine vision applications including graphical assistance for the configuration and debugging of 3D acquisition systems.

More:   http://www.aqsense.com/products/3dexpress.html

https://www.ximea.com/support/wiki/vision-libraries/3DExpress

### 5.2.2. ActiveGeni



**ActiveGen<i>** developed by A&B Software is an industrial grade camera SDK designed to provide developers and end-users with an easy access to GenICam-compliant cameras.

More:   http://www.ab-soft.com/activegeni.php

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

### 5.2.3. Adaptive Vision Studio



**Adaptive Vision Studio** is a comprehensive software tool for creating machine vision applications regardless of the target industry or hardware that is used.

More:   http://www.adaptive-vision.com/en/

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

### 5.2.4. Aforge.NET Framework



**Aforge.NET** is a C# framework for image processing, neural networks, genetic algorithms, machine learning, and robotics. It is free for use published under the LGPL v3 license.

More:   http://www.aforgenet.com/

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

### 5.2.5. AQSENSE SAL3D



**AQSENSE SAL3D** provides tools and technology solutions for in-line and off-line 3D measuring and inspection procedures.

More:   http://www.aqsense.com/products/sal3d.html

https://www.ximea.com/support/wiki/vision-libraries/AQSENSE_SAL3D

## 5.2.6. Astroart 5.0



Astroart 5.0 developed by MSB Software is a complete software for image processing, photometry, astrometry, camera control and image stacking for digital and film images.

More:  http://www.msb-astroart.com/

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

## 5.2.7. Cognex VisionPro



VisionPro® has proven itself in more than 500,000 installations worldwide. Cognex vision software is the industry benchmark for vision performance.

More:  http://www.cognex.com/ProductsServices/VisionSoftware/

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

## 5.2.8. Digital Optics V++



Digital Optics V++ is a high performance scientific imaging and spectroscopy application used in thousands of laboratories around the world.

More:  http://www.digitaloptics.net/vpp.html

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

## 5.2.9. EVT - EyeVision



The ready-to-use image processing software EyeVision by EVT allows the customer to create image processing solutions with just a few mouse clicks using drag-and-drop function.

More:  http://www.evt-web.com/home/

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

### 5.2.10. ImageWarp



ImageWarp is a universal image analysis, processing and editing software, which combines the power of graphic development environment, a comprehensive image analysis toolset, and programming development techniques.

More:   http://www.imagewarp.com

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

### 5.2.11. Integrating Vision Toolkit



The Integrating Vision Toolkit is a stand-alone easy-to-use, platform-independent open source C++ computer vision library with an object-oriented architecture.

More:   http://ivt.sourceforge.net/

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

### 5.2.12. Intopii Pinta



Pinta, developed by Intopii, is a fast and simple way to create high-performance applications that know what's in the image.

More:   http://intopii.com/en/home

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

### 5.2.13. Keyetech



Keyetech offers key technologies in computer vision, in particular for robotics and automation, in industry as well as in research.

More:   http://www.keyetech.de/en/home.html

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

### 5.2.14. libdmtx



Libdmtx is open source software for reading and writing Data Matrix 2D barcodes on Linux, Unix, OS X, Windows, and mobile devices.

More:   http://www.libdmtx.org/

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

### 5.2.15. Matrox Imaging Library (MIL)



Matrox Imaging Library is a comprehensive collection of software tools for developing machine vision, image analysis and medical imaging software applications.

More:   http://www.matrox.com/imaging/en/products/software/mil/

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

### 5.2.16. MathWorks MATLAB



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

More:   http://www.mathworks.de/

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

### 5.2.17. Micro-Manager



μManager is a software package for control of automated microscopes.

More:   http://micro-manager.org

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

### 5.2.18. 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/

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

## 5.2.19. National Instruments LabVIEW Vision Library



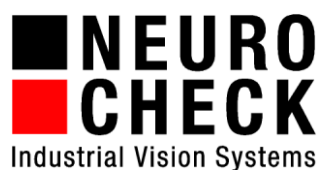LabVIEW is a graphical programming environment.

More:   http://www.ni.com/labview/

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

## 5.2.20. NeuroCheck



NeuroCheck® is a general purpose image processing software for industrial quality control.

More:   http://www.neurocheck.com/

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

## 5.2.21. Neurotechnology SentiSight



SentiSight is intended for developers who want to use computer vision-based object recognition in their applications.

More:   http://www.neurotechnology.com/sentisight.html

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

## 5.2.22. StreamPix



StreamPix is Norpix's flagship software product. Resulting from more than 10 years of interaction with their  vast group of customers, StreamPix has become the ultimate Digital Video Recording software.

More:   http://www.norpix.com/products/streampix5/streampix5.php

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

### 5.2.23. OpenCV

**OpenCV** is an open source library of programming functions mainly aimed at real time computer vision, developed by Intel and now supported by Willow Garage.

More:   http://opencv.willowgarage.com/wiki/

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

### 5.2.24. RoboRealm

**RoboRealm®** is an application for use in computer vision, image analysis, and robotic vision systems. Using an easy point and click interface RoboRealm simplifies vision programming.

More:   http://www.roborealm.com/index.php

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

### 5.2.25. STEMMER IMAGING Common Vision Blox

**Common Vision Blox** is an open architecture, hardware independent toolkit that supports both PC and embedded smart camera technology.

More:   http://www.commonvisionblox.com/

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

### 5.2.26. SANXO Modular-X

**SANXO Modular-X** is a powerful application builder for computer vision, image analysis, measurements and quality control utilizing the vision library functions of National Instrument **LabVIEW**.

More:   http://sanxo.hu/modular-x/index_e.html

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

### 5.2.27. ThirdSight



ThirdSight is an expert in state of the art technologies in the fields of computer-based face and emotion recognition.

More:   http://www.thirdsight.co/

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

### 5.2.28. Tordivel Scorpion



Scorpion Vision Software® from Tordivel AS is an independent and open software tool for industrial vision.

More:   http://www.scorpionvision.com/

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

### 5.2.29. VisionLab



Developed by Van de Loosdrecht Machine Vision BV, VisionLab is a portable library (C++) and a development environment for machine vision applications, pattern recognition and classification with neural networks.

More:   http://www.vdlmv.nl/

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

### 5.2.30. Voyant Vision



Voyant Vision is library of software functions that makes developing machine vision solutions easier.

More:   http://www.voyantvision.net/

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

## 5.3.   Windows software package

XIMEA API Software Package  can be installed on: Microsoft Windows 8, Microsoft Windows 7 (and Microsoft Windows 7 Embedded), Microsoft Windows XP SP3 (and Microsoft Windows Embedded Standard 2009), Microsoft Windows 2008 R2.

### 5.3.1.  Contents

The package contains:

- OS Drivers of all XIMEA camera types for OS Microsoft Windows XP SP3 32bit, Windows 7 32/64 bit, Windows 8 32/64 bit, Windows 2008 R2 x86-64.
- APIs (M3API, xiAPI, xiAPI.NET, GenTL)
- Examples (xiViewer - camera live image viewer for picture check)
- Utilities (newCCDTest viewer application)
- *GenTL Producer* - for connection of *GenTL Consumer* applications.
- Vision Libraries integration demonstrations:
  - LabView demo with sources
  - OpenCV demo with sources
  - Libdmtx demo with sources
  - Aforge.NET framework demo with sources
  - Integrating Vision Toolkit demo with sources
  - Halcon demo with sources
  - Cognex demo with sources
  - Matrox MIL demo with sources
  - Voyant Vision demo with sources

## 5.3.2. Installation

- Download and execute the XIMEA API Software Package installer (EXE-file, approx. 50 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):
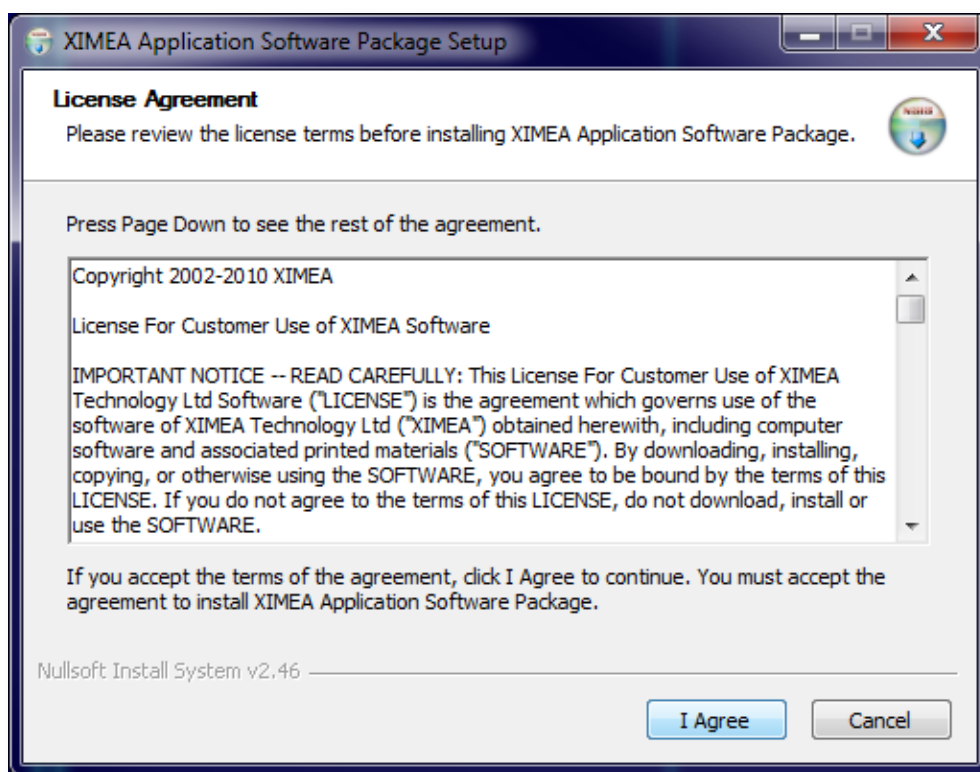


*figure 5-1, xiAPI installation, Windows - 1*

- 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.
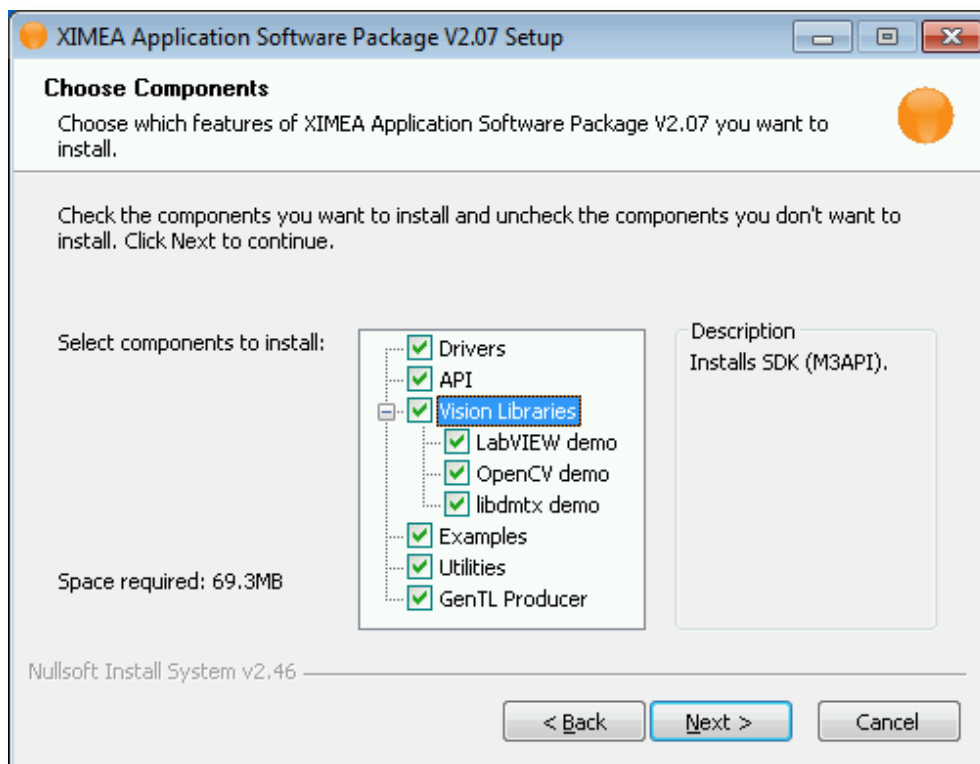


*figure 5-2, xiAPI installation, Windows - 2*

- Specify the install location - you can leave the default location or change it to your desired location. Selecting the pre-defined location will make updates easier.
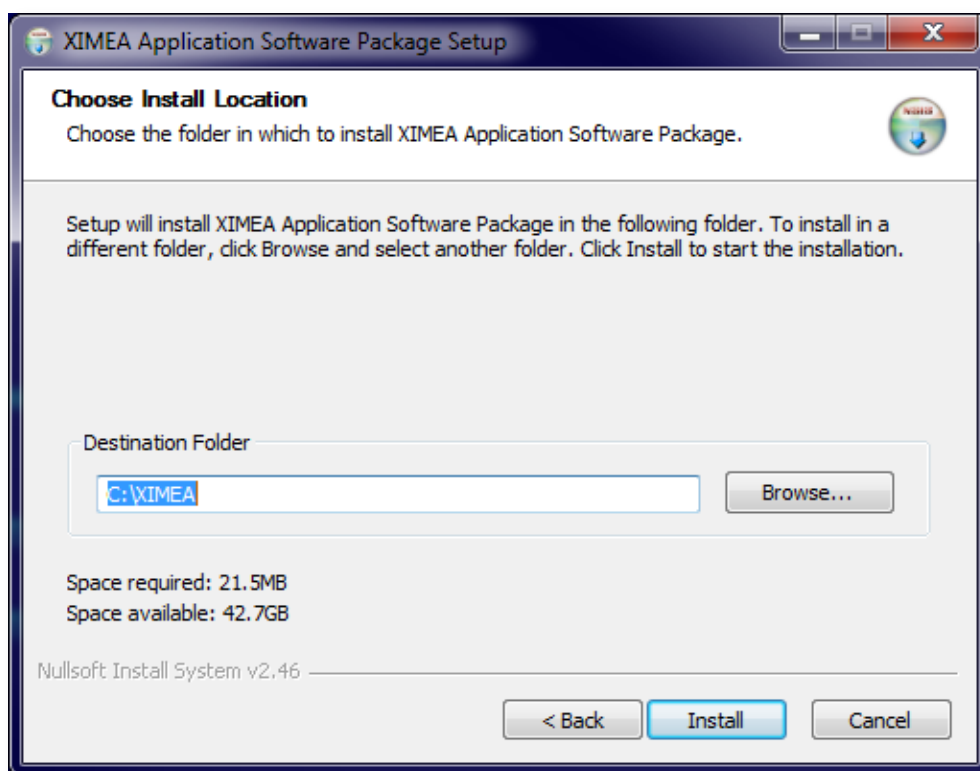


*figure 5-3, xiAPI installation, Windows - 3*

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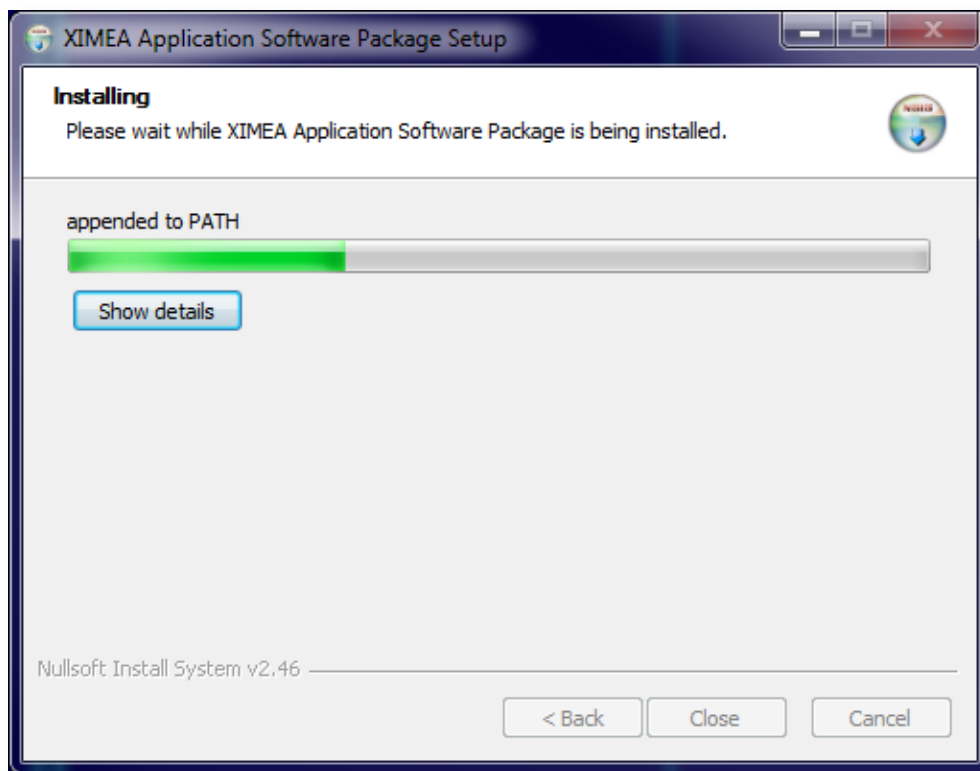


*figure 5-4, xiAPI installation, Windows - 4*
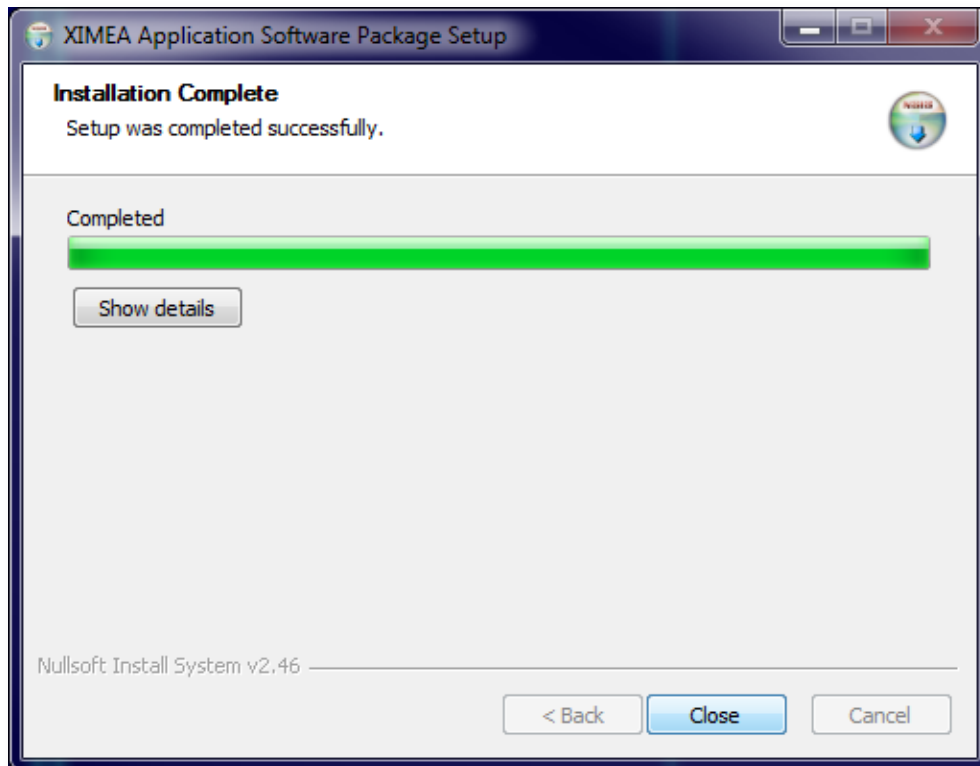
- Installation is completed.



*figure 5-5, xiAPI installation, Windows - 5*

- Changes to System Environment Variables may require a system reboot. If you want to reboot immediately select 'Reboot Now' option, otherwise select 'I want to manually reboot later'.

### 5.3.3.  XIMEA Viewer

The XIMEA software package for Windows includes two viewer applications – xiViewer and newCCDtest.

### 5.3.3.1.  xiViewer

The xiViewer is a simple viewer application which is capable of setting basic camera parameters, controlling certain features, displaying the video stream and saving snapshots.

xiVIewer is based on xiAPI and uses a subset of the parameters and functions that are available in xiAPI. The source code of xiViewer is included in the XIMEA software package and can be used as a reference for custom application development.

**Usage:**

- Start xiViewer with the shortcut located on your desktop or the executable found in C:\XIMEA\Examples\Bin
- If multiple cameras are connected, a pop-up will appear, which offer the selection of a desired cameras by its serial number
- The image acquisition starts in free-run mode and video stream is displayed
- Right-Click inside the camera window opens the settings menu which is divided into sub-categories. Each category can be extended by clicking on the respective button
- Value fields can be manipulated by their adjacent sliders or by using the mouse wheel (up-down) while a field is selected. Holding SHIFT or CTRL while using the mouse wheel will increase the increment of the value change (+-10, +-100).
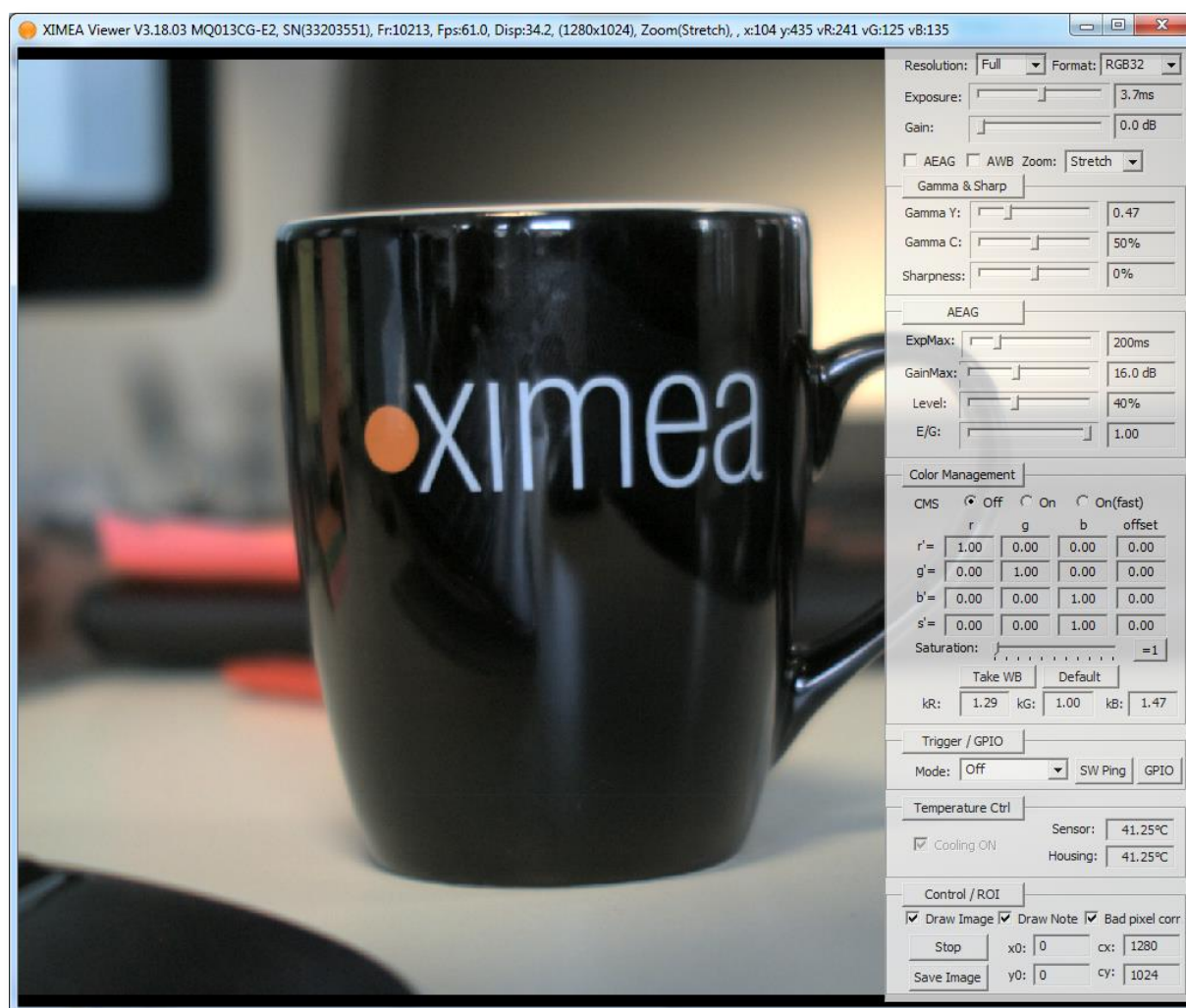


*figure 5-6, Windows – xiViewer*

### 5.3.3.2. New CCD Test

newCCDtest is a legacy viewer application, based on the *m3Api*. Please note that not all new functions are available in this viewer because new functions are developed in xiAPI.

**Usage:**

- Run newCCDtest_mm.exe (newCCDtest_mmX64.exe for 64 Bit systems) located in C:\XIMEA\Utilities
- Select Acquistion – Run to start the image acquisition and display, or use the green Play Button.
- Select Acquisiton – Setup to open the settings window
- Value fields can be manipulated by their adjacent sliders or by using the mouse wheel (up-down) while a field is selected. Holding SHIFT or CTRL while using the mouse wheel will increase the increment of the value change (+-10, +-100).
- Select Configuration – GPIO open the GPIO settings window
- Note: newCCDtest does not measure the available bandwidth for connected xiQ camera automatically.
  If a USB host controller is used that cannot deliver a sufficient bandwidth, it is necessary to limit the bandwidth manually.
  To do so, before starting the acquisition, open Configuration – Bus Speed, press Start/Stop to initiate the bandwidth measure and press Set to apply the measure value as bandwidth limit.



*figure 5-7, Windows - newCCDtest*

## 5.4. Linux Software Package

XIMEA Linux Software Package is tarred installer with files that can be run on Linux Ubuntu 12.04 (32 and 64 Bit) and newer releases.

### 5.4.1. Contents

The package contains:

- Driver (beta version) for XIMEA USB2 and USB3 cameras

- xiAPI
- Examples:
  - o xiSample - sample showing basic image acquisition in xiAPI
  - o streamViewer - camera live image viewer for picture check.
  - o vaViewer – alternative camera live image viewer for picture check.
    vaViewer is based on libva, which must be installed before vaViewer is started, see *5.4.2* *Installation*.
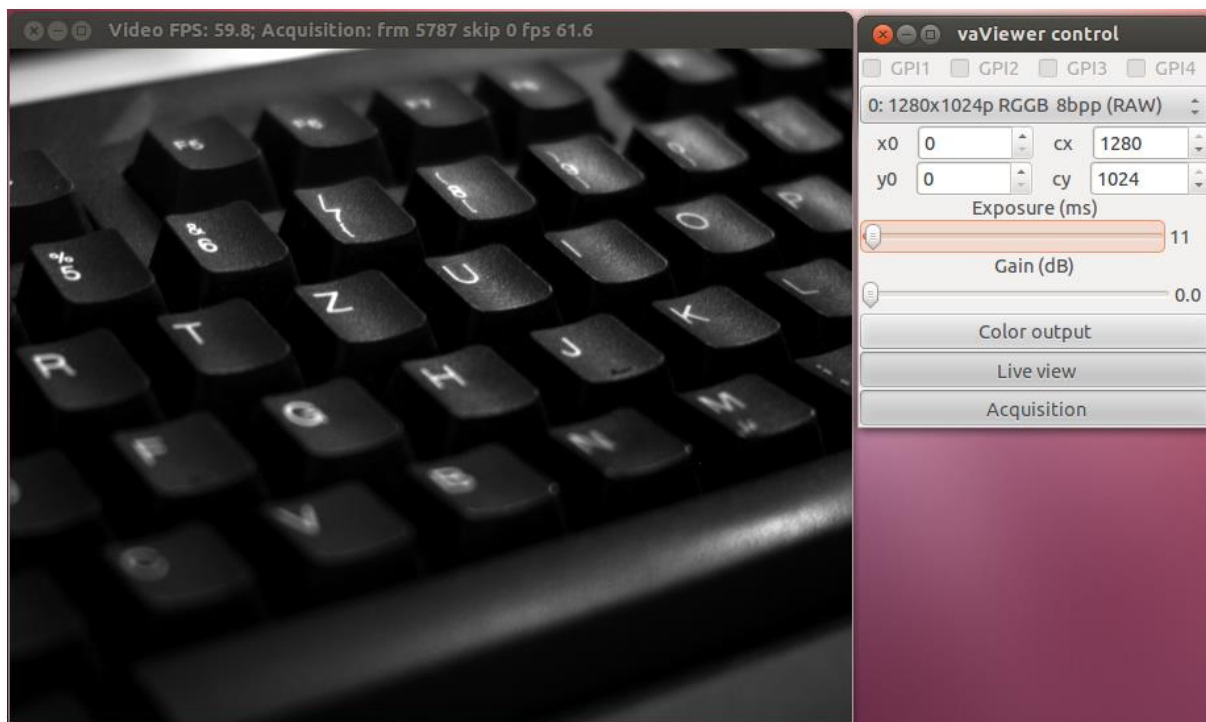
**vaViewer**



*figure 5-8, Linux - vaViewer*

## 5.4.2.  Installation

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



*figure 5-9, xiAPI installation, Linux - 1*

- Untar

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

- Start installation script

  ```
  ./install -cam_usb30
  ```



*figure 5-10, xiAPI installation, Linux - 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*.

**Installing libva (for vaViewer)**

When Your PC contains Intel card do following:

```
sudo apt-get update
sudo apt-get install vainfo
sudo apt-get install i965-va-driver
```

## 5.5. Mac OS X Software Package

XIMEA OSX Software Package is native DMG installer that can be run on OS X 10.8 (Mountain Lion).

### 5.5.1. Contents

The package contains:

- Driver (beta version) for XIMEA USB2 and USB3 cameras
- xiAPI
- Examples:
  - o xiSample - sample showing basic image acquisition in xiAPI
  - o streamViewer - camera live image viewer for picture check.

### 5.5.2. Installation

Before installing XIMEA OSX 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 OSX Software Package due to the fact that the current version is unsigned.

Open System Preferences application and click on Security & Privacy.



*figure 5-11, xiAPI installation, MacOS - 1*

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



*figure 5-12, xiAPI installation, MacOS - 2*

- Download XIMEA OSX Software. Package:
  https://www.ximea.com/support/attachments/1112/XIMEA_OSX_SP.dmg
- Mount it by double-clicking this file in Finder.
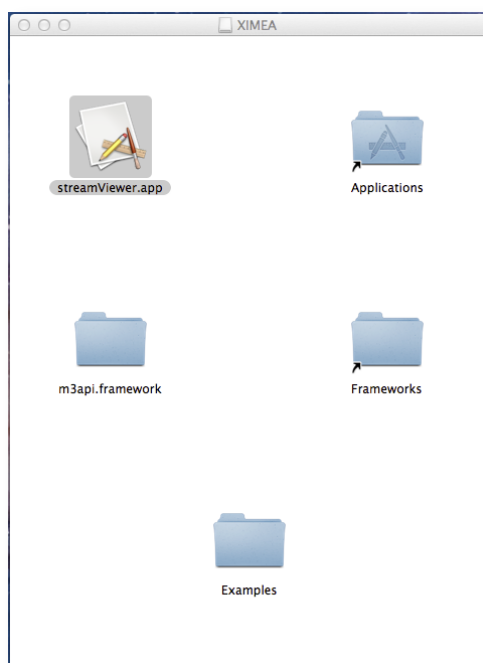- A window with package contents will open.



*figure 5-13, xiAPI installation, MacOS - 3*

- Drag streamViewer to Applications folder.
- Drag m3api.framework to Frameworks folder (popup dialog will appear asking for your password, enter it).
- You can check contents of Examples folder and copy the files you want anywhere you like.

### 5.5.3.  Usage

streamViewer application can be run without installing (just mount DMG file and double-click its icon) and does not depend on m3api.framework being installed. It is a sample viewer with a minimalistic interface.



*figure 5-14, MacOS - streamViewer*

m3api framework is API library and its headers. It's needed for software development. You can check Examples folder to see how to use it properly.

#### Opening streamViewer from terminal

The streamViewer can be opened from terminal using:

```
cd ~
/Applications/streamViewer.app/Contents/MacOS/streamViewer
```

#### Opening multiple streamViewers

When multiple XIMEA cameras are connected to OSX, multiple streamViewers can be used to display image from each of the cameras.

To open multiple streamViewers follow steps:

- Open Applications
- Click on streamViewer with right button
- Select Duplicate - to create new copy of streamViewer application
- Start each instance of application for each camera

## 5.6.    Programming

### 5.6.1.  XIMEA APIs

- **m3API** -  Legacy API , plain C/C++ (Not recommended for new developments)
- **xiAPI** - Streamlined API. The standard API for C/C++ based projects, see *5.6.2  xiAPI Overview*.
- **xiAPI.NET** - Managed .NET Common Language Runtime (CLR) API.
  xiAPI.NET is designed as a wrapper around xiAPI and therefore shares most of its functionality.

### 5.6.2.  xiAPI Overview

xiAPI stands for XIMEA Application Programming Interface. It is a new common interface for all XIMEA cameras, and represents a simplified version of generic **m3API**.

#### Architecture

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

- On Windows: xiAPI is compiled into m3api.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 *5.3 Windows software package* ff.

### 5.6.3.  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);
```

### 5.6.4. xiAPI Parameters Description

For a complete list of available parameter, 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_RET* structure which is defined in *xiApi.h.* If a parameter is not supported by a certain camera, the rerun value will represent a respective error code (e.g. *106 - Parameter not supported).*

### 5.6.5. xiAPI Examples

### 5.6.5.1. 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;
XI_RETURN stat = XI_OK;

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

if (!dwNumberOfDevices)
{
  printf("No camera found\n");
  goto finish;
}

// Retrieving a handle to the camera device
stat = xiOpenDevice(0, &xiH);

…

finish:
  // Close device
  if (xiH)
      xiCloseDevice(xiH);
```

### 5.6.5.2. 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 doensampling rate
int dspl_max;
xiGetParamInt(xiH, XI_PRM_DOWNSAMPLING XI_PRM_INFO_MAX, &dspl_max);

// Setting maxium possible doensampling rate
xiSetParamInt(xiH, XI_PRM_DOWNSAMPLING, dspl_max);
```

### 5.6.5.3. Acquire Images

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

```
xiStartAcquisition(xiH);
HandleResult(stat,"xiStartAcquisition");

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

xiStopAcquisition(xiH);
```

### 5.6.5.4. Control Digital Input / Output (GPIO)

#### 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. This time should be less than 10μs.
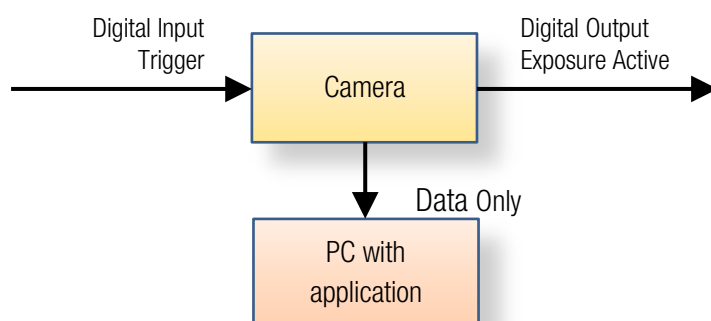


*figure 5-15, GPIO - schematic*

```
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…
```

### 5.6.6. 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.

### 5.6.7. USB3 Vision

For more information on programing according the USB3 VISION standard, please visit the standard's website at
http://www.visiononline.org/vision-standards-details.cfm?type=11

### 5.6.8. GenICam

For more information on programing according the GenICam standard, please visit the standard's website at
http://www.emva.org/cms/index.php?idcat=27

## 5.7. XIMEA Control Panel

The XIMEA Control Panel, or short xiCOP, is a diagnostics and management tool for all XIMEA cameras.

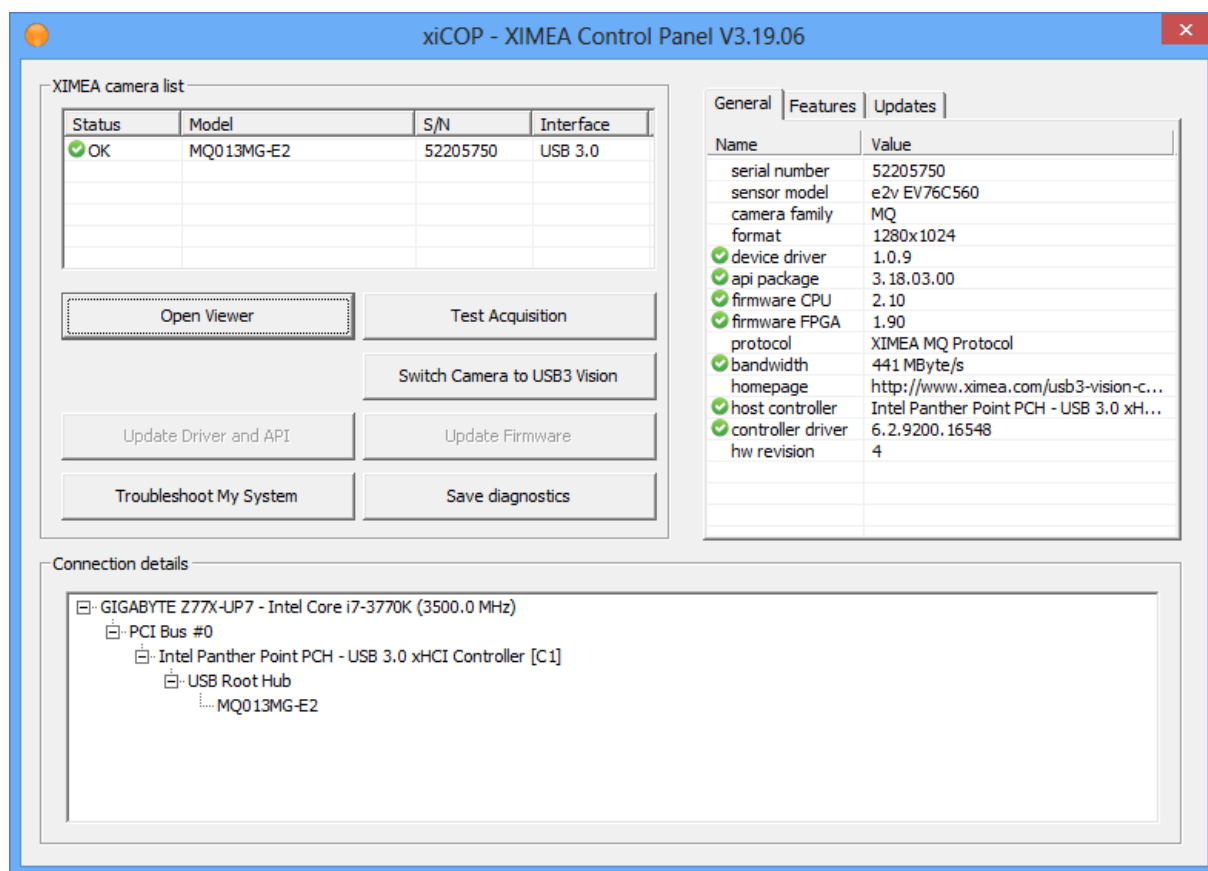xiCOP is currently only available for Windows operating system.



*figure 5-16, 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 is a component is not up-to-date.
- List all currently attached XIMEA devices and their features.
- Suggests solution for diagnosed issues.
- One click to switch selected XIMEA cameras to USB3 Vision standard.
- One click to switch selected XIMEA cameras to back to XIMEA API.
- One click update to the latest XIMEA API Software Package.
- One click update of firmware in selected cameras.

# 6. Appendix

## 6.1. Troubleshooting and Support

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

At first, please make sure, that you have installed the latest version of the following XIMEA software:

- XIMEA API Software Package    http://www.ximea.com/downloads/recent/XIMEA_Installer.exe
- xiCOP                          http://www.ximea.com/support/attachments/690/xiCOP_Beta.exe

Please make sure, that you have connected your xiQ camera with the XIMEA USB 3.0 cable to an appropriate USB 2.0 or USB 3.0 port. Ensure that the connections are carefully locked. Follow the instructions described in chapter *5.3.3 XIMEA Viewer* (run the xiQ camera with the xiApi Viewer). 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 xiQ 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 xiQ camera, please open the XIMEA xiCOP software (please see *5.7 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 *4.1 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 take 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. What is USB 3.0 SuperSpeed?

USB 3.0 is the latest major revision of Universal Serial Bus (USB) standard which brings transfer speed of 5Gb/s and enables delivery of up to 5W of power to the target device. It uses communication technology similar to that of PCI Express Gen2.

### 6.1.3.2. What is the real transfer speed?

xiQ camera can deliver up to 450Mbyte/sec. This requires that certain conditions are met, see *4.1 System Requirements.*

Maximum transfer speeds of different interfaces:

| Interface | Transfer speed | Usable bandwidth | System costs |
|---|---|---|---|
| IEEE1394A | 400 Mbit/s | 45 MByte/sec | Medium |
| CameraLink base | 2.04 Gbit/s | 255 MByte/sec | High |
| GigE | 1024 Mbit/s | 100 MByte/sec | Medium |
| USB 2.0 | 480 Mbit/s | 49 MByte/sec | Low |
| USB 3.0 | 5 Gbit/s | 450 MByte/sec | Low |

*table 6-2, interface depending transfer rates*

### 6.1.3.3. Why can I not achieve maximum transfer speed?

In order to reliably achieve maximum transfer speed it is necessary to verify that you are using recommended hardware (please see *4.1 System Requirements)*, and that all software requirements are met.

xiCOP (please see *5.7 XIMEA Control Panel*) - XIMEA Control Panel free software tool, facilitates the task of verification of XIMEA USB3 Vision camera installations.

### 6.1.3.4. What voltage should be applied to Digital Input of xiQ to turn it on/off?

Following table shows different levels of Voltage on Digital Input (VDI) on xiQ and their logical interpretation.

| VDI (Opto-isolated) | Logical level |
|---|---|
| 0-5Vdc | Off (zero) |
| 5-15Vdc | Undefined |
| 15-24Vdc | On (one) |

*table 6-3, voltage levels for digital input*

Maximal input voltage 24Vdc

For more details see also *3.8.3 Digital Input*.

### 6.1.3.5. What is the implementation of Digital Output (VDO) of xiQ?

VDO is opto-isolated NPN open collector type, max. load current 25mA, max. open voltage 24Vdc.

For more details see also *3.8.4 Digital Output*.

## 6.2. Product service request (PSR)

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

### 6.2.1. Step 1 - Contact Support

If your xiQ 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 Product Service Request form  http://www.ximea.com/support/projects/service/issues/new
- Fill in all fields
- Confirm with the button „Create"

### 6.2.3. Step 3 - Wait for PSR Approval

Our support personnel will verify the PSR for validity.

If your PSR is valid, it will be approved for sending the camera to us. This is done usually within 24 business hours. After that you will get a PSR Approval email (sent to the email address that you have entered in the field "Contact person – email").

The email contains:

- shipping instructions
- attached document containing the Product Service Request Number (PSRN)

When you received the PSR Approval email - please continue to Step 4.

In case your PSR was rejected – please do not send your camera 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 6-4, service operations overview*

If the camera will be returned, you will receive the 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 xiQ cameras and special considerations regarding XIMEA board level cameras. In order to avoid harm or damage your xiQ camera, please handle it like described in this manual,paying special attention to the cautions shown in the following table:

### 6.3.1.  Disassembling

Do not disassemble the camera except for conversion to CS-Mount, see *3.3 Lens* Mount.

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 *3.12 Tripod Adapter – MQ-BRACKET-T*.

Use only the specified screws and torques when fastening, see *3.3.1 Screws*.

### 6.3.3.  Connections

Use only recommended connectors and cables. Please check the system requirements described in *4.1 System Requirements*.

### 6.3.4.  Power supply

Use only the recommended electrical power supply via the USB cable, see *3.1 Power Supply*

The I/O connection is not usable for powering the camera.

### 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 too much 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 may affect the image quality and may damage the surfaces.

Mount / dismount lenses and additional filters only in a dust free environment.

Do not use compressed air as this could push dust into the camera (and lenses).

### 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.

### 6.3.11. Safety instructions for board level cameras

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

- Only qualified personnel is allowed to handle, install and operate the board level cameras.
- Board level cameras are delivered without housing. Handle the PCB and the sensor with care. Do not bend the boards. Do not touch the components or contacts on a board. Hold the board by its edges only.
- Protect the board level camera against static discharge (see *6.3.10 Protect against static discharge (ESD)*).
- Do not hold any components of your board level cameras against your clothing, even if you are wearing a wrist strap.
- Do not remove the board level camera from its anti-static packaging unless your body is grounded.
- To protect the boards from radiation of other modules or devices a housing or shielding may be required.
- Be sure that the board level camera has no contact to any electrical source before mounting or making connections to the board level camera.
- Do not connect or disconnect any cables or use the board level camera during an electrical storm.
- Avoid any mechanical forces to the board level cameras, especially torsional, tensile and compressive forces. Any of these forces may result in damage of the board level cameras.
- Always use clean boards.
- To protect the boards from dirt like dust or liquids always use the board level cameras in clean room environment or use a protective housing.

## 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.

Please note our explanations regarding the usage and handling of board level cameras and related restrictions of warranty (see *6.3.11 Safety instructions for board level cameras*).

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, xiQ, xiMU, xiCool, xiRAY, xiCe and CURRERA are trademarks or registered trademarks of XIMEA GmbH in Germany, Slovakia, USA and other countries.

Microsoft, Windows, Windows8, 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 subjectmatter of the Supplies has subsequently been brought to another location than the Purchaser's branch office, unless doing so complies with the normal use of the Supplies.

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.

### Artikel 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 |
|---------|------|-------|
| 1.0 | 06/21/2013 | Initial version |
| 1.01 | 06/24/2013 | -- |
| 1.02 | 07/01/2013 | Minor changes in chapter "optical path" |
| | | |

# 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 |
| $T_{int}$ | Integration time |

# 8.    list of figures

# 9.    list of tables