Allied Vision

GigE Vision Cameras

Mako G

Technical Manual

V4.2.1

Allied Vision Technologies GmbH // Taschenweg 2a, 07646 Stadtroda / Germany

2016-Nov-08

Mako G at a glance

Mako G cameras have a Gigabit Ethernet (GigE) interface and work with Gigabit Ethernet hardware and cable lengths up to 100 m. Mako G cameras are GigE Vision V1.2 and GenICam Standard Feature Naming Convention (SFNC) V1.2.1 compliant.

Applied standards

GigE Vision®

The GigE Vision standard is an interface standard for digital machine vision cameras administered by the Automated Imaging Association (AIA) that is widely supported in the machine vision industry. In contrast, Gigabit Ethernet is the network GigE Vision is built upon.

GenICam™

GenICam is a machine vision standard hosted by the European Machine Vision Association (EMVA). The aim of GenICam is to provide a generic configuration interface for cameras and devices independent of the used interface technology (i.e., GigE Vision, USB3 Vision, DCAM IEEE 1394, Camera Link). This approach enables proper interoperability between GenICam compliant hardware and software solutions without the need for customization.

The GenICam standard consists of multiple modules that specify tasks to be solved. Allied Vision cameras and software make use of these modules, like the Standard Feature Naming Convention (SFNC) that standardizes feature names and types via an XML file or the transport layer interface (GenTL) that is used to grab images.

What else do you need?

Content	URL
Camera data sheets GigE Installation Manual GigE Features Reference Modular Concept 3D CAD STEP files Software and firmware downloads	https://www.alliedvision.com/en/support/technical-documentation/mako-g-documentation.html
Technical papers and knowledge base	https://www.alliedvision.com/en/support/technical-papers-knowledge-base.html

Read this manual carefully

Learn how to protect your camera from damage and fully understand its functions.

Contact us

Connect with Allied Vision by function

https://www.alliedvision.com/en/meta-header/contact.html

Find an Allied Vision office or Allied Vision distribution partner

https://www.alliedvision.com/en/about-us/where-we-are.html

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Contents

Document history and conventions

This chapter includes:

- Document history
- Layout styles and symbols used in this manual

Document history

Version	Date	Remarks
V2.0.0	2013-Aug-30	New Manual- Release status
V2.0.1	2013-Sep-11	Added table of contents Added Camera cleaning Updated the specifications for Mako G-223 and G-419
V2.0.2	2013-Sep-16	Updated the frame rate information for Mako G-223 and G-419 in Specifications chapter Updated introduction to include link to Mako G documentation web page Updated Status LEDs section Added captions to tables in Camera lenses section Added links to GigE Camera and Driver Features document
V2.0.3	2013-Nov-27	Updated gain control values for Mako G-223B, G-223B NIR, G-223C and Mako G-223B, G-223B NIR, G-223C Updated Status LED 2 table Updated the note on StreamHoldCapacity in Notes on specifications and Frame memory sections Updated block diagrams in Image data flow chapter Updated the Index
V2.0.4	2014-Feb-28	Updated available color pixel formats for Mako G-223B, G-223B NIR, G-223C and Mako G-223B, G-223B NIR, G-223C Updated optional accessories in the Notes on specifications chapter Updated section Cross section: C-Mount and CS-Mount Added section Heat dissipation Updated the operating temperature specification for Mako G-032B, G-032C, Mako G-125B, G-125C, Mako G-223B, G-223B NIR, G-223C, and Mako G-223B, G-223B NIR, G-223C Updated block diagrams in Image data flow to remove the RS232 mention Added Hirose cable information
V2.1.0	2014-Oct-07	Updated and rearranged Notes on specifications chapter Added Camera features comparison Added trigger latency and jitter values for Mako G-032B, G-032C and Mako G-125B, G-125C Updated Mako G standard housing drawing Updated Mako G-503C section Added camera lens information Updated Image data flow and Mechanical dimensions chapters

Table 1: Document history

Version	Date	Remarks
V3.0.0	2015-Jan-15	Updated Allied Vision logo Updated Cleaning optical components section Added Mako G-030, G-131, and G-192 cameras Added Mako G-030B, G-030C, Mako G-131B, G-131C, and Mako G-192B, G-192C specifications and spectral sensitivity plots Updated Mako G camera smart features table Added camera lens information Added ROI frame rate, ROI frame rate, and ROI frame rate sections Updated Image data flow and Mechanical dimensions chapters
V3.1.0	2015-Mar-10	Added Mako G-503 camera Added Mako G-503B, G-503C specifications and spectral sensitivity plots Added camera lens information Added ROI frame rate section Updated Image data flow and Mechanical dimensions chapters
V3.2.0	2015-Mar-20	Replaced old links with new Allied Vision website links Changed file name from 'GigE Camera and Driver Features' to 'GigE Features Reference' Changed chapter name from 'Description of data path' to 'Camera data path'

Table 1: Document history (continued)

Version	Date	Remarks
V4.0.0	2015-Nov-24	Changed the technical manual layout Changed chapter name from 'Camera data path' to Image data flow Changed chapter name from 'Camera dimensions' to Mechanical dimensions Merged the 'Resolution and ROI frame rate' chapter of V3.2.0 into Specifications chapter Added *Mako G at a glance* section Added General safety notes section Added Regulations section in Safety and regulations chapter to replace 'Legal notice' and 'Conformity' sections in V3.2.0 Moved 'Sensor position accuracy' section from Appendix to 'Mechanical dimensions' chapter Deleted 'Appendix' Added Camera feature comparison section in Specifications chapter to replace 'Camera smart features' and 'Camera features' sections in V3.2.0 Added Cross section: C-Mount and CS-Mount section to replace 'Cross section: C-Mount' and 'Cross section: CS-Mount' sections in V3.2.0 Added Cleaning optical components chapter to replace 'Camera cleaning' section of V3.2.0 Added *Contact us* section to replace 'Contacting Allied Vision' section of V3.2.0 Added Mako G-234B, G-234C camera information Removed all references to Mako G-050 and G-095 Updated interfaces chapter
V4.1.0	2016-Oct-12	Added a tripod adapter warning message Added new model: Mako G-507B, G-507C Updated absolute QE plots for models with Sony sensors Added spectral response plots for models with Sony sensors Added REACH certification statement Added optical filter information to specification tables Added overlapping trigger note for Mako G-131 and G-192 in Specification chapter and Camera interfaces chapter. Updated image flow diagrams Updated Mako G-234B, G-234C specifications Added 10/12-bit switchability to Mako G-234B/G-234C
V4.2.0	2016-Nov-07	Added new model: Mako G-319B, G-319C Added missing information in specification tables
V4.2.1	2016-Nov-08	Corrected typographic issues Corrected Mako G-503 shutter type

Table 1: Document history (continued)

Manual conventions

To give this manual an easily understood layout and to emphasize important information, the following typographical styles and symbols that are used.

Styles

Style	Function	Example
Bold	Program names, UI elements, highlighting important things	**bold**
Italics	Publication names, UI non-interactive elements	*Italics*
Courier New	Code listings, feature names	`Input`
Courier New Italics	Feature options	*`Mode`*
Blue	Cross references, web page URLs, email links	Link

Symbols

Safety Note

Note to prevent physical injury.

Possible material damage

This symbol addresses important information to avoid material damage; however, is not related to physical injury.

Damage to the camera by electrostatic discharge (ESD)

This symbol addresses important information to avoid material damage by ESD.

Safety-related instructions to avoid malfunctions

This symbol indicates important or specific instructions or procedures that are related to product safety. You have to follow these instructions to avoid malfunctions.

Practical hint

This symbol highlights a practical hint that helps to better understand the camera‘s features and functions, and to make better use of it.

Further information available online

This symbol highlights URLs for further information. The URL itself is shown in blue. Example:

https://www.alliedvision.com

Safety and regulations

This chapter includes:

- General safety notes for Mako G cameras
- Information about the legal requirements and restrictions for Mako G cameras based on current and relevant regulations
- Particular emphasis has been given to regulations of the European Economic Area (CE, REACH, RoHS, WEEE) as well as regulations of the United States of America (FCC) and Canada (ICES)

General safety notes

Avoid damage to the camera by ESD

Inadequate protection of the camera from ESD can damage the camera permanently. Read the safety instructions and ESD warnings in the *GigE Installation Manual*.

Do not operate the camera beyond the environmental specifications

Due to the small packaging and high speed of Mako G cameras, ensure that housing temperature of the camera does not exceed 45 °C. The following are general guidelines for heat dissipation:

- Mount the camera on a heat sink such as a metal bracket.
- Lenses, when attached to a camera, act as a heat sink and help reduce housing temperature.
- Ensure sufficient air flow. Use a fan if necessary.

Avoid damage to the camera from high output current or voltage

- Connecting the camera to a device exceeding the allowed maximum current (20 mA per output) can damage the camera.
- Providing Isolated Out Power > 30 V may damage the camera.

Do not disassemble the camera housing

This camera contains sensitive internal components. The warranty is void if the camera is disassembled.

Camera housing temperature

Housing temperature of the camera increases during power-up and initial operation. This temperature will later stabilize.

Cleaning optical components

This product can be damaged by some volatile cleaning agents. Avoid cleaning the image sensor unless absolutely necessary. Please see instructions on optics cleaning in this document.

Allied Vision can clean your camera as a service for you, if necessary. For more information, contact Allied Vision support.

Regulations

European Economic Area requirements

CE and RoHS

Allied Vision Technologies declares under its sole responsibility that all standard cameras of the Allied Vision Mako G family to which this declaration relates are in conformity with the following standard(s) or other normative document(s):

- CE, following the provisions of 2004/108/EG directive
- RoHS (2011/65/EU)

REACH

Allied Vision Technologies products are in compliance with the Regulation (EC) No 1907/2006 REACH.

WEEE

This product must be disposed of in compliance with the directive 2002/96/EC on waste electrical and electronic equipment (WEEE).

FCC – Class B Device

For customers in the U.S.A.

This equipment has been tested and found to comply with the limits for a Class B 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 residential 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. However there is no guarantee that interferences will not occur in a particular installation. If the equipment does cause harmful interference to radio or television reception, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the distance between the equipment and the receiver.
- Use a different line outlet for the receiver.
- Consult a radio or TV technician for help.

You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment. 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 B of Part 15 of FCC Rules.

Industry Canada Equipment Standard for Digital Equipment (ICES)

CAN ICES-3 (A) / NMB-3 (A)

For customers in Canada

This apparatus complies with the Class A limits for radio noise emissions set out in the Radio Interference Regulations.

Pour utilisateurs au Canada

Cet appareil est conforme aux normes classe A pour bruits radioélectriques, spécifiées dans le Règlement sur le brouillage radioélectrique.

Life support applications

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Allied Vision Technologies customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Allied Vision Technologies for any damages resulting from such improper use or sale.

Other legal notices

Trademarks

Unless stated otherwise, all trademarks shown in this document of Allied Vision Technologies are brands protected by law. All other product or company names may be trademarks of their respective owners.

Warranty

The information provided by Allied Vision Technologies is supplied without any guarantees or warranty whatsoever, be it specific or implicit. Also excluded are all implicit warranties concerning the negotiability, the suitability for specific applications or the non-breaking of laws and patents. Even if we assume that the information supplied to us is accurate, errors and inaccuracy may still occur.

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.

Specifications

This chapter provides:

- Technical specifications
- Absolute quantum efficiency plots
- Spectral sensitivity plots
- ROI frame rate
- Comparison of feature availability in Mako G camera models

Notes on specifications

Dimensions and mass

The dimensions listed in the following tables are for Mako G standard housing models. Dimensions include connectors but not the tripod and lens.

The mass listed in the following table are for Mako G standard housing models. Mass does not include the tripod and lens.

Unless otherwise stated, frame rate, exposure control, trigger latency, and trigger jitter values are for 8 and 12-bit pixel formats only; i.e., Mono8, Bayer8, Mono12Packed, Bayer12Packed, and YUV411Packed.

Monochrome and NIR models

As monochrome and NIR models do not have an optical filter always attach a dust cap when a lens is not attached to minimize the possibility of contaminants falling on the sensor surface.

Frame memory

Normally, an image is captured and transported in consecutive steps. The image is taken, read out from the sensor, digitized and sent over the GigE network. Mako G cameras are equipped with an image buffer. Specifications tables for each camera show how many frames can be stored by each model.

The number of frames (*StreamHoldCapacity*) depends on resolution, pixel format, and packet size. Stated number of frames is typical for full resolution, Mono8/ Bayer8, and *GevSCPSPacketSize* = 8192.

The memory operates according to the FIFO principle. This makes addressing for individual images unnecessary.

Resolution and ROI frame rate

ROI frame rate is listed after the specification table. The resulting frame rate from changing sensor height from full image to a single line. Unless otherwise noted, sensors do not give an increase in readout speed with a reduction in width.

Resolution and ROI measurements

- Data was generated using *StreamBytesPerSecond* = 124 Mbit/s (full bandwidth) and an 8-bit pixel format. Frame rates may be lower if using network hardware incapable of 124 Mbit/s.
- ROIs are taken as center image for maximum speed advantage, where feature *OffsetY* = (full sensor height – ROI height)/2.
- *BinningVertical* is horizontal row summing on CCD before readout. The frame rate for an ROI at the same effective height as binning will be slower because the CCD still needs to read out the “fast readout rows” in ROI mode.

Absolute quantum efficiency plots

Important notice before reading the specifications tables

All measurements were done without protection glass or IR cut filter. With protection glass or filters, quantum efficiency (QE) decreases by approximately 10%.

The uncertainty in measurement of the QE values is ±10.25%.

This is mainly due to uncertainties in the measuring apparatus itself (Ulbricht sphere, optometer, etc.).

Manufacturing tolerance of the sensor increases overall uncertainty.

Monochrome Sony CCD/CMOS sensors

The curve in the absolute QE plots shown in this chapter were calculated from a single measured quantum efficiency for monochrome sensors. The shape of the curve is from the sensor data sheet but the values have been adjusted based on this measured value.

Color Sony CCD/CMOS sensors

The curves in the absolute QE plots shown in this chapter were calculated from three measured quantum efficiency values for color sensors. The shape of the curves are from the sensor data sheet but the values have been adjusted based on these measured values.

ON Semiconductor CCD/CMOS sensors & CMOSIS/e2v CMOS sensors

The curve in the absolute QE plots shown in this chapter is from the sensor manufacturer data sheet.

The information was correct at the time of publishing.

Wavelength

The wavelength range in the absolute QE plots reflects the information available in the sensor manufacturer data sheet at the time of publishing. Many color sensors are documented by the sensor manufacturer only for wavelengths from 400 nm to 700 nm.

For additional wavelength information, contact the sensor manufacturer.

Spectral response plots

For select models

The curves in the spectral response plots shown in this chapter were calculated from measured quantum efficiencies at 448 nm, 529 nm, and 632 nm. The shape of the curve is from the sensor data sheet but the values have been adjusted based on these measured values.

Mako G-030B, G-030C

Feature	Specification	
	Mako G-030B	**Mako G-030C**
Resolution	644 (H) x 484 (V) 0.3 MP	
Sensor	CMOSIS CMV300-3E7M1WP	CMOSIS CMV300-3E7C1WP
Sensor type	CMOS	
Shutter type	Global	
Sensor size	Type 1/3 5.9 mm diagonal	
Cell size	7.4 µm x 7.4 µm	
Lens mount	Standard: C-Mount Optional: See the Modular Concept	
Optical filter[1]	No optical filter	Hoya C-5000 IR cut filter
Maximum frame rate at full resolution	309 frames per second	
Maximum image bit depth	12-bit	
Image buffer	64 MB	
StreamHoldCapacity	Up to 99 frames at full resolution	
Monochrome formats	Mono8, Mono12Packed, Mono12	Mono8
Color formats (YUV)	n/a	YUV411Packed, YUV422Packed, YUV444Packed
Color formats (RGB)	n/a	RGB8Packed, BGR8Packed
RAW formats	n/a	BayerRG8, BayerRG12Packed, BayerRG12
Exposure control	83 µs to 2 s; 1 µs increments	
Gain control	0 to 26 dB; 1 dB increments	
Binning	n/a	
Decimation	Horizontal and Vertical: 1, 2, 4 factor	
Opto-isolated I/Os	1 input, 3 outputs	
Voltage requirements	12 to 24 VDC; PoE	
Power consumption	2.1 W @ 12 VDC; 2.3 W PoE	
Trigger latency[2]	Idle state: 3.1 µs; Frame valid state: 3.1 µs	
Trigger jitter[2]	Idle state: 1.2 µs; Frame valid state: 3.1 µs	
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)	
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	

Table 2: Mako G-030B, G-030C model specifications

Feature	Specification	
	Mako G-030B	Mako G-030C
Mass (typical)	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only. Resolution: 0.031; Accuracy: ± 1 °C	

[1] For more information on available optical filters see the Modular Concept.

[2] These values are calculated directly from the microcontroller source. These values are only valid for pixel formats < 16 bits per pixel and applicable in both Idle and Frame valid states:

- Idle state: sensor is ready and camera is idle, waiting for the next trigger.
- Frame valid state: sensor is reading out and camera is busy. If next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state.

Table 2: Mako G-030B, G-030C model specifications (continued)

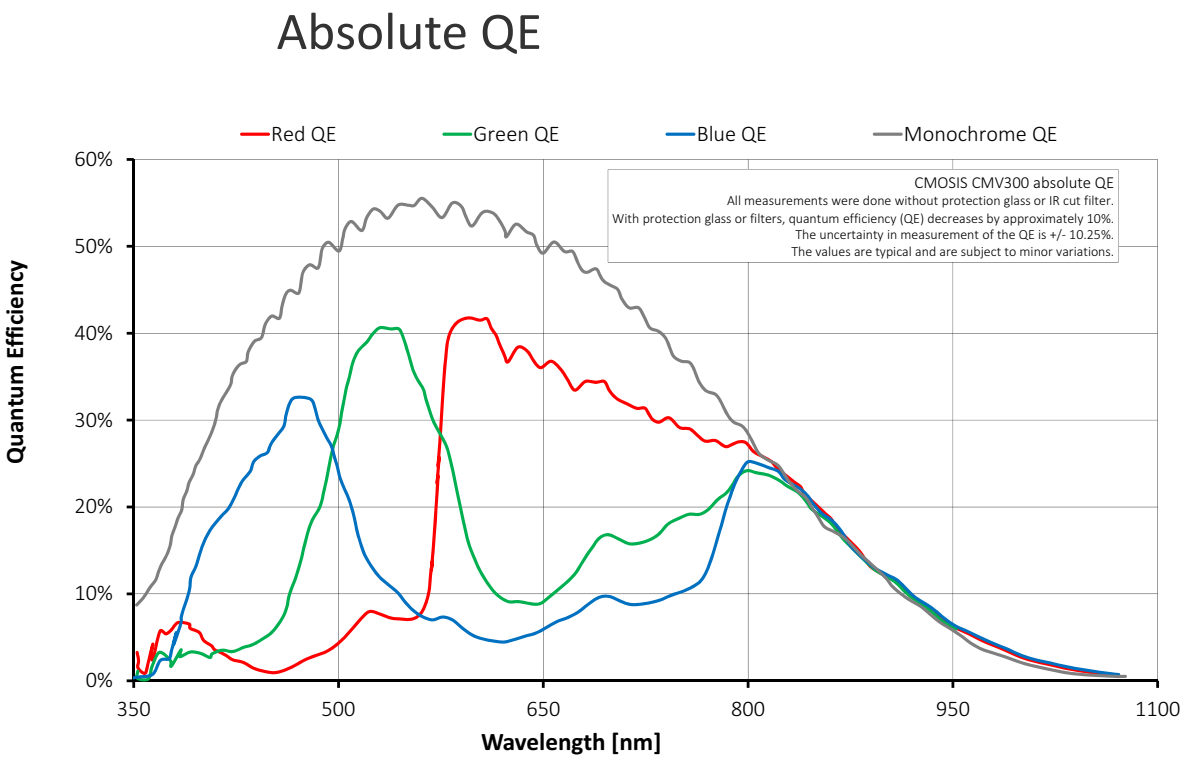


Figure 1: Mako G-030B, G-030C (CMOSIS CMV300) absolute QE

ROI frame rate

$$\text{Max. frame rate} = \frac{1}{204\ \mu s + 6.25\ \mu s \times \text{ROI height}}$$

Maximum frame rate at full resolution according to formula: 309 fps

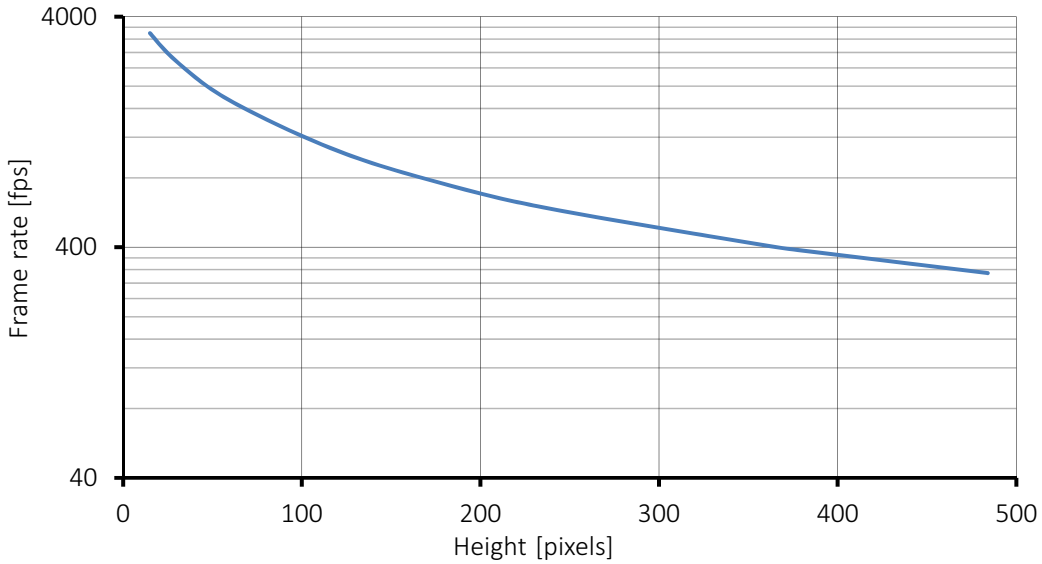


Figure 2: Frame rate as a function of ROI height

Height in pixels	Frame rate
484	309
480	312
384	384
360	407
240	586
180	752
120	1048
60	1727
30	2554
15	3393

Width = 644 pixels

Table 3: Frame rate as a function of ROI height

There will be an increase in frame rate with reduced width if the camera is bandwidth limited.

Mako G-032B, G-032C

Feature	Specification	
	Mako G-032B	**Mako G-032C**
Resolution	658 (H) x 492 (V) 0.3 MP	
Sensor	Sony ICX424AL	Sony ICX424AQ
Sensor type	CCD	
Shutter type	Global	
Sensor size	Type 1/3 6.0 mm diagonal	
Cell size	7.4 µm x 7.4 µm	
Lens mount	Standard: C-Mount Optional: See the Modular Concept	
Optical filter[1]	No optical filter	Hoya C-5000 IR cut filter
Maximum frame rate at full resolution	102.3 frames per second	
Maximum image bit depth	12-bit	
Image buffer	64 MB	
StreamHoldCapacity	Up to 202 frames at full resolution	
Monochrome formats	Mono8, Mono12Packed, Mono12	Mono8
Color formats (YUV)	n/a	YUV411Packed, YUV422Packed, YUV444Packed
Color formats (RGB)	n/a	RGB8Packed, BGR8Packed
RAW formats	n/a	BayerRG8, BayerRG12, BayerRG12Packed
Exposure control	10 µs to 93 s; 1 µs increments	
Gain control	0 to 30 dB; 1 dB increments	
Binning	Horizontal: 1 to 8 columns Vertical: 1 to 14 rows	
Decimation	n/a	
Opto-isolated I/Os	1 input, 3 outputs	
Voltage requirements	12 to 24 VDC; PoE	
Power consumption	2.4 W @ 12 VDC; 2.8 W PoE	
Trigger latency[2]	Idle state: 7.2 µs; Frame valid state: 16.9µs	
Trigger jitter[2]	Idle state: 4.0 µs; Frame valid state: 13.7 µs	
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10°C to +70°C ambient temperature (without condensation)	

Table 4: Mako G-032B, G-032C model specifications

Feature	Specification	
	Mako G-032B	Mako G-032C
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	
Mass (typical)	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only. Resolution: 0.031; Accuracy: ± 1 °C	

[1] For more information on available optical filters see the Modular Concept.

[2] It is possible to start the exposure of next frame while previous frame is read out:

- Idle state: sensor is ready and camera is idle, waiting for the next trigger.
- Frame valid state: sensor is reading out and camera is busy. If next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state.

Table 4: Mako G-032B, G-032C model specifications (continued)

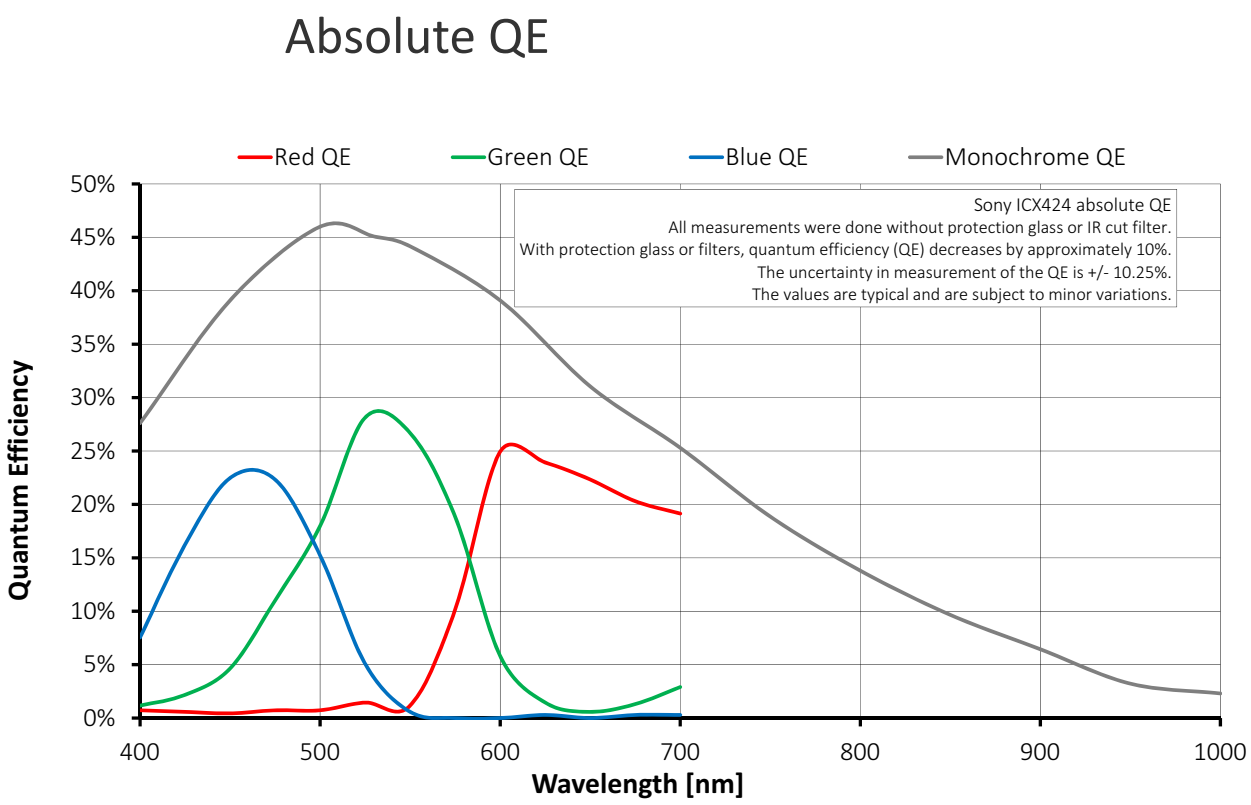


Figure 3: Mako G-032B, G-032C (Sony ICX424) absolute QE

ROI frame rate

$$\text{Max. frame rate} = \frac{1}{19.46\ \mu s \times \text{ROI height} + 2.29\ \mu s \times (492 - \text{ROI height}) + 195.81\ \mu s}$$

Maximum frame rate at full resolution according to formula: 102.3 fps

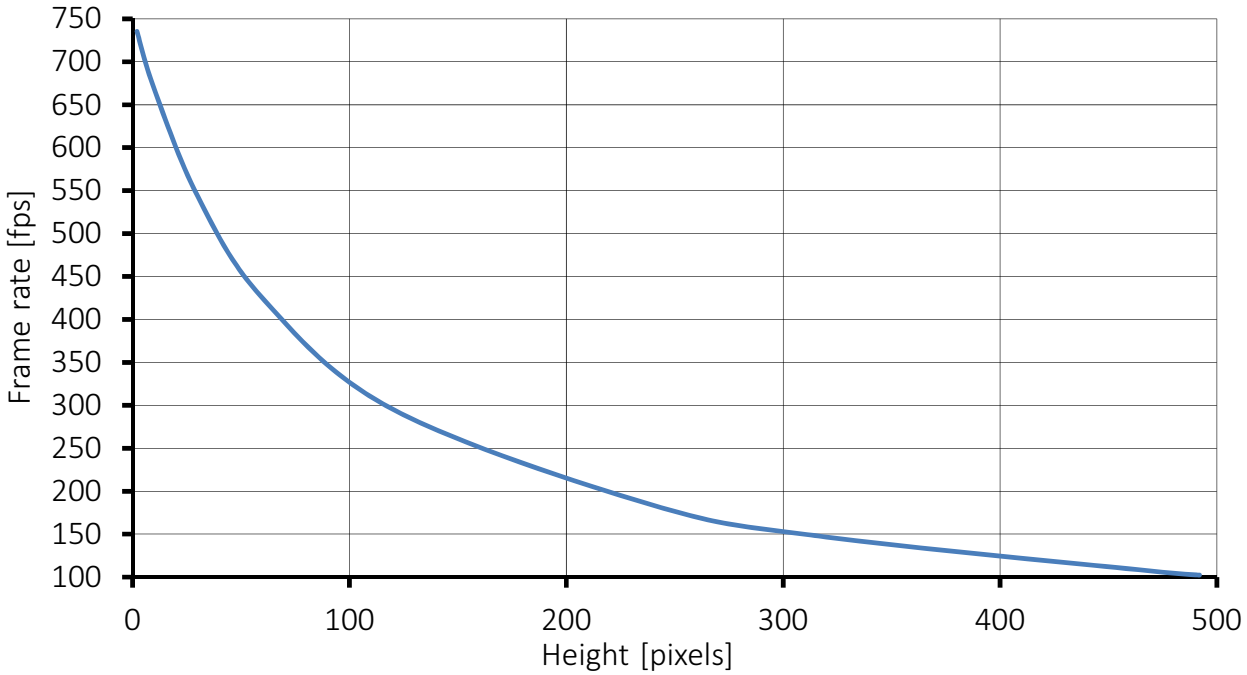


Figure 4: Frame rate as a function of ROI height

Height in pixels	Frame rate
492	102.3
480	104.5
320	146.6
240	183.5
120	295.3

Height in pixels	Frame rate
60	424.5
30	543.3
10	667.9
2	735.4

Width = 658 pixels

Table 5: Frame rate as a function of ROI height

Frame rate = theoretical maximum frame rate (in frames per second) of the CCD sensor according to given formula.

Mako G-125B, G-125C

Feature	Specification	
	Mako G-125B	**Mako G-125C**
Resolution	1292 (H) x 964 (V) 1.2 MP	
Sensor	Sony ICX445ALA	Sony ICX445AQA
Sensor type	CCD	
Shutter type	Global	
Sensor size	Type 1/3 6.0 mm diagonal	
Cell size	3.75 µm x 3.75 µm	
Lens mount	Standard: C-Mount Optional: See the Modular Concept	
Optical filter[1]	No optical filter	Hoya C-5000 IR cut filter
Maximum frame rate at full resolution	30.3 frames per second	
Maximum image bit depth	12-bit	
Image buffer	64 MB	
StreamHoldCapacity	Up to 52 frames at full resolution	
Monochrome formats	Mono8, Mono12Packed, Mono12	Mono8
Color formats (YUV)	n/a	YUV411Packed, YUV422Packed, YUV444Packed
Color formats (RGB)	n/a	RGB8Packed, BGR8Packed
RAW formats	n/a	BayerRG8, BayerRG12, BayerRG12Packed
Exposure control	12 µs to 84 s; 1 µs increments	
Gain control	0 to 30 dB; 1 dB increments	
Binning	Horizontal: 1 to 8 columns Vertical: 1 to 14 rows	
Decimation	n/a	
Opto-isolated I/Os	1 input, 3 outputs	
Voltage requirements	12 to 24 VDC; PoE	
Power consumption	2.3 W @ 12 VDC; 2.7 W PoE	
Trigger latency[2]	Idle state: 8.0 µs; Frame valid state: 25.0 µs	
Trigger jitter[2]	Idle state: 4.0 µs; Frame valid state: 21.0 µs	
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)	

Table 6: Mako G-125B, G-125C model specifications

Feature	Specification	
	Mako G-125B	Mako G-125C
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	
Mass (typical)	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only. Resolution: 0.031; Accuracy: ± 1 °C	

[1] For more information on available optical filters see the Modular Concept.

[2] It is possible to start the exposure of next frame while previous frame is read out:

- Idle state: sensor is ready and camera is idle, waiting for the next trigger.
- Frame valid state: sensor is reading out and camera is busy. If next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state.

Table 6: Mako G-125B, G-125C model specifications (continued)

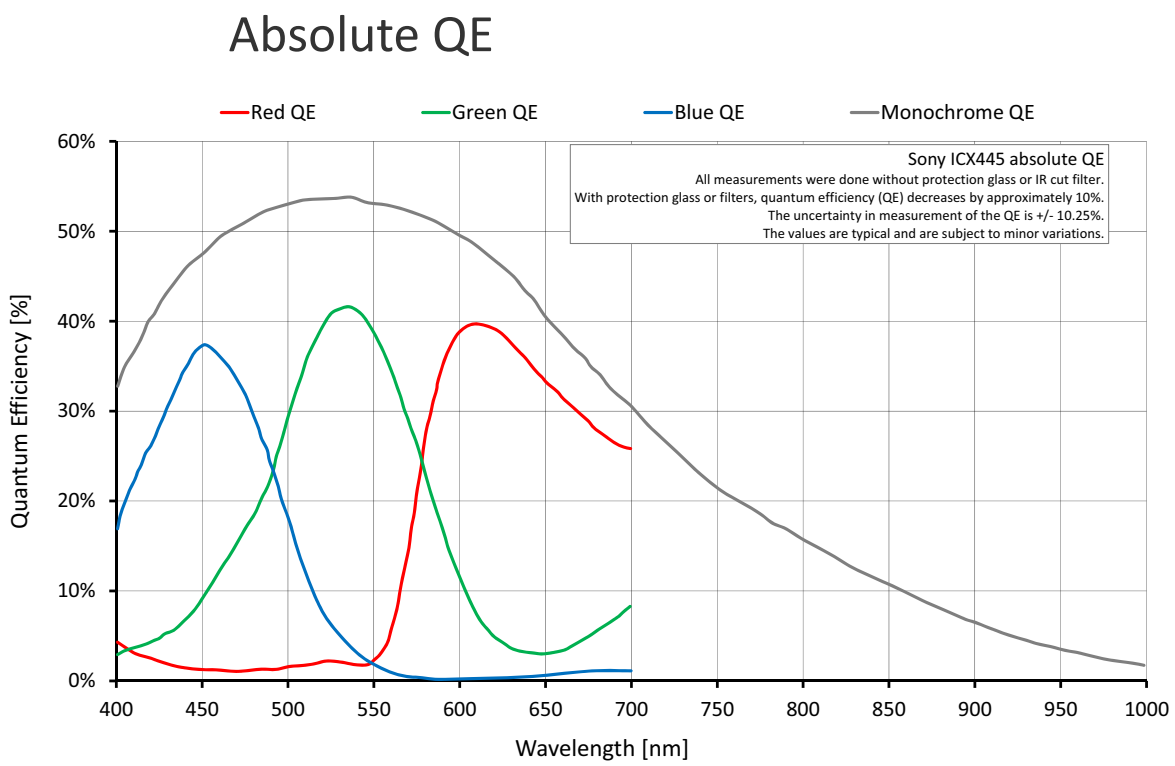


Figure 5: Mako G-125B, G-125C (Sony ICX445) absolute QE

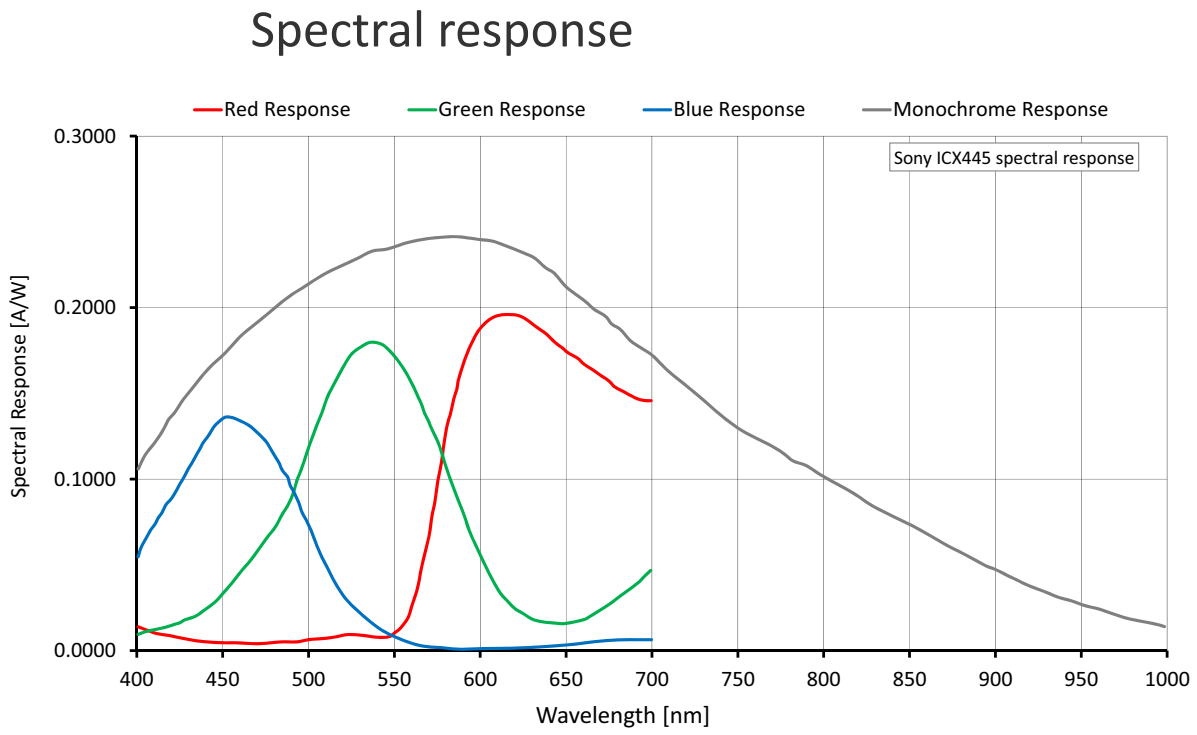


Figure 6: Mako G-125B, G-125C (Sony ICX445) spectral response

ROI frame rate

$$\text{Max. frame rate} = \frac{1}{34.01\ \mu s \times \text{ROI height} + 3.09\ \mu s \times (964 - \text{ROI height}) + 176.42\ \mu s}$$

Maximum frame rate at full resolution according to formula: 30.3 fps

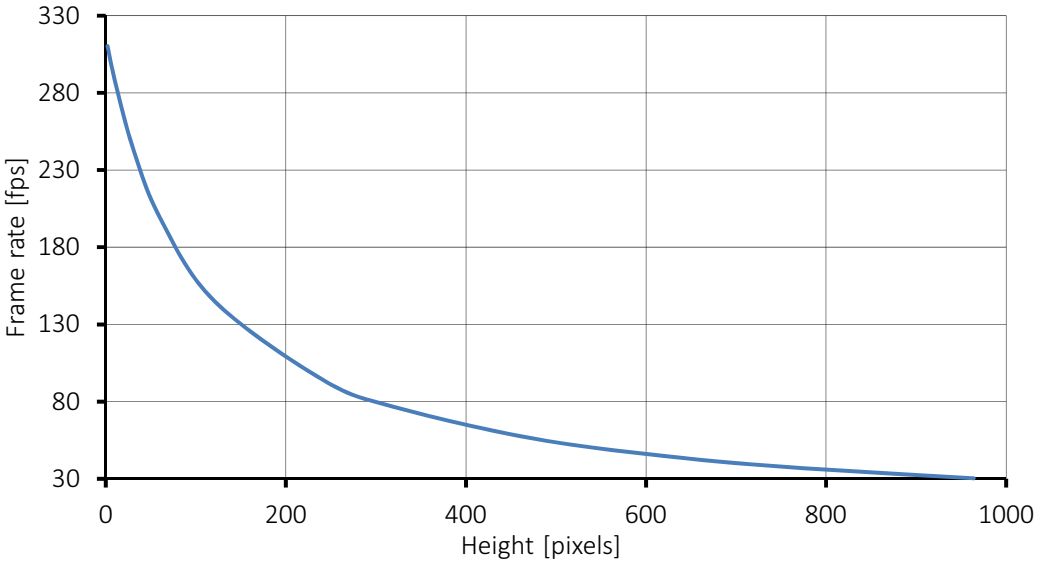


Figure 7: Frame rate as a function of ROI height

Height in pixels	Frame rate
964	30.3
960	30.4
768	37.1
640	43.5
480	55.5
320	76.5

Height in pixels	Frame rate
240	94.4
120	145.5
60	199.3
30	244.5
10	288.1
2	310.3

Width = 1292 pixels

Table 7: Frame rate as a function of ROI height

Frame rate = theoretical maximum frame rate (in frames per second) of the CCD sensor according to given formula.

Mako G-131B, G-131C

Feature	Specification			
	Mako G-131B		Mako G-131C	
Resolution	1280 (H) x 1024 (V) 1.3 MP			
Sensor	e2v EV76C560			
Sensor type	CMOS			
Shutter type	Global, Global Reset, and Rolling			
Sensor size	Type 1/1.8 8.7 mm diagonal			
Cell size	5.3 µm x 5.3 µm			
Lens mount	Standard: C-Mount Optional: See the Modular Concept			
Optical filter[1]	No optical filter		Hoya C-5000 IR cut filter	
Maximum frame rate at full resolution	62 frames per second			
Maximum image bit depth	10-bit			
Image buffer	64 MB			
StreamHoldCapacity	Up to 50 frames at full resolution			
Monochrome formats	Mono8, Mono10		Mono8	
Color formats (YUV)	n/a		YUV411Packed, YUV422Packed, YUV444Packed	
Color formats (RGB)	n/a		RGB8Packed, BGR8Packed	
RAW formats	n/a		BayerBG8, BayerBG10	
Exposure control	**Pixel format**	**Shutter mode: Global**	**Shutter mode: Global Reset**	**Shutter mode: Rolling**
	Mono8, Mono10, BayerBG8, BayerBG10, YUV411Packed, YUV422Packed	12 µs to 1.012 s; 1 µs increments	12 µs to 0.978 s; 1 µs increments	12 µs to 0.994 s; 1 µs increments
	RGB8Packed, BGR8Packed, YUV444Packed	12 µs to 2.124 s; 1 µs increments	12 µs to 2.053 s; 1 µs increments	12 µs to 2.086 s; 1 µs increments
Gain control	0 to 24 dB; 1 dB increments			
Binning	Horizontal: 1 to 2 pixels Vertical: 1 to 2 rows e2v sensors support 1x1 and 2x2 binning.			

Table 8: Mako G-131B, G-131C model specifications

Feature	Specification	
	Mako G-131B	Mako G-131C
Decimation	Horizontal and Vertical: 1, 2, 4, 8 factor	
Opto-isolated I/Os	1 input, 3 outputs	
Voltage requirements	12 to 24 VDC; PoE	
Power consumption	2.0 W @ 12 VDC; 2.2 W PoE	
Trigger latency[2]	Idle state: 32.6 µs; Frame valid state: 32.6 µs	
Trigger jitter[2]	Idle state: 8.1 µs; Frame valid state: 8.1 µs	
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)	
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	
Mass (typical)	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only. Resolution: 0.031; Accuracy: ± 1 °C	

[1] For more information on available optical filters see the Modular Concept.

[2] These values are calculated directly from the microcontroller source. These values are only valid for pixel formats < 16 bits per pixel and applicable in both Idle and Frame valid states:

- Idle state: sensor is ready and camera is idle, waiting for the next trigger.
- Frame valid state: sensor is reading out and camera is busy. If next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state.
- The e2v sensor does not support exposure duration via external level trigger.

Table 8: Mako G-131B, G-131C model specifications (continued)

Overlapping exposure and readout

The e2v sensor does not support overlapped exposure and readout in hardware trigger mode or in global reset mode.

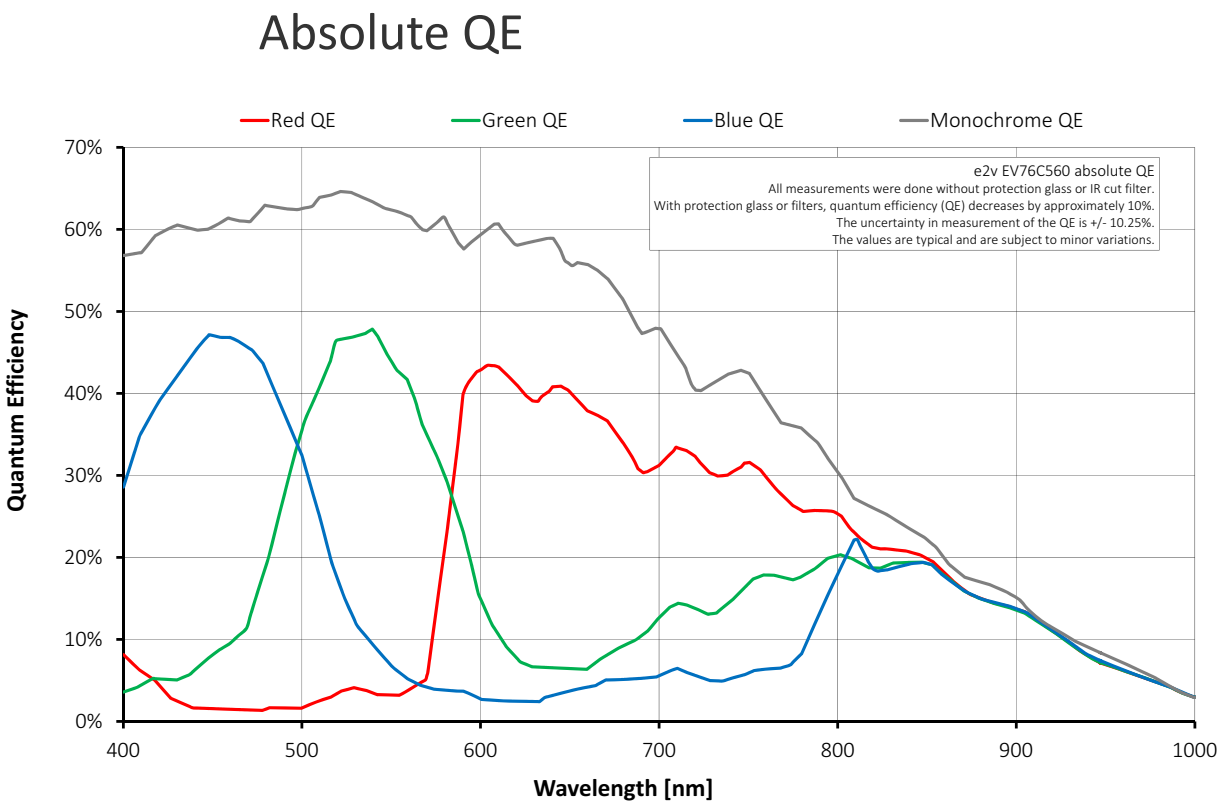


Figure 8: Mako G-131B, G-131C (e2v EV76C560) absolute QE

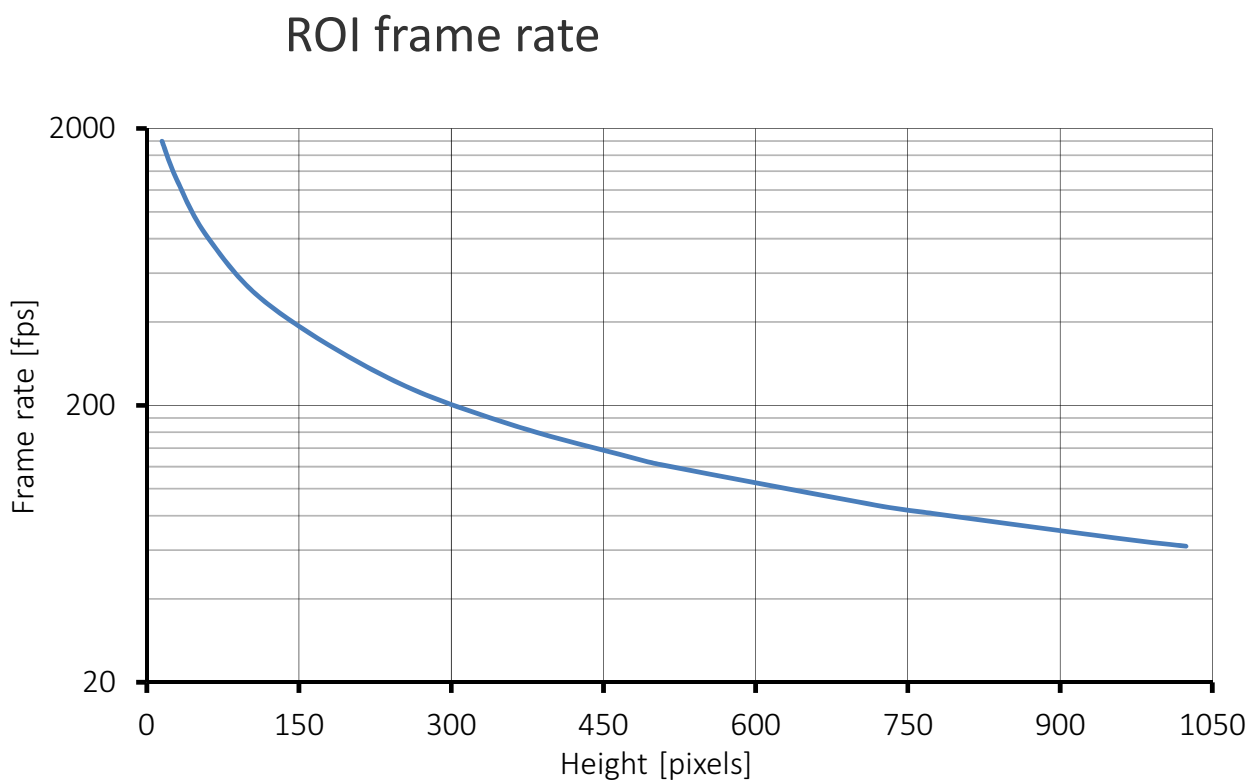


Figure 9: Frame rate as a function of ROI height

Height in pixels	Frame rate
1024	62
960	66
768	82
720	87
512	121
480	129
360	170
240	249
120	462
60	809
30	1295
15	1798

Width = 1280 pixels

Table 9: Frame rate as a function of ROI height

There will be an increase in frame rate with reduced width if the camera is bandwidth limited.

Mako G-192B, G-192C

Feature	Specification			
	Mako G-192B	Mako G-192C		
Resolution	1600 (H) x 1200 (V) 1.9 MP			
Sensor	e2v EV76C570			
Sensor type	CMOS			
Shutter type	Global, Global Reset, and Rolling			
Sensor size	Type 1/1.8 9 mm diagonal			
Cell size	4.5 µm x 4.5 µm			
Lens mount	Standard: C-Mount Optional: See the Modular Concept			
Optical filter[1]	No optical filter	Hoya C-5000 IR cut filter		
Maximum frame rate at full resolution	60 frames per second			
Maximum image bit depth	10-bit			
Image buffer	64 MB			
StreamHoldCapacity	Up to 34 frames at full resolution			
Monochrome formats	Mono8, Mono10	Mono8		
Color formats (YUV)	n/a	YUV411Packed, YUV422Packed, YUV444Packed		
Color formats (RGB)	n/a	RGB8Packed, BGR8Packed		
RAW formats	n/a	BayerBG8, BayerBG10		
Exposure control	**Pixel format**	**Shutter mode: Global or Rolling**	**Shutter mode: Global Reset**	
	Mono8, Mono10, BayerBG8, BayerBG10, YUV411Packed, YUV422Packed	14 µs to 0.891 s; 1 µs increments	14 µs to 0.874 s; 1 µs increments	
	RGB8Packed, BGR8Packed, YUV444Packed	14 µs to 1.870 s; 1 µs increments	14 µs to 1.835 s; 1 µs increments	
Gain control	0 to 24 dB; 1 dB increments			
Binning	Horizontal: 1 to 2 pixels Vertical: 1 to 2 rows e2v sensors support 1x1 and 2x2 binning.			
Decimation	Horizontal and Vertical: 1, 2, 4, 8 factor			
Opto-isolated I/Os	1 input, 3 outputs			

Table 10: Mako G-192B, G-192C model specifications

Feature	Specification	
	Mako G-192B	Mako G-192C
Voltage requirements	12 to 24 VDC; PoE	
Power consumption	2.1 W @ 12 VDC; 2.4 W PoE	
Trigger latency[2]	Idle state: 27.7 µs; Frame valid state: 27.7 µs	
Trigger jitter[2]	Idle state: 6.9 µs; Frame valid state: 6.9 µs	
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)	
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	
Mass (typical)	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only. Resolution: 0.031; Accuracy: ± 1 °C	

[1] For more information on available optical filters see the Modular Concept.

[2] These values are calculated directly from the microcontroller source. These values are only valid for pixel formats < 16 bits per pixel and applicable in both Idle and Frame valid state:

- Idle state: sensor is ready and camera is idle, waiting for the next trigger.
- Frame valid state: sensor is reading out and camera is busy. If next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state.
- The e2V sensor does not support exposure duration via external level trigger.

Table 10: Mako G-192B, G-192C model specifications (continued)

Overlapping exposure and readout

The e2v sensor does not support overlapped exposure and readout in hardware trigger mode or in global reset mode.

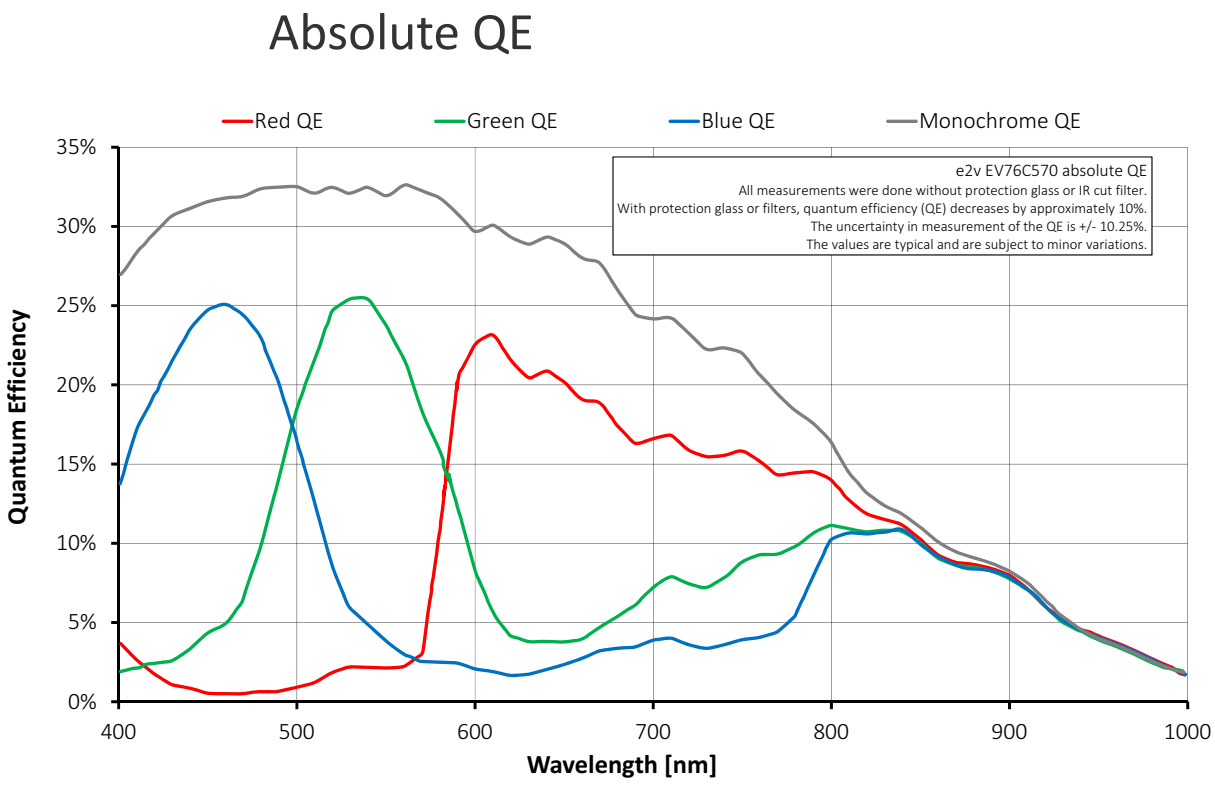


Figure 10: Mako G-192B, G-192C (e2v EV76C570) absolute QE

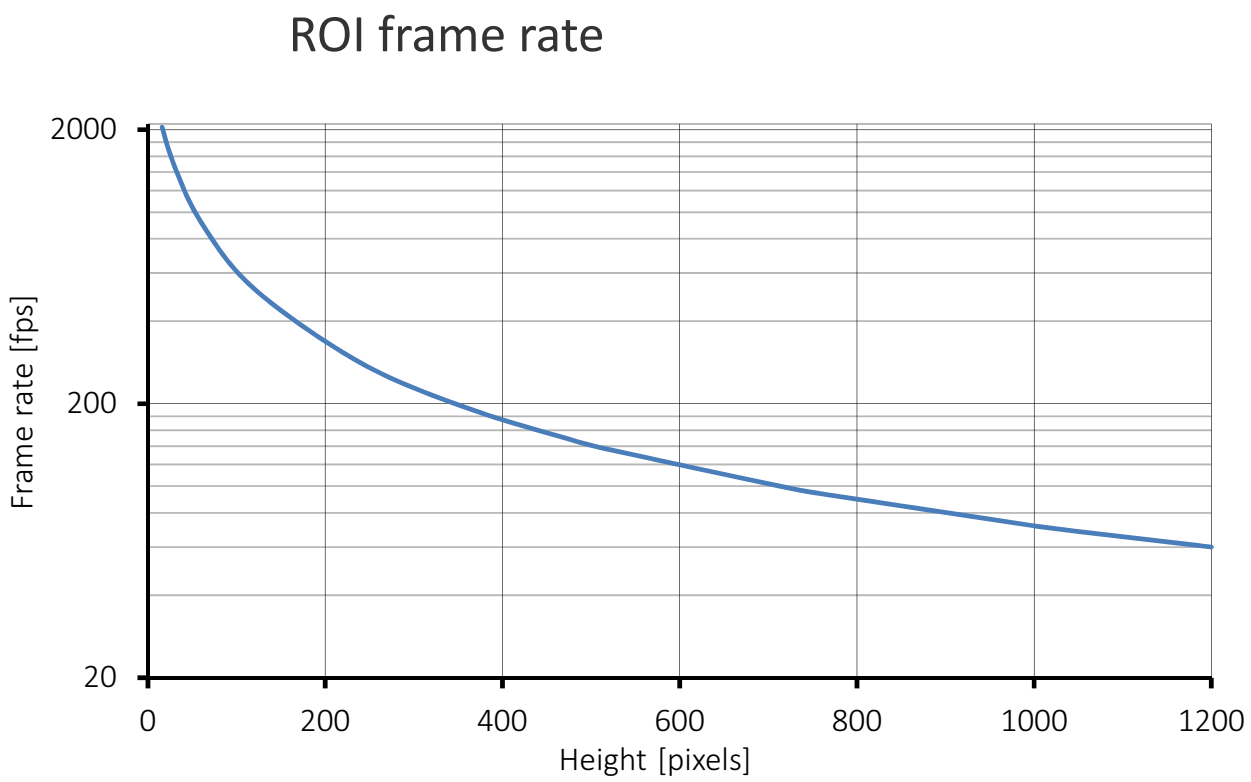


Figure 11: Frame rate as a function of ROI height

Height in pixels	Frame rate
1200	60
1024	70
960	75
768	93
720	99
512	138
480	147

Height in pixels	Frame rate
360	193
240	282
120	525
60	919
30	1470
16	2042

Width = 1600 pixels

Table 11: Frame rate as a function of ROI height

There will be an increase in frame rate with reduced width if the camera is bandwidth limited.

Mako G-223B, G-223B NIR, G-223C

Feature	Specification	
	Mako G-223B, G-223B NIR	**Mako G-223C**
Resolution	2048 (H) x 1088 (V) 2.2 MP	
Sensor	CMOSIS CMV2000	
Sensor type	CMOS	
Shutter type	Global	
Sensor size	Type 2/3 12.7 mm diagonal	
Cell size	5.5 µm x 5.5 µm	
Lens mount	Standard: C-Mount Optional: See the Modular Concept	
Optical filter[1]	No optical filter	Hoya C-5000 IR cut filter
Maximum frame rate at full resolution	49.5 frames per second	
Maximum image bit depth	12-bit	
Image buffer	64 MB	
StreamHoldCapacity	Up to 29 frames at full resolution	
Monochrome formats	Mono8, Mono12Packed, Mono12	Mono8
Color formats (YUV)	n/a	YUV411Packed, YUV422Packed, YUV444Packed
Color formats (RGB)	n/a	RGB8Packed, BGR8Packed, RGBA8Packed, BGRA8Packed
RAW formats	n/a	BayerGB8, BayerGB12, BayerGB12Packed
Exposure control[2]	21 µs to 153 s; 1 µs increments	
Gain control	0 to 26 dB; 1 dB increments	
Binning	n/a	
Decimation	n/a	
Opto-isolated I/Os	1 input, 3 outputs	
Voltage requirements	12 to 24 VDC; PoE	
Power consumption	2.4 W @ 12 VDC; 2.8 W PoE	
Trigger latency	Please contact support for more information.	
Trigger jitter	Please contact support for more information.	
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)	

Table 12: Mako G-223B, G-223B NIR, G-223C model specifications

Feature	Specification	
	Mako G-223B, G-223B NIR	Mako G-223C
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	
Mass (typical)	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only. Resolution: 0.031; Accuracy: ± 1 °C	

[1] For more information on available optical filters see the Modular Concept.

[2] Camera firmware v1.52.8151 shows minimum exposure values without frame overhead time, i.e., 1 µs. See sensor data sheet for details on frame overhead time. This will be fixed in the next firmware release.

Table 12: Mako G-223B, G-223B NIR, G-223C model specifications (continued)

Absolute QE

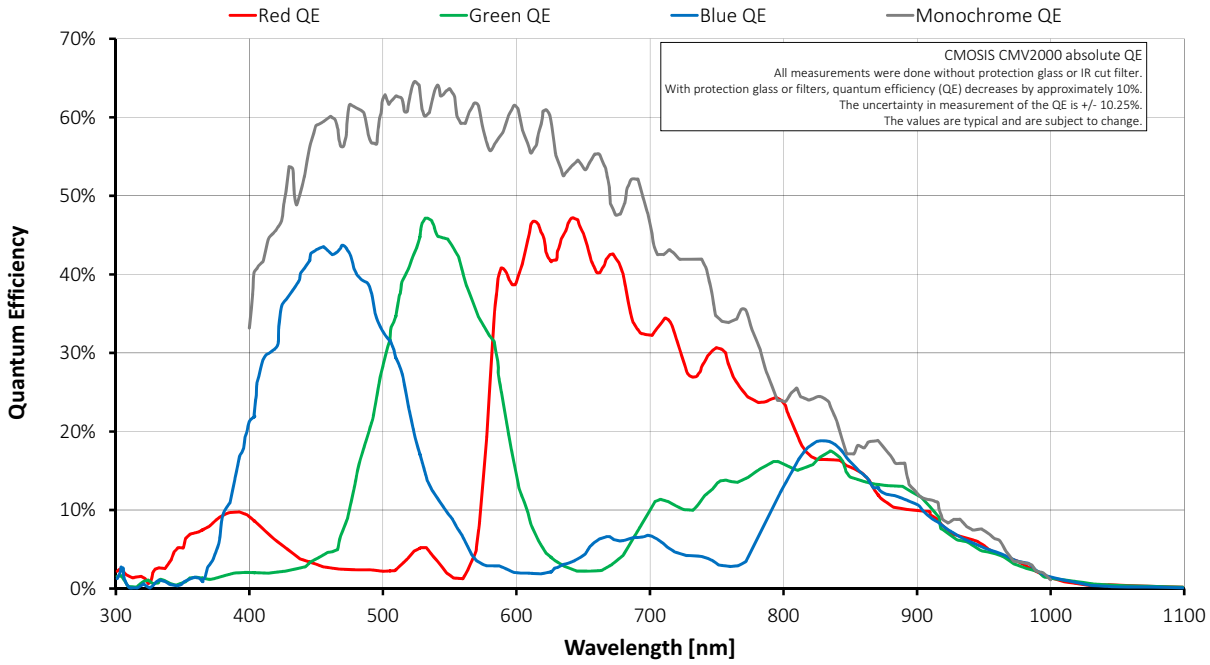


Figure 12: Mako G-223B, G-223B NIR, G-223C (CMOSIS CMV2000) absolute QE (without IR cut filter)

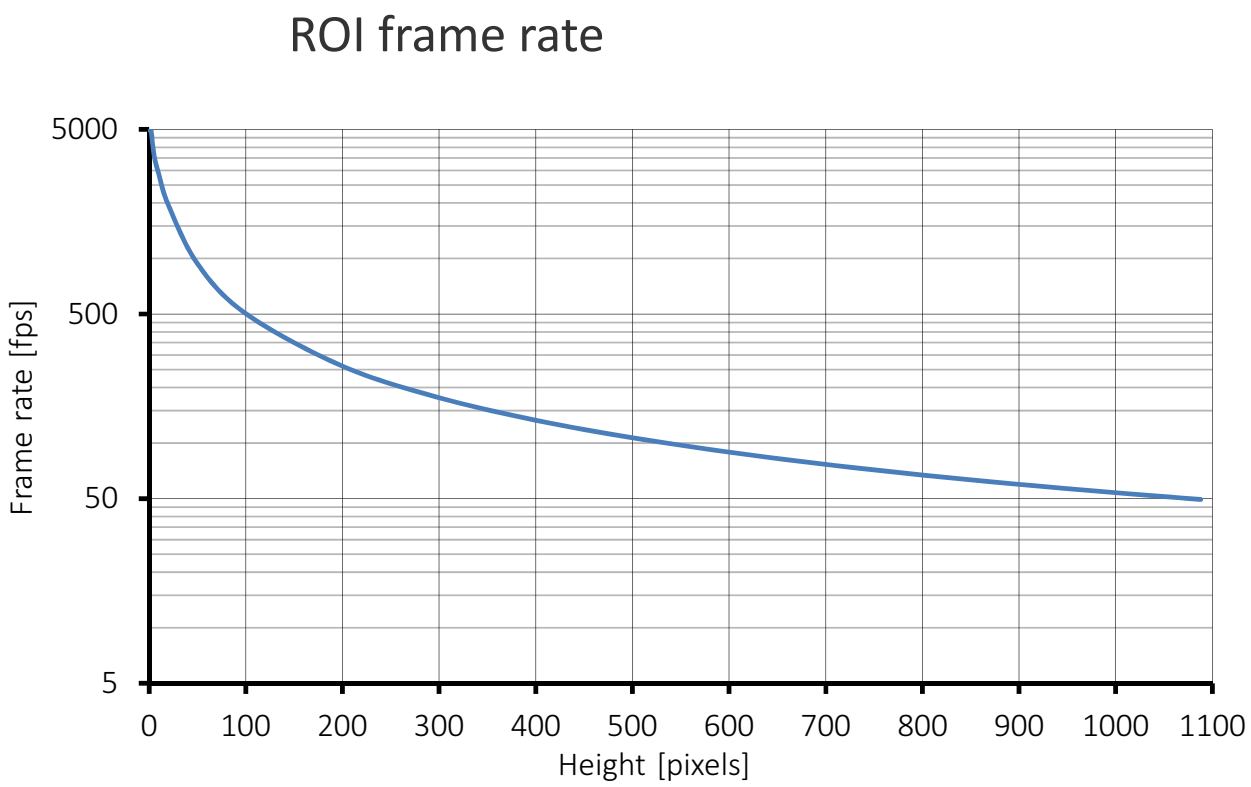


Figure 13: Frame rate as a function of ROI height

Height in pixels	Frame rate
1088	49.5
1000	53.8
900	59.7
800	67.1
700	76.6
600	89.2
500	106.8
400	132.9
300	176.1

Height in pixels	Frame rate
200	260.8
100	502.1
50	934.6
20	1933.8
10	2847.3
5	3624.5
2	4906.7
1	4926.1

Width = 2048 pixels

Table 13: Frame rate as a function of ROI height

There will be an increase in frame rate with reduced width if the camera is bandwidth limited.

Mako G-234B, G-234C

Feature	Specification	
	Mako G-234B	**Mako G-234C**
Resolution	1936 (H) x 1216 (V) 2.35 MP	
Sensor	Sony IMX249LLJ	Sony IMX249LQJ
Sensor type	CMOS	
Shutter type	Global	
Sensor size	Type 1/1.2 13.4 mm diagonal	
Cell size	5.86 µm x 5.86 µm	
Lens mount	Standard: C-Mount Optional: See the Modular Concept	
Optical filter[1]	No optical filter	Hoya C-5000 IR cut filter
Sensor output	10-bit or 12-bit	
Maximum frame rate at full resolution	41.2 frames per second (10-bit) 31.8 frames per second (12-bit)	
Maximum image bit depth	12-bit	
Image buffer	64 MB	
StreamHoldCapacity	Up to 28 frames at full resolution	
Monochrome formats	Mono8, Mono12Packed, Mono12	Mono8
Color formats (YUV)	n/a	YUV411Packed, YUV422Packed, YUV444Packed
Color formats (RGB)	n/a	RGB8Packed, BGR8Packed
RAW formats	n/a	BayerRG8, BayerRG12, BayerRG12Packed
Exposure control[2]	**Pixel format**	**Value**
	Mono8, BayerRG8, BayerRG12, BayerRG12Packed, YUV411Packed, YUV422Packed	52 µs to 71 s; 19.3 µs increments (10-bit) 63 µs to 71 s; 25 µs increments (12-bit)
	RGB8Packed, BGR8Packed, YUV444Packed	91 µs to 71 s; 38.6 µs increments (10-bit) 113 µs to 71 s; 50 µs increments (12-bit)
Gain control	0 to 40 dB; 0.1 dB increments	
Binning	Horizontal: 1 to 4 pixels Vertical: 1 to 4 rows	
Decimation	Horizontal and Vertical: 1, 2, 4, 8 factor	
Opto-isolated I/Os	1 input, 3 outputs	
Voltage requirements	12 to 24 VDC; PoE	
Power consumption	2.4 W @ 12 VDC; 2.8 W PoE	

Table 14: Mako G-234B, G-234C model specifications

Feature	Specification	
	Mako G-234B	Mako G-234C
Trigger latency[3]	**Pixel format**	**Value**
	Mono8, BayerRG8, BayerRG12, BayerRG12Packed, YUV411Packed, YUV422Packed	58.2 µs (10-bit), 75.6 µs (12-bit)
	RGB8Packed, BGR8Packed, YUV444Packed	116.4 µs (10-bit), 151.2 µs (12-bit)
Trigger jitter[3]	**Pixel format**	**Value**
	Mono8, BayerRG8, BayerRG12, BayerRG12Packed, YUV411Packed, YUV422Packed	9.6 µs (10-bit), 12.5 µs (12-bit)
	RGB8Packed, BGR8Packed, YUV444Packed	19.3 µs (10-bit), 25 µs (12-bit)
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)	
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	
Mass (typical)	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only. Resolution: 0.031; Accuracy: ± 1 °C	

[1] For more information on available optical filters see the Modular Concept.

[2] Whenever pixel format is changed, Exposure will adjust itself to the nearest multiple of Exposure increment.

[3] It is possible to start the exposure of next frame while previous frame is read out:

- Idle state: sensor is ready and camera is idle, waiting for the next trigger.
- Frame valid state: sensor is reading out and camera is busy. If next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state.

Table 14: Mako G-234B, G-234C model specifications (continued)

With 10-bit sensor readout mode you can achieve a higher frame rate. The sensor is capable of higher frame rates but readout is limited by GigE bandwidth and exposure value. You can improve frame rates with a reduced region of interest and shorter exposure values.

SensorReadoutMode

For more information, see the GigE Features Reference.

Absolute QE

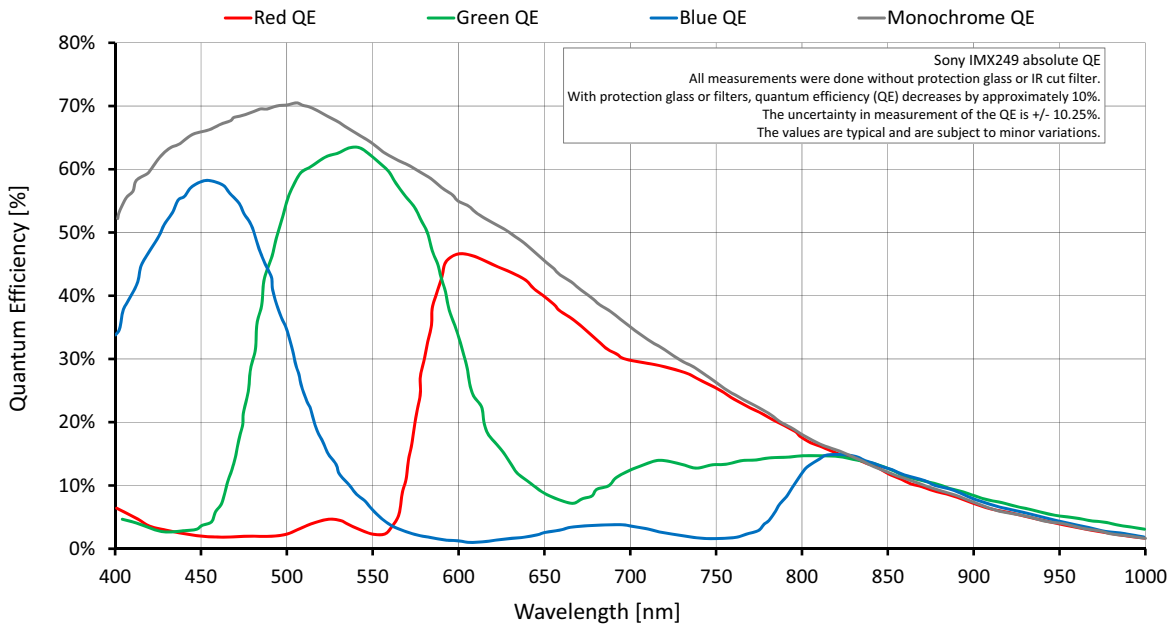


Figure 14: Mako G-234B, G-234C (Sony IMX249) absolute QE

Spectral response

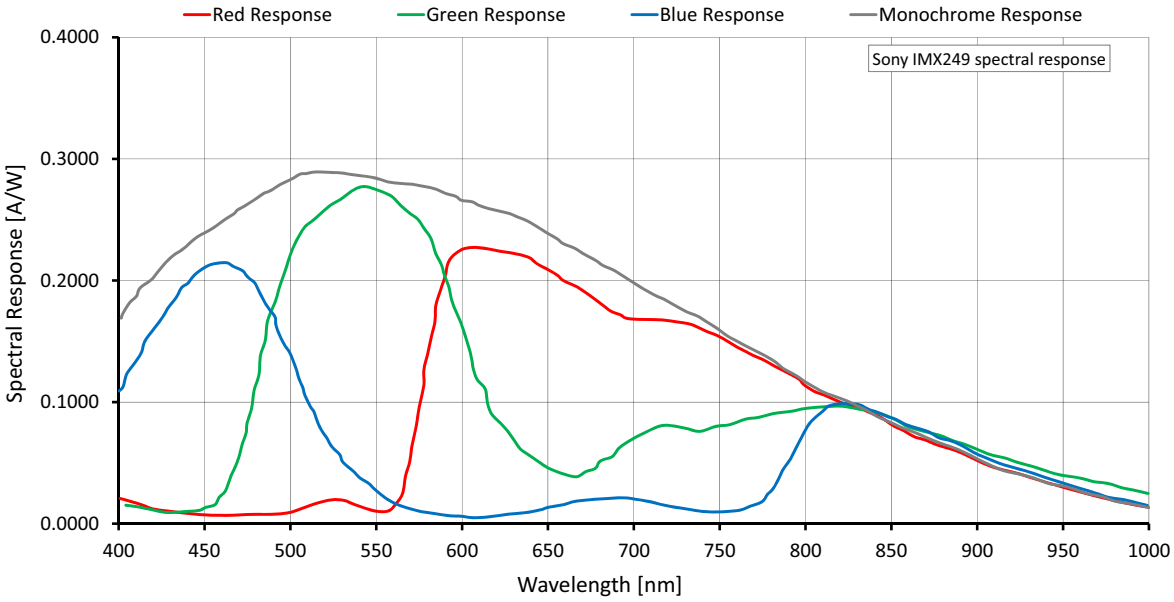


Figure 15: Mako G-234B, G-234C (Sony IMX249) spectral response

ROI frame rate

12-bit sensor readout

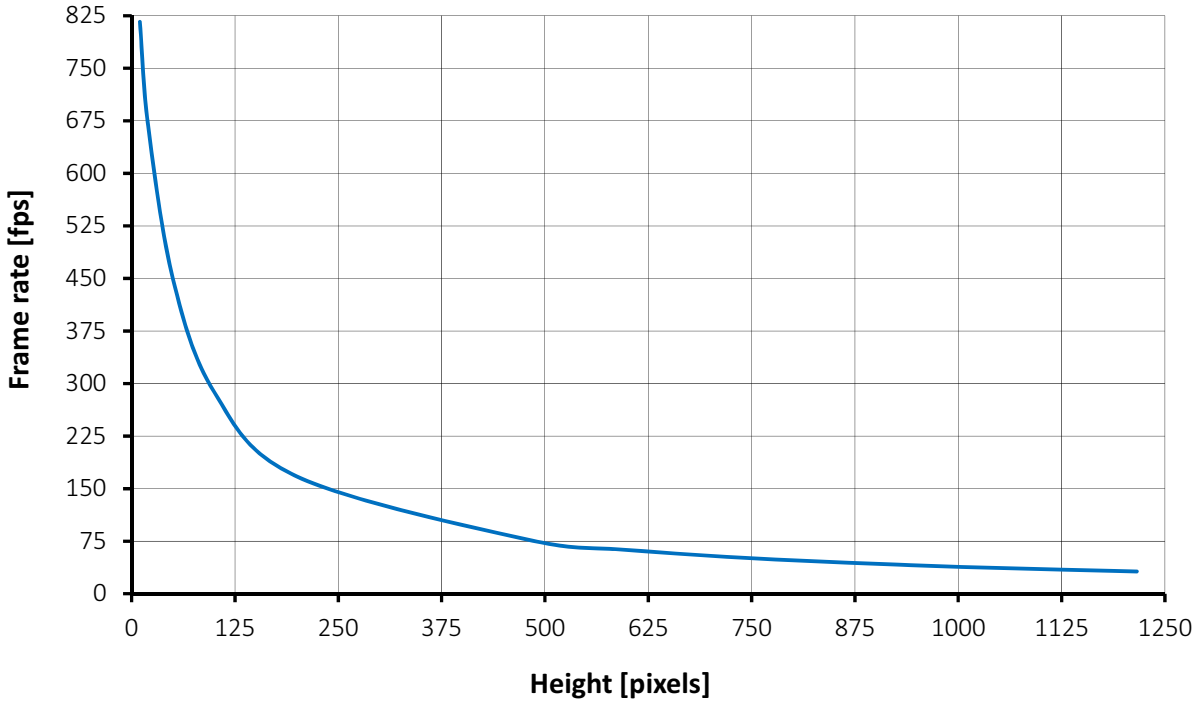


Figure 16: 12-bit sensor frame rate as a function of ROI height

Height in pixels	Frame rate
1216	31.8
1080	35.7
1024	37.6
960	40.0
768	49.5
600	62.5
480	77.0
200	167.3
100	287.7
50	449.4
20	677.9
10	816.3

Width = 1936 pixels

Table 15: 12-bit sensor frame rate as a function of ROI height

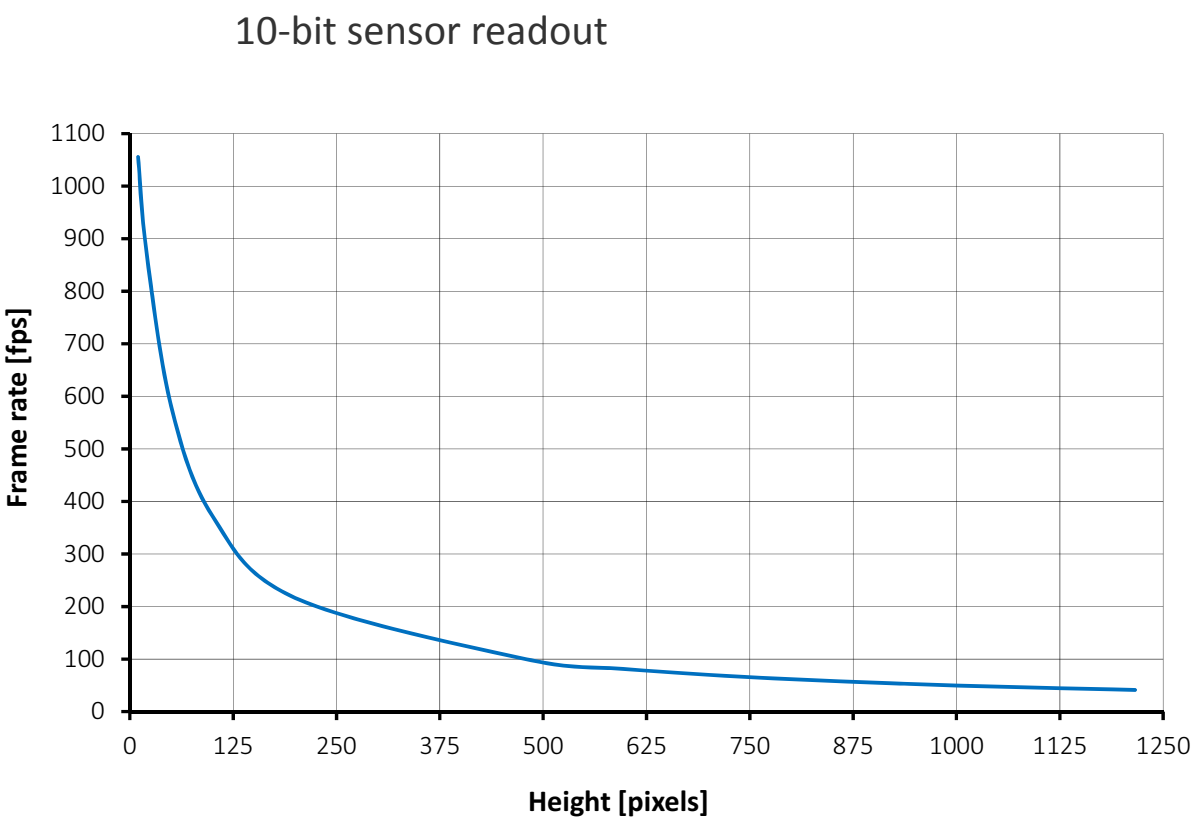


Figure 17: 10-bit sensor frame rate as a function of ROI height

Height in pixels	Frame rate	Height in pixels	Frame rate
1216	41.2	480	99.6
1080	46.2	200	216.4
1024	48.6	100	372.1
960	51.7	50	581.1
768	64.0	20	876.6
600	80.9	10	1055.6

Width = 1936 pixels

Table 16: Frame rate as a function of ROI height

Mako G-319B, G-319C

Feature	Specification	
	Mako G-319B	**Mako G-319C**
Resolution	2064 (H) x 1544 (V) 3.2 MP	
Sensor	Sony IMX265LLR	Sony IMX265LQR
Type	CMOS	
Shutter type	Global	
Sensor size	Type 1/1.8 8.9 mm diagonal	
Cell size	3.45 µm x 3.45 µm	
Lens mount	Standard: C-Mount Optional: See the Modular Concept	
Optical filter[1]	No optical filter	Hoya C-5000 IR cut filter
Maximum frame rate at full resolution	37.5 frames per second	
Maximum image bit depth	12-bit	
Image buffer	64 MB	
StreamHoldCapacity	Up to 20 frames at full resolution	
Monochrome formats	Mono8, Mono12Packed, Mono12	Mono8
Color formats (YUV)	n/a	YUV411Packed, YUV422Packed, YUV444Packed
Color formats (RGB)	n/a	RGB8Packed, BGR8Packed
RAW formats	n/a	BayerRG8, BayerRG12, BayerRG12Packed
Exposure control[2]	**Pixel format**	**Value**
	Mono8, Mono12Packed, BayerRG8 BayerRG12Packed, YUV411Packed	46 µs to 85.9 s; 16.5 µs increments
	Mono12, BayerRG12, YUV422Packed	57 µs to 85.9 s; 21.9 µs increments
	RGB8Packed, BGR8Packed, YUV444Packed	79 µs to 85.9 s; 32.9 µs increments
Gain control	0 to 40 dB; 0.1 dB increments	
Binning	Horizontal: 1 to 4 pixels Vertical: 1 to 4 rows	Horizontal: 1 to 4 pixels
Decimation	Horizontal and Vertical: 1, 2, 4, 8 factor	
Opto-isolated I/Os	1 input, 3 outputs	
Voltage requirements	12 to 24 VDC; PoE	

Table 17: Mako G-319B, G-319C model specifications

Feature	Specification	
	Mako G-319B	**Mako G-319C**
Power consumption	2.5 W @ 12 VDC; 2.7 W PoE	
Trigger latency[3]	**Pixel format**	**Value**
	Mono8, Mono12Packed, BayerRG8 BayerRG12Packed, YUV411Packed	49.4 µs
	Mono12, BayerRG12, YUV422Packed	65.8 µs
	RGB8Packed, BGR8Packed, YUV444Packed	98.9 µs
Trigger jitter[3]	**Pixel format**	**Value**
	Mono8, Mono12Packed, BayerRG8 BayerRG12Packed, YUV411Packed	8.1 µs
	Mono12, BayerRG12, YUV422Packed	10.9 µs
	RGB8Packed, BGR8Packed, YUV444Packed	16.5 µs
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)	
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	
Mass	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only. Resolution: 0.031; Accuracy: ± 1 °C	

1 For more information on available optical filters see the Modular Concept.

[2] Whenever `PixelFormat` is changed, exposure will adjust itself to the nearest multiple of exposure increment.

[3] It is possible to start the exposure of next frame while previous frame is read out:

- Idle state: sensor is ready and camera is idle, waiting for the next trigger.
- Frame valid state: sensor is reading out and camera is busy. If next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state.

Table 17: Mako G-319B, G-319C model specifications (continued)

Absolute QE

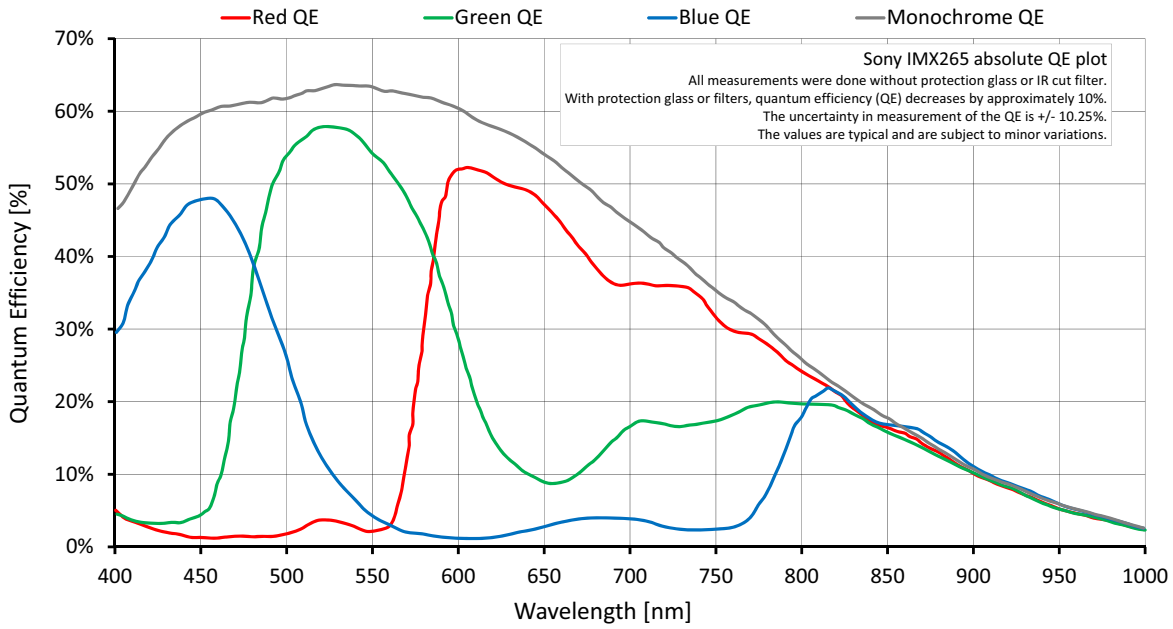


Figure 18: Mako G-319B, G-319C (Sony IMX265) absolute QE

Spectral response

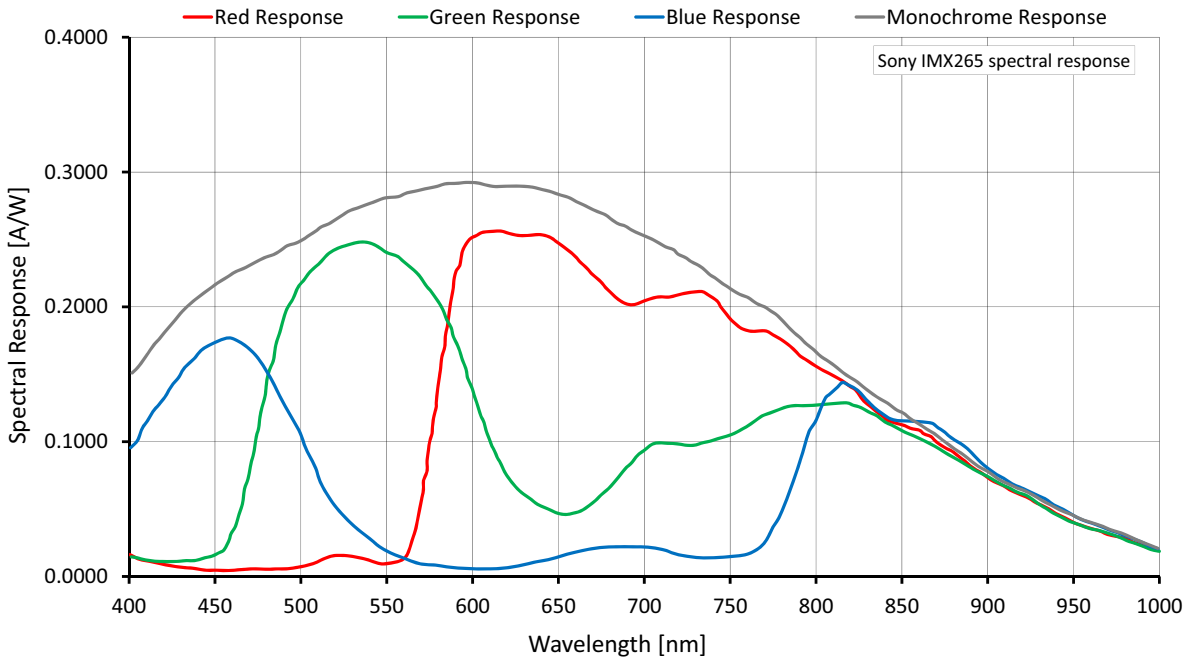


Figure 19: Mako G-319B, G-319C (Sony IMX265) spectral response

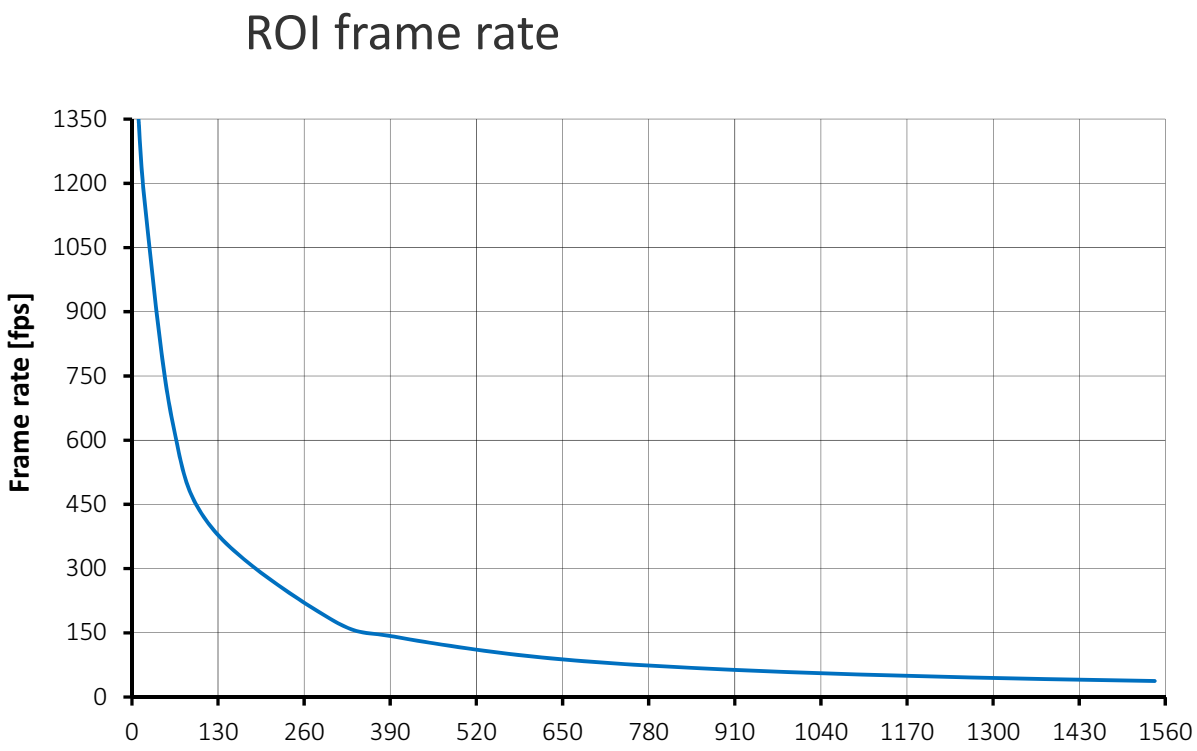


Figure 20: Frame rate as a function of ROI height

Height in pixels	Frame rate
1544	37.5
1280	45.3
1024	56.5
800	71.9
600	95.4
400	140.1
300	182.2
120	396.5
60	652.4
20	1144.8
10	1348.4

Width = 2064 pixels

Table 18: Frame rate as a function of ROI height

There will be an increase in frame rate with reduced width if the camera is bandwidth limited. Reducing the exposure time may result in higher frame rates.

Mako G-419B, G-419B NIR, G-419C

Feature	Specification	
	Mako G-419B, G-419B NIR	**Mako G-419C**
Resolution	2048 (H) x 2048 (V) 4.2 MP	
Sensor	CMOSIS CMV4000	
Sensor type	CMOS	
Shutter type	Global	
Sensor size	Type 1 16.0 mm diagonal	
Cell size	5.5 µm x 5.5 µm	
Lens mount	Standard: C-Mount Optional: See the Modular Concept	
Optical filter[1]	No optical filter	Hoya C-5000 IR cut filter
Maximum frame rate at full resolution	26.3 frames per second	
Maximum image bit depth	12-bit	
Image buffer	64 MB	
StreamHoldCapacity	Up to 15 frames at full resolution	
Monochrome formats	Mono8, Mono12Packed, Mono12	Mono8
Color formats (YUV)	n/a	YUV411Packed, YUV422Packed, YUV444Packed
Color formats (RGB)	n/a	RGB8Packed, BGR8Packed, RGBA8Packed, BGRA8Packed
RAW formats	n/a	BayerGB8, BayerGB12, BayerGB12Packed
Exposure control[1]	41 µs to 153 s; 1 µs increments	
Gain control	0 to 26 dB; 1 dB increments	
Binning	n/a	
Decimation	n/a	
Opto-isolated I/Os	1 input, 3 outputs	
Voltage requirements	12 to 24 VDC; PoE	
Power consumption	2.3 W @ 12 VDC; 2.7 W PoE	
Trigger latency	Please contact support for more information.	
Trigger jitter	Please contact support for more information.	
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)	

Table 19: Mako G-419B, G-419B NIR, G-419C model specifications

Feature	Specification	
	Mako G-419B, G-419B NIR	Mako G-419C
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	
Mass (typical)	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only Resolution: 0.031; Accuracy: ± 1 °C	

1 For more information on available optical filters see the Modular Concept.

[2] Camera firmware version 01.52.8151 shows minimum exposure values without frame overhead time, i.e., 1 µs. See sensor data sheet for details on frame overhead time. This will be fixed in the next firmware release.

Table 19: Mako G-419B, G-419B NIR, G-419C model specifications (continued)

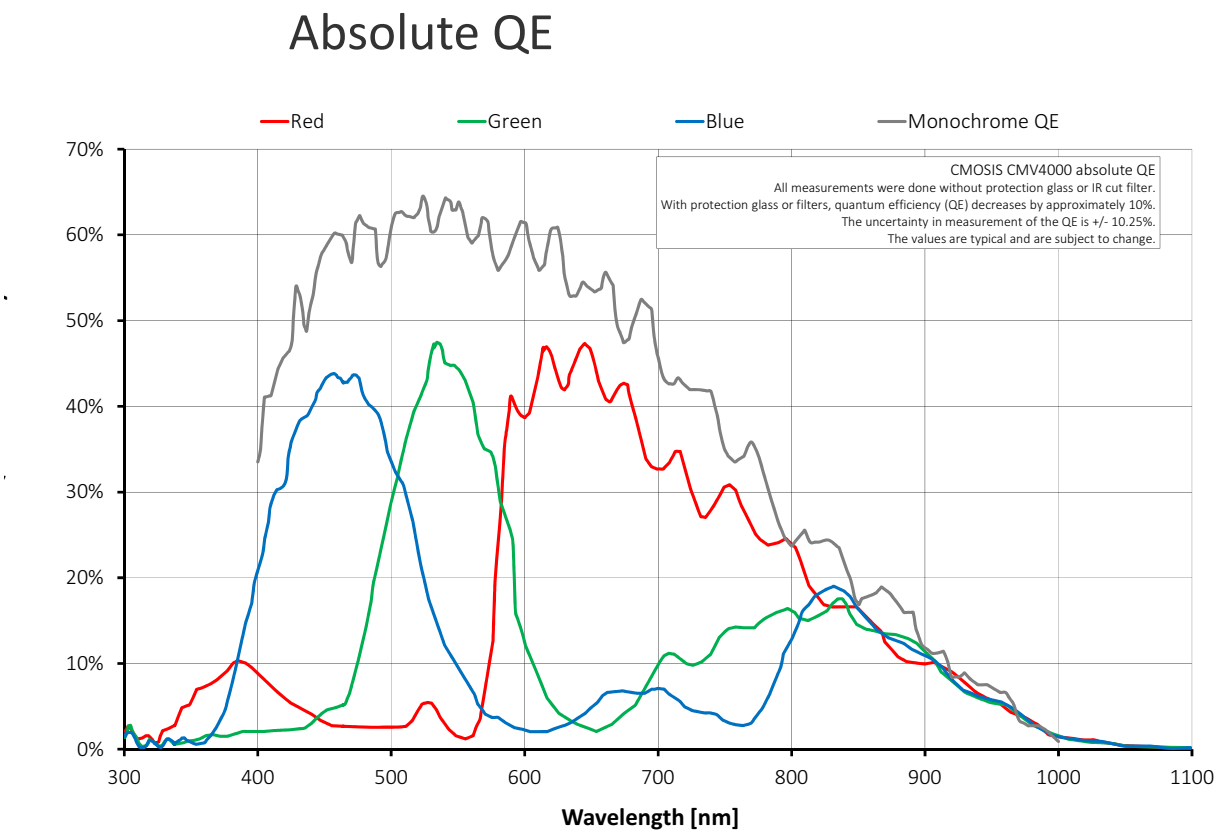


Figure 21: Mako G-419B, G-419B NIR, G-419C (CMOSIS CMV4000) absolute QE

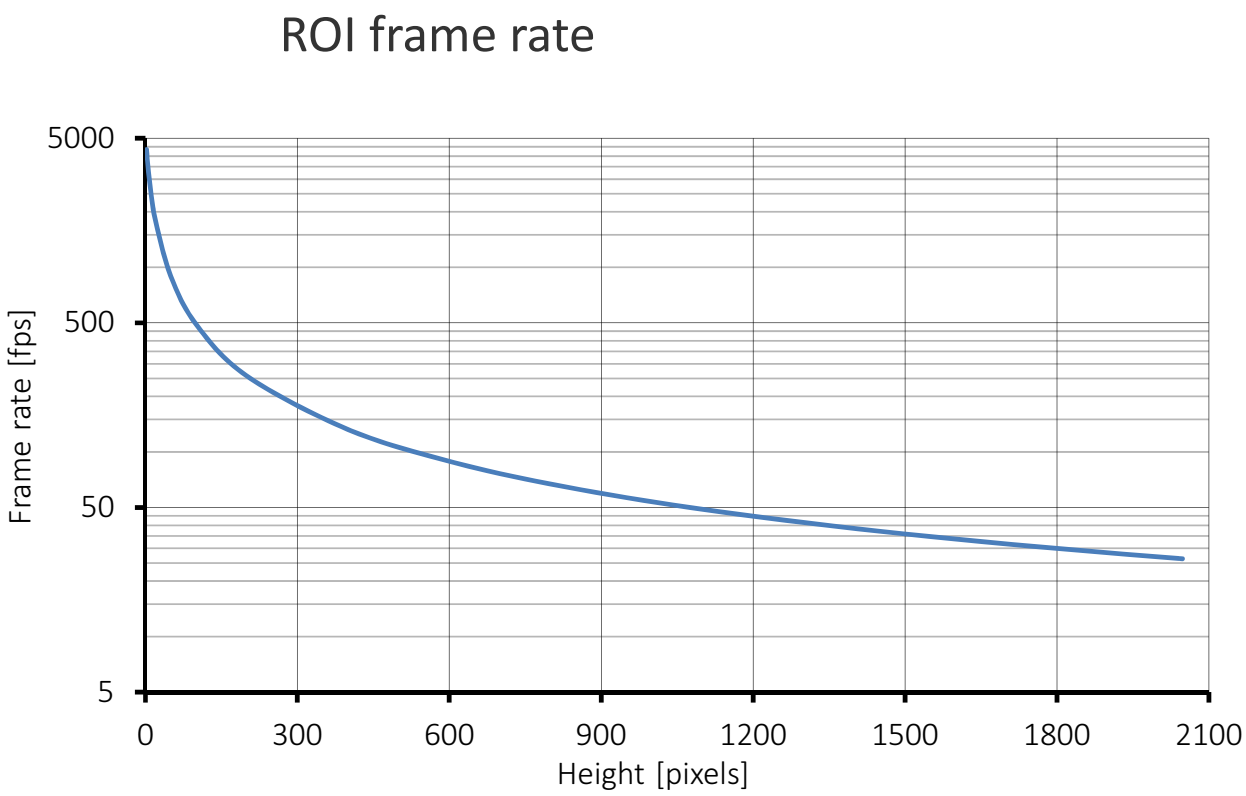


Figure 22: Frame rate as a function of ROI height

Height in pixels	Frame rate
2048	26.3
2000	26.9
1800	29.9
1600	33.6
1400	38.4
1200	44.8
1000	53.7
800	66.9
600	88.8
400	132.1
200	257.7
100	490.8
50	895.9
20	1775.5
10	2639.2
5	3486.7
2	4342.1

Width = 2048 pixels

Table 20: Frame rate as a function of ROI height

There will be an increase in frame rate with reduced width if the camera is bandwidth limited.

Mako G-503B, G-503C

Feature	Specification	
	Mako G-503B	**Mako G-503C**
Resolution	2592 (H) x 1944 (V) 5 MP	
Sensor	ON Semiconductor (Aptina) MT9P031	ON Semiconductor (Aptina) MT9P006
Sensor type	CMOS	
Shutter type	Global Reset, Rolling	
Sensor size	Type 1/2.5 7.13 mm diagonal	
Cell size	2.2 µm x 2.2 µm	
Lens mount	Standard: C-Mount Optional: See the Modular Concept	
Optical filter[1]	No optical filter	Hoya C-5000 IR cut filter
Maximum frame rate at full resolution	14 frames per second	
Maximum image bit depth	12-bit	
Image buffer	64 MB	
StreamHoldCapacity	Up to 13 frames at full resolution	
Monochrome formats	Mono8, Mono12, Mono12Packed	Mono8
Color formats (YUV)	n/a	YUV411Packed, YUV422Packed, YUV444Packed
Color formats (RGB)	n/a	RGB8Packed, BGR8Packed
RAW formats	n/a	BayerGR8, BayerGR12Packed, BayerGR12
Exposure control[2]	31 µs to 1 s; 36.4 µs increments	
Gain control	0 to 24 dB; 1 dB increments	
Binning	Horizontal: 1 to 4 pixels Vertical: 1 to 4 rows	
Decimation	Horizontal and Vertical: 1, 2, 4 factor	
Opto-isolated I/Os	1 input, 3 outputs	
Voltage requirements	12 to 24 VDC; PoE	
Power consumption	2.0 W @ 12 VDC; 2.2 W PoE	
Trigger latency[3]	Idle state: 73.4 µs; Frame valid state: 73.4 µs	
Trigger jitter[3]	Idle state: 18.4 µs; Frame valid state: 18.4 µs	
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)	

Table 21: Mako G-503B, G-503C model specifications

Feature	Specification	
	Mako G-503B	Mako G-503C
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	
Mass (typical)	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only Resolution: 0.031; Accuracy: ± 1 °C	

[1] For more information on available optical filters see the Modular Concept.

[2] These exposure control values are only valid with factory/default settings. Exposure control values vary depending upon pixel format and width.

[3] These values are calculated directly from the microcontroller source. These values are only valid for pixel formats < 16 bits per pixel and applicable in both Idle and Frame valid states:

- Idle state: sensor is ready and camera is idle, waiting for the next trigger.
- Frame valid state: sensor is reading out and camera is busy. If next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state.

Table 21: Mako G-503B, G-503C model specifications (continued)

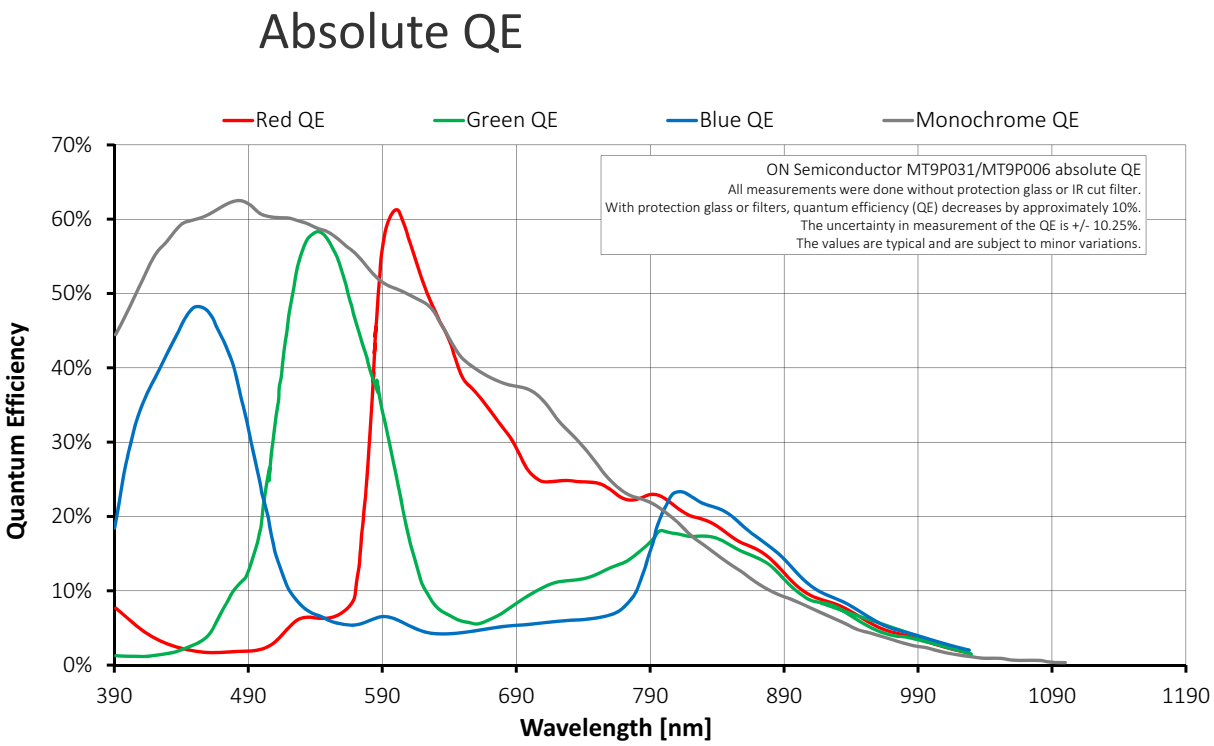


Figure 23: Mako G-503B, G-503C (ON Semiconductor MT9P031/MT9P006) absolute QE

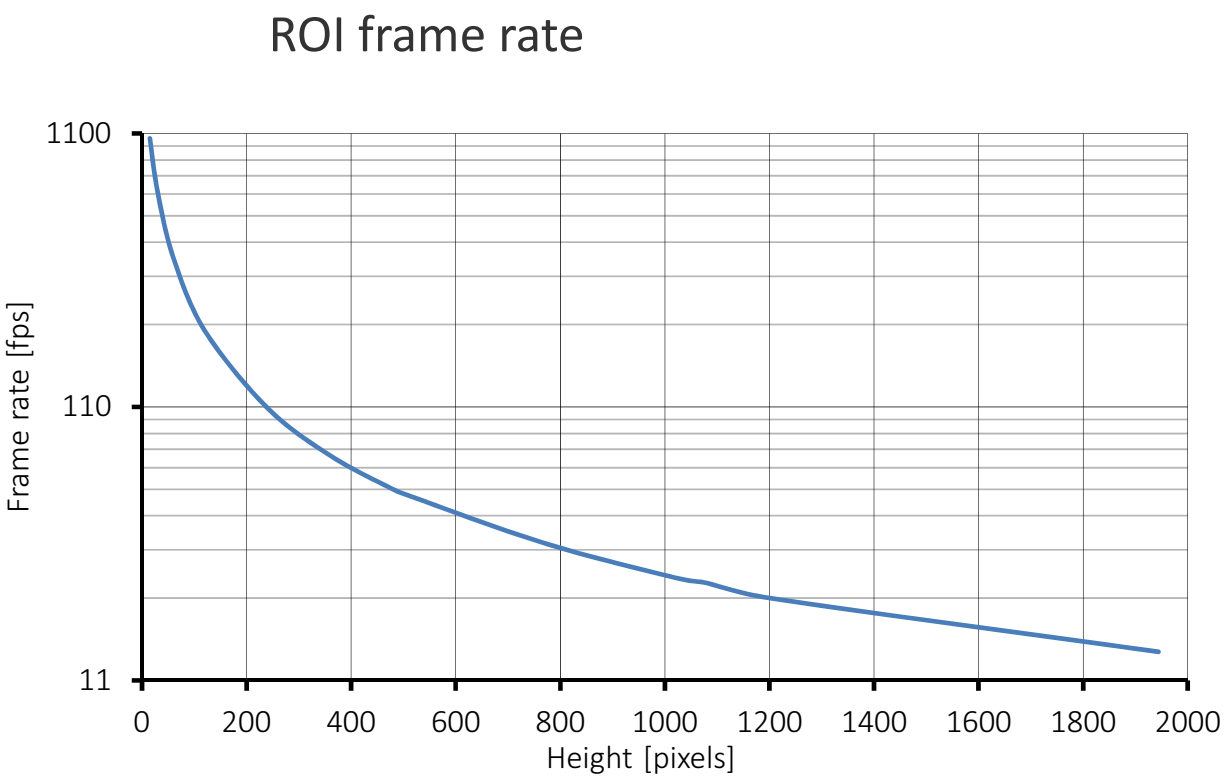


Figure 24: Frame rate as a function of ROI height

Height in pixels	Frame rate
1944	14
1200	22
1080	25
1024	26
768	35
512	52
480	55
360	73
240	109
120	209
60	386
30	669
15	1055

Width = 2592 pixels

Table 22: Frame rate as a function of ROI height

There will be an increase in frame rate with reduced width if the camera is bandwidth limited.

Mako G-507B, G-507C

Feature	Specification	
	Mako G-507B	**Mako G-507C**
Resolution	2464 (H) x 2056 (V) 5.1 MP	
Sensor	Sony IMX264LLR	Sony IMX264LQR
Type	CMOS	
Shutter type	Global	
Sensor size	Type 2/3 11.1 mm diagonal	
Cell size	3.45 µm x 3.45 µm	
Lens mount	Standard: C-Mount Optional: See the Modular Concept	
Optical filter[1]	No optical filter	Hoya C-5000 IR cut filter
Maximum frame rate at full resolution	23.7 frames per second	
Maximum image bit depth	12-bit	
Image buffer	64 MB	
StreamHoldCapacity	Up to 13 frames at full resolution	
Monochrome formats	Mono8, Mono12Packed, Mono12	Mono8
Color formats (YUV)	n/a	YUV411Packed, YUV422Packed, YUV444Packed
Color formats (RGB)	n/a	RGB8Packed, BGR8Packed
RAW formats	n/a	BayerRG8, BayerRG12, BayerRG12Packed
Exposure control[2]	**Pixel format**	**Value**
	Mono8, Mono12Packed, BayerRG8 BayerRG12Packed, YUV411Packed	52 µs to 85.9 s; 19.5 µs increments
	Mono12, BayerRG12, YUV422Packed	65 µs to 85.9 s; 26 µs increments
	RGB8Packed, BGR8Packed, YUV444Packed	91 µs to 85.9 s; 39.0 µs increments
Gain control	0 to 40 dB; 0.1 dB increments	
Binning	Horizontal: 1 to 4 pixels Vertical: 1 to 4 rows	Horizontal: 1 to 4 pixels
Decimation	Horizontal and Vertical: 1, 2, 4, 8 factor	
Opto-isolated I/Os	1 input, 3 outputs	
Voltage requirements	12 to 24 VDC; PoE	

Table 23: Mako G-507B, G-507C model specifications

Feature	Specification	
	Mako G-507B	**Mako G-507C**
Power consumption	2.4 W @ 12 VDC; 2.8 W PoE	
Trigger latency[3]	**Pixel format**	**Value**
	Mono8, Mono12Packed, BayerRG8 BayerRG12Packed, YUV411Packed	58.6 µs
	Mono12, BayerRG12, YUV422Packed	78 µs
	RGB8Packed, BGR8Packed, YUV444Packed	117.1 µs
Trigger jitter[3]	**Pixel format**	**Value**
	Mono8, Mono12Packed, BayerRG8 BayerRG12Packed, YUV411Packed	9.8 µs
	Mono12, BayerRG12, YUV422Packed	13 µs
	RGB8Packed, BGR8Packed, YUV444Packed	19.5 µs
Operating temperature	+5 °C to +45 °C housing temperature	
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)	
Body dimensions (L x W x H)	60.5 x 29 x 29 mm	
Mass (typical)	80 g	
Interface	IEEE 802.3 1000BASE-T (Gigabit Ethernet), IEEE 802.3af (PoE)	
Interface standard	GigE Vision Standard V1.2	
Camera control standard	GenICam SFNC V1.2.1	
Regulations	CE, RoHS, REACH, WEEE, FCC, ICES	
Temperature monitoring	Available for main board only Resolution: 0.031; Accuracy: ± 1 °C	

[1] For more information on available optical filters see the Modular Concept.

[2] Whenever pixel format is changed, exposure will adjust itself to the nearest multiple of exposure increment.

[3] It is possible to start the exposure of next frame while previous frame is read out:

- Idle state: sensor is ready and camera is idle, waiting for the next trigger.
- Frame valid state: sensor is reading out and camera is busy. If next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state.

Table 23: Mako G-507B, G-507C model specifications (continued)

Absolute QE

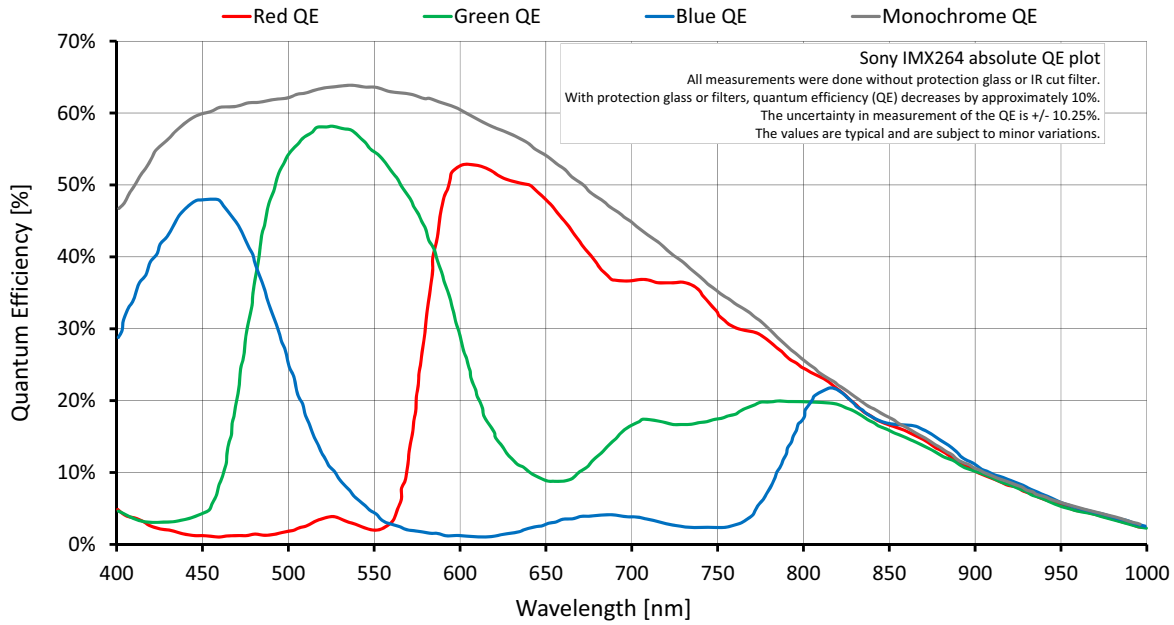


Figure 25: Mako G-507B, G-507C (Sony IMX264) absolute QE

Spectral response

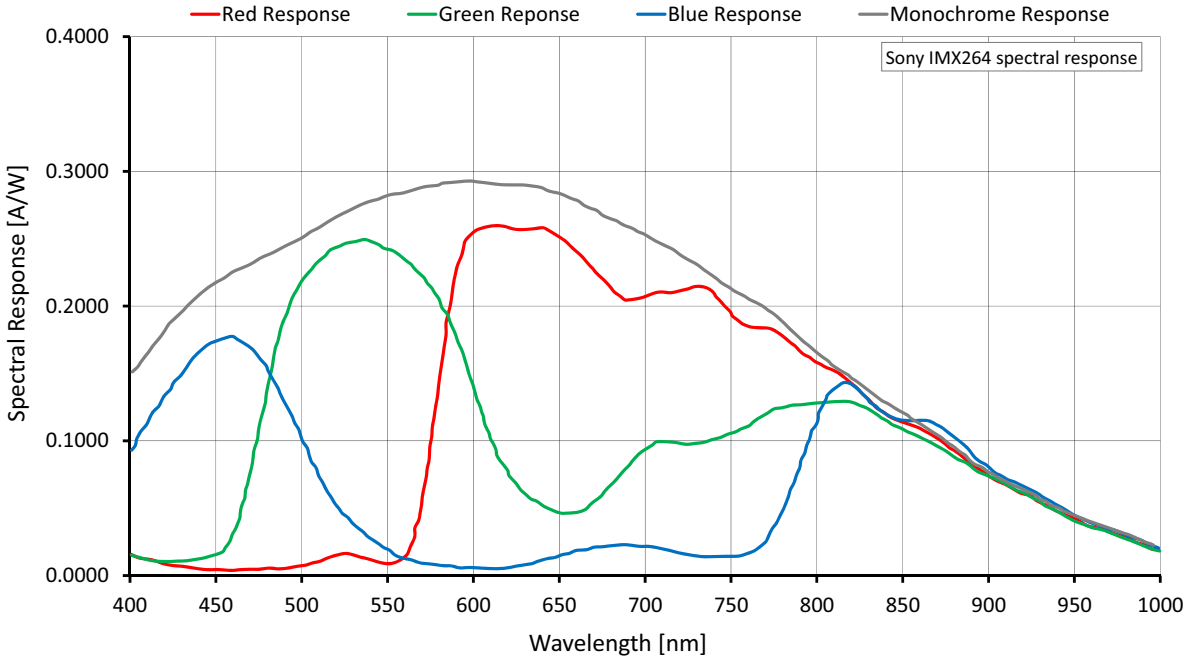


Figure 26: Mako G-507B, G-507C (Sony IMX264) spectral response

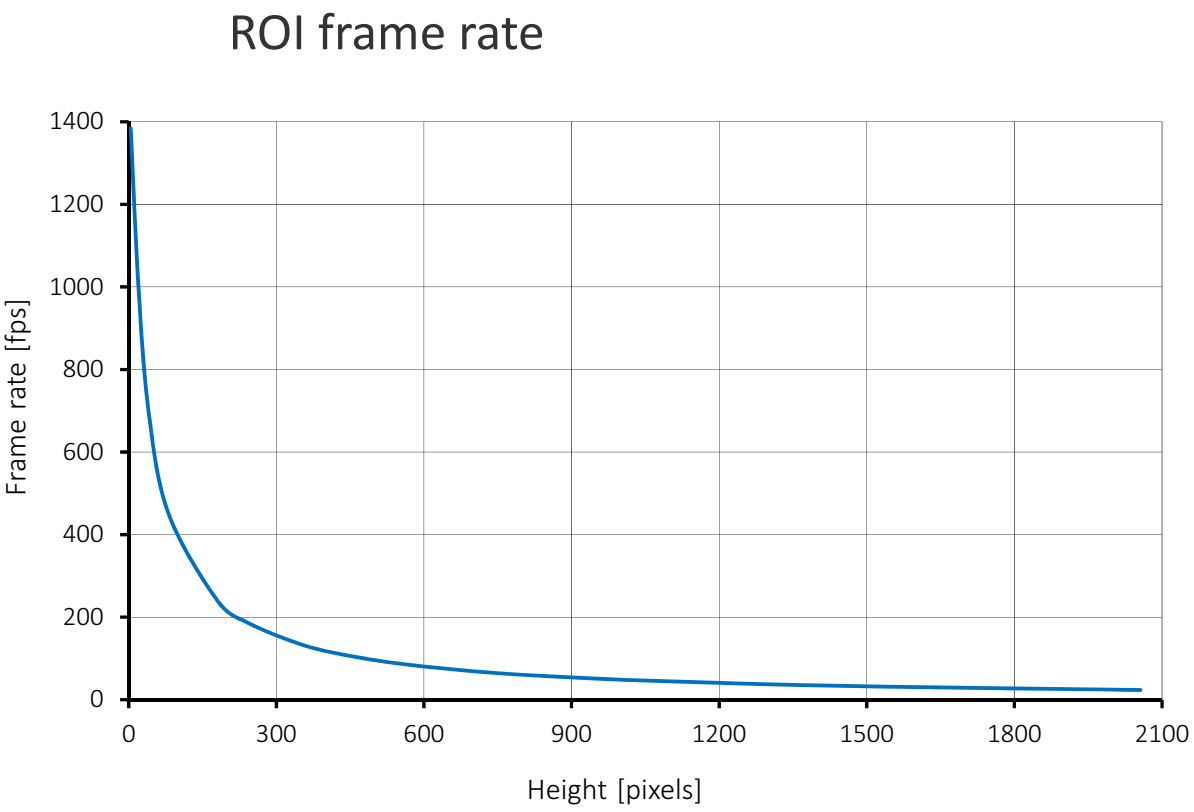


Figure 27: Frame rate as a function of ROI height

Height in pixels	Frame rate	Height in pixels	Frame rate
2056	23.7	480	99.9
1544	31.5	360	130.4
1324	36.8	240	187.7
1280	38.0	180	240.5
1024	47.4	80	453.4
960	50.6	40	701.8
768	62.9	20	996.6
600	80.5	4	1384.5

Width = 2464 pixels

Table 24: Frame rate as a function of ROI height

There will be an increase in frame rate with reduced width if the camera is bandwidth limited. Reducing the exposure time may result in higher frame rates.

Camera feature comparison

Allied Vision cameras support a number of standard and extended features. The table below identifies a selection of capabilities and compares the availability of features in Mako G camera models.

Camera feature references

A complete listing of camera features, including feature definitions can be found online:

- Vimba and third-party users: GigE Features Reference
- PvAPI users: GigE Camera and Driver Attributes document

Some features are firmware dependent, please refer to the GigE Release Notes for more information.

		Mako G-030	Mako G-032	Mako G-125	Mako G-131	Mako G-192	Mako G-223	Mako G-234	Mako G-319	Mako G-419	Mako G-503	Mako G-507
Image optimization features	Auto gain	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Auto exposure	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Auto white balance[1]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	BinningHorizontal		✓	✓	✓	✓		✓	✓		✓	✓
	BinningVertical		✓	✓	✓	✓		✓	✓[2]		✓	✓[2]
	Black level (offset)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Decimation	✓			✓	✓		✓	✓		✓	✓
	Column defect masking						✓			✓		
	Pixel defect masking	✓			✓	✓					✓	
	Gamma correction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Hue, saturation, color transformation[1]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Look-up tables (LUTs)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Region of interest (ROI)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Piecewise linear HDR	✓										
	Reverse X/Y	✓			✓	✓		✓	✓		✓	✓
	Sensor shutter mode[3]	2	2	2	1	1	2	2	2	2	3	2

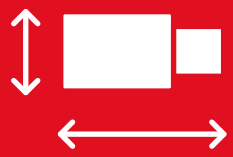
Table 25: Feature comparison by model

		Mako G-030	Mako G-032	Mako G-125	Mako G-131	Mako G-192	Mako G-223	Mako G-234	Mako G-319	Mako G-419	Mako G-503	Mako G-507
Camera control features	10/12 bit sensor output mode							✓				
	Event channel	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Image chunk data	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Storable user sets (config files)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Stream hold	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Sync out modes	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Temperature monitoring (main board only)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

[1] Color models only
[2] Monochrome models only
[3] Sensor shutter mode: (1) Global, Rolling, Global Reset, (2) Global, (3) Global Reset, Rolling

Table 25: Feature comparison by model (continued)

Mechanical dimensions



This chapter includes:

- CAD drawing and dimensions of standard housing model and tripod adapter
- Sensor position accuracy
- Maximum protrusion distance and filter diameter for C-Mount and CS-Mount

Mako G standard housing

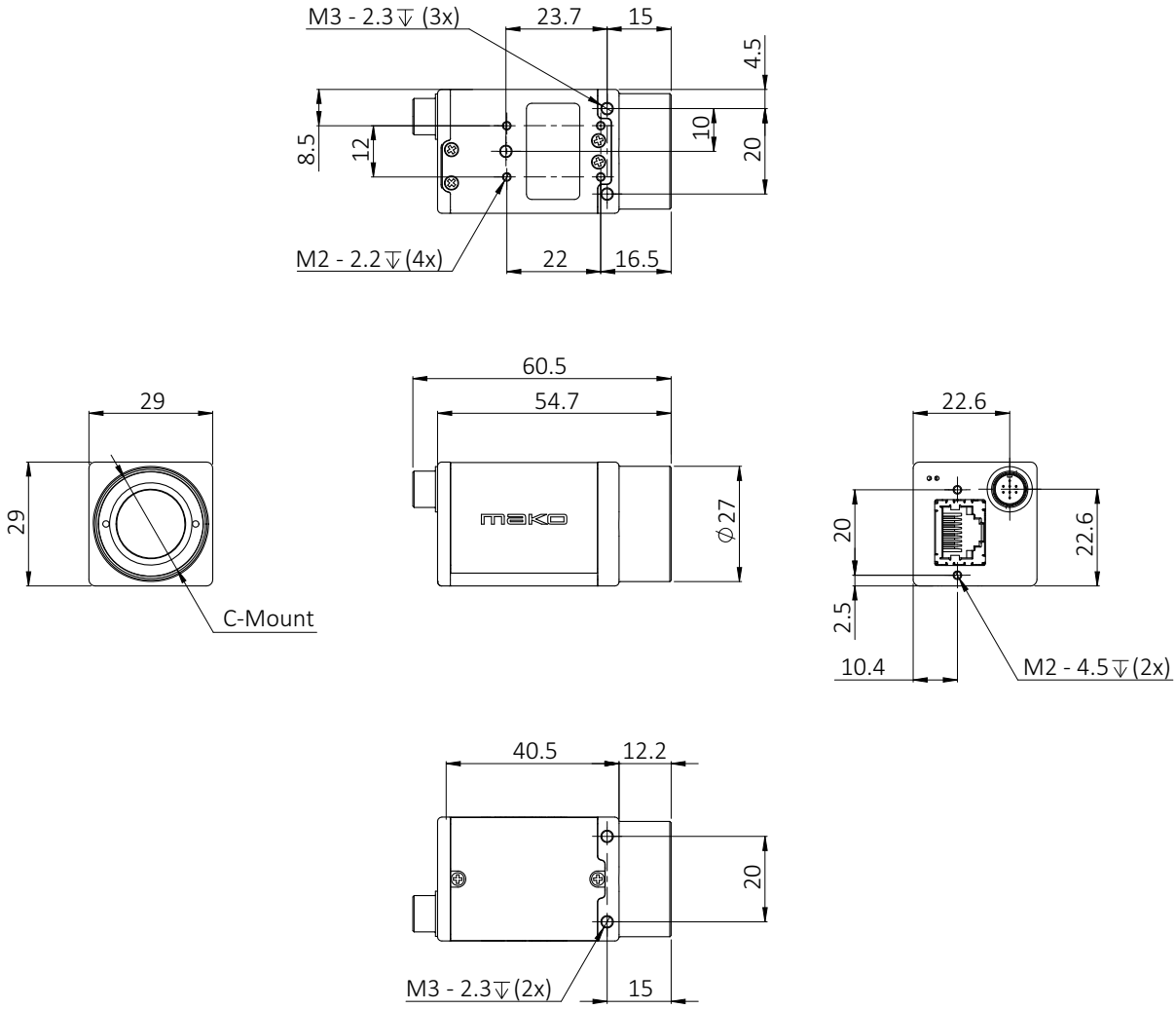


Figure 28: Mako G standard housing dimensions (including connectors)

Tripod adapter

This tripod adapter (Allied Vision order number 4807) can be used for all Mako G cameras with the standard housing.

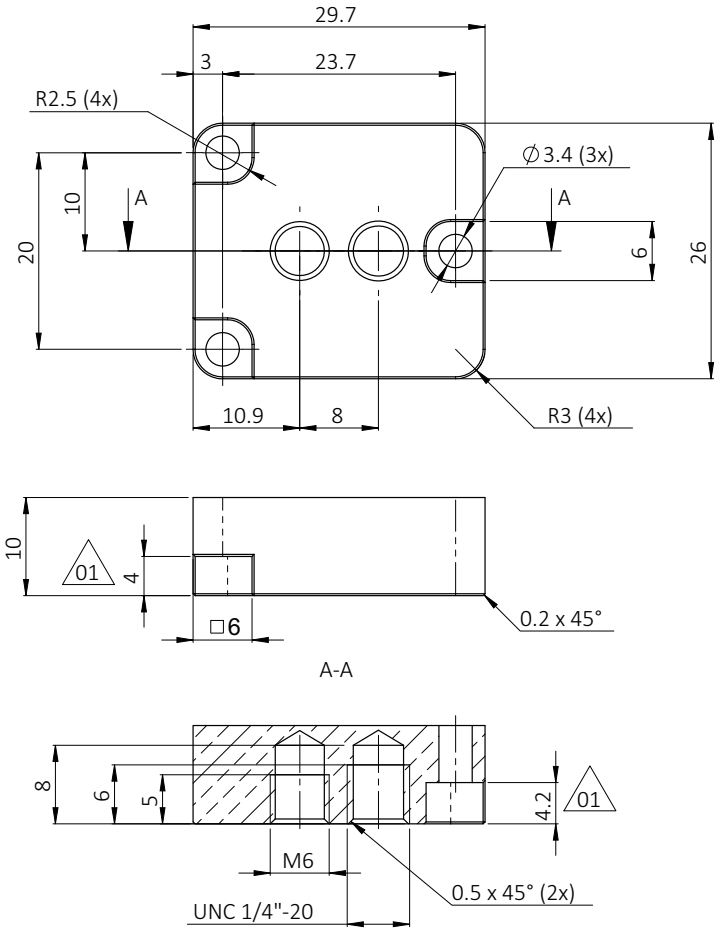


Figure 29: Tripod adapter dimensions (in mm)

Avoid damage to the camera by using inappropriate accessories

The Mako U tripod adapter is not compatible with Mako G cameras.

Sensor position accuracy

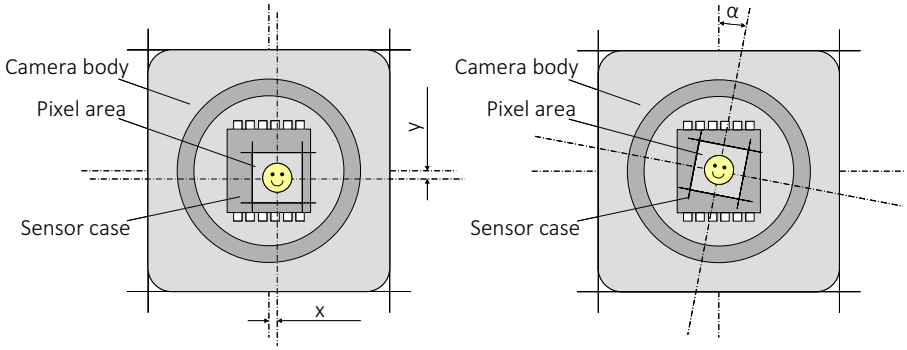


Figure 30: Allied Vision sensor position accuracy

Unless stated otherwise, the following values are applicable:

Criteria	Subject	Properties
Alignment method		Optical alignment of photo sensitive sensor area into camera front module (lens mount front flange).
Reference points	Sensor	Center of pixel area (photo sensitive cells)
	Camera	Center of camera front flange (outer case edges)
Accuracy	x/y	±150 µm (sensor shift)
	z	0 µm to-150 µm (optical back focal length)
	α	±0.5° (sensor rotation as the deviation from the parallel to the camera bottom)

Table 26: Sensor position accuracy criteria

Cross section: C-Mount and CS-Mount

All standard color Mako G cameras are equipped with a Hoya C-5000 IR cut filter with a 22 mm diameter. Standard monochrome Mako G cameras are not equipped with any filter or protection glass.

Filter and protection glass options

Allied Vision offers several filter options for both monochrome and color Mako G cameras. Choose protection glass or filter according to the Modular Concept document.

https://www.alliedvision.com/en/support/technical-documentation.html

Product change notice

Monochrome Mako G cameras with serial number 536873083 or higher are shipped without a cover ring in the C-Mount thread. Refer to product change notice for more details.

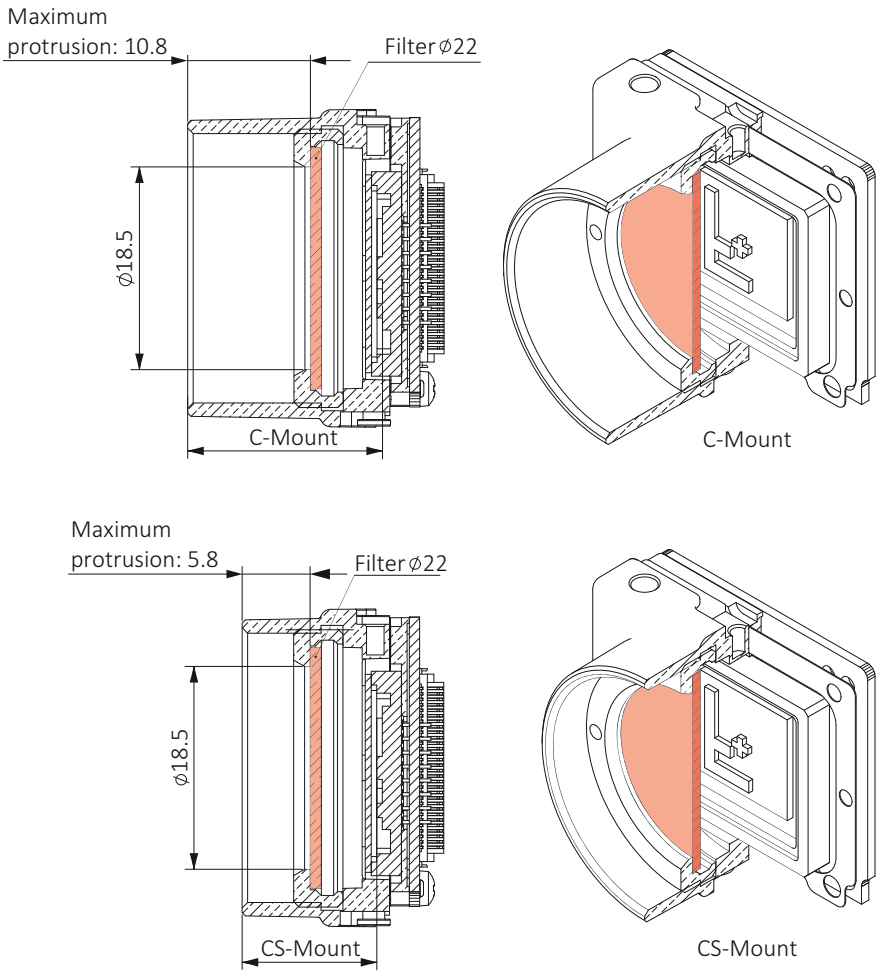


Figure 31: C-Mount and CS-Mount dimensions for Mako G models

Adjusting C-Mount and CS-Mount

The dimensional adjustment cannot be done by the customer. All modifications have to be done by Allied Vision.

Dimensional mount adjustment

Dimensional mount adjustment cannot be done by the customer. If you need any mount related adjustments, please contact Allied Vision.

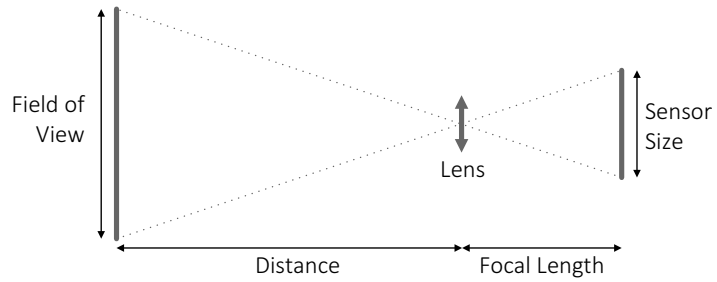
Filter and lenses

This chapter includes information on:

- Suitable lens formats for Mako G camera models
- Standard IR cut filter and its transmission characteristics

Camera lenses

Allied Vision offers different lenses from a variety of manufacturers. This section presents tables that list selected image field of view (width x height) depending on sensor size, distance and focal length of the lens.



Accessories

Please contact Allied Vision sales representative or your Allied Vision distribution partner for information on accessories offered by Allied Vision:

https://www.alliedvision.com/en/about-us/where-we-are.html

Lenses with focal lengths < 8 mm may show shading in the edges of the image due to microlenses on the sensor. The exact values vary and depend on the respective lens.

Mako G-030B, G-030C

Focal length	Field of view	
	Distance = 500 mm	Distance = 1000 mm
4.8 mm	495 x 371 mm	995 x 746 mm
8 mm	295 x 221 mm	595 x 446 mm
12.5 mm	187 x 140 mm	379 x 284 mm
16 mm	145 x 109 mm	295 x 221 mm
25 mm	91 x 68 mm	187 x 140 mm
50 mm	43 x 32 mm	91 x 68 mm

Table 27: Mako G-030B, G-030C focal length vs. field of view

Mako G-032B, G-032C

Focal length	Field of view	
	Distance = 500 mm	Distance = 1000 mm
4.0 mm	608 x 446 mm	1220 x 896 mm
4.8 mm	506 x 371 mm	1016 x 746 mm
8 mm	301 x 221 mm	608 x 446 mm
12 mm	199 x 146 mm	403 x 296 mm
16 mm	148 x 109 mm	301 x 221 mm
25 mm	93 x 68 mm	191 x 140 mm
35 mm	65 x 48 mm	135 x 99 mm

Table 28: Mako G-032B, G-032C focal length vs. field of view

Mako G-125B, G-125C

Focal length	Field of view	
	Distance = 500 mm	Distance = 1000 mm
4.0 mm	595 x 446 mm	1195 x 896 mm
4.8 mm	495 x 371 mm	995 x 746 mm
8 mm	295 x 221 mm	595 x 446 mm
12 mm	195 x 146 mm	395 x 296 mm
16 mm	145 x 109 mm	295 x 221 mm
25 mm	91 x 68 mm	187 x 140 mm
35 mm	64 x 48 mm	132 x 99 mm

Table 29: Mako G-125B, G-125C focal length vs. field of view

Mako G-131B, G-131C

Focal length	Field of view	
	Distance = 500 mm	Distance = 1000 mm
4.5 mm	760 x 606 mm	1526 x 1217 mm
6 mm	568 x 453 mm	1143 x 911 mm
10 mm	338 x 270 mm	683 x 545 mm
17 mm	196 x 156 mm	399 x 318 mm
25 mm	131 x 105 mm	269 x 215 mm
35 mm	92 x 73 mm	190 x 152 mm

Table 30: Mako G-131B, G-131C focal length vs. field of view

Mako G-192B, G-192C

Focal length	Field of view	
	Distance = 500 mm	Distance = 1000 mm
4.5 mm	793 x 595 mm	1593 x 1195 mm
6 mm	593 x 445 mm	1193 x 895 mm
10 mm	353 x 265 mm	713 x 535 mm
17 mm	205 x 153 mm	416 x 312 mm
25 mm	137 x 103 mm	281 x 211 mm
35 mm	96 x 72 mm	199 x 149 mm

Table 31: Mako G-192B, G-192C focal length vs. field of view

Mako G-223B, G-223B NIR, G-223C

Focal length[1]	Field of view	
	Distance = 500 mm	Distance = 1000 mm
4.8 mm	1162 x 617 mm	2335 x 1240 mm
6 mm	927 x 492 mm	1865 x 991 mm
6.5 mm	855 x 454 mm	1721 x 914 mm
8 mm	692 x 368 mm	1396 x 742 mm
10 mm	552 x 293 mm	1114 x 597 mm
12 mm	458 x 243 mm	927 x 492 mm
16 mm	341 x 181 mm	692 x 369 mm
25 mm	214 x 114 mm	439 x 223 mm
35 mm	150 x 79 mm	310 x 165 mm
50 mm	101 x 54 mm	214 x 114 mm
75 mm	64 x 34 mm	139 x 74 mm
90 mm	51 x 27 mm	114 x 60 mm

[1] A 2/3 inch lens may cause vignetting (1 inch lens recommended)

Table 32: Mako G-223B, G-223B NIR, G-223C focal length vs. field of view

Mako G-234B, G-234C

Focal length	Field of view	
	Distance = 500 mm	Distance = 1000 mm
12 mm	461 x 290 mm	933 x 586 mm
16 mm	343 x 215 mm	697 x 438 mm
25 mm	215 x 135 mm	442 x 278 mm
35 mm	150 x 94 mm	312 x 196 mm
50 mm	102 x 64 mm	215 x 135 mm

Table 33: Mako G-234B, G-234C focal length vs. field of view

Mako G-319B, G-319C

Focal length	Field of view	
	Distance = 500 mm	Distance = 1000 mm
5 mm	705 x 525 mm	1417 x 1055 mm
6 mm	586 x 436 mm	1180 x 878 mm
8 mm	438 x 326 mm	883 x 657 mm
10 mm	349 x 260 mm	705 x 525 mm
12 mm	290 x 216 mm	586 x 436 mm
16 mm	215 x 160 mm	438 x 326 mm
25 mm	135 x 101 mm	278 x 207 mm
35 mm	95 x 70 mm	196 x 146 mm
50 mm	64 x 48 mm	135 x 101 mm
75 mm	40 x 30 mm	88 x 65 mm

Table 34: Mako G-319B, G-319C focal length vs. field of view

Mako G-419B, G-419B NIR, G-419C

Focal length	Field of view	
	Distance = 500 mm	Distance = 1000 mm
8 mm	692 x 692mm	1396 x 1396 mm
10 mm	552 x 552 mm	1114 x 1114 mm
12 mm	458 x 458 mm	928 x 928 mm
16 mm	340 x 340 mm	692 x 692 mm
25 mm	214 x 214 mm	439 x 439 mm
35 mm	150 x 150 mm	310 x 310 mm
50 mm	101 x 101 mm	214 x 214 mm
75 mm	64 x 64 mm	139 x 139 mm
90 mm	51 x 51 mm	104 x 104 mm

Table 35: Mako G-419B, G-419B NIR, G-419C focal length vs. field of view

Mako G-503B, G-503C

Focal length	Field of view	
	Distance = 500 mm	Distance = 1000 mm
4.8 mm	588 x 442 mm	1182 x 887 mm
8 mm	351 x 263 mm	707 x 531 mm
12 mm	232 x 174 mm	469 x 352 mm
16 mm	172 x 129 mm	351 x 263 mm
25 mm	108 x 81 mm	222 x 167 mm
35 mm	76 x 57 mm	157 x 118 mm

Figure 32: Mako G-503B, G-503C focal length vs. field of view

Mako G-507B, G-507C

Focal length	Field of view	
	Distance = 500 mm	Distance = 1000 mm
5 mm	842 x 703 mm	1692 x 1413 mm
8 mm	526 x 437 mm	1054 x 880 mm
10 mm	417 x 348 mm	842 x 703 mm
12 mm	346 x 289 mm	700 x 585 mm
16 mm	257 x 215 mm	523 x 437 mm
25 mm	162 x 135 mm	332 x 277 mm
35 mm	113 x 94 mm	234 x 196 mm
50 mm	77 x 64 mm	162 x 135 mm
75 mm	48 x 40 mm	105 x 88 mm

Figure 33: Mako G-507B, G-507C focal length vs. field of view

IR cut filter

Color cameras are equipped with IR cut filter. The following illustration shows the spectral transmission of the IR cut filter.

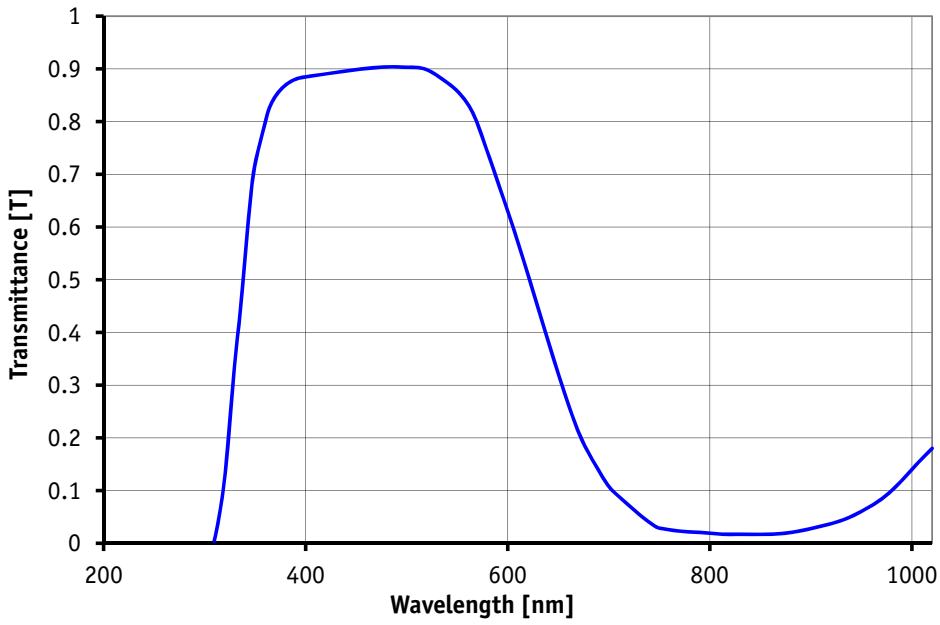
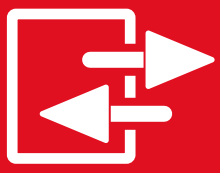


Figure 34: Approximate spectral transmission of IR cut filter type Hoya C-5000 (may vary slightly by filter lot)

Camera interfaces



This chapter includes:

- A general description of the inputs and outputs (including trigger features)
- I/O connector pin assignments
- I/O block diagrams
- A general description of trigger rules including a timing diagram and definitions

Back panel

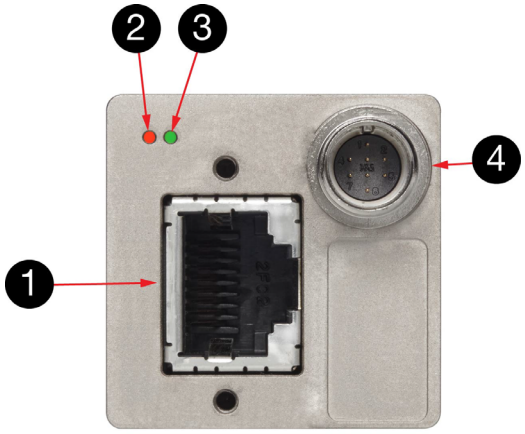


Figure 35: Rear view of Mako G camera

1	Gigabit Ethernet interface
2	LED 1 (orange)
3	LED 2 (green)
4	Hirose I/O port

Status LEDs

The tables below describe the status LEDs of Mako G cameras.

LED 1 color	Status
Solid orange	Ethernet link established
Flashing orange	Network traffic

Table 36: Status LED 1

LED 2 color	Status
Solid green	Camera powered
Slow flashing green	Booting routine
Four rapid flashes per second	Transmission error Contact support@alliedvision.com

Table 37: Status LED 2

Gigabit Ethernet interface

The Gigabit Ethernet interface conforms to the IEEE 802.3 1000BASE-T standard for Gigabit Ethernet over copper. To prevent electromagnetic interference (EMI) and for best performance, Category 6 (or higher) cables with S/STP shielding and connectors are recommended. Applications with longer cable lengths or harsh EMI conditions require Category 7 (or higher) cables.

- Cable lengths up to 100 m are supported.
- The 8-pin RJ-45 jack provides a pin assignment according to the Ethernet standard, IEEE 802.3 1000BASE-T.
- All Mako G cameras are PoE capable (IEEE 802.3af-2003).
- If both the Hirose I/O port and Gigabit Ethernet interface (via PoE) are used for power, the camera will only use the power from the Hirose I/O port.

Accessories

Please contact Allied Vision sales representative or your Allied Vision distribution partner for information on accessories offered by Allied Vision:

https://www.alliedvision.com/en/about-us/where-we-are.html

Camera I/O connector pin assignment

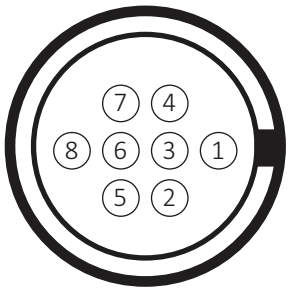
The general purpose I/O port uses a Hirose HR25-7TR-8PA(73) connector on the camera side. The mating cable connector is Hirose HR25-7TP-8S.

Safety-related instructions to avoid malfunctions

Read all *Notes and Cautions* in the GigE Installation Manual before using the Hirose I/O connector.

Hirose connector

The cable side Hirose connector is available for purchase from Allied Vision (order code K7600503).



Pin	Signal	Direction	Level	Description
1	Out 1	Out	Open emitter, maximum 20 mA	Opto-isolated output 1
2	Out 2	Out	Open emitter, maximum 20 mA	Opto-isolated output 2
3	Out 3	Out	Open emitter, maximum 20 mA	Opto-isolated output 3
4	In 1	In	U_{in}(high) = 3.0 to 24.0 V up to 36 V with external resistor of 3.3 kΩ in series U_{in}(low) = 0 to 1.0 V	Opto-isolated input 1
5	Isolated In GND	In	---	Isolated input signal ground
6	Isolated Out Power	In	Common VCC for outputs maximum 30 VDC	Power input for opto-isolated outputs
7	Camera Power	In	12 to 24 VDC +/- 10%	Camera power supply
8	Camera GND	In	GND for external power	Ground for camera power supply

Table 38: I/O connector pin assignment

Input block diagram

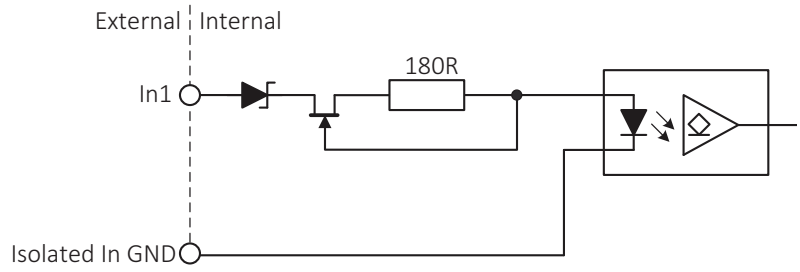


Figure 36: Input block diagram

The input can be connected directly to the system for voltages up to 24 VDC. An external resistor is not necessary.

Cycle delay

Parameter	Value
U_{in} (low)	0 to 1.0 V
U_{in} (high)	3 to 24 V
Current (constant-current source)	3 to 4 mA

Table 39: Input parameters

Minimum pulse width

The minimum pulse width for all Mako G cameras is:

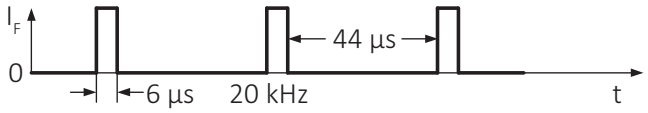


Figure 37: Minimum pulse width

Test conditions

The input signal was driven with 3.3 V and no external additional series resistor.

Output block diagram

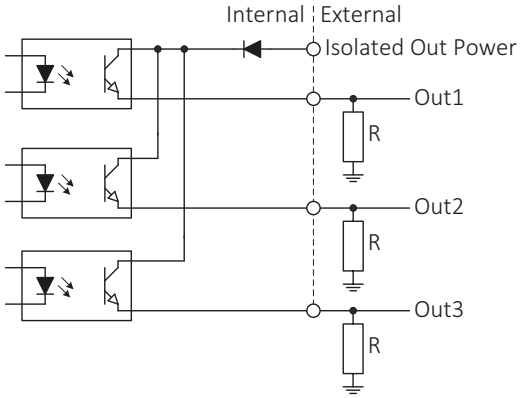


Figure 38: Output block diagram

Output and isolated out power

- Maximum 20 mA per output
- Isolated out power > 30 V may damage the camera

Isolated Out Power	Resistor value[1]	
5 V	1.0 kΩ	at ~ 5 mA minimum required current draw
12 V	2.4 kΩ	
24 V	4.7 kΩ	

[1] Resistor required if Out1/2/3 connected to a device with < 5 mA draw, i.e. high impedance

Table 40: Isolated Out Power and external resistor

Output switching times

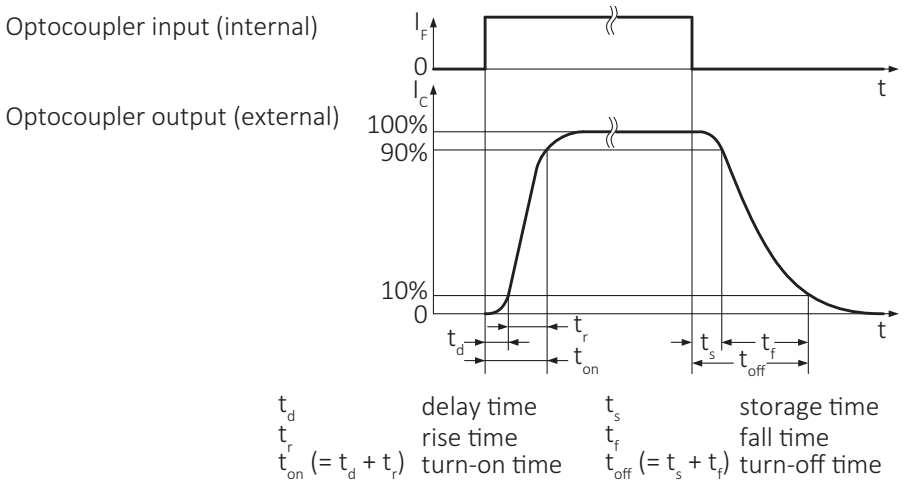


Figure 39: Output switching times

Parameter and value	
$t_d \approx 1$ µs	$t_s \approx 26$ µs
$t_r \approx 1$ µs	$t_f \approx 21$ µs
$t_{on} = t_d + t_r \approx 2$ µs	$t_{off} = t_s + t_f \approx 47$ µs (t_{off} can deviate by ± 5 µs)

Table 41: Parameters

Test conditions

Output: external 2.4 kΩ resistor to GND, Isolated Out Power set to 12 V.

- Higher external values increase the times in table 41 above.
- It is recommended to trigger on the rising edge. This guarantees the fastest possible reaction time.

Control signals

The inputs and outputs of the camera can be configured by software. The different modes are described below. All input and output signals that pass the I/O connector are controlled by the I/O strobe commands.

Input block diagram

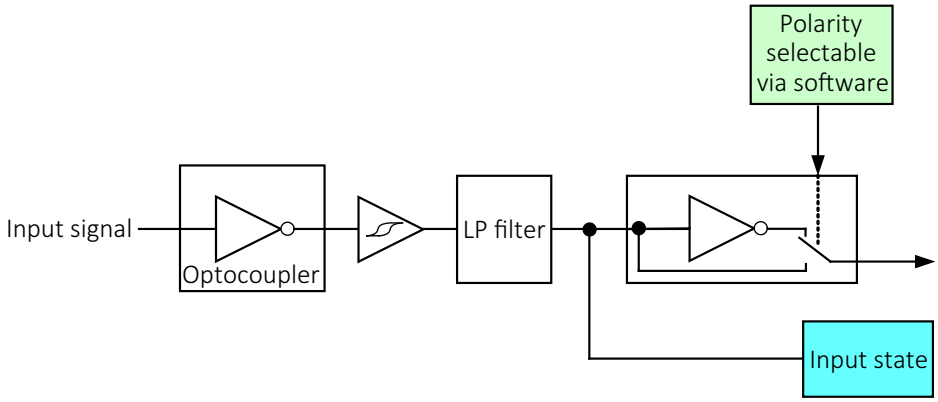


Figure 40: Input block diagram

Output signals

Output signals are configured by software. Any signal can be placed on any output. The main output signals are described below:

Signal	Description
GPO	Configured to be a general purpose output, control is assigned to SyncOutGpoLevels.
AcquisitionTriggerReady	Active once the camera has been recognized by the host PC and is ready to start acquisition.
FrameTriggerReady	Active when the camera is in a state that will accept the next frame trigger.

Table 42: Output signals

Signal	Description
FrameTrigger	Active when an image has been initiated to start. This is a logic trigger internal to the camera, which is initiated by an external trigger or software trigger event.
Exposing	Active for the duration of sensor exposure.
FrameReadout	Active during frame readout, i.e., the transferring of image data from the CCD to the camera memory.
Imaging	Imaging is high when the camera image sensor is either exposing and/or reading out data.
Acquiring	Active during an acquisition stream.
SyncIn1	Active when there is an external trigger at SyncIn1.
Strobe1	The output signal is controlled according to Strobe1 settings.

Table 42: Output signals (continued)

Output block diagram

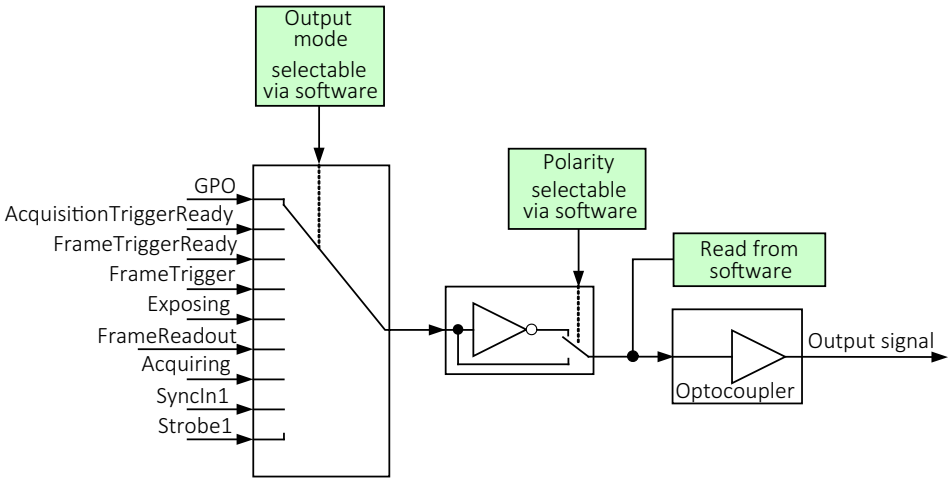


Figure 41: Output block diagram

Trigger timing diagram

The following diagram explains the general trigger concept.

Further information available online

For trigger description on camera control basis, see GigE Features Reference:

https://www.alliedvision.com/en/support/technical-documentation/mako-g-documentation.html

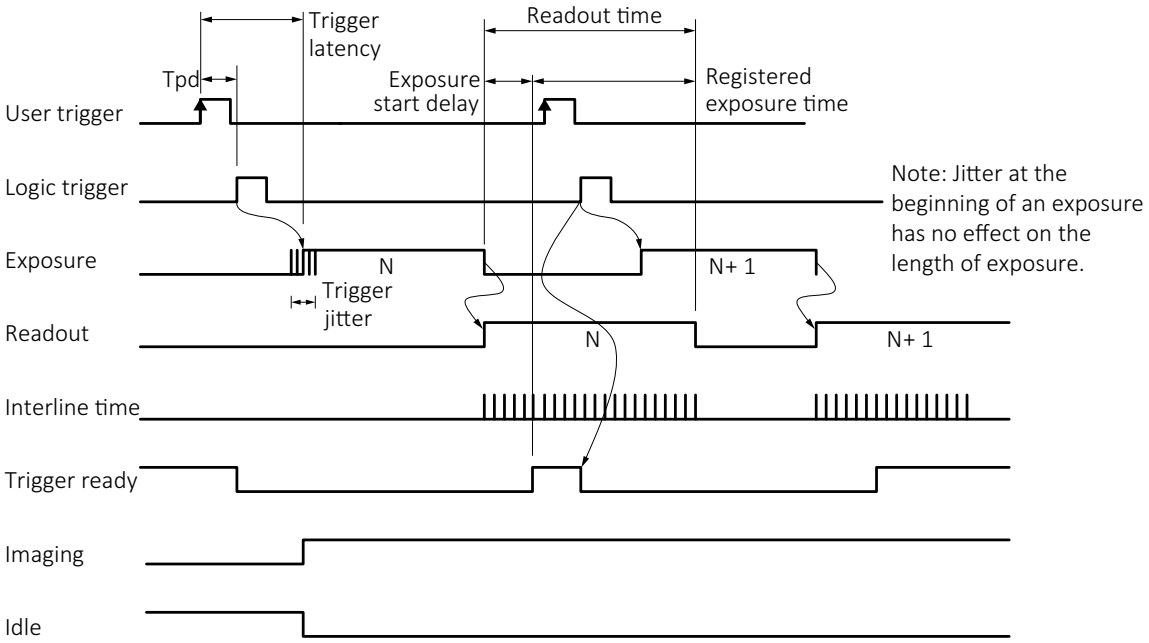


Figure 42: Trigger timing diagram

Trigger definitions

Term	Definition
User trigger	Trigger signal applied by the user (hardware trigger, software trigger)
Logic trigger	Trigger signal seen by the camera internal logic (not visible to the user)
Tpd	Propagation delay between the user trigger and the logic trigger
Exposure	High when the camera image sensor is integrating light
Readout	High when the camera image sensor is reading out data
Trigger latency	Time delay between user trigger and start of exposure
Trigger jitter	Error in the trigger latency time
Trigger ready	Indicates that the camera will accept the next trigger
Registered exposure time	Exposure time value currently stored in the camera memory
Exposure start delay	Registered exposure time subtracted from the readout time and indicates when the next exposure cycle can begin such that the exposure will end after the current readout
Interline time	Time between sensor row readout cycles
Imaging	High when the camera image sensor is either exposing and/or reading out data
Idle	High if the camera image sensor is not exposing and/or reading out data

Table 43: Trigger definitions

Trigger rules

User trigger pulse width

The user trigger pulse width should be at least three times the width of the trigger latency as indicated in *Specifications* on page 17.

Overlapping exposure and readout (Mako G-131 and G-192)

The e2v sensor does not support overlapped exposure and readout in hardware trigger mode or in global reset mode.

- The end of exposure will always trigger the next readout.
- The end of exposure must always end after the current readout.
- The start of exposure must always correspond with the interline time if readout is true.
- Exposure start delay equals the readout time minus the registered exposure time.

Triggering during the idle state

For applications requiring the shortest possible trigger latency and the smallest possible trigger jitter, the user trigger signal should be applied when imaging is false and idle is true.

Triggering during the readout state

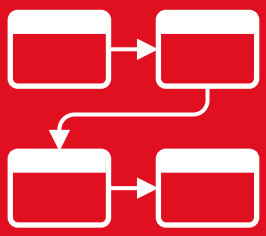
For applications requiring the fastest triggering cycle time whereby the camera image sensor is exposing and reading out simultaneously, the user trigger signal should be applied as soon as a valid trigger ready is detected.

In this case, trigger latency and trigger jitter can be up to 1 line time since exposure must always begin on an Interline boundary.

For a more detailed description of the trigger concept for advanced users and special scenarios, see the Triggering Concept application note:

https://www.alliedvision.com/en/support/technical-papers-knowledge-base.html

Image data flow



This chapter presents diagrams that illustrate data flow and bit resolution of the image data.

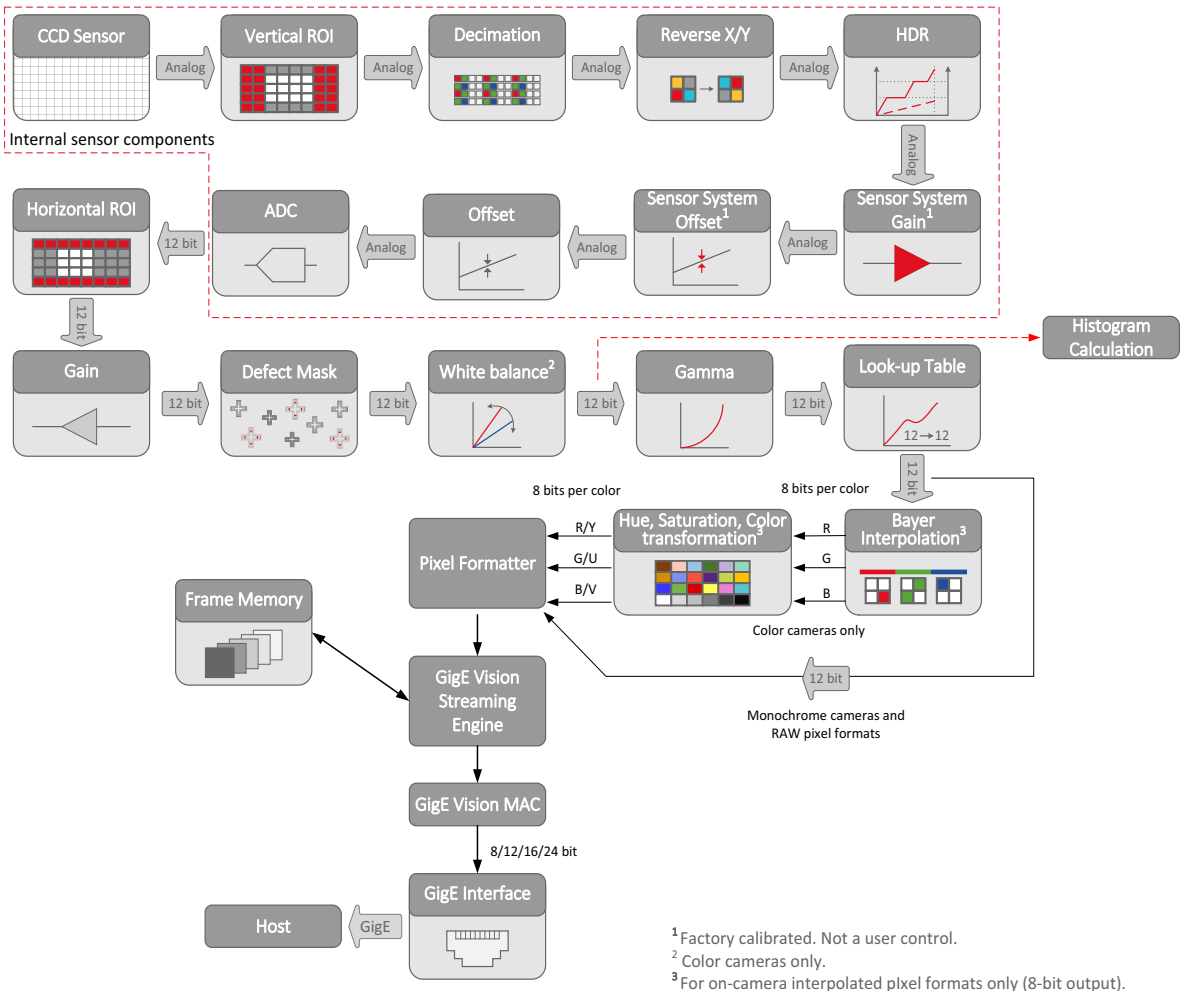
Camera control documents

A complete description of individual blocks can be found online:

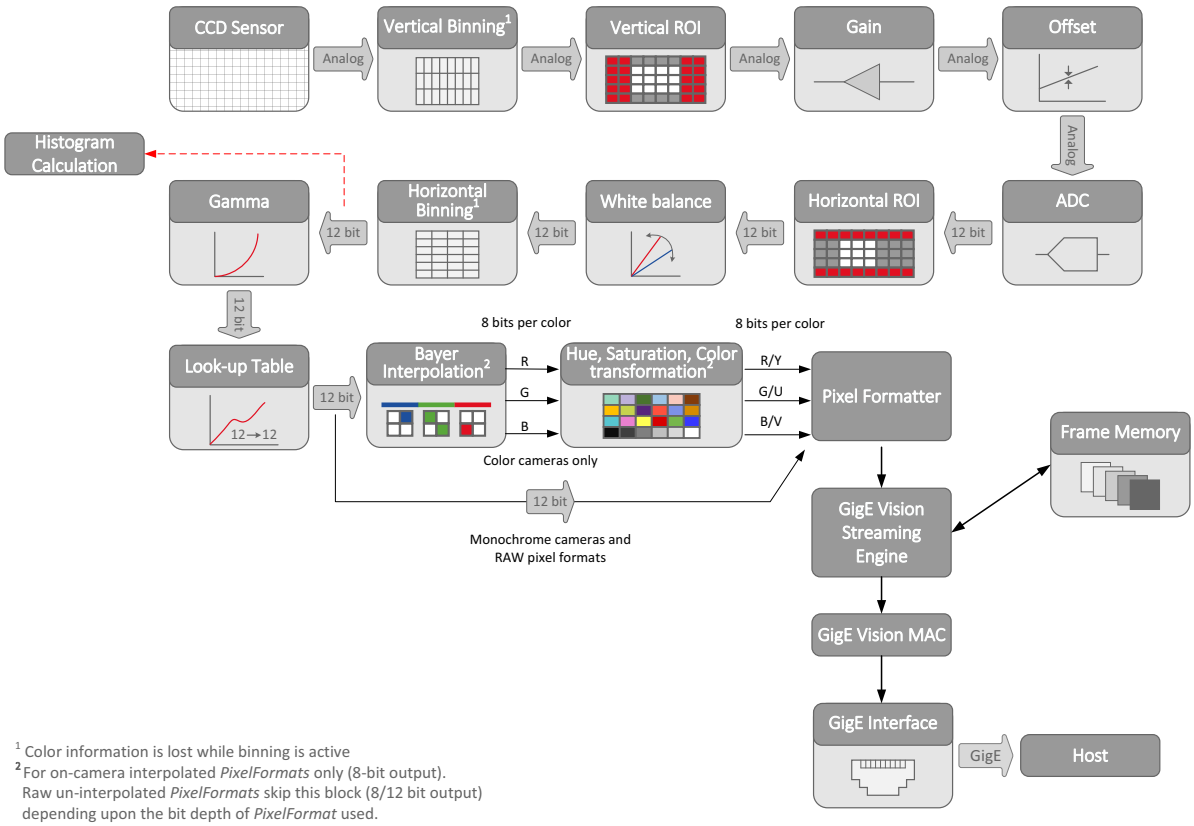
- Vimba and third-party users: GigE Features Reference
- PvAPI users: GigE Camera and Driver Attributes document

Mako G models with CCD sensors

Mako G-030

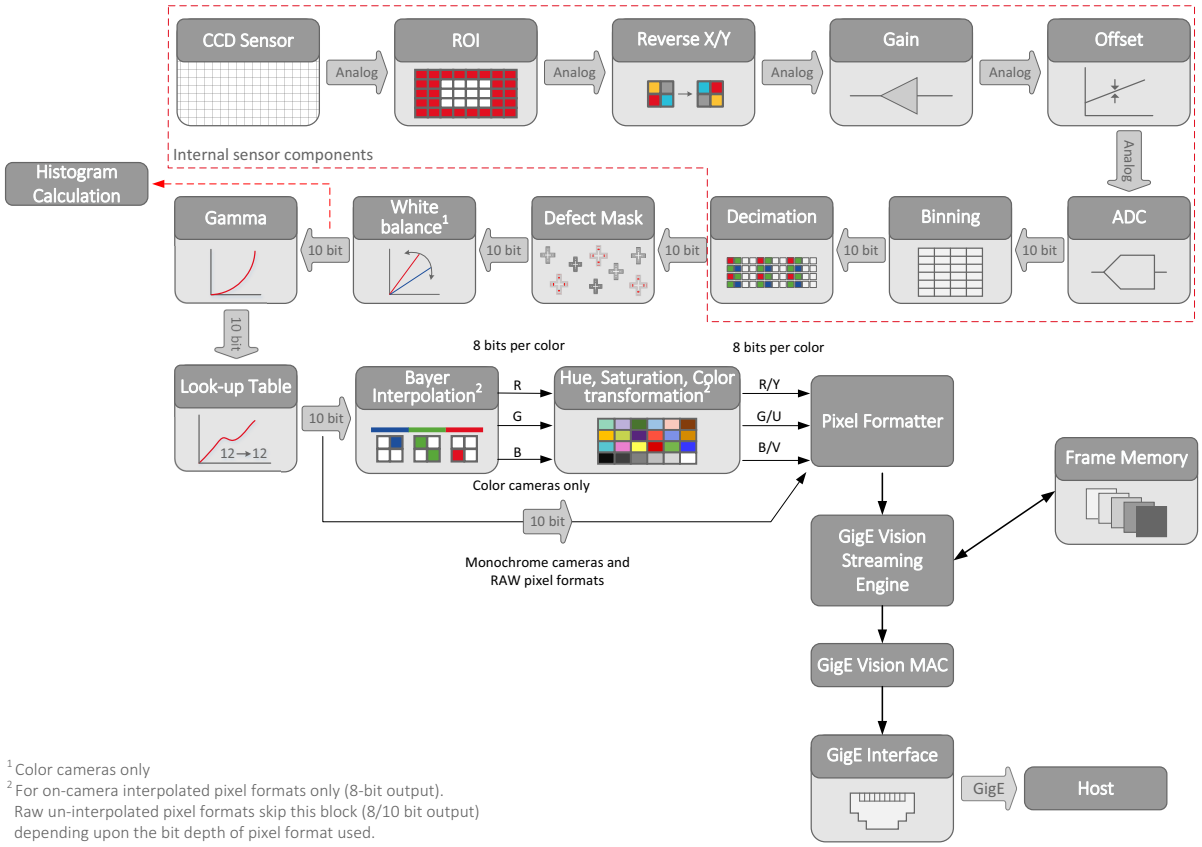


Mako G-032, G-125



[1] Color information is lost while binning is active
[2] For on-camera interpolated *PixelFormats* only (8-bit output). Raw un-interpolated *PixelFormats* skip this block (8/12 bit output) depending upon the bit depth of *PixelFormat* used.

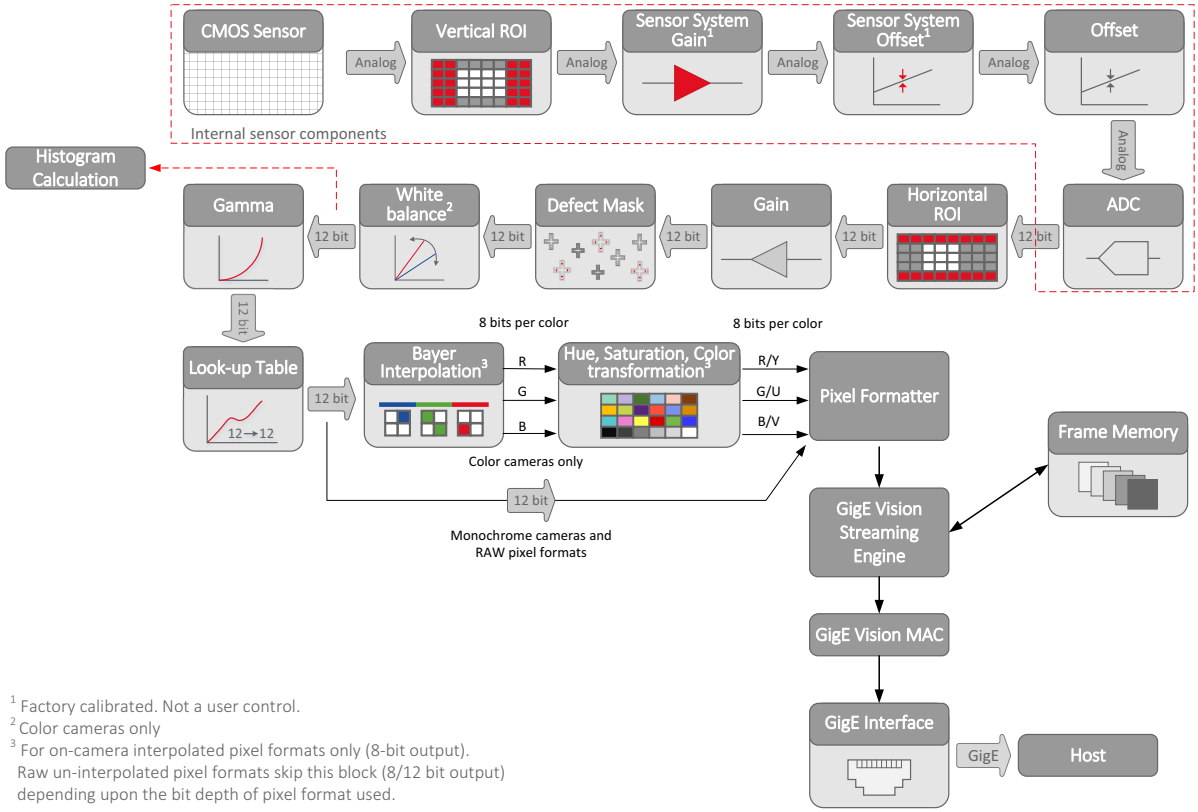
Mako G-131, G-192



[1] Color cameras only
[2] For on-camera interpolated pixel formats only (8-bit output). Raw un-interpolated pixel formats skip this block (8/10 bit output) depending upon the bit depth of pixel format used.

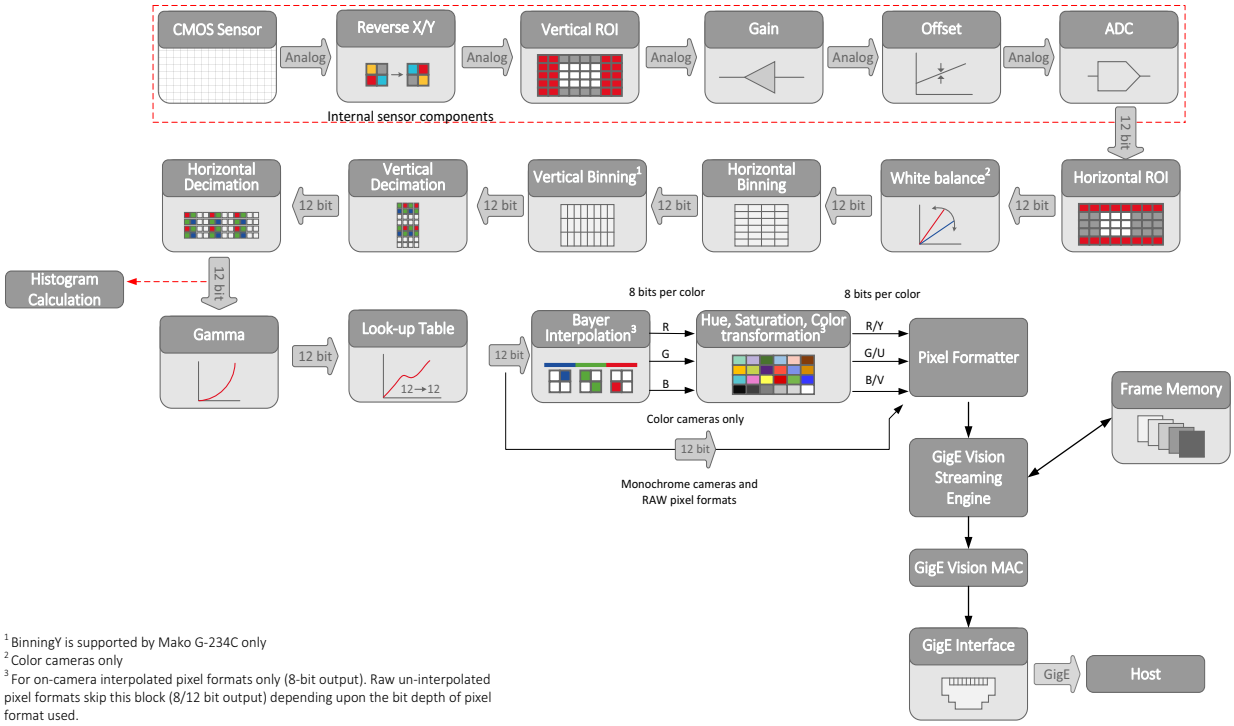
Mako G models with CMOS sensors

Mako G-223, G-419



[1] Factory calibrated. Not a user control.
[2] Color cameras only
[3] For on-camera interpolated pixel formats only (8-bit output). Raw un-interpolated pixel formats skip this block (8/12 bit output) depending upon the bit depth of pixel format used.

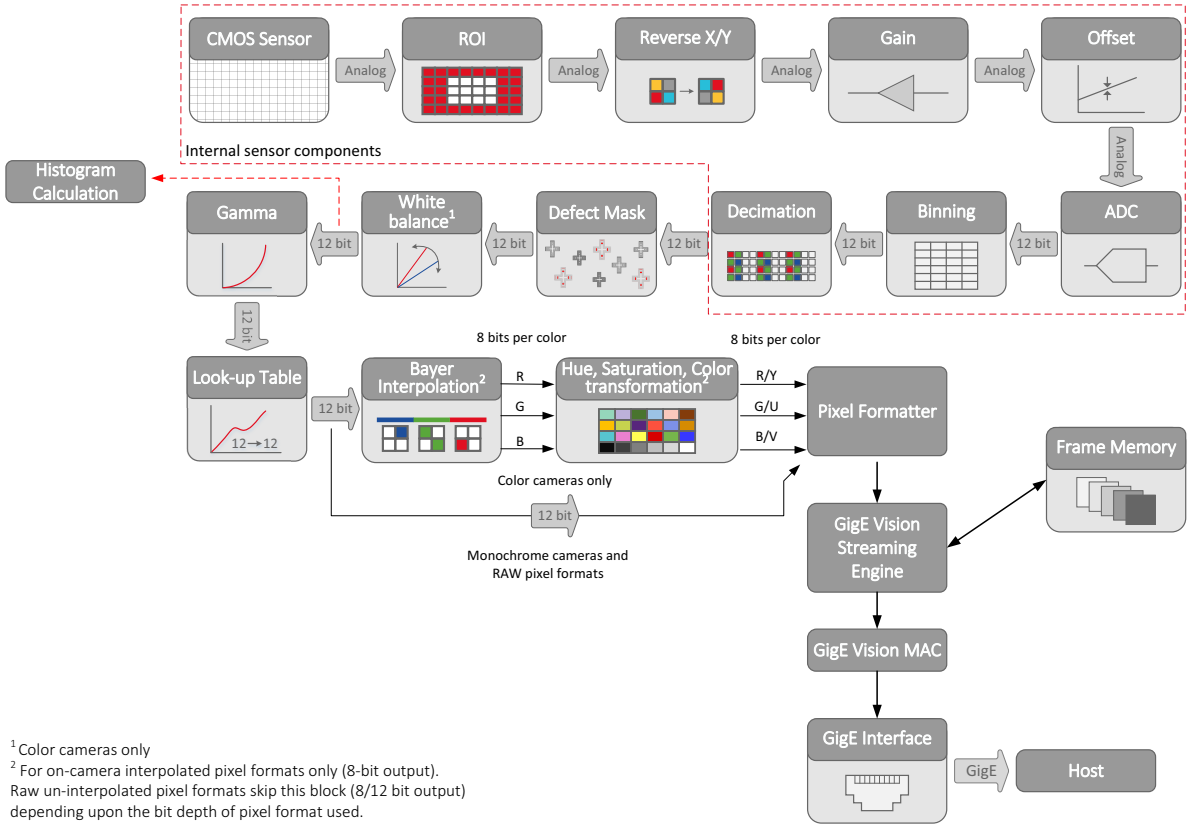
Mako G-234, G-319, G-507



[1] BinningY is supported by Mako G-234C only
[2] Color cameras only
[3] For on-camera interpolated pixel formats only (8-bit output). Raw un-interpolated pixel formats skip this block (8/12 bit output) depending upon the bit depth of pixel format used.

Mako G-234B/G-234C supports 10-bit and 12-bit sensor readout mode. 10-bit data will still be processed as 12-bit data with 2 LSB bits padded with zeros.

Mako G-503



[1] Color cameras only
[2] For on-camera interpolated pixel formats only (8-bit output).
Raw un-interpolated pixel formats skip this block (8/12 bit output) depending upon the bit depth of pixel format used.

Cleaning optical components

This chapter describes safety instructions and cautions for cleaning lenses, optical filters, protection glass, or sensors.

Important instructions to be read first

Please read these instructions before you contact Allied Vision or your Allied Vision distribution partner for assistance.

Ask Allied Vision or your Allied Vision distribution partner if you are not familiar with the procedures described below.

Monochrome and NIR models

As monochrome and NIR models do not have an optical filter, always attach a dust cap when a lens is not attached to minimize the possibility of contaminants falling on the sensor surface.

Warranty

Warranty information available online

For details about camera warranty duration and sensor warranty terms, go to:

https://www.alliedvision.com/en/support/warranty

Warranty precautions

To ensure your warranty remains in effect:

- Do not open the camera housing.
- Follow instructions described below.
- Use only optical quality tissue/cloth if you must clean a lens or filter.
- Use only optics cleaner. Do not use aggressive cleaners like benzine or spirit. Such cleaners may destroy the optical component's surface.
- Do not use compressed air which can push dust into camera and lens unless you are trained to clean a camera using this method.

Allied Vision does not warranty against any physical damage to the sensor, filter, protection glass, or lenses. Use utmost care when cleaning optical components.

Keep optical components clean

The best way to ensure the camera remains clean is to avoid penetration of foreign substances into the camera.

When screwing/unscrewing the camera lens or dust cap, hold the camera with the C-Mount / CS-Mount opening towards the floor. This minimizes the possibility of any contaminants falling on the glass surface. Always store cameras and lenses with dust-caps on.

Figure 43: Illustration of camera orientation when removing lens or dust cap

Identifying impurities

If you observe any image artifacts in your video preview of your Mako G camera you may have impurities either on the lens, filter/protection glass, or on the sensor protection glass. Every Mako G camera is cleaned prior to sealing and shipment; however, impurities may develop due to handling or unclean environments.

As shown in figure 44, impurities (dust, particles or fluids) on the sensor or optical components appear as a dark area, patch or spot on the image and remain fixed in the preview window while you rotate the camera over the target.

Do not confuse this with a pixel defect which appears as a distinct point. Particles can either rest loosely or can be more or less stuck to the optical surface.

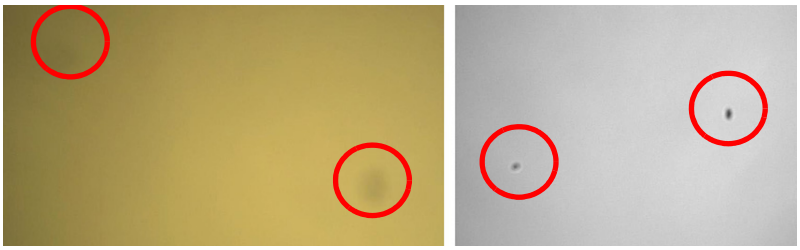


Figure 44: Image with tiny dust on the filter (left) and dust on the sensor (right)

Locating impurities

Before you dismount the lens you should find out if the impurity is on the filter, lens, or sensor.

1. Start acquiring a uniform image (e.g. a white sheet of paper) with the camera.
2. To identify the affected surface, move the suspected optical component and see if the contamination follows this movement.
   a. If you move only the lens (not the camera) and the impurity moves as well, the impurity is on the lens.
   b. If you move the IR cut filter/protection glass window and the impurity moves as well, the impurity is on the filter/protection glass. Carefully remove the filter/protection glass and clean it on both sides using the techniques explained in the next section.

3. If the impurity is neither on the lens nor the IR cut filter/protection glass, it is probably on the sensor.

Removing IR cut filter/protection glass

To remove the IR cut filter/protection glass use the special tool (Allied Vision order code 3851; 22 mm filter).

Materials for cleaning optical components

Use only these cleaning materials for optical components

- Optic approved lens cotton, cloth, or tissue that is chemically pure and free from silicones and other additives.
- Optic approved low residue cleaning liquid.

Never use these cleaning materials for optical components

- Dry swabs or tissue may cause scratches.
- Metal tools may cause scratches.
- Disposable cotton cosmetic swabs may contain contaminants harmful to optical glass.
- Cosmetic cotton my cause scratches or get caught in small gaps.
- Consumer eyeglass cleaning cloths may be pretreated with silicone harmful to optical glass.
- Aggressive cleaners like benzine, acetone, or spirits may damage the surface.

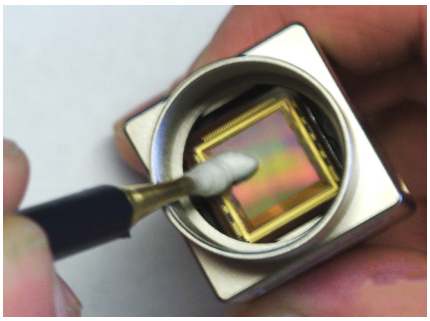
Cleaning Instructions

Workplace conditions

- Perform all cleaning operations (lenses, filter/protection glass, and sensor) in a dust-free clean-room.
- Avoid touching the optical components with your fingers or any hard material.
- Nitrile cleanroom gloves or powder free latex gloves are recommended to maintain low particulate levels.
- Use an ESD mat to prevent damage from an electrostatic discharge.

1. Unplug the camera from any power supply before cleaning.
2. Apply a small amount of cleaning liquid to a new lens cleaning cotton, cloth, or tissue. The cotton, cloth, or lens tissue should be moist, but not dripping.

3. Hold the camera sensor diagonally upwards. Ensure that the camera is away from your body to prevent particles like skin flakes from falling on the sensor.



4. Wipe the glass surface with a spiral motion from the center to the rim. Normally, several spiral wipes are recommended. Wipe only on glass avoiding contact to metal surfaces, because microscopic dirt could be released and could cause scratches on the glass.
5. When you have finished cleaning, examine the surface in a strong light. Take an out-of-focus picture of a flat, illuminated surface to see if any dirt or dust remains.
6. If dust spots remain, repeat this procedure using new clean lens tissue (as described above).

Cleaning issues

If you notice that the camera lens or sensor is not clean after attempting to clean twice, or if you have any questions regarding cleaning your camera, please contact your Allied Vision distribution partner.

Cleaning with compressed air

Allied Vision does not recommend cleaning Mako G cameras with compressed air.

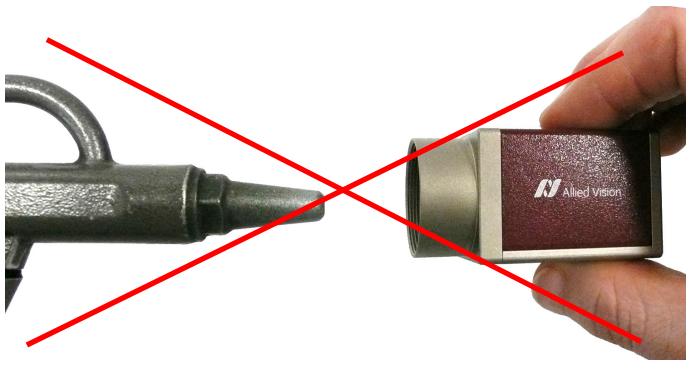


Figure 45: Do not use compressed air

Possible material damage

- Compressed air at high pressure and/or shorter operating distances may push dust into the camera/lens and physically damage the camera, sensor, or optical components.
- Propellant from non-optic approved compressed air products may leave a residue on the camera or lens and may physically damage the camera, sensor, or optical components.
- Compressed air may contain oil or moisture that could contaminate or damage the optical components.
- Use an air blower/compressed air only if you are familiar with cleaning a camera using this method.

If you want to clean your camera with compressed air despite of all the warnings:

- Use an optic approved compressed air product or compressor.
- Use an anti-static ionizer attachment to reduce the risk of static-caused damage.
- Use a filter to remove moisture and oil from the air.
- Use short directed bursts of air to remove impurities.

Compressed air pressure and operating distance

- Keep the compressed air pressure at a moderate strength only. Pressure at the nozzle should be less than 1 bar (15 psi).
- Operating distance from the camera should be 5 to 30 cm.

Firmware update

This chapter includes instruction on how to update the firmware on your Allied Vision Mako G camera.

Download the latest GigE firmware loader from the Allied Vision website:

https://www.alliedvision.com/en/support/firmware

Saved camera user sets

If new firmware contains a new feature or control, saved camera UserSets/ ConfigFiles will be invalidated and erased!

Before loading new firmware, backup your current camera settings.

Vimba Viewer: select the **Save Camera Settings** icon from the **Cameras** window to export the camera settings file (XML) to the host PC.

GigE SampleViewer: select the **Disk** icon from the **Cameras** window to export camera settings file (XML) to the host PC.

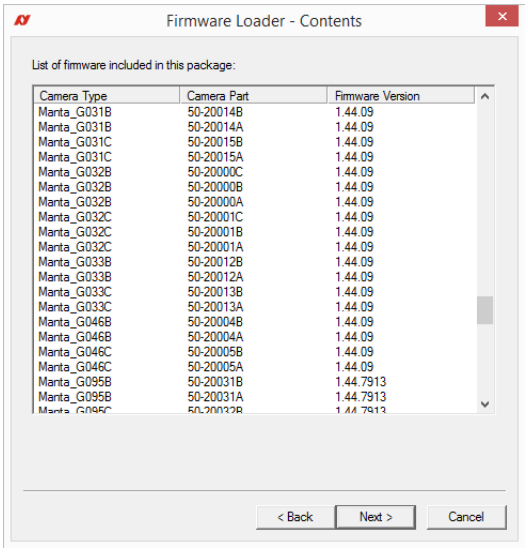
Possible material damage

Do not unplug the GigE cable or camera power supply during the update procedure.

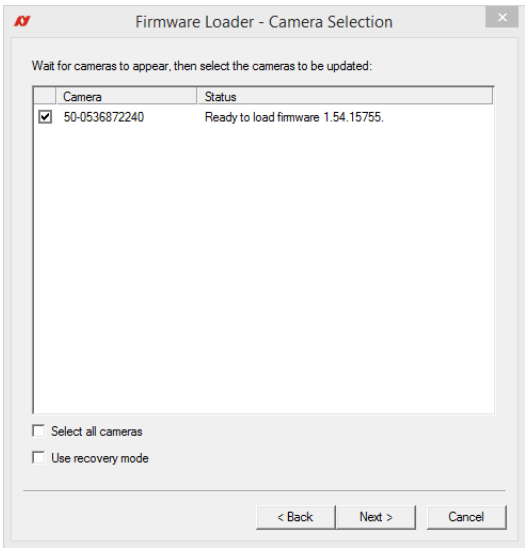
To update the firmware on your Allied Vision GigE camera

1. Launch the *Allied Vision Firmware Loader*.

2. Click **Next**. The *Firmware Loader* displays a list of firmware included in the package



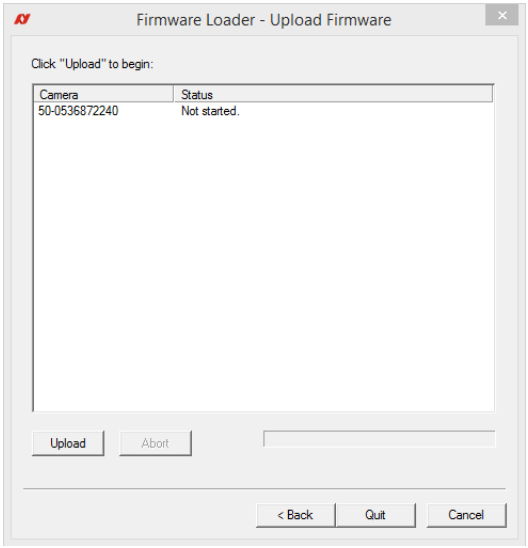
3. Click **Next**. You can select your camera model on this page.



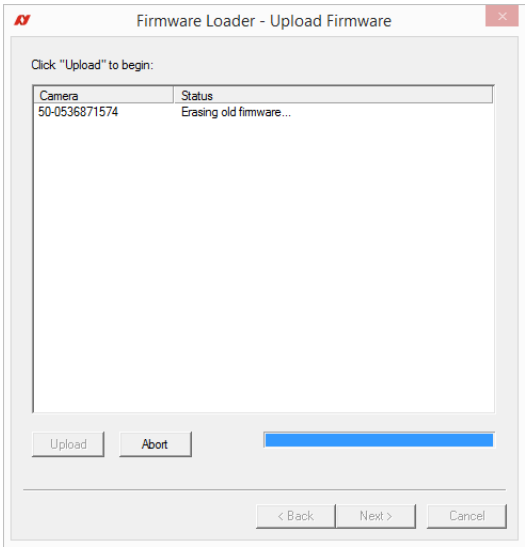
Recovery Mode

Select the **Use recovery mode** checkbox if the connected GigE camera is not found by the firmware loader, or if the GigE camera is listed as unavailable. When selected, power cycle the camera to enter the **Boot Loader** mode.

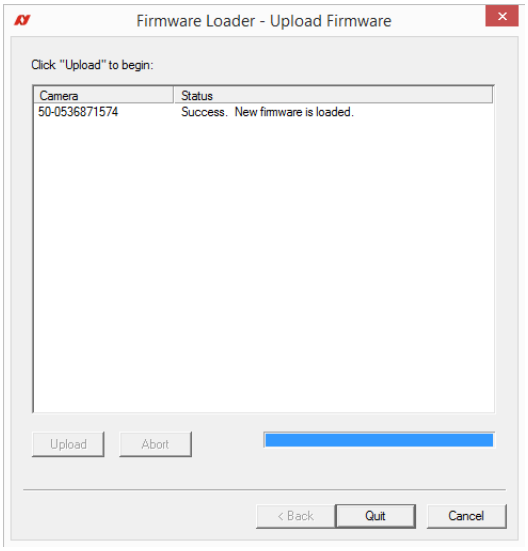
4. Click **Next**.



5. Click **Upload** to start the update. The existing firmware will be erased and the new firmware will be updated to the camera.



6. The *Firmware Loader* displays a success status upon completion. Click **Quit** to exit the loader.



Power cycle after upgrade or downgrade

You should always power cycle the camera after a firmware upgrade or downgrade.

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