Allied Vision Mako

Technical Manual

GigE Vision Cameras

V3.2.0

20 March 2015

Allied Vision

Legal notice

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.

For customers in Canada
This apparatus complies with the Class B limits for radio noise emissions set out in the Radio Interference Regulations.

Pour utilisateurs au Canada
Cet appareil est conforme aux normes classe B 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.

Trademarks
Unless stated otherwise, all trademarks appearing in this document of Allied Vision Technologies are brands protected by law.

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.

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Allied Vision Technologies GmbH 03/2015

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Contents

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Introduction

This **Mako Technical Manual** describes in depth the technical specifications, dimensions, all pixel formats, bandwidth and frame rate related subjects.

For detailed information on camera features and controls refer to the **GigE Features Reference** and **GigE Camera and Driver Attributes** documents.

www

Mako literature:
http://www.alliedvision.com/en/support/technical-documentation/mako-documentation

Note

We assume that you have already read the **GigE Installation Guide** and that you have installed the hardware and software on your PC or laptop (Gigabit Ethernet network card, cables). The **GigE Installation Guide** contains important safety warnings.

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 • Updated chapter Resolution and ROI frame rates on page 69
V2.0.2	2013-Sep-16	• Updated the frame rate information for Mako G-223 and Mako G-419 in Specifications and Resolution and ROI frame rates chapters • Updated introduction to include link to Mako literature webpage • Updated Status LEDs section • Added captions to tables in Camera lenses section • Added links to **AVT GigE Camera and Driver Features** document on page 56 and 59
		to be continued on next page

Table 1: Document history

Version	Date	Remarks
		continued from last page
V2.0.3	2013-Nov-27	• Updated gain control values for Mako G-223B/C (NIR) and Mako G-223B/C (NIR) • Updated Table 25: Status LED (green) on page 47 • Updated the note on *StreamHoldCapacity* in Specifications and Frame memory sections • Updated block diagrams in chapter Camera data path on page 56 • Updated the Index
V2.0.4	2014-Feb-28	• Updated available color pixel formats for Mako G-223B/C (NIR)and Mako G-223B/C (NIR) • Updated optional accessories in the Specifications chapter • Updated section Cross section: C-Mount on page 44 • Added section Heat dissipation on page 9 • Updated the operating temperature specification for Mako G-032B/C, Mako G-125B/C, Mako G-223B/C (NIR), and Mako G-223B/C (NIR) • Updated block diagrams in chapter Camera data path on page 56 to remove the RS232 mention • Added Hirose cable information on page 48
V2.1.0	2014-Oct-07	• Updated and rearranged Specifications chapter • Added Camera smart features on page 38 • Added trigger latency and jitter values for Mako G-032B/C and Mako G-125B/C • Updated Mako standard housing drawing • Updated table 30 on page 60 • Updated Mako G-503C section • Added Mako G-050 and Mako G-095 cameras: – Added Mako G-050B/C and Mako G-095B/C specifications and spectral sensitivity plots – Added camera lens information on page 40 – Added Mako G-050B/C: ROI frame rates and Mako G-095B/C: ROI frame rates sections – Updated Camera data path and Camera dimensions chapters
V3.0.0	2015-Jan-15	• Updated Allied Vision logo • Updated Camera cleaning section • Added Mako G-030, Mako G-131, and Mako G-192 cameras: – Added Mako G-030B/C, Mako G-131B/C, and Mako G-192B/C specifications and spectral sensitivity plots – Updated Table 13 : Mako camera smart features on page 38 – Added camera lens information on page 40 and 41 – Added Mako G-030B/C: ROI frame rates, Mako G-131B/C: ROI frame rates, and Mako G-192B/C: ROI frame rates sections – Updated Camera data path and Camera dimensions chapters
		to be continued on next page

Table 1: Document history

Version	Date	Remarks
		continued from last page

V3.1.0	2015-Mar-10	• Added Mako G-503 camera:
		   – Added Mako G-503B/C specifications and spectral sensitivity plots
		   – Added camera lens information on page 42
		   – Added Mako G-503B/C: ROI frame rates section
		   – Updated Camera data path and Camera 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

Manual conventions

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

Styles

Style	Function	Example
Bold	Programs, inputs or highlighting important things	**bold**
Courier	Code listings etc.	Input
Upper case	Register	REGISTER
Italics	Modes, fields	*Mode*
Parentheses and/or blue	Links	(Link)

Table 2: Styles

Symbols

Note   This symbol highlights important information.

Caution   This symbol highlights important instructions. You have to follow these instructions to avoid malfunctions.

| www | This symbol highlights URLs for further information. The URL itself is shown in blue.

Example: http://www.alliedvision.com |

More information

For more information on hardware and software read the following:

- The **GigE Installation Guide** describes the hardware installation procedures for Allied Vision GigE cameras and contains important safety instructions.
- **GigE Features Reference** describes the camera controls of Allied Vision's VIMBA SDK (GenICam) and feature related items.

| www | To **download the GigE Installation Guide** and **GigE Features Reference**, go to:

http://www.alliedvision.com/en/support/technical-documentation/mako-documentation |

| www | **Software packages** (including **documentation** and **release notes**) provided by Allied Vision can be downloaded from:

http://www.alliedvision.com/en/support/software-downloads |

Before operation

Target group This **Technical Manual** is the guide to detailed technical information of the camera and **is written for experts**.

Getting started For a quick guide on how to get started, read the **GigE Installation Guide** first.

| Caution | Before operating any Allied Vision camera, read the **safety instructions** and **ESD warnings** in the **GigE Installation Guide**. |

Heat dissipation

Due to the small packaging and high speed of Mako cameras, take care to ensure that the 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.

Note

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

Camera cleaning

This chapter describes safety instructions/cautions valid for **Mako** cameras in case of cleaning lenses, optical filters/protection glass or sensors.

Note

- Please read these instructions before you contact your Allied Vision camera dealer for assistance.
- Ask your Allied Vision camera dealer if you are not familiar with the procedures described below.

Warranty

www

For details about camera warranty duration and sensor warranty terms, visit:

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

Caution

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 (60% ethyl alcohol, 40% ether). Never use aggressive cleaners like benzine or spirit. Such cleaners may destroy the surface.
  - **Do not use compressed air which can push dust into camera and lens.**
- Allied Vision does not warranty against any physical damage to the sensor/filter/protection glass or lenses. **Use utmost care when cleaning optical components**.

Avoiding the necessity of camera cleaning

When screwing/unscrewing the camera lens or dust cap, hold the camera with the C-Mount / CS-Mount opening towards the floor as shown in figure 1. This minimizes the possibility of any contaminants falling on the glass surface. Always store cameras and lenses with dust-caps installed.

Figure 1: Illustration of camera orientation when removing lens or dust cap

Identifying impurities

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

As shown in figure 2, 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.
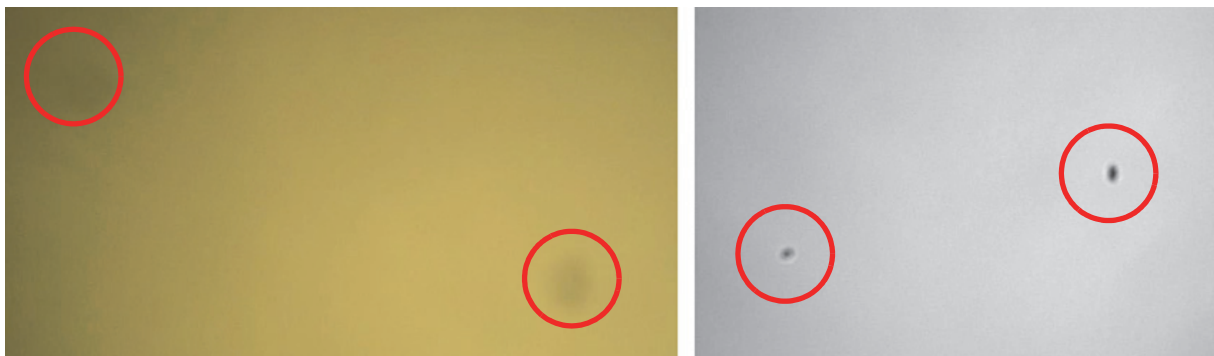

Figure 2: Image with tiny dust on the filter (left) and dust on the sensor (right)

Locating impurities

Before you dismount the lens you should find out if the impurity is on the filter, lens, or sensor. Therefore, you should capture a uniform image (e.g. a white sheet of paper) with the camera. The affected optical surface is identified when a suspected optical component is moved and the dirt follows this movement.

1. If you move only the lens (not the camera) and the impurity moves as well, the impurity is on the lens.

2. If you move the IR cut filter/protection glass window and the impurity moves as well:

Please carefully remove the filter/protection glass and clean it on both sides using the techniques explained below.

Note

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- Taking out the filter requires special care.
- Ask your dealer to help you if you are not confident with the procedure.

Figure 3: Removing IR cut filter/protection glass using special tools
(P/N: E9020001 for 16mm filter and P/N: 3851 for 22 mm filter)

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

Cleaning Instructions

Perform all cleaning operations (lenses, filter/protection glass, and sensor) in a **dust-free clean-room**. The optical components are very fragile so it is important to avoid touching them with your fingers or any hard material.

1. Unplug the camera from any power supply before cleaning.

2. Apply a small amount of optics cleaner (60% ethyl alcohol, 40% ether) to a clean, new lens cleaning tissue.

   Acceptable material includes medical-grade sterile optical cotton, or lens tissue that is chemically pure and free from silicones and other additives.
   - **Do not** use cosmetic cotton.
   - **Do not** use consumer eyeglass cleaning cloths pre-treated with silicon.

   The cotton or lens tissue should be moist, but not dripping. Please hold the camera away from your body to avoid falling particles like flakes from skin on the sensor. Hold the camera sensor diagonally upwards.

Figure 4: Medical-grade sterile optical cotton

3. 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.

4. When you've 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.

5. If dust spots remain, repeat this procedure using new clean lens tissue (as described above).
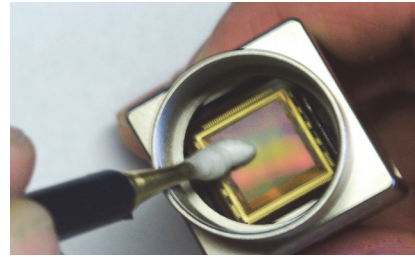

Figure 5: Sensor cleaning

Figure 6: Don't use compressed air

Caution

- Never wipe lenses with dry swabs or tissue—this causes scratches.
- Do not use any disposable cotton cosmetic swabs; they may contain contaminants.

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

Caution

- Use an air blower/compressed air only if you are familiar with cleaning a camera with this instrument.
- **Compressed air may push dust into cameras and lenses**. Therefore keep the pressure at a moderate strength only:
    - The pressure at the tube should be less than 1 bar (15 psi)
    - Operating distance: 5–30 cm

7. Gently blow the impurities off with dust-filtered, oil-free air (< 1 bar). Using ionized air helps to remove any dirt stuck to the optical component because of static electricity.

Note

If dust spots remain after cleaning twice, please contact your Allied Vision dealer.

About Mako GigE cameras

Mako	Mako cameras have a Gigabit Ethernet interface.
GigE	GigE is the abbreviation for **Gig**abit **E**thernet.
	All Mako cameras are GigE Vision V1.2 compliant cameras with Gigabit Ethernet interface. Mako cameras work with Gigabit Ethernet hardware and cable lengths up to 100 m.
GigE Vision	The GigE Vision standard is an interface standard for digital machine vision cameras widely supported in the industrial imaging industry. In contrast, GigE (Gigabit Ethernet) is the network GigE Vision is built upon.
GenICam	GenICam is the command structure for the GigE Vision camera controls. GenICam is administered by the European Machine Vision Association (EMVA). GenICam establishes a common camera control interface allowing third-party software to communicate with cameras from various manufacturers without customization. Allied Vision GigE cameras are GenICam V1.0 compliant.

Conformity

Allied Vision Technologies declares under its sole responsibility that all standard cameras of the Allied Vision Mako 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
- FCC Part 15 Class B
- RoHS (2011/65/EU)
- CE
- WEEE

We declare, under our sole responsibility, that the previously described Allied Vision Mako cameras conform to the directives of the CE.

FCC – Class B Device

Note: 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 in a residential environment. This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment.

Specifications

Caution

Before operating any Allied Vision camera, read the **safety instructions** and **ESD warnings** in the **GigE Installation Guide**.

http://www.alliedvision.com/fileadmin/content/documents/products/cameras/various/installation-manual/GigE_Installation_Manual.pdf

Caution

Due to the small packaging and high speed of Mako cameras, take care to ensure that the **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.

Note

All measurements were done without protection glass / without filter.

The uncertainty in measurement of the quantum efficiency values is ±10%.

This is due to:

• Manufacturing tolerance of the sensor.
• Uncertainties in the measuring apparatus itself (Ulbricht sphere, optometer, etc.).

Mako G-030B/C

Feature	Specification
Resolution	644 x 484
Sensor	CMV300-3E7M1WP (mono) / CMV300-3E7C1WP (color)
Type	CMOS Progressive
Sensor size	Type 1/3
Cell size	7.4 μm
Lens mount	C / CS-Mount
Max frame rate at full resolution	309 fps
Max image bit depth	12 bit

Table 3: Mako G-030B/C camera specifications

Feature	Specification
On-board FIFO	64 MByte, up to 99 frames at full resolution, Mono8/Bayer8, and a *GevSCPSPacketSize* = 8192 bytes per packet
Mono formats	Mono8, Mono12Packed, Mono12
Color formats	BayerRG8, BayerRG12Packed, BayerRG12, Mono8, RGB8Packed, BGR8Packed, YUV411Packed, YUV422Packed, YUV444Packed
Exposure control	83 μs to 2.0 s; 1 μs increments
Gain control	0–26 dB
Binning	N/A
Decimation	Horizontal and Vertical: 1, 2, 4 factor
Opto-coupled I/Os	1 input, 3 outputs
Voltage requirements	12–24 VDC or PoE
Power consumption	2.1 W @ 12 VDC, 2.3 W PoE
Trigger latency*	Idle state: 3.1 μs Frame valid state: 3.1 μs
Trigger jitter*	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; including connectors, without tripod and lens
Mass	80 g (without lens)
Hardware interface standard	PoE, IEEE 802.3af 1000BASE-T, 100BASE-TX
Software interface standard	GigE Vision Standard 1.2
Camera control interface	GenICam V1.0 compliant
Regulatory	CE, FCC Class B, RoHS (2011/65/EU), WEEE

*These values are calculated directly from the microcontroller source. These values are only valid for pixel formats < 16 bit 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 the next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state

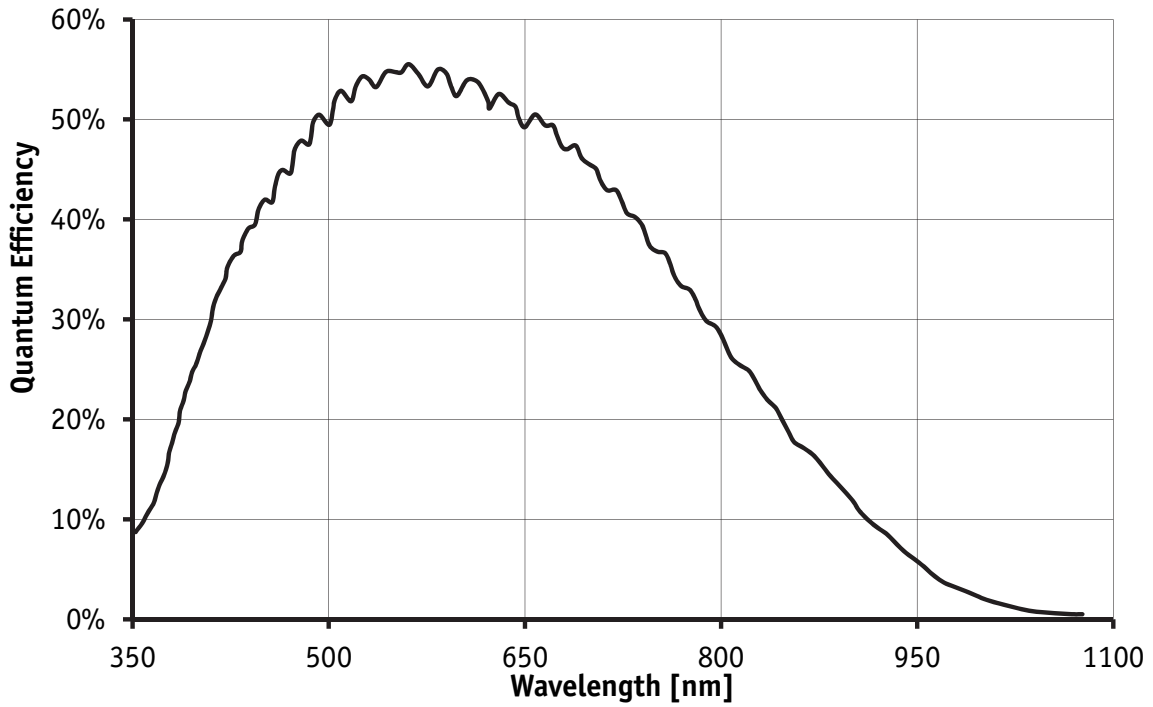Table 3: Mako G-030B/C camera specifications
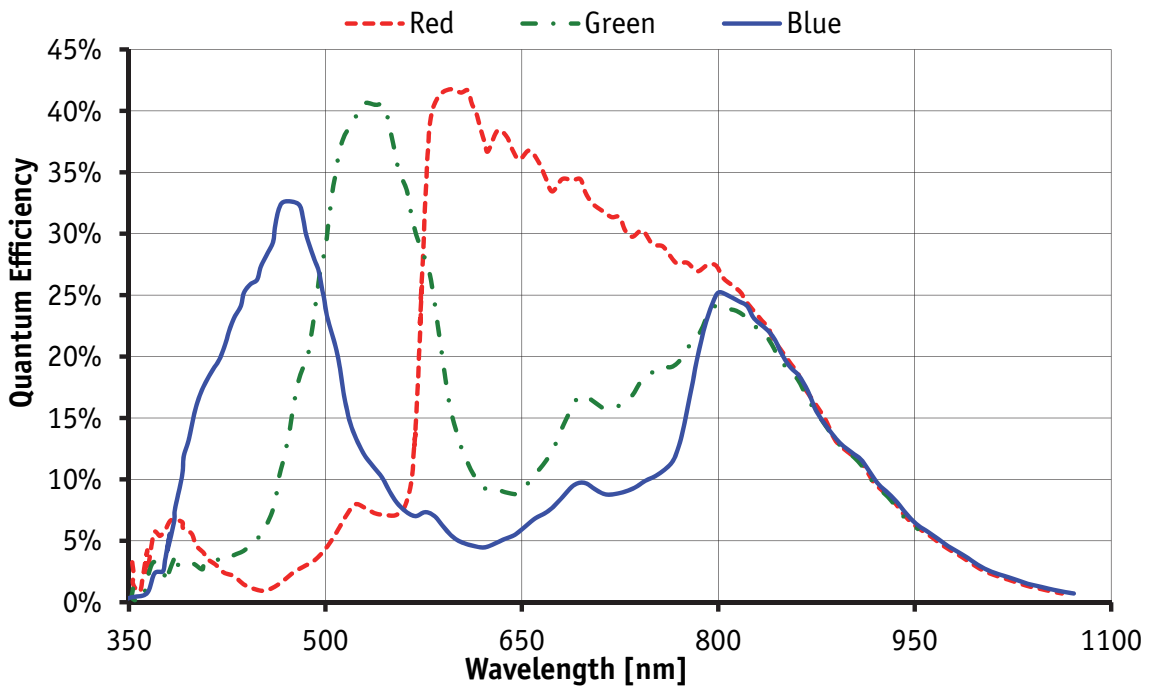
Figure 7: Spectral sensitivity of Mako G-030B

Figure 8: Spectral sensitivity of Mako G-030C

Mako G-032B/C

Feature	Specification
Resolution	658 x 492
Sensor	SONY IT CCD ICX424AL/AQ with HAD microlens
Type	CCD Progressive
Sensor size	Type 1/3
Cell size	7.4 µm
Lens mount	C / CS-Mount
Max frame rate at full resolution	102 fps
Max image bit depth	12 bit
On-board FIFO	64 MByte, up to 202 frames at full resolution, Mono8/Bayer8, and a *GevSCPSPacketSize* = 8192 bytes per packet
Mono formats	Mono8, Mono12Packed, Mono12
Color formats	BayerRG8, BayerRG12, BayerRG12Packed, Mono8, RGB8Packed, YUV411Packed, YUV422Packed, YUV444Packed, BGR8Packed
Exposure control	10 µs to 93 s
Gain control	0–30 dB
Horizontal binning	1 to 8 columns
Vertical binning	1 to 14 rows
Opto-coupled I/Os	1 input, 3 outputs
Voltage requirements	12–24 VDC or PoE
Power consumption	2.4 W @ 12 VDC, 2.8 W PoE
Trigger latency*	Idle state: 7.2 µs Frame valid state: 16.9µs
Trigger jitter*	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)
Body dimensions (L x W x H)	60.5 x 29 x 29 mm; including connectors, without tripod and lens
Mass	80 g (without lens)
Hardware interface standard	PoE, IEEE 802.3af 1000BASE-T, 100BASE-TX
Software interface standard	GigE Vision Standard 1.2
Camera control interface	GenICam V1.0 compliant
Regulatory	CE, FCC Class B, RoHS (2011/65/EU), WEEE

*It is possible to start the exposure of the next frame while the 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 the Next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state

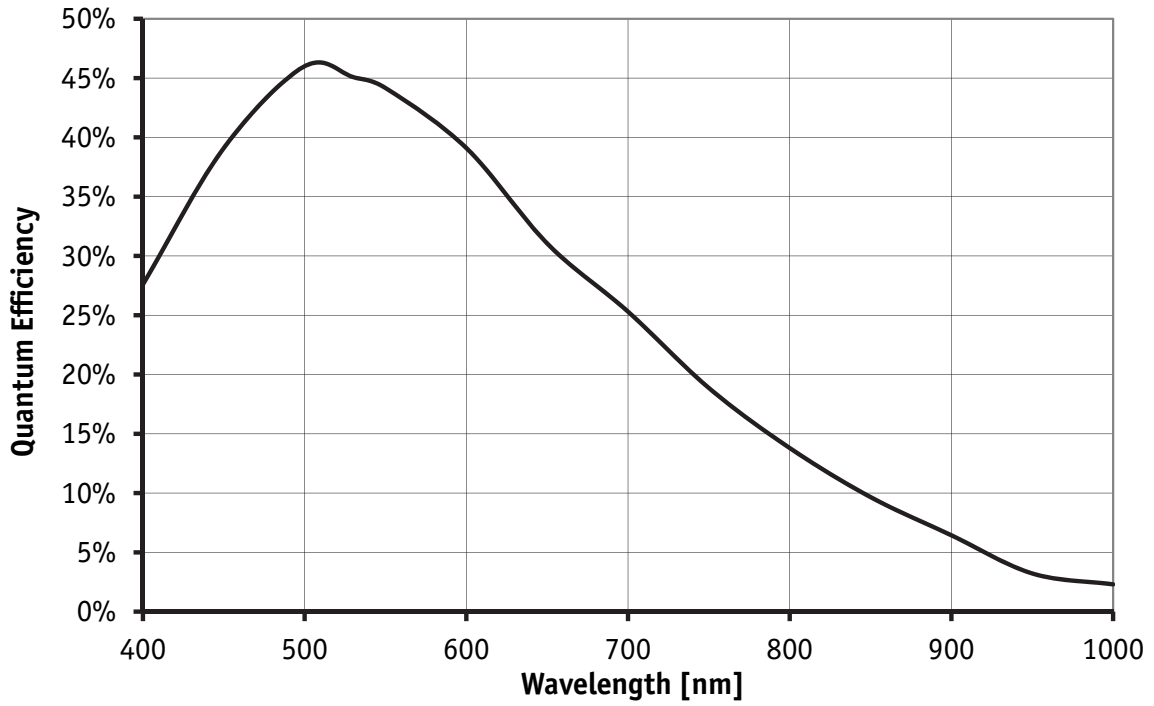Table 4: Mako G-032B/C camera specifications

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Figure 9: Spectral sensitivity of Mako G-032B (without protection/cover glass)

Figure 10: Spectral sensitivity of Mako G-032C (with IR cut filter)

Mako G-050B/C

Feature	Specification
Resolution	812 x 614
Sensor	SONY CCD ICX693ALA/AQA with Super HAD CCD II
Type	CCD Progressive
Sensor size	Type 1/3
Cell size	6.00 µm
Lens mount	C / CS-Mount
Max frame rate at full resolution	71.2 fps
Max image bit depth	12 bit
On-board FIFO	64 MByte, up to 130 frames at full resolution, Mono8/Bayer8, and a *GevSCPSPacketSize* = 8192 bytes per packet
Mono formats	Mono8, Mono12Packed, Mono12
Color formats	BayerRG8, BayerRG12, BayerRG12Packed, Mono8, RGB8Packed, YUV411Packed, YUV422Packed, YUV444Packed, BGR8Packed
Exposure control	46 µs to 84 s
Gain control	0–35 dB
Horizontal binning	1 to 8 columns
Vertical binning	1 to 14 rows
Opto-coupled I/Os	1 input, 3 outputs
Voltage requirements	12–24 VDC or PoE
Power consumption	2.1 W @ 12 VDC, 2.4 W PoE
Trigger latency*	Idle state: 7.1 µs Frame valid state: 18.3 µs
Trigger jitter*	Idle state: 4.0 µs Frame valid state: 15.3 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; including connectors, without tripod and lens
Mass	80 g (without lens)
Hardware interface standard	PoE, IEEE 802.3af 1000BASE-T, 100BASE-TX
Software interface standard	GigE Vision Standard 1.2
Camera control interface	GenICam V1.0 compliant
Regulatory	CE, FCC Class B, RoHS (2011/65/EU), WEEE

*It is possible to start the exposure of the next frame while the 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 the Next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state

Table 5: Mako G-050B/C camera specifications

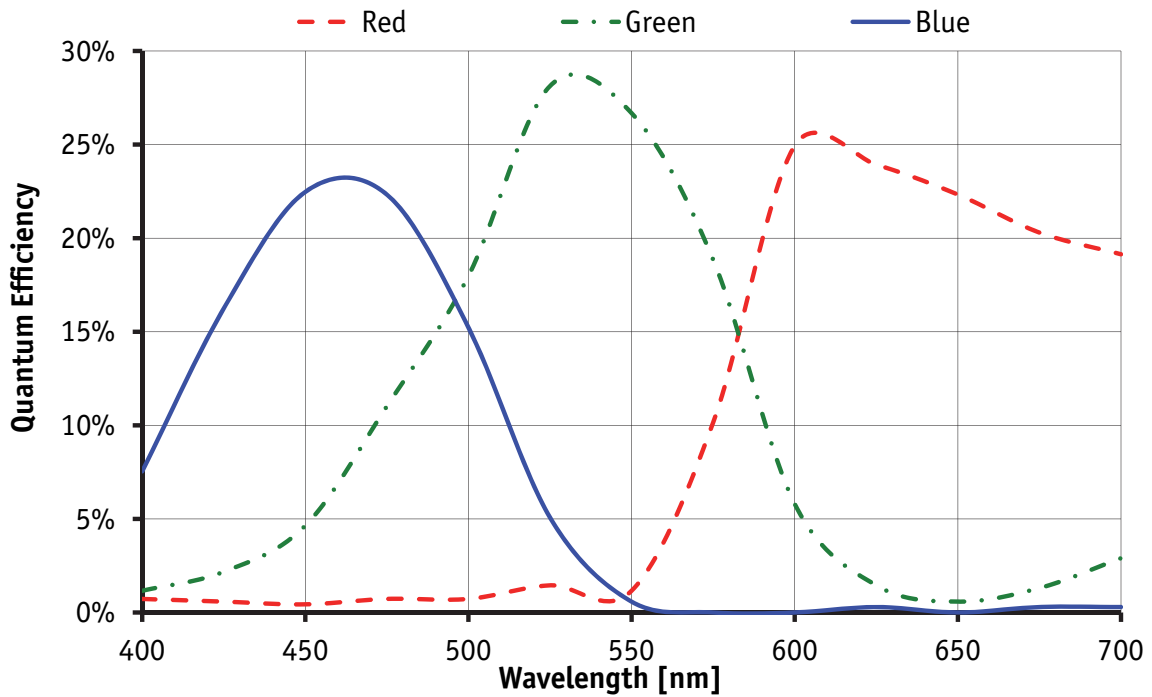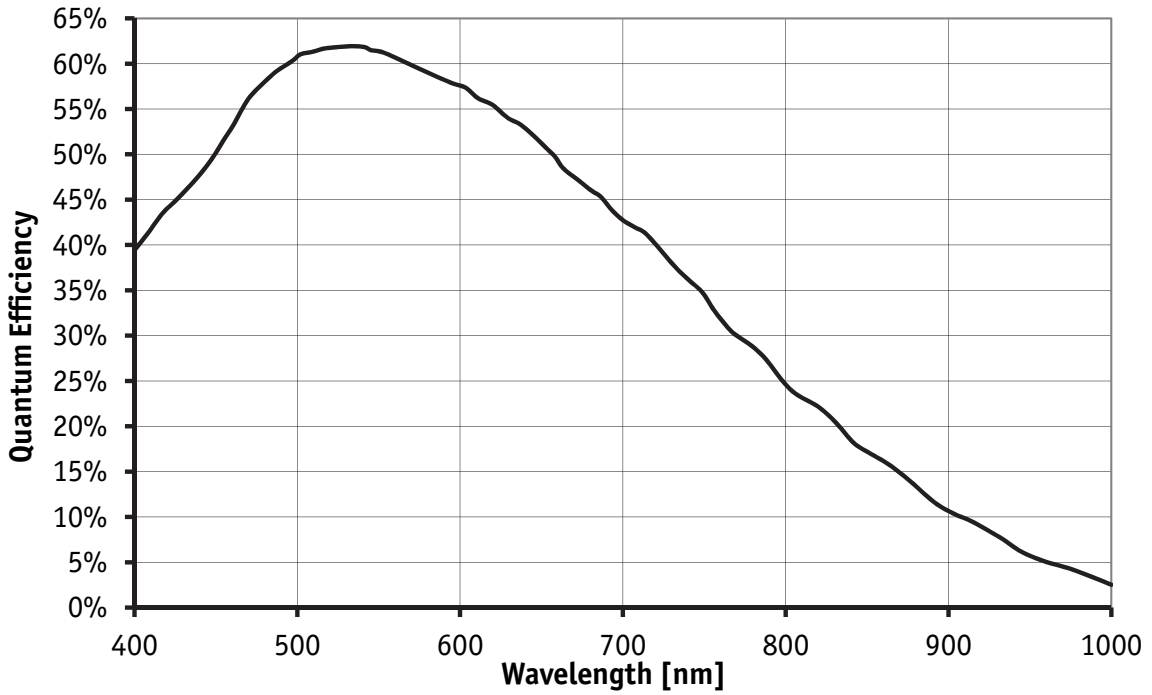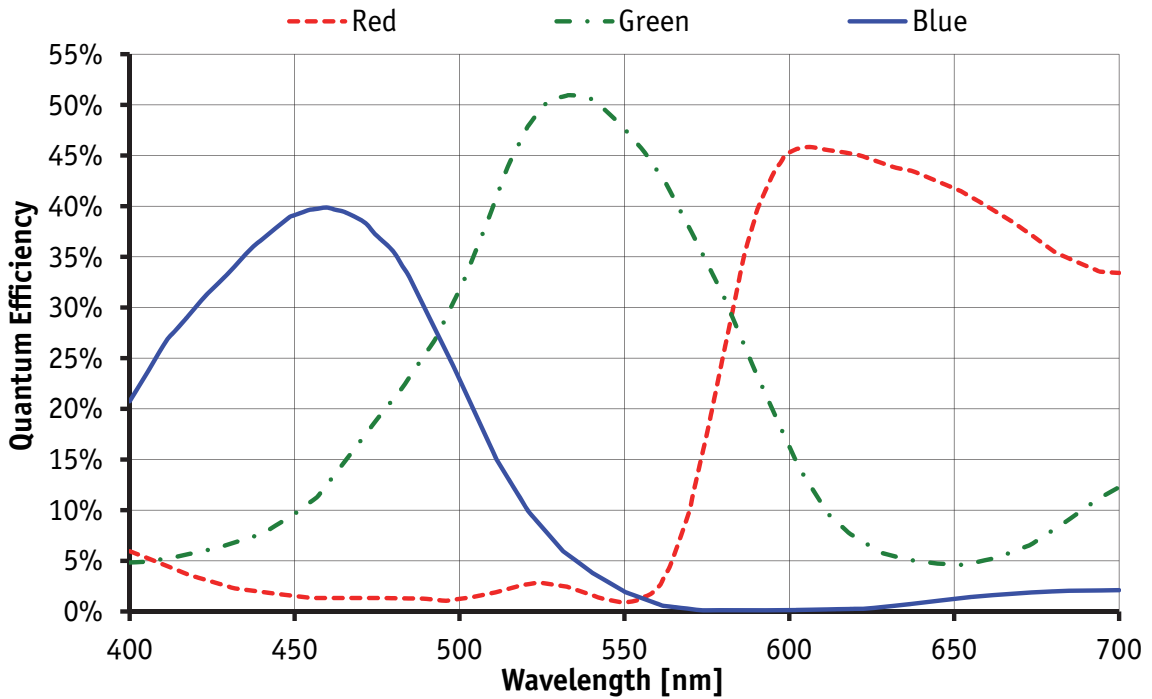Figure 11: Spectral sensitivity of Mako G-050B (without protection/cover glass)

Figure 12: Spectral sensitivity of Mako G-050C (without IR cut filter)

Mako G-095B/C

Feature	Specification
Resolution	1292 x 734
Sensor	SONY IT CCD ICX692ALA/AQA with EXview HAD CCD II
Type	CCD Progressive
Sensor size	Type 1/3
Cell size	4.08 µm
Lens mount	C / CS-Mount
Max frame rate at full resolution	42.8 fps
Max image bit depth	12 bit
On-board FIFO	64 MByte, up to 69 frames at full resolution, Mono8/Bayer8, and a *GevSCPSPacketSize* = 8192 bytes per packet
Mono formats	Mono8, Mono12Packed, Mono12
Color formats	BayerRG8, BayerRG12, BayerRG12Packed, Mono8, RGB8Packed, YUV411Packed, YUV422Packed, YUV444Packed, BGR8Packed
Exposure control	41 µs to 84 s
Gain control	0–32 dB
Horizontal binning	1 to 8 columns
Vertical binning	1 to 14 rows
Opto-coupled I/Os	1 input, 3 outputs
Voltage requirements	12–24 VDC or PoE
Power consumption	2.2 W @ 12 VDC, 2.5 W PoE
Trigger latency*	Idle state: 7.0 µs Frame valid state: 22.8 µs
Trigger jitter*	Idle state: 4.0 µs Frame valid state: 19.8 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; including connectors, without tripod and lens
Mass	80 g (without lens)
Hardware interface standard	PoE, IEEE 802.3af 1000BASE-T, 100BASE-TX
Software interface standard	GigE Vision Standard 1.2
Camera control interface	GenICam V1.0 compliant
Regulatory	CE, FCC Class B, RoHS (2011/65/EU), WEEE
*It is possible to start the exposure of the next frame while the 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 the Next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state	

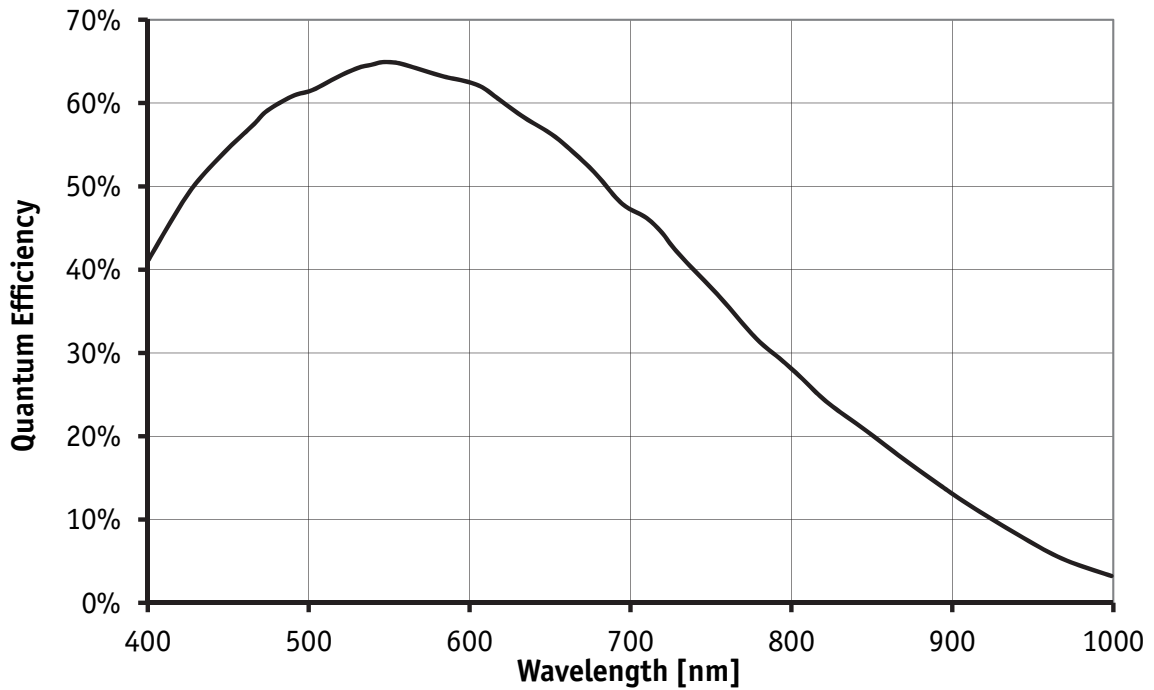Table 6: Mako G-095B/C camera specifications

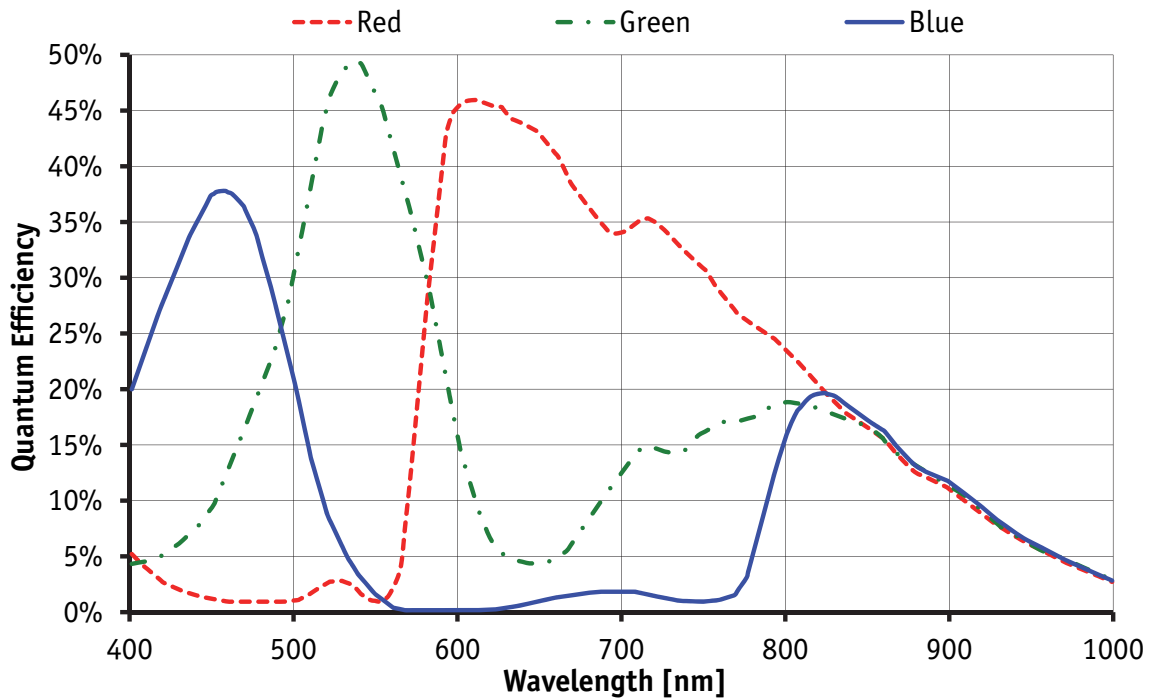Figure 13: Spectral sensitivity of Mako G-095B (without protection/cover glass)

Figure 14: Spectral sensitivity of Mako G-095C (without IR cut filter)

Mako G-125B/C

Feature	Specification
Resolution	1292 x 964
Sensor	SONY IT CCD ICX445ALA/AQA with EXview HAD microlens
Type	CCD Progressive
Sensor size	Type 1/3
Cell size	3.75 µm
Lens mount	C / CS-Mount
Max frame rate at full resolution	30 fps
Max image bit depth	12 bit
On-board FIFO	64 MByte, up to 52 frames at full resolution, Mono8/Bayer8, and a *GevSCPSPacketSize* = 8192 bytes per packet
Mono formats	Mono8, Mono12Packed, Mono12
Color formats	BayerRG8, BayerRG12, BayerRG12Packed, Mono8, RGB8Packed, YUV411Packed, YUV422Packed, YUV444Packed, BGR8Packed
Exposure control	12 µs to 84 s
Gain control	0–30 dB
Horizontal binning	1 to 8 columns
Vertical binning	1 to 14 rows
Opto-coupled I/Os	1 input, 3 outputs
Voltage requirements	12–24 VDC or PoE
Power consumption	2.3 W @ 12 VDC, 2.7 W PoE
Trigger latency*	Idle state: 8.0 µs Frame valid state: 25.0 µs
Trigger jitter*	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)
Body dimensions (L x W x H)	60.5 x 29 x 29 mm; including connectors, without tripod and lens
Mass	80 g (without lens)
Hardware interface standard	PoE, IEEE 802.3af 1000BASE-T, 100BASE-TX
Software interface standard	GigE Vision Standard 1.2
Camera control interface	GenICam V1.0 compliant
Regulatory	CE, FCC Class B, RoHS (2011/65/EU), WEEE

*It is possible to start the exposure of the next frame while the 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 the Next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state

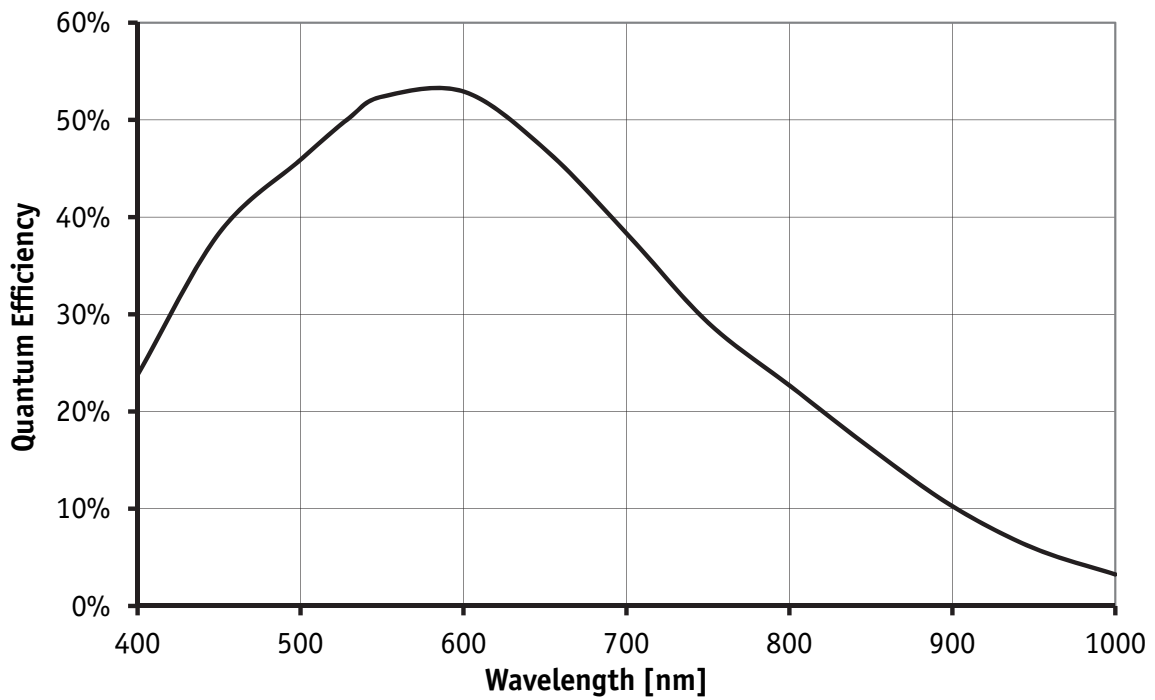Table 7: Mako G-125B/C camera specifications

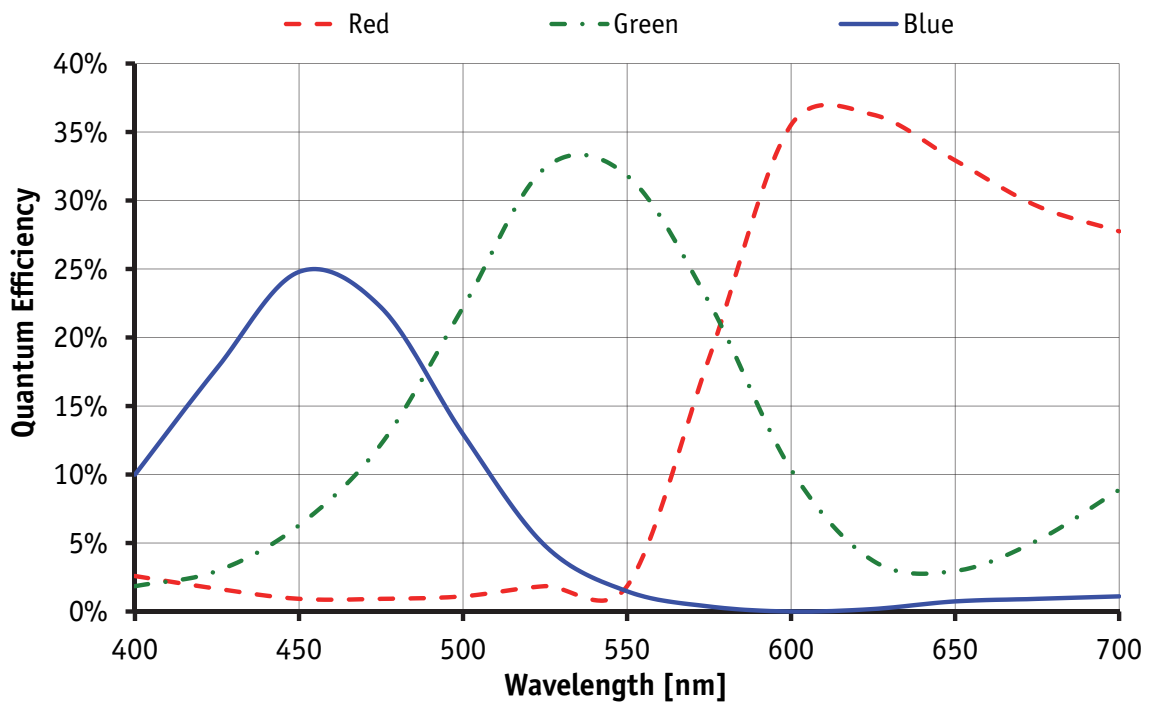Figure 15: Spectral sensitivity of Mako G-125B (without protection/cover glass)

Figure 16: Spectral sensitivity of Mako G-125C (with IR cut filter)

Mako G-131B/C

Feature	Specification			
Resolution	1280 x 1024			
Sensor	e2v EV76C560			
Type	CMOS Progressive			
Sensor size	Type 1/1.8			
Cell size	5.3 µm			
Lens mount	C / CS-Mount			
Max frame rate at full resolution	62 fps			
Max image bit depth	10 bit			
On-board FIFO	64 MByte, up to 50 frames at full resolution, Mono8/Bayer8, and a *GevSCP-SPacketSize* = 8192 bytes per packet			
Mono formats	Mono8, Mono10			
Color formats	BayerGB8, BayerGB10, Mono8, RGB8Packed, BGR8Packed, YUV411Packed, YUV422Packed, YUV444Packed			
Exposure control	PixelFormat	ShutterMode: Global	ShutterMode: GlobaReset	ShutterMode: Rolling
	Mono8, Mono10, BayerGB8, BayerGB10, YUV411Packed, YUV422Packed	12 µs to 1.012 s	12 µs to 0.978 s	12 µs to 0.994 s
	RGB8Packed, BGR8Packed, YUV444Packed	12 µs to 2.124 s	12 µs to 2.053 s	12 µs to 2.086 s
Gain control	0–24 dB			
Binning	Horizontal: 1 to 2 pixels; Vertical: 1 to 2 rows			
Decimation	Horizontal and Vertical: 1, 2, 4, 8 factor			
Opto-coupled I/Os	1 input, 3 outputs			
Voltage requirements	12–24 VDC or PoE			
Power consumption	2.0 W @ 12 VDC, 2.2 W PoE			
Trigger latency*	Idle state: 32.6 µs Frame valid state: 32.6 µs			
Trigger jitter*	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; including connectors, without tripod and lens			
Mass	80 g (without lens)			
Hardware interface standard	PoE, IEEE 802.3af 1000BASE-T, 100BASE-TX			
Software interface standard	GigE Vision Standard 1.2			
Camera control interface	GenICam V1.0 compliant			
Regulatory	CE, FCC Class B, RoHS (2011/65/EU), WEEE			

*These values are calculated directly from the microcontroller source. These values are only valid for pixel formats < 16 bit 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 the next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state

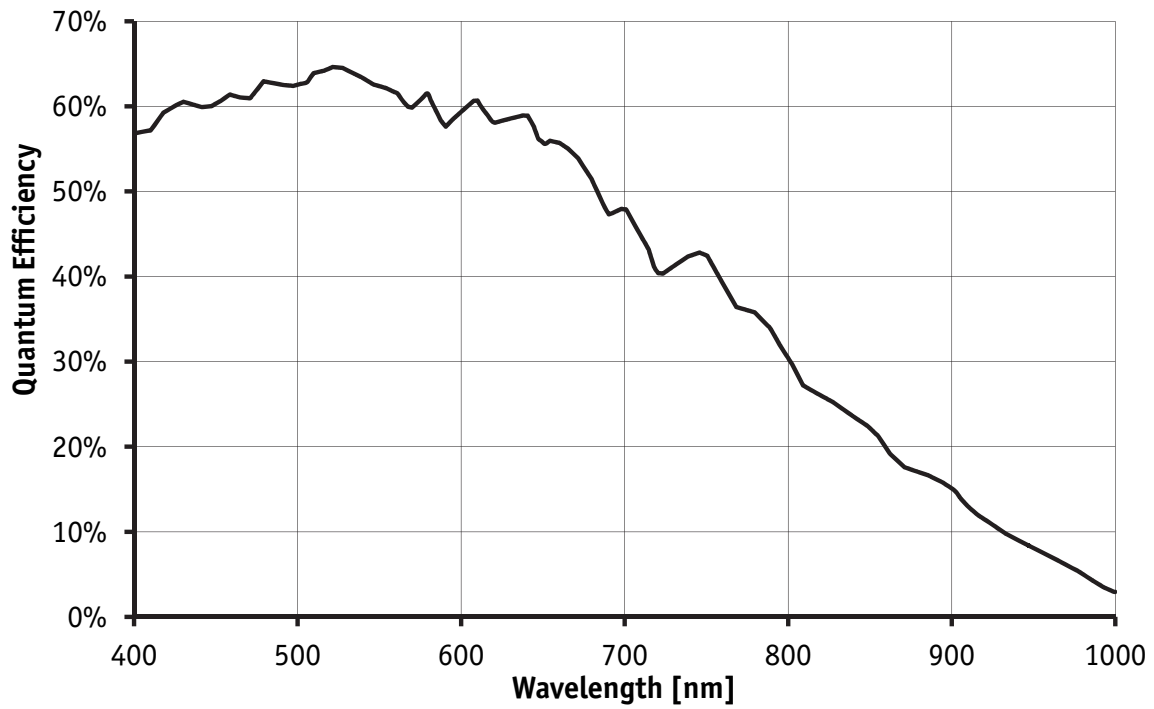Table 8: Mako G-131B/C camera specifications
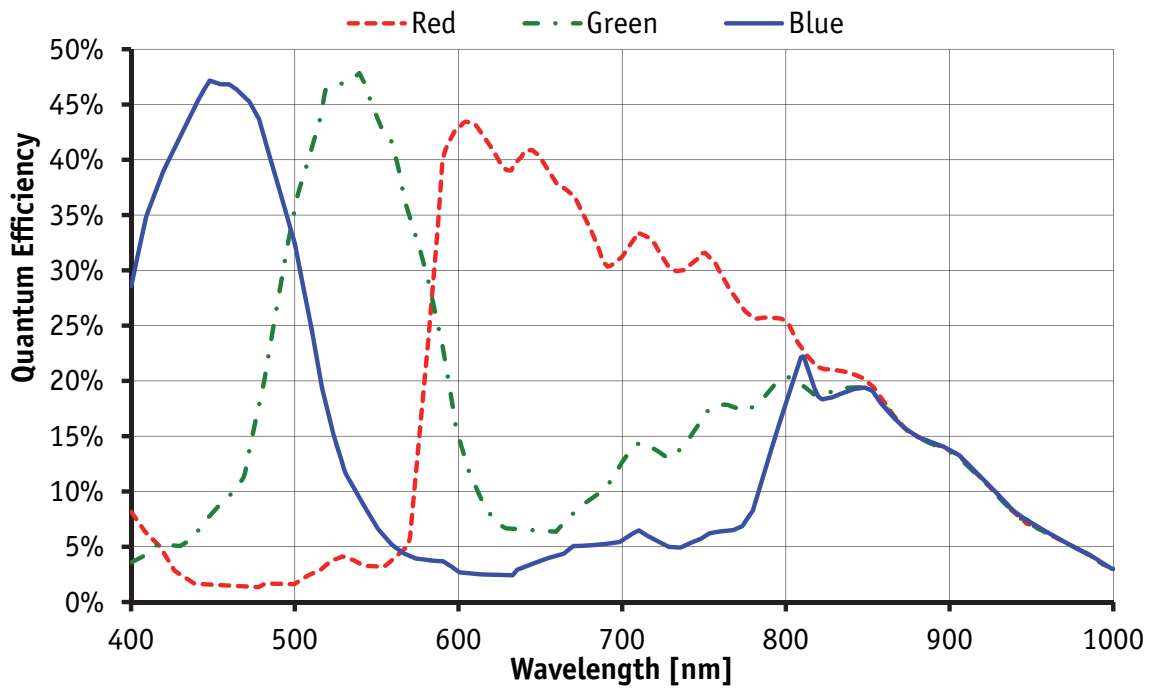
Figure 17: Spectral sensitivity of Mako G-131B

Figure 18: Spectral sensitivity of Mako G-131C

Mako G-192B/C

Feature	Specification		
Resolution	1600 x 1200		
Sensor	e2v EV76C570		
Type	CMOS Progressive		
Sensor size	Type 1/1.8		
Cell size	4.5 µm		
Lens mount	C / CS-Mount		
Max frame rate at full resolution	60 fps		
Max image bit depth	10 bit		
On-board FIFO	64 MByte, up to 34 frames at full resolution, Mono8/Bayer8, and a *GevSCP-SPacketSize* = 8192 bytes per packet		
Mono formats	Mono8, Mono10		
Color formats	BayerGB8, BayerGB10, Mono 8, RGB8Packed, BGR8Packed, YUV411Packed, YUV422Packed, YUV444Packed		
Exposure control	PixelFormat	ShutterMode: Global / Rolling	ShutterMode: GlobaReset
	Mono8, Mono10, BayerGB8, BayerGB10, YUV411Packed, YUV422Packed	14 µs to 0.891 s	14 µs to 0.874 s
	RGB8Packed, BGR8Packed, YUV444Packed	14 µs to 1.870 s	14 µs to 1.835 s
Gain control	0–24 dB		
Binning	Horizontal: 1 to 2 pixels; Vertical: 1 to 2 rows		
Decimation	Horizontal and Vertical: 1, 2, 4, 8 factor		
Opto-coupled I/Os	1 input, 3 outputs		
Voltage requirements	12–24 VDC or PoE		
Power consumption	2.1 W @ 12 VDC, 2.4 W PoE		
Trigger latency*	Idle state: 27.7 µs Frame valid state: 27.7 µs		
Trigger jitter*	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; including connectors, without tripod and lens		
Mass	80 g (without lens)		
Hardware interface standard	PoE, IEEE 802.3af 1000BASE-T, 100BASE-TX		
Software interface standard	GigE Vision Standard 1.2		
Camera control interface	GenICam V1.0 compliant		
Regulatory	CE, FCC Class B, RoHS (2011/65/EU), WEEE		

*These values are calculated directly from the microcontroller source. These values are only valid for pixel formats < 16 bit 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 the next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state
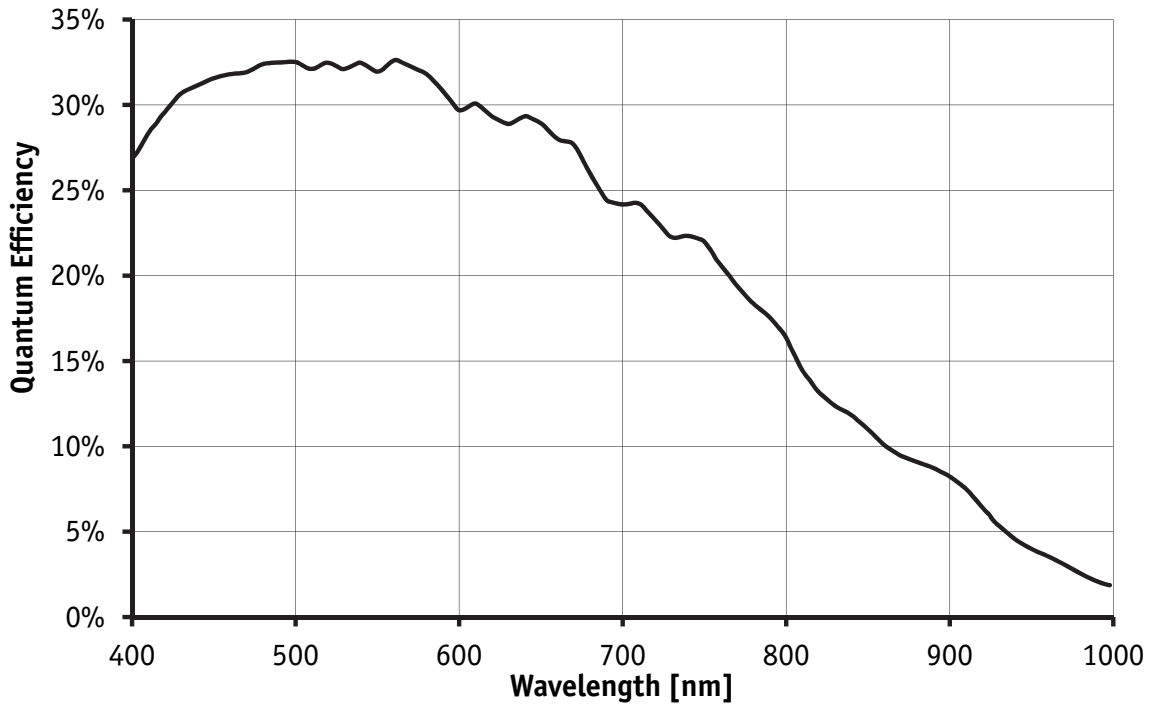
Table 9: Mako G-192B/C camera specifications

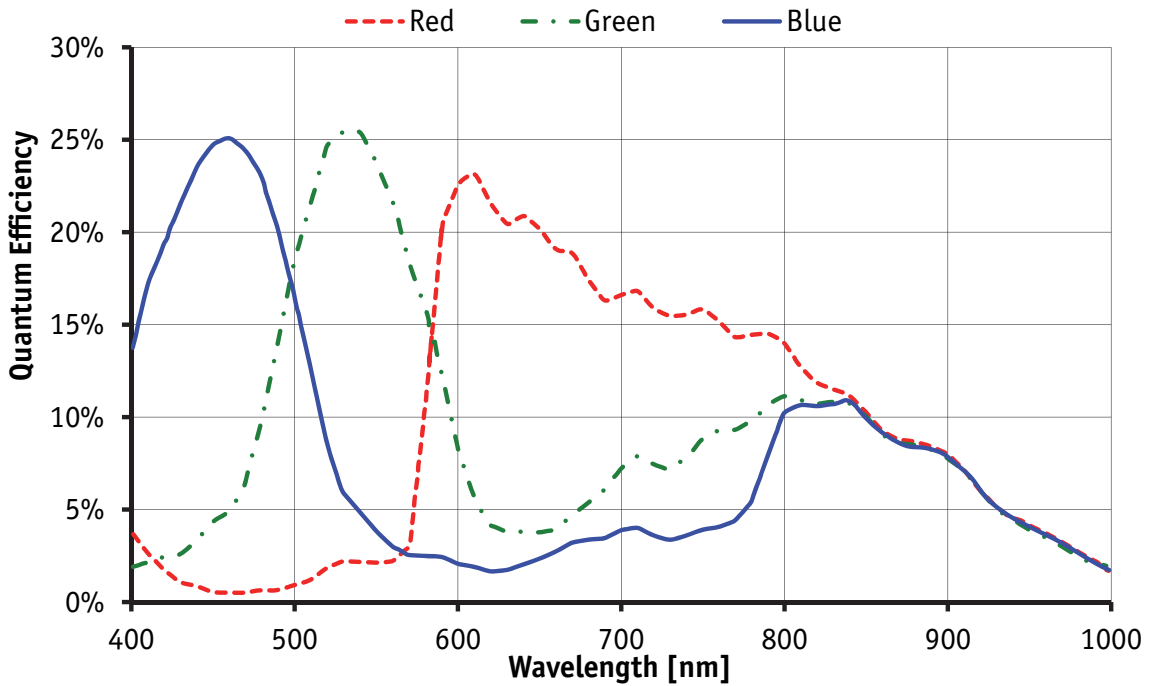Figure 19: Spectral sensitivity of Mako G-192B

Figure 20: Spectral sensitivity of Mako G-192C

Mako G-223B/C (NIR)

Feature	Specification
Resolution	2048 x 1088
Sensor	CMV2000 with microlenses and global shutter
Type	CMOS
Sensor size	Type 2/3
Cell size	5.5 µm
Lens mount	C / CS-Mount
Max frame rate at full resolution	49.5 fps
Max image bit depth	12 bit
On-board FIFO	64 MByte, up to 29 frames at full resolution, Mono8/Bayer8, and a *GevSCPSPacketSize* = 8192 bytes per packet
Mono formats	Mono8, Mono12Packed, Mono12
Color formats	BayerGB8, BayerGB12, BayerGB12Packed, Mono8, RGB8Packed, BGR8Packed, RGBA8Packed, BGRA8Packed, YUV411Packed, YUV422Packed, YUV444Packed
Exposure control	21 µs† to 153 s
Gain control	0–26 dB
Opto-coupled I/Os	1 input, 3 outputs
Voltage requirements	12–24 VDC or PoE
Power consumption	2.4 W @ 12 VDC, 2.8 W PoE
Trigger latency	N/A
Trigger jitter	N/A
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; including connectors, without tripod and lens
Mass	80 g (without lens)
Hardware interface standard	PoE, IEEE 802.3af 1000BASE-T, 100BASE-TX
Software interface standard	GigE Vision Standard 1.2
Camera control interface	GenICam V1.0 compliant
Regulatory	CE, FCC Class B, RoHS (2011/65/EU), WEEE

†Camera firmware v1.52.8151 shows minimum exposure values without frame overhead time, i.e., 1 µs. See sensor datasheet for details on frame overhead time. This will be fixed in the next firmware release.
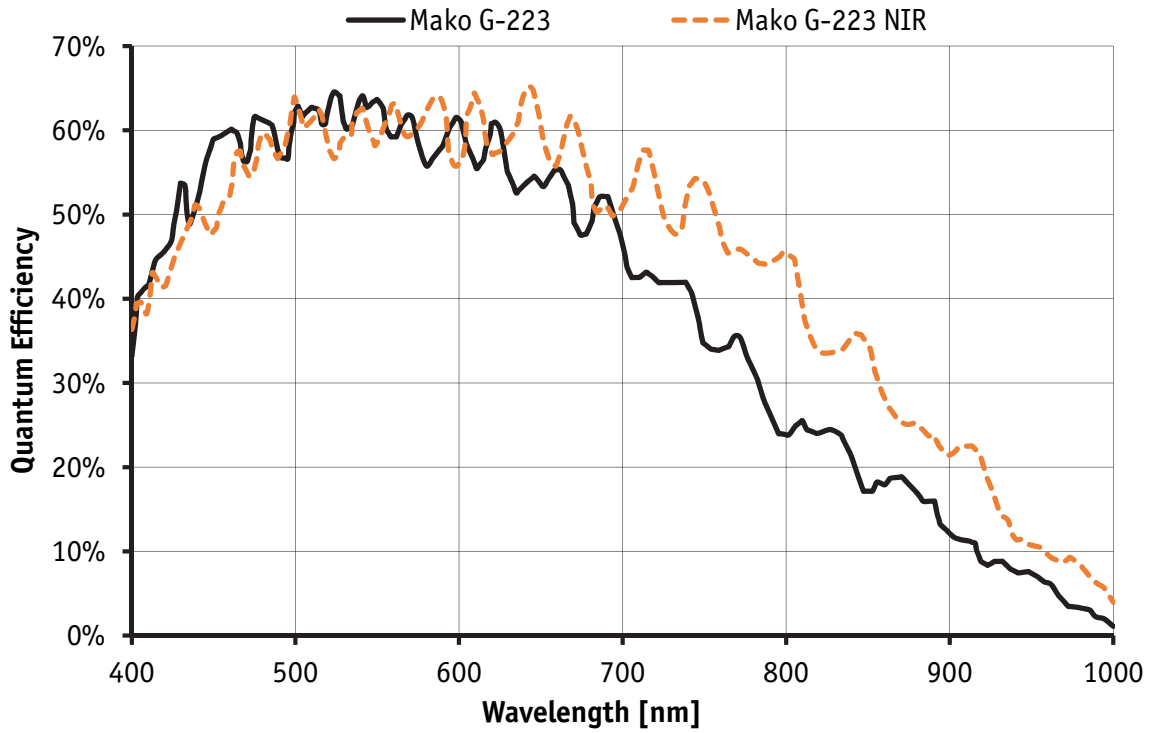
Table 10: Mako G-223 B/C (NIR) camera specifications

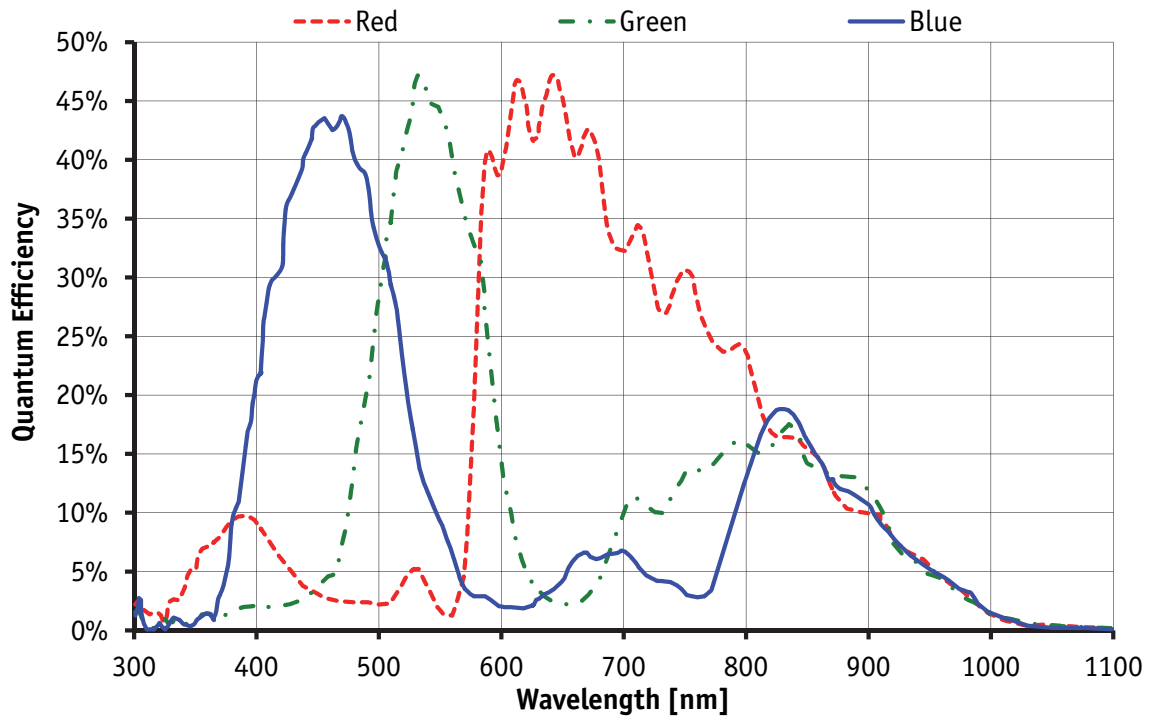Figure 21: Spectral sensitivity of Mako G-223B (NIR)

Figure 22: Spectral sensitivity of Mako G-223C (without IR cut filter)

Mako G-419B/C (NIR)

Feature	Specification
Resolution	2048 x 2048
Sensor	CMV4000 with microlenses and global shutter
Type	CMOS
Sensor size	Type 1
Cell size	5.5 µm
Lens mount	C / CS-Mount
Max frame rate at full resolution	26.3 fps
Max image bit depth	12 bit
On-board FIFO	64 MByte, up to 15 frames at full resolution, Mono8/Bayer8, and a *GevSCPSPacketSize* = 8192 bytes per packet
Mono formats	Mono8, Mono12Packed, Mono12
Color formats	BayerGB8, BayerGB12, BayerGB12Packed, Mono8, RGB8Packed, BGR8Packed, RGBA8Packed, BGRA8Packed, YUV411Packed, YUV422Packed, YUV444Packed
Exposure control	41 µs[†] to 153 s
Gain control	0–26 dB
Opto-coupled I/Os	1 input, 3 outputs
Voltage requirements	12–24 VDC or PoE
Power consumption	2.3 W @ 12 VDC, 2.7 W PoE
Trigger latency	N/A
Trigger jitter	N/A
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; including connectors, without tripod and lens
Mass	80 g (without lens)
Hardware interface standard	PoE, IEEE 802.3af 1000BASE-T, 100BASE-TX
Software interface standard	GigE Vision Standard 1.2
Camera control interface	GenICam V1.0 compliant
Regulatory	CE, FCC Class B, RoHS (2011/65/EU), WEEE

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

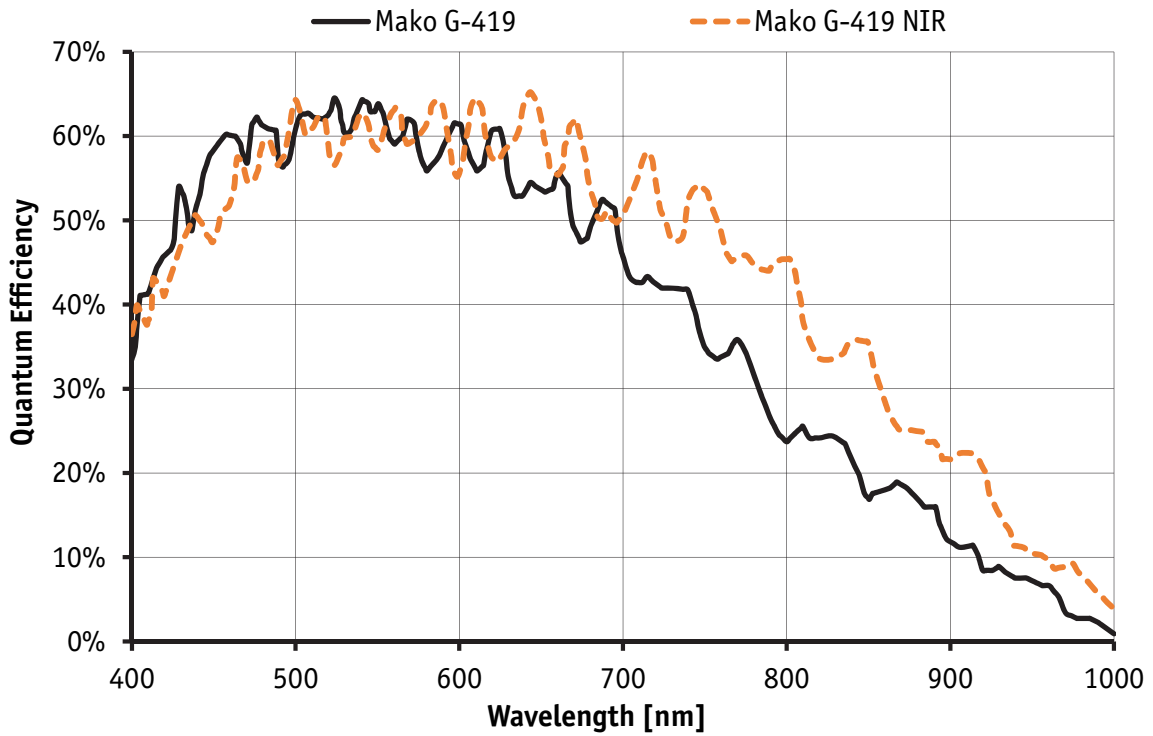Table 11: Mako G-419 B/C (NIR) camera specifications

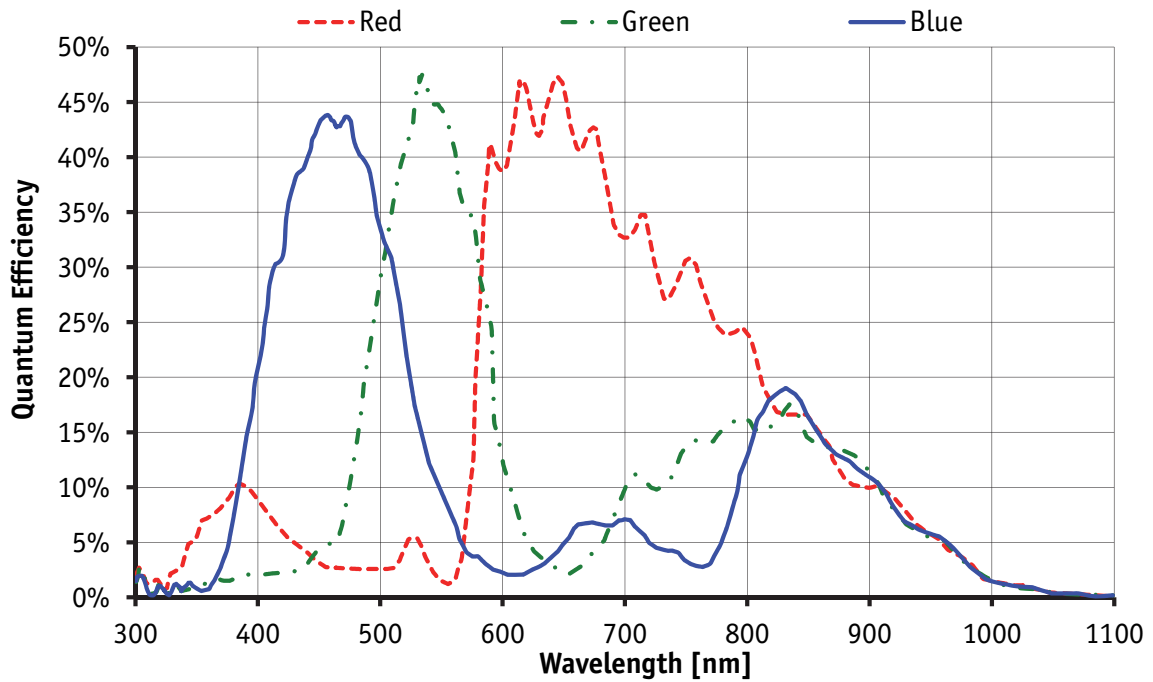Figure 23: Spectral sensitivity of Mako G-419B (NIR)

Figure 24: Spectral sensitivity of Mako G-419C (without IR cut filter)

Mako G-503B/C

Feature	Specification
Resolution	2592 x 1944
Sensor	Aptina MT9p031 (mono) / MT9p006 (color)
Type	CMOS Progressive
Sensor size	Type 1/2.5
Cell size	2.2 µm
Lens mount	C / CS-Mount
Max frame rate at full resolution	14 fps
Max image bit depth	12 bit
On-board FIFO	64 MByte, up to 13 frames at full resolution, Mono8/Bayer8, and a *GevSCPSPacketSize* = 8192 bytes per packet
Mono formats	Mono8, Mono12, Mono12Packed
Color formats	BayerGR8, BayerGR12Packed, BayerGR12, Mono8, RGB8Packed, BGR8Packed, YUV411Packed, YUV422Packed, YUV444Packed
Exposure control†	31 µs to 1 s; 36.375 µs increments
Gain control	0–24 dB
Binning	Horizontal: 1 to 4 pixels; Vertical: 1 to 4 rows
Decimation	Horizontal and Vertical: 1, 2, 4 factor
Opto-coupled I/Os	1 input, 3 outputs
Voltage requirements	12–24 VDC or PoE
Power consumption	2.0 W @ 12 VDC, 2.2 W PoE
Trigger latency*	Idle state: 73.4 µs Frame valid state: 73.4 µs
Trigger jitter*	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)
Body dimensions (L x W x H)	60.5 x 29 x 29 mm; including connectors, without tripod and lens
Mass	80 g (without lens)
Hardware interface standard	PoE, IEEE 802.3af 1000BASE-T, 100BASE-TX
Software interface standard	GigE Vision Standard 1.2
Camera control interface	GenICam V1.0 compliant
Regulatory	CE, FCC Class B, RoHS (2011/65/EU), WEEE

† These exposure control values are only valid with factory/default settings. Exposure control values vary depending upon pixel format and width.
*These values are calculated directly from the microcontroller source. These values are only valid for pixel formats < 16 bit 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 the next frame is requested by an external trigger in this state, higher latency may occur as compared to the Idle state
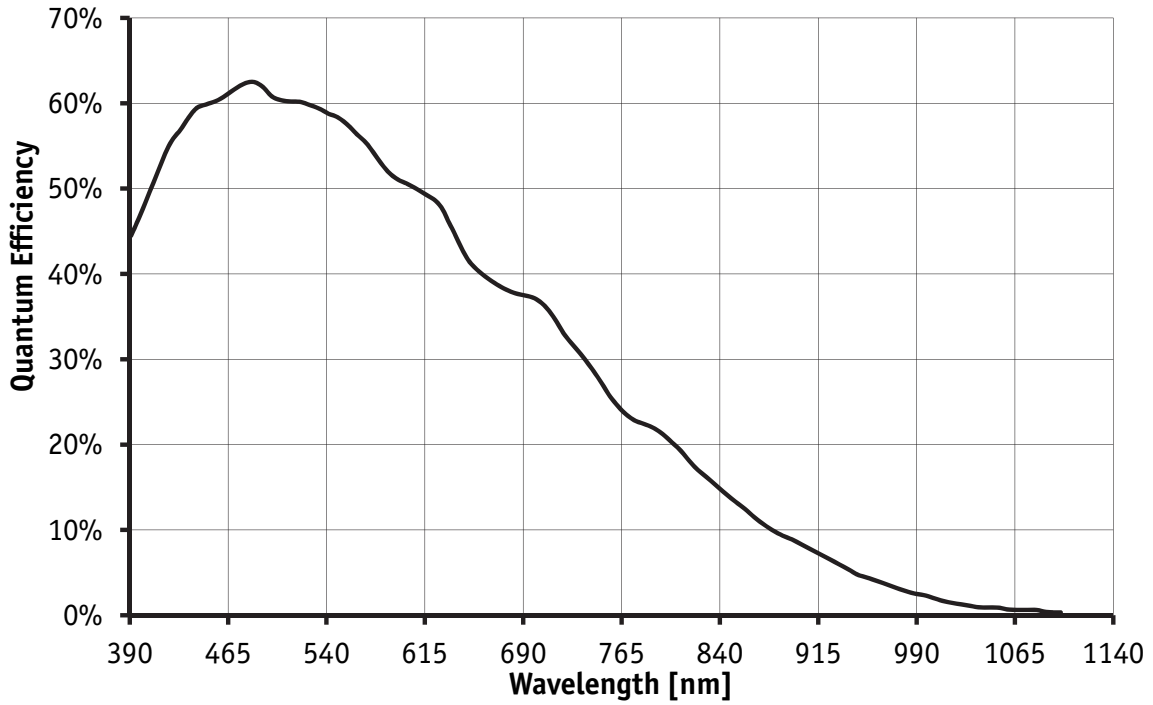
Table 12: Mako G-503B/C camera specifications
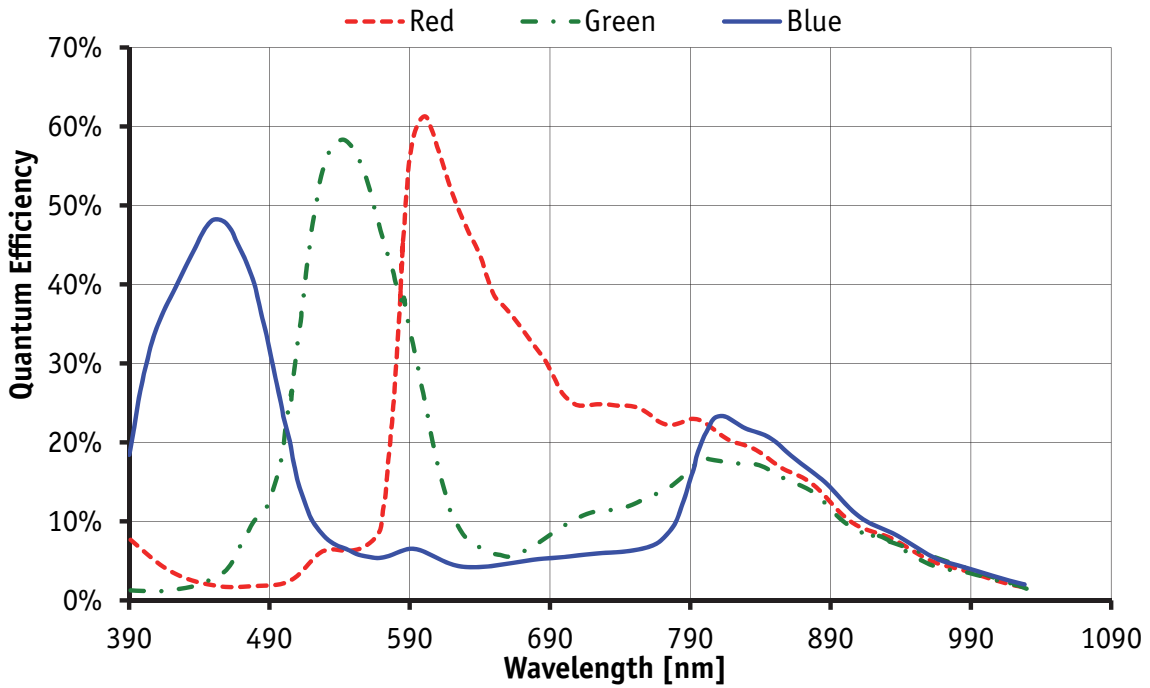
Figure 25: Spectral sensitivity of Mako G-503B

Figure 26: Spectral sensitivity of Mako G-503C

Camera smart features

Allied Vision cameras support a number of standard and extended features. The table below identifies a selection of interesting capabilities of the Mako camera family.

www   A complete listing of camera controls, including control definitions can be found online:

PvAPI users: GigE Camera and Driver Attributes document

VIMBA and third-party users: GigE Features Reference document

Control	Description
Gain control	Manual and auto
Exposure control	Manual and auto
White balance	Red and blue channel; manual and auto control
External trigger event	Rising edge, falling edge, any edge, level high, level low
Imaging modes	Free-running, external trigger, fixed rate, software trigger
Sync out modes	Trigger ready, trigger input, exposing, readout, imaging, strobe, GPO
Region of interest	Independent x and y control with 1 pixel resolution
Multicast	Streaming to multiple computers
Event channel	In-camera events including exposure start and trigger are asynchronously broadcasted to the host computer
Chunk data	Captured images are bundled with attribute information such as exposure and gain value
Color correction matrix	Correct color rendering for specific color temperature
Gamma, Hue, Saturation	Adjust image gamma, hue, and saturation
Look-up table (LUT)	LUTs available on all models
Temperature monitoring	Monitor camera temperature: resolution 0.031, accuracy ±1 °C
Decimation	Sub-sampling available on select models
Mirroring	ReverseX and ReverseY available on select models
Binning	Different binning modes available on select models: Average and Sum
Sensor shutter modes	Different shutter modes available on select models: Global, Rolling and GlobalReset
HDR mode	Available on Mako G-030
Defect pixel correction	Available on select models

Table 13: Mako camera smart features

Filter and lenses

IR cut filter

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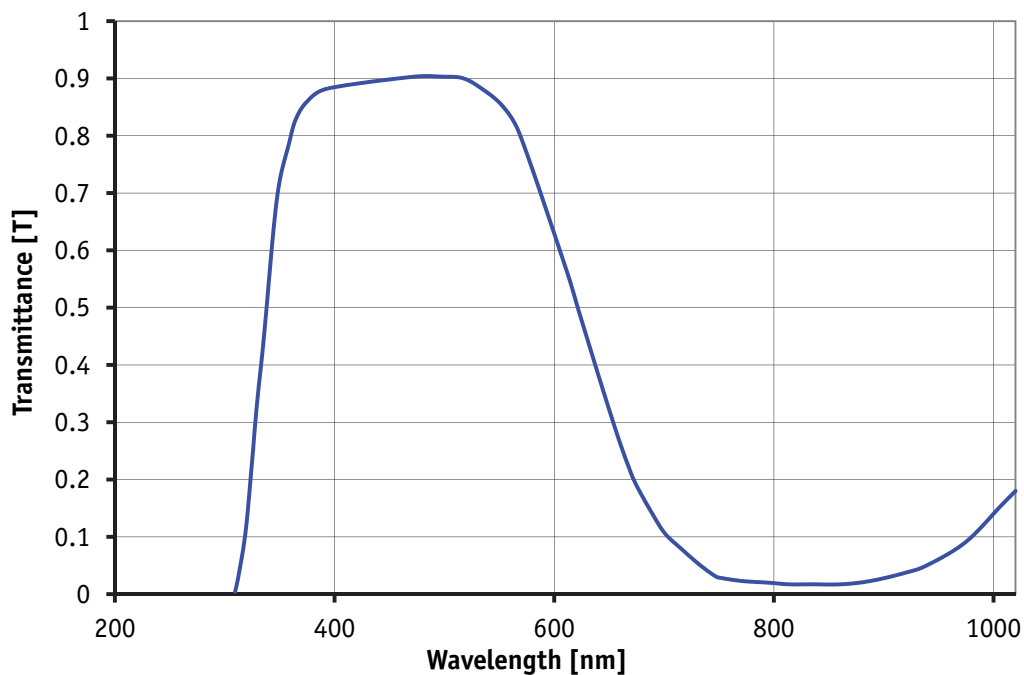

Figure 27: Approximate spectral transmission of IR cut filter (may vary slightly by filter lot) (type Hoya C5000)

Camera lenses

Allied Vision offers different lenses from a variety of manufacturers.

www

Accessories:

Please contact Allied Vision sales representative or your local Allied Vision dealer for information on accessories offered by Allied Vision:

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

The following table lists selected image formats in **width x height** depending on camera type, distance and the focal length of the lens.

Note • 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-030

Focal length for type 1/3 sensor	Distance = 500 mm	Distance = 1000 mm
4.8 mm	495mm x 371 mm	995 mm x746 mm
8 mm	295 mm x 221 mm	595 mm x446 mm
12.5 mm	187mm x 140 mm	379 mm x284 mm
16 mm	145 mm x 109 mm	295 mm x221 mm
25 mm	91 mm x 68 mm	187 mm x140 mm
50 mm	43 mm x 32 mm	91 mm x68 mm

Table 14: Focal length vs. field of view (Mako G-030)

Mako G-032

Focal length for type 1/3 sensor	Distance = 500 mm	Distance = 1000 mm
4.0 mm	608 mm x 446 mm	1220 mm x 896 mm
4.8 mm	506 mm x 371 mm	1016 mm x 746 mm
8 mm	301 mm x 221 mm	608 mm x 446 mm
12 mm	199 mm x 146 mm	403 mm x 296 mm
16 mm	148 mm x 109 mm	301 mm x 221 mm
25 mm	93 mm x 68 mm	191 mm x 140 mm
35 mm	65 mm x 48 mm	135 mm x 99 mm

Table 15: Focal length vs. field of view (Mako G-032)

Mako G-050

Focal length for type 1/3 sensor	Distance = 500 mm	Distance = 1000 mm
4 mm	604 mm x 457 mm	1213 mm x 917 mm
6 mm	401 mm x 303 mm	807 mm x 610 mm
8 mm	300 mm x 227 mm	604 mm x 457 mm
10 mm	239 mm x 181 mm	482 mm x 365 mm
12 mm	198 mm x 150 mm	401 mm x 303 mm
16 mm	147 mm x 111 mm	300 mm x 227 mm
25 mm	93 mm x 70 mm	190 mm x 144 mm

Table 16: Focal length vs. field of view (Mako G-050)

Mako G-095

Focal length for type 1/3 sensor	Distance = 500 mm	Distance = 1000 mm
4 mm	654 mm x 371 mm	1313 mm x 746 mm
6 mm	434 mm x 247 mm	873 mm x 496 mm
8 mm	324 mm x 184 mm	654 mm x 371 mm
10 mm	258 mm x 147 mm	522 mm x 296 mm
12 mm	214 mm x 122 mm	434 mm x 247 mm
16 mm	159 mm x 91 mm	324 mm x 184 mm
25 mm	100 mm x 57 mm	206 mm x 117 mm

Table 17: Focal length vs. field of view (Mako G-095)

Mako G-125

Focal length for type 1/3 sensor	Distance = 500 mm	Distance = 1000 mm
4.0 mm	595 mm x 446 mm	1195 mm x 896 mm
4.8 mm	495 mm x 371 mm	995 mm x 746 mm
8 mm	295 mm x 221 mm	595 mm x 446 mm
12 mm	195 mm x 146 mm	395 mm x 296 mm
16 mm	145 mm x 109 mm	295 mm x 221 mm
25 mm	91 mm x 68 mm	187 mm x 140 mm
35 mm	64 mm x 48 mm	132 mm x 99 mm

Table 18: Focal length vs. field of view (Mako G-125)

Mako G-131

Focal length for type 1/1.8 sensor	Distance = 500 mm	Distance = 1000 mm
4.5 mm	760 mm x 606 mm	1526 mm x1 217 mm
6 mm	568 mm x 453 mm	1143 mm x 911 mm
10 mm	338 mm x 270 mm	683 mm x 545 mm
17 mm	196 mm x 156 mm	399 mm x 318 mm
25 mm	131 mm x 105 mm	269 mm x 215 mm
35 mm	92 mm x 73 mm	190 mm x 152 mm

Table 19: Focal length vs. field of view (Mako G-131)

Mako G-192

Focal length for type 1/1.8 sensor	Distance = 500 mm	Distance = 1000 mm
4.5 mm	793 mm x 595 mm	1593 mm x 1195 mm
6 mm	593 mm x 445 mm	1193 mm x 895 mm
10 mm	353 mm x 265 mm	713 mm x 535 mm
17 mm	205 mm x 153 mm	416 mm x 312 mm
25 mm	137 mm x 103 mm	281 mm x 211 mm
35 mm	793 mm x 595 mm	1593 mm x 1195 mm

Table 20: Focal length vs. field of view (Mako G-192)

Mako G-223

Focal length for type 2/3*sensors	Distance = 500 mm	Distance = 1000 mm
4.8 mm	1162 mm x 617 mm	2335 mm x 1240 mm
6 mm	927 mm x 492 mm	1865 mm x 991 mm
6.5 mm	855 mm x 454 mm	1721 mm x 914 mm
8 mm	692 mm x 368 mm	1396 mm x 742 mm
10 mm	552 mm x 293 mm	1114 mm x 597 mm
12 mm	458 mm x 243 mm	927 mm x 492 mm
16 mm	341 mm x 181 mm	692 mm x 369 mm
25 mm	214 mm x 114 mm	439 mm x 223 mm
35 mm	150 mm x 79 mm	310 mm x 165 mm
50 mm	101 mm x 54 mm	214 mm x 114 mm
75 mm	64 mm x 34 mm	139 mm x 74 mm
90 mm	51 mm x 27 mm	114 mm x 60 mm

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

Table 21: Focal length vs. field of view (Mako G-223)

Mako G-419

Focal length for type 1 sensors	Distance = 500 mm	Distance = 1000 mm
8 mm	692 mm x 692mm	1396 mm x 1396 mm
10 mm	552 mm x 552 mm	1114 mm x 1114 mm
12 mm	458 mm x 458 mm	928 mm x 928 mm
16 mm	340 mm x 340 mm	692 mm x 692 mm
25 mm	214 mm x 214 mm	439 mm x 439 mm
35 mm	150 mm x 150 mm	310 mm x 310 mm
50 mm	101 mm x 101 mm	214 mm x 214 mm
75 mm	64 mm x 64 mm	139 mm x 139 mm
90 mm	51 mm x 51 mm	104 mm x 104 mm

Table 22: Focal length vs. field of view (Mako G-419)

Mako G-503

Focal length for type 1/2.5 sensor	Distance = 500 mm	Distance = 1000 mm
4.8 mm	588 mm x 442 mm	1182 mm x 887 mm
8 mm	351 mm x 263 mm	707 mm x 531 mm
12 mm	232 mm x 174 mm	469 mm x 352 mm
16 mm	172 mm x 129 mm	351 mm x 263 mm
25 mm	108 mm x 81 mm	222 mm x 167 mm
35 mm	76 mm x 57 mm	157 mm x 118 mm

Table 23: Focal length vs. field of view (Mako G-503)

Camera dimensions

Note	For information on **sensor position accuracy** (sensor shift x/y, optical back focal length z and sensor rotation α):
(i)	see Appendix on page 80.

Tripod adapter

This tripod adapter (Allied Vision order number 4807) …

- … can be used for Mako cameras.
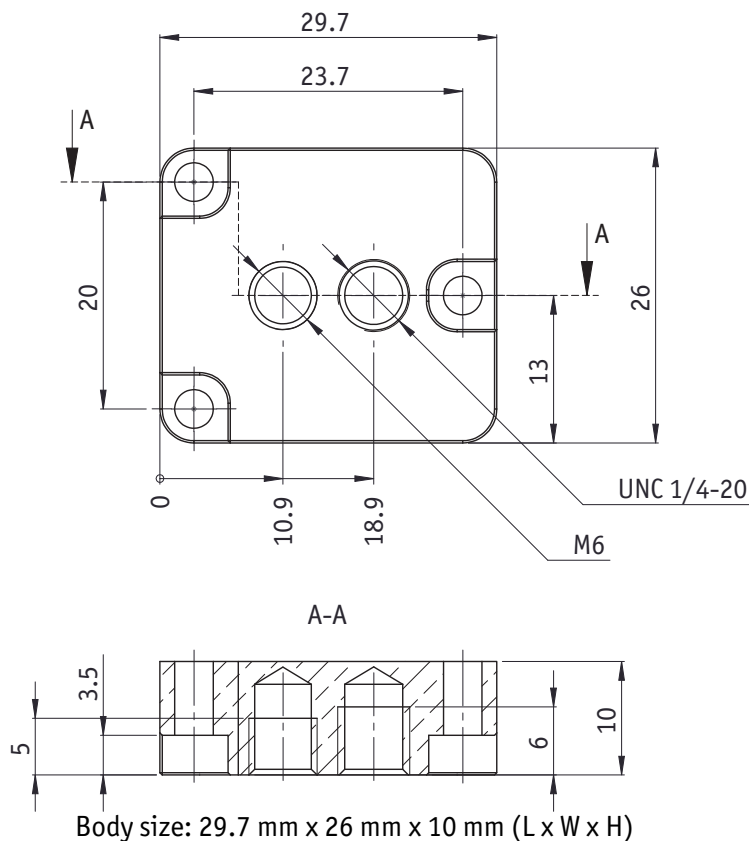- … is only designed for standard housings.

Body size: 29.7 mm x 26 mm x 10 mm (L x W x H)

Figure 28: Tripod adapter dimensions

Cross section: C-Mount

www	Choose protection glass or filter according to the **Modular Concept**: http://www.alliedvision.com/fileadmin/content/documents/ products/cameras/various/modular-concept/ Modular_concept_external.pdf
Note	Monochrome Mako 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.

- All color Mako cameras are equipped with the same IR cut filter type.
- Mako G-030, Mako G-032, Mako G-050, Mako G-095, Mako G-125, Mako G-131, Mako G-192, and Mako G-503 are equipped with a 16 mm diameter filter.

Figure 29: C-Mount dimensions for Mako G-030 / G-032 / G-050 / G-095 / G-125 / G-131 / G-192 / G-503 (16 mm filter)

- Mako G-223 and Mako G-419 are equipped with a 22 mm diameter filter.

Figure 30: C-Mount dimensions for Mako G-223 / G-419 (22 mm filter)

Cross section: CS-Mount

Choose protection glass or filter according to the **Allied Vision Modular Concept**.

www   Download the **Modular Concept** at:

http://www.alliedvision.com/fileadmin/content/documents/products/cameras/various/modular-concept/Modular_concept_external.pdf
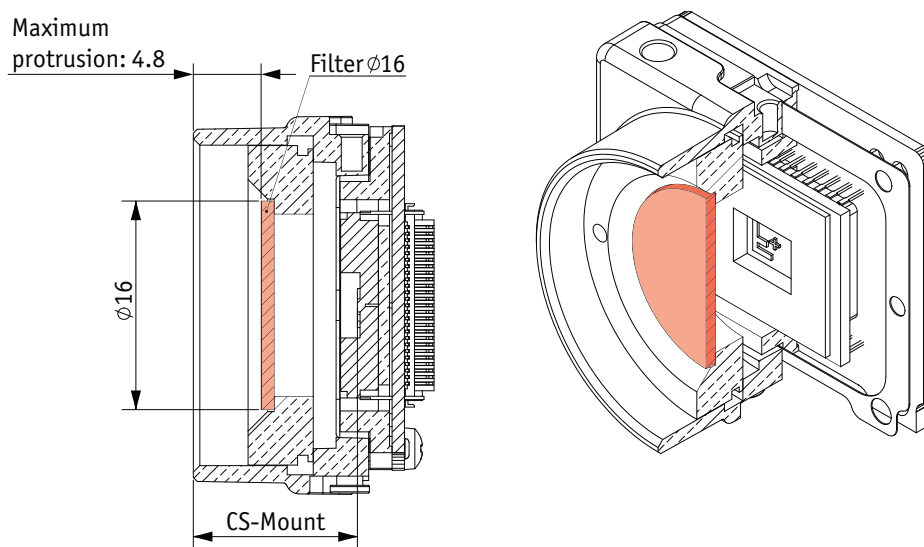

Figure 31: CS-Mount dimensions for Mako G-030 / G-032 / G-050 / G-095 / G-125 / G-131 / G-192 / G-503 (16 mm filter)
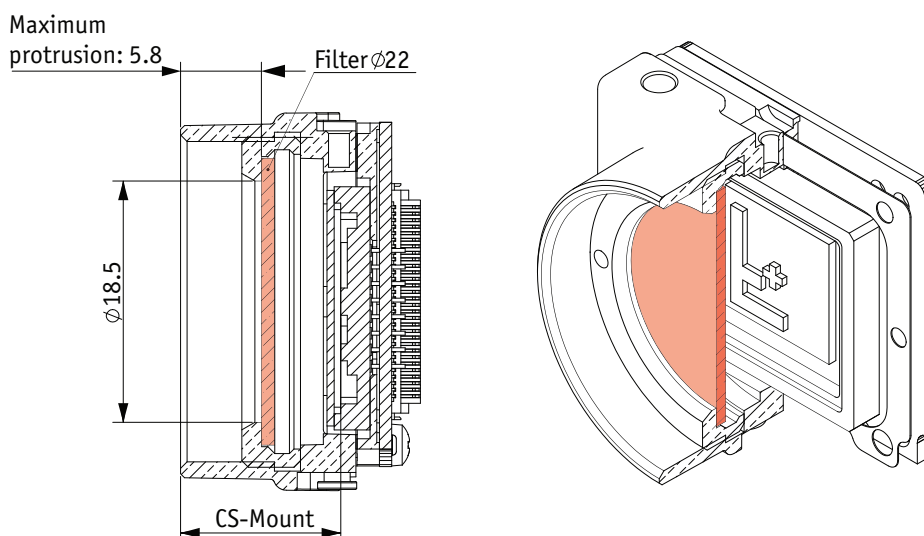

Figure 32: CS-Mount dimensions for Mako G-223 /G-419 (22 mm filter)

Adjusting C-Mount and CS-Mount

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

Note

ⓘ

If you need any adjustments, please contact Customer Care:
For phone numbers and e-mail:

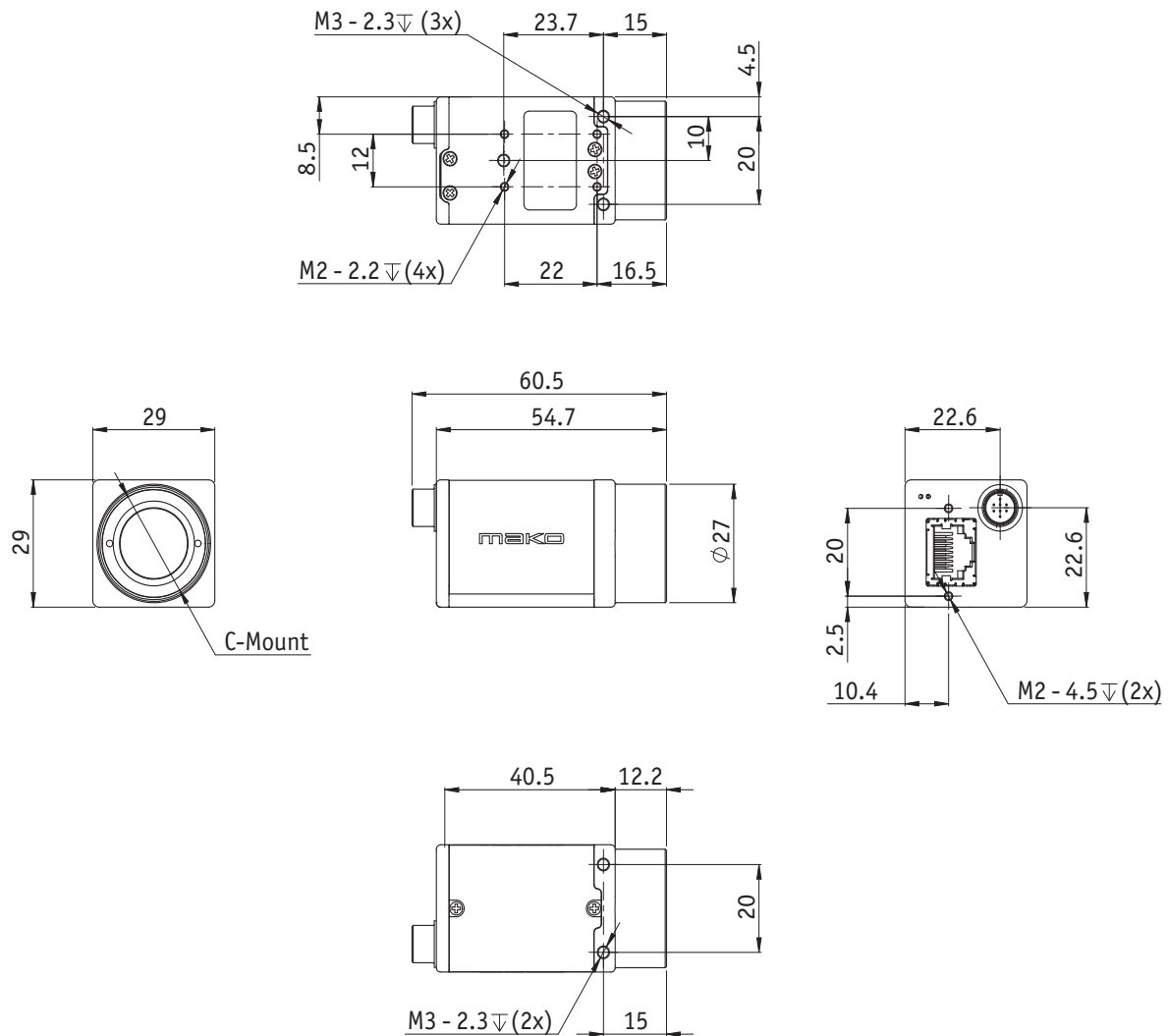see Contacting Allied Vision on page 5.

Mako standard housing

Figure 33: Camera dimensions standard housing (in mm)

Camera interfaces

This chapter describes the Gigabit Ethernet port, inputs and outputs, and trigger features.

Note	Read all *Notes* and *Cautions* in the **GigE Installation Manual** before using any interfaces.

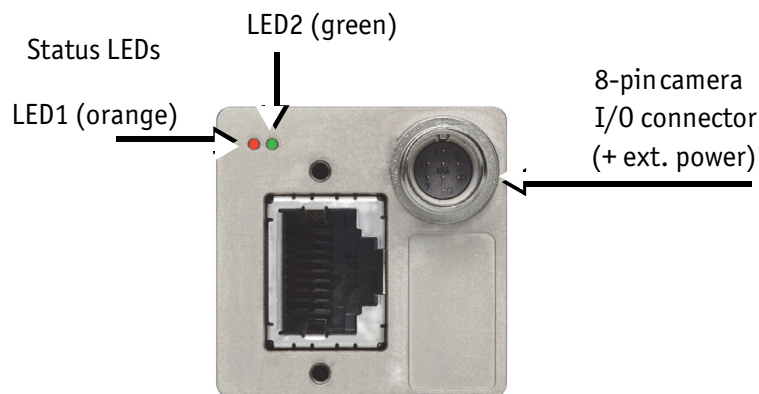| www	**Accessories:** Please contact Allied Vision sales representative or your local Allied Vision dealer for information on accessories offered by Allied Vision: http://www.alliedvision.com/en/about-us/where-we-are.html

Figure 34: Example: Rear view of **Mako** camera

Status LEDs

The tables below describe the status LEDs of Mako cameras.

LED1 color	Status
Solid orange	Ethernet link established
Flashing orange	Network traffic

Table 24: Status LED **(orange)**

LED2 color	Status
Solid green	Camera powered
Slow flashing green	Booting routine
Four rapid flashes per second	Transmission error. Contact support@alliedvision.com

Table 25: Status LED **(green)**

![Allied Vision logo]

Gigabit Ethernet port

The Gigabit Ethernet port conforms to the IEEE 802.31000BASE-T standard for Gigabit Ethernet over copper. To prevent EMI (electromagnetic interference) 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.

Note

- 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 cameras are PoE capable (802.3af/at).
- If both interfaces are used for power (I/O and GigE connector via **PoE**), the camera will only use the power from the I/O connector.

Accessories

- Please contact Allied Vision sales representative or your local Allied Vision dealer for information on accessories: http://www.alliedvision.com/en/about-us/where-we-are.html

Mako I/O connector pin assignment

Pin	Signal	Direction	Level	Description
1	Out 1	Out	Open emitter, max. 20 mA	Output 1
2	Out 2	Out	Open emitter, max. 20 mA	Output 2
3	Out 3	Out	Open emitter, max. 20 mA	Output 3
4	In 1	In	U_{in}(high) = 3.0–24.0 V up to 36 V with external resistor of 3.3 kΩ in series U_{in}(low) = 0–1.0 V	Input 1
5	Camera In GND	In	---	GND for input
6	Camera Out Power	In	Common VCC for outputs max. 30 V DC	Power input for opto-isolated outputs
7	Camera Power	---	12–24 V DC +/- 10%	Camera power supply
8	Ext GND	---	GND for ext. Power	External Ground for external Power

Figure 35: 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.

Note The cable side Hirose connector is available for purchase from Allied Vision. P/N: K7600503

Mako input description
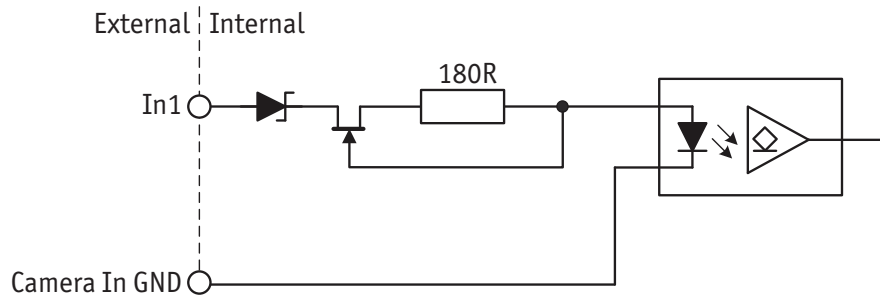
Mako input block diagram

Figure 36: Mako input block diagram

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

Mako delay and minimum pulse width

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

Table 26: Mako input parameters
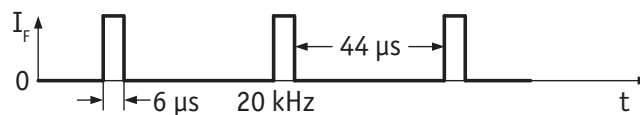
The **minimum pulse width** for all Mako cameras is:

Figure 37: Mako minimum pulse width

Test conditions

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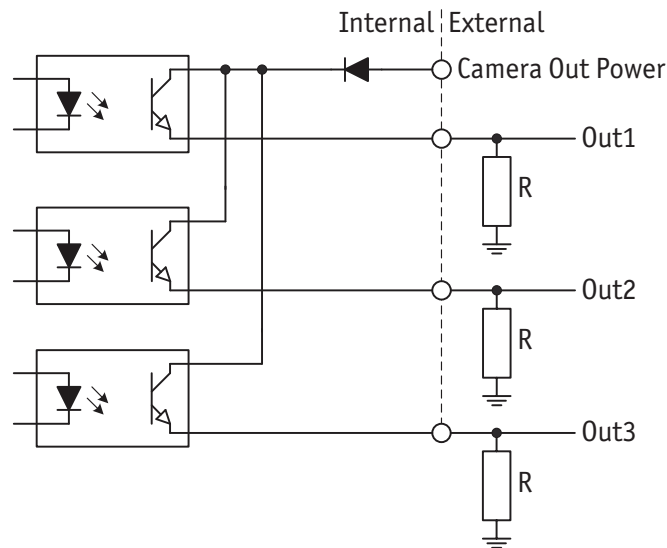
Mako output description

Mako block diagram

Figure 38: Mako output block diagram

Caution
- Maximum 20 mA per output
- **Camera Out Power** > 30 V may damage the camera

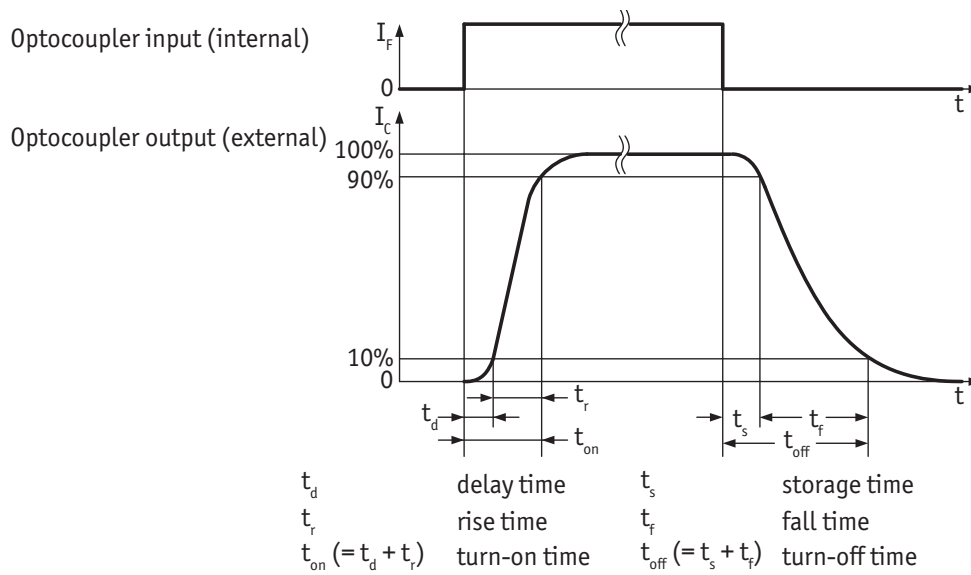| Camera Out Power	Resistor value*	
5 V	1.0 kΩ	at ~ 5 mA minimum required current draw
12 V	2.4 kΩ	
24 V	4.7 kΩ	
* Resistor required if **Out1/2/3** connected to a device with < 5 mA draw, i.e. high impedance		

Figure 39: Mako: Camera Out Power and external resistor

Figure 40: Mako output switching times

For all Mako models:

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

Table 27: Parameters for Mako

Test conditions
Output: external 2.4 kΩ resistor to GND, **Camera Out Power** set to 12 V.

Note

- Higher external values increase the times in the table above.
- We recommend to trigger on the rising edge. This guarantees a fastest possible reaction time.

Control signals

The inputs and outputs of the camera can be configured by software. The different modes are described below.
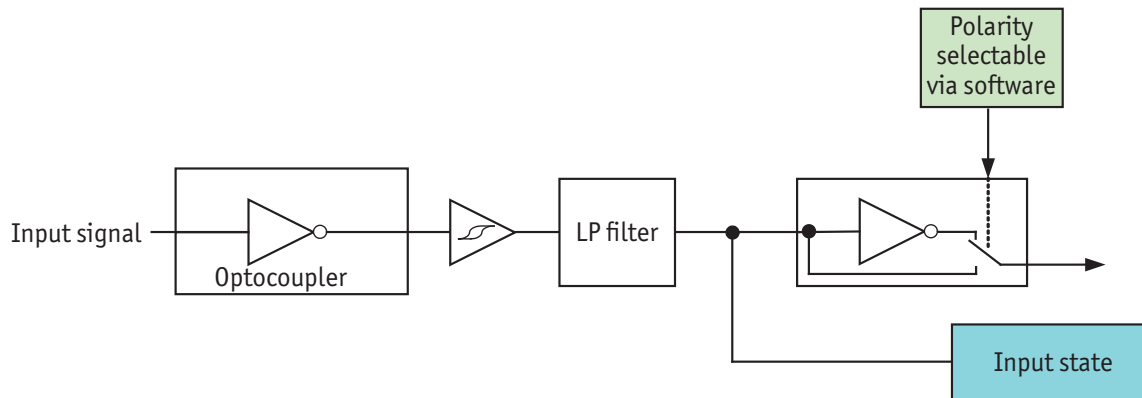
Inputs

Figure 41: Input block diagram

Input/output pin control

All input and output signals that pass the I/O connector are controlled by the I/O strobe commands.

Outputs

Output features are configured by software. Any signal can be placed on any output. The main features of the 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.
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	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.

Table 28: Output signals

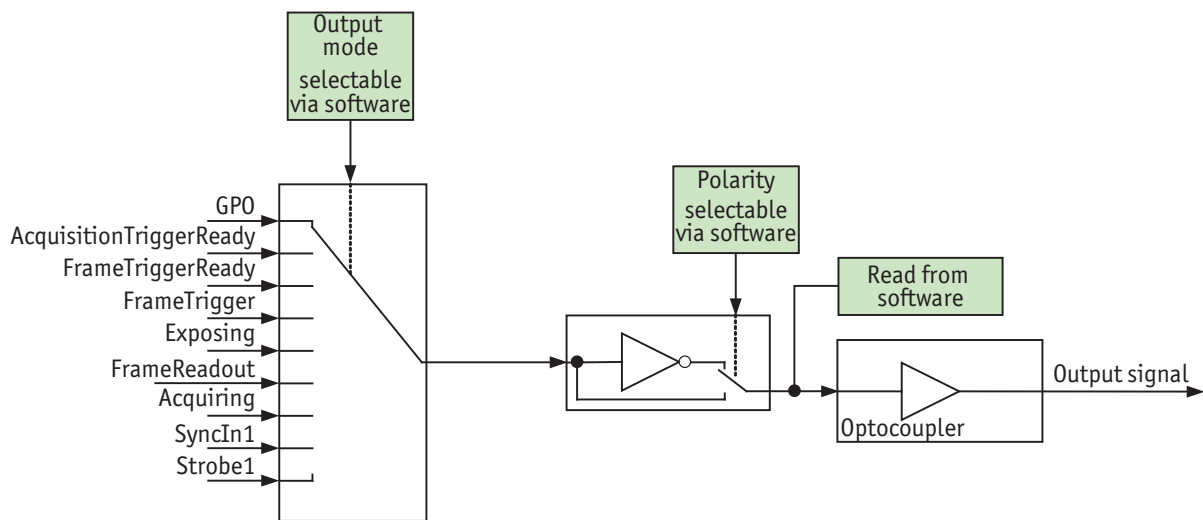| Signal	Description
Imaging	Imaging is high when the camera image sensor is either exposing and/or reading out data.
Acquiring	Active during an acquisition stream.
SyncIn1	Active when there is an external trigger at SyncIn1.
Strobe1	The output signal is controlled according to Strobe1 settings.

Table 28: Output signals

Figure 42: Output block diagram

Trigger timing diagram

The following diagram explains the trigger concept in general.

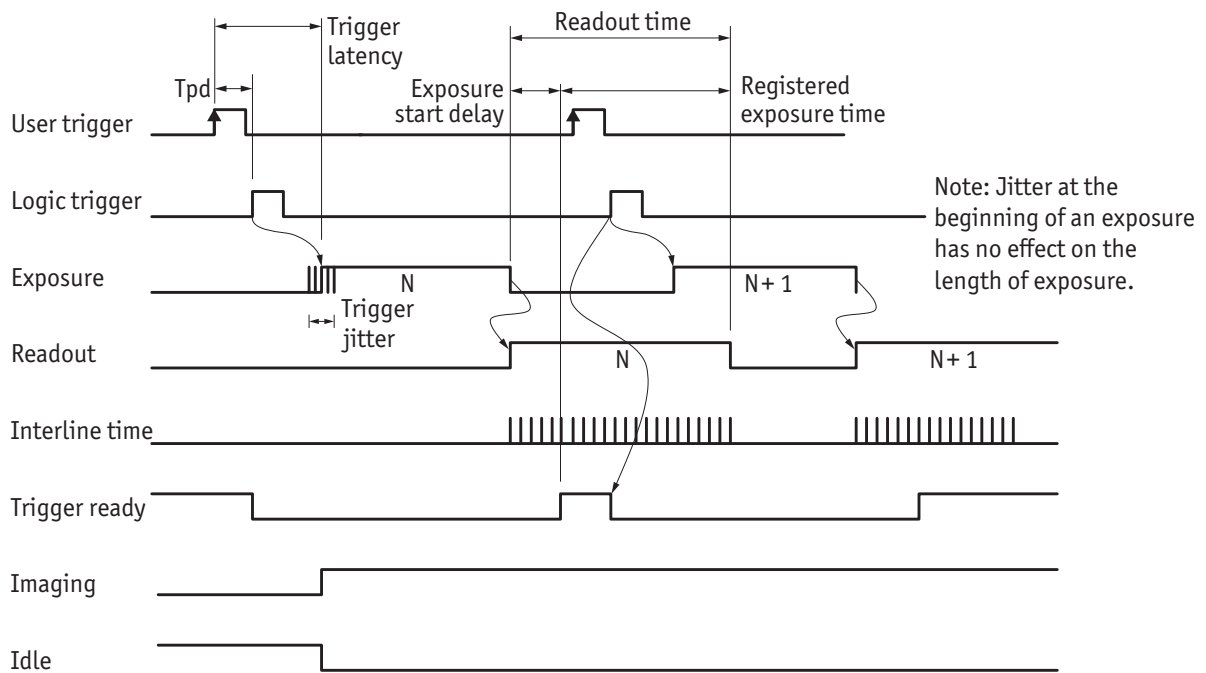**Note**   For trigger description on camera control basis, see **GigE Features Reference**.

Figure 43: Trigger timing diagram

Notes on triggering

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

Table 29: Trigger definitions

Term	Definition
Trigger latency	Time delay between the user trigger and the start of exposure
Trigger jitter	Error in the trigger latency time
Trigger ready	Indicates to the user 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 29: Trigger definitions

Trigger rules

Note

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

- 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.

Camera data path

The following diagrams illustrate the data flow and the bit resolution of the image data. The individual blocks are described in more detail in the GigE Features Reference document.

Mako monochrome cameras

Mako with CCD sensors

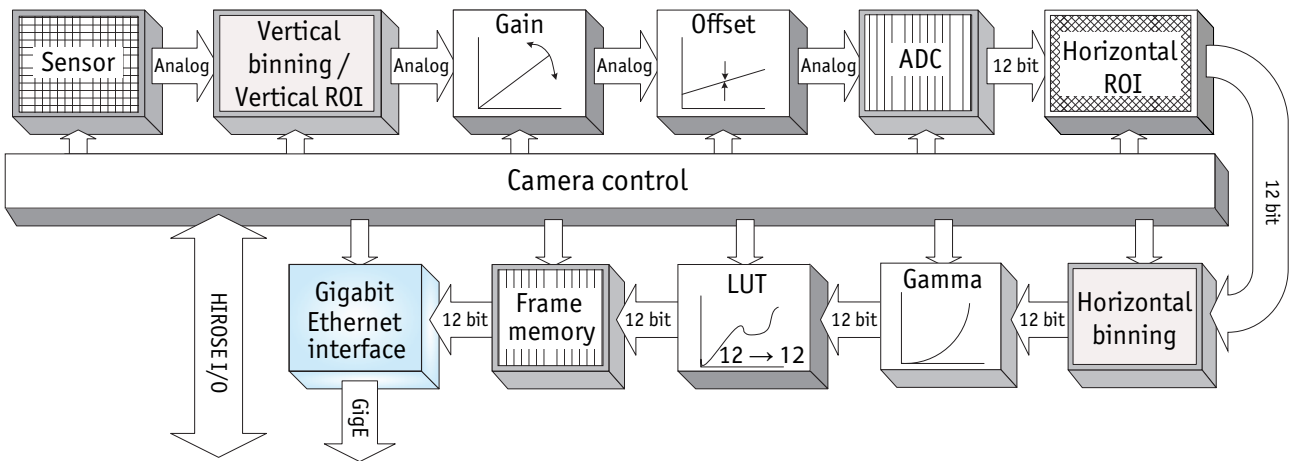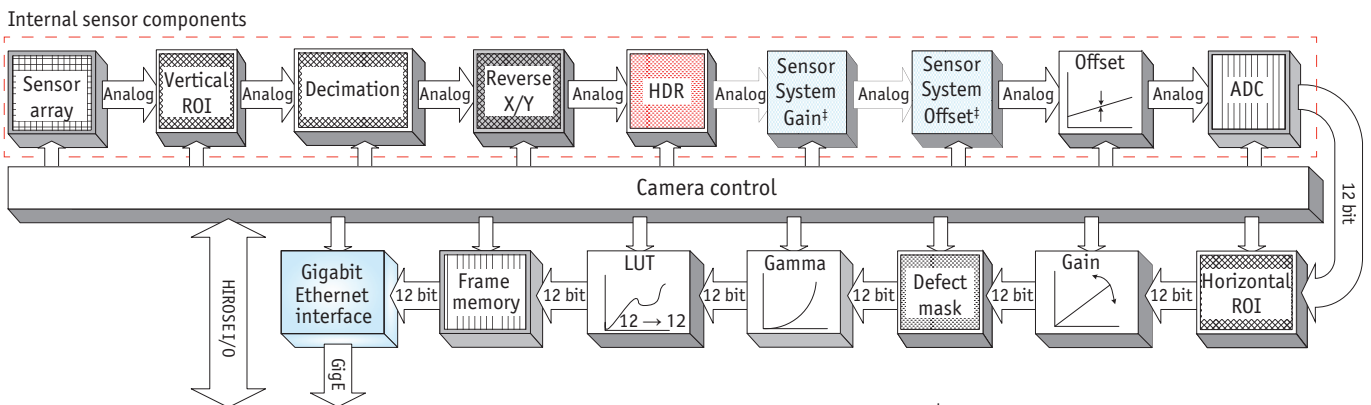#### Mako G-032B, Mako G-050B, Mako G-095B, Mako G-125B

Figure 44: Block diagram of Mako monochrome cameras with CCD sensors

Mako with CMOS sensors

Mako G-030B

‡ Factory calibrated. NOT a user control.

Figure 45: Block diagram of Mako G-030 monochrome cameras
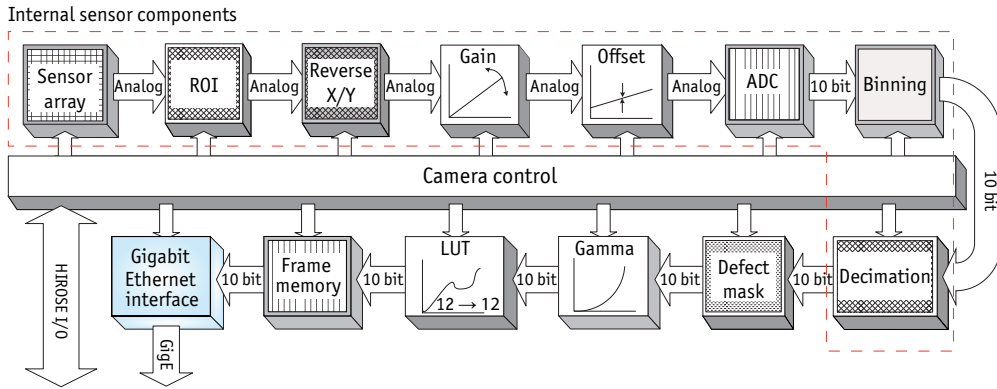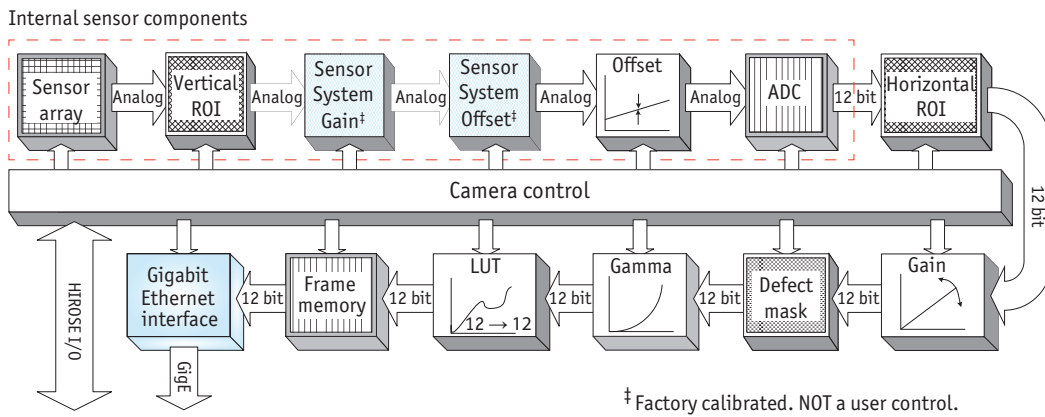
Mako G-131B, Mako G-192B

Figure 46: Block diagram of Mako G-131 and Mako G-192 monochrome cameras

Mako G-223B, Mako G-223 NIR, Mako G-419B, Mako G-419 NIR

‡ Factory calibrated. NOT a user control.

Figure 47: Block diagram of Mako G-223, Mako G-223 NIR, Mako G-419, and Mako G-419 NIR monochrome cameras
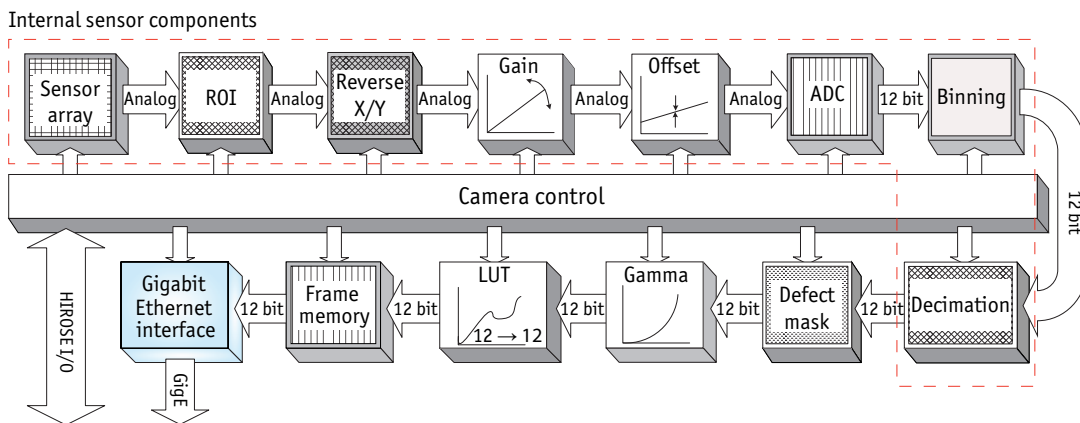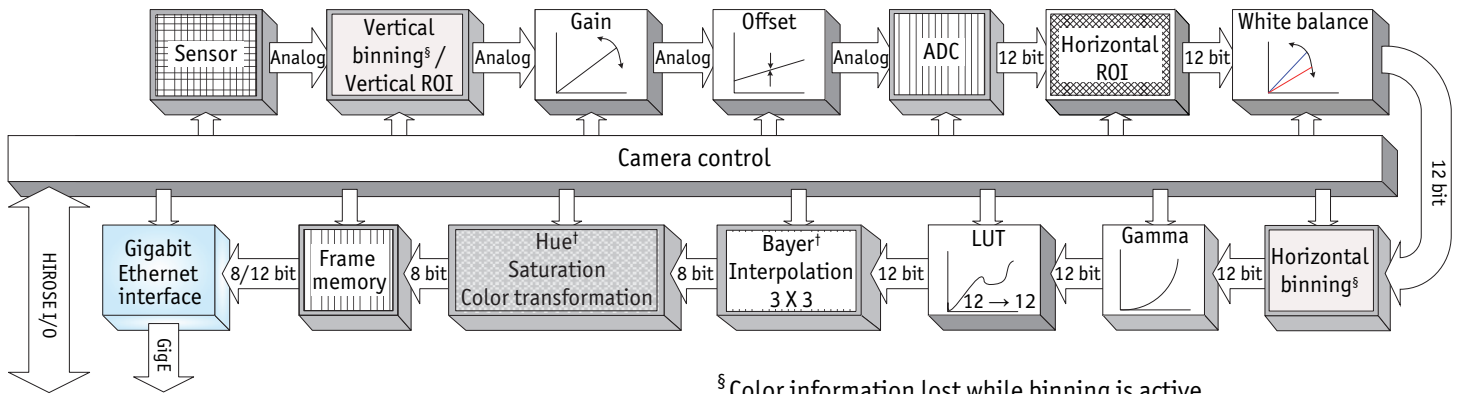
Mako G-503

Figure 48: Block diagram of Mako G-503 monochrome cameras

Mako color cameras

Mako with CCD sensors

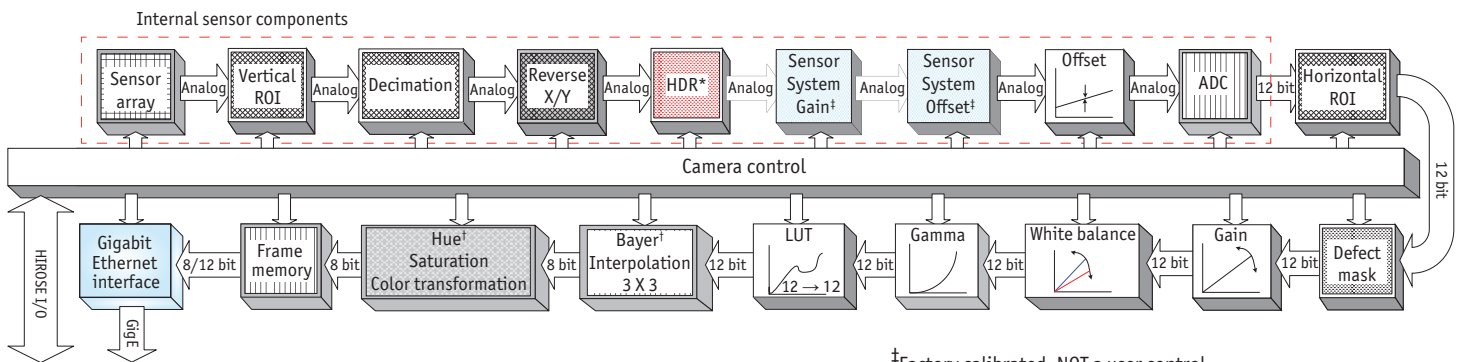### Mako G-032C, Mako G-050C, Mako G-095C, Mako G-125C

§ Color information lost while binning is active.

† For on-camera interpolated *PixelFormats* only—outputs 8 bit.
Raw un-interpolated *PixelFormats* skip this block—outputs 8/12 bit depending upon the bit depth of *PixelFormat* used.

Figure 49: Block diagram of Mako color cameras with CCD sensors

Mako with CMOS sensors

Mako G-030C

‡ Factory calibrated. NOT a user control.

† For on-camera interpolated *PixelFormats* only—outputs 8 bit.
Raw un-interpolated *PixelFormats* skip this block—outputs 8/12 bit depending upon the bit depth of *PixelFormat* used.

Figure 50: Block diagram of Mako G-030C color cameras
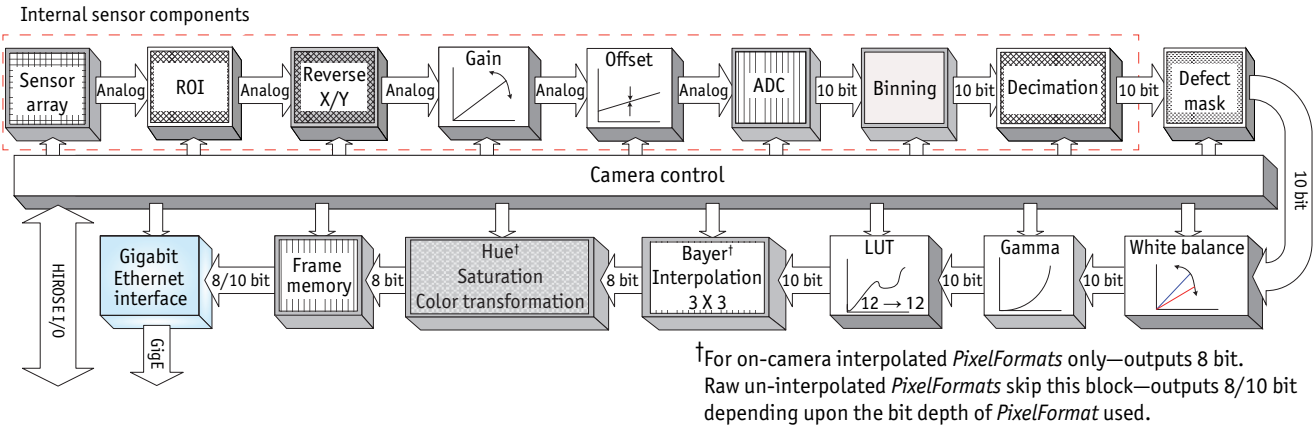
Mako G-131C, Mako G-192C

Figure 51: Block diagram of Mako G-131 and Mako G-192 color cameras
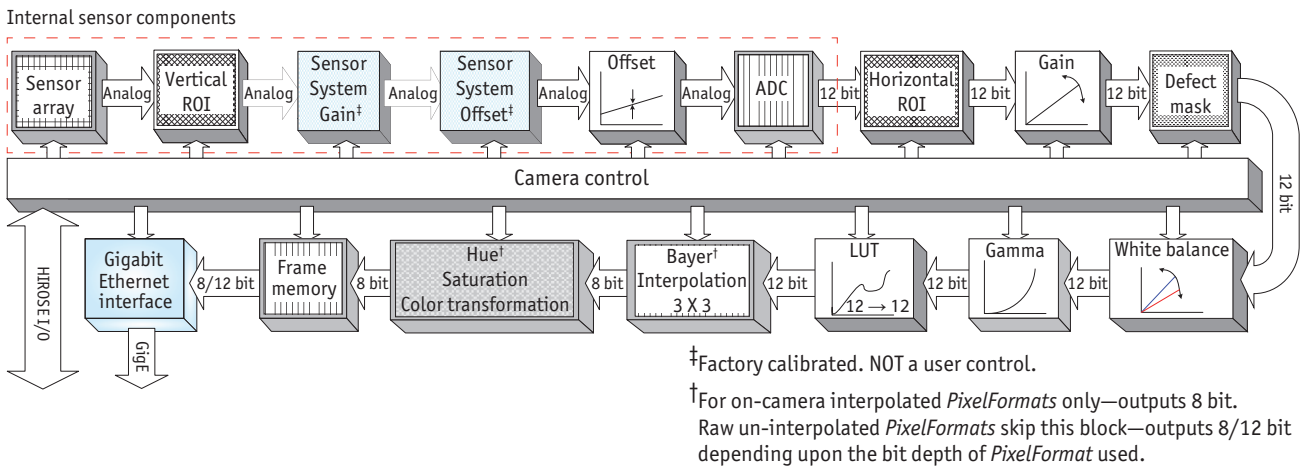
Mako G-223C, Mako G-419C

Figure 52: Block diagram of Mako G-223 and Mako G-419 color cameras
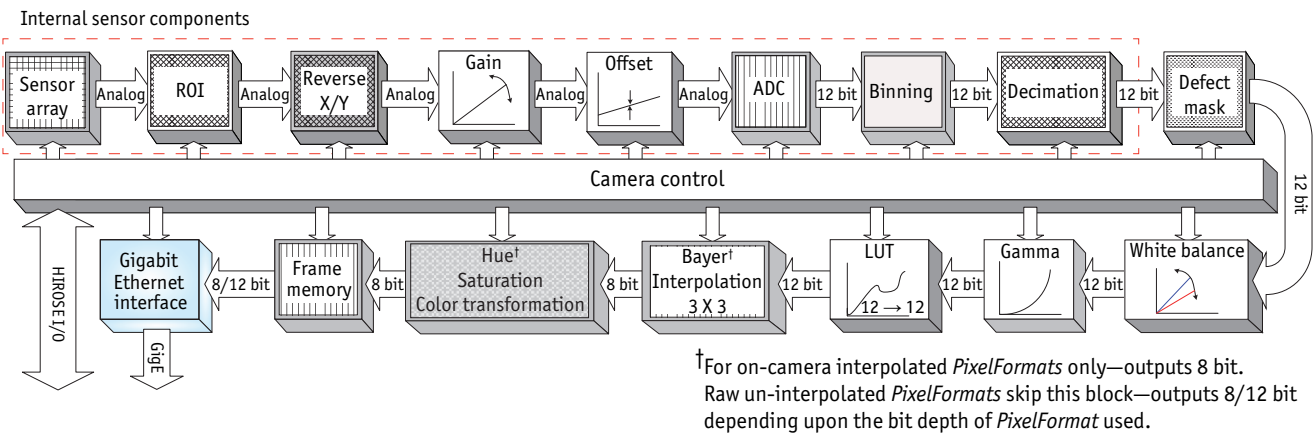
Mako G-503C

Figure 53: Block diagram of Mako G-503 color cameras

Camera features

This chapter lists the camera and driver features for Mako cameras as displayed with the Vimba Viewer.

| www | For a detailed description of all GigE camera and driver controls, refer to the **GigE Features Reference** document:

http://www.alliedvision.com/fileadmin/content/documents/products/cameras/various/features/GigE_Features_Reference.pdf

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
Acquisition			
	AcquisitionAbort		
	AcquisitionFrameCount		
	AcquisitionFrameRateAbs		
	AcquisitionFrameRateLimit		
	AcquisitionMode		
		Continous	
		SingleFrame	
		MultiFrame	
		Recorder	
	AcquisitionStart		
	AcquisitionStop		
	RecorderPreEventCount		
	SensorShutterMode (available only on G-131 and G-192)		
		Global	
		Rolling	
		GlobalReset	
	Trigger		
		TriggerActivation	
			RisingEdge
			FallingEdge
			AnyEdge
			LevelHigh
			LevelLow
		TriggerDelayAbs	
		TriggerMode	
			On
			Off
		TriggerOverlap	

Table 30: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
			Off
			PreviousFrame
		TriggerSelector	
			FrameStart
			AcquisitionStart
			AcquisitionEnd
			AcquisitionRecord
		TriggerSoftware	
		TriggerSource	
			Freerun
			Line1
			FixedRate
			Software
BufferHandlingControl (Vimba v1.3 or higher)			
	StreamAnnounceBufferMinimum		
	StreamAnnouncedBufferCount		
	StreamBufferHandlingMode		
Controls			
	BlackLevelControl		
		BlackLevel	
		BlackLevelSelector	
			All
	ColorTransformationControl		
		ColorTransformationMode	
			Off
			Manual
		ColorTransformationSelector	
			RBGtoRGB
		ColorTransformationValue	
		ColorTransformationValueSelector	
	DSPSubregion		
		DSPSubregionBottom	
		DSPSubregionLeft	
		DSPSubregionRight	
		DSPSubregionTop	
	DefectMaskEnable (available on all models except G-032, G-050, G-095, and G-125)		
	Exposure		
		ExposureAuto	
			Off
			Once

Table 30: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
			Continuous
		ExposureAutoControl	
			ExposureAutoAdjustTol
			ExposureAutoAlg
			ExposureAutoMax
			ExposureAutoMin
			ExposureAutoOutliers
			ExposureAutoRate
			ExposureAutoTarget
		ExposureMode	
			Timed
			TriggerWidth
			PieceWiseLinearHDR (available only on G-030)
		ExposureTimeAbs	
		ExposureTimeIncrement	
		ExposureTimePWL1 (available only on G-030)	
		ExposureTimePWL2 (available only on G-030)	
		ThresholdPWL1 (available only on G-030)	
		ThresholdPWL2 (available only on G-030)	
	GainControl		
		Gain	
		GainAuto	
			Off
			Once
			Continuous
		GainAutoControl	
			GainAutoAdjustTol
			GainAutoMax
			GainAutoMin
			GainAutoOutliers
			GainAutoRate
			GainAutoTarget
		GainSelector	
	Gamma		
	Hue		
	LUTControl		
		LUTEnable	
		LUTIndex	
		LUTInfo	
			LUTAddress
			LUTBitLengthIn
			LUTBitLengthOut
			LUTSize

Table 30: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
		LUTLoadAll	
		LUTMode	
			Luminance
			Red
			Green
			Blue
		LUTSaveAll	
		LUTSelector	
			LUT1
		LUTValue	
	Saturation		
	Whitebalance		
		BalanceRatioAbs	
		BalanceRatioSelector	
			Red
			Blue
		BalanceWhiteAuto	
			Off
			Once
			Continuous
		BalanceWhiteAutoControl	
			BalanceWhiteAutoAdjustTol
			BalanceWhiteAutoRate
DeviceStatus			
	DeviceTemperature		
	DeviceTemperatureSelector		
EventControl			
	EventData		
		EventAcquisitionEndFrameID	
		EventAcquisitionEndTimestamp	
		EventAcquisitionRecordTriggerFrameID	
		EventAcquisitionRecordTriggerTimestamp	
		EventAcquisitionStartFrameID	
		EventAcquisitionStartTimestamp	
		EventErrorFrameID	
		EventErrorTimestamp	
		EvenExposureEndFrameID	
		EventExposureEndTimestamp	
		EventFrameTriggerFrameID	
		EventFrameTriggerReadyFrameID	
		EventFrameTriggerReadyTimestamp	
		EventLine1FallingEdgeFrameID	
		EventLineFallingEdgeTimestamp	

Table 30: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
		EventLineRisingEdgeFrameID	
		EventLineRisingEdgeTimestamp	
		EventOverflowFrameID	
		EventOverflowTimestamp	
	EventID		
		EventAcquisitionEnd	
		EventAcquisitionRecordTrigger	
		EventAcquisitionStart	
		EventError	
		EventExposureEnd	
		EventFrameTrigger	
		EventFrameTriggerReady	
		EventLine1FallingEdge	
		EventLine1RisingEdge	
		EventLine2FallingEdge	
		EventLine2RisingEdge	
		EventLine3FallingEdge	
		EventLine3RisingEdge	
		EventLine4FallingEdge	
		EventLine4RisingEdge	
		EventOverflow	
	EventNotification		
	EventSelector		
	EventsEnable1		
GigE			
	BandwidthCtrlMode		
	ChunkModeActive		
	Configuration		
		IP Configuration Mode	
	Current		
		Current Default Gateway	
		Current IP Address	
		Current Subnet Mask	
	GVCP		
		Command Retries	
		Command Timeout	
		Heartbeat Interval	
		Heartbeat Timeout (Vimba 1.3 and higher)	
	GevSCPSPacketSize		
	NonImagePayloadSize		
	PayloadSize		
	Persistent		

Table 30: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
		Persistent Default Gateway	
		Persistent IP Address	
		Persistent Subnet Mask	
	StreamBytesPerSecond		
	StreamFrameRateConstrain		
	StreamHold		
		StreamHoldCapacity	
		StreamHoldEnable	
			Off
			On
	Timestamp		
		GevTimestampControlLatch	
		GevTimestampControlReset	
		GevTimestampTickFrequency	
		GevTimestampValue	
IO			
	Strobe		
		StrobeDelay	
		StrobeDuration	
		StrobeDurationMode	
			Source
			Controlled
		StrobeSource	
			AcquisitionTriggerReady
			FrameTriggerReady
			FrameTrigger
			Exposung
			FrameReadout
			Acquiring
			LineIn1
	SyncIn		
		SyncInGlitchFilter	
		SyncInLevels	
		SyncInSelector	
			SyncIn1
	SyncOut		
		SyncOutLevels	
		SyncOutPolarity	
			Normal
			Invert
		SyncOutSelector	
			SyncOut1
			SyncOut2

Table 30: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
			SyncOut3
		SyncOutSource	
			GPO
			AcquisitionTriggerReady
			FrameTriggerReady
			Exposing
			FrameReadout
			Imaging
			Acquiring
			LineIn1
			Strobe1
ImageFormat			
	Height		
	HeightMax		
	ImageSize		
	OffsetX		
	OffsetY		
	PixelFormat		
	Width		
	WidthMax		
ImageMode			
	BinningHorizontal		
	BinningHorizontalMode		
		Sum	
		Average	
	BinningVertical		
	BinningVerticalMode		
		Sum	
		Average	
	DecimationHorizontal		
	DecimationVertical		
	ReverseX		
	ReverseY		
	SensorHeight		
	SensorWidth		
Info			
	Device MAC address		
	DeviceFirmwareVersion		
	DeviceID		
	DeviceModelName		
	DevicePartNumber		
	DeviceScanType		
	DeviceVendorName		

Table 30: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
	FirmwareVerBuild		
	FirmwareVerMajor		
	FirmwareVerMinor		
	SensorBits		
	SensorType		
SavedUserSets			
	UserSetDefaultSelector		
		Default	
		UserSet1	
		UserSet2	
		UserSet3	
	UserSetLoad		
	UserSetSave		
	UserSetSelector		
		Default	
		UserSet1	
		UserSet2	
		UserSet3	
Stream			
	Info		
		GSVP Filter Version	
	Multicast		
		MulticastEnable	
		Multicast IP Address	
	Settings		
		GSVP Adjust Packet Size	
		GSVP Burst Size	
		GSVP Driver Selector	
		GSVP Host Receive Buffers	
		GSVP Max Look Back	
		GSVP Max Requests	
		GSVP Max Wait Size	
		GSVP Missing Size	
		GSVP Packet Size	
		GSVP Tilting Size	
		GSVP Timeout	
	Statistics		
		Stat Frame Rate	
		Stat Frames Delivered	
		Stat Frames Dropped	
		Stat Frames Rescued	
		Stat Frames Shoved	
		Stat Frames Underrun	

Table 30: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
		Stat Local Rate	
		Stat Packets Errors	
		Stat Packets Missed	
		Stat Packets Received	
		Stat Packets Requested	
		Stat Packets Resent	
		Stat Time Elapsed	
StreamInformation (Vimba v1.3 or higher)			
	StreamID		
	StreamType		

Table 30: Available Mako camera and driver features

Frame memory

An image is normally captured and transported in consecutive steps. The image is taken, read out from the sensor, digitized and sent over the Gigabit Ethernet network. Mako cameras are equipped with a RAM. Table 31 shows how many frames can be stored by each model.

Note

ⓘ

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 (first in, first out) principle. This makes addressing for individual images unnecessary.

Model	Memory size	Pixel format / Resolution / Packet size
Mako G-030B/C	64 MB memory: 99 frames	
Mako G-032B/C	64 MB memory: 202 frames	
Mako G-050B/C	64 MB memory: 130 frames	
Mako G-095B/C	64 MB memory: 69 frames	Mono8/Bayer8
Mako G-125B/C	64 MB memory: 52 frames	
Mako G-131B/C	64 MB memory: 50 frames	Full resolution
Mako G-192B/C	64 MB memory: 34 frames	
Mako G-223B/C	64 MB memory: 29 frames	Payload size of 8192 bytes per packet
Mako G-419B/C	64 MB memory: 15 frames	
Mako G-503B/C	64 MB memory: 13 frames	

Table 31: Image memory size

Resolution and ROI frame rates

This section charts 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.

Note

- Data was generated using **StreamBytesPerSecond = 124 MB/s** (full bandwidth) and an 8-bit pixel format. Frame rates may be lower if using network hardware incapable of 124 MB/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.

Mako G-030B/C: ROI frame rates

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

Formula 1: **Mako G-030**: theoretical maximum frame rate of CCD

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

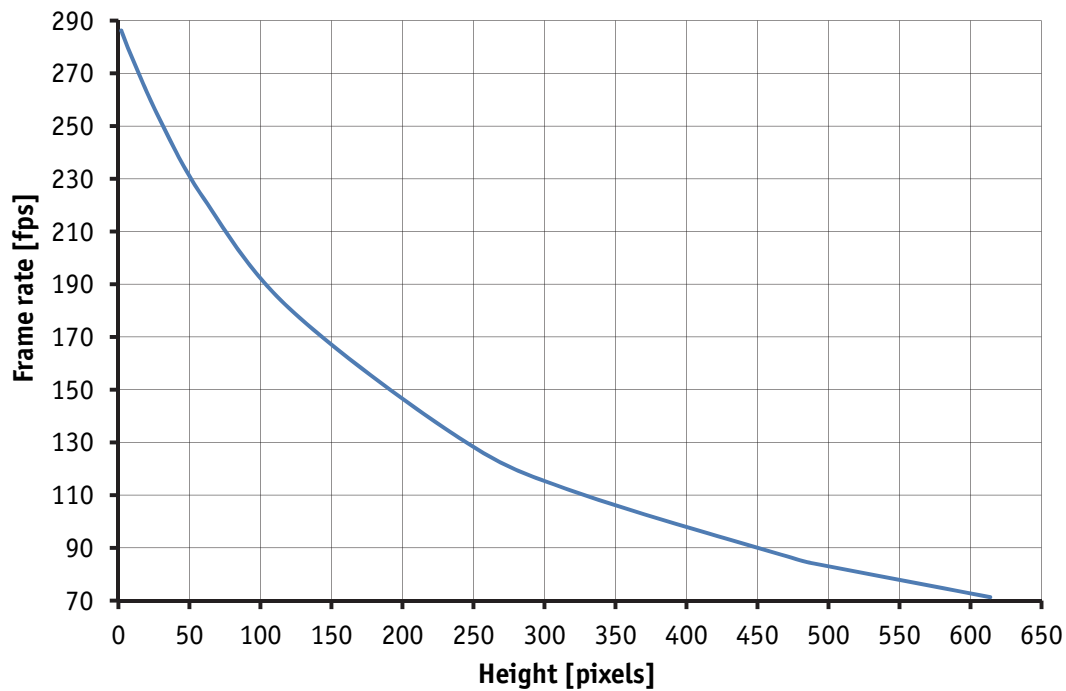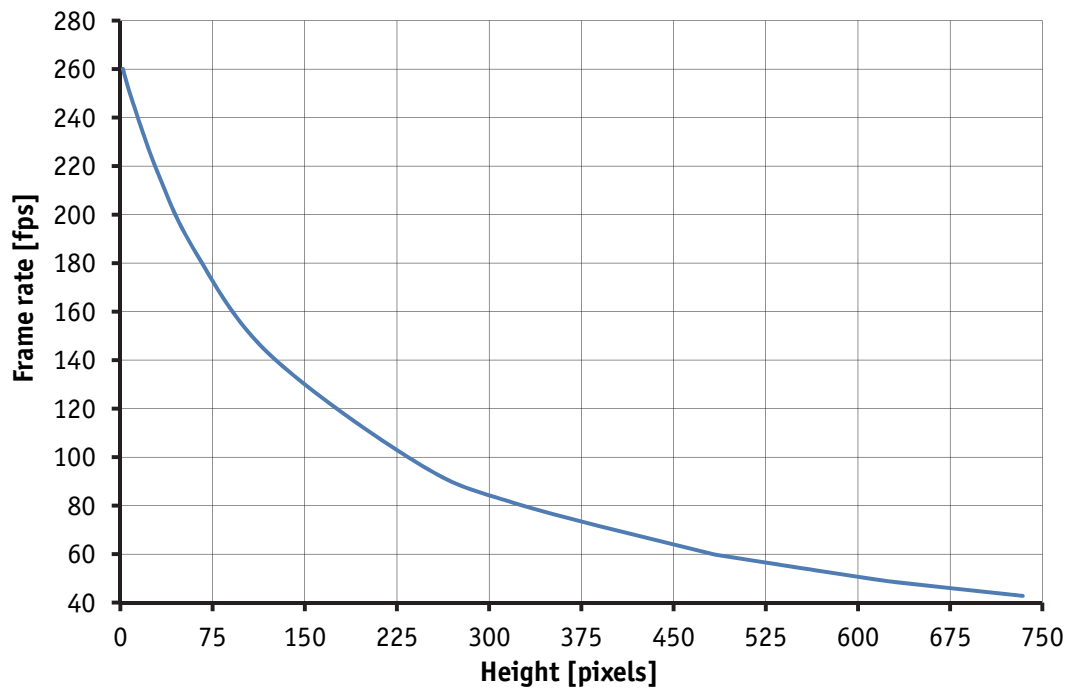Figure 54: Frame rates **Mako G-030** as function of ROI height [**width=644**]

ROI height	Width*	Frame rate
484	644	309
480	644	312
384	644	384
360	644	407
240	644	586
180	644	752
120	644	1048
60	644	1727
30	644	2554
15	644	3393

Table 32: Frame rates (fps) of **Mako G-030** as function of ROI height (pixel) [**width=644**]

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

Mako G-032B/C: ROI frame rates

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

Formula 2: **Mako G-032**: theoretical maximum frame rate of CCD

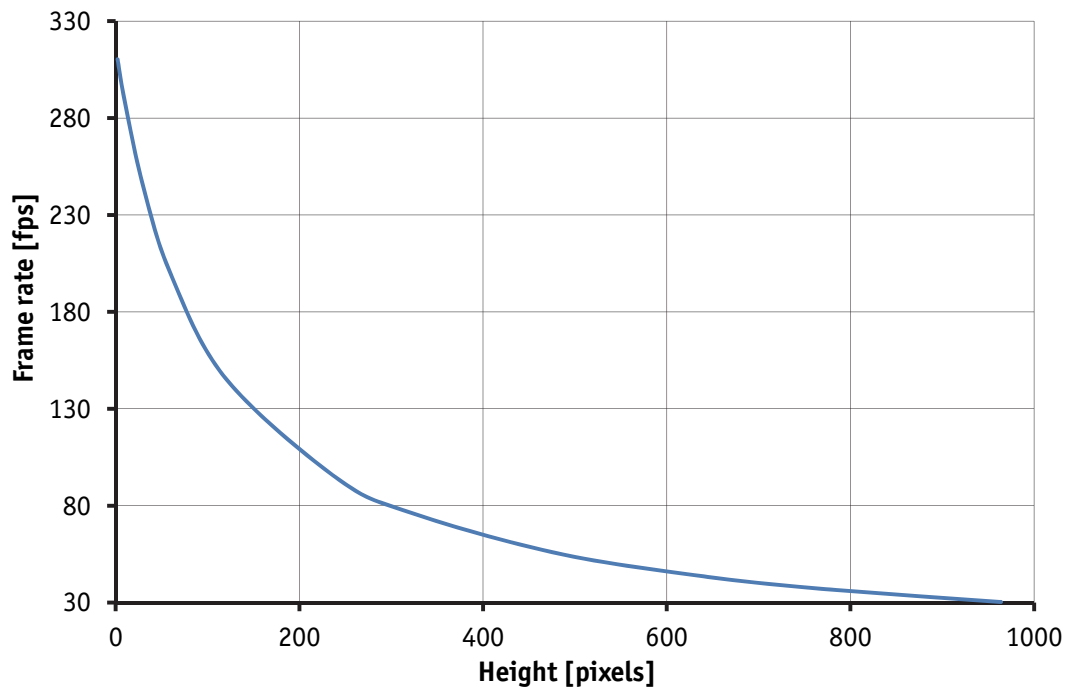Maximum frame rate at full resolution according to formula: 102.3 fps

Figure 55: Frame rates **Mako G-032** as function of ROI height [**width=658**]

ROI height	Frame rate*
492	102.3
480	104.5
320	146.6
240	183.5
120	295.3
60	424.5
30	543.3
10	667.9
2	735.4

Table 33: Frame rates (fps) of **Mako G-032** as function of ROI height (pixel) [**width=658**]

* CCD = theoretical maximum frame rate (in fps) of CCD according to given formula
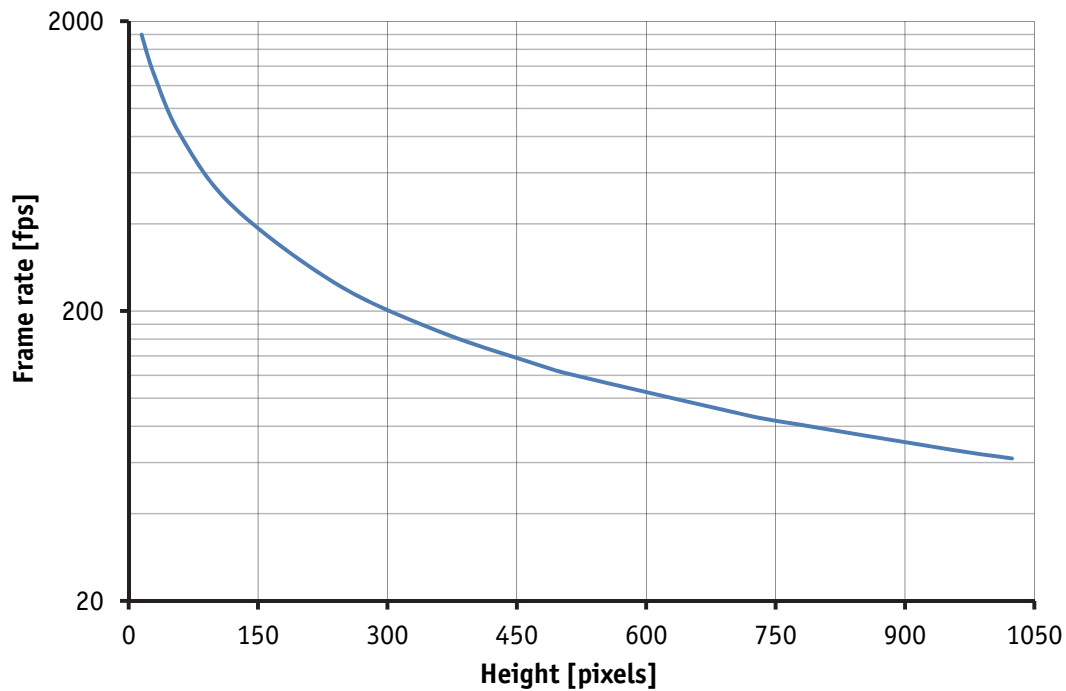
Mako G-050B/C: ROI frame rates

$$\text{Max. frame rate of CCD} = \frac{1}{22.53\ \mu s \times \text{ROI height} + 5.32\ \mu s \times (614 - \text{ROI height}) + 193.63\ \mu s}$$

Formula 3: **Mako G-050**: theoretical maximum frame rate of CCD

Maximum frame rate at full resolution according to formula: 71.2 fps

Figure 56: Frame rates **Mako G-050** as function of ROI height [**width=812**]

ROI height	Frame rate*
614	71.2
492	83.8
480	85.3
320	111.5
240	131.7
120	181.0
60	222.6
30	251.5
10	275.4
2	286.2

Table 34: Frame rates (fps) of **Mako G-050** as function of ROI height (pixel) [**width=812**]

* CCD = theoretical maximum frame rate (in fps) of CCD according to given formula

Mako G-095B/C: ROI frame rates

$$\text{Max. frame rate of CCD} = \frac{1}{31.54\ \mu s \times \text{ROI height} + 4.87\ \mu s \times (734 - \text{ROI height}) + 219.97\ \mu s}$$

Formula 4: **Mako G-095**: theoretical maximum frame rate of CCD

Maximum frame rate at full resolution according to formula: 42.8 fps

Figure 57: Frame rates **Mako G-095** as function of ROI height [**width=1292**]

ROI height	Frame rate*
734	42.8
640	47.9
614	49.5
492	59.1
480	60.2
320	81.1
240	98.1
120	143.0
60	185.4
30	217.8
10	246.4
2	260.1

Table 35: Frame rates (fps) of **Mako G-095** as function of ROI height (pixel) [**width=1292**]

* CCD = theoretical maximum frame rate (in fps) of CCD according to given formula

Mako G-125B/C: ROI frame rates

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

Formula 5: **Mako G-125**: theoretical maximum frame rate of CCD

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

Figure 58: Frame rates **Mako G-125** as function of ROI height [**width=1292**]

ROI height	Frame rate*
964	30.3
960	30.4
768	37.1
640	43.5
480	55.5
320	76.5
240	94.4
120	145.5
60	199.3
30	244.5
10	288.1
2	310.3

Table 36: Frame rates (fps) of **Mako G-125** as function of ROI height (pixel) [**width=1292**]

* CCD = theoretical maximum frame rate (in fps) of CCD according to given formula

Mako G-131B/C: ROI frame rates

Figure 59: Frame rates **Mako G-131** as function of ROI height [**width=1280**]

ROI height	Width*	Frame rate
1024	1280	62
960	1280	66
768	1280	82
720	1280	87
512	1280	121
480	1280	129
360	1280	170
240	1280	249
120	1280	462
60	1280	809
30	1280	1295
15	1280	1798

Table 37: Frame rates (fps) of **Mako G-131** as function of ROI height (pixel) [**width=1280**]

*There will be an increase in frame rate with reduced width for color camera if it is bandwidth limited.

Mako G-192B/C: ROI frame rates

Figure 60: Frame rates **Mako G-192** as function of ROI height [**width=1600**]

ROI height	Width*	Frame rate
1200	1600	60
1024	1600	70
960	1600	75
768	1600	93
720	1600	99
512	1600	138
480	1600	147
360	1600	193
240	1600	282
120	1600	525
60	1600	919
30	1600	1470
16	1600	2042

Table 38: Frame rates (fps) of **Mako G-192** as function of ROI height (pixel) [**width=1600**]

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

Allied Vision

Mako G-223B/C: ROI frame rates

Figure 61: Frame rates **Mako G-223** as function of ROI height

ROI height	Width*	Frame rate
1088	2048	49.5
1000	2048	53.8
900	2048	59.7
800	2048	67.1
700	2048	76.6
600	2048	89.2
500	2048	106.8
400	2048	132.9
300	2048	176.1
200	2048	260.8
100	2048	502.1
50	2048	934.6
20	2048	1933.8
10	2048	2847.3
5	2048	3624.5
2	2048	4906.7
1	2048	4926.1

Table 39: Frame rates (fps) of **Mako G-223** as function of ROI height (pixel)

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

Mako G-419B/C: ROI frame rates

Figure 62: Frame rates **Mako G-419** as function of ROI height

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

Table 40: Frame rates (fps) of **Mako G-419** as function of ROI height (pixel)

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

Mako G-503B/C: ROI frame rates

Figure 63: Frame rates **Mako G-503** as function of ROI height

ROI height	Width*	Frame rate
1944	2592	14
1200	2592	22
1080	2592	25
1024	2592	26
768	2592	35
512	2592	52
480	2592	55
360	2592	73
240	2592	109
120	2592	209
60	2592	386
30	2592	669
15	2592	1055

Table 41: Frame rates (fps) of **Mako G-503** as function of ROI height (pixel)

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

Appendix

Sensor position accuracy of Mako cameras

Figure 64: Allied Vision sensor position accuracy

Method of positioning

Optical alignment of the photo sensitive sensor area into the camera front module (lens mount front flange).

Reference points

Sensor: center of the pixel area (photo sensitive cells).
Camera: Center of the 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)

Note   x/y - tolerances between the C-Mount hole and the pixel area may be higher.

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