



Technical Manual

AVT GigE Vision Cameras

V2.1.0

07 October 2014

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.

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Allied Vision Technologies GmbH 10/2014

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Contents

Contacting Allied Vision Technologies	5
Introduction	6
Document history	6
Conventions used in this manual.....	8
Styles	8
Symbols	8
More information	8
Before operation	9
Heat dissipation.....	9
Camera cleaning instructions	10
Warranty	10
Avoiding the necessity of camera cleaning	10
Is it an impurity? – Identifying impurities.....	11
Where is the impurity? – Locating impurities.....	11
Cleaning Instructions.....	12
About Mako GigE cameras	15
Conformity.....	16
FCC – Class B Device	16
Specifications.....	17
Mako G-032B/C	17
Mako G-050B/C	20
Mako G-095B/C	22
Mako G-125B/C	24
Mako G-223B/C (NIR)	26
Mako G-419B/C (NIR)	28
Camera smart features	30
Filter and lenses.....	31
IR cut filter.....	31
Camera lenses.....	31
Mako G-032.....	32
Mako G-050.....	32
Mako G-095.....	32
Mako G-125.....	33
Mako G-223.....	33
Mako G-419.....	33
Camera dimensions.....	34
Tripod adapter	34
Cross section: C-Mount	35
Cross section: CS-Mount.....	36
Adjustment of the C-Mount and CS-Mount.....	37

Mako standard housing	37
Camera interfaces	38
Status LEDs	38
Gigabit Ethernet port	39
Mako I/O connector pin assignment	39
Mako input description	40
Mako output description	41
Control signals	43
Inputs	43
Input/output pin control	43
Outputs	43
Trigger timing diagram	45
Notes on triggering	45
Description of the data path	47
Mako monochrome cameras	47
Mako with CCD sensors	47
Mako with CMOS sensors	47
Mako color cameras	48
Mako with CCD sensors	48
Mako with CMOS sensors	48
Camera features	49
Frame memory	57
Resolution and ROI frame rates	58
Mako G-032B/C: ROI frame rates	59
Mako G-050B/C: ROI frame rates	60
Mako G-095B/C: ROI frame rates	61
Mako G-125B/C: ROI frame rates	62
Mako G-223B/C: ROI frame rates	63
Mako G-419B/C: ROI frame rates	64
Appendix	65
Sensor position accuracy of AVT Mako cameras	65
Index	66

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Info



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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 **AVT GigE Camera and Driver Features** and **AVT GigE Camera and Driver Attributes** documents.

www



AVT Mako literature:

<http://www.alliedvisiontec.com/us/support/downloads/product-literature/mako.html>

Note



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

<http://www.alliedvisiontec.com/emea/support/downloads/product-literature/hardware-installation-guide.html>

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 instructions - Updated the specifications for Mako G-223 and G-419 - Updated chapter Resolution and ROI frame rates on page 58
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 47 and 49
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 17: Status LED (green) on page 38 - Updated the note on <i>StreamHoldCapacity</i> in Specifications and Frame memory sections - Updated block diagrams in chapter Description of the data path on page 47 - 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 35 - 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 Description of the data path on page 47 to remove the RS232 mention - Added Hirose cable information on page 39
V2.1.0	2014-Oct-07	- Updated and rearranged Specifications chapter - Added Camera smart features on page 30 - Added trigger latency and jitter values for Mako G-032B/C and Mako G-125B/C - Updated Mako standard housing drawing - Updated table 22 on page 49 - Updated Camera features 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 32 - Added Mako G-050B/C: ROI frame rates and Mako G-095B/C: ROI frame rates sections - Updated Description of the data path and Camera dimensions chapters

Table 1: Document history

Conventions used in this manual

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	<i>Mode</i>
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.alliedvisiontec.com>

More information

For more information on hardware and software read the following:

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

www

To download the **AVT GigE Installation Guide** and **AVT GigE Camera and Driver Features**, go to:

<http://www.alliedvisiontec.com/emea/support/downloads/product-literature.html>

www

Software packages (including **documentation** and **release notes**) provided by AVT can be downloaded from:

<http://www.alliedvisiontec.com/emea/products/software.html>

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 **AVT GigE Installation Guide** first.

Caution

Before operating any AVT camera, read the **safety instructions** and **ESD warnings** in the **AVT 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 instructions

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 AVT camera dealer for assistance.
- Ask your AVT 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.alliedvisiontec.com/emea/support/warranty.html>

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.**
- AVT 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

Is it an impurity? – 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.

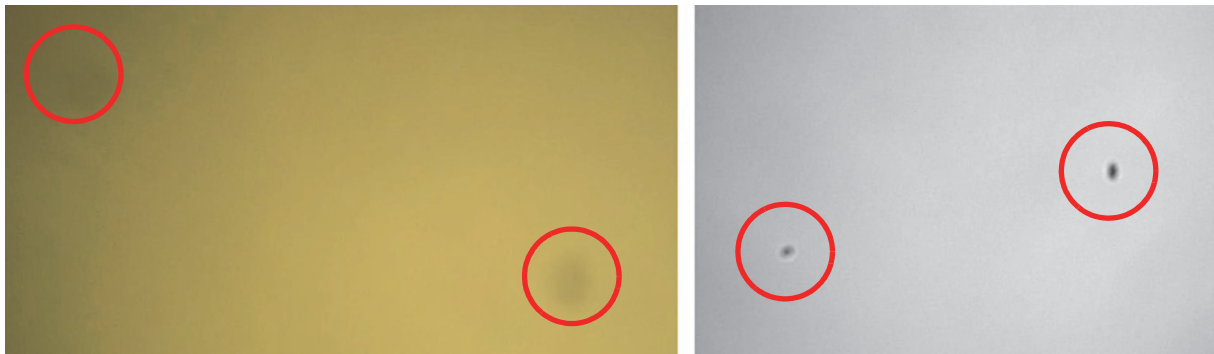


Figure 2: Image with tiny dust on the filter (left) and dust on the sensor (right)

Where is the impurity? – 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

- 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 tool (E9020001)

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).

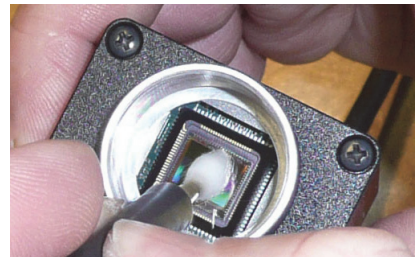


Figure 5: Sensor cleaning



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 AVT dealer.

About Mako GigE cameras

Mako Mako cameras have a Gigabit Ethernet interface.

GigE GigE is the abbreviation for **Gigabit Ethernet**.

All AVT Mako cameras are GigE Vision V1.2 compliant cameras with Gigabit Ethernet interface. AVT 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. AVT GigE cameras are GenICam V1.0 compliant.

Conformity

Allied Vision Technologies declares under its sole responsibility that all standard cameras of the AVT 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 AVT 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 AVT camera, read the **safety instructions** and **ESD warnings** in the **AVT GigE Installation Guide**.

<http://www.alliedvisiontec.com/emea/support/downloads/product-literature/hardware-installation-guide.html>

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 $\pm 10\%$.

This is due to:

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

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 <i>GevSCPSPacketSize</i> = 8192 bytes per packet
Mono formats	Mono8, Mono12Packed, Mono12

Table 3: Mako G-032B/C camera specifications

Feature	Specification
Color formats	BayerRG8, BayerRG12, BayerRG12Packed, Mono8, RGB8Packed, YUV411Packed, YUV422Packed, YUV444Packed, BGR8Packed
Exposure control	10 μ s to 93 s
Gain control	0–30 dB
Horizontal binning	1 to 8 pixels
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 μ s Frame valid state: 16.9 μ s
Trigger jitter*	Idle state: 4.0 μ s Frame valid state: 13.7 μ s
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 3: Mako G-032B/C camera specifications

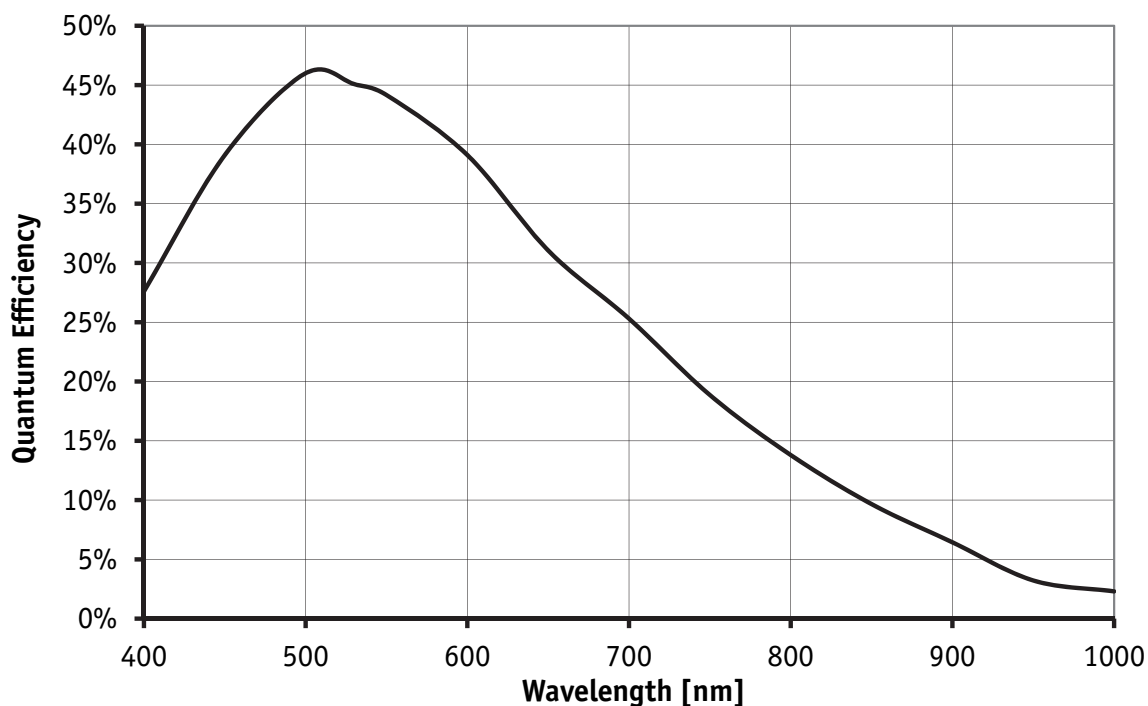


Figure 7: Spectral sensitivity of Mako G-032B (without protection/cover glass)

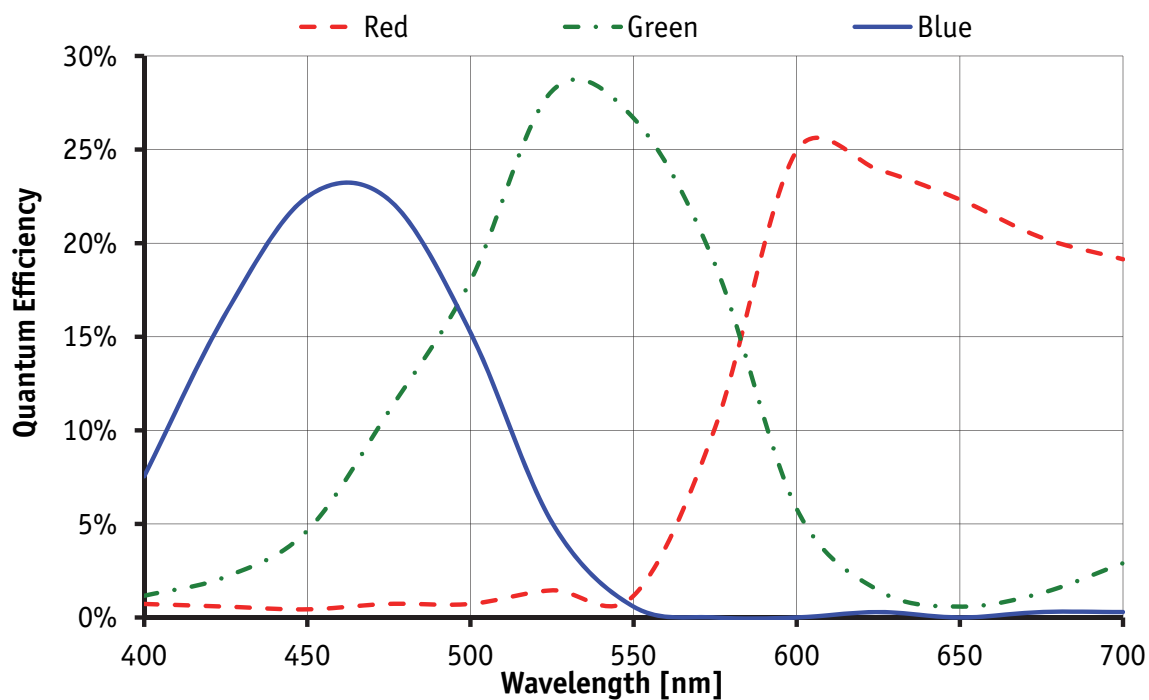


Figure 8: Spectral sensitivity of Mako G-032C (with IR cut filter)

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 <i>GevSCPSPacketSize</i> = 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 pixels
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 4: Mako G-050B/C camera specifications

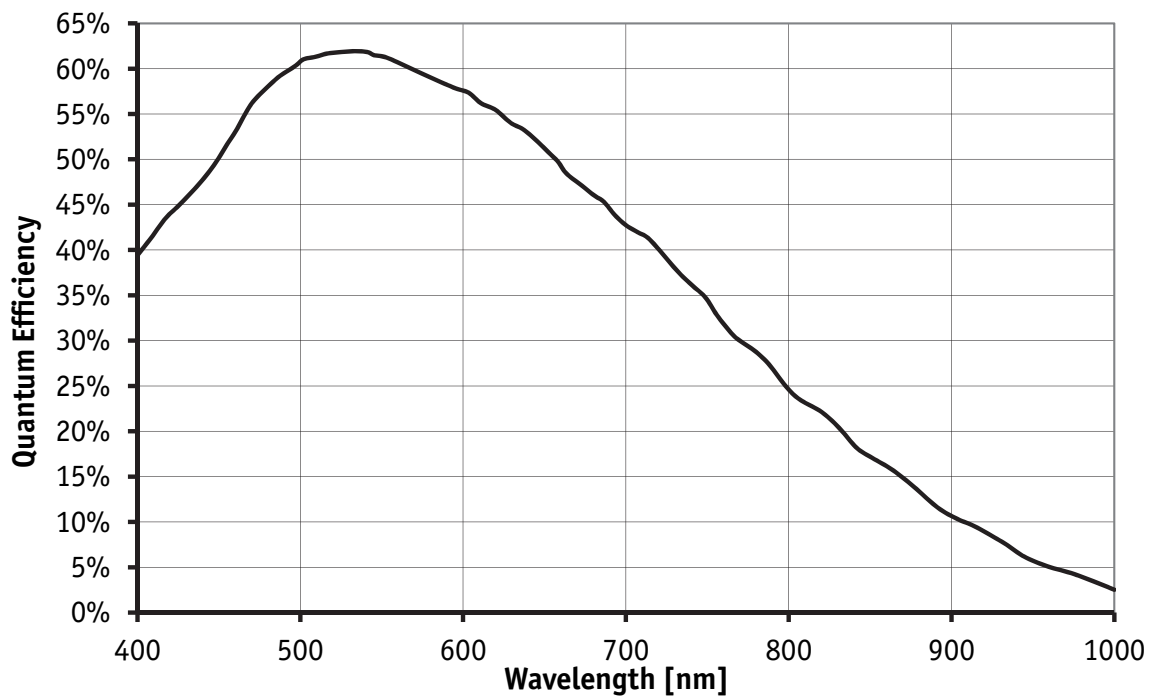


Figure 9: Spectral sensitivity of Mako G-050B (without protection/cover glass)

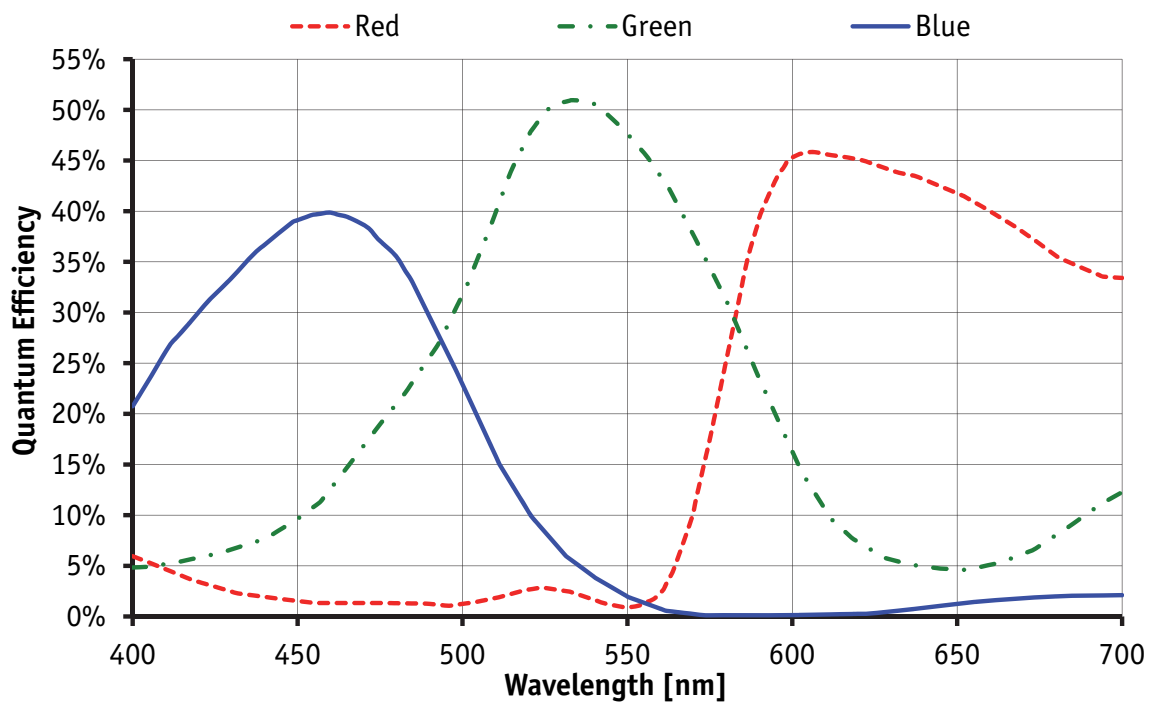


Figure 10: Spectral sensitivity of Mako G-050C (without IR cut filter)

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 <i>GevSCPSPacketSize</i> = 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 pixels
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 5: Mako G-095B/C camera specifications

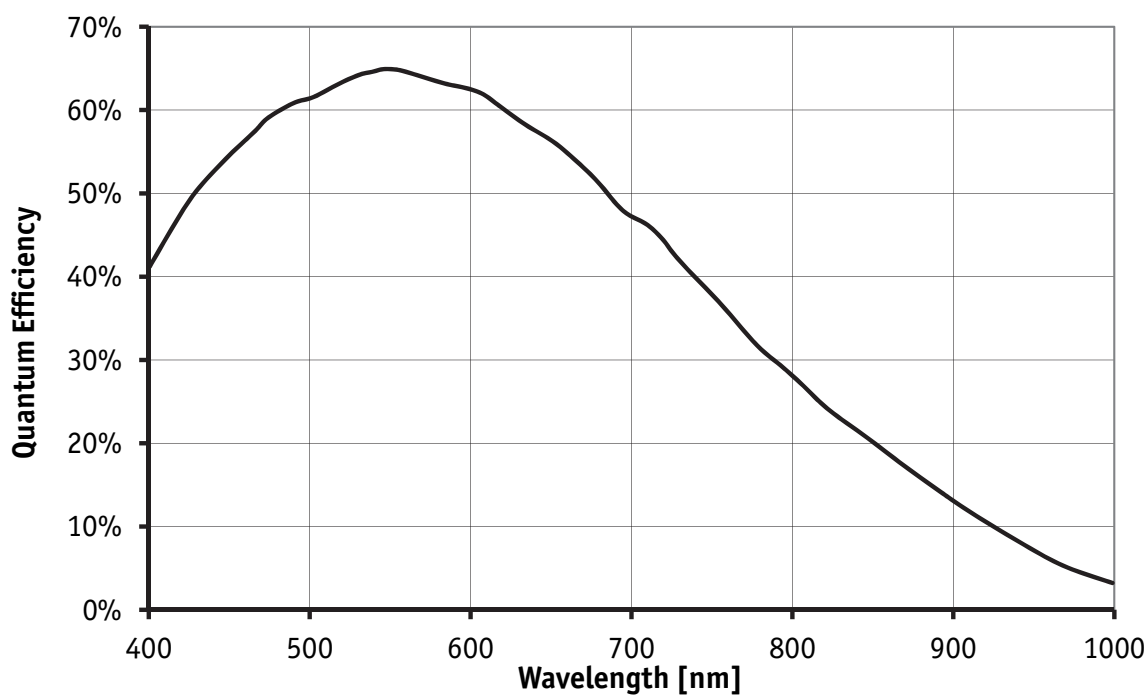


Figure 11: Spectral sensitivity of Mako G-095B (without protection/cover glass)

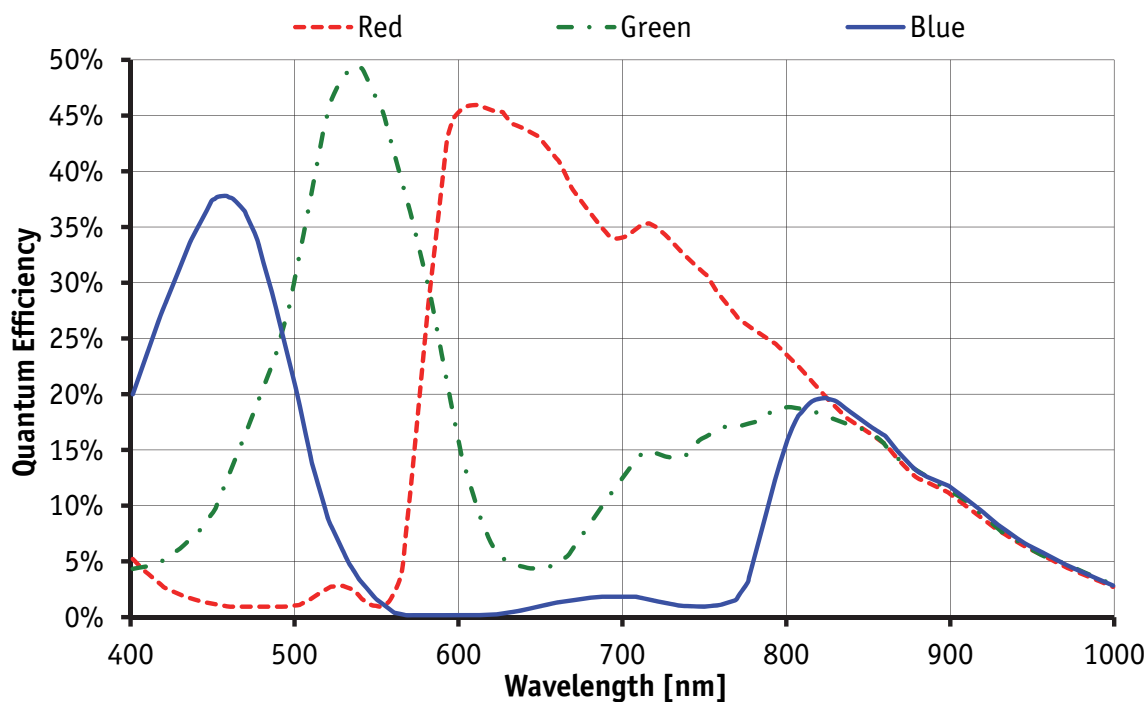


Figure 12: Spectral sensitivity of Mako G-095C (without IR cut filter)

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 <i>GevSCPSPacketSize</i> = 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 pixels
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 6: Mako G-125B/C camera specifications

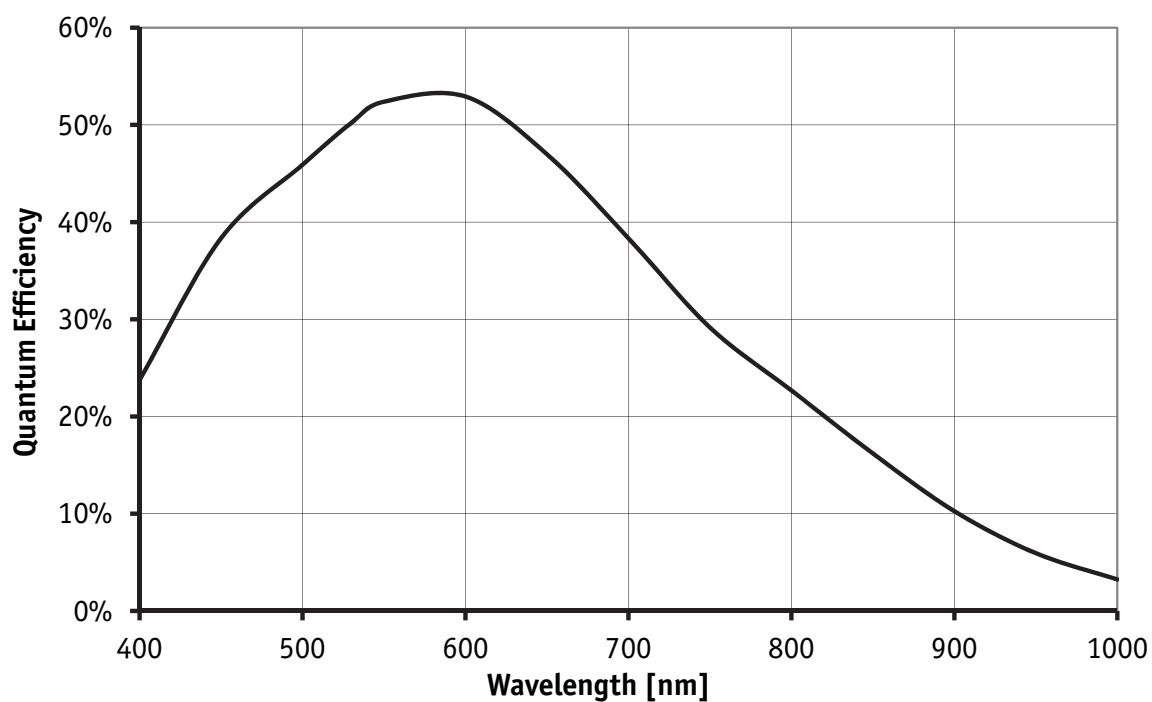


Figure 13: Spectral sensitivity of Mako G-125B (without protection/cover glass)

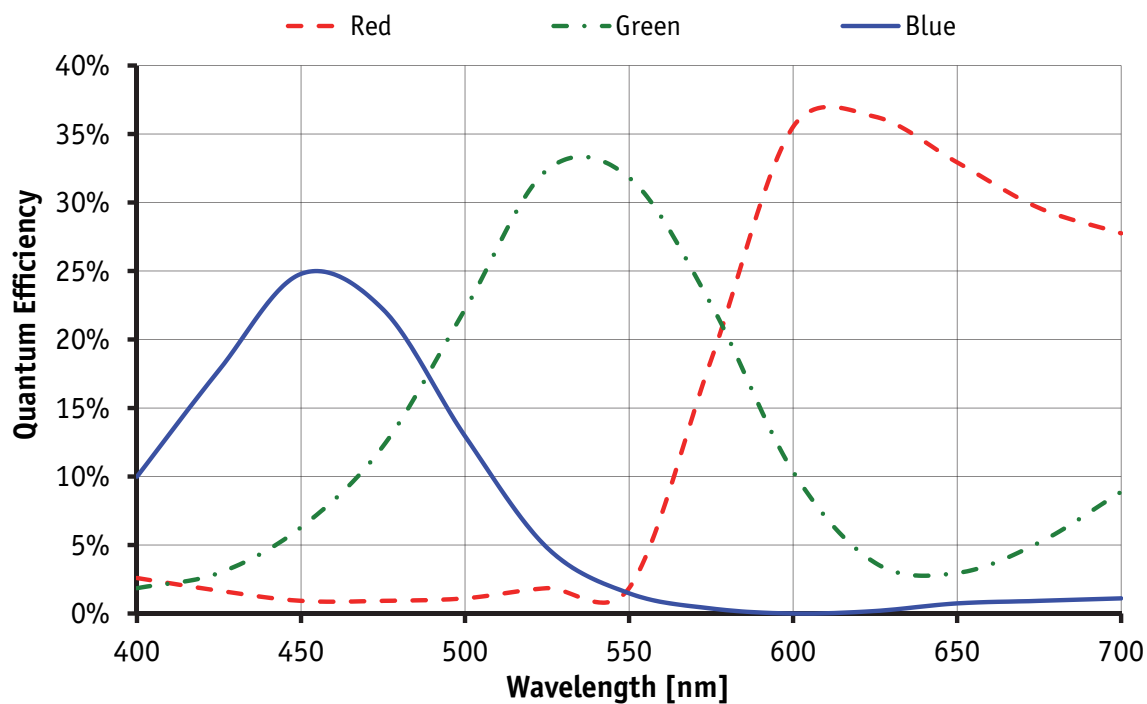


Figure 14: Spectral sensitivity of Mako G-125C (with IR cut filter)

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 <i>GevSCPSPacketSize</i> = 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 $\mu\text{s}^\dagger$ 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

Table 7: Mako G-223 B/C (NIR) camera specifications

[†] 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.

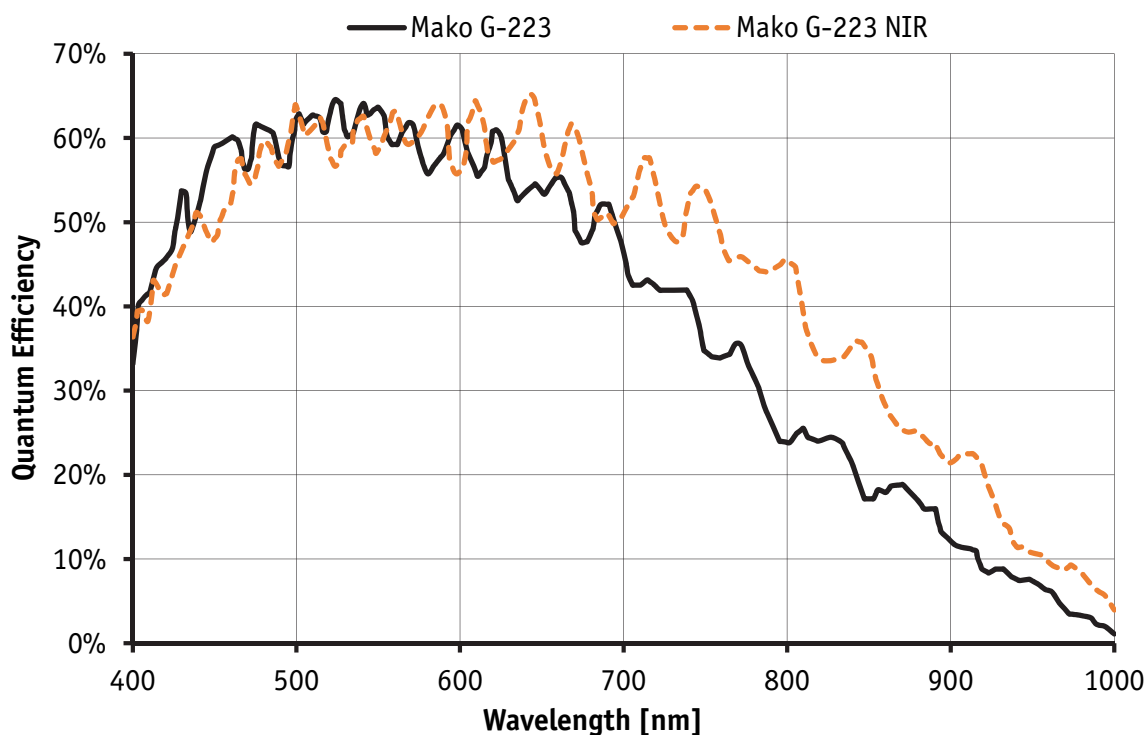


Figure 15: Spectral sensitivity of Mako G-223B (NIR)

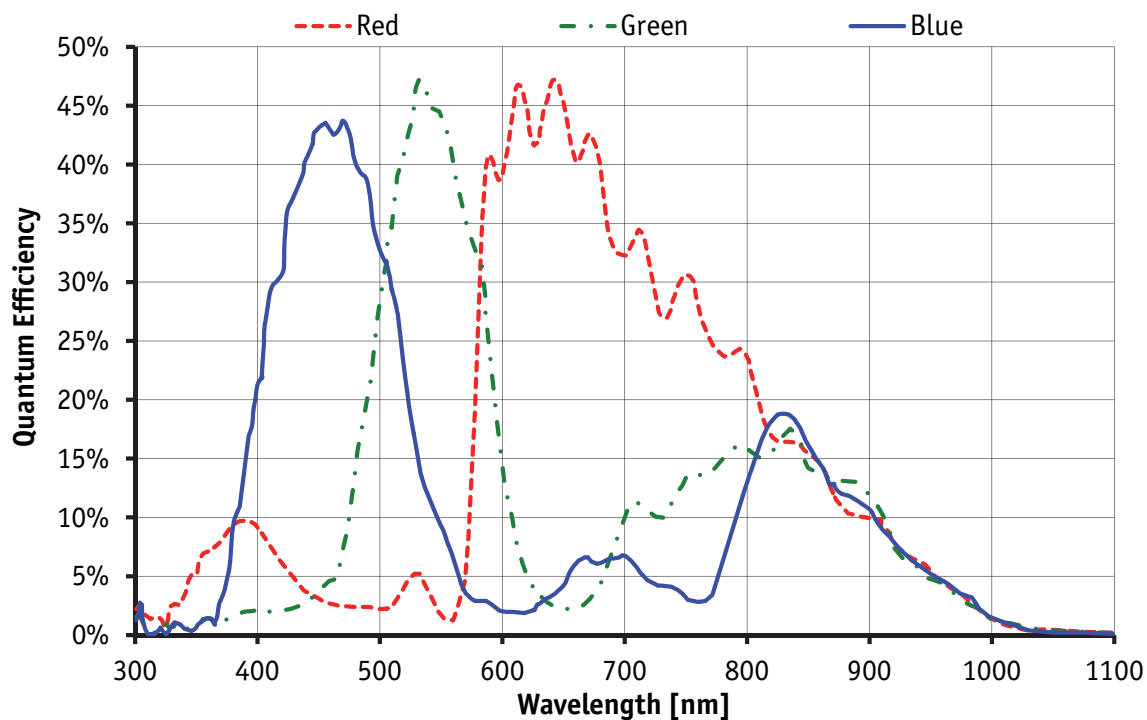


Figure 16: Spectral sensitivity of Mako G-223C (without IR cut filter)

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 <i>GevSCPSPacketSize</i> = 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 $\mu\text{s}^\dagger$ 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

Table 8: Mako G-419 B/C (NIR) camera specifications

[†] 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.

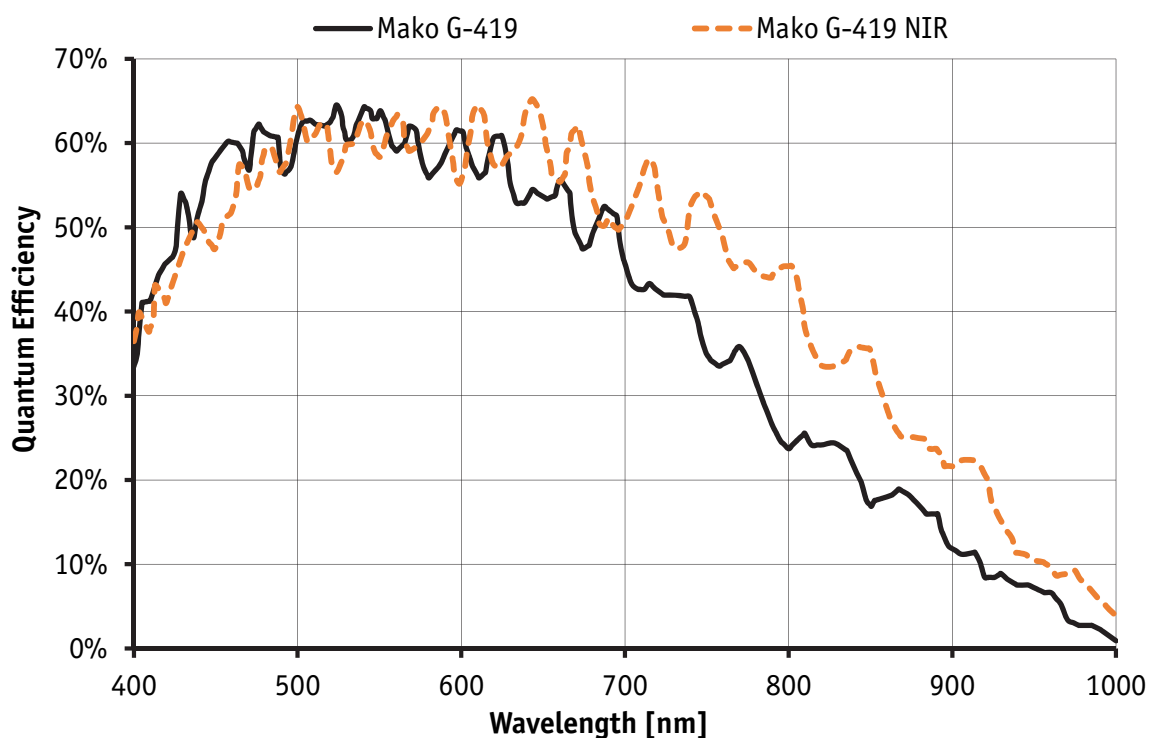


Figure 17: Spectral sensitivity of Mako G-419B (NIR)

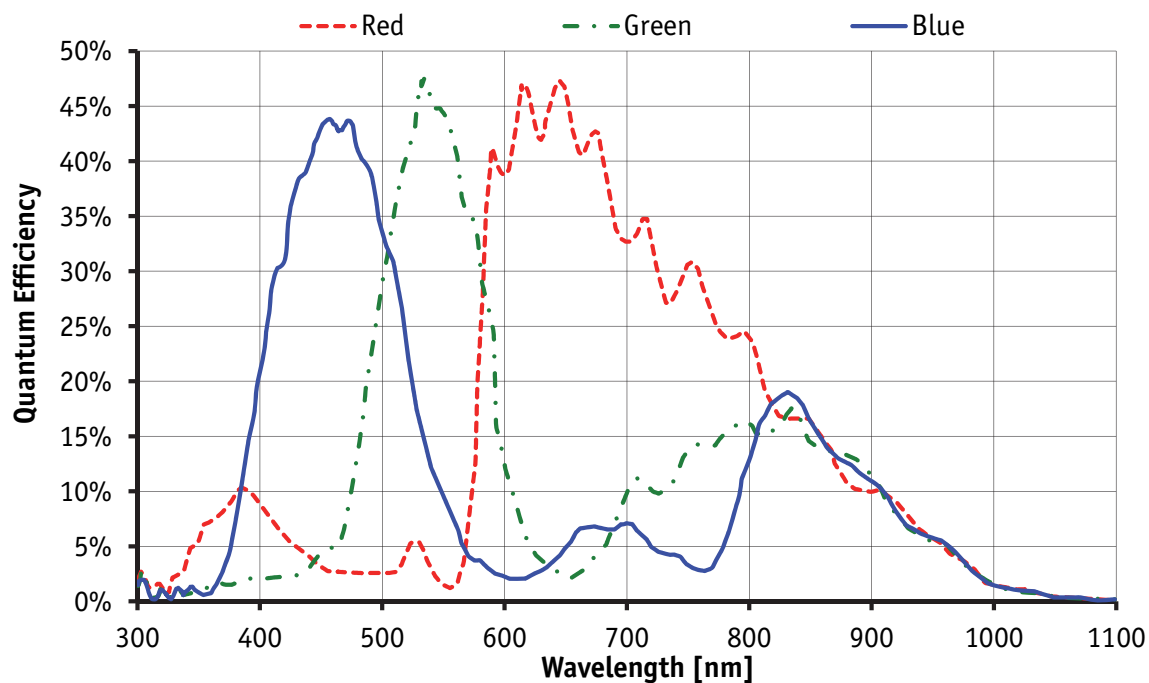


Figure 18: Spectral sensitivity of Mako G-419C (without IR cut filter)

Camera smart features

AVT 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: [AVT GigE Camera and Driver Attributes](#) document

VIMBA and third-party users: [AVT GigE Camera and Driver Features](#) 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 $\pm 1^{\circ}\text{C}$

Table 9: 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:

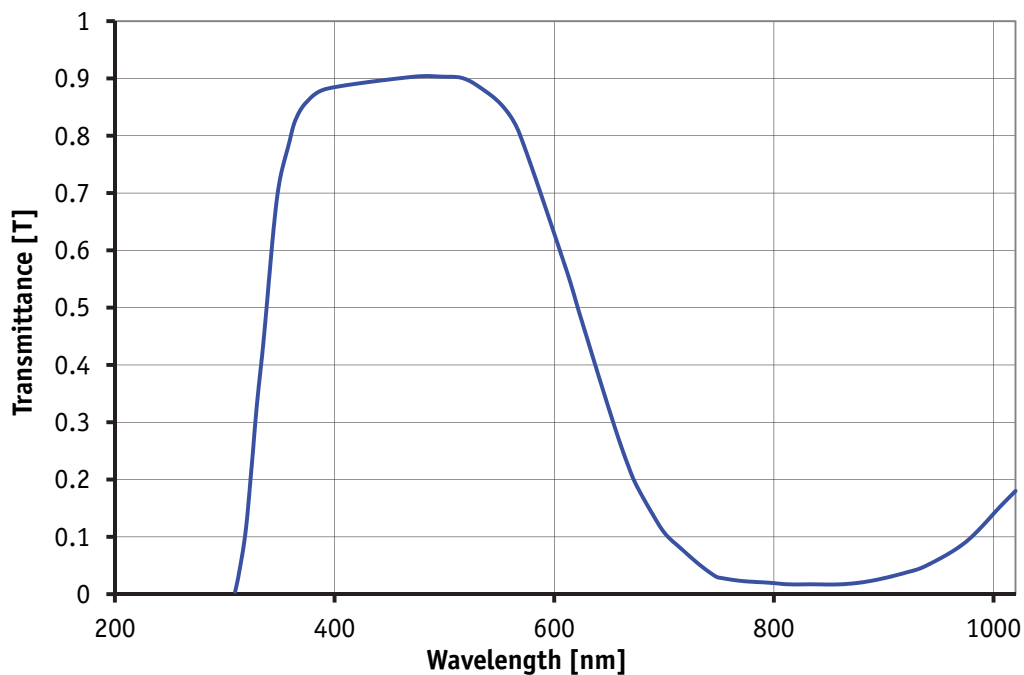


Figure 19: Approximate spectral transmission of IR cut filter (may vary slightly by filter lot)
(type Hoya C5000)

Camera lenses

AVT offers different lenses from a variety of manufacturers.

www



For more information, see:

<http://www.alliedvisiontec.com/emea/products/accessories/lenses.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-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 10: 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 11: 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 12: 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 13: Focal length vs. field of view (Mako G-125)

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 14: 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 692 mm	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 15: Focal length vs. field of view (Mako G-419)

Camera dimensions

Note



For information on **sensor position accuracy** (sensor shift x/y , optical back focal length z and sensor rotation α):

see [Appendix](#) on page 65.

Tripod adapter

This tripod adapter (AVT order number 4807) ...

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

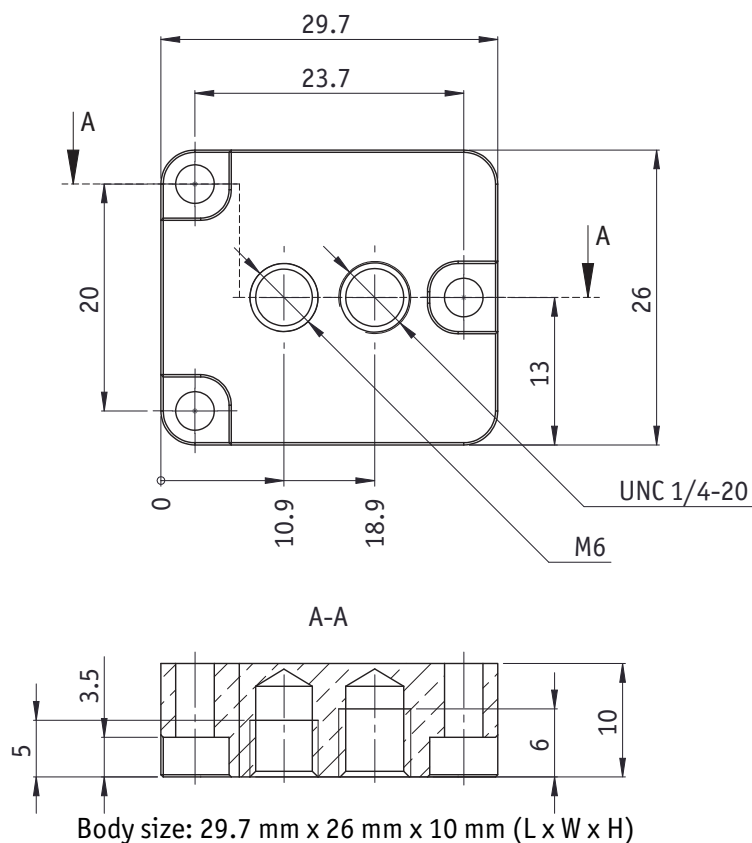


Figure 20: Tripod adapter dimensions

Cross section: C-Mount

www



Choose protection glass or filter according to the **AVT Modular Camera Concept**:

<http://www.alliedvisiontec.com/us/support/downloads/product-literature/avt-modular-concept.html>

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-032, Mako G-050, Mako G-095, and Mako G-125 are equipped with a 16 mm diameter filter.

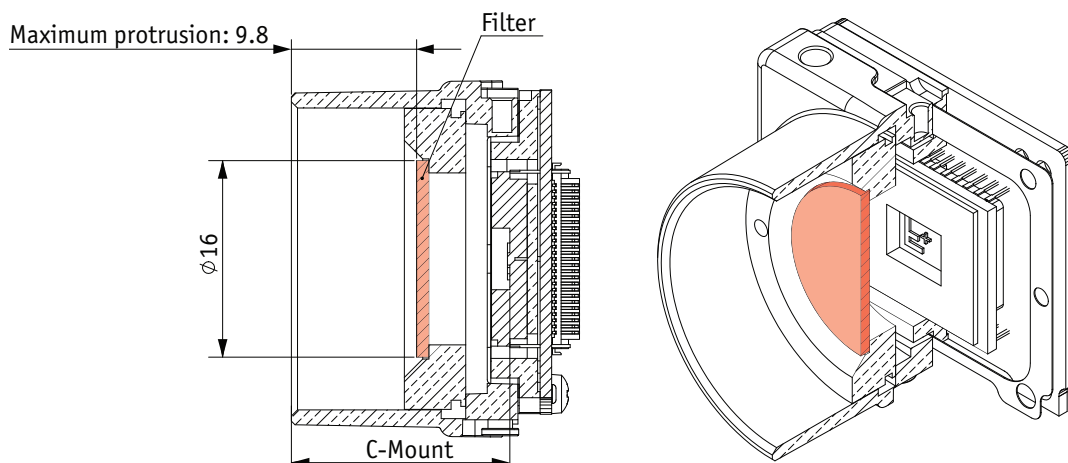


Figure 21: C-Mount dimensions for Mako G-032 / G-050 / G-095 / G-125 (16 mm filter)

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

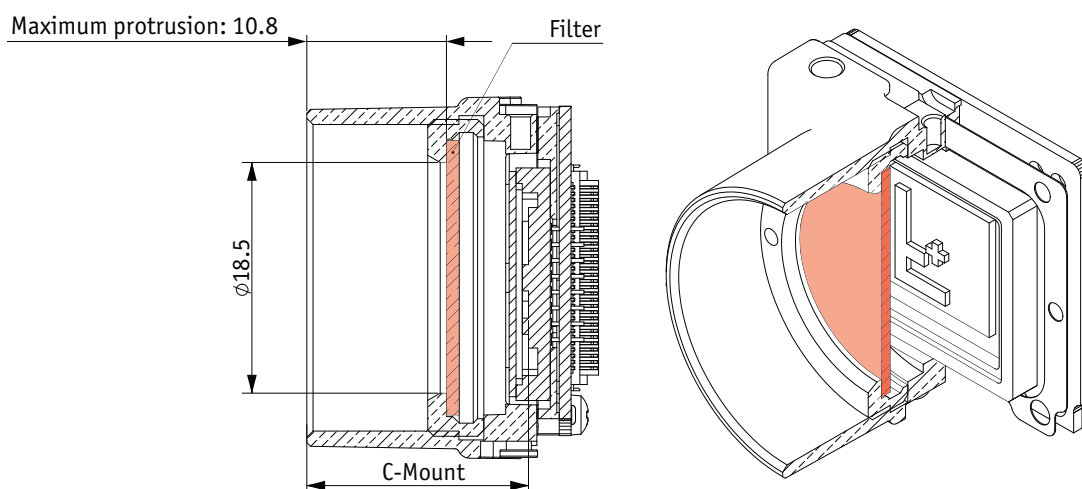


Figure 22: C-Mount dimensions for Mako G-223 / G-419 (22 mm filter)

Cross section: CS-Mount

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

[www](http://www.alliedvisiontec.com)



Download the **AVT Modular Concept** at:

<http://www.alliedvisiontec.com/emea/support/downloads/product-literature.html>

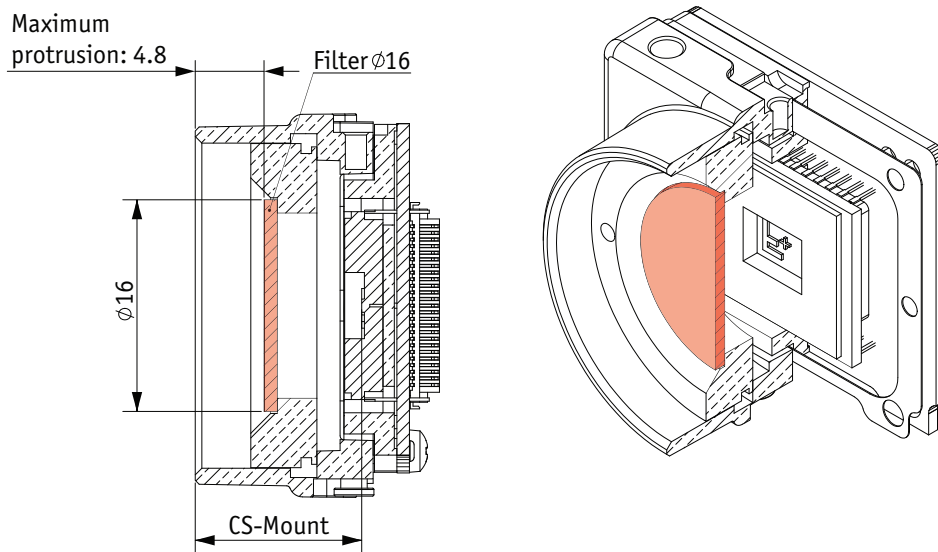


Figure 23: CS-Mount dimensions for Mako G-032 / G-050 / G-095 / G-125 (16 mm filter)

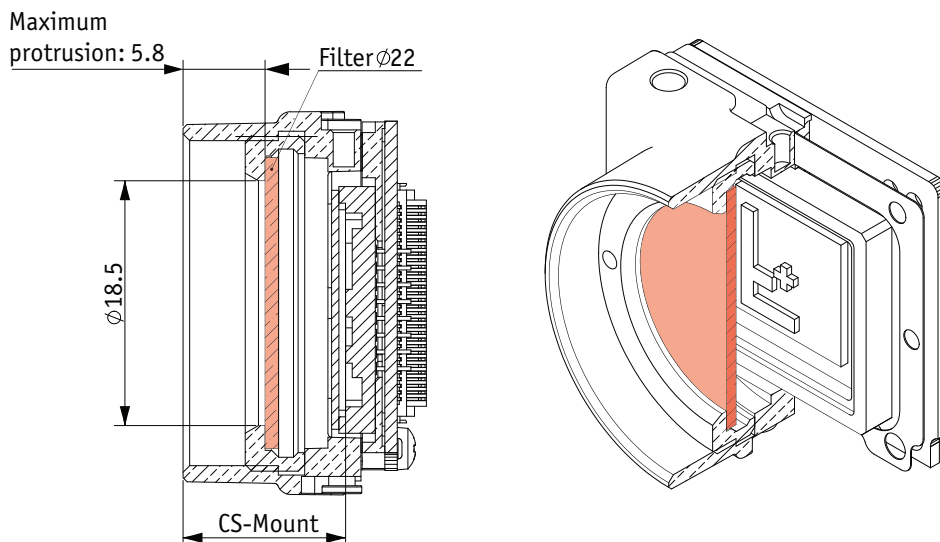


Figure 24: CS-Mount dimensions for Mako G-223 / G-419 (22 mm filter)

Adjustment of the C-Mount and CS-Mount

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

Note



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

see [Contacting Allied Vision Technologies](#) on page 5.

Mako standard housing

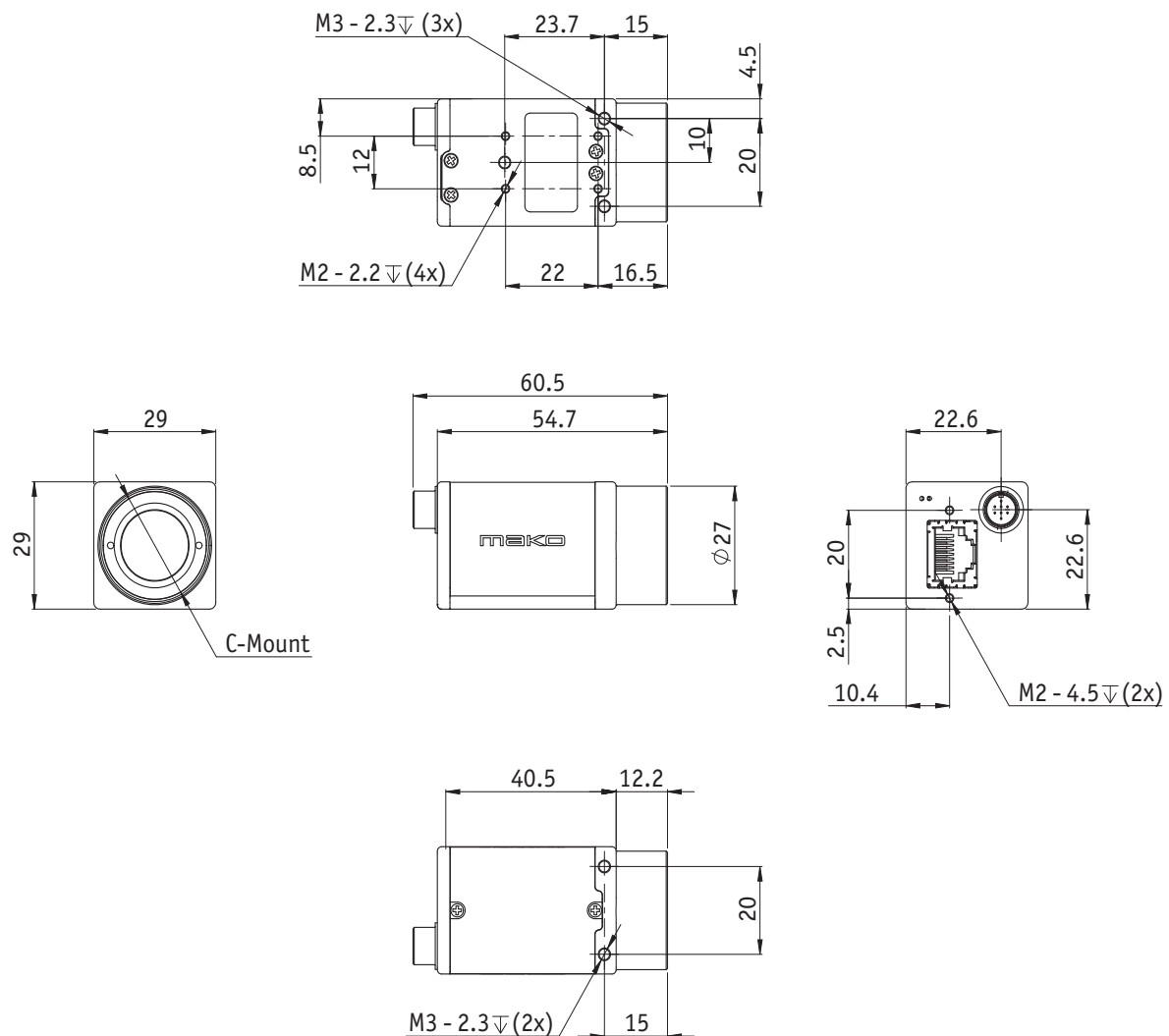


Figure 25: Camera dimensions standard housing (in mm)

Camera interfaces

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

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



www For accessories like cables see:



<http://www.alliedvisiontec.com/emea/products/accessories/gige-accessories.html>

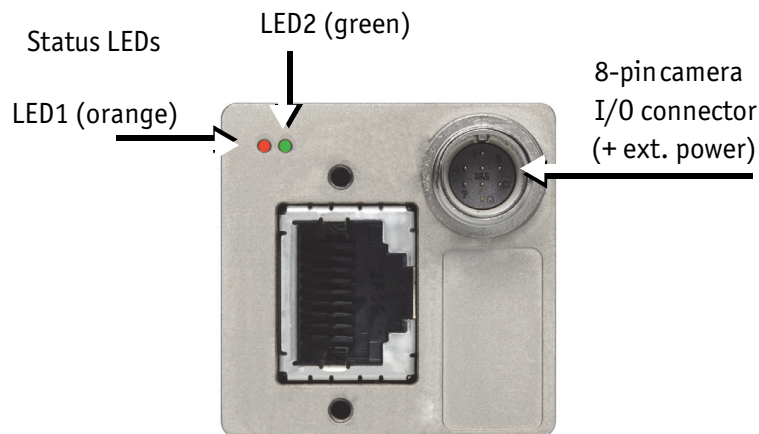


Figure 26: Example: Rear view of **Mako** camera

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 16: Status LED (**orange**)

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

Table 17: Status LED (**green**)

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

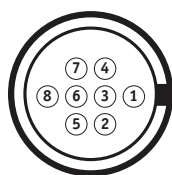


- Cable lengths up to 100 m are supported.
- The 8-pin RJ-45 jack provides a pin assignment according to the Ethernet standard (IEEE 802.3 1000BASE-T).
- All Mako cameras are PoE capable (802.3af/at).
- If both interfaces are used for power (I/O and GigE connector via **PoE**), the camera will only use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

Accessories

- Cables are available from AVT:
<http://www.alliedvisiontec.com/emea/products/accessories/gige-accessories.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	$U_{in}(\text{high}) = 3.0\text{--}24.0\text{ V}$ up to 36 V with external resistor of 3.3 k Ω in series $U_{in}(\text{low}) = 0\text{--}1.0\text{ V}$	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 27: 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 AVT.
 AVT P/N: K7600503

Mako input description

Mako input block diagram

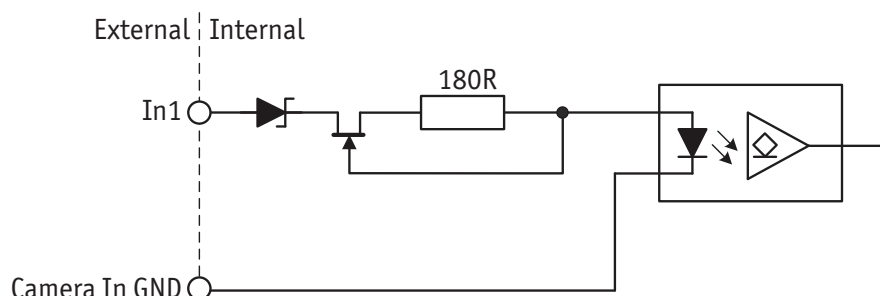


Figure 28: Mako input block diagram

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 18: Mako input parameters

The **minimum pulse width** for all Mako cameras is:

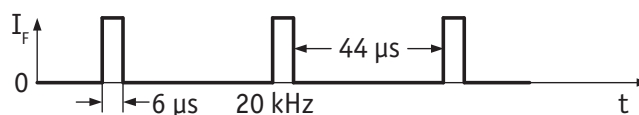


Figure 29: Mako minimum pulse width

Test conditions

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

Mako output description

Mako block diagram

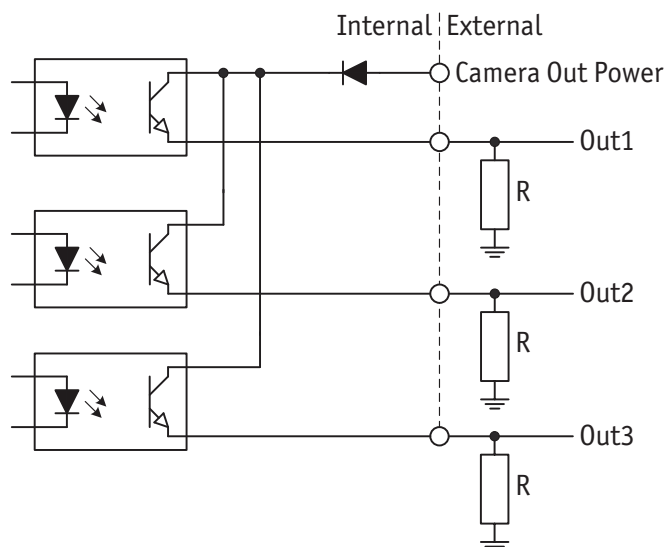


Figure 30: Mako output block diagram

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 31: Mako: Camera Out Power and external resistor

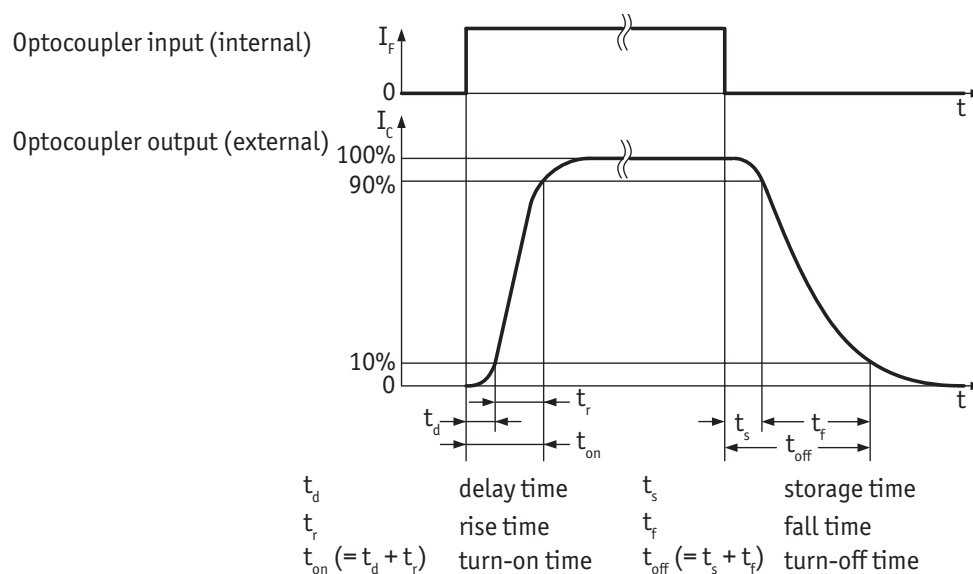


Figure 32: Mako output switching times

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 19: Parameters for Mako

Test conditions

Output: external 2.4 k Ω resistor to GND, **Camera Out Power** set to 12 V.

Note Higher external values increase the times in the table above.



Note 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

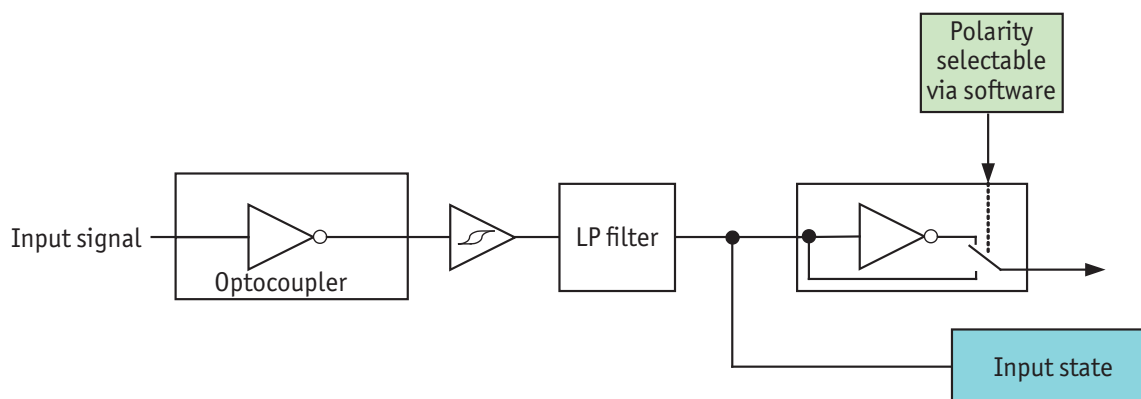


Figure 33: Input block diagram

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 20: 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 20: Output signals

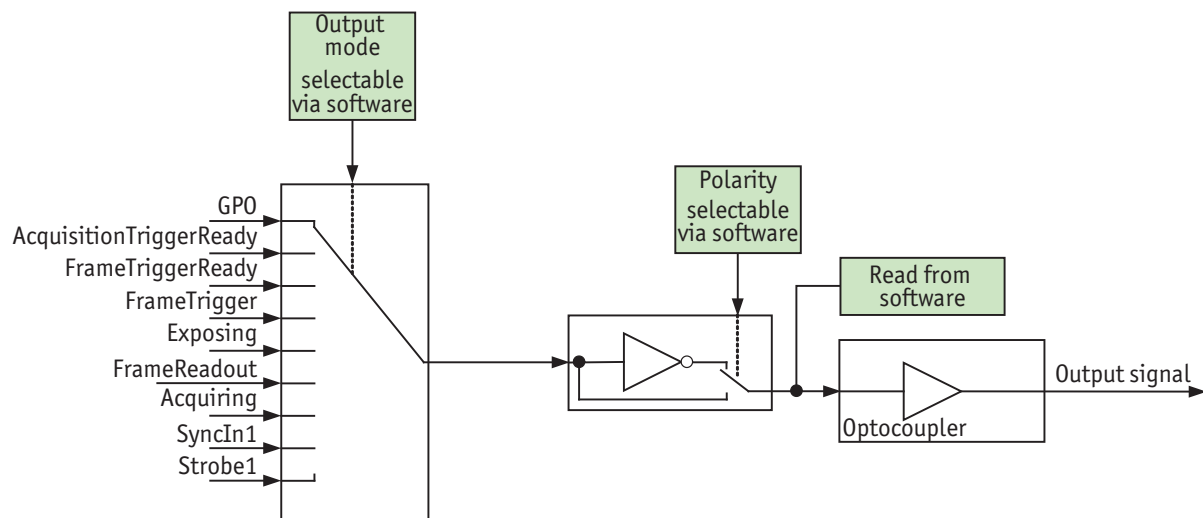


Figure 34: Output block diagram

Trigger timing diagram

The following diagram explains the trigger concept in general.

Note

For trigger description on camera control basis, see **AVT GigE Camera and Driver Features**.

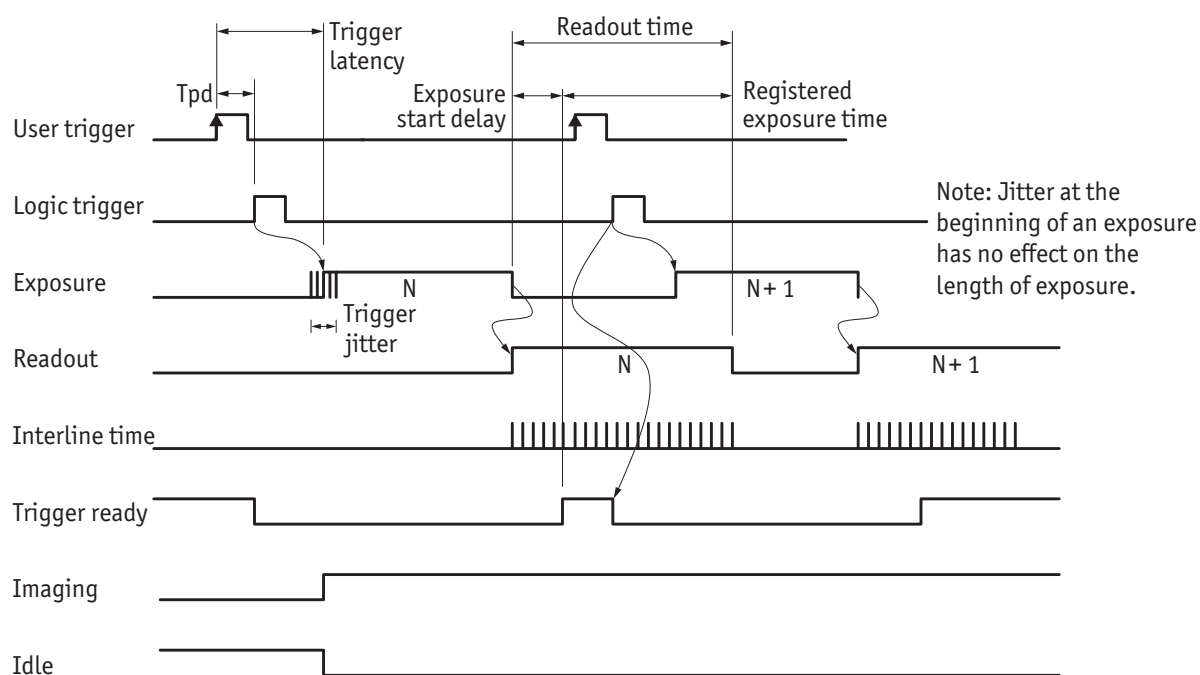


Figure 35: Trigger timing diagram

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)
T_{pd}	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 21: 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 21: 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.

Description of the 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 [AVT GigE Camera and Driver Features](#) document.

Mako monochrome cameras

Mako with CCD sensors

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

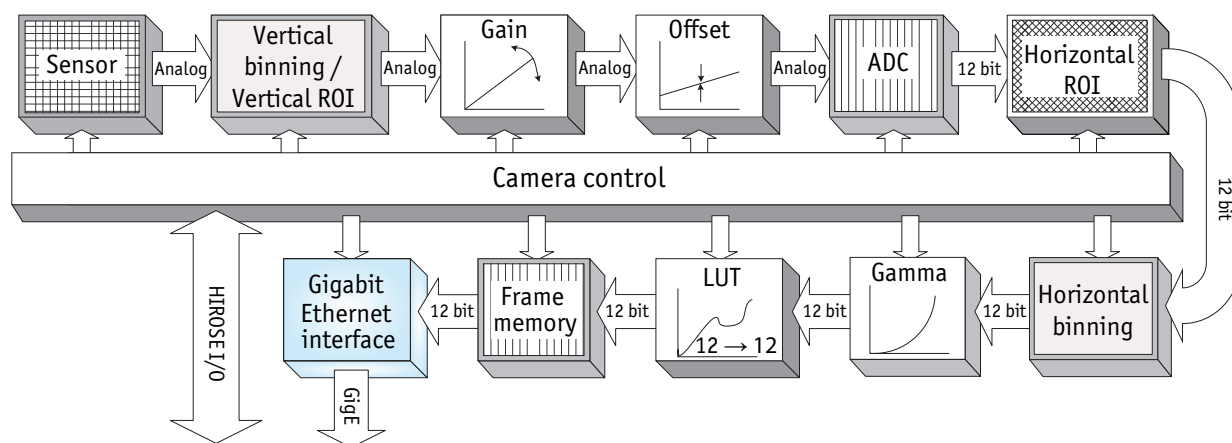
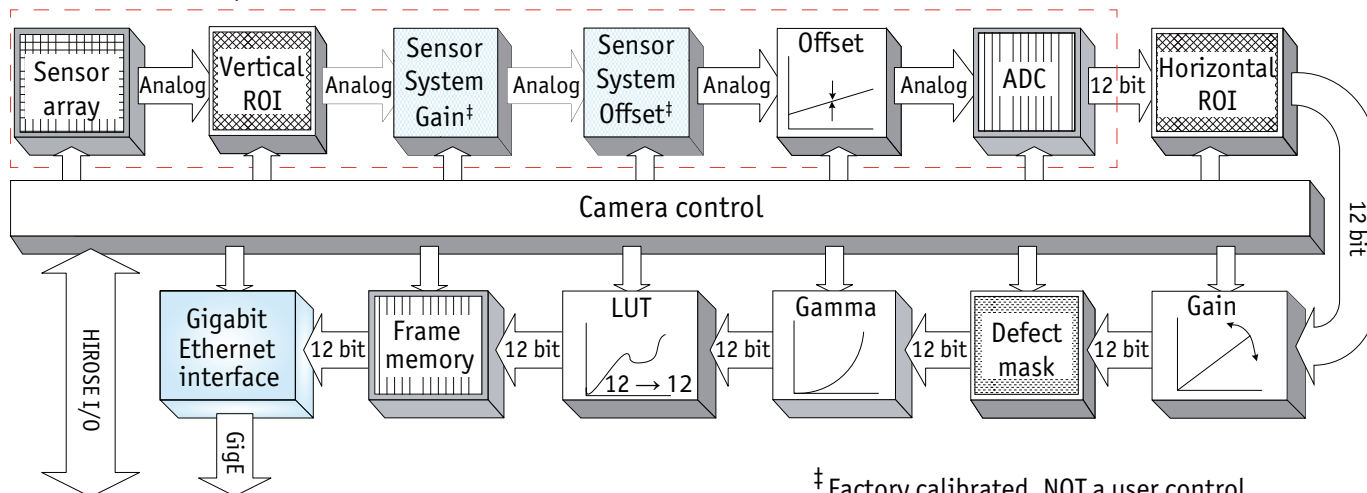


Figure 36: Block diagram of Mako monochrome cameras with CCD sensors

Mako with CMOS sensors

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

Internal sensor components



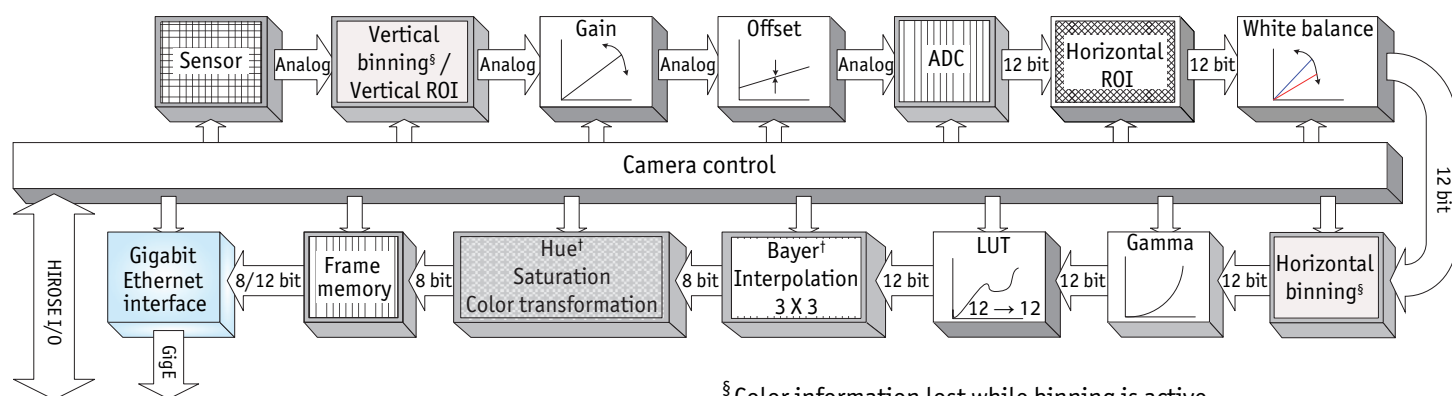
† Factory calibrated. NOT a user control.

Figure 37: Block diagram of Mako monochrome cameras with CMOS sensors

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.

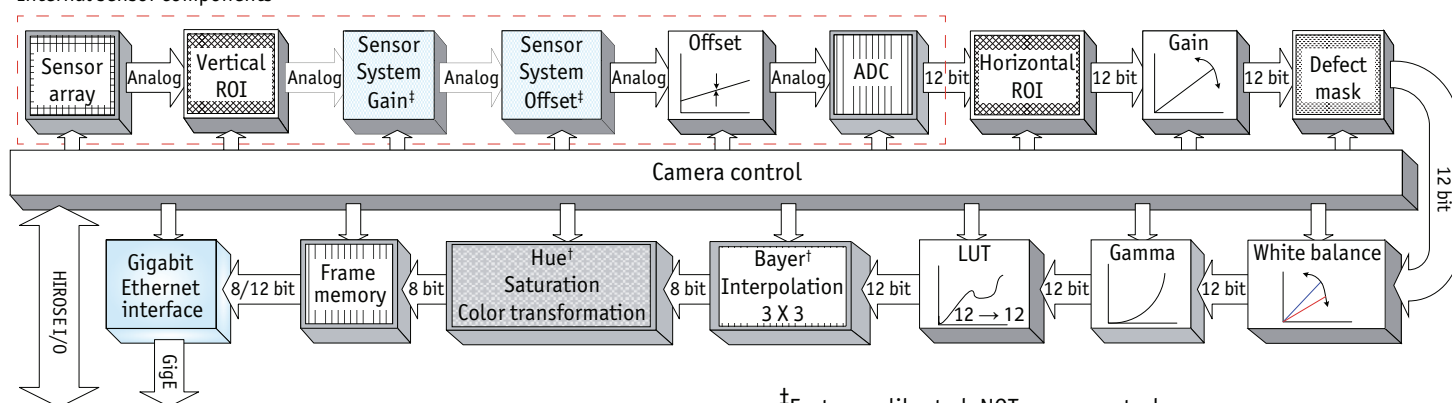
† For on-camera interpolated *PixelFormat*s only—outputs 8 bit.
Raw un-interpolated *PixelFormat*s skip this block—outputs 8/12 bit depending upon the bit depth of *PixelFormat* used.

Figure 38: Block diagram of Mako color cameras with CCD sensors

Mako with CMOS sensors

Mako G-223C, Mako G-419C

Internal sensor components



† Factory calibrated. NOT a user control.

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

Figure 39: Block diagram of Mako color cameras with CMOS sensors

Camera features

This chapter lists the camera and driver features for Mako cameras as displayed with the [AVT Vimba Viewer](#).

www



For a detailed description of all GigE camera and driver controls, refer to the **AVT GigE Camera and Driver Features** document:

http://www.alliedvisiontec.com/fileadmin/content/PDF/Software/Prosilica_software/Prosilica_firmware/AVT_GigE_Camera_and_Driver_Features.pdf

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
Acquisition			
	AcquisitionAbort		
	AcquisitionFrameCount		
	AcquisitionFrameRateAbs		
	AcquisitionFrameRateLimit		
	AcquisitionMode		
		Continuous	
		SingleFrame	
		MultiFrame	
		Recorder	
	AcquisitionStart		
	AcquisitionStop		
	RecorderPreEventCount		
	Trigger		
		TriggerActivation	
			RisingEdge
			FallingEdge
			AnyEdge
			LevelHigh
			LevelLow
		TriggerDelayAbs	
		TriggerMode	
			On
			Off
		TriggerOverlap	
			Off
			PreviousFrame
		TriggerSelector	
			FrameStart
			AcquisitionStart

Table 22: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
			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	
	DefectMask (only G-223/G-419)		
		DefectMaskColumnEnable	
	Exposure		
		ExposureAuto	
			Off
			Once
			Continuous
		ExposureAutoControl	
			ExposureAutoAdjustTol
			ExposureAutoAlg
			ExposureAutoMax
			ExposureAutoMin

Table 22: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
			ExposureAutoOutliers
			ExposureAutoRate
			ExposureAutoTarget
		ExposureMode	
			Timed
			TriggerWidth
		ExposureTimeAbs	
		ExposureTimeIncrement	
	GainControl		
		Gain	
		GainAuto	
			Off
			Once
			Continuous
		GainAutoControl	
			GainAutoAdjustTol
			GainAutoMax
			GainAutoMin
			GainAutoOutliers
			GainAutoRate
			GainAutoTarget
		GainSelector	
	Gamma		
	Hue		
	LUTControl		
		LUTEnable	
		LUTIndex	
		LUTInfo	
			LUTAddress
			LUTBitLengthIn
			LUTBitLengthOut
			LUTSize
		LUTLoadAll	
		LUTMode	
			Luminance
			Red
			Green
			Blue
		LUTSaveAll	
		LUTSelector	
			LUT1
		LUTValue	
	Saturation		

Table 22: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
	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	
		EventExposureEndFrameID	
		EventExposureEndTimestamp	
		EventFrameTriggerFrameID	
		EventFrameTriggerReadyFrameID	
		EventFrameTriggerReadyTimestamp	
		EventLine1FallingEdgeFrameID	
		EventLineFallingEdgeTimestamp	
		EventLineRisingEdgeFrameID	
		EventLineRisingEdgeTimestamp	
		EventOverflowFrameID	
		EventOverflowTimestamp	
	EventID		
		EventAcquisitionEnd	
		EventAcquisitionRecordTrigger	
		EventAcquisitionStart	
		EventError	
		EventExposureEnd	
		EventFrameTrigger	

Table 22: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
		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		
		Persistent Default Gateway	
		Persistent IP Address	
		Persistent Subnet Mask	
	StreamBytesPerSecond		
	StreamFrameRateConstrain		
	StreamHold		
		StreamHoldCapacity	
		StreamHoldEnable	
			Off
			On
	Timestamp		

Table 22: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
		GevTimestampControlLatch	
		GevTimestampControlReset	
		GevTimestampTickFrequency	
		GevTimestampValue	
I0			
	Strobe		
		StrobeDelay	
		StrobeDuration	
		StrobeDurationMode	
			Source
			Controlled
		StrobeSource	
			AcquisitionTriggerReady
			FrameTriggerReady
			FrameTrigger
			Exposing
			FrameReadout
			Acquiring
			LineIn1
	SyncIn		
		SyncInGlitchFilter	
		SyncInLevels	
		SyncInSelector	
			SyncIn1
	SyncOut		
		SyncOutLevels	
		SyncOutPolarity	
			Normal
			Invert
		SyncOutSelector	
			SyncOut1
			SyncOut2
			SyncOut3
		SyncOutSource	
			GPO
			AcquisitionTriggerReady
			FrameTriggerReady
			Exposing
			FrameReadout
			Imaging
			Acquiring
			LineIn1
			Strobe1

Table 22: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
ImageFormat			
	Height		
	HeightMax		
	ImageSize		
	OffsetX		
	OffsetY		
	PixelFormat		
	Width		
	WidthMax		
ImageMode			
	BinningHorizontal (CCD cameras only)		
	BinningVertical (CCD cameras only)		
	SensorHeight		
	SensorWidth		
Info			
	Device MAC address		
	DeviceFirmwareVersion		
	DeviceID		
	DeviceModelName		
	DevicePartNumber		
	DeviceScanType		
	DeviceVendorName		
	FirmwareVerBuild		
	FirmwareVerMajor		
	FirmwareVerMinor		
	SensorBits		
	SensorType		
SavedUserSets			
	UserSetDefaultSelector		
		Default	
		UserSet1	
		UserSet2	
		UserSet3	
	UserSetLoad		
	UserSetSave		
	UserSetSelector		
		Default	
		UserSet1	
		UserSet2	
		UserSet3	
Stream			

Table 22: Available Mako camera and driver features

Hierarchy level 1	Hierarchy level 2	Hierarchy level 3	Hierarchy level 4
	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	
		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 22: 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 23](#) 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-032B/C	64 MB memory: 202 frames	Mono8/Bayer8 Full resolution Payload size of 8192 bytes per packet
Mako G-050B/C	64 MB memory: 130 frames	
Mako G-095B/C	64 MB memory: 69 frames	
Mako G-125B/C	64 MB memory: 52 frames	
Mako G-223B/C	64 MB memory: 29 frames	
Mako G-419B/C	64 MB memory: 15 frames	

Table 23: 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 attribute RegionY = (full sensor height – ROI height)/2.
- BinningY is horizontal row summing on CCD before read-out. 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-032B/C: ROI frame rates

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

Formula 1: **Mako G-032**: theoretical maximum frame rate of CCD

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

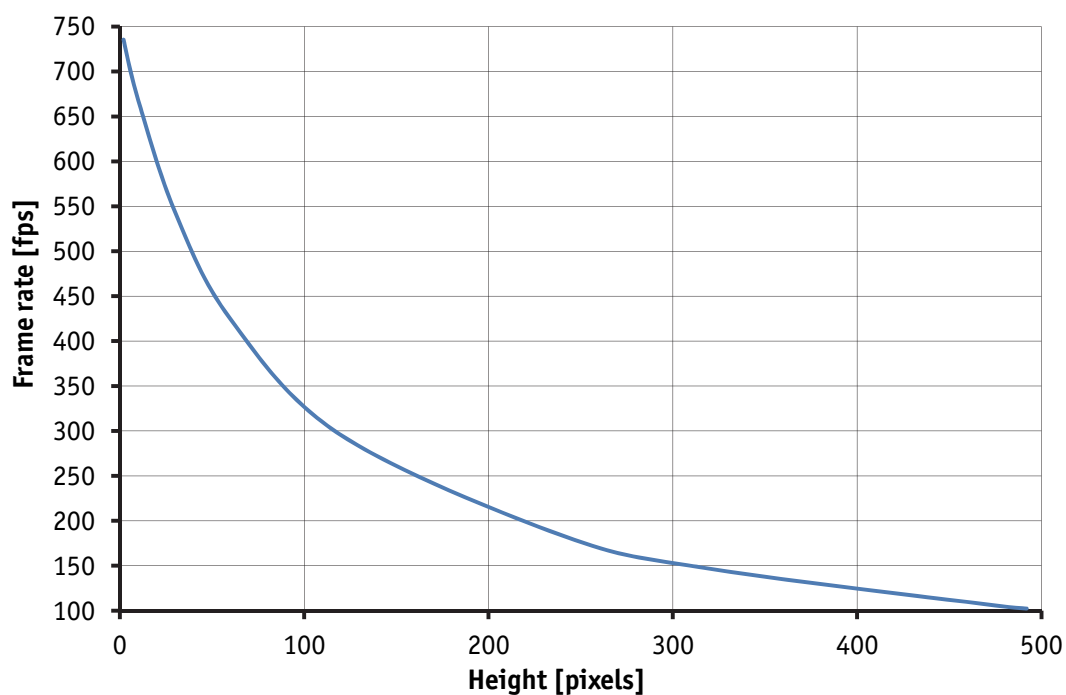


Figure 40: Frame rates **Mako G-032** as function of ROI height [**width=658**]

ROI height	CCD*
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 24: 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

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

Formula 2: **Mako G-050**: theoretical maximum frame rate of CCD

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

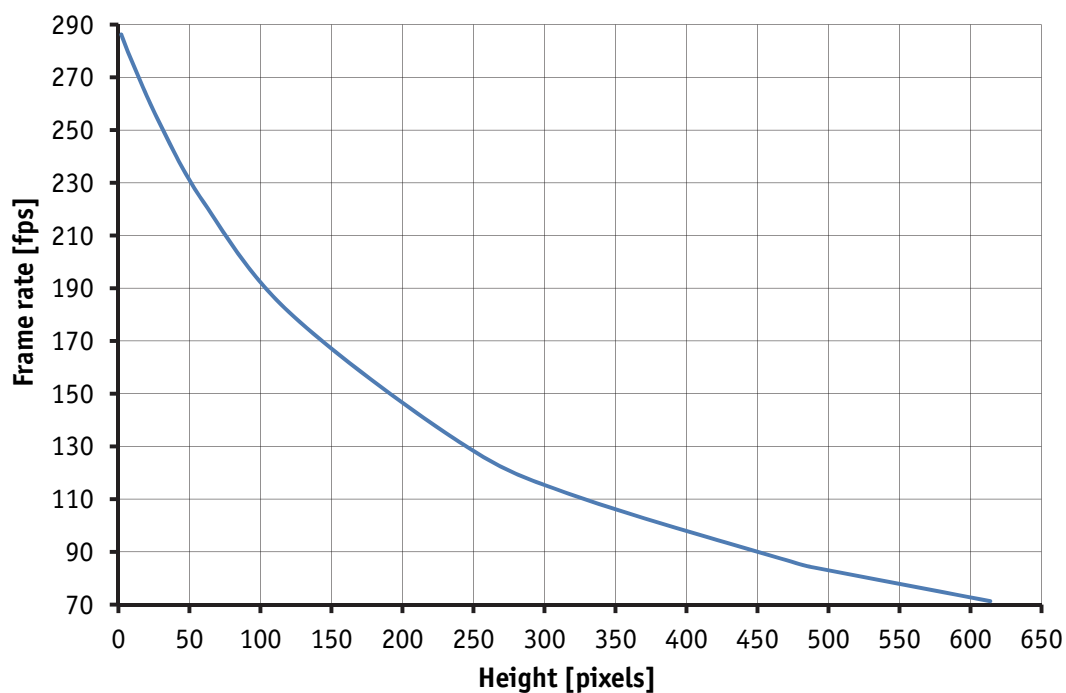


Figure 41: Frame rates **Mako G-050** as function of ROI height [**width=812**]

ROI height	CCD*
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 25: 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

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

Formula 3: **Mako G-095**: theoretical maximum frame rate of CCD

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

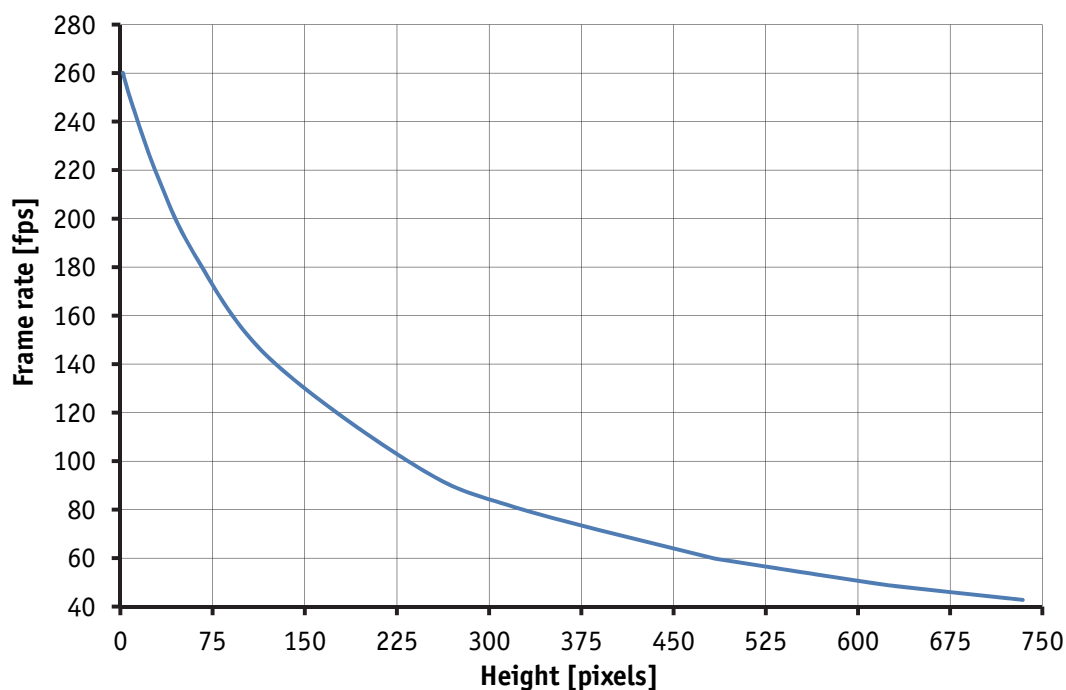


Figure 42: Frame rates **Mako G-095** as function of ROI height [**width=1292**]

ROI height	CCD*
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 26: 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

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

Formula 4: **Mako G-125**: theoretical maximum frame rate of CCD

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

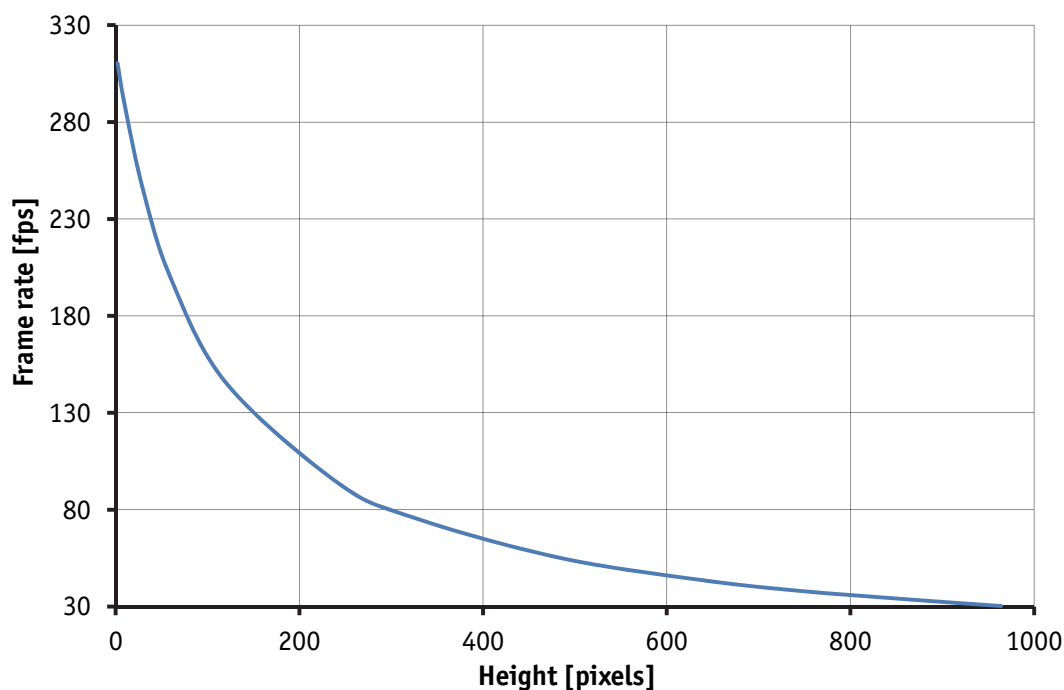


Figure 43: Frame rates **Mako G-125** as function of ROI height [**width=1292**]

ROI height	CCD*
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 27: 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-223B/C: ROI frame rates

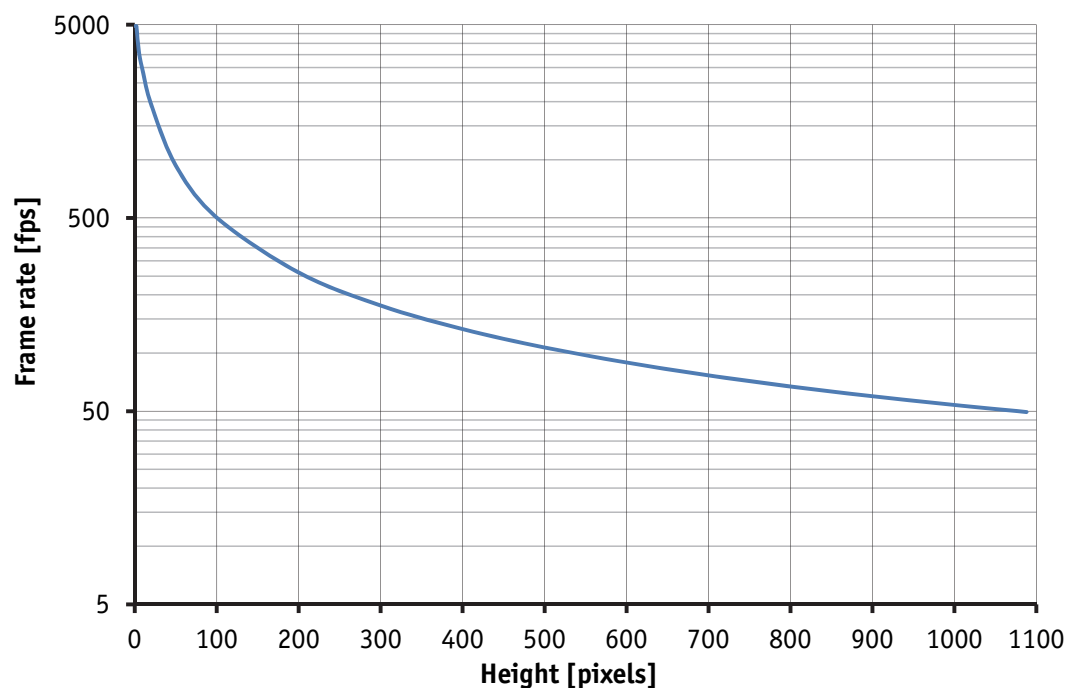


Figure 44: Frame rates **Mako G-223** as function of ROI height

ROI height	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
200	260.8
100	502.1
50	934.6
20	1933.8
10	2847.3
5	3624.5
2	4906.7
1	4926.1

Table 28: Frame rates (fps) of **Mako G-223** as function of ROI height (pixel)

Mako G-419B/C: ROI frame rates

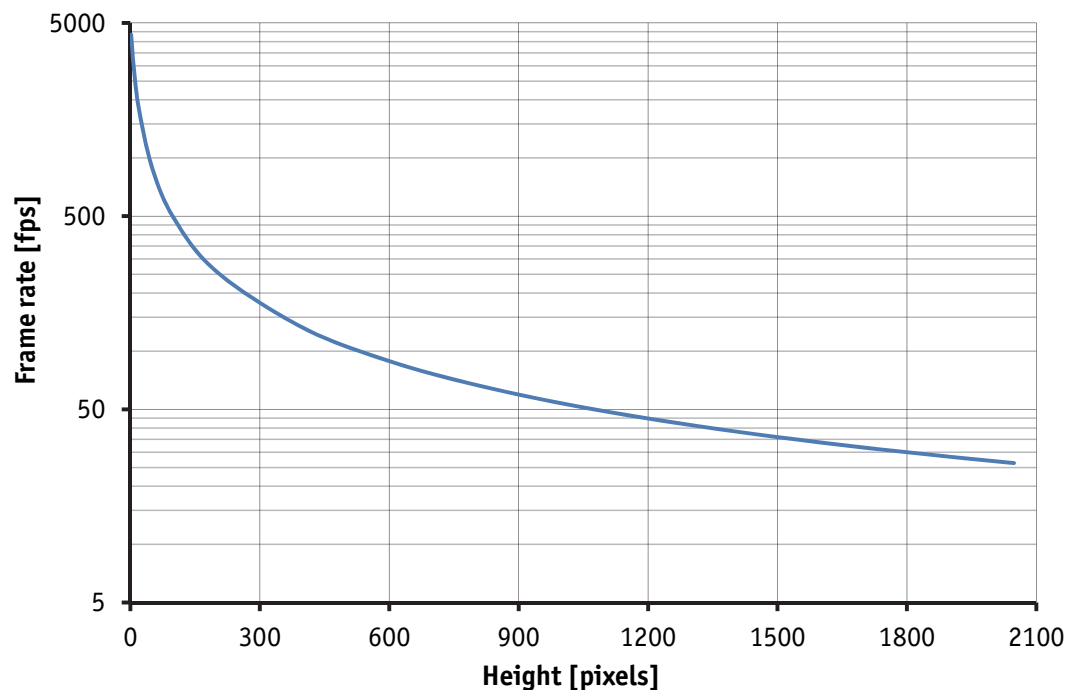


Figure 45: Frame rates **Mako G-419** as function of ROI height

ROI height	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

Table 29: Frame rates (fps) of **Mako G-419** as function of ROI height (pixel)

Appendix

Sensor position accuracy of AVT Mako cameras

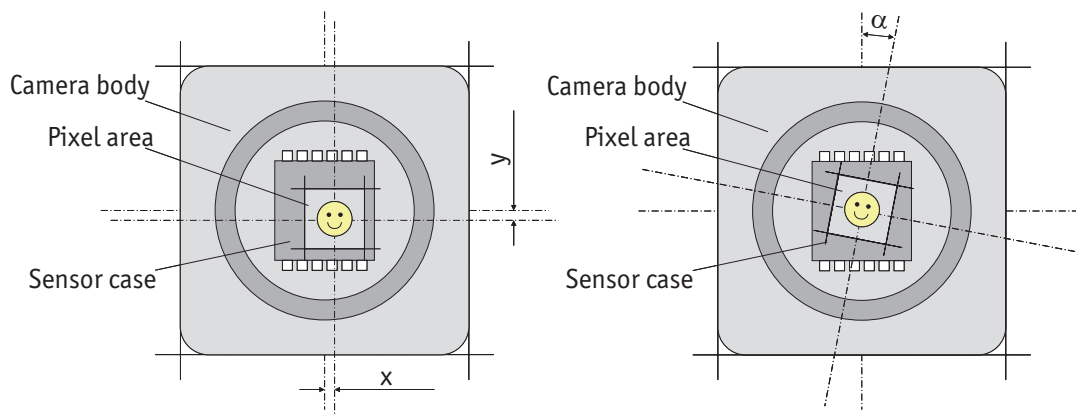


Figure 46: AVT sensor position accuracy

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: $\pm 150 \mu\text{m}$ (sensor shift)

z: $0 \mu\text{m}$ to $-150 \mu\text{m}$ (optical back focal length)

α : $\pm 0.5^\circ$ (sensor rotation)

Note

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



Index

A

acquiring (signal)	44
acquisition stream	44
AcquisitionTriggerReady (signal)	43
AVT sensor position accuracy	65

B

Block diagram	
Mako color cameras with CCD sensors	48
Mako color cameras with CMOS sensors ...	48
Mako mono cameras with CCD sensors	47
Mako mono cameras with CMOS sensors ..	47

C

camera lenses	31
Camera rear view	38
Camera standard housing	37
CE	16
Cleaning instructions	10, 12
Compressed air	13, 14
Cross section	
C-Mount	35
CS-Mount	36

D

declaration of conformity	16
Description of the data path	47
document history	6
duration of sensor exposure	43
Dust-free clean-room	12

E

exposing (signal)	43
exposing (trigger)	46
exposure (definition)	45
exposure cycle (trigger)	46
exposure start delay (signal)	46
exposure time value (trigger)	46
external trigger	43
external trigger at SyncIn1	44

F

FCC Class B	16
focal length	32
frame readout	43
frame trigger	43
FrameReadout (signal)	43
FrameTrigger (signal)	43
FrameTriggerReady (signal)	43

G

GenICam	15
Gigabit Ethernet	15
Gigabit Ethernet interface	15
GigE	15
GigE cameras	
Mako	15
GigE Vision	15
GPO (general purpose output)	43

I

Identifying impurities	11
idle (signal)	46
imaging (signal)	44, 46
Input block diagram	43
inputs	
in detail	43
integrating light (trigger)	45
interline boundary	46
interline time (signal)	46

L

legal notice	2
Locating impurities	11
logic trigger	43
logic trigger (definition)	45

M

Mako GigE cameras	15
Minimum pulse width	40

O

Output block diagram	44
Output signals	43
Output switching times	42
outputs	43
OutVCC	41

P

PoE	39
propagation delay (trigger)	45

R

reading out data (trigger)	46
readout (definition)	45
readout data (trigger)	45
registered exposure time (signal)	46
RoHS (2002/95/EC)	16

S

sensor row readout cycles	46
software trigger	43
specifications	17
Spectral sensitivity	
Mako G-032B	19
Mako G-032C	19
Mako G-050B	21
Mako G-050C	21
Mako G-095B	23
Mako G-095C	23
Mako G-125B	25
Mako G-125C	25
Mako G-223B (NIR)	27
Mako G-223C	27
Mako G-419B (NIR)	29
Mako G-419C	29
spectral transmission	
IR cut filter	31
type Hoya C5000	31
start acquisition	43
Strobe1 (signal)	44
styles	8
symbols	8
SyncIn1 (signal)	44
SyncOutGpoLevels	43
system components	31

T

time delay (trigger)	46
timing diagram	
trigger	45
Tpd (definition)	45
trigger	
timing diagram	45
trigger definitions	45
trigger jitter (definition)	46
trigger latency (definition)	46
trigger latency time	46
trigger ready (signal)	46
trigger rules	46
Tripod dimensions	34
types	
Mako GigE cameras	15

U

user trigger (definition)	45
---------------------------------	----

W

Warranty	10
Warranty precautions	10