Allied Vision

USB3 Vision Cameras

Mako U

Technical Manual

V1.0.0

Mako U at a glance

Read this manual carefully

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

Applied standards

Download applied common standards

For SFNC, PFNC, GenTL, see *http://GenICam.org*.

For USB3 Vision, see *http://www.visiononline.org*.

Mako U cameras have a USB 3.0 interface. They are USB3 Vision V1.0.1 compliant.

GenICam™

GenICam™ is the programming interface for the USB3 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.

Mako U cameras comply with:

- GenICam™ Standard Features Naming Convention (SFNC) V2.2
- GenICam™ Generic Control Protocol V1.0 (GenCP)
- GenICam™ Pixel Format Naming Convention V2.0 (PFNC).

GenICam™ GenTL

The GenICam™ GenTL provides generic communication of devices to a system, including streaming data independent from the underlying transport technology. The GenICam™ GenTL can be used by any third-party software that is standard compliant.

AIA Pixel Format Naming Convention

The AIA Pixel Format Naming Convention (PFNC) defines a generic convention to name the pixel formats used in machine vision.

USB 3.0

USB 3.0 is the third version of an industry standard that defines the cables, connectors, and communications protocols between computers and electronic devices. USB 3.0 adds “SuperSpeed” transfer mode that can transfer data at up to 5 Gbit/s and uses different connectors than USB 2.0.

USB3 Vision

USB3 Vision standard for cameras and imaging products is based on USB 3.0 standard, using USB 3.0 ports. It provides control over compliant devices by GenICam™ Applications programming interface (API). USB3 Vision standard is administered by the Automated Imaging Association (AIA).

Delivery contents

Your Mako U delivery consists of the following items:

- Shipping box
- Mako U camera
- *USB3 Vision Cameras Quickstart Guide*.

Micro-B USB 3.0 cable not included

You need a Micro-B USB 3.0 cable to connect your Mako U camera to a host adapter.

- For USB 3.0 accessories, see *USB 3.0 cards, hubs, and cables* on page 53.
- For ordering USB 3.0 accessories, see *https://www.alliedvision.com/en/meta-header/contact/contact-sales*.

Notice

Avoid damage to the camera by excessive heat

Operating the camera beyond the allowed maximum temperature can damage the camera.

- For operation, keep the housing temperature between +5 °C and +45 °C (see *Specifications* on page 20).
- Follow the instructions described in *Providing optimum heat dissipation* on page 58.

What else do you need?

The following downloads provide additional information and software.

Document	Web link
USB3 Vision Cameras Quickstart Guide USB Features Reference	*https://www.alliedvision.com/en/support/technical-documentation*, at **Additional Documents** for the Mako U camera.
USB Triggering Concept	*https://www.alliedvision.com/en/support/technical-papers-knowledge-base*
Software	**Web link**
Vimba, including **Vimba Viewer** and **Vimba Driver Installer** for Windows®	*https://www.alliedvision.com/software*

Table 1: *Mako U -> Additional downloads overview*

Contact us

Connect with Allied Vision by function

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

Find an Allied Vision office or distributor

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

Email

info@alliedvision.com
support@alliedvision.com

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EMEA: +49 36428-677-0
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Contents

Document history and conventions

This chapter includes:

Document history

Version	Date	Remarks
V.1.0.0	13 November 2015	New manual: Release status

Table 2: *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
Emphasis	Programs, or highlighting important things	**Emphasis**
Publication title	Publication titles	*Title*
Cross reference	Links inside this document	*Link*
Web reference	Links to web pages	*Link*
Output	Outputs from software GUI	**`Output`**
Input	Input commands, modes	*`Input`*
Feature	Feature names	`Feature`

Table 3: *Styles*

Symbols and notes

Caution

Warning to prevent personal injuries

Notice

Avoid electrostatic discharge

Note to prevent material damage by electrostatic discharge (ESD)

Notice

Avoid material damage

Practical Tip

Safety-related instructions to avoid malfunctions

Instructions to avoid malfunctions

Further information available online

Safety and legislation

This chapter includes:

General safety notes

Notice

Avoid damage to the camera by electrostatic discharge (ESD)

Inadequate protection of the camera from ESD can damage the camera or interfere with camera functions.

Notice

Avoid damage to the camera, PC, or peripherals by ground loops

Unsuitable connection can lead to a short circuit between USB GND and GPIO GND caused by ground loops destroying the camera and connected devices.

- All wiring must be done by authorized personnel, according to the corresponding technical standards.
- Connect the camera according to your environmental grounding concept. See *Ground loops* on page 69.

Notice

Avoid damage to the camera by exceeding the allowed temperature range

Operation outside the allowed temperature range can damage the camera.

- For operation, keep the housing temperature between +5 °C and +45 °C.
- Follow the instructions described in *Providing optimum heat dissipation* on page 58.

Notice

Avoid damage to the camera by high output current or voltage

Connecting the camera to a device that exceeds the allowed maximum current or voltage can damage the camera.

- Max. current = 25 mA per output
- Max. Out VCC = 24 VDC

Notice

Avoid damage to the camera by high input voltage

Exceeding maximum input voltage can damage the camera.

- Keep maximum input voltage below 30 VDC.

European Economic Area (EEA) requirements

CE

Allied Vision declares under its sole responsibility that all cameras of the Mako U family are in conformity with the following standard(s) or other normative document(s):

- CE, following the provisions of 2014/30/EU
- RoHS (2011/65/EU)

WEEE

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

IP class

Equipped with a lens as intended, the Mako U camera complies with IP3X class according to IEC standard 60529.

FCC - Class B Device

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 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 referenced in this manual must be used with this equipment 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 customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Allied Vision for any damages resulting from such improper use or sale.

Other legal notices

Appliance classification

The camera family described in this manual is intended for commercial use only, without audio recording, without internal storage facility.

Target audience

This technical documentation intends to enable users operate the Mako U camera reliably and safely. For basic operation, expert knowledge is not required.

In addition, this documentation intends to provide detailed information to enable demanding applications requiring maximum performance.

Intended use

- The Mako U camera family is intended for commercial use.
- The Mako U camera family is no protective gear.
- The Mako U camera family must be operated with lens mounted.
- Liability covers only the camera and the software created by Allied Vision. This manual includes references to software and accessories that have been tested by Allied Vision and fulfill Allied Vision‘s high quality requirements. However, Allied Vision is not liable for any damage caused by third-party software and/or third-party accessories.
- Allied Vision cannot grant any liability if the user does not adhere to the installation instructions in *Installing the camera* on page 57.
- Allied Vision cannot grant any liability if the user does not adhere to the safety advice in this technical manual.
- For any questions concerning camera operation that are not covered by this technical manual, contact Allied Vision support or your Allied Vision distributor.
- No part of the camera can be repaired by the user. Contact your Allied Vision distributor for any repair or maintenance work.
- The camera must not be opened without prior written consent of Allied Vision. Tampering with the camera terminates the warranty immediately.

Trademarks

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

Warranty

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

Copyright

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Specifications

This chapter includes:

Notes on specifications

Additional information

- For an overview of the corresponding documents and downloads, see *Mako U at a glance* on page 2.
- For full functionality of the Mako U camera, see *Installing the camera* on page 57.
- For USB 3.0 cards, hubs, and cables, see *Accessories* on page 52.

Power consumption

Values are given for “typical” operation, with the camera running full frame rate at full resolution.

Frame memory

Normally, an image is captured and transported in consecutive steps. The image is taken, read out from the sensor, digitized and sent over the USB 3.0 interface.

Mako U cameras are equipped with RAM. The number of frames that can be stored in this RAM depends on resolution and pixel format. The stated number of frames is typical for full resolution and Mono8.

The memory operates according to the FIFO (first in, first out) principle. This makes addressing for individual images unnecessary.

UserData memory

The Mako U camera has a data memory used to store individual UserData. UserSets, Correction data and firmware are not stored in the UserData memory.

Writing data to the UserData memory

1. Copy previous data from the UserData memory for recovery.
2. Delete previous data from the UserData memory.
3. Write new data to the UserData memory.

Fixed frame rate control

The maximum frame rate which can be selected depends on various values, such as available bandwidth, pixel format, exposure time, and Region of interest (ROI).

Trigger latency

Trigger latency is the camera specific delay between an incoming trigger and, for example, ExposureStart. Trigger latency depends on the input type.

Trigger latency with the opto-isolated input

The opto-isolated input has a higher trigger latency than the GPIOs as TTL input.

- Consider camera aging. Specification values are typical for a new camera.
- Trigger on the rising edge to reduce trigger latency. Triggering on the falling edge doubles trigger latency.

ExposureModes

Mako U-503 cameras support `ExposureMode = Timed`.
Mako U-029 / 051 / 130 models support `Timed` and `TriggerWidth`.

Controlling exposure time using TriggerWidth

For Mako U-029 / 051 / 130 cameras, to control exposure time by `TriggerWidth`, set `TriggerActivation` to `LevelHigh` or `LevelLow`.

ROI frame rates

Calculation of Region of interest (ROI) frame rates for Mako U cameras does not allow to give a formula. Data was determined for Mono8 at shortest exposure time. Bandwidth can limit the available maximum.

USB hardware and bandwidth

Currently, USB hardware often limits the available bandwidth.
See *USB 3.0 cards, hubs, and cables* on page 53.

For maximum bandwidth, connect each camera to a separate bus. For more information, read *Optimizing performance* on page 112.

ROI position, height and width settings affecting the frame rate

- **Offset: Moving ROI** out of the center does not change available frame rates.
- **Swapping Height and Width settings** affects frame rates significantly. When `Width` is used for the longer side of the ROI, available frame rates reach the maximum. When `Height` is used for the longer side of the ROI, available frame rates are lower.

M12-Mount adapter

Description of the M12-Mount adapter

The M12-Mount adapter enables the use of M12-Mount lenses with a CS-Mount camera. The adapter is an optional accessory described in the *Modular Concept.* *https://www.alliedvision.com/en/support/technical-documentation*, at **Additional Documents** for the Mako U camera.

Maximum protrusion (see *Lens mounts* on page 40) with the M12-Mount adapter is different for the particular lenses. *Table 4* shows safe values with/out filter. Ask *support@alliedvision.com* for exact protrusion values for your camera.

Filter	Maximum protrusion
Without IR cut filter	16.1 mm
16 mm IR cut filter	8.3 mm
22 mm IR cut filter	8.8 mm

Table 4: *Maximum protrusion with M12-Mount adapter*

Mako U-029B/051B/130B characteristics

Black Level Compensation for Python sensor cameras

Python sensors have a typical black level value drift that depends on `DeviceTemperature` (measured at the mainboard) and `ExposureTime`. The **Black Level Compensation** for Mako U-029 / 051 / 130 models adjusts this effect as shown in the following table.

Temperature [°C]	ExposureTime [ms]							
	1	10	50	100	250	500	750	1,000
35								
40								
45								
50								
55								
60								
65								
70								
75								

Table 5: *Black Level Compensation for Python sensor cameras*

Legend

	Full compensation
	Basic compensation

Should additional compensation be needed, we recommend to:

- Cool the camera
- Reduce `ExposureTime`.

Mako U-029B specifications

Camera characteristics

See *Mako U-029B/051B/130B characteristics* on page 24.

Feature	Specification
Sensor	
Sensor details	1/4” (diag. 3.8 mm) progressive scan CMOS OnSemi PYTHON 300, global shutter
Effective chip size	3.04 x 2.28 mm
Cell size	4.8 x 4.8 µm
Resolution (H x V)	640 x 480
ADC	10 bit
Pixel formats	Mono8, Mono10p
Camera controls	
Frame rate	Up to 550 fps @ full resolution, Mono8
AcquisitionFrameRate	1 frame per hour to 550 fps (increments equal sensor cycle time)
Exposure time	44.2 µs to 1.4 s
Gain control	0 to 20 dB (0.1 dB/increment)
Frame memory	128 MByte, up to 436 frames @ full resolution, Mono8
UserData memory	1 MByte
Trigger ExposureModes	Timed, TriggerWidth
Trigger latency	25 to 38 µs (TTL GPIOs as input) 27 to 41 µs (opto-isolated input, new camera, triggered on the rising edge)
TriggerDelay	0 to 59.6 s (0.013 µs/increment)
Interfaces	
I/Os	1 opto-isolated input, 1 opto-isolated output
GPIOs	2 programmable GPIOs As direct inputs: 0–0.8 VDC (low) / 2–24 VDC (high) As open collector outputs: 3.3–24 VDC @ 25 mA
Digital interface	Micro-B USB 3.0 interface
Mechanics	
Dimensions (L x W x H)	49.5 x 29 x 29 mm, including connectors, without tripod and lens
Mass	60 g (without lens)
Lens mount	For details, see *Lens mounts*. C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi), max. protrusion: 9.7 mm CS-Mount: 12.526 mm (in air); Ø 25.4 mm (32 tpi), max. protrusion: 4.7 mm M12-Mount: see *M12-Mount adapter* on page 23.
Conditions for operation and storage	
Power requirements	Power over USB 3.0
Power consumption	Typical 2.7 W @ 5 VDC, maximum frame rate, full resolution, 20 °C
Operating temperature	+5 °C to +45 °C housing temperature (without condensation)
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)
Standards and regulations	
	CE, FCC Class B, RoHS (2011/65/EU), IP3X (with lens mounted), GenICam™ SFNC V2.2, GenICam™ GenCP V1.0, GenICam™ PFNC V2.0, USB3 Vision V.1.0.1

Table 6: *Specifications Mako U-029B*

Mako U-029B spectral sensitivity

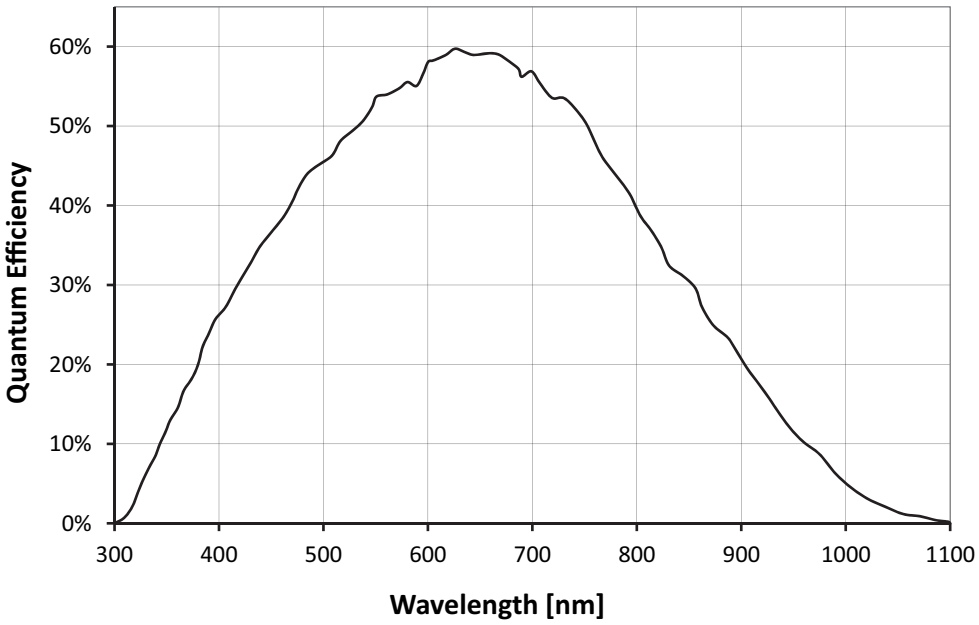


Figure 1: *Spectral sensitivity of Mako U-029B*

Mako U-029B ROI frame rates

This section charts the resulting frame rates from changing image heights and widths.

Available maximum frame rates

For this sensor, maximum frame rates are limited by minimal exposure times.

Width	Height	ROI area	Frame rate
640	480	307,200	550
640	32	20,480	3,097
640	16	10,240	3,710
640	8	5,120	4,118
320	240	76,800	1,350
16	2	32	4,971

Table 7: *Frame rates for different ROIs with Mako U-029*

Mako U-051B specifications

Camera characteristics

See *Mako U-029B/051B/130B characteristics* on page 24.

Feature	Specification
Sensor	
Sensor details	1/3.6” (diag. 4.8 mm) progressive scan CMOS OnSemi PYTHON 500, global shutter
Effective chip size	3.84 x 2.88 mm
Cell size	4.8 x 4.8 µm
Resolution (H x V)	800 x 600
ADC	10 bit
Pixel formats	Mono8, Mono10p
Camera controls	
Frame rate	Up to 391 fps @ full resolution, Mono8
AcquisitionFrameRate	1 frame per hour to 391 fps (increments equal sensor cycle time)
Exposure time	44.2 µs to 1.4 s
Gain control	0 to 20 dB (0.1 dB/increment)
Frame memory	128 MByte, up to 279 frames @ full resolution, Mono8
UserData memory	1 MByte
Trigger ExposureModes	Timed, TriggerWidth
Trigger latency	25 to 38 µs (TTL GPIOs as input) 27 to 41 µs (opto-isolated input, new camera, triggered on the rising edge)
TriggerDelay	0 to 59.6 s (0.013 µs/increment)
Interfaces	
I/Os	1 opto-isolated input, 1 opto-isolated output
GPIOs	2 programmable GPIOs As direct inputs: 0–0.8 VDC (low) / 2–24 VDC (high) As open collector outputs: 3.3–24 VDC @ 25 mA
Digital interface	Micro-B USB 3.0 interface
Mechanics	
Dimensions (L x W x H)	49.5 x 29 x 29 mm, including connectors, without tripod and lens
Mass	60 g (without lens)
Lens mount	For details, see *Lens mounts*. C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi), max. protrusion: 9.7 mm CS-Mount: 12.526 mm (in air); Ø 25.4 mm (32 tpi), max. protrusion: 4.7 mm M12-Mount: see *M12-Mount adapter* on page 23.
Conditions for operation and storage	
Power requirements	Power over USB 3.0
Power consumption	Typical 2.7 W @ 5 VDC, maximum frame rate, full resolution, 20 °C
Operating temperature	+5 °C to +45 °C housing temperature (without condensation)
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)
Standards and regulations	
	CE, FCC Class B, RoHS (2011/65/EU), IP3X (with lens mounted), GenICam™ SFNC V2.2, GenICam™ GenCP V1.0, GenICam™ PFNC V2.0, USB3 Vision V.1.0.1

Table 8: *Specifications Mako U-051B*

Mako U-051B spectral sensitivity

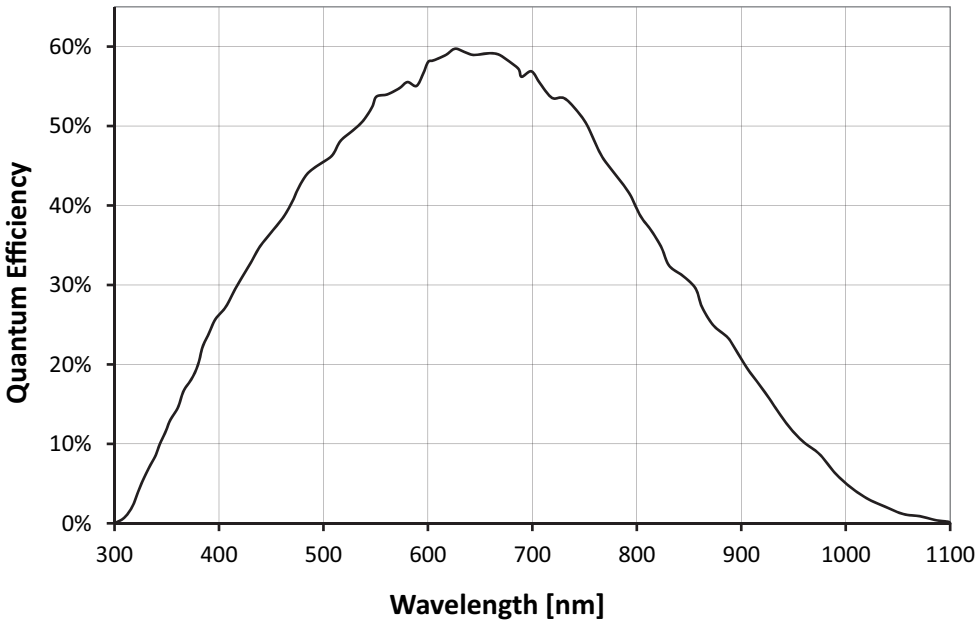


Figure 2: *Spectral sensitivity of Mako U-051B*

Mako U-051B ROI frame rates

This section charts the resulting frame rates from changing image heights and widths.

Available maximum frame rates

For this sensor, maximum frame rates are limited by minimal exposure times.

Width	Height	ROI area	Frame rate
800	600	480,000	391
800	32	25,600	2,898
800	16	12,800	3,535
800	8	6,400	3,973
640	480	307,200	550
640	32	20,480	3,097
640	16	10,240	3,710
640	8	5,120	4,118
320	240	76,800	1,350
16	2	32	4,971

Table 9: *Frame rates for different ROIs with Mako U-051*

Mako U-130B specifications

Camera characteristics

See *Mako U-029B/051B/130B characteristics* on page 24.

Feature	Specification
Sensor	
Sensor details	1/2” (diag. 7.9 mm) progressive scan CMOS OnSemi PYTHON 1300, global shutter
Effective chip size	6.32 x 4.74 mm
Cell size	4.8 x 4.8 µm
Resolution (H x V)	1280 x 1024
ADC	10bit
Pixel formats	Mono8, Mono10p
Camera controls	
Frame rate	Up to 168 fps @ full resolution, Mono8
AcquisitionFrameRate	1 frame per hour to 168 fps (increments equal sensor cycle time)
Exposure time	44.2 µs to 1.4 s
Gain control	0 to 20 dB (0.1 dB/increment)
Frame memory	128 MByte, up to 102 frames @ full resolution, Mono8
UserData memory	1 MByte
Trigger ExposureModes	Timed, TriggerWidth
Trigger latency	25 to 38 µs (TTL GPIOs as input) 27 to 41 µs (opto-isolated input, new camera, triggered on the rising edge)
TriggerDelay	0 to 59.6 s (0.013 µs/increment)
Interfaces	
I/Os	1 opto-isolated input, 1 opto-isolated output
GPIOs	2 programmable GPIOs As direct inputs: 0–0.8 VDC (low) / 2–24 VDC (high) As open collector outputs: 3.3–24 VDC @ 25 mA
Digital interface	Micro-B USB 3.0 interface
Mechanics	
Dimensions (L x W x H)	49.5 x 29 x 29 mm, including connectors, without tripod and lens
Mass	60 g (without lens)
Lens mount	For details, see *Lens mounts*. C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi), max. protrusion: 9.7 mm CS-Mount: 12.526 mm (in air); Ø 25.4 mm (32 tpi), max. protrusion: 4.7 mm M12-Mount: see *M12-Mount adapter* on page 23.
Conditions for operation and storage	
Power requirements	Power over USB 3.0
Power consumption	Typical 2.7 W @ 5 VDC, maximum frame rate, full resolution, 20 °C
Operating temperature	+5 °C to +45 °C housing temperature (without condensation)
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)
Standards and regulations	
	CE, FCC Class B, RoHS (2011/65/EU), IP3X (with lens mounted), GenICam™ SFNC V2.2, GenICam™ GenCP V1.0, GenICam™ PFNC V2.0, USB3 Vision V.1.0.1

Table 10: *Specifications Mako U-130B*

Mako U-130B spectral sensitivity

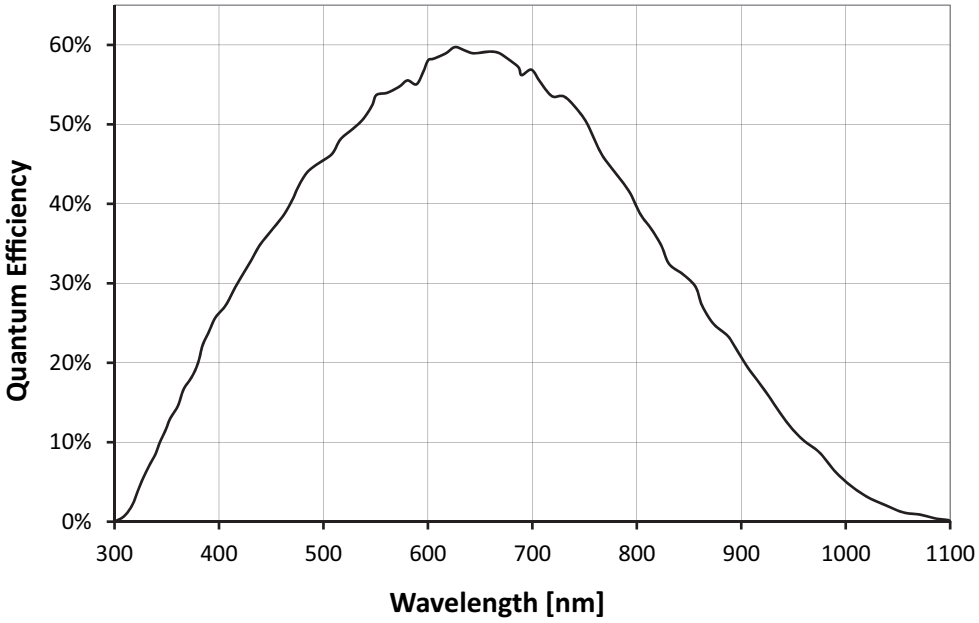


Figure 3: *Spectral sensitivity of Mako U-130B*

Mako U-130B ROI frame rates

This section charts the resulting frame rates from changing image heights and widths.

Available maximum frame rates

For this sensor, maximum frame rates are limited by minimal exposure times.

Width	Height	ROI area	Frame rate
1,280	1,024	1,310,720	168
1,280	960	1,228,800	179
1,280	32	40,960	2,428
1,280	16	20,480	3,097
1,280	8	10,240	3,592
1,024	768	786,432	262
800	600	480,000	391
800	32	25,600	2,898
800	16	12,800	3,535
800	8	6,400	3,973
640	480	307,200	550
640	32	20,480	3,097
640	16	10,240	3,710
640	8	5,120	4,118
320	240	76,800	1,350
16	2	32	4,971

Table 11: *Frame rates for different ROIs with Mako U-130*

Mako U-503B characteristics

Mako U-503 is equipped with an Aptina MT9P031 sensor determining certain camera abilities. This section is about Mako U-503 characteristics:

ExposureModes for triggering

USB3 Vision features provide *TriggerWidth* as ExposureMode to control exposure by the trigger duration. Mako U-503 does not support *TriggerWidth*.

Alternatively, use ExposureMode = *Timed*.

Information about USB triggering

For more information, see the *USB Triggering Concept* at *https://www.alliedvision.com/en/support/technical-papers-knowledge-base*

Rolling shutter

Sensors have either global or rolling shutter, depending on the readout.

The Mako U-503 camera has a rolling shutter. *Figure 4* shows the rolling shutter effect: Sensor lines (left) are integrated sequentially, the image (right) of a rotating fan appears distorted.

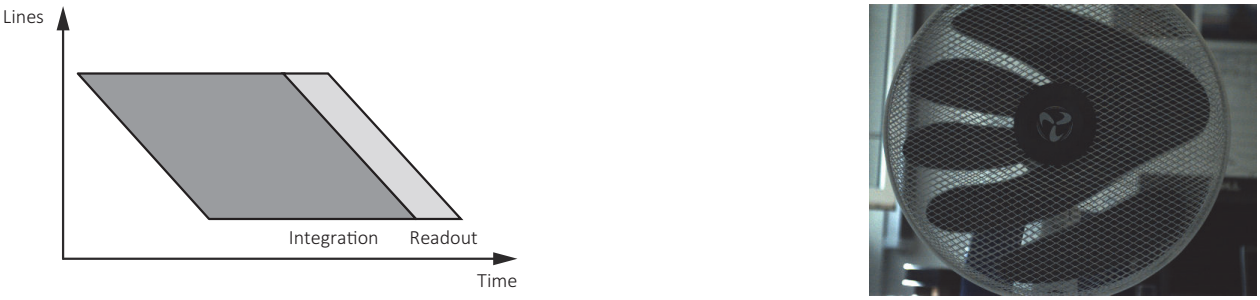


Figure 4: *Rolling shutter effect with Mako U-503*

Mako U-029 / 051 / 130 models have global shutter. *Figure 5* shows the global shutter: All sensor lines (left) are integrated simultaneously, the image (right) of a rotating fan appears natural.

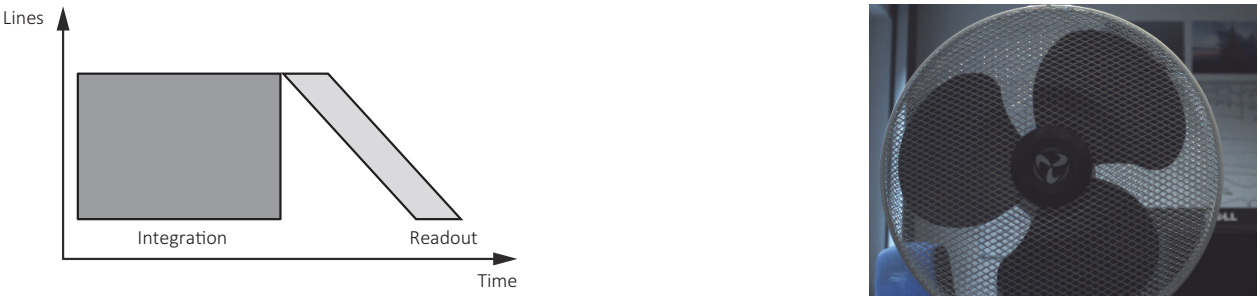


Figure 5: *Global shutter effect with Mako U-029 / 051 / 130*

Avoiding the rolling shutter effect with the Mako U-503 camera: *Figure 6* shows how the rolling shutter effect can be avoided. With a strobe light fired while all sensor lines (left) are integrating, the image (right) of a rotating fan appears natural.

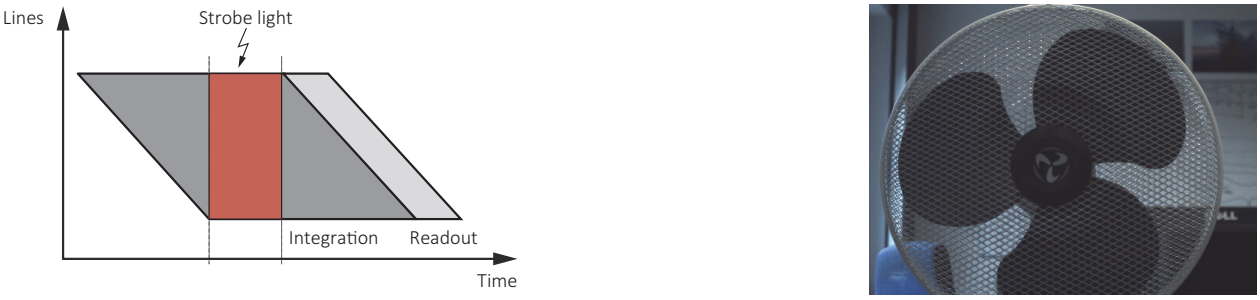


Figure 6: *Avoiding the rolling shutter effect with Mako U-503*

Gain

The Aptina MT9P031 sensor provides analog gain for the following increments only:

- 2.5 dB
- 3.2 dB
- 5.0 dB
- 14.9 dB

You can set gain for the Mako U-503 camera in 0.1 dB increments. To set increments in-between the analog increments listed above, the digital gain is used. In this case, image brightness is not transferred into fully proportional gray levels. Displayed in a histogram, the camera image signal shows this effect: while the curve for the image with analog gain is continuous, the curve for the image with digital gain is discontinuous.

Reconfiguration delay

Generally, some parameters can be changed during exposure without affecting the timing. Changing the following parameters during exposure leads to a delay:

- `BlackLevel`
- `ExposureTime`
- `Gain`
- `OffsetX`
- `OffsetY`

When any of these parameters is entered, the next frame starts only after readout and sensor reconfiguration delay are finished. The reconfiguration delay is typically 0 to 1200 µs, depending on the individual parameters change. Please, consider this delay for your application.

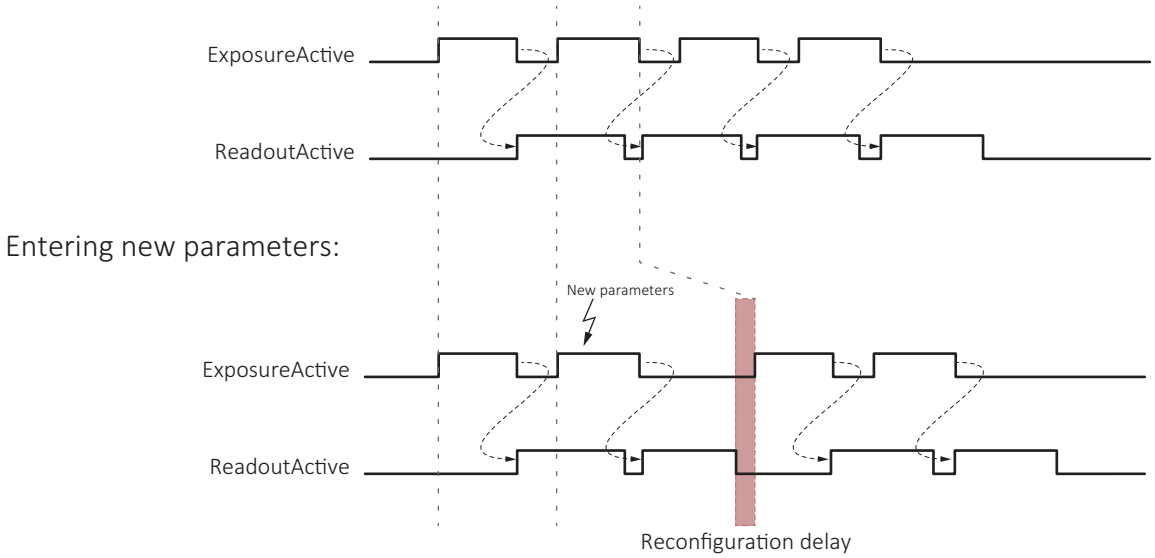


Figure 7: *Delayed exposure due to parameters change -> Mako U-503B*

Mako U-503B specifications

Camera characteristics

See *Mechanical dimensions* on page 38.

Feature	Specification
Sensor	
Sensor details	1/2.5” (diag. 7.13 mm) progressive scan CMOS Aptina MT9P031, rolling shutter
Effective chip size	5.7 x 4.28 mm
Cell size	2.2 x 2.2 µm
Resolution (H x V)	2592 x 1944
ADC	12 bit
Pixel formats	Mono8, Mono12, Mono12p
Camera controls	
Frame rate	Up to 14 fps @ full resolution, Mono8
AcquisitionFrameRate	1 frame per hour to 14 fps (increments equal sensor cycle time)
Exposure time	32 µs to 1.4 s
Gain control	0 to 17 dB (0.1 dB/increment)
Frame memory	128 MByte, up to 26 frames @ full resolution, Mono8
UserData memory	1 MByte
Trigger ExposureModes	Timed
Trigger latency	0 to 29 µs (TTL GPIOs as input) 2 to 32 µs (opto-isolated input, new camera, triggered on the rising edge) See *Mechanical dimensions* on page 38.
TriggerDelay	0 to 143 s in 0.033 µs increments
Interfaces	
I/Os	1 opto-isolated input, 1 opto-isolated output
GPIOs	2 programmable GPIOs As direct inputs: 0–0.8 VDC (low) / 2–24 VDC (high) As open collector outputs: 3.3–24 VDC @ 25 mA
Digital interface	Micro-B USB 3.0 interface
Mechanics	
Dimensions (L x W x H)	49.5 x 29 x 29 mm, including connectors, without tripod and lens
Mass	60 g (without lens)
Lens mount	For details, see *Lens mounts*. C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi), max. protrusion: 9.7 mm CS-Mount: 12.526 mm (in air); Ø 25.4 mm (32 tpi), max. protrusion: 4.7 mm M12-Mount: see *M12-Mount adapter* on page 23.
Conditions for operation and storage	
Power requirements	Power over USB 3.0
Power consumption	Typical 1.9 W @ 5 VDC, maximum frame rate, full resolution, 20 °C
Operating temperature	+5 °C to +45 °C housing temperature (without condensation)
Storage temperature	-10 °C to +70 °C ambient temperature (without condensation)
Standards and regulations	
	CE, FCC Class B, RoHS (2011/65/EU), IP3X (with lens mounted), GenICam™ SFNC V2.2, GenICam™ GenCP V1.0, GenICam™ PFNC V2.0, USB3 Vision V.1.0.1

Table 12: *Specifications Mako U-503B*

Mako U-503B spectral sensitivity

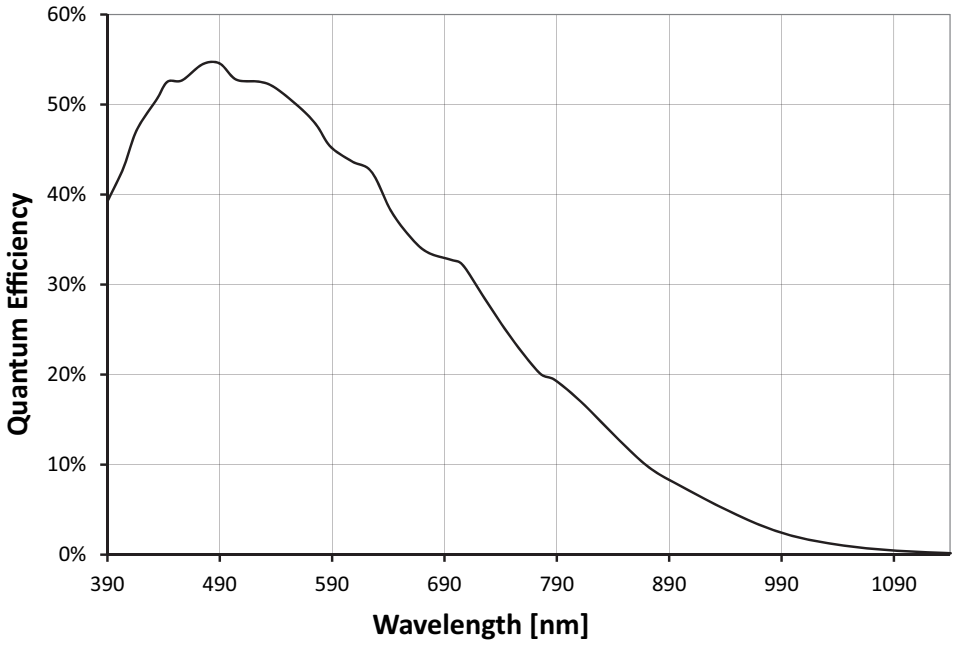


Figure 8: *Spectral sensitivity of Mako U-503B*

Mako U-503B ROI frame rates

This section charts the resulting frame rates from changing image heights and widths.

Width	Height	ROI area	Frame rate
2,592	1,944	5,038,848	14
2,592	30	77,760	640
2,592	10	25,920	1200
2,592	2	5,184	1,850
2,048	1,536	3,145,728	21
1,920	1,080	2,073,600	31
1,600	1,200	1,920,000	31
1,280	1,024	1,310,720	42
1,280	960	1,228,800	45
1,024	768	786,432	63
800	600	480,000	92
640	480	307,200	126
320	240	76,800	311
256	256	65,536	309
4	2	8	6,900

Table 13: *Frame rates for different ROIs with Mako U-503*

Available exposure increments

Minimum and maximum exposure and available exposure increments might vary with ROI width settings.

Mechanical dimensions

Handling and attaching the camera

To mount the camera properly, see *Mounting the camera* on page 65.

Mako U housing

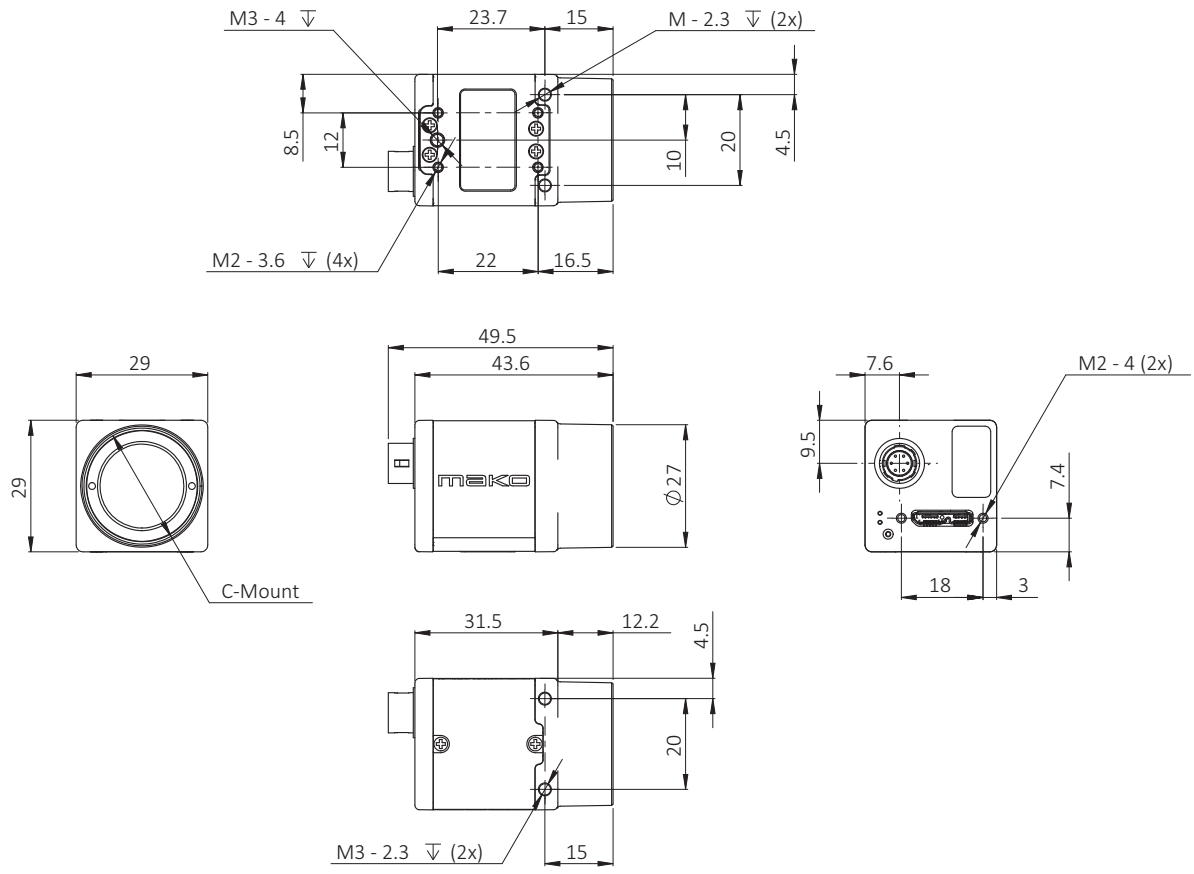


Figure 9: *Camera dimensions Mako U housing*

Tripod adapter

For details on the tripod adapter, see *Tripod adapter* on page 54.

Lens mounts

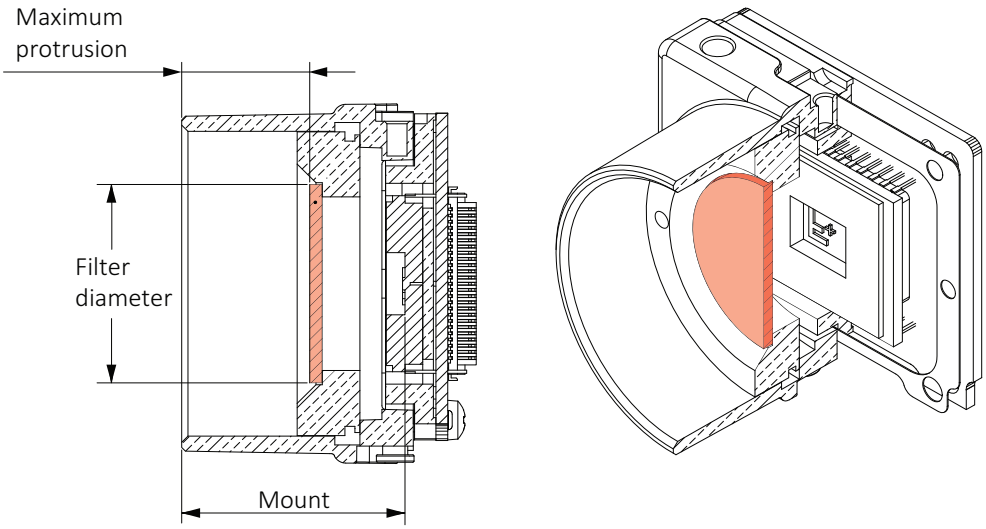


Figure 10: *Mount and protrusion*

Figure 10 shows maximum protrusion with a built-in filter. Monochrome Mako U cameras come without filter or protection glass. *Table 14* shows values for maximum protrusion for the standard version and for modular options.

Modular options

For Mako U modular options, see the *Modular Concept* at **Additional Documents** for the Mako U camera:
https://www.alliedvision.com/en/support/technical-documentation

Notice

Avoid damage by unsuitable lenses

To protect camera and lens, use lenses only up to the allowed maximum protrusion, as shown below:

	Maximum protrusion	
Mount	**Without filter (Standard)**	**With filter (Modular Concept)**
C-Mount	14.0 mm	9.9 mm
CS-Mount	9.0 mm	4.9 mm

Table 14: *Mako U -> Maximum protrusion for different mounts and filters*

Adjustment of mount dimensions

If you want to adjust mount dimensions, contact support@alliedvision.com.

CS- and M12-Mount option

Mako U standard cameras are equipped with a C-Mount. For a CS-Mount or the M12-Mount adapter, or to individually choose a protection glass or filter, see *Modular Concept*, at **Additional Documents** for the Mako U camera: https://www.alliedvision.com/en/support/technical-documentation.

Sensor position accuracy

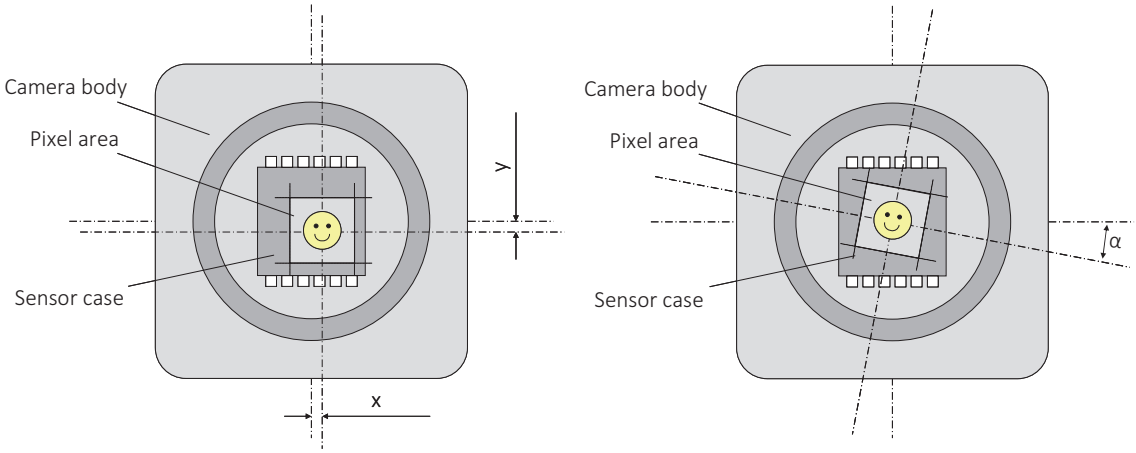


Figure 11: *Defining sensor position accuracy*

The following table defines the manufacturing accuracy of fitting sensors into Mako U cameras:

Criteria	Subject	Properties
Alignment method		Optical alignment of the photosensitive 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 lens mount
Accuracy	x/y	±150 µm (sensor shift)
	z	+0 µm to -150 µm (optical back focal length)
	α	±0.5 ° (sensor rotation as the deviation from the parallel to the camera bottom)

Table 15: *Mako U cameras -> criteria of sensor position accuracy*

Camera features available in Vimba

This chapter provides a list of camera features available for Mako U cameras.

About camera features

This chapter lists available camera features used for:

- Software coding with the Allied Vision transport layer (TL)
- Camera control with the **Vimba Viewer**.

Features and third-party TL

Under a third-party TL, Vimba features may appear differently or disappear.

Features and image processing

For image processing, see *Image data flow* on page 94.

Feature standards

USB3 Vision camera features comply with:

- USB3 Vision Standard V1.0.1
- GenICam™ Standard Features Naming Convention V2.2 (SFNC)
- GenICam™ Transport Layer Standard Features Naming Convention V1.0 (GenTL SFNC)
- GenICam™ Pixel Format Naming Convention V2.0 (PFNC).

For corresponding standards, see *Applied standards* on page 2.

Features that can be saved in UserSets

You can define `UserSets` to restart the camera with individual settings for the following features, listed from A to Z:

Feature name	Feature name	Feature name
AcquisitionFrameCount	Gamma	OutputDurationTime
AcquisitionFrameRateMode	Height	PixelFormat
AcquisitionMode	InputDebounceMode	ReverseX
BlackLevel	InputDebounceTime	TriggerActivation
CorrectionMode	LineInverter	TriggerDelay
DeviceLinkThroughputLimit	LineMode	TriggerMode
DeviceLinkThroughputLimitMode	LineSource	TriggerSource
ExposureMode	OffsetX	UserOutputValue
ExposureTime	OffsetY	Width
Gain	OutputDurationMode	

Table 16: *Features that can be stored in UserSets*

Camera features list

This section describes the camera features as displayed with **Vimba Viewer**, listed in categories in alphabetical order.

Selectors

Some features have multiple instances. For these features, `Selector` features define which instance of the feature is accessed.

Example: the `LineInverter` feature, used to invert internal signal polarity, can be applied to all input and output lines of the camera. The line is selected by the `LineSelector` feature.

The naming in the **Feature** column is `LineInverter[LineSelector]`, according to the C language convention for arrays: a pair of brackets follows the feature name, like in SelectedFeature[Selector].

Feature description

For a description of the listed features, see the *USB Features Reference*, at **Additional Documents** for the Mako U camera: *https://www.alliedvision.com/en/support/technical-documentation*.

Table legend

Tag	Function
1	Modified SFNC Features and proprietary features
2	Mako U models 29/51/130 only
Italics	Default values

Category	Feature	Type	Value
AcquisitionControl			
	AcquisitionAbort	Command	
	AcquisitionFrameCount	Integer	
	AcquisitionFrameRate	Float	
	AcquisitionFrameRateMode[1]	Enumeration	
			Off
			Basic
	AcquisitionMode	Enumeration	
			SingleFrame
			MultiFrame
			Continuous
	AcquisitionStart	Command	
	AcquisitionStatus [AcquisitionStatusSelector]	Boolean	
			False
			True
	AcquisitionStatusSelector	Enumeration	
			AcquisitionTriggerWait
			AcquisitionActive
			AcquisitionTransfer
			FrameTriggerWait
			FrameActive
			ExposureActive
	AcquisitionStop	Command	
	ExposureMode	Enumeration	
			Timed
			TriggerWidth[2]
	ExposureTime[ExposureTimeSelector]	Float	
	TriggerActivation[TriggerSelector]	Enumeration	
			RisingEdge
			FallingEdge
			AnyEdge
			LevelHigh
			LevelLow
	TriggerDelay[TriggerSelector]	Float	
	TriggerMode[TriggerSelector]	Enumeration	
			Off

Table 17: *Camera features as seen with Vimba*

Category	Feature	Type	Value
			On
	TriggerSelector	Enumeration	
			AcquisitionStart
			FrameStart
	TriggerSoftware[TriggerSelector]	Command	
	TriggerSource[TriggerSelector]	Enumeration	
			Software
			Line0
			Line1
			Line2
			Line3
AnalogControl			
	BlackLevel[BlackLevelSelector]	Float	
	BlackLevelSelector	Enumeration	
			All
	Gain[GainSelector]	Float	
	GainSelector	Enumeration	
			All
	Gamma	Float	
BufferHandlingControl			
	MaxDriverBuffersCount[1]	Integer	
	StreamAnnounceBufferMinimum	Integer	
	StreamAnnouncedBufferCount	Integer	
	StreamBufferHandlingMode	Enumeration	
			Default
CorrectionControl[1]			
	CorrectionMode[1] [CorrectionSelector[1]] [CorrectionSetSelector[1]]	Enumeration	
			On
			Off
	CorrectionSelector[1]	Enumeration	
			DefectPixelCorrection
			FixedPatternNoise Correction[2]
	CorrectionSetSelector[1]	Enumeration	

Table 17: *Camera features as seen with Vimba*

Category	Feature	Type	Value
			Factory
			User
CorrectionControl[1]/ CorrectionInfo[1]			
	CorrectionDataSize[1][CorrectionSelector][CorrectionSetSelector]	Integer	
	CorrectionDescription[1] [CorrectionSelector]	String	
	CorrectionEntryType[1] [CorrectionSelector[1]]	Enumeration	
			2
DeviceControl			
	DeviceFamilyName	String	
	DeviceFirmwareID[1] [DeviceFirmwareIDSelector]	String	
	DeviceFirmwareIDSelector[1]	Enumeration	
			Current
			Supported
	DeviceFirmwareVersion [DeviceFirmwareVersionSelector]	String	
	DeviceFirmwareVersionSelector[1]	Enumeration	
			Current
			Programmed
	DeviceGenCPVersionMajor	Integer	
	DeviceGenCPVersionMinor	Integer	
	DeviceIndicatorMode	Enumeration	
			Inactive
			Active
			ErrorStatus
	DeviceLinkThroughputLimit	Integer	
	DeviceLinkThroughputLimitMode	Enumeration	
			On
			Off
	DeviceManufacturerInfo	String	
	DeviceModelName	String	
	DeviceReset	Command	
	DeviceSFNCVersionMajor	Integer	

Table 17: *Camera features as seen with Vimba*

Category	Feature	Type	Value
	DeviceSFNCVersionMinor	Integer	
	DeviceSFNCVersionSubMinor	Integer	
	DeviceScanType	Enumeration	
			Areascan
	DeviceSerialNumber	String	
	DeviceTemperature	Float	
	DeviceTemperatureSelector	Enumeration	
			Mainboard
	DeviceUserID	String	
	DeviceVendorName	String	
	DeviceVersion	String	
	Timestamp	Integer	
DigitalIOControl			
	InputDebounceMode[1][LineSelector]	Enumeration	
			Off
			On
	InputDebounceTime[1][LineSelector]	Float	
	LineInverter[LineSelector]	Boolean	
			False
			True
	LineMode[LineSelector]	Enumeration	
			Input
			Output
	LineSelector	Enumeration	
			Line0
			Line1
			Line2
			Line3
	LineSource[1][LineSelector]	Enumeration	
			Off
			AcqusitionActive
			FrameTriggerWait
			FrameActive
			ExosureActive
			Stream0TransferActive
			ReadoutActive[1]

Table 17: *Camera features as seen with Vimba*

Category	Feature	Type	Value
			AcquisitionTriggerWait
			UserOutput0
			UserOutput1
			UserOutput2
			UserOutput3
	LineStatus[LineSelector]	Boolean	
			True
			False
	OutputDurationMode[1][LineSelector]	Enumeration	
			Off
			On
	OutputDurationTime[1][LineSelector]	Float	
	UserOutputSelector	Enumeration	
			UserOutput0
			UserOutput1
			UserOutput2
			UserOutput3
	UserOutputValue [UserOutputSelector]	Boolean	
			False
			True
FileAccessControl			
	FileAccessBuffer	DataRaw	
	FileAccessLength [FileSelector][FileOperationSelector]	Integer	
	FileAccessOffset [FileSelector][FileOperationSelector]	Integer	
	FileOpenMode[FileSelector]	Enumeration	
			Read
			Write
	FileOperationExecute [FileSelector][FileOperationSelector]	Command	
	FileOperationResult [FileSelector][FileOperationSelector]	Integer	
	FileOperationSelector[FileSelector]	Enumeration	
			Open
			Close
			Read

Table 17: *Camera features as seen with Vimba*

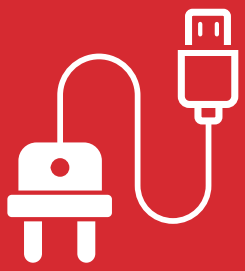
Category	Feature	Type	Value
			Write
			Delete
	FileOperationStatus [FileSelector][FileOperationSelector]	Enumeration	
			Success
			Failure
			Invalid
			Denied
			Error
	FileProcessStatus[1] [FileSelector][FileOperationSelector]	Enumeration	
			UpdateNotRequired
			None
	FileSelector	Enumeration	
			Firmware
			UserData
			DefectPixelCorrection
			FixedPatternNoise Correction[2]
	FileSize[FileSelector]	Integer	
	FileStatus[1]	Enumeration	
			Open
			Closed
ImageFormatControl			
	Height	Integer	
	HeightMax	Integer	
	OffsetX	Integer	
	OffsetY	Integer	
	PixelFormat	Enumeration	
			Mono8
			Mono10
			Mono10p
			Mono12
			Mono12p
	PixelSize	Enumeration	
			Bpp8

Table 17: *Camera features as seen with Vimba*

Category	Feature	Type	Value
			Bpp10
			Bpp12
			Bpp16
	ReverseX	Boolean	
			false
			true
	SensorHeight	Integer	
	SensorWidth	Integer	
	Width	Integer	
	Width Max	Integer	
StreamInformation			
	StreamID	String	
	StreamIsGrabbing	Boolean	
			False
			True
	StreamType	Enumeration	
			USB3
TestControl			
	TestPendingAck	Integer	
TransportLayerControl			
	PayloadSize	Integer	
UserSetControl			
	UserSetDefault	Enumeration	
			Default
			UserSet1
			UserSet2
			UserSet3
			UserSet4
	UserSetLoad[UserSetSelector]	Command	
	UserSetSave[UserSetSelector]	Command	
	UserSetSelector	Enumeration	
			Default
			UserSet1
			UserSet2
			UserSet3
			UserSet4

Table 17: *Camera features as seen with Vimba*

Accessories



This chapter includes:

USB 3.0 cards, hubs, and cables

For proper function and maximum performance of Mako U cameras, we recommend USB 3.0 accessories tested by Allied Vision. The particular combination of USB 3.0 accessories influences the result; therefore, predicting the available bandwidth is impossible.

Crashing USB 3.0 hubs

If suddenly your camera is not recognized anymore, check for a crashed USB 3.0 hub.

Disconnect the USB and power supply cable from the hub. Reconnect both.

Recommended USB 3.0 accessories

Host controller cards

Host controller cards	Properties	Order codes
2-port card	USB 3.0 to PCI Express x1 Gen2, with screw locks	9451
4-port card	USB 3.0 to PCI Express x4 Gen2, with screw locks	9452

Table 18: *Recommended host controller cards*

Hubs

Hubs	Properties	Order codes
4-port hub	USB 3.0 4-port hub, with screw locks	9449

Table 19: *Recommended hubs*

Cables

Cables	Properties	Order codes
USB 3.0 cable	1 m standard A to micro-B, screw lock on both sides	9432
USB 3.0 cable	3 m standard A to micro-B, screw lock on both sides	9433
USB 3.0 cable	5 m standard A to micro-B, screw lock on both sides	9434
USB 3.0 cable	8 m standard A to micro-B, screw lock on both sides	9435

Table 20: *Recommended cables*

Hubs

To ensure proper operation with long cable lengths, please use our recommended hubs.

More information on Allied Vision tested USB 3.0 accessories

For more information, contact support@alliedvision.com.

6-pin Hirose I/O cables

The General Purpose I/O port uses a Hirose HR10A-7R-6PB(73) connector on the camera side. The mating cable connector is:

- Hirose HR HR10A-7P-6S(73) for soldering
- Hirose HR HR10A-7P-6SC(73) for crimping

Hirose connector cables for purchase from Allied Vision:

I/O cables	Properties	Order codes
6-pin Hirose	2 m to open end	9436
6-pin Hirose	5 m to open end	9437
6-pin Hirose	10 m to open end	9438

Table 21: *6-pin Hirose I/O cables for Mako U*

Tripod adapter

Notice

Avoid damage to the camera by using inappropriate accessories

The Mako G tripod adapter uses screws that would damage the Mako U camera.

Only use the Mako U tripod adapter, order number 9222.

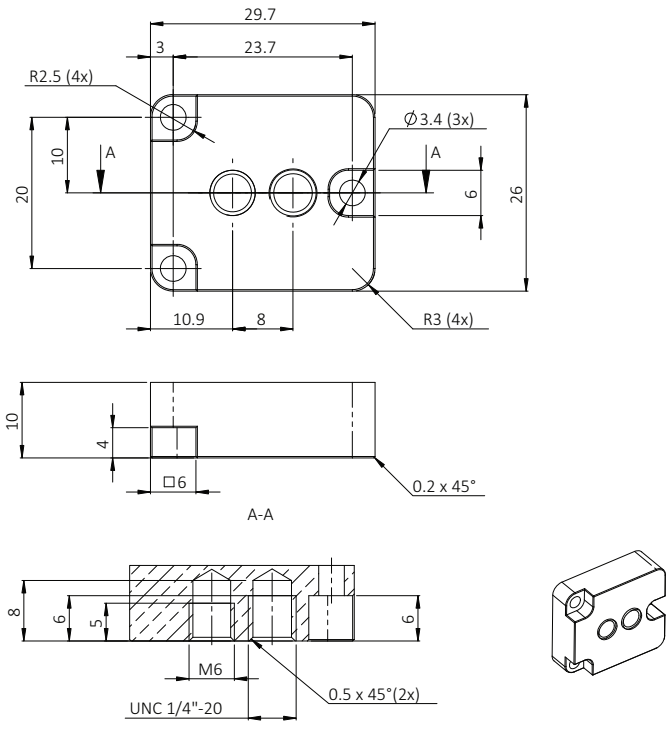


Figure 12: *Allied Vision Mako U tripod adapter dimensions (Allied Vision order number 9222)*

Filters and M12-Mount adapter

Monochrome Mako U cameras have a C-Mount and no filter or protection glass. Among others, you can order the Mako U modular options:

- IR-cut/IRC filters or protection glass
- CS-Mount
- M12-Mount adapter (with CS-Mount).

Modular options

For Mako U modular options, see *Modular Concept* at **Additional Documents** for the Mako U camera:
https://www.alliedvision.com/en/support/technical-documentation.

Lenses: Focal length vs. field of view

Ordering lenses for Allied Vision cameras

Contact Allied Vision for lens recommendations:
https://www.alliedvision.com/en/meta-header/contact/contact-sales.

About the following tables

Accuracy

- The sensor area may be larger than the effective optical area.
- Consider tolerances of the lenses' nominal and actual focal lengths.

Focal lengths

Focal length increments vary for the different sensor sizes.

Distance

Distance of the object to the first principal plane of the lens.

Shading with certain lenses

Lenses with **short focal lengths** may show shading at the edges of the image because of optical vignetting. **Microlenses** on the sensor pixels can increase shading.

For demanding applications, we suggest testing camera and lens to find a suitable setup. In doubt, please contact Allied Vision.

Allied Vision collaborates with leading lens manufacturers. We do extensive testing to recommend appropriate lenses for your cameras.

The tables below list selected image formats in **width x height** depending on:

- Sensor size
- Object distance
- Focal length of the lens

Focal length: Mako U-029, Type 1/4 sensor	Distance = 500 mm	Distance = 1000 mm
4.5 mm	680 x 545 mm	1367 x 1095 mm
4.8 mm	314 x 235 mm	630 x 473 mm
6 mm	250 x 188 mm	504 x 378 mm
8.5 mm	176 x 132 mm	355 x 266 mm
12 mm	124 x 93 mm	250 x 188 mm
17 mm	86 x 65 mm	176 x 132 mm
25 mm	58 x 43 mm	119 x 89 mm
35 mm	40 x 30 mm	84 x 63 mm

Table 22: *Focal length vs. field of view (Mako U-029)*

Focal length: Mako U-051, Type 1/3.6 sensor	Distance = 500 mm	Distance = 1000 mm
4.8 mm	396 x 297 mm	796 x 597 mm
6 mm	316 x 237 mm	636 x 477 mm
8.5 mm	222 x 167 mm	448 x 336 mm
12 mm	156 x 117 mm	316 x 237 mm
17 mm	109 x 82 mm	222 x 167 mm
25 mm	73 x 55 mm	150 x 112 mm
35 mm	51 x 38 mm	106 x 79 mm

Table 23: *Focal length vs. field of view (Mako U-051)*

Focal length: Mako U-130, Type 1/2 sensor	Distance = 500 mm	Distance = 1000 mm
4.5 mm	680 x 545 mm	1367 x 1095 mm
6 mm	509 x 407 mm	1023 x 820 mm
8.5 mm	357 x 286 mm	721 x 577 mm
12 mm	251 x 201 mm	509 x 407 mm
17 mm	176 x 141 mm	257 x 286 mm
25 mm	117 x 94 mm	241 x 193 mm
35 mm	82 x 66 mm	170 x 136 mm

Table 24: *Focal length vs. field of view (Mako U-130)*

Focal length: Mako U-503, Type 1/2.5 sensor	Distance = 500 mm	Distance = 1000 mm
4.8 mm	588 x 442 mm	1182 x 887 mm
8 mm	351 x 263 mm	707 x 531 mm
12 mm	232 x 174 mm	469 x 352 mm
16 mm	172 x 129 mm	351 x 263 mm
25 mm	108 x 81 mm	222 x 167 mm
35 mm	76 x 57 mm	157 x 118 mm

Table 25: *Focal length vs. field of view (Mako U-503)*

Installing the camera

This chapter includes:

Precautions

Notice

Avoid damage to the camera by exceeding the allowed temperature range

Operation outside the allowed temperature range can damage the camera.

- For operation, keep the housing temperature between +5 °C and +45 °C.
- Follow the instructions described in *Providing optimum heat dissipation* on page 58.

Providing optimum heat dissipation

For best performance and to protect the camera from damage, keep the housing temperature between +5 °C and +45 °C for operation. Observe the following:

- To avoid camera crashes, **operate the camera with a lens or lens adapter attached only.**
- For maximum heat dissipation, affix the camera to a **heat sink**, using the mounting threads (see *Mounting the camera* on page 65).
- Factors to improve heat dissipation:
  - Size of the contact area to the mounting base
  - Thermal conductivity of the mounting base
  - Ventilation or other active cooling of the camera and the mounting base

Prerequisites

More details on requirements and software installation

This section lists general requirements to operate Allied Vision USB3 Vision cameras on your system.

To download **Vimba**, including **Vimba Viewer** and **Vimba Driver Installer** for Windows®, see *https://www.alliedvision.com/software*.

For more details see **ReleaseNotes_Linux.txt** or **ReleaseNotes_Windows.txt** in the root directory of **Vimba**.

Needed components

Component	Windows®	Linux® (tested distributions)
Intel-compatible 32-bit or 64-bit x86 processor with 1 GHz or better	Windows® XP, 32-bit/64-bit Windows® 7, 32-bit/64-bit Windows® 8.1, 32-bit/64-bit Windows® 10, 32-bit/64-bit	Ubuntu 12.04 LTS "Precise Pangolin" Debian 6 "Squeeze" Fedora 17 "Beefy Miracle"
ARMv7-compatible 32-bit processor with 500 MHz or better	n/a	Ubuntu hard float 12.04 LTS "Precise Pangolin" Ubuntu soft-float 11.10 "Oneiric Ocelot" Angstrom hard-float 2012.12
Accessories	USB 3.0 external host controller card or on-board host controller USB 3.0 A to USB 3.0 Micro-B cable See *USB 3.0 cards, hubs, and cables* on page 53	
Software	Appropriate USB 3.0 host controller driver **Vimba 1.4** or higher, including Allied Vision USB3 Vision device driver: *https://www.alliedvision.com/software*	

Powering the camera

Mako U cameras are USB powered. They do not need external power to be operated or to be configured.

Notice

Power Mako U cameras via USB only

Mako U cameras are powered via USB. The Hirose I/O connector is for camera control only. **Connecting a power supply to the Hirose I/O connector damages the camera.**

- To avoid damage to USB 3.0 host controller cards or hubs, make sure these components provide sufficient current supply for the connected cameras.
- For suitable USB 3.0 accessories, see *Accessories* on page 52.

Connecting the camera to USB ports

Notice

Avoid damage to the camera, PC, or peripherals by ground loops

Unsuitable connection can lead to a short circuit between USB GND and GPIO GND caused by ground loops destroying the camera and connected devices.

- All wiring must be done by authorized personnel, according to the corresponding technical standards.
- Connect the camera according to your environmental grounding concept.
  See *Ground loops* on page 69.

Handling USB 3.0 cables

- Use only shielded cables to avoid electromagnetic interferences.
- Please use cables recommended by Allied Vision.
- Avoid unnecessary bending to prevent damaging the cables.
- Avoid coiling to prevent electromagnetic interference.

Mako U camera connected to USB 2.0

If the Mako U camera is connected to a USB 2.0 port, it is recognized as USB3 Vision device in the **Device Manager**; it is not shown in Vimba and cannot be operated.

Crashing USB 3.0 hubs

If suddenly your camera is not recognized anymore, check for a crashed USB 3.0 hub.

Disconnect the USB and power supply cable from the hub. Reconnect both.

Increase performance

To provide full bandwidth to the camera, no other device should be sharing the same bus. See *Dividing bandwidth between devices on a common USB 3.0 bus* on page 112.

Using third-party software

Using the camera with third-party software

Allied Vision USB cameras comply with the USB3 Vision standard. They can be used with many non-vendor specific third-party software that complies with the USB3 Vision standard.

Using the camera with third-party drivers

Allied Vision USB cameras work properly with most third-party drivers. We recommend to use the **Vimba camera driver**. If a third-party driver required for your application causes the camera to crash, see *Unexpected event 5* on page 110.

Using the camera under Linux®

To use the camera under Linux®, download and install **Vimba** on your system.

Vimba download and installation

To download **Vimba**, including **Vimba Viewer** for simple camera access, see *https://www.alliedvision.com/software*.

For a description, see *Installing Vimba under Linux*: *https://www.alliedvision.com/fileadmin/content/documents/products/software/software/Vimba/appnote/Vimba_installation_under_Linux.pdf*

Using the camera under Windows®

Supported Windows® versions

In this chapter, the supported Windows® versions: XP/7/8.1/10 are just named **Windows®.**

Unexpected events

Should installation or operation not work properly, see *Troubleshooting* on page 106.

Installing USB host adapter and Vimba

1. Install the USB 3.0 host controller card and driver according to the manufacturer's instructions.
2. Download and install **Vimba 1.4** or higher: *https://www.alliedvision.com/software*
3. Next step: *Installing the camera driver* on page 62.

Installing the camera driver

1. Connect your Mako U camera to the PC.
2. Start **Vimba Driver Installer** and open the **USB3 Vision Cameras** tab.
   The **Driver Source** is not installed, yet.
   If other USB3 Vision devices are installed, another USB3 Vision driver may be assigned to your camera.
3. Click on the Mako U camera entry.
   The current Vimba driver is offered as a popup (**Vimba 1.4.1** in the example).
4. Click on the Vimba driver popup.

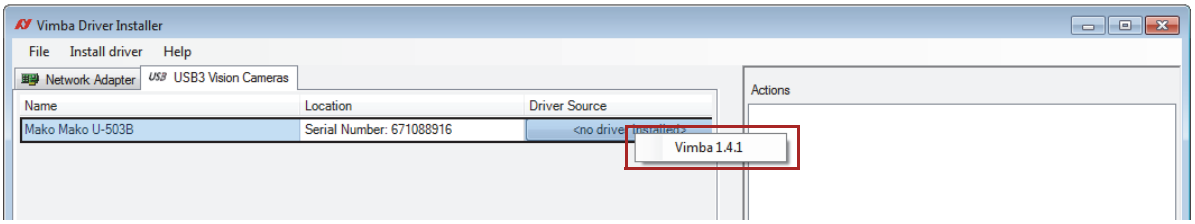


Figure 13: *Vimba Driver Installer -> Camera driver not installed*

5. Click `Apply` to install the Vimba driver for the camera.

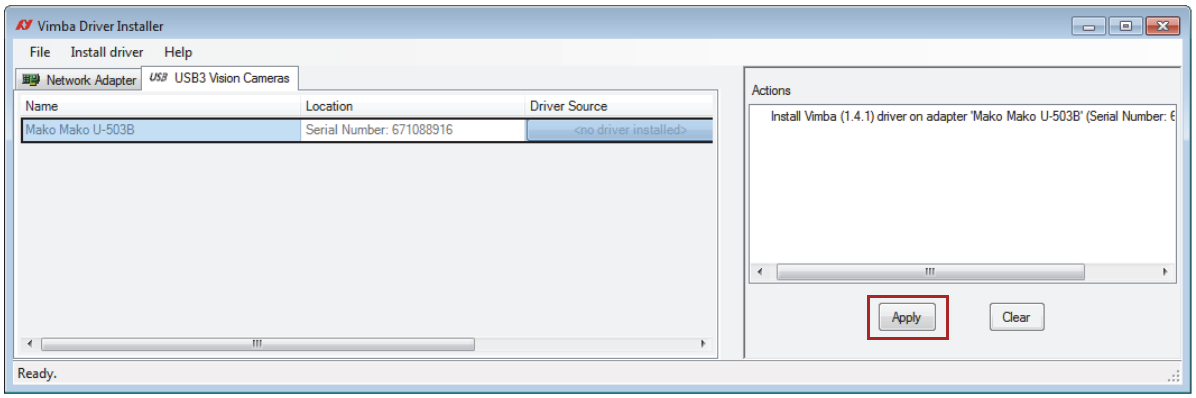


Figure 14: *Vimba Driver Installer -> Driver installation started*

The driver has been installed successfully.

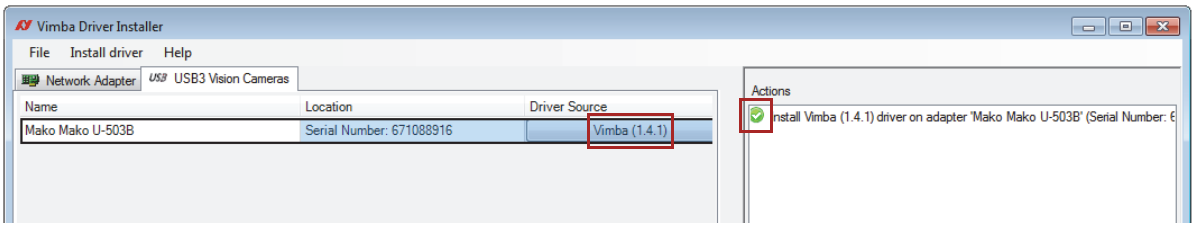


Figure 15: *Vimba Driver Installer -> Driver installed successfully*

Manual Vimba Driver installation

For manual Vimba Driver installation, see *Installing the camera driver with Windows® tools* on page 63.

Installing the camera driver with Windows® tools

As alternative practice, you can install the Vimba driver manually. Check for connected USB 3.0 devices on your Windows® system.

Screenshots are examples

The following screenshots were taken on a test system. The view may be different, depending on the configuration of your system.

Under Windows®, the **Device Manager** provides an overview of USB 3.0 resources and connected devices. As long as the Allied Vision USB 3.0 device driver is not installed, the camera is not recognized.

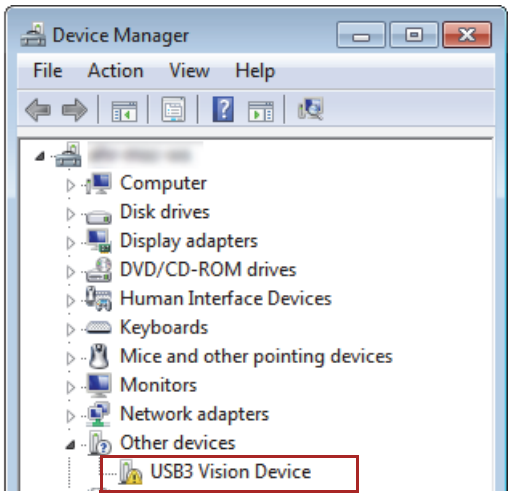


Figure 16: *Windows® Device Manager -> Unrecognized USB3 Vision camera*

No USB3 Vision Device displayed

If no **USB3 Vision Device** is displayed under **Other devices**, look at the section **Universal Serial Bus controllers**. Disable the new found **USB Composite Device** and enable it again. This creates the **Other Devices** entry shown in Figure 16.

1. Right-click the unrecognized **USB3 Vision Device**.

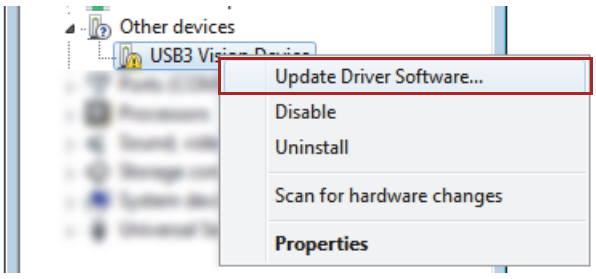


Figure 17: *Windows® Device Manager -> Windows® Driver Installer*

2. Click: “Browse my computer for driver software”.
3. Select [Your local Vimba directory]\Allied Vision\Vimba_1.4\VimbaUSBTL\Driver.
4. Follow the instructions.
   The camera driver is installed successfully.

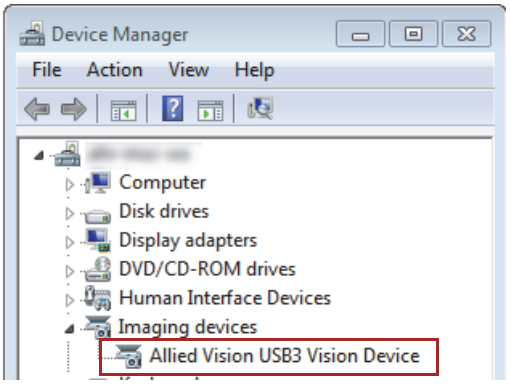


Figure 18: *Windows® Device Manager -> USB3 Vision camera installed successfully*

Mounting the camera

Mount the camera using suitable bolts:

- 2 x M3 - 2.3, 1 x M3 - 4
- 4 x M2 - 3.6

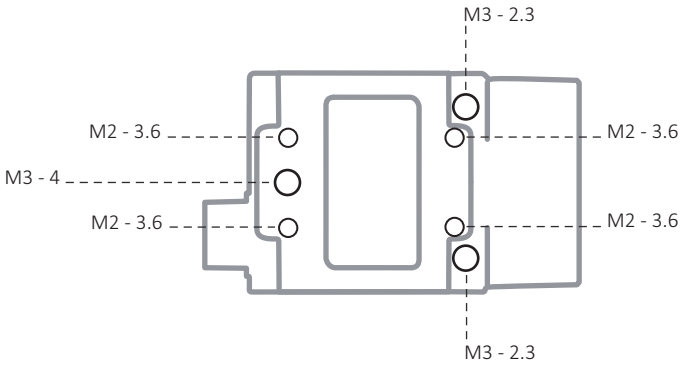


Figure 19: *Mako U -> Camera bottom with mounting threads*

For more technical drawings, see *Mako U housing* on page 39.

Notice

Avoid damage to the camera by high voltage

Mount the camera electrically isolated to avoid ground loops.
For more information on ground loops, see *Ground loops* on page 69.

Notice

Protect the camera from falling

- Use all mounting threads to mount the camera.
- Make sure the mounting threads are intact.

Tripod adapter

1. Attach the camera to the tripod adapter using the M3 mounting threads (see *Figure 19* above).
2. Screw the tripod adapter to the tripod with 1/4 - 20 bolts.

For more information, see *Tripod adapter* on page 54.

Mounting and storing of lenses

Provide the following conditions to keep dirt out of the optical system of camera and lens:

- Dust-free environment
- Low relative humidity
- No condensation

Notice

Keep dirt out of the lens mount

- To keep dirt out of the lens mount, hold the camera with the lens mount facing the ground.
- Keep filter and camera back lens clean, because dirt becomes more visible the closer it gets to the sensor.

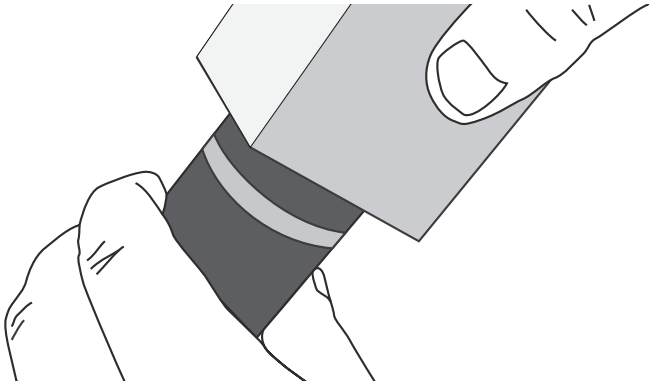


Figure 20: *Holding the camera with the lens mount facing the ground*

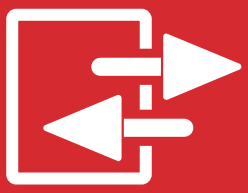
Notice

Avoid damage to camera or lens by unsuitable lenses

If the lens exceeds maximum protrusion, camera or lens may be damaged.

To **avoid damaging the back lens or the sensor** (or filter/protection glass as modular options, see *Filters and M12-Mount adapter* on page 55), use lenses with a maximum protrusion within camera specifications. For details, see *Lens mounts* on page 40.

Camera interfaces



This chapter includes:

Precautions

Notice

Avoid damage to the camera by ESD (electrostatic discharge)

Inadequate protection of the camera from ESD can damage the camera or interfere with camera functions.

Notice

Avoid damage to the camera, PC, or peripherals by ground loops

Unsuitable connection can lead to a short circuit between USB GND and GPIO GND caused by ground loops destroying the camera and connected devices.

- All wiring must be done by authorized personnel, according to the corresponding technical standards.
- Connect the camera according to your environmental grounding concept. See *Ground loops* on page 69.

Notice

Avoid damage to the camera by high output current or voltage

Connecting the camera to a device that exceeds the allowed maximum current or voltage can damage the camera.

- Max. current = 25 mA per output
- Max. Out VCC = 24 VDC

Notice

Avoid damage to the camera by high input voltage

Exceeding maximum input voltage can damage the camera.

Keep the maximum input voltage below 30 VDC.

Handling GPIOs

GPIOs are more sensitive to electromagnetic interference than opto-isolated I/Os.

Use GPIOs only in environments with low electromagnetic interference.

Ground loops

Notice

Avoid damage to the camera, PC, or peripherals by ground loops

Unsuitable connection can lead to a short circuit between USB GND and GPIO GND caused by ground loops destroying the camera and connected devices.

- **To protect the camera from damage, read the following instructions carefully.**
- Mount the camera electrically isolated to avoid ground loops.

Interference with environmental devices

Ground loops can cause interference with environmental devices.

Read the following carefully to avoid malfunctions.

Uncritical setup

Ground loops are a general risk of setups with USB cameras.

An environmental setup is uncritical with a Mako U camera, if no devices powered by PELV (Protective extra low voltage) are involved. In this case, you must observe nothing special about grounding.

Graphics legend

Gray line	Cable connection
Blue line	PE ground

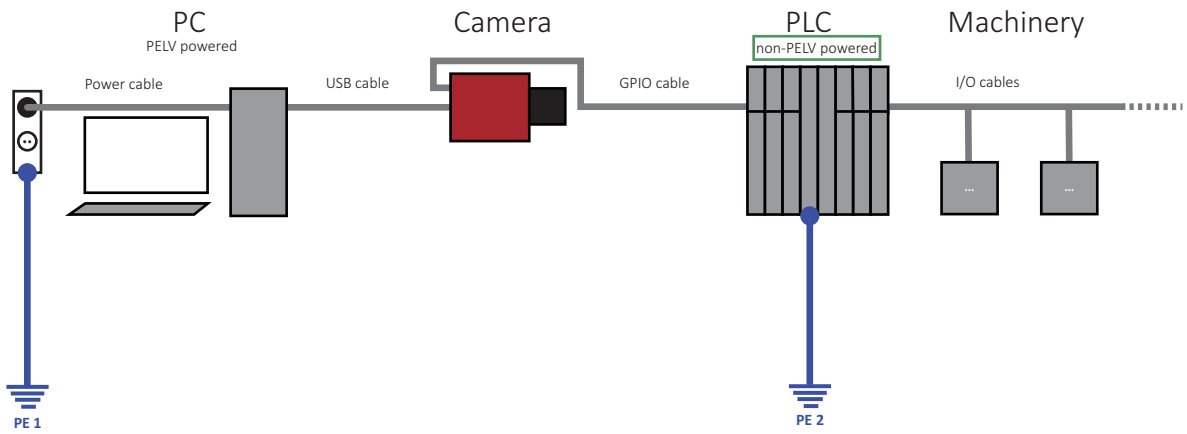


Figure 21: *No ground loop in an environmental setup* ***without*** *PELV-powering*

In the example above, only the PC is PELV-powered. Therefore, no ground loop is possible.

The following section is about ground loops between PELV-powered devices and how to avoid them.

Ground loop explanation

Ground loops can occur only for camera applications including both:

- PELV-powered devices in the machine application
- Use of camera GPIOs

With the graphics on the following pages, you can easily recognize if ground loops can occur for your application.

Abbreviations

I/Os	Opto-isolated in and outputs
GPIOs	Non-isolated general purpose in and outputs
PE	Protective earth
PELV	Protective extra low voltage
PLC	Programmable logic controller, such as Siemens SIMATIC®

Ground loop factors

PELV on PCs PELV power supplies are used to better protect the user from injuries and death. PCs are equipped with PELV power supplies.

USB ground USB ground is connected to the PE of the PC mainboard that is connected to the PELV power supply of the PC.

PELV devices PELV-powered devices in the environment of the machine application bear the risk of a ground loop.

PELV ground The PELV power supply's output zero conductor is connected to the ground of the device. Through the line power supply, this PE conductor is connected to earth.

Fault currents On PE, fault currents up to 2500 V can occur that are caused by such as:

- Machine defects in the environmental setup
- Friction from ground movements or moving machine parts
- Chemical processes in the ground.

Ground loop risks

Ground loop If a device of the environmental setup has a PELV power supply, it is connected to PE as is the PC; a ground loop is created.

Material damage A fault current can destroy the camera or connected devices, such as the PC or peripherals.

Setup causing a ground loop

Graphics legend

Gray line	Cable connection
Blue line	PE ground
Red line	Ground loop

Ground loop: GPIOs and PELV devices

In *Figure 22*, a USB camera uses non-isolated GPIOs, while PELV-powered devices are resident in the environmental setup. In this case, avoid ground loops with a barrier isolator. See *No ground loop: GPIOs and barrier isolator* on page 72.

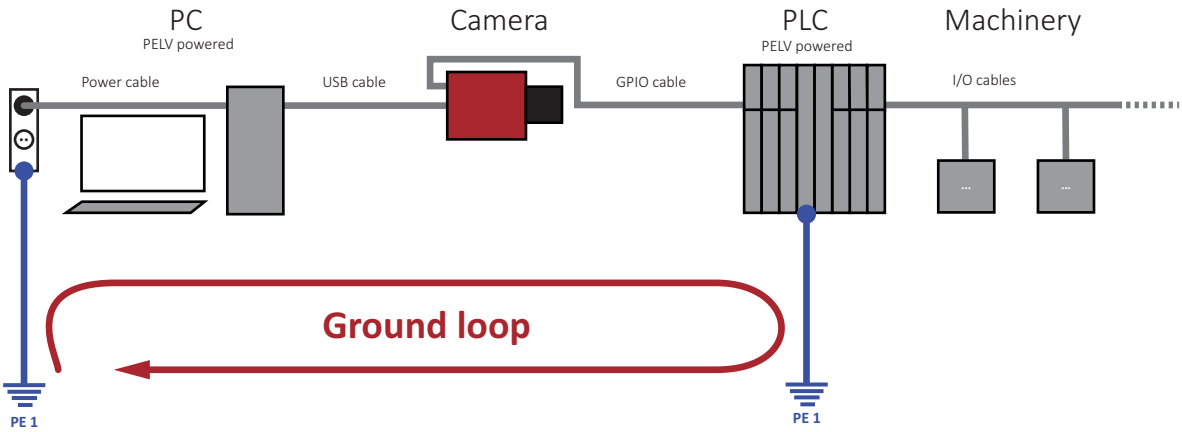


Figure 22: *Ground loop when using GPIOs*

Notice

Avoid damage to the camera, PC, or peripherals by ground loops

Unsuitable connection can lead to a short circuit between USB GND and GPIO GND caused by ground loops destroying the camera and connected devices.

To avoid ground loops, see *Setups to avoid ground loops* on page 72.

Setups to avoid ground loops

Graphics legend

Gray line	Cable connection
Blue line	PE ground
Green square	Isolator avoiding ground loops

No ground loop: GPIOs and barrier isolator

In *Figure 23*, a **barrier isolator** between camera GPIO and the environmental setup avoids ground loops.

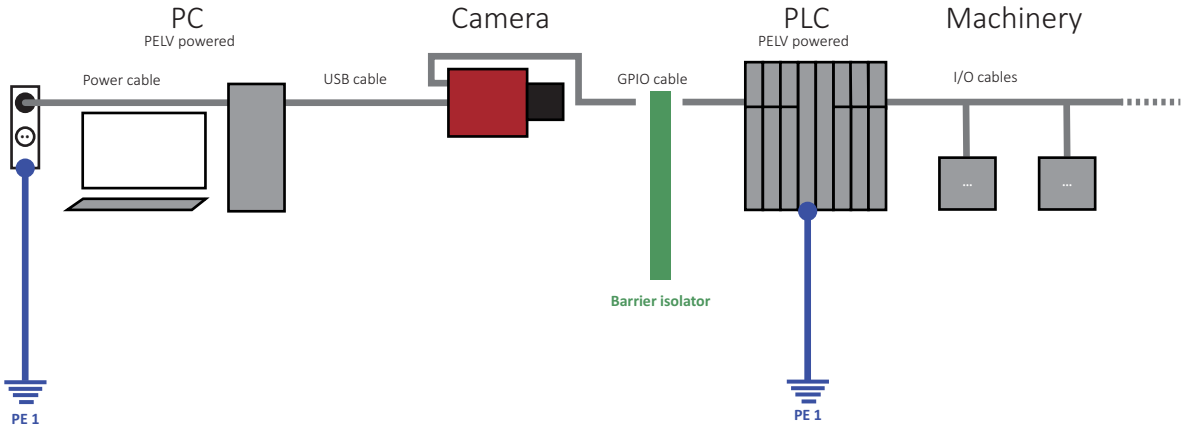


Figure 23: *No ground loop when using a barrier isolator*

No ground loop: Opto-isolated I/Os

In *Figure 24*, the I/O's opto-isolator inside the camera avoids ground loops. Depending on your application, instead of using the non-isolated GPIOs, you can use the opto-isolated I/Os to control the camera.

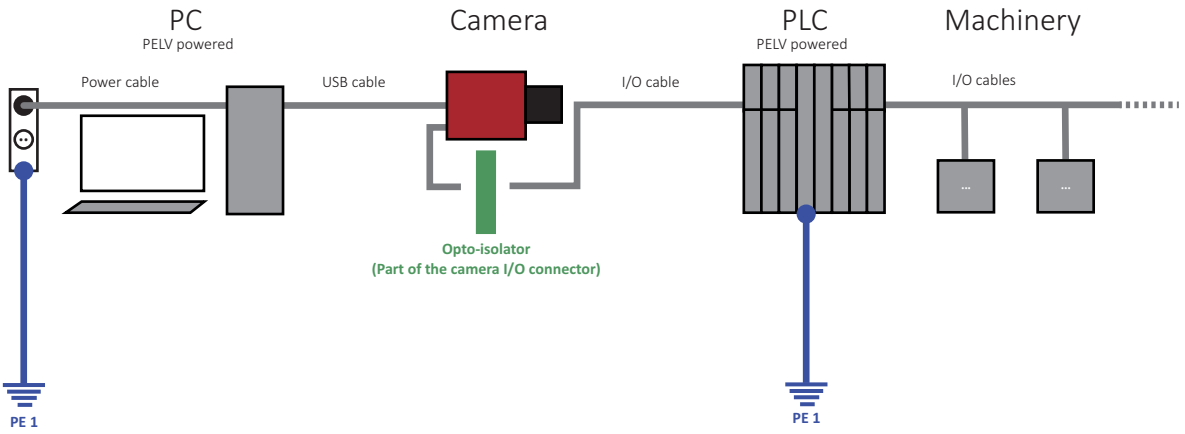


Figure 24: *No ground loop when using opto-isolated I/Os (instead of GPIOs)*

Back panel

Connectors naming

For control, the camera has in and outputs named as follows:

I/Os	Opto-isolated in and outputs
GPIOs	Non-isolated general purpose in and outputs

Back panel

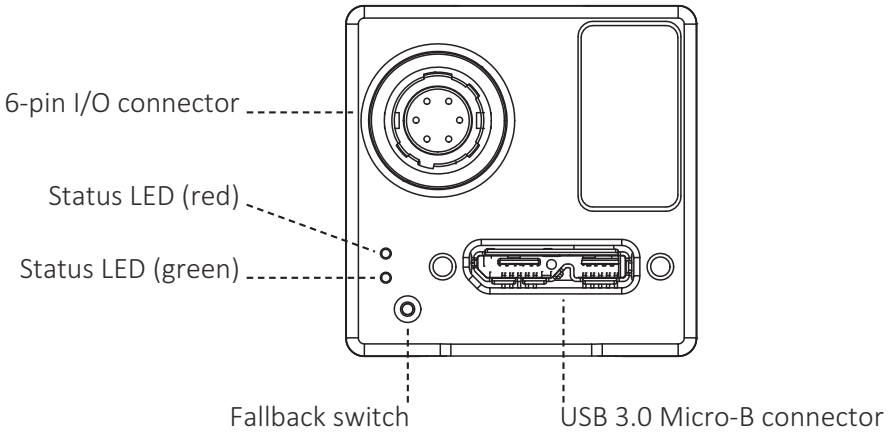


Figure 25: *Mako U back panel view*

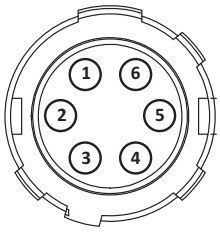
Interface descriptions

Interface	Section in this manual
6-pin I/O connector	*I/O connector pin assignment* on page 74
Status LEDs	*Status LEDs* on page 85
Fallback switch	*Setting the camera to fallback mode* on page 114
USB 3.0 Micro-B connector	*Power and USB connection* on page 75

Table 26: *Interface descriptions overview*

I/O connector pin assignment

The Mako U camera has a 6-pin Hirose in- and output (I/O) connector.



Pin	Line	Signal	<->	Level	Description
1	0	GPIO 1	I/O	U_{in} (low) = 0–0.8 VDC U_{in} (high) = 2–24 VDC U_{out} (low) = 0–1.0 VDC U_{out} (high) = 3.3–24 VDC @ max. 25 mA (open collector)	Non-isolated, programmable GPIO
2	1	GPIO 2	I/O	U_{in} (low) = 0–0.8 VDC U_{in} (high) = 2–24 VDC U_{out} (low) = 0–1.0 VDC U_{out} (high) = 3.3–24 VDC @ max. 25 mA (open collector)	Non-isolated, programmable GPIO
3	2	In 1	In	U_{in} (low) = 0–1.0 VDC U_{in} (high) = 3–24 VDC	Opto-isolated input
4	3	Out 1	Out	U_{out} (low) = 0.3–2 VDC U_{out} (high) = 3–24 VDC @ max. 25 mA (open collector)	Opto-isolated output (open collector)
5	---	Isolated GND	---	---	GND for isolated Input/output
6	---	GND	---	---	GND for GPIOs

Table 27: *Camera I/O connector pin assignment*

6-pin Hirose I/O cables

The General Purpose I/O port uses a Hirose HR10A-7R-6PB(73) connector on the camera side. The mating cable connector is:

- Hirose HR HR10A-7P-6S(73) for soldering
- Hirose HR HR10A-7P-6SC(73) for crimping

Hirose connector cables

For ordering 6-pin Hirose I/O cables, see *6-pin Hirose I/O cables* on page 54.

Power and USB connection

Mako U cameras are connected to the PC with the USB 3.0 Micro-B connector.

Notice

Avoid damage to the camera, PC, or peripherals by ground loops

Unsuitable connection can lead to a short circuit between USB GND and GPIO GND caused by ground loops destroying the camera and connected devices.

- All wiring must be done by authorized personnel, according to the corresponding technical standards.
- Connect the camera according to your environmental grounding concept. See *Ground loops* on page 69.

Notice

Power Mako U cameras via USB only

Mako U cameras are powered via USB. The Hirose I/O connector is for camera control only. **Connecting a power supply to the Hirose I/O connector damages the camera.**

- To avoid damage to USB 3.0 host controller cards or hubs, make sure these components provide sufficient current supply for the connected cameras.
- For suitable USB 3.0 accessories, see *Accessories* on page 52.

Handling USB 3.0 cables

- Use only shielded cables to avoid electromagnetic interferences.
- Please use cables recommended by Allied Vision.
- Avoid unnecessary bending to prevent damaging the cables.
- Avoid coiling to prevent electromagnetic interference.

Opto-isolated I/Os

The Mako U camera has opto-isolated I/Os:

- In 1
- Out 1

Input description

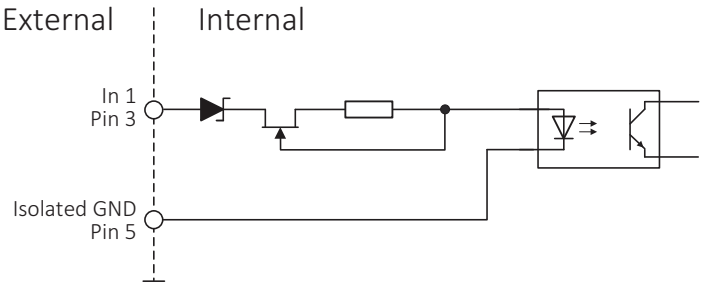


Figure 26: *Opto-isolated input -> Block diagram*

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

Input levels

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

Table 28: *Opto-isolated input -> Parameters*

Input timing delay and minimum pulse width

The input delay is part of the entire trigger latency. For trigger latency values, see *Specifications* on page 20.

The minimum pulse width for Mako U cameras is:

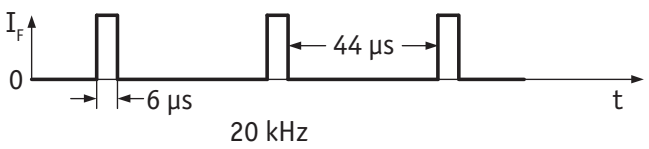


Figure 27: *Opto-isolated input -> Minimum pulse width*

The input signal was driven with 3.3 VDC and no external additional serial resistor.

Output description

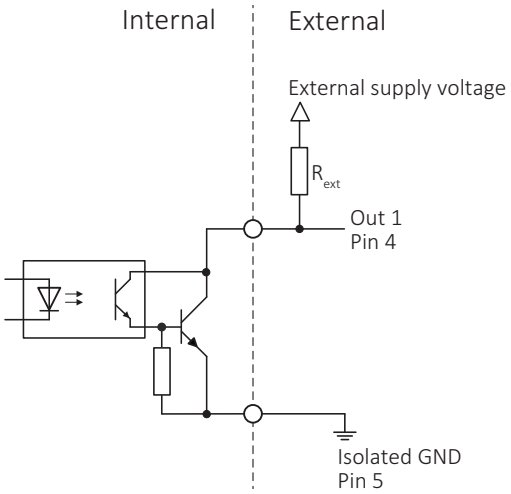


Figure 28: *Opto-isolated output -> Block diagram*

Physical and logical lines

A logical **high in Vimba** is a **physical low level** due to the open collector output circuit.

Inverting the logical signal level

To ease camera control, you can invert the logical signal level with the `LineInverter` feature. See *USB Features Reference* at **Additional Documents** for the Mako U camera: *https://www.alliedvision.com/en/support/technical-documentation*.

Logical signal	Vimba value	Voltage level
Active	High	Low
No signal	Low	High

Table 29: *Opto-isolated output -> Physical and logical lines*

Output levels

Parameter	Value
U_{out} (low)	0.3–2 VDC
U_{out} (high)	3–24 VDC
Undefined levels	2–3 VDC
Maximum external output voltage	25 VDC
Maximum output current	25 mA

Table 30: *Opto-isolated output -> Parameters*

Output voltage in the *On* state

Output voltage in the *On* state is 0.3–2 VDC @ housing temperature +25 °C.
Factors determining the voltage level in the *On* state:

- Load current (lower currents yield lower voltages)
- Camera operating temperature
- Production spread

Output switching times

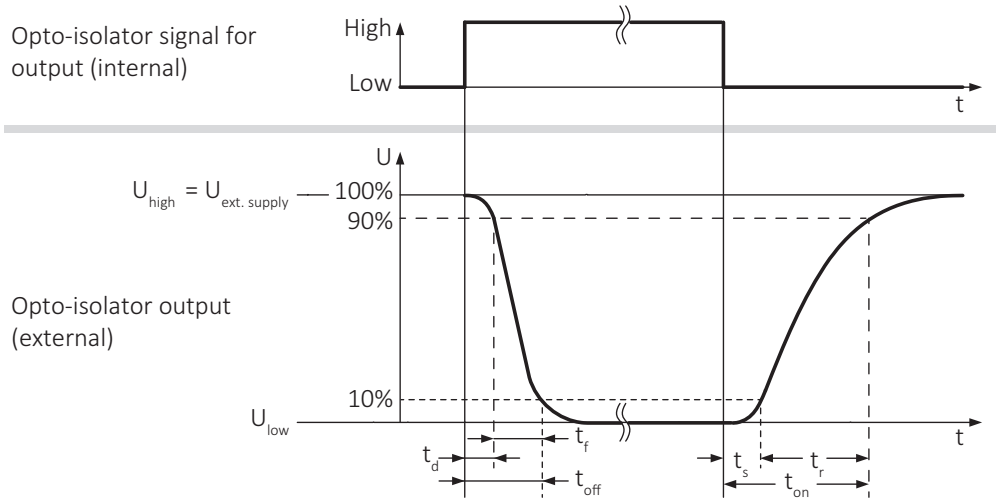


Figure 29: *Opto-isolated output -> Switching times*

Symbol	Description
t_d	Delay time
t_f	Fall time
t_{on}	Turn-on time
t_{off}	Turn-off time
t_r	Rise time
t_s	Fall time

Table 31: *Opto-isolated output -> Legend for switching times*

Output timing examples

U_{ext} supply	R_{ext}	t_d	t_f	t_{off}	t_s	t_r	t_{on}
5 VDC	1.0 kΩ	0.5	0.5	1	21	9.5	30.5
12 VDC	2.4 kΩ	0.5	0.7	1.2	21	14	35
24 VDC	4.8 kΩ	0.5	1	1.5	21.5	19	40.5

Table 32: *Opto-isolated output -> Timing [µs]*

Values may vary, due to operating temperature and production spread.
For values with other current draw than 5 mA, please contact customer support.

Non-isolated, programmable GPIOs

Precautions

Notice

Avoid damage to the camera, PC, or peripherals by ground loops

Unsuitable connection can lead to a short circuit between USB GND and GPIO GND caused by ground loops destroying the camera and connected devices.

- All wiring must be done by authorized personnel, according to the corresponding technical standards.
- Connect the camera according to your environmental grounding concept. See *Ground loops* on page 69.

Handling GPIOs

GPIOs are more sensitive to electromagnetic interference than opto-isolated I/Os.

Use GPIOs only in environments with low electromagnetic interference.

GPIOs description

The camera has two non-isolated GPIOs that can be configured by software to act as inputs or outputs. These GPIOs have a shorter delay than opto-isolated I/Os.

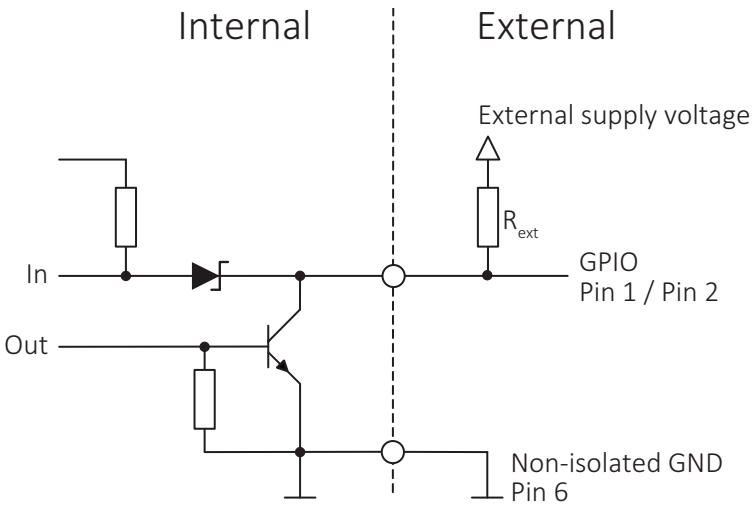


Figure 30: *GPIOs -> Block diagram*

Physical and logical lines

- For **input use**, a physical high level is a logical high in Vimba.
- For **output use**, a logical high in Vimba is a physical low level due to the open collector output circuit.

Inverting the logical signal level

To ease camera control, you can invert the logical signal level with the `LineInverter` feature. See *USB Features Reference* at **Additional Documents** for the Mako U camera: https://www.alliedvision.com/en/support/technical-documentation.

Logical input signal	Vimba input value	Voltage level
Active	High	High
No signal	Low	Low
Not connected	High	High

Table 33: *GPIOs as input -> Physical and logical lines*

Logical output signal	Vimba output value	Voltage level
Active	High	Low
No signal	Low	High

Table 34: *GPIOs as output -> Physical and logical lines*

Input levels

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

Notice

Damage to the camera

Maximum input voltage is 30 VDC. Exceeding this voltage damages the camera.

Parameter	Value
U_{in} (low)	0–0.8 VDC
U_{in} (high)	2–24 VDC
Undefined levels	0.8–2 VDC

Table 35: *GPIOs as input -> Parameters*

Input timing delay and minimum pulse width

The hardware input delay is 10–70 ns, it is part of the entire trigger latency.
For trigger latency values, see *Specifications* on page 20.

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

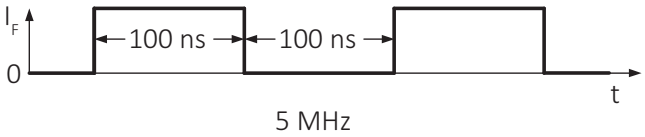


Figure 31: *GPIOs as input -> Minimum pulse width*

Test conditions

The input signal was driven with 3.3 VDC and no external additional serial resistor.

Output levels

Parameter	Value
External output voltage U_{out} (low)	0–1.0 VDC
External output voltage U_{out} (high)	3.3–24 VDC
Undefined levels	1.0–3.3 VDC
Maximum external output voltage	30 VDC
Maximum output current	25 mA

Table 36: *GPIOs as output -> Parameters*

Output voltage in the *On* state

Output voltage in the *On* state is 0.0–1.0 VDC @ housing temperature +25 °C.

Voltage level in the *On* state depends on the load current. Lower currents yield lower voltage.

Output switching times

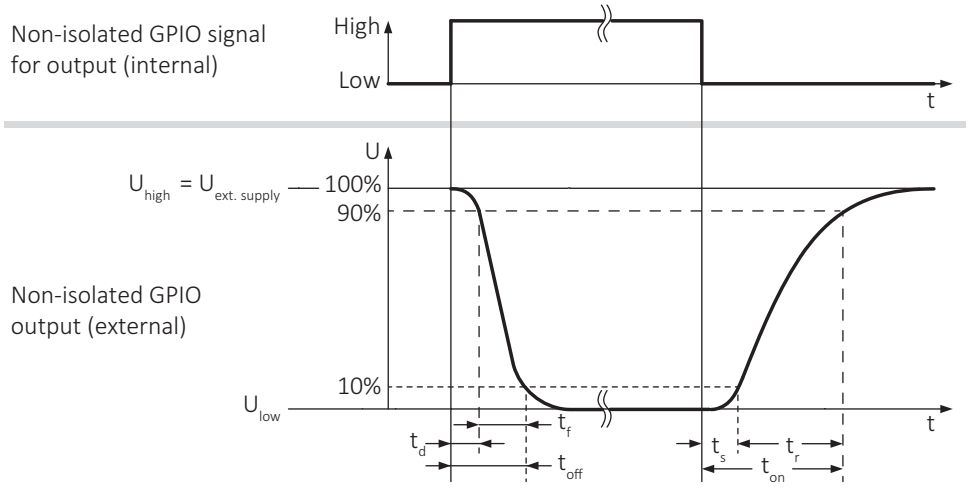


Figure 32: *GPIOs as output -> Switching times*

Symbol	Description
t_d	Delay time
t_f	Fall time
t_{on}	Turn-on time
t_{off}	Turn-off time
t_r	Rise time
t_s	Fall time

Table 37: *GIPIOs as output -> Legend for switching times*

Output timing examples

U_{ext} supply	R_{ext}	t_d	t_f	t_{off}	t_s	t_r	t_{on}
5 VDC	1.0 kΩ	0.03	0.03	0.06	0.3	0.24	0.54
12 VDC	2.4 kΩ	0.03	0.05	0.08	0.33	0.52	0.85
24 VDC	4.8 kΩ	0.07	0.08	0.15	0.36	0.96	1.32

Table 38: *GPIOs as output -> Timing [µs]*

For values with other current draw than 5 mA, contact customer support.

Optimizing performance

- Higher currents reduce times.
- Higher currents also increase U_{low} (low level of the output voltage).

-> Find the best compromise for your application.

Status LEDs

The Mako U camera has a green and a red status LED. The following tables describe the flashing pattern indicating different events.

For some events, only one LED is active at a time, for others, both LEDs are active simultaneously.

A pulse defines irregular flashing.

Inverse flashing

If an LED is already on, it is switched off for a short time.

Normal operation

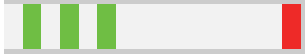
LED signal pattern		Status
	Fast bi-color sequence	Camera startup
	Green continuous	Power on
	Green pulse (inverse)	Command or image traffic
	Green continuous Red flashing	Camera busy

Table 39: *LEDs signaling -> Normal conditions*

LED codes at firmware update

- For LED codes signaling a firmware update, see *LED codes for a firmware update* on page 99.

Triggering

This chapter includes:

Trigger Control features

Additional information

- For the SFNC standard, see *http://GenICam.org*.
- For the *USB Triggering Concept***,** see *https://www.alliedvision.com/en/support/technical-papers-knowledge-base.html*.

Trigger features

- For available `ExposureModes`, see *Specifications* on page 20.
- For a features description, see *USB Features Reference* at **Additional Documents** for the Mako U camera: *https://www.alliedvision.com/en/support/technical-documentation*.

With the trigger signal, you can start and control image acquisition.

Mako U cameras comply with GenICam™ Standard Features Naming Convention (SFNC) Version 2.2, including triggering features. This section introduces SFNC trigger features and additional proprietary Allied Vision features.

TriggerSelector

The `TriggerSelector` selects the type of trigger to configure:

- `AcquisitionStart` starts the acquisition of one or many frames.
- *`FrameStart`* starts the capture of one frame.

Trigger path

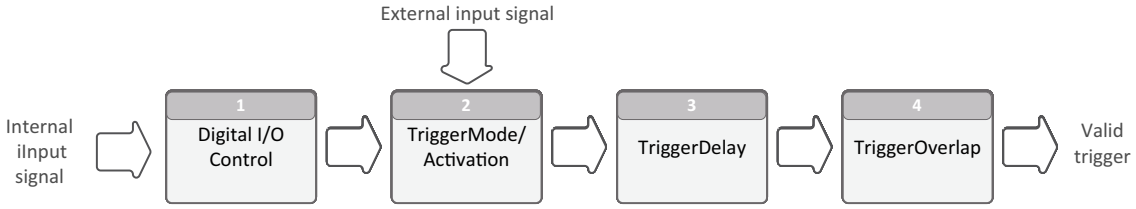


Figure 33: *Trigger path*

Depending on the `TriggerSource`, the trigger signal is processed through the trigger path, see *Figure 33* ("Trigger generation functional model," SFNC).

The camera provides separate trigger paths for *`FrameStart`*, *`AcquisitionStart`*, and *`FrameBurstStart`*.

External signal input
Hardware trigger from an external device such as a PC, a light barrier, or a strobe light.

Internal signal input
Software trigger or camera internal signal, such as idle state, frame counter, time out.

Digital I/O Control

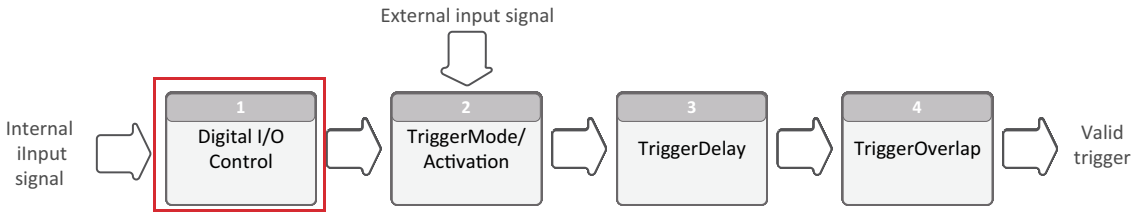


Figure 34: *Digital I/O control (DigitalIOControl)*

`DigitalIOControl` is a category that provides control features for the general input and output signals of the device, including:

- Input and output control signals for triggers
- Static signals, such as user configurable input or output bits.

Digital I/O Lines

For input path/`TriggerSource` and output path/`LineSource`, see *Digital I/O lines* on page 90.

TriggerMode/TriggerActivation

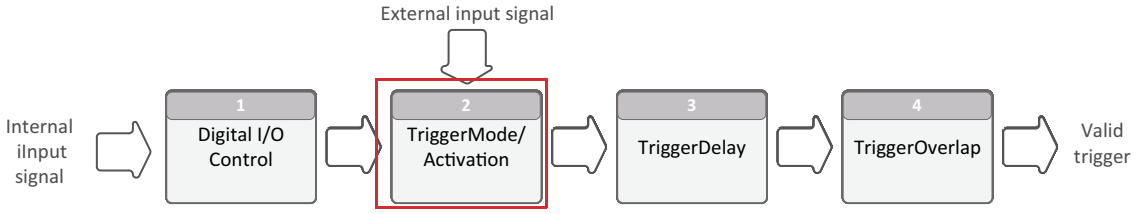


Figure 35: *TriggerMode/TriggerActivation features*

TriggerMode[TriggerSelector]

`TriggerMode` controls if the selected trigger is active:

- *`Off`* disables the selected trigger.
- *`On`* enables the selected trigger.

TriggerActivation[TriggerSelector]

`TriggerActivation` specifies the activation mode of the trigger:

- *`RisingEdge`* specifies that the trigger is considered valid on the rising edge of the source signal.
- *`FallingEdge`* specifies that the trigger is considered valid on the falling edge of the source signal.
- *`AnyEdge`* specifies that the trigger is considered valid on the falling or rising edge of the source signal.
- *`LevelHigh`* specifies that the trigger is considered valid as long as the level of the source signal is high.
- *`LevelLow`* specifies that the trigger is considered valid as long as the level of the source signal is low.

TriggerDelay[TriggerSelector]

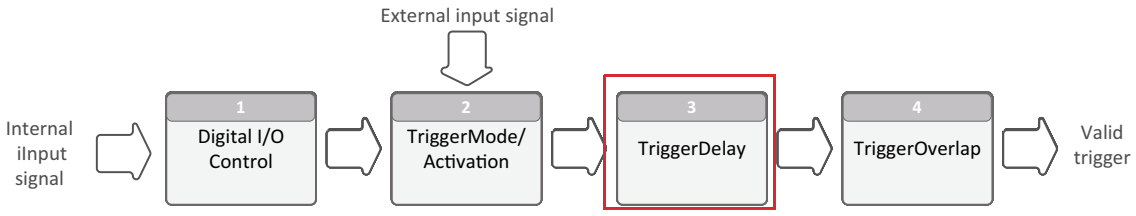


Figure 36: *TriggerDelay feature*

`TriggerDelay` specifies the delay between receiving and activating the trigger in µs.

Digital I/O lines

Input path/TriggerSource[TriggerSelector]

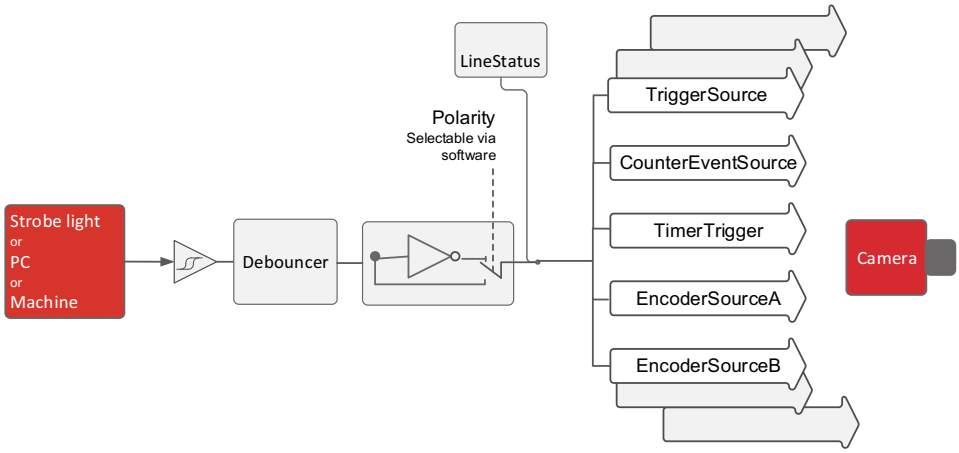


Figure 37: *Input block diagram*

`TriggerSource[TriggerSelector]` specifies the internal signal or physical input line to use as trigger source.

To enable a trigger, its `TriggerMode[TriggerSelector]` must be set to *`On`*.

TriggerSource values

Signal	Description
`Software`	Specifies that the `TriggerSource` will be generated by software using the `TriggerSoftware` command.
`Line0`, *`Line1`*, etc.	Specifies which physical line (or pin) and associated I/O control block to use as external source for the trigger signal.

Table 40: *Input path / TriggerSource values*

Output path/LineSource[LineSelector]

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

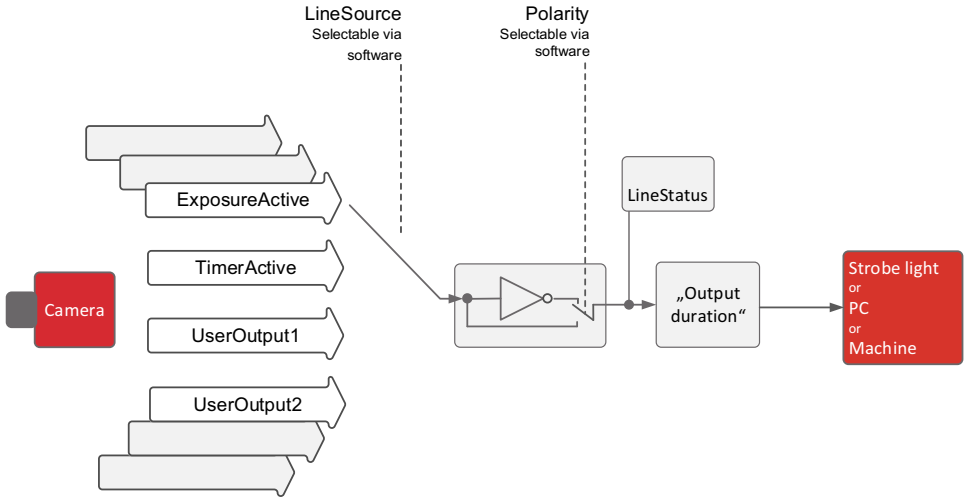


Figure 38: *Line I/O Control: Output block diagram*

LineSource[LineSelector] values

Signal	Description
`AcquisitionTriggerWait`	The device is currently waiting for a trigger to start the capture of one or many frames.
`AcquisitionActive`	The device is currently doing an acquisition of one or many frames.
`FrameTriggerWait`	The device is currently waiting for a FrameStart trigger.
`FrameActive`	The device is currently capturing a frame.
`ExposureActive`	The device is currently exposing a frame.
`UserOutput0`, `UserOutput2`, `etc.`	The chosen UserOutput Bit state as defined by its current `UserOutputValue`
`Stream0TransferActive`	Transfer on the stream is `Active`, `Paused`, `Stopping`, `Stopped`, or `Overflow`.

Table 41: *Output path / LineSource values*

Trigger signal flow

The following diagram shows the exposure of a frame started by an external signal. High levels show the active state of a signal. Proportions and dependencies are simplified to show the basic signal flow. Signal 1 starts Cycle 1.

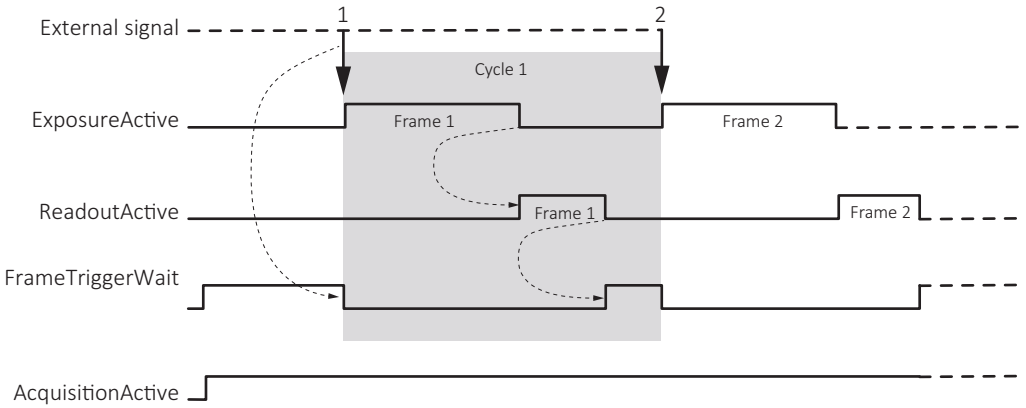


Table 42: *Trigger signal flow*

Term	Description
External signal	Electrical trigger signal starting the signal flow
`ExposureActive`	Exposing a frame
`ReadoutActive`	Reading out a frame, high when the image sensor is reading out data
`FrameTriggerWait`	Waiting for a trigger
`AcquisitionActive`	Acquiring of frames, needs to be high to start triggering High when the camera image sensor is either exposing, reading out data, or waiting for a trigger

Table 43: *Legend for Trigger signal flow*

Trigger latency

Trigger latency is the time delay between the FrameStart trigger and the start of exposure. Trigger latency consists of:

- Jitter and delay of ExposureStart
- `TriggerDelay`

Term	Description
ExposureStart jitter	Deviation from the average periodical signal time Time range mainly caused by sensor line synchronization
ExposureStart delay	Deviation from the average periodical signal time Time range caused by camera internal timing
`TriggerDelay`	Value set by the user to extend the trigger latency

Table 44: *Trigger latency -> Components*

Best practice rules for triggering

- Set the trigger to `RisingEdge` for fastest possible reaction time.
- Set the trigger pulse width in the supported range, see *Input timing delay and minimum pulse width* on page 76.
- Consider that the end of exposure triggers the next readout.
- Make sure the exposure of a frame ends after the readout of the previous frame.
- Start exposure only between the readouts of two lines.
- Consider that ExposureStart delay = readout time - `ExposureTime`.

Triggering when ReadoutActive is low

Apply FrameStart trigger when `ReadoutActive` is low. This way, you keep trigger latency (including ExposureStart jitter) short.

Triggering when ReadoutActive is high

For fastest triggering cycle time with simultaneous exposure and readout, apply FrameStart trigger immediately when `FrameTriggerWait` is high.

Because exposure must always begin at sensor line synchronization, the ExposureStart jitter can be up to 1 line cycle.

More information about the triggering concept

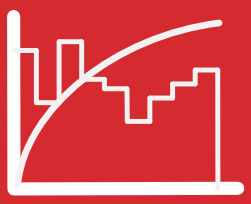
See *USB3V Triggering Concept*:

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

USB3 Vision features reference

For a features description, see *USB Features Reference* at **Additional Documents** for the Mako U camera:
https://www.alliedvision.com/en/support/technical-documentation

Image data flow



This chapter includes the image data flow for Mako U monochrome cameras.

Mako U monochrome cameras

Camera feature descriptions

For a features description, see *USB Features Reference* at **Additional Documents** for the Mako U camera: https://www.alliedvision.com/en/support/technical-documentation

The following flow chart shows image data processing for Mako U monochrome cameras in general.
The legend below informs about image processing details for the (numbers) in the flow chart.
Some models differ from these graphics, see *Table 45*.

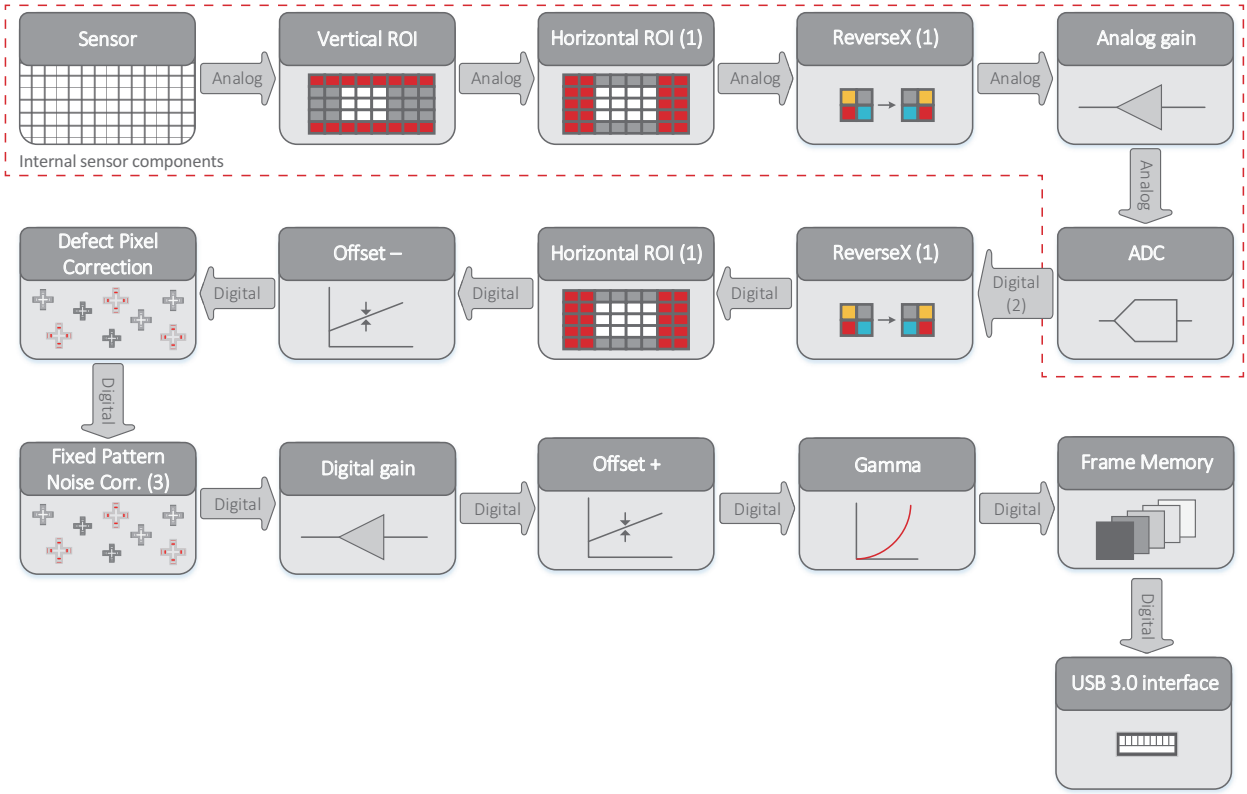


Figure 39: *Image data flow of Mako U monochrome cameras*

Legend

1. Processing is done either on the sensor or in the camera electronics, depending on sensor capabilities.
2. For the bit depth of your camera's internal digital processing, see *Specifications* on page 20.
3. Different Mako U models provide different types of image correction depending on sensor capabilities. See below.

Image corrections for Mako U cameras

These image corrections are available for the different Mako U camera models:

Camera model	ADC bit depth	Defect Pixel Correction	Fixed Pattern Noise Correction (FPNC)
Mako U-029	10	✓	✓
Mako U-051	10	✓	✓
Mako U-130	10	✓	✓
Mako U-503	12	✓	

Table 45: *Different image corrections for Mako U monochrome cameras*

Firmware update

This chapter includes:

Updating the firmware

You should update firmware only to:

- Change camera functions
- Fix bugs.

Precautions

Keep the camera connected

Keep the camera connected, while you are executing a firmware update.

If you disconnect the camera from USB during firmware update, the camera firmware may get into a non-functional state.

In this case, see Chapter *Setting the camera to fallback mode* on page 114.

Firmware update affecting features

Any firmware update may not only add new features to a camera or fix bugs. It may also replace previous features or change camera characteristics.

Firmware update with Vimba

To update firmware:

1. Download and install Vimba.
   The download includes the **Vimba Firmware Updater** and the *Vimba Manual.*
2. To update the firmware, follow the instructions of the *Vimba Manual*.

Downloads

- For **Vimba**, see *https://www.alliedvision.com/software*.
- For the latest **firmware**, see *https://www.alliedvision.com/en/support/firmware.html*.

Updating firmware without Vimba

We recommend to use the **Vimba Firmware Updater** for easy handling.
If you want to update the firmware without installing Vimba, please contact *support@alliedvision.com*.

LED codes for a firmware update

The Mako U camera has a green and a red status LED. The following tables describe the flashing pattern indicating different events. For some events, only one LED is active at a time, for others, both LEDs are active simultaneously.

A pulse defines irregular flashing.

Inverse flashing

If an LED is already on, it is switched off for a short time.

LED color and flashing pattern	Status
Green continuous	Power on
Green pulse inverse	Command traffic
Green continuous Red flashing	Camera busy

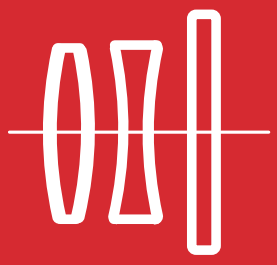
Table 46: *LEDs signaling -> Firmware update*

Firmware update errors

Should the firmware update not succeed, please contact support@alliedvision.com.

Allied Vision

Cleaning optical components



This chapter includes:

Precautions

Clean optical components only when this is necessary. To do this cleaning successfully, observe the following advice.

Caution

Avoid causing fire with the cleaning liquids

The cleaning liquids appropriate for camera cleaning are highly flammable.

- Always ensure proper ventilation when working with these liquids. Avoid accumulation of dangerous fumes.
- Always observe the applicable accident prevention regulations.
- Always allow the camera to completely cool down to room temperature before attempting any cleaning. Disconnect the camera.

Caution

Avoid poisoning by fumes from cleaning liquids

Inhaling dangerous fumes may harm your health.

- Always ensure proper ventilation when working with these liquids.
- Pay attention to the safety instructions of the cleaning liquids.

Do not clean a new Allied Vision camera

- Allied Vision cameras are clean at delivery
- Cameras are cleaned before shipping. We record a reference image with each camera to document cleaning quality.

Notice

Protect the sensor of Mako U monochrome cameras

Monochrome Mako U cameras are not fitted with filter or protection glass.

- Removing the lens or dust cap on these cameras immediately exposes the sensor.
- Always ensure that you are not inadvertently damaging the sensor surface.

Notice

Be extremely careful when using compressed air

As a general precaution, never use compressed air to clean a camera.

If you want to use compressed air in spite of all warnings, consider:

- High pressure air may crack the sensor or glass you want to clean.
- Compressed air may contain oil that could contaminate or damage the optical components.
- Compressed air may blow dust into cameras and lenses.

Notice

Follow the instructions to keep optical components intact

- Follow the cleaning instructions described in this chapter.
- Use only recommended cleaning material.
- Use maximum care when cleaning optical components.
- Never attempt to remove any solid or fluid substances that penetrated into the camera body. Should that happen, always contact Allied Vision.

Keep optical components clean

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

Always store cameras and lenses with dust caps on.

When mounting or dismounting a camera lens or dust cap, always hold the camera with the mount opening pointing downwards. This minimizes the possibility of any dirt falling onto the glass surface:

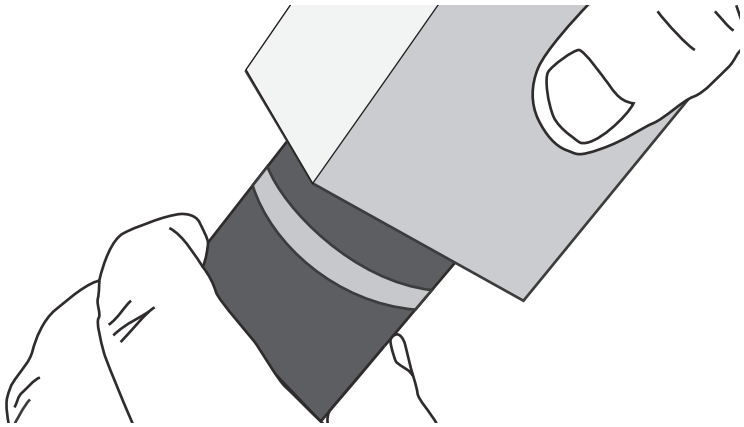


Figure 40: *Hold the camera like this when removing lens or dust cap*

Dirt

Dirt vs. pixel defects

Do not confuse Dirt 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.

Dirt not affecting the image

If small visible dust or dirt particles on glass surfaces can be observed from the outside, this does not necessarily mean that these particles affect image quality.

Since these particles are out of focus, they are not likely to have any impact on the image. An impact on the image may only be given if any particles can be observed in the video preview of your camera under working conditions (distance and aperture settings).

Moreover, dirt on the edge of the lens or the filter may not be in the field of view and therefore invisible.

Dirt affecting the image

The dirt you observe in the video preview may be situated either on the lens, on the filter/protection glass, or on the sensor. Dirt may develop due to handling or unclean environments, even if your camera has been cleaned prior to sealing and shipment.

As shown in Figure 41, dirt (dust, particles, or fluids) on the sensor or on optical components may 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.

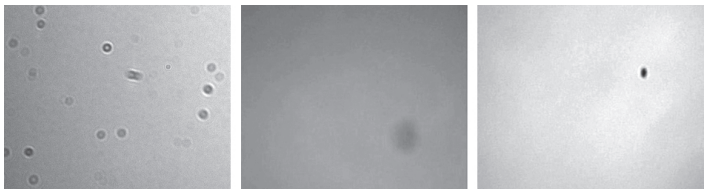


Figure 41: *Examples for the appearance of dust on the filter (left and middle) and the sensor (right)*

Examining optical components for dirt

Before dismounting the lens, determine whether the dirt is situated **on the filter, lens, or sensor.**

Examination instructions

1. Acquire a uniform image, such as a white sheet of paper.
2. Rotate the optical component. If the dirt spots follows rotation, they are on this component's optical surface.

Identifying the affected optical component

- If you rotate only the lens (not the camera) and the dirt spots move as well, these spots are **on the lens**.
- If the dirt is not on the lens, it is **on the filter/protection glass or on the sensor**.

Materials for cleaning optical components

Use only these cleaning materials for optical components:

Cleaning tissue

- Use only lens cleaning tissue chemically pure and free from silicones and other additives.
- The tissue should be wrapped around a small piece of plastic.

Cleaning liquid

- As cleaning liquid, use only optics cleaner (60% ethyl alcohol, 40% ether) or isopropyl alcohol.

Notice

Never use these cleaning materials for optical components:

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

Cleaning instructions

Workplace conditions

- Carry out all cleaning operations (on lenses, filter or protection glass, and sensor) in a clean dust-free room.
- Avoid touching optical components with your fingers or any hard material. Otherwise, they may be damaged.

1. Disconnect the camera, including power supply, before cleaning.
2. Have the cleaning materials ready before you start the cleaning.

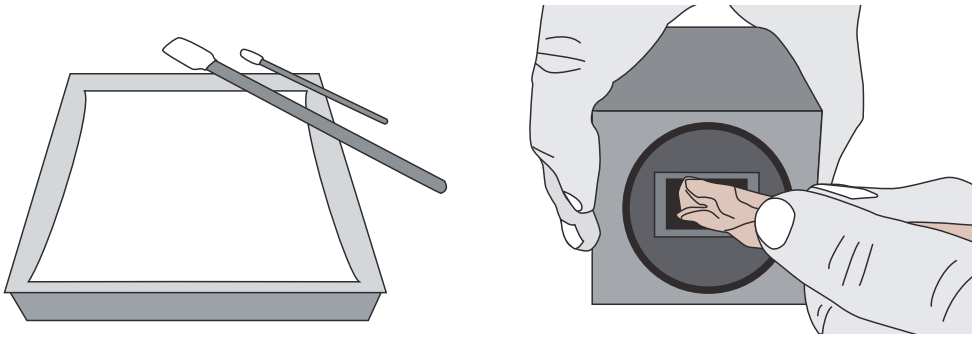


Figure 42: *left -> lens cleaning tissues and cleaning pads*
right -> use of a cleaning tissue to clean a sensor

3. Apply a small amount of cleaning liquid to a clean, new lens cleaning pad or tissue.
   The pad or tissue should be moist, not dripping. Hold the camera away from your body to avoid that particles like skin flakes fall onto the sensor.
   The camera front should point roughly 45 degrees upwards.
4. Wipe the glass surface in either one of the two ways described below to ensure any dirt present on the surface be moved to the edge of the surface:
   a. 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.
   b. With a straight motion across the glass surface from one end to the opposite end.
5. When you have finished cleaning, examine the surface in a strong light. Take an out-of-focus picture of a flat, illuminated surface to see if any dirt remains.
6. If dust spots remain, repeat this procedure once, using new clean lens tissue (as described above).

If dust spots remain despite cleaning twice:

Contact support@alliedvision.com.

Troubleshooting

This chapter includes:

Questions and answers

This section is about unexpected events with the operation of the Mako U camera. The events are ordered from general to detail:

- *Camera recognition*
- *Unexpected events*
- *Performance*
- *Radio signal interference*

Each entry consists of:

- Observed unwanted event, numbered for easier handling
- Short description of the solution
- Step-by-step instructions to resolve the issue.

Hardware installation

For background information, see *Installing the camera* on page 57.

Camera recognition

How can I make the PC/Vimba Viewer recognize the camera?

1. Check if the **hardware** supports your USB camera.

See *Recommended USB 3.0 accessories* on page 53.

Linux®

2. Check if **all required drivers** are properly installed.

1. From the Vimba installation folder, unpack **Vimba.tgz** to your system.
2. Follow the instructions in **ReleaseNotes_Linux.txt** to install the required drivers.
   For **Vimba** download, see
   https://www.alliedvision.com/software

Result: The camera is recognized.

Windows®

3. Check if your PC has an appropriate **USB 3.0 host controller driver** installed.

Windows® 8 and later OS provide a USB 3.0 host controller driver. On a properly installed OS, no problems should occur.

Windows® 7 and earlier OS do not provide a USB 3.0 host controller driver.
To install the host controller card:

1. Download the manufacturer 3.0 host controller driver.
   Install the driver on your PC.

Result: The installed driver enables the host controller.

Windows® **4.** Check if the **USB3 Vision device driver** is properly installed and assigned to the camera.

Follow the instructions in *Using the camera under Windows®* on page 61.

Windows® **5.** Check if the **USB3 Vision transport layer** is properly installed.

Either: Install **Vimba**, including the USB3 Vision transport layer driver.

Or: Install the USB3 Vision transport layer, according to the Vimba Manual. For **Vimba** download, see *https://www.alliedvision.com/software*

Result: The camera is recognized.

6. The camera, **connected to a USB 3.0 hub**, is not recognized anymore. Check if the USB 3.0 hub has crashed.

1. Disconnect the USB and power supply cable from the hub.
2. Reconnect both.

Result: The camera is recognized again.

7. The camera, **connected directly to the PC**, is not recognized anymore. Check if a hub included in the **USB host controller** has crashed.

1. In the **Device Manager**, deactivate the host controller. For **Windows®**, see *Installing the camera driver with Windows® tools* on page 63.
2. Reactivate the host controller.

Result: The camera is recognized again.

Unexpected events

How do I get the camera back to normal operation?

1. Check if an error is displayed by the **camera LEDs**.

   If: The *Status LEDs* signal other codes than for normal operation.

   Then: Please contact support with this information: *support@alliedvision.com*

2. Check if **power cables**, such as cables with a high current in the environmental setup, **harmfully interfere with camera cables**.

   If: Any camera cable crosses or goes parallel with a power cable.

   Then: Separate camera cables from power cables.

3. Make sure the **camera is intact**.
   For this, exclude issues of the cable or the connected PC:

   1. Connect the camera with a **different cable** to a **different PC**.

   If: The camera works properly.

   Then: The camera is intact, but your previous PC and/or cable have/has a defect. Continue with 2.

   If: The camera does not work properly.

   Then: Most likely, the camera has a defect. Please contact Allied Vision support.

   2. Connect the camera with the **previous cable** to the **different PC**.

   If: The camera works properly.

   Then: Replace the cable.

   3. Connect the camera with the **replaced cable** to the **previous PC**.

   If: The camera does not work properly.

   Then: Check the PC to fix the issue.

4. **Why does the camera not transfer images after restart?**
   This happens if the camera is started with a user set including trigger settings, but the camera does not receive a trigger.

   Check if a user set is active that is requiring a trigger for camera acquisition or exposure.

   If: User settings require a trigger.

   Then: Send the camera the corresponding trigger.

   Or: Change user settings and deactivate trigger settings to control the camera without triggering.

5. **What can I do if the camera crashes when using a third party camera driver?**

   Check if the camera is operated with a third-party driver causing the crash, the camera cannot be controlled nor stream images.

   This behavior may happen if:

   - The camera is operated in `AcquisitionMode` = *`Continuous`*.
   - The application sends register write commands immediately after an `AcquisitionStop` command.

   First aid

   Disconnect the camera and reconnect it again for a hard reset.

   Permanent solution (if possible)

   Install the Vimba camera driver, see *Installing the camera driver* on page 62.

   Interim solution (until we can offer a permanent solution)

   Insert a timed delay of 100ms between an `AcquisitionStop` command and the next register write command.

Performance

How can I improve camera performance?

1. Check if the **hardware** sufficiently supports your USB camera.

   See *Recommended USB 3.0 accessories* on page 53.

2. Check if the **camera shares the bus with other devices** reducing the available bandwidth.

   Connect the camera to an individual bus, not shared by other devices.
   For more information, see *Dividing bandwidth between devices on a common USB 3.0 bus* on page 112.

3. Check if the **camera is connected to cascading hubs**, reducing the available bandwidth.

   Attach devices directly to a separate USB 3.0 bus. If you want cameras to share a common bus, use only a single hub to attach devices. For more information, see *Dividing bandwidth between devices on a common USB 3.0 bus* on page 112.

4. Check if all your USB **accessories support USB 3.0**.

   See *USB 3.0 cards, hubs, and cables* on page 53 for recommended USB 3.0 accessories.

Radio signal interference

How can I avoid radio signal interference from wireless devices?

1. Ensure camera installation complies with **Electromagnetic Compatibility**.

   Wireless devices and USB 3.0 commonly use 2.4 GHz frequency (WLAN uses 2.4, 3.6, and 4.9 GHz).

   Even USB 3.0 cables can interfere harmfully with other electromagnetic devices. For example, despite shielding, a USB 3.0 cable can interfere with a wireless mouse. Tests have shown an increase of the noise floor up to 20 dB for the affected devices.

   - To enable maximum bandwidth, 2.4 GHz radio frequencies must be avoided; therefore, use **maximum shielded cables only**.
   - Keep **maximum distance** between USB 3.0 camera setup and interfering devices.
   - Use **high-gain antenna**s to reduce power of the radio signals.

   For tested USB 3.0 accessories, see *Accessories* on page 52.

Optimizing performance

Dividing bandwidth between devices on a common USB 3.0 bus

Increase bandwidth

- To obtain maximum bandwidth, attach the camera to a separate bus. Sharing bandwidth with other devices decreases maximum bandwidth for the Mako U camera.
- For maximum bandwidth, use a current version host controller card (see *USB 3.0 cards, hubs, and cables* on page 53).
- USB3 Vision devices use bulk transfer. When these devices are combined using other transfer modes, bandwidth may be assigned differently.
- Control bandwidth by assigning the desired amount to the separate cameras.

The following example is about 2 cameras in an ideal setup:

- Control traffic is ignored.
- The possibility of the host being busy with other tasks is ignored.
- Cameras share 100% bus bandwidth.
- Cameras need 100% bus bandwidth in total.
- Cameras stream in the same way because they are the same model and have identical settings.
- No other device is connected.

Result:

- Bandwidth is divided by two, they get 50% bandwidth each. (For 3 cameras, the bandwidth is 33,3% each.)
- If one camera sends no data, the other camera will be assigned 100% bandwidth. To always assign 50% to both cameras, they have to be controlled to use no more than 50% bandwidth each.
- If the PC does not receive images from a camera, images may be delayed or even dropped.

Reducing bandwidth use for a camera

To insure sufficient bandwidth to each camera, you can limit maximum bandwidth use by the `DeviceLinkThroughputLimit` feature.
See *USB Vision Features Reference* at **Additional Documents** for the Mako U camera: https://www.alliedvision.com/en/support/technical-documentation.

Assigning maximum bandwidth to a camera

To assign maximum bandwidth to a camera, make sure your camera is the only device on the bus.

Consider devices, such as a monitor or a mouse, sharing bandwidth with the USB3 Vision camera connected to the same bus.

Delayed data transfer

For more demanding applications, using the camera's image memory allows high performance acquisition with delayed data transfer to the PC for a limited period of time. For more information, see tables for each camera in *Specifications* on page 20.

Cascading hubs divide bandwidth

The following example applies to standard behavior without individual settings. The graphics show bandwidth distribution on a common bus. Three cameras try to use full bandwidth at the same time. If one camera is inactive, the host will provide its share to the others until this camera sends data again.

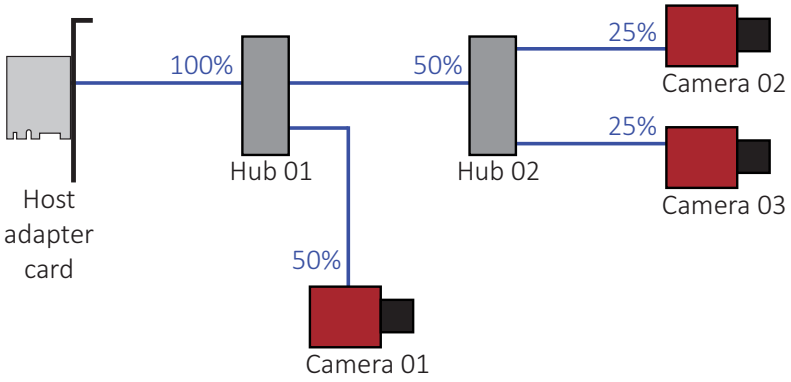


Figure 43: *Bandwidth assignment for cascading hubs*

Setting the camera to fallback mode

If a firmware update fails for any reason (for example, when disconnected during an update), the camera firmware may get into a non-functional state. To ensure a successful firmware update, follow the instructions below.

Notice

Use the fallback switch cautiously

Slightly press a paper clip into the hole with the fallback switch.

A needle or a thin wire could damage the switch.
Pressing anything against the LEDs can damage them.

Camera settings are preserved

At fallback, camera settings are preserved. You do not have to reconfigure the camera after setting the camera to fallback mode.

1. Before you continue with step 2, read the warnings above.
2. Disconnect the camera.
3. Push a paper clip against the fallback switch (see *Figure 44*).
4. Keeping the paper clip pressed, connect the camera to USB.

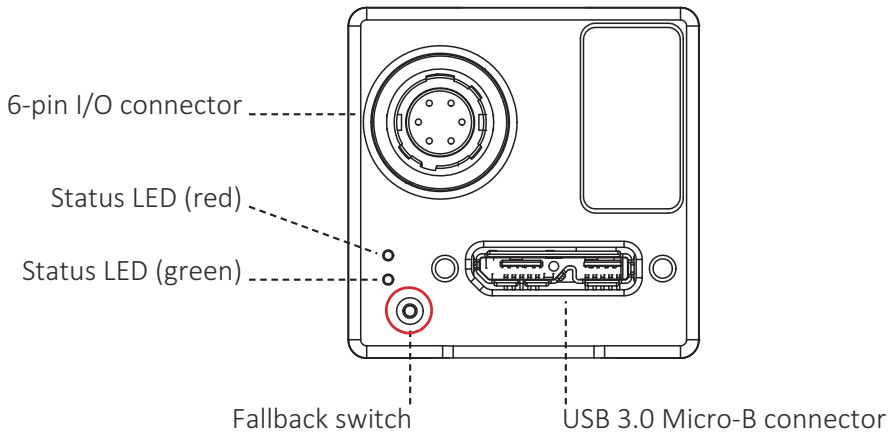


Figure 44: *Mako U back panel view with fallback switch*

Result: this sets the camera to **Firmware fallback mode.**

5. Execute the firmware update, see *Updating the firmware* on page 98.

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