Allied Vision

USB3 Vision Cameras

Mako U

Technical Manual

V1.1.7

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

2019-Feb-27

Mako U at a glance

Read this manual carefully

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

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 60.
- For ordering USB 3.0 accessories, see https://www.alliedvision.com/en/meta-header/contact/contact-sales.

Notice

Avoid damage to the camera by exceeding the allowed temperature range

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 26).
- Follow the instructions described in Heat dissipation on page 25.

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 SDK for Windows and Linux (Windows: including USB driver installer)	https://www.alliedvision.com/software

Table 1: Mako U, additional downloads overview

Contact us

Connect with Allied Vision colleagues by function:

www.alliedvision.com/en/contact

Find an Allied Vision office or distributor:

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

Email:

info@alliedvision.com (for commercial and general inquiries)
support@alliedvision.com (for technical assistance with Allied Vision products)

Sales offices:

Europe, Middle East, and Africa: +49 36428-677-230
North, Central, and South America: +1 877 USA-1394
Asia-Pacific: +65 6634-9027
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Document history and conventions

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Document history

Version	Date	Remarks
V1.0.0	2015-Nov-13	New manual: Release status
V1.1.0	2017-Jul-27	Added information that S-Mount is the same as M12-Mount in Applied standards and in Filters and M12-Mount adapter. Added information on EMVA1288 measurement uncertainty in Applied standards. Corrected plots for absolute quantum efficiency in Specifications. Added information about the LED indicator status in Status LEDs and in LED codes for a firmware recovery. Updated styles to improve usability. Added notes on BIOS and driver updates to avoid material damage or to increase performance. Corrected note about tripod adapter in Mako tripod adapters. Added note about an error when connecting the camera to a USB 2.0 port in Installing the camera driver. Corrected technical drawing of Mechanical dimensions. Updated descriptions of Symbols and notes. Added color codes for I/O cables in I/O connector pin assignment. Replaced information on supported operating systems in Installing the camera by referring to the **Vimba** website. Updated screen shots related to **Vimba Driver Installer**. Corrected typographic, grammatical, and formatting issues.
V1.1.1	2017-Sep-27	Corrected trigger cable color coding in I/O connector pin assignment on page 77.
V1.1.2	2017-Nov-06	Corrected exposure times for Mako U-503 in Mako U-503B specifications on page 43.
V1.1.3	2018-Jan-16	Reorganized contents in Safety on page 17. Applied minor changes.

Table 2: Document history

Version	Date	Remarks
V1.1.4	2018-Jul-10	Updated figures in Ground loops on page 18. Removed discontinued hub from Accessories on page 59.
V1.1.5	2018-Dec-14	Fixed broken links. Corrected information on power input and I/Os in Electrical connections on page 17. Minor corrections. Added contents for camera EMC compliance in Camera power on page 17 and in I/Os and GPIOs on page 17.
V1.1.6	2019-Feb-19	Updated title image. Added data about shock and vibration.
V1.1.7	2019-Feb-27	Applied editorial changes.

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
Emphasis	Programs, or highlighting important things
Publication titles	Publication titles
Weblinks and references	Links to web pages and internal cross references
`Features`	Feature names
`Feature values`	Input value names

Table 3: Styles

Symbols and notes

Safety message

Note to prevent physical injury.

Property damage message

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

Safety-related instructions to avoid malfunctions

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

Practical hint

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

Further information available online

This symbol highlights URLs for further information. The URL itself is shown in blue. Example: https://www.alliedvision.com

Product naming

Names of third-party products in this document are shortened to ease reading. Nevertheless, we respect all manufacturer rights and trademarks.

Official product name	Naming in this document	Manufacturer website
Linux operating system	Linux	https://www.linux.com/
Microsoft Windows Operating System	Windows	https://www.microsoft.com
ON Semiconductor	ON Semiconductor	http://www.onsemi.com
Siemens Simatic	Siemens Simatic	https://www.siemens.com

Table 4: Third-party product naming

Compliance, safety, and intended use

This chapter includes:

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Compliance notifications

For customers in Europe:

Allied Vision has demonstrated the fulfillment of the requirements relating to the Mako U camera family:

- Directive 2014/30/EU (Electromagnetic compatibility)
- Directive 2011/65/EU, incl. amendment 2015/863/EU (RoHS)
- Directive 2012/19/EU (Waste of Electric and Electronic Equipment, WEEE)

For customers in the USA

United States of America: Supplier Declaration of Conformity

Mako U cameras comply with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

Responsible Party – U.S. Contact Information

Allied Vision Technologies, Inc.
102 Pickering Way – Suite 502
Exton, PA 19341
Tel: +1 978 225 2030

Note: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Class B digital device

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, 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 separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

We caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Avoid electromagnetic interferences

For all power and interface connections, only use shielded cables or cables recommended by Allied Vision.

Camera applications and intended use

General use

- The camera is intended for use in a commercial, industrial, or business environment. The test phase and programming should be carried out by advanced users.
- The user is responsible for operating the camera within the specifications that are defined in this document, and within appropriate environmental conditions and technical prerequisites, to ensure trouble-free camera operation.
- The camera is compliant with current data communication standards; however, those standards do not allow for self-monitoring. Thus, the camera cannot be used as a standalone device for security-related monitoring operations.
- The camera is a hardware product. Only when used with appropriate accompanying software, the camera will produce the desired results.
  The realization of intelligent solutions requires additional software that is suitable to run with the camera.
- The camera is a component, it is neither a complete product, nor is it a ready-made technical solution.
- The camera-supporting software can be obtained and installed separately from the camera. Usage of the software is solely the responsibility of the user.
- The camera must not be opened. For all repair tasks, contact Allied Vision or one of Allied Vision's authorized representatives.
- For usage in product with specific safety requirements a Quality Assurance Agreement with Allied Vision is required.
- Observe the intended use. The camera must only be used for purposes that are in conformity with the stated intended use.
- Additionally, refer to the warranty information on the Allied Vision website.

Use in medical devices

The camera provides basic adequacy to be used in medical devices as well, however, is not specially designated for operation in medical devices. When used as part of a medical device, a review of the specific application is necessary. For usage in medical product, a Quality Assurance Agreement with Allied Vision is required. Users who integrate the camera into an application must comply with the rules and regulations concerning medical devices.

Copyright and trademarks

Safety

Handling and operating of Mako U cameras does not include risks of personal injury. To prevent material damage, read the following and understand how to safely handle and operate the camera. Get helpful details about USB 3.0 and learn how to optimize camera performance.

Electrical connections

Electrostatic discharge (ESD)

The phenomenon is commonly known: when walking on a carpet, we get charged. Touching a door handle, we get an electric shock. Such electrostatic discharge (ESD) is dangerous for electronic devices, especially when tools or hands get in contact with connectors. We recommend measures to avoid damage by ESD:

- Unpacking: Remove the camera from its anti-static packaging only when your body is grounded.
- Workplace: Use a static-safe workplace with static-dissipative mat and air ionization.
- Wrist strap: Wear a static-dissipative wrist strap to ground your body.
- Clothing: Wear ESD-protective clothing. Keep components away from your body and clothing. Even if you are wearing a wrist strap, your body is grounded but your clothes are not.

Camera power

Mako U cameras are powered over USB 3.0. They do not need external power to be operated or to be configured. The Hirose I/O connector is for camera control only. Connecting a power supply to the Hirose I/O connector can damage the camera.

The camera is not intended to be connected to a DC distribution network.

I/Os and GPIOs

Mako U GPIOs are for camera control only, see Camera power on page 17.
Exceeding maximum input voltage can damage the camera. Keep maximum input voltage below 30 VDC.
Connecting the camera to a device that exceeds the allowed maximum current or voltage can damage the camera. Keep maximum current below 25 mA per output and maximum Out VCC below 24 VDC. See Specifications on page 26 for details.

The maximum length for I/O cables must not exceed 30 m.

GPIOs are more sensitive to electromagnetic interference than opto-isolated I/Os. Use GPIOs only in environments with low electromagnetic interference.

Ground loops

Unsuitable connection can lead to a short circuit caused by ground loops between USB GND, GPIO GND, and environmental setup GND. This short circuit can lead to malfunctions or destroy camera and connected devices. Mount the camera electrically isolated to avoid ground loops.

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.

Graphics legend

Gray line	Cable connection
Black line	PE ground

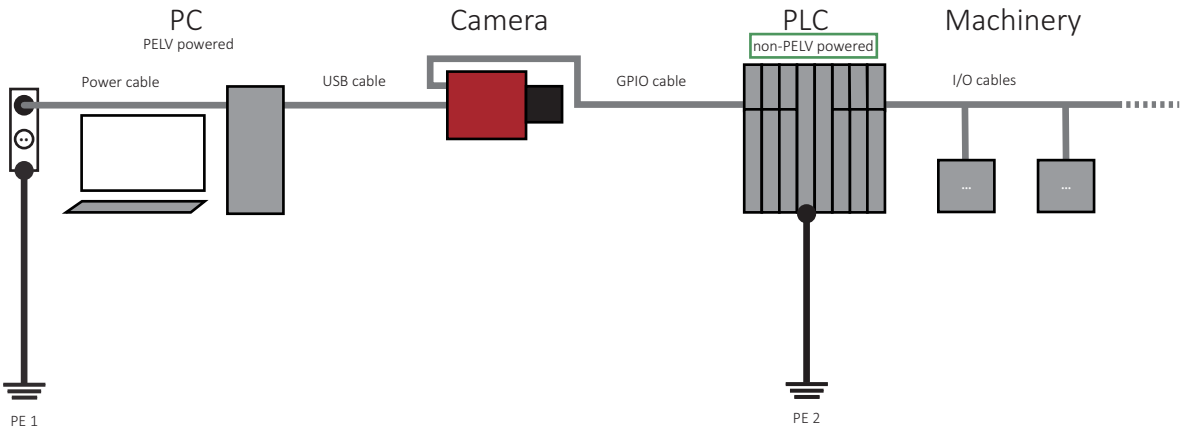

*Figure 1: No ground loop in an environmental setup **without** PELV-powering*

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 may 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
Black line	PE ground
Red line	Ground loop

Ground loop: GPIOs and PELV devices

In Figure 2, 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 21.

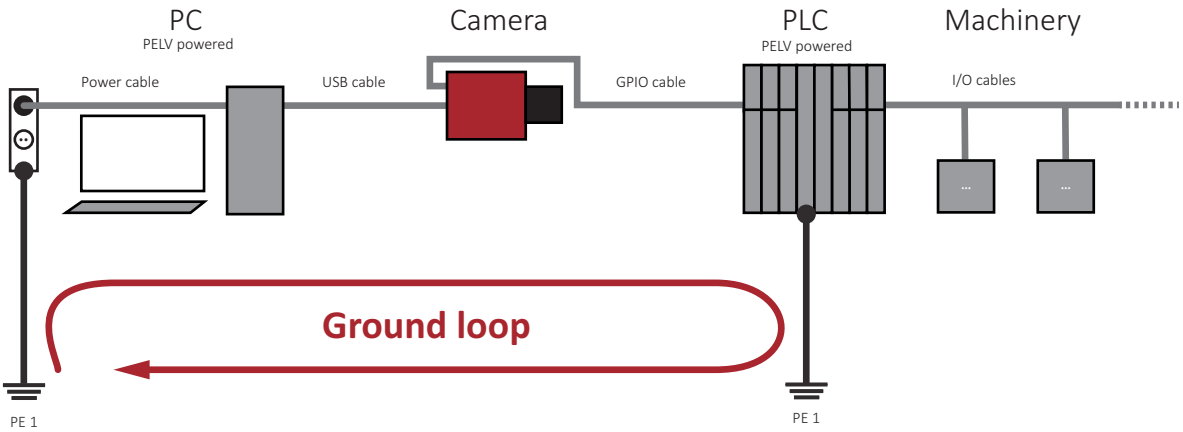

Figure 2: Ground loop when using GPIOs

Setups to avoid ground loops

Graphics legend

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

No ground loop: GPIOs and barrier isolator

In Figure 3, a **barrier isolator** between camera GPIO and the environmental setup avoids ground loops.

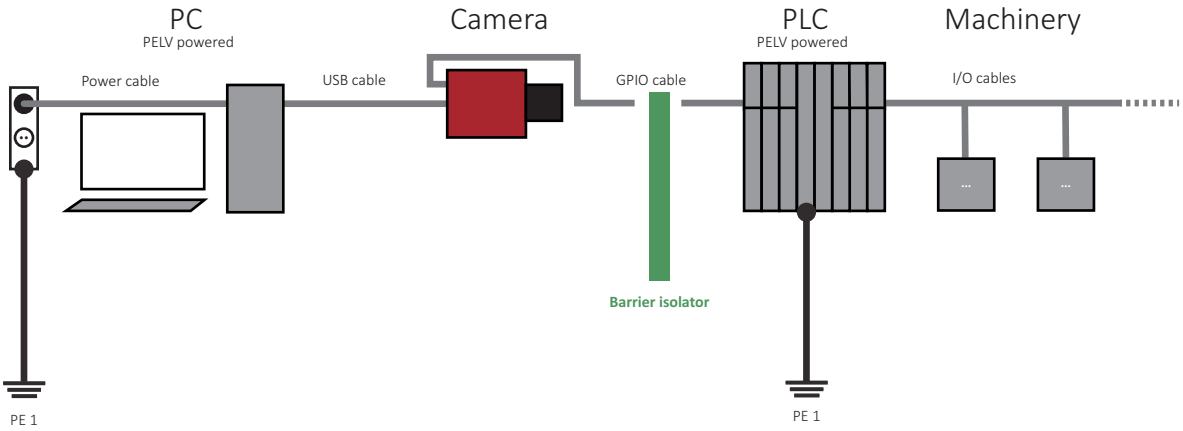

Figure 3: No ground loop when using a barrier isolator

No ground loop: Opto-isolated I/Os

In Figure 4, 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.

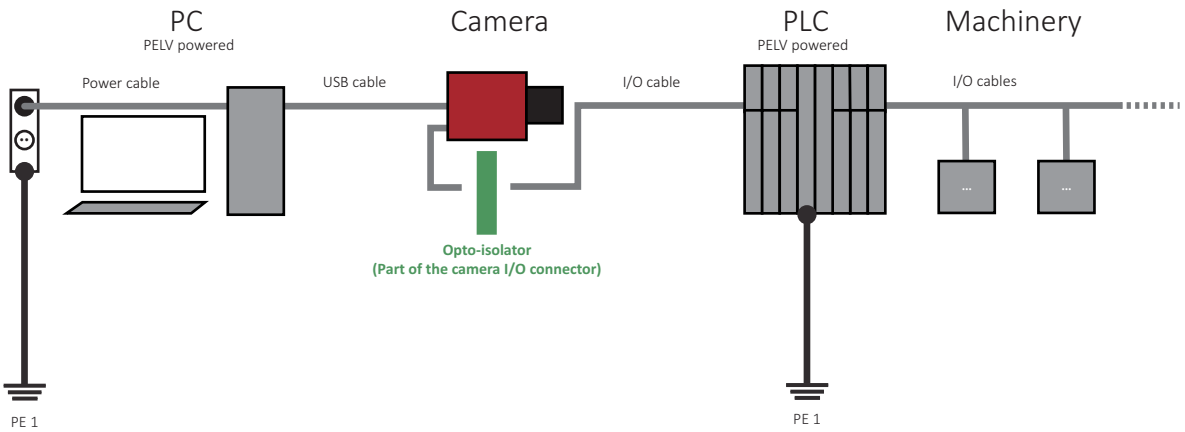

Figure 4: No ground loop when using opto-isolated I/Os (instead of GPIOs)

USB connection

USB 3.0 host controllers and hubs

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 59.

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.

USB cables

Proper cable handling enables reliable performance:

- 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 cameras and USB 2.0

If Mako U cameras are connected to USB 2.0 ports, they are recognized as USB3 Vision devices in the Device Manager; but they are not shown in Vimba and cannot be operated.

Performance

For reliable bandwidth assignment to the camera, it should share the same bus only with devices using bulk transfer. See Dividing bandwidth between devices on a common USB 3.0 bus on page 114.

Optical components

Image sensor

Image sensors are sensitive to excessive radiation: focused sunlight, lasers, and X-rays can damage the sensor. Mako U cameras are not fitted with filter or protection glass. Consider, when removing the lens or dust cap on these cameras, the sensor is not protected against dirt or scratches.

Lenses

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

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

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:

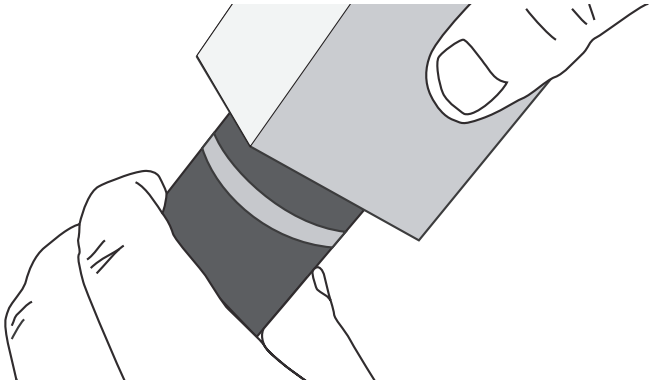

Figure 5: Holding the camera with the lens mount facing the ground

Maximum protrusion

If the lens exceeds maximum protrusion, camera or lens may be damaged. Use lenses with a maximum protrusion within camera specifications. The figure below shows maximum protrusion with a built-in filter. Mako U cameras come without filter or protection glass. For details, see Lens mounts on page 47.

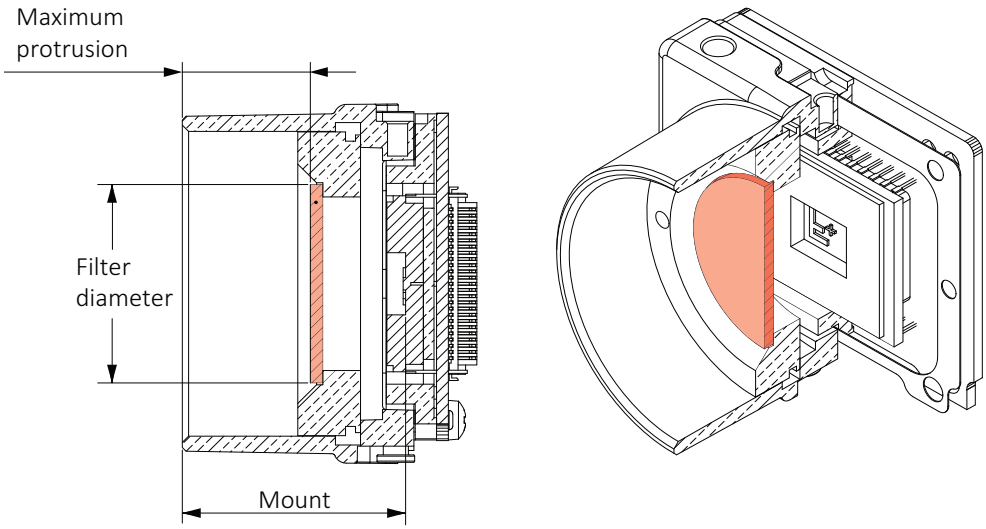

Figure 6: Mount and protrusion

Cleaning optical components

New Allied Vision cameras do not need additional cleaning. Cameras are cleaned before shipping. Reference images for each camera document cleaning quality.

However, if cleaning is necessary:

- Use only recommended cleaning material.
- Be extremely careful 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.
- Follow the cleaning instructions in Cleaning optical components on page 102.

Cleaning liquids

The cleaning liquids appropriate for camera cleaning are highly flammable.

- Ensure proper ventilation when working with these liquids. Avoid accumulation of dangerous fumes.
- Disconnect the camera and let it cool down to room temperature before cleaning.

Compressed air

We recommend wet cleaning, see Cleaning optical components on page 102.
If wet cleaning does not succeed, we recommend you to contact support@alliedvision.com.

In general, compressed air should be avoided. Wrong handling can damage optical components irreversibly, especially the sensitive sensor. 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.

Heat dissipation

Operation outside the allowed temperature range can damage the camera.
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 74).
  - Use mounting base and heat sink with large surface areas.
  - Use a mounting base with a high thermal conductivity.
- Reduce ambient temperature. For example, in an outdoor application with direct sunlight, provide shading by an enclosure.
- Provide ventilation or other active cooling of camera, mounting base, and heat sink.

BIOS drivers

Sometimes, USB 3.0 component's firmware must be updated before operation, including devices, such as host adapters cards.

To avoid damage and to benefit from possible updates to increase performance: Check for BIOS updates related to USB 3.0.

Specifications

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Applied standards

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 (GenCP) V1.0
- GenICam Pixel Format Naming Convention (PFNC). V2.0

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).

IP class

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

Shock and vibration

Cameras were successfully tested according to the following standards:

- DIN ISO 9022-3-37-01-1, Random vibration testing
- DIN ISO 9022-3-30-03-1, Shock testing
- DIN ISO 9022-3-31-01-1, Bump testing.

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 67.
- For USB 3.0 cards and cables, see Accessories on page 59.

Mako U-503B characteristics

Mako U-503B differ in some characteristics from Mako U-029B, 051B, and 130B models. See Mako U-503B characteristics on page 40.

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.

User data memory

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

Writing data to the user data memory

1. Copy previous data from the user data memory for recovery.
2. Delete previous data from the user data memory.
3. Write new data to the user data 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, exposure start. 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.

ExposureMode

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

Controlling exposure time using TriggerWidth

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

Absolute quantum efficiency (QE) plots

All measurements were done without protection glass / IR cut filter. With protection glass or filters, quantum efficiency (QE) decreases by approximately 10%. The uncertainty in measurement of the QE values is ±10.25%. This is mainly due to uncertainties in the measuring apparatus itself (Ulbricht sphere, optometer, etc.). Manufacturing tolerance of the sensor increases overall uncertainty.

ON Semiconductor CMOS sensors

The curve in the absolute QE plots shown in this chapter is from the sensor manufacturer data sheet. The information was correct at the time of publishing.

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 60.

For maximum bandwidth, connect each camera to a separate bus. For more information, read Optimizing performance on page 114.

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.

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-029B / 051B / 130B 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 31.

Feature	Specification
Sensor	
Sensor details	1/4” (diag. 3.8 mm) progressive scan CMOS ON Semiconductor 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
User data memory	1 MByte
Trigger ExposureMode types	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 to 0.8 VDC (low) / 2 to 24 VDC (high) As open collector outputs: 3.3 to 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 Filters and M12-Mount adapter on page 64.
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)

Table 6: Specifications Mako U-029B

Mako U-029B absolute quantum efficiency

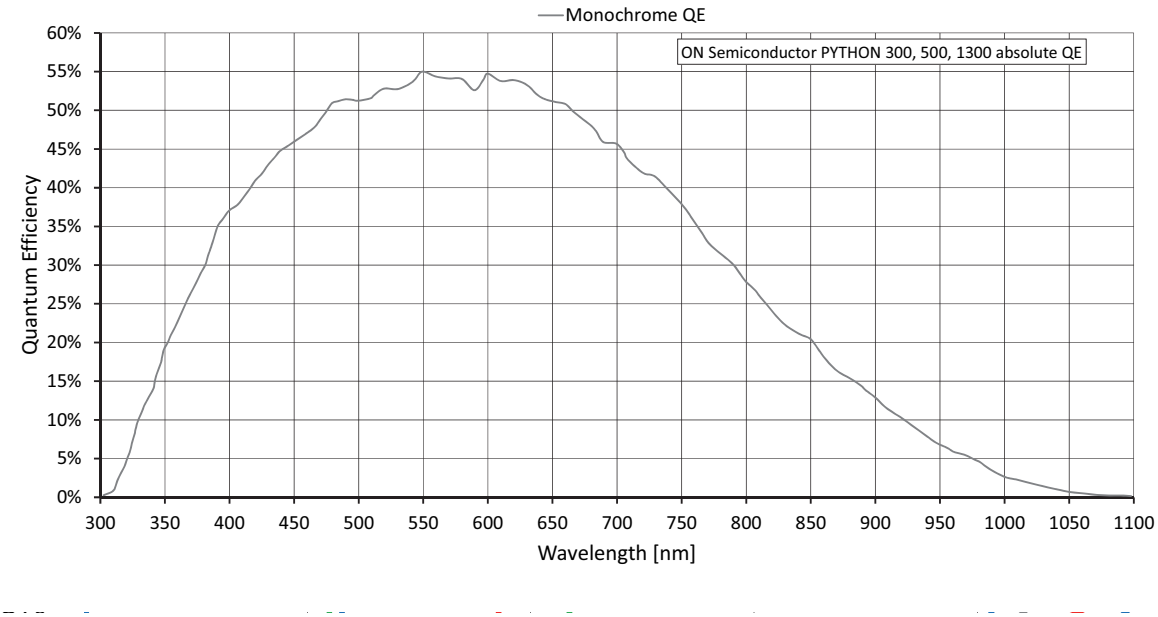


Figure 7: Absolute quantum efficiency Mako U-029B (ON Semiconductor PYTHON 300)

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-029B

Mako U-051B specifications

Camera characteristics

See Mako U-029B/051B/130B characteristics on page 31.

Feature	Specification
Sensor	
Sensor details	1/3.6” (diag. 4.8 mm) progressive scan CMOS ON Semiconductor 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
User data memory	1 MByte
Trigger ExposureMode types	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 to 0.8 VDC (low) / 2 to 24 VDC (high) As open collector outputs: 3.3 to 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 Filters and M12-Mount adapter on page 64.
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)

Table 8: Specifications Mako U-051B

Mako U-051B absolute quantum efficiency

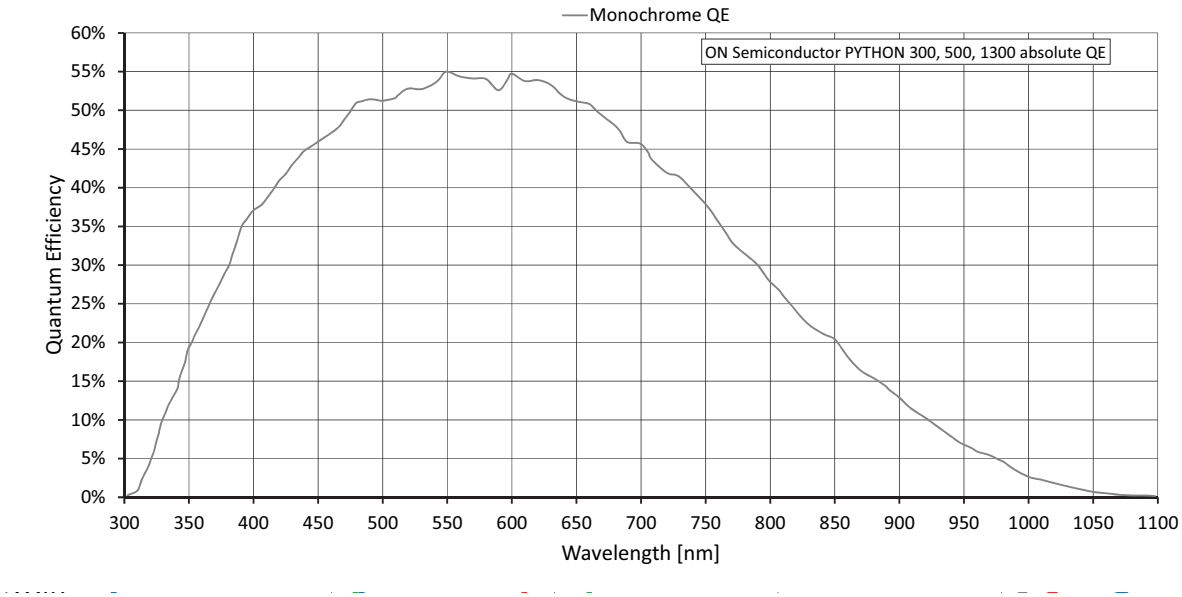


Figure 8: Absolute quantum efficiency Mako U-051B (ON Semiconductor PYTHON 500)

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-051B

Mako U-130B specifications

Camera characteristics

See Mako U-029B/051B/130B characteristics on page 31.

Feature	Specification
Sensor	
Sensor details	1/2” (diag. 7.9 mm) progressive scan CMOS ON Semiconductor 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	10-bit
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
User data memory	1 MByte
Trigger ExposureMode types	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 to 0.8 VDC (low) / 2 to 24 VDC (high) As open collector outputs: 3.3 to 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 Filters and M12-Mount adapter on page 64.
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)

Table 10: Specifications Mako U-130B

Mako U-130B absolute quantum efficiency

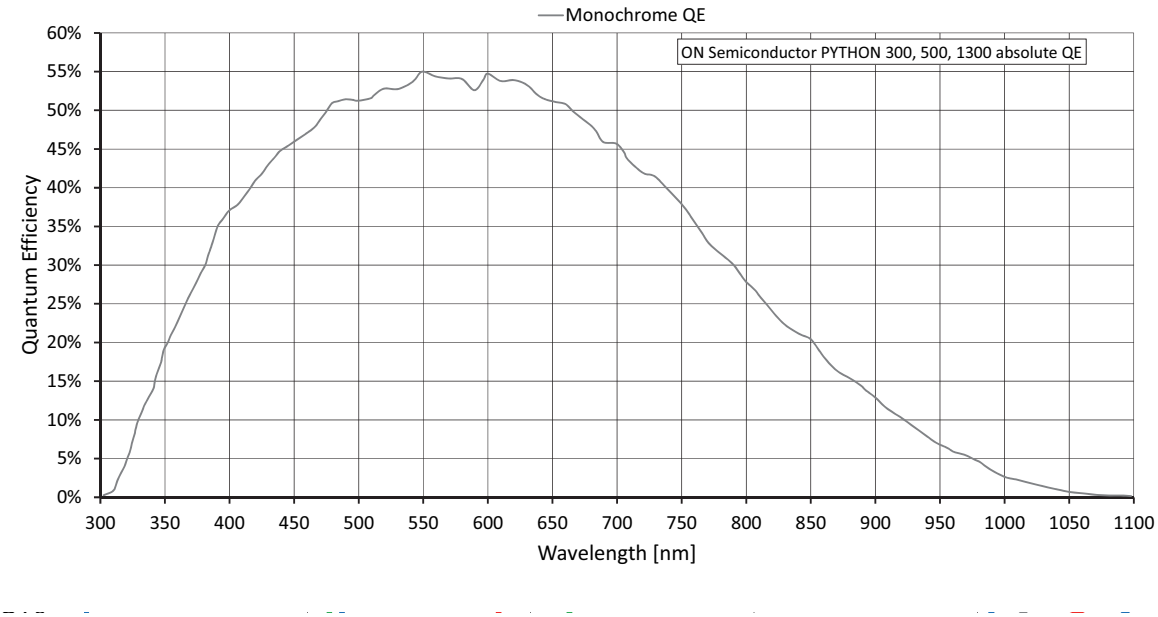


Figure 9: Absolute quantum efficiency Mako U-130B (ON Semiconductor PYTHON 1300)

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-130B

Mako U-503B characteristics

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

- ExposureMode and triggering on page 40
- Rolling shutter on page 41
- Gain on page 42
- Reconfiguration delay on page 42.

ExposureMode and triggering

USB3 Vision features provide *TriggerWidth* as ExposureMode to control exposure by the trigger duration. Mako U-503B 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-503B camera has a rolling shutter. Figure 10 shows the rolling shutter effect: Sensor lines (left) are integrated sequentially, the image (right) of a rotating fan appears distorted.

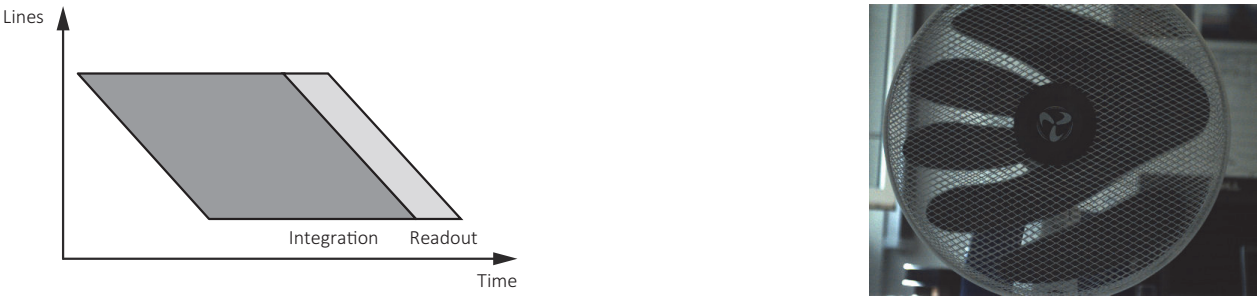


Figure 10: Rolling shutter effect with Mako U-503B

Mako U-029B / 051B / 130B models have global shutter. Figure 11 shows the global shutter: All sensor lines (left) are integrated simultaneously, the image (right) of a rotating fan appears natural.

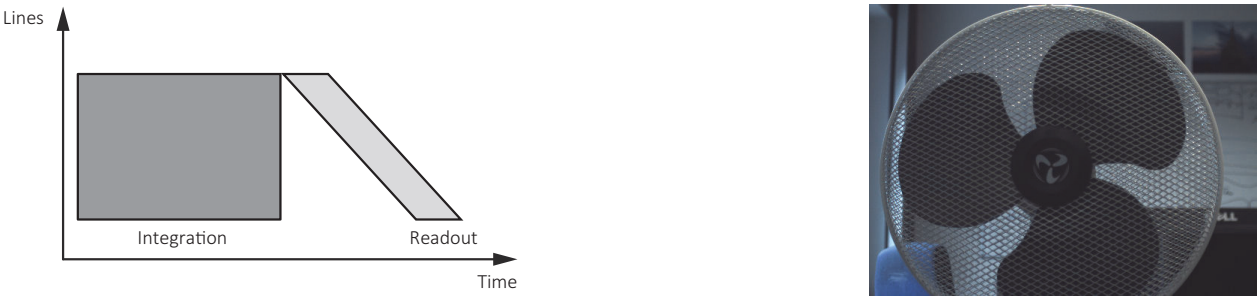


Figure 11: Global shutter effect with Mako U-029B / 051B / 130B

Avoiding the rolling shutter effect with the Mako U-503B camera. Figure 12 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.

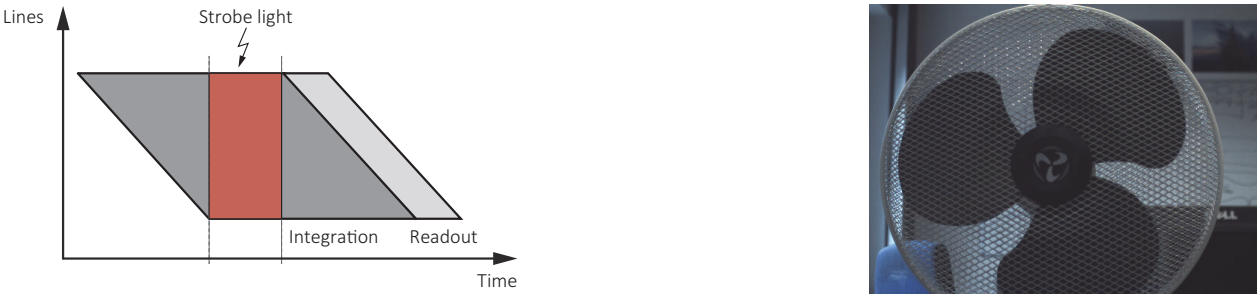


Figure 12: Avoiding the rolling shutter effect with Mako U-503B

Gain

The ON Semiconductor 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-503B 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.

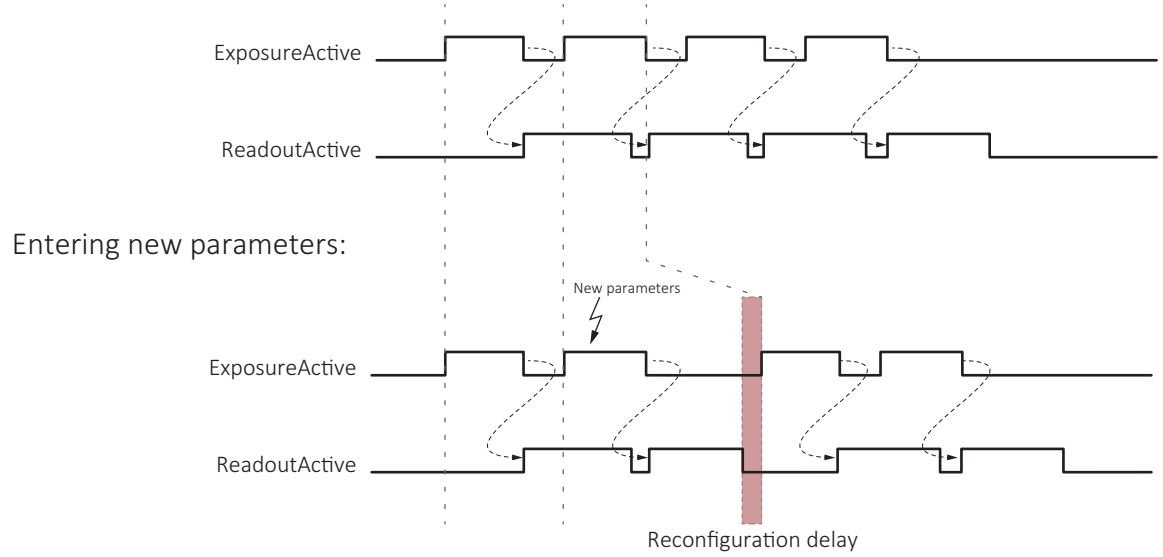


Figure 13: Delayed exposure due to parameters change, Mako U-503B

Mako U-503B specifications

Camera characteristics

See Mako U-503B specifications on page 43.

Feature	Specification
Sensor	
Sensor details	1/2.5” (diag. 7.13 mm) progressive scan CMOS ON Semiconductor 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 1.0 s
Gain control	0 to 17 dB (0.1 dB/increment)
Frame memory	128 MByte, up to 26 frames @ full resolution, Mono8
User data memory	1 MByte
Trigger ExposureMode types	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 46.
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 to 0.8 VDC (low) / 2 to 24 VDC (high) As open collector outputs: 3.3 to 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 Filters and M12-Mount adapter on page 64.
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)

Table 12: Specifications Mako U-503B

Mako U-503B absolute quantum efficiency

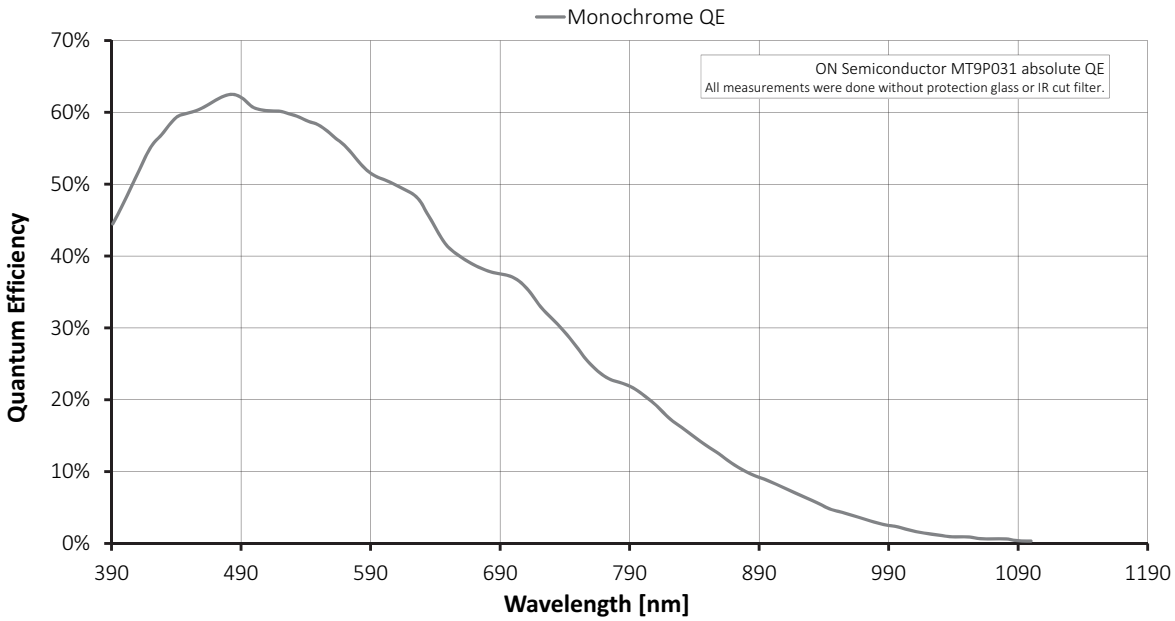


Figure 14: Absolute quantum efficiency Mako U-503B (ON Semiconductor MT9P031)

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 74.

Mako U housing

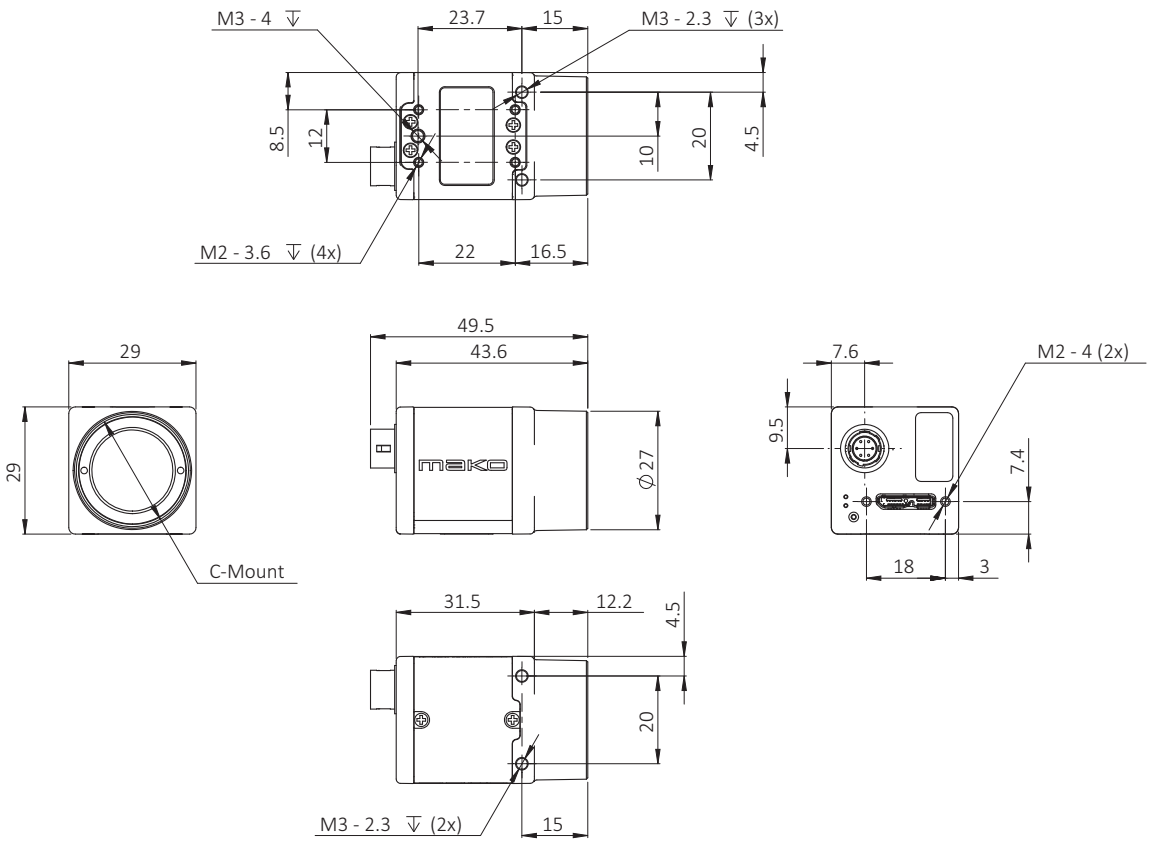


Figure 15: Camera dimensions Mako U housing

Mounting threads

For details on mounting threads, see Mounting the camera on page 74.

Tripod adapter

For details on the tripod adapter, see Mako tripod adapters on page 62.

Lens mounts

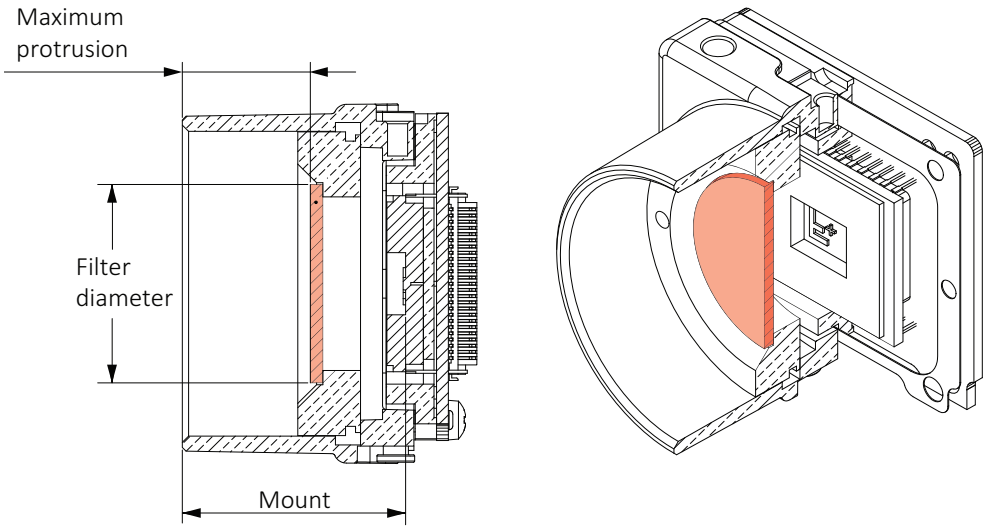


Figure 16: Mount and protrusion

Figure 16 shows maximum protrusion with a built-in filter. 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:

M12-Mount adapter

For M12-Mount adapter and maximum protrusion, see Filters and M12-Mount adapter on page 64.

Mount	Maximum protrusion	
	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.

The M12-Mount is also called S-Mount.

Sensor position accuracy

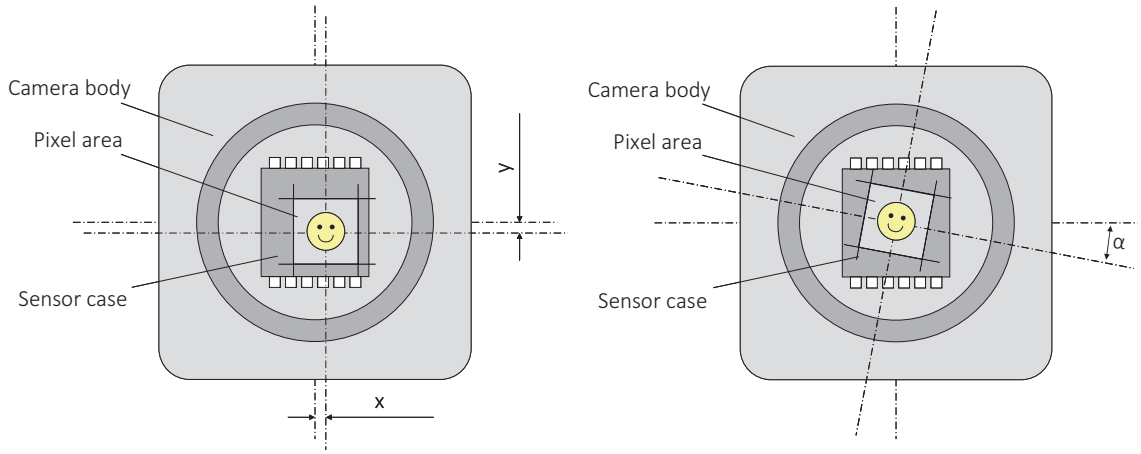


Figure 17: Defining sensor position accuracy

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 with Vimba

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

About camera features

This chapter lists available camera features for:

- Software coding with the Allied Vision transport layer (TL)
- Camera control with **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 96.

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 27.

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

Features list order

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 custom features
2	Mako U- 029B / 051B / 130B only
Italics	Default values

Camera features list

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	

Table 17: Camera features as seen with Vimba (Sheet 1 of 7)

Category	Feature	Type	Value
	TriggerMode[TriggerSelector]	Enumeration	
			Off
			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]

Table 17: Camera features as seen with Vimba (Sheet 2 of 7)

Category	Feature	Type	Value
	CorrectionSetSelector[1]	Enumeration	
			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 (Sheet 3 of 7)

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]
			AcquisitionTriggerWait

Table 17: Camera features as seen with Vimba (Sheet 4 of 7)

Category	Feature	Type	Value
			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
			Write
			Delete

Table 17: Camera features as seen with Vimba (Sheet 5 of 7)

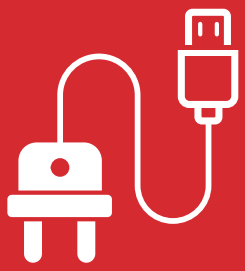
Category	Feature	Type	Value
	FileOperationStatus [FileSelector][FileOperationSelector]	Enumeration	
			Success
			Failure
			Invalid
			Denied
			Error
	FileProcessStatus[1] [FileSelector][FileOperationSelector]	Enumeration	
			UpdateNotRequired
			None
	FileSelector	Enumeration	
			Firmware
			UserData
			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
			Bpp10
			Bpp12
			Bpp16

Table 17: Camera features as seen with Vimba (Sheet 6 of 7)

Category	Feature	Type	Value
	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 (Sheet 7 of 7)

Accessories



This chapter informs about:

USB 3.0 cards, hubs, and cables 60
6-pin Hirose I/O cables 61
Mako tripod adapters 62
Filters and M12-Mount adapter 64
Lenses: Focal length vs. field of view 65

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 hardware combination influences the result; therefore, the available bandwidth cannot be predicted..

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	Product 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

Cables

Cables	Properties	Product 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 19: Recommended cables

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

Hirose connector cables for purchase from Allied Vision:

I/O cables	Properties	Product 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 20: 6-pin Hirose I/O cables for Mako U

Mako tripod adapters

Notice

Avoid damage to the camera by using inappropriate accessories

To avoid damage to Mako cameras, **use suitable tripod adapters only.**

The rear through hole of the Mako U tripod adapter enables the bolt to **dive in deeper**. This way, identical bolts can be used with both for Mako cameras.

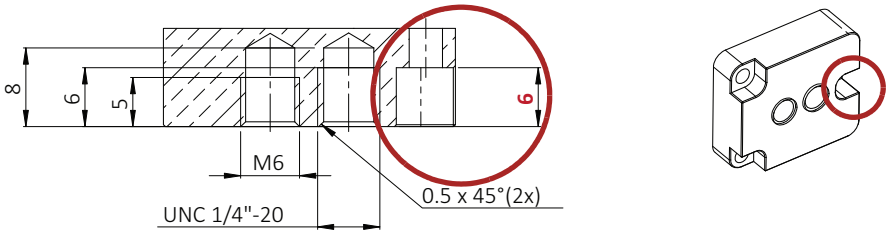
Mako U cameras

When the bolt is fit into the rear through hole of the **Mako U tripod adapter**, the bolt head dives 6 mm into the plate. The thread of the bolt dives 1.8 mm deeper into the Mako U screw holes to firmly connect camera and adapter.

If you mount the Mako U camera to the Mako U tripod adapter, all bolts can be fixed properly. Camera mounting is reliable.

If you mount the Mako U camera to the Mako G tripod adapter, the rear bolt cannot be fixed properly. Camera mounting is risky.

Mako U tripod adapter, product code 9222
see the rear mounting hole (red circles):



Mako G cameras

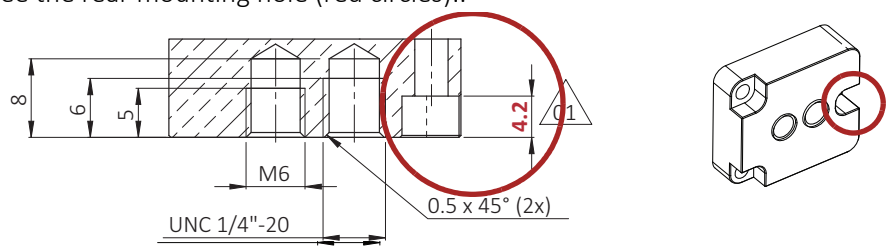
When the bolt is fit into the rear through hole of the **Mako G tripod adapter**, the bolt head dives 4.2 mm into the plate. This avoids the bolt penetrating the camera interiors, causing damage to the electronics.

If you mount the Mako G camera to the Mako G tripod adapter, all bolts can be fixed properly without causing damage to the camera. Camera mounting is reliable.

If you mount the Mako G camera to the Mako U tripod adapter, the rear bolt may intrude the camera interiors, causing damage to the electronics.

Mako G cameras: Mako G tripod adapter, product code 4807

see the rear mounting hole (red circles):.



Mako U tripod adapter dimensions

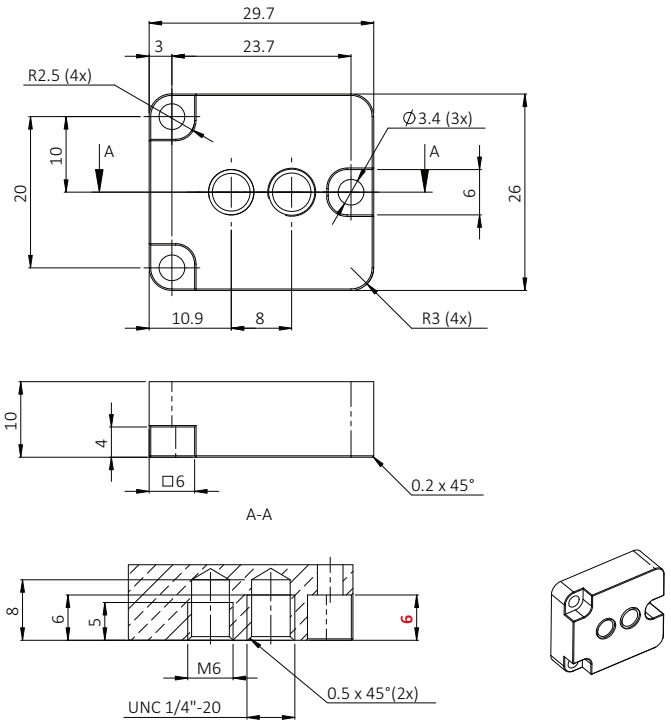


Figure 18: *Allied Vision Mako U tripod adapter dimensions (Allied Vision product code 9222)*

Filters and M12-Mount adapter

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).

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.

The M12-Mount is also called S-Mount.

Maximum protrusion (see Lens mounts on page 47) with the M12-Mount adapter is different for the particular lenses. Table 21 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 21: Maximum protrusion with M12-Mount adapter

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-029B, 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-029B)

Focal length: Mako U-051B, 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-051B)

Focal length: Mako U-130B, 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-130B)

Focal length: Mako U-503B, 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-503B)

Installing the camera

This chapter includes:

Prerequisites 68
Installing the camera using Vimba on a Windows system ... 69
Mounting the camera 74

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 directory of your **Vimba** installation, or see https://www.alliedvision.com/software.

Required components

Driver installation and OS support

Windows: Please use Vimba to install the camera driver. For Vimba system requirements and supported Windows versions, see https://www.alliedvision.com/software.

Linux: Allied Vision does not provide a special driver. For Vimba system requirements and supported operating systems, see https://www.alliedvision.com/software.

You need the following 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 60.

Installing the camera using Vimba on a Windows system

Instructions in this chapter describe camera installation using Vimba on a Windows system. Vimba supports various Linux distributions, including Vimba for ARM. However, it is impossible to give instructions suitable for Linux systems in this manual.

Vimba and Linux: 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 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 using the **Vimba camera driver**. If a third-party driver required for your application causes the camera to crash, see Unexpected event 5 on page 112.

Unexpected events

Should installation or operation not work properly, see Troubleshooting on page 108.

Installing USB 3.0 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**: https://www.alliedvision.com/software according to the instructions provided with the software download. During the Vimba installation, select at least **Camera Demonstration** and **Vimba Applications** to operate Mako U cameras.
3. Next step: Installing the camera driver on page 70.

Installing the camera driver

Connecting the camera to a USB 2.0 port

If the Mako U camera is connected to a USB 2.0 port, the Vimba driver cannot be installed, as shown below.

- Disconnect the camera and reconnect it to a USB 3.0 port.

1. Connect the Mako U camera to a USB 3.0 port of your PC.
   You can operate the camera under Vimba.

   If the camera is not recognized or if you want to subsequently change an assigned driver, follow the instructions below.

Command line driver installer

Vimba also provides a command line driver installer. For more information about the Vimba Driver Installer, see the *Vimba Manual*.

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 the Mako U camera entry.
   The current Vimba driver is offered as a popup (Vimba 2.1.1 in the example).
4. Click the Vimba driver popup.

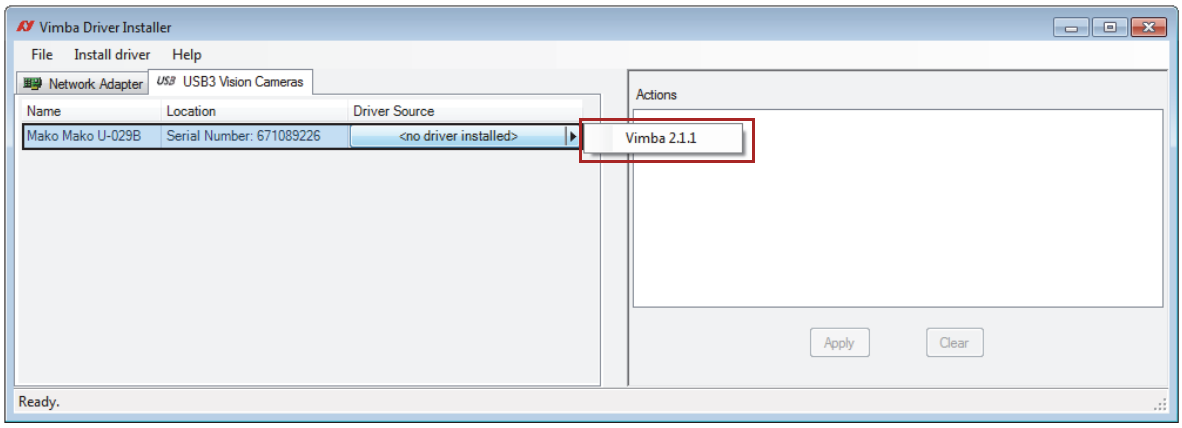


Figure 19: Vimba Driver Installer, camera driver not installed

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

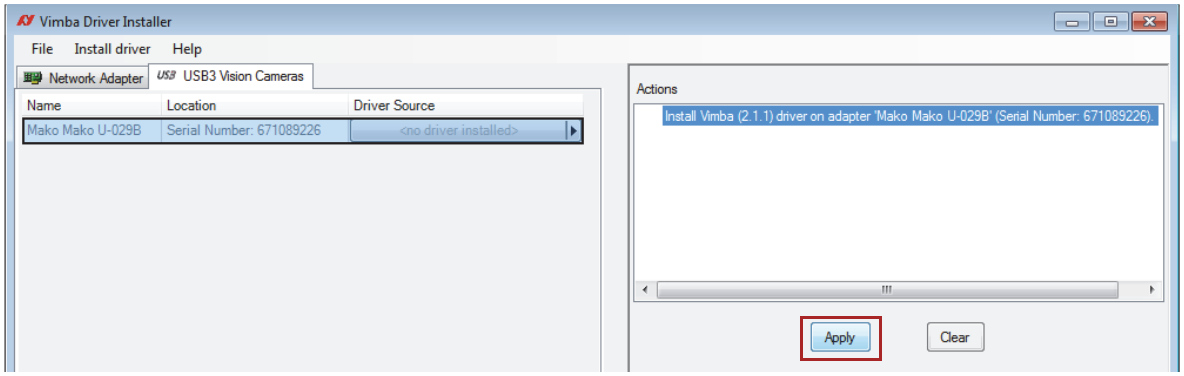


Figure 20: Vimba Driver Installer, driver installation started

The driver has been installed successfully.

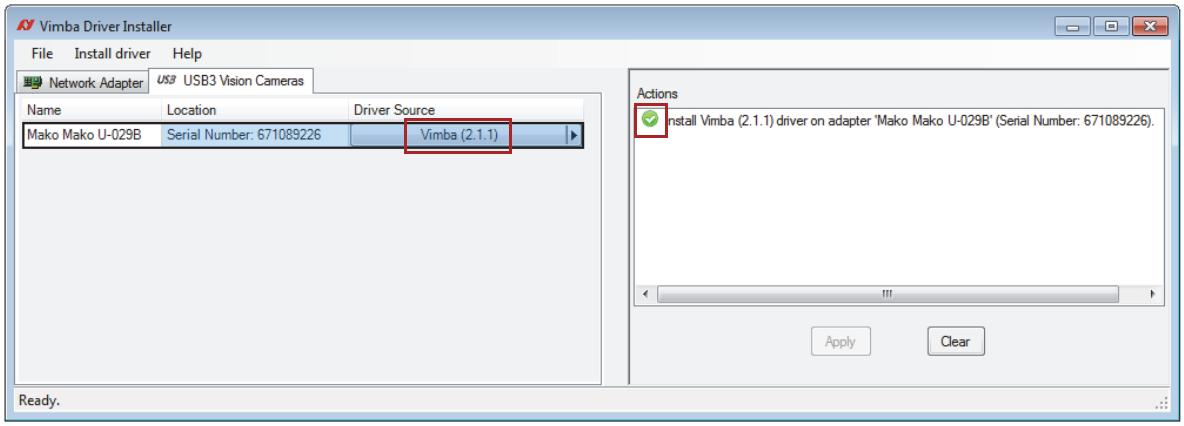


Figure 21: Vimba Driver Installer, driver installed successfully

Manual Vimba Driver installation

For manual Vimba Driver installation, see Installing the camera driver with Windows tools on page 72.

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.

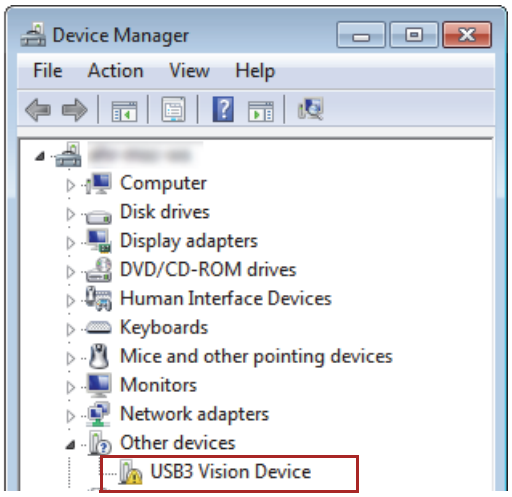


Figure 22: Windows Device Manager, Unrecognized USB3 Vision camera

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**.

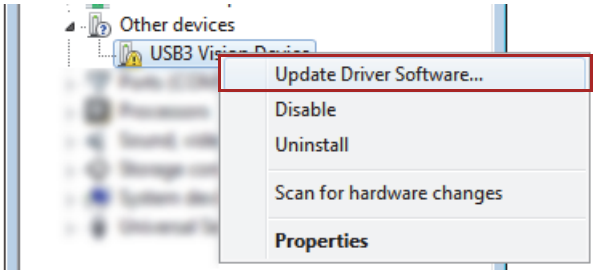


Figure 23: Windows Device Manager, Windows Driver Installer

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

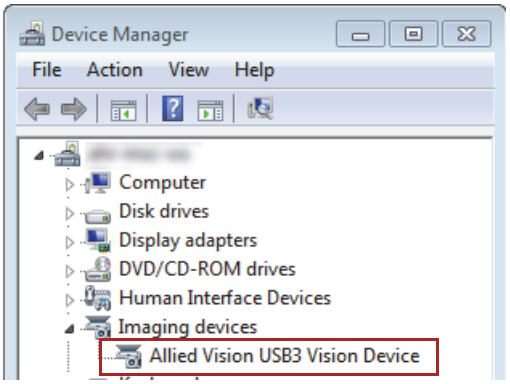


Figure 24: Windows Device Manager, USB3 Vision camera installed successfully

Mounting the camera

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 18.

Mount the camera using suitable bolts.

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

Make sure the mounting threads are intact.

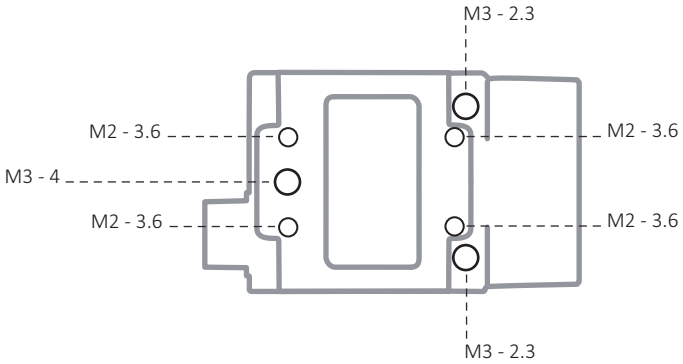


Figure 25: Mako U, Camera bottom with mounting threads

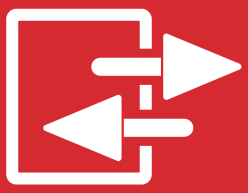
For the technical drawing, see Mako U housing on page 46.

Tripod adapter

1. Attach the camera to the tripod adapter using the M3 mounting threads (see Figure 25 above).
2. Screw the tripod adapter to the tripod with 1/4- 20 bolts.

For more information, see Mako tripod adapters on page 62.

Camera interfaces



This chapter includes:

Back panel 76
I/O connector pin assignment 77
Opto-isolated I/Os 78
Non-isolated, programmable GPIOs 82
Status LEDs 86

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

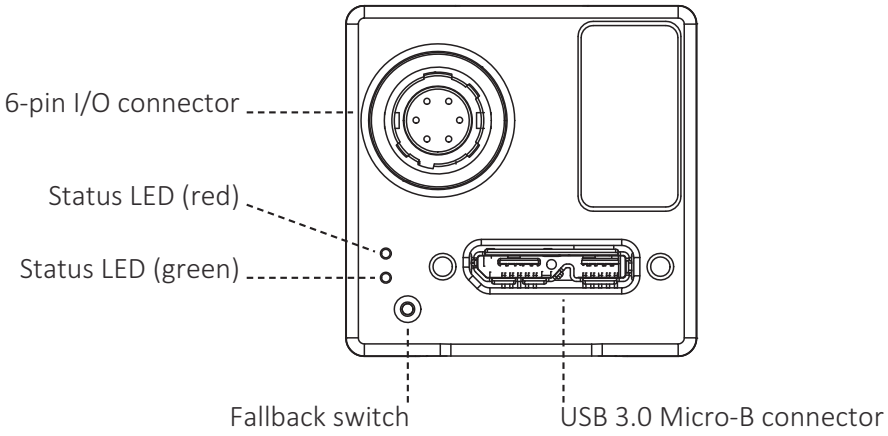


Figure 26: Mako U back panel view

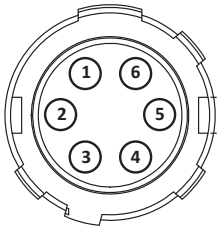
Interface descriptions

Interface	Section in this manual
6-pin I/O connector	I/O connector pin assignment on page 77
Status LEDs	Status LEDs on page 86
Fallback switch	Setting the camera to fallback mode on page 116
USB 3.0 Micro-B connector	Opto-isolated I/Os on page 78

Table 26: Interface descriptions overview

I/O connector pin assignment

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



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

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 HR10A-7P-6S(73) for soldering
- Hirose 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 61.

Opto-isolated I/Os

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

- In 1
- Out 1

Input description

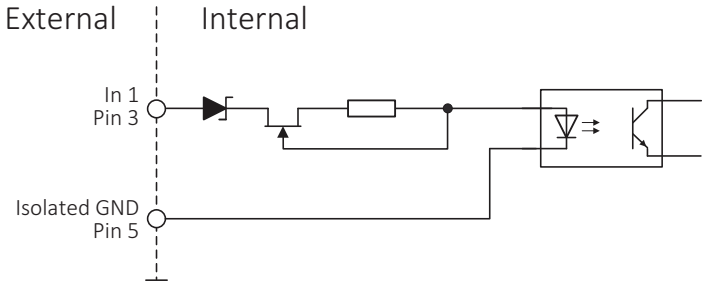


Figure 27: Opto-isolated input, block diagram

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 to 1.0 VDC
U_{in} (high)	3 to 24 VDC
Undefined levels	1.0 to 3 VDC
Current (constant-current source)	3 to 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 26.

The minimum pulse width for Mako U cameras is:

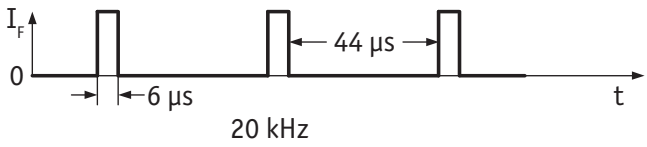


Figure 28: Opto-isolated input, minimum pulse width

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

Output description

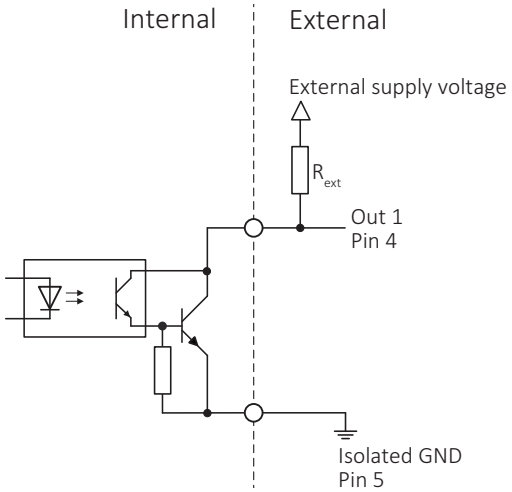


Figure 29: Opto-isolated output, block diagram

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 to 2 VDC
U_{out} (high)	3 to 24 VDC
Undefined levels	2 to 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 to 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

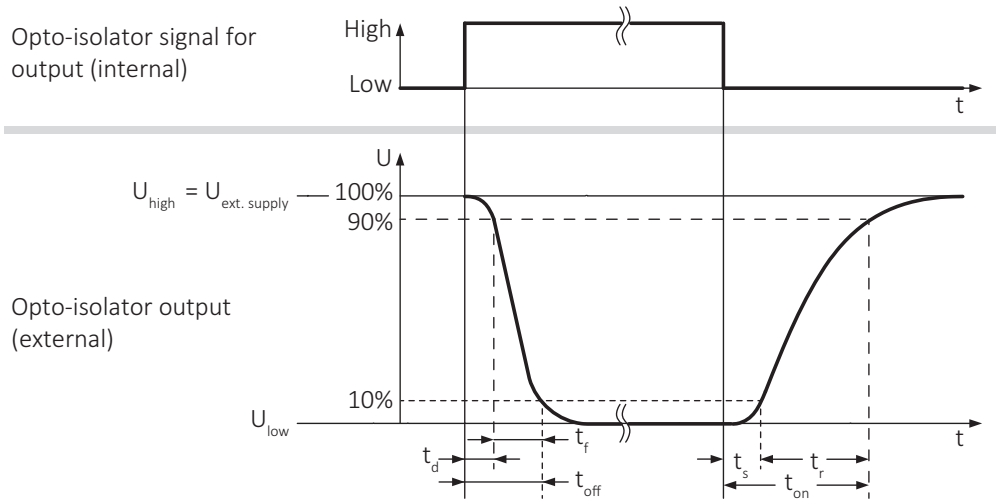


Figure 30: Opto-isolated output, switching times

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

Notice

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

- Mount the camera electrically isolated to avoid ground loops.
- See Ground loops on page 18.

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.

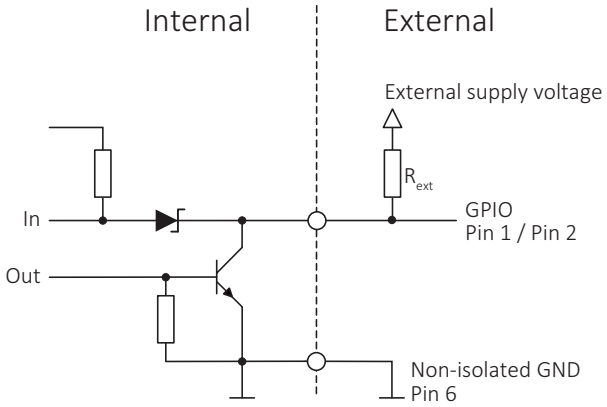


Figure 31: GPIOs, block diagram

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, 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 to 0.8 VDC
U_{in} (high)	2 to 24 VDC
Undefined levels	0.8 to 2 VDC

Table 35: GPIOs as input, parameters

Input timing delay and minimum pulse width

The hardware input delay is 10 to 70 ns, it is part of the entire trigger latency.
For trigger latency values, see Specifications on page 26.

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

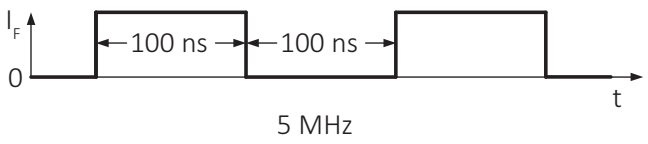


Figure 32: GPIOs as input, minimum pulse width

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 to 1.0 VDC
External output voltage U_{out} (high)	3.3 to 24 VDC
Undefined levels	1.0 to 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 to 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

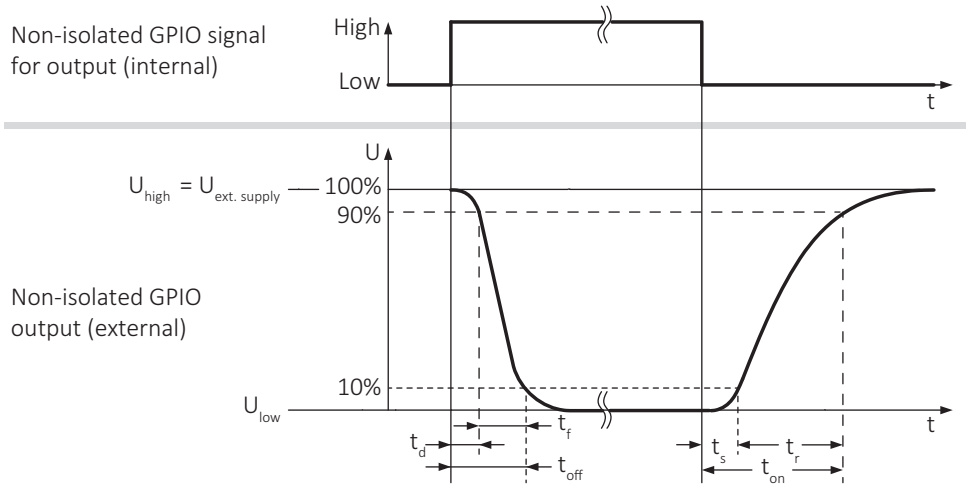


Figure 33: GPIOs as output, switching times

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.

LED settings

You can define LED settings with the `DeviceIndicatorMode` feature.

`Active` (default) enables LED signaling.

`Inactive` disables LED signaling.

`ErrorStatus` enables LED signaling in case of errors only.

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 recovery

For LED codes signaling a firmware recovery, see LED codes for a firmware recovery on page 101.

Error conditions

In rare cases the camera may crash and not respond anymore.

The LEDs signal another code than described in Table 39 on page 86.

Try the following to get the camera back to normal operation:

- Restart the camera.
- Should this fail, recover the firmware. See Firmware recovery on page 99.
- Should this fail, please contact support@alliedvision.com.

Triggering

This chapter includes:

Trigger Control features 89
Trigger path 90
Digital I/O Control 90
TriggerMode and TriggerActivation 91
TriggerDelay 91
Digital I/O lines 92
Trigger signal flow 94
Best practice rules for triggering 95

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 types of `ExposureMode`, see Specifications on page 26.
- 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 custom 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

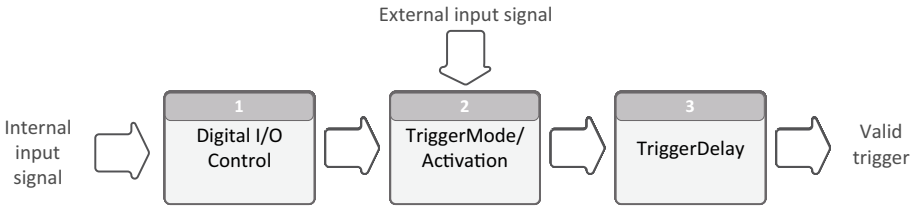


Figure 34: Trigger path

Depending on the `TriggerSource`, the trigger signal is processed through the trigger path, see Figure 34 (“Trigger generation functional model,” SFNC).

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

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

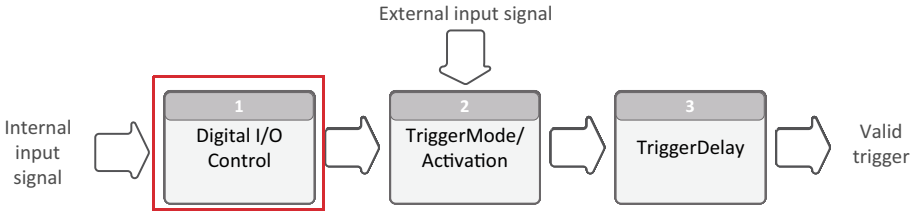


Figure 35: Digital I/O control (DigitalIOControl)

`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 defined by `TriggerSource` and output path defined by `LineSource`, see Digital I/O lines on page 92.

TriggerMode and TriggerActivation

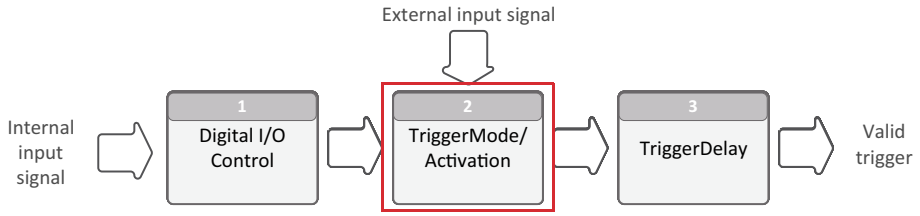


Figure 36: TriggerMode/TriggerActivation features

TriggerMode

`TriggerMode[TriggerSelector]` controls if the selected trigger is active:

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

TriggerActivation

`TriggerActivation[TriggerSelector]` 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

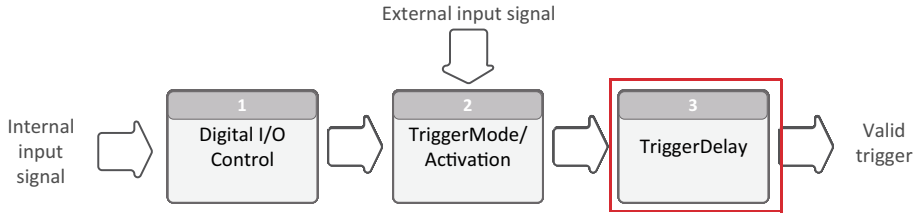


Figure 37: TriggerDelay[TriggerSelector] feature

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

Digital I/O lines

Input path and TriggerSource

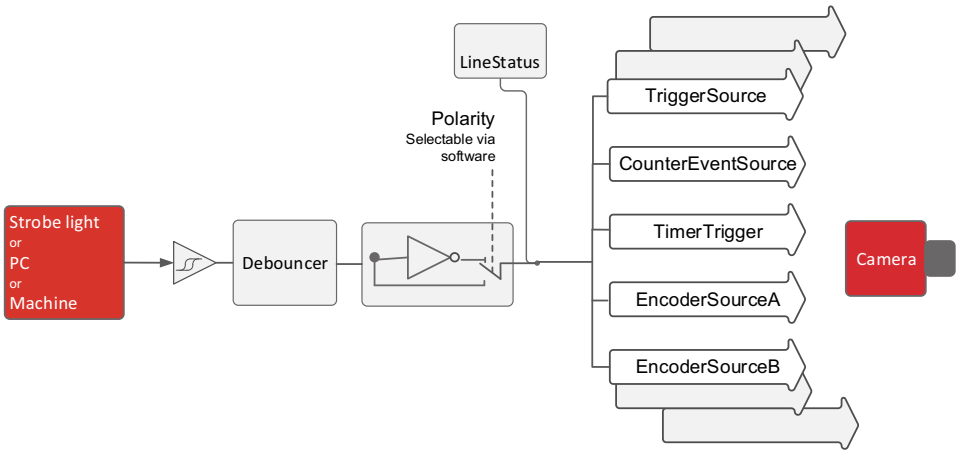


Figure 38: Input block diagram

`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[TriggerSelector]` 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 and TriggerSource values

Output path and LineSource

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

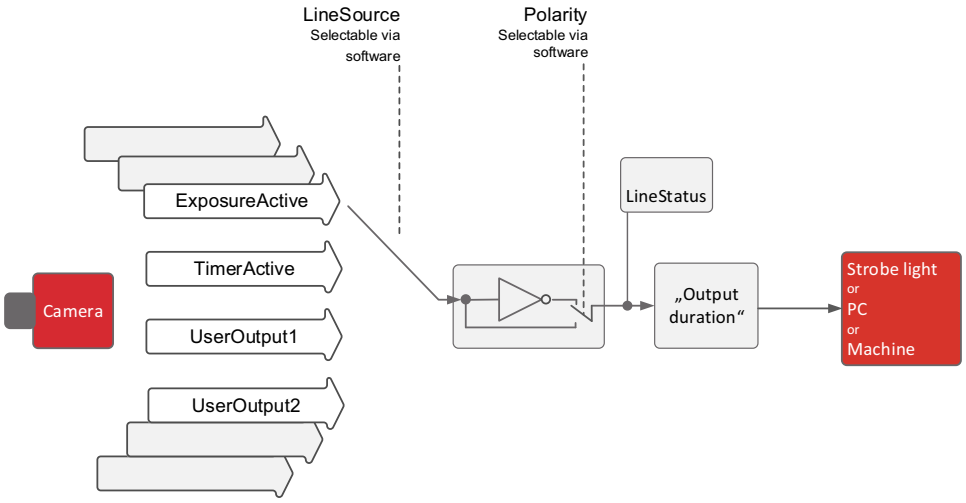


Figure 39: Line I/O Control, output block diagram

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 user output bit state as defined by its current UserOutputValue
Stream0TransferActive	Transfer on the stream is *Active*, *Paused*, *Stopping*, *Stopped*, or *Overflow*.

Table 41: Output path and 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.

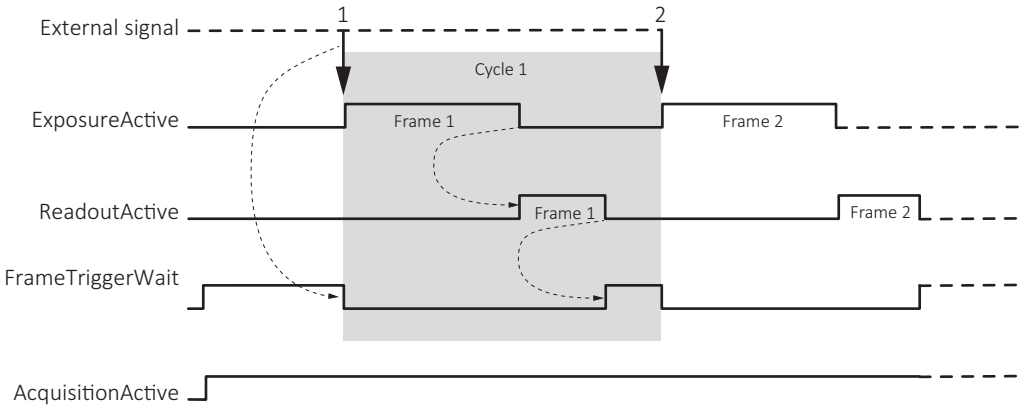


Figure 40: Trigger signal flow

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 42: 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 exposure start
- `TriggerDelay`

Term	Description
Exposure start jitter	Deviation from the average periodical signal time Time range mainly caused by sensor line synchronization
Exposure start 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 43: 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 78.
- 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 exposure start delay = readout time- exposure time.

Triggering when ReadoutActive is low

Apply `FrameStart` trigger when `ReadoutActive` is low. This way, you keep trigger latency (including exposure start 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 exposure start jitter can be up to 1 line cycle.

More information about the triggering concept

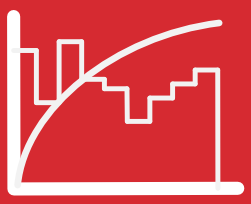
See *USB3V Triggering Concept*:

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

USB 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 cameras.

Mako U 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 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 44.

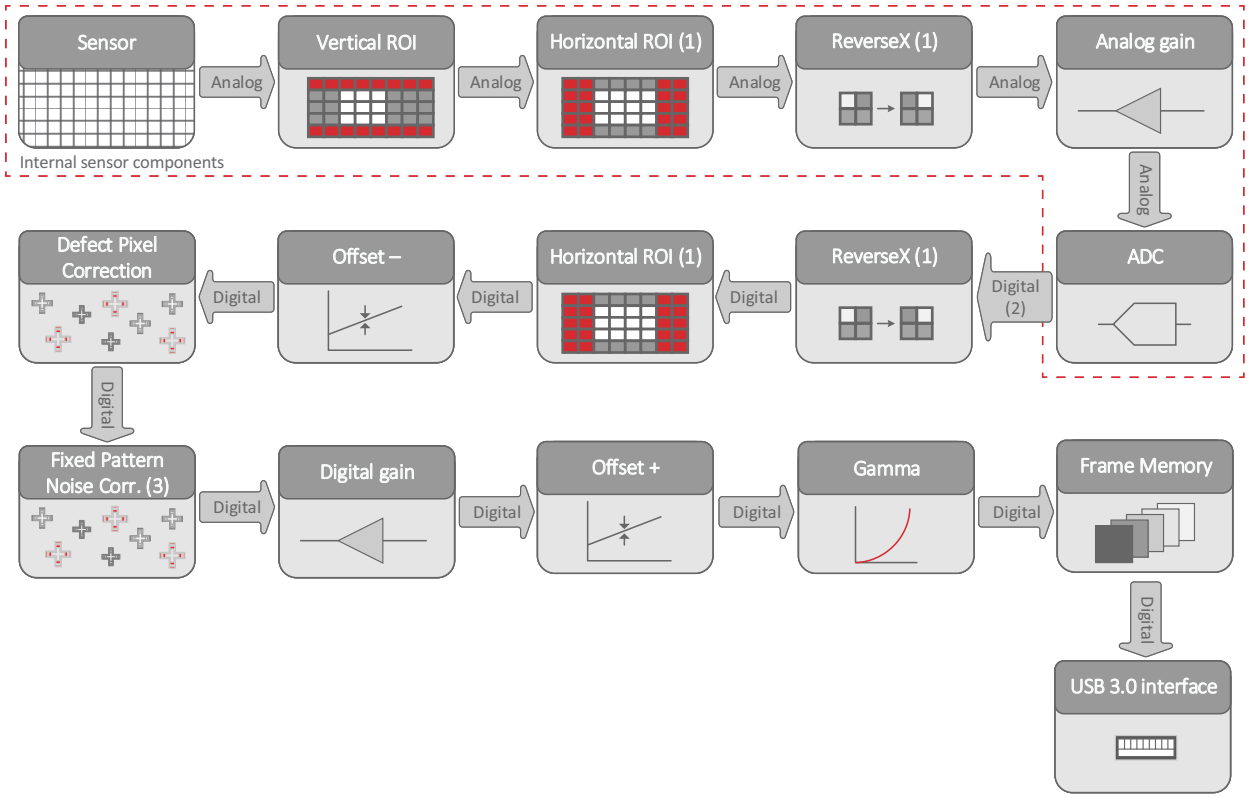


Figure 41: Image data flow of Mako U cameras

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 26.
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-029B	10	✓	✓
Mako U-051B	10	✓	✓
Mako U-130B	10	✓	✓
Mako U-503B	12	✓	

Table 44: Different image corrections for Mako U cameras

Firmware recovery

This chapter includes:

Recovering the firmware..... 100
LED codes for a firmware recovery..... 101

Recovering the firmware

You should recover firmware only when the camera cannot be operated properly, even after several restarts.

Precautions

Keep the camera connected

Keep the camera connected while you are executing a firmware recovery.

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

In this case, see Setting the camera to fallback mode on page 116.

Firmware recovery with Vimba

To recover firmware:

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

Downloads

- For **Vimba**, see https://www.alliedvision.com/software.
- For Mako U **firmware**, please contact support@alliedvision.com.

Recovering firmware without Vimba

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

LED codes for a firmware recovery

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 settings

You can define LED settings with the `DeviceIndicatorMode` feature.

`Active` (default) enables LED signaling.

`Inactive` disables LED signaling.

`ErrorStatus` enables LED signaling in case of errors only.

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

Table 45: LEDs signaling, firmware recovery

Firmware recovery errors

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

Cleaning optical components

This chapter includes:

Keep optical components clean 103
Dirt 104
Examining optical components for dirt 105
Materials for cleaning optical components 105
Cleaning instructions 106

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:

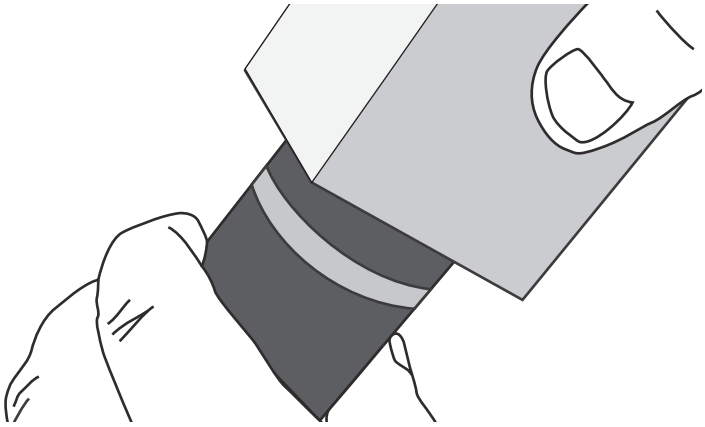


Figure 42: Hold the camera like this when removing lens or dust cap

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 43, 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.

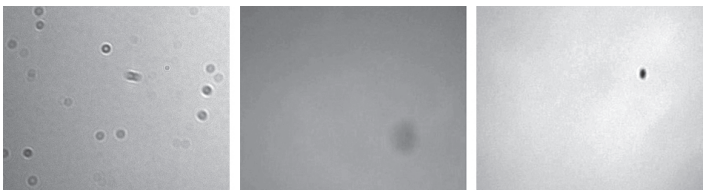


Figure 43: Examples for the appearance of dust on the filter (left and middle) and the sensor (right)

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.

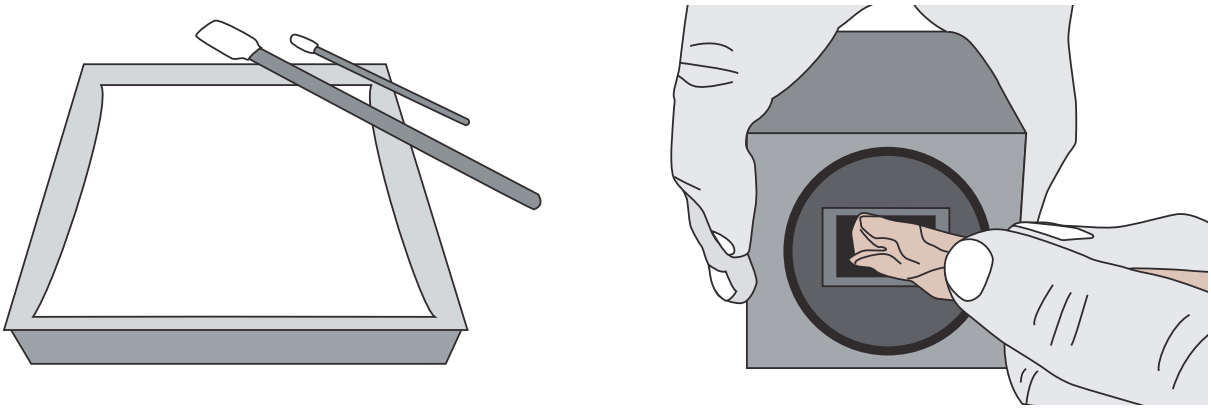


Figure 44: left, lens cleaning tissues and cleaning pads
right, use of a cleaning tissue to clean a sensor

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.

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.
3. 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.

4. 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 109
Optimizing performance 114
Setting the camera to fallback mode 116

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 67.

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 60.

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 USB 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 Installing the camera using Vimba on a Windows system on page 69.

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 72.
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** Status LEDs.

If: The status LEDs signal other codes than for Normal operation.
Then: Restart the camera.
If: If the camera still does not respond.
Then: Recover the firmware, see Firmware recovery on page 99.
Then: If the camera still does not respond.
Then: Please contact 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 70.

   Interim solution (until we can offer a permanent solution)

   Insert a timed delay of 100 ms 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 60.

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 114.

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 114.

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

   See USB 3.0 cards, hubs, and cables on page 60 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 antennas** to reduce power of the radio signals.

   For tested USB 3.0 accessories, see Accessories on page 59.

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 60).
- 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 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 26.

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.

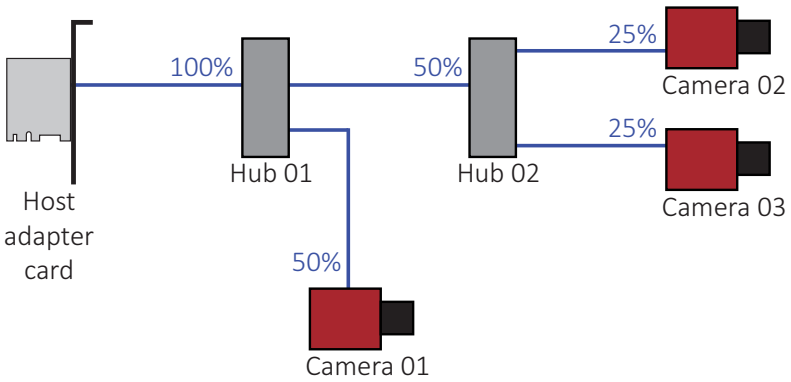


Figure 45: Bandwidth assignment for cascading hubs

Setting the camera to fallback mode

If a firmware recovery fails for any reason (for example, when disconnected during a recovery), the camera firmware may get into a non-functional state. To ensure a successful firmware recovery, 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 notice above.
2. Disconnect the camera.
3. Push a paper clip against the fallback switch (see Figure 46).
4. Keeping the paper clip pressed, connect the camera to USB.

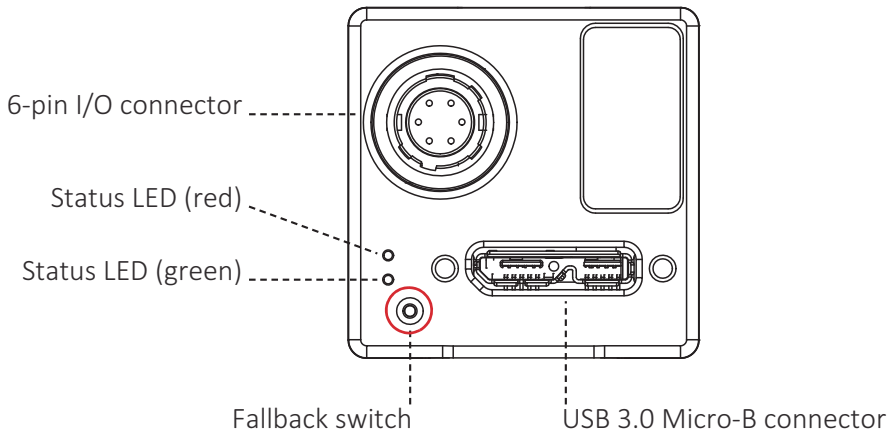


Figure 46: Mako U back panel view with fallback switch

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

5. Execute the firmware recovery, see Recovering the firmware on page 100.

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