Allied Vision



EXO series
Manual

exo174, exo252, exo250, exo267, exo304, exo183

Allied Vision Gilching GmbH // Ferdinand-Porsche-Str. 3, 82205 Gilching, Germany

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General information

1.1 Company information

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1.1.1 Disclaimer

This manual contains important instructions for safe and efficient handling of our products. This manual is part of the product and must be kept accessible in the immediate vicinity of the product for any person working on or with this product .

Read carefully and make sure you understand this manual prior to starting any work with this product. The basic prerequisite for safe work is compliant with all specified safety and handling instructions.

Accident prevention guidelines and general safety regulations should be applied.

Illustrations in this manual are provided for basic understanding and can vary from the actual model of this product. No claims can be derived from the illustrations in this manual.

The product has been produced with care and has been thoroughly tested. In case of any complaint, contact your local Allied Vision distributor. You will find a list of distributors in your area on Allied Vision Distributors.

1.1.2 Copyright notice

Forwarding and duplicating of this document, as well as using or revealing its contents are prohibited without written approval. All rights reserved with regard to patent claims or submission of design or utility patent.

The specification is subject to change without notice in advance. The brand and product names are trademarks of their respective companies. Any configuration other than original product specification is not guaranteed.

1.2 Legal information

Errors and omissions excepted.

These products are designed for industrial applications only. Cameras from Allied Vision Gilching GmbH are not designed for life support systems where malfunction of the products might result in any risk of personal harm or injury. Customers, integrators and end users of Allied Vision Gilching GmbH products might sell these products and agree to do so at their own risk, as Allied Vision Gilching GmbH will not take any liability for any damage from improper use or sale.

1.2.1 Registered trademarks

In this manual the following registered trademarks may be used:

- GenICam®
- Microsoft® and Windows®
- Intel®

Throughout the manual, these trademarks are not specifically marked as registered trademarks. This in no way implies that these trademarks can be used in another context without the trademark sign.

1.2.2 Conformity and use

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These requirements are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions given in this guide, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will have to correct the interference at its own expense.

You are herewith cautioned that any changes or modifications not expressly approved in this description could void your authority to operate this equipment.

1.2.3 Rules and regulations for USA and Canada

This device complies with part 15 of the FCC Rules. Operation is subject to the following conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment is compliant with Class A of CISPR 32. In a residential environment this equipment may cause radio interference.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules.

It is necessary to use a shielded power supply cable. You can then use the “shield contact” on the connector which has GND contact to the device housing. This is essential for any use. If not done and the device is destroyed due to Radio Magnetic Interference (RMI) WARRANTY is void!

- Power: US/UK and European line adapter can be delivered. Otherwise use filtered and stabilized DC power supply.
- Shock & vibration resistance is tested. For detailed specifications refer to the section on specifications.

1.2.4 Rules and regulations for Europe

This device is CE tested, the following rules apply:

- EN 55032:2015
- EN 61000-6-2:2019

The product is in compliance with the requirements of the following European directives:

- 2011/65/EU
- 2015/863/EU

All products of Allied Vision Gilching GmbH comply with the recommendation of the European Union concerning RoHS rules.

1.2.5 Warranty and non-warranty clause

The camera does not contain serviceable parts. Do not open the body of the camera. If the camera has been opened, the warranty will be void.

The camera has to be used with a supply voltage according to the camera's specification. Connecting a lower or higher supply voltage, AC voltage, reversal polarity or using wrong pins of the power connector may damage the camera. Doing so will void warranty.

Our warranty does not protect against accidental damage, loss, or acts of nature.

Allied Vision Gilching GmbH cannot be held responsible for the loss of data. We recommend a backup plan.

1.3 Supplements

FOR CUSTOMERS IN CANADA

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

POUR LES UTILISATEURS AU CANADA

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

LIFE SUPPORT APPLICATIONS

The products described in this manual are not designed for use in life support appliances or devices and systems where malfunction of these products can reasonably be expected to result in personal injury.

Allied Vision Gilching GmbH customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Allied Vision Gilching GmbH for any damages resulting from such improper use or sale.

1.4 Tips and notes

This manual contains notes that help to avoid data loss or camera damage, and tips that provide information to improve handling the camera. They are marked as follows:

TIPS

> Provides information that may help to improve camera handling or avoid data loss.

NOTES

> Provides information to avoid damage to the system.

1.5 Support

In case of issues with the camera we are happy to help. For being able to help you in a fast and efficient way, we ask you for a description of the issues using camera in your support request.

1. Put your support request to us via the support form: Support & Repair (RMA)
2. Fill the form with information about the camera model, the frame grabber model, and operating system. Our support team will come back to you.

The EXO camera series

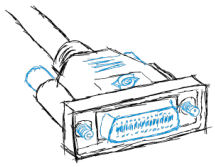
The EXO camera series is a series of machine vision cameras for the low and mid-range resolutions up to 20 MP. The EXO is available with different industry standard interfaces such as GigE Vision, Camera Link and USB3 Vision.

The EXO is easy to integrate and comes with a full package of useful hardware features.

The EXO-Series comes in a new 50 x 50 mm aluminum body. The elaborate, high precision machined unibody housing ensures perfect temperature distribution even for the most demanding sensors. A massive lens mount is designed to keep any kind of lens in its proper position. The electric circuitry of the EXO is optimized for low power dissipation, helped by the excellent temperature performance of the housing. The EXO features the latest global shutter CMOS sensors from SONY, CMOSIS and ON Semi.

A uniform form factor and identical standard interface connectors with identical pinout facilitate camera model interchangeability, allowing system integrators to adapt applications with varying conditions and requirements very quickly with minimum design effort.

2.1 Camera Link features



Camera Link is the most direct interface connection to the camera sensor and preferred by integrators with high demands on bandwidth and especially low and defined latency times. Camera Link provides a deterministic timing of the camera, what is different to all other interface types.

As operating Camera Link always involves a frame grabber, the specs given in the specifications|topic=Specifications might differ from your setup. Please contact us for a recommendation of frame grabbers.

Depending on your camera model, following Camera Link specifics might apply (Please refer to the technical data of your specific camera model):

There are different transfer rates with different camera link types. Camera Link full (80 bit technology) is also known as “Camera Link Deca”

Some models support Power over Camera Link (PoCL). Please note, in case you use the 4IO PWM outputs to drive your lights, you need an external power supply as the PoCL is unable to deliver the high currents requested.

2.2 4I/O adds light and functionality

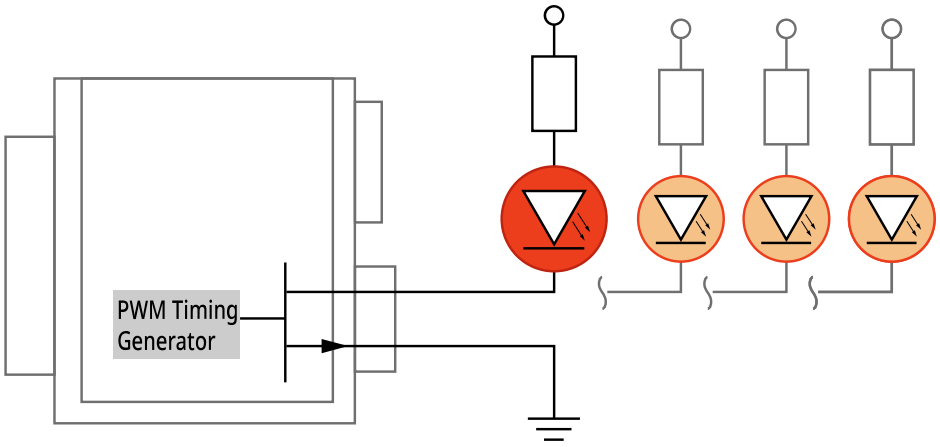


Fig. 2-1: Illustration of 4I/O concept of switching LEDs

The camera is equipped with the 4I/O-interface allowing full light control, replacing external strobe controllers. Each of the outputs can be individually configured and managed using pulse width modulation. With its high current output, the camera is able to drive LED lights directly without external light controller.

The integrated sequencer allows multiple exposures with settings to be programmed. Logical functions like AND / OR are supported.

- Up to 4 x open drain high power OUT
- Up to 4 x high voltage IN – TTL up to 25 Volts
- Power MOSFET transistors
- PWM strobe control
- Sequencer for various configurations
- PLC functionality with AND, OR and timers
- Safe trigger (debouncer, prescaler, high low trigger)

Connections

Cameras from Allied Vision feature a combined I/O and power supply connector (Hirose) and a data connector.

3.1 Camera Link™

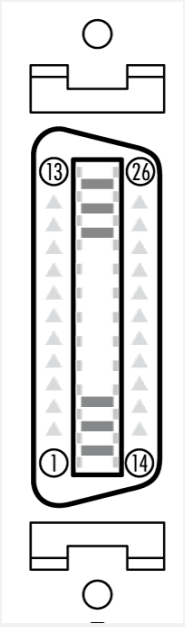
> To use Camera Link a frame grabber is needed.

3.1.1 Camera Link connector

Type	26 Pin connector SDR socket
Matching connector	3M
Part-no. connector	10126-6000EL
Part-no. hood	10326-A200-00
Operating mode	Camera Link™ with RS 232 communication

Table: 3-1: Camera Link connector specification

3.1.2 Camera Link pinout



Pinout Pin	Signal Name	Direction	Signal Description
- 1 -	GND / 12 V	-	Shield 1 / 12 V power*
- 2 -	X0-	Camera to FG	Data
- 3 -	X1-	Camera to FG	Data
- 4 -	X2-	Camera to FG	Data
- 5 -	Xclk-	Camera to FG	Transmitter Clock / PVAL
- 6 -	X3-	Camera to FG	Data
- 7 -	SerTC+	FG to Camera	Camera Control (RS232)
- 8 -	SerTFG-	Camera to FG	Camera Control (RS232)
- 9 -	CC1-	FG to Camera	ExSync
- 10 -	CC2+	FG to Camera	Prin (not used)
- 11 -	CC3-	FG to Camera	External Camera Clock
- 12 -	CC4+	FG to Camera	nc
- 13 -	GND	-	Shield 3 / power return*
- 14 -	GND	-	Shield 2 / power return*
- 15 -	X0+	Camera to FG	Data
- 16 -	X1+	Camera to FG	Data
- 17 -	X2+	Camera to FG	Data
- 18 -	Xclk+	Camera to FG	Transmitter Clock
- 19 -	X3+	Camera to FG	Data
- 20 -	SerTC-	FG to Camera	Camera Control (RS232)
- 21 -	SerTFG+	Camera to FG	Camera Control (RS232)
- 22 -	CC1+	FG to Camera	Exsync
- 23 -	CC2-	FG to Camera	Prin (not used)
- 24 -	CC3+	FG to Camera	External Camera Clock
- 25 -	CC4 -	FG to Camera	nc
- 26 -	GND / 12 V	-	Shield 4 / 12 V power *

Table: 3-2: Camera Link pinout

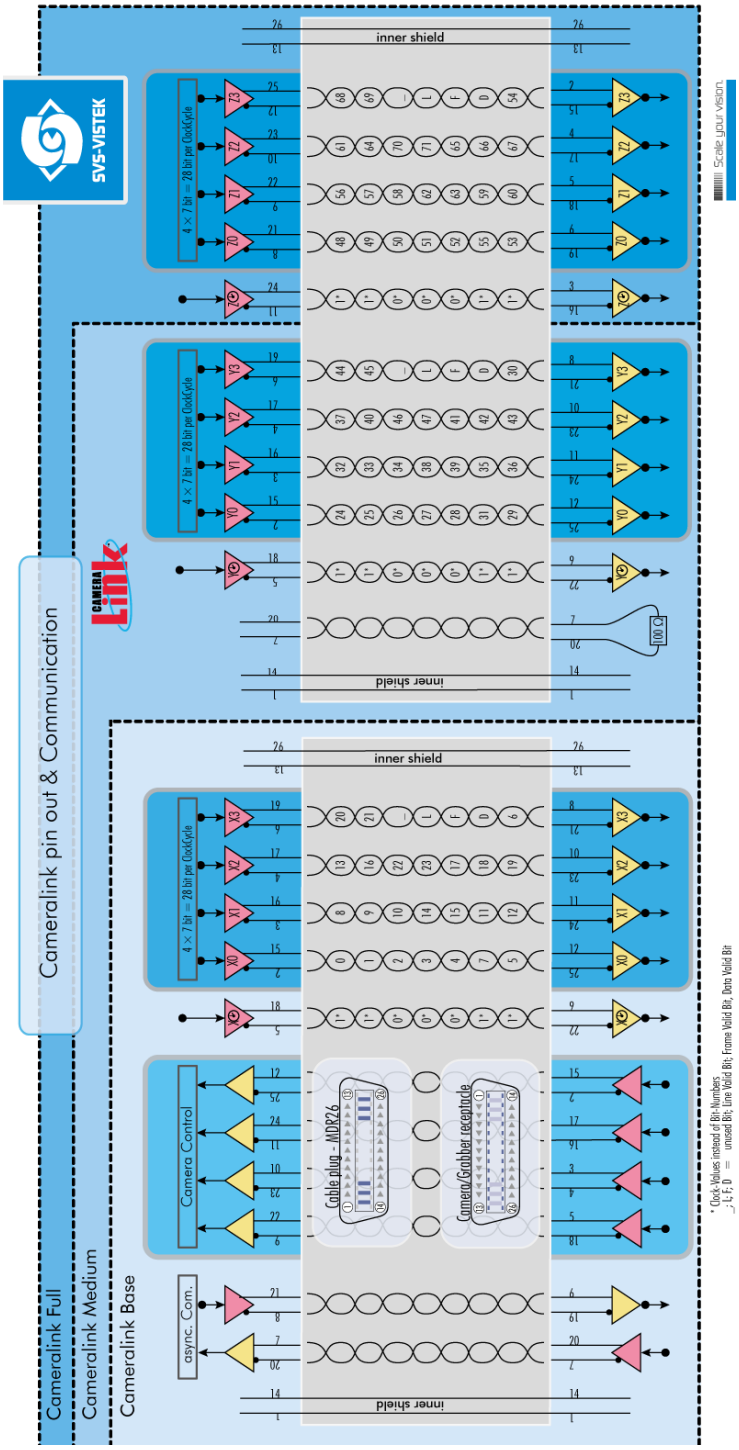


Fig. 3-1: Camera Link pinout & communication

3.2 Hirose I/O connector

The Hirose™ connector provides power, input and output signal access.

> Maximum power output is 2 A.

Inputs and outputs connect via in the GenICam software tree to the appropriate actions.

For detailed information about switching lights with the power outputs via GenICam, refer to "LED strobe control" on page 54.

Type	HR10A-10R-12P
Matching connector	HR10A-10P-12S

Table: 3-3: Hirose connector types

Getting started

4.1 Find camera specs

For technical data sheets visit FAQs und Application Notes.

Search for a specific camera, using series and model name or by using the SVCam camera finder. The details and download section provides you with manuals, drawings, as well as software and firmware.

4.2 Connect the camera

Before connecting your camera to power, make sure your data cable is connected properly. Always connect data cable before power.

1. Connect the data cable.
2. Connect power supply.
3. Connect the power supply with the M12 connector. When using your own power supply (voltage range 10 -25 V DC) refer also to the M12 pin layout of the power and I/O connector.

> For power input specifications refer to specifications.

4.3 Cooling

During operation, the heat from the camera’s sensor dissipates to the housing. To maintain reliable performance, it is crucial to adhere to the operating temperature range specified in the camera's technical data.

- Install the camera so that the housing openings at the back or at the sides are not blocked and ventilation is possible under all operating conditions.
- Check the unhindered air flow after installation of surrounding components such as cables.

ADDITIONAL COOLING

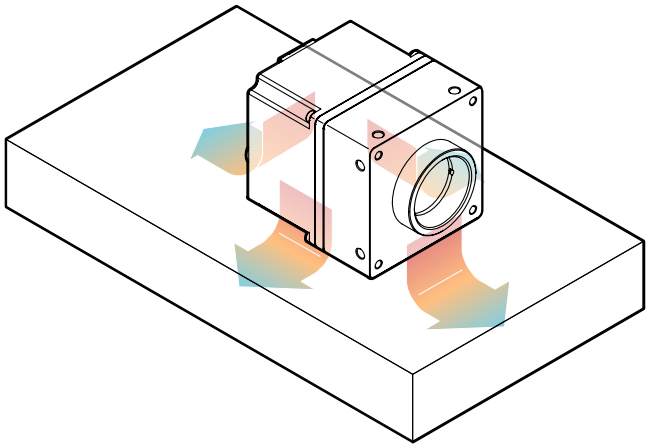


Fig. 4-1: Camera mounted to a heat sink (example)

If the temperature consistently exceeds the maximum operating temperature specified for the camera, additional cooling measures are necessary. This can be achieved by:

- Mounting the camera housing to a heat sink or other heat-dissipating material. For optimal cooling efficiency, ensure that the contact area between the camera housing and the cooling material is as large as possible, allowing for better heat transfer.
  In addition, vibrations will be minimized within the entire system.
- If available, activating the built-in fan or adjust the fan control threshold.
- If available, activating the built-in thermoelectric cooling feature.
- Using an air- or water-cooling system.

> Even if the housing temperature remains below the maximum operating temperature, using additional cooling is recommended to ensure optimal image quality and power efficiency.

4.4 Camera status LED codes

On power up, the camera will indicate its current status with a flashing LED on its back. The LED will change color and rhythm.

The meaning of the blinking LED status codes translates as follows:

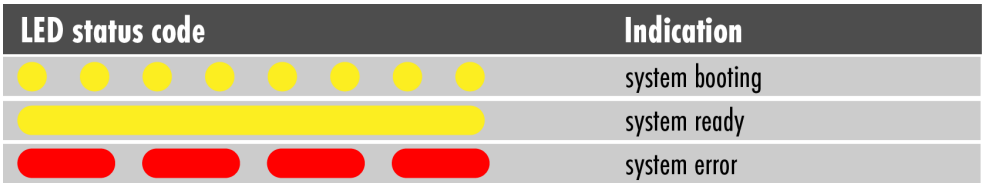


Fig. 4-2: Camera status LED codes

Feature description

This chapter covers features of SVCam cameras. Not every feature might be supported by your specific camera model. For information about the features of your specific model, refer to the specifications area of our website with your exact model with our Camera Selector.

5.1 Basic features

5.1.1 Gain

Setting gain above 0 dB (default) is a way to boost the signal coming from the sensor. Especially useful for low light conditions. Setting gain amplifies the signal of individual or binned pixels before the ADC. Referring to photography adding gain corresponds to increasing ISO. Increasing gain will increase noise as well.

add 6 dB	double ISO value
6 dB	400 ISO
12 dB	800 ISO
18 dB	1600 ISO
24 dB	3200 ISO

Table: 5-1: Table of dB and corresponding ISO value

> Gain also amplifies the sensor's noise. Therefore, gain should be last choice for increasing image brightness. Modifying gain will not change the camera's dynamic range.



Fig. 5-1: Noise caused by too much gain

AUTO GAIN

> For automatic adjustment of gain refer to auto exposure (see "Auto exposure" on page 39).

When using auto-gain with steps of gain, the non-continuous gain adjustment might be visible in final image. Depending on your application it might be preferable to use fixed gain values instead and modify exposure with exposure time.

5.1.2 Resolution

As mentioned in the specifications, there is a difference between the numerical sensor resolution and the camera resolution. Some pixels towards the borders of the sensor will be used only internally to calibrate sensor values (“Dark pixels”). The amount of dark current in these areas is used to adjust the offset (see "Offset" on page 22).

For calculating image sizes, the maximum camera resolution is determining maximum image resolution, refer to the specifications of the camera model).

5.1.3 Offset

For physical reasons the output of a sensor will never be zero, even the camera is placed in total darkness or simply closed. Always there will be noise or randomly appearing electrons that will be detected as a signal (dark noise: noise generated without light exposure).

To avoid this dark noise to be interpreted as a valuable signal, an offset will be set.

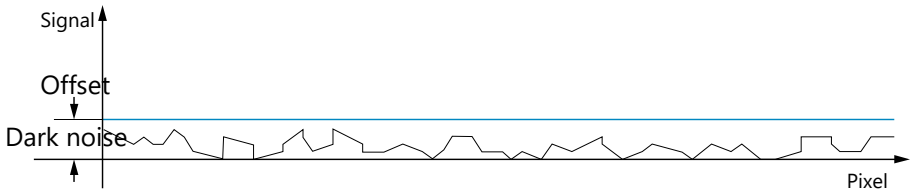


Fig. 5-2: Dark noise cut off by the offset

Most noise is proportional to temperature. The offset is automatically regulated by the camera sensor to compensate for the surrounding temperature changes by referencing specific pixels as „black“, i.e. never exposed to light. So the offset will be set dynamically and conditioned to external influences.

The offset can be limited by a maximum bit value. If higher values are needed, try to set a look up table.

5.1.4 Color

Color cameras are identical to the monochrome versions. The color pixels are transferred in sequence from the camera, in the same manner as the monochrome, but considered as “raw”-format.

The camera sensor has a color mosaic filter called “Bayer” filter pattern. The pattern alternates as follows:

- First line: GRGRGR... (R=red, B=blue, G=green)
- Second line: BGBGBG...

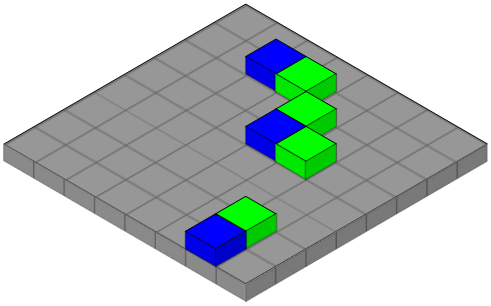


Fig. 5-3: Example of Bayer pattern (source: wikipedia)

Note that about half of the pixels are green, a quarter red and a quarter blue. This is due to the maximum sensitivity of the human eye at about 550 nm (green). De-Bayering is not done in the camera, it must be done in the client software . Not all sensors have the same sequence of color. The GenICam property **PixelColorFilter** indicates the sequence of the color pixels when reading color images.

Using color information from the neighboring pixels the RG and B values of each pixel is interpolated by software, e.g. the red pixel does not have information of green and blue components. The performance of the image depends on the software used. Due to this, physical resolution of color cameras is always lower than resolution of monochrome cameras.

Camera Link frame grabbers need information of the sequence order of the colors. The order depends on sensor type. USB3 and GigE cameras provide this in their XML file.

> It is recommended to use an IR cut filter for color applications

> Industrial vision cameras are not intended to display colors according to human perception.

WHITE BALANCE

The human eye adapts to the definition of white depending on the lighting conditions. The human brain will define a surface as white, e.g. a sheet of paper, even when it is illuminated with a bluish light.

White balance of a camera does the same. It defines white or removes influences of a color-based on a non-white illumination.

- **Continuous**: Auto white balance will analyze the taken images and adjust exposure per color accordingly as long as the camera is taking images. Different colors of the same object in a sequence might be the result depending on the other objects in the image
- **Once**: Auto white balance will adjust white balance as soon it is started and will stop modifying parameters as soon white balance is finished.

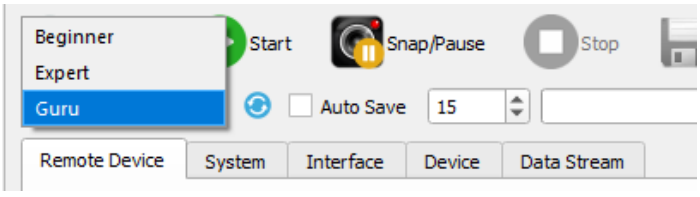
COLOR CALIBRATION

> The color cameras are delivered without color calibration.

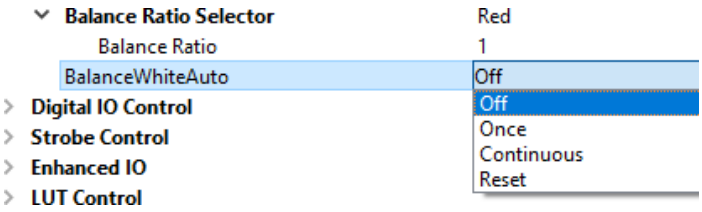
If a color calibration is necessary e.g., because the image has a green cast, the color can be adjusted with a white balance.

The feature "White Balance" is part of the camera firmware and can be operated with a GenICam compliant software.

1. When using SVCapture 2, select **Guru** as **Feature Mode**.



2. Select **BalanceWhiteAuto** in **Analog Control** in the GenICam feature tree.



> The White Balance “Continuous” mode is only recommended in a slow triggered mode. Usually, it is sufficient to perform a white balance once with the given lighting.

3. Use a white, not too dark, but not overexposed surface (white wall or paper) as image. Only then the white balance algorithm can calibrate the color optimally.
4. If unsuccessful, adjust the RGB values manually e.g., by adjusting the green value downwards.
5. After calibration, save the settings in the camera (User Set Save) so that the color correction is preserved after a camera restart.
6. Use a white, not too dark, but not overexposed surface (white wall or paper) as image. Only then the white balance algorithm can calibrate the color optimally.
7. If unsuccessful, adjust the RGB values manually e.g., by adjusting the green value downwards.
8. After calibration, save the settings in the camera (User Set Save) so that the color correction is preserved after a camera restart.

5.1.5 Image flipping

Images can be mirrored horizontally or vertically. Image flip is done inside the memory of the camera, therefore not increasing the CPU load of the PC.

Image flipping is referred to in the GenICam specifications and hence in the software as follows:

- Reverse X: Flips the image along the Y axis horizontally, hence "Horizontal flipping"
- Reverse Y: Flips the image along the X axis vertically, hence "Vertical flipping"



Fig. 5-4: Original image



Fig. 5-5: Horizontal flip



Fig. 5-6: Vertical flip

5.1.6 Binning

Binning provides a way to enhance dynamic range, but at the cost of lower resolution. Binning combines electron charges from neighboring pixels directly on the chip, before readout.

On CMOS sensors, binning will not affect image quality. In any case, binning will reduce the amount of pixel data to be transferred.

The selected binning value describes the number of combined photosensitive cells, where the following value settings apply:

- Value 1 equals the value *Binning Off* from previous versions.
- Value 2 equals the previous value *Binning On* (combination of 2 cells).
- Additionally, value 4 combines four cells horizontally or vertically.

> Binning is now solely executed in the image processing chain of the FPGA and never in the sensor.

Furthermore, it is possible to set the binning mode between *Average* or *Sum*:

- Average: The response from the combined cells will be the average value (Value: 0:
- Sum: The response from the combined cells will be added (Value: 1)

VERTICAL BINNING

Accumulates vertical pixels.

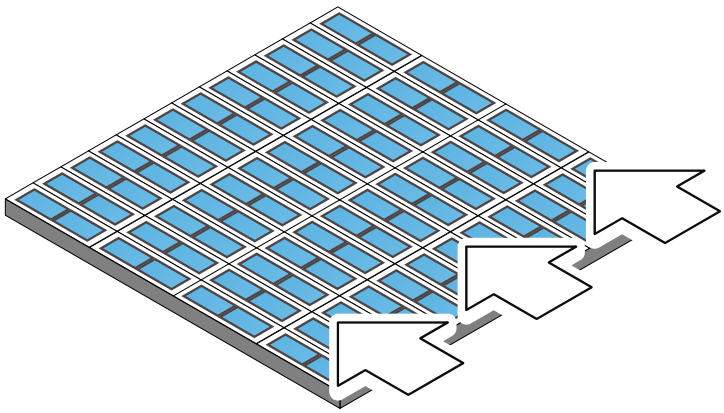


Fig. 5-7: Vertical binning

HORIZONTAL BINNING

Accumulates horizontal pixels.

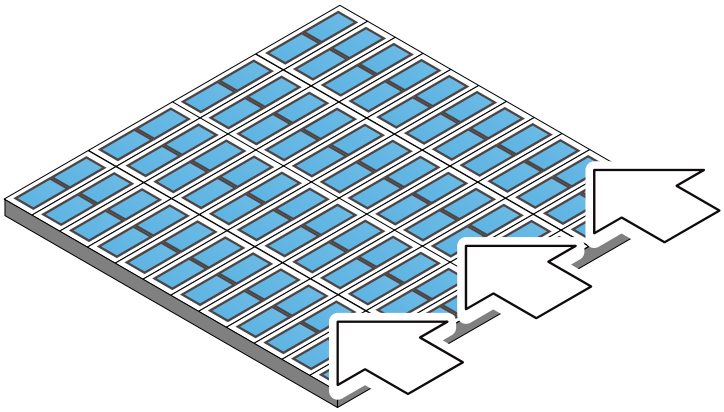


Fig. 5-8: Horizontal binning

2×2 BINNING

A combination of horizontal and vertical binning.

When DVAL signal is enabled only every third pixel in horizontal direction is grabbed.

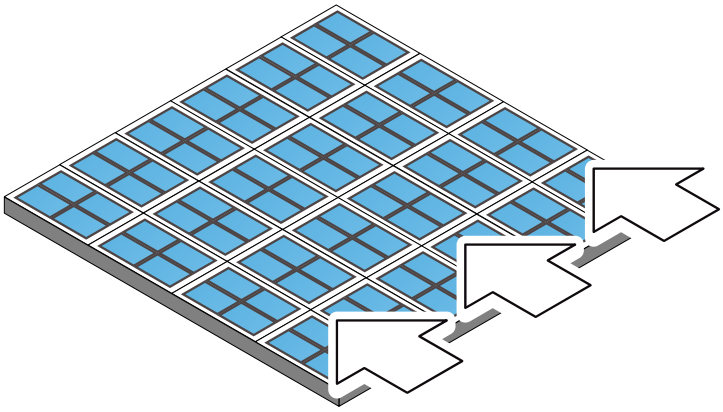


Fig. 5-9: 2x2 binning

5.1.7 Decimation

For reducing width or height of an image, decimation can be used. Columns or rows can be ignored.

> For reducing data rate by reducing the region you are interested in, refer to "ROI / AOI" on page 46.



Fig. 5-10: Horizontal decimation



Fig. 5-11: Vertical decimation

5.1.8 GenICam

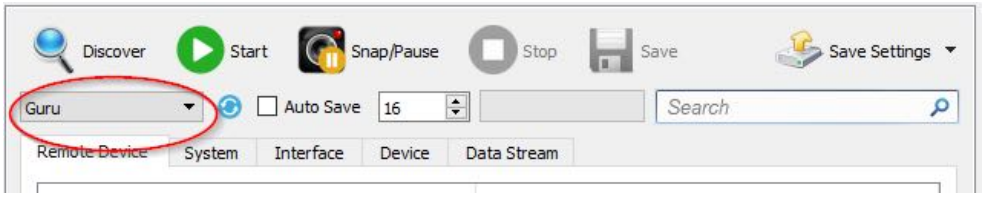
The GenICam standard provides a generic programming interface to control all kinds of cameras and devices. Regardless of the interface technology (GigE Vision, USB 3 Vision, CoaXPress, Camera Link, etc.) or implemented feature, the application programming interface (API) will always be the same. The SNFC makes sure the feature names are similar throughout the manufacturers, making it more easy to switch camera models.

The GenICam™ standard consists of multiple modules according to the main tasks to be solved:

- GenApi: configuring the camera
- SNFC: Standard Feature Naming Convention, a catalog of standardized names and types for common device features
- GenTL: transport layer interface, grabbing images
- GenCP: generic GenICam control protocol
- GenTL SFNC: recommended names and types for transport layer interface.

The GenICam properties are organized as a tree. Manufacturers can add more features.

With your SVCam, the GenICam tree does have some hardware related extensions, especially in the I/O sector. See the Quick guide install for a short introduction into the Allied Vision GenICam tree.



The GenICam properties are organized in views. The recommended way to view and adjust is by using SVCapture. If you want to have a full view of all adjustable GenICam items, activate the Guru mode. Beginner mode will show only most common attributes.

> All modifications in the GenICam tree will have immediate effect.

5.1.9 Trigger modes

To start capturing images, the camera has to receive a trigger signal. This trigger signal can be a software trigger, it might be an electric signal on the hardware I/O or it can be a timed trigger (sequence of images or "Precision Time Protocol").

SOFTWARE TRIGGER

The camera exposure can be started via software. With some interface types like GigE and USB3 it is impossible to have a 100% precise software trigger. CoaXPress and Camera Link permit relatively precise triggering of the camera. If you need to have a precise trigger, we recommend the usage of an "External hardware trigger" on page 31.

EXTERNAL HARDWARE TRIGGER

External trigger with programmable exposure time. In this mode the camera is waiting for an external trigger pulse that starts integration, whereas exposure time is programmable via the serial interface and calculated by the internal microcontroller of the camera.

> Default input for trigger is Input1.

At the rising edge of the trigger the camera will initiate the exposure.

The software provided by Allied Vision lets the user set exposure time e.g. from 60 µs to 60 sec (camera type dependent).

Exposure time of the next image can overlap with the frame readout of the current image (trigger pulse occurs when FVAL is high). When this happens, the start of exposure time is synchronized to the negative edge of the LVAL signal (see figure)

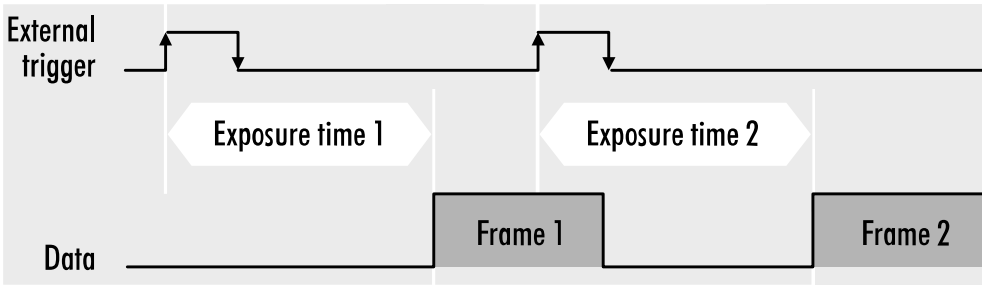


Fig. 5-12: Mode 2: External trigger with programmable exposure time (overlap)

When the rising edge of trigger signal occurs after frame readout has ended (FVAL is low), the start of exposure time is not synchronized to LVAL and exposure time starts after a short and persistent delay.

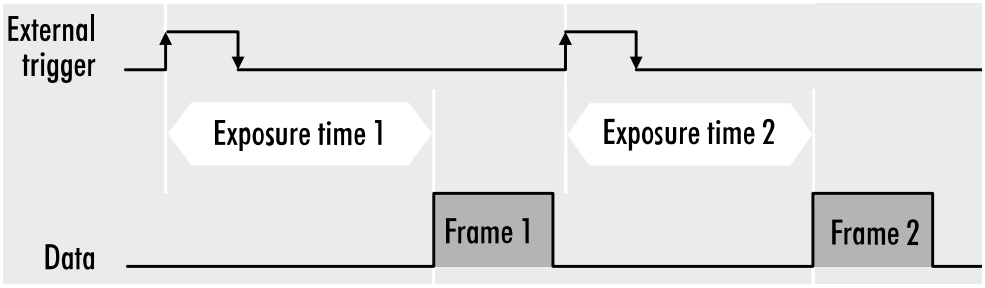


Fig. 5-13: Mode 2: External trigger with programmable exposure time (non overlap)

Exposure time can be changed during operation. No frame is distorted during switching time. If the configuration is saved to the EEPROM, the set exposure time will remain also when power is removed.

DETAILED INFO OF EXTERNAL TRIGGER MODE

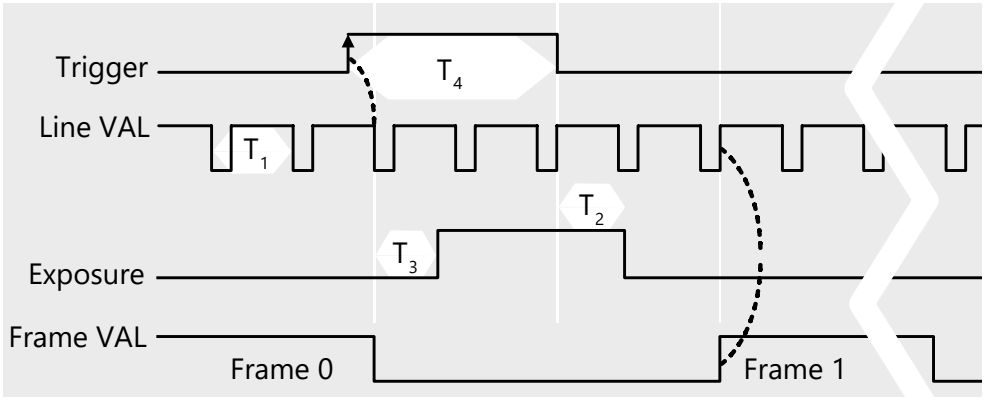


Fig. 5-14: Mode 1: External trigger with pulse width exposure control (overlap)

T_1	Line duration	**T_2**	Transfer delay
T_3	Exposure delay	**T_4**	Min. trigger pulse width

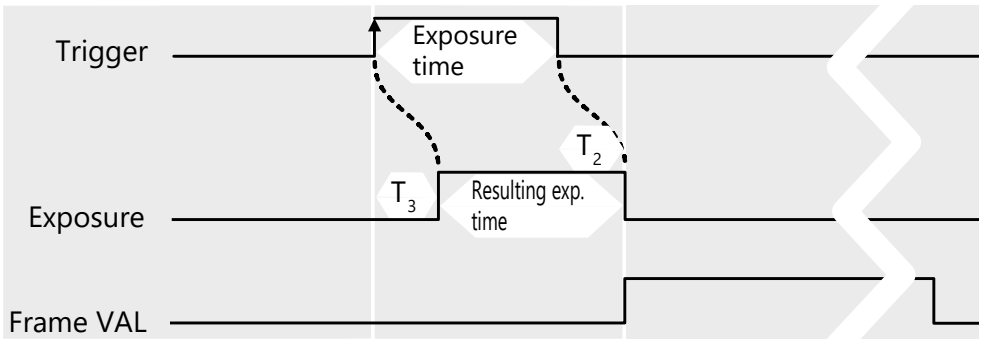


Fig. 5-15: Mode 1: External trigger with pulse width exposure control (non-overlap)

T_2	Transfer delay	**T_3**	Exposure delay

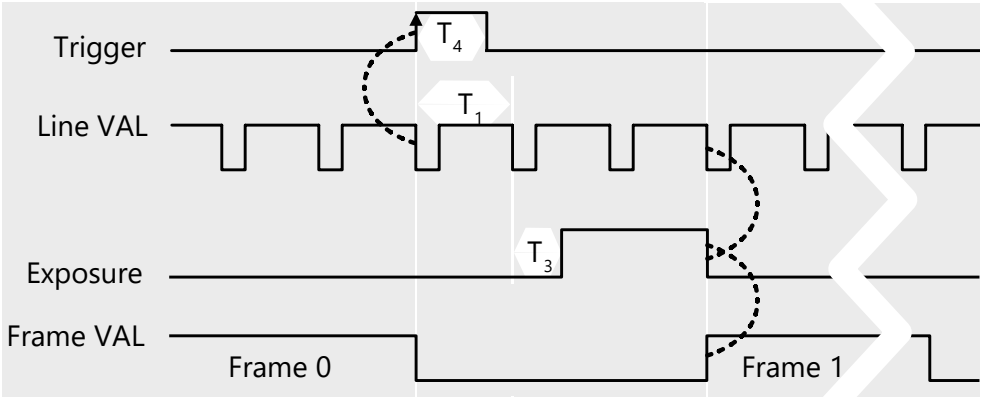


Fig. 5-16: Mode 1: External trigger with programmable exposure time (overlap)

T_1	Line duration	**T_3**	Exposure delay
T_4	Min. trigger pulse width		

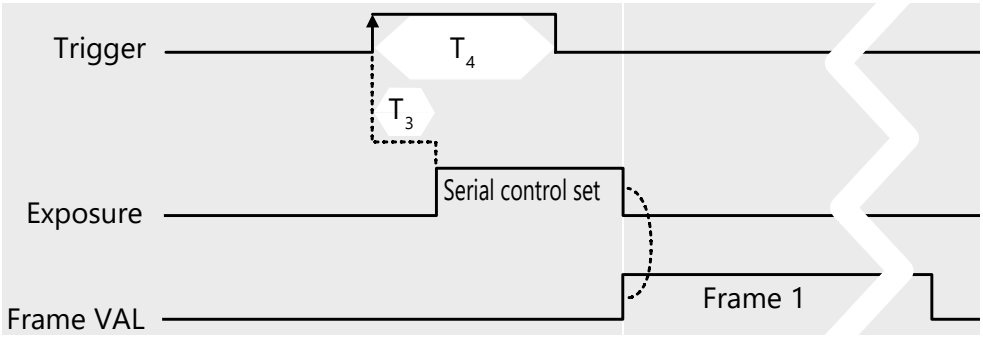


Fig. 5-17: Mode 1: External trigger with programmable exposure time (non-overlap)

T_3	Exposure delay	**T_4**	Min. trigger pulse width

5.1.10 Shutter modes

CMOS area cameras consist of pixels, ordered in lines and columns. All pixel are exposed to light and then read out to camera electronics.

GLOBAL SHUTTER MODE

- Global reset of all pixels
- All pixels start light integration at the same time
- All pixels stop integration at same time
- Readout line by line after exposure of whole frame is completed

ROLLING SHUTTER MODE

- Pixel reset line by line
- Line by line light integration

- Integration starts with different point of time for each line
- All lines stop integration at different time
- Line readout immediately after line exposure
- Next integration has to wait for finished readout (per line)
- No external exposure control (expose while trigger signal active)

LIMITATIONS

Use short exposure times for preventing blur / deforming artifacts. Image of moving object on sensor must not move more than half pixel width. In case of moving objects, exposure movement on sensor has to be shorter than half a pixel for whole image.

Make sure your light is ON as long any pixel are going to be exposed. Total imaging time is exposure time plus scanning time.

Minimum scan time in most cases is about 1 frame length.

With rolling shutter the whole sensor has to be read out – always. That means applying ROI will reduce the amount of final data being transmitted out of the camera (and the frame rate might rise, due to the limited bandwidth of the interface). Nonetheless, the maximum achievable frame rate with applied ROI will be the maximum frame rate of the sensor reading the full sensor area (internal full sensor speed), please refer to relating sensor specs.

ARTIFACTS

- All pixel show same artifacts
- Deformed image of moving objects

EXPOSURE WITH FLASH

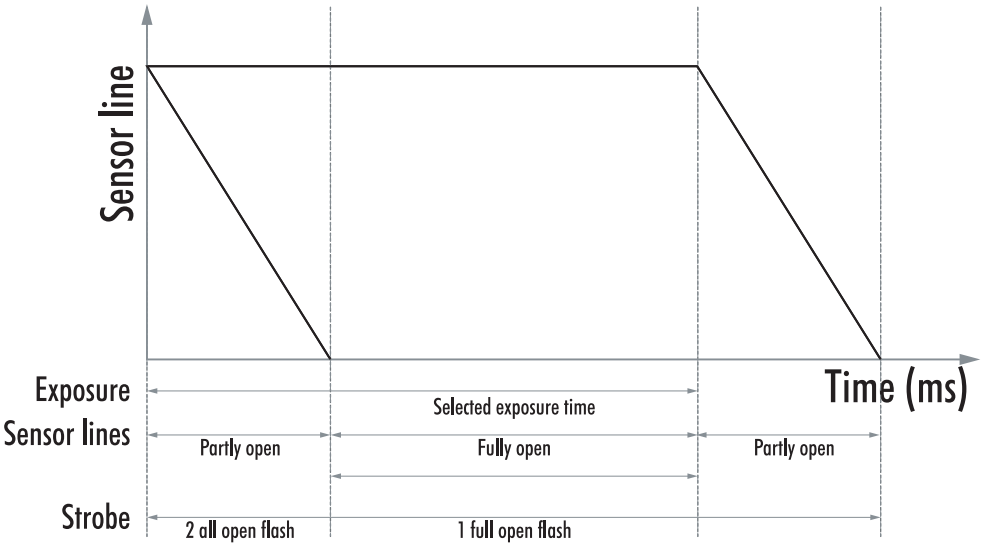


Fig. 5-18: Flash control with rolling shutter

- Flash strobe on whole exposure time
- Optionally, flash strobe only while all lines are sensitive to light at the same time (delay flash strobe until all lines are sensitive to light)

Make sure to protect from changing environment light (recommendation: flash strobe in darkness). Short Flash strobe times with moving objects.

Light control with rolling shutter

Not all sensor lines are sensitive to light at the same time. Make sure your light is ON as long any pixel are going to e exposed. An exo183xGE i.e. needs about 62ms of minimal scanning time. An exo183xCL i.e. needs about 120ms of minimal scanning time. Minimum scan time in most cases is about 1 frame length.

There are 2 general guidelines for flashing with rolling shutter:

- Make sure your light is ON and stable the whole period of time while scanning / exposing. Minimum flash time is scanning time plus exposure time. In this case, while flashing you will get geometric distortions as mentioned above. Exposure will be determined by camera exposure time and light intensity.

- If flash time is less than scanning time then exposure time has to be at least scanning time + flash time, with a delay of scanning time. In other words, your exposure time will be scanning time plus flash time, while you use a flash delay of scanning time. Thus flash release will start after the delay of scanning time, as soon the sensor is fully open. You should keep the object in total darkness while the first scanning time.
  In this case, as all lines are sensitive to light at the same time after the first scan time, flashing time can be as short as you like. You will not see the typical geometric rolling shutter distortions as shown above. Imaging will be similar to global shutter. Exposure will be determined by flash time / intensity.

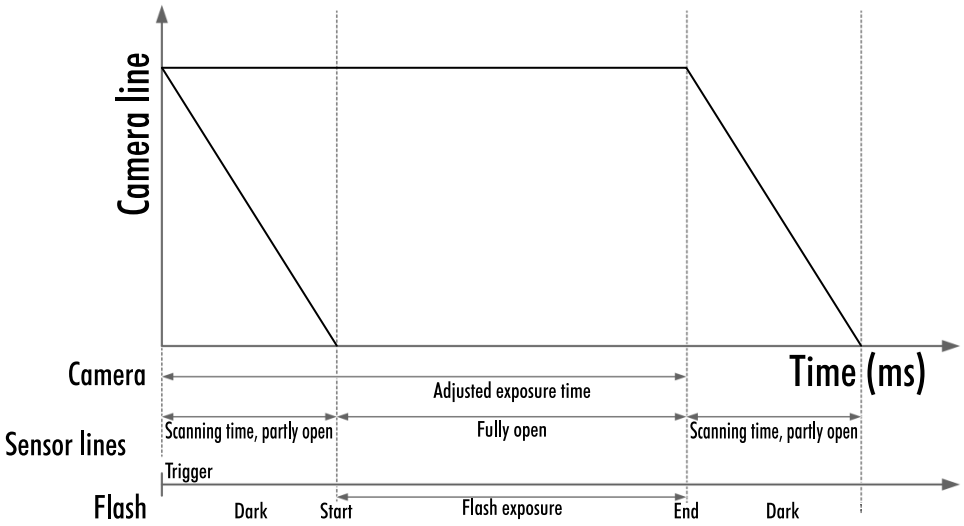


Fig. 5-19: Rolling shutter lines light sensitivity versus time

As shown here, after triggering only part of the sensor is sensitive to light (scanning time). As soon as scanning time has finished, all pixels are sensitive to light, the sensor is fully open. While being fully open this is the time where flashing should happen. In the final scanning time, less and less pixels are sensitive to light until the sensor light sensitivity will finish.

Rolling shutter limitations

Due to the principles of rolling shutter, some standard features of Allied Vision cameras are not applicable.

- External exposure control (expose while trigger signal active) does not make sense with rolling shutter
- ROI with rolling shutter: With rolling shutter the whole sensor must always be read out. Applying ROI will reduce the amount of final data being transmitted out of the camera. The maximum achievable frame rate with applied ROI will be the maximum frame rate of the sensor reading the full sensor area (internal full sensor speed).

Calculate frame rates

According to the calculation below, the requested times for scanning through all lines of the sensor will affect maximum frame rate calculation as well.

In this example, the camera is an exo183 with 3672 lines and 54 dummy lines. Each line takes 22.2 ms readout time (depending on configuration). The camera does have about 300 µs exposure time delay at worst case.

Frame rate calculation with exo183 with rolling shutter			
lines			3672
dummy lines		+	54
total lines			3726
readout time 1x3_1Y	22,2 µs	* 3726 =	82717,2 µs
exp delay		+	300 µs
frame readout time			83017,2 µs
This is minimum time for camera readout with 0s exposure time.			
Exposure time has to be added:			
frame readout time			83017,2 µs
exposure time			2500 µs
total frame time			85517,2 µs
maximum sensor acquisition time		1/ frame time	11,6 fps
note: readout time 1x2_1Y = 32,63 µs			

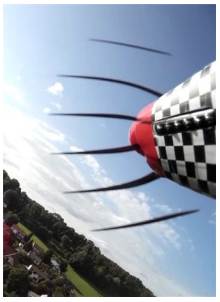
5.1.11 Global shutter

The shutter is describing the functionality of exposing the light sensitive pixels of the sensor to light for a limited time. With global shutter all pixels are exposed to light at the same time for the same time.

All pixels will be exposed to light at the same starting point, and all pixel light exposure will stop at the same time. Fast moving objects will be captured without movement distortion, except motion blur if the moving object is so fast that the same point of the object covers different pixels at start and end while exposing.

Using flash with global shutter is straight forward: make sure your flash is on while shutter is open, thus all pixels are exposed to light the same time. You might flash at any time within exposure time.

5.1.12 Rolling shutter



Rolling shutter is a method of reading out a CMOS sensor, where the whole scene is scanned line after line very rapidly. Despite the speed of scanning the lines one line after the other („rolling“) is very high, it is important to note that the instant of imaging a single line will be different to the point of time of the next line imaging. As this works out without any effect in the final image with still scenarios, at moving objects you get geometric distortions (see example of rotating propeller), showing fast moving structures in an predictable, in the first moment yet surprising way.

As it takes some time to read out a whole sensor (and the whole sensor has always to be read out!) you need to make sure that light conditions are stable while reading the sensor. This restriction applies especially to using PWM driven lights or flash lighting with rolling shutter. Unstable light conditions will result in a horizontal line structured pattern noise. Rolling shutter cameras in general are more sensitive in their light response than global shutter ones.

PWM LIGHTS WITH ROLLING SHUTTER

PWM (Pulse Width Modulated) powered light or dimmed light is run at a fixed frequency. Experience teaches us this frequency might be less stable than expected. Unstable frequency might show up as unstable light, creating noise / line structures in the final rolling shutter image (in global shutter images the whole image is just more / less bright)

As a rule of thumb, make sure your PWM lighting frequency is at least double or triple the bit depth of your image (e.g. 8bit image = 256, this means your PWM has to be switched at least 256*2=512 times) while exposing. If exposure time is 5 ms,

required minimum PWM freq = 5ms/512 ~ 10 µs ~ 100 kHz

If you have the possibility to use a strobe controller or dimmer with linear regulation, this might be preferable on short exposure times.

5.1.13 Exposure

- For various exposure and timing modes, refer to "Basic capture modes".
- For combining various exposure timings with PWM LED illumination, refer to "Sequencer" on page 57.

SETTING EXPOSURE TIME

Exposure time can be set by width of the external or internal triggers or programmed by a given value.

5.1.14 Exposure speed

Frames per second, or frame rate describes the number of frames output per second (1/ frame time). Especially GigE and USB cameras cannot guarantee predictable maximum frame rates with heavy interface bus load.

Maximum frame rate might depend on:

- Pixel clock
- Image size
- Tap structure
- Data transport limitation
- Processing time

LIMITATIONS EXO183 ON EXPOSURE TIME

In general, the camera design permits frame rates close to this formula:

$$Fps_max = 1 / exposure\ time$$

The exo183 has some specific sensor properties. Most important, due to its sensor design it comes with an additional readout time of about 56 ms. Thus, the maximum exo183 frame rate calculates as follows (as long not restricted by interface speed):

$$Fps_max = 1 / (exposure\ time + 56\ ms)$$

The implication is that if you want to have full speed in frames per second, with the exo183 sensor you need to take care for short exposure times.

5.1.15 Auto exposure

Auto Luminance or auto exposure automatically calculates and adjusts exposure time and gain, frame-by-frame.

The auto exposure or automatic luminance control of the camera signal is a combination of an automatic adjustment of the camera exposure time (electronic shutter) and the gain.

The first priority is to adjust the exposure time and if the exposure time range is not sufficient, gain adjustment is applied. It is possibility to predefine the range (min / max-values) of exposure time and of gain.

The condition to use this function is to set a targeted averaged brightness of the camera image. The algorithm computes a gain and exposure for each image to reach this target brightness in the next image (control loop). Enabling this functionality uses always both – gain and exposure time.

LIMITATIONS

As this feature is based on a control loop, the result is only useful in an averaged, continuous stream of images. Strong variations in brightness from one image to next image will result in a swing of the control loop. Therefore it is not recommended to use the auto-luminance function in such cases.

5.1.16 Acquisition and processing time

The camera has to read the sensor, process the data to a valid image and transfer this to the host computer. Some of these tasks are done in parallel. This implies the data transfer does not end immediately after end of exposure, as the image has to be processed and transferred after exposure.

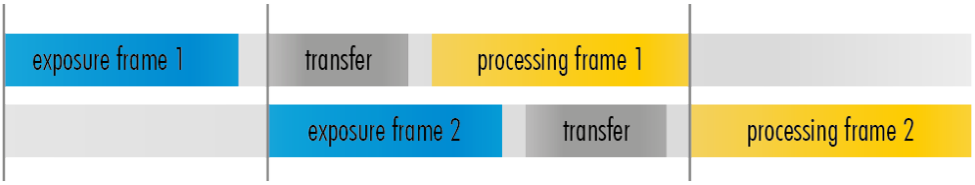


Fig. 5-20: Acquisition and processing time

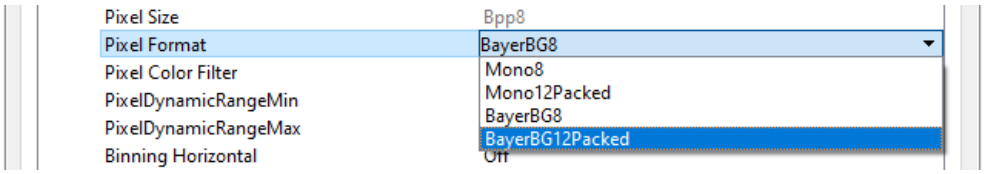
On the other hand, while processing and transferring the image the sensor might capture already the next frame.

5.1.17 Bit depth

Values of brightness are internally represented by numbers. The number of bits for brightness representation is limiting the number of color values that can be represented. Bit depth defines the maximum unique colors or gray levels in an image.

No of gray values = $2^{\text{bit depth}}$

All SVCam models support 8-bit format. In most cases, the sensor itself is limiting maximum bit depth. Refer to specifications whether your model is supporting higher bit depth.



Depending on camera model, different bit depths are supported.

5.2 Camera features

The features of the Allied Vision cameras are defined by the combination of its electronics and firmware features. Firmware features can be upgraded with new firmware releases.

5.2.1 IR / glass filter

To avoid influences of infrared light to your image, cameras are equipped with an IR (Infrared) cut filter or an anti-refection coated glass (AR filter).

- Monochrome cameras come by default with an AR-Filter (anti reflex)
- Color models version comes by default with an IR-cut-filter
- IP67 BlackLine models do have an IR-cut filter (color) or glass (monochrome)

Refer to your camera order to see if a filter is built in. Alternatively look at the sensor. Built-in IR-filters are screwed into the lens mount. Filters will change the optical path length. The camera specs are including the standard filters.

IMAGE IMPACT OF IR CUT FILTER

Due to chromatic aberration, limiting the spectral bandwidth of light will result in sharper images. Without an IR cut filter:

- Monochrome sensor images might get muddy.
- Color sensor images are affected, especially red will be higher in intensity than visible with bare eyes. White balance gets much more difficult. Contrast is lower.

> Allied Vision recommends IR cut filter for high demands on sharpness with monochrome or color sensors.

SPECTRAL IMPACT OF IR CUT FILTERS

IR cut filter influence the spectral sensitivity of the sensor. The spectral graph below shows the wavelength relative impact of the Allied Vision standard filter.

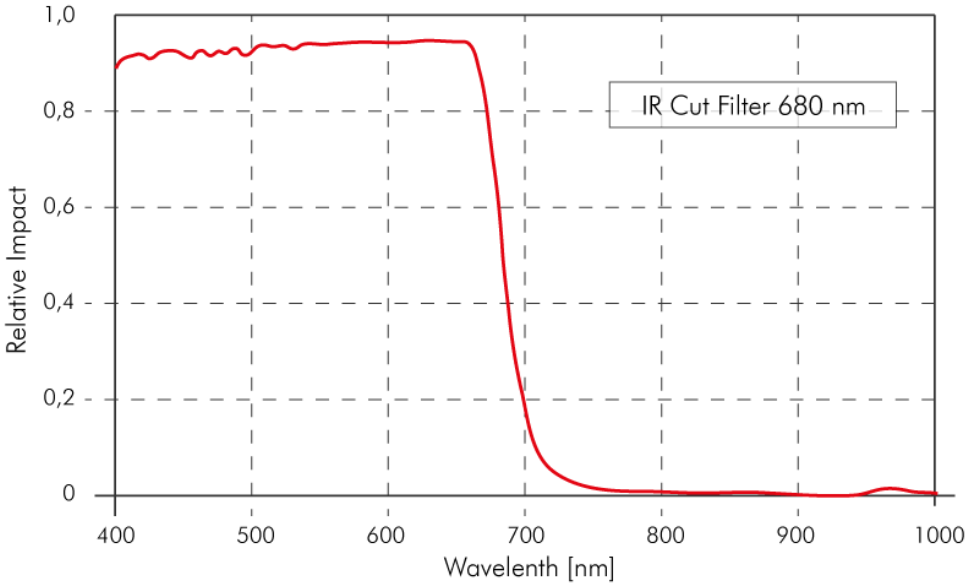


Fig. 5-21: IR cut filter light transmission

FOCAL IMPACT OF FILTERS

As an IR cut filter mainly consist of a small layer of glass (1 mm thick) there is an impact on the flange focal distance. Refraction within the layer cause shortening this distance.

When ordering a standard camera with an extra IR cut filter you might have to compensate the focal length with an extra ring. Please refer to your local distributor for more detailed information on your camera behaving on C-Mount integrated filters.

As BlackLine models have an IR cut filter by default, the focal distance is compensated by default.

> Removing the IR cut filter lengthen the focal distance and will invalidate camera warranty.

5.2.2 Look-up table

The look-up table feature (LUT) lets the user define certain values to every bit value that comes from the ADC. To visualize a LUT a curve diagram can be used, similar to the diagrams used in photo editing software.

The shown custom curve indicates a contrast increase by applying an S-shaped curve. The maximum resolution is shifted to the mid-range. Contrasts in this illumination range is increased while black values will be interpreted more black and more of the bright pixels will be displayed as 100 % white.

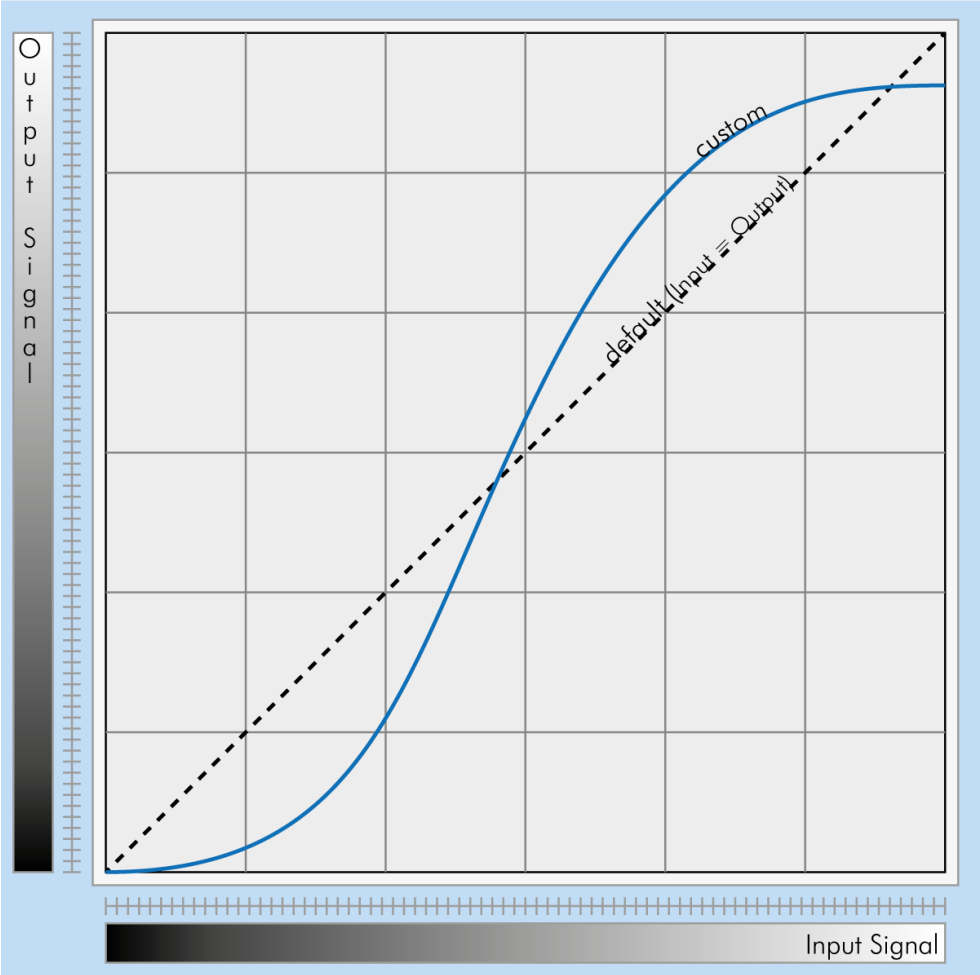


Fig. 5-22: Custom LUT adding contrast to the mid-tones

LUT implementation reduces bit depth from 12 bit to 8 bit on the output.

GAMMA CORRECTION

Using the look-up table makes is also possible to implement a logarithmic correction. This is commonly called “gamma correction”.

Historically gamma correction was used to correct the illumination behavior of CRT displays, by compensating brightness-to-voltage with a gamma value between 1,8 up to 2,55.

The gamma algorithms for correction can simplify resolution shifting as shown seen below.

- Input & output signal range from 0 to 1
- Output-signal = Input-signal^{Gamma}

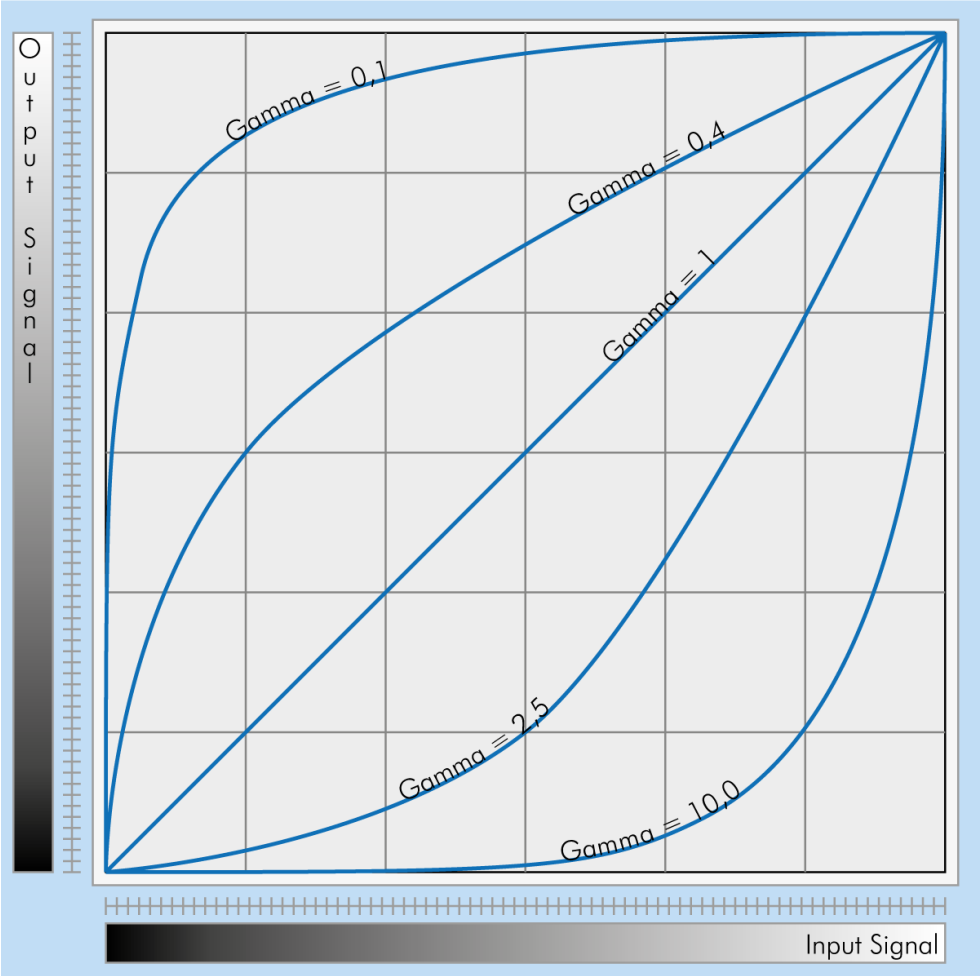


Fig. 5-23: Several gamma curves comparable to a LUT

- Gamma values less than 1.0 map darker image values into a wider ranger.
- Gamma values greater than 1.0 do the same for brighter values.

> Gamma algorithm is just a way to generate a LUT. It is not implemented in the camera directly.

GAMMA CORRECTION

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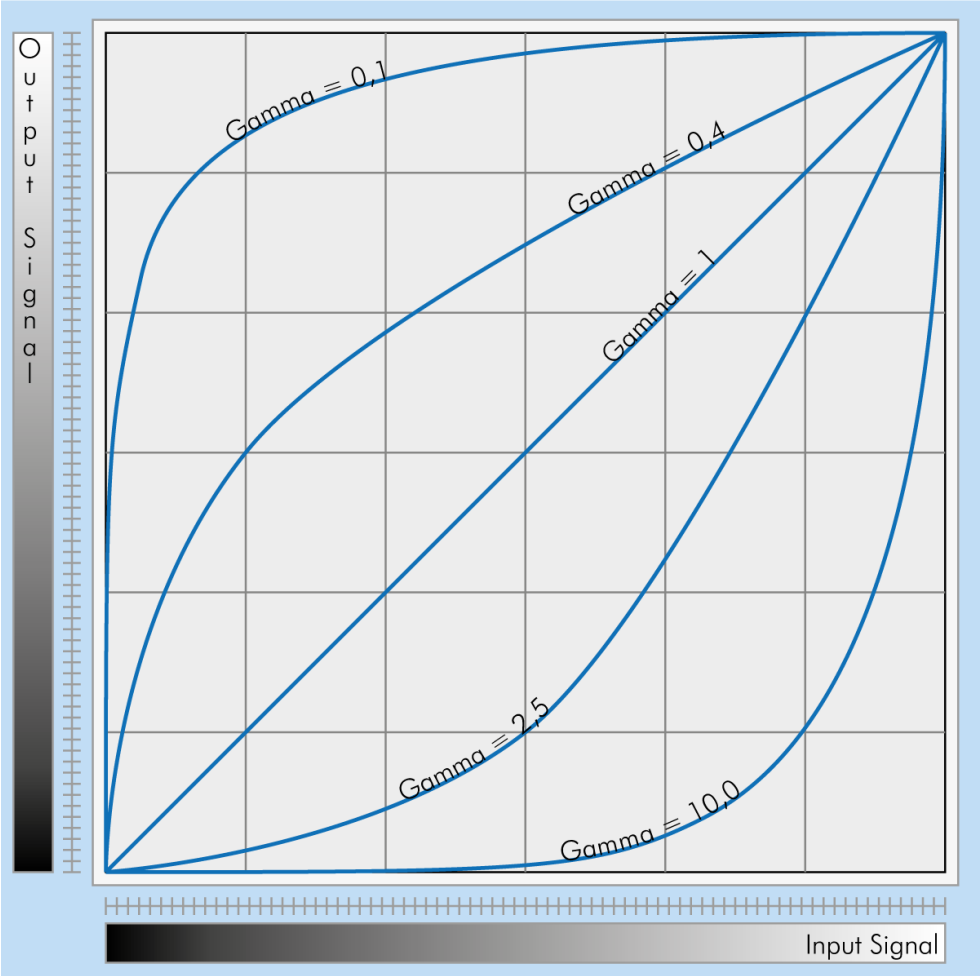


Fig. 5-24: Several gamma curves comparable to a LUT

- Gamma values less than 1.0 map darker image values into a wider ranger.
- Gamma values greater than 1.0 do the same for brighter values.

> Gamma algorithm is just a way to generate a LUT. It is not implemented in the camera directly.

5.2.3 ROI / AOI

In partial scan mode or Area-Of-Interest (AOI) mode (or Region-Of-Interest (ROI) mode) only a certain region of the sensor will be read.

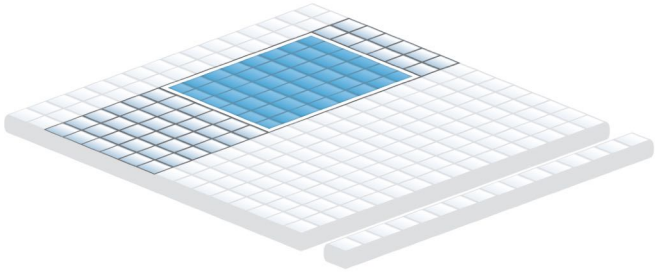


Fig. 5-25: AOI on area sensor

Selecting an AOI will reduce the number of horizontal lines being read. This will reduce the amount of data to be transferred, thus increasing the maximum speed in terms of frames per second.

With CMOS Sensors, AOI is sensor dependent. Some CMOS sensors require the camera to read full horizontal sensor lines internally. Reducing horizontal size with AOI might result in limited frame rate gain.

5.2.4 Basic capture modes

The camera has 2 basic operation modes.

- Free run (timed) run: The camera will expose and deliver images on a fixed schedule.
- Triggered: The camera will wait for an external signal and start exposure after receiving the external trigger signal.

FREE RUNNING

Free running (fixed frequency) with programmable exposure time. Frames are read continuously and valid data is indicated by LVAL for each line and FVAL for the entire frame.

There is no need to trigger the camera in order to get data. The exposure time is set via the serial interface and calculated by the internal logic of the camera.

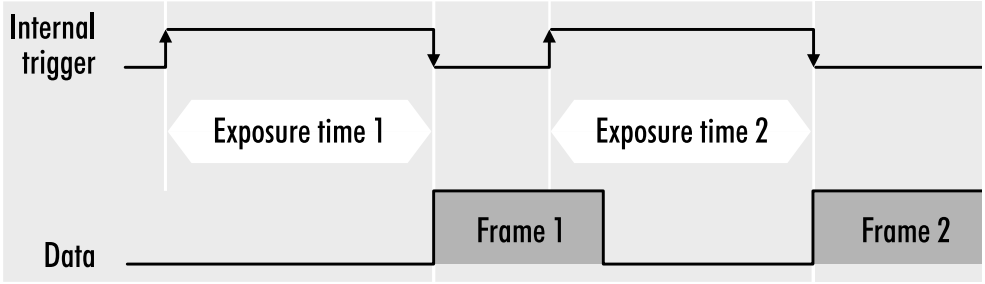


Fig. 5-26: Mode 0 - Free running with programmable exposure time

The fundamental signals are:

- Line Valid: LVAL
- Frame Valid: FVAL
- For triggered modes: trigger input

TRIGGERED MODE (PULSE WIDTH)

External trigger and pulse-width controlled exposure time. In this mode the camera is waiting for an external trigger, which starts integration and readout. Exposure time can be varied using the length of the trigger pulse (rising edge starts integration time, falling edge terminates the integration time and starts frame read out). This mode is useful in applications where the light level of the scene changes during operation. Change of exposure time is possible from one frame to the next.

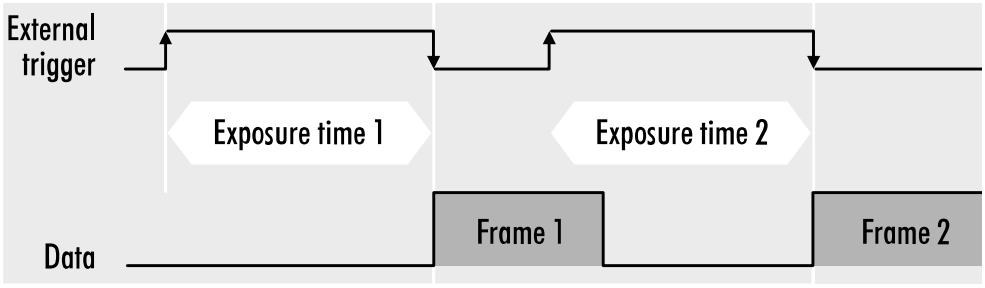


Fig. 5-27: Mode 1: External Trigger with Pulse Width Exposure Control (overlap)

Exposure time of the next image can overlap with the frame readout of the current image (rising edge of trigger pulse occurs when FVAL is high). When this happens: the start of exposure time is synchronized to the falling edge of the LVAL signal.

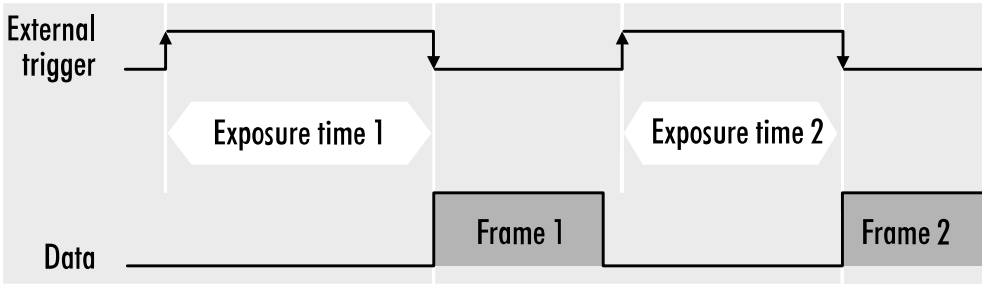


Fig. 5-28: Basic capture modes - triggered mode (pulse width without overlap)

When the rising edge of trigger signal occurs after frame readout has ended (FVAL is low) the start of exposure time is not synchronized to LVAL and exposure time starts after a short and persistent delay.

The falling edge of the trigger signal must always occur after readout of the previous frame has ended (FVAL is low).

SOFTWARE TRIGGER

Trigger can also be initiated by software or serial interface.

> Software trigger can be influenced by jitter. Avoid software trigger when using time sensitive applications.

EXTERNAL TRIGGER (EXPOSURE TIME)

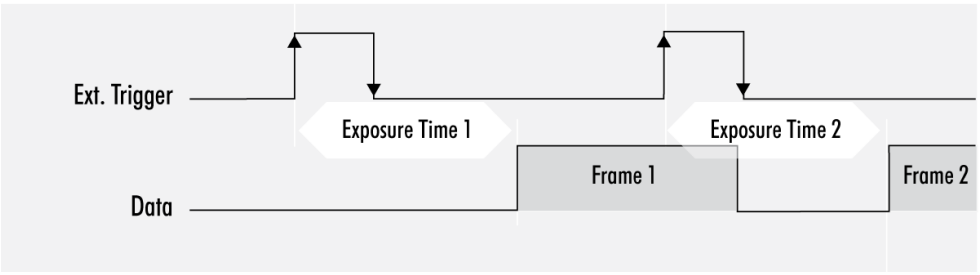
External trigger with programmable exposure time. In this mode the camera is waiting for an external trigger pulse that starts integration, whereas exposure time is programmable via the serial interface and calculated by the internal microcontroller of the camera.

At the rising edge of the trigger the camera will initiate the exposure.

The software provided by Allied Vision lets the user set exposure time e.g. from 60 µs to 60 sec (camera type dependent).

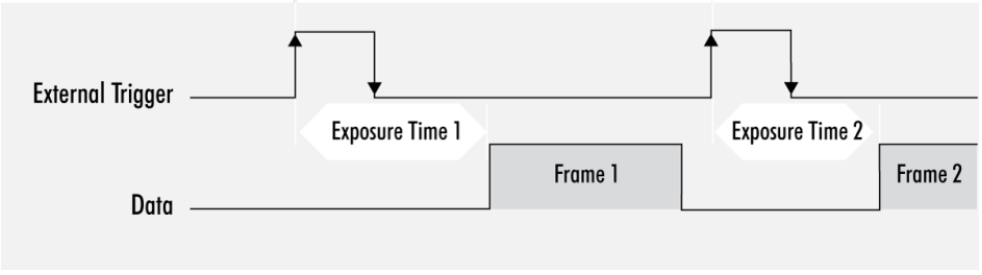
Exposure time of the next image can overlap with the frame readout of the current image (trigger pulse occurs when FVAL is high). When this happens, the start of exposure time is synchronized to the negative edge of the LVAL signal (see figure).

Mode 2: External Trigger with Programmable Exposure Time (overlap)



When the rising edge of trigger signal occurs after frame readout has ended (FVAL is low), the start of exposure time is not synchronized to LVAL and exposure time starts after a short and persistent delay.

Mode 2: External Trigger with Programmable Exposure Time (non overlap)



Exposure time can be changed during operation. No frame is distorted during switching time. If the configuration is saved to the EEPROM, the set exposure time will remain also when power is removed.

5.2.5 Temperature sensor

A temperature sensor is installed on the main board of the camera. To avoid overheating, the temperature is constantly monitored and read. Besides software monitoring, the camera indicates high temperature by a red flashing LED (see flashing LED codes).

5.2.6 System clock frequency

Default system clock frequency in almost every SVCam is set to 66.6 MHz. To validate your system frequency refer to: specifications.

Using the system clock as reference of time, time settings can only be made in steps. In this example, the transfer rate is 66.7 MHz, thus resulting in steps of 15 ns.

$$t = \frac{1}{66.\overline{6}\ MHz} = \frac{1}{66\,666\,666.\overline{6}\ \frac{1}{s}} = 15 \bullet 10^{-9}\ s = 15\ ns$$

Use multiples of 15 ns to write durations into camera memory.

5.2.7 Pixel clock frequency selection

Besides the factory frequency setting other values can be available for some sensors. Charges will be transported faster, more frames per second will be generated. IMX sensors from Sony are running with default value as recommended in sensor specifications and cannot be modified.

Higher Frequencies can result in a loss of quality.

5.2.8 Camera Link timings

Camera Link permits to calculate when “valid data” can be expected exactly.

px_h= pixel horizontal [count]
px_v = pixel vertical [count]

LVAL – T_{LVD}

Every line has periods with no valid data. The Duration of None Valid Data between two lines (t_{nvd}) is three time the Camera Link clock (clk). Delay before every first line is 2 times clk.

$$t_{Lvd} = \frac{px_h}{CL_geometry_X} \times \frac{1}{CL_clock}$$

CL_clock = 85 MHz

FVAL – T_{FVD}

Frames are not sent permanently. Between two frames will be a gap – even at highest frame rates. Minimum duration between two valid frame signals is the duration of one line.

$$t_{Fvd} = 2 \times \frac{1}{CL_clock} + (t_{Lvd} + t_{nvd}) \times \frac{px_v}{CL_geometry_Y}$$

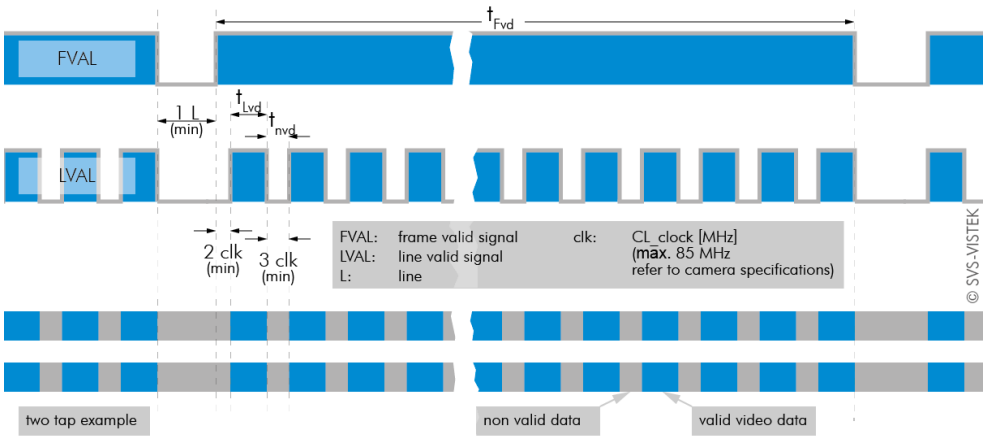


Fig. 5-29: Overview of FVAL and LVAL signal timing on Camera Link

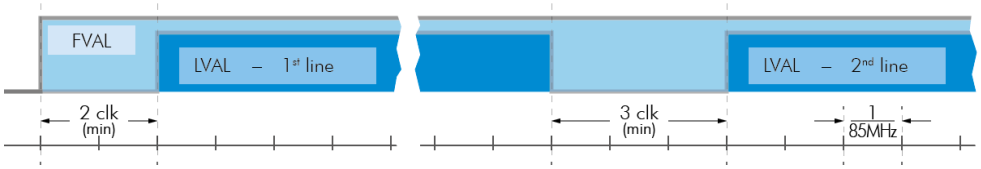


Fig. 5-30: Detailed view of LVAL signal timing on Camera Link

>	t_{Lvd}	=	(1920 / 2) px in line / sent at once	×	(1/85MHz) CL_clock		
		=	960	×	$(1/85e^6)$ s	≈	11,29 µs

Table: 5-2: Example calculation

>	t_{nvd}	=	3 × (1/85MHz) Time between two valid line data packages	=	$(3/85e^6)$ s	≈	35,3 ns

>	**t_{Fvd}**	**=**	**2 x (1/85MHz) delay before first line**	**+**	**(t_{LVd}**	**+**	**t_{nvd})**	**×**	**1200 lines [count]**
		=	$(2/85e^6)$ s	+	(11,29 µs	+	35,3 ns)	×	1200
		=	23,5 ns	+	(11,29 µs	+	35,3 ns)	×	1200

>	t_{Fvd}	=	2 x (1/85MHz) delay before first line	+	(t_{LVd}	+	t_{nvd})	×	1200 lines [count]
		=	(2 + (960 + 3) × 1200) s			/	85e6	≈	13,6 ms
Camera Link architecture exo174*CL: • 1X2_1Y count = 2 • pixelh =1920 • pixelv = 1200 • CL_clock = 85 MHz									

Table: 5-3: Example calculation of Camera Link timing on a exo174*CL

5.3 I/O Features

The SVCam cameras are equipped with several inputs and outputs, providing state-of-the-art control regarding input and output channels. All I/O functions are realized as modules. These functions can be connected in the GenICam tree.

5.3.1 Pulse width modulation

During pulse width modulation (PWM), a duty cycle is modulated by a fixed frequency square wave. This describes the ratio of ON to OFF as duty factor or duty ratio.

WHY PWM?

Pulse width modulation is an extremely efficient way (in terms of power dissipation) to provide or regulate electrical power to consumers as long as they do not need uninterrupted supply (such as diodes or LEDs). The interruption times might be as short as nano seconds.

LED CHARACTERISTICS

Since LEDs have a bounded workspace, the PWM ensures a variable intensity of illumination at a constant current on the diodes. The constant current guarantees a linear light emission response curve of the LED from 0-100% PWM intensity.
Running LED lighting in flash mode will increase LED lifetime because of reduced LED heat dissipation.

IMPLEMENTATION OF PWM

The basic frequency of the modulation is defined by the cycle duration "T".

$$T_{PWM} = \frac{1}{f_{PWM}}$$

Duty cycle "T" is written into the registry by multiple of the inverse of camera frequency in 15 ns steps.

$$T_{PWM} = \frac{1}{66{,}\overline{6}\,MHz} \bullet \mathrm{PWMMax}\left[\mathrm{SeqSelector}\right] = 15\ ns \bullet \mathrm{PWMMax}\left[\mathrm{SeqSelector}\right]$$

THE INTENSITY OF A PWM

The duty ratio is calculated as: Δ% = t / T. It is written above the value of "t" as PWMChange0-3[SeqSelector] per sequence into the registry.

PWMChange0-3[SeqSelector] unit is percentage value.

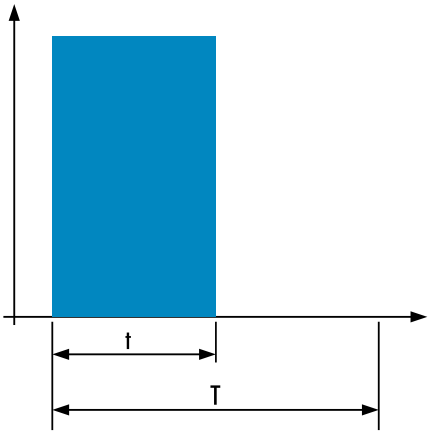


Fig. 5-31: PWM intensity

EXAMPLES OF PWMS

The integrals over both periods T_A and T_A are equal.

$$\int_{t_{A1}}^{t_{A2}} \mathbf{A} = \int_{t_{B1}}^{t_{B2}} \mathbf{B}$$

An equal amount of Photons will be emitted. The intensity of light is the same.

$$t_{A2} - t_{A1} = t_{B2} - t_{B1}$$

The periods T_A and T_B are equal in length.

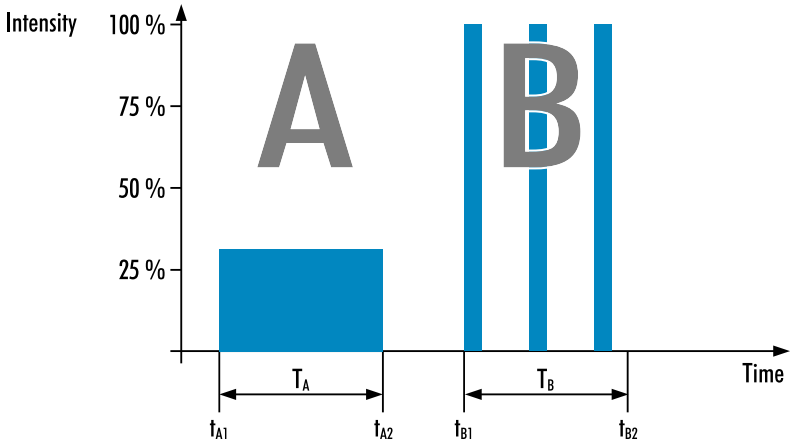


Fig. 5-32: Example: 25% PWM load

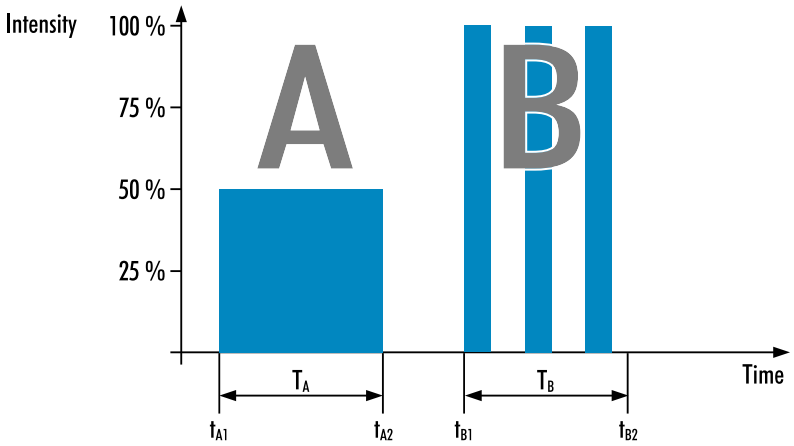


Fig. 5-33: Example: 50% PWM load

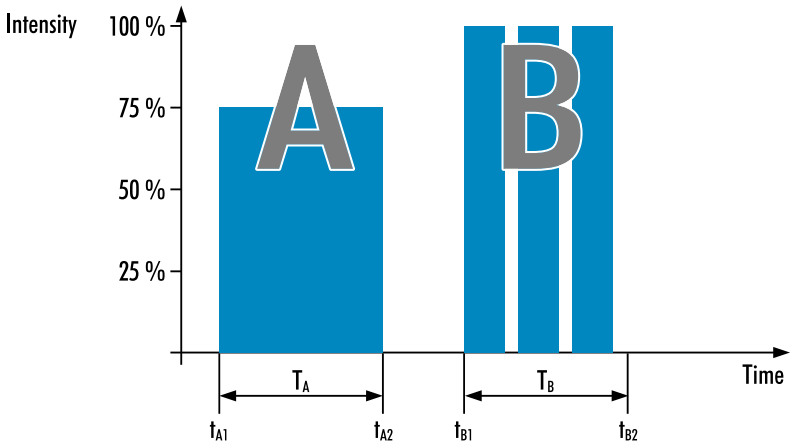


Fig. 5-34: Example: 75% PWM load

THE PWM MODULE

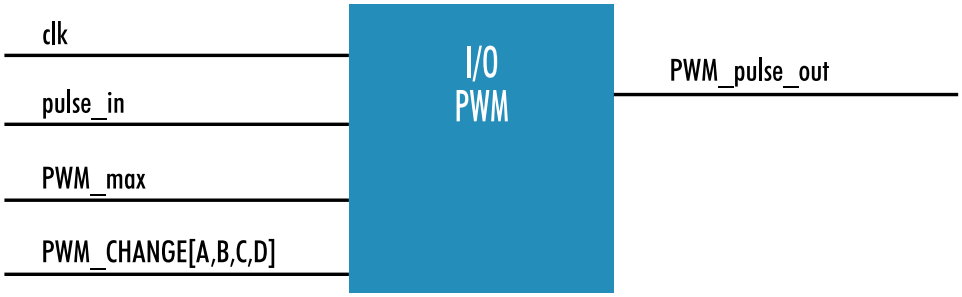


Fig. 5-35: The PWM module

5.3.2 LED strobe control

The SVCam 4I/O concept contains an integrated strobe controller. Its controls are integrated into the GenICam tree. With LED lights attached to the outputs, this enables the user to control the light without external devices. Being controlled via GenICam, any GenICam-compliant 3rd party software is able to control the light as well. Maximum ON-time is 100 ms. Depending on the camera model, up to four (see specifications) independent channels are supported with a max current of 3A@40 ms per 1 s (or 4 %). Maximum continuous current is 0.3 A. Despite internal protections, higher current peaks might be able to damage the camera.

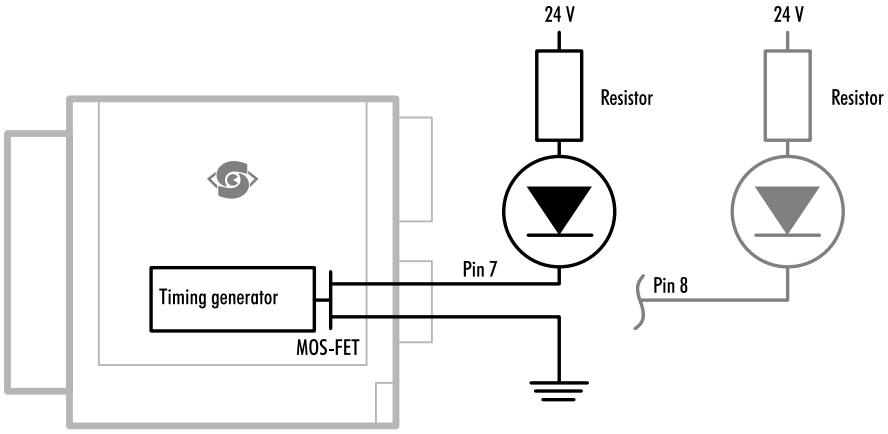


Fig. 5-36: Attach LED lights to camera outputs

> To avoid destruction of your LED light or camera, make sure to use the right dimension of shunt resistor.

STROBE POLARITY

Positive or negative polarity of the hardware strobe output can be selected.

STROBE DURATION

The exposure time of LED lights can be set in tics. The min duration is 1 µs. The longest time is 1 second.

STROBE DELAY

The delay between the (logical) positive edge of trigger pulse and strobe pulse output.

EXPOSURE DELAY

A tic value, representing the time between the (logical) positive edge of trigger pulse and start of integration time.

CALCULATE LED SHUNT RESISTORS

Shunt resistors are used to limit the LED current. Make sure, neither shunt nor LED run above specs.

LEDS IN CONTINUOUS MODE

Specification	Value
Voltage drop al 5 LEDs, 2,2V per LED (see spec. of LED)	11 V
Max. continuous current (see spec. of LED)	250 mA
Voltage supply	24 V
Voltage drop at resistor (24 V – 11 V)	13 V
Pull up Resistor R = $\frac{13\ V}{250\ mA}$	52 Ω

Table: 5-4: LEDs in continuous mode

Specification	Value
Total power ($P = U \times I$)	6 W
Power at LEDs ($11\ V \times 250\ mA$)	2,75 W
Power loss at resistor ($13\ V \times 250\ mA$)	3,25 W

Table: 5-5: Example Calculation “No Flash” (CW Mode)

LEDS IN FLASH MODE

Most LED lights can cope with currents higher than specs. This gives you higher light output when light is ON. Refer to your LED specs if LED overdrive is permitted.

By controlling the duty cycle the intensity of light and current can be controlled. See sequencer example how to adjust the values in the GenICam tree for strobe control.

> The shorter the „time on“ – the higher current can be used when driving LEDs with current higher than spec

> Make sure your PWM lighting frequency is at least double or triple the bit-depth of your image (e.g. 8 bit image = 256, this means your PWM has to be switched at least 256*2=512 times) while exposing. If exposure time is 5 ms, the required minimum PWM freq = 5 ms / 512 ~ 10 µs ~ 100 kHz.

STROBE VOCABULARY

For an example how to enable and adjust the integrated strobe controller refer to sequencer (see "Sequencer" on page 57). Times and frequencies are set in tics. 1 tic = 15 ns.

EXPOSURE DELAY

A tic value, representing the time between the (logical) positive edge of trigger pulse and start of integration time.

STROBE POLARITY

Positive or negative polarity of the hardware strobe output can be selected.

STROBE DURATION

The exposure time of LED lights can be set in tics. The min duration is 1 µs. The longest time is 1 second.

STROBE DELAY

The delay between the (logical) positive edge of trigger pulse and strobe pulse output.

5.3.3 Sequencer

The sequencer is used when different exposure settings and illuminations are needed in a row.

Values to set	Description
Sequencer interval	Duration of the interval
Exposure start	Exposure delay after interval start
Exposure stop	Exposure stop related to interval Start
Strobe start	Strobe delay after interval start
Strobe stop	Strobe stop related to interval Start
PWM frequency	Basic duty cycle (1 / Hz) for PWM
PWM change	Demodulation results

In the current GenICam implementation, all values have to be entered in tic values.

1 tic = 15 ns

Every adjustment (times, frequencies) has to be recalculated into tics and done in tics. See the example below.

When setting “Exposure Start” and “Stop” consider ‘read-out-time’ of the sensor. It has to be within the Sequencer interval.

For physical input and output connections refer to pin-out or specifications or see example below. After trigger signal all programmed intervals will start. Up to 16 intervals can be programmed.

Sequencer settings can be saved to camera EEPROM.

EXAMPLE

SCENARIO

An object should be inspected with a monochrome camera. For accentuating different aspects of the image, 4 images should be taken in a row with 4 different colors of light: red, green, blue, white. White light should be generated from the RGB lights being activated at the same time. Basis is a dark environment without other light sources.

CAMERA WIRING

- 3 LED lights are physically connected to the camera on out 0-2 (red, green, blue)

- Out 3 is not used

I/O MATRIX

- 4 images to be taken (RGBW) result in 4 sequences
- RGB PWM change with different intensities (duty cycle) taking care for differences in spectral response of the camera sensor
- PWM change 0-2 is connected to out 0-2
- Seq pulse A is driving the exposure (trigger)
- Seq pulse B is driving the strobe
- Seq pulse B in WHITE sequence is reduced down to 33% as light intensities of 3 lights (RGB) will add up

NOTES

- Different exposure / strobe timings are used for illustration. In most cases they will show values same as exposure
- The resulting exposure time shows the period of sensor light exposure. ("masking" of exposure time by creating strobe light impulses shorter than exposure time). This value is not adjustable at the camera
- PWM change is shown with reduced height for demonstrating reduced intensity. In reality though, PWM change will be full height (full voltage, shunt resistor might be necessary) with the adjusted duty cycle
- Use a PWM frequency high enough not to interfere with your timings (here: 1000 Hz)

Scenario values	Interval 0 (RED)	Interval 1 (GREEN)	Interval 2 (BLUE)	Interval 3 (WHITE)
Sequencer Interval	1000 ms	1000 ms	1000 ms	1000 ms
Seq pulse A start	0 ms	0 ms	100 ms	0 ms
Seq pulse A stop	100 ms	300 ms	300 ms	100 ms
Seq pulse B start	0 ms	100 ms	200 ms	0 ms
Seq pulse B stop	100 ms	200 ms	300 ms	33 ms
PWM Frequency f	1000 Hz	1000 Hz	1000 Hz	1000 Hz
PWM change 0 (RED)	100%	0%	0%	100%
PWM change 1 (GREEN)	0%	70%	0%	70%
PWM change 2 (BLUE)	0%	0%	80%	80%
PWM change 3	-	-	-	-

As stated before, all these values have to be entered into the camera's GenICam tree as tic values.

The timing values translate like this into tics:

Values to set in GenICam properties	Interval 0 (RED)	Interval 1 (GREEN)	Interval 2 (BLUE)	Interval 3 (WHITE)
Sequencer Interval	66666667 tic (1000 ms)	66666667 tic (1000 ms)	66666667 tic (1000 ms)	66666667 tic (1000 ms)
Seq pulse A start	0 tic (0 ms)	0 tic (0 ms)	6666667 tic (100 ms)	0 tic (0 ms)
Seq pulse A stop	6666667 tic (100 ms)	20000000 tic (300 ms)	20000000 tic (300 ms)	6666667 tic (100 ms)
Seq pulse B start	0 tic (0 ms)	6666667 tic (100 ms)	13333333 tic (200 ms)	0 tic (0 ms)
Seq pulse B stop	6666667 tic (100 ms)	13333333 tic (200 ms)	20000000 tic (300 ms)	2200000 tic (33 ms)
Effective exposure time	100 ms	100 ms	100 ms	33 ms
PWM Frequency f	66667 tic (1000 Hz)	66667 tic (1000 Hz)	66667 tic (1000 Hz)	66667 tic (1000 Hz)
PWM change 0 (RED)	66667 tic (100% of 1000 Hz)	0 tic	0 tic	66667 tic (100% of 1000 Hz)
PWM change 1 (GREEN)	0 tic	46667 tic (70% of 1000 Hz)	0 tic	46667 tic (70% of 1000 Hz)
PWM change 2 (BLUE)	0 tic	0 tic	53333 tic (80% of 1000 Hz)	53333 tic (80% of 1000 Hz)
PWM change 3	-	-	-	-

In a timings diagram, the sequence values above will look like the following diagram:

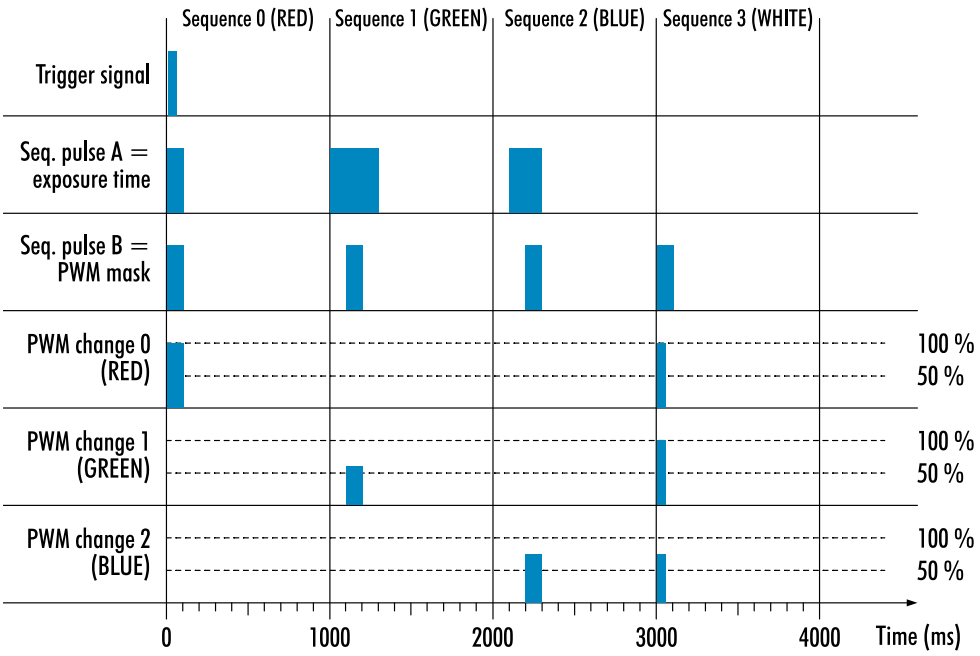


Fig. 5-37: Sequencer timing diagram

5.3.4 Optical input

In many trigger signals you find noise, transients and voltage spikes. These are able to damage components in the camera and trigger signal interpretation might be difficult.

An optical input separates the electrical trigger and camera circuits. The benefit of such an optical input is to avoid all these kinds of interaction from power sources or switches. The disadvantage of an optical input is that it is slower in terms of signal transmission and slew rate than a direct electrical connection.

If you need super fast response from the camera, direct electrical access is your choice. If your camera trigger is in the ms range or slower, we recommend to use the optical input.

An optical input needs some current for operation. The Allied Vision optical input is specified to 5-24 V, 8 mA.

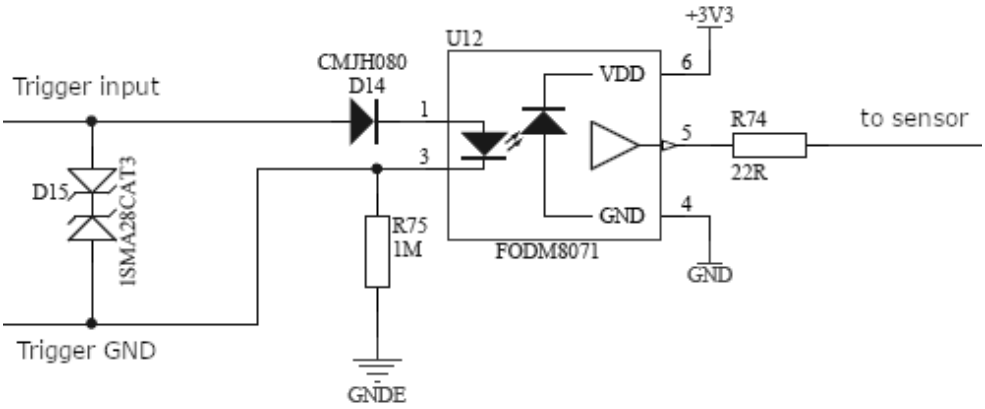


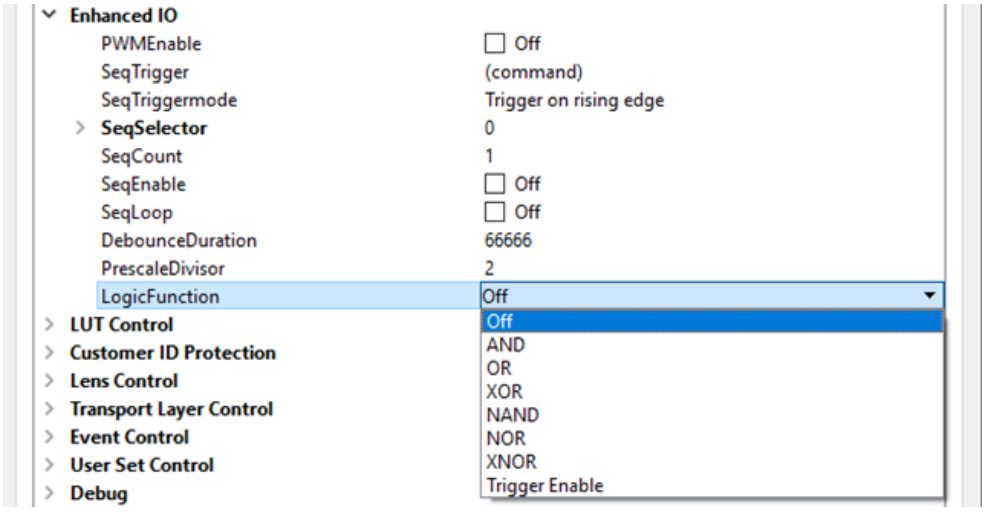
Fig. 5-38: Optical input

The optocoupler galvanically separates electrical circuits by emitting light on one side and interpreting light in the other. There is no direct electric interaction between both electrical circuits.

5.3.5 PLC / Logical operation on inputs

The logic input combines trigger signals with Boolean algorithms. The camera provides AND, NAND, OR, NOR, XOR, XNOR as below. You might combine combine true or false states of the inputs to determine camera actions. The result can be connected to a camera trigger signal or it may be source for the next logical operation with another input. It is possible to connect it to an OUT line as well.

GENICAM TREE SETTING



The logic function always combines the values of Digital IO InputA / LogicA and InputB / LogicB. In case of the trigger enabled logic function, LogicB is the trigger enable signal and will be combined with LogicA value.

AND	NAND	OR	NOR	XOR	XNOR
A B Y	A B Y	A B Y	A B Y	A B Y	A B Y
|0|0|0|	|0|0|1|	|0|0|0|	|0|0|1|	|0|0|0|	|0|0|1|
|0|1|0|	|0|1|1|	|0|1|1|	|0|1|0|	|0|1|1|	|0|1|0|
|1|0|0|	|1|0|1|	|1|0|1|	|1|0|0|	|1|0|1|	|1|0|0|
|1|1|1|	|1|1|0|	|1|1|1|	|1|1|0|	|1|1|0|	|1|1|1|

Table: 5-6: Truth table of logic function

Expert view of the GenICam tree has to be activated to see logic functions.

5.3.6 Serial data interfaces

(ANSI EIA/) TIA-232-F

RS-232 and RS-422 (from EIA, read as Radio Sector or commonly as Recommended Standard) are technical standards to specify electrical characteristics of digital signaling circuits. Serial connection might be used to control SVCams. These signals are used to send low-power data signals to control exposure, light or lenses (MFT). Usage scenario is a control possibility without network. Be aware of low connection speed.

Serial interface parameter	RS-232	RS-422
Maximum open-circuit voltage	±25 V	±6 V
Max differential voltage	25 V	10 V
Min. signal range	±3 V	2 V
Max. signal range	±15V	10 V

Table: 5-7: Serial interface parameters – RS-232 and RS-422

See your camera data sheet regarding its serial capabilities.

Data transport is always asynchronous. Synchronization is implemented by fist and last bit of a package. Data rate (bits per second) must be defined before transmission.

RS232

RS232 is split into 2 lines receiving and transferring data.

- RXD: receive data
- TXD: transmit data

Signal voltage values are:

- Low: -3 ... -15 V
- High: +3 ... +15 V

> For restrictions, refer to table of serial interface parameter above.

Packaging data into containers (adding start and stop bits) is implemented by the UART (Universal Asynchronous Receiver Transmitter).

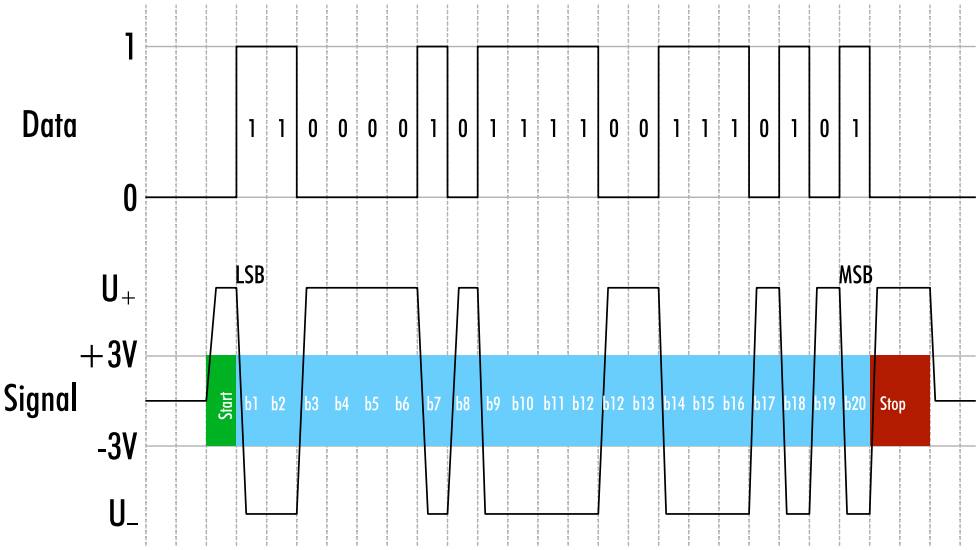


Fig. 5-39: UART encoding of a data stream

5.3.7 Trigger-edge sensitivity

Trigger-edge sensitivity is implemented by a “Schmitt trigger”. Instead of triggering to a certain value, the Schmitt trigger provides a threshold.

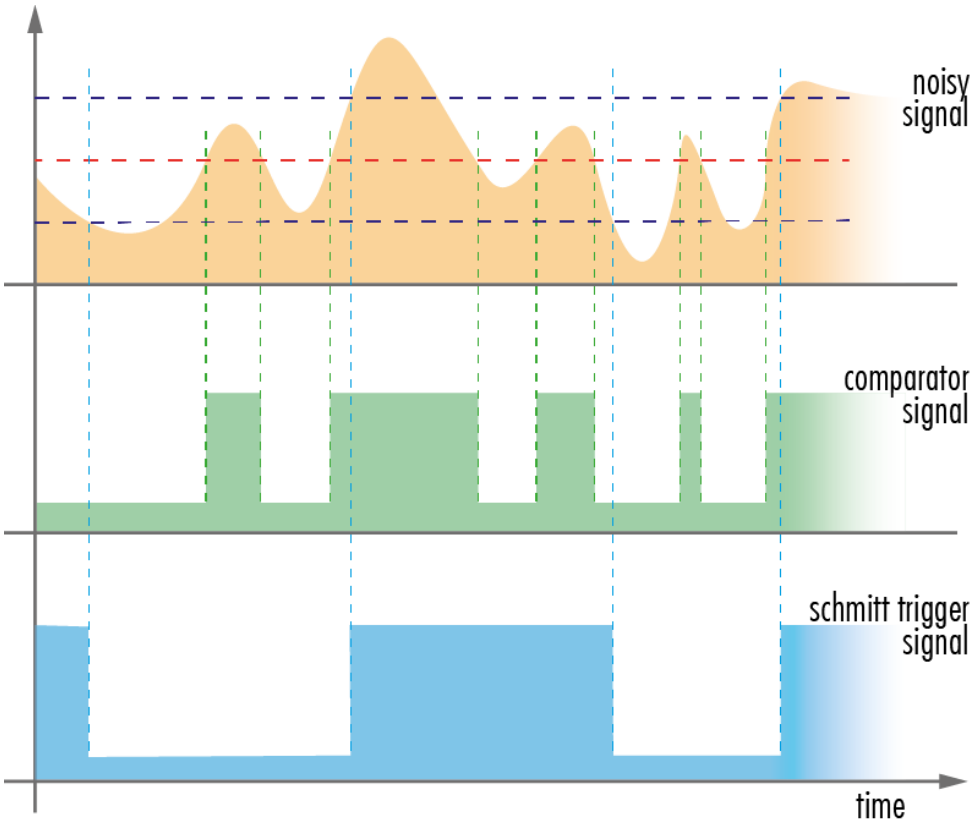


Fig. 5-40: Schmitt trigger noise suppression

5.3.8 Debouncing trigger signals

Bounces or glitches caused by a switch can be avoided by software within SVCam.

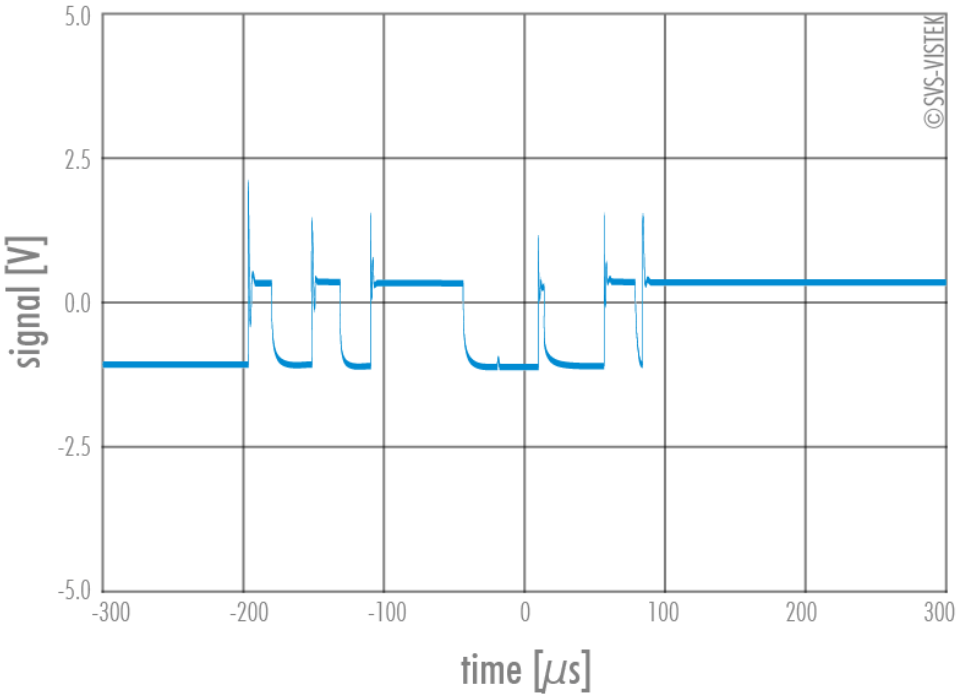


Fig. 5-41: Bounces or glitches caused by a switch

Therefore the signal will not be accepted until it lasts at least a certain time.

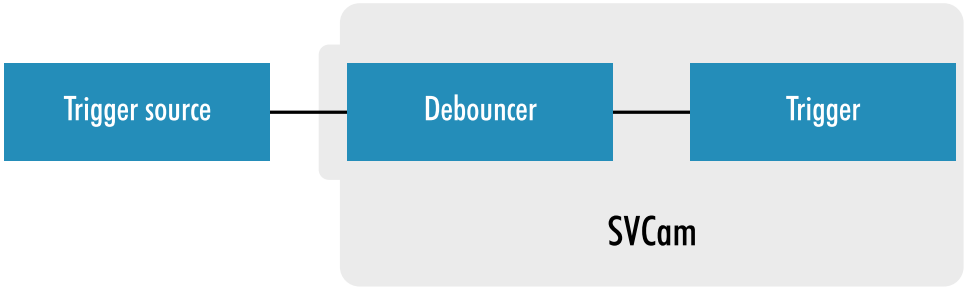
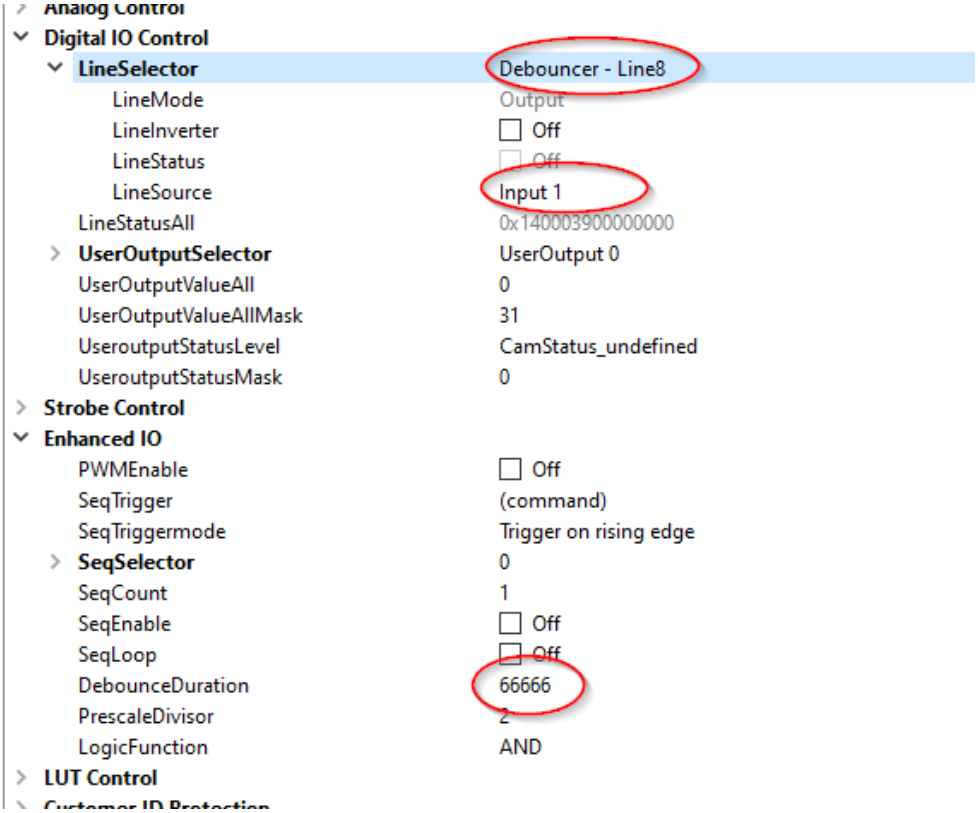


Fig. 5-42: Debouncer between the trigger source and trigger



1. Use the IO Assignment tool to place and enable the debouncer module in between the “trigger” (Schmitt trigger) and the input source (e.g.: line 1).
2. Set the register “DebounceDuration” in multiples of 15 ns (implementation of system clock), e.g. 66 666 ≈ 1 ms.



Fig. 5-43: The debouncer module

5.3.9 Prescale

The prescale function can be used for masking off input pulses by applying a divisor with a 4-bit word, resulting in 16 unique settings.

- Reducing count of interpreted trigger signal
- Use the prescale function to ignore a certain count of trigger signals.
- Divide the amount of trigger signals by setting a divisor.
- Maximum value for prescale divisor: is 16 (4 bit)

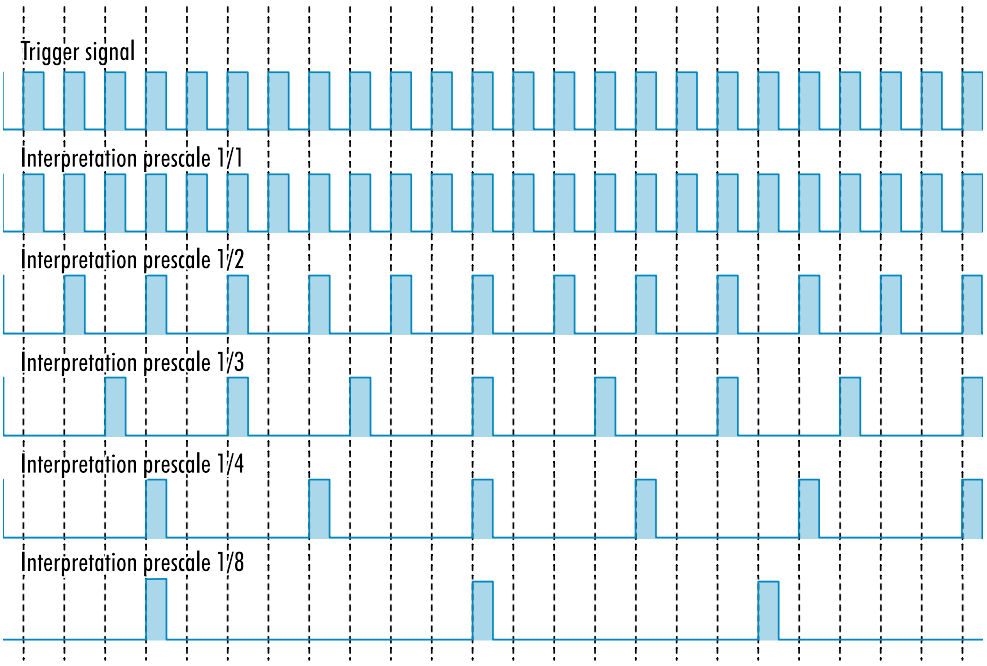


Fig. 5-44: Prescale values and their result on trigger signal

THE PRESCALE MODULE



Fig. 5-45: The prescale module

Annex

6.1 Dimensions

> All length units in mm.
> Find the technical drawings in the web download area at Documents and downloads - Technical documentation

6.2 I/O driver circuit schematics

Camera power supply and power supply for PWM out is 25V max., both being camera outputs.

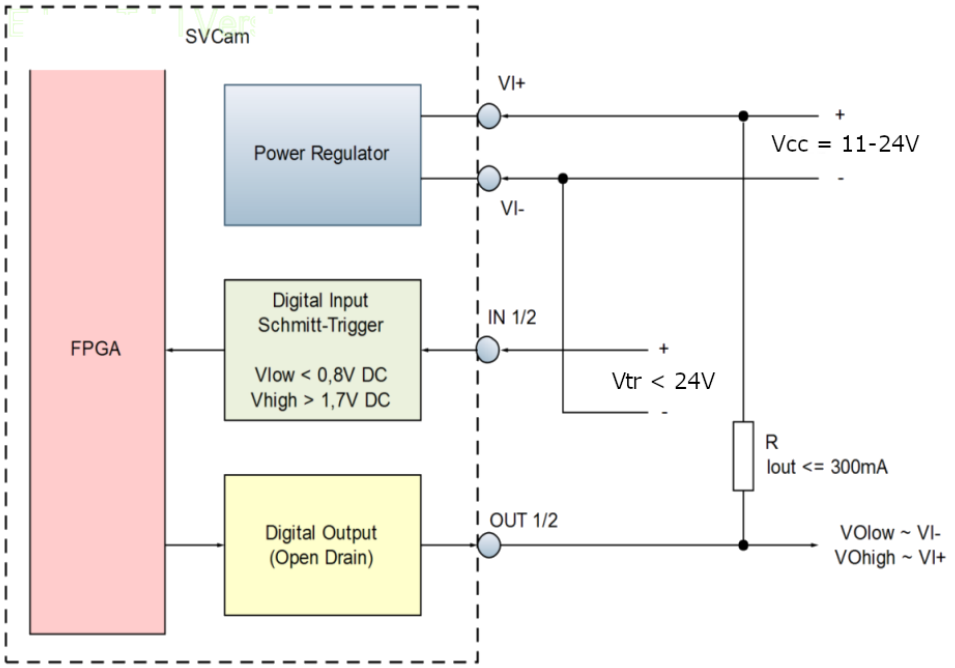


Fig. 6-1: I/O driver circuit schematics

6.3 Action commands

Action commands are dedicated Ethernet packets used as external so called "Trigger over Ethernet" (ToE). The trigger can be sent to one camera as uni-cast or to a all cameras as broadcast.

Each action command contains the following values:

- **DeviceKey** to authorize the action on this device.
- **GroupKey** to define a group of devices on which actions have to be executed.
- **GroupMask** to be used to filter out some of these devices from the group.

All these values can be set here:



Fig. 6-2: Action control

> To fire a trigger in the camera, the DeviceKey and the GroupKey have to match and at least one bit in the GroupMask has to match.

Here are some examples of the GroupMask:

Sent GroupMask	Camera GroupMask	Camera reaction
0x7FFF FFFF	0x0000 0001	YES
0x0000 000E	0x0000 0001	NO
0x0000 FFFF	0x0000 005F	YES
0x0000 FFFF	0x0000 0800	YES
0x0000 FFFF	0x0f11 0000	NO

Table: 6-1: Examples of GroupMask

Here are some examples of action commands “ActionCMD” and the reaction of three cameras receiving these commands:

	ActionCMD	Device0			Device1	Device2
DeviceKey	0xaffe	0xaffe			0xaffe	0xaffe
GroupKey	0x1234	0x1	0x1234	0x1234	0x1	0x1234
GroupMask	0x0002	0x0001	0x0002	0x0003	0xffff	0x0001

	ActionCMD	Device0			Device1	Device2
		invalid	valid	valid	invalid	invalid
DeviceKey	0xaffe		0xaffe		0xaffe	0xaffe
GroupKey	0x0001	0x1	0x1234	0x1234	0x1	0x1234
GroupMask	1-65535	0xffff	0xffff	0xffff	0xffff	0xffff
		valid	invalid	invalid	valid	invalid

Table: 6-2: Example of action command

A short Phyton program example to generate an action command. The IP address of "server.bind" shall be adapted to the IP address of the local network card.

```
1  import socket import time
2  from struct import *
3  server = socket.socket(socket.AF_INET, socket.SOCK_DGRAM, socket.IPPROTO_UDP)
   server.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
4  # Enable broadcasting mode server.setsockopt(socket.SOL_SOCKET, socket.SO_
   BROADCAST, 1) server.settimeout(0.2)
5  # use local address to bind socket server.bind(("169.254.191.50", 44444))
6  #message = b"your very important message" #    net8 id;
7  #net8 flag; #net16 command; #net16 length; #net16 req_id; #net32 device_key;
   #net32 group_key; #net32 group_mask;
8  # gv_cmd_action;
9  # action ack request
10 #    id    flag command length req_id device_key group_key
11 group_mask
12 message = pack("!BBhhhlll", 0x42, 0x01, 0x0100, 12, 5, 1, 1, 1)
13 # without action ack request
14 #message = pack("!BBhhhlll", 0x42, 0x00, 0x0100, 12, 5, 1, 1, 1)
15 while True:
16 server.sendto(message, ('<broadcast>', 3956))
17 #server.sendto(message, ("169.254.185.58", 3956))
18 print(".") time.sleep(1/40)
```

Generating an action command

> The time between receiving an action command and releasing the trigger was measured with maximum load and values between 25605 ns and 50130 ns.

6.4 FAQ

> For questions and issues, refer to the FAQ page on our website: FAQs and application notes



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