
# HR series CoaXPress Manual

hr25, hr342, hr49, hr51, hr455, hr65, hr120

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



## 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 HR camera series

## 2.1 Focusing on details

The SVCam HR series is a series of industrial machine vision cameras featuring especially on very high image resolutions and interface high speed without compromising on image quality. Camera sensors and interfaces are built to deliver maximum sensor and interface bandwidth.

These high resolution sensors in most cases are large, thus the HR series comes with an M58 mount with the possibility to adapt for any kind of lens.

High-quality image sensors with high resolutions allow fast and effortless acquisition of a large field of view. This makes this camera series your first choice for demanding applications such as optical meteorology, quality monitoring, wide field surveillance or traffic monitoring.

## 2.2 CoaXPress features

CoaXPress (CXP) is the latest development regarding high speed high volume data transfer for imaging. The interface needs a frame grabber. The CoaXPress standard is very precise and is incorporating a lot of features like power-over-CoaXPress (PoCXP) already in the standard definition.

Main advantages of CXP are

- 6.25 Gbit/s transfer rate (CXP-6) per line
- Lines can be teamed: a 4-line aggregation delivers up to 25 Gbit/s
- Provides data and power on a single line
- Very thin and flexible cables
- 25 m data cable supported
- Extremely low latency times

Please note, in case you use the 4IO PWM outputs to drive your lights, you need an external power supply as PoCXP is unable to deliver the high currents requested by the lights.

# Connections

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

## 3.1 CoaXPress

### 3.1.1 Protocol description

CoaXPress was established as a standard protocol in machine vision 2009. It is targeted to high bandwidth connections. The CoaXPress standard is scalable from 1.25 Gbit/s up to 25 Gbit/s with a maximum distance of more than 200 m.

The standard connector for CoaXPress is a 75Ω DIN 1.0/2.3 connector. Depending on the desired bit rate, environment and speed you might use 75Ω coaxial cables like RG11, RG6, RG59 and RG187 (recommended). Allied Vision uses female connectors on their cameras according to JIIA standard.

> You need cables with male connectors (plugs).

Protocol type is serial and is designed as an end-to-end connection. Forwarding the data stream to multiple receivers does require additional hardware.

Allied Vision cameras are supporting CoaXPress with up to 6.25 Gbit/s per line. Transmission speeds above this can be managed by operating multiple CoaXPress lines in parallel. Currently the cameras (depending on the model) from Allied Vision are supporting up to 4 lines in parallel. All Allied Vision CoaXPress cameras support the GEN<i>CAM interface.

CoaXPress standard supports camera control and power over CoaXPress (PoCXP, 24 V@13W). It is recommended to use the frame grabber power supply over CoaXPress.

### 3.1.2 CoaXPress-12

The cameras support an extended CoaXPress-12 (or CoaXPress 2.0) interface with connectors and a bandwidth of up to 12.5 Gbit/s per line.

The connectors are µBNC connectors. For cables, an impedance of 75 Ohm, RG187 is recommended. Allied Vision Gilching GmbH uses connectors according to JIIA standard.

The CoaXPress standard supports camera control and power over CoaXPress (PoCXP).

> It is recommended to use the frame grabber power supply over CoaXPress (PoCXP).

### 3.1.3 Connecting the data cable(s)

You need a CoaXPress frame grabber for connecting the camera to your host computer.

Before powering on, connect the cables to the camera and the frame grabber. CXP connectors have a locking mechanism. Always plug and unplug the cable at the connector, never pull the cable.

If your frame grabber has got less channels than the camera, the data transfer will not reach the maximum values mentioned in the specifications. If your frame grabber has more CoaXPress lines than your camera, try to connect the low channel numbers (0,1,...) first.

You may connect more than 1 camera to a multi-channel frame grabber. Always connect the CoaXPress data cables before power on!

> Be careful with the tiny connectors. They slide up neatly and are locking quite well, but too much force might easily break the connectors.

## 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 60.

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

Table: 3-1: Hirose connector types

## 3.3 Using PoCXP (Power over CXP)

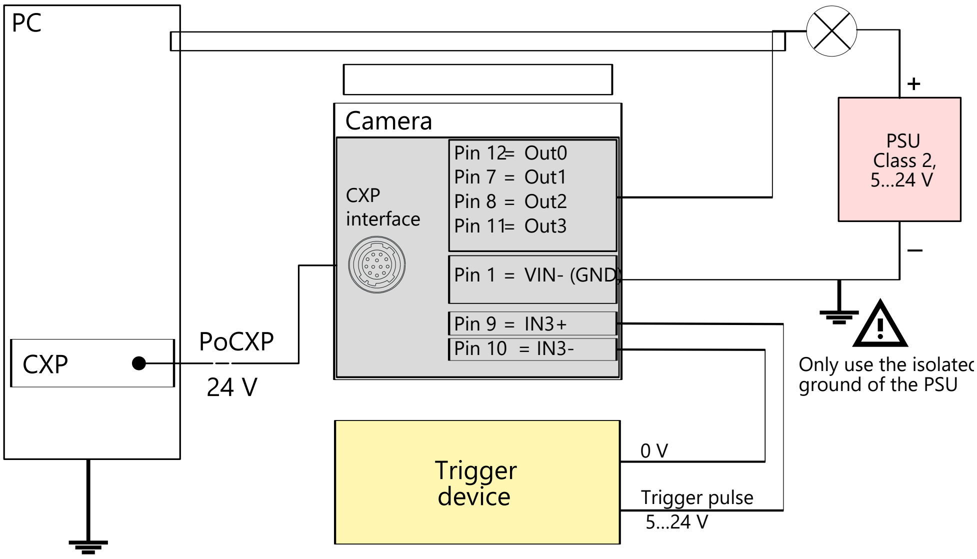



Fig. 3-1: Connection diagram for PoCXP output

- The camera is grounded via the frame grabber card in the PC and the CXP connection.
- For pins and signals, refer to "Hirose I/O connector" on page 14.
- If power is supplied via PoCXP, the external power supply unit for the output must be grounded. To avoid a ground loop, use an isolated power source (PSU).
- Do not connect Pin 2 ($V_{IN}$+).
- To trigger the camera via the inputs, we recommend using the opto-coupled input 3.
- You may also use input 1 or 2, but then an isolated power source for your trigger device is required.

# 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 Power safety

> For safety reasons, for protection of the camera and users, use certified power supplies (Low power supply according IEC 62368-1) only. Refer to specifications for your camera model. Appropriate power supplies can be ordered at Allied Vision Gilching GmbH.

The camera does not have a power switch. The camera is powered on as soon power is available to the camera. This might happen via the Hirose connector or (in case of USB or CoaXPress) through the interface cables.

For making sure the camera is not connected to power

- Disconnect Hirose (or M12) plug from camera
- If the camera interface is USB or CoaXPress, disconnect interface connector from the camera
- Disconnect power plug from power AC wall outlet to disable the DC power supply as well.

The power supply must be easily accessible at all times! For Power specs, refer to the data sheet of your model.

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

## 4.3 Connect the camera

The camera is powered on by connecting power to to the camera. Connect the power supply with the Hirose connector. When using your own power supply (voltage range 10 -25 V DC) see also Hirose™ 12-Pin layout of the power connector. For power input specifications refer to specifications.

Generally external power supply for USB3 Vision, CoaXPress (if PoCXP enabled) or PoE cameras is not needed. Nonetheless, you might want to use a separate power on the Hirose connector to reduce load on the data port. The external power on the Hirose connector is the preferred power source.

> Only power supply with external dedicated power supply is powering 4I/O LED lights. Power supply via data lines covers camera supply only. If you want to use the I/O-output lines to drive LED lights, the camera needs an external dedicated power supply on the Hirose connector.

The power up is defined as follows:

- Power over USB3, CoaXPress port or GigE port (with PoE) or on the Hirose connector will power on the camera
- If power is found on the Hirose connector, camera power supply will switch to the Hirose connector
- If Hirose power supply is cut, camera power supply will switch back to power over USB3, PoE or power over CXP supply

When using your own power supply (voltage range 10-25 V DC) see also Hirose 12- pin layout of the power connector. For power input specifications refer to specifications.

## 4.4 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**

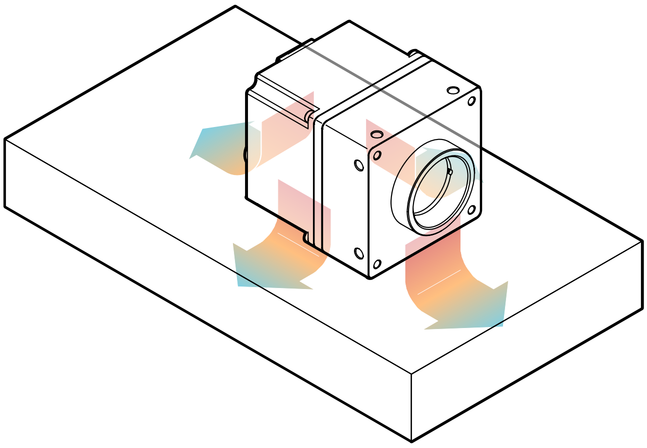


Fig. 4-1: Camera mounted to a heat sink (example)

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.

# 4.5 Camera status LED codes

Latest SVCam CoaXPress cameras provides status information per CXP line. A LED is located close to each CXP connector and will indicate the current status for the appropriate CXP line. The LEDs will change color and rhythm.

The meaning of the CXP line blinking codes is depending whether PoCXP is used and translates as follows:

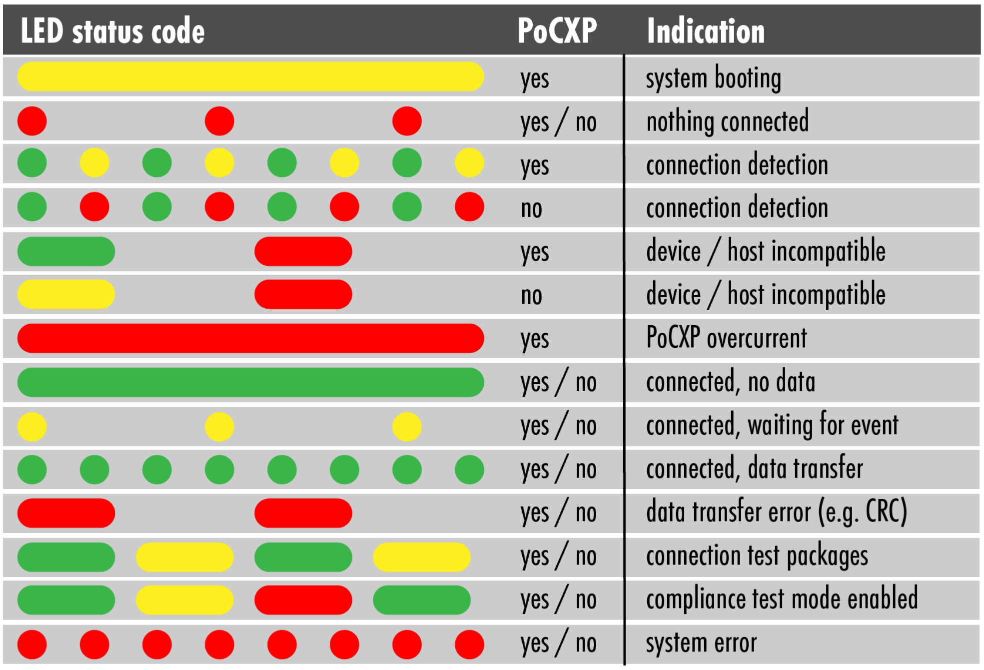



Fig. 4-2: Camera status LED codes

# 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 37).

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 21).

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.

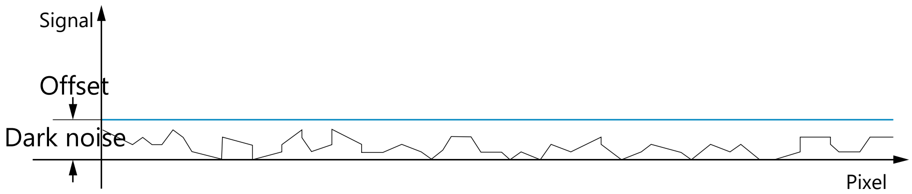



Fig. 5-2: Dark noise cut off by the offset

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...

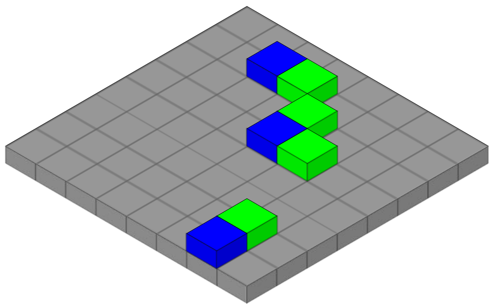


Fig. 5-3: Example of Bayer pattern (source: wikipedia)

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.

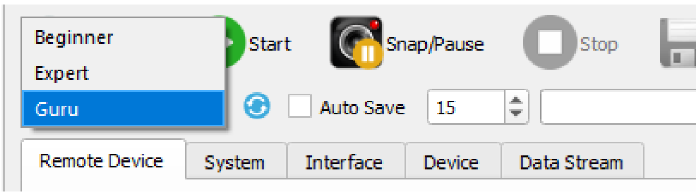
## COLOR CALIBRATION

> The color cameras are delivered without color calibration.

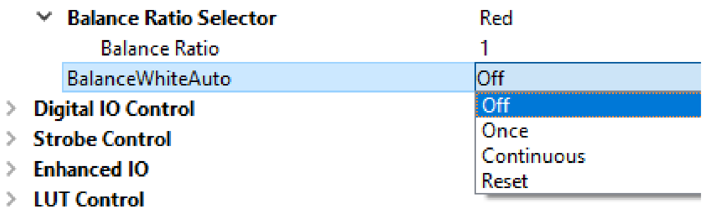
If a color calibration is necessary e.g., because the image has a green cast, the color can be adjusted with a white balance.

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.

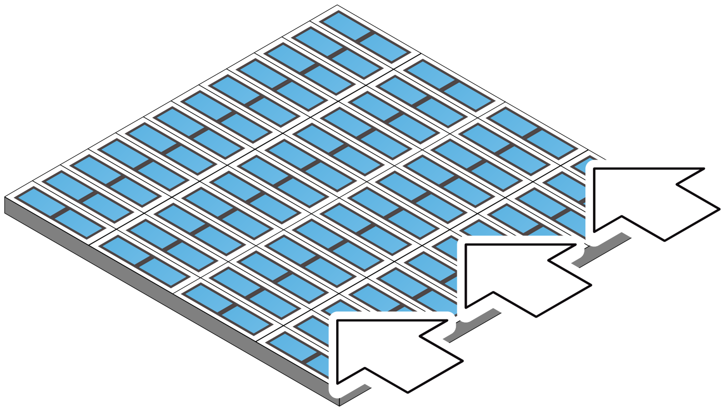


Fig. 5-7: Vertical binning

## HORIZONTAL BINNING

Accumulates horizontal pixels.

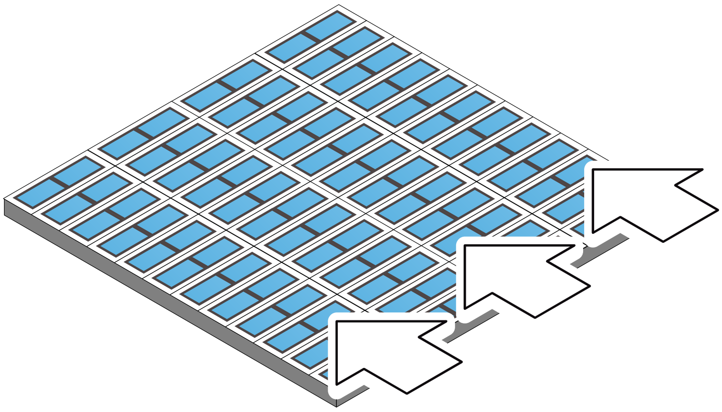


Fig. 5-8: Horizontal binning

## 2×2 BINNING

A combination of horizontal and vertical binning.

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

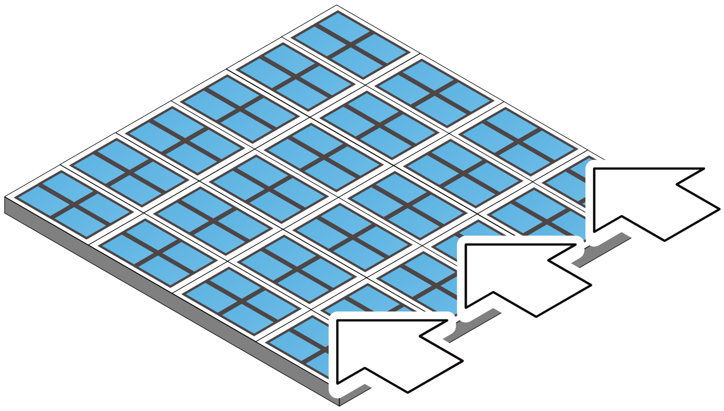


Fig. 5-9: 2x2 binning

## 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 53.

Fig. 5-10: Horizontal decimation

Fig. 5-11: Vertical decimation

## 5.1.8 GenICam

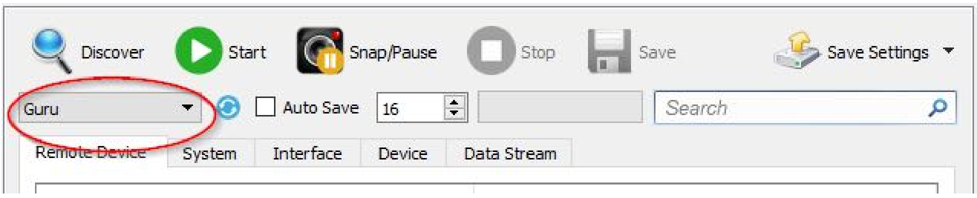
The GenICam standard provides a generic programming interface to control all kinds of cameras and devices. Regardless of the interface technology (GigE Vision, USB 3 Vision, CoaXPress, Camera Link, etc.) or implemented feature, the application programming interface (API) will always be the same. The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

The GenICam$^{TM}$ 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 30.

### 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)

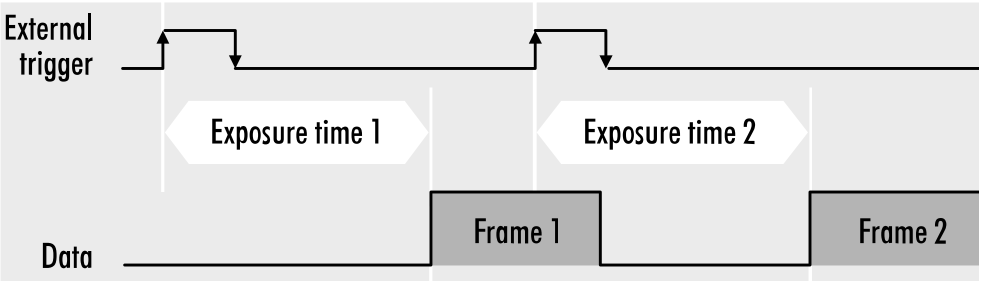



Fig. 5-12: Mode 2: External trigger with programmable exposure time (overlap)

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.

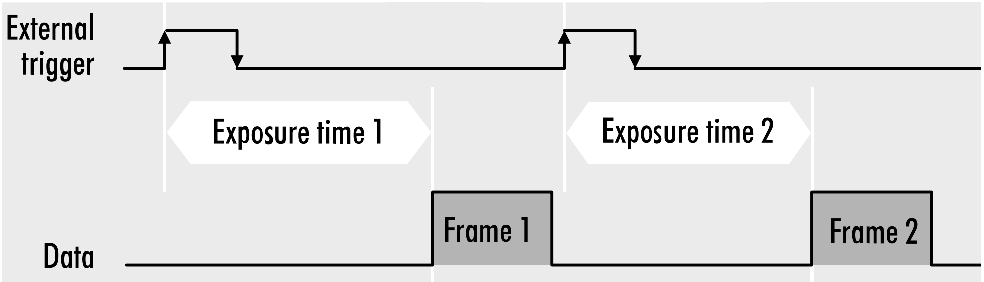



Fig. 5-13: Mode 2: External trigger with programmable exposure time (non overlap)

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

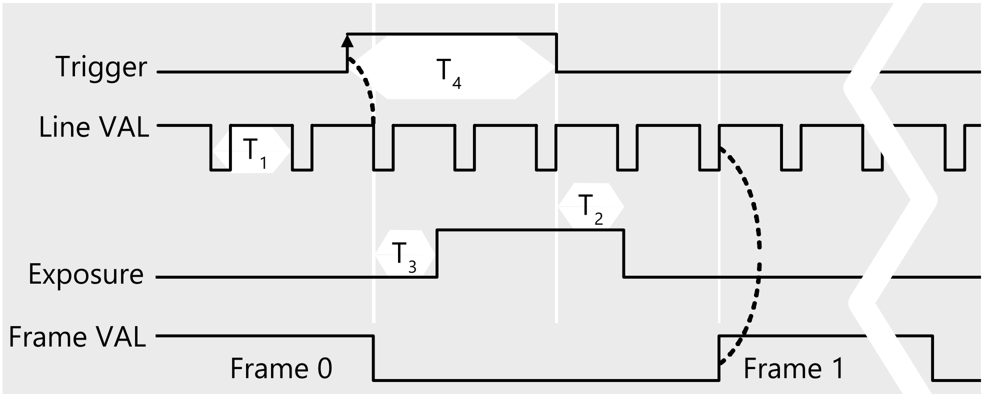



Fig. 5-14: Mode 1: External trigger with pulse width exposure control (overlap)

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

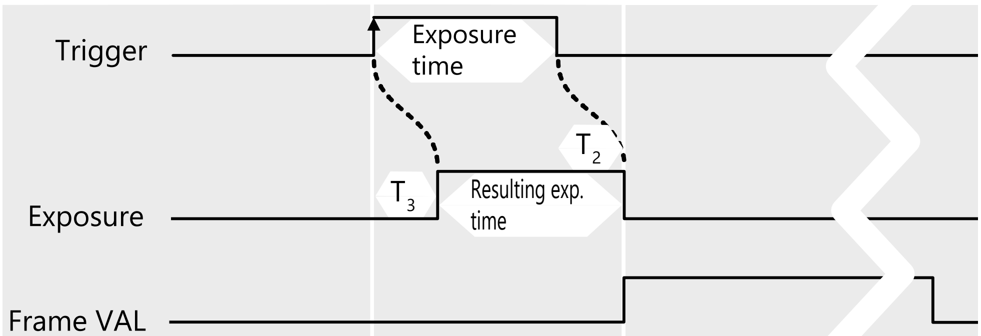



Fig. 5-15: Mode 1: External trigger with pulse width exposure control (non-overlap)

| | | | |
|---|---|---|---|
| **$T_2$** | Transfer delay | **$T_3$** | Exposure delay |

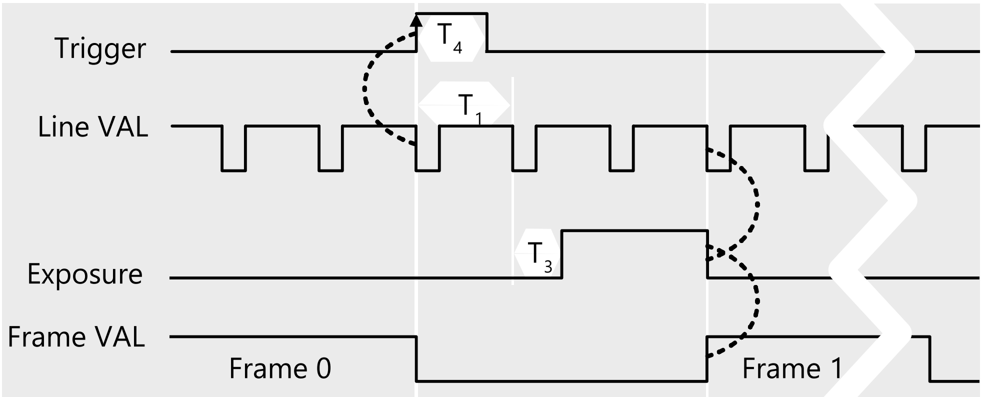



Fig. 5-16: Mode 1: External trigger with programmable exposure time (overlap)

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

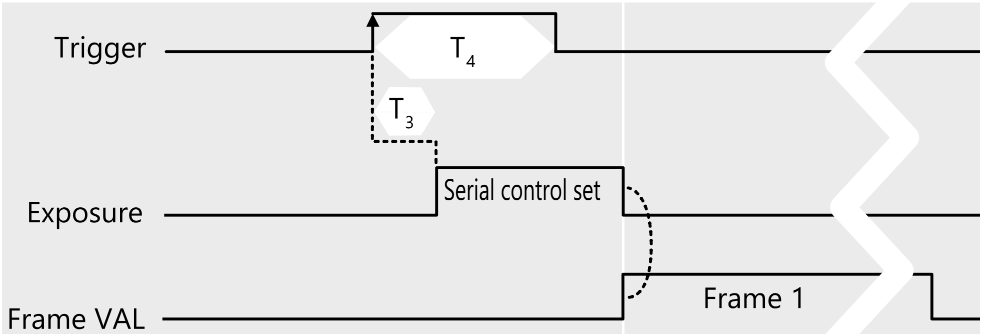



Fig. 5-17: Mode 1: External trigger with programmable exposure time (non-overlap)

| | | | |
|---|---|---|---|
| **$T_3$** | 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

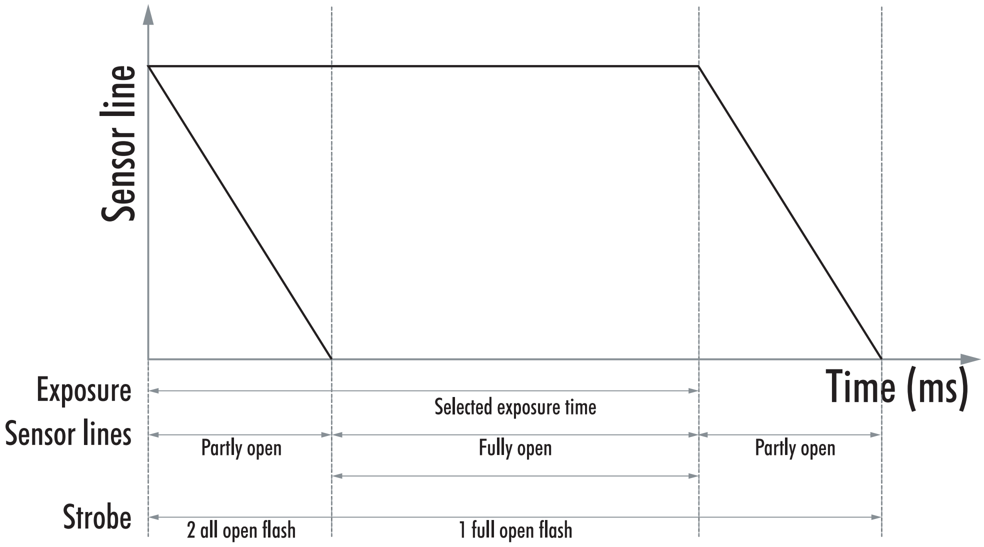



Fig. 5-18: Flash control with rolling shutter

- 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.

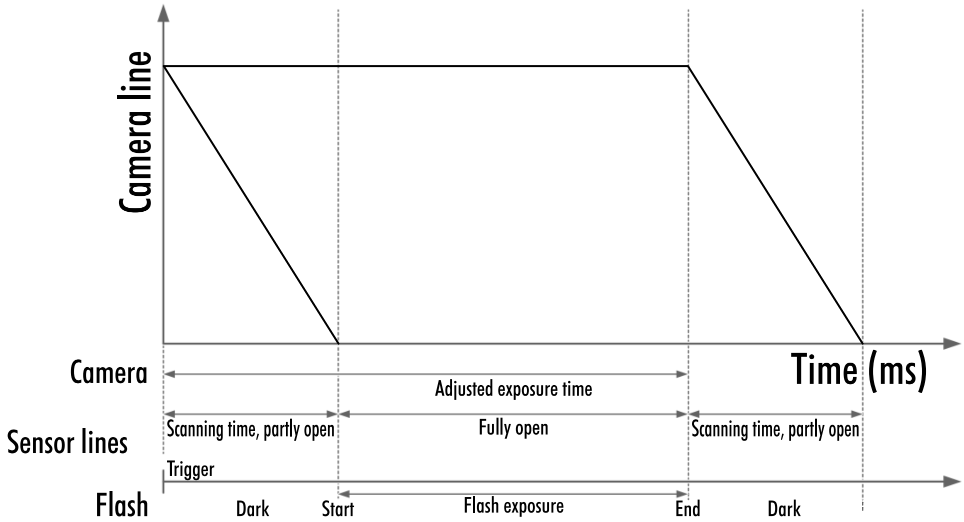



Fig. 5-19: Rolling shutter lines light sensitivity versus time

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 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 63.

### SETTING EXPOSURE TIME

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

## 5.1.12 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

## 5.1.13 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.

## 5.1.14 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.

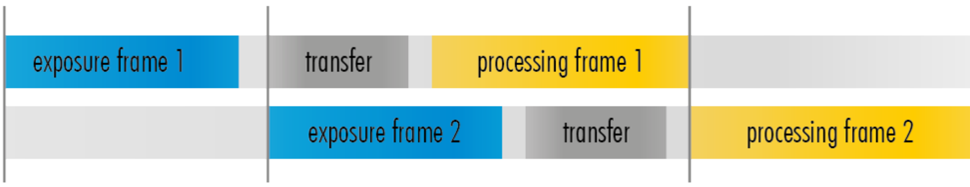



Fig. 5-20: Acquisition and processing time

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

## 5.1.15 hr120 operation modes

The camera is supporting free run and 2 triggerable operation modes ("precise mode" and "fast mode") which do have effects on camera speed and trigger timing (jitter). Due to sensor architecture, the sensor (rolling shutter) is not supporting to deliver an image immediately after trigger signal.

The camera can be set up in the SVCapture GenIcam tree with

Trigger mode -> [Free | Fast | Precise]

### HR120 TRIGGER MODES

The HR120xCX utilizes a CANON rolling shutter sensor and can be operated in 3 different modes.

| hr120 trigger mode | Max speed (fps) | Sync | Jitter |
|---|---|---|---|
| Free run | 9.3 | no | n/a |
| Precise mode triggered | 4.6 | yes | no |
| Fast mode triggered | 9.3 | yes | max 1/fps |

Table: 5-2: hr120 trigger modes

### FREE RUN MODE

In free run, the camera is running full speed and the driver is delivering any arriving images to the software as soon the image is delivered. There is no sync to any external signal in free run mode.

### FAST MODE TRIGGERED

In fast triggered mode the sensor is running in its speed, taking internally images. Being triggered, the camera will finish current exposure operation and start a new exposure. The image of this (next) new exposure will be delivered as fast mode triggered image.

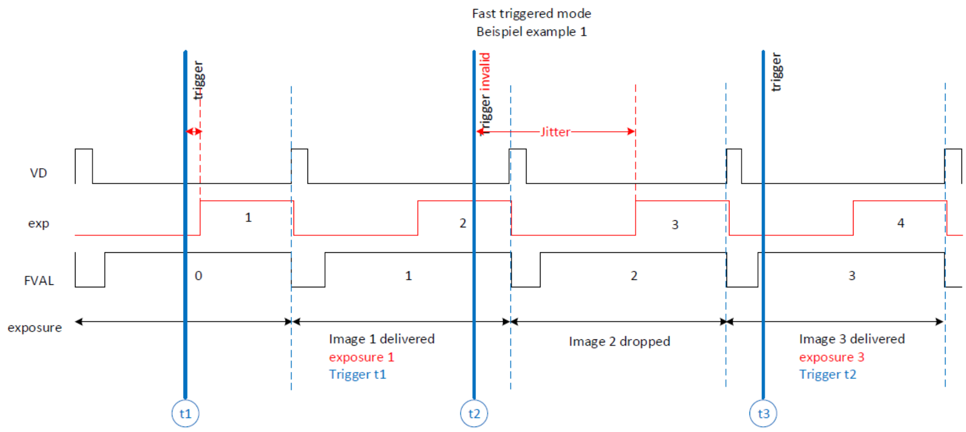



Fig. 5-21: Fast mode triggered - example 1

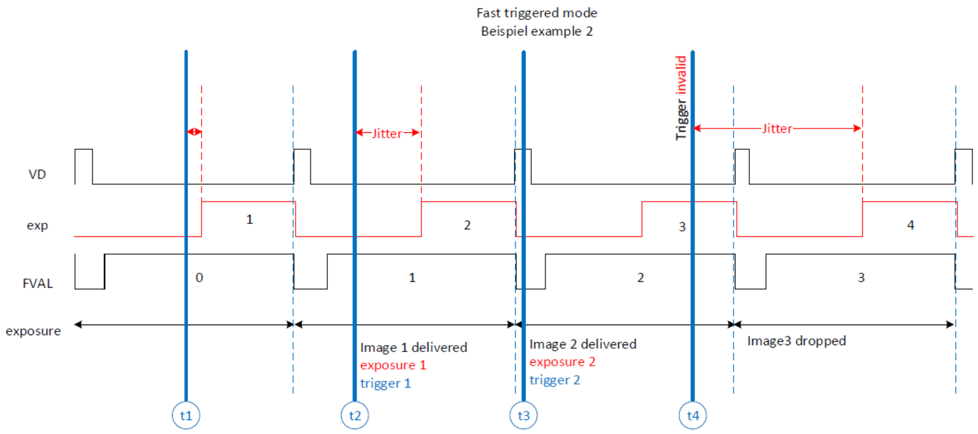



Fig. 5-22: Fast mode triggered - example 2

Both examples above demonstrate that if the trigger signal arrives before exposure time, the camera will deliver a valid exposure OUT signal and the image of the frame cycle where the trigger signal was put.

If the trigger arrives while exposure has already started the image of the current frame cycle is dropped. The trigger signal will initiate delivery of the following frame cycle's image.

As it is not possible to determine in advance the time difference between trigger impulse and start of the new image a timing jitter is the result. Given that, maximum jitter is 1/fps.

## PRECISE MODE TRIGGERED

Precise mode triggering gives you exact knowledge about the start of exposure. Precise mode trigger is requesting the camera to start with exposure, frame cycle starts with trigger. As the sensor has to set up before exposing, the first image cycle or frame is lost and the second image will be delivered. With a static frame cycle, the exposure of the second frame starts with a fixed delay of 1 frame.

Maximum imaging speed will be about half of fast mode triggered. Benefit is the exact knowledge of exposure start time.

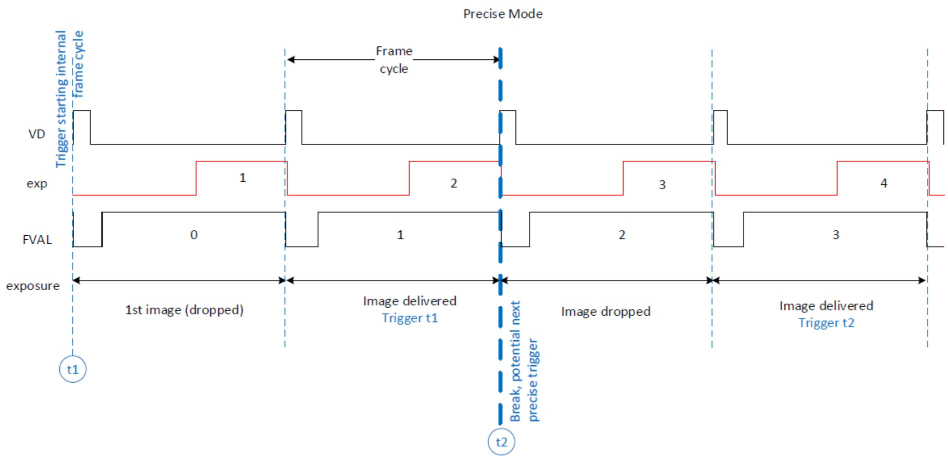


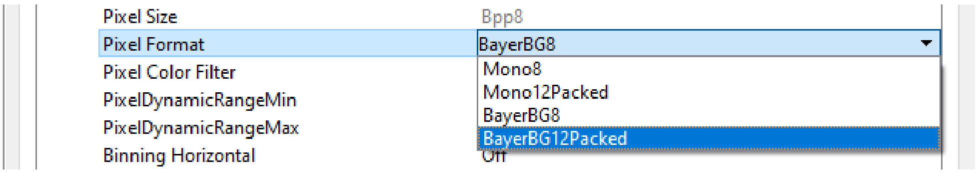

Fig. 5-23: Precise mode triggered

## 5.1.16 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 Glass filter

The camera is equipped with a glass filter for sensor protection reasons (dust). Optical length of the glass filter is included in the mount specifications.

### 5.2.2 Shading correction

**OVERVIEW**

The interactions between objects, illumination, and the camera lens might lead to a non-uniform flat-field in brightness. Shading describes the non-uniformity of brightness from one edge to the other or center towards edge(s).

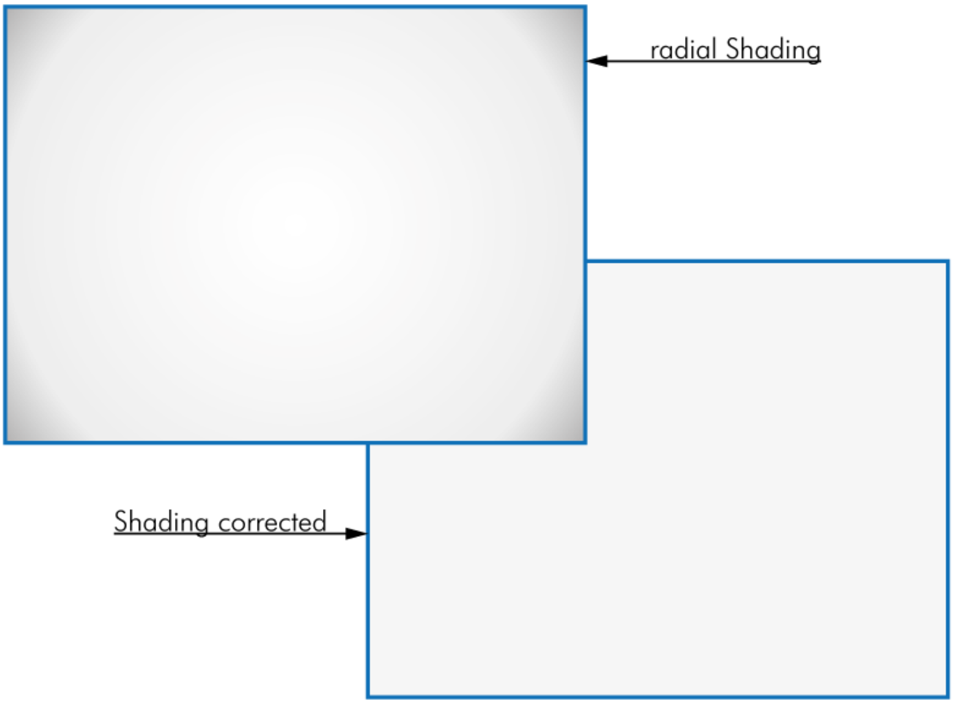



Fig. 5-24: Original and shading corrected image

This shading can be caused by non-uniform illumination, non-uniform camera sensitivity, vignetting of the lens, or even dirt and dust on glass surfaces (lens).

Shading correction is a procedure to create a flat-field image out of a non-uniform image regardless of the reasons of the non-uniformity. Before doing shading correction, make sure your lens is clean and in perfect condition. If the lens is not clean or the lighting not uniform, the algorithm tries to compensate these as well, resulting in a wrong shading table and visible artifacts, loss of details, or local noise in the final image.

In theory, there are several locations of shading

- In the host computer: significant loss of dynamic range
- In the camera, digital: better (smoother) shading than on computer, still loss of dynamic range
- In the camera, analog: set gain / offset locally direct on sensor to get optimum shading correction with only small changes in dynamic range

> Shading correction might reduce the dynamic range of the images. By using different gains and offsets on the sensor local noise might be less uniform. Structures in the reference image might lead to visible shading artifacts.

#### HOW IT WORKS

The tool will divide the image into squares of 16x16 pixel. Out of every 16x16 pixel cluster a set of shading values consisting of specific gain and offset per cluster is calculated. The resulting map can be uploaded into the camera and will compensate for any shading, lens-based or based on illumination.

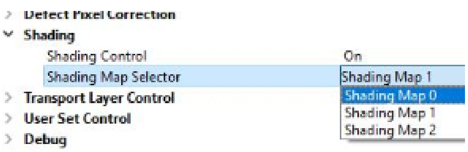
### CREATING A SHADING MAP

Shading maps are test files containing a description for the camera how to balance shading control. Shading maps can be created and uploaded to the camera with SVCapture. The shading map creation process takes any image with any illumination and creates a shading map out of it. This shading map will be uploaded into the camera afterward.

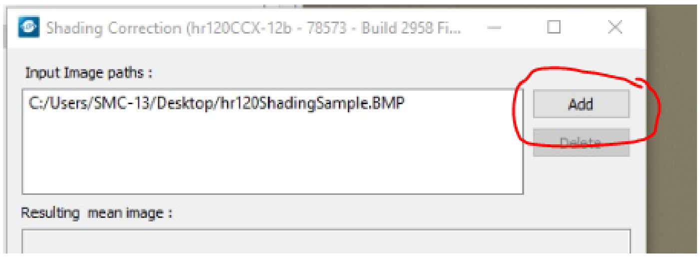
1. Connect the camera to the PC and open it with SVCapture2.
2. Make a picture in which you can see the vignetting (shading).

> Check that the image is not overexposed and AOI and Binning is disabled.

3. In **Shading Correction > Control**, enable or disable shading correction.
4. In **Shading > Shading Map Selector** select a shading map.



5. Open **Assistant > Shading Correction** and select **Generate Map...**.
6. Add the *.bmp file to the shading map generator.




7. Select **Generate map**. The map is saved in the background.
8. After the map is successfully created, upload the map in the camera by selecting **Upload map to camera**.
9. Select **Yes** for saving the map in the user set.

> Shading correction is possible with certain models only. See camera specs whether your model does support this. In case your camera is not supporting, the assistant will not be selectable.

1. Take shading reference images with shading correction disabled (use 16 images minimum) and save the to the local hard drive. As file format, use .bmp files with more than 8 bit.
2. Start **Assistants** > **Shading Correction** > **Generate Map**.

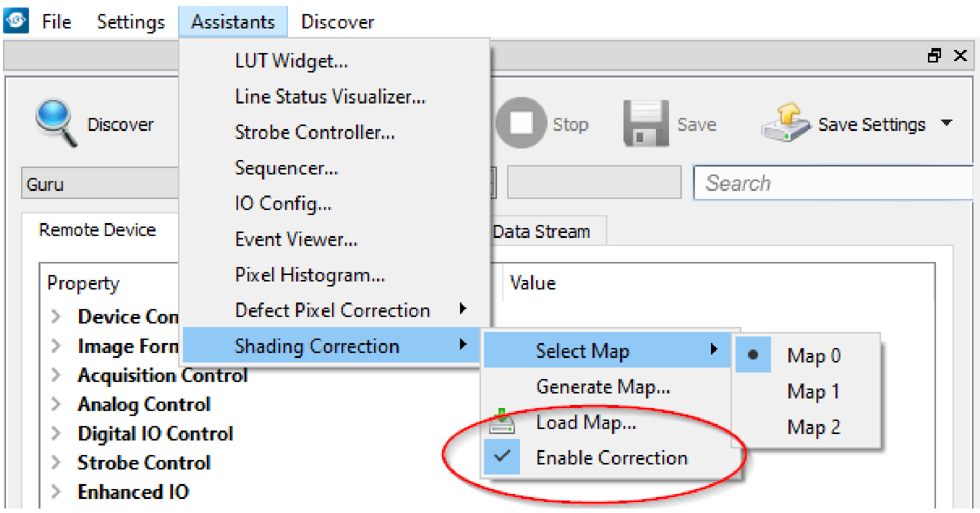
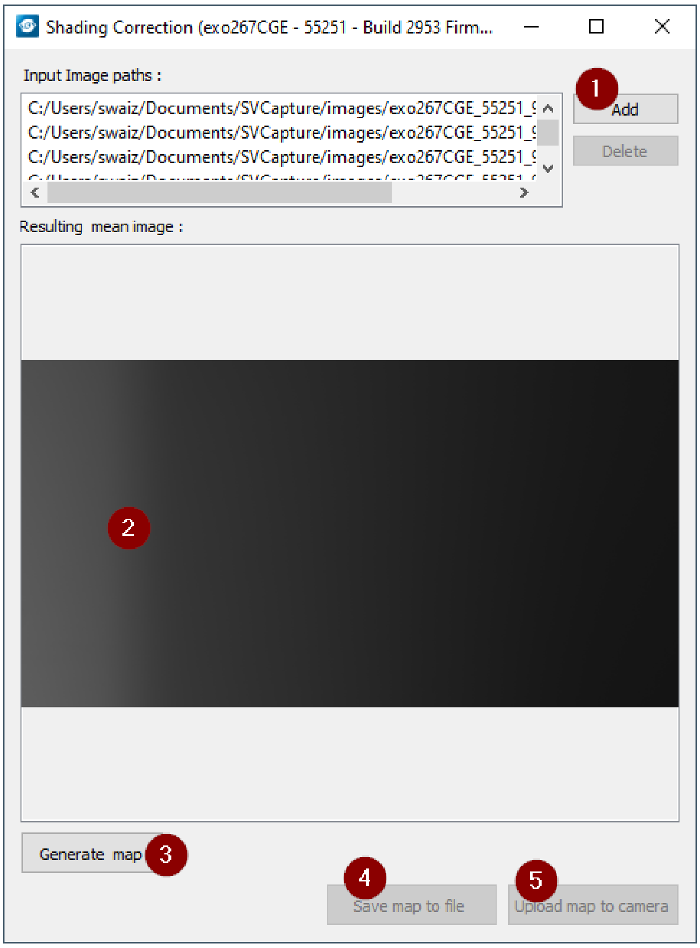
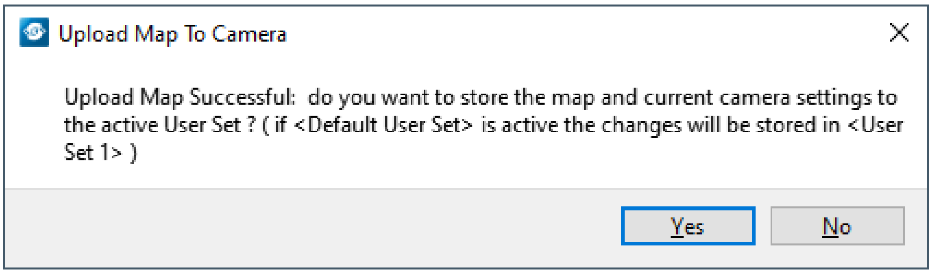



Fig. 5-25: Shading control disabled

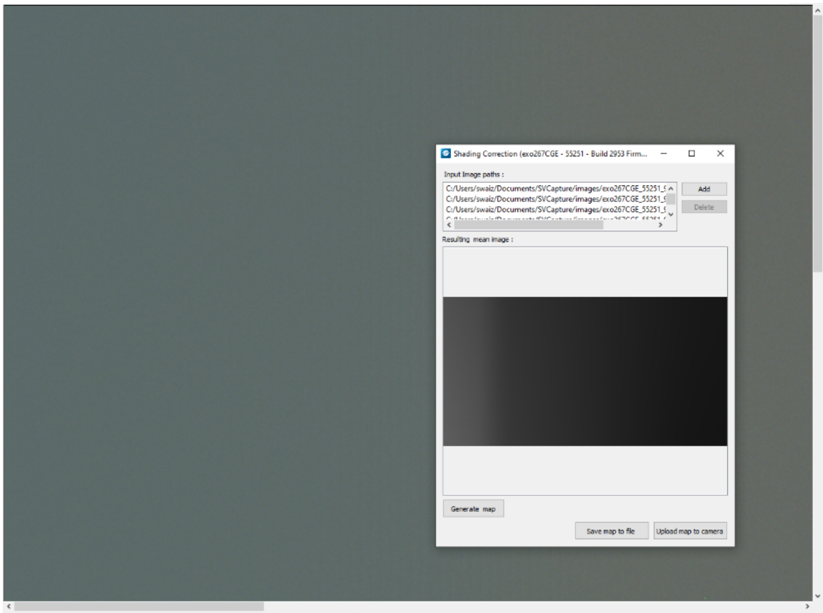
3. Load the reference images.




4. Observe the shading in the preview (2).
5. Select **Generate map** (3) to create the shading map.
6. Select **Save map to file**. This file can be used in programmed environments via SDK as well.
7. Select **Upload map to camera** and check the result. If the lighting did not change from start of procedure, you should see a uniform image with enabled shading control.



8. Run the camera with same lighting to see corrected image.




## 5.2.3 Defect pixel correction

All image sensor have defect pixels in a lesser or greater extent. Type and number of defects determine the quality grade (quality classification) of the sensor.

Defect pixel correction is using information from neighboring pixels to compensate for defect pixels or defect pixel clusters (cluster may have up to five defect pixels).

Defect pixels can either be dark pixels, i.e. that don't collect any light, or bright pixels (hot pixel) that always are outputting a bright signal.

The amount of "hot" pixels is proportional to exposure time and temperature of the sensor.

By default, all known defect pixels or clusters are corrected as a factory default.

Under challenging conditions or high temperature environments defect pixel behavior might change. This can be corrected.

- A factory created defect map (Allied Vision map), defying known defects, is stored in the camera.
- A custom defect map can be created by the user. A simple *.txt file with coordinates must be created. The user must locate the pixel defects manually.
- The *.txt file can be uploaded into the camera. Beware of possible Offset!
- Defect maps can be switched off to show all default defects, and switched back on to improve image quality.

Unlike shading correction, defect pixel correction suppresses single pixels or clusters and reconstructs the expected value by interpolating neighboring pixel values. The standard interpolation algorithm uses the pixel to the left or to the right of the defect. This simple algorithm prevents high run-time losses.

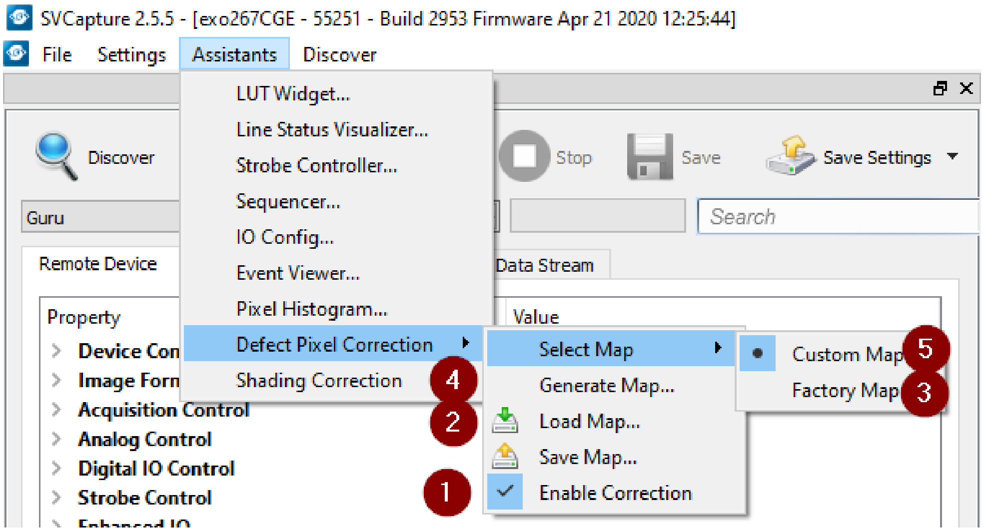
More sophisticated algorithms can be used by software.


Fig. 5-26: Illustration of a defect pixel

## PROCEDURE OF PIXEL CORRECTION

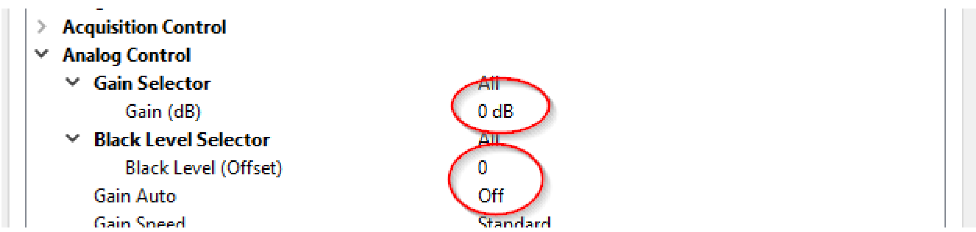
SVCapture is the tool to generate pixel correction maps. The pixel correction assistant provides everything to create, load, enable and restore defect pixel creation maps.

Defect pixel correction is possible with certain models only. See camera specs whether your model does support this. In case your camera is not supporting, the assistant will not be selectable.




- For easy image processing, it is recommended to have pixel correction activated
- Pixel correction maps can be saved and loaded
- The std factory map can be selected any time
- Generate your own custom map
- Select your own defect pixel map

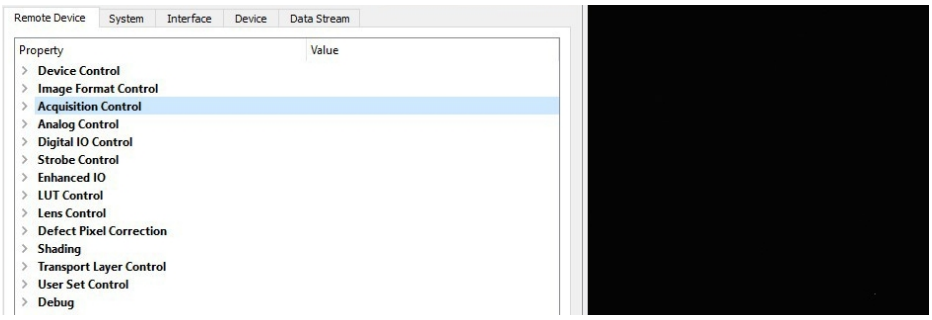
The procedure to create a std map is pretty straight forward. Before starting generating the map, in the GenICam tree do the following:



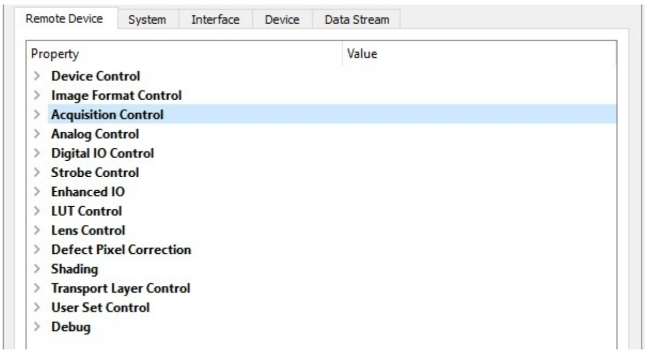

1. Set gain to "0 dB".
2. Disable **Gain Auto**.
3. Set **Offset** to "0".
4. Record a set of dark images with the lens cap on.

## DEFECT PIXEL MAP GENERATION

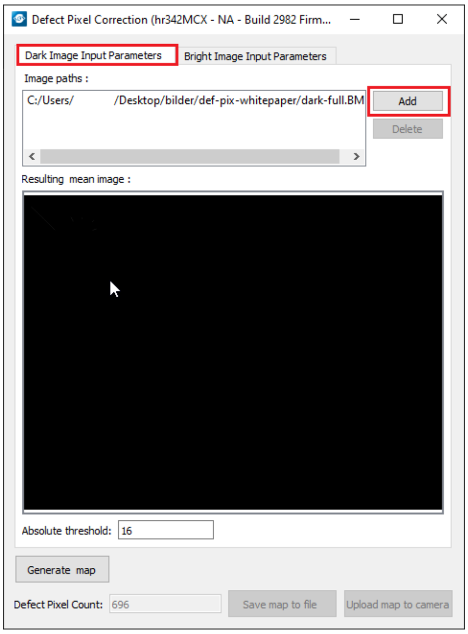
1. Save a completely dark image as bmp file.



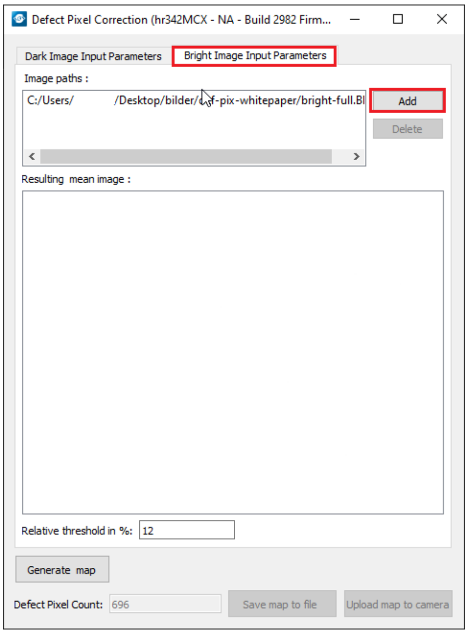

2. Save a completely white image as bmp file.



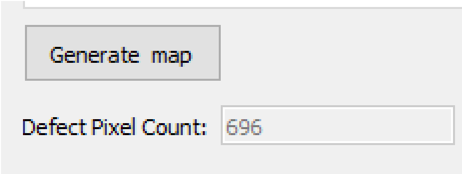

3. Open **Assistant > Defect Pixel Correction > Select Map > Custom Map**.
4. Select **Generate Map...**.
5. Add a "Dark Image".



6. Add a “Bright Image”.




7. Select **Generate map**.
8. Observe how many defect pixel were detected in the “Defect Pixel Count”.




9. Select **Upload map to camera**.

## 5.2.4 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.

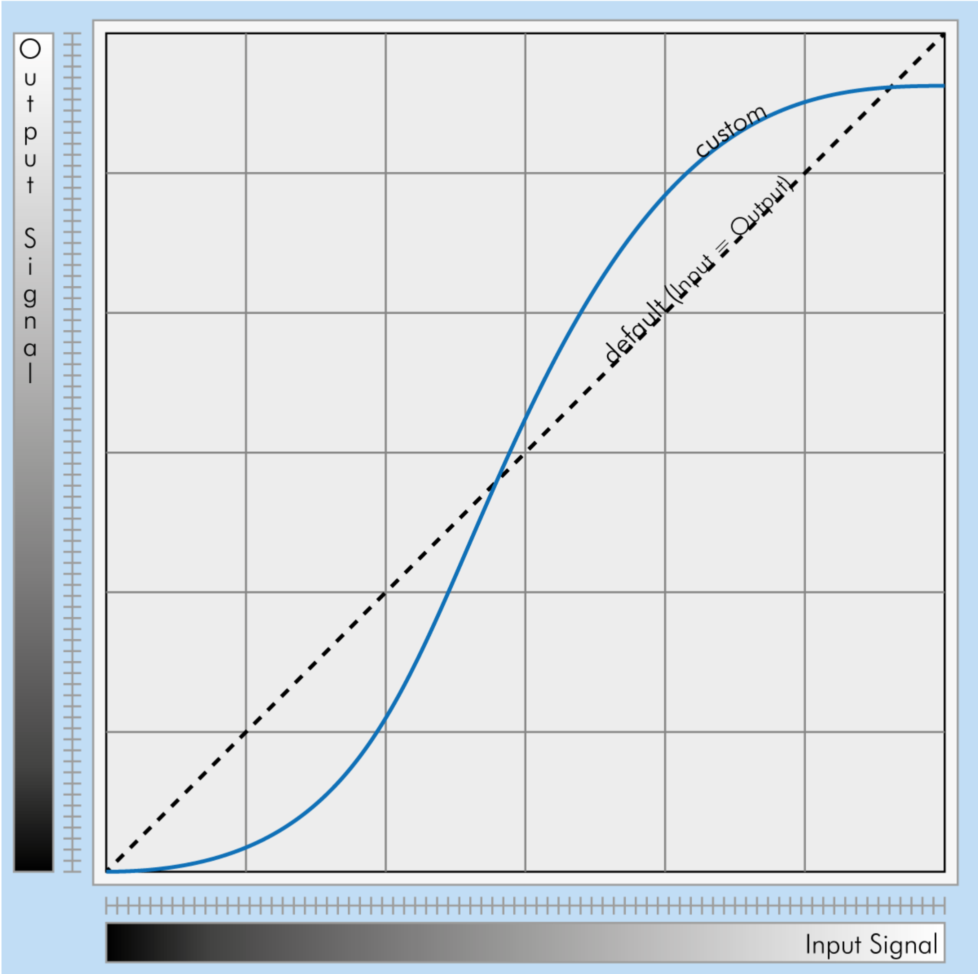



Fig. 5-27: Custom LUT adding contrast to the mid-tones

> 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$^{Gamma}$

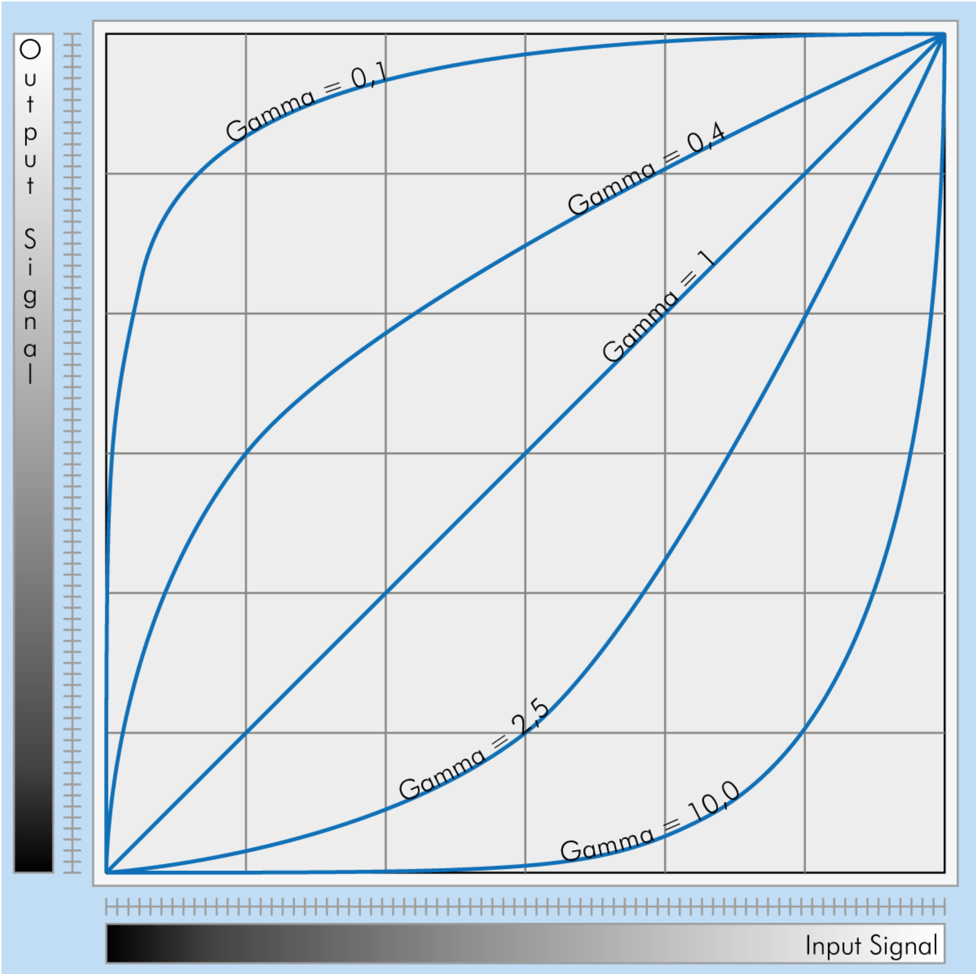



Fig. 5-28: Several gamma curves comparable to a LUT

- 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.

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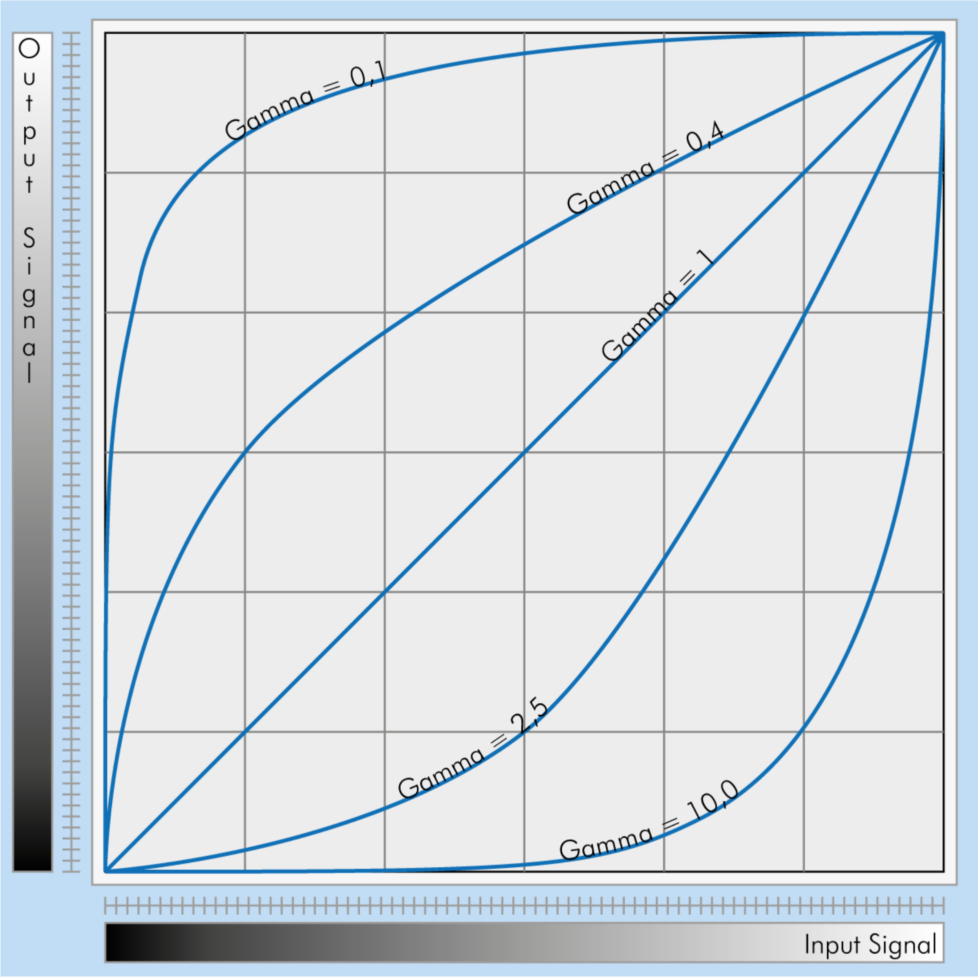



Fig. 5-29: Several gamma curves comparable to a LUT

- 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.

## 5.2.5 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.

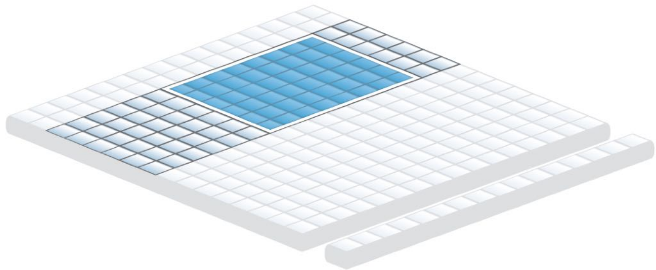


Fig. 5-30: AOI on area sensor

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.

## 5.2.6 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.

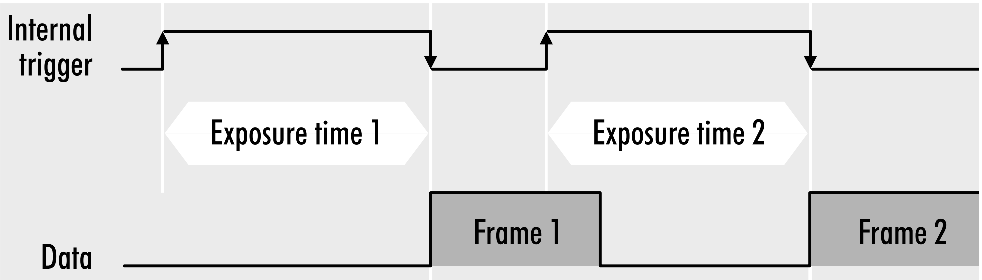



Fig. 5-31: Mode 0 - Free running with programmable exposure time

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.

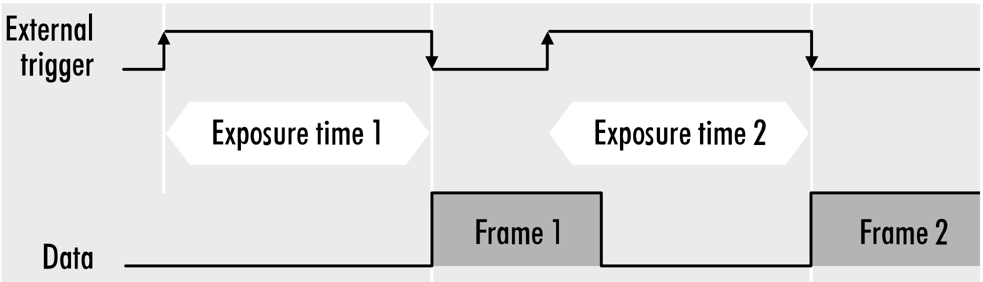



Fig. 5-32: Mode 1: External Trigger with Pulse Width Exposure Control (overlap)

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.

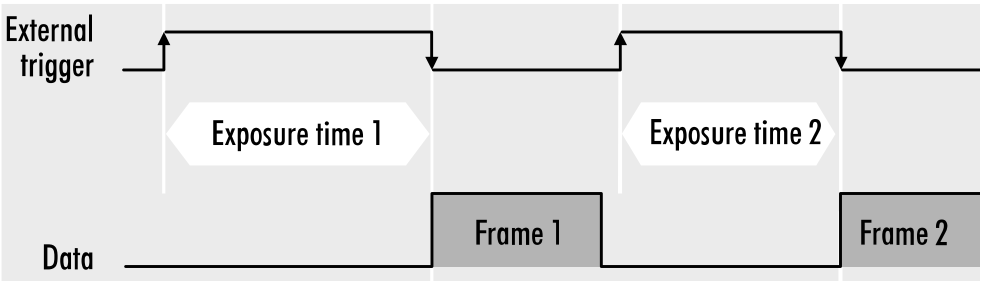



Fig. 5-33: Basic capture modes - triggered mode (pulse width without overlap)

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.

## 5.2.7 Read-out control

Read-out control defines a delay between exposure and data transfer. Read-out control is used to program a delay value (time) for the readout from the sensor.

With more than one camera connected to a single computer, image acquisition and rendering can cause conflicts for data transfer, on CPU or bus system.

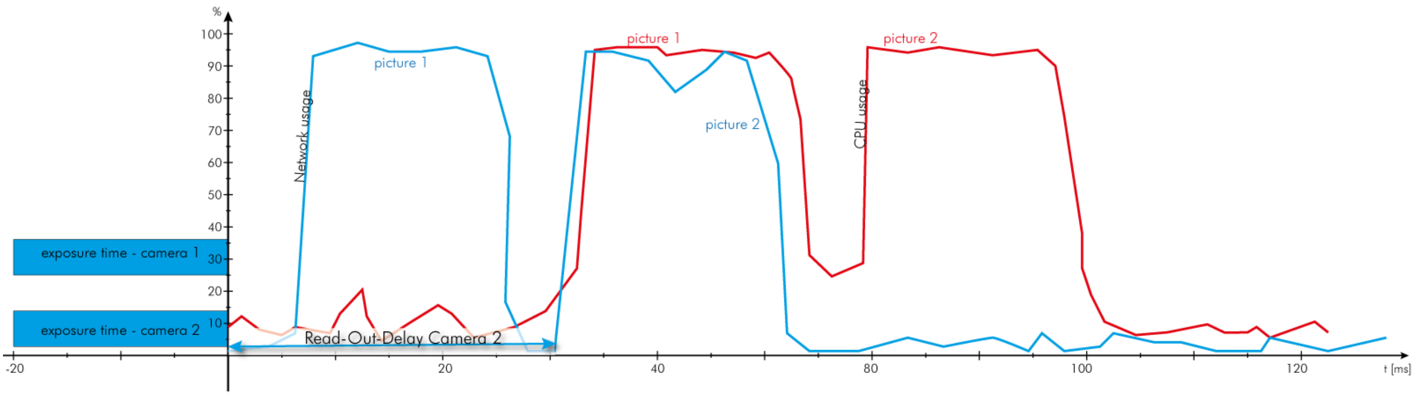



Fig. 5-34: Illustration of physical data stream in time

## 5.2.8 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).

## 5.2.9 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.

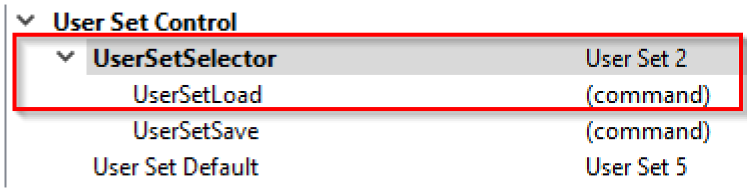
## 5.2.10 Predefined configurations (user sets)

The camera starts with default values for all features when turned on. Settings made during operation will expire when the camera is turned off.

All preset adjustments are located in the GenICam tree in the "User Set Control" property. It is possible to save up to 8 user sets. Each of these setups consists of a complete configuration set including exposure time, delays, I/O configuration for the camera. These user sets can be loaded at run-time. In addition, you can specify which setup is loaded as default when the camera is switched on.

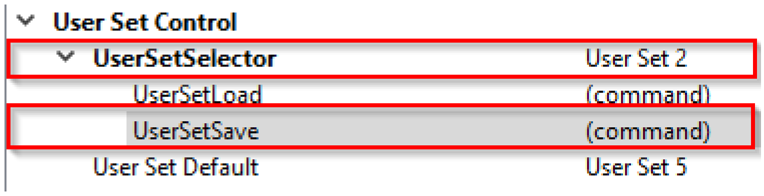
## LOAD A USER SET

With UserSetSelector a user set can be selected. Select the desired user set and press UserSetLoad (command) twice to load the user set. The following example loads user set 2.




## SAVE USER SETS

Select the user set to be saved in the UserSetSelector and save it with the UserSetSave command.

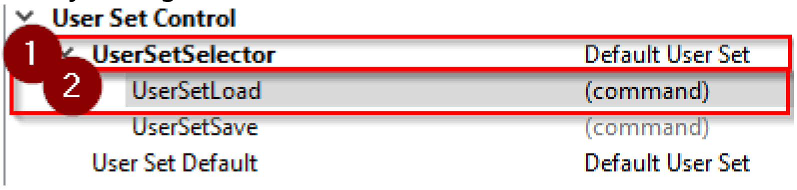



## SET A USER SET AS DEFAULT

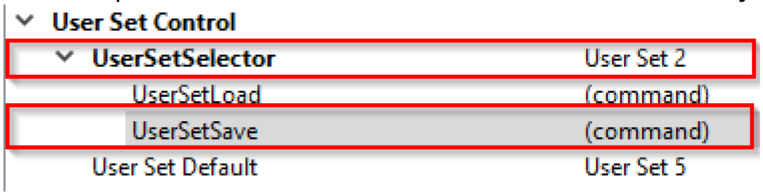
Use User Set Default to select the user set that is to be loaded when the camera is started. Save this setting with UserSetSave (In the example below, user set 5 is saved as default).

### RESET TO FACTORY DEFAULT

User sets can be reset to factory settings. This is a two-step process. First, the factory settings must be loaded:




Afterwards this factory default user set must be saved again as user set (in the example below, user set 2 is overwritten with the factory settings).




### 5.2.11 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.

## 5.3 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.

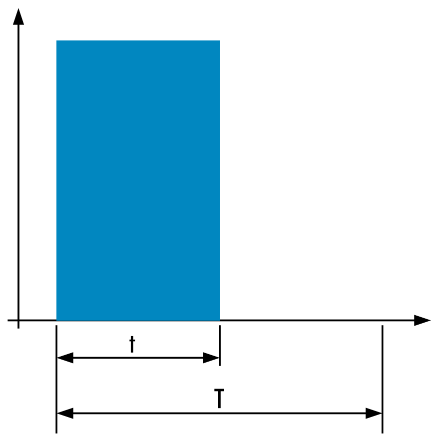



Fig. 5-35: PWM intensity

## 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.

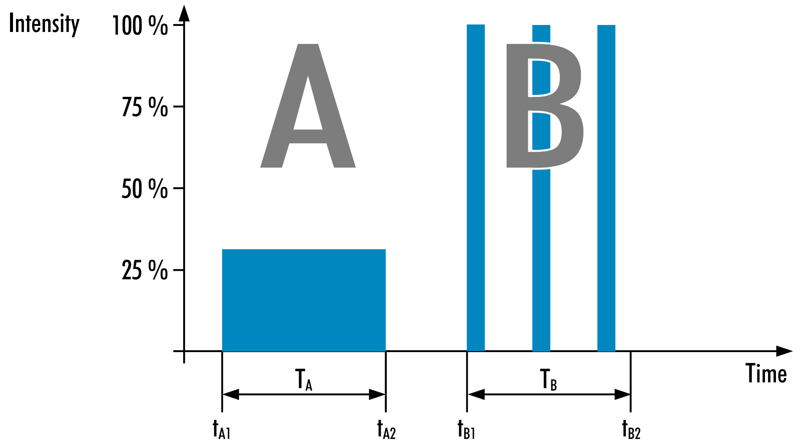



Fig. 5-36: Example: 25% PWM load

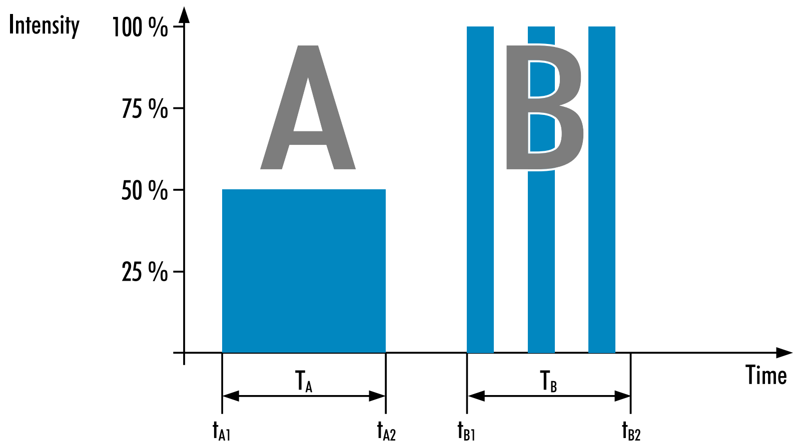



Fig. 5-37: Example: 50% PWM load

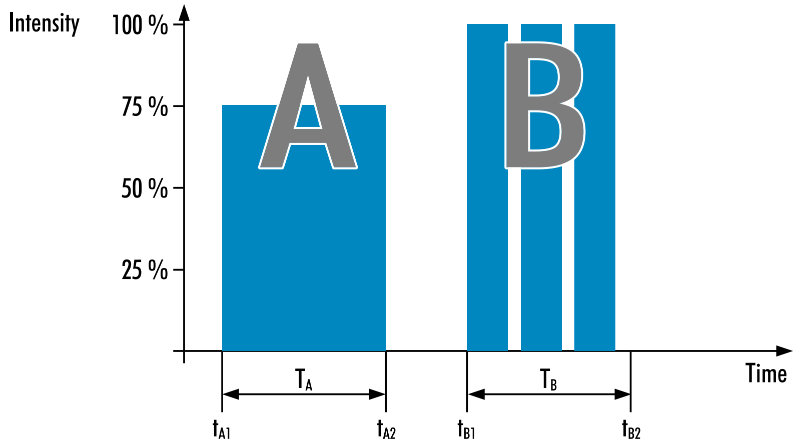



Fig. 5-38: Example: 75% PWM load

## THE PWM MODULE

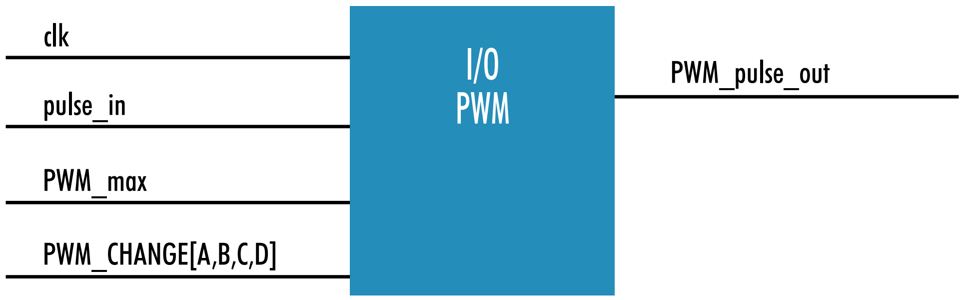



Fig. 5-39: The PWM module

## 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.

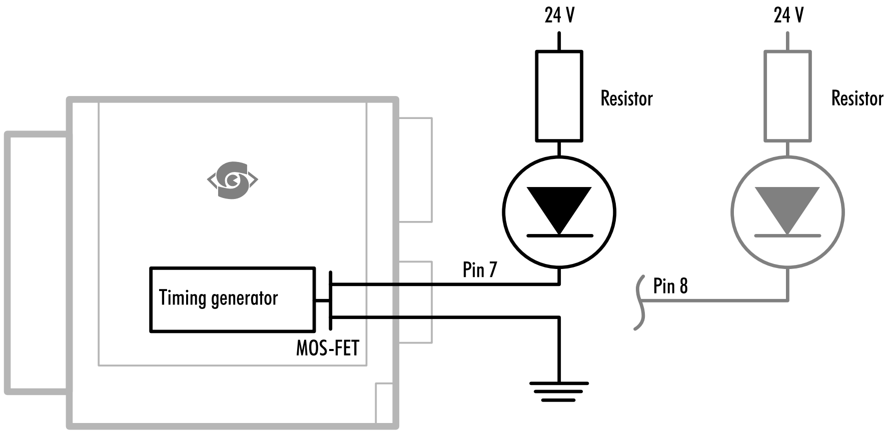



Fig. 5-40: Attach LED lights to camera outputs

> 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: 5-3: 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: 5-4: 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 63). 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) |

| **Values to set in GenICam properties** | **Interval 0 (RED)** | **Interval 1 (GREEN)** | **Interval 2 (BLUE)** | **Interval 3 (WHITE)** |
|---|---|---|---|---|
| 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:

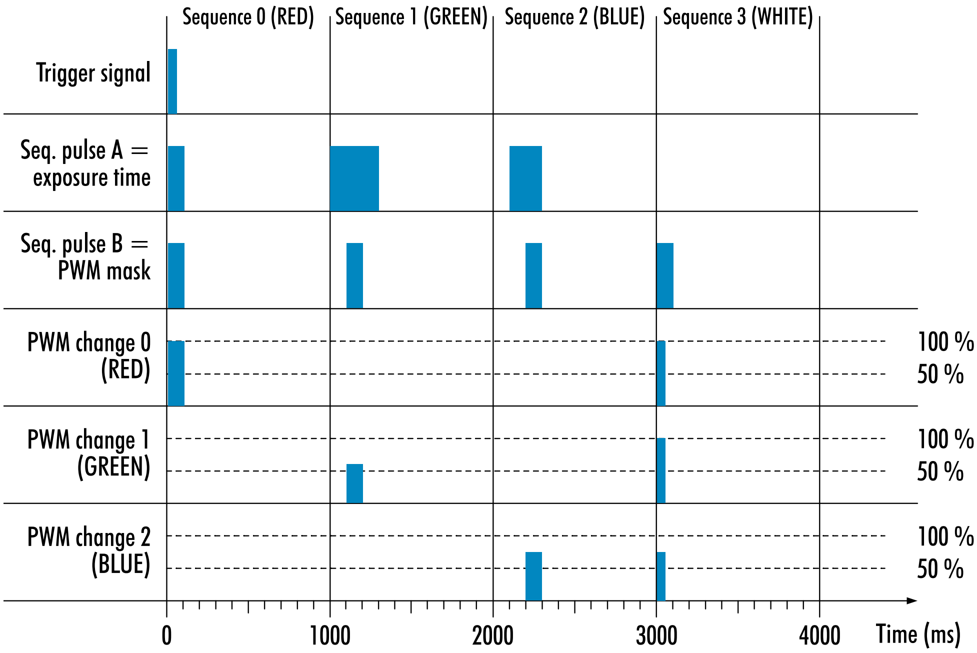



Fig. 5-41: Sequencer timing diagram

## 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.

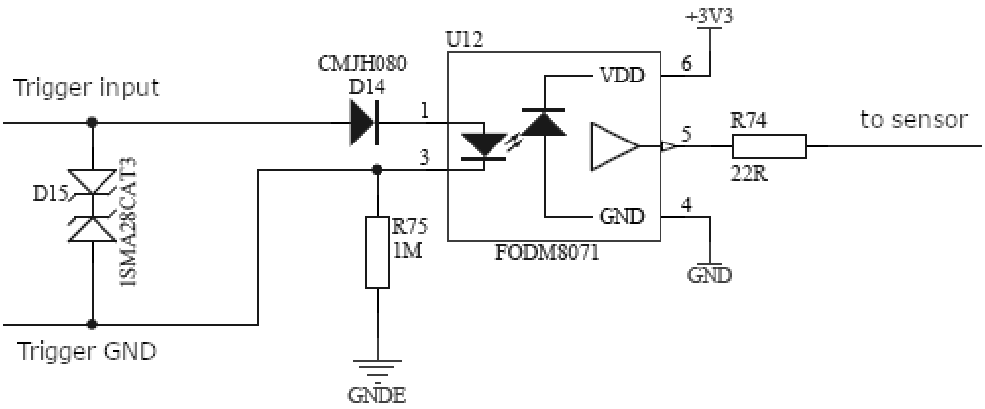


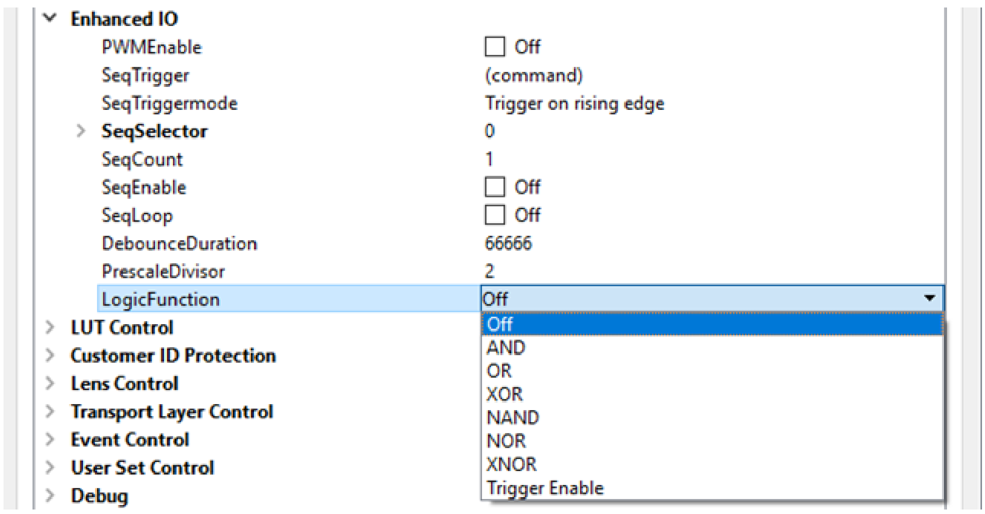

Fig. 5-42: Optical input

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: 5-5: 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: 5-6: 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).

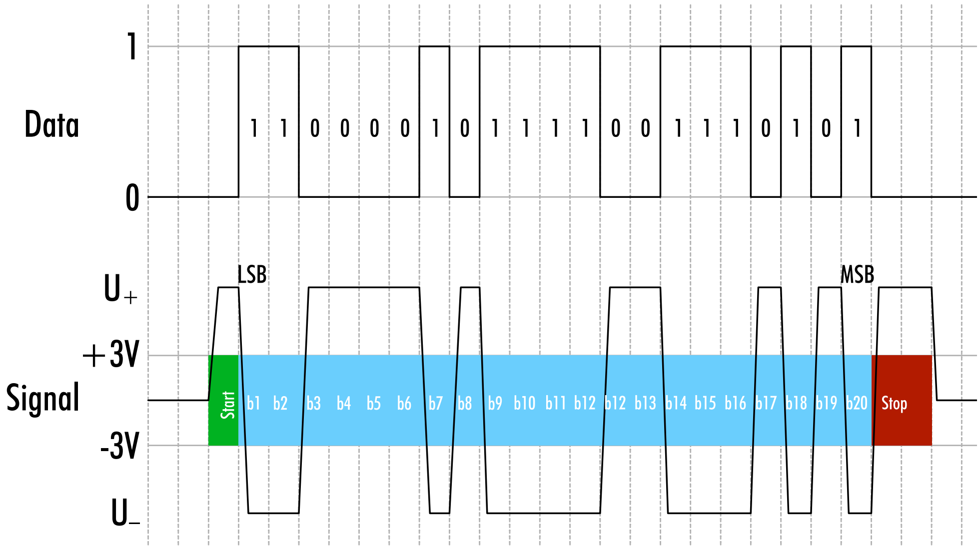



Fig. 5-43: UART encoding of a data stream

## 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.

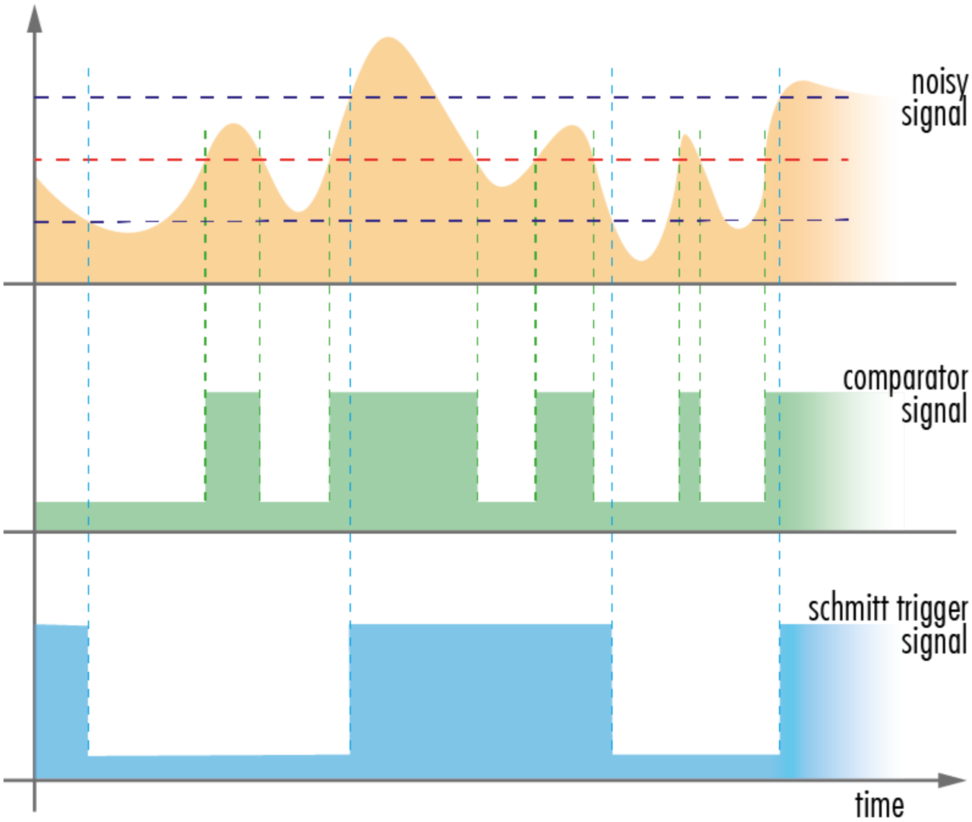



Fig. 5-44: Schmitt trigger noise suppression

### 5.3.8 Debouncing trigger signals

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

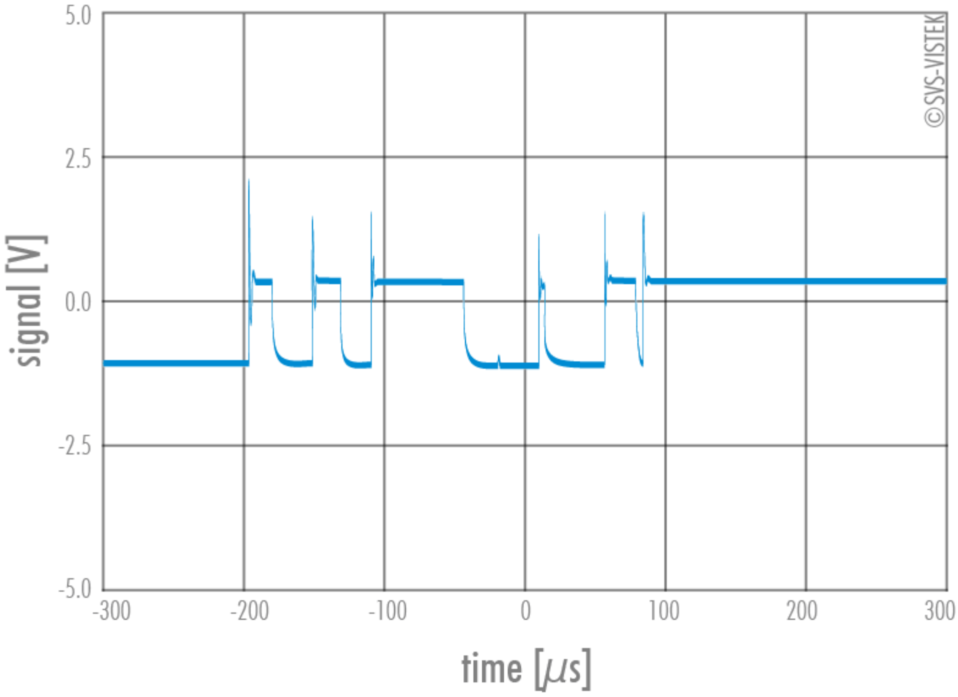



Fig. 5-45: Bounces or glitches caused by a switch

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

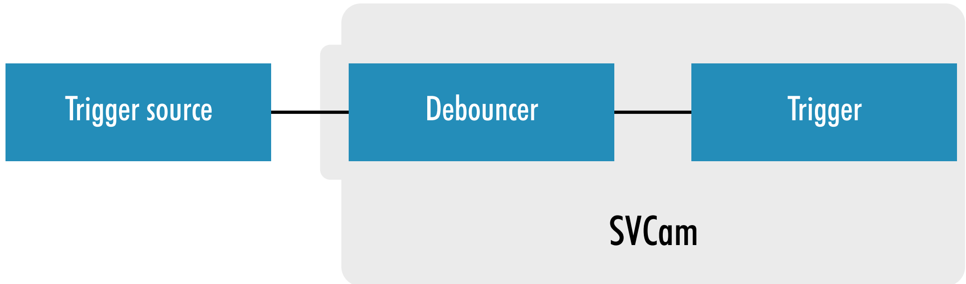
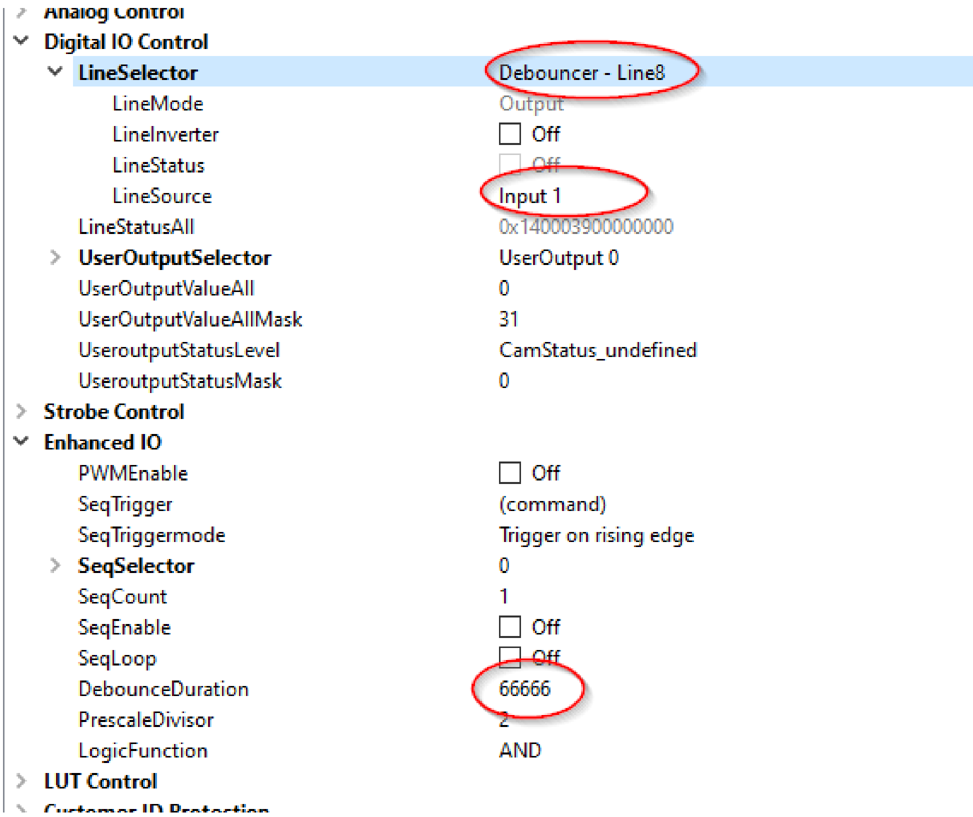



Fig. 5-46: Debouncer between the trigger source and trigger




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. 5-47: 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)

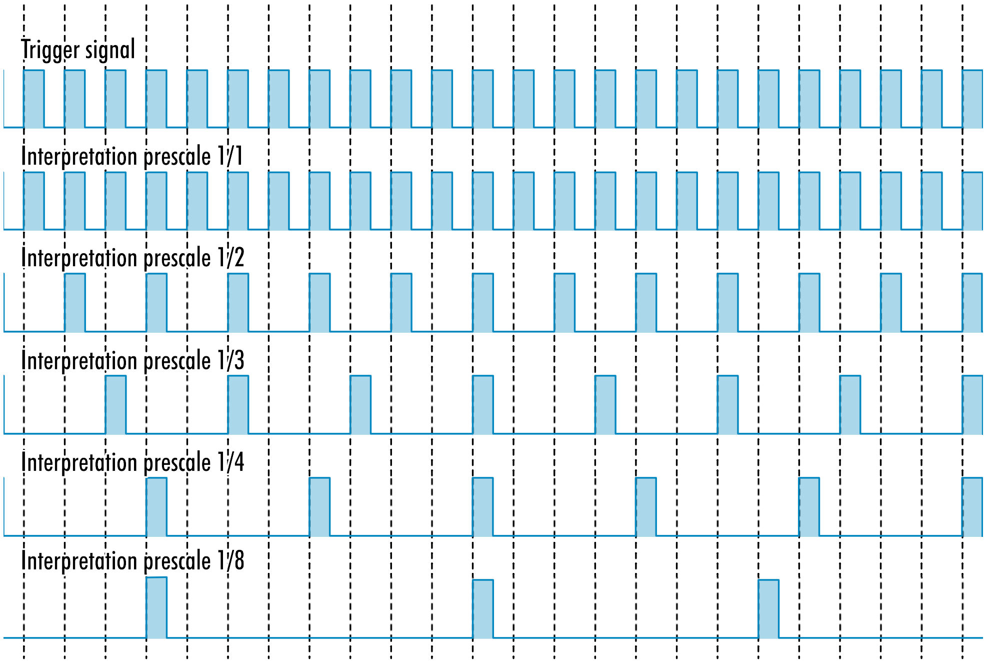



Fig. 5-48: Prescale values and their result on trigger signal

## THE PRESCALE MODULE


Fig. 5-49: 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.

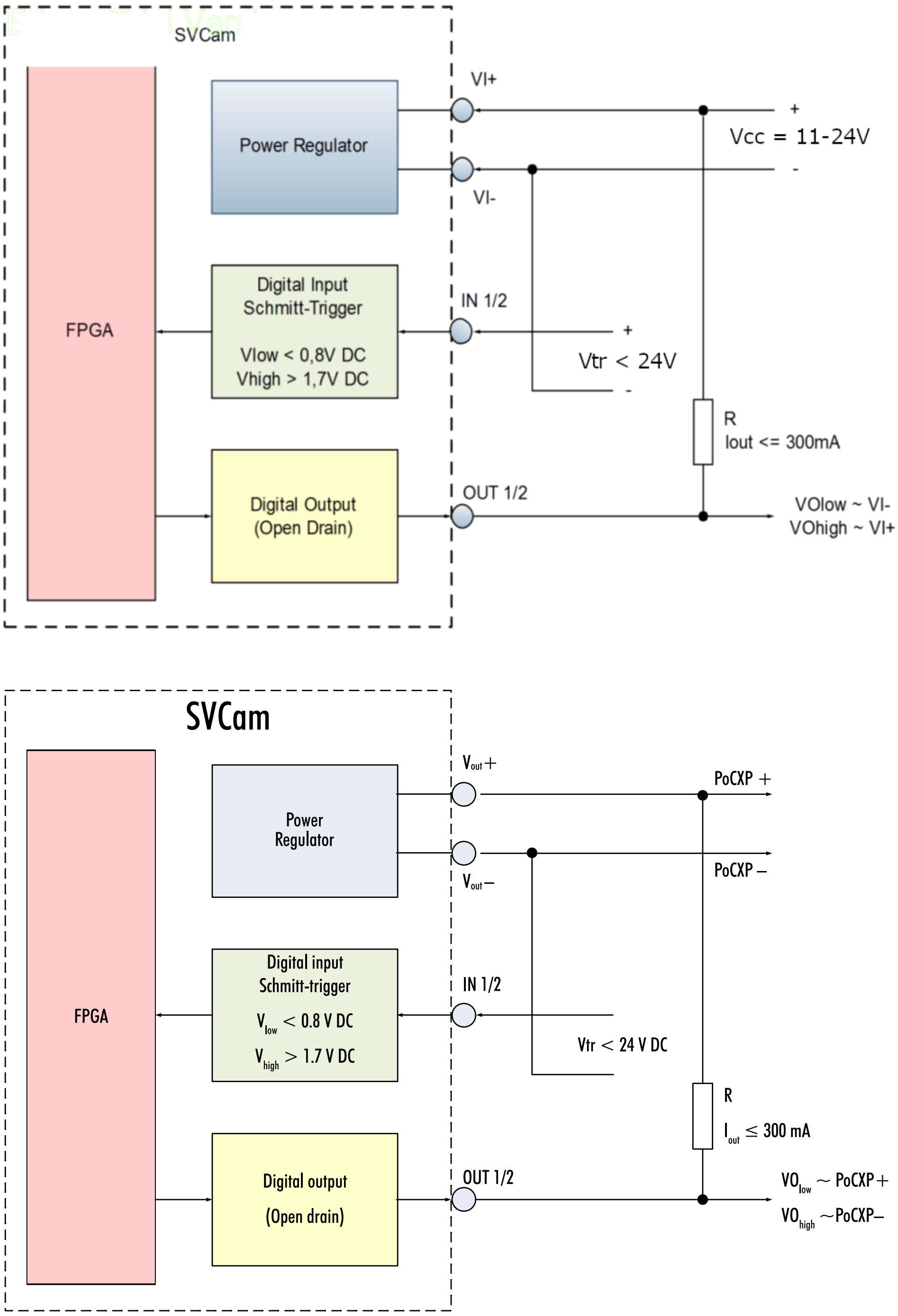



Fig. 6-1: I/O driver circuit schematics

## 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 |
| | | invalid | valid | valid | invalid | invalid |
| | | | | | | |
| DeviceKey | 0xaffe | 0xaffe | | | 0xaffe | 0xaffe |
| GroupKey | 0x0001 | 0x1 | 0x1234 | 0x1234 | 0x1 | 0x1234 |

| | ActionCMD | Device0 | | | Device1 | Device2 |
|---|---|---|---|---|---|---|
| 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.

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