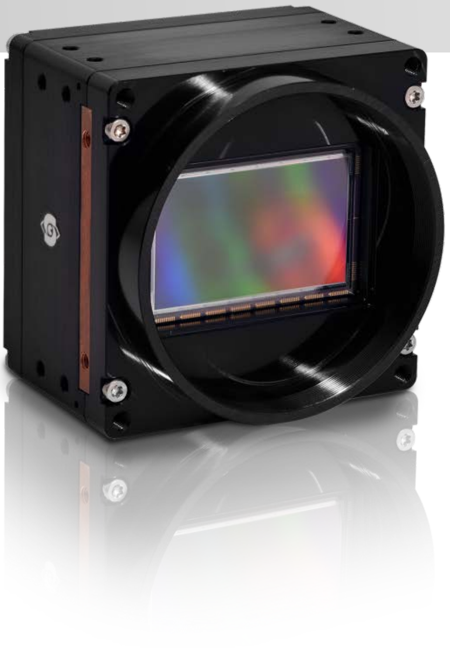

Manual SHR series

shr47051*CL

Company Information

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Web: http://www.svs-vistek.com

This Operation Manual is based on the following standards:

DIN EN 62079
DIN EN ISO 12100
ISO Guide 37
DIN ISO 3864-2
DIN ISO 3864-4

This Operation Manual contains important instructions for safe and efficient handling of SVCam Cameras (hereinafter referred to as „camera“). This Operating Manual is part of the camera and must be kept accessible in the immediate vicinity of the camera for any person working on or with this camera.

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

Accident prevention guidelines and general safety regulations shoud be applied.

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

The camera in your possession has been produced with great care and has been thoroughly tested. Nonetheless, should you have reasons for complaint, then please contact your local SVS-VISTEK distributor. You will find a list of distributors in your area under: http://www.svs-vistek.com/company/distributors/distributors.php

Copyright Protection Statement

Contents

1 Safety Messages

The classification of hazards is made pursuant to ISO 3864-2 and ANSI Y535.6 with the help of key words.

This Operating Manual uses the following Safety Messages:

Risk of death or serious injury	**DANGER!** Danger indicates a hazard with a high level of risk which, if not avoided will result in death or serious injury.
	WARNING! Warning indicates a hazard with a medium level of risk which, if not avoided will result in death or serious injury.
	CAUTION! Caution indicates a hazard with a low level of risk which, if not avoided will result in death or serious injury.
Risk of damage	**PROHIBITION!** A black graphical symbol inside a red circular band with a red diagonal bar defines a safety sign that indicates that an action shall not be taken or shall be stopped.
	CAUTION! A black graphical symbol inside a yellow triangle defines a safety sign that indicates a hazard.
	MANDATORY ACTION! A white graphical symbol inside a blue circle defines a safety sign that indicates that an action shall be taken to avoid a hazard.
Cross-reference	**NOTICE** Provides references and tips

FIGURE 1: TABLE OF SAFETY MESSAGES

2 Legal Information

Information given within the manual accurate as to: May 2, 2017, errors and omissions excepted.

These products are designed for industrial applications only. Cameras from SVS-Vistek 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 SVS-Vistek products might sell these products and agree to do so at their own risk, as SVS-Vistek will not take any liability for any damage from improper use or sale.

Europe

This camera is CE tested, rules of EN 55022:2010+AC2011 and EN61000-6-2:2005 apply.

All SVS-VISTEK cameras comply with the recommendation of the European Union concerning RoHS Rules

USA and Canada

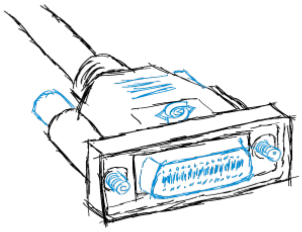
This device complies with part 15 of the FCC Rules. Operation is subject to the following conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: 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 limits 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 instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at its own expense.

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 camera housing. This is essential for any use. If not done and camera 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 Specification.

2.1 Camera Link Features



Camera Link is the most direct serial connection to the sensor and preferred by integrators with high demands on bandwidth and integration in existing systems.

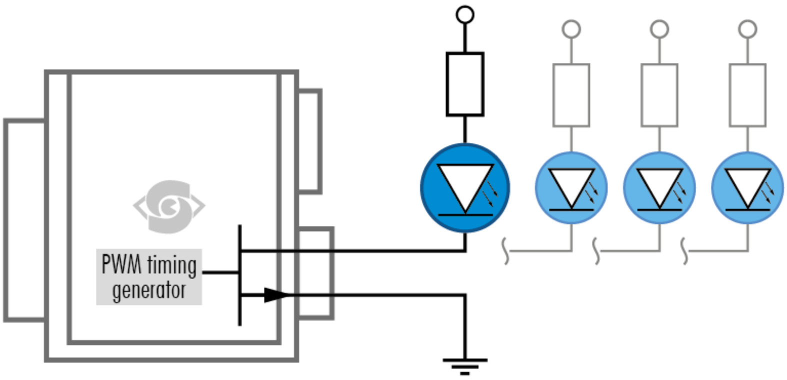
Please note, as operating Camera Link always involves a frame grabber, the specs given in the appendix might differ from your setup. Please contact us for a recommendation of frame grabbers.

Some frame grabbers support 1x3 tap configuration. With this configuration you might achieve framerates of more than 50% faster than in specs. Again, contact us for recommended frame grabbers.

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 4IO adds Light and Functionality



Your SVS-Vistek camera is equipped with the innovative 4IO-interface
Figure 2: Illustration of 4IO concept of switching LEDs (depending on camera model up to 4 inputs/outputs, see specs)

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.

If you attach any light to the camera, make sure the power supply has enough power not to fail when the camera is putting light ON.

The integrated sequencer allows multiple exposures with settings to be programmed, creating new and cost effective options. 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 fuctionality with AND, OR and timers
- Safe Trigger (debouncer, prescaler, high low trigger)

3 Getting Started

3.1 Contents of Camera Set

- Camera
- Power supply (if ordered/option)
- Quick guide
- User Manual
- Software installer – ConvCam
- Euresys camera file (optional)

3.2 Power supply

Connect the power supply.

CAUTION! – This camera does not support hotplugging

1. First, connect the data cable.
2. Then connect power supply.

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

3.3 Camera Link Flashing 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 codes translates as follows:

Flashing	Description
Yellow quickly (≈ 8 Hz)	booting
Yellow permanent	ready
Red slow (≈ 1 Hz)	error

Table 1 table of flashing LED codes

3.4 Software

Further information, documentations, release notes, latest software and application manuals can be downloaded in the download area on:
https://www.svs-vistek.com/en/login/svs-loginarea-login.php

Depending on the type of camera you bought, several software packages apply.

3.4.1 Installation of ConvCam5

CAUTION!

Make sure you have the latest ConvCam5. At time of printing, this is version 1.0.13

Your SVCam combined software installer including:

> SVConvCam
  (a controller app for SVCam Camera Link cameras)
> TL_Driver
  (GenICam drivers and transport layer DDLs)

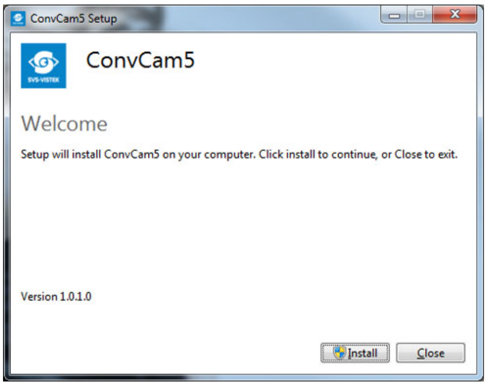
1st Expand ZIP

> Extract the zip archive to your local hard drive.

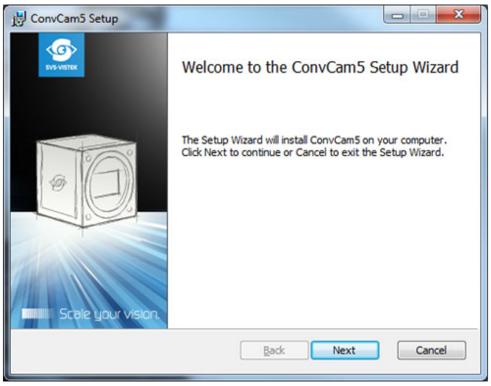
2st Install

> Run the executable file.1*

> Click "Install"

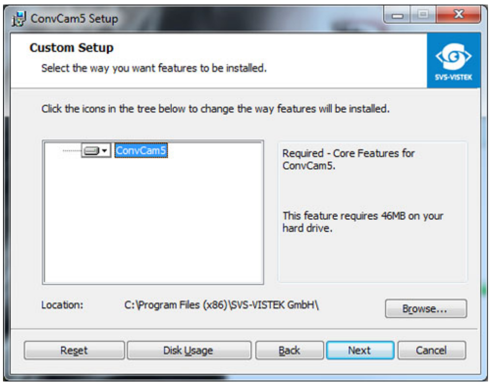


> Click "Next"

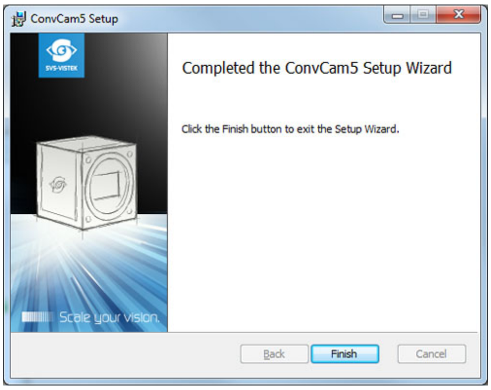


> Read and accept terms of License Agreement

> Choose Options 2* and Location to install



> Click "Finish"



1 * x64 for 64 bit operating systems
x86 for 32 bit operating systems

2 * It is recommended to install all applications included to the installation package.

3.4.2 Connecting the camera

1. Connect the camera with a Camera Link cable to your frame grabber
2. Connect power source to the camera

Run the camera controller tool: ConvCam

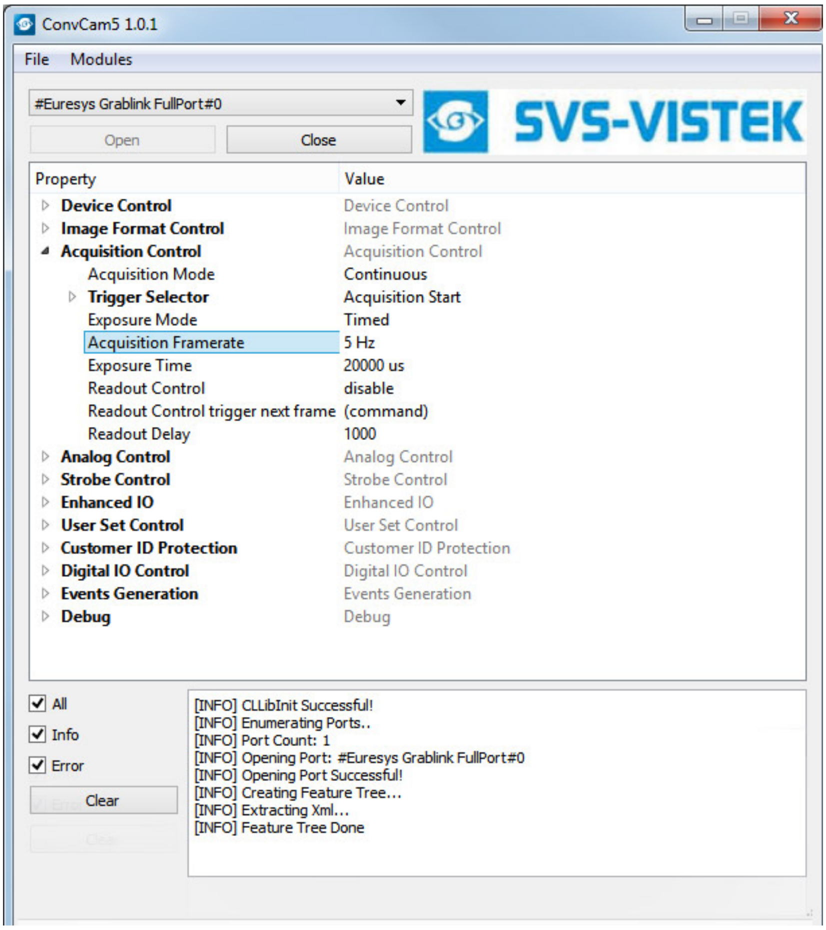
Select your frame grabber.

Information needed by your Framegrabber:

> Tap configuration
> Trigger mode
> Pixel width and height

3.4.3 ConvCam5

Set values as needed



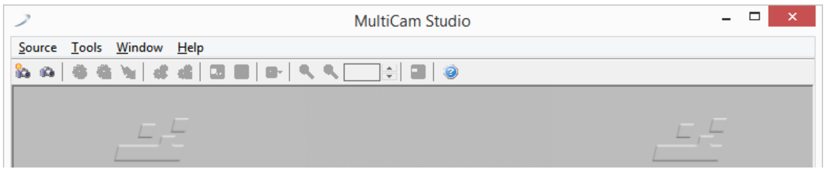
3.4.4 Viewer Software

The final image will be shown or processed by your own valued software package. After camera configuration an image will be directed to the software connected to your frame grabber.

E.g. Multicam by Euresys

While using a Euresys frame grabber the first impression imaging tool "Multicam" is available to the hardware.

Run Multicam Studio.



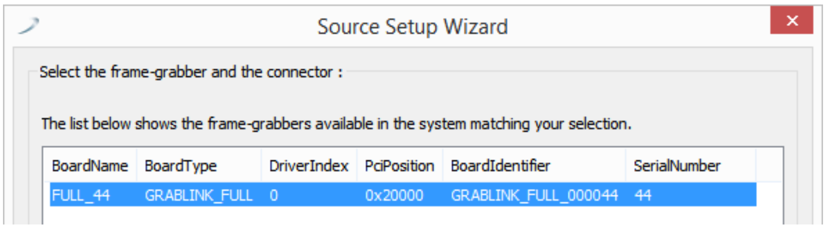
> Add a new "source" to the application

> Choose "Camera Link industrial Camera…"

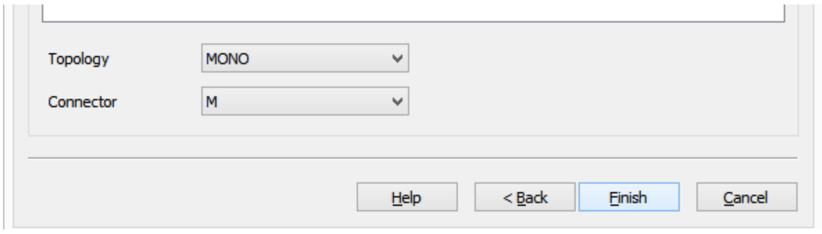
> Click "next"

> In the list of camera vendors choose "SVS-VISTEK" and the camera you want to view.

> Select frame grabber and connector



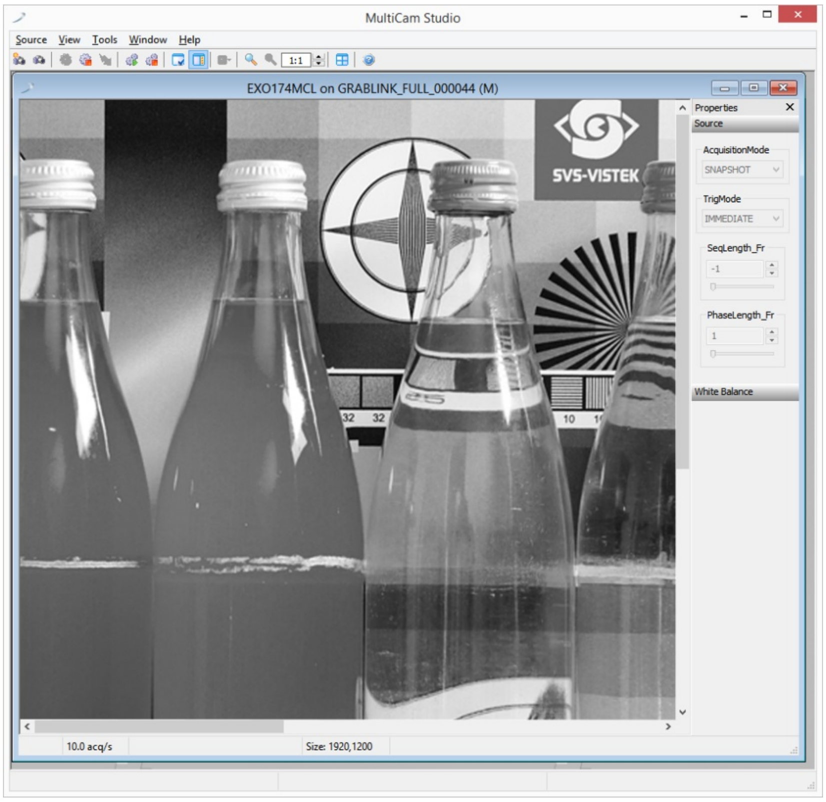
> For "Topology" values refer to the Euresys documentation. At first: stay with "Mono" for topology.



> Choose your connector configuration

> click "Finish"

Now an image should appear, according to your setup configurations made with ConvCam



For further information on Euresys Multicam Studio refer to the documentation from Euresys.

3.5 Driver Circuit Schematics

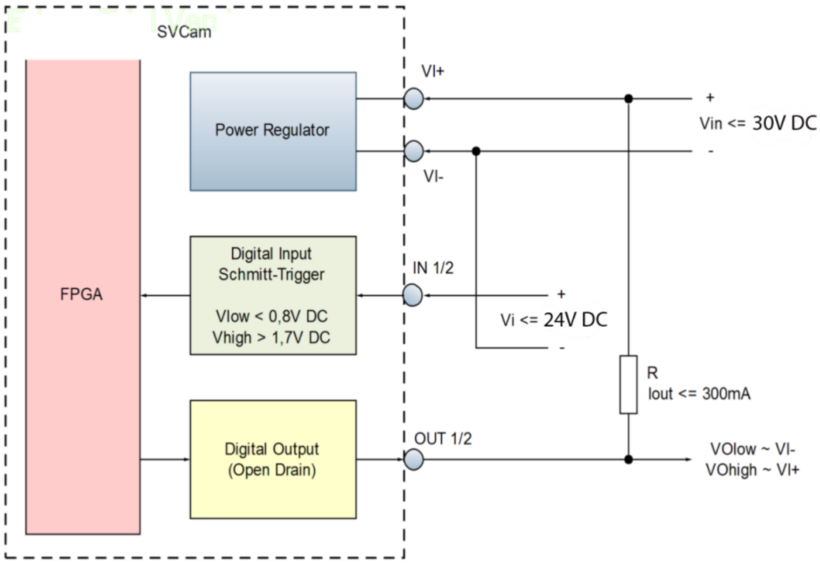
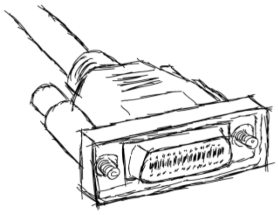


Figure 3: basic Illustration of driver circuit

4 Connectors

4.1 Camera Link™

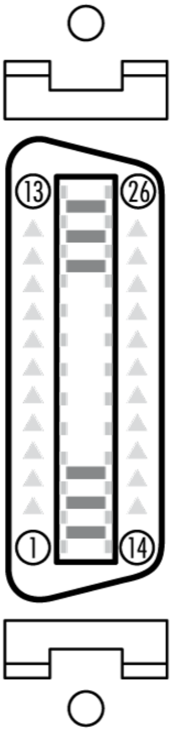


To use Camera Link a frame grabber is needed.

Frame grabbers can be purchased at SVS-VISTEK, too.

4.1.1 Connectors Camera Link™

Specification	
Type	26 Pin connector MDR female
Mating Connector	3M
Part-Nr. connector	10126-6000EL
Part-Nr. hood	10326-A200-00
Operating Mode	Camera Link™ with RS 232 communication



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 *

Figure 4: Table of Camera Link pin-out / *PoCL

4.1.2 Pinout Diagram

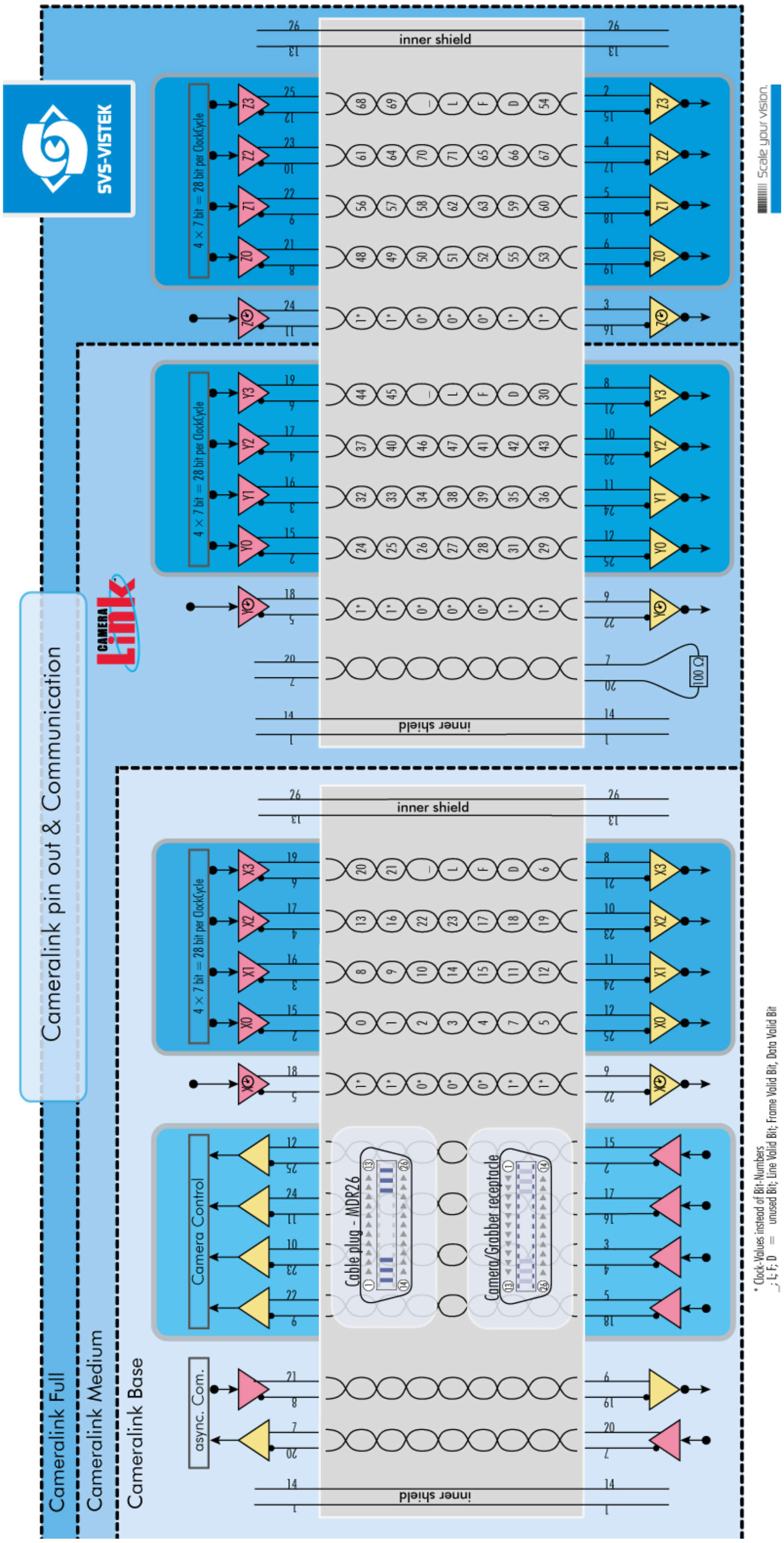


Figure 5: Illustration of Camera Link pin-out

4.1.3 Camera Link timing

It might be interesting to know 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.

$$t_{Fvd} = 2 \times \frac{1}{CL\_clock} + (t_{Lvd} + t_{nvd}) \times \frac{px_v}{CL\_geometry\_Y}$$

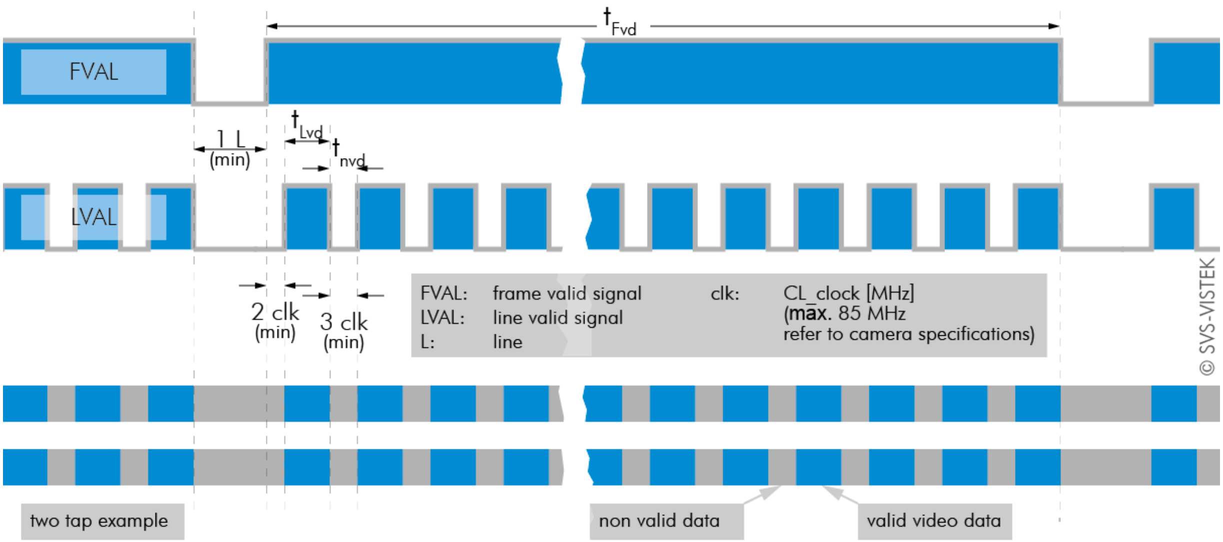


Figure 6: overview of FVAL and LVAL signal timing on Camera Link

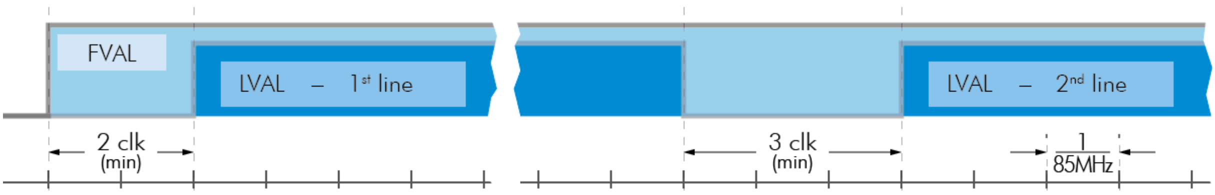


Figure 7: more detailed view of LVAL signal timing on Camera Link

Example calculation									on exo174*CL
>	t_{Lvd}	=	(1920 / 2) px in line / sent at once	×	(1/85MHz) CL_clock				
		=	960	×	$(1/85e^6)$ s			≈	11,29 µs
>	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
		=	(2 + (960 + 3) × 1200) s			/	$85e^6$	≈	13,6 ms

Camera Link architecture exo174*CL: 1X2_1Y count = 2
pixelh =1920 pixelv = 1200 CL_clock = 85 MHz

Figure 8: example calculation of Camera Link timing on a exo174*CL

4.2 Input / output connectors

For further information using the **breakout box** and simplifying I/O connection refer to **SVCam Sensor Actor** manual (with Murr and Phoenix breakout boxes). To be found separate within the USP manuals.

Hirose™ 12Pin

For detailed information about switching lights from inside the camera, refer to strobe control.

Specification	
Type	HR10A-10R-12S
Mating Connector	HR10A-10R-12P

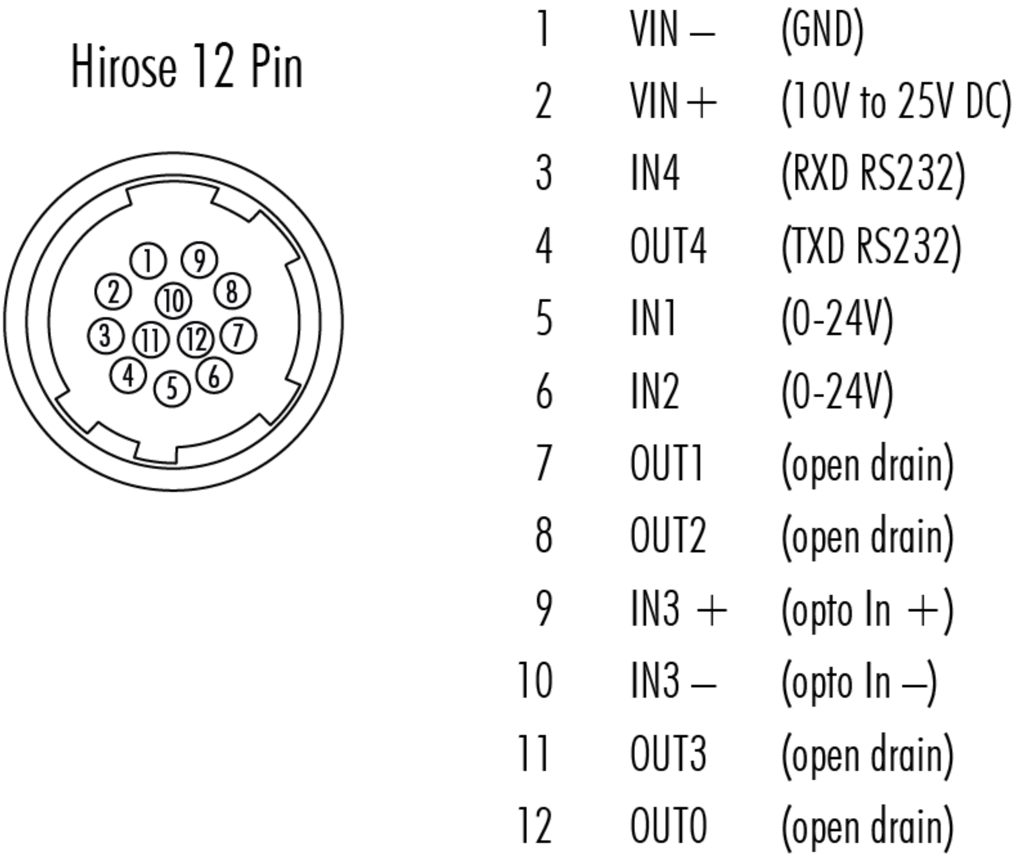


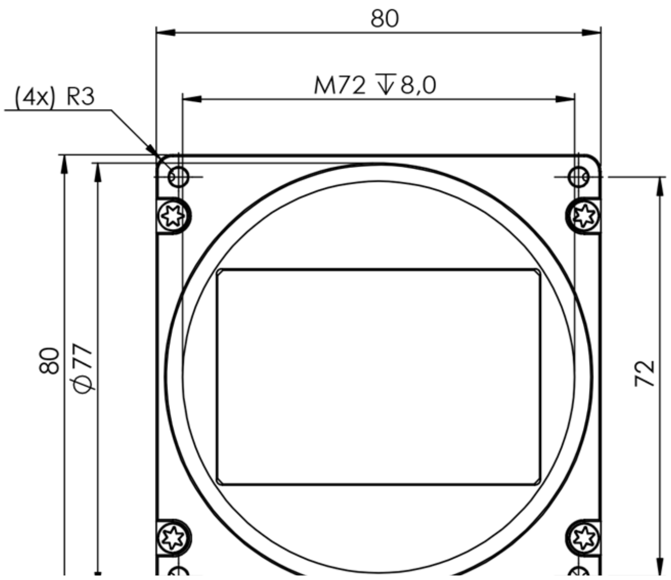
Figure 9: Illustration of Hirose 12 Pin & pin-out (HR10A-10R-12PB)

5 Dimensions

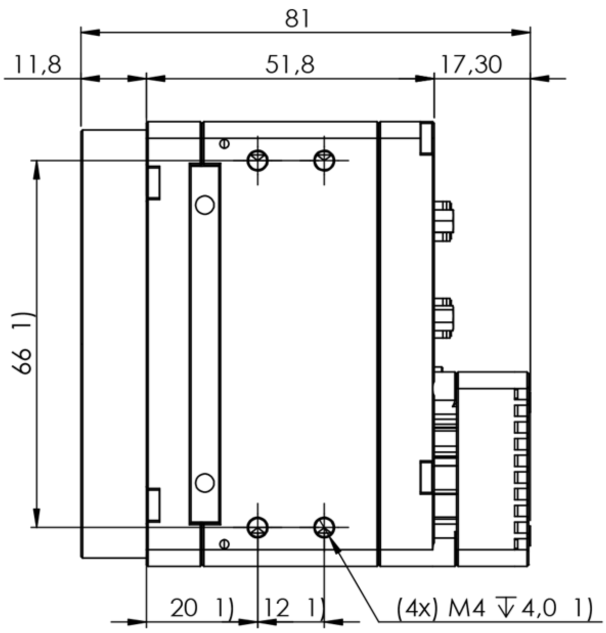
All length units in mm. CAD step files available on DVD or SVS-VISTEK.com

5.1 SHR47051 Camera Link

front



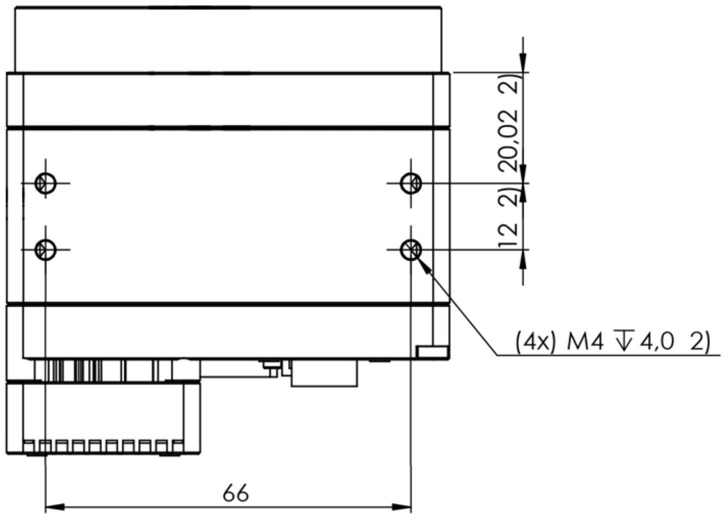
side Left



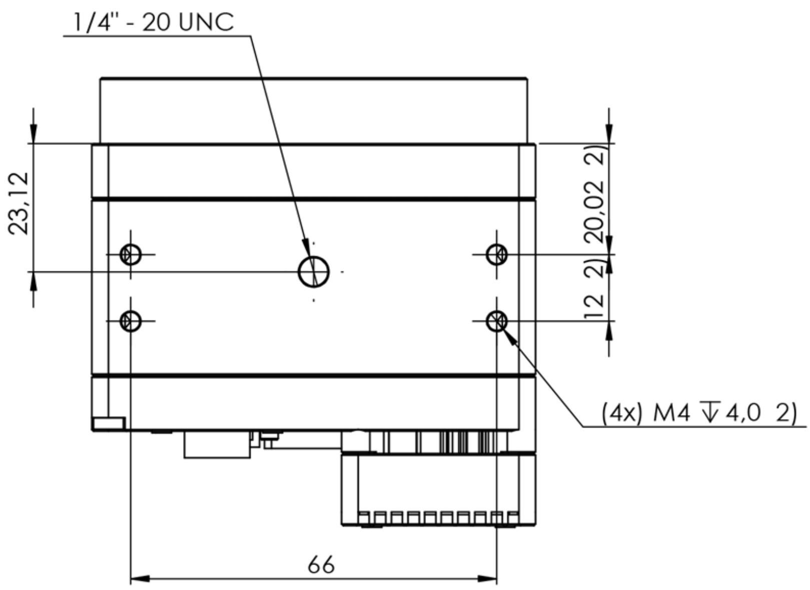
ATTENTION

The blue/red metal bar is the heatsink of the sensor itself. Do not attach anything here. Attaching devices to the colored metal bar will deadjust/destroy the sensor.

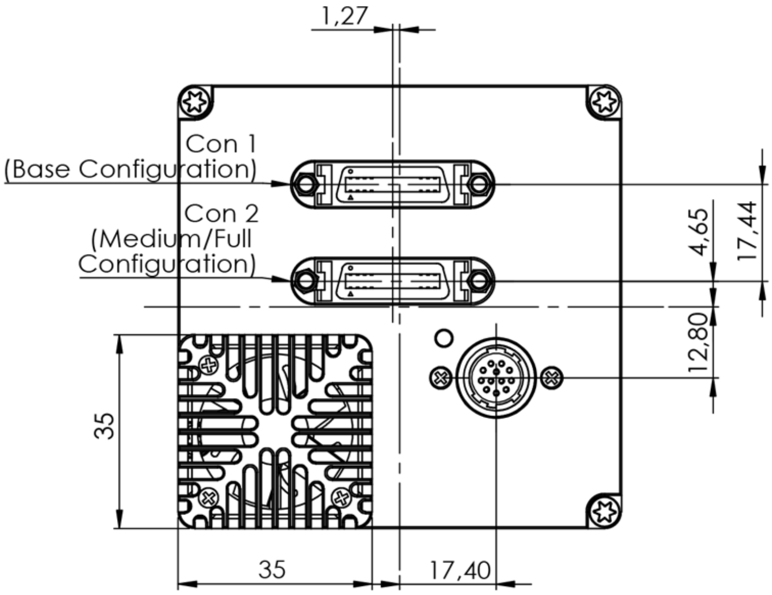
Top



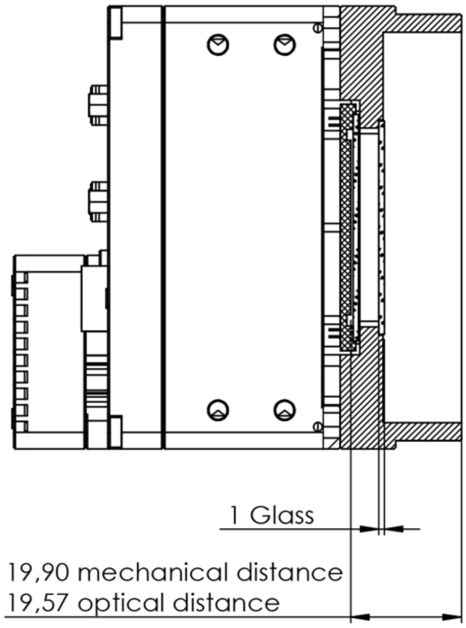
Bottom



Back



Cross Section



5.2 M72 Mount

Diameter = 72 mm

Mechanical sensor flange distance: 19,90mm

Including the cover glas to the calculation of the distance:
the optical sensor flange distance shrinks to 19,57 mm

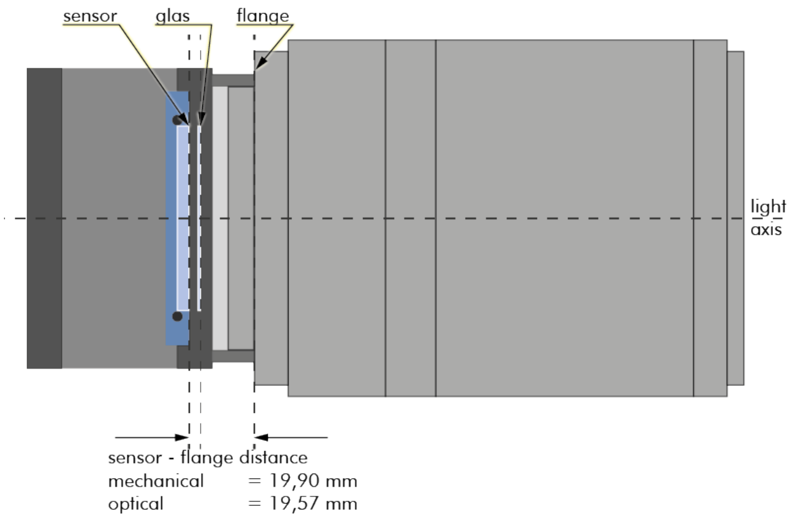


Figure 10: Illustration of M72-mount

6 Feature-Set

6.1 Basic Understanding

6.1.1 Basic Understanding of CCD Technology

CCD is the abbreviation for Charge Coupled Device.

In an area device light sensitive semiconductor elements are arranged in rows and columns. Each row in the array represents a single line in the resulting image. When light falls onto the sensor elements, photons are converted into electrons, creating a proportional light input signal.

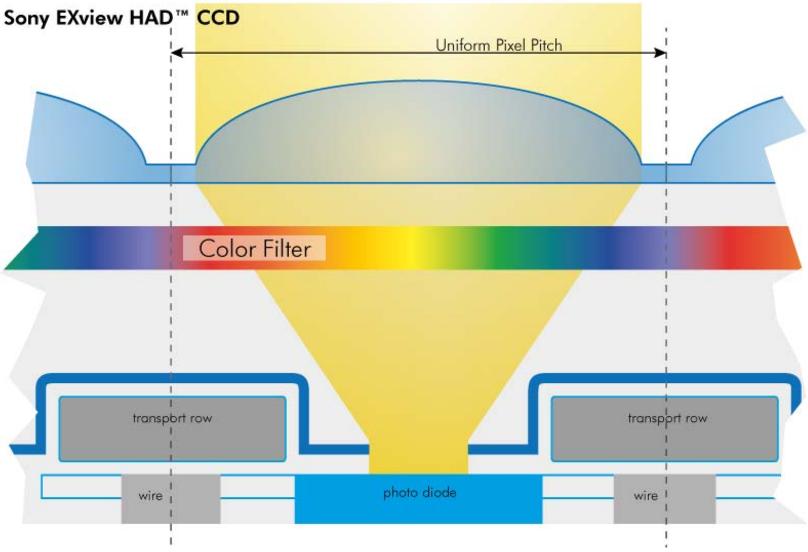
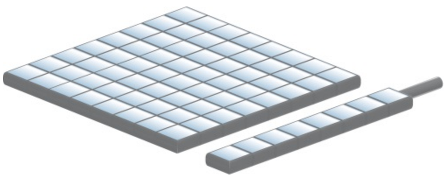


Figure 11: Illustration Cross-section of a CCD sensor from Sony



Charge is an integration of time and light intensity on the element. Like this the image gets brighter the longer the CCD cell is exposed to light.

The sensor converts light into charge and transports it to an amplifier and subsequently to the analog to digital converter (ADC).

6.1.2 Interline Transfer

Interline Transfer is only used in CCD sensors.

With a single pixel clock the charge from each pixel is transferred to the vertical shift register. At this time, the light sensitive elements are again collecting light. The charge in the vertical registers is transferred line by line into the horizontal shift register. Between each (downward) transfer of the vertical register, the horizontal register transfers each line the output stage, where charge is converted to a voltage, amplified and sent on to the ADC. When all lines in the image have been transferred to the horizontal register and read out, the vertical registers can accept the next image…

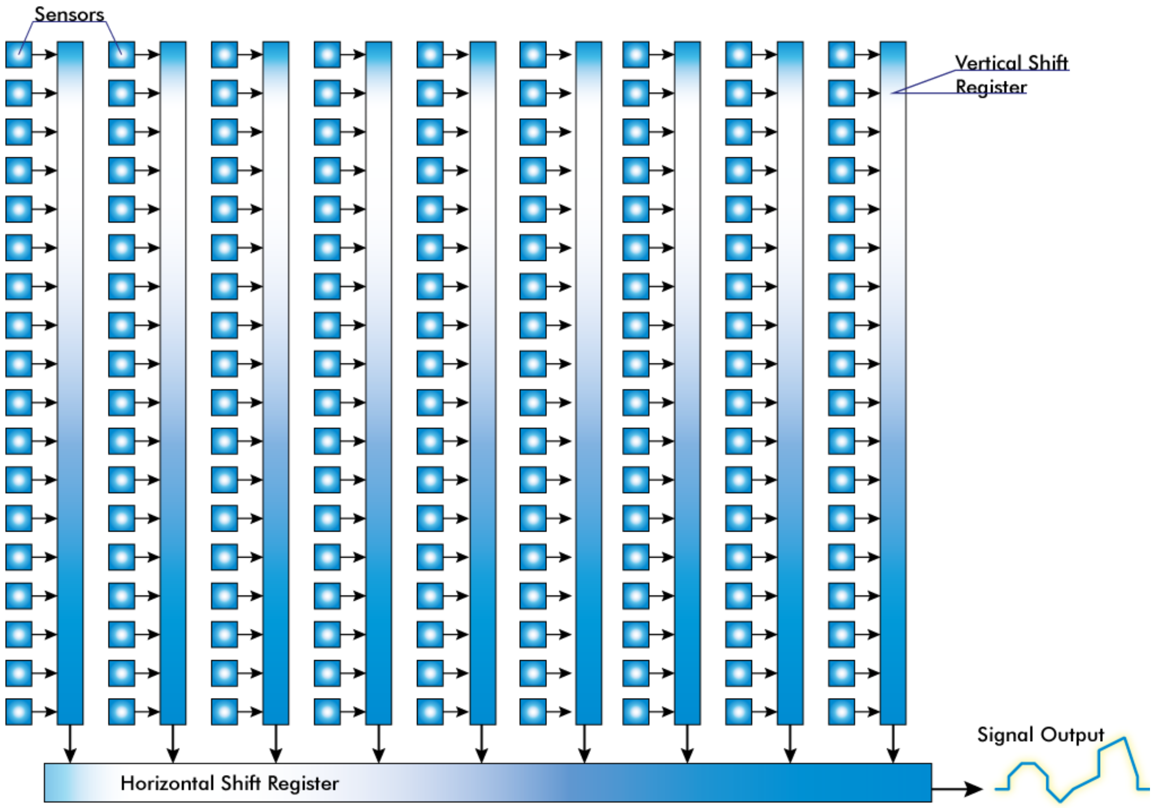


Figure 12: Illustration of interline transfer with columns and rows

6.1.3 Global and rolling Shutter

CCD and CMOS cameras are consisting of pixels. All pixel are exposed to light and then read out to camera electronics. There is a difference of reading out the sensor between global and rolling shutter. Especially flashing might need some more attention with rolling shutter.

Global shutter

Unlike rolling shutter or interlaced scan modes all pixels are exposed to light at the same time. All pixel 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 showing movement distortion, except motion blur if the moving object is so fast that the same point of the object is covers different pixels at start and end of the exposure time in the image.

A global shutter image is a snapshot of the whole scene.

Figure 13: motion blur with global shutter and moving objects

Figure 14 rolling shutter with moving objects(geometric distortion)

Figure 15: interlaced effect

Using flash with global shutter is simpel: just make sure your flash is on while shutter is open.

6.1.4 Frames per Second

Frames per second, or frame rate describes the number of frames output per second. The inverse (1/ frame rate) defines the frame time.

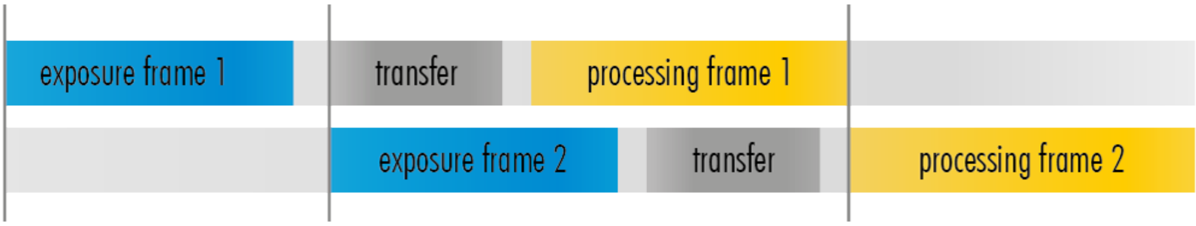
frame per second	frame time (Exposure)	applicable standard
0,25	4 s	
1	1s	
2	500ms	
20	50 ms	
24	41,$\overline{6}$ ms	Cinema
25	40 ms	PAL progressive
29,97	33,$\overline{366700033}$… ms	NTSC
30	33,$\overline{33}$ ms	NTSC
50	20 ms	PAL interlaced
75	13, $\overline{33}$ ms	
100	10 ms	

Virtually any value within the specification can be chosen.
Maximum frame rate depends on:

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

6.1.5 Acquisition and Processing Time

The whole period of tome a picture is exposed, transferred and processed can differ and takes longer.



6.1.6 Exposure

See various exposure and timing modes in chapter: Basic capture modes.

Combine various exposure timings with PWM LED illumination, refer to sequencer.

Setting Exposure time

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

6.1.7 Auto Luminance

Auto Luminance 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 pre-define 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.

Limitation

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.

6.1.8 Bit-Depth

Values of brighness are internally represented by numbers. Numbers are represented by bytes, consisting out of single bits. The number of bits for brightness representation is limiting the number of brightness values or colour values that can be represented. Bit depth defines how many unique colors or grey levels are available in an image after digitization. The number of bits used to quantify limits the number of levels to be used.

e.g.: 4 bits limits the quantification levels to $2^4 = 16$.
Each pixel can represent 16 grey levels

8 bits	to	2^8	=	256 values per pixel
12 bits	to	2^{12}	=	4096 values per pixel
16 bit	to	2^{16}	=	65536 values per pixel

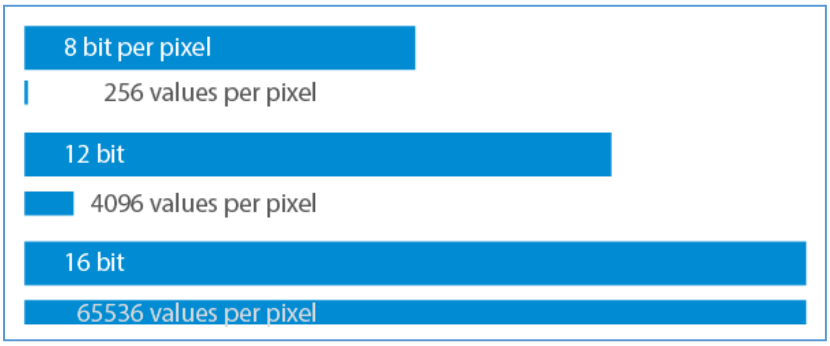


Figure 16: illustration of rising amount of values/gray scales by increasing the bit format

Every additional bit doubles the number for quantification.

SVCam output is 8, 12 or 16 bit, depending on your camera model and the way you read the values from the camera.

Be aware that increasing the bit format from 8 to 12 bit also increases the total amount of data. According to the interface framerates can be limited with higher bit depth values.

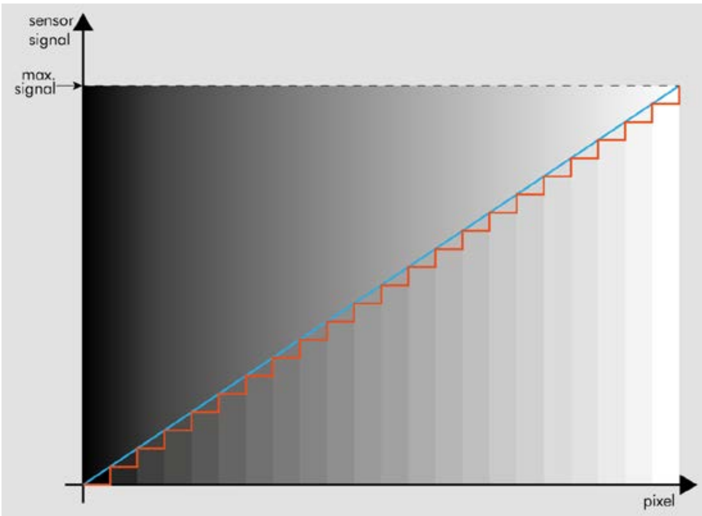


Figure 17: Simplified illustration of a quantification graph

As SVCam's export pure RAW-format only, color will be created on the host computer in accordance with the known Bayer-pattern by computing the brightness values into colour values..

Figure 18: illustration of shade difference in 8 bit format

As shown in figure 19 differences in shades of gray are hardly visable on screen or in print.

Figure 20: Figure of original picture - black & white

Figure 21: Figure of quantification with 6 shades of gray (reduced colour depth)

6.1.9 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.

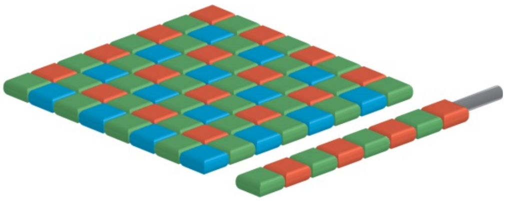


Figure 22: CCD with Bayer Pattern

The camera sensor has a color mosaic filter called "Bayer" filter pattern named after the person who invented it. The pattern alternates as follows:

E.g.: First line: GRGRGR... and so on. (R=red, B=blue, G=green) Second line: BGBGBG... and so on. Please 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).

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.

NOTICE

It is recommended to use a IR cut filter for color applications!

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 tint in the image.

Influences normally depend on the light source used. These tints are measured in Kelvin (K) to indicate the color temperature of the illumination.

Light sources and their typical temperatures:

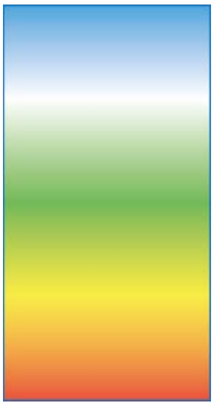
	Temperature	Common Light Source
	10.000 – 15.000 K	Clear Blue Sky
	6.500 – 8.000 K	Cloudy Sky / Shade
	5.500 – 6500 K	Noon Sunlight
	5.000 – 5.500 K	Average Daylight
	4.000 – 5.000 K	Electronic Flash
	4.000 – 5.000 K	Fluorescent Light
	3.000 – 4.000 K	Early AM / Late PM
	2.500 – 3.000 K	Domestic Lightning
	1.000 – 2.000 K	Candle Flame

Figure 23: Table of color temperatures

6.1.10 Resolution – active & effective

As mentions in the specifications, there is a difference between the active and the effective resolution of almost every sensor. Some pixels towards the borders of the sensor will be used only to calibrate the sensor values.

These pixels are totally darkened. The amount of dark current in these areas is used to adjust the offset.

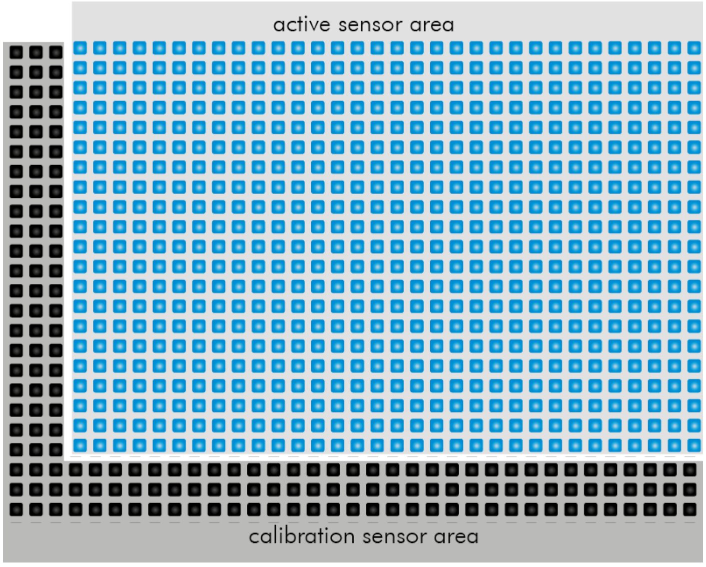


Figure 24: Illustration of active and effective sensor pixels

6.1.11 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.

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

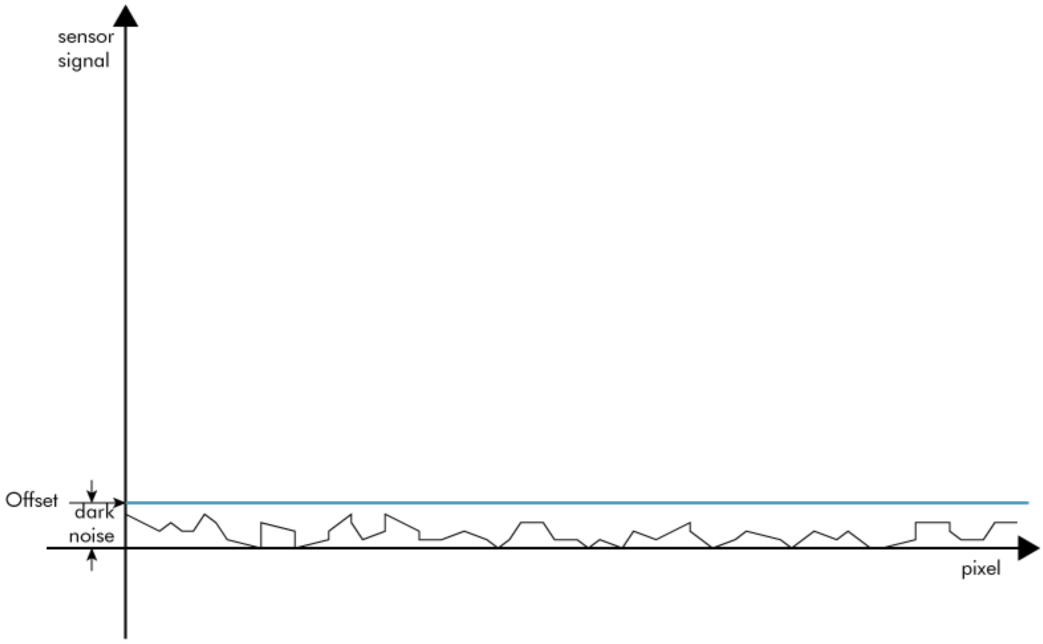


Figure 25: Illustration of dark noise cut off by the offset

Most noise is proportional to temperature. To spare you regulating the offset every time the temperature changes. A precedent offset is set by the camera itself. It references certain pixels that never were exposed to light as black (refer to "resolution – active and effective"). 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.

In case of multi-tap CCD sensors:
Offset can be altered for each tap separately. Refer to "tap balancing".

6.1.12 Gain

Setting gain above 0 dB (default) is another 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.

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

Figure 26: Table of dB and corresponding ISO

NOTICE

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.

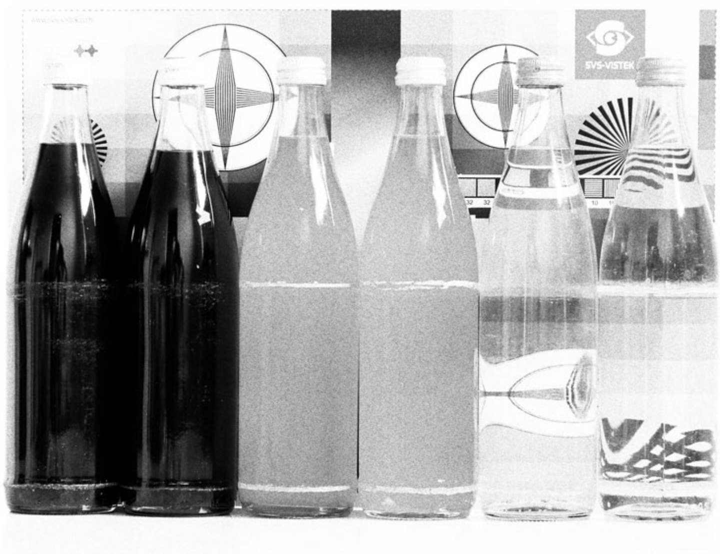


Figure 27: noise caused by increasing gain excessively

Auto Gain

For automatically adjusting Gain please refer to Auto Luminance.

6.1.13 Image Flip

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.

Figure 28: Figure of original image

Figure 29: Figure of image horizontally flipped

Figure 30: Figure of image vertically flipped

6.1.14 Binning

Binning provides a way to enhance dynamic range, but at the cost of lower resolution. Instead of reading out each individual pixel, binning combines charge from neighboring pixels directly on the chip, before readout.

Binning is only used with monochrome CCD Sensors. For reducing resolution on color sensors refer to decimation.

Vertical Binning

Accumulates vertical pixels.

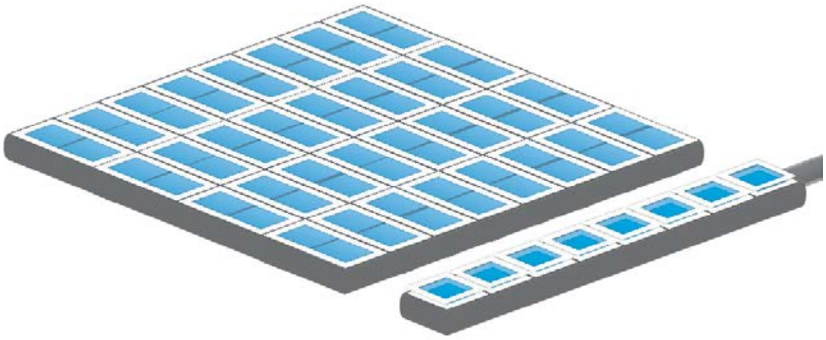


Figure 31: Illustration of vertical binning

Horizontal Binning

Accumulates horizontal pixels.

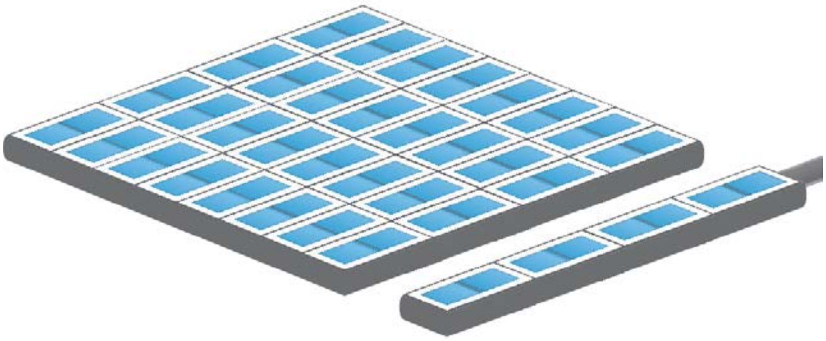


Figure 32: Illustration of horizontal binning

2×2 Binning

A combination of horizontal and vertical binning.

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

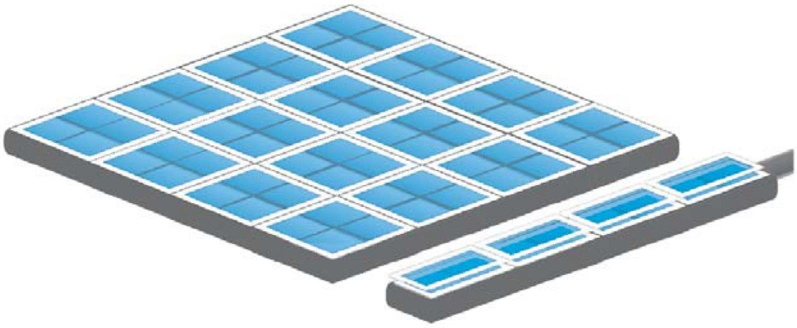


Figure 33: Illustration of 2x2 binning

6.1.15 Decimation

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

Refer to AOI for reducing data rate by reducing the region you are interested in.

Figure 34 Horizontal decimation Figure 35 Vertical decimation

Decimation on Color Sensors

The Bayer pattern color information is preserved with 1/3 horizontal and vertical resolution. The frame readout speed increases approx. by factor 2.5.

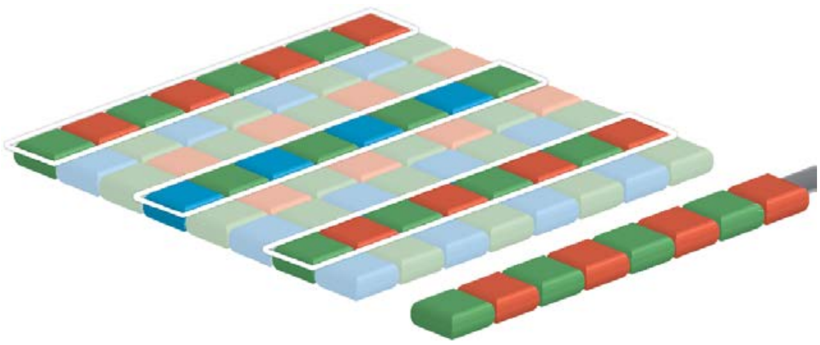


Figure 36: Illustration of decimation on color sensors

6.1.16 Burst Mode

The hardware interface (GigE, USB3 etc) of your camera very often will limit the maximum framerate of the camera to the maximum framerate of the interface of the camera. Inside the camera, the sensor speed (internal framerate) might be higher than the external interface's speed (e.g. GigE).

In triggered mode though, trigger frequency might be higher than the external interface's speed. The triggered images will stay in the internal memory buffer and will be delivered one after the other with interface speed. If trigger frequency is higher than interface max fps frequency, more and more images will stick in the internal image buffer. As soon as the buffer is filled up, frames will be dropped.

This internal-save-images and deliver-later thing is called Burst Mode.

Due to internal restriction in the image request process of the camera, on USB cameras the maximum sensor speed is limited to the maximum interface speed. This means the maximum trigger frequency cannot be higher than camera freerun frequency. The image buffer will protect against breaking datarates of the USB line, though.

Usage of Burst Mode

Burst Mode has 2 main purposes:

- If transfer speed breaks down (e.g. Ethernet transfer rate due to high network load), tolerate low speed transfer for a short time and deliver frames later on (buffering low speed interface performance for a short time)
- For several frames (up to full internal memory) images can be taken with higher frame rate than camera specs are suggesting (as soon as there is enough time later on to deliver the images) (not applicable to USB cameras)

Please note, as soon as the internal memory buffer is filled up, frames will be dropped. Due to this reason, SVS-Vistek camers provide up to 512MB image buffer memory.

6.2 Camera Features

6.2.1 Standard Tap Geometries

Similar to other sensor readout technologies Camera Link is sending many pixel values in parallel at the same time. The image can be split in “taps” or “channels” which can be sent in parallel. The tap geometry is describing how many taps are read and how they are transmitted through the Camera Link interface.

Table 2: recommende tap configuration for HR25 and SHR47

Camera	Tap config	Tap geometry	Maximum speed	CL type
HR25	8T8	1X8_1Y	25	Full
	10T8	1X10_1Y	31	Deca
SHR47	2T8	1X2_1Y	3,5	Base
	4T8	1X2_2YE	7	Medium
	4T12	1X2_2YE	7	Medium

6.2.2 Tap Structure

Your camera may be equipped with a two, four or even higher taped sensor.

Camera output format	Tap geometry
1X–1Y	Single tap
1X–2YE	Dual tap
2X–1Y	Dual tap
2X–2YE	Four tap

Figure 37: table of tap geometry/configurations

Tap configuration

For information according to your sensor refer to specifications.

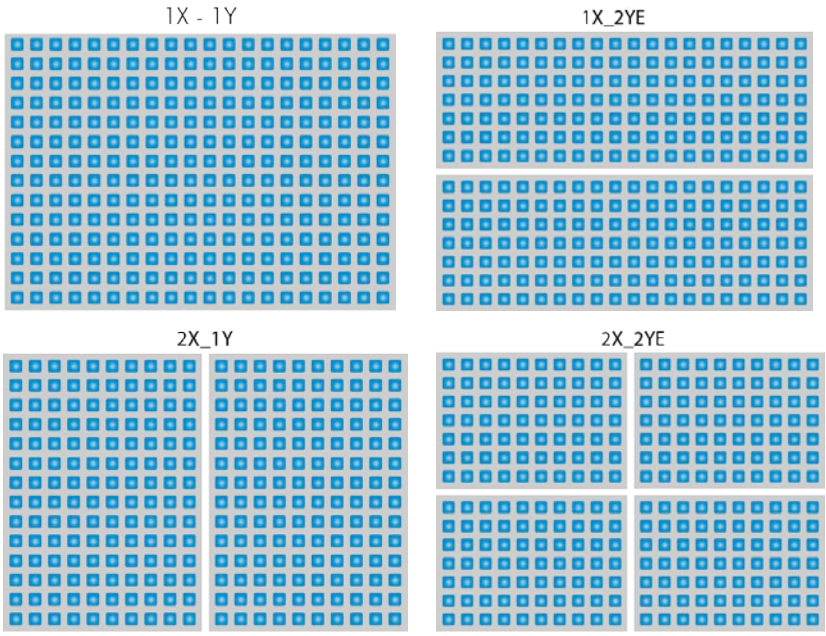


Figure 38: Illustrations of the nomenclature used in specifications

Single-Tap

In a single-tap CCD sensor the readout of pixel charge is done sequentially. Pixel by pixel, line by line. The maximum frame rate is determined by the pixel clock frequency and the total number of pixels to be read out.

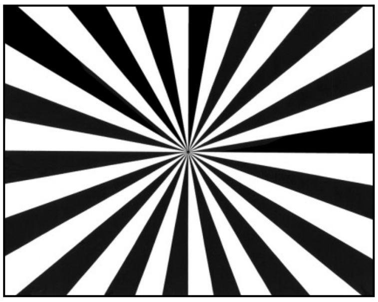


Figure 39: Figure of 1 Tap

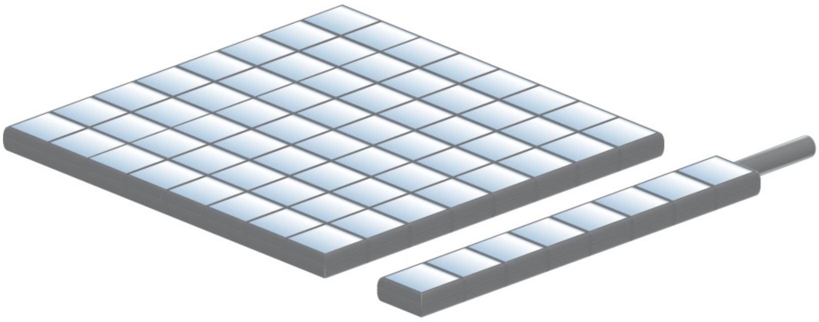


Figure 40: Illustration of 1 tap

Dual-Tap

In a dual-tap CCDs, (CCD with two outputs) the readout of pixel charge takes place in a serial/parallel sequence. Each line is divided in half and the pixels of both halves are read out simultaneously, line by line. For a given pixel clock frequency, only half the time is required to read out the entire array, resulting in twice the framerate.

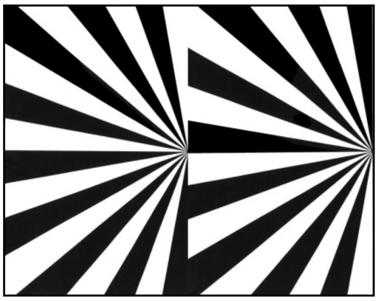


Figure 41: Figure of 2 taps

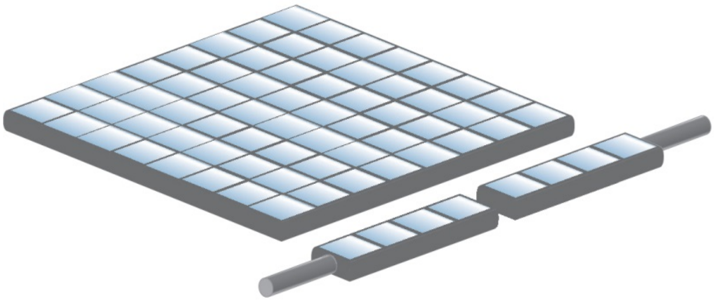


Figure 42: Illustration of 2 taps

Quad-Tap

Quad-tap CCDs (CCD with four outputs) the read out of pixels is four times faster than in a "regular" sensor.

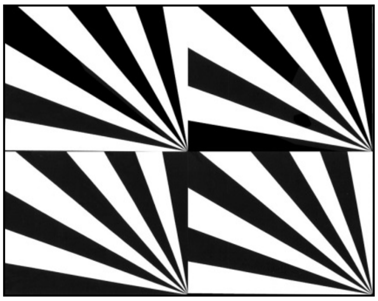


Figure 43: Figure of 4 taps

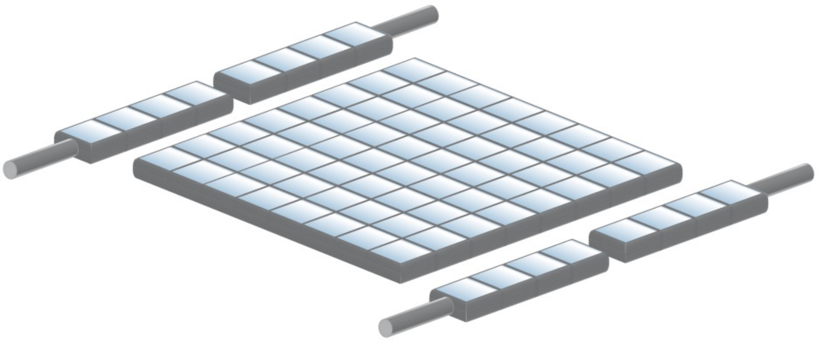


Figure 44: Illustration of 4 tap

Tap Reconstruction on Camera Link

Due to the sequence of arriving pixel information the frame grabber has to "reconstruct" the pixel information in order to display the image correctly.

6.2.3 Tap Balancing

In sensors with multiple the tap structure, parts of the picture may appear differently. Taps may display difference in dynamics and brightness.

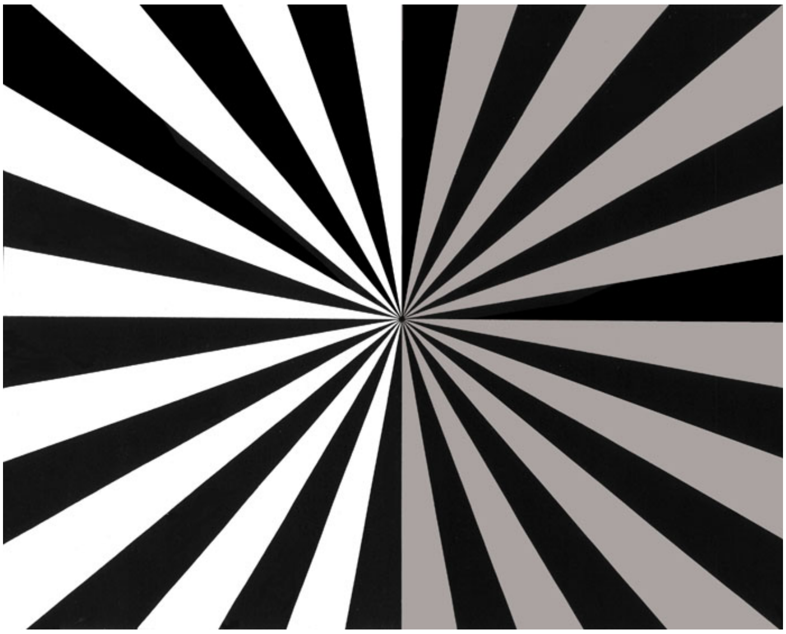


Figure 45: Figure of an unbalanced 2 tap image

To eliminate these differences, tap balancing offers gain adjustments separately for each tap.

This is due to the requirement for a dual or quad -ADC circuit to handle the simultaneous digitization of the two or more channels of analog signal coming from the CCD. The fact that the separate analog output channels not being perfectly linear and the separate output amplifiers having physically different slopes leads to the necessity to sometimes manually or automatically adjust the gain levels of each channel independently to obtain a homogenous image.

Automatic Tap Balancing

Automatic Tap Balancing analyses a narrow strip at the border of the taps. It adjusts the gain value to the average brightness value of these strips.

6.2.3.1.1 Continuously Tap Balancing

Automatic Tap Balancing can be done continuously. Taps will be balanced from one image to the next.

6.2.3.1.2 Tap Balancing once

When performing Tap Balancing once. Only one specific image will be analyzed. The gain-correction values will be saved and applied to subsequent images.

Manual Tap Balancing

Tap Balancing can be performed manually

6.2.4 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 multiples of 15 ns.

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

NOTICE

Use multiples of 15 ns to write durations into camera memory

6.2.5 Temperature Sensor

A temperature sensor is installed on the mainboard of the camera.

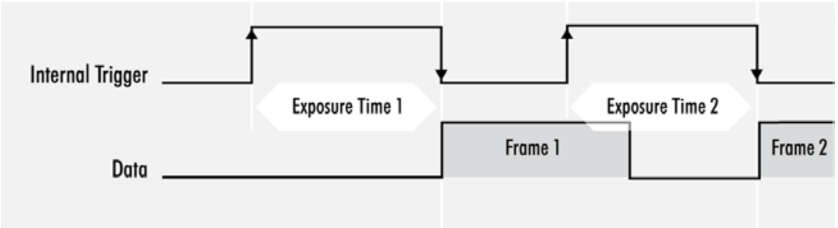
To avoid overheating, the temperature is constantly monitored and read. Besides software monitoring, the camera indicates high temperature by a red flashing LED. (See flashing LED codes)

6.2.6 Basic Capture Modes

Free Running

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

Mode 0: Free Running with Programmable Exposure Time



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

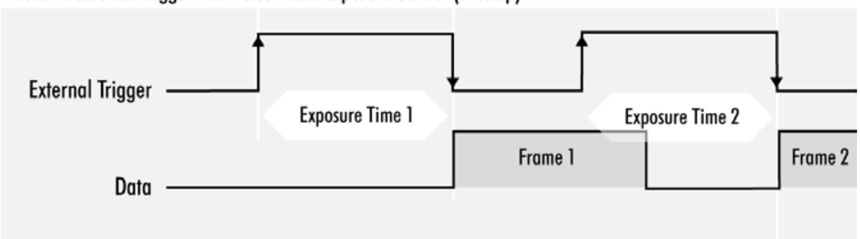
NOTICE

The fundamental signals are:
Line Valid: LVAL, Frame Valid: FVAL,
And in case of triggered modes: trigger input.

Triggered Mode (pulse width)

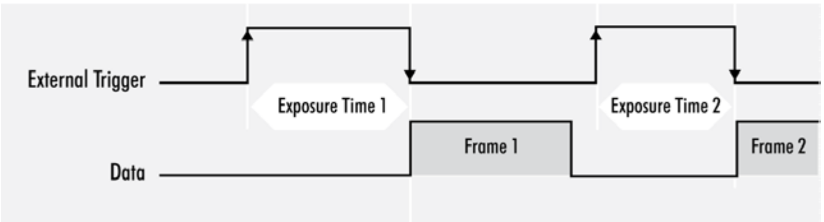
External trigger and pulse-width controlled exposure time. In this mode the camera is waiting for an external trigger, which starts integration and readout. Exposure time can be varied using the length of the trigger pulse (rising edge starts integration time, falling edge terminates the integration 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.

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.

Mode 1: External Trigger with Pulse Width Exposure Control (non 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 persistant delay.

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

External Trigger (Exposure Time)

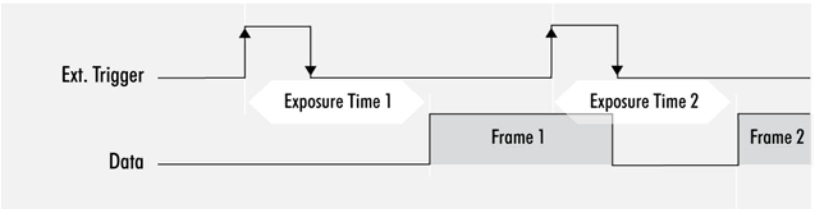
External trigger with programmable exposure time. In this mode the camera is waiting for an external trigger pulse that starts integration, whereas exposure time is programmable via the serial interface and calculated by the internal microcontroller of the camera.

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

The software provided by SVS-Vistek allows the user to set exposure time e.g. from 60 µs 60 Sec (camera type dependent).

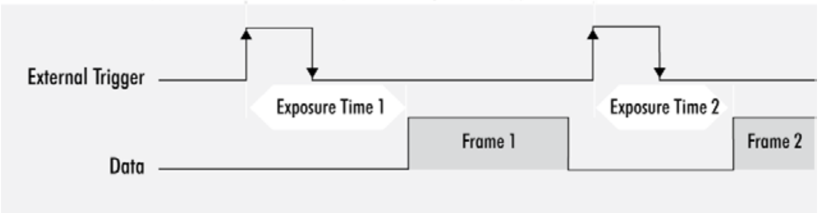
Exposure time of the next image can overlap with the frame readout of the current image (trigger pulse occurs when FVAL is high). When this happens, the start of exposure time is synchronized to the negative edge of the LVAL signal (see figure)

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 persistant delay.

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

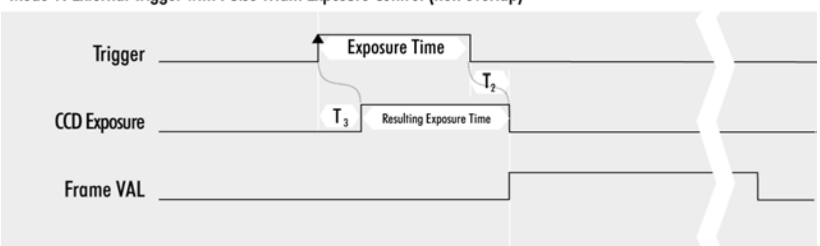


Exposure time can be changed during operation. No frame is distorted during switching time. If the configuration is saved to the EEPROM, the set exposure time will remain also when power is removed.

Detailed Info of External Trigger Mode

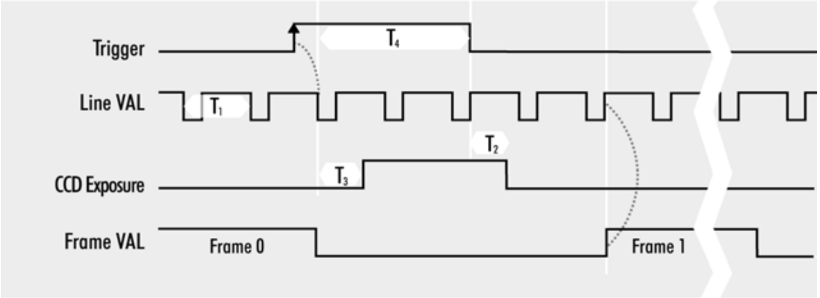
Dagrams below are aquivalent for CCD and CMOS technique.

Mode 1: External Trigger with Pulse Width Exposure Control (non overlap)



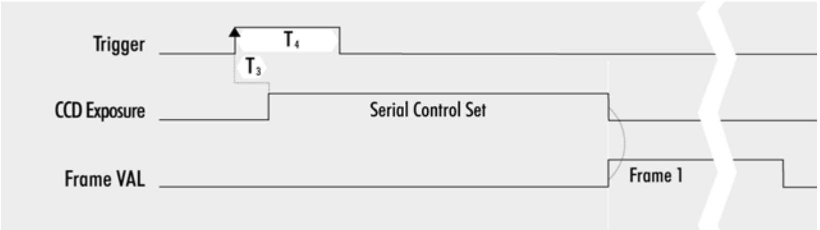
T_1: Line Duration T_2: Transfer Delay T_3: Exposure Delay T_4: min. Trigger Pulse Width

Mode 1: External Trigger with Pulse Width Exposure Control (overlap)



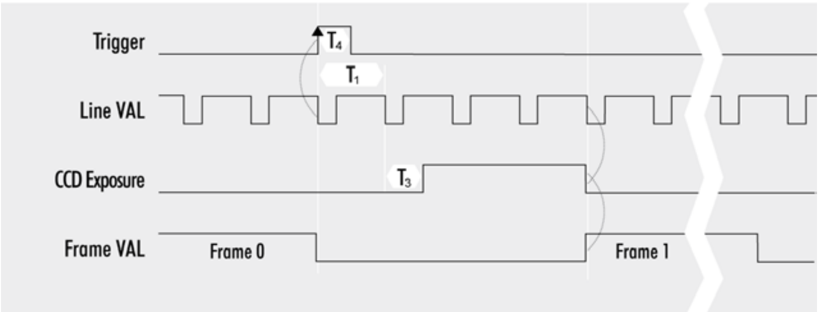
T_1: Line Duration T_2: Transfer Delay T_3: Exposure Delay T_4: min. Trigger Pulse Width

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



T_1: Line Duration T_2: Transfer Delay T_3: Exposure Delay T_4: min. Trigger Pulse Width

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



T_1: Line Duration T_2: Transfer Delay T_3: Exposure Delay T_4: min. Trigger

Software Trigger

Trigger can also be initiated by software (serial interface).

NOTICE

Software trigger can be influenced by jitter. Avoid Software trigger at time sensitive applications

6.2.7 ROI / AOI

In Partial Scan or Area-Of-Interest or Region-Of-Interest (ROI) -mode only a certain region will be read.

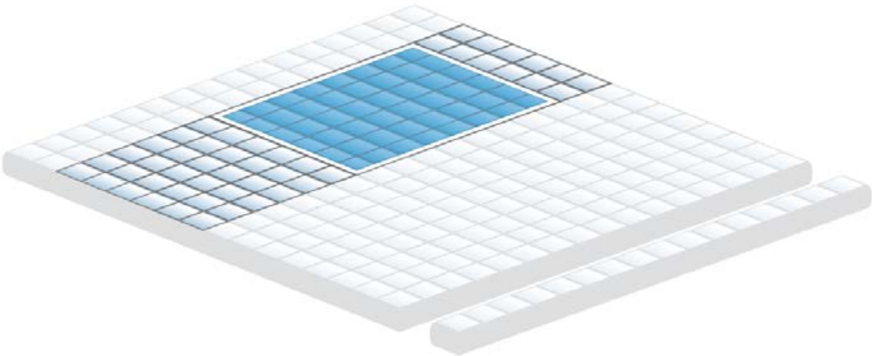


Figure 46: Illustration of AOI limitation on a CCD sensor

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 term of frames per second.

With CCD sensors, setting an AOI on the left or right side does not affect the frame rate, as lines must be read out completely.

6.2.8 Defect Pixel Correction

Defect Pixel Correction interpolates information from neighboring pixels to compensate for defect pixels or clusters (cluster may have up to five defect pixels).

All image sensor have defect pixels in a lesser or greater extent. The number of defects determines the quality grade and the value of all sensors integrated by SVS-VISTEK.

Defect Pixels 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 by SVS-VISTEK.

Under challenging conditions or high temperature environments additional defect pixels can may appear. These can be corrected.

> A factory created defect map (SVS 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 has to 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 pixels or clusters and reconstructs the expected value by interpolating neighboring pixels that. The standard interpolation algorithm uses the pixel to the left or to the right of the defect. This simple algorithm prevents high runtime losses.

More sophisticated algorithms can be used by software.

Figure 47: Illustration of a defect pixel

6.2.9 Shading Correction

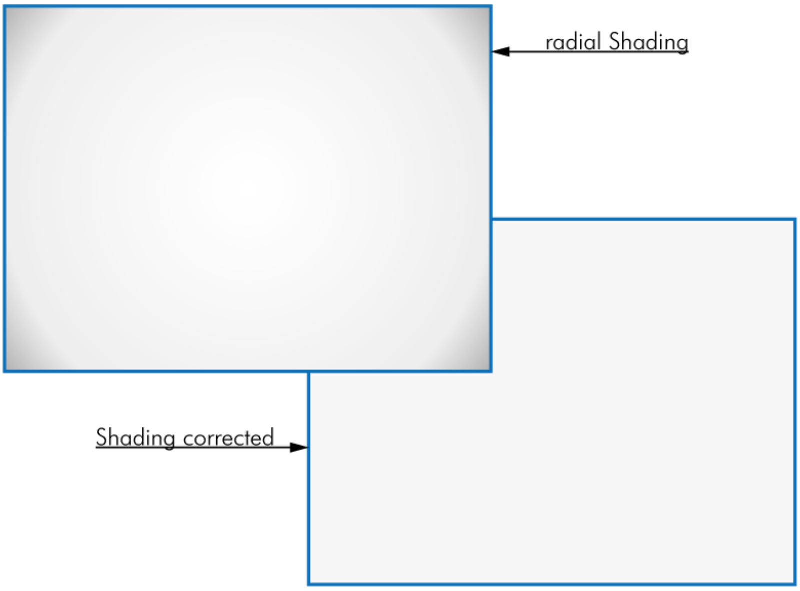


Figure 1: illustration of original and shading corrected image

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

- In the host computer: Significant loss of dynamic range, colour ruptures
- In the camera, digital: better (smoother) shading than on the computer side (10 or 12 bit), loss of dyn range
- In the camera, analog: Change gain/offset locally on sensor to get optimum shading correction with only small changes in dynamic range

Performing builtin shading correction

In order to perform a correction for an image with non-uniform image a reference "white" image is captured. This will allow creating correction values to "adjust" the pixels by individual gain settings.

8 frames are taken for averaging of white images.

Generation of the white image for correction:

The ideal white image consists of a uniform image with only one pixel value. Pixel values lower than the brightest value are adjusted via the pixel gain factor. The maximum gain factor is 4 (relatively to initial gain setting). A better grey value resolution with maximum gain factor 2 can be achieved, if the factor between the lowest and the highest pixel value of the white image is smaller than 2.

The white image should be uniform, without saturation. To suppress small image structures, the camera can be defocused.

The generated gain correction values are be stored to the non-volatile memory of the camera (EPROM).

> **NOTICE**
> White balance should be completed before acquisition of correction values for Shading Correction.

Correct shading with Shading Tool

Images taken with shading correction will seem to have a perfectly balanced illumination. The original idea was to correct the shading of sensor and lens, but it can be used to correct shading of illumination (a non-homogenous illumination) as well.

Shading correction is not a replacement for correct illumination. It is important to have in mind that illumination shading correction might reduce dynamic range of the images taken. 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.

In contrary to any shading correction being done after image recording, the method described here will hardly affect the dynamic range of the image.

The task is done with shading maps. Together with the software package comes a tool SVCamCC5_Shading to create shading maps. The shading tool takes any image with any (!!) illumination and creates a shading map out of it. This shading map will be uploaded into the camera.

Procedure

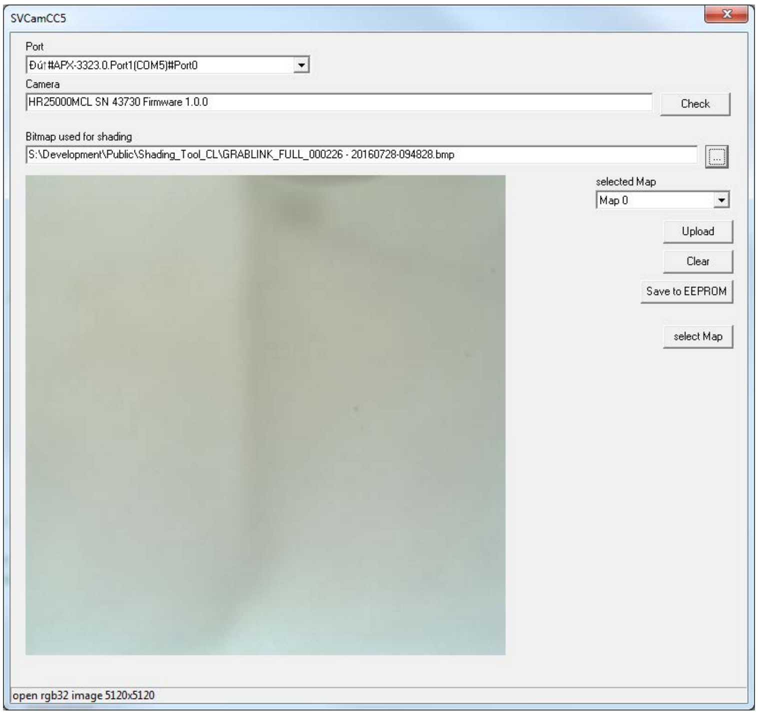
NOTICE

The uploading process takes 4 minutes minimum. Please do not interrupt this process, otherwise the result will be an incomplete map

First, a shading reference image has to be taken with shading correction disabled. Save it on disk. Use std .bmp files here, if possible with more than 8 bit.

With the shading tool SVCamCC5_Shading load this reference image. Select the Map position out of positions [012]. By uploading the generated shading map will be written to the camera. If you want to have it persistent, press SAVE TO EEPROM. Verify the result by selecting a map and press SELECT MAP. You can remove any shading map by SELECTING MAP, CLEAR, SAVE TO EEPROM.

Figure 48 SVCamCC5 shading tool with shading reference image loaded



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. Maximum 3 different shading maps can be uploaded and connected with a user preset. Like this by switching the user set you can use 3 different shadings (use this for example if the illumination in 3 colors is not the same) in sequential shots.

6.3 I/O Features

6.3.1 Assigning I/O Lines – IOMUX

The IOMUX is best described as a switch matrix. It connects inputs, and outputs with the various functions of SVCam I/O. It also allows combining inputs with Boolean arguments.

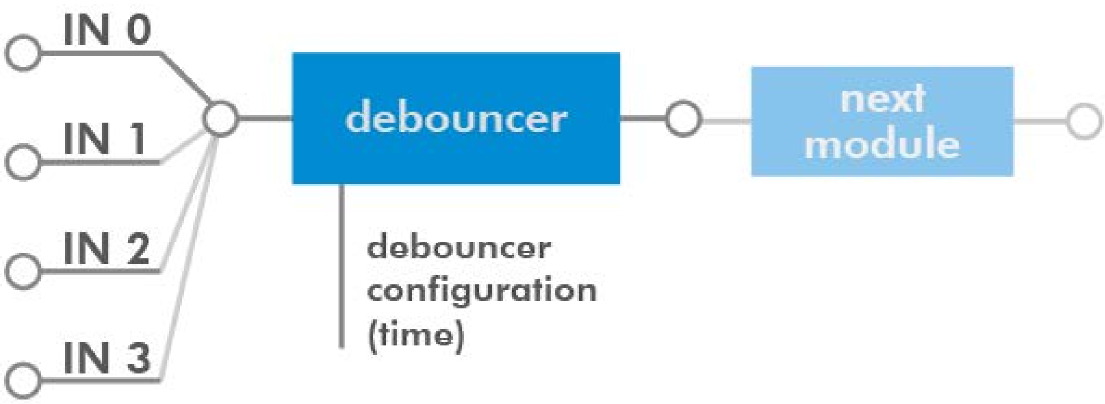


Figure 49: "IN0" connected to "debouncer"

The input and output lines for Strobe and Trigger impulses can be arbitrarily assigned to actual data lines. Individual assignments can be stored persistently to the EPROM. Default setting can be restored from within the Camera.

LineSelector	translation
Line0	Output0
Line1	Output1
Line2	Output2
Line3	Output3
Line3	Output4
Line5	Uart In
Line6	Trigger
Line7	Sequencer
Line8	Debouncer
Line9	Prescaler
Line10	Input0
Line11	Input1
Line12	Input2
Line13	Input3
Line14	Input4
Line15	LogicA
Line16	LogicB
Line17	LensTXD
Line18	Pulse0
Line19	Pulse1
Line20	Pulse2
Line21	Pulse3
Line22	Uart2 In

Note:

If you connect the camera with a non-SVS-Vistek GigEVision client, you might not see the clearnames of the lines, but only line numbers. In this case, use this list of line names

Refer to pinout in input / output connectors when physically wiring.

Also the IOMUX can be illustrated as a three dimensional dice. Long address spaces indicate which signals are routed to witch module within the camera.

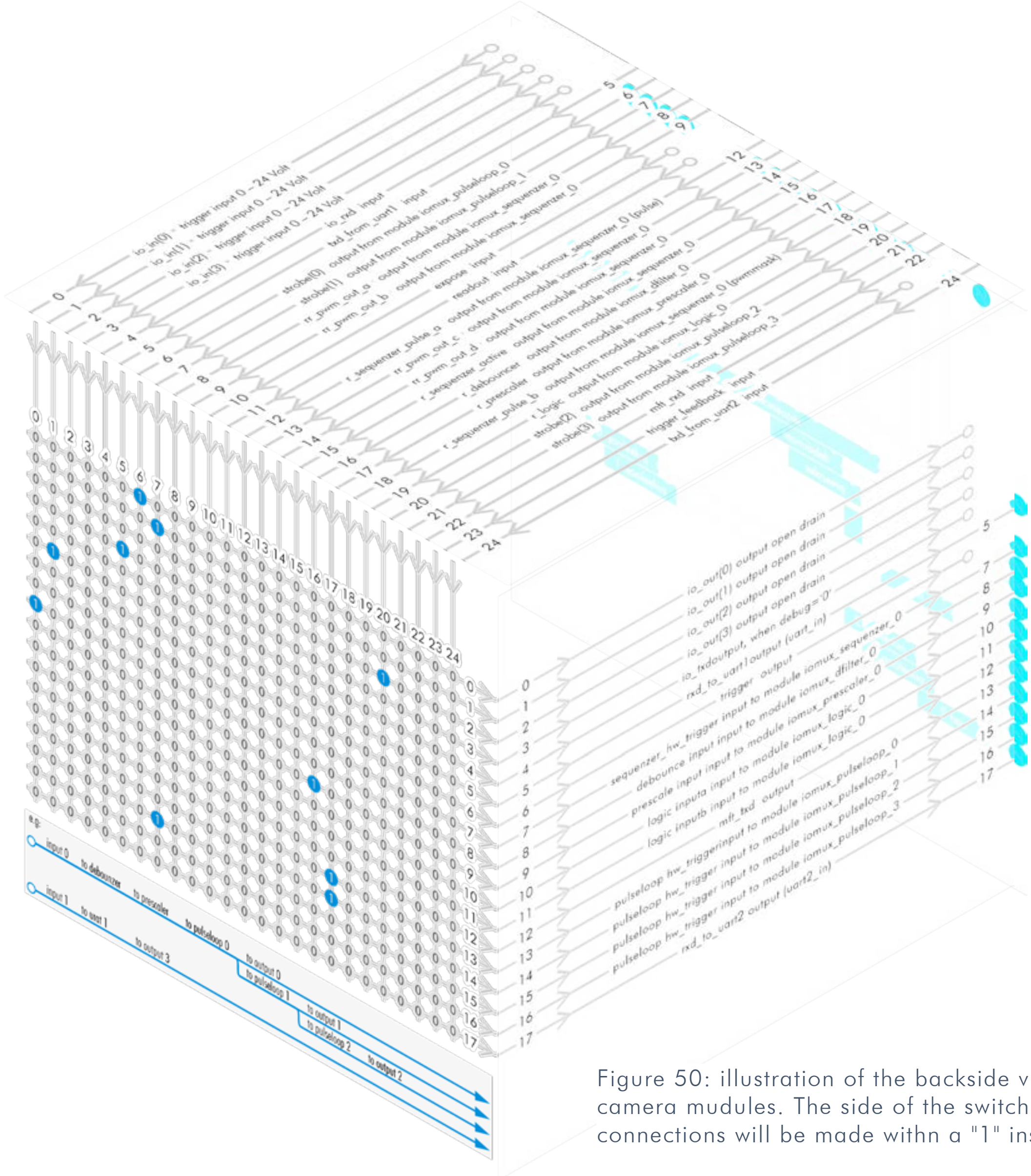
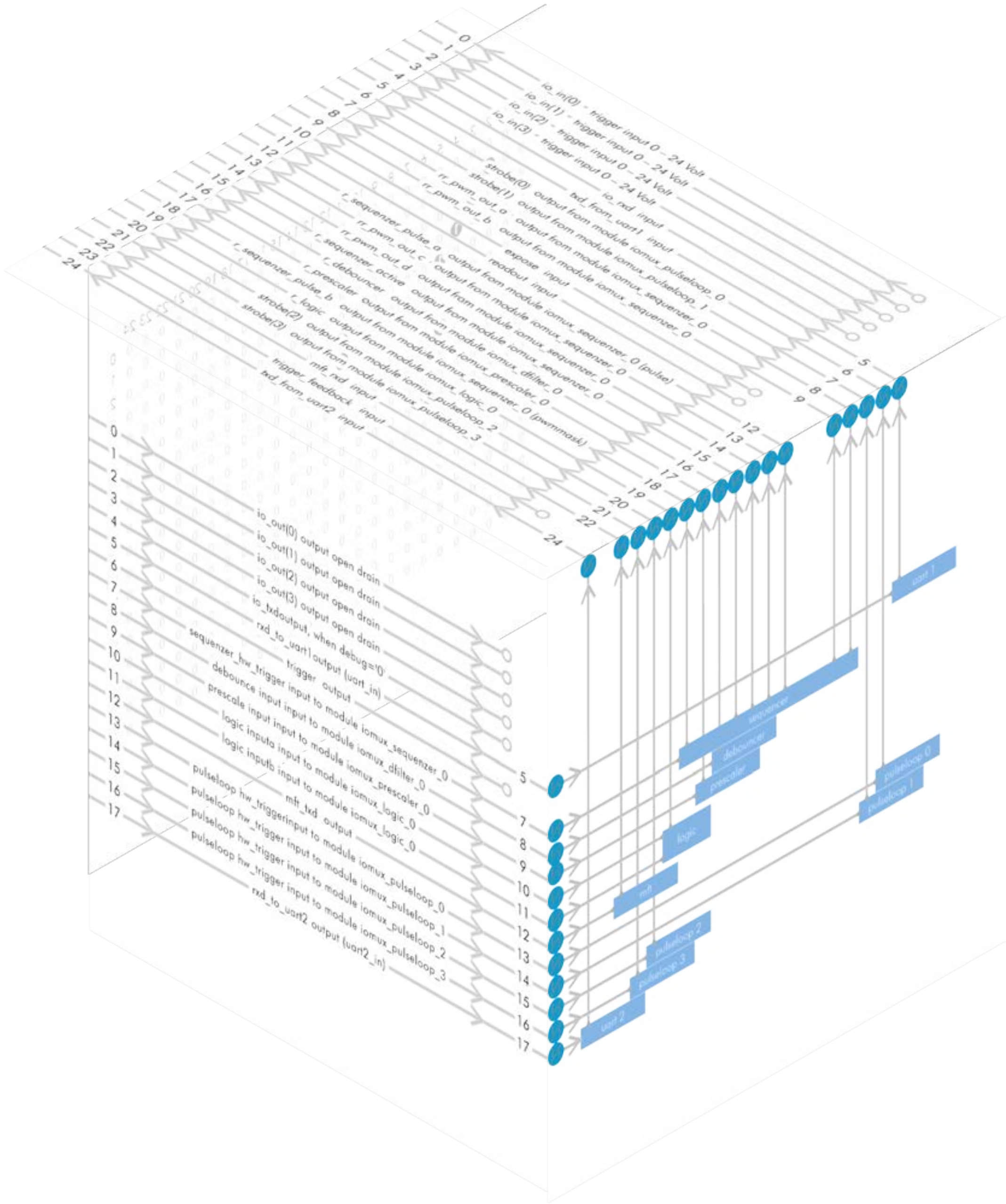


Figure 50: illustration of the backside view of the camera mudules. The side of the switch matrix. connections will be made withn a "1" instead of a "0"

Figure 51: illustration of frontside view to the camera modules.

Lines with open end indicate physical in- and outputs



input vector to switch matrix

nr.	name	description
0	io_in(0)	trigger input 0 – 24 Volt / RS-232 / opto *
1	io_in(1)	trigger input 0 – 24 Volt / RS-232 / opto *
2	io_in(2)	trigger input 0 – 24 Volt / RS-232 / opto *
3	io_in(3)	trigger input 0 – 24 Volt / RS-232 / opto *
4	io_rxd input	
5	txd_from_uart1	input
6	strobe(0)	output from module iomux_pulseloop_0
7	strobe(1)	output from module iomux_pulseloop_1
8	rr_pwm_out_a	output from module iomux_sequenzer_0
9	rr_pwm_out_b	output from module iomux_sequenzer_0
10	expose input	
11	readout input	
12	r_sequenzer_pulse_a	output from module iomux_sequenzer_0 (pulse)
13	rr_pwm_out_c	output from module iomux_sequenzer_0
14	rr_pwm_out_d	output from module iomux_sequenzer_0
15	r_sequenzer_active	output from module iomux_sequenzer_0
16	r_debouncer	output from module iomux_dfilter_0
17	r_prescaler	output from module iomux_prescaler_0
18	r_sequenzer_pulse_b	output from module iomux_sequenzer_0 (pwmmask)
19	r_logic	output from module iomux_logic_0
20	strobe(2)	output from module iomux_pulseloop_2
21	strobe(3)	output from module iomux_pulseloop_3
22	mft_rxd input	
23	trigger_feedback	input
24	txd_from_uart2	input

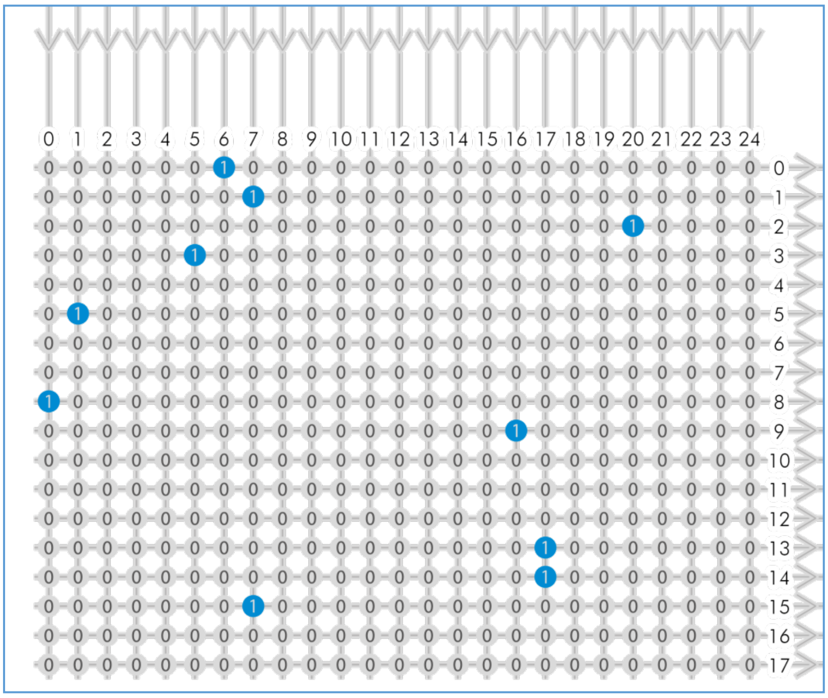
* refer to pinout or specifications

output vector from switch matrix

nr.	name / register	describtion
0	io_out(0)	output open drain
1	io_out(1)	output open drain
2	io_out(2)	output open drain *
3	io_out(3)	output open drain *
4	io_txd	output, when debug='0'
5	rxd_to_uart1	output (uart_in)
6	trigger	output
7	sequenzer_hw_trigger	input to module iomux_sequenzer_0
8	debounce input	input to module iomux_dfilter_0
9	prescale input	input to module iomux_prescaler_0
10	logic inputa	input to module iomux_logic_0
11	logic inputb	input to module iomux_logic_0
12	mft_txd	output
13	pulseloop hw_trigger	input to module iomux_pulseloop_0
14	pulseloop hw_trigger	input to module iomux_pulseloop_1
15	pulseloop hw_trigger	input to module iomux_pulseloop_2
16	pulseloop hw_trigger	input to module iomux_pulseloop_3
17	rxd_to_uart2	output (uart2_in)

* for physical number of open drain outputs refer to pinout or specifications

Example of an IOMUX configuration



> The trigger signal comes in on line 0

> Debounce it.

connect line 0 to 8:
1000000000000000000000000
signal appears again on line 15 – debouncer out

> Use the prescaler to act only on every second pulse.

connect line 16 to 9.
0000000000000000100000000
signal appears again on line 17 – debouncer out

> Configure a strobe illumination with pulseloop module 0

connect line 17 to 13
signal from pulse loop module 0 appears on line 6
connect line 6 to 0 (output 0)

> Set an exposure signal with pulseloop module 1.

connect line 17 to 6

> Tell another component that the camera is exposing the sensor.

connect line 17 to 14
signal from pulse loop module 1 appears on line 7
connect line 7 to 1 (output 1)

> Turn of a light that was ON during the time between two pictures.

connect line 17 to 15
invert signal from pulse loop module 2
it appears on line 20
connect line 20 to 2 (output 2)

Inverter & Set-to-1

Inverter and "set to 1" is part of every input and every output of the modules included in the IOMUX.

Inverter

The inverter enabled at a certain line provides the reverse signal to or from a module.

Set to "1"

With set to "1" enabled in a certain line, this line will provide a high signal no matter what signal was connected to the line before.

Set to "1" – invers

The inverse of a set to "1" line will occour as a low signal, regardle the actual signal that came to the inverter modul.

6.3.2 Strobe Control

Drive LED lights from within your camera. Control them via ethernet.

Figure 2: use the breakout box to simplify your wiring

- SVCam cameras provide a flash controller integrated into the camera, saving money and hassle
- Maximum current of up to 3 Amperes @ 40ms
- High frequency pulse width modulation (PWM) for no flickering
- Less cables
- Setting of pulse and duty cycle is controlled via the SVCam progam or SVCam library
- Only one programming interface for camera and flash
- LED-lights can be controlled over 4 different channels that can be used simultaneously or independent from each other
- According to the I/O specification of your camera two or four channels can be used as open drain. Refer to specifications.

4 IO high voltage drain

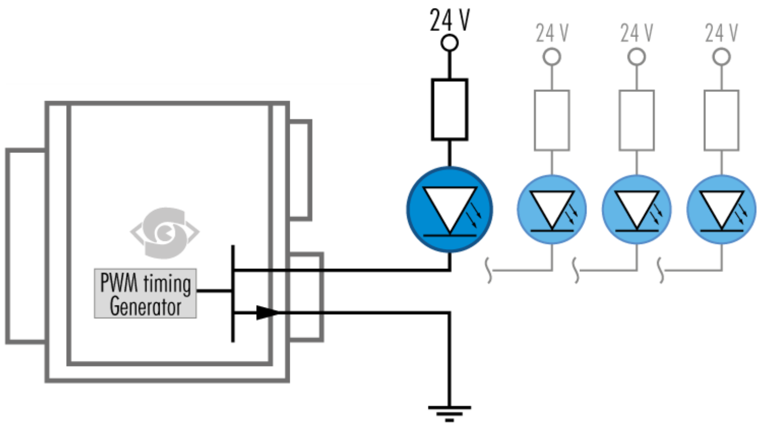


Figure 52: Illustration of four LEDs switched internal by the camera

For detailed connector pin out refer to Connectors.

For further information using the **breakout box** and simplifying OIs refer **SVCam Connectivity** manual. To be found separate within the USP manuals.

USE RIGHT DIMENSION OF RESISTOR!

Protect your display from damage by selecting the appropriate resistor dimension. The PWM output will put full operational voltage to the LED display!

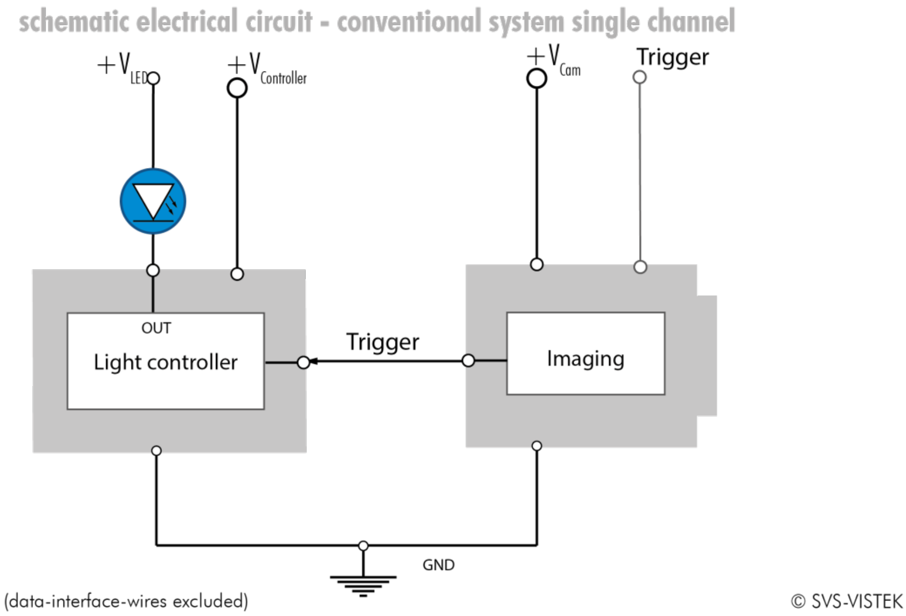


Figure 53: Illustration of conventional schematic electric circuit

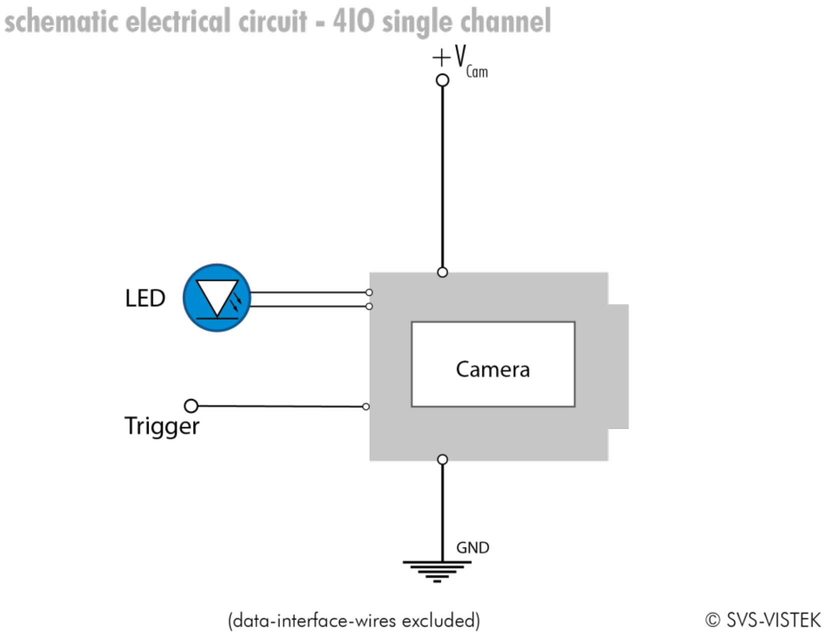


Figure 3: 4IO simplifies light control

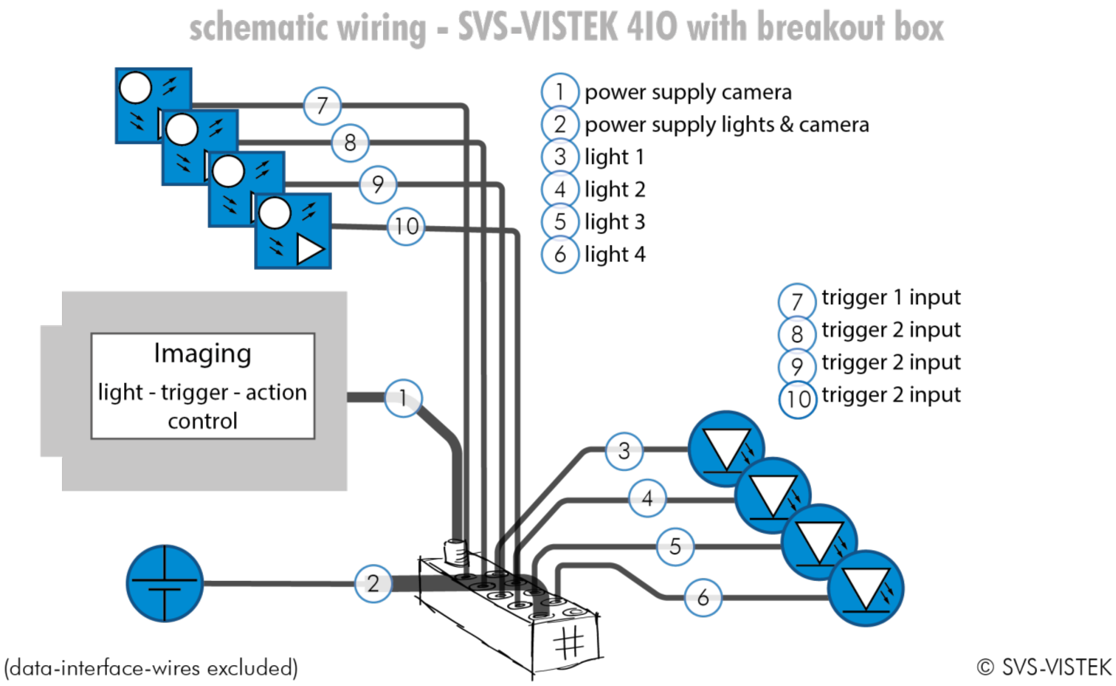


Figure 4: Illustration of schematic wiring with 4IO model using the break out box (matrix)

The pulseloop module

A fully programmable timer/counter function with four individual pulse generators (pulseloop0 - 3) that can be combined with all SVCam I/O functions, as well as physical inputs and outputs. All timing settings are programmable in 15ns intervals.

PROGRAMMABLE PARAMETERS:

> Trigger source (hardware or software)
> Edge or level trigger (HW trigger)
> Pulse output starting on low or high level
> Pre and post duration time
> Number of loops

EXAMPLE APPLICATIONS

Initiated by an external trigger, the camera drives an LED illumination directly from the open drain output and initiates the camera exposure after a pre-defined delay.

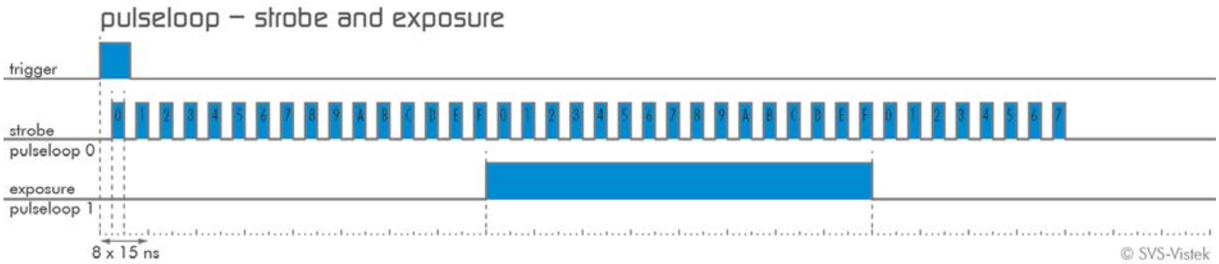


Figure 54: pulseloop for strobe and exposure

CAMERA CASCADE

Three cameras are triggered in cascade where the first camera is the master receiving the external trigger, and the master subsequently triggers the two slave cameras.

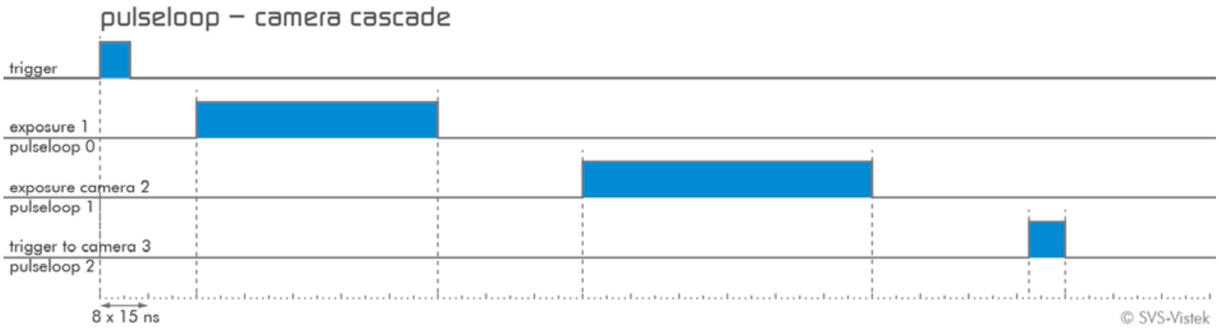
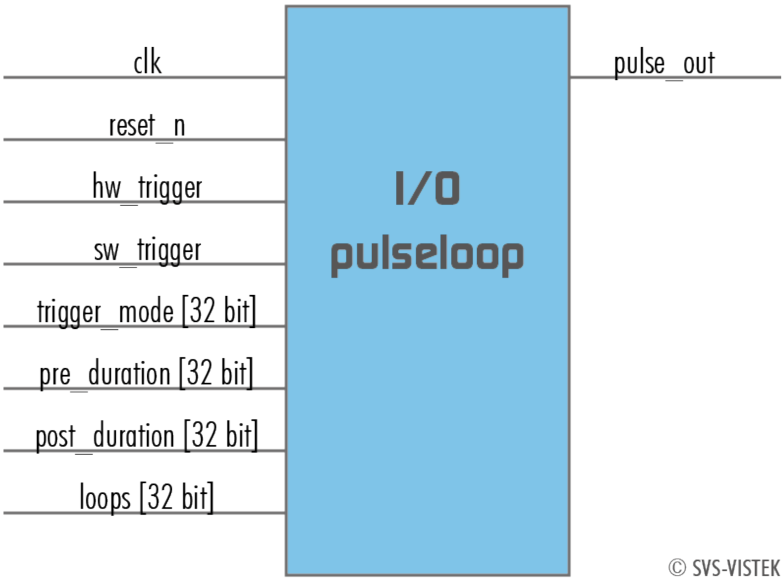


Figure 55: pulseloop – activating three cameras

MODULE PULSELOOP



LEDs in Continuous Mode

Example Calculation "No Flash" (CW Mode)	
Voltage drop al 5 LEDs, 2,2 V 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

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

USE RIGHT DIMENSION OF RESISTOR!

Protect your display from damage by selecting the appropriate resistor dimension. The PWM output will put full operational voltage to the LED display!

LEDs in Flash Mode

Most LEDs can be operated with much higher currents than spec in flash mode. This will result in more light. Plese refer to the specification of your LED panel.

The MOS FETs at "OUT1" and "OUT2" are used like a "switch". By controlling "on time" and "off time" (duty cycle) the intensity of light and current can be controlled.

Current		"time ON" within a 1 Sec		PWM %	
0,75	A	500	ms	50	%
1	A	300	ms	33,3	%
2	A	70	ms	7	%
3	A	40	ms	4	%

Example: If pulse is 1.5 A the max. "on" time is 150 mSec. This means the "off" time is 850 mSec. The sum of "time on" and "time off" is 1000 mSec = 1 Sec.

NOTICE

The shorter the „time on" – the higher current can be used –the longer LEDs will work.

Strobe Timing

6.3.2.1.1 Exposure Delay

A value, representing the time between the (logical) positive edge of trigger pulse and start of integration time. Unit is 1µs. Default is 0µs.

6.3.2.1.2 Strobe Polarity

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

6.3.2.1.3 Strobe Duration

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

6.3.2.1.4 Strobe Delay

The delay between the (logical) positive edge of trigger pulse and strobe pulse output can be set in µsec. Unit is 1µs. Default is 0µs.

Strobe Control Example Setup

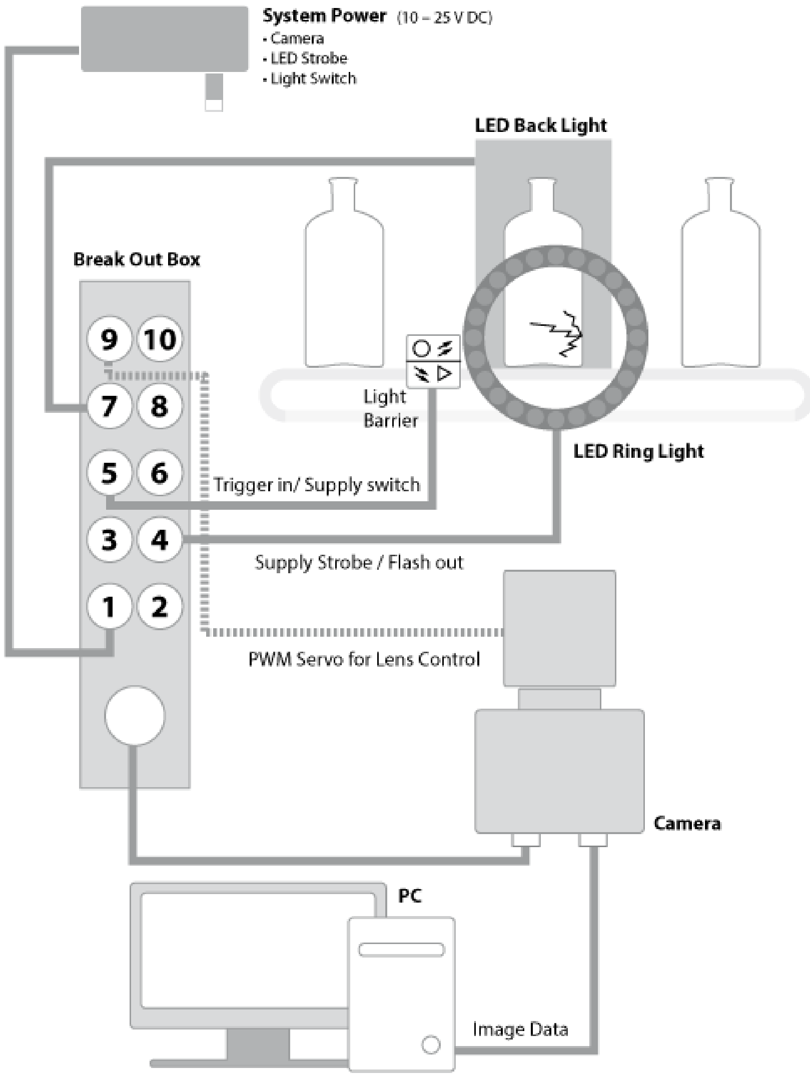


Figure 56: Illustration of an application using the 4IO

6.3.3 Sequencer

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

E.g. the scenario to be captured may occur in three different versions and should therefore be recorded with three different light source settings. Each scenario/interval needs different illumination and exposure time.

The Sequencer allows not only detecting which scenario just appeared. Depending on the scenario there will be one optimal image for further analyzes.

Values to set	Unit	Description
Sequencer Interval	µs	Duration of the Interval
Exposure Start	µs	Exposure delay after Interval start
Exposure Stop	µs	Exposure Stop related to Interval Start
Strobe Start	µs	Strobe delay after Interval start
Strobe Stop	µs	Strobe Stop related to Interval Start
PWM Frequency	T	Basic duty cycle (1 / Hz) for PWM
PWM Line 1	%	Demodulation Result
PWM Line 2	%	Demodulation Result
PWM Line 3	%	Demodulation Result
PWM Line 4	%	Demodulation Result
Values can be set for every scenario/interval		

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

> Trigger Input can be set with the 4IO feature set
> For pysikal trigger input refer to pinout or specifications
> After trigger signal all programmed Interval will start.
> Up to 16 Intervals can be programmed.

Sequencer settings can be saved to EPROM or to desktop

Example:

Values to set	Interval 0	Interval 1	Interval 2
Sequencer Interval	1.000.000 µs (1s)	1.000.000 µs (1s)	1.000.000 µs (1s)
Exposure Start	220.000 µs	875.000 µs	190.000 µs
Exposure Stop	700.000 µs	125.000 µs	720.000 µs
Strobe Start	110.000 µs	125.000 µs	350.000 µs
Strobe Stop	875.000 µs	875.000 µs	875.000 µs
PWM Frequency	4 Hz	4 Hz	4 Hz
PWM Line 0	100	0	80
PWM Line 1	20	50	0
PWM Line 2	0	100	30
PWM Line 3	-	-	-
Trigger set to negative slope	Use higher frequencies		

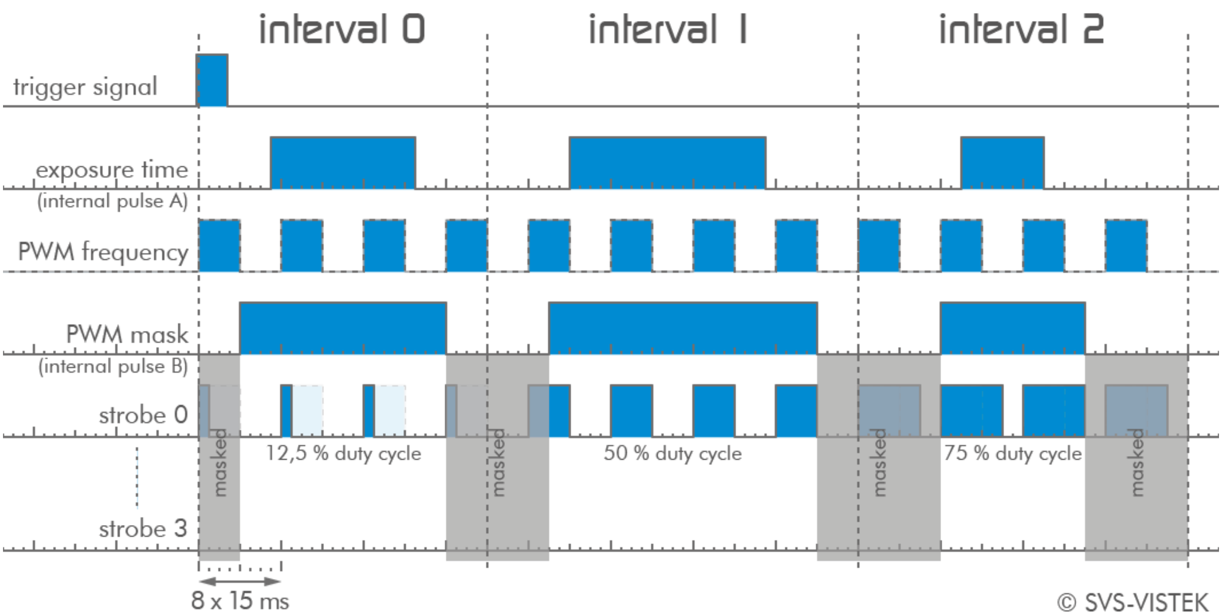


Figure 57: illustration of three sequencer intervals

6.3.4 PWM

Pulse width modulation

Description of the function used within the sequencer or implemented by the pulseloop module

During Pulse Width Modulation, 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?

Many electrical components must be provided with a defined voltage. Whether it's because they do not work otherwise or because they have the best performance at a certain voltage range (such as diodes or LEDs).

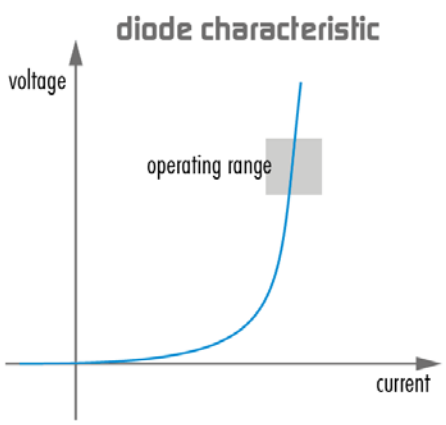
Diode characteristic

Since LEDs have a bounded workspace, the PWM ensures a variable intensity of illumination at a constant voltage on the diodes.

In addition, the lifetime of a diode increases. The internal resistance is ideal in this area. The diode gets time to cool down when operated with a PWM in its workspace.

Implementation of PWM

Modulation frequency:

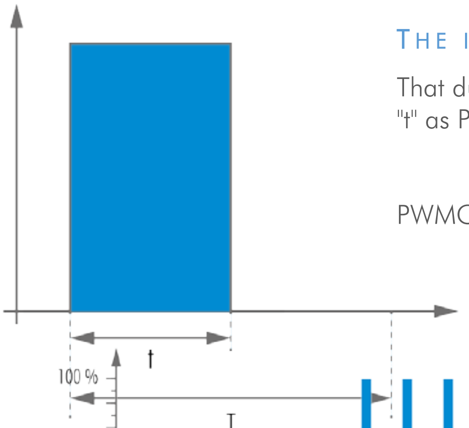


The basic frequency of the modulation is defined by the cycle duration "T".

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

Cycle duration "T" is written into the registry by multiple of the inverse of camera frequency. (15 ns steps) Refer to: Time unit of the camera.

$$T_{PWM} = \frac{1}{66,\bar{6}MHz} \cdot \mathrm{PWMMax[SeqSelector]} = 15\,ns \cdot \mathrm{PWMMax[SeqSelector]}$$



THE INTENSITY OF A PWM:

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

PWMChange0-3[SeqSelector] is to be written as a percentage value.

EXAMPLES OF PWMS:

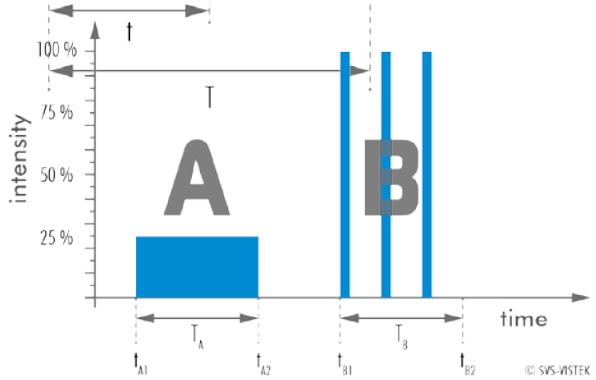


Figure 58: 25 % intensity

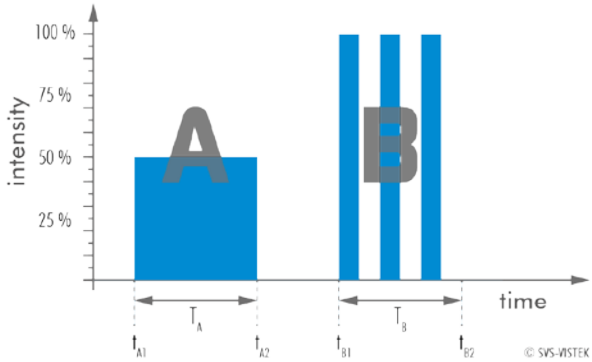


Figure 59: 50 % intensity

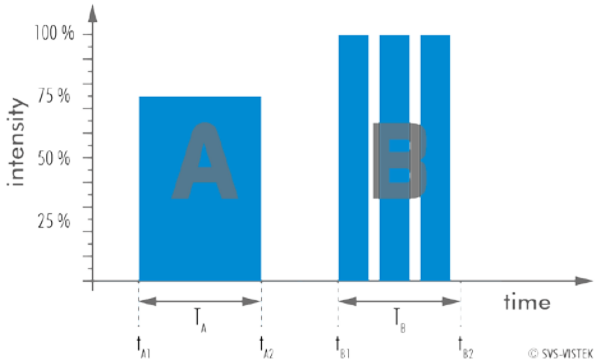


Figure 60: 75 % intensity

The integrals over both periods T_A and T_A are equal.

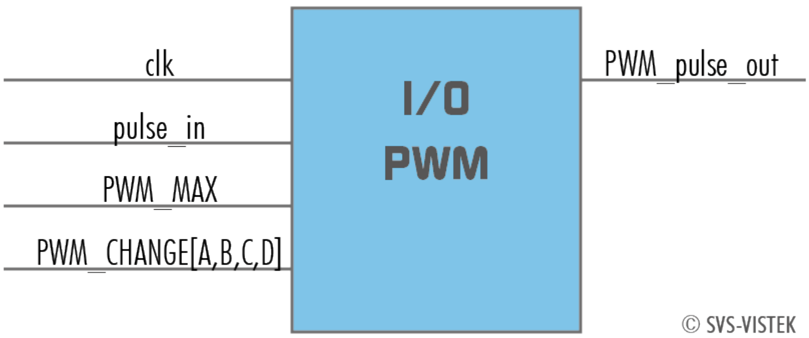
$$\int_{t_{A1}}^{t_{A2}} \mathbf{A} = \int_{t_{B1}}^{t_{B2}} \mathbf{B}$$

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.

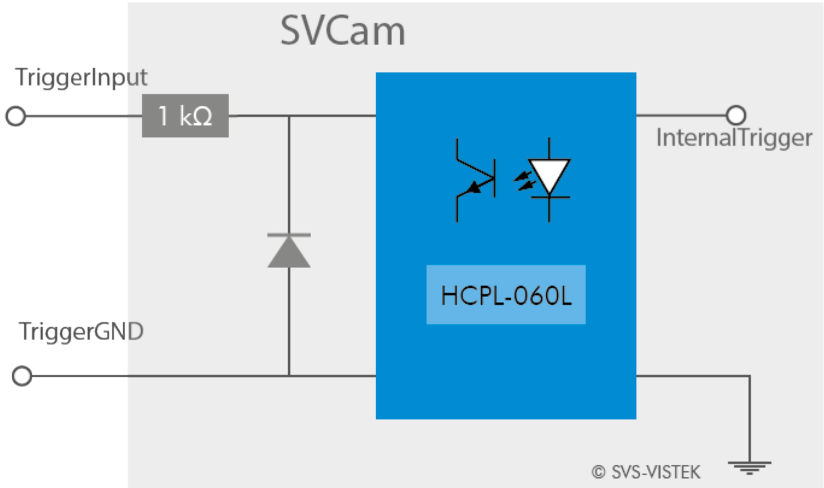
THE PWM MODULE:



6.3.5 Optical Input

An optical input is designed for galvanic separation of camera and triggering device. Noise, transients and voltage spikes might damage your components. Also trigger signal interpretation can be difficult with unclear voltage potentials within a system. The benefit of 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 than a direct electrical connection.

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

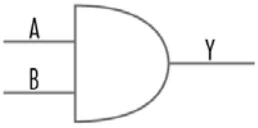


The opto coupler galvanically divides electrical circuits by emitting light on one side and interpreting light in the other. There is no direct electric interaction between both electrical circuits.

Figure 5 Optical input schematics

6.3.6 PLC/Logical Operation on Inputs

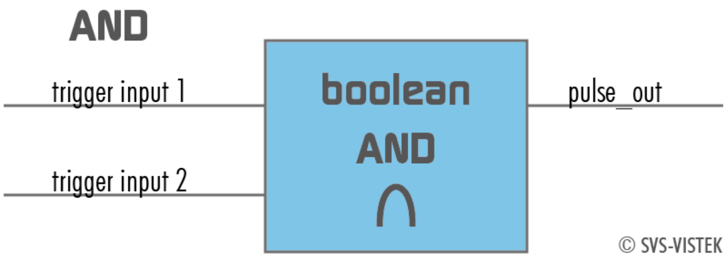
The logic input combines trigger signals with Boolean algorithms. The camera provides AND, NAND, OR, NOR as below. You might connect 2 signals on the logic input. The result can be connected to a camera trigger signal or it may be source for the next logical operation with another input. It is possible to connect it to an OUT line as well.

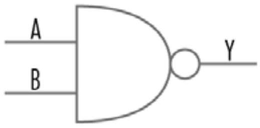


AND

Both trigger inputs have to be true.

A	B	Y = A ∧ B
0	0	0
0	1	0
1	0	0
1	1	1



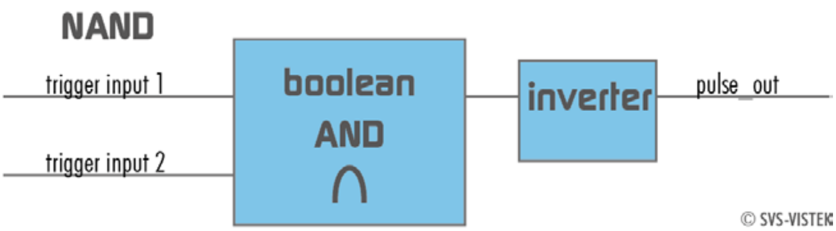


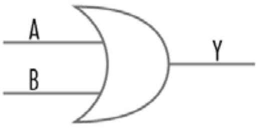
NAND

The NEGATIVE-AND is true only if its inputs are false.

Invert the output of the AND module.

A	B	Y = A NAND B
0	0	1
0	1	1
1	0	1
1	1	0



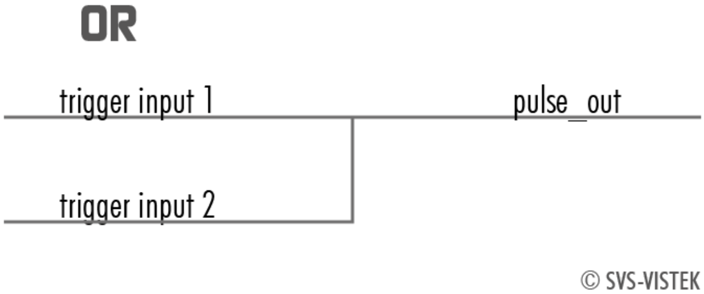


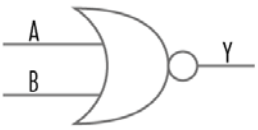
OR

If neither input is high, a low pulse_out (0) results.

Combine trigger input one and two.

A	B	Y = A v B
0	0	0
0	1	1
1	0	1
1	1	1



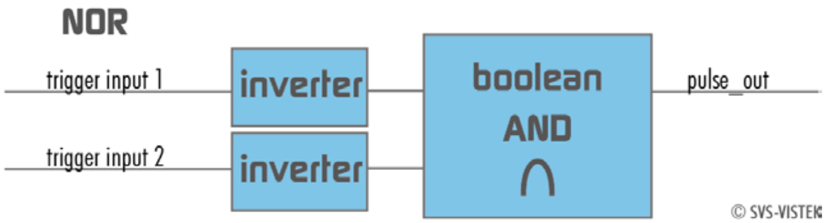


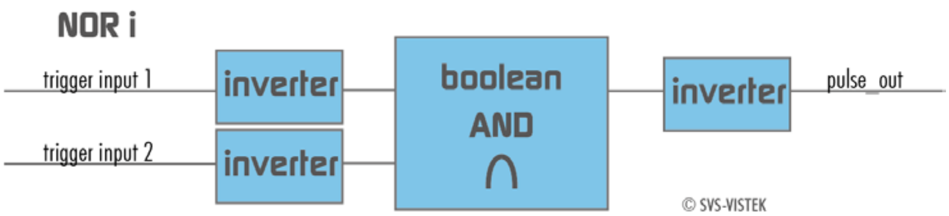
NOR

No trigger input – one nor two – results in a high or a low level pulse_out.

Invert both trigger inputs. By inverting the resulting pulse_out you will get the NOR I pulse

A	B	Y = A ⊽ B	NOR	Y = A v B	NOR i
0	0	1		0	
0	1	0		1	
1	0	0		1	
1	1	0		1	





6.3.7 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.

In the SVCam's these signals are used to send low-power data signals to control light or lenses (MFT).

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 3: serial interface parameter – RS-232 and RS-422

RS-232

It is splitted 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

With restrictions: refer to Table: serial interface parameter above.

Data transportis asynchronous. Synchronization is implemented by fist and last bit of a package. Therefore the last bit can be longer, e.g. 1.5 or 2 times the bit duration). Datarate (bits per second) must be defined before transmission.

UART

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

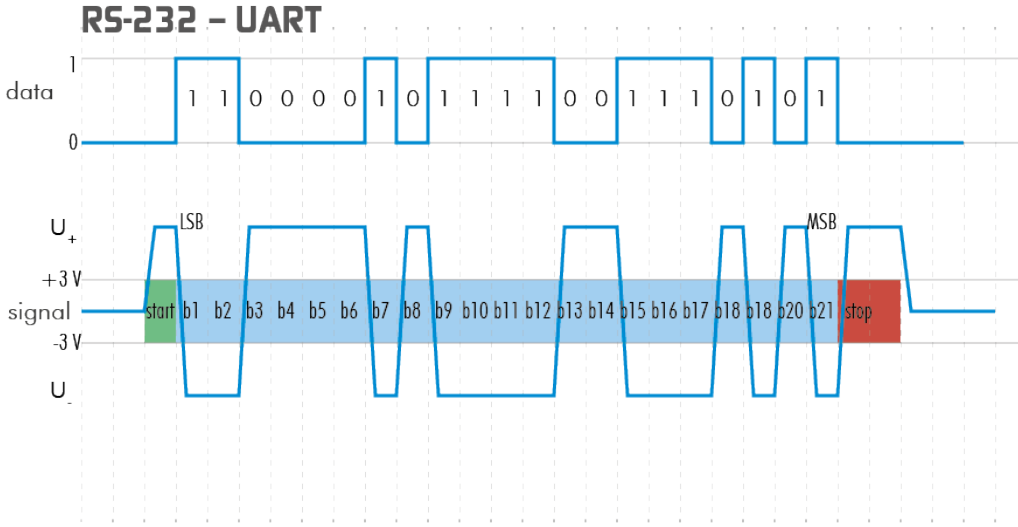


Figure 61: UART encoding of a data stream

RS-422

RS-422 is a differential low voltage communication standard.

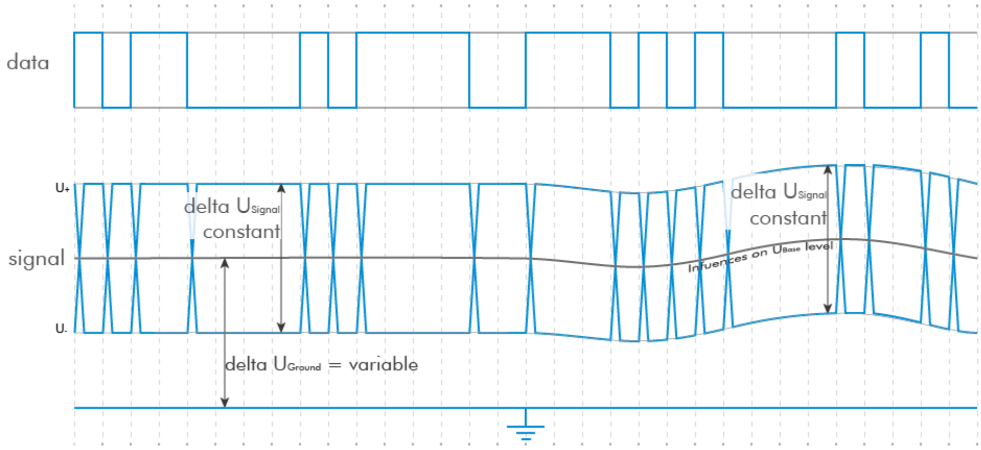


Figure 62: LVDS signal – no return to zero volt

Refer to specifications to see if RS-422 is implemented in your camera.

6.3.8 Trigger-Edge Sensitivity

Trigger-Edge Sensitivity is implemented by a "schmitt trigger". Instead of triggering to a certain value Schmitt trigger provides a threshold.

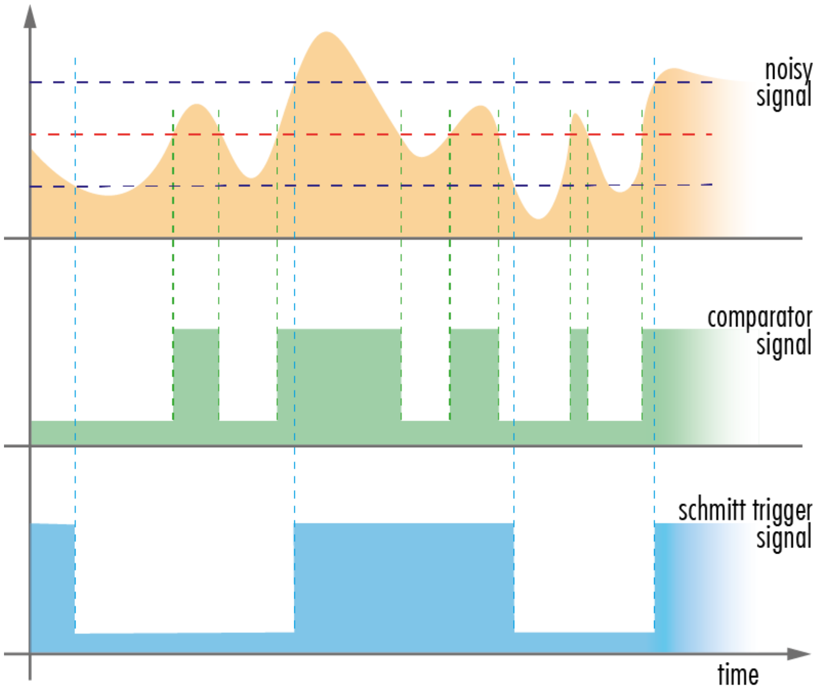


Figure 63:illlustration of schmitt trigger noise suspension - high to low I low to high

6.3.9 Debouncing Trigger Signals

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

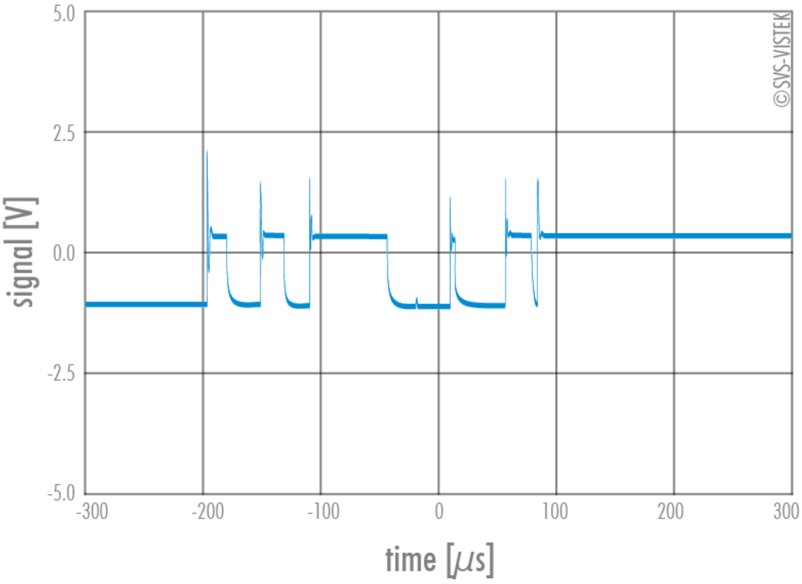


Figure 64: bounces or glitches caused by a switch during 300 µs

Therefor the signal will not be accepted till it lasts at least a certain time.

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).

DebouncDuration register can be set in multiples of 15ns (implement of system clock). E.g. 66 666 ≈ 1 ms

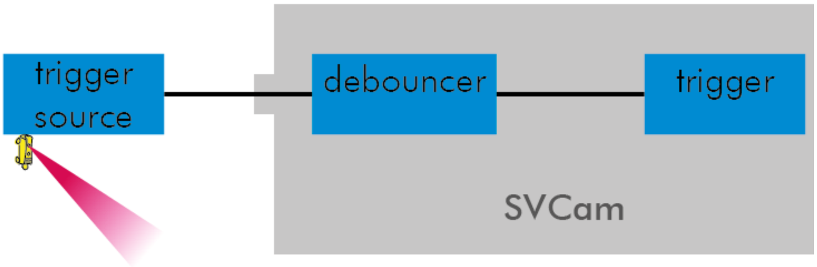


Figure 65: block diagram – debouncer in between the trigger source and the trigger

The Debouncer module

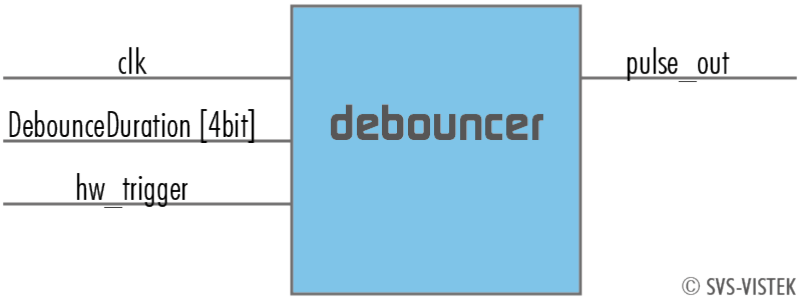


Figure 66: Illustration of the debouncer module

6.3.10 Prescale

The Prescaler 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 prescaler 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)

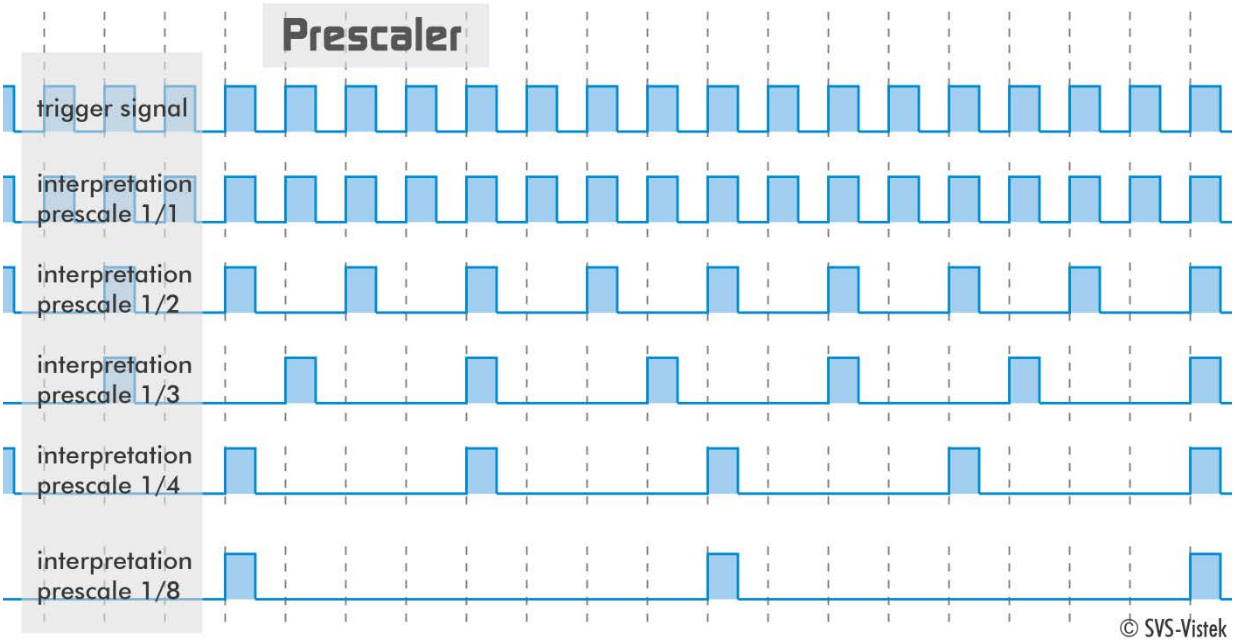


Figure 67: illustration of prescale values

The prescale module

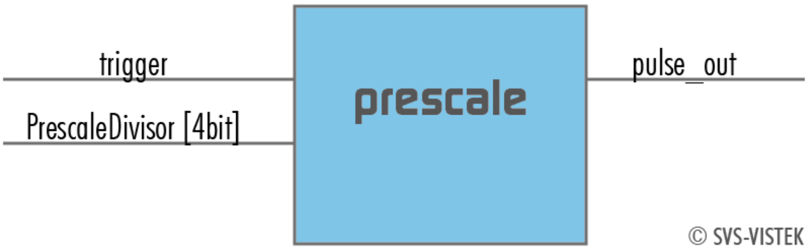


Figure 68: Illustration of the prescale module

7 Specifications

All specifications can be viewed as well on our website, www.svs-vistek.com We are proud to have ongoing development on our cameras, so specs might change and new features being added.

7.1 shr47051*CL

Model	shr47051MCL	shr47051CCL
familiy	HR	HR
active pixel w x h	8856 x 5280	8856 x 5280
max. frame rate	7 fps	7 fps
chroma	mono	color
interface	Camera Link Medium	Camera Link Medium

sensor name	KAI-47051-A	KAI-47051-F
sensor manufacturer	ON Semiconductor	ON Semiconductor
sensor architecture	Area CCD	Area CCD
shutter type	global	global
equivalent format	Medium Format	Medium Format
diagonal	56,7 mm	56,7 mm
pixel w x h	5,5x5,5 µm	5,5x5,5 µm
optic sensor w x h	48,7x29 mm	48,7x29 mm
exposure time	28 µs / 1s	28 µs / 1s
max. gain	18 dB	18 dB
dynamic range	62 dB	62 dB
S/N Ratio	42.6	42.6

frame buffer	256 MB	256 MB
CL_geometry	1x2-1y;1x2-2ye	1x2-1y;1x2-2ye
frequency select	-	-
camera pixel clock	40 MHz	40 MHz
exp. time adjustment	manual;auto;external	manual;auto;external
px format 8 / 12 / 16	x / x / -	x / x / -
packed readout	-	-
max binning h / v	2 / 2	2 / 2
LUT	12to12(1)	12to12(1)
ROI	-	-
white balancing	-	-
tap balancing	-	-
gain	auto;manual	auto;manual
black level	manual	manual
PIV mode	-	-
readout control	-	-
flat field correction	x	x
shading correction	external	external
defect pixel correction	true	true
image flip	horizontal;vertical	horizontal;vertical

trigger intern / extern / soft	x / x / x	x / x / x
trigger edge high / low	x / x	x / x
sequencer	x	x
PWM power out	x	x
trigger IN TTL-24 V	2	2
outputs open drain	4	4
optical in / out	1 / -	1 / -
RS-232 in / out	1 / 1	1 / 1
RS-422 in / out	- / -	- / -
power supply	10...25 V	10...25 V

lens mount	M72x0.75	M72x0.75
dynamic lens control	-	-
size w / h / d (1)	80x80x69,1 mm	80x80x69,1 mm
weight	560 g	560 g
protection class	IP30	IP30
power consumption	15,0 W	15,0 W
ambient temperature	-10...45°C	-10...45°C
rel. humidity non-condensing	0…0 %	0…0 %
status	production	production

(1) please refer to model drawings

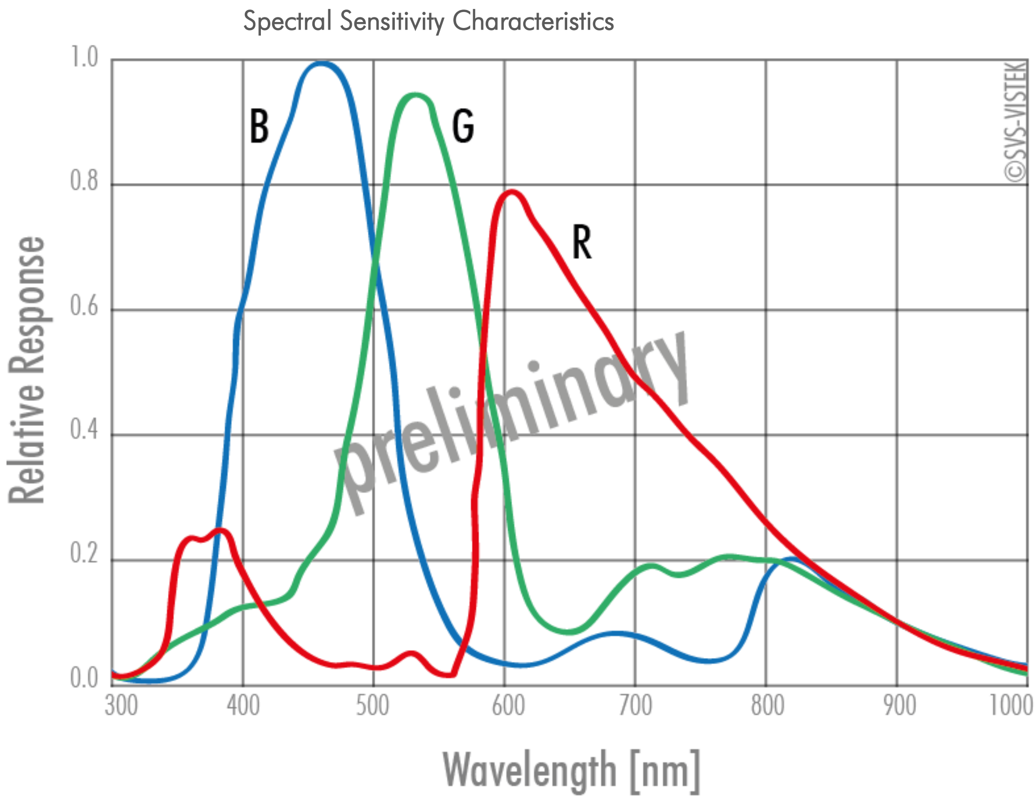


Figure 6: Spectral Sensitivity Characteristics KAI-47051-F

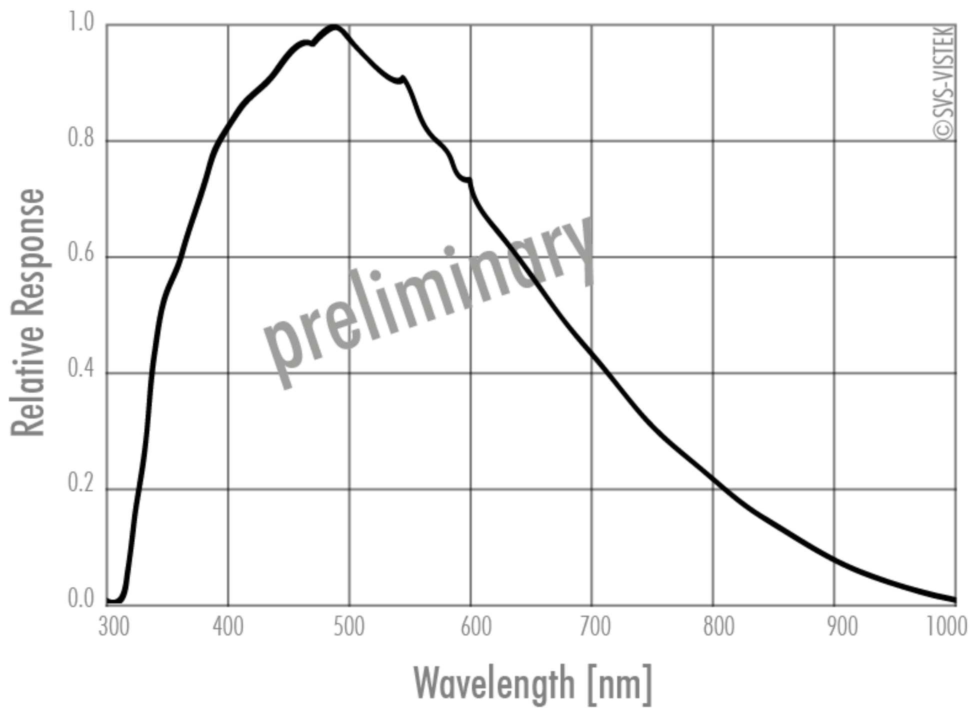


Figure 7: Spectral Sensitivity Characteristics KAI-47051-A

8 Terms of warranty

Standard Products Warranty and Adjustment	Seller warrants that the article to be delivered under this order will be free from defects in material and workmanship under normal use and service for a period of 2 years from date of shipment. The liability of Seller under this warranty is limited solely to replacing or repairing or issuing credit (at the discretion of Seller) for such products that become defective during the warranty period. In order to permit Seller to properly administer this warranty, Buyer shall notify Seller promptly in writing of any claims,; provide Seller with an opportunity to inspect and test the products claimed to be detective. Such inspection may be on customer's premises or Seller may request return of such products at customer's expense. Such expense will subsequently be reimbursed to customer if the product is found to be defective and Buyer shall not return any product without prior return authorization from Seller. If a returned product is found to be out of warranty or found to be within the applicable specification, Buyer will have to pay an evaluation and handling charge, independent of possible repair and/or replacement costs. Seller will notify Buyer of the amount of said evaluation and handling charges at the time the return authorization is issued. Seller will inform Buyer of related repair and/or replacement costs and request authorization before incurring such costs. Buyer shall identify all returned material with Sellers invoice number, under which material has been received. If more than one invoice applies, material has to be clearly segregated and identified by applicable invoice numbers. Adjustment is contingent upon Sellers examination of product, disclosing that apparent defects have not been caused by misuse, abuse, improper installation of application, repair, alteration, accident or negligence in use, storage, transportation or handling. In no event shall Seller be liable to Buyer for loss of profits, loss of use, or damages of any kind based upon a claim for breach of warranty.
Development Product Warranty	Developmental products of Seller are warranted to be free from defects in materials and workmanship and to meet the applicable preliminary specification only at the time of receipt by Buyer and for no longer period of time in all other respects the warranties made above apply to development products. The aforementioned provisions do not extend the original warranty period of any article which has been repaired or replaced by Seller.
Do not break Warranty Label	If warranty label of camera is broken warranty is void. Seller makes no other warranties express or implied, and specifically, seller makes no warranty of merchantability of fitness for particular purpose.
What to do in case of Malfunction	Please contact your local distributor first.

9 Troubleshooting

9.1 FAQ

Problem	Solution
Camera does not respond to light.	Check if camera is set to "Mode 0". I.e. free running with programmed exposure ctrl. When done, check with the program "Convenient Cam" if you can read back any data from the camera, such as "Mode", "type" of CCD, exposure time settings, etc.. If "Mode 0" works properly, check the signals of the camera in the desired operation mode like "Mode 1" or "Mode 2". In these modes, check if the ExSync signal is present. Please note that a TTL signal must be fed to the trigger connector if it is not provided by the frame grabber (LVDS type). The typical signal swing must be around 5 V. Lower levels will not be detected by the camera... If you use a TTL level signal fed to the "TB 5 connector" check the quality and swing. If these signals are not present or don't have the proper quality, the camera cannot read out any frame (Mode 1 and 2). Beware of spikes on the signal.
Image is present but distorted.	Check the camera configuration file of your frame grabber. Check number of "front- and back porch" pixel. Wrong numbers in configuration file can cause sync problems. Check if your frame grabber can work with the data rate of the camera.
Image of a color version camera looks strange or false colors appear.	If the raw image looks OK, check the camera file to see if the pixels need to be shifted by either one pixel or one line. The image depends on the algorithm used. If the algorithm is starting with the wrong pixel such effects appear.
Colors rendition of a color versions not as expected – especially when using halogen light.	Halogen light contains strong portions of IR radiation. Use cut-off filters at around 730 nm like "Schott KG 3" to prevent IR radiation reaching the CCD.
No serial communication is possible between the camera and the PC.	Use "load camera DLL" and try again.

9.2 Camera Specific

Problem	Solution
Operating in CameraLink Medium, lower half of image is black	After *Load Default User Sets*, the camera will be set to 8 tap mode (2X_1Y). ➔ Set the camera to your required tap mode (2T8 tap geo 2X2YE in CL Base, 4T8 or 4T12 geo 2X_2YE in CL Medium)

Please fax this form to your local distributor. The right Fax number you can find on our homepage: http://www.svs-vistek.com

SENDER:

FIRM:

TEL:

MAIL:

9.3 Support Request Form / Check List

Dear valued customer,

In order to help you with your camera and any interfacing problems we request that you fill in a description of your problems when you use the camera. Please fax or email this form to the dealer/distributor from which you purchased the product.

	Operating System (E.g. Win 7, XP):
Which Camera are you using?	Type (e.g.: svs3625MTHCPC):
	Serial Number:
Which Accessories are you using?	Power Supply:
	Cable:
	Lens Type and Focal Length:
Firmware	No. of Version:
	Operation Mode:
	Please send a screenshot of “ConvCam” screen or log file.
In case of EURESYS Grabber:	Brand and Type:
	Driver Version:
	If Patch please specify:
	Camera file used:
Short Description of Problem	(E.g. missing lines, noisy image, missing bits etc.):

Space for further descriptions, screenshots and log-files

10 IP protection classes

There is a classification system regarding the kind of environment influences which might do harm to your product. These are called IP Protection Classes and consist of the letters „IP" followed by two numbers.

First Digit	Second Digit	Brief description	Definition
0		Not protected	-
1		Protected against solid foreign objects,	A probing object, a ball of 50mm in diameter, must not enter or penetrate the enclosure
		50 mm and larger	
2		Protected against solid foreign objects, 12.5 mm and larger	A probing object, a ball of 12.5mm in diameter, must not enter or penetrate the enclosure
3		Protected against solid foreign objects,	A probing object, a ball of 2.5mm in diameter, must not penetrate at all
		2.5 mm and larger	
4		Protected against solid foreign objects,	A probing object, a ball of 1mm in diameter, must not penetrate at all
		1.0 mm and larger	
5		Protected against dust	The ingress of dust is not completly prevented. The quantity of dust that enters not impair the safety or satisfactory operation of the equipment
6		Dustproof	No ingress of dust
	0	Not protected against liquids	-
	1	Protected against water droplets	Vertically falling droplets must not have any harmful effect when the enclosure is at an angle of 15° either side of the vertical
	2	Protected against water droplets	Droplets falling vertically must not have any harmful effect with enclosure at an angle of 15° either side of the vertical
	3	Protected against spray water	Water sprayed at any angle of up to 60° either side of the vertical must not have any harmful effect
	4	Protected against water splashes	Water splashing against the enclosure from any angle must not have any harmful effect
	5	Protected against water jets	Water jets directed at the enclosure from any angle must not have any harmful effect
	6	Protected against powerful water jets	Powerful water jets directed against the enclosure from any angle must not have any harmful effect
	7	Protected against the effect of brief submersion in water	Water must not enter the equipment in amounts that can have a harmful effect if the enclosure is briefly submerged in water under standardised pressure and time conditions
	8	Protected against the effect of continuous submersion in water	Water must not enter the equipment in amounts that can have a harmful effect if the enclosure is continuously submerged in water.
			The conditions must be agreed between the manufacturer and the user. The conditions must, however, be more severe than code 7
	9K	Protected against water from high- pressure and steam jet cleaning	Water directed at the enclosure from any angle under high pressure must not have any harmful effect

11 Glossary of Terms

Aberration
Spherical aberration occurs when light rays enter near the edge of the lens; Chromatic aberration is caused by different refractive indexes of different wavelengths of the light. (Blue is more refractive than red)

ADC
Analogue-to-Digital Converter, also known as A/D converter

Aperture
In optics, Aperture defines a hole or an opening through which light travels. In optical system the Aperture determines the cone angle of a bundle of rays that come to a focus in the image plane. The Aperture can be limited by an iris, but it is not solely reliant on the iris. The diameter of the lens has a larger influence on the capability of the optical system.

Bayer Pattern
A Bayer filter mosaic or pattern is a color filter array (CFA) deposited onto the surface of a CCD or CMOS sensor for capturing RGB color images. The filter mosaic has a defied sequence of red, green and blue pixels such that the captured image can be transported as a monochrome image to the host (using less bandwidth); where after the RGB information is recombined in a computer algorithm.

Binning
Binning combines the charge from two (or more) pixels to achieve higher dynamics while sacrifying resolution.

Bit-Depth
Bit-depth is the number of digital bits available at the output of the Analog-to-Digital Converter (ADC) indicating the distribution of the darkest to the brightest value of a single pixel.

Camera Link
Camera Link is a multiple-pair serial communication protocol standard [1] designed for computer vision applications based on the National Semiconductor interface Channel-link. It was designed for the purpose of standardizing scientific and industrial video products including cameras, cables and frame grabbers.

CCD
Charge Coupled Device. Commonly used technology used for camera sensors used to detect & quantify light, i.e. for capturing images in an electronic manner. CCDs were first introduced in the early 70ies.

CMOS
Complementary Metal–Oxide–Semiconductor. A more recently adopted technology used for camera sensors with in-pixel amplifiers used to detect & quantify light, i.e. capturing images in an electronic manner.

CPU
Central Processing Unit of a computer. Also referred to as the processor chip.

dB
Decibel (dB) is a logarithmic unit used to express the ratio between two values of a physical quantity.

Decimation
For reducing width or height of an image, decimation can be used (CMOS sensors only). Columns or rows can be ignored. Image readout time is thereby reduced.

Defect map
Identifies the location of defect pixels unique for every sensor. A factory generated defect map is delivered and implemented with each camera.

EPROM
Erasable Programmable Read Only Memory is a type of memory chip that retains its data when its power supply is switched off.

External Trigger
Erasable Programmable Read Only Memory is a type of memory chip that retains its data when its power supply is switched off.

fixed frequency
or programmed exposure time. Frames are read out continuously.

Gain
In electronics, gain is a measure of the ability of a two-port circuit (often an amplifier) to increase the power or amplitude of a signal from the input to the output port by adding energy to the signal.

Gamma	Gamma correction is a nonlinear operation used to code and decode luminance values in video or still image systems.
GenICam	Provides a generic programming interface for all kinds of cameras and devices. Regardless what interface technology is used (GigE Vision, USB3 Vision, CoaXPress, Camera Link, etc.) or which features are implemented, the application programming interface (API) will always be the same.
GigE Vision	GigE Vision is an interface standard introduced in 2006 for high-performance industrial cameras. It provides a framework for transmitting high-speed video and related control data over Gigabit Ethernet networks.
GPU	Graphics Processing Unit of a computer.
Hirose	Cable connectors commonly used for power, triggers, I/Os and strobe lights
ISO	see Gain.
Jumbo Frames	In computer networking, jumbo frames are Ethernet frames with more than 1500 bytes of payload. Conventionally, jumbo frames can carry up to 9000 bytes of payload. Some Gigabit Ethernet switches and Gigabit Ethernet network interface cards do not support jumbo frames.
Mount	Mechanical interface/connection for attaching lenses to the camera.
Multicast	Multicast (one-to-many or many-to-many distribution) is an ethernet group communication where information is addressed to a group of destination computers simultaneously. Multicast should not be confused with physical layer point-to-multipoint communication.
PWM	Pulse width modulation. Keeping voltage at the same level while limiting current flow by switching on an off at a very high frequency.
Partial Scan	A method for reading out fewer lines from the sensor, but “skipping” lines above and below the desired area. Typically applied to CCD sensors. In most CMOS image sensors an AOI (area of interest) or ROI (region of interest) can be defined by selecting the area to be read. This leads to increased frame rate.
Pixel clock	The base clock (beat) that operates the sensor chip is. It is typically also the clock with which pixels are presented at the output node of the image sensor.
RAW	A camera RAW image file contains minimally processed data from the image sensor. It is referred as raw in its meaning. SVS-VISTEK plays out RAW only.
Read-Out-Control	Read-Out control defines a delay between exposure and image readout. It allows the user to program a delay value (time) for the readout from the sensor. It is useful for preventing CPU overload when handling very large images or managing several cameras on a limited Ethernet connection.
Shading	Shading manifests itself a decreasing brightness towards the edges of the image or a brightness variation from one side of the image to the other. 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	An in-camera algorithm for real time correction of shading. It typically permits user configuration. By pointing at a known uniform evenly illuminated surface it allows the microprocessor in the camera to create a correction definition, subsequently applied to the image during readout.
Shutter	Shutter is a device or technique that allows light to pass for a determined period of time, exposing photographic film or a light-sensitive electronic sensor to light in order to capture a permanent image of a scene.

Strobe light	A bright light source with a very short light pulse. Ideal for use with industrial cameras, e.g. for "freezing" the image capture of fast moving objects. Can often be a substitute for the electronic shutter of the image sensor. Certain industrial cameras have dedicated in-camera output drivers for precisely controlling one or more strobe lights.
Tap	CCD sensors can occur divided into two, four or more regions to double/quadruple the read out time.
TCP/IP	TCP/IP provides end-to-end connectivity specifying how data should be packetized, addressed, transmitted, routed and received at the destination.
USB3 Vision	The USB3 Vision interface is based on the standard USB 3.0 interface and uses USB 3.0 ports. Components from different manufacturers will easily communicate with each other.
Trigger modes	Cameras for industrial use usually provide a set of different trigger modes with which they can be operated. The most common trigger modes are: (1) Programmable shutter trigger mode. Each image is captured with a pre-defined shutter time; (2) Pulse-Width Control trigger. The image capture is initiated by the leading edge of the trigger pulse and the shutter time is governed by the width of the pulse; (3) Internal trigger or Free-Running mode. The camera captures images at the fastest possible frame rate permitted by the readout time.
XML Files	Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format which is both human-readable and machine-readable

12 Index of figures

13 Index