GiGE™
VISION

Manual HR series

hr11002*GE, hr16000*GE, hr16050*GE, hr16071*GE, hr29050*GE

Distributor Information

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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 Pyramid Imaging.

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: January 19, 2018, 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.

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

2014/30/EU   Electromagnetic compatibility (EMC)
2011/65/EU   Restriction of the use of certain hazardous substances
                in electrical and electronic equipment (RoHS)

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.

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

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

It is necessary to use a shielded power supply cable. You can then use the "shield contact" on the connector which has GND contact to the 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.

3 The HR-Series – GigE Vision

3.1 Details matter

The SVCam-HR series with its 11 to 29 megapixels resolution is ideal for truly demanding industrial image processing applications, offering among the highest possible resolution combined with maximum speed performance.

The SVCam-HR series meets exclusive demands to resolution at very high speed.

Cameras of the SVCam-HR series deliver the highest possible resolutions in the field of industrial image processing and thus offer maximum performance for demanding applications. The high resolution allows to easily and quickly capture a wide field of view, which makes the camera ideal for applications such as optical metrology, quality control, monitoring of large areas or traffic monitoring.

One of the most compact camera modules of its class

Thanks to the sophisticated electro-mechanical design and the use of ON Semi Dual- and Quad-Tap sensors, cameras from the SVCam-HR series provide the best image quality at high frame rates and at the same time exceptionally low noise. The extensive know-how with the timing and the analog signals of the CCD sensor is a particular topic at SVS VISTEK and leads to maximum quality of your application solution. We thus provide the best tool for your image processing task.

The SVCam-HR camera series also offer a variety of different operating modes, allowing to quickly integrate our product in your software and hardware environments.

In its category, the HR series is one of the most compact camera modules of the entire world market. Thanks to the sophisticated heat management it needs no external cooling and can be used in a wide temperature range.

The interface to the lenses was designed so that almost all lenses can be connected using an appropriate adapter and can thus be tailored to your imaging task. Here, we can support you with our expertise.

The HR series is a sound investment to reach your cost and quality targets in sensitive tasks in the inspection of high quality products.

3.2 GigE-Vision features

GigE Vision is an industrial interface standard for video transmission and device control over Ethernet networks. It provides numerous software and hardware advantages for machine vision. Being an industry standard, it facilitates easy and quick interchangeability between units, shortening design cycles and reducing development costs.
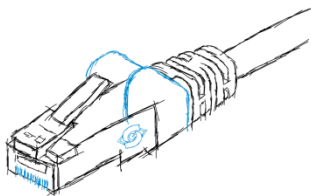
> Cost effective
> Wide range of „off the shelf" industrial-standard plugs and cables
> High bandwidth data transfer rate (120 MB/sec per output)
> Up to 100 m range without additional switch
> Wide range of applications in image processing
> Remote service capability
> GenICam compliant
> SDK for Windows XP/10 (32/64 bit) and Linux

In case your camera features a Dual GigE connector, the bandwidth and data transfer rate are close to double this value. Not every operating system is supporting link aggregation, though.

3.3 4IO adds Light and Functionality
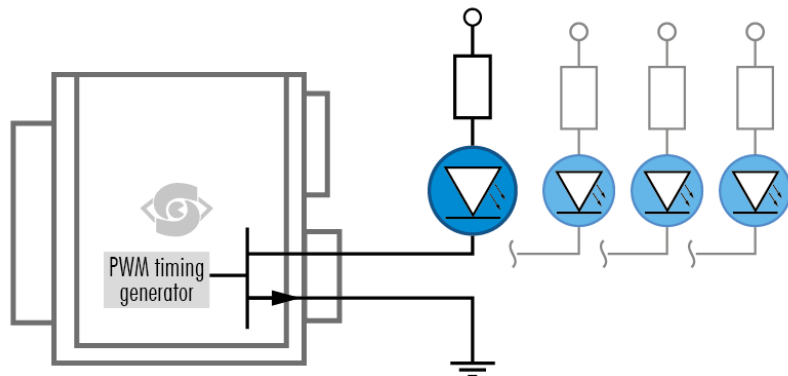
Your SVS-Vistek camera is equipped with the innovative 4IO-interface
Figure 2: 4IO concept with up to 4 switching LED lights

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)

4 Getting Started

4.1 Contents of Camera Set

> Camera
> Power supply (if ordered/option)
> DVD
> **3D CAD files**
> Manuals
> Software: GigE-Kit (Win 32/64 & Linux)

4.2 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.

4.3 Camera status LED codes

On power up, the camera will indicate its current operation 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 slow (1Hz)	No Connection
Yellow quickly (8 Hz)	Assignment of Network address
Yellow permanent	Network address assigned
Green permanent	Connected with application
Green slow (1Hz)	Streaming channel available
Green quickly (8 Hz)	Acquisition enabled
Red slow (1 Hz)	Problem with initialization
Red quickly (8 Hz)	Camera overheating
Blue permanent	Waiting for trigger
Cyan permanent	Exposure active
Violet permanent	Readout/FVAL

Figure 3: **Camera status LED codes**

4.4 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.

4.4.1 SVCapture 2.x

Your SVCam combined software installer including:

> SVCapture 2.x
> (a viewer/controler program for SVCam USB3 cameras)
> PC USB3 driver & filter driver
> TL_Driver
> (GenICam drivers and transport layer DDLs)

SVCapture 2.x is a XML based software tool provided for free. It is created to show the capabilities of your SVS-Vistek camera and to show/modify values to your cam.

Get control of exposure timing, trigger delay, image correction etc. or control up to 4 LED lights connected to the SVCam directly via the PC. Use the built-in sequencer to program several intervals executed by one single trigger impulse.
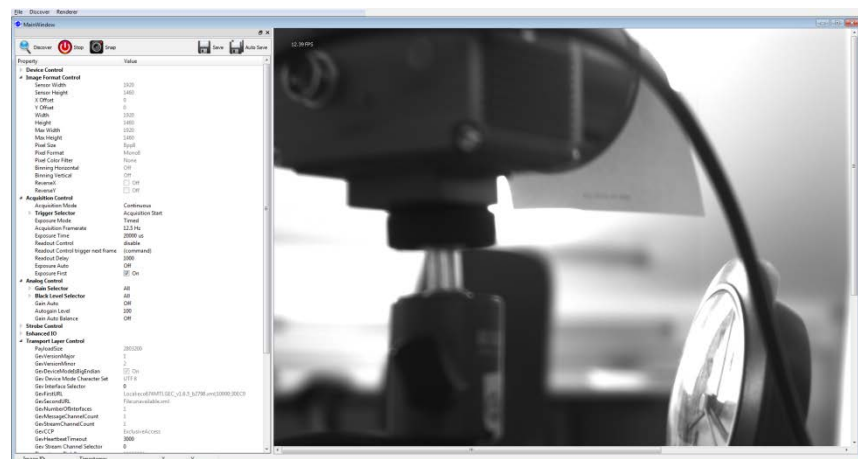
Figure 4: Screenshot of SVCapture 2.x

Software Setup

Installation prosecco may differ from PC to PC. It is recommended to install the whole software package.

1. Copy/expand the installation executable file to your hard drive.

2. Run installation
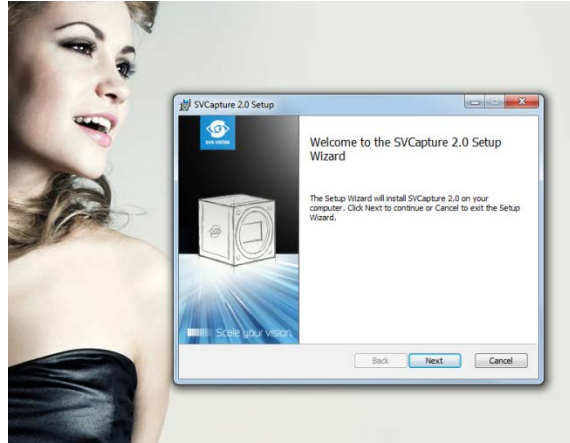
3. Read and accept the terms of license agreement
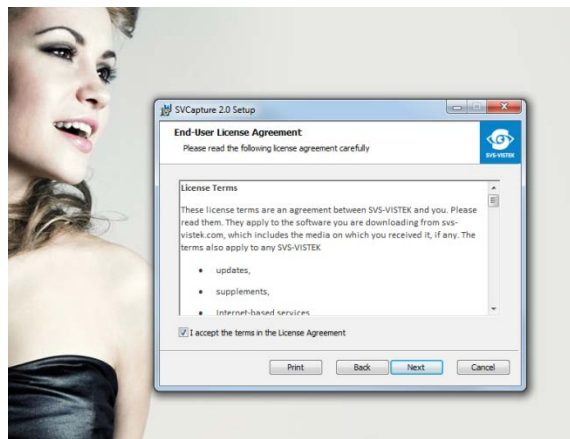
4. Choose destination folder
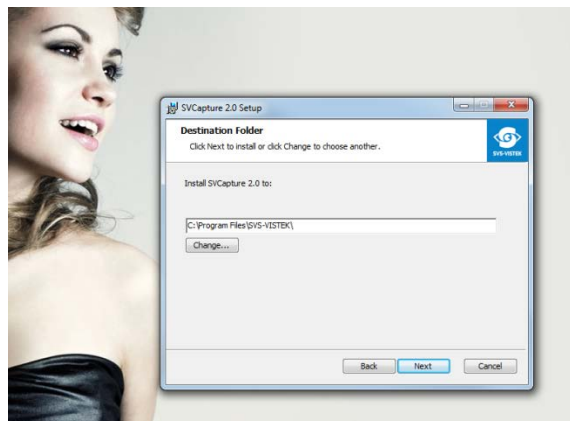
5. Install the USB 3.0 Driver

   Generic driver included in the windows system will not
   match all SVS-VISTEK USB3 Vision features.
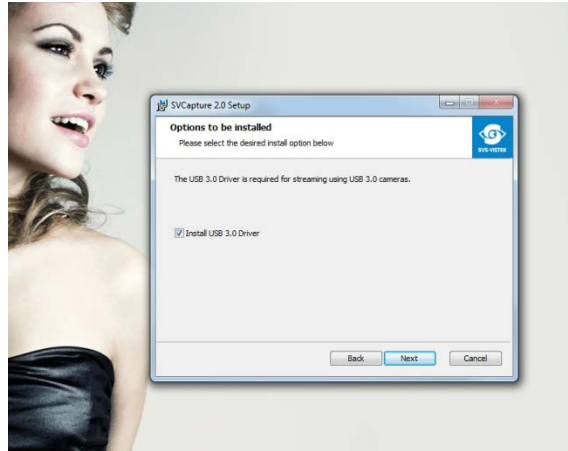
6. Start installation
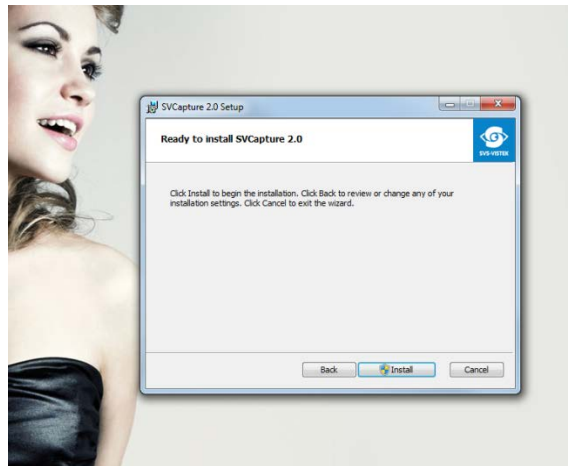
7. System, warning

   The installer will modify your system (USB 3.0 driver);
   there for windows systems will warn you with an
   interrupt.

   Accept system modification

Installation will proceed
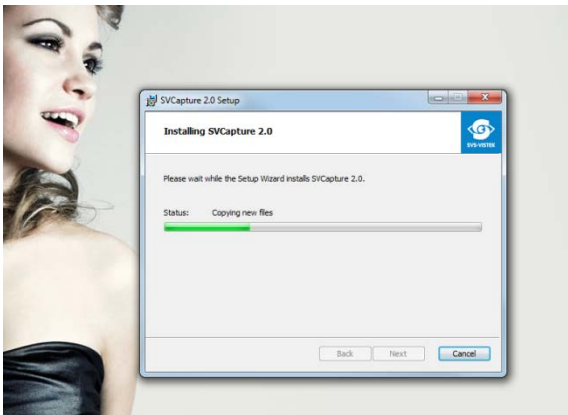
8. Installation completed
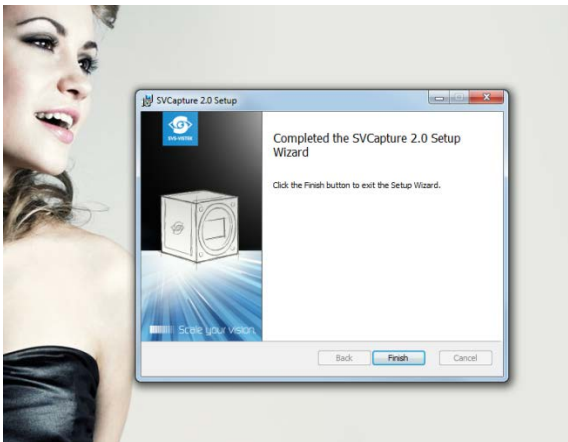
Initialization

FIRST LAUNCH

The software is XML based. So in case there is no Camera connected to the USB slot, no XML camera properties can be loaded, no values to control are available.

The screen will be empty.
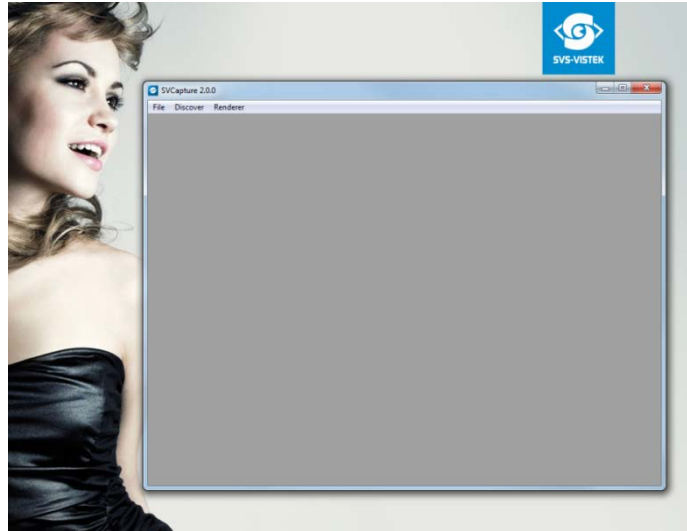
Connect the camera to your USB 3.0 slot.

Hardware installation will pop up.
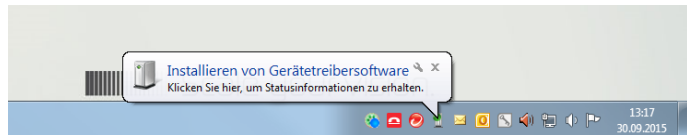
Discover the camera with SVCapture 2.x by clicking "discover".
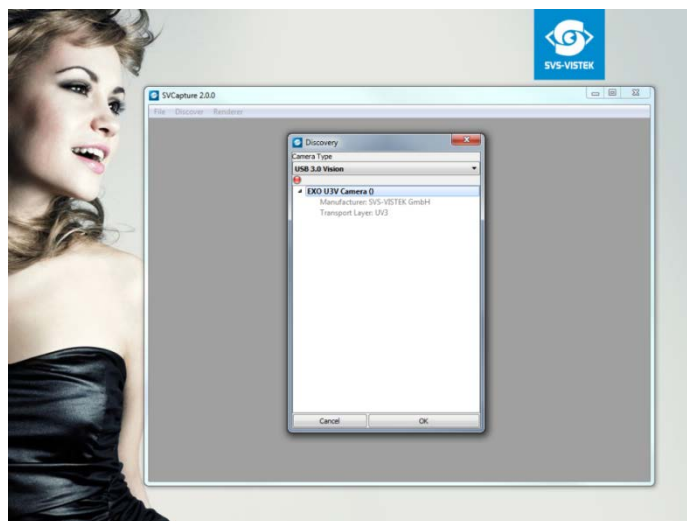
Connected cameras will be listed.

Choose your camera.

Conform to GenICam all control features will be listed in a flat tree diagram.
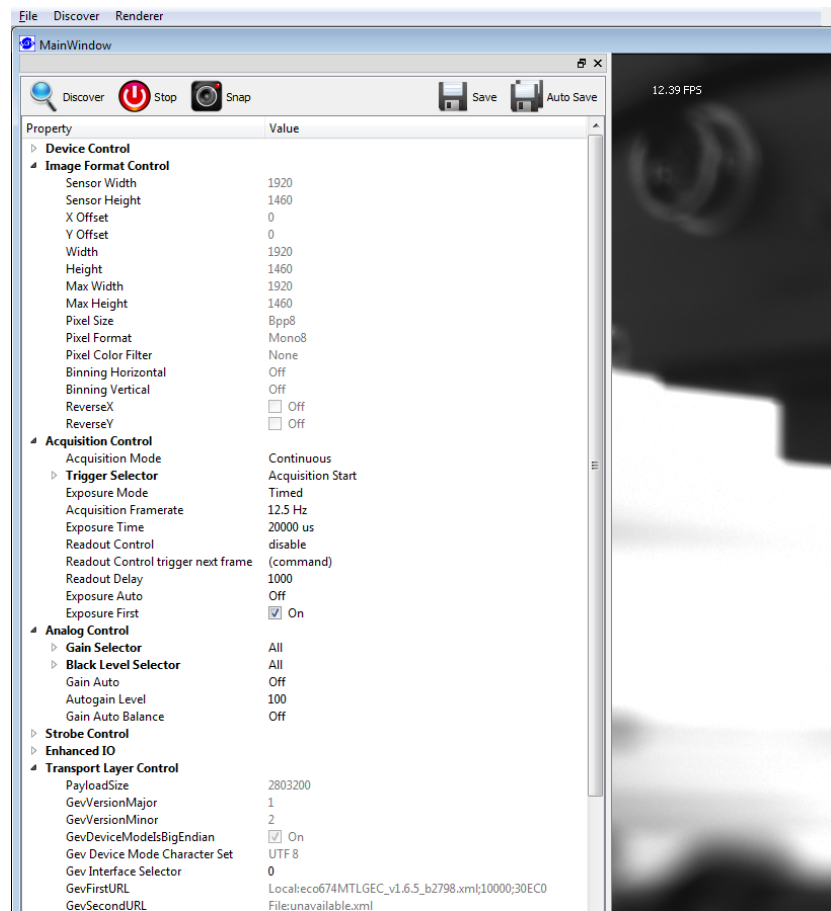
USB 3.0 driver

The USB 3.0 driver

You can find the USB 3.0 driver within your hardware manager:
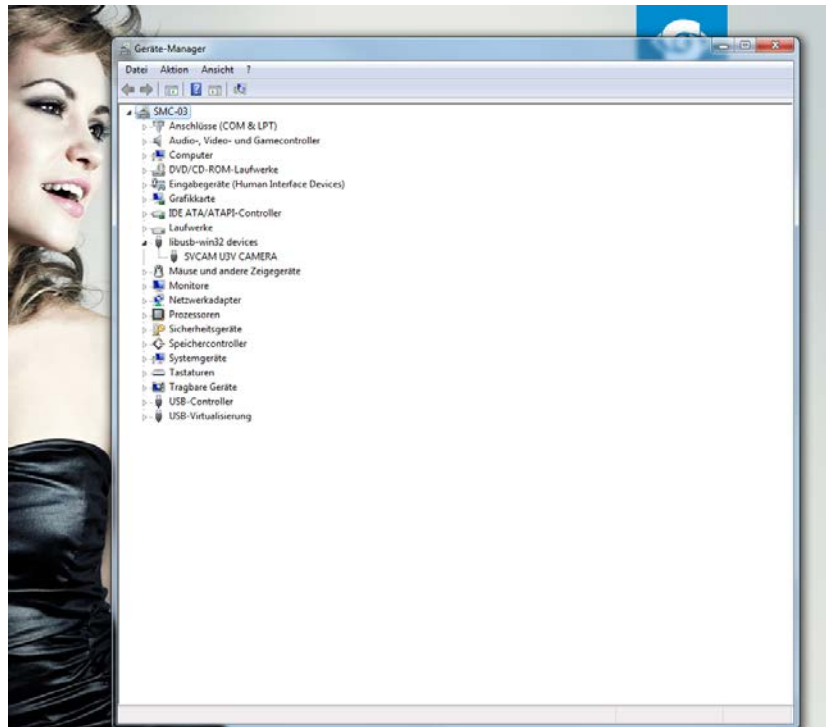
Firmware update

From time to time make sure your camera is running up to date firmware.

A firmware update tool is integrated in the software.

Internet connection needed.
    In case there is no connection contact your local support:

4.5 Firmware

Some features may not have been implemented in older versions. For updating your camera firmware to the most recent version, you need the firmware tool and a firmware file (download it from website, login area) matching your camera model.

4.5.1 Firmware Update GigE

A separate tool called "Firmware Update Tool.exe" is provided in the login area of the SVS-Vistek website.

Execute firmware update

> Download the firmware tool and the firmware file from the SVS-Vistek website.
> Unpack everything into any folder, e.g. "C:\temp"
> Ensure proper network configuration
> Run the GigE update tool

Your camera should appear, choose camera by entering camera index, e.g. 1 and press ENTER.
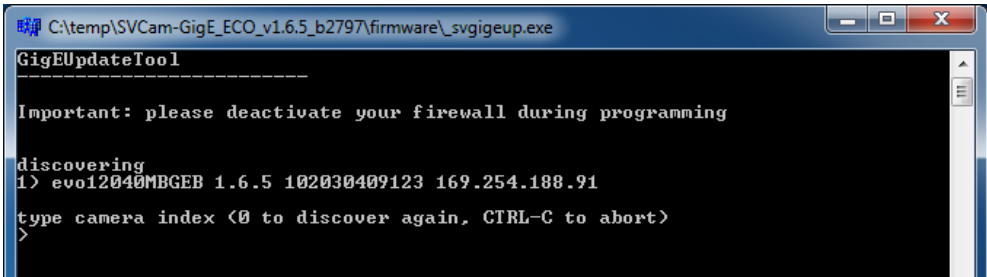
Figure 5: searching the camera to be updated
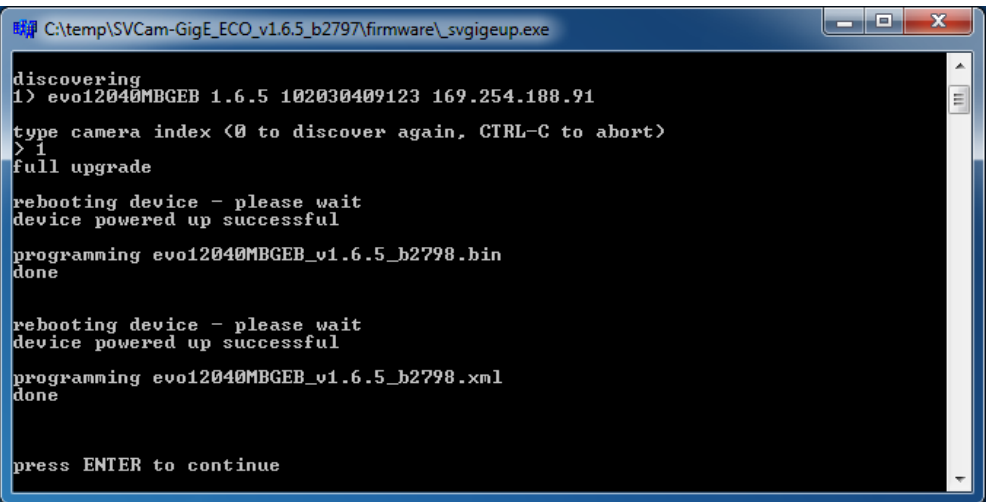
Wail until firmware update has been finished

Figure 6: firmware update has just been executed

4.6 GigE IP Setup

Your GigEVision camera needs a working network connection. Make sure the camera is attached to the network and is powered on. Make sure everything is plugged in properly and that the firewall settings are not blocking the connection to the camera or SVCapture.

Start SVCapture on your computer. As soon as the camera has booted, all SVS-Vistek GigE cameras are showing up in the main window.
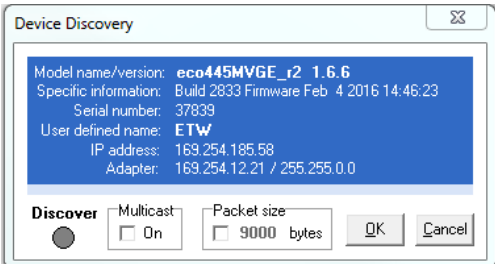
The cameras will show their IP addresses. In any case, the last number (1-254) has to be unique in your subnet. For better understanding of TCP/IP protocol, refer to applicable documents on the web. The camera's behavior is like a standard network device. If you're not sure about TCP/IP configuration or your network, try automatic network configuration as below.

With right-Click on the selected camera, a menu will show up with 3 options. Depending on whether you want the network changes to be permanent or not choose one of these options:
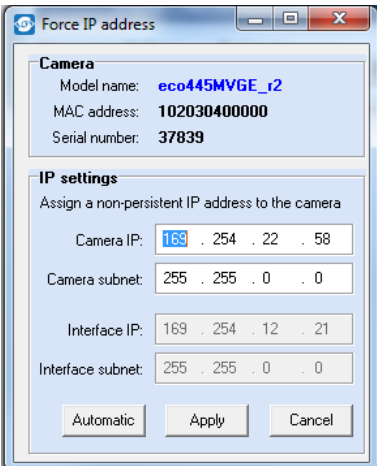
1. **Force IP address**
(Setup of a network address)
This dialog will put a new IP address (with subnet) to the camera. This address is volatile, it will be lost as soon the camera is powered off.
Automatic mode will try to setup a valid network address via DHCP/LLA

2. **Network settings**
(Setup of a network address and save it permanently in the camera's memory)
The procedure is the same as above, but the data will be saved permanently in the camera even when powered off. You might as well give a clear name inside the network (for the DHCP server)

3. **Restart automatic network configuration**
(do configuration of network IP automatically)

4.7 Driver Circuit Schematics
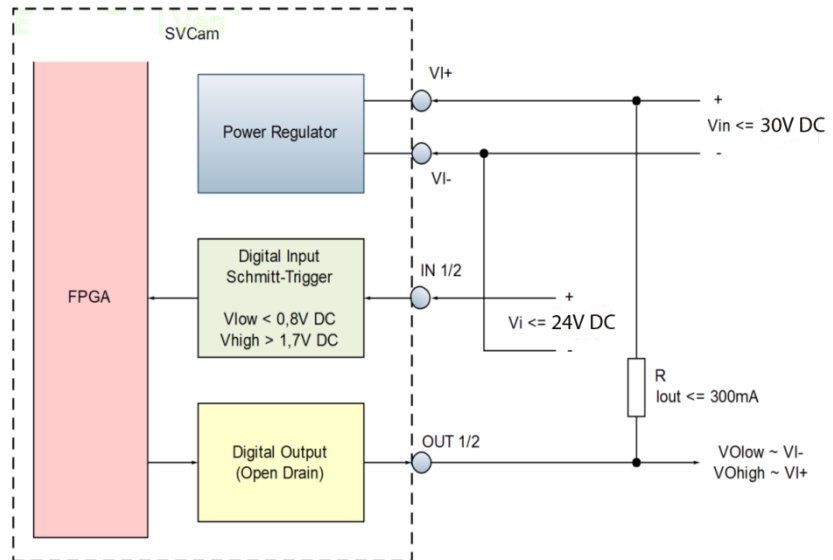
Figure 7: basic Illustration of driver circuit

5 Connectors
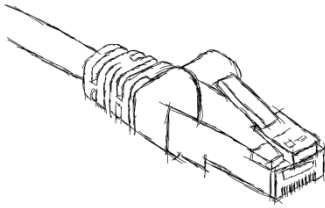
5.1 Dual GigE Vision

5.1.1 Network (TCP/IP)

Address Assignment

By default, the camera does not have a persistent IP address.

For Dual GigE Vision a "Static Link Aggregation" (SLA) is recommended. Refer to Teaming.

When forcing an IP address by using the PC internal network dialog, changes are only valid until the next restart of the Camera.

For a peer-to-peer connection of a GigE camera to a PC a network address assignment based on LLA (Local Link Address) is recommended. This involves a network mask "255.255.0.0" as well as a fixed preamble "169.254.xxx.xxx" of the network address range. A GigE camera will fall back to LLA when no DHCP server is available and no fixed network address was assigned to the camera.
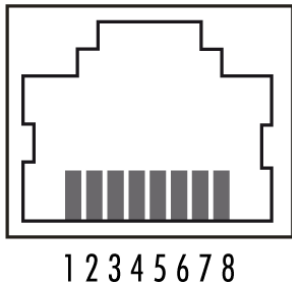
Figure 8: physical layout of RJ45 female connector

NOTICE

Any dual GigE camera can be run as well with a single network connection.

5.1.2 Single line operation of dual GigE cameras

Use the **upper right network port** for single line operation.

NOTICE

Dual GigE connection is required only if single network connection does not provide sufficient bandwidth. For dual GigE operation, 2 NICs need to be **teamed.** NIC teaming is a feature of the operating system

5.1.3 Teaming Dual GigE

CE**

Windows 10 does not support static link aggregation. You need to run win7, win8, macOS or linux if you want to use dual GigE

For higher transfer rates on GigE, you might want to team 2 GigE ports together. The host computer requires 2 network interfaces or a dual NIC. The configuration below shows the configuration.
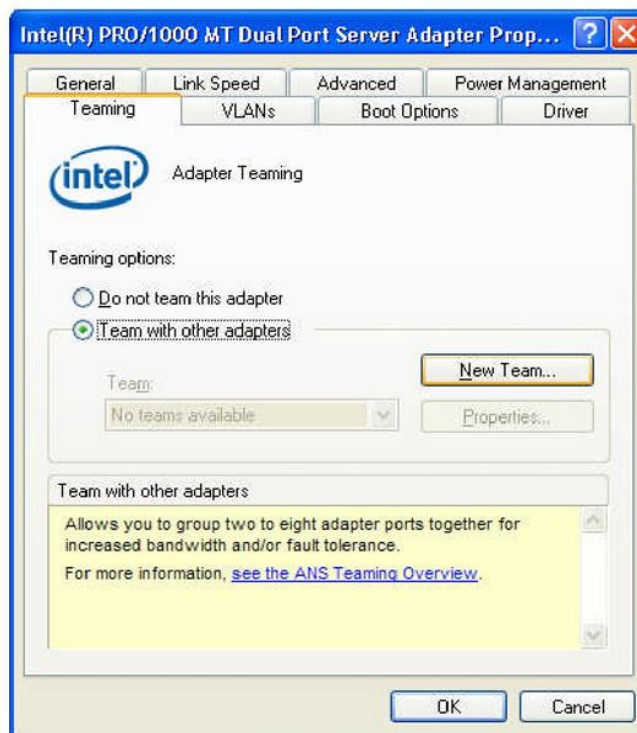
Figure 9: Teaming configuration on network adapter Intel pro 1000 dual/ Windows7

After naming your Team, select doth dual port adapters to team.
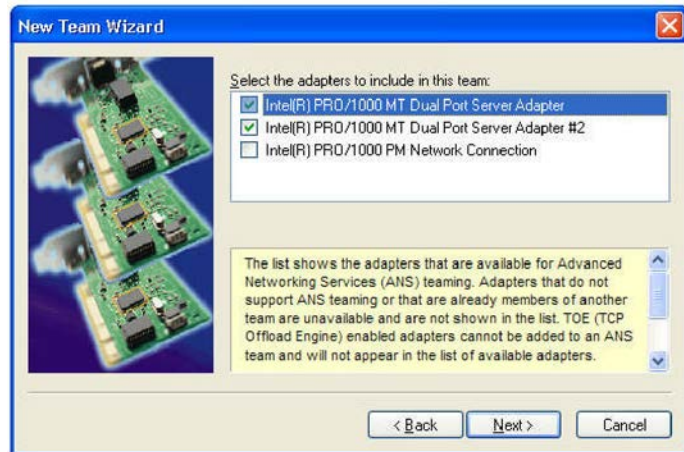
Figure 10: team wizard

Choose Static Link Aggregation, next and finish.
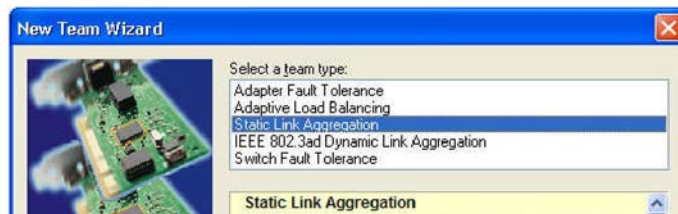
Figure 11: setting Static Link Aggregation (SLA)

Jumbo Frames

The transport efficiency in the streaming channel can be improved by using "jumbo frames". This will reduce overhead caused by maintaining header data upon each data packet sent.

For Dual GigE Vision a value of 16128 Byte per package is recommended (instead of 9056 B).

Figure 12: Illustration of data reduction with jumbo frames

ℹ	**NOTICE**
	Higher packet sizes require network cards that support jumbo packets.

Packet lost

In accordance with the TCP protocol, lost or corrupted packages will be resent.

	NOTICE
i	Resends result in higher consumption of bandwidths and will lead to drop frames.
	High quality cables prevent resends.

5.1.4 XML Files

According to the GigE Vision standard a GigE camera provides an XML file that defines the camera's capabilities and current settings.

The XML file can be processed by software like SVCapture allowing displaying and saving it to disk. Settings can also be saved and restored on the Camera internal EEPROM.

5.2 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-12P
Mating Connector	HR10A-10R-12S

Hirose 12 Pin
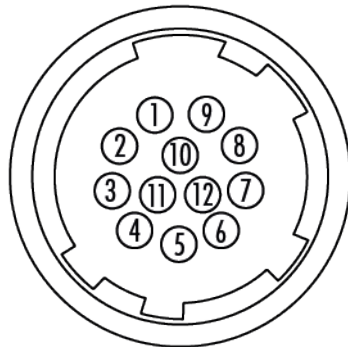
1	VIN −	(GND)
2	VIN+	(10V to 25V DC)
3	IN4	(RXD RS232)
4	OUT4	(TXD RS232)
5	IN1	(0-24V)
6	IN2	(0-24V)
7	OUT1	(open drain)
8	OUT2	(open drain)
9	IN3+	(RS422)
10	IN3-	(RS422)
11	OUT3+	(RS422)
12	OUT3 −	(RS422)

Figure 13: Illustration of Hirose 12 Pin & pin-out (HR10A-10R-12PB)

NOTICE

The PoE (Power over Ethernet) versions do not support RS232 on pins 3,4

6 Dimensions

All length units in mm.
Find drawings in the web download area at
https://www.svs-vistek.com/en/support/svs-support-download-center.php

CAD step files available with valid login at SVS-VISTEK.com

6.1 HR GigE with M58 mount

Including:
hr11002CTLGEC, hr11002MTLGEC, hr16000CTLGEC,
hr16000MTLGEC, hr16050CFLGEA, hr16050CFLGEC,
hr16050MFLGEA, hr16050MFLGEC, hr16070CFLGEA,
hr16070CFLGEC, hr16070MFLGEA, hr16070MFLGEC,
hr29050CFLGEA, hr29050CFLGEC, hr29050MFLGEA,
hr29050MFLGEA4IO, hr29050MFLGEC

side

55,23

50

$\varnothing$ 64

bottom

4x M3
4 mm deep

24,50

50

24,50

back

70

cross section A-A
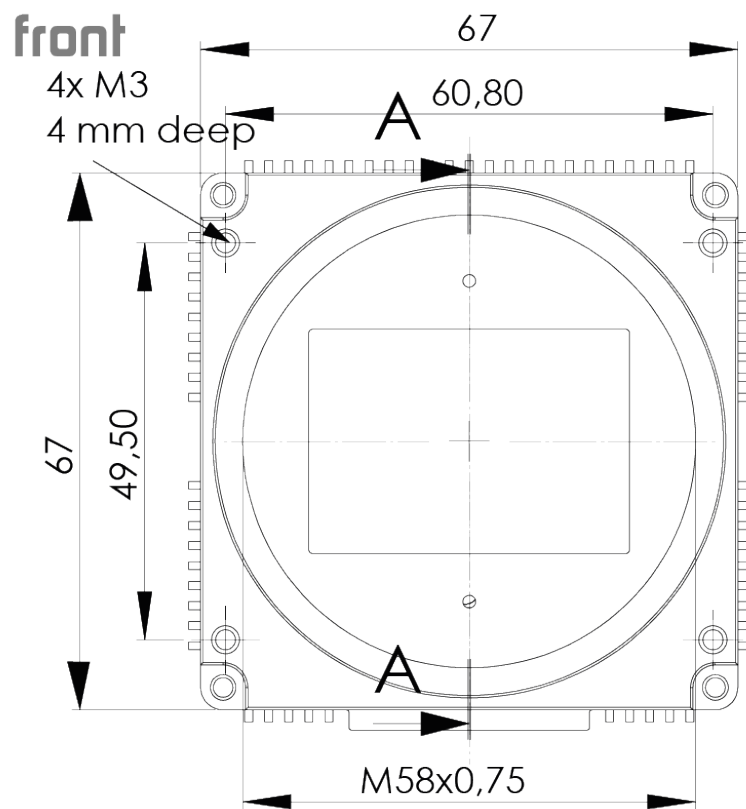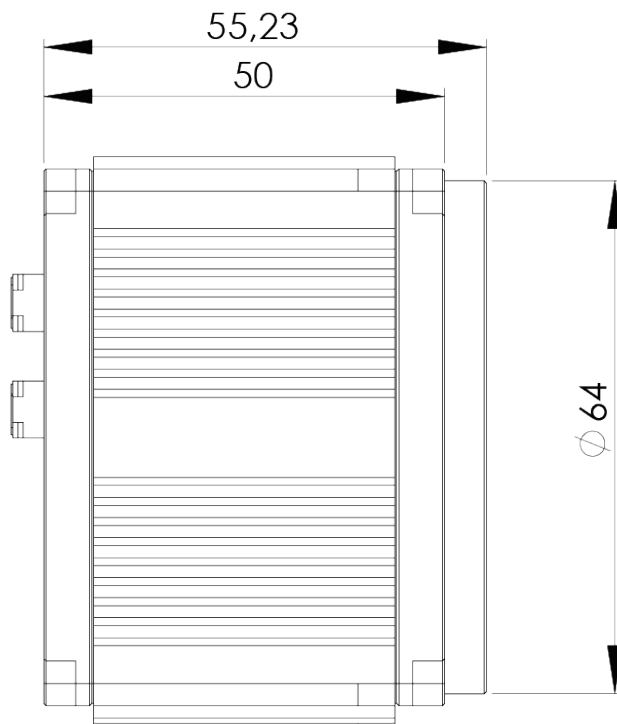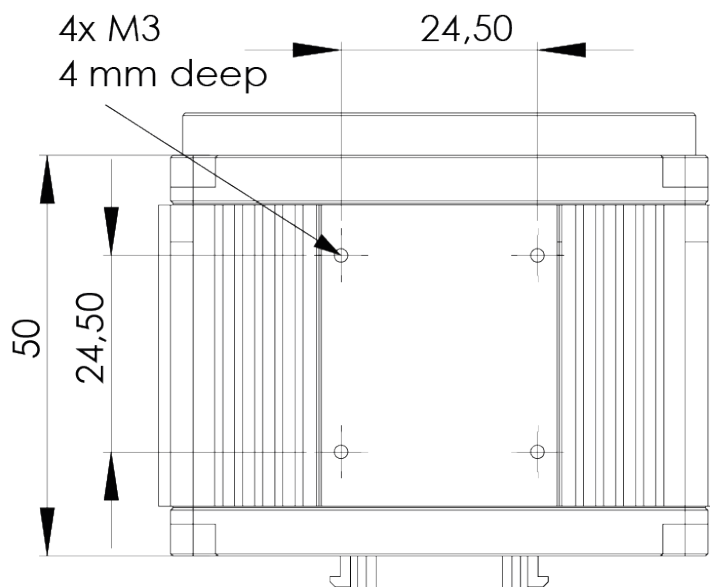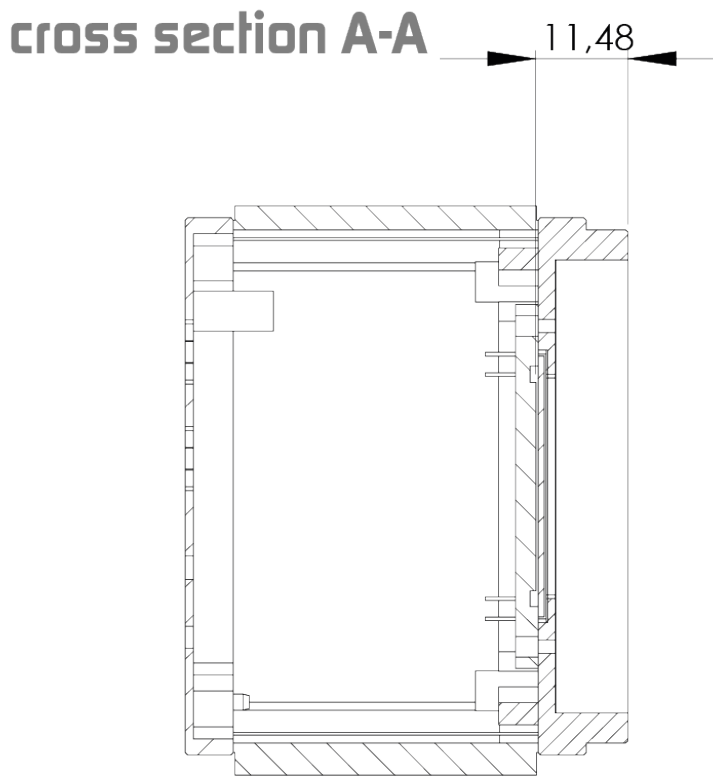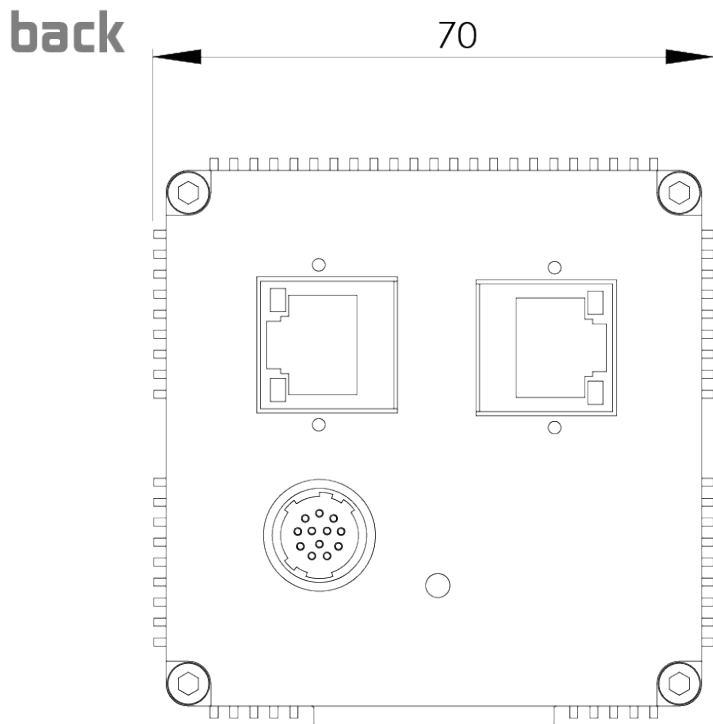
11,48

6.2   M58 Mount

Diameter: 58 mm

Thred pitch 0.75 mm

Back-focus distance from sensor to flange of the camera: 11.48 mm

Distance from sensor surface to lens differs depending on lens specifications and how far the lens is screwed in.
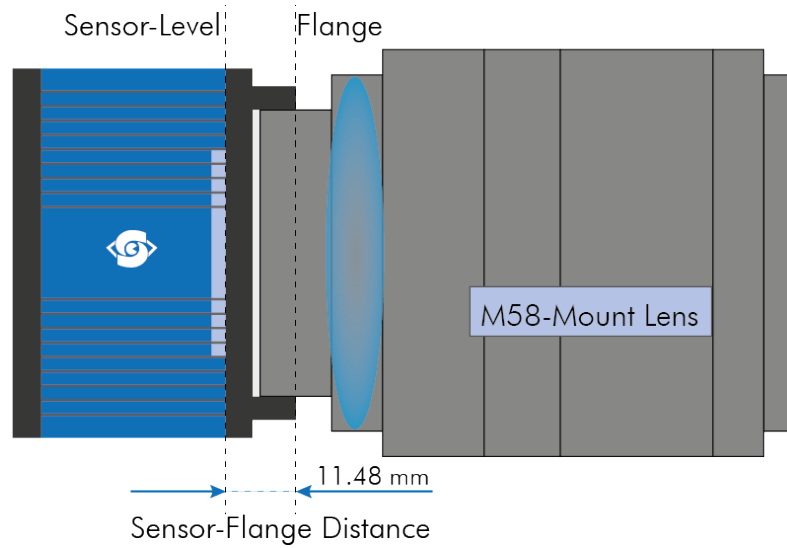
Figure 14: Illustration of M58-Mount

7 Feature-Set

7.1 Basic Understanding

7.1.1 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.
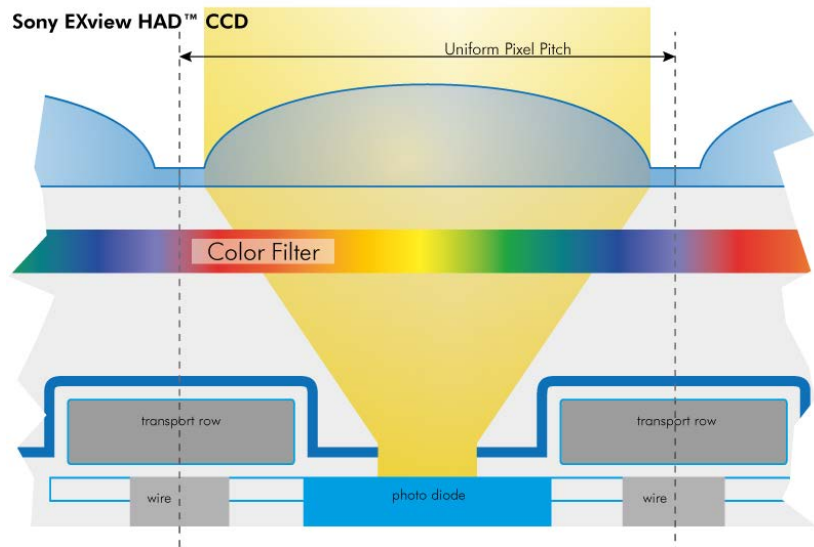
Figure 15: Illustration Cross-section of a CCD sensor from Sony
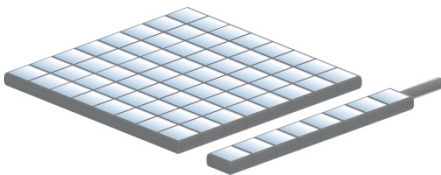
Charge is an integration of time and light intensity on the element. Like this the image gets brighter the longer the CCD cell is exposed to light.

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

7.1.2 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...
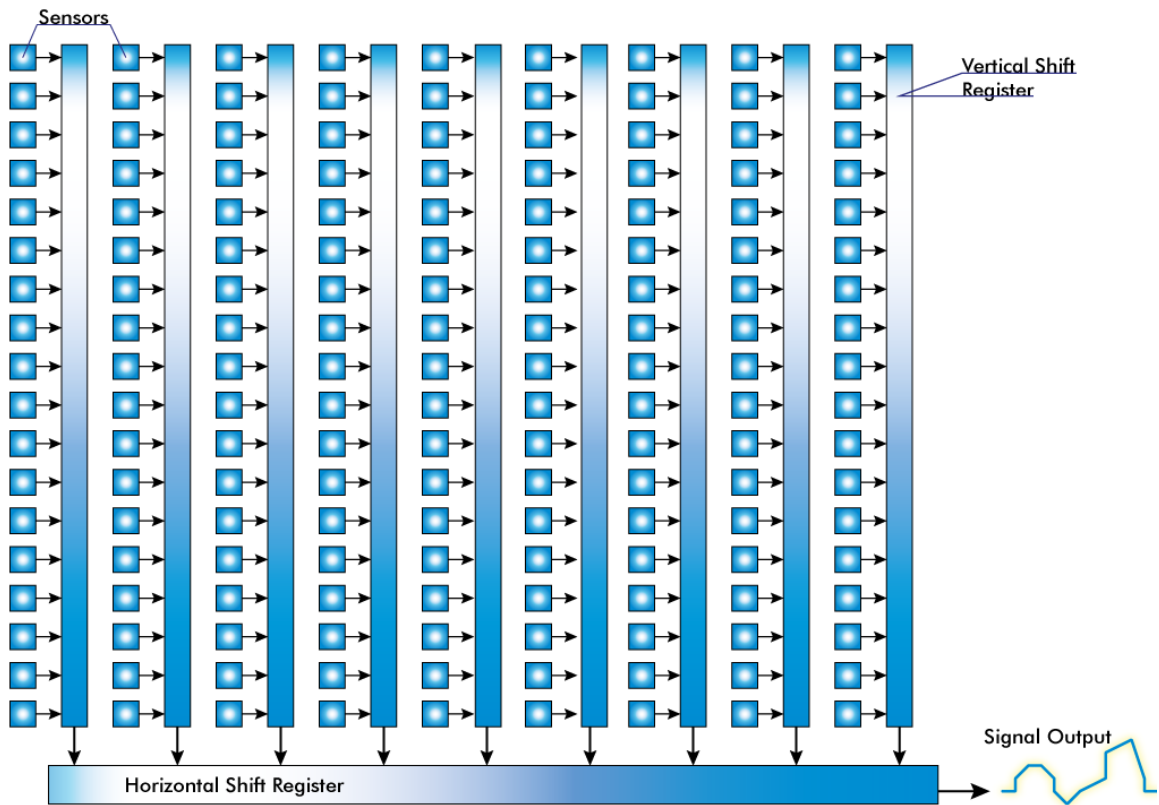
Figure 16: Illustration of interline transfer with columns and rows

7.1.3 Global shutter

The shutter is describing the functionality of exposing the light sensitive pixels of the sensor to light for a limited time. With Global shutterall 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 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. Below are illustrations of some images taken with different shutter types. The camera does not move, the bottles are sitting on an assembly line driving by.
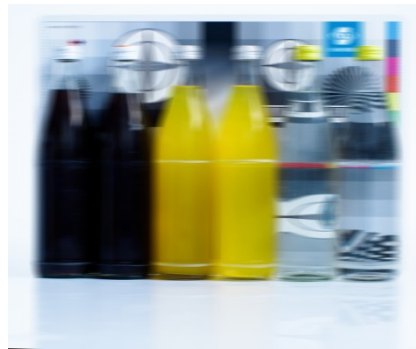
Figure 17: motion blur with global shutter and moving objects

Figure 18 rolling shutter with moving objects(geometric distortion)

Figure 19: interlaced effect

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

camera-
line

time (ms)
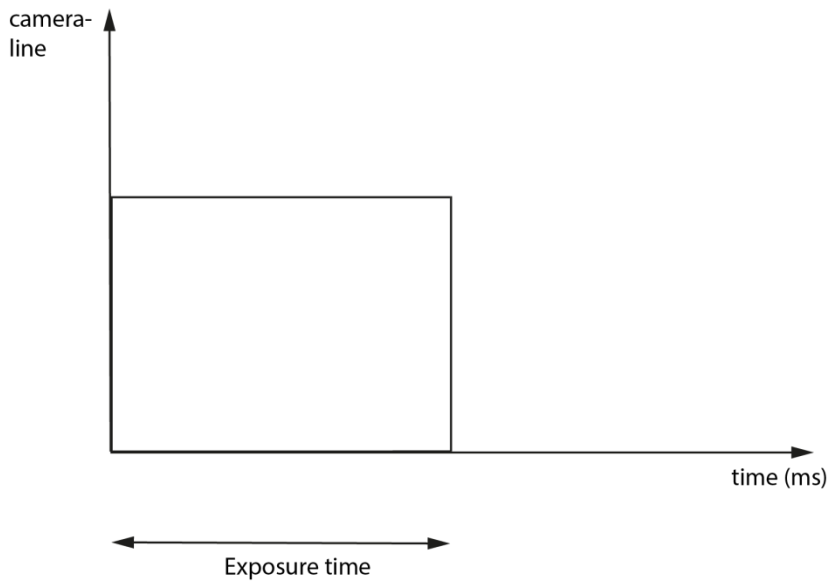
Exposure time

Figure 1: All pixel lines are sensitive to light the same time

All pixels are open the same time. You might flash at any time within exposure time.

7.1.4 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

7.1.5 Acquisition and Processing Time

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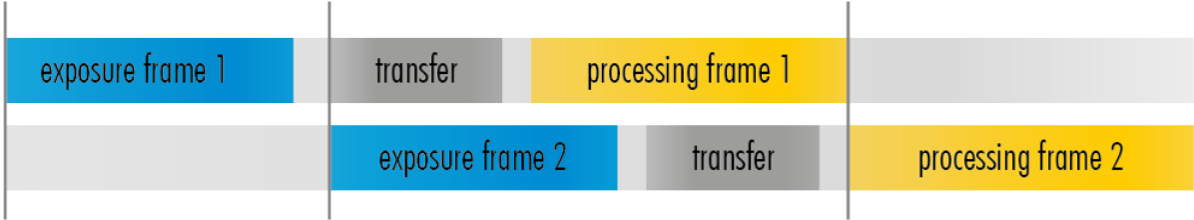
7.1.6 Exposure

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.

7.1.7 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.

7.1.8 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

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
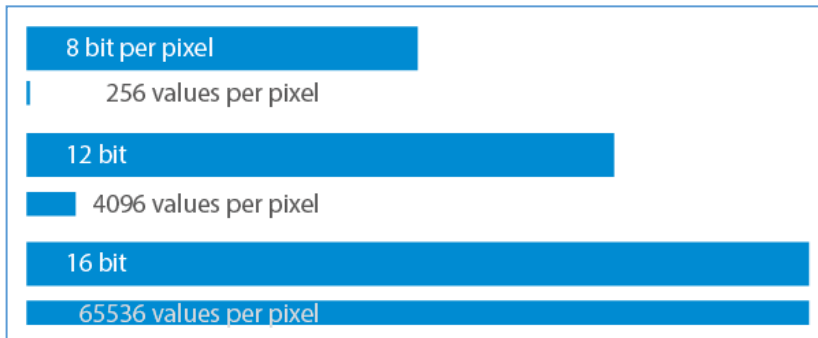
Figure 20: illustration of rising amount of values/gray scales by increasing the bit format

depth values.
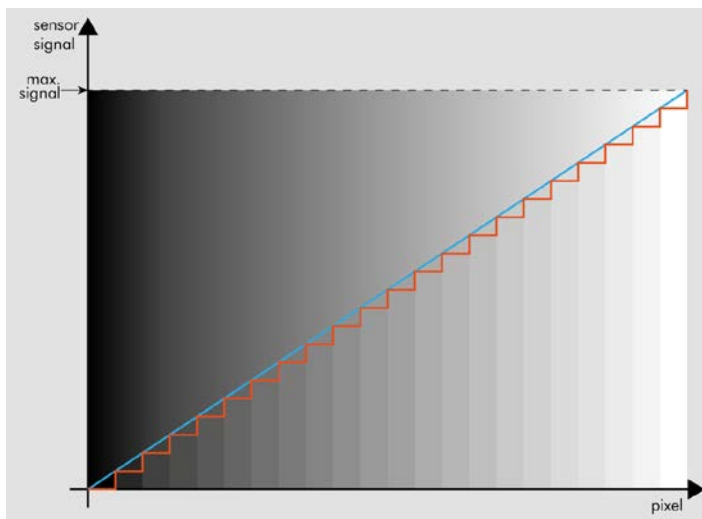
Figure 21: Simplified illustration of a quantification graph

screen or in print.

 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 22: Shade difference in 8 bit format

As shown in figure 23 differences in shades of gray are hardly visable on

Figure 24: Figure of original picture - black & white

Figure 25: Reduced color depth quantification

7.1.9 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.

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.
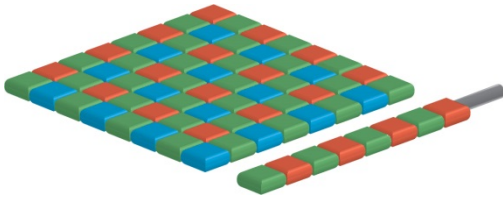
Figure 26: CCD with Bayer Pattern

	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 27: Table of color temperatures

7.1.10 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.
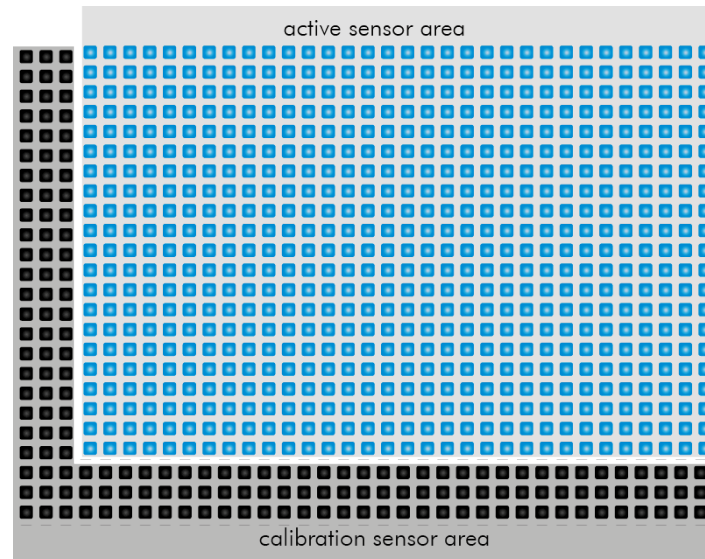
Figure 28: Illustration of active and effective sensor pixels

7.1.11 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 (dark noise: noise generated without light exposure).

To avoid this dark noise to be interpreted as a valuable signal, an offset will be set.
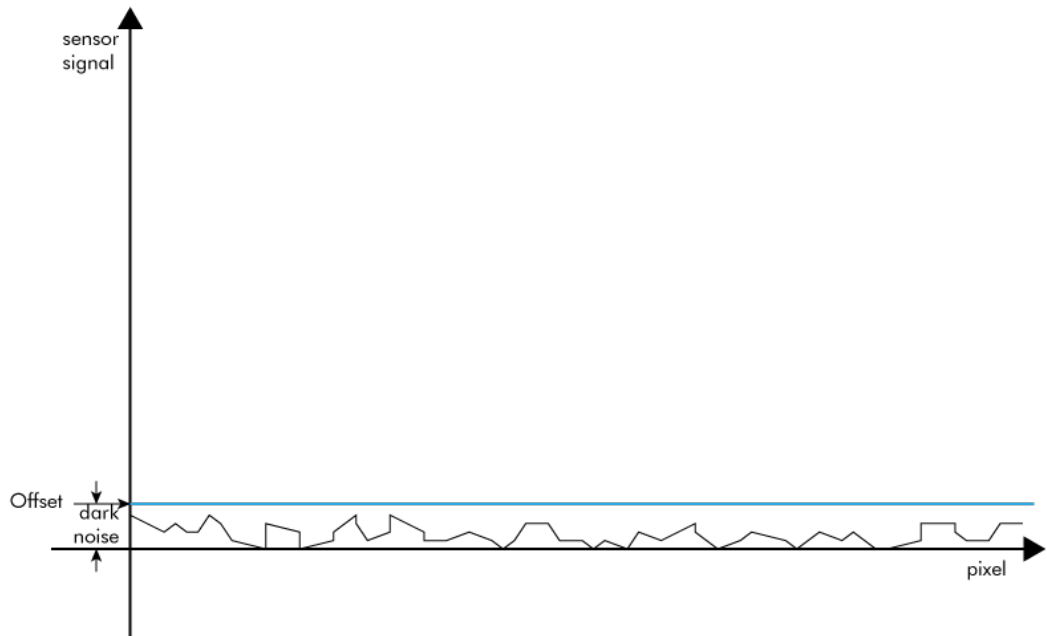
Figure 29: Illustration of dark noise cut off by the offset

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 (see tap balancing).

7.1.12 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 30: 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.
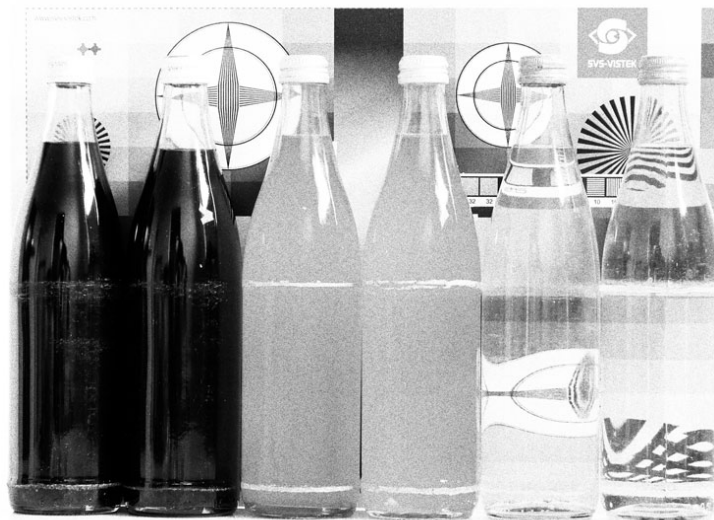
Figure 31: noise caused by too much gain

Auto Gain

For automatic adjustment of Gain please refer to Auto Luminance.

Please note, with CMV4000 sensors gain adjustment is possible in steps only. Please find step values are as below.

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

Steps of Gain CMV4000
0 dB
1.6 dB
2.9 dB
4.1 dB
6.0 dB
7.6 dB
8.9 dB
10.1 dB (reduces Dynamic to 52 dB)

7.1.13 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 32: Figure of original image

Figure 33: Figure of image horizontally flipped

Figure 34: Figure of image vertically flipped

7.1.14 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.
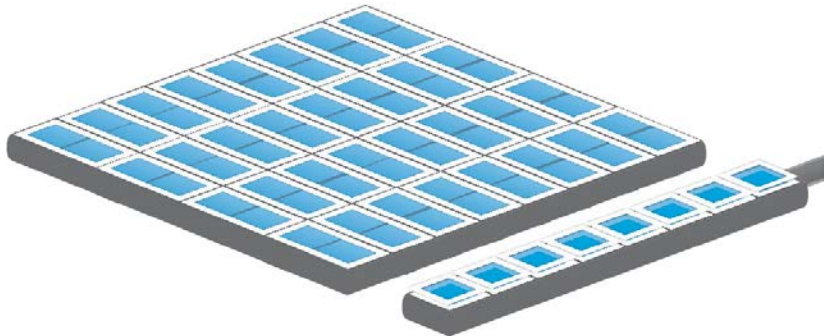
Figure 35: Illustration of vertical binning

Horizontal Binning

Accumulates horizontal pixels.
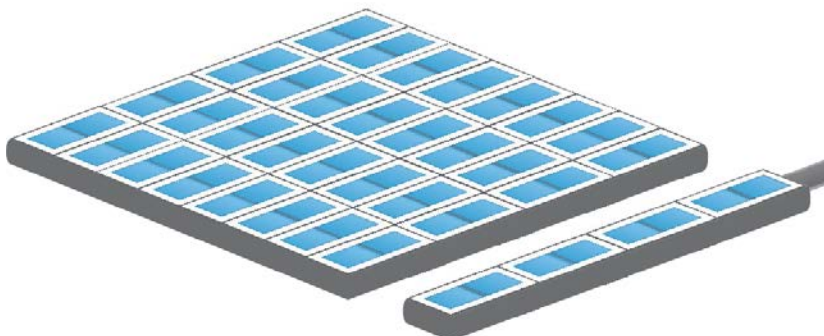
Figure 36: Illustration of horizontal binning

2×2 Binning

A combination of horizontal and vertical binning.

When DVAL signal is enabled only every third pixel in horizontal direction is grabbed.
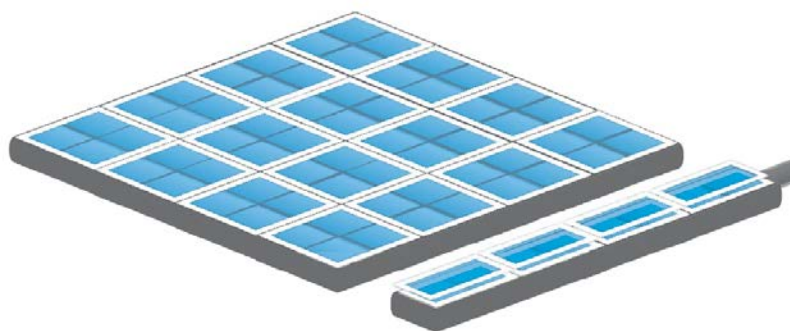
Figure 37: Illustration of 2x2 binning

7.1.15 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.

7.2 Camera Features

7.2.1 System Clock Frequency

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

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

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

> **NOTICE**
> Use multiples of 15 ns to write durations into camera memory

7.2.2 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)

7.2.3 Read-Out-Control

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

With more than one camera connected to a single computer, image acquisition and rendering can cause conflicts for data transfer, on CPU or bus-system.
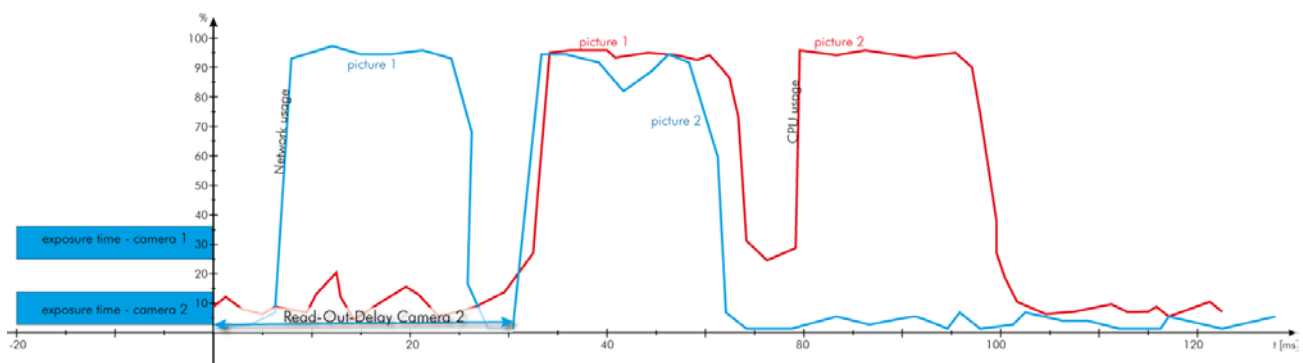
Figure 38: Illustration of physical data stream in time

7.2.4   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
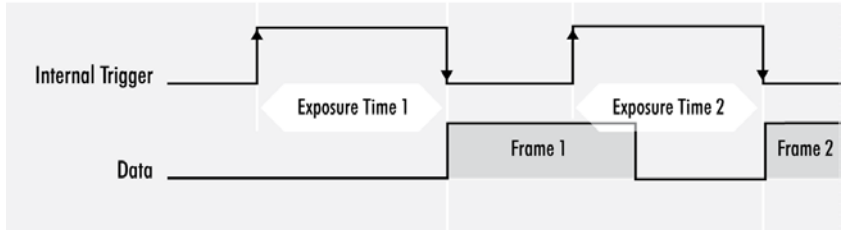
There is no need to trigger the camera in order to get data. Exposure time is programmable via serial interface and calculated by the internal logic of the camera.

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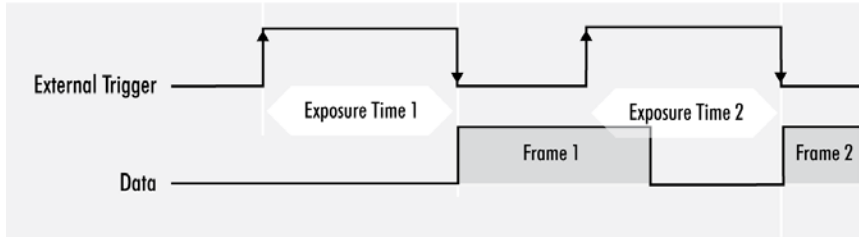
Exposure time of the next image can overlap with the frame readout of the current image (rising edge of trigger pulse occurs when FVAL is high). When this happens: the start of exposure time is synchronized to the falling edge of the LVAL signal.

Mode 1: External Trigger with Pulse Width Exposure Control (non overlap)
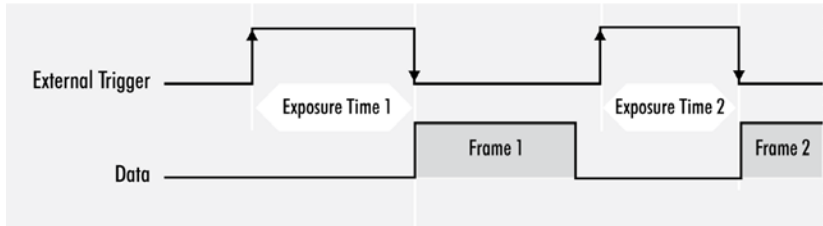
When the rising edge of trigger signal occurs after frame readout has ended (FVAL is low) the start of exposure time is not synchronized to LVAL and exposure time starts after a short and persistant delay.

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

Software Trigger

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

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

External Trigger (Exposure Time)

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

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

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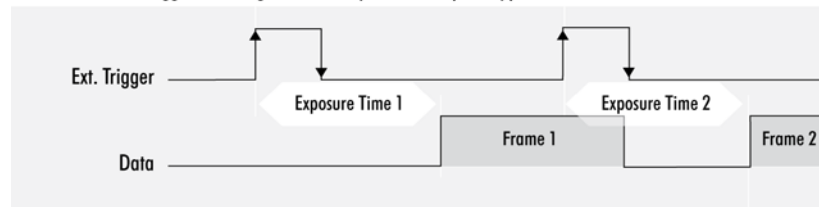
When the rising edge of trigger signal occurs after frame readout has ended (FVAL is low), the start of exposure time is not synchronized to LVAL and exposure time starts after a short and persistant delay.

Mode 2: External Trigger with Programmable Exposure Time (non overlap)
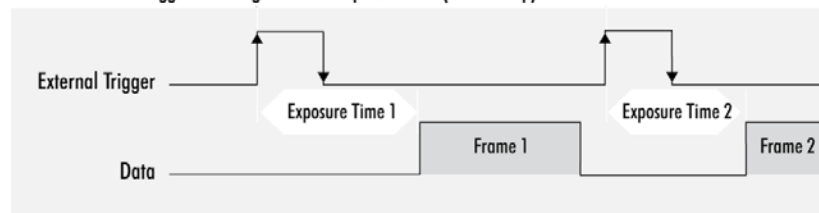
Exposure time can be changed during operation. No frame is distorted during switching time. If the configuration is saved to the EEPROM, the set exposure time will remain also when power is removed.

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)

Trigger — Exposure Time

T_2

CCD Exposure — T_3 Resulting Exposure Time

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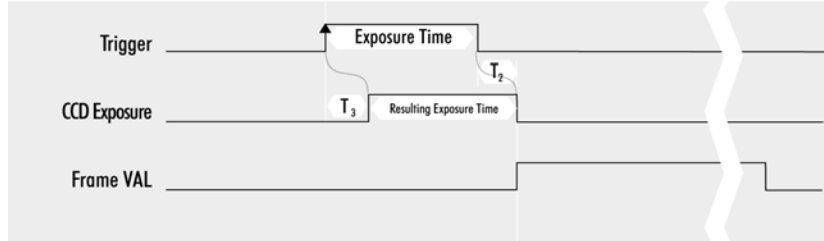
T_1: Line Duration T_2: Transfer Delay T_3: Exposure Delay T_4: min. Trigger Pulse Width

Mode 1: External Trigger with Pulse Width Exposure Control (overlap)
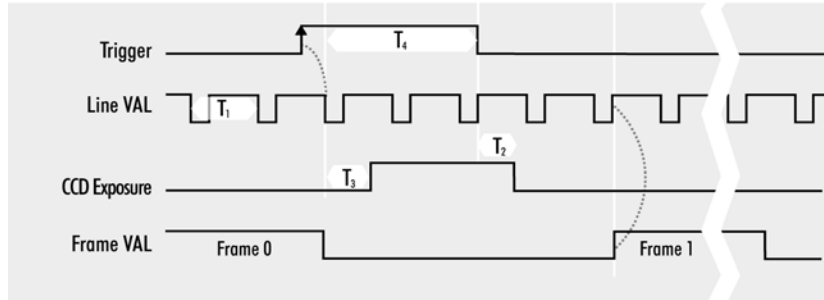
Trigger — T_4

Line VAL — T_1

CCD Exposure — T_3 T_2

Frame VAL — Frame 0   Frame 1

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)

Trigger — T_4 T_3

CCD Exposure — Serial Control Set

Frame VAL — Frame 1

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)

Trigger — T_4 T_1

Line VAL

CCD Exposure — T_3

Frame VAL — Frame 0   Frame 1

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

SVS-VISTEK
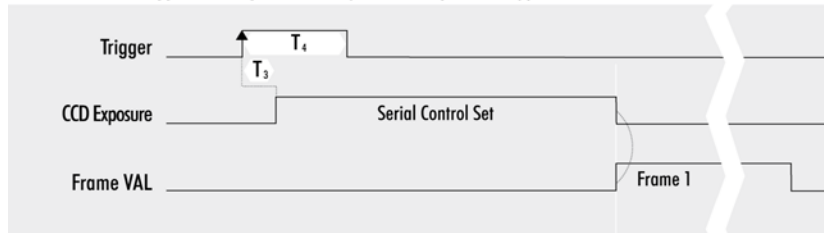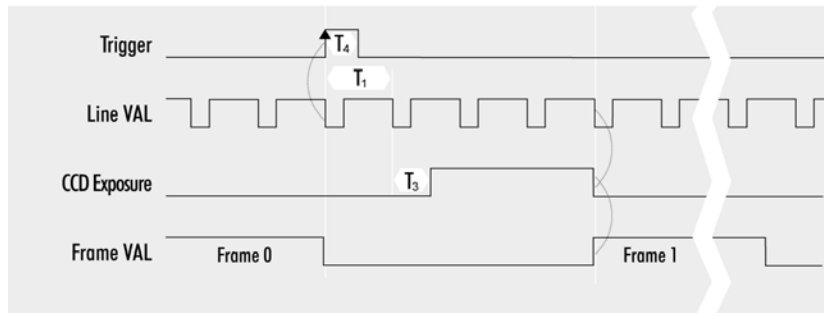
7.2.5 LookUp Table

The LookUp Table Feature (LUT) lets the user define certain values to every bit value that comes from the ADC.

To visualize a LUT a curve diagram can be used, similar to the diagrams used in photo editing software.

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

For further Information about curves and their impact on the image refer to our homepage: Knowledge Base – LUT
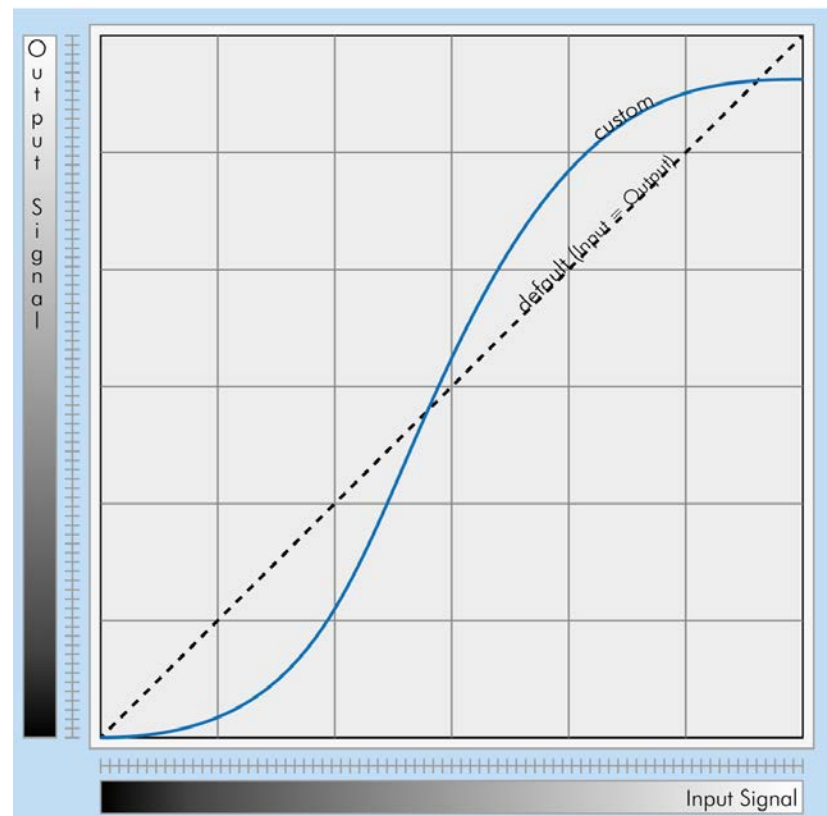
Figure 39: Custom LUT adding contrast to the midtones

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

Feature-Set   51

Gamma Correction

Using the LookUp Table makes is also possible to implement a logarithmic correction. Commonly called Gamma Correction.

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

The Gamma algorithms for correction can simplify resolution shifting as shown seen above.

Input & Output signal range from 0 to 1

$$\text{Output-Signal} = \text{Input-Signal}^{\text{Gamma}}$$
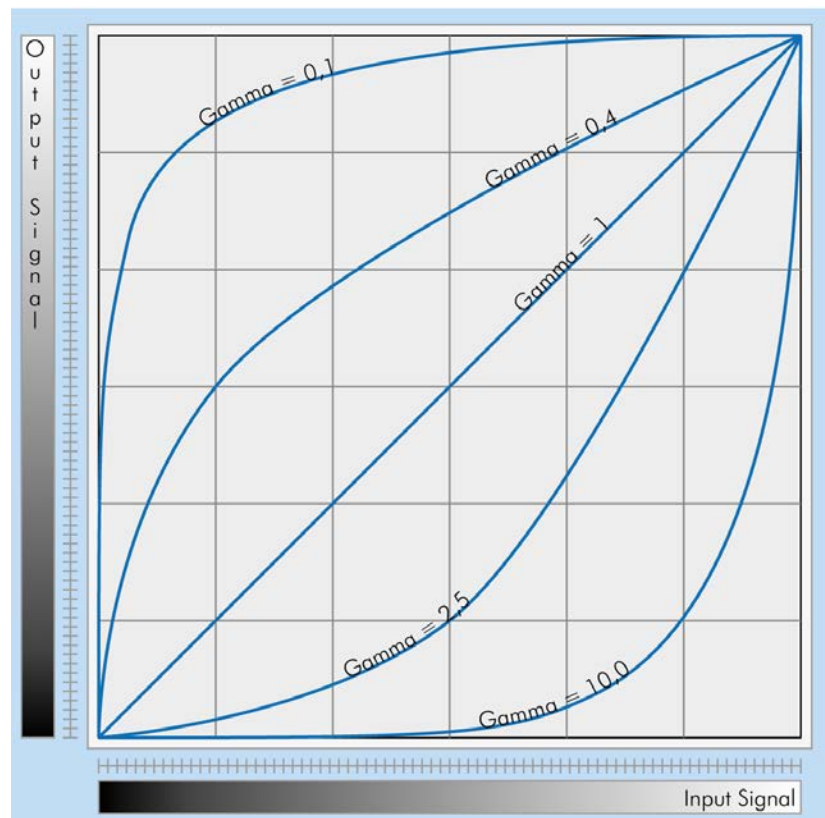
Figure 40: Several gamma curves comparable to a LUT

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

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

7.2.6 ROI / AOI

In Partial Scan or Area-Of-Interest or Region-Of-Interest (ROI) -mode only a certain region will be read.
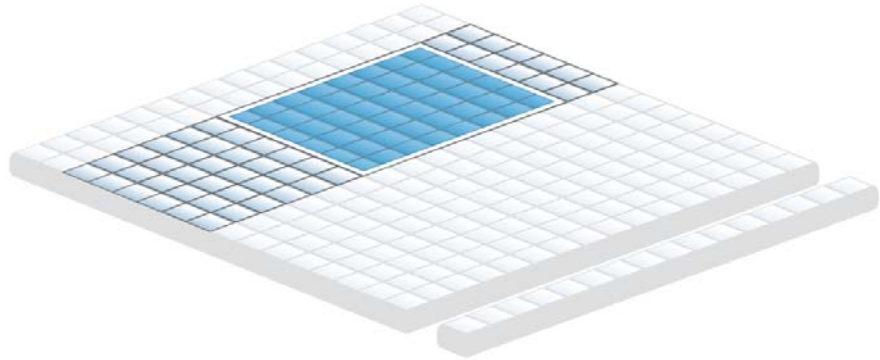
Figure 41: AOI on a CCD sensor

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.

7.2.7 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.
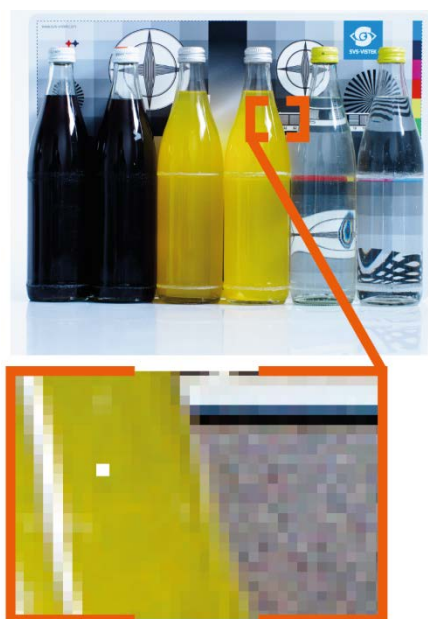
Figure 42: Illustration of a defect pixel

7.2.8 Shading Correction
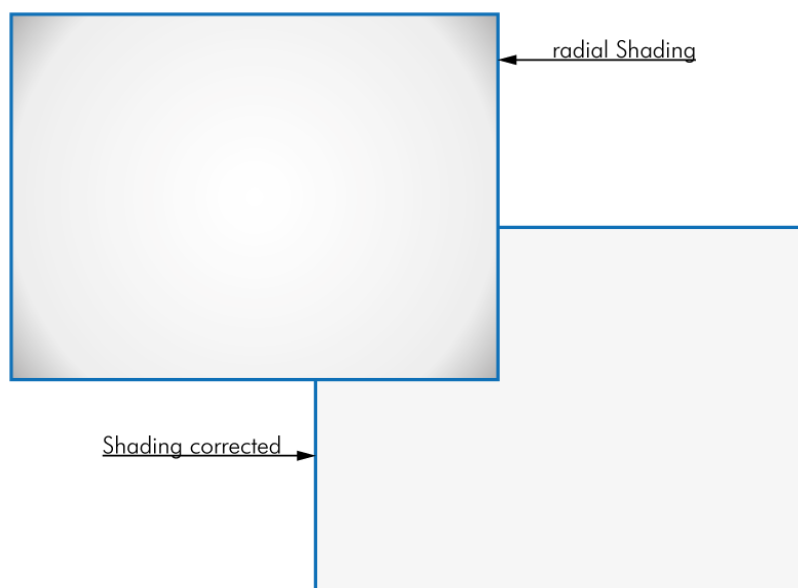
Figure 43: Original and shading corrected image

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
ℹ	White balance should be completed before acquisition of correction values for Shading Correction.

7.3 I/O Features

7.3.1   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.
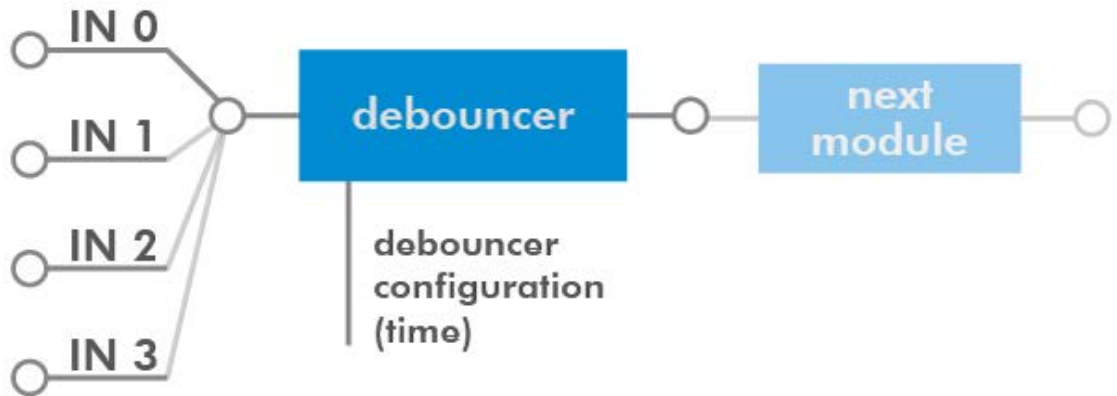
Figure 44: "IN0" connected to "debouncer"

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

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.

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 <u>input / output connectors</u> 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.
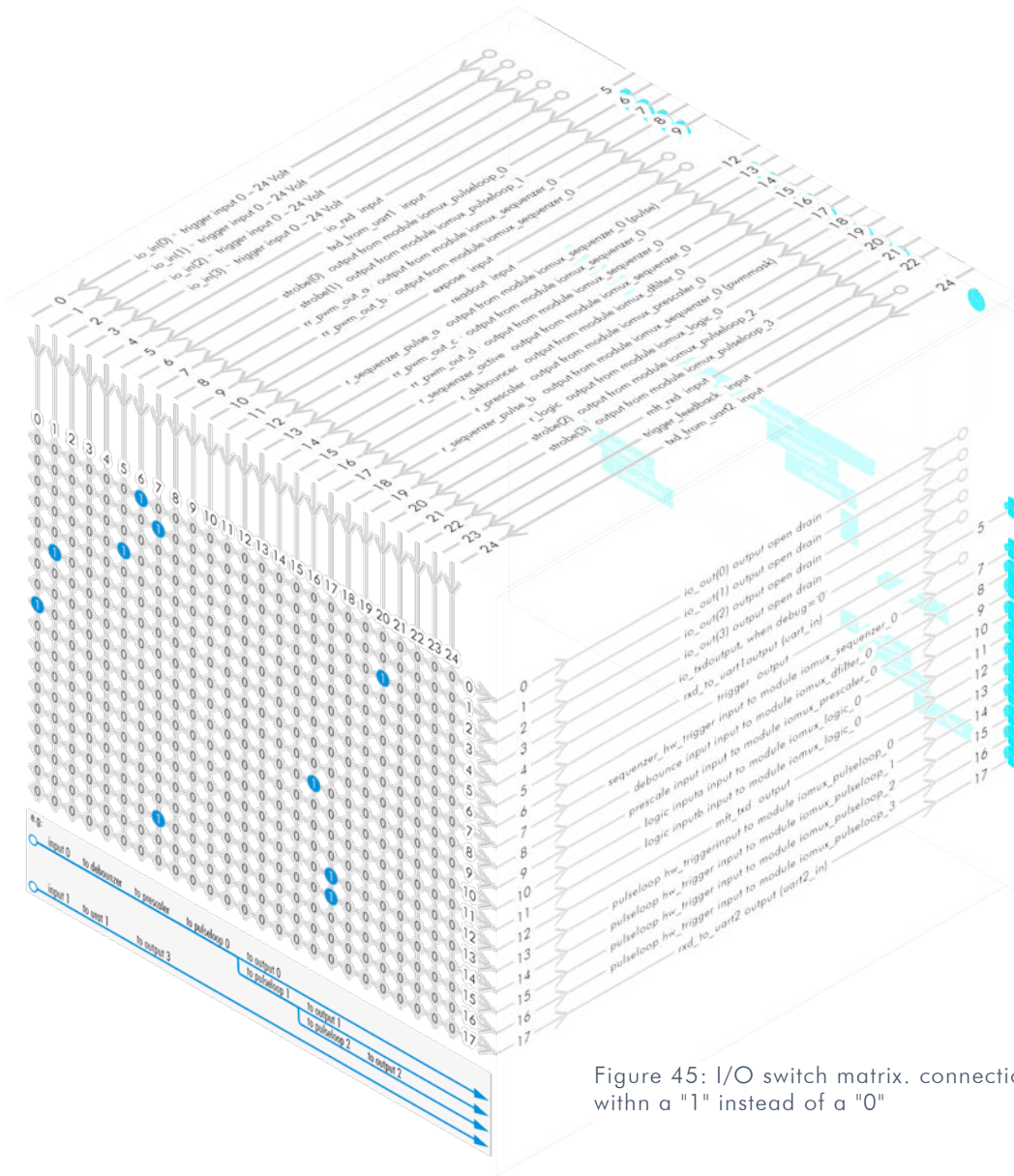
Figure 45: I/O switch matrix. connections will be made withn a "1" instead of a "0"

Figure 46: I/O 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
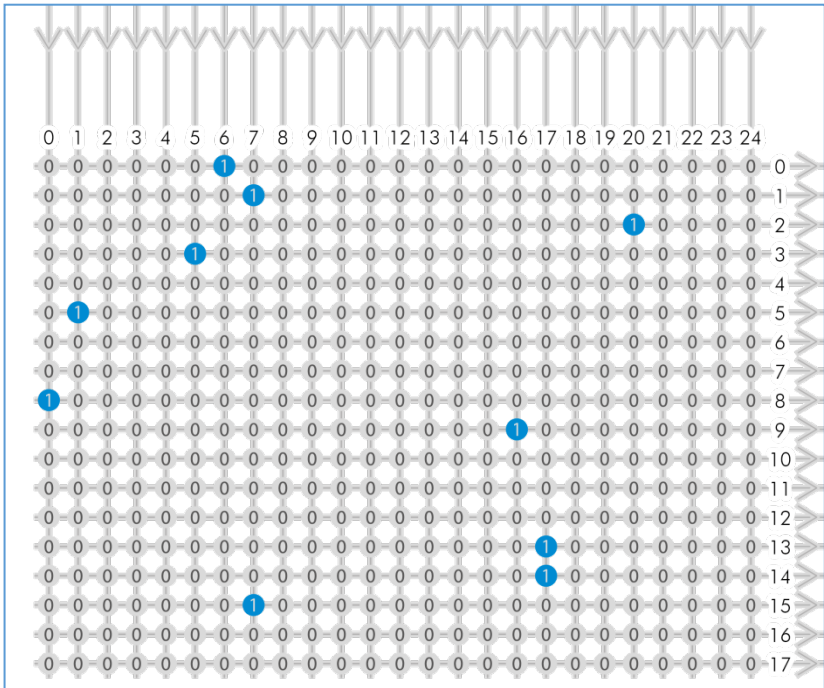
> The trigger signal comes in on line 0
> Debounce it.
connect line 0 to 8:
1000000000000000000000000
signal appears again on line 15 – debouncer out
> Use the prescaler to act only on every second pulse.
connect line 16 to 9.
00000000000000100000000
signal appears again on line 17 – debouncer out
> 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.
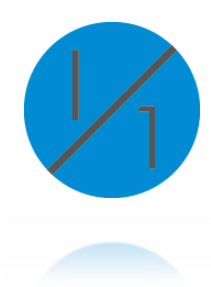
7.3.2   Strobe Control
Drive LED lights form within your camera. Control them via ethernet.
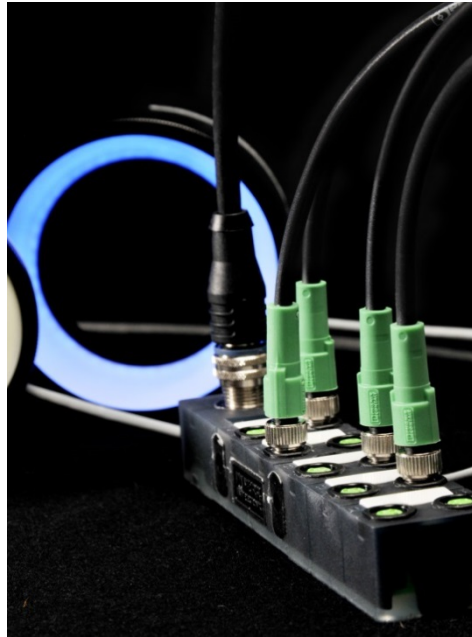
Figure 47: use the breakout box to simplify your wiring

> SVCam cameras have built-in MOSFETs that can drive up to 3 Amperes.
> This allows using the cameras as a strobe controller – saving costs.
> High frequency pulse width modulation (PWM) for no flickering.
> Power to the LED light is provided through power of the camera.
> Setting of pulse, duty cycle is controlled via data connection / PC.
> 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 canals can be used as open drain. Refer to specifications.
> Max. current at 40 mSec. is 3 A

2 IO's high voltage drain
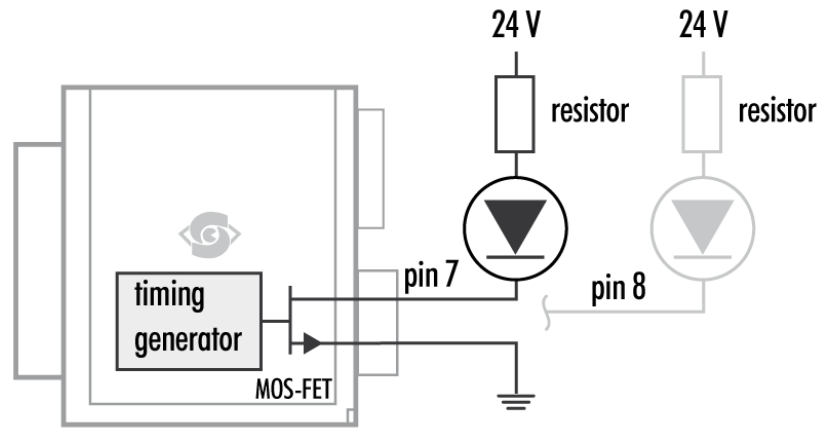
Figure 48: Illustration of two LEDs switched internal by the camera

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!

To avoid overload of Driver, make sure to use the right dimension of resistor. If not done so, LEDs and/or Camera might be damaged.

schematic electrical circuit - conventional system
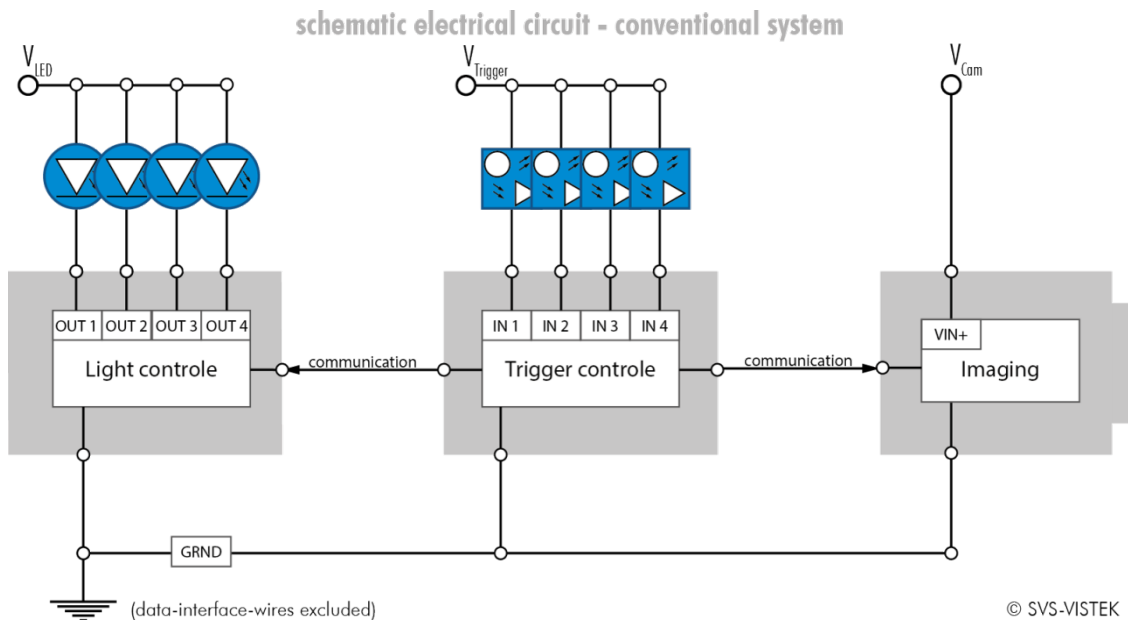
Figure 49: Illustration of conventional schematic electric circuit

schematic wiring - SVS-VISTEK 4IO

1) power supply & controle connection to/from camera
2) power supply camera, trigger & action, LED lights
3) power supply light 1
4) power supply light 2
5) power supply light 3
6) power supply light 4

7) power supply trigger/action 1
8) power supply trigger/action 2
9) power supply trigger/action 3
10) power supply trigger/action 4

Imaging
light - trigger - action controle

(data-interface-wires excluded)

© SVS-VISTEK

Figure 50: 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.
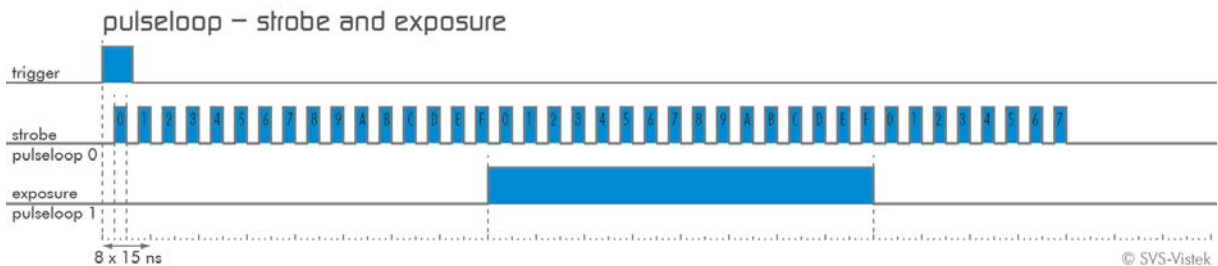
Figure 51: pulseloop for strobe and exposure

- 8

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.
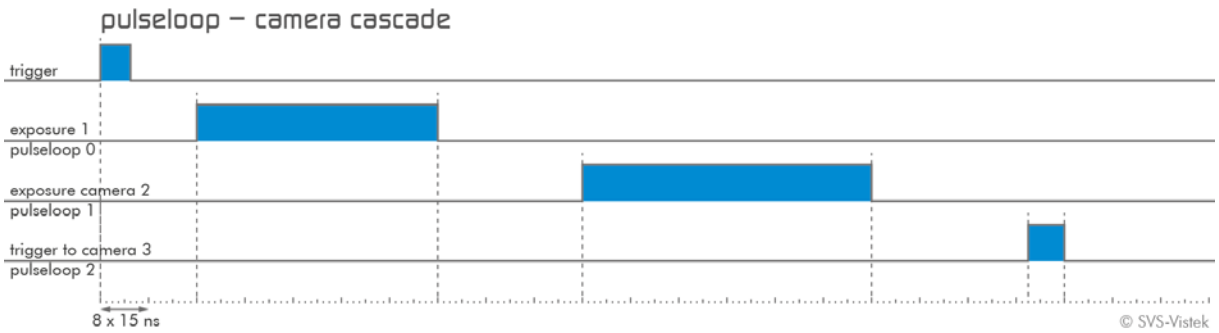
Figure 52: pulseloop – activating three cameras

MODULE PULSELOOP
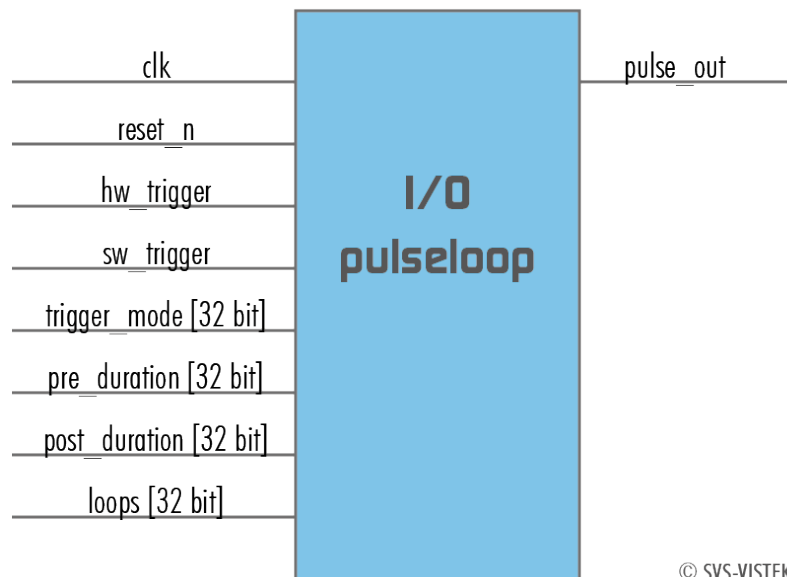
LEDs in Continuous Mode

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

LEDs in Flash Mode

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

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.

Strobe Polarity

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

Strobe Duration

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

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 53: Illustration of an application using the 4IO

7.3.3 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	
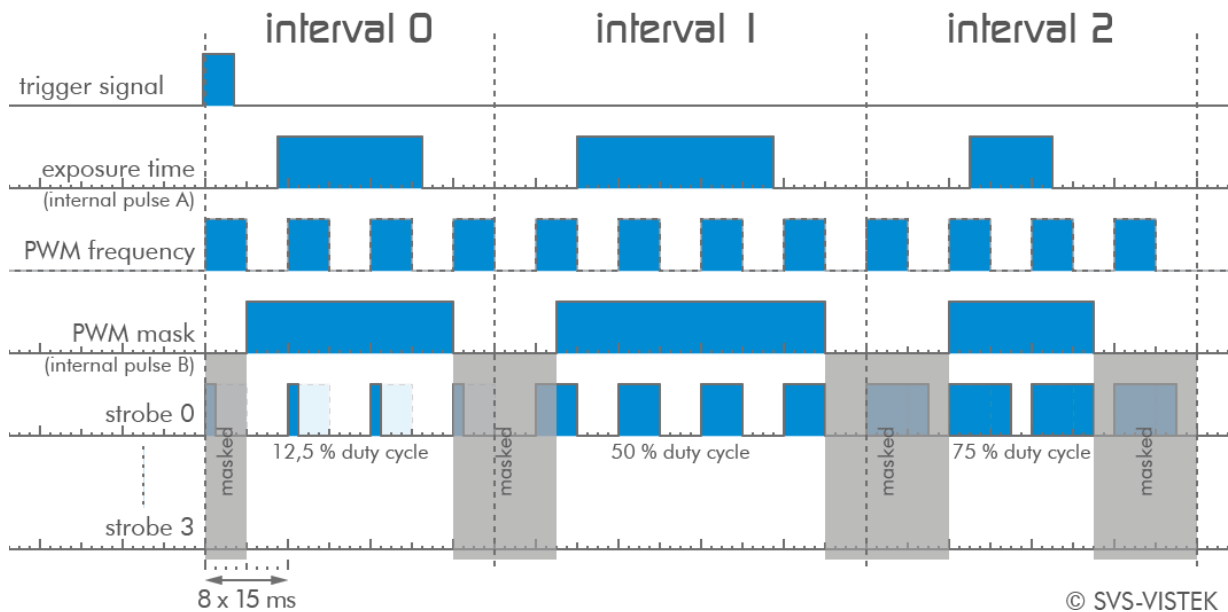
Figure 54: illustration of three sequencer intervals

7.3.4 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:

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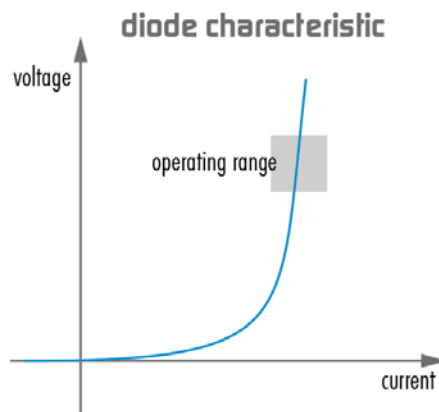
The basic frequency of the modulation is defined by the cycle duration "T".

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

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.

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

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:
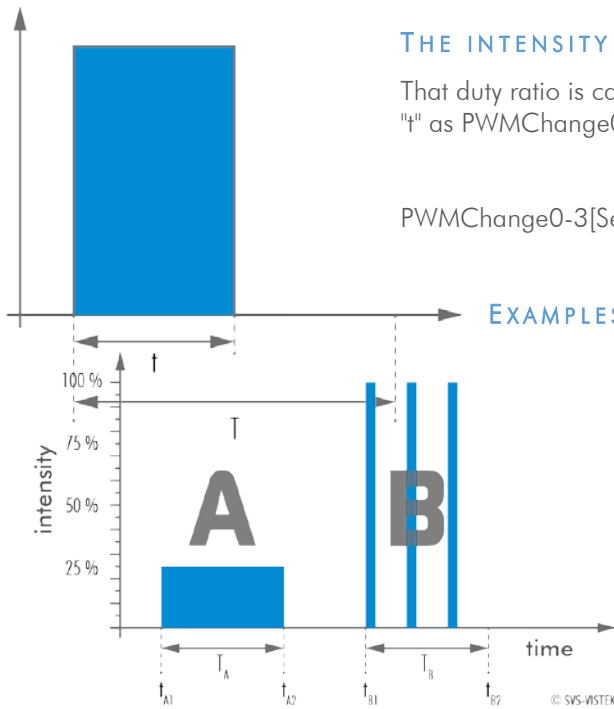
Figure 55: 25 % intensity
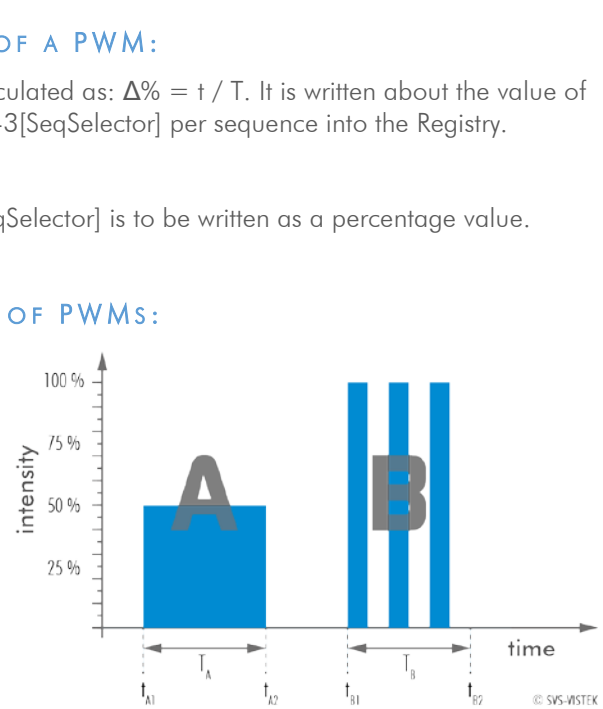
Figure 56: 50 % intensity

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.
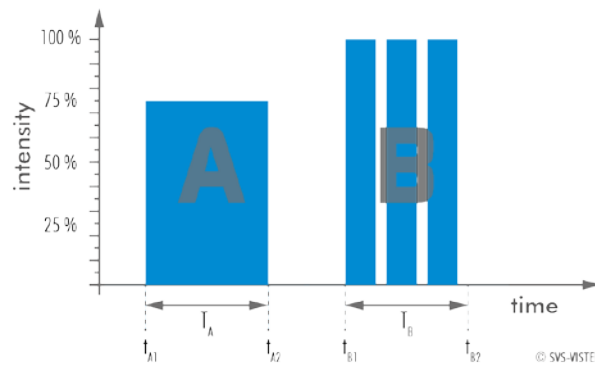
Figure 57: 75 % intensity

THE PWM MODULE:

clk

pulse_in

PWM_MAX

PWM_CHANGE[A,B,C,D]

I/O
PWM

PWM_pulse_out
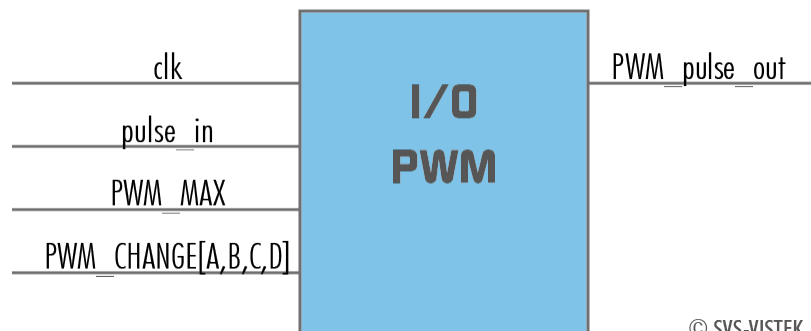
© SVS-VISTEK

7.3.5 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.
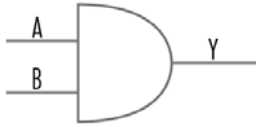
AND

Both trigger inputs have to be true.

A	B	$Y = A \wedge B$
0	0	0
0	1	0
1	0	0
1	1	1
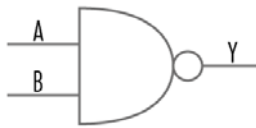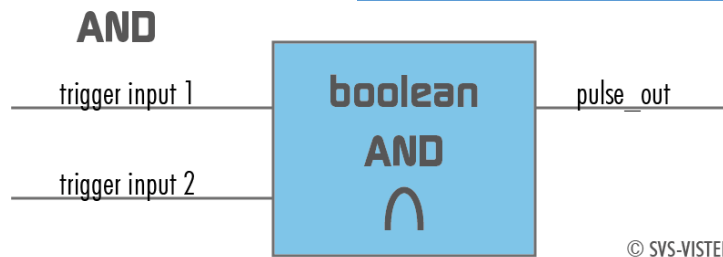
NAND

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
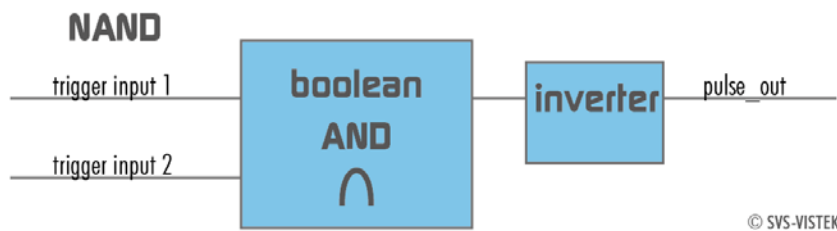
OR

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	$Y = A \bar{v} B$	NOR	Y = A v B	NOR i
0	0	1		0	
0	1	0		1	
1	0	0		1	
1	1	0		1	
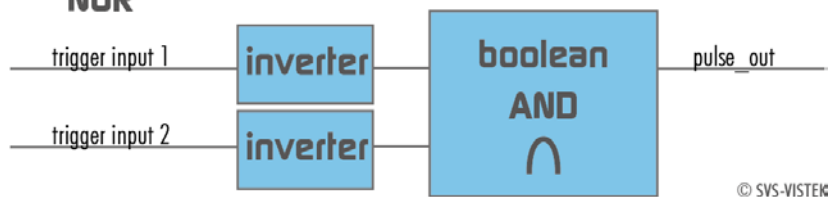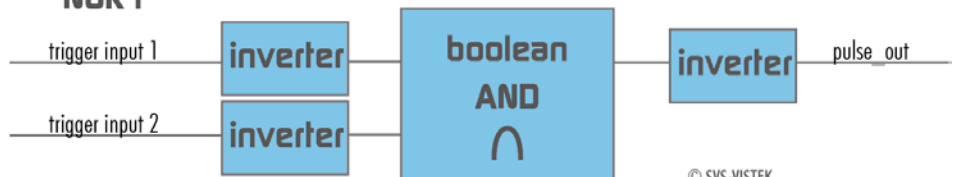
7.3.6 Serial data interfaces

(ANSI EIA/) TIA-232-F

RS-232 and RS-422 (from EIA, read as Radio Sector or commonly as Recommended Standard) are technical standards to specify electrical characteristics of digital signaling circuits.

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 1: 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)
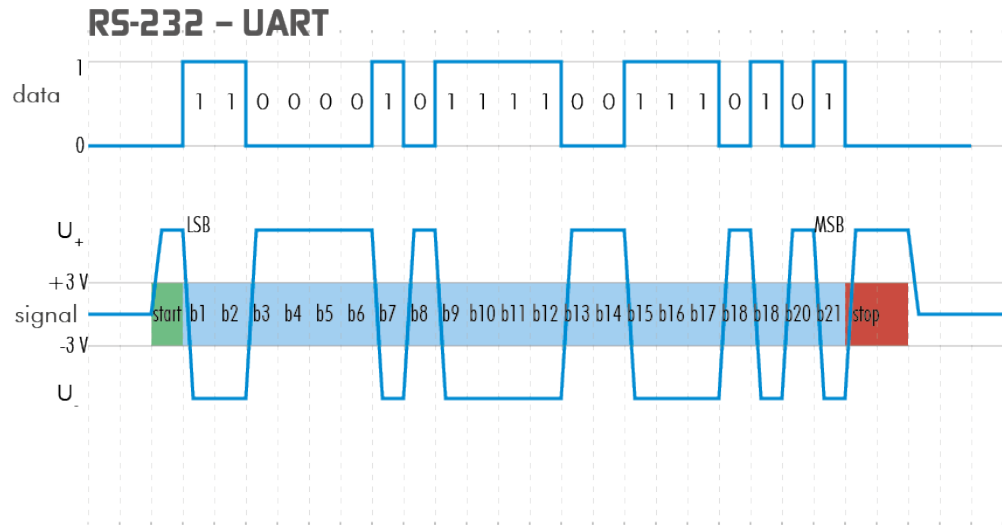
Figure 58: UART encoding of a data stream

RS-422

RS-422 is a differential low voltage communication standard.
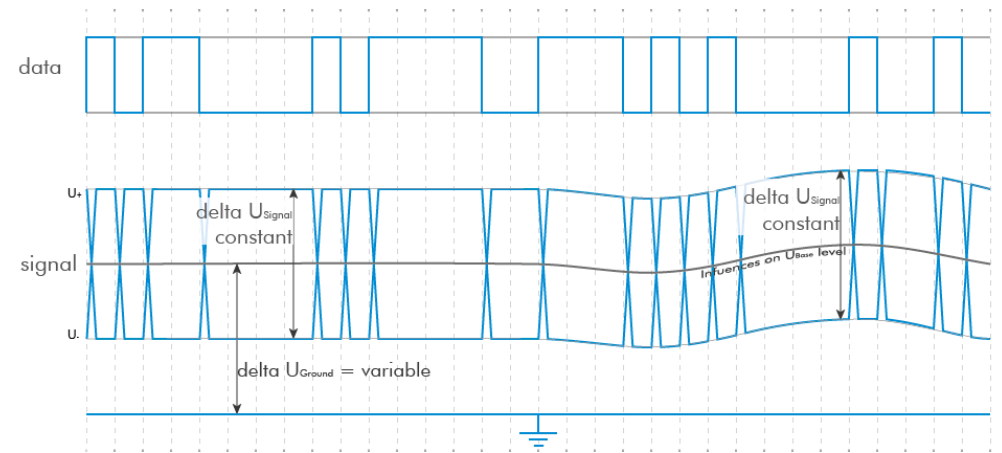
Figure 59: LVDS signal – no return to zero volt

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

7.3.7 Trigger-Edge Sensitivity

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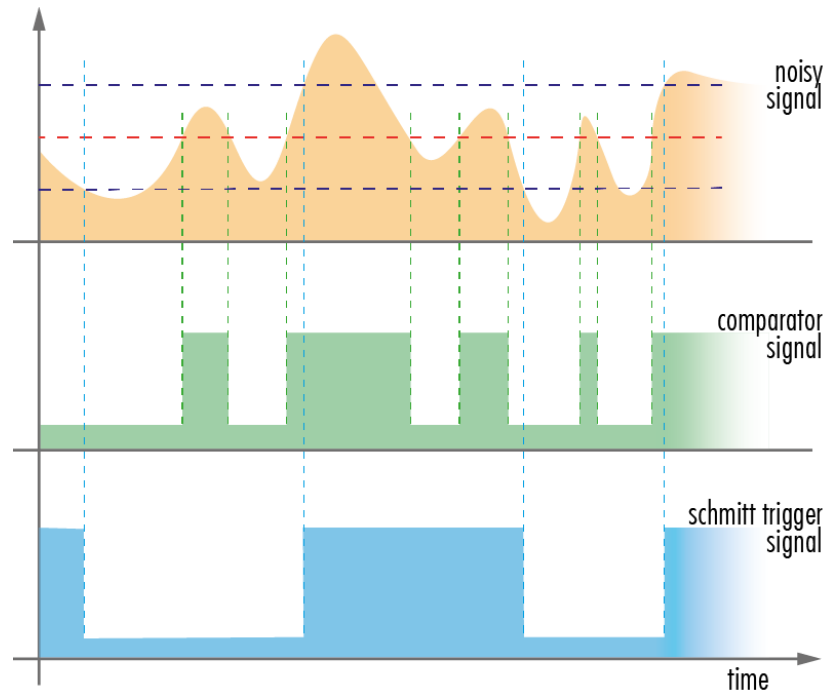
7.3.8 Debouncing Trigger Signals

Bounces or glitches caused by a switch can be avoided by software within the SVCam.
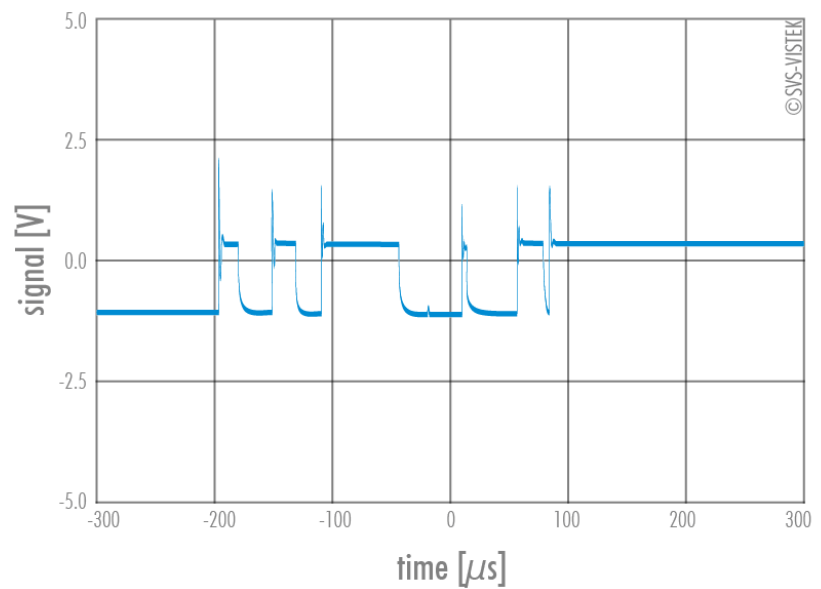
Figure 61: bounces or glitches caused by a switch

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
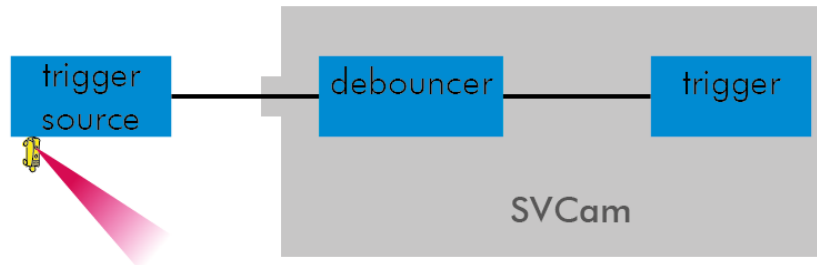
Figure 62: debouncer between the trigger source and trigger

The Debouncer module
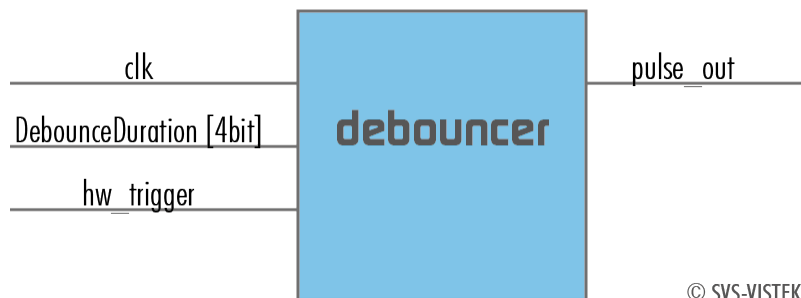
Figure 63: Illustration of the debouncer module

7.3.9 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)
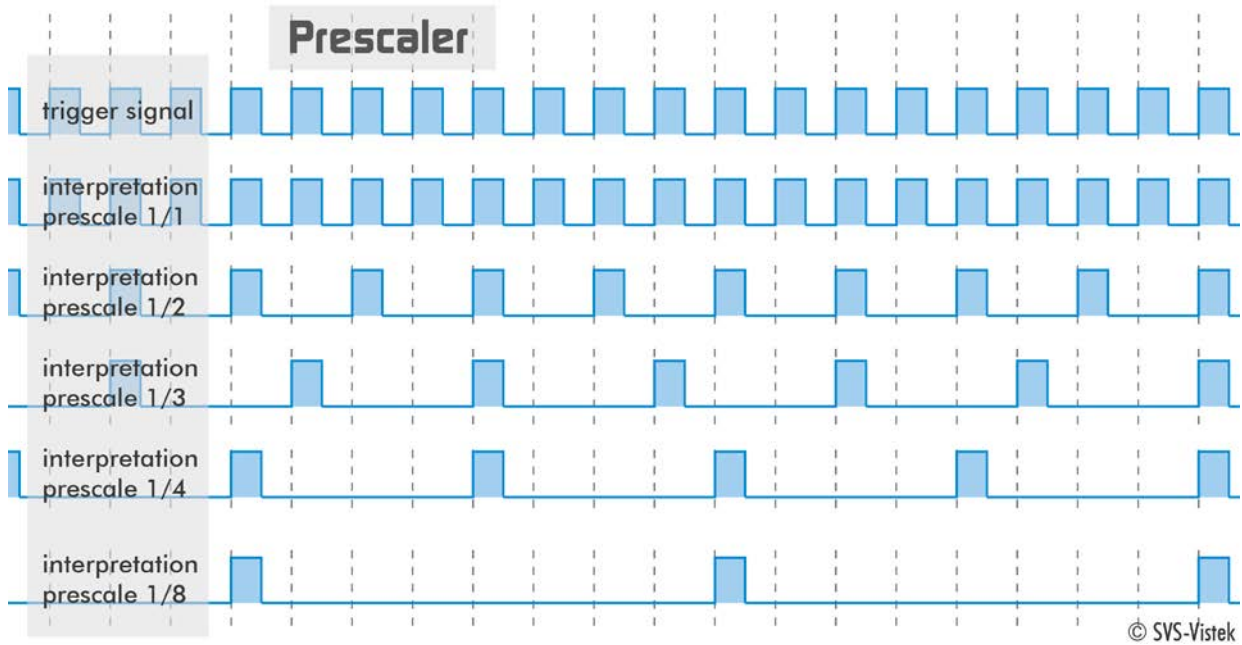
Figure 64: Prescale values

The prescale module
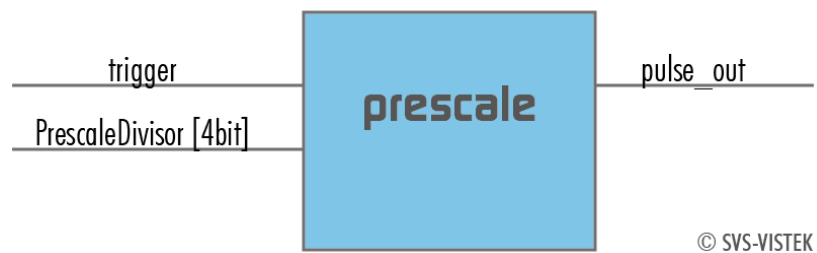
Figure 65: Illustration of the prescale module

8 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.

8.1 hr11002*TLGEC

Model	hr11002MTLGEC	hr11002CTLGEC
familiy	HR	HR
active pixel w x h	4032 x 2672	4032 x 2672
max. frame rate	6,5 fps	6,5 fps
chroma	mono	color
interface	Dual GigE Vision	Dual GigE Vision
sensor name	KAI-11002-A	KAI-11002-C
sensor manufacturer	ON Semiconductor	ON Semiconductor
sensor architecture	Area CCD	Area CCD
shutter type	global	global
equivalent format	35 mm	35 mm
diagonal	43,4 mm	43,4 mm
pixel w x h	9x9 μm	9x9 μm
optic sensor w x h	37,35x25,7 mm	37,35x25,7 mm
exposure time	121 μs / 60s	121 μs / 60s
max. gain	18 dB	18 dB
dynamic range	60 dB	60 dB
S/N Ratio		
frame buffer	128MB RAM 0MB Flash	128MB RAM 0MB Flash
CL_geometry	-	-
frequency select	-	-
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	12to8(1)	12to8(1)
ROI	1	1
white balancing	-	auto;manual
tap balancing	manual;auto	manual;auto
gain	manual	manual
black level	manual	manual
particle image velocimetry	x	x
readout control	manual;delayed	manual;delayed
flat field correction	-	-
shading correction	x	x
defect pixel correction	off;factory;custom	off;factory;custom
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	2	2
optical in / out	- / -	- / -
RS-232 in / out	1 / 1	1 / 1
RS-422 in / out	1 / 1	1 / 1
power supply	10...25 V	10...25 V

lens mount	M58x0.75	M58x0.75
dynamic lens control	-	-
size w / h / d (1)	70x71x55,4 mm	70x71x55,4 mm
weight	320 g	320 g
protection class	IP30	IP30
power consumption	8,0 W	8,0 W
ambient temperature	-10...45°C	-10...45°C
rel. humidity non-condensing	10…90 %	10…90 %
status	production	production

(1) please refer to model drawings

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Spectral Sensitivity Characteristics

Figure 66: Spectral Sensitivity Characteristics KAI-11002-C
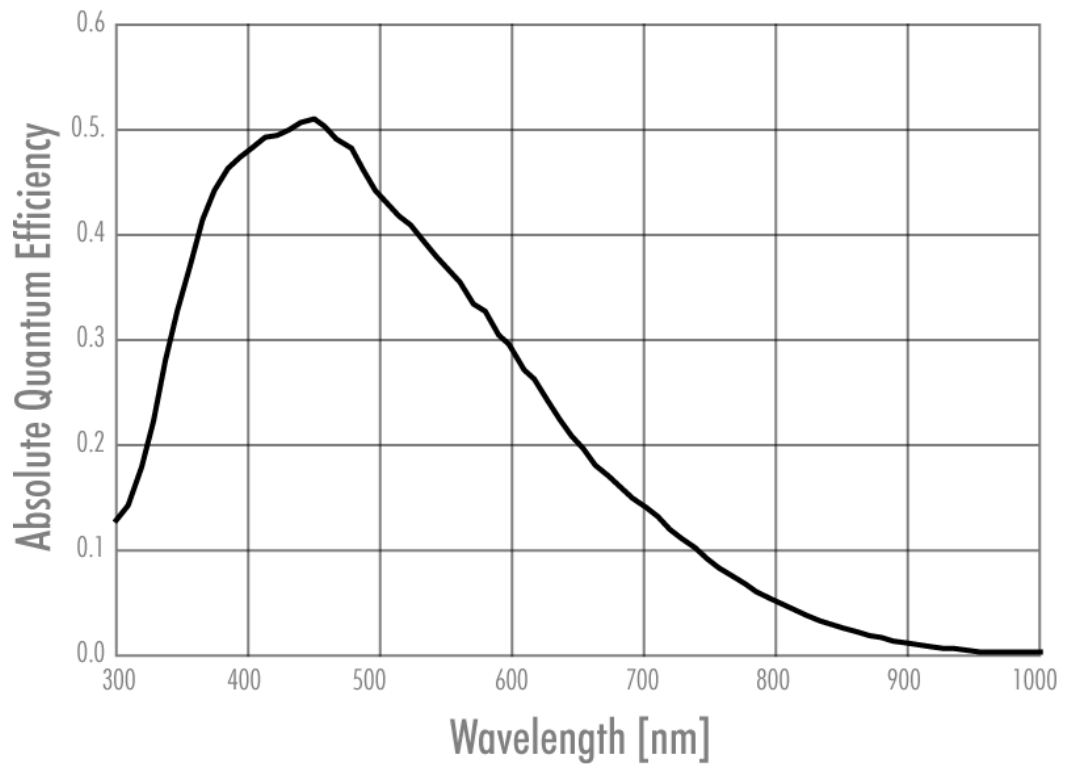
Figure 67: Spectral Sensitivity Characteristics KAI-11002-A

8.2 hr16000*TLGEC

Model	hr16000MTLGEC	hr16000CTLGEC
familiy	HR	HR
active pixel w x h	4896 x 3248	4896 x 3248
max. frame rate	4 fps	4 fps
chroma	mono	color
interface	Dual GigE Vision	Dual GigE Vision

sensor name	KAI-16000-A	KAI-16000-C
sensor manufacturer	ON Semiconductor	ON Semiconductor
sensor architecture	Area CCD	Area CCD
shutter type	global	global
equivalent format	35 mm	35 mm
diagonal	43,3 mm	43,3 mm
pixel w x h	7,4x7,4 μm	7,4x7,4 μm
optic sensor w x h	36,1x24 mm	36,1x24 mm
exposure time	203 μs / 60s	203 μs / 60s
max. gain	18 dB	18 dB
dynamic range	60 dB	60 dB
S/N Ratio		

frame buffer	128MB RAM 0MB Flash	128MB RAM 0MB Flash
CL_geometry	-	-
frequency select	-	-
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	12to8(1)	12to8(1)
ROI	1	1
white balancing	-	auto;manual
tap balancing	manual;auto	manual;auto
gain	manual	manual
black level	manual	manual
particle image velocimetry	x	x
readout control	manual;delayed	manual;delayed
flat field correction	-	-
shading correction	x	x
defect pixel correction	off;factory;custom	off;factory;custom
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	2	2
optical in / out	- / -	- / -
RS-232 in / out	1 / 1	1 / 1
RS-422 in / out	1 / 1	1 / 1
power supply	10...25 V	10...25 V

lens mount	M58x0.75	M58x0.75
dynamic lens control	-	-
size w / h / d (1)	70x71x55,4 mm	70x71x55,4 mm
weight	320 g	320 g
protection class	IP30	IP30
power consumption	7,0 W	7,0 W
ambient temperature	-10...45°C	-10...45°C
rel. humidity non-condensing	10...90 %	10...90 %
status	production	production

(1) please refer to model drawings

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Spectral Sensitivity Characteristics

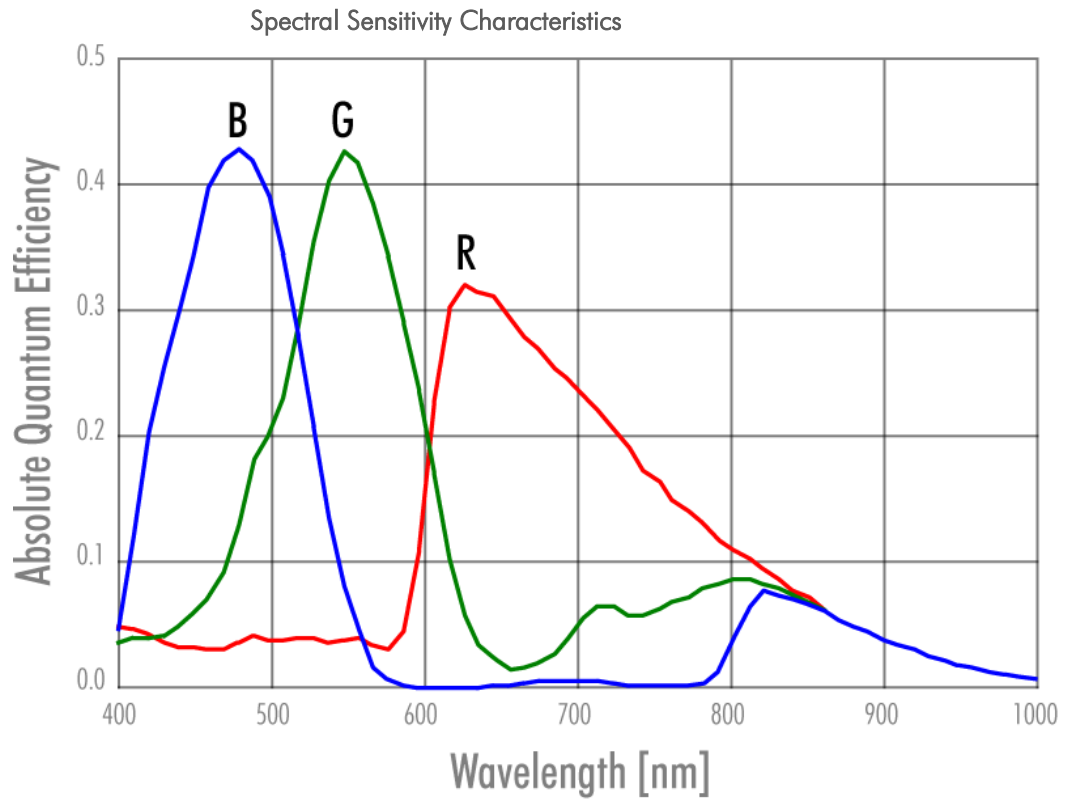Figure 68: Spectral Sensitivity Characteristics KAI-16000-C
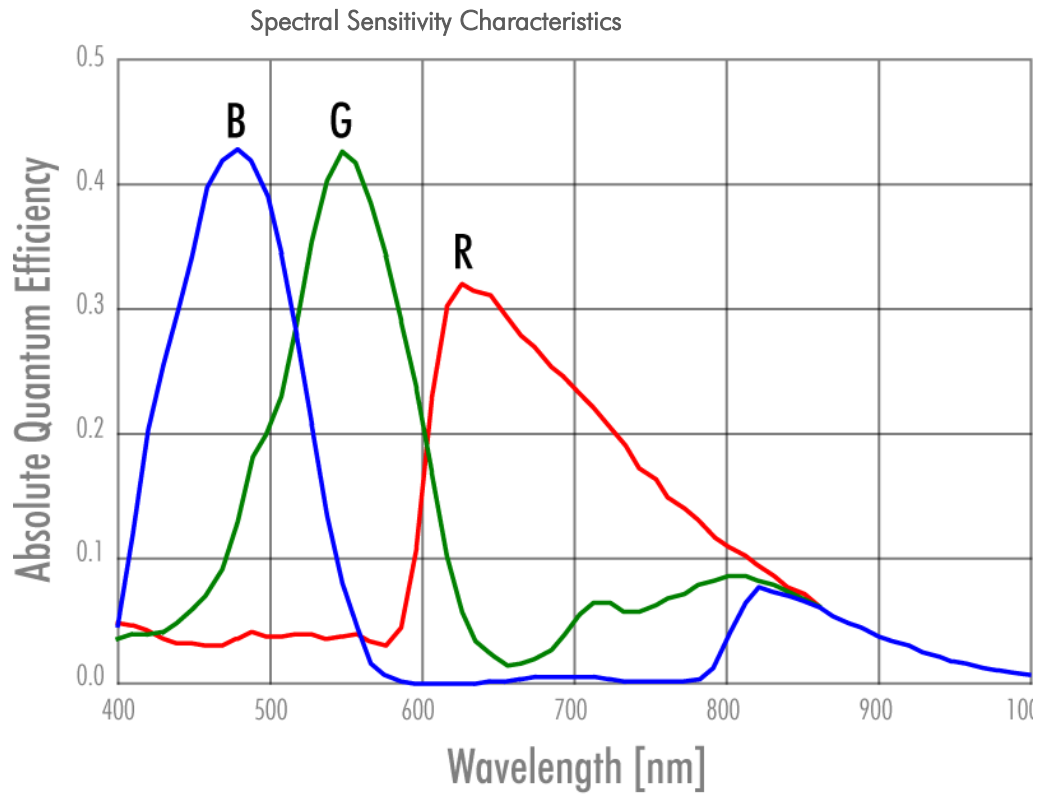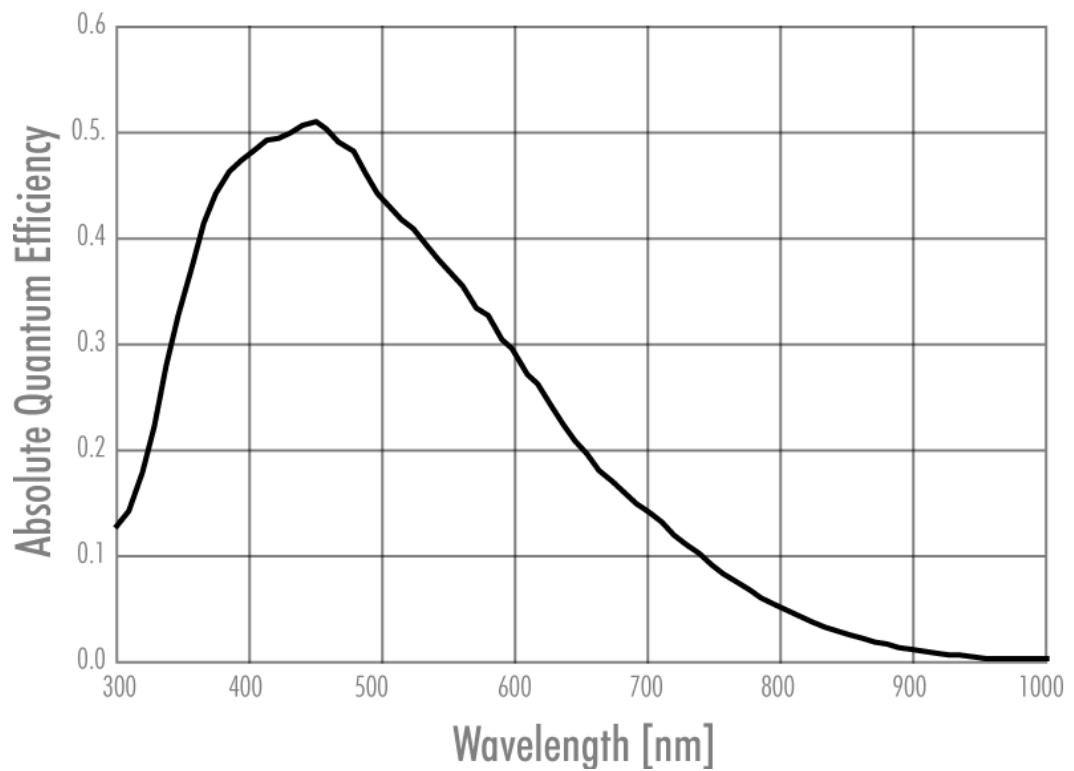

Figure 69: Spectral Sensitivity Characteristics KAI-16000-A

8.3 hr16050*FLGEA

Model	hr16050MFLGEA	hr16050CFLGEA
familiy	HR	HR
active pixel w x h	4896 x 3264	4896 x 3264
max. frame rate	10 fps	10,8 fps
chroma	mono	color
interface	Dual GigE Vision	Dual GigE Vision

sensor name	KAI-16050-A	KAI-16050-C
sensor manufacturer	ON Semiconductor	ON Semiconductor
sensor architecture	Area CCD	Area CCD
shutter type	global	global
equivalent format	APS-H	APS-H
diagonal	32,4 mm	32,4 mm
pixel w x h	5,5x5,5 μm	5,5x5,5 μm
optic sensor w x h	26,93x19,95 mm	26,93x19,95 mm
exposure time	17 μs / 60s	17 μs / 60s
max. gain	18 dB	18 dB
dynamic range	62 dB	61 dB
S/N Ratio	43.5	43.6

frame buffer	128MB RAM 136MB Flash	128MB RAM 136MB
CL_geometry	-	-
frequency select	-	-
exp. time adjustment	manual;auto;external	manual;auto;external
px format 8 / 12 / 16	x / - / -	x / - / -
packed readout	-	-
max binning h / v	2 / 2	2 / 2
LUT	12to8(1)	12to8(1)
ROI	1	1
white balancing	-	auto;manual
tap balancing	manual;auto	manual;auto
gain	manual	manual
black level	manual	manual
particle image velocimetry	x	x
readout control	manual;delayed	manual;delayed
flat field correction	-	-
shading correction	x	x
defect pixel correction	off;factory;custom	off;factory;custom
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	2	2
optical in / out	- / -	- / -
RS-232 in / out	1 / 1	1 / 1
RS-422 in / out	1 / 1	1 / 1
power supply	10...25 V	10...25 V

lens mount	M58x0.75	M58x0.75
dynamic lens control	-	-
size w / h / d (1)	70x71x55,4 mm	70x71x55,4 mm
weight	320 g	320 g
protection class	IP30	IP30
power consumption	10,0 W	10,0 W
ambient temperature	-10...45°C	-10...45°C
rel. humidity non-condensing	10…90 %	10…90 %
status	production	production

(1) please refer to model drawings

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8.4 hr16050*FLGEC

Model	hr16050MFLGEC	hr16050CFLGEC
familiy	HR	HR
active pixel w x h	4896 x 3264	4896 x 3264
max. frame rate	8 fps	8 fps
chroma	mono	color
interface	Dual GigE Vision	Dual GigE Vision

sensor name	KAI-16050-A	KAI-16050-C
sensor manufacturer	ON Semiconductor	ON Semiconductor
sensor architecture	Area CCD	Area CCD
shutter type	global	global
equivalent format	APS-H	APS-H
diagonal	32,4 mm	32,4 mm
pixel w x h	5,5x5,5 μm	5,5x5,5 μm
optic sensor w x h	26,93x19,95 mm	26,93x19,95 mm
exposure time	17 μs / 60s	17 μs / 60s
max. gain	18 dB	18 dB
dynamic range	61 dB	61 dB
S/N Ratio		

frame buffer	128MB RAM 136MB Flash	128MB RAM 136MB
CL_geometry	-	-
frequency select	-	-
exp. time adjustment	manual;auto;external	manual;auto;external
px format 8 / 12 / 16	x / x / -	x / x / -
packed readout	x	x
max binning h / v	2 / 2	2 / 2
LUT	12to8(1)	12to8(1)
ROI	1	1
white balancing	-	auto;manual
tap balancing	manual;auto	manual;auto
gain	manual	manual
black level	manual	manual
particle image velocimetry	x	x
readout control	manual;delayed	manual;delayed
flat field correction	-	-
shading correction	x	x
defect pixel correction	off;factory;custom	off;factory;custom
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	2	2
optical in / out	- / -	- / -
RS-232 in / out	1 / 1	1 / 1
RS-422 in / out	1 / 1	1 / 1
power supply	10...25 V	10...25 V

lens mount	M58x0.75	M58x0.75
dynamic lens control	-	-
size w / h / d (1)	70x71x55,4 mm	70x71x55,4 mm
weight	320 g	320 g
protection class	IP30	IP30
power consumption	10,0 W	10,0 W
ambient temperature	-10...45°C	-10...45°C
rel. humidity non-condensing	10…90 %	10…90 %
status	production	production

(1) please refer to model drawings

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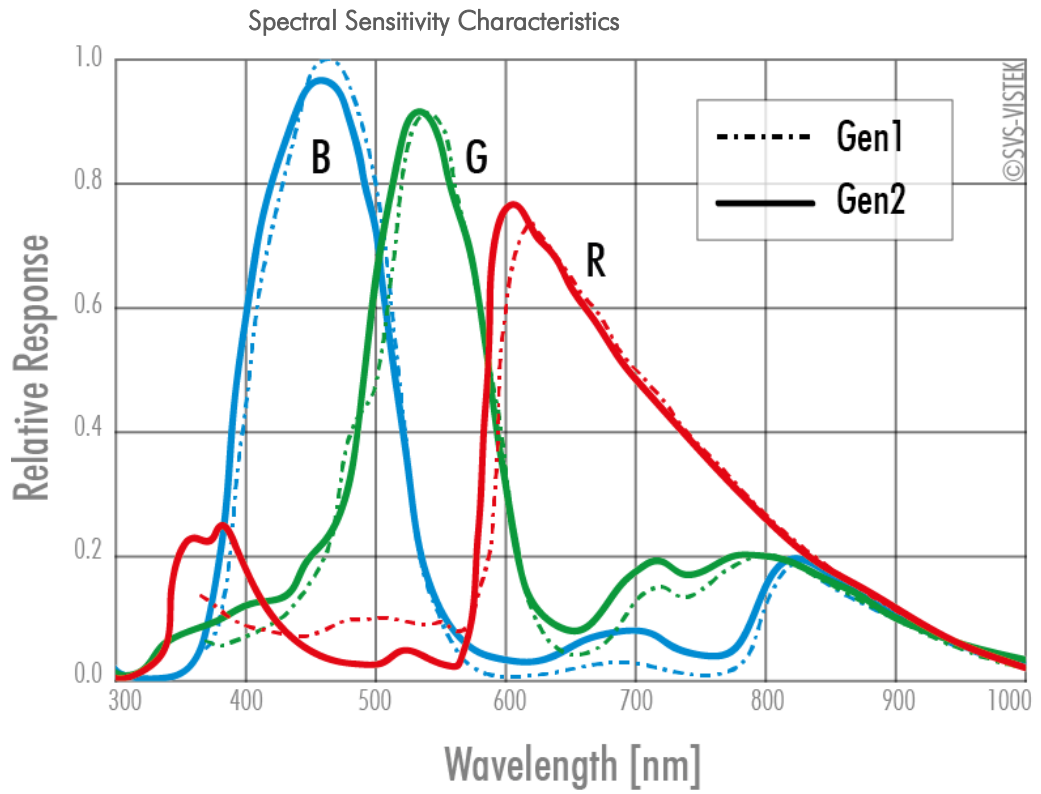
Spectral Sensitivity Characteristics

Figure 70 Spectral Sensitivity Characteristics KAI-16050-A
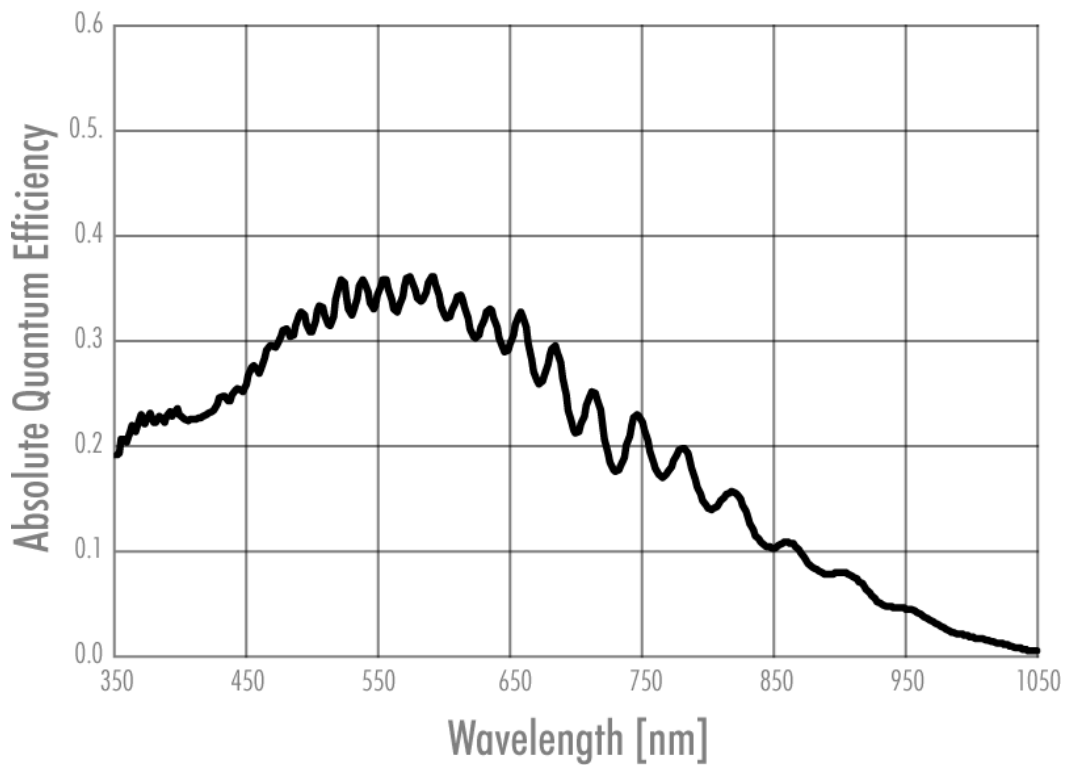
Figure 71: Spectral Sensitivity Characteristics KAI-16050-C

8.5 hr16070*FLGEA

Model	hr16070MFLGEA	hr16070CFLGEA
familiy	HR	HR
active pixel w x h	4864 x 3232	4864 x 3232
max. frame rate	11 fps	11 fps
chroma	mono	color
interface	Dual GigE Vision	Dual GigE Vision
sensor name	KAI-16070-A	KAI-16070-C
sensor manufacturer	ON Semiconductor	ON Semiconductor
sensor architecture	Area CCD	Area CCD
shutter type	global	global
equivalent format	35 mm	35 mm
diagonal	43,2 mm	43,2 mm
pixel w x h	7,4x7,4 μm	7,4x7,4 μm
optic sensor w x h	36x23,9 mm	36x23,9 mm
exposure time	17 μs / 60s	17 μs / 60s
max. gain	18 dB	18 dB
dynamic range	59 dB	59 dB
S/N Ratio		
frame buffer	128MB RAM 136MB Flash	128MB RAM 136MB
CL_geometry	-	-
frequency select	-	-
exp. time adjustment	manual;auto;external	manual;auto;external
px format 8 / 12 / 16	x / - / -	x / - / -
packed readout	-	-
max binning h / v	2 / 2	2 / 2
LUT	12to8(1)	12to8(1)
ROI	1	1
white balancing	-	auto;manual
tap balancing	manual;auto	manual;auto
gain	manual	manual
black level	manual	manual
particle image velocimetry	x	x
readout control	manual;delayed	manual;delayed
flat field correction	-	-
shading correction	x	x
defect pixel correction	off;factory;custom	off;factory;custom
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	2	2
optical in / out	- / -	- / -
RS-232 in / out	1 / 1	1 / 1
RS-422 in / out	1 / 1	1 / 1
power supply	10...25 V	10...25 V

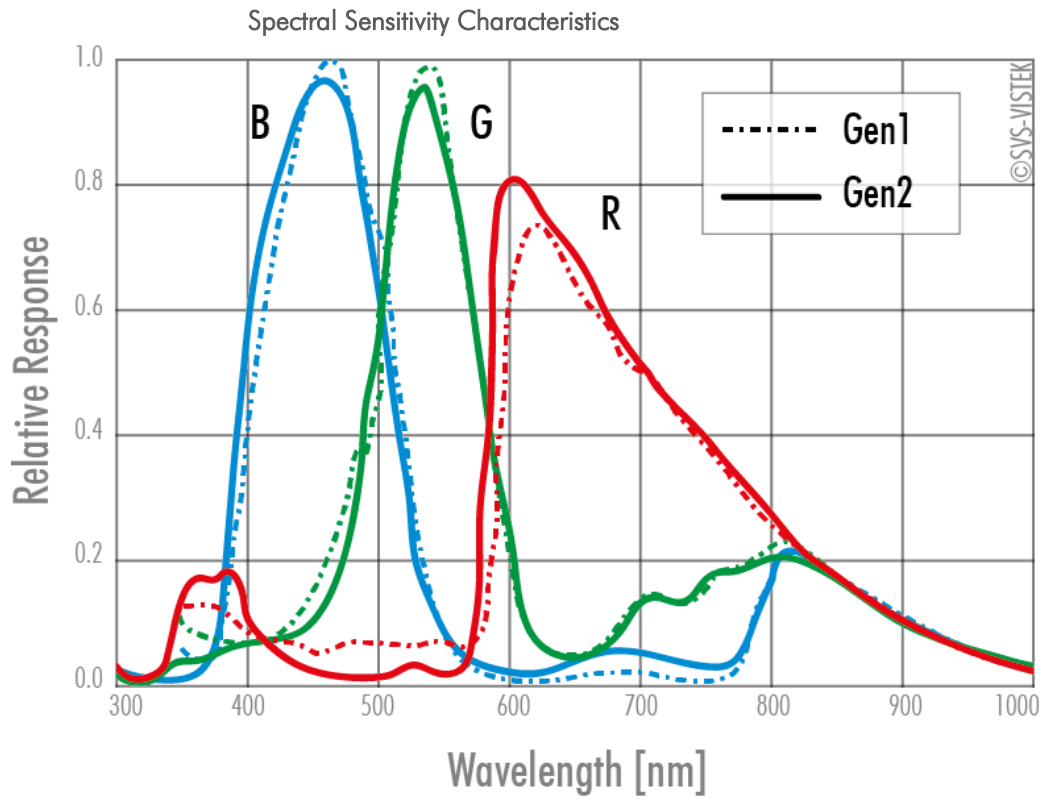|		
lens mount	M58x0.75	M58x0.75
dynamic lens control	-	-
size w / h / d (1)	70x71x55,4 mm	70x71x55,4 mm
weight	320 g	320 g
protection class	IP30	IP30
power consumption	10,0 W	10,0 W
ambient temperature	-10...45°C	-10...45°C
rel. humidity non-condensing	10...90 %	10...90 %
status	production	production

(1) please refer to model drawings

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8.6 hr16070*FLGEC

Model	hr16070MFLGEC	hr16070CFLGEC
familiy	HR	HR
active pixel w x h	4864 x 3232	4864 x 3232
max. frame rate	8,8 fps	8,8 fps
chroma	mono	color
interface	Dual GigE Vision	Dual GigE Vision

sensor name	KAI-16070-A	KAI-16070-C
sensor manufacturer	ON Semiconductor	ON Semiconductor
sensor architecture	Area CCD	Area CCD
shutter type	global	global
equivalent format	35 mm	35 mm
diagonal	43,2 mm	43,2 mm
pixel w x h	7,4x7,4 µm	7,4x7,4 µm
optic sensor w x h	36x23,9 mm	36x23,9 mm
exposure time	22 µs / 60s	22 µs / 60s
max. gain	18 dB	18 dB
dynamic range	62 dB	62 dB
S/N Ratio		

frame buffer	128MB RAM 136MB Flash	128MB RAM 136MB
CL_geometry	-	-
frequency select	-	-
exp. time adjustment	manual;auto;external	manual;auto;external
px format 8 / 12 / 16	x / x / -	x / x / -
packed readout	x	x
max binning h / v	2 / 2	2 / 2
LUT	12to8(1)	12to8(1)
ROI	1	1
white balancing	-	auto;manual
tap balancing	manual;auto	manual;auto
gain	manual	manual
black level	manual	manual
particle image velocimetry	x	x
readout control	manual;delayed	manual;delayed
flat field correction	-	-
shading correction	x	x
defect pixel correction	off;factory;custom	off;factory;custom
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	2	2
optical in / out	- / -	- / -
RS-232 in / out	1 / 1	1 / 1
RS-422 in / out	1 / 1	1 / 1
power supply	10...25 V	10...25 V

lens mount	M58x0.75	M58x0.75
dynamic lens control	-	-
size w / h / d (1)	70x71x55,4 mm	70x71x55,4 mm
weight	320 g	320 g
protection class	IP30	IP30
power consumption	10,0 W	10,0 W
ambient temperature	-10...45°C	-10...45°C
rel. humidity non-condensing	10…90 %	10…90 %
status	production	production

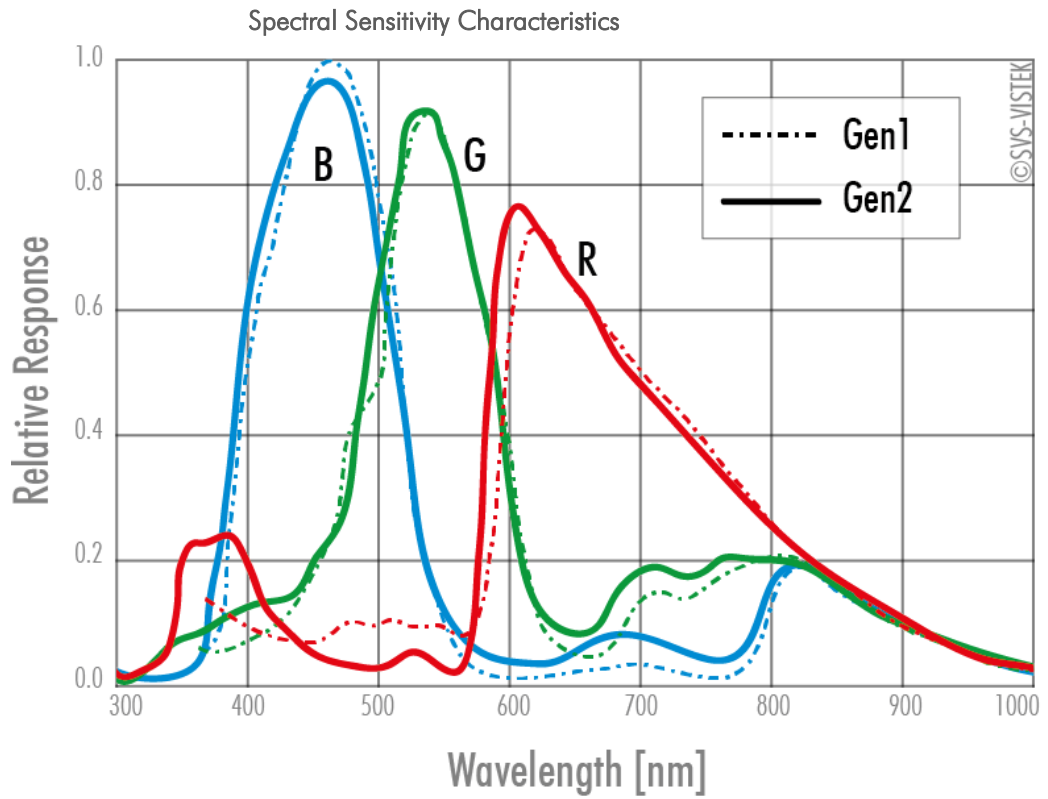(1) please refer to model drawings

Figure 72: Spectral Sensitivity Characteristics KAI-16070-C
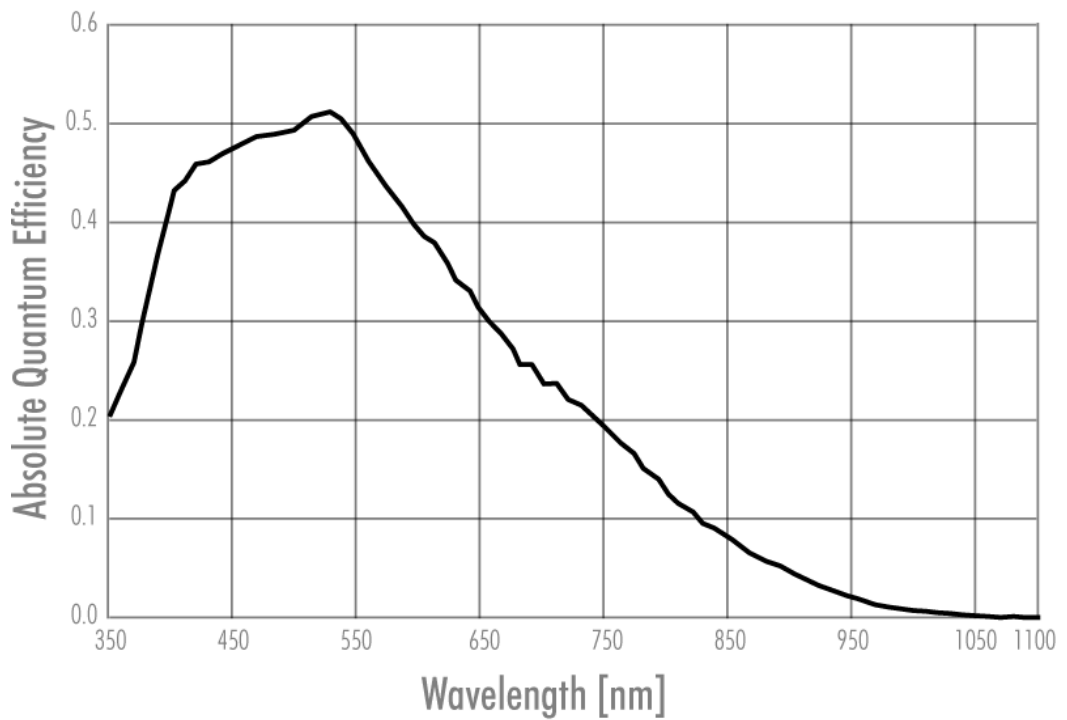
Figure 73: Spectral Sensitivity Characteristics KAI-16070-C

8.7 hr29050*FLGEA

Model	hr29050MFLGEA	hr29050CFLGEA
familiy	HR	HR
active pixel w x h	6576 x 4384	6576 x 4384
max. frame rate	6,2 fps	6,2 fps
chroma	mono	color
interface	Dual GigE Vision	Dual GigE Vision

sensor name	KAI-29050-A	KAI-29050-C
sensor manufacturer	ON Semiconductor	ON Semiconductor
sensor architecture	Area CCD	Area CCD
shutter type	global	global
equivalent format	35 mm	35 mm
diagonal	43,5 mm	43,5 mm
pixel w x h	5,5x5,5 μm	5,5x5,5 μm
optic sensor w x h	36,17x24,11 mm	36,17x24,11 mm
exposure time	10 μs / 60s	10 μs / 60s
max. gain	18 dB	18 dB
dynamic range	59 dB	59 dB
S/N Ratio	43.6	43

frame buffer	128MB RAM 136MB Flash	128MB RAM 136MB
CL_geometry	-	-
frequency select	-	-
exp. time adjustment	manual;auto;external	manual;auto;external
px format 8 / 12 / 16	x / - / -	x / - / -
packed readout	-	-
max binning h / v	2 / 2	2 / 2
LUT	12to8(1)	12to8(1)
ROI	1	1
white balancing	-	auto;manual
tap balancing	manual;auto	manual;auto
gain	manual	manual
black level	manual	manual
particle image velocimetry	x	x
readout control	manual;delayed	manual;delayed
flat field correction	-	-
shading correction	x	x
defect pixel correction	off;factory;custom	off;factory;custom
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	2	2
optical in / out	- / -	- / -
RS-232 in / out	1 / 1	1 / 1
RS-422 in / out	1 / 1	1 / 1
power supply	10...25 V	10...25 V

lens mount	M58x0.75	M58x0.75
dynamic lens control	-	-
size w / h / d (1)	70x71x55,4 mm	70x71x55,4 mm
weight	320 g	320 g
protection class	IP30	IP30
power consumption	10,0 W	10,0 W
ambient temperature	-10...45°C	-10...45°C
rel. humidity non-condensing	10...90 %	10...90 %
status	production	production

(1) please refer to model drawings

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8.8 hr29050*FLGEC

Model	hr29050MFLGEC	hr29050CFLGEC
familiy	HR	HR
active pixel w x h	6576 x 4384	6576 x 4384
max. frame rate	4,9 fps	4,9 fps
chroma	mono	color
interface	Dual GigE Vision	Dual GigE Vision

sensor name	KAI-29050-A	KAI-29050-C
sensor manufacturer	ON Semiconductor	ON Semiconductor
sensor architecture	Area CCD	Area CCD
shutter type	global	global
equivalent format	35 mm	35 mm
diagonal	43,5 mm	43,5 mm
pixel w x h	5,5x5,5 μm	5,5x5,5 μm
optic sensor w x h	36,17x24,11 mm	36,17x24,11 mm
exposure time	22 μs / 60s	22 μs / 60s
max. gain	18 dB	18 dB
dynamic range	59 dB	59 dB
S/N Ratio		

frame buffer	128MB RAM 0MB Flash	128MB RAM 0MB Flash
CL_geometry	-	-
frequency select	-	-
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	12to8(1)	12to8(1)
ROI	1	1
white balancing	-	auto;manual
tap balancing	manual;auto	manual;auto
gain	manual	manual
black level	manual	manual
particle image velocimetry	x	x
readout control	manual;delayed	manual;delayed
flat field correction	-	-
shading correction	x	x
defect pixel correction	off;factory;custom	off;factory;custom
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	2	2
optical in / out	- / -	- / -
RS-232 in / out	1 / 1	1 / 1
RS-422 in / out	1 / 1	1 / 1
power supply	10...25 V	10...25 V

lens mount	M58x0.75	M58x0.75
dynamic lens control	-	-
size w / h / d (1)	70x71x55,4 mm	70x71x55,4 mm
weight	320 g	320 g
protection class	IP30	IP30
power consumption	10,0 W	10,0 W
ambient temperature	-10...45°C	-10...45°C
rel. humidity non-condensing	10...90 %	10...90 %
status	production	production

(1) please refer to model drawings

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Spectral Sensitivity Characteristics

Figure 74: Spectral Sensitivity Characteristics KAI-29050-C
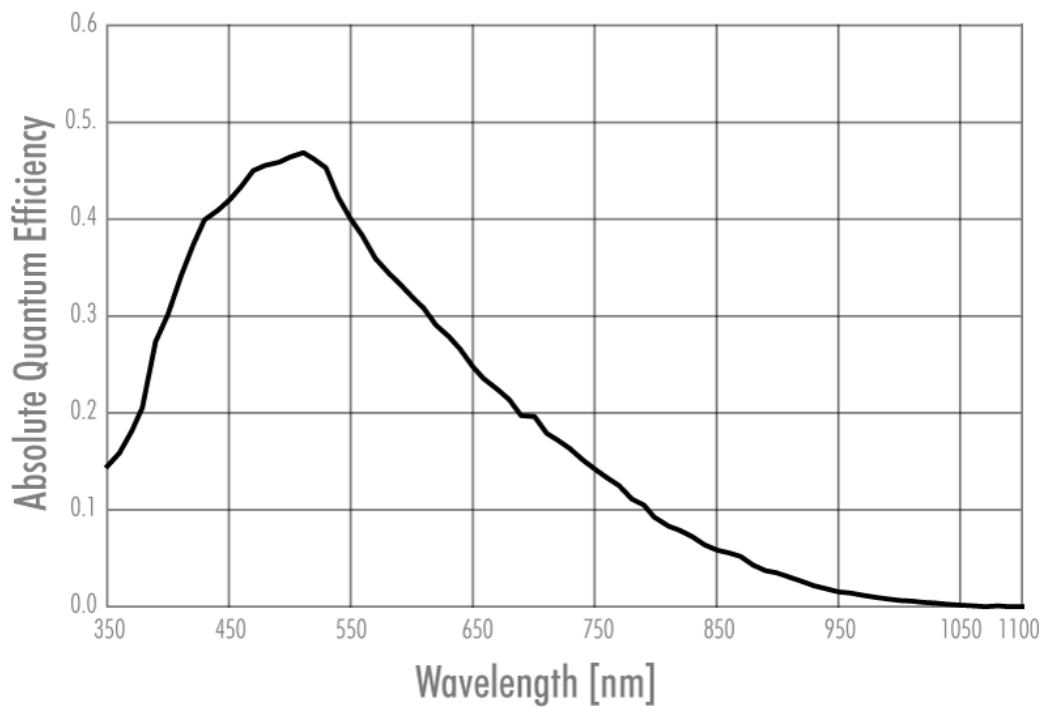
Figure 75: Spectral Sensitivity Characteristics KAI-29050-A

9 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 Pyramid Imaging.

10 Troubleshooting

10.1 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.

Please fax this form to
+1 (866) 874-9521

SENDER:

FIRM:

TEL:

MAIL:

10.2 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 Pyramid Imaging.

	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

11 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

12 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

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