SK2048VJR-4L
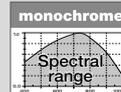
Monochrome Line Scan Camera

2048 pixels 14 x 14 µm², line frequency up to 4.7 kHz

Line scan camera with high sensitivity
and 4.7 kHz maximum line rate.

CCD

monochrome
Spectral range

GiGE™ VISION GEN<i>CAM

Instruction Manual

Sample Configuration

1 CCD line scan camera
SK2048VJR-4L
mounted with

2 Mounting bracket SK5105-L

3 Clamping claws SK5101

4 Focus adapter FA22R-45 (two-piece),
facilitates adjustment of any rotation angle

5 Enlarging lens Apo-Rodagon N 4.0/80

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How to Use this Instruction Manual

!

Please read the following sections of this Instruction Manual before unpacking, assembly or use of the Line Camera System:

The safety warnings on this page

Introduction to the system, page *4*

Installation and Setup, page *7*

Keep this Instruction Manual in a safe place for future reference.

Safety Warnings

▶ **Electricity Warning**

Assembly and initial operation of the line scan camera must be carried out under dry conditions.

Do not operate the camera if you notice any condensation or moisture in order to avoid danger of a short circuit or static discharge!

Line scan cameras are mostly used in combination with a motion device such as a translation stage, a conveyer or a rotational drive, as well as with high intensity light sources.

For assembly close down these devices whenever possible. Beyond that, please consider the following warnings:

▶ **Mechanics Warning**

Ensure that the motion device and the scan way is free to move and that no obstacles are in the way.

Do not place any part of the body in the way of moving parts!

▶ **Risk of High Power Lighting**

According to the application, laser or high power LED light sources might be used. These can affect your eyesight temporarily or even cause permanent damage to the eyes or skin.

Do not look directly into the light beam!

◼ Contents

■ 1 Introducing the SK2048VJR-4L Line Scan Camera

■ 1.1 Intended Purpose and Overview

The SK line scan camera series is designed for a wide range of vision and inspection applications in both industrial and scientific environments.

The SK2048VJR-4L GigE Vision™ line scan camera uses the Gigabit Ethernet communication protocol and is 100% compliant with the GigE Vision™ specifications and the Gen<I>Cam™ standard.

GigE Vision allows for fast image transfer using low cost standard cables up to distances of 100 m. With GigE Vision, hardware and software from different vendors can interoperate seamlessly via the GigE connections. The camera is connected to a computer either via the GigE socket directly or through a Gigabit Ethernet switch.

When taking the camera into operation the first time the Schäfter+Kirchhoff SkLineScan® program is recommended. Once the camera driver and the SkLineScan® program have been loaded from the SkLineScan CD or zip-file then the camera can be parameterized. The parameters, such as integration time, synchronization mode or shading correction, are permanently stored in the camera even after a power-down or disconnection from the PC.

The oscilloscope display in the SkLineScan® program can be used to adjust the focus and aperture settings, for evaluating field-flattening of the lens and for orientation of the illumination and the sensor, see *14.6 GigE Connections and SkLineScan Software Installation (p. 69)*.

The Schäfter+Kirchhoff GigE Vision line scan cameras implement a superset of the Gen<I>Cam™ specification which defines the device capabilities. The settings made in the SkLineScan® program are automatically provided to the device feature list of any Gen<I>Cam compliant software.

The Gen<I>Cam™ standard provides a generic programming interface for all kinds of cameras and, no
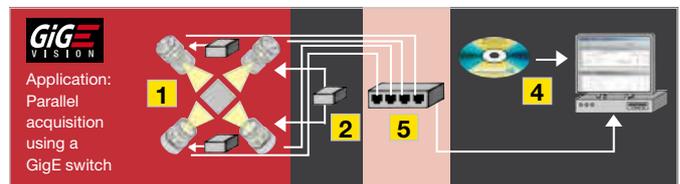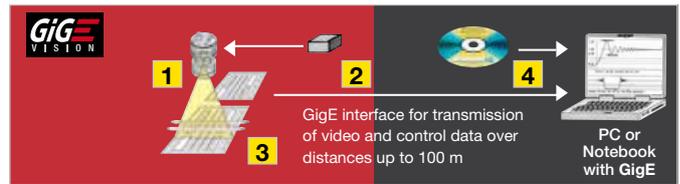
1	CCD line scan camera	4	Software GEN<I>CAM -compliant, eBus driver
2	Power supply		
3	Illumination	5	GigE switch

matter what features they implement, the application programming interface (API) always remains the same. The Gen<I>Cam™ standard consists of multiple modules relevant to the main tasks to be solved:

GenApi: for configuring the camera

Standard Feature Naming Convention (SFNC): recommended names and types for common features

GenTL: transport layer interface, for grabbing images

For more information on the GigE Vision™ specification, see:

https://www.visiononline.org/vision-standards-details. cfm?type=5

or the Gen<I>Cam™ standard:

http://www.emva.org/standards-technology/genicam/

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1.2 System Setup at a Glance

red: SK2048VJR-4L scope of delivery
blue: accessories for minimum system configuration
black: optional accessories

For accessory order details see *Accessories (p. 38)*.

Gigabit Ethernet cable

Power supply cable

Synchronization cable

Computer

Power supply
unit

Line scan camera

Clamping claw

Mounting bracket

Optics (e. g. lens,
focus adapter, tube
extension ring)

Schäfter+Kirchhoff
SkLineScan® adjustment
and control software

3rd party software
that supports the
GEN<i>CAM™ standard

Motion unit
with encoder
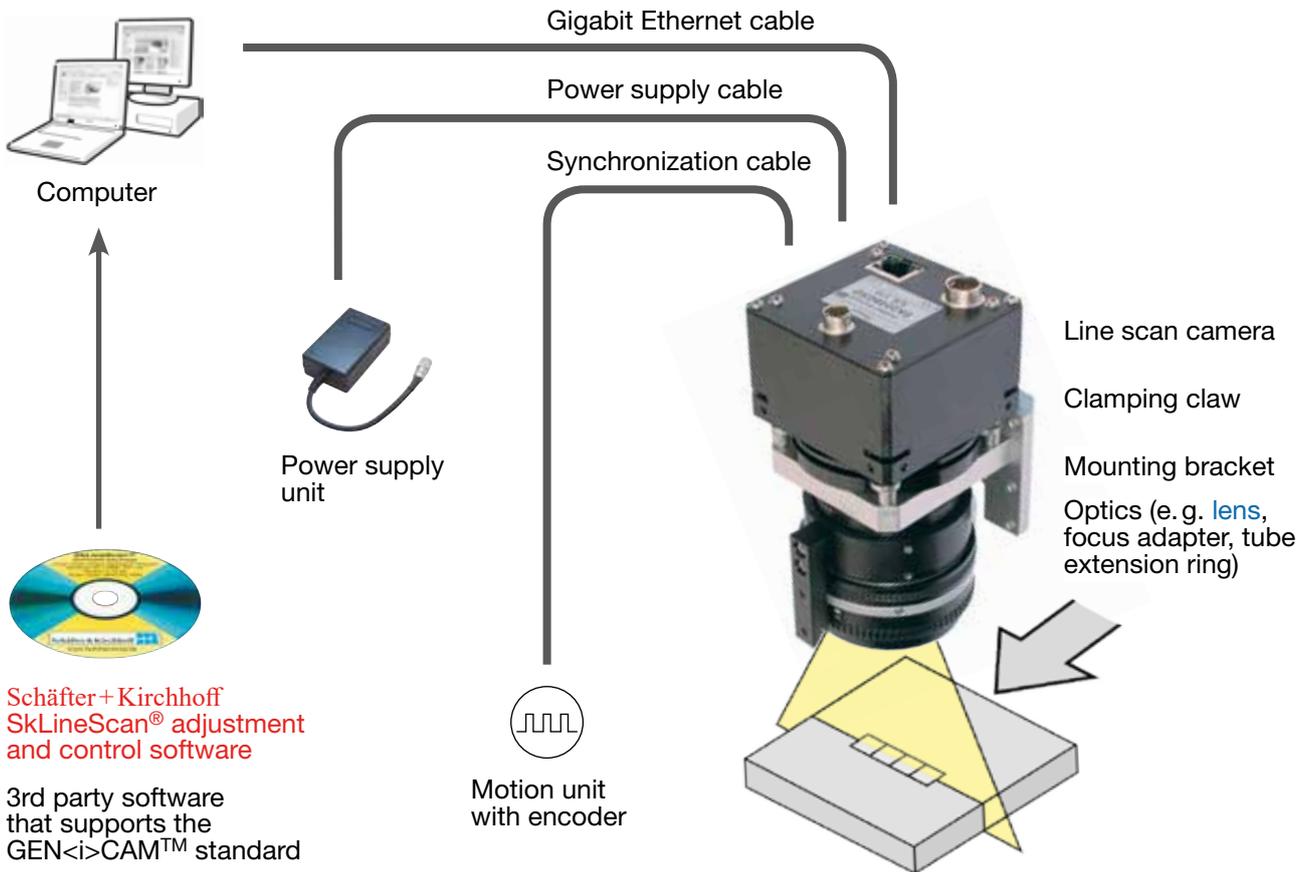
■ 1.3 Computer System Requirements

- Intel Pentium Dual Core or AMD equivalent
- RAM min. 4 GB, depending on size of acquired images
- High-performance video card, PCIe bus
- Operating Systems:
  Windows 7 / 8.1 / 10 (64 or 32-bit) or
  Linux kernel 3.13 or higher
- CD/DVD drive for software installation.

Network Adapter:

- Any Gigabit Ethernet network adapter as a card or on the motherboard is suitable. For the best performance, a network interface card (NIC) with Intel PRO/1000 chip is recommended.
- PCIe adapters outperform PCI adapters.
- Network adapters that support Jumbo Frames outperform adapters with fixed packet-size frames.

■ 1.4 SK2048VJR-4L Line Scan Camera - Specifications

Sensor category	CCD Monochrome Sensor
Sensor type	ILX751
Pixel number	2048
Pixel size (width x length)	14 x 14 µm^2
Pixel spacing	14 µm
Active sensor length	28.7 mm
Anti blooming	-
Integration control	x
Shading correction	x
Threshold detection	-
Line synchronization modes	Line Sync, Line Start, Exposure Start, Exposure Active
Frame synchronization	x
Pixel frequency	10 MHz
Maximum line frequency	4.7 kHz
Integration time	0.01 ... 20 ms
Dynamic range	1:625 (rms)
Spectral range	400 ... 900 nm
Video signal	monochrome 8/12 Bit digital
Interface	GigE Vision
Voltage	18 - 36 V DC
Power consumption	3.8 W
Casing	65 mm x 65 mm x 72.4 mm (Case type BG3)
Objective mount	M45x0.75
Flange focal length	19.5 mm
Weight	0.3 kg
Operating temperature	+5 ... +45°C

2 Installation and Setup

### 2.1 Mechanical Installation: Mounting Options and Dimensions

Mounting Options

- The best fixing point of the camera is the collar for the mounting bracket SK5105-L (available as an accessory).

- Four threaded holes M3 x 6.5 mm provide further options for customized brackets.

- The length and weight of the optics might be beyond the capability of the standard mounting bracket SK5105-L. For this purpose, a second mounting bracket type SK5105-2L to hold the tube extension ring(s) is more appropriate.

Optics Handling

- If the camera and the optics are ordered as a kit, the components are pre-assembled and shipped as one unit. Keep the protective cap on the lens until the mechanical installation is finished.

- If you must expose the sensor or lens surface, ensure the environment is as dust-free as possible.

- Gently blow off loose particles using clean compressed air.

- The sensor and lens surfaces can be cleaned with a soft tissue moistened with water or a water-based glass cleaner.

Casing type BG3

BG3	Lens mount:	M45x0.75
	Seat for bracket:	Ø47.5 mm
	Flange focal length:	FFL = 19.5 mm
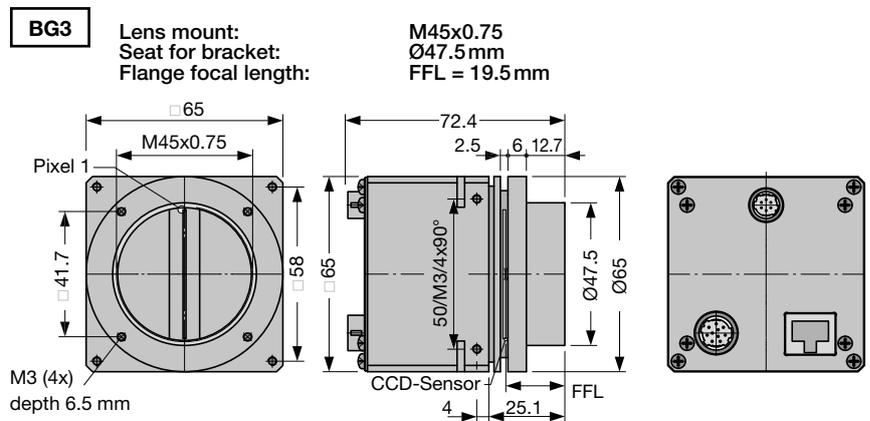
Mounting bracket SK5105-L
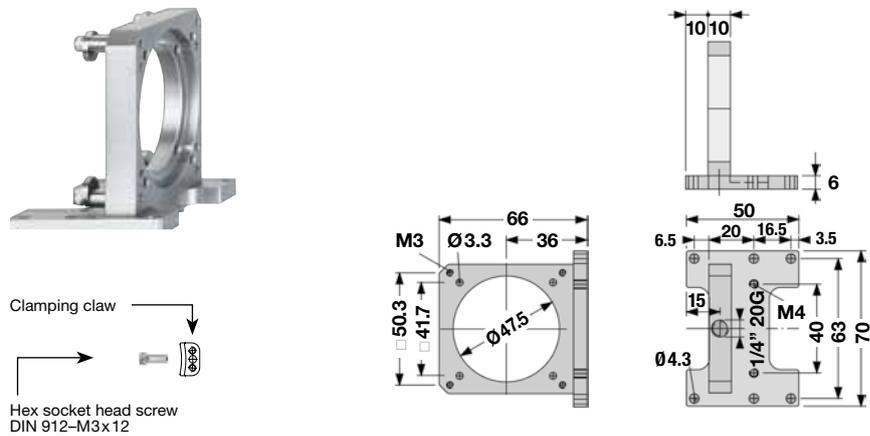
Clamping set SK5101

Set of 4 pcs. clamping claws incl. screws

Clamping claw

Hex socket head screw DIN 912–M3 x 12
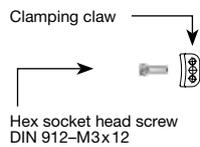
Mounting system SK5105-2L

for cameras with a tube extension > 52 mm

Schäfter+Kirchhoff
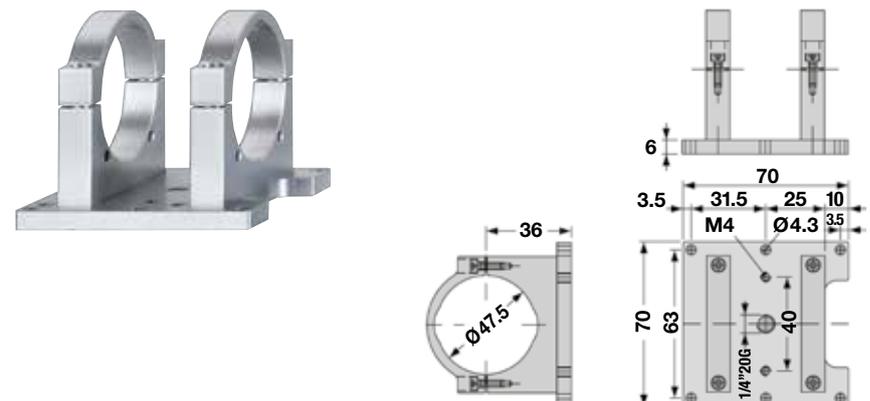
■ 2.2 Electrical Installation: Connections and I/O Signals

- For the SK2048VJR-4L line scan camera-data transfer and camera control is provded by the Gigabit Ethernet interface **3**. Use a CAT6 twisted-pair cable to connect the camera to a PC; the maximum cable length is 100 m.

- The operating power must be supplied by an external source using socket **1**

- If you want to operate the camera in FREE RUN trigger mode, the connections are complete with the CAT6 Ethernet cable and the connection to an external power supply.

- For any kind of synchronized operation, the external trigger signal(s) must be wired to socket **2** as well. A frame-synchronization signal and two separate line-synchronization signals can be handled. The various trigger modes are described fully in section *Synchronization of the Image Acquisition with the Feed Rate of the Object (p. 18)*
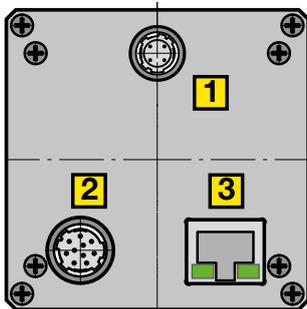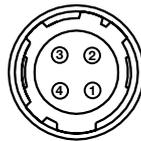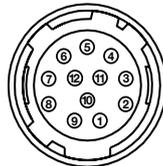
1 Power +24 V

Hirose series 10A, male 4-pin

Pin	Signal	Pin	Signal
1	n.c.	3	n.c.
2	GND	4	min. +18 V max. +36 V

Total power: 3.8 W

2 I/O Connector

Hirose series 10A, male 12-pin

Pin	Signal *)
1	GND
8	FrameSync IN
10	LineSync A IN
6	LineSync B IN

*) Signal Specification (TTL)

Max. input frequency	16.5 MHz
Input voltage, absolute max. range	min -0.5 V max 7.0 V
Input voltage max. low	0.99 V
Input voltage min. high	2.31 V
Input current	10 µA

3 Data
RJ-45 connector for Gigabit Ethernet cable

Status indicators
Network connection speed   Network activity

off	no connection, 10 Mbyte/s connection, or 100 Mbyte/s connection	
on	1 Gbyte/s connection	

off	no connection	
on	connected	
flash light	data is being transmitted or received	

Accessories *(see also Acessories (p. 36)*:

Network Cable CAT6.x
For connecting socket **3** with the PC Ethernet interface. Both ends with RJ45 connectors.

External Synchronization Cable SK9024.x
Use this cable to feed external synchronization signals into socket **2**.
Connectors:
Hirose plug HR10A, female 12 pin (camera side)
Phoenix 6 pin connector incl. terminal block (for synchronization signals)
Length 3 m or 5 m. Other lengths on request.

Power Cable SK9014.xF
Use this cable to feed external supply voltage into socket **1**.
Connector:
Hirose plug HR10A, female 4 pin (camera side),
open cable end (other side)
Length 1.5 m (standard), 3 m, or 5 m

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◼ 2.3 GigE Connections and Software Installation

The SK2048VJR-4L GigE Vision™ line scan camera uses the Gigabit Ethernet communication protocol, which is 100% compliant with the GigE Vision™ specifications and the Gen<I>Cam™ standard.

The Gen<I>Cam™ standard provides a generic programming interface for all kinds of cameras and, no matter what features they implement, the application programming interface (API) always remains the same.

For software and Network Interface Controller (NIC) driver installation, the following possibilities apply:

1. The Gen<I>Cam™ compliant 3rd party software you want to install includes a particular filter driver for the NIC.
   ➡ Install the software package. Commonly this will also cover the driver installation.

2. The 3rd party software does not include a NIC filter driver, and your NIC has an INTEL PRO/100 chip.
   ➡ Install the Pleora eBUS Optimal Driver.

3. The 3rd party software does not include a NIC filter driver, and your NIC has a different chip.
   ➡ Keep the manufacturer driver and follow the instructions in the next section.

The Pleora eBUS driver installation tool is available from Schäfter + Kirchhoff either on CD or as download from *http://www.sukhamburg.com/supporte.html*

◼ GigE Network Integration for Standard GigE Network Adapters

This section is relevant for systems with a standard NIC (not INTEL PRO/1000) in combination with the manufacturer driver (case 3).

a) Subnet Setting

The GigE Vision camera has an enforced static IP address. The NIC IP address must be part of the same subnet otherwise the camera is not accessible.

An example of a persistent IP address that is assigned to a class B network is:

Persistent IP	=	169.254.35.10
Subnet Mask	=	255.255.0.0
Default Gateway	=	0.0.0.0
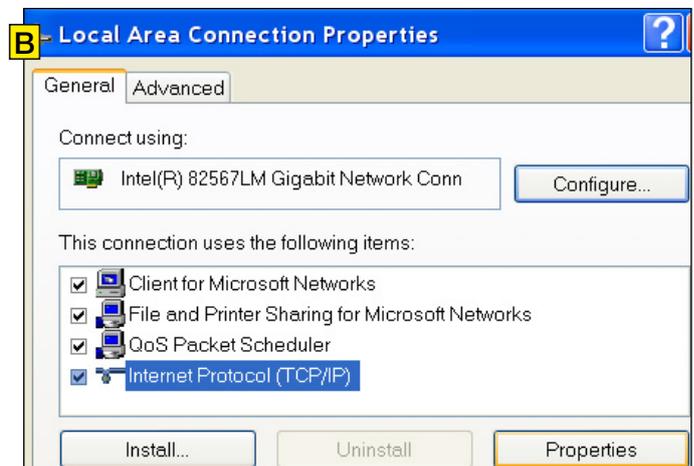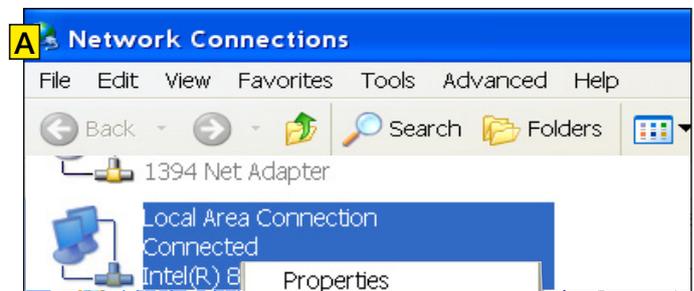
To Set the NIC IP address:

Start > Control Panel > Network Connections.

A Right-click Local Area Connection and select Properties. The Local Area Connection Properties dialog appears.

B Select Internet Protocol (TCP/IP) and click Properties. The Internet Protocol (TCP/IP) Properties dialog appears.

C Enable "Use the following IP address" and enter the following settings:

IP address:	169.254.35.10
Subnet mask:	255.255.0.0
Default gateway:	leave blank

Ensure these do not conflict with an existing IP address on another NIC. For multiple dedicated connections on the same host PC, increment the third IP address by one for each NIC (i.e. 36, 37, etc., subnet 255.255.255.0 - class C).
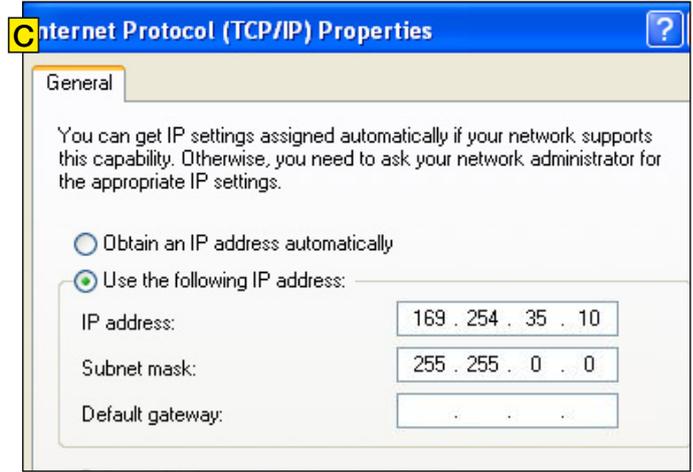
Click OK to close the Internet Protocol (TCP/IP) Properties dialog.

Click Close to close the Local Area Connection Properties dialog.

Your NIC is now configured for a dedicated connection.

LAN Connection 4
Speed: 1.0 GBit/s
Status: Connected

DE　14:52

C Internet Protocol (TCP/IP) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
◉ Use the following IP address:

IP address:	169 . 254 . 35 . 10
Subnet mask:	255 . 255 . 0 . 0
Default gateway:	. . .

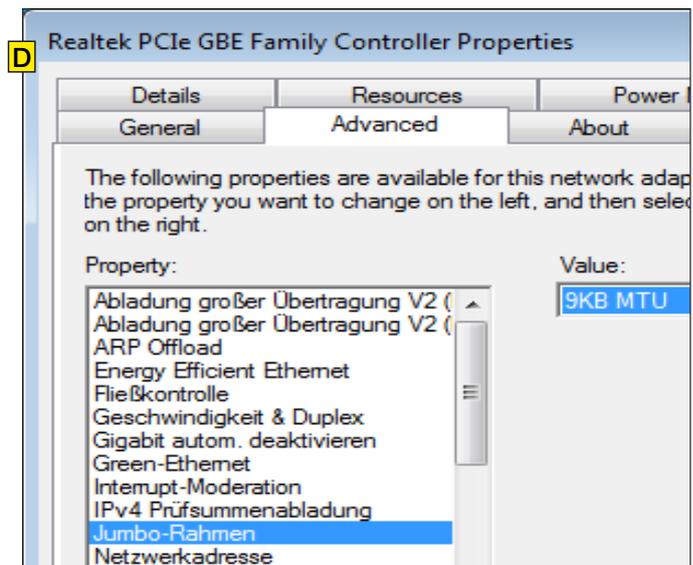## b) Windows Firewall

a) **Switch off the Windows Firewall** or

b) **Allow an exception:**

Start > Control Panel > Open the Windows Firewall

Select the Exceptions tab

Click Add Program

The "Add a Program" dialog appears

Select the camera control program and click "OK"

Click "OK" to close the Windows Firewall dialog

c) Optimizing the Network Adapter Settings

Open the "Advanced" Properties tab **D** of the Network Adapter and enter the following values:

Jumbo Frames	9014 Bytes
Receive Descriptors	2048
Interrupt Moderation Rate	extreme
Energy Efficient Ethernet	OFF

D Realtek PCIe GBE Family Controller Properties

| Details | Resources | Power |
| General | Advanced | About |

The following properties are available for this network adap the property you want to change on the left, and then sele on the right.

Property:

Abladung großer Übertragung V2 (
Abladung großer Übertragung V2 (
ARP Offload
Energy Efficient Ethernet
Fließkontrolle
Geschwindigkeit & Duplex
Gigabit autom. deaktivieren
Green-Ethernet
Interrupt-Moderation
IPv4 Prüfsummenabladung
Jumbo-Rahmen
Netzwerkadresse

Value:

9KB MTU

Network Controller Properties: Note, the terms can differ depending on the installed Ethernet card and driver.

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■ 2.4 SkLineScan Software Installation (Optional)

This section is a quick reference for installing the **SkLineScan** adjustment and configuration software. SkLineScan and the SkLineScan manual is provided for download on the Schäfter + Kirchhoff website under *http://www.sukhamburg.com/supporte.html*.

■ SkLineScan Installation

Prior to the installation, power on the PC (not the camera) and unpack the downloaded zip-file to a temporary folder. Alternatively, if your installation medium is a CD, insert the disk into the drive.

The autostart function may launch the setup program automatically from CD. Otherwise, look for the installation file:
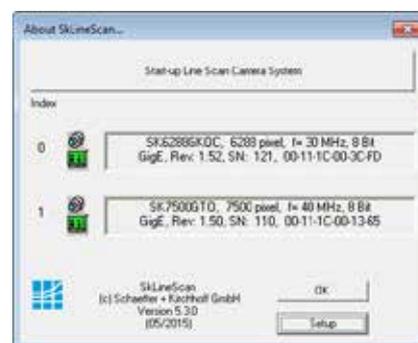
> SkLineScan_GEV.msi

Then start the applicable installation file manually. This will set up the Schäfter + Kirchhoff **SkLineScan** camera control and adjustment tool.

■ SkLineScan Start-up

• Start SkLineScan. A start-up dialog box pops up and displays the connected cameras that have been automatically detected.
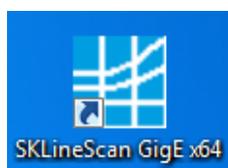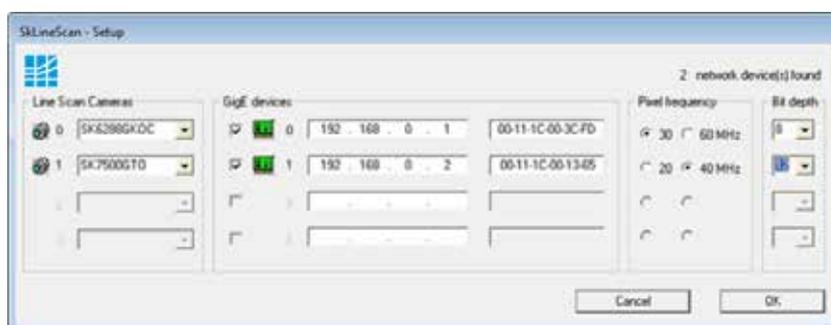

Desktop Icon

■ Camera Setup

Use the Setup dialog for

• activating/deactivating a connected GigE camera (activated device is ticked)
• changing the IP address
• changing the pixel frequency
• setting the bit depth of the video signal to 8 or 12-bit.

SkLineScan Setup dialog

The MAC addresses are displayed for identification of each camera with the defined CamID (0, 1, …). This is useful when several cameras with the same name are connected.

■ Initial Function Test

• Quit the SkLineScan startup dialog box.
• Select "OK" in the SkLineScan start-up dialog.

The Signal Window plotting the current brightness versus the pixel number indicates the correct installation.

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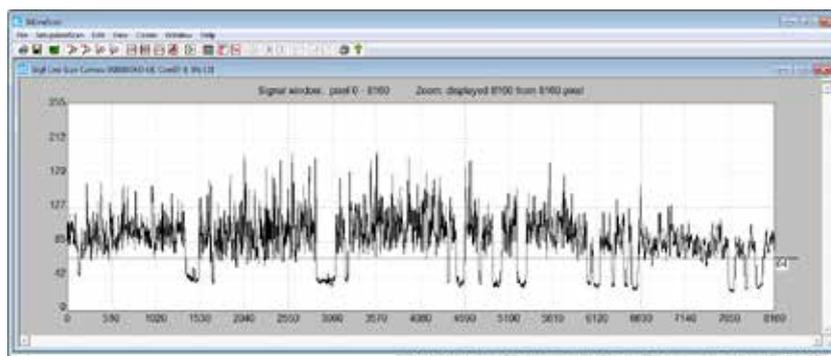
3 Camera Control and Performing a Scan

3.1 Software: SkLineScan

This section is a brief introduction to the SkLineScan adjustment and configuration software. A more detailed description is provided in the separate SkLineScan manual. The pdf is included in the SkLineScan installation package or is available for download from the Schäfter+Kirchhoff website under *http://www.sukhamburg.com/supporte.html*.

> Detailed instructions on how to obtain optimal image data and use the data with the Schäfter+Kirchhoff software package can be found in the *SkLineScan Software Manual*.
>
> The most common functions of the line scan camera can be controlled by menu items and dialog boxes.
>
> In the "Camera Gain / Offset Control" dialog there is a command line for entering further control commands.

Click on the desktop icon to start the **SkLineScan** program.

The SkLineScan program recognizes the connected line scan cameras automatically. The identified cameras are shown in the start-up dialog **A**.

If the SK2048VJR-4L camera is identified correctly, confirm with "OK". The "Signal window" graphicaly showing the intensity signals of the sensor pixels (oscilloscope display) will open. It is responsive in real-time and the zoom function can be used to highlight an area of interest. The oscilloscope display is ideally suited for parameterizing the camera, for evaluating object illumination, for focussing the image or for aligning the line scan camera correctly.
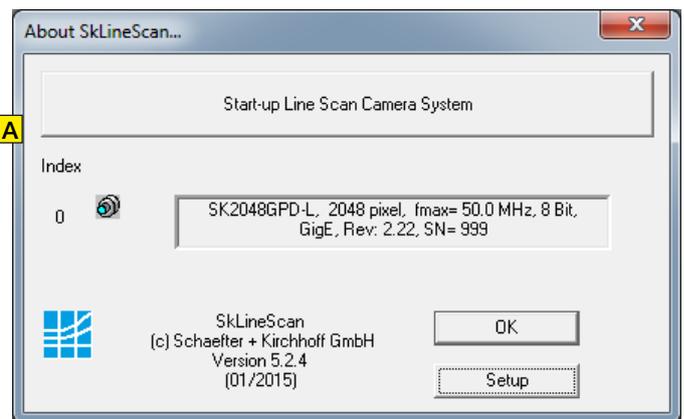
SkLineScan: Start-up dialog

■ Function Overview: SkLineScan Toolbar

SkLineScan: Toolbar

|	
	New line scan. All open "Signal window" windows will be closed. [F2]
	"Camera Control" dialog for parameter settings: integration time, line frequency, synchronization mode, thresholding
	Zooming in and out
	New line scan. "Area Scan" windows will be closed, "Signal window" windows will remain open. [F2]
	Threshold mode in new binary signal window.
	"Shading Correction" dialog to adjust the white balance [Alt+s]
	"Gain/Offset Control" dialog, also for commands input [Shif+F4]
	New area scan

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■ Visualization of the Sensor Output

• Signal Window / Oscilloscope Display

The signal window plots the digitalized brightness profile as signal intensity (y-axis) versus the sensor length (x-axis) at a high refresh rate. The scaling of the y-axis depends on the resolution of the A/D converter: The scale range is from 0 to 255 for 8-bits and from 0 to 4095 for 12-bits. The scaling of the x-axis corresponds with the number of pixels in the line sensor.
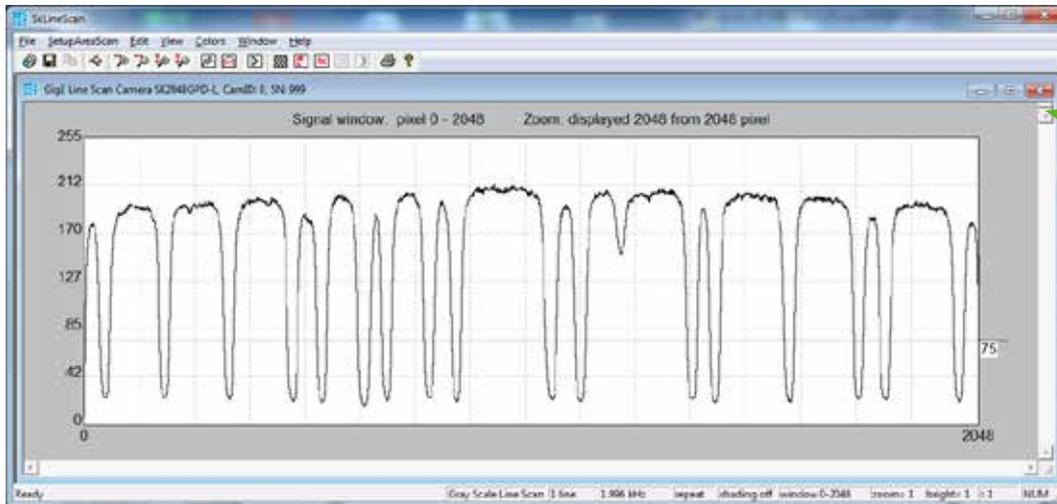
Line scan in Signal Window: brightness vs. pixel number

• Zoom Function

With a high number of sensor pixels, details are lost due to the limited number of display pixels. With the zoom function you select a part of the sensor for the detailed display. The possible magnification ranges up to the representation of the intensity signal of individual pixels.

• Window Split Function

The signal window can be divided horizontally into two areas. Use the slider B at the top of the vertical scroll bar. If you then use the zoom function in one frame, the selected section in the other frame will be highlighted in yellow.
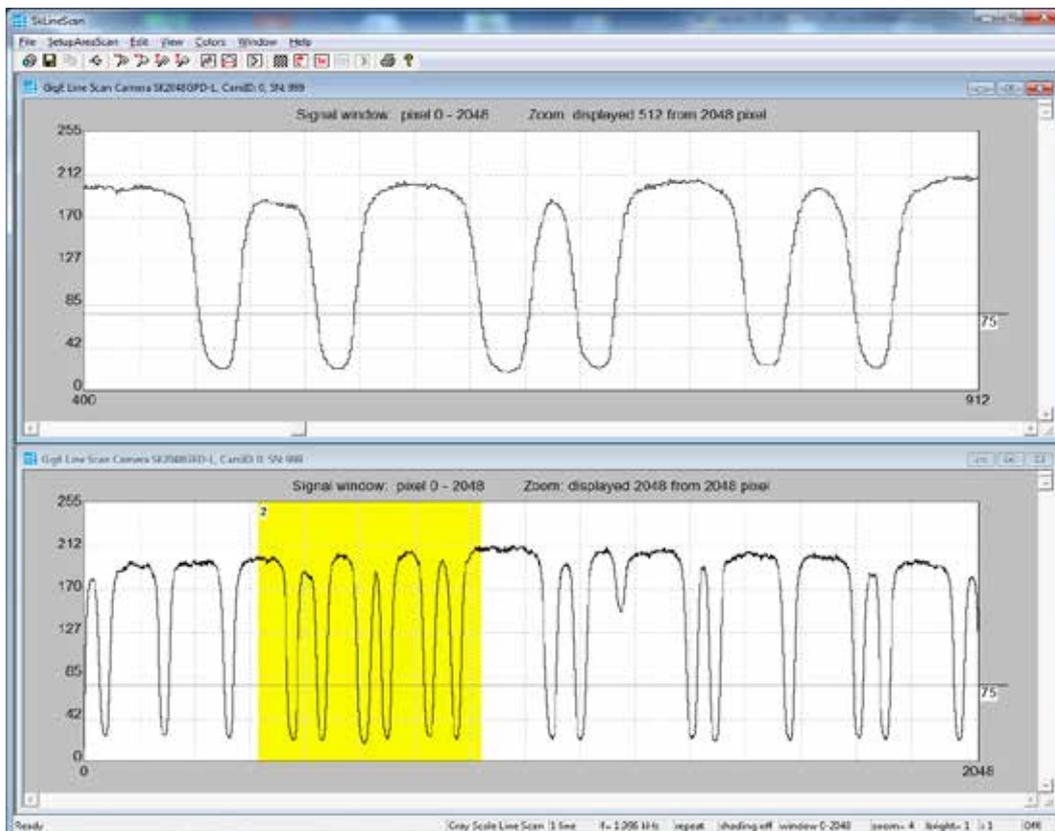
Line scan in split signal window: The upper frame shows an enlarged section of the lower frame.

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3.2   Adjustments for Optimum Scan Results

Prior to a scan, the following adjustments and parameter settings should be considered for optimum scan signals:

- Lens focussing
- Sensor alignment
- Gain/Offset
- Shading correction

- Integration time
- Synchronization of the sensor exposure and the object surface velocity, trigger mode options.

Start with the signal window / oscilloscope display. Any changes in the optical system or camera parameters are displayed in real-time when using an open dialog box.

Lens Focussing

The real time Signal Window facilitates the effective focussing of the line scan camera system, even for two-dimensional measurement tasks. For determining the correct focus, the edge steepness at dark-bright transitions and the modulation of the line scan signal are the most important factors.

Adjust the focus with the aperture fully open to limit the depth of field and enhance the effects of changing the working distance.

If the sensor is overloaded when the aperture is fully open, the easiest way to reduce the signal amplitude is to shorten the integration time, as described in section *Optimum brightness adjustment, Integration Time (p. 17)*.
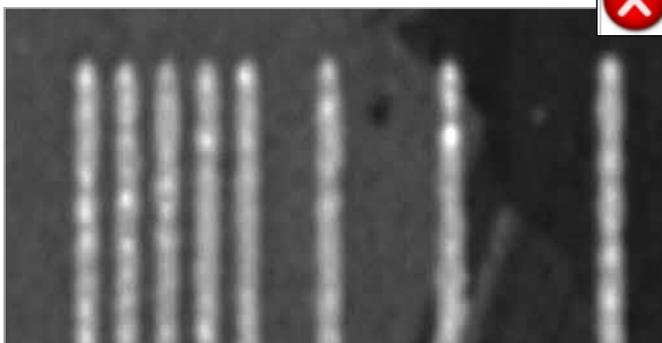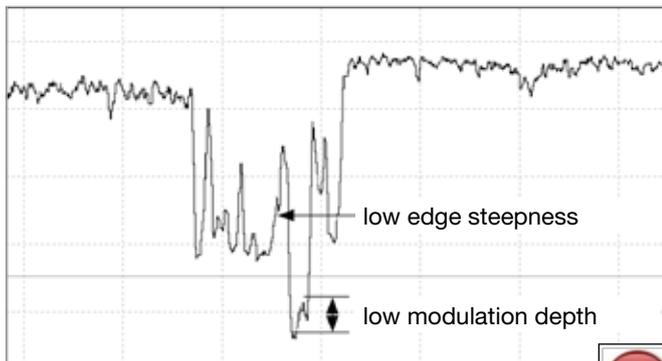
Out-of-focus:
- Low edge steepness
- Signal peaks are blurred
- High spatial frequencies with low modulation depth
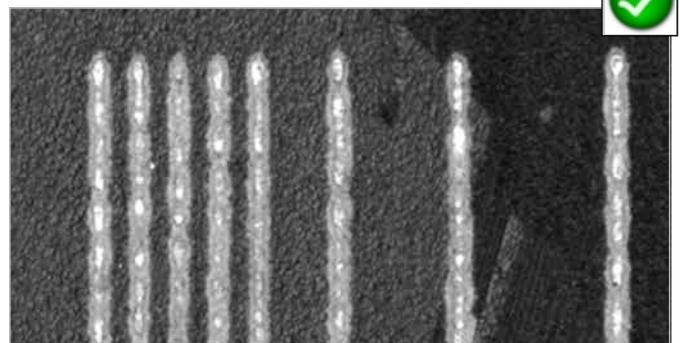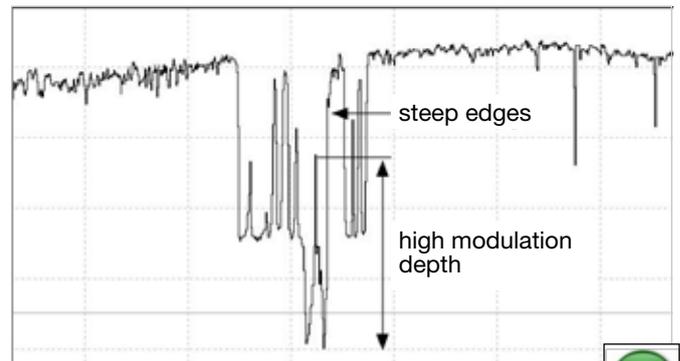
Optimum focus:
- Dark-bright transitions with steep edges
- Large modulation in the signal peaks
- High spatial frequencies with high modulation depth

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■ Sensor Alignment

If you are using a linear light source, check the alignment of the light source and sensor before shading correction, as rotating the line sensor will result in asymmetric vignetting.
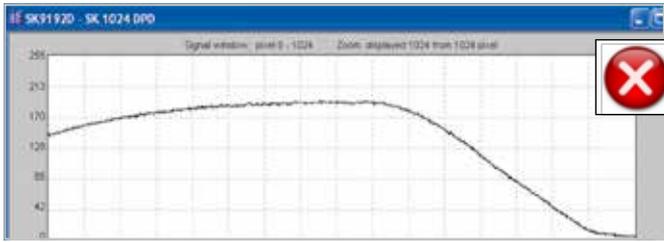
Sensor and line lighting slightly twisted in relation to each other, asymmetric vignetting

Sensor and line lighting aligned in parallel, symmetric vignetting

■ Gain/Offset Adjustment

The cameras are supplied with factory-set gain/offset. Open the "Gain/Offset Control" dialog to adjust these settings.
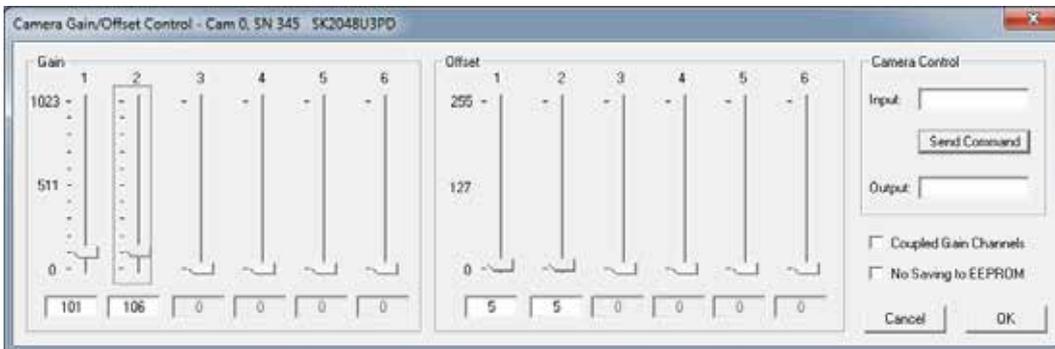
Gain/Offset Control dialog

The gain/offset dialog contains up to 6 sliders for altering gain and offset. The number of active sliders depends on the individual number of adjustable gain/offset channels of the camera. If "Coupled Gain Channels" is checked, all channels are set synchronously with one slider.
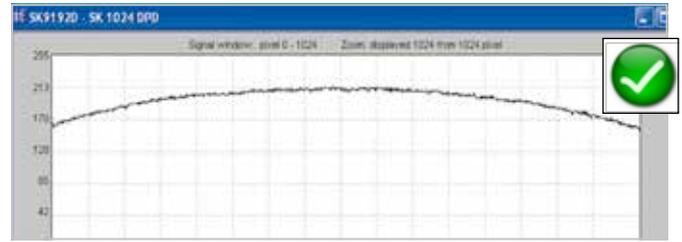
Enter commands for advanced software functions in the 'Camera Control' field (see page *14*).

Adjustment principle

1. Offset

To adjust the zero baseline of the video signal, totally block the incident light and enter "00" (volts) for channel 1.

For a two- or multi-channel sensor, minimize any differences between the channels by adjusting the other Offset sliders.

A slight signal noise should be visible in the zero baseline.

2. Gain

Illuminate the sensor with a slight overexposure in order to identify the maximum clipping. Use the Gain slider "1" to adjust the maximum output voltage.

For a two- or multi-channel sensor, minimize any differences between the channels by adjusting the other Gain sliders.

For the full 8-bit resolution of the camera, the maximum output voltage is set to 255 and for 12-bit is set to 4095.

2. Adjust the gain of channel 1. Minimize the difference between the channels with the other gain controls.

1. Adjust the zero level of channel 1. Minimize the difference between the channels using the other Offset controls.
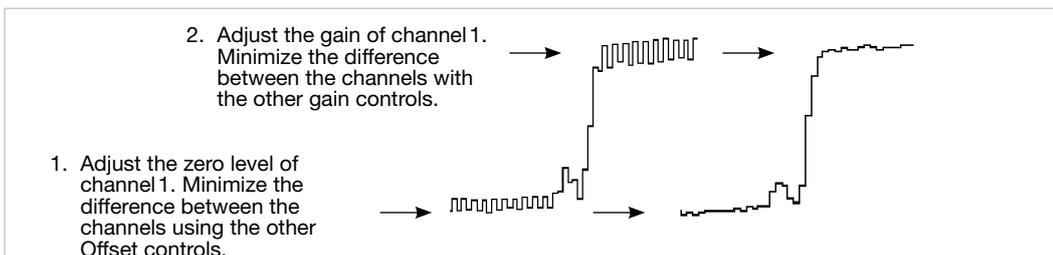
Offset and gain adjustment for more than one gain/offset channel

■ Shading Correction

Shading correction compensates for non-uniform illumination, lens vignetting as well as any differences in pixel sensitivity. The signal of a white homogeneous background is used as a reference. For correction, each pixel of the sensor is scaled to the intensity maximum with an individual factor (255 at 8 bit resolution and 4095 at 12 bit). The reference signal is stored in the camera's Shading Correction Memory (SCM). Subsequent scans are normalized with the scaling factors of this white reference.

• Open the "Shading Correction" dialog (Alt+s).

Shading Correction dialog

• Use a homogeneous white object to capture the reference data, e.g. a white sheet of paper.

• Either take a 2-dimesional scan ("Area Scan Function" [F3]) or

use a single line signal that was averaged over a number of single line scans.

• To suppress influences of the surface structure, move the displayed object during image acquisition.

• Input the scale range:

Minimum in %: intensity values lower than "Minimum" will not be changed.

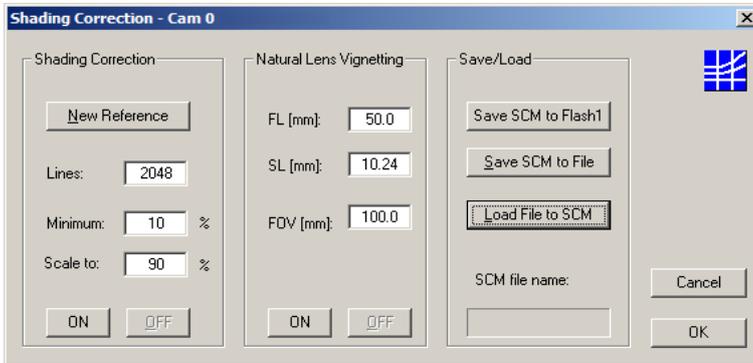A typical appropriate value is 10% of the full intensity range, i.e. 26 (= 10% · 255) for an 8-bit intensity scale.

Maximum in %: target value for scaling

A typical appropriate value is 90% of the full intensity range. The result will be a homogeneous line at 230 (= 90% · 255) for an 8-bit intensity scale.

• Click on button **New Reference**

• Click on **Save SCM to Flash** to save the SCM reference signal in the flash memory of the camera

Once the reference signal is copied from the shading correction memory (SCM) to the camera flash memory it will persist even after a power down.

On a re-start, this data will be restored from the flash memory back to the SCM.

The current shading correction status - active or not active - is also retained after power down.

ON Activate shading correction with the reference signal stored in the SCM.

OFF Switch off Shading Correction. The shading correction data will not be loaded from the flash memory into the SCM the next time the camera is started - even if the SCM data was previously stored in the flash memory.

Load File to SCM A stored reference signal is loaded into the SCM of the camera. Shading correction is then active.

After shading correction, the line scan signal has a homogeneous intensity
at 255 (8 bit, Maximum 100%)

Shading Correction Memories and API Functions

As an alternative to the user dialog, a new shading correction reference signal can also be generated using API (Application Programming Interface) functions. The relationship between the memory locations and the related API functions are shown in the following figure. The API functions are included in the SK91USB3-WIN software package. For more information, refer to the *SK91USB3-WIN manual*.
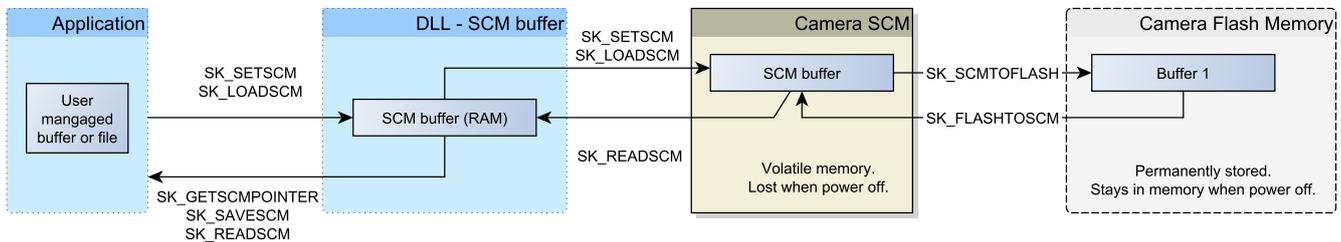
Structure of the shading correction memories (SCM) and the related API functions for memory handling

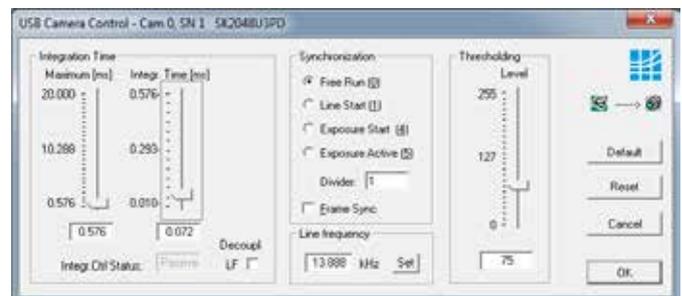### ■ Optimum brightness adjustment, Integration Time

The brightness distribution of the line signal is influenced not only by the integration time, but also by the illumination and the aperture setting. It should be noted that the aperture setting affects the depth of field and thus the overall quality of the image.

The line signal is optimal if the signal from the brightest area of the object corresponds to 95% of the maximum output value. At 8-bit digitizing depth, 256 brightness levels are available, at 12-bit 4096. In this setting, optimum signal sensitivity is achieved and overexposure or even blooming is avoided.

Open the **Camera Control** dialog.
Menu *Edit -> Operation Parameters* or *[F4]*

- The integration time can be set by two vertical sliders or two input fields in the section **Integration Time** of this dialog. The left slider is for coarser the right for finer adjustments.

- The current line frequency is displayed in the **Line Frequency** status field.

- For cameras with integration control function (shutter), it is possible to shorten the integration time without increasing the line frequency. This integration control mode is activated as soon as the maximum line frequency of the camera is reached by shortening the integration time or by checking **Decoupl. LF** and thus the integration time is decoupled from the line frequency.

The **Default** button sets the integration time to the minimum exposure period that is determined from the maximum line frequency.

Reset restores the start values.

Cancel closes the dialog without changes.

OK stores the integration time values and closes the dialog.

For synchronization settings, see section *Synchronization of the Image Acquisition with the Feed Rate of the Object (p. 18)*.

SkLineScan **Camera Control** dialog
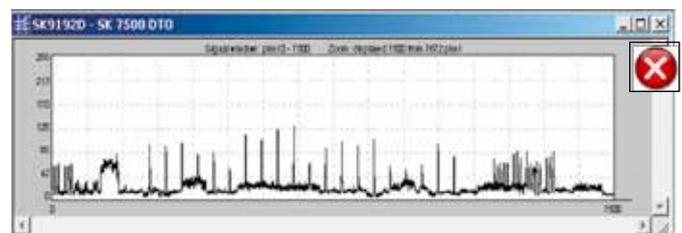
A camera signal with insufficient level: The integration time is too short, since only about 50% of the gray levels are used.
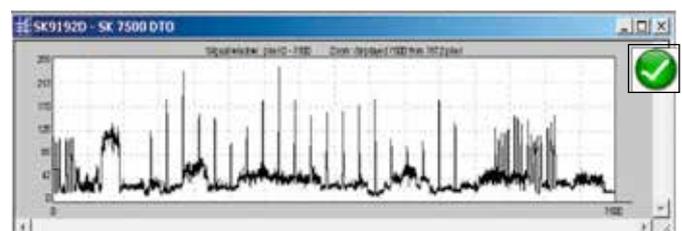
Optimized level of the camera signal after increasing the integration time by a factor of 4 to 95 % of the available scale.

■ Synchronization of the Image Acquisition with the Feed Rate of the Object

A line scan camera produces a two-dimensional image by moving either the object or the camera. The direction of the translation movement must be orthogonal to the sensor axis of the line scan camera.

In order to obtain an image with the correct aspect ratio, a line synchronous feed is required. With RGB color sensors, the color sequence of the individual sensor lines must also be taken into account when processing the sensor data. The software development kits from Schäfter+Kirchhoff contain easy-to-use functions for this purpose.

If the object speed is variable or the accuracy requirements are high, external synchronization is required. The various synchronization modes are described in the next section.
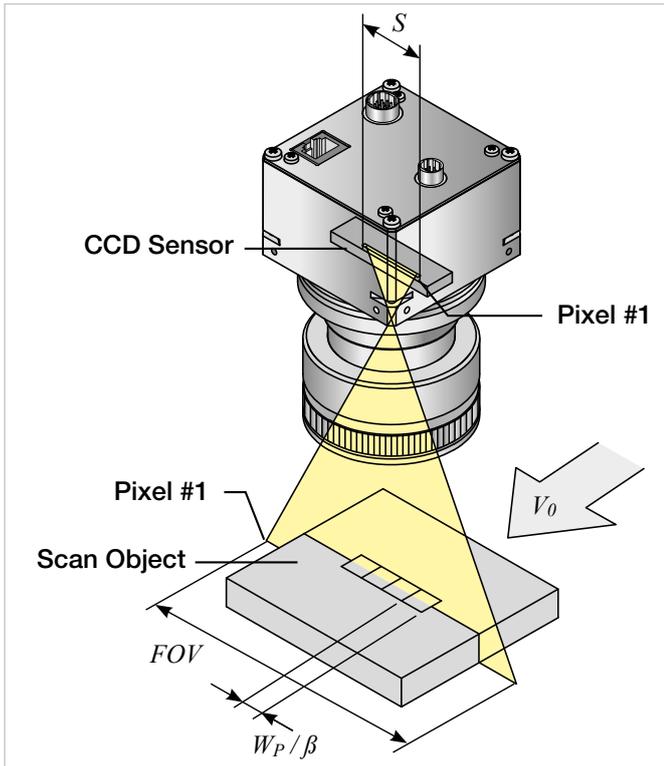
The optimal scan speed for a given line frequency is calculated as follows:

$$V_O = \frac{W_P \cdot f_L}{\beta}$$

If the scanning speed is fixed, the line frequency must be adjusted accordingly in order to obtain the correct aspect ratio in the image:

$$f_L = \frac{V_O \cdot \beta}{W_P}$$

V_O	=	object scan velocity
W_P	=	pixel width
f_L	=	line frequency
S	=	sensor length
FOV	=	field of view
β	=	magnification factor
	=	S / FOV

Example 1:

Calculating the scan velocity for a given field of view and a given line frequency:

Pixel width	= 14 µm
Line frequency	= 4.7 kHz
S	= 28.7 mm
FOV	= 50 mm

$$V_O = \frac{14\,\mu m \cdot 4.7\,kHz}{(28.7\,mm\,/\,50\,mm)}$$
$$= 115\ mm/s$$

Example 2:

Calculating the line frequency for a given field of view and object scan velocity:

Pixel width	= 14 µm
Scan velocity	= 100 mm/s
S	= 28.7 mm
FOV	= 50 mm

$$f_L = \frac{100\,mm/s \cdot (28.7\,mm\,/\,50\,mm)}{14\,\mu m}$$
$$= 4.1\ kHz$$

■ Synchronization Modes

The synchronization mode determines the exact timing of the exposure. Synchronization can either be performed internally or triggered by an external source, e.g. an encoder signal.

There are two different synchronization functions that can be applied together or individually:

1. Line synchronization:

The falling edge of a TTL signal at the LINE SYNC A input triggers each individual exposure of the sensor line by line.

The SK2048VJR-4L line scan camera enables extended synchronization control by means of a second trigger input LINE SYNC B. A detailed description can be found .under *Advanced Synchronization Control, p. 26*.

2. Frame synchronization:

The recording of a set of lines (frame) representing a two-dimensional image is started by the falling edge of a TTL signal at the FRAME SYNC input.

Free Run / SK Mode 0

The acquisition of each line is synchronized internally (free-running) and the next scan is started automatically after completion of the previous line scan. The line frequency is determined by the programmed value.

LineStart / SK Mode 1

After an external trigger pulse, the currently exposed line is read out at the next internal line clock. The start and duration of the exposure are controlled internally by the camera and are not affected by the trigger pulse. The exposure time is programmable. The line frequency is determined by the frequency of the trigger signal.

Limitations: The period of the trigger signal must be longer than the exposure time used. Between the external trigger signal and the internally generated line clock, jitter occurs in the range of the exposure time.

ExposureStart / SK Mode 4 (only available when camera supports integration control)

A new exposure is started exactly at the point in time of the external trigger pulse. The exposure time is determined by the programmed value. The exposed line is read out after the exposure time has elapsed. The frequency of the trigger signal determines the line frequency.

Restriction: The period duration of the trigger signal must be longer than the exposure time used.

ExposureActive / SK extSOS (Mode 5)

The exposure time and the line frequency are controlled by the external trigger signal. This affects both the start of a new exposure (Start of Scan-Pulse, SOS) and the readout of the previously exposed line.

FrameTrigger / SK FrameSync

The camera suppresses the data transfer until a falling edge of a TTL signal occurs at the FRAME SYNC input. This starts the acquisition of a 2D area scan. The number of image lines must be programmed in advance. Any of the available line synchronization modes can be used for the individual line scans.
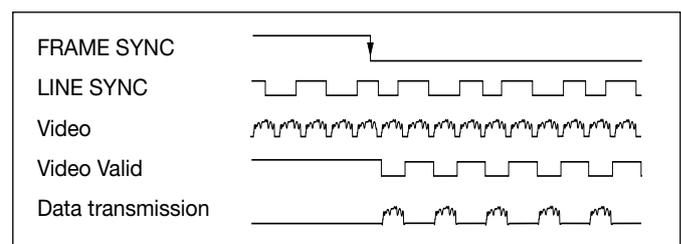
Combined frame and line synchronization

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- To configure synchronization, open the **Camera Control** dialog. [F4]

- Within the **Synchronization** frame, select one of the numbered line synchronization modes.

- Within the camera, the trigger control stage is followed by a divider stage with which the trigger frequency can be divided by integer dividers. Enter the division ratio in the **Divider** field.

- Select the **Frame Sync** check box to activate frame synchronization. In the **Delay** field, enter the delay time in milliseconds.
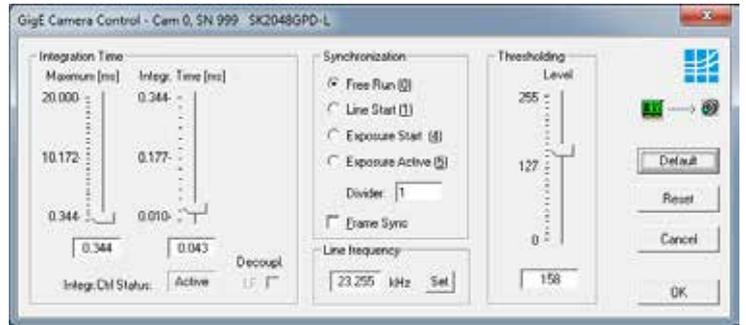
Camera Control dialog
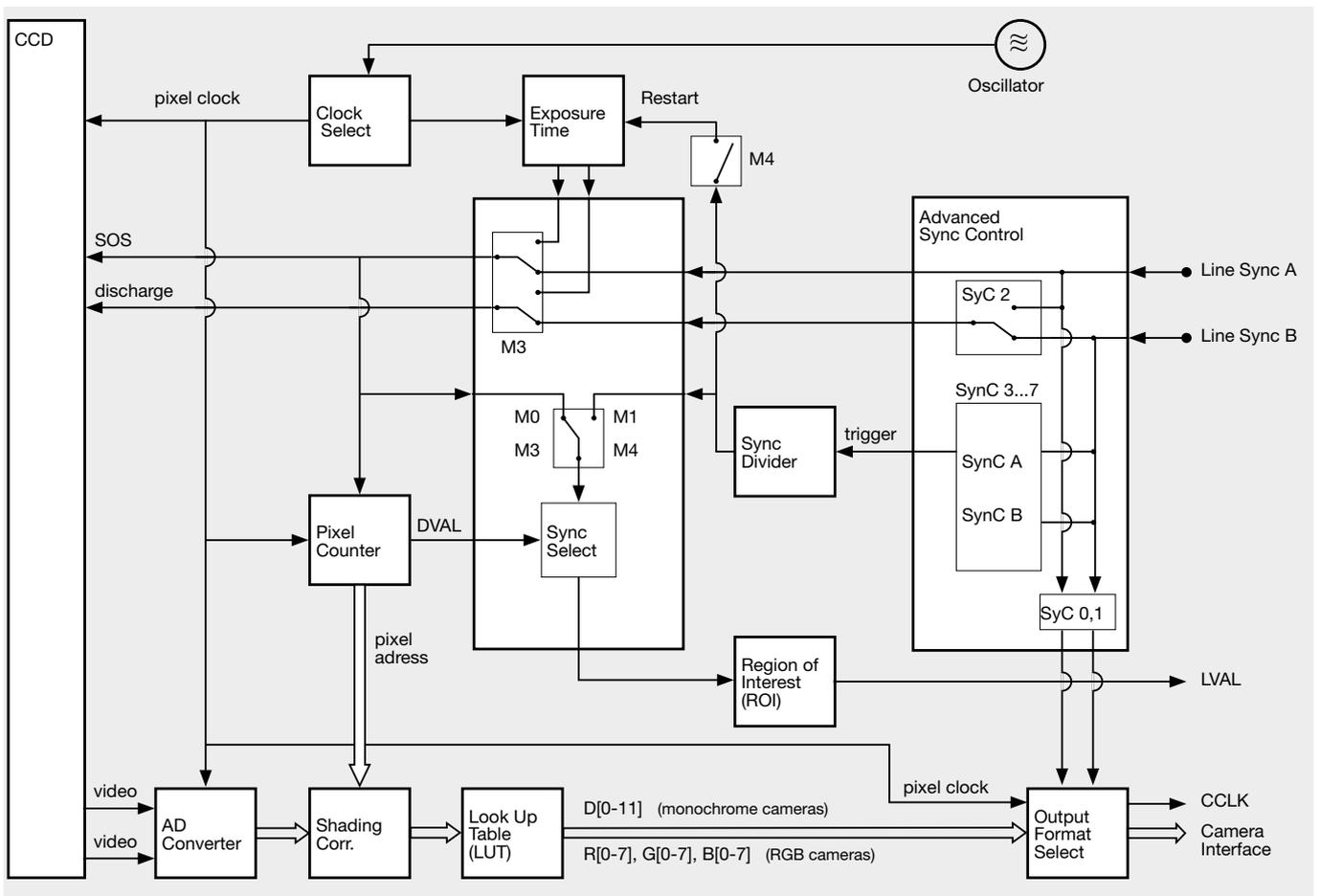
Functional diagram of the Camera Control System

3.3 GigE Vision Device Feature List (Gen<i>Cam compliant)

a) Device Information

Display of device information, not editable.

⚠ Data in this dialog are editable, if they are not greyed out. Some data can only be edited as long as acquisition is stopped.

GEV Device Control

Visibility: Beginner

DeviceInformation	
DeviceVendorName	Schaefter + Kirchhoff
DeviceModelName	SK2048VJR-4L
DeviceManufacturerInfo	Hamburg (00080602
DeviceVersion	Version 2.35 (02.01.
DeviceID	S/N 110
DeviceUserID	
DeviceScanType	Linescan

b) Image Size Control

SensorWidth: number of pixels in line sensor (fixed)
SensorHeight: 1 (fixed)

Width: image width = SensorWidth (fixed)
Height: image height (number of lines per image)
    1   for Line Scanning
    ≥2   for Area Scanning,
           limited by 32 MByte buffer size

PixelFormat: Mono8 = gray scale 8-bit
           Mono10 = gray scale 10-bit
           Mono12 = gray scale 12-bit

PixelSize: bits per pixel, depends on PixelFormat
    Mono8:   PixelSize = Bpp8 = 8-bit
    Mono10: PixelSize = Bpp16 = 16-bit
    Mono12: PixelSize = Bpp16 = 16-bit

ImageSizeControl	
SensorWidth	2048
SensorHeight	1
SensorDigitizationTaps	One
Width	2048
Height	16383
DecimationHorizontal	1
DecimationVertical	1
PixelFormat	Mono8
PixelCoding	Mono
PixelSize	Bpp8

c) Acquisition And Trigger Controls
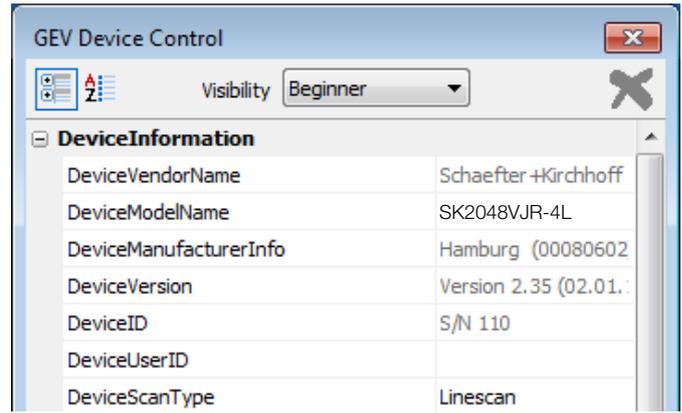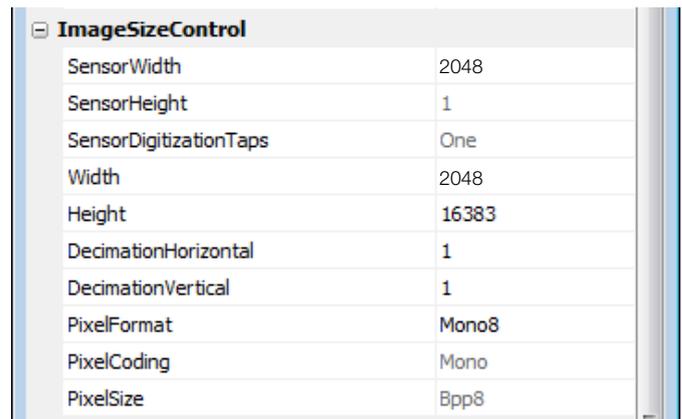
AcquisitionMode: Continuous: repetitive acquisition
           SingleFrame: one snapshot

AcquisitionLineRateAbs: line rate in Hz
           minimum: 20 Hz
           maximum: 4700 Hz

Trigger Selector: for line synchronization
  FreeRun: each line is acquired, no trigger
  LineStart: external trigger, reading in next line
  ExposureStart: external trigger and restart exposure
  ExposureActive: exposure time is determined by the
              external trigger period

ExposureTimeRaw: exposure time in µs, 10 ... 20000
           (master feature of exposure control)

ExposureTimeAbs: exposure time in ms, 0.01 ... 20

AcquisitionAndTriggerControls	
AcquisitionMode	Continuous
AcquisitionStart	{Command}
AcquisitionStop	{Command}
AcquisitionFrameCount	1
AcquisitionLineRateAbs	11627 Hz
TriggerSelector	FreeRun
ExposureTimeAbs	0.086 ms
ExposureTimeRaw	86

TriggerSelector	FreeRun ▼
	LineStart
	ExposureStart
	ExposureActive
	FreeRun
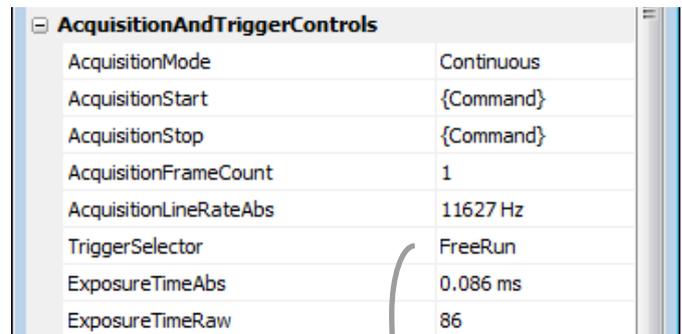
See *Synchronization Modes (p. 20)*

d) Analog Controls (Gain / Offset)

GainSelector: gain control for all taps
           or for each tap separately
GainRaw: gain adjustment
           range: 0 ... 1023, typical 70 (integer)
           (master feature of gain control)
GainAbs: gain adjustment in dB
           range: 0 ... 24.0 (float)

BlackLevelSelector: offset control for for all taps
           or for each tap separately
BlackLevelRaw: offset adjustment
           range: 0 ... 255 (integer)

AnalogControls	
GainSelector	All
GainRaw	70
GainAbs	0.778361 dB
BlackLevelSelector	All
BlackLevelRaw	255
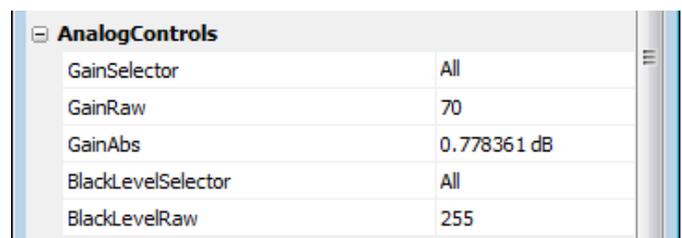
See *Gain/Offset Adjustment (p. 15)*

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e) Custom Features, Beginner view

SkGetPixFrequencyHigh: returns the high pixel frequency in kHz

SkGetPixFrequencyLow: returns the low pixel frequency in kHz

SkSetPixelFrequency: sets the pixel frequency in kHz (low or high) with reciprocal effect on line frequency.
For lower line frequencies, a low value for pixel frequency is recommended.

SkSetShadingCorrection: ON: activates Shading Correction
OFF: deactivates Shading Correction
See *White Balance and Shading Correction (p. 16)*.

SkGetMaxLineFrequency: returns the maximum line rate in Hz

SkGetMinExposureTime: returns the minimum exposure time in microseconds

SkFrameTrigger: selects "Frame Sync" for external trigger of images
True: Frame Trigger is active
FALSE: Frame Trigger is off
The Frame Trigger works with all Line Trigger modes.
See *Synchronization Modes (p. 20)*.

SkGetVideoChannels: returns the number of taps for gain / offset control

SkGetSerialNumber: returns the serial number of the camera

SkGetRevisionNumber: returns the revision number for the camera

SkSyncControl: Sync Control Register setting, see *Advanced Trigger Functions and Sync Control Register (SCR) Settings (p. 26)*.

SkSyncDivider: incoming trigger clock divider (integer)

f) Additional Custom Features, Guru view

SkShadCorrReference: a single line scan is acquired using a white background and saved in the Shading Correction Memory (SCM). For each pixel, a correction factor is calculated for adjusting the intensity to the maximum (255 at Mono8). When Shading Correction is active then all of following scans are normalized using this factor.

SkSaveScmToFlash: writes the Shading Correction Memory factors into the non-volatile flash memory of the camera, allowing use of the SCM even after a complete shut down or loss of power.

SkTestPattern: switch on test pattern, turns off with power off
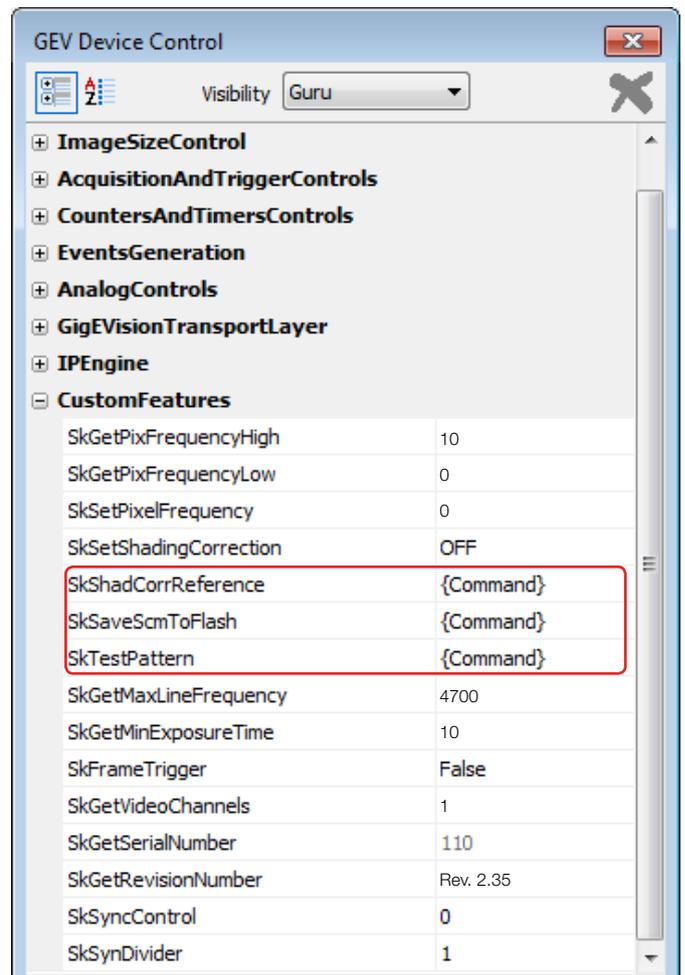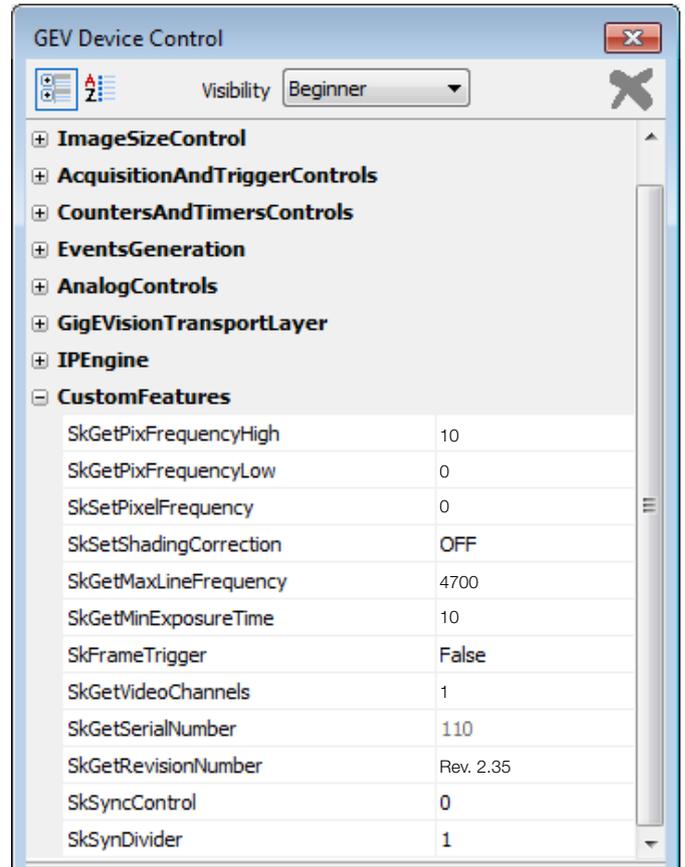
4   Advanced Camera Control Functions

4.1   Camera Control by Commands

In addition to user dialog inputs, the SkLineScan software also provides the option to adjust camera settings, such as gain, offset, trigger modes, by sending control commands directly.

Similarly, current parameters, as well as specific product information, can be read from the camera using the request commands. All set and request commands are listed in the tables below.

- The commands are entered in the 'Input' field in the 'Camera Control' section of the "Camera Gain/Offset Control" user dialog, [Shift+F4].
- In the 'Output' field, either the acknowledgement of the set commands (0 = OK, 1 = not OK) or the return values of the request commands are output.

The parameter settings are stored in the non-volatile flash memory of the camera and are available after a rapid start-up, even after a complete shut down or loss of power.
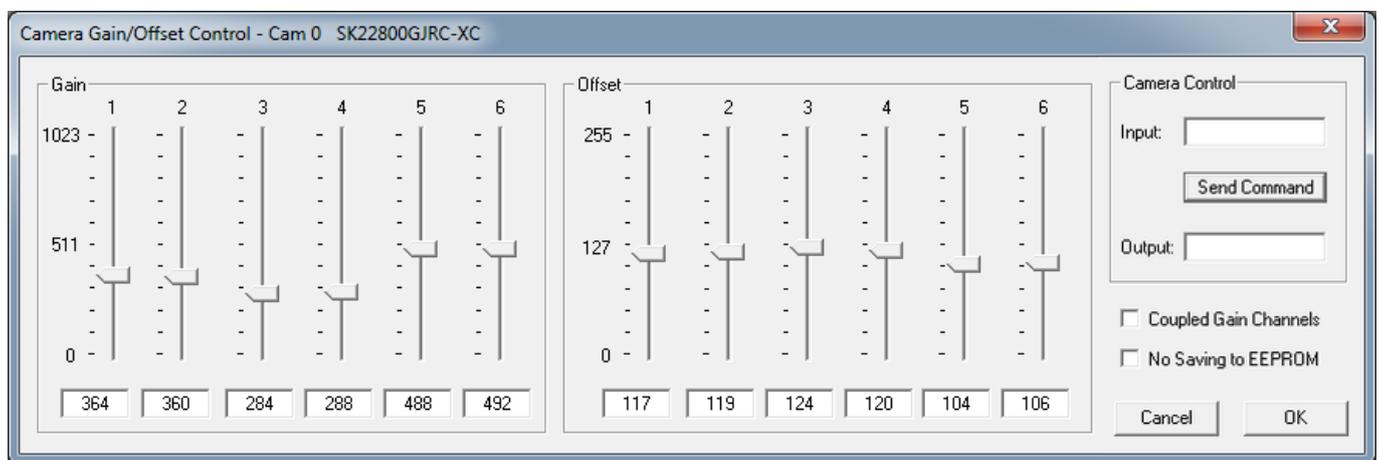
Gain/Offset Control dialog: Camera Control input and output in the right section

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■ Set Commands

Set Operation	Description
G*oooo*<CR>	gain setting 0-24 dB
O*ppp*<CR>	offset setting
F8<CR>	output format: 8 bit output data
F10<CR>	output format: 10 bit output data
F12<CR>	output format: 12 bit output data
C10<CR>	camera clock: 10 MHz data rate
T0<CR>	test pattern off / SCM off
T1<CR>	test pattern on (turns off with power off)
T2<CR>	shading correction on
T3<CR>	auto program Shading Correction / SCM on
T4<CR>	copy flash memory 1 to SCM
T5<CR>	save SCM to flash memory 1
T6<CR>	video out = SCM data
T7<CR>	copy Flash Memory 2 to LUT Memory
T8<CR>	save LUT Memory to Flash Memory 2
T9<CR>	output data = LUT data
M0<CR>	line trigger mode0: internal all lines
M1<CR>	line trigger mode1: extern trigger, next line
M2<CR>	line trigger mode0: internal all lines and set max line rate
M3<CR>	Pleora sync modes
M4<CR>	line trigger mode4: extern trigger and restart
M5<CR>	line trigger mode5: extern SOS, all lines
A*xxxx*<CR>	SCM address (xxxxx = A0-A2047) or LUTM (xxxxx = A32768-A34815)
D*xxxx*<CR>	Memory data (*xxxx* = 0-4095), increment memory address counter
E*yyyyy*<CR>	frames / multiframe (*yyyyy* = 0-32767)
EF*yyyyy*<CR>	external frame trigger delay (*yyyyy* = 0-32767 lines)
N*yyyyy*<CR>	lines / frame (*yyyyy* = 1-32767)
W*yyyyy*<CR>	line clock frequency (*yyyyy* = 20-4700) [Hz]
WL*yyyyy*<CR>	Window Pixel length (*yyyyy* =1-Line length)
WF*yyyyy*<CR>	Window First Pixel (*yyyyy* = 1-Line length)
X*yyyyy*<CR>	exposure time (*yyyyy* = 10-20000) [µs]
V*yyyyy*<CR>	extern sync divider (*yyyyy* = 1-32767)
Y*ppp*<CR>	set sync control (*ppp* = 255)
SDXT<CR>	enable DXT (decoupling of line clock frequency and exposure time)
RDXT<CR>	disable DXT (decoupling of line clock frequency and exposure time)
SLUT<CR>	enable LUT
RLUT<CR>	disable LUT
SNES<CR>	enable NES (no EEPROM save)
RNES<CR>	disable NES (no EEPROM save)
RESET<CR>	reset Memory to manufacturer default

Acknowledgement for all set commands:
0 = OK, 1 = not OK

■ Request Commands

Request	Return	Description
K<CR>	*SK2048VJR-4L*	returns SK type number
R<CR>	*Rev. 2.35*	returns Revision number
S<CR>	*SNr00163*	returns Serial number
I<CR>	*SK2048VJR-4L Rev. 2.35 SNr00163*	camera identification readout
I1<CR>	VCC: *yyyyy*	returns VCC (1=10mV)
I2<CR>	VDD: *yyyyy*	returns VDD (1=10mV)
I3<CR>	moo: *yyyyy*	returns mode of operation
I4<CR>	CLo: *yyyyy*	returns camera clock low frequency (MHz)
I5<CR>	CHi: *yyyyy*	returns camera clock high frequency (MHz)
I6<CR>	Ga: *yyyyy*	returns gain
I8<CR>	Of: *yyyyy*	returns offset
I19<CR>	Tab: *yyyyy*	returns number of video channels
I20<CR>	CLK: *yyyyy*	returns selected clock frequency (MHz)
I21<CR>	ODF: *yyyyy*	returns selected output data format
I22<CR>	TRM: *yyyyy*	returns selected trigger mode
I23<CR>	SCO: *yyyyy*	returns shading corr. on/off
I24<CR>	Exp: *yyyyy*	returns exposure time
I25<CR>	miX: *yyyyy*	returns min. exposure time (µs)
I26<CR>	LCK: *yyyyy*	returns line frequency (Hz)
I27<CR>	maZ: *yyyyy*	returns max. line frequency (Hz)
I28<CR>	TSc: *yyyyy*	returns Sync Divider
I29<CR>	SyC: *yyyyy*	returns Sync Control
I30<CR>	Lin: *yyyyy*	returns Lines/Frame
I31<CR>	DXT: *yyyyy*	returns DXT on/off
I32<CR>	Tmp: *yyyyy*	returns Video Board Temper.
I33<CR>	FSD: *yyyyy*	returns Frame Trigger Delay
I36<CR>	WPL: *yyyyy*	returns Window Pixel Length
I37<CR>	WFP: *yyyyy*	returns Window First Pixel
I38<CR>	LUT: *yyyyy*	returns LUT on/off
I39<CR>	KST: *yyyyy*	returns Status

LUT: Lookup Table
SCM: Shading Correction Memory
SOS: Start of Scan

Range of values:
oooo = 0 ... 1023
ppp = 0 ... 255
xxxx = 4 digits integer value as ASCII
yyyyy = 5 digits integer value as ASCII

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■ 4.2 Advanced Synchronization Control

The basic synchronization function makes use of the trigger input LINE SYNC A. The trigger mode is determined by the settings in the 'Camera Control' dialog, e.g. LineStart (1) or ExposureStart (4).

Advanced trigger functions are provided by combining LINE SYNC A with a second trigger input LINE SYNC B. The operation mode is controlled by the entries in the **Sync Control Register (SCR)**.

Control commands to write to or to read from the Sync Control Register:

Y*ppp***<CR>**   **set SCR** with *ppp* = 0...255 (decimal)
Return value: 0 = OK; 1 = not OK

I29<CR>   **return sync control**
Return value: SyC:*yyyyy* (5-digits integer value as ASCII)

Example:

Y232
ppp = 232(dec) = 11101000(bin)

new SCR value: 11101000   → E

■ Advanced Trigger Functions and Sync Control Register (SCR) Settings

- Basic synchronization function, 'Camera Control' dialog settings are valid   → A
- Detection of direction   → B, C, D, E
- Trigger pulses are valid only in one direction, trigger pulses in the other direction are ignored → B
- Trigger on 4 edges   → D, E
- Suppression of jitter in the encoder signal, programmable hysteresis for trigger control   → E

Sync Control Register (SCR)	SyC7	SyC6	SyC5	SyC4	SyC3	SyC2	SyC1	SyC0
default	x	x	x	x	x	x	0	0
pixel #1 data = external trigger input states	x	x	x	x	x	x	0	1
pixel #1 data = Linecounter (8 bit)	x	x	x	x	x	x	1	0
pixel #1, #2 data = ext. trigger states (3 bit) + line counter (13 bit)	x	x	x	x	x	x	1	1
ExSOS and Sync at LINE SYNC A (Mode5)	x	x	x	x	x	0	x	x
ExSOS at LINE SYNC B, Sync at LINE SYNC A (Mode5)	x	x	x	x	x	1	x	x
Jitter Hysterese off	x	x	x	0	0	x	x	x
Jitter Hysterese 4	x	x	x	0	1	x	x	x
Jitter Hysterese 16	x	x	x	1	0	x	x	x
Jitter Hysterese 64	x	x	x	1	1	x	x	x
Sync 1x Enable	x	x	0	x	x	x	x	x
Sync 4x Enable	x	x	1	x	x	x	x	x
Sync up Enable / down disable	x	0	x	x	x	x	x	x
Sync up/down Enable	x	1	x	x	x	x	x	x
Sync Ctrl. Disable, SyC3...SyC6 without function	0	x	x	x	x	x	x	x
Sync Control Enable	1	x	x	x	x	x	x	x
	128	64	32	16	8	4	2	1

For diagnostic purposes, the present state of external trigger inputs (LINE SYNC A, LINE SYNC B, FRAME SYNC) or the internal line counter can be output instead of pixel #1 and/or pixel #2 data.
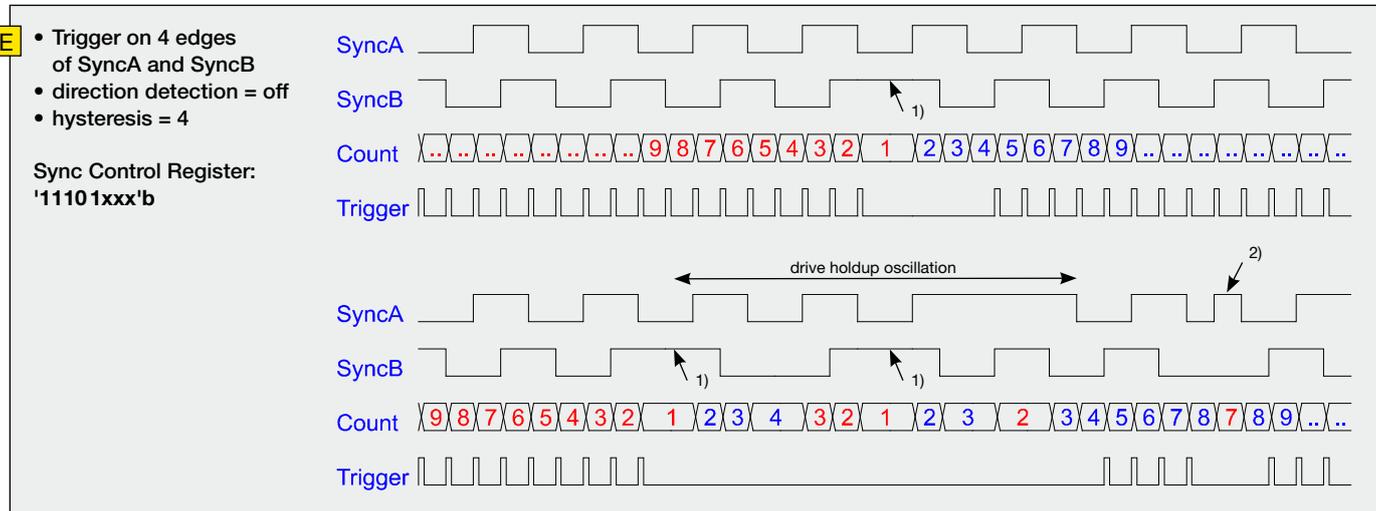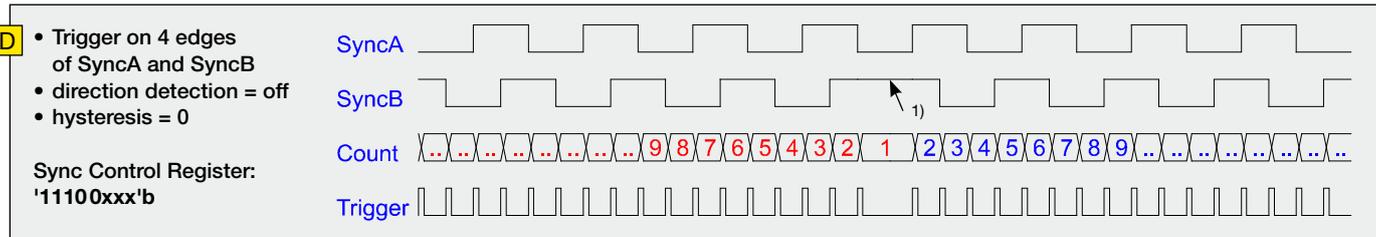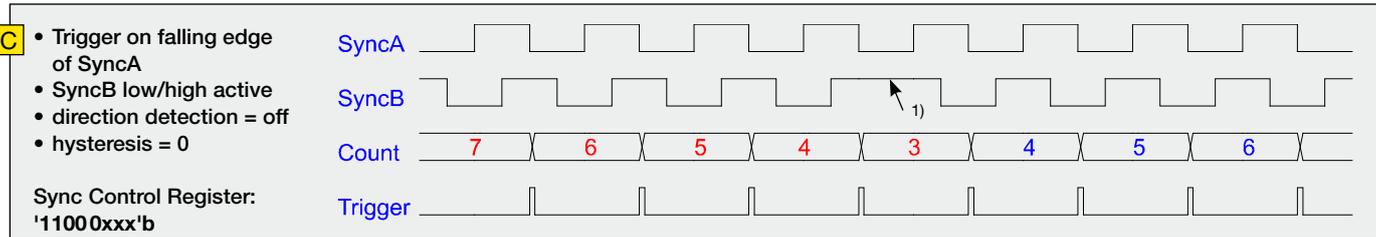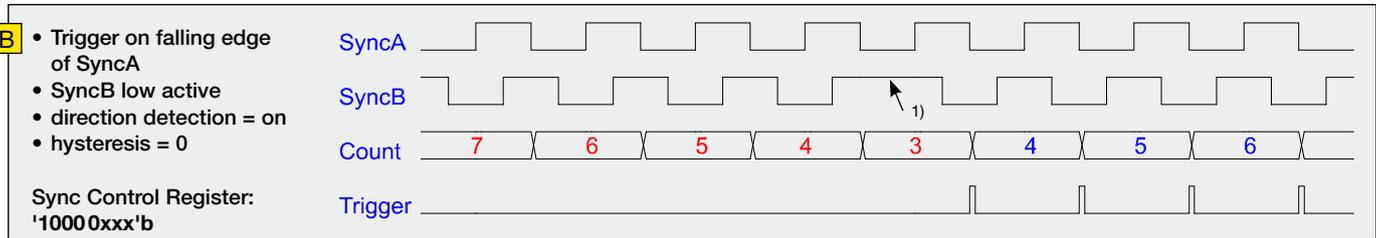
SCR	Pixel #1 Data (lowByte)	Pixel #2 Data (lowByte)
*xxxxx*00	intensity	intensity
*xxxxx*01	D7 = FRAME SYNC D6 = LINE SYNC A D5 = LINE SYNC B D4 ... D0 = 0	intensity
*xxxxx*10	internal line counter (8 bit)	intensity
*xxxxx*11	D7 = FRAME SYNC D6 = LINE SYNC A D5 = LINE SYNC B D4 ... D0 = line counter (bit 12 ... 8)	internal line counter (bit 7 ... 0)

■ Example Timing Diagrams

Annotations:

SyncA	=	LINE SYNC A	(external line synchronization input, I/O connector)
SyncB	=	LINE SYNC B	(external line synchronization input, I/O connector)
Count	=	internal counter	
Trigger	=	Generated trigger pulses from the Trigger Control stage. The signal goes to the Trigger Divider stage inside the camera. For setting the divider, use the V*yyyyy*<CR> command or the 'Divider' input field in the *4.1 Camera Control by Commands (p. 20)*.	

1) direction changed
2) glitch

A
- Trigger on falling edge of SyncA
- SyncB without function
- direction detection = off
- hysteresis = 0

Sync Control Register:
'0xxx xxxx'b

SyncA
SyncB   1)
Count   2   3   4   5   6   7   8   9
Trigger

B
- Trigger on falling edge of SyncA
- SyncB low active
- direction detection = on
- hysteresis = 0

Sync Control Register:
'1000 0xxx'b

SyncA
SyncB   1)
Count   7   6   5   4   3   4   5   6
Trigger

C
- Trigger on falling edge of SyncA
- SyncB low/high active
- direction detection = off
- hysteresis = 0

Sync Control Register:
'1100 0xxx'b

SyncA
SyncB   1)
Count   7   6   5   4   3   4   5   6
Trigger

D
- Trigger on 4 edges of SyncA and SyncB
- direction detection = off
- hysteresis = 0

Sync Control Register:
'1110 0xxx'b

SyncA
SyncB   1)
Count   .. .. 9 8 7 6 5 4 3 2   1   2 3 4 5 6 7 8 9 .. ..
Trigger

E
- Trigger on 4 edges of SyncA and SyncB
- direction detection = off
- hysteresis = 4

Sync Control Register:
'1110 1xxx'b

SyncA
SyncB   1)
Count   .. .. 9 8 7 6 5 4 3 2   1   2 3 4 5 6 7 8 9 .. ..
Trigger

drive holdup oscillation   2)

SyncA
SyncB   1)   1)
Count   9 8 7 6 5 4 3 2   1   2 3   4   3 2   1   2   3   2   3 4 5 6 7 8 7 8 9 .. ..
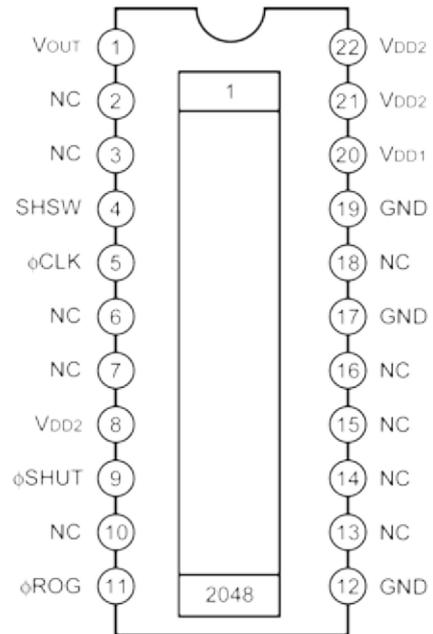Trigger

■ 5 Sensor Information

Manufacturer: Sony
Type: ILX751
Data source: Sony ILX751B Linear Sensor Document E97X25B97-PS
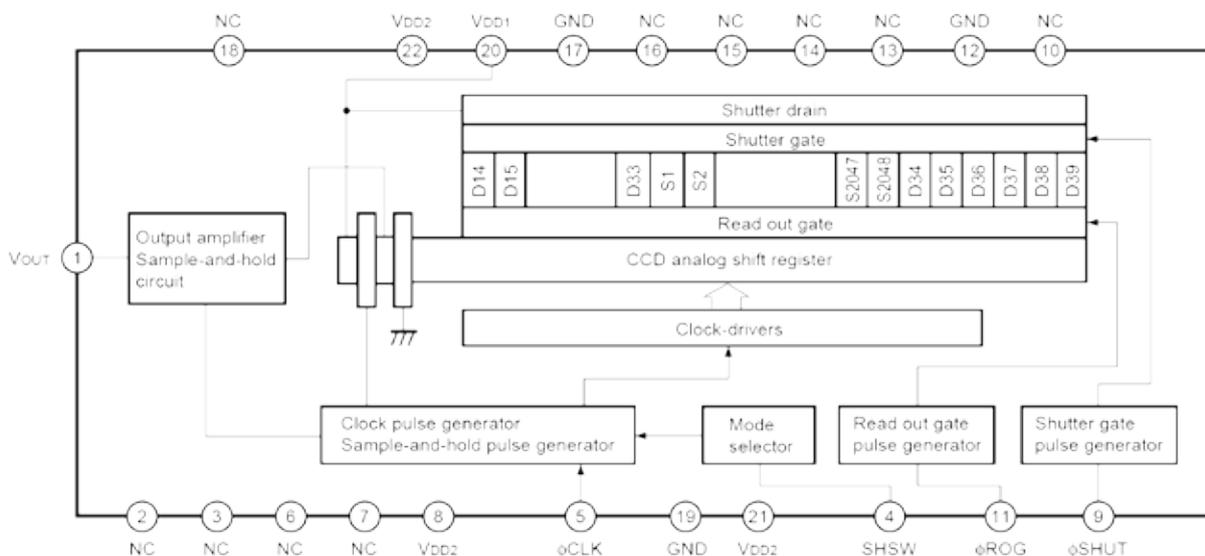
d) Features

- Number of effective pixels: 2048 pixels
- Pixel size: 14µm × 14µm (14µm pitch)
- Built-in timing generator and clock-drivers
- Shutter function
- Ultra low lag
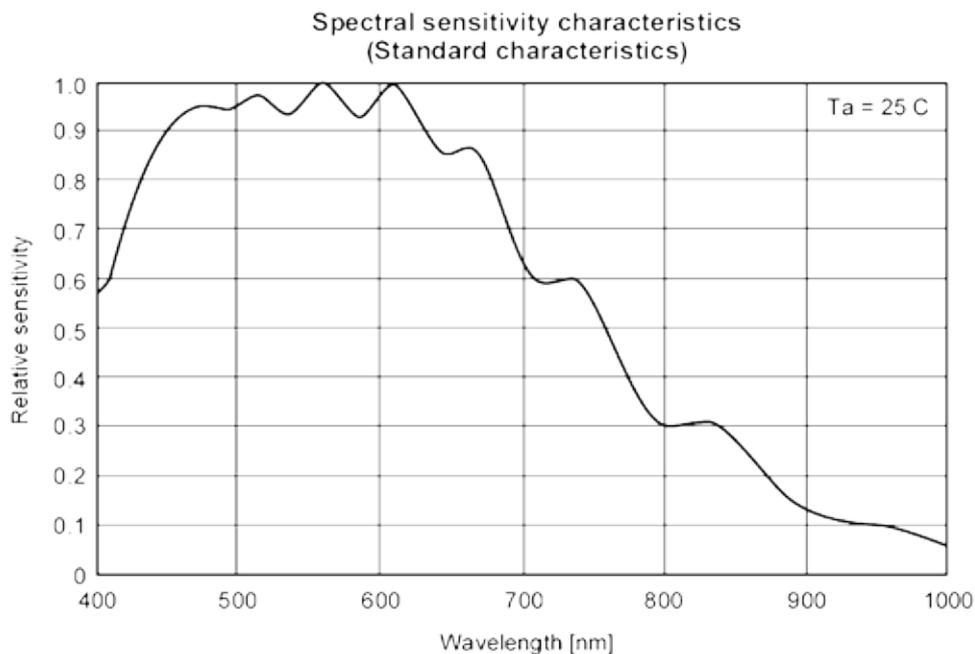- Maximum clock frequency: 5MHz

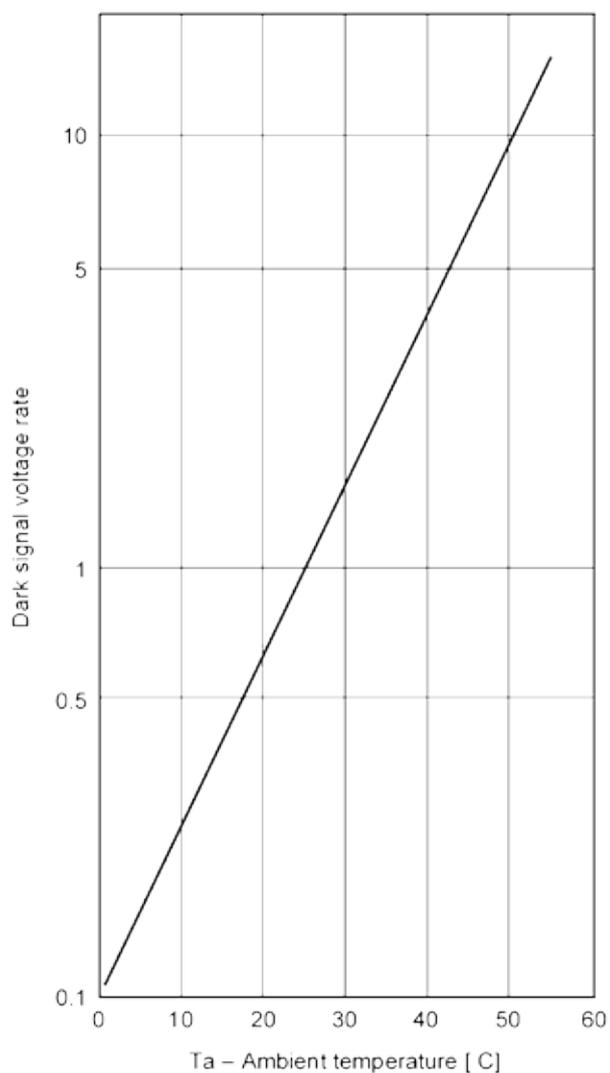### e) Pin Configuration (Top View)

a) Block Diagram

b) Example of Representative Characteristics

Spectral sensitivity characteristics
(Standard characteristics)

Ta = 25 C

Relative sensitivity vs. Wavelength [nm]

Dark signal voltage rate vs. Ambient temperature
(Standard characteristics)

Dark signal voltage rate vs. Ta – Ambient temperature [C]

VDD1, VDD2 supply current vs. Clock frequency
(Standard characteristics)

IvDD1
IvDD2

$I_{VDD1}, I_{VDD2} - V_{DD1}, V_{DD2}$ supply current [mA] vs. Clock frequency [Hz]
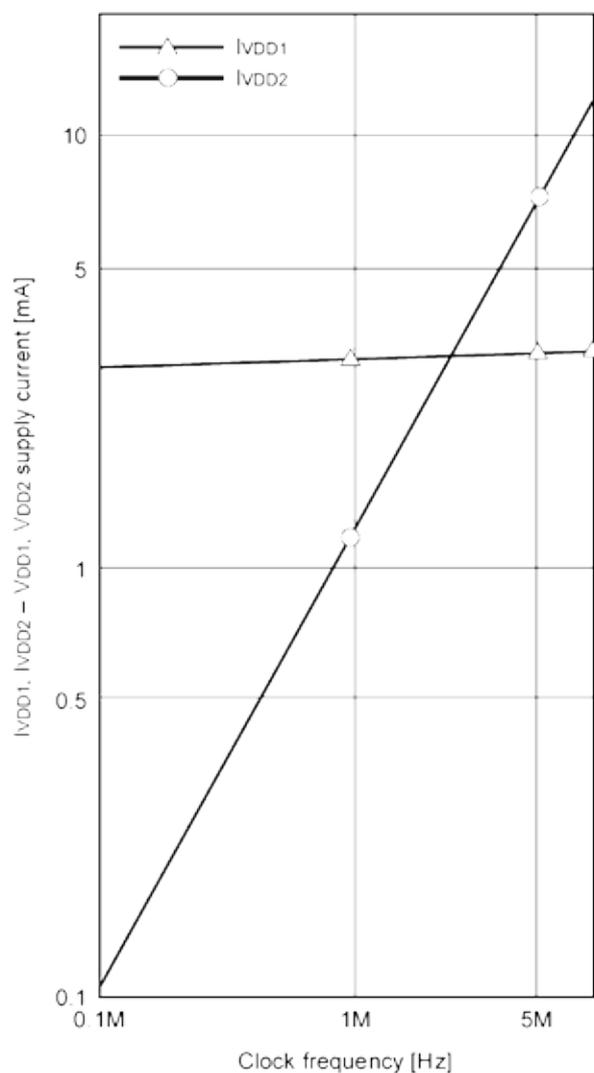
Instruction Manual SK2048VJR-4L
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c) Electrooptical Characteristics

(Ta = 25°C, V$_{DD1}$ = 9V, V$_{DD2}$ = 5V, Clock frequency = 1MHz, Light source = 3200K, IR cut filter: CM-500S (t = 1.0mm))

Item	Symbol	Min.	Typ.	Max.	Unit	Remarks
Sensitivity	R	(30)	40	(50)	V/(lx · s)	Note 1
Sensitivity nonuniformity	PRNU	—	2.0	(8.0)	%	Note 2
Saturation output voltage	V$_{SAT}$	(1.5)	1.8	—	V	—
Dark voltage average	V$_{DRK}$	—	0.3	(2.0)	mV	Note 3
Dark signal nonuniformity	DSNU	—	0.5	(3.0)	mV	Note 3
Image lag	IL	—	0.02	—	%	Note 4
Dynamic range	DR	—	6000	—	—	Note 5
Saturation exposure	SE	—	0.045	—	lx · s	Note 6
9V supply current	I$_{VDD1}$	—	4.0	(8.0)	mA	—
5V supply current	I$_{VDD2}$	—	1.8	(5.0)	mA	—
Total transfer efficiency	TTE	92.0	97.0	—	%	—
Output impedance	Zo	—	600	—	Ω	—
Offset level	Vos	—	4.0	—	V	Note 7
Shutter lag	SHUT	0	1.0	(5.0)	%	Note 8

Note)
1. For the sensitivity test light is applied with a uniform intensity of illumination.
2. PRNU is defined as indicated below. Ray incidence conditions are the same as for Note 1.

$$PRNU = \frac{(V_{MAX} - V_{MIN})/2}{V_{AVE}} \times 100 \ [\%]$$

The maximum output is set to V$_{MAX}$, the minimum output to V$_{MIN}$ and the average output to V$_{AVE}$.
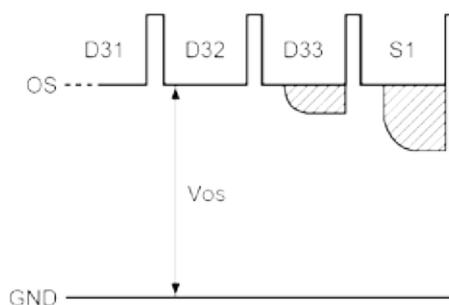
3. Integration time is 10ms.
4. V$_{OUT}$ = 500mV

5. $DR = \dfrac{V_{SAT}}{V_{DRK}}$

When optical accumulated time is shorter, the dynamic range gets wider because dark voltage is in proportion to optical accumulated time.

6. $SE = \dfrac{V_{SAT}}{R}$

7. Vos is defined as indicated below.

8. To stipulate the lag during shutter opetation, use the formula below.

Place the output voltage average value during shutter operation at V_{SHUT} and the output Voltage average value when the shutter is not in operation at V_{AVE}. (Refer to Fig. 5.)

$$SHUT = \frac{V_{SAT}}{R} \times 100 \ [\%]$$

Please note that the shutter pulse at this time accord with Fig.5.

Blooming

If by overexposure too many charge carriers are produced in one or several photosensitive elements (pixels) of the line sensor, the transport register is „flooded" with charge carriers, and also the following register bins are charged over the saturation limit. This spreading of a local overexposure along a line is called „blooming". In the resulting video signal an overexposed area includes too many pixels. In that area the geometric mapping between image and object is not correct.

CCD line scan cameras with anti-blooming sensors direct the abundant charge to a "drain gate". Charge overflow into adjacent, less illuminated pixels is prevented. Depending on pixel frequency and spectral range, overexposure up to factor of 50 can thus be handled.

Exposure period

is the illumination cycle of a line scan sensor. It is the → *integration time* plus the additional time to complete the read-out of the accumulated charges and the output procedure. While the charges from a finished line scan are being read out, the next line scan is being exposed. The exposure period is a function of the pixel number and the → *pixel frequency*. The minimum exposure period of a particular line scan camera determines the maximum → *line frequency* that is declared in the specifications.

Integration control

Cameras with integration control are capable of curtailing the → *integration* time within an → *exposure period*. This performs an action equivalent to a shutter mechanism.

Integration time

The light-sensitive elements of the photoelectric sensor accumulate the charge that is generated by the incident light. The duration of this charge accumulation is called the integration time. Longer integration times increase the intensity of the line scan signal, assuming constant illumination conditions. The complete read-out of accumulated charges and output procedure determines the minimum → *exposure period*.

Line frequency, line scan frequency

is the reciprocal value of the → *exposure period*. The maximum line frequency is a key criterion for line scan sensors as this is the limiting factor for the scan velocity.

Optical resolution

Two elements of a line scan camera determine the optical resolution of the system: first, the pixel configuration of the line sensor and, secondly, the optical resolution of the lens. The worst value is the determining value. In a phased set-up, both are within the same range.

The optical resolution of the line sensor is primarily determined by the number of pixels and secondarily by their size and spacing, the inter-pixel distance. Currently available line scan cameras have up to 12 000 pixels, ranging from 4 to 14 µm in size and spacing, for sensors up to 56 mm in length and line scan frequencies up to 83 kHz.

During a scanning run, the effective resolution perpendicular to the sensor orientation is determined by the velocity of the scan and by the → *line frequency*

Pixel frequency

The pixel frequency for an individual sensor is the rate of charge transfer from pixel to pixel and its ultimate conversion into a signal.

Region of Interest

A freely programmable window (region of interest, ROI) can be applied to the line sensor so that only the pixel information within the ROI can reach the memory.

By only illuminating these ranges, data volume and data processing is accelerated for both line and area scan acquisitions.

Constraint: the ROI memory allocation must be divisible by 8.

Shading correction

→ *Shading Correction*, section 3.2

SCM

Shading Correction Memory,

→ *Shading Correction Memories and API Functions*, section 3.2

SoI (Start of Integration)

In addition to → *SoS*, cameras with → *Integration Control* function generate an internal SoI-signal that initiates the integration period.

SoS (Start of Scan)

is an internally generated trigger signal for sequential control of the camera, The signal is induced either by an internal counter or by an external line synchronization signal, depending on the selected line synchronization mode.

→ *Synchronization*

→ *Advanced Synchronization Control*, section 4.2

SkLineScan

is the software application from Schäfter + Kirchhoff for controlling and adjusting the line scan cameras,

→ *Software: SkLineScan*, section 3.1

Synchronization

To obtain a proportional image with the correct aspect ratio, a line synchronous transport with the laterally correct pixel assignment is required. The → *Line frequency* and constant object velocity have to be compatible with each other.

For more accurate requirements or with a variable object velocity, external synchronization is necessary.

→ *Synchronization of the Imaging Procedure and the Object Scan Velocity*, section 3.2

Thresholding (monochrome cameras only)

The thresholding process generates a binary signal from the gray scale data, with values below the threshold yielding 0 and those above yielding 1. Only the pixel addresses of the location and threshold transition (from high→low or low→high) are transmitted, reducing data throughput.

Thresholding is particularly appropriate for measuring widths or edge positions, by simply masking the required pixel addresses.

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CE-Conformity

CE

The product complies with the following standards and directives:

2014/30/EU

EMC Directive

DIN EN 61326-1:2013

Electrical equipment for measurement, control and laboratory use – EMC requirements

Part 1: General requirements

Warranty

This manual has been prepared and reviewed as carefully as possible but no warranty is given or implied for any errors of fact or in interpretation that may arise. If an error is suspected then the reader is kindly requested to inform us for appropriate action.

The circuits, descriptions and tables may be subject to and are not meant to infringe upon the rights of a third party and are provided for informational purposes only.

The technical descriptions are general in nature and apply only to an assembly group. A particular feature set, as well as its suitability for a particular purpose, is not guaranteed.

Each product is subjected to a quality control process. If a failure should occur then please contact the supplier or Schäfter + Kirchhoff immediately.

The warranty period covers the 24 months from the delivery date. After the warranty has expired, the manufacturer guarantees an additional 6 months warranty for all repaired or substituted product components.

Warranty does not apply to any damage resulting from misuse, inappropriate modification or neglect. The warranty also expires if the product is opened. The manufacturer is not liable for consequential damage.

If a failure occurs during the warranty period then the product will be replaced, calibrated or repaired without further charge. Freight costs must be paid by the sender. The manufacturer reserves the right to exchange components of the product instead of making a repair. If the failure results from misuse or neglect then the user must pay for the repair. A cost estimate can be provided beforehand.

Software

The Schäfter + Kirchhoff GigE Vision™ line scan cameras use the Gigabit Ethernet communication protocol and are 100% compliant with the GigE Vision™ specifications and the Gen<I>Cam™ standard. They implement a superset of the Gen<I>Cam™ specification which defines the device capabilities. The settings are made in the device feature list of any Gen<I>Cam™ compliant software.

The Gen<I>Cam™ standard provides a generic programming interface for all kinds of cameras and, no matter what features they implement, the application programming interface (API) always remains the same.

Accessories

CAT6 Network cable

Shielded CAT6 patch cable, halogen-free, both ends with RJ45 connectors for Gigabit Ethernet

CAT6.x   `Order Code`

cable length 3 / 5 / 10 m or
length according to choice, max. 100 m

Power cable SK9014.xF

for GigE Vision™ line scan cameras with 24 V DC supply voltage.

Shielded cable with Hirose plug HR10A, female 4-pin (camera side), and open-ended line.

SK9014.xF   `Order Code`

cable length 1.5 / 3 / 5 m

External synchronization cable SK9024...

for line scan cameras with GigE / GigE Vision™ interface.

Shielded cable with Hirose plug HR10A, female 12 pin (camera side), and Phoenix 4 pin connector incl. terminal block.

SK9024.x   `Order Code`

cable length 3 / 5 m
Other lengths on request

Power cable SK9014.xMF

for GigE Vision™ line scan cameras with 24 V DC supply voltage.

Shielded cable with Hirose plug HR10A, female 4-pin (camera side), and XLR connector type NC6MXX.

SK9014.xMF   `Order Code`

cable length 1.5 / 3 / 5 m

Adapter cable for sync signals CAB-AD Sync-BNC-1

BNC/SMA (3x) to Line Scan Camera Synchronization Cable SK9016/SK9024/SK9026.

Shielded cable, length 0.25 m

Connectors:
1x Phoenix 4-pin connector
3x SMA plug (Line Sync A, Line Sync B, Frame Sync)
3x adapter SMA socket (outside threading) to BNC-plug

CAB-AD Sync-BNC-1   `Order Code`

Power supply unit PS243005

| Input: | 100-240 VAC, 0.8 A, 50/60 Hz IEC 60320 C14 coupler (for IEC C13 power cord) |
| Output: | +24 V DC, 3.0 A |

Cable length: 1 m, with XLR connector type NC6FXX

PS243005   `Order Code`

Power cord IEC 60320 C13, 1.5 m, 10 A, 250 V AC

DE US UK

PC150DE   `Order Code`
DE = Europe / US = USA, Canada, Japan /
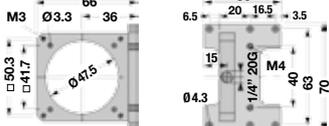UK = United Kingdom

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M2 **Mounting Bracket SK5105-L**

`Order Code`
SK5105-L

Mounting diameter 47.5 mm, for cameras with square housing Bxx and round housing Ax3

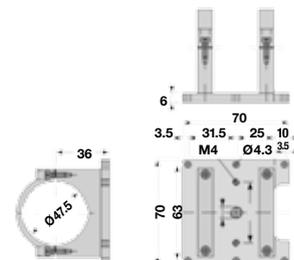SK5105-L with clamping set SK5101#

MC **Clamping Set SK5101**

Clamp

`Order Code`
SK5101
(set of 4 pcs.)

Allen screw DIN 912–M3x12

M4 **Mounting System SK5105-2L**

`Order Code`
SK5105-2L

For camera configurations with tube length > 55 mm using extension rings **ZR-L**
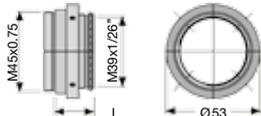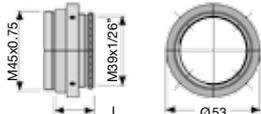

FA3 **Focus adapter L-Mount (M39x1/26" Leica)**

any rotation angle adjustable (V-groove)
attachement thread M45x0.75, male

FA22R-45   `Order Code`
length L: 22 ... 32 mm

FA22RL-45   `Order Code`
length L: 29 ... 38 mm

A3 **Lens Adapter F-Mount**

for line scan cameras with case type **Axx** or **BGx**.

AOC-F-...   `Order Code`

Attachment thread:
45 = M45x0.75
40 = M40x0.75
32 = M32x0.75
C = C-Mount 1"-32-TP

ZR-L **Extension rings M45x0.75**

attachment threads M45x0.75 male/female

ZR-L 25   `Order Code`

15 = Length 15 mm
25 = Length 25 mm
60 = Length 60 mm
87 = Length 87 mm

L=Length

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