

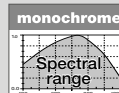
# SK5150VJR-4L

## Monochrome Line Scan Camera

5152 pixels  $7 \times 7 \mu\text{m}^2$ , line frequency up to 7.52 kHz

Line scan camera with very high sensitivity, 7.52 kHz maximum line rate.

CCD



**GiG**  
VISION  
GEN<math>\langle \rangle</math>CAM

## Instruction Manual



### Sample Configuration

- 1 CCD line scan camera  
**SK5150VJR-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



## 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!**

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# 1 Introducing the SK5150VJR-4L Line Scan Camera

## 1.1 Intended Purpose and Overview

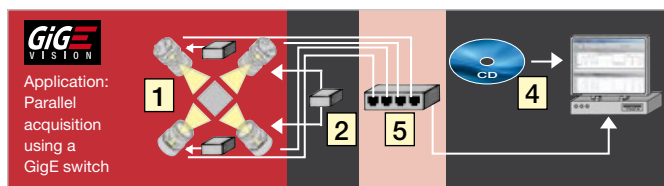
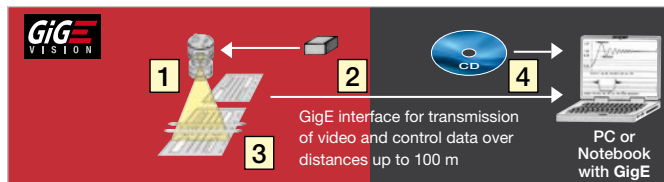
The SK line scan camera series is designed for a wide range of vision and inspection applications in both industrial and scientific environments.

The SK5150VJR-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.

The Schäfter+Kirchhoff GigE Vision line scan cameras implement a superset of the Gen<I>Cam™ specification which defines the device capabilities.

The device feature list is described in section 4 *GigE Vision Device Feature List (Gen<i>Cam compliant)* (p. 15). The section *Camera Head Feature* (p. 18) contains the features created specifically for this camera. Any Gen<I>Cam compatible software can access these as well as the other features.



- |   |                      |                                   |          |
|---|----------------------|-----------------------------------|----------|
| 1 | CCD line scan camera | 4                                 | Software |
| 2 | Power supply         | <b>GEN&lt;i&gt;CAM</b> -compliant |          |
| 3 | Illumination         |                                   |          |

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. 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:

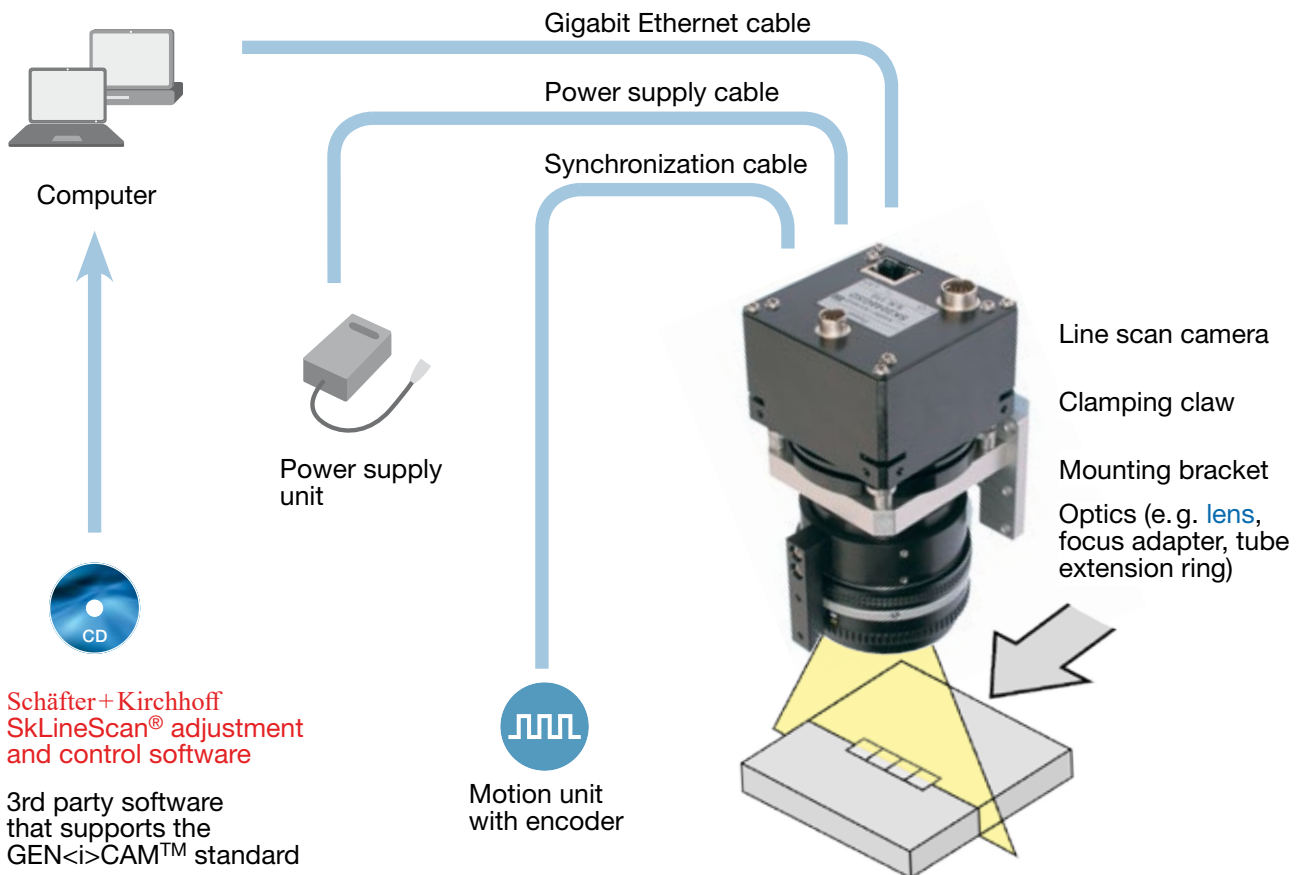
<https://www.visiononline.org/vision-standards-details.cfm?type=5>

or the Gen<I>Cam™ standard:  
<http://www.emva.org/standards-technology/genicam/>

## 1.2 System Setup at a Glance

- red: SK5150VJR-4L scope of delivery
- blue: accessories for minimum system configuration
- black: optional accessories

For accessory order details see *Accessories (p. 28)*.



### 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

#### 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.
- Network adapters that support Jumbo Frames outperform adapters with fixed packet-size frames.

### 1.4 SK5150VJR-4L Line Scan Camera - Specifications

Sensor category	CCD Monochrome Sensor
Sensor type	ILX531
Pixel number	5152
Pixel size (width x length)	7 x 7 $\mu\text{m}^2$
Pixel spacing	7 $\mu\text{m}$
Active sensor length	36 mm
Anti blooming	-
Integration control	-
Shading correction	x
Threshold detection	-
Line synchronization modes	Line Sync, Line Start, Exposure Start
Frame synchronization	x
Pixel frequency	40 / 20 MHz
Maximum line frequency	7.52 kHz
Integration time	0.133 ... 20 ms
Dynamic range	1:500 (rms)
Spectral range	400 ... 900 nm
Video signal	monochrome 8/12 Bit digital
Interface	GigE Vision
Voltage	18 - 36 V DC
Power consumption	5.4 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
Admissible casing temperature	+5 ... +45°C

The camera must be mounted thermally coupled so that the acceptable casing temperature is not exceeded during operation. Therefore applies to the thermal resistance of the bracket or heat sink:

$$R_{thHS} \leq \frac{\theta_{amb} - \theta_{casing}}{P_{camera}}$$

where

$R_{thHS}$  [K/W] = thermal resistance of the bracket or heat sink

$\theta_{amb}$  [°C] = ambient temperature

$\theta_{casing}$  [°C] = temperature of the camera casing (not to be confused with the internal camera temperature that is queried and output with the request command I32)

$P_{camera}$  [W] = camera power consumption

## 2 Installation and Setup

### 2.1 Mechanical Installation: Dimensions, Mounting Options, and Heat Dissipation

#### Mounting Options

When mounting the camera, pay attention to the following:

- Mechanical stability to avoid vibrations.
- Good thermal coupling for cooling the housing. The power consumption and the maximum housing temperature of the camera are specified in section 1.4 - *Specifications*.

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

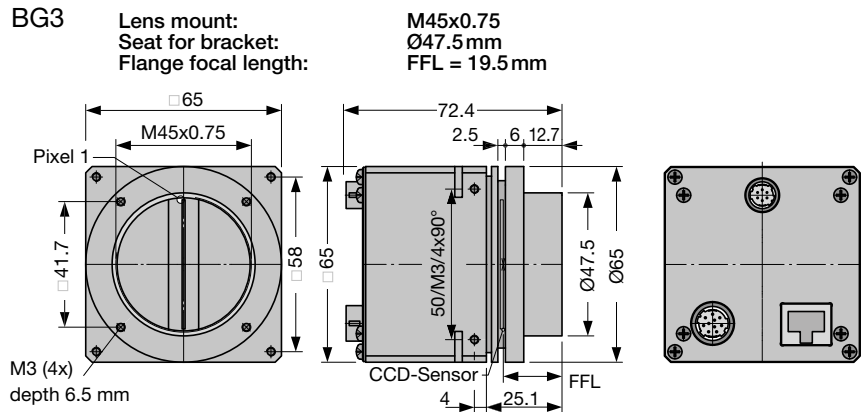
Four threaded holes M3x6.5 mm provide further options for customized brackets.

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.

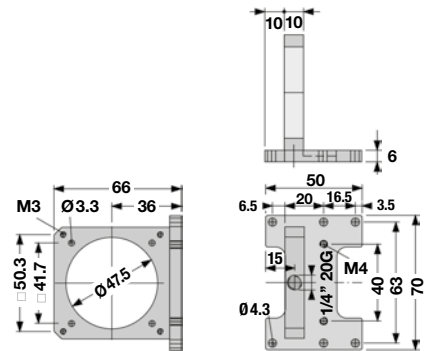
#### Optics Handling

- 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



#### Mounting bracket SK5105-L



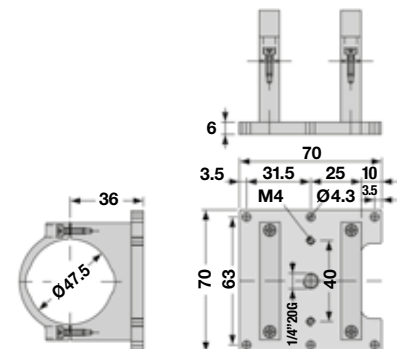
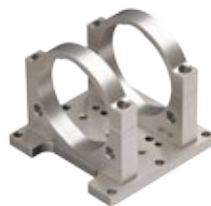
#### Clamping set SK5101

Set of 4 pcs. clamping claws incl. hex socket screws (EN ISO 4762-M3x12)



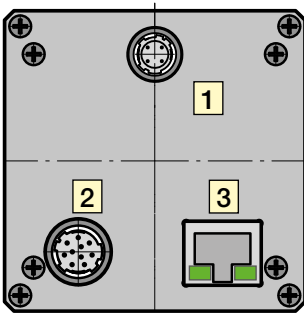
#### Mounting system SK5105-2L

for cameras with a tube extension > 52 mm

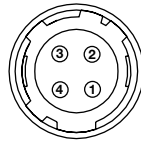


## 2.2 Electrical Installation: Connections and I/O Signals

- For the SK5150VJR-4L line scan camera-data transfer and camera control is provided 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. 11)



### 1 Power +24V

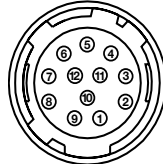


Hirose series 10A, male 4-pin

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

Total power: 5.4 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

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



Network activity

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

### Accessories (see also Accessories (p. 28):

#### 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

#### 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.

## 2.3 GigE Connections and Software Installation

The SK5150VJR-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

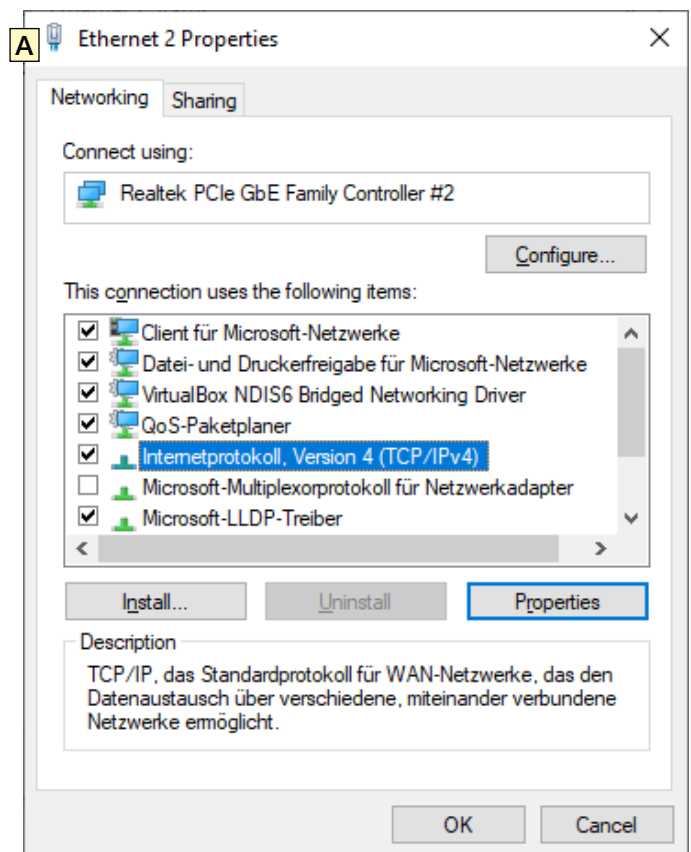
This section is relevant for systems with a standard NIC (not INTEL PRO/1000) in combination with the manufacturer driver (case 3).

### 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:**

Open the Network Connection Properties dialog **A**.

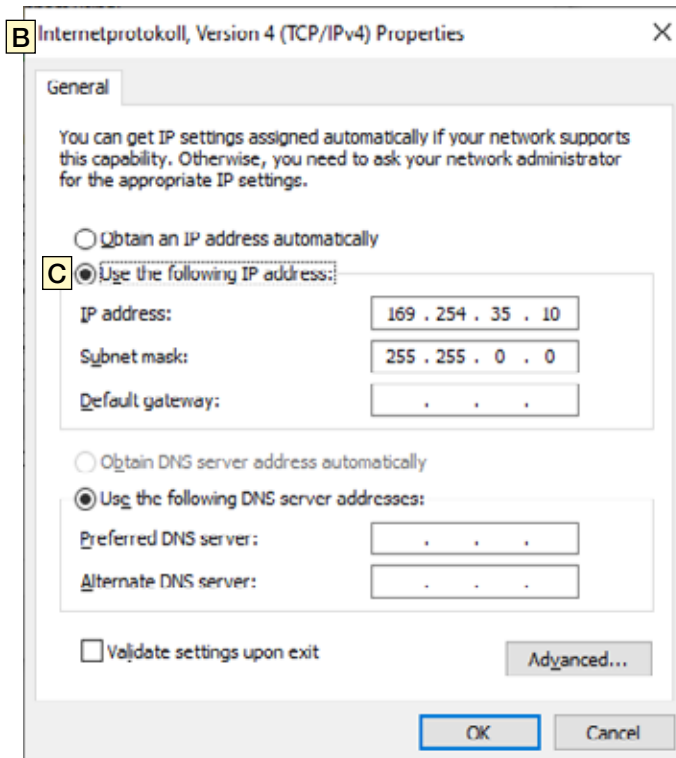
Select Internet Protocol (TCP/IPv4) and click Properties. The Internet Protocol, Version 4 (TCP/IPv4) dialog **B** Properties shows up.

Enable "Use the following IP address" **C** 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).

Close the opened dialogs with "OK". Your NIC is now configured for a dedicated connection.



**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

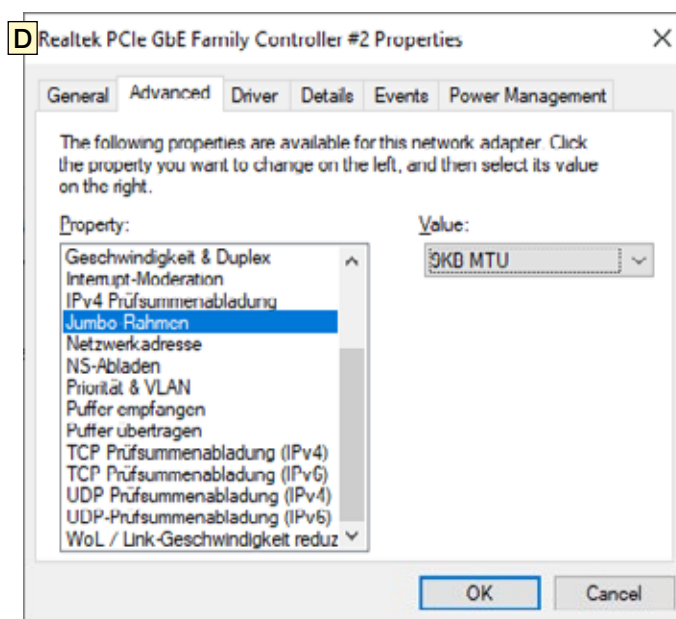
Select the camera control program and click "OK"

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



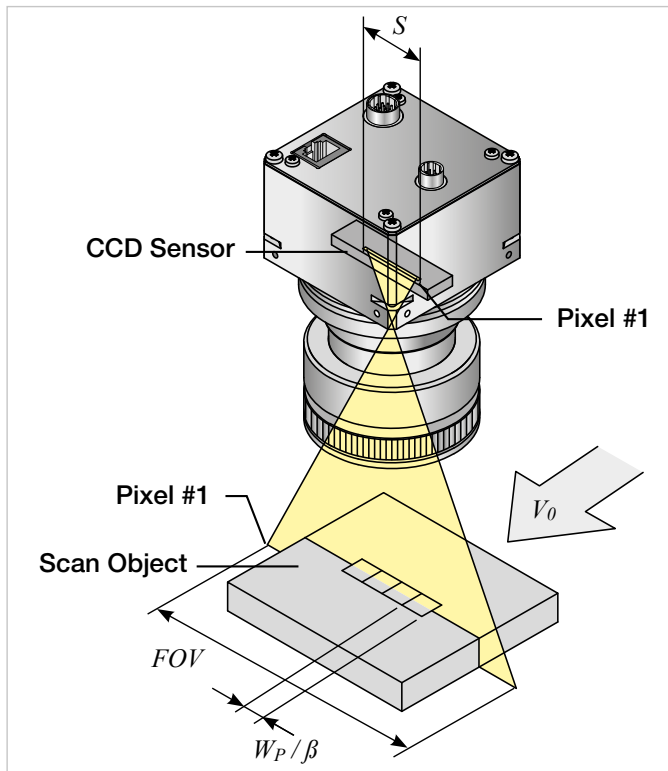
Network Controller Properties: Note, the terms can differ depending on the installed Ethernet card and driver.

### 3 Synchronization

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
- $\beta$  = magnification factor
- =  $S / FOV$

#### Example 1:

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

- Pixel width = 7  $\mu$ m
- Line frequency = 7.52 kHz
- $S$  = 36 mm
- $FOV$  = 60 mm

$$V_O = \frac{7 \mu\text{m} \cdot 7.52 \text{ kHz}}{(36 \text{ mm} / 60 \text{ mm})} = 88 \text{ mm/s}$$

#### Example 2:

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

- Pixel width = 7  $\mu$ m
- Scan velocity = 80 mm/s
- $S$  = 36 mm
- $FOV$  = 60 mm

$$f_L = \frac{80 \text{ mm/s} \cdot (36 \text{ mm} / 60 \text{ mm})}{7 \mu\text{m}} = 6.9 \text{ kHz}$$

Instruction Manual SK5150VJR-4L | shared\_CameraControl(3)\_Sync\_IL.indd

## ■ 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 SK5150VJR-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, S. 19**.

### 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.

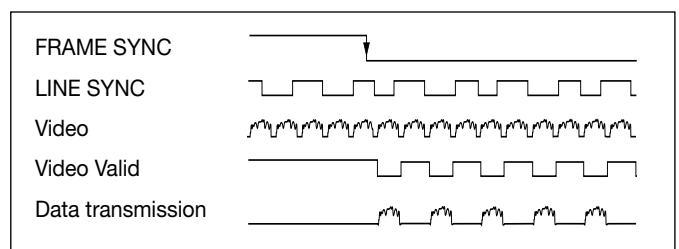
Restriction: The period duration of the trigger signal must be longer than the exposure time used.

## 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.

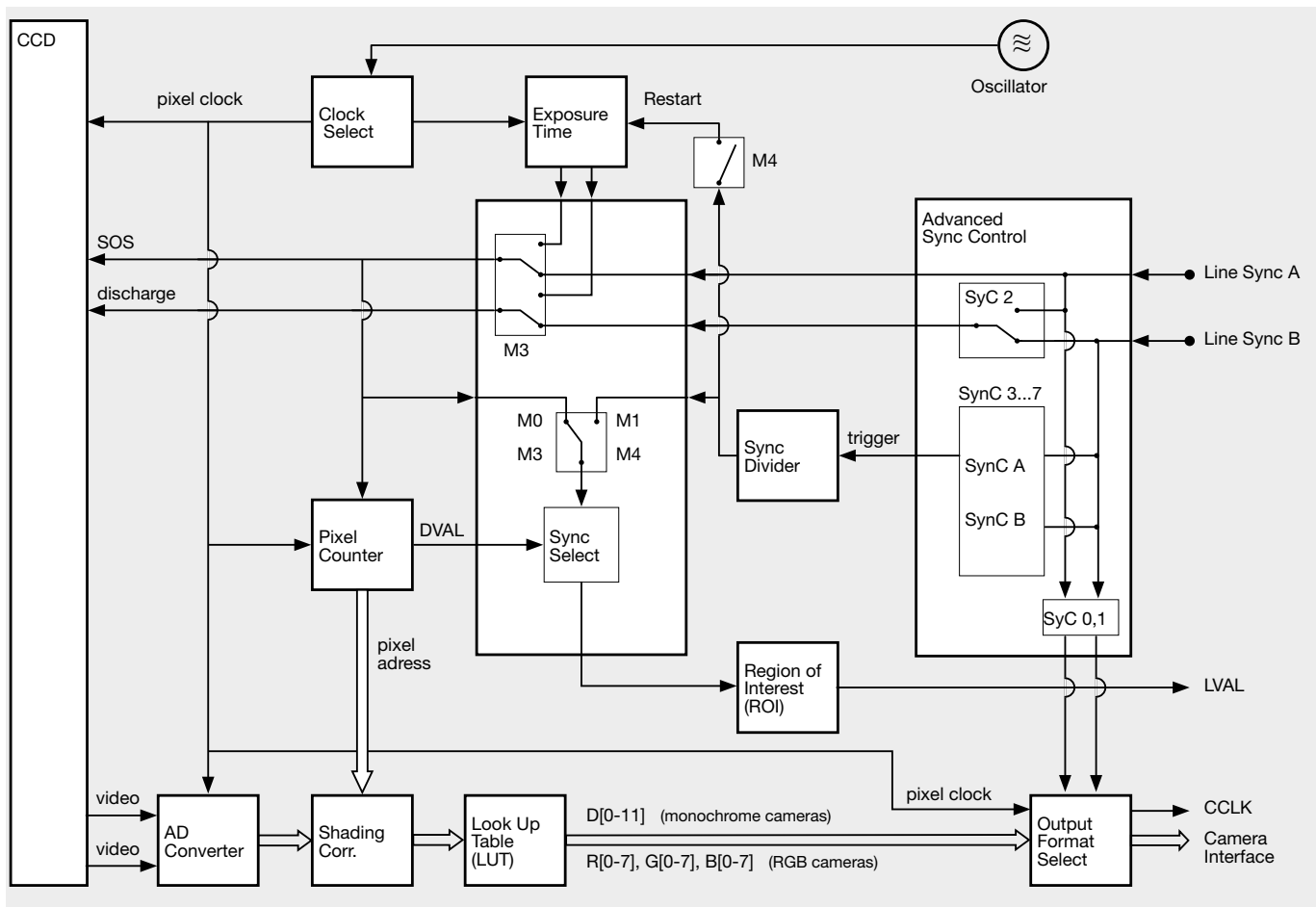
## FrameTrigger / SK FrameSync

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

The configuration of the synchronization, i.e. setting the synchronization mode for line triggering, activating frame triggering, setting the frame trigger delay time, is done either by parameters in the Camera Head Feature or Custom Feature section of the *GigEVision Device Feature List* (see section 4), or via serially transmitted commands (see *Advanced Camera Control Functions*, section 5).



Functional diagram of the Camera Control System

Instruction Manual SK5150VJR-4L | @lared\_CamemControl@b | Sync-Module\_GigE-V\_USB3\_ML.ind

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

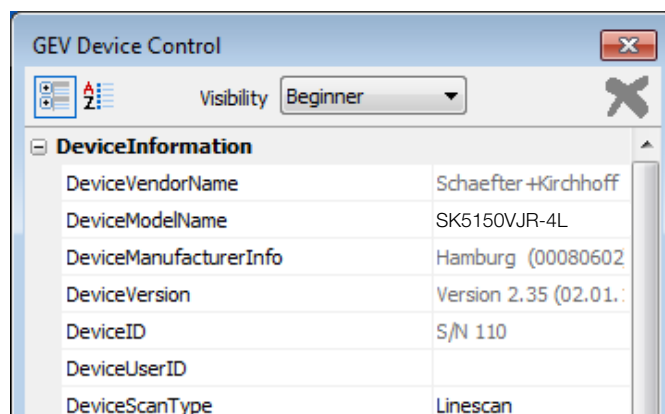
This chapter describes the parameters of the GigE Vision Device Feature list that are relevant for the configuration and operation of the camera.



The data can be edited, as long as they are not grayed out. Some parameters can only be edited if image acquisition has been stopped.

### ■ Device Information

Device Feature	Description	Access	Expert mode only
<b>DeviceVendorName</b>		Read only	
<b>DeviceModelName</b>		Read only	
<b>DeviceManufacturerInfo</b>		Read only	
<b>DeviceVersion</b>		Read only	
<b>DeviceID</b>		Read only	x
<b>DevcieUserID</b>		Read only	
<b>DeviceScanType</b>		Read only	



## ■ Image Size Control

Device Feature	Description	Access	Expert mode only
<b>SensorWidth</b>	Number of pixels of line sensor (fixed)	Read only	
<b>SensorHeight</b>	1 (fixed)	Read only	x
<b>SensorDigitization Taps</b>		Read only	
<b>Width</b>	Image width = ROI ... SensorWidth	Read/write	
<b>Height</b>	Image height (number of lines per image) 1 for Line Scanning ≥2for Area Scanning, limited by 32 MByte buffer size	Read/write	
<b>DecimationHorizontal</b>		Read only	
<b>DecimationVertical</b>		Read only	
<b>OffsetX</b>	Start pixel address of ROI	Read/write	
<b>PixelFormat</b>	Mono8= gray scale 8-bit Mono10 = gray scale 10-bit Mono12= gray scale 12-bit	Read/write	
<b>PixelSize</b>	bits per pixel, depends on PixelFormat Mono8:PixelSize = Bpp8 = 8-bit Mono10:PixelSize = Bpp16 = 16-bit Mono12:PixelSize = Bpp16 = 16-bit	Read/write	
<b>TestPattern</b>	Off = normal sensor output signal On = Output of a sawtooth-shaped test signal	Read/write	

ImageSizeControl	
SensorWidth	5152
SensorHeight	1
SensorDigitizationTaps	One
Width	5152
Height	16383
DecimationHorizontal	1
DecimationVertical	1
PixelFormat	Mono8
PixelCoding	Mono
PixelSize	Bpp8

## ■ Acquisition and Trigger Controls

Device Feature	Description	Access	Expert mode only
<b>AcquisitionMode</b>	Continuous: repetitive acquisition SingleFrame: one snapshot	Read/write	
<b>AcquisitionStart</b>		Command	
<b>AcquisitionStop</b>		Command	
<b>AcquisitionFrameCount</b>		Read only	
<b>AcquisitionLineRateAbs</b>	Line rate in Hz minimum: 50 Hz maximum: 7520 Hz	Read/write	
<b>Trigger Selector</b>	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		
<b>ExposureTimeRaw</b>	Exposure time in $\mu$ s, range 133 ... 20000 (master feature of exposure control)	Read/write	
<b>ExposureTimeAbs</b>	Exposure time in ms, range 0.133 ... 20	Read/write	

Note: The parameters *Acquisition Line Rate* and *Exposure Time* depend on each other. A change of the Line Rate affects a changing of Exposure Time, and reverse too

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

## ■ Analog Controls

Device Feature	Description	Access	Expert mode only
<b>GainSelector</b>	Gain control for all taps or for each tap separately		
<b>GainRaw</b>	Gain adjustment absolute (master feature of gain control), range: 0 ... 1023, typical 70 (integer)	Read/write	
<b>GainAbs</b>	Gain adjustment in dB, range: 0 ... 24.0 (float)	Read/write	
<b>BlackLevelSelector</b>	Offset control for all taps or for each tap separately		
<b>BlackLevelRaw</b>	Offset adjustment, range: 0 ... 255 (integer)		

AnalogControls	
GainSelector	All
GainRaw	70
GainAbs	0.778361 dB
BlackLevelSelector	All
BlackLevelRaw	255

## ■ Custom Features

Device Feature	Description	Access	Expert mode only
<b>SkGetPixFrequencyHigh</b>	Returns the higher pixel frequency of the camera in MHz, for information only.	Read only	x
<b>SkGetPixFrequencyLow</b>	Returns the lower pixel frequency of the camera in MHz, for information only.	Read only	x
<b>SkSetPixelFrequency</b>	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.	Read/write	
<b>SkSetShadingCorrection</b>	ON: activates Shading Correction OFF: deactivates Shading Correction See White Balance and Shading Correction (p. <?>).		
<b>SkShadCorrReference</b>	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.	Command	x
<b>SkSaveScmToFlash</b>	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.	Command	x
<b>SkTestPattern</b>	Switch on test pattern, turns off with power off	Command	x
<b>SkGetMaxLineFrequency</b>	Returns the maximum line rate in Hz	Read only	
<b>SkGetMinExposureTime</b>	Returns the minimum exposure time in microseconds		
<b>SkFrameTrigger</b>	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. <?>).		
<b>SkGetVideoChannels</b>	Returns the number of taps for gain /offset control		
<b>SkGetSerialNumber</b>	Returns the serial number of the camera		
<b>SkGetRevisionNumber</b>	Returns the revision number for the camera		
<b>SkSyncControl</b>	Sync Control Register setting, see Advanced Trigger Functions and Sync Control Register (SCR) Settings (p. <?>).		
<b>SkSyncDivider</b>	Incoming trigger clock divider (integer)		

## 5 Advanced Camera Control Functions

### 5.1 Camera Control by Commands

#### Set Commands

Set Operation	Description
G0000<CR>	gain 1 setting 0-24 dB
B0000<CR>	gain 2 setting 0-24 dB
O0000<CR>	offset 1 setting
P0000<CR>	offset 2 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
C40<CR>	camera clock: 40 MHz data rate
C20<CR>	camera clock: 20 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: free run (no triggering) at selected line rate
M1<CR>	line trigger mode1: extern trigger, next line
M2<CR>	line trigger mode0: free run (no triggering) at maximum line rate
M3<CR>	Pleora sync modes
M5<CR>	line trigger mode5: extern SOS, all lines
Axxxx<CR>	SCM address (xxxxx = A0-A5149) or LUTM (xxxxx = A32768-A36863)
Dxxxx<CR>	Memory data (xxxx = 0-4095), increment memory address counter
Eyyyyy<CR>	frames / multiframe (yyyyy = 0-32767)
EFyyyyy<CR>	external frame trigger delay (yyyyy = 0-32767 lines)
Nyyyyy<CR>	lines / frame (yyyyy = 1-32767)
Wyyyyy<CR>	line clock frequency (yyyyy = 50-7520) [Hz]
WLyyyyy<CR>	Window Pixel length (yyyyy = 1-Line length)
WFyyyyy<CR>	Window First Pixel (yyyyy = 1-Line length)
Xyyyyy<CR>	exposure time (yyyyy = 133-20000) [μs]
Vyyyyy<CR>	extern sync divider (yyyyy = 1-32767)
Yppp<CR>	set sync control (ppp = 255)
SCOG<CR>	enable COG (coupling of gain settings)
RCOG<CR>	disable COG (coupling of gain settings)
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

#### Request Commands

Request	Return	Description
K<CR>	SK5150VJR-4L	returns SK type number
R<CR>	Rev. 2.35	returns Revision number
S<CR>	SNr00163	returns Serial number
I<CR>	SK5150VJR-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 1
I7<CR>	Ga2: yyyyy	returns gain 2
I8<CR>	Of: yyyyy	returns offset 1
I9<CR>	Of2: yyyyy	returns offset 2
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
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

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

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

## 5.2 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:

**Yppp<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 Hysteresis off	x	x	x	0	0	x	x	x
Jitter Hysteresis 4	x	x	x	0	1	x	x	x
Jitter Hysteresis 16	x	x	x	1	0	x	x	x
Jitter Hysteresis 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.

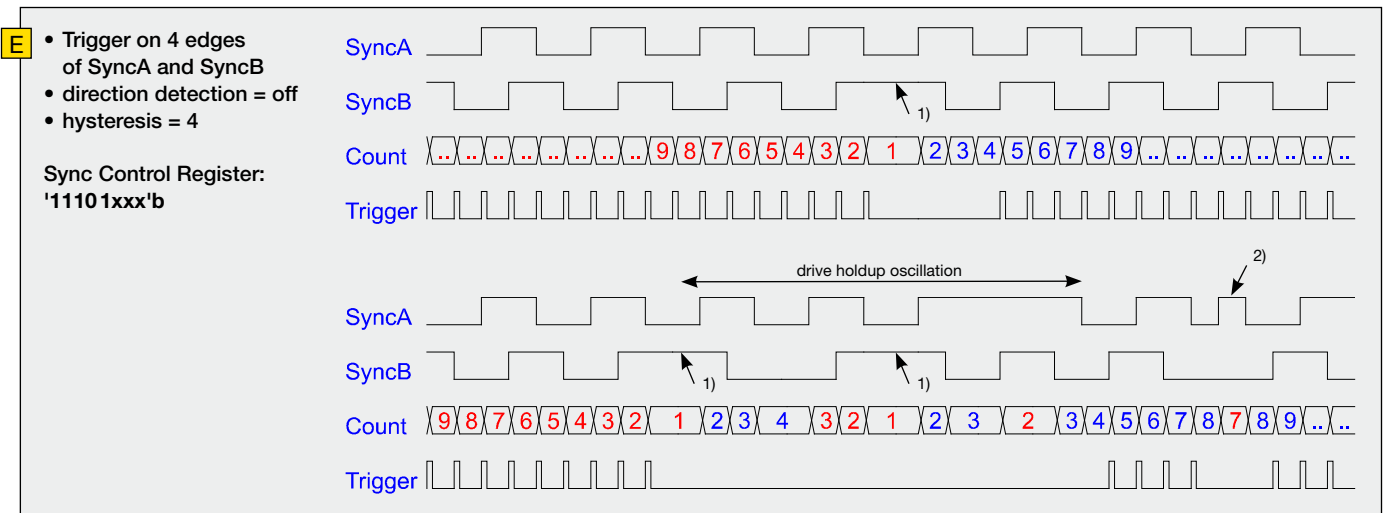
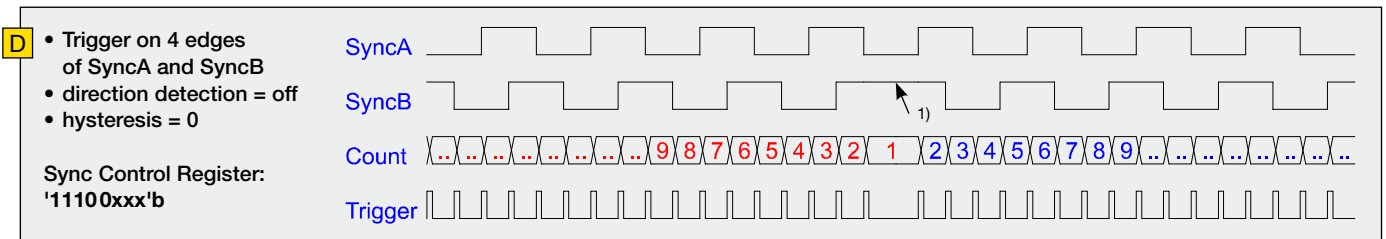
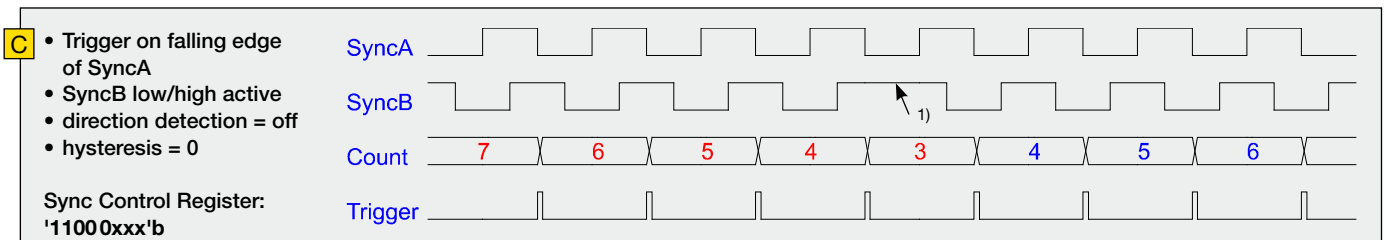
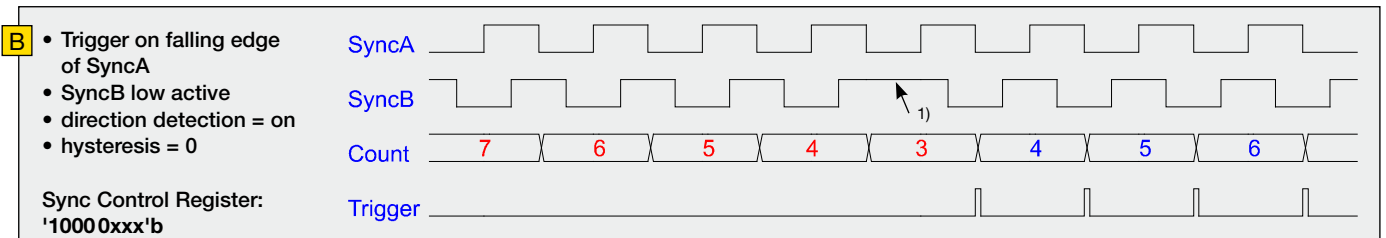
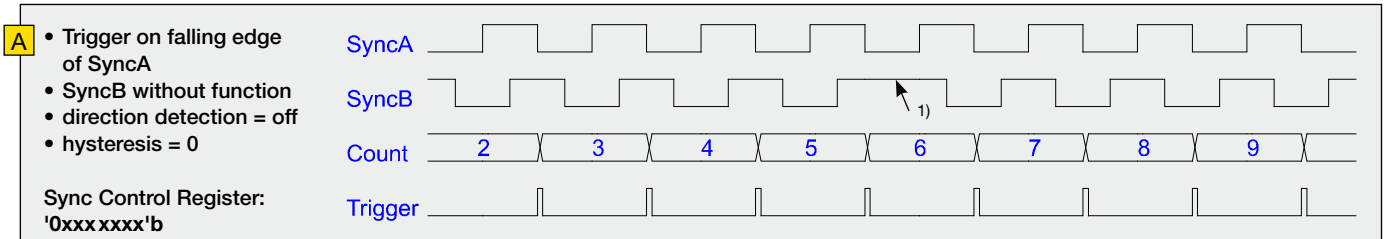
SCR	Pixel #1 Data (lowByte)	Pixel #2 Data (lowByte)
xxxxxx00	intensity	intensity
xxxxxx01	D7 = FRAME SYNC D6 = LINE SYNC B D5 = LINE SYNC A D4 ... D0 = 0	intensity
xxxxxx10	internal line counter (8 bit)	intensity
xxxxxx11	D7 = FRAME SYNC D6 = LINE SYNC B D5 = LINE SYNC A D4 ... D0 = line counter (bit 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 Vyyyyy<CR> command or the 'Divider' input field in the **4.1 Camera Control by Commands (p. 20)**.

- 1) direction changed
- 2) glitch





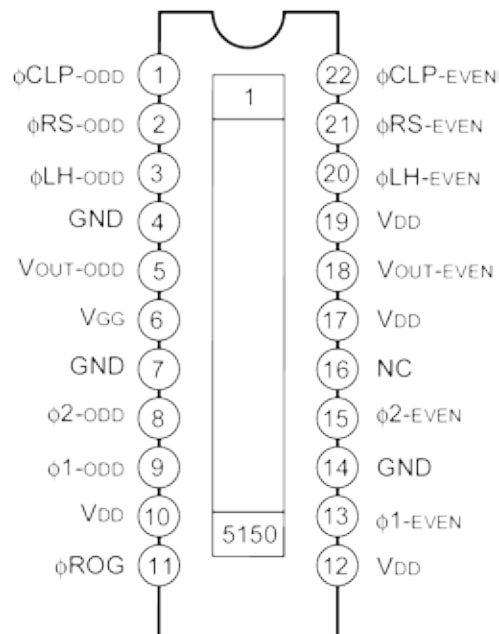
## 6 Sensor Information

Manufacturer: Sony  
 Type: ILX531  
 Data source: Sony ILX531A Linear Sensor Document E97X25B97-PS

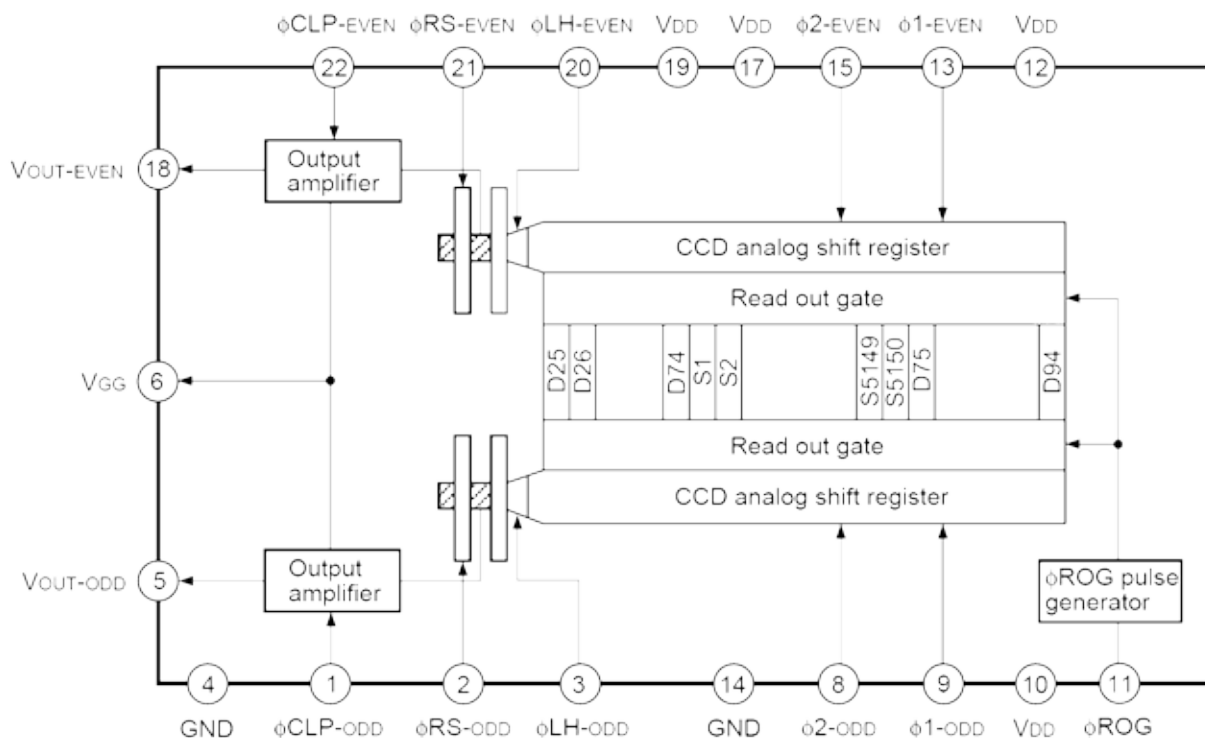
### d) Features

- Number of effective pixels: 5150 pixels
- Pixel size:  $7\mu\text{m} \times 7\mu\text{m}$  ( $7\mu\text{m}$  pitch)
- Clamp circuit are on-chip
- Signal output phase of two-output simultaneous-output (alternate-output is available)
- Ultra high sensitivity/Ultra low lag
- Maximum data rate: 40MHz
- Single 12V power supply
- Input clock pulse: CMOS 5V drive
- Package: 22 pin Plastic DIP (400mil)

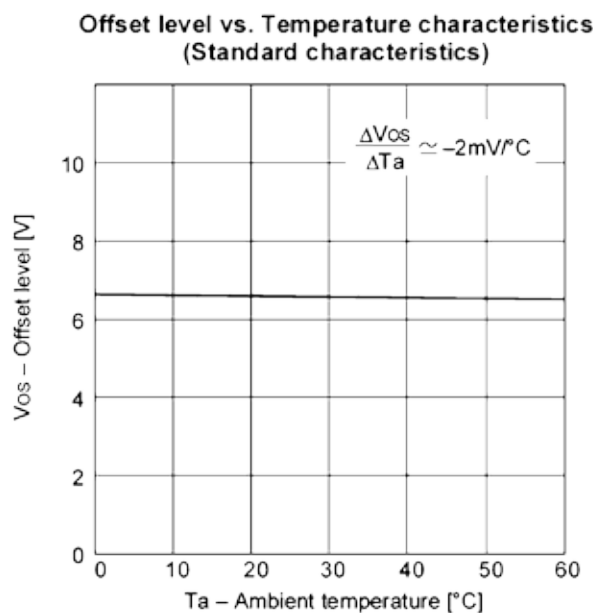
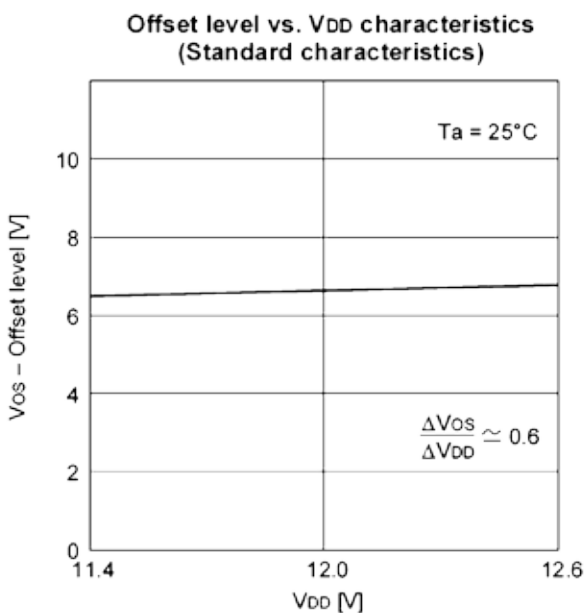
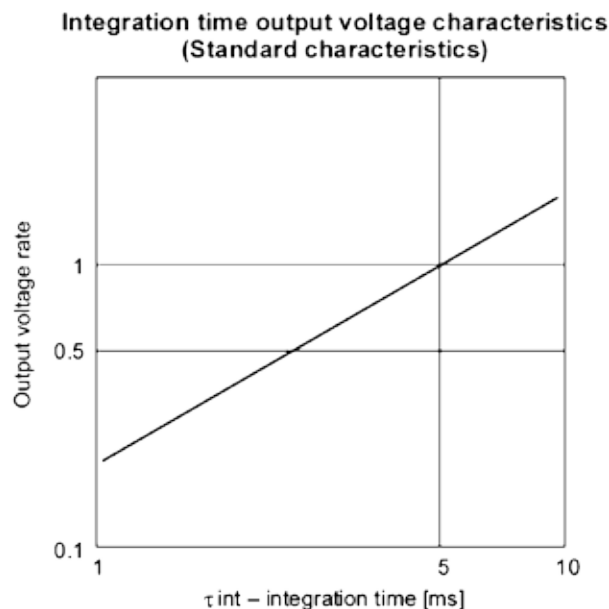
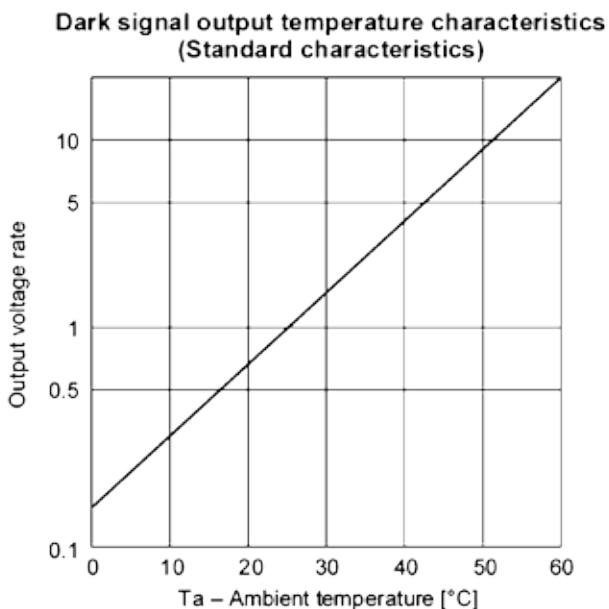
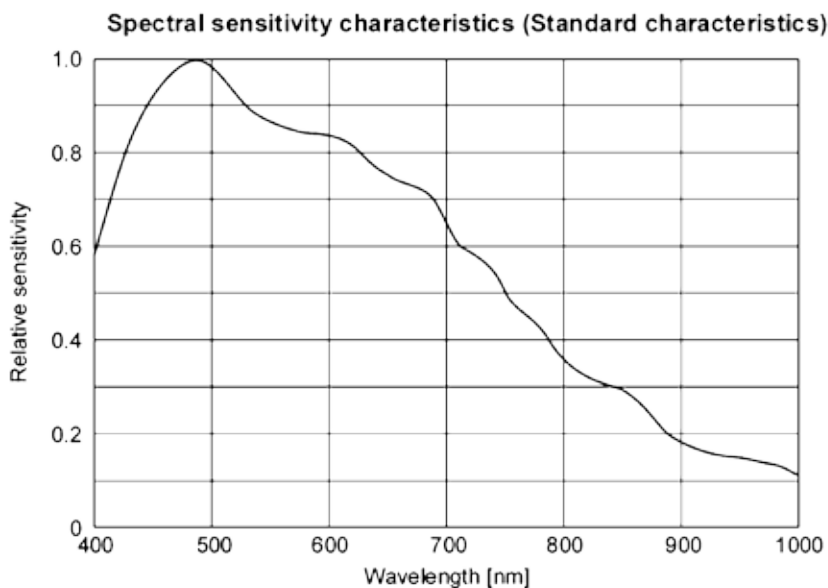
### e) Pin Configuration (Top View)



### a) Block Diagram



b) Example of Representative Characteristics



Instruction Manual SK5150VJR-4L | shared\_Sensor\_LX331.indd

## c) Electrooptical Characteristics

( $T_a = 25^\circ\text{C}$ ,  $V_{DD} = 12\text{V}$ ,  $f_{\phi R} = 2\text{MHz}$ , Input clock = 5Vp-p,  
Light source = 3200K, IR cut filter CM-500S ( $t = 1.0\text{mm}$ ))

Item	Symbol	Min.	Typ.	Max.	Unit	Remarks
Sensitivity1	R1	8.2	11	13.8	V/(lx · s)	Note 2
Sensitivity2	R2	—	25.1	—	V/(lx · s)	Note 3
Sensitivity nonuniformity	PRNU	—	4	10	%	Note 4
Saturation output voltage	$V_{SAT}$	1.8	2.5	—	V	Note 5
Saturation exposure	SE	0.13	0.23	—	lx · s	Note 6
Register imbalance	RI	—	1	7	%	Note 7
Dark voltage average	$V_{DRK}$	—	0.3	2.0	mV	Note 8
Dark signal nonuniformity	DSNU	—	0.6	5.0	mV	Note 9
Image lag	IL	—	0.02	—	%	Note 10
Supply current	$I_{VDD}$	—	30	60	mA	—
Total transfer efficiency	TTE	92	98	—	%	—
Output impedance	$Z_o$	—	150	—	$\Omega$	—
Offset level	$V_{OS}$	—	6.5	—	V	Note 11

## Notes

- 1) In accordance with the given electrooptical characteristics, the even black level is defined as the average value of D6, D8, to D24. The odd black level is defined as the average value of D5, D7, to D23.
- 2) For the sensitivity test light is applied with a uniform intensity of illumination.
- 3) W lamp (2854K)
- 4) PRNU is defined as indicated below. Ray incidence conditions are the same as for Note 2.

$$V_{OUT} = 500\text{mV (Typ.)}$$

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

Where the 5150 pixels are divided into blocks of even and odd pixels, respectively. The maximum output of each block is set to  $V_{MAX}$ , the minimum output to  $V_{MIN}$  and the average output to  $V_{AVE}$ .

- 5) Use below the minimum value of the saturation output voltage.
- 6) Saturation exposure is defined as follows.  $SE = V_{SAT}/R1$
- 7) RI is defined as indicated bellow.  $V_{OUT} = 500\text{mV (Typ.)}$

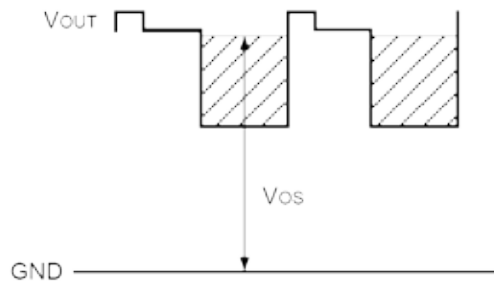
$$\text{RI} = \frac{|V_{ODD-AVE} - V_{EVEN-AVE}|}{\left(\frac{V_{ODD-AVE} + V_{EVEN-AVE}}{2}\right)} \times 100 [\%]$$

Where average of odd pixels output is set to  $V_{ODD-AVE}$ , even pixels to  $V_{EVEN-AVE}$ .

- 8) Optical signal accumulated time  $\tau_{int}$  stands at 10ms.
- 9) The difference between the maximum and average values of the dark output voltage is calculated for even and odd respectively. The larger value is defined as the dark signal nonuniformity.  
Optical signal accumulated time  $\tau_{int}$  stands at 10ms.

10)  $V_{OUT} = 500 \text{ mV}$  (Typ.)

11)  $V_{OS}$  is defined as indicated bellow.



### Blooming

Extended illumination of saturated pixels, which are not able to accumulate further charge due to long exposure, leads to charge overflow into adjacent pixels. This effect is called blooming. Blooming causes a corruption of the geometrical allocation of image and object in the line signal. 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 12000 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

### 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

### 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



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

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.

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We reserve the right to improve or change specifications so that the system description and depictions in the Instruction Manual may differ in detail from the system actually supplied. The Instruction Manual is not covered by an update service.

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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 24VDC 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.x**

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 24VDC 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-ADSync-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-ADSync-BNC-1

**Order Code**



**Power supply unit PS243005**

Input: 100-240 VAC, 0.8A, 50/60 Hz  
IEC 60320 C14 coupler (for IEC C13 power cord)

Output: +24 V DC, 3.0A

Cable length: 1 m, with XLR connector type NC6FFX

PS243005

**Order Code**

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

PC150DE

**Order Code**

DE = Europe / US = USA, Canada, Japan / UK = United Kingdom

DE US UK

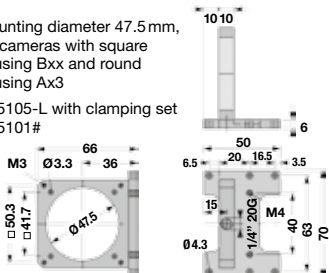
**M2 Mounting Bracket SK5105-L**



**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**

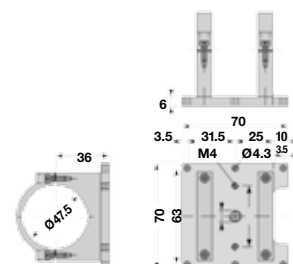


**Order Code**  
SK5101

**M4 Mounting System SK5105-2L**



**Order Code**  
SK5105-2L



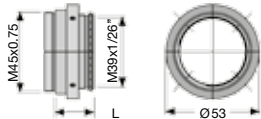
For camera configurations with tube length > 55 mm using extension rings **ZR-L**

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

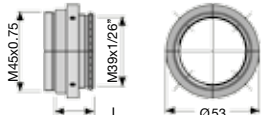
any rotation angle adjustable (V-groove)  
attachment thread M45x0.75, male



**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

