SK512CSH

Monochrome Line Scan Camera

512 pixels 14 x 14 µm², line frequency up to 35.70 kHz

Instruction Manual

Sample Configuration

1	CCD line scan camera **SK512CSH** mounted with
2	Mounting bracket SK5105
3	Clamping claws SK5102
4	Video (CCTV)-objectiv

Contents

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 *6*

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!

1 Introducing the SK512CSH 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 SK512CSH is compliant with CameraLink Specification Rev 1.1.

Data acquisition requires that the grabber board conforms to the CameraLink™ standard. The grabber board provides the Start-Of-Scan (SOS) signals and thereby determines the exposure time and line frequency of the camera.

CameraLink reads the camera specifications from configuration files. Prior to the iniatial start-up, the appropriate camera specific file must be created for the grabber in use.

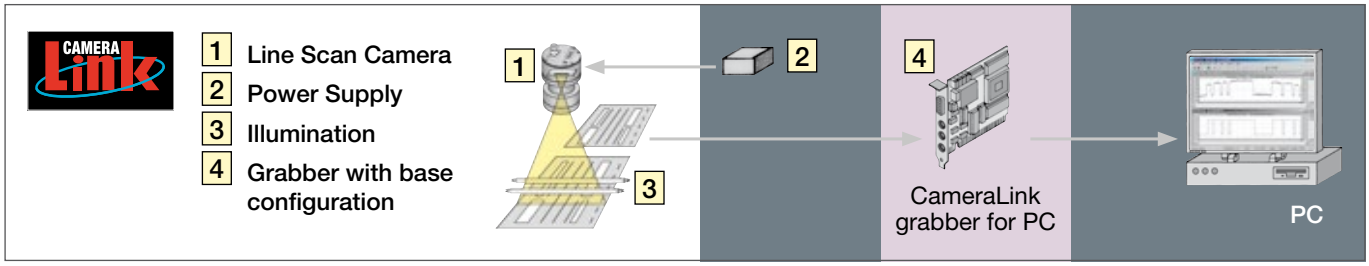
Beyond, the configuration program SkCLConfig allows the full parameterization of the camera settings, such as gain, offset and pixel frequency, via the Camera-Link™ serial port interface. SkCLConfig uses the ***clser*.dll*** driver that is supplied with the CameraLink grabber board.

For the development of custom applications use the software development kits released from the grabber board producers.

Normally, functions like Shading Correction, signal modification with a look-up table (LUT) or the definition of a region of interest (ROI) are implemented in the grabber board. For special requirements these functions can be made availabel within the camera, please contact the Schäfter + Kirchhoff customer support where appropriate.

The camera is supplied precalibrated, with factory settings for gain and offset. A readjustment is normally not necessary.

The successful use of the line scan camera requires that the complete optical system is properly set up, especially the location of the illumination, the degree of focus of the lens and the aperture setting. The most critical factor is the perpendicular alignment of the sensor axis either with the object to be measured or the direction of its relative travel when scanned. For further guidance see section ***4.2 Adjustments for Optimum Scan Results (p. 15)***.



1.2 Computer System Requirements

The SK512CSH is compliant with CameraLink Specification Rev 1.1. It is operated in the "Base Configuration" where the signals are carried over a single connector/cable.

Power supply is provided by a separate power connector.

Along with the camera the Schäfter+Kirchhoff configuration program **SkCLConfig** is delivered. Provided a clser**.dll driver by the grabber board manufacturer is available, this program facilitates transferring the ***Set*** and ***Request*** commands for camera configuration (see page ***4.1 Camera Control by Commands (p. 12)***).

1.3 SK512CSH Line Scan Camera - Specifications

Sensor category	CCD Monochrome Sensor
Sensor type	S12551-1024
Pixel number	512
Pixel size (width x height)	14 x 14 µm^2
Pixel spacing	14 µm
Active sensor length	7.17 mm
Anti-blooming	x
Integration control	x
Shading correction	x
Line synchronization modes	Line Sync, Line Start, Exposure Start, Exposure Active
Pixel frequency	30 / 20 MHz
Maximum line frequency	35.70 kHz
Integration time	0.01 ... 20 ms
Dynamic range	1:2000 (rms)
Spectral range	200 ... 1000 nm
Video signal	monochrome 8/12 Bit digital
Interface	Camera Link
Voltage	+5V, +15V
Power consumption	2.5 W
Casing	Ø65 mm x 52.4 mm (Case type AC1)
Objective mount	C-Mount
Flange focal length	17.53 mm
Weight	0.2 kg
Permissible 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
θ_{amb} [°C] = ambient temperature
θ_{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 (available as an accessory).

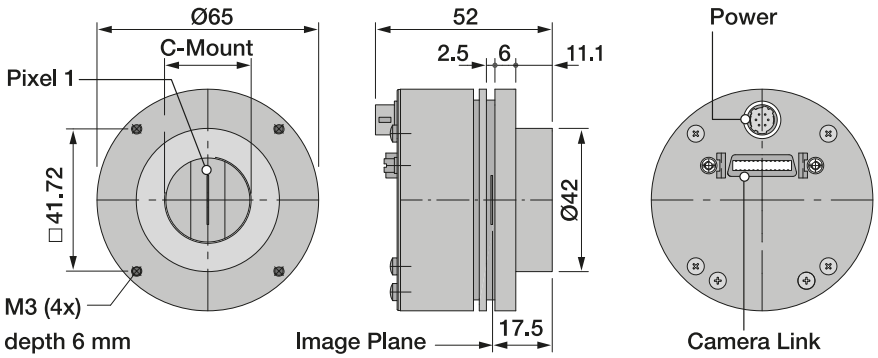
Four threaded holes M3 x 6.5 mm provide further options for customized brackets.

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

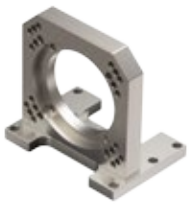
Optics Handling

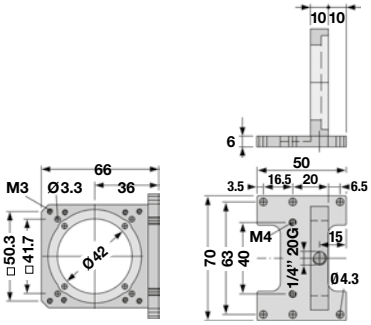
- If the camera and the optics are ordered as a kit, the components are pre-assembled and shipped as one unit. Keep the protective cap on the lens until the mechanical installation is finished.
- If you must expose the sensor or lens surface, ensure the environment is as dust-free as possible.
- Gently 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 AC1



Mounting bracket SK5105



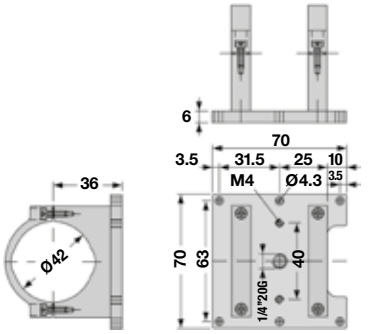


Clamping set SK5102

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

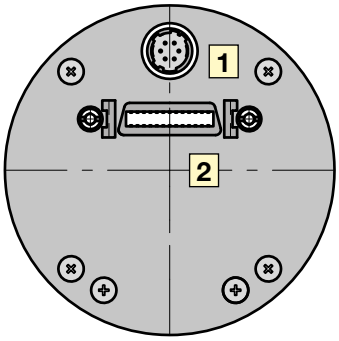
Mounting system SK5105-2

for cameras with a tube extension > 52 mm

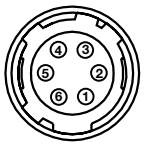


2.2 Electrical Installation: Connections and I/O Signals

- For the SK512CSH line scan camera data transfer and camera control is provded by the Camera Link interface 2. Use a control cable SK9018.... to connect the camera with the frame grabber card in the PC. The maximum cable length is 10 m.
- The operating power has to be supplied by an external source into socket 1
- For any kind of synchronized operation the external trigger signal(s) have to be wired to the frame grabber in addition. The camera can handle two trigger signals. These must be supplied on the CC1 and CC2-pins of the Camera Link interface. For a detailed description of the interface see section ***3 Interface and Camera Control (p. 8)***.



1 **Power +5V, +15V**



Hirose series 10A, male 6-pin

Pin	Signal	Pin	Signal
1	+15 V	4	+5 V
2	+15 V	5	GND
3	+5 V	6	GND

Total power: 2.5 W

2 **Data Connector**

Miniature Delta Ribbon,
female 26-pin (MDR-26)

Signal	Pin		Pin	Signal
GND	1	o o	14	GND
X0-	2	o o	15	X0+
X1-	3	o o	16	X1+
X2-	4	o o	17	X2+
Xclk-	5	o o	18	Xclk+
X3-	6	o o	19	X3+
SerTC+	7	o o	20	SerTC-
SerTFG-	8	o o	21	SerTFG+
CC1	9	o o	22	CC1+
CC2+	10	o o	23	CC2-
CC3-	11	o o	24	CC3+
CC4+	12	o o	25	CC4-
GND	13	o o	26	GND

Accessories (see also *Accessories (p. 22)*):

Control cable SK9018...
for line scan cameras with CameraLink interface
26-pin shielded cable, both ends with mini-ribbon connector (male 26-pin)

SK9018.xMM
MM = connector both ends male
cable length 3 / 5 m or
length according to choice, max. 10 m

Power Supply Unit PS051515
Input: 100-240 VAC, 0.8 A, 50/60 Hz, IEC 320 C14 coupler (for IEC C13 power cord)
Output: +5V DC, 2.5 A / +15 V DC, 0.5 A / -15 V DC, 0.3 A
Cable length 1 m, with Lumberg connector KV60, female 6-pin
(for power cable SK9015.x or SK9016.x)

Power Cable SK9015.xMF
Use this cable to feed external supply voltage into socket 1.
Connectors:
Hirose plug HR10A, female 6 pin (camera side)
Lumberg SV60, male 6-pin connector (for supply voltage)
Length 1.5 m (standard) or 0.2 m

3 Interface and Camera Control

3.1 Input/Output Signals and Control System

Camera control

Signal Name	I/O	Type	Description
LINE SYNC A	I	RS644	CC1 - Synchronization input (SOS)
LINE SYNC B	I	RS644	CC2 - Start Integration period in dual synchro modus (only cameras with Integration Control)
FRAME SYNC	I	RS644	CC3 - Start acquisition of 2D area scan
	I	RS644	CC4 - not used

I = Input, O = Output, IO = Bidirectional, P = Power/Ground, NC = not connected

Video data

The differential LVDS signals X0-X3 and XCLK are reserved for the transmission of high-speed video data from the camera to the grabber board. The video data is transmitted using numerous serial channels simultaneously, according to the protocol for the channel link chipset from National Semiconductor.

The CameraLink standard defines the names of the pixel signals, the description of the signal level and the pin assignments and pinout of the chip.

Signal Name	I/O	Type	Description
D[0–11]	O	RS644	Pixel data, 00 = LSB, 11 = MSB
STROBE	O	RS644	Output data clock Data are valid for a rising edge
LVAL	O	RS644	Line Valid, active High Signal

I = Input, O = Output, IO = Bidirectional, P = Power/Ground, NC = not connected

Warning: FVAL and DVAL are not used here as defined in the CameraLink standard.

FVAL is always set to the value = 1 (low).
DVAL is always set to the value = 1 (high).

Bit	DS90CR285 Pin Name	Bit	DS90CR285 Pin Name	Bit	DS90CR285 Pin Name	Bit	DS90CR285 Pin Name
D 0	Tx0	D 8	Tx7	NC	Tx15	STROBE	TxCLK
D 1	Tx1	D 9	Tx8	NC	Tx16	LVAL	Tx24
D 2	Tx2	D10	Tx9	NC	Tx17		
D 3	Tx3	D11	Tx12	NC	Tx18		
D 4	Tx4	NC	Tx10	NC	Tx19		
D 5	Tx6	NC	Tx11	NC	Tx20		
D 6	Tx27	NC	Tx13	NC	Tx21		
D 7	Tx5	NC	Tx14	NC	Tx22		

Bit allocation 12-bit data: D[0-11], Serial command: F12

Bit	DS90CR285 Pin Name	Bit	DS90CR285 Pin Name	Bit	DS90CR285 Pin Name	Bit	DS90CR285 Pin Name
D 0	Tx0	NC	Tx7	NC	Tx15	STROBE	TxCLK
D 1	Tx1	NC	Tx8	NC	Tx16	LVAL	Tx24
D 2	Tx2	NC	Tx9	NC	Tx17		
D 3	Tx3	NC	Tx12	NC	Tx18		
D 4	Tx4	NC	Tx10	NC	Tx19		
D 5	Tx6	NC	Tx11	NC	Tx20		
D 6	Tx27	NC	Tx13	NC	Tx21		
D 7	Tx5	NC	Tx14	NC	Tx22		

Bit allocation 8-bit data: D[0-7], Serial command: F8

The bit allocation conforms to the CameraLink Standard basic configuration.

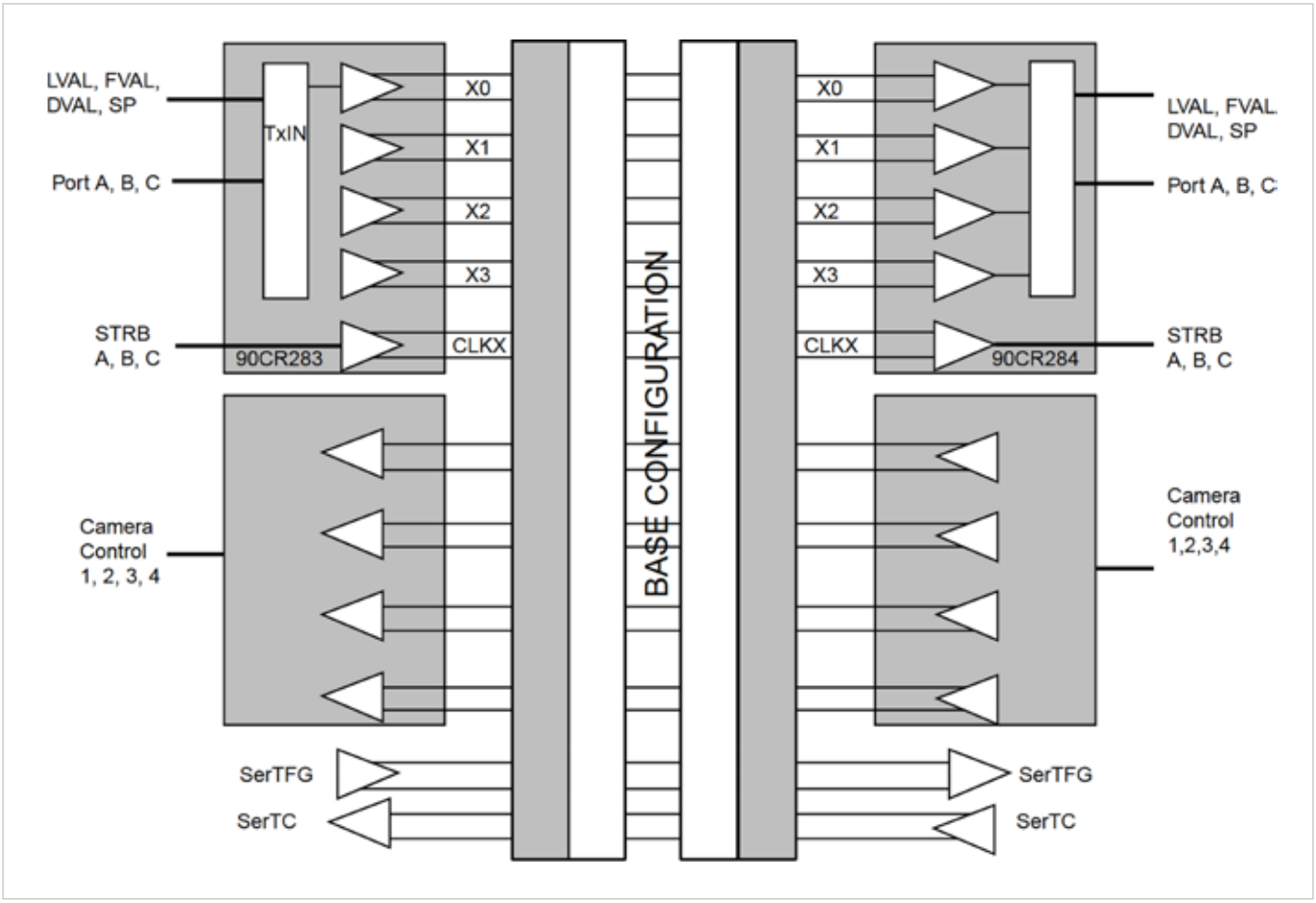
Serial communication

Signal Name	I/O	Type	Description
SerTFG	O	RS644	Differential pair for serial communications to the grabber board
SerTC	I	RS644	Differential pair for serial communications from the grabber board

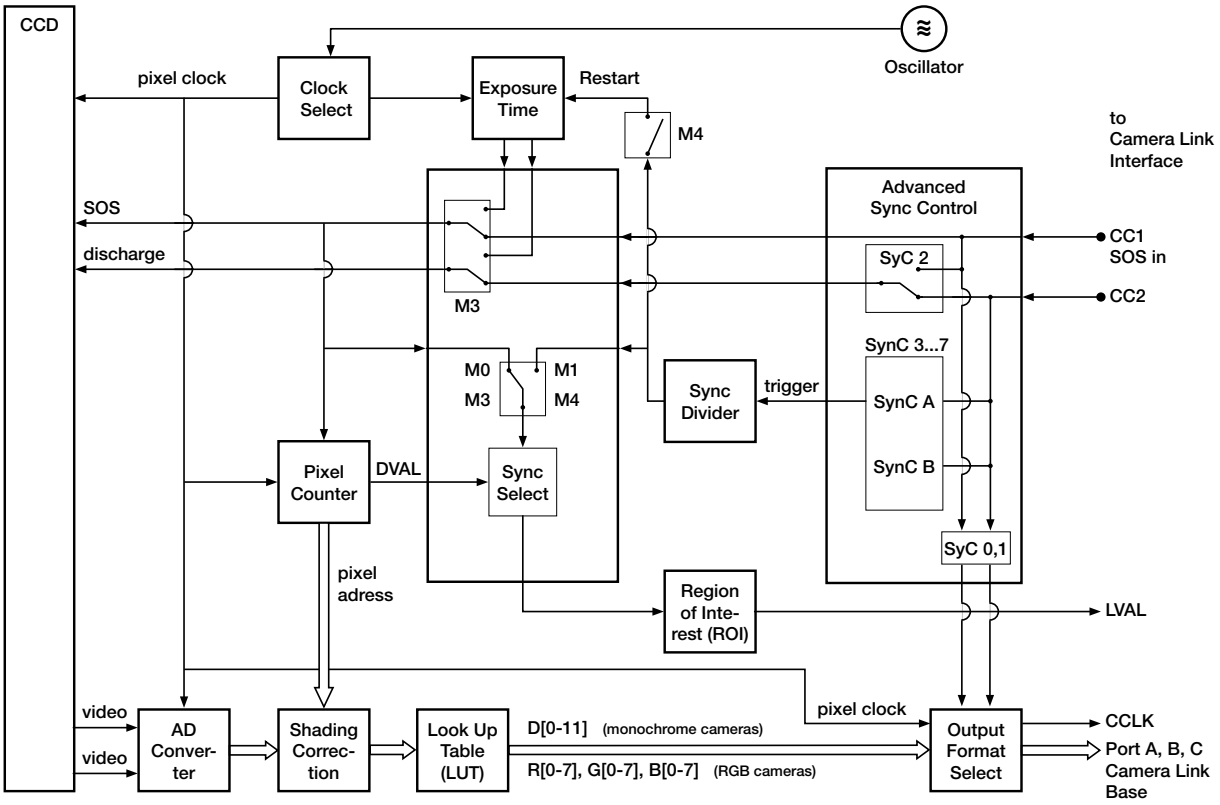
The CameraLink interface supports two LVDS signal pairs for communication between the camera and grabber board, which conform with the RS232 protocol for asynchronous communication:

– full duplex, no handshake

– 9600 baud, 8-bit, no parity bit, 1 stop bit.



Block Diagram of Camera Link Base Configuration



Logical Diagram of the Camera Control System

3.2 Control Signals and Timing Diagram

The control signals needed to run the CCD line scan camera are "Clock" (CCLK) and "Start Of Scan" (SOS). The clock signal is generated internally by a programmable oscillator.

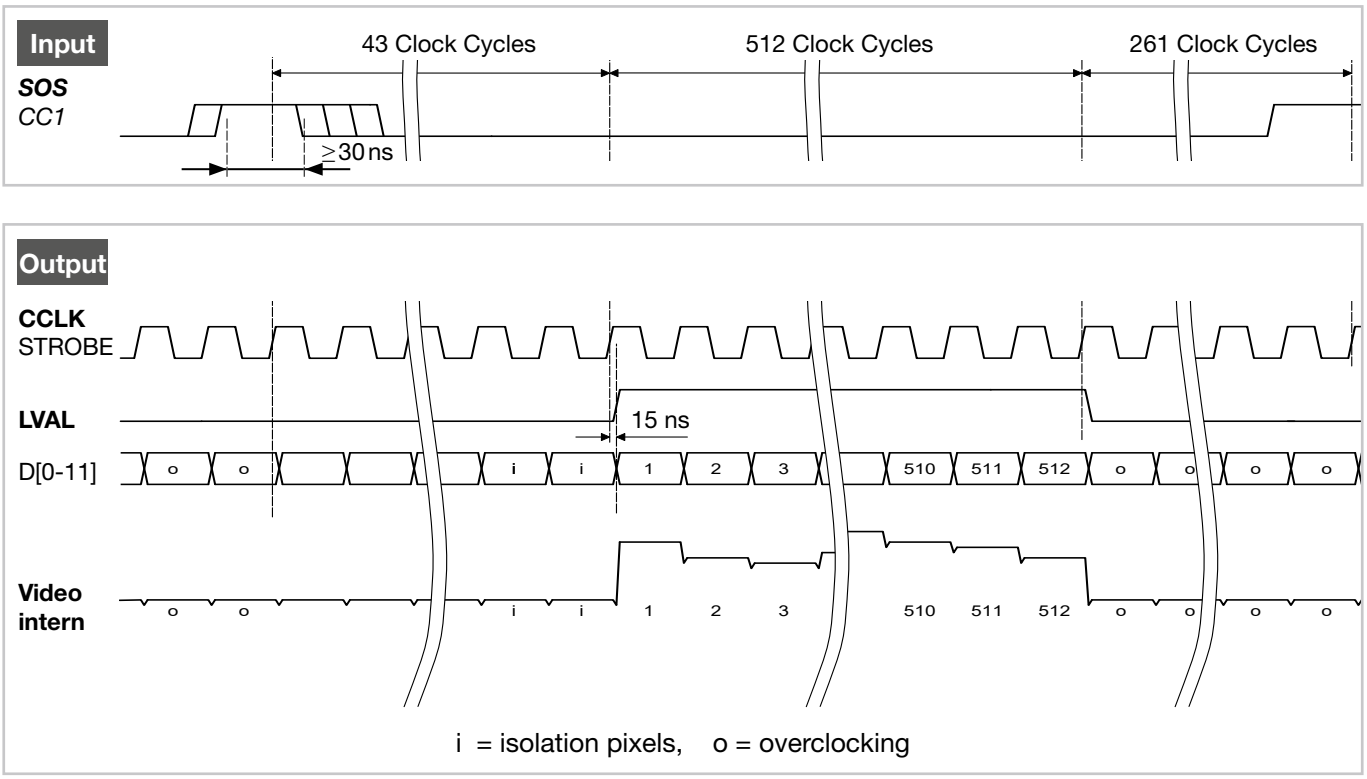
The SOS can be initiated internally by adjusting the Exposure Time or externally by the grabber board. For internal control, the camera must be set in the **'Free Run' mode** by using command **'M0'**. When the SOS signal is generated by the grabber board then the camera must be set to the **'external Trigger CC1' mode** using **'M3'**.

The frequency of the 'SOS' signal determines the number of lines that are read per second (= line frequency). On each rising edge of this signal, the accumulated charges within the sensor are transferred to the analog transport registers in parallel with the sensor line information.

Thus, the frequency of the clock signal determines the speed at which the charges of the individual pixels of the line sensor appear in the camera video output. At each positive edge, the accumulated charges of the subsequent pixels are released as video output.

The SK512CSH camera requires 816 clock pulses for a line scan to be read out completely. This corresponds to the number of pixels per line plus several extra cycles prior and past the charge acquisition.

Accordingly, the line frequency is limited to 1/816 part of the clock freqeuncy. Lower line frequency values can be used without restriction. The minimum SOS pulse length is 30 ns.



4 Advanced Camera Control Functions

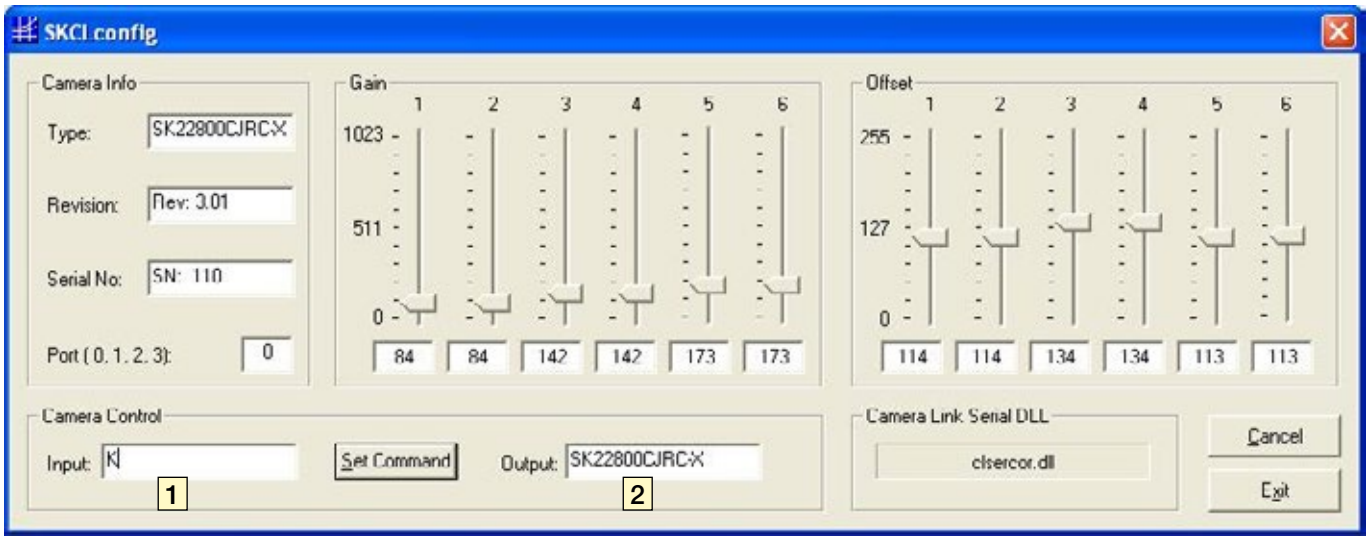
4.1 Camera Control by Commands

The configuration program SkCIConfig 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" dialog. 1
- 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. 2

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 bottom left section

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
C30<CR>	camera clock: 30 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>	free run (no triggering) at selected line rate
M1<CR>	line trigger mode1: extern trigger next Line CC1-input
M2<CR>	free run (no triggering) at maximum line rate
M3<CR>	extern SOS CC1-input and integration control CC1 or CC2-input
M4<CR>	line trigger mode4: external triggering and restart
Mx+8	frame trigger external, start on falling edge, CC3 input
Mx+16	frame trigger external, active low, CC3 input
A*xxxx*<CR>	SCM address (Axxxx = A0-A511) or LUTM (Axxxx = A32768-A36863)
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)
V*yyyyy*<CR>	extern sync divider (*yyyyy* = 1-32767)
Y*pppp*<CR>	set sync control (*ppp* = 0-4095)
W*yyyyy*<CR>	line clock frequency (*yyyyy* = 50-35700) [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]
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>	*SK512CSH*	returns S**K** type number
R<CR>	*Rev. 2.50*	returns **R**evision number
S<CR>	*SNr00163*	returns **S**erial number
I<CR>	*SK512CSH* *Rev. 2.50* *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

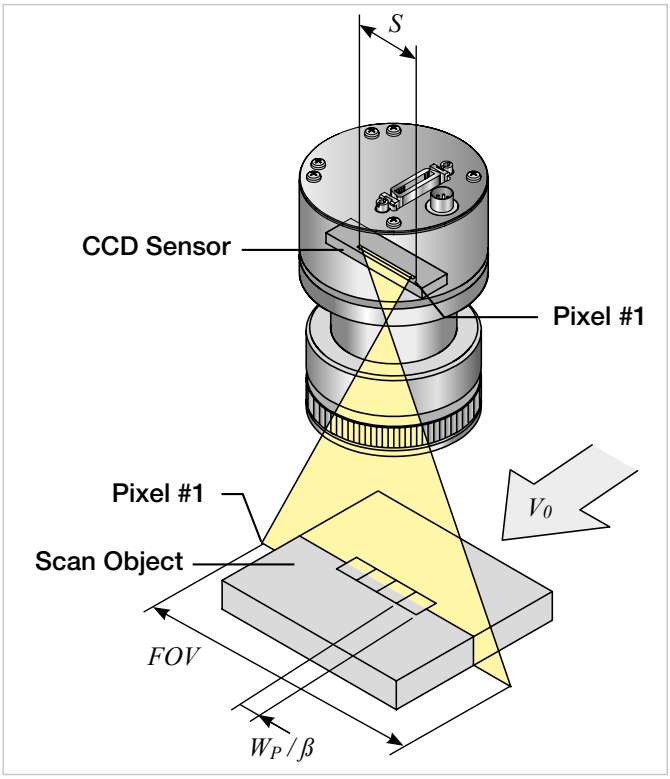
Range of values:
oooo = 0 ... 1023
ppp = 0 ... 255
xxxx = 4 digits integer value as ASCII
yyyyy = 5 digits integer value as ASCII

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	= 35.70 kHz
S	= 7.17 mm
FOV	= 20 mm

$$V_O = \frac{14\,\mu m \cdot 35.70\,kHz}{(7.17\,mm / 20\,mm)} = 1394\,mm/s$$

Example 2:

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

Pixel width	= 14 µm
Scan velocity	= 1300 mm/s
S	= 7.17 mm
FOV	= 20 mm

$$f_L = \frac{1300\,mm/s \cdot (7.17\,mm / 20\,mm)}{14\,\mu m} = 33.3\,kHz$$

4.2 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.

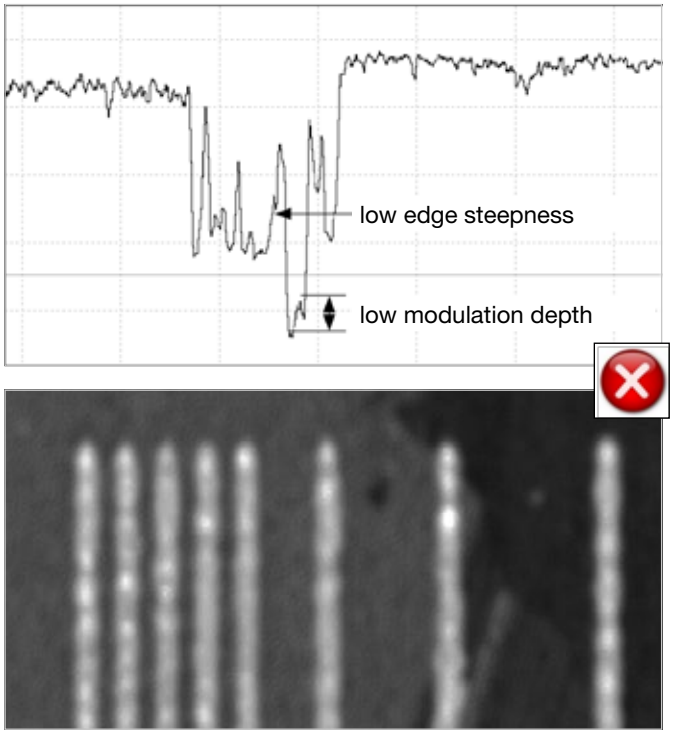
Start with the signal window / oscilloscope display. Any changes in the optical system or camera parameters are displayed in real-time when using an open dialog box.

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.

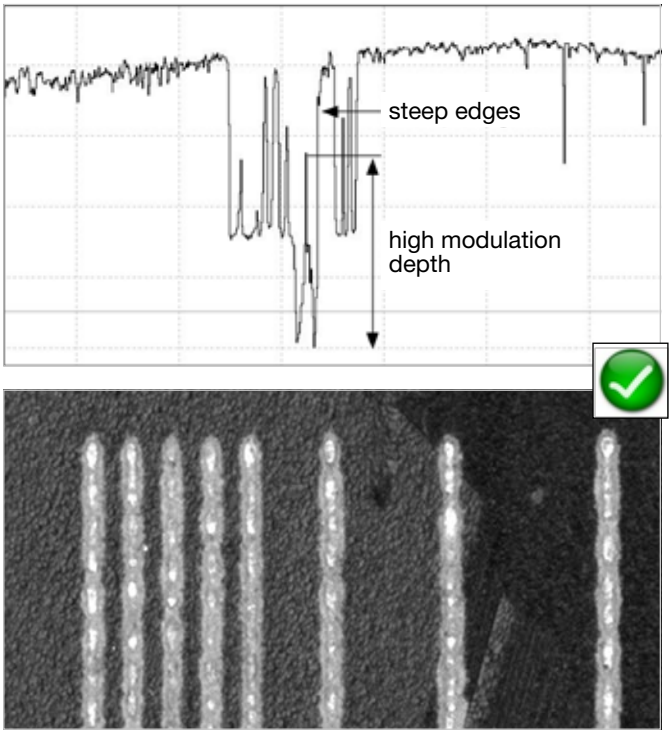
Adjust the focus with the aperture fully open to limit the depth of field and enhance the effects of changing the working distance.

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. 16)***.



Out-of-focus:

- Low edge steepness
- Signal peaks are blurred
- High spatial frequencies with low modulation depth

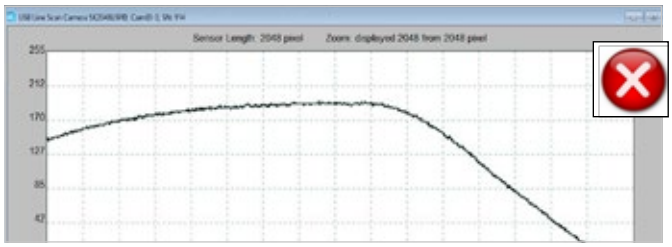


Optimum focus:

- Dark-bright transitions with steep edges
- Large modulation in the signal peaks
- High spatial frequencies with high modulation depth

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.

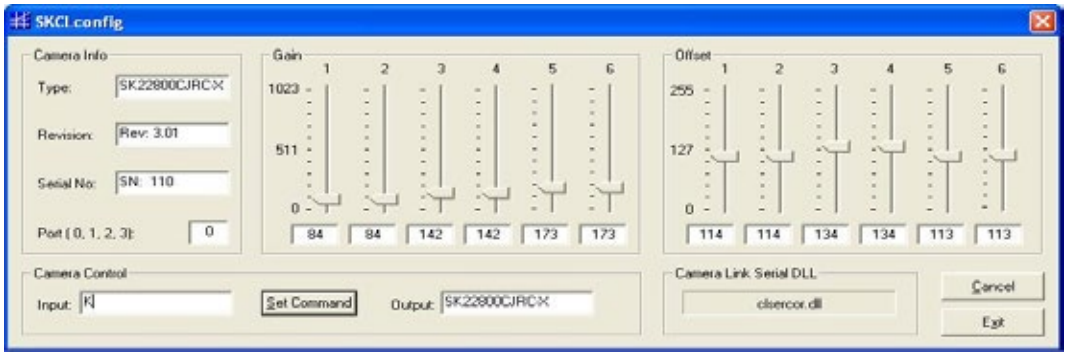


Sensor and line lighting slightly twisted in relation to each other, asymmetric vignetting

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.

Enter commands for advanced software functions in the 'Camera Control' field (see page *12*).

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.

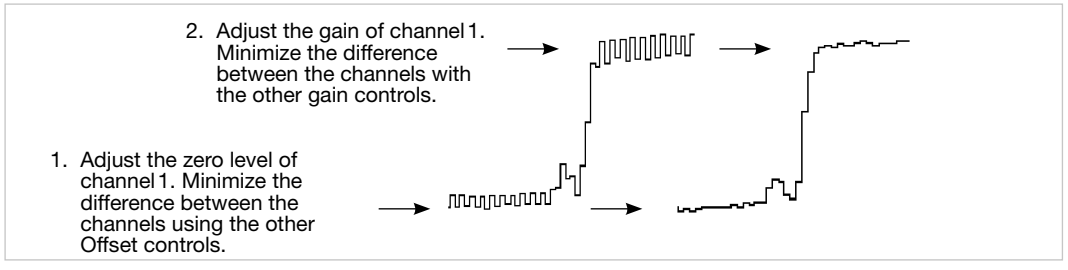
A slight signal noise should be visible in the zero baseline.

2. Gain

Illuminate the sensor with a slight overexposure in order to identify the amplitude 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.



Offset and gain adjustment for more than one gain/ offset channel

5 Sensor Information

Manufacturer: Hamamatsu

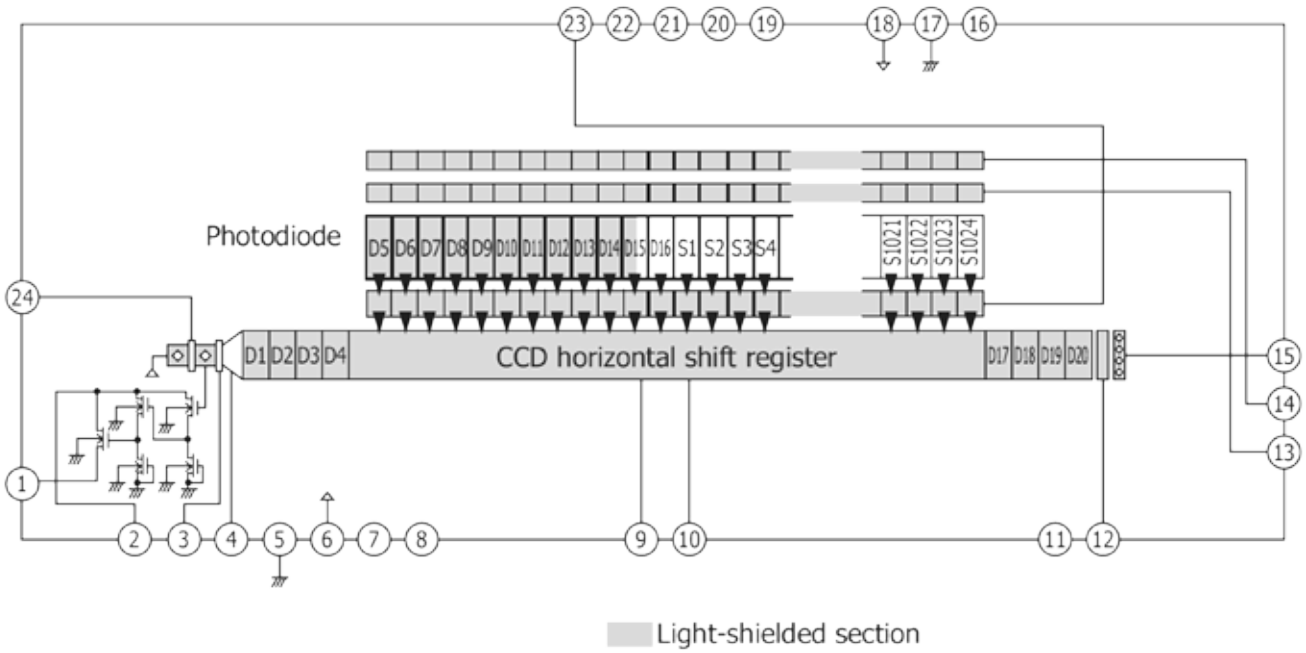
Type: S12551-1024

Data source: Hamamatsu CCD linear image sensors S12551 series
Cat. No. KMPD1147E05 Mar. 2020 DN

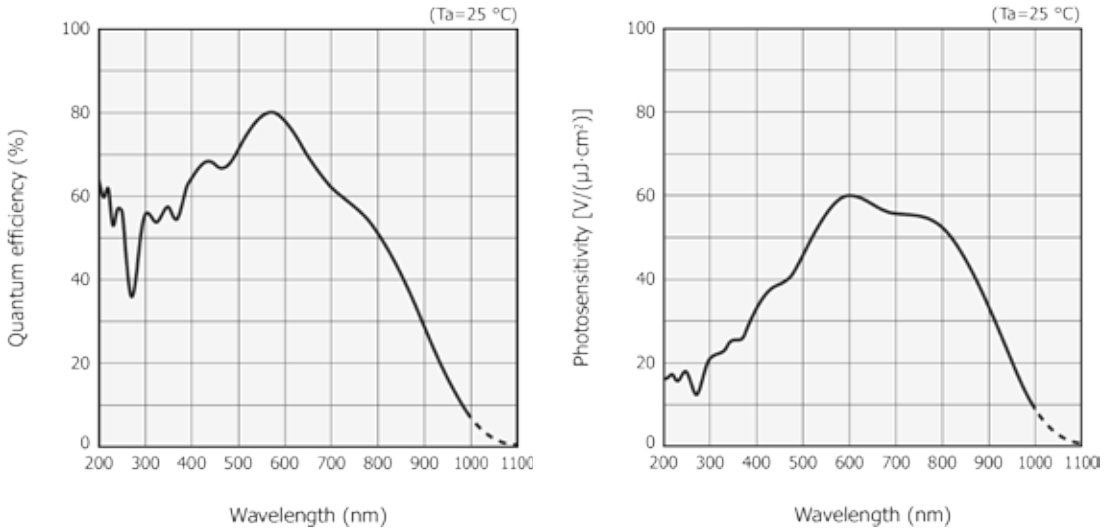
a) Features

- 1024 pixels, pixel size: 14 x 14 µm
- High CCD node sensitivity: 13 µV/e^- typ.
- Readout speed: 40 MHz max.
- Anti-blooming function
- Built-in electronic shutter

b) Device Structure (conceptual drawing)

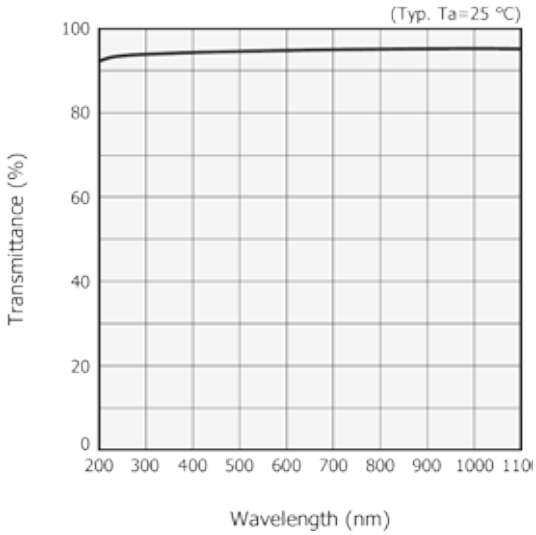


c) Spectral Response (without window, typical example)



Spectral response with quartz glass is decreased according to the spectral transmittance characteristics of window material.

d) Spectral Transmittance Characteristics of Window Material



e) Electrical and Optical Characteristics (Ta = 25°C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Saturation output voltage	Vsat	-	Fw × CE	-	V
Full well capacity	Fw	70	100	-	ke⁻
Conversion efficiency	CE	11	13	15	µV/e⁻
Dark current (maximum of all effective pixels)	ID max	-	15	75	e⁻/pixel/ms
Readout noise*7	Nread	-	40	60	e⁻ rms
Dynamic range*8	Drange	1167	2500	-	-
Spectral response range	λ	-	200 to 1000	-	nm
Photoresponse nonuniformity*9 *10	PRNU	-	±3	±10	%
Image lag*9	Lag	-	0.1	1	%

*6: Dark current is reduced to half for every 5 to 7 °C decrease in temperature.
*7: Readout frequency 40 MHz
*8: Dynamic range = Full well capacity / Readout noise
*9: Measured at one-half of the saturation output (full well capacity) using LED light (peak emission wavelength: 470 nm)
*10: Photoresponse nonuniformity = $\frac{\text{Fixed pattern noise (peak to peak)}}{\text{Signal}} \times 100\ [\%]$

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 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

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

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.

An EU Declaration of Conformity has been issued for this product.

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Internet: www.SuKHamburg.com

Features

- **Extended Trigger Functions**
  Direction of movement or slippage can be detected by using two external synchronization signals.
- **Shading Correction Memory (SCM) and Look-Up Table (LUT) options**
  The calibration data in the SCM automatically adjusts the line signal data directly in the camera after each exposure.
  The LUT is a separate memory block that can also be used for postprocessing the line signal data, such as applying a Gamma function.
- **Window-Function**
  The line signal data to be transferred can be restricted to a defined section of the line sensor.
- The **Gains or Offsets** for all AD-converter channels can be **adjusted simultaneously**, simplifying handling.
- **Integrated Temperature Sensor**

Accessories

Power supply unit PS051515

Input: 100-240 VAC, 0.8 A, 50/60 Hz
IEC 60320 C14 coupler (for IEC C13 power cord)
Output: +5 VDC, 2.5 A / +15 VDC, 0.5 A / -15 VDC, 0.3 A
Cable length: 1 m, with Lumberg connector KV60, female 6-pin

PS051515 Order Code

Power cord IEC 60320 C13, 1.5 m, 10 A, 250 VAC

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

Control cable SK9018...

26-pin shielded cable, both ends with mini-ribbon connector (male 26-pin)

SK9018.x-MM Order Code
└ MM = connector both ends male
cable length 3 / 5 m or
length according to choice, max. 10 m

Power cable SK9015.x

for GigE Vision™, CameraLink and externally supplied USB 3 line scan cameras.

Shielded cable with Hirose plug HR10A, female 6-pin (camera side), and Lumberg SV60, male 6-pin connector (power supply unit side).

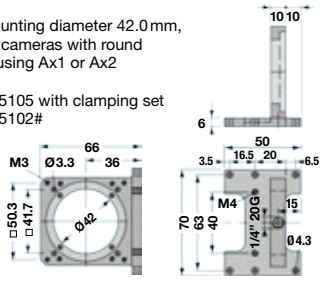
SK9015.x Order Code
└ cable length 0.2 / 1.5 m

M1 **Mounting Bracket SK5105**

Order Code
SK5105

Mounting diameter 42.0 mm, for cameras with round housing Ax1 or Ax2

SK5105 with clamping set SK5102#



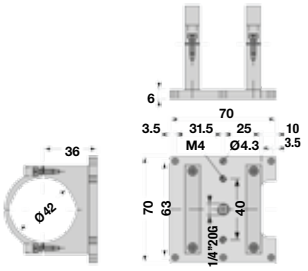
MC **Clamping Set SK5102**

Order Code
SK5102

M3 **Mounting System SK5105-2**

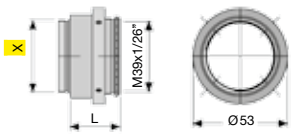
Order Code
SK5105-2

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



FA1 **Focus adapter FA22...**

FA22-x Order Code
42 = M42 x 1
40 = M40 x 0.75
39 = M39 x 1/26"
32 = M32 x 0.75
C = C-Mount
length L: **22 ... 32 mm**



A3 **Lens Adapter F-Mount**

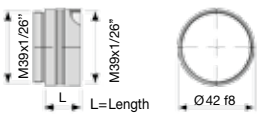
for line scan cameras with case type **Axx** or **BGx**.

AOC-F-... Order Code
└
Attachment thread:
45 = M45x0.75
40 = M40x0.75
32 = M32x0.75
C = C-Mount 1"-32-TP

ZR **Extension rings L-Mount (M39x1/26" Leica)**

attachment threads M39x1/26" male/female

ZR 10 Order Code
10 = Length 10 mm
15 = Length 15 mm
20 = Length 20 mm
50 = Length 50 mm



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