Schäfter+Kirchhoff

SK6288U3KOC

Color Line Scan Camera

3x 2096 pixels, 14 µm x 14 µm, 60 / 30 MHz pixel frequency

USB 3.0

- Robust cable connections
- Hot-pluggable
- Perfect for movable setups

Instruction Manual

02.2016

Sample Configuration

1	CCD line scan camera **SK6288U3KOC** mounted with
2	Mounting bracket SK5105
3	Clamping claws SK5102
4	Photo lens SK1.4/50-40 (integrated focus/aperture adjustment)

Read the manual carefully before the initial start-up. For the contents table, refer to page 3.
The right to change the described specifications is retained as the products undergo continuous cycles of improvement.

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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**
- **Assembly and initial 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!

For typical use in a scanning application, please consider the following warnings:

Mechanical Warning

Ensure that the scanner axis is free to move and that no obstacles are in the way – **especially fingers!**

Do not place any body parts 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 Introduction

1.1 Intended Purpose and Overview

The SK line scan camera series is designed for a wide range of vision and inspection applications in industrial and scientific environments. The SK6288U3KOC is highly portable and the robustly attached dedicated connections enable external synchronization of the camera and the output of data to the USB 3.0 port of the computer.

The USB 3.0 connection supplies power to the camera and the camera is hot-pluggable, providing the greatest degree of flexibility and mobility. The computer does not require a grabber board, allowing a laptop to be used when space or weight restrictions are also at a premium.

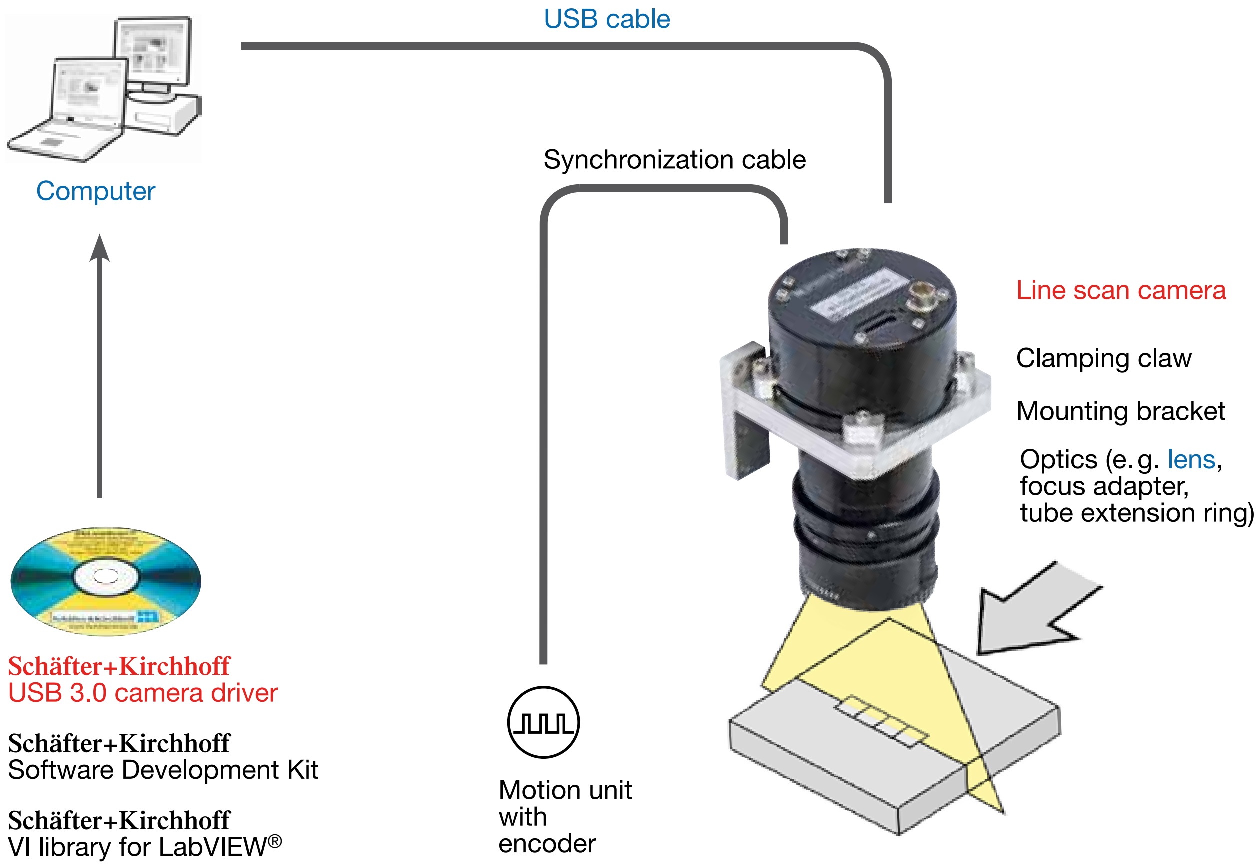
Once the camera driver and the SkLineScan® program have been loaded from the SK91USB3-WIN CD then the camera can be parameterized. The parameters, such as integration time, synchronization mode or shading correction, are permanently stored in the camera even after a power-down or disconnection from the 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 ***3.1 Software: SkLineScan, p. 10***.

1.2 System Setup at a Glance

red: SK6288U3KOC scope of delivery
blue: accessories for minimum system configuration
black: optional accessories

For accessory order details see ***Accessories and Spare Parts, p. 32***.



1.3 Computer System Requirements

- Intel Pentium Dual Core or AMD equivalent
- RAM min. 4 GB, depending on the size of acquired images
- USB 3.0 interface. With a USB 2.0 interface, there are limitations, see footer.
- High-performance video card, PCIe bus
- Operating Systems:
  Windows 7 / 8.1 / 10 (64 or 32-bit) or
  Linux kernel 3.13 or higher, Debian or openSUSE
- CD/DVD drive for software installation

1.4 SK6288U3KOC Line Scan Camera - Specifications

Sensor category	CCD Color Sensor
Sensor type	KLI2113
Pixel number	3x 2096
Pixel size (width x height)	14 x 14 µm²
Pixel spacing	14 µm
Line spacing, line sequence	112 µm, blue (B) - green (G) - red (R)
Active sensor length	29.3 mm
Anti-blooming	-
Integration control	x
Shading correction	x
Line synchronization modes	Line Sync, Line Start, Exposure Start, Exposure Active
Frame synchronization	x
Pixel frequency	60 / 30 MHz
Maximum line frequency	9.28 kHz
Integration time	0.01 ... 20 ms
Dynamic range	1:2500 (rms)
Spectral range	400 ... 700 nm
Video signal	color 8/12 Bit digital
Interface	USB 3.0
Voltage	USB (600 mA)
Power consumption	3.0 W
Casing	Ø65 mm x 54 mm (Case type AT2)
Objective mount	M40x0.75
Flange focal length	19.5 mm
Weight	0.2 kg
Operating temperature	+5 ... +45°C

Note:

This camera is not USB 2.0 compatible. For operation with an USB 2.0 interface request for a factory-preset pixel frequency limitation. This will reduce the data transfer rate as well as the power consumption to the USB 2.0 specifications.

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 (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.

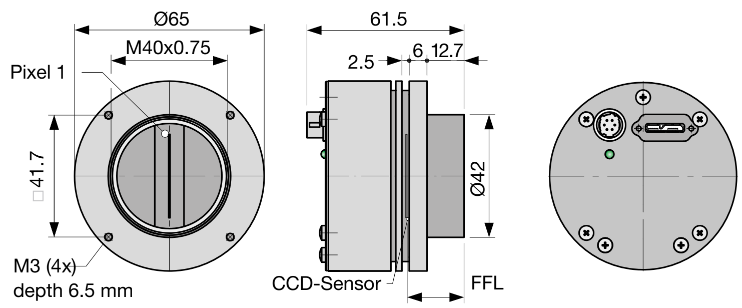
Optics Handling

- 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.

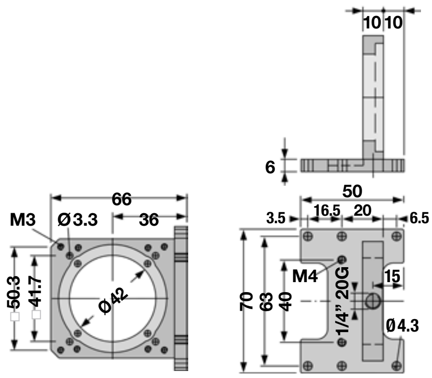
Casing type AT2

AT2

Lens mount:	M40x0.75
Seat for bracket:	Ø42 mm
Flange focal length:	FFL = 19.5 mm

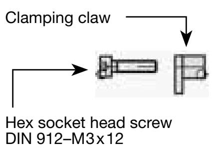


Mounting bracket SK5105



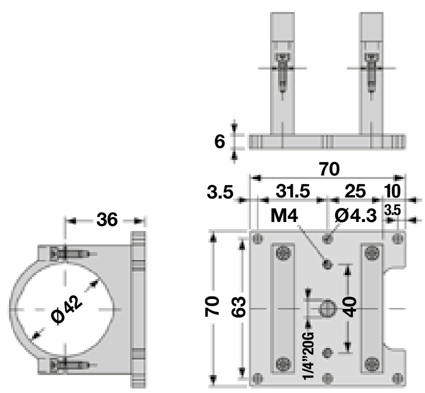
Clamping set SK5102

Set of 4 pcs. clamping claws incl. screws



Mounting system SK5105-2

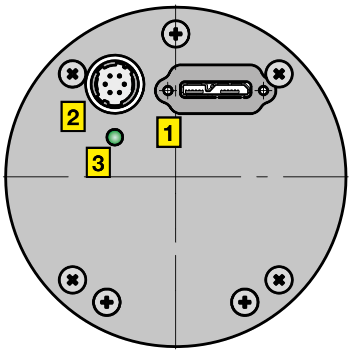
for cameras with a tube extension > 52 mm



2.2 Electrical Installation: Connections and I/O Signals

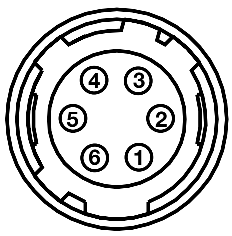
- The USB 3.0 interface provides data transfer, camera control and power supply capabilities to the SK6288U3KOC line scan camera. If you want to operate the camera in Free Run (SK Mode 0) trigger mode the USB 3.0 cable is the only connection you have to make.
- For any kind of synchronized operation, the external trigger signal(s) must be wired to socket **2**. 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 Imaging Procedure and the Object Scan Velocity, p. 18*

All Schäfter + Kirchhoff USB 3.0 line scan cameras can be operated with a USB 2.0 interface. Note that there might be limitations in terms of the maximum data transfer rate and the power supply. The details for your camera can be found in section *1.4 Line Scan Camera - Specifications, p. 5*.



1 **Data and power**
USB 3.0 socket type µB with threaded holes for locking screws
Power: 3.0 W

2 **Synchronization**
Socket: Hirose series 10A, male 6-pin



Pin	Signal	Pin	Signal
1	Line Sync B	4	NC
2	NC	5	Line Sync A
3	Frame Sync	6	GND

Line Sync A/B and Frame Sync: TTL levels

3 **Status indicator**

●	off	no power, check the USB link for a fault.
●	red	power on
●	green	power on, firmware is loaded, camera is ready

Accessories (see also *Accessories and Spare Parts, p. 32)*:

USB 3.0 cable SK9020.x

For connecting socket **1** with the PC or USB hub.

Cable length:

3.0 m SK9020.3 (standard)
5.0 m SK9020.5

External synchronization cable SK9026.x

Use this cable to feed external synchronization signals into socket **2**.

Connectors:

Hirose plug HR10A, female 6 pin (camera side)
Phoenix 6 pin connector incl. terminal block

Cable length:

3.0 m SK9026.3
5.0 m SK9026.5

2.3 USB3 Connections and SkLineScan Software Installation

This section is a quick reference for installing the **SkLineScan** adjustment and configuration software and to set up the USB3 camera driver. SkLineScan and the SkLineScan manual is provided for download on the Schäfter+Kirchhoff website under ***http://www.sukhamburg.com/support.html***. It is also part of the fee-based software development kit **SK91USB3-WIN**.

Step 1: Install **SkLineScan**. The setup program will automatically install the Schaefter + Kirchhoff USB3 Line Scan Camera Driver.

Step 2: Plug in the USB3 connection cable to the camera. if appropriate switch on the external power supply.

Step 3: Start the **SkLineScan** program.

SkLineScan Installation and Automatic Camera Driver 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 to the drive.

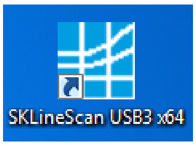
The autostart function may launch the setup program automatically from CD. Otherwise, look for one of these installation files:

SkLineScan-USB3-Win_x64.msi   SK91USB3-Win_x64.msi
SkLineScan-USB3-Win_x86.msi   SK91USB3-Win_x86.msi

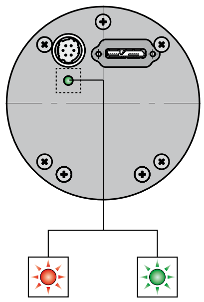
Then start the applicable installation file manually. This will set up the Schäfter + Kirchhoff **SkLineScan** camera control and adjustment tool as well as the USB3 Line Scan Camera Driver.

SkLineScan Start-up

- Start SkLineScan.
- A start-up dialog box pops up and displays the connected camera(s) that have been automatically detected. It also indicates the active USB standard. The optimum performance is provided by USB 3.0.
- The camera LED changes from red to green color light.



Desktop Icon

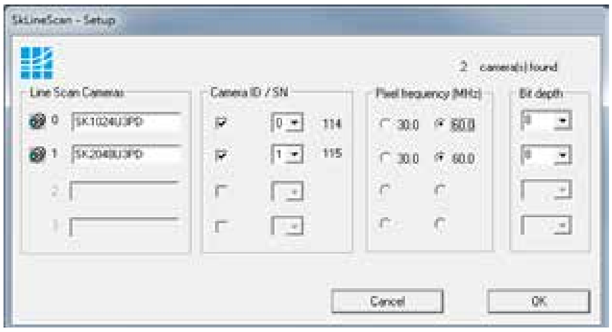


Camera Setup

Use the Setup dialog for

- activating/deactivating a connected USB3 camera (activated device is ticked)
- changing the pixel frequency
- setting the bit depth of the video signal to 8 or 12-bit.

In USB 2.0 mode the lower pixel frequency and 8-bit video signal is recommended

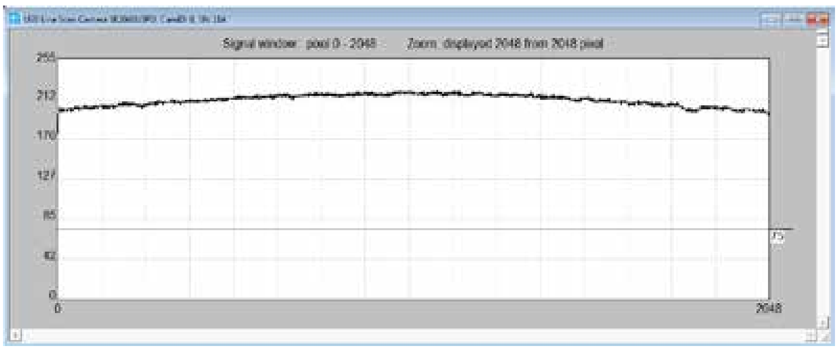


SkLineScan Setup dialog

Initial Function Test

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

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



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/support.html***.

For an in-depth guide on how to perform imaging and to use the obtained data using the Schäfter + Kirchhoff software package, see the ***SkLineScan Software Manual***.

The most common functions of the line scan camera can be controlled by menu items and dialog boxes.

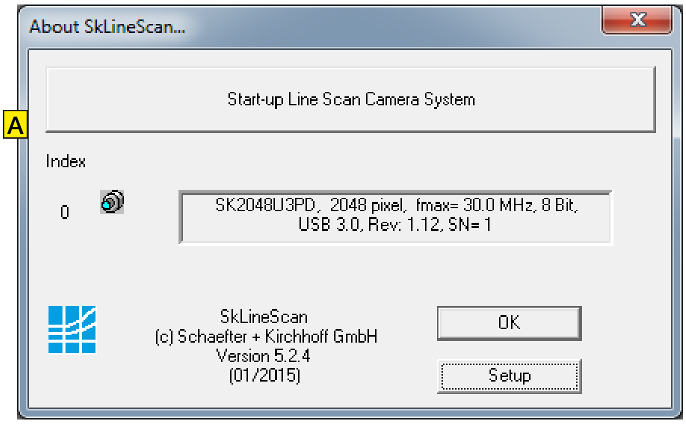
Commands controlling comprehensive camera functionality can be entered in the "Camera Gain / Offset Control" dialog.

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, and the index order corresponds with the individual MAC addresses of the cameras.

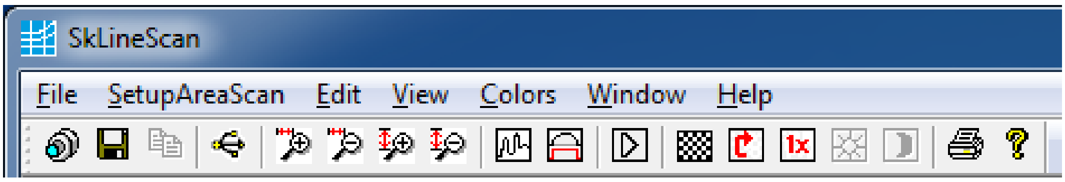
If the SK6288U3KOC camera is identified correctly, confirm with "OK". The "Signal window" graphicaly showing the intensity signals of the sensor pixels (oscilloscope display) will open. It is responsive in real-time and the zoom function can be used to highlight an area of interest. The oscilloscope display is ideally suited for parameterizing the camera, for evaluating object illumination, for focussing the image or for aligning the line scan camera correctly.

A



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]

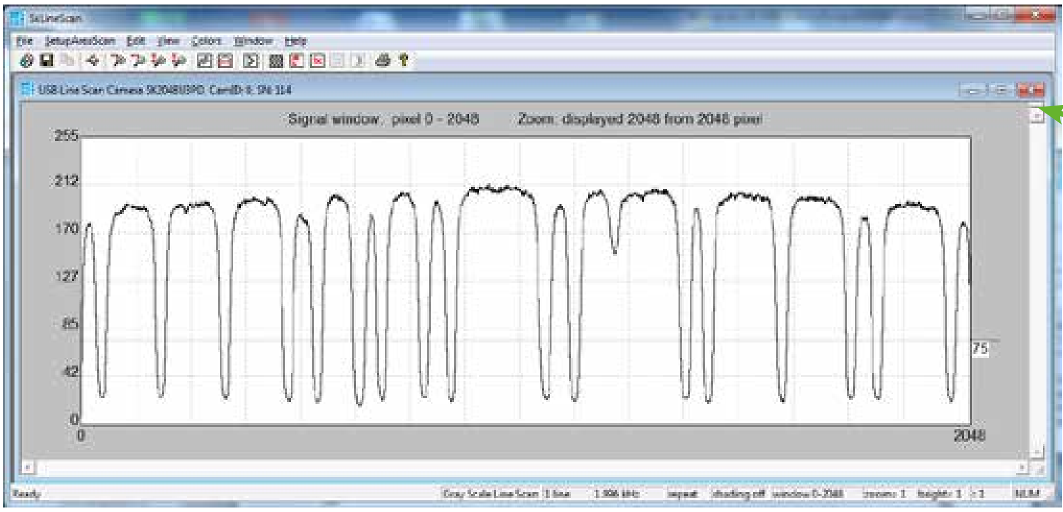
"Gain/Offset Control" dialog, also for commands input [Shif+F4]

New area scan

Basic 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.



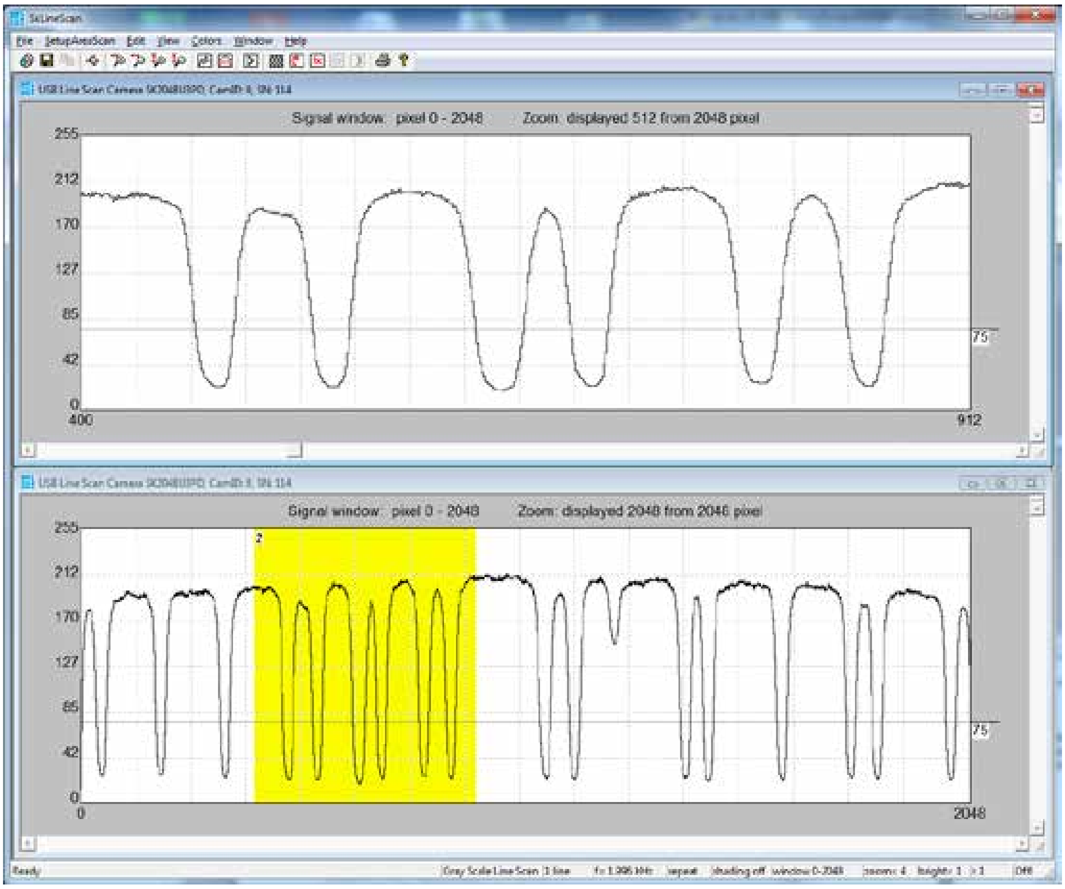
Line scan in Signal Window: brightness vs. pixel number

Zoom Function

For high numbers of sensor pixels, the limited number of display pixels might be out of range, in which case the zoom function can be used to visualize the brightness profile in detail. Magnification of one or several sections of the signal allows individual pixels to be resolved for a detailed evaluation of the line scan signal.

Window Split Function

The signal window can be split horizontally into two sections. Use the split handle B at the top of the vertical scroll bar and afterwards arrange the frames using the zoom buttons in the toolbar.



Line scan in Signal Split signal window. The upper frame shows a magnified section of the lower frame.

3.2 Adjustments for Optimum Scan Results

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

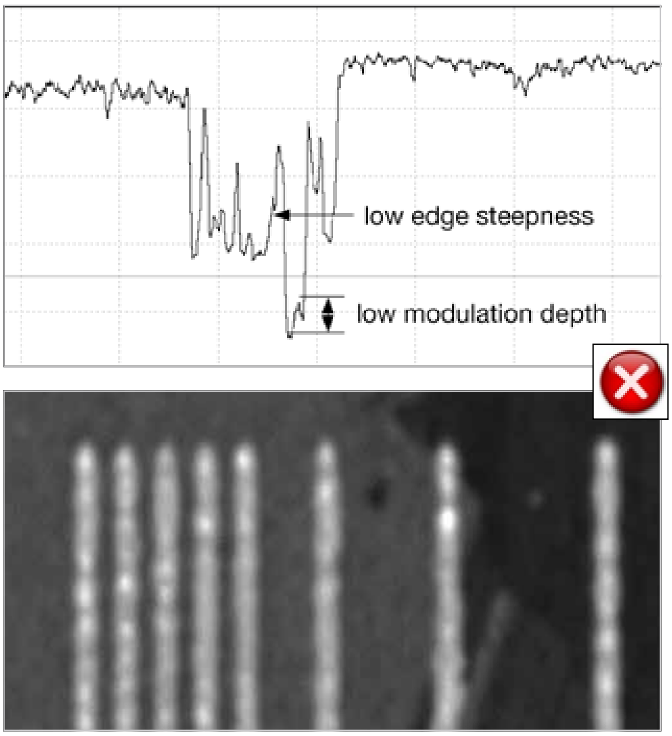
- Lens focussing
- Sensor alignment
- Gain/Offset
- Shading correction
- Integration time
- Synchronization of the sensor exposure and the object surface velocity, trigger mode options

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

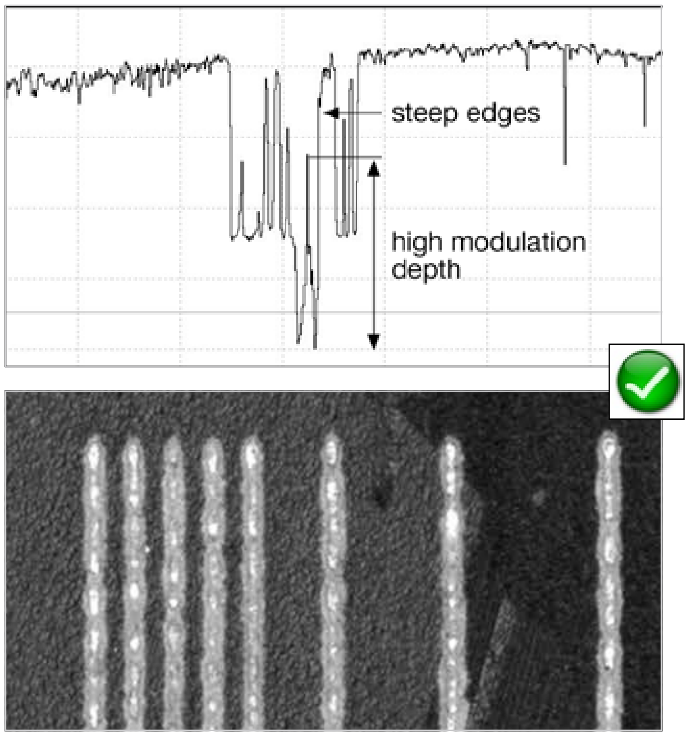
The oscilloscope display facilitates the effective focussing of the line scan camera system, even for two-dimensional measurement tasks. For determining the correct focus, the edge steepness at dark-bright transitions and the modulation of the line scan signal are the most important factors.

- Adjust the focus using a fully opened aperture to restrict the depth of field and to amplify the effects of focus adjustments.
- The signal amplitude may require trimming when using a fully opened aperture and this can achieved most readily by shortening the integration time, as described in section *Integration Time, p. 17*.



Out-of-focus:

- Low edge steepness
- Signal peaks are blurred
- High-frequency gray values with low modulation

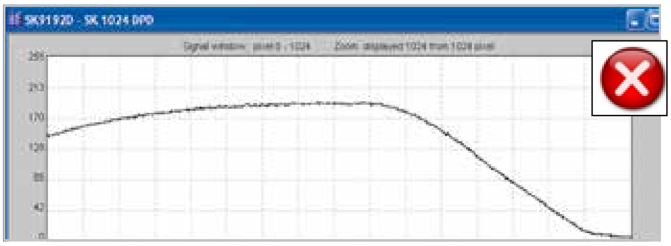


Optimum focus:

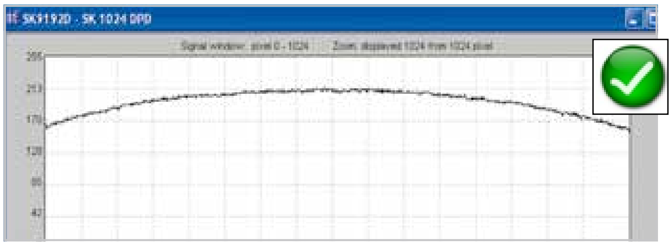
- Dark-bright transitions with steep edges
- Large modulation in the signal peaks
- High-frequency gray value variations

Sensor Alignment

If you are operating with a linear illumination source, check the alignment of the illumination source and the sensor prior to performing a shading correction, as rotating the line sensor results in asymmetric vignetting.



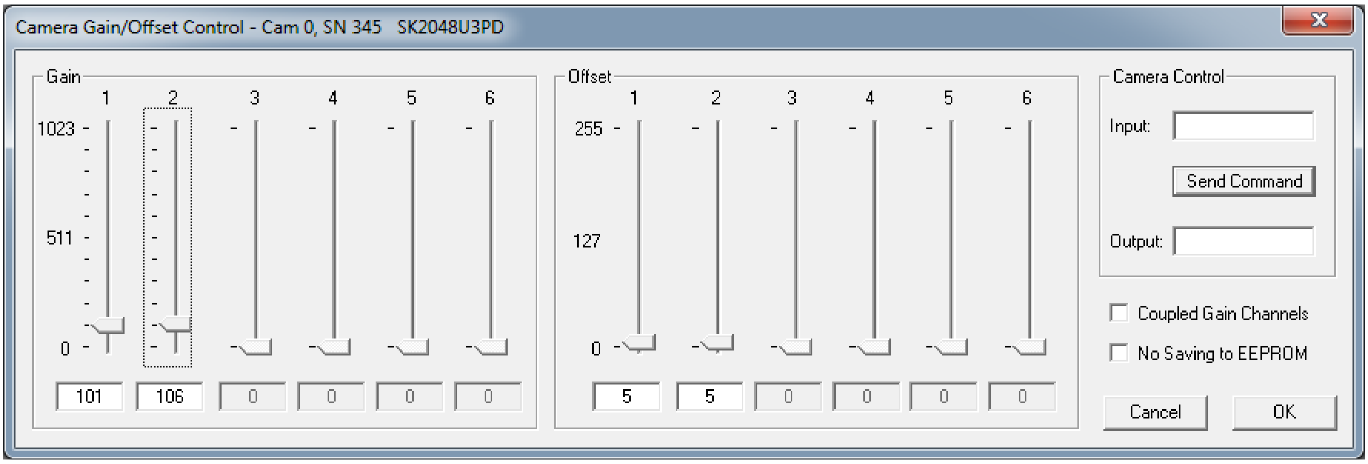
Sensor and optics rotated in apposition



Sensor and optics aligned

Gain/Offset Control Dialog

Cameras are shipped prealigned with gain/offset factory settings. Open the "Gain/Offset Control" dialog [Shift+F4] to re-adjust or customize 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. When "Coupled Gain Channels" is ticked, all channels are adjusted synchronously with one slider.

The 'Camera Control' frame on the right is available for using commands and advanced software functions. (→ ***4.1 Camera Control by Commands, p. 20***)

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.

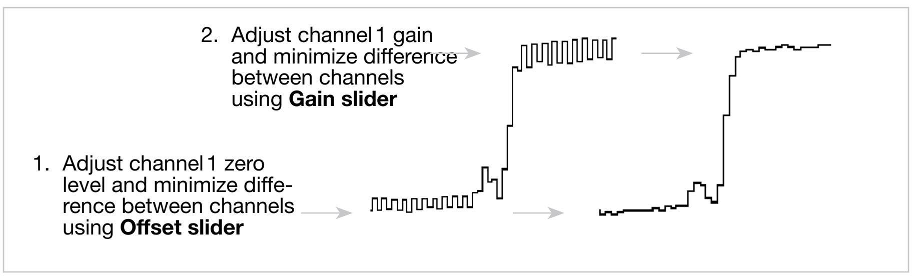
A slight signal noise should be visible in the zero baseline.

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.



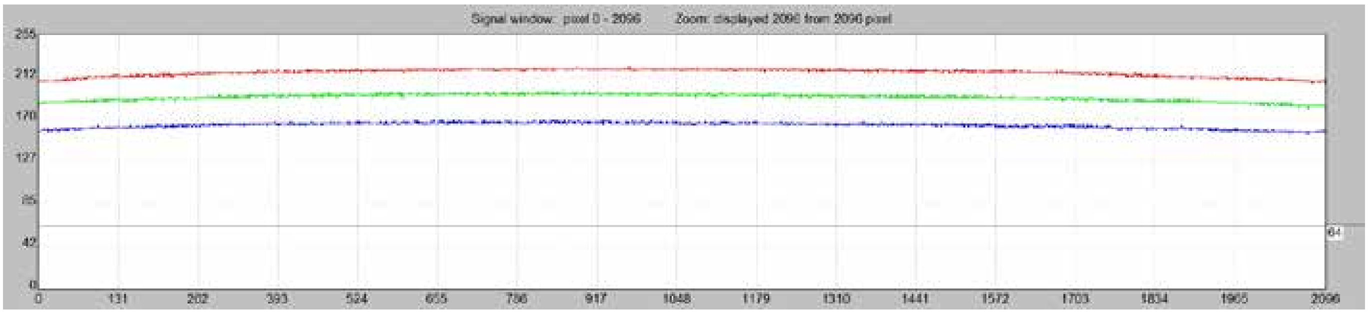
Offset and gain adjustment for more than one gain/offset channel

White Balance and Shading Correction

Shading Correction compensates for non-uniform illumination and lens vignetting, as well as any differences in pixel sensitivity. The signal from a white homogeneous background is obtained and used as a reference to correct each pixel of the sensor with an individual factor. The result is a leveled signal along the full sensor length. A shading correction with a balanced RGB sensitivity ensures a natural color reading. The reference signal is stored in the Shading Correction Memory (SCM) of the camera and subsequent scans are normalized using the scale factors from this white reference.

Step 1: White Balancing

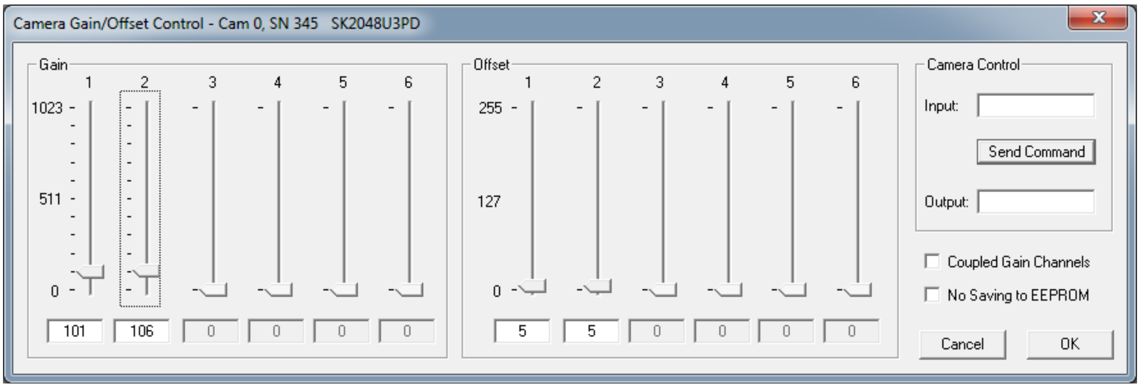
- Use a homogeneous white object, e.g. a white sheet of paper, to acquire the RGB line signals.



Color line signal with separated RGB curves

White Balancing by Gain Adjustment

- Open the "Gain/Offset Control" dialog. Use the gain sliders to adjust all three curves to the same level. Some camera models provide two gain/offset channels - thus two sliders - per color.



"Gain/Offset Control" Dialog

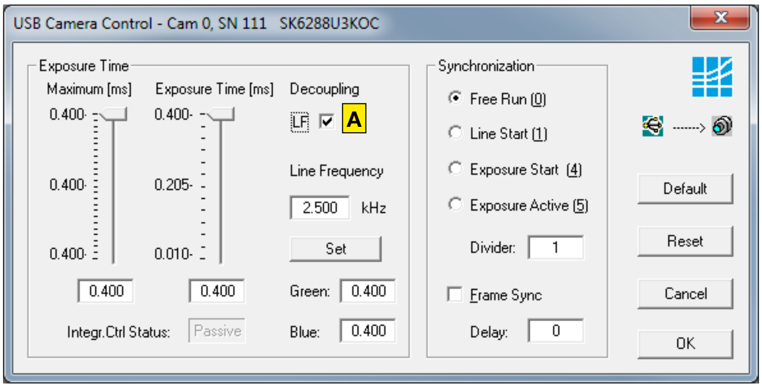
White Balancing by Individual Integration Time Control

In some circumstances, it is not possible to adjust the white balance using the gain setting because of:

- dynamic limitations from a very intensive or weak illumination,
- undesired changes in noise level.

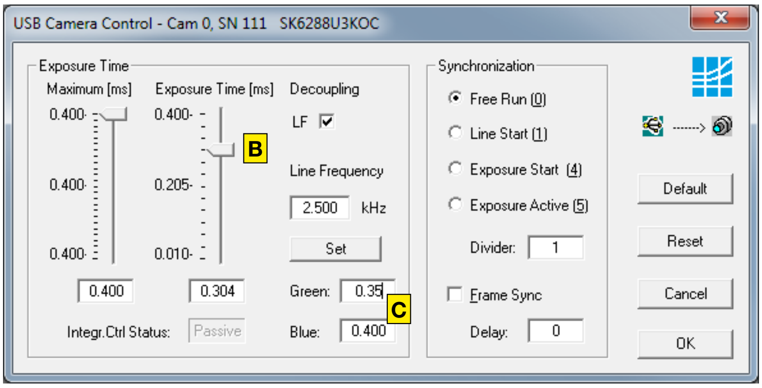
For such situations, an individual adjustment of integration times for the Red, Green, and Blue channels is available, for a general description of the integration time adjustment, see section *Integration Time, p. 17*.

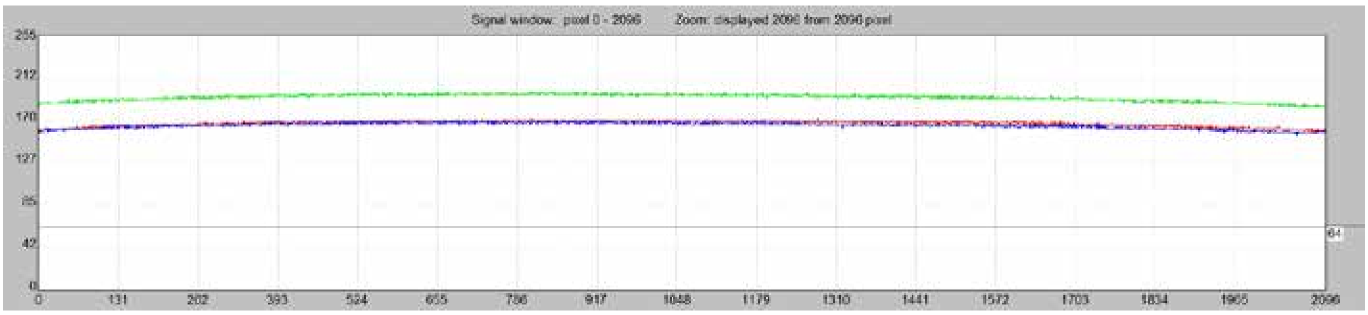
1. Check that the weakest color signal is higher than about 70%. If necessary, adjust the line frequency or the illumination intensity accordingly.
2. Tick the box "Decoupling LF" **A** in the "Camera Control" dialog.



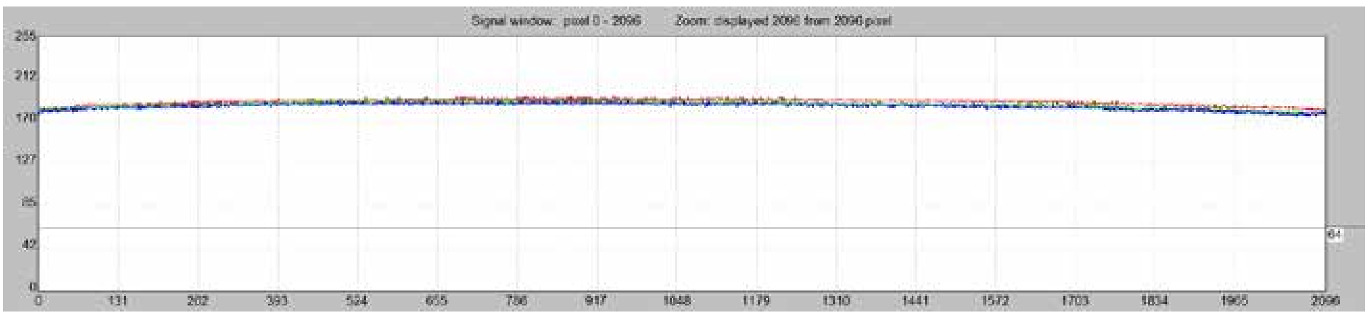
3. Reduce the integration times for the two color channels with the higher signals in order to align the Red, Green and Blue channels to the same level.

   The Red channel is adjusted using the slider "Exposure Time". **B**
   For the Green and Blue channels, enter the exposure time into the respective boxes. **C**





Color line signal with the Red signal adjusted to that of the Blue channel; the Green channel is still separate



Color line signal with balanced RGB curves

Step 2: Obtaining the Shading Correction Data

The shading correction refrence data that is stored in the shading correction memory (SCM) can be obtained in two ways:

A Using a white homogeneous background

- Open the **Shading Correction** dialog (Alt+s).

  Use the entries in the left column to obtain shading correction reference data from a white homogeneous background.
- Use a homogeneous white object to acquire the reference data, e.g. a white sheet of paper.
- Either take a 2-dimensional scan ("Area Scan Function" [F3]) or

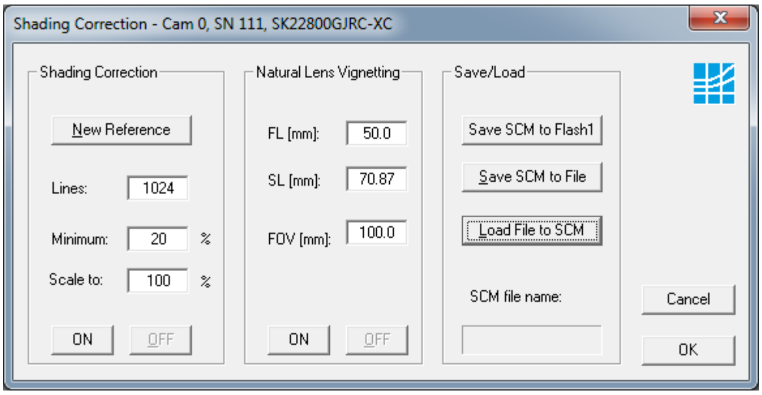
  use a single line signal that was averaged over a number of single line scans.
- To suppress any influence from the surface structure, move the imaged object during the image acquisition.
- Input the scale range:

  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



Shading Correction dialog

Parameters for correction of natural lens vignetting:

FL = Focal Length of the lens in mm
SL = Sensor Length in mm
FOV = Field Of View in mm

Save SCM to Flash	Save the SCM reference signal in the flash memory of the camera
ON	Activate Shading Correction with the reference signal that is stored in the SCM.
OFF	Switch off Shading Correction. This does not affect the content of the camera SCM buffer or the camera flash memory.
Save SCM to File	The SCM reference signal will be stored in a file.
Load File to SCM	A stored reference signal will be loaded into the SCM of the camera. If the load process completes then the Shading Correction is active.

B Analytic compensation of natural lens vignetting

- Open the **Shading Correction** dialog (Alt+s).

  Use the entries in the middle column to calculate the reference data based on the imaging setup.
- Enter the parameters focal length (FL), sensor length (SL) and field of view (FOV) according to your setup.

  The implemented algorithm will compensate the natural lens vignetting.
- Click on **Save SCM to Flash** to save the SCM reference signal in the flash memory of the camera

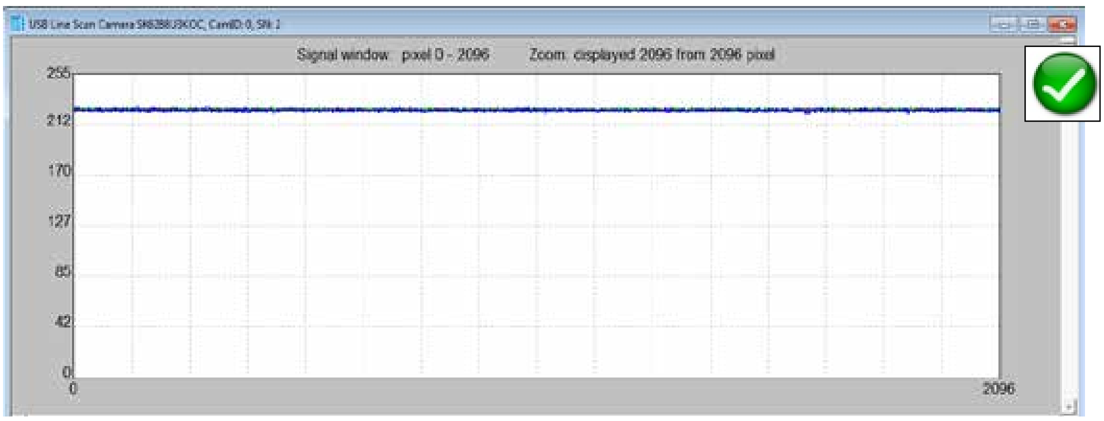
Power-down and Power-up Behaviour

The shading correction memory (SCM) buffer is a volatile memory. Its content is lost on power-off.

Once the reference signal is copied from the SCM to the camera flash memory, it will persist even after a power-down. On a re-start, this data will be restored automatically from the flash memory back into the SCM.

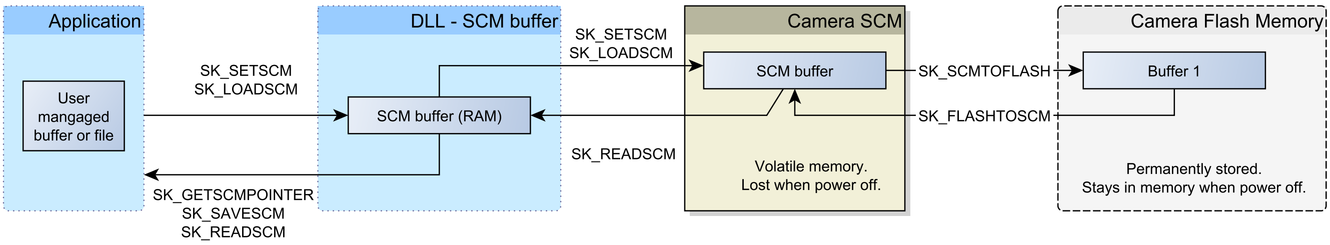
The shading correction status on shutting down - active or not active - will be retained and automatically restored on power-up.

Color line signal with separated RGB curves after Gain Adjustment and Shading Correction



Shading Correction Memories and API Functions

As an alternative to the user dialog, a new shading correction reference signal can also be created by using application programming interface (API) functions. The relationshhip between the storage locations and the related API functions are shown in the diagram below. The API functions are included in the SK91USB3-WIN software package. See the ***SK91USB3-WIN manual*** for details.

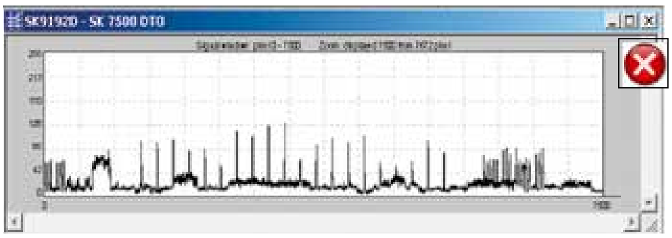


Structure of the shading correction memories and the related API functions for memory handling

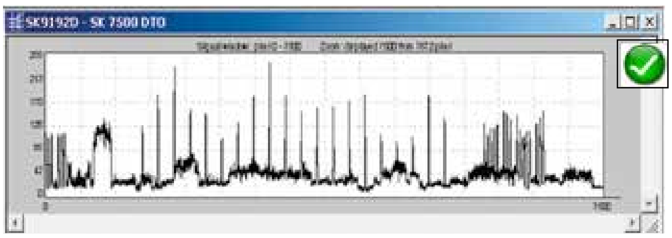
Integration Time

The range of intensity distribution of the line scan signal is affected by the illumination intensity, the aperture setting and the camera integration time. Conversely, the aperture setting influences the depth of field as well as the overall quality of the image and the perceived illumination intensity.

The line scan signal is optimum when the signal from the brightest region of the object corresponds to 95% of the maximum gain. Full use of the digitalization depth (256 at 8-bit, 4096 at 12-bit) provides an optimum signal sensitivity and avoids over-exposure (and blooming).

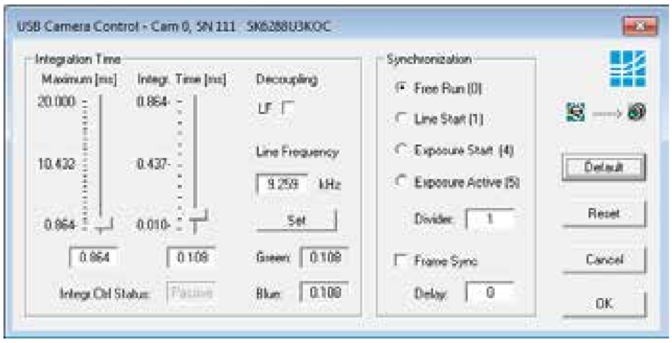


A camera signal exhibiting insufficient gain: the integration time is too short as only about 50% of the B/W gray scale is used.



Optimized gain of the camera signal after increasing the integration time, by a factor of 4, to 95% of the available scale.

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

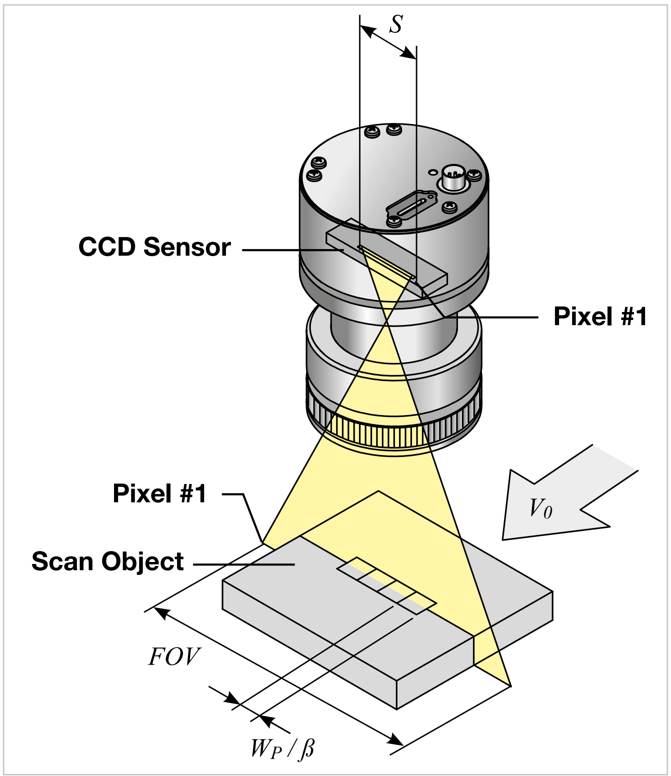


SkLineScan Camera Control dialog

- 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.
- The adjustment of the integration time in the range of Integration Control (shutter) that is shorter than the minimum exposure period does not change the line frequency. This will be held at the maximum.
- 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 Imaging Procedure and the Object Scan Velocity, p. 18***.

Synchronization of the Imaging Procedure and the Object Scan Velocity

- A two-dimensional image is generated by moving either the object or the camera. The direction of the translation movement must be orthogonal to the sensor axis of the CCD line scan camera.
- 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 the constant object velocity have to be coordinated.
- In cases of a variable object velocity or particularly high accuracy requirements then an **external synchronization** is necessary. The various **synchronization modes** are described below.



The optimum object scan velocity is calculated from:

$$V_O = \frac{W_P \cdot f_L}{ß}$$

If the velocity of the object carrier is not adjustable then the line frequency of the camera must be adjusted to provide an image with the correct aspect ratio, where:

$$f_L = \frac{V_O \cdot ß}{W_P}$$

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

Example 1:

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

Pixel width	= 14 µm
Line frequency	= 9.28 kHz
S	= 29.3 mm
FOV	= 50 mm

$$V_O = \frac{14\,\mu m \cdot 9.28\,kHz}{(29.3\,mm / 50\,mm)} = 222\,mm/s$$

Example 2:

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

Pixel width	= 14 µm
Object scan velocity	= 200 mm/s
S	= 29.3 mm
FOV	= 50 mm

$$f_L = \frac{200\,mm/s \cdot (29.3\,mm / 50\,mm)}{14\,\mu m} = 8.4\,kHz$$

Synchronization Modes

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

The line scan camera can be externally triggered in two different ways:

1. Line-triggered synchronization:

Each single line scan is triggered by the falling edge of a TTL signal supplied to LINE SYNC A input.

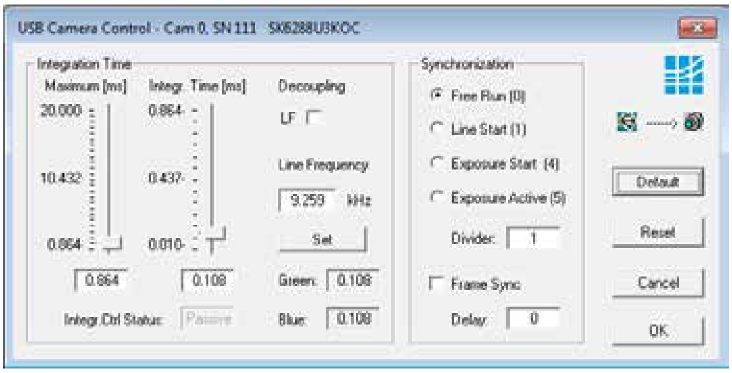
The SK6288U3KOC line scan camera facilitates advanced synchronization control by a second trigger input LINE SYNC B. For a detailed description, see *4.2 Advanced Synchronization Control, p. 24*

2. Frame-triggered synchronization:

A set of lines resulting in a 2-dimensional frame or image is triggered by the falling edge of a TTL signal on FRAME SYNC input.

Schäfter + Kirchhoff differentiates several trigger modes identified by a number, which can be selected in the control dialog as appropriate.

- Open the 'Camera Control' dialog [F4] to configure the synchronization. The trigger mode settings are available in the middle frame.
- Frame- and line-triggered synchronization can be combined. Tick the 'Frame Sync' box to activate the frame synchronization mode.
- The Trigger Control stage is followed by a Trigger Divider stage inside the camera. Enter the division ratio into the 'Divider' field.



Camera Control dialog

Free Run / SK Mode 0

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

LineStart / SK Mode 1

On an external trigger, the currently exposed line will be read out at the next internal line clock. The start and duration of exposure are controlled internally by the camera and are not affected by the trigger. The exposure time is programmable and the trigger does not affect the integration time. The line frequency is determined by the trigger clock frequency.

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

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

A new exposure is started exactly at the time of external triggering and the current exposure process will be interrupted. The exposure time is determined by the programmed value. The exposed line will be read out with the next external trigger. The trigger clock frequency determines the line frequency.

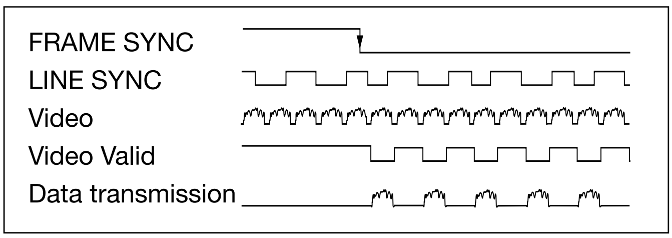
Restriction: The period of the trigger signal must be longer than the exposure time used.

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 reading out of the previously exposed line.

FrameTrigger / SK FrameSync

The frame trigger synchronizes the acquisition of a 2D area scan. The individual line scans in this area scan can be synchronized in any of the available line trigger modes. The camera suppresses the data transfer until a falling edge of a TTL signal occurs at the FRAME SYNC input. The number of lines that defines the size of the frame must be programmed in advance.

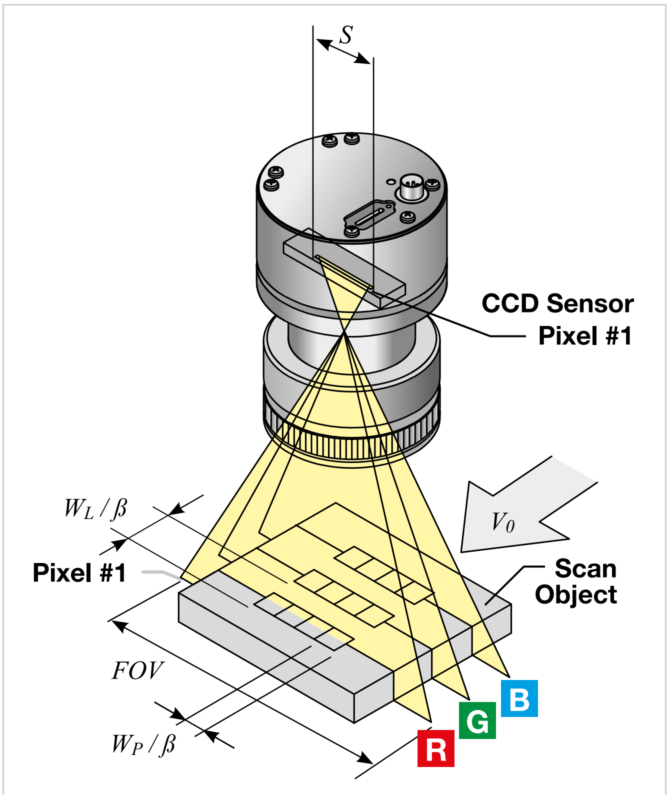


Combined frame and line synchronization

RGB Sensors: 2D Imaging and Pixel Allocation

The three lines of the implemented triple line sensor are sensitive for the primary colors blue (B), green (G) and red (R). For the spectral sensitivity characteristics, see section ***5 Sensor Information***. The pixel width W_P is 14 µm and the line spacing W_L of 112 µm is 8 times the pixel width.

During object travel, an object point reaches the blue (B) line sensor first. If the object is translated by one pixel height per clock pulse then after 8 lines the green (G) pixels are exposed. After another 8 lines then the red (R) pixels have been covered and all color information has been acquired.



V_O: object scan velocity

W_P: pixel width = pixel height H_P (for sensors with square pixels)

W_L: line spacing

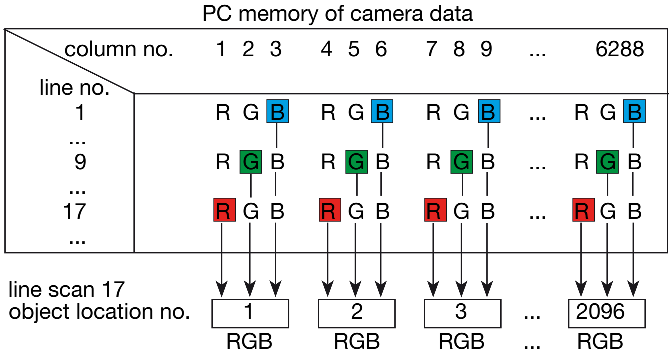
S: sensor length

FOV: field of view

β: magnification = S / FOV

The Camera SK6288U3KOC outputs the blue (B), green (G) and red (R)-information sequentially in one single video output signal.

The color information originating from the different parts of the object is stored in the buffer of the PC and subsequently reallocated correctly.



Generating the color information of object locations for display

Triple line sensors require a precise synchronous translation of the object for the correct allocation of pixels. Also, the transport direction has to conform to the sequence of the line acquisition: first blue (B) then green (G) and red (R).

Images with color convergence aberrations are generated, when these conditions are not met.

Monochrome font pattern

A line synchronous object transport

B asynchronous transport of the object causes color convergence aberration

4 Advanced SkLineScan Software Functions

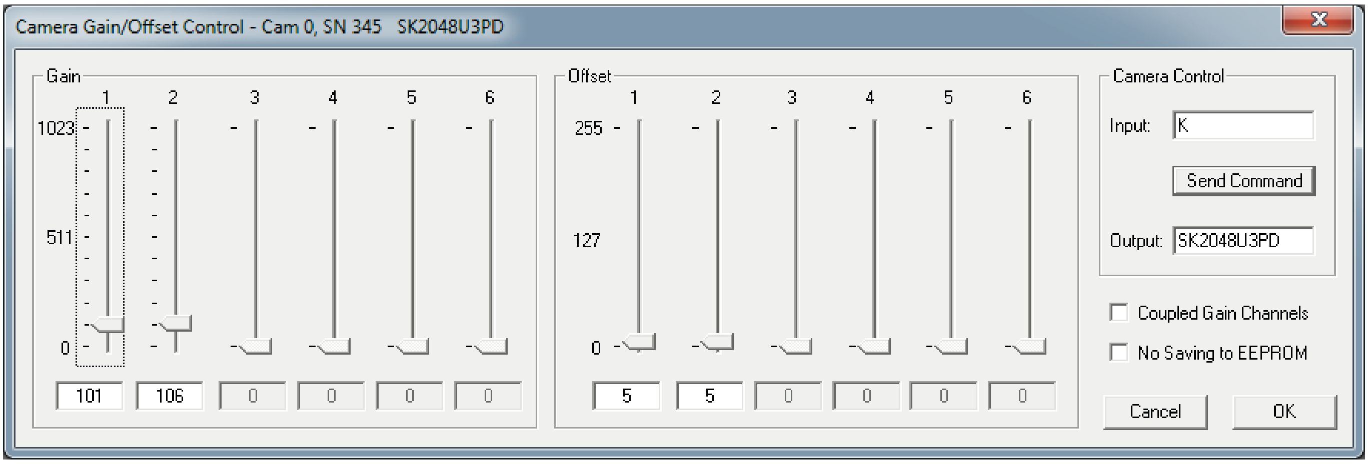
4.1 Camera Control by Commands

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

Set Commands

Set Operation	Description
Goooo<CR>	gain 1 (red) setting 0-24 dB
Boooo<CR>	gain 2 (green) setting 0-24 dB
Hoooo<CR>	gain 3 (blue) setting 0-24 dB
Oppp<CR>	offset 1 (red) setting
Pppp<CR>	offset 2 (green) setting
Qppp<CR>	offset 3 (blue) setting
F8<CR>	output format: 8 bit video data
F12<CR>	output format: 12 bit video data
C30<CR>	camera clock: 30 MHz data rate
C60<CR>	camera clock: 60 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>	Video out = 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
M4<CR>	line trigger mode4: extern trigger and restart
M5<CR>	line trigger mode5: extern SOS, all lines
Mx+8	frame trigger extern, start on falling edge
Mx+16	frame trigger extern, active low
Axxxx<CR>	SCM address (xxxxx = A0-A6287) or LUTM (xxxxx = A32768-A36863 = LUTM 0-4095) and increment address counter
Dxxxx<CR>	SCM data (*xxxx* = 0-4095) and increment SCM address
Eyyyyy<CR>	frames / multiframe (*yyyyy* = 0-32767)
EFyyyyy<CR>	external frame trigger delay (yyyyy = 0-32767 lines)
Nyyyyy<CR>	lines / frame (*yyyyy* = 1-32767)
SLUT<CR>	enable LUT
RLUT<CR>	disable LUT
Wyyyyy<CR>	line clock frequency (*yyyyy* = 50-9259) (Hz)
WLyyyyy<CR>	Window Pixel length (yyyyy =1-Line length)
WFyyyyy<CR>	Window First Pixel (yyyyy = 1-Line length)
Xyyyyy<CR>	exposure time or if DXT=on: exposure time red (yyyyy = 10-20000) (µs)
XGyyyyy<CR>	if DXT=on: exposure time green (yyyyy = 10-20000) (µs)
XByyyyy<CR>	if DXT=on: exposure time blue (yyyyy = 10-20000) (µs)
Vyyyyy<CR>	extern sync divider (*yyyyy* = 1-32767)
Yppp<CR>	set sync control
SDXT<CR>	enable DXT (decoupling of line clock frequency and exposure time)
SNES<CR>	enable NES (no EEPROM save)
SCOG<CR>	enable COG (coupling of gain1-gain3)
RDXT<CR>	disable DXT (decoupling of line clock frequency and exposure time)
RNES<CR>	disable NES (no EEPROM save)
RCOG<CR>	disable COG (coupling of gain1-gain3)
RESET<CR>	reset Memory to manufacturer default

Request Commands

Request	Return	Description
K<CR>	*SK6288U3KOC*	returns SK type number
R<CR>	*Rev1.22*	returns Revision number
S<CR>	*SNr00163*	returns Serial number
I<CR>	*SK6288U3KOC Rev2.35 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>	Ga1: *yyyyy*	returns gain 1 (red)
I7<CR>	Ga2: *yyyyy*	returns gain 2 (green)
I8<CR>	Of1: *yyyyy*	returns offset 1 (red)
I9<CR>	Of2: *yyyyy*	returns offset 2 (green)
I10<CR>	Ga3 *yyyyy*	returns gain 3 (blue)
I12<CR>	Of3: *yyyyy*	returns offset 3 (blue)
I19<CR>	Tab: *yyyyy*	returns 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 or if DXT=on: exposure time red (yyyyy = 10-20000) (µs)
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 Temperature
I34<CR>	ExG: *yyyyy*	returns exposure time green (µs)
I35<CR>	ExB: *yyyyy*	returns exposure time blue (µs)
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

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)**.

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

Y*ppp*<CR> **set sync control**

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 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 machine-encoded jitter, 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)
*xxxxxx*00	intensity	intensity
*xxxxxx*01	D7 = FRAME SYNC D6 = LINE SYNC A D5 = LINE SYNC B D4 ... D0 = 0	intensity
*xxxxxx*10	internal line counter (8 bit)	intensity
*xxxxxx*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 of Advanced Synchronization Control

Annotations:

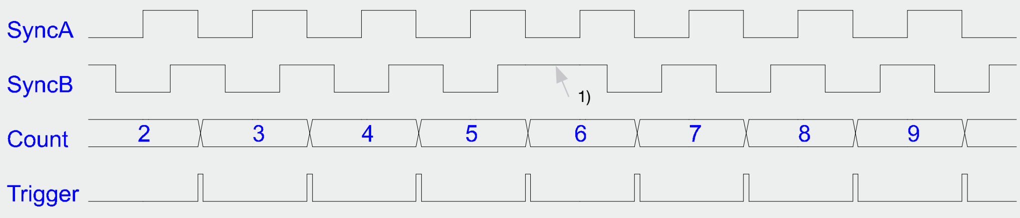
SyncA	=	LINE SYNC A (external line synchronization input, I/O connector)
SyncB	=	LINE SYNC B (external line synchronization input, I/O connector)
Count	=	internal counter
Trigger	=	Generated trigger pulses from the Trigger Control stage. The signal goes to the Trigger Divider stage inside the camera. 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

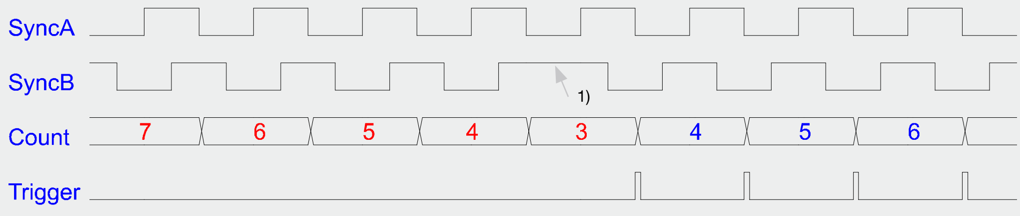
Sync Control Register:
'0xxx xxxx'b



B

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

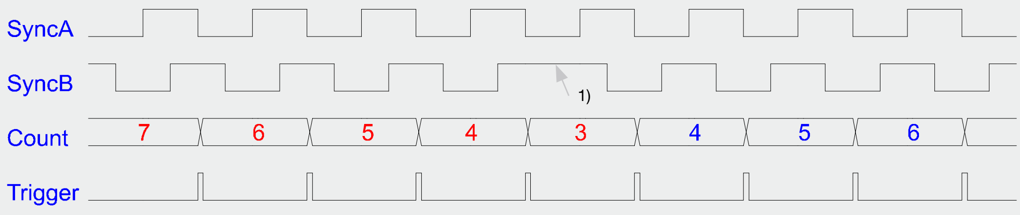
Sync Control Register:
'1000 0xxx'b



C

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

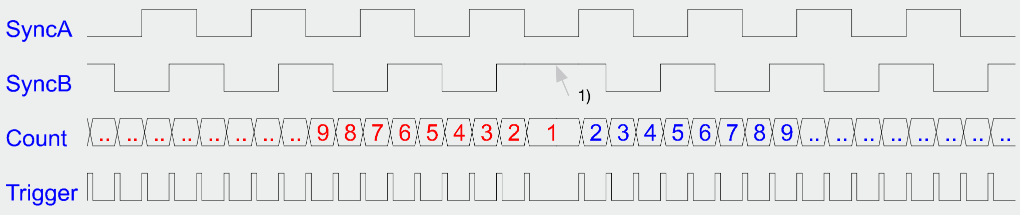
Sync Control Register:
'1100 0xxx'b



D

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

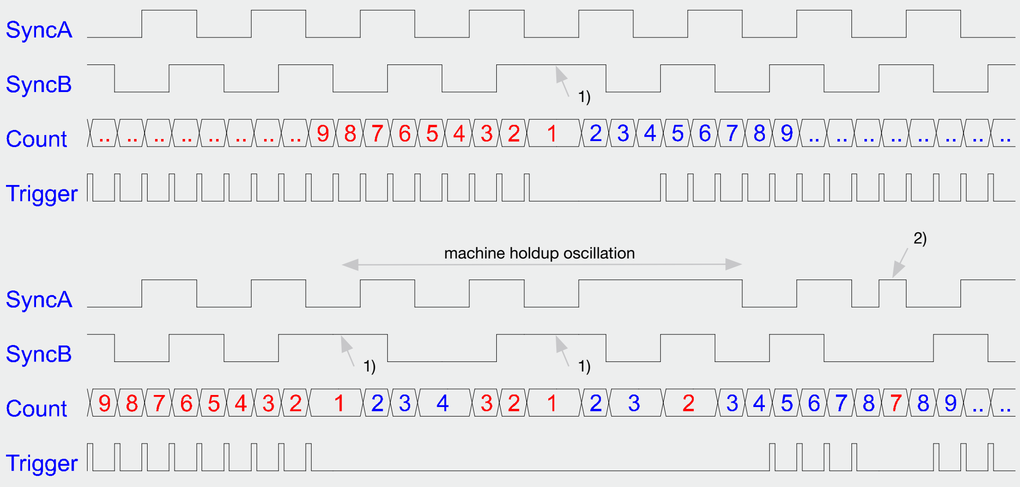
Sync Control Register:
'1110 0xxx'b



E

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

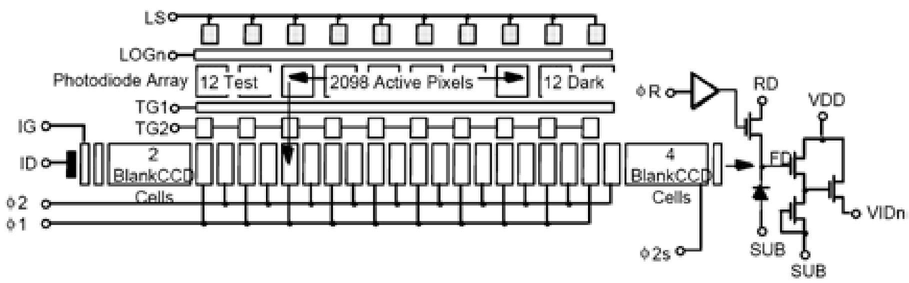
Sync Control Register:
'1110 1xxx'b



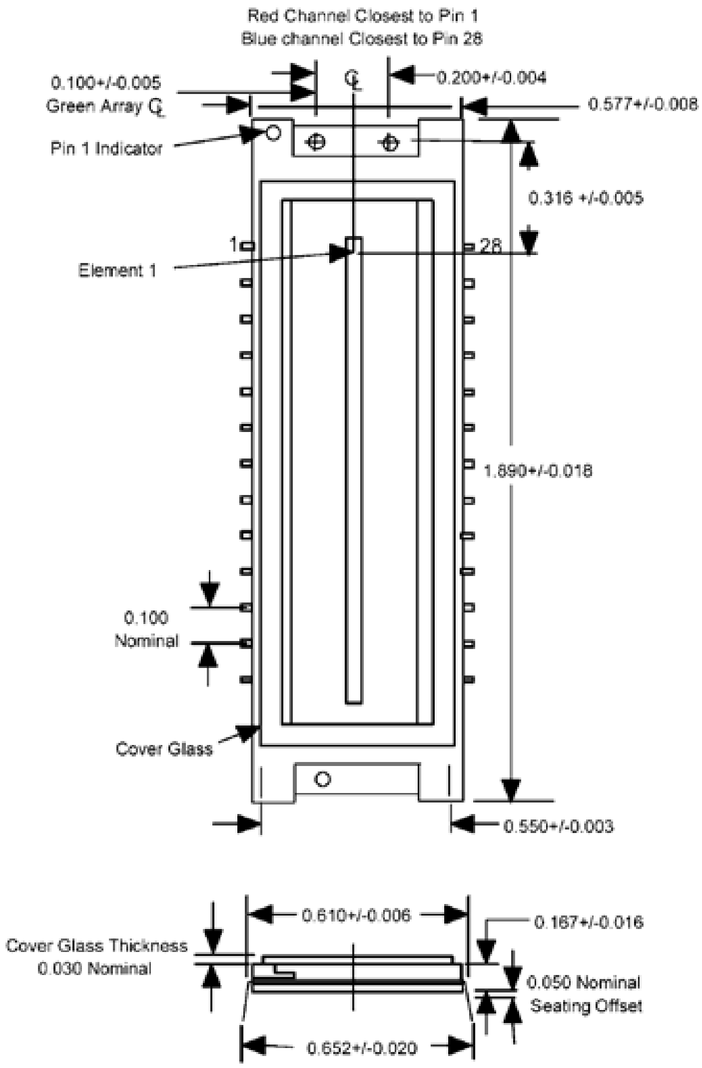
5 Sensor Information

Manufacturer: Eastman Kodak Company
Type: KLI2113
Data source: Kodak Digital Science KLI-2113 Image Sensor, Technical Data Revision 4

Single Channel Schematic

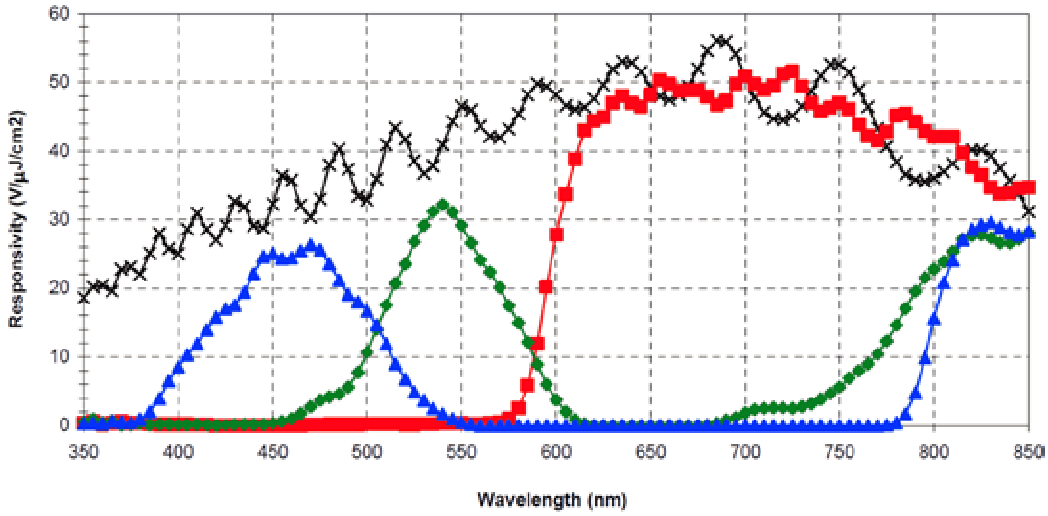


Package Configuration



All dimension in inches.
Detailed drawings available upon request.

Typical Responsivity



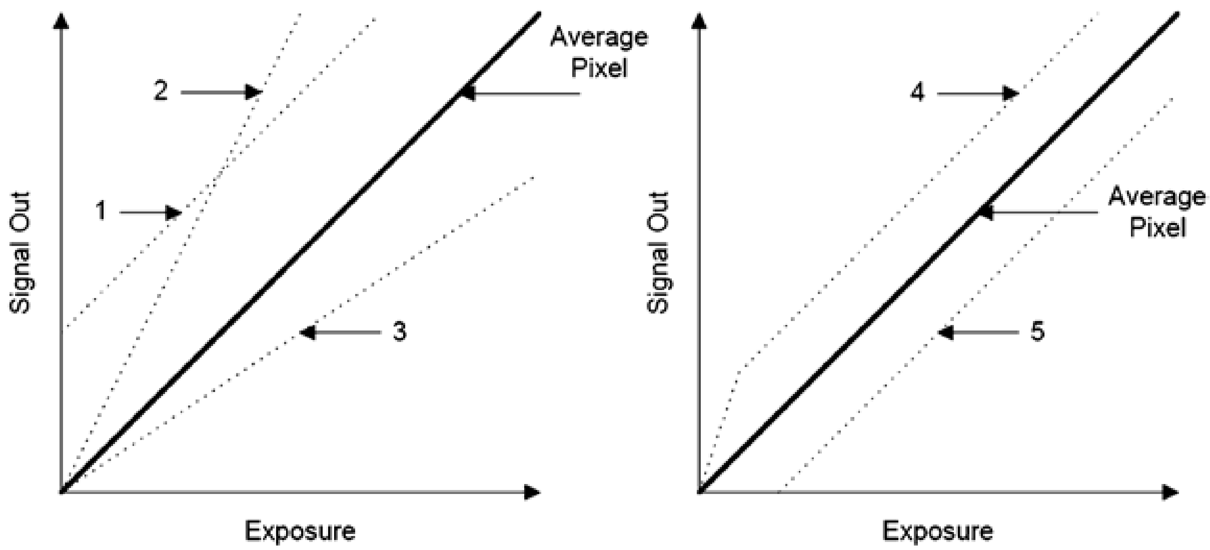
Note: Color filter arrays become transparent after 700nm. It is recommended that a suitable IR cut filter be used to maintain spectral balance and optimal MTF.

Defect Classification

Test conditions: T = 25°C, f_{CLK} = 2 MHz, tint = 1.066 ms

Field	Defect Type	Threshold	Units	Notes	Number
Dark	Bright	8.0	mV	1, 2	0
Bright	Bright/Dark	10	%	1, 3	0
Bright	Exposure Control	4.0	mV	1, 4, 5	≤16

Notes:
1. Defective pixels will be separated by at least one non-defective pixel within and across channels.
2. Pixels whose response is greater than the average response by the specified threshold. See line 1 in figure below.
3. Pixels whose response is greater or less than the average response by the specified threshold. See lines 2 and 3 in figure below.
4. Pixels whose response deviates from the average pixel response by the specified threshold when operating in exposure control mode. See lines 4 and 5 in the figure below.
5. Defect coordinates are available upon request.



Electro-optical Characteristics

Specifications given under nominal operating conditions @ 25°C ambient. f_{CLK} =2 MHz and nominal external VIDn load resistors unless otherwise specified.

Symbol	Parameter	Min.	Nom.	Max.	Units	Notes
V_{sat}	Saturation Output Voltage		2.0		V_{p-p}	1, 7
$\Delta V_o/\Delta N_e$	Output Sensitivity		11.5		µV/e⁻	7
$N_{e,sat}$	Saturation Signal Charge		170k		electrons	
R	Responsivity (@ 650nm)		50		V/µJ/cm²	2, 7
	(@ 540nm)		32		V/µJ/cm²	
	(@ 460nm)		25		V/µJ/cm²	
f_{-3dB}	Output Buffer Bandwidth		75		MHz	@ C_{LOAD} = 10 pF
DR	Dynamic Range		76		dB	3
I_{dark}	Dark Current		0.02		pA/pixel	4
CTE, η	Charge Transfer Efficiency		.99999		-	5
L	Lag		0.6	1	%	1st Field
$V_{o,dc}$	DC Output Offset	6	7	9	Volts	7
PRNU	Photoresponse Uniformity		5	10	% p-p	6
C_ϕ	Register Clock Capacitance		500		pF	/phase
C_{TG}	Transfer Gate Capacitance		400		pF	

Notes:

1. Defined as the maximum output level achievable before linearity or PRNU performance is degraded.
2. With color filter. Values specified at filter peaks. 50% bandwidth = ±30 nm.
3. This device utilizes 2-phase clocking for cancellation of driver displacement currents. Symmetry between Φ1 and Φ2 phases must be maintained to minimize clock noise.
4. Dark current doubles approximately every −9°C.
5. Measured per transfer. For total line h < $(.99999)^{4256}$ =0.96.
6. Low frequency response across array with color filter array.
7. Decreasing external VIDn load resistors to improve signal bandwidth will decrease these parameters.

Glossary

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.

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.

Shading correction

→ ***Shading Correction***, section 3.2

SCM

Shading Correction Memory,

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

SOS

Start of scan,

→ ***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

CE-Conformity

CE

The product complies with the following standards and directives:

2004/108/EG

EMC Directive

DIN EN 61326-1:2013

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

Part 1: General requirements

Part 2-3: Particular requirements – Test configuration, operational conditions and performance criteria for transducers with integrated or remote signal conditioning

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 GmbH 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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Accessories and Spare Parts

USB 3.0 cable SK9020.x

Camera connector: USB 3.0 plug, type micro-B, with safety lock screws

PC connector: USB 3.0 plug, type A (also fits into a USB 2.0 type A socket)

SK9020.x — Order Code

1 = 1 m cable length

3 = 3 m cable length (standard)

External synchronization cable SK9026...

for line scan cameras with USB 3.0 interface.

Shielded cable with Hirose plug HR10A, female 6 pin (camera side), and Phoenix 4 pin connector incl. terminal block.

SK9024.x — Order Code

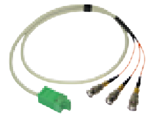
cable length 3 / 5 m
Other lengths on request

USB 3.0 active extension cable USB3.EXT.AA10

External power supply +5 V DC, length 10 m

Connectors:
1x socket USB 3.0 socket, type A,
1x plug Power in, 5 VDC,
1x plug USB3.0, type A (also fits a USB 2.0 type A socket)

USB3.EXT.AA10 — Order Code



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

USB 3.0 active extension cable USB3.EXT.A2A...

Hybrid cable (copper/fiber), power supply by another USB-connection, cable lenght up to 100 m on request.

Connectors:
USB 3.0 plug and socket, with locking screws

USB3.EXT.A2Ax — Order Code

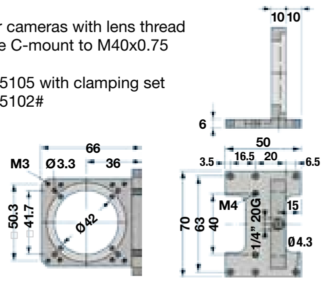
20 = 20 m cable length
30 = 30 m
50 = 50 m
other lengths up to 100 m on request

M1 **Mounting Bracket SK5105**

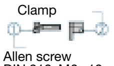
Order Code
SK5105

For cameras with lens thread size C-mount to M40x0.75

SK5105 with clamping set SK5102#

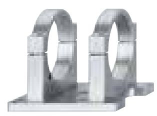


MC1 **Clamping Set SK5102**



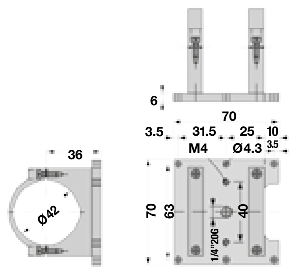
Order Code
SK5102
(set of 4 pcs.)

M3 **Mounting System SK5105-2**



Order Code
SK5105-2

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

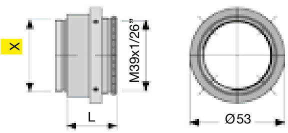


FA1 **Focus adapter FA22...**

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

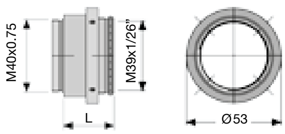
Attachment thread:
45 = M45x0.75
40 = M40x0.75
32 = M32x0.75
C = C-Mount 1"-32-TP

FA2 **Focus adapter L-Mount (M39x1/26" Leica)**

any rotation angle adjustable (V-groove)
attachement thread M40x0.75, male

FA22R-40 — Order Code
length L: 28 ... 38 mm

FA22RL-40 — Order Code
length L: 35 ... 45 mm

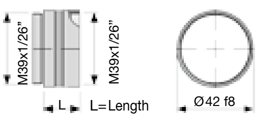


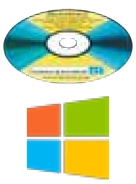
ZR **Extension rings L-Mount (M39x1/26" Leica)**

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





Software

SK91USB3-WIN — Order Code

SDK from *Schäfter + Kirchhoff* including the **SKLineScan** operating program, as well as API, C++ class library and examples.

Operating systems:
Windows 7 / 8.1 / 10 - x64 and x86

SK91USB3-LV VI — Order Code

VI-Library for LabVIEW®, requires **SK91GigE-WIN**

Software

SK91USB3-LX — Order Code

SDK from *Schäfter + Kirchhoff* including the **SKLineScan** operating program, as well as libraries and examples.

Operating systems:
Linux kernel 3.13 or higher, compiled for Debian or openSUSE