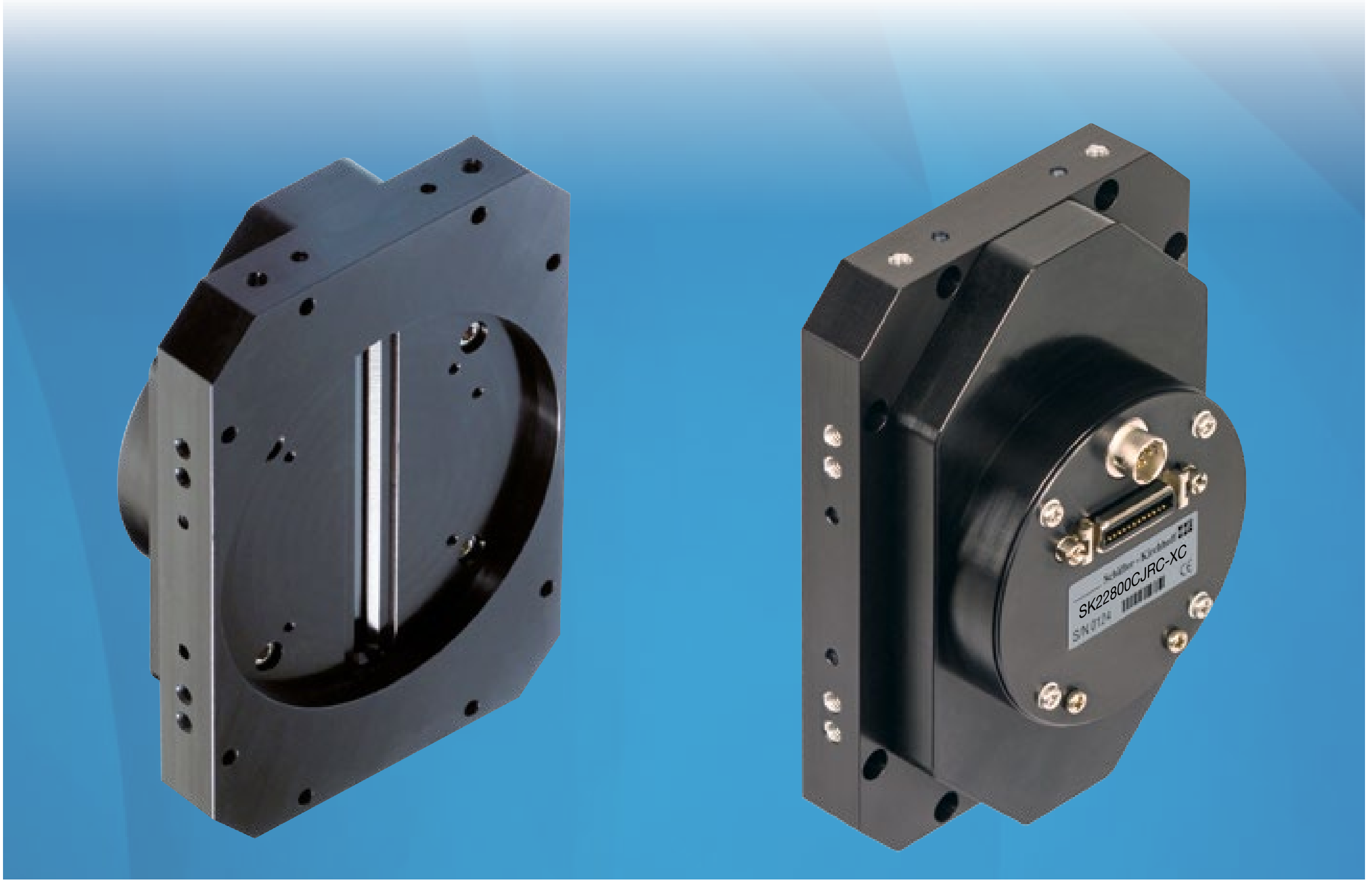
SK22800CJRC-XC

Color Line Scan Camera

7600 x 3 pixels 9.325 x 9.325 µm², line frequency up to 6.17 kHz

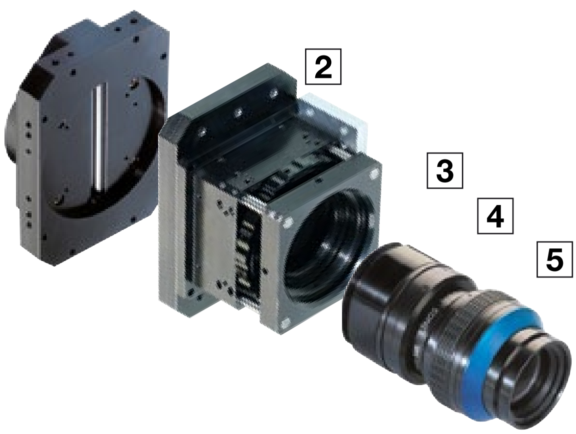
Color line scan camera (Triple-Line) with 3 x 7600 RGB pixels, 6.17 kHz maximum line rate, high resolution.

Instruction Manual



Sample Configuration

1	CCD line scan camera **SK22800CJRC-XC** mounted with
2	Focus adapter FA26XC-S55
3	Extension ring ZR55-15
4	Lens adapter AC46-55
5	Macro lens inspec.x L 5.6/105 ß-0.76



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!

Contents

1 Introducing the SK22800CJRC-XC 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 SK22800CJRC-XC 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.

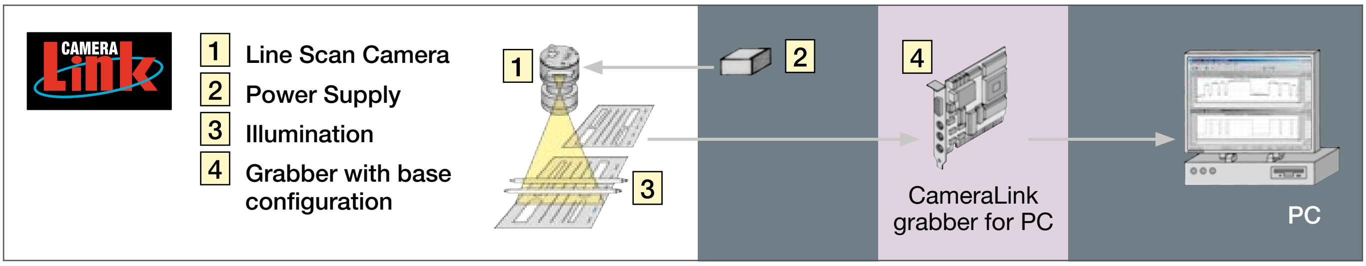
Beyond, the configuration program SkCLConfig allows the full parameterization of the camera settings, such as gain, offset and pixel frequency, via the CameraLink™ serial port interface. SkCLConfig uses the ***clser*.dll*** driver that is supplied with the CameraLink grabber board.

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 ***4.3 Adjustments for Optimum Scan Results (p. 16)***.



1.2 Computer System Requirements

The SK22800CJRC-XC 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 *13*).

1.3 SK22800CJRC-XC Line Scan Camera - Specifications

Sensor category	CCD Color Sensor
Sensor type	ILX146K
Pixel number	7600 x 3
Pixel size (width x height)	9.325 x 9.325 μm^2
Pixel spacing	9.325 μm
Line spacing, line sequence	9.325 μm, blue (B) - green (G) - red (R)
Active sensor length	70.87 mm
Anti-blooming	-
Integration control	-
Shading correction	x
Line synchronization modes	Line Sync, Line Start, Exposure Start
Frame synchronization	x
Pixel frequency	150 / 60 MHz
Maximum line frequency	6.17 kHz
Integration time	0.162 ... 20 ms
Dynamic range	1:1000 (rms)
Spectral range	350 ... 680 nm
Video signal	color 3*8 Bit digital
Interface	Camera Link
Voltage	+5V, +15V
Power consumption	7.6 W
Casing	84 mm x 120 mm x 59.5 mm (Case type FC7)
Objective mount	Ø80 H8
Flange focal length	10.16 mm
Weight	0.4 kg
Operating temperature	+5 ... +45°C

2 Installation and Setup

2.1 Mechanical Installation: Mounting Options and Dimensions

Mounting Options

- Threaded holes at the front side and the outer edges of the camera flange.
- Attaching the camera to the focus adapter FA26-Sxx (accessorie) and fixing the assembly with the mounting console.

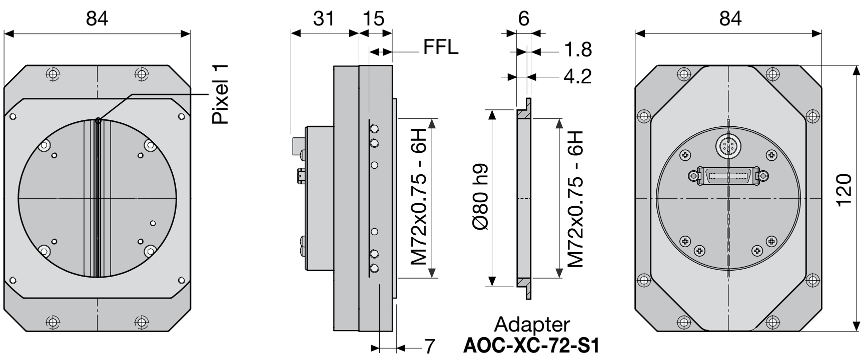
Both options allow to mount the camera in steps of 90° rotation angle.

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 have to handle with open sensor or lens surfaces, make sure the environment is as dust free as possible.
- 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 FC7

Lens mount: **M72x0.75 (with adapter)**
Flange focal length: **FFL = 10.2 mm, with adapter FFL = 12.0 mm**

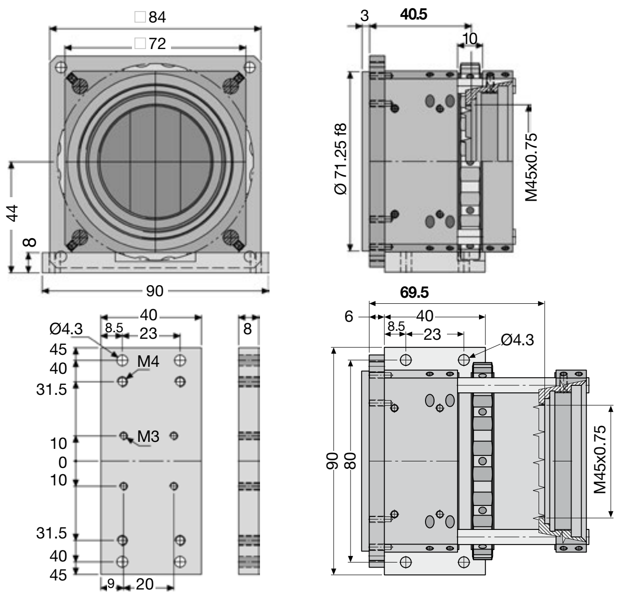


Accessory:

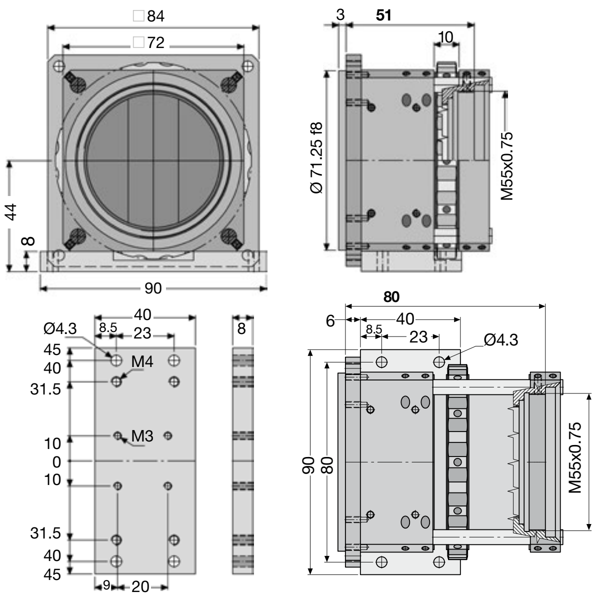
Fokus Adapter **FA26-S45** = thread M45x0.75
FA26-S55 = thread M55x0.75

High-precision adapter with linear tracking rods for precise travel of the focussing encasement and for locking focus position.
Focussing range 30 mm, 1 turn of the focussing ring corresponds to 10 mm. Screws for focus locking.

Dimensions FA26-S45



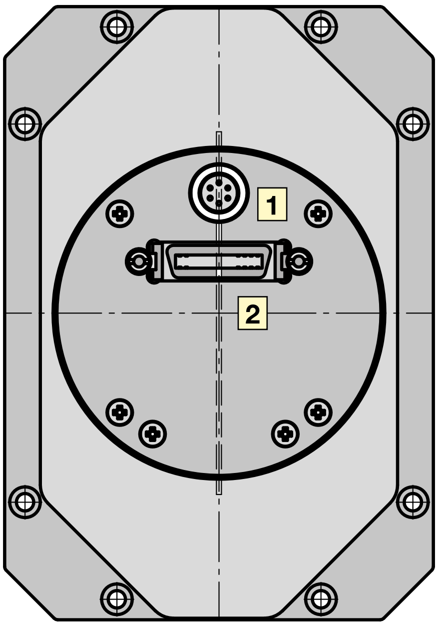
Dimensions FA26-S55



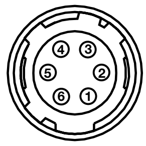
Schäfter+Kirchhoff

2.2 Electrical Installation: Connections and I/O Signals

- For the SK22800CJRC-XC 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 +5 V, +15 V**



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: 7.6 W

2 **Data Connector**

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

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

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

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: +5 V 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
R[0–7]	O	RS644	Red pixel data, 0 = LSB, 7 = MSB
G[0–7]	O	RS644	Green pixel data, 0 = LSB, 7 = MSB
B[0–7]	O	RS644	Blue pixel data, 0 = LSB, 7 = 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
R 0	Tx0	G 0	Tx7	B 0	Tx21	STROBE	TxCLK
R 1	Tx1	G 1	Tx8	B 1	Tx22	LVAL	Tx24
R 2	Tx2	G 2	Tx9	B 2	Tx16		
R 3	Tx3	G 3	Tx12	B 3	Tx17		
R 4	Tx4	G 4	Tx15	B 4	Tx13		
R 5	Tx6	G 5	Tx18	B 5	Tx14		
R 6	Tx27	G 6	Tx19	B 6	Tx10		
R 7	Tx5	G 7	Tx20	B 7	Tx11		

Bit allocation 24-bit (3*8 bit data: R[0-7], G[0-7], B[0-7])

Serial command: F24

The bit allocation conforms to the CameraLink Standard "Base Configuration".

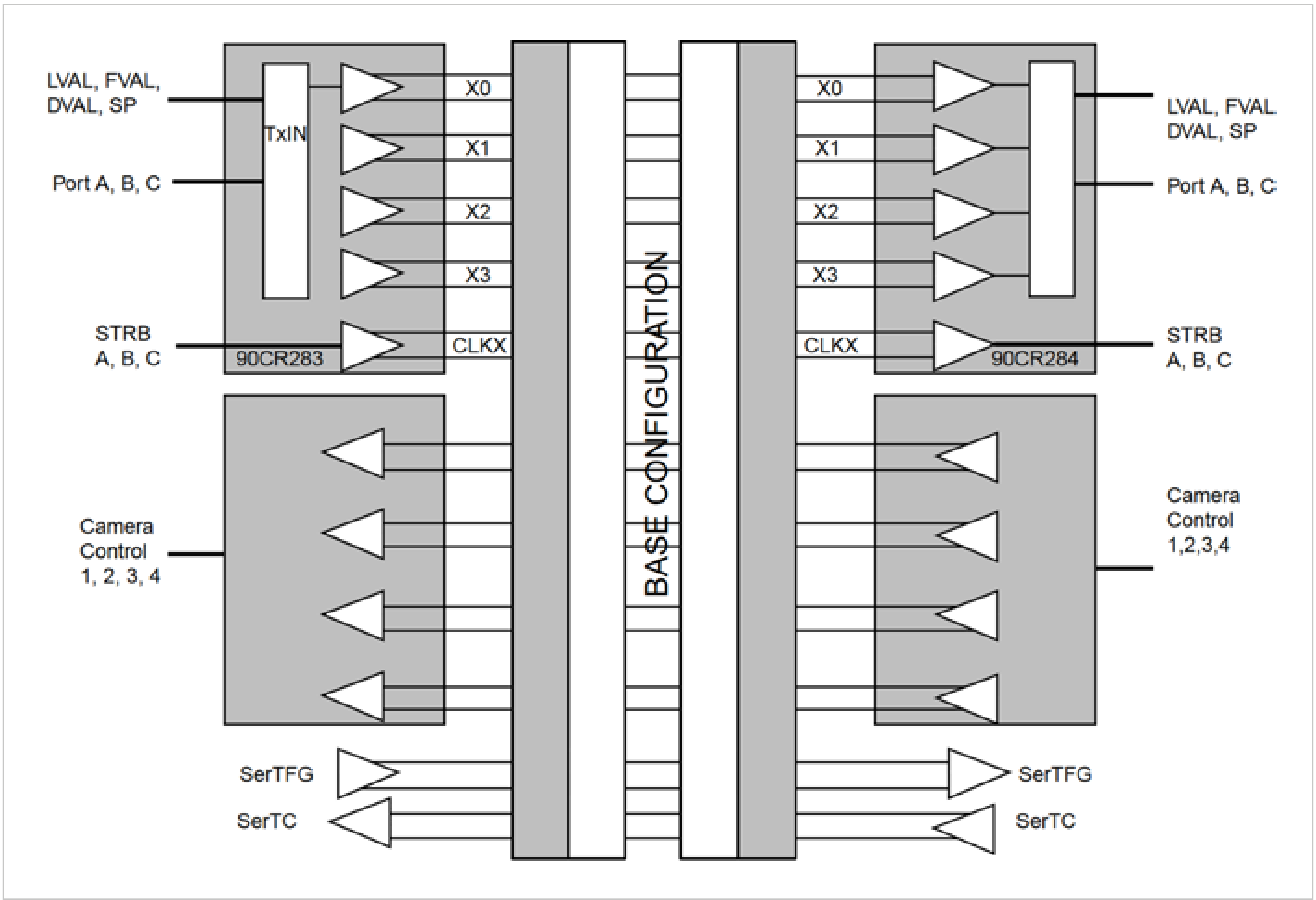
Serial communication

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

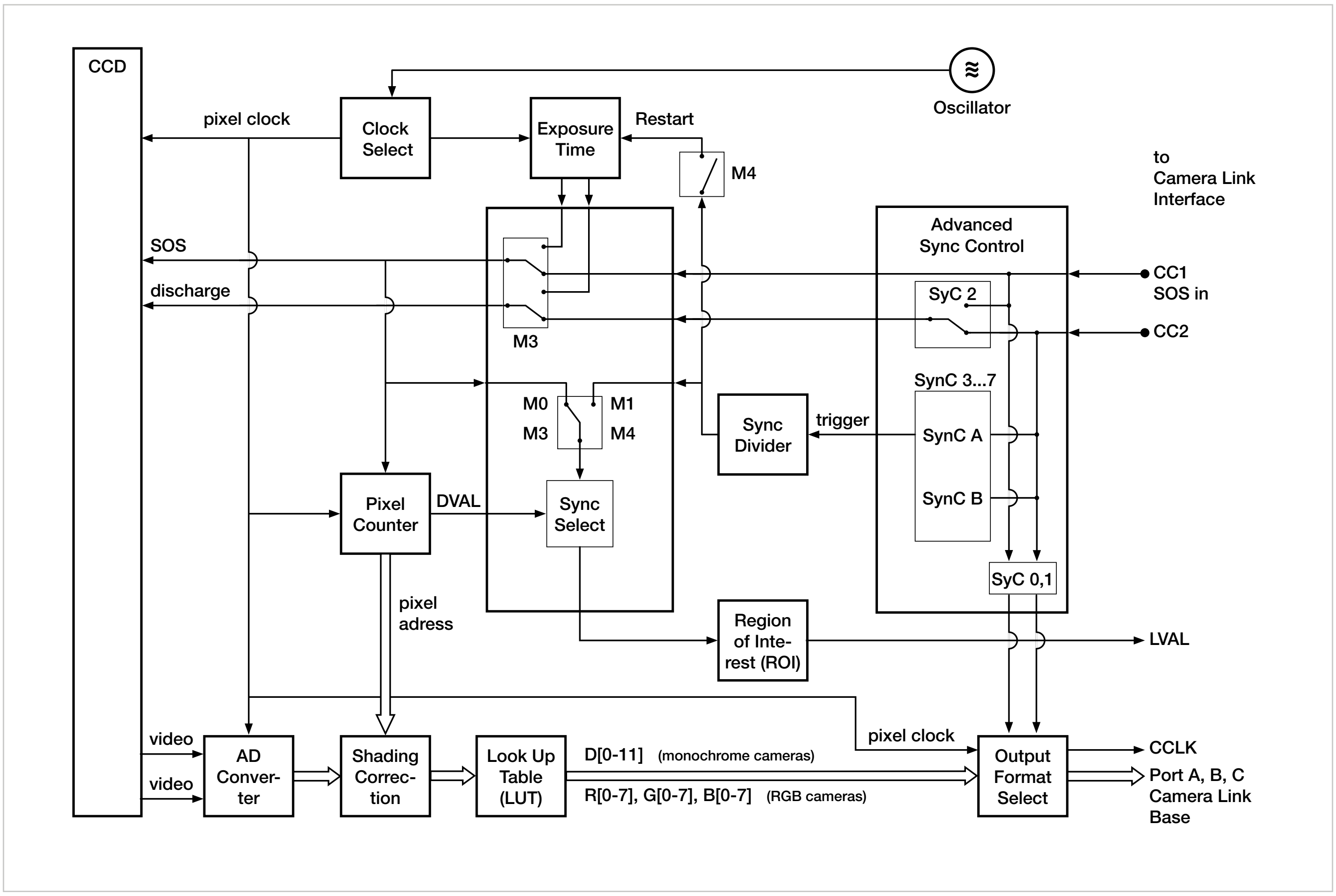
The CameraLink interface supports two LVDS signal pairs for communication between the camera and grabber board, which conform with the RS232 protocol for asynchronous communication:

– 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.

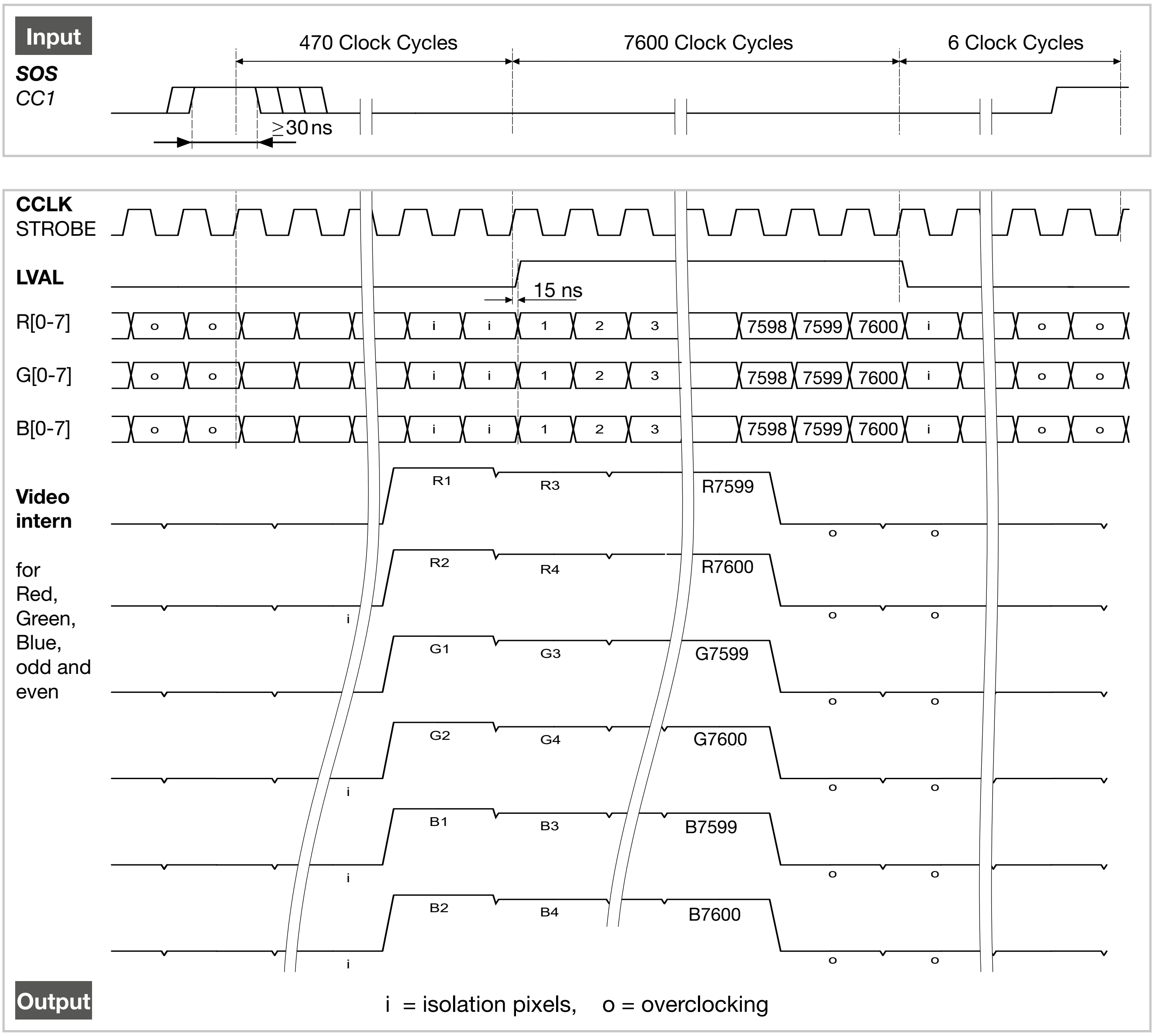
The SOS can be initiated internally by adjusting the Exposure Time or externally by the grabber board. For internal control, the camera must be set in the **'Free Run' mode** by using command **'M0'**. When the SOS signal is generated by the grabber board then the camera must be set to the **'external 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 SK22800CJRC-XC camera requires 8076 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 1/8076 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

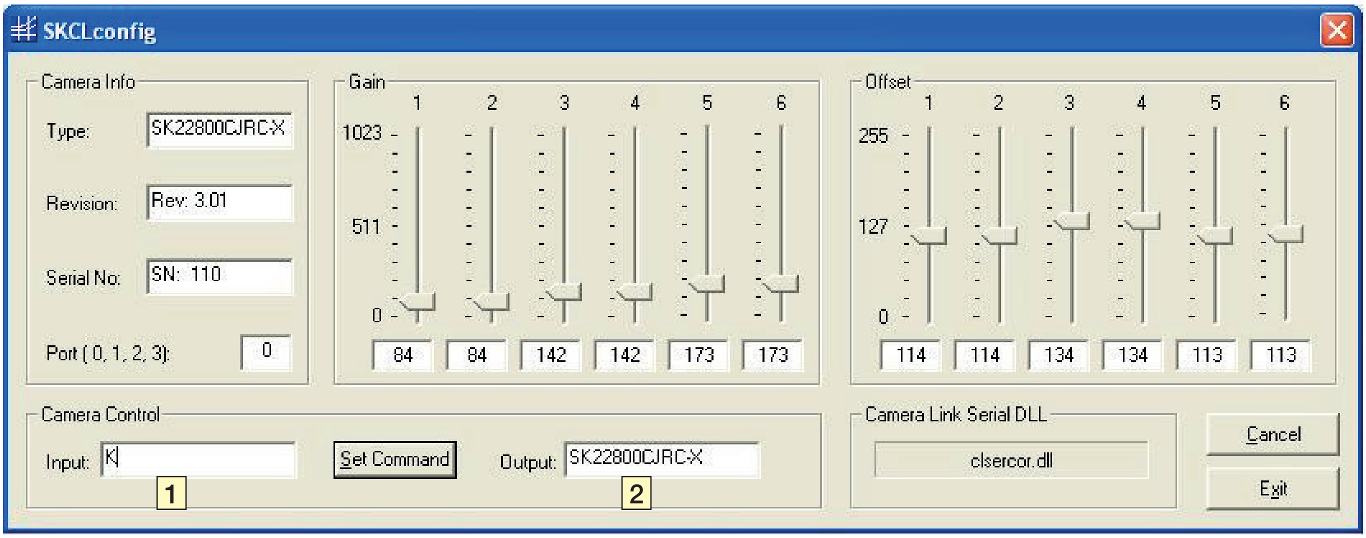
4.1 Camera Control by Commands

The configuration program SkClConfig 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 1 (red odd) setting 0-24 dB
B*oooo*<CR>	gain 2 (red even) setting 0-24 dB
H*oooo*<CR>	gain 3 (green odd) setting 0-24 dB
J*oooo*<CR>	gain 4 (green even) setting 0-24 dB
[*oooo*<CR>	gain 5 (blue odd) setting 0-24 dB
@*oooo*<CR>	gain 6 (blue even) setting 0-24 dB
O*ppp*<CR>	offset 1 (re) setting
P*ppp*<CR>	offset 2 (green) setting
Q*ppp*<CR>	offset 3 (blue) setting
F24<CR>	output format: 3x8 bit output data
C150<CR>	camera clock: 150 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>	output data = LUT data
M0<CR>	free run with selected line rate
M1<CR>	line trigger mode1: extern trigger next Line CC1-input
M2<CR>	free run with maximum line rate
M3<CR>	extern SOS CC1-input
A*xxxx*<CR>	SCM address (xxxxx = A0-A22799) or LUTM (xxxxx = A32768-A36863)
D*xxxx*<CR>	Memory data (*xxxx* = 0-4095), increment memory address counter
W*yyyyy*<CR>	line clock frequency (*yyyyy* = 50-6170) [Hz]
X*yyyyy*<CR>	exposure time (*yyyyy* = 162-20000) [µs]
SCOG<CR>	enable COG (coupling of gain settings)
RCOG<CR>	disable COG (coupling of gain settings)
SLUT<CR>	enable LUT
RLUT<CR>	disable LUT
SNES<CR>	enable NES (no EEPROM save)
RNES<CR>	disable NES (no EEPROM save)
RESET<CR>	reset Memory to manufacturer default

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

Request Commands

Request	Return	Description
K<CR>	*SK22800CJRC-XC*	returns SK type number
R<CR>	*Rev. 2.50*	returns Revision number
S<CR>	*SNr00163*	returns Serial number
I<CR>	*SK22800CJRC-XC* *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 1
I7<CR>	Ga2: *yyyyy*	returns gain 2
I8<CR>	Of: *yyyyy*	returns offset 1
I9<CR>	Of2: *yyyyy*	returns offset 2
I10<CR>	Ga3 *yyyyy*	returns gain 3
I11<CR>	Ga4 *yyyyy*	returns gain 4
I12<CR>	Of3: *yyyyy*	returns offset 3
I14<CR>	Ga5 *yyyyy*	returns gain 5
I15<CR>	Ga6 *yyyyy*	returns gain 6
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)
I32<CR>	Tmp: *yyyyy*	returns Video Board Temper.
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

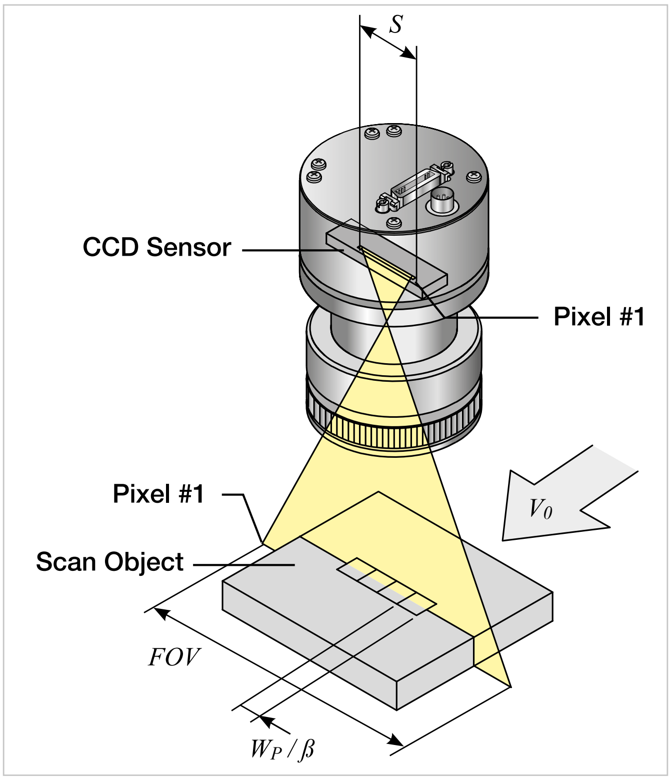
Range of values:
oooo = 0 ... 1023
ppp = 0 ... 255
xxxx = 4 digits integer value as ASCII
yyyyy = 5 digits integer value as ASCII

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	= 9.325 µm
Line frequency	= 6.17 kHz
S	= 70.87 mm
FOV	= 110 mm

$$V_O = \frac{9.325\,\mu m \cdot 6.17\,kHz}{(70.87\,mm / 110\,mm)} = 89\,mm/s$$

Example 2:

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

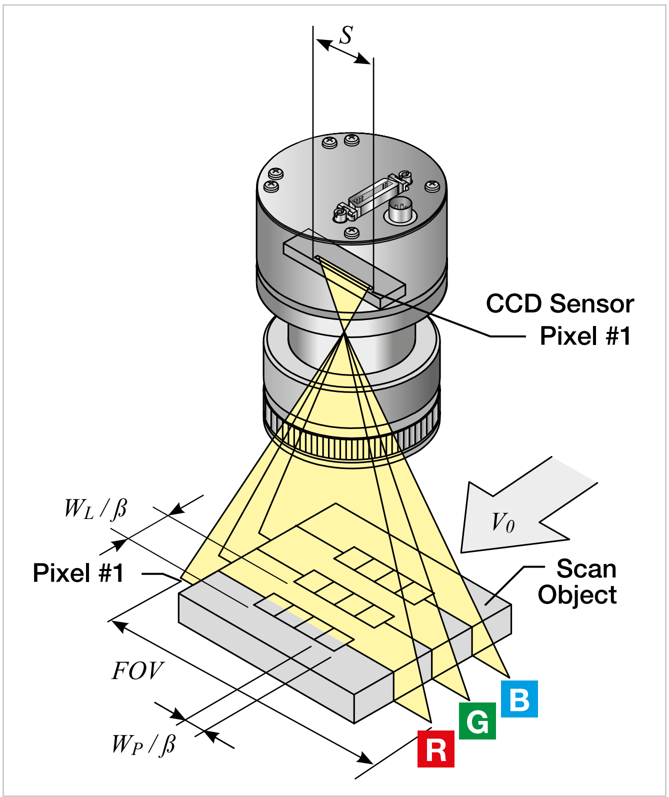
Pixel width	= 9.325 µm
Scan velocity	= 80 mm/s
S	= 70.87 mm
FOV	= 110 mm

$$f_L = \frac{80\,mm/s \cdot (70.87\,mm / 110\,mm)}{9.325\,\mu m} = 5.5\,kHz$$

4.2 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 9.325 µm and the line spacing W_L of 9.325 µm is 1 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 1 lines the green (G) pixels are exposed. After another 1 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

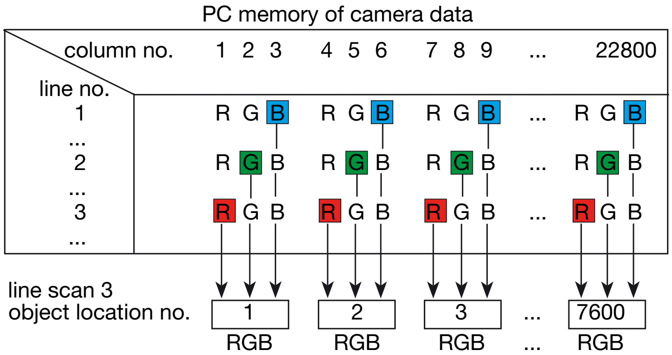
S: sensor length

FOV: field of view

ß: magnification = *S / FOV*

The Camera SK22800CJRC-XC 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

4.3 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.

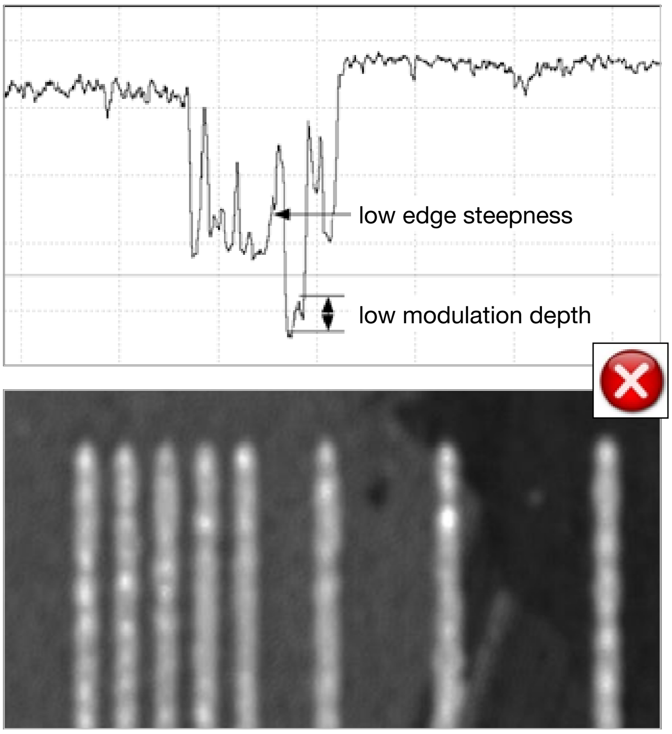
Start with the signal window / oscilloscope display. Any changes in the optical system or camera parameters are displayed in real-time when using an open dialog box.

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.

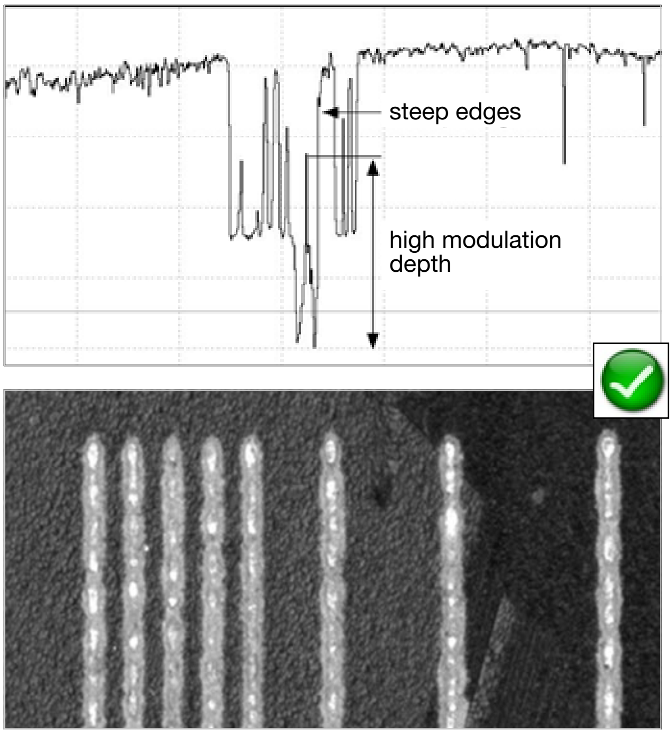
Adjust the focus with the aperture fully open to limit the depth of field and enhance the effects of changing the working distance.

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

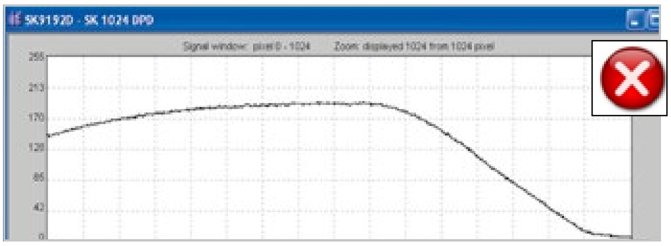


Optimum focus:

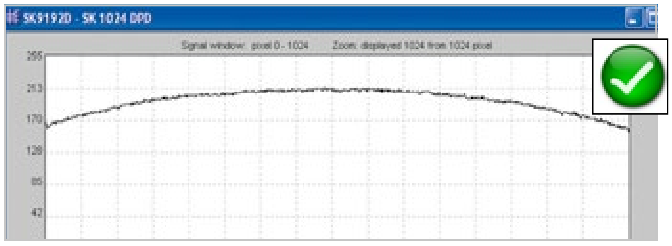
- Dark-bright transitions with steep edges
- Large modulation in the signal peaks
- High spatial frequencies with high modulation depth

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.



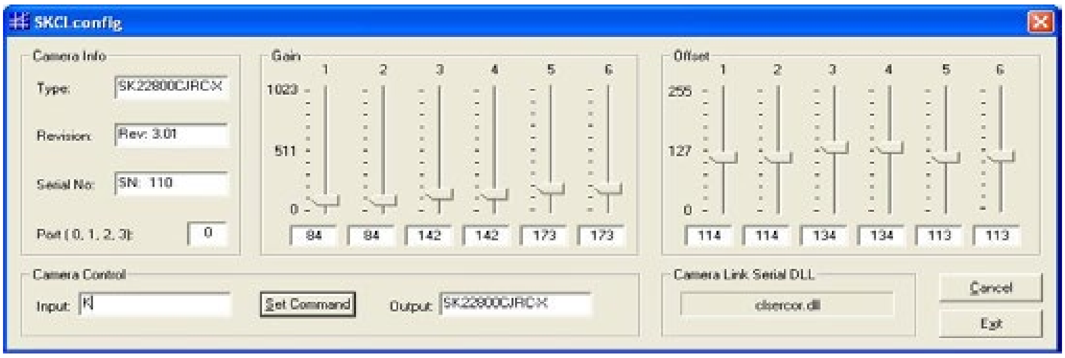
Sensor and line lighting slightly twisted in relation to each other, asymmetric vignetting



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 *11*).

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.

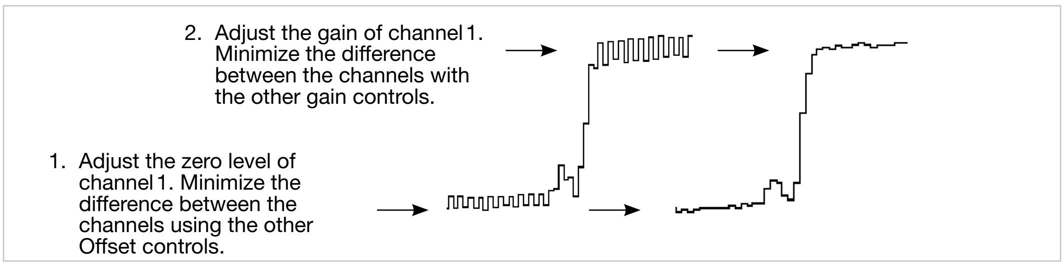
A slight signal noise should be visible in the zero baseline.

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.

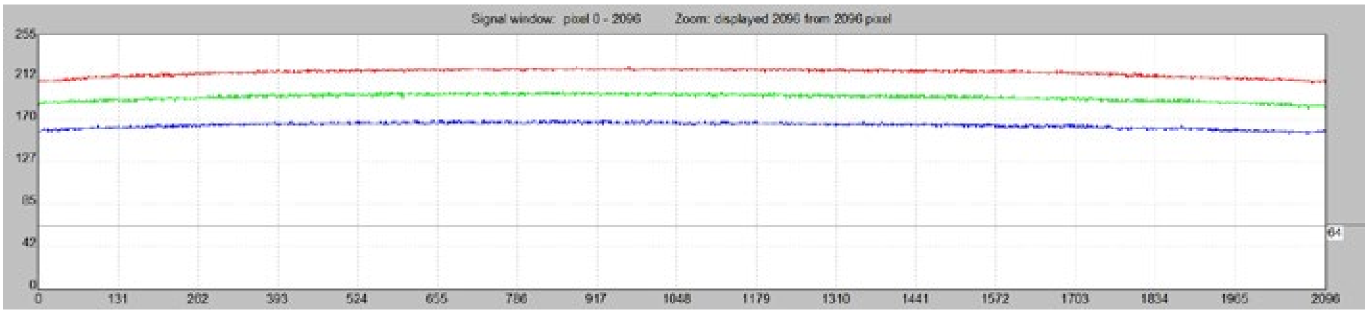
For the full 8-bit resolution of the camera, the maximum output voltage is set to 255 and for 12-bit is set to 4095.



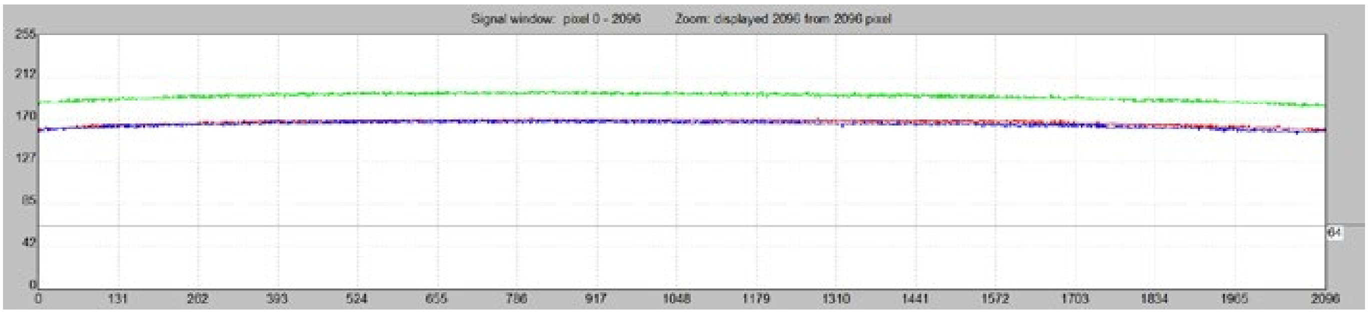
Offset and gain adjustment for more than one gain/offset channel

4.4 White Balance and Shading Correction

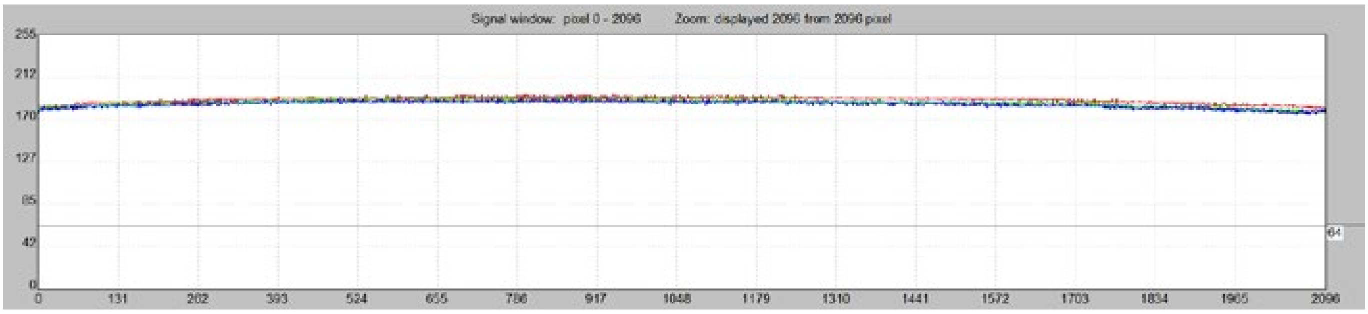
- Use a homogeneous white object, e.g. a white sheet of paper, to acquire the RGB line signals.
- Open the "Gain/Offset Control" dialog. Use the gain sliders to adjust all three curves to the same level. Some camera models provide two gain/offset channels - thus two sliders - per color.
- Afterwards, use the Shading Correction function of your grabber. 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.



Color line signal with separated RGB curves

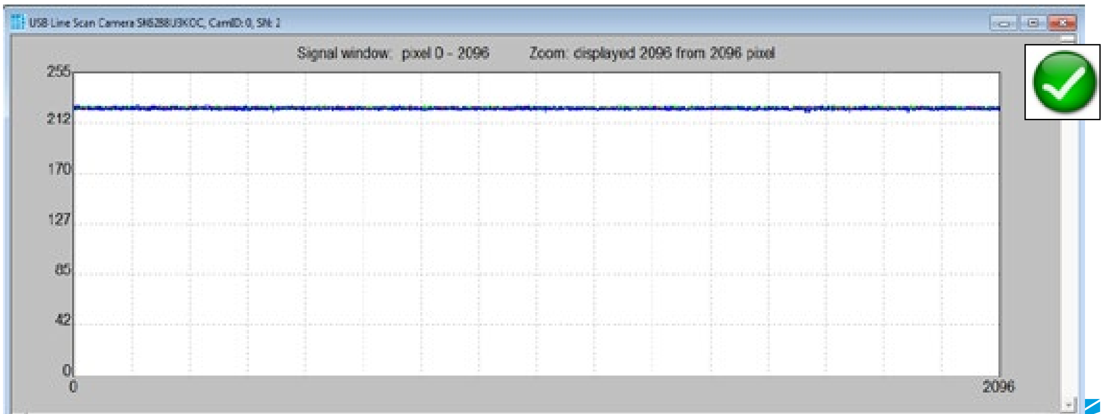


Color line signal with the Red signal adjusted to that of the Blue channel; the Green channel is still separate



Color line signal with balanced RGB curves

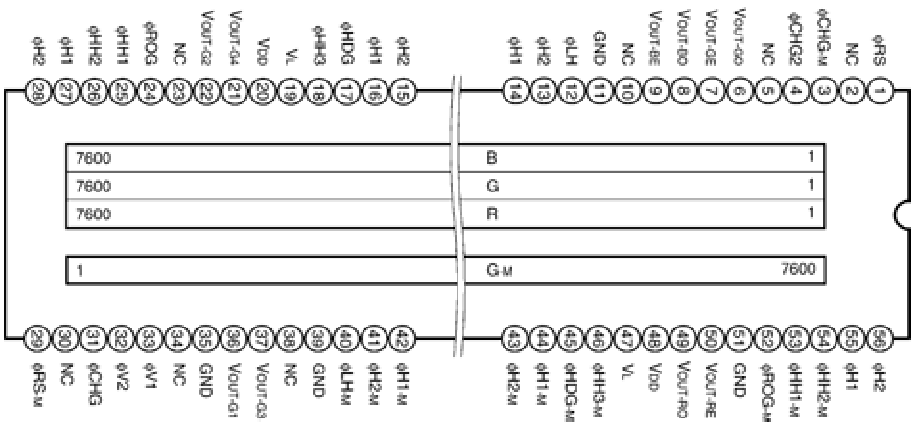
Color line signal with balanced RGB curves after Gain Adjustment and Shading Correction

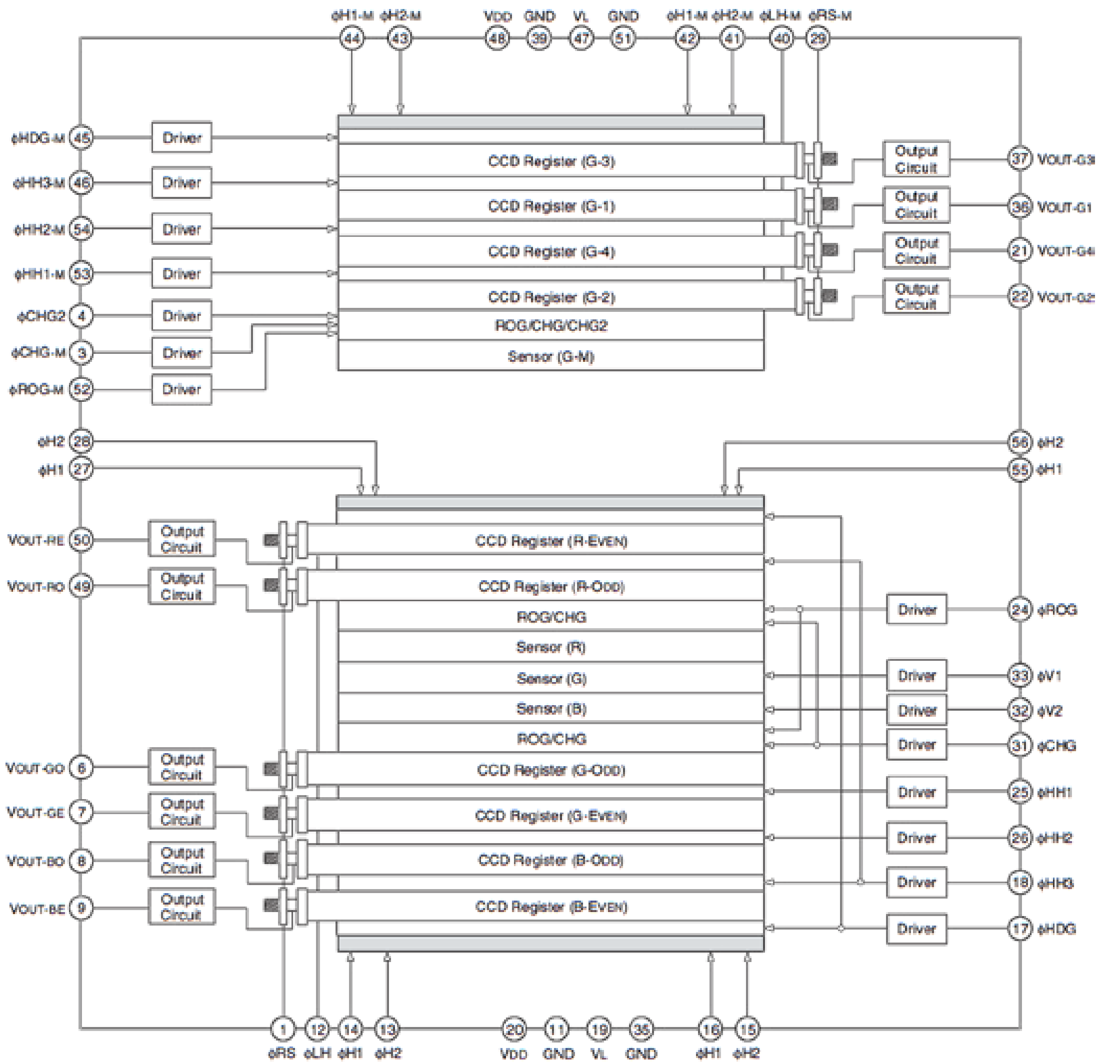


5 Sensor Information

Manufacturer: Sony Corporation
Type: ILX146K
Data source: SONY ILX146K 7600-pixel x 4-line CCD Linear Sensor (Color), Document E03X47-PS

a) Pin-out and Block Diagram





Schäfter+Kirchhoff

b) Electrooptical Characteristics

(Note 1)

(Ta = 25°C, V_{DD} = 10V, V_L = –3V, $f\phi_{RS}$ = 25MHz, Input clock = 5Vp-p,
Light source = 3200K, IR cut filter CM-500S (t = 1.0mm) used)

Item		Symbol	Min.	Typ.	Max.	Unit	Remarks
Sensitivity	R	R_R	7	10	13	V/(lx·s)	Note 2
	G	R_G	10.5	15	19.5		
	B	RB	5.2	7.5	9.8		
	Monochrome	RM	10.1	14.5	18.9		
Sensitivity nonuniformity		PRNU	—	10	20	%	Note 3
Adjacent pixel difference		PDF	—	10	20	%	Note 4
Saturation output voltage		V_{SAT}	1.2	—	—	V	Note 5
Saturation exposure	R	SE_R	0.092	—	—	lx·s	Note 6
	G	SE_G	0.061	—	—		
	B	SE_B	0.122	—	—		
	Monochrome	SE_M	0.063	—	—		
Dark voltage average		V_{DRK}	—	0.4	2.0	mV	Note 7
Dark voltage nonuniformity		DSNU	—	1.0	5.0	mV	Note 8
Image lag		IL	—	0.1	1.0	%	Note 9
Current consumption		I_{VDD}	—	125	150	mA	—
Total transfer efficiency		TTE	92	—	—	%	—
Output impedance		Zo	—	50	—	Ω	—
Offset level		V_{OS}	6.3	7.8	9.3	V	Note 10

Note) 1. For each color, the following electrooptical characteristics signal processing is performed with the black level of odd pixels defined as the average value of D33, D35,... to D131, and the black level of even pixels defined as the average value of D34, D36,... to D132.

2. For the sensitivity measurement, light is applied with a uniform intensity of illumination.

3. PRNU is defined as indicated below.
The incident light intensity conditions are the same as for Note 2. In addition, the standard output signal amplitude during the measurement is 500mV.

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

Where the maximum output of the effective pixels is V_{MAX}, the minimum output is V_{MIN}, and the average output is V_{AVE}.

4. $PDF = (DV_{MAX}/V_{AVE}) \times 100\ [\%]$
Here, V_{AVE} is defined as the average output, and DV_{MAX} as the maximum value of DVi within the following pixel range.
Red, green, blue pixel arrangement PDF is when i = 1 to 7599. However, DVi is defined as follows

$$DVi = ABS\ \{V_{OUT}\ (i) – V_{OUT}\ (i + 1)\}$$

V_{OUT} (i) is the signal output of an effective pixel (i pixel) and V_{OUT} (i + 1) is the signal output of the adjacent pixel (i + 1 pixel). The standard output signal amplitude is 500mV.

5. Specified at the minimum value of the saturation output voltage.

6. Saturation exposure is defined by the following formula for each color.

$$SE = V_{SAT}/R$$

7. For each color, odd pixels are defined by the difference between the average value of the D3 to D29 dummy signals during no incident light and the average value of D35 to D133 and S1 to S7599. Even pixels are defined by the difference between the average value of the D4 to D30 dummy signals during no incident light and the average value of D36 to D134 and S2 to S7600.
   The optical signal integration time τint is 10ms.
8. For each color, calculate the difference between the maximum/minimum values of the dark output voltage and the dark voltage average value for the odd pixels and even pixels or the G1 to G4 pixels, respectively. The largest value among these is specified as the dark voltage nonuniformity.
   The optical signal integration time τint is 10ms.
9. Specified as the ratio of the output value during the output period relative to the output value during the effective output period when light is incident once every four integration periods.
10. V_{OS} is defined as the output DC value when ϕRS is High.

Blooming

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

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

Exposure period

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

Integration control

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

Integration time

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

Line frequency, line scan frequency

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

Optical resolution

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

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

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

Pixel frequency

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

Region of Interest

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

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

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

Shading correction

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

SCM

Shading Correction Memory,

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

SoI (Start of Integration)

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

SoS (Start of Scan)

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

→ ***Synchronization***

→ ***Advanced Synchronization Control***, section 4.2

SkLineScan

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

→ ***Software: SkLineScan***, section 3.1

Synchronization

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

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

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

Thresholding (monochrome cameras only)

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

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

CE-Conformity

The product complies with the following standards and directives:

2014/30/EU

EMC Directive

DIN EN 61326-1:2013

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

Part 1: General requirements

Warranty

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

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

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

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

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

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

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

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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)

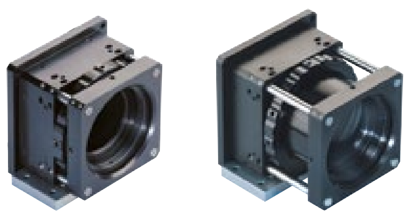
SK9018.x-MM Order Code
MM = connector both ends male
cable length 3 / 5 m or length according to choice, max. 10 m

Power cable SK9015.x

for GigE Vision™, CameraLink and externally supplied USB3 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



Focus Adapter FA26-Sx

High-precision adapter with linear tracking rods for precise travel of the focussing encasement and for locking focus position. Focussing range 29 mm, 1 turn of the focussing ring corresponds to 10 mm. Screws for focus locking.

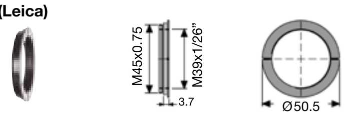
FA26-Sx Order Code
45 = thread M45x0.75, length 40.5 ... 69.5 mm
55 = thread M55x0.75, length 51 ... 80 mm

Lens Adapters and Extension Rings M45x0.75

Lens Adapter M45x0.75 to M39x1/26 (Leica)

Order Code
M39-45

length L=3.7 mm

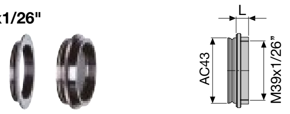


Adapter M45 x 0.75 46 mm to AM43

Order Code
AM43-M45-S L=20 mm
AM43-M45 L=35 mm
The AM43-M45 accepts the V-groove lens adapter M39x26G-AC43.

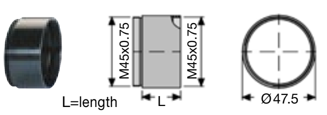
Lens Adapter V-Groove AC43 to M39x1/26"

Order Code
M39x26G-AC43-S L=1.5 mm
M39xG26-AC43 L=8.2 mm



Extension Ring M45x0.75

ZR-L... Order Code
15 = length 15 mm
25 = length 25 mm
60 = length 60 mm
87 = length 87 mm

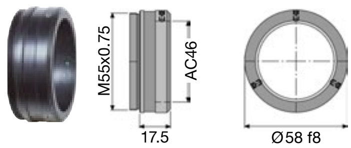


Lens Adapters and Extension Rings M55x0.75

Lens adapter 46 mm V-groove – M55 x 0.75
for macro lens inspec.x L5.6/105

AC46-55 Order Code

The Adapter AC46-55 adds 17.5 mm to the optical tube length. It accepts the AC46 V-groove of the Inspec.x macro lenses.



Extension Ring M55x0.75

ZR55-... Order Code
15 = length 15 mm
25 = length 25 mm
60 = length 60 mm