Schäfter+Kirchhoff

SK7500CTF-XB

Monochrome Line Scan Camera

7500 pixels, 7 µm x 7 µm, 80 MHz pixel frequency

Instruction Manual

07.2016

Sample Configuration

1	CCD line scan camera **SK7500CTF-XB** mounted with
2	Focus adapter FA26-S45
3	Extension ring ZR-L25
4	Lens adapter M39-45
5	Enlarging lens Apo-Rodagon N 4.0/80

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.

Schäfter+Kirchhoff
Kieler Str. 212, 22525 Hamburg, Germany • Tel: +49 40 85 39 97-0 • Fax: +49 40 85 39 97-79 • info@SuKHamburg.de • www.SuKHamburg.de

Schäfter + Kirchhoff © 2016 • Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Titel_ML.indd (07.2016)

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 8**

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!

Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Hinweise.indd (07.2016)

© 2016 Schäfter+Kirchhoff GmbH • Hamburg

Contents

Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Contents.indd (07.2016)

© 2016
Schäfter+Kirchhoff GmbH • Hamburg

1 Introducing the SK7500CTF-XB 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 SK7500CTF-XB is compliant with CameraLink Specification Rev 1.1.

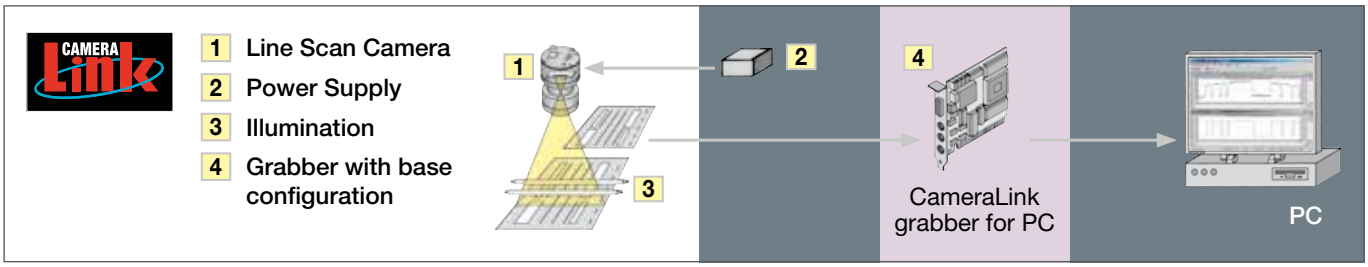
Data acquisition requires that the grabber board conforms to the CameraLink™ standard. The grabber board provides the Start-Of-Scan (SOS) signals and thereby determines the exposure time and line frequency of the camera.

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 and personalized applications can also be developed using the SDKs available from the grabber board producers.

The camera is supplied precalibrated, with factory settings for gain and offset that can be changed according to requirements using the supplied software. Significant losses in signal quality do accrue when the gain or offset parameters are set incorrectly. The gain and offset values in current use are stored in the camera in non-volatile memory and are immediately available when the camera is reactivated or switched on again.

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 objective 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.



Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Introduction_CamLink.indd (07.2016)

© 2016
Schäfter+Kirchhoff GmbH • Hamburg

1.2 Computer System Requirements

The SK7500CTF-XB 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 8).

1.3 SK7500CTF-XB Line Scan Camera - Specifications

Sensor category	CCD Monochrome Sensor
Sensor type	TCD1704CG
Pixel number	7500
Pixel size (width x height)	7 x 7 µm^2
Pixel spacing	7 µm
Active sensor length	52.5 mm
Anti-blooming	-
Integration control	-
Shading correction	x
Threshold detection	-
Line synchronization modes	Line Sync, Line Start, Exposure Start
Frame synchronization	x
Pixel frequency	80 MHz
Maximum line frequency	10.1 kHz
Integration time	0.121 ... 20 ms
Dynamic range	1:1000 (rms)
Spectral range	400 ... 900 nm
Video signal	monochrome 8/12 Bit digital
Interface	Camera Link
Voltage	+5V, +15V
Power consumption	
Casing	84 mm x 98 mm x 42.5 mm (Case type EC5)
Objective mount	M72x0.75
Flange focal length	8 mm
Weight	0.4 kg
Operating temperature	+5 ... +45°C

Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_SystemRequirements_Specs_ML.indd (07.2016)

© 2016
Schäfter+Kirchhoff GmbH • Hamburg

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.

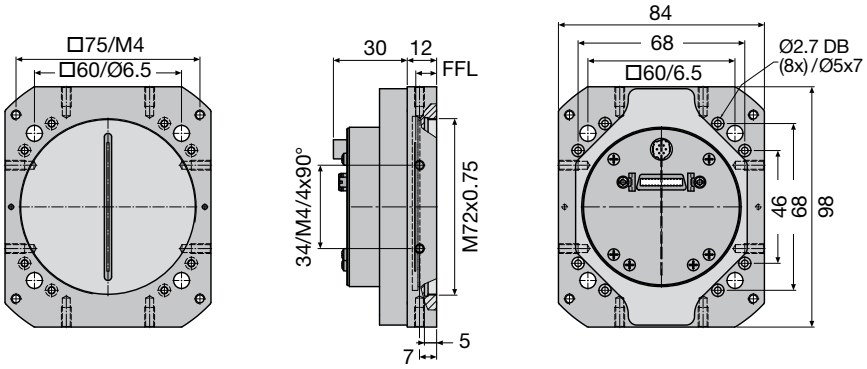
Optics Handling

- 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 EC5

EC5

Lens mount: **M72x0.75**
Flange focal length: **FFL = 8 mm**

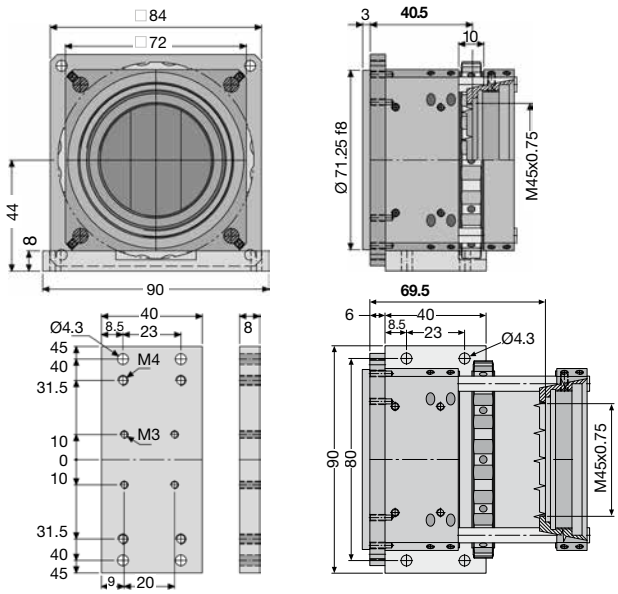


Accessory:

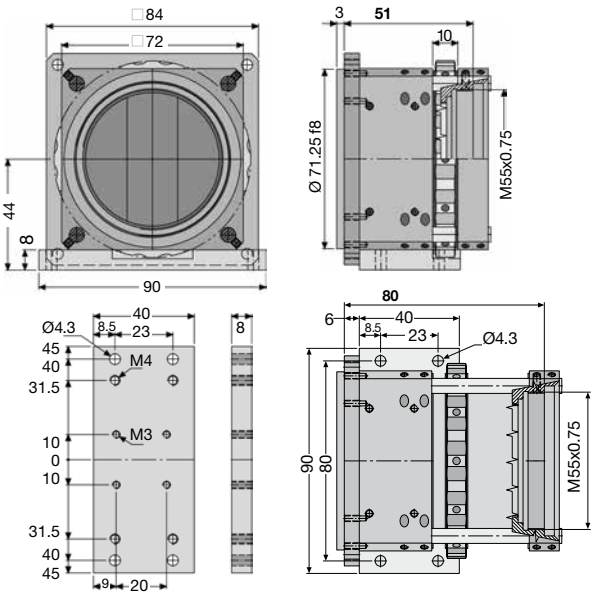
Fokus Adapter **FA26-S45** = thread M45x0.75
FA26-S55 = thread M55x0.75

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

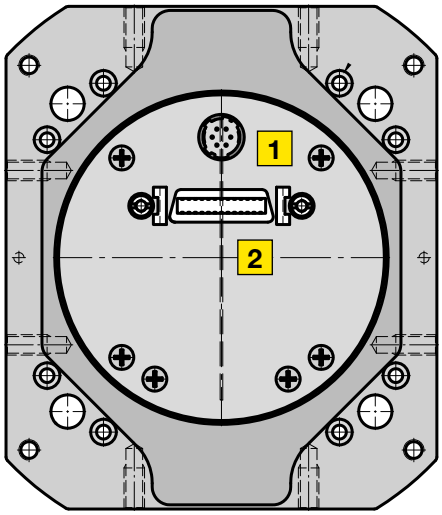


Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Installation-Mechanic_Cx5-Ex5-Fx7_ML.indd (07.2016)

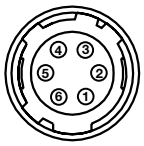
© 2016
Schäfter+Kirchhoff GmbH • Hamburg

2.2 Electrical Installation: Connections and I/O Signals

- For the SK7500CTF-XB 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 page 5.



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



Hirose series 10A, male 6-pin

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

Total power:
@ f_P=50MHz: 3.1 W (= 5V · 300mA + 15V · 105mA),
@ f_P=100MHz: 5.3 W (= 5V · 320mA + 15V · 245mA)

2 **Data Connector**

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

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

Accessories (see also *Accessories, p. 20)*:

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

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

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

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

Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Installation-Electric_CamLink_ML.indd (07.2016)

© 2016
Schäfter + Kirchhoff GmbH • Hamburg

3 Interface and Camera Control

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 = Input, O = Output, IO = Bidirectional, P = Power/Ground, NC = not connected
CC4 is not used

Video data

The differential LVDS signals X0-X3 and XCLK are reserved for the transmission of high-speed video data from the camera to the grabber board. The video data is transmitted using numerous serial channels simultaneously, according to the protocol for the channel link chipset from National Semiconductor.
The CameraLink standard defines the names of the pixel signals, the description of the signal level and the pin assignments and pinout of the chip.

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

I = Input, O = Output, IO = Bidirectional, P = Power/Ground, NC = not connected
Warning: FVAL and DVAL are not used here as defined in the CameraLink standard.
FVAL is always set to the value = 0 (low).
DVAL is always set to the value = 11 (high).
For a single output, the data is output as ODD (multiplex).

Bit allocation 12-bit data (Serial command: F12)

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

Bit allocation 8-bit data (Serial command: F8)

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

The bit allocation conforms to the CameraLink Standard basic configuration.

Serial communication

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

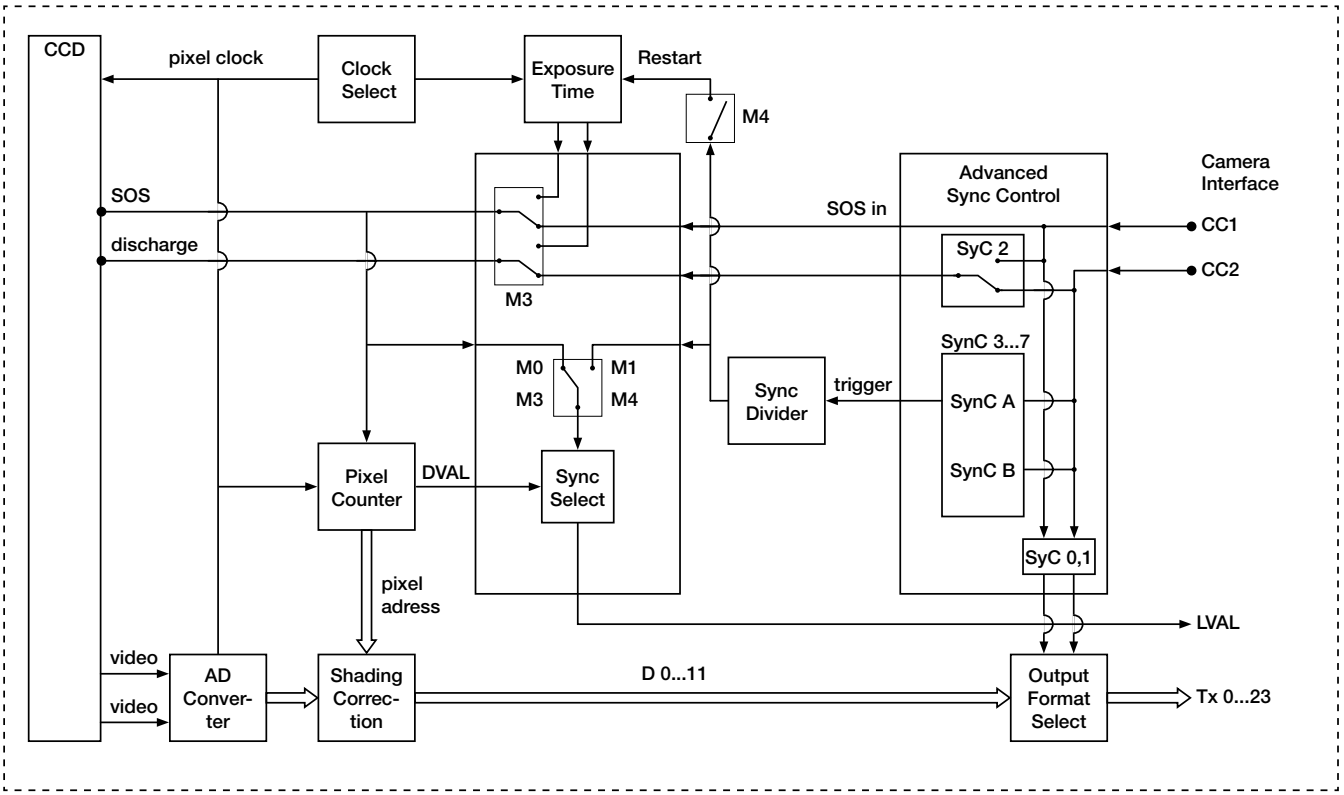
– full duplex, no handshake

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

Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Interface_CamLink.indd (07.2016)

© 2016
Schäfter+Kirchhoff GmbH • Hamburg

3.1 Control System Logical Diagram



Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Interface_CamLink.indd (07.2016)

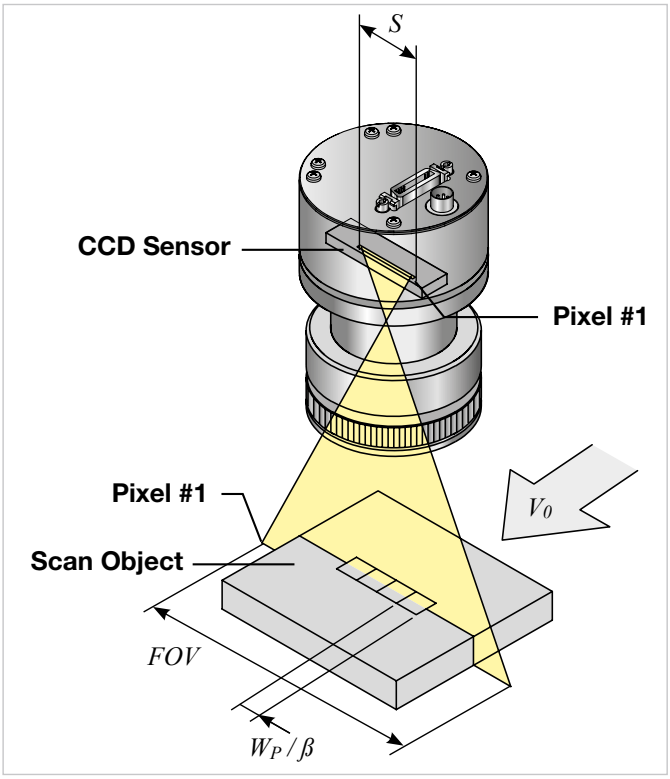
© 2016
Schäfter + Kirchhoff GmbH • Hamburg

Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_blank.indd (07.2016)

© 2016
Schäfter+Kirchhoff GmbH • Hamburg

3.2 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:

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

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:

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

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

Example 1:

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

Pixel width	= 7 µm
Line frequency	= 10.1 kHz
S	= 52.5 mm
FOV	= 80 mm

$$V_O = \frac{7\,\mu m \cdot 10.1\,kHz}{(52.5\,mm / 80\,mm)} = 108\ mm/s$$

Example 2:

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

Pixel width	= 7 µm
Object scan velocity	= 100 mm/s
S	= 52.5 mm
FOV	= 80 mm

$$f_L = \frac{100\,mm/s \cdot (52.5\,mm / 80\,mm)}{7\,\mu m} = 9.4\ kHz$$

Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_CameraControl(3)_Sync_ML.indd (07.2016)

© 2016
Schäfter + Kirchhoff GmbH • Hamburg

4 Advanced SkLineScan Software Functions

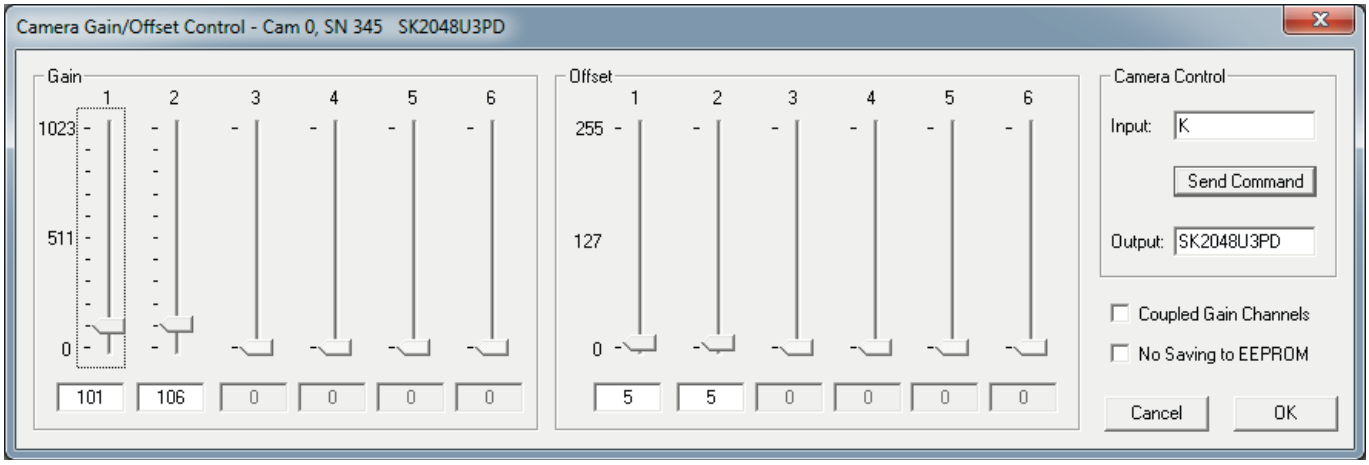
4.1 Camera Control by Commands

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

Line Scan Camera SK7500CTF-XB Manual (07.2016) • SK7500CTF-XB_CameraControl(4)_ByCommands.indd (07.2016)

© 2016
Schäfter+Kirchhoff GmbH • Hamburg

Set Commands

Set Operation	Description
G*oooo*<CR>	gain 1 setting 0-24 dB
B*oooo*<CR>	gain 2 setting 0-24 dB
H*oooo*<CR>	gain 3 setting 0-24 dB
J*oooo*<CR>	gain 4 setting 0-24 dB
O*ppp*<CR>	offset 1 setting
P*ppp*<CR>	offset 2 setting
Q*ppp*<CR>	offset 3 setting
U*ppp*<CR>	offset 4 setting
F8<CR>	output format: 8 bit video data
F10<CR>	output format: 10 bit video data
F12<CR>	output format: 12 bit video data
F16<CR>	output format: 2*8 bit video data
C40<CR>	camera clock: 40 MHz data rate
C80<CR>	camera clock: 80 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 SCM
T8<CR>	save SCM to flash memory 2
L0<CR>	line mirroring off, pixel realignment off
L1<CR>	line mirroring off, pixel realignment on
L2<CR>	line mirroring on, pixel realignment on
M0<CR>	free run with selected line rate
M1<CR>	extern SOS, CC1-input
M2<CR>	free run with maximum line rate
A*xxxx*<CR>	SCM address (*xxxx* = 0-7499)
D*xxxx*<CR>	SCM data (*xxxx* = 0-4095) and increment SCM address
W*yyyyy*<CR>	line clock frequency (*yyyyy* = 50-10101) (Hz)
X*yyyyy*<CR>	exposure time (*yyyyy* = 99-20000) (µs)
V*yyyyy*<CR>	extern sync divider (*yyyyy* = 1-32767)
Y*ppp*<CR>	set sync control (*ppp* = 255)

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

Request Commands

Request	Return	Description
K<CR>	*SK7500CTF-XB*	returns **SK** type number
R<CR>	*Rev2.23*	returns **R**evision number
S<CR>	*SNr00163*	returns **S**erial number
I<CR>	*SK7500CTF-XB Rev2.23 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
I7<CR>	Ga2: *yyyyy*	returns gain 2
I8<CR>	Of1: *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
I13<CR>	Of4: *yyyyy*	returns offset 4
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 correction on/off
I24<CR>	Exp: *yyyyy*	returns exposure time (µs)
I25<CR>	miX: *yyyyy*	returns minimum exposure time (µs)
I26<CR>	LCK: *yyyyy*	returns line frequency (Hz)
I27<CR>	maZ: *yyyyy*	returns maximum line frequency (Hz)
I28<CR>	TSc: *yyyyy*	returns sync divider
I29<CR>	SyC: *yyyyy*	returns sync control

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

Line Scan Camera SK7500CTF-XB Manual (07.2016) • SK7500CTF-XB_CameraControl(4)_ByCommands.indd (07.2016)

© 2016
Schäfter + Kirchhoff GmbH • Hamburg

4.3 Advanced Synchronization Control

We recommend to make use of the functions of the Camera Link grabber in the first place.

The basic synchronization function makes use of only one trigger input LINE SYNC A (CC1). The trigger mode is determined by the Set Commands "Mx".

Advanced trigger functions are provided by combining LINE SYNC A (CC1) with a second trigger input LINE SYNC B (CC2). 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:

Yppp<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 → **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 (Mode3)	x	x	x	x	x	0	x	x
ExSOS at LINE SYNC B, Sync at LINE SYNC A (Mode3)	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 = CC1, LINE SYNC B = CC2, FRAME SYNC = CC3) 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 (CC3) D6 = LINE SYNC B (CC2) D5 = LINE SYNC A (CC1) D4 ... D0 = 0	intensity
*xxxxxx*10	internal line counter (8 bit)	intensity
*xxxxxx*11	D7 = FRAME SYNC (CC3) D6 = LINE SYNC B (CC2) D5 = LINE SYNC A (CC1) D4 ... D0 = line counter (bit 12 ... 8)	internal line counter (bit 7 ... 0)

© 2016 Schäfter+Kirchhoff GmbH • Hamburg
Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_CameraControl(6)_Advanced-Sync-Ctrl_ML.indd (07.2016)

Example Timing Diagrams of Advanced Synchronization Control

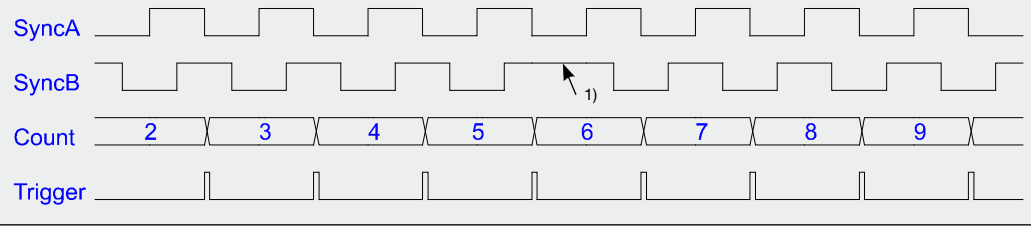
Annotations:

SyncA = LINE SYNC A (CC1) (CameraLink interface, MDR-26 connector, pins 9 and 22)
SyncB = LINE SYNC B (CC2) (CameraLink interface, MDR-26 connector, pins 10 and 23)
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.

1) direction changed
2) glitch

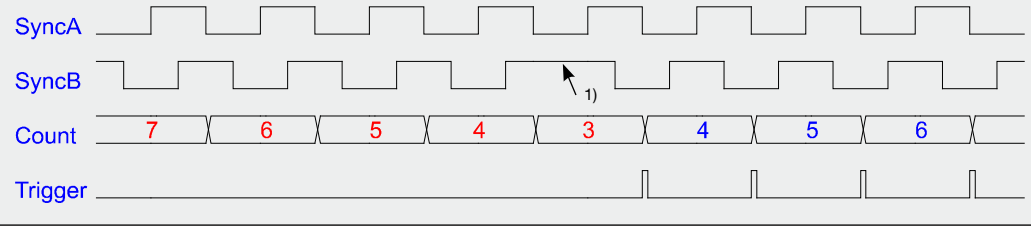
A
- Trigger on falling edge of SyncA
- SyncB without function
- direction detection = off
- hysteresis = 0

Sync Control Register: '0xxx xxxx'b



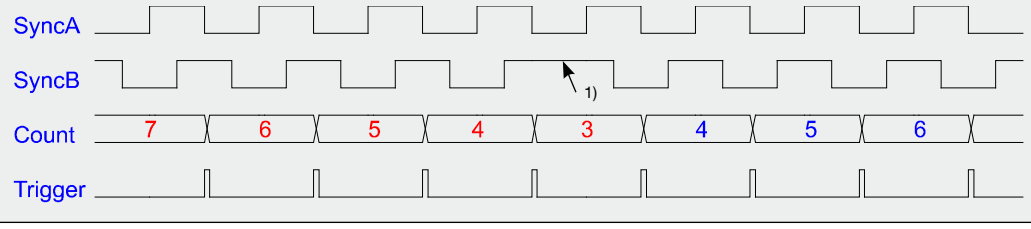
B
- Trigger on falling edge of SyncA
- SyncB = low active
- direction detection = on
- hysteresis = 0

Sync Control Register: '1000 0xxx'b



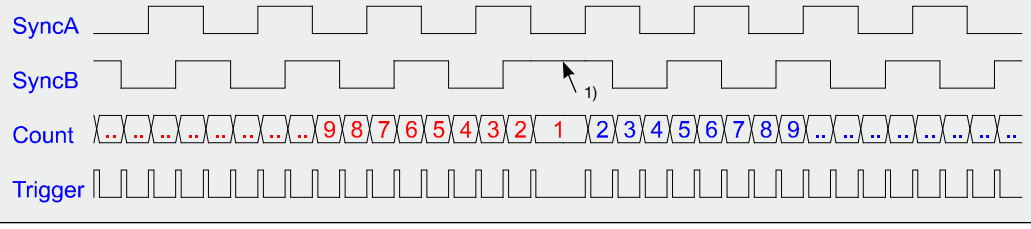
C
- Trigger on falling edge of SyncA
- SyncB = low/high active
- direction detection = on
- hysteresis = 0

Sync Control Register: '1100 0xxx'b



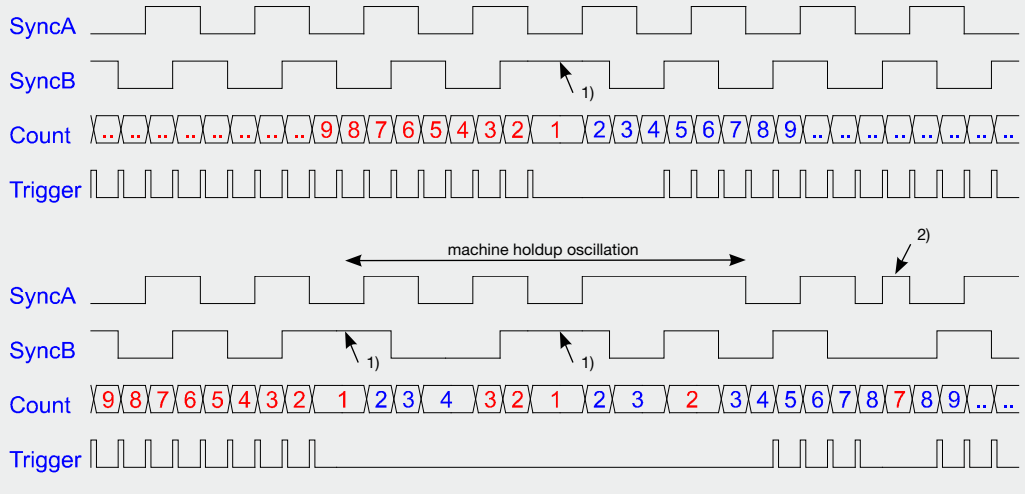
D
- Trigger on 4 edges of SyncA and SyncB
- direction detection = on
- hysteresis = 0

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



Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_CameraControl(5)_Advanced-Sync-Ctrl_MLindd (07.2016)

© 2016
Schäfter + Kirchhoff GmbH • Hamburg

5 Sensor Information

Manufacturer: TOSHIBA Corporation
Type: TCD1704CG
Data source: TOSHIBA CCD Linear Image Sensor CCD (Charge Coupled Device) TCD1704C, 2001-02-16

Features

- Number of image sensing elements: 7500 elements
- Image sensing element size: 7 µm by 7 µm on 7 µm centers
- Photo sensing region: High sensitive and low voltage dark signal pn photodiode
- Clock: 2-phase (5 V)
- Package: 24-pin DIP

Optical/Electrical Characteristics

(Ta = 25°C, V_{OD} = 12 V, $V_{\varphi} = V_{SH} = V_{RS} = V_{CP}$ = 5 V (PULSE), f_{φ} = 1 MHz, t_{INT} (INTEGRATION TIME) = 10 ms, LIGHT SOURCE = DAYLIGHT FLUORESCENT LAMP, LOAD RESISTANCE = 100 kΩ)

CHARACTERISTIC	SYMBOL	MIN	TYP.	MAX	UNIT	NOTE
Sensitivity	R	13.6	17	20.4	V / lx·s	
Photo Response Non Uniformity	PRNU	—	3	10	%	(Note 2)
	PRNU (3)	—	5	12	mV	(Note 8)
Saturation Output Voltage	V_{SAT}	1.5	2.5	—	V	(Note 3)
Saturation Exposure	SE	0.07	0.14	—	lx·s	(Note 4)
Dark Signal Voltage	V_{DRK}	—	1	3	mV	(Note 5)
Dark Signal Non Uniformity	DSNU	—	2	4	mV	(Note 5)
DC Power Dissipation	P_D	—	800	1200	mW	
Total Transfer Efficiency	TTE	92	98	—	%	
Output Impedance	Z_o	—	0.2	1	kΩ	
Dynamic Range	DR	—	2500	—	—	(Note 6)
DC Signal Output Voltage	V_{OS}	3.5	5.0	6.5	V	(Note 7)
DC Differential Error Voltage	$\|V_{OSX} - V_{OSY}\|$	—	—	300	mV	(Note 9)
Random Noise	ND_{σ}	—	1.0	—	mV	(Note 10)

Note 2: Measured at 50% of SE (Typ.)

Definition of PRNU : PRNU = $\frac{\Delta\chi}{\bar{\chi}} \times 100(\%)$

Where $\bar{\chi}$ is average of total signal outputs and $\Delta\chi$ is maximum deviation from $\bar{\chi}$ under uniform illumination. (Channel 1)

In the case of 1875 elements (Channel 2, Channel 3 and Channel 4), the condition is the same as above too.

Note 3: V_{SAT} is defined as minimum saturation output voltage of all effective pixels.

Note 4: Definition of SE : SE = $\frac{V_{SAT}}{R}$ (lx·s)

Note 5: V_{DRK} is defined as average dark signal voltage of all effective pixels.
DSNU is defined as different voltage between V_{DRK} and V_{MDK} when V_{MDK} is maximum dark signal voltage.

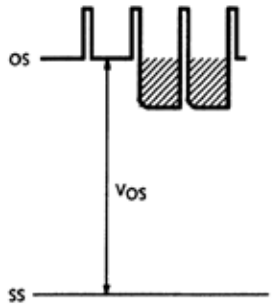
Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Sensor_TCD1704C.indd (07.2016)

© 2016
Schäfter+Kirchhoff GmbH • Hamburg

Note 6: Definition of DR : DR = $\frac{V_{SAT}}{V_{DRK}}$

V_{DRK} is proportional to t_{INT} (Integration Time).
So the shorter t_{INT} condition makes wider DR values.

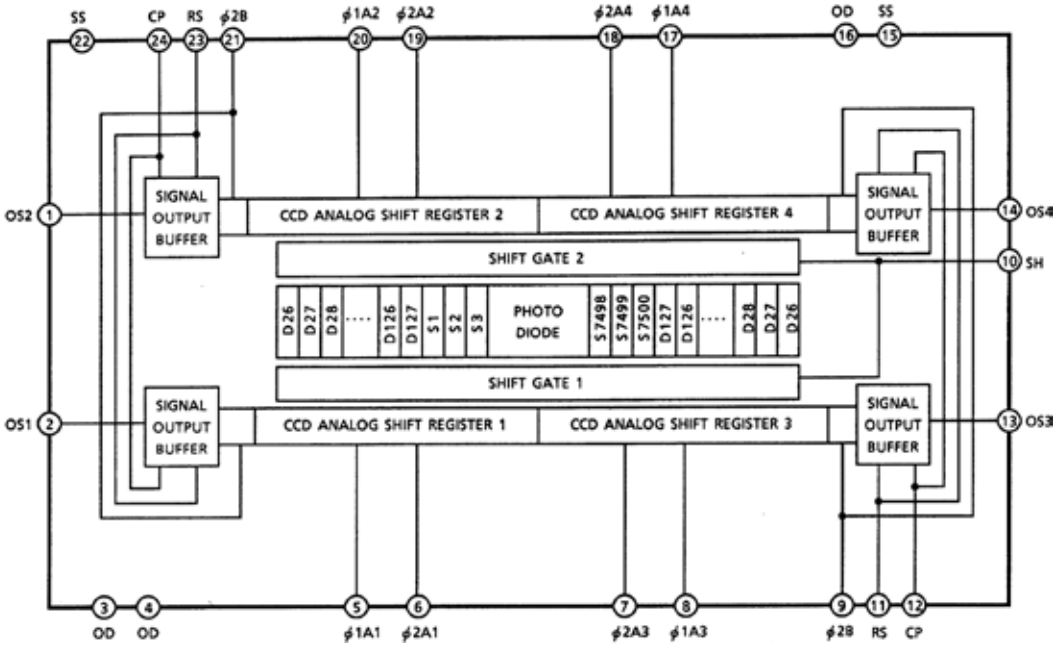
Note 7: DC signal output voltage and DC compensation output voltage are defined as follows:



Note 8: PRNU (3) is defined as maximum voltage with next pixel, where measured 5% of SE (Typ.)

Note 9: DC Differential Error Voltage is defined as follows:
Definition of DC differential Error Voltage = $|V_{OSX} - V_{OSY}|$
V_{OSX} : Maximum DC Signal Output Voltage
V_{OSY} : Minimum DC Signal Output Voltage

Circuit Diagram



φ1A1, 2, 3, 4	Clock (Phase 1)
φ2A1, 2, 3, 4	Clock (Phase 2)
φ2B	Final Stage Clock (Phase 2)
SH	Shift Gate
RS	Reset Gate
CP	Clamp Gate
OS1	Signal Output 1
OS2	Signal Output 2
OS3	Signal Output 3
OS4	Signal Output 4
OD	Power
SS	Ground
NC	Non Connection

Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Sensor_TCD1704C.indd (07.2016)

© 2016
Schäfter + Kirchhoff GmbH • Hamburg

Glossary

Blooming

Extended illumination of saturated pixels, which are not able to accumulate further charge due to long exposure, leads to charge overflow into adjacent pixels. This effect is called blooming. Blooming causes a corruption of the geometrical allocation of image and object in the line signal. CCD line scan cameras with anti-blooming sensors direct the abundant charge to a ”drain gate”. Charge overflow into adjacent, less illuminated pixels is prevented. Depending on pixel frequency and spectral range, overexposure up to factor of 50 can thus be handled.

Exposure period

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

Integration control

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

Integration time

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

Line frequency, line scan frequency

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

Optical resolution

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

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

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

Pixel frequency

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

Region of Interest

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

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

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

Shading correction

→ *Shading Correction*, section 3.2

SoI (Start of Integration)

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

SoS (Start of Scan)

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

→ *Synchronization*

→ *Advanced Synchronization Control*, section 4.2

Synchronization

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

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

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

Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Glossary_Kurzfassung-1Seite.indd (07.2016)

© 2016 Schäfter+Kirchhoff GmbH • Hamburg

CE-Conformity

CE

The product complies with the following standards and directives:

2014/30/EU

EMC Directive

DIN EN 61326-1:2013

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

Part 1: General requirements

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.

Copyright ©

Unless explicitly allowed, the duplication, distribution, sale or use of this document or its contents, for purposes other than those intended, is forbidden. Repeated transgressions will lead to prosecution and demands for compensation.

All rights of patent protection and registration or copyright of a product or its design lie with Schäfter+Kirchhoff. Schäfter+Kirchhoff GmbH and the Schäfter+Kirchhoff logo are registered trademarks.

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

Date of document publication: 15.07.2016

Schäfter+Kirchhoff GmbH
Kieler Straße 212
22525 Hamburg
Germany

Tel.: +49 40 853997-0
Fax: +49 40 853997-10
Email: info@SuKHamburg.de
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 four AD-converter channels can be **adjusted simultaneously**, simplifying handling.

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 V AC

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

Control cable SK9018...

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

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

Power cable SK9015.x

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

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

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

Focus Adapter FA26-Sx Order Code

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.

FA26-Sx Order Code
└ 45 = thread M45x0.75
55 = thread M55x0.75

Lenses
- high resolution scan and macro lenses

Lens Adapters, thread M45x0.75
- M39x1/26" / AC43

Lens Adapters, thread M55x0.75
- M55x1/26" / AC46

Extension rings, thread M45x0.75
ZR-L-x Order Code
└ length 15 / 25 / 60 / 87 mm

Extension rings, thread M55x0.75
M55-L-x Order Code
└ length 15 / 25 / 60 mm

Schäfter + Kirchhoff © 2016 • Line Scan Camera SK7500CTF-XB Manual (07.2016) • shared_Accessories_ML.indd (07.2016)