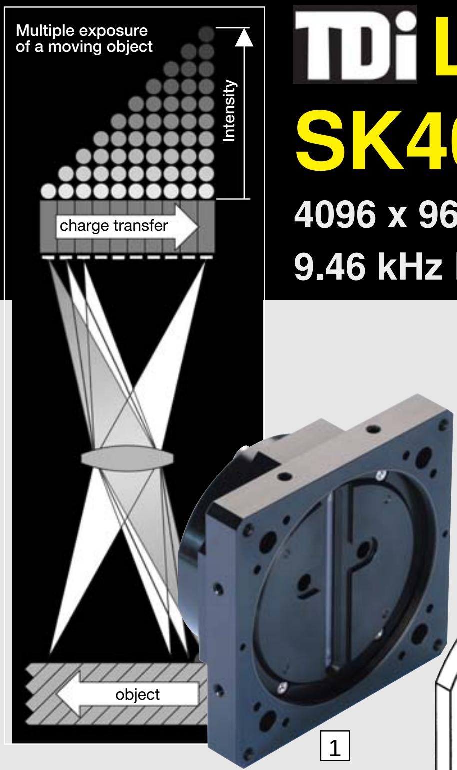
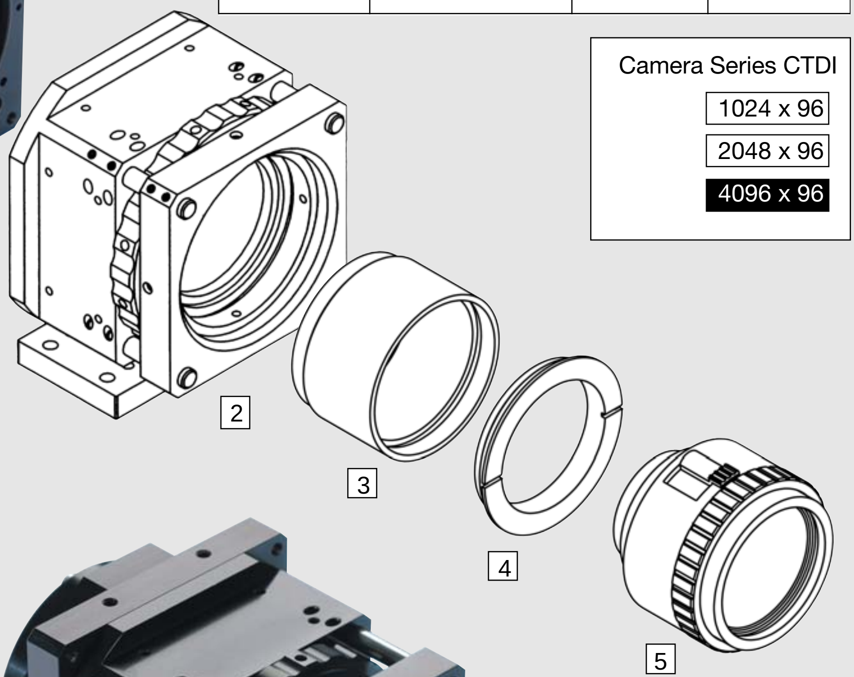
TDi Line Scan Camera SK4096CTDI-40XL

4096 x 96 Pixel, 13x13 µm, 40 MHz Pixel Frequency, 9.46 kHz Line Frequency, Interface: CameraLink



Interface	Order Code	max. pixel frequency	max. line frequency
GiGE VISION	SK4096GTDI-XL	60 MHz	14.00 kHz
CAMERA Link	SK4096CTDI-40XL	40 MHz	9.46 kHz
LVDS	SK4096ZTDI-XL	60 MHz	14.00 kHz

Camera Series CTDI
- 1024 x 96
- 2048 x 96
- 4096 x 96



1 TDI Line Scan Camera **SK4096CTDI-40XL** mounted with:
2 focus adapter **FA26-S45**
3 extension ring ZR-L...
4 lens adapter M39-45
5 lens APO-Rodagon D1x

Characteristics:
- video 8/12 bit
- line frequency up to 5.20 kHz
- Anti-Blooming
- TDI sensor, 96 stages
- very high light sensivity
- 100% fill factor
- CameraLink (Base) interface

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SK4096CTDI-40XL.rtd

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Schäfter + Kirchhoff

Accessories (optional)

Connecting Cable

for line scan cameras with CameraLink interface.

1. Control cable SK9018...26-pin shielded cable, both ends with mini-ribbon connector (male 26-pin).

SK9018.5 MM — Order Code

- MM= Connector both ends (male)
- 3 = 3m cable length (standard)
- 5 = 5m cable length

2. Cable for power supply SK9015...: Shielded cable with connector Lumberg SV60 (male 6-pin) and Hirose HR10A (female 6-pin)

SK9015.5 MF — Order Code

- MF= connector male / female
- 1.5=1.5m cabel length(standard)
- 3= 3m cabel length
- x= cable length custom made

Power supply

PS 051515 — Order Code

Input: 100-240 VAC, 0,8A, 50/60Hz, 3-pin input connector (IEC 320).

Output: 5VDC/2,5A, 15VDC/0,5A, -15VDC/0,3A, output connector Lumberg KV60 (6-pin, female, length 1m)

Software

SK91CL-WIN — Order Code

1. **Configuration tool SkCLConfig (supplied with camera)**
2. **SkLineScan for selected CameraLink grabber:**
   - **Matrox Solios**
   - **NI PCI-1428, - microEnable III**
   - **other grabbers on request**

Lenses, Adapter

Focus adapter
FA26-S45 — Order Code

High-precision adapter with linear guide and thread for precise adjustment and durable fixing of the focal position.
- Travel 27 mm, 10 mm travel per one turn
- Locking screws for the focal position
- Lens thread M45x0.75, M39x1/26" by adapter M39-45

Extension rings
ZR-L25 — Order Code

- 15= length 15 mm
- 25= length 24,5 mm
- 60= length 60 mm
- 87= length 87 mm

Lens adapter
M39-45 — Order Code

Lens: M39 x 1/26"
Camera: M45 x 0.75

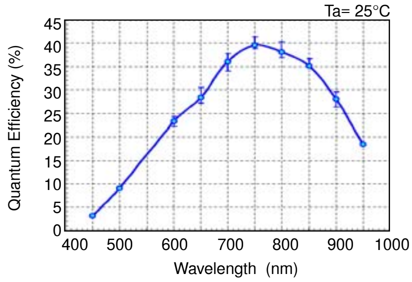
Scan and Macro Lenses

M39 x 1/26",
e.g.:
- APO-Rodagon D1x 4.0/75
- APO-Rodagon D2x 4.5/50
- APO-Rodagon N 4.0/80

Technical Specifications

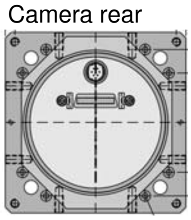
Camera Model Order Code	SK4096CTDI-40XL
Sensor:	CCD, TDI
Type:	CCD 5045
Number of pixels:	7500 x 96
Pixel size:	7x7µm
Pixel distance:	7µm
Line width:	7µm
Active length:	52.50 mm
Pixel frequency:	40 MHz
Line frequ. max:	5.20 kHz
Line frequ. min:	0.05 kHz
Integration time min:	0.106 ms
Integration time max:	20.0 ms
Dynamic range:	1:750
Spectral range:	400-900 nm

Spectral Responsivity



Input control signals:	MasterCock (optional) StartOfScan
Output signal:	LVAL
Video signal:	8/12 bit digital, Single Tap
Interface:	CameraLink
Voltages:	+5 V, +15 V
Power consumption:	3.8 W

Camera rear



Connector:
Power:
Hirose Serie HR10A, 6pin-male
Data:
Mini D Ribbon, 26pin-female

Operating Temp.:	+ 5°C ... + 45 °
Housing (B x T):	84 mm x 43 mm
Weight:	0.3 kg
Lens thread:	M72 x 0.75

1. Technical Specifications of the CTDI Camera Series

Camera Model	SK1024CTDI	SK2048CTDI	SK4096CTDI-40XL
Sensor:	CCD, TDI 96 stages	CCD, TDI 96 stages	CCD, TDI 96 stages
Type:	CCD525	CCD525	CCD5045
Number of pixels:	1024 x 96	2048 x 96	4096 x 96
Pixel size:	13x13µm	13x13µm	13x13µm
Pixel distance:	13µm	13µm	13µm
Line width:	13µm	13µm	13µm
Active length:	13.30 mm	26.60 mm	53.20 mm
Anti-Blooming	ja	ja	ja
Integration Control	nein	nein	nein
CDS 1)	ja	ja	ja
Pixel frequency:	50 MHz	100 MHz	40 MHz
Line frequency max:	43.40 kHz	43.40 kHz	9.46 kHz
Line frequency min:	0.05 kHz	0.05 kHz	0.05 kHz
Integration time min:	0.023 ms	0.023 ms	0.106 ms
Integration time max: 2)	20.0 ms	20.0 ms	20.0 ms
Dynamic range:	1:2500	1:2500	1:3000
Spectral range:	400-1000 nm	400-1000 nm	400-1000 nm
Video signal:	8/12 Bit	2*8 Bit	8/12 Bit
Interface:	Camera Link	Camera Link	Camera Link
Voltage supply:	+5V, +15V	+5V, +15V	+5V, +15V
Power consumption	2,4 W	2,6 W	3,8 W
Lens thread:	M40x0.75	M40x0.75	M72x0.75
Housing (Ø x T):	Ø65mm x 54 mm	Ø65mm x 54 mm	□84 mm x 43 mm
Weight:	0.2 kg	0.2 kg	0.3 kg
Temperature range:	+ 5°C ... + 45 °	+ 5°C ... + 45 °	+ 5°C ... + 45 °

1) CDS = Correlated Double Sampling. Noise reduction technology, increase of photosensitivity.
2) Longer exposure times are possible, but the signal-to-noise ratio will be reduced.
For further sensor specifications obtain the details of the sensor manufacturer. See the datasheet at the end.

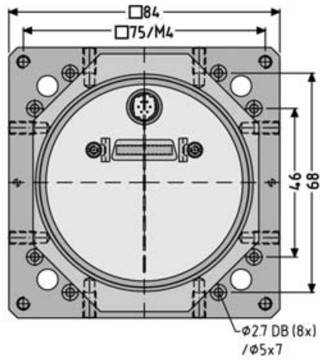
2. Handling details of line scan cameras with CameraLink interface

A successful application of the line scan camera is based upon a careful adjustment of the whole optical system. Attention should be paid to the arrangement of the illumination, the aperture setting, the focussing range of the lens, as well as the orientation of the sensor axis to the scanning direction.

For controlling a CCD line scan camera made by **Schäfter+Kirchhoff**, any third party grabber board is suitable when it complies with the base configuration the CameraLink standard.
The configuration program SkCLConfig is shipped with all **Schäfter+Kirchhoff** cameras and enables the adjustment of line scan camera parameters, such as gain, offset, and pixel frequency, via the serial channel of the CameraLink interface. The software uses the clser***.dll supplied with the CameraLink grabber board. For the software development the SDK provided by the grabber manufacturer has to be used. For selected grabber boards, including Matrox Solios, National Instruments PCI-1428, CORECO X64-CL iPro and microEnable III, **Schäfter+Kirchhoff** provides the SkLineScan® operating program. The oscilloscope display of the line scan signals, which can be fully zoomed to individual pixels over a selected area, enables the parameterization and set up of the camera and optical system.

The camera is shiped aligned and set to default settings in gain and offset. Extensive modifications of the gain/offset-parameter can lead to a decrease in signal quality. The parameter settings are stored within the camera board and are retained for immediate subsequent use even after a complete shut down.

3. Connection and Control Signals

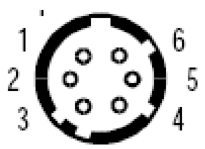


Connector:
<u>Power:</u>
Hirose Serie HR10A,
6pin-male

<u>Data:</u>
Mini D Ribbon,
26pin-female

Voltage Supply

+ 5 V	± 5%	ca. 300 mA	(20 MHz Clock)
		ca. 320 mA	(40 MHz Clock)
+15 V	± 5%	ca. 105 mA	(20 MHz Clock)
		ca. 245 mA	(40 MHz Clock)



Signal	Pin	Signal	Pin
+ 15 V	.	+ 5 V	.
+ 15 V	.	GND	.
+ 5 V	.	GND	.

Pin out

Mini D Ribbon 26 pin female

Signal	Pin		Pin	Signal
GND	.	o o	.	GND
X0-	.	o o	.	X0+
X1-	.	o o	.	X1+
X2-	.	o o	.	X2+
Xclk-	.	o o	.	Xclk+
X3-	.	o o	.	X3+
SerTC+	.	o o	.	SerTC-
SerTFG-	.	o o	.	SerTFG+
CC1-	.	o o	.	CC1+
CC2+	.	o o	.	CC2-
CC3-	.	o o	.	CC3+
CC4+	.	o o	.	CC4-
GND	.	o o	.	GND

Input Control Signals

The CCD line scan camera uses the control signals "Clock" (MCLK) and "Start Of Scan" (SOS) for operation. The Clock signal will be generated internal by an 40 MHz oscillator. Alternative the oscillator frequency can divided by 2 to 20 MHz. Optional an external source can provide the Clock signal.

The camera electronics respond to the rising signal edges that should be 'sharp' and free from noise.

The frequency of the "Start of Scan" signal determines the total count of line scans per second. On the rising edge of this signal all the accumulated charges inside the pixels will be tranferred to the analog shift register of the sensor. The shift register (transport register) will be read out with the 'Clock' signal.
The 'Clock' signal frequency gives the read-out rate for single pixel informations of the linear sensor. This is just the rate of the video output signal of the camera. Every rising edge of 'Clock' transfers the next following pixel's charges to the video output amplifier.

The 'Clock' and the 'SOS' signals need not to be syncronized. The 'Clock' frequency should be set to a sufficient large number to ensure enough 'Clock' pulses to read out the line sensor completely between two successive 'SOS' signals. The camera SK4096CTDI-40XL needs 4096+134 = 4230 clock pulses to read out a line scan completely. The 'Clock' frequency determines the pixel rate of the camera.

MCLK: Master-Clock in: determines the pixel transport frequency, maximum 40 MHz.

SOS: Start of Scan: 30 ns minimum pulslength. Differential input. The frequency of the 'SOS' signal determines the line frequency readout of the camera.
The charges of the sensor are accumulated while the 'SOS' signal is low. This way the length of the 'low' period can be used to effectively control the actual integration time at a fixed or rapidly changing line

4. CameraLink Interface

Camera Control

Signal Name	I/O	Type	Description
TRIG1	I	RS644	CC1 - synchronization input (SOS)
TRIG2	I	RS644	CC2 - start Integration period in the dual synchro mode (only cameras with Integration Control)
CLK_IN	I	RS644	CC3 - external pixel clock (optional)

I= Input, O= Output, IO= Bi-Directional, P= Power/Ground, NC= not connected,
Note: CC4 is not used

Video Data

For transmission of high-speed video data from the camera to the frame grabber the differential LVDS signals X0-X3 and XCLK are reserved. The Video data between camera and grabber are transmitted via several serial channels. The basic principle of the serial protocol is built by the Channel Link Chip set by National Semiconductor. The CameraLink standard defines the pixel signal names, the description of the signal level as well as the connector pin assignment and the pin content of the chip.

Signal Name	I/O	Type	Description
D[0-15]	O	RS644	Pixel Data
STROBE	O	RS644	Output Data Clock, With rising edge data are not valid
LVAL	O	RS644	Line Valid, active High Signal

I= Input, O= Output, IO= Bi-Direktional, P= Power/Ground, NC= not connected,
Note: FVAL, as defined in the CameraLink standard, is not used here. FVAL is permanently set to 0 (Low) level. DVAL is not used. DVAL is permanently set to 1(High) level.
With Single output, data are output on ODD (multiplex).

Bit allocation
16-Bit Data (F16)

Bit	DS90CR285 Pin Name	Bit	DS90CR285 Pin Name	Bit	DS90CR285 Pin Name	Bit	DS90CR285 Pin Name
D 0	Tx0	D 7	Tx5	D14	Tx19	NC	Tx14
D 1	Tx1	D 8	Tx7	D15	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	D12	Tx15	NC	Tx17		
D 6	Tx27	D13	Tx18	NC	Tx13		

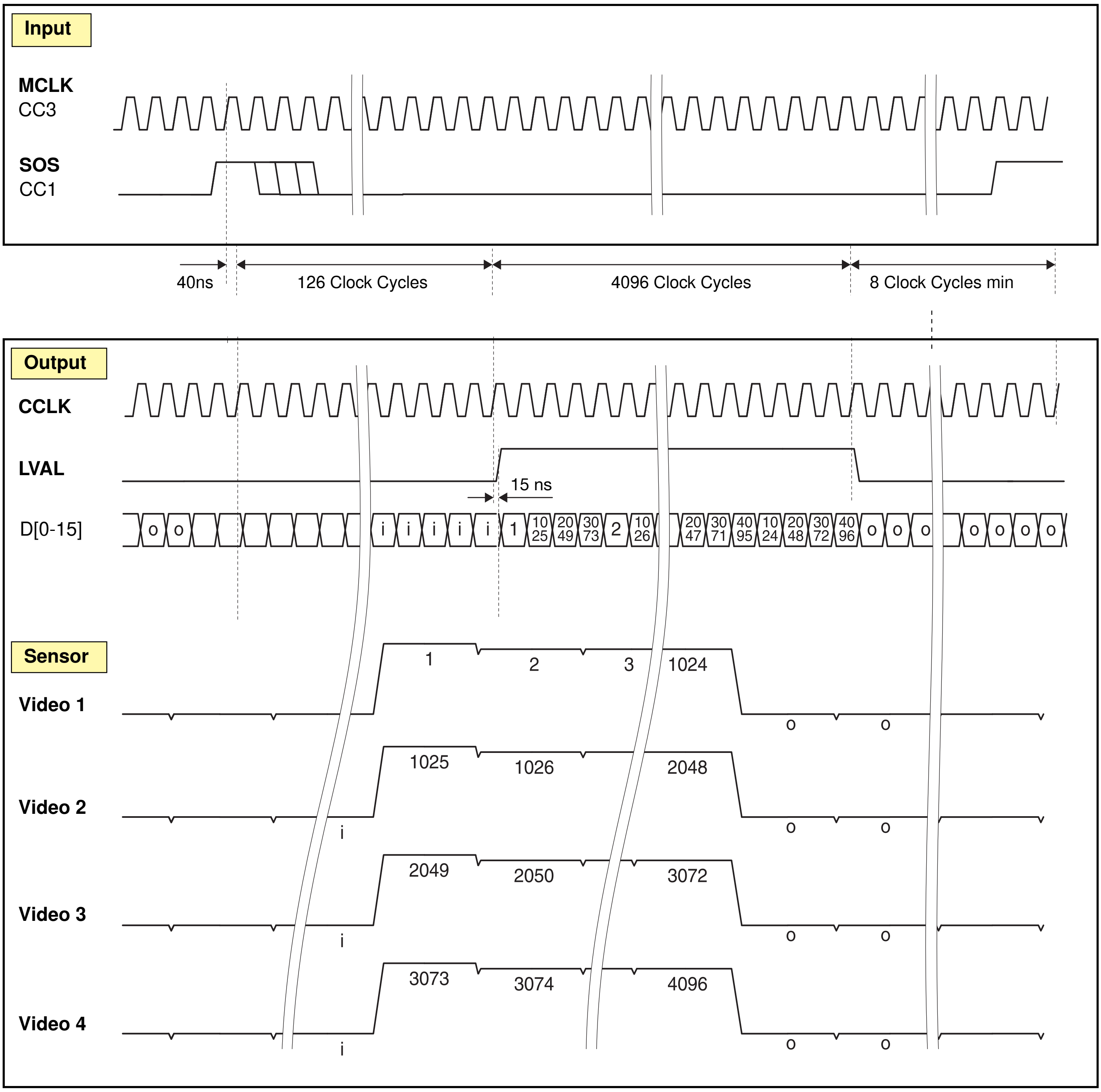
The bit allocations are conform with the CameraLink specifications in the base configuration.

Serial communication

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

The CameraLink interface supports two LVDS signal pairs for the communication between camera and frame
grabber. This asynchronous serial communication is based on the RS232 protocol.
The configuration of the serial line is:
- full duplex / without handshake
- 9600 bauds, 8-bit data, no parity bit, 1 stop bit

5. Timing Diagram



The black level pixels are located 7 to 20 pixels before pixel #1.

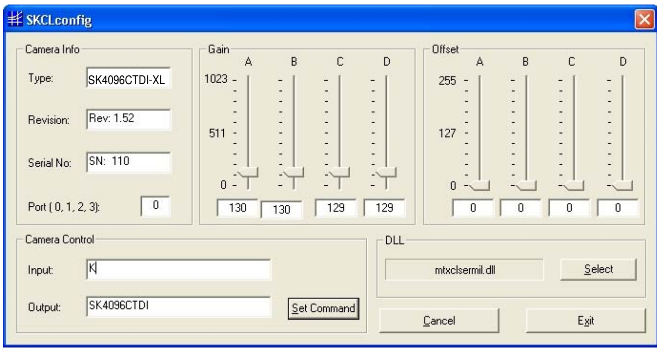
i = Isolation pixels, o = Overclocking

The pixel matching should be done by the CameraLink grabber.

Sample for pixel matching by software for SK4096CTDI

```
PUCHAR       pSegment[4];
int          pOffset= 1024;
int          i, s, p, line;
PUCHAR       pSource;       // ptr to camera data
PUCHAR       pDestination;  // ptr to image buffer
.....
if (pDestination==NULL) pDestination= pSource;
for (i= 0; i< 4; i++)
{
     pSegment[i]= new UCHAR[1024];
}
for ( line= 0; line< MAXLINES; line++)
{
     PUCHAR pScan= (PUCHAR)pSource+line*pixelPerLine;
     for (p= 0; p< pOffset; p++)
     {
          for ( s= 0; s< 4; s++)
               *(pSegment[s]+p)= *pScan++;
     }
     pScan= (PUCHAR)pDestination+line*pixelPerLine;
     for (s= 0; s< 4; s++)
          memcpy(pScan+s*pOffset, pSegment[s], pOffset);
}
```

6. Configuration program SKCLConfig



The configuration program **SKCLconfig** is a tool for programming the CameraLink camera and its status request. It communicates with the camera via the serial interface of the CameraLink interface. For this purpose, the program uses the clser***.dll, which is inscribed in the system register when installing the grabber. The DLL name begins with the standard 'clser' and contains specific characters of the grabber manufacturer (***). As the commands in the DLL are standardized, the program operates with any grabber that fulfils the CameraLink standard. In case more than one clser***.dll's are installed on the computer, the program operates with the DLL it detects first. The DLL name is displayed.
At the start, information about type, revision and serial number of the camera are requested. In the field "Type" the name of the camera must be displayed. Download:
http://www.sukhamburg.de/service/SKCLconfig.zip

Gain / Offset Adjustment

After the start of the SKCLConfig program the sliders for gain and offset are positioned according to the values stored in the camera. With the sliders the settings for gain and offset can be modified. The maximum possible amplification for the camera signal is 36dB (gain=1023). When varying gain and offset, the camera line signal should be monitored (e.g. with the SkLineScan program). With increasing amplification, noise is also raised - the signal-to-noise ratio degrades.
The camera SK4096CTDI-40XL has 4 ranges for gain and 4 ranges for offset. The signal intensities of this ranges have to be fitted.
The camera is provided with optimum gain/offset adjustment (base setting). After modifying gain and offset, a new calibration can be necessary. This is achieved as follows:

1. Offset:
With shaded sensor the video signal is set near to 0 with the offset slider A. The line signal should visible still remain visible.

2. Gain:
The sensor is slightly overexposed. With the gain slider A the limit of the video signal is set to about '255' (8-bit data) or higher. With cameras with multi-tap sensors, the sliders for gain and offset are activated automatically. The pixel intensities of all tap ranges are brought into line at the best.

Camera Commands

Command	Feedback	Description
Gxxxx<CR>	0=ok, 1= not ok	Gain1 settting 0 - 24 dB (xxxx= 0-1023)
Bxxxx<CR>	0=ok, 1= not ok	Gain2 setting 0 - 24 dB (xxxx= 0-1023)
Hxxxx<CR>	0=ok, 1= not ok	Gain3 setting 0 - 24 dB (xxxx= 0-1023)
Jxxxx<CR>	0=ok, 1= not ok	Gain4 setting 0 - 24 dB (xxxx= 0-1023)
Oxxx<CR>	0=ok, 1= not ok	Offset1 setting (xxx= 0-255)
Pxxx<CR>	0=ok, 1= not ok	Offset2 setting (xxx= 0-255)
Qxxx<CR>	0=ok, 1= not ok	Offset3 setting (xxx= 0-255)
Uxxx<CR>	0=ok, 1= not ok	Offset4 setting (xxx= 0-255)
F8<CR>	0=ok, 1= not ok	Output format: 8 Bit data
F10<CR>	0=ok, 1= not ok	Output format: 10 Bit data
F12<CR>	0=ok, 1= not ok	Output format: 12 Bit data
C20<CR>	0=ok, 1= not ok	Camera clock: 20 MHz
C40<CR>	0=ok, 1= not ok	Camera clock: 40 MHz
T0<CR>	0=ok, 1= not ok	test pattern off
M1<CR>	0=ok, 1= not ok	Extern trigger CC1 input
M2<CR>	0=ok, 1= not ok	Free run with max line rate
Queries:		
K<CR>	SK4096CTDI<CR>	SK type number
R<CR>	Rev1.20<CR>	Revision number
S<CR>	SNr00140<CR>	Serial number
I<CR>	SK4096CTDI<CR>	Camera identification
I1<CR>	VCC:00501<CR>	Operation voltage VCC
I2<CR>	VDD:01523<CR>	Operation voltage VDD
I3<CR>	moo:00003	Operation mode
I4<CR>	CLo:00020<CR>	Camera clock low frequency
I5<CR>	CHi:00040<CR>	Camera clock high frequency
I6<CR>	Ga1:00043<CR>	Gain1
I7<CR>	Ga2:00044<CR>	Gain2
I8<CR>	Of1:00011<CR>	Offset1
I9<CR>	Of2:00009<CR>	Offset2
I10<CR>	Ga3:00043<CR>	Gain3
I11<CR>	Ga4:00044<CR>	Gain4
I12<CR>	Of3:00011<CR>	Offset3
I13<CR>	Of4:00009<CR>	Offset4

Ctrl. Register CLink3 EPLD	EN7	EN6	EN5	EN4	EN3	EN2	EN1	EN0
8 Bit							0	0
10 Bit							0	1
12 Bit							1	0
Low Clock					0	0		
High Clock					0	1		
Clock CC3					1	0		
Mode 1 extern Trigger			0	0				
Mode 2 free run, max line rate			0	1				

7. Exposure

The camera SK4096CTDI-40XL has a maximum line frequency of 5.20 kHz. The programmable range for the illumination period amounts 0.106 ms to 20.0 ms.
For programming the minimum illumination period or the maximum line frequency, respectively, the timing between two SOS signals minimum has to least N= 4096 pixel clocks plus sensor dependent passive pixel clocks N_P. The camera SK4096CTDI-40XL has 134 of these. So the sensor needs 4096+134 = 4230 clock pulses to read out a line scan completely.
Read out velocity is determined by the pixel frequency (MCLK).

The illumination period (exposure time) T_E of a camera is calculated as follows:

$$T_E = \frac{(N + N_P)}{fp}$$

The line frequency results as:

$$f_L = 1 / T_E$$

Example: SK4096CTDI-40XL
40 MHz pixel frequency

T_E = (4096+134) / 40 MHz
t_E = 0,106 ms

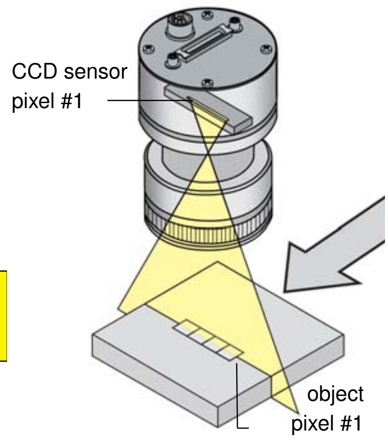
f_L = 40 MHz / (4096 +134)
f_L = 5.20 kHz

Technical details on illumination:
Charge carriers originating from light shining in within a specific time interval are stored by the light-sensitive elements of the sensor. The accumulated charges are converted to voltage values. The voltage values indicate the intensity of light falling on the individual pixels. Integration time is the time within the charge carriers are accumulated.

The **illumination period** (or **exposure time**) **T_E** is the time within the charge carriers of the line sensor. It is determined by the time between two following edges of the SOS signal. The maximum line frequency results as **$f_{L\,max} = 1/T_E$**.
Cameras with **Integration Control** function are able to shorten the integration time within an illumination period (shutter). As the illumination period stays constant, the line frequency is not affected by this operation.

8. Image generation

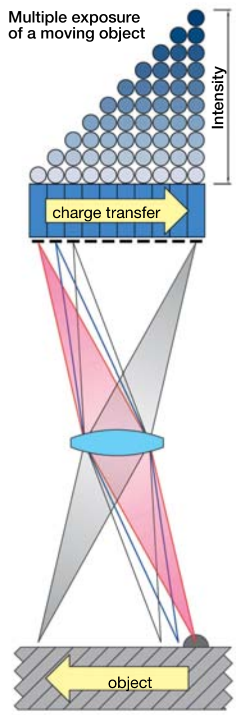
A two-dimensional image is generated by moving either the object or the camera. The direction of transport is upright to the sensor axis of the CCD line scan camera. TDI cameras have a designated motion direction. A proportional image with correct aspect ratio requires a line synchronous feed motion.
A sharp image of the scanned object is only achieved with perfect synchronization of the transport speed, exposutime and magnification. The optimal transport speed is calculated as:



$$V_O = \frac{W_P \cdot \beta}{t_E} \quad [1]$$

V_O = object velocity
W_P = pixel width
β = magnification
t_E = exposure time

Cameras using Time Delayed Integration (TDI) technology have a sensitivity 96-times greater than conventional line scan cameras. TDI line scan cameras are especially useful for dimly-lit objects (e.g. wafer inspection with dark field illumination) and they can achieve extremely high measurement and scan velocities.
To utilize a TDI camera, it is necessary to transport the test object in a designated direction, in relation to the camera (or vice versa), and at a defined velocity.



9. Principle of TDI technology

The **principle of TDI** is based on the time-delayed multiple exposure of a moving object. The sensor is composed of 96 CCD line sensors arranged in parallel. At the end of one period of exposure, the accumulated charges in that line sensor are shifted to the next line (see right figure). During the next exposure period, new charges are acquired, added to the already existing charges and the new sum is again shifted to the next line. Finally, after 96 exposures, the sum of all lines is output as a video signal.
Synchronous transport of a scanned object across the field of the camera actually produces a 96-fold multiple exposure. For each exposure period, the object has moved far enough that the next sensor line is not only ready for exposure but also already filled with the accumulated charges from the previous sensor line(s).

10. Blooming

Blooming
Pixels which are saturated caused by over-exposure, i.e. cannot accumulate more charges, partly transfer their charges to neighboring pixels. This effect is called blooming. Blooming leads to corruption of the geometrical mapping between signal and image on the line sensor.

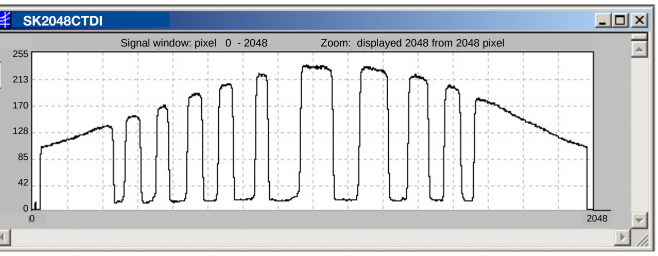
CCD line scan cameras with anti-blooming sensor drain the charge surplus in case of over-exposure via a 'drain gate'. Neighboring, less exposed pixels are not filled any more. In spite of over-exposure, the signal structure is maintained accurately.

CCD line scan cameras of the CTDI series feature an Anti-Blooming sensor and thus have a protection against over-exposure. However, the blooming drain gate has limited capacity.

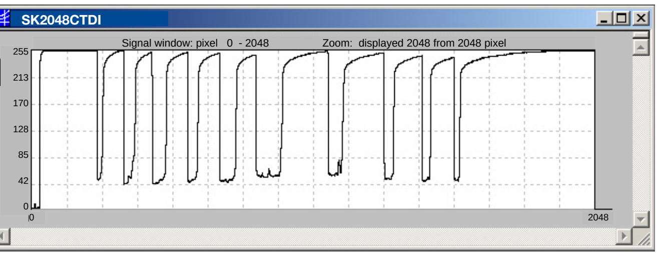
In general:

The less pixels are overexposed, the better the anti-blooming effect of the drain gate. For individual pixels the charge surplus of up to the 2000-fold saturation charge is drained. With an increasing number of overexposed pixels, the drainable charge surplus is reduced. The electronic of the CTDI camera series supports the blooming-control features of the sensor.

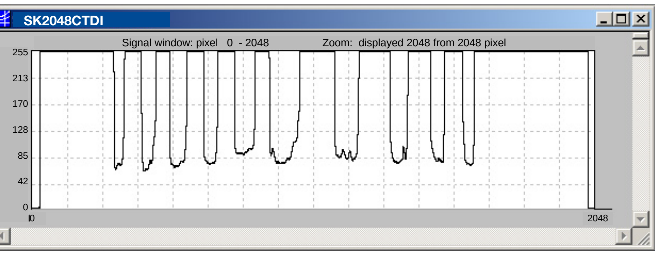
1



2



3



Oscilloscopic displays of CCD line signals (bar code with incident light), SK2048CTDI

1 CCD line signal with center-accentuated illumination and steep signal edges. Integration time tA= 0,158 ms

2 Over-exposure by means of longer integration time (tA= 0,533 ms). The blooming effect in the sensor is initi ted by modifying the blooming control voltage (low VA). Signal structures are distorted.

3 Blooming control voltage limits the output signal of the sensor to approx. 90% of the saturation voltage VSAT. The anti-blooming function is active. With even longer integration time (tA= 0,806 ms), the edge positions of Figure 1 are maintained.

11. Dimension Drawings

1 CCD Line scan Camera **SK4096CTDI-40XL** mounted with:

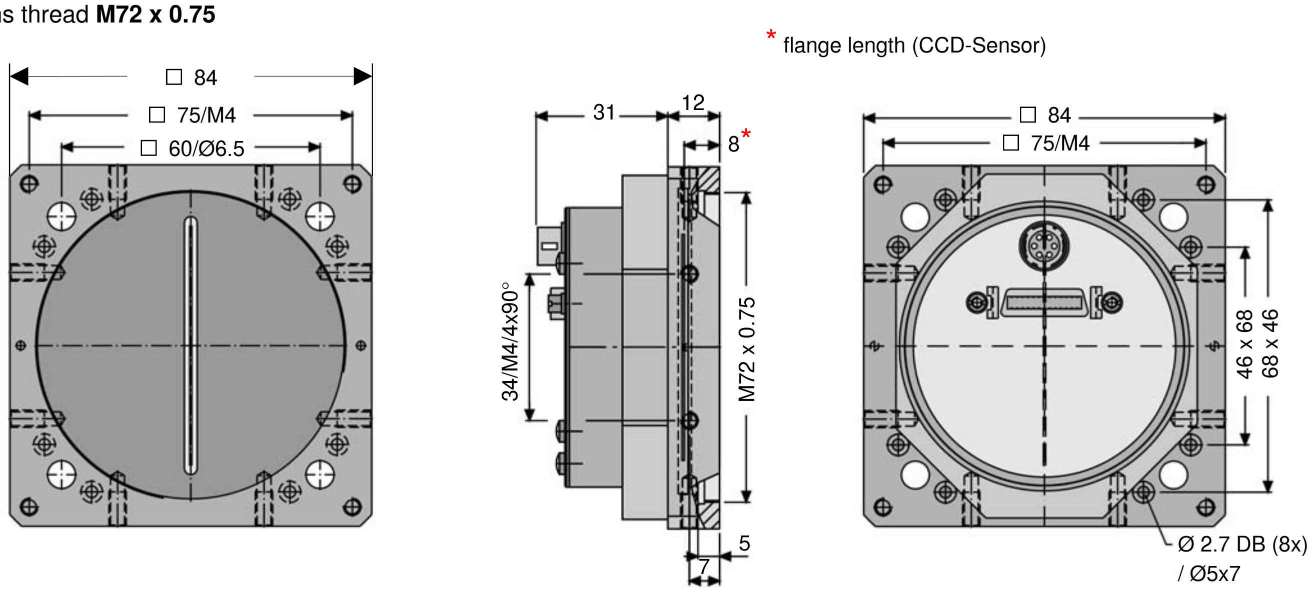
2 Focus adapter FA26-S45

3 Extension ring ZR-L...

4 Lens adapter M39-45

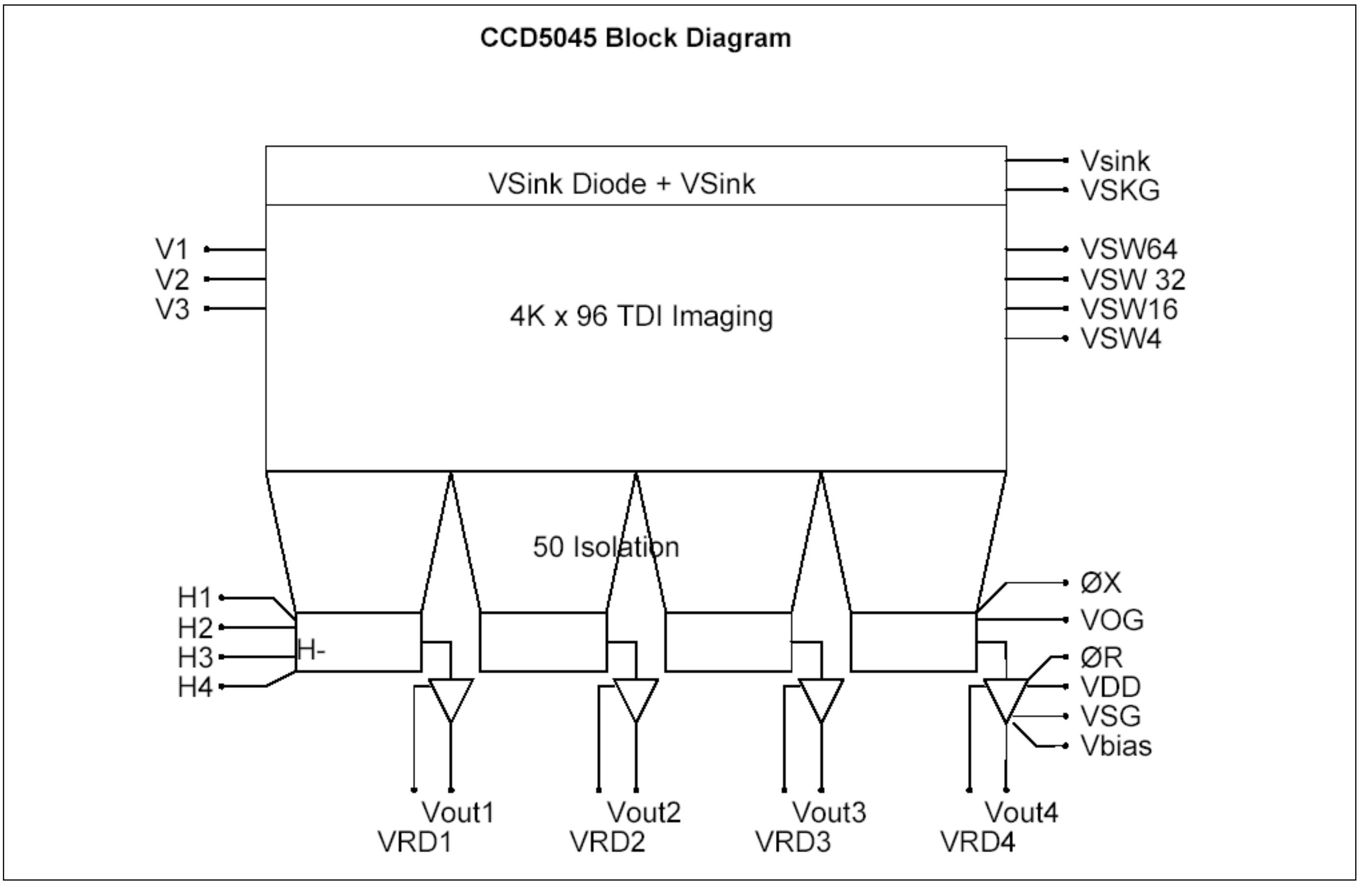
5 Macro lens 1:1, APO-Rodagon D1x 4.0/75

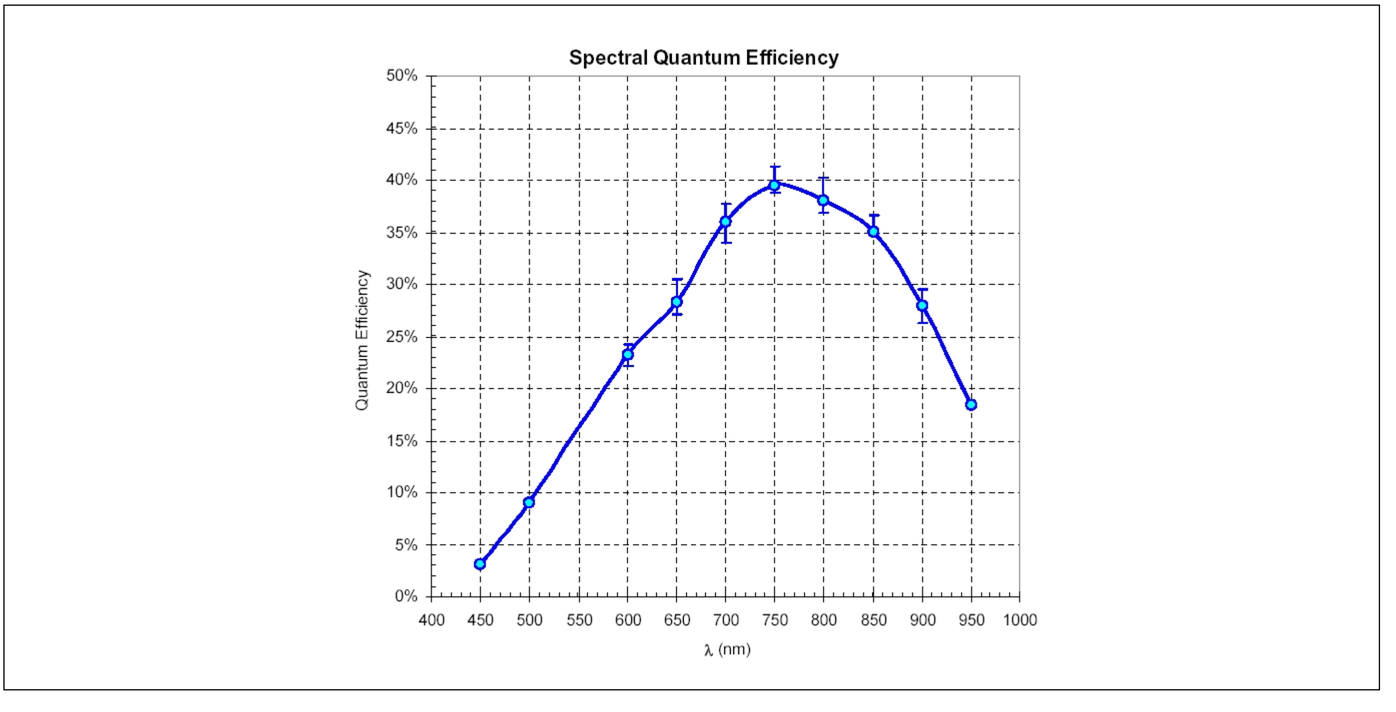
CameraLink case group **CC5**
Lens thread **M72 x 0.75**



12. Sensor Data

Manufacturer: Fairchild Imaging®
Type: CCD5045
Data source:: Fairchild Imaging® CCD5045 - Data Sheet





Performance Specifications

Description	Symbol	Min	Typical	Max	Units	Remarks
Vertical saturation charge	Qsat	150	200	-	Ke-	
QE at 650 nm	QE	20	22	-	%	
Readout noise	Noise	-	70	100	e-	
Dynamic range	DR	2700	3000	-		
Horizontal CTE	HCTE	0.9999	0.99995	-		Per transfer
Vertical CTE	VCTE	0.999	0.9995	-		Per transfer
Photoresponse non-uniformity	PRNU	-	5	10	%	TDI = 96
Dark current	Idark	-	1	-	nA/cm^2	
Dark signal charge density	Idark	-	10500	-	Elec/pixel/sec	
Dark signal non-uniformity	DSNU	-	< 5%	-	Qsat	
Output amplifier DC offset		-	10.3	-	Vdc	
Output amplifier sensitivity		2.5	3	3.5	µV/e-	
Antiblooming	AB	1500	2000	-		X saturation
Peak responsitivity	Resp.	-	320	-	V/µj/cm^2	At 650 nm

Test Conditions:

Tests were performed at 25°C with horizontal clock frequency of 25 MHz per output and vertical clock frequency of 23 kHz.

13. References and warranty

This technical manual was provided with largest care. However no guarantee is given that it is free of errors and mistakes. For the indicated circuits, descriptions and tables no guarantee is assumed concerning third party rights.
With the data in the technical descriptions assembly groups are specified, no characteristics are assured. The warranty for the CCD line scan camera amounts to 24 months. The warranty expires with inappropriate interferences.

14. European Union Conformity Explanation

This product is in accordance with the EC Directive 89/336/EWG. The requirements of DIN EN 61326 are accomplished.