


CCD line scan camera digital b/w SK 512 ZPD


512 Pixels, 10 x 10 µm, 50 MHz Pixel Frequency





- Characteristics**
- digital camera 8 Bit / 12 Bit
 - high dynamics
 - high line frequency up to 78.1 kHz
 - anti blooming
 - gain / offset programmable
 - integration control
 - very low noise
 - CDS-Technology
 - light sensitive
 - round housing Ø 65 mm

Accessoires (optional)


Camera mount SK 5105 (Order Code)  Wrap resistant construction for the mounting of the CCD line scan camera. Optional: Clamp set SK 5102 (Order code) to lock the CCD line scan camera in arbitrary rotation.


Mounting console SK 5105-2  for adaptation of macro lens, extension ring ZR..., focus adapter FA22-C and the CCD- line scan camera

Lenses  - high resolution **Enlarging lenses and macro lenses**
- high speed **photo lenses**
- lenses with additional **blocking bridge** for locking of focus and aperture setting.

Adapter  **Lens adapter AOC-...** for adapting photo lenses onto the CCD line scan camera
Focus adapter FA22-... für adapting Enlarging lenses and macro lenses.

Connecting cable SK9019 for Digital CCD Line Scan Cameras  of Camera Series XSD, DPD, ZPD, DPT, DJR, DJRC etc. **SK9019.3 FF** **Order Code**
36-pin shielded cabel for camera and video signals. Standard: 3m cabel length, one- or double-sided with Centronics connectors (female, 36-pin).
FF = Connector double-sided (female)
F = Connector one-sided (female)
3 = 3 m (standard cabel length)
5 = 5 m cabel length
x = Cabel length custom made

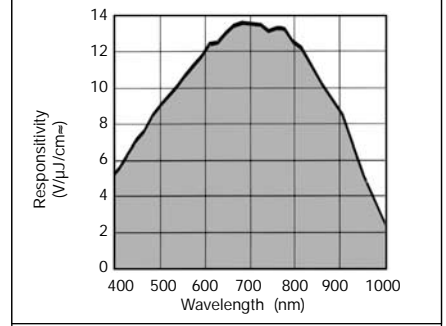
PC-Interface SK 9193 D (recommended)  Interface für digitale CCD-Zeilenkameras
PCI-Bus, preprocessing on-board: shading correction, windowing, thresholding external synchronisation (LineSync, FrameSync)

Software  **SK91PCI-WIN ***
SK91PCI-LX **
System Software, Drivers, DLLs,
* Windows, ** Linux

Performance Specifications

Camera Type:	SK 512 ZPD
Order Code	
Physical Characteristics	
Sensor:	CCD linear Type IL-P1-512
Pixel Number:	512
Pixel Size:	10 µm x 10 µm
Pixel Distance:	10 µm
Line Width:	10 µm
Active Length:	5.12 mm
Operating Ranges	
Pixel Frequency:	maximum 50 MHz
Line Frequency:	maximum 78.1 kHz
Integration Time:	minimum 10 µs maximum 20 ms
Dynamic Range:	1 : 2500 (rms)
Spectral Range:	400 - 1000 nm

Typical Spectral Responsivity



Input Control Signals

- Master Clock
- StartOfScan (SOS)
- Gain / Offset control

Output Signals


Video Signal: 8 Bit digital
Interface: LVDS

Power Supply

Voltage: +5 V, +15 V, -15 V
Power Consumption: 3 W

Connector

Mini Centronics 36 pin-male



Opposite connector: Series Harting Bellows
Typ: 6013 036 5100

Others:

Operating Temp.: + 5°C ... + 45 °
Size: Ø 65mm
x 51mm
Weight: 0.2 kg
Lens Thread: C-Mount

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SK_512_DPD_E

1. Technical Specifications of the ZPD Camera Series

Camera Model	SK 512 ZPD	SK 1024 ZPD	SK 2048 ZPD	SK 4096 ZPD
CCD sensor	IL-P1-512	IL-P1-1024	IL-P1-2048	IL-P1-4096
Number of pixels	512	1024	2048	4096
Pixel size	10 µm x 10 µm	10 µm x 10 µm	10 µm x 10 µm	10 µm x 10 µm
Sensor width	10 µm	10 µm	10 µm	10 µm
Pixel distance	10 µm	10 µm	10 µm	10 µm
Active length	5.12 mm	10.24 mm	20.48 mm	40.96 mm
PRNU <i>Photo Response Non Uniformity</i>	4)	4)	4)	4)
Anti-Blooming	yes	yes	yes	yes
Integration Control	yes	yes	yes	yes
CDS ¹⁾	yes	yes	yes	yes
Pixel frequency max	50 MHz ³⁾	50 MHz ³⁾	50 MHz ³⁾	50 MHz ³⁾
Min. integration time	10 µs	10 µs	10 µs	10 µs
Max. integration time	20 ms ²⁾	20 ms ²⁾	20 ms ²⁾	20 ms ²⁾
Max. line frequency	78.1 kHz ³⁾	43.4 kHz ³⁾	23 kHz ³⁾	11.8 kHz ³⁾
Min. line frequency	0.05 kHz	0.05 kHz	0.05 kHz	0.05 kHz
Dynamic range	1 : 2500 (rms)	1 : 2500 (rms)	1 : 2500 (rms)	1 : 2500 (rms)
Spectral range	400 - 1000 nm	400 - 1000 nm	400 - 1000 nm	400 - 1000 nm
optical filling factor	100%	100%	100%	100%
Video signal	8 Bit digital	8 Bit digital	8 Bit digital	8 Bit digital
Interface	LVDS	LVDS	LVDS	LVDS
Voltage supply	+5V, +15V, -15V	+5V, +15V, -15V	+5V, +15V, -15V	+5V, +15V, -15V
Power consumption	3 W	3W	3W	3W
Lens connection	C-Mount	C-Mount	M40 x 0,75	M40 x 0,75
Housing (W x H x D)	Ø65mm x 50mm	Ø65mm x 50mm	Ø65mm x 50mm	Ø65mm x 50mm
Weight	0.2 kg	0.2 kg	0.2 kg	0.2 kg
Temperature range	+5°C ... +45°C	+5°C ... +45°C	+5°C ... +45°C	+5°C ... +45°C

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.

3) 50 MHz operation with SK 9793D and AUX2 enable only.

4) For further sensor specifications obtain the details of the sensor manufacturer. See the datasheet at the end.

2. Handling details of the line scan camera

Attention:

Before the line scan camera is attached to or detached from the power supply make sure the power supply is switched off.

Otherwise, a permanent damage of the line scan camera device is risked.

To prevent damage due to heat accumulation and keep the temperature of the camera below 45°C, a sufficient air circulation around the camera housing has to be ensured.

To start operation the camera has to be connected to the necessary voltage, the MasterClock- and StartOfScan-Signals using a 36-pin Centronics Miniature Connector.

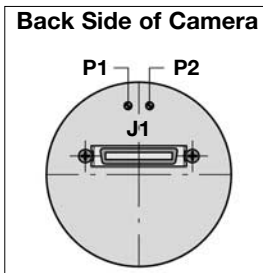
The camera is shipped aligned and set to default settings in gain and offset. Extensive modifications of the gain/offset-parameter can lead to a decrease in signal quality.

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.

Recommendation:

Using the PC-Interface and the **SkLineScan®** software by **Schäfter+Kirchhoff** the camera is ready for operation immediately. The oscilloscopic display of the line scan camera signal including the zoom-function and the online parameter setting of the camera is a valuable tool while arranging the optical system setup. The hardware preprocessing on the Interface board (Shading Correction, Windowing, Thresholding) enables recording and evaluation with maximum line frequency. Furthermore, the comfortable methods of the class libraries for C++ support the development of user software.

3. Connection and Control Signals



J1 = Mini Centronics 36pin-male, P1 = Gain even, P2 = Gain oddt

Voltage Supply

+ 5 V ± 5% ca. 210 mA (10 MHz Clock)

ca. 320 mA (50 MHz Clock)

- 12 V to -15 V ± 5% ca. 10 mA

+15 V ± 5% ca. 60 mA

Digital Control Inputs

Pin out

Miniature Centronics 36 pin Connector (male)

Signal	Pin	Pin	Signal
GND	18	0 0	36 GND
(+5V) VCC	17	0 0	35 VCC (+5V)
GND	16	0 0	34 D7 - out
(+5V) VCC	15	0 0	33 D7 + out
CCLK - out	14	0 0	32 D6 - out
CCLK + out	13	0 0	31 D6 + out
LVAL - out	12	0 0	30 D5 - out
LVAL + out	11	0 0	29 D5 + out
SOS - in	10	0 0	28 D4 - out
SOS + in	9	0 0	27 D4 + out
MCLK - in	8	0 0	26 D3 - out
MCLK + in	7	0 0	25 D3 + out
GND	6	0 0	24 D2 - out
(-12V/-15V) VEE	5	0 0	23 D2 + out
(+15V) VDD	4	0 0	22 D1 - out
(+15V) VDD	3	0 0	21 D1 + out
GND	2	0 0	20 DO - out
	1	0 0	19 DO + out

4. Exposure and Integration Control

Exposure:

The light sensitive elements of the sensor store the charge which are generated by the incident light during the exposure cycle. This accumulated charge is then converted into voltage. These values are a measure for the incident light intensity on each pixel.

The process of integration starts with the falling edge of the 'StartOfScan' (SOS)-signal. While the SOS-signal is 'Low', charge is accumulated. With the rising edge of the SOS-signal the exposure is concluded. The SOS-signal level stays a short time on 'High', before the next falling edge triggers the next exposure cycle.

Exposure time:

The exposure time of a single line scan t_B is the time interval of adjacent positive edges of the 'StartOfScan' (SOS)-signal. The time period of this interval (pixel clock) is determined by the minimum number of necessary pulses to read the accumulated charge into the shift register of the line scan sensor.

The sum of the pixel clock pulses results from the number of pixels N plus sensor dependent passive pixel clock pulses N_P .

The camera SK 512 ZPD needs min. 512+80 pixel clock pulses. The read out frequency is determined by the pixel frequency (MCLK). The exposure time t_B of a camera calculates:

$$t_B = \frac{(N + N_P)}{f_P}$$

The line frequency is given by:

$$f_L = 1/t_B$$

Example: SK 512 ZPD, SK 9193D, 50 MHz pixel frequency
 Aux1 disable, Aux2 enable
 $t_B = (512 + 128) / 50 \text{ MHz}$
 $t_B = 12.8 \mu\text{s}$
 $f_L = 50 \text{ MHz} / (512 + 128)$
 $f_L = 78.1 \text{ kHz}$

- **Exposure time:** Time interval between successive "SOS" signals.
- **Integration time:** Duration of the actual charge accumulation during the exposure time.
- **Integration Control:** for CCD line scan cameras it is possible to program shorter integration times within the actual exposure time (Shutter operation).

Integration Control:

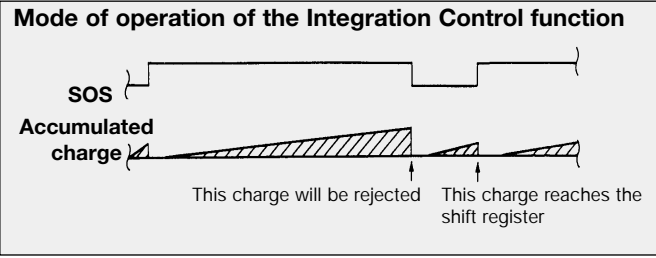
In the default setting of the camera the SOS signal between two exposure cycles shows 'High' only at very few pixel clock pulses. The Integration time and the exposure time are virtually of the same length.

The Integration Control function allows the extension of the 'High'-level condition in the SOS signal about a specified number of pixel clock pulses. The start of the accumulation of charge during an exposure cycle is thus delayed.

The integration time t_A is shortened to the difference of during one exposure period necessary pixel clock pulses ($N + N_P$) and the specified number of clock pulses for the extension of the 'High'-level condition in the SOS signal ($SOSL$).

The line scan frequency is not influenced by the Integration Control function.

$$t_A = \frac{(N + N_P) - SOSL}{f_P}$$



Integration Ctrl: $SOSL = 256;$
 $t_A = ((512+128) - 256) / 50 \text{ MHz}$
 $t_A = 7.7 \mu\text{s}$
 $t_B = 12.8 \mu\text{s},$
 $f_L = 78.1 \text{ kHz}$

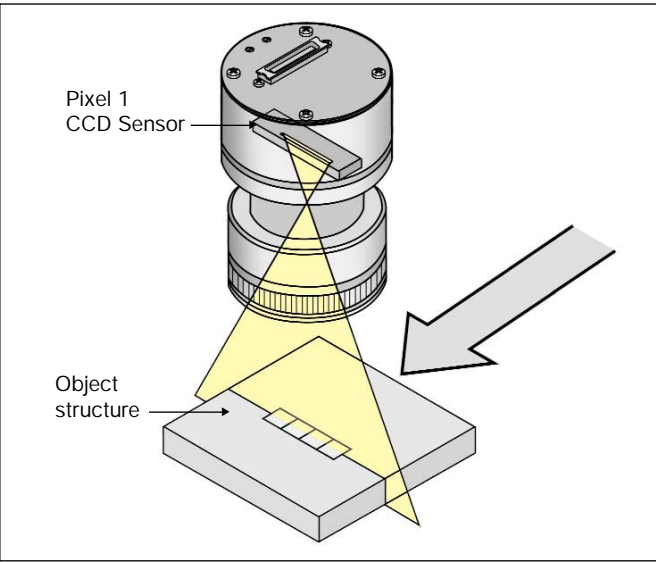
5. Generating an Image – Scan a Surface

A two-dimensional image is generated by moving the object or the camera. The direction of the movement needs to be orthogonal to the sensor axis of the CCD line scan camera.

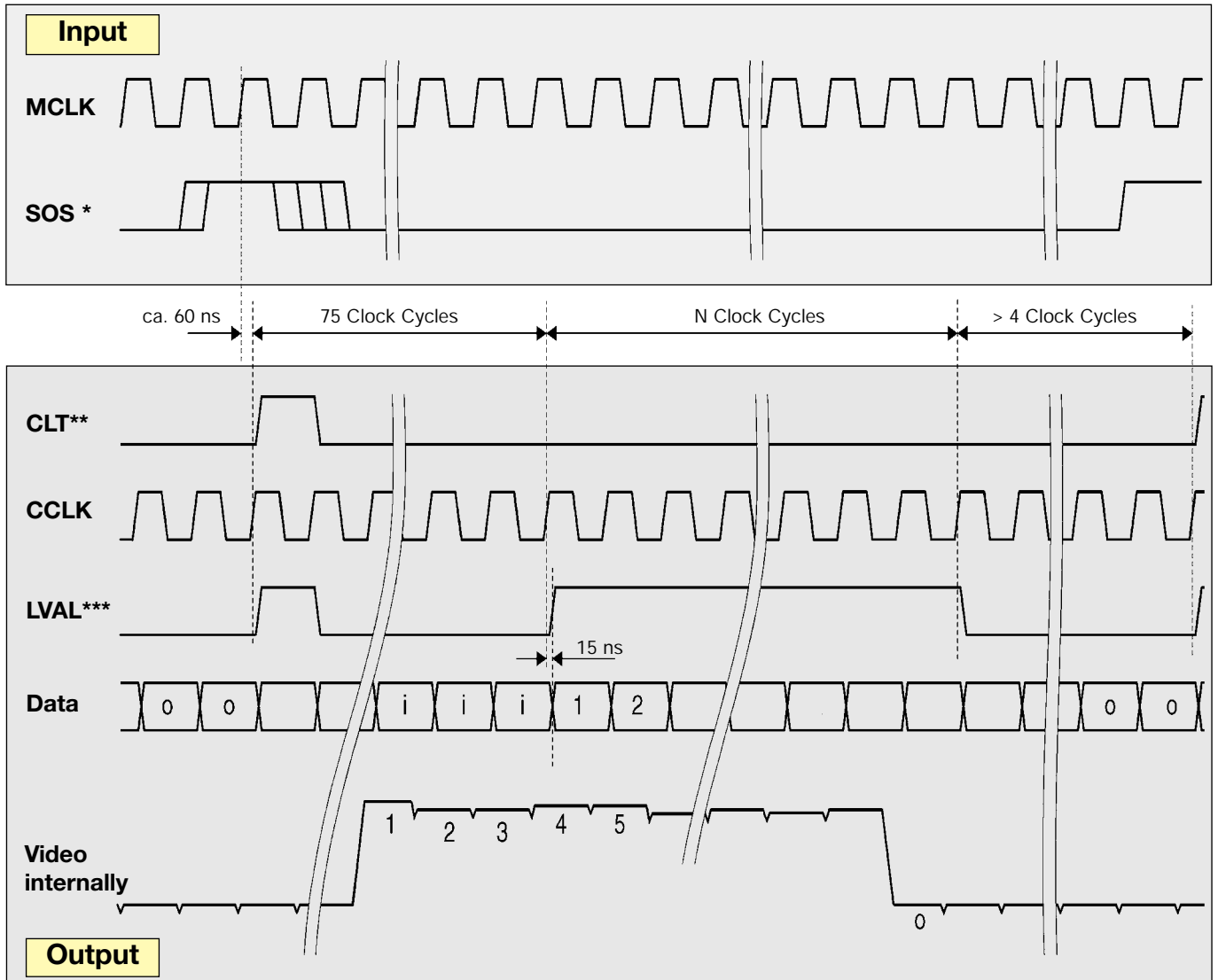
To obtain a proportional image with correct aspect ratios a line synchronous transport and a laterally correct pixel assignment is required.

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

- V_O = Object rate
- W_P = Pixel width
- β = Magnification
- t_B = Exposure time



6. Timing Diagram



* The rising edge of 'SOS' should not occur within a range of 3 to 25 ns before leading edge of 'MCLK'.
(Integration Control Timing see below)

** CLT = Camera Line Transfer (internal line scan camera Signal)

*** The signal 'LVAL' contains a 'CLT' pulse at the line beginning, which is required for the synchronisation of the **Schäfter+Kirchhoff** Interface boards.

If requested, the CCD line scan camera is available without 'CLT' pulse at the line beginning of the 'LVAL'.
Order Code SK 512 ZPD-3

The pixels determining the black level value are the 4th to the 7th before pixel no. 1.

N = Sensor pixels

i = Isolation pixels

o = Overclocking

7. Anti Blooming

Blooming

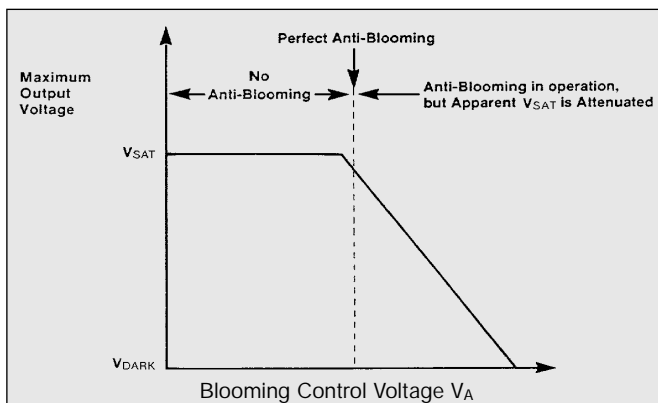
Extended illumination of saturated pixels, which are not able to accumulate further charge due to long exposure, leads to charge overflow into adjacent pixels. This effect is called **blooming**. Blooming causes a corruption of the geometrical allocation of image and object in the line signal.

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.

The CCD line scan cameras of the ZPD-series do contain anti-blooming sensors, i.e. they are prevented from overexposure due to a special design. The Blooming Drain Gate has a limited capacity, though.

The less pixels are overexposed, the better is the anti blooming effect of the drain gate. For single pixels a charge excess of up to a factor of 50 above saturation can be drained. With increasing quantities of oversaturated pixels the charge drainage decreases.

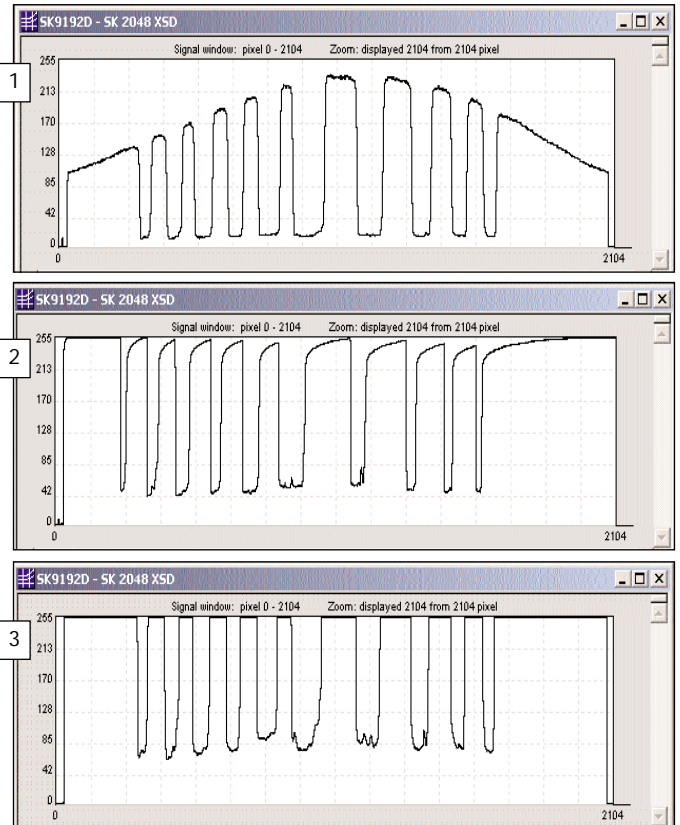
The electronics of the ZPD camera series support the blooming control possibilities of the sensor. The saturation load is regulated by the blooming control voltage V_A . The higher the voltage V_A the lower the level of anti blooming effect initiation. A high voltage V_A increases the saturation protection, but it limits the output voltage of the video signal and reduces the dynamic range of the camera. Tuning the voltage V_A to a level too small, the anti blooming effect is switched off completely. The maximum output voltage of the sensor reaches the saturation level V_{SAT} .



The blooming control voltage V_A is by default prepared to a level where the output voltage of the camera reaches approx. 90% of the saturation voltage V_{SAT} at maximum. Thus, an optimum anti blooming effect is ensured. **The voltage V_A should only be altered in exceptional cases.**

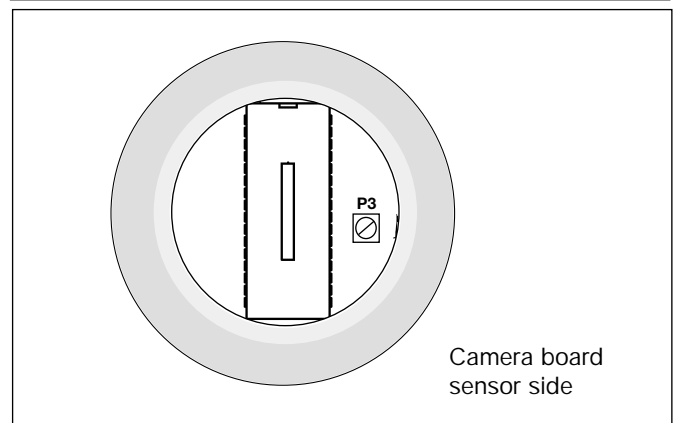
The anti blooming control voltage V_A is adjusted with the trimmer P3. Turning the trimmer P3 to the left, the voltage V_A rises. Turning it to the right the voltage V_A decreases. Turning it to the right bedstop, the anti blooming is switched off.

The trimmer P3 is accessed from the front of the



Oscilloscopic signal display of the CCD line scan signal (barcode with incident light), SK 2048 XSD

- 1 Line scan signal with central enhanced illumination and sharp rising signal edges. Integration time $t_A = 0,158$ ms
- 2 Over exposure due to longer integration time ($t_A = 0,533$ ms). The blooming effect is raised in the sensor by misadjusting the blooming control voltage (low V_A). The structures of the signal are distorted.
- 3 The blooming control voltage limits the output signal of the sensor to approx. 90% of the saturation voltage V_{SAT} . The anti blooming technique is active. Also, with even longer integration time ($t_A = 0,806$ ms) the signal edge positions from Fig. 1 are preserved.

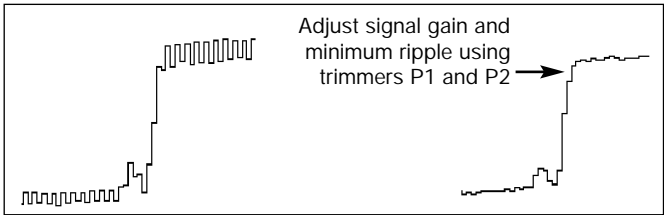
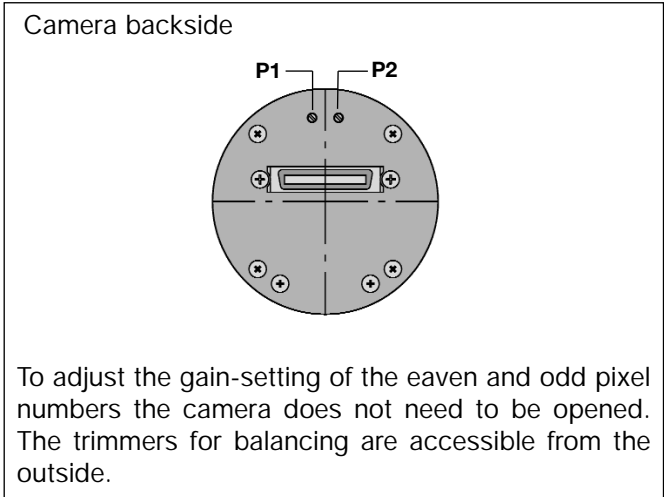


camera with the lens taken off.

To prevent misadjustment of the line scan camera, the effect of the P3 adjustment should be performed and tracked with sufficient illumination observing an oscilloscopic display of the line scan signal on the PC monitor.

8. Gain / Offset - Settings

Gain and offset of the cameras of the ZPD series can be set either by trimmer or through software. By default the trimmer are activated. Thus, a manual gain adjustment is possible. In the manual operation mode it isn't possible to change the offset parameters. They are taken from the last software programming. To use the gain and offset adjustment through the software, the gain / offset control has to be activated with a command. After this, regarding the gain / offset control, the camera responds to the software commands only. In this control mode the trimmer are bypassed. Only after deactivating the gain / offset control via software the manual gain control is possible again.



Programming of gain / offset

The programming of gain and offset is by now only possible by using the PC interface board **SK9193D** and the software **SkLineScan®** by **Schäfter+Kirchhoff**.

The basic software program **SkLineScan®** offers a special dialog for the gain and offset setting of the ZPD cameras. Changes of these settings are prompt visible in the oscilloscopic display of the line scan signal. The software package **SkLineScan®** contains library functions for gain and offset setting of the ZPD cameras.

The programming of the ZPD cameras provide an internal camera number setting between 0 and 3 by default. Using "Camera Select" the desired camera is selected. "Enable Control" transfers the gain / offset control to the software. The gain / offset slides simplify the handling, and the setting can be easily optimized. Once the values for gain and offset are set they are memorized in the system, even when it is switched off or completely disconnected. Deactivating "Enable Control" implicates reimplantation of the gain / offset setting of the trimmer on the camera.

"Aux1 enable" activates the video resolution of 12 Bit. The video transfer happen in the multiplex mode. Due to the twice data bus load the maximum line frequency is going to halve. "Aux2 enable" activates the internal 50 MHz oscillator. Otherwise the clock signal is generated by the external interface (40 MHz).

Camera Gain/Offset Control

Camera Select: Camera 0, Camera 1, Camera 2, Camera 3

Gain: A (0-127), B (0-28)

Offset: A (0-63), B (0-3)

Camera Setting: To No: 0

Software Control: Enable Control, Aux1, Aux2

Cancel OK

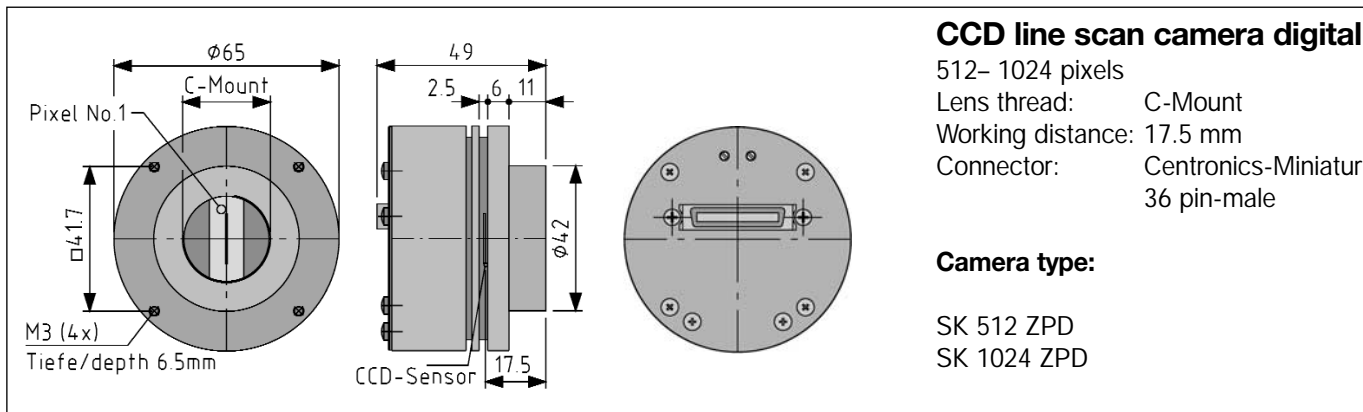
Enable control Activates the gain / offset setting by software

Aux1 Video signal resolution 12 Bit
 Video signal resolution 8 Bit

Aux2 Pixel frequency 50 MHz (intern)
 Pixel frequency up to 40 MHz durch externe Interfacekarte

- Advantages of the gain / offset setting of the ZPD cameras by software**
- The gain / offset setting can be altered during the measurement, although the trimmer are not accessible.
 - Adaption to changing illumination conditions without modifying the aperture of the lens.
 - Control of the signal intensity with constant exposure time setting with the interface board.
 - Matching of the signal intensities individually by operating several ZPD cameras parallel with the Merger box SK9194 or SK9195.
- The selection of the camera is accomplished by the programmed internal number 0...3, set before delivery.

9. Dimension Diagrams

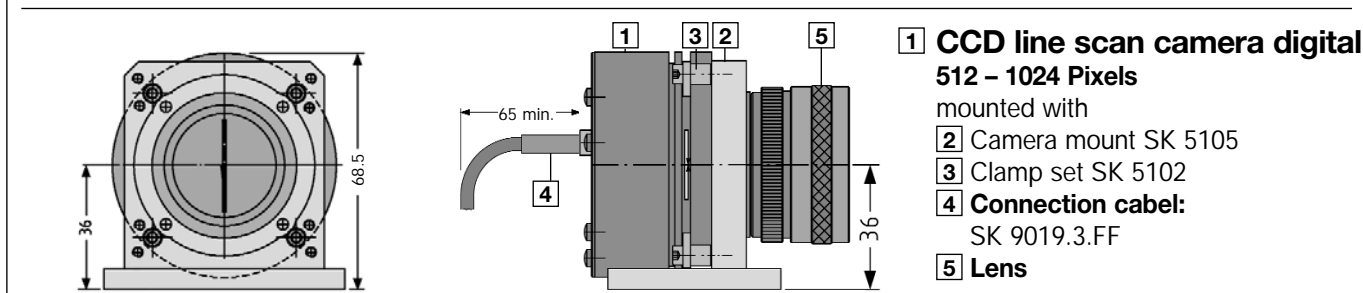


CCD line scan camera digital

512– 1024 pixels
 Lens thread: C-Mount
 Working distance: 17.5 mm
 Connector: Centronics-Miniatur
 36 pin-male

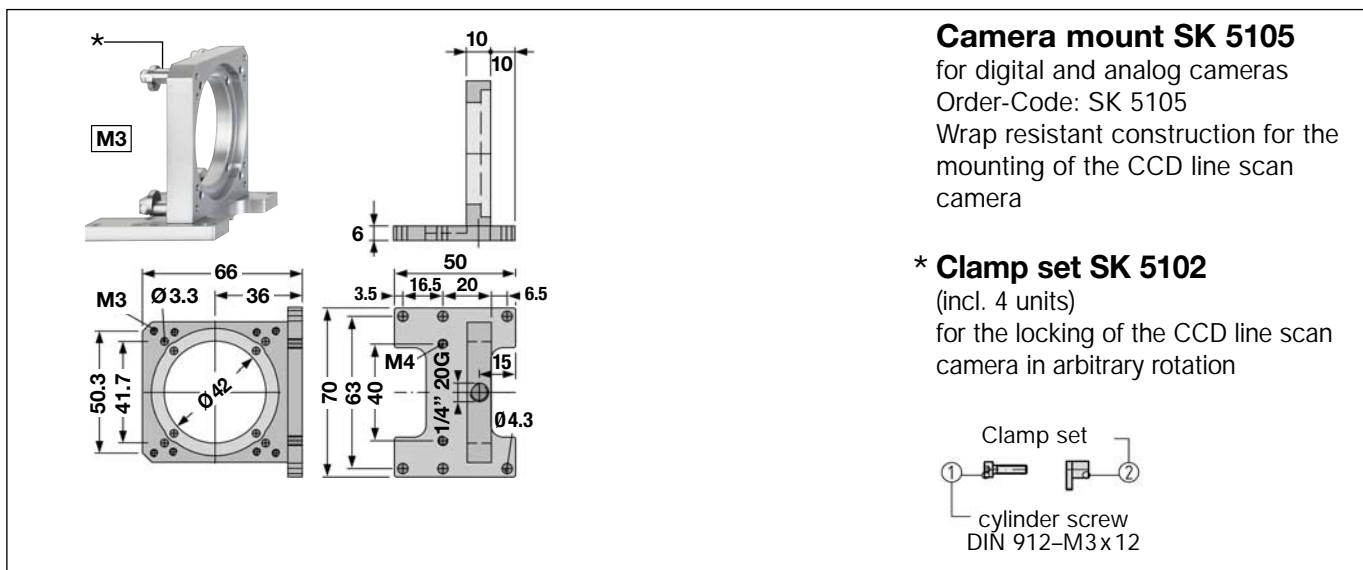
Camera type:

SK 512 ZPD
 SK 1024 ZPD



1 CCD line scan camera digital 512 – 1024 Pixels

- mounted with
- 2 Camera mount SK 5105
 - 3 Clamp set SK 5102
 - 4 Connection cable:
SK 9019.3.FF
 - 5 Lens

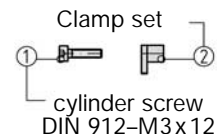


Camera mount SK 5105

for digital and analog cameras
 Order-Code: SK 5105
 Wrap resistant construction for the
 mounting of the CCD line scan
 camera

* Clamp set SK 5102

(incl. 4 units)
 for the locking of the CCD line scan
 camera in arbitrary rotation



1 CCD line scan camera digital 512 – 1024 Pixels

mounted with

- 2 Camera mount SK 5105
- 3 Clamp set SK 5102
locking the CCD line scan
camera in arbitrary rotation

optional

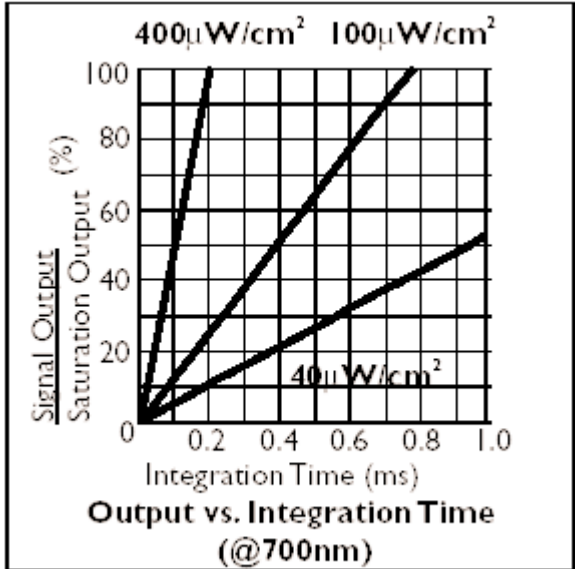
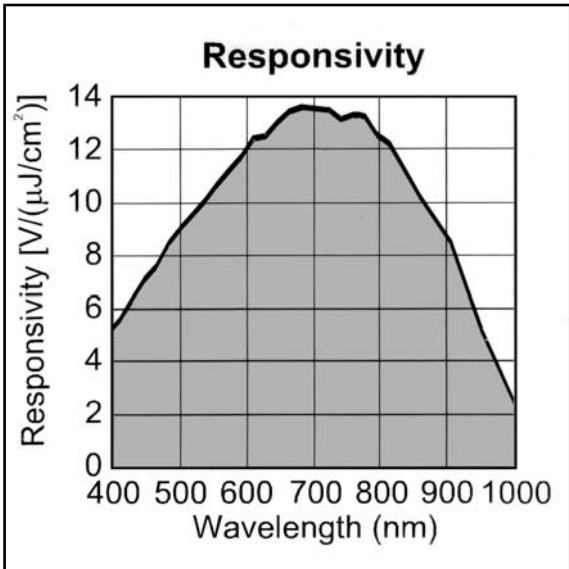
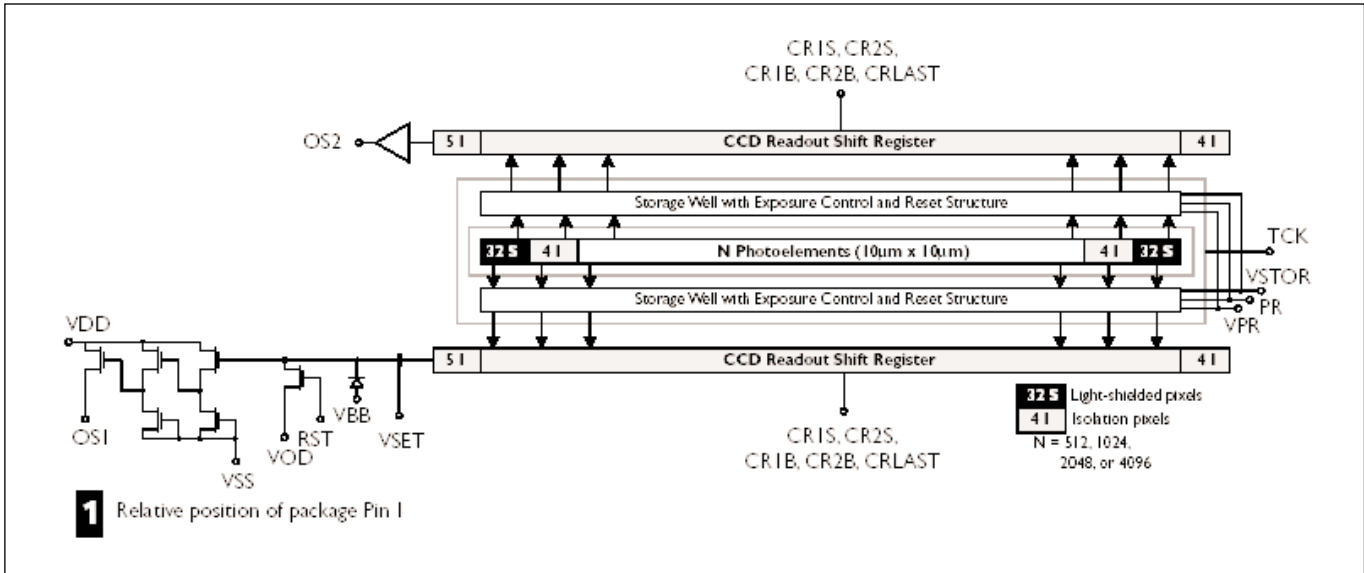
- 4 Locking with 4 units
cylinder screws
DIN 912 - M3x16

5 Lens, e. g.:
 Video-CCTV lens C2514M
 Lens thread: C-Mount
 1:1.4, $f' = 25$ mm
 1" size, free aperture 15.9 mm
 sensor length max. 15.9 mm

Alternative video-, enlargement and
 macro lenses see brochure CCD
 Line Scan Cameras

10. Sensor Data

Produced by: DALSA®
 Type: IL-P1-512, IL-P1-1024, IL-P1-2048
 Data source: DALSA® Line Scan Sensors ,DALSA IL-P1 - Data Sheet



11. Performance specifications

Specification	Unit	Min.	Typ.	Max.
Saturation Output Voltage (VSAT)	mV	700	900	1100
rms Noise	mV		0.28	0.31
Wavelength of Peak Responsivity	nm		700	
Peak Responsivity	V/($\mu\text{J}/\text{cm}^2$)	11.0	12.0	13.5
Dynamic Range		2250:1	3200:1	3900:1
Charge Conversion Efficiency (CCE)	$\mu\text{V}/\text{e}^-$	4.7	5.0	5.3
Noise Equivalent Exposure (NEE)	pJ/cm^2	21	23	28
Saturation Equivalent Exposure (SEE)	nJ/cm^2	52	75	
Full Well Capacity	ke^-	132	180	
Fixed Pattern Noise (FPN) ^{1,2}	pk-pk		0.5	1.0
	PR exposure control disabled		2.0	5.0
Photoresponse Non-Uniformity (PRNU) ^{3,4}	% OS			
PR exposure control disabled	8 pixel local neighborhood		2.2	6.0
	Global		3.5	8.5
PR exposure control enabled	8 pixel local neighborhood		2.5	6.5
	Global		3.8	8.8
Charge Transfer Efficiency (CTE) (readout register)		0.99999	0.999999	
First Field Lag ⁵	mV		11.5	
Dark Signal, Integration time = 84 μs	mV		0.15	0.5

Notes:

1. Maximum peak-to-peak variation of all outputs.
2. Due to its general purpose design, DALSA's camera and sensor evaluation hardware provides an output that cannot be used to directly measure low FPN.
3. The peak-to-peak variation is measured at ~50% SEE.
4. With output gain mismatch correction.
5. Lag is measured at VSAT with $f_{\text{LINE}} = 10\text{kHz}$.

Test Conditions:

- Operating temperature = 35°C.
- $f_{\text{RST}} = \text{data rate per output} = 25\text{MHz}$.
- $I_{\text{LOAD}} = 8\text{mA}$.
- $C_{\text{LOAD}} = 10\text{pF}$.
- Tungsten halogen light source, black body color temperature 3200K, filtered with 750nm IR cutoff filter.
- See Sensor Measurement Definitions (doc# 03-36-00149) for specification definitions.

12. References and Warranty

Although this manual has been reviewed carefully for technical accuracy, errors are possible. The reader is kindly asked to contact us, if errors are suspected.

The indicated circuits, descriptions and tables are not warranted to be free from rights of third parties.

With the statements in the technical descriptions only assembly groups are specified. Characteristics as well as the suitability for a particular purpose is not guaranteed.

The warranty period for the CCD line scan camera is 24 months. The warranty ends with inappropriate actions.

EC-Declaration of Conformity



This product meets the requirement of the EC directive 89/336/E.E.G. The requirements of DIN EN 61326 are fulfilled.