SK2048MVSH

Monochrome Line Scan Camera

2048 pixels 14 x 14 µm², line frequency up to 14.10 kHz

Line scan camera with large dynamic range and 14.1 kHz maximum line rate, anti blooming and integration control.

Instruction Manual

Sample Configuration

1	CCD line scan camera **SK2048MVSH** mounted with
2	Mounting bracket SK5105
3	Clamping claws SK5102
4	Focus adapter FA22R-40 (two-piece), facilitates adjustment of any rotation angle
5	Enlarging lens Apo-Rodagon N 4.0/80

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 *7*

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 SK2048MVSH Line Scan Camera

1.1 Intended Purpose and Overview

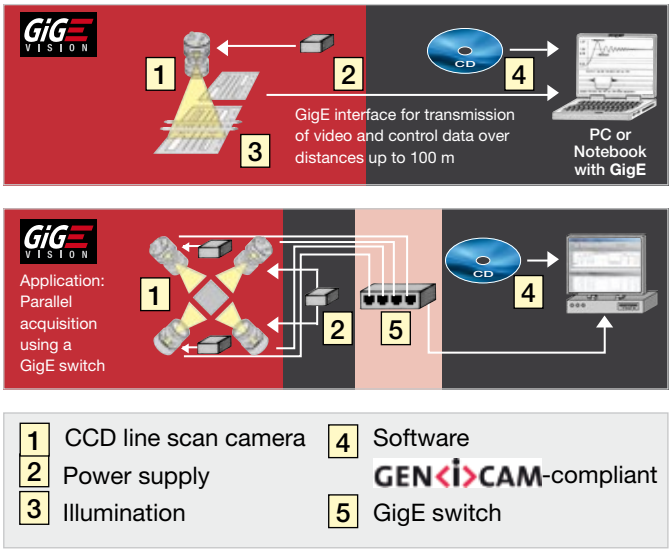
The SK line scan camera series is designed for a wide range of vision and inspection applications in both industrial and scientific environments.

The SK2048MVSH GigE Vision™ line scan camera uses the Gigabit Ethernet communication protocol and is 100% compliant with the GigE Vision™ specifications and the Gen<I>Cam™ standard.

GigE Vision allows for fast image transfer using low cost standard cables up to distances of 100 m. With GigE Vision, hardware and software from different vendors can interoperate seamlessly via the GigE connections. The camera is connected to a computer either via the GigE socket directly or through a Gigabit Ethernet switch.

The Schäfter+Kirchhoff GigE Vision line scan cameras implement a superset of the Gen<I>Cam™ specification which defines the device capabilities.

Te device feature list is described in section ***4 GigE Vision Device Feature List (Gen<i>Cam compliant) (p. 25)***. The section ***Custom Features (p. 28)*** contains the features created specifically for this camera. Any Gen<I>Cam compatible software can access these as well as the other features.



The Gen<I>Cam™ standard provides a generic programming interface for all kinds of cameras and, no matter what features they implement, the application programming interface (API) always remains the same. The Gen<I>Cam™ standard consists of multiple modules relevant to the main tasks to be solved:

GenApi: for configuring the camera

Standard Feature Naming Convention (SFNC): recommended names and types for common features

GenTL: transport layer interface, for grabbing images

For more information on the GigE Vision™ specification, see:

https://www.visiononline.org/vision-standards-details.cfm?type=5

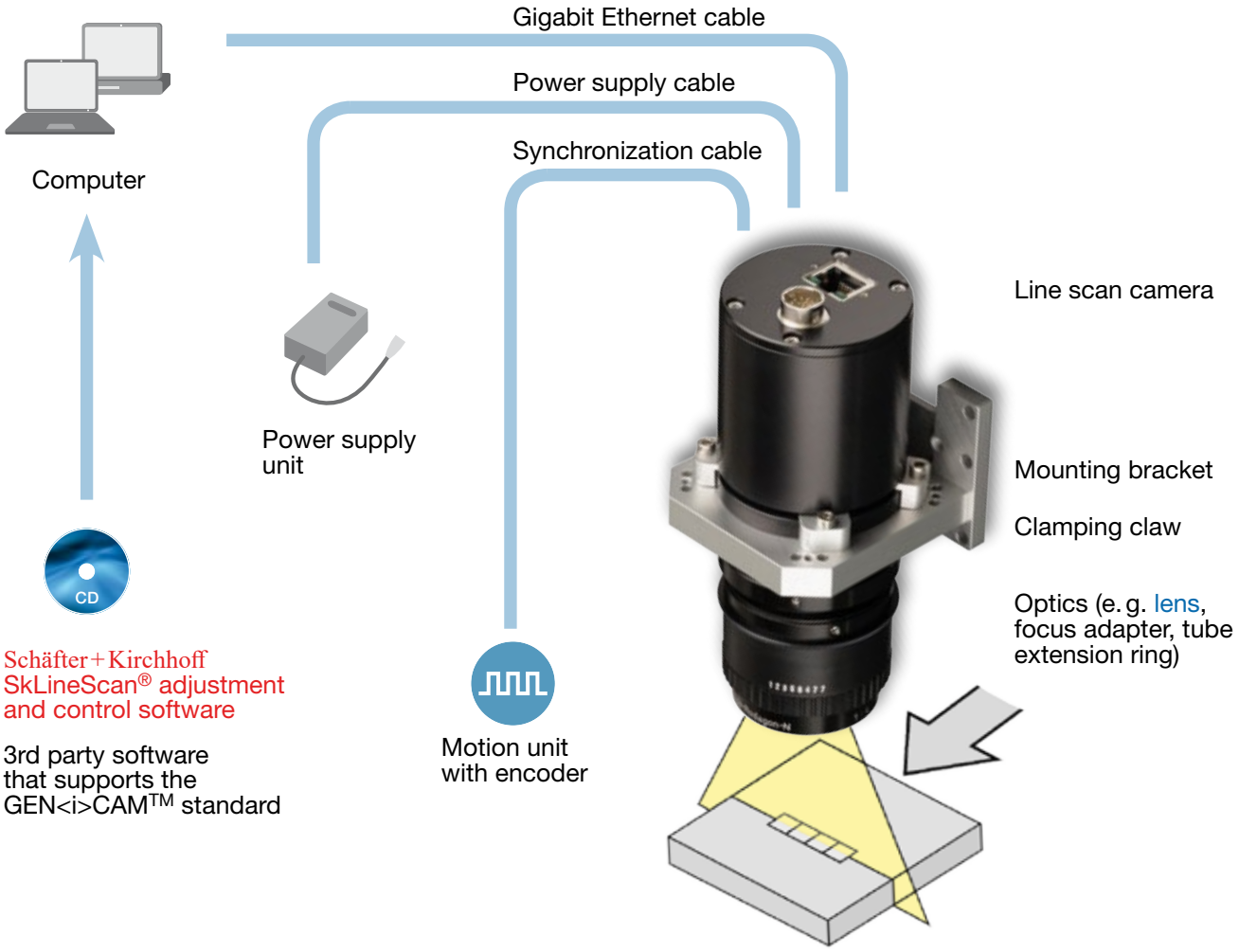
or the Gen<I>Cam™ standard:

http://www.emva.org/standards-technology/genicam/

1.2 System Setup at a Glance

red: SK2048MVSH scope of delivery
blue: accessories for minimum system configuration
black: optional accessories

For accessory order details see ***Accessories (p. 38)***.



1.3 Computer System Requirements

- Intel Pentium Dual Core or AMD equivalent
- RAM min. 4 GB, depending on size of acquired images
- High-performance video card, PCIe bus
- Operating Systems:
  Windows 7 / 8.1 / 10 (64 or 32-bit) or
  Linux kernel 3.13 or higher

Network Adapter:

- Any Gigabit Ethernet network adapter as a card or on the motherboard is suitable. For the best performance, a network interface card (NIC) with Intel PRO/1000 chip is recommended.
- Network adapters that support Jumbo Frames outperform adapters with fixed packet-size frames.

1.4 SK2048MVSH Line Scan Camera - Specifications

Sensor category	CCD Monochrome Sensor
Sensor type	S12551-2048
Pixel number	2048
Pixel size (width x length)	14 x 14 µm²
Pixel spacing	14 µm
Active sensor length	28.7 mm
Anti blooming	x
Integration control	x
Shading correction	x
Threshold detection	-
Line synchronization modes	Line Sync, Line Start, Exposure Start, Exposure Active
Frame synchronization	x
Pixel frequency	30 / 20 MHz
Maximum line frequency	14.10 kHz
Integration time	0.01 ... 20 ms
Dynamic range	1:2500 (rms)
Spectral range	200 ... 1000 nm
Video signal	monochrome 8/12 Bit digital
Interface	GigE Vision
Voltage	8 - 16 V DC
Power consumption	4.4 W @ 30 MHz
Casing	Ø54 mm x 69.2 mm (Case type RG2)
Objective mount	M40x0.75
Flange focal length	19.5 mm
Weight	0.16 kg
Admissible casing temperature	+5 ... +45°C

The camera must be mounted thermally coupled so that the acceptable casing temperature is not exceeded during operation. Therefore applies to the thermal resistance of the bracket or heat sink:

$$R_{thHS} \leq \frac{\theta_{amb} - \theta_{casing}}{P_{camera}}$$

where

R_{thHS} [K/W] = thermal resistance of the bracket or heat sink
θ_{amb} [°C] = ambient temperature
θ_{casing} [°C] = temperature of the camera casing (not to be confused with the internal camera temperature that is queried and output with the request command I32)
P_{camera} [W] = camera power consumption

2 Installation and Setup

2.1 Mechanical Installation: Dimensions, Mounting Options, and Heat Dissipation

Mounting Options

When mounting the camera, pay attention to the following:

- Mechanical stability to avoid vibrations.
- Good thermal coupling for cooling the housing. The power consumption and the maximum housing temperature of the camera are specified in section ***1.4 - Specifications***.

The best fixing point of the camera is the collar for the mounting bracket SK5105 (available as an accessory).

Four threaded holes M3 x 6.5 mm provide further options for customized brackets.

The length and weight of the optics might be beyond the capability of the standard mounting bracket SK5105. For this purpose, a second mounting bracket type SK5105-2 to hold the tube extension ring(s) is more appropriate.

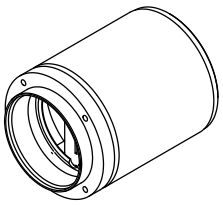
Optics Handling

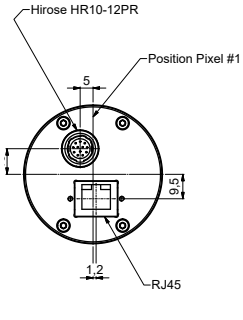
- If the camera and the optics are ordered as a kit, the components are pre-assembled and shipped as one unit. Keep the protective cap on the lens until the mechanical installation is finished.
- If you must expose the sensor or lens surface, ensure the environment is as dust-free as possible.
- Gently blow off loose particles using clean compressed air.
- The sensor and lens surfaces can be cleaned with a soft tissue moistened with water or a water-based glass cleaner.

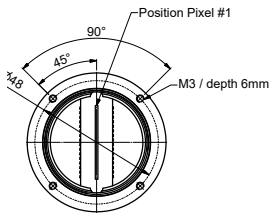
Casing type RG2

RG2

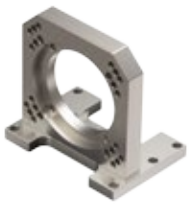
Lens mount:	**M40x0.75**
Seat for bracket:	**Ø42 mm**
Flange focal length:	**FFL = 19.5 mm**

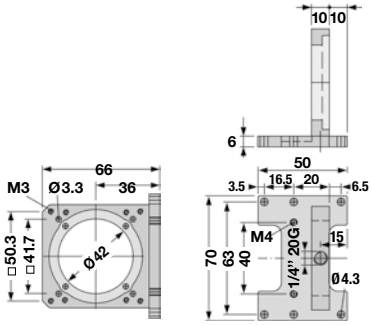






Mounting bracket SK5105



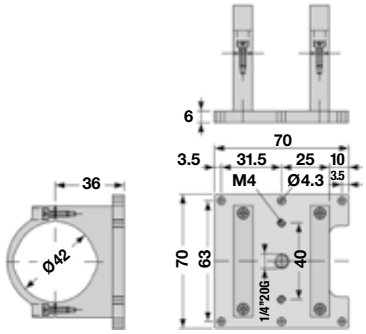


Clamping set SK5102

Set of 4 pcs. clamping claws incl. hex socket screws (EN ISO 4762–M3x12)

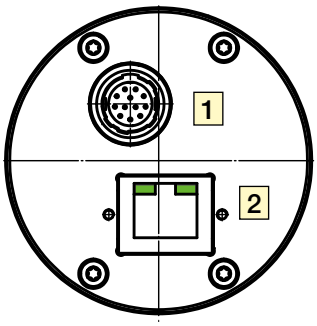
Mounting system SK5105-2

for cameras with a tube extension > 52 mm



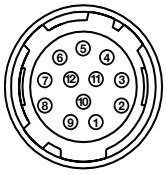
2.2 Electrical Installation: Connections and I/O Signals

- For the SK2048MVSH line scan camera-data transfer and camera control is provded by the Gigabit Ethernet interface 2. Use a CAT6 twisted-pair cable to connect the camera to a PC; the maximum cable length is 100 m.
- The operating power must be supplied by an external source using socket 1
- For any kind of synchronized operation, the external trigger signal(s) must be wired to socket 2 as well. A frame-synchronization signal and two separate line-synchronization signals can be handled. The various trigger modes are described fully in section ***Synchronization of the Image Acquisition with the Feed Rate of the Object (p. 17)***



1 **Power, Control** — Synchronization, Camera Select Setting [1]

Connector — Hirose series 10A, 12-pin, male



Supply Voltage — 8-16 V DC, power 4.4 W @ 30 MHz

Pin assignment

Pin	Signal	Output Data [2]
1	GND_V_S	
2	Supply Voltage VS	
3, 4, 11	Camera Select[1] Setting	Device Feature: SkCamID
5	GND	
6	LineSyncB IN+ (RS422 [4])	Pix#1, D6
7	FrameSync IN- (RS422 [4])	Pix#1, D7
8	FrameSync IN+ (RS422 [4])	Pix#1, D7
9	LineSyncA IN- (RS422 [4])	Pix#1, D5
10	LineSyncA IN+ (RS422 [4])	Pix#1, D5
12	LineSyncB IN- (RS422 [4])	Pix#1, D6

[1] Camera Select

Two cameras connected to the network can be distinguished using the *SkCamID* parameter in the Device Feature List.

The *SkCamID* is defined by the bridges set in the connector according to this scheme:

Pin #	Bridges for Camera Select						
	0	1	2				
3		●	●				
4			●				
11		●					

[2] Output Data

See 4.3 - Advanced Synchronization Control:
Sync control register (SCR) settings and diagnostic data output via pixel #1 (output data low byte) and pixel #2 (output data, low byte) alternatively to the detected brightness.

Line Counter
When the Sync Control Register is set to SCR = (bin)xxxx.xx11, 16-Bit Line Counter values are output via pixels #1 and #2.

[3] TTL Signal Specification

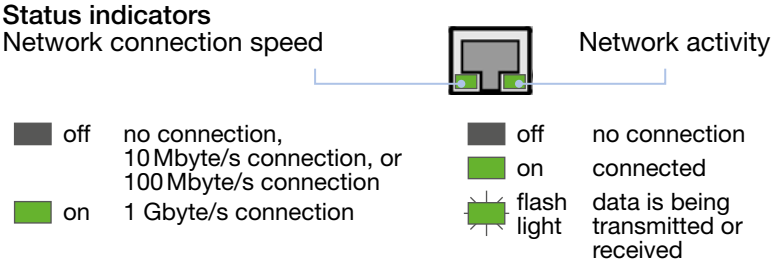
Max. input frequency	10 MHz
Input voltage, absolute max. range	-0.5 V to 25 V
Input voltage, max. low level	0.99 V
Input voltage, min. high level	2.31 V
Input current, typ.	0.5 mA
Input resistance (pull up)	10 kΩ

[4] RS422 Signal Specification

ESD Protection	±15 kV
Max. input frequency	10 MHz
Input voltage, absolute max. range	-7.5 V to +12.5 V
Input resistance (between + and -)	100 Ω

2 **Data**
RJ-45 connector for Gigabit Ethernet cable

Status indicators



2.3 GigE Connections and Software Installation

The SK2048MVSH GigE Vision™ line scan camera uses the Gigabit Ethernet communication protocol, which is 100% compliant with the GigE Vision™ specifications and the Gen<I>Cam™ standard.

The Gen<I>Cam™ standard provides a generic programming interface for all kinds of cameras and, no matter what features they implement, the application programming interface (API) always remains the same.

For software and Network Interface Controller (NIC) driver installation, the following possibilities apply:

1. **The Gen<I>Cam™ compliant 3rd party software you want to install includes a particular filter driver for the NIC.**
   ➔ **Install the software package. Commonly this will also cover the driver installation.**
2. **The 3rd party software does not include a NIC filter driver, and your NIC has an INTEL PRO/100 chip.**
   ➔ **Install the Pleora eBUS Optimal Driver.**
3. **The 3rd party software does not include a NIC filter driver, and your NIC has a different chip.**
   ➔ **Keep the manufacturer driver and follow the instructions in the next section.**

The Pleora eBUS driver installation tool is available from Schäfter + Kirchhoff either on CD or as download from ***http://www.sukhamburg.com/supporte.html***

GigE Network Integration for Standard GigE Network Adapters

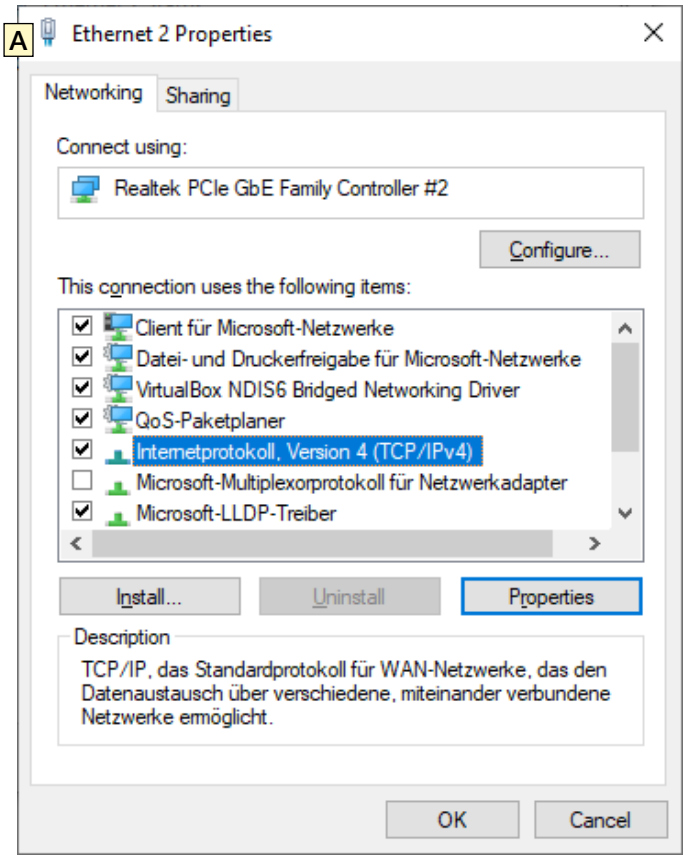
This section is relevant for systems with a standard NIC (not INTEL PRO/1000) in combination with the manufacturer driver (case 3).

a) Subnet Setting

The GigE Vision camera has an enforced static IP address. The NIC IP address must be part of the same subnet otherwise the camera is not accessible.

An example of a persistent IP address that is assigned to a class B network is:

Persistent IP	=	169.254.35.10
Subnet Mask	=	255.255.0.0
Default Gateway	=	0.0.0.0



To Set the NIC IP address:

Open the Network Connection Properties dialog A.

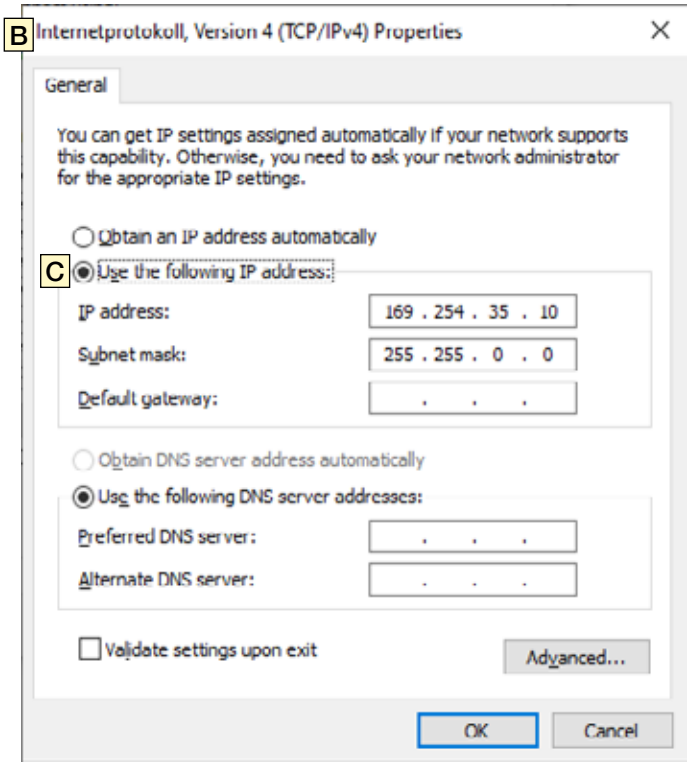
Select Internet Protocol (TCP/IPv4) and click Properties. The Internet Protocol, Version 4 (TCP/IPv4) dialog B Properties shows up.

Enable "Use the following IP address" C and enter the following settings:

IP address:	169.254.35.10
Subnet mask:	255.255.0.0
Default gateway:	leave blank

Ensure these do not conflict with an existing IP address on another NIC. For multiple dedicated connections on the same host PC, increment the third IP address by one for each NIC (i.e. 36, 37, etc., subnet 255.255.255.0 - class C).

Close the opened dialogs with "OK". Your NIC is now configured for a dedicated connection.



b) Windows Firewall

a) **Switch off the Windows Firewall** or

b) **Allow an exception:**

Start > Control Panel > Open the Windows Firewall

Select the Exceptions tab

Click Add Program

The "Add a Program" dialog appears

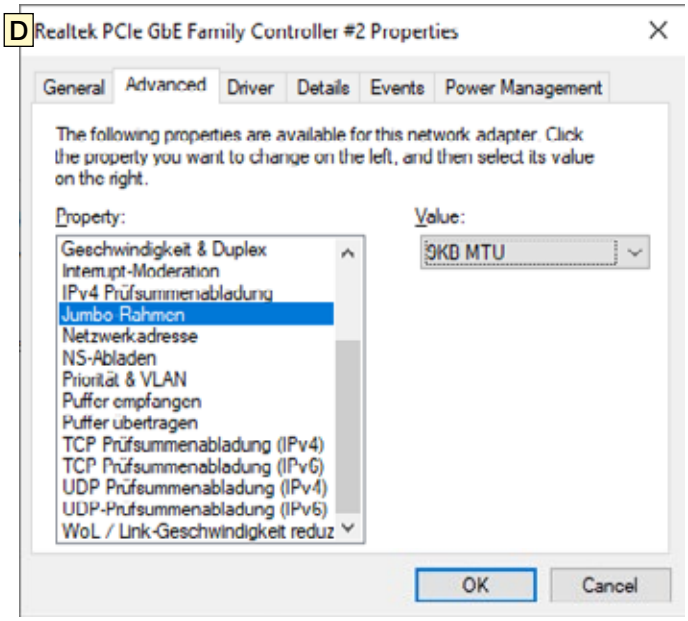
Select the camera control program and click "OK"

Click "OK" to close the Windows Firewall dialog

c) Optimizing the Network Adapter Settings

Open the "Advanced" Properties tab D of the Network Adapter and enter the following values:

Jumbo Frames	9014 Bytes
Receive Descriptors	2048
Interrupt Moderation Rate	extreme
Energy Efficient Ethernet	OFF



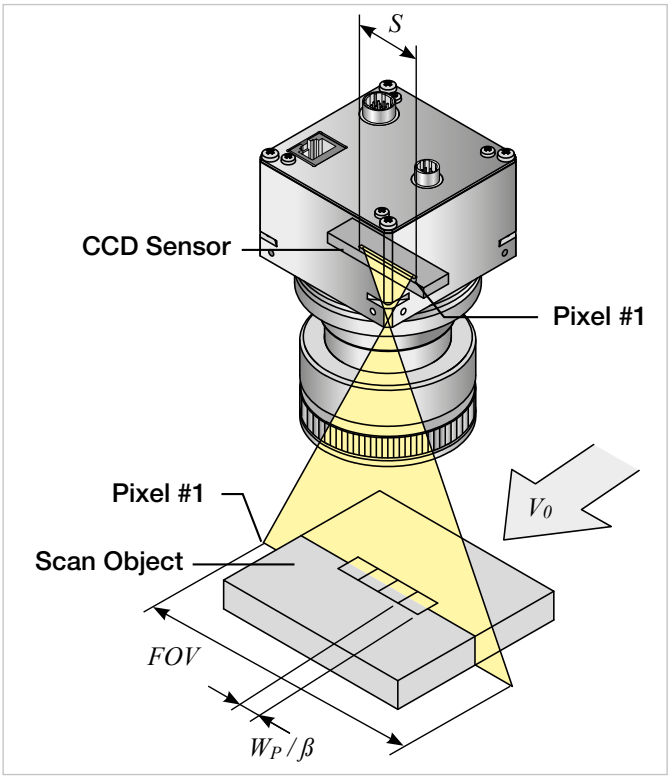
Network Controller Properties: Note, the terms can differ depending on the installed Ethernet card and driver.

3 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	= 14 µm
Line frequency	= 14.10 kHz
S	= 28.7 mm
FOV	= 50 mm

$$V_O = \frac{14\,\mu m \cdot 14.10\,kHz}{(28.7\,mm / 50\,mm)} = 344\,mm/s$$

Example 2:

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

Pixel width	= 14 µm
Scan velocity	= 300 mm/s
S	= 28.7 mm
FOV	= 50 mm

$$f_L = \frac{300\,mm/s \cdot (28.7\,mm / 50\,mm)}{14\,\mu m} = 12.3\,kHz$$

Synchronization Modes

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

There are two different synchronization functions that can be applied together or individually:

1. **Line synchronization:**

The falling edge of a TTL signal at the LINE SYNC A input triggers each individual exposure of the sensor line by line.

The SK2048MVSH line scan camera enables extended synchronization control by means of a second trigger input LINE SYNC B. A detailed description can be found .under ***5.2 Advanced Synchronization Control (p. 24)***.

2. **Frame synchronization:**

The recording of a set of lines (frame) representing a two-dimensional image is started by the falling edge of a TTL signal at the FRAME SYNC input.

The configuration of the synchronization behavior is done with the parameter ***SkTriggerMode*** and following in the section ***Camera Head Feature*** of the device feature List, see ***Camera Head Feature (p. 18)***

Free Run / SK Mode 0

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

LineStart / SK Mode 1

After an external trigger pulse, the currently exposed line is read out at the next internal line clock. The start and duration of the exposure are controlled internally by the camera and are not affected by the trigger pulse. The exposure time is programmable. The line frequency is determined by the frequency of the trigger signal.

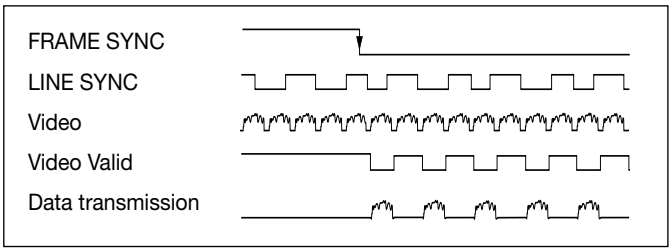
Limitations: The period of the trigger signal must be longer than the exposure time used. Between the external trigger signal and the internally generated line clock, jitter occurs in the range of the exposure time.

ExposureActive / SK extSOS (Mode 5)

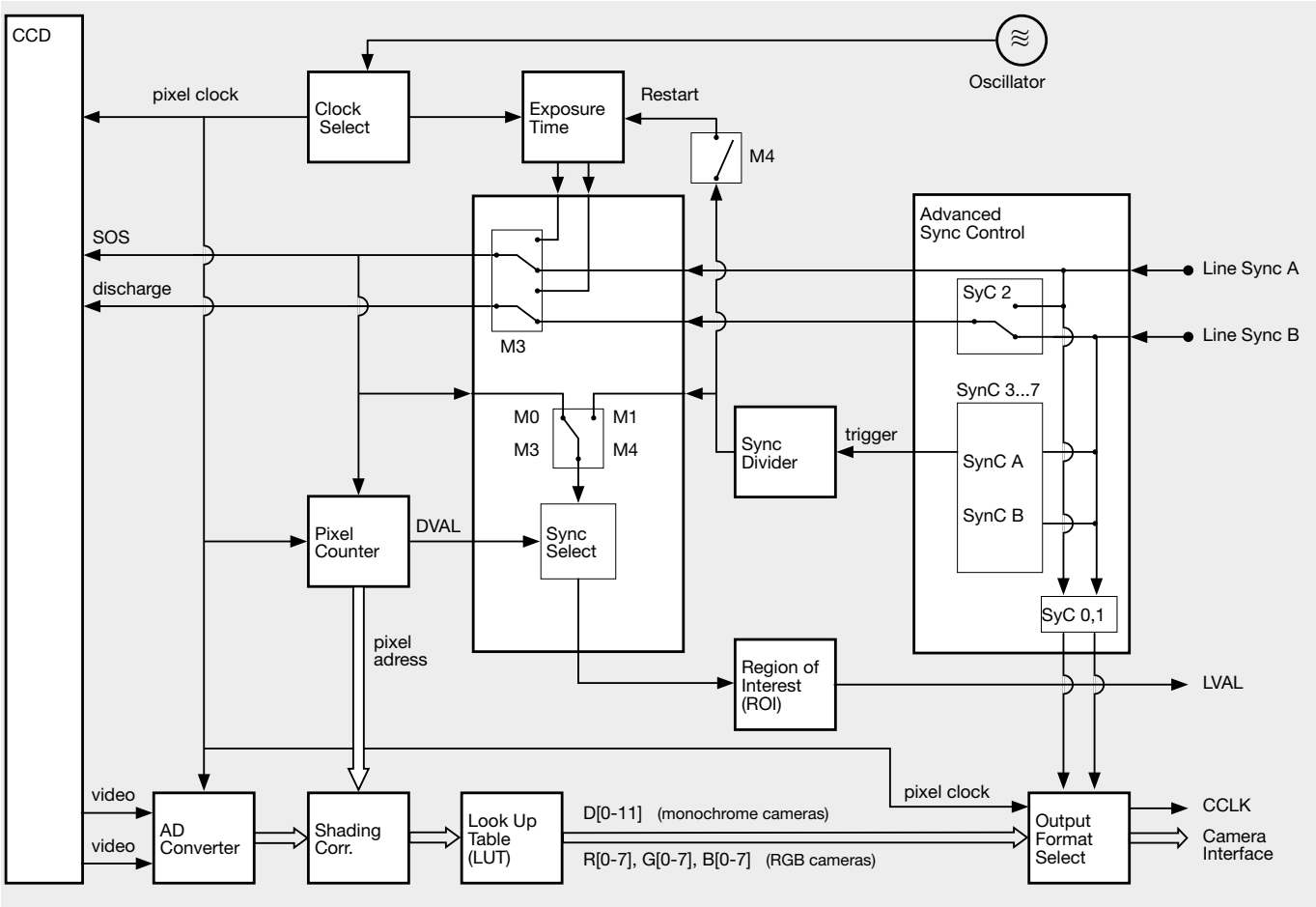
The exposure time and the line frequency are controlled by the external trigger signal. This affects both the start of a new exposure (Start of Scan-Pulse, SOS) and the readout of the previously exposed line.

FrameTrigger / SK FrameSync

The camera suppresses the data transfer until a falling edge of a TTL signal occurs at the FRAME SYNC input. This starts the acquisition of a 2D area scan. The number of image lines must be programmed in advance. Any of the available line synchronization modes can be used for the individual line scans.



Combined frame and line synchronization



Functional diagram of the Camera Control System

4 GigE Vision Device Feature List (Gen<i>Cam compliant)

This chapter describes the parameters of the GigE Vision Device Feature list that are relevant for the configuration and operation of the camera.

The data can be edited, as long as they are not grayed out. Some parameters can only be edited if image acquisition has been stopped.

Device Control

Device Feature	Description	Access	Expert mode only
DeviceScanType		Read only	x
DeviceVendorName		Read only	
DeviceModelName		Read only	
DeviceManufacturerInfo		Read only	
DeviceVersion		Read only	
DeviceSerialNumber		Read only	x
DevcieUserID		Read only	
DeviceSFNCVersionMajor		Read only	
DeviceSFNCVersionMinor		Read only	
DeviceSFNCVersionSubMinor		Read only	
DeviceTLVersionMajor		Read only	
DeviceTLVersionMinor		Read only	
DeviceLinkSelector		Read only	
DeviceLinkSpeed		Read only	x

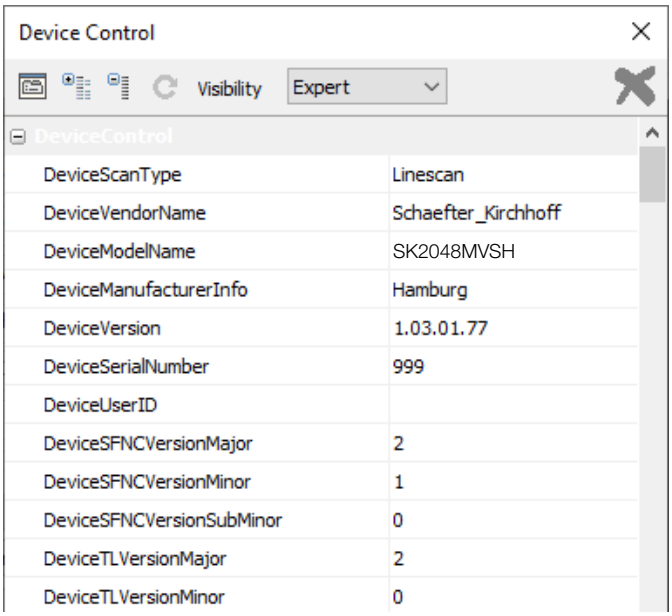
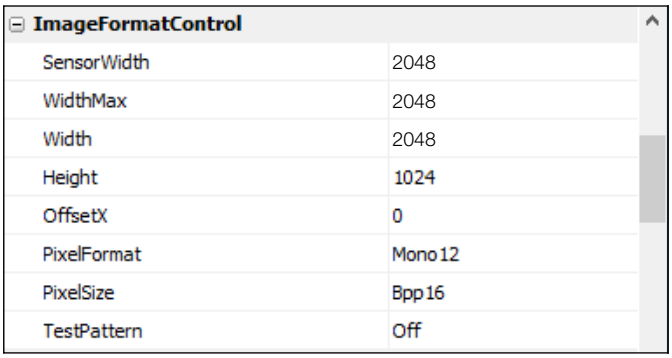


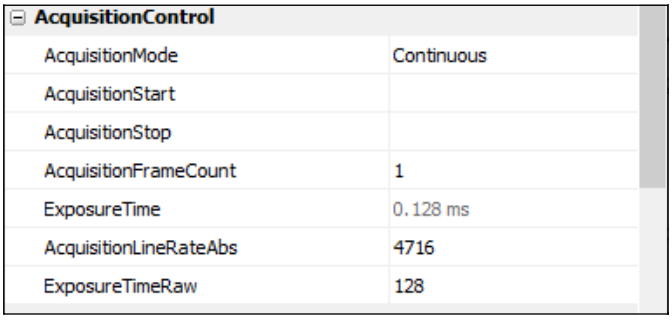
Image Format Control

Device Feature	Description	Access	Expert mode only
SensorWidth	Number of pixels of line sensor (fixed)	Read only	
SensorHeight	1 (fixed)	Read only	x
WidthMax	Image width maximum (= SensorWidth)	Read/write	
Width	Image width = ROI ... SensorWidth	Read/write	
Height	Image height (number of lines per image) 1 for Line Scanning ≥2for Area Scanning	Read/write	
OffsetX	Start pixel address of ROI	Read/write	
PixelFormat	Mono8= gray scale 8-bit Mono12= gray scale 12-bit **Note: The PixelFormat must be matched to the DataOutputFormat of CameraHeadFeatures**	Read/write	
PixelSize	bits per pixel, depends on PixelFormat Mono8:PixelSize = Bpp8 = 8-bit Mono12:PixelSize = Bpp16 = 16-bit	Read/write	
TestPattern	Off = normal sensor output signal On = Output of a sawtooth-shaped test signal	Read/write	



Acquisition Control

Device Feature	Description	Access	Expert mode only
AcquisitionMode	Continuous: repetitive acquisition SingleFrame: one snapshot	Read/write	
AcquisitionStart		Command	
AcquisitionStop		Command	
AcquisitionFrameCount		Read only	
ExposureTime		Read/write	
AcquisitionLineRateAbs	Line rate in Hz, minimum:50 Hz maximum:14300 Hz see also „SkSetLineFrequency“	Read/write	
ExposureTimeRaw	Exposure time in µs, 10 ... 20000 (master feature of exposure control) see also „SkExposureTime (CameraHeadFeature)“ **Note: The parameters Line Rate and Exposure Time depend on each other. A changig of the Line Rate affects a changing of Exposure Time, and reverse too**	Read/write	

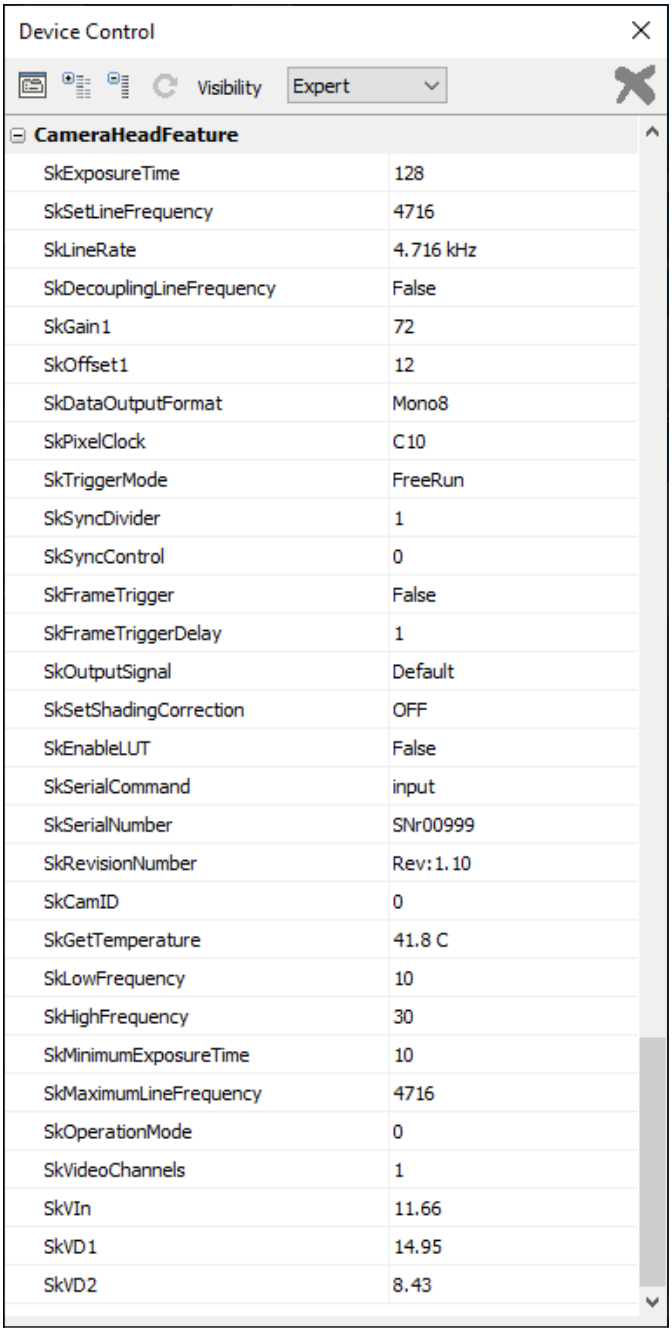


Analog Control

Device Feature	Description	Access	Expert mode only
Gain	Gain adjustment, absolute, range: 0 ... 1023, typical 70 (integer). This feature is referenced by SkGain1 of the Camera Head Features.	Read/write	

Camera Head Feature

Device Feature	Description	Access	Expert mode only
SkExposureTime	Current exposure time in µs, can be changed by entering a new value, range: 10 … 20000. The input of a new value affects the line frequency of the camera.	Read/write	
SkSetLineFrequency	Sets the camera line frequency in Hz, range: 50 … 14300.	Read/write	
SkLineRate	Returns the line frequency in kHz, for information only.	Read only	
SkDecouplingLineFrequency	TRUE= Allows shorter exposure time than the reciprocal line frequency. Only selectable for camera types with integration control. FALSE= Line frequency and exposure time are synchronized. The line frequency is the reciprocal of the exposure time, and vice versa.	Command	x
SkGain1	Gain value (absolute), range: 64 … 1023	Read/write	



Camera Head Feature (continued)

Device Feature	Description	Access	Expert mode only
SkOffset1	Offset value (absolute), range: 0 … 255	Read/write	
SkDataOutputFormat	Mono8 = 8 bit (0 … 255) Mono12 = 12 bit (0 …4095)	Read/write	
SkPixelClock	Sets the pixel frequency C20 = 20 MHz C30 = 30 MHz	Read/write	
SkTriggerMode	Sets the line synchronization mode: FreeRun = internal synchronization with preset line frequency, no external trigger LineStart = after the falling edge of the sync signal the most recent exposure will be readout MaxLineRate = internal synchronization with highest possible line frequency, no external trigger ExposureStart = the falling edge of the sync signal immediately triggers the next exposure cycle ExposureActive = the trigger period determines the exposure time	Read/write	
SkSyncDivider	Incoming trigger clock divider, range 1...32767	Read/write	
SkSyncControl	Advanced Sync Control Register settings, see Synchronization Modes (p. 13).	Read/write	
SkFrameTrigger	Selects "Frame Sync" for external trigger of images, see ***Synchronization Modes (p. 13)*** TRUE = "Frame Trigger" is active, i.e. the acquisition of a 2D area scan is started by the negative edge of the FrameSync signal. Each line is triggered according to the adjusted LineSync mode (SkTriggerMode) FALSE = "Frame Trigger" is off.	Command	
SkFrameTriggerDelay	Delay of starting the grabbing after incoming FrameSync trigger signal, specified in lines	Read/write	
SkOutputSignal	0 = Default, simple line signal of the camera 1 = the camera provides a saw tooth as test pattern 2 = the Shading Correction is active 3 = takes the current line signal as reference for Shading Correction 4 = writes back the flash memory to the Shading Correction Memory (SCM) 5 = writes SCM into the flash memory of the camera 6 = the content of SCM is displayed 7 = the 2nd flash memory is written into the 2nd SCM 8 = the content of the 2nd SCM is written into the 2nd flash memory 9 = the content of the lookup table is displayed **Note: The SkOutputSignal feature corresponds to the serial command ("Txxxxx", xxxxx= 0 … 9)**	Read/write	x
SkSetShadingCorrection	ON = Incomming line signals will be scaled by the content of the Shading Correction Memory (SCM). For writing new SCM scale factors, using the SkLineScan tool is recommended. OFF = Shading Correction is not active.	Command	x
SkEnableLUT	TRUE = Incomming line signals will be scaled by the content of Lookup Table Memory (LUT). For writing new LUT scale factors, using the SkLineScan tool is recommended. FALSE = the video data is not affected by the Lookup Table.	Command	x
SkSerialCommand	input = sends a serial command to the camera. output = Success, or Failure	Write only	x

Camera Head Feature (continued)

Device Feature	Description	Access	Expert mode only
SkSerialNumber	Returns the serial number of the camera.	Read only	
SkRevisionNumber	Returns the firmware revision number of the camera.	Read only	
SkCamID	Returns the camera ID that is determined by the "Camera Select" bridges in the Power/Control connector, see *2.2 Electrical Installation: Connections and I/O Signals (p. 8)*.	Read only	
SkGetTemperature	Returns the video board temperature in C°.	Read only	
SkLowFrequency	Returns the lower pixel frequency of the camera in MHz, for information only.	Read only	x
SkHighFrequency	Returns the higher pixel frequency of the camera in MHz, for information only.	Read only	x
SkMinimumExposureTime	Returns the shortest possible exposure time.	Read only	
SkMaximumLineFrequency	Returns the highest possible line frequency.	Read only	
SkOperationMode	Returns the coded operation mode, for information only.	Read only	x
SkVideoChannels	Returns the number of video channels. The number of gain/offset channels is correlated with this value.	Read only	x
SkVIn	Returns the incomming voltage VIn in Volt.	Read only	x
SkVD1	Returns the voltage D1 in Volt.	Read only	x
SkVD2	Returns the voltage D2 in Volt.	Read only	x

User Set Control

This section contains functions for permanently storing camera settings. Defining a "UserSet" is useful, for example, if you always want the camera to start in 12-bit data format or if you want to use other preferred settings other than the default settings.

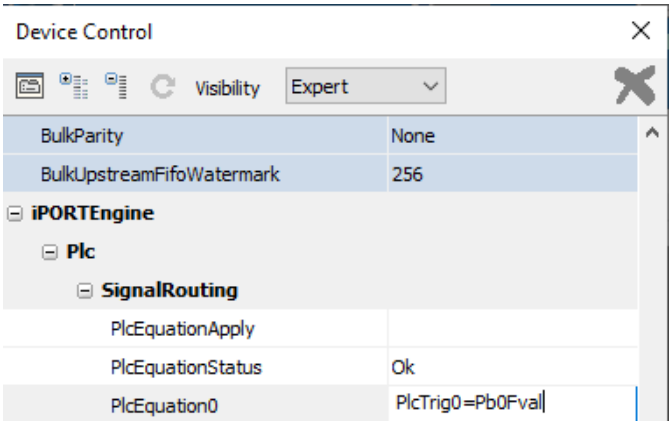
Example setting:

CameraHeadFeature / SkDataOutputFormat
= Mono12
ImageFormatControl / PixelFormat
= Mono12

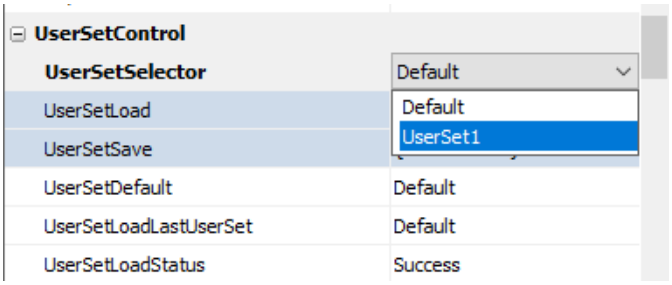
Note, for the frame synchronization function a parameter has been factory-preset:

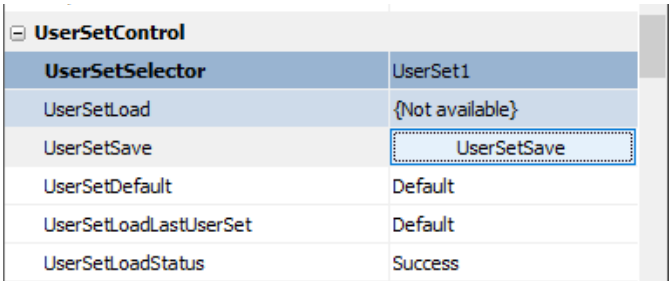
iPORTEngine / Plc / SignalRouting / **PlcEquation0**
= **PlcTrig0=Pb0Fval**

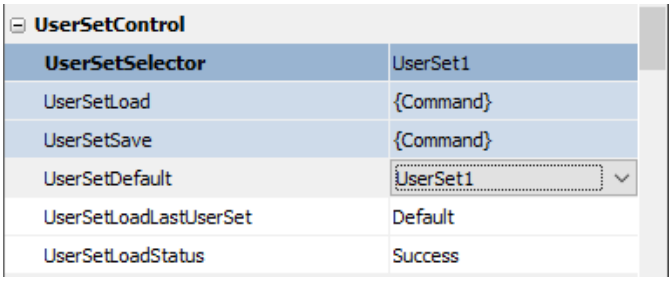
This setting must be retained in the UserSet. Otherwise, Frame Synchronization will not work.



Device Feature	Description	Access	Expert mode only
UserSetSelector	select „UserSet1“	Read/write	
UserSetSave	Writes the current camera settings into a non-volatile memory of the camera. The settings are retained beyond power-off.	Command	
UserSetDefault	"UserSet1" = The settings of UserSet1 are loaded at the beginning of a new session.	Read/write	







5 Advanced Camera Control Functions

5.1 Camera Control by Commands

The GigE Vision Device Feature list already contains some camera specific parameters and commands in section ***Camera Head Feature (p. 18)***. Normally, the commands and parameters available there are sufficient for setting up and operating the camera.

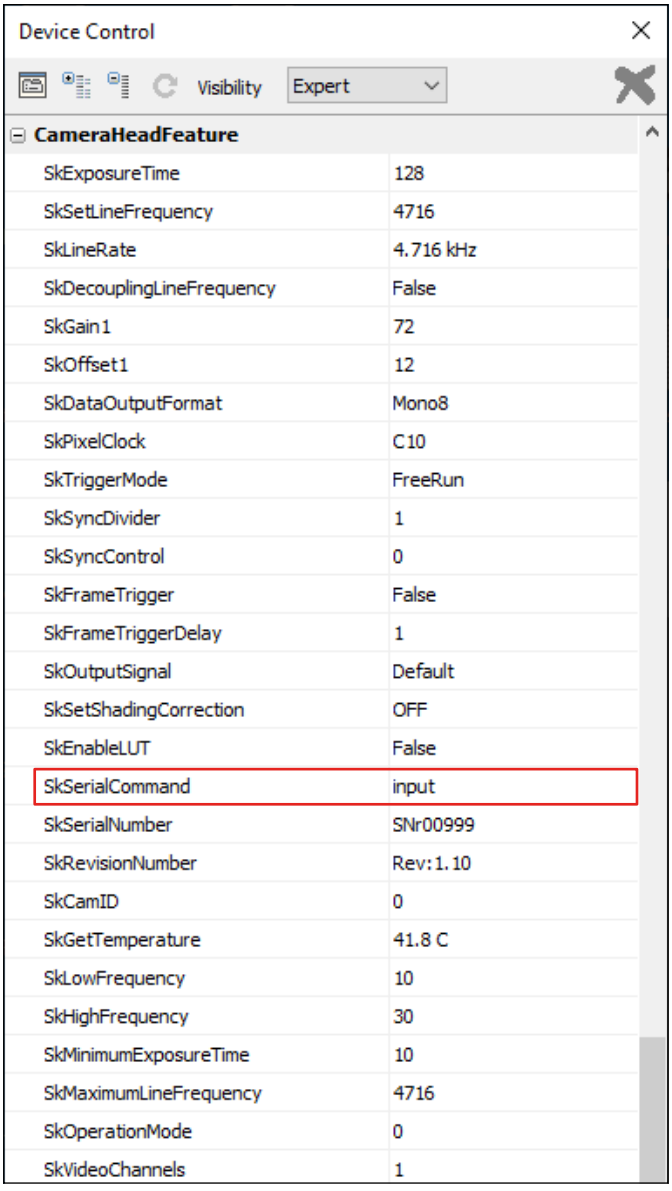
For special cases, e.g. when searching for the cause of a malfunction, a set of hardware-related serial commands is available, which are sent via the ***SkSerialCommand*** command. A distinction must be made between ***Set*** and ***Request Commands***. Included are commands to set parameters directly such as gain, offset, or trigger modes. Similarly, current parameter settings, as well as specific product information, can be read from the camera using the request commands. They are described in the two tables below.

INFO

Note that you can put the camera into an undefined state with careless use of Set Commands.

- The commands are entered in the 'Input' field in the 'Camera Head Feature' section of the "GigE Vision Device Feature List".
- The feedback is output at the same point, either the acknowledgement of a Set Command (0 = OK, 1 = not OK) or the return values of a Request Command.

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.



Serial command input: ***SkSerialCommand***

Set Commands

Set Operation	Description
G*oooo*<CR>	gain setting from 3 to 39 dB, 3+0,0538 dB/Step
O*xxx*<CR>	offset setting from 0 to 511 LSB, 0,25 LSB/Step (xxx = 0-2047)
ON*xxx*<CR>	digital negative offset (xxx = 0-2047)
F8<CR>	output format: 8 bit output data
F12<CR>	output format: 12 bit output data
C30<CR>	camera clock: 30 MHz data rate
C20<CR>	camera clock: 20 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>	line trigger mode0: free run (no triggering) at selected line rate
M1<CR>	line trigger mode1: extern trigger, next line
M2<CR>	line trigger mode0: free run (no triggering) at maximum line rate
M4<CR>	line trigger mode4: external triggering and restart
M5<CR>	line trigger mode5: extern SOS, all lines
A*xxxx*<CR>	SCM address (Axxxx = A0-A2047)
D*xxxx*<CR>	SCM memory data (*xxxx* = 0-4095), increment memory address counter
EF*yyyyy*<CR>	external frame trigger delay (*yyyyy* = 0-32767 lines)
V*yyyyy*<CR>	extern sync divider (*yyyyy* = 1-32767)
Y*pppp*<CR>	set sync control (*ppp* = 0-4095)
W*yyyyy*<CR>	line clock frequency (*yyyyy* = 50-14084) [Hz]
X*yyyyy*<CR>	exposure time (*yyyyy* = 10-20000) [µs]
SDXT<CR>	enable DXT (decoupling of line clock frequency and exposure time)
RDXT<CR>	disable DXT (decoupling of line clock frequency and exposure time)
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>	*SK2048MVSH*	returns **SK** type number
R<CR>	*Rev. 1.2*	returns **R**evision number
S<CR>	*SNr00163*	returns **S**erial number
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
I8<CR>	Of: *yyyyy*	returns offset
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)
I28<CR>	TSc: *yyyyy*	returns Sync Divider
I29<CR>	SyC: *yyyyy*	returns Sync Control
I31<CR>	DXT: *yyyyy*	returns DXT on/off
I32<CR>	Tmp: *yyyyy*	returns Video Board Temper.
I33<CR>	FSD: *yyyyy*	returns Frame Trigger Delay
I38<CR>	LUT: *yyyyy*	returns LUT on/off
I39<CR>	KST: *yyyyy*	returns Status
I41<CR>	DNO: *yyyyy*	returns digital negative offset
I42<CR>	KNr: *yyyyy*	camera identification readout
I43<CR>	VD2: *yyyyy*	returns CCD driver voltage VD2 (1=10mV)

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

5.2 Advanced Synchronization Control

The basic synchronization function makes use of the trigger input LINE SYNC A. The trigger mode is determined by the settings in the 'Camera Control' dialog, e.g. LineStart (1) or ExposureStart (4).

Advanced trigger functions are provided by combining LINE SYNC A with a second trigger input LINE SYNC B. The operation mode is controlled by the entries in the **Sync Control Register (SCR)**.

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

Y*ppp*<CR> **set SCR** 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 (SCR) Settings

- Basic synchronization function, 'Camera Control' dialog settings are valid → A
- Detection of direction → B, C, D, E
- Trigger pulses are valid only in one direction, trigger pulses in the other direction are ignored → B
- Trigger on 4 edges → D, E
- Suppression of jitter in the encoder signal, programmable hysteresis for trigger control → E

Sync Control Register (SCR)	SyC7	SyC6	SyC5	SyC4	SyC3	SyC2	SyC1	SyC0
default	x	x	x	x	x	x	0	0
pixel #1 data = external trigger input states	x	x	x	x	x	x	0	1
pixel #1 data = Linecounter (8 bit)	x	x	x	x	x	x	1	0
pixel #1, #2 data = ext. trigger states (3 bit) + line counter (13 bit)	x	x	x	x	x	x	1	1
ExSOS and Sync at LINE SYNC A (Mode5)	x	x	x	x	x	0	x	x
ExSOS at LINE SYNC B, Sync at LINE SYNC A (Mode5)	x	x	x	x	x	1	x	x
Jitter Hysterese off	x	x	x	0	0	x	x	x
Jitter Hysterese 4	x	x	x	0	1	x	x	x
Jitter Hysterese 16	x	x	x	1	0	x	x	x
Jitter Hysterese 64	x	x	x	1	1	x	x	x
Sync 1x Enable	x	x	0	x	x	x	x	x
Sync 4x Enable	x	x	1	x	x	x	x	x
Sync up Enable / down disable	x	0	x	x	x	x	x	x
Sync up/down Enable	x	1	x	x	x	x	x	x
Sync Ctrl. Disable, SyC3...SyC6 without function	0	x	x	x	x	x	x	x
Sync Control Enable	1	x	x	x	x	x	x	x
	128	64	32	16	8	4	2	1

For diagnostic purposes, the present state of external trigger inputs (LINE SYNC A, LINE SYNC B, FRAME SYNC) or the internal line counter can be output instead of pixel #1 and/or pixel #2 data.

SCR	Pixel #1 Data (lowByte)	Pixel #2 Data (lowByte)
*xxxxxx*00	intensity	intensity
*xxxxxx*01	D7 = FRAME SYNC D6 = LINE SYNC B D5 = LINE SYNC A D4 ... D0 = 0	intensity
*xxxxxx*10	internal line counter (8 bit)	intensity
*xxxxxx*11	D7 ... D0 = line counter (bit 15 ... 8)	internal line counter (bit 7 ... 0)

The internal line counter is reset by the FRAME SYNC trigger signal.

Example Timing Diagrams

Annotations:

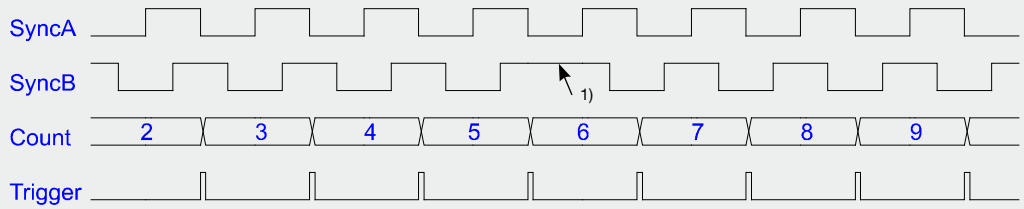
SyncA = LINE SYNC A (external line synchronization input, I/O connector)
SyncB = LINE SYNC B (external line synchronization input, I/O connector)
Count = internal counter
Trigger = Generated trigger pulses from the Trigger Control stage. The signal goes to the Trigger Divider stage inside the camera. For setting the divider, use the V*yyyyy*<CR> command or the 'Divider' input field in the ***5.1 Camera Control by Commands (p. 22)***.

1) direction changed
2) glitch

A

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

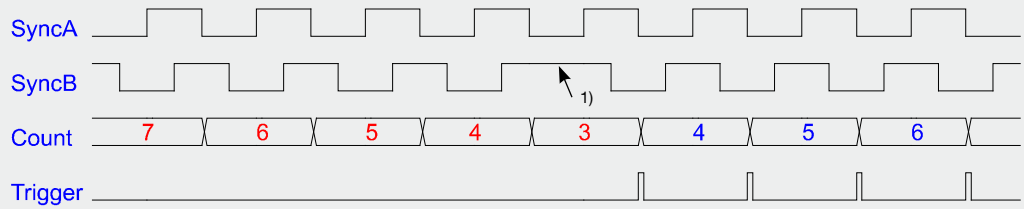
Sync Control Register: '0xxx xxxx'b



B

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

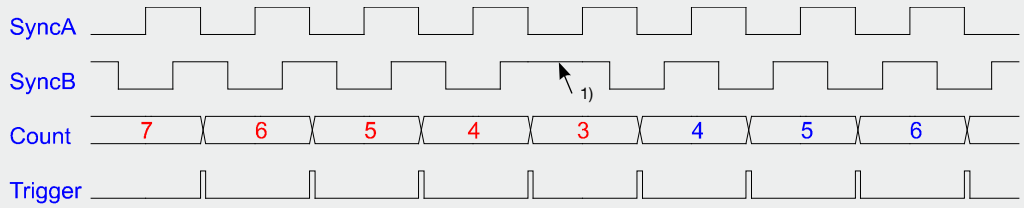
Sync Control Register: '1000 0xxx'b



C

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

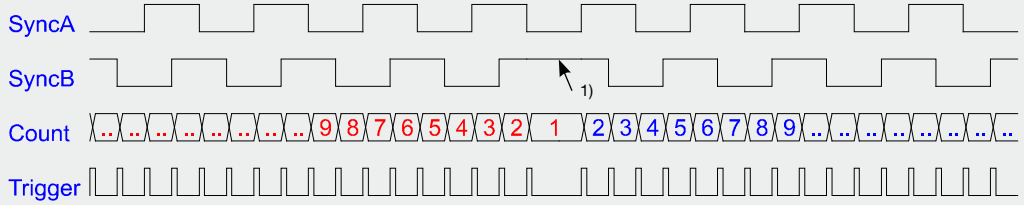
Sync Control Register: '1100 0xxx'b



D

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

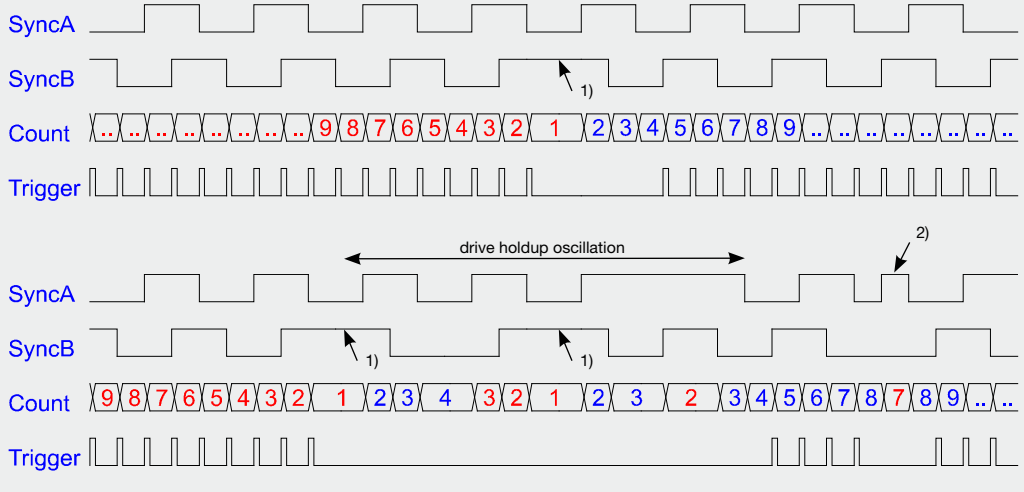
Sync Control Register: '1110 0xxx'b



E

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

Sync Control Register: '1110 1xxx'b



6 Sensor Information

Manufacturer: Hamamatsu

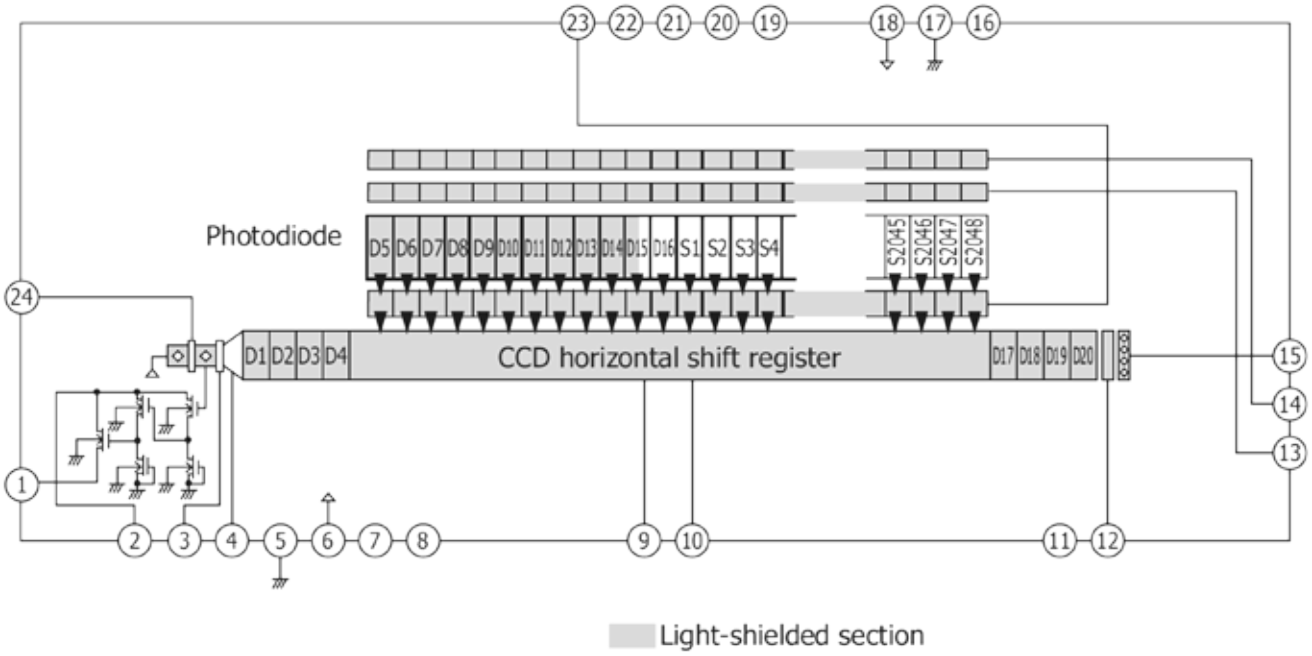
Type: S12551-2048

Data source: Hamamatsu CCD linear image sensor S12551-2048
Cat. No. KMPD1147E04 Oct. 2016 DN

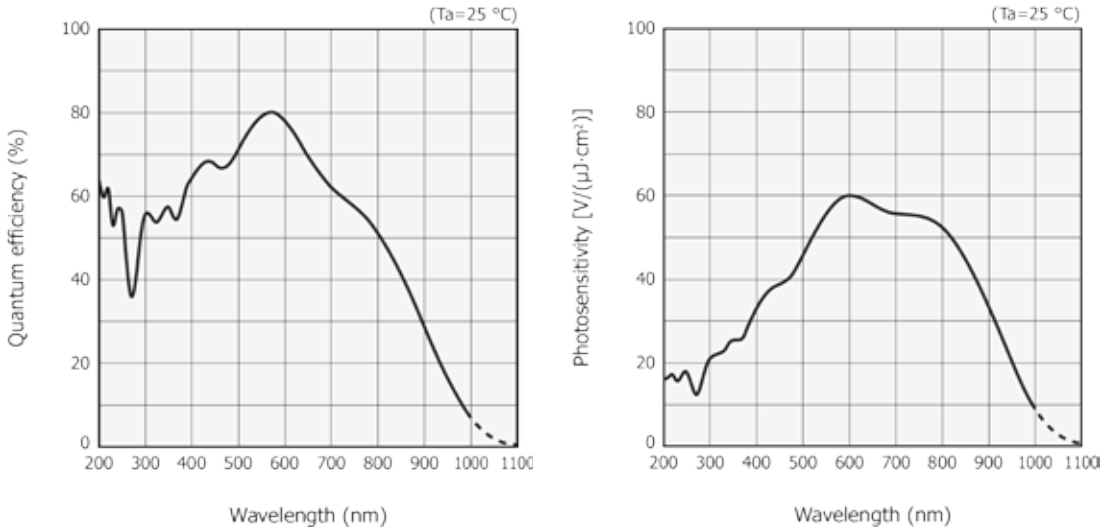
a) Features

- 2048 pixels, pixel size: 14 x 14 µm
- High CCD node sensitivity: 13 µV/e^- typ.
- Readout speed: 40 MHz max.
- Anti-blooming function
- Built-in electronic shutter

b) Device Structure (conceptual drawing)

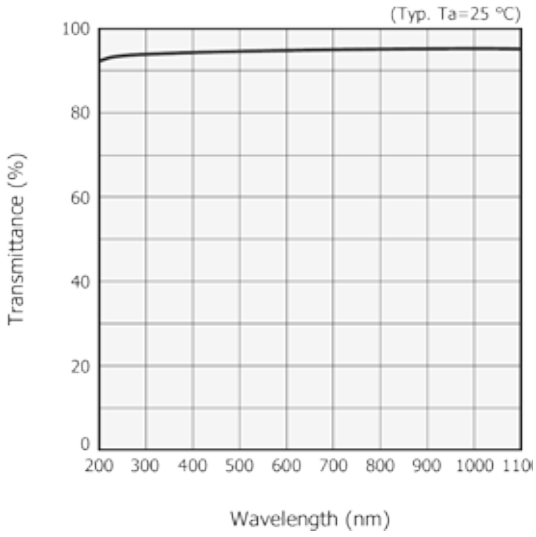


c) Spectral Response (without window, typical example)



Spectral response with quartz glass is decreased according to the spectral transmittance characteristics of window material.

d) Spectral Transmittance Characteristics of Window Material



e) Electrical and Optical Characteristics (Ta = 25°C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Saturation output voltage	Vsat	-	Fw × CE	-	V
Full well capacity	Fw	70	100	-	ke⁻
Conversion efficiency	CE	11	13	15	μV/e⁻
Dark current (maximum of all effective pixels)	ID max	-	15	75	e⁻/pixel/ms
Readout noise*7	Nread	-	40	60	e⁻ rms
Dynamic range*8	Drange	1167	2500	-	-
Spectral response range	λ	-	200 to 1000	-	nm
Photoresponse nonuniformity*9 *10	PRNU	-	±3	±10	%
Image lag*9	Lag	-	0.1	1	%

*6: Dark current is reduced to half for every 5 to 7 °C decrease in temperature.
*7: Readout frequency 40 MHz
*8: Dynamic range = Full well capacity / Readout noise
*9: Measured at one-half of the saturation output (full well capacity) using LED light (peak emission wavelength: 470 nm)
*10: Photoresponse nonuniformity = $\frac{\text{Fixed pattern noise (peak to peak)}}{\text{Signal}} \times 100\ [\%]$

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

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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