C5 Series

User Manual

for High Speed 3D Cameras

Rev 1.6

AT - Automation Technology GmbH

Automation Technology

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General Notes

Copyright

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Trademarks

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Symbols and Notes

The following general safety rules must be taken into account during installation, operation and maintenance. Failure to do so may cause damage to the operator, the camera or the environment.

Warning

- Do not use the camera in adverse environmental conditions, such as in rooms with a high concentration of flammable gases, vapors or dust.
- Make sure that all cables are routed without risk of tripping.
- Only connect the power cord to the mains voltage after finishing the installation of the camera.

Read the manual

- Read the operating instructions before using the camera.
- Make sure that the operating personnel have read the operating instructions and understood the contents!
- Observe the safety instructions.
- Observe the locally applicable safety and accident prevention regulations.
- In case of any uncertainty contact the manufacturer.

CE marking, see Declaration of Conformity

RoHS RoHS mark, the system complies with RoHS Directive 2002/95 / EG

WEEE mark, the system is registered according to the WEEE directive under the WEEE-Reg.-No. DE 13042735

Safety information

General remark

Maintenance Instructions

Cleaning

The camera is maintenance-free. This chapter is limited to cleaning the camera. Use only the following items:

- Water
- Residue-free, weak detergent solution
- Soft cloth
- Lens cleaner liquid or 96% ethyl alcohol
- Lens cleaning cloths

Clean the camera with the wetted, non-dripping cloth. Don´t expose the camera to running liquids or immerse it.

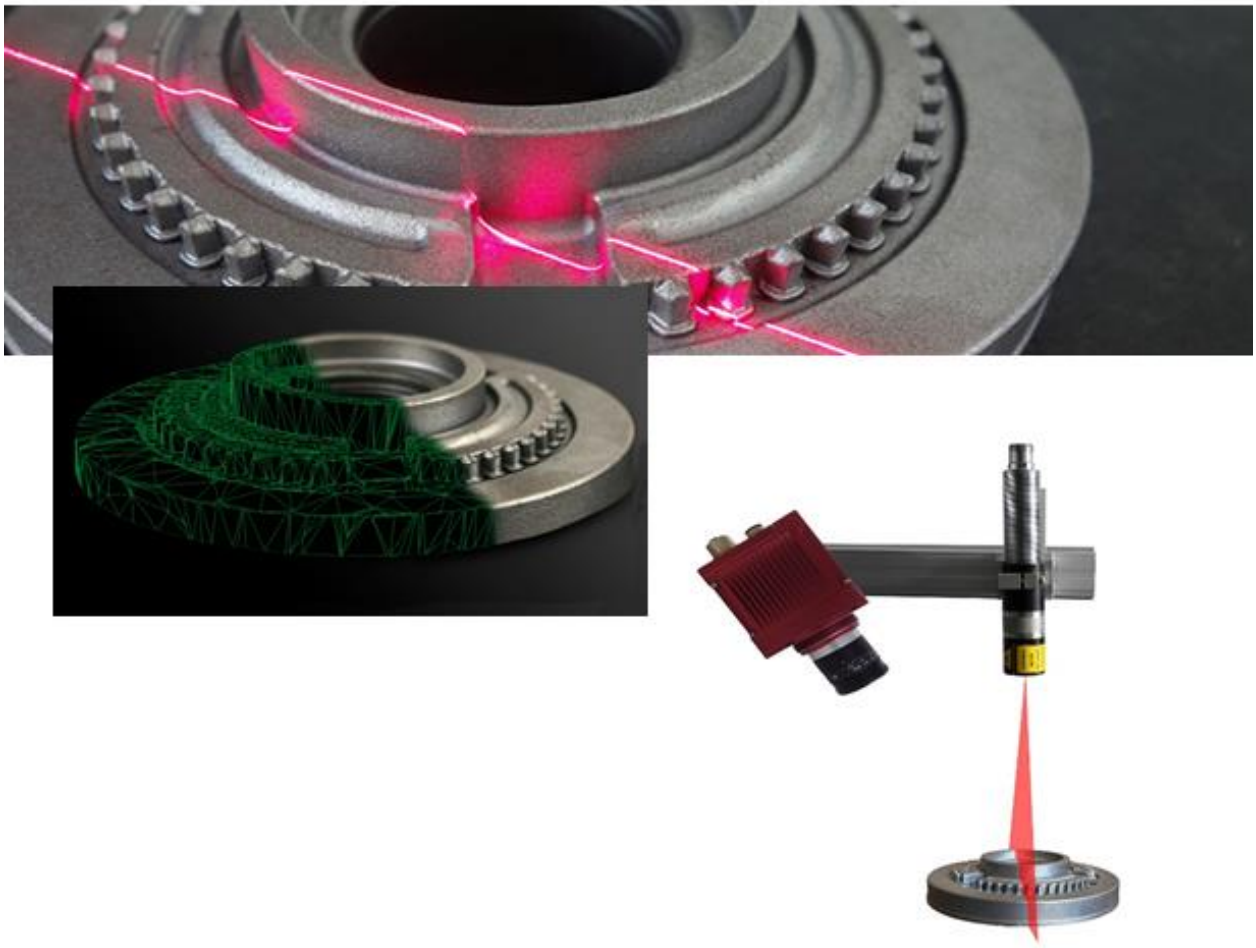
If the sensor is dirty, it must only be cleaned by authorized specialist personnel. Unscrew the optics only when absolutely necessary and within a clean environment. Hold the camera with the sensor facing down.

Never use solvents or similar liquids to clean the camera, cables or accessories. This can lead to damage.

C5 Series Overview

Introduction

The C5 series is a revolutionary product family of intelligent high speed sensors. It is optimised for 3D profile measurement by means of laser triangulation technique. The 3D profile extraction is performed in the camera by using high performance Field Programmable Gate Array processors. At the same time the 3D profile data is sent to the PC over a Gigabit Ethernet interface (GigE). This extreme data reduction boosts the measuring speed to unprecedented levels without affecting the performance of the connected image processing unit.



The C5 Series General Specifications

Sensor Controls	
Synchronization Modes	Free Running, Triggered, Software Triggered
Exposure Modes	Programmable, Pulse Controlled
Shutter Modes	Global Shutter
Digital Input	2 electrical isolated inputs, +5V to +24V DC VIL, logic "0" Voltage < 1.5V VIH, logic "1" Voltage > 3.5V Max. frequency: 450 kHz Min. pulse width: >2µs
Digital Output	2 electrical isolated outputs, +5 to +24V DC VOL, logic "0" Voltage < 0.5V VOH, logic "1" Voltage ≥ 3.8V IOL, logic "0" drive current max. 100 mA IOH, logic "1" drive current max. 100 mA
Analog Output	Range: 0V to +5V DC
Encoder/Resolver Input[1]	A+, A-, B+, B-, Z+, Z- High-Speed Triple RS-422 Receiver Max. input voltage +5V DC (TTL level) Max. current consumption per channel: 21mA RS-422-Mode, max. frequency: 15 MHz Min. pulse width: >32ns
Sensor Features	
High Dynamic Range Imaging	Multiple Slope, Multi-Frame Readout
3D-Algorithms	MAX, TRSH, COG, FIR PEAK
3D-Scan Features	Automatic AOI-Tracking, Automatic AOI-Search, Multiple AOIs, AutoStart
Optical Interface	
Lens Mount	M42x1 with flange focal distance 6.52 mm
Adapter for C-Mount lens[2]	With flange focal distance 17.52 mm
Adapter for Nikon F-Mount lens with Bayonet mount[1]	With flange focal distance 46.50 mm
Adapter for Scheimpflug[1]	For C-Mount lens

[1] Valid for differential TTL (standard). For HTL and single ended options see section **The C5 Series I/O Schematics**

[2] Must be ordered separately. See section **Part Number for Scheimpflug Adapter Option**

Electrical Interface		
Camera Supply	+10V to +24V DC (max. +27V DC)	
Power consumption	6 W to 10 W (depending on camera type)	
Operating Temperature	0°C to +50°C (non-condensing)	
Output Data Interface	Gigabit Ethernet (IEEE 802.3)	
Communication Protocol	GigE Vision with GenICam	
Mechanical Interface		
Camera Size	55 mm x 55 mm x 66 mm	
Mass (without optics)	250 g	
Power connector	17 pin, M12 connector	
Ethernet connector	8 pin, A-coded M12 connector	
Mechanical Stress Specification		
Vibration (sinusoidal each axis)	1 g, 10…2000Hz	IEC 60068-2-6
Vibration (random each axis)	5 g, 5…1000Hz	IEC 60068-2-64
Shock (each axis)	50 g	IEC 60068-2-27
Enclosure rating	IP67	IEC 60529

The Sensor Specifications

C5-1280-GigE

Parameters	**Specifications**		
Responsivity	9.6 V/lux.s		
Shutter Type	Pipelined Global Shutter		
QE * FF	55% @ 525 nm		
Resolution (H x V)	1280 x 1024 pixels		
Pixel Size	6.6 µm x 6.6 µm		
Sensor Size	8.448 mm x 6.758 mm, diagonal: 10.82 mm		
Optical Format	2/3"		
Power Consumption	10 W		
ADC Resolution	12 bit		
Dynamic Range	57 dB		
Extended Dynamic Range	Up to 90dB with HDR		
Max. Internal Full-Frame Rate for Image Mode	288 fps		
Max. External Full-Frame Rate for Image Mode (limited due to GigE bandwidth)	94 fps		
Effective Profile Rate (Hz) at max. Row Width[1]	Number of Rows	Effective Frame / Profile Rate (Hz)	
		1280 Pixel	688 Pixel[2]
	8	94737	155172
	16	56040	95744
	32	30843	54216
	64	16240	29032
	128	8341	15050
	256	4228	7666
	512	2128	3870
	1024	1068	1943

[1] With a PRSNTwidth = 45

[2] C5-1280-GigE can reduce the sensor width to increase the profile rate

C5-2040-GigE

Parameters	**Specifications**	
Responsivity	5.56 V/lux.s 0.27 A/W	With micro lens @ 550 nm
Shutter Type	Pipelined Global Shutter	
QE * FF	60% @ 550 nm	
Resolution (H x V)	2048 x 1088 pixels	
Pixel Size	5.5 µm x 5.5 µm	
Sensor Size	11.264 mm x 5.984 mm, diagonal: 12.75 mm	
Optical Format	2/3"	
Power Consumption	6 W	
ADC Resolution	10 bit	
Dynamic Range	60 dB	
Extended Dynamic Range	Up to 90dB with HDR	
Max. Internal Full-Frame Rate for Image Mode[1]	170 fps	
Max. External Full-Frame Rate for Image Mode[2] (limited due to GigE bandwidth)	50 fps	
Effective Profile Rate (Hz) at max. Row Width[3]	Number of Rows	Effective Frame / Profile Rate (Hz)
	8 16 32 64 128 256 512 1088	25641 16667 9709 5291 2770 1418 718 340

[1] With Acquisition Mode „Multiple Frame" and Pixel Format "Mono8"

[2] With Pixel Format "Mono8"

[3] With a FOT (Frame Overhead Time) = 3

C5-2040-4M-GigE

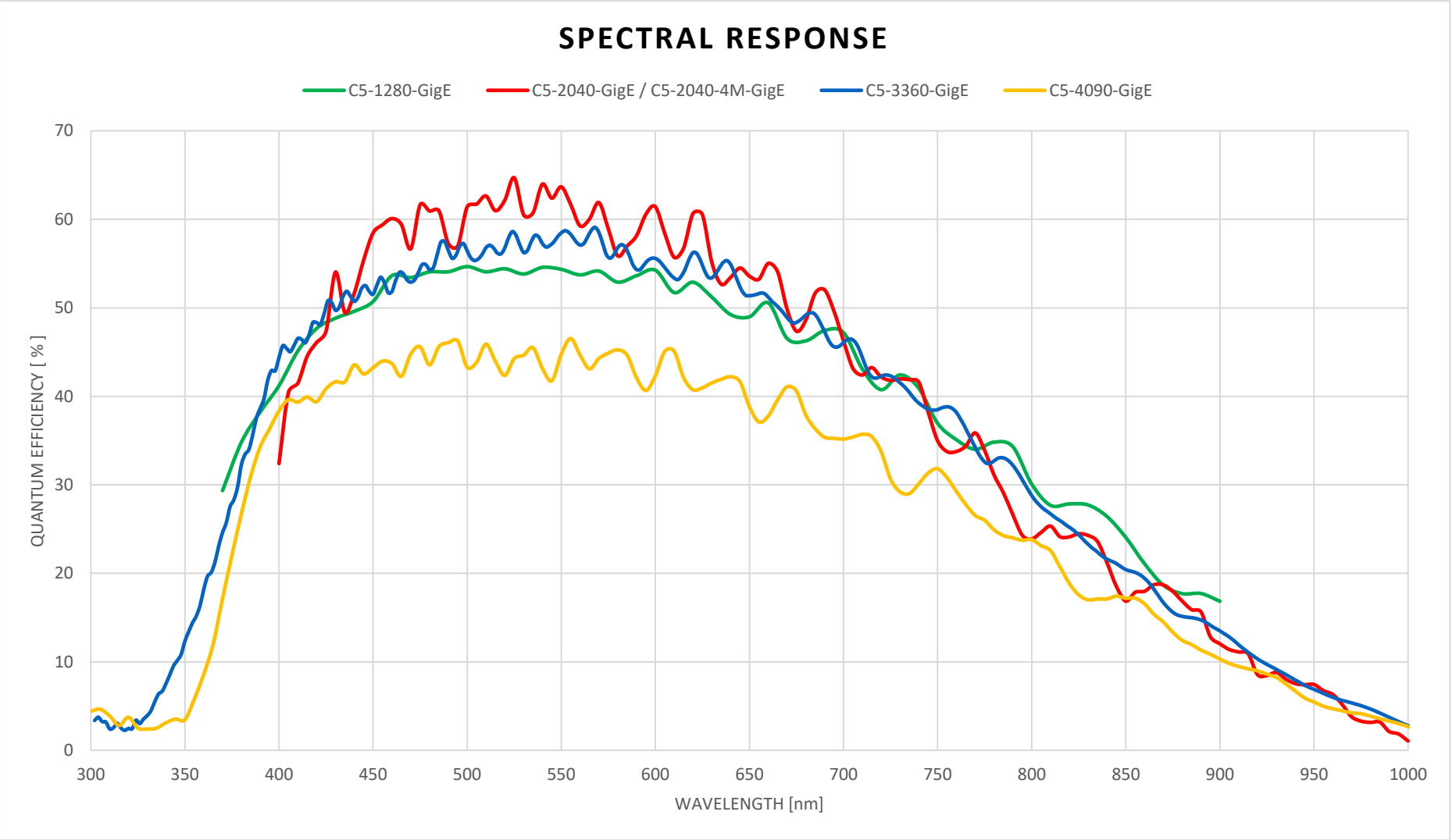
Parameters	**Specifications**	
Responsivity	5.56 V/lux.s 0.27 A/W	With micro lens @ 550 nm
Shutter Type	Pipelined Global Shutter	
QE * FF	60% @ 550 nm	
Resolution (H x V)	2048 x 2048 pixels	
Pixel Size	5.5 µm x 5.5 µm	
Sensor Size	11.264 mm x 11.264 mm, diagonal: 15.93 mm	
Optical Format	1"	
Power Consumption	8 W	
ADC Resolution	10 bit	
Dynamic Range	60 dB	
Extended Dynamic Range	Up to 90dB with HDR	
Max. Internal Full-Frame Rate for Image Mode	90 fps	
Max. External Full-Frame Rate for Image Mode (limited due to GigE bandwidth)	25 fps	
Effective Profile Rate (Hz) at max. Row Width[1]	Number of Rows	Effective Frame / Profile Rate (Hz)
	8	25641
	16	16667
	32	9709
	64	5291
	128	2770
	256	1418
	512	718
	1088	340
	2048	180

[1] With a FOT (Frame Overhead Time) = 3

C5-4090-GigE

Parameters	**Specifications**	
Responsivity	4.64 V/lux.s 0.22 A/W	With micro lens @ 550 nm
Shutter Type	Pipelined Global Shutter	
QE * FF	50% @ 550 nm	
Resolution (H x V)	4096 x 3072 pixels	
Pixel Size	5.5 µm x 5.5 µm	
Sensor Size	22.528 mm x 16.896 mm, diagonal: 28.16 mm	
Optical Format	4/3"	
Power Consumption	10 W	
ADC Resolution	10 bit	
Dynamic Range	60 dB	
Extended Dynamic Range	Up to 90dB with HDR	
Max. Internal Full-Frame Rate for Image Mode	32 fps	
Max. External Full-Frame Rate for Image Mode (limited due to GigE bandwidth)	9 fps	
Effective Profile Rate (Hz) at max. Row Width	Number of Rows	Effective Frame / Profile Rate (Hz)
	8 16 32 64 128 256 512 1024 2048 3072	14493 9709 5814 3226 1709 881 447 225 113 76

The Sensors Spectral Response



Temperature Range (Operation/Storage)

Housing temperature during operation:	0 °C to +50 °C (+32 °F to +122 °F)
Mainboard temperature during operation:	0 °C to +60 °C (+32 °F to +140 °F)
Humidity during operation:	20 % to 80 %, relative, non-condensing
Storage temperature:	-20 °C to +80 °C (-4 °F to +176 °F)
Storage humidity:	20 % to 80 %, relative, non-condensing

The temperature affects the lifetime of the C5 camera. We recommend to ensure a proper heat dissipation.

Heat Dissipation

The operation of the C5 camera requires sufficient heat dissipation. Depending on the environmental conditions the sensor housing may not provide a sufficient cooling surface to dissipate the thermal power loss, which is generated by the core electronics and the sensor chip.

All 3D cameras of the C5 series feature high-speed CMOS sensor chips. A typical property of a CMOS sensor is that it provides best image quality by low temperatures. High temperatures will lead to an increase of dark current, noise and hence to a reduction of signal-to-noise ratio (SNR).

To eliminate these effects, it is often sufficient to mount the C5 sensor on a heat conductive material, such as a metal surface.

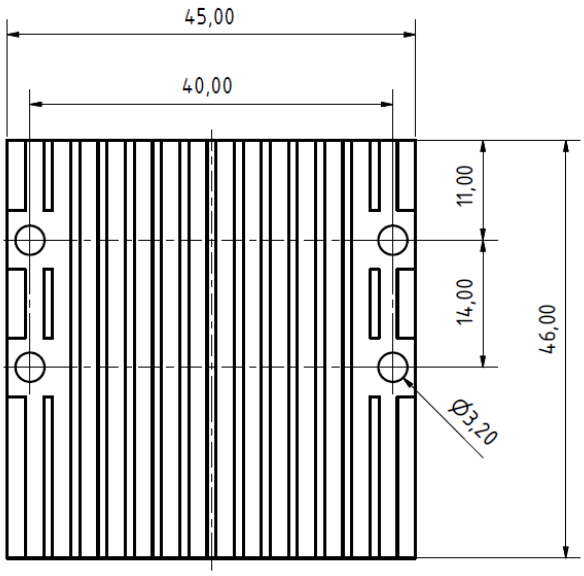
In case that it is not possible to mount the camera on any heat dissipating carrier, then it is recommended to use a heat sink with the required specification of AT.

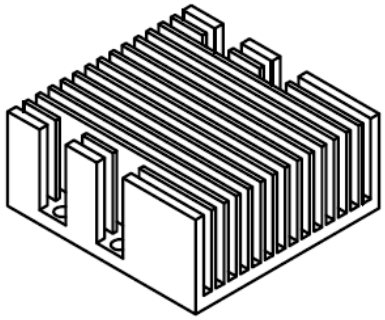
General Guidelines for Heat Dissipation

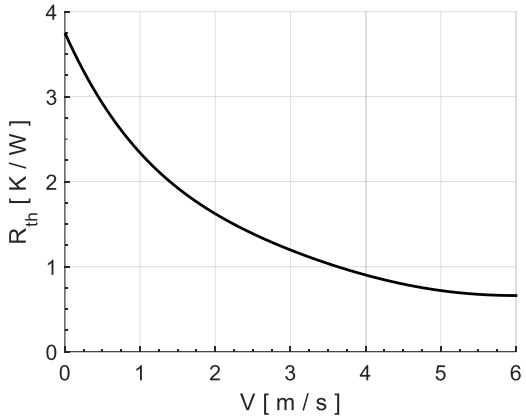
- Mount the 3D camera to a heat conductive material with an absolute thermal resistance of at least 6 K / W.
- Always monitor the temperature of the sensor (on-board, available over GenICam) and make sure that the temperature does not exceed 60 °C.
- Keep in mind that dark current and noise performance for CMOS sensor will degrade at higher temperature.
- The 3D camera of the C5 series will gradually become warmer during the first hour of operation. After one hour of operation, the housing temperature as well as the sensor temperature should be stable and no longer increase.

Using the C5 Heat Sink

AT provide a specially designed heat sink to improve the cooling of C5 cameras in applications lacking sufficient thermal dissipation.





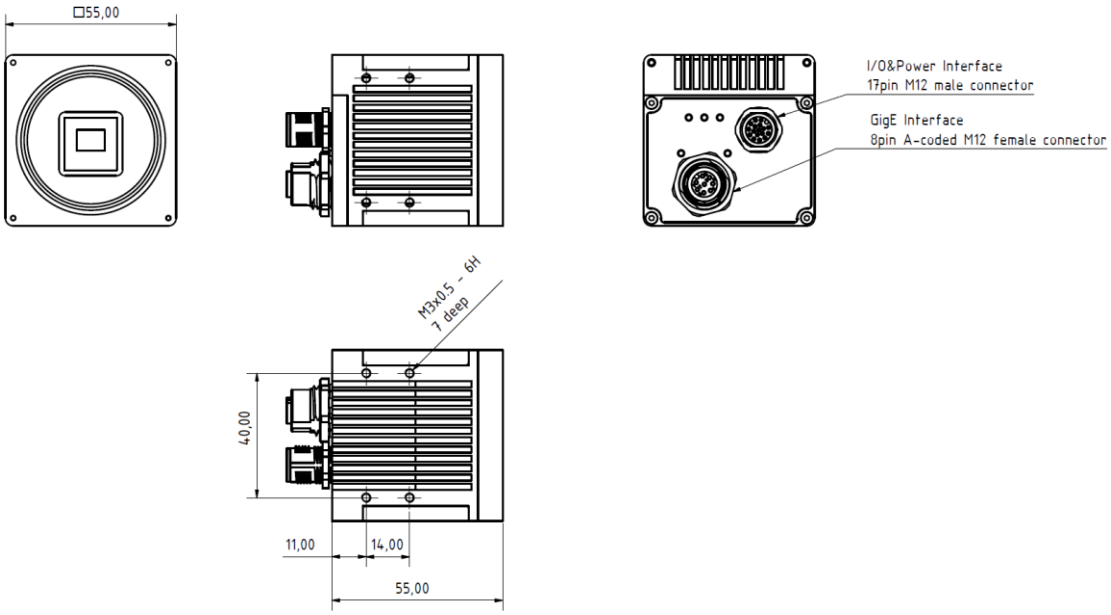


Absolute thermal resistance for camera housing: R_{th} = 5 [K / W]

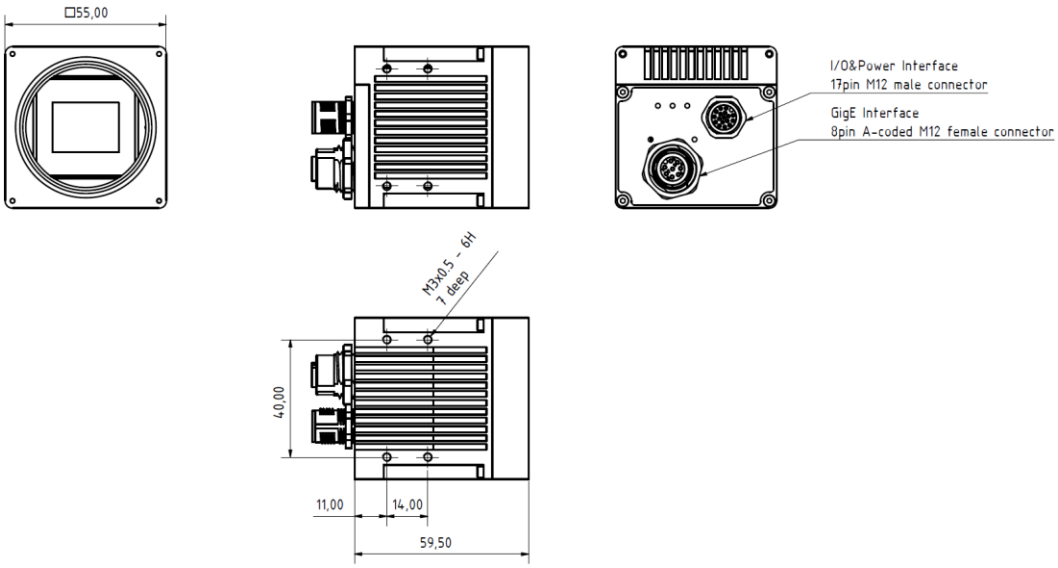
Absolute thermal resistance for heat sink: R_{th} = 3.75 [K / W]

Mechanical Drawings

C5-1280/2040/2040-4M-GigE with M42x1 mount (Standard)



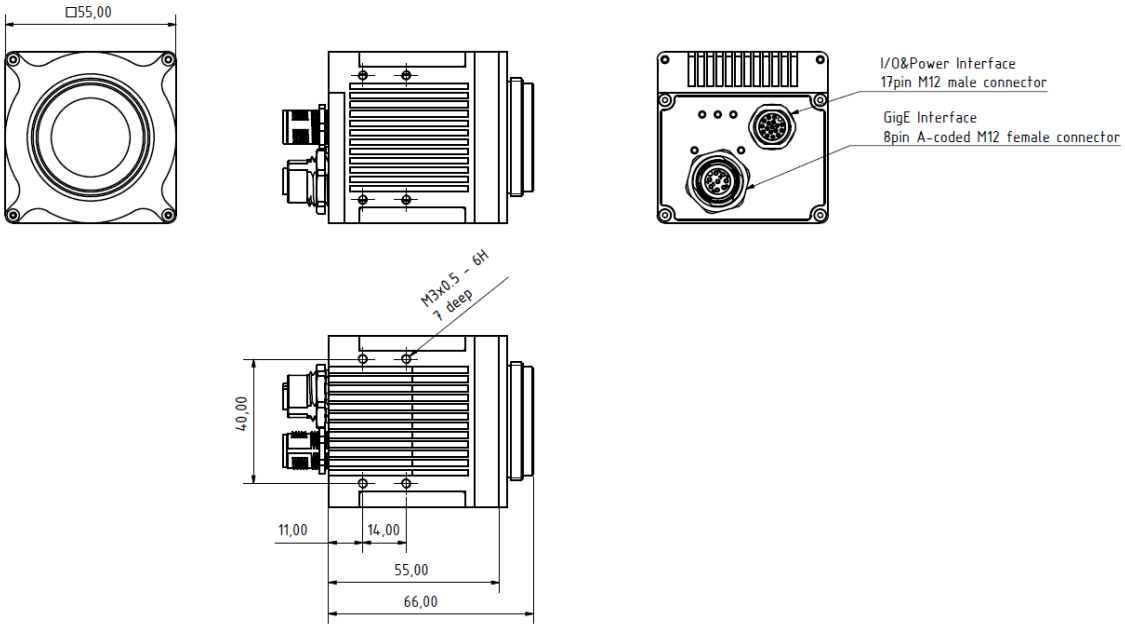
C5-4090-GigE with M42x1 mount (Standard)



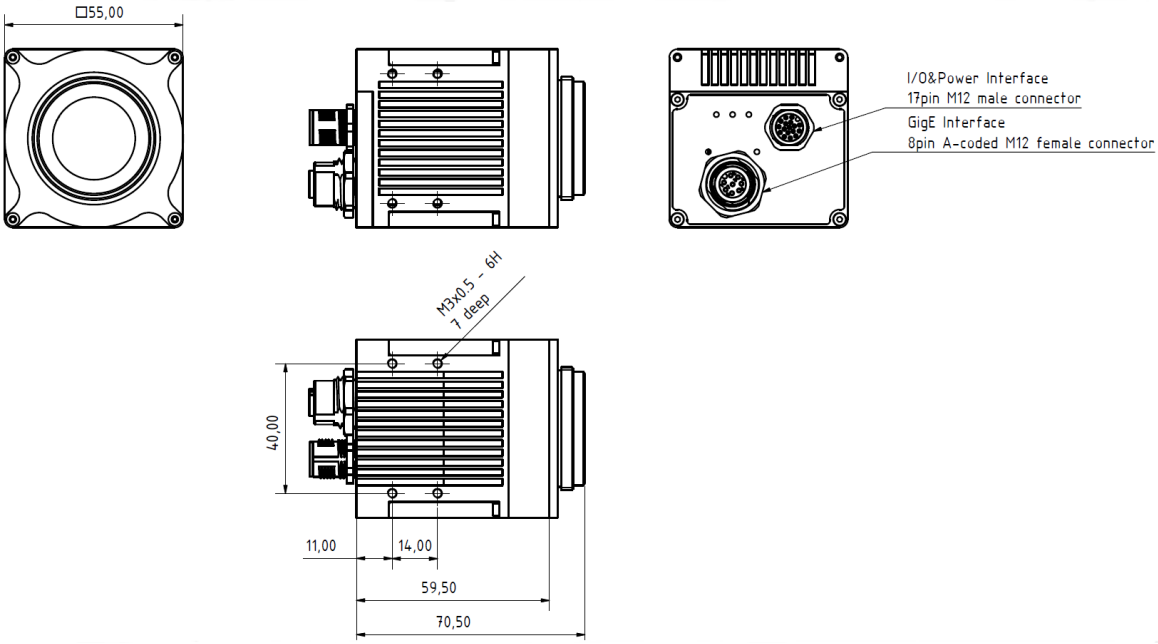
Part Number for C5 Series

Part Number #	Product Name
202 203 002	C5-4090-GigE, lens mount M42x1
202 203 003	C5-2040-GigE, lens mount M42x1
202 203 004	C5-2040-4M-GigE, lens mount M42x1
202 203 005	C5-1280-GigE, lens mount M42x1

C5-1280/2040/2040-4M-GigE with C-Mount Adapter (Option)



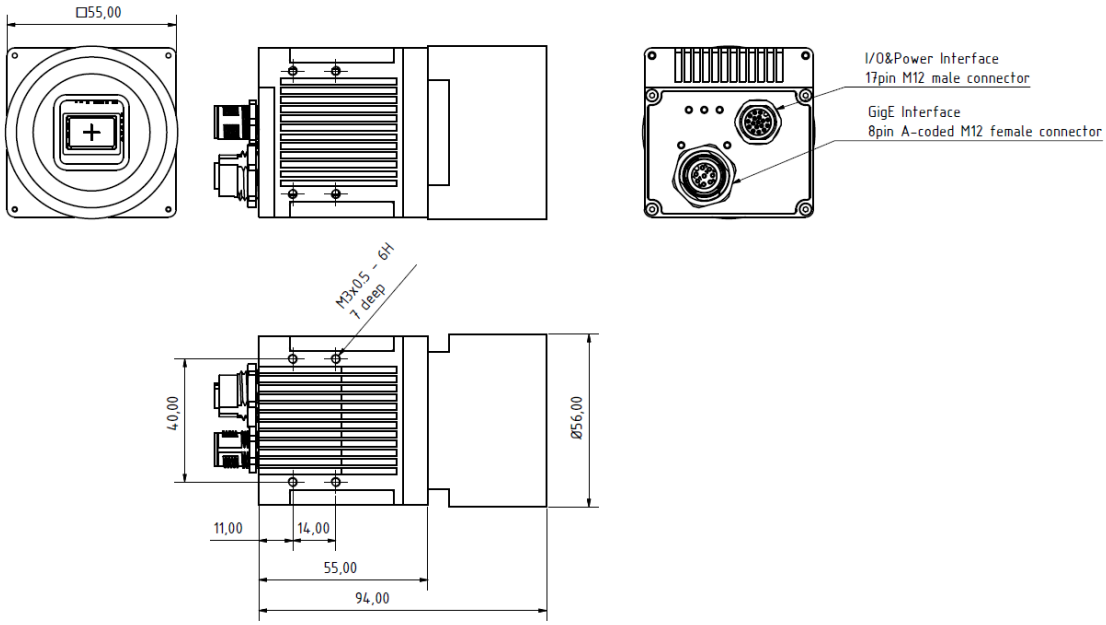
C5-4090-GigE with C-Mount Adapter (Option)



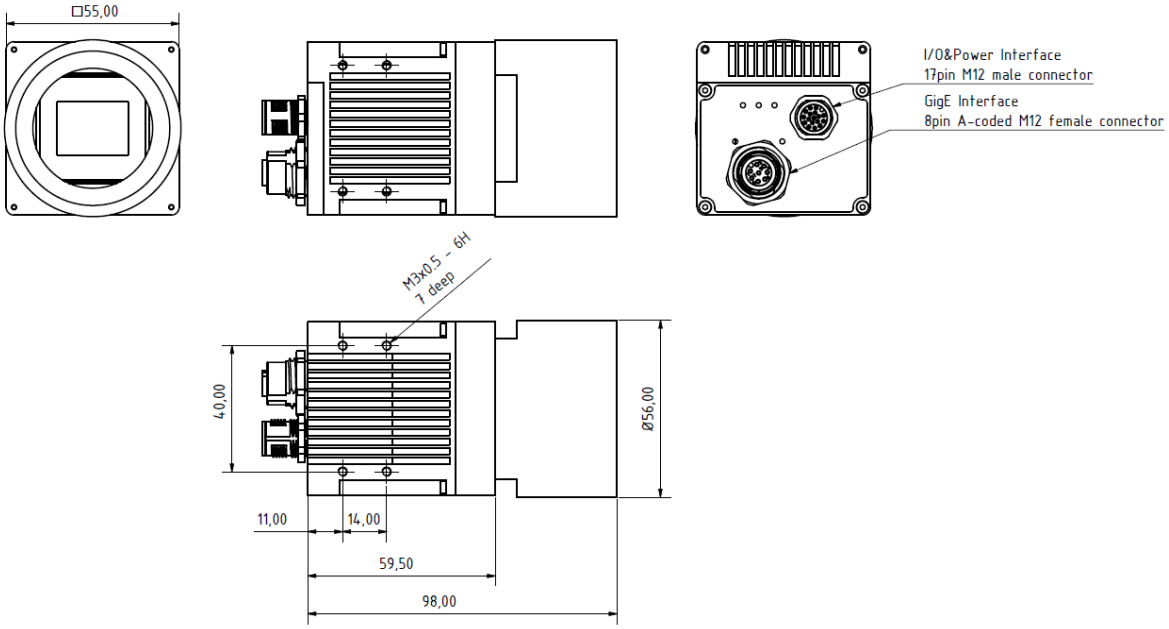
Part Number for C-Mount Adapter Option

Part Number #	Product Name
202 188 001	C5 C-Mount: M42x1 adapter with thread for lens protective cover to use with C-Mount type lens, for C5-4090-GigE
202 188 002	C5 C-Mount: M42x1 adapter with thread for lens protective cover to use with C-Mount type lens, for C5-1280-GigE / C5-2040-GigE / C5-2040-4M-GigE

C5-1280/2040/2040-4M-GigE with F-Mount Adapter (Option)



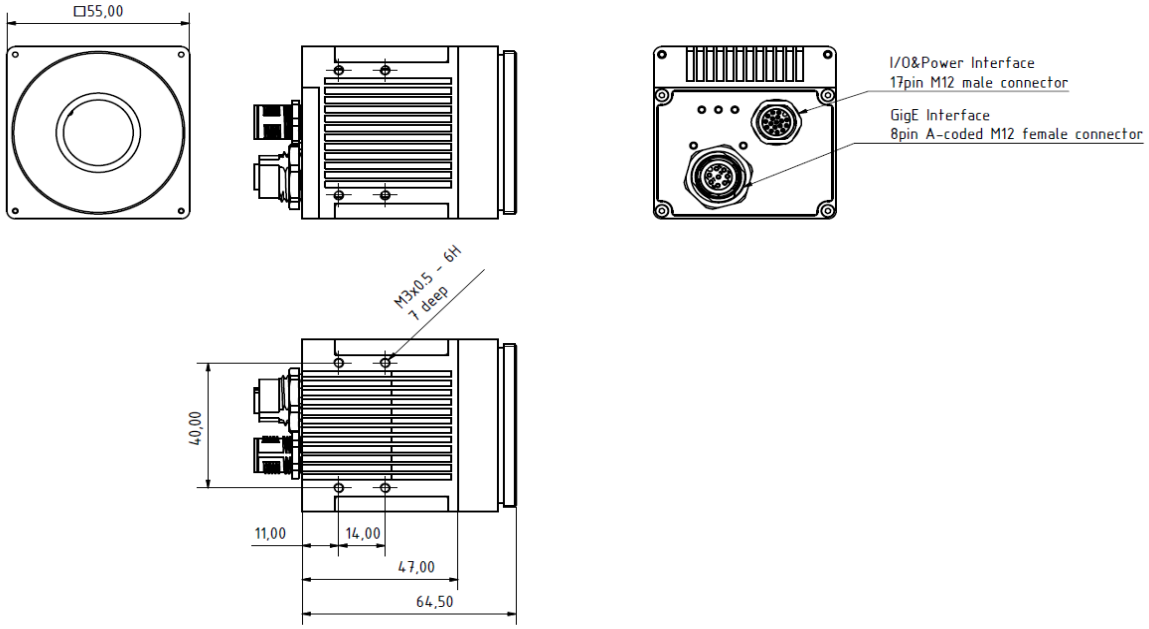
C5-4090-GigE with F-Mount Adapter (Option)



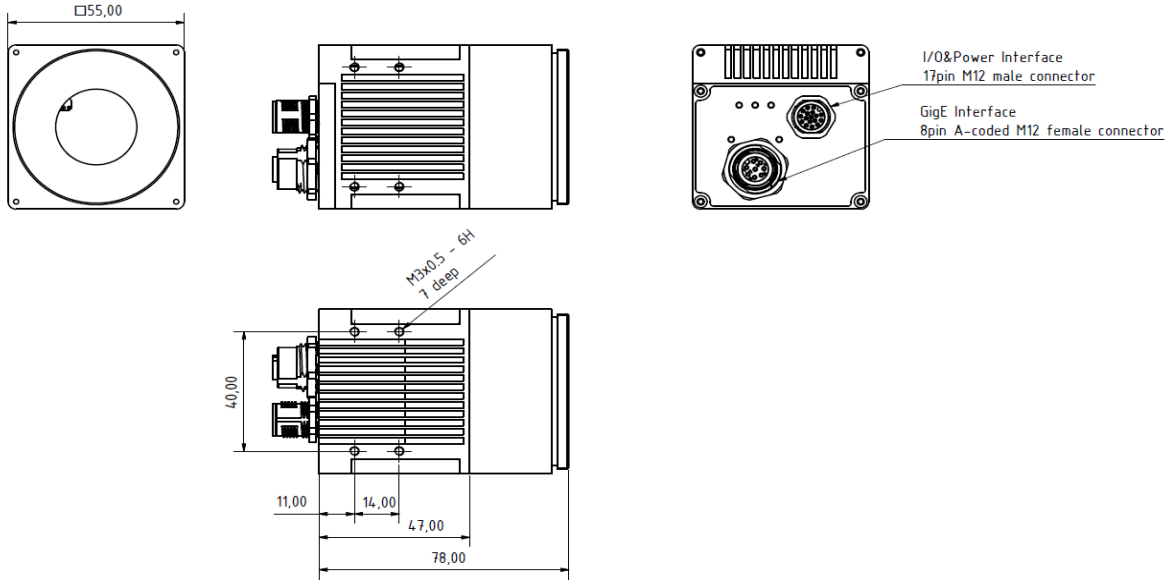
Part Number for F-Mount Adapter Option

Part Number #	Product Name
202 182 011	C4/C5 F-Mount: M42x1 adapter to use with Nikon-F Bayonet type lens

C5-1280/2040/2040-4M-GigE with integrated Scheimpflug Adapter (Option)[1]



C5-4090-GigE with integrated Scheimpflug Adapter (Option)



[1] For C5-1280-GigE with C5 Scheimpflug adapter 35° housing from C5-4090-GigE with integrated Scheimpflug adapter is used.

Part Number for Scheimpflug Adapter Option

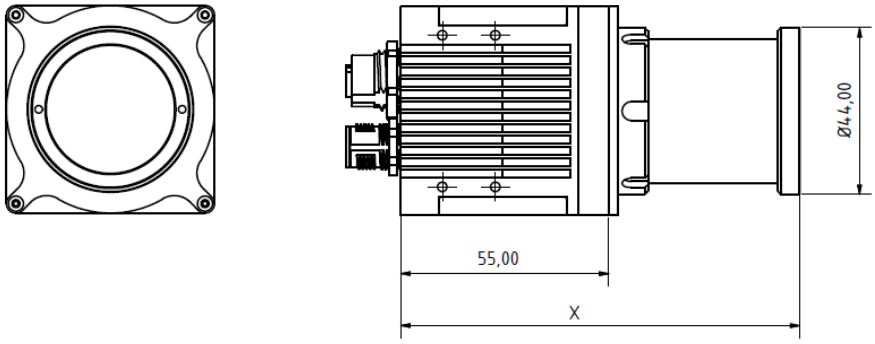
Part Number #	Product Name
202 186 027	C5 Scheimpflug-Adapter 0° with C-Mount, for C5-1280-GigE/C5-2040-GigE/C5-2040-4M-GigE
202 186 025	C5 Scheimpflug-Adapter 2.4° with C-Mount, for C5-1280-GigE/C5-2040-GigE/C5-2040-4M-GigE
202 186 024	C5 Scheimpflug-Adapter 8.5° with C-Mount, for C5-1280-GigE/C5-2040-GigE/C5-2040-4M-GigE
202 186 023	C5 Scheimpflug-Adapter 10° with C-Mount, for C5-1280-GigE
202 186 022[1]	C5 Scheimpflug-Adapter 35° with C-Mount, for C5-1280-GigE
202 186 021	C5 Scheimpflug-Adapter 5° with C-Mount, for C5-2040-GigE/C5-2040-4M-GigE
202 186 015	C5 Scheimpflug-Adapter 10° with C-Mount, for C5-2040-GigE/C5-2040-4M-GigE
202 186 014	C5 Scheimpflug-Adapter 25° with C-Mount, for C5-2040-GigE/C5-2040-4M-GigE
202 186 020	C5 Scheimpflug-Adapter 30° with C-Mount, for C5-2040-GigE/C5-2040-4M-GigE
202 186 016	C5 Scheimpflug-Adapter 35° with C-Mount, for C5-2040-GigE/C5-2040-4M-GigE
202 186 026	C5 Scheimpflug-Adapter 0° with C-Mount, for C5-4090-GigE
202 186 011	C5 Scheimpflug-Adapter 10° with C-Mount, for C5-4090-GigE
202 186 010	C5 Scheimpflug-Adapter 25° with C-Mount, for C5-4090-GigE

[1] Housing from C5-4090-GigE with integrated Scheimpflug adapter is used.

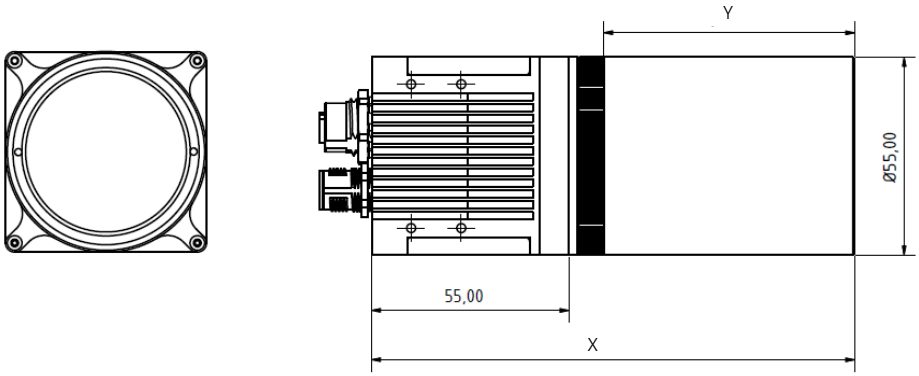
Lens Protection Tubes for the C5 Series

The C5 series offers a high IP67 protection class. Therefore a wide range of C-mount lens protection tubes are available for C-mount lenses with different sizes.

C-Mount Lens Protection Tube with Ø 44mm



C-Mount Lens Protection Tube with Ø 55mm



Part Number for Lens Protection Tubes

Part Number #	Tube Ø (mm)	Tube Length Y (mm)	Max. Lens Ø (mm)	Max. Lens Length (mm)	Camera Overall Length X (mm)
202 201 100[1]	44	48	36	30	105
202 201 101[1]	44	98	36	80	155
202 201 102[1]	44	58	36	40	115
202 201 103[1]	44	68	36	50	125
202 201 104	55	70	50	55	135
202 201 105	55	80	50	65	145
202 201 106	55	90	50	75	155
202 201 107	55	100	50	85	165
202 201 108	55	62,5	50	47	127,5

[1] Not suitable for cameras with Scheimpflug adapter

Subpixel Limitations

The range values of the 3D cameras are limited to 16bit which result to possible values between 0 and 65535. Setting the subpixel value to 6 correspond to a factor of 2^6 = 64. If the laser line appears at a sensor row higher than #1023 (with 6 subpixel) will result in a bit overflow. For example: laser line at row #1500 -> 1500 x 2^6 = 96000.

Therefore, it can be necessary to use a lower subpixel value to avoid a bit overflow. The table below shows the maximum subpixel value compared to the used number of rows and the laser line appearance on the sensor ship without bit overflow.

Subpixel / Rows	0	1	2	3	4	5	6
1023	✓	✓	✓	✓	✓	✓	✓
2047	✓	✓	✓	✓	✓	✓	×
3072	✓	✓	✓	✓	✓	×	×

Nevertheless, it is still possible to use a higher subpixel value even when the laser line appears on a sensor row >#1023. In that case make sure that the defined AOI is smaller or even 1023/2047 rows and that the flag AbsOffsetPos (Camera Control -> Mode and Algorithm Control -> AbsOffsetPos) is set to false. Then the offset position with respect to the start row of the AOI is returned and thus the laser line can appear on sensor rows >#1023.

With the release of the C5-1280-GigE camera some new features were implemented based on the SFNC 2.3 standard as well as some AT specific features.

One new feature is the Mono8 mode in 3D line mode to reduce the amount of acquired data to be able to increase the maximum profile frequency. This reduction leads to a specific set up which is described in the table below.

Subpixel / Rows	0	1	2	3	4	5	6
3	✓	✓	✓	✓	✓	✓	✓
7	✓	✓	✓	✓	✓	✓	×
15	✓	✓	✓	✓	✓	×	×
31	✓	✓	✓	✓	×	×	×
63	✓	✓	✓	×	×	×	×
127	✓	✓	×	×	×	×	×
255	✓	×	×	×	×	×	×

Using number of rows with a higher subpixel accuracy then stated in the table above can result in a bit overflow. That happen easy, when the pixel values go over the 8 Bit (2^8 - 1 = 255) range.

More details regarding the operation of the C5-1280-GigE camera can be found in a separate application note.

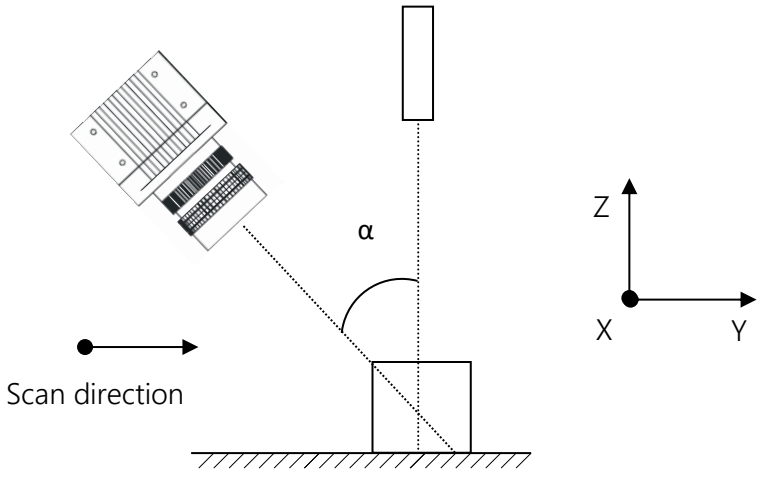
C5 Series Operational Reference

Measuring Principle

The C5 sensor acquires height profiles and height images based on the laser triangulation principle. According to this method a laser line is projected on the object from one direction. The C5 sensor views the object from another angle defining the triangulation geometry. The resulting sensor image is evaluated by the C5 processing unit and converted into a single height profile. By scanning the laser line over the object a complete height image can be acquired.
The figures below demonstrate some typical triangulation geometries. The following notation is used in the approximation of height resolution:
ΔX= resolution along the laser line (lateral),
ΔY= resolution perpendicular to the laser line (longitudinal in the direction of motion),
ΔZ= height resolution.

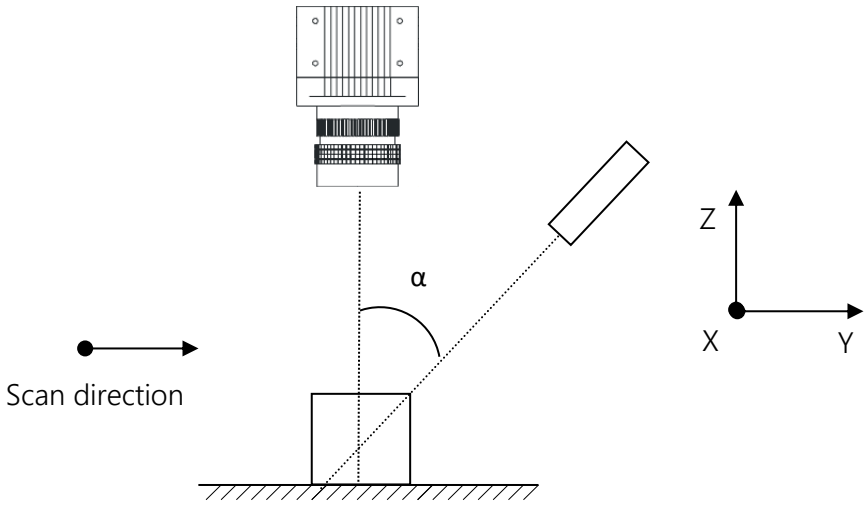
Geometry 1

The laser line is projected perpendicular to the object surface, while the camera views the object under the triangulation angle α.
The height resolution can be approximated: $\Delta Z \approx \Delta X / \sin(\alpha)$



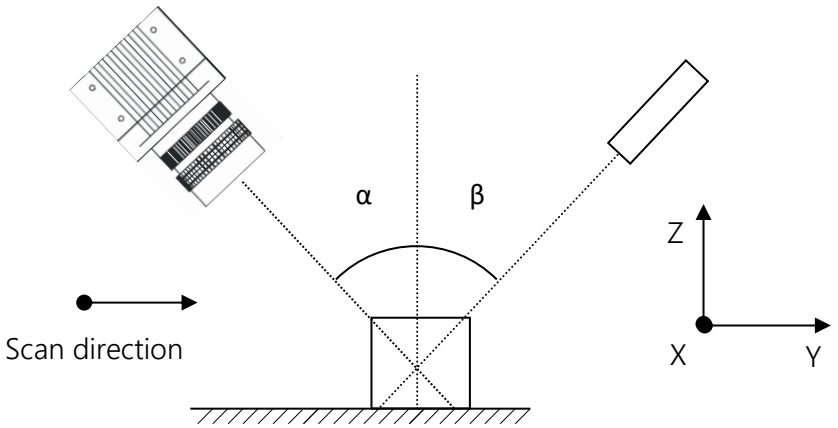
Geometry 2

The camera views the object perpendicularly to its surface, while the laser line is projected under the triangulation angle α.
The height resolution can be approximated: $\Delta Z \approx \Delta X / \tan(\alpha)$



Geometry 3

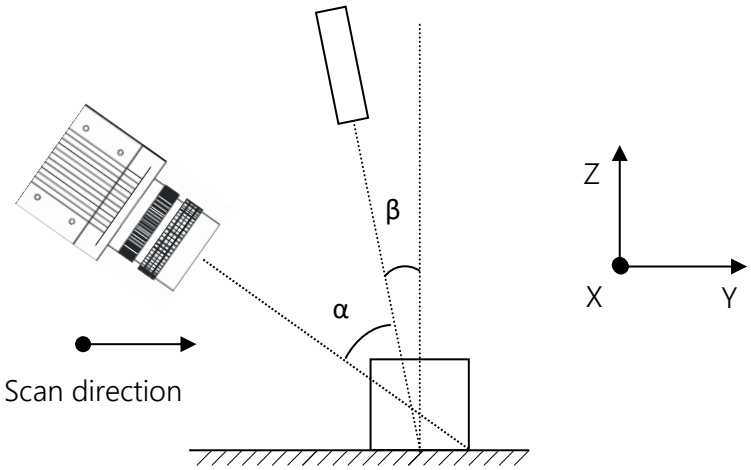
The camera views the object under an angle α, while the laser line is projected under a different angle β.
The height resolution can be approximated: $\Delta Z \approx \Delta X * \cos(\beta) / \sin(\alpha + \beta)$,
in case $\alpha = \beta$ (direct reflex) : $\Delta Z \approx \Delta X / 2 * \sin(\alpha)$



Geometry 4

The camera views the object under an angle α, while the laser line is projected under a different angle β at the camera side.

The height resolution can be approximated: $\Delta Z \approx \Delta X * \cos(\beta) / \sin(\alpha)$



The C5 Sensor Algorithms

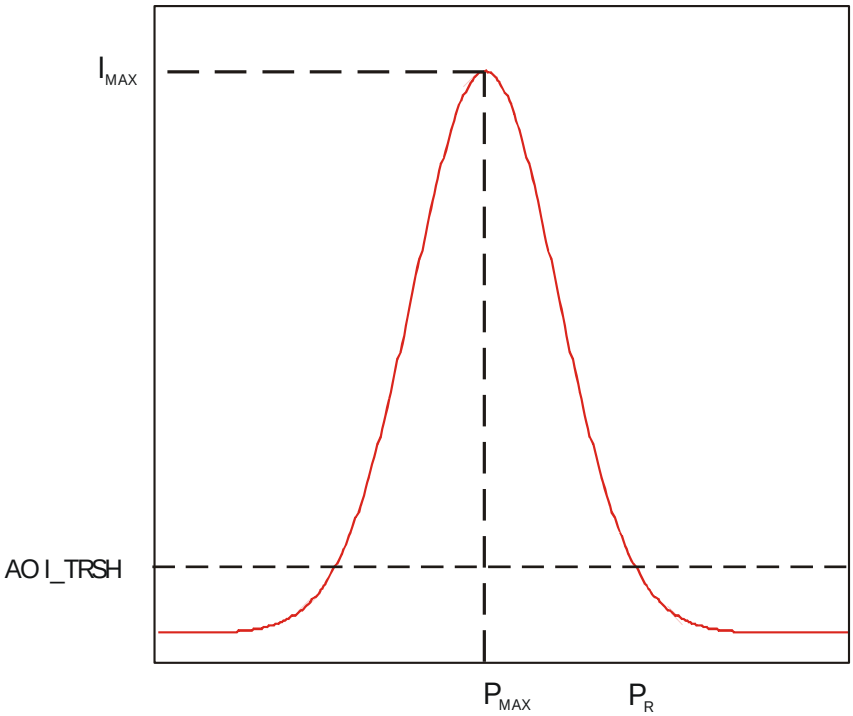
The C5 series can be operated both in a variety of 3D profile modes and in image mode. The current operation mode can be chosen by setting the following parameter:
Camera Controls→ ModeAndAlgorithmControls→CameraMode.
The frame rate can be increased in all camera modes by reducing the AOI size. In the image mode the frame rate is limited by the output rate of the camera interface (GigE). However, due to reduced data size in profile mode the frame rate is limited only by the sensor output rate. As a matter of principle, the processing speed is independent of the chosen profile mode and is determined by the AOI size.
In all profile modes only intensity values higher than the AOI intensity threshold AOI_TRSH are processed in order to suppress weak signal noise. In case that no position value can be found, e.g. no intensity value is higher than threshold, the position value 0 is returned.

The Image Mode (IMG)

In the image mode the C5 camera series is operated similar to a standard CMOS camera. In this mode grey scale data of 8- or 10-bit resolution are acquired over the camera interface. Furthermore, the sensor can be divided into multiple regions, whose data can be summarised in one output frame.

The Maximum Intensity Profile Mode (MAX)

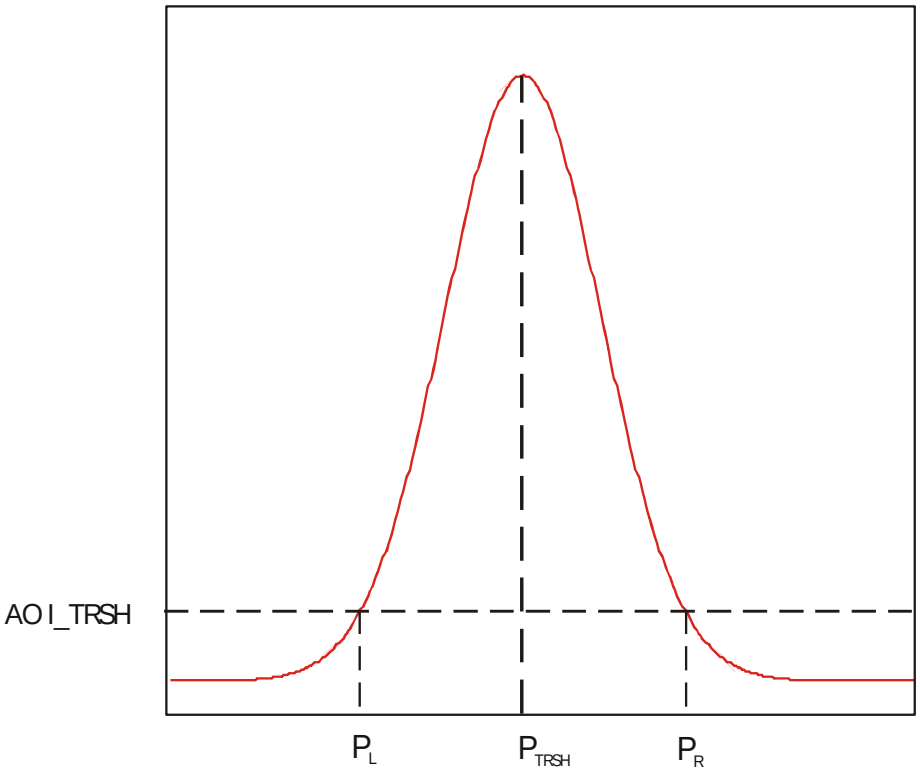
In this mode the position of the maximum intensity of laser beam profile is calculated. The result includes the position value of the maximum (P_{MAX}) as well as the maximum intensity value (I_{MAX}).



The calculation of position value is performed with simple pixel accuracy, i.e. the evaluation of 1088 rows delivers a position range from 0 to 1087 pixels (11 bit). If there is more than one local maximum (e.g. when the intensity is saturated), the position of the first detected maximum is output. To avoid intensity saturation, it is recommended to activate the Multiple Slope Mode of the camera.
The detection of the maximum intensity position can be improved by enabling the smoothing mode of the FIR filter of the camera.

The Threshold Mode (TRSH)

In this mode the positions of left (P_L) and right (P_R) edge of the laser beam profile are detected for a given threshold value of intensity AOI_TRSH.



The position value of the laser line is approximated: $P_{TRSH} = (P_L+P_R) / 2$. In order to simplify the digital representation, the division over 2 is not performed and thus an integer representation with one subpixel is realised. The evaluation of 1088 rows delivers a position range from 0 to 2174 pixels (11 bit).

In threshold mode the camera can output either the left and right threshold position separately or the subpixel position (P_L+P_R) and the line width (P_R-P_L). Moreover, the maximum intensity value can be optionally output.

The precision of the position calculation can be improved by enabling the smoothing mode of the FIR filter of the camera.

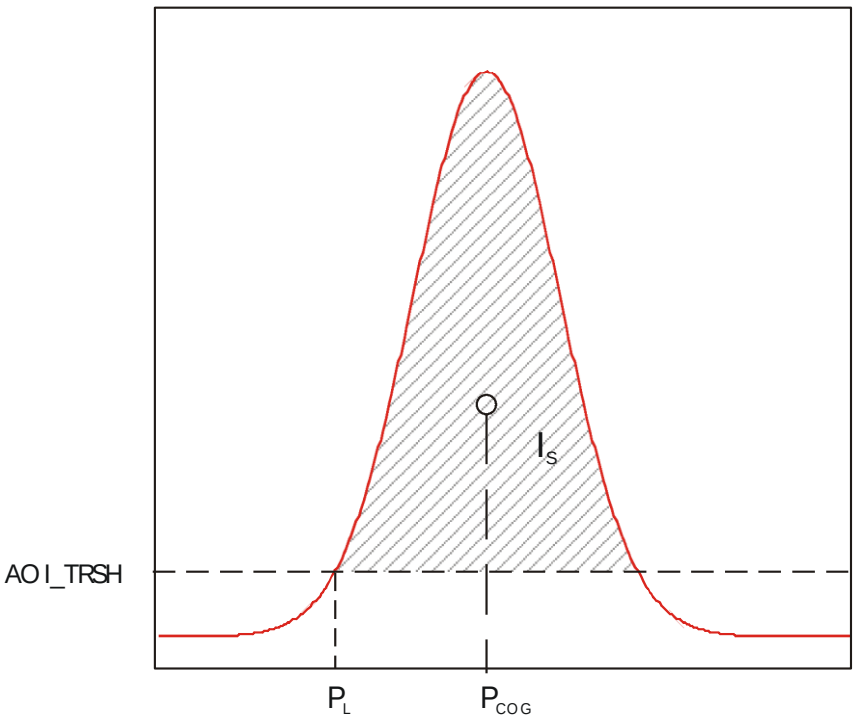
The Center Of Gravity Mode (COG)

In this mode the center of gravity of laser beam profile is calculated. For this purpose, the following parameters are computed:

Position value of the left edge of laser beam profile for a given intensity threshold value P_L ,

Sum of intensity value $I_s = \sum I_p$,

Sum of first order moment $M_s = \sum I_p * P$.



The position value of laser line (center of gravity of beam profile) is then obtained from:

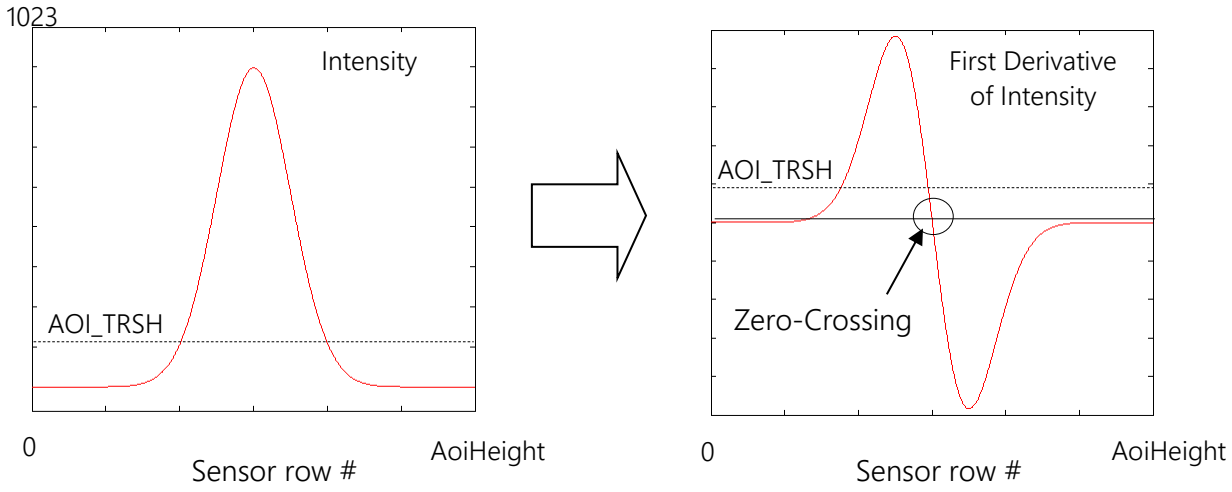
$P_{COG} = P_L + M_s / I_s$.

In addition, the laser line width can be delivered over the Data Channel DC1. The average intensity of the illumination profile can be calculated by normalising the sum of intensity value I_s with the line width.

The precision of the COG calculation can be improved by enabling the smoothing mode of the FIR filter of the camera.

The FIR Peak Mode (FIR PEAK)

In this mode the first derivative of the intensity Gauss curve of laser beam profile is calculated.



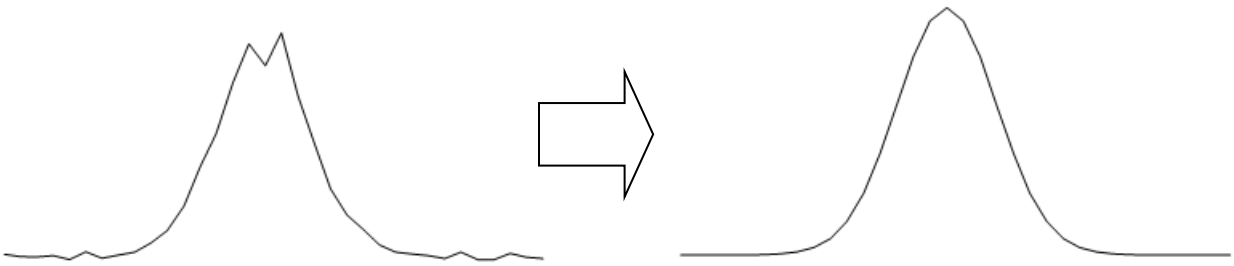
The position of zero-crossing of first derivative is detected and output with subpixel accuracy (up to 6 subpixels). In this case the threshold AOI_TRSH is used to detect the first rising edge of the derived intensity signal. Valid values of AOI_TRSH range from 513 to 1023 (Mono16).

More details regarding the operation of the FIR Peak mode can be found in a separate application note.

The FIR Filter Function

The FIR filter is a signal processing function aiming to increase the precision of laser line detection in the sensor image. It consists of a digital Finite Impulse Response filter (FIR) and can be operated in a smoothing or differentiating mode.

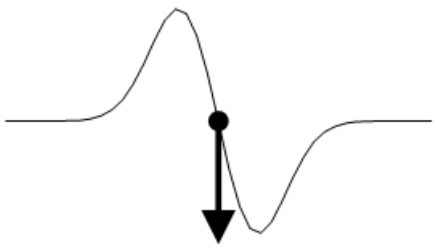
FIR in smoothing mode (in combination with MAX, TRSH and COG algorithms):



Raw Gauss Curve

Smoothed Gauss Curve

FIR in derivative mode (FIR PEAK):



Zero-Crossing of
First Derivative

Pre-defined templates with 5, 7 or 9 coefficients let the FIR filter to be customized to the Gauss size and shape of the application.

More details regarding the operation of the FIR filter function can be found in a separate application note.

The High Dynamic Range 3D Feature (HDR-3D)

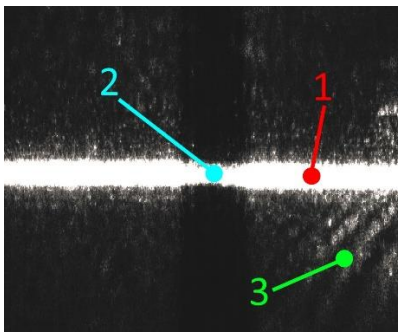
One of the most powerful features of the C5 series is the HDR-3D (High Dynamic Range) functionality, which allows scanning materials and surfaces with inhomogeneous reflection properties. Using HDR-3D the dynamic range of image intensity is extended up to 90dB, thus avoiding intensity saturation. The HDR-3D comprises two independent sensor functions:

MultipleSlope Function

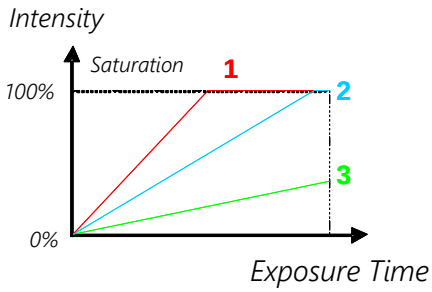
The aim of the Multiple Slope function is to avoid the saturation of pixels during sensor chip exposure. This high optical dynamic range is achieved by using a piecewise linear response. The intensity of illuminated pixels, which reach a certain level, is clipped, while darker pixels remain untouched. The clipping level can be adjusted 2 times within one exposure time to achieve a maximum of 3 slopes in the response curve. The points of the curve, where the slope changes, are called "knee points". The latter are defined through the setting of clipping levels for the intensity (thresholds) and time points within the exposure time.

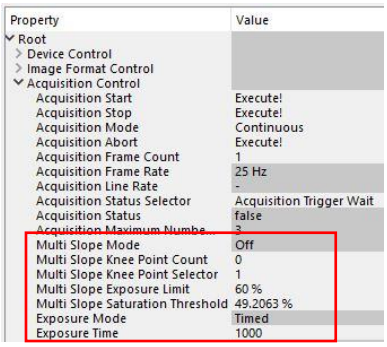
These parameters can be adjusted using the GenICam registers Multi Slope Exposure Limit and Multi Slope Saturation Threshold of the Acquisition Control (XML grid visibility must be set to "Expert"). A knee point time is defined as percentage of the overall exposure time. A clipping level is defined as percentage of the maximum sensor intensity (saturation).

Single Slope Mode (Default Mode)

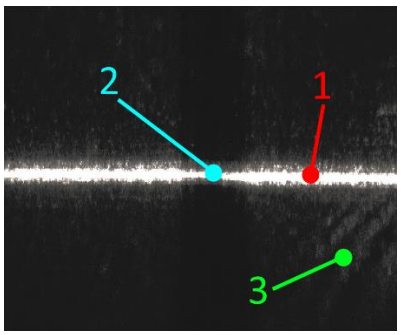


Weld Seam

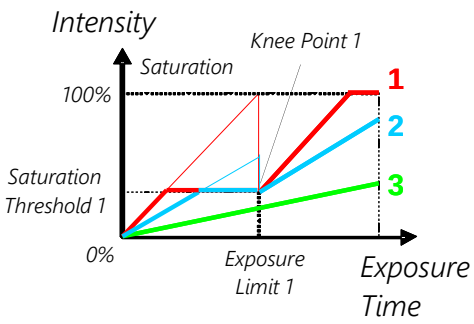


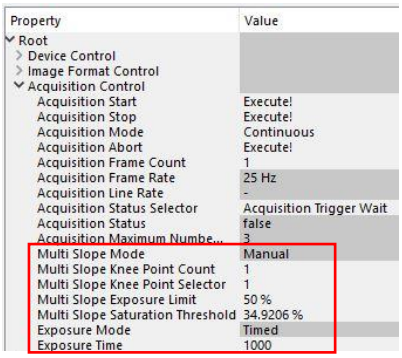


Dual Slope Mode (1 Knee Point)

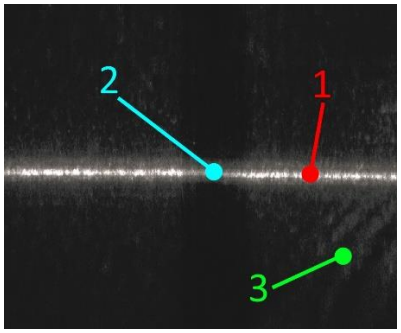


Weld Seam

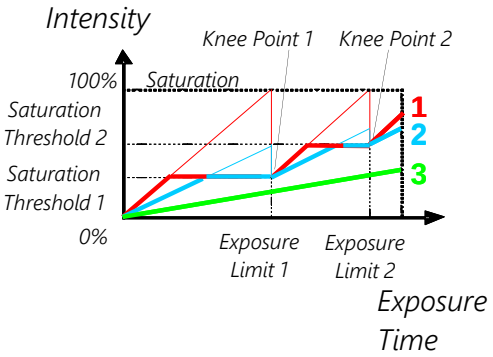


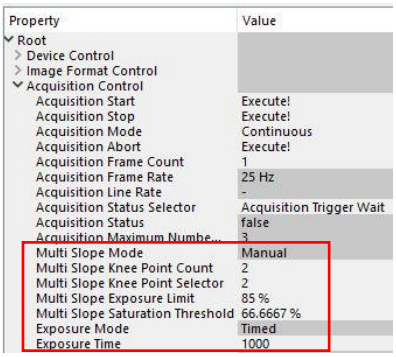


Triple Slope Mode (2 Knee Points)



Weld Seam

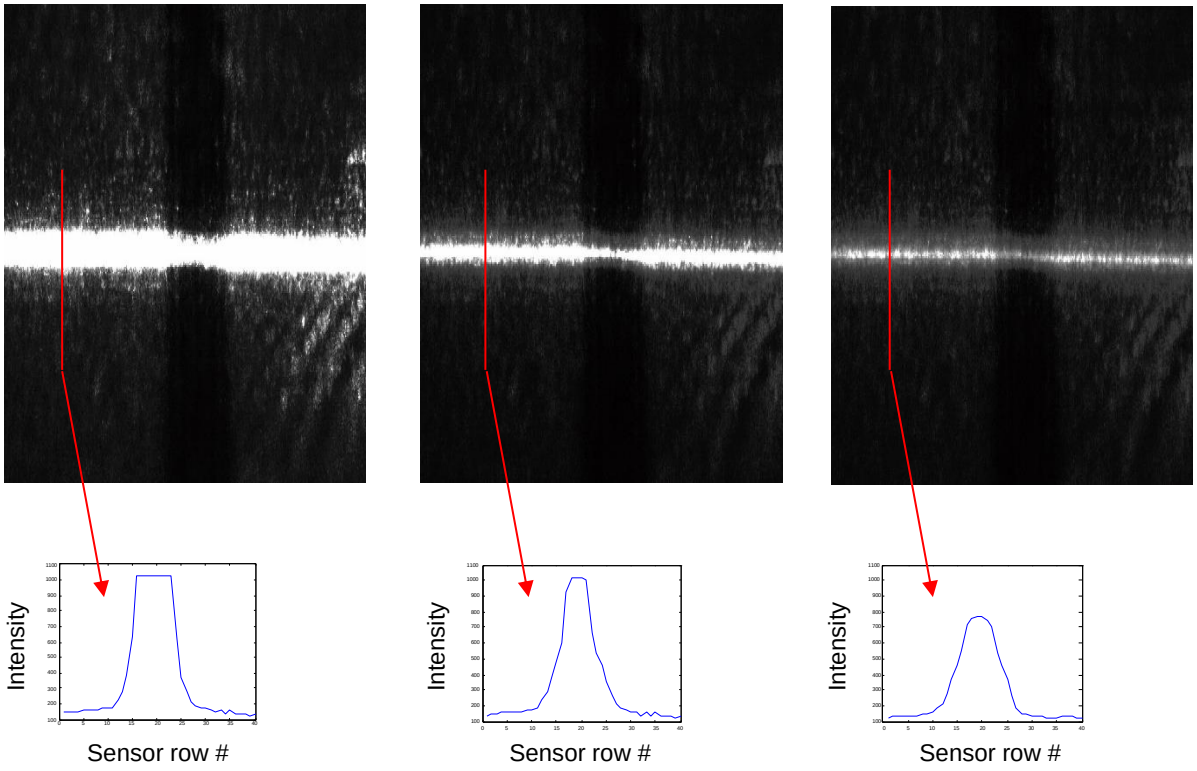




Comparison of Slope Modes

Application of MultipleSlope function on the image of a laser line projected on a surface with non-homogeneous reflectivity (weld seam).

SingleSlope **DualSlope** **TripleSlope**

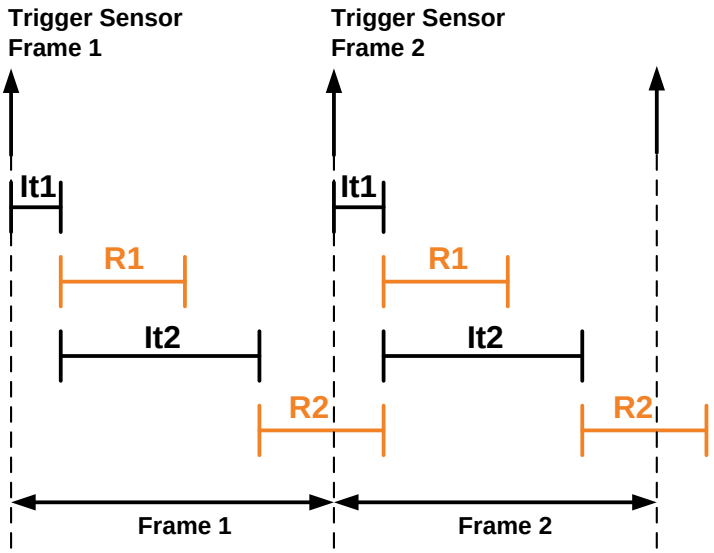


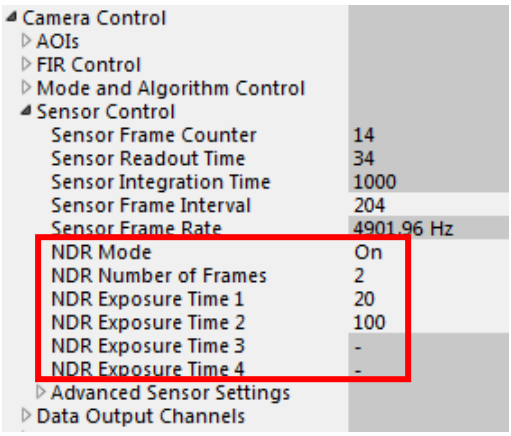
More details regarding the operation of the MultipleSlope function can be found in a separate application note.

Multi-Frame Readout Mode (NDR)

With the Non-Destructive Readout (NDR) mode it is possible to readout up to 4 images at different exposure times. It allows the combination of profile data from different integration levels, and it ensures accurate profile data even for difficult surfaces with strong changes in reflectance.

The following timing diagram shows the function of NDR with 2 frames, when subsequent sensor images are acquired. The exposure times for NDR frame 1 and 2 are depicted with It1 and It2 respectively. Please note that the readout of the second frame R2 cannot begin unless the first frame R1 has been readout. The same applies also between two subsequent sensor images, i.e. the first NDR frame of sensor image 2 cannot be readout unless the last NDR frame of sensor image 1 has been readout.





It1 : Exposure Time 1
It2 : Exposure Time 2
R1 : Readout Frame It1
R2 : Readout Frame It2

The Data Output Format

The image and 3D data output is performed by selecting the data channel DC0-DC2 (node Camera Controls→DataOutput). Depending on the algorithm the data can be acquired by enabling the corresponding output Data Channel (DC). Every DC is saved in a new image row. The bit depth of output data depends on the selected algorithm. In 3D mode the camera outputs data with 16-bit. In Image mode the camera can output 8- or 16-bit data. When in 8-bit Image mode, the DC0 delivers the 8 most significant bits of the 10 bit intensity data.

The Data Channel Assignment DC0, DC1 and DC2

Camera Mode	FIR	FIRMode	DC0	DC1	DC2
Image	False	-	Sensor intensity	Not used	Not used
	True	Derivative	First derivative of sensor intensity	Not used	Not used
	True	Smoothing	Smoothed sensor intensity	Not used	Not used
MaximumIntensity	False	-	Maximum intensity of Gauss	Position of rising edge of Gauss (PosL)	Position of maximum intensity of Gauss (PosM)
	True	Smoothing	Maximum intensity of Gauss detected in smoothed sensor image	Position of rising edge of Gauss (PosL) detected in smoothed sensor image	Position of maximum intensity of Gauss (PosM) detected in smoothed sensor image
Threshold	False	-	Maximum intensity of Gauss	- Position of rising edge of Gauss (PosL) or - Gauss width (PosR-PosL)	- Position of falling edge of Gauss (PosR) or - Position of Gauss with 1/2 pixel resolution (PosL+PosR)
	True	Smoothing	Maximum intensity of Gauss detected in smoothed sensor image	- Position of rising edge of Gauss (PosL) or	- Position of falling edge of Gauss (PosR) or

Camera Mode	FIR	FIRMode	DC0	DC1	DC2
				- Gauss width (PosR-PosL) detected in smoothed sensor image	- Position of Gauss with 1/2 pixel resolution (PosL+PosR) detected in smoothed sensor image
CenterOfGravity	False	-	Sum of intensity values of Gauss I_s	- Position of rising edge of Gauss (PosL) or - Gauss width (PosR-PosL)	Position of center of gravity of Gauss with $1/(2^N)$ pixel resolution, where N=number of subpixel bits (0-6)
	True	Smoothing	Sum of intensity values of Gauss I_s in smoothed sensor image	- Position of rising edge of Gauss line (PosL) or - Gauss width (PosR-PosL)	Position of center of gravity of Gauss in smoothed sensor image with $1/(2^N)$ pixel resolution, where N=number of subpixel bits (0-6)
FIRPeak	True	Derivative	Zero-crossing slope (Absolute value)	- Index of next sensor row to the left of zero-crossing or - maximum value of intensity first derivative	Position of Gauss peak with $1/(2^N)$ pixel resolution, where N=number of subpixel bits (0-6)

The Output Frame Structure

Depending on configuration, the C5 sensor writes data to the output frame according to following scheme:

1) NDR mode disabled (NDRMode="Off")

```
for(profile_idx=1; profile_idx <=ProfilesPerFrame; profile_idx ++)
{
        for(AOI_idx=1; AOI_idx<=NumAOIs; AOI_idx++)
        {
                if(EnableDC0==true)
                        write_data_of_DC0(AOI_idx);
                if(EnableDC1==true)
                        write_data_of_DC1(AOI_idx);
                if(EnableDC2==true)
                        write_data_of_DC2(AOI_idx);
        }
}
```

2) NDR mode enabled (NDRMode="On")

```
for (profile_idx=1; profile_idx <=ProfilesPerFrame/2; profile_idx ++)
{
        for(AOI_idx=1; AOI_idx<=NumAOIs; AOI_idx++)
        {
                for(NDR_idx=1: NDR_idx <= NumberOfNDRFrames; NDR_idx ++)
                {
                        if(EnableDC0==true)
                                write_data_of_DC0(AOI_idx,NDR_idx);
                        if(EnableDC1==true)
                                write_data_of_DC1(AOI_idx,NDR_idx);
                        if(EnableDC2==true)
                                write_data_of_DC2(AOI_idx,NDR_idx);
                }
        }
}
```

Index Definition

Index #	Range	Description
Profile_idx	1-17475	Index of Profile
AOI_idx	1-8	Index of sensor AOI
NDR_idx	1-4	Index of NDR frame

Examples of Output Frame Structure

1) Configuration with single AOI, single DC, disabled NDR mode and output of 6 profiles resulting to a frame height of 6 rows:

ProfilesPerFrame = 6
NumAOIs = 1
EnableDC0 = false
EnableDC1 = false
EnableDC2 = true
NDRMode = "Off"

Row #	Description	Profile #
1	Data of DC2 readout from AOI1	1
2	Data of DC2 readout from AOI1	2
3	Data of DC2 readout from AOI1	3
4	Data of DC2 readout from AOI1	4
5	Data of DC2 readout from AOI1	5
6	Data of DC2 readout from AOI1	6

2) Configuration with two AOIs, two DCs, disabled NDR mode and output of 5 profiles resulting to a frame height of 20 rows:

ProfilesPerFrame = 5
NumAOIs = 2
EnableDC0 = true
EnableDC1 = false
EnableDC2 = true
NDRMode = "Off"

Row #	Description	Profile #
1	Data of DC0 readout from AOI1	1
2	Data of DC2 readout from AOI1	
3	Data of DC0 readout from AOI2	
4	Data of DC2 readout from AOI2	
5	Data of DC0 readout from AOI1	2
6	Data of DC2 readout from AOI1	
7	Data of DC0 readout from AOI2	
8	Data of DC2 readout from AOI2	
9	Data of DC0 readout from AOI1	3
10	Data of DC2 readout from AOI1	
11	Data of DC0 readout from AOI2	
12	Data of DC2 readout from AOI2	
13	Data of DC0 readout from AOI1	4
14	Data of DC2 readout from AOI1	
15	Data of DC0 readout from AOI2	
16	Data of DC2 readout from AOI2	
17	Data of DC0 readout from AOI1	5
18	Data of DC2 readout from AOI1	
19	Data of DC0 readout from AOI2	
20	Data of DC2 readout from AOI2	

3) Configuration with single AOI, single DC, NDR mode with two NDR frames and output of 3 profiles resulting to a frame height of 6 rows:

ProfilesPerFrame = 3
NumAOIs = 1
EnableDC0 = false
EnableDC1 = false
EnableDC2 = true
NDRMode = "On"
NumberOfNDRFrames = 2

Row #	Description	Profile #
1	Data of DC2 extracted from NDR1, readout from AOI1	1
2	Data of DC2 extracted from NDR2, readout from AOI1	
3	Data of DC2 extracted from NDR1, readout from AOI1	2
4	Data of DC2 extracted from NDR2, readout from AOI1	
5	Data of DC2 extracted from NDR1, readout from AOI1	3
6	Data of DC2 extracted from NDR2, readout from AOI1	

The Advanced AOI Functions

The C5 series features an area CMOS sensor, whose frame rate depends on the number of pixels to readout. By defining a sensor Area of Interest (AOI) the frame rate and hence the profile speed will be significantly increased due to the smaller number of pixels to readout.
In some cases the AOI position may not be constant and it should follow the image of laser line on the camera sensor. The C5 series features functions for performing an automatic AOI positioning (AOI-Search) as well as line tracking (AOI-Tracking).

AOI-Search

The AOI-Search mode can be used in 2D mode as well as in 3D mode and has the benefit to adjust the AOI at the start of the acquisition to the optimal position of the laser line. In that case the laser line is automatically centered to the AOI.
The user must only define the minimum required AOI Height (number of required sensor rows) for the expected laser line and afterwards the camera will adjust the vertical AOI-Offset (AoiOffsetY) value to the best position.

AOI-Tracking

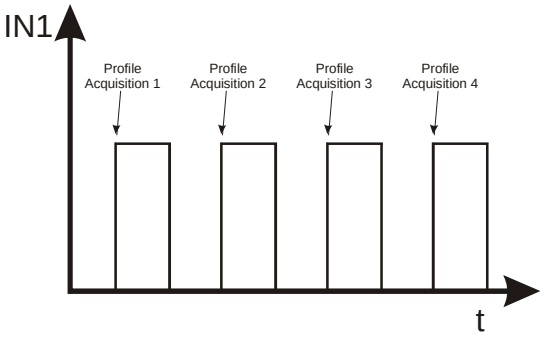
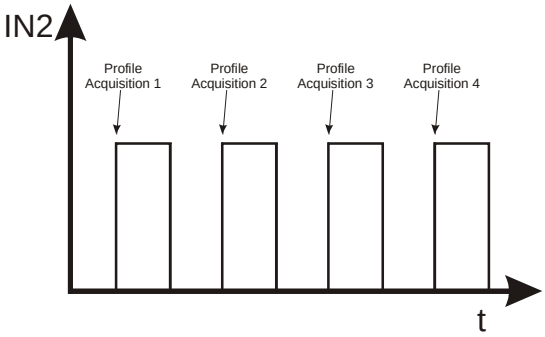
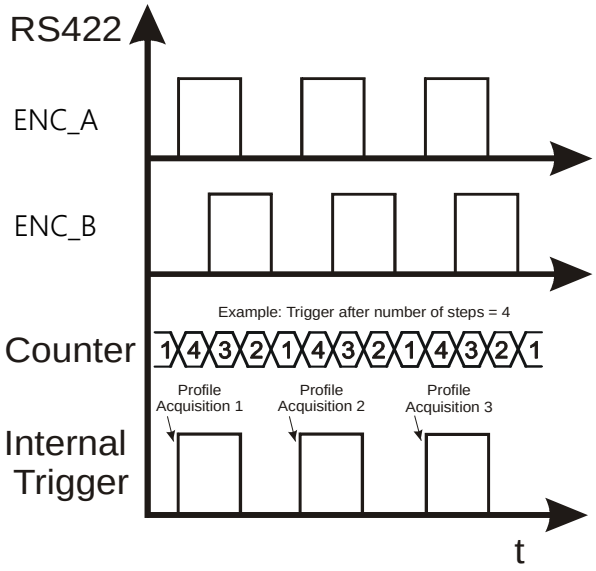
The automatic AOI-Tracking is the dynamic version of the static AOI-Search mode. While the AOI-Search is only working at the beginning of each 3D acquisition, the AOI-Tracking mode is working continuously during 3D image acquisition.

Thus, 3D profile acquisition with AOI-Tracking is able to cover the complete image/sensor size although the defined AOI size could be much smaller. This is very useful in case of applications involving continuous profile measurements with variable distances to the surface.

A detailed description of these functions can be found in a separate application note.

The C5 Series Triggering Mode

Description of Profile Trigger Modes

No.	Profile Trigger Mode (PTM)
0	**Free-run (PTM0)**
1	**Camera input 1 (PTM1)** 
2	**Camera input 2 (PTM2)** 
3	**Encoder/Resolver Interface (PTM3)** 

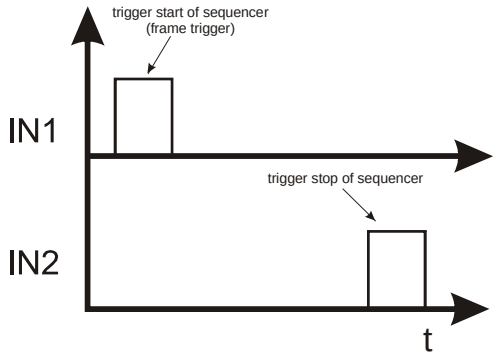
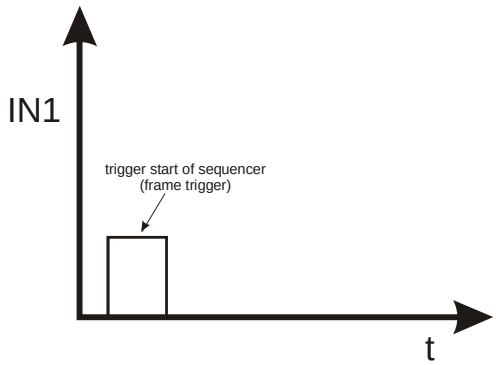
Trigger Control – RS422 Resolver

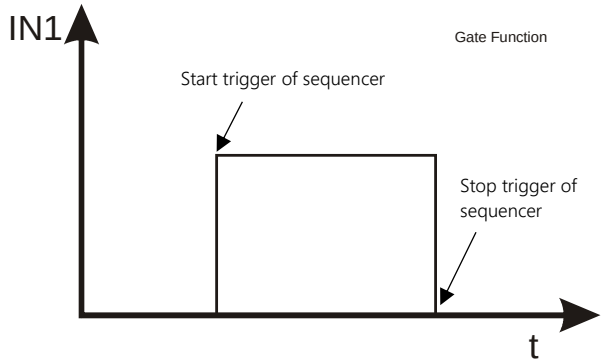
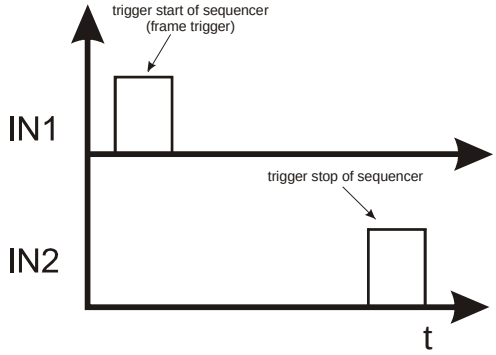
The *TriggerCoord* node always counts all the raw trigger signals arriving at the camera -> rising AND falling edge!
The *TriggerDivider* is used internally by the camera. The camera doesn't change its behavior if the *TriggerDivider* is set to another value. A *TriggerDivider* of 10 for example will use every tenth incoming trigger for one profile measurement.
If single-ended encoder signals are required, it is set over *TriggerSingleChannelMode*. Triggering over Channel A or B or over Input1 and Input2 is then possible.
If other encoder signals than RS422 are needed, use the Inputs of the camera instead of the encoder inputs and set *UseAlternateResolverInputs* to true.

Name	Interface	Access	Visibility	Description
TriggerDivider *(*)*	IInteger	RW	Beginner	Trigger divider Min: 1 Max: 65535 Increment: 1
TriggerCoord	IInteger	RO	Beginner	Trigger coordinate
TriggerDirectionMode	IBoolean	RW	Beginner	Count resolver pulses in both directions
TriggerReverseDirection	IBoolean	RW	Beginner	Reverse the resolver count direction
TriggerSingleChannelMode *(*)*	IEnumeration	RW	Guru	Enable resolver in single channel mode (1): Disabled (Value= 0) (2): EnableIn1 (Value= 1) (3): EnableIn2 (Value= 2)
TriggerDividerLoadAtStart *(*)*	IBoolean	RW	Beginner	Load trigger divider upon start trigger
LoadTriggerDivider *(*)*	ICommand	WO*	Beginner	Load trigger divider
ClearTriggerCoord	ICommand	WO*	Beginner	Reset trigger coordinate
ResetTriggerCoordZeroPos	IEnumeration	RW	Beginner	Reset the Trigger Coordinate/Counter at Zero Position (Index, Z-Channel) (1): Off (Value= 0) (2): On (Value= 1)

TriggerCoordinateCountAlways	IBoolean	RW	Guru	TRUE: Count trigger coordinate always, FALSE: Count trigger coordinate during image acquisition only
UseAlternateResolverInputs (*)	IBoolean	RW	Guru	Use IN1/IN2 instead of A/B as inputs
UseAlternateResolverInputsInverted (*)	IBoolean	RW	Guru	Use inverted IN1/IN2

Description of Modes for Triggering of Sequencer/Frame and Profile Acquisition

No.	Sequencer/Frame Trigger Mode	Profile Trigger Mode (PTM)
0	**Free-run**	PTM0 (free-run)
		PTM1 (IN1)
		PTM2 (IN2)
1	**Start/stop over camera input 1/2** Continuous frame acquisition is started with the rising edge of camera input 1 (IN1) and stopped with rising edge of camera input 2 (IN2)  When "stop" occurs, the frame is not transmitted immediately over the GigE interface but the camera continues to acquire profile data, until the predefined frame height is reached.	PTM0 (free-run)
		PTM3 (RS422)
2	**Trigger one frame over camera input 1** Single frame acquisition is triggered over the rising edge of camera input 1 (IN1)  	PTM0 (free-run)
		PTM2 (IN2)
		PTM3 (RS422)

No.	Sequencer/Frame Trigger Mode	Profile Trigger Mode (PTM)
3	**Gate over camera input 1** Continuous frame acquisition is performed as long as the camera input 1 is on high state  	PTM0 (free-run) PTM2 (IN2) PTM3 (RS422)
4	**Start/stop with instant transmission over camera input 1/2** Continuous frame acquisition is started with rising edge of camera input 1 (IN1) and stopped with rising edge of camera input 2 (IN2)  When "stop" occurs, the frame is transmitted immediately over the GigE interface. Using the Chunk Data mode of C5 camera, it is possible to determine how many rows of the frame contain valid data (see ChunkImageInfo for details).	PTM0 (free-run) PTM3 (RS422)
5	**AutoStart (no external signal is required)**	PTM0 (free-run) PTM1(IN1) PTM2 (IN2) PTM3 (RS422)

Remarks:

The above table (except AutoStart) applies also to acquisition in image mode. In this case the camera delivers a gray scale sensor image for every profile trigger.

A detailed description of the AutoStart function can be found in a separate application note.

The C5 Series Chunk Data Mode

General Description

The C5 series features a Chunk Data mode for providing additional information to the acquired image data. The implementation of XML nodes is performed according to SFNC 1.4:

- Category ChunkDataControl
- ChunkModeActive
- ChunkModeSelector (OneChunkPerFrame, OneChunkPerProfile)

The ChunkData generated by the camera have the following format:

- ChunkImage
- 1…N x ChunkAcqInfo
- ChunkImageInfo

Depending on camera mode (image or 3D) the ChunkData block („ChunkAcqInfo“) can be sent as follows:

- In image mode, the camera can send only one ChunkAcqInfo block per image frame.
- In 3D mode, the camera can send one ChunkAcqInfo block either per 3D frame (“OneChunkPerFrame”) or per 3D profile (“OneChunkPerProfile”).

The „ChunkImageInfo“ is the last ChunkData sent by the camera and contains following data:

- Number of valid rows in ChunkImage
- Number of valid ChunkAcqInfo blocks
- Flags identifying the current frame as „Start“ or „Stop“ and the buffer status in AutoStart mode

The ChunkAcqInfo block consists of totally 32 bytes containing following data

- 64-bit timestamp
- 32-bit frame counter
- 32-bit trigger coordinate
- 8-bit Trigger status
- 32-bit I/O Status
- 88-bit AOI information

The data of timestamp, frame counter, trigger coordinate, trigger status and I/O status are assigned at the start of every image integration.
When ChunkMode is disabled, the camera uses the “regular“ GEV image protocol, in which the optional transfer of frames with variable height and payload is supported.

Furthermore, when ChunkMode is enabled, the camera sends the full payload, even if the ChunkImage or ChunkAcqInfo blocks contain partially valid data. The number of valid ChunkImage rows and ChunkAcqInfo blocks can be read from ChunkImageInfo.

For example, when in Start/Stop mode with instant frame transmission, the camera stops the frame acquisition as soon as the stop trigger occurs and transfers the complete contents of internal image

buffer. Using the ChunkImageInfo data block, it is possible to detect how many image rows and ChunkAcqInfo blocks are valid in the payload buffer.
The tag of ChunkData has big endian byte order. The data of ChunkData has little endian byte order. An endian converter for ChunkData is not supported.

Payload Layout in Chunk Data Mode

Chunk Image Data
GV_ChunkDescriptorData for Image Data
N x GV_ChunkAcqInfo
GV_ChunkDescriptorData for ChunkAcqInfo
GV_ChunkImageInfo
GV_ChunkDescriptorData for ChunkImageInfo

XML Descriptors and ID's

ChunkImageInfo

```
<Port Name="FrameInfoPort">
        <ChunkID>11119999</ChunkID>
</Port>
```

ChunkAcqInfo

```
<Port Name="CameraChunkPort">
        <ChunkID>66669999</ChunkID>
</Port>
```

ChunkImage

```
<Port Name="ImageInfoPort">
        <ChunkID>A5A5A5A5</ChunkID>
</Port>
```

Chunk Data Structure

```
#pragma pack(push)
#pragma pack(1)

#define CHUNKACQINFO_TRIGGERSTATUS_BIT_TRIGGER_OVERRUN 0x01
#define CHUNKACQINFO_TRIGGERSTATUS_BIT_RESOLVER_CNT_UP 0x02
#define CHUNKACQINFO_TRIGGERSTATUS_BIT_IN0             0x10
#define CHUNKACQINFO_TRIGGERSTATUS_BIT_IN1             0x20
#define CHUNKACQINFO_TRIGGERSTATUS_BIT_OUT0                    0x40
#define CHUNKACQINFO_TRIGGERSTATUS_BIT_OUT1                    0x80

typedef struct _GV_ChunkAcqInfo
{
    unsigned int        timeStamp64L;// 0..3
    unsigned int        timeStamp64H;       // 4..7
    unsigned int        frameCnt;           // 8..11
    signed int      triggerCoord;  // 12..15
    unsigned char       triggerStatus;  // 16
    unsigned short      DAC;                // 17..18
    unsigned short      ADC;                // 19..20
    unsigned char       INT_idx;            // 21
    unsigned char       AOI_idx;            // 22
    unsigned short      AOI_ys;         // 23..24
    unsigned short      AOI_dy;             // 25..26
    unsigned short      AOI_xs;         // 27..28
    unsigned short      AOI_trsh;           // 29..30
    unsigned char       AOI_alg;            // 31
} GV_ChunkAcqInfo;

#define CHUNKIMAGEINFO_FLAG_BIT_START_FRAME            0x01
#define CHUNKIMAGEINFO_FLAG_BIT_STOP_FRAME             0x02
#define CHUNKIMAGEINFO_FLAG_BIT_BUFFER_OVERRUN         0x04

typedef struct _GV_ChunkImageInfo
{
    unsigned int mSizeYReal;
    unsigned int numChunkAcqInfo;
    unsigned int flag;
} GV_ChunkImageInfo;

typedef struct _GV_ChunkDescriptor
{
    unsigned int descriptor;
    unsigned int length;
} GV_ChunkDescriptorData;

#pragma pack(pop)
```

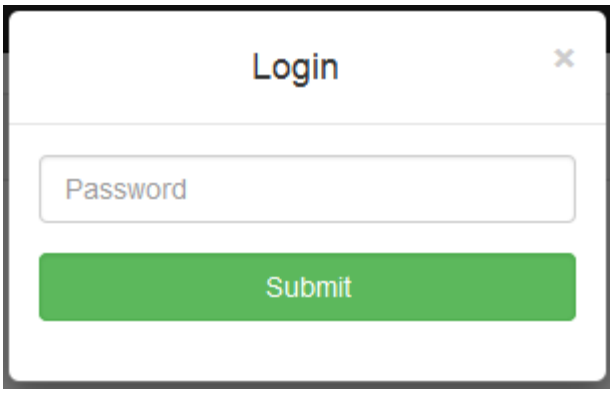
The GigE-Vision Events

The C5 series supports a number of events that can be monitored by a software application by means of a callback function. Events provide real time notification on various stages of the acquisition sequence and data transfer.

Event Name	Event ID , (Hex)	Description
AcquisitionStart	36882 , (9012)	Frame Acquisition is started
AcquisitionEnd	36883 , (9013)	Frame Acquisition is terminated
TransferStart	36884 , (9014)	Frame transfer is started from the camera
TransferEnd	36885 , (9015)	Frame transfer is terminated
AoiTrackingOn	36886 , (9016)	The AOI tracking process is started and the laser line image is valid for AOI alignment
AoiTrackingOff	36887 , (9017)	The AOI tracking process is stopped and the AOI position is not updated anymore
AoiSearchFailed	36888 , (9018)	AOI-Search failed to detect the laser line
AutoStarted	36889 , (9019)	Frame Acquisition is initiated through AutoStart

The Web Interface

The service web interface gives access to basic device and runtime information aside from the common GenICam interface. It can be accessed with an ordinary web browser, by simply typing the cameras IP address into the browsers URL field, e.g.: http://169.254.64.2. A login window appears, as the following figure shows. The static password "**admin**" gives access to the camera service web interface.



Connect via web browser by using the set IP e.g. "http://169.254.64.2/".
The static password for login is "admin".

In the header bar is the manufacture info, the model name and the serial number.

Every info panel has an *Update Button* in the panel header. Each button updates the data for the specific panel. Collapsing and opening the panel by clicking the *Arrow* on the right hand side.

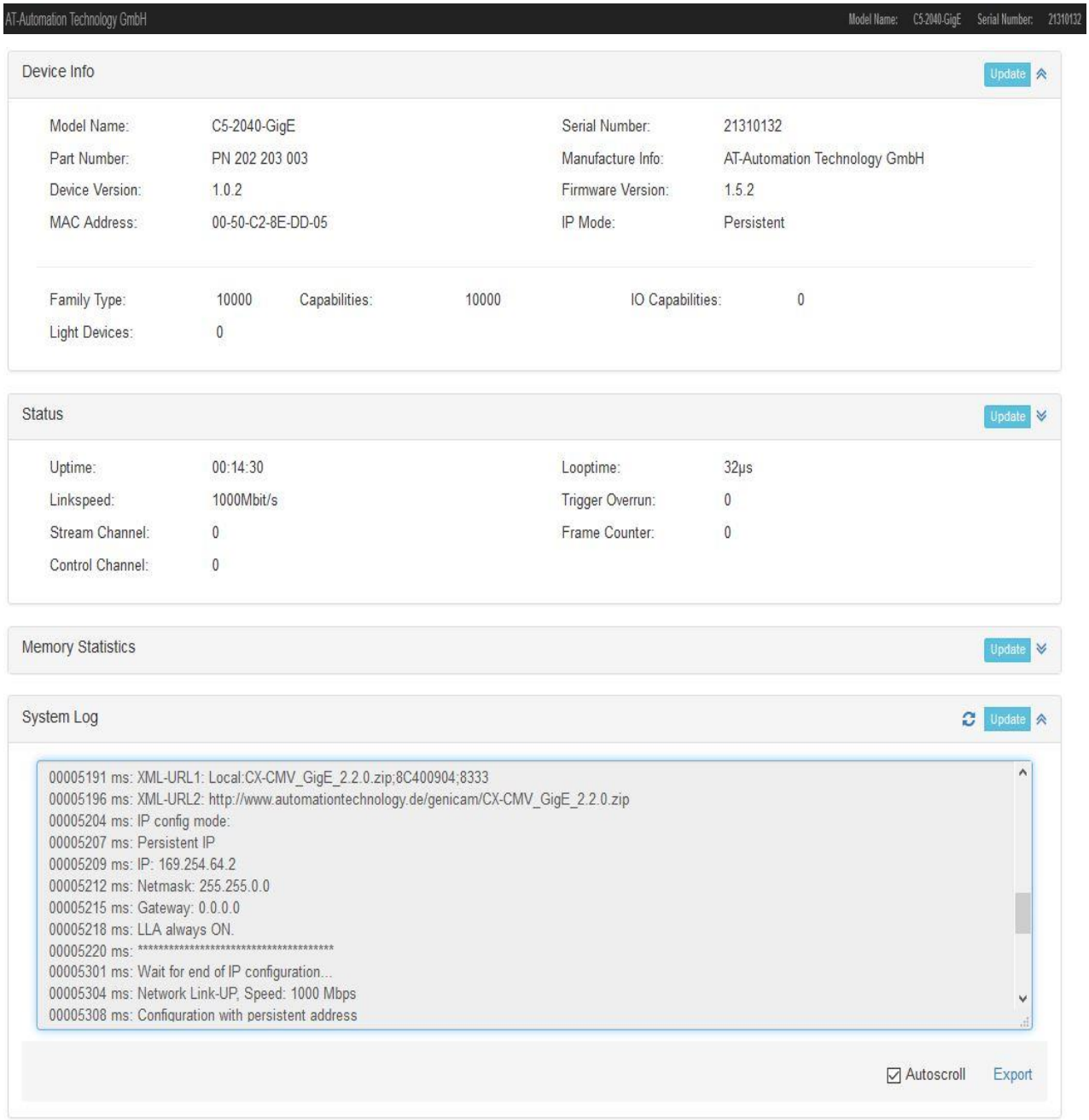
At the "System Log" panel is an additional button which starts an update process and will fetches every two seconds the log data. The state of auto update process is shown by *Spinning Button* (ON) or not spinning (OFF). The *Autoscroll* flag enable an automatically scroll down to the latest log entry. Over *Export* the complete log and JSON data of each panel data, wrapped in a single text file.

The "Device Info" panel displays model specific information.

The "Status" panel shows runtime status information.

The "Memory Statistics" have an overview of used memory for each component displaying current usage, memory size, maximum usage and error.

The "System Log" shows the complete serial log of the device.

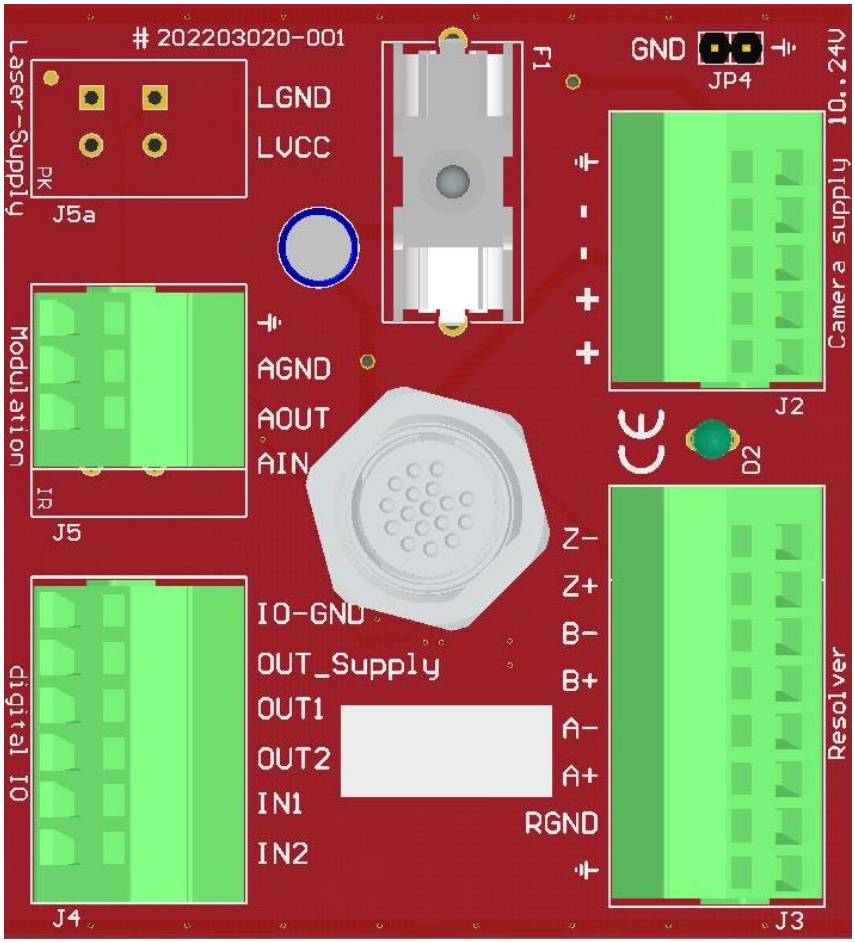

AT-Automation Technology GmbH
Model Name: C5-2040-GigE Serial Number: 21310132
Device Info
Update
Model Name: C5-2040-GigE
Serial Number: 21310132
Part Number: PN 202 203 003
Manufacture Info: AT-Automation Technology GmbH
Device Version: 1.0.2
Firmware Version: 1.5.2
MAC Address: 00-50-C2-8E-DD-05
IP Mode: Persistent
Family Type: 10000
Capabilities: 10000
IO Capabilities: 0
Light Devices: 0
Status
Update
Uptime: 00:14:30
Looptime: 32µs
Linkspeed: 1000Mbit/s
Trigger Overrun: 0
Stream Channel: 0
Frame Counter: 0
Control Channel: 0
Memory Statistics
Update
System Log
Update
00005191 ms: XML-URL1: Local:CX-CMV_GigE_2.2.0.zip;8C400904;8333
00005196 ms: XML-URL2: http://www.automationtechnology.de/genicam/CX-CMV_GigE_2.2.0.zip
00005204 ms: IP config mode:
00005207 ms: Persistent IP
00005209 ms: IP: 169.254.64.2
00005212 ms: Netmask: 255.255.0.0
00005215 ms: Gateway: 0.0.0.0
00005218 ms: LLA always ON.
00005220 ms: **
00005301 ms: Wait for end of IP configuration...
00005304 ms: Network Link-UP, Speed: 1000 Mbps
00005308 ms: Configuration with persistent address
Autoscroll
Export

The External C5-IO-Panel (Breakout Board)

The C5-IO-Panel (#202 202 006) provides a user friendly way to connect the power and the I/O functionality of the C5 sensor. The power supply includes a reverse voltage protection and features a 2A (two ampere) micro-fuse.

Fuse Specification	
Current	2A
Dimension	5 x 20mm
Characteristic	T
Operating Temperature	-50°C…+125°C

Mechanical Drawings



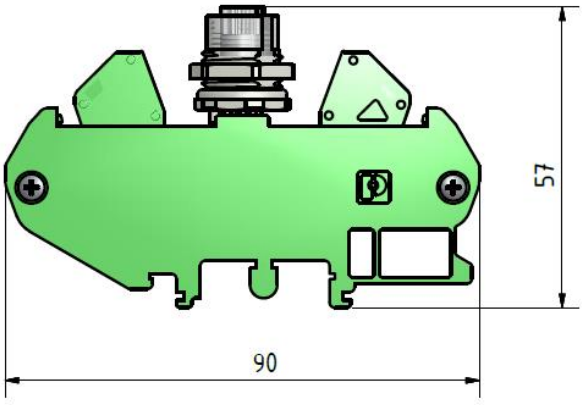
Never connect a C5 camera to a CS-IO-Panel for compact sensors. Wrong wiring can cause damage to the camera.

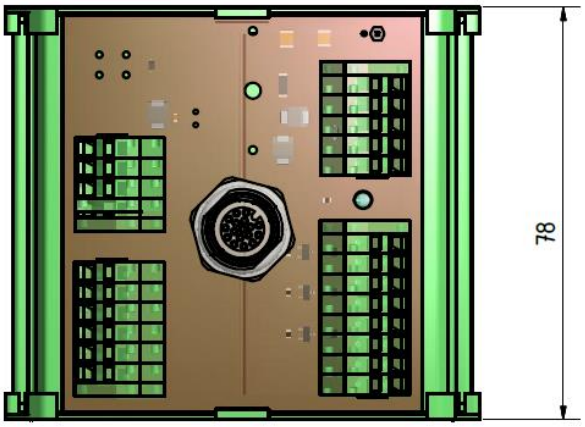
Clamp Configuration

Clamp No.	Signal Name	Description
J2/1	SHIELD	Camera shield
J2/2	GND_EXT (-)	Camera supply ground
J2/3	GND_EXT (-)	Camera supply ground
J2/3	VCC_EXT (+)	Camera supply voltage (10-24V DC)
J2/4	VCC_EXT (+)	Camera supply voltage (10-24V DC)
J3/1	Z-	Differential encoder/resolver index track Z-
J3/2	Z+	Differential encoder/resolver index track Z+
J3/3	B-	Differential encoder/resolver track B-
J3/4	B+	Differential encoder/resolver track B+
J3/5	A-	Differential encoder/resolver track A-
J3/6	A+	Differential encoder/resolver track A+
J3/7	RGND	Encoder/Resolver ground
J3/8	SHIELD	Encoder/Resolver shield
J4/1	IO_GND	Reference ground for digital inputs (IN1, 2) and outputs (OUT1, 2)
J4/2	OUT_Supply	Power supply voltage of camera isolated outputs (5-24V DC)
J4/3	OUT1	Isolated output #1 (reference voltage OUT_Supply)
J4/4	OUT2	Isolated output #2 (reference voltage OUT_Supply)
J4/5	IN1	Isolated input #1 (5-24V)
J4/6	IN2	Isolated input #2 (5-24V)
J5/1	SHIELD	Camera shield
J5/2	AGND	Analog output ground
J5/3	AOUT	Output for analog modulation of illumination device (0–5 V DC)

The analog output ground is directly connected to the internal camera ground. The analog output is NOT electrically isolated from the device ground! Please take care for a correct operation.

Mechanical Dimension

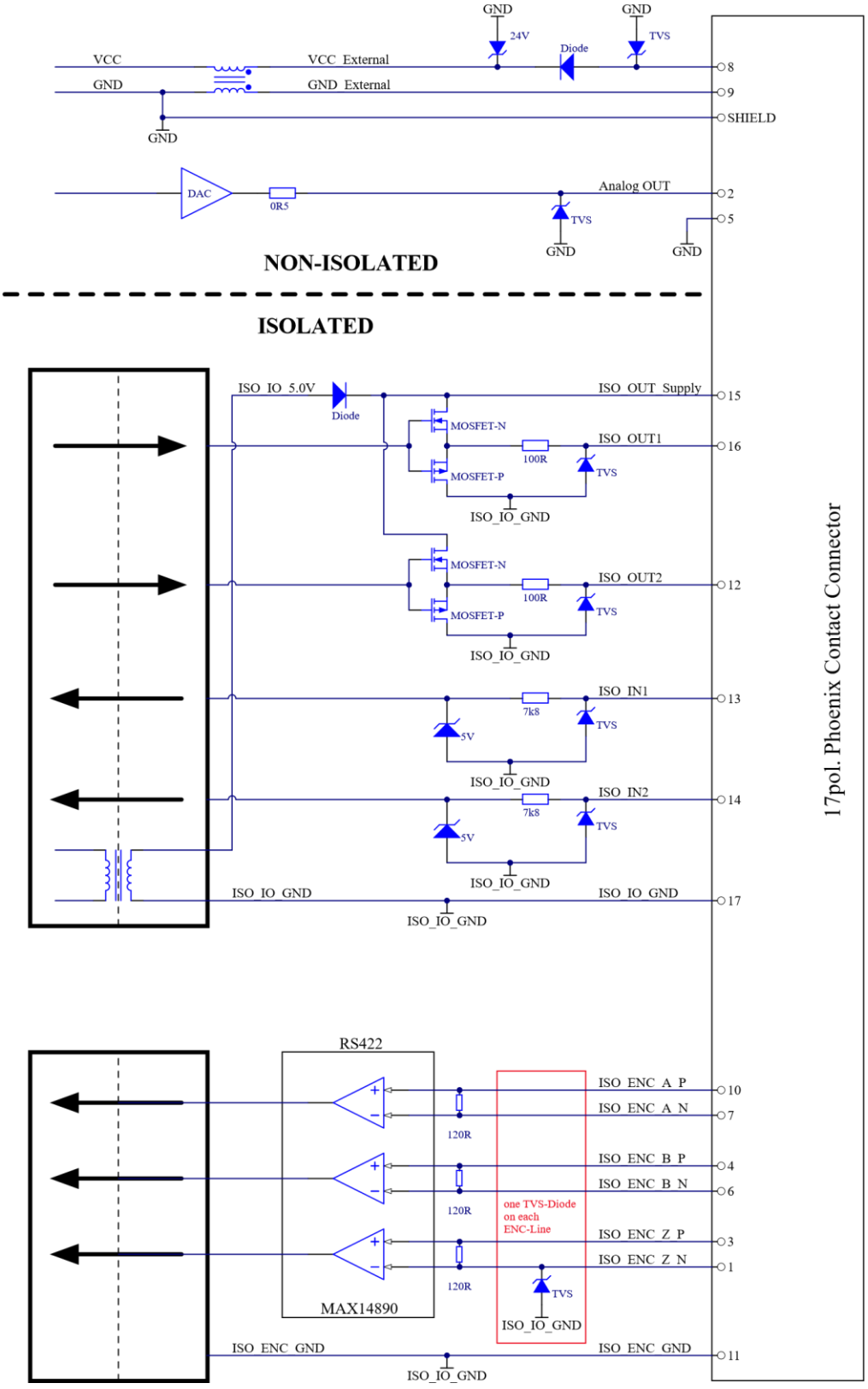




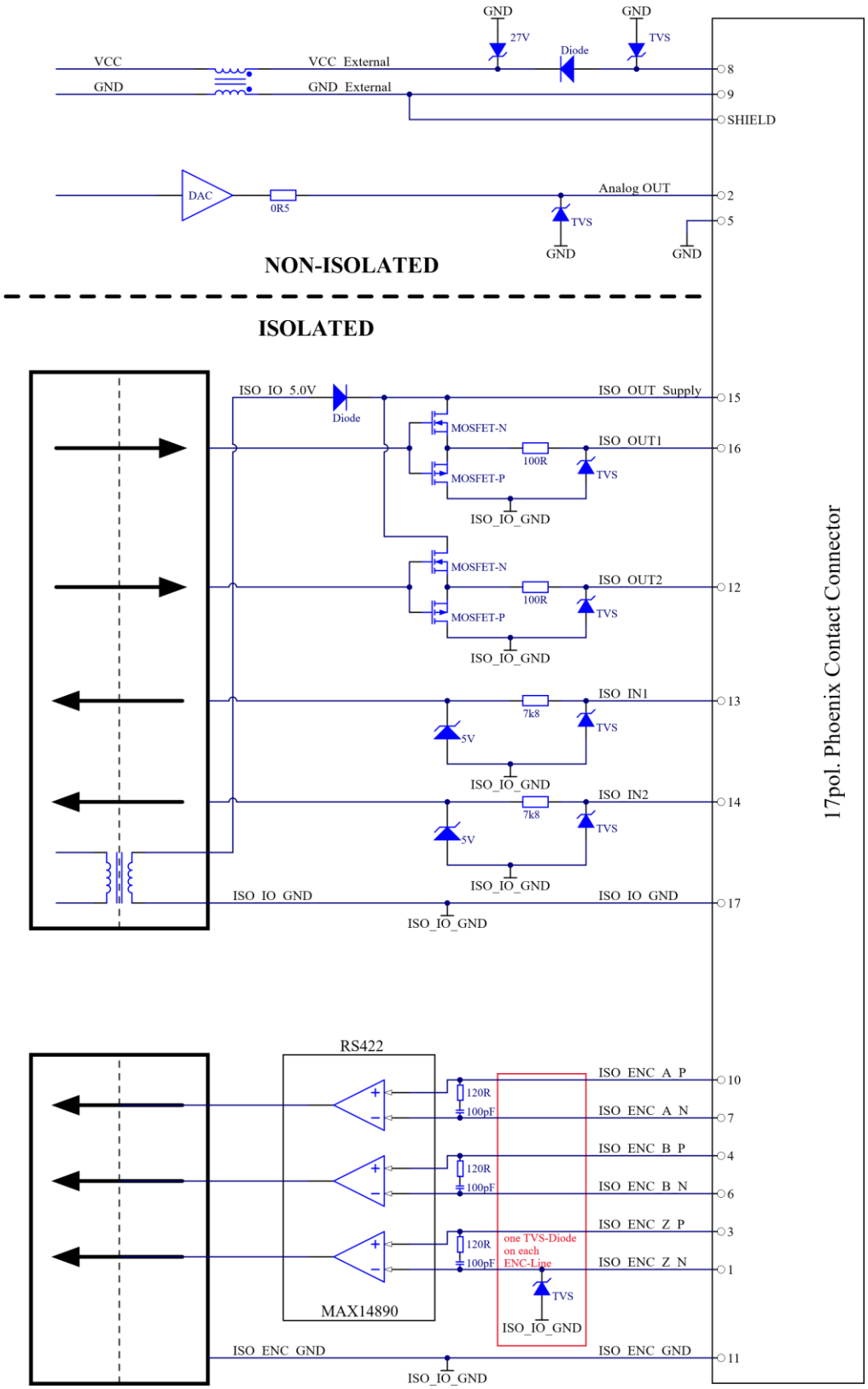
All dimensions in mm
Mount for DIN rail assembly

The C5 Series I/O Schematics

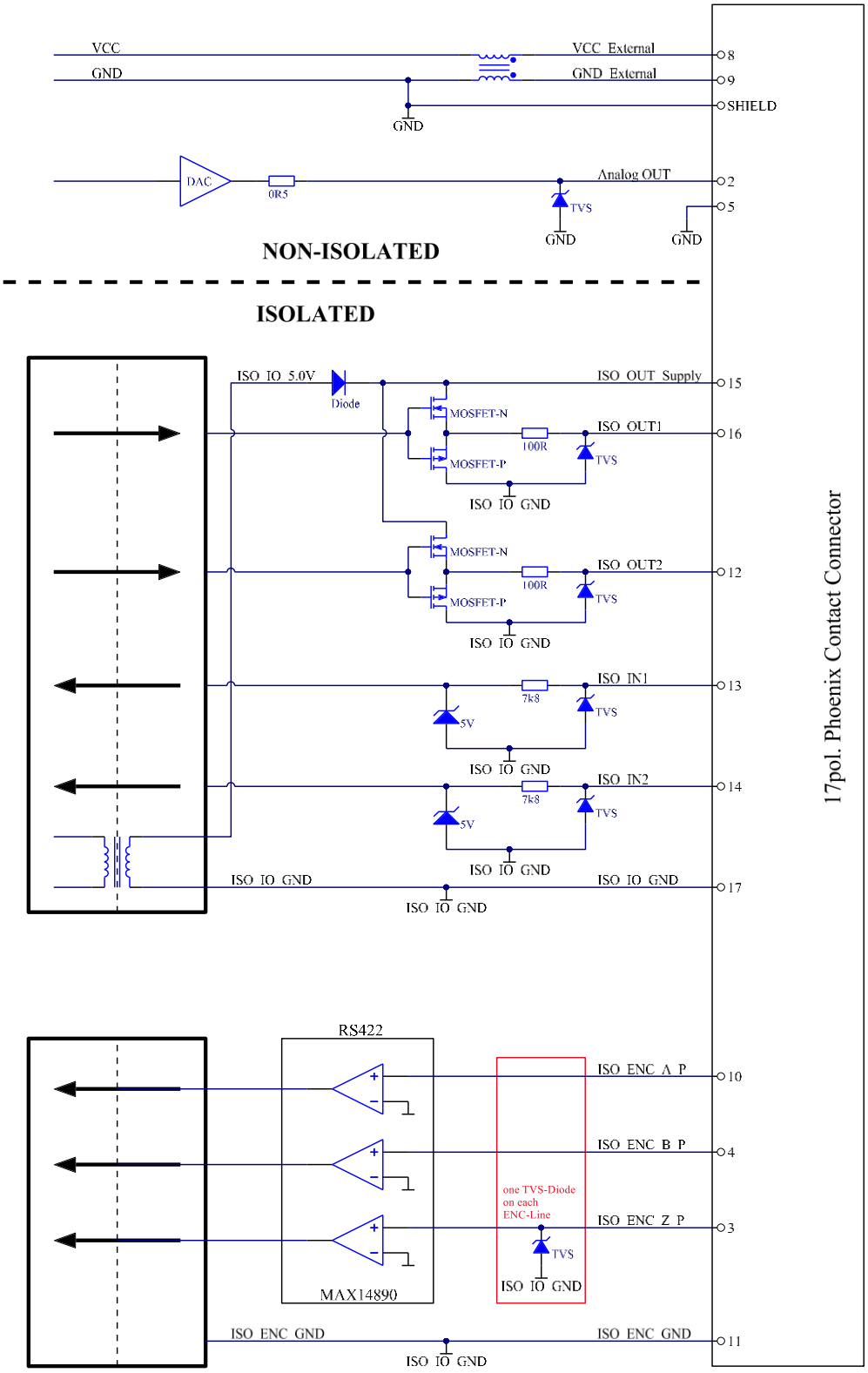
I/O and Encoder with Differential TTL-Mode for RS422 (Standard)



I/O and Encoder with Differential HTL-Mode for RS422 (Option)



I/O and Encoder with Single Ended HTL or TTL Mode for RS422 (Option)



Part Number for I/O and Encoder Option

Part Number #	Product Option
202 187 001	C5 Camera / CS HTL Encoder Option
202 187 002	C5 Camera / CS Single-Ended TTL Encoder Option
202 187 003	C5 Camera / CS Single-Ended HTL Encoder Option

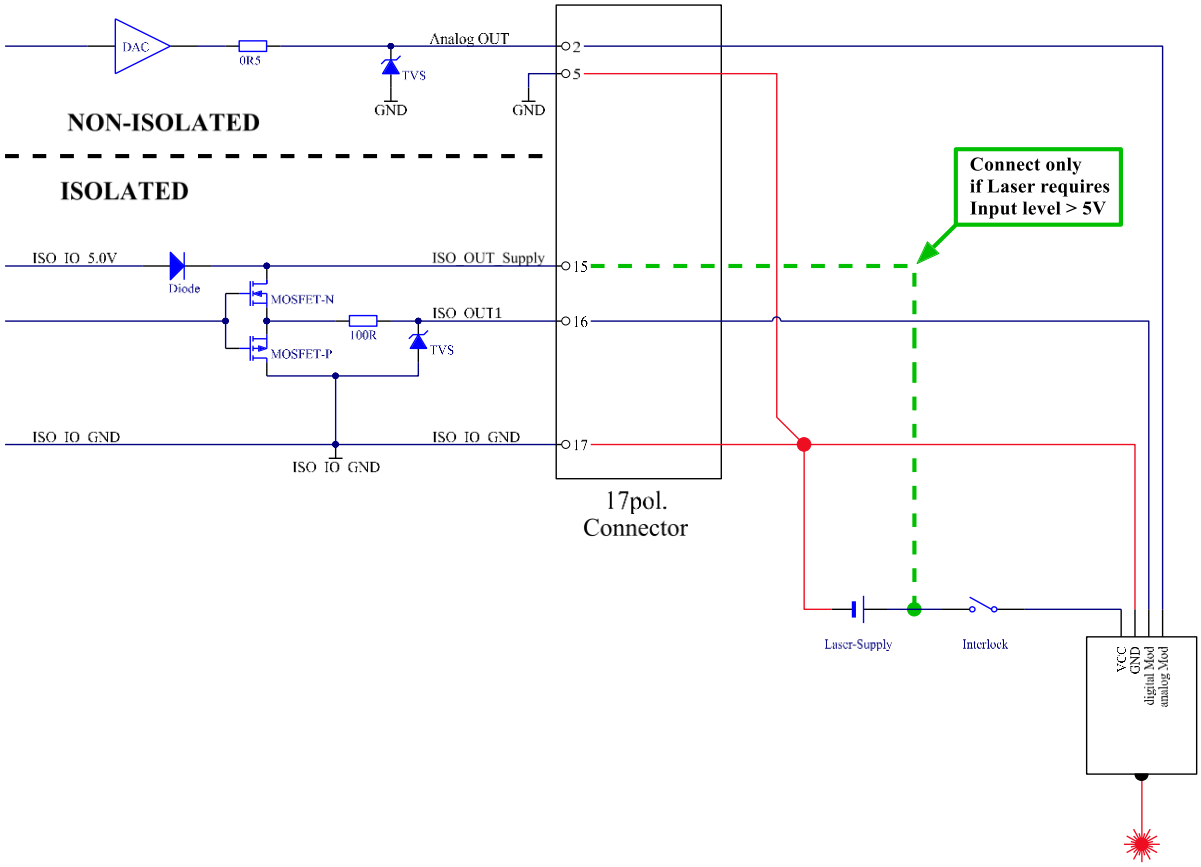
Encoder / Resolver Input Specification

Option	Specification
Differential HTL	Max. input voltage +24V DC Max. frequency: 1 MHz Min. pulse width: 475ns
Single-Ended TTL	Max. input voltage +5V DC (TTL level) Max. frequency: 5 MHz Min. pulse width: 80 ns
Single-Ended HTL	Max. input voltage +24V DC Max. frequency: 400 kHz Min. pulse width: 1.2µs

Laser Connection with Analog and Digital Modulation

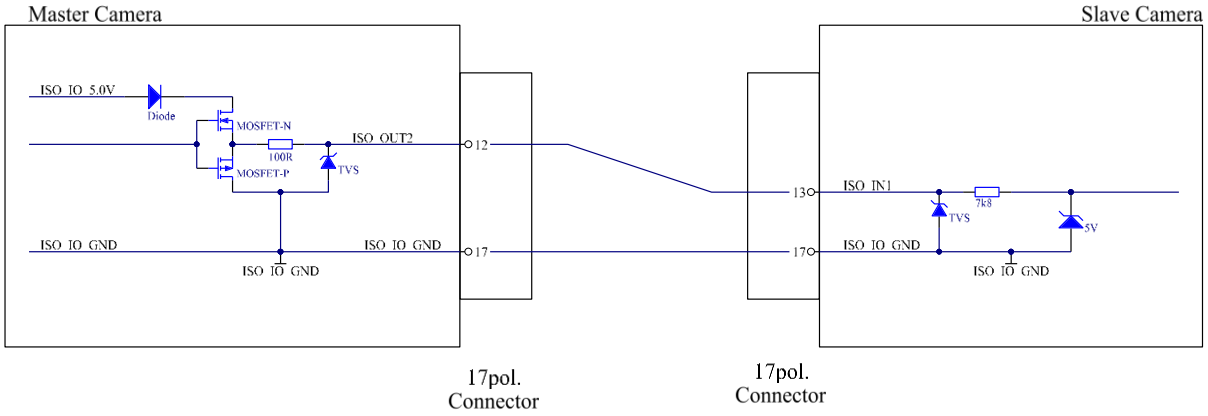
This schematic describes how a C5 camera can be used to control a laser module with respect to its digital and analog modulation.

- Connect the analog modulation wire of the laser to AOUT of the camera.
- Connect the digital modulation wire of the laser to OUT1 or OUT2 of the camera.
- If the laser requires modulation voltage >5V, connect higher voltage to OUT_Supply.

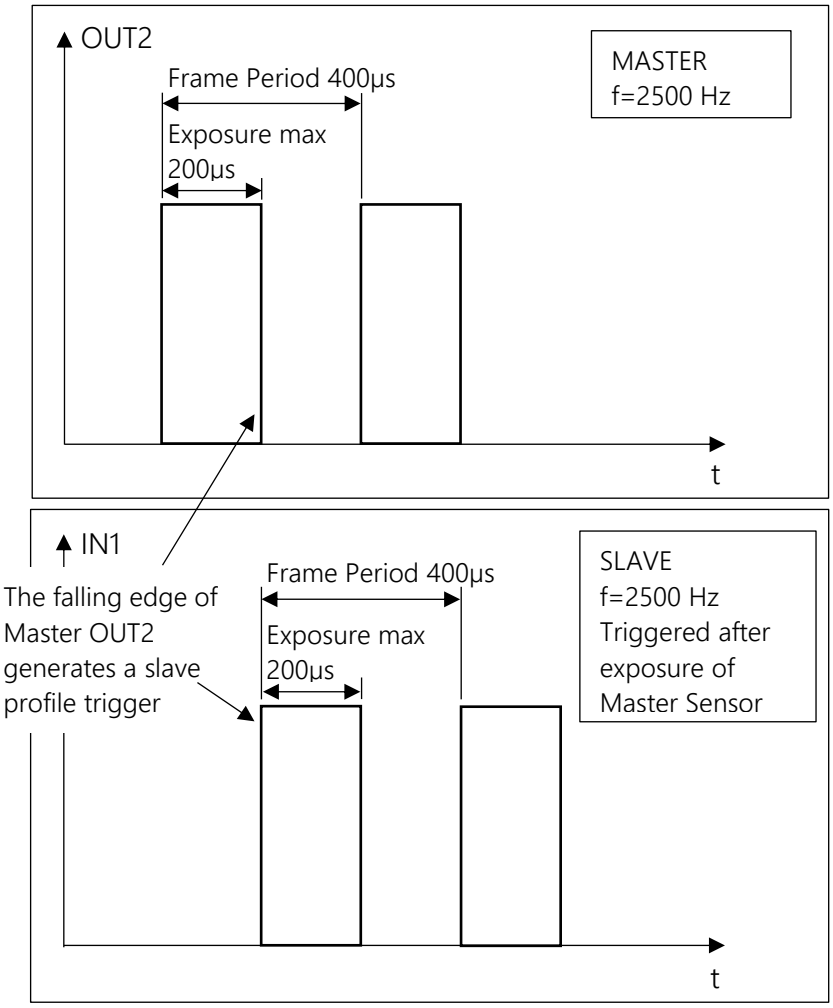


Master/Slave Connection

This schematic shows the required wiring to operate two C5 cameras in a Master/Slave mode. For this purpose the OUT2 of the master camera is exemplary connected to the trigger input IN1 of the slave camera. The Master/Slave mode can be realized with both inputs (IN1/IN2) and outputs (OUT1/OUT2).



Example configuration for Master/Slave Connection



Use Registers:

Master:
Output2 = Out2_IntegrationActive
Output2Invert = true

Slave:
ProfileTriggerMode = CameraInput1

The Digital Outputs

The C5 series features the possibility to output various digital signals. Those signals can be used to handle further machines or to check the internal signals.

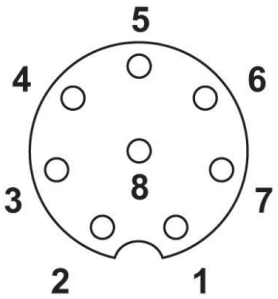
A list of all digital outputs can be found below.

Name	Interface	Access	Visibility	Description
Output1	IEnumeration	RW	Beginner	List the output signals available for first output (1): Out1_IntegrationActive (Value= 0) (2): Out1_SequencerActive (Value= 1) (3): Out1_IntegrationDualSlopeActive (Value= 2) (4): Out1_IntegrationTripleSlopeActive (Value= 3) (5): Out1_High (Value= 4) (6): Out1_Low (Value= 5) (7): Out1_InternalTrigger (Value= 6) (8): Out1_SequencerTriggerActive (Value= 7) (9): Out1_FrameValid (Value= 8) (10): LightController0 (Value= 9)
Output2	IEnumeration	RW	Beginner	List the output signals available for second output (1): Out2_IntegrationActive (Value= 0) (2): Out2_IntegrationDualSlopeActive (Value= 1) (3): Out2_IntegrationTripleSlopeActive (Value= 2) (4): Out2_High (Value= 3) (5): Out2_Low (Value= 4) (6): Out2_TriggerOverrun (Value= 5) (7): Out2_ResolverCountDir (Value= 6) (8): Out2_TriggerBusy (Value= 7) (9): Out2_AutoStart (Value= 8) (10): LightController0 (Value= 9)

A detailed description of the digital outputs can be found in a separate application note.

The C5-GigE Interface

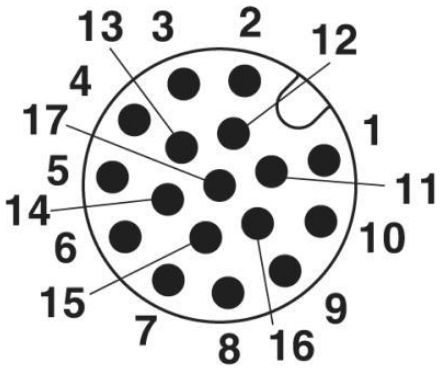
The GigE Interface



M12 GigE Female Connector Pin Assignment

Pin No.	GigE Signal Name
1	BI_DC-
2	BI_DD+
3	BI_DD-
4	BI_DA-
5	BI_DB+
6	BI_DA+
7	BI_DC+
8	BI_DB-
Shield	Shield

The Power & I/O Interface

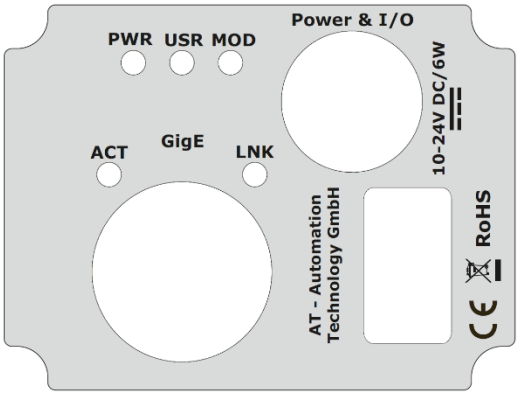


M12 I/O Male Connector Pin Assignment

Pin No.	Signal Name	Description
1	ENC_Z-	Encoder index track Z-
2	AO	Output for analog modulation of illumination device (0–5V DC)
3	ENC_Z+	Encoder/Resolver index track Z+
4	ENC_B+	Encoder/Resolver Track B+
5	GND	Internal camera GND for analog output (AO)
6	ENC_B-	Encoder/Resolver Track B -
7	ENC_A-	Encoder/Resolver Track A -
8	VCC_EXT	Camera supply voltage (12-24V DC)
9	GND_EXT	Camera supply ground
10	ENC_A+	Encoder/Resolver Track A+
11	ENC_GND	Encoder/Resolver ground
12	OUT2	Electrically isolated digital output 2
13	IN1	Electrically isolated digital input 1 (5-24V DC)
14	IN2	Electrically isolated digital input 2 (5-24V DC)
15	OUT_Supply	Reference supply for digital isolated outputs (5-24V DC)
16	OUT1	Electrically isolated output 1
17	IO_GND	Reference ground for digital inputs (IN1, 2) and outputs (OUT1, 2)
Shield	SHIELD	Is connected to camera case

The analog output ground is directly connected to the internal camera ground. The analog output is NOT electrically isolated from the device ground! Please take care for a correct operation.

Description of LEDs



LED	Description
1 (PWR)	Green On= Power On and camera start up completed Off = Power Off or camera start up failed
2 (USR)	<u>After Power On:</u> Off = no network cable connected Green On = network connected <u>After Network connected:</u> Green On = CCP status connected Off = CCP status disconnected Red On= no network found, no network cable connected
3 (MOD)	Not assigned to any function
4 (ACT)	Green blink = Indication of network activity
5 (LNK)	Green On = Linkspeed 1 Gbit Amber On = Linkspeed 100 Mbit Off = Linkspeed 10 Mbit or wait for end of autonegotiation

The C5 Series Cables

Cables for Power, I/O and Laser Control

Part Number #	Description
202 202 300	M12 17 pin cable for power, I/O and laser control, custom length and connector configuration (straight/angled), shielded, high flex
202 202 301	M12 17 pin cable for power, I/O and laser control, straight M12 female connector (IP67) to straight M12 male connector (IP67), shielded, length 0.5m, high flex
202 202 302	M12 17 pin cable for power, I/O and laser control, straight M12 female connector (IP67) to straight M12 male connector (IP67), shielded, length 3m, high flex
202 202 303	M12 17 pin cable for power, I/O and laser control, straight M12 female connector (IP67) to straight M12 male connector (IP67), shielded, length 5m, high flex
202 202 304	M12 17 pin cable for power, I/O and laser control, straight M12 female connector (IP67) to straight M12 male connector (IP67), shielded, length 10m, high flex
202 202 305	M12 17 pin cable for power, I/O and laser control, straight M12 female connector (IP67) to straight M12 male connector (IP67), shielded, length 15m, high flex

Pigtail cables:

202 202 311	M12 17 pin pigtail cable for power, I/O and laser control, straight M12 female connector (IP67) on camera plug, shielded, length 3m, high flex
202 202 312	M12 17 pin pigtail cable for power, I/O and laser control, straight M12 female connector (IP67) on camera plug, shielded, length 5m, high flex
202 202 313	M12 17 pin pigtail cable for power, I/O and laser control, straight M12 female connector (IP67) on camera plug, shielded, length 10m, high flex
202 202 314	M12 17 pin pigtail cable for power, I/O and laser control, straight M12 female connector (IP67) on camera plug, shielded, length 15m, high flex
202 202 315	M12 17 pin pigtail cable for power, I/O and laser control, straight M12 female connector (IP67) on camera plug, shielded, length 30m, high flex

Angled adapter cables:

202 201 501	M12 17 pin angled adapter cable for power, I/O and laser control, 90° angled M12 female connector (IP64) on camera plug to straight M12 male (IP64), angled connector configuration "TYPE #1", length 0.2m, standard
202 201 511	M12 17 pin angled adapter cable for power, I/O and laser control, 90° angled M12 female connector (IP64) on camera plug to straight M12 male (IP64), angled connector configuration "TYPE #2", length 0.2m, standard

Wire Assignment of M12 17 pin Pigtail Cable

Pin/Wire No.	Wire Colour	Signal Name	Description
1	Brown	ENC_Z-	Encoder index track Z-
2	Blue	AO	Output for analog modulation of illumination device (0V to +5V DC)
3	White	ENC_Z+	Encoder/Resolver index track Z+
4	Green	ENC_B+	Encoder/Resolver Track B+
5	Pink	GND	Reference GND for analog output AO (internal camera GND)
6	Yellow	ENC_B-	Encoder/Resolver Track B -
7	Black	ENC_A-	Encoder/Resolver Track A -
8	Gray	VCC_EXT	Camera supply voltage (+10V to +24V DC)
9	Red	GND_EXT	Camera supply GND
10	Violette	ENC_A+	Encoder/Resolver Track A+
11	Gray/Pink	ENC_GND	Encoder/Resolver ground
12	Red/Blue	OUT2	Opto-isolated digital output 2
13	White/Green	IN1	Opto-isolated digital input 1 (+5V to +24V DC)
14	Orange/Green	IN2	Opto-isolated digital input 2 (+5V to +24V DC)
15	White/Yellow	OUT_Supply	Supply for digital output signals OUT1, 2 (+5V to +24V DC)
16	Yellow/ Orange	OUT1	Opto-isolated digital output 1
17	White/Gray	IO_GND	Reference ground for digital inputs (IN1, 2) and outputs (OUT1, 2)

The analog output ground is directly connected to the internal camera ground. The analog output is NOT electrically isolated from the device ground! Please take care for a correct operation.

Cables for GigE Interface

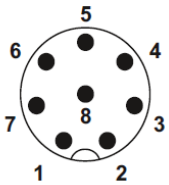
Part Number #	Description
202 201 200	M12 GigE cable with custom length and connector configuration (straight/angled)
202 201 201	M12 GigE cable, straight M12 male connector (IP67) on camera plug to RJ45 (IP20), length 0.5m, standard
202 201 202	M12 GigE cable, straight M12 male connector (IP67) on camera plug to RJ45 (IP20), length 3m, standard
202 201 203	M12 GigE cable, straight M12 male connector (IP67) on camera plug to RJ45 (IP20), length 5m, standard
202 201 204	M12 GigE cable, straight M12 male connector (IP67) on camera plug to RJ45 (IP20), length 10m, standard
202 201 205	M12 GigE cable, straight M12 male connector (IP67) on camera plug to RJ45 (IP20), length 15m, standard
202 201 206	M12 GigE cable, straight M12 male connector (IP67) on camera plug to RJ45 (IP20), length 30m, standard

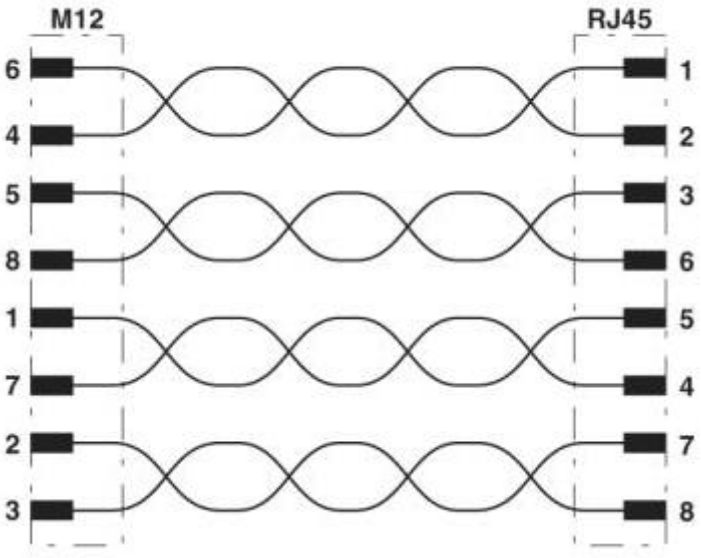
Angled adapter cables:

202 201 502	M12 GigE angled adapter cable for GigE, 90° angled M12 male connector (IP64) on camera plug to straight M12 female (IP64), angled connector configuration "TYPE #1", length 0.2m, standard
202 201 512	M12 GigE angled adapter cable for GigE, 90° angled M12 male connector (IP64) on camera plug to straight M12 female (IP64), angled connector configuration "TYPE #2", length 0.2m, standard

M12

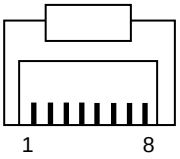
Male Plug





RJ45

Male Plug

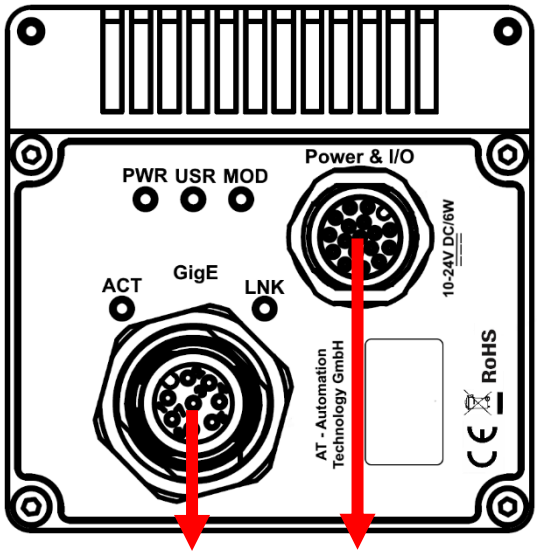
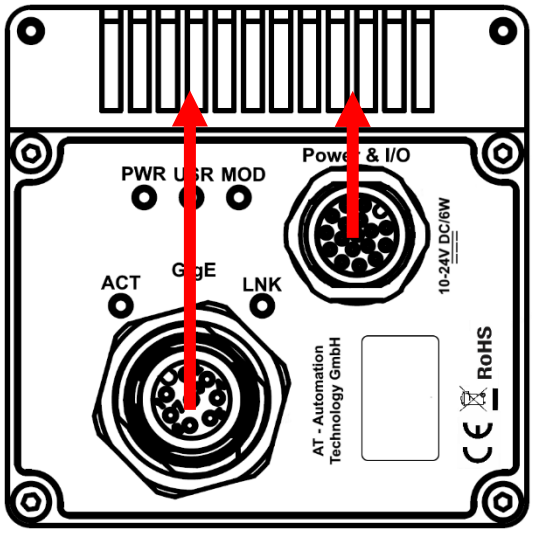


GigE Signal Name	Pin No. M12	Pin No. RJ45
BI_DC-	1	5
BI_DD+	2	7
BI_DD-	3	8
BI_DA-	4	2
BI_DB+	5	3
BI_DA+	6	1
BI_DC+	7	4
BI_DB-	8	6
Shield	Shield	Shield

Orientation of Angled Adapter Cable

Depending on the used adapter cable the orientation differs. The option “TYPE #1” or “TYPE #2” will change the outlet direction of the angled cables.

Part Number #	Description
202 201 501	Power & I/O “TYPE #1”
202 201 502	GigE “TYPE #1”
202 201 511	Power & I/O “TYPE #2”
202 201 512	GigE “TYPE #2”

TYPE #1	TYPE #2
	

The C5 Series GenICam Features

A complete list of all GenICam features for all types of C5 cameras (C5-1280-GigE, C5-2040-GigE and C5-4090-GigE) can be found in separate notes.

Device Control

Description of the camera and its sensor

Image Format Control

Features controlling the size and type of the transmitted image

Acquisition Control

Feature relating to actual frame acquisition

Camera Control

Features relating to camera control

AOIs

Features relating to area of interest

FIR Control

Features relating to FIR

Mode and Algorithm Control

Features relating to camera mode and algorithm

AoiTracking
Features relating to AOI-Tracking mode

AoiSearch
Features relating to the AOI-Search mode

ColumnEvaluationMask
Features relating to the Column Evaluation Mask. It is a global mask and valid for all functions (AOI-Tracking, AOI-Search, AutoStart)

Sensor Control

Features relating to sensor control

Advanced Sensor Settings
Features relating to advanced sensor settings

Data Output Channels

Features relating to data output

Commands

Commands for camera

Light Control

Features relating to Light Control

Camera IO

Features relating to camera input and output

Trigger Control

Features relating to trigger controls

RS422 Resolver

Features relating to RS422 resolver

AutoStart

Features relating to AutoStart

Transport Layer Control

Features related to GigE Vision specification

GigE Vision

Features related to GigE Vision specification

User Set Control

Features related to the User Set Control to save and load the user device settings

Chunk Data Control

Features relating to chunk data control

Event Control

Features required to control the generation of event notifications sent to host application

File Access Control

Category that contains the file access control features

Additional Features for Scatter Firmware

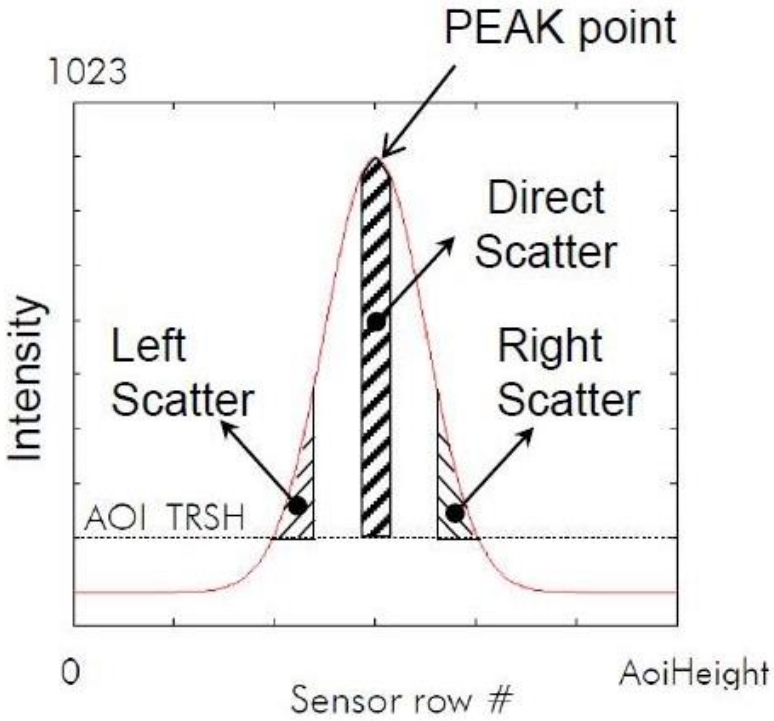
C5-2040-SCT-GigE

The Scatter Mode

The C5-2040-SCT-GigE is a customized firmware of the C5-2040-GigE featuring 3D profile scan by means of FIR PEAK algorithm and output of laser scatter data.

The different behaviour of the scattering of light on the object surface can highlight various features that would be hard to detect in a normal grayscale image.

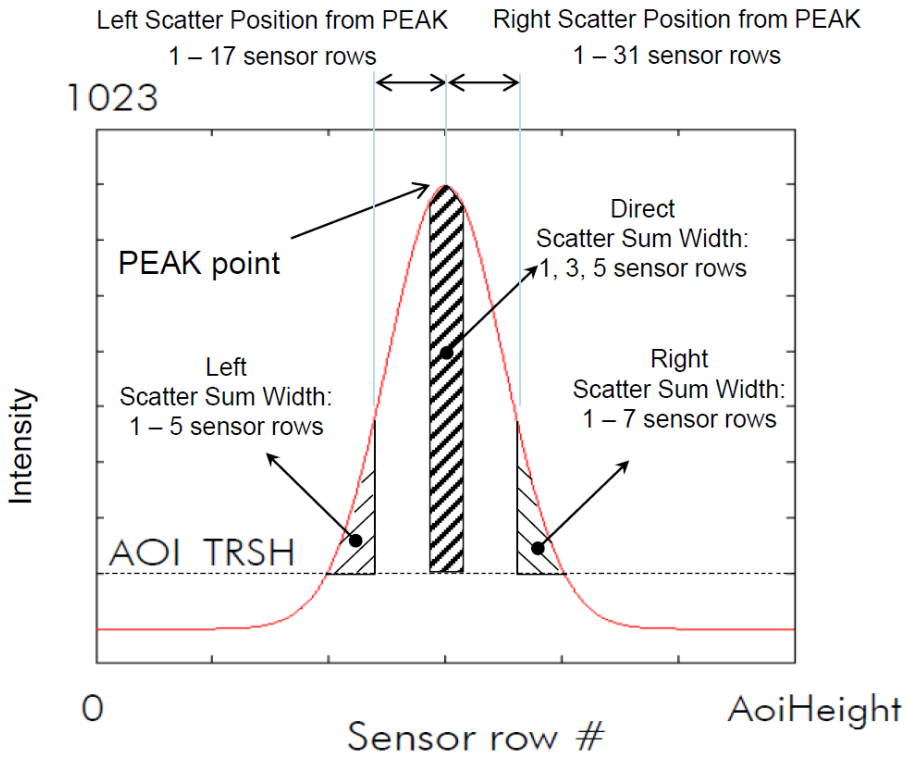
The scatter component can output the direct scatter which is the sum of intensities around the PEAK position and the left or right scatter component which are the sum of intensities left and right to the PEAK point.



The left and right scatter feature have two adjustable parameters. First the Left Scatter Width / Right Scatter Width to set the number of rows which will sum together and second the Left Scatter Position / Right Scatter Position to state how far away from the PEAK the intensities are summed.

The direct scatter can determine the width (Direct Scatter Width) of the sum of intensities at the peak point.

Parameter	Range
Left Scatter Position	1-17
Left Scatter Width	1-5
Right Scatter Position	1-31
Right Scatter Width	1-7
Direct Scatter Width	1, 3 or 5



According to the possibility to adjust positions and widths of the scatter functions there are some conditions which have to follow for the right adjustment.

Conditions for adjusting the scatter functions

1. "Left Scatter Position" + "Left Scatter Width" ≤ 18
2. "Right Scatter Position" + "Right Scatter Width" ≤ 32
3. "Direct Scatter Width" = 1 -> "Left / Right Scatter Position" min. = 1
4. "Direct Scatter Width" = 3 -> "Left / Right Scatter Position" min. = 2
5. "Direct Scatter Width" = 5 -> "Left / Right Scatter Position" min. = 3

Simultaneous Output of 3D & Laser Scatter Data

Over the different data output channels, it is possible to acquire the 3D information of the scanned object and in the same moment to get the laser scatter information.

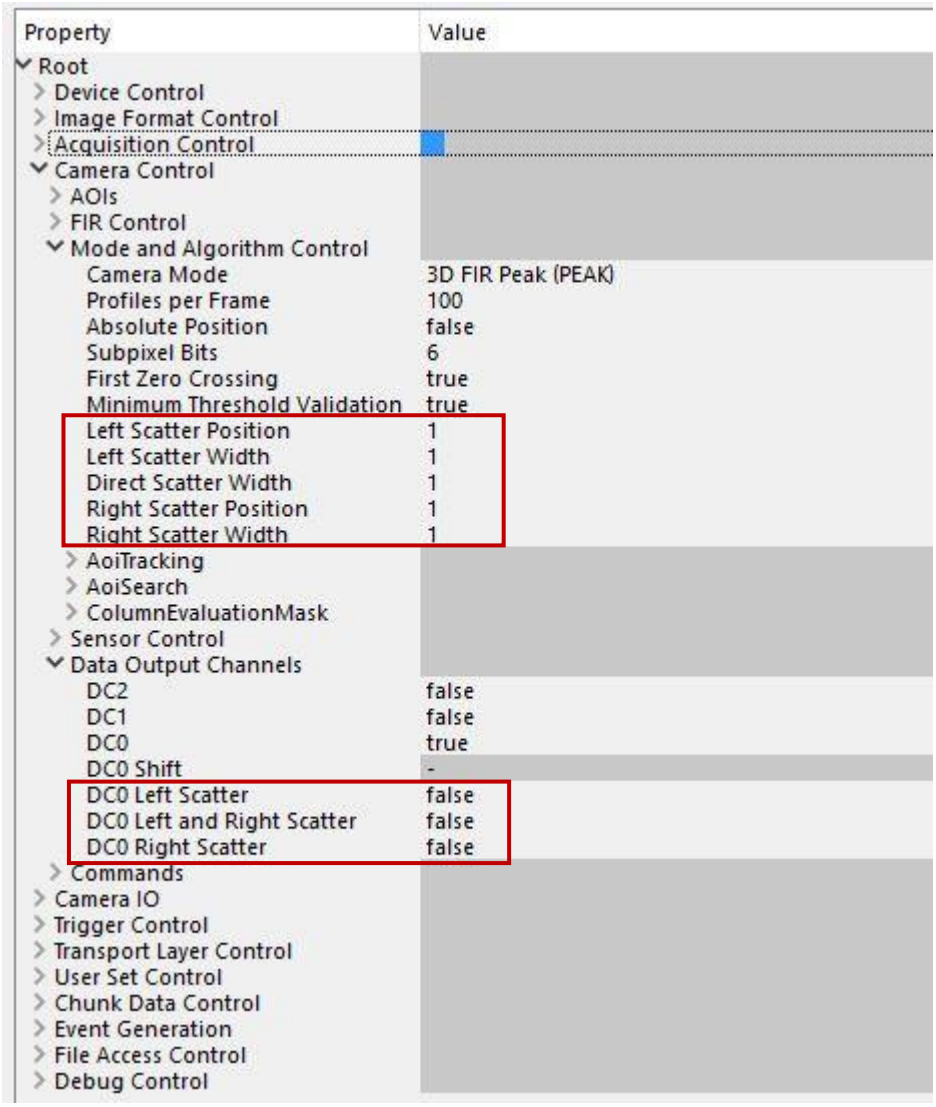
For left and right scatter there are three possibilities to define which information should be transmitted over the data output channel 0.

DC0 = Left Scatter

DC0 = Left and Right Scatter

DC0 = Right Scatter

XML view of the scatter functions



Mode and Algorithm Control

Name	Interface	Access	Visibility	Description
LeftScatterPosition *(**)*	IInteger	RW	Beginner	Left Scatter Position Min: 1 Max: 17 Increment: 1
LeftScatterWidth *(**)*	IInteger	RW	Beginner	Left Scatter Width Min: 1 Max: 5 Increment: 1
DirectScatterWidth *(**)*	IInteger	RW	Beginner	Direct Scatter Width Min: 1 Max: 5 Increment: 2
RightScatterPosition *(**)*	IInteger	RW	Beginner	Right Scatter Position Min: 1 Max: 31 Increment: 1
RightScatterWidth *(**)*	IInteger	RW	Beginner	Right Scatter Width Min: 1 Max: 7 Increment: 1

*: THIS FEATURE CAN BE TEMPORARILY LOCKED DEPENDING ON CAMERASTATUS
**: THIS FEATURE CAN BE TEMPORARILY NOT AVAILABLE DEPENDING ON CAMERASTATUS
***: THIS FEATURE CAN BE NOT IMPLEMENTED AT ALL DEPENDING ON SENSORTYPE OR SOFTWAREVERSION

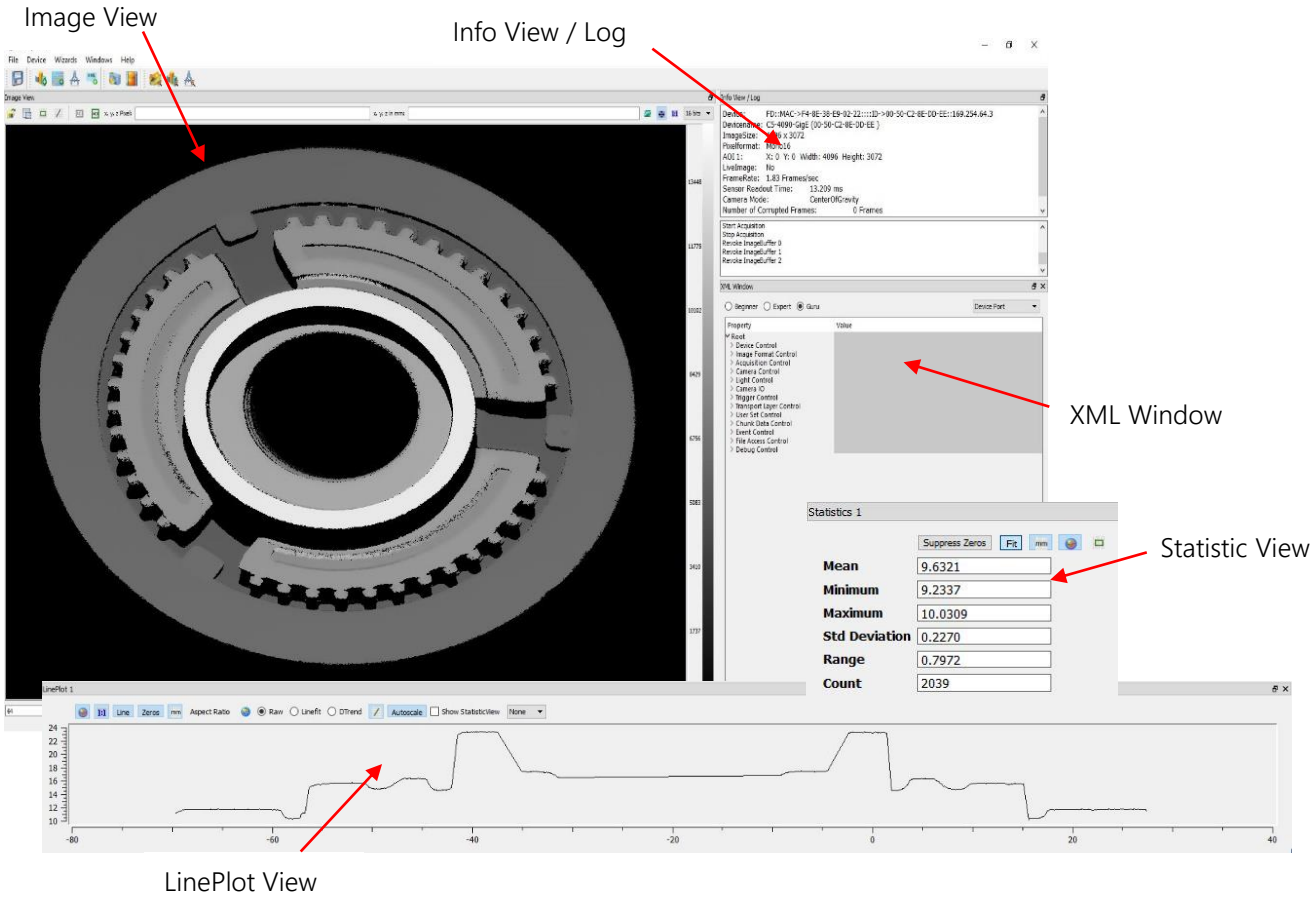
cxExplorer Overview

The cxExplorer

Configuration of a C5 camera can be easily done with the cxExplorer, which is a graphical user interface provided by AT - Automation Technology. With the help of the cxExplorer a camera can be simply adjusted to the required settings. Furthermore, the cxExplorer gives the opportunity to display various information like the 2D image, 3D height image and many more.

This chapter gives some general information about the layout of the cxExplorer such as an overview of how to set parameters and features.

More details regarding the operation of the cxExplorer can be found in a separate application note.



cxExplorer Features

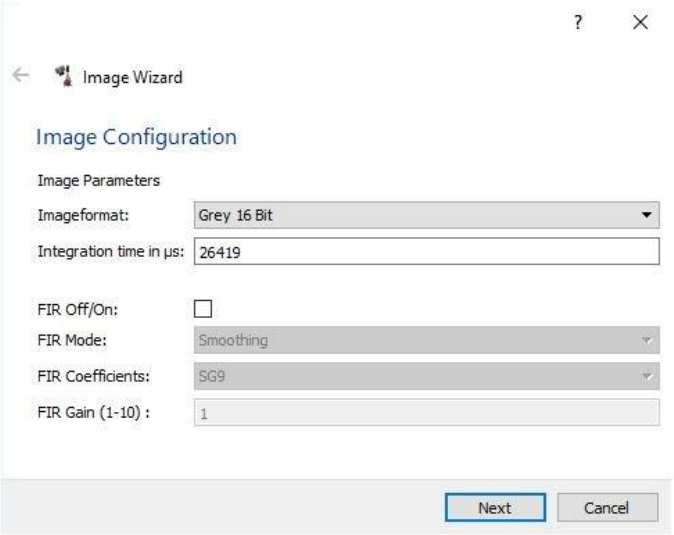
As mentioned in the previous chapter **The C5 Sensor Algorithms** every C5 camera is able to run in 2D image mode or in 3D mode.

The configuration of the required mode can be easily done with the cxExplorer via the *Image Wizard, 3D Wizard* or over the *XML Window*.

Image Wizard 3D Wizard

Image Wizard

The Image Wizard is the easy way to set the camera manually to the 2D greyscale image mode. Select the image format, set the integration time and enable or disable the FIR filter.



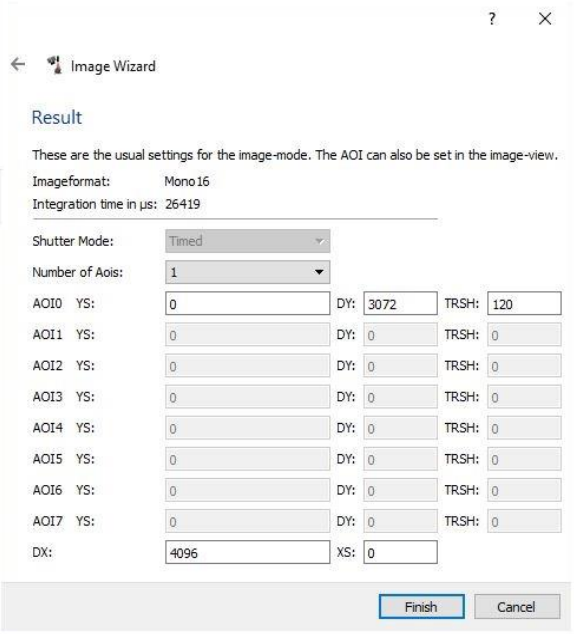
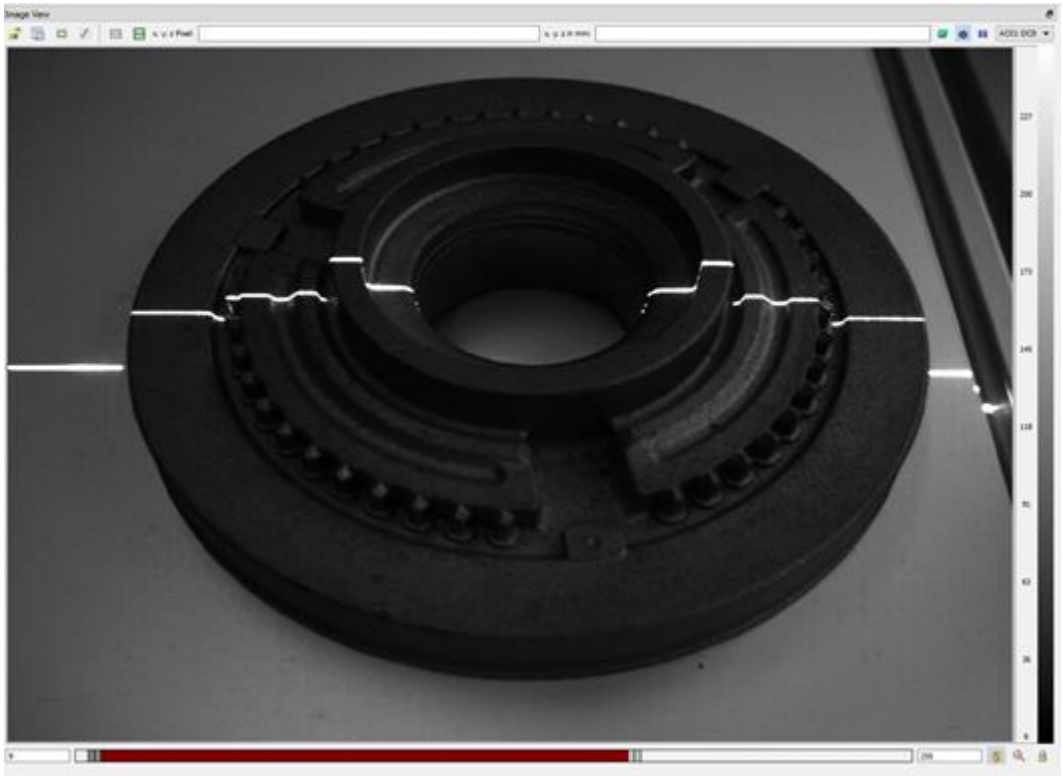


Image Mode

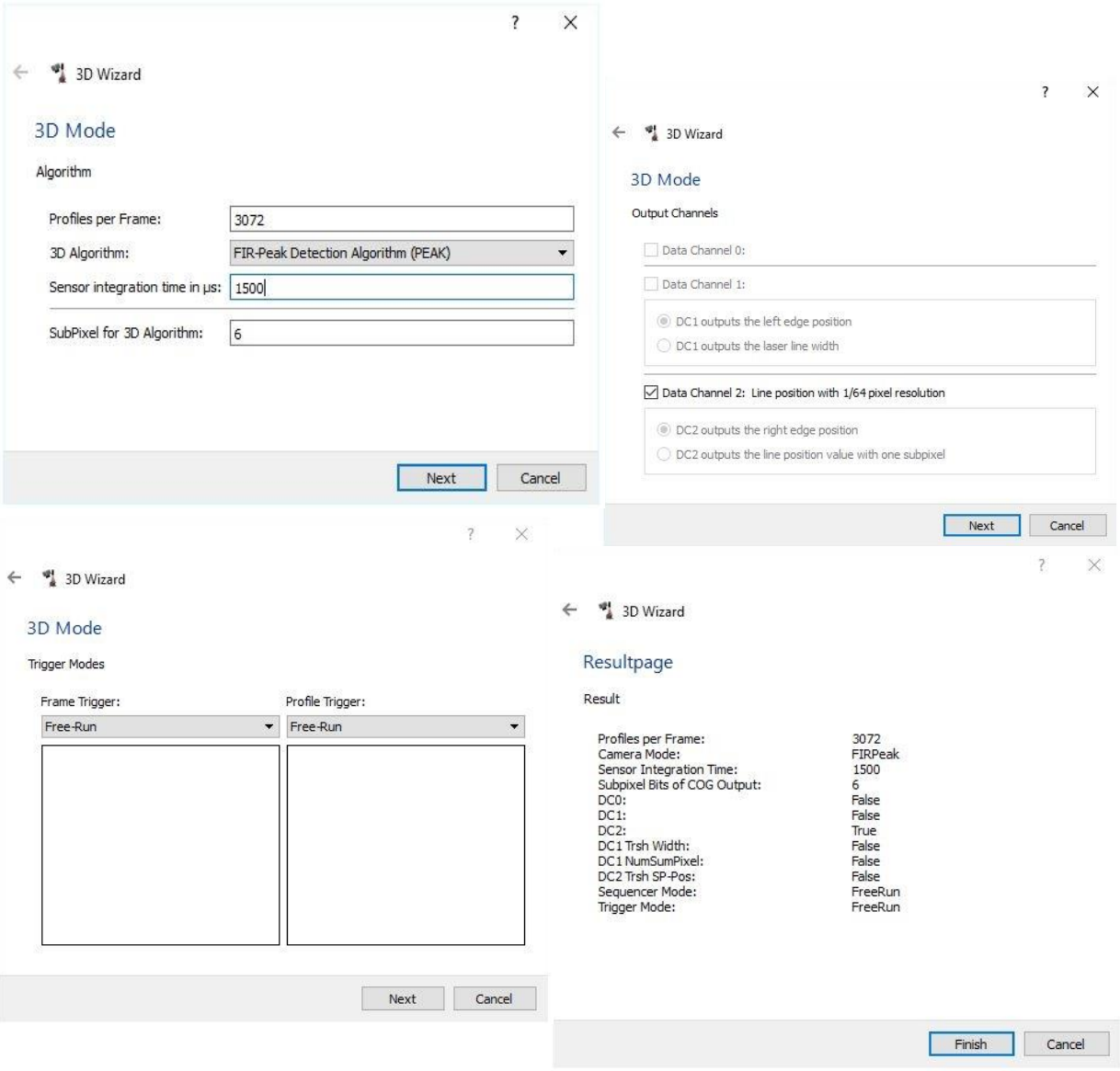
The image mode enables the output of the 2D CMOS sensor images of the camera. That can be helpful e.g. to set and optimize the laser power, the Area Of Interest or the exposure time.



(2D greyscale image)

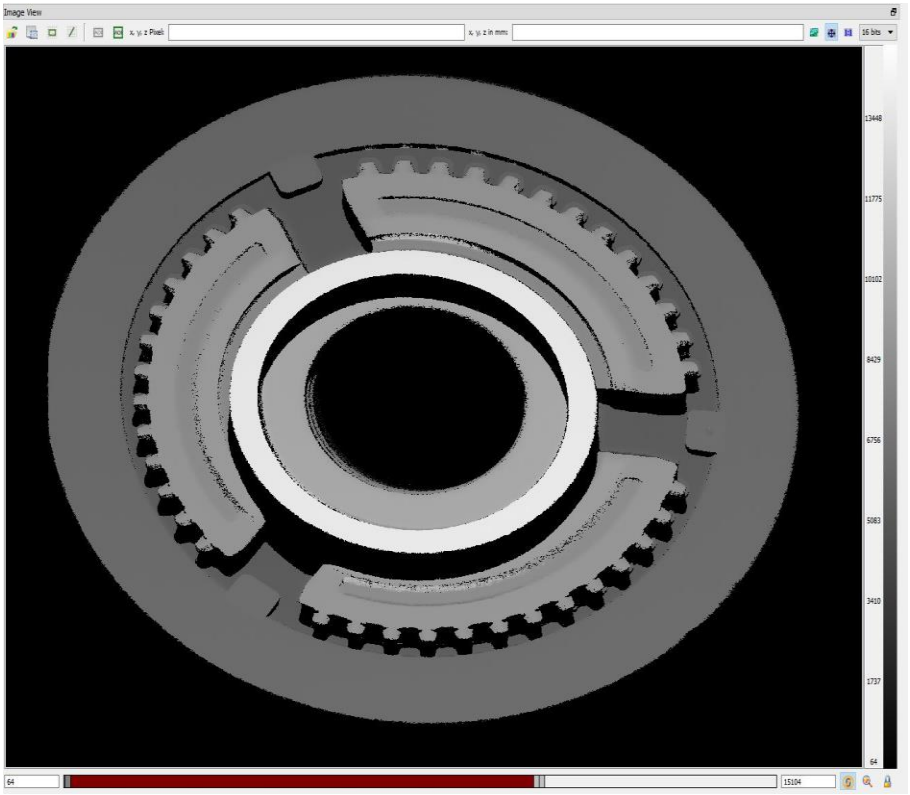
3D Wizard

With the 3D Wizard the camera mode can be easily switched to 3D mode. Set the number of profiles per frame, choose the 3D algorithm, set the integration time and select the number of subpixels. Enable the required Output Channels and select the trigger mode to finish the wizard.



3D Mode

In the 3D a greyscale height image can be acquired and displayed in the Image View using one of the four different algorithms. Furthermore, the intensity image can be also displayed.



(3D greyscale height image)

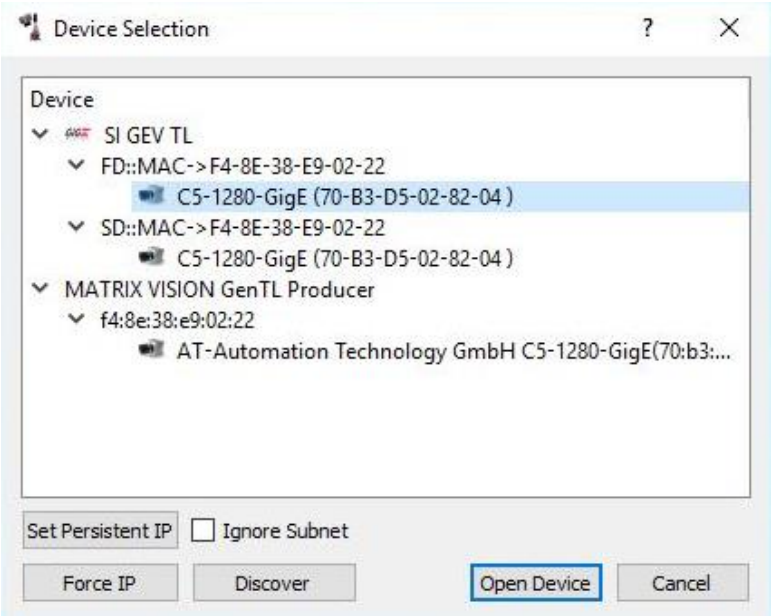
A detailed description of the operation of the cxExplorer can be found in a separate application note.

Quickstart a C5 camera

This chapter explains the handling to set up a C5 camera and the computer to acquire the first images.

Set the computer to the recommended settings in the following.

1. **Turn off** all possible software which can block sent packages from the camera to the PC or the other way around like **Firewalls** or **Antivirus** software.
2. **Connect the camera** directly or over a switch to the PC. Identify which network interface card (NIC) is linked to the camera.
3. **Disable** not needed **filter drivers** and **protocols** of the NIC port.
4. **Set** the **NICs** Internet Protocol Version 4 (TCP/IPv4) to a **fix IP address** and a fix subnet mask. For example: 169.254.64.1, 255.255.0.0.
5. **Set** the **camera** to a **fix IP address** into the same range as well as the subnet mask.
6. **Enable Jumbo Frames** if possible.
7. **Starting the cxExplorer** lead to the *Device Selection.* Chose the camera over a present transport layer and open the device. If the camera isn´t visible check the IP address or search for subnets. Use the Filter Driver (FD) if available.



By default the camera starts in the factory mode. For the C5 camera the factory mode is the 2D image mode. **Start** the continuous **image grab** over or do a single image snap over .

The first images were acquired.

For more information how to connect a C5 camera please have a look into our FAQ.

cxSoftware Development Kit

Automation Technology´s Software Development Kit (cxSDK) is free of charge and allows the programmatically access and control of C5 cameras and further the possibility of a 3D calibration.
The cxSDK provides a C-based application-programming interface (API) with language wrappers for C++, C#, Python, Matlab and Octave.
The cxSDK consists of the cxCam and cx3d library.
The cxCam library provides functions for discovering and enumerating connected devices via the GEV standard as well as the camera configuration, image acquisition and event handling.
The cx3d library provides functions for intrinsic and extrinsic calibration models to transform the height images (range maps) from the camera to 3D point cloud images or rectified images.

cx_3d_snap_point_cloud.py

```
167     # get image from buffer
168         # the img object holds a reference to the data in the internal buffer, if you need the image data after cx_queueBu
169     result, img = cam.cx_getBufferImage(hBuffer, 0)
170     if result != base.CX_STATUS_OK:
171         print("cx_getBufferImage returned error %d" % (result))
172
173     # deep co
174     rimg = np
175
176     # Queue b
177     result =
178     if result
179         print
180
181     # stop ac
182     result =
183     if result
184         print
185
186     #cleanup
187     result =
188     if result
189         print
190
191     result =
192     if result
193         print
194
195
196     # 6. calc
```

cx_3d_snap_point_cloud.cpp | cx_3d_show_point_cloud.cpp

cx_3d_snap_point_cloud | (Globaler Gültigkeitsbereich)

```
        // show range image in OpenCV window
        cv::Mat rangeImgMat = rangeImg;

        // save range image to file using OpenCV function
        cv::imwrite("range_image.tif", rangeImgMat);

        // normalize imgmat to Mono8 for display
        double minVal, maxVal;
        cv::minMaxLoc(rangeImgMat, &minVal, &maxVal);
        std::cout << "pixel range is: " << minVal << " - " << maxVal << std::endl;
        rangeImgMat -= minVal;
        rangeImgMat.convertTo(rangeImgMat, CV_8U, 255.0 / (maxVal - minVal));
        cv::imshow("Range Image", rangeImgMat);


        // convert range image to Point Cloud image
        cx::Image pointCloudImg;
        t1 = clock();
        cx::checkOk(cx_3d_range2calibratedABC(hCalib, rangeImg, NULL, CX_PF_COORD3D_ABC32f, pointCloudImg, CX_3D_METRIC_M
        t2 = clock();
        cout << "time elapsed for transformation to point cloud: " << double(t2 - t1) / double(CLOCKS_PER_SEC) << endl;

        // convert to OpenCV for visualization and saving
        cv::Mat normals, colors;
        cv::Mat cloud = pointCloudImg;
        cloud.convertTo(cloud, CV_32FC3);   // must be CV_32FC3 for WCloud to work
        cx::computeCloudNormals(cloud, normals);
        cx::normalizeMinMax8U(rangeImgMat, colors);

        // show point cloud
        cx::showPointCloud(viz, cloud, colors, normals);
```

For more information about the handling and the integration of the cxSDK, please refer to the documentation and to various example programs contained in the cxSDK.

Service Information

Contact

AT-Automation Technology GmbH
Hermann-Bössow-Str.6-8
D-23843 Bad Oldesloe, Germany
Phone: +49 4531/88011-0
Fax: +49 4531/88011-20
Mail: info@AutomationTechnology.de

Support

To process your support inquiries immediately, we always need the serial number of the camera, the firmware version, the device version, the camera configuration file (*.cfg), a snapshot as Tiff saved with the cxExplorer and a precise problem description.

support@AutomationTechnology.de

Product Inquiries and Price Quotations

For product inquiries and price quotations please get in touch with our sales team.

sales@AutomationTechnology.de

Warranty Conditions

Only the manufacturer can recognize the conditions of warranty. Should other parties than the manufacturer be responsible for the malfunctioning, we consider the right of warranty as void. This is the case if the unit is modified electrically or mechanically, particularly in its wiring/soldering, or if the unit is used for purposes not intended by the manufacturer, or if the unit's external wiring is faulty, or if the unit is used under conditions outside those stated in its manual.

Warranty Period

2-year warranty for C5 series sold inside of the European Union (EU)
1-year warranty for all C5 series sold outside of the European Union (EU)

Extended Warranty

The warranty period can be extended to maximum 36 months.

Return Policy

Before returning a sensor for repair (warranty or non-warranty) to AT – Automation Technology GmbH, AT must provide a Return Material Authorization (RMA) number. Please get in contact with AT to receive an RMA number.

rma@automationtechnology.de

The RMA form to ask for an RMA number can be downloaded at:

www.automationtechnology.de/rma

Ship the sensor carefully packed in its original shipping box or an equivalent box back to our destination in Germany, 23843 Bad Oldesloe, Hermann-Bössow-Straße 6-8.

If you purchased a camera over a distributor, please get in contact with them to start the RMA process.

Document Revision

Rev. No.	Date	Modification
1.0	19.01.2016	Official release
1.1	02.03.2017	Modified technical drawings. Add screw thread dimensioning Add C5-1280-GigE camera Add XML Features Add new chapters: The Web Interface, CX Explorer Overview, Quickstart a C5 camera, Return Police Add Information to warranty period and extended warranty condition
1.2	24.08.2018	Correct Encoder Specification Add Master/Slave Example Changed The GenICam Features Configuration example Add new Scheimpflug options Add warning not to connect C5 cameras to C5-CS-I/O Panels Add description of Trigger Control – RS422 Resolver
1.3	24.01.2019	Add terms for C5-3360 frequency Add Orientation of Angled Adapter Cables Add new Multiple Slope image examples Delete extended GenICam feature list
1.4	05.07.2019	Add digital input and encoder input information Add information for Laser Connection Correct mechanical drawing image of C5-IO-Panel Change part number and description for C5 series cables Correct color wire assignment for M12 17 pin pigtail cable Modify cxExplorer overview Add cxSDK information Modify Quickstart information Add subpixel limitations
1.5	04.05.2021	Add General Notes Add max. current for encoder inputs Correct value in AOI information of ChunkAcqInfo Correct mechanical drawing for C5-3360-GigE with C-Mount Correct IEC number of enclosure rating Add lens protection tube
1.6	09.07.2021	Change description of angled adapter cables

		Add note for housing of C5-1280 with Scheimpflug Update service information Change temperature information Removed C5-3360 Corrected specification Update TTL and HTL options

Automation Technology