C2 Series

User Manual

for High Speed 3D Sensors

Rev 1.9

AT - Automation Technology GmbH

Automation Technology
Vision Sensors and Systems

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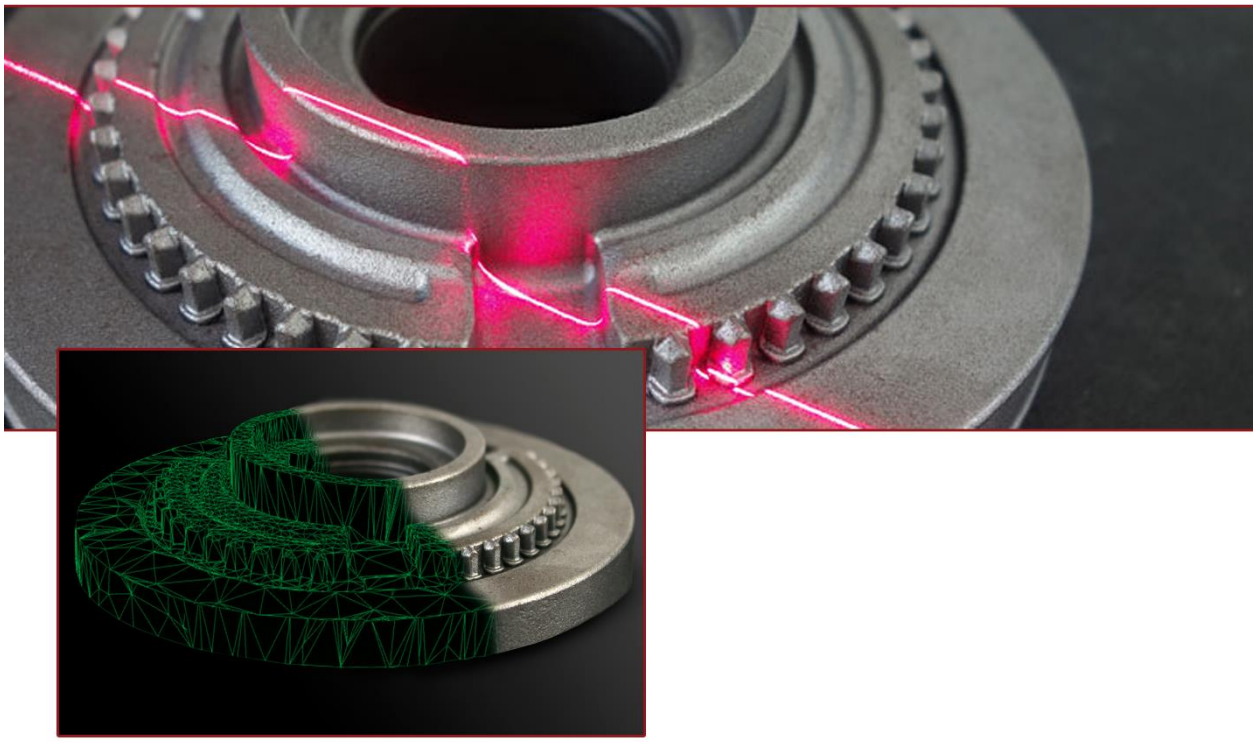
C2 Series Overview

Introduction

The C2 camera 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 C2 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
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	A+,A-, B+,B-, Z+, Z- High-Speed Triple RS-422 Receiver Max. input voltage +5V DC (TTL level) RS-422-Mode, max. frequency: 15 MHz
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 C2-640-GigE	CS-Mount with Back Focal Distance 12.526 mm
Lens Mount C2-2040-GigE	C-Mount with Back Focal Distance 17.526 mm
Adapter for Scheimpflug*	For C-Mount lens

* Must be ordered separate.

Electrical Interface		
Power Supply	+10V to +24V DC (max. +27V DC)	
Power consumption	< 6 W	
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	44 mm x 44 mm x 61/66 mm	
Mass (without optics)	125 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 600529

The Sensor Specifications

C2-640-GigE

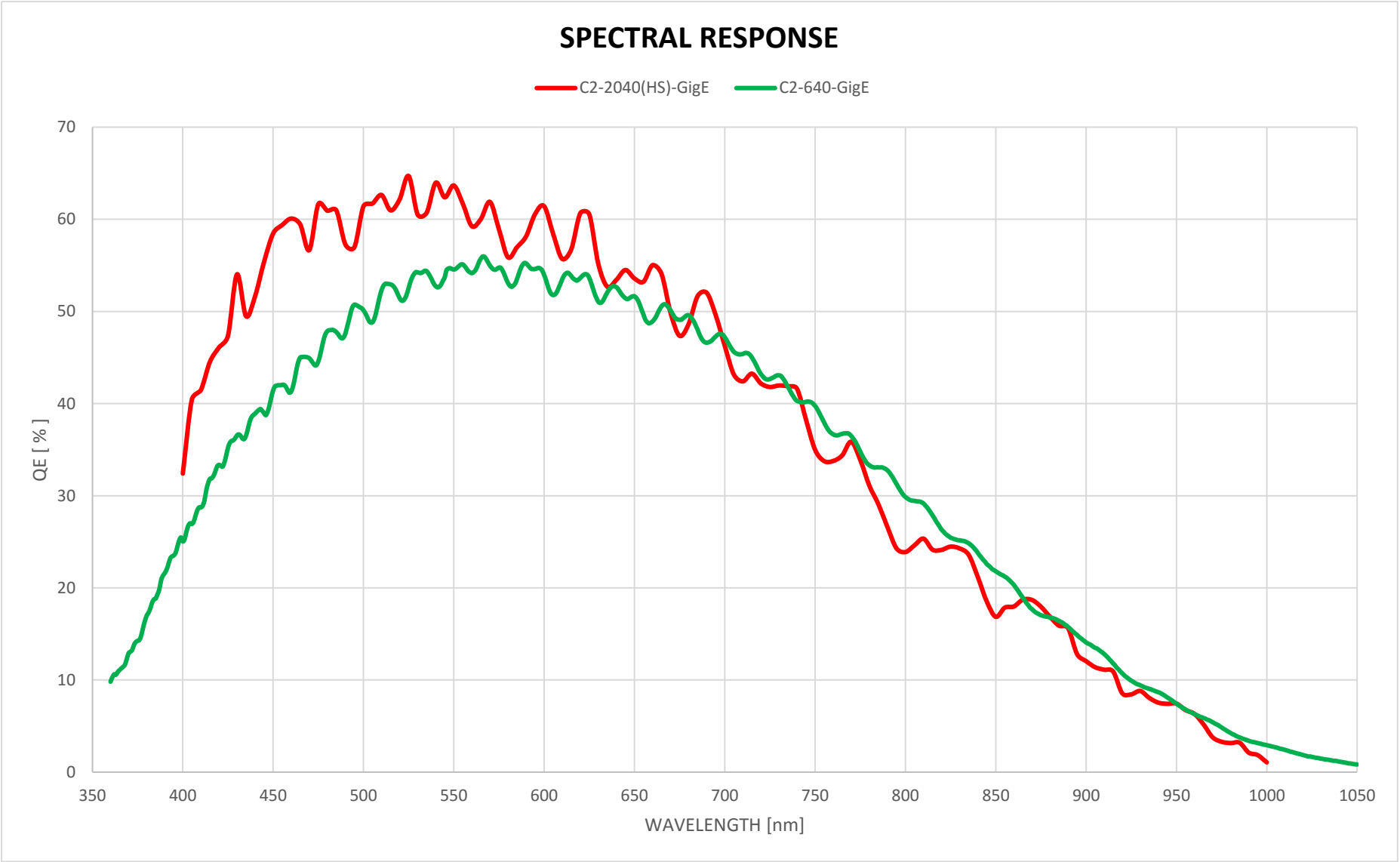
Parameters	Specifications	
Sensitivity	17000 LSB / µJ / cm^2 @ 630 nm	
Maximum Spectral Response	0.37 A / (W nm) @ 665 nm	
Resolution	648 x 488 pixels	
Pixel Size	7.4 µm x 7.4 µm	
Sensor Size	4.795 mm x 3.611 mm, diagonal: 6 mm	
Sensor Format	1/3"	
Sensor ADC Resolution	10 bit	
Sensor Dynamic Range	90 dB with HDR	
Max. Internal Full-Frame Rate for Image Mode	520 fps	
Max. External Full-Frame Rate for Image Mode (limited due to GigE bandwidth)	320 fps	
Effective Frame / Profile Rate at Max. Row Length	Number of Rows	Effective Frame / Profile Rate (Hz)
	8	15083
	16	10256
	32	6254
	64	3512
	128	1872
	256	968
	488	516

C2-2040(HS)-GigE

Parameters	Specifications		
Sensitivity	16000 LSB / µJ / cm^2 @ 550 nm		
Maximum Spectral Response	0.290 A / (W nm) @ 665 nm		
Resolution	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		
Sensor Format	2/3"		
Sensor ADC Resolution	10 bit		
Sensor Dynamic Range	90 dB with HDR		
Max. Internal Full-Frame Rate for Image Mode	340 fps		
Max. External Full-Frame Rate for Image Mode (limited due to GigE bandwidth)	50 fps		
Effective Frame / Profile Rate at Max. Row Length	Number of Rows	Effective Frame / Profile Rate (Hz)*	
		C2-2040HS-GigE	C2-2040-GigE
	8	25000	1400
	16	16000	1400
	32	9540	1400
	64	5240	1400
	128	2700	1400
	256	1400	1400
	512	723	723
	1088	340	340

*with Frame Overhead Time (FOT) = 3

The Sensors Spectral Response



Temperature Range (Operation/Storage)

Housing temperature during operation:	0°C to +50°C (+32°F to +122°F)
Sensor chip temperature (on-board) during operation:	0°C to +65°C (+32°F to +149°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

Heat Dissipation

The operation of the C2 sensors requires sufficient heat dissipation. Due to the small size of the camera housing there is not enough cooling surface to dissipate the thermal power loss generated by the core electronics and sensor chip.

All 3D sensors of the C2 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 C2 sensor on a heat conductive material, such as a metal surface.

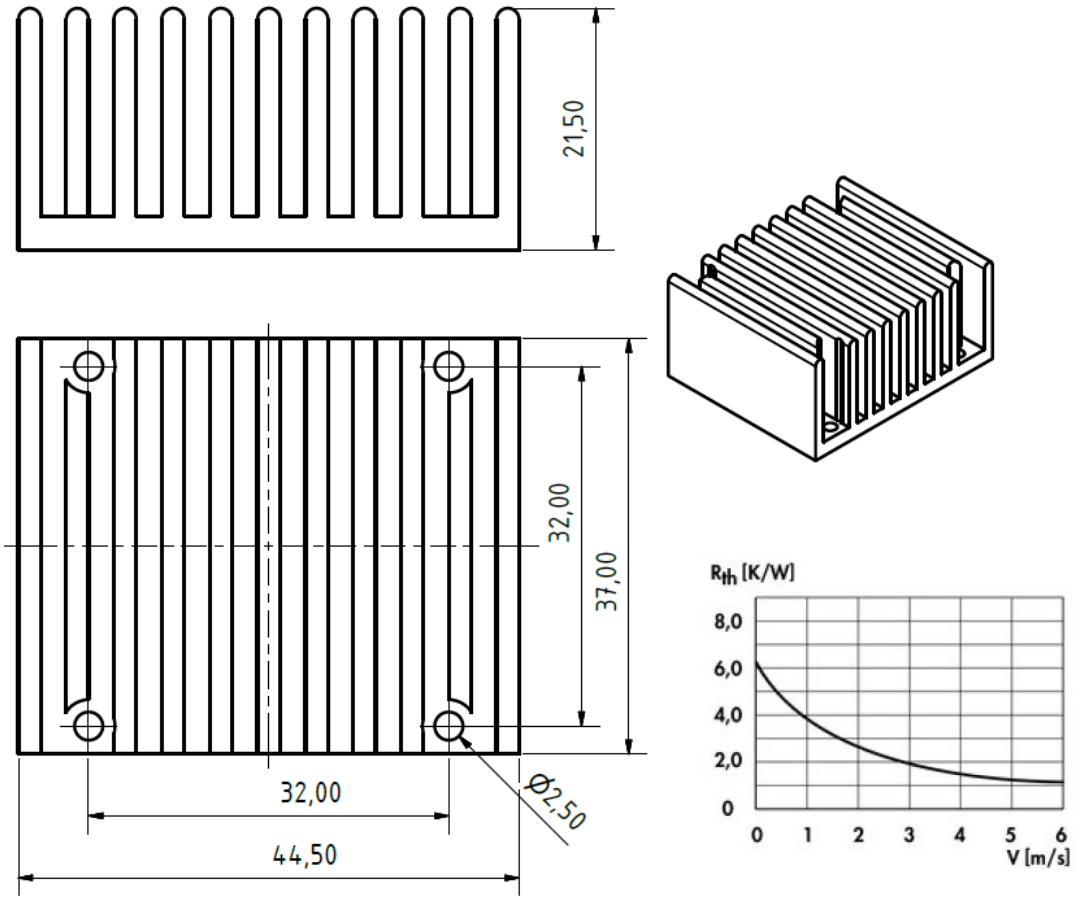
In case that it is not possible to mount the camera on any heat dissipating carrier, then it is recommended to use a heat sink with the required specification of AT.

General Guidelines for Heat Dissipation

- Mount the 3D sensor 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 65°C.
- Keep in mind that dark current and noise performance for CMOS sensor will degrade at higher temperature.
- The 3D sensor of the C2 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 C2 Heat Sink

AT provide a specially designed heat sink to improve the cooling of C2 sensors in applications lacking sufficient thermal dissipation:



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

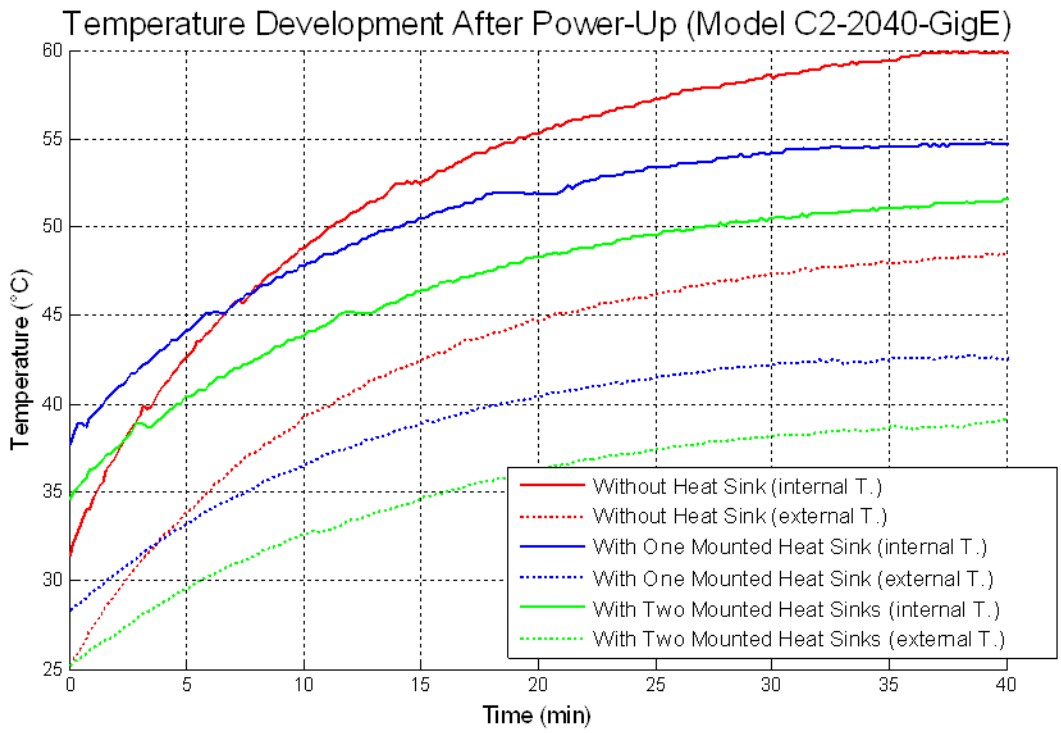
Absolute thermal resistance for heat sink: R_{th} = 6 [K / W]

Temperature Development of C2 Series after Power-Up

This section gives information about the temperature development of C2 series after power-up. A total of three temperature measurement cases are shown and compared.

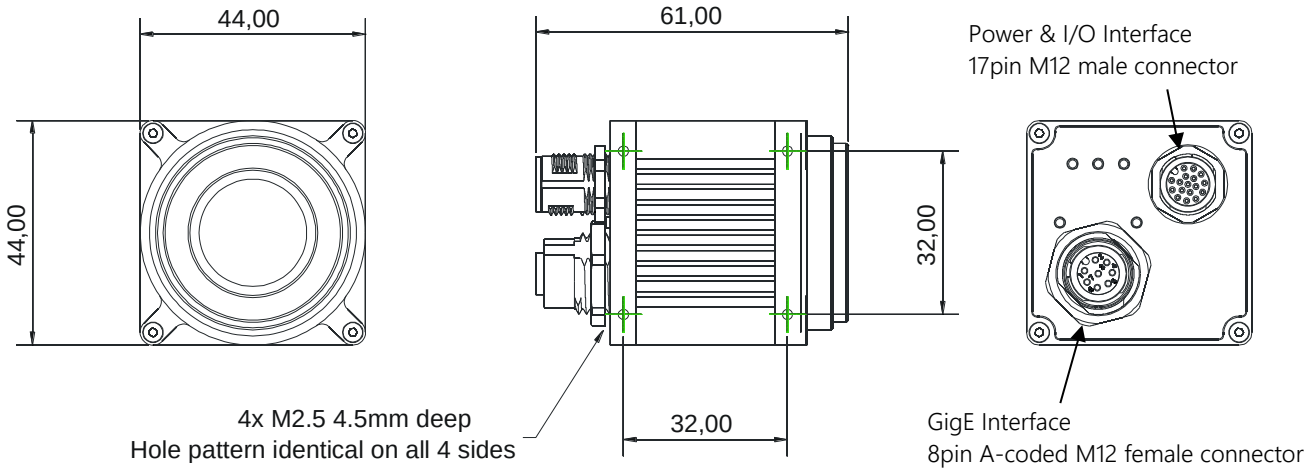
The first case indicates the development of internal temperature and external housing temperature after power-up without any additional mounted heat sink. This case is very unlike, because in most industrial applications the C2 sensor is mounted on a heat conductive carrier (e.g. metal plate), which works as a heat dissipater. The operation of C2 sensor without any metal plate (e.g. during evaluation and/or testing in laboratory environment), requires the mount of a heat sink on the housing.

The other two cases show the temperature development after power-up with one and two mounted heat sinks. In all test cases the ambient temperature was 22 °C.

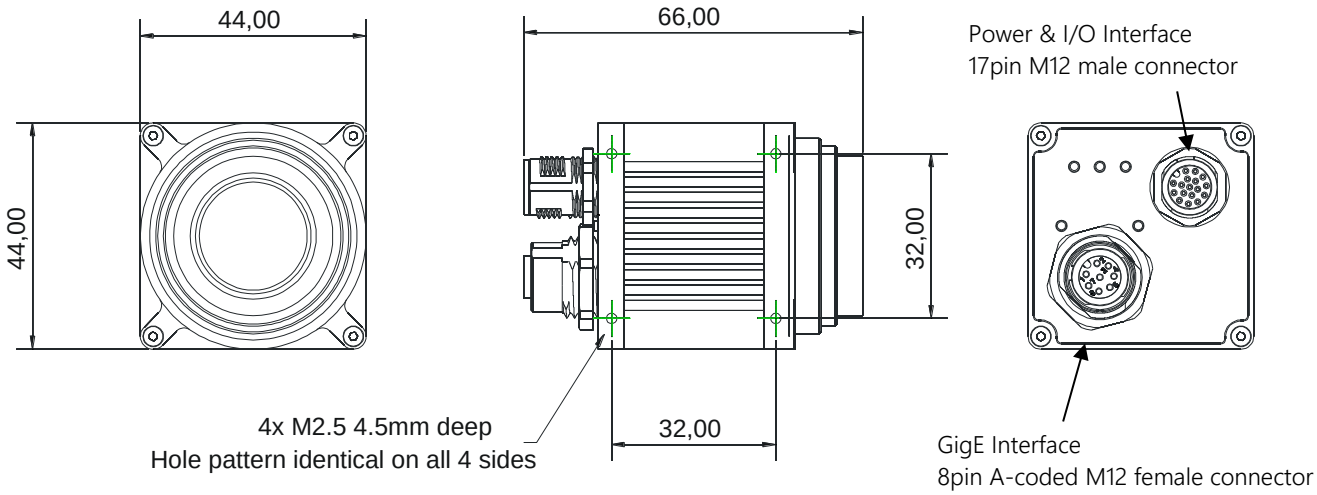


Mechanical Drawings

C2-640-GigE with CS-Mount (Standard)



C2-2040-GigE with C-Mount (Standard)



Part Number for C2 Series

Part Number #	Product Name
202 201 005	C2-2040-GigE, lens mount C-Mount
202 201 006	C2-2040HS-GigE, lens mount C-Mount
202 201 007	C2-640-GigE, lens mount CS-Mount

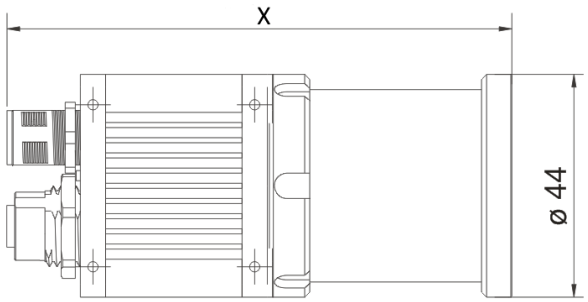
Part Number for Scheimpflug Adapter Option

Part Number #	Product Name
202 186 007	C2 Scheimpflug-Adapter 10° with C-Mount, for C2-640GigE/C2-2040(HS)-GigE

Lens Protection Tubes for the C2 Series

The C2 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



Part Number for Lens Protection Tubes

Part Number #	Tube Ø (mm)	Tube Length (mm)	Max. Lens Ø (mm)	Max. Lens Length (mm)	Camera Overall Length X (mm)
202 201 100	44	48	36	30	105
202 201 101	44	98	36	80	155
202 201 102	44	58	36	40	115
202 201 103	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

C2 Series Operational Reference

Measuring Principle

The C2 camera 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 C2 camera views the object from another angle defining the triangulation geometry. The resulting sensor image is evaluated by the C2 camera core 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),

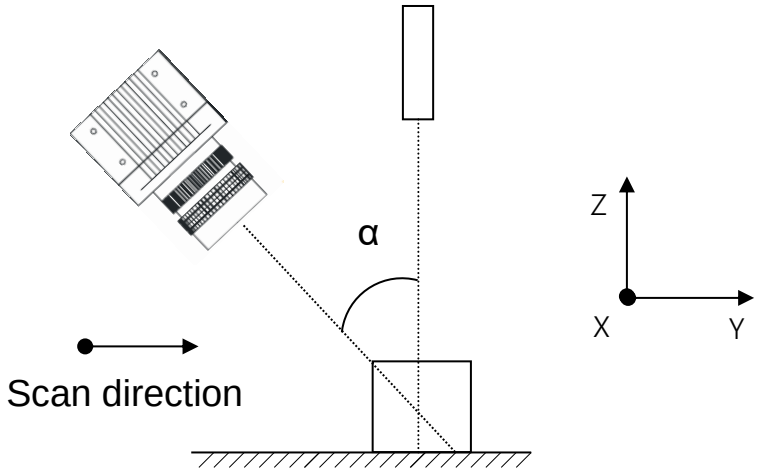
ΔY= resolution perpendicular to the laser line (longitudinal in the direction of motion),

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.

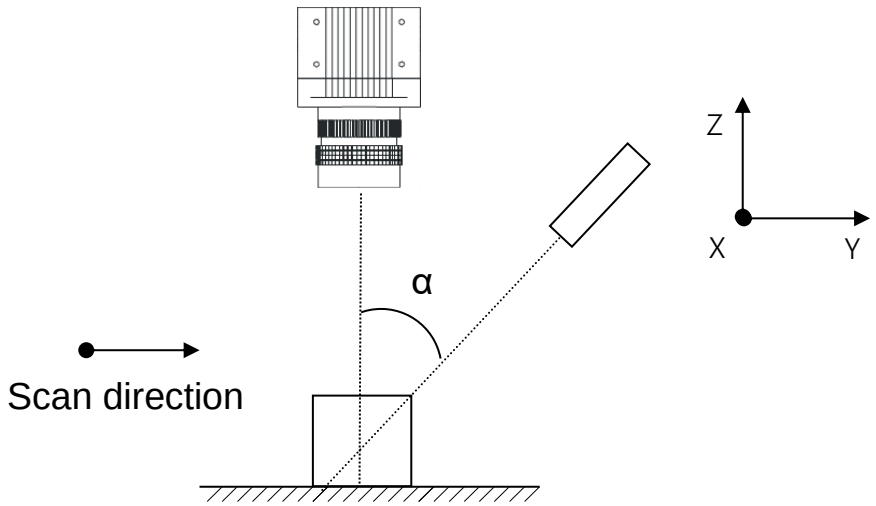
The height resolution can be approximated: $\Delta Z \approx \Delta X / \sin(\alpha)$



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: $\Delta Z \approx \Delta X / \tan(\alpha)$

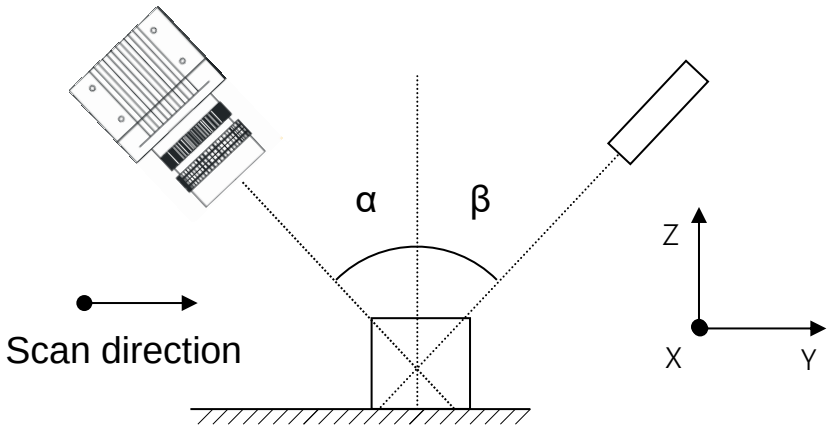


Geometry 3

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: $\Delta Z \approx \Delta X * \cos(\beta) / \sin(\alpha + \beta)$,

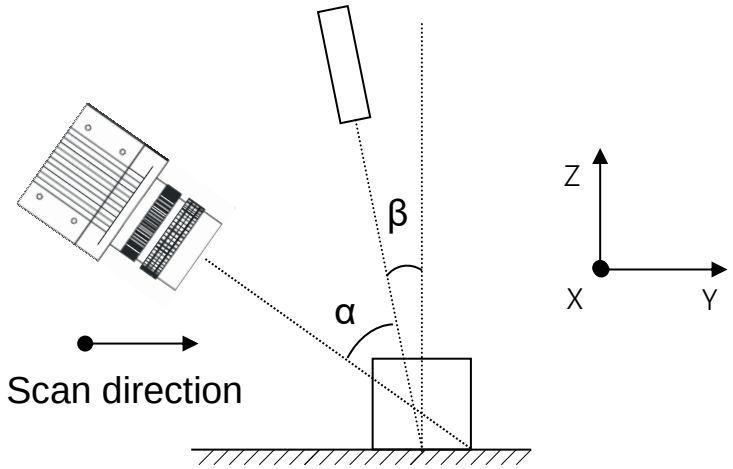
in case $\alpha = \beta$ (direct reflex) : $\Delta Z \approx \Delta X / 2 * \sin(\alpha)$



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 C2 Sensor Algorithms

The C2 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 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.

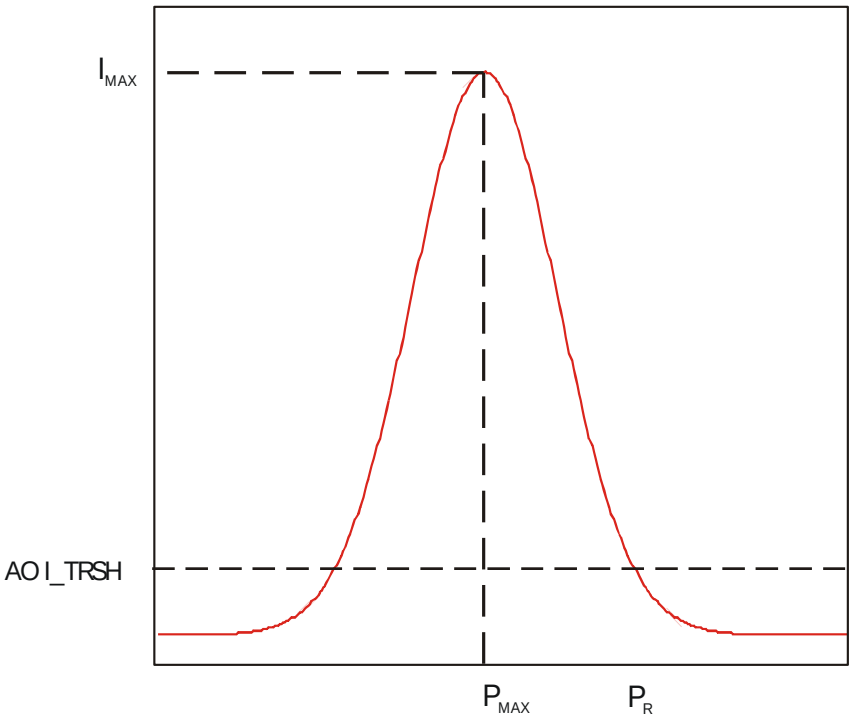
In all profile modes only intensity values higher than the AOI intensity threshold AOI_TRSH are processed in order to suppress weak signal noise. In case that no position value can be found, e.g. no intensity value is higher than threshold, the position value 0 is returned.

The Image Mode (IMG)

In the image mode the C2 camera 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}).

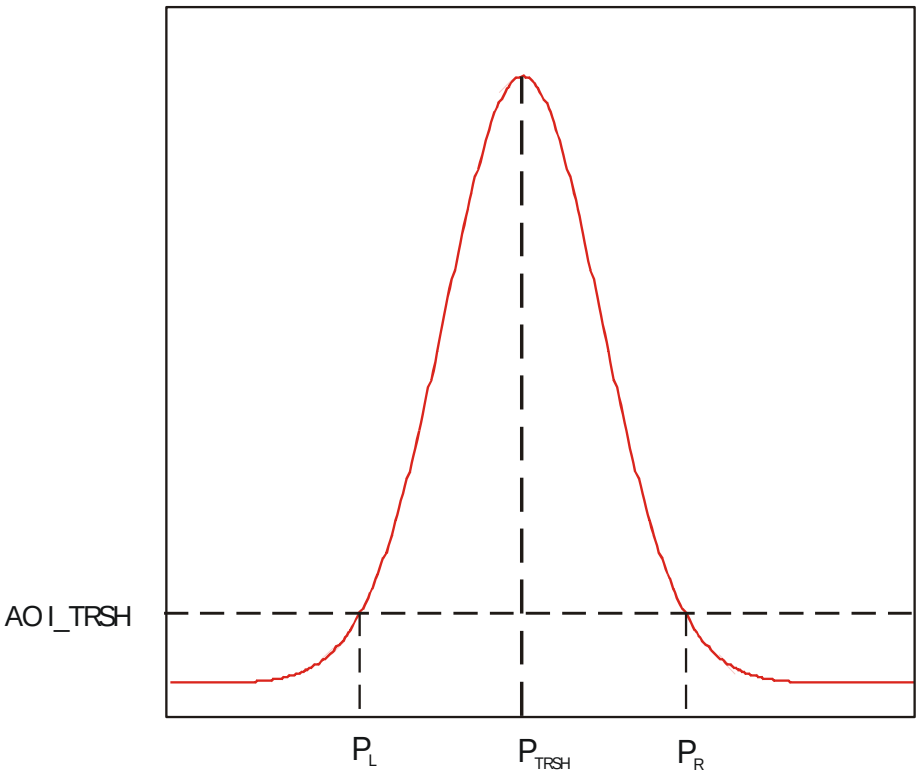


The calculation of position value is performed with simple pixel accuracy, i.e. the evaluation of 1088 rows delivers a position range from 0 to 1087 pixels (11 bit). If there is more than one local maximum (e.g. when the intensity is saturated), the position of the first detected maximum is output. In order 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 position 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.

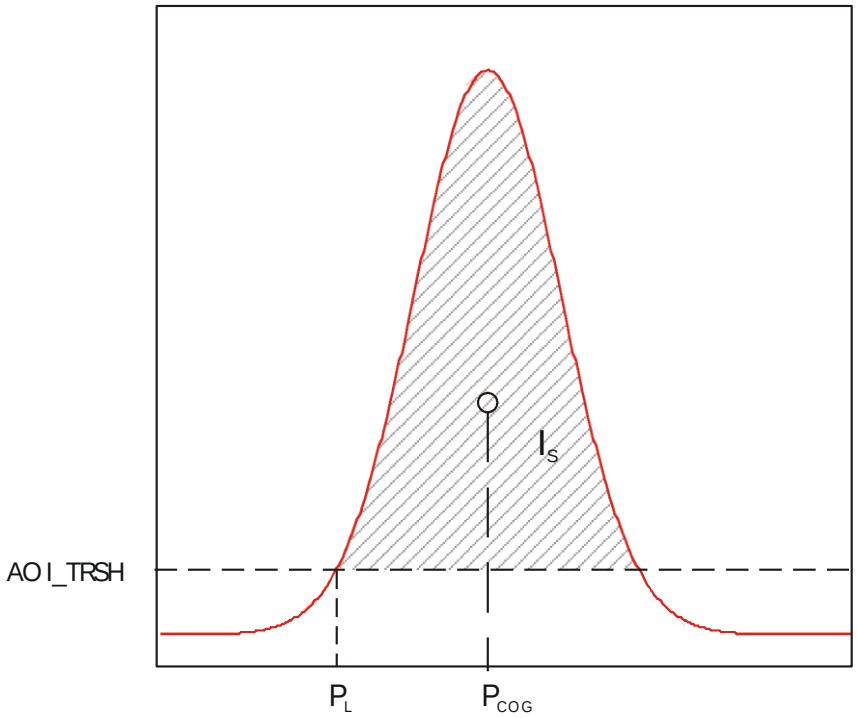
The Center Of Gravity Mode (COG)

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:

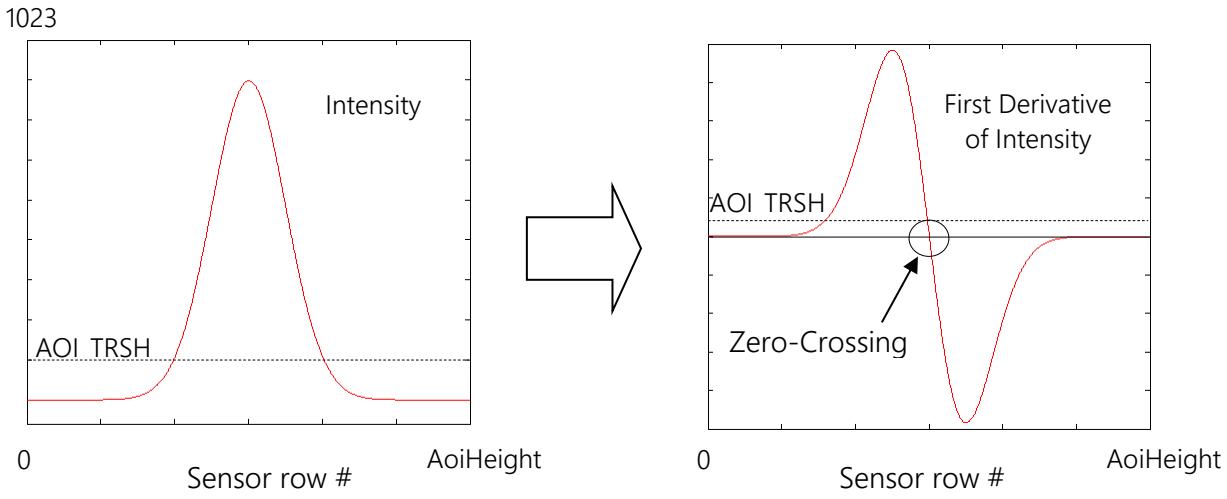
$P_{COG} = P_L + M_s / I_s$.

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.



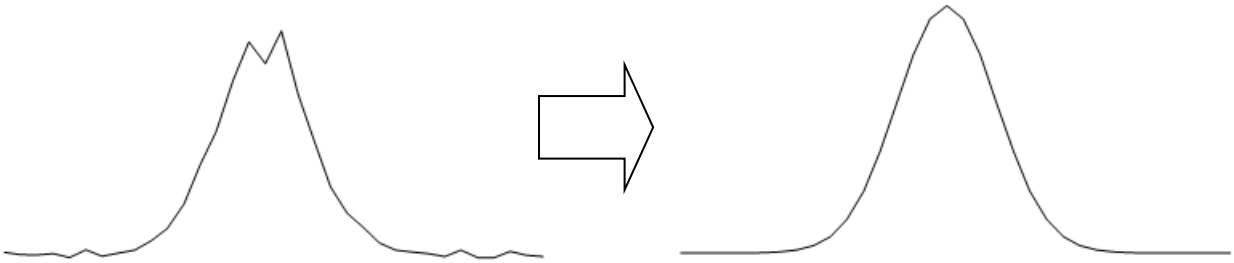
The position of zero-crossing of first derivative is detected and output with subpixel accuracy (up to 6 subpixels). In this case the threshold AOI_TRSH is used to detect the first rising edge of the derived intensity signal. Valid values of AOI_TRSH range from 513 to 1023 (Mono16).

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.

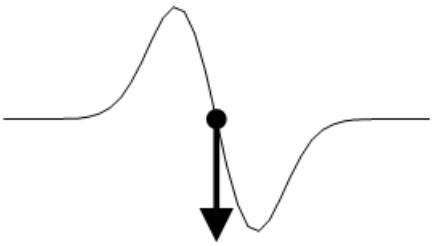
FIR in smoothing mode (in combination with MAX, TRSH and COG algorithms):



Raw Gauss Curve

Smoothed Gauss Curve

FIR in differentiating mode (FIR PEAK):



Zero-Crossing of
First Derivative

Pre-defined templates with 5, 7 or 9 coefficients let the FIR filter to be customised 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)

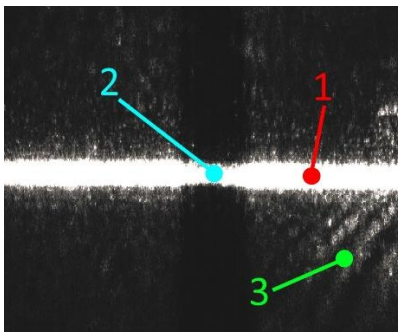
One of the most powerful features of the C2 series is the HDR-3D (High Dynamic Range) functionality, which allows scanning materials and surfaces with inhomogeneous reflection properties. Using HDR-3D the dynamic range of image intensity is extended up to 90dB, thus avoiding intensity saturation.

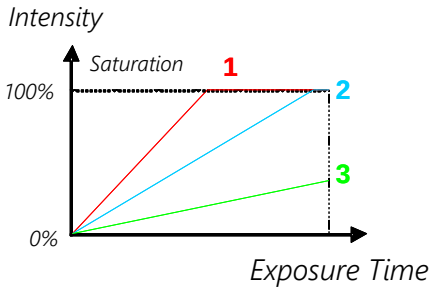
The HDR-3D comprises two independent sensor functions:

Multiple Slope 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 ExposureSlopeDuration and ExposureSlopeThreshold of the AcquisitionControl (XML grid visibility must be set to "Expert"). A knee point times 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)

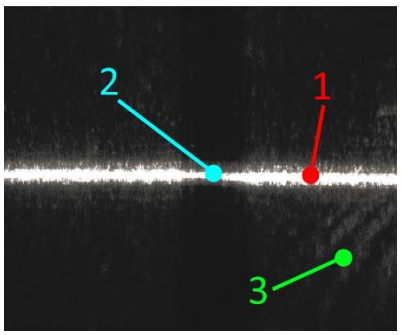


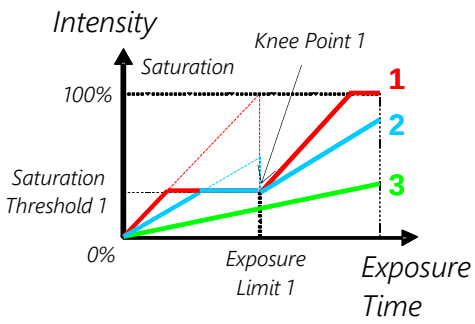


Property	Value
Root	
Device Control	
Image Format Control	
Acquisition Control	
Acquisition Start	Execute!
Acquisition Stop	Execute!
Acquisition Mode	Continuous
Acquisition Abort	Execute!
Acquisition Frame Count	1
Acquisition Frame Rate	25 Hz
Acquisition Line Rate	-
Acquisition Status Selector	Acquisition Trigger Wait
Acquisition Status	false
Acquisition Maximum Numbe...	3
Multi Slope Mode	Off
Multi Slope Knee Point Count	0
Multi Slope Knee Point Selector	1
Multi Slope Exposure Limit	60 %
Multi Slope Saturation Threshold	49.2063 %
Exposure Mode	Timed
Exposure Time	1000

Weld Seam

Dual Slope Mode (1 Knee Point)

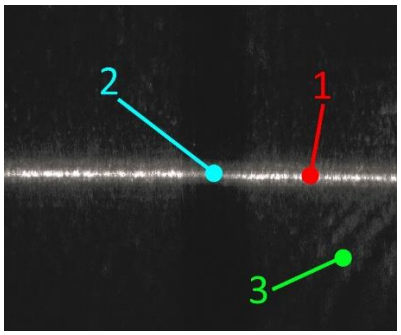


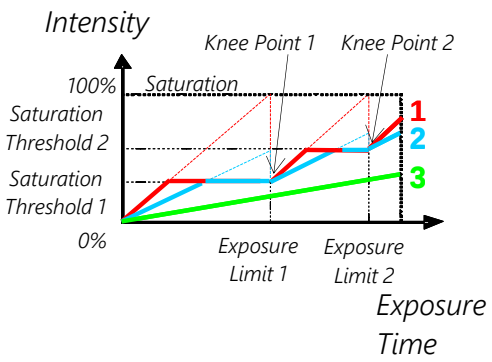


Property	Value
Root	
Device Control	
Image Format Control	
Acquisition Control	
Acquisition Start	Execute!
Acquisition Stop	Execute!
Acquisition Mode	Continuous
Acquisition Abort	Execute!
Acquisition Frame Count	1
Acquisition Frame Rate	25 Hz
Acquisition Line Rate	-
Acquisition Status Selector	Acquisition Trigger Wait
Acquisition Status	false
Acquisition Maximum Numbe...	3
Multi Slope Mode	Manual
Multi Slope Knee Point Count	1
Multi Slope Knee Point Selector	1
Multi Slope Exposure Limit	50 %
Multi Slope Saturation Threshold	34.9206 %
Exposure Mode	Timed
Exposure Time	1000

Weld Seam

Triple Slope Mode (2 Knee Points)





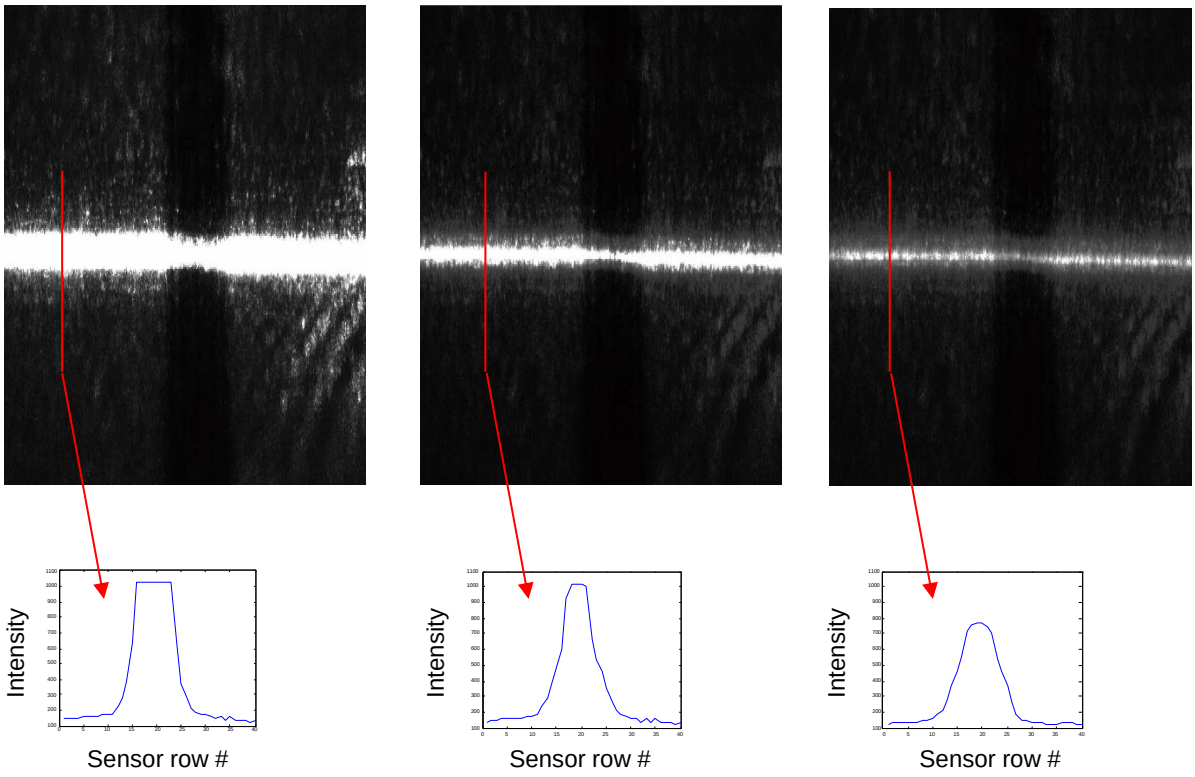
Property	Value
Root	
Device Control	
Image Format Control	
Acquisition Control	
Acquisition Start	Execute!
Acquisition Stop	Execute!
Acquisition Mode	Continuous
Acquisition Abort	Execute!
Acquisition Frame Count	1
Acquisition Frame Rate	25 Hz
Acquisition Line Rate	-
Acquisition Status Selector	Acquisition Trigger Wait
Acquisition Status	false
Acquisition Maximum Numbe...	3
Multi Slope Mode	Manual
Multi Slope Knee Point Count	2
Multi Slope Knee Point Selector	2
Multi Slope Exposure Limit	85 %
Multi Slope Saturation Threshold	66.6667 %
Exposure Mode	Timed
Exposure Time	1000

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

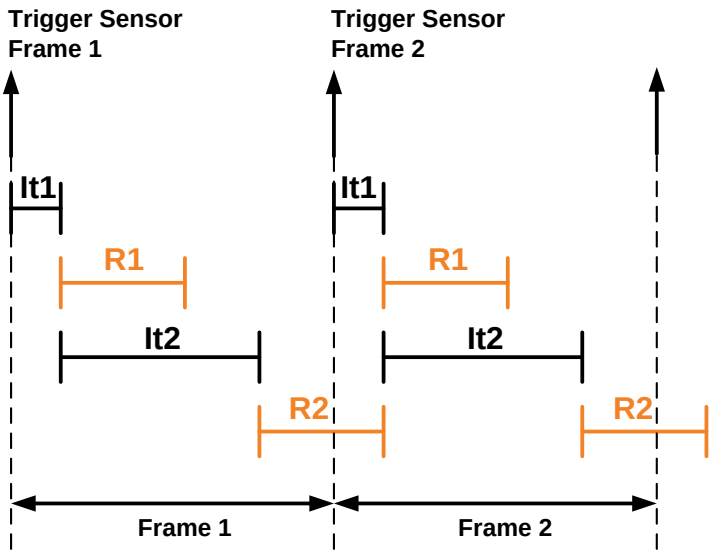


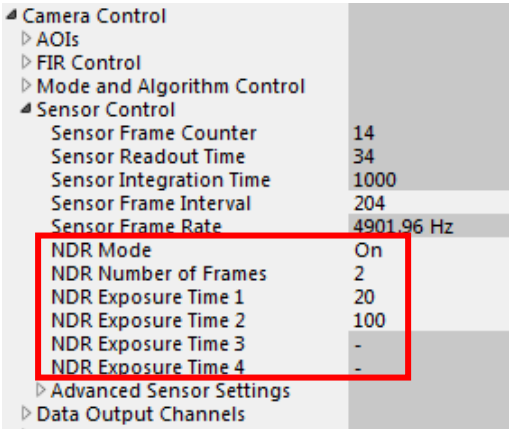
More details regarding the operation of the MultipleSlope function can be found in a separate application note.

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 C2 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	1-16384	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 C2 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 C2 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

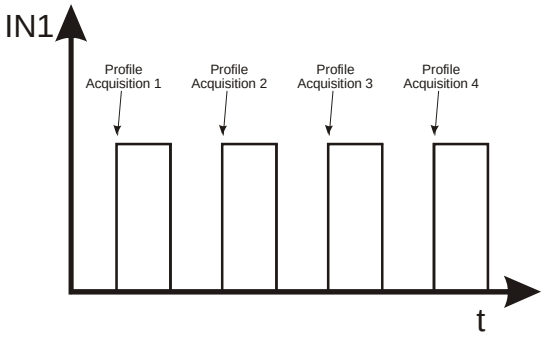
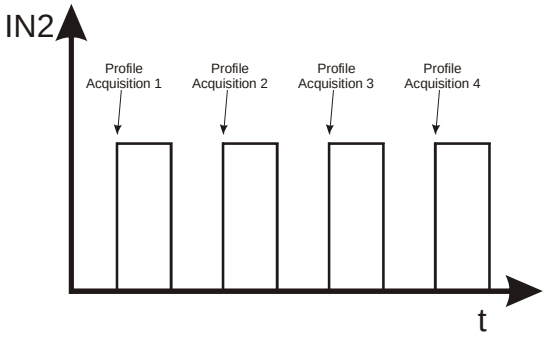
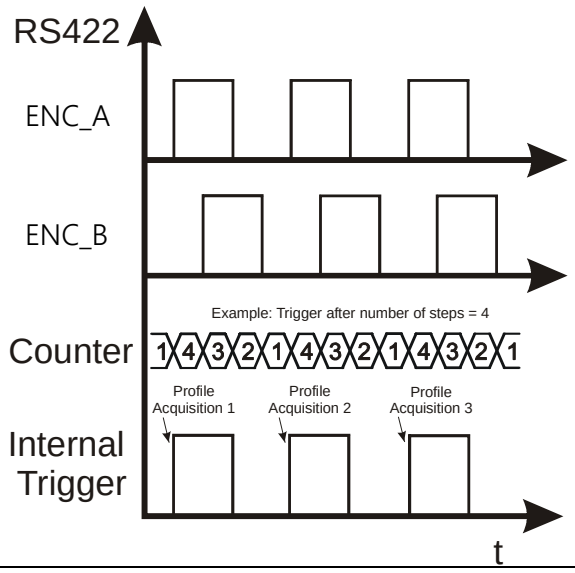
The automatic AOI-Tracking is the dynamic version of the static AOI-Search mode. While the AOI-Search is only working at the beginning of each 3D acquisition, the AOI-Tracking mode is working continuously during 3D image acquisition.

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 C2 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

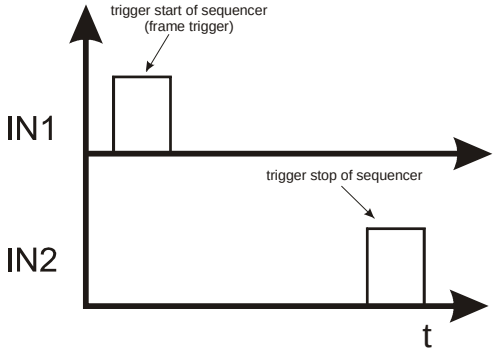
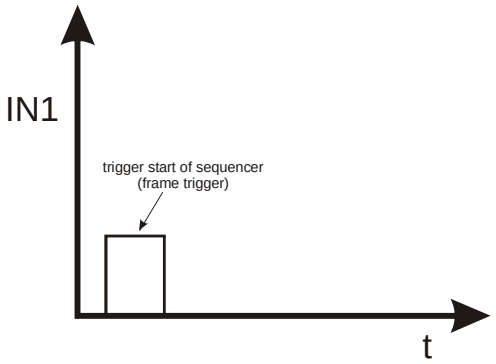
The *TriggerCoord* node always counts all the raw trigger signals arriving at the camera
-> rising AND falling edge!
The *TriggerDivider* is used internally by the camera. The camera doesn't change its behavior if the *TriggerDivider* is set to another value. A *TriggerDivider* of 10 for example will use every tenth incoming trigger for one profile measurement.

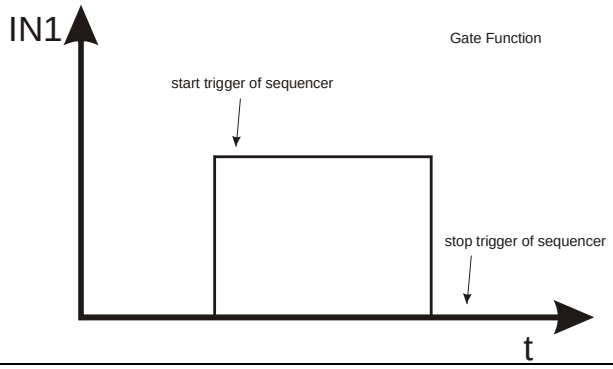
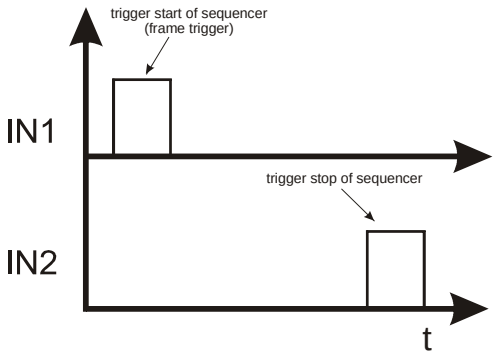
If single-ended encoder signals are required it is set over *TriggerSingleChannelMode*. Triggering over Channel A or B or over Input1 and Input2 is then possible.
If other encoder signals than RS422 are needed, use the Inputs of the camera instead of the encoder inputs and set *UseAlternateResolverInputs* 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 C2 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 C2 Series Chunk Data Mode

General Description

The C2 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

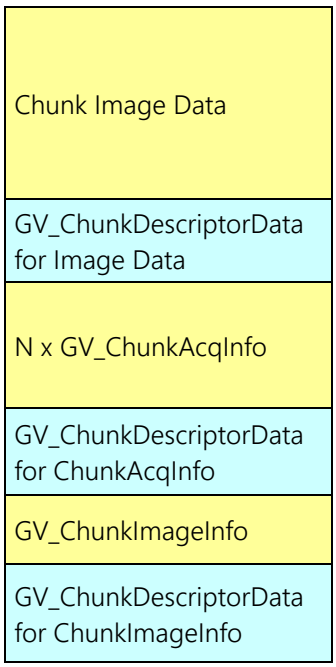
- 64 bit timestamp
- 32 bit frame counter
- 32 bit trigger coordinate
- 8 bit Trigger status
- 32 bit I/O Status
- 72 bit AOI information

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



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)
```

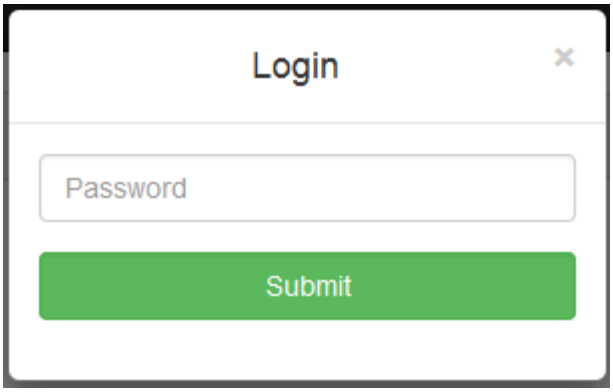
The GigE-Vision Events

The C2 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.

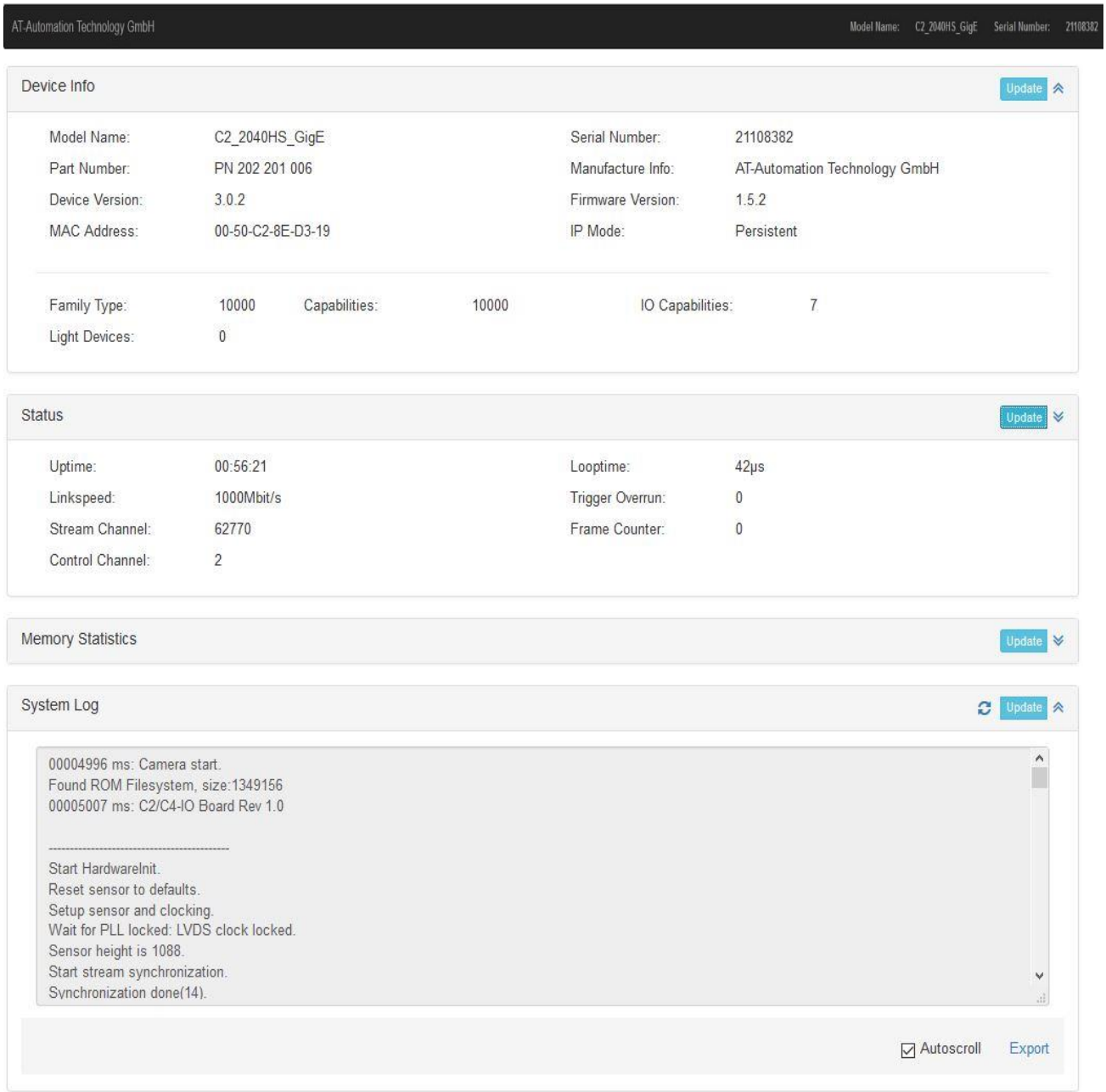
At the "System Log" panel is an additional button which start an update process and will fetches every two seconds the log data. The state of auto update process is shown by *Spinning Button* (ON) or not spinning (OFF). The *Autoscroll* flag enable an automatically scroll down to the latest log entry. 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.

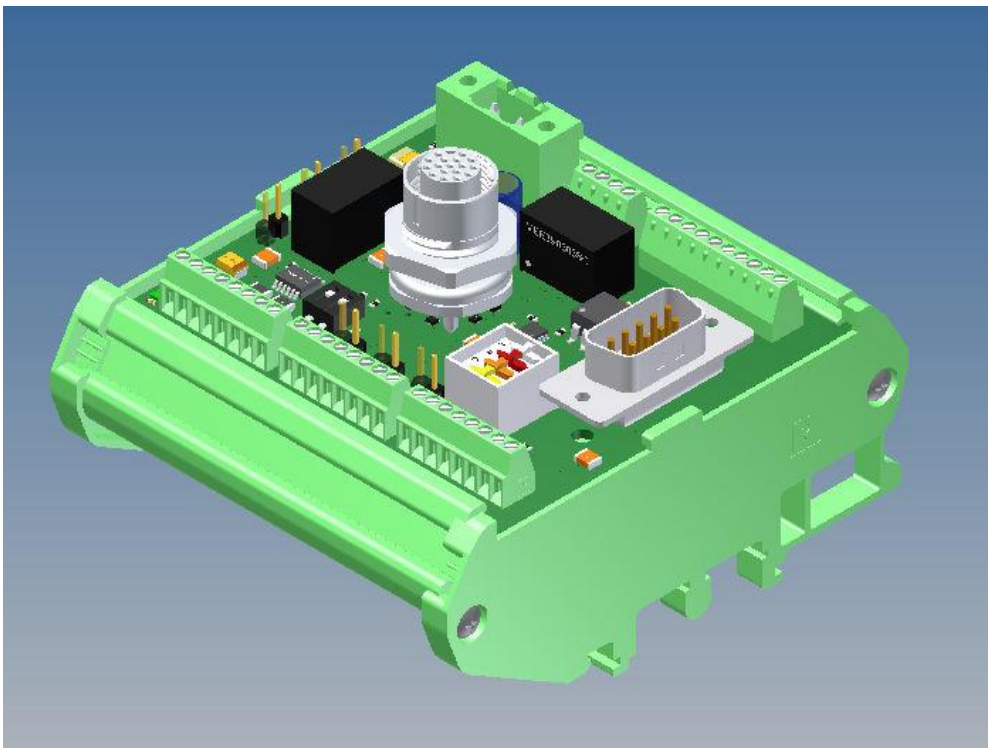

AT-Automation Technology GmbH
Model Name: C2_2040HS_GigE Serial Number: 21108382
Device Info
Update
Model Name: C2_2040HS_GigE
Serial Number: 21108382
Part Number: PN 202 201 006
Manufacture Info: AT-Automation Technology GmbH
Device Version: 3.0.2
Firmware Version: 1.5.2
MAC Address: 00-50-C2-8E-D3-19
IP Mode: Persistent
Family Type: 10000
Capabilities: 10000
IO Capabilities: 7
Light Devices: 0
Status
Update
Uptime: 00:56:21
Looptime: 42µs
Linkspeed: 1000Mbit/s
Trigger Overrun: 0
Stream Channel: 62770
Frame Counter: 0
Control Channel: 2
Memory Statistics
Update
System Log
Update
00004996 ms: Camera start.
Found ROM Filesystem, size:1349156
00005007 ms: C2/C4-IO Board Rev 1.0

Start HardwareInit.
Reset sensor to defaults.
Setup sensor and clocking.
Wait for PLL locked: LVDS clock locked.
Sensor height is 1088.
Start stream synchronization.
Synchronization done(14).
Autoscroll
Export

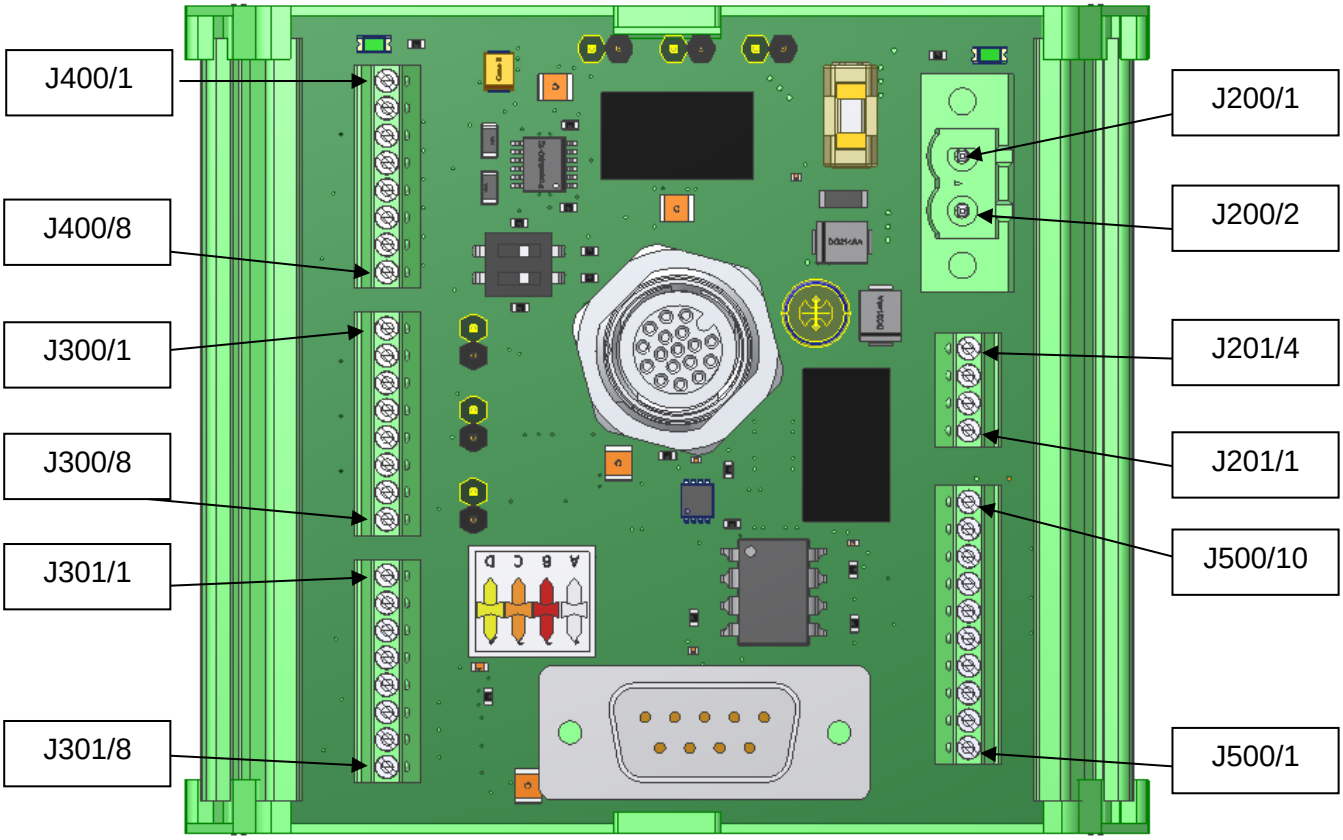
The External C2-I/O Panel (Rev. 2.0)

The C2-I/O-Panel Rev. 2.0 (#202 201 020) provides a user friendly way to connect the power, I/O and laser control signals of the C2 camera. It features the following functions:

- integrated receiver for use with differential RS422/HTL as well as single-ended encoder signals
- direct I²C interface to control laser or other external devices
- isolation of I/O, encoder and laser control signals
- adjustable digital input voltage level (5V/24V)
- digital outputs support master/slave camera operation
- reverse polarity protection



Mechanical Drawing

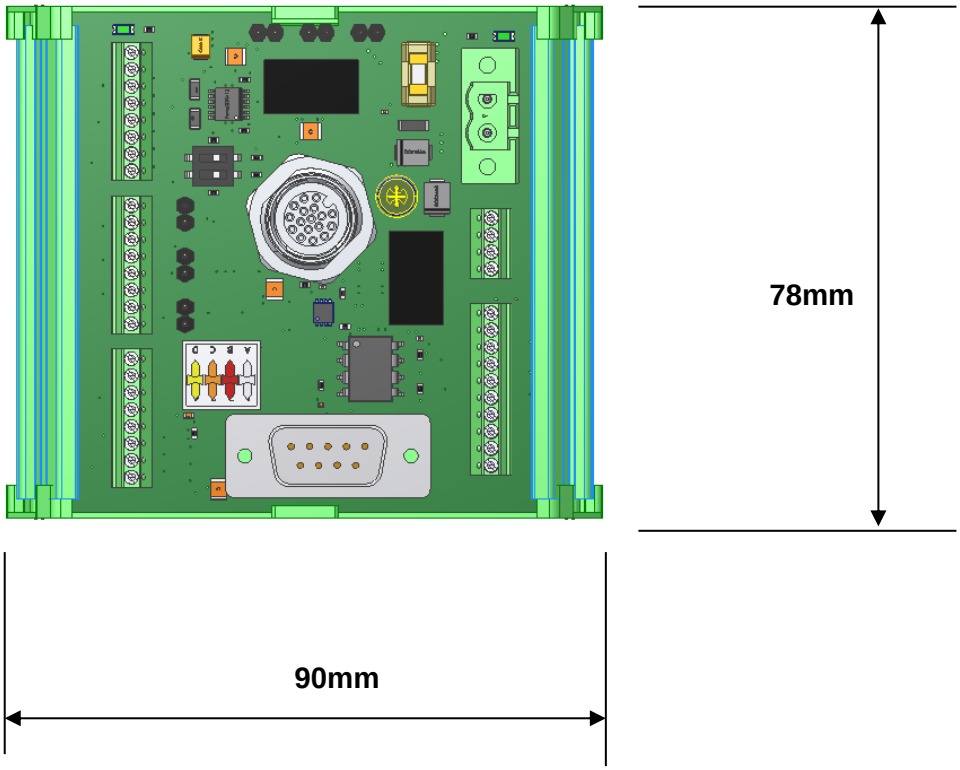


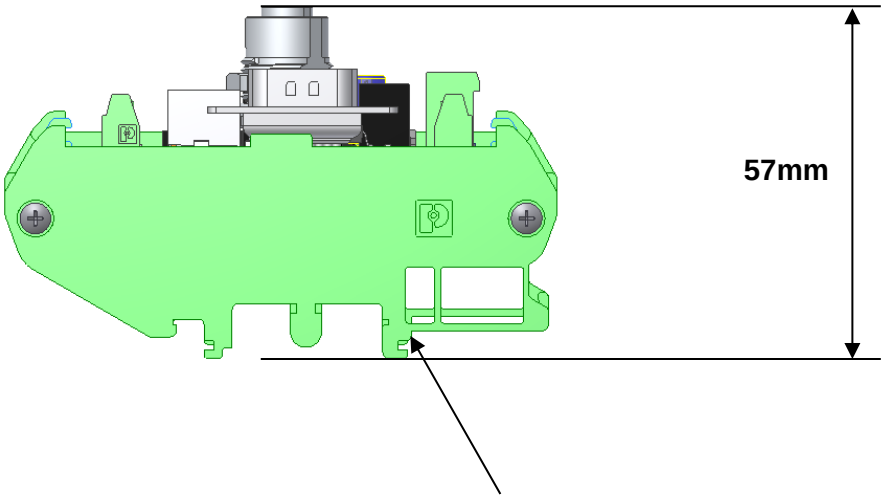
Clamp Configuration

Clamp No.	Signal Name	Description
J200/1	POWER_EXT	Camera supply voltage (10-24V DC)
J200/2	GND_EXT	Camera ground
J201/1	SHIELD	Camera shield
J201/2	SHIELD	Camera shield
J201/3	GND	Supply chain of camera ground
J201/4	VCC	Supply chain of camera voltage
J300/1	GND	Encoder ground
J300/2	HZ-	HTL encoder index track Z-
J300/3	HZ+	HTL encoder index track Z+ / single-ended index track Z
J300/4	HB-	HTL encoder track B-
J300/5	HB+	HTL encoder track B+ / single-ended track B
J300/6	HA-	HTL encoder track A-
J300/7	HA+	HTL encoder track A+ / single-ended track A

Clamp No.	Signal Name	Description
J300/8	SHIELD	Camera shield
J301/1	GND	Encoder ground
J301/2	Z-	RS422 encoder index track Z-
J301/3	Z+	RS422 encoder index track Z+ / single-ended index track Z
J301/4	B-	RS422 encoder track B-
J301/5	B+	RS422 encoder track B+ / single-ended track B
J301/6	A-	RS422 encoder track A-
J301/7	A+	RS422 encoder track A+ / single-ended track A
J301/8	SHIELD	Camera shield
J400/1	GND_IO	I/O ground
J400/2	PWR_IO	Power supply voltage of camera isolated outputs (9V-24V DC)
J400/3	HV-OUT1	Isolated output #1 (9V-24V)
J400/4	HV-OUT2	Isolated output #2 (9V-24V)
J400/5	OUT1	Isolated output #1 (5V)
J400/6	OUT2	Isolated output #2 (5V)
J400/7	IN1	Isolated input #1 (5V/24V)
J400/8	IN2	Isolated input #2 (5V/24V)
J500/1	VCC_L	Input power supply voltage for laser control
J500/2	VCC_L	Input power supply voltage for laser control
J500/3	GND_L	Input ground for laser control
J500/4	GND_L	Input ground for laser control
J500/5	DO	Output for digital modulation of laser (TTL signal)
J500/6	AO	Output for analog modulation of laser (0-5V DC)
J500/7	AI	Analog Input for monitoring specific functions of laser (0-5V DC)
J500/8	SDA	Data line of I^2C bus interface
J500/9	SCL	Clock line of I^2C bus interface
J500/10	SHIELD	Camera shield

Mechanical Dimension



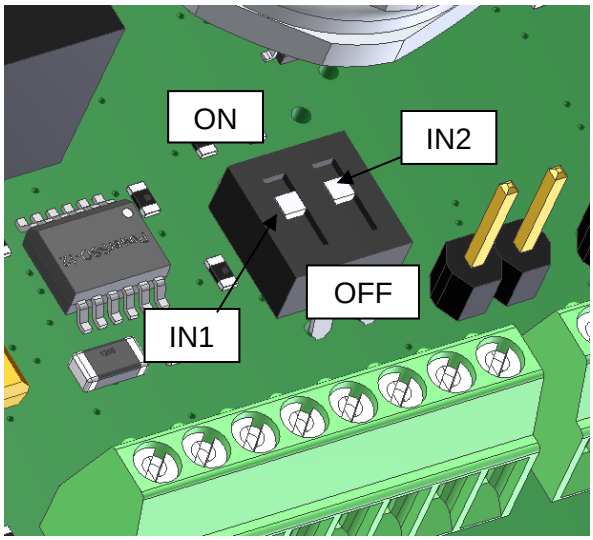


Weight: 110 g

Electrical Specifications of C2-I/O-Panel

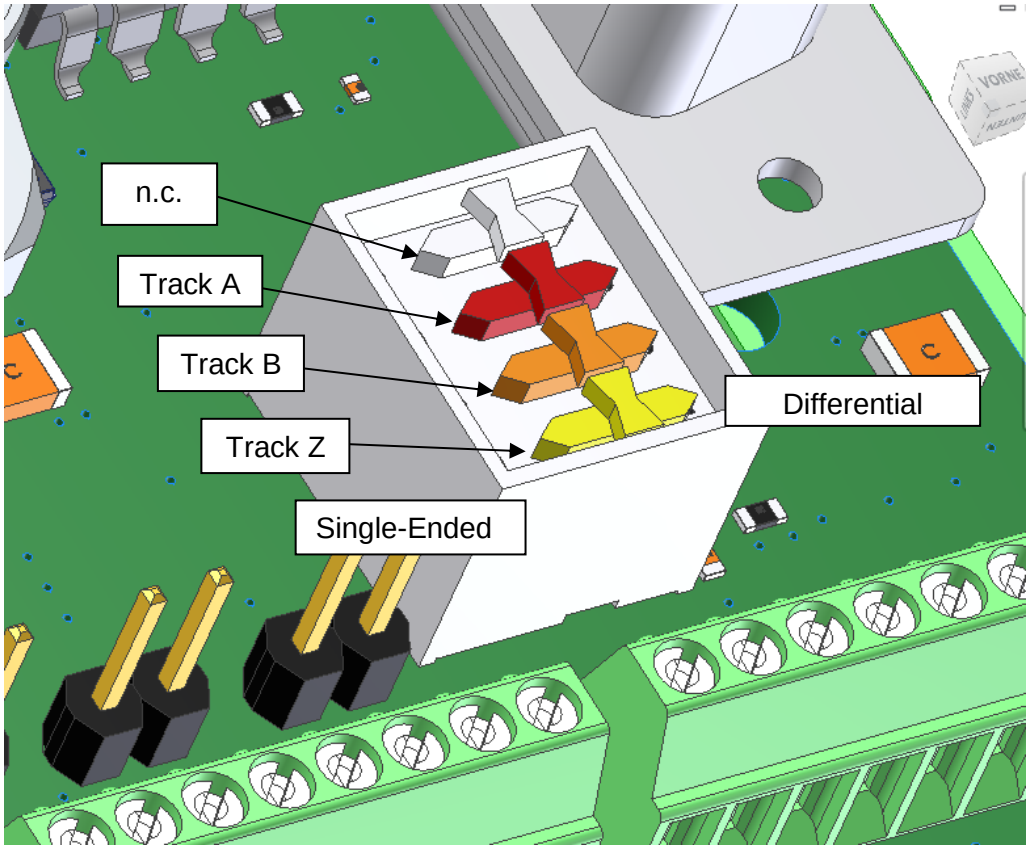
	TTL	HV
Inputs	VIL, logic "0" Voltage < 1.5V VIH, logic "1" Voltage > 3.5V Max. current 2 mA	VIL, logic "0" Voltage < 7.5V VIH, logic "1" Voltage > 17.0V
Outputs	VOL, logic "0" Voltage < 0.4V VOH, logic "1" Voltage > 3.3V (driving capacity 4 mA)	VCC_ext: 9V to 45V (absolute max. ratings) VOL, logic "0" Voltage < 3V (no load) VOH, logic "1" Voltage = VCC_ext – 0.1V (driving capacity 1 A)

- The isolated Inputs of the C2-I/O Panel Rev. 2.0 can be operated both with 5V and 24V DC signals. The voltage level can be set over the DIP switch S400.

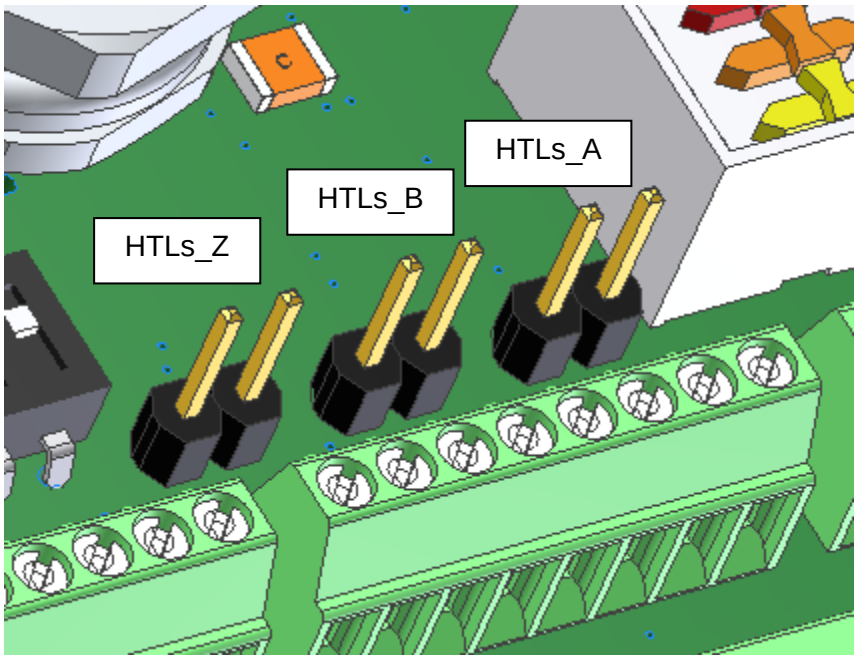


S400	IN1	IN2
ON	5V	5V
OFF	24V	24V

- The panel features a 1A fuse for camera protection.
- The type of encoder signal (differential or single-ended) can be set over the DIP switch S300.

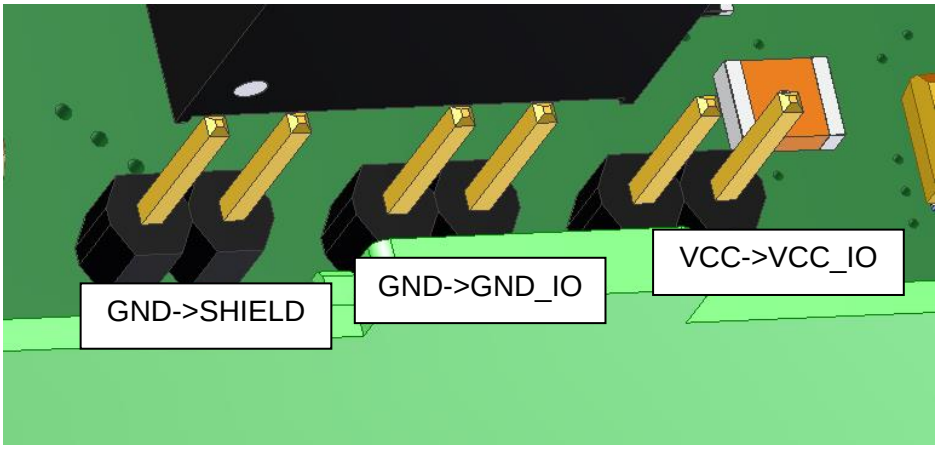


- In addition when using Single-Ended Encoders of HTL type the jumpers HTLs_A, HTLs_B and HTLs_Z must be set.



- The isolated digital outputs of C2-I/O Panel can be operated either with TTL level or with higher voltage (9–24V DC). In the latter case an external voltage supply must be connected

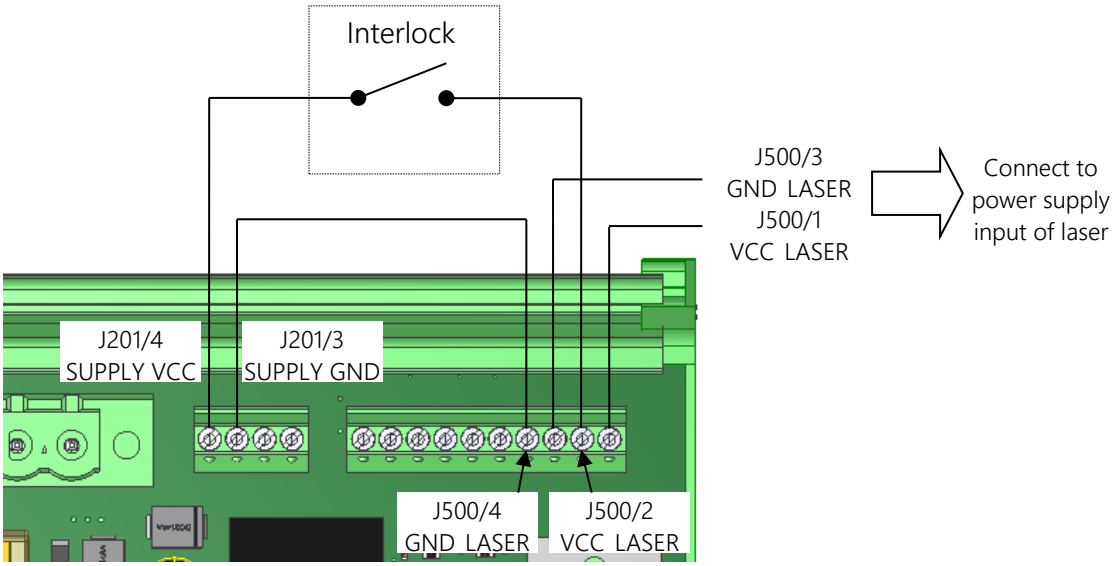
to clamp J400/2 (PWR_IO) and J400/1(GND_IO) or the main voltage supply of the camera can be used by setting the jumpers "GND->GND_IO" and "VCC->VCC_IO".



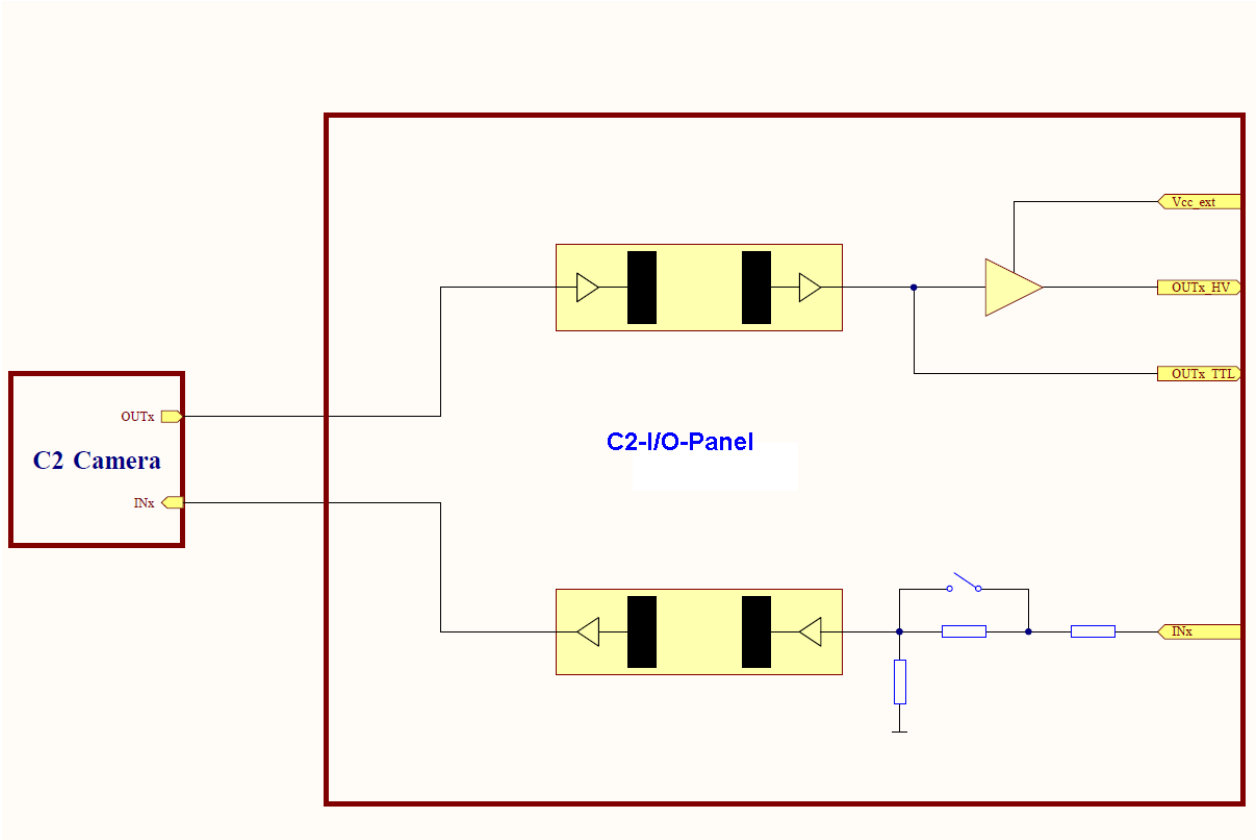
- The jumper "GND->SHIELD" may be set in order to let the camera ground be connected to the shield.

Use of Power Supply Chain with Interlock Function to supply a Laser

- Suitable for lasers capable of operating with camera supply voltage



Schematic of Isolated digital I/Os located on the C2-I/O Panel



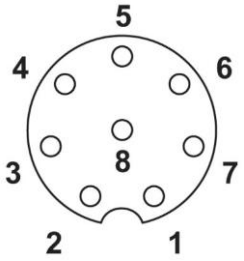
C2-I/O Panel and C2 camera (Compatibility Overview)

Availability of I/O and Laser Control Signals depending on the revision of C2-I/O-Panel and C2 camera.

	C2-I/O Panel Rev.< 2.0		C2-I/O Panel Rev.≥ 2.0	
C2-I/O-Panel Signal	Camera Device Version 3.0.0/3.0.1	Camera Device Version ≥ 3.0.2	Camera Device Version 3.0.0/3.0.1	Camera Device Version ≥ 3.0.2
HV-OUT1	Not available	Not available	Available	Available
HV-OUT2	Not available	Not available	Available	Available
OUT1	Available	Available	Available	Available
OUT2	Available	Available	Available	Available
IN1	Available	Available	Available	Available
IN2	Available	Available	Available	Available
LASER_DO	Available	Available	Available	Available
LASER_AO	Available	Available	Not available	Available
LASER_AI	Available	Available	Not available	Available
SDA (I^2C)	Not available	Not available	Not available	Available
SCL (I^2C)	Not available	Not available	Not available	Available

The C2-GigE Interface

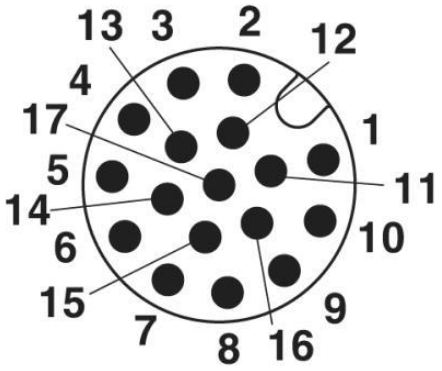
The GigE Interface



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

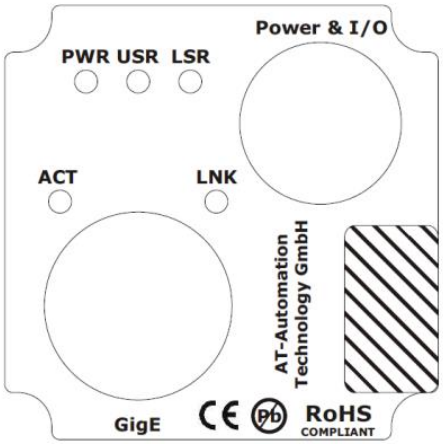
The I/O & Power Interface



M12 I/O Male Connector Pin Assignment

Pin No.	Signal Name	Description
1	SCL	Clock line of I²C bus interface
2	DO_0 (OUT1)	Digital Output 1 (TTL)
3	DI_4 (Z)	Encoder input Z index (TTL)
4	DI_3 (B)	Encoder input B track (TTL)
5	DI_2 (A)	Encoder input A track (TTL)
6	SDA	Data line of I²C bus interface
7	AO (LASER_AOUT)	Output for analog modulation of illumination device (0–5V DC)
8	VCC_EXT	camera supply voltage (12–24V DC)
9	GND_EXT	Camera supply ground
10	RS232_RX	RS-232 compatible input
11	RS232_TX	RS-232 compatible output
12	DO_1 (OUT2)	Digital Output 2 (TTL)
13	DI_0 (IN1)	Digital Input 1 (TTL)
14	DI_1 (IN2)	Digital Input 2 (TTL)
15	AIN	Input for monitoring specific functions of illumination device (0–5V DC)
16	DO_2 (LASER_DOUT)	Output for digital modulation of illumination device (TTL)
17	GND	Reference ground for IO and Laser signals
Shield	SHIELD	Is connected to camera case

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 (LSR)	Red On = Laser is On Off = Laser is Off
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

Integrated RS232 Serial Interface and Camera Boot Log

During boot procedure, the camera outputs a log via the integrated RS232 serial interface. The external C2- I/O-Panel provides a D-sub 9-pin male socket for monitoring the boot log. A null-modem cable (crosslinked) must be used to connect the C2- I/O-Panel to a host PC. The parameters of the serial communication are listed as follows:

Baudrate	115200
Data bits	8
Parity	None
Stopbits	1
Handshake	None

Sample camera boot log

```
**************************************
Bootloader (build May 31 2013, 16:24:31)

Executing program starting at address: 0x50000000
**************************************
00004682 ms: Camera start.
------------------------------------------
Start HardwareInit.
Reset sensor to defaults.
Setup sensor and clocking.
Wait for PLL locked. Locked.
Sensor height is 1088.
Start stream synchronization.
Synchronization done (2).
------------------------------------------
CMOSIS AN2.2 fix.
Ready to start GEV.
00004823 ms: Start system monitoring.
Stack info: Current Stack position changed to 0x00001F98.
00004831 ms: Load Bootstrap registers.
00004835 ms: ************************************
00004839 ms: Camera type: 2042
00004842 ms: Sensor height: 1088
```

00004845 ms: Model: C2_2040_GigE

00004848 ms: MAC: 0-50-C2-8E-D4-7

00004851 ms: Serial Number: 20502103

00004854 ms: Device Version: 3.0.0

00004857 ms: Firmware Version: 1.2.3

00004861 ms: Application build: Development 1.3.0.3903 - Wed Feb 6 10:55:51 2013

00004868 ms: LwIP build: Patched Lwlp 1.30 May 31 2013, 16:23:32

00004874 ms: Installed Modules:

00004877 ms: File: C2_2040_GigE_1.0.4.zip, Rev.: 1000400, Device: 1, Length: 21979

00004884 ms: File: bitstream.bin, Rev.: 1020300, Device: 1, Length: 2453092

00004891 ms: File: bitstreamfb.bin, Rev.: 1020300, Device: 1, Length: 2453092

00004897 ms: File: CMV2k4k.srec, Rev.: 1020300, Device: 1, Length: 726124

00004904 ms: File: CMV2k4k.srec, Rev.: 1020300, Device: 1, Length: 726124

00004910 ms: GEV Version 1.1

00004913 ms: XML-URL1: Local: C2_2040_GigE_1.0.4.zip;8C400904;55DB

00004919 ms: XML-URL2: http://www.automationtechnology.de/genicam/C2_2040_GigE_1.0.4.zip

00004927 ms: IP config mode:

00004929 ms: Persistent IP

00004932 ms: IP: 169.254.64.2

00004934 ms: Netmask: 255.255.0.0

00004937 ms: Gateway: 0.0.0.0

00004940 ms: LLA always ON.

00004942 ms: **********

auto-negotiated link speed: 1000

00004974 ms: Wait for end of IP configuration...

00004977 ms: Start IP configuration with persistent IP

00004981 ms: Enable hw InterPacketDelay.

00004985 ms: Network interface is up, speed: 1000 Mbps

00004990 ms: IP: 169.254. 64. 2

00004993 ms: Netmask: 255.255. 0. 0

00004997 ms: Gateway: 0. 0. 0. 0

00005000 ms: Assigned from static address

The C2 Cables

Cables for Power, I/O and Laser Control

Part Number #	Description
202 201 070	C2 cable for power, I/O and laser control, custom length and connector configuration IP64 (straight/angled), shielded
202 201 071	C2 cable for power, I/O and laser control, straight M12 female connector (IP64) to straight M12 male connector (IP64), shielded, length 3m, standard
202 201 072	C2 cable for power, I/O and laser control, straight M12 female connector (IP64) to straight M12 male connector (IP64), shielded, length 5m, standard
202 201 073	C2 cable for power, I/O and laser control, straight M12 female connector (IP64) to straight M12 male connector (IP64), shielded, length 10m, standard

Pigtail cables:

202 201 074	C2 pigtail cable for power, I/O and laser control, straight M12 female connector (IP64) on camera plug, shielded, length 3m, standard
202 201 075	C2 pigtail cable for power, I/O and laser control, straight M12 female connector (IP64) on camera plug, shielded, length 5m, standard
202 201 076	C2 pigtail cable for power, I/O and laser control, straight M12 female connector (IP64) on camera plug, shielded, length 10m, standard

Angles adapter cables:

202 201 060	C2 & C5 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 “UP”, length 0.2m, standard
202 201 066	C2 & C5 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 “DOWN”, length 0.2m, standard

Wire Assignment of C2 Pigtail Cable

Pin/Wire No.	Wire Colour	Signal Name	Description
1	Violet	SCL	Clock line of I^2C bus interface
2	Pink/Black	DO_0 (OUT1)	Digital Output 1 (TTL)
3	Blue/White	DI_4 (Z)	Encoder input Z index (TTL)
4	Blue	DI_3 (B)	Encoder input B track (TTL)
5	Gray	DI_2 (A)	Encoder input A track (TTL)
6	Violet/White	SDA	Data line of I^2C bus interface
7	Light Green	AO (LASER_AOUT)	Output for analog modulation of illumination device (0–5V DC)
8	Yellow	VCC_EXT	camera supply voltage (12–24V DC)
9	Yellow/Black	GND_EXT	Main Camera Ground
10	Light Blue	RS232_RX	RS-232 compatible input
11	Light Blue/Black	RS232_TX	RS-232 compatible output
12	Pink	DO_1 (OUT2)	Digital Output 2 (TTL)
13	Black/White	DI_0 (IN1)	Digital Input 1 (TTL)
14	Black	DI_1 (IN2)	Digital Input 2 (TTL)
15	Light Green/Black	AIN	Input for monitoring specific functions of illumination device (0–5V DC)
16	Brown	DO_2 (LASER_DOUT)	Output for digital modulation of illumination device (TTL)
17	Brown/White	GND	Reference ground for IO and Laser signals

(Note when using the C2 pigtail cable: I/O signals are not isolated. The maximum voltage level is limited to 5V. The outputs are not capable of load driving)

When using C2 power & I/O cables (standard or pigtail) with length longer than 20 m it is recommended to supply the camera with a voltage of 24V.

Cables for GigE Interface

Part Number #	Description
202 201 040	C2 & C5 GigE cable with custom length and connector configuration (straight/angled)
202 201 041	C2 & C5 GigE cable, straight M12 male connector (IP67) on camera plug to RJ45 (IP20), length 3m, standard
202 201 042	C2 & C5 GigE cable, straight M12 male connector (IP67) on camera plug to RJ45 (IP20), length 5m, standard
202 201 043	C2 & C5 GigE cable, straight M12 male connector (IP67) on camera plug to RJ45 (IP20), length 10m, standard
202 201 044	C2 & C5 GigE cable, straight M12 male connector (IP67) on camera plug to RJ45 (IP20), length 15m, standard

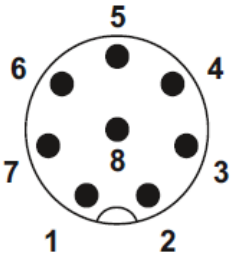
High-flex cables:

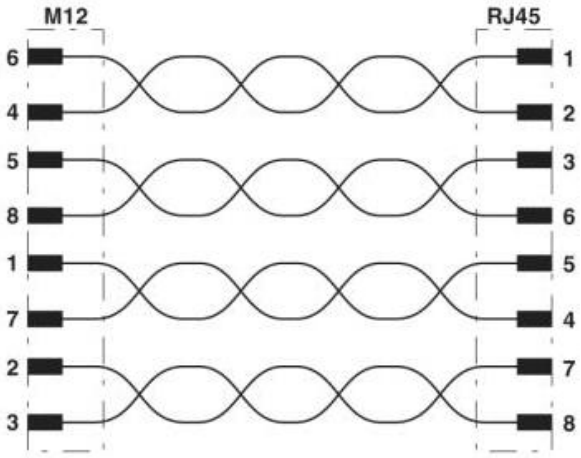
202 201 062	C2 & C5 GigE cable, straight M12 connector (IP67) to RJ45 (IP20), length 3m, high flex
202 201 063	C2 & C5 GigE cable, straight M12 connector (IP67) to RJ45 (IP20), length 5m, high flex
202 201 064	C2 & C5 GigE cable, straight M12 connector (IP67) to RJ45 (IP20), length 10m, high flex

Angled adapter cables:

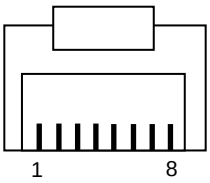
202 201 061	C2 & C5 angled adapter cable for GigE, 90° angled M12 male connector (IP64) on camera plug to straight M12 female (IP64), angled connector configuration “UP”, length 0.2m, standard
202 201 067	C2 & C5 angled adapter cable for GigE, 90° angled M12 male connector (IP64) on camera plug to straight M12 female (IP64), angled connector configuration “DOWN”, 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

*** Discontinued ***

Cables for Power, I/O and Laser Control (***discontinued***)

Part #	Description
202 201 030	C2 cable for power, I/O and laser control, custom length and connector configuration (straight/angled), unshielded
202 201 031	C2 cable for power, I/O and laser control, straight M12 female connector (IP67) to straight M12 male connector (IP67), unshielded, length 3m
202 201 032	C2 cable for power, I/O and laser control, straight M12 female connector (IP67) to straight M12 male connector (IP67), unshielded, length 5m
202 201 036	C2 cable for power, I/O and laser control, straight M12 female connector (IP67) to straight M12 male connector (IP67), unshielded, length 10m

Pigtail cables:

202 201 033	C2 pigtail cable for power, I/O and laser control, straight M12 female connector (IP67) on camera plug, unshielded, length 3m
202 201 034	C2 pigtail cable for power, I/O and laser control, straight M12 female connector (IP67) on camera plug, unshielded, length 5m
202 201 035	C2 pigtail cable for power, I/O and laser control, straight M12 female connector (IP67) on camera plug, unshielded, length 10m

Wire Assignment of C2 Pigtail Cable

Valid for cables with PN# 202 201 033, 202 201 034 and 202 201 035(***discontinued***)

Pin/Wire No.	Wire Colour	Signal Name	Description
1	Brown	SCL	Clock line of I^2C bus interface
2	Blue	DO_0 (OUT1)	Digital Output 1 (TTL)
3	White	DI_4 (Z)	Encoder input Z index (TTL)
4	Green	DI_3 (B)	Encoder input B track (TTL)
5	Pink	DI_2 (A)	Encoder input A track (TTL)
6	Yellow	SDA	Data line of I^2C bus interface
7	Black	AO (LASER_AOUT)	Output for analog modulation of illumination device (0–5V DC)
8	Gray	VCC_EXT	camera supply voltage (12–24V DC)
9	Red	GND_EXT	Camera supply ground
10	Violette	RS232_RX	RS-232 compatible input
11	Gray/Pink	RS232_TX	RS-232 compatible output
12	Red/Blue	DO_1 (OUT2)	Digital Output 2 (TTL)
13	White/Green	DI_0 (IN1)	Digital Input 1 (TTL)
14	Brown /Green	DI_1 (IN2)	Digital Input 2 (TTL)
15	White/Yellow	AIN	Input for monitoring specific functions of illumination device (0–5V DC)
16	Yellow/ Brown	DO_2 (LASER_DOUT)	Output for digital modulation of illumination device (TTL)
17	White/Gray	GND	Reference ground for IO and Laser signals

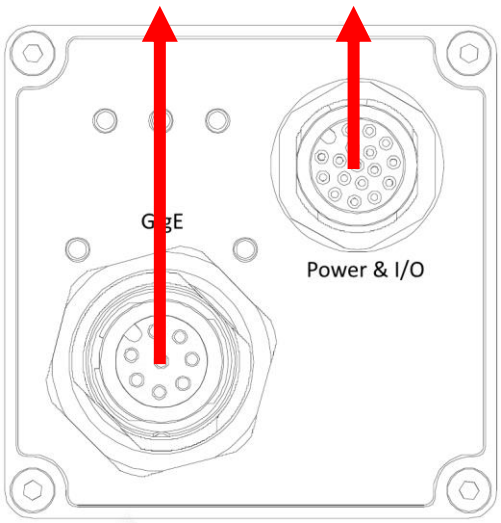
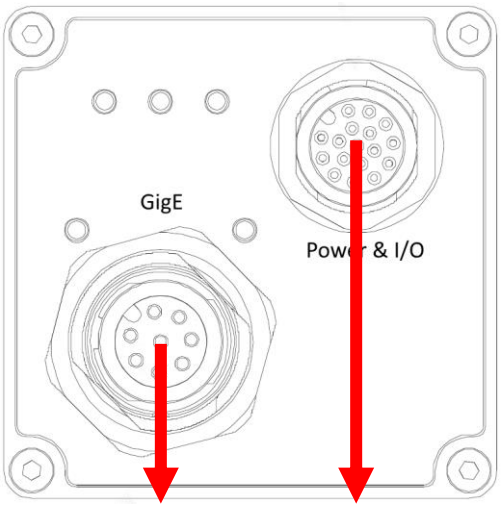
(Note when using the C2 pigtail cable: I/O signals are not isolated. The maximum voltage level is limited to 5V. The outputs are not capable of load driving)

When using C2 power & I/O cables (standard or pigtail) with length longer than 20 m it is recommended to supply the camera with a voltage of 24V.

Orientation of Angled Adapter Cable

Depending on the used adapter cable the orientation differs. The option “UP” or “DOWN” will change the outlet direction of the angled cables.

Power & I/O “UP”:	#202 201 060
GigE “UP”:	#202 201 061
Power & I/O “DOWN”:	#202 201 066
GigE “DOWN”:	#202 201 067

UP	DOWN
	

The C2 Series GenICam Features

A complete list of all GenICam features for all types of C2 cameras (C2-640-GigE and C2-2040(HS)-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

CXExplorer Overview

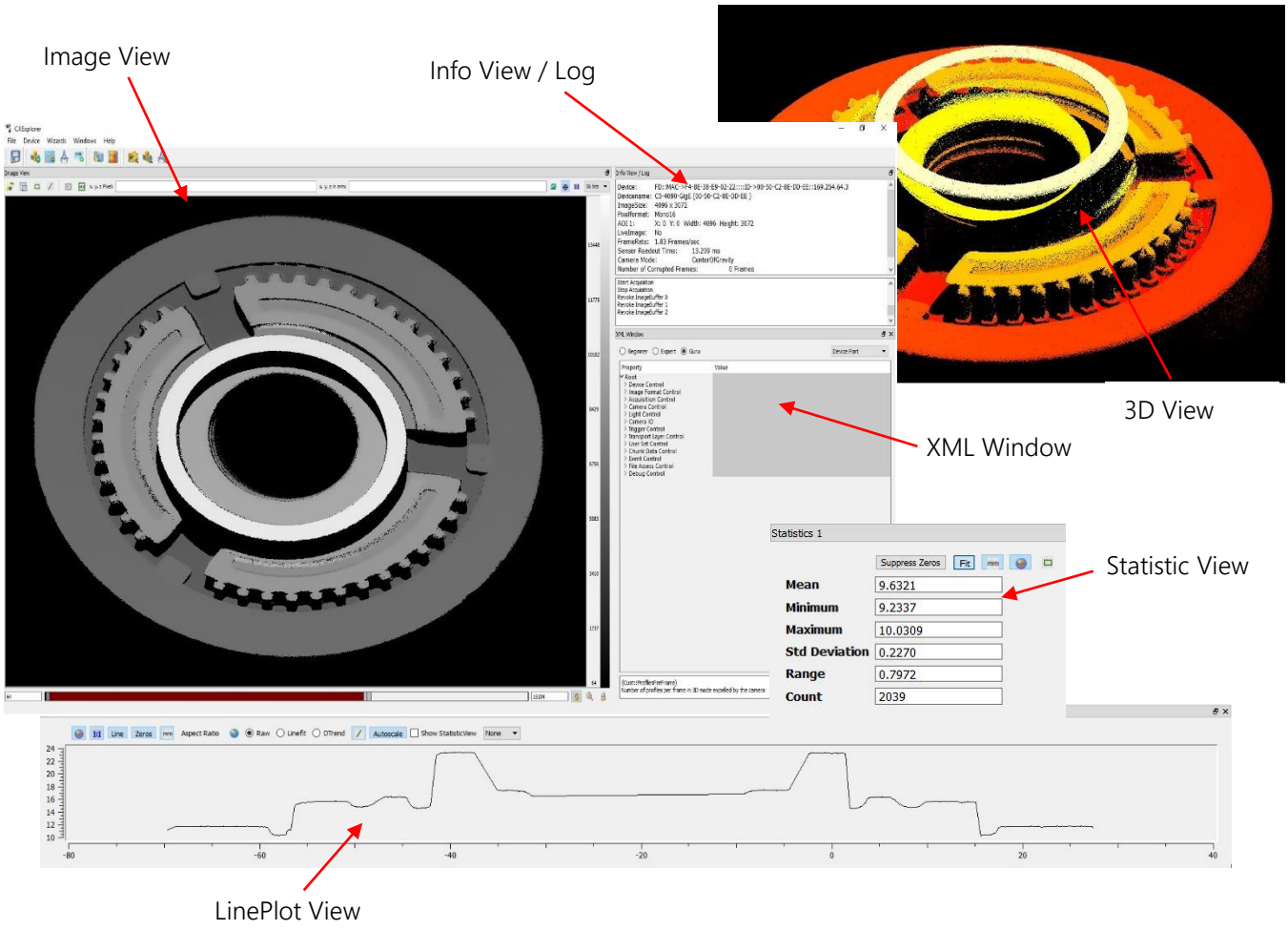
The CXExplorer

Configuration of a C2 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, 3D view and many more.

This chapter gives some general information about the layout of the CX Explorer 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.

The CXExplorer consists of maximum six different window panes. The *Image View*, *Info View / Log*, *XML Window*, *LinePlot View*, *3D View* and the *Statistic View*.



CXExplorer Features

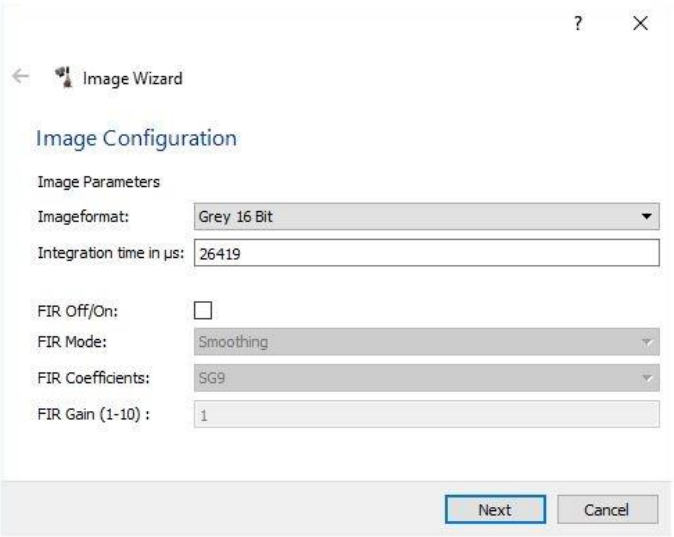
As mentioned in the previous chapter The C2 Sensor Algorithms every C2 camera is able to run in 2D image mode or in 3D mode.

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.



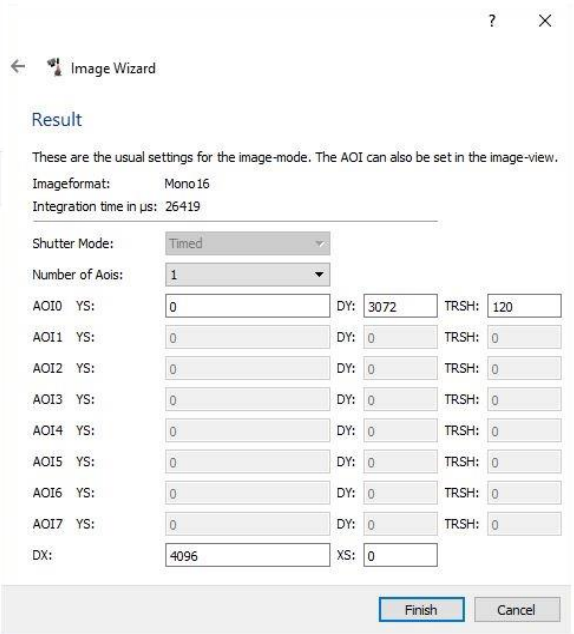
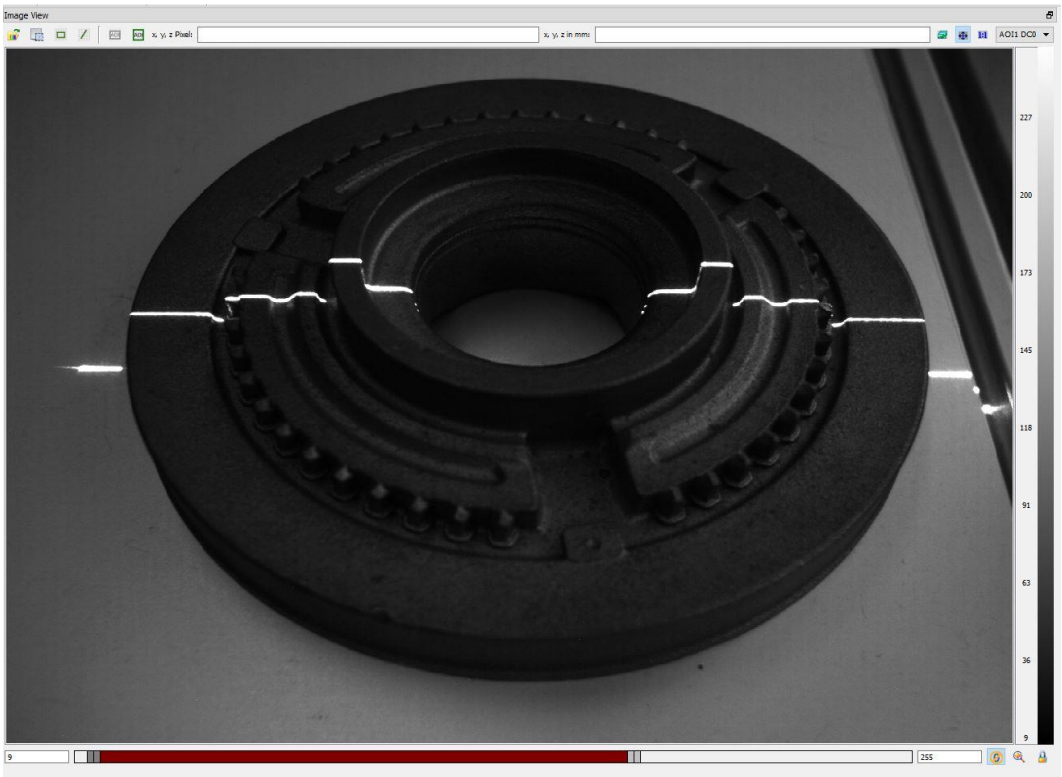


Image Mode

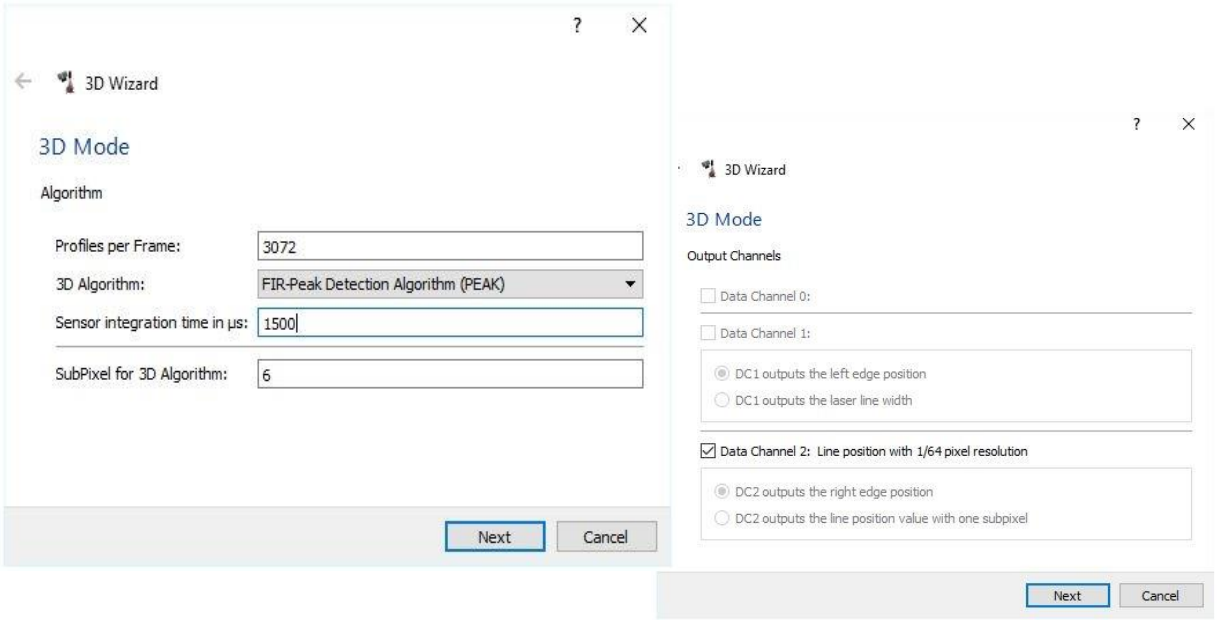
The image mode enables the output of the 2D CMOS sensor images of the camera. That can be helpful e.g. to set and optimize the laser power, the Area Of Interest or the exposure time.

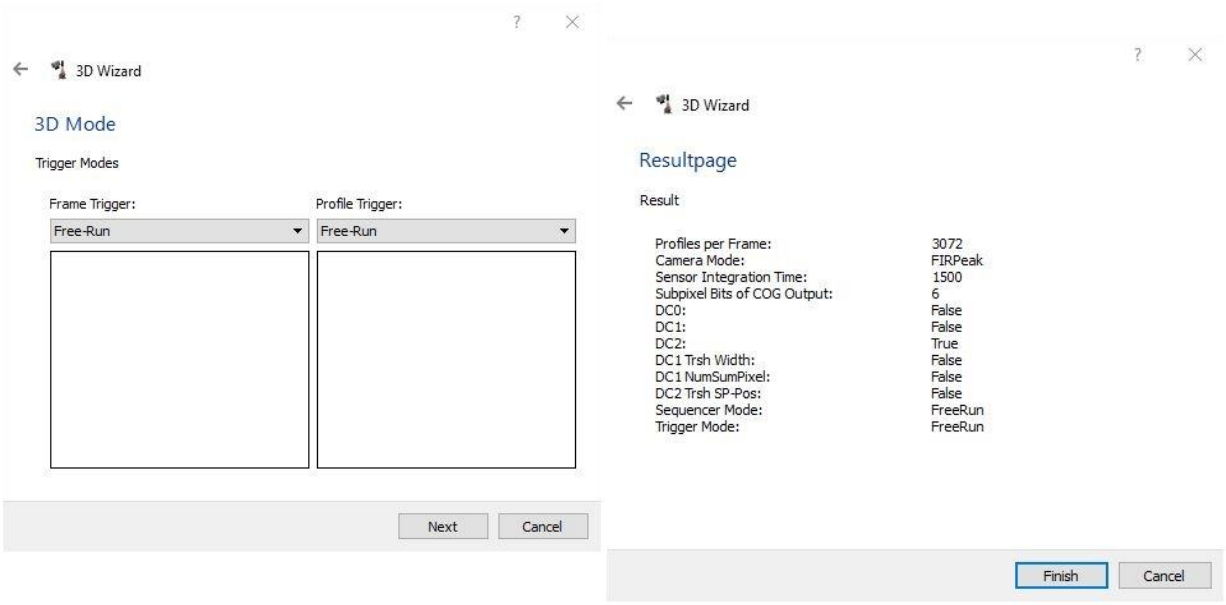


(2D greyscale image)

3D Wizard

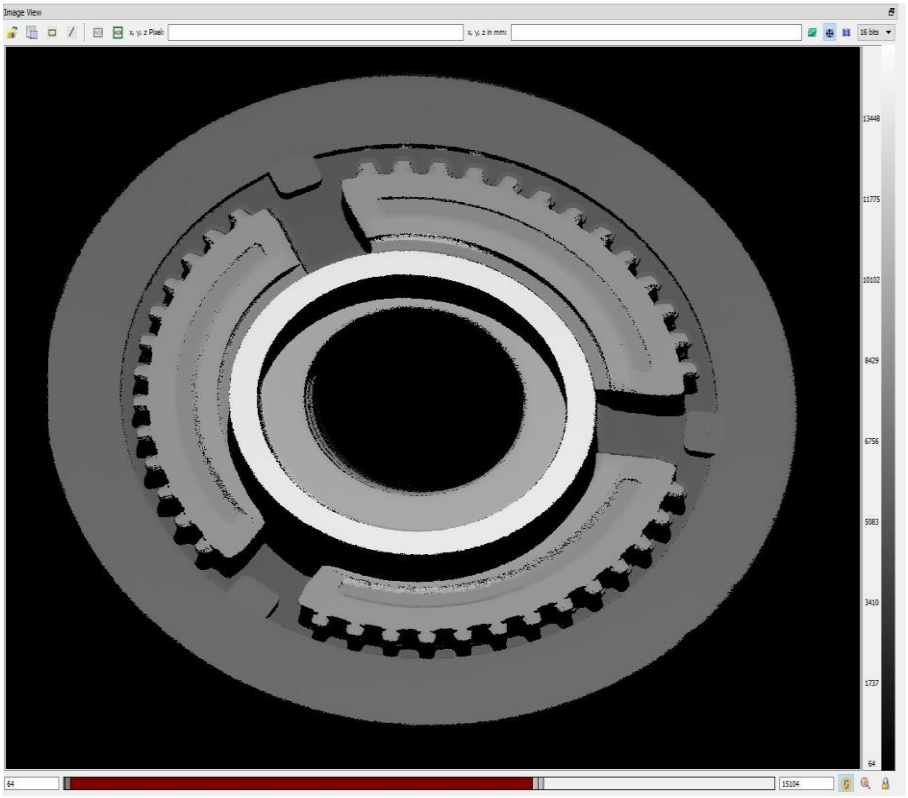
With the 3D Wizard the camera mode can be easily switched to 3D mode. Set the number of profiles per frame, choose the 3D algorithm, set the integration time and select the number of subpixel. Enable the required Output Channels and select the trigger mode to finish the wizard.





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)

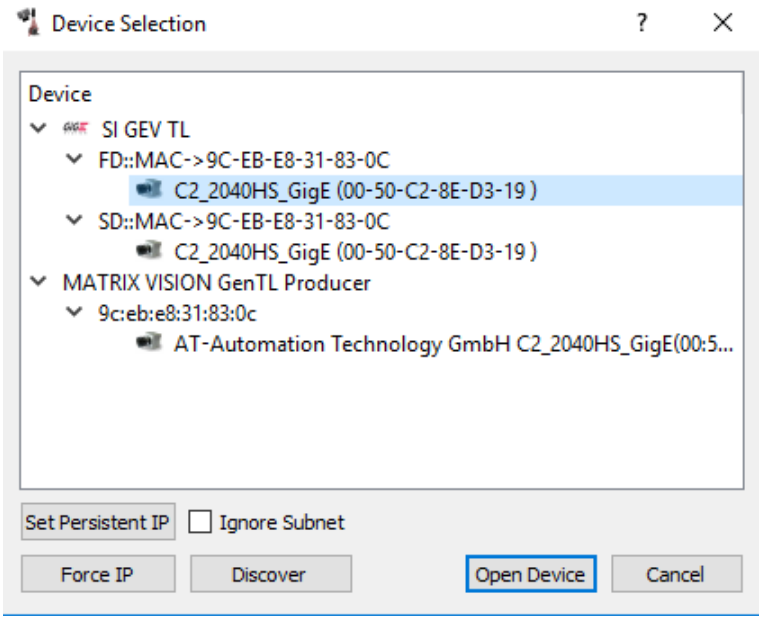
A detailed description of the operation of the CXExplorer can be found in a separate application note.

Quickstart a C2 camera

This chapter explains the handling to set up a C2 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 computer 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. Enable Jumbo Frames if possible.
6. Starting the CXExplorer lead to the *Device Selection*. Chose the camera over the available Transport Layer and open the device. If the camera isn´t visible check the IP address or search for subnets. Set a persistent camera IP or force the IP address if needed and open the device.



By default the camera start in the factory mode. For the C2 camera the factory mode is the 2D image mode. Start the continuous image grab over  or do a snapshot over  .
The first images were acquired.

Service Information

Product Information and Updates

Contact

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Updates

www.AutomationTechnology.de

Service and Support

service@AutomationTechnology.de

In order 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 (*.cxc), a snapshot and a precise problem description.

Product Inquiries and Price Quotations

info@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 C2 series sold inside of the European Union (EU)
1-year warranty for all C2 series sold outside of the European Union (EU)

Extended Warranty

The warranty period can be extend to maximum 36 months.

Return Policy

Before returning a sensor for repair (warranty or non-warranty) to AT – Automation Technology GmbH a Return Material Authorization (RMA) number have provided by AT. Please get in contact with the AT support to receive a 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 the camera was purchased over a distributor, please get in contact with them to start the RMA process.

Document Revision

Rev. No.	Date	Modification
1.0	06.03.2013	First Draft
1.1	21.06.2013	Corrections
1.2	28.11.2013	Minor corrections, 5V digital input limitation
1.3	06.01.2014	Correction GigE Pin out
1.4	28.02.2014	Minor corrections, added Vlow2 and Vlow3
1.5	08.04.2014	Minor corrections
1.6	05.06.2014	Minor corrections, added C2-I/O Panel Rev. 2.0
1.7	11.08.2014	Minor corrections, added information regarding C2-I/O Panel Rev. 2.0
1.8	20.02.2015	Minor corrections, added new HDR Genicam registers, shielded cables
1.9	18.01.2019	Corrected colour assignment for C2 pigtail cables (PN# 202 201 074, 202 201 075 and 202 201 076) Corrected height resolution equation for Geometry 4 Add Information to warranty period and extended warranty condition Remove extended GenICam feature list Add new chapters: The Web Interface, CXExplorer Overview, Quickstart a C2 camera, Return Police Add new Multiple Slope image examples Add Orientation of Angled Adapter Cables

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