



## Software Manual

ifm Vision Assistant  
for mobile 2D/3D sensors

**UK**

**O3M150**

**O3M151**

**O3M160**

**O3M161**

**O3M250**

**O3M251**

**O3M260**

**O3M261**

## Contents

1	Preliminary note	6
1.1	Symbols used	6
1.2	Safety instructions	6
1.3	Further documents	6
2	System requirements	7
2.1	Software	7
2.2	Hardware and accessories	7
3	Installation	8
3.1	Hardware	8
3.2	Mounting accessories	8
3.3	Software (ifm Vision Assistant)	9
4	Start page	10
4.1	Find sensor	11
4.1.1	Direct search	11
4.1.2	Manual connection	13
4.2	Recent	14
4.3	Replay	15
4.4	Wiring	17
4.5	Settings	18
4.6	Close	18
5	Structure of the user surface	19
5.1	Navigation bar	20
5.2	Status bar	20
5.3	Main area	20
6	Monitoring window	21
6.1	View Options	21
6.1.1	2D View	22
6.1.2	2D3D view	26
6.1.3	3D view	29
6.1.4	Slider bar	35
6.2	Recording	36
6.3	Service options	38
7	Device setup	40
7.1	Device	41
7.1.1	Name	41
7.1.2	General settings wizard	41
7.1.3	Firmware update	50
7.1.4	Export settings	51
7.1.5	Import settings	51
7.1.6	Reboot the sensor	52
7.1.7	Online parameter setting	53
7.2	CAN settings	54
7.3	Ethernet	55
8	Device Information	57
9	Calibration settings	58
9.1	What is calibration?	58
9.2	World coordinate system	60
9.3	Reference point of the device	60
9.4	Position of the device	61
9.5	Reference point of the illumination unit	63
9.6	Position of the illumination unit	63
9.7	Mounting angle of the device	64
9.7.1	Normal mode	65
9.7.2	Expert mode	65
9.8	Automatic calibration	66
9.8.1	Equipment failure causes	69

10	Image settings	70
10.1	Live image display	71
10.1.1	Pixel properties	72
10.2	Applying filters	73
10.2.1	Example of area monitoring	73
10.3	Signal quality filter	73
10.4	Noise reduction filter	74
10.5	Detection of spray/fog/dust	75
10.6	Soiling detection	76
10.6.1	Setting the sensitivity	76
10.6.2	Removal of soiling	77
10.7	Frame rate	77
10.8	Modulation frequency mode	78
10.8.1	Fixed modulation frequencies	78
10.8.2	Random modulation frequencies	79
10.9	Intelligent data averaging	80
10.9.1	Operating principle	81
10.9.2	Example of a signal noise reduction	81
10.9.3	Example for increasing the number of valid pixels	82
10.10	Reflector threshold value	83
10.11	Measuring range	84
10.11.1	Exclusion area	85
11	2D overlay	86
11.1	Overlay options	87
11.2	Pallet	87
11.2.1	Add text	88
11.2.2	Adding a vector	89
11.2.3	Adding a graphic	90
11.2.4	Live ticker	91
11.3	Variant options of the OD firmware	92
11.4	Variant options of the DI firmware	93
11.4.1	Visualising 3D ROIs as a moving wall	93
11.4.2	Visualisation of 3D ROIs as a projection on the floor	98
11.4.3	Visualisation of 2D ROIs	103
12	DI firmware - basic functions	107
12.1	ROI mode	107
12.2	Global settings	108
12.3	Several ROIs	109
12.3.1	Min/max values and separation	110
12.3.2	Result type	111
12.3.3	Output value	112
12.3.4	Reference value for min/max	115
12.3.5	Existing ROIs	117
12.3.6	Select group option	117
12.4	ROI groups	117
12.5	ROIs	118
13	Firmware OD - object detection	119
13.1	Object recognition	119
13.2	Collision avoidance	121
13.2.1	The "intelligent" collision avoidance mode	122
13.2.2	Collision avoidance mode "Intelligent with side collision"	125
13.2.3	Collision avoidance mode "zone-based"	126
14	Firmware LG - line guidance	129
14.1	Max. angle to the driving direction	130
14.2	3D line structure	130
14.3	Automatic ground plane detection	131
14.4	Search area for line detection	132
14.5	Additional crop edge settings	133
14.6	Filter on line output (low pass)	133
14.7	Steering computation	134

14.8	CAN data for vehicle movement	134
15	Logic editor	136
15.1	General creation rules	136
15.2	Place and connect modules	137
15.2.1	Generate example	138
15.2.2	Place new logic module in main area	138
15.2.3	Delete a module	138
15.2.4	Set a module	139
15.2.5	Connect modules	141
15.2.6	Delete module connections	141
15.3	Description of the "Input" modules	142
15.3.1	"Digital CAN input signals" module	142
15.3.2	"Analogue CAN input signals" module	142
15.3.3	Example for "Analogue CAN input signals" module	143
15.3.4	"Extrinsic calibration" module	144
15.3.5	"Diagnostic" module	144
15.4	Description of the "Input" modules – Firmware DI	146
15.4.1	"Basic function" module	146
15.4.2	"Input value of index" module	147
15.4.3	Example for the "Input value of index" module	148
15.5	Description of the "Input" modules – Firmware OD	149
15.5.1	"Object detection" module	149
15.5.2	"Zone-based" module	151
15.5.3	"Time-based" module	151
15.5.4	"Input value of index" module	152
15.6	Description of the "Input" modules – Firmware LG	154
15.6.1	"Line detection" module	154
15.6.2	"Input value of index" module	155
15.7	Description of the "Memory function" modules	156
15.7.1	"Teach" module	157
15.7.2	Example for the "Teach" module	157
15.7.3	"RAM write" module	159
15.7.4	"RAM read" module	159
15.7.5	Example: "Exponential smoothing filter" for "RAM write" / "RAM read" modules	160
15.7.6	Example "Event counter" for "RAM write" / "RAM read" modules	161
15.8	Description of the "Arithmetic" modules	162
15.8.1	Examples for processing input signals	164
15.9	Description of the "Digitalisation" modules	167
15.10	Description of the "Logical functions" modules	168
15.11	Description of the "Vector-specific functions" modules	169
15.11.1	Example for the "Vector Min" module	170
15.12	Description of the "Output" modules	170
15.12.1	"Digital output" module	170
15.12.2	Example for the "Digital output" module	171
15.12.3	"Analogue output" module	172
15.12.4	Example for the "Analogue output" module	173
15.13	Description of the switches "Enable CAN output"	174
15.14	Description of the "Logic teach commands"	174
16	Annex	175
16.1	Network settings	175
16.2	Text replacements and conditional codes	178
16.2.1	Example	178
16.2.2	Hints for the usage	179
16.2.3	Text replacement - common codes for all variants	179
16.2.4	Text replacement – DI specific codes	180
16.2.5	Text replacement – OD specific codes	181
16.3	Connect O3M to external devices	187
16.3.1	Ethernet (UDP)	187
16.3.2	CAN (J1939, CANOpen)	187
16.4	Glossary	188

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# 1 Preliminary note

This document describes the following tasks with the 3D sensor of the O3M product family and the ifm Vision Assistant software:

- Setting the parameters of the sensor (in the following referred to as "device")
- Setting up the applications using the ifm Vision Assistant
- Monitoring the applications with the ifm Vision Assistant

As soon as an application has been installed on the device, the device can be operated without the ifm Vision Assistant.

## 1.1 Symbols used

- ▶ Instructions
- > Reaction, result
- [...] Designation of keys and buttons
- "..." Name of display text
- Cross-reference



Important note  
Non-compliance may result in malfunction or interference.



Information  
Supplementary note

## 1.2 Safety instructions

Please read the operating instructions prior to set-up of the device. Ensure that the device is suitable for your application without any restrictions.

If the operating instructions or the technical data are not adhered to, personal injury and/or damage to property can occur.

## 1.3 Further documents

Document
Operating instructions
Short instructions



The documents can be downloaded at: [www.ifm.com](http://www.ifm.com)

## 2 System requirements

### 2.1 Software

The following software versions are required for operation:

- Operating system: Windows 7 (32/64 bits), Windows 8.1 (32/64 bits), Windows 10 (32/64 bits)
- Application software: ifm Vision Assistant 1.8.9.0
- Firmware DI: 4.21.x
- Firmware OD: 4.21.x
- Firmware LG: 4.21.x



The required software can be found at [www.ifm.com](http://www.ifm.com).



Other versions of the ifm Vision Assistant may contain changed or new functions which are not described in this software manual.

### 2.2 Hardware and accessories

The following hardware is required for operation:

- Sensor of the O3M family
- PC with x86 or x64 type processor
- Screen: min. 1024 x 768 pixels, 32-bit colour depth

The following accessories are required for operation:

- Cable for network connection (Ethernet) for parameter setting, M12 connector/RJ45 connector, 4 poles, e.g. article no. E11898 (2 m), E12283 (5 m)
- Illumination unit
  - Article no. O3M950 for O3M15x and O3M25x
  - Article no. O3M960 for O3M16x and O3M26x
- MCI connection cable between sensor and illumination unit, article no. E3M121, E3M122 or E3M123
- Power supply cable for the illumination unit, article no. E3M131, E3M132 or E3M133
- Sensor cable for CAN bus and power supply, article no. E11596, E11597 or EVC492 (EVC492 incl. terminating resistor)
- CAN USB interface "CANfox", article no. EC2112
- CANfox adapter cable, article no. EC2114
- Power supply 24 V, minimum 2.4 A, e.g. article no. DN4012



You will find further information about available accessories at [www.ifm.com](http://www.ifm.com).

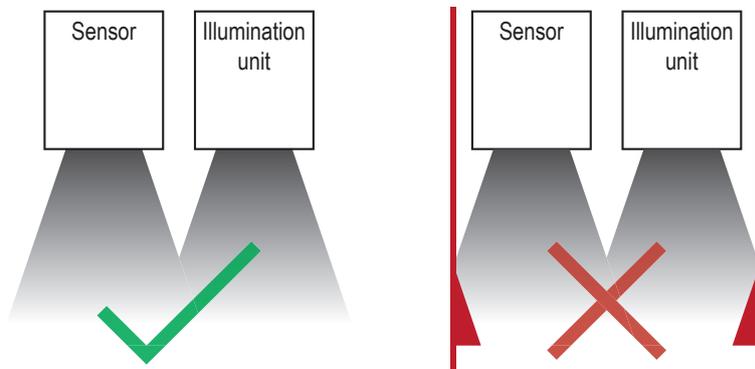
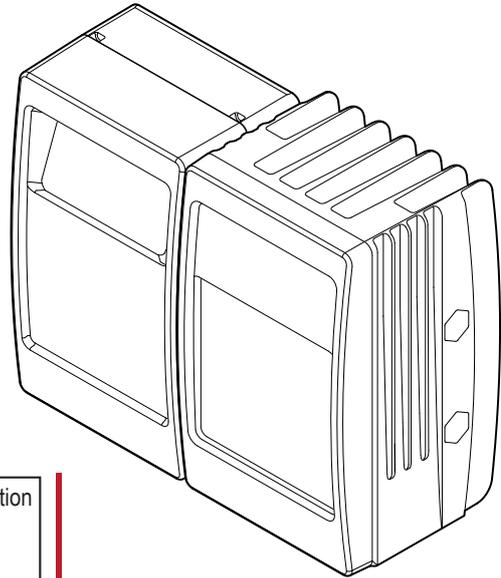
### 3 Installation

#### 3.1 Hardware

The mobile 3D sensor is operated as a system together with the illumination unit.

During installation note the following:

- ▶ Operate sensor and illumination unit in conjunction.
- ▶ Install sensor and illumination unit between 0 and 2.80 m apart.
- > Select the matching MCI connection cable depending on the distance.
- ▶ Keep the area illuminated by the illumination unit free from any obstructions in a close range (up to 50 cm) (see figure below).
- ▶ Use cables with strain relief.



Further information about the electrical connection and the correct pin connection  
 → Short instructions or operating instructions.

#### 3.2 Mounting accessories

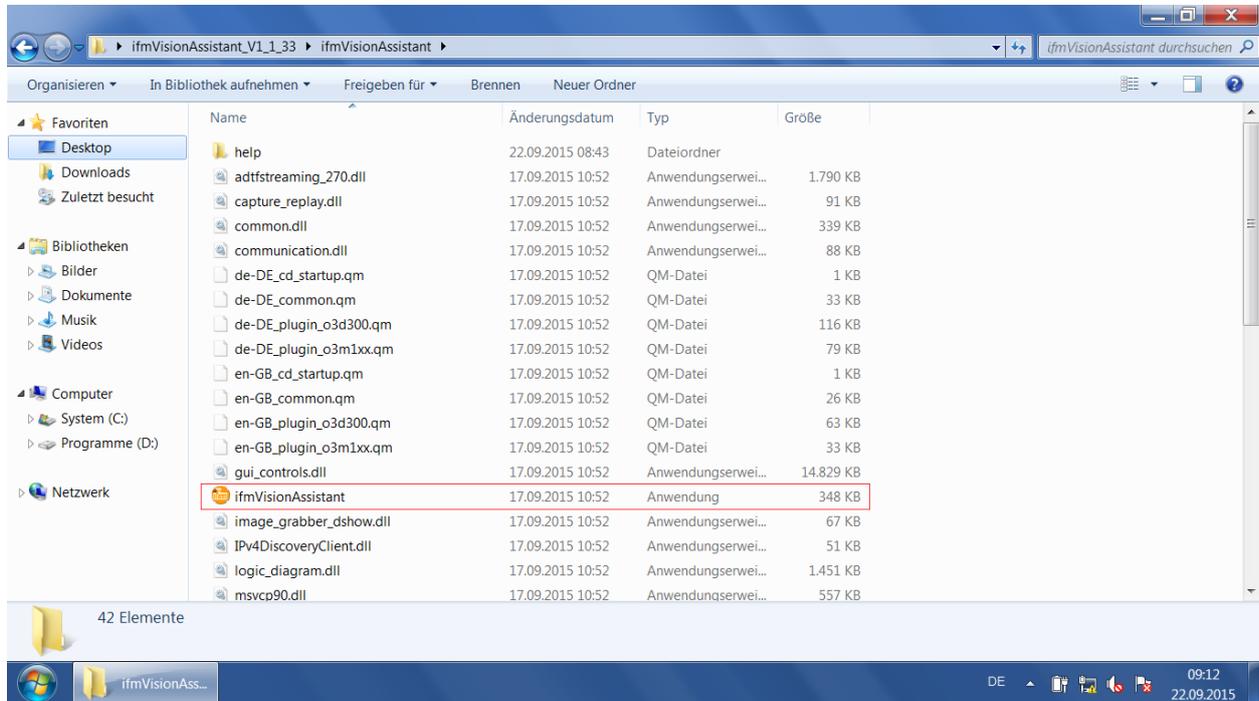
Depending on the intended mounting location and the type of installation, the following mounting accessories are available:

Description	Art. no.
Mounting set "U-tube" (u-shaped fixture with adjustment options for O3Mxxx housings)	E3M100
Mounting set for rod mounting Ø 14 mm (clamp and bracket for O3Mxxx housings)	E3M103
Rod, angled Ø 14 mm, length 130 mm, M12	E20939
Rod, angled Ø 14 mm, length 200 mm, M12	E20941

You can find more information about the accessories at: [www.ifm.com](http://www.ifm.com)

### 3.3 Software (ifm Vision Assistant)

- ▶ Insert the data carrier with the ifm Vision Assistant software.  
Alternative: Download ifm Vision Assistant software from the ifm website:  
[www.ifm.com](http://www.ifm.com) → Service → Download
- ▶ Copy the Zip file "ifmVisionAssistant" into an appropriate directory on the PC and unzip.
- ▶ Start the "ifmVisionAssistant" application file.



- > The start page of the ifm Vision Assistant opens.
- ▶ If the start page does not appear after 5–10 seconds, please check if the software requirements are complied with and if all files are properly unzipped.

## 4 Start page

On the start page, the basic functions of the ifm Vision Assistant can be selected.



Basic functions of the start page:

Symbol	name	Function	The device must be connected
	Find sensor	Connection with the new added device. Searches for connected devices and displays a selection list of the devices found (→ „4.1 Find sensor“).	yes
	Recent	Connection with the device that has connected itself successfully once before. Opens a selection list of the devices which have been connected before (→ „4.2 Recent“).	yes
	Replay	Plays recorded sequences (→ „4.3 Replay“).	no
	Wiring	Display of the wiring of the voltage supply. The display is used to simplify the connection during set-up (→ „4.4 Wiring“).	no
	Settings	Language and image mode setting of the user interface (→ „4.5 Settings“).	no
	Close	Quits the ifm Vision assistant.	no

## 4.1 Find sensor

With this function, it is possible to search for the connected devices or to establish a manual connection with a connected device.

- ▶ Ensure that the device and the PC are ready for operation and that there is a CAN bus and Ethernet connection.
- > If the device is neither connected via CAN bus nor via Ethernet, only a restricted 3D visualisation is possible and the connection is not automatically established.
- > If the device is connected via Ethernet and not via CAN bus, no parameters can be written to the device. Only monitoring is possible.



If possible, always connect the device both via CAN bus and Ethernet. Otherwise, functionality is restricted. This documentation assumes that the device is connected via both CAN bus and Ethernet.

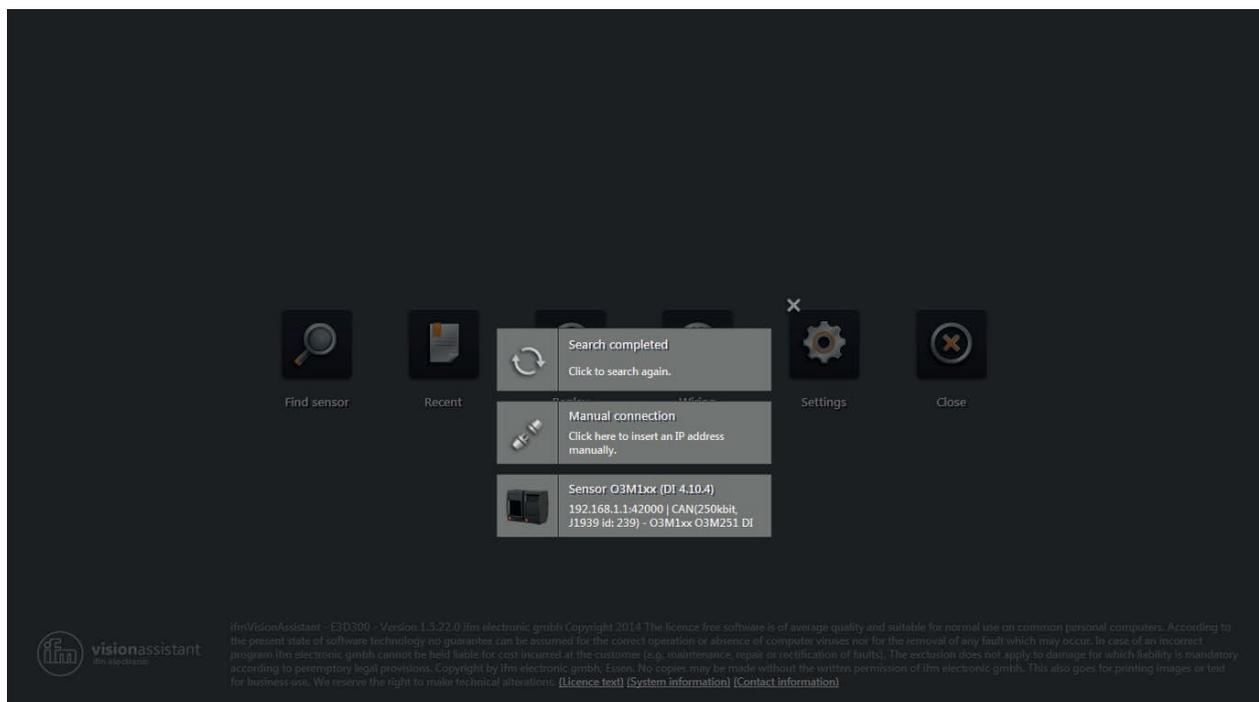


The following ports must be open (if necessary, adjust the settings of the firewall):

- UDP: 42000

### 4.1.1 Direct search

- ▶ Click .
- > The ifm Vision Assistant searches for connected devices via the Ethernet connection.
- > All devices found are shown in a list for selection. If there is a CAN bus connection, the CAN settings are shown additionally.
- ▶ Click on the button of the found device in order to establish connection.



- ▶ If the ifm Vision Assistant does not find a device automatically:
  - Check if the device is correctly connected and ready for operation and click on [Search completed] to start a new search.
  - Connect the device directly with the PC without any additional network devices in the connection (e.g. router).
  - Click on [Manual connection] and enter the connection settings manually (→ „4.1.2 Manual connection“).

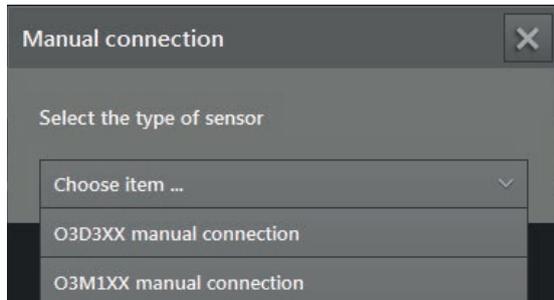
Buttons and notifications after the direct search:

Button and notification	Description
 <p>Search completed Click to search again.</p>	Starts a new search.
 <p>Manual connection Click here to insert an IP address manually</p>	Makes it possible to enter the IP address manually (→ „4.1.2 Manual connection“).
 <p>Sensor O3M1xx (DI 4.10.4) 192.168.1.1:42000   CAN(250kbit, J1939 id: 239) - O3M1xx O3M251 DI</p>	Shows connection settings of the CAN bus such as IP address, name of the device and the firmware version. Connects the device and continues according to the application data.

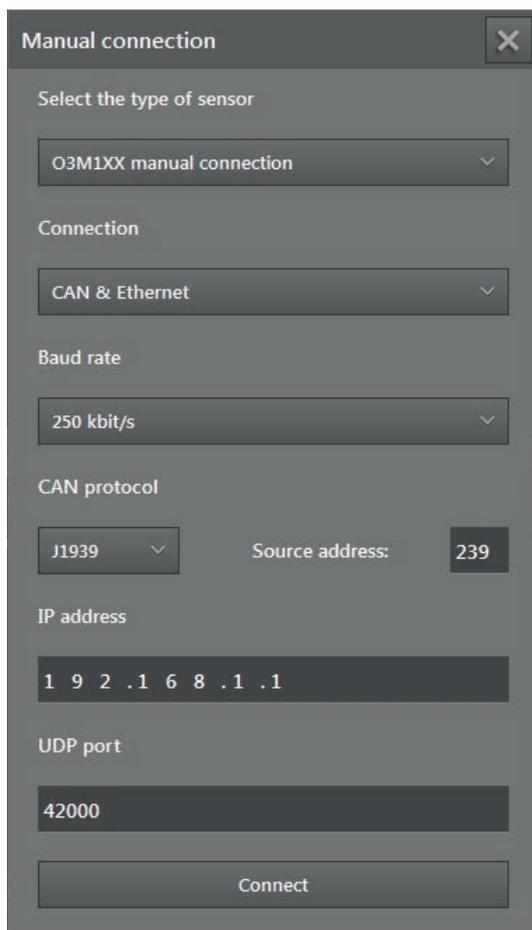
### 4.1.2 Manual connection

If the ifm Vision Assistant was not able to establish an automatic connection with the device, the connection settings can be entered manually via the button [Manual connection].

- ▶ Click .
- ▶ Click on [Manual connection].
- > The "Manual connection" window is displayed:



- ▶ Select "O3M manual connection".
- ▶ Enter the IP address of the device (standard: 192.168.0.69).



- ▶ Click on [Connect].

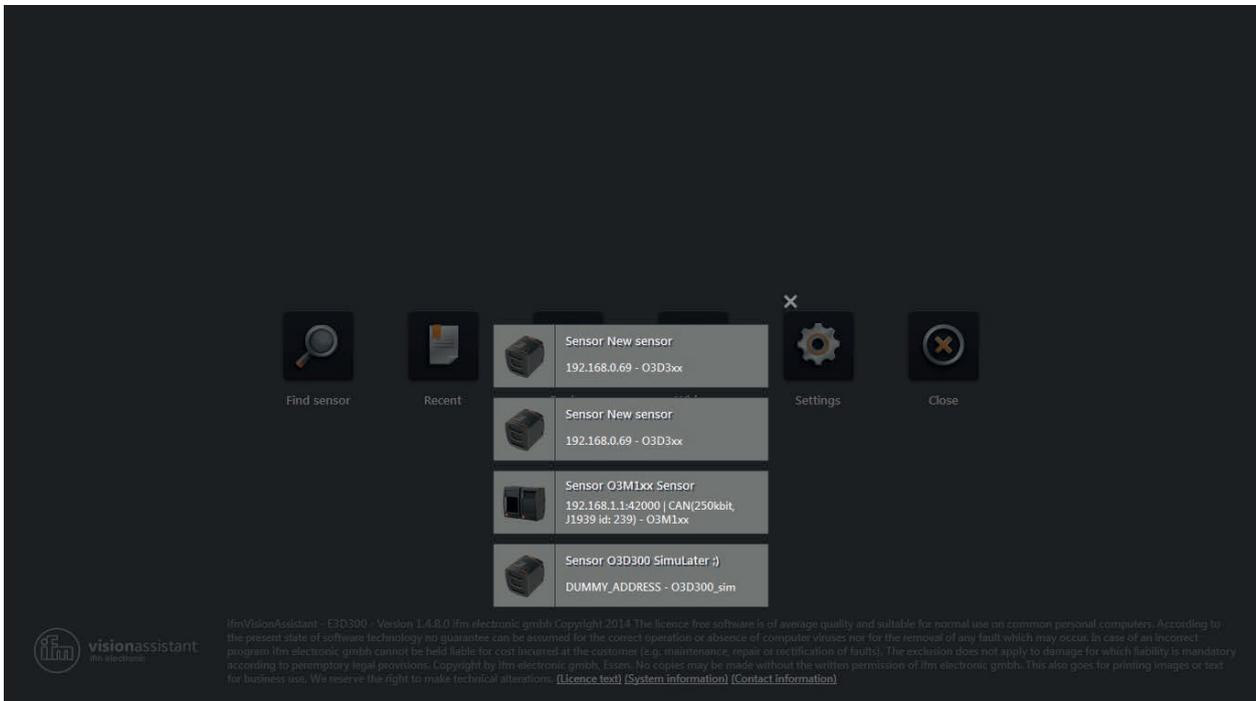


The IP addresses of device and PC with ifm Vision Assistant must be in the same subnet.

## 4.2 Recent

This function opens a selection list of the devices that have already been connected.

▶  Click .

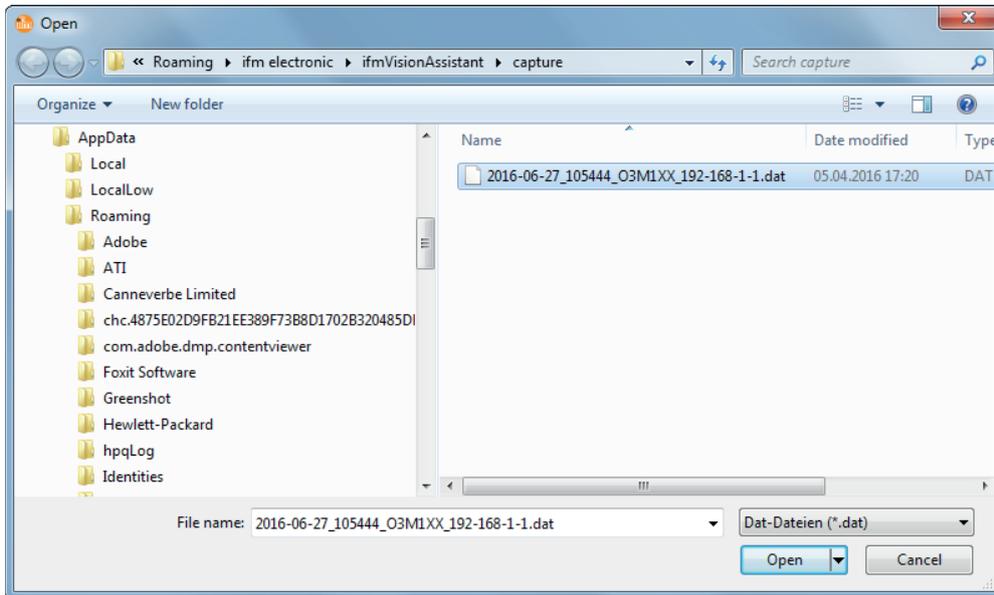


- ▶ Ensure that the corresponding device is connected with the PC via Ethernet or available in the network.
- ▶ Click on the device in the selection list.
- > The ifm Vision Assistant establishes a connection with the device.

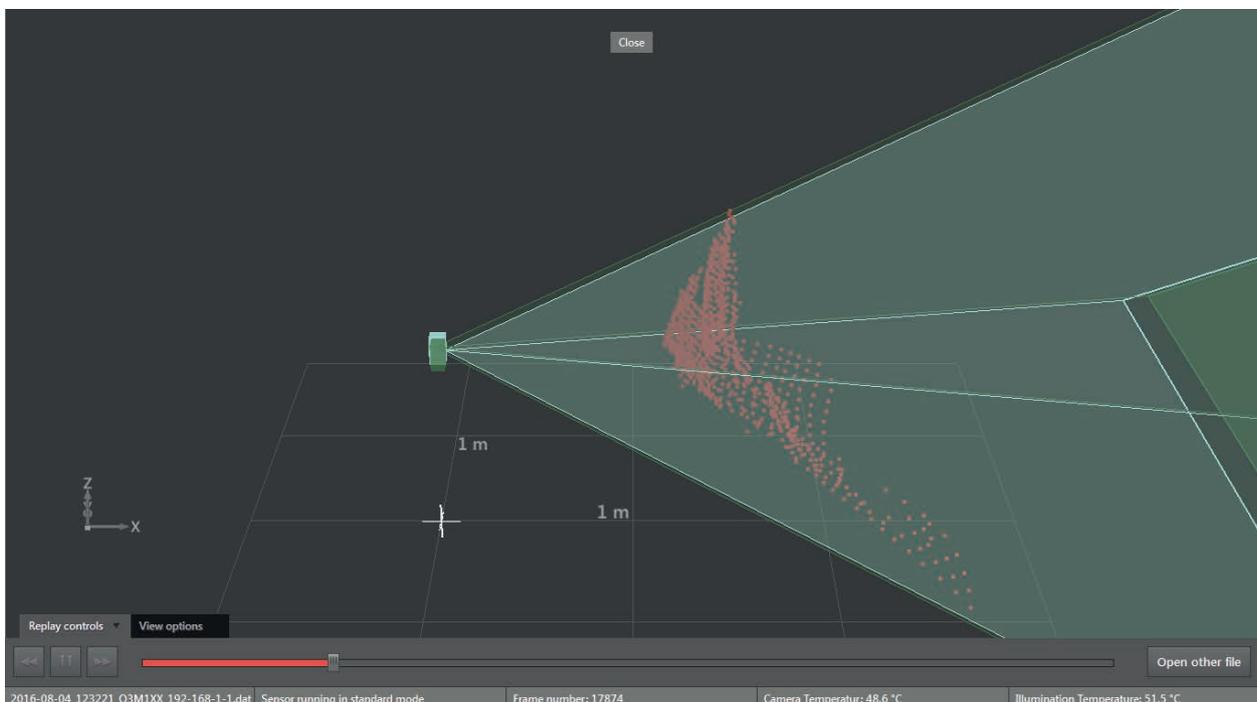
### 4.3 Replay

With this function, data that has been recorded can be viewed (→ „6 Monitoring window“). No connection to a device is needed.

- ▶ Click .
- ▶ Select the required file (\*.dat) and click on [Open].



- > The playback screen appears.



Options on the playback screen:

Tab	Option / button	Description
Replay controls	 pause	Stops playback.
	 Down	Stops playback and shows the previous picture.
	 Up	Stops playback and shows the next picture.
	 Start	Continues playback.
	Progress bar	Indicates the current position in the recording. By clicking on a position in the progress bar, playback continues at the corresponding image.
		Opens a window in which a file can be selected.
View options	–	→ „6.1 View Options“
–		Closes the playback screen and opens the start screen.

► Click on [Close] to return to the start screen.

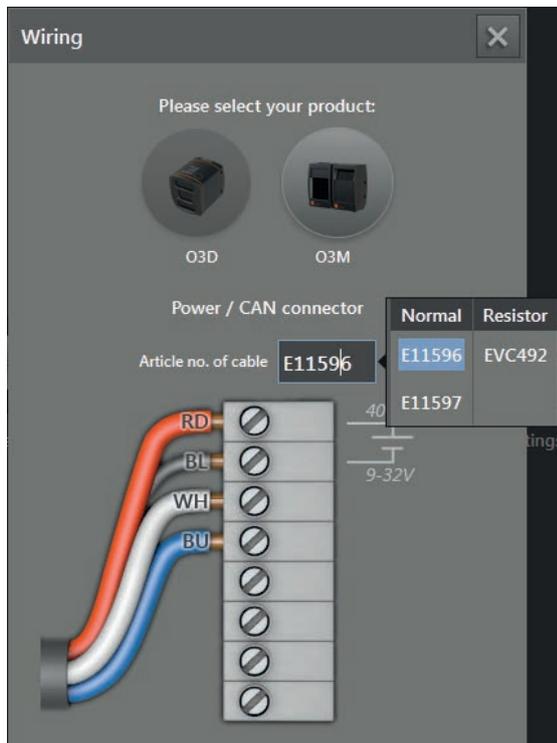
## 4.4 Wiring

This function allows correct wiring of the voltage supply of the 5-pole connector.

- ▶ Click .
- ▶ Selected article [O3M].
- > Only necessary if a new device has been selected.



- ▶ Click on the selection field [Article number] and select a connection cable from the selection list.
- > For the selected cable, the wiring of the voltage supply and the CAN bus is shown.



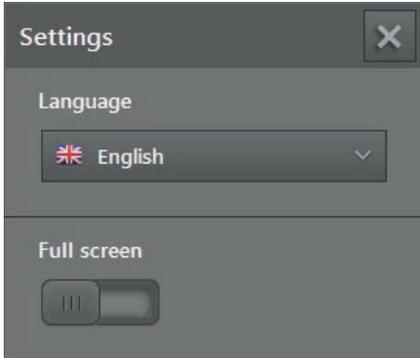
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## 4.5 Settings

You can use this function to change the language and to switch between full screen and window view.

► Click  .

> The "Settings" window is displayed.



Options in the settings window:

Field	Option	Description
Language	English	Selection of the available language. "English" is set by default.
	German	
	etc.	
Full screen	 on	Switches between full screen (on) and window view (off). Full screen is set by default.
	 off	



With the F11 key, you can switch between full screen and window view at any time.

## 4.6 Close

► Click on  to quit the ifm Vision Assistant.

## 5 Structure of the user surface

The screen of the ifm Vision Assistant has the following areas:

1. navigation bar:  
In the navigation bar on the left, the required option can be selected (→ „5.1 Navigation bar“).
2. main area:  
The main area shows the selected option or application.
3. Status bar:

The status bar at the bottom of the screen shows the status information of the device.



- 1: Navigation bar
- 2: Main area
- 3: Status bar

## 5.1 Navigation bar

The navigation bar on the left features the following options:

Button	Name	Description
	Monitor	Opens a 2D or 3D view and shows the current device data (→ „6 Monitoring window“).
	Applications	Opens an overview of the applications (→ „11 2D overlay“). Managing and adjusting the applications.
	Device setup	Opens the device setup (→ „11 2D overlay“). For device settings that are independent of the applications.
	Device information	Shows basic information (e.g. hardware firmware, device status) (→ „8 Device Information“).
	Calibration Settings	In the calibration settings, the device is calibrated for the intended application (→ „9 Calibration settings“).
	Settings	Opens the "Settings" window (→ „4.5 Settings“).
	Disconnect	Disconnects the ifm Vision Assistant from the device. The ifm Vision Assistant returns to the start screen.

## 5.2 Status bar

The status bar at the bottom of the screen gives the following information:

- Availability status
- Temperature information of the device, e.g. "Temperature normal"
- Connection type of the device, e.g. CAN and Ethernet
- Error mode of the device, e.g. xyz
- Frame count shows the number of frames



The availability status gives information about:

- Usability of the data
- Recognition of soiling (sensor disk dirty or frosted)
- Recognition of spray (can be activated in the programming mode)

## 5.3 Main area

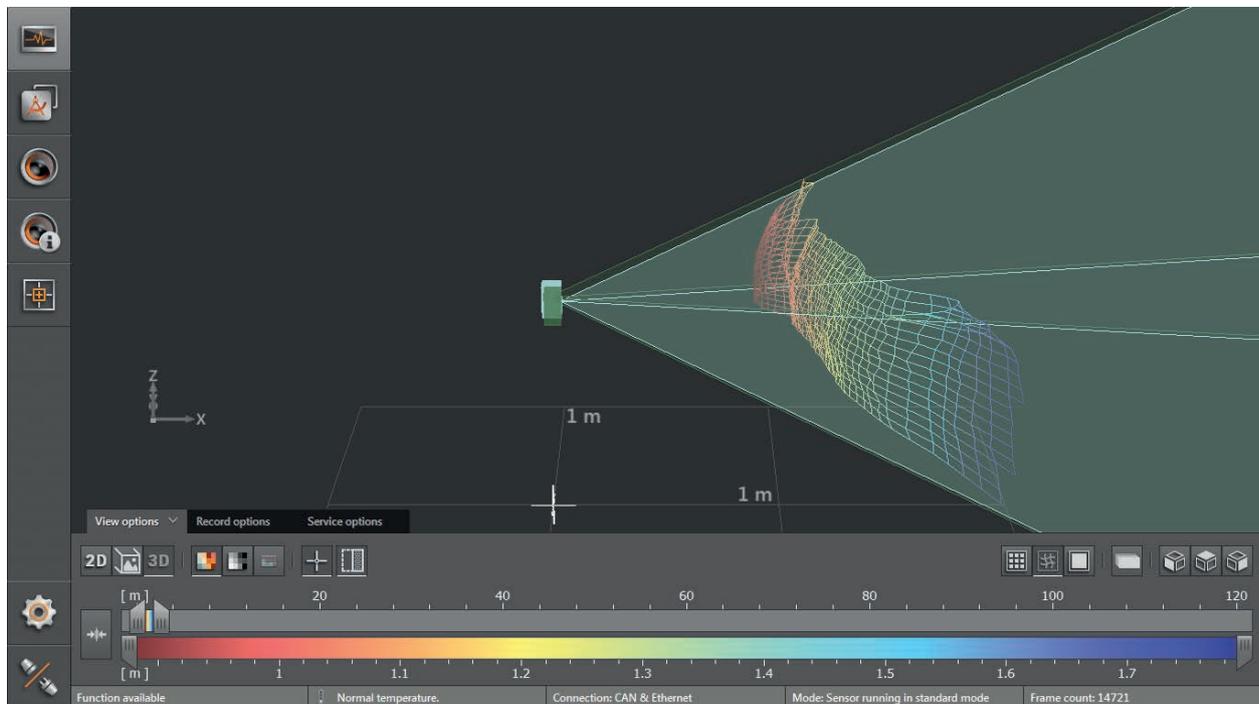
While the device is operated, the main area shows the monitoring window (→ „6 Monitoring window“).

When the device is being set up, the main area shows the corresponding screen pages.

## 6 Monitoring window

The monitoring window is activated via the [Monitor] button. The unit is in the operating mode. In the monitoring window, the running application can be monitored but neither interrupted nor changed. Additionally, system and error information is indicated.

► Click .



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Under the live image of the device, you see the following tabs:

- [View options] (→ „6.1 View Options“)
- [Record options] (→ „6.2 Recording“)
- [Service options] (→ „6.3 Service options“)

### 6.1 View Options

► Select options:

Button	Name	Description
	2D view	Shows the device data as a 2D visualisation (→ „6.1.1 2D View“).
	2D3D view	Shows the device data as 2D/3D visualisation (→ „6.1.2 2D3D view“).
	3D view	Shows the device data as a 3D visualisation (→ „6.1.3 3D view“).



The figures in the following chapters are examples. Depending on the objects and the individual settings, the representation may differ significantly.

### 6.1.1 2D View

- ▶ Click **2D** to show the 2D view.
- ▶ Adjust the 2D view.

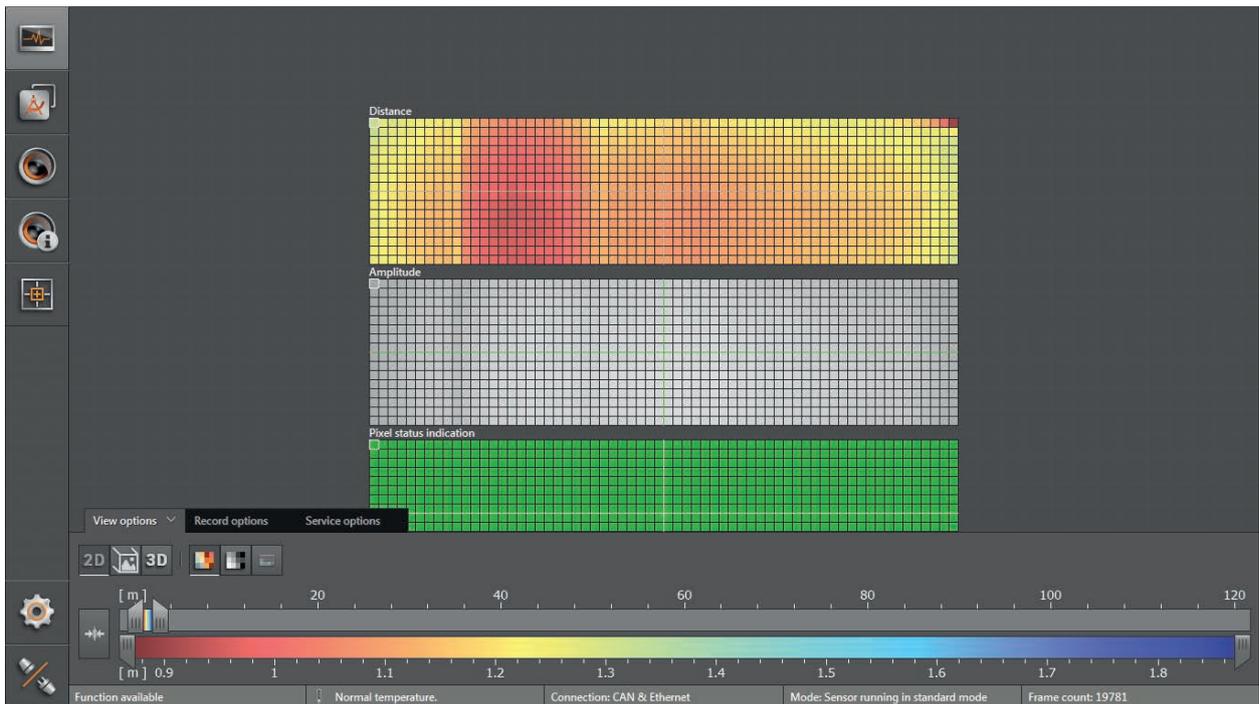
The following settings are available in the tab "View options":

Button	Name	Description
	Distance image	Visualises the pixels in the 2D view in relation to the distance values.
	Amplitude image	Visualises the pixels in the 2D view in relation to the amplitude values in levels of grey (brightness).
<div style="border: 1px solid black; padding: 2px;">                     Logarithmic                 </div> <div style="border: 1px solid black; padding: 2px;">                     Linear                 </div>	Logarithmic	Visualises the amplitude values of the 2D view in logarithmic levels of grey (only available for the amplitude image).
	Linear	Visualises the amplitude values of the 2D view in linear levels of grey (only available for the amplitude image). The "linear" view is particularly helpful when setting up the image.
	Rescaling	Sets the colour range automatically to an adequate area. The settings of the slider bars are dismissed.

 The display settings (e.g. [Logarithmic] or [Linear]) only change the calculation and type of visualisation. The application itself is not affected by it.

### Distance image

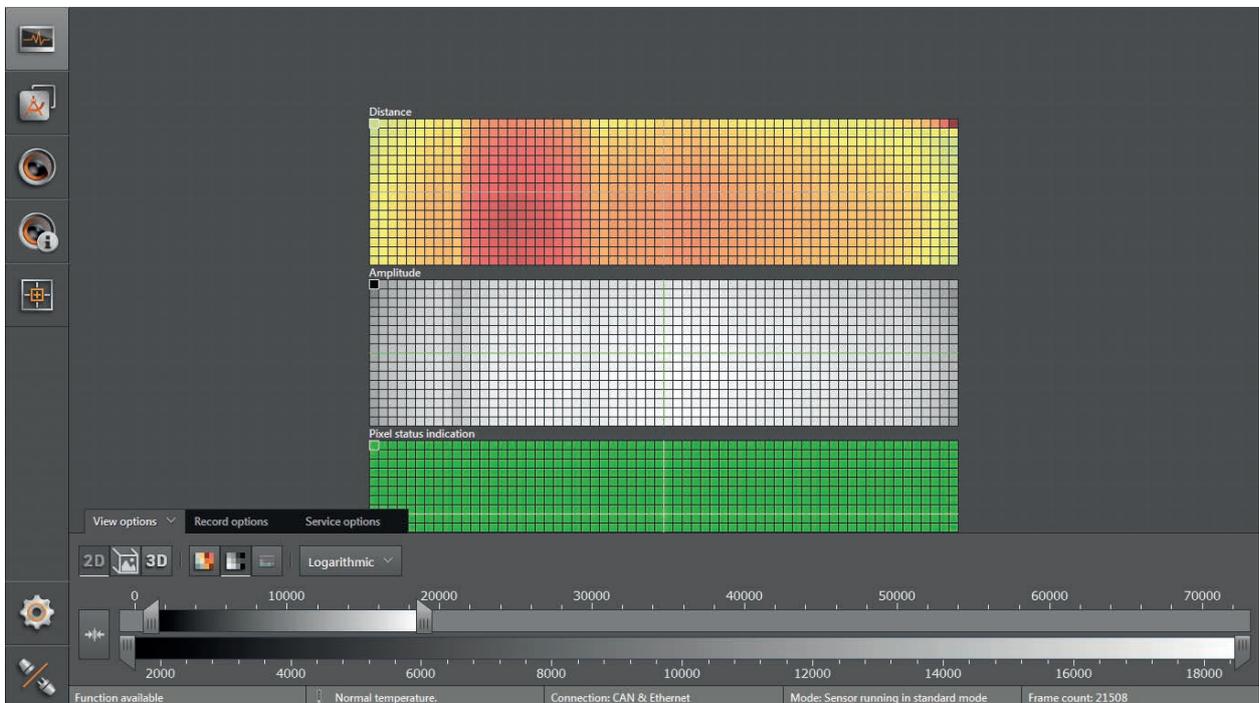
► Click  to display the distance image.



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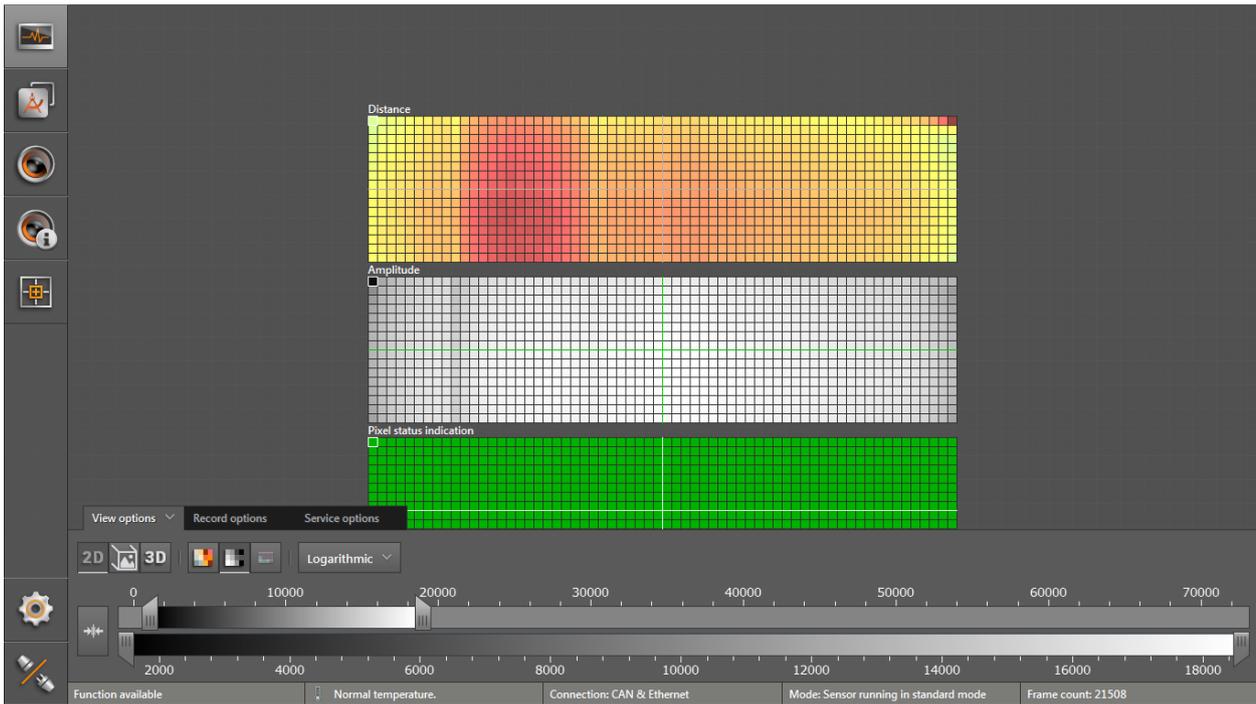
### Amplitude image

► Click  to display the amplitude image.

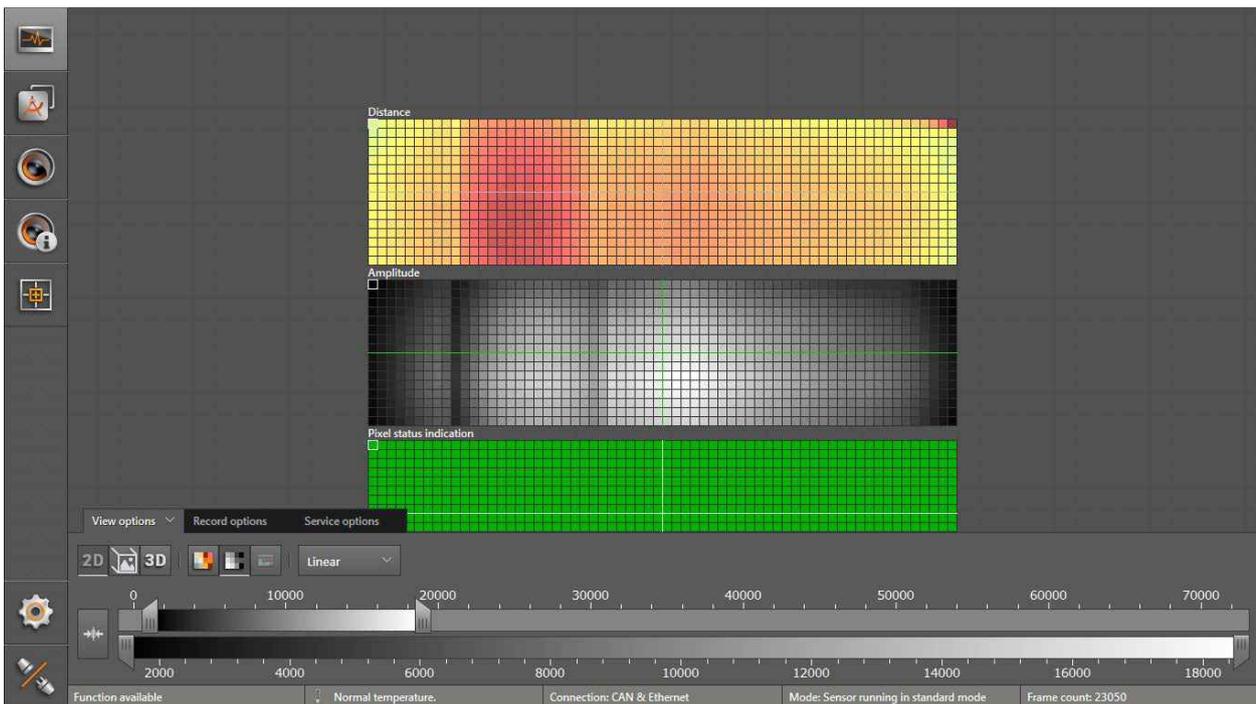


► Select the required view via [Logarithmic] or [Linear].

Logarithmic view:



Linear view:



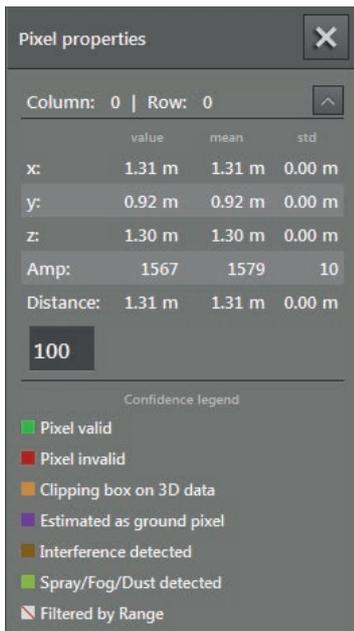
### Pixel properties

Via this function, the following information about the selected pixel can be displayed:

Field	Description
Column   Row	Indicates the number of columns and rows of a pixel
x	x coordinate of the pixel: current measured value and deviation (related to the world coordinate system)
y	y coordinate of the pixel: current measured value and deviation (related to the world coordinate system)
z	z coordinate of the pixel: current measured value and deviation (related to the world coordinate system)
Amplitude	Amplitude of the pixel
Distance	Distance of the pixel to the device
Colour legend	 Valid pixel
	 Invalid pixel (signal too strong or too weak)
	 Spatially filtered 3D data (→ „10.11 Measuring range“)
	 Estimated as ground
	 Pixel detected as disturbed (interference can be produced by neighbouring O3Ms)
	 Spray / fog / dust detected
	 Filtered according to distance (if the pixel is outside the set distance, the ifm Vision Assistant is marked as invalid. )

UK

► Click  to open the "pixel properties" window.



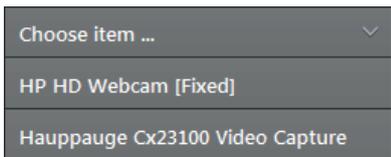
- Click on the pixel in the 2D view.
- > Position, amplitude and distance of the pixel are indicated in metres.
- Click  to open extended information.
- Click  to close extended information.

### 6.1.2 2D3D view

 The 2D3D view is only possible with the O3M2xx devices.

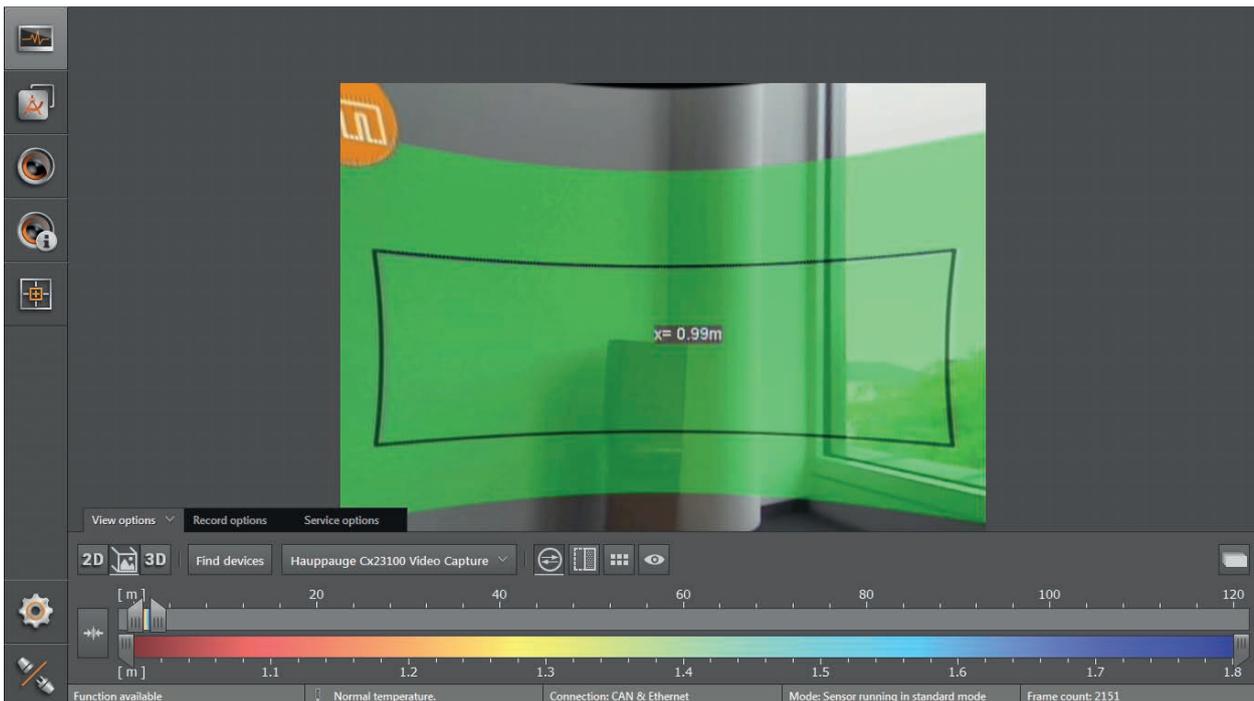
- ▶ Click  to show the 2D3D view.
- ▶ Adjust the 2D3D view.

The following settings are available in the tab "View options":

Button	Name	Description
	Search for video converter	Searches for connected compatible video converters.
	Select video converter	Connects a compatible video converter.
	2D rectification	Eliminates geometric distortions in the image data.
	Spatially filtered 3D data	Shows the spatially filtered 3D data.
	Pixel	Shows the distance values per pixel.
	Visible 3D range	Highlights the visible 3D range.
	2D preview	Shows the 2D data as an overlay within the 2D3D view.

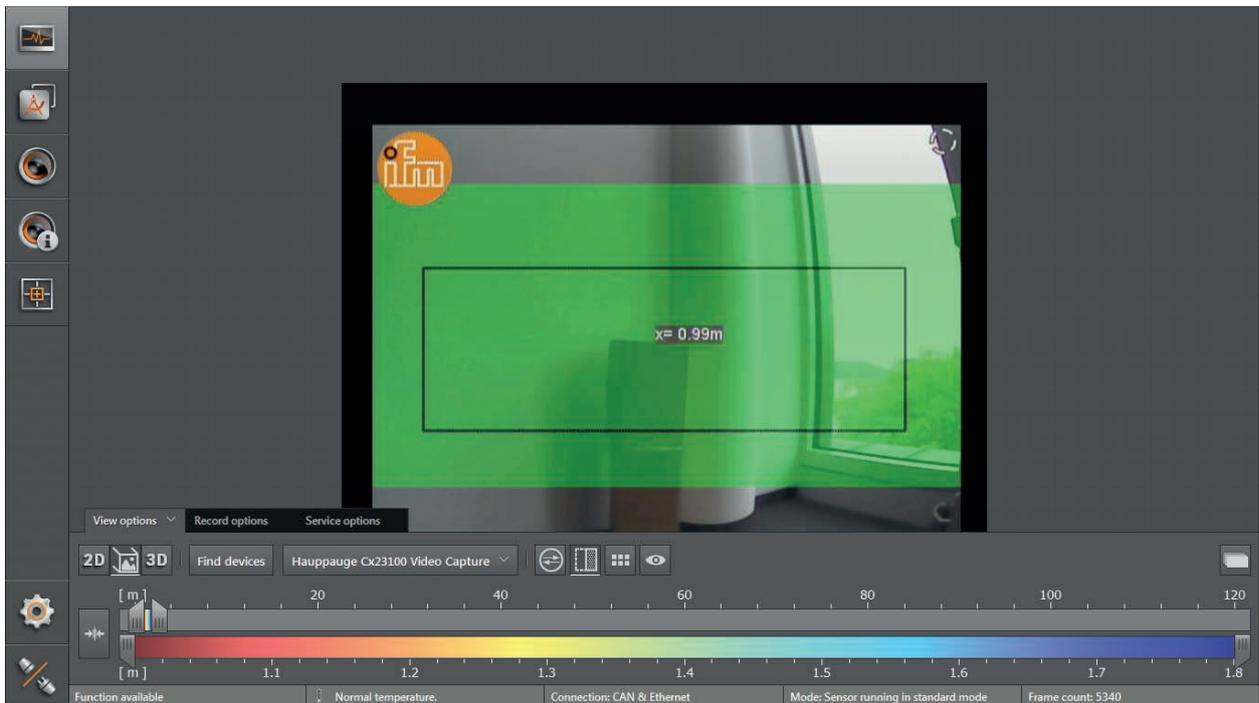
#### 2D rectification

- ▶ Click  to activate the 2D rectification.



### Spatially filtered 3D data

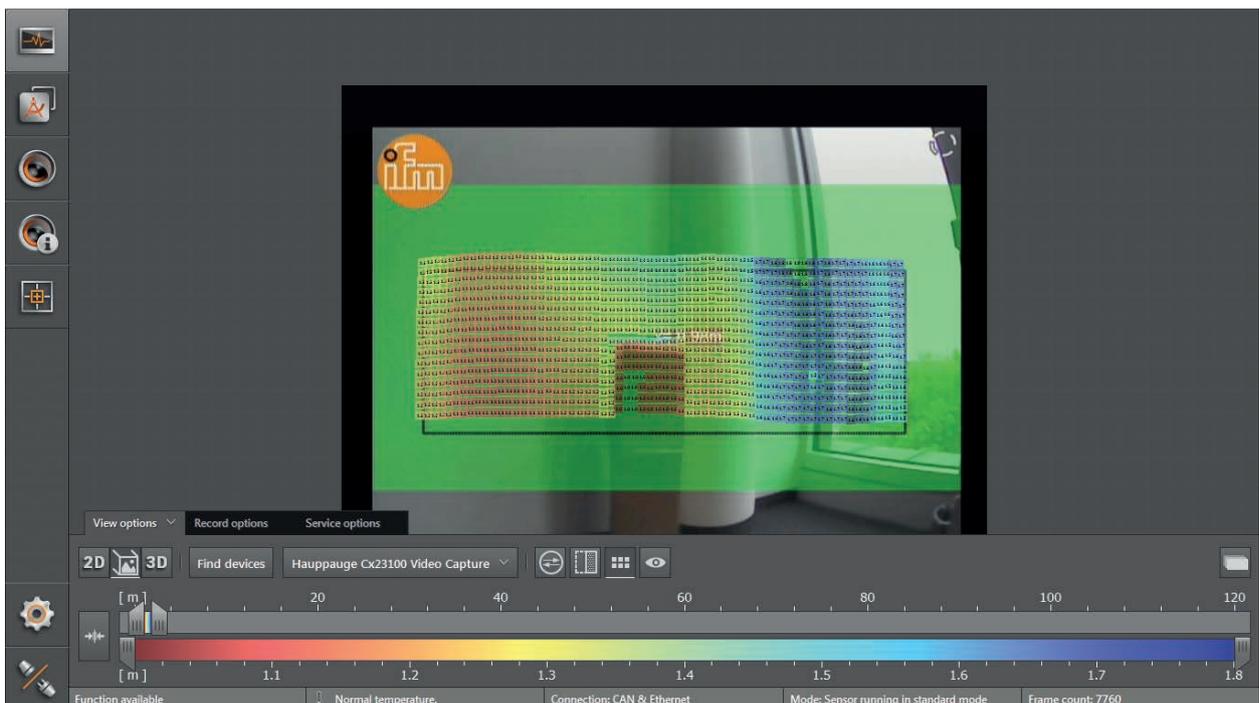
- ▶ Click  to activate the spatially filtered 3D data.
- > Which 3D data is to be spatially filtered can be configured in chap. „10.11 Measuring range“.



UK

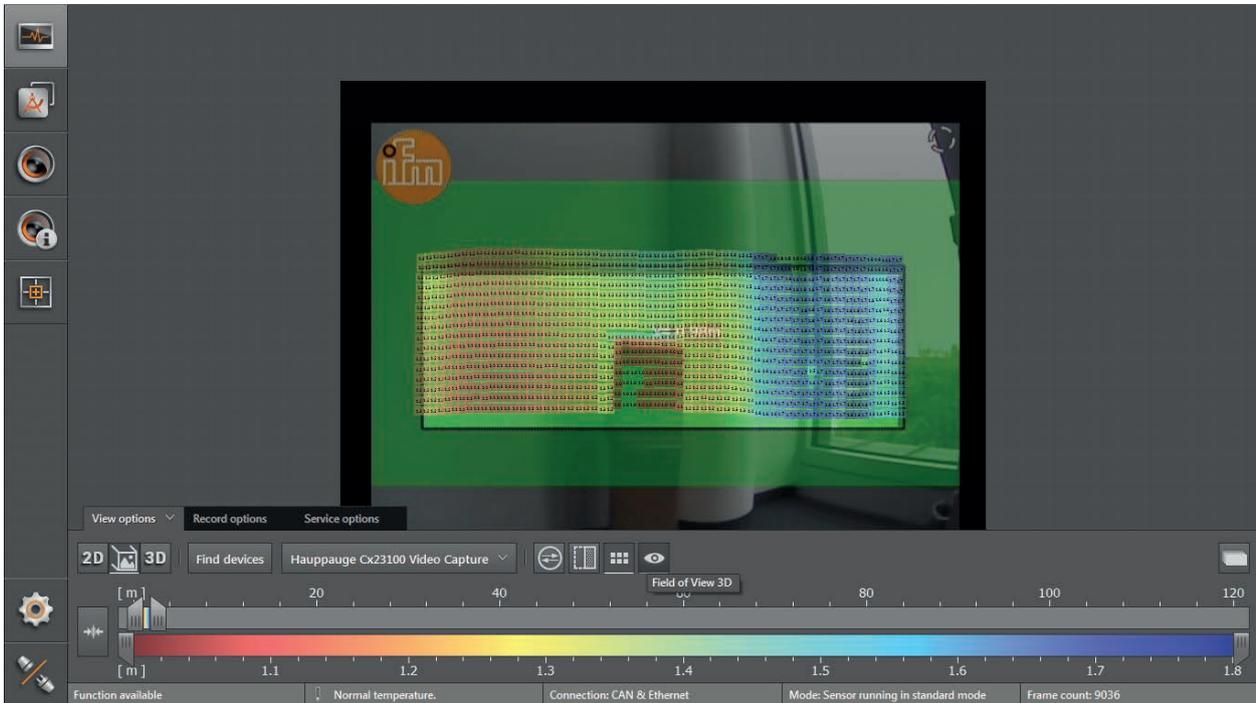
### Pixel

- ▶ Click  to display the distance values per pixel.
- > Each pixel contains the distance as a numeric value. The colour shade depends on the measured distance of the pixel and the setting of the colour scale (→ „6.1.4 Slider bar“).



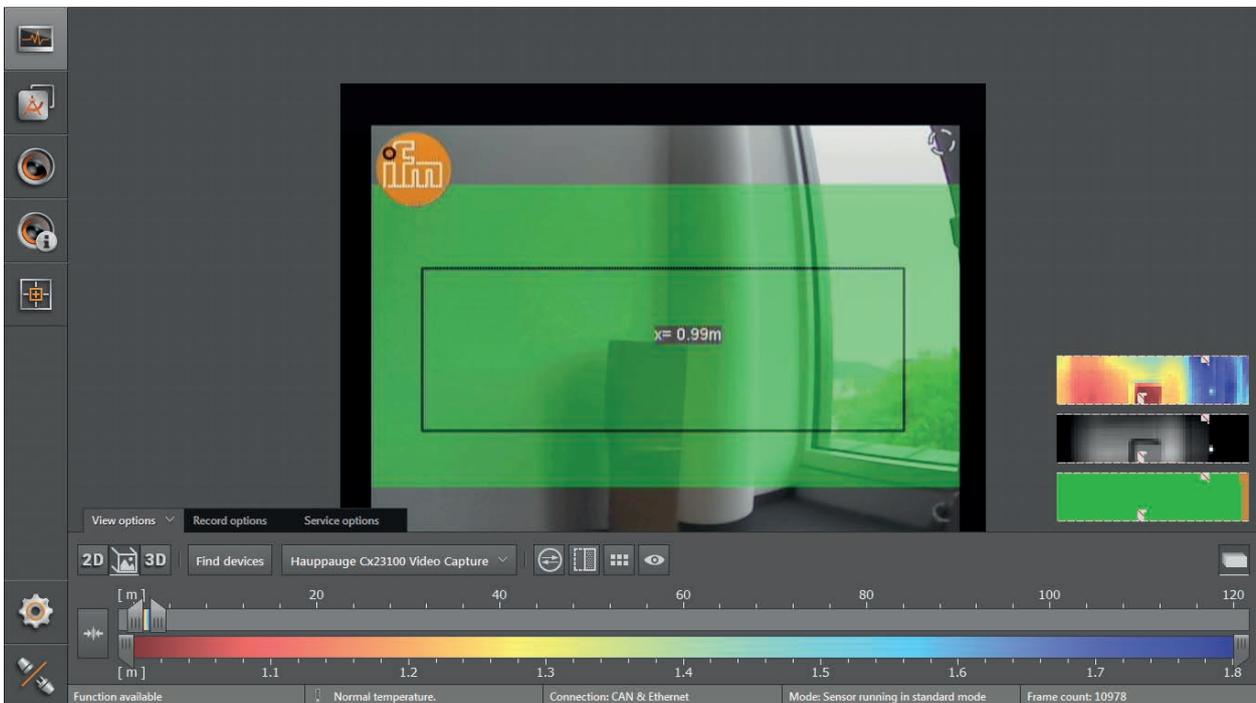
### Visible 3D range

- ▶ Click  to activate the visible 3D range.
- > The area outside the visible 3D range is visualised in a darker shade.



### 2D preview

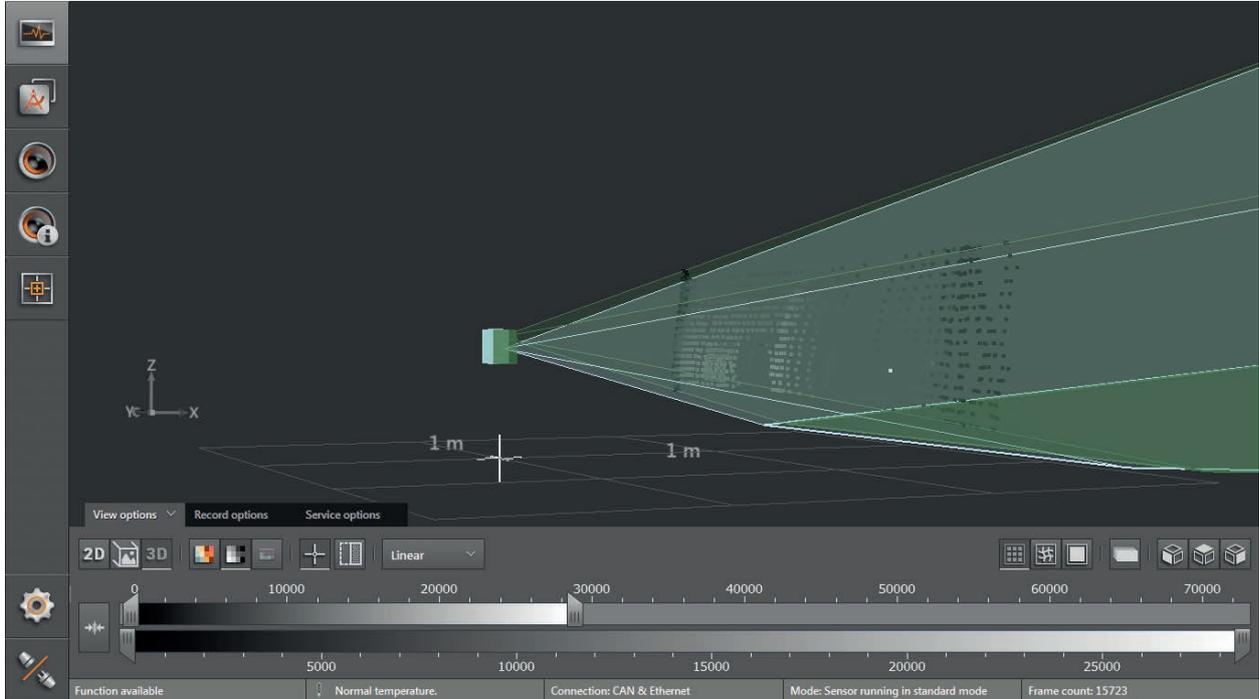
- ▶ Click  to show the 2D data as an overlay within the 2D3D view.



### 6.1.3 3D view

The 3D view is a visualisation of the 3D views of the device and the illumination unit. The individual vision cones of the 3D views have different colours:

- Device: green
- Illumination unit: light green



- ▶ Click **3D** to show the 3D view.
- ▶ Adjust the 3D view.

The following settings are available in the tab "View options":

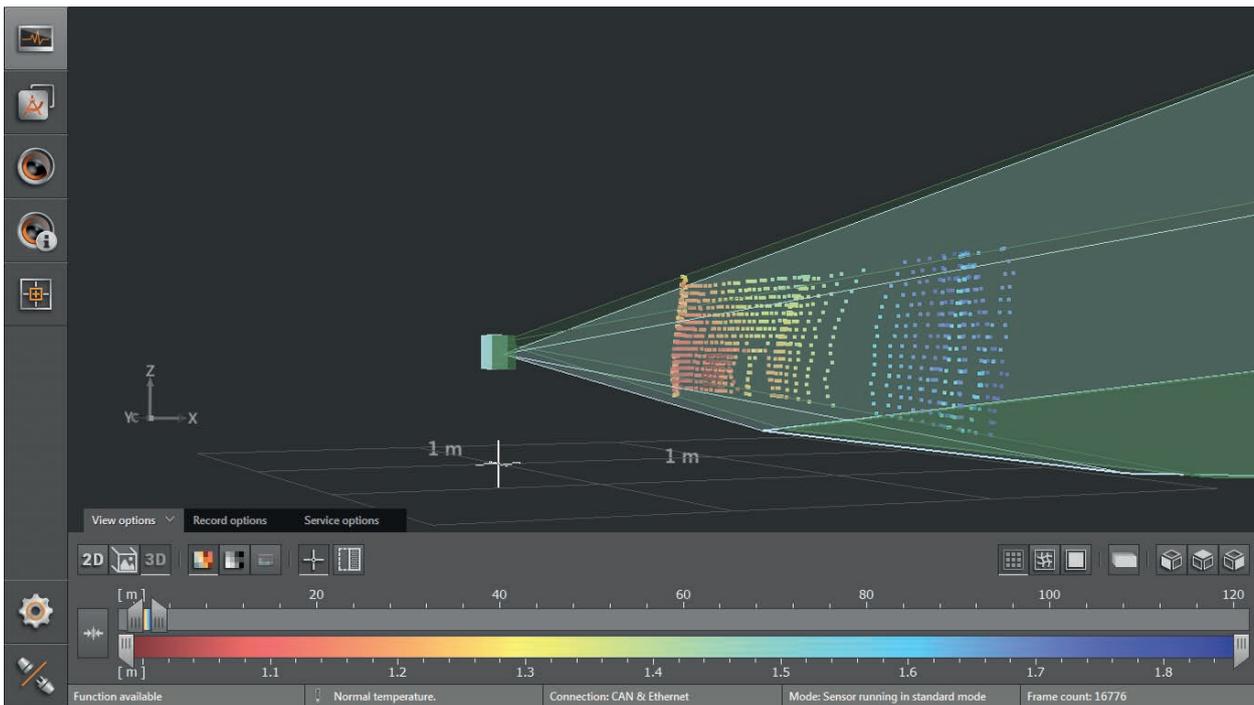
Button	Name	Description
	Distance image	Visualises the pixels in the 3D view in relation to the distance values.
	Amplitude image	Visualises the pixels in the 3D view in relation to the amplitude values in levels of grey (brightness).
	Confidence	Shows the pixels of the 3D view with the corresponding status from the colour legend (→ Pixel properties, previous page).
	Logarithmic	Visualises the amplitude values of the 3D view in logarithmic levels of grey (only available for the amplitude image).
	Linear	Visualises the amplitude values of the 3D view in linear levels of grey (only available for the amplitude image).
	Origin	Shows and hides the origin of the coordinate system in the 3D view.
	Spatially filtered 3D data	Shows the spatially filtered 3D data.
	Dots	Shows the data as a pixel cloud.
	Grid	Shows the data as a grid.

Button	Name	Description
	Surface model	Shows the ascending slopes as colour gradients.
	2D preview	Shows the 2D data as an overlay within the 3D view.
	Default view 1	Turns the 3D view to the xy level.
	Default view 2	Turns the 3D view to the xz level.
	Default view 3	Turns the 3D level to the yz level.

 The settings of the view (e.g. [Logarithmic] or [Linear]) only change the calculation and type of visualisation. The application itself is not affected by it.

### Distance image

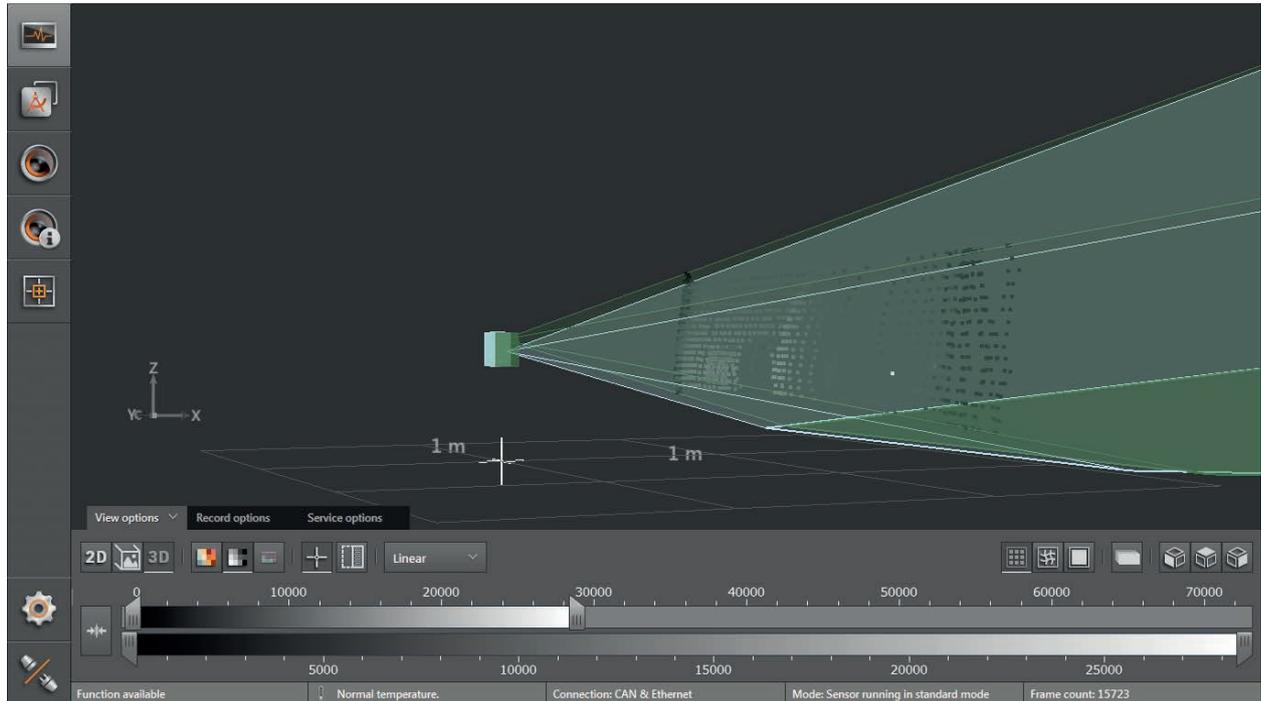
► Click  to display the distance image.



Visualisation in the 3D image	Description
Pixel position	Space coordinate of the point (x, y, z coordinates).
Pixel colour	Distance (x-coordinate). The colour shade depends on the measured distance of the point and the setting of the colour scale (→ „6.1.4 Slider bar“).

### Amplitude image

► Click  to display the amplitude image.



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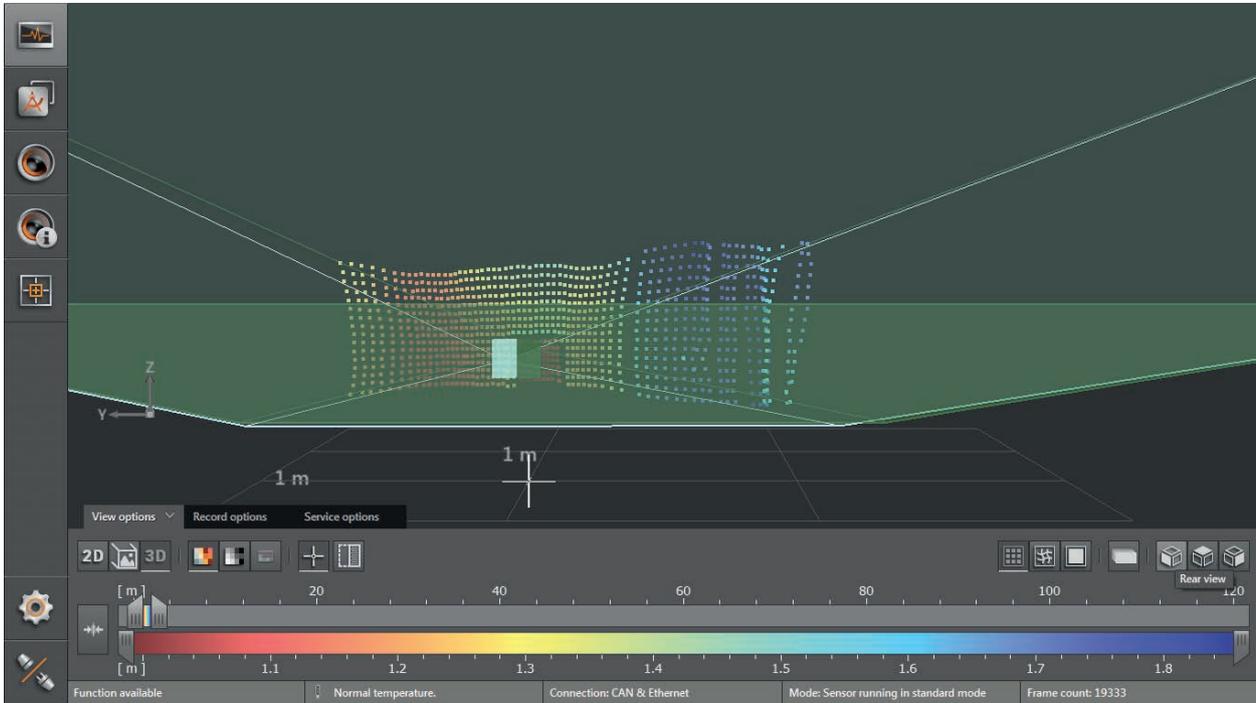
► Select the required view via [Logarithmic] or [Linear].

Visualisation in the 3D image	Description
Pixel position	Space coordinate of the point (x, y, z coordinates).
Pixel colour (grey-scale)	Amplitude value. The brightness follows the measured amplitude and the setting of the grey scale (→ „6.1.4 Slider bar“).
Black	Amplitude value $\leq$ minimum of the set scale.
White	Amplitude value $\geq$ maximum of the set scale.

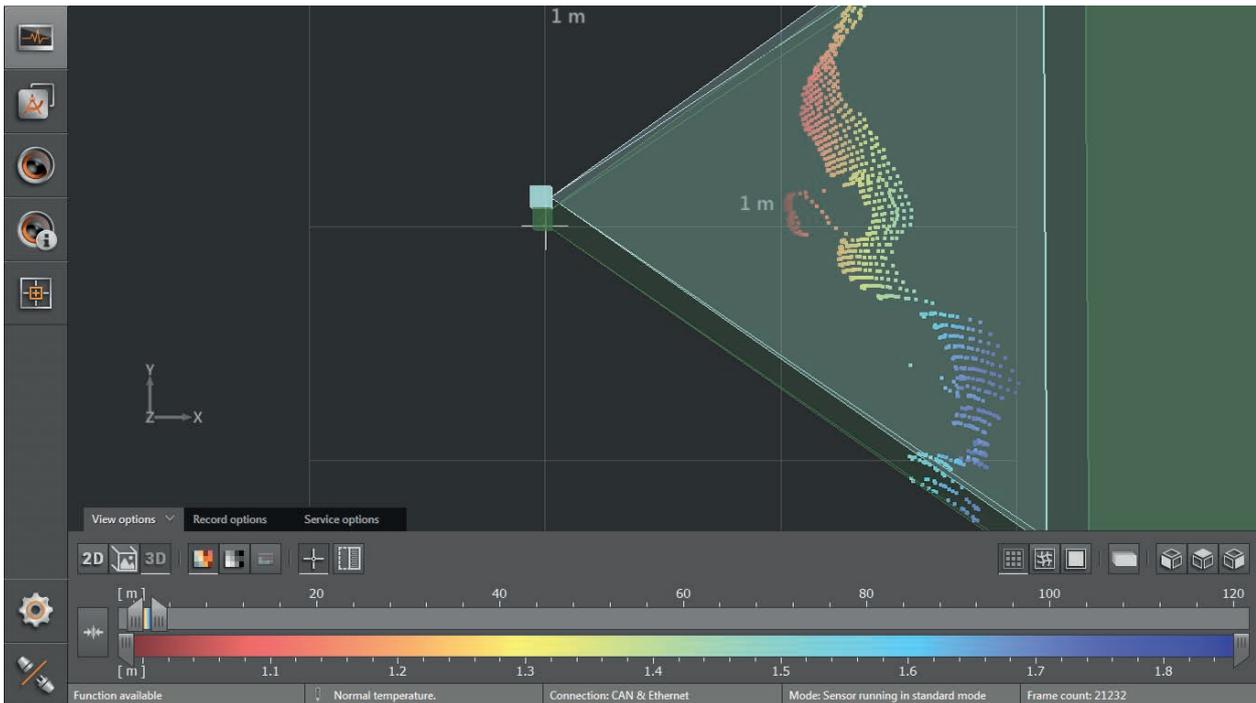
### Views in the coordinate system

The 3D view can be turned into a preset view in the coordinate system.

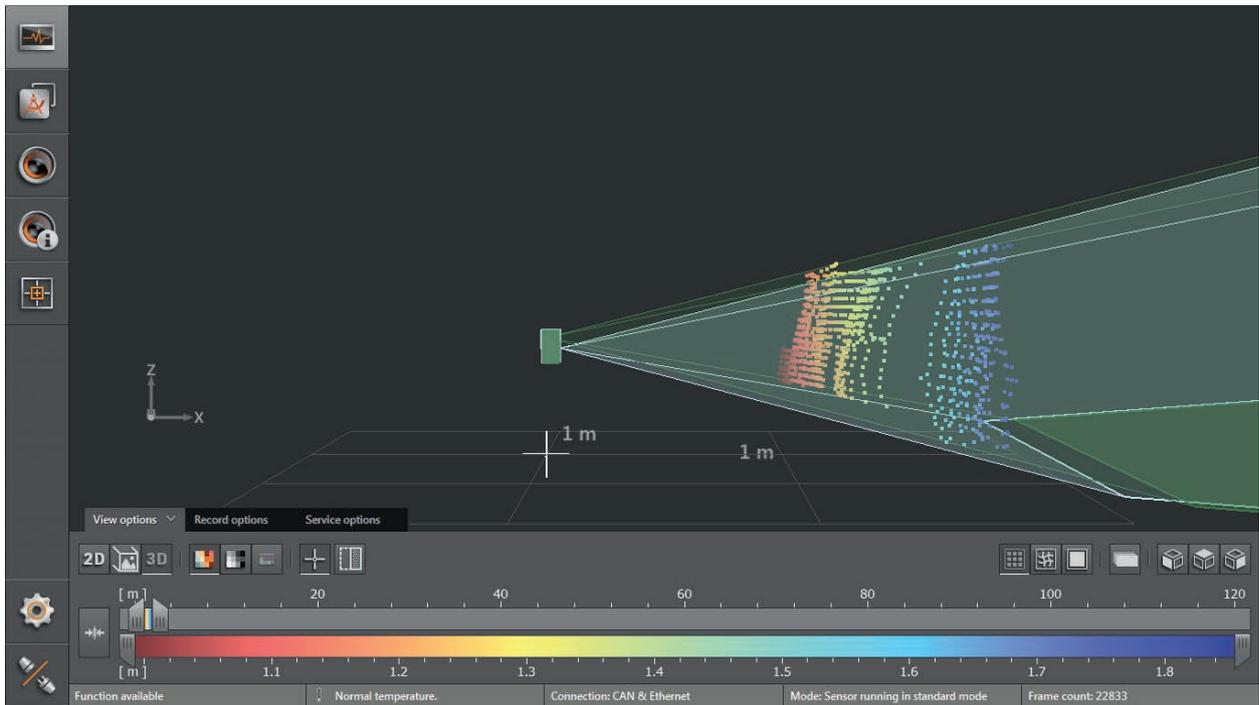
- ▶ Click  to show the rear view.
- > The object is shown on the yz level.



- ▶ Click  to show the top view.
- > The object is shown on the xy level.



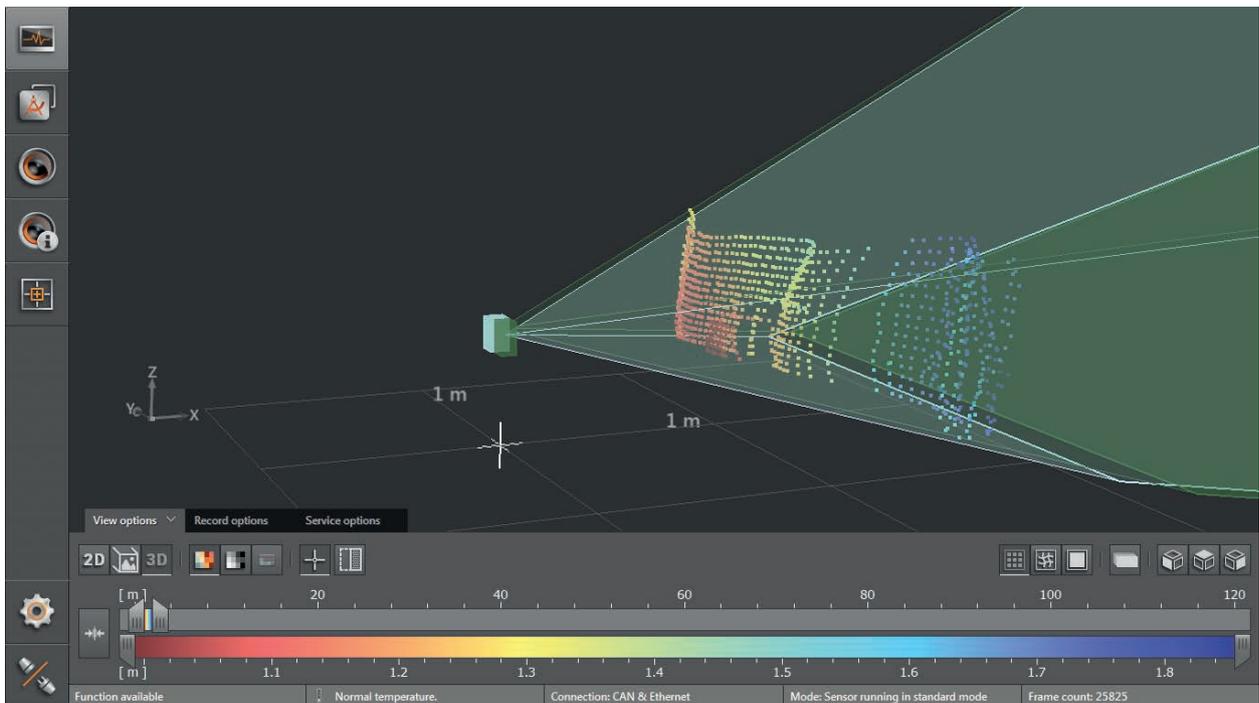
- ▶ Click  to show the side view.
- > The object is shown on the xz level.



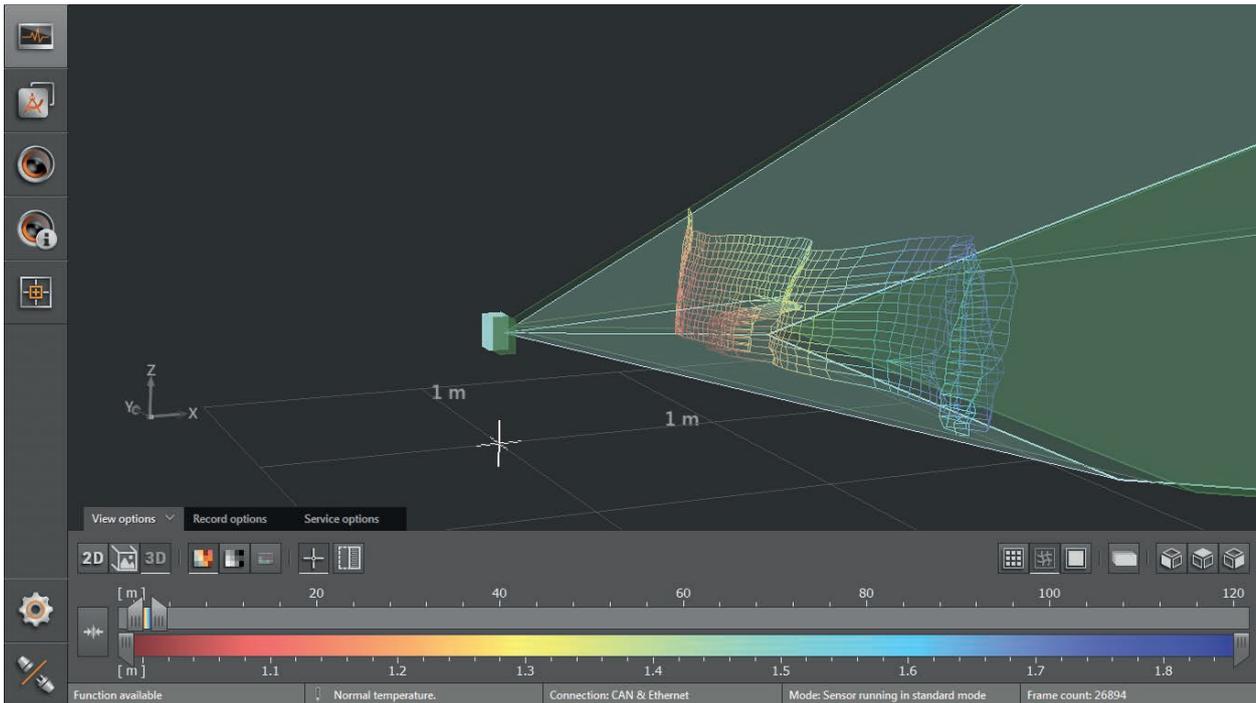
UK

### Visualisation pattern

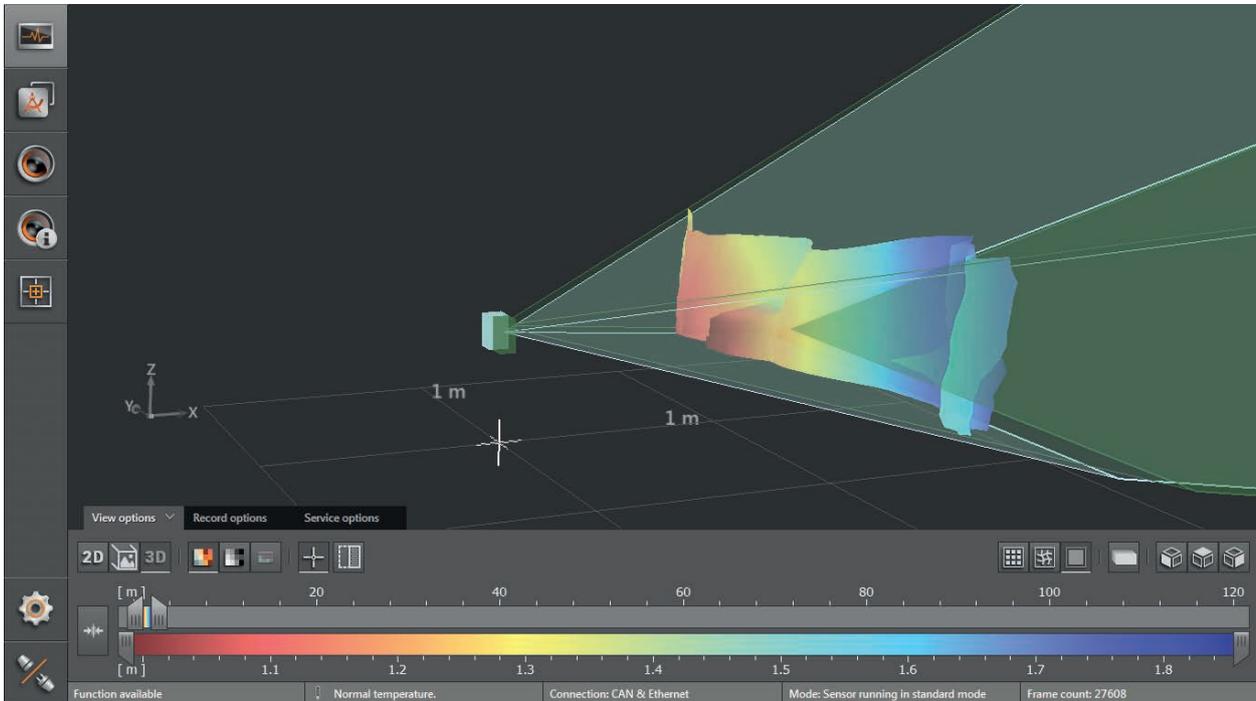
- ▶ Click  to show the 3D view as a pixel cloud.



► Click  to show the 3D view as a grid.



► Click  to show the ascending slopes in the 3D view as a surface model.

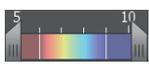


### 6.1.4 Slider bar

With the slider bar, the colour range of the display can be set manually. The results of the application are not changed by it.

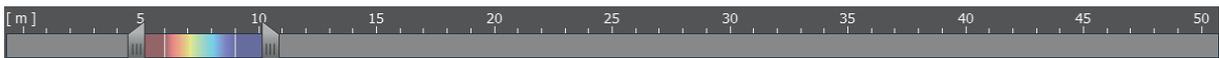
- Distance image: Measuring range in metres (from-to)
- Amplitude image: Measuring range in amplitudes (from-to)

#### Setting the colour range

Operating element		Description
Automatic range selection		The button sets the colour range automatically to an appropriate area. The settings of the slider bars are dismissed.
Upper slider bar		With the upper slider bar, the colour range for the distance or amplitude image can be roughly set.
Lower slider bar		With the lower slider bar, the set colour range can be fine-adjusted.
Colour range		The set colour range can be shifted using the left mouse button without changing the size of the range. The vertical white lines within the colour range indicate the colour range that is fine-adjusted with the lower slider bars.

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- ▶ The upper slider bar can be set to the required colour range.



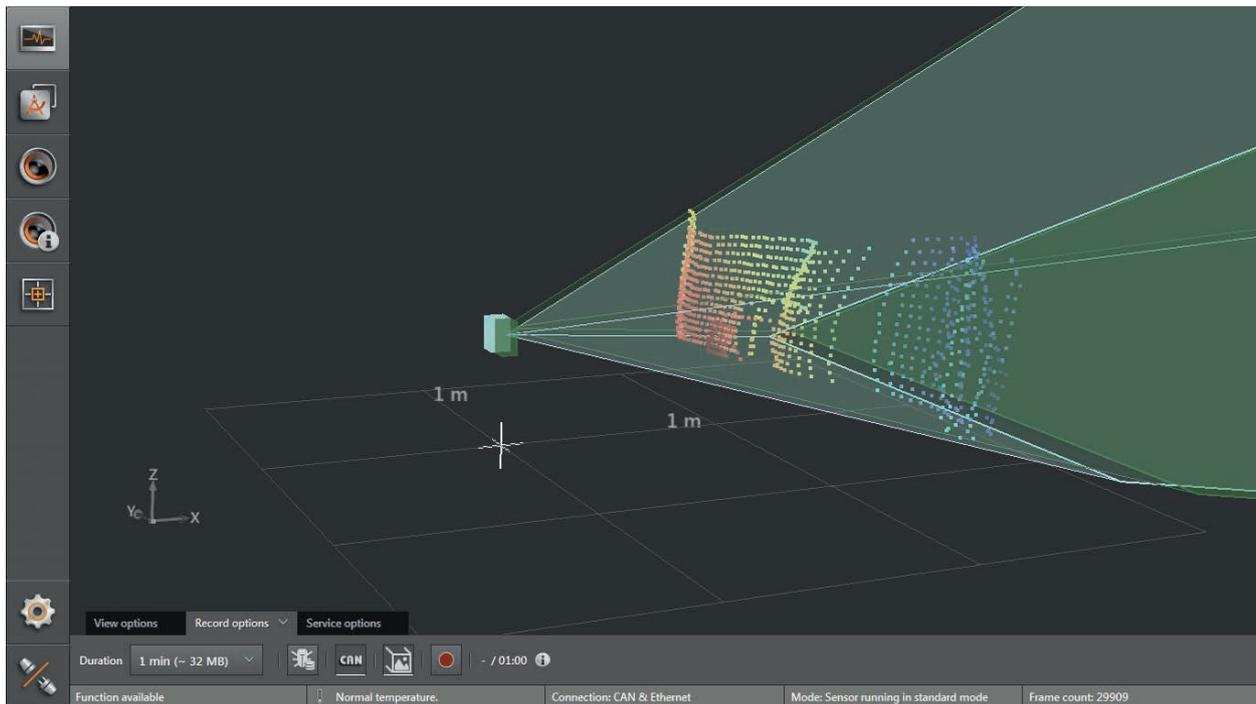
- ▶ Set the lower slider bar to fine-adjust the colour range.



- > The scale of the lower slider bar corresponds with the colour range that is set above.

## 6.2 Recording

This function is used to make recordings of any length of Ethernet and CAN data.



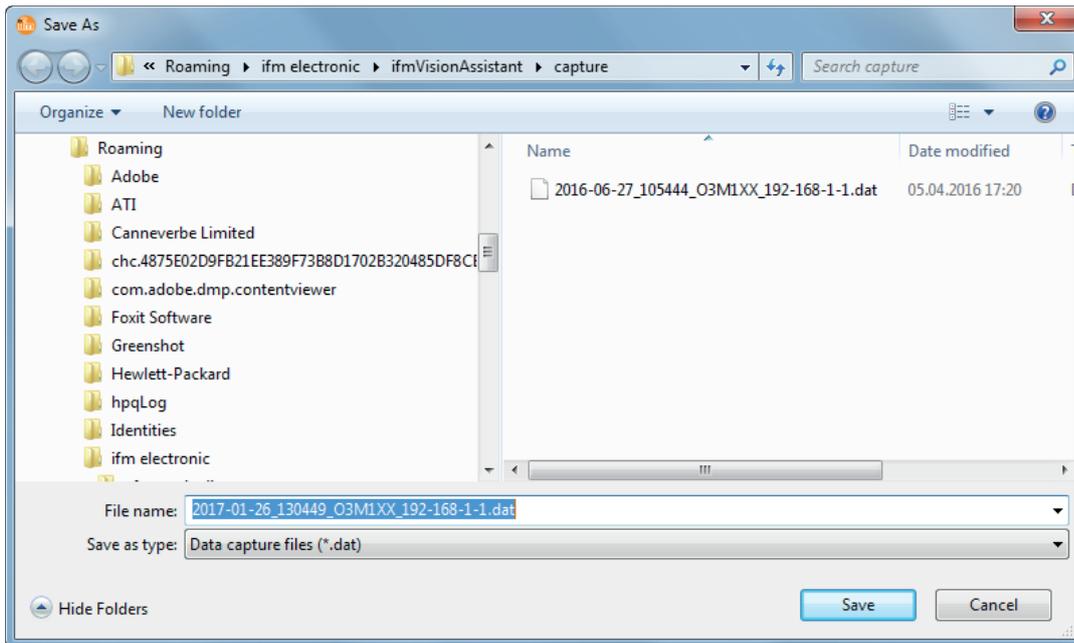
- ▶ Select the duration of the recording in the "Record options" tab (1, 2, 4, 8 minutes or infinite duration). The space required is about 56 MB/minute (with debug data approx. 160 MB/minute).
- ▶ Click  to start a recording.
- ▶ Click  to additionally record debug data.
- > The debug data is necessary to analyse service requests.
- ▶ Click  to additionally record the CAN data.
- > The "Save As" window opens with a standard storage location and standard file name:
  - Standard storage location: "...ifm electronic\ifmVisionAssistant\capture" (the exact and complete storage location depends on the Windows version and settings)
  - Standard file name: "yyyy-mm-dd\_hhmmss\_O3M1XX\_192-168-1-1.dat"



The file name consists of year, month, day and the IP address of the device.

Example: The file "2016-06-27\_154754\_O3M1XX\_192-168-1-1.dat" was recorded on 27 June 2016 at 15:47:54 on the device with IP address 192.168.1.1.

- > All measurement and process data is recorded (e.g. recognised objects and results of the applications).

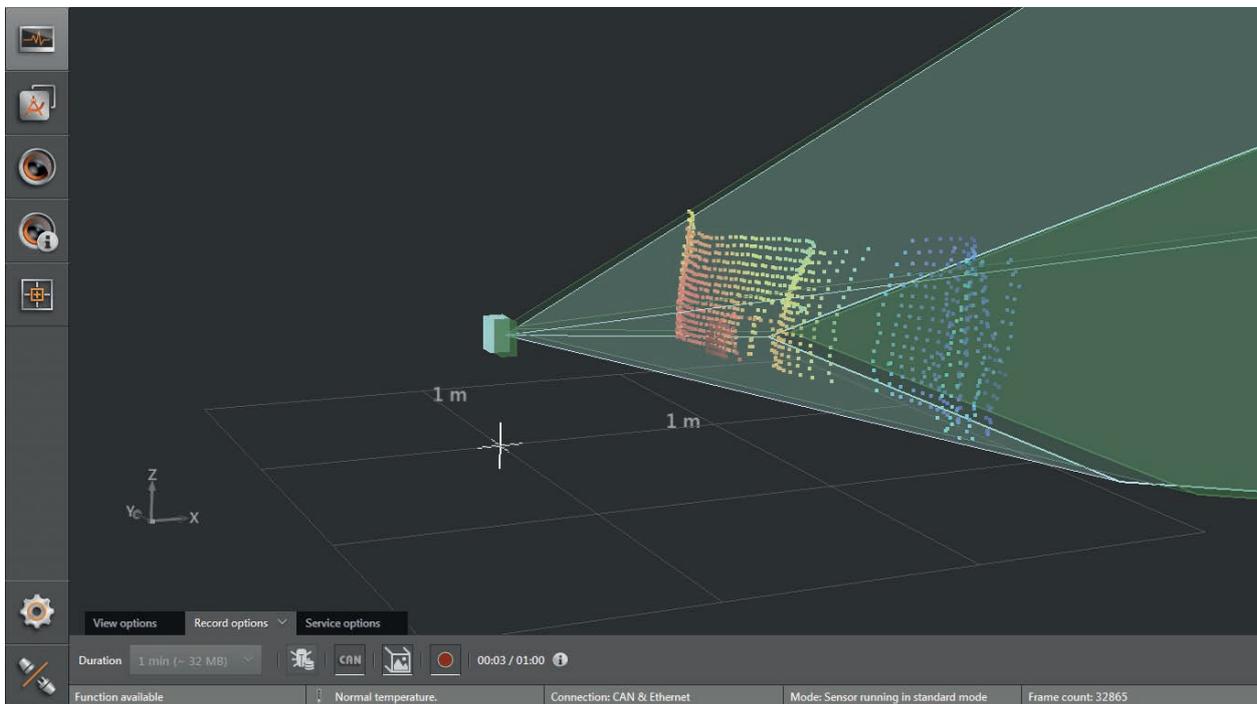


► Click [Save].

> The recording starts and the recorded time is displayed next to the  button.

Example: 1 minute and 5 seconds of the set 2 minutes are displayed as 01:05/02:00.

> The recording ends automatically as soon as the set recording time is reached. In case the duration is set to "infinite", the recording is limited by the free memory capacity of the data carrier.



► Click  again to manually stop the recording before the set recording duration is reached.

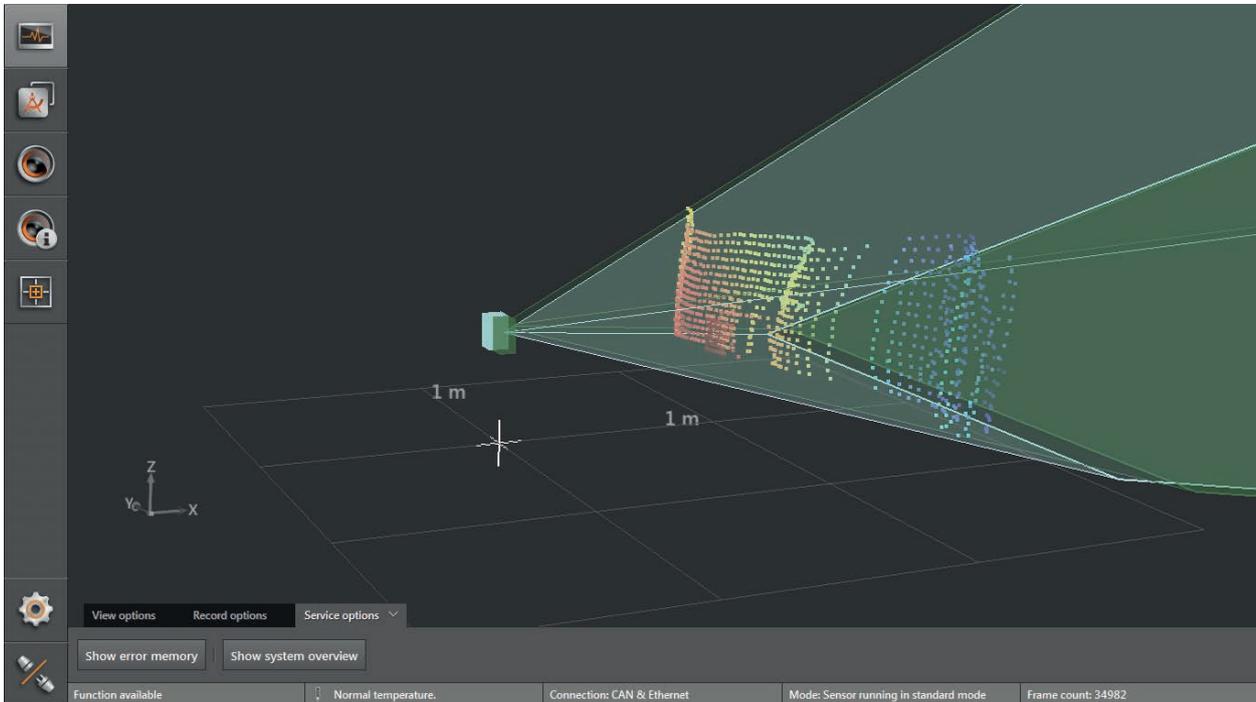
> The sequence is stored and can be played back using the [Replay] option on the start screen.

### 6.3 Service options

Via the service options function, the error memory and the system overview can be displayed. The service options contain software and hardware information that can be displayed and stored.

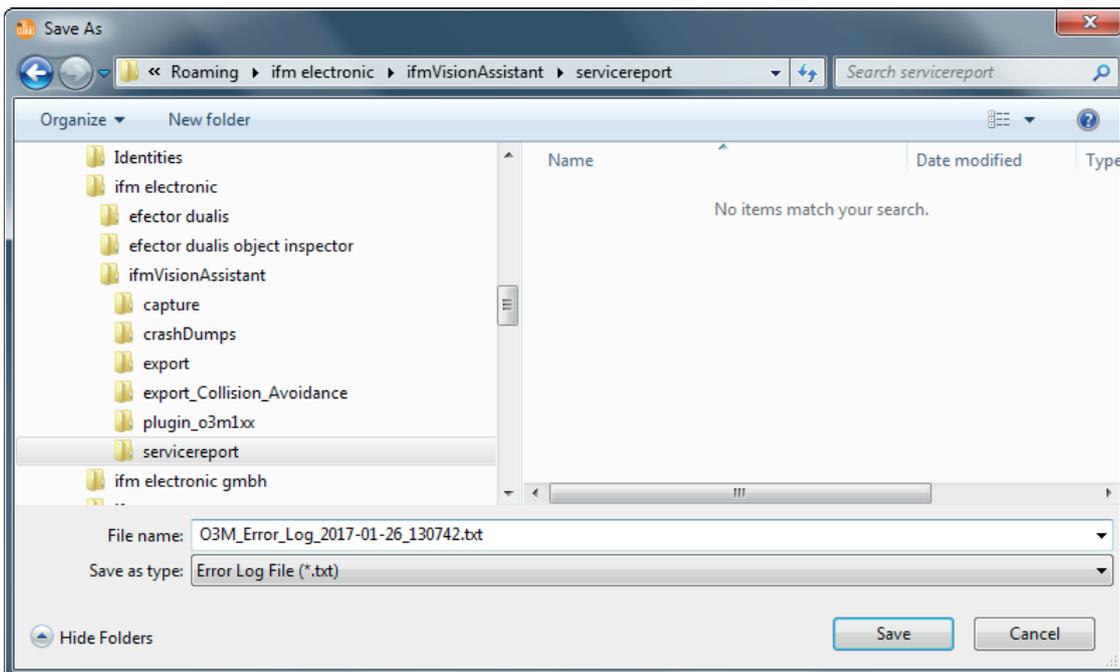


The error memory and the system overview are used to analyse service requests.



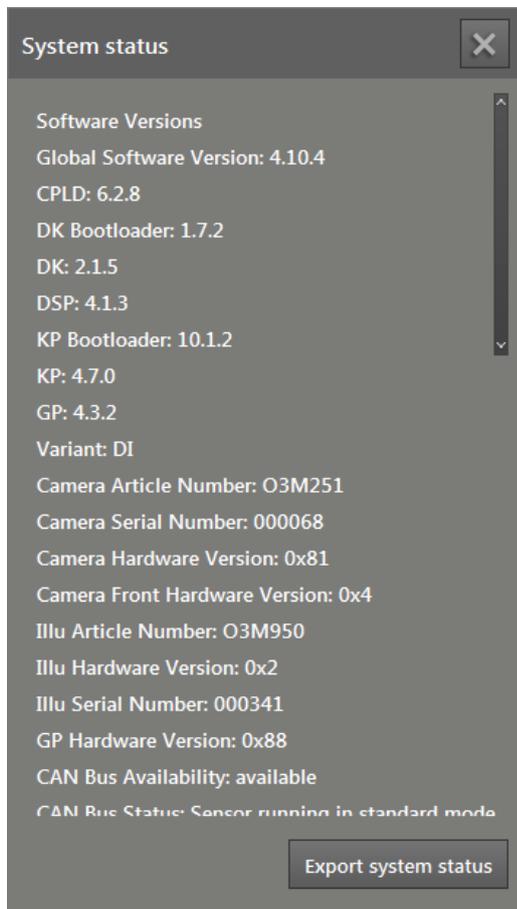
#### Error memory export

- ▶ Click on [Show error memory].
- ▶ Click on [Export error memory].
- > The error memory is stored as text format (\*.txt).



### Show system overview

- ▶ Click on [Show system overview].
- > The "System status" window appears.



- ▶ Click on [Export system status] to save the system overview.
- ▶ Click on [X] to close the system overview.

## 7 Device setup

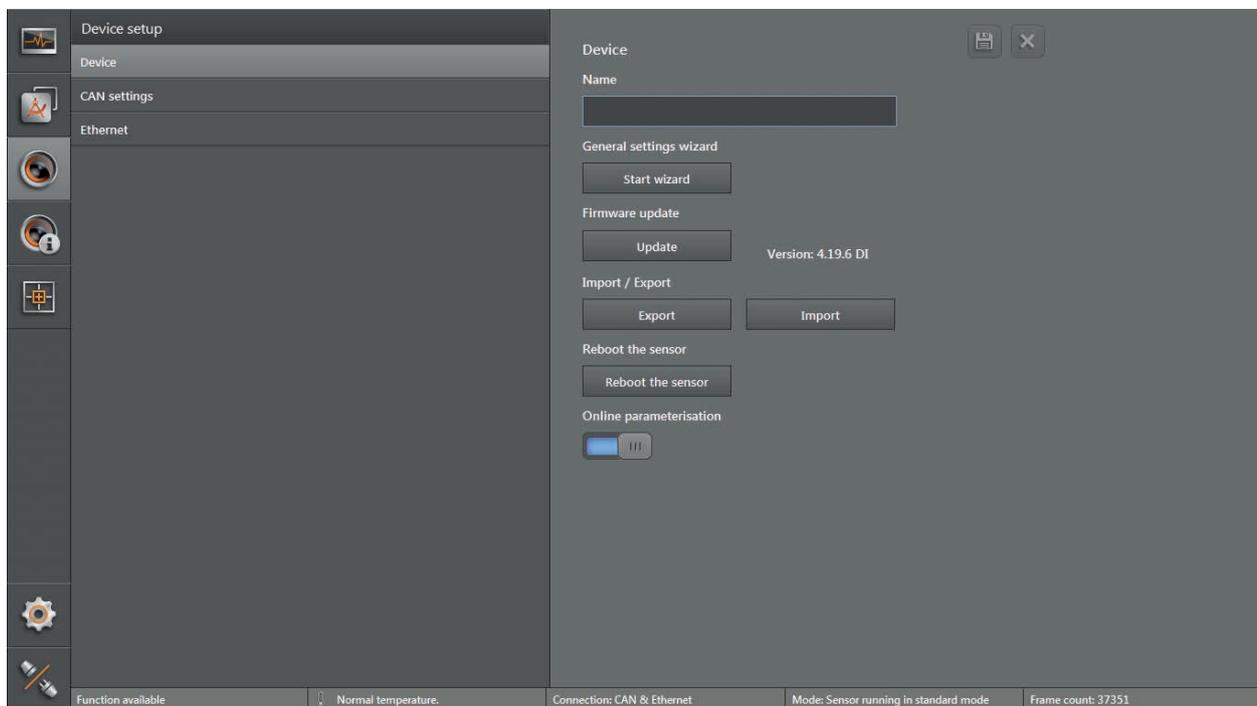
In the device setup, the basic settings of the device and the applied networks is set.



> The "Device setup" screen appears.

Configurations in the device setup:

- Device (→ „7.1 Device“)
  - Set the name of the device
  - Execute the assistant for general sensor settings
  - Execute firmware update
  - Import and export settings
  - Reboot the sensor
  - Activate online parameter setting
- CAN settings (→ „7.2 CAN settings“)
  - Set the network protocol and the network address of the CAN bus
- Ethernet (→ „7.3 Ethernet“)
  - Set the process interface



## 7.1 Device

In the "Device" window, basic settings of the device can be made.

- ▶ Click on [Device].
- > The "Device" window appears.

### Functions

Field	Button	Description
Name	–	Editable field to set the device name
General settings wizard	[Start]	Starts the assistant for general sensor settings
firmware update	[Update]	Installs a firmware update. The current version of the firmware is shown next to the button.
Import / Export	[Export]	Creates a copy of the settings and applications on the PC.
	[Import]	Saves a copy of the settings and applications that are on the PC to the device.
Reboot the sensor	[Reboot sensor]	Reboots the device.

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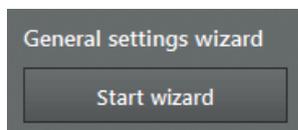
### 7.1.1 Name

The name of the device can be edited at will.

- ▶ Click on the input box.
- ▶ Enter name.
- ▶ Click  to save the changes.

### 7.1.2 General settings wizard

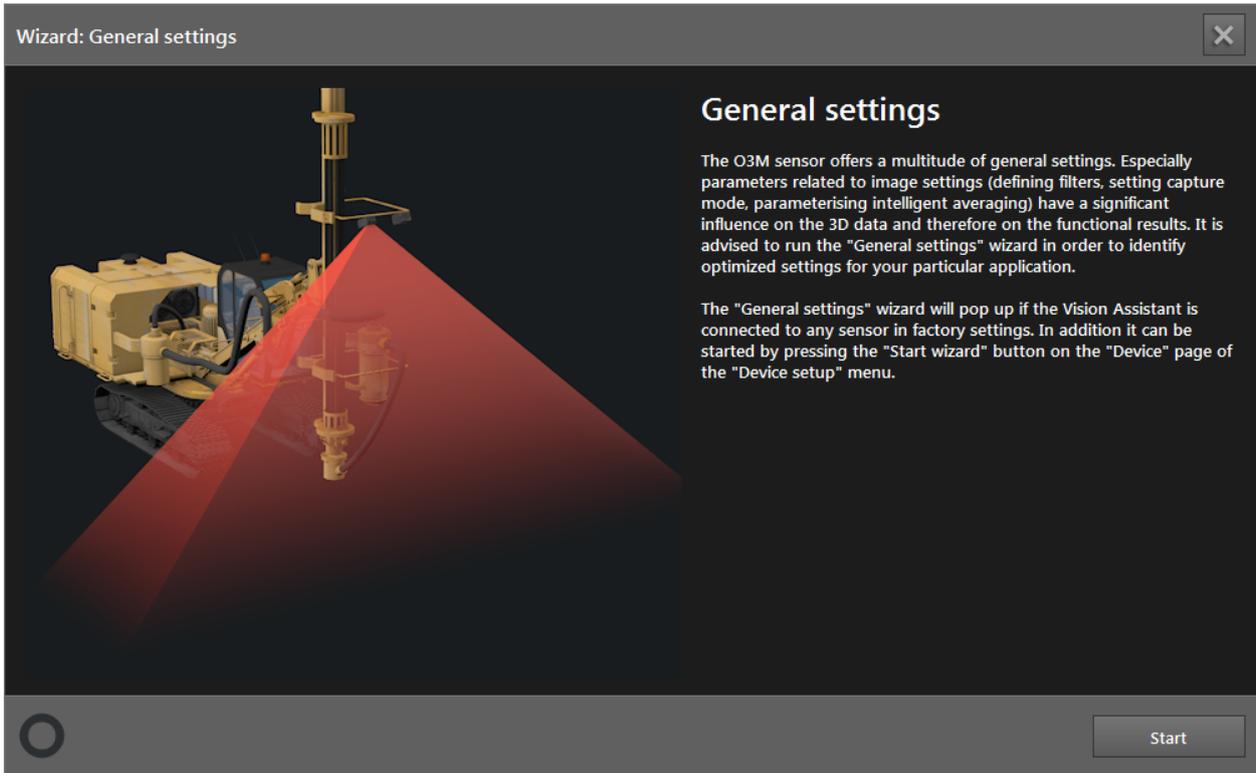
The "General settings wizard" adjusts the device to the corresponding application. At the beginning, the assistant retrieves basic settings about the application of the device. At the end, the device is set by the assistant.



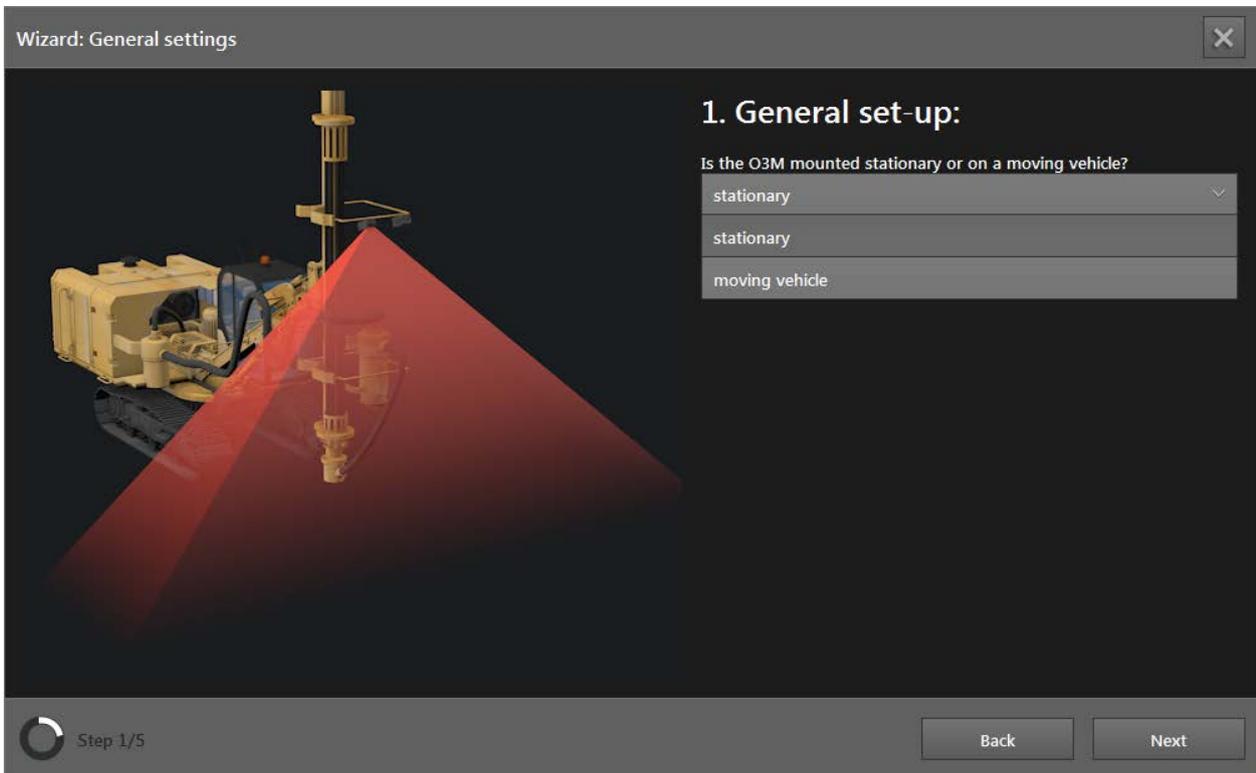
- ▶ Click on [Start].
- > The general settings wizard appears.



The general settings wizard starts automatically after flashing a firmware (→ „7.1.3 Firmware update“).



► Click on [Start].



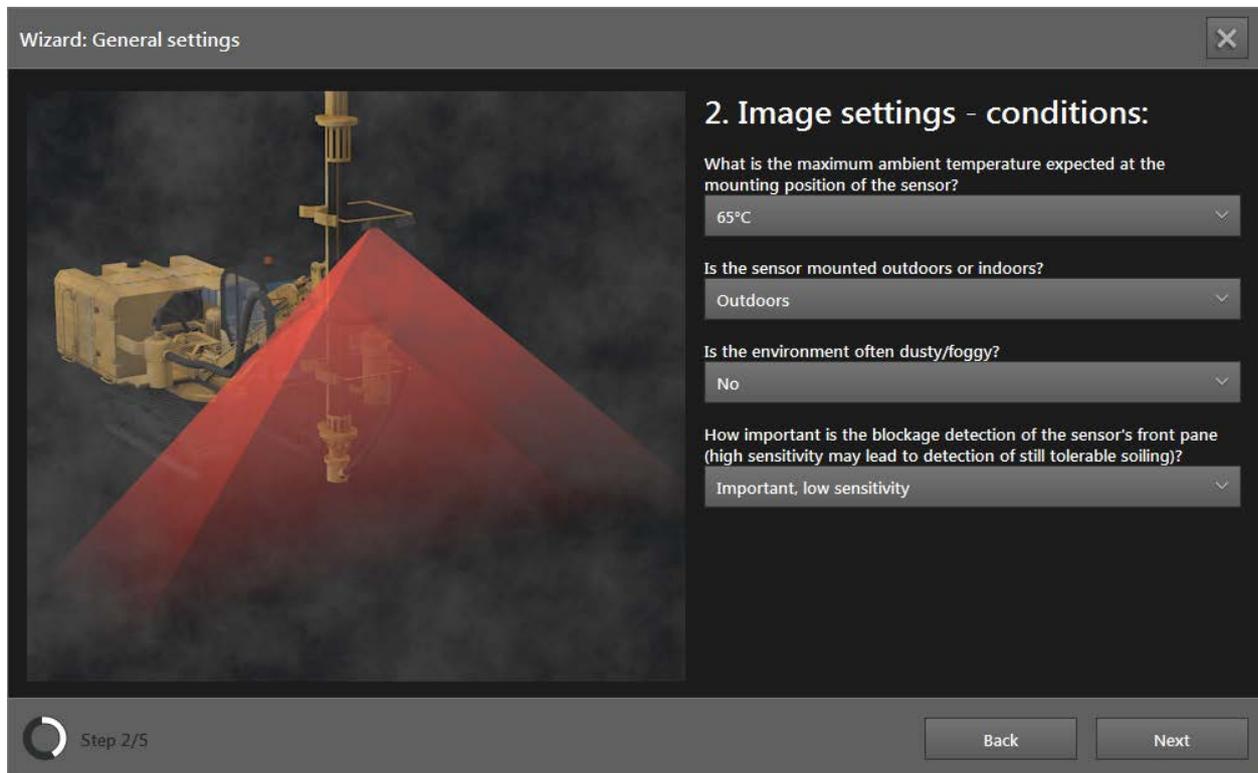
Button	Name	Description
stationary moving vehicle	Stationary	Use the setting "stationary" for the installation on: <ul style="list-style-type: none"> <li>stationary vehicles</li> <li>objects</li> <li>moving vehicles that are stationary during device operations</li> </ul>  With the setting "stationary", higher averaging settings can be used (→ „10.9 Intelligent data averaging“).
	Moving vehicle	Use the "vehicle" setting for installation on moving vehicles (→ „The "moving vehicle" setting“).



- ▶ Click on [stationary] or [moving vehicle].
- > The [moving vehicle] setting requires additional settings.
- ▶ Click on [Next].

### "Stationary" setting

In the following, the general setting "stationary" is described.

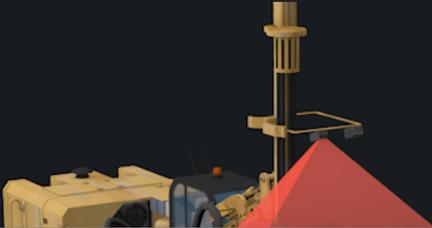


Button	Name	Description
65°C 75°C 85°C	Ambient temperature	Set the frame rate of the device according to the ambient temperature: <ul style="list-style-type: none"> <li>85°C: Frame rate of 25 Hz</li> <li>75°C: Frame rate of 33 Hz</li> <li>65°C: Frame rate of 50 Hz</li> </ul>  Always use the highest possible frame rate.

Button	Name	Description
<p>Outdoors</p> <p>Indoors</p>	Application	<p>Use the "Outdoors" setting if strong environmental influences are to be expected in the application. The setting affects the:</p> <ul style="list-style-type: none"> <li>• Filter signal quality (→ „10.3 Signal quality filter“)</li> <li>• Noise reduction filter (→ „10.4 Noise reduction filter“)</li> </ul> <p>Use the "Indoors" setting if insignificant environmental influences are to be expected in the application. The setting affects the:</p> <ul style="list-style-type: none"> <li>• Filter signal quality (→ „10.3 Signal quality filter“)</li> <li>• Noise reduction filter (→ „10.4 Noise reduction filter“)</li> </ul>
<p>Yes</p> <p>No</p>	Visibility conditions	<p>Activate the "Visibility conditions" setting if the visibility conditions are often bad. The setting affects the:</p> <ul style="list-style-type: none"> <li>• Filter signal quality (→ „10.3 Signal quality filter“)</li> <li>• Spray detection (→ „10.5 Detection of spray/fog/dust“)</li> </ul> <p> Dusty and foggy environmental conditions require stronger data filtering. The "Visual conditions" setting reduces the device's range.</p>
<p>Not important</p> <p>Important, low sensitivity</p> <p>Important, medium sensitivity</p> <p>Important, high sensitivity</p>	Detection of soiling	<p>Setting the sensitivity of the soiling detection:</p> <p>The setting affects the: Soiling detection (→ „10.6 Soiling detection“).</p>

► Click on [Next].

Wizard: General settings
✕



### 3. Image settings – data quality:

It is possible to optimise the sensor output depending on the typical movement dynamics in the application.

In case of high dynamics (either the objects to be measured or the vehicle on which the sensor is mounted), it is recommended to parameterise the sensor to a low latency/fast response setting.

*In case of low dynamics (sensor is not moved during measurement*

Wizard: General settings
✕



### 4. Result settings:

Will the sensor results be used in the application set-up on CAN or Ethernet?

CAN & Ethernet

With which update rate shall the sensor data be transmitted via CAN & Ethernet?

Every sensor cycle (50 HZ)

Which result data shall be sent via Ethernet?

Full data (3D pixel data + functional results)

Step 4/5
Back
Next



The result settings affect the connection of the device within the application.

The connection settings between ifm Vision Assistant and the device are described in chapter „4.1.2 Manual connection“.

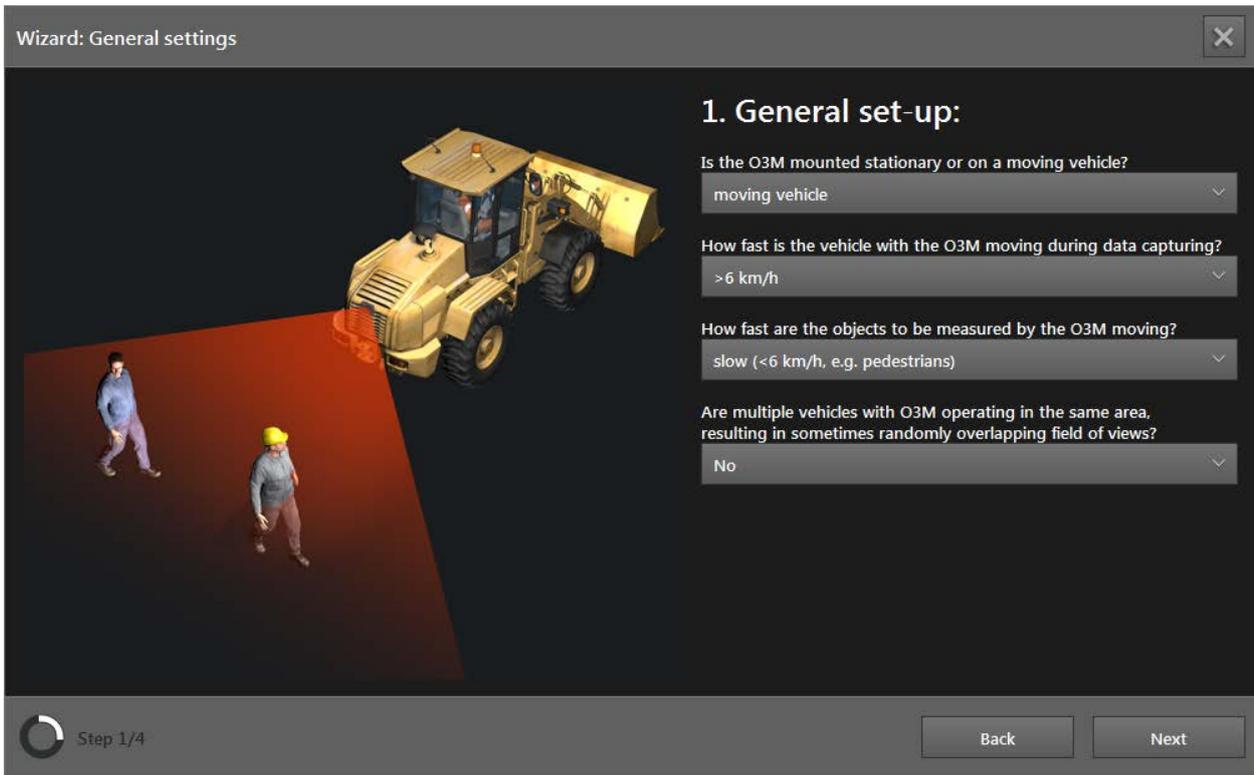
Button	Name	Description
CAN Ethernet CAN & Ethernet	Using the results	Use the "CAN" setting if the measurement results of the application are transferred via CAN. Use the "Ethernet" setting if the measurement results of the application are transferred via Ethernet. Use the "CAN & Ethernet" setting if the measurement results of the application are transferred via CAN and Ethernet.
Every sensor cycle (50 HZ) Every 2nd sensor cycle (25 HZ) Every 3rd sensor cycle (16 HZ)	Repetition rate	The setting determines the repetition rate of the data. A high repetition rate increases the data flow-rate. The repetition rate of the data depends on the ambient temperature (→ Seite 43, image settings - environment). The setting affects the: Data refresh to CAN / Ethernet in relation to the sensor cycle (→ „7.2 CAN settings“) / (→ „7.3 Ethernet“).
Only functional results Full data (3D pixel data + functional results)	Results via Ethernet	The "Only function results" setting sends object data and ROI results via Ethernet (no 3D pixel data). The setting reduces the data flow-rate via Ethernet. The setting "All results (full 3D data + functional results)" sends 3D pixel data, object data and ROI results via Ethernet. The setting increases the data flow-rate via Ethernet.

► Click on [Next].

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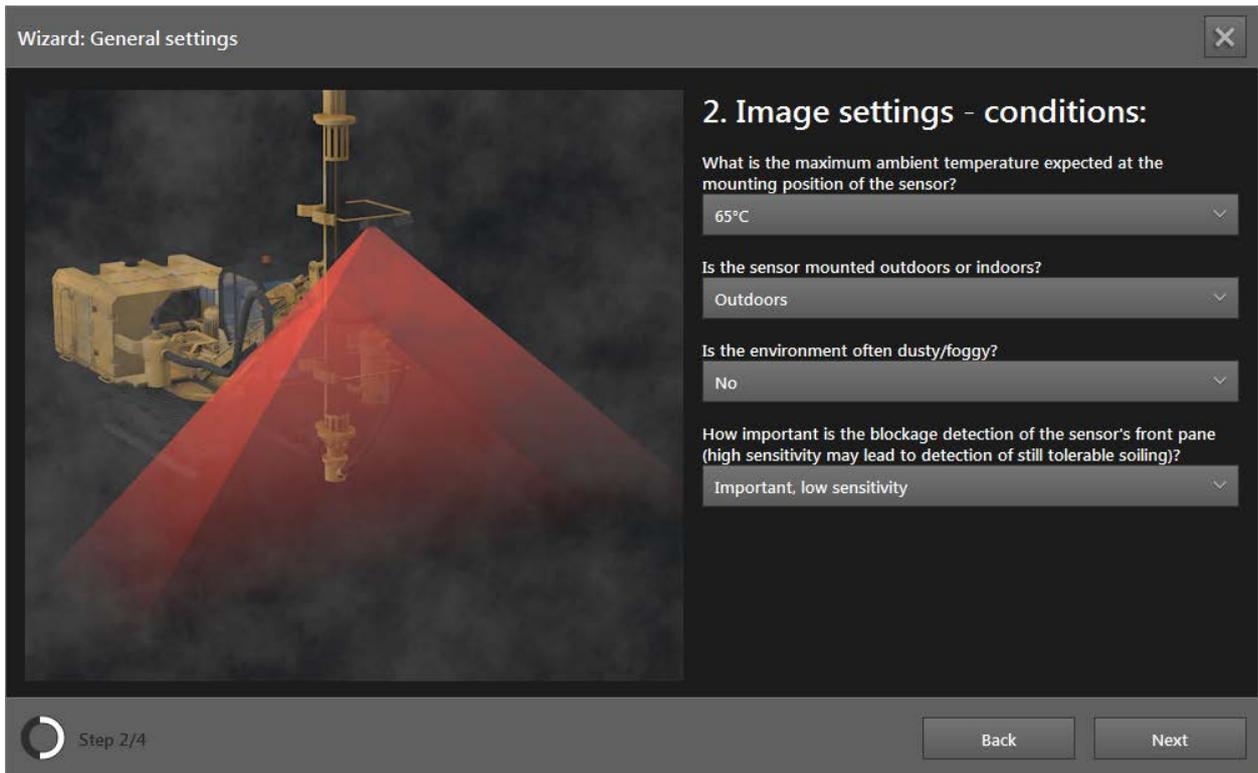
### The "moving vehicle" setting

In the following, the general setting "moving vehicle" is described.



Button	Name	Description
stationary quasi static (<3 km/h) slow (<6 km/h) >6 km/h	Vehicle speed	Set the speed of the vehicle. The setting affects the: Intelligent data averaging (→ „10.9 Intelligent data averaging“).  In case of high vehicle speeds, it is recommended to reduce the value of the intelligent data averaging (→ „10.9 Intelligent data averaging“).
stationary slow (<6 km/h, e.g. pedestrians) medium (<10 km/h, e.g. slowly moving vehicles) >10 km/h	Object speed	Setting the speed of the objects. The setting affects the: Intelligent data averaging (→ „10.9 Intelligent data averaging“).  In case of high object speeds, it is recommended to reduce the value of the intelligent data averaging (→ „10.9 Intelligent data averaging“).
Yes No	Several vehicles	If several vehicles with devices move in the working area, this may produce measurement errors. The "Yes" setting applies random modulation frequencies for the devices. The "Yes" setting affects the: Modulation frequency mode (→ „10.8 Modulation frequency mode“) The setting "no" affects: Intelligent data averaging (→ „10.9 Intelligent data averaging“)

► Click on [Next].



Button	Name	Description
<p>65°C</p> <p>75°C</p> <p>85°C</p>	Ambient temperature	<p>Set the frame rate of the device according to the ambient temperature:</p> <ul style="list-style-type: none"> <li>• 85°C: Frame rate of 25 Hz</li> <li>• 75°C: Frame rate of 33 Hz</li> <li>• 65°C: Frame rate of 50 Hz</li> </ul> <p> Always use the highest possible frame rate.</p>
<p>Outdoors</p> <p>Indoors</p>	Application	<p>Use the "Outdoors" setting if strong environmental influences are to be expected in the application. The setting affects the:</p> <ul style="list-style-type: none"> <li>• Filter signal quality (→ „10.3 Signal quality filter“)</li> <li>• Noise reduction filter (→ „10.4 Noise reduction filter“)</li> </ul> <p>Use the "Indoors" setting if insignificant environmental influences are to be expected in the application. The setting affects the:</p> <ul style="list-style-type: none"> <li>• Filter signal quality (→ „10.3 Signal quality filter“)</li> <li>• Noise reduction filter (→ „10.4 Noise reduction filter“)</li> </ul>
<p>Yes</p> <p>No</p>	Visibility conditions	<p>Activate the "Visibility conditions" setting if the visibility conditions are often bad. The setting affects the:</p> <ul style="list-style-type: none"> <li>• Filter signal quality (→ „10.3 Signal quality filter“)</li> <li>• Spray detection (→ „10.5 Detection of spray/fog/dust“)</li> </ul> <p> Dusty and foggy environmental conditions require stronger data filtering. The "Visual conditions" setting reduces the device's range.</p>
<p>Not important</p> <p>Important, low sensitivity</p> <p>Important, medium sensitivity</p> <p>Important, high sensitivity</p>	Detection of soiling	<p>Use the setting "Soiling detection" to set the sensitivity of the soiling detection:</p> <p>The setting affects the: Soiling detection (→ „10.6 Soiling detection“).</p>

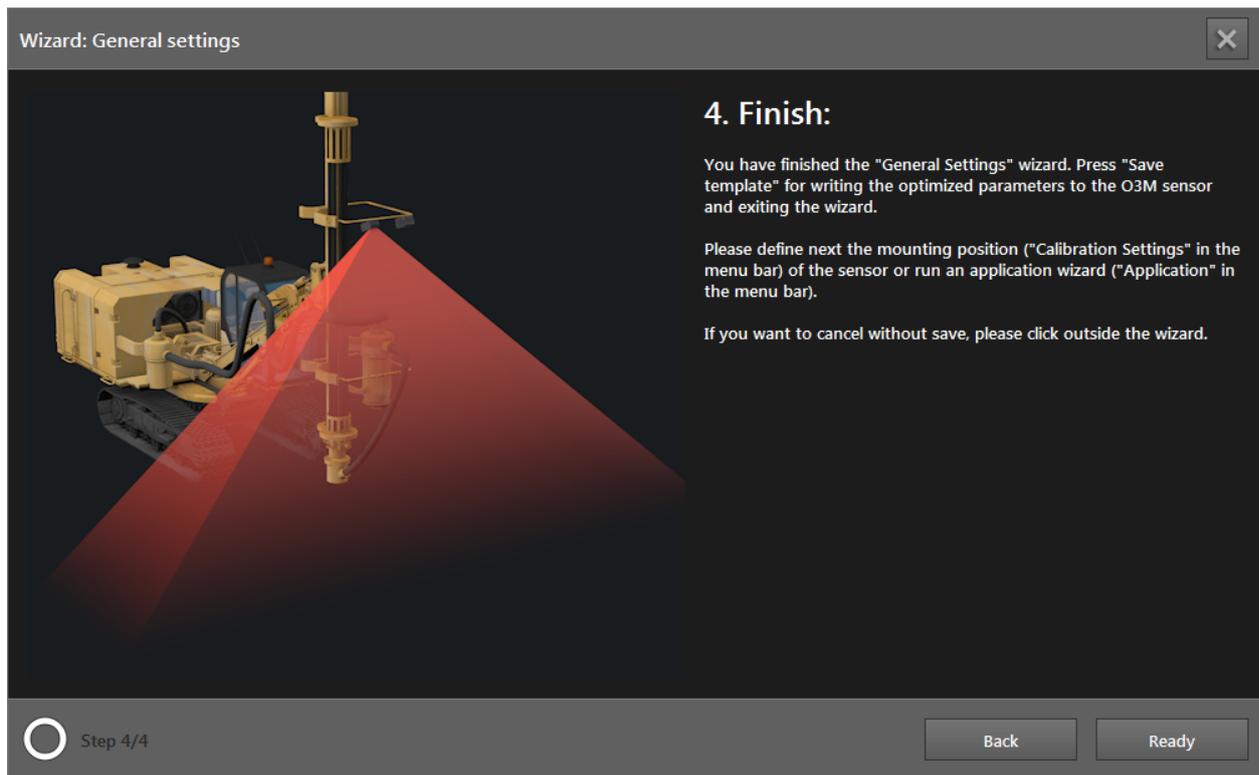
► Click on [Next].



**!** The result settings affect the connection of the device within the application.  
 The connection settings between ifm Vision Assistant and the device are described in chapter „4.1.2 Manual connection“.

Button	Name	Description
<ul style="list-style-type: none"> <li>CAN</li> <li>Ethernet</li> <li>CAN &amp; Ethernet</li> </ul>	Using the results	Use the "CAN" setting if the measurement results of the application are transferred via CAN. Use the "Ethernet" setting if the measurement results of the application are transferred via Ethernet. Use the "CAN & Ethernet" setting if the measurement results of the application are transferred via CAN and Ethernet.
<ul style="list-style-type: none"> <li>Every sensor cycle (50 HZ)</li> <li>Every 2nd sensor cycle (25 HZ)</li> <li>Every 3rd sensor cycle (16 HZ)</li> </ul>	Repetition rate	The setting determines the repetition rate of the data. A high repetition rate increases the data flow-rate. The repetition rate of the data depends on the ambient temperature (→ Seite 43, image settings - environment). The setting affects the: Data refresh to CAN / Ethernet in relation to the sensor cycle (→ „7.2 CAN settings“) / (→ „7.3 Ethernet“).

► Click on [Next].



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- ▶ Click on [Ready].
- > The setting of the device via the assistant "General sensor settings" is finished.

### 7.1.3 Firmware update

The current firmware is on the supplied data carrier or can be downloaded from the internet if needed:  
 www.ifm.com → Service → Download



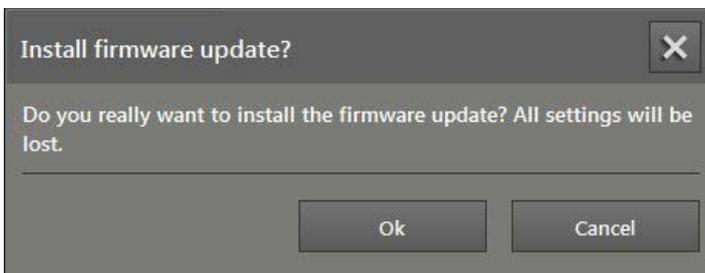
The DI firmware is installed by default on the device. The following firmware is currently available:

- DI - Basic functions (standard firmware)
- OD - Object detection and collision avoidance
- LG - Line guidance



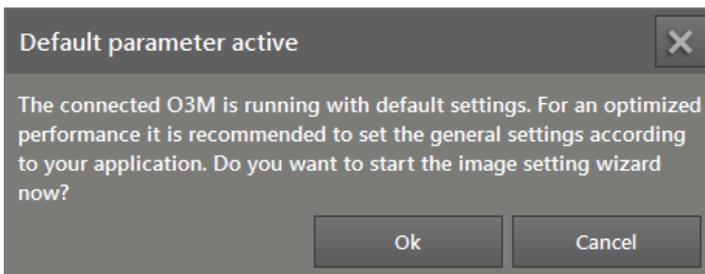
All settings and applications will be deleted when the firmware is updated.

- ▶ Export the settings before the firmware update.
- ▶ Click on [Refresh] to update the firmware.
- > A safety query is displayed.



- ▶ Click on [OK].
- > The "Open" window appears.
- ▶ Select the required firmware file (\*.fcr).
- ▶ Click on [Open].
- > The firmware is being updated. After that, the ifm Vision Assistant re-establishes the connection to the device.

After the firmware update, the following window appears:



Start the assistant by clicking on [Ok] in order to adjust the settings for the corresponding applications.

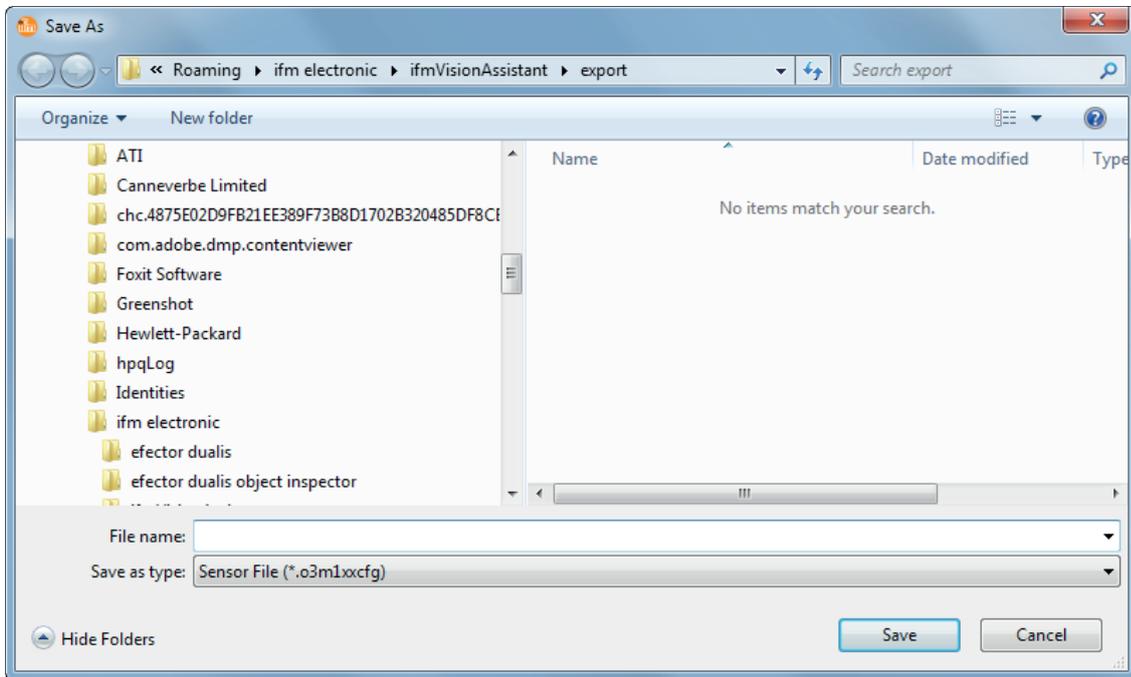
#### Error messages

Error message	Solution
 <p><b>Common update error</b>                      General error. [130011]</p>	<p>If the connection to the device is interrupted during a firmware update, this error message appears.</p> <ul style="list-style-type: none"> <li>▶ Restore the firmware via the manual connection (→ „4.1.2 Manual connection“).</li> </ul>
 <p><b>Software/hardware compatibility...</b>                      This firmware update cannot be installed on this sensor. [130013]</p>	<p>If the connected device of the illumination unit is compatible with the firmware, the error message below appears.</p> <ul style="list-style-type: none"> <li>▶ Use a different firmware version or compatible hardware.</li> </ul>

### 7.1.4 Export settings

With the "Export" function, all settings and applications are exported from the device to the PC.

- ▶ Click on [Export] to start the export of the settings.
- > The "Save As" window appears.



- ▶ Enter the name and click on [Save].
- > The settings will be saved to a file with the extension .o3m1xxcfg.

### 7.1.5 Import settings

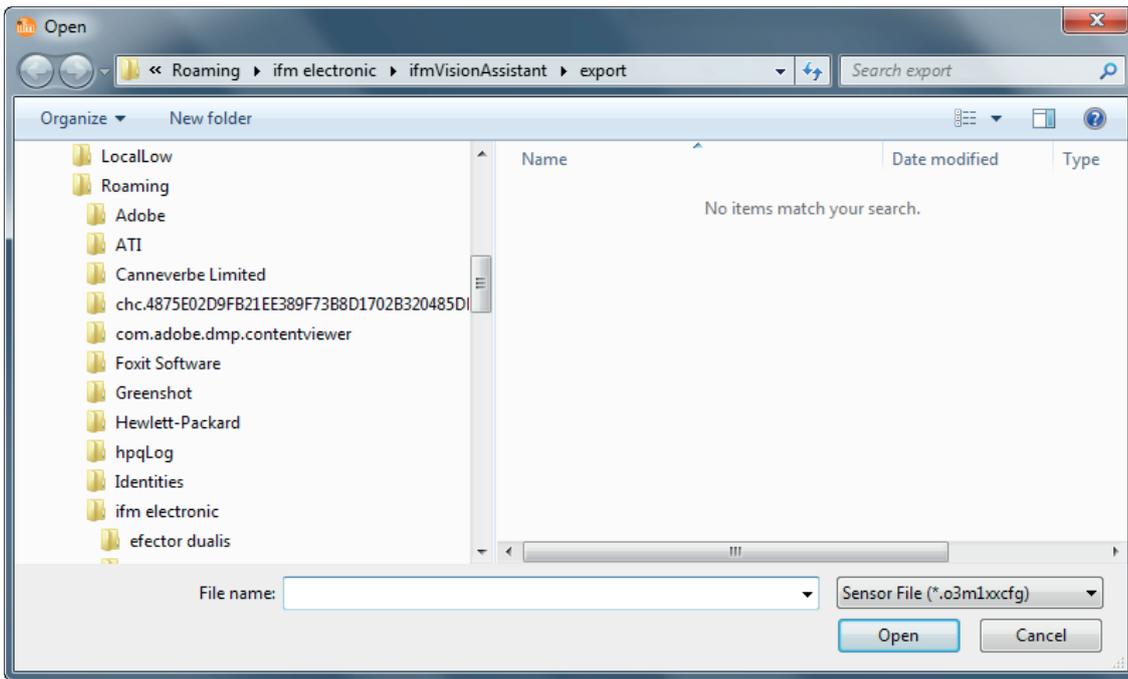
With the "Import" function, the settings and applications are imported from the OC to the device.



Existing settings and applications are overwritten during the import.

- ▶ If necessary, export the existing settings beforehand.
- ▶ Click on [Import] to start the import of the settings.

> The "Open" window appears.



▶ Select the required file with the ending .o3m1xxcfg and click on [Open].

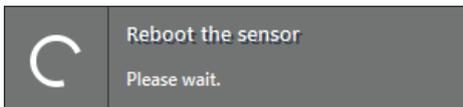
> The settings will be imported.

### 7.1.6 Reboot the sensor

The device can be rebooted using the [Reboot sensor] button.

▶ Click on [Reboot the sensor].

> The device reboots.

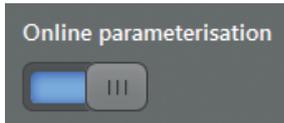


> The ifm Vision Assistant establishes a new connection with the device.

▶ If the new connection to the device fails, search the device via  on the start screen or connect it manually.

## 7.1.7 Online parameter setting

With the [Online parameterisation] switch, the online parameter setting of the device is activated.



When "online parameterisation" is activated, changed parameters will be immediately written to the device. The changes are visible within a very short time (real-time).



The changes are written in a volatile partition of the RAM and are lost e.g. when the device is rebooted.

► Save the changes permanently by clicking on  [Save].

If "online parameterisation" is deactivated, changed parameters are only written after clicking on  [Save]. The changes are stored in a non volatile partition of the RAM and will be visible after approx. 15 seconds.



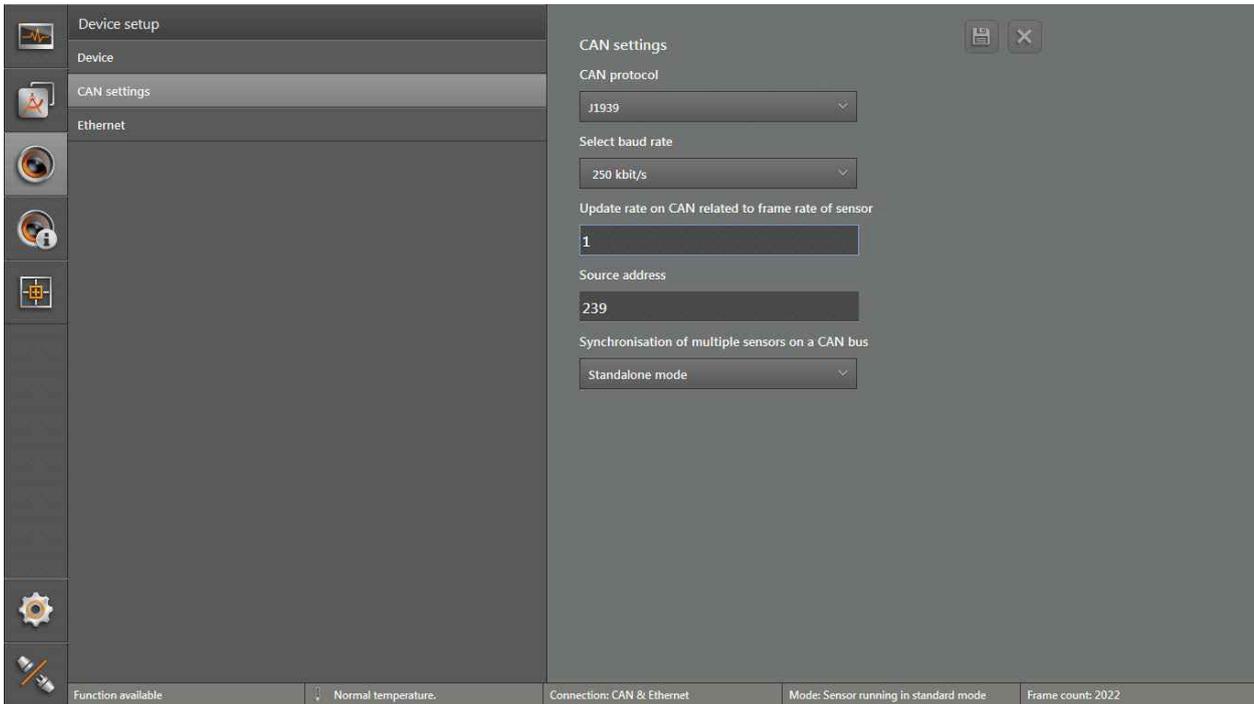
"Online parameterisation" is deactivated by default.



"Online parameterisation" can be used by controllers (CAN controllers). Adequate libraries are available for ifm mobile controllers with CAN input (→ „16.3 Connect O3M to external devices“).

## 7.2 CAN settings

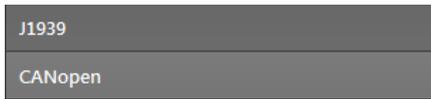
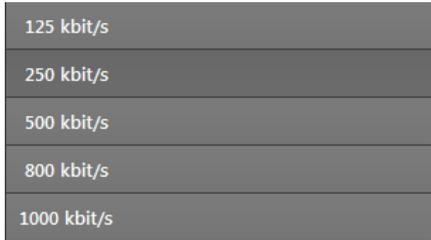
In the "CAN settings" window, different parameters of the CAN bus can be set.



► Click on [CAN settings].

> The "CAN settings" window appears.

### Functions

Field	Description
CAN protocol	Selection menu to set the CAN protocol: 
Select baud rate	Selection menu to set the baud rate: 
Refresh rate on CAN relating to frame rate of sensor	Editable field to set data refreshing via the CAN bus. Frequent refreshing utilises more CAN bus capacity which may slow down response times. The following refresh rates can be set: <ul style="list-style-type: none"> <li>● 1: Each image of the device updates the data via the CAN bus (high CAN bus capacity utilisation)</li> <li>● 2: Every second image of the device refreshes the data via the CAN bus</li> <li>● 3: Every third image of the device refreshes the data via the CAN bus</li> <li>● 4: Every fourth image of the device refreshes the data via the CAN bus</li> <li>● 5: Every fifth image of the device refreshes the data via the CAN bus (low CAN bus capacity utilisation)</li> </ul>
Source address	Editable field to set the source address. Default value is "239". The field is only visible if the CAN protocol "J1939" is set.
Node ID	Editable field to set the node ID, default value is "10". The field is only visible if the CAN protocol "CANopen" is set.



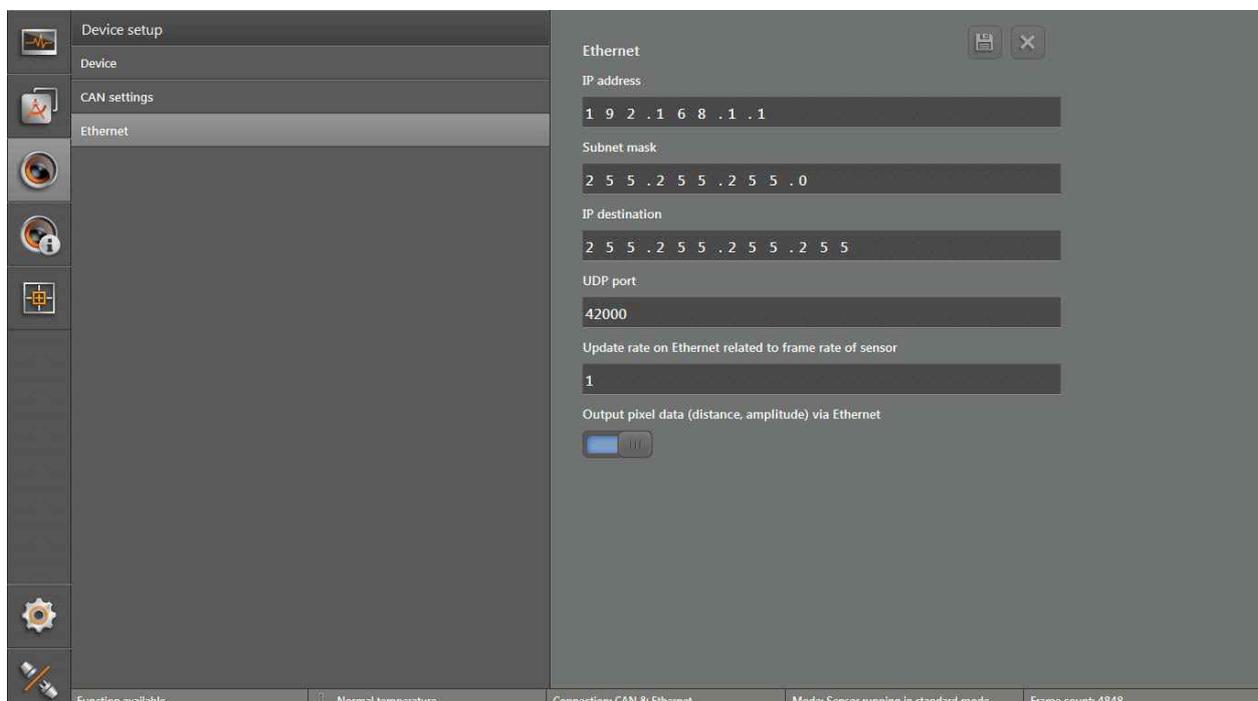
Field	Description
Synchronisation of several sensors on one CAN	<p>Selection menu to set the behaviour of several sensors on one CAN bus.</p> <div style="background-color: #cccccc; padding: 2px; margin-bottom: 2px;">Standalone mode</div> <div style="background-color: #cccccc; padding: 2px; margin-bottom: 2px;">Exposure master - sends sync messages</div> <div style="background-color: #cccccc; padding: 2px; margin-bottom: 2px;">Exp. slave 2 (time shifted) - receives sync</div> <div style="background-color: #cccccc; padding: 2px;">Exp. slave 1 (simultaneous) - receives sync</div> <p>To synchronise several devices, one device is set as "Exposure Master". The Exposure Master sends sync messages to further devices.</p> <p>Further devices are set as "Exposure slave 2 (time shifted)" or "Exposure slave 1 (simultaneous)" The devices receive the sync messages of the Exposure Master and synchronise themselves correspondingly.</p> <ul style="list-style-type: none"> <li>▶ Set further devices as "Exposure slave 1 (simultaneous)" if the fields of view of the devices do not overlap.</li> <li>▶ Set further devices as "Exposure slave 2 (time shifted)" if the fields of view of the devices do not overlap.</li> </ul> <p>It is possible to synchronise several units on one CAN bus if the following points apply:</p> <ul style="list-style-type: none"> <li>• The CAN protocol "J1939" is set.</li> <li>• The frame rate is set to 25 Hz or 33 Hz.</li> <li>• The Exposure Master has source address "239".</li> </ul> <p>To ensure that the synchronisation is as error-free as possible, it is recommended to set up a separate CAN bus for the devices.</p>

### 7.3 Ethernet

In the "Ethernet" window, the network settings of the device are changed.

▶ Click on [Ethernet].

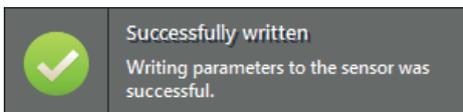
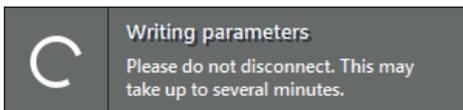
> The "Ethernet" window appears.



## Functions

Field	Description
IP address	Editable field to set the IP address of the device. Default value is "192.168.1.1".
Subnet mask	Editable field to set the subnet mask. Default value is "255.255.255.0".
IP destination	Editable field to set the IP address of the receiver. Default value is "255,255,255,255".
UDP port	Editable field to set the UDP port. Default value is "42000".
Update rate on Ethernet related to frame rate of sensor	<p>Editable field to set the data update via Ethernet. Frequent refreshing utilises more Ethernet capacity which may slow down response times. The following refresh rates can be set:</p> <ul style="list-style-type: none"> <li>• 1: Each image of the device refreshes the data via Ethernet (high Ethernet capacity utilisation)</li> <li>• 2: Every second image of the device refreshes the data via Ethernet</li> <li>• 3: Every third image of the device refreshes the data via Ethernet</li> <li>• 4: Every fourth image of the device refreshes the data via Ethernet</li> <li>• 5: Every fifth image of the device refreshes the data via Ethernet (low Ethernet capacity utilisation)</li> </ul>
Output pixel data (distance, amplitude)	<p>With this switch, the pixel data output via Ethernet can either be activated or deactivated. Deactivating the pixel data reduces the bus load because only the functional results will be transmitted. By default, the switch is set to "on".</p> <p>In the interface descriptions, the CAN and Ethernet interfaces are described in detail.</p>

- ▶ Enter network settings in the input fields.
- ▶ Click  to save the changes.
- > The ifm Vision Assistant writes the new settings to the device.



- > The ifm Vision Assistant establishes a new connection with the device:



- ▶ If the new connection to the device fails, search the device via  on the start screen or connect it manually.

## 8 Device Information

The device information gives the current information about the device and the applied networks.

► Click  .

> An image of the device and the device information is shown.



UK

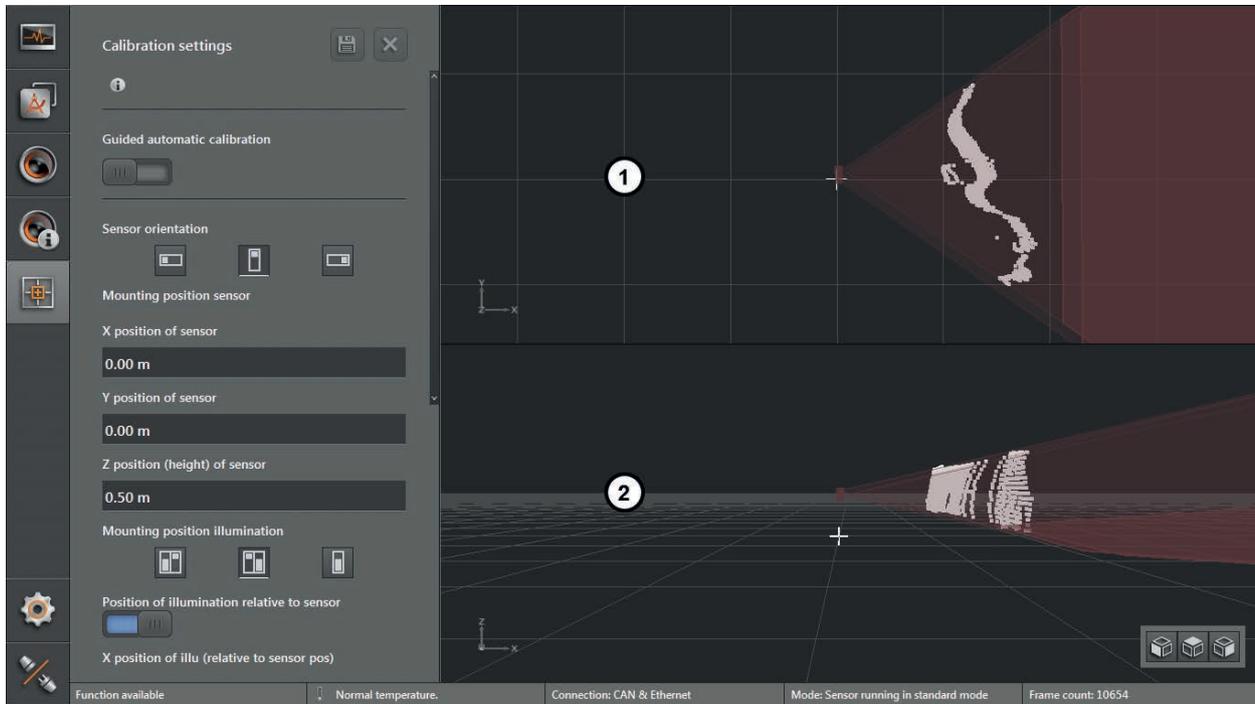
Field	Description
Hardware & firmware	Applied hardware, installed firmware version and the application
Status	Device status
Temperature	Temperature of the device and the illumination unit
Connection	The type of connection between the ifm Vision Assistant and the device
Voltage	Terminal voltage of the device and the illumination unit

## 9 Calibration settings

In the calibration settings, the device can be calibrated for the intended application.

► Click .

> The calibration settings are shown.



1: 3D view from above (not adjustable)

2: 3D view (freely adjustable)

### 9.1 What is calibration?

The device provides 3D coordinates for each pixel. The 3D coordinates always relate to the coordinate origin of the world coordinate system. The calibration settings make it possible to freely define the world coordinate system and to adjust the device to it.

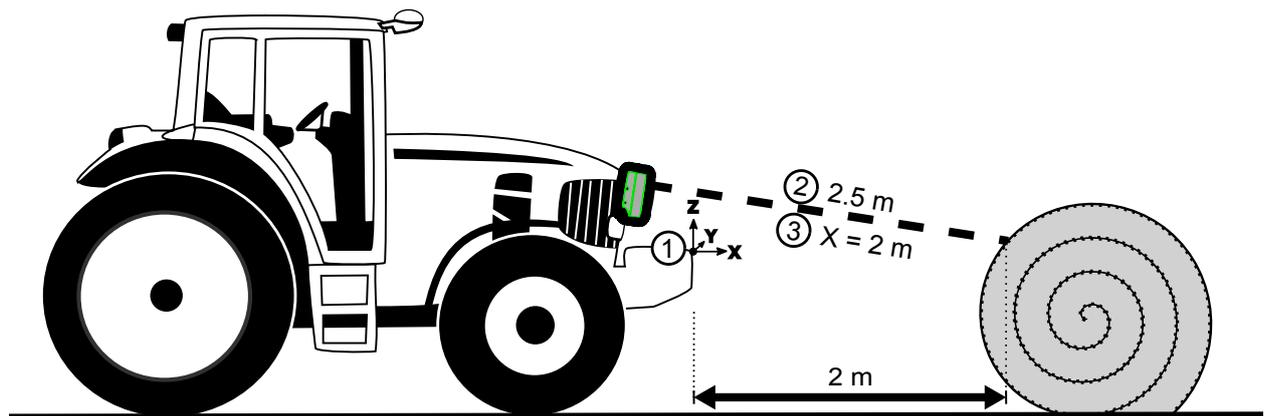
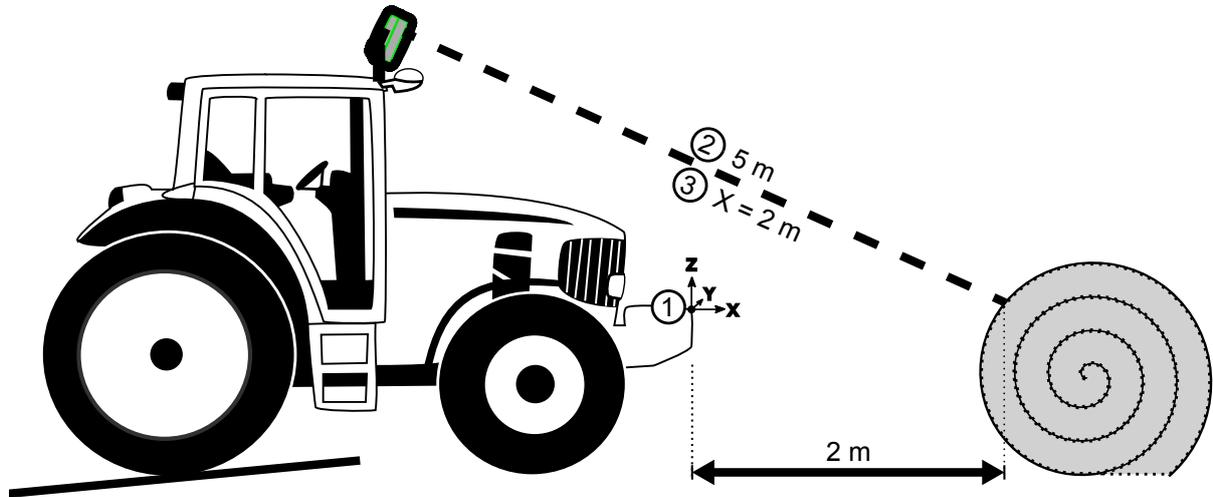
The help options in the calibration settings are adapted to mobile machines. Regardless of this, the calibration settings can be used for any application.

The three coordinate axes are X, Y and Z. The reference point of the 3D coordinate system can be defined at will. Examples:

- measured object distance related to the device
- front part of a vehicle
- any reference point of a machine

The calibration settings provide the tools that are necessary for this.

In the figure below, the significance of the world coordinate system is outlined as an example. The provided 3D coordinates are always provided in the calibrated world coordinate system. This makes it possible that the processing of the coordinate positions can take place regardless of the installation position and angle of the device.



The image above shows two different mounting positions of the device on a mobile machine. In both cases, the world coordinate system is defined identically (1). For both mounting positions, the internal measured value of the device differs by the mounting position (2).

By correctly calibrating the device to the world coordinate system, the same X value is provided for the object and both mounting positions (within the world coordinate system).

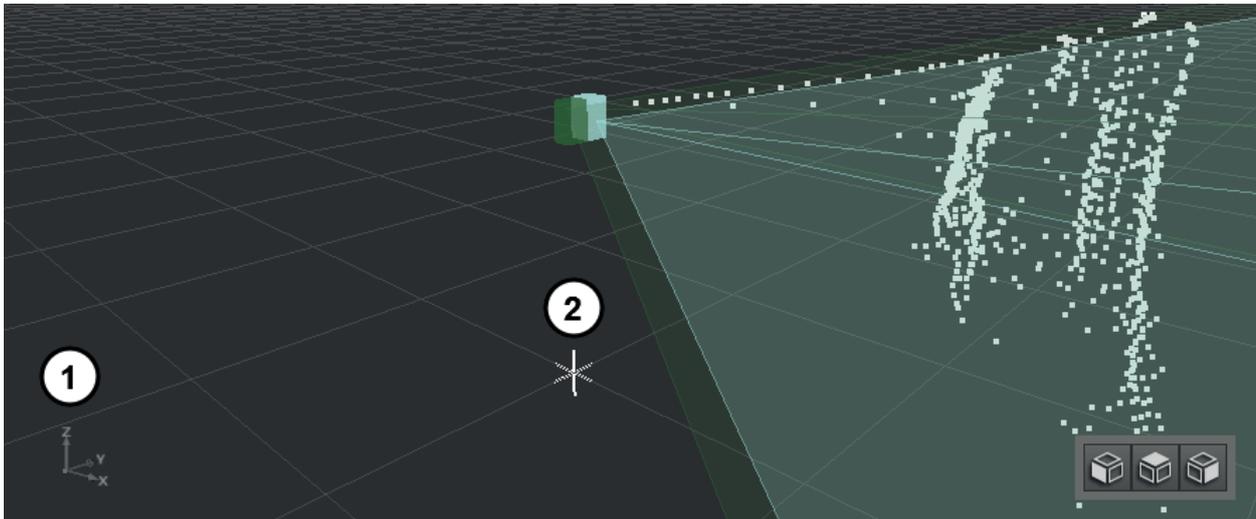
UK

## 9.2 World coordinate system

The 3D data measured by the device is provided in the world coordinate system. To ensure that the world coordinate system can be adapted to the application, the transformation between the device coordinate system and the world coordinate system must be communicated to the system.

The device offers manual setting of the world coordinate system and automatic fine adjustment of the world coordinate system.

The world coordinate system is defined as a right-handed, right-angled coordinate system. In the ifm Vision Assistant, the pixels are always drawn in the currently set world coordinate system.

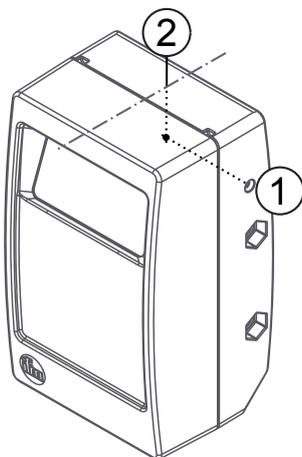


The world coordinate system is represented with its three axes (1). The coordinate origin is represented by a cross (2). The rectangular pattern on the X/Y level represents the ground level (grid 1 m). The Z axis looks up from the ground level. The X axis looks in the machine's direction of travel.

In the illustration, the device's visible range is dark green. The visible range of the illumination unit is light green in the illustration. The areas are an aid to determine if the overlapping area of device and illumination unit sufficiently covers the working area

## 9.3 Reference point of the device

The reference point of the device is defined in order to determine the correct position of the device in the world coordinate system.



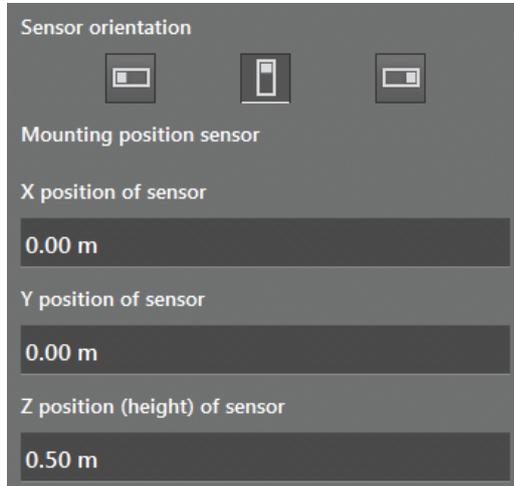
The reference point of the device is determined via the lateral reference socket (1). The reference socket cuts the coordinate origin in the middle of the sensor (2).

## 9.4 Position of the device

The following describes how the position of the device is indicated in the ifm Vision Assistant.



The following explanations refer to a reference surface to which the device is oriented. For vehicles, the reference surface is, in most cases, the road surface. A wall or a virtual plane can be selected as reference surface.



The sensor orientation determines the installation of the device:

- vertical to the surface (portrait format)
- horizontal to the surface (landscape format)

The pictograms in the figure indicate the position of the device (view from the front).



Please consider the position of sensor screen when orienting the sensor. In the figure above, the sensor screen is marked with a dot.



If none of the pictograms corresponds with the mounted device, please chose the pictogram that looks most similar. The precise adjustment can be carried out later.

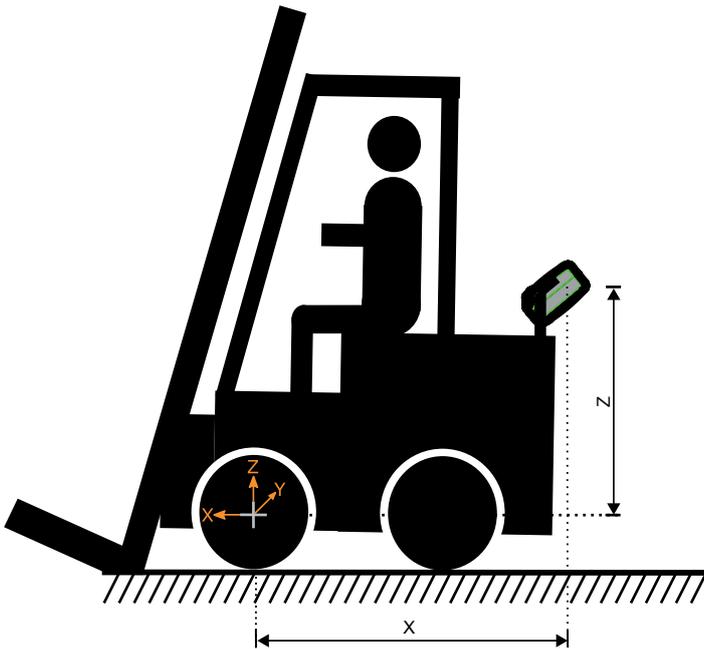
In this section, the reference surface is parallel to the X/Y level. The position of the reference point is described in chapter 9.3.

With the fields "X position of sensor" and "Y position of sensor", the device can be relocated in the world coordinate system. Due to this, the coordinate origin can be relocated to a point that is most adequate for the application. Since the 3D coordinates of the device are provided in this world coordinate system, in most cases, no further calculation is necessary.

In the field "Z position (height) of the sensor", the position of the device is indicated on the Z axis. The Z axis is vertical to the reference surface. The Z position indicates the mounting height of the device.

**Example**

The following figure illustrates how to apply the world coordinate system to an application.



The reference point, the origin of the world coordinate system, is set in the front axle of the vehicle (grey cross). The distance of the device to the reference point on the X axis is entered in the field "X position of sensor". The distance of the device to the reference point on the Y axis is entered in the field "Y position of sensor". The distance of the device to the reference point on the Z axis is entered in the field "Z position of sensor".

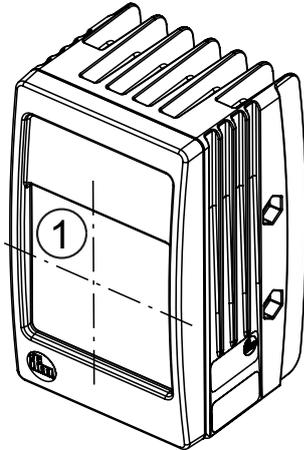
Finally, the 3D data is calculated taking into account the entered position of the device.



The signs for the X/Y/Z axes depend on the corresponding coordinate direction in the world coordinate system. In the figure above, the device on the X axis has a negative sign (against driving direction) and on the Z axis a positive sign.

## 9.5 Reference point of the illumination unit

The reference point of the illumination unit is defined in order to determine the correct position of the illumination unit in the world coordinate system.



The reference point of the illumination unit is in the centre of the illumination screen (1).

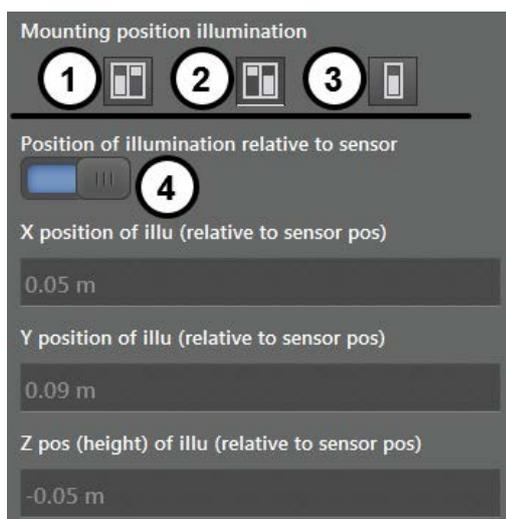
## 9.6 Position of the illumination unit

The following describes how the position of the illumination unit is indicated in the ifm Vision Assistant.

The illumination unit is an essential element of an O3M system. The two-housing design of the system has been developed to meet the requirement that in certain cases is helpful to separate the illumination and the sensor (e.g. in fog or dust).

In order to calculate the emitted signals correctly into 3D coordinates, the position of the illumination unit must be adjusted in relation to the device.

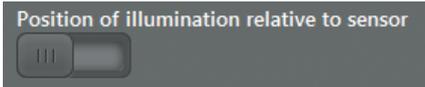
The illumination unit shines in the direction of the measuring range. The visible range of the illumination unit is indicated light green in the ifm Vision Assistant. Usually, the device and the illumination unit are mounted next to each other.



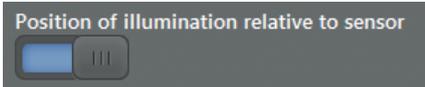
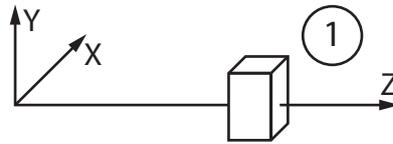
The pictograms in the figure indicate the position of the illumination unit (view from the front):

- (1): illumination unit mounted to the left of the device
- (2): illumination unit mounted to the right of the device
- (3): illumination unit mounted separately from the device

If the illumination unit is mounted separately from the device (3), the position of the illumination unit must be specified. The switch (4) determines how the position of the illumination unit is specified:



Absolute in the world coordinates: The position of the illumination unit (1) is specified with the absolute coordinates of the world coordinate system.



Relative to the sensor: the position of the illumination unit (1) is specified in relation to the device (2) in the world coordinate system.



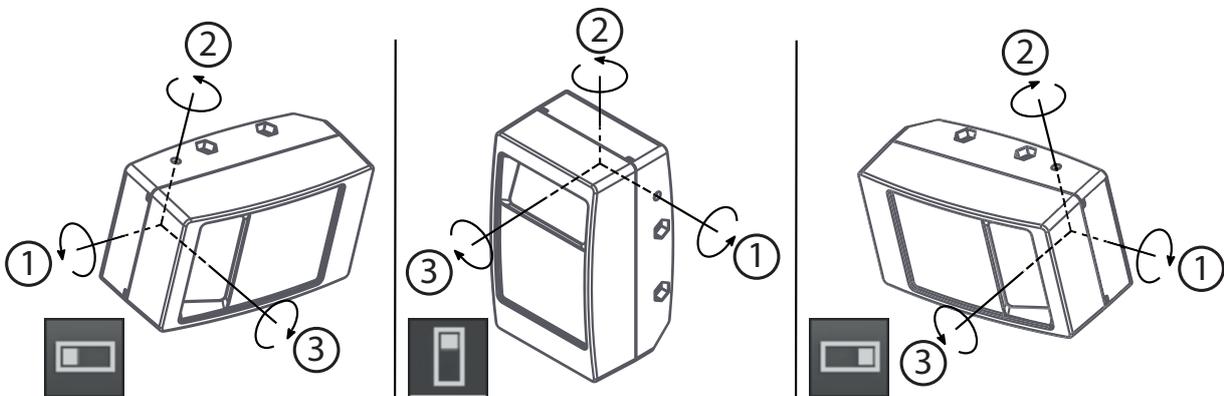
### 9.7 Mounting angle of the device

The device is capable of compensating mounting angles and to convert the 3D data into the desired orientation.

For example, it is possible to transform the pixels of the road level irrespectively of the pitch angle of the device, so that the pixels are parallel to the X axis. For the transformation, the device needs information about its orientation in relation to the world coordinate system.

All in all, three angles can be set. The angles are indicated as follows:

- (1): angle of pitch
- (2): angle of rotation
- (3): angle of roll



The figure shows the angles in relation to the orientation of the sensor.

 Please note which sensor orientation is set when entering the angles (→ „9.4 Position of the device“).

The angles can be set in two ways:

- normal mode
- expert mode

### 9.7.1 Normal mode

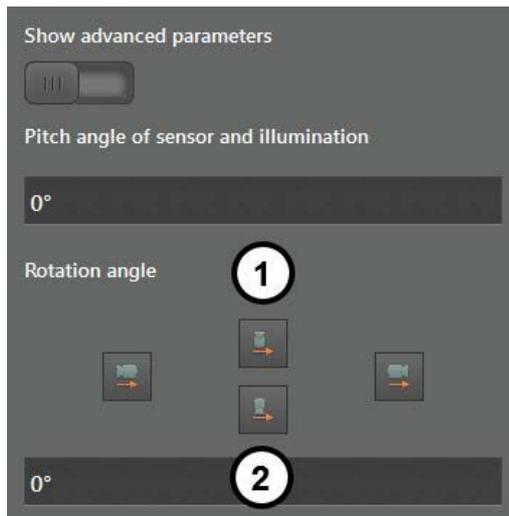
In the normal mode, the angle of pitch and the angle of rotation can be set. The angle of roll is not specified.



It is best to mount the device with an angle of roll of 0 degrees.

The angle of pitch is set in degrees in the field "Pitch angle of sensor and illumination".

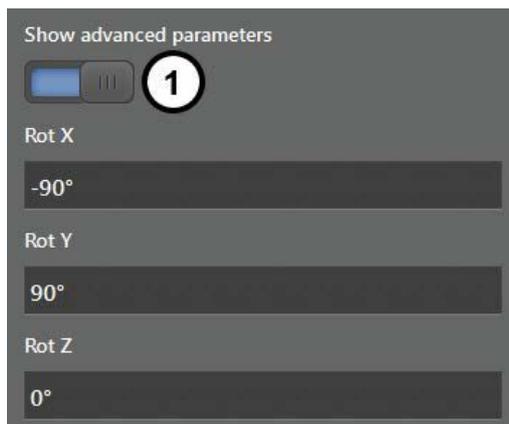
The angle of rotation is set via the four buttons (1). The arrows on the four buttons indicate the driving direction of the vehicle. The camera that is shown above the arrows shows the device's direction of view. In the input box (2), the angle of rotation can be set precisely.



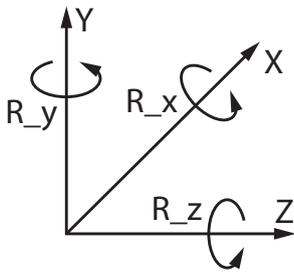
The angle of roll is determined and corrected automatically if the automatic calibration function is later used (→ „9.8 Automatic calibration“).

### 9.7.2 Expert mode

The switch (1) is used to activate the expert mode. In the expert mode, the rotation of the device is entered separately for the X, Y and Z axis in the world coordinate system.



The image shows three input boxes for the rotation of the device. Depending on the orientation of the sensor, the input boxes already contain values (→ „9.4 Position of the device“). With the values, the overall rotation is calculated.

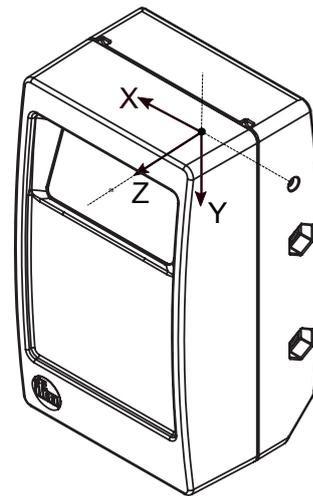


The overall rotation is calculated by multiplying the rotation matrices. The rotations around the X, Y and Z axis are described by the rotation matrices  $R_x$ ,  $R_y$  and  $R_z$ . The rotation matrices  $R_x$ ,  $R_y$  and  $R_z$  are formed internally from the Euler angles that are entered in the input boxes.

The indices x, y and z describe the axis of rotation in the coordinate system of the device. The overall rotation  $R$  of the device coordinate system into the world coordinate system is defined as matrix multiplication:

$$R = R_x * R_y * R_z$$

The figure on the right shows the coordinate system of the device originating from the reference point. The definition of the coordinate axes is necessary for the configuration of the expert mode.



### 9.8 Automatic calibration

The device can be calibrated automatically in the world coordinate system. Especially setting the orientation angle of the device is simplified by the automatic calibration.

For the automatic calibration, the following conditions must be met:

1. The origin of the world coordinate system must be placed on a plane.
2. Plane must be adjusted so that it covers a large part of the visible 3D image panel.



The automatic calibration is also possible if the origin of the world coordinate system is not on the plane. Then, the height of the device is set to the reference level and, after the automatic calibration, again referred to the actual world coordinate system.

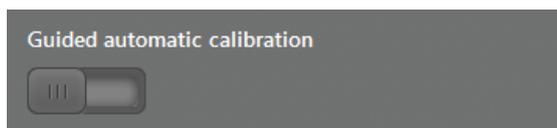
3. If the automatic calibration is carried out for the first time, the position and the rotation of the device must be set and stored manually.



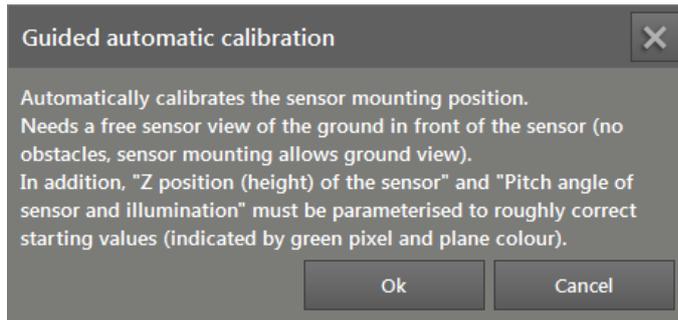
Necessary accuracy for the manual setting of the position and the rotation:

- Height estimation above the plane: approx. +/-0.5 m
- Angle of pitch: approx. +/-10%

If the conditions are met, the automatic calibration can be released with the illustrated button.

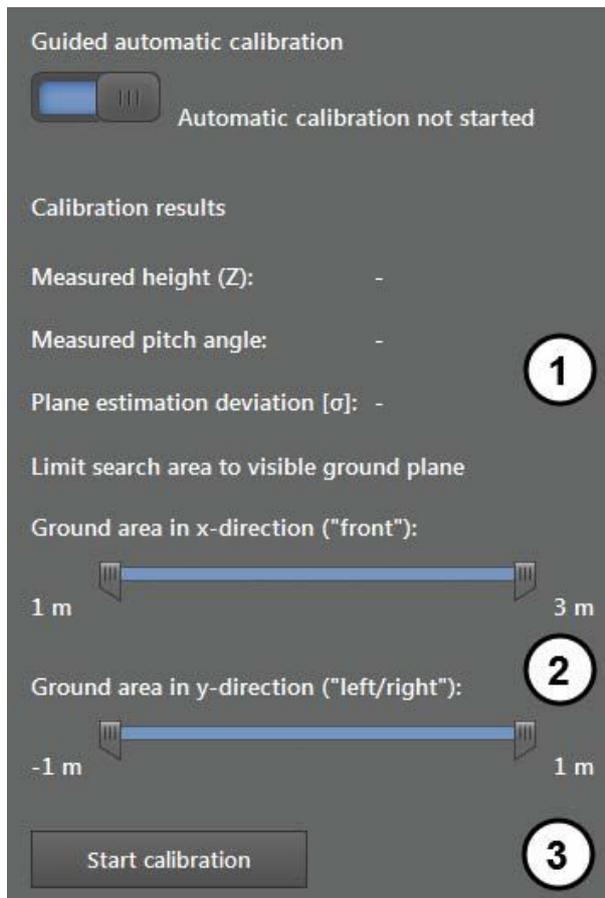


After the automatic calibration is released, the following note appears.



Please read the note and confirm by clicking "Ok".

If the automatic calibration is released, the following status information and settings are displayed.

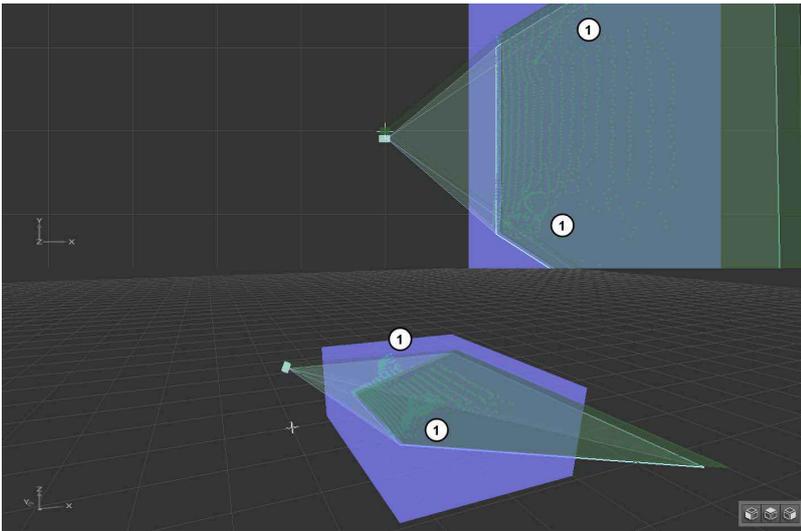


After the automatic calibration is started, the status information is displayed under (1).

The setting bar (2) restricts the area along the X and Y axis.

The button "Start calibration" (3) starts the automatic calibration.

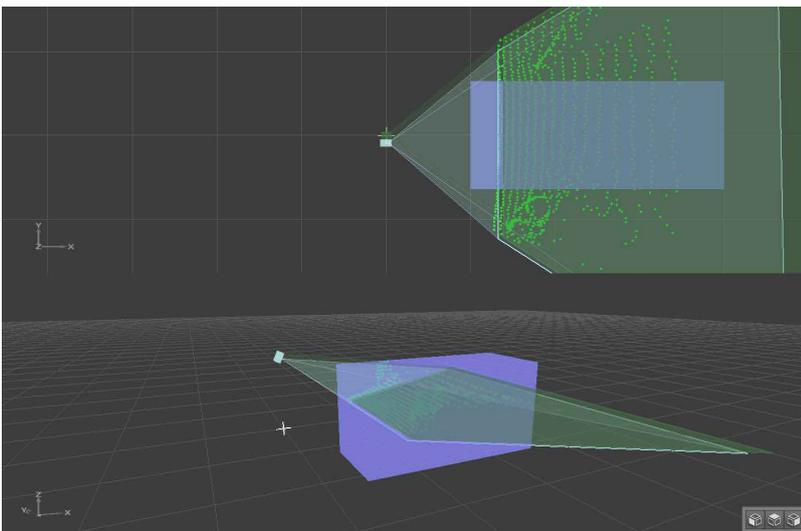
After the start, a blue transparent cube is shown in the 3D view. The cube shows the search zone for the reference level in three dimensions.



The markings (1) show objects in the search zone that interfere with the automatic calibration.

► Reduce the search zone with the setting bar (2).

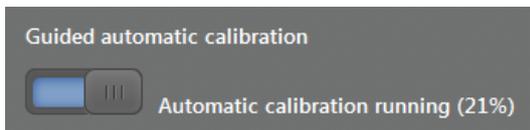
In the following figure, the search zone has been limited. The interfering objects are not considered.



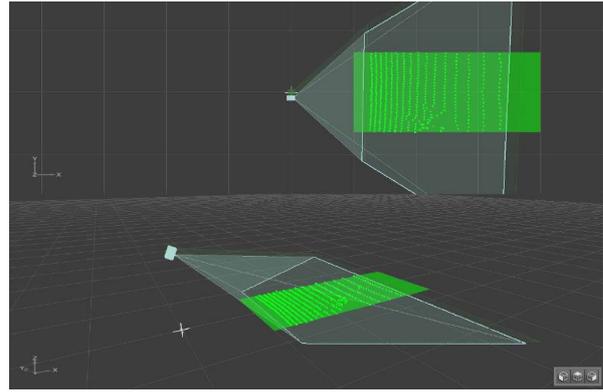
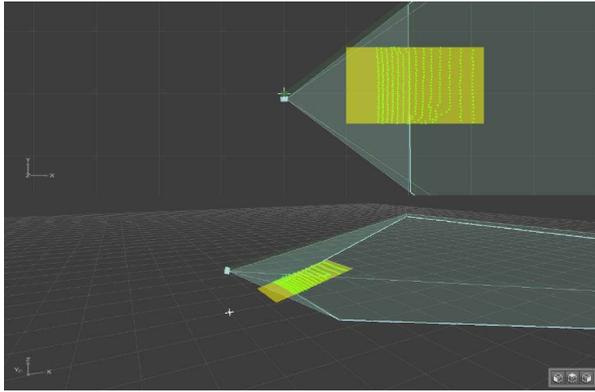
The automatic calibration can now be restarted.



During the automatic calibration, the parameters are written to the device. This can take up to 15 seconds. The progress of the automatic calibration is shown next to the button.



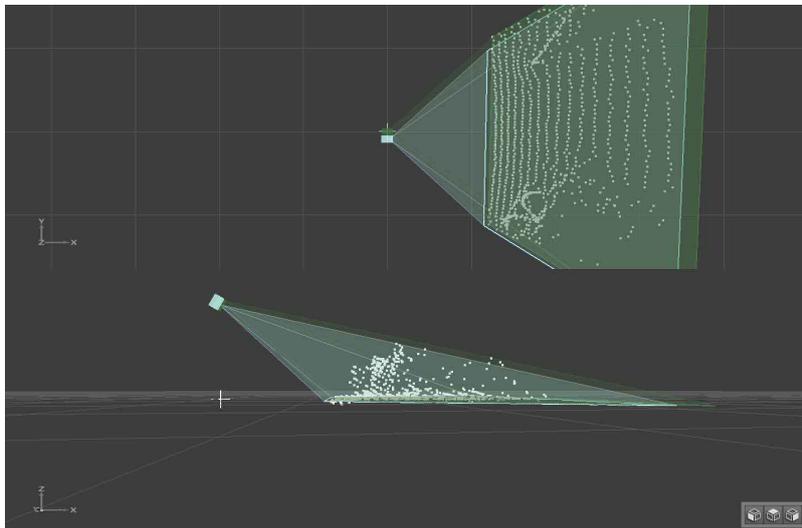
The 3D view shows how well the automatic calibration works.



- The colours yellow and orange signalise that the automatic calibration is not yet satisfactory.
- The colour green signalises that the automatic calibration will be successful.

 The colours change during the automatic calibration.

After the automatic calibration is finished, the 3D values of the plane are placed on the plane grid:



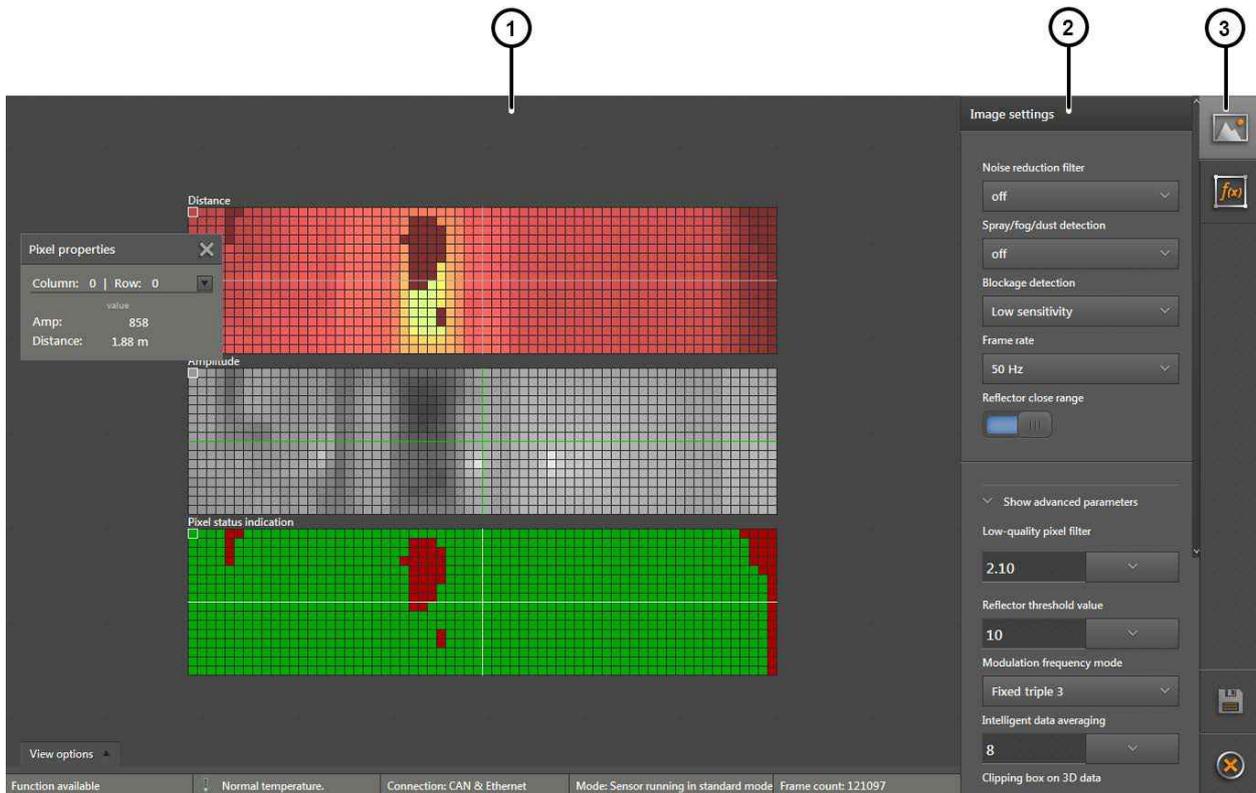
### 9.8.1 Equipment failure causes

The following causes can prevent the automatic calibration.

Cause	Description
The initial values for height, inclination and orientation of the device are not accurate enough	The level pixels cannot be detected in the blue search zone. Correct the following values: <ul style="list-style-type: none"> <li>• sensor orientation</li> <li>• Z position of the sensor</li> <li>• angle of pitch</li> </ul>
The search zone is too small	Remove interfering objects during the automatic calibration. Set a larger search zone.
There is no sufficiently large plane in the device's field of view	Rotate the device to carry out the plane calibration. Important: The rotation must not affect the angle of pitch or the angle of roll. Alternatively, put a plane object into the field of view.
There are not enough valid pixels in the search zone	The device is mounted in a very high position. In this case, highly reflective material on the ground can help.

## 10 Image settings

In the image settings, the image of the device can be changed with different filters and parameters.



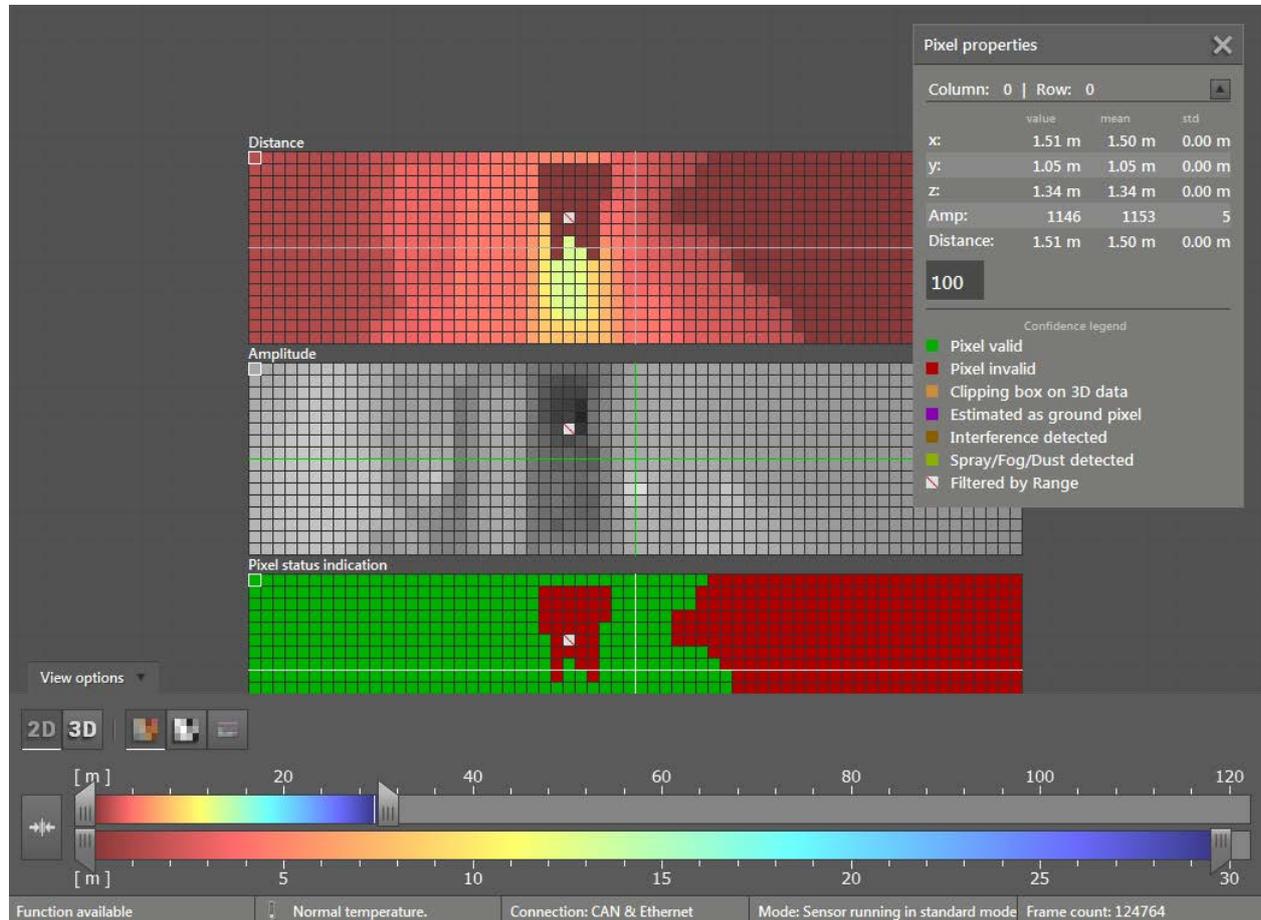
The image settings are divided into three areas:

- 1: Live image display (→ „10.1 Live image display“)
- 2: Image settings
- 3: Functions

## 10.1 Live image display

The live image display shows the live image of the device in 2D or 3D. In the default 2D view, the live image in the three views is displayed simultaneously:

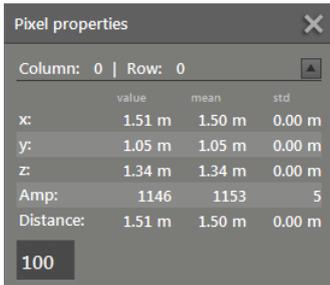
- Distance: The pixels are shown in colour depending on the distance value.
- Amplitude: The pixels are shown in shades of grey depending on the amplitude value.
- Confidence: The pixels are displayed in accordance with the legend of the pixel properties.



 In the view options, it is possible to change between a 2D and 3D view. The "view options" are described in chapter (→ „6.1 View Options“).

### 10.1.1 Pixel properties

In the 2D view, the properties of a selected pixel can be displayed.

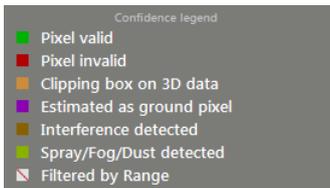


In the figure above, the pixel in column 0 and row 0 is selected.

The pixel properties contain the following values of a pixel:

Field	Pixel property
Column   Row	Column and row number
x	x coordinates: Measured value, average value and deviation [m]
y	y coordinates: Measured value, average value and deviation [m]
z	z coordinates: Measured value, average value and deviation [m]
Amp	Amplitude
Distance	Distance

In the pixel properties, the legend of the pixel status indication is also explained.



In the pixel status indication, a pixel can have one of the following statuses:

Pixel status	Description
	Pixel valid
	Pixel invalid, e.g. signal too strong or too weak
	Pixel is within the range of spatially filtered data (→ „10.11 Measuring range“)
	Pixel estimated as ground pixel
	Pixel interference detected, e.g. caused by adjacent devices (→ „10.8 Modulation frequency mode“)
	Spray/fog/dust detected (→ „10.5 Detection of spray/fog/dust“)
	Pixel filtered by distance. The pixel is outside the set distance. The distance is set in the view options (→ „6.1 View Options“)



The legend of the pixel status indication is only valid for the pixel status indication.

## 10.2 Applying filters

The setting of the filters depends on the application and the environment. The filters must be set separately for each application. When setting the filters, several aspects must be considered.



When looking at the filtered data, there is scope for interpretation, for example, due to noisy pixels. The combination of different filters increases the reliability. However, a slight degree of uncertainty always remains.

### 10.2.1 Example of area monitoring

For a better understanding of the connections between filter and application, the application "area monitoring" and possible uncertainties are explained as an example.

The application "area monitoring" is supposed to trigger an alarm if a person enters a specific area.

The filters "signal quality filter" and "noise reduction filter" are set to [low] / [weak]. For these settings, there are not many uncertainties caused by noisy pixels.

The filter "soiling detection" is set to [high sensitivity]. With this setting, there are not many uncertainties caused by fog, water or ice.

Possible uncertainties due to wrongly interpreted pixels are tolerable since the security staff can inspect the situation.

## 10.3 Signal quality filter

The "Signal quality filter" can filter pixels of dark objects. This reduces the number of incorrect measurements. It does not matter how far the pixels are away. Typical applications are:

- Filtering image zones with dark objects
- Filtering invalid pixels caused by fog
- Filtering invalid pixels caused by very close objects (< 0.5 m)

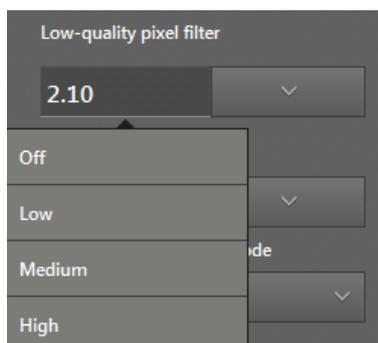


Dark objects are objects that reflect little light in the infrared range (850 nm).

To the human eye, dark objects are often quite visible in the infrared range. How much light an object reflects at 850 nm can be verified in the monitoring screen with the amplitude image (→ „6 Monitoring window“).



Do not use the signal quality filter to track dark objects in the infrared range.



Depending on the setting, the filter works with low, medium or high sensitivity. The higher the sensitivity, the more pixels are filtered and marked as invalid.



Test the ideal filter setting under difficult conditions:

- strong sunlight
- wet surfaces



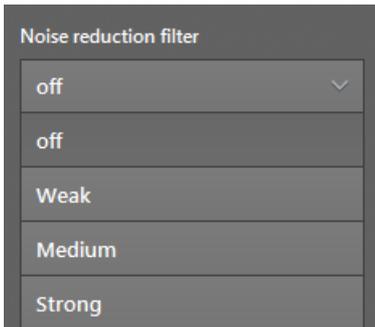
The filtered pixels are invalid (pixel properties set to 0) and cannot be used for applications.



The "signal quality filter" additionally filters noisy pixels with medium and high sensitivity. Do not use the "noise reduction filter" simultaneously since otherwise too many invalid pixels will be filtered.

### 10.4 Noise reduction filter

The "Noise reduction filter" filters pixels with excessive noise. The filter estimates the noise level and the errors that are caused by movements that are too fast.



Depending on the setting, weak, medium or strong noise is filtered. The higher the filter is set, the lower is the decision threshold of the filter.



Test the ideal filter setting under difficult conditions:

- strong sunlight
- wet surfaces



Do not use the noise reduction filter for the following applications:

- counting a specific number of valid pixels,
- following the movement of an object's edges.

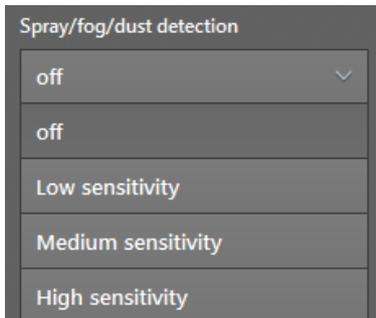


The filters "intelligent data averaging" and "noise reduction filter" can be used simultaneously with the following settings:

- Noise reduction filter set to "weak" or "off"
- Intelligent data averaging set to "high" (→ „10.9 Intelligent data averaging“)

## 10.5 Detection of spray/fog/dust

"Spray/fog/dust detection" can mark recognised pixels as spray/fog/dust (→ „10.1.1 Pixel properties“).



Spray may distort the measurement results. Spray is:

- dust
- humidity / fog
- particle clouds

The distortion of measurement results caused by spray can be reduced by increasing the lateral distance between the device and the illumination unit.



Test the ideal filter setting under difficult conditions:

- strong sunlight
- wet surfaces



When detecting reflectors, the distance between the device and the illumination must be as short as possible. Otherwise, the reflectors will not be properly recognised.



In narrow and closed locations, spray/fog/dust can only be recognised with restrictions.



The pixels recognised as spray, fog or dust are invalid (pixel properties set to 0) and cannot be used for applications.



If more than 30% of the pixels are recognised as spray, fog or dust, the "availability" bit is set to 0 (not available). The status of the bit can be retrieved via the CAN and Ethernet interface. In the interface descriptions, the CAN and Ethernet interfaces are described in detail.

## 10.6 Soiling detection

The "Soiling detection" recognises soiling of the device's front screen. A soiled front screen leads to incorrect measuring results. A dedicated LED regularly checks the permeability of the front screen and detects soiling.

Typical types of soiling are:

- Ice
- Dust
- Humidity/fog/water
- Oil/grease



Soiling of the front screen of the illumination unit is not recognised.

The current degree of soiling is indicated as a percentage value in the status bar in the bottom left corner. In the status bar, "Function available" is displayed if no soiling is detected:



The degree of soiling (warning value) is provided as a percentage value via CAN and can be evaluated in applications.

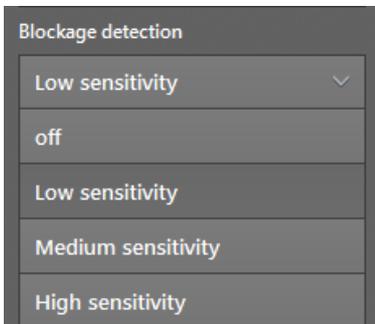


Test the ideal filter setting under difficult conditions:

- strong sunlight
- wet surfaces

### 10.6.1 Setting the sensitivity

Depending on the setting, the filter works with low, medium or high sensitivity.



The following table shows the sensitivity with which soiling is recognised most reliably.

Dirt	Low sensitivity	Medium sensitivity	High sensitivity
Ice	recognised	recognised	recognised
Dead leaves	recognised	recognised	recognised
Dust	partially recognised	recognised	recognised
Humidity/fog/water	not recognised	partially recognised	recognised
Dirt	not recognised	not recognised	recognised



The setting "high sensitivity" detects smallest degrees of soiling and may lead to false alerts. Highly reflective objects close to the device (< 0.5 m) are detected as soiling.

## 10.6.2 Removal of soiling

Depending on the soiling, use one of the following methods of removal:

Dirt	Method of removal
Ice	<ul style="list-style-type: none"> <li>▶ scratch the ice off carefully or</li> <li>▶ wait until the device is warmed up and the ice has melted (depends on the ambient temperature)</li> </ul>
Dust	▶ remove with a damp micro-fibre cloth
Humidity/fog/water	▶ remove with a micro-fibre cloth
Oil/grease	▶ remove using a cleaning agent



Due to the hysteresis, it takes a few seconds after the soiling is removed before "Function available" appears in the status bar.

## 10.7 Frame rate

The "frame rate" of the device, i.e. the frequency with which the images are captured, can be set.



The frame rate is set as Hertz [Hz] frequency. The default value is 50 Hz.



A low frame rate has several advantages:

- low bus load
- low electric power (important factor for battery-operated systems)
- reduced heating of the illumination unit



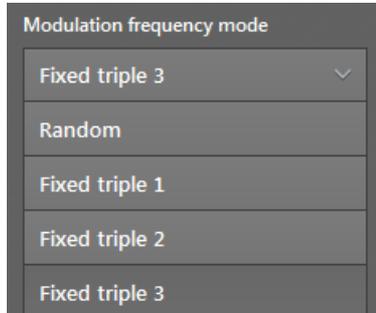
Choose the highest possible frame rate when using the device on mobile machines.

## 10.8 Modulation frequency mode

The "Modulation frequency mode" enables the use of several devices in the same field of view.

Each device uses several modulation frequencies to increase the range. If more than one device is needed for an application, interferences may occur. The devices interfere with each other by using the same modulation frequency.

With the "Modulation frequency mode", you can assign different modulation frequencies to the devices. The modulation frequency is set in the "Modulation frequency mode":



You can choose among the following:

- three frequency sets with fixed default modulation frequencies
- one frequency set with a random choice of modulation frequencies

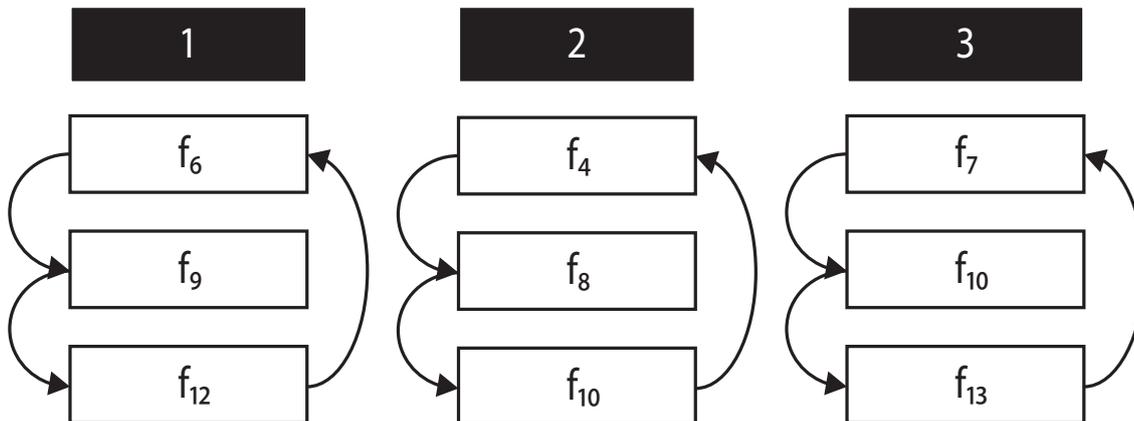


Test the ideal filter setting under difficult conditions:

- strong sunlight
- wet surfaces

### 10.8.1 Fixed modulation frequencies

The fixed frequency sets consist of three modulation frequencies which cannot be changed.



The fixed frequency sets are suited for applications with the following properties:

- fixed device position (no vehicles)
- maximum of three devices in one field of view

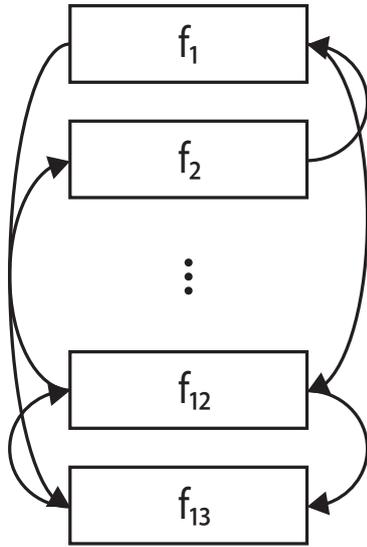


The noise level of the fixed modulation frequencies is lower than the one of the random modulation frequencies (→ „10.8.2 Random modulation frequencies“).

- ▶ Use the fixed modulation frequencies by preference.

## 10.8.2 Random modulation frequencies

The random modulation frequencies apply a method that changes the frequency with each image (arbitrary frequency hopping). The frequencies are selected randomly.



The frequency set with random selection of modulation frequencies is suited for applications with the following properties:

- mobile use of the devices (AGV, drone, vehicles, etc.)
- more than three devices in the field of view



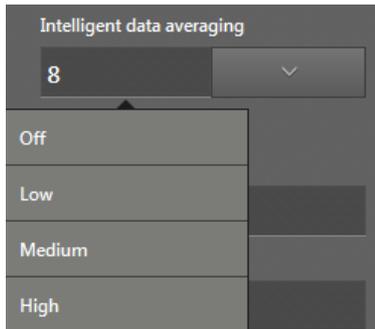
When using the random modulation frequencies, interferences are possible. The interferences are recognised and the affected pixels are marked as invalid.

- ▶ Use the fixed modulation frequencies by preference.

## 10.9 Intelligent data averaging

The "intelligent data averaging" accesses raw data of the device and calculates an average value of the raw data. Typical applications are:

- Signal noise reduction (→ „10.9.2 Example of a signal noise reduction“)
- Increase the number of valid pixels (→ „10.9.3 Example for increasing the number of valid pixels“)
- Compensation of bright sunlight
- Improve the recognition of distant objects
- Improve the recognition of objects with low reflectivity



The set value indicates the number of raw data (frames) that are to be used for the calculation of the average value.



The intelligent data averaging may only be used with fixed modulation frequencies (→ „10.8.1 Fixed modulation frequencies“).



The calculation of the average value causes a motion blur effect.

► Select the "low" setting if the application has objects with high dynamics.



Test the ideal filter setting under difficult conditions:

- strong sunlight
- wet surfaces



The intelligent data averaging can reduce the sensitivity of the noise reduction filter (→ „10.4 Noise reduction filter“).

### 10.9.1 Operating principle

The device can calculate average values in two different ways:

- Basic functions (→ „11 2D overlay“)
- Intelligent data averaging

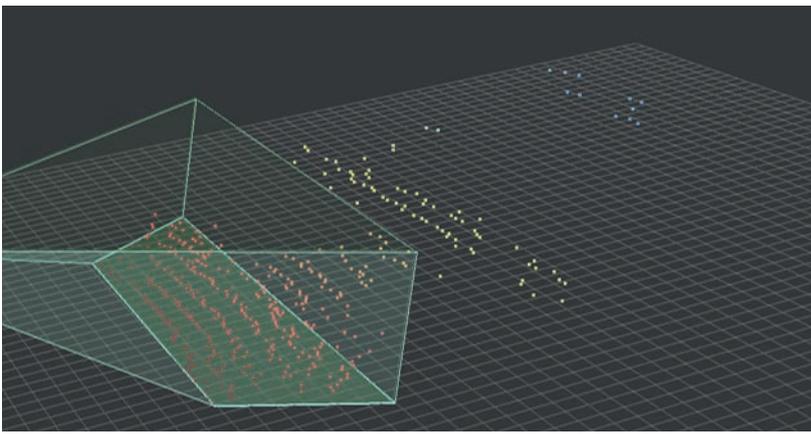
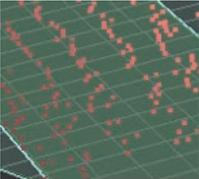
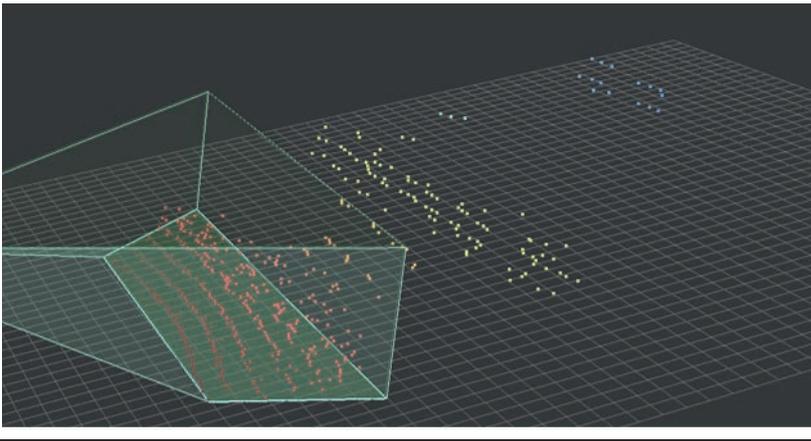
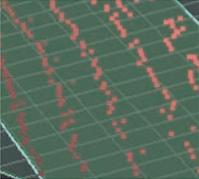
For the calculation of average values via the basic functions, only the valid pixels in an ROI are used.

For the calculation of average values via the intelligent data averaging, the raw data is used. The raw data contains valid and invalid pixels. The intelligent data averaging can make invalid pixels valid again.

### 10.9.2 Example of a signal noise reduction

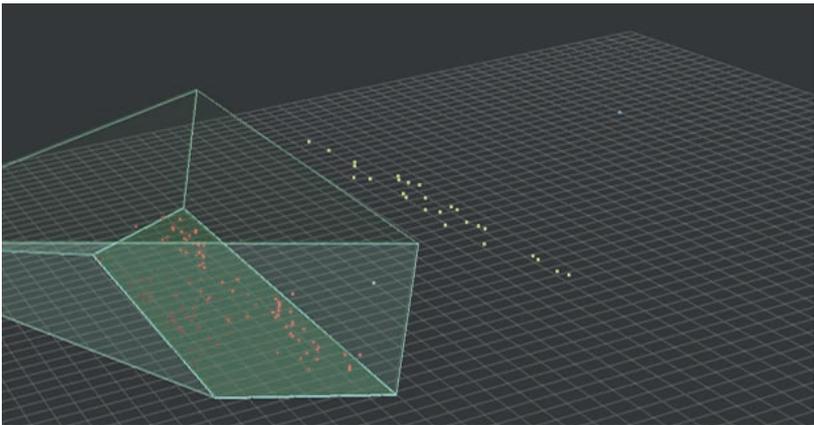
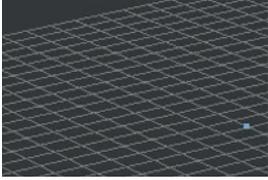
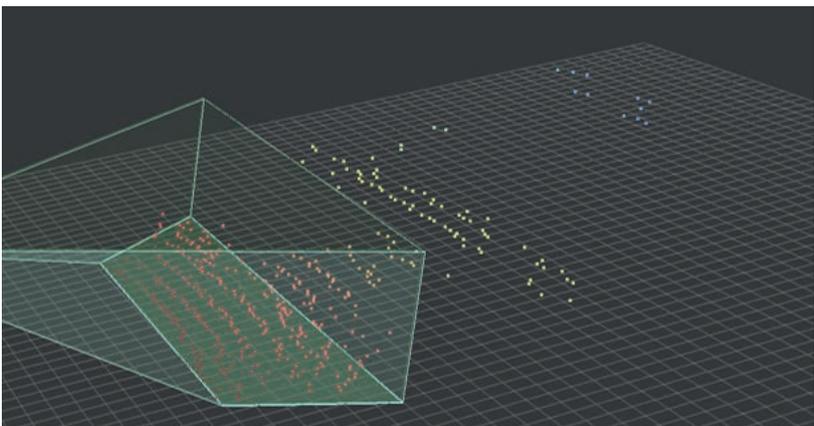
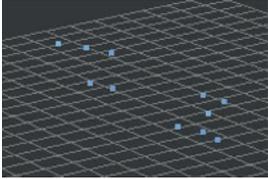
In the following, you will find an example of how the intelligent data averaging reduces the signal noise.



Example	Description
	<p>The device is oriented towards a car park with cars.</p> <p>The distances between the device and cars are indicated by means of the colours (→ „6 Monitoring window“):</p> <ul style="list-style-type: none"> <li>• 1st row of cars in red</li> <li>• 2nd row of cars in yellow</li> <li>• 3rd row of cars in blue</li> </ul>
	<p>Monitoring screen</p> <p>Calculation of the average value with low sensitivity:</p> 
	<p>Monitoring screen</p> <p>Calculation of the average value with high sensitivity:</p>  <p>Result: The signal noise is significantly reduced.</p>

### 10.9.3 Example for increasing the number of valid pixels

In the following, you find an example of how the intelligent data averaging increases the number of valid pixels.

Example	Description
	<p>The device is oriented towards a car park with cars.</p> <p>The distances between the device and cars are indicated by means of the colours (→ „6 Monitoring window“):</p> <ul style="list-style-type: none"> <li>● 1st row of cars in red</li> <li>● 2nd row of cars in yellow</li> <li>● 3rd row of cars in blue</li> </ul>
	<p>Monitoring screen</p> <p>The calculation of the average value is switched off:</p> 
	<p>Monitoring screen</p> <p>Calculation of the average value with low sensitivity:</p>  <p>Result: The number of valid pixels has increased.</p>

## 10.10 Reflector threshold value

The filter "Reflector threshold value" can filter pixels of bright objects. It does not matter how far the pixels are away. Typical applications are:

- Filtering image zones with bright objects



The filter "Reflector threshold value" only works with the firmware "OD - Object Detection and Collision Avoidance" (→ „7.1.3 Firmware update“).

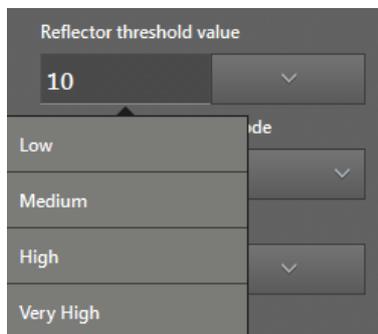


Bright objects are objects that reflect much light in the infrared range. The objects are brighter than white in the infrared range, e.g. a reflector (cat's eye, reflective tape, etc.).

How much light an object reflects can be verified in the monitoring screen with the amplitude image (→ „6 Monitoring window“).



Do not use the reflector threshold value filter to track bright objects in the infrared range.



Depending on the setting, the filter works with a low, medium or very high threshold level. The lower the threshold level, the more pixels are recognised and filtered as a reflector. With a low threshold level, the probability that a pixel is mistaken for a reflector increases.



When detecting reflectors, the distance between the device and the illumination must be as short as possible. Otherwise, the reflectors will not be properly recognised.



Test the ideal filter setting under difficult conditions:

- strong sunlight
- wet surfaces

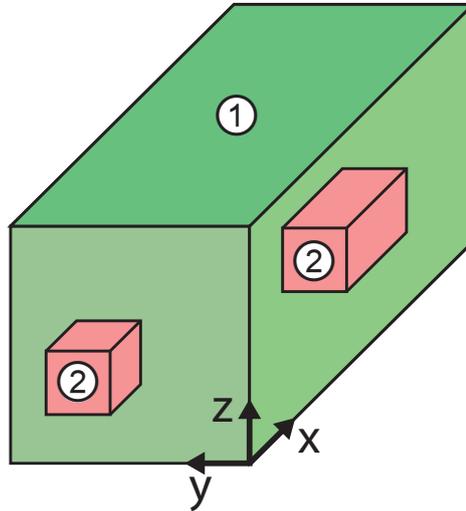
### 10.11 Measuring range

The measuring range ① isolates the data which is to be used for further calculations. If the measuring range ① is set, only the data within the min/max values are used for further calculation. The data outside the min/max values is abandoned and is available for further functions.

#### Setting the measuring range

- ▶ Enter min/max values for the coordinate axes.

Measurement volume	
X Min	0.00 m
X Max	2.00 m
Y Min	-1.00 m
Y Max	1.00 m
Z Min	-1.00 m
Z Max	1.00 m



The measuring range can be displayed and hidden in the monitoring window (→ „6 Monitoring window“).

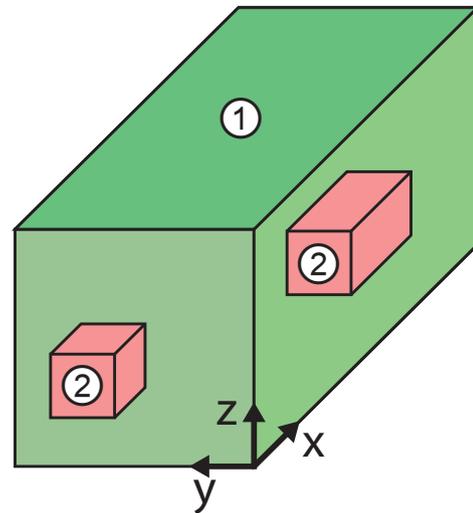
### 10.11.1 Exclusion area

In addition to the measuring range, up to two exclusion areas ② can be set within the measuring range ①. The data within the min/max values are excluded from further calculations. This ignores, for example, attachments in the visible range.

#### Setting exclusion areas

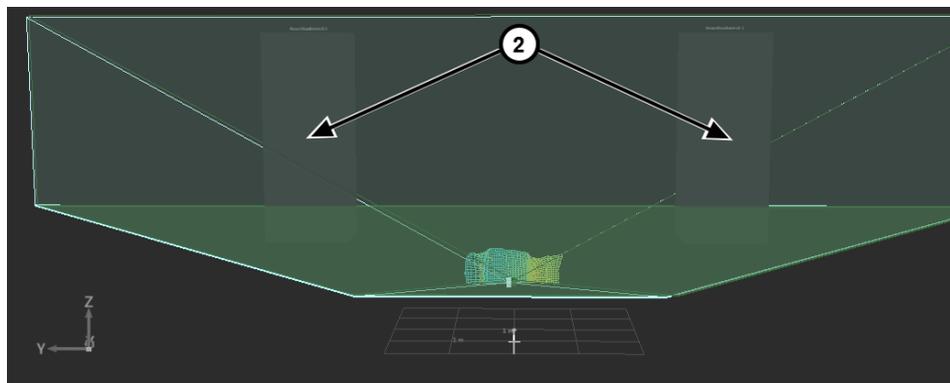
► Enter min/max values for the coordinate axes.

Exclusion volume 1	Exclusion volume 2
X Min 0.00 m	X Min 0.00 m
X Max 0.00 m	X Max 0.00 m
Y Min 0.00 m	Y Min 0.00 m
Y Max 0.00 m	Y Max 0.00 m
Z Min 0.00 m	Z Min 0.00 m
Z Max 0.00 m	Z Max 0.00 m



UK

The exclusion areas ② are displayed in the monitoring window:



 Set the exclusion area a bit larger than the objects to be excluded. Thereby, measuring errors on object edges caused by mixed pixels are excluded by further calculations.

 If the 3D pixel data is transmitted via Ethernet, the spatial filtering is marked in the confidence interval. The originally measured 3D pixel data is additionally available.

## 11 2D overlay

The 2D overlay is a function which is available for each firmware.



Some functions of the 2D overlay require a specific type of firmware (→ „7.1.3 Firmware update“).

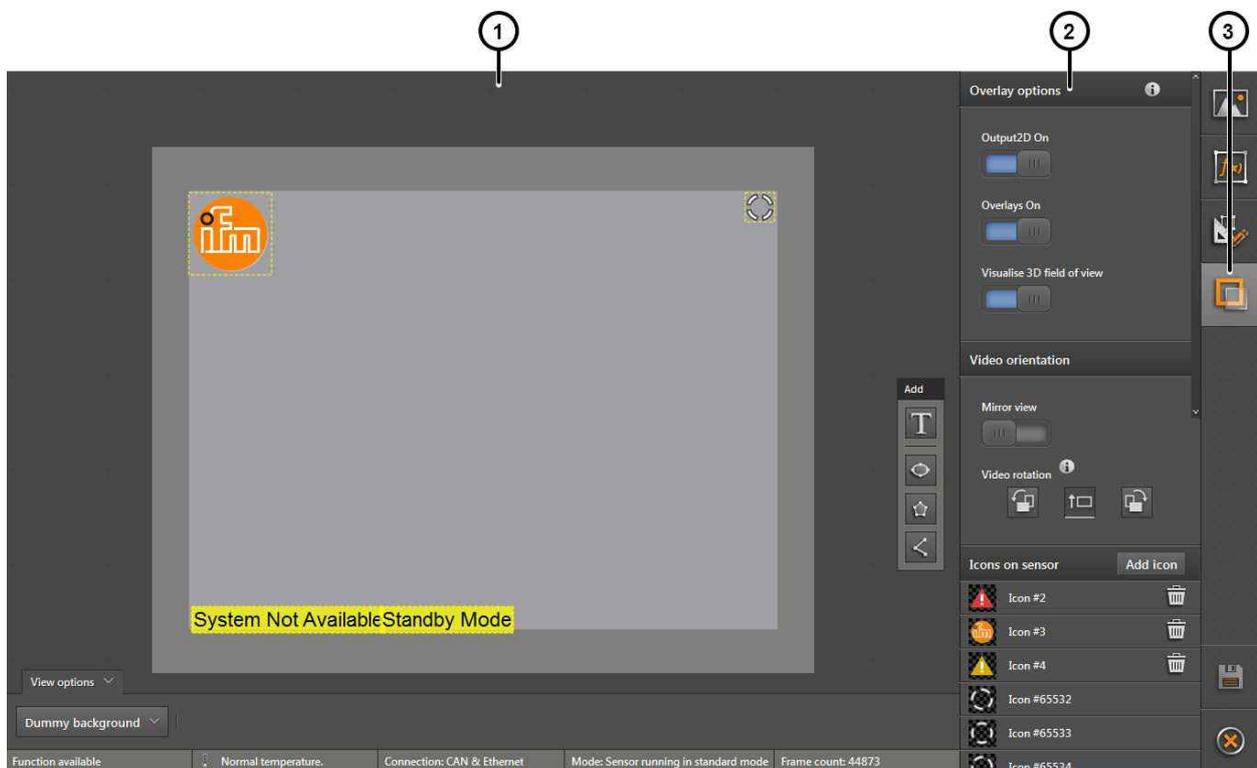


The 2D overlay is only available for the O3M2xx devices.

The 2D camera of the O3M2xx displays a 2D image of the application. With the 2D overlay, the output of the 2D image can be set. Additionally, the following elements can be shown as an overlay in the 2D image:

- Graphics (logos, warning symbols, etc.)
- Text (system status, distance information, etc.)
- Vectors (ellipses, polygons, polylines)

Each element has its own ID. The visibility of the elements can be adjusted in many ways.

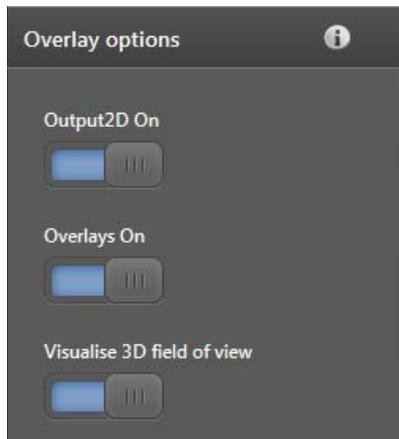


The 2D overlay is divided into three areas:

- 1: Preview of the 2D overlay
- 2: Settings: Functions

## 11.1 Overlay options

With the "overlay options", the way the 2D image is displayed can be set.



The "2D output on" switch activates the output of the 2D image. If the switch is in the off position, no image is provided via the analogue video interface of the device.

The "Overlay on" switch activates the overlay. If the switch is in the off position, only the 2D output is displayed (provided that the 2D output is activated).

The switch "Visualise 3D field of view" activates the visualisation of a frame in the 2D overlay which indicates the 3D measuring range. The angle of aperture of the 3D measuring range is smaller on the vertical axis.



Due to perspective distortions, the display of the 3D measuring range is merely an indicator.

## 11.2 Pallet

The "pallet" is used to add texts, vectors (ellipses, polygons, polylines) and images to the 2D overlay.



The pallet contains 4 buttons:

The [Add text] button adds a configurable text to the 2D overlay (→ „11.2.1 Add text“).

The [Add ellipse] button adds a configurable ellipse to the 2D overlay (→ „11.2.2 Adding a vector“).

The [Add polygon] button adds a configurable polygon to the 2D overlay (→ „11.2.2 Adding a vector“).

The [Add polyline] button adds a configurable polyline to the 2D overlay (→ „11.2.2 Adding a vector“).

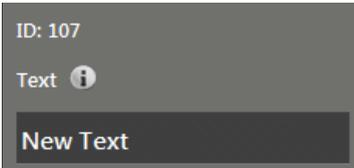
### 11.2.1 Add text



The [Add text] button changes the mouse pointer into a cross hair. After that, a text can be added to the "Preview of the 2D overlay" by clicking.



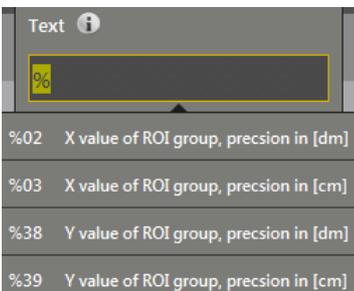
By clicking on , the text can be edited and the following window opens.



The text has the ID 107. Each text has its own ID.  
In the "text" field, the text to be displayed can be edited.



In the "text" field, the variables can be used in the form of text replacement codes (→ „16.2 Text replacements and conditional codes“).



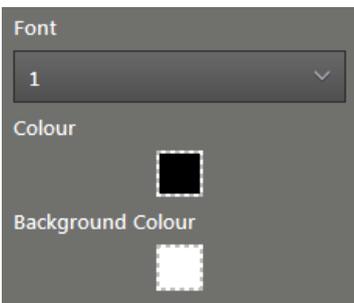
The text replacement codes start with a "%". By entering the "%" in the text field, a selection list opens that features the available text replacement codes. Several text replacement codes additionally require entering an ID (e.g. the ROI group number).



The functions of the selected text replacement code are shown by clicking.

The available text replacement codes depend on the installed firmware.

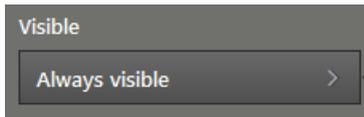
Only one text replacement code can be used per text field.



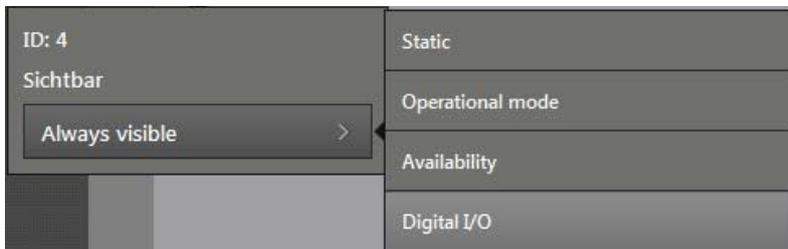
4 fonts are available for the text design. The fonts differ in shape and size.

With the "Colour" field, the text colour can be changed.

With the "Background colour" field, the background colour of the text can be changed.



In the list "Visible", the visibility of the text can be set.



The visibility of the text can be coupled to the conditions of the device.

UK



The available conditions depend on the installed firmware (→ „7.1.3 Firmware update“).

The following conditions are available in each firmware:

- Static
- Operation Mode
- Availability
- Digital I/O

Clicking on  deletes the text.

## 11.2.2 Adding a vector

The following buttons add a vector to the "Preview of the 2D overlay":



[Add ellipse]: After clicking on the button, the mouse pointer changes into a cross hair. After clicking on the button, the mouse pointer changes into a cross hair.



[Add polygon]: After clicking on the button, the mouse pointer changes into a cross hair. Then, the polygon can be drawn in the "Preview of the 2D overlay" by holding the mouse button.



Drawing the polygon can be quit by double-clicking the mouse button.



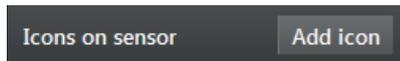
[Add polyline]: After clicking on the button, the mouse pointer changes into a cross hair. Then, the polyline can be drawn in the "Preview of the 2D overlay" by holding the mouse button.



Drawing the polyline can be quit by double-clicking the mouse button.

### 11.2.3 Adding a graphic.

The following buttons add a graphic to the "Preview of the 2D overlay".



The [Add] button opens the file selection which is used to add further graphics to the selection shown below.



The selection shows all graphics stored on the device.

The graphics "Icons #2", "Icons #3" and "Icons #4" are already stored on the device when delivered. Each added graphic is shown below the icon. Each graphic includes its own ID (e.g.: "#65532").

The following graphic formats are supported:  
png, jpg, bmp, ico and gif.

 Graphics with transparency are only possible in png format.

With the symbol , the graphic is deleted from the selection and from the device.

After clicking on the graphic in the selection, the mouse pointer turns into a cross hair. Then, the graphic in the 2D overlay is shown in the "Preview of the 2D overlay".

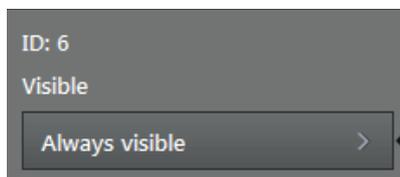
The graphics can be edited in the "Preview of the 2D overlay":

- move the graphic by holding the mouse button,
- scale the graphic by clicking on the corner dots.

 The graphic is always scaled at a fixed aspect ratio. The graphic can only be scaled up to its original size.

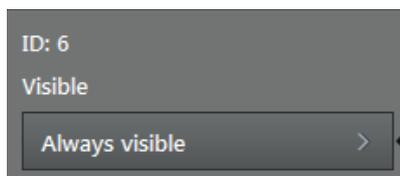


By clicking on , the graphic can be edited and the following window opens.

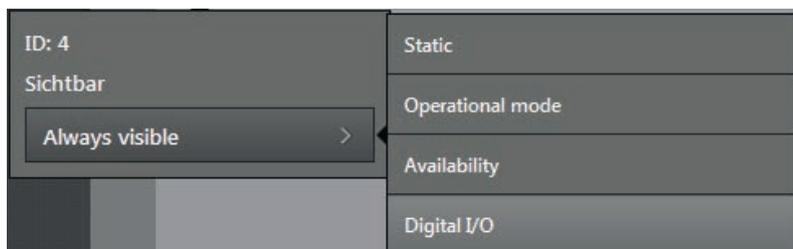


The graphic has the ID 6. Each graphic has an own ID.

 The graphics are directly saved on the device. Thereby, the graphics can be controlled via CAN. To control them, the IDs are required.



In the list "visible", the visibility of the graphic can be set.



The visibility of the graphic can be coupled to the different conditions of the device.

 The available conditions depend on the installed firmware (→ „7.1.3 Firmware update“).

The following conditions are available in each firmware:

- Static
- Operation Mode
- Availability
- Digital I/O

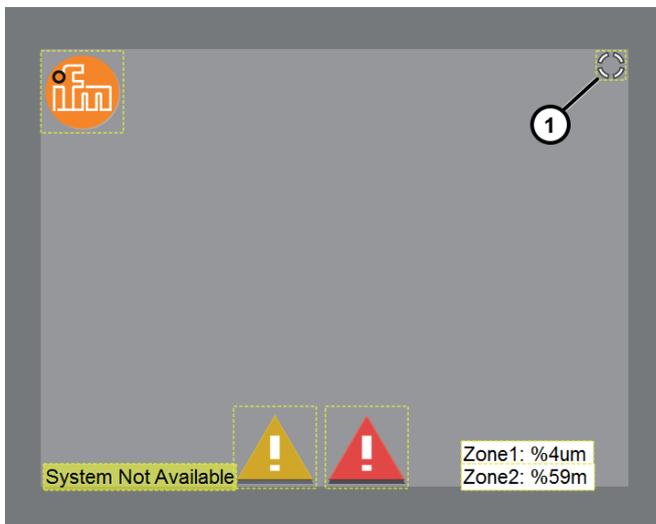
By clicking on , the graphics is deleted from the selection, but it stays in the device.

 With the symbol , the graphic is deleted from the selection and from the device.

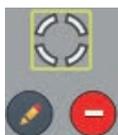


### 11.2.4 Live ticker

The live ticker  shows at a glance whether the video image is active.



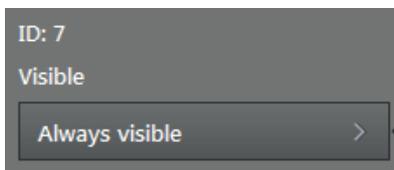
If the video image is active, the live ticker is turning in the top right corner in the "Preview of the 2D overlay" (1).



The live ticker can be edited in the "Preview of the 2D overlay":

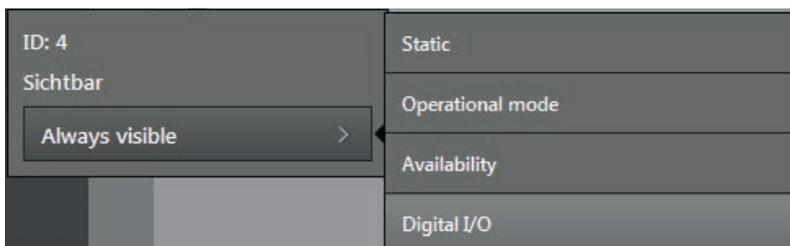
- Move the live ticker by holding the mouse button.

By clicking on , the live ticker can be edited and the following window opens.



The ID of the live ticker is 7.

In the list "Visible", the visibility of the live ticker can be set.



The visibility of the text can be coupled to the different conditions of the device.



The available conditions depend on the installed firmware (→ „7.1.3 Firmware update“).

The following conditions are available in each firmware:

- Static
- Operation Mode
- Availability
- Digital I/O

Clicking on  deletes the live ticker. The live ticker can be restored.



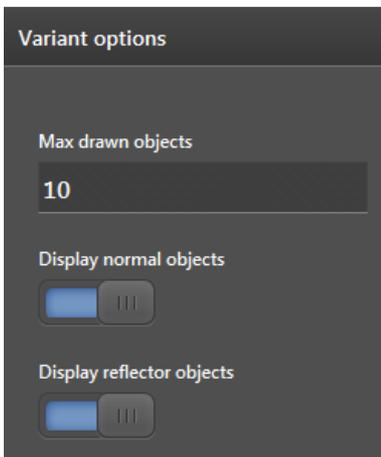
To restore the live ticker, click on an icon of the live ticker in the selection. The mouse pointer turns into a cross hair. Then, the live ticker in the 2D overlay is shown in the "Preview of the 2D overlay".

### 11.3 Variant options of the OD firmware

The variant options contain options to display 3D objects in the 2D overlay.



The available options depend on the installed firmware (→ „7.1.3 Firmware update“). The following options require the OD firmware object detection.



In the field "Max. drawn objects", the maximum number of normal objects and reflector objects which are simultaneously indicated with the 2D overlay can be entered. If more objects are recognised as are specified in the "Max drawn objects" field, the objects at the shortest distance will be indicated with priority. If "Display reflector objects" is activated, reflector objects are shown with priority.

The switch "Display normal objects" activates the visualisation of normal objects in the 2D overlay.

The switch "Display reflector objects" activates the visualisation of reflector objects in the 2D overlay.



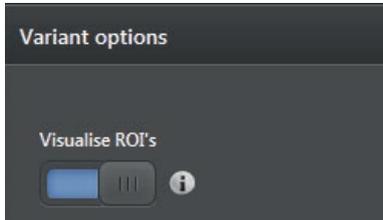
For the visualisation of reflector objects in the 2D overlay, the 3D reflector recognition must be active. The 3D reflector recognition can be activated in the object recognition application.

## 11.4 Variant options of the DI firmware

The variant options contain options to display 3D objects in the 2D overlay.

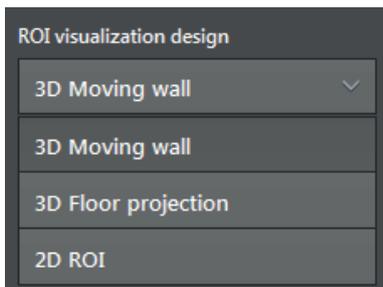


The available options depend on the installed firmware (→ „7.1.3 Firmware update“). The following options require the DI firmware basic functions.



With the variant options of the DI firmware, Regions of Interest (ROI) are shown and configured in the 2D overlay.

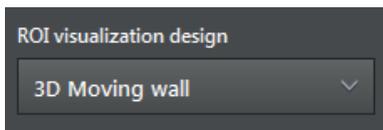
The switch "Visualise ROIs" activates the visualisation of ROIs in the 2D overlay.



In the list "ROI visualization design", the way the ROIs are visualised can be set. The following types of visualisation are available:

- [3D moving wall] (→ „11.4.1 Visualising 3D ROIs as a moving wall“)
- [3D projection floor projection] (→ „Colour mode [Colour map]“)
- [2D ROI] (→ „11.4.3 Visualisation of 2D ROIs“)

### 11.4.1 Visualising 3D ROIs as a moving wall

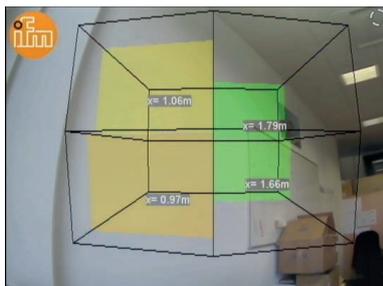


The ROI visualisation type "3D moving wall" shows the provision of the ROI groups in the x, y and z axis (length, width and height) as a coloured overlay. The coloured overlay is visualised as a wall.

"Output" refers to the measuring result of the ROI group (→ „12.2 Global settings“).



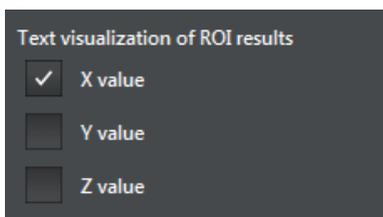
The ROI visualisation type "3D moving wall" is only suitable for three-dimensionally defined ROIs (→ „12.1 ROI mode“).



In the figure on the left, the output of 4 ROI groups is visualised as a coloured overlay and the X values as a text.

[Colour map] is set as "colour mode".

The "3D ROI frame" is set to [black].

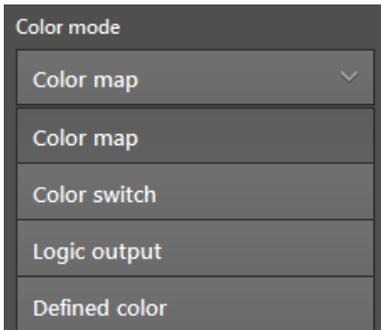


The output of the ROI group can additionally be shown as text. In "text visualisation ROI results", the control fields can be activated:

- X value
- Y value
- Z value



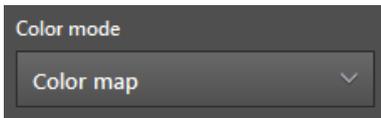
The text fields can overlap if several ROI groups are provided at the same time.



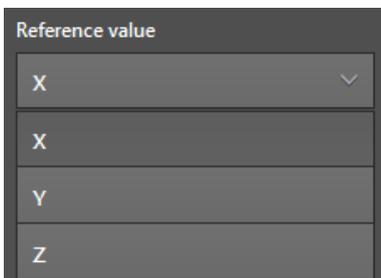
In the list "colour mode", the behaviour of the colours of the colour overlay can be set. The following colour modes are available:

- [Colour map]  
The colour changes with the set reference value.
- [Colour switch]  
After a threshold value is reached, there is a change between 2 colours.
- [Logic output]  
The colour changes according to the condition of the virtual digital outputs of the ROI groups.
- [Defined colour]  
The colour setting is fixed and does not change.

Colour mode [Colour map]



In the colour mode [Colour map], the colour changes with the set reference value.

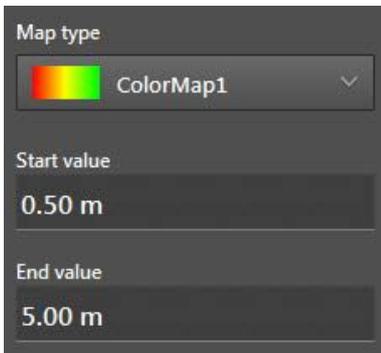


The "reference value" defines with which ROI group output the moving wall shifts. The following reference values can be selected:

- [X] - The moving wall is projected in the Y-Z level and moves with the reference value X.
- [Y] - The moving wall is projected in the X-Z level and moves with the reference value Y.
- [Z] - The moving wall is projected in the Y-X level and moves with the reference value Z.



The reference value additionally defines which ROI group output is used as basis for the colouring of the moving wall.

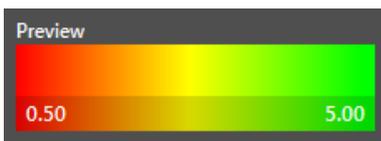


The "Map type" defines the type of the colour gradient. You can choose among the following:

- Colour map 1
- Colour map 1 mirrored
- Colour map 2
- Colour map 2 mirrored

A start and end value can be set:

- Output of the ROI group < start value: The colour of the start value is used.
- Output of the ROI group > end value: The colour of the end values is applied.



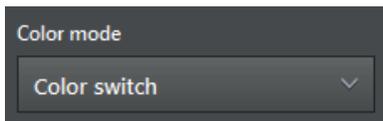
The "preview" graphically shows the set colour map in combination with the start and end value.



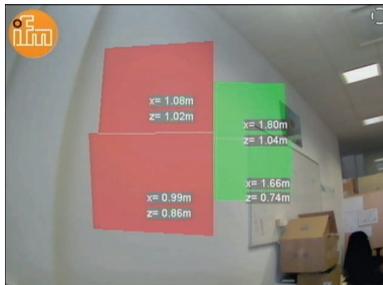
The "3D ROI frame" is configurable:

- By activating the control field, the "3D ROI frame" is shown.
- By clicking on the colour field, the colour of the "3D ROI frame" can be changed.

Colour mode [Colour switch]



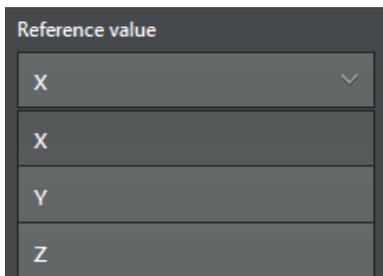
In the colour mode [Colour switch], there is a change between 2 colours when a threshold is reached.



In the figure on the left, the output of 4 ROI groups and the X and Z values are visualised as a colour change.

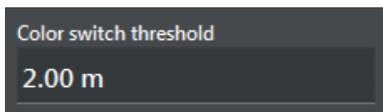
[Colour switch] is set as colour mode.

The "3D ROI frame" is deactivated.



The "reference value" defines the output of the ROI group which the threshold value takes as a reference. The following reference values can be selected:

- [X] - The moving wall is projected in the Y-Z level and moves with the reference value X.
- [Y] - The moving wall is projected in the X-Z level and moves with the reference value Y.
- [Z] - The moving wall is projected in the Y-X level and moves with the reference value Z.



The "colour switch threshold" defines the threshold for the colour change. The threshold value is based on the set reference value.



The "colour direction" determines what is to happen when the threshold is exceeded or not reached. Change from

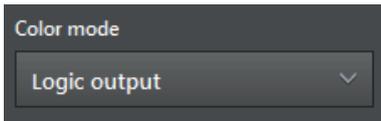
- [read to green]
- [green to read]



The "3D ROI frame" is configurable:

- By activating the control field, the "3D ROI frame" is shown.
- By clicking on the colour field, the colour of the "3D ROI frame" can be changed.

Colour mode [Logic output]

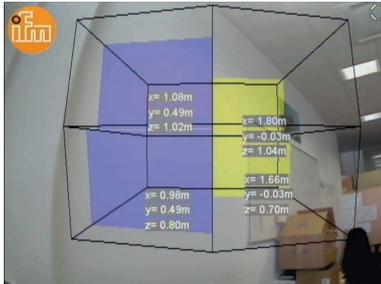


In the colour mode [Logic output] the colour changes in relation to the condition of the virtual digital outputs of the ROI groups.



When using the standard logic of the device, the virtual output with the number of the ROI group is used.

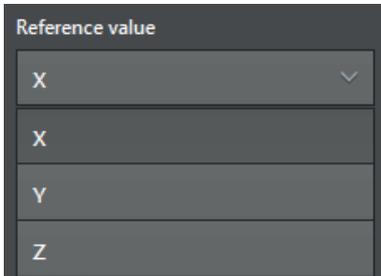
- ▶ Ensure that the numbering of the virtual outputs is correct if a logic is used that you have defined yourself.



In the figure on the left, the output of 4 ROI groups and the X and Y values are visualised as a logic output.

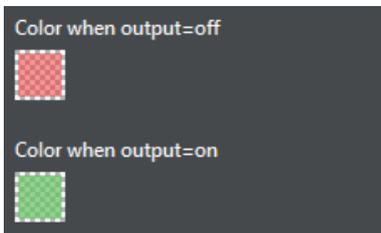
[Logic output] is set to "colour mode".

The "3D ROI frame" is set to [black].



The "reference value" defines with which ROI group output the moving wall shifts. The following reference values can be selected:

- [X] - The moving wall is projected in the Y-Z level and moves with the reference value X.
- [Y] - The moving wall is projected in the X-Z level and moves with the reference value Y.
- [Z] - The moving wall is projected in the Y-X level and moves with the reference value Z.



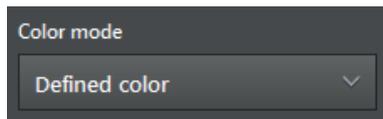
The colour fields "Color when output=off" and "Color when output=on" determine how the moving wall is visualised for the 2 possible conditions.



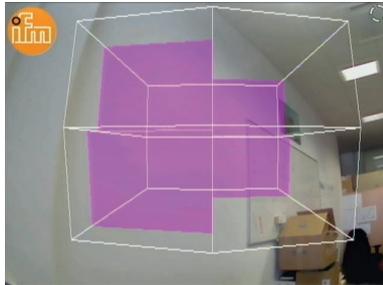
The "3D ROI frame" is configurable:

- By activating the control field, the "3D ROI frame" is shown.
- By clicking on the colour field, the colour of the "3D ROI frame" can be changed.

## Colour mode [defined colour]



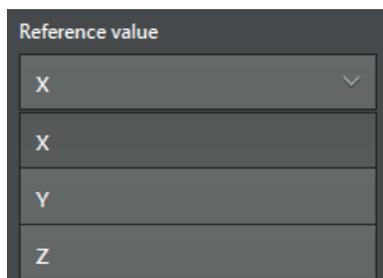
In the colour mode [defined colour], the colour setting is fixed and does not change.



In the figure on the left, the outputs of 4 ROI groups are shown as defined colour.

[Defined colour] is set as "colour mode".

The "3D ROI frame" is shown in [white].

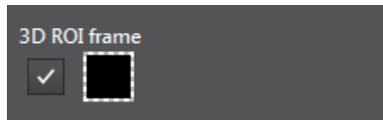


The "reference value" defines with which ROI group output the moving wall shifts. The following reference values can be selected:

- [X] - The moving wall is projected in the Y-Z level and moves with the reference value X.
- [Y] - The moving wall is projected in the X-Z level and moves with the reference value Y.
- [Z] - The moving wall is projected in the Y-X level and moves with the reference value Z.



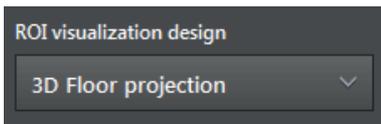
The "fixed colour" determines the defined colour for the moving wall. The the setting of the colour of the moving wall is fixed and does not change.



The "3D ROI frame" is configurable:

- By activating the control field, the "3D ROI frame" is shown.
- By clicking on the colour field, the colour of the "3D ROI frame" can be changed.

### 11.4.2 Visualisation of 3D ROIs as a projection on the floor



The ROI visualisation type "3D floor projection" shows the provision of the ROI groups in the x, y and z axis (length and width) as a coloured overlay. The coloured overlay is visualised as a projection on the floor.

"Output" refers to the measuring result of the ROI group (→ „12.2 Global settings“).

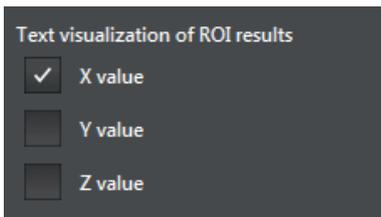
-  The ROI visualisation type "3D floor projection" is only suitable for:
- three-dimensionally defined ROIs (→ „12.1 ROI mode“),
  - ROIs lying next to each other (x and y axis) (not suited for ROIs stacked on top of each other (z axis)).



In the figure on the left, the provision of 2 ROI groups is visualised as a coloured overlay on the floor and the X values as a text.

[Colour map] is set as "colour mode".

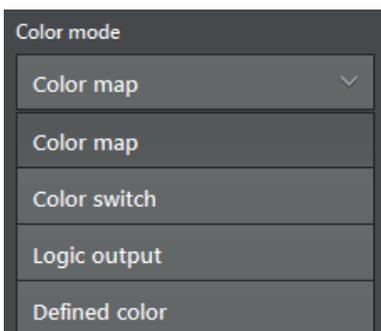
The "moving reference line" is set to [white].



The output of the ROI group can additionally be shown as text. In "text visualisation ROI results", the control fields can be activated:

- X value
- Y value
- Z value

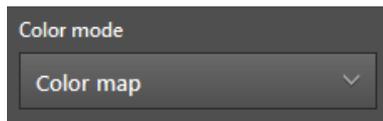
 The text fields can overlap if several ROI groups are provided at the same time.



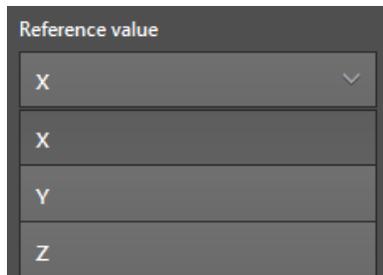
In the list "colour mode", the behaviour of the colours of the colour overlay can be set. The following colour modes are available:

- [Colour map] The colour changes with the set reference value.
- [Colour switch] After a threshold value is reached, there is a change between 2 colours.
- [Logic output] The colour changes according to the condition of the virtual digital outputs of the ROI groups.
- [Defined colour] The colour setting is fixed and does not change.

## Colour mode [Colour map]



In the colour mode [Colour map], the colour changes with the set reference value.

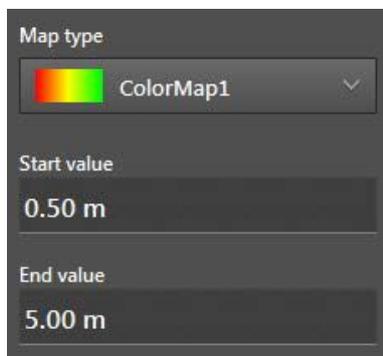


The "reference value" defines with which output of the ROI group the "moving reference line" shifts. The following reference values can be selected:

- [X] - The "moving reference line" is projected in the Y-Z level and moves with the reference value X.
- [Y] - The projection on the floor is projected in the X-Z level and moves with the reference value Y.
- [Z] - The projection on the floor is projected in the Y-X level and moves with the reference value Z.



The reference value additionally defines which provision of the ROI group is used as basis for the projection on the floor.

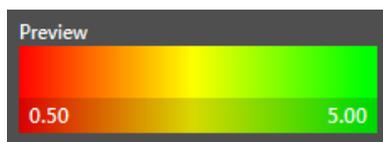


The "Map type" defines the type of the colour gradient. You can choose among the following:

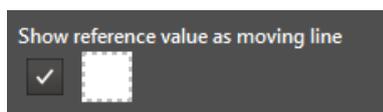
- Colour map 1
- Colour map 1 mirrored
- Colour map 2
- Colour map 2 mirrored

A start and end value can be set:

- Output of the ROI group < start value: The colour of the start value is used.
- Output of the ROI group > end value: The colour of the end values is applied.



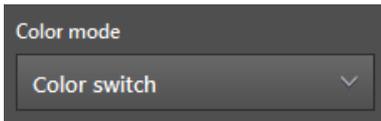
The "preview" graphically shows the set colour map in combination with the start and end value.



The "moving reference line" shows the output of the ROI groups graphically as a line in the projection on the floor. The "moving reference line" can be set:

- By activating the control field, the "moving reference line" is shown.
- By clicking on the colour field, the colour of the "moving reference line" can be changed.

Colour mode [Colour switch]



In the colour mode [Colour switch], there is a change between 2 colours when a threshold is reached.

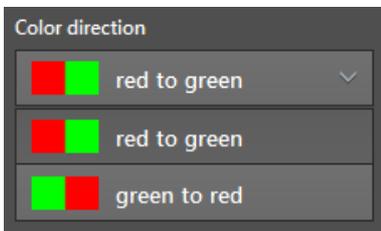


The "reference value" defines with which ROI group output the "moving reference line" shifts. The following reference values can be selected:

- [X] - The "moving reference line" is projected in the Y-Z level and moves with the reference value X.
- [Y] - The projection on the floor is projected in the X-Z level and moves with the reference value Y.
- [Z] - The projection on the floor is projected in the Y-X level and moves with the reference value Z.

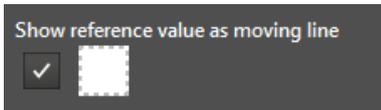


The "colour switch threshold" defines the threshold for the colour change. The threshold value is based on the set reference value.



The "colour direction" determines what is to happen when the threshold is exceeded or not reached. Change from

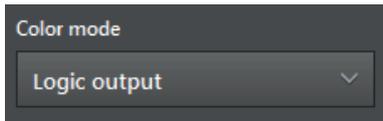
- [read to green]
- [green to read]



The "moving reference line" shows the output of the ROI groups graphically as a line in the projection on the floor. The "moving reference line" can be set:

- By activating the control field, the "moving reference line" is shown.
- By clicking on the colour field, the colour of the "moving reference line" can be changed.

Colour mode [Logic output]



In the colour mode [Logic output] the colour changes in relation to the condition of the virtual digital outputs of the ROI groups.



When using the standard logic of the device, the virtual output with the number of the ROI group is used.

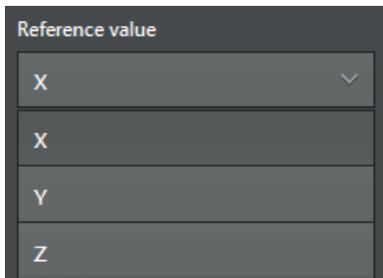
- ▶ Ensure that the numbering of the virtual outputs is correct if a logic is used that you have defined yourself.



In the image on the left, the outputs of 24 ROI groups are shown as logic output.

[Logic output] is set to "colour mode".

The "reference value" is set to [Z].

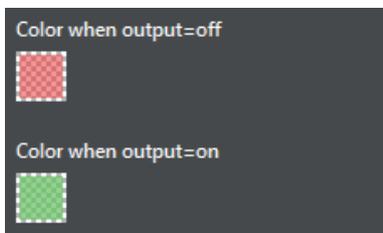


The "reference value" defines with which ROI group output the "moving reference line" shifts. The following reference values can be selected:

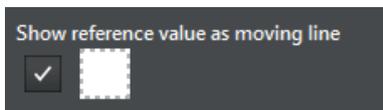
- [X] - The "moving reference line" is projected in the Y-Z level and moves with the reference value X.
- [Y] - The projection on the floor is projected in the X-Z level and moves with the reference value Y.
- [Z] - The projection on the floor is projected in the Y-X level and moves with the reference value Z.



The reference value additionally defines which provision of the ROI group is used as basis for the projection on the floor.



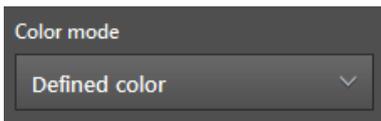
The colour fields "Color when output=off" and "Color when output=on" determine how the projection on the floor is visualised for the 2 possible conditions.



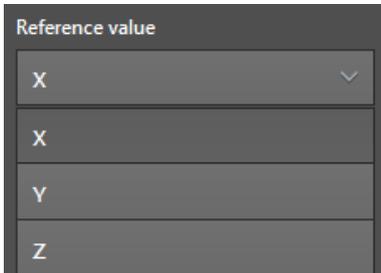
The "moving reference line" shows the output of the ROI groups graphically as a line in the projection on the floor. The "moving reference line" can be set:

- By activating the control field, the "moving reference line" is shown.
- By clicking on the colour field, the colour of the "moving reference line" can be changed.

Colour mode [defined colour]



In the colour mode [defined colour], the colour setting is fixed and does not change.

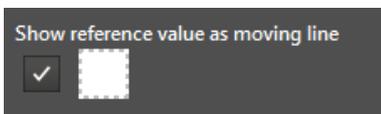


The "reference value" defines with which ROI group output the "moving reference line" shifts. The following reference values can be selected:

- [X] - The "moving reference line" is projected in the Y-Z level and moves with the reference value X.
- [Y] - The projection on the floor is projected in the X-Z level and moves with the reference value Y.
- [Z] - The projection on the floor is projected in the Y-X level and moves with the reference value Z.



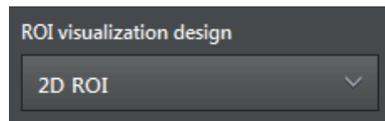
The "fixed colour" determines the defined colour for the projection on the floor. The setting of the colour of the projection on the floor is fixed and does not change.



The "moving reference line" shows the output of the ROI groups graphically as a line in the projection on the floor. The "moving reference line" can be set:

- By activating the control field, the "moving reference line" is shown.
- By clicking on the colour field, the colour of the "moving reference line" can be changed.

### 11.4.3 Visualisation of 2D ROIs

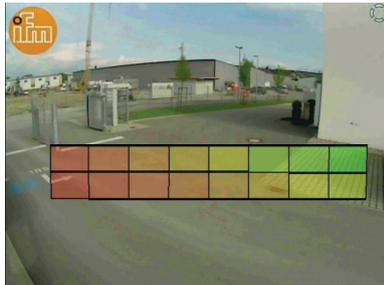


The ROI visualisation type "2D ROI" visualises the output of the ROI group as a coloured overlay.

"Output" refers to the measuring result of the ROI group (→ „12.2 Global settings“).



The ROI visualisation type "2D ROI" is only suitable for two-dimensionally defined ROIs (→ „12.1 ROI mode“).

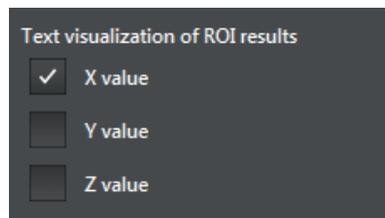


In the image on the left, the outputs of 16 2D ROI groups are shown as a coloured overlay.

[Colour map] is set as "colour mode".

The "reference value" is set to [X].

The "3D ROI frame" is set to [black].



The output of the ROI group can additionally be shown as text. In "text visualisation ROI results", the control fields can be activated:

- X value
- Y value
- Z value



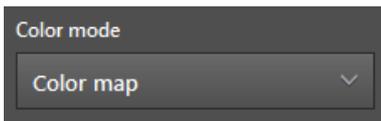
The text fields can overlap if several ROI groups are provided at the same time.



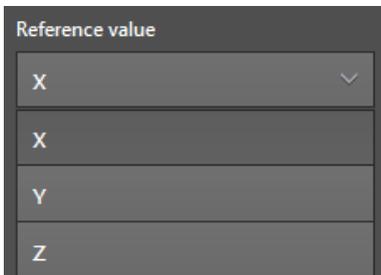
In the "colour mode" list, the behaviour of the colours of the colour overlay can be set. The following colour modes are available:

- [Colour map]  
The colour changes with the set reference value.
- [Colour switch]  
After a threshold value is reached, there is a change between 2 colours.
- [Logic output]  
The colour changes according to the condition of the virtual digital outputs of the ROI groups.

Colour mode [Colour map]

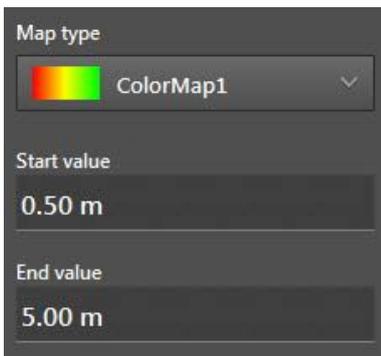


In the colour mode [Colour map], the colour changes with the set reference value.



The "reference value" defines which output of the ROI groups is used as a basis for the colouring of the overlay. The following reference values can be selected:

- [X]
- [Y]
- [Z]



The "Map type" defines the type of the colour gradient. You can choose among the following:

- Colour map 1
- Colour map 1 mirrored
- Colour map 2
- Colour map 2 mirrored

A start and end value can be set:

- Output of the ROI group < start value: The colour of the start value is used.
- Output of the ROI group > end value: The colour of the end values is applied.



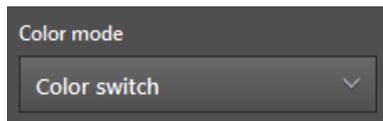
The "preview" graphically shows the set colour map in combination with the start and end value.



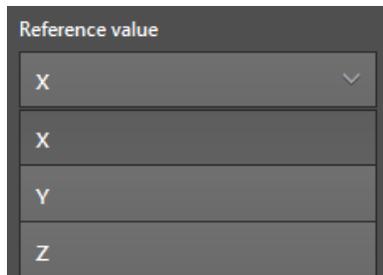
The "2D ROI frame" is configurable:

- By activating the control field, the "2D ROI frame" is shown.
- By clicking on the colour field, the colour of the "2D ROI frame" can be changed.

## Colour mode [Colour switch]



In the colour mode [Colour switch], there is a change between 2 colours when a threshold is reached.

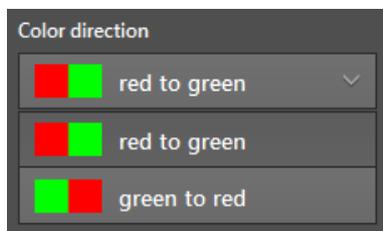


The "reference value" defines which output of the ROI groups is used as a basis for the colouring of the overlay. The following reference values can be selected:

- [X]
- [Y]
- [Z]



The "colour switch threshold" defines the threshold for the colour change. The threshold value is based on the set reference value.



The "colour direction" determines what is to happen when the threshold is exceeded or not reached. Change from

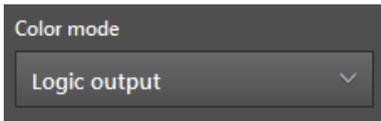
- [read to green]
- [green to read]



The "2D ROI frame" is configurable:

- By activating the control field, the "2D ROI frame" is shown.
- By clicking on the colour field, the colour of the "2D ROI frame" can be changed.

Colour mode [Logic output]



In the colour mode [Logic output] the colour changes in relation to the condition of the virtual digital outputs of the ROI groups.



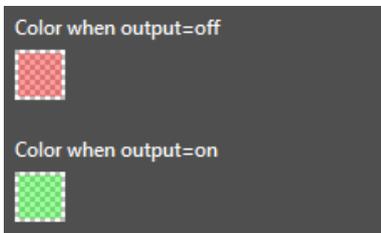
When using the standard logic of the device, the virtual output with the number of the ROI group is used.

- ▶ Ensure that the numbering of the virtual outputs is correct if a logic is used that you have defined yourself.

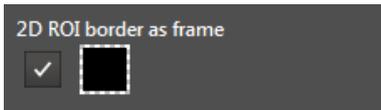


The "reference value" defines which output of the ROI groups is used as a basis for the colouring of the overlay. The following reference values can be selected:

- [X]
- [Y]
- [Z]



The colour fields "Color when output=off" and "Color when output=on" determine how the projection on the floor is visualised for the 2 possible conditions.



The "2D ROI frame" is configurable:

- By activating the control field, the "2D ROI frame" is shown.
- By clicking on the colour field, the colour of the "2D ROI frame" can be changed.

## 12 DI firmware - basic functions

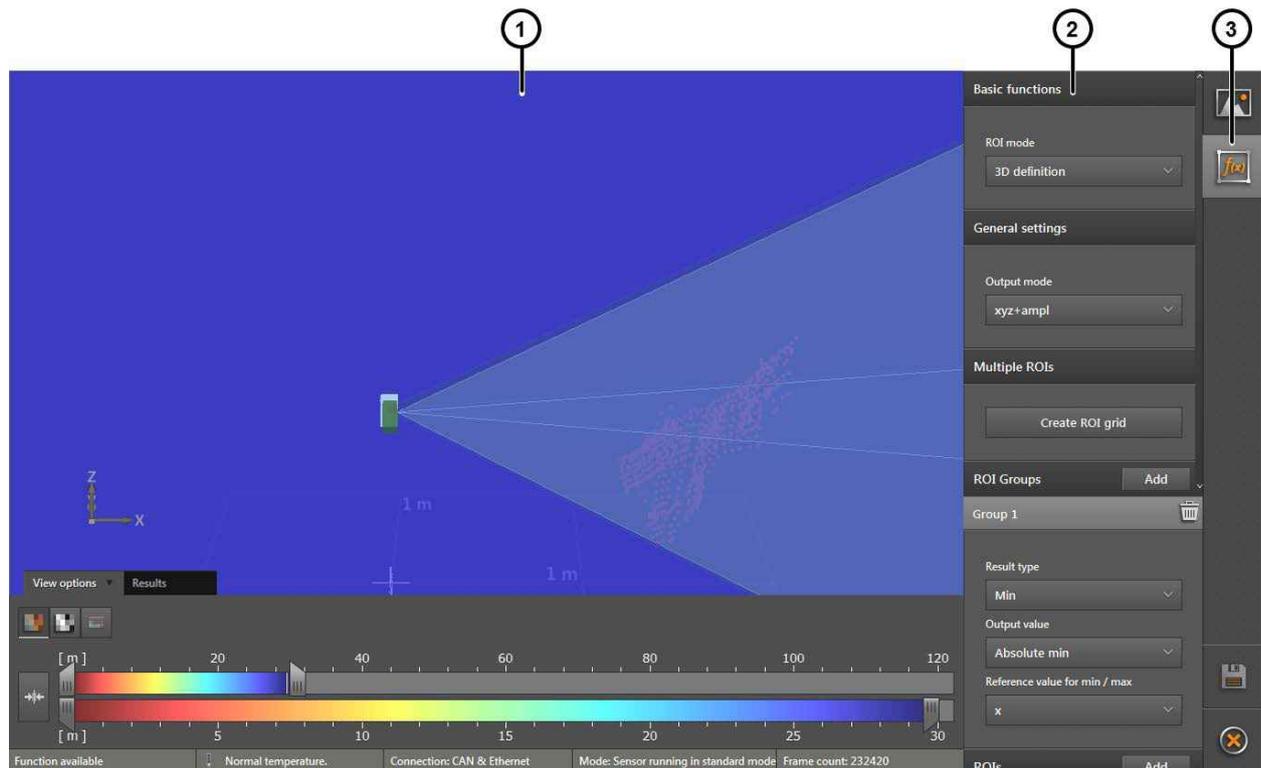
The basic functions are a function of the DI firmware (→ „7.1.3 Firmware update“). With the basic functions

- the ROIs can be set up (region of interest),
- the ROIs can be grouped together,
- the result types and the output values of the groups can be set.

ROIs are image zones and contain the pixels to be processed. An ROI or several ROIs are grouped together. The pixels contained in the groups are used together for calculations.



The programming manual "Basic functions" contains detailed information about the ROIs and groups.

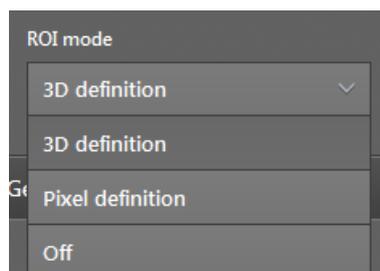


The basic functions are divided into three areas:

- 1: Live image display (→ „10.1 Live image display“)
- 2: Settings: Functions

### 12.1 ROI mode

With the "ROI mode", the class of the ROIs can be set.



Only one class can be active at a time. There are two different classes of ROIs:

- 3D definition (preset)
- Pixel definition
- off

The "3D definition" works with 3D data. The applied ROIs are defined in the world coordinate system. For the 3D definition, devices with 3D capabilities, such as the O3M151, are required.

The "pixel definition" works with 2D data. The applied ROIs are defined two-dimensionally on the basis of the pixels.

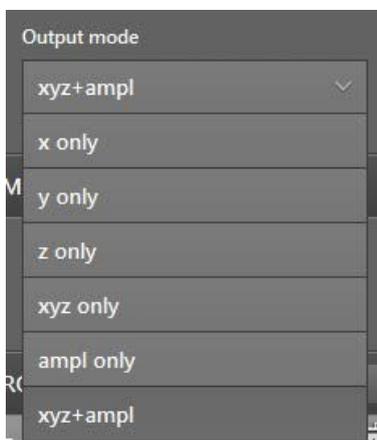
"Off" completely deactivates the ROIs. The following settings are not available.



The separate programming manual "basic functions" contains further information about which ROI mode is appropriate for which application.

## 12.2 Global settings

With the "Global settings", the output of the ROI groups can be set. "Output" signifies the measuring result per ROI group.



The following trigger sources can be set:

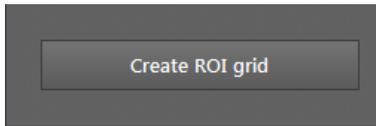
- xyz+ampl: the three coordinate axes and the amplitude
- x only: the x coordinate axis
- y only: the y coordinate axis
- z only: the z coordinate axis
- xyz only: the three coordinate axes
- ampl only: the amplitude



The set output applies to all defined ROI groups. ROIs that are already set are deleted when the global settings are changed.

## 12.3 Several ROIs

With "Several ROIs", a three-dimensional grid of ROIs is generated.



The button [Create ROI grid] opens the following window with which a grid of several ROIs can be created.

The dialog box 'Generate ROI grid' contains the following fields and options:

- 1**: A group of three input fields for 'X min' (0.50 m), 'X max' (10.00 m), and 'X splits' (1).
- 2**: A dropdown menu for 'Result type' set to 'Min'.
- 3**: A dropdown menu for 'Output value' set to 'Absolute min'.
- 4**: A dropdown menu for 'Reference value for min / max' set to 'x'.
- 5**: A dropdown menu for 'Existing ROIs' set to 'Replace'.
- 6**: A dropdown menu for 'Select group options' set to 'Individual group'.

At the bottom of the dialog are 'Generate' and 'Cancel' buttons.

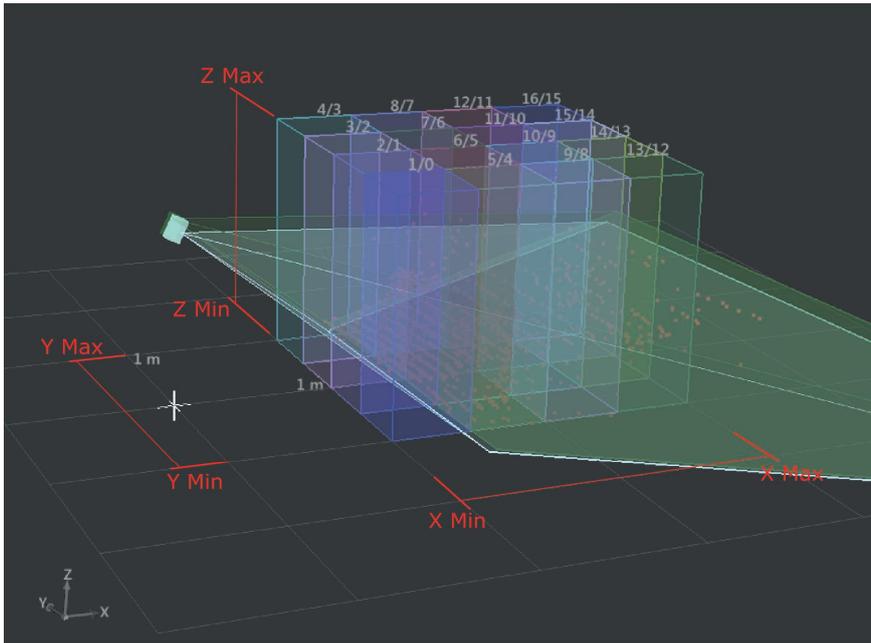
The window is divided into six areas:

1. With "min/max values", the position of the grid in the world coordinate system is indicated. The "X/Y/Z separation" indicates the division of the grid and hence the number of ROIs (→ „12.3.1 Min/max values and separation“).
2. With "Result type", the result type for the pixels of the ROI group can be set (→ „12.3.2 Result type“).
3. With "Output values" the properties of the result type can be set. The term "Output value" changes according to the set result type (→ „12.3.3 Output value“).
4. With "Reference value for min/max", the output value is limited by only providing certain values in relation to the reference value (→ „12.3.4 Reference value for min/max“).
5. With "Existing ROIs" you can set what is supposed to happen with ROIs which exist before the ROI grid is set (→ „12.3.5 Existing ROIs“).
6. With "Select group option" the division of ROIs into groups can be set (→ „12.3.6 Select group option“).

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### 12.3.1 Min/max values and separation

The following figure shows the effect of the settings on the ROI grid.



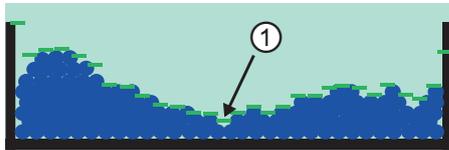
The "min/max values" for the x, y and z axis indicate the position of the grid in the world coordinate system. The three axes are marked in red in the figure above. The origin of the coordinate system is marked with a white cross. The grid of the level has a division of 1 m.

The x, y, and z division separates the grid into ROIs.

### 12.3.2 Result type

With the "result type", the result type for the pixels of the ROI group is set. For each ROI group, one of the following results can be set:

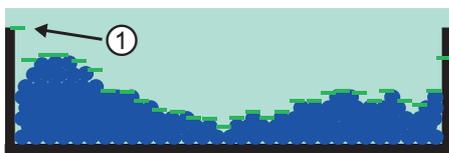
- [Min]



The figure on the left shows the result type "Min" with a 3D grid made of ROIs. The result is marked with ①.



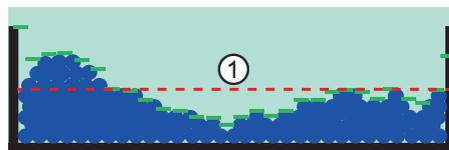
- [Max]



The figure on the left shows the result type "Max" with a 3D grid made of ROIs. The result is marked with ①.



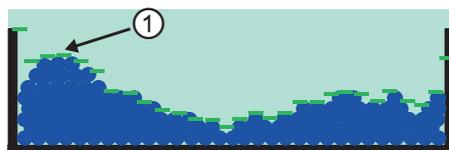
- [Mean value]



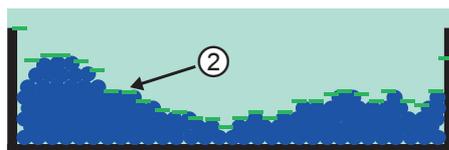
The figure on the left shows the result type "mean value" with a 3D grid made of ROIs. The result is marked with ①.



- [Percentile]



The figure on the left shows the result type "Percentile" with a 3D grid made of ROIs.  $P_1 = 90\%$  is marked with ① (30 pixels).



The figure on the left shows the result type "Percentile" with a 3D grid made of ROIs.  $P_2 = 50\%$  is marked with ② (30 pixels).



### 12.3.3 Output value

The field changes according to the set "result type".

- Result type "min":

The screenshot shows a configuration window with two sections. The top section, labeled 'Result type', has a dropdown menu currently set to 'Min'. The bottom section, labeled 'Output value', contains a list of six options: 'Absolute min', 'Absolute min', '2nd lowest', '3rd lowest', '4th lowest', and '5th lowest'.

The following output values can be provided:

- [Absolute min]
- [2nd lowest]
- [3rd lowest]
- [4th lowest]
- [5th lowest]

- Result type "max":

The screenshot shows a configuration window with two sections. The top section, labeled 'Result type', has a dropdown menu currently set to 'Max'. The bottom section, labeled 'Output value', contains a list of six options: 'Absolute max', 'Absolute max', '2nd highest', '3rd highest', '4th highest', and '5th highest'.

The following output values can be provided:

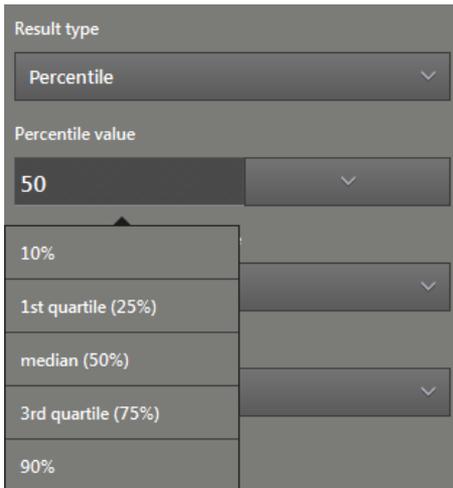
- [Absolute max]
- [2nd highest]
- [3rd highest]
- [4th highest]
- [5th highest]

- Result type "average value":

The screenshot shows a configuration window with two sections. The top section, labeled 'Result type', has a dropdown menu currently set to 'Avg'. The bottom section, labeled 'Min number of valid pixels', has a text input field containing the number '1'.

for the result type "average value" (Avg), the minimum number of valid pixels can be set which are necessary for the average value output.

• Result type "percentile":



For the result type "percentile", the percentile value can be set.

A percentile is, like the quantile, a threshold value, but in case of the percentile, the distribution is given as a percentage. The result type "percentile" helps when answering the question "What percentage of the pixels have a lower or identical value?".

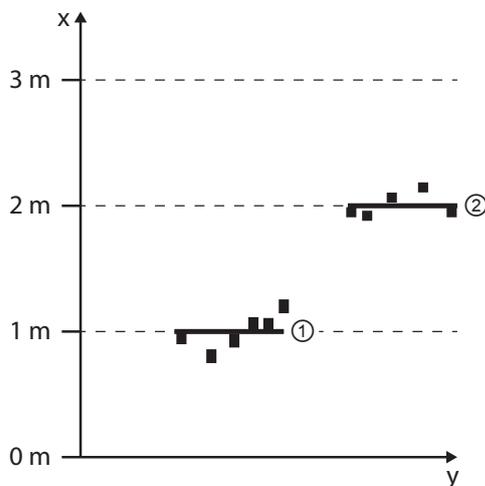
The result type "percentile" has the following values:

- robust against outliers
- scales with different pixel quantities of the ROI group
- enables a primitive statistical evaluation of the pixel quantity. For example, by placing two superimposable ROIs with different percentile values (25% and 75%):
  - the pixel dispersion can be estimated,
  - outliers can be detected.

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By clicking on the arrow  on the right next to the percentile value, a list with typical values opens.

 Use the "Percentile" result type only if the object of interest consists of more than one pixel.



Exemplary applications for the result type "percentile":

The distance between wall ① and wall ② is to be defined (see figure on the left).

For wall ①, the percentile value "1st quartile 25 %" is used.

For wall ②, the percentile value "3rd quartile 75 %" is used.

The result type "percentile" calculates the correct distance between the walls with an error rate of <1 %.

 If you try to approximate the result via the min/max values, an error rate of ~50 % is possible.

$$P_d = 100 \% / N$$
$$P_n = P_d \pm P_d * 0.5$$

Define percentile values

In the following, the definition of percentile values is explained.

N: Number of the sets to be expected  
(in the example above: Set = number of walls = 2)

$P_d$ : Intermediate values

$P_n$ : Percentile values

In the first step, the 100 % are divided by the number of sets:

$$P_d = 100 \% / 2 = 50 \%$$

In the second step,  $P_d$  is divided in half and the result to  $P_d$  is added or subtracted:

$$P_1 = 50 \% + 25 \% = 75 \%$$

$$P_2 = 50 \% - 25 \% = 25 \%$$

The percentile values are 25 % and 75 %.

### 12.3.4 Reference value for min/max

With "Reference value for min/max", the output value is limited by only providing certain values in relation to the reference value.

The "reference value for min/max" refers to the set result type (→ „12.3.2 Result type“) and output value (→ „12.3.3 Output value“).

One pixel contains four values: x, y, z and amplitude.



The following reference values can be set

- [Independent]
- [x]
- [y]
- [z]
- [Amplitude]

#### Example:

- Set result type: "min"
- Set output value: "absolute min"
- Set reference value for min/max:"x"

The values of a pixel whose x-value is minimal is provided.

#### Example:

- Set result type: "min"
- Set output value: "absolute min"
- Set reference value for min/max: "independent"

The minimum values are provided without any assignation to the pixel.

#### Example:

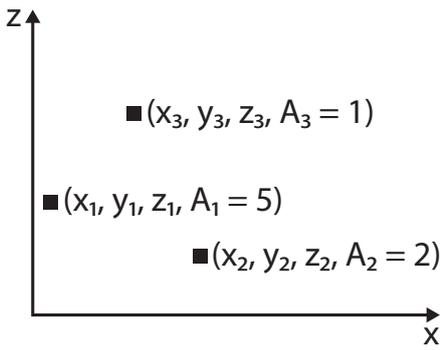
- Set result type: "min"
- Set output value: "absolute min"
- Set reference value for min/max: "y"

One pixel contains four values: x, y, z and amplitude. The following pixels are available as 3D data:

Pixel	x	y	z	Amplitude
1	1	2	3	1000
2	2	1	5	580
3	1.5	3	1	2030

The pixel 2 is provided since the reference value is set to "y" and only the absolute min values are considered.

**Example:**



- Set result type: "min"
  - Set output value: "absolute min"
  - Set reference value for min/max:"x"
- The pixel  $(x_1, y_1, z_1, A_1)$  is provided.

- Set result type: "min"
  - Set output value: "absolute min"
  - Set reference value for min/max: "z"
- The pixel  $(x_2, y_2, z_2, A_2)$  is provided.

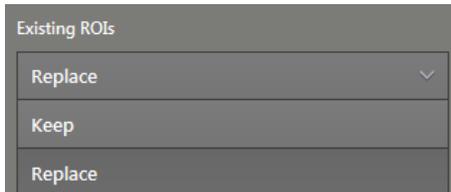
- Set result type: "min"
  - Set output value: "absolute min"
  - Set reference value for min/max:"amplitude"
- The pixel  $(x_3, y_3, z_3, A_3)$  is provided.

- Set result type: "min"
  - Set output value: "absolute min"
  - Set reference value for min/max: "independent"
- The value  $(x_1, y?, z_2, A_3)$  is provided.

 The y value is not shown in the diagram.

### 12.3.5 Existing ROIs

With "Existing ROI" you can set what is supposed to happen with ROIs which exist before the ROI grid is set.

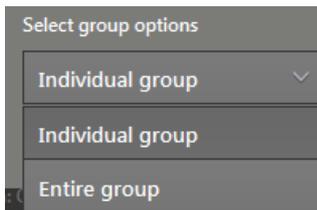


The following behaviour can be set:

- "Replace": Already existing ROIs are deleted.
- "Keep": Already existing ROIs are kept.

### 12.3.6 Select group option

With "Select group options", the division of ROIs into groups can be set.

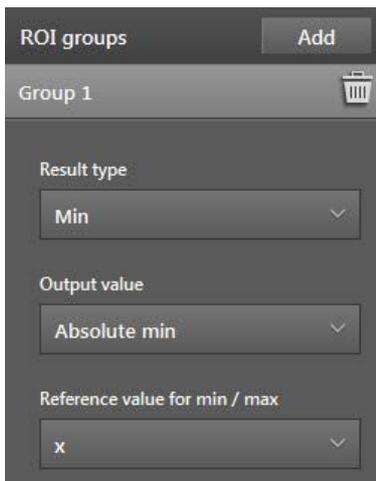


The following behaviour can be set:

- "Individual group": A separate ROI is created for each group.
- "Entire group": All ROIs are bundled in one group.

## 12.4 ROI groups

With "ROI groups", ROIs can be bundled in groups.



For each ROI group, the following settings can be defined:

- With "Result type", the result type for the pixels of the ROI group can be set (→ „12.3.2 Result type“).
- With "Output values" the properties of the result type can be set. The term "Output value" changes according to the set result type (→ „12.3.3 Output value“).
- With "Reference value for min/max", the output value is limited by only providing certain values in relation to the reference value (→ „12.3.4 Reference value for min/max“).

Several ROI groups can be created.



The [Add] button creates a new ROI group. The existing ROI groups are displayed below each other.



With the left mouse button you can select an ROI group. The selected ROI group is highlighted light grey.



The [Recycle bin] button deletes the ROI group.

## 12.5 ROIs

With the "ROIs", new ROIs can be set up. The ROIs are assigned to the ROI groups (→ „12.4 ROI groups“).

ROIs are image zones and contain the pixels to be processed. An ROI or several ROIs are grouped together. The pixels contained in the groups are used together for calculations.



An ROI is set up via the x, y and z values in the world coordinate system. The volume of interest within the coordinate axes is used for the ROI.



The [Add] button creates a new ROI.

The x, y, and z values of the new ROI are entered in the world coordinate system.



With the left mouse button, an ROI can be selected. The selected ROI is highlighted light grey.



The [Shift] button shifts the ROI to a new or existing ROI group.



The [Recycle bin] button deletes the ROI.

**!** If the assigned ROI group only contains this ROI, the ROI group will be deleted.

## 13 Firmware OD - object detection

The object detection is a function of the OD firmware (→ „7.1.3 Firmware update“). The object detection detects objects and classifies them according to the setting.

The object detection detects two different types of objects:

- Normal objects (no or only little reflection)
- Reflectors (high reflection)

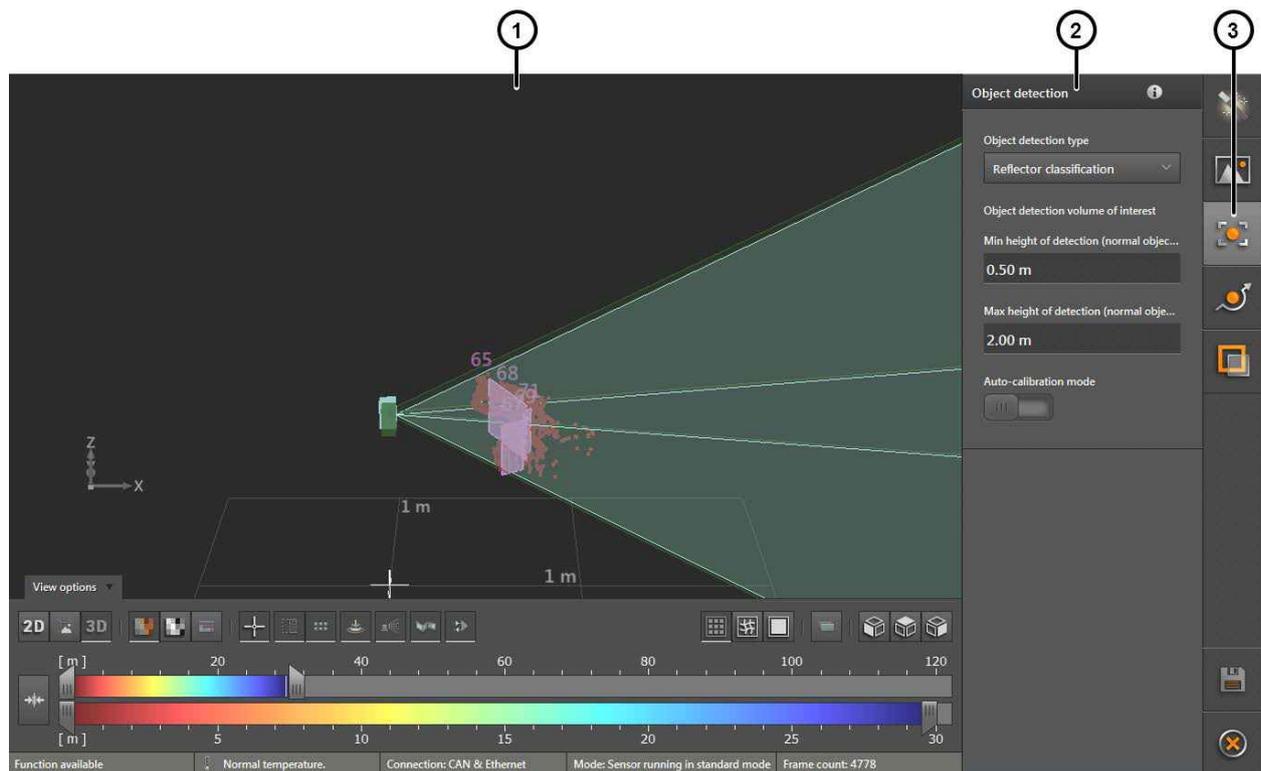
The following applications can be set via a Wizard:

- Guidance of an automated guided vehicle (AGV):  
The distance and the speed between the AGVs are controlled.
- Area monitoring:  
All objects or only reflectors are monitored within a defined zone.
- Collision avoidance:

Information about the speed and the movements of objects is recognised to prevent collisions. If the CAN data of the vehicle is provided, the accuracy of the collision avoidance can be improved.

### 13.1 Object recognition

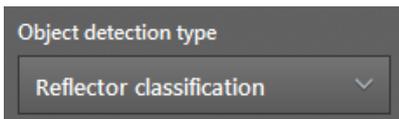
The application "Object detection" can recognise and classify objects.



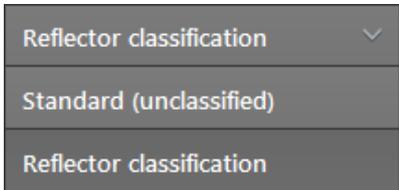
The object recognition is divided into three areas:

- 1: Live image display (→ „10.1 Live image display“)
- 2: Settings: Functions

The following settings are available for the object recognition.



With the object detection type, you can set which objects are to be detected and classified.

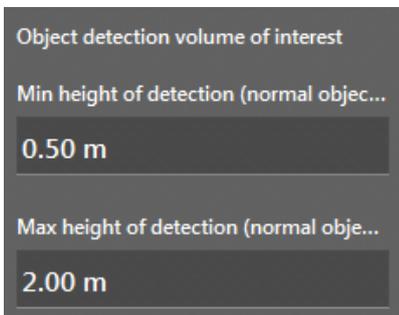


The following object detection types can be set:

- Standard (unclassified)
- Reflector classification

The object detection type [Standard (unclassified)] detects all objects irrespectively of the reflectivity. The detected objects are not classified.

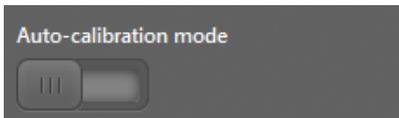
The object detection type [Classification by reflector] detects all objects irrespectively of the reflectivity. The detected reflectors are classified, normal objects are not classified.



With the "Spatial filter for object generation", the data that is used for the detection of normal objects can be limited.

If a minimum and maximum height is set, only the data within the min/max values is used for the detection of objects. The data outside the min/max values is abandoned and is available for further functions.

 The setting only has an effect on normal objects. Reflectors are recognised regardless of this setting.



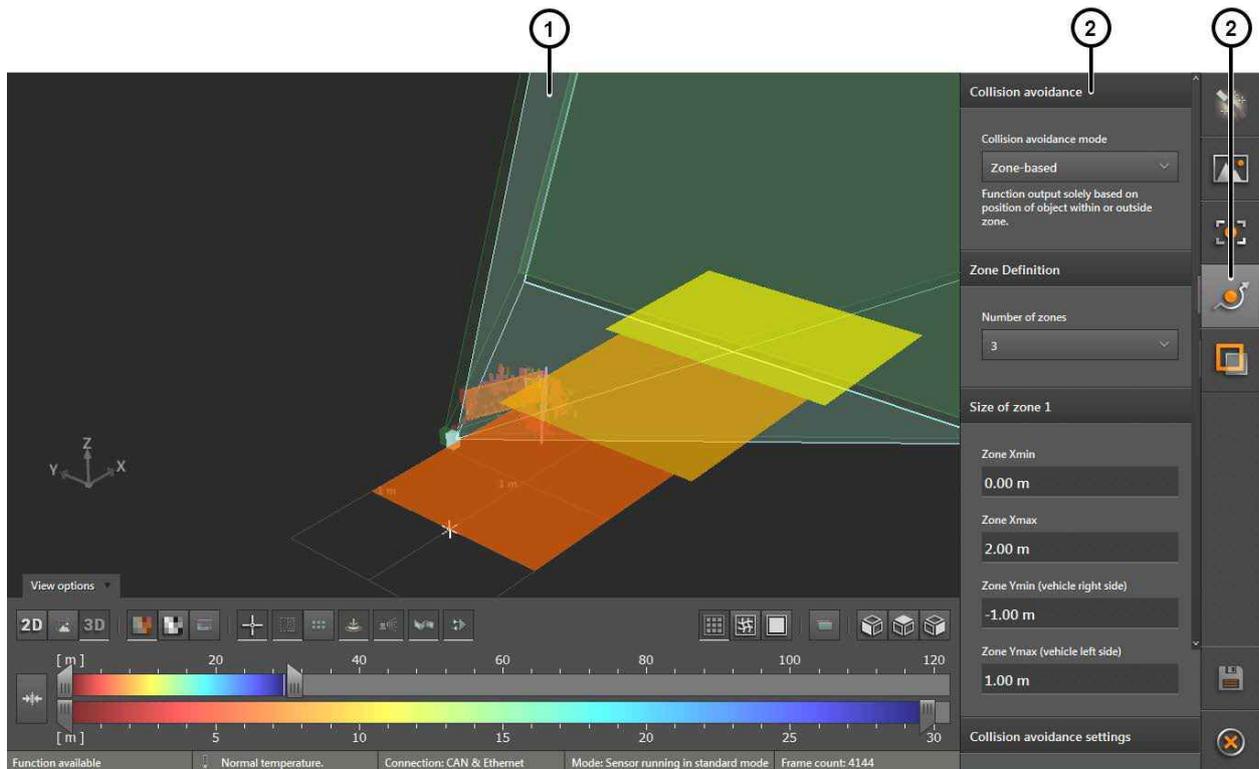
The switch "Auto calibration mode" corrects the following parameters of the device during the object detection:

- angle of pitch
- angle of roll
- height

 The auto calibration mode works very slowly. This is why the auto calibration mode is only used when the object detection is supposed to detect objects that move slowly.

## 13.2 Collision avoidance

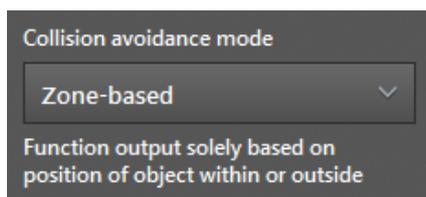
The application "Collision avoidance" uses movement-related information to avoid collisions. If the movement-related information of the vehicle is provided, the accuracy of the collision avoidance increases.



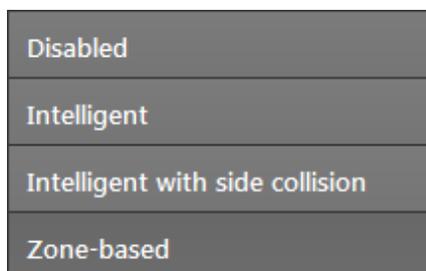
The collision avoidance is divided into three areas:

- 1: Live image display (→ „10.1 Live image display“)
- 2: Settings: Functions

For the collision avoidance the following settings are available.



With the "Collision avoidance mode", the type of the collision avoidance can be set.



For the collision avoidance, one of the following modes can be selected:

- [Disabled]: The collision avoidance is deactivated.
- [Intelligent]: The collision avoidance uses the movement-related information of the objects and the vehicle (→ „13.2.1 The "intelligent" collision avoidance mode“).
- [Intelligent with side collision]: The collision avoidance uses the movement-related information of the objects and the vehicle. Additionally, the system looks out for potential collisions from the side (→ „13.2.2 Collision avoidance mode "Intelligent with side collision"“).
- [Zone-based]: The collision avoidance monitors the created zones with different priorities (→ „13.2.3 Collision avoidance mode "zone-based"“).

### 13.2.1 The "intelligent" collision avoidance mode

The collision avoidance mode "intelligent" uses the movement-related information of the objects and the vehicle. For this, the device needs cyclic vehicle data via the CAN bus in the J1939 protocol.



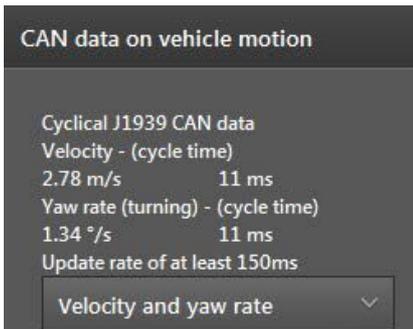
The "Intelligent" collision avoidance mode considers collisions at the vehicle rear or front. Lateral vehicle collisions are ignored.

This mode is recommended for most applications.

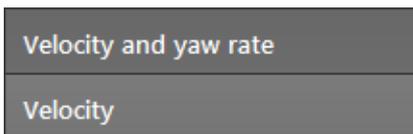


Further information about the interfaces is given in the "Object Detection Software Manual".

For the "intelligent" collision avoidance mode, the following settings are available.

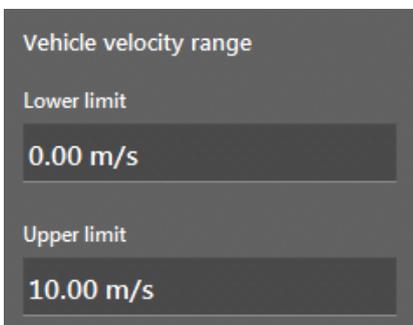


The "CAN data on vehicle motion" display the movement-related information of the vehicle provided via the CAN bus.



In the list, the movement-related information can be selected that is to be used for the collision avoidance:

- [Speed and vehicle yaw rate]: The vehicle yaw rate indicates the steering angle. This movement-related information is not provided by every vehicle via CAN bus.
- [Speed]: The speed is provided by each vehicle via CAN bus.



With "Speed range", you can limit the range which you would like to use for the collision avoidance. The movement-related information below the lower limit and above the upper limit is not used for the collision avoidance.



It is, for example, useful to set an upper limit for vehicle brake applications. The collision avoidance should ignore the movement-related information when the vehicle is braked to avoid any danger to persons.

**Collision avoidance settings**

Sensitivity of crash prediction

medium ▾

low

medium

high

With the "Collision avoidance settings", the collision avoidance can be set. The reliability of the collision avoidance increases if the settings correspond with the properties of the vehicle.

The "Sensitivity of crash prediction" indicates how sensitive the reactions of the collision avoidance are supposed to be.

- [Low]: minimum detection.
- [medium]: medium detection.
- [high]: maximum detection.



The sensitivity depends on the application. Use [medium] sensitivity by preference.

Vehicle dynamics

high (e.g. car) ▾

low (e.g. rail-bound)

medium (e.g. truck)

high (e.g. car)

With the "Vehicle dynamics" the dynamics of the vehicle can be set.

- [low (e.g. rail-bound)]: The vehicle has low dynamics. Vehicles with low dynamics usually drive long curves.
- [medium (e.g. truck)]: The vehicle (HGV) has medium dynamics.
- [high (e.g. car)]: The vehicle has high dynamics.

Average braking deceleration

5.00 m/s<sup>2</sup>

With "average braking deceleration" you can set how well the vehicle brakes. The setting is different for each vehicle type: Car approx. 10 m/s<sup>2</sup>, HGV approx. 5 m/s<sup>2</sup>.

Number of Warning Steps

1 ▾

1

2

3

With "number of warning steps", the number of response times to be expected is increased to up to 3.

Selecting more than one response time enables graded response. For example, an acoustic warning is triggered with "estimated response time 1" = "10 s". The "estimated response time 2" = "2 s" then actuates automatic braking if the vehicle driver does not respond.

Estimated Reaction time 1

1.00 s

With "estimated response time 1", the sum of the driver's response time and the deceleration of the vehicle can be set.



Automatic brakes have a short response time.

Closest allowed distance

0.50 m

The zone in which collisions in front of the vehicle are recognised adjusts itself dynamically to the speed and driving direction of the vehicle. In case of very low speeds, it is recommended to use "closest allowed distance" (minimum distance) to set an area in front of the device. In this zone from the device up to "closest allowed distance" (minimum distance), collisions are always recognised since this zone is independent from the speed and the driving direction of the vehicle.

Max distance for function

25.00 m

The zone in which collisions in front of the vehicle are recognised adjusts itself dynamically to the speed and driving direction of the vehicle. In case of very high speeds, it is recommended to use "max distance for function" to set a maximum distance in front of the device. After that, collisions are only detected up to the "max distance for function".

Inactive time after predicted crash

10.00 s

With "inactive time after predicted crash", you can set a waiting time which begins after a recognised collision. Within the set time, no collisions are recognised. Further collisions are only recognised after the time is elapsed.

**Vehicle size in world coordinates**

With "Vehicle size in world coordinates", the size of the vehicle can be specified and the reference point set. The reference point is the origin of the coordinate system.

 The reference point must be on the ground, in the middle of the vehicle width, under the non-controlled axle (pivot point of the vehicle) if [Speed and vehicle yaw rate] is set in the "CAN movement-related information."

 The reference point must be on the ground in the middle of the device if

- [Speed] is set in the "CAN data on vehicle motion" or
- the collision avoidance mode "zone-based" is set.

Xmin (vehicle rear end)

-3.00 m

Xmax (vehicle front end)

1.00 m

With "Xmin (vehicle rear)" and "Xmax (vehicle front)", the length of the vehicle can be set.

 The settings are relative to the reference point.

Ymin (vehicle right side)

-1.30 m

Ymax (vehicle left side)

1.30 m

With "Ymin (vehicle right side)" and "Ymax (vehicle left side)", the vehicle width can be set.

 The settings are relative to the reference point.

Zmax (height of vehicle)

2.00 m

With "Zmax (height of vehicle)", the height of the vehicle can be set.

### 13.2.2 Collision avoidance mode "Intelligent with side collision"

The collision avoidance mode "Intelligent with side collision" uses the movement-related information of the objects and the vehicle. For this, the device needs cyclic vehicle data via the CAN bus in the J1939 protocol.



The collision avoidance mode "Intelligent with side collision" considers the following collisions:

- on sides of the vehicle (provided that the collisions are in the field of view of the device) and
- at the vehicle rear or front.

Only use this mode if

- collisions on the vehicle sides are possible,
- the vehicle can turn very dynamically (vehicle with two controlled axles or steering axle with wide steering angle).

For most applications, the collision avoidance mode "intelligent" is recommended.



Further information about the interfaces is given in the "Object Detection Software Manual".

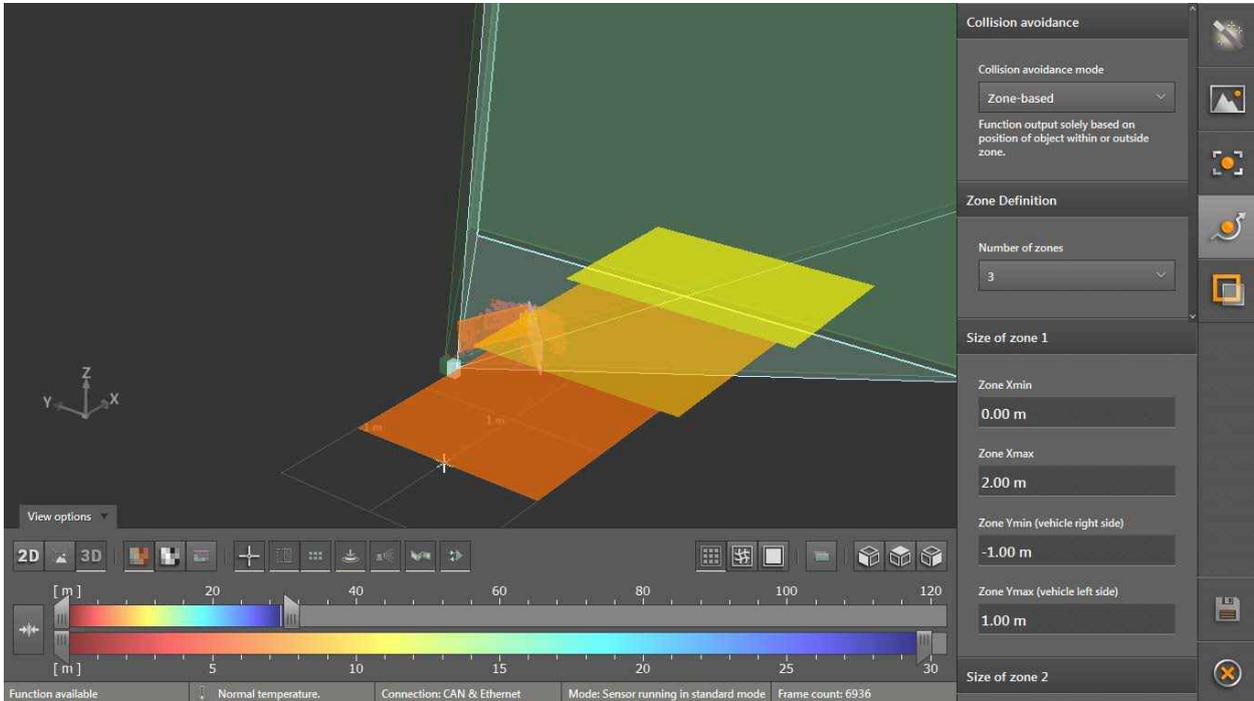
The settings of the collision avoidance "Intelligent with side collision" and collision avoidance "Intelligent" are identical (→ „13.2.1 The "intelligent" collision avoidance mode“).

### 13.2.3 Collision avoidance mode "zone-based"

The collision avoidance mode "zone-based" uses the movement-related information of the objects. For the object recognition, three zones can be set in the world coordinate system.



The collision avoidance mode "zone-based" is used if no movement-related information of the vehicle is provided via the CAN bus.



In case of more than one set zone, different priorities are assigned to the zones:

- The first zone has highest priority (red colour in the screenshot). Object in the second zone treated as critical.
- The second zone has medium priority (orange colour in the screenshot). Objects in the second zone are treated as less critical.
- The third zone has a low priority (yellow colour in the screenshot). Objects in the third zone are treated with a lower priority.



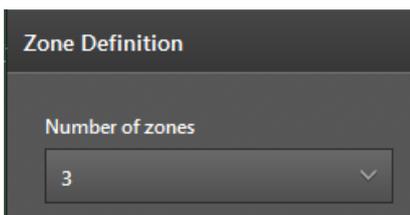
The "Intelligent" collision avoidance mode considers collisions at the vehicle rear or front. Lateral vehicle collisions are ignored.

This mode is recommended for most applications.



Further information about the interfaces is given in the "Object Detection Software Manual".

For the "Zone-based" collision avoidance mode, the following settings are available.



With "zone definition", the number of zones can be set.

In case of more than one set zone, different priorities are assigned to the zones.

**Size of zone 1**

Zone Xmin  
0.00 m

Zone Xmax  
2.00 m

Zone Ymin (vehicle right side)  
-1.00 m

Zone Ymax (vehicle left side)  
1.00 m

With "Size of zone 1", the size and position of the first zone can be set.

The first zone has highest priority (red colour in the screenshot). Object in the second zone treated as critical.



The settings are relative to the reference point. The reference point is in the middle of the device.

**Size of zone 2**

Zone Xmin  
2.00 m

Zone Xmax  
4.00 m

Zone Ymin (vehicle right side)  
-1.20 m

Zone Ymax (vehicle left side)  
1.20 m

With "Size of zone 2", the size and position of the second zone can be set.

The second zone has medium priority (orange colour in the screenshot). Objects in the second zone are treated as less critical.



The settings are relative to the reference point. The reference point is in the middle of the device.

**Size of zone 3**

Zone Xmin  
4.00 m

Zone Xmax  
6.00 m

Zone Ymin (vehicle right side)  
-1.40 m

Zone Ymax (vehicle left side)  
1.40 m

With "Size of zone 3", the size and position of the third zone can be set.

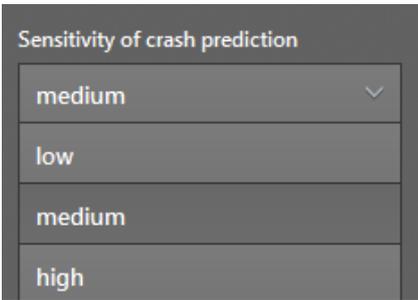
The third zone has a low priority (yellow colour in the screenshot). Objects in the third zone are treated with a lower priority.



The settings are relative to the reference point. The reference point is in the middle of the device.

**Collision avoidance settings**

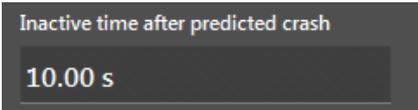
With the "Collision avoidance settings", the collision avoidance can be set. The reliability of the collision avoidance increases if the settings correspond with the properties of the vehicle.



The "Sensitivity of crash prediction" indicates how sensitive the reactions of the collision avoidance are supposed to be.

- [low]: minimum detection.
- [medium]: medium detection.
- [high]: maximum detection.

 The sensitivity depends on the application. The sensitivity [medium] is recommended for most applications.

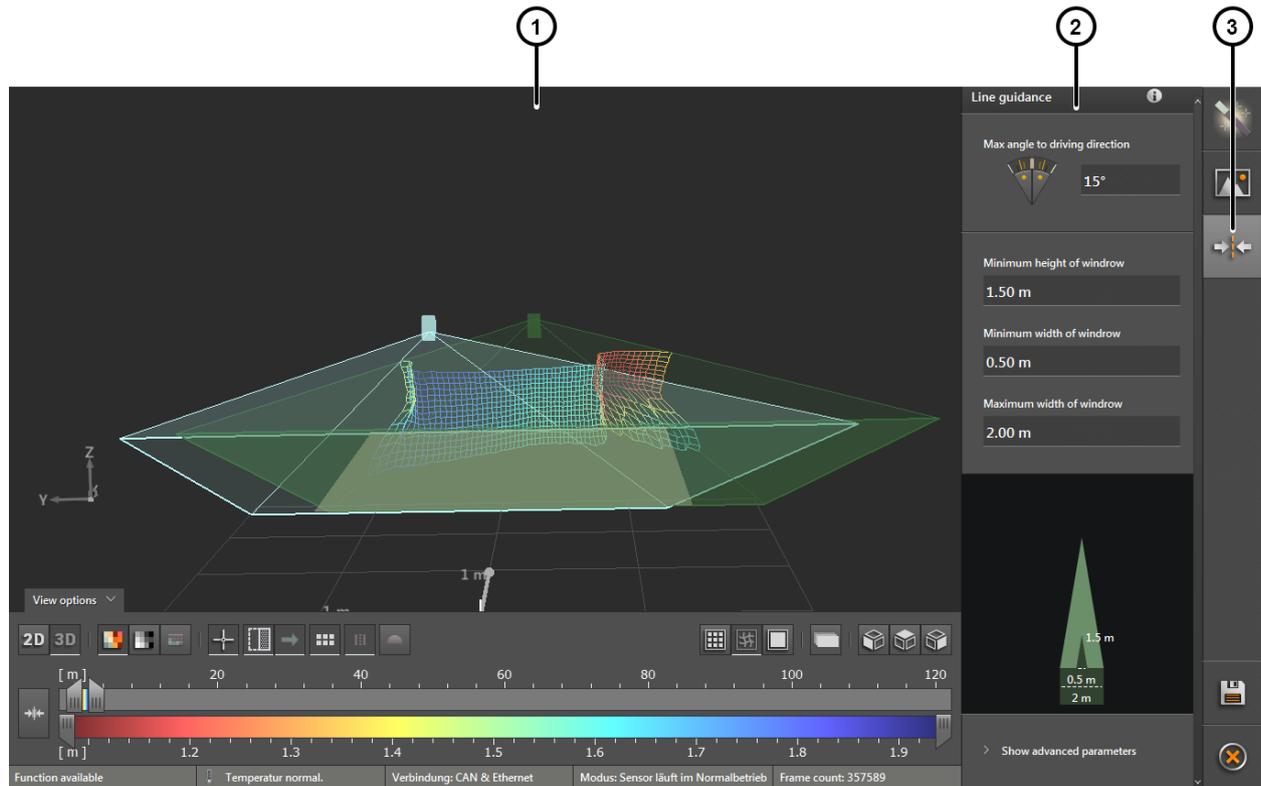


With "inactive time after predicted crash", you can set a waiting time which begins after a recognised collision. Within the set time, no collisions are recognised. Further collisions are only recognised after the time is elapsed.

## 14 Firmware LG - line guidance

The line guidance is a function of the LG firmware (→ „7.1.3 Firmware update“). With the line guidance, the device recognises the lines in the visible area and compares them with the driving direction. If the recognised line is within the set parameter, the driving direction is readjusted accordingly.

The line guidance function is typically used in agriculture with the device mounted to an agricultural machine. The device faces the driving direction, recognises the driving lane and keeps the agricultural machine within the lane.

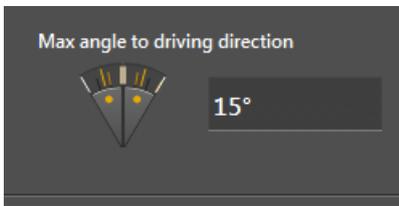


The line guidance is divided into three areas:

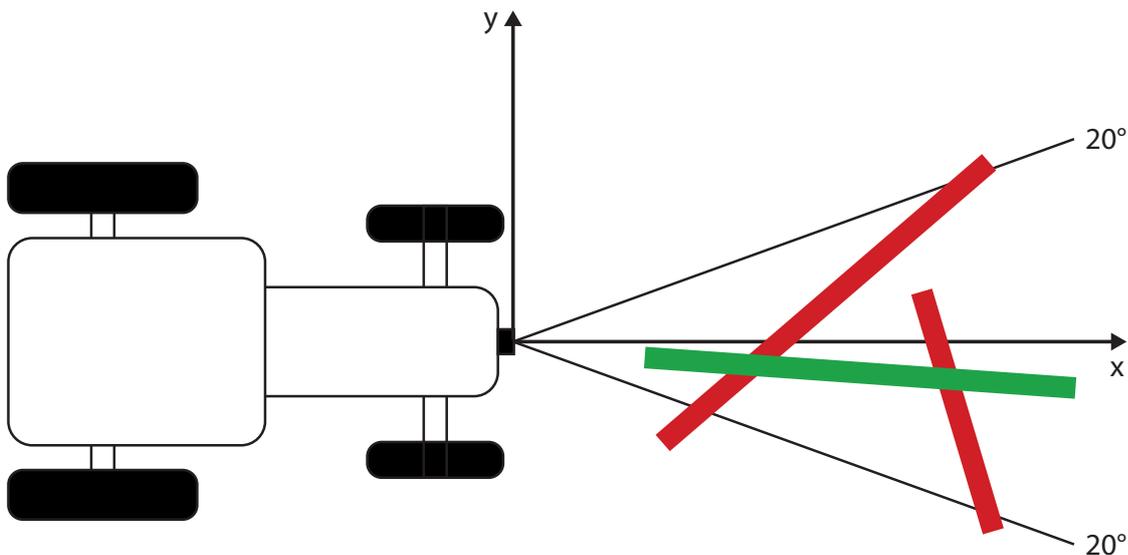
- 1: Live image display (→ „10.1 Live image display“)
- 2: Settings: Functions

### 14.1 Max. angle to the driving direction

The filter "Max. angle to driving direction" compares recognised lines with the driving direction. If the angle of the recognised line exceeds the set value in relation to the driving direction, the line will be filtered out.



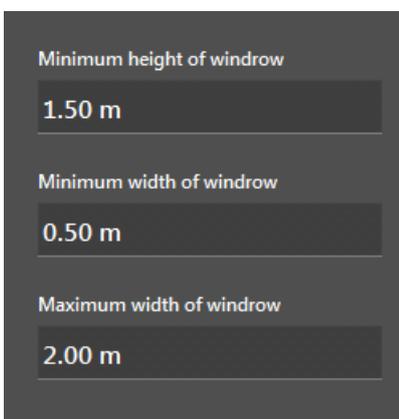
The "Max. angle to driving direction" can be set graphically using the mouse or by entering the value. Values ranging from 0 to 30° are permissible.



In the figure, the red lines are filtered. The green line is within the angle set to 20° and will not be filtered.

### 14.2 3D line structure

The filter "3D line structure" filters the data on the basis of the y and z axis. The data outside the set area is filtered. The setting of the filter "3D line structure" is visualised graphically:

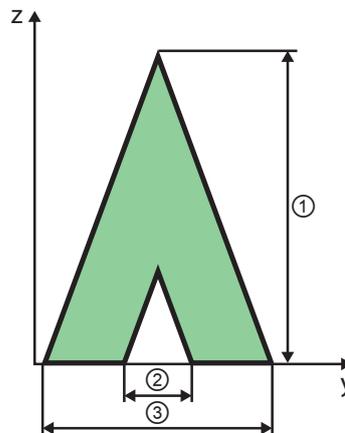
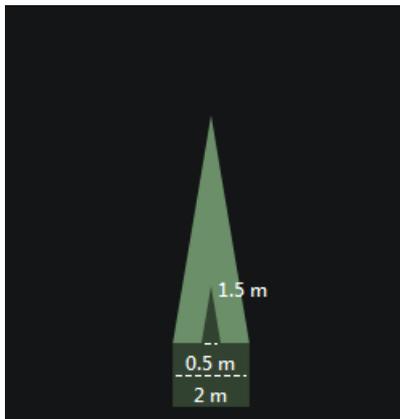


With "Min height 3D line structure", the minimum height of the filter can be set (see ① in the illustration). The data below the value is filtered and no longer processed.

With "Min width 3D line structure", the minimum width of the filter can be set (see ② in the illustration). The data below the value is filtered and no longer processed.

With "Max width 3D line structure", the minimum width of the filter is set (see ③ in the illustration). The data above the value is filtered and no longer processed.

The settings of the "3D line structure" filter are visualised graphically from the perspective of the device:



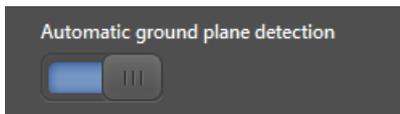
- ① Min height 3D line structure
- ② Min width 3D line structure
- ③ Max width 3D line structure



Only the data within the set range is further processed (green area in the figure). The data without the range is filtered and no longer processed.

### 14.3 Automatic ground plane detection

The switch is used to activate or deactivate the automatic ground plane recognition. The automatic ground plane detection corrects the position values of the device in real time, especially the pitch angle, the roll angle and the height. The ground in the visible range of the device is used as basis.



The "automatic ground plane detection" is used for line structures with little height, for example, window with a height < 0.3 m.

In case of line structures with a height of > 0.5 m, the "automatic ground plane detection" is not necessary.



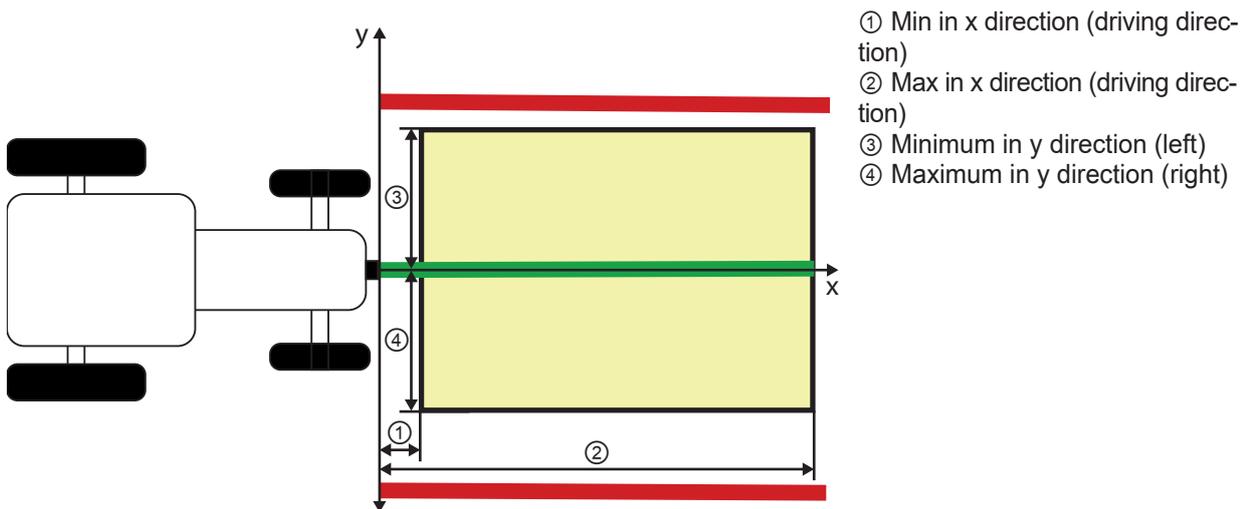
Only use the "automatic ground plane detection" if the ground in the visible are of the device is constantly visible. The line structure must not cover the entire ground.

### 14.4 Search area for line detection

The filter "search area for line detection" restricts the search for line structures to a rectangular search area.



The line structures outside the search range are ignored. In the following figure, the set search range is highlighted in yellow.



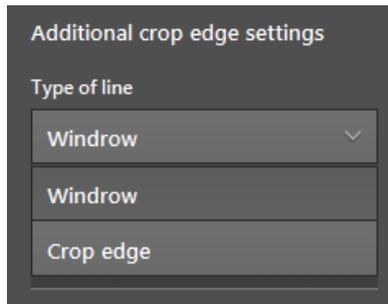
In the figure, the red lines are filtered. The green line is within the set search range and is further processed.



Restricting the search for line structures to one search range reduces potential errors.

## 14.5 Additional crop edge settings

With "Additional crop edge settings", the mode of the line guidance can be set.



Two modes are available:

- Line type [Windrow]
- Line type [Crop edge]

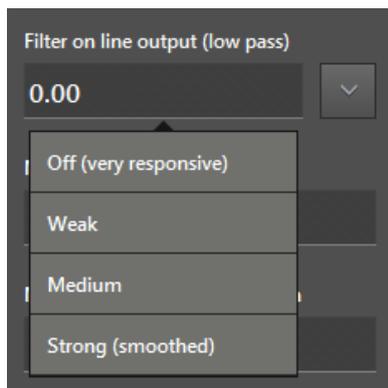
The set line type is used for the line guidance.



If the line type [Windrow] is set, the setting "min / max width 3D line structure" is ignored.

## 14.6 Filter on line output (low pass)

The filter "line output (low pass)" weakens the result of the line recognition.



Depending on the set frame rate, the result of the line recognition is provided nearly in real time (→ „10.7 Frame rate“). High frame rates lead to fast responding changes of the line recognition results.

The fast response of the behaviour may cause problems during applications such as steering vehicles. With the low pass filter, the result of the line recognition is smoothed. By doing so, abrupt changes at the line output are avoided.

Values from 0 to 1 can be set:

- 0: no low pass filter (fast response)
- 0 to 0.3: Applications with flat line structures (e.g.: windrow)
- 0.4 to 0.7: Applications with high line structure (e.g.: grapevine)
- 1: strong low pass filter

## 14.7 Steering computation

With the "steering computation", the standard output format for recognised line structures is set. The standard output format is set via CAN and Ethernet and contains, among other things, the following information:

- Line offset to the reference point
- Line angle to the driving direction
- Colour and height of the line structure

Min x for steering computation
10.00 m
Max x for steering computation
20.00 m
Foresight time steering computation
2.50 s

If the device receives CAN input data, the vehicle can be steered via an alternative output and with a curving command. The curving command describes the direction to which the vehicle is supposed to turn by putting the point of intersection on a defined radius. It is provided in the format "1/km".

With "steering angle output computation point" and the speed of the vehicle, a distance is set at which the vehicle is supposed to intersect the projection of the line direction. With "Min x for steering computation" and "Max x for steering computation", the distance can be limited.



The higher the value "steering angle output computation point" the greater the damping of the vehicle behaviour.

## 14.8 CAN data for vehicle movement

It is possible to supply the device via CAN with movement-related information of the vehicle. With the movement-related information, the knowledge of vehicle movements improves and thereby the recognition of line structures.

Velocity and yaw rate
Velocity
No CAN data
No CAN data <span>∨</span>

The device expects cyclic messages that contain the vehicle speed and optionally the yaw rate. The messages must be J1939 messages and updated at least every 120 ms.

The following table contains information about the structure of the J1939 messages.

Name Standard Message	Message	Start bit	Length [bit]	Value type	Factor	Offset	Min.	Max.	Unit	Comment
Wheel based vehicle speed	EBS21	16	16	unsigned	0.00390625	0	0	251	km/h	Current vehicle speed (positive value for forward, negative value for backward) calculated from the mean value of the rotational speed of an axle. The current speed is influenced by the slip and filtered through a frequency range of 5 to 20 Hz.
Direction indicator	TCO1	30	2	unsigned	1	0	0	3	-	Direction of the vehicle
Yaw rate	VDC2	24	16	unsigned	0.00012207	-3.92	-3.92	+3.92	rad/s	Rotation of the vertical axis

## 15 Logic editor

On the "Logic" screen, sensor signals and CAN input signals are calculated, compared and combined into results. For example, the sensor signals can contain object properties, line information and results of ROI groups. The CAN input signals can contain digital (Boolean) and analogue numerical values.

The summarised results are typically transferred to a controller via the CAN or Ethernet interface. When using a device with 2D/3D functions (e.g. O3M251), the results are optionally displayed as an overlay.



The "Logic" screen is available in every firmware version (DI, OD and LG).

### 15.1 General creation rules

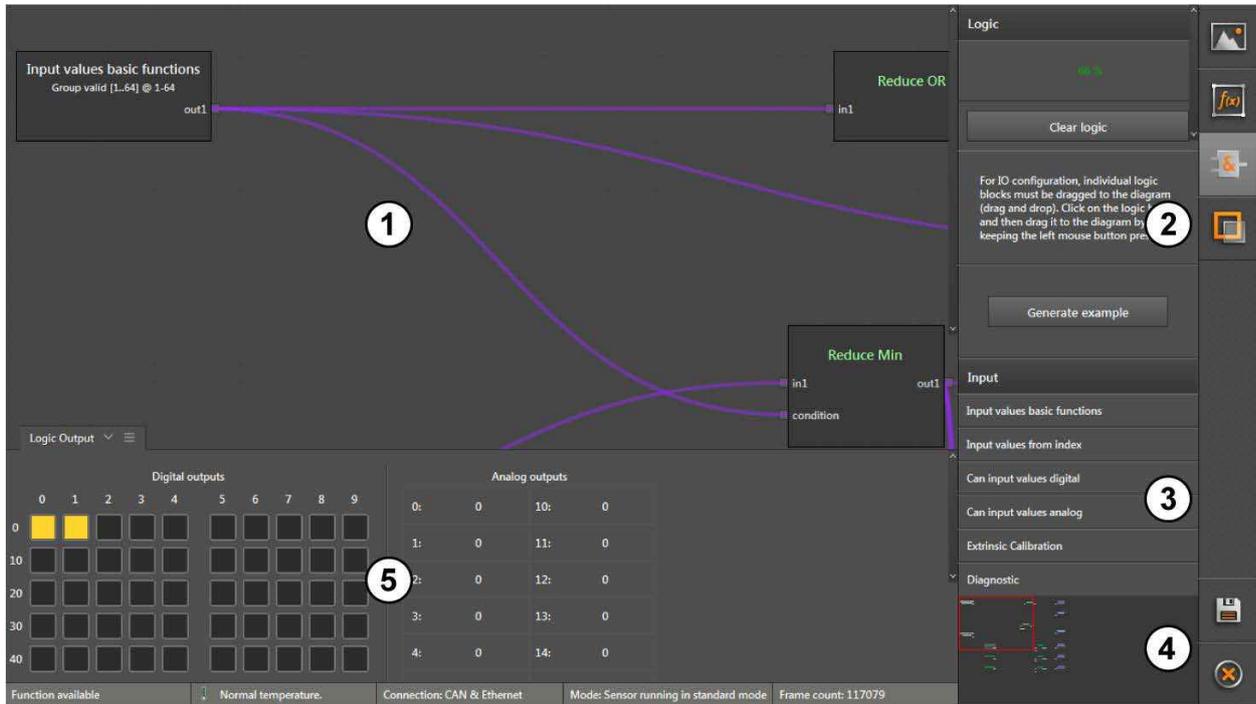
The creation of the output logic is based on the following rules:

- All signals are interpreted as numerical values. This allows Boolean numerical values (after digitalisation or from a digital input) to be used in arithmetic modules and interpreted as "0" (false) or "1" (true).
- The signal lines can connect single values and vectors of values. The connections are set via the input modules. For example, distance results ( $x$ ) of a maximum of 64 ROI groups can be compared with a threshold value.
- Numerical values can be processed as follows:
  - direct output via a virtual output.
  - use of arithmetic operators and then output via a virtual analogue output.
  - digitalisation by comparison with other results or values.
  - further processing of digitalised numerical values by applying arithmetic operators and/or logic functions. Subsequently, output of a Boolean value via a virtual digital output.
  - buffering of the result for use in the next evaluation cycle.
  - permanent buffering for use as comparison value (can be triggered via CAN bus).

## 15.2 Place and connect modules

► Click on .

> The "Logic" screen is displayed.



The logic editor is divided into five areas:

- 1: Main area
- 2: Information area
- 3: Selection area
- 4: Overview area
- 5: Result area

Window area	Description
Main area	In the main area, the assignment of the input signals (sensor results) to the outputs is displayed. Input signals, operators and outputs are shown as modules with different font colours. Lines between these modules represent the connection. If the modules in the main area go beyond the visible area, this area can be shifted using the scroll bar at the edge of the main area.
Information area	In the information area, the logic status is displayed. The status of the logic primarily indicates the memory usage on the device.  The number of outputs used simultaneously is limited. An error message appears if modules with further outputs are placed and the capacity is exceeded.
Selection area	In the selection area, all input signals, operators and outputs are listed.
Overview area	In the overview area, a smaller version of the main area is displayed. If the modules in the main area go beyond the visible area, this area can be shifted by dragging the red frame with the mouse.
Result area	The result area displays the status of the 100 digital and 20 analogue outputs. The status of the digital outputs is indicated by colours: Colour "grey": "0" (false); Colour "yellow": "1" (true). Hovering over one of the digital outputs opens a tooltip with the respective output number.

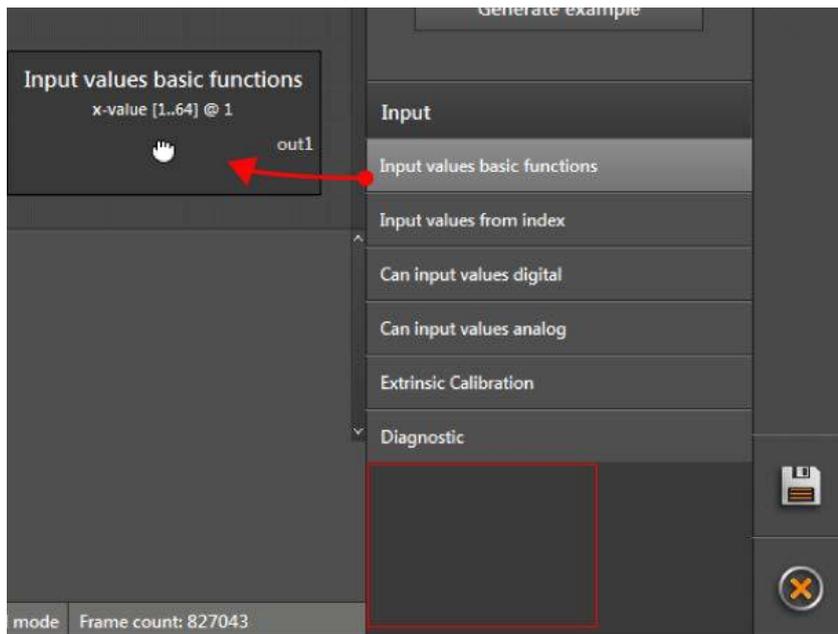
### 15.2.1 Generate example

This function is intended for users who have no or little experience in creating output logics.

- ▶ Click [Generate example].
- > An output logic suitable for the sensor parameterisation is generated as an example.

### 15.2.2 Place new logic module in main area

- ▶ Click on the module in the selection area and keep the mouse button pressed.
- ▶ Hold the mouse button down to drag & drop the module at the requested position.

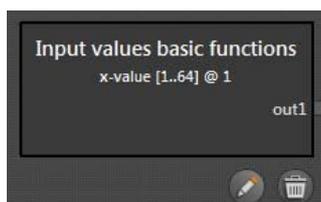


- > The module is placed in the main area. The module can be moved to any position in the main area using drag & drop.
- > Each module has at least one pin to connect further modules.

 The number of outputs used simultaneously is limited. An error message appears if modules with further outputs are placed and the capacity is exceeded.

### 15.2.3 Delete a module

- ▶ Click on the module.
- > In the bottom right corner of the module a recycle bin is displayed.

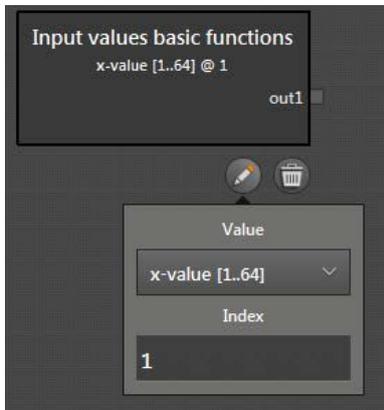


- ▶ Click on recycle bin.
- > The module and the connection, if any, to another module are deleted.

## 15.2.4 Set a module

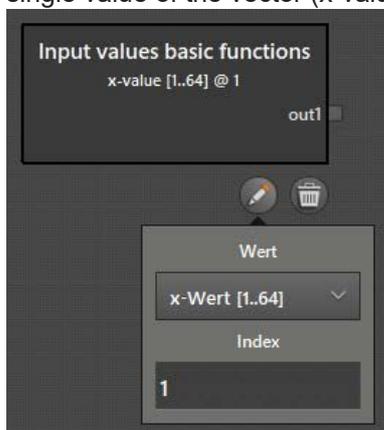
A module can be set if a drawing pen is displayed below the module.

- ▶ Click on the module.

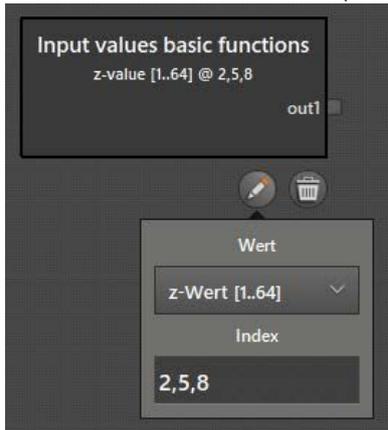


- ▶ Click on pen.

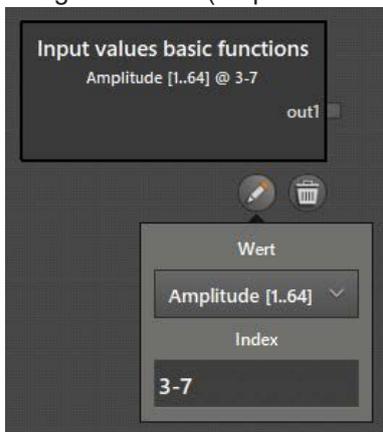
- > A window with the settings opens. Depending on the module, a list and an input field are used to make settings.
- > The "Value" list sets the output value. In the "Basic function" module, the output value sets the value to be filtered.
- > The "Index" input field is displayed if a value is set in the "Value" list which belongs to a vector (a vector contains several values). The input field "Index" provides access to single results of the vector (for example the results of certain ROI groups). Several values and value ranges can be entered in the "Index" input field. Examples for values:
  - single value of the vector (x-value of the ROI group): "1"



- several values of the vector (z values of the ROI groups): "2,5,8"



- Range of values (amplitude values of the ROI groups): "3-7"



- Combination (validity of the binary values of the ROI groups): "1,4-10,13,16-32"



### 15.2.5 Connect modules

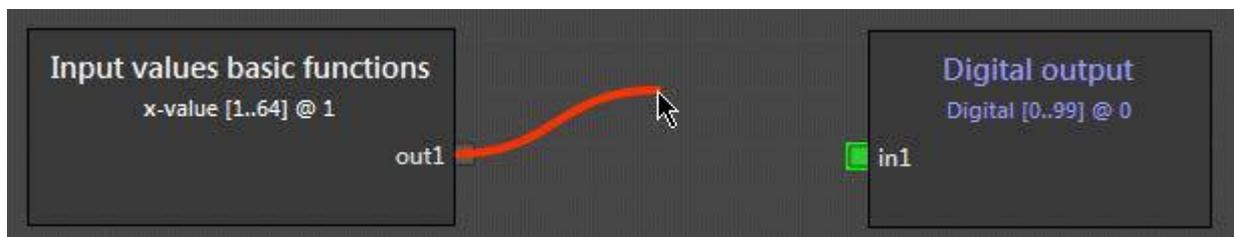
- ▶ Set the mouse pointer to the output pin at the right edge of the module.
- ▶ Keeping the mouse button pressed, drag the mouse pointer out of the output pin.
- > Free usable input pins are displayed in green.
  - Only one signal can be assigned to each input pin.
  - An output pin can be assigned to several input pins.



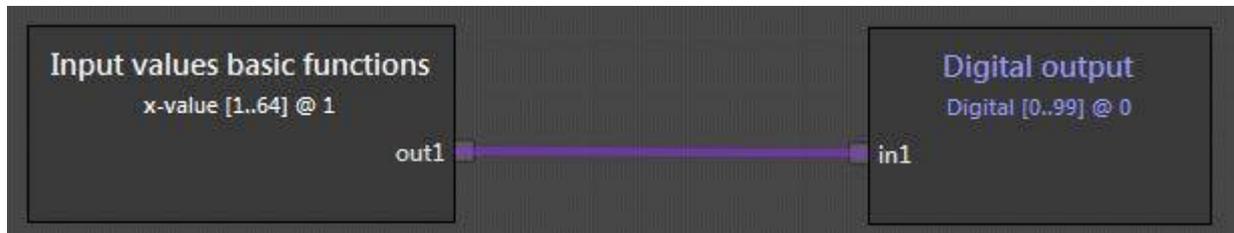
Pay attention to the properties of the modules when assigning the signals:

- data types
- units of measurement
- vector quantities

- > A red connecting line is displayed between the pin and the mouse pointer.



- ▶ Move the mouse pointer to the green pin of the module.
- ▶ When the connecting line turns green, release the mouse button.
- > Successful connections between modules are represented by purple connecting lines.



- > When moving modules, the connecting lines are carried over.

### 15.2.6 Delete module connections

- ▶ Click on the connecting line to be deleted.
- > A recycle bin is displayed.



- ▶ Click on the recycle bin.

## 15.3 Description of the "Input" modules

In the "Input" selection area, available modules for entering signals are displayed.



The available modules depend on the installed firmware. Depending on the firmware variant (DI, OD or LG) different input modules are available.

The following input modules are available in each firmware version:

- Digital CAN input signals
- Analogue CAN input signals
- Extrinsic calibration
- Diagnostics

### 15.3.1 "Digital CAN input signals" module

The "Digital CAN input signals" module can receive up to 14 binary input values (1 bit) dynamically across the CAN interface.



The CAN interface is described in a separate CAN document.

The "Digital CAN input signals" module has the following setting:

Setting	Data type	Description
Index	Binary	Vector with 14 values, address range from 0-13

### 15.3.2 "Analogue CAN input signals" module

The "Analogue CAN input signals" module can receive up to 6 binary input values (12 bit) dynamically across the CAN interface.



The CAN interface is described in a separate CAN document.

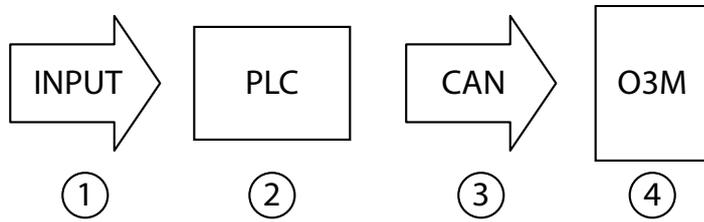
The "Analogue CAN input signals" module has the following setting:

Setting	Data type	Description
Index	Numerical	Vector with 6 values, address range from 0-5

### 15.3.3 Example for "Analogue CAN input signals" module

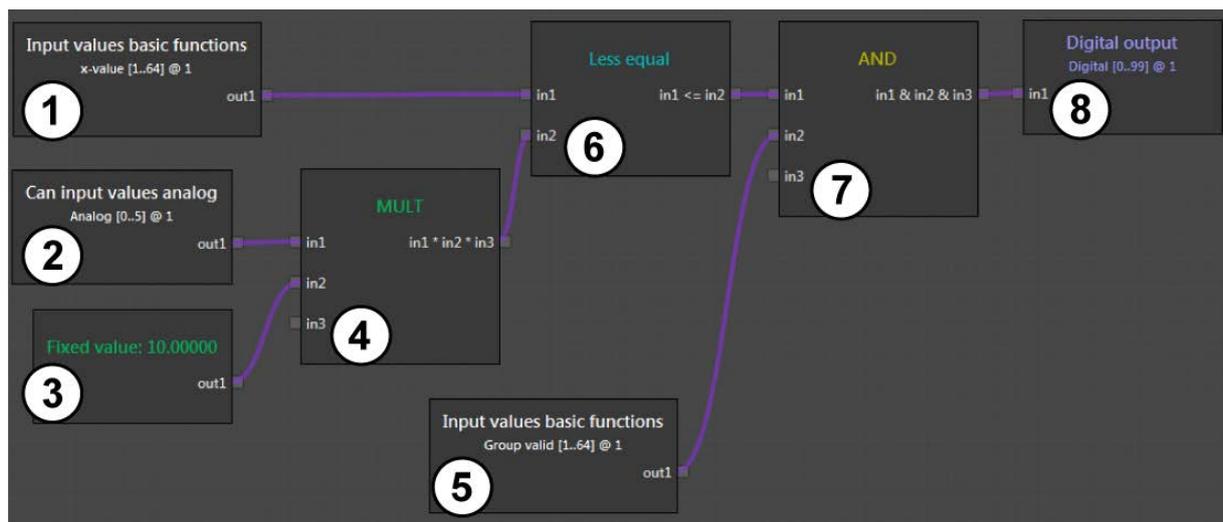
In logic, the "Analogue CAN input signals" module is used to process the motion speed of a machine. The calculated values are used to adjust the size of the warning range of the machine.

A programmable controller is connected to the device as follows:



Description of the devices and interfaces used:

Number	Function	Description
1	Input value	The speed is applied as a scaling value to the analogue input of the programmable controller (current or voltage).
2	Programmable controller (e.g. CR0403)	The programmable controller converts the values to a 12-bit CAN value between 0...1 um.
3	CAN interface	The CAN interface transmits the motion speed in 12-bit resolution.
4	Device (e.g. O3M251)	The device uses the analogue input value to scale the warning range.



Description of the modules used in the example:

Module number	Module	Description
1	Basic function	The x value is filtered out of ROI group 1.
2	Analogue CAN input signals	The CAN input values from the controller are processed at analogue input 1. Previously, the controller has scaled the values to the range 0...1.
3	Fixed value	The fixed value "10" defines the maximum warning distance in metres.
4	MULT	The speed value is multiplied by the maximum warning distance. This calculates the threshold value (warning value). The threshold value is dynamic (depending on the speed at the analogue input).
5	Basic function	The validity of ROI group 1 is checked.
6	Less than or equal	It is checked whether the current measured distance value is less than or equal to (<=) the speed-dependent warning value.
7	AND	If the measurement is valid (module 5) and the measured distance value <= the warning value (module 6), a "1" is provided.
8	Digital output	Digital output 1 applies the binary information to the CAN output. The value is provided via the controller as a physical output.



Table of values:

Value	1	2	3	4	5	6	7	8	9	10
Analogue input of the controller [mA]	20	20	16	12.4	12.4	10	8.1	8.1	0.2	0
Digitalised and scaled for CAN [12-bit]	1	1	0.8	0.62	0.62	0.5	0.405	0.405	0.01	0
Threshold multiplied by maximum value [m]	10	10	8	6.2	6.2	5	4.05	4.05	0.1	0
Distance measurement of the device multiplied by group 1 [m]	12.34	9.87	8.76	7.41	5.28	4.65	4.23	3.65	1.59	0.87
Binary result of the device at digital output 1	0	1	0	0	1	1	0	1	0	0



In order to visualise a direct conversion of the physical switching outputs, the analogue speed value is scaled to the range 0...1. This value can be mapped directly from the physical analogue input to the 12-bit value of the CAN interface.

By moving the scaling into the logic, the programming of the controller becomes independent of the device function.

### 15.3.4 "Extrinsic calibration" module

The "Extrinsic calibration" module provides the calibration settings of the device (→ „9 Calibration settings“).

The "Extrinsic calibration" module has the following settings:

Setting	Data type	Index	Description
Sensor angle ROT X	Numerical	Single value (no index)	The angle of rotation of the device around the x-axis [rad].
Sensor angle ROT Y	Numerical	Single value (no index)	The angle of rotation of the device around the y-axis [rad].
Sensor angle ROT Z	Numerical	Single value (no index)	The angle of rotation of the device around the z-axis [rad].
Sensor position X	Numerical	Single value (no index)	Distance of the device from the origin of the defined world coordinates on the x-axis [m].
Sensor position Y	Numerical	Single value (no index)	Distance of the device from the origin of the defined world coordinates on the y-axis [m].
Sensor position Z	Numerical	Single value (no index)	Distance of the device from the origin of the defined world coordinates on the z-axis [m].

### 15.3.5 "Diagnostic" module

The "Diagnostic" module provides information on the current status of the device.

The "Diagnostic" module has the following settings:

Setting	Data type	Index	Description
Available	Binary	Single value (no index)	The availability of CAN input values at the modules "Digital CAN input signals" and "Analogue CAN input signals" is provided: <ul style="list-style-type: none"> <li>• "0": CAN input values not available</li> <li>• "1": CAN input values available</li> </ul>
Sensor temperature	Numerical	Single value (no index)	The current temperature of the device is provided [°C].
Illumination temperature	Numerical	Single value (no index)	The current temperature of the illumination unit is provided [°C].

Setting	Data type	Index	Description																				
Availability	Numerical (enum)	Single value (no index)	<p>The current system availability is provided as enum with discreet values:</p> <table border="1"> <thead> <tr> <th>System availability</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>System available: no limitations</td> </tr> <tr> <td>1</td> <td>System not available: Interference from identical system detected</td> </tr> <tr> <td>2</td> <td>System not available: Interference from fog, dust or snow detected</td> </tr> <tr> <td>4</td> <td>System not available: Intelligent collision prediction not available</td> </tr> <tr> <td>8</td> <td>System not available: Extrinsic calibration invalid</td> </tr> <tr> <td>16</td> <td>System not available: MCI connection cable between device and illumination unit defective or not suited</td> </tr> <tr> <td>32</td> <td>System not available: Internal error</td> </tr> <tr> <td>64</td> <td>System not available: Device contamination detected</td> </tr> <tr> <td>128</td> <td>System not available: Automatic calibration is running</td> </tr> </tbody> </table> <p> If several system availabilities are active at the same time, the sum of the corresponding numerical values is provided.</p> <p> Some system availabilities can only be provided when the corresponding filter is active.</p>	System availability	Description	0	System available: no limitations	1	System not available: Interference from identical system detected	2	System not available: Interference from fog, dust or snow detected	4	System not available: Intelligent collision prediction not available	8	System not available: Extrinsic calibration invalid	16	System not available: MCI connection cable between device and illumination unit defective or not suited	32	System not available: Internal error	64	System not available: Device contamination detected	128	System not available: Automatic calibration is running
System availability	Description																						
0	System available: no limitations																						
1	System not available: Interference from identical system detected																						
2	System not available: Interference from fog, dust or snow detected																						
4	System not available: Intelligent collision prediction not available																						
8	System not available: Extrinsic calibration invalid																						
16	System not available: MCI connection cable between device and illumination unit defective or not suited																						
32	System not available: Internal error																						
64	System not available: Device contamination detected																						
128	System not available: Automatic calibration is running																						
Sensor contamination	Numerical	Single value (no index)	<p>Contamination of the front pane of the device is provided:</p> <ul style="list-style-type: none"> <li>• "0": Front pane not contaminated</li> <li>• "0..1": Front pane partly contaminated</li> <li>• "1": Front pane completely contaminated</li> </ul>																				
Frame counter	Numerical	Single value (no index)	<p>The system cycles since the last reset or restart are provided. The duration of a single system cycle depends on the frame rate set:</p> <ul style="list-style-type: none"> <li>• 50 Hz: 20 ms</li> <li>• 33 Hz: 30 ms</li> <li>• 25 Hz: 40 ms</li> </ul> <p>For example, the value "System cycle" can be used to:</p> <ul style="list-style-type: none"> <li>• trigger system start events</li> <li>• determine time interval between 2 events</li> <li>• hold an output signal for a certain number of system cycles</li> </ul> <p> In continuous operation, the data type of the system cycle "uint32" generates an overflow:</p> <ul style="list-style-type: none"> <li>• 50 Hz: after ~ 994 days</li> <li>• 33 Hz: after ~ 1491 days</li> <li>• 25 Hz: after ~ 1988 days</li> </ul>																				
Timestamp	Numerical	Single value (no index)	<p>The master time of the device since the last reset or restart is provided [µs]. For example, this value can be used to:</p> <ul style="list-style-type: none"> <li>• determine time interval between 2 events</li> </ul> <p> The data type "uint32" of the master time generates an overflow after ~ 71 minutes:</p>																				

## 15.4 Description of the "Input" modules – Firmware DI

The following input modules are only available in the DI firmware version:

- Basic function
- Input value of index

### 15.4.1 "Basic function" module

The "Basic function" module provides results of ROI groups in the logic editor.

The "Value" list is used to specify which value of the ROI groups is to be provided (e.g. x value).

The "Index" field is used to specify which ROI groups are to be provided. The indices correspond to the numbers of the ROI groups (1 to 64). Only the measured values of the set ROI groups are taken into account (→ „12.3 Several ROIs“).

You can use single indices or multiple indexes simultaneously (vectors).

The "Basic function" module has the following settings:

Setting	Data type	Index	Description
Amplitude	Numerical	Index corresponds to ROI group number (vector with 64 values, address range from 1-64)	The current amplitude value of the ROI group is provided (brightness). The assignment of the value is set in the basic functions (→ „12 DI firmware - basic functions“). Depending on the setting, the value is the minimum, maximum or average of all values. Alternatively, the value can be assigned to the minimum or maximum of x, y or z. For undefined ROI groups or ROI groups without valid measurements, the value "0" is provided.
x-value	Numerical	Index corresponds to ROI group number (vector with 64 values, address range from 1-64)	The current x-value in [m] is provided (distance). For each ROI group, an x-value is provided. The assignment of the value is set in the basic functions (→ „12 DI firmware - basic functions“). Depending on the setting, the value is the minimum, maximum or average of all values. Alternatively, the value can be assigned to the minimum or maximum of x, y or z. For undefined ROI groups or ROI groups without valid measurements, the value "0" is provided.
y-value	Numerical	Index corresponds to ROI group number (vector with 64 values, address range from 1-64)	The current y-value in [m] is provided. For each ROI group, a y-value is provided. The assignment of the value is set in the basic functions (→ „12 DI firmware - basic functions“). Depending on the setting, the value is the minimum, maximum or average of all values. Alternatively, the value can be assigned to the minimum or maximum of x, y or z. For undefined ROI groups or ROI groups without valid measurements, the value "0" is provided.
z-value	Numerical	Index corresponds to ROI group number (vector with 64 values, address range from 1-64)	The current z-value in [m] is provided (height). For each ROI group, a z-value is provided. The assignment of the value is set in the basic functions (→ „12 DI firmware - basic functions“). Depending on the setting, the value is the minimum, maximum or average of all values. Alternatively, the value can be assigned to the minimum or maximum of x, y or z. For undefined ROI groups or ROI groups without valid measurements, the value "0" is provided.
Number of groups	Numerical	Single value (no index)	The number of ROI groups defined on the device is provided.
Number of ROIs	Numerical	Single value (no index)	The number of ROI defined on the device is provided.
Validity	Binary	Index corresponds to ROI group number (vector with 64 values, address range from 1-64)	For a valid measurement, the value "1" is provided. For undefined ROI groups or ROI groups without valid measurements, the value "0" is provided.

## 15.4.2 "Input value of index" module

The "Input value of index" module addresses measured values using the index. An index is assigned to each signal at input "in1" of the module. The number of values at the input is always identical to the number of values at the output.

The "Value" list is used to specify which value of the ROI groups is to be provided (e.g. x value).

The module addresses the values using indices determined within the logic (dynamic addressing). This is possible because internally, an index is added to each value.

You can use single indices or multiple indexes simultaneously (vectors).



The following values have no index:

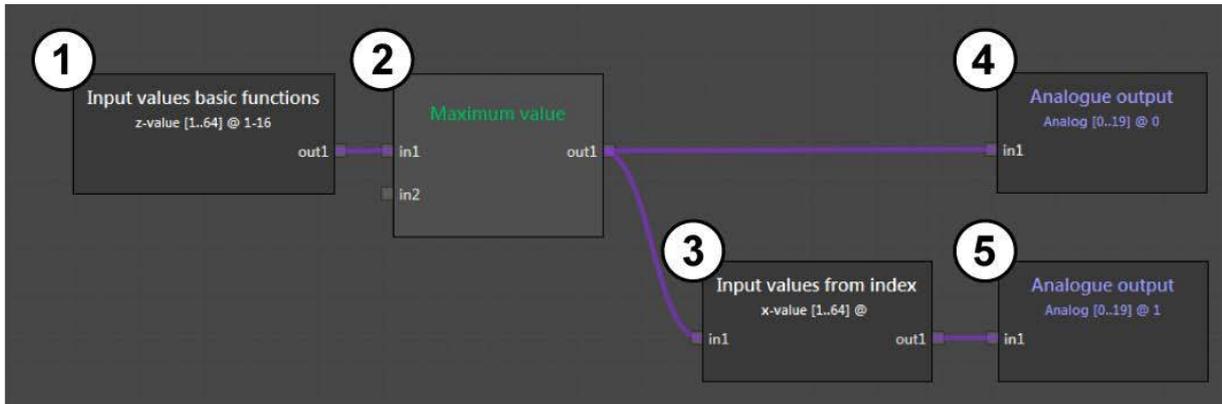
- fixed values (e.g. defined with the "Fixed value" module)
- the sum of values with different indices

The "Input value of index" module has the following settings:

Setting	Data type	Index	Description
Amplitude	Numerical	Index corresponds to ROI group number (vector with 64 values, address range from 1-64)	The current amplitude value of the ROI group is provided (brightness). The assignment of the value is set in the basic functions (→ „12 DI firmware - basic functions“). Depending on the setting, the value is the minimum, maximum or average of all values. Alternatively, the value can be assigned to the minimum or maximum of x, y or z. For undefined ROI groups or ROI groups without valid measurements, the value "0" is provided.
x-value	Numerical	Index corresponds to ROI group number (vector with 64 values, address range from 1-64)	The current x-value in [m] is provided (distance). For each ROI group, an x-value is provided. The assignment of the value is set in the basic functions (→ „12 DI firmware - basic functions“). Depending on the setting, the value is the minimum, maximum or average of all values. Alternatively, the value can be assigned to the minimum or maximum of x, y or z. For undefined ROI groups or ROI groups without valid measurements, the value "0" is provided.
y-value	Numerical	Index corresponds to ROI group number (vector with 64 values, address range from 1-64)	The current y-value in [m] is provided. For each ROI group, a y-value is provided. The assignment of the value is set in the basic functions (→ „12 DI firmware - basic functions“). Depending on the setting, the value is the minimum, maximum or average of all values. Alternatively, the value can be assigned to the minimum or maximum of x, y or z. For undefined ROI groups or ROI groups without valid measurements, the value "0" is provided.
z-value	Numerical	Index corresponds to ROI group number (vector with 64 values, address range from 1-64)	The current z-value in [m] is provided (height). For each ROI group, a z-value is provided. The assignment of the value is set in the basic functions (→ „12 DI firmware - basic functions“). Depending on the setting, the value is the minimum, maximum or average of all values. Alternatively, the value can be assigned to the minimum or maximum of x, y or z. For undefined ROI groups or ROI groups without valid measurements, the value "0" is provided.
Validity	Binary	Index corresponds to ROI group number (vector with 64 values, address range from 1-64)	For a valid measurement, the value "1" is provided. For undefined ROI groups or ROI groups without valid measurements, the value "0" is provided.

### 15.4.3 Example for the "Input value of index" module

In the logic shown, filtering is applied according to the maximum z-value (height) and the corresponding x-value (distance) is provided.



Description of the modules used in the example:

Module number	Module	Description
1	Basic function	The z-values are filtered out of ROI groups 1-16.
2	Maximum value	The maximum value is filtered out of the 16 z-values.
3	Input value of index	Based on the index of the maximum z-value, the corresponding x-value is filtered out.
4	Analogue output	The maximum z-value is returned via analogue output 0.
5	Analogue output	The x-value associated with the maximum z-value is provided via analogue output 1.

Table of input values:

ROI group (index)	z-value (height)
1	0.05 m
2	-0.02 m
3	0.25 m
4	-0.18 m
5	0.07 m
6	0.02 m
7	-0.09 m
8	0.16 m

Result of the "Maximum value" module on analogue output 0:

ROI group (index)	z-value (height)
14	1.97 m

Result of the "Input value of index" module on analogue output 1:

ROI group (index)	x-value (distance)
14	5.38 m

Table of input values:

ROI group (index)	z-value (height)	x-value (distance)
1	0.05 m	1.31 m
2	-0.02 m	2.43 m
3	1.12 m	0.91 m
4	1.51 m	7.69 m
5	0.07 m	3.52 m
6	0.02 m	5.40 m
7	1.29 m	2.37 m
8	1.79 m	4.14 m

ROI group (index)	z-value (height)	x-value (distance)
9	-0.01 m	3.56 m
10	0.95 m	1.11 m
11	0.18 m	8.14 m
12	0.03 m	3.97 m
13	1.86 m	6.79 m
14	1.97 m	5.38 m
15	0.06 m	2.87 m
16	0.00 m	3.91 m

## 15.5 Description of the "Input" modules – Firmware OD

The following input modules are only available in the OD firmware variant:

- Object detection
- Zone-based
- Time-based
- Input value of index

### 15.5.1 "Object detection" module

The "Object detection" module has the following settings:

Setting	Data type	Index	Description
Object -> acceleration x [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The acceleration of the object along the x-axis of the world coordinate system is provided. This value is the relative acceleration between device and object [m/s <sup>2</sup> ].
Object -> acceleration y [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The acceleration of the object along the y-axis of the world coordinate system is provided. This value is the relative acceleration between device and object [m/s <sup>2</sup> ].
Object -> acceleration z [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The acceleration of the object along the z-axis of the world coordinate system is provided. This value is the relative acceleration between device and object [m/s <sup>2</sup> ].  The value along the z-axis is only available when reflector objects are used. For normal objects this value is always "0" (zero).
Object -> age [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The age of the object is provided in measuring cycles. The value indicates the number of measurement cycles for which this object has already been recorded and tracked [measurement cycle].
Object -> distance to vehicle [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The minimum distance between the defined vehicle size and the object is provided (radially proximate distance).  The value is only available if normal objects are used. For reflector objects this value is always "0" (zero).
Object -> probability of existence [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The probability of existence of the object is provided as a measure of quality: <ul style="list-style-type: none"> <li>• "0": very low probability of existence of the object</li> <li>• "0..1": the higher the value, the higher the probability of the object's existence</li> <li>• "1": very high probability of existence of the object</li> </ul>

Setting	Data type	Index	Description
Object -> ID [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The internal ID of the object is provided.</p>  The ID is not the index. The ID is a unique value. The ID of an object always remains the same as long as an object remains detected. The ID "0" is output if no valid object was detected.
Object -> type [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The type of the object is provided:</p> <ul style="list-style-type: none"> <li>• "0": normal object</li> <li>• "1": reflector object</li> </ul>  Reflector detection must be active for an object to be recognised as a retroreflector. An object whose reflectivity exceeds the set threshold is recognised as a retroreflector.
Object ->speed x [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The speed of the object along the x-axis of the world coordinate system is provided.</p> <p>This value is the relative speed between device and object [m/s<sup>2</sup>].</p>
Object ->speed y [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The speed of the object along the y-axis of the world coordinate system is provided.</p> <p>This value is the relative speed between device and object [m/s<sup>2</sup>].</p>
Object ->speed z [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The speed of the object along the z-axis of the world coordinate system is provided.</p> <p>This value is the relative speed between device and object [m/s<sup>2</sup>].</p>  The value along the z-axis is only available when reflector objects are used. For normal objects this value is always "0" (zero).
Object -> x1 [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The x-coordinate of the first point of the object in the world coordinate system is provided.</p> <p>With reflector objects, this value corresponds to the minimum x-value. In the case of normal objects, this is the first corner point with reference to the background model (also allows "oblique" objects).</p>
Object -> x2 [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The x-coordinate of the second point of the object in the world coordinate system is provided.</p> <p>With reflector objects, this value corresponds to the minimum x-value. In the case of normal objects, this is the second corner point with reference to the background model (also allows "oblique" objects).</p>
Object -> y1 [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The y-coordinate of the first point of the object in the world coordinate system is provided.</p> <p>With reflector objects, this value corresponds to the minimum y-value. In the case of normal objects, this is the first corner point with reference to the background model (also allows "oblique" objects).</p>
Object -> y2 [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The y-coordinate of the second point of the object in the world coordinate system is provided.</p> <p>With reflector objects, this value corresponds to the maximum y-value. In the case of normal objects, this is the second corner point with reference to the background model (also allows "oblique" objects).</p>
Object -> z(min) [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The minimum z-coordinate of the object in the world coordinate system is provided.</p> <p>For normal objects, the value can be minimised to the values of the height of the object detection (ground separation, default value = "0.5 m").</p>
Object -> z(max) [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	<p>The maximum z-coordinate of the object in the world coordinate system is provided.</p>

## 15.5.2 "Zone-based" module

The "Zone-based" module has the following settings:

Setting	Data type	Index	Description
Zone-based collision warning -> object ID in zone [0..2]	Numerical	Index from zone number (vector with 3 values, address range from 0-2)	The ID of the next object in the zone is provided. If the zone is free from objects, then the value is "0".
Zone-based collision warning -> Status of zone [0..2]	Numerical	Index from zone number (vector with 3 values, address range from 0-2)	The zone status is provided: <ul style="list-style-type: none"> <li>• "-1": zone not defined or zone-based warning not active</li> <li>• "0": no object in the zone</li> <li>• "1": at least one object in the zone</li> </ul>

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## 15.5.3 "Time-based" module

The "Time-based" module has the following settings:



The "Time-based" module only outputs values if the "Collision avoidance" mode (→ „13.2 Collision avoidance“) is set to:

- [Intelligent]
- [Intelligent with side collision]

Setting	Data type	Index	Description
ID of predicted collision object	Numerical	Single value (no index)	The object ID of the object on collision course is provided. If there is no risk of collision, the value "0" is provided.
Predicted time to collision [s]	Numerical	Single value (no index)	The remaining time to collision [s] is provided (calculated from vehicle and object speed). If there is no risk of collision, the value "-1" is provided.
Attention collision	Numerical	Single value (no index)	The status of the time-based collision prediction is provided: <ul style="list-style-type: none"> <li>• "-2": time-based collision prediction not active</li> <li>• "-1": time-based collision prediction not available. Possible reasons: The collision prediction was recently triggered or the vehicle speed is outside the parameterised range.</li> <li>• "0": no collision predicted</li> <li>• "1": collision predicted</li> </ul>
Criticality of predicted collision	Numerical	Single value (no index)	The criticality of the predicted collision is provided. 3 warning levels with different warning times can be set: <ul style="list-style-type: none"> <li>• "0": no collision predicted</li> <li>• "1": warning level 1 with highest criticality (shortest warning time)</li> <li>• "2": warning level 2 with intermediate criticality</li> <li>• "3": warning level 3 with lowest criticality (longest warning time)</li> </ul>
Status of the next zone	Numerical	Single value (no index)	The status of the minimum zone is provided: <ul style="list-style-type: none"> <li>• "0": minimum zone free</li> <li>• "1": minimum zone occupied</li> </ul>
Predicted collision speed [m/s]	Numerical	Single value (no index)	The collision speed is provided (calculated from vehicle and object speed). If there is no risk of collision, the value "-1" is provided.

### 15.5.4 "Input value of index" module

The "Input value of index" module addresses measured values using the index. An index is assigned to each signal at input "in1" of the module. The number of values at the input is always identical to the number of values at the output. The module addresses the values using indices determined within the logic (dynamic addressing). This is possible because internally, an index is added to each value.



The following values have no index:

- fixed values (e.g. defined with the "Fixed value" module)
- the sum of values with different indices

The "Input value of index" module has the following settings:

Setting	Data type	Index	Description
Object -> acceleration x [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The acceleration of the object along the x-axis of the world coordinate system is provided. This value is the relative acceleration between device and object [m/s <sup>2</sup> ].
Object -> acceleration y [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The acceleration of the object along the y-axis of the world coordinate system is provided. This value is the relative acceleration between device and object [m/s <sup>2</sup> ].
Object -> acceleration z [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The acceleration of the object along the z-axis of the world coordinate system is provided. This value is the relative acceleration between device and object [m/s <sup>2</sup> ]. The value along the z-axis is only available when reflector objects are used. For normal objects this value is always "0" (zero).
Object -> age [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The age of the object is provided in measuring cycles. The value indicates the number of measurement cycles for which this object has already been recorded and tracked [measurement cycle].
Object -> distance to vehicle [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The minimum distance between the defined vehicle size and the object is provided (radially proximate distance). The value is only available if normal objects are used. For reflector objects this value is always "0" (zero).
Object -> probability of existence [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The probability of existence of the object is provided as a measure of quality: <ul style="list-style-type: none"> <li>• "0": very low probability of existence of the object</li> <li>• "0..1": the higher the value, the higher the probability of the object's existence</li> <li>• "1": very high probability of existence of the object</li> </ul>
Object -> ID [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The internal ID of the object is provided. The ID is not the index. The ID is a unique value. The ID of an object always remains the same as long as an object remains detected. The ID "0" is output if no valid object was detected.
Object -> type [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The type of the object is provided: <ul style="list-style-type: none"> <li>• "0": normal object</li> <li>• "1": reflector object</li> </ul> Reflector detection must be active for an object to be recognised as a retroreflector. An object whose reflectivity exceeds the set threshold is recognised as a retroreflector.
Object -> speed x [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The speed of the object along the x-axis of the world coordinate system is provided. This value is the relative speed between device and object [m/s <sup>2</sup> ].

Setting	Data type	Index	Description
Object -> speed y [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The speed of the object along the y-axis of the world coordinate system is provided. This value is the relative speed between device and object [m/s <sup>2</sup> ].
Object -> speed z [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The speed of the object along the z-axis of the world coordinate system is provided. This value is the relative speed between device and object [m/s <sup>2</sup> ].  The value along the z-axis is only available when reflector objects are used. For normal objects this value is always "0" (zero).
Object -> x1 [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The x-coordinate of the first point of the object in the world coordinate system is provided. With reflector objects, this value corresponds to the minimum x-value. In the case of normal objects, this is the first corner point with reference to the background model (also allows "oblique" objects).
Object -> x2 [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The x-coordinate of the second point of the object in the world coordinate system is provided. With reflector objects, this value corresponds to the minimum x-value. In the case of normal objects, this is the second corner point with reference to the background model (also allows "oblique" objects).
Object -> y1 [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The y-coordinate of the first point of the object in the world coordinate system is provided. With reflector objects, this value corresponds to the minimum y-value. In the case of normal objects, this is the first corner point with reference to the background model (also allows "oblique" objects).
Object -> y2 [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The y-coordinate of the second point of the object in the world coordinate system is provided. With reflector objects, this value corresponds to the maximum y-value. In the case of normal objects, this is the second corner point with reference to the background model (also allows "oblique" objects).
Object -> z(min) [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The minimum z-coordinate of the object in the world coordinate system is provided. For normal objects, the value can be minimised to the values of the height of the object detection (ground separation, default value = "0.5 m").
Object -> z(max) [1..20]	Numerical	Index from object list (vector with 20 values, address range from 1-20)	The maximum z-coordinate of the object in the world coordinate system is provided.

## 15.6 Description of the "Input" modules – Firmware LG

The following input modules are only available in the LG firmware variant:

- Line detection
- Input value of index

### 15.6.1 "Line detection" module

The "Line detection" module addresses measured values using indices. The indices are assigned to the ROI groups via a vector with up to 8 values.

You can use single indices or multiple indexes simultaneously (vectors).

The "Line detection" module has the following settings:

Setting	Data type	Index	Description
Alignment [1..8]	Numerical	Vector with 8 values, address range from 1-8	The angle between the detected line and the x-axis (direction of travel) is provided [rad].
Predictive detection [1..8]	Numerical	Vector with 8 values, address range from 1-8	The distance to the currently predictively detected line is provided [m].
Cross-section area line structure [1..8]	Numerical	Vector with 8 values, address range from 1-8	The cross-section area of the detected line structure in the y,z plane is provided (heap-like, e.g. swath).  The value is only available if swath detection is active (→ „14.3 Automatic ground plane detection“).
Cross-section area line structure valid [1..8]	Binary	Vector with 8 values, address range from 1-8	The availability of "Cross-section area line structure [1..8]" is provided: <ul style="list-style-type: none"> <li>• "0": cross-section area line structure [1..8] not available</li> <li>• "1": cross-section area line structure [1..8] available</li> </ul>
Height line structure [1..8]	Numerical	Vector with 8 values, address range from 1-8	The maximum height of the detected line structure above the ground level is provided (heap-like, e.g. swath).  The value is only available if swath detection is active (→ „14.3 Automatic ground plane detection“).
Height line structure valid [1..8]	Binary	Vector with 8 values, address range from 1-8	The availability of "Height line structure [1..8]" is provided: <ul style="list-style-type: none"> <li>• "0": height line structure [1..8] not available</li> <li>• "1": height line structure [1..8] available</li> </ul>
Width line structure [1..8]	Numerical	Vector with 8 values, address range from 1-8	The width of the detected line structure at the ground level is provided (heap-like, e.g. swath).  The value is only available if swath detection is active (→ „14.3 Automatic ground plane detection“).
Width line structure valid [1..8]	Binary	Vector with 8 values, address range from 1-8	The availability of "Width line structure [1..8]" is provided: <ul style="list-style-type: none"> <li>• "0": width line structure [1..8] not available</li> <li>• "1": width line structure [1..8] available</li> </ul>
ID [1..8]	Numerical	Vector with 8 values, address range from 1-8	The internal ID of the line is provided.  The ID is not the index. The ID is a unique value. The ID of a line always remains the same as long as the line remains detected. The ID "0" is output if no valid line was detected.
Height offset line structure [1..8]	Numerical	Vector with 8 values, address range from 1-8	The offset of the maximum height compared to the centerline of the detected line structure is provided (heap-like, e.g. swath). The centerline is described by the normal offset.  The value is only available if swath detection is active (→ „14.3 Automatic ground plane detection“).
Height offset line structure valid [1..8]	Binary	Vector with 8 values, address range from 1-8	The availability of "Height offset line structure [1..8]" is provided: <ul style="list-style-type: none"> <li>• "0": height offset line structure [1..8] not available</li> <li>• "1": height offset line structure [1..8] available</li> </ul>



Setting	Data type	Index	Description
Offset [1..8]	Numerical	Vector with 8 values, address range from 1-8	The offset between the detected line and the x-axis at the position of the reference point is provided.  The reference point can be configured (→ „9.3 Reference point of the device“).
Quality [1..8]	Numerical	Vector with 8 values, address range from 1-8	The quality of the line detection is provided: <ul style="list-style-type: none"> <li>• "0": very low quality of line detection</li> <li>• "0..1": the higher the value, the higher the quality of the line detection</li> <li>• "1": very high quality of line detection</li> </ul>
Steering curvature [1..8]	Numerical	Vector with 8 values, address range from 1-8	The signal for automatic steering is provided. Automatic steering is set by specifying a target point in a specific radius.
Type [1..8]	Numerical	Vector with 8 values, address range from 1-8	The type of the detected line is provided: <ul style="list-style-type: none"> <li>• "0": heap-like line structure (e.g. swath)</li> <li>• "1": crop edge</li> </ul>
Height of crop edge [1..8]	Numerical	Vector with 8 values, address range from 1-8	The height of the detected cutting edge is provided.  The value only available the crop edge mode is active (→ „14.5 Additional crop edge settings“).
Height of crop edge valid [1..8]	Binary	Vector with 8 values, address range from 1-8	The availability of "Height of crop edge [1..8]" is provided: <ul style="list-style-type: none"> <li>• "0": height of crop edge [1..8] not available</li> <li>• "1": height of crop edge [1..8] available</li> </ul>
index	Numerical	Vector with 8 values, address range from 1-8	

### 15.6.2 "Input value of index" module

The "Input value of index" module addresses measured values using the index. An index is assigned to each signal at input "in1" of the module. The number of values at the input is always identical to the number of values at the output. The module addresses the values using indices determined within the logic (dynamic addressing). This is possible because internally, an index is added to each value.

 The following values have no index:

- fixed values (e.g. defined with the "Fixed value" module)
- the sum of values with different indices

The "Input value of index" module has the following settings:

Setting	Data type	Index	Description
Alignment [1..8]	Numerical	Vector with 8 values, address range from 1-8	The angle between the detected line and the x-axis (direction of travel) is provided [rad].
Predictive detection [1..8]	Numerical	Vector with 8 values, address range from 1-8	The distance to the currently predictively detected line is provided [m].
Cross-section area line structure [1..8]	Numerical	Vector with 8 values, address range from 1-8	The cross-section area of the detected line structure in the y,z plane is provided (heap-like, e.g. swath).  The value is only available if swath detection is active (→ „14.3 Automatic ground plane detection“).
Cross-section area line structure valid [1..8]	Binary	Vector with 8 values, address range from 1-8	The availability of "Cross-section area line structure [1..8]" is provided: <ul style="list-style-type: none"> <li>• "0": cross-section area line structure [1..8] not available</li> <li>• "1": cross-section area line structure [1..8] available</li> </ul>
Height line structure [1..8]	Numerical	Vector with 8 values, address range from 1-8	The maximum height of the detected line structure above the ground level is provided (heap-like, e.g. swath).  The value is only available if swath detection is active (→ „14.3 Automatic ground plane detection“).

Setting	Data type	Index	Description
Height line structure valid [1..8]	Binary	Vector with 8 values, address range from 1-8	The availability of "Height line structure [1..8]" is provided: <ul style="list-style-type: none"> <li>• "0": height line structure [1..8] not available</li> <li>• "1": height line structure [1..8] available</li> </ul>
Width line structure [1..8]	Numerical	Vector with 8 values, address range from 1-8	The width of the detected line structure at the ground level is provided (heap-like, e.g. swath).  The value is only available if swath detection is active (→ „14.3 Automatic ground plane detection“).
Width line structure valid [1..8]	Binary	Vector with 8 values, address range from 1-8	The availability of "Width line structure [1..8]" is provided: <ul style="list-style-type: none"> <li>• "0": width line structure [1..8] not available</li> <li>• "1": width line structure [1..8] available</li> </ul>
ID [1..8]	Numerical	Vector with 8 values, address range from 1-8	The internal ID of the line is provided.  The ID is not the index. The ID is a unique value. The ID of a line always remains the same as long as the line remains detected. The ID "0" is output if no valid line was detected.
Height offset line structure [1..8]	Numerical	Vector with 8 values, address range from 1-8	The offset of the maximum height compared to the centerline of the detected line structure is provided (heap-like, e.g. swath). The centerline is described by the normal offset.  The value is only available if swath detection is active (→ „14.3 Automatic ground plane detection“).
Height offset line structure valid [1..8]	Binary	Vector with 8 values, address range from 1-8	The availability of "Height offset line structure [1..8]" is provided: <ul style="list-style-type: none"> <li>• "0": height offset line structure [1..8] not available</li> <li>• "1": height offset line structure [1..8] available</li> </ul>
Offset [1..8]	Numerical	Vector with 8 values, address range from 1-8	The offset between the detected line and the x-axis at the position of the reference point is provided.  The reference point can be configured (→ „9.3 Reference point of the device“).
Quality [1..8]	Numerical	Vector with 8 values, address range from 1-8	The quality of the line detection is provided: <ul style="list-style-type: none"> <li>• "0": very low quality of line detection</li> <li>• "0..1": the higher the value, the higher the quality of the line detection</li> <li>• "1": very high quality of line detection</li> </ul>
Steering curvature [1..8]	Numerical	Vector with 8 values, address range from 1-8	The signal for automatic steering is provided. Automatic steering is set by specifying a target point in a specific radius.
Type [1..8]	Numerical	Vector with 8 values, address range from 1-8	The type of the detected line is provided: <ul style="list-style-type: none"> <li>• "0": heap-like line structure (e.g. swath)</li> <li>• "1": cut edge</li> </ul>
Height of crop edge [1..8]	Numerical	Vector with 8 values, address range from 1-8	The height of the detected cutting edge is provided.  The value only available the crop edge mode is active (→ „14.5 Additional crop edge settings“).
Height of crop edge valid [1..8]	Binary	Vector with 8 values, address range from 1-8	The availability of "Height of crop edge [1..8]" is provided: <ul style="list-style-type: none"> <li>• "0": height of crop edge [1..8] not available</li> <li>• "1": height of crop edge [1..8] available</li> </ul>

### 15.7 Description of the "Memory function" modules

In the "Memory functions" selection area, available modules for storing information are displayed.

The following modules are available:

- Teach
- RAM write
- RAM read



### 15.7.1 "Teach" module

The "Teach" module allows permanent storage of information on the device. A typical use case is the storage of reference values.

The module has an input and an output. The module can store both single signals and vectors. Saving does not affect the size of a vector. In total, a maximum of 64 values can be stored.

The information at the input is stored when the teach signal is sent to the device on the CAN interface.

The nomenclature of the CAN signal for "Teach" is described in:

- a separate CAN document,
- libraries of ifm controllers.

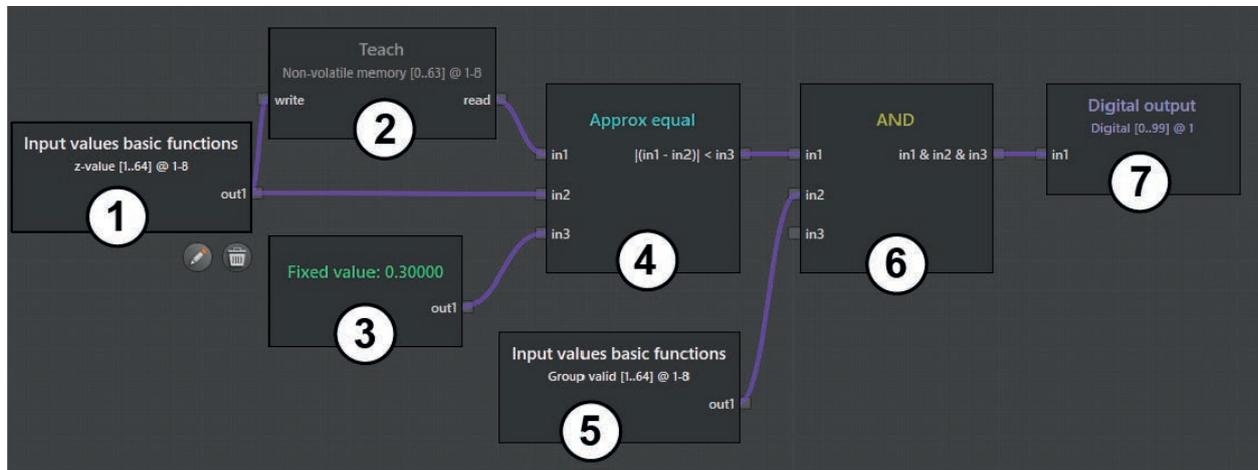
An external signal can be simulated with the logic teach commands (→ „15.13 Description of the switches "Enable CAN output"“).

The "Teach" module has the following setting:

Setting	Data type	Description
Index	Numerical	You can use single indices or multiple indexes simultaneously (vectors). If only a start index is specified, then the following indices are filled up to the vector size.

### 15.7.2 Example for the "Teach" module

The device is mounted on the mast of a vertical drilling rig and facing vertically downward. There are 8 ROI groups set up to monitor the area around the drill hole. The output of the ROI groups is set to the average z-value.



Description of the modules used in the example:

Module number	Module	Description
1	Basic function	The z-values are filtered out of ROI groups 1-8 (height).
2	Teach	The input values are stored as soon as the teach signal is sent to the device on the CAN interface. The output values always correspond to the input values of the last teach.
3	Fixed value	The fixed value "0.3" defines the tolerance.
4	Approx. equal	The reference values are compared with the current measured values taking into account the specified tolerance.
5	Basic function	The validity of the current measured values is filtered out of ROI groups 1-8 (binary value).

Module number	Module	Description
6	AND	If the measurement is valid and in the tolerance range of the reference value, a "1" is output (area free). If the measurement is invalid or not in the tolerance range of the reference value, a "0" is output (area not free).
7	Digital output	If a "1" is present at input "in1", a "1" is output at digital output "1".

Table of input values:

ROI group (index)	z-value (height)
1	0.05 m
2	-0.02 m
3	0.25 m
4	-0.18 m
5	0.07 m
6	0.02 m
7	-0.09 m
8	0.16 m

Memory contents after teach signal via CAN:

ROI group (index)	Value
1	0.05 m
2	-0.02 m
3	0.25 m
4	-0.18 m
5	0.07 m
6	0.02 m
7	-0.09 m
8	0.16 m

Current input values:

ROI group (index)	z-value (height)	Validity
1	-0.03 m	1
2	0 m	0
3	-0.11 m	1
4	-0.11 m	1
5	0.13 m	1
6	-0.02 m	1
7	0.07 m	1
8	0.18 m	1

Result of "Approx equal" module:

Index	Calculated value	Binary output
1	0.08 m	1
2	0.02 m	1
3	0.36 m	0
4	0.07 m	1
5	0.06 m	1
6	0.04 m	1
7	0.16 m	1
8	0.02 m	1

Logic output (after "AND" module with valid values):

Index	Digital output
1	1
2	0
3	0
4	1
5	1
6	1
7	1
8	1

### 15.7.3 "RAM write" module

The "RAM write" module allows volatile storage of information on the device. After a restart, the information is deleted from the device. Typical use cases for the "RAM write" and "RAM read" modules are exponential smoothing filters and event counters.

The module can store both single signals and vectors. Saving does not affect the size of a vector. In total, a maximum of 128 values can be stored.

The module offers an additional "Condition" input. If a "1" is present at this input, the information is stored at the "Value" input. If a "0" is present at this input, the old information is kept and information at the "Value" input is ignored.



If the "Condition" input is not connected, the input is internally set to "1". Thus, the stored values are overwritten in each cycle.

The "RAM write" module has the following setting:

Setting	Data type	Description
Index	Numerical	You can use single indices or multiple indexes simultaneously (vectors).  If only a start index is specified, then the following indices are filled up to the vector size.

### 15.7.4 "RAM read" module

The "RAM read" module reads the information stored on the "RAM write" module. Typical use cases for the "RAM write" and "RAM read" modules are exponential smoothing filters and event counters.

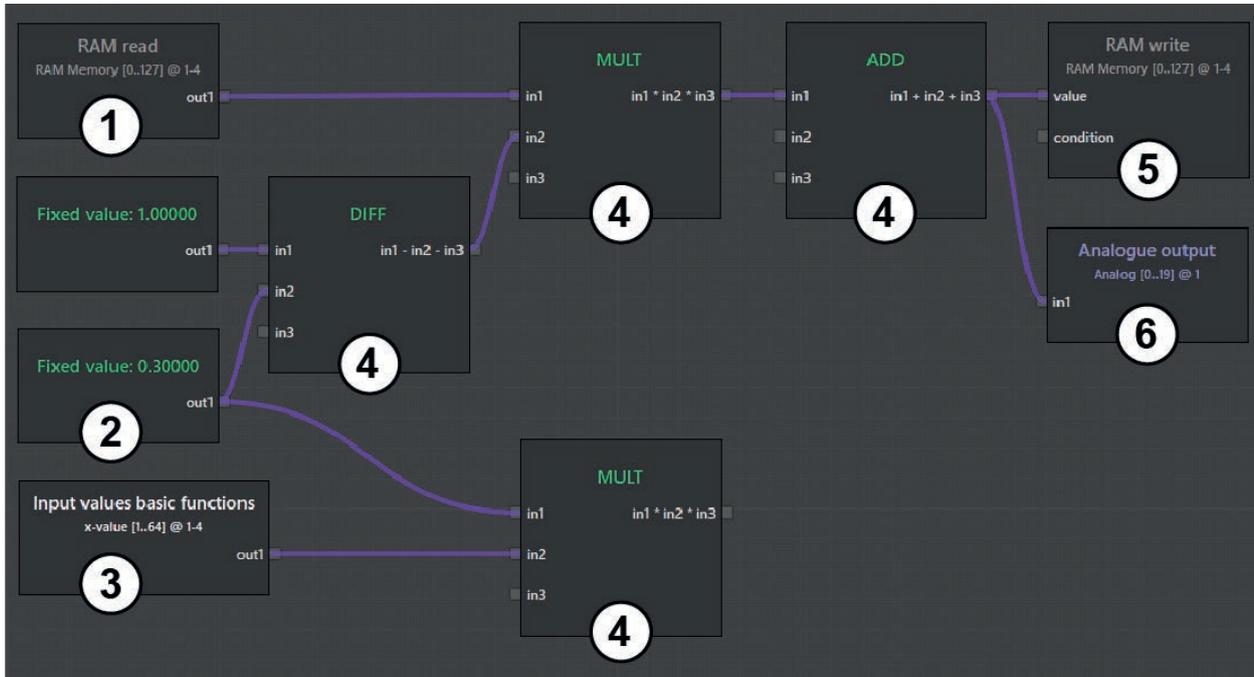
The "RAM read" module has the following setting:

Setting	Data type	Description
Index	Numerical	You can use single indices or multiple indexes simultaneously (vectors).

### 15.7.5 Example: "Exponential smoothing filter" for "RAM write" / "RAM read" modules

In this example, the results from the device or from a logic calculation are averaged over time (smoothed). The exponential smoothing filter generates a mean value via a weighted addition of the newest mean value and the old value:

$$y_t^* = \alpha y_t + (1 - \alpha)y_{t-1}^*$$

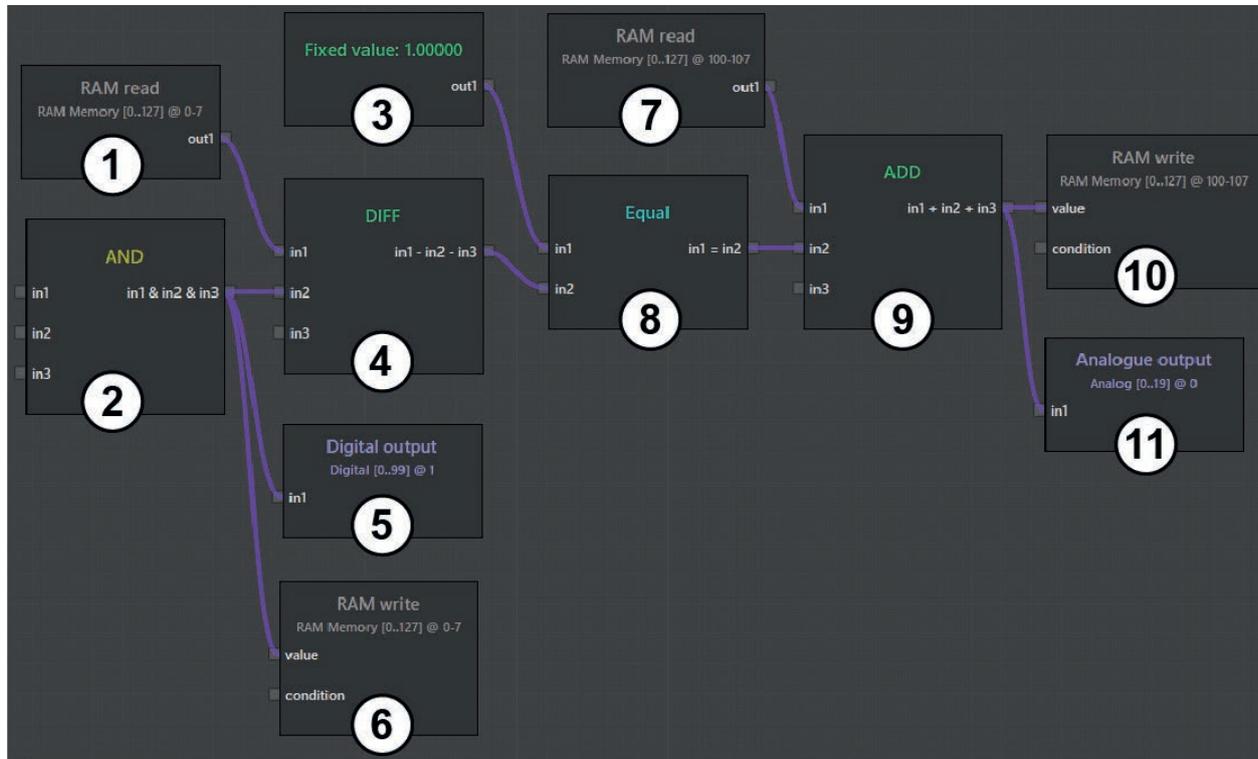


Description of the modules used in the example:

Module number	Module	Description
1	RAM read	The value " $y_{t-1}^*$ " is stored in the module and is output.
2	Fixed value	The fixed value "1" is defined as part of the above formula.
3	Fixed value	The fixed value "0.3" is defined as the smoothing value $\alpha$ .
4	DIFF / MULT / ADD	The 4 components calculate the exponential smoothing according to the above formula.
5	RAM write	The calculated value $y_t^*$ is stored in the module.
6	Analogue output	The calculated value $y_t^*$ is output at analogue output 1.

### 15.7.6 Example "Event counter" for "RAM write" / "RAM read" modules

In this example, an event counter is implemented for the vertical drilling rig (→ „15.7.1 "Teach" module“). The "Area not free" events of ROI groups 1-8 of the vertical drilling rig are taken into account. The transition from "Area free" to "Area not free" (falling edge of the binary signal) is counted.



Description of the modules used in the example:

Module number	Module	Description
1	RAM read	The state is read from the RAM. Index 0 to 7 is used as address. The read state corresponds to the values stored in module 6 from the previous cycle (n-1).
2	AND	If the measurement is valid and in the tolerance range of the reference value, a "1" is output (area free). If the measurement is invalid or not in the tolerance range of the reference value, a "0" is output (area not free). This corresponds to the behaviour of the vertical drilling rig (→ „15.7.2 Example for the "Teach" module“)
3	Fixed value	The fixed value "1" is defined.
4	DIFF	The difference between the previous and current cycle is established. At the transition from "Area free" to "Area not free", a "1" is output (falling edge of the binary signal). In all other cases, a "0" or "-1" is output.
5	Digital output	The result of the AND module is output at digital output 1.
6	RAM write	The state of the 8 ROI groups is written to the RAM. Index 0 to 7 is used as address.
7	RAM read	The count of the last cycle is delivered.
8	Equal	If a "1" is present at the inputs, a "1" is output. In all other cases, a "0" is output. So in the example, a "1" is only output whenever a transition from free (value ="1") to occupied (value ="0") occurs in the areas.
9	ADD	The counts of the previous and current cycle are added and output.
10	RAM write	The counter reading is saved.
11	Analogue output	The count is output at analogue output 0.

## 15.8 Description of the "Arithmetic" modules

In the "Arithmetic" selection area, available modules for calculating with numbers are displayed. The modules can handle both single signals and vectors.

The "Arithmetic" selection area contains the following modules:

Module	Input	Output	Description
Fixed value	No input	1 output (numerical, single value)	The "Fixed value" module outputs an adjustable floating point number. Typical applications are arithmetic operations (e.g. setting an offset). The module has the following setting: set the fixed value (numeric).
ADD	3 inputs (numerical, single values / vectors)	1 output (numerical, single values / vectors depending on inputs)	The "ADD" module adds the signals present at the inputs. The binary values "1" and "0" are treated as numerical values. Input "in3" is interpreted as "0" if it is not used.  How the module processes vectors and single values at the inputs is illustrated in an example (→ „15.8.1 Examples for processing input signals“).
DIFF	3 inputs (numerical, single values / vectors)	1 output (numerical, single values / vectors depending on inputs)	The "DIFF" module subtracts the signals present at the inputs. The binary values "1" and "0" are treated as numerical values. Input "in3" is interpreted as "0" if it is not used.  How the module processes vectors and single values at the inputs is illustrated in an example (→ „15.8.1 Examples for processing input signals“).
MULT	3 inputs (numerical, single values / vectors)	1 output (numerical, single values / vectors depending on inputs)	The "MULT" module multiplies the signals present at the inputs. The binary values "1" and "0" are treated as numerical values. Input "in3" is interpreted as "1" if it is not used.  How the module processes vectors and single values at the inputs is illustrated in an example (→ „15.8.1 Examples for processing input signals“).
DIV	3 inputs (numerical, single values / vectors)	1 output (numerical, single values / vectors depending on inputs)	The "DIV" module divides the signals present at the inputs. Input "in3" is interpreted as "1" if it is not used.  How the module processes vectors and single values at the inputs is illustrated in an example (→ „15.8.1 Examples for processing input signals“).
SQRT	1 input (numerical, single value / vector)	1 output (numerical, single value / vector depending on inputs)	The output of the "SQRT" module is the square root of the signal present at the input.
Scale	3 inputs (numerical, single values / vectors)	1 output (numerical, single values / vectors depending on inputs)	The "Scale" module scales the signal present at input "in1". The range to be scaled is set by the inputs "in2" (start value) and "in3" (end value). The binary values "1" and "0" are treated as numerical values. Input "in3" is interpreted as "0" if it is not used. If "in1" < "in2", the output is "0" (clipping). If "in1" > "in3", the output is "1" (clipping).  How the module processes vectors and single values at the inputs is illustrated in an example (→ „15.8.1 Examples for processing input signals“).
SIN	1 input (numerical [rad], single value / vector)	1 output (numerical, single value / vector depending on inputs)	The "SIN" module calculates the sine from the input signal. The signal at the input is interpreted as [rad].
COS	1 input (numerical [rad], single value / vector)	1 output (numerical, single value / vector depending on inputs)	The "COS" module calculates the cosine from the input signal. The signal at the input is interpreted as [rad].

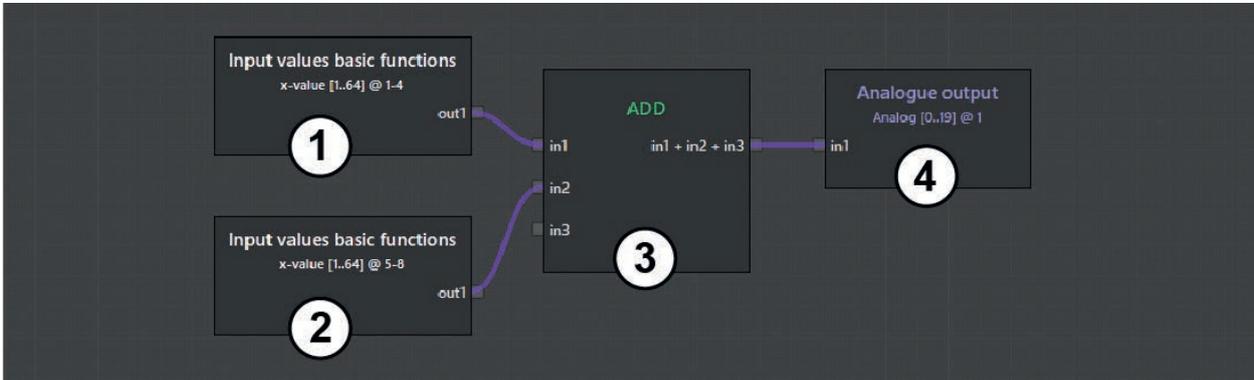
Module	Input	Output	Description
TAN	1 input (numerical [rad], single value / vector)	1 output (numerical, single value / vector depending on inputs)	The "TAN" module calculates the tangent from the input signal. The signal at the input is interpreted as [rad].
ARCSIN	1 input (numerical, single value / vector)	1 output (numerical [rad], single value / vector depending on inputs)	The "ARCSIN" module calculates the arcsine from the input signal. The output signal is provided as [rad].
ARCCOS	1 input (numerical, single value / vector)	1 output (numerical [rad], single value / vector depending on inputs)	The "ARCCOS" module calculates the arc cosine from the input signal. The output signal is provided as [rad].
ARCTAN	1 input (numerical, single value / vector)	1 output (numerical [rad], single value / vector depending on inputs)	The "ARCTAN" module calculates the arctangent from the input signal. The output signal is provided as [rad].
ARCTAN2	2 inputs (numerical, single values / vectors)	1 output (numerical [rad], single value / vector depending on inputs)	<p>The "ARCTAN2" module is an extension of the inverse trigonometric function called "arctangent" and calculates the arctangent from the input signal. The output signal is provided as [rad].</p> <p> How the module processes vectors and single values at the inputs is illustrated in an example (→ „15.8.1 Examples for processing input signals“).</p>
Absolute	1 input (numerical, single value / vector)	1 output (numerical, single value / vector depending on inputs)	The "Absolute" module outputs the absolute value of the input signal (amount).
Maximum value	2 inputs (numerical, single values / vectors)	1 output (numerical, single value / vector depending on inputs)	<p>The "Maximum value" module provides the maximum value of the input signals. If vectors are present at both inputs, the maximum of each of the individual elements of the vectors is determined. A vector is then sent to the output. The size of the vector at the output corresponds to size of the vectors at the input. If there is a vector at one input and a single value at the other input, the maximum is determined from each value of the vector and the single value. A vector is then sent to the output. The size of the vector at the output corresponds to size of the vector at the input.</p> <p> The absolute maximum within a vector can be determined using the "Vector Max" module (→ „15.11 Description of the "Vector-specific functions" modules“).</p> <p> How the module processes vectors and single values at the inputs is illustrated in an example (→ „15.8.1 Examples for processing input signals“).</p>
Minimum value	2 inputs (numerical, single values / vectors)	1 output (numerical, single value / vector depending on inputs)	<p>The "Minimum value" module provides the minimum value of the input signals. If vectors are present at both inputs, the minimum of each of the individual elements of the vectors is determined. A vector is then sent to the output. The size of the vector at the output corresponds to size of the vectors at the input. If there is a vector at one input and a single value at the other input, the minimum is determined from each value of the vector and the single value. A vector is then sent to the output. The size of the vector at the output corresponds to size of the vector at the input.</p> <p> The absolute minimum within a vector can be determined using the "Vector Min" module (→ „15.11 Description of the "Vector-specific functions" modules“).</p> <p> How the module processes vectors and single values at the inputs is illustrated in an example (→ „15.8.1 Examples for processing input signals“).</p>

### 15.8.1 Examples for processing input signals

All modules with several inputs and one output process vectors as follows:

#### Addition of two vectors of equal size

If vectors of the same size are present at the inputs, the respective values of the vectors are added. A vector is then sent to the output. The size of the vector at the output corresponds to size of the vectors at the input.



Description of the modules used in the example:

Module number	Module	Description								
1	Basic function	The x-values are filtered out of ROI groups 1-4. The ROI groups contain the following x-values: <table border="1" style="margin-left: 20px;"> <tr><td>1</td><td>3.25 m</td></tr> <tr><td>2</td><td>3.32 m</td></tr> <tr><td>3</td><td>3.19 m</td></tr> <tr><td>4</td><td>3.37 m</td></tr> </table>	1	3.25 m	2	3.32 m	3	3.19 m	4	3.37 m
1	3.25 m									
2	3.32 m									
3	3.19 m									
4	3.37 m									
2	Basic function	The x-values are filtered out of ROI groups 5-8. The ROI groups contain the following values: <table border="1" style="margin-left: 20px;"> <tr><td>5</td><td>5.07 m</td></tr> <tr><td>6</td><td>4.98 m</td></tr> <tr><td>7</td><td>5.12 m</td></tr> <tr><td>8</td><td>5.02 m</td></tr> </table>	5	5.07 m	6	4.98 m	7	5.12 m	8	5.02 m
5	5.07 m									
6	4.98 m									
7	5.12 m									
8	5.02 m									
3	ADD	The respective x-values of the vectors are added.								
4	Analogue output	The following vector is provided at analogue output 1: <table border="1" style="margin-left: 20px;"> <tr><td>1</td><td>(ROI 1 (3.25 m)) + (ROI 5 (5.07 m)) = 8.32 m</td></tr> <tr><td>2</td><td>(ROI 2 (3.32 m)) + (ROI 6 (4.98 m)) = 8.30 m</td></tr> <tr><td>3</td><td>(ROI 3 (3.19 m)) + (ROI 7 (5.12 m)) = 8.31 m</td></tr> <tr><td>4</td><td>(ROI 4 (3.37 m)) + (ROI 8 (5.02 m)) = 8.39 m</td></tr> </table>	1	(ROI 1 (3.25 m)) + (ROI 5 (5.07 m)) = 8.32 m	2	(ROI 2 (3.32 m)) + (ROI 6 (4.98 m)) = 8.30 m	3	(ROI 3 (3.19 m)) + (ROI 7 (5.12 m)) = 8.31 m	4	(ROI 4 (3.37 m)) + (ROI 8 (5.02 m)) = 8.39 m
1	(ROI 1 (3.25 m)) + (ROI 5 (5.07 m)) = 8.32 m									
2	(ROI 2 (3.32 m)) + (ROI 6 (4.98 m)) = 8.30 m									
3	(ROI 3 (3.19 m)) + (ROI 7 (5.12 m)) = 8.31 m									
4	(ROI 4 (3.37 m)) + (ROI 8 (5.02 m)) = 8.39 m									

### Addition of two vectors of different size

If vectors of different size are present at the inputs, the respective values of the vectors are added. Missing values of the smaller vector are replaced by the last value used. A vector is then sent to the output. The size of the vector at the output corresponds to size of the largest vector at the input.

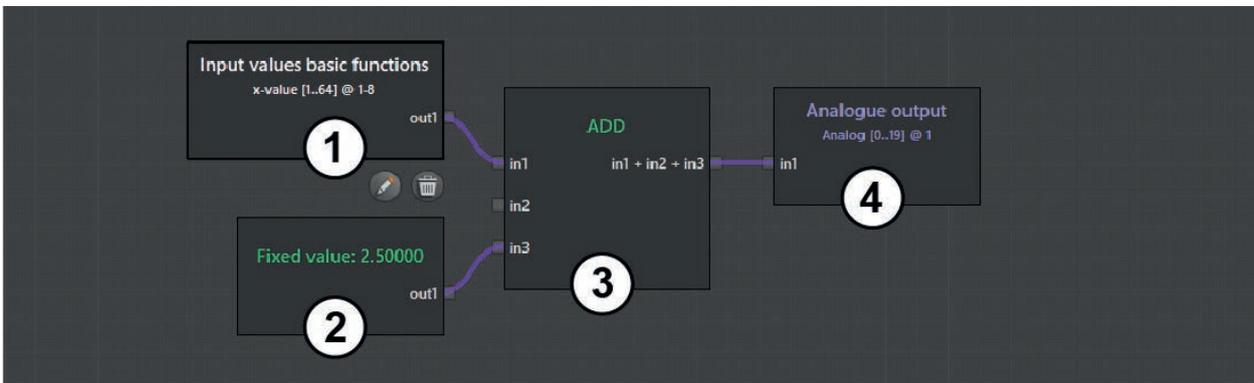


Description of the modules used in the example:

Module number	Module	Description								
1	Basic function	<p>The x-values are filtered out of ROI groups 1-4. The ROI groups contain the following x-values:</p> <table border="1"> <tr><td>1</td><td>3.25 m</td></tr> <tr><td>2</td><td>3.32 m</td></tr> <tr><td>3</td><td>3.19 m</td></tr> <tr><td>4</td><td>3.37 m</td></tr> </table>	1	3.25 m	2	3.32 m	3	3.19 m	4	3.37 m
1	3.25 m									
2	3.32 m									
3	3.19 m									
4	3.37 m									
2	Basic function	<p>The x-values are filtered out of ROI groups 5-7. The ROI groups contain the following values:</p> <table border="1"> <tr><td>5</td><td>5.07 m</td></tr> <tr><td>6</td><td>4.98 m</td></tr> <tr><td>7</td><td>5.12 m</td></tr> </table>	5	5.07 m	6	4.98 m	7	5.12 m		
5	5.07 m									
6	4.98 m									
7	5.12 m									
3	ADD	The respective x-values of the vectors are added.								
4	Analogue output	<p>The following vector is provided at analogue output 1:</p> <table border="1"> <tr><td>1</td><td>(ROI 1 (3.25 m)) + (ROI 5 (5.07 m)) = 8.32 m</td></tr> <tr><td>2</td><td>(ROI 2 (3.32 m)) + (ROI 6 (4.98 m)) = 8.30 m</td></tr> <tr><td>3</td><td>(ROI 3 (3.19 m)) + (ROI 7 (5.12 m)) = 8.31 m</td></tr> <tr><td>4</td><td>(ROI 4 (3.37 m)) + (ROI 8 (5.12 m)) = 8.49 m</td></tr> </table>	1	(ROI 1 (3.25 m)) + (ROI 5 (5.07 m)) = 8.32 m	2	(ROI 2 (3.32 m)) + (ROI 6 (4.98 m)) = 8.30 m	3	(ROI 3 (3.19 m)) + (ROI 7 (5.12 m)) = 8.31 m	4	(ROI 4 (3.37 m)) + (ROI 8 (5.12 m)) = 8.49 m
1	(ROI 1 (3.25 m)) + (ROI 5 (5.07 m)) = 8.32 m									
2	(ROI 2 (3.32 m)) + (ROI 6 (4.98 m)) = 8.30 m									
3	(ROI 3 (3.19 m)) + (ROI 7 (5.12 m)) = 8.31 m									
4	(ROI 4 (3.37 m)) + (ROI 8 (5.12 m)) = 8.49 m									

### Addition of a vector and a single value

If there is a vector at one input and a single value at the other input, each value of the vector is added to the single value. A vector is then sent to the output. The size of the vector at the output corresponds to size of the vector at the input.



Description of the modules used in the example:

Module number	Module	Description																
1	Basic function	<p>The x-values are filtered out of ROI groups 1-8. The ROI groups contain the following x-values:</p> <table border="1"> <tr><td>1</td><td>3.25 m</td></tr> <tr><td>2</td><td>3.32 m</td></tr> <tr><td>3</td><td>3.19 m</td></tr> <tr><td>4</td><td>3.37 m</td></tr> <tr><td>5</td><td>5.07 m</td></tr> <tr><td>6</td><td>4.98 m</td></tr> <tr><td>7</td><td>5.12 m</td></tr> <tr><td>8</td><td>5.02 m</td></tr> </table>	1	3.25 m	2	3.32 m	3	3.19 m	4	3.37 m	5	5.07 m	6	4.98 m	7	5.12 m	8	5.02 m
1	3.25 m																	
2	3.32 m																	
3	3.19 m																	
4	3.37 m																	
5	5.07 m																	
6	4.98 m																	
7	5.12 m																	
8	5.02 m																	
2	Fixed value	The fixed value "2.5" is defined.																
3	ADD	The x-values of the vector are added to the fixed value.																
4	Analogue output	<p>The following vector is provided at analogue output 1:</p> <table border="1"> <tr><td>1</td><td>(ROI 1 (3.25 m)) + 2.5 m = 5.75 m</td></tr> <tr><td>2</td><td>(ROI 2 (3.32 m)) + 2.5 m = 5.82 m</td></tr> <tr><td>3</td><td>(ROI 3 (3.19 m)) + 2.5 m = 5.69 m</td></tr> <tr><td>4</td><td>(ROI 4 (3.37 m)) + 2.5 m = 5.87 m</td></tr> <tr><td>5</td><td>(ROI 5 (5.07 m)) + 2.5 m = 7.57 m</td></tr> <tr><td>6</td><td>(ROI 6 (4.98 m)) + 2.5 m = 7.48 m</td></tr> <tr><td>7</td><td>(ROI 7 (5.12 m)) + 2.5 m = 7.62 m</td></tr> <tr><td>8</td><td>(ROI 8 (5.02 m)) + 2.5 m = 7.52 m</td></tr> </table>	1	(ROI 1 (3.25 m)) + 2.5 m = 5.75 m	2	(ROI 2 (3.32 m)) + 2.5 m = 5.82 m	3	(ROI 3 (3.19 m)) + 2.5 m = 5.69 m	4	(ROI 4 (3.37 m)) + 2.5 m = 5.87 m	5	(ROI 5 (5.07 m)) + 2.5 m = 7.57 m	6	(ROI 6 (4.98 m)) + 2.5 m = 7.48 m	7	(ROI 7 (5.12 m)) + 2.5 m = 7.62 m	8	(ROI 8 (5.02 m)) + 2.5 m = 7.52 m
1	(ROI 1 (3.25 m)) + 2.5 m = 5.75 m																	
2	(ROI 2 (3.32 m)) + 2.5 m = 5.82 m																	
3	(ROI 3 (3.19 m)) + 2.5 m = 5.69 m																	
4	(ROI 4 (3.37 m)) + 2.5 m = 5.87 m																	
5	(ROI 5 (5.07 m)) + 2.5 m = 7.57 m																	
6	(ROI 6 (4.98 m)) + 2.5 m = 7.48 m																	
7	(ROI 7 (5.12 m)) + 2.5 m = 7.62 m																	
8	(ROI 8 (5.02 m)) + 2.5 m = 7.52 m																	

## 15.9 Description of the "Digitalisation" modules

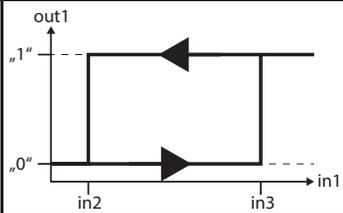
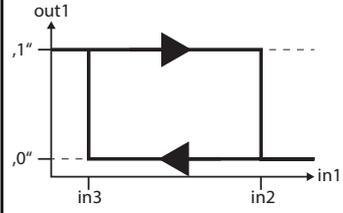
In the "Digitalisation" selection area, available modules for digitalisation are displayed. The modules convert numerical values at the inputs into comparable binary expressions.



The "Digitalisation" modules can process individual signals or vectors at the inputs:

- ▶ No combination of single values and vectors.
- ▶ Use vectors of the same size.
- ▶ Use single values only.

The "Digitalisation" selection area contains the following modules:

Module	Input	Output	Description
Hysteresis	3 inputs (numerical, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	<p>The signal at input "in1" is compared with the threshold values "in2" and "in3".</p> <p>"in2" &lt; "in3":</p> <ul style="list-style-type: none"> <li>• if "in1" &lt; "in2", then "out1" = "0"</li> <li>• if "in1" &gt; "in3", then "out1" = "1"</li> <li>• if "in2" ≤ "in1" ≤ "in3", then "out1" remains unchanged</li> </ul> 
			<p>"in2" &gt; "in3":</p> <ul style="list-style-type: none"> <li>• if "in1" &gt; "in2", then "out1" = "0"</li> <li>• if "in1" &lt; "in3", then "out1" = "1"</li> <li>• if "in3" ≤ "in1" ≤ "in2", then "out1" remains unchanged</li> </ul> 
Greater	2 inputs (numerical, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	<p>The signals at the inputs are compared according to the following scheme:</p> <ul style="list-style-type: none"> <li>• if "in1" &gt; "in2", then "out1" = "1"</li> <li>• if "in1" &lt; "in2", then "out1" = "0"</li> </ul>
Greater equal	2 inputs (numerical, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	<p>The signals at the inputs are compared according to the following scheme:</p> <ul style="list-style-type: none"> <li>• if "in1" ≥ "in2", then "out1" = "1"</li> <li>• if "in1" &lt; "in2", then "out1" = "0"</li> </ul>
Equal	2 inputs (numerical, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	<p>The signals at the inputs are compared according to the following scheme:</p> <ul style="list-style-type: none"> <li>• if "in1" = "in2", then "out1" = "1"</li> <li>• if "in1" ≠ "in2", then "out1" = "0"</li> </ul>
Not equal	2 inputs (numerical, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	<p>The signals at the inputs are compared according to the following scheme:</p> <ul style="list-style-type: none"> <li>• if "in1" ≠ "in2", then "out1" = "1"</li> <li>• if "in1" = "in2", then "out1" = "0"</li> </ul>
Less	2 inputs (numerical, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	<p>The signals at the inputs are compared according to the following scheme:</p> <ul style="list-style-type: none"> <li>• if "in1" &lt; "in2", then "out1" = "1"</li> <li>• if "in1" &gt; "in2", then "out1" = "0"</li> </ul>
Less than or equal	2 inputs (numerical, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	<p>The signals at the inputs are compared according to the following scheme:</p> <ul style="list-style-type: none"> <li>• if "in1" ≤ "in2", then "out1" = "1"</li> <li>• if "in1" &gt; "in2", then "out1" = "0"</li> </ul>
Between	3 inputs (numerical, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	<p>The signals at the inputs are compared according to the following scheme:</p> <ul style="list-style-type: none"> <li>• if "in2" ≤ "in1" ≤ "in3", then "out1" = "1"</li> <li>• if "in1" &lt; "in2" or "in1" &gt; "in3", then "out1" = "0"</li> </ul>

Module	Input	Output	Description
Approx. equal	3 inputs (numerical, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	The signals at inputs "in1" and "in2" are compared at input "in3" taking into account the tolerance: <ul style="list-style-type: none"> <li>• if the difference between "in1" and "in2" &lt; "in3", then "out1" = "1"</li> <li>• if the difference between "in1" and "in2" ≥ "in3", then "out1" = "0"</li> </ul>

### 15.10 Description of the "Logical functions" modules

In the "Logical functions" selection area, available logical functions are displayed. The modules depends upon binary signals at the inputs (exception: "Select" module).



The "Digitalisation" modules can process individual signals or vectors at the inputs:

- ▶ No combination of single values and vectors.
- ▶ Use vectors of the same size.
- ▶ Use single values only.

The "Logical functions" selection area contains the following modules:

Module	Input	Output	Description																																																
AND	3 inputs (binary, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	The "AND" module creates an AND relation between the input signals: If all signals at the inputs are "1", a "1" is provided at output "out1". Input "in3" is interpreted as "1" if it is not used.																																																
OR	3 inputs (binary, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	The "OR" module creates an OR relation between the input signals: If at least one of the signals at the inputs is "1", a "1" is provided at output "out1". Input "in3" is interpreted as "0" if it is not used.																																																
XOR	3 inputs (binary, single values or vectors)	1 output (binary, single values or vectors depending on inputs)	The "XOR" module creates an "Exclusive or" relation between the input signals (see table on the right). The "in3" input is only taken into account by the "Exclusive or" combination if it is used. <table border="1" style="margin-left: auto; margin-right: auto;"> <tbody> <tr><td>0</td><td>0</td><td>n.c.</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>n.c.</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>n.c.</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>n.c.</td><td>0</td></tr> <tr><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>0</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>0</td><td>1</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>1</td><td>0</td></tr> </tbody> </table>	0	0	n.c.	0	1	0	n.c.	1	0	1	n.c.	1	1	1	n.c.	0	0	0	0	0	1	0	0	1	0	1	0	1	1	1	0	1	0	0	1	1	1	0	1	1	0	1	1	1	1	1	1	0
0	0	n.c.	0																																																
1	0	n.c.	1																																																
0	1	n.c.	1																																																
1	1	n.c.	0																																																
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1	0	0	1																																																
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0	0	1	1																																																
1	0	1	1																																																
0	1	1	1																																																
1	1	1	0																																																
NOT	1 input (binary, single value or vector)	1 output (binary, single value or vector depending on inputs)	The "NOT" module negates the input signal: <ul style="list-style-type: none"> <li>• if "in1" == "1", then "out1" = "0"</li> <li>• if "in1" == "0", then "out1" = "1"</li> </ul>																																																
Select	2 numerical inputs, 1 binary input (single values or vectors)	1 output (numerical, single values or vectors depending on inputs)	The "Select" module selects one of the numerical input signals "in2" or "in3" depending on the status of the binary input "in1": <ul style="list-style-type: none"> <li>• if "in1" == "1", then "out1" = "in3"</li> <li>• if "in1" == "0", then "out1" = "in2"</li> </ul>																																																

## 15.11 Description of the "Vector-specific functions" modules

In the "Vector-specific functions" selection area, functions are displayed which convert vectors into single values.



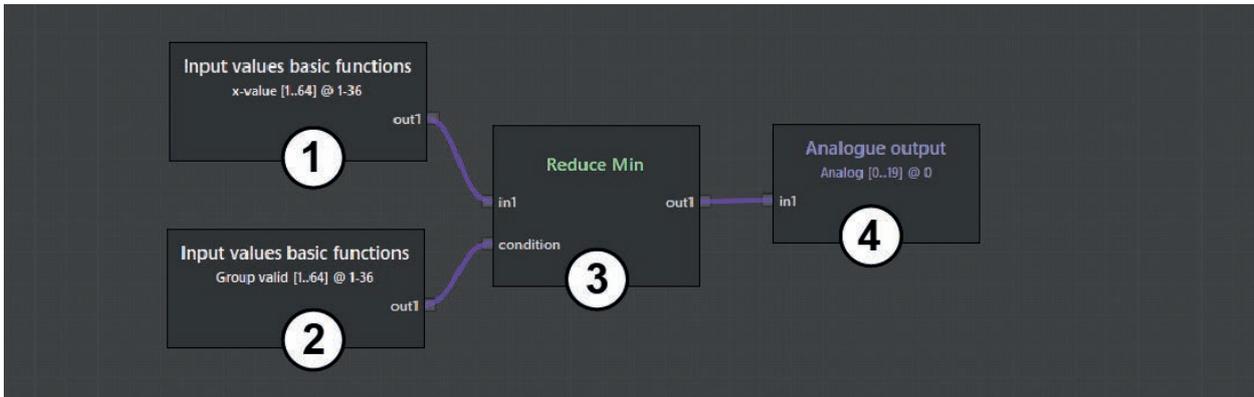
The "Vector-specific functions" modules require vectors as input signals.

The "Vector-specific functions" selection area contains the following modules:

Module	Input	Output	Description
Vector AND	1 input (binary, vector)	1 output (binary, single value)	<p>The "Vector AND" module creates an AND relation between the binary values of the vector at the input:</p> <ul style="list-style-type: none"> <li>• if all binary values of the vector are "1", then "out1" = "1".</li> <li>• if at least one of the binary values of the vector is "0", then "out1" = "0".</li> </ul>
Vector OR	1 input (binary, vector)	1 output (binary, single value)	<p>The "Vector OR" module creates an OR relation between the binary values of the vector at the input:</p> <ul style="list-style-type: none"> <li>• if at least one of the binary values of the vector is "1", then "out1" = "1".</li> </ul>
Vector Min	2 inputs ("in1": numerical, vector. "Condition": binary, vector)	1 output (numerical, single value)	<p>The "Vector Min" module determines the smallest value from the numerical vector at input "in1".</p> <p>The "Condition" input is optional and can evaluate the validity of the values. Valid values are marked with a "1". Only the valid values are taken into account when determining the smallest value from the numerical vector.</p> <p>Invalid values are output as "0" at output "out1".</p> <p> If possible, the "Condition" input should always be used. This ensures that only valid values are used for determining the smallest value.</p> <p> The size of the binary vector at the "Condition" input must correspond to the size of the numeric vector at the "in1" input.</p> <p> The validity can be queried with the following modules:</p> <ul style="list-style-type: none"> <li>• Firmware DI: "Basic function" module, "Validity" setting.</li> <li>• Firmware OD: "Object detection" module, "Object -&gt; ID [1..20]" setting.</li> <li>• Firmware LG: "Line detection" module, "... valid [...]" setting.</li> </ul>
Vector Max	2 inputs ("in1": numerical, vector. "Condition": binary, vector)	1 output (numerical, single value)	<p>The "Vector Max" module determines the greatest value from the numerical vector at input "in1".</p> <p>The "Condition" input is optional and can evaluate the validity of the values. Valid values are marked with a "1". Only the valid values are taken into account when determining the greatest value from the numerical vector.</p> <p>Invalid values are output as "0" at output "out1".</p> <p> If possible, the "Condition" input should always be used. This ensures that only valid values are used for determining the greatest value.</p> <p> The size of the binary vector at the "Condition" input must correspond to the size of the numeric vector at the "in1" input.</p> <p> The validity can be queried with the following modules:</p> <ul style="list-style-type: none"> <li>• Firmware DI: "Basic function" module, "Validity" setting.</li> <li>• Firmware OD: "Object detection" module, "Object -&gt; ID [1..20]" setting.</li> <li>• Firmware LG: "Line detection" module, "... valid [...]" setting.</li> </ul>
Vector Sum	1 input (numerical, vector)	1 output (numerical, single value)	<p>The "Vector Sum" module adds up the values of the numerical vector at input "in1".</p> <p>A numerical single value is output at output "out1".</p>

### 15.11.1 Example for the "Vector Min" module

The "Vector Min" module checks the validity of the x-values at input "in1". Then the smallest x-value is determined from the x-values and output at analogue output 0.



Description of the modules used in the example:

Module number	Module	Description
1	Basic function	The "Basic function" module filters out the x-values.
2	Basic function	The "Basic function" module checks the validity of the x-values.
3	Vector Min	The "Vector Min" module processes the x-values at input "in1" and the validity at input "Condition". The smallest x-value is then determined from the x-values.
4	Analogue output	The smallest x value is provided as a numerical single value at analogue output 0.

### 15.12 Description of the "Output" modules

The "Output" selection area displays functions for outputting digital and analogue signals.

The following modules are available:

- Digital output
- Analogue output

#### 15.12.1 "Digital output" module

The "Digital output" module transfers the binary results from the logic editor to the connected peripherals. A maximum of 100 binary outputs are available. The "in1" input processes single binary values or vectors.

The results are available at the following interfaces:

- Ethernet (UDP) (→ „16.3.1 Ethernet (UDP)“)
- CAN (J1939, CANOpen) (→ „16.3.2 CAN (J1939, CANOpen)“)
- Internal for configuring the 2D overlay (→ „11 2D overlay“): Output binary results via text replacement within the 2D overlay (→ „11.2.1 Add text“)



When using the DI firmware in combination with the "Logic output" colour mode (→ „11.4.1 Visualising 3D ROIs as a moving wall“): The indices set in the output must correspond to the numbers of the ROI groups.

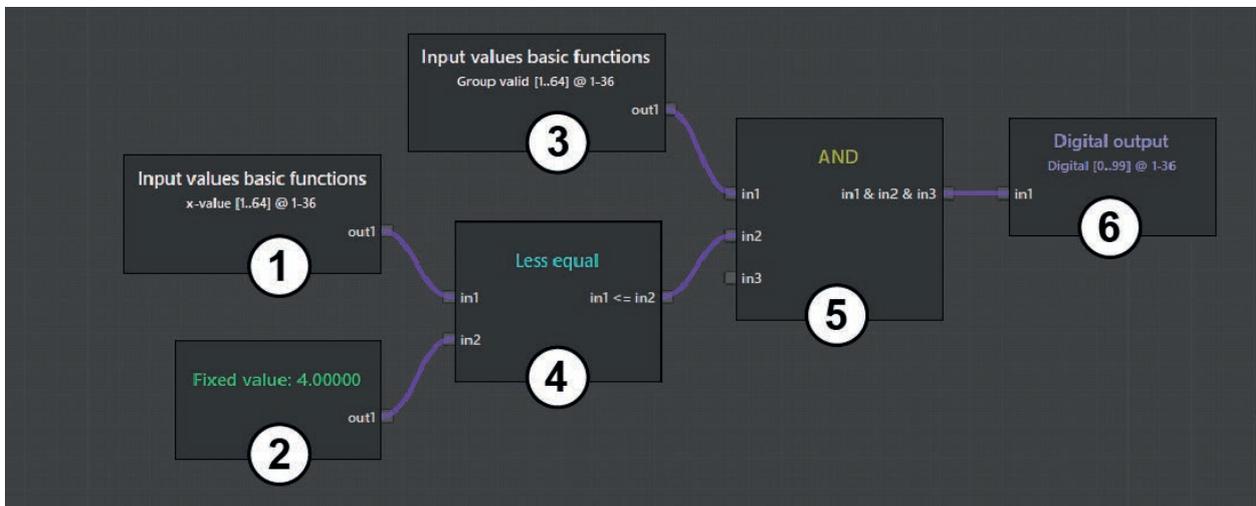
The "Digital output" module has the following setting:

Setting	Data type	Description
Index	Numerical	<p>You can use single indices or multiple indexes simultaneously (vectors).</p> <p> Duplicate addresses lead to an undefined state at the output. ▶ Assign each address only once.</p> <p> When using vectors at the "in1" input: If only one index is set, this index is used as the start index. Example: A vector with 8 binary values is present at input "in1" and index "3" is set. Thus, the start index is "3". The 8 binary values are assigned to the digital outputs "3..10".</p>



### 15.12.2 Example for the "Digital output" module

In the example, 36 ROI groups are checked against a threshold value. The status is to be displayed in the 2D overlay based on the results of the digital output using colour representation. To achieve this, the indices of the "Basic function" and "Digital output" modules must be identical.



Description of the modules used in the example:

Module number	Module	Description
1	Basic function	The x-values are filtered out.
2	Fixed value	The fixed value "4" is set as the threshold value.
3	Basic function	The validity is checked.
4	Less than or equal	The x-values are compared with the threshold value.
5	AND	The validity and the result of the threshold check are linked with an AND relation.
6	Digital output	The result is provided at the digital output. The indices are selected (1-36) so that they correspond to the indices of the ROI groups (module 1).

### 15.12.3 "Analogue output" module

The "Analogue output" module transfers the numerical results from the logic editor to the connected peripherals. A maximum of 20 numerical outputs are available. The "in1" input processes numerical values or vectors.

The results are available at the following interfaces:

- Ethernet (UDP) (→ „16.3.1 Ethernet (UDP)“)
- CAN (J1939, CANOpen) (→ „16.3.2 CAN (J1939, CANOpen)“)



The numerical results are scaled to 0..1 when using the CAN interface. The scaled results can be transferred directly to a physical analogue output on the receiver side (e.g. CAN control).

Thanks to the scaling it is possible to implement uniform standard programming regardless of the functions of the device.



The bandwidth of the CAN interface is limited. Only the analogue outputs 0..5 can be transferred via the CAN interface.

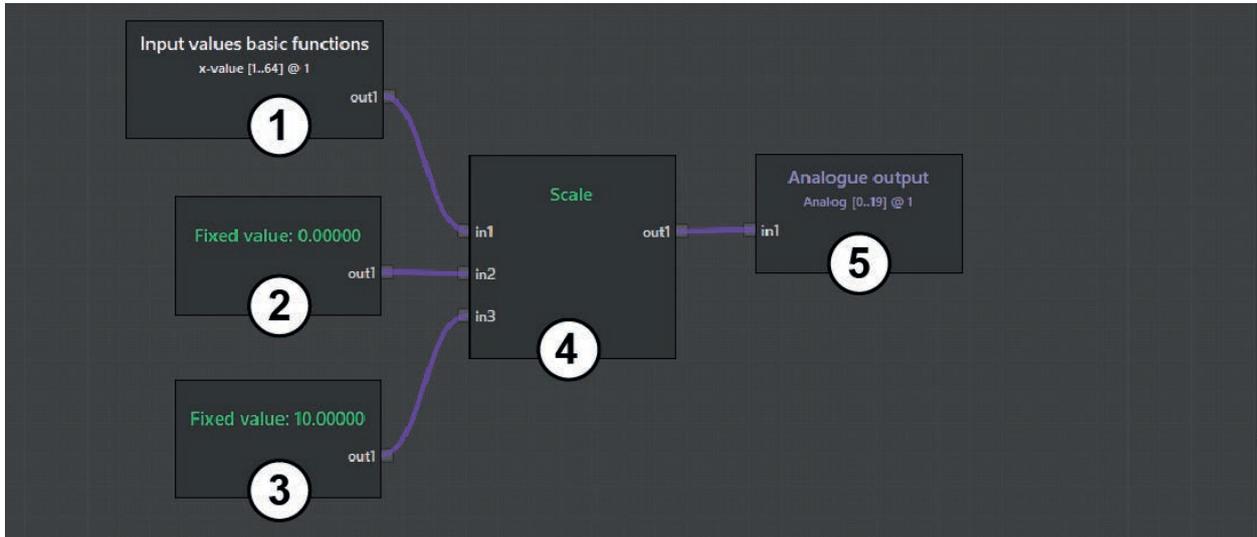
- Internal for configuring the 2D overlay (→ „11 2D overlay“): Output binary results via text replacement within the 2D overlay (→ „11.2.1 Add text“)

The "Analogue output" module has the following setting:

Setting	Data type	Description
Index	Numerical	<p>You can use single indices or multiple indexes simultaneously (vectors).</p> <p> Duplicate addresses lead to an undefined state at the output. ▶ Assign each address only once.</p> <p> When using vectors at the "in1" input: If only one index is set, this index is used as the start index. Example: A vector with 8 binary values is present at input "in1" and index "3" is set. Thus, the start index is "3". The 8 numerical values are assigned to the analogue outputs "3..10".</p>

### 15.12.4 Example for the "Analogue output" module

In the example, a device is connected to a mobile controller via the CAN interface. The device scales the signals to 0..1. The signals are then output via the mobile controller via a physical analogue switching output.

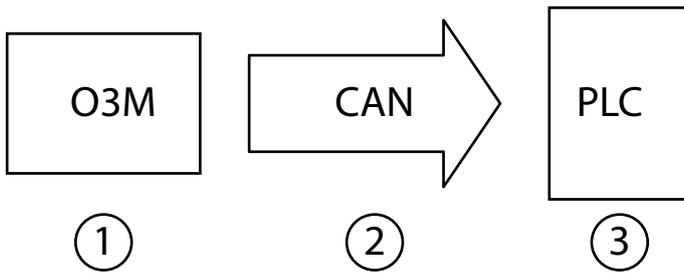


Description of the modules used in the example:

Module number	Module	Description																																	
1	Basic function	The x values are filtered out (distance of ROI group 1).																																	
2	Fixed value	The fixed value "0" determines the start value for scaling.																																	
3	Fixed value	The fixed value "10" determines the end value for scaling.																																	
4	Scale	The x-values are set to the control range 0...10 m. Example: <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Distance x [m]</th> <th>12.32</th> <th>10.76</th> <th>8.34</th> <th>5.19</th> <th>4.32</th> <th>1.84</th> <th>-0.08</th> <th>3.97</th> <th>8.75</th> <th>10.12</th> </tr> </thead> <tbody> <tr> <td>Scaled distance [12 bit]</td> <td>1</td> <td>1</td> <td>0.834</td> <td>0.519</td> <td>0.432</td> <td>0.184</td> <td>0</td> <td>0.397</td> <td>0.875</td> <td>1</td> </tr> <tr> <td>Analogue output [mA]</td> <td>20</td> <td>20</td> <td>16.68</td> <td>10</td> <td>8.64</td> <td>3.68</td> <td>0</td> <td>7.94</td> <td>17.5</td> <td>1</td> </tr> </tbody> </table>	Distance x [m]	12.32	10.76	8.34	5.19	4.32	1.84	-0.08	3.97	8.75	10.12	Scaled distance [12 bit]	1	1	0.834	0.519	0.432	0.184	0	0.397	0.875	1	Analogue output [mA]	20	20	16.68	10	8.64	3.68	0	7.94	17.5	1
Distance x [m]	12.32	10.76	8.34	5.19	4.32	1.84	-0.08	3.97	8.75	10.12																									
Scaled distance [12 bit]	1	1	0.834	0.519	0.432	0.184	0	0.397	0.875	1																									
Analogue output [mA]	20	20	16.68	10	8.64	3.68	0	7.94	17.5	1																									
5	Analogue output	The x-values are scaled to 0..1 and output via the CAN interface.																																	

**!** To be able to process the analogue output values as current or voltage values via a physical output, a programmable controller is required.

A programmable controller is connected to the device as follows:



Description of the devices and interfaces used:

Number	Function	Description
1	Programmable controller (e.g. CR0403)	The programmable controller converts the 12-bit CAN value to a physical output.
2	CAN interface	The CAN interface transmits the analogue value (distance) in 12-bit resolution.
3	Device (e.g. O3M251)	The device returns the analogue output value. The output values (distance) are scaled to the value range 0..1 ("0" corresponds to a distance of $\leq 0$ m, "1" corresponds to a distance of $\geq 10$ m).

### 15.13 Description of the switches "Enable CAN output"

In the "Enable CAN output" selection area, switches for signal transmission via the CAN interface are displayed. To keep the bus load low, a maximum of 3 CAN messages (size: 64 bits) are sent. The switches each activate one of the CAN messages.

Each switch activates a fixed set of outputs:

- Switch 1: digital 0 - 37 and analogue 0 - 1
- Switch 2: digital 38-99
- Switch 3: analogue 2-5



Keep the bus load of the CAN interface as low as possible.

► Only activate the necessary digital or analogue outputs via one of the switches.



The CAN interface is described in a separate CAN document.

### 15.14 Description of the "Logic teach commands"

In the "Logic teach commands" selection area, commands for triggering and deleting signals are displayed.

The "Logic teach commands" simulate a signal for storing information with the "Teach" module:

- [Teach] button: The signal for storing information with the "Teach" module is triggered.
- [Reset] button: The memory contents of the "Teach" module are deleted.



The "Logic teach commands" can be found at the end of the selection list (→ „15.2 Place and connect modules“).

## 16 Annex

### 16.1 Network settings



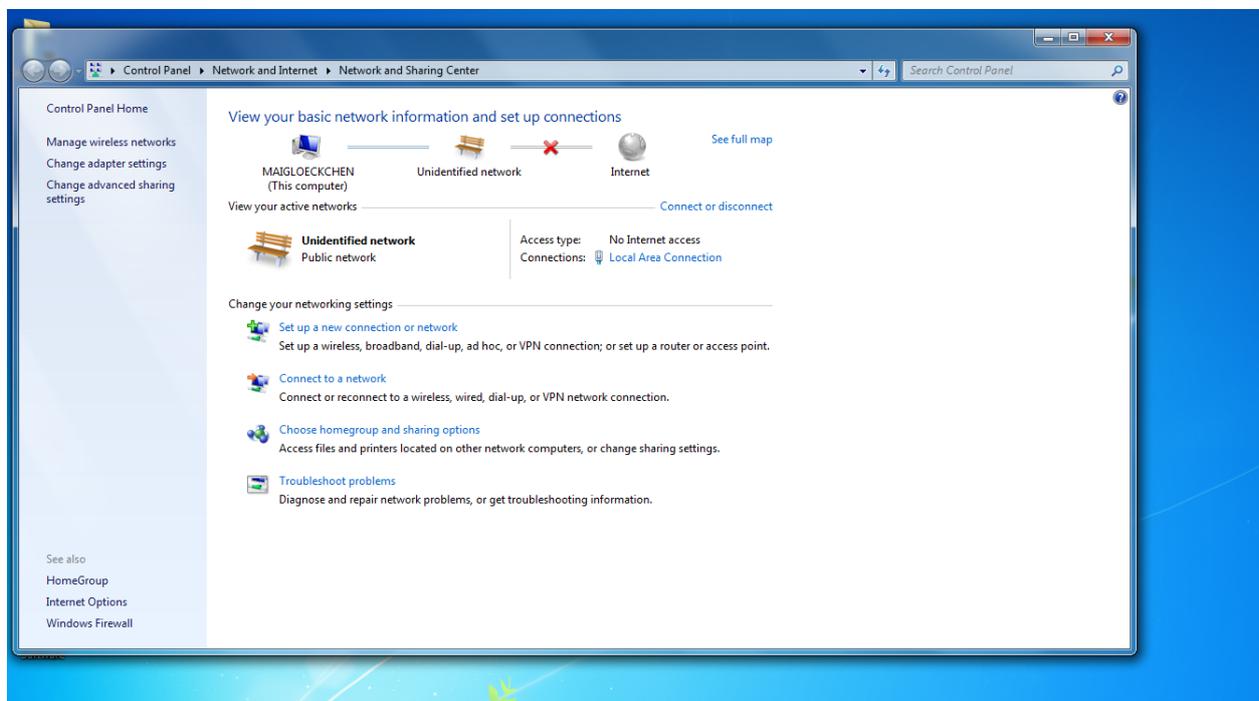
The details of the network setting in this document describe the procedure for PCs with Windows 7.

Modifying network settings in a PC requires administrator rights.

The following ports must be open (if necessary, adjust the firewall settings):

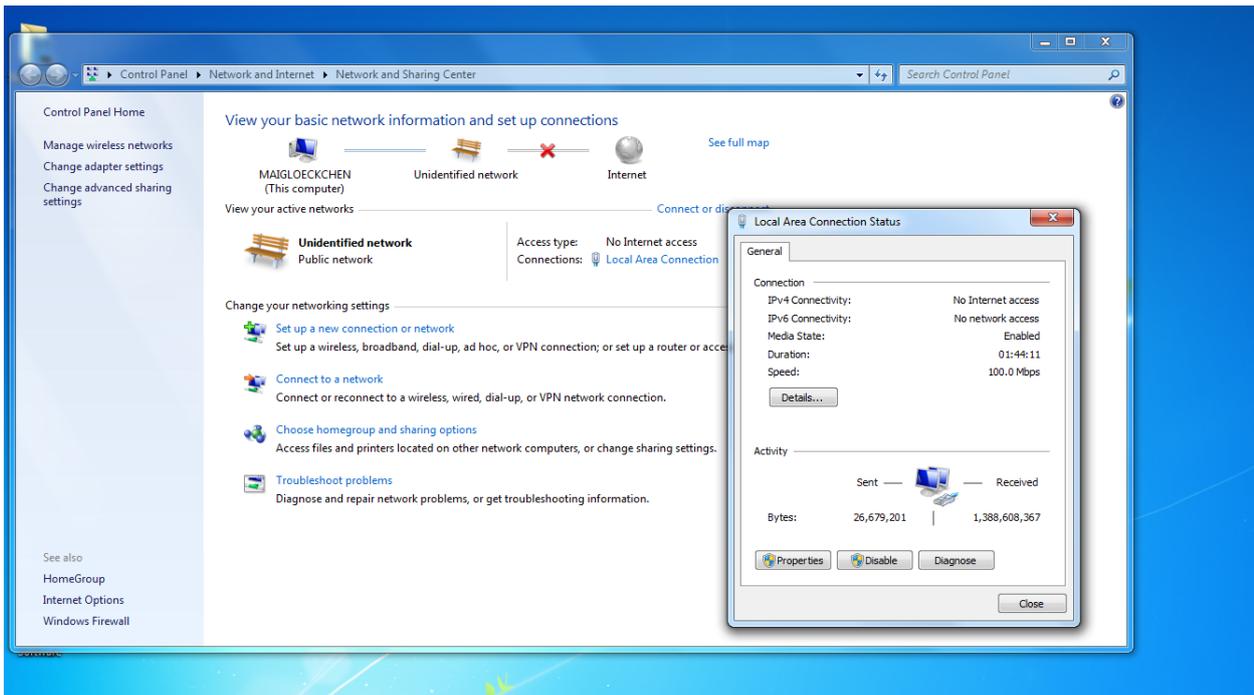
- UDP: 3321
- TCP / HTTP: and
- TCP: 50010

► Open [Network and Sharing Centre].

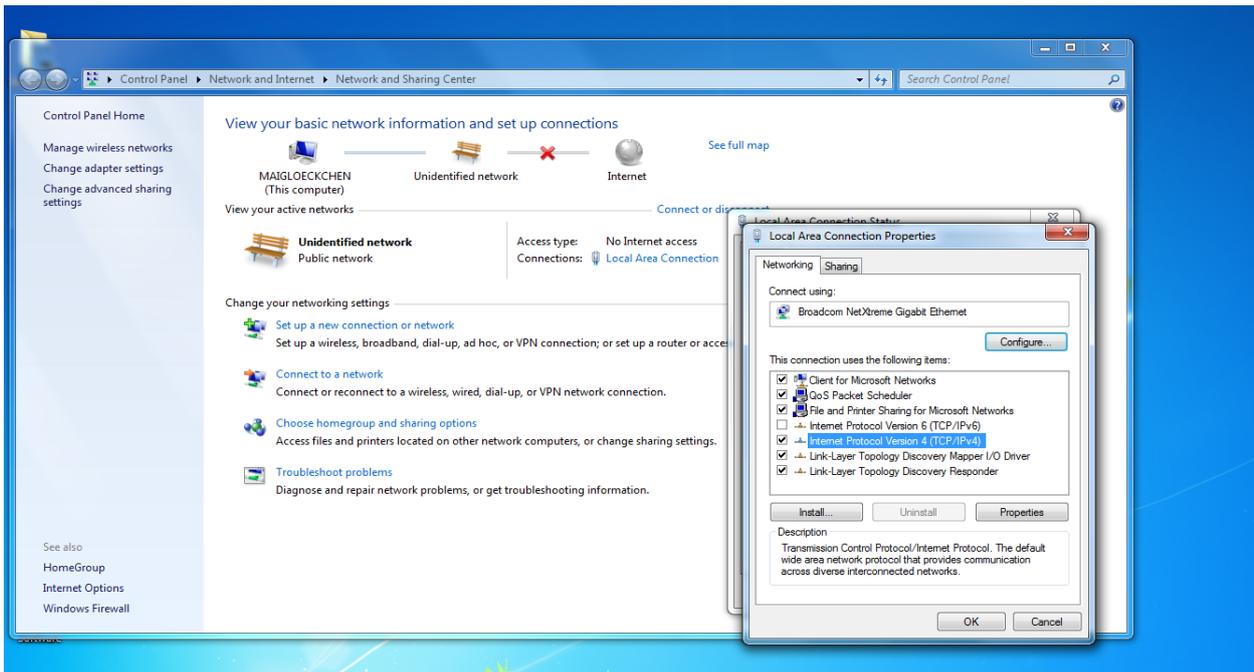


► Click on the name of the local network under [Connections].

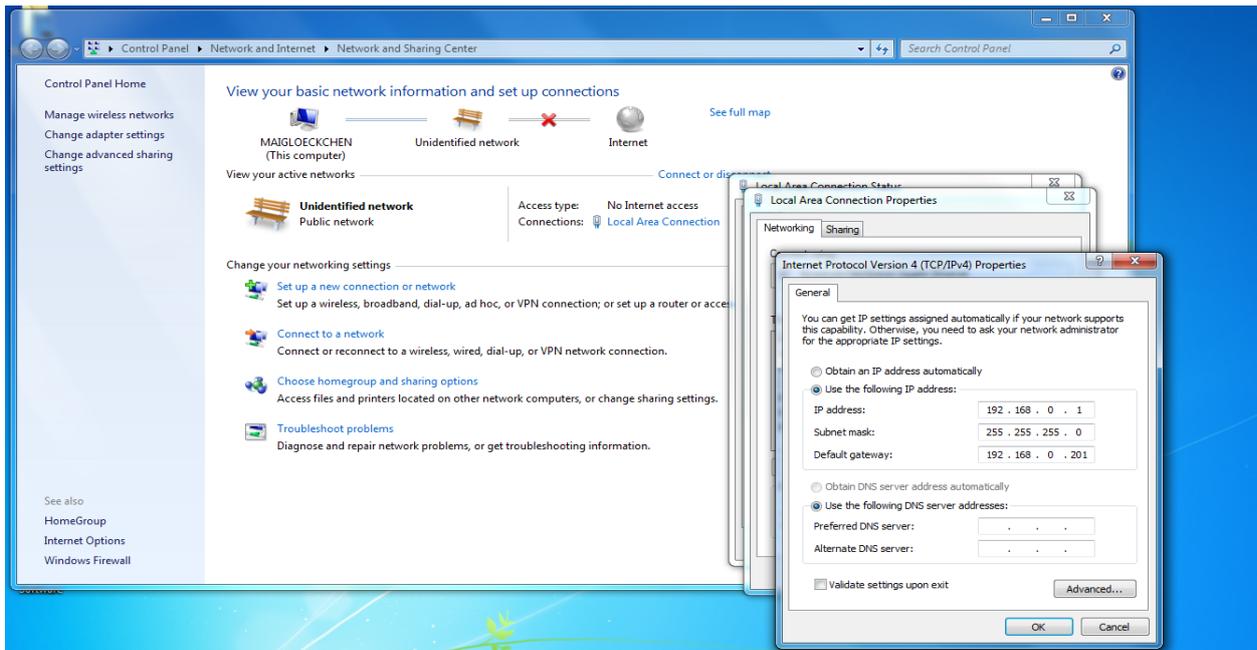
> The window "Local Area Connection Status" of the local network opens.



- ▶ Click on [Properties].
- > The window "Local Area Connection Properties" of the local network opens.



- ▶ Select [Internet Protocol Version 4 (TCP/IPv4)].
- ▶ Click on [Properties].
- > The window "Internet Protocol Version 4 (TCP/IPv4)" opens.



- ▶ Select the option [Use the following IP address:].
- ▶ Set the following standard values:
  - IP address: 192.168.0.1
  - Subnet mask: 255.255.255.0
  - Default gateway: 192.168.0.201
- ▶ Click on [OK].

UK

## 16.2 Text replacements and conditional codes

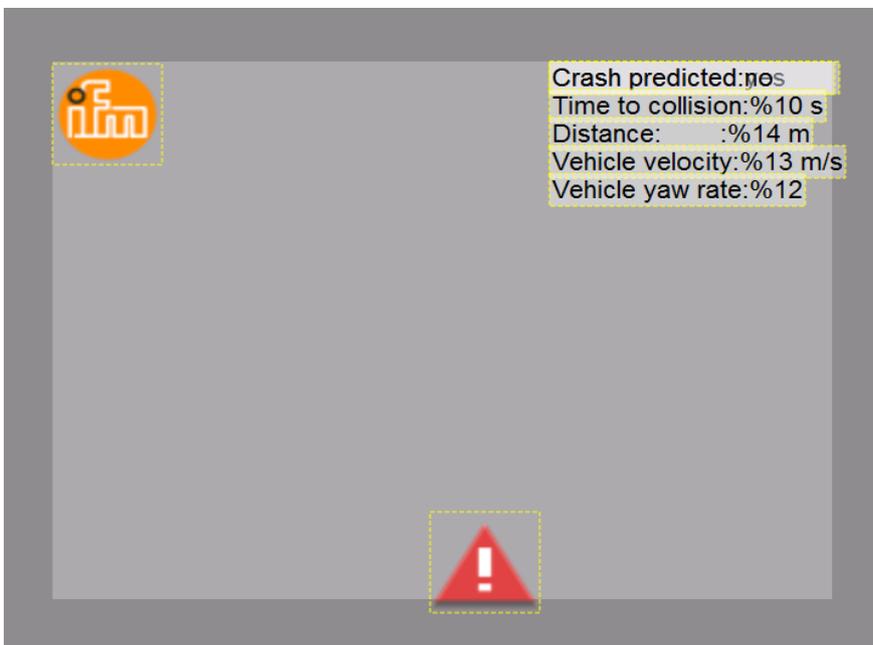
The O3M2xx series with internal overlay can e.g. display text. The text can be static text that never changes. Alternatively, the text can indicate changing values, such as function results or the system status (dynamically). Moreover, the text can only be displayed under certain conditions, e.g. if a certain value is calculated or if a certain event occurs.

Procedure of the O3M2xx:

- Fixed text can be entered in the Vision Assistant exactly the way it is supposed to be displayed, without additional "decoration" or property settings.
- Dynamic text that is also supposed to include system status information or function results requires a code. This code is called "text replacement code" because the camera replaces this code with real values during the runtime. These text replacement codes begin with a percentage sign ("%") that is followed by 2 characters (letters and numbers); 2 or 3 additional numbers can follow.
- Sometimes the text replacement codes are replaced by a number, even if a word or a sentence would be more informative. The reason for this are the different languages. In this case, different texts can be set that are only shown if the referenced variable has a specific value. This is one way to use conditional codes.
- Sometimes it only makes sense to display a text or an icon if "something" happens, i.e. if a certain event occurs. This is expressed by adding a condition. The condition describes the occurrence or absence of "something". In most cases, the condition refers to a diagnostic status or the result of a function, a process value (e.g. it could make sense to display a warning if a collision was predicted - this is a function-related condition. Or it could make sense to display a message if something is blocked or the sensor window is soiled - this is a diagnostics-related condition).
- The conditions are Boolean expressions. These expressions are evaluated for each frame. If an expression is true, the attributed icon, text or graphic will be displayed.

### 16.2.1 Example

The following image demonstrates some text replacements and conditions. The explanation is below the image:



**Time to collision: %10 s:** the %10 will be replaced by the actual time before a predicted collision. The resulting text could be (in case the time to collision is e.g. 3sec.): **Time to collision: 3 s**

**Distance 14 m:** The %14 will be replaced by the current distance to the object for which the collision was predicted. The text would be (in case the distance is e.g. 9m): **Distance 9 m**

**Speed: %13 m/s:** the %13 will be replaced by the own speed as indicated by a J1939 message on the CAN bus, e.g. 8 m/s (~ 29km/h) : **Speed: 8 m/s**

**Vehicle yaw rate: %12:** indicates the rotation about the vertical axis as indicated by a J1939 message on the CAN bus, e.g. 30°: **Vehicle yaw rate: 30**

**Collision predicted: no** are in fact two text fields in one place. They are **Collision predicted: no** and **Collision predicted: yes** with different conditions. The text **Collision predicted: no** has the condition "No crash predicted". The text **Collision predicted: yes** has the condition "Crash predicted". Only **Collision predicted: Yes** or **no** is displayed.

In fact, all texts have a condition. If no condition is set in the Vision Assistant, the condition "Always" is automatically set. "Always" means that the text will be shown at all times. The existing conditions are shown in a list of the Vision Assistant.

Conditions could also be set for icons and other graphic elements, not only for text. This can be used to display these icons or graphics only if certain events appear. In the example above, the  icon has the condition "Collision predicted" and will be displayed only if the sensor detects a possible collision.

In the example above, the  icon has the condition "always", so it will be displayed at all times.

## 16.2.2 Hints for the usage

There is a limit in the maximum number for all displays. If the condition was evaluated positively to "display this graphic or text" but there already are too many other graphics or texts on the display, it may occur that this graphic or this text will not be displayed. This is a general limitation to the number of elements to be displayed.

Using text replacement codes could produce surprising results when there is a mistake in the codes. If a non-existent code, for example, is entered, the code is displayed, but no replacement, no error message.

If a code with a wrong qualifier extension is entered (e.g. as in the code %1e, see below), it may occur that the system will display the correct replacement with several unexpected numbers, but no error message.

## 16.2.3 Text replacement - common codes for all variants

The following codes represent system status values, virtual input / output values and logic results. They are available in all SW versions.

Placeholder	Replacement	Data type	Comment	Examples	Application
%27	article number	article number	Eg. "O3M251"		
%28	software variant	software variant	DI or OD or LG		
%29<no>	fixed text from KP-CPAR2D with unique ID <no> (the braces <.> are not needed)	fixed text from KP-CPAR2D with unique ID <no> (the braces <.> are not needed)	no further scanning/ text analysis will be done in the replacement text. <no> = 00..55		
%2a	frame counter, frame cycle	frame counter, frame cycle			
%2b	operational mode as number	operational mode as number	if the operational mode is needed as text, then a conditional text shall be used.		
%2c	sensor availability as number	sensor availability as number	if the availability is needed as text, then a conditional text shall be used.		
%2d	blockage status as percentage value	uint8	if the blockage status is needed as text, then a conditional text shall be used. This is a percent value between 0 and 100.		general text replacement (used in standard text primitives, cannot be used for text bound to dynamic overlays)

Placeholder	Replacement	Data type	Comment	Examples	Application
%2e<n>	Logic Output number n displayed as "on" / "off".	boolean (on, off)	n=000..099	%2e001% ==> displays the value of the calculated digital output #1, e.g. "off"	general text replacement (used in standard text primitives, cannot be used for text bound to dynamic overlays)
%2f<n>	Logic Output number n displayed as "1" / "0".	uint8 (0,1)	n=000..099	%2f001% ==> displays the value of the calculated digital output #1, e.g. "0"	general text replacement (used in standard text primitives, cannot be used for text bound to dynamic overlays)
%2g<n> %2h<n> %2i<n>	Analog Output number n	float(1,1) float(1,2) float(1,3)	n=00..19	%2g10% ==> displays the value of the virtual analog output12, e.g.0,52	general text replacement (used in standard text primitives, cannot be used for text bound to dynamic overlays)
%2j<n>	Logic Input number n displayed as "on" / "off".	boolean (on, off)	n=00..13	%2j12 ==> displays the value of the CAN signal for the digital input12, e.g. "on"	general text replacement (used in standard text primitives, cannot be used for text bound to dynamic overlays)
%2k<n>	Logic Input number n displayed as "1" / "0".	uint8 (0,1)	n=00..13	%2k12 ==> displays the value of the CAN signal for the digital input#12, e.g. "1"	general text replacement (used in standard text primitives, cannot be used for text bound to dynamic overlays)
%2l<n> %2m<n> %2n<n>	Analog Input number n	float(1,1) float(1,2) float(1,3)	n=0..5	%2m5 ==> displays the value of the CAN signal for the analog input #5, e.g. 0,5	general text replacement (used in standard text primitives, cannot be used for text bound to dynamic overlays)

### 16.2.4 Text replacement – DI specific codes

The codes in this paragraph represent process values of the ROI calculation, available only in the DI/BF version.

Some of the replacement codes are valid only if the text is placed in relation to an ROI. In this case, the text "knows" which ROI event is referred to. It is not necessary to set the ROI number in the code. This is currently not available in Vision Assistant. There is a text replacement code always available with the same functionality but with explicit addressing.

Placeholder	Replacement	Data type	Comments	Examples	Application
%01<n> %02<n> %03<n>	the x value of the calculated pixel in the ROI group number n, unit [m]	float (3.0) float (3.1) float (3.2)	n=01..64	%0204 ==> output will be the function result for axis x of ROI group 4, with one fraction	general text replacement (used in standard text primitives, cannot be used for text bound to ROI overlay)
4% 5% 6%	the x value of the calculated pixel in the associated ROI group, unit [m]	float (3.0) float (3.1) float (3.2)	only valid for text, that is related to ROIs	%06 ==> e.g. results in "5.15", if the result for the x axis of the ROI group was 5.15234m	associated text replacement (used only for text bound to ROI overlay, cannot be used in standard text primitives) - therefore no ROI group number necessary
%37<n> %38<n> %39<n>	the y value of the calculated pixel in the ROI group number n, unit [m]	float (3.0) float (3.1) float (3.2)	n=00..63	%3700 ==> output will be the function result for axis y of ROI group 0, with no fraction	general text replacement (used in standard text primitives, cannot be used for text bound to ROI overlay)
9% %0a %0b	the y value of the calculated pixel in the associated ROI group, unit [m]	float (3.0) float (3.1) float (3.2)	only valid for text, that is related to ROIs	%0b ==> e.g. results in "5.15", if the result for the y axis of the ROI group was 5.15234m	associated text replacement (used only for text bound to ROI overlay, cannot be used in standard text primitives) - therefore no ROI group number necessary

Placeholder	Replacement	Data type	Comments	Examples	Application
%0c<n> %0d<n> %0e<n>	the z value of the calculated pixel in the ROI group number n, unit [m]	float (3.0) float (3.1) float (3.2)	n = 01..64	%0c0 ==> output will be the function result for axis y of ROI group 10, with no decimal places	general text replacement (used in standard text primitives, cannot be used for text bound to ROI overlay)
%0f %0g %0h	the z value of the calculated pixel in the associated ROI group, unit [m]	float (3,0) float (3,1) float (3,2)	only valid for text, that is related to ROIs	%0h ==> e.g. results in "5.15", if the result for the z axis of the ROI group was 5.15234m	associated text replacement (used only for text bound to ROI overlay, cannot be used in standard text primitives) - therefore no ROI group number necessary
%0i<n> %0j<n> %0k<n>	the amplitude value of the calculated pixel in the ROI group number n, unit [m]	float (3.0) float (3.1) float (3.2)	n = 01..64	%0i04 ==> output will be the result of the amplitude measurement of ROI group 4	general text replacement (used in standard text primitives, cannot be used for text bound to ROI overlay)
%3l %3m %3n	the amplitude value of the calculated pixel in the associated ROI group, unit [m]	float (3.0) float (3.1) float (3.2)	only valid for text, that is related to ROIs	%3l ==> output will be the result of the amplitude measurement of the associated ROI group	associated text replacement (used only for text bound to ROI overlay, cannot be used in standard text primitives) - therefore no ROI group number necessary
%0m	the number of the ROI	uint8	only valid for text, that is related to ROIs	%m ==> e.g. results in 10 if displayed next to ROI10	associated text replacement (used only for text bound to ROI overlay, cannot be used in standard text primitives) - therefore no ROI group number necessary
%0n	the number of the ROI group to which the ROI is related	uint8	only valid for text, that is related to ROIs	%0n ==> e.g. results in 5, if displayed next to some ROI that belongs to ROI group No.5	associated text replacement (used only for text bound to ROI overlay, cannot be used in standard text primitives) - therefore no ROI group number necessary

### 16.2.5 Text replacement – OD specific codes

The codes in this paragraph represent process values of the object detection and crash prediction, available only in the OD variant.

Some of the replacement codes are valid only, if the text is placed in relation to objects. In this case, the text "knows" which objects result is to be selected. This is currently not available in Vision Assistant. There is a text replacement code always available with the same functionality but with explicit addressing.

Placeholder	Replacement	Data type	Comments	Examples	Application
%0o 41%	Minimum x-value of associated object in [m].	float (3.1) float (3.2)	Only valid for text that is related to objects	%0o ==> e.g. results in "4.2", if the result for the Min x value of the object was 4.157 m	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
42% 43%	Maximum x-value of associated object in [m].	float (3.1) float (3.2)	Only valid for text that is related to objects	%bd ==> e.g. results in "5.3", if the result for the Max x value of the object was 5.327 m	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
%0p 45%	Middle y-position of associated object in [m].	float (3.1) float (3.2)	Only valid for text that is related to objects	%0p ==> e.g. results in "-0.7", if the result for the middle y position of the object was -0.723 m	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary

Placeholder	Replacement	Data type	Comments	Examples	Application
46% 47%	Width (projected) of associated object in [m].	float (3,1) float (3,2)	Only valid for text that is related to objects	%tbd ==> e.g. results in "1.2", if the result for the width (y-axis) of the object was 1.231 m	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
48% 49%	Minimum z-position (height) of associated object in [m].	float (3,1) float (3,2)	Only valid for text that is related to objects	%tbd ==> e.g. results in "0.0", if the result for the min z value of the object was 0.03 m	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
%0q %4b	Maximum z-position (height) of associated object in [m].	float (3,1) float (3,2)	Only valid for text that is related to objects	%0q ==> e.g. results in "1.8", if the result for the max z value of the object was 1.787 m	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
%0r	Object velocity in x-direction of associated object in [km/h].	float (3,0)	converted to km/h, Only valid for text that is related to objects	%0r ==> e.g. results in "7", if the result for the velocity in x-direction of the object was 7.3 km/h	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
%0s	Object velocity in y-direction of associated object in [km/h].	float (3,0)	converted to km/h, Only valid for text that is related to objects	%0s ==> e.g. results in "-2", if the result for the velocity in y-direction of the object was -1.9 km/h	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
%0t	Object velocity in z-direction of associated object in [km/h].	float (3,0)	converted to km/h, Only valid for text that is related to objects	%0t ==> e.g. results in "0", if the result for the velocity in z-direction of the object was 0.1 km/h	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
%0u %4e	Minimum x-value of the object which is predicted to cause a collision in [m].	float (3,1) float (3,2)	only valid for the object for which a collision is predicted	%0u ==> e.g. results in "4.2", if the result for the Min x value of the object was 4.157m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%4f %4g	Maximum x-value of the object which is predicted to cause a collision in [m].	float (3,1) float (3,2)	only valid for the object for which a collision is predicted	%tbd ==> e.g. results in "5.3", if the result for the Max x value of the object was 5.327m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%0v %4h	Middle y-position of the object which is predicted to cause a collision in [m].	float (3,1) float (3,2)	only valid for the object for which a collision is predicted	%0v ==> e.g. results in "-0.7", if the result for the middle y position of the object was -0.723 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%4i %4j	Width (projection) of the object which is predicted to cause a collision in [m].	float (3,1) float (3,2)	only valid for the object for which a collision is predicted	%tbd ==> e.g. results in "1.2", if the result for the width (y-axis) of the object was 1.231 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)

Placeholder	Replacement	Data type	Comments	Examples	Application
%4k %4l	Minimum z-position (height) of the object which is predicted to cause a collision in [m].	float (3.1) float (3.2)	only valid for the object for which a collision is predicted	%4k ==> e.g. results in "0.0", if the result for the min z value of the object was 0.03 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%0w %4n	Maximum z-position (height) of the object which is predicted to cause a collision in [m].	float (3.1) float (3.2)	only valid for the object for which a collision is predicted	%0w ==> e.g. results in "1.8", if the result for the max z value of the object was 1.787 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%0x	Velocity in x-direction in [km/h] of the object which is predicted to cause a collision.	float (3.0)	only valid for the object for which a collision is predicted, converted to km/h	%0x ==> e.g. results in "7", if the result for the velocity in x-direction of the object was 7.3 km/h	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
%0y	Velocity in y-direction in [km/h] of the object which is predicted to cause a collision.	float (3.0)	only valid for the object for which a collision is predicted, converted to km/h	%0y ==> e.g. results in "-2", if the result for the velocity in y-direction of the object was -1.9 km/h	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
%0z	Velocity in z-direction in [km/h] of the object which is predicted to cause a collision.	float (3.0)	only valid for the object for which a collision is predicted, converted to km/h	%0z ==> e.g. results in "0", if the result for the velocity in z-direction of the object was 0.1 km/h	associated text replacement (used only for text bound to Object overlay, cannot be used in standard text primitives) - therefore no object number necessary
10%	Remaining time in [s] until crash will happen if no reaction (braking) is done.	float (1.1)	only valid if collision is predicted	%10 ==> e.g. results in "1.3", if the predicted time to crash was 1.31 s	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
11%	Remaining velocity in case of crash in [km/h] until if no reaction (braking) is done.	float (3.0)	only valid if collision is predicted, converted to km/h	%11 ==> e.g. results in "7", if the predicted impact velocity was 6.9 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
12%	Own vehicle yaw rate received on CAN bus in [°/s].	float (3.1)	only valid if externally supplied, converted to deg/s		general text replacement (used in standard text primitives, cannot be used for text bound to objects)
13%	Own vehicle velocity received on CAN bus in [km/h].	float (3.1)	only valid if externally supplied, converted to km/h	%13 ==> e.g. results in "23.5", if the velocity on CAN send to O3M was 23,5 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
7% %4s	Minimum Distance of the object which is predicted to cause a collision and the vehicle in [m].	float (3.1) float (3.2)	smallest value for: (x value of the crash predicted object) minus (extrinsic calibration for x)	%07 ==> e.g. results in "6.7", if the minimum distance between the vehicle and the object was 6.72 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%4t %4u	Minimum x-value of the nearest object in zone 1 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 1	%4t ==> e.g. results in "4.2", if the result for the Min x value of the object triggering zone 1 was 4.157 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)

Placeholder	Replacement	Data type	Comments	Examples	Application
%4v %4w	Maximum x-value of the nearest object in zone 1 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 1	%tbd ==> e.g. results in "8.2", if the result for the Max x value of the object triggering zone 1 was 8.214 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%4x %4y	Middle y-position of the nearest object in zone 1 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 1	%tbd ==> e.g. results in "-1.2", if the result for the middle y position of the object triggering zone 1 was -1.187 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%4sz 50%	Width (projection) of the nearest object in zone 1 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 1	%tbd ==> e.g. results in "1.8", if the result for the width (y-axis) value of the object triggering zone 1 was 1.827 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
51% 52%	Minimum z-position (height) of the nearest object in zone 1 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 1	%tbd ==> e.g. results in "0.1", if the result for the Min z value (Height) of the object triggering zone 1 was 0.098 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
53% 54%	Maximum z-position (height) of the nearest object in zone 1 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 1	%tbd ==> e.g. results in "2.1", if the result for the Max z value (Height) of the object triggering zone 1 was 2.098 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
55%	Velocity in x-direction in [km/h] of the nearest object in zone 1.	float (3.0)	only valid for the object triggering zone 1	%tbd ==> e.g. results in "7", if the result for the velocity in x-direction of the object triggering zone 1 was 7.3 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
56%	Velocity in y-direction in [km/h] of the nearest object in zone 1.	float (3.0)	only valid for the object triggering zone 1	%tbd ==> e.g. results in "-2", if the result for the velocity in y-direction of the object triggering zone 1 was -1.9 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
57%	Velocity in z-direction in [km/h] of the nearest object in zone 1.	float (3.0)	only valid for the object triggering zone 1	%tbd ==> e.g. results in "0", if the result for the velocity in z-direction of the object triggering zone 1 was 0.1 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
58% 59%	Minimum x-value of the nearest object in zone 2 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 2	%tbd ==> e.g. results in "4.2", if the result for the Min x value of the object triggering zone 2 was 4.157 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5a %5b	Maximum x-value of the nearest object in zone 2 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 2	%tbd ==> e.g. results in "8.2", if the result for the Max x value of the object triggering zone 2 was 8.214 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5c %5d	Middle y-position of the nearest object in zone 2 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 2	%tbd ==> e.g. results in "-1.2", if the result for the middle y position of the object triggering zone 2 was -1.187 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5e %5f	Width (projection) of the nearest object in zone 2 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 2	%tbd ==> e.g. results in "1.8", if the result for the width (y-axis) value of the object triggering zone 2 was 1.827 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5g %5h	Minimum z-position (height) of the nearest object in zone 2 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 2	%tbd ==> e.g. results in "0.1", if the result for the Min z value (Height) of the object triggering zone 2 was 0.098 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5i %5j	Maximum z-position (height) of the nearest object in zone 2 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 2	%tbd ==> e.g. results in "2.1", if the result for the Max z value (Height) of the object triggering zone 2 was 2.098 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)

Placeholder	Replacement	Data type	Comments	Examples	Application
%5k	Velocity in x-direction in [km/h] of the nearest object in zone 2.	float (3.0)	only valid for the object triggering zone 2	%tbd ==> e.g. results in "7", if the result for the velocity in x-direction of the object triggering zone 2 was 7.3 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5l	Velocity in y-direction in [km/h] of the nearest object in zone 2.	float (3.0)	only valid for the object triggering zone 2	%tbd ==> e.g. results in "-2", if the result for the velocity in y-direction of the object triggering zone 2 was -1.9 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5m	Velocity in z-direction in [km/h] of the nearest object in zone 2.	float (3.0)	only valid for the object triggering zone 2	%tbd ==> e.g. results in "0", if the result for the velocity in z-direction of the object triggering zone 2 was 0.1 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5n %5o	Minimum x-value of the nearest object in zone 3 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 3	%tbd ==> e.g. results in "4.2", if the result for the Min x value of the object triggering zone 3 was 4.157 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5p %5q	Maximum x-value of the nearest object in zone 3 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 3	%tbd ==> e.g. results in "8.2", if the result for the Max x value of the object triggering zone 3 was 8.214 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5r %5s	Middle y-position of the nearest object in zone 3 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 3	%tbd ==> e.g. results in "-1.2", if the result for the middle y position of the object triggering zone 3 was -1.187 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5t %5u	Width (projection) of the nearest object in zone 3 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 3	%tbd ==> e.g. results in "1.8", if the result for the width (y-axis) value of the object triggering zone 3 was 1.827 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5v %5w	Minimum z-position (height) of the nearest object in zone 3 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 3	%tbd ==> e.g. results in "0.1", if the result for the Min z value (Height) of the object triggering zone 3 was 0.098 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5x %5y	Maximum z-position (height) of the nearest object in zone 3 in [m].	float (3.1) float (3.2)	only valid for the object triggering zone 3	%tbd ==> e.g. results in "2.1", if the result for the Max z value (Height) of the object triggering zone 3 was 2.098 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%5z	Velocity in x-direction in [km/h] of the nearest object in zone 3.	float (3.0)	only valid for the object triggering zone 3	%tbd ==> e.g. results in "7", if the result for the velocity in x-direction of the object triggering zone 3 was 7.3 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
60%	Velocity in y-direction in [km/h] of the nearest object in zone 3.	float (3.0)	only valid for the object triggering zone 3	%tbd ==> e.g. results in "-2", if the result for the velocity in y-direction of the object triggering zone 3 was -1.9 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
61%	Velocity in z-direction in [km/h] of the nearest object in zone 3.	float (3.0)	only valid for the object triggering zone 3	%tbd ==> e.g. results in "0", if the result for the velocity in z-direction of the object triggering zone 3 was 0.1 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
62% 63%	Minimum x-value of the nearest reflector object in [m].	float (3.1) float (3.2)	only valid for reflector object	%tbd ==> e.g. results in "4.2", if the result for the Min x value of the nearest reflector object was 4.157 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
64% 65%	Maximum x value of the nearest reflector object in [m].	float (3.1) float (3.2)	only valid for reflector object	%tbd ==> e.g. results in "8.2", if the result for the Max x value of the nearest reflector object was 8.214 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)

Placeholder	Replacement	Data type	Comments	Examples	Application
66% 67%	y value of the nearest reflector object (middle) in [m].	float (3.1) float (3.2)	only valid for reflector object	%tbd ==> e.g. results in "-1.2", if the result for the middle y position of the nearest reflector object was -1.187 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
68% 69%	Width of the nearest reflector object in [m].	float (3.1) float (3.2)	only valid for reflector object	%tbd ==> e.g. results in "1.8", if the result for the width (y-axis) value of the nearest reflector object was 1.827 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%6a %6b	Minimum z value of the nearest reflector object in [m].	float (3.1) float (3.2)	only valid for reflector object	%tbd ==> e.g. results in "0.1", if the result for the Min z value (Height) of the nearest reflector object was 0.098 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%6c %6d	Maximum z value of the nearest reflector object (height) in [m].	float (3.1) float (3.2)	only valid for reflector object	%tbd ==> e.g. results in "2.1", if the result for the Max z value (Height) of the nearest reflector object was 2.098 m	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%6e	Velocity in x-direction in [km/h] of the nearest reflector object.	float (3.0)	only valid for reflector object	%tbd ==> e.g. results in "7", if the result for the velocity in x-direction of the nearest reflector object was 7.3 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%6f	Velocity in y-direction in [km/h] of the nearest reflector object.	float (3.0)	only valid for reflector object	%tbd ==> e.g. results in "-2", if the result for the velocity in y-direction of the nearest reflector object was -1.9 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)
%6g	Velocity in z-direction in [km/h] of the nearest reflector object.	float (3.0)	only valid for reflector object	%tbd ==> e.g. results in "0", if the result for the velocity in z-direction of the nearest reflector object was 0.1 km/h	general text replacement (used in standard text primitives, cannot be used for text bound to objects)

## 16.3 Connect O3M to external devices

The ifm Vision Assistant is the PC configuration software for the O3M devices. In live operation, the O3M is connected to external devices. It is connected via the following interfaces:

- Ethernet (UDP) – available for all O3M versions
- CAN (J1939 / CANOpen) – available for "smart" versions (O3M151, O3M161, O3M251, O3M261)
- Analog Video (PAL) – available for "smart camera" versions (O3M251, O3M261)

### 16.3.1 Ethernet (UDP)

The Ethernet interface uses the UDP protocol to dispatch events. The results include:

- current 3D data (per pixel: x, y, z, amplitude, radial distance and confidence (status))
- Function results (depending on the firmware; the OD firmware e.g. provides object results)

For a simple integration of the Ethernet interface, the downloadable firmware packages include:

- documentation of the Ethernet interface
- documentation of the contents
- examples in C
- libraries for ifm mobile controllers / displays with Ethernet input

The firmware packages are available as compressed zip files on the ifm website and are regularly updated (→ „7.1.3 Firmware update“).

### 16.3.2 CAN (J1939, CANOpen)

The CAN interface uses the SAE J1939 or CANOpen protocol to dispatch events. The results include:

- Function results (depending on the firmware; the OD firmware e.g. provides object results)



For diagnostics, the CAN interface supports the UDS protocol.

For a simple integration of the Ethernet interface, the downloadable firmware packages include:

- Documentation of the CAN interface
- documentation of the contents
- electronically readable specifications (J1939: dbc, CANOpen: eds, UDS: cdd)
- Examples for Codesys (V2.3 and V3.5)
- Libraries for ifm mobile controllers / displays with CAN input

The firmware packages are available as compressed zip files on the ifm website and are regularly updated (→ „7.1.3 Firmware update“).

## 16.4 Glossary

### **Active application**

The application set to "active" in the device: This application is running when the device is ready for operation.

### **Amplitude**

Refers to the reflectivity of the objects in the infrared range: The device provides a greyscale representation of the measuring result - the higher the reflection, the lighter the shade of grey.

### **Anchor function**

The anchor function enables the detection of the object's position and orientation, for example in the completeness monitoring. This enables to compensate for a rotation of the object by up to 40°.

### **Change of application**

The change of application can be triggered via the process interface or via the digital inputs.

### **Operation Mode**

Mode is active as default if an active application is available on the device. The active application is in the process of being executed.

### **Parameter setting mode**

Mode to set the device and the applications: no application is executed.

### **Pixel**

Individual data point in a 2D/3D image.

### **Process interface**

Interface for external hardware: Data can be provided or received (e.g. by a PLC) via the process interface.