multiScan136

3D LiDAR sensor

SICK
Sensor Intelligence.

Described product

multiScan136

ℹ️ **NOTE**

The functional scope of the multiScan depends on the selected configuration. Certain functions are supported or not supported, depending on the configured variant. The operating instructions describe the full functional scope of the multiScan.

Manufacturer

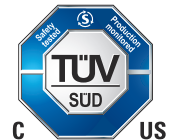SICK AG
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Germany

Legal information

Original document

This document is an original document of SICK AG.

Contents

1 About this document

1.1 Information on the operating instructions

These operating instructions provide important information on how to use devices from SICK AG.

Prerequisites for safe work are:

- Compliance with all safety notes and handling instructions supplied.
- Compliance with local work safety regulations and general safety regulations for device applications

The operating instructions are intended to be used by qualified personnel and electrical specialists.

NOTE
Read these operating instructions carefully to familiarize yourself with the device and its functions before commencing any work.

The operating instructions are an integral part of the product. Store the instructions in the immediate vicinity of the device so they remain accessible to staff at all times. Should the device be passed on to a third party, these operating instructions should be handed over with it.

These operating instructions do not provide information on the handling and safe operation of the machine or system in which the device is integrated. Information on this can be found in the operating instructions for the machine or system.

1.2 Explanation of symbols

Warnings and important information in this document are labeled with symbols. Signal words introduce the instructions and indicate the extent of the hazard. To avoid accidents, damage, and personal injury, always comply with the instructions and act carefully.

DANGER
... indicates a situation of imminent danger, which will lead to a fatality or serious injuries if not prevented.

WARNING
... indicates a potentially dangerous situation, which may lead to a fatality or serious injuries if not prevented.

CAUTION
... indicates a potentially dangerous situation, which may lead to minor/slight injuries if not prevented.

NOTICE
... indicates a potentially harmful situation, which may lead to material damage if not prevented.

NOTE
... highlights useful tips and recommendations as well as information for efficient and trouble-free operation.

1.3 Further information

More information can be found on the product page. It can be called up via **SICK Product ID: pid.sick.com**/{P/N}/{S/N}

{P/N} corresponds to the part number of the product (see type label).

{S/N} corresponds to the serial number of the product (see type label).

The following information is available depending on the product:
- Data sheets
- This document in all available language versions
- CAD files and dimensional drawings
- Certificates (e.g., declaration of conformity)
- Other publications
- Software
- Accessories

2 Safety information

2.1 Intended use

The multiScan 3D LiDAR sensor is an intelligent sensor for invisibly detecting objects in areas to be monitored. It has been designed for indoor or outdoor and mobile or stationary use in stand-alone operation.

Typical application areas are, for example, anti-collision monitoring and rear area monitoring in industrial (autonomous) vehicles, person counts at access gates, monitoring of land and buildings, volume monitoring, automated guided vehicle systems for outdoors, robot area, traffic and park management systems.

> **NOTE**
> The functional scope of the multiScan depends on the selected configuration. Certain functions are supported or not supported, depending on the configured variant. The operating instructions describe the full functional scope of the multiScan.

SICK AG assumes no liability for losses or damage arising from the use of the product, either directly or indirectly. This applies in particular to use of the product that does not conform to its intended purpose and is not described in this documentation.

2.2 Improper use

Any use outside of the stated areas, in particular use outside of the technical specifications and the requirements for intended use, will be deemed to be incorrect use.

- The device does not constitute a safety component in accordance with the respective applicable safety standards for machines.
- The device must not be used in explosion-hazardous areas, in corrosive environments or under extreme environmental conditions.
- Any use of accessories not specifically approved by SICK AG is at your own risk.

> **WARNING**
> **Danger due to improper use!**
>
> Any improper use can result in dangerous situations.
>
> Therefore, observe the following information:
>
> - Product should be used only in accordance with its intended use.
> - All information in the documentation must be strictly observed.
> - Shut down the product immediately in case of damage.

2.3 Cybersecurity

Overview

To protect against cybersecurity threats, it is necessary to continuously monitor and maintain a comprehensive cybersecurity concept. A suitable concept consists of organizational, technical, procedural, electronic, and physical levels of defense and considers suitable measures for different types of risks. The measures implemented in this product can only support protection against cybersecurity threats if the product is used as part of such a concept.

You will find further information at **www.sick.com/psirt**, e.g.:
- General information on cybersecurity
- Contact option for reporting vulnerabilities
- Information on known vulnerabilities (security advisories)

2.4 Limitation of liability

Relevant standards and regulations, the latest technological developments, and our many years of knowledge and experience have all been taken into account when compiling the data and information contained in these operating instructions. The manufacturer accepts no liability for damage caused by:

- Non-adherence to the product documentation (e.g., operating instructions)
- Incorrect use
- Use of untrained staff
- Unauthorized conversions or repair
- Technical modifications
- Use of unauthorized spare parts, consumables, and accessories

2.5 Modifications and conversions

> **!** **NOTICE**
> Modifications and conversions to the device may result in unforeseeable dangers.

Interrupting or modifying the device or SICK software will invalidate any warranty claims against SICK AG. This applies in particular to opening the housing, even as part of mounting and electrical installation.

2.6 Requirements for skilled persons and operating personnel

> ⚠️ **WARNING**
> **Risk of injury due to insufficient training.**
> Improper handling of the device may result in considerable personal injury and material damage.
>
> - All work must only ever be carried out by the stipulated persons.

The following qualifications are required for various activities:

Table 1: Activities and technical requirements

Activities	Qualification
Mounting, maintenance	- Basic practical technical training - Knowledge of the current safety regulations in the workplace
Electrical installation, device replacement	- Practical electrical training - Knowledge of current electrical safety regulations - Knowledge of the operation and control of the devices in their particular application
Commissioning, configuration	- Basic knowledge of the computer operating system used - Basic knowledge of the design and setup of the described connections and interfaces - Basic knowledge of data transmission
Operation of the device for the particular application	- Knowledge of the operation and control of the devices in their particular application - Knowledge of the software and hardware environment for the particular application

2.7 Operational safety and specific hazards

Please observe the safety notes and the warnings listed here and in other sections of this product documentation to reduce the possibility of risks to health and avoid dangerous situations.

CAUTION
Optical radiation: Class 1 Laser Product

The accessible radiation does not pose a danger when viewed directly for up to 100 seconds. It may pose a danger to the eyes and skin in the event of incorrect use.

- Do not open the housing. Opening the housing may increase the level of risk.
- Current national regulations regarding laser protection must be observed.

WARNING
Electrical voltage!

Electrical voltage can cause severe injury or death.

- Work on electrical systems must only be performed by qualified electricians.
- The power supply must be disconnected when attaching and detaching electrical connections.
- The product must only be connected to a voltage supply as set out in the requirements in the operating instructions.
- National and regional regulations must be complied with.
- Safety requirements relating to work on electrical systems must be complied with.

WARNING
Risk of injury and damage caused by potential equalization currents!

Improper grounding can lead to dangerous equipotential bonding currents, which may in turn lead to dangerous voltages on metallic surfaces, such as the housing. Electrical voltage can cause severe injury or death.

- Work on electrical systems must only be performed by qualified electricians.
- Follow the notes in the operating instructions.
- Install the grounding for the product and the system in accordance with national and regional regulations.

3 Product description

3.1 Scope of delivery

Depending on the chosen device version, the scope of delivery of a device will include the following components:

Table 2: Scope of delivery

No. of units	Component	Note
1	Device in the ordered version (complete device or basic device). The functional scope of the device depends on the ordered configuration.	Complete device: • Components are mounted at the factory (housing and system plug). Basic device: • To mount the housing and system plug yourself, see "Mounting the system plug on the device", page 39. All devices: • Without holders and connecting cables
1	Printed safety notes, multilingual	Brief information and general safety notes

The actual scope of delivery may differ for special designs, additional orders or due to the latest technical changes.

3.2 Status indicators

Figure 1: Position of the four status LEDs, front and top view

①   LED1
②   LED2
③   LED3
④   LED4

LED1/LED3 (color)	LED2/LED4 (color)	Description
● (Red)	● (Red)	Start-up, parameterization, firmware update, correctable error
-	-	Off
☀ (Red)	☀ (Red)	Fatal error
-	● (Green)	On / Ready for operation
-	● (Yellow)	Standby / energy saving
-	☀ (Yellow)	Warning
● (Green)	☀ (Yellow)	Restart after time; input
● (Green)	☀ (Yellow)	Contamination warning
☀ (Red)	☀ (Yellow)	Contamination error
☀ (Green)	☀ (Red)	Alignment mode
● (Green) ● (Yellow) ● (Red)	● (Green) ● (Yellow) ● (Red)	Identifying the device

● = illuminated; ☀ = flashing

3.3 Type label

Device

Information for identifying the sensor can be found on the bottom of the device.
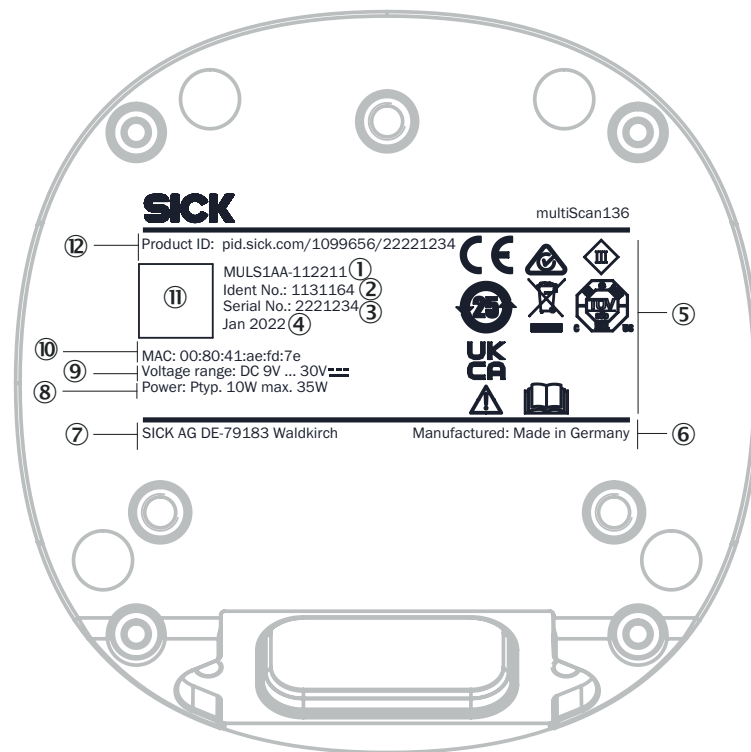
Figure 2: multiScan type label (example)

①　　Type code

②　　Part number

③　　Serial number

④　　Production date

⑤　　Conformity mark/certification mark, protection class, symbol: Observe the operating instructions!

⑥　　Production site

⑦　　Manufacturer

⑧　　Typical power, max. power

⑨　　Voltage supply

⑩　　MAC address

⑪　　Data Matrix code with product data and link to product page

⑫　　Web address of product page

Male connector

Information for identifying the male connector is located on the connector.
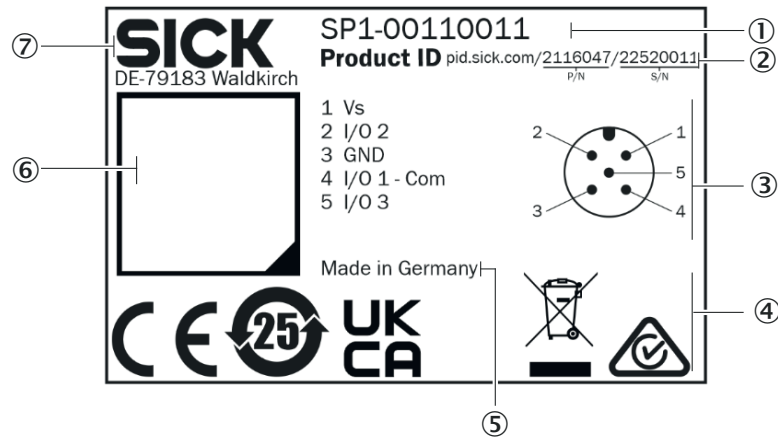
Figure 3: Type label for system plug (example)

①   Type code

②   Product ID with part number (P/N) and serial number (S/N)

③   Pin assignment or wire colors

④   Conformity mark/certification mark

⑤   Production site

⑥   Data Matrix code with product data and link to product page

⑦   Manufacturer

3.4 Principle of operation

3.4.1 Measurement principle

The device is an opto-electronic LiDAR sensor that scans the outline of its surroundings with the help of laser beams without making contact. The device measures its surroundings in spherical coordinates relative to its measurement origin. This is marked by a circular indentation in the center of the optics cover. If a laser beam strikes an object, the position of that object is determined in terms of distance and angle.
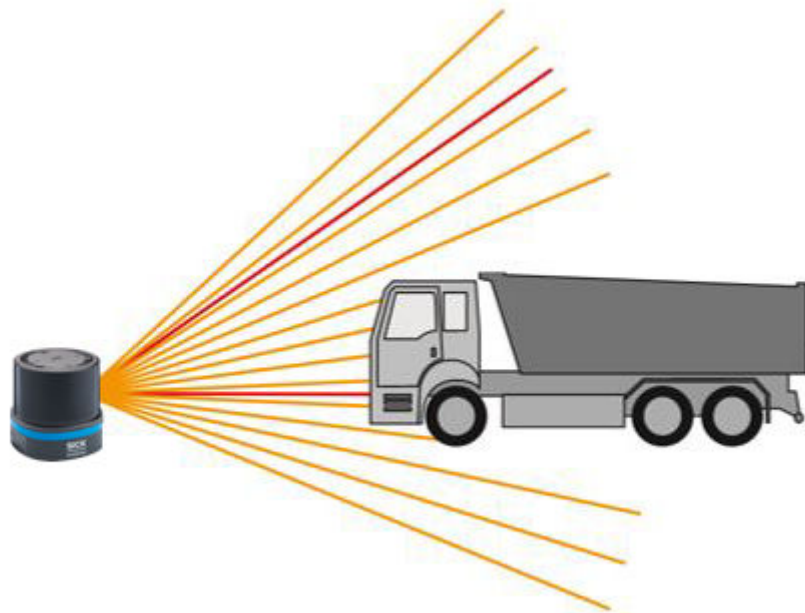
Figure 4: Device with 16 scan layers, side view

Scan layers

The device has 16 scan layers:

- A high-resolution planar scan layer at an elevation angle of 0°, which was developed for high-precision navigation.
- 15 conical scan layers (5 oriented downwards and 10 upwards). This includes another high-resolution scan layer at an elevation angle of 34.5°, which can be used, for example, for checking overhangs in high-bay warehouses.

The scan layers are numbered in ascending order - starting with 1 - with descending elevation angle.
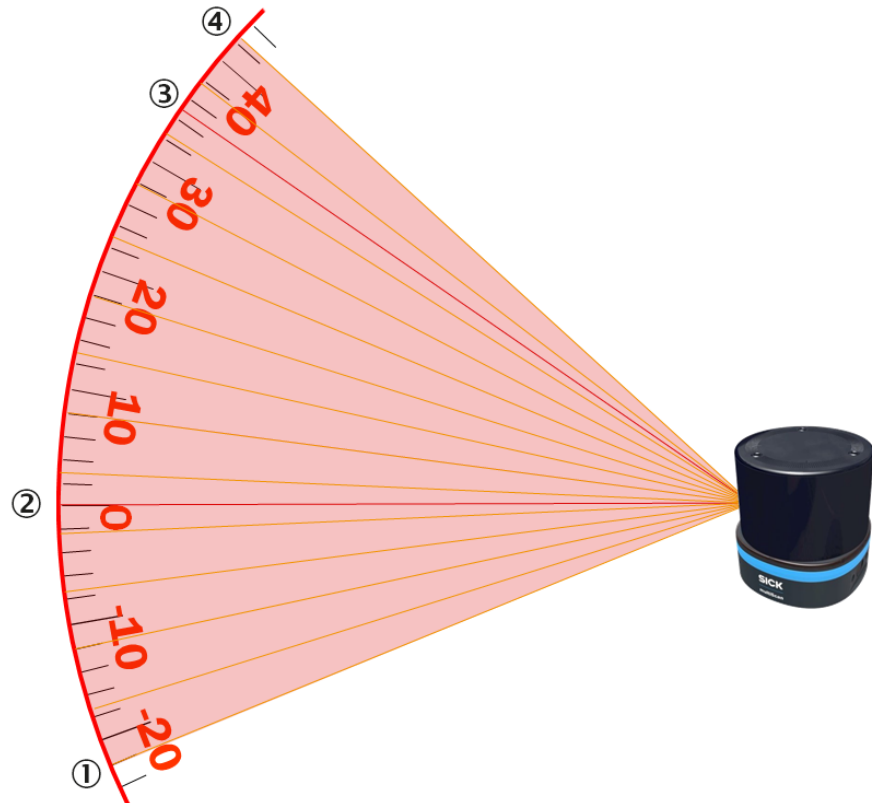
Figure 5: Positions of the 16 scan layers, side view

①   Scan layer 1
②   Scan layer 6 (high resolution)
③   Scan layer 14 (high resolution)
④   Scan layer 16
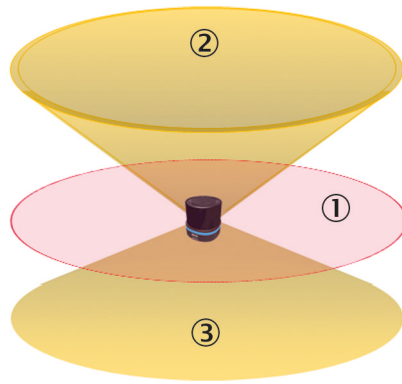
Figure 6: Possible shapes of a scan layer, 3D view

①   Navigation scan layer with an elevation angle of 0°

②   Scan layers with an elevation angle < 0°

③   Scan layers with an elevation angle > 0°
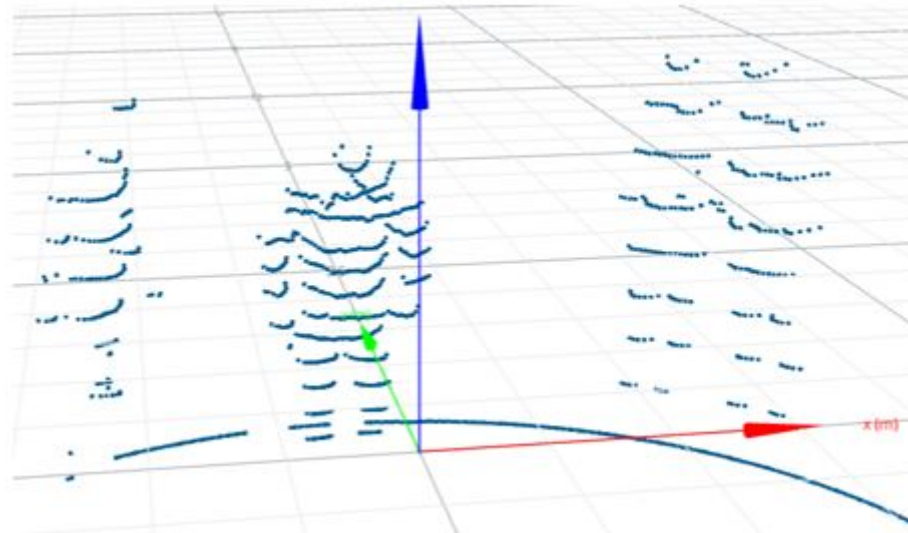
Figure 7: Each of the 16 horizontal point lines is created by one scan layer of the device. In the example, four people have been detected by the device.

Due to their conical shape, all scan layers except for the one with an elevation angle of 0° are bent slightly upwards or downwards when they hit a flat object depending on where the cone opens out. The larger the elevation angle value, the stronger the curvature.
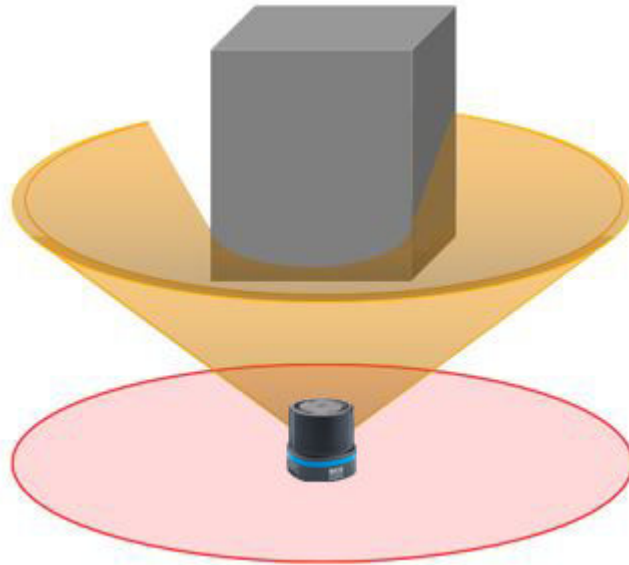
Figure 8: Cone-shaped scan layer as the cause for a bent scan line
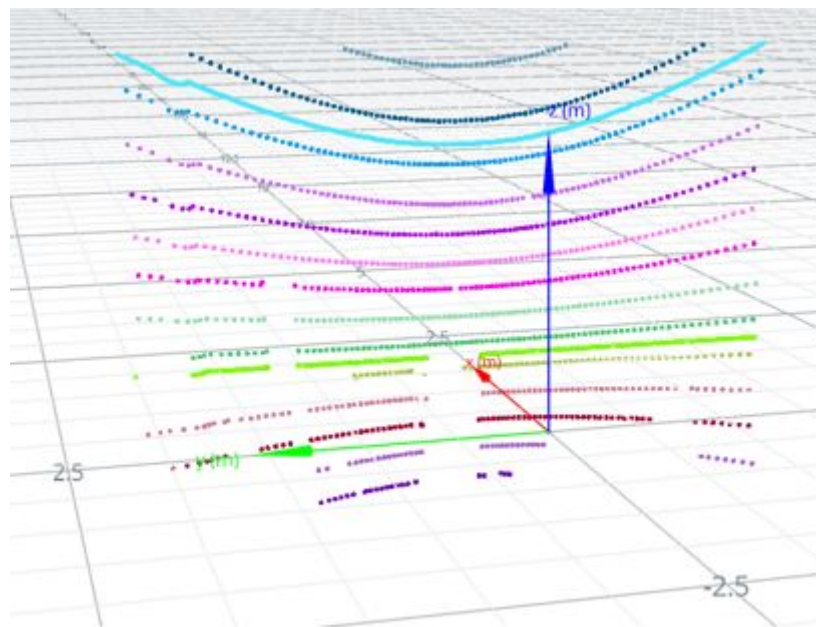
Figure 9: Visualization of a scanned wand as an example for the effect of the cone-shaped scan layer

3.4.2 Distance measurement

The device emits beams pulsed by a laser diode. If the laser beam is reflected by an object, the reflected beam is received by the sensor.

The distance to the object is calculated on the basis of the time that the pulsed light beam requires to be reflected and received by the sensor.

The device uses an in-house technology from SICK. With this measurement process, a measured value is formed statistical evaluation of multiple single pulses. The multi-echo concept evaluates up to 691200 measured values per second. The measured value consists not only of a single time-of-flight measurement, but includes evaluated information from numerous pulses. This ensures a significantly more stable time and distance measurement.

①   Emitted pulse
②   Receive pulse
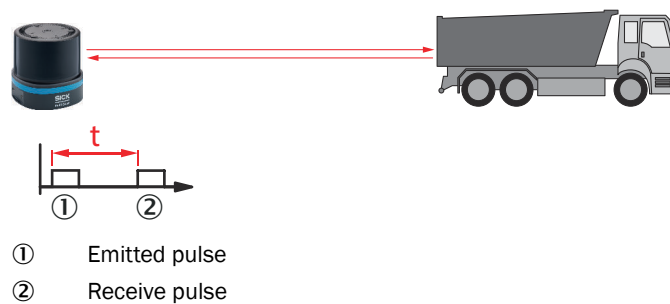
3.4.3   Multi-echo analysis

The distance between the device and an object is calculated via the time-of-flight of the emitted pulse. The device can evaluate up to three echo signals for each measuring beam to deliver reliable measurement results, even under adverse ambient conditions.
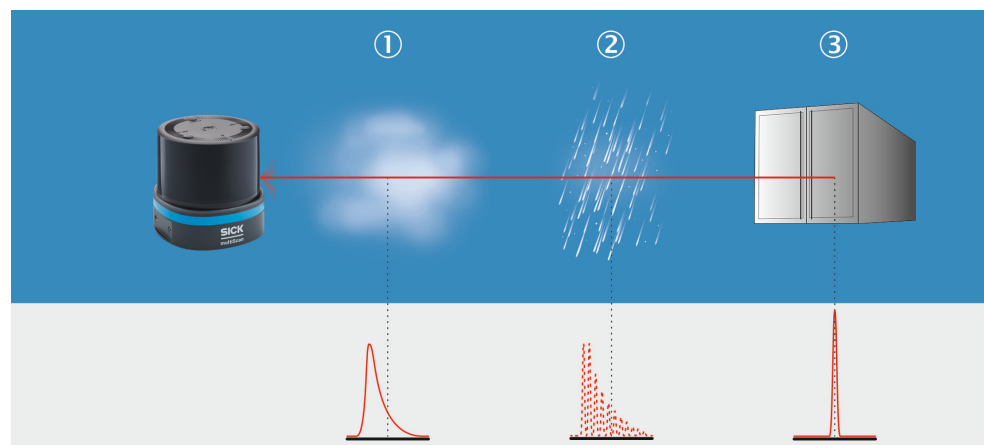
Figure 10: Multi-echo analysis: example industrial application for building management.

①   Fog
②   Rain
③   Measuring object

3.4.4   Direction measurement

The laser beams are emitted using internally rotating sender-receiver units (SRUs) and scan the surroundings orbitally. The received measured values are assigned to the associated angular cut and thus to the direction.

The rate at which a laser beam is emitted in a counterclockwise direction differs depending on the scan layer and device variant. The two high-resolution scan layers (scan layer 6 and 14 see figure 5, page 15) send a set of 24 pulses over an angular range of 0.125° every 0.125°. A measured value is then derived from the received signals for these pulses. All other scan layers send 24 pulses over an angular range of 0.125° every 1° of rotation. This gives an angular resolution of 0.125° for the high-resolution scan layers and 1° for every other scan layer.
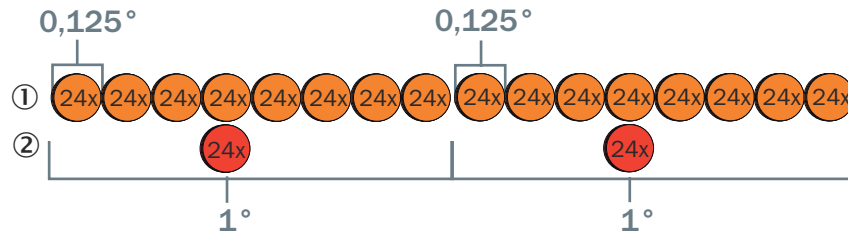
Figure 11: Schematic representation of the sequence of events based on the example of one high-resolution scan layer and one scan layer

①   High-resolution scan layer

②   Scan layer

3.4.5   Multi-layer technology

The multi-layer technology of the device uses 16 scan layers at different vertical angles to compensate for pitch angle, for example when the device is attached to a vehicle. This enables the device to reliably detect an object even, for example, when the vehicle accelerates or brakes.

Figure 12: Multi-plane technology

①   LiDAR sensor

②   Scan layers

③   Object

3.4.6   Coordinate system

Device coordinate system

The origin of the device coordinate system (X=0, Y=0, Z=0) is a single point that serves as the origin and reference for all laser beams and the distance measurement of the device. When no translation is applied to the device in the world coordinate system, this point coincides with the origin of the world coordinate system.

The azimuthal (horizontal) angle of a beam is called theta. The beam at zero azimuth angle lies in the middle of the main viewing direction of the device so the scan is symmetrical.
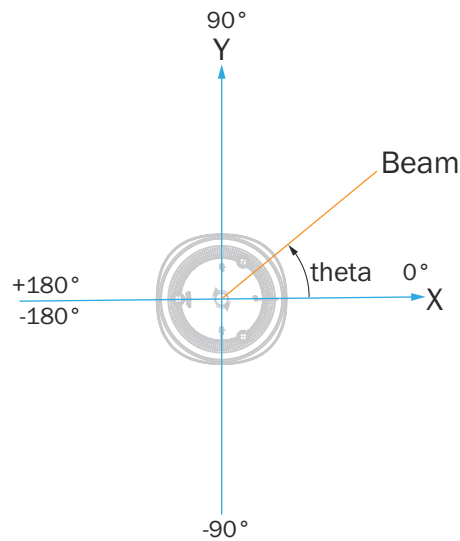
The elevation angle (vertical angle) of a beam is designated phi and is measured relative to the x-y plane:

- Elevation angle < 0 is above the x-y plane, i.e., for positive z-values
- Elevation angle > 0 is below the x-y plane, i.e., for negative z-values
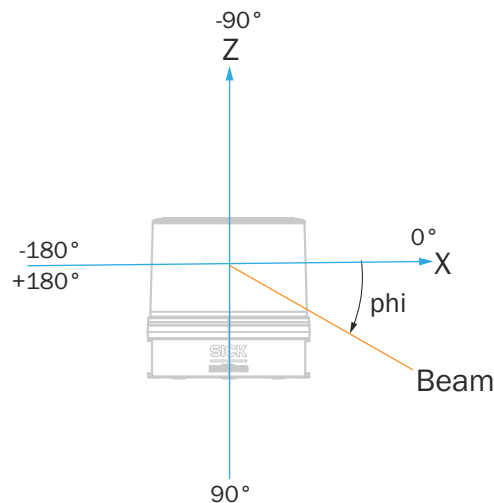
The data is always output in the device coordinate system, not in the world coordinate system.

World coordinate system

The world coordinate system is based on the DIN ISO 8855 standard. The directions of rotation are based on a clockwise coordinate system. The orientation of the device in the world coordinate system is specified by means of a yaw angle, pitch angle and roll angle and the position using the Cartesian coordinates x, y and z. If no difference between the world and device coordinate systems is defined, for example to define a specific mounting position, then the origin of both coordinate systems is identical and corresponds to the origin of the device.

The alignment of the device is defined as follows:
- The beam with the azimuthal angle (horizontal) of 0° and the elevation angle (vertical) of 0° points along the x-axis
- The scan layer with an elevation angle of 0° lies on the x-y plane of the coordinate system

- The origin of the device coincides with the world coordinates origin
- The top of the device is oriented towards the increasing z-values of the coordinate system
- The direction of rotation is determined by the orientation of the device, where theta corresponds to the yaw angle and phi to the pitch angle.
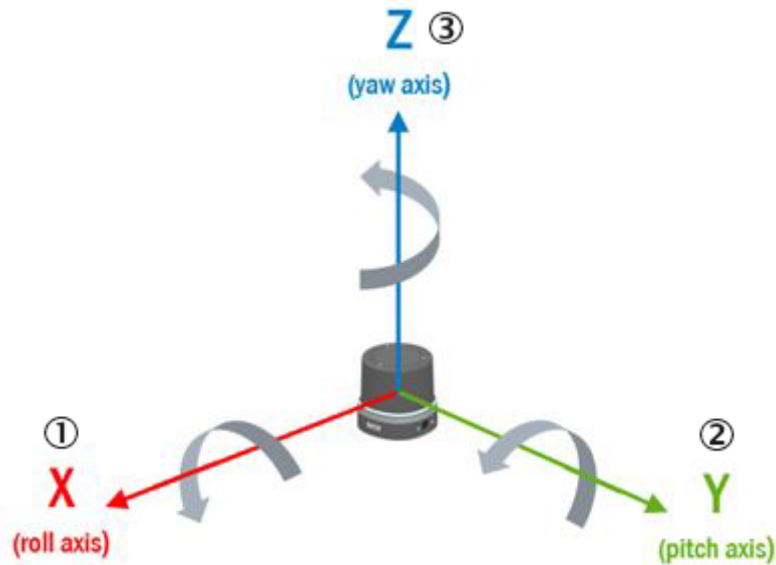
①   Roll angle
②   pitch angle
③   Yaw angle

3.4.7   Filter

By using digital filters to pre-process and optimize the measured distance values, the device can be tailored to the specific requirements of the respective application. This makes it possible to prevent virtually all faults.

The active filter functions affect the outputted measured values. It is not possible to recalculate the original measured values from the filtered output values.

3.4.7.1   Fog filter

The fog filter enables the device to eliminate unwanted echoes at close range. This considerably lowers the probability of false activations at close range in fog.
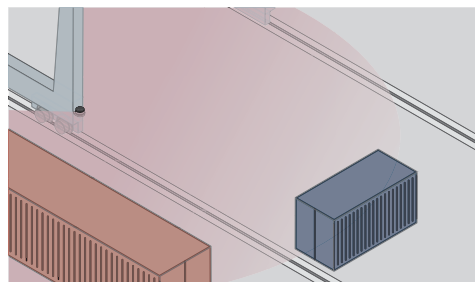
Figure 13: Without the fog filter: objects are difficult to detect through the fog due to reflections.
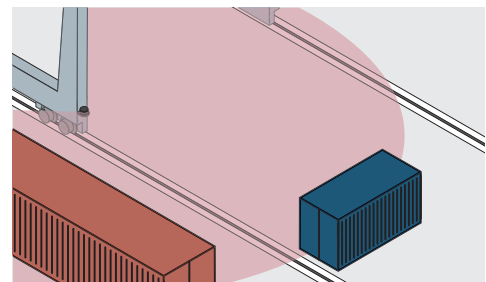
Figure 14: Using the fog filter: objects can be detected reliably because unwanted echoes are screened out.

3.4.7.2 Echo filter

The echo filter screens out unwanted measurement data and signals caused by edge hits, rain, dust, snow and other ambient conditions.

You can set whether the first, the last, or all three echoes are output.

The other pulses triggered by undesirable ambient conditions are not taken into account.
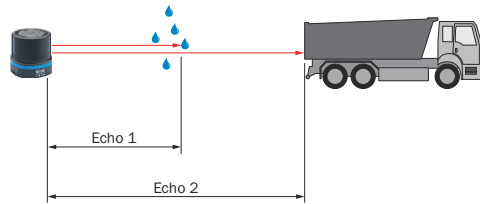
Figure 15: Without the echo filter: The device receives unwanted echoes from ambient conditions such as rain.
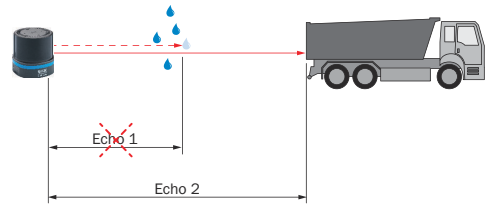
Figure 16: Using the echo filter (setting: last echo): the device screens out unwanted echoes from ambient conditions as per the settings chosen. Measured on white objects, two echoes can be separated at a distance of 1.5 m or greater.

3.4.7.3 Particle filter

The particle filter blanks small, irrelevant reflection pulses in dusty environments and in rain or snow which are caused by dust particles, raindrops, snowflakes or the like.

In doing so, successive scans are continuously evaluated in order to detect static objects.

If the distance between a measured value and its temporal spatial neighbors is greater than a defined threshold value, this measured value is discarded as faulty.

> **NOTE**
> If the particle filter is activated, measurement data output is delayed by one scan.
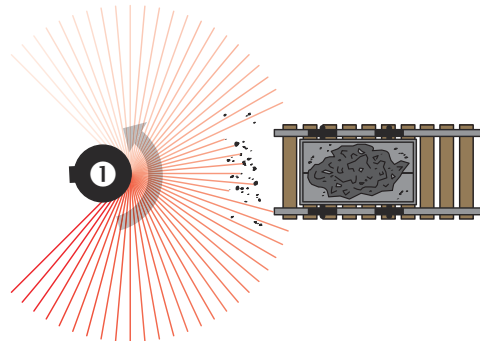
Figure 17: Without the particle filter: Violation of the contour due to dust particles in the vicinity of the object.
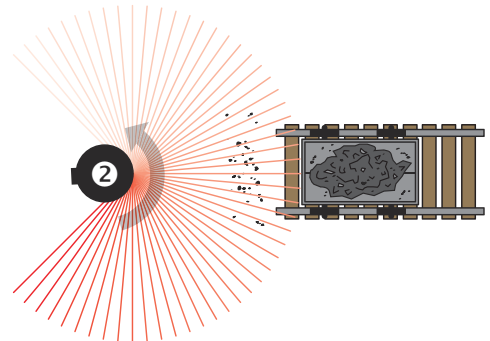
Figure 18: Using the particle filter: The response to dust particles in the detection field is delayed by one scan. Particles can thereby be blanked.

3.4.7.4 Moving average filter

The sliding average filter smooths the distance value. It does this by calculating the arithmetic mean from several scans of the same point. The number of scans can be configured. Each scan layer is filtered separately.

Table 3: Example: Moving average filter over 4 scans

| Scan | Angle (distance values in mm) | | | | | | | | | |
	1	2	3	4	5	6	7	8	9	...
1	0	0	1100	1100	1150	1150	1380	1380	0	...
2	0	0	1200	1200	1190	**950**	1500	1500	0	...
3	0	0	1150	**1450**	1200	1200	1450	1450	0	...
4	0	0	1170	1170	1220	1220	1470	**1150**	0	...
1. Output value (scan 1-4)	0	0	1155	1230	1190	1130	1450	1370	0	...
5	0	0	**0**	1110	1150	1150	1380	1380	0	...
2. Output value (scan 2-5)	0	0	1173	1233	1190	1130	1450	1370	0	
6	0	0	1200	1210	1190	**0**	1500	1500	0	...
3. Output value (scan 3-6)	0	0	1173	1235	1190	1190	1450	1370	0	
7	0	**730**	1150	**0**	1200	1200	1450	1450	0	...
4. Output value (4-7)	0	730	1173	1163	1190	1190	1450	1370	0	
...	...	...	...	...	...	...	...	...	...	...

Individual outliers (shown in **bold** in the table) influence the average value.

Once the measured value telegram has been confirmed, the first measured value is not output until after the configured number of scans. Therefore, there is always a time delay equivalent to the number of scans configured for averaging. The scan counter is taken from the latest scan included in the averaging process. Invalid distance values (= 0) are not included in the averaging calculation, so that in these places a smaller number of scans is used in the division calculation.

Based on the scanning frequency of 20 Hz, a measured value is generated every 50 ms. The time delay for data output results from this base value multiplied by the number of averaging operations (e.g., 2 averaging operations = 100 ms, 10 averaging operations = 500 ms).

3.4.7.5 Data reduction filter

A data reduction filter is an algorithm that selects, based on various criteria, the relevant measurement data that should be excluded from the further processing.

3.4.7.5.1 Interval filter

The interval filter reduces the scan output rate by a configurable factor (reduction factor). When the reduction factor is set to three, for example, the output rate is reduced to one third. In this case only every third scan is output.

By combining the moving average filter with an averaging depth d and the interval filter with a reduction factor of d, a "block average filter" can be implemented that outputs the average over the previous scans while at the same time reducing the output rate by a factor d.

3.4.7.5.2 Scan range filter

The scan range filter is used to restrict the horizontal angular range output per scan.

The scan range filter is switched off by default. When it is activated, it can be set to a value between - 180° and + 180°.

The range can be restricted by increasing the start angle or reducing the stop angle. Please note that the angle beam orthogonal to the front screen is defined as 0°, and the direction of rotation of the device is set to counterclockwise.

If a complete range of the output data is outside the angular range, it is not output. If a range is partially within the specified angular range, it is filled with 0 values.
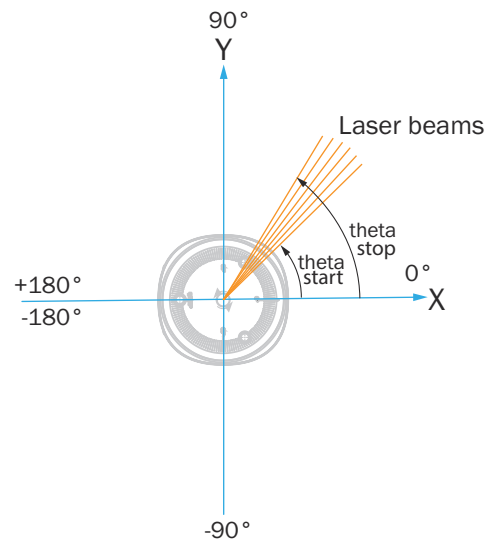
Figure 19: Definition of the thetaStart and thetaStop angle (top view)

3.4.7.5.3 Scan layer filter

The scan layer filter can be used to hide the measurement data of individual scan layers.

3.4.7.6 Region of interest

The region of interest is an algorithm that uses various criteria to select relevant measurement data that are set to a distance value and RSSI value of zero for further processing. Angle values are retained.

3.4.7.6.1 Cubic area filter

When the cubic area filter is activated, it cuts out everything except for the parts of the scan within an axis parallel cuboid. Note that this filter does not reduce the data, it sets the data points outside the cuboid to zero.

The cuboid can be adjusted by setting the minimum and maximum values [mm] for the X, Y and Z axis.

3.4.7.6.2 Distance filter

The distance filter affects the display of a spherical area around the device by limiting the minimum and maximum radial distance that is measured.

The distance filter does not reduce the data, but sets the data points outside the radial distance to zero.

To cut out a spherical area, set the min range to a specific radius [mm] for a very large selected max range.

To keep a spherical area, set the max area to a specific radius [mm].

To keep a hollow sphere, set the min range and max range to a specific radius [mm] and the min range to 0.

3.4.8   Measurement data output

3.4.8.1   Data formats

The device offers two data output formats: MSGPACK and Compact. Both data formats allow the data to be output segment by segment via UDP.

Both data formats contain information such as device identification, serial number, time stamp, and device status. While MSGPACK can be integrated easily using existing libraries and is easy to parse, it requires more computing power and bandwidth than the compact data format due to the descriptive names. Compact is significantly more efficient and has a lower bandwidth. Compared to MSGPACK, however, the compact data format is not descriptive and may require more integration effort.

> **NOTE**
> The contents and structure of the two data formats is explained in the Data format description technical information (**www.sick.com/8028132**).

3.4.8.2   Scan layer address

The actual position of a scan layer can vary. The exact actual vertical angle value of each scan layer can be read from the device.

> **NOTE**
> For more information on this, see the Data format description technical information at **www.sick.com/8028132**.

Table 4: Address assignment method

Scan layer	Measuring module allocation to scan layers	DIN ISO 8855	Physical
1	Measuring module 0	22.2°	-22.2°
2	Measuring module 0	17.2°	-17.2°
3	Measuring module 0	12.3°	-12.3°
4	Measuring module 0	7.3°	-7.3°
5	Measuring module 0	2.5°	- 2.5°
6 (high resolution)	Measuring module 0	0°	0°
7	Measuring module 0	-2.2°	2.2°
8	Measuring module 0	-7.0°	7.0°
9	Measuring module 1	-12.9°	12.9°
10	Measuring module 1	-17.2°	17.2°
11	Measuring module 1	-21.8°	21.8°
12	Measuring module 1	-26.6°	26.6°

Scan layer	Measuring module allocation to scan layers	DIN ISO 8855	Physical
13	Measuring module 1	-31.5°	31.5°
14 (high resolution)	Measuring module 1	-34.2°	34.2°
15	Measuring module 1	-36.7°	36.7°
16	Measuring module 1	-42.2°	42.2°
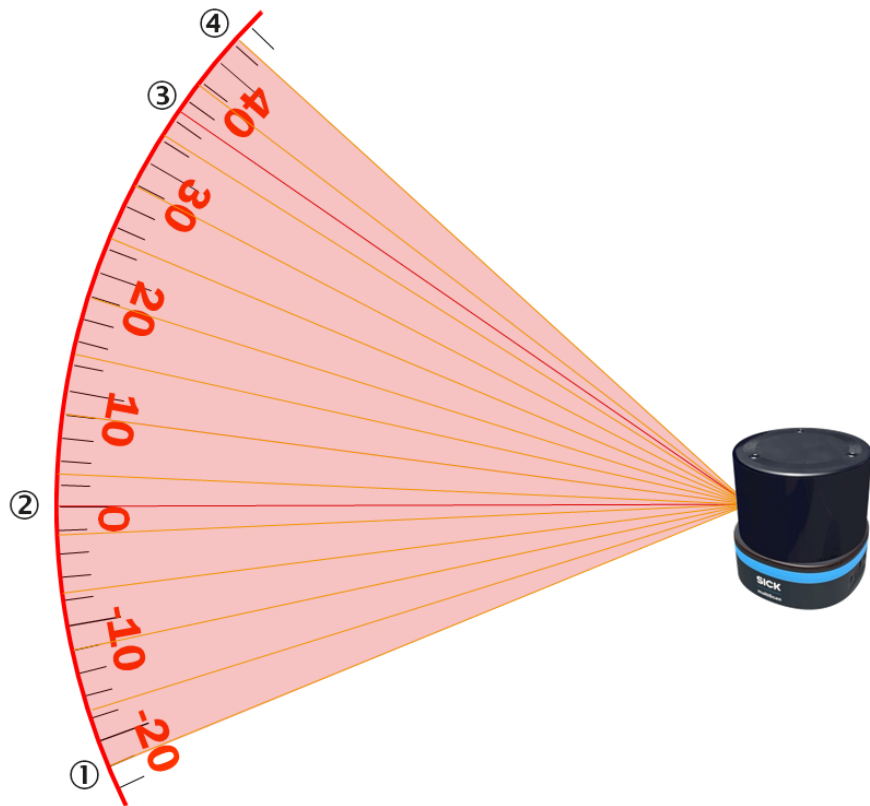
Figure 20: Positions of the 16 scan layers, side view

①   Scan layer 1
②   Scan layer 6 (high resolution)
③   Scan layer 14 (high resolution)
④   Scan layer 16

3.4.8.3 Segmented data output

The device records data over an azimuth range of 360°. The data acquired within a 360° rotation for all scan layers are referred to below as a frame. For data output, a frame is divided into segments each of which contain the data of all scan layers for a smaller azimuth interval.

In this case it is important to note that a segment defines a temporally related portion of the data which does not (necessarily) have to be a spatially related portion of the data, i.e., the azimuth range of each scan layer in a segment may be different.

The following figure shows 12 segments each covering a range of 30°. The segment i is recorded in the time interval [t_(i-1),t_i], which means the motor rotates by 30° during that time interval.
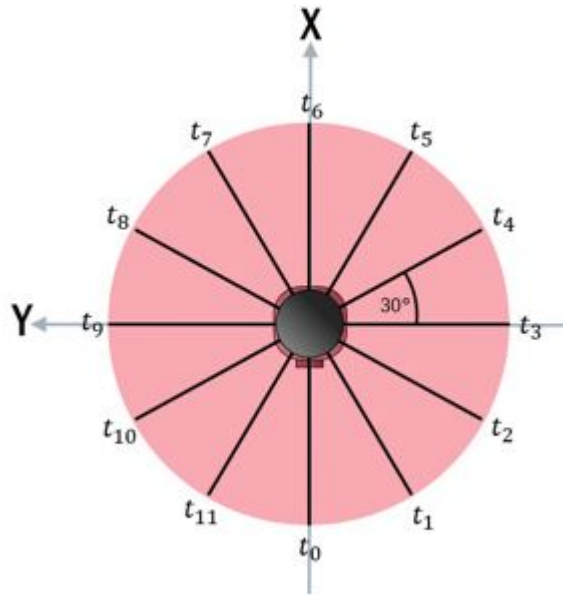
Figure 21: Sequence of segment output. The segment i is from the time t_{i-1} to t_i

3.4.8.4 Data preparation

The yellow bars in the following figures indicate the number of measuring points depending on the resolution over a range of 30°.

Raw data (RAW)

Because the device has two measuring modules that point in opposite directions and the sender/receiver units on each measuring module have an azimuth offset, the azimuth range that is recorded for each scan layer in a segment is different.
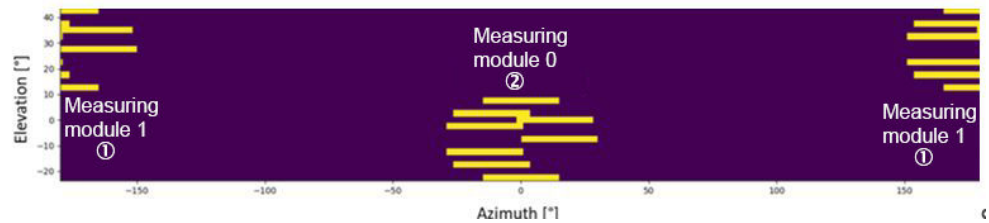
Figure 22: Example azimuth and elevation angles for the data recorded within a segment (RAW)

① Measuring module 1
② Measuring module 0

Rectified data (RECTIFIED)

The data for each scan layer recorded by a measuring module are rearranged so their start angles match (apart from a small deviation that is attributable to the different sending times of the transmitter elements of a measuring module). This rearrangement affects the latency, however, and leads to a delay of at least one time interval.
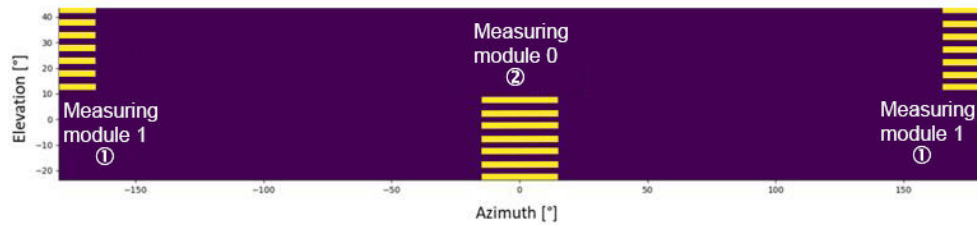
Figure 23: Example azimuth and elevation angles for the data recorded within a segment (RECTI-FIED)

①   Measuring module 1
②   Measuring module 0

3.4.8.5   ROS driver

Suitable drivers for integrating the device into the ROS (Robot Operating System) are available for download on the product page.

The page can be accessed via the **SICK Product ID**: **pid.sick.com**/{P/N}/{S/N}

{P/N} corresponds to the part number of the product, see type label.

{S/N} corresponds to the serial number of the product, see type label (if indicated).

3.4.8.6   Calculation of the field size for mobile applications

In order to prevent collisions between vehicles, and between vehicles and fixed objects, the switching field must have sufficient length and width.

To calculate the switching field length, you need to take into consideration the stopping distance of the vehicle. This comprises the following:
- the braking distance, which can be found in the vehicle documentation
- the distance covered during the vehicle control's response time, which can be found in the vehicle documentation
- The distance covered during the response time of the LiDAR sensor, "Technical data", page 57.

> **NOTE**
> - We recommend adding a supplement of at least 100 mm to the protective field length in order to stop the vehicle before a possible collision.
> - If retro-reflectors are situated in the path of the vehicles, or if you anticipate that the braking force of the vehicle will diminish over time, you may, under certain circumstances, need to increase the recommended supplement.
> - The width of the switching field should cover the vehicle width. You should also configure a supplement of at least 100 mm on every side.

Mounting height

The recommended mounting height for mobile applications is at least 150 mm.

3.4.8.6.1   Switching field length

You must configure the switching field so that a minimum distance to the vehicle is maintained at all times. This ensures that a vehicle monitored by the LiDAR sensor stops before an object is reached. You can define multiple monitoring cases each with different switching fields. These can be switched over dynamically via static control inputs, for example to adjust the protective field size based on the vehicle speed.

In this kind of application, you must calculate the switching field sizes (in particular the switching field lengths) for all speeds.

The switching field length SL can be calculated using the following formula (guideline values based on a pixel calculation):

SL = SA + ZG + ZR + ZB

SA = Stopping distance

ZG = General supplement of the LiDAR sensor = 100 mm

ZR = Supplement for application-related influences or the selected application parameters

ZB = Supplement for the decreasing braking force of the vehicle. This can be obtained from the relevant vehicle documentation, or alternatively: 10% of the stopping distance.

Stopping distance SA

The stopping distance comprises the vehicle's braking distance and the distance covered during the response time of the LiDAR sensor and the vehicle control's response time.

ℹ️ **NOTE**

Please note that a vehicle's braking distance does not increase linearly with increasing speed, but rather in a squared relationship. This is particularly important if you switch between different-sized switching fields depending on the speed.

How to calculate the stopping distance SA:

SA = S_{AnF} + S_{AnS} + S_{Br}

S_{AnF} = The distance covered during the vehicle control's response time, which is specified in the vehicle documentation

S_{AnS} = The distance covered during the response time of the LiDAR sensor

S_{Br} = The braking distance, found in the vehicle documentation

The distance S_{AnS} covered during the response time of the LiDAR sensor depends on:
- the response time of the LiDAR sensor
- the maximum speed of the vehicle in your mobile application

For more information on the response time T_S of the LiDAR sensor, .

How to calculate the distance S_{AnS} covered during the response time of the LiDAR sensor:

S_{AnS} = T_S × V_{max}

T_S = Response time of the LiDAR sensor

V_{max} Maximum speed of the vehicle, from the relevant vehicle documentation

The response time T_S of the LiDAR sensor depends on:
- the base response time of the LiDAR sensor
- whether multiple sampling is set
- Filter settings (e.g., particle filter)

ZR supplement

This supplement must be determined on an application-specific basis and taken into account appropriately. The following factors can make it necessary to use a supplement: reflectors or shiny objects on the scan plane, multi-echo analysis, blanking size, device filter (e.g., particle filter).

Switching field width

The width of the switching field must cover the width of the vehicle and take into account the supplements for the measurement error.

The switching field width SB can be calculated using the following formula (guideline values based on a pixel calculation):

SB = FB + 2 × (ZG + ZR)

FB = Vehicle width

ZG = General supplement of the LiDAR sensor = 100 mm

ZR = Supplement for application-related influences or the selected application parameters

3.4.9 Object sizes

Due to the angle between two scan layers, the detection of an object depends on its size and distance from the device. The device may not be able to detect the object if the beams go past it rather than hit it. This applies both to the width and also the height of the relevant object.

The transmit spot is never smaller than 13 mm (diameter of the transmitter opening/lens)
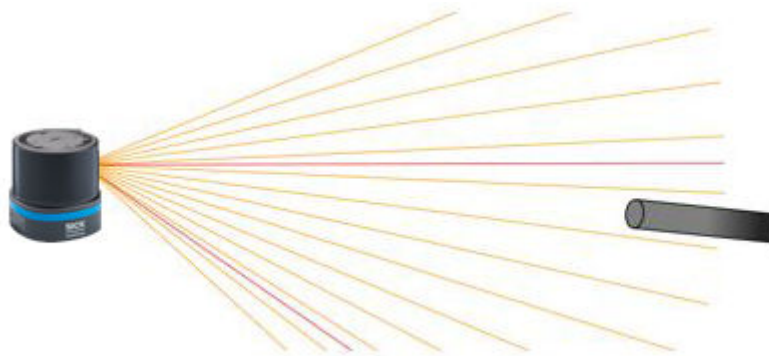
Figure 24: Laser beams pass the object without hitting it (side view)

The smallest object at a desired distance that can still be reliably detected is described by the size `obj_sz`$_{min}$ [mm] and is defined by the following formula.

The formula is only valid for objects larger than 13 mm.

$$obj\_sz_{min} = Distance \times \tan(obj_{min})$$

$$obj_{min} = \alpha_{spot} + \alpha_{meas} + \alpha_{res}$$

obj$_{min}$ Minimum object angle [°]

α_{spot} Beam spot size [°], here 0.3°

α_{meas} Measuring interval [°], see table 5, page 31

α_{res} Angular resolution [°], horizontal 0.125°, vertical 0°

Table 5: Typical minimum object size [mm] as a function of distance and angular resolution

Angular resolution [α_{res}] Distance [mm]	Horizontal 0.125° (red high-resolution scan layer see figure 24)	Horizontal 1.0° (orange scan layer see figure 24)	Vertical 2.5° (between red and orange scan layer see figure 24)	Vertical 5.0° (between two orange scan layers see figure 24)
100	13	13	13	13
200	13	13	13	19
500	13	13	26	47
1000	13	25	51	95
2000	19	50	102	190
3000	29	75	153	285
5000	48	124	255	475
10000	96	249	511	950
15000	144	373	766	1425
20000	192	498	1022	1899
25000	240	622	1277	2374
30000	288	746	1533	2849

> **NOTE**
> For reliable measurement, in particular when using the device to output measured values, the laser needs to hit the object with multiple beams. An object should therefore be larger than the minimum object size.

3.4.10 Impact of object surfaces on the measurement

Reflection

Most surfaces produce a diffuse reflection of the laser beam in all directions. The structure (smooth or rough), shape (flat or curved), and color (light or dark) of the surface determine how well the laser beam is reflected.

On very rough surfaces, a large proportion of the energy is lost due to absorption. Curved surfaces produce a higher diffusion. Dark surfaces reflect the laser beam worse than light ones (brilliant white plaster reflects approx. 100% of the light, while black foam rubber reflects approx. 2.4%). The aforementioned surface characteristics can reduce the scanning range of the device, in particular for surfaces with low remission values.
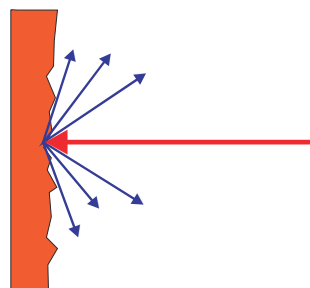
Figure 25: Reflection of light on the surface of the object

Angle of reflection

The angle of reflection corresponds to the angle of incidence. If the laser beam hits a surface at right angles, the energy is optimally reflected. If the laser beam hits a surface at an oblique angle, energy and range are lost accordingly.
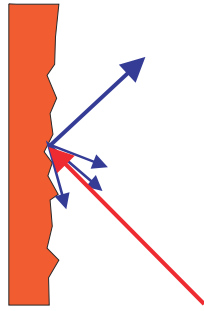
Figure 26: Angle of reflection

Retroreflection

If the reflective energy is greater than 100%, the beam is not reflected diffusely in all directions; instead it is reflected in a targeted way (retroreflection). Thus a large part of the emitted energy can be received by the laser distance measurer. Plastic reflectors (cat's eyes), reflective tape, and triple prisms have these properties.
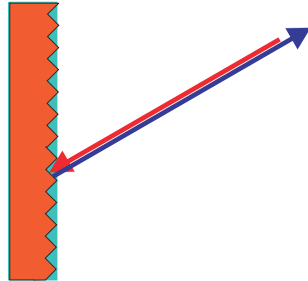
Figure 27: Retroreflection

Reflective surfaces

The laser beam is almost completely deflected on reflective surfaces. This means that an object hit by the deflected beam may be detected instead of the reflective surface.
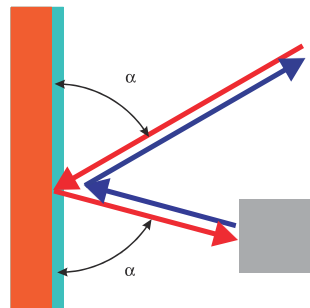
Figure 28: Specular surfaces

Small objects

Objects that are smaller than the diameter of the laser beam cannot reflect the laser light's full energy. The portion of the light beam that does not reach the object is lost. If all of the light reflected to the sensor is insufficient, the object may not be detected.

The portion of the light that does not reach the front object can be reflected by a larger object in the background. If all of the light reflected to the sensor is sufficient, this object is detected. This can lead to a corruption of the measured value.
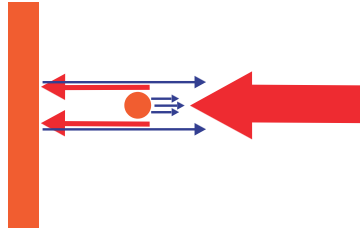
Figure 29: Object smaller than the laser beam diameter

3.4.11   Scanning range

The scanning range of the device depends on the remission of the object to be detected. The better a surface reflects the incident beam back to the device, the greater the scanning range of the device.
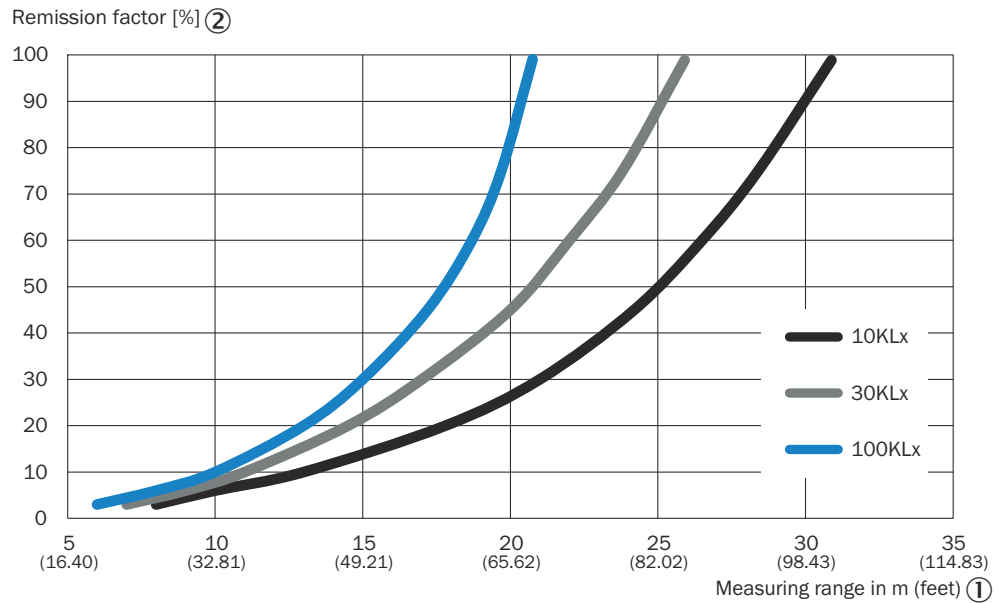
Figure 30: Scanning range as a function of the remission factor for various ambient light influences (no filter activated; no influence from fog, rain or dust)

Statistical error in mm (inch) ②
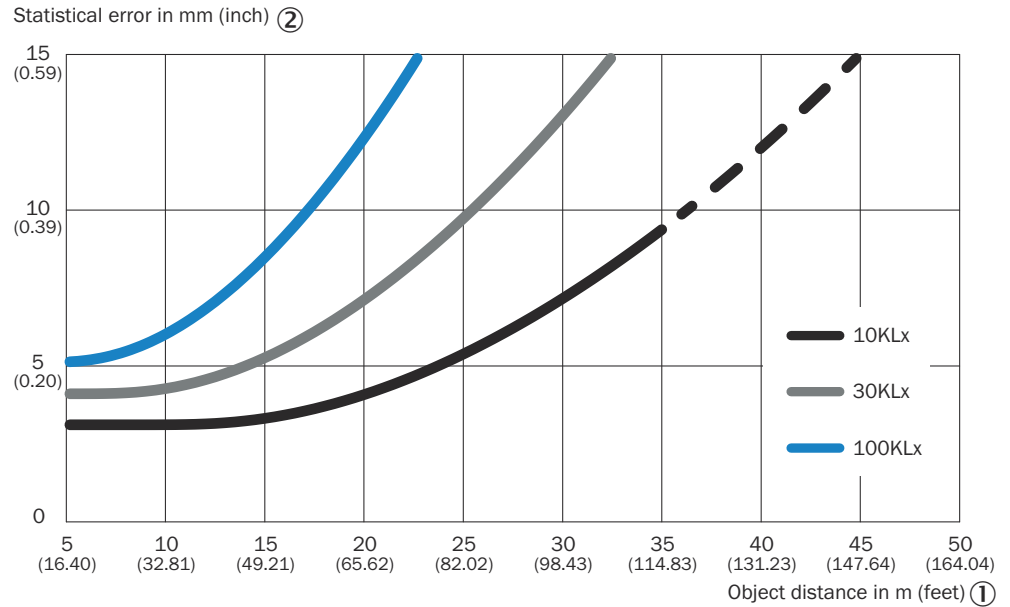
*Figure 31: Statistical error for **white objects** as a function of object distance for various ambient light influences*

Statistical error in mm (inch) ②
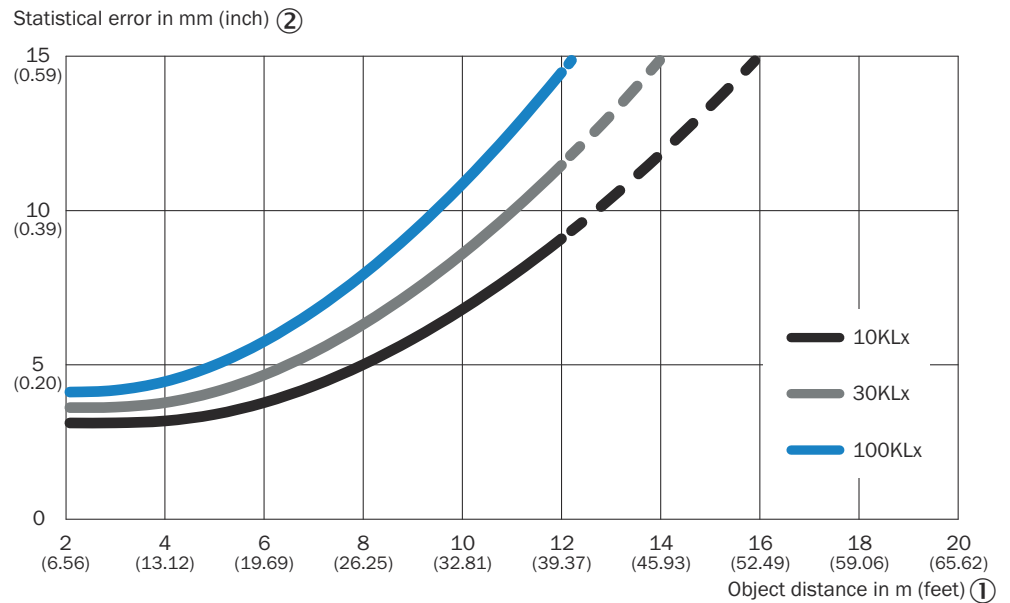
*Figure 32: Statistical error for **black objects** as a function of object distance for various ambient light influences*

3.4.12   RSSI values

RSSI (Received Signal Strength Indicator) is the measure of the signal strength that the device receives. This value is calculated for every measurement. The device therefore provides, for every echo signal, an associated RSSI value for the signal strength.

The value 0 (zero) means that the received energy was too low to produce a valid measured value and also represents the lowest possible RSSI value. An RSSI value of 1 represents the highest possible measured value. A linear scaling is applied between the values 0 and 1 using a resolution specific to the data format (see "Data formats", page 25).

If the RSSI value is 0, then no distance measurement is possible. There can be two reasons for this:

- The target object lies outside the sensing range.
- The target object has an extremely low remission.

Please note that white paper can have very similar values as a reflector at a short distance.

The RSSI values are sensor-specific, relative values that can vary slightly between different devices and during the service life of the device.

3.4.13   Contamination indication

The device has an optics cover to protect it. This optics cover can get dirty. Contamination reduces the energy emitted and received by the laser beam. As a result, scanned objects appear to have a lower remission factor than they actually have and, from a certain degree of contamination, it will no longer be possible to perform measurements.

The contamination is constantly measured by a separate system during operation. A contamination warning is output first for the different degrees of contamination. If the optics cover is not cleaned and contamination increases, then a contamination error is output.

The device supports a contamination indication over the full 360°. 12 sectors are monitored independently. When a scan configuration of -144° to +144° is selected, sectors without measurement are set to deactivated status. Each sector can be individually enabled for the contamination indication.

You can select different settings, depending on the application in which the device is used.

Warning/error output

- **All sectors contaminated:** If all sectors have the same or a higher value, the device status "Contamination warning" or "Contamination error" is displayed.
- **One sector contaminated:** At least one sector must have a level of "Warning" or "Error" for a contamination warning or contamination error to be displayed.
- **No output:** Warning and error device status display is deactivated. The contamination measurement for the individual sectors continues to be performed but has no effect on the device status.

Sensitivity: Low, medium, high: Threshold for triggering contamination warnings and errors. The parameter makes it possible to tailor the display to the specific requirements of the application.

Sector preset: If an accessory is used that limits the angular range used, this can be specified in the contamination indication.

Response time: This can be used to define how quickly the contamination should result in an error or warning.

Default setting: In the default setting, the contamination display is deactivated. The monitoring of individual sectors is active and can be seen for each sector in the user interface and the command interface to assist with integrating the device into the application.

Strategy and evaluation are deactivated so no device warnings or errors are triggered. All associated parameters can be permanently changed.

ⓘ   NOTE

- The cleaner the application environment is, the lower you can set the contamination indication sensitivity. If a high precision of the measured values is required, the contamination indication must be set to the most sensitive level.
- Sectors that are not relevant should be deactivated to ensure a higher availability.

Contamination warnings and contamination errors are indicated on the display elements of the device see "Status indicators", page 11.

3.4.14 Field evaluation

The device uses the integrated field evaluation to evaluate the fields within its scan area. You can use the field evaluation, for example, to implement systems for collision protection, object protection or access monitoring.

Up to 48 fields can be defined, of which 20 can be active at the same time.

Limitations of simultaneously active fields:
- More active fields results in a greater computing effort and therefore a higher system load.
- A too high system load can lead to performance problems or system errors.
- The system load can be reduced by deactivating other functions, for example GUI, filter, and measurement data output, which may allow more fields to be active at the same time.
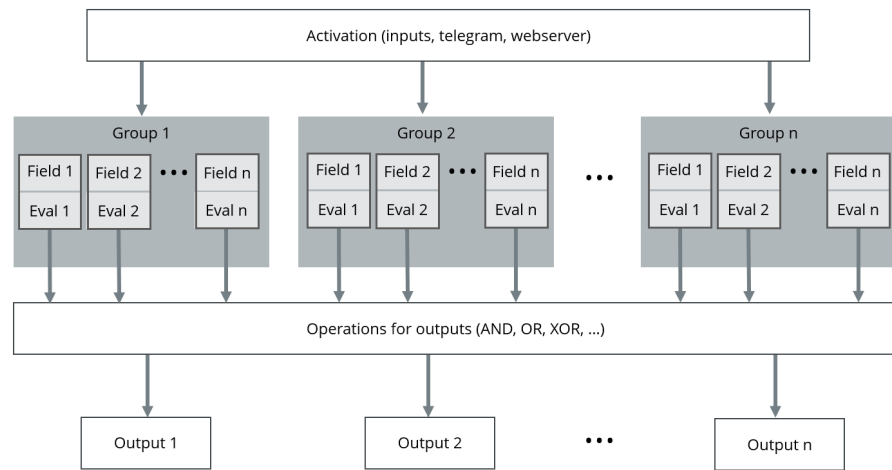
Figure 33: Principle of field evaluation

Multiple groups can be created, depending on application requirements. A group can be switched to active either by switching inputs of the device, telegrams, or permanently. A group can comprise several fields, each of which can be configured for the particular situation via its own evaluation.

The results of the evaluation can be linked to a switching output. It is also possible to link the respective evaluation to other signals using logical operands (AND, OR, XOR, ...).

4 Transport and storage

4.1 Transport

> **!** **NOTICE**
> **Damage due to improper transport!**
>
> - The product must be packaged with protection against shock and damp.
> - Recommendation: Use the original packaging.
> - Note the symbols on the packaging.
> - Do not remove packaging until immediately before you start mounting.

4.2 Unpacking

- To protect the device against condensation, allow it to equilibrate with the ambient temperature before unpacking if necessary.
- Handle the device with care and protect it from mechanical damage.

4.3 Transport inspection

Immediately upon receipt in Goods-in, check the delivery for completeness and for any damage that may have occurred in transit. In the case of transit damage that is visible externally, proceed as follows:

- Do not accept the delivery or only do so conditionally.
- Note the scope of damage on the transport documents or on the transport company's delivery note.
- File a complaint.

> **i** **NOTE**
> Complaints regarding defects should be filed as soon as these are detected. Damage claims are only valid before the applicable complaint deadlines.

4.4 Storage

- Do not store outdoors.
- Store in a place protected from moisture and dust.
- Recommendation: Use the original packaging.
- Do not expose to any aggressive substances.
- Protect from sunlight.
- Avoid mechanical shocks.
- Storage temperature: see "Technical data", page 57.
- Relative humidity: see "Technical data", page 57.
- For storage periods of longer than 3 months, check the general condition of all components and packaging on a regular basis.

5 Mounting

5.1 Mounting instructions

- Observe the technical data.
- Protect the sensor from direct sunlight.
- To prevent condensation, avoid exposing the device to rapid changes in temperature.
- The mounting site has to be designed for the weight of the device.
- The device can be mounted in any position.
- It should be mounted so that it is exposed to as little shock and vibration as possible. Optional mounting accessories are available, see "Accessories", page 62.
- Regularly check the tightness of the fixing screws.
- Do not mount the device on or directly in front of a bright metallic surface or other reflective surface, since reflections can falsify the measurements.
- Avoid having shiny or reflective surfaces in the scanning range, e.g., stainless steel, aluminum, glass, reflectors, or surfaces with these types of coatings.
- Protect the device from moisture, contamination, and damage.
- Make sure that the status indicator is clearly visible.
- Do not affix any labels or stickers to the optics cover.
- Do not subject the device to excessive shock or vibrations. In systems subjected to heavy vibrations, secure the fixing screws with screw-locking devices.
- The ventilation element must not be sealed off during installation.
- The device must be mounted in such a way that no water can pool on the ventilation element. When using a mounting bracket, we recommend providing a drill hole in the area of the ventilation element.

5.1.1 Ventilation element

The ventilation element ensures an improved pressure equalization and allows the exchange of air and heat between the housing and surroundings.

The breathable membrane allows ambient air to either penetrate into the device or escape again depending on the prevailing ambient conditions see "Dimensional drawing", page 60.

In particular for applications with frequently changing environmental influences (e.g., large temperature fluctuations or rapid temperature changes) or with standing water, the ventilation element ensures a reliable pressure equalization and thereby relieves the seals and adhesive joints of the housing. This can improve the expected service life of the device in the application.

Note the following information:
- Do not affix any labels or stickers to the ventilation element.
- Do not paint over the ventilation element.
- Devices that have been subjected to a long period of moisture or very rapid temperature changes need to first equilibrate after being switched on. In some circumstances, therefore, a period of time should be allowed before measurement readiness of the device because any moisture in the housing must first be taken up by the air in the housing, which is heated up through the operation of the device, so that it can then escape via the ventilation element. Depending on the nature of the precipitated moisture, this time period might be several minutes or even up to hours.

5.2 Mounting the system plug on the device

Notes

- Depending on the device variant ordered, the system plug is either already mounted on the device or is supplied separately.
- Compliance with the technical specifications of the device is possible only when the system plug is mounted.

Prerequisites

- The system plug, the seal on the device, and the entire connection area are free of contamination and moisture and show no signs of damage.

Fitting the system plug
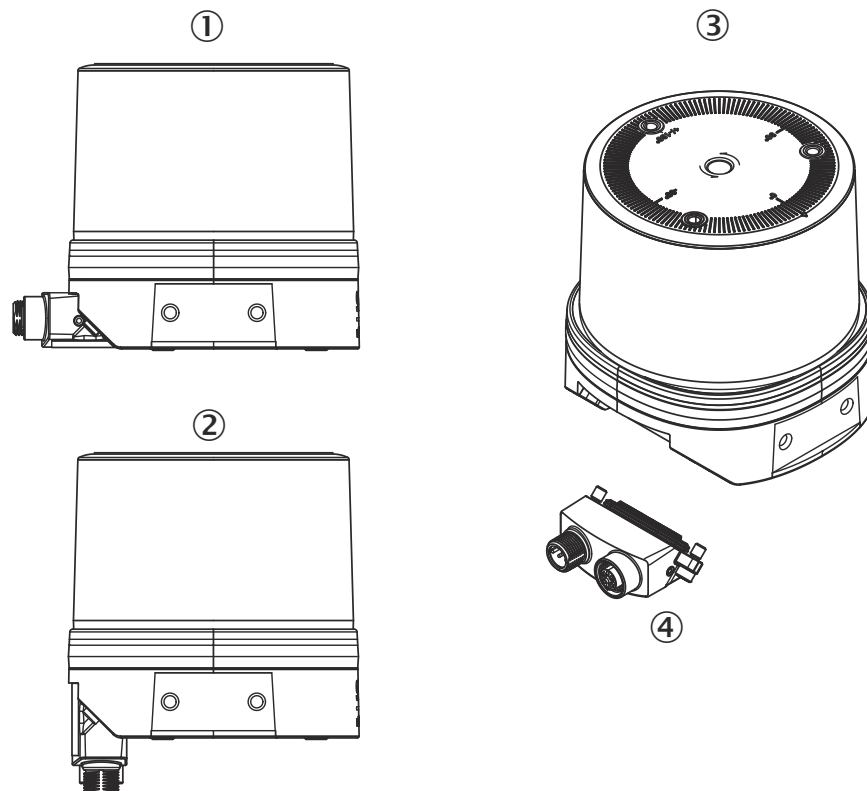
① System plug, installation at top
② System plug, installation at bottom
③ Device - system plug not mounted
④ System plug

1. Attach the system plug at the desired installation position on the device.
2. Tighten the screws (tightening torque: max. 2 Nm).

5.3 Mounting the device

Prerequisites

- The connector is mounted on the device see "Mounting the system plug on the device", page 39.

1. Mount the device in a suitably prepared bracket using the fixing holes provided (see "Dimensional drawing", page 60). Mounting brackets are available as accessories, see "Accessories", page 62.
2. Make the electrical connection. Attach and tighten the tension-free cable, see "Connecting the device electrically", page 48.
3. Align the vertical center line of the field of view of the device with the center of the area to be monitored. The marking on the upper side of the optics cover serves as a bearing alignment aid.
4. Switch on the supply voltage.
✓ After successful initialization, the two status LEDs light up green. The device is ready for use.
5. Perform a fine adjustment using a test target and, if necessary, use the alignment aid.

5.4 Mounting multiple devices

> **!** **NOTICE RISK OF INTERFERENCE FROM OTHER DEVICES!**
> Radiation sources with a wavelength of 850 nm can cause interference if they affect the device directly.

The device has been designed to minimize the probability of mutual interference, including between different LiDAR sensors. To rule out even the slightest effects on the measurement accuracy, the devices should be arranged in such a way that as few laser beams as possible are received from other devices.

6 Electrical installation

6.1 Wiring instructions

> **(i) NOTE**
>
> Pre-assembled cables can be found on the product page.
>
> The page can be accessed via the **SICK Product ID: pid.sick.com**/{P/N}/{S/N}
>
> {P/N} corresponds to the part number of the product, see type label.
>
> {S/N} corresponds to the serial number of the product, see type label (if indicated).

> **[!] NOTICE**
>
> **Faults during operation and defects in the device or the system**
>
> Incorrect wiring may result in operational faults and defects.
>
> - Follow the wiring notes precisely.

The electrical connection of the device is configured as an M12 round connector.

The enclosure rating stated in the technical data is achieved only with screwed plug connectors or protective caps.

All circuits connected to the device must be configured as SELV or PELV circuits. SELV = safety extra-low voltage, PELV = protective extra-low voltage.

Protect the device with an external fuse of 3 A slow-blow at the beginning of the supply cable.

Connect the connecting cables in a de-energized state. Do not switch on the supply voltage until installation is complete and all connecting cables are connected to the device and control.

Wire cross-sections in the supply cable from the customer's power system must be implemented in accordance with the applicable standards.

Prior to connecting the I/O line, check the device configuration for the inputs/outputs.

Avoid tensile loads to the connecting cables.

Maximum cable lengths for the voltage supply, depending on the available power supply voltage. The maximum cable length and the permissible minimum voltage at the power supply unit can be calculated with the help of the calculation rule in the following sections.

6.2 Prerequisites for safe operation of the device

⚠️ **WARNING**
Risk of injury and damage caused by electrical current!

As a result of equipotential bonding currents between the device and other grounded devices in the system, faulty grounding of the device can give rise to the following dangers and faults:

- Dangerous voltages are applied to the metal housings.
- Devices will behave incorrectly or be destroyed.
- Cable shielding will be damaged by overheating and cause cable fires.

Remedial measures

- Only skilled electricians should be permitted to carry out work on the electrical system.
- If the cable insulation is damaged, disconnect the voltage supply immediately and have the damage repaired.
- Ensure that the ground potential is the same at all grounding points.
- Where local conditions do not meet the requirements for a safe earthing method, take appropriate measures. For example, ensure low-impedance and current-carrying equipotential bonding.

The device is connected to the peripheral devices (any local trigger sensor(s), system controller) via shielded cables. The cable shield – for the data cable, for example – rests against the metal housing of the device.

The device can be grounded through the cable shield or through a blind tapped hole in the housing, for example.

If the peripheral devices have metal housings and the cable shields are also in contact with their housings, it is assumed that all devices involved in the installation have the **same ground potential**.

This is achieved by complying with the following conditions:

- Mounting the devices on conductive metal surfaces
- Correctly grounding the devices and metal surfaces in the system
- If necessary: low-impedance and current-carrying equipotential bonding between areas with different ground potentials
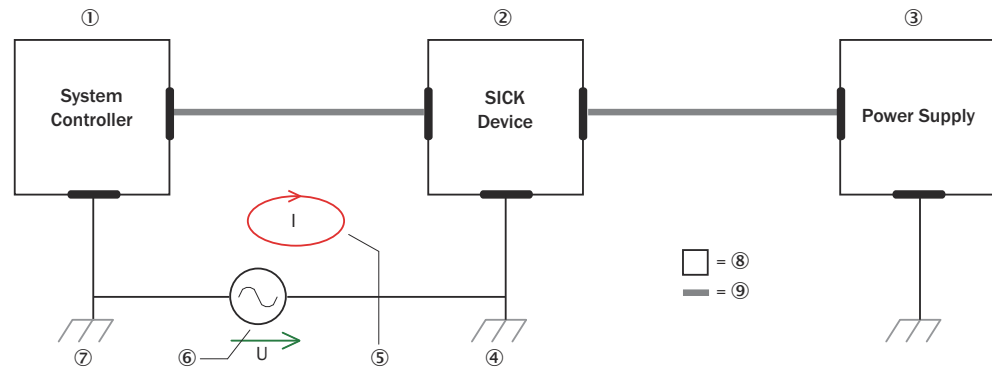
Figure 34: Example: Occurrence of equipotential bonding currents in the system configuration

① System controller

② Device

③ Voltage supply

④ Grounding point 2

⑤ Closed current loop with equalizing currents via cable shield

⑥ Ground potential difference

⑦ Grounding point 1

⑧ Metal housing

⑨ Shielded electrical cable

If these conditions are not fulfilled, equipotential bonding currents can flow along the cable shielding between the devices due to differing ground potentials and cause the hazards specified. This is, for example, possible in cases where there are devices within a widely distributed system covering several buildings.

Remedial measures

The most common solution to prevent equipotential bonding currents on cable shields is to ensure low-impedance and current-carrying equipotential bonding. If this equipotential bonding is not possible, the following solution approaches serve as a suggestion.

! NOTICE

We expressly advise against opening up the cable shields. This would mean that the EMC limit values can no longer be complied with and that the safe operation of the device data interfaces can no longer be guaranteed.

Measures for widely distributed system installations

On widely distributed system installations with correspondingly large potential differences, the setting up of local islands and connecting them using commercially available **electro-optical signal isolators** is recommended. This measure achieves a high degree of resistance to electromagnetic interference.
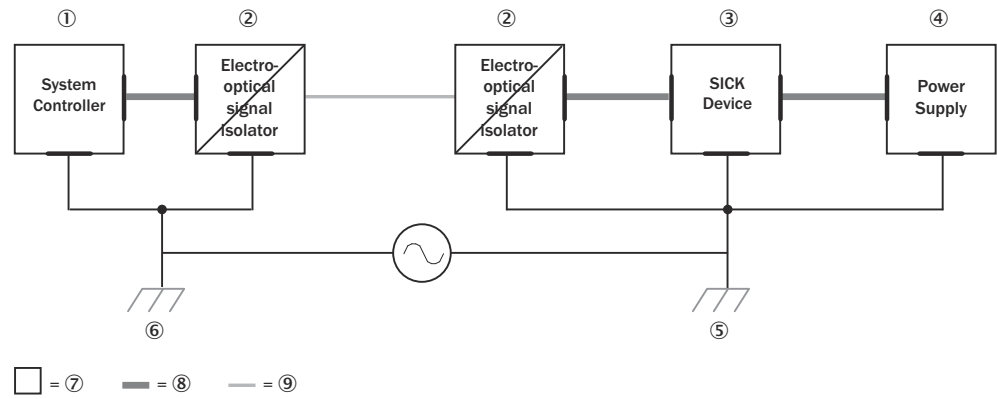
Figure 35: Example: Prevention of equipotential bonding currents in the system configuration by the use of electro-optical signal isolators

① System controller
② Electro-optical signal isolator
③ Device
④ Voltage supply
⑤ Grounding point 2
⑥ Grounding point 1
⑦ Metal housing
⑧ Shielded electrical cable
⑨ Optical fiber

The use of electro-optical signal isolators between the islands isolates the ground loop. Within the islands, a stable equipotential bonding prevents equalizing currents on the cable shields.

Measures for small system installations

For smaller installations with only slight potential differences, insulated mounting of the device and peripheral devices may be an adequate solution.
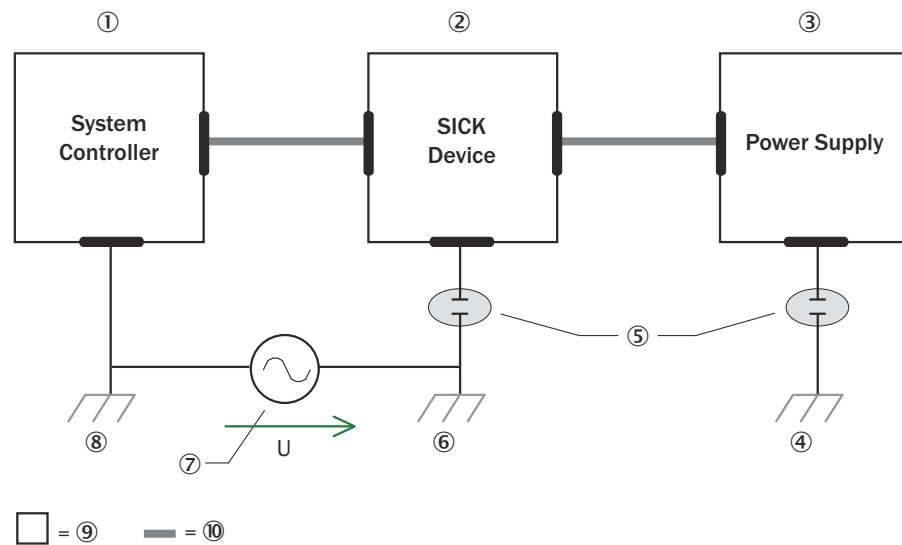
Figure 36: Example: Prevention of equipotential bonding currents in the system configuration by the insulated mounting of the device

① System controller
② Device
③ Voltage supply
④ Grounding point 3
⑤ Insulated mounting
⑥ Grounding point 2
⑦ Ground potential difference
⑧ Grounding point 1
⑨ Metal housing
⑩ Shielded electrical cable

Even in the event of large differences in the ground potential, ground loops are effectively prevented. As a result, equalizing currents can no longer flow via the cable shields and metal housing.

> **NOTICE**
> The voltage supply for the device and the connected peripheral devices must also guarantee the required level of insulation.
>
> Under certain circumstances, a tangible potential can develop between the insulated metal housings and the local ground potential.

6.3 Calculation rule

The device can be connected via optional accessories, .

The following formulas can be used to estimate the required cable lengths or supply voltages. Other conditions of the system must be considered in detail.

Formula for the voltage drop to be considered

$$\Delta V = \frac{I \bullet 2 \bullet L}{A} \bullet \rho \bullet (1 + \alpha \bullet (T - T_0))$$

Formula for permissible length of cable

$$L = \frac{\Delta V \bullet A}{2 \bullet I \bullet \rho \bullet (1 + \alpha \bullet (T - T_0))}$$

Sample calculations

Prerequisites:
- Steady state of the voltage supply
- Only applies for copper cable material

Table 6: Values used in both example calculations

Cable properties	
$A = 0.34 \bullet 10^{-6} \text{ m}^2$	Cross-section of the cable surface [m²]
$\rho = 1.72 \bullet 10^{-8} \text{ }\Omega\text{m}$	Specific resistance of copper [Ωm]
$\alpha = 3.9 \bullet 10^{-3} \text{ K}^{-1}$	Temperature coefficient of copper [1/K]
Ambient conditions	
$T_0 = 20 \text{ °C}$	Reference temperature [°C]
$T = 80 \text{ °C}$	Cable temperature [°C]
Cable load	
$I = P/U = 1.46 \text{ A}$ $P = 35 \text{ W}$ $U = 24 \text{ V}$	Load current I [A] Supply voltage U [V] Maximum expected power consumption P

Table 7: Example: voltage drop to be considered for cable part no. 2096241

L = 10 m	Cable length [m]
$\Delta V = \dfrac{I \bullet 2 \bullet L}{A} \bullet \rho \bullet (1 + \alpha \bullet (T - T_0)) = 1.82 \text{ V}$	Voltage drop ΔV [V]

Table 8: Calculation of the cable length for allowed voltage drop of 1.82 V

ΔV = 1.82 V	Voltage drop on the cable [V]
$L = \dfrac{\Delta V \bullet A}{2 \bullet I \bullet \rho \bullet (1 + \alpha \bullet (T - T_0))} = 10 \text{ m}$	Permissible length of cable [m]

6.4 Cable reserve on system plug

Allow for sufficient cable reserve of the supplied cables at the system plug. You can easily exchange the device with the cable reserve if needed.

Keep the cable reserve only long enough that the system plug cannot be accidentally plugged into an adjacent device when replacing the device! This prevents a device with an incorrect configuration being put into operation. Experience has shown that 200 to 300 mm of cable reserve on the device is ideal.

The reserve cable should be laid as a drip loop so no moisture (e.g., condensation) is directed towards the device but instead drips off the cable beforehand.

6.5 Connection diagram

> ℹ️ **NOTE**
> The recommended connecting cables and their associated technical data can be found on the online product page.
>
> The page can be accessed via the **SICK Product ID: pid.sick.com**/{P/N}/{S/N}
>
> {P/N} corresponds to the part number of the product, see type label.
>
> {S/N} corresponds to the serial number of the product, see type label (if indicated).

PWR connection
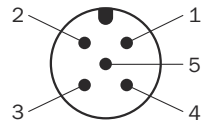
Figure 37: Male connector, M12, 5-pin, A-coded

Table 9: Pin assignment for PWR connection

Contact	Signs	Description	Wire color, part number 2095733 [1]
1	Vs	Supply voltage: +9 … +30 V DC	Brown
2	IN2 / OUT2	Digital input 2 / digital output 2	White
3	GND	Supply voltage: 0 V	Blue
4	IN1 / OUT1	Digital input 1 / digital output 1	Black
5	IN3 / OUT3	Digital input 3 / digital output 3	Gray

[1] Data only valid when using the specified connecting cable with flying leads, which is available as an accessory
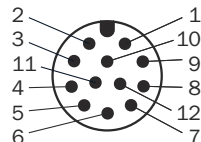
Figure 38: M12 male connector, 12-pin, A-coded

Table 10: Pin assignment for PWR connection

Contact	Labels	Description
1	IN1/OUT1	Digital input 1 / digital output 1
2	GND	Supply voltage: 0 V
3	IN2/OUT2	Digital input 2 / digital output 2
4	IN7/OUT7	Digital input 7 / digital output 7
5	IN8/OUT8	Digital input 8 / digital output 8
6	IN8/OUT3	Digital input 3 / digital output 3
7	IN4/OUT4	Digital input 4 / digital output 4
8	IN6/OUT6	Digital input 6 / digital output 6
9	Vs	Supply voltage: +9 … +30 V DC
10	IN5/OUT5	Digital input 5 / digital output 5
11	–	–
12	–	–

Ethernet connection
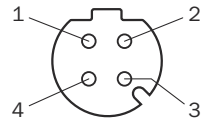
Figure 39: M12 female connector, 4-pin, D-coded

Table 11: Pin assignment for Ethernet connection

Contact	Signs	Description
1	TX+	Sender+
2	RX+	Receiver+
3	TX-	Sender-
4	RX-	Receiver-

6.6 Connecting the device electrically

> ! **NOTICE**
> Observe the wiring instructions, see "Wiring instructions", page 41.

1. Ensure that the power supply unit can provide the necessary voltage and current for operating the device. Particular attention must be given to the voltage drop across the supply line (see "Calculation rule", page 45),and for digital outputs the additional voltage drop in the opposite direction and the required start-up power (see "Mechanics/Electronics", page 59), without which the device cannot start reliably.
2. Ensure the voltage supply is not connected.
3. Connect the device according to the connection diagram, see "Connection diagram", page 47.

7 Commissioning

7.1 Operation using SOPASair

The browser-based SOPASair software can be used to parameterize the device and for service and diagnostic purposes.

To parameterize the device, you will require a computer with a web browser installed and a free Ethernet connection. Alternatively, the connection can be established via a USB connection using an Ethernet USB adapter.

7.1.1 Opening the web server user interface (SOPASair)

Before opening the user interface, perform the following work steps:
- Connect the device to the computer via Ethernet.
- Set up the voltage supply for the device.
- Ensure that the computer and device are located in the same network.
- Ensure that the computer uses a different IP address than the device, but is in the same IP address range (e.g. 192.168.0.xxx)

Opening user interface:
1. Open web browser (recommendation: Google Chrome).
2. Enter the device IP address into the address line. The standard IP address is: 192.168.0.1
✓ The SOPASair user interface is displayed.

7.1.2 Overview
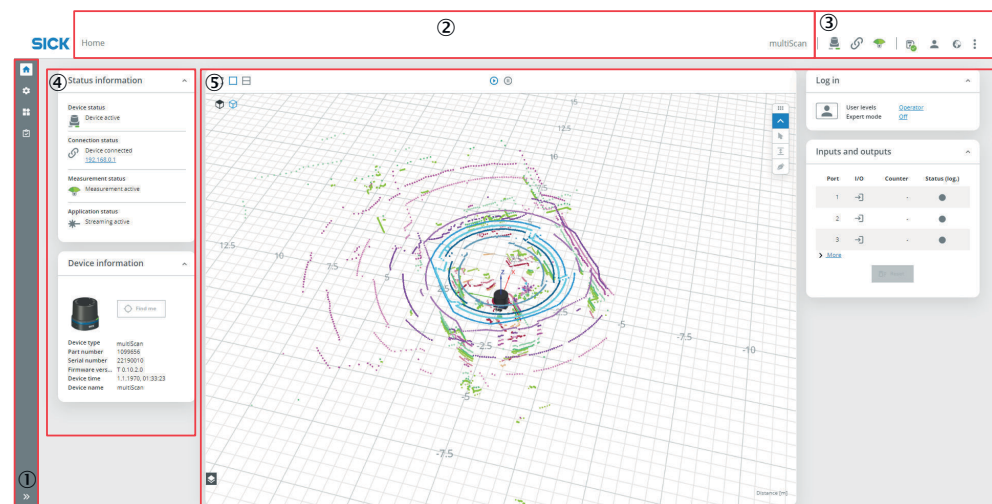
①   Show and hide menu bar
②   Menu path for opened menu
③   Status indicators | toolbar
④   Menu panel **Status** and **Device**
⑤   Workspace with live image and menu panels

Status indicators

     LED display

     Device connection status

Measurement status

Toolbar

Save permanently

Open login window

Change user interface language

Device menu

Navigation

1. Click on the desired menu.
✓ The workspace changes depending on the selected menu.

7.1.3 Navigating in the live image

Overview

The view of the scan data In SOPASair can be adjusted using the computer mouse.

Using the computer mouse

Function	Computer mouse
Zoom in and zoom out	Using the scroll wheel
Rotate and tilt the view	Left mouse button
Move the view	Right mouse button

7.1.4 User levels

The device has different user levels.

The user levels have different authorizations for configuring the device.

The current user level is displayed in the **Log in** panel.

1.
   Click on the button.
✓ The **Log in to device** input screen opens.
2. Select user level(**User level**), enter a password(**Password**) then click **Login** in.

User levels	Password	User and authorizations
Maintenance	main	Customers: Display only, no configuration
Authorized customer	client	Technical staff: Install and configure device
Service	service	Service staff: Make advanced configuration settings

> **NOTE**
> Change the passwords during initial commissioning to protect your device.
> A higher user level can change the password of a lower user level.

7.1.5 Resetting the password

> **NOTE**
>
> The responsible SICK sales company or the responsible SICK service partner carefully checks each code request to reset the password. A risk of deception by third parties nevertheless exists. The operating entity should therefore take suitable security measures.
>
> The operating entity should also take suitable measures to limit, as best as possible, access to the product. This includes, in particular, physical access as well as access to the software interfaces of the product.

Resetting the password for the Service user

1. Click on the ● button.
✓ The **Log in to device** input screen opens.
2. Click on **Password forgotten?**.

Resetting the password for the Authorized client/Maintenance personnel user

1. The password for the **Service** user has been reset.
2. Save the device parameterization using the parameter export in SOPAS ET.
3. Click on the ⋮ button.
4. Select **Reset to factory settings**.

7.1.6 Displaying live data

1. In SOPASair: Open the user interface see "Opening the web server user interface (SOPASair)", page 49.

If no scan data are shown:

1. Click **Configuration** > **Defaults**.
2. Select **Measuring**.

7.1.6.1 Activating/deactivating filters

Prerequisites

*   You must be logged into the device see "User levels", page 50.

Selecting filters

1. Menu: Select **Configuration** > **Default**.
2. Activate or deactivate one or more filters.

Selecting the data reduction filter/region of interest filter

1. Menu: Select **Application** > **Data output** .
2. Activate or deactivate one or more filters.

7.1.7 Configuring interfaces

Settings for using the multifunctional I/Os can be configured in the **Application** > **Inputs and outputs** menu. In addition, the current status and saved function of the input/output are displayed.

The multifunctional I/Os are switchable and can therefore each be used as either a digital input or output.

The inputs may switch on, switch off, and switch over analysis cases, for example. The inputs can also be used to activate other functions, such as measurement data output triggering.

The outputs can be used as digital switching outputs, for example to ground (PNP) (depending on the device type). For each output, it is necessary to define whether it is to be switched by means of SOPAS ET telegrams, or whether it is being used to signal device readiness.

7.2 Operation in SOPAS ET

Execute the functions listed below via the SOPAS ET configuration software.

Functions
- Install firmware updates
- Import and export data

> ℹ️ **NOTE**
>
> To use the sensor with SOPAS ET, we recommend using port 2122 or port 80 in SOPAS ET. When using the aforementioned ports, no limitation with regard to SOPASair can be expected.
>
> If a legacy protocol (CoLa A/B) is used on the ports 2111 and 2112, however, functional limitations in the SOPAS ET interface may arise.

The most up-to-date version of the SOPAS ET software can be downloaded from **www.sick.com/software**, category: **Configuration software**, software type: **SOPAS ET**.

7.2.1 Operation with SOPAS ET

Version 3.3.3 and higher of the SOPAS Engineering Tool (SOPAS ET) software can be used to parameterization of the device and for service and diagnostic purposes.

To configure the device, you will require a computer with SOPAS ET installed and a free Ethernet connection. Alternatively, the connection can be established via a USB connection using an Ethernet USB adapter.

1. Connect the communication interface (Ethernet, 4-pin M12 female connector) of the device to the computer.
2. Switch on and start the computer.
3. Supply the device with voltage (5-pin M12 male connector, supply voltage 9 … 30 V DC).
✓ After successful initialization, the two status LEDs light up green. The device is ready for use.

> ℹ️ **NOTE**
>
> To use SOPAS ET with the device, you need a device description file (SDD, SOPAS Device Description) for this device. You can install this within SOPAS ET using the device catalog. The device description file is saved on the device and can be installed there. Alternatively, installation is possible from the SICK website (Internet connection required).

Following installation of the device description file, the device can be selected from the device catalog and added to a project.

A connection to the device is established via the communication interface. The connection must be activated for data transmission (**online**).

Certain functions (e.g., Edit parameters) require you to be logged in to the device (**Device > Log In** menu, **User Level**: Authorized customer, **Password** (factory default): client).

Table 12: Keywords for factory setting

User levels	Keyword according to factory setting
Maintenance personnel	main

User levels	Keyword according to factory setting
Authorized client	client
Service	servicelevel

> **NOTE**
>
> Change the passwords during initial commissioning to protect your device.
>
> A higher user level can change the password of a lower user level.

Information about the device is displayed in the device window and the device can also be configured here (**Device**> **Open** menu).

Resetting the password

> **NOTE**
>
> The responsible SICK sales company or the responsible SICK service partner carefully checks each code request to reset the password. A risk of deception by third parties nevertheless exists. The operating entity should therefore take suitable security measures.
>
> The operating entity should also take suitable measures to limit, as best as possible, access to the product. This includes, in particular, physical access as well as access to the software interfaces of the product.

Resetting the password for the Service user

1. Click on the 👤 button.
✓ The **Log in to device** input screen opens.
2. Click on **Password forgotten?**.

Resetting the password for the Authorized client/Maintenance personnel user

1. The password for the **Service** user has been reset.
2. Save the device parameterization using the parameter export (**Device** menu > **Export** > **To a file**).
3. In the device window, click on the ⋮ button.
4. Select **Reset to factory settings**.

8 Maintenance

8.1 Maintenance plan

During operation, the device works maintenance-free.

> **NOTE**
> No maintenance is required to ensure compliance with the laser class.

Depending on the assignment location, the following preventive maintenance tasks may be required for the device at regular intervals:

Table 13: Maintenance plan

Maintenance work	Interval	To be carried out by
Check device and connecting cables for damage at regular intervals.	Depends on ambient conditions and climate.	Specialist
Clean housing.	Depends on ambient conditions and climate.	Specialist
Clean housing and optics cover.	Depends on ambient conditions and climate.	Specialist
Check the screw connections and plug connectors.	Depends on the place of use, ambient conditions or operating requirements. Recommended: At least every 6 months.	Specialist
Check the mounting accessories and vibration dampers used.	Depends on the place of use, ambient conditions or operating requirements. Recommended: At least every 6 months.	Specialist

8.2 Cleaning

> **!** **NOTICE**
> **Equipment damage due to improper cleaning.**
> Improper cleaning may result in equipment damage.
> - Only use recommended cleaning agents and tools.
> - Never use sharp objects for cleaning.

▶ Clean the optics cover at regular intervals and in the event of contamination with a lint-free lens cloth and plastic cleaning agent. Rinse off coarse dirt first with water. The cleaning interval essentially depends on the ambient conditions.

> **!** **NOTICE**
> If the optics cover is scratched or damaged (cracked, broken), it must be replaced. Contact SICK Support to arrange this.
> - If the optics cover is cracked or broken, take the device out of operation immediately for safety reasons and have it repaired by SICK.

9 Troubleshooting

9.1 General faults, warnings, and errors

Possible faults and corrective actions are described in the table below for troubleshooting. For faults that cannot be rectified using the information below, please contact SICK Service. To find your agency, see the final page of this document.

> **NOTE**
> Before calling, make a note of all type label data such as type designation, serial number, etc., to ensure faster assistance.

Table 14: Troubleshooting questions and replies

Question / status	Response / remedial actions
Both LEDs flash red.	Device error: Read the error code via the SOPAS ET PC software and remedy the cause of the error.
LEDs indicate an undefined status.	Check the device status, if necessary contact the SICK Service department.
All LEDs are off	Check the voltage supply to the device. In SOPASair, check whether the LEDs were switched off.
All LEDs of the device light up red at startup and do not change to green.	Check the voltage supply to the device. The power supply unit may not be supplying the required current or the required voltage to start the device.
All LEDs of the device flash red.	The device may not be able to recognize the system plug. Check that the system plug is mounted correctly and that both contact sides are clean and dry.
Measurement data show anomalies.	Optics cover contaminated: Clean the optics cover.
When accessing the device via a web browser, the SOPASair user interface is not loaded, the SOPASair loading screen is permanently displayed.	Try connecting again. If this does not work: Restart the device.
SOPASair is not started in the browser.	Check the IP address of device and network adapter (e.g., using device search in SOPAS ET) and adjust if necessary. Then try to establish the connection again.
No connection to the device possible.	Check whether the system plug is securely mounted see "Mounting the system plug on the device", page 39.

9.2 Repairs

Repair work on the device may only be performed by qualified and authorized personnel from SICK AG. Interruptions or modifications to the device by the customer will invalidate any warranty claims against SICK AG.

9.3 Returns

► Only send in devices after consulting with SICK Service.
► The device must be sent in the original packaging or an equivalent padded packaging.

> **NOTE**
> To enable efficient processing and allow us to determine the cause quickly, please include the following when making a return:
>
> - Details of the contact person
> - Description of the application
> - Description of the fault that occurred

9.4 Disposal

If a device can no longer be used, dispose of it in an environmentally friendly manner in accordance with the applicable country-specific waste disposal regulations. Do not dispose of the product along with household waste.

> **!** **NOTICE**
> **Danger to the environment due to improper disposal of the device.**
> Disposing of devices improperly may cause damage to the environment.
> Therefore, observe the following information:
>
> - Always observe the national regulations on environmental protection.
> - Separate the recyclable materials by type and place them in recycling containers.

10 Technical data

> **i** **NOTE**
> The relevant online product page for your product, including technical data, dimensional drawing, and connection diagrams, can be downloaded, saved, and printed from the Internet.
>
> The page can be accessed via the **SICK Product ID: pid.sick.com/{P/N}/{S/N}**
>
> {P/N} corresponds to the part number of the product, see type label.
>
> {S/N} corresponds to the serial number of the product, see type label (if indicated).
>
> Please note: This documentation may contain further technical data.

10.1 Features

Measurement principle	Statistical measurement procedure
Application	Indoor and outdoor
Light source	Infrared (wavelength 850 nm)
Laser class	Laser class 1 (EN 60825-1:2014+A11:2021, IEC 60825-1:2014, EN/IEC 60825-1:2007) Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3 as described in Laser Notice No. 56, dated May 8, 2019.
Horizontal aperture angle	360°
Vertical aperture angle	65° (+22.5° to -42.5°, DIN ISO 8855)
Scan field flatness	High-resolution scan layer (0°): ± 0.5° Other 15 scan layers: ± 0.6°
Scanning frequency	20 Hz
Angular resolution	Horizontal: 0.125° (2 high resolution scan layers) & 1° (14 scan layers) Vertical: approx. 2.5° and 5° see "Scan layer address", page 25. Note: The actual position of a scan layer may differ. The exact actual vertical angle value of each scan layer can be read from the device.
Working range	0.05 m ≤ x ≤ 60 m [1]
Scanning range for 10% remission	10 m @ 100 kLux 12 m @ 10 kLux
Scanning range for 90% remission	15 m @ 100 kLux 30 m @ 10 kLux
Spot divergence	5.3 mrad x (5.3 mrad + 2.2 mrad); 0.3° x (0.3° + 0.125°)
Light spot size at front screen	13 mm
Number of echoes evaluated	3

[1] Specified measurement accuracy for ≥ 0.1 m

Working range diagram
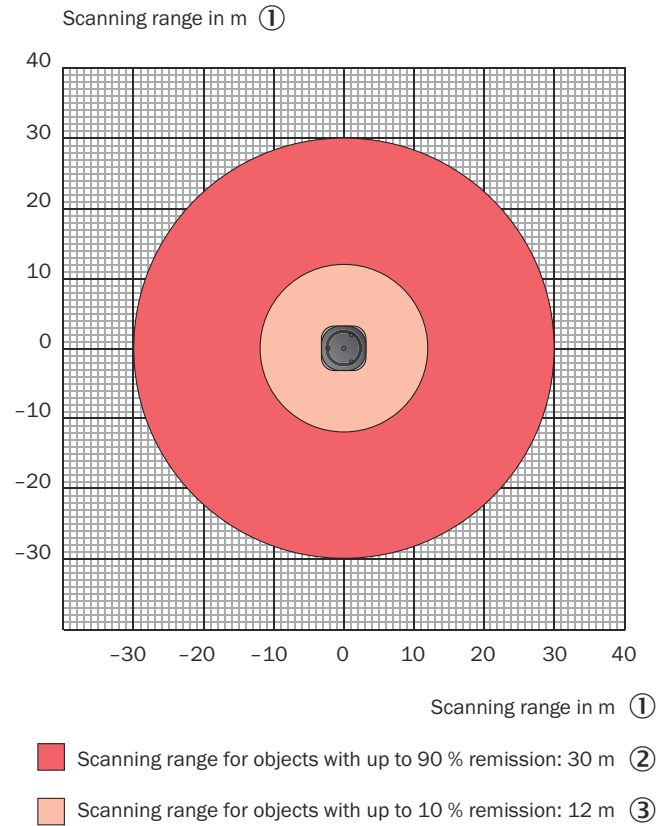

Figure 40: Diagram of the working range (10 kLux), top view

①   Scanning range in m
②   Scanning range for object with up to 90 % remission: 30 m
③   Scanning range for object with up to 10 % remission: 12 m
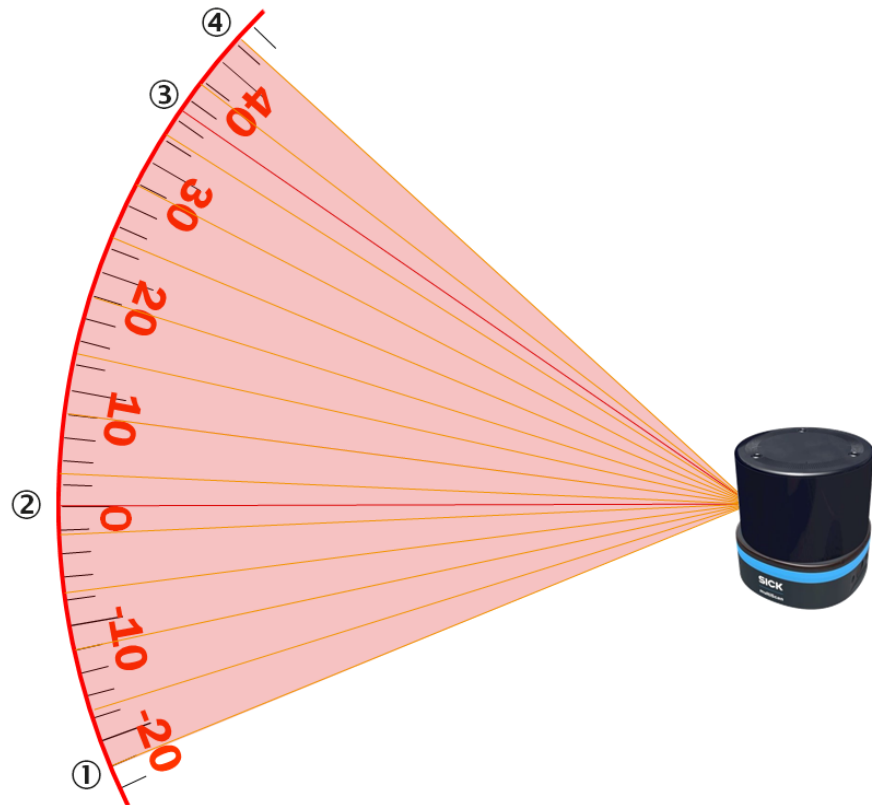
Figure 41: Positions of the 16 scan layers, side view

①   Scan layer 1

②   Scan layer 6 (high resolution)

③   Scan layer 14 (high resolution)

④   Scan layer 16

10.2   Mechanics/Electronics

Connection type	2 x M12 round connectors
Supply voltage	9 V DC … 30 V DC
Permissible residual ripple	± 5%
Power consumption	P_{typ} = 10 W P_{start} = 35 W for 5 s (motor start-up) P_{max} = 22 W (with full specified current at all outputs)
Housing	ALSi12 Optics cover: polycarbonate
Housing color	Grey (RAL 7016)
Enclosure rating	IP65 / IP67 / IP69 (IEC 60529:1989+AMD1:1999+AMD2:2013) IPX9K (ISO 20653:2013) Test conditions: • Water spray volume: 14 l/min … 16 l/min • Water pressure/temperature: 10000 KPa (100 bar) / 80 °C • Flat jet nozzle distance: 100 mm … 150 mm • Spray angle: 0°, 30°, 60°, 90° • Cycle: 30 seconds per position • Rotational speed of test specimen: 5 rpm

Protection class	III (IEC 61140:2016-11)
Electrical safety	IEC 61010-1:2010-06
Weight	0.7 kg
Dimensions (L x W x H)	100.3 mm x 100.3 mm x 98.5 mm
Maximum output current	Depends on the number of outputs used/parameterized. 100 mA per channel when using 4 outputs, 200 mA per channel for 2 outputs, 50 mA per channel for 8 outputs.

10.3 Dimensional drawing
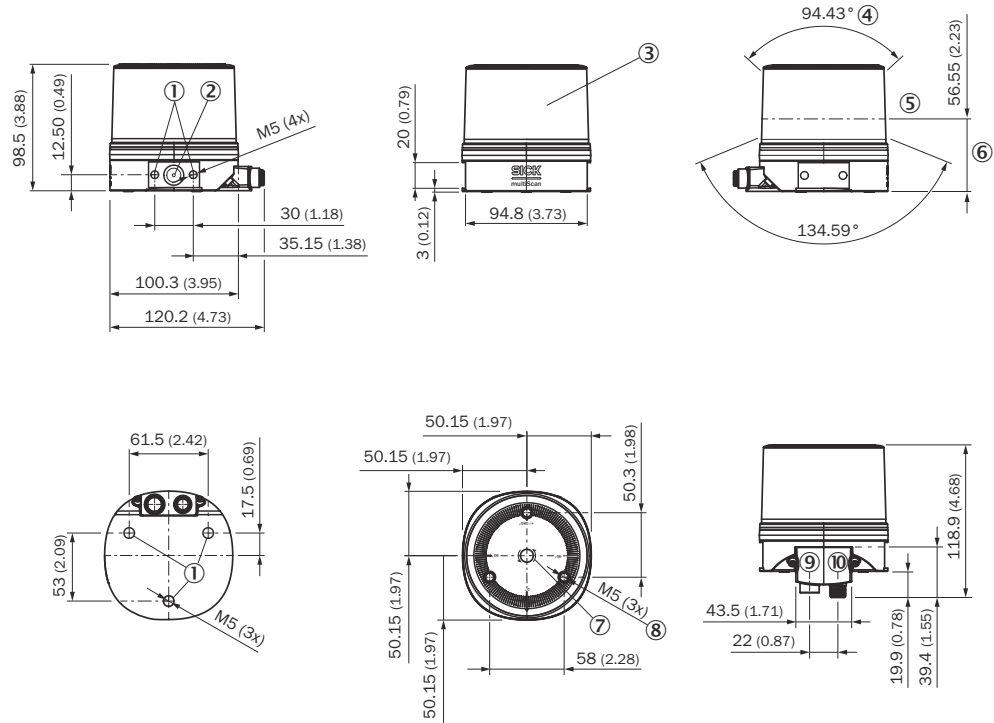
Figure 42: Device structure and dimensions, dimensions in mm (inch)

① M5x7.5 fixing holes for mounting the device

② Ventilation element (membrane)

③ Optics cover

④ Aperture angle (vertical field of vision)

⑤ Visual zero position with maximum viewing range

⑥ Dimension referenced to the flat floor, not to the support surfaces on the attachment points. These set the device 0.5 mm higher.

⑦ Direction of rotation

⑧ M5x7.5 fixing holes for accessories only

⑨ Supply voltage connection

⑩ Ethernet connection

10.4 Performance

Measurement data rate	216000 … 648000 measuring points/second
Scanning frequency	20 Hz
Frame rate per frame	≤ 50 ms
Frame rate per segment	< 5 ms

Systematic error	± 50 mm; reflector: - 80 to + 50 mm Temperature drift: Typically ± 0.5 mm/K
Statistical error	≤ 20 mm
Integrated application	Date output, integrated field evaluation with flexible fields
Number of configured fields	Up to 48 fields
Simultaneous evaluation cases	Up to 20 evaluations
Filters	Fog filter, echo filter, particle filter, moving average filter, interval filter, scan range filter, scan layer filter, cuboid area filter, distance filter

10.5 Interfaces

Ethernet	✓, TCP/IP, UDP/IP Function: HOST, NTP, PTP Measured data output (distance, RSSI) Data transmission rate: 100 Mbit/s
Digital inputs/outputs	I/O (8 multiports) depending on the mounted system plug
Measurement data output format	MSGPACK, Compact
Output data	Contamination indication, IMU (secondary sensor data)
IMU (inertial measuring unit)	Sampling rate: 100 Hz **Relative position of the IMU to the optical origin:** • X: -17 mm • Y: +23.5 mm • Z: -28.1 mm
Optical displays	4 LEDs
Configuration software	SOPASair, SOPAS ET

10.6 Ambient data

Remission factor	2 % ... > 1,000% (reflector)
Electromagnetic compatibility (EMC)	EN 61000-6-2:2005 EN 61000-6-3:2007+A1:2011
Vibration resistance	Sine resonance scan: 10 Hz ... 1,000 Hz (IEC 60068-2-6:2007) Sine test: 10 Hz ... 500 Hz; 0.35 mm/5 g; 10 cycles (IEC 60068-2-6:2007) Noise test: 10 Hz ... 250 Hz; 4.24 g RMS, 5 h (IEC 60068-2-64:2008)
Shock resistance	IEC 60068-2-27:2008 50 g, 11 ms, ± 3 single shocks/axis 25 g, 6 ms, ± 1,000 continuous shocks/axis 50 g, 3 ms, ± 5,000 continuous shocks/axis
Ambient operating temperature	- 30 °C ... + 50 °C
Storage temperature	- 40 °C ... + 70 °C
Operating and storage air humidity	Max 90 % air humidity (non-condensing)
Ambient light immunity	100 klx

11   Accessories

ⓘ **NOTE**
On the product page you will find accessories and, if applicable, related installation information for your product.

The page can be accessed via the **SICK Product ID: pid.sick.com**/{P/N}/{S/N}

{P/N} corresponds to the part number of the product, see type label.

{S/N} corresponds to the serial number of the product, see type label (if indicated).

Support Portal

ⓘ **NOTE**
In the SICK Support Portal (supportportal.sick.com, registration required) you will find not only useful service and support information for your product as well as commands for test purposes via the REST communication interface, but also the Cybersecurity Hardening Guide as well as further detailed information on the available accessories and their use.

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12 Annex

12.1 Declarations of conformity and certificates

You can download declarations of conformity and certificates via the product page.

The page can be accessed via the **SICK Product ID: pid.sick.com**/{P/N}/{S/N}

{P/N} corresponds to the part number of the product, see type label.

{S/N} corresponds to the serial number of the product, see type label (if indicated).

12.2 Licenses

SICK uses open source software which is published by the rights holders under a free license. Among others, the following license types are used: GNU General Public License (GPL version 2, GPL version 3), GNU Lesser General Public License (LGPL), MIT license, zlib license and licenses derived from the BSD license.

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More details can be found in the GNU General Public License.

For license texts see www.sick.com/licensetexts.

Printed copies of the license texts are also available on request.

12.3 Communication interfaces

Communication with the device is possible via CoLa A/B and REST. More information is available in the telegram listing www.sick.com/8014631.

Under Downloads on the product page, you can download, for example, the Open API file.

The page can be accessed via the **SICK Product ID: pid.sick.com**/{P/N}/{S/N}

{P/N} corresponds to the part number of the product, see type label.

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