OPERATING INSTRUCTIONS

safe Brake Assist

Safety System

SICK
Sensor Intelligence.

Described product

safe Brake Assist

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

Read these operating instructions carefully before starting any work in order to familiarize yourself with the product and its functions.

The operating instructions are an integral part of the product and should remain accessible to the personnel at all times. When handing this product over to a third party, include these operating instructions.

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

1.2 Target group

This document is intended for persons who project plan, install, commission, operate and maintain the product.

1.3 Further information

You can find the product page with further information via the SICK Product ID:
pid.sick.com/{P/N}/{S/N}
(see "Product identification via the SICK product ID", page 11).

The following information is available depending on the product:

- This document in all available language versions
- Data sheets
- Other publications
- CAD files and dimensional drawings
- Certificates (e.g., declaration of conformity)
- Software
- Accessories

1.4 Related applicable documents

Related applicable documents from SICK

Document	Title	Part number
Operating instructions	multiScan136	8027118

Related applicable documents from other manufacturers

Document	Title	Part number	Source
Manual	Orion-Tr DC-DC converters, isolated	–	https://www.victronenergy.com/upload/documents/Manual-Orion-Tr-isolated-DC-DC-converters-EN-FR-NL-ES-IT-DE-.pdf
User manual	Mobile Computing Solutions Artificial Intelligent Platform ATC 3530	–	https://www.nexcom.com/Products/mobile-computing-solutions/ai-edge-telematics-solution/nvidia-solution/advanced-telematics-computer-atc-3540-ip7-4c

1.5 Symbols and document conventions

Warnings and other notes

DANGER
Indicates a situation presenting imminent danger, which will lead to death or serious injuries if not prevented.

WARNING
Indicates a situation presenting possible danger, which may lead to death or serious injuries if not prevented.

CAUTION
Indicates a situation presenting possible danger, which may lead to moderate or minor injuries if not prevented.

NOTICE
Indicates a situation presenting possible danger, which may lead to property damage if not prevented.

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

Instructions to action

► The arrow denotes instructions to action.

1. The sequence of instructions is numbered.
2. Follow the order in which the numbered instructions are given.

✓ The tick denotes the results of an action.

2 Safety information

2.1 Basic safety notes

Integrating the product

The information and tools will not fulfill the safety requirements for your application without further adjustments being made! The project planning provided by way of example is intended to serve as the basis for performing your specific project planning. Some adjustments must also be made by SICK. You will receive configuration files from SICK for custom parameterization of your machine data (geometry and user data). Please contact your internal sales department.

When it comes to your own project planning, you will need to rely on qualified staff given that it is your responsibility to ensure that the following requirements are complied with at the very least:

- ► Carry out a risk assessment.
- ► Take applicable standards into account.
- ► Verify and validate the safety functions.

Laser notes

CAUTION
Optical radiation: Class 1 Laser Product

Caution - if any operating or calibrating equipment other than those specified here are used or other methods are employed, this can lead to dangerous exposure to radiation.

- ► Use only the tools and auxiliary equipment specified in this documentation.
- ► Only carry out the procedures specified in this documentation.
- ► Do not open the housing unless carrying out the mounting and maintenance operations provided in this documentation. Opening the housing will not switch off the laser. Opening the housing may increase the level of risk.

Mounting and electrical installation

DANGER
Death or severe injury due to electrical voltage and/or an unexpected startup of the machine

- ► Make sure that the machine is (and remains) disconnected from the voltage supply during mounting and electrical installation.
- ► Make sure that the dangerous state of the machine is and remains switched off.

Repairs and modifications

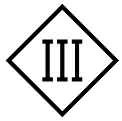
DANGER
Improper work on the product

A modified product may not offer the expected protection if it is integrated incorrectly.

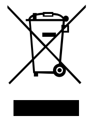
- ► Apart from the procedures described in this document, do not repair, open, manipulate or otherwise modify the product.

2.2 Warnings on the industrial PC

DC – The safety system is operated with DC voltage


Electrical protection class 3


Warning! Please read the operating instructions!


WEEE mark of conformity – devices must not be disposed of with household waste.

2.3 Intended use

The Safe Brake Assist safety system is used on mobile machines to protect people. The safety system is suitable for the following applications:

- Mobile hazardous area protection
- Active collision avoidance

The safety system detects objects in the travel path (movement corridor of the mobile machine). The distance to the nearest object is provided via a safe signal. This signal can be used for safety functions. The integrator is responsible for implementing the safety functions.

The product must only be used within the limits of the prescribed and specified technical specifications and operating conditions at all times.

Incorrect use, improper modification or manipulation of the product will invalidate any warranty from SICK; in addition, any responsibility and liability of SICK for damage and secondary damage caused by this is excluded.

2.4 Improper use

Impermissible use

- As a physical guard. The product works as an indirect protective measure and cannot provide protection from parts thrown from the application nor from emitted radiation.
- Detection of small persons, e.g. children (< 1 m)
- Detection of persons in a lying position
- Detection of vehicles in regular road traffic (e.g., when entering and exiting a construction site).
- In the aerospace industry
- In road-approved vehicles (e.g. passenger cars)

Impermissible ambient conditions

- Underwater
- corrosive environment
- explosion-hazardous areas

2.5 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)

Secure authentication

Secure authentication when updating the IPC software is performed using SSH public and private keys. These are delivered with the system image and are automatically used by the update script.

2.6 Limitation of liability

Applicable standards and regulations, the latest technological developments, and our many years of knowledge and experience have all been taken into account when assembling the data and information contained in this document.

The manufacturer accepts no liability for damage caused by:

- Failure to observe this document.
- Non-compliance with notes and regulations.
- Unauthorized mounting and installation.
- Unauthorized technical and other changes.
- Use of unauthorized spare parts, wear and tear parts, and accessories.
- Unauthorized changes, adjustments, and/or manipulations of software.

The actual scope of delivery may differ from the features and illustrations shown here where special variants are involved, if optional extras have been ordered, or as a result of the latest technical changes.

2.7 Qualification of personnel

Any work on the product may only be carried out by personnel qualified and authorized to do so.

Qualified personnel are able to perform tasks assigned to them and can independently recognize and avoid any potential hazards. This requires, for example:

- technical training
- experience
- knowledge of the applicable regulations and standards

2.8 Normative references

The safety system meets the requirements of the following standards:

- EN ISO 13849-1 Safety-related parts of control systems – Part 1: General principles for design
- IEC TS 62998-1 – Safety of machinery – Safety-related sensors
- EN 60204-1, Safety of machinery – Electrical equipment of machines
- IEC 60825-1 – Safety of laser products – Part 1: Equipment classification and requirements
- DIN EN 60529 – Degrees of protection provided by enclosures (IP Code)
- ISO 13766-2 – Electromagnetic compatibility of machines with internal electrical power supply – Part 2: Additional EMC requirements for functional safety

3 Product description

3.1 Ordering information for the safety system

Table 1: Ordering information for the safety system

Component	Quantity	Description	Part number
multiScan 136	2 ×	3D LiDAR sensor, variant for this safety system	On request
Application Processing Unit APU	1 ×	Industrial PC for data processing	On request
DC-DC transducer	2 ×	Voltage converter for on-board power supply	On request
Ethernet cable	2 ×	Data cable - sensors to IPC	On request

3.2 Product identification

3.2.1 Product identification via the SICK product ID

SICK product ID

The SICK product ID uniquely identifies the product. It also serves as the address of the web page with information on the product.

The SICK product ID comprises the host name pid.sick.com, the part number (P/N), and the serial number (S/N), each separated by a forward slash.

The SICK product ID is displayed as text and QR code on the type label and/or on the packaging.

Figure 1: SICK product ID

3.3 Design and function

Design

The following elements work together:

- 2 × 3D LiDAR sensor
- Industrial PC (IPC)
- Interface of the mobile machine
- 2 × DC-DC voltage converter

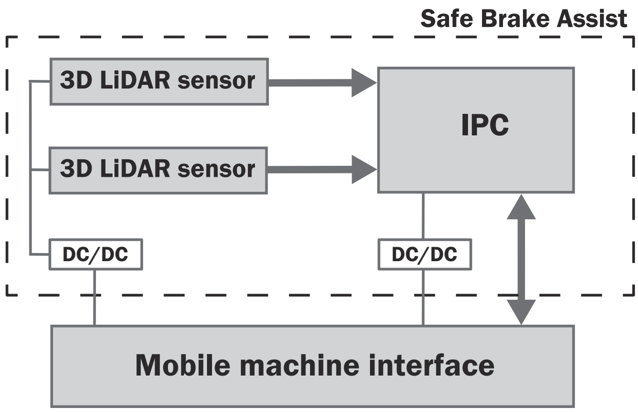


Figure 2: Design

The 3D LiDAR sensors are mounted at an angle on the mobile machine so that the areas in front of and behind the mobile machine are covered by the detection zone.

Function

The industrial PC calculates the current travel path of the mobile machine, e.g., using the steering angle.

The sensors monitor the area around the mobile machine and measure the distance to detected objects.

When a sensor detects an object, the industrial PC calculates whether the object is in the travel path. If yes, the distance until collision with the object is calculated. This information is provided as a safe signal via CAN to the interface of the mobile machine.

Figure 3: How distance measurement and collision avoidance works – example for road roller

Safety functions

- Detection of objects in the travel path (see table 3, page 18)
- Continuous output of the distance to the next detected object in the travel path

The information about the distance to the next detected object in the travel path is output via CAN. The signal can be used for safety functions, e.g., stopping the vehicle.

3.4 Product characteristics

3.4.1 Requirements on the application

Suitable mobile machines

General requirements

- The mobile machine must not be autonomous. A person must control the machine.
- The mobile machine moves in an environment in which all objects move at a relatively slow speed, e.g., construction site or closed highway. Safe detection of fast objects is not possible, e.g. road-approved vehicles.
- Only the standard rear-view mirrors are within the detection zone of the sensors. Other shiny or reflective attachments or objects impair the detection capability.

Further topics

- "General requirements on integration", page 16

3.4.2 System states

System states

System status	Description	DistanceToCollision signal...		Error code message to ErrorCode signal...	
		...Front	...Rear	...Front	...Rear
1	Normal operation	1 ... 32000		No	No
2	Error condition	0	1 ... 32000	Yes	No
		1 ... 32000	0	No	Yes
		0	0	Yes	Yes

System status changes

Change to system status 1
- After switching on
- After clearing all errors

Change to system status 2
- After an error occurs

Further topics

- see "CAN interface", page 25

3.4.3 How the sensors work

Measurement principle

The 3D LiDAR sensors scan the environment horizontally in a 360° radius. Vertical detection occurs on 16 scan planes from +22.5° ... -42.5° (vertical aperture angle 65°).

2 of the 16 scan layers have a high resolution.

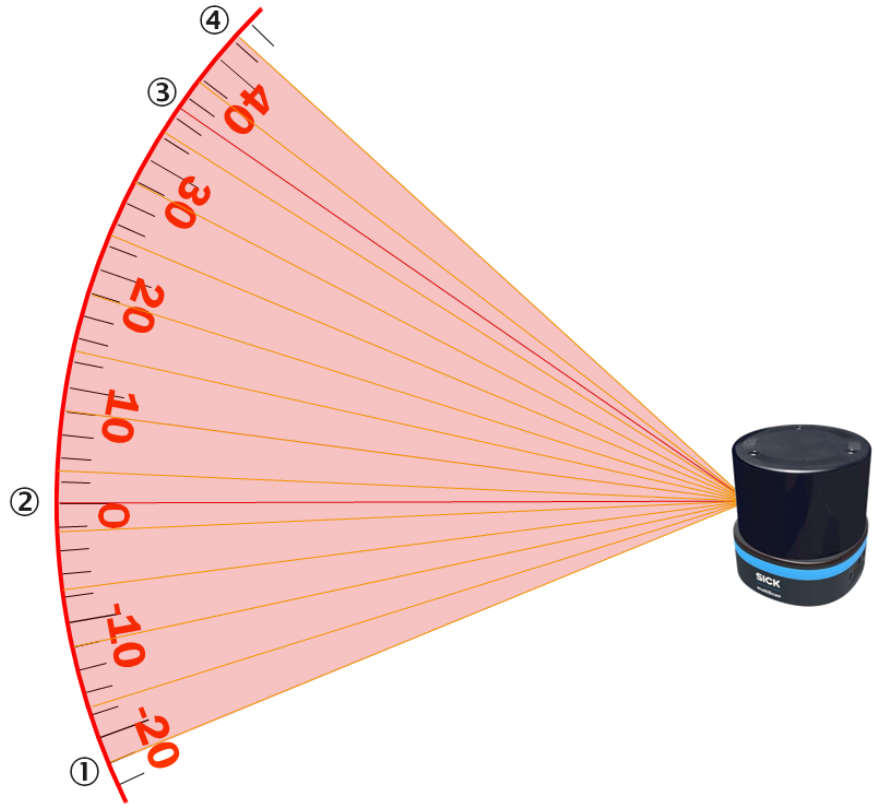


Figure 4: Positions of the 16 scan layers, side view

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

Ranging

The 3D LiDAR sensors emit pulsed beams from a laser diode. When the laser beam is reflected by an object, the reflected beam is received by the 3D LiDAR sensors. The distance to the object is calculated based on the time it takes for the pulsed light beam to be reflected and received by the sensor (time-of-flight measurement).

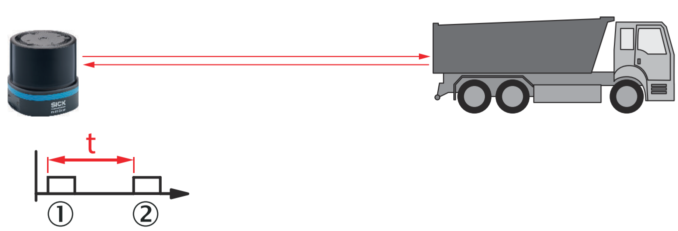


Figure 5: 3D LiDAR sensor

① Emitted pulse
② Receive pulse

The device uses a measurement technology developed by SICK. With this measuring method, a measured value is obtained by statistical evaluation of several individual pulses. The multi-pulse function evaluates up to 691,200 echoes per second. Each individual measured value that is output therefore provides even more information as it is not only made up of a single time-of-flight measurement, but also contains the evaluated information from numerous pulses. The digitized echoes are compiled into data packets that overlap during evaluation. This ensures a much more stable time and distance measurement.

4 Project planning

4.1 Manufacturer of the overall system

The safety system was developed under consideration of typical application cases. A partial safety function can be implemented with the safety system in these application cases. The manufacturer must check whether the safety system is suitable for its specific application case (risk assessment according to ISO 12100). Further protective measures may be required in addition to the safety system.

If the thorough check shows that the safety system is not suitable for the specific application case, the safety system can be used as a basis for an individualized development suitable for the specific application case. This case will not be considered further in this document.

In any event, additional work is necessary for the safety system to be used, e.g. subsequent configuration of the safety controller.

The manufacturer has the following duties:

- ► Executing a risk assessment.
- ► Verifying and validating the safety functions.
- ► Integrating the individual components in accordance with the appropriate standards.
- ► Please note that C standards have priority compared to statements about this safety system.

4.2 Operating entity of the overall system

Changes to the electrical integration of the safety system in the machine control and changes to the mechanical mounting of the safety system necessitate a new risk assessment. The results of this risk assessment may require the entity operating the machine to meet the obligations of a manufacturer.

Changes to the safety system's configuration may impair the protective function. The effectiveness of the safety system must be checked after any change to the configuration. The person carrying out the change is also responsible for maintaining the protective function of the safety system.

4.3 General requirements on integration

Table 2: General requirements on integration

No.	Requirement
1	The operator still retains control over the movement of the mobile machine. The operator is responsible for actively avoiding collisions during normal operation.
2	The operator must be able to deactivate the collision avoidance assistance system at any time, e.g., via a pushbutton or touchscreen.
3	The integrator must take measures to ensure that an operator is present on the mobile machine.
4	The integrator is responsible for implementing the safety function (i.e. brake application). The safety system only calculates and transmits the distance to the next detected object.

No.	Requirement
5	The information on the response time in this document only takes into account the response time of the safety system. The integrator must take the entire stopping time of the mobile machine into account. The stopping time is the sum of all response times of the components in the safety chain, including the braking time until complete standstill. The manufacturer of the mobile machine must provide the integrator with the process safety time for the overall system/brake application.
6	The integrator must ensure that manual deactivation of the safety system is logged (black box). The time of deactivation must be logged.
7	The integrator must ensure that any deactivation of the collision avoidance assistance system by the operator is logged (black box). This applies both to targeted manual deactivation of the function and overriding of the function by other inputs, such as accelerating.
8	The safety controller of the mobile machine must provide the input signals for the safety system via CAN and accept the output signals via CAN. Specifications (see "CAN interface", page 25)
9	The safety controller of the mobile machine must control the safety system via a watchdog. A failure of the safety system or a fault must initiate a defined state.
10	The integrator must ensure that the correct initialization of the safety system is monitored for a defined time window during each start-up. This ensures correct synchronization between the safety system and the safety controller of the mobile machine.
11	The integrator must ensure that the information and error codes of the safety system are evaluated by the safety controller of the mobile machine. Depending on the output of the safety system, a defined state must be initiated. (see "Error codes", page 42)
12	The integrator must implement plausibility checks for the following data of the safety controller of the mobile machine: • Speed of the mobile machine • Steering angle • Direction of travel • Information on attachments
13	The integrator must ensure that the operator is informed when “reduced availability mode” is activated. (see "“Reduced availability” mode", page 18)

4.4 Undetected errors and faults

WARNING
Risk of ineffectiveness of the protective device!

Undetected errors and faults can cause impairment, reduction or complete loss of detection capability, such that the safety system is no longer able to perform the safety function.

The safety system will not detect the following errors and faults, among others:

- 3D-LiDAR sensor: Failure of diagnostic LEDs
- IPC: Failure of diagnostic LEDs
- 3D-LiDAR sensor: Contamination of the optics and/or front screen. Consequence: Detection capability is impaired, reduced or completely lost. The safety system can no longer perform the safety function.
- Ambient light outside the operating range: Malfunctions due to interference from other sensors and light sources within the detection zone. Consequence: Detection capability is impaired, reduced or completely lost. The safety system can no longer perform the safety function.

4.5 Design

4.5.1 Detection zone depending on the application

The detection zone depends on the particular machine and mounting position of the 3D LiDAR sensors. This must be taken into account as part of the risk assessment. In the following sections, the factors relevant for integration are explained using the example of a road roller.

4.5.2 Detection capability

Whether an object is reliably detected depends on various factors, e.g., size, shape, remission factor or speed of the object.

Table 3: Tested object sizes for safe detection

Simulated object	Length	Width	Height	Remission factor at 850 nm	Maximum speed[1]
Kneeling person	Diameter: 190 mm		1,139 mm	6 %	1.6 m/s
Machine	2,200 mm	800 mm	460 mm	10 %	5.6 m/s
Infrastructure 1	4,000 mm	300 mm	750 mm	10 %	0 m/s
Infrastructure 2	200 mm	200 mm	1,000 mm	10 %	0 m/s

1) The objects are not blanked out at higher speeds. Detection is not assured, however. The safety system was developed to support the operator in critical scenarios on the construction site where vehicles are moving at slow speeds.

4.5.2.1 Detection capability limits

Detection on edges or corners

The detection capability can be impaired by objects with edges and/or corners. This can lead to incorrect distance values being determined. As a result, the detection capability may be impaired, reduced or completely lost, so that the safety system can no longer fulfill its function.

Detection of vegetation

Vegetation such as hanging branches or tall grass inside the travel path can lead to false positive detections (availability problem).

Fog filter

The safety system is equipped with a fog filter to prevent false positive detections for steam caused by rain or spray on hot asphalt or heavy fog. This groups related objects and classifies them as valid objects or as fog. Objects classified as fog are ignored. The algorithm of the fog filter is based on an AI.

WARNING
Dark objects with a very low remission factor can lead to incorrect classification. In this case, the collision distance is not output, even though there is an object in the travel path.

“Reduced availability” mode

As soon as the fog filter classifies too many objects as fog due to excessive vapor formation, the safety system activates “Reduced availability” mode. This status is signaled as an error code in the CAN output data for both directions of travel (eReducedAvailability). In this case, the detection capability is no longer assured. The safety system continues to output distances.

The integrator must decide how the overall system should behave when the safety system switches to “Reduced availability” mode. The overall system must either automatically deactivate the collision avoidance function or leave the decision to the operator. In the latter case, the operator must be informed by the system that “Reduced availability” mode is active.

NOTE

If steam or mist arises suddenly, there may be a delay before “Reduced availability” mode is activated. This leads to unnecessary braking processes, as a lot of vapor and fog leads to an increased number of false positive classifications of objects. This is an availability problem.

The integrator should ensure that the operators are informed about the possibility of delayed activation. SICK recommends manually deactivating the collision avoidance function in the event of sudden vapor or fog formation.

Lateral entry of dynamic objects into the travel path

No analysis of the trajectory of objects is performed. If dynamic objects (e.g. people walking) enter the travel path laterally, the distance that is output can change arbitrarily quickly. This means that it may not be possible to apply the brakes in time.

Measurement on reflectors

When using reflectors as the target, the statistical and systematic measurement accuracy diminishes at lower temperatures and therefore also the detection capability of the sensor.

Example: Turning on a highway or road in the direction of oncoming traffic

When turning the machine on a closed highway or a road in the direction of oncoming traffic, the safety-related detection capability may be impaired or reduced. In this case, the driver is fully responsible for ensuring the safe turning or braking of the machine. Collisions with cross traffic are not prevented by the system; the driver is fully responsible for this at all times (including when the detection field in the travel path is directed towards cross traffic when turning the machine).

4.5.3 Blind zones

Blind zones

Blind zones depend on the following factors:

- Position of the 3D LiDAR sensors
- The machine cladding and attachments lead to blind zones, especially in the vicinity of the machine.
- The available adjustment range of the rear-view mirrors in both directions of travel is blanked out. The blanking occurs regardless of the actual position of the mirrors.
- Depending on the attached chip spreader, part of the travel path is obstructed in the reverse direction.

Objects that enter a blind zone due to the movement of the machine are still taken into account for a certain period of time and an output signal is generated. If the object moves into the blind zone while the machine is stationary, no distance to the collision is output.

4.5.4 Safety zone - forward

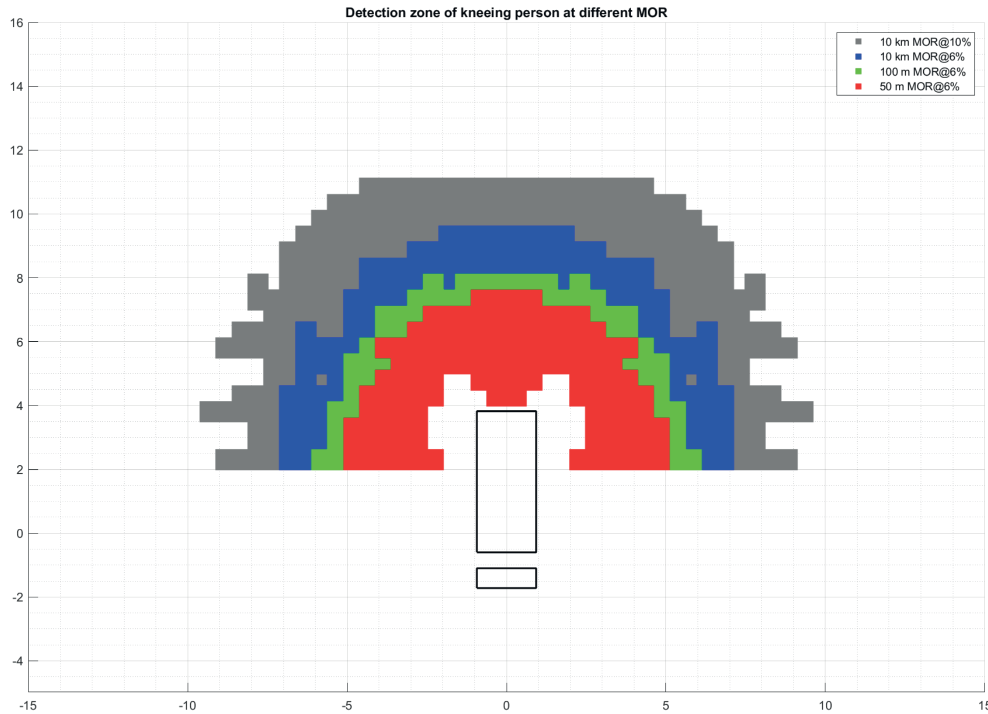


Figure 6: Safety zone - forward direction of travel

4.5.5 Safety zone - reverse

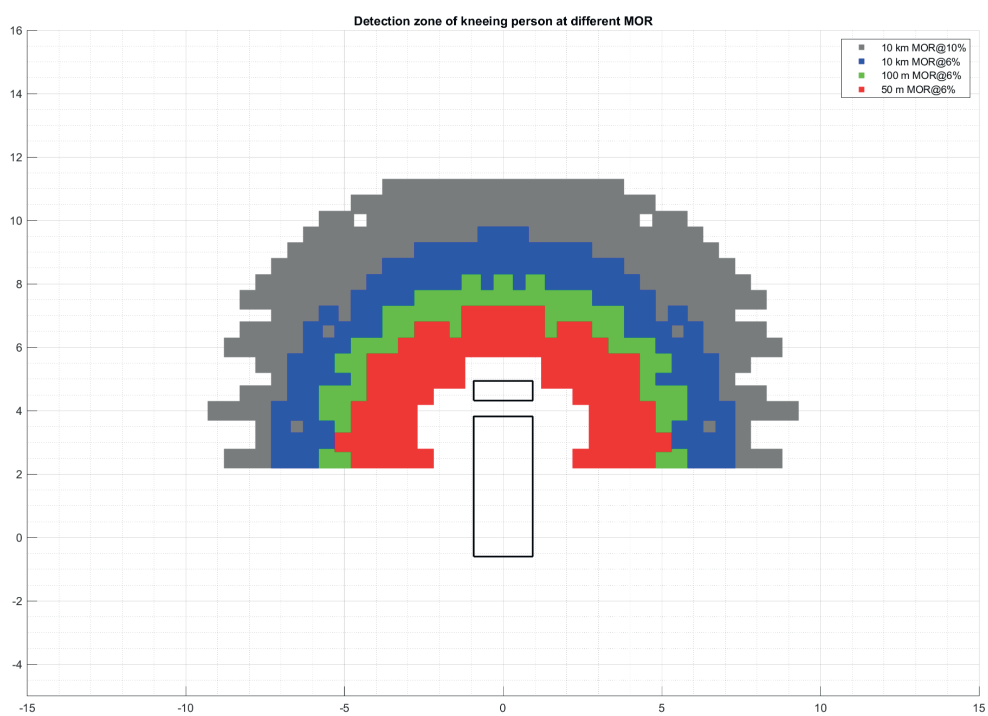


Figure 7: Safety zone - reverse direction of travel with chip spreader

4.5.6 Travel path and critical outline

The travel path is the area in which the movement of the mobile machine can lead to collisions with objects. The safety system only determines the distance to the collision if objects are detected inside the travel path. The travel path is calculated automatically.

The critical outline of the mobile machine and the steering geometry are taken into account when calculating the travel path. The critical outline includes the perimeter of the mobile machine with all attachments.

To precisely parameterize the critical contour, SICK requires the geometric data of the mobile machine in a configuration file. Please contact your internal sales department.

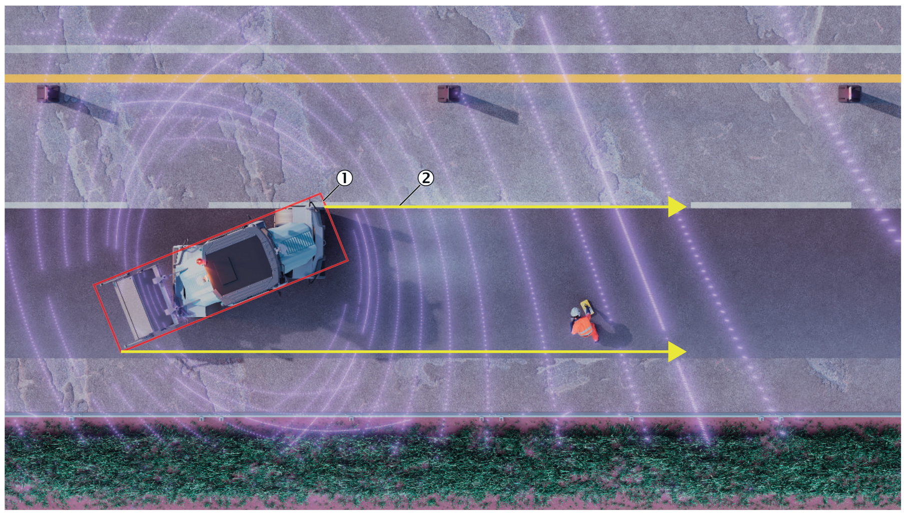


Figure 8: Travel path and critical outline

① Critical outline

② Travel path

4.5.6.1 “Driving along a wall” mode

Important information

WARNING
The travel path is reduced on both sides when the mode is active. The travel path becomes narrower than the width of the mobile machine.

Increased risk of collision

- ► Integrate the mode in such a way that the operator is continuously informed of the status when the mode is active.
- ► Ensure that the operator is informed of the following: When the mode is active, only the operator can prevent collisions at the edge of the mobile machine. The safety system cannot provide assistance in this case.

“Driving along a wall” mode

The integrator can request via CAN a special mode for driving very close, for example, to a boundary wall. This makes the travel path 20 cm narrower on both sides so that no collision is detected in the event of slight steering movements. This happens regardless of whether a wall is detected and, if so, on which side it is.

Figure 9: Close passing of a crash barrier

4.5.6.2 Chip spreader detection

The critical outline of the machine changes when the chip spreader is attached. The safety system can take the chip spreader into account for the critical contour via a CAN signal.

The chip spreader is detected once after system start-up or when the input signal changes with information about the electrical connection.

The CAN signal can, for example, indicate that a standard chip spreader is connected.

4.5.7 Integration of the 3D LiDAR sensors

Design recommendations for integration of the 3D LiDAR sensors

- Requirements on the mounting surface to ensure sufficient thermal conductivity:
  - Material: Aluminum
  - Material thickness: 7 mm
- The sensors must not be completely enclosed. Sensors must be cooled by air flow from the environment.
- The sensors must be protected against sunlight from angles of more than 30°. The maximum heating due to solar radiation must be limited to 700 W/m^2.
- The mounting surfaces must be thermally decoupled from the canopies as far as possible.

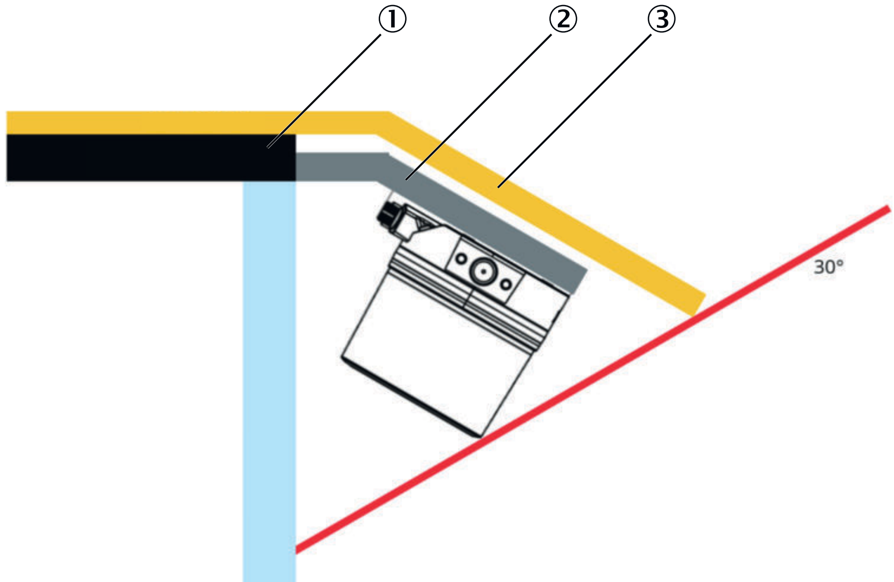


Figure 10: Integration of sensors

① Cabin roof of the mobile machine
② Mounting pate
③ Canopy

Mounting position

The mounting positions are located on the front and rear of the machine on the cabin roof

A suitable bracket for the sensors must be pre-installed on the mobile machines. These are used to ensure the correct position and rotation of the sensors during mounting (see table 4, page 23).

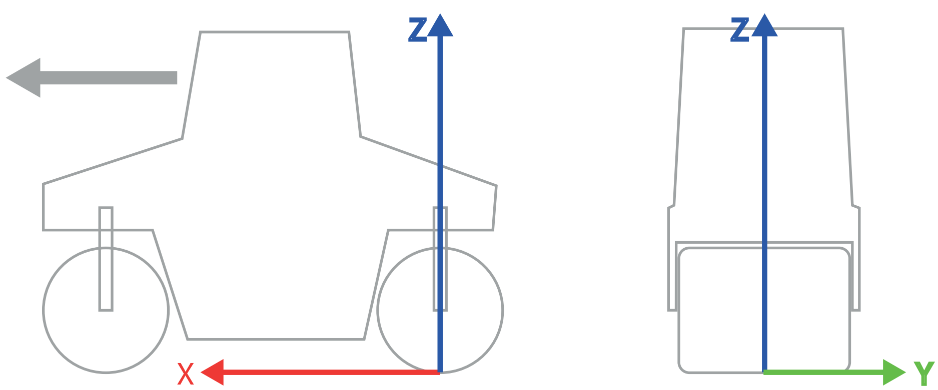


Figure 11: Definition of coordinate system

Table 4: Mounting position (example)

	Start	End
Position (in mm)		
X	2,500 ± 10	800 ± 10
Z	0 ± 10	0 ± 10
Y	3,000 ± 10	3,000 ± 10
Rotation		

	Start	End
Roll (X-axis rotation)	180° ± 1° (mounting upside down)	180° ± 1° (mounting upside down)
Tilt (Y-axis rotation)	21° ± 1°	21° ± 1°
Yaw (Z-axis rotation)	0° ± 1°	0° ± 1°

4.5.8 Calculating the stopping distance

Procedure

1. When calculating the stopping distance, take into account the statistical measurement error and the response time of the overall system.
2. Determine or calculate the braking distance individually for each machine, as each machine has different driving characteristics.
3. Take into account that the minimum distance S must be determined separately for forward travel and reverse travel. The shape of the machine and any attachments usually result in different minimum distances.

Example

The overall system must be designed in such a way that the mobile machine comes to a safe standstill before a collision with people occurs. There are different ways to determine this. The following example is based on the calculation of the minimum distance S to the hazardous area in accordance with ISO 13855.

For scan planes < 30°, the following formula can be used for an approach direction parallel to the scan plane.

$S = (K \times T) + C$

Table 5: Parameters according to ISO 13855

Parameter	Description
S	Minimum distance to hazardous area (mm)
K	Speed of approach to hazardous area (mm/s) 1,600 mm/s is assumed for persons in industrial environments.
T	Period of time until the dangerous state ends (s)
Z	Supplement to protect against reaching over (mm)

For this application (protection of mobile machines), the formula can be interpreted as follows:

$S = (K \times T) + C$

$S = (K \times T) + C_1 + C_2 + C_3$

Table 6: Parameter

Parameter	Description
S	Minimum distance between the 3D LiDAR sensor and objects appearing in the travel path from the direction of travel. During project planning, it must be ensured that the minimum distance S ≤ the detection range of the 3D LiDAR sensors. The actual detection range depends on the ambient conditions and the object properties (size, remission factor).
K	Maximum speed v_{max} of the mobile machine when the collision avoidance function is activated (mm/s)

Parameter	Description
T	Response time of the overall system in seconds (s), which comprises the following parameters: • Response time of the safety system (300 ms) • Response time of the safety controller (logic) of the mobile machine • Response time of the brake • Signal propagation times
C_1	Braking distance of the mobile machine (v_{max} ... 0 mm/s) The value is usually determined using measurements. Theoretically, this can be determined using the following formula: V_{max}^2 / (2 × a), where a = minimum applied braking deceleration of the mobile machine
C_2	Horizontal distance between the 3D LiDAR sensor and the end of the mobile machine housing (mm) ⚠ **WARNING** | Depending on the machine type and mounting position, different values may result for the front and rear. This can lead to different speeds for forward and reverse travel.
C_3	Length of any attachments (e.g. chip spreader), measured in the direction of travel (mm) ⚠ **WARNING** | The use of attachments results in different values for the front and rear of the mobile machine. This can lead to different speeds for forward and reverse travel.

Complementary information

In the example above, the “safety working range” value in the data sheet corresponds to the formula part: (K × T) + C_1.

The supplement C2 was determined and calculated for a typical machine. The supplement C3 is set to 0 (no attachment in the direction of travel).

4.6 Integrating the equipment into the electrical control

NOTE
Several safety functions are generally necessary in order to ensure a safe design for the entire application. This requires additional components that are not part of the safety system, such as switches, fuses, and contactors. The circuit diagrams contain information on wiring the safety system with additional components within an application.

4.7 Integration into the network

4.7.1 CAN interface

CRC checksums

The checksum calculation used is a 16-bit CRC using the CRC-16 algorithm with a 0 x C86C polynomial. The calculation incorporates all bits including the CAN consistency check bytes (message counter bytes, see below) and unused bytes of a single message. The initial value for the CRC calculation is 0 x 0000.

CAN consistency check

Some messages with cyclically changing values have 8-bit message counters that are incremented every cycle. These bytes are checked on the receiving end and indicate any lost or duplicated messages. It is not uncommon for messages to be lost if the receiving mailboxes are too small or the CAN cabling is faulty.

Configuration

The safety system configures itself independently based on the transmitted serial number of the machine.

Depending on the machine type and variants, several combinations of machine generation and type can be supported. Corresponding parameter sets must be stored for this purpose.

Table 7: Example supported machine types

Machine	Model 1	Model 2
Generation/Type	12344	12355
	12344	12355
	12344	12355
	12344	12355

Table 8: Decoding the serial number

Serial number example	123446000
Generation	123
Type	44
Serial	6000

Overview of CAN messages (safety-related)

Table 9: Overview of CAN messages

Function	Sender	Message name	CAN ID	Cycle time	Byte Order
Machine data	Mobile machine	Vehicle_ECU_MSG_01	0x01	50 ms	Intel
Machine configuration	Mobile machine	Vehicle_ECU_MSG_02	0x02	1,000 ms	Intel
Output signals forward	Safety system	SICK_ECU_MSG_03	0x03	50 ms	Intel
Output signals backwards	Safety system	SICK_ECU_MSG_04	0x04	50 ms	Intel
System information for safety system	Safety system	SICK_ECU_MSG_05	0x05	1,000 ms	Intel
Version information for safety system	Safety system	SICK_ECU_MSG_06	0x06	1,000 ms	Intel

CAN input data (safety-related)

Table 10: Vehicle_ECU_MSG_01

Signal	Start bit	Length	Value range	Type	Offset	Factor	Unit
SteeringAngleFront [1)]	0	12	-40.94 ... 40.94	unsigned	-40.94	0.02	°
	Steering angle on the front axle. Required value in the event of an error: 0 x FFF Positive value = clockwise rotation of steering axis (right turn) Negative value = counterclockwise rotation of steering axle (left turn)						
SteeringAngleRear [1)]	12	12	-40.94 ... 40.94	unsigned	-40.94	0.02	°
	Steering angle at the rear axle. Required value in the event of an error: 0 x FFF Positive value = clockwise rotation of steering axis (right turn) Negative value = counterclockwise rotation of steering axle (left turn)						

Signal	Start bit	Length	Value range	Type	Offset	Factor	Unit
StatusChipSpreader [1]	24	4	0 ... 3	unsigned	–	–	–
	0 = detached, 1 = attached, 2 = error, 3 = not available						
MachineSpeed [1]	28	12	–20.47 ... 20.47	unsigned	–20.47	0.01	m/s
	Speed of travel of the mobile machine. Required value in the event of an error: 0xFFF						
SequenceID	40	8	0 ... 255	unsigned	–		–
	Message counter						
CRC	48	16	0 ... 65535	unsigned	–		–
	Checksum						

1) Safety-related signal. A plausibility check must be implemented for these signals.

Table 11: Vehicle_ECU_MSG_02

Signal	Start bit	Length	Value range	Type	Offset	Factor	Unit
System status	0	5	0 ... 31	unsigned	–	–	–
	System status of the mobile machine. Is not evaluated by the safety system.						
OperationModeRequest	5	3	0 ... 1	unsigned	–	–	–
	Request for “Driving along a wall” mode (see "“Driving along a wall” mode", page 21) 0 = deactivate mode 1 = activate mode						
Serial number	8	32	0 ... 4294967295	unsigned	–	–	–
	Serial number with information about the type of mobile machine. The safety system configures itself automatically based on this information. If the type of mobile machine is not supported, an error code is output.						
SequenceID	40	8	0 ... 255	unsigned	–		–
	Message counter						
CRC	48	16	0 ... 65535	unsigned	–		–
	Checksum						

CAN output data (safety-related)

Table 12: SICK_ECU_MSG_03

Signal	Start bit	Length	Value range	Type	Offset	Factor	Unit
SequenceID_Front	0	8	0 ... 255	unsigned	–	–	–
	Message counter						
DistanceToCollision-Front	8	16	0 ... 32000	unsigned	0	1	mm
	Distance to the next object in the forward travel path of the mobile machine. 32000 = no object detected, value in case of error = 0						
ErrorCodeFront	24	16	0 ... 65535	unsigned	–		–
	Error code output						
SequenceID	40	8	0 ... 0	unsigned	–		–
	Message counter						
CRC	48	16	0 ... 65535	unsigned	–		–
	Checksum						

Table 13: SICK_ECU_MSG_6A3

Signal	Start bit	Length	Value range	Type	Offset	Factor	Unit
SequenceID_Rear	0	8	0 ... 255	unsigned	–	–	–
	Message counter						

Signal	Start bit	Length	Value range	Type	Offset	Factor	Unit
DistanceToCollision-Rear	8	16	0 ... 32000	unsigned	0	1	mm
	Distance to the next object in the forward travel path of the mobile machine. 32000 = no object detected, value in case of error = 0						
ErrorCodeRear	24	16	0 ... 65535	unsigned	–		–
	Error code output						
SequenceID	40	8	0 ... 0	unsigned	–		–
	Message counter						
CRC	48	16	0 ... 65535	unsigned	–		–
	Checksum						

Table 14: SICK_ECU_MSG_05

Signal	Start bit	Length	Value range	Type
SensorDirtyFront	0	8	0 ... 255	unsigned
	Measured contamination of the optics cover of the front 3D LiDAR sensor (see table 16, page 29).			
SensorDirtyRear	8	8	0 ... 255	unsigned
	Measured contamination of the optics cover of the rear 3D LiDAR sensor (see table 16, page 29).			
ProtocolVersion	16	8	0 ... 255	unsigned
	Protocol version			
OperationMode	24	8	0 ... 1	unsigned
ChipSpreader	32	8	0 ... 4	unsigned
	Confirmation for the detected chip spreader. 0=no chip spreader; 1=standard chip spreader; 2=adjustable chip spreader; 3, 4: reserved for other chip spreaders			
NotUsed2	40	8	0 ... 0	unsigned
CRC	48	16	0 ... 65535	unsigned
	Checksum			

Table 15: SICK_ECU_MSG_06

Signal	Start bit	Length	Value range	Type
SickProductNumber	0	24	[0 ... 16777215]	unsigned
	Product number of the safety system. ⓘ **NOTE** | The product number is not a part number. (see "Ordering information for the safety system", page 11)			
SickSystemVersionMa-jor	24	8	[0 ... 99]	unsigned
	SW Version **X**._._			
SickSystemVersionMi-nor	32	8	[0 ... 99]	unsigned
	SW Version _.**X**._			
SickSystemVersion-Patch	40	8	[0 ... 255]	unsigned
	SW Version _._.**X**			
CRC	48	16	[0 ... 65535]	unsigned
	Checksum			

Complementary information

The order of the signals within the CAN messages can be adapted to the CAN protocol used in the project.

4.7.2 Contamination measurement

Overview

The 3D LiDAR sensors are equipped with a contamination measurement. The degree of contamination is determined individually for each device and output via a CAN signal.

Important information

WARNING
Sudden onset of contamination

The contamination measurement takes place over time. In the event of sudden contamination, the CAN signal responds after a time delay (max. 60 seconds).

► Ensure that operators are informed about the possible delay of the contamination signal.

Integration of the contamination measurement

The contamination measurement is only performed on the forward-facing 180° of the field of view of the 3D LiDAR sensors. The signals for contamination measurement must be evaluated in such a way that the operator is informed of the contamination.

In the “Error” and “Sensor blocked” statuses, the safety system no longer functions. The integrator must integrate the signal in such a way that the collision avoidance function is deactivated in these cases. The degree of contamination of the 3D LiDAR sensors must be displayed to the operator.

Table 16: Degree of contamination of the 3D LiDAR sensors

Name	Description	Value in CAN signals “SensorDirtyFront” and “SensorDirtyRear”
Clean	The optics cover is clean.	0
Warning	The optics cover is slightly contaminated. Clean promptly.	70
Error	The optics cover is very contaminated. Detection capabilities of the safety system no longer exist.	100
3D LiDAR sensor blocked	No clear view Detection capabilities of the safety system no longer exist.	255

Further topics

- "CAN interface", page 25

4.7.3 Plausibility check of the input data of the machine controller

The integrator is responsible for ensuring that the input data for the system is within the specified physical range. In the event of an error on the integrator side, the system expects the maximum value 0xFFF.

4.7.4 Program sequence control (PSM)

Program sequence monitoring (PSM) is a measure for checking the correct processing of the calculation sequence for the output signal with the distance to collision. The PSM is divided into two parts, one runs directly on the IPC and checks the time stamp of all input signals required for the calculation as well as the output signals. If the age of a signal exceeds a limit value, the error ePsmError is set in the transmitted error code of the messages 0 x 6A2 and 0 x 6A3. The second part of the PSM, the supervisor, takes place on the safety controller of the mobile machine.

The supervisor must check the payload of the incoming CAN telegrams as follows:

- Check whether the sequence ID has been incremented by “1”.
- Check whether the checksum of the telegram on the CAN bus matches the calculated checksum.
- Check whether the value of the ePsmError bit is not set in the error code.
- Check the watchdog timer independently of the CAN communication. In the event of a timeout, the system must initiate a safe state.

If one of these checks fails, the safety system must be deactivated.

If the sequence ID is not incremented by exactly 1, it is advisable to assume a safe state directly on the machine side.

4.8 Testing plan

The manufacturer of the machine and the operating entity must define all required thorough checks. The definition must be based on the application conditions and the risk assessment.

The following tests must be planned:

- A thorough check must be carried out during commissioning and following modifications.
  The check must establish whether the safety system detects the intended test objects in the travel path and measures the distance. Such possibilities may exist due to modifications, manipulations or external influences.
- The regular thorough checks of the safety system must fulfill certain minimum requirements. The minimum requirements for the thorough check of the safety system comply at least with the sum of the minimum requirements for the thorough check of the components of the safety system (see operating instructions of the components).
- The time interval for the regular thorough checks must be determined and specified for the specific application, place of application and influencing factors prevailing there (e.g., dirt, demand rate, EMC, ...).
- In many cases, depending on the application conditions, the risk assessment can determine that further thorough checks are required.

The thorough checks must be carried out by qualified safety personnel or specially qualified and authorized personnel, and must be documented in a traceable manner.

The regular thorough checks serve to assess the effectiveness of the safety system and to identify defects as a result of changes or other influences (e.g., damage or manipulation).

5 Mounting

5.1 Mounting the 3D LiDAR sensors

Important information

NOTE
Additional general mounting-related information can be found in the operating instructions for the component.

Prerequisites

- Mounting position defined by project planning (see "Integration of the 3D LiDAR sensors", page 22).

Procedure

1. Lay the connecting cables.
2. Connect the connecting cables to the 3D LiDAR sensor.
3. Mount the 3D LiDAR sensor upside down in the bracket. Use 3 × M5 screws. Tightening torque: 2.5 Nm

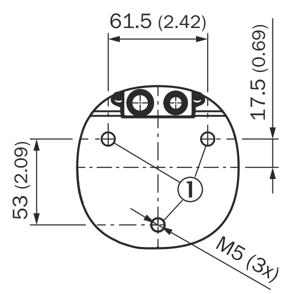


Figure 12: Dimensions of sensor

① M5x7.5 fixing holes for mounting the device

4. In case of strong vibrations, use screw locking devices to secure the fixing screws.
5. Repeat the procedure for the second 3D LiDAR sensor.

5.2 Mounting the industrial PC

Important information

NOTE
Additional general mounting-related information can be found in the operating instructions for the component.

Procedure

1. Determine the mounting position. The industrial PC is placed under the cover in the cabin with the connections facing forwards. The mounting surface must not become hot.
2. Mount the industrial PC. 4 × M5 screws.

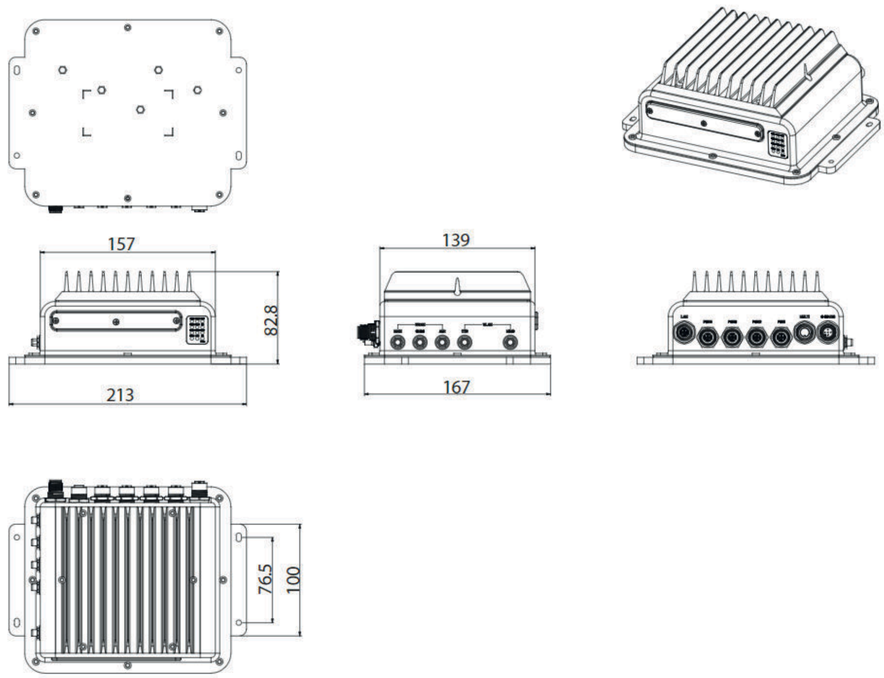


Figure 13: Dimensions of the industrial PC

Complementary information

- Maximum length of cable for the voltage supply: 5 m
- Maximum length of cable for the data connection (CAN): 25 m

5.3 Mounting the voltage converters

Important information

NOTE
Additional general mounting-related information can be found in the operating instructions for the component.

Procedure

1. Determine the mounting position. The mounting surface must not become hot. The voltage converters must be protected against leaking chemicals. The voltage converters should be installed close to the industrial PC.
2. Mount the voltage converters. Hole size: 5 mm

Figure 14: DC/DC transducer

Complementary information

- Maximum length of cable for the voltage supply: 5 m

6 Electrical installation

6.1 Circuit diagram

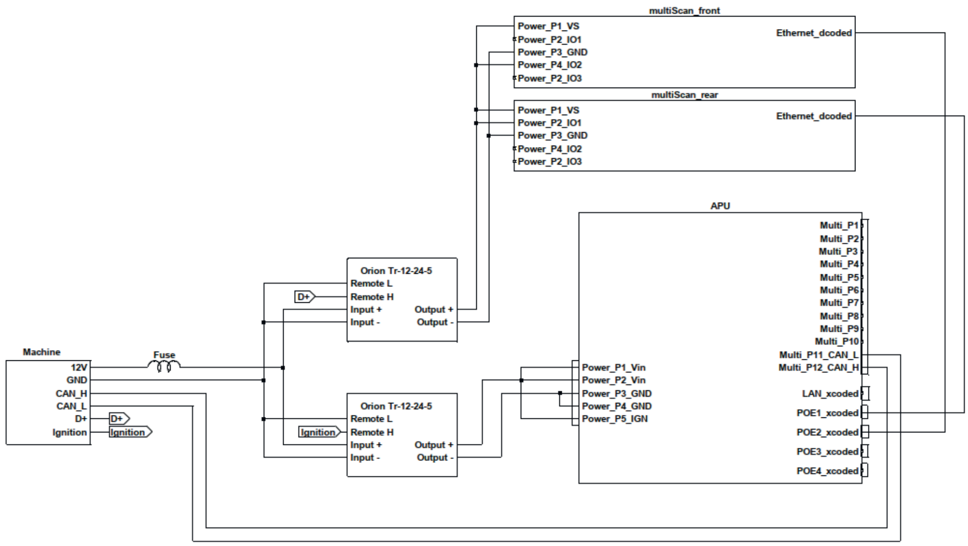


Figure 15: Circuit diagram

Fuse: 10 A

6.2 Connection overview

Table 17: Connection overview

Sender	Signal	Male connector	Pin	Wiring with	Receiver	Signal	Male connector	Pin
3D LiDAR sensor – front	Vs (+24 V)	M12 male connector, 5-pin, A-coded	1		DC-DC transducer 1	+24 V	Screw terminal	Output +
	GND		3			GND		Output -
	I/O 2		2			+24 V		Output +
	Data (ETH)	M12 female connector, 4-pin, D-coded	1		APU	Data (ETH)	PoE2 (M12 female contact, 8-pin, X-coded)	1
			2					3
			3					2
			4					4
3D LiDAR sensor – rear	Vs (+24 V)	M12 male connector, 5-pin, A-coded	1		DC-DC transducer 1	+24 V	Screw terminal	Output +
	GND		3			GND		Output -
	I/O 1		4			+24 V		Output +
	Data (ETH)	M12 female connector, 4-pin, D-coded	1		APU	Data (ETH)	PoE1 (M12 female contact, 8-pin, X-coded)	1
			2					3
			3					2
			4					4
IPC	Vs (+24 V)	M12 female connector, 5-pin, A-coded	1, 2		DC-DC transducer 2	+24 V	Screw terminal	Output +
	GND		3, 4			GND		Output -
	Ignition		5			+24 V		Output +
	CAN_L	M12 female connector, 12-pin, A-coded	11		Safety controller of mobile machine	CAN low	Cable harness	n/a
	CAN_H		12			CAN high		n/a
Battery of mobile machine	+12 V	Cable harness	n/a		DC-DC transducer 1	+12 V	Screw terminal	Input +
					DC-DC transducer 2			
	GND				DC-DC transducer 1	GND		Input -
					DC-DC transducer 2			
					DC-DC transducer 1	+12 V		Remote L
Relay (central electrics)	Ignition/ other condition	-	-		DC-DC transducer 2	-	-	-

6.3 Sensor interfaces

Table 18: Voltage supply to sensors (M12 male connector, 5-pin, A-coded)

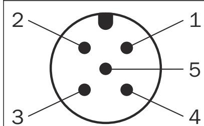
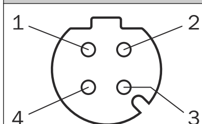
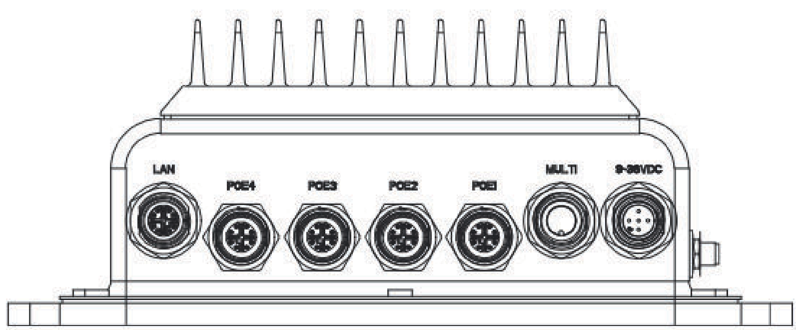
Figure	Pin	Labels	3D LiDAR sensor – Front	3D LiDAR sensor – Rear
 *Figure 16: M12 male connector, 5-pin, A-coded*	1	VS	+24 V	+24 V
	2	I/O 2	+24 V	NC
	3	GND	GND	GND
	4	I/O 1	NC	+24 V
	5	I/O 3	NC	NC

Table 19: Ethernet interface of sensor (M12 female connector, 4-pin, D-coded)

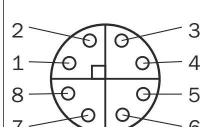
Figure	PIN	Identifica-tion	Description
 *Figure 17: M12 female connector, 4-pin, D-coded*	1	TX+	Sender+
	2	RX+	Receiver+
	3	TX-	Sender-
	4	RX-	Receiver-

6.4 Application Processing Unit (APU) interfaces



6.5 Ethernet for service (LAN)

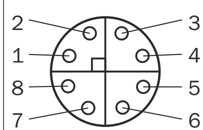
Table 20: Ethernet interface for service APU (M12 female connector, 8-pin, X-coded)

Figure	PIN	Identification
 *Figure 18: View of connecting cable female connector*	1	TRD0_P
	2	TRD0_N
	3	TRD1_P
	4	TRD1_N
	5	TRD3_P
	6	TRD3_N
	7	TRD2_P
	8	TRD2_N

6.6 Ethernet sensors (PoE1-4)

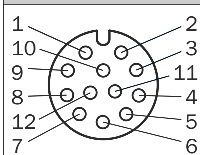
NOTE
Sensors must be connected to PoE1 and PoE2.

Table 21: Ethernet interface for sensors APU (M12 female connector, 8-pin, X-coded)

Figure	PIN	Identification
 *Figure 19: View of connecting cable female connector*	1	TRD0_P
	2	TRD0_N
	3	TRD1_P
	4	TRD1_N
	5	TRD3_P
	6	TRD3_N
	7	TRD2_P
	8	TRD2_N

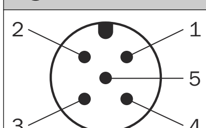
6.7 CAN interface (MULTI)

Table 22: CAN interface for APU (M12 female connector, 12-pin, A-coded)

Figure	PIN	Identification	Description
 *Figure 20: View of APU female connector*	11	CAN_L	CAN LOW
	12	CAN_H	CAN HIGH

6.8 Voltage supply to APU (9-36 VDC)

Table 23: Voltage supply to APU (M12 male connector, 5-pin, A-coded)

Figure	PIN	Identification	Description
 *Figure 21: View of APU male connector*	1, 2	Vs	Voltage supply 24 VDC
	3, 4	GND	Mass
	5	Ignition	Voltage supply (ignition) 24 VDC

7 Commissioning

7.1 Safety

WARNING
Hazard due to lack of effectiveness of the protective device

- ► Before commissioning the machine, make sure that the machine is first checked and released by qualified safety personnel.
- ► Only operate the machine with a perfectly functioning protective device.

DANGER
Dangerous state of the machine

During commissioning, the machine or the protective device may not yet behave as you have planned.

- ► Make sure that there is no-one in the hazardous area during commissioning.

Before commissioning can be performed, project planning, mounting, electrical installation and configuration must be completed in accordance with this document.

7.2 Regular thorough checks

At regular intervals the user must demonstrate that the measures taken still fulfill the protective purpose, and that the protective device still functions correctly in the application during the service life.

Thorough checks and tests are required in this regard:

- Upon commissioning (e.g., initial commissioning, recommissioning)
- After changes and extraordinary events (e.g., conversion, change of parameters, modification, retrofitting and equipment, damage, repair, ...)
- At regular intervals (e.g., recurring thorough checks intended to ensure that a safety-related function and/or safety function still functions correctly in the application)

Related topics “Checklist for initial commissioning and commissioning”.

These thorough checks must be documented clearly and comprehensibly.

Determination of the time intervals for thorough checks at regular intervals must be decided and established by the manufacturer of the machine and/or by the operating entity depending on the specific application, place of application and influencing factors prevailing there. (e.g., dirt, demand rate, EMC, ...).

Place the supplied test object in the path of the mobile machine and check whether the specified output signal is generated.

8 Operation

8.1 Operating the components

NOTE
Information is included in the operating instructions for the components.

8.2 Regular thorough check

The thorough check is intended to ensure that the safety functions are fulfilling their planned purpose and whether persons are being adequately protected.

► Carry out the checks specified in the test plan of the manufacturer of the machine and the operating entity.

9 Maintenance

9.1 Maintenance of the components

NOTE
Information is included in the operating instructions for the components.

9.2 Maintenance and care

The safety system must not be opened. Maintenance is not necessary to ensure compliance with laser class 1, either.

The black, infrared-transparent optics cover should be cleaned, at regular intervals and in the event of contamination, with a lint-free lens cloth and plastic cleaning agent. In this regard, the cleaning interval essentially depends on the ambient conditions.

9.3 Transport and storage

Transport and store the safety system in its original packaging. Do not store outdoors. The safety system must not be stored in airtight containers, so that any residual moisture is able to escape. Do not expose to aggressive media (e.g. solvents).

Storage conditions: Dry, dust-free, no direct sunlight, as little vibration as possible.

Storage temperature –40 … +85 °C, relative air humidity max. 90 % (non-condensing).

10 Troubleshooting

10.1 LED flash codes of sensor

Table 24: Meaning of the flash codes

LED1 + LED3 (color)	LED2 + LED4 (color)	Description
● Red	● Red	Start-up, parameterization, firmware update, recoverable error
○	○	Off
☀ Red	☀ Red	Fatal error
○	● Green	On/ready
○	● Yellow	Standby/energy-saving mode
● Green	☀ Yellow	Restart after time; input
● Green	☀ Yellow	Warning: contamination
☀ Red	☀ Yellow	Contamination error
☀ Green	☀ Red	Alignment mode
● ● ●Green, yellow, red	● ● ●Green, yellow, red	Identify product

○ LED off. ☀ LED flashes. ● LED illuminates.

10.2 LED flash codes of Application Processing Unit

Table 25: Meaning of the APU flash codes

Signal	LED	Description
PWR	● Green	Power up (9 V ~ 36 V)
	● Red	Power fail
	○ Off	Power off
IGN	● Green	Ignition on (9 V ~ 36 V)
	○ Off	Ignition off (< 9 V voltage level)
STAT	● Green	Ready
	☀ Green	System booting
	● Red	Any fatal error
	○ Off	Power off
SD/NVMe	● Green	Ready
	☀ Green	Read/write data
	● Red	Any fatal error
	○ Off	No storage installed
WWAN	● Yellow	Signal
	● Green	Service
WLAN	● Yellow	Signal
	● Green	Service
PROG	○ Off	User programming
LAN	● Green	Link
	☀ Green	ACT

Signal	LED	Description
POE1	● Green	Power feed to PD device
	○ Off	No power feed to PD device
POE2	● Green	Power feed to PD device
	○ Off	No power feed to PD device
POE3	● Green	Power feed to PD device
	○ Off	No power feed to PD device
POE4	● Green	Power feed to PD device
	○ Off	No power feed to PD device

○ LED off. ☀ LED flashes. ● LED illuminates.

10.3 Error codes

The error codes are sent in the CAN output data separately for each direction of travel as a 16-bit value. Some errors occur depending on the direction of travel, others always for both directions. If an error is detected and the error code is greater than 0, the function must be disabled and the driver informed accordingly.

Table 26: Error codes

Bit	Error code	Description
-	eNoError	Error code 0 x 0000 means no error detected.
0 (LSB)	eReducedAvaila-bility	Too many false detections for vapor were filtered out. The detection capabilities of the system can no longer be assured.
1	eSensorCommu-nicationTimeout	Communication to the sensor disrupted. – No communication – Frequency of the data outside the tolerance – Incomplete data Remedy: Check the voltage supply and data connection to the sensor. Error occurs depending on the direction of travel.
2	eInternalError	Frequency of internal data processing outside the tolerance. Remedy: Restart the system. If error persists, replace the APU.
3	Free	n/a
4	eCanTimeoutEr-ror	One of the input messages of the machine was not sent cyclically within the tolerance (watchdog). Remedy: Check the CAN communication.
5	eCanMachineDa-taError	Error in the input data of the machine in the Vehi-cle_ECU_MSG_6A0 message. At least one signal has the value 0 x FFF and the safety system no longer functions. Remedy: Search for the error on the machine side.
6	eCanInvalidMsg-Content	In one of the 2 messages with input data, the SequenceID was not incremented correctly or the CRC check failed. Remedy: Check the CAN communication.
7	Free	n/a

Bit	Error code	Description
8	eCtcTestFailed	One of the reference targets was not detected. – 2 targets on the sides of the sensor – Reference contour on the machine surface (tank, cooler) Remedy: If a sensor communication error is also present, rectify that error first. Otherwise check for correct physical mounting. Error occurs depending on the direction of travel.
9	eChipSpreader-Detection	No chip spreader detected and the StatusChipSpreader signal in message 0 x 6 A0 is 1 (attached). StatusChipSpreader signal in message 0 x 6 A0 is 2 (error).
10	Free	n/a
11	ePsmError	Timeout during internal data processing. The last calculated distance to collision is too old. Remedy: First rectify any errors in the input data and configuration. Restart the system. If the error persists and there is no other error, replace the APU.
12	Free	n/a
13	eSensorSwVersionMismatch	Incorrect firmware or incorrect product number detected on the sensor. (e.g. after sensor replacement). Remedy: Check the origin of the sensor. Device is not approved for the system. Error occurs depending on the direction of travel.
14	eInvalidConfiguration	No known machine type in the serial number of the Vehicle_ECU_MSG_6A1 message. No configuration is stored for this machine type. Remedy: Check the machine configuration.
15 (MSB)	Free	n/a

10.4 Firmware update for Application Processing Unit

To perform a firmware update of the safety system, a connection must be established via the “LAN” port of the APU using an M12 X-coded Ethernet cable.

The APU has the static IP address 192.168.0.25/24. The connection must be established with a Windows PC and it must be ensured that the Windows PC has an IP address within the same subnet.

Firmware updates are always provided via a ZIP file released by SICK. Installation of third-party software on the safety system is strictly prohibited. It must also be ensured that the machine is at a standstill during the update process.

The ZIP file must be unpacked and the .bat script contained in it must be executed. If the update is successful, the script returns the code 0. Code 1 in the event of an error. In the event of an error, the APU must be restarted by a power cycle and the update can be carried out again.

After each firmware update, the safety system must be checked and validated again.

10.5 Reference targets

The sensor units are continuously checked for proper function. To do this, targets must be attached in the direction of the machine that are hit by all sensor scan layers. This can be carried out in consultation with SICK. If this diagnostic fails, an error code is output.

10.6 Manipulation

The safety machine does not have any protective measures against manipulation, especially none that relate to the optical system. Objects, especially covering objects on the optics cover and/or in the blind zone, are not detected by the safety system, causing impairment, reduction or complete loss of detection capability, and the safety system no longer being able to perform the safety function.

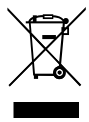
Manipulations with effects similar to undetected errors are also not detected (see "Undetected errors and faults", page 17) .

11 Decommissioning

11.1 Disposal

Procedure

► Always dispose of unusable devices in accordance with national waste disposal regulations.



Complementary information

SICK will be glad to help you dispose of these devices on request.

12 Technical data

12.1 Dimensions of the mobile machine

The dimensions of the machine must be parameterized and taken into account during project planning. The following table contains example parameter values

Table 27: Dimensions of the mobile machine

Parameter	Machine X	Machine Y
Wheelbase	3,000 mm	3,000 mm
Length of mobile machine	4,600 mm	4,100 mm
Length of mobile machine with chip spreader	6,400 mm	5,700 mm
Height of mobile machine	3,200 mm	3,250 mm
Wide of mobile machine (incl. chip spreader)	2,000 mm	1,800 mm
Wheel diameter	1,300 mm	1,200 mm

12.2 Data sheet

NOTE
The safety system is intended for outdoor use. It is not suitable for use in special surroundings (e.g., radiation and sparks from welding systems, strong sources of infrared, thermal convection, fluorescent and stroboscopic light sources, heavy snowfall, heavy rain, contamination) or must yet be made suitable, if applicable.

Table 28: Safety-related parameters

Category (EN ISO 13849-1)	B
Performance level (EN ISO 13849-1)	PL b
Diagnostic coverage (EN ISO 13849-1)	60 %
SRS performance class (IEC TS 62998-1)	B
MTTFd (mean time to dangerous failure) (EN ISO 13849-1)	46 years, at 40 °C ambient temperature
Mission time (service life) (EN ISO 13849-1)	20 years
Max. cumulative downtime per year (IEC 62998-1)	5 minutes
PFH_D	2.65 x 10^{-6} FIT
Conformities	EN ISO 13849-1, IEC TS 62998-1, EN ISO 13842, EN ISO 13855, ANSI/ITSDF B 56.5
Blind zones	see "Blind zones", page 19

Table 29: Data sheet

Supply voltage	8 ... 17 V DC Adaptation to 24 V DC possible (DC/DC transducer)
Current	Idle: 3 A Max: 7 A
Power consumption	Idle: ~36 W Max: 80 W

Electrical protection class	3
IP protection class	Mobile process unit: IP65 (connected) Sensor: IP69K (connected)
Storage temperature	–40 °C ... +85 °C
Ambient operating temperature	–30 °C ... +50 °C Accessories are required for operation during maximum solar heating
EMC	ISO 7637-1 & ISO 7637-2 ISO 16750-2 (voltage peak) ISO 13766-2
Shock resistance (DIN EN 60068-2-27)	30 g,11 ms pulse duration
Vibration resistance (DIN EN 60068-2-6)	Vibration amplitude: 7.5 mm / 5 Hz ... 8.2 Hz Acceleration amplitude: 20 m/s^2 / 8.2 Hz ... 200 Hz 50 m/s^2 / 200 Hz... 1,000 Hz

Table 30: Interfaces

CAN	1 x CAN 2.0 A/B (M12 male connector)
Ethernet	1 x GbE 1000 Base-TX, 4 x GbE PoE For service: 1 x GbE port (M12 male connector, X-coded)

Table 31: Application

Output signal	Safe distance to the nearest relevant object via CAN message
Output signal frequency	20 Hz
Response time	< 300 ms ⚠ **WARNING** | The value relates only to the response time of the safety system. Other factors must be taken into account when calculating the response time of the overall system, e.g., braking distance.
Accuracy of the output signal	Systematic error: ±100 mm Statistical error: < 20 mm
Maximum working speed of the mobile machine	Depends on the braking deceleration of the mobile machine (according to the integration) see "Calculating the stopping distance", page 24
Safe working range (distance between the mobile machine and objects to be detected)	Depends on the shape of the mobile machine, attachments, and positioning of the 3D LiDAR sensors. The following values are examples. 0.5 m ... 5.7 m (6 % remission factor) @ 100 kLux; for optical range up to 10 km (MOR, Meteorological Optical Range) 0.5 m ... 4.0 m (6 % remission factor) @ 10 kLux; for optical range up to 50 m (MOR, Meteorological Optical Range) Values apply from the front edge of the mobile machine in both directions. Resolution: 10 cm ⓘ **NOTE** | Worst-case object according to IEC 62998; distance relative to the front of the machine see "Calculating the stopping distance", page 24

Input signals (IEC 62998)	Steering angle front/rear (PC B) • Physical value range: -25° ... +25° • Systematic error: ±0.1° • Statistical error: < 0.01° Machine speed (PC B) • Physical value range: -10.5 km/h ... +10.5 km/h • Systematic error: ±0.1 m/s • Statistical error: < 0.01 m/s Appendix (PC B) • Binary (1 = appendix enclosed; 0 = no appendix)

Table 32: Sensor

Light source	Infrared (invisible; wavelength 850 nm)
Measurement principle	Time-of-Flight (ToF)
Laser class (IEC 60825-1:2014, EN 60825-1:2014)	1
Aperture angle/field of view (DIN 70000)	Horizontal: ≤180° in the application / 360° (max.) Vertical: 65° (+22.5° to –42.5°)
Angular resolution (angle between two planes)	Horizontal: 0.125° (NAV level) & 1° Vertical: 2.5° (between a NAV and another level) & 5°

Table 33: Ambient data

Ambient operating temperature	–30 °C ... +50 °C
Storage temperature	–40 °C ... +85 °C
Precipitation, rain	< 2.5 mm (within 60 minutes) or < 0.5 mm (within 10 minutes)
Sunlight	1,090 W/m^2 < 100 kLux
Air humidity	Max. 95 %
Icing	Icing of the safety system is not taken into account.
Precipitation, snow	< 1.0 mm (within 60 minutes) or < 0.2 mm (within 10 minutes)
Fog	> 50 m (MOR, Meteorological Optical Range)
Enclosure rating	Industrial PC: IP65 3D LiDAR sensor: IP69K
Permissible operating height	< 2,900 m above sea level.

12.3 Dimensions of components

3D LiDAR sensor

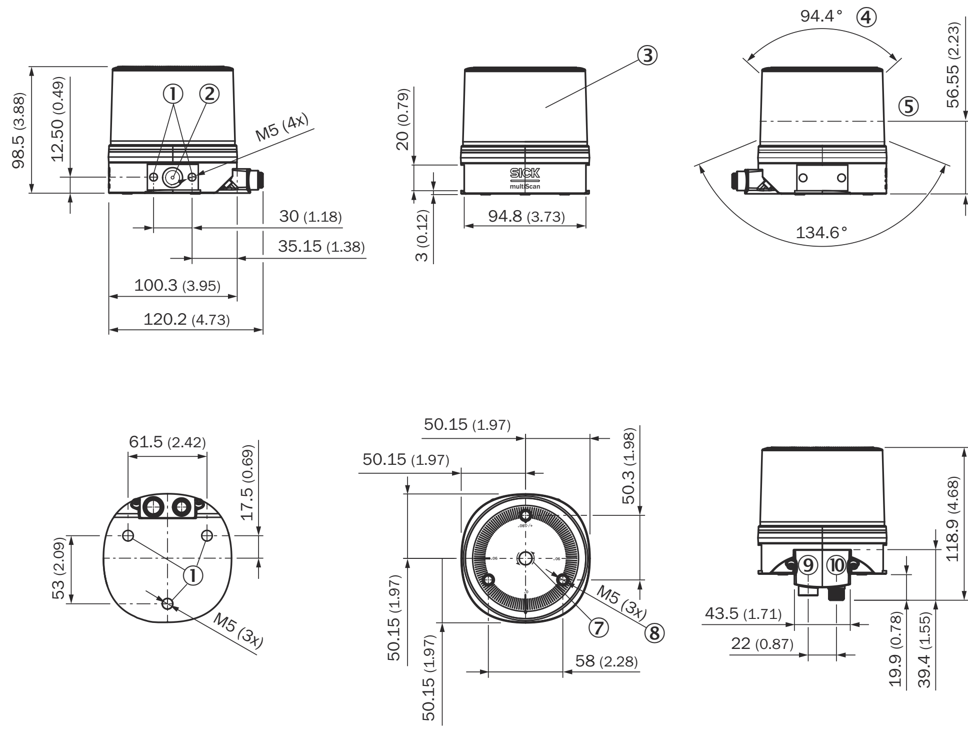


Figure 22: Dimensional drawing of multiScan

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

Industrial PC

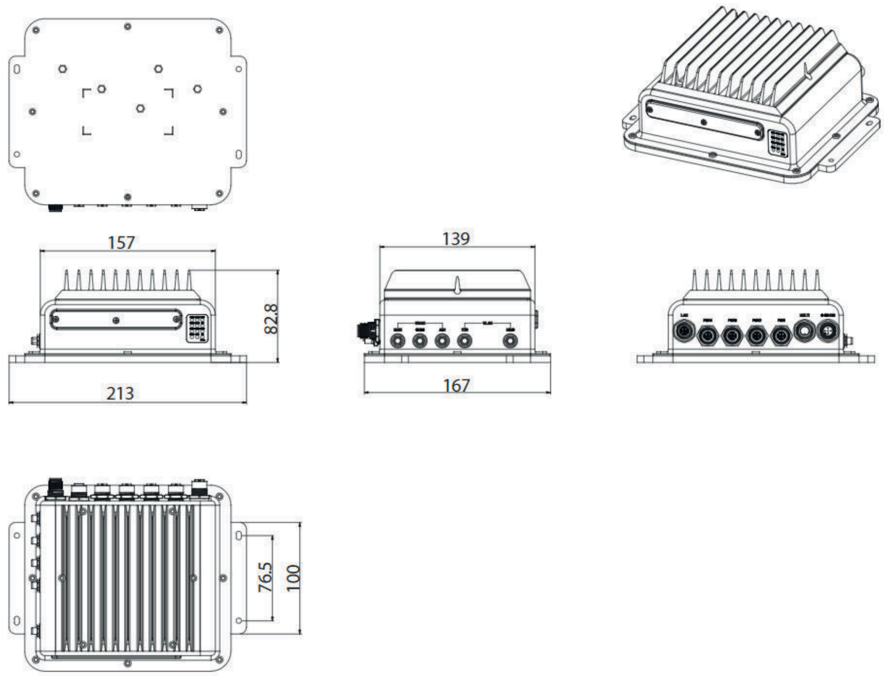


Figure 23: Dimensional drawing of APU

Voltage transformer

Table 34: Dimensions of voltage converter

	In mm	In inches
Height	130	5.1
Width	186	7.3
Depth	70	2.8

13 Annex

13.1 EU declaration of conformity

Excerpt

The undersigned, representing the manufacturer, herewith declares that the product is in conformity with the provisions of the following EU directive(s) (including all applicable amendments), and that the standards and/or technical specifications stated in the EU declaration of conformity have been used as a basis for this.

- ROHS DIRECTIVE 2011/65/EU
- EMC DIRECTIVE 2014/30/EU
- MACHINERY DIRECTIVE 2006/42/EC

13.2 Checklists

13.2.1 Checklist for initial commissioning and commissioning

The details relating to the items listed below must be available no later than when the system is commissioned for the first time. However, these depend on the specific application (the requirements of which must be reviewed by the manufacturer or installer). This checklist should be retained and kept with the machine documentation to serve as reference during recurring thorough checks.

Table 35: Checklist

Have the safety rules and regulations been observed in compliance with the directives and standards applicable to the machine?	☐ YES ☐ NO
Are the 3D LiDAR sensors properly attached to the mounting plate (see "Mounting the 3D LiDAR sensors", page 31)?	☐ YES ☐ NO
Have all requirements on the integrator been taken into account (see "General requirements on integration", page 16)?	☐ YES ☐ NO
Has the safety system been properly commissioned? • Error-free communication/no error codes on the CAN interface • Correct released software version • Correct protocol version	☐ YES ☐ NO
The optics cover / 3D-LiDAR sensors must be cleaned regularly, and a regular visual inspection carried out when starting work.	☐ YES ☐ NO
For use with chip spreaders. Test whether the chip spreader is detected correctly.	☐ YES ☐ NO
Test of the safety system in combination with the SCS. Approaching the test body: • Test setup: the test body (test body based on) is set up on an open area. • Check for correct detection of an obstacle in the travel path. The test body is to be approached from different directions (forwards and backwards) and at different angles and in different steering modes. The machine should come to a standstill on its own. • The test body must not be touched by the machine. When checking for false triggerings, no false triggerings must occur.	☐ YES ☐ NO

13.3 Licenses

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

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