TOPOSENS

ECHO ONE ®

Advanced 3D Collision Avoidance

Instruction Manual Draft 1.1 | 2023

For Firmware version 1.4.1

The contents of this document are subject to change without notice.
The latest version of this document can be downloaded on toposens.com/members.

Described Product

ECHO ONE ® 3D Ultrasonic Sensor

Hardware Version 1.0

Manufacturer

Toposens GmbH

Lyonel-Feininger-Str. 28

80807 Munich

Germany

Legal Notice

Original Document

This document is an original document of Toposens GmbH.

CONTENT

1 ABOUT THIS DOCUMENT

1.1 Purpose of this Document

This instruction manual contains information on the installation process, setup and the safe use of the ECHO ONE® 3D Ultrasonic Sensor by Toposens GmbH. This document will aid you in using the sensor in a safe and efficient manner. Basic requirements for safe use are:

- Compliance with all supplied safety notes and handling instructions.
- Compliance with local occupational health and safety regulations and general safety regulations for equipment applications.

This instruction manual is intended exclusively for use by qualified personnel, in particular trained specialists.

NOTICE

Read this instruction manual carefully to familiarize yourself with the device and its functions before starting to work with it.

NOTICE

This instruction manual is an integral part of the product and must be kept available for later reference.

1.2 Target Group

This instruction manual is intended for:

- Professionals who integrate an ECHO ONE® sensor into a machine or vehicle.
- Professionals who perform initial commissioning, operation, setup, testing and maintenance of the ECHO ONE® sensor.
- Professionals, that perform maintenance and checks on the machine or vehicle, which has been equipped with an ECHO ONE® sensor.
- Planners, developers and operators of machines and vehicles.
- Personnel who have been appointed with transporting, storing or disposing of the ECHO ONE ® sensor.

This instruction manual does not contain any information on the operation of the machine or vehicle on which the device has been integrated into. Corresponding information can be found in the instruction manual of the respective machine or vehicle. The applicable health, safety and legal regulations must be observed when operating devices, machines, and vehicles. Using the ECHO ONE ® sensor requires additional technical skills which are not covered by this document.

1.3 Scope of Information

This instruction manual contains the following information:

- Safety Information
- Product Description
- Operation/Handling
- Assembly
- Electrical Installation
- Initial Start-Up and Configuration
- Maintenance and Care/Fault Diagnosis and Correction
- Technical Data and Dimensional Drawings

1.4 Explanation of Symbols

Safety warnings and important information contained in this document are marked with corresponding signal words. The respective signal word indicates the extent of the Danger. Always observe these warnings to avoid accidents, bodily injury and property damage.

⚠DANGER

DANGER

… indicates a dangerous situation that will result in death or serious injury if not avoided.

⚠WARNING

WARNING

… indicates a dangerous situation which, if not avoided, could result in death or serious injury.

⚠ATTENTION

ATTENTION

… indicates a dangerous situation which, if not avoided, may result in minor or moderate injury.

FOR ATTENTION

FOR ATTENTION

… indicates a potentially dangerous situation that may result in property damage if not avoided.

"FOR ATTENTION" is used to draw attention to practices that are unrelated to bodily injury.

NOTICE

… highlights tips and recommendations as well as information for efficient and smooth operation.

In the following, the term ECHO ONE system or just system refers to a combination of one or more ECHO ONE sensors and a Toposens Processing Unit (TPU) or another controller with Toposens software. When referring to the ECHO ONE sensor or sensor only, the text refers to a sensor as a single device.

1.5 Symbols on the device

FOR ATTENTION

Product markings

The product label attached to the device must not be removed

Symbol	Description
CE	Complies with EU regulations
FC	FCC conformity mark

	Read Manual before installation, use or maintenance
	This device complies with EU directive 2011/65/EU
	When disposing of electronic equipment, observe local and national regulations

2 SAFETY INFORMATION

2.1 Qualified Personnel

⚠WARNING **Risk of injury due to inadequate training/education**

Improper handling of this device can result in significant bodily injury and property damage.

» All work must be carried out by personnel with appropriate qualifications.

The following qualifications are required to perform work on the device:

- **Instructed personnel** that have been briefed by the operator on their tasks and potential hazards due to improper procedures.
- **Qualified personnel** that have specialized training, competencies and experience as well as knowledge related to the relevant regulations. These personnel can independently perform tasks and recognize and avoid potential hazards.

The following qualifications are required for the performance of the corresponding activities:

Activities	Qualifications
Assembly, Maintenance	• Basic practical-technical training/education. • Knowledge of work safety regulations
Electric Installation, Device Replacement	• Practical electrical training/education • Knowledge of current safety regulations • Knowledge of how to operate and control equipment for the specific application
Start-Up and Configuration	• Basic knowledge of the operating system used • Basic knowledge of the structure and setup of the described connections and interfaces • Basic knowledge of data transmission

Activities	Qualifications
Operation of the device for the respective application	• Knowledge of the operation and control of the devices for the respective application • Knowledge of the software and hardware environment for the respective application

2.2 Intended Use

The ECHO ONE sensor is a 3D ultrasonic sensor that perceives its environment via echolocation and distance measurement and locates each echo reflected from the environment in three-dimensional space.

The ECHO ONE system consists of 3D ultrasonic sensors (ECHO ONE) which in combination with the Toposens Processing Unit (TPU) is intended for collision avoidance of partially or fully autonomous vehicles with obstacles or other vehicles. The system does not have a personal safety level. As a Class A device, the sensor is intended for use in industrial environments only. The ECHO ONE sensor, its accessories and software components are provided "as is".

Typical applications are:

Integration in machines as a sensor system for collision avoidance with; or approaching objects, as well as non-safety-related areas of application developed by customers themselves.

Toposens GmbH assumes no liability for loss or damage resulting directly or indirectly from the use of the ECHO ONE sensor.

The ECHO ONE sensor as well as the Toposens Processing Unit (TPU) must not be used as the only sensor system for collision avoidance on vehicles if the vehicle is operated outside of cordoned-off areas that can also be entered by untrained persons.

Any use outside the specification shall result in the expiry of all claims against Toposens GmbH.

2.3 Improper Use

All uses deviating from the "Intended use" are considered improper use. Modifications to the device or the software are considered improper use. In particular, use of the device is not permitted in the following cases:

- Outside the technical specifications and other areas of application
- As a safety component in accordance with the relevant applicable machine safety standards
- As a safety component for occupational safety
- In potentially explosive atmospheres
- In corrosive environments
- Under extreme environmental conditions

The use of accessories not approved by Toposens GmbH is at the user's own risk.

⚠WARNING **Danger due to improper use**

Any kind of improper use can lead to dangerous situations.

» The device may only be operated in accordance with its intended use.
» All information contained in this instruction manual must be strictly observed.
» If the device is mechanically damaged or defective, it must be removed from operation immediately.

2.4 Disclaimer

This instruction manual has been prepared based on the relevant standards and regulations, the latest technical developments and our knowledge and experience. The manufacturer accepts no liability for damage caused by the following:

- Non-compliance with the product documentation (e.g. the instruction manual)
- Incorrect or improper use
- Use of untrained or unqualified personnel
- Modifications to the hardware or software
- Damages resulting from excessive mechanical stresses
- Disregarding installation requirements
- Use of unauthorized spare parts, consumables, and accessories

Toposens GmbH cannot be held liable for any direct or indirect damages or losses that may arise from the use of the product.

The safety and conformity of the machine or vehicle in which this product is integrated is the responsibility of the system installer and/or operator.

Observe the operating and safety instructions for the machine or vehicle in which this product is integrated. These operating instructions do not contain any information or safety instructions relating to the machine or the vehicle in which this product has been integrated.

2.5 Modifications and Conversions

⚠WARNING

Danger due to changes to the device or software

Changes and modifications to the device or to the Toposens TPU software can lead to unforeseeable dangers or damage.

Any warranty claims against Toposens GmbH shall become invalid if the device or the Toposens software are used for purposes other than those for which they are intended or if they are modified. This applies in particular to the opening of the housing, also within the scope of assembly and electrical installation.

2.6 Safety precautions and potential hazards

To reduce the risk of injury and to avoid dangerous situations, the warnings given here and in the other chapters must be strictly observed.

⚠WARNING

Electrocution

Electrical voltage can cause severe or lethal injury.

» The device must not be modified.
» If the device is connected to a power source, the enclosure must be completely closed.
» If the housing of the sensor is damaged, the device must be disconnected from the power supply and may only be put back into operation after repair and inspection by the manufacturer.

⚠WARNING **Electrical Voltage**

Electrical voltage can cause serious or fatal injuries as well as property damage.

» Work on electrical installations may only be carried out by qualified personnel.
» Before making or disconnecting electrical connections, the power supply must be completely shut down. Residual charges must be dissipated.
» Observe the national and local regulations.
» Observe the safety requirements for working on electrical installations.

⚠WARNING **Risk of bodily injury and property damage from potential equalizing currents.**

Improper grounding can result in dangerous equipotential bonding currents, which in turn can cause dangerous voltages on metal surfaces, such as connector housings. Electrical voltage can cause serious or fatal injuries.

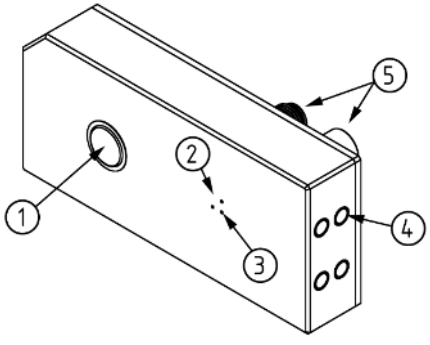
» Work on electrical equipment may only be carried out by qualified personnel.
» Follow the instructions.
» Ensure correct grounding.

3 PRODUCT DESCRIPTION

3.1 Product Overview

The ECHO ONE® 3D ultrasonic echolocation and distance sensor operates according to the time-of-flight (ToF) principle and, as a sensor system, enables machines and mobile robots to determine the position of objects in three-dimensional space. Due to the large aperture angle (depending on configuration, geometry and position of the reflective object) and the integrated near-field detection, the sensor has no blind zone. This enables reliable avoidance of collisions with objects and thus leads to increased availability and productivity of your machine.

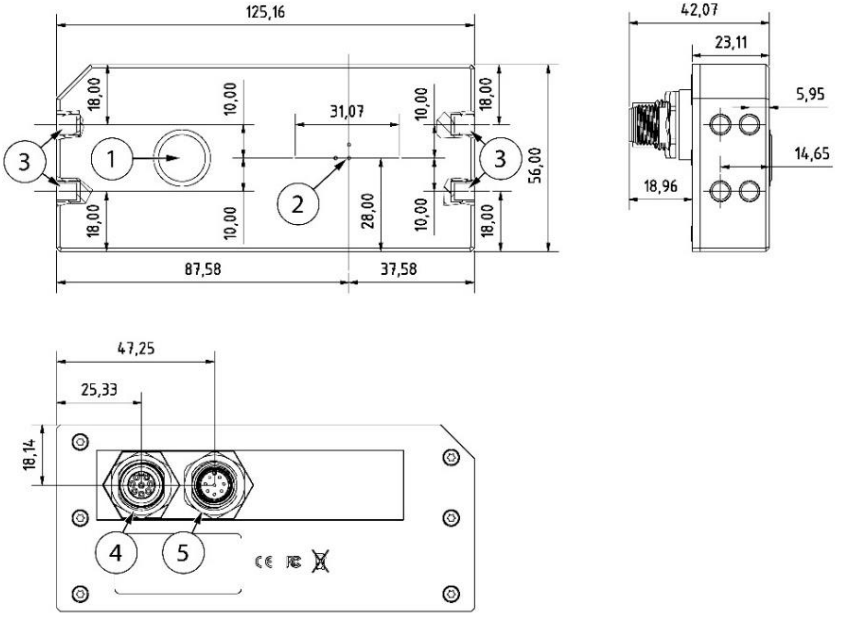
3.2 Device Description



1	**Ultrasonic emitter “Transducer”**
2	**Microphone array**
3	**Acoustic axis**
4	**M5 thread, 5mm depth**
5	**M12 A-coded 8-pin plug and socket**

4 SPECIFICATIONS

4.1 Dimensions



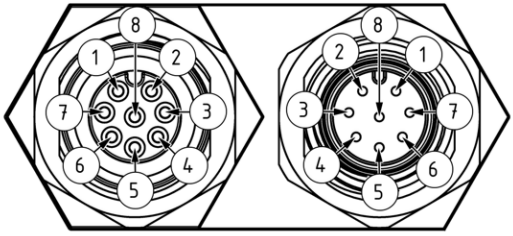
1	**Ultrasonic emitter “Transducer”**
2	**Microphone array**
3	**M5 thread, 5mm depth**
4	**M12 A-coded 8-pin plug**
5	**M12 A-coded 8-pin socket**

4.2 Interfaces

Interfaces

CAN	**ISO 11898-2:2016/CAN 2.0A**
Connector In	**M12 A-coded, 8 Pin, plug**
Connector Out	**M12 A-coded, 8 Pin, socket**
Termination	**120 Ohms, pluggable Terminator***

*See section 13, Accessories list



M12 A-Kodiert 8-Pin Buchse

Pin Nr.	Funktion
1	+V Out
2	+V Out
3	CAN High
4	CAN Low
5	-V Out
6	Reserviert / Mit Schirm verbinden
7	Reserviert / Mit Schirm verbinden
8	-V Out
Gehäuse	CAN GND / Schirm

M12 A-Kodiert 8-Pin Stecker

Pin Nr.	Funktion
1	+V In
2	+V In
3	CAN High
4	CAN Low
5	-V In
6	Reserviert / Mit Schirm verbinden
7	Reserviert / Mit Schirm verbinden
8	-V In
Gehäuse	CAN GND / Schirm

4.3 Connection cable requirements

Toposens recommends only using cables listed in the accessory list available on the website. If other cables are used these minimum requirements need to be observed:

4.3.1 TPU to Sensor connection

Wire gauge	**≥ 0.22 mm² (AWG 24)**
Number of conductors	**8**
Shielding	**Yes, Cu-Mesh**
Permissible operating voltage	**≥ 30 V DC**
Current carrying capacity (all conductors)	**≥ 2 A**
Flammability	**UL 2556 VW-1**

The used connectors must fulfill the following specifications:

Connector type	**M12 A-coded**
Number of contacts	**8**
Shielding	**Yes, cable shield and connector housing**
Permissible operating voltage	**≥ 30 V DC**
Current carrying capacity per contact	**≥ 2 A**
Termination requirements	**Shrouded ferrules or solid wire, max. 0.5 mm² (AWG20)**

⚠Warning

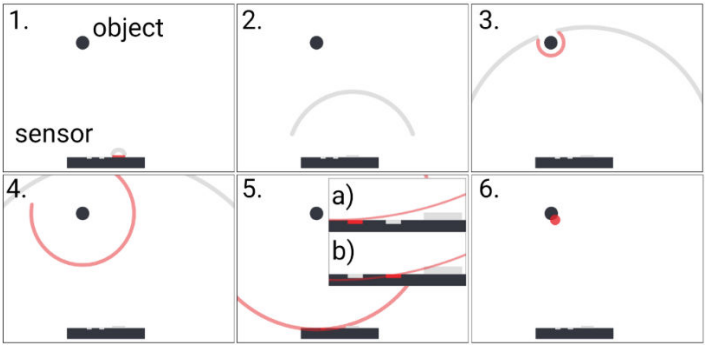
Unsuitable cables or connectors

Using improper cables or connectors may result in malfunction and injury.

- » Observe the minimum requirements for the cables and connectors.
- » Also check the cable and connector requirements that the machine or system places on the wiring.
- » Connectors can reduce the protection class of the sensor.

5 OPERATING PRINCIPLE

The Toposens ECHO ONE sensor extends the time-of-flight principle of conventional ultrasonic sensors by two additional spatial dimensions. At the beginning of each measurement cycle, the transducer in the sensor sends an ultrasonic pulse. This pulse is reflected by surrounding objects and received by multiple microphones on the sensor. Based on the signal propagation time (time-of-flight) measured at each microphone, the positions of the echo sources are calculated as 3D coordinates. These 3D coordinates are output at the end of each measurement cycle.



1	**The transducer (red) sends an ultrasonic impulse.**
2	**The impulse is propagated as a wave through the air.**
3	**The impulse is reflected off an object.**
4	**Part of the echo is refelcted towards the sensor.**
5	**The echo is first detected by the left microphone (a) and then by the right microphone (b).**
6	**The 3D position of the echo source (red circle) is calculated from time-of-flight and the known positions of the individual microphones.**

5.1 Avoidance of Possible Application Errors

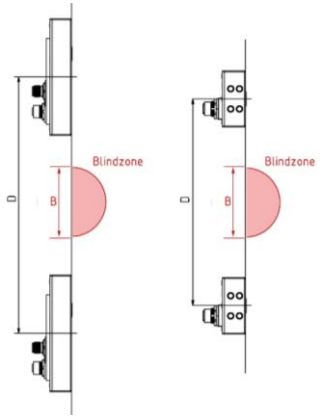
- The sensor system must not be used in a safety function or as a safety component, especially for personal protection.
- The sensor system must not be used in potentially explosive atmospheres.
- The mounting position, the bus structure and the power supply must comply with the requirements of these operating instructions.
- Observe the possible system configurations mentioned in these operating instructions. The use of multiple, independent sensor systems and controllers on one machine is not recommended.
- Do not use the sensor system under environmental conditions that are outside the specification.
- Do not use the sensor system with other, incompatible ultrasonic sensor systems at the same mounting location.

5.2 Performance Characteristics

Technology	3D Ultrasonic Echolocation
Measuring distance	Up to 3000 mm
Field of View	±55 ° horizontally (±80 ° if target <100 cm) ±55 ° vertically (±80 ° if target <100 cm)
Range resolution	Accuracy (typ.): 1 cm Precision (typ.): ±2.5 cm
Positional resolution (azimuth and elevation)	±0.2 cm per degree
Working frequency	40 kHz +/- 1kHz

5.2.1 Multi Sensor Use

It is possible to operate up to 4 ECHO ONE sensors on one CAN-capable processing unit (controller), for example to extend the detection range. It is planned to offer this mode as a feature of the Toposens Processing Unit in the future. The following graphic helps to determine the blind area between the sensors when two sensors are used on one axis:



D: Sensorabstand

B: Blindbereich

$$B = D - 40\ cm$$

If the sensors are installed at a distance smaller than 100cm from each other, there is no blind zone between the devices. If the distance is greater than 100cm, the blind zone can be approximated as a semicircle with its center halfway between the sensors. The diameter of the semicircle is (D - 40) centimeters.

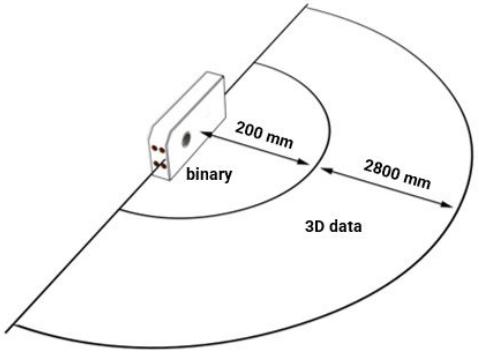
5.2.2 Medium Monitoring Mode (MMM)

The ECHO ONE sensor supports simultaneous operation with other ECHO ONE systems mounted on other vehicles, for example. Mutual interference of independent sensor systems can be assumed, especially if the sensors are facing each other. If the "Medium Monitoring Mode", or "MMM" for short, is activated, measurement time windows are automatically and dynamically allocated among the sensors as long as mutual interference is detected. This may result in a reduction of the measurement rate (measurements per second) for the duration of the interference, the detection capabilities of the sensors are not limited.

The theoretical frame rate R (in Hz) for N sensors is given by the formula "*R = 20 / N*" (for example: in a scenario with 3 active sensors, the average frame rate is around 7 Hz).

NOTE	**Parallel operation of several systems**
	It is not recommended to operate the sensor system without MMM mode activated. If several sensors are used on one machine, they must be connected to the same controller (e.g. Toposens Processing Unit).

5.2.3 Near Field Detection



The ECHO ONE sensor system offers binary object detection as standard in the area up to 200 mm in front of the sensor front. This function prevents the monitored area from being released if an obstacle enters the sensor's close range. This happens, for example, when the autonomous vehicle comes to a stop just in front of the obstacle after braking and stopping. From a distance of >200 mm, the detected reflection points are output as 3D coordinates with corresponding measurement data.

Note: from an installation height of <200 mm, we recommend switching off the close-range detection in the user interface, otherwise triggering via the floor will occur.

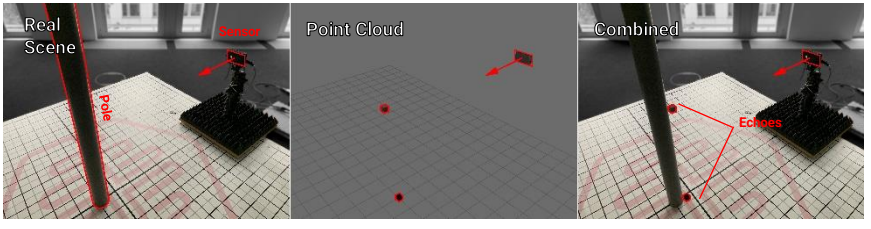
5.3 Output Data

Objects reflect the transmitted signal and generate one or more reflections depending on their shape and size. Due to the short wavelength of ultrasound (less than 1 cm), at least a small part of the object surface must be approximately facing the sensor in order to be able to detect the ultrasonic reflections from a distance. The surface structure and size has a direct influence on the detection distance and the amplitude of the received signal.

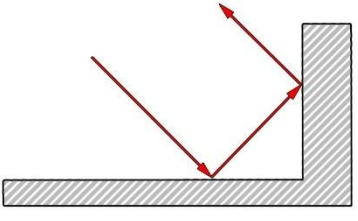
The following examples are used to explain the expected point clouds for a less complex object (e.g. a wall) and a complex object (e.g. a person).

5.3.1 Point Cloud Examples

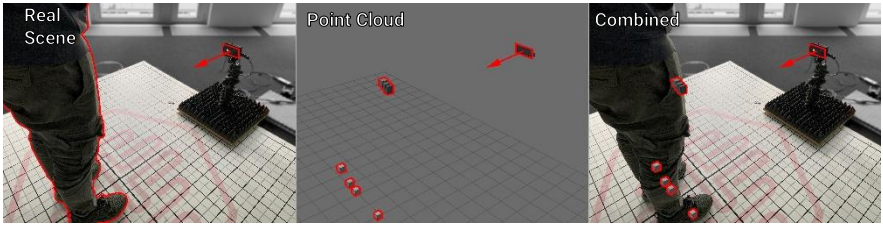
Less complex objects (e.g. walls and bars) consist of a limited number of faces. This results in fewer points per object (see figure below).



Objects positioned on the ground in front of the sensor can be reliably detected by retroreflection. This results in reflection detection at the base of the object.

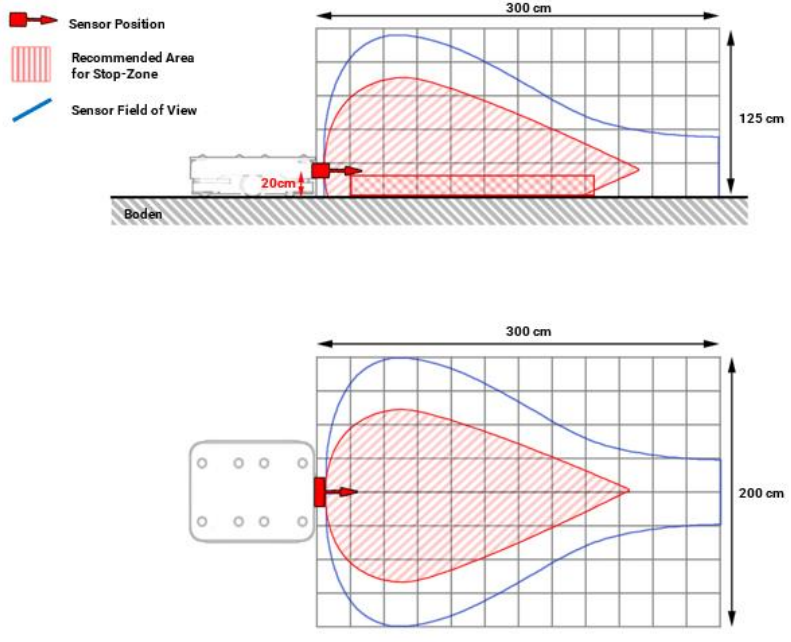


A complex object (e.g. a person) is a composition of several surfaces that form the shape. The sensor detects all surfaces facing the sensor that are large enough to reflect a sufficient amount of sound energy. This results in a point cloud (see figure below).



5.4 Mounting Example

The sensor system can be mounted in different positions, also rotated. The decisive factor here is not only the available installation space but also the desired detection range.



The view shows two different ranges. The area marked in blue corresponds to the maximum measuring range of the sensor. Objects with favorable geometry can be detected well in this range. The red shaded area marks the part of the measuring range in which even weakly reflective objects can be reliably detected. It is recommended to configure the monitored zone within this area and, if necessary, to use several ECHO ONE sensors in a network if the coverage by one sensor is not sufficient.

6 STORAGE AND PACKAGING

6.1 Scope of delivery

1x	ECHO ONE® - 3D Ultrasonic Sensor
1x	Safety Note

6.2 Unpacking

Allow the packed devices to acclimatize in the event of large temperature differences so that no condensation can form, e.g. in the connectors. Use suitable tools when opening the packaging. If a knife is used, ensure a minimum incision depth to avoid damage to the contents. If the packaging is no longer required for later repackaging, please take it to a recycling center.

NOTE	**Secure storage**
	Place the sensor, connectors and accessories on a soft surface before mounting to avoid damage. Do not place the sensor on the front side (microphones, transducers).

6.3 Storage and repackaging

Store the ECHO ONE sensor in a dry environment in the original packaging. The ambient temperature should be between -20° C - 80° C. Do not expose the packed sensor to strong sunlight, aerosols, chemicals or strong smoke or dust.

If you want to repack an ECHO ONE sensor, ideally use the original packaging. If this is no longer available, it is recommended to pack the sensor in a clean plastic bag to prevent dust from entering or scratching the transducer. Remove all accessories that were mounted on the sensor and pack them separately. Make sure that the device is fixed in the packaging (e.g. padding) and that the safety instructions are enclosed.

NOTE	**Secure storage**
	Place the sensor, connectors and accessories on a soft surface before mounting to avoid damage. Do not place the sensor on the front side (microphones, transducers).

7 INSTALLATION

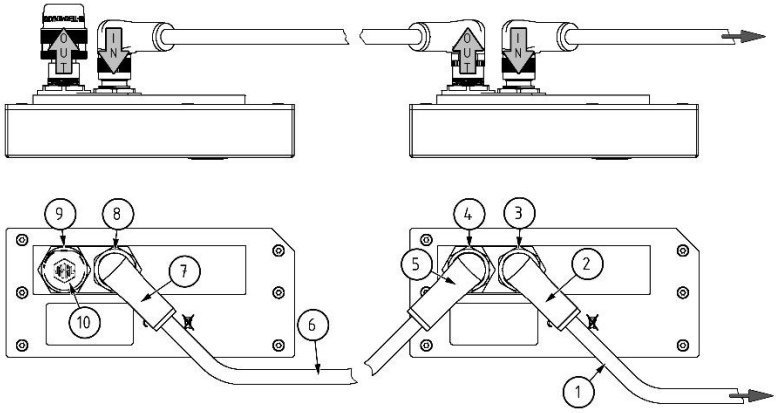
7.1 Preparations

Leave the sensor and accessories in the packaging until the mounting position is prepared. Make sure that the mounting area is free of dirt before mounting. It is recommended to break sharp edges and -if necessary- to use edge protection rubbers to reduce the risk of cutting and to prevent damage to the sensor.

7.1.1 Required tools and accessories

- Allen key (size 3)
- Key for M12 connector
- Mounting bracket with screws M5x6 (available via Toposens)
- Screws for fastening the bracket to the mounting location
- Terminator for the last sensor of the network

7.2 System Structure

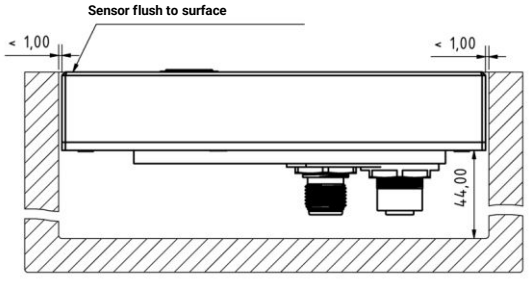


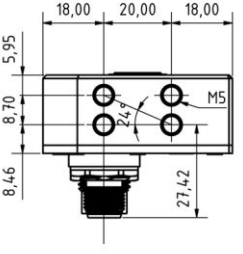
Nr.	Beschreibung
1	Shielded connection cable sensor to TPU (e.g. M12FS, M12FA, M12BO)
2	M12 A-coded cable socket with 8 contacts (included in M12FS, M12FA, M12BO)
3	M12 A-coded device connector with 8 contacts - Input connector (On sensor)
4	M12 A-coded device socket with 8 contacts - Output connector (On sensor)
5	M12 A-coded cable connector with 8 contacts (Included in M12EX)
6	Shielded connection cable between the sensors (Included in M12EX)
7	M12 A-coded cable socket with 8 contacts (Included in M12EX)
8	M12 A-coded device connector with 8 contacts - Input connector (On sensor)
9	M12 A-coded device socket with 8 contacts - Output connector (On sensor)
10	M12 120 Ohm Terminator (M12MT)

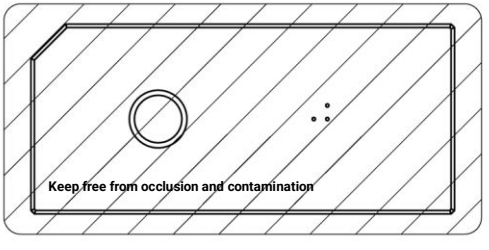
7.3 Mechanical Installation

The sensor is equipped with eight threaded sleeves with an M5 thread according to DIN13-1 for mounting. We recommend screws according to ISO 4762, an immersing thread length of 5 mm and a maximum tightening torque of 2.5 Nm.

The mounting surface must be load-bearing and should not vibrate or oscillate strongly during normal operation of the machine.







WARNING

Danger due to unintentional restart

If the sensor system is mounted on a machine, follow the operating instructions of the machine or system to bring it into a safe condition in which the safe mounting of the sensor is possible and a restart, during the work is excluded. Observe the applicable rules of occupational health and safety as well as the safety regulations for electrical systems.

NOTE

Damage of the connector in humid environments

The connected M12 screw connector is moisture or dust resistant only when screwed tight and may only be connected or disconnected in a dry environment and in a dry state.

Make sure that both connections are occupied by cables or a terminator. Open connections are not moisture or dust resistant and reduce the device protection class to IP20.

NOTE

Damage to the threaded sleeves

The integrated threaded sleeves can break out of the housing if the tightening torque is too high.

- » Only use the appropriate screws - See accessories list.
- » The screws must not be tightened beyond a tightening torque of 2.5 Nm.

NOTE

Damage to the connection cables

The connection cables can be damaged if the wrong procedure is followed during installation or operation.

- » Do not tension the cables during installation.
- » Do not subject the cables to tensile stress.
- » Do not pull the cables over sharp edges.
- » Observe the minimum bending radius of the cables.
- » If the cable is repeatedly moved or guided in a drag chain, it must be suitable for this.

NOTE

Inadequate sensor mounting

The sensor may be damaged if it is not fastened properly.

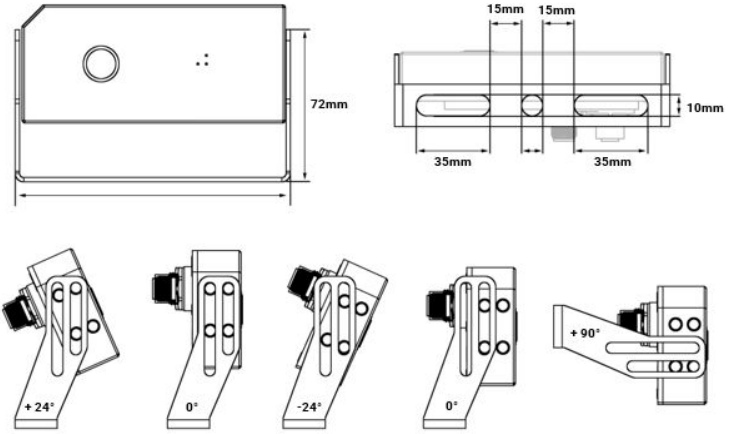
- » Always fasten the sensor on both sides.
- » If a C-bracket is used, it is recommended to attach it to the mounting surface at at least two points.
- » If two L-brackets are used, attach them to the mounting surface at two points each.
- » If vibrations are expected, use a medium-strength threadlocker for brass sleeves.

NOTE	Installation conditions of the sensor
	» Keep the sensor front free of obstructions. » When installing the sensor in a recessed position, make sure the sensor front is installed flush with the mounting surface. » A gap >1mm around the sensor may reduce detection capability. » Depending on the installation situation, calibration of the sensor may be necessary.

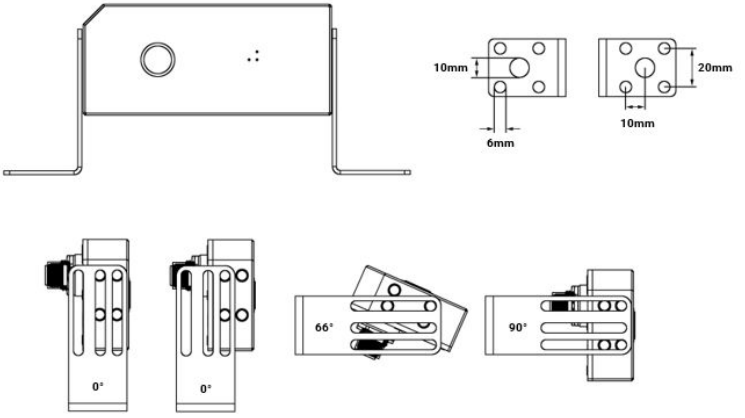
7.4 Installation via Mounting Brackets

For the installation of the ECHO ONE sensor, the metal mounting devices shown in the following figures are available:

C-bracket: EOBRC



L-bracket: EOBRL



7.5 Electrical Installation

⚠WARNING **Electrical Voltage**

The connector complies with protection class IP67 only when connected. Electrical voltage can cause serious or fatal injuries.

- » In damp or wet environments, switch off the power supply and dry the sensor and all connected components before electrical installation.
- » Ensure that the sensor connectors are always kept dry when unplugged.
- » Observe the applicable rules of occupational health and safety as well as the safety regulations for electrical installations.

⚠WARNING **Electric Shock**

Potentially dangerous voltages are used inside the housing of the device during operation. Electrical voltage can cause serious or fatal injuries.

- » The housing must not be opened.
- » The sensor must not be modified.
- » The housing must be protected from damage.
- » If the housing, the cable, the seals or the connected accessories are damaged, the sensor must be disconnected from the power supply and may only be put back into operation after repair and testing by the manufacturer (Toposens GmbH).

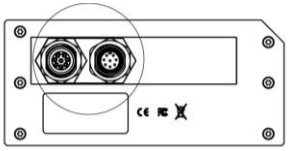
7.5.1 Connection instructions

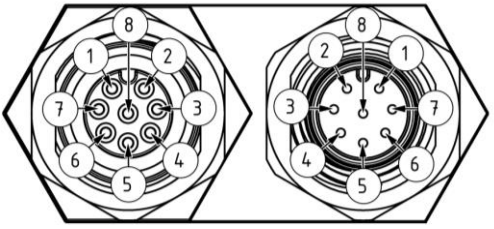
Observe the following instructions for safe and trouble-free operation:

- Connect the connecting cables in a de-energized state. The supply voltage must not be switched on until the installation has been completed and all connection cables have been connected to the device and accessories.
- The connecting cables used must at least meet the requirements from section 7.5.
- The sensor must be protected by a slow-blow fuse with a nominal value of 2 A, which should be located as close as possible to the power supply source.
- All circuits connected to the device must be designed as circuits with safety extra-low voltage (SELV) or functional extra-low voltage with electrically safe isolation (PELV).
- The device is not intended for connection to the AC mains.
- The device is intended for operation on a fused DC power source, with a voltage range of 10-30V, capable of providing a minimum current of 700mA per sensor.
- For mounting, use suitable cable plugs and sockets or protective caps, which have the necessary voltage and current carrying capacity. The device protection type also depends on the cable plug and socket protection type.
- For reasons of protection against accidental contact, the bus running direction must be designed according to the following principle: The plug of the sensor is used for feeding, the socket for connecting further sensors or for terminating the bus with a suitable terminator.
- To achieve the best signal integrity, it is strongly recommended to use a shielded connection cable (see accessories list, section 13) and to connect contacts 6 & 7 on controller side with this shield. The shield potential is galvanically isolated from the power supply and serves as ground potential for the CAN bus.
- Before connecting cables or devices to the sensor, check the configuration, pin assignment and voltage ranges.

- The connection cables must not be subjected to tensile stress, it is recommended to install strain reliefs and to plan for relaxation loops.
- Observe the minimum bending radius of the cables used.
- Do not pull cables over sharp edges and use edge protectors if necessary.

7.5.2 Plug and Socket assingment





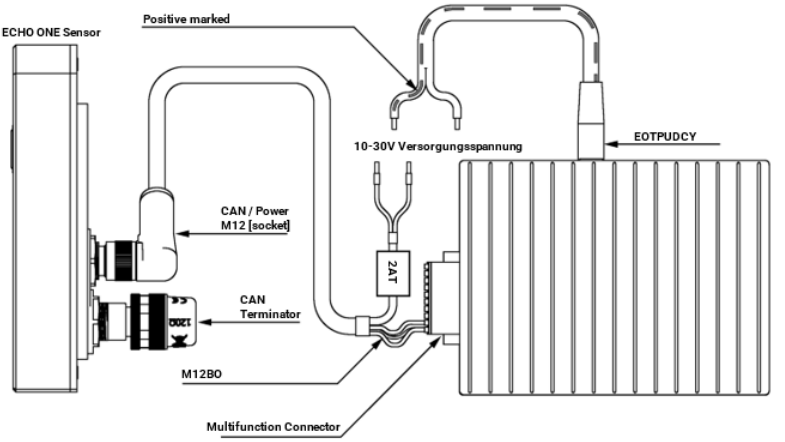
M12 A-coded 8-pin socket

Pin No.	Function
1	+V Out
2	+V Out
3	CAN High
4	CAN Low
5	-V Out
6	Reserved / Connect to shield
7	Reserved / Connect to shield
8	-V Out
Gehäuse	CAN GND / Shield

M12 A-coded 8-pin plug

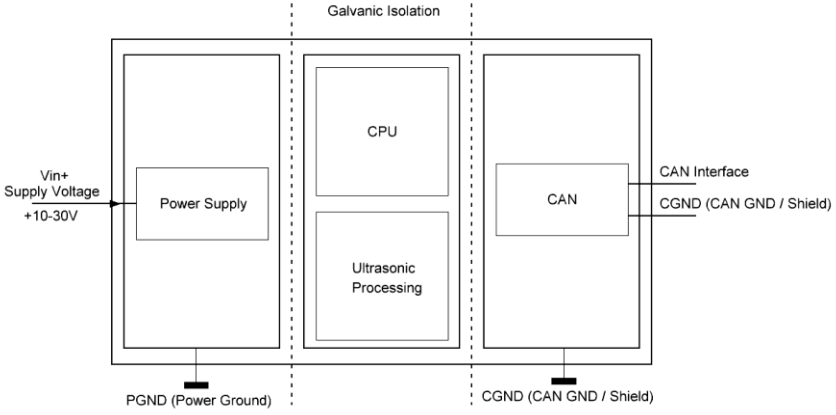
Pin No.	Function
1	+V In
2	+V In
3	CAN High
4	CAN Low
5	-V In
6	Reserved / Connect to shield
7	Reserved / Connect to shield
8	-V In
Gehäuse	CAN GND / Shield

7.5.3 Wiring Diagram Single Sensor with TPU



For further information on commissioning the system, please refer to the documentation for the Toposens Processing Unit.

7.5.4 Insulation concept



The ECHO ONE sensor has a galvanic isolation between the ground potential of the power supply and the CAN interface. This safety measure serves the signal integrity and prevents ground equalization currents between controller and power supply via the sensor bus.

NOTE

High compensating currents

Make sure that the potential difference between power supply ground potential and communication ground potential is not higher than 30V, otherwise the maximum permissible operating voltage of the M12 connectors could be exceeded.

8 STARTUP

8.1 Startup Checklist

Check	Zu Überprüfen
	The sensor shows no optical damage.
	The sensor is not dirty.
	Polarity of the power supply is correct.
	The supply voltage is between 10 - 30 V DC.
	The power supply can apply a minimum current of 700mA per sensor without voltage drop.
	The supply line contains a fuse element (max. 2AT).
	Both M12 slots on the sensor are occupied.
	The cable used complies with the specification.
	The CAN bus is terminated with a terminator.
	The CAN bus is also terminated (120 Ohm) in the controller, such as the Toposens Processing Unit.
	CAN_H, CAN_L and CGND (cable shield) are connected correctly.
	The cable length of the superstructure is less than 30m total length.
	A maximum of 4 sensors are connected to the CAN bus.
	No external devices are connected to the CAN bus.
	Sensor and controller are firmly mounted according to the mounting instructions of both devices.
	The mounting surface is load-bearing and does not vibrate during operation of the machine. It is suitable for mounting sensors in accordance with the operating instructions.
	The near field of the sensor(s) is free of objects.
	The sensors are either mounted protruding on a surface or recessed flush into it with a circumferential slit <1mm.
	The connectors are free from contamination.
	The connectors are tightened to the specified tightening torque (2.5 Nm).

8.2 First Startup

Perform installation according to section 7.

Go through the commissioning checklist in this section.

Start the Toposens Processing Unit/Controller.

Activate power supply from sensor bus.

For further steps, refer to the documentation of the Toposens Processing Unit or the controller used. Please note that a functional test and, depending on the installation situation, a calibration of the near field detection (installation height <200 mm) are necessary before using the system.

⚠WARNING **Danger of ultrasonic emissions**

Ultrasonic emissions can be irritating to animals and put them in dangerous situations.

- The sensor may trigger and/or interfere with other ultrasonic devices (e.g. alarm systems). This can lead to dangerous situations.
- The sensor can be triggered and/or obstructed by other ultrasonic devices. This can lead to unreliable detection results.
- Observe the local ultrasonic exposure limits.
- During operation, do not point the sensor at people or animals from close range.
- Do not hold the sensor close to the ear, maintain a minimum distance of 150 mm.
- Do not touch the ultrasonic transmitter or the microphone array when the sensor is in operation.
- Do not operate the sensor near other, non-compatible ultrasonic devices.

⚠WARNING **Electrocution**

Electrical voltage can cause serious or fatal injuries.

- » The housing must not be opened.
- » The sensor must not be modified.
- » The housing must be protected against damage.
- » If the housing, the cable, the seals or the connected accessories are damaged, the sensor must be disconnected from the power supply and may only be put back into operation after repair and inspection by the manufacturer (Toposens GmbH).

8.3 Checking the correct function

After the system has been switched on, the sensor performs various environmental measurements and self-tests. This process takes a maximum of five seconds. A controller, such as the Toposens Processing Unit, and its documentation are required to check the functionality. The system must not be released without a functional check.

9 MAINTENANCE

⚠WARNING **Danger of ultrasonic emissions**

Ultrasonic emissions can be irritating to animals and put them in dangerous situations.

- » The sensor may trigger and/or interfere with other ultrasonic devices (e.g. alarm systems). This can lead to dangerous situations.
- » The sensor can be triggered and/or obstructed by other ultrasonic devices. This can lead to unreliable detection results.
- » Observe the local ultrasonic exposure limits.
- » During operation, do not point the sensor at people or animals from close range.
- » Do not hold the sensor close to the ear, maintain a minimum distance of 150 mm.
- » Do not touch the ultrasonic transmitter or the microphone array when the sensor is in operation.
- » Do not operate the sensor near other, non-compatible ultrasonic devices.

⚠WARNING **Electrocution**

Electrical voltage can cause serious or fatal injuries.

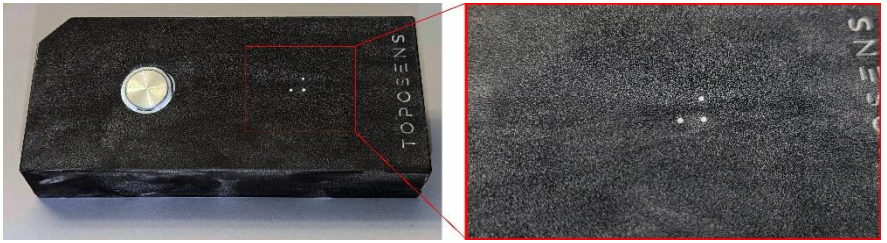
» The housing must not be opened.

» The sensor must not be modified.

» The housing must be protected against damage.

» If the housing, the cable, the seals or the connected accessories are damaged, the sensor must be disconnected from the power supply and may only be put back into operation after repair and inspection by the manufacturer (Toposens GmbH).

9.1 Cleaning



- Sensor cleaning can be carried out in the installed state if the power supply has been switched off beforehand and the machine in which the sensor system is integrated has been set to a safe state.
- Clean the sensor with water.
- Use soft material (e.g. a lint-free cloth) to remove dirt from the sensor.
- Use compressed air at low pressure (max. 4 bar/60 psi at 20 cm distance) to clean the microphone openings.

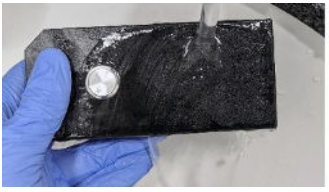
NOTE

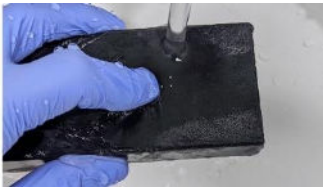
Sensor damage due to incorrect cleaning

Seals can be damaged by aggressive chemicals. Aggressive chemicals, pointed objects or abrasive cleaning agents can damage the sensor or its components.

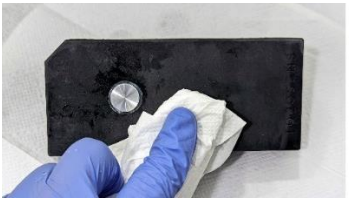
- » Do not use aggressive chemicals.
- » Do not use sharp objects to clean the microphone openings.
- » Do not use abrasive cleaning agents, cloths or brushes to clean the sensor.

Using a soft, lint-free cleaning cloth or gloved finger, loosen dirt trapped in the microphone openings by making circular motions over the microphone openings. Lightly tapping the microphones can help increase pressure in the openings and loosen additional dirt. Use a soft, lint-free cloth for cleaning. Do not use corrosive or solvent-based cleaners or alcohol.





After cleaning the microphone openings, dry the sensor with a paper towel. Blow excess water out of the microphone openings with a little compressed air. Do not shake the sensor strongly to remove liquid residues.



9.2 Maintenance Measures

⚠WARNING **Unsuitable maintenance measures**

The device does not contain any internal components intended for user maintenance. External maintenance, such as visual and functional checks and cleaning, must be performed by qualified personnel according to the procedures described below.

It is recommended to carefully check the sensor housing, microphone openings, connected cables and connectors during installation and at regular intervals of maximum 6 months. If the sensor system is used in a harsh environment (heavy pollution, dust), it is recommended to shorten the inspection interval.

If parts of the acoustic system are covered or damaged, the output data may be corrupted or the function may be lost. If the microphone openings are covered with dust or dirt, use the method described in this section to restore correct sensor function.

Dents or deep scratches on the transducer reduce the performance capability. A damaged transducer can only be replaced by the manufacturer.

In case of defective connectors, housing cracks or damaged cables, please contact Toposens (support@toposens.com) and take the device out of operation.

Device	Wartungsaufgaben	Interval	Implementation by
ECHO ONE Sensor	Cleaning the microphone openings	As needed	Trained staff
ECHO ONE Sensor	Cleaning the transducer surface	As needed	Trained staff
General	Visual inspection of the sensor for mechanical stability	Every 6 months	Trained staff
	Visual inspection of the microphone openings	Every 6 months	Trained staff
	Visual inspection of the transducer surface	Every 6 months	Trained staff
	Visual inspection of the wiring for damage, loose connections and water ingress.	Every 6 months	Trained staff

NOTE

Connectors damaged by corrosion

Die Steckverbinder entsprechen im verschraubten Zustand der Schutzart IP67. Dringt bei der Installation Feuchtigkeit in die Steckverbinder ein, kann es zu Korrosion kommen.

- » Sensoren mit beschädigten Steckverbindern müssen unverzüglich außer Betrieb genommen werden.
- » Ersetzen Sie defekte Kabelsteckverbinder nur im stromlosen Zustand.
- » Ersetzen Sie defekte Steckverbinder nur mit solchen, die der Spezifikation entsprechen.
- » Die Steckverbinder am Gerät selbst können nicht gewechselt werden.

NOTE

Loose, damaged or discolored cables

Beschädigte Kabelisolierungen können zu Kurzschlüssen und zur Beschädigung des Sensors, des Controllers und der Maschine führen, an der das System montiert ist.

- » Beschädigte Kabel und Zubehörteile müssen unverzüglich außer Betrieb genommen werden.
- » Ersetzen Sie defekte Kabel nur im stromlosen Zustand.
- » Ersetzen Sie defekte Kabel nur mit solchen, die der Spezifikation entsprechen.

NOTE

Loose or damaged sensor

Unreliable data due to a loose or damaged sensor can result in damage to the machine or vehicle.

- » The sensor must be installed securely.
- » When installing in an environment with constant vibration, the sensor must be mounted with screw lock and the bracket must be mounted with self-locking screws.
- » Check compliance with the mounting guidelines.

NOTE

Contamination/damage of transducer or microphones

- » Scratches or dents to the transducer will reduce sensor performance.
- » Damage to the microphones will cause the sensor to lose function.
- » If the acoustic elements are obscured by dust or dirt, remove the sensor according to the procedure in this section.

9.3 Firmware Update

9.3.1 Update Using Toposens Processing Unit (TPU):

The instructions for updating the sensor firmware can be found in the operating manual of the Toposens Processing Unit (TPU).

9.3.2 Update Using Third Party Controller

The Toposens Python Library can be used to update the sensor firmware.

The Toposens Python Library and further information can be found at: www.toposens.com

9.4 Troubleshooting

⚠WARNING **Danger due to malfunctions**

Sensor malfunctions can lead to dangerous situations.

» In the event of unidentifiable malfunctions, stop operation and contact Toposens Support (support@toposens.com).

⚠WARNING **Danger due to unintentional restart**

Wird das Sensorsystem an einer Maschine montiert, folgen Sie der Betriebsanleitung der Maschine oder des Systems, um sie in einem sicheren Zustand zu bringen, in dem die gefahrlose Montage des Sensors möglich ist und ein Wiederanlauf, während der Arbeiten ausgeschlossen ist. Beachten Sie die geltenden Regeln des Arbeitsschutzes sowie die Sicherheitsvorschriften für Elektrische Anlagen.

Situation	Possible cause	Remedy
The sensor is not found by the controller on the CAN bus.	No supply voltage available or supply voltage too low. Bus topology and/or termination faulty.	Check power supply and fuses. Check the structure and termination of the CAN bus.
The sensor does not respond to commands from the TPU.	The sensor cannot be addressed via its address.	Remove the sensor in the TPU configuration and pay attention to the correct CAN address when adding it again.
No communication possible.	Use of incorrect/damaged cables. The CAN bus is not terminated properly. The cable used does not meet the specifications. Third-party devices are connected to the CAN bus.	Set up CAN BUS according to topology diagram and connect terminator to last sensor (see accessories list). If self-manufactured cables are used, cables from the following manufacturers can be considered: Lapp UNITRONIC® BUS CAN 2x0,22 HELUKABEL 81286 2x0,22 Lapp UNITRONIC® FD CP plus A 2X0,25
The sensor reacts with empty images or low data quality.	The sensor is contaminated or water is trapped in the microphone openings.	Check the sensor for occlusion by dirt or water and clean/dry if necessary.
	The sensor configuration has been changed to unsuitable values.	When using the Toposens Processing Unit, the "Default Parameters" can be changed back at any time. If the sensor is used alone, the "Filter" setting is incorrect and should be reset to the value: 1.0.
The data output is unreliable.	The sensor connection is loose or damaged. Third party devices or more than 4 sensors are connected to the CAN bus. The total cable length is greater than 30 meters.	Check the sensor connection. Tighten the connection if necessary or replace it if damaged. Set up a dedicated CAN network for the sensor. Shorten the cable length between host and sensor.
The sensor or third-party devices behave differently than expected.	The sensor is connected to a CAN bus shared with other devices.	Set up a dedicated CAN bus for the sensor.

9.4.1 Technical Support

E-Mail	Support@Toposens.com
Anschrift	Toposens GmbH Lyonel-Feininger-Straße 28 80807 München

9.5 Decommissioning

9.5.1 Switching off the Sensor

If you wish to install, maintain or remove the ECHO ONE system, the machine or the vehicle in which the system is or has been integrated must be placed in a condition in accordance with the operating instructions that excludes any danger during the work. Switch off the power supply before connections are made or released. If the collision avoidance system (consisting of the ECHO ONE sensor and the Toposens Processing Unit) has been connected to the machine control system via I/O signals, these connections may also be live.

⚠WARNING **Electrical voltage**

Der Steckverbinder entspricht nur im gesteckten Zustand der Schutzart IP67. Elektrische Spannung kann schwere oder tödliche Verletzungen verursachen.

- » In feuchten oder nassen Umgebungen vor der elektrischen Installation die Stromversorgung abschalten und den Sensor und alle angeschlossenen Komponenten trocknen.
- » Stellen Sie sicher, dass die Sensorsteckverbinder im ungesteckten Zustand stets trocken gehalten werden.
- » Es sind für die Strom- und Spannungsbelastung geeignete Kabel sowie eine Bussicherung zu verwenden.
- » Stellen sie sicher, dass die Spannungsversorgung erst eingeschaltet wird, wenn alle Verbindungen hergestellt sind.
- » Beachten Sie die geltenden Regeln des Arbeitsschutzes sowie die Sicherheitsvorschriften für Elektrische Anlagen.

⚠WARNING **Electrocution**

Electrical voltage can cause serious or fatal injuries.

- » The housing must not be opened.
- » The sensor must not be modified.
- » The housing must be protected against damage.
- » If the housing, the cable, the seals or the connected accessories are damaged, the sensor must be disconnected from the power supply and may only be put back into operation after repair and inspection by the manufacturer (Toposens GmbH).

9.5.2 Disposal

The applicable national regulations for electronic components must be observed during disposal.

This Toposens product complies with the requirements of the EU Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment ("RoHS recast" or "RoHS 2").

The symbol on the device or on the packaging indicates that the device may harm the environment at the end of its life cycle. The device must not be disposed of in unsorted municipal waste. Disposal must be carried out properly in accordance with the locally applicable regulations. The device must be returned to the appropriate dealer or disposed of at a local recycling company. In case of doubt, contact the local waste disposal authorities.

WEEE-Reg.-Nr. DE 39801091

NOTE

Danger to the environment due to improper disposal

Improper disposal of the device may cause environmental damage.

» Observe the valid environmental regulations.

10 TECHNICAL DATA

10.1 Parameters

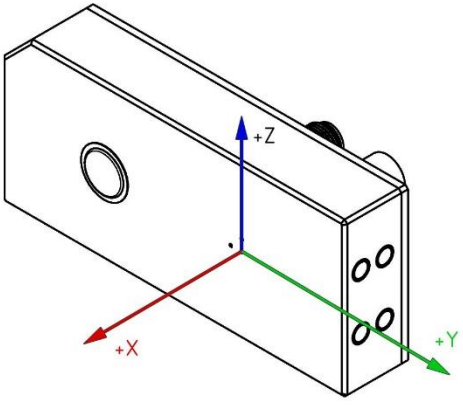
Features	
Technology	3D ultrasound sensor
Measuring distance	Up to 3,000 mm
Field of view	Up to ±80° horizontal Up to ±40° vertical
Distance resolution	1 cm (without atmospheric disturbances) 5 cm Nominal value
Position resolution (azimuth and elevation)	±3 cm at 100 cm distance ±6 cm at 200 cm distance ±8 cm at 300 cm distance
Signal source	40 kHz ±1 kHz, 90 dBSPL (peak) at 1 m distance

Performance	
Max. Number of points	Max. 40 points per image
Response time	< 400 ms
Start-up delay	< 5000 ms

Operating voltage	12 V DC
Operating voltage range	10 V - 30 V DC
Current consumption typ. (12 V)	170 mA
Peak current consumption (12V)	700 mA
Avg. Power consumption (12V)	2.0 W
Fuse elements	Fine device protection (fuse) Bus fuse for output socket Reverse polarity protection Overvoltage protection Galvanic isolation between communication and power supply
CAN	ISO 11898-2:2016/CAN 2.0A
Connection type input	M12 A-coded, 8 pin, connector
Connection type output	M12 A-coded, 8 pin, socket
Termination	120 Ohm, via pluggable terminator

Environmental data	
Ambient operating temperature	0 °C - 55 °C
Storage temperature	-20 °C - 80 °C
Housing protection type	IP67

Mechanical data	
Outer dimensions [L x W x H]	42 mm x 126 mm x 52 mm
Weight	180 g (without cable)
Minimum installation height	200 mm



Sensor coordinate system

11 MEASUREMENT CURVES

The following graphs show the expected aperture angles of the sensor system as a function of the target object. The field of view measurements were performed in a laboratory environment in two procedures:

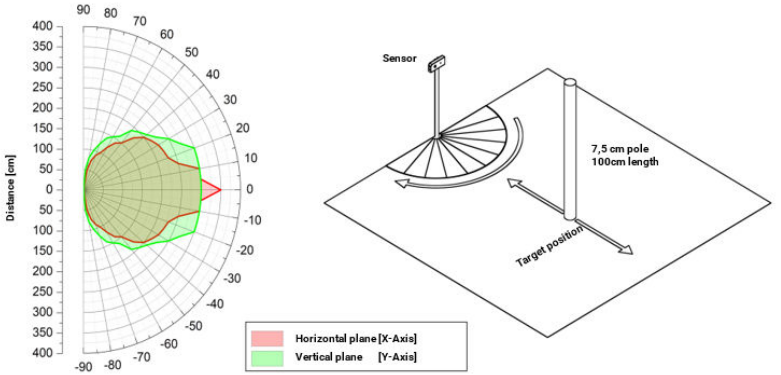
Measurement method: Rotation measurements

The sensor is positioned at a defined height of 50cm above ground level. The sensor is mounted on a rotating platform that can rotate the sensor horizontally from -90° to +90° in 5° increments. The target object is positioned at various distances from the sensor along the 0° X-axis position of the sensor. 100 measurements are taken per rotation step. The expected spatial volume of the target position is monitored. Positions with a detection rate of > 95 % are displayed graphically. To measure the vertical field of view, the sensor is rotated 90° around its Z axis and the measurement is repeated.

Measurement method: Lateral measurements

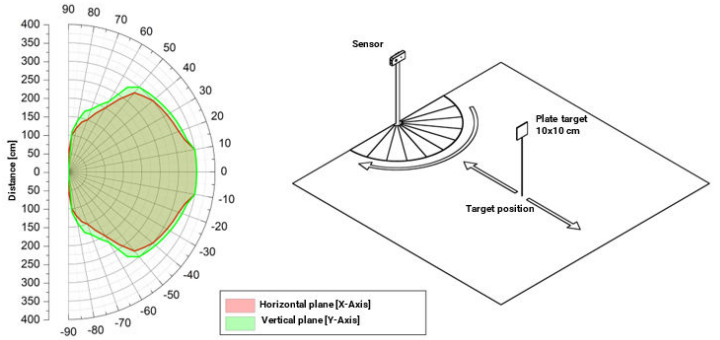
The sensor is mounted on a moving vehicle at a defined height of 30cm above ground level. The target object is placed with a fixed position at the opposite end of the measuring range and is adjustable in height. The measurement is performed by moving the sensor past the object on lateral paths with different distances. Positions with a detection rate of > 95 % are displayed graphically. To measure the vertical field of view, the target object is adjusted in height and the measurement is repeated.

11.1 Rotation measurement standard pole target



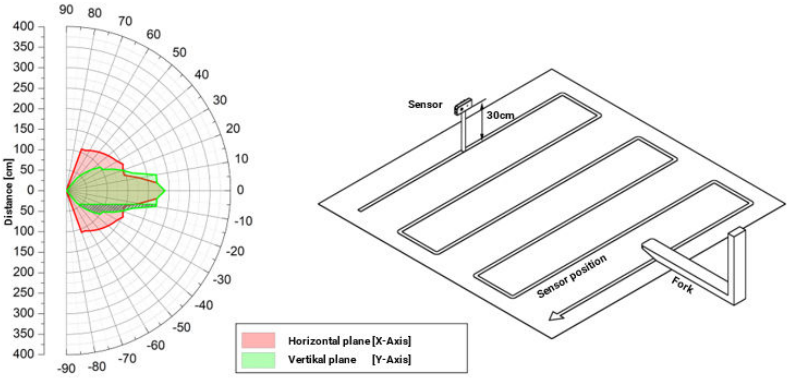
Expected field of view of the sensor for cylindrical bodies with a diameter of 75 mm.

11.2 Rotation measurement with plate target



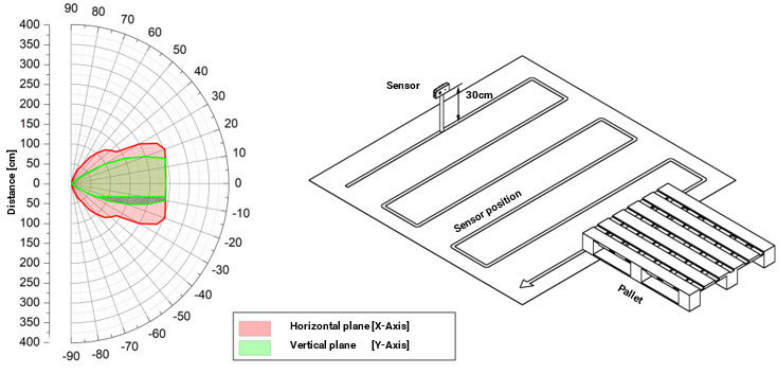
Expected field of view of the sensor for areas of at least 100 cm² aligned with the sensor.

11.3 Lateral measurement with forklift fork target



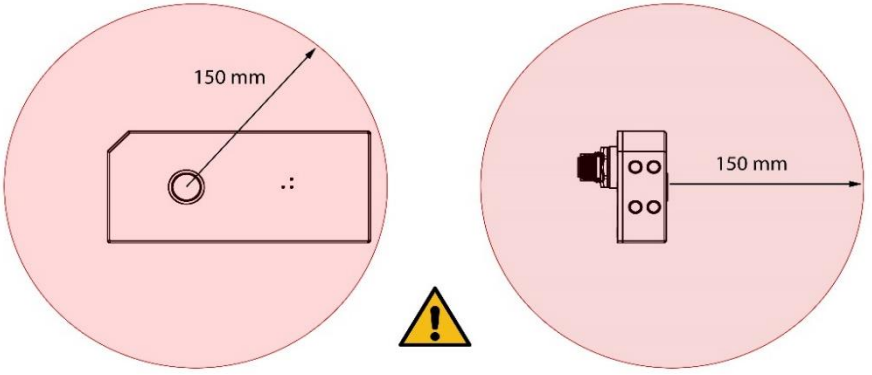
Expected field of view for forks in direct approach. The area shaded gray in the graphic is below the ground and was interpolated from the available data.

11.4 Lateral measurement with pallet target



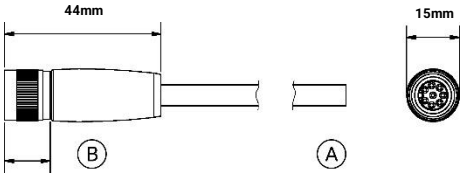
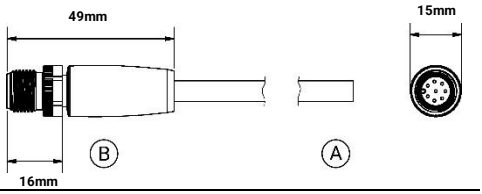
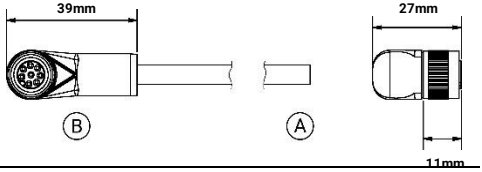
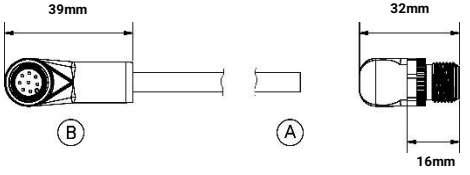
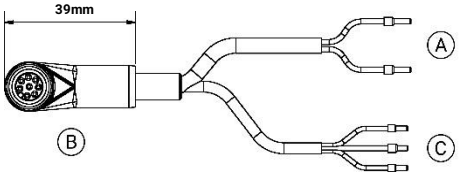
Expected field of view for the detection of Euro pallets in direct approach to the 800 mm wide side of the pallet.

11.4.1 Safety distance due to ultrasonic emissions



Always maintain a safety distance of at least 150 mm from the ultrasonic transducer and do not touch the sensor face when the sensor is in operation.

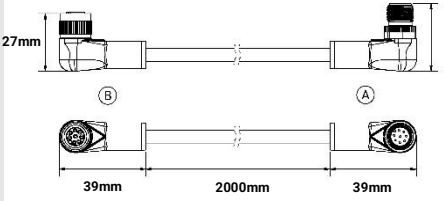
12 ACCESSORIES LIST

Article description	Picture
M12FS **Input side sensor connection cable** 2m cable length 6mm cable outer diameter Conductor cross section 0.22 mm² Shielded version End A: Open End B: Straight, M12a cable socket	
M12MS **Output side sensor connection cable** 2m cable length 6mm cable outer diameter Conductor cross section 0.22 mm² Shielded version End A: Open End B: Straight, M12a cable connecto	
M12FA **Input side sensor connection cable** 2m cable length 6mm cable outer diameter Conductor cross section 0.22 mm² Shielded version End A: Open End B: Angled, M12a cable socket	
M12MA **Output side sensor connection cable** 2m cable length 6mm cable outer diameter Conductor cross section 0.22 mm² Shielded version End A: Open End B: Angled, M12a cable connector	
M12BO **Input side sensor port resolution** 2m cable length Conductor cross section power supply 2x 0.5 mm² Conductor cross-section data 2x 0.25 mm² Shielded version End A: End ferrules 2x 0.25 mm² End B: Angled, M12a cable socket End C: End ferrules 2x 0.25 mm² & 1x 0.5 mm²	

M12EX2

Sensor patch cable

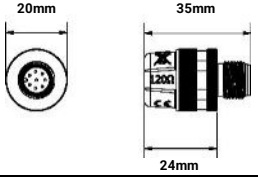
2m cable length
6mm cable outer diameter
Shielded version
End A: M12a cable plug angled
End B: M12a cable socket angled
Conductor cross section 8x0.22 mm²



M12MT

120 Ohm terminating resistor

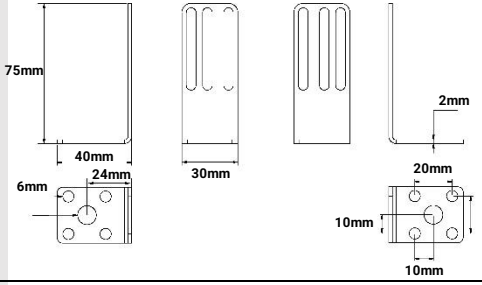
M12a connector
Directly screwable to the sensor
IP67



EOBRL

2x L-brackets for through-hole and surface mounting

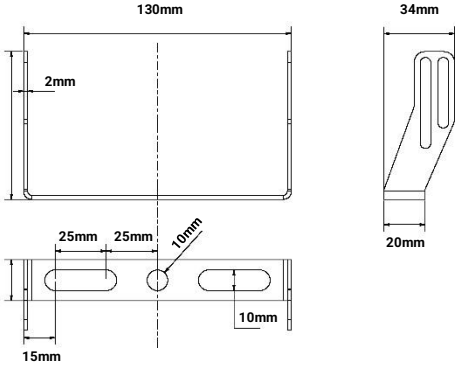
Coated steel
Color: RAL 9005 Matt



EOBRC

C-bracket for rotatable surface mounting

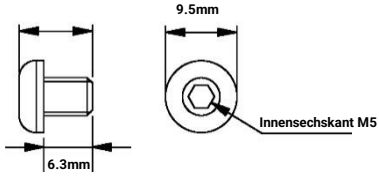
Coated steel
Color: RAL 9005 Matt



EOSCW

Screw set 8x M5x6

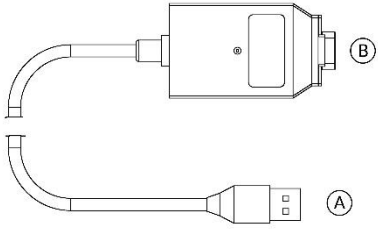
Hexagon socket screw
Black passivated steel
Strength class 10.9
Wrench size 3



CANUSB

USB-CAN Adapter

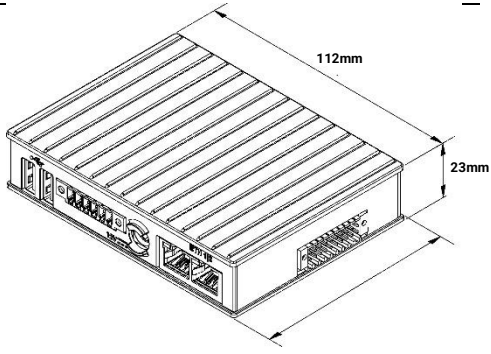
End A: USB-A connector
End B: D-SUB 9 connector
Assignment according to CIA 303-1



EOTPU

Toposens Processing Unit (TPU)

4x digital inputs and outputs (24V)
1x Ethernet 10/100 (RJ45)
1x Ethernet 10/100/1000 (RJ45)
3x USB-A interface
RS485 & RS232
Versatile mounting options



EOTPUETH

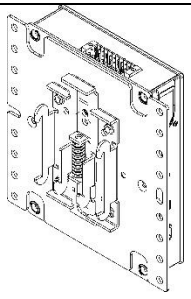
CAT 6a Ethernet Kabel

Cable length 0.5m
End A: RJ45 plug
End B: RJ45 plug

EOTPUDIN

Top-hat rail adapter for flat mounting of the TPU

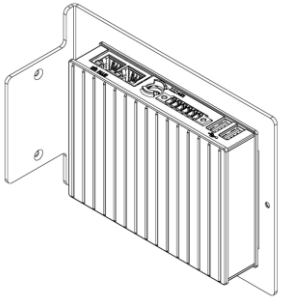
Spring pressure system
Space requirement with TPU: 5TE



SDIN

Top-hat rail adapter for side mounting of the TPU

Spring pressure system
Space requirement with TPU: 3TE



Toposens offers customized connection cables for an additional charge. Contact our sales department for a quote: sales@toposens.com

13 CONFORMITY & FURTHER INFORMATION

To facilitate integration, the EU declaration of conformity and further evidence, test reports and certificates can be provided on request. You can reach us for this purpose via e-mail at: support@toposens.com

NOTE	Online resources
	Further documentation on this device can be found on the online product page at: www.toposens.com » Model-specific online data sheets with technical data, dimensional drawings, templates and specification diagrams. » 3D CAD dimensional models in various formats » Additional resources related to the devices described herein » Resources related to accessories

Contact and additional documents	
Software and application packages	www.toposens.com/members
Support	support@toposens.com
Sales	sales@toposens.com

Toposens GmbH

Lyonel-Feininger-Straße 28
80807 München

www.toposens.com.

+49 (0) 89 237 515 40

Dokumentversion: 1.0
Veröffentlichungsdatum: Januar 2023