Annex acc. to FCC Title 47 CFR Part 15
relating to
mecorad GmbH
1224-FCC

Annex no. 4
User Manual
Functional Description

Title 47 - Telecommunication
Part 15 - Radio Frequency Devices
Subpart C – Intentional Radiators
Measurement Procedure:
ANSI C63.4-2014
ANSI C63.10-2013

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User manual/ Functional description of the test equipment (EUT)

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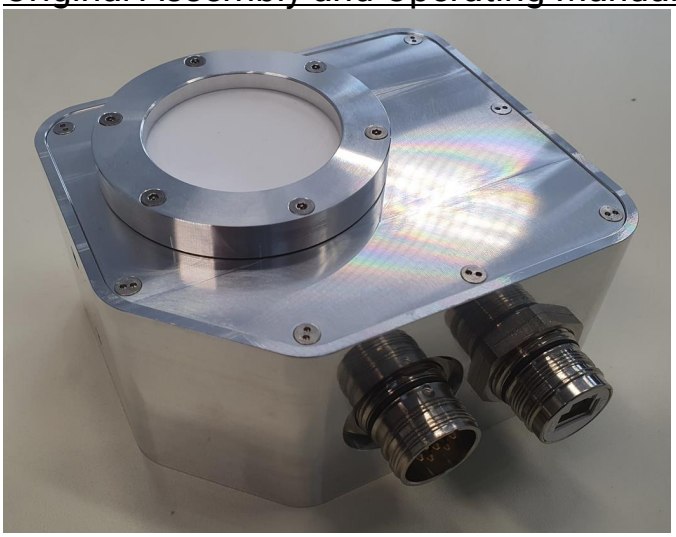
mecorad

Original Assembly and Operating Manual in Englisch Language



1224

Radar Sensor unit for Industrial Use

Legal Notice

Original: Assembly and Operating Manual in English Language
Device designation: Radar Sensor unit (Type: 1224) for Industrial Use

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Subject to technical changes

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Glossary

Term	Description
Sensor unit	Complete sensor unit consisting of: Housing, supply PCB PoE, radar frontend, dielectric lens, calculation unit, relay and plug connector
Radar frontend	Radar frontend built in sensor unit
Supply PCB	Printed circuit board for power supply, communication and calculation unit
PoE	Power over ethernet
PoE-Switch	Ethernet switch with PoE power supply
Dielectric lens	Lens for focusing the radar waves
Relay output	Relay output of sensor unit
FMCW	Frequency modulated continuous wave
VCO	Part of the radar frontend: Voltage controlled oscillator
TX antenna	Transmitting antenna
RX antenna	Receiving antenna
Mixer	Mixer of the radar frontend
ADC	Analog to digital converter
Calculation unit	Calculation unit as part of the sensor unit 1224
Web interface	Commissioning/configuration and status interface of the sensor unit
Web browser	
NO	Normal-open contact of relay
NC	Normal-closed contact of relay
Measurement object	Object detected by the sensor unit
Cross line laser	
Alignment laser	
Commissioning PC	Computer used for sensor unit setup
Operator	The operator of the sensor unit also customer or CO (contractor)
Sensor Webconf, Web application	Web interface of the sensor unit
Plumb direction	Direction of gravity acceleration

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1 About this document

This operating manual is part of the sensor unit, which is intended for the measurement of certain parameters (distance, level, object detection). The device is built according to the current state of the art. Nevertheless, its use may cause function-related hazards to life and limb of the user or third parties or impairment of the device and other material assets.

- Read the operating manual carefully before using the sensor unit.
- Keep the operating manual for the entire service life of the sensor unit.
- Make the operating manual available to the operating and maintenance personnel at all times.
- Pass on the operating manual to each subsequent owner and user.
- Update the operating manual each time you receive a supplement from the manufacturer.

1.1 Other applicable documents

Name	Description	Supplied as
Supplier's Declaration of Conformity	Supplier's Declaration of Conformity 47 CFR § 2.1077 Compliance Information	pdf
Technical datasheet	Datasheet 1224	pdf
Protocol description Modbus/TCP	ModbusTCP_distance ModbusTCP_level ModbusTCP_scout	pdf

2 Safety instructions

This section contains information on the protection of people, domestic animals, livestock and the environment.

2.1 General safety instructions

The following instructions must be observed:

- Never open the sensor unit
- Never perform an installation during a thunderstorm
- Make sure that all cables and tubes are laid so that they cannot be tripped over or stepped on
- Do not use the device in potentially explosive areas
- Repairs may only be carried out by trained employees of the manufacturer
- In case of improper use, any liability on the part of mecorad GmbH is excluded
- Transport the packaging (cardboard box, pallet, etc.) properly. Do not throw, push or tilt.

2.2 Intended use

The sensor unit is used exclusively for distance and level measurements of workpieces or fluids (e.g., molten steel, steel blocks, rolled sheet and other conductive materials) as well as object detection in industrial areas of metal forming. The following conditions must be met for this purpose:

- the workpieces have good electrical conductivity (e.g., steel, stainless steel, aluminum, copper or magnesium),
- the distance between the workpiece and the sensor unit is within the defined range of 300 mm up to 25,000 mm (500-4,000 mm for high precision measurement),
- the distance is not chosen larger than structurally necessary in order to reduce scattering of the radar waves.
- The sensor unit is used for applications in industrial environments in covered areas in enclosed spaces.

The unit is not suitable for use in hazardous areas, as no protective measures have been taken in this respect.

2.3 Foreseeable misuse

The sensor unit is not intended for applications other than those in its intended use. The manufacturer is not liable for damage caused by foreseeable misuse:

- When dismantling and bypassing protection and safety devices.
- The operation with defective, deactivated safety devices.
- The operation in a potentially explosive atmosphere.
- When deliberately tampering with covers and other components.
- Operation with insufficient maintenance and outside the defined operating parameters.

Objects with strongly insulating properties (e.g., ceramics & some plastics) cannot be detected or measured with the sensor unit.

2.4 Structural modifications, extensions and conversions, spare parts

The following interventions are not permitted without the consent of mecorad GmbH:

- Carrying out the calibration.
- Unauthorized structural changes to the device.
- Replacing parts of the device

Repairs to the sensor unit may only be carried out by mecorad GmbH. Only original spare parts may be used.

2.5 Prohibited operating conditions

Operation of the device is prohibited under the following circumstances:

- Malfunctions, faults or damage are detected by personnel.
- Protective and safety equipment or devices have been removed.
- The maintenance intervals have been exceeded.

2.5.1 Normal operation

- Operate the device only when it is in a safe and functional condition.
- In case of malfunctions of the device functions, have them eliminated immediately.
- Operate the device only if all protective equipment is present and functional.

2.5.2 Maintenance

- Observe the prescribed maintenance intervals.
- Have maintenance work performed only by personnel trained for this purpose and authorized by the customer.
- Ensure that all required tools and aids are in a technically perfect and operationally safe condition.

2.6 Behavior in an emergency

This section contains information on how to behave in an emergency in order to end a potentially dangerous situation as quickly as possible.

In the event of acute danger, switch off the power to the system (factory protective equipment) and contact the responsible safety agency (e.g., the plant fire department, etc.).

2.7 IT security

This section contains information on how to ensure IT security. The sensor unit only has a basic access control. Security against unauthorized access must be ensured by the responsible IT department. The provision of an Internet-enabled connection to the sensor unit is expressly not recommended. The manufacturer is not liable for any damage resulting from these points.

2.8 Residual risks

The following residual risks exist:

- The electromagnetic radiation of the sensor unit can have negative effects on humans and animals. Avoid the presence of people and animals in the radiation area of the sensor unit, which is located directly in front of the cover plate.
- Residual voltage remaining in the device in the area of the sockets must be taken into account. This can lead to injuries and damage due to the electrical voltage.
- The dead weight of the sensor unit can lead to physical injuries if it falls from a certain height. Furthermore, injuries can be caused by sharp edges.

2.9 Notes on occupational health and safety

The operator of the system is responsible for implementing the occupational health and safety obligations. The occupational health and safety regulations of the country in which the system is used apply.
The obligations include the following points:

- Providing this operating manual to persons who perform tasks with or in connection with the low-voltage equipment.
- Making the applicable documents available to these persons.
- Instructing the persons with regard to the intended use and misapplications.
- Instructing the persons with regard to protective equipment and supplementary protective equipment.
- Instructing the persons with regard to residual risks.

This list does not claim to be complete.

3 Scope of delivery

The standard scope of delivery consists of the following components:

- Sensor unit type 1224
- Implemented software
- Assembly and Operating Manual in English Language

3.1 Identification

Designation: 1224
Serial number: see nameplate sensor unit or order confirmation
FCC ID: 2BDO41224
IC: 31657-1224
FVIN: 1.3
HVIN: 4.3

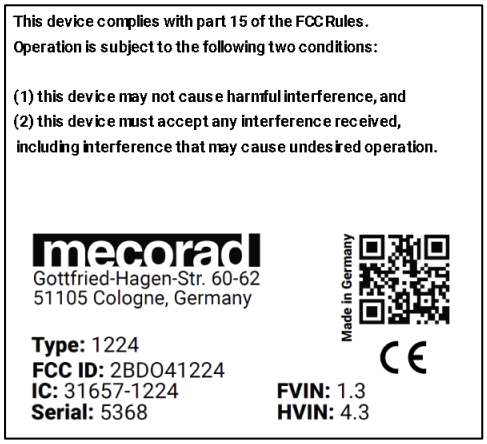


Figure: Nameplate sensor unit 1224

4 Product description

The sensor unit is used exclusively for the detection of distance (model Distance), level (model Level) and object detection (model Scout) of conductive workpieces in the customer's production halls. The measurement data obtained is available to the customer in real time. The sensor unit works under dust and aerosol load, functions independent of temperature. The cover plate is temperature stable for peak values up to 260°C, the ambient temperature of the sensor unit must not fall below or exceed the range of -20°C to +70°C.

4.1 Equipment

The equipment and design of the device as well as the description of the functions correspond to the wording of the order confirmation.

4.2 Details of the device

Manufacturer/Supplier	**mecorad GmbH**
Designation	Sensor unit 1224 in the model Distance, Level or Scout
Outer dimensions/weight	130 mm x 131 mm x 74.5 mm (l x w x h), weight approx. 1500 g

4.3 Technical data

The sensor unit is exclusively designed for the operating mode **normal operation**. The automatic measurement mode starts by connecting the sensor unit to the power supply (PoE). If the power supply is interrupted, an automatic restart to normal operation is performed when it is restored. For the operating mode normal operation, the following applies to the expected application:

Operating days per year:	365 days per year
Operating hours per day:	24h
Normal operation interventions:	No interventions required

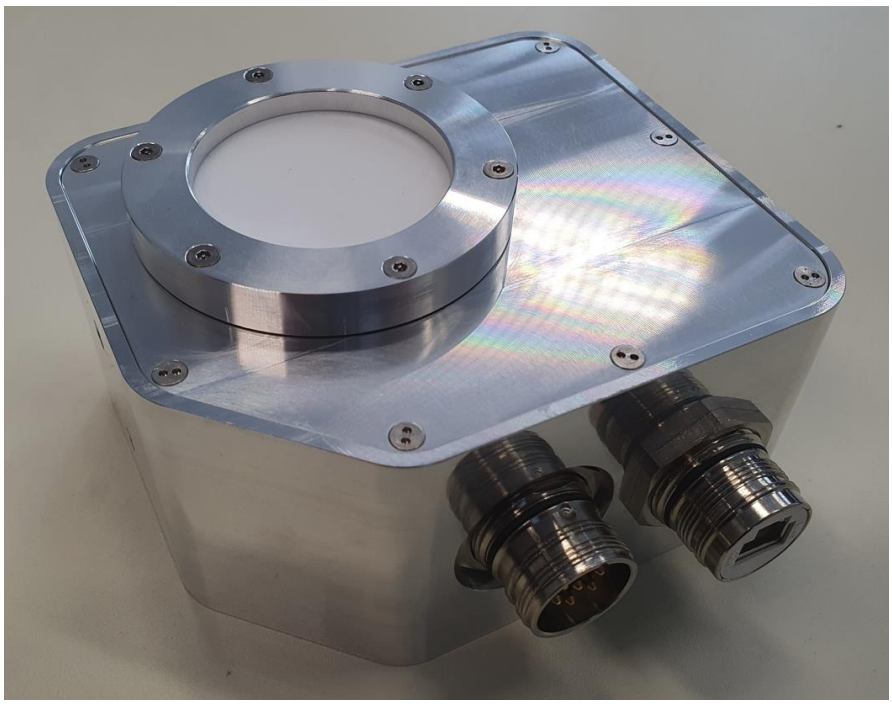


Figure: 1224 sensor unit

Center frequency	121.15 GHz
Bandwidth	3 GHz
Transmit power	<2 mW
Beam angle	4° (+/-2°)
Modulation	FMCW
Repeatability[1]	Without phase evaluation: Range=460 µm (min2max), std=71 µm With phase evaluation: Range=5.66 µm (min2max), std= 0.7 µm
Linearity error[2]	<1 mm
Temperature drift[3]	Without phase evaluation: 20 µm typical With phase evaluation: <5 µm typical
Switch-on drift[4]	Without phase evaluation: <50 µm typical in the first 15 minutes With phase evaluation: <5 µm typical in the first 5 minutes
Protection class	IP69K/ NEMA6 (Prerequisite: electrical connectors have been properly installed and tested)
Approvals	EN 62368-1; EN 62479; EN 305 550; EN 301 489-1,-3
Operating temperature	-20 to +70°C (-4 to 158°F)
Storage temperature	-40 to +85°C (-40 to 185°F)
Power consumption	approx. 6 W
Measurement range	200 to 25,000 mm
Measurement rate	approx. 75 Hz
Weight	1500g
Operating voltage	PoE 802.3af-2003 or higher (36-57VDC)

[1] 10,000 measurements on copper plate with a static distance of 1200 mm, no filtering
[2] Measurement on steel plate 100x100 mm, distance 900 mm to 1400 mm
[3] Measured at a temperature change of 20K (64°C → 44°C, cooling rate <=0.4K/min)
[4] Sensor unit switched on at room temperature, measurement on copper plate with a static distance of 1200 mm, no filtering

4.4 Ambient conditions

The device can be used within the following ambient conditions:

Ambient and room temperature of the sensor unit: **Temperature at cover plate of sensor unit:**	Normal operation: -20°C to +70°C (-4°F to 158°F) PTFE cover plate temperature stable up to 260°C (500°F)
Range of application	industrial applications

4.5 Product features

The sensor unit has the following features:

- Non-contact detection of distance/ level/ material presence of objects made of metal (or conductive objects).
- Surface and material independent (for conductive materials).
- High accuracy and measurement rate.
- Low radiation exposure (approx. 500x less than an ordinary cell phone).
- More accurate and less sensitive to extreme ambient conditions than comparable optical measurement technologies.
- Easy installation and commissioning.
- Low operating costs.

4.6 Set-up sensor unit

The sensor unit consists of the following components:

- Housing incl. connector
- Supply PCB for power supply, communication and calculation unit
- Radar frontend
- Dielectric lens

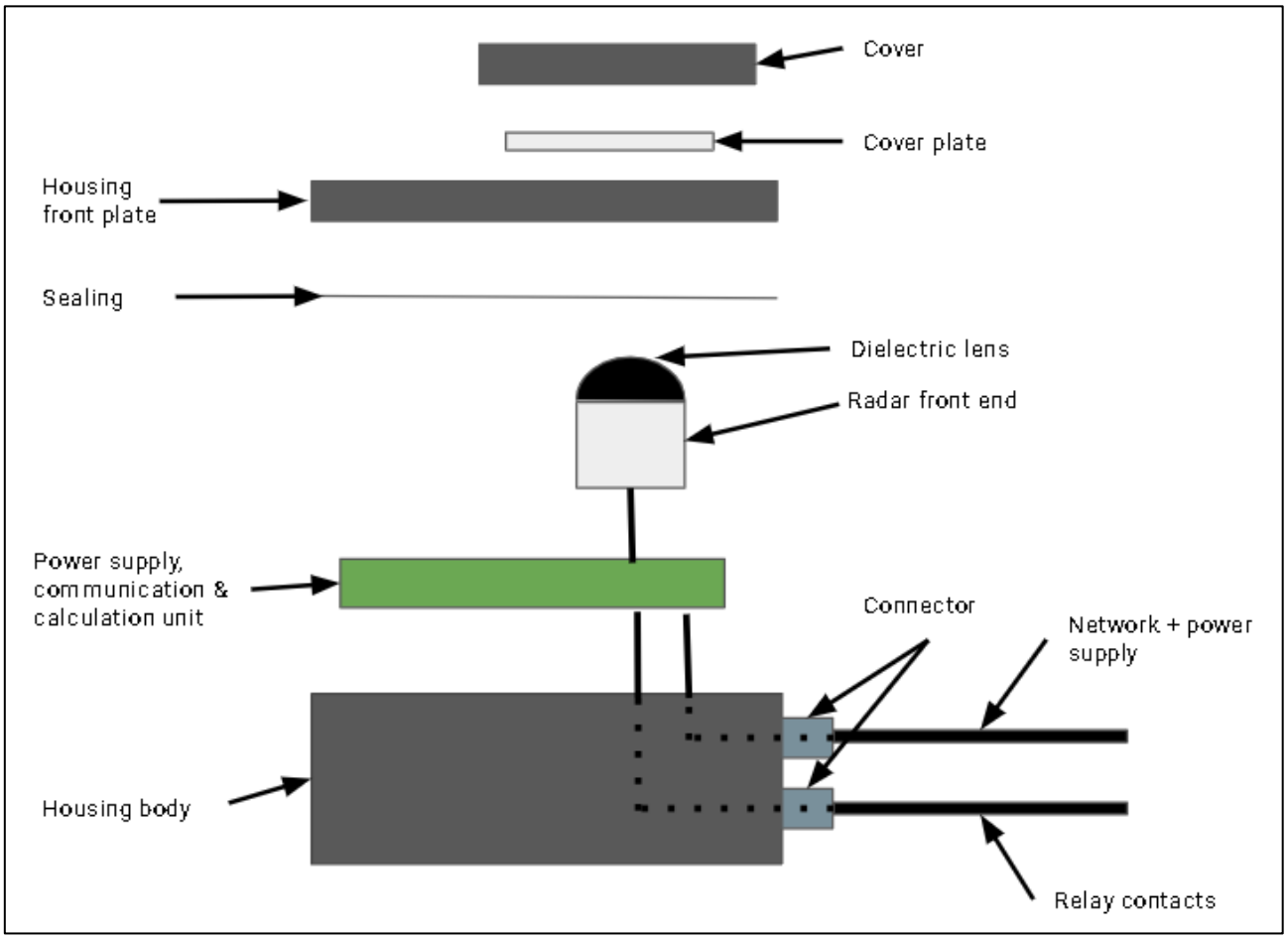


Figure: Block diagram sensor unit

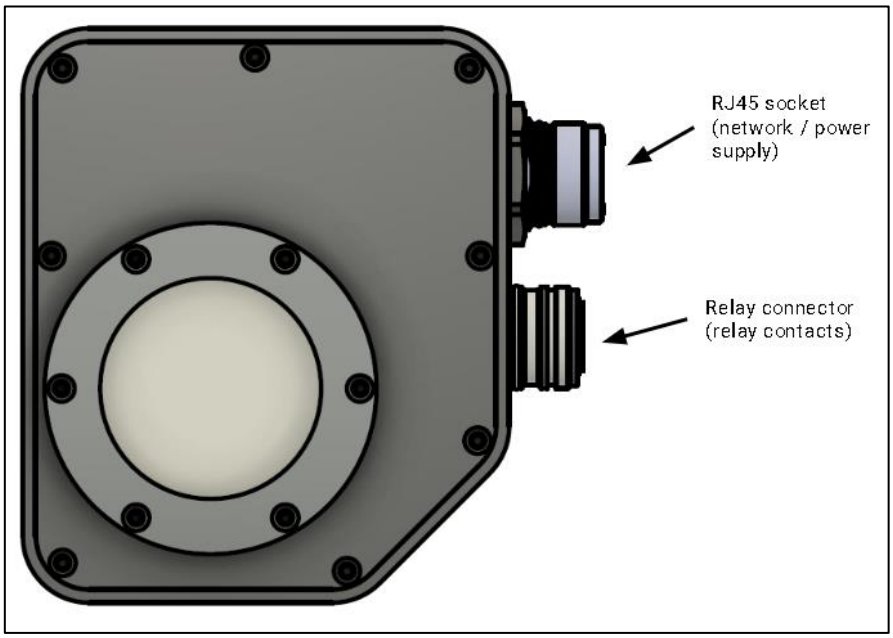


Figure: Connectors of the sensor unit

4.6.1 Assignment of power supply/ network connection

The power supply/network connector complies with the EIA/TIA-568 standard.

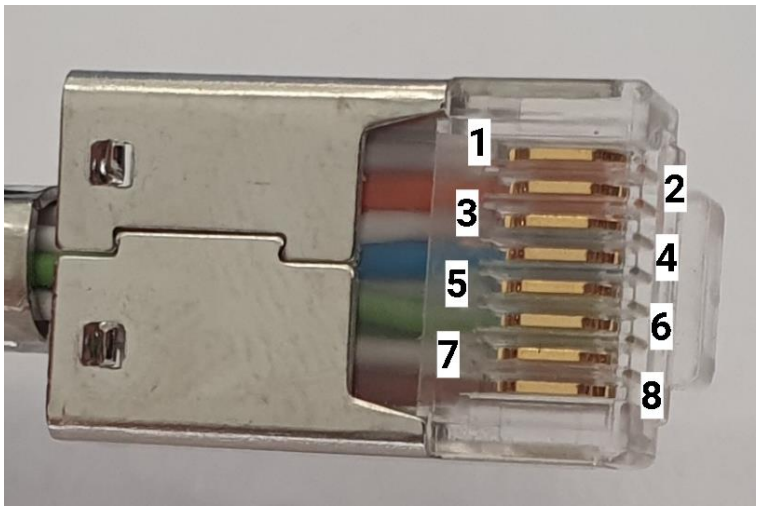


Figure: Pin assignment RJ45 connector

Pin	Color according to T568A	Color according to T568B	10/100 Mbit/s Alternative A (MDI)	10/100 Mbit/s Alternative B	from 1 Gbit/s Alternative A	from 1 Gbit/s Alternative B
1	white/green	white/orange	Tx+ / DC+	Tx+	TxRx B+ / DC+	TxRx B+
2	green	orange	Tx- / DC+	Tx-	RXRX B- / DC+	RXRX B-
3	white/orange	white/green	RX+ / DC-	Rx+	TxRx A+ / DC-	TxRx A+
4	blue	blue	unused	DC+	TxRx D+	TxRx D+ / DC+
5	white/blue	white/blue	unused	DC+	TxRx D-	TxRx D- / DC+
6	orange	green	RX- / DC-	Rx-	TxRx A- / DC-	TxRx A-
7	white/brown	white/brown	unused	DC-	TxRx C+	TxRx C+ / DC-
8	brown	brown	unused	DC-	TxRx C-	TxRx C- / DC-

Table: Overview 802.3af/at standard Alternatives A and B

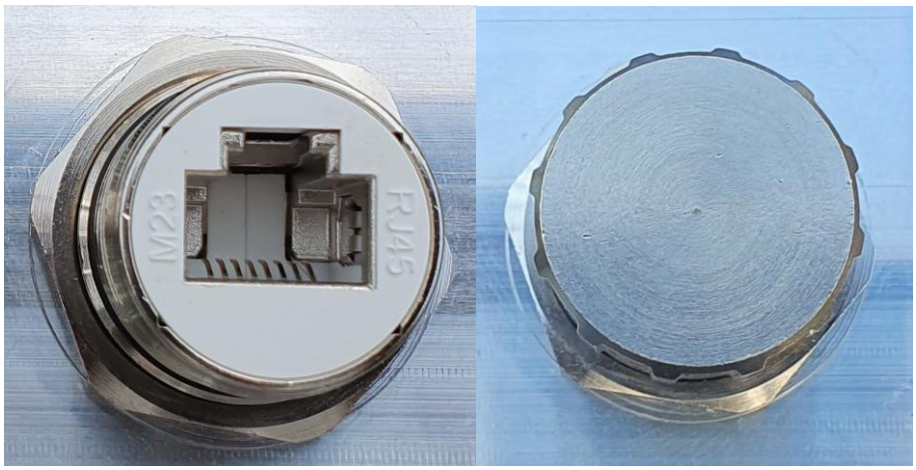


Figure: RJ45 socket on sensor unit open (left) and with protective cap (right)

4.6.2 Assignment of relay contact

The relay contact can be used in the models Scout and Level. In total, the sensor unit contains two relays. The M23 connector has the following pin assignment:

Pin	Color	Usage
1	red	Relay 1 NO (normal open)
2	blue	Relay 1 Center
3	green	Relay 1 NC (normal closed)
4	yellow	Relay 2 NO (normal open)
5	white	Relay 2 Center
6	black	Relay 2 NC (normal closed)

Table: Pin assignment of the relay contacts

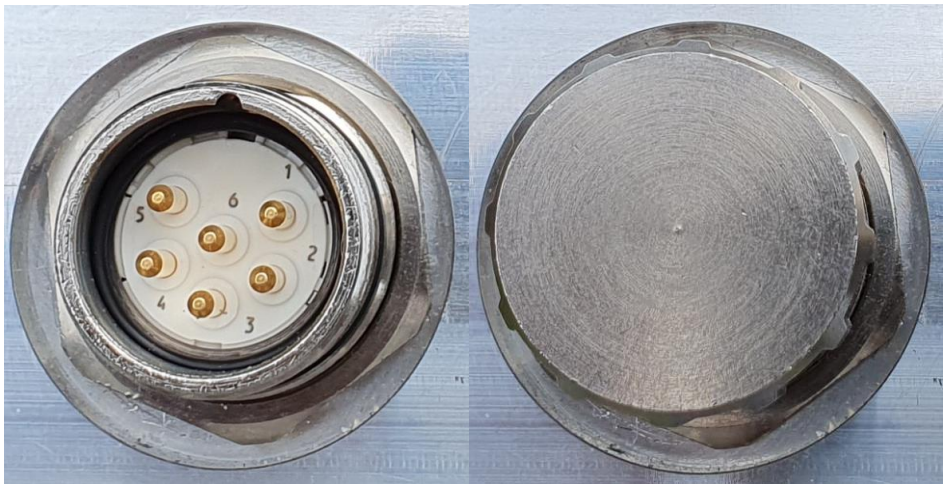


Figure: Connector relay contacts sensor unit open (left) and with protective cap (right)

4.6.3 Measured values via Modbus/TCP

By default, the acquired measured values are provided via a digital interface using Modbus/TCP. The protocol description can be found in the supplied document (see chapter 1.1 – Other applicable documents).

4.7 Hardware components

This chapter provides information about the individual hardware components.

4.7.1 Sensor unit

The sensor unit includes the radar sensor, power supply, calculation unit, dielectric lens, protective housing and connector.

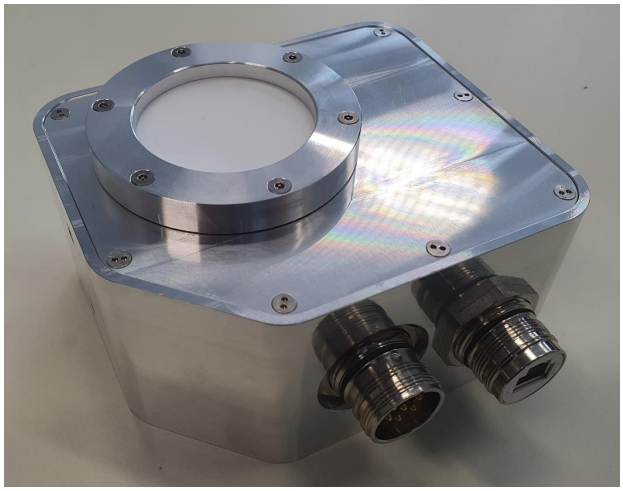


Figure: Photo sensor unit

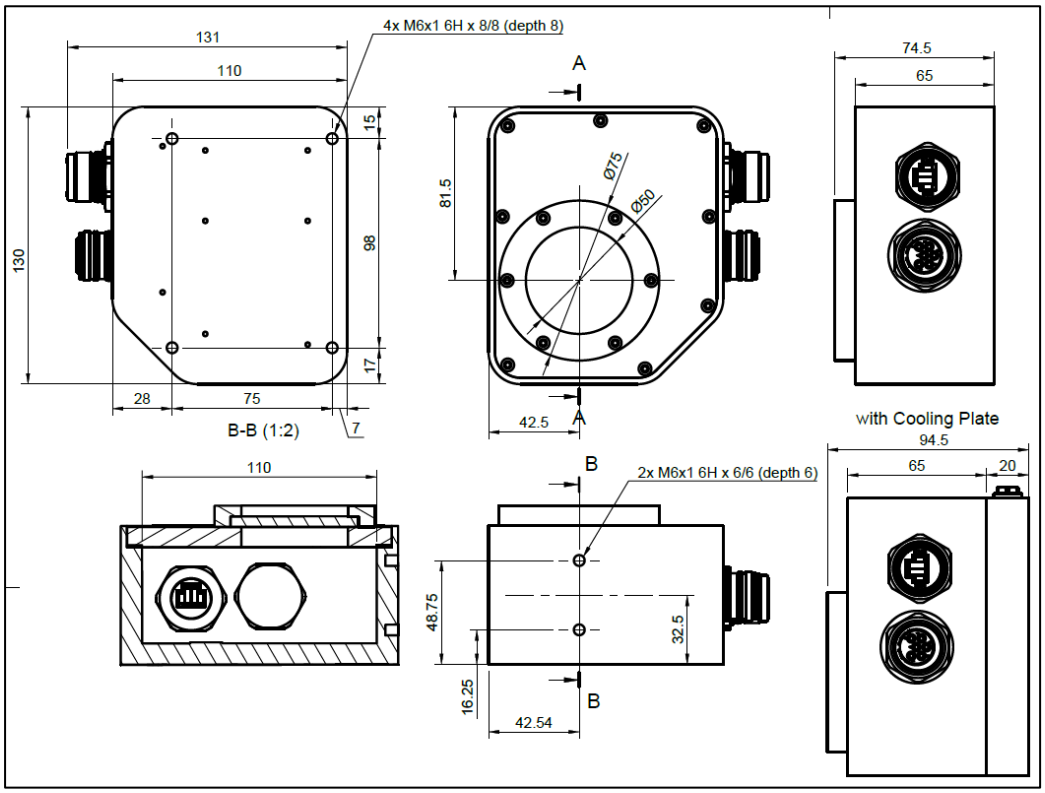


Figure: Drawing sensor unit

4.8 Software components

This chapter describes the connection to the web application of the sensor unit (Sensor Webconf).
The connection to the web application is established via a web browser (Google Chrome preferred).

4.8.1 Connection setup

Sensor Webconf is a web application that runs on the individual sensor unit. Access is thus via a web browser running on a PC in the network mentioned below. The following table lists various browsers with which the web application has been tested. Error-free use is not guaranteed for other browsers or browser versions.

Browser	Version
Google Chrome	116.0.5845.179 (64-bit)
Mozilla Firefox	117.0 (64-bit)
Microsoft Edge	116.0.1938.69 (64-bit)

Table: List of compatible browsers

The web application can be called by entering the following address in the address line of the browser, where the placeholder <ip-address> must be replaced by the actual IP address of the corresponding sensor unit:

https://<ip-address>:8000

Note:

The default IP address of the sensor unit is 192.168.0.100, this can be reached via https://192.168.0.100:8000.

To be able to reach the web application, the following requirements must be fulfilled:

- The PC on which the browser is located must be physically connected to the sensor unit's network.
- The PC on which the browser is located must be in the same IP network as the sensor unit.

Example:

If the sensor unit has the IP address 192.168.0.<x>, the PC must also be set to an IP address starting with 192.168.0.<x>.

- The port (8000) must not be blocked by a firewall or similar measures

Note:

Administration rights on the PC used are required for the steps mentioned. If necessary, contact the IT/system administration of your company.

4.8.2 Setup: add exception in browser

Since this is an encrypted connection, whose certificate cannot be verified, an exception must be added to the web browser. The following illustrations show how to do this using Google Chrome:

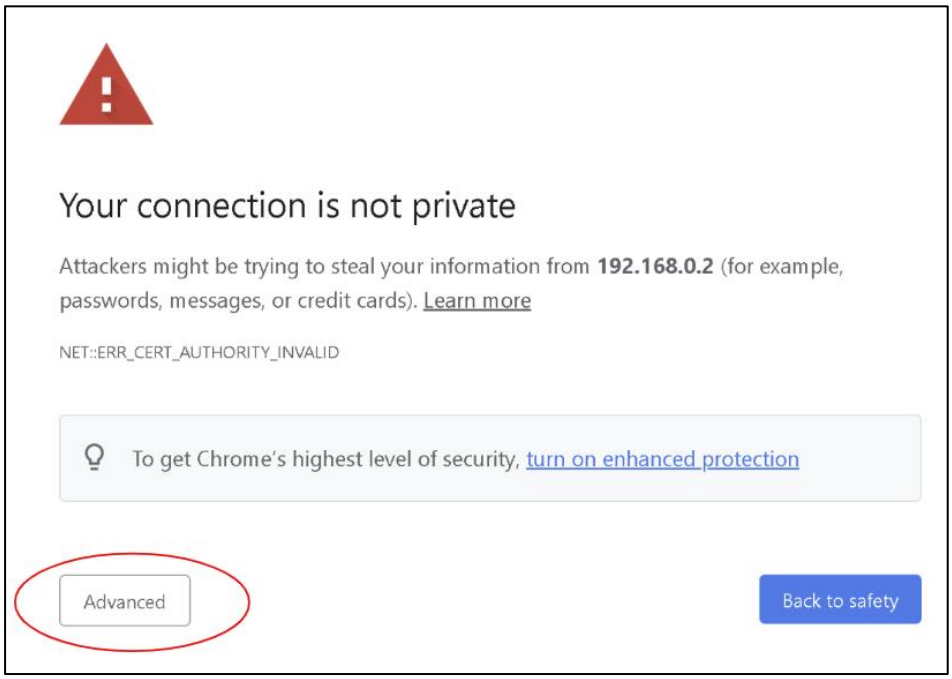


Figure: Set up security certificate exception rule

→Click the "Advanced" button.

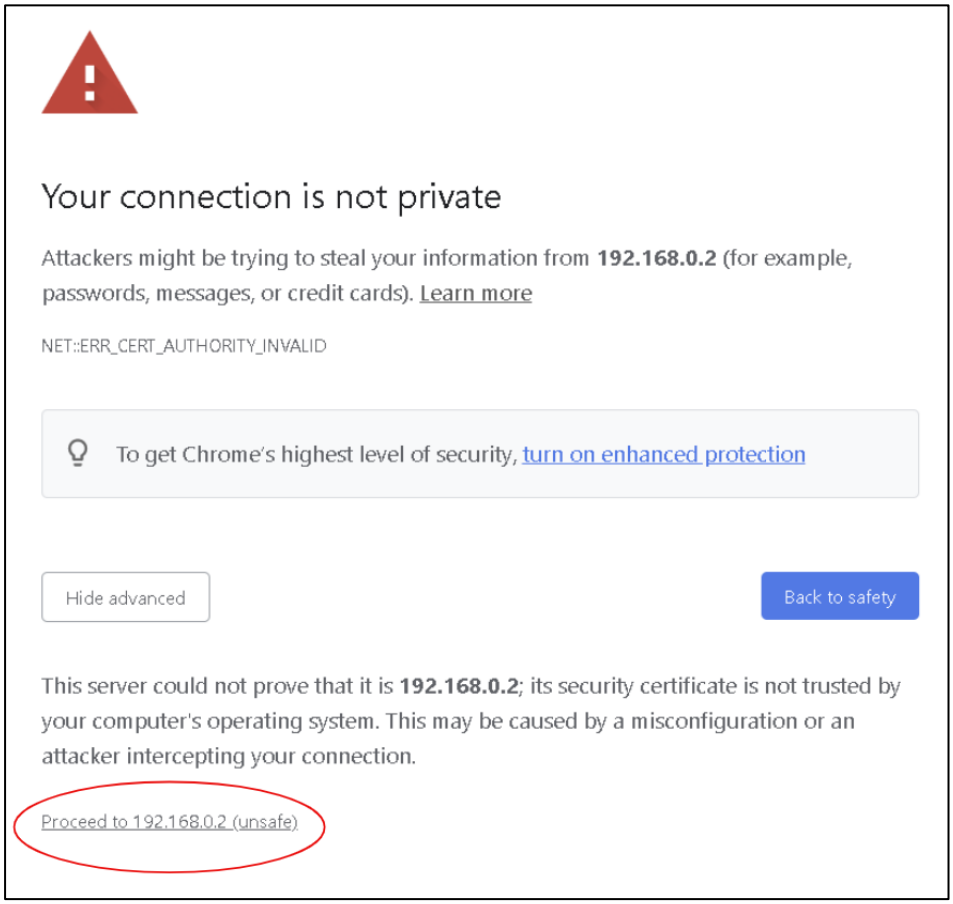


Figure: Set up security certificate exception rule, advanced view.

→ Click on “Proceed to 192.168.0.100 (insecure)”.

4.8.3 User credentials

The different use cases are mapped via different technical users:

User	Use Case
user_status	• Function check • Display of current measurement
user_config	• Function check • Display of current measurement • Parameterization of the sensor unit
user_admin	• Function check • Display of current measurement • Parameterization of the sensor unit • Administration of the sensor unit

Note:

The list described above represents all users in the standard version. If additional users have been set up for the specific use of the product, refer to the documentation supplied with the product.

4.8.4 Login / logout

Once the connection has been successfully established, a login can be performed with the supplied user credentials.

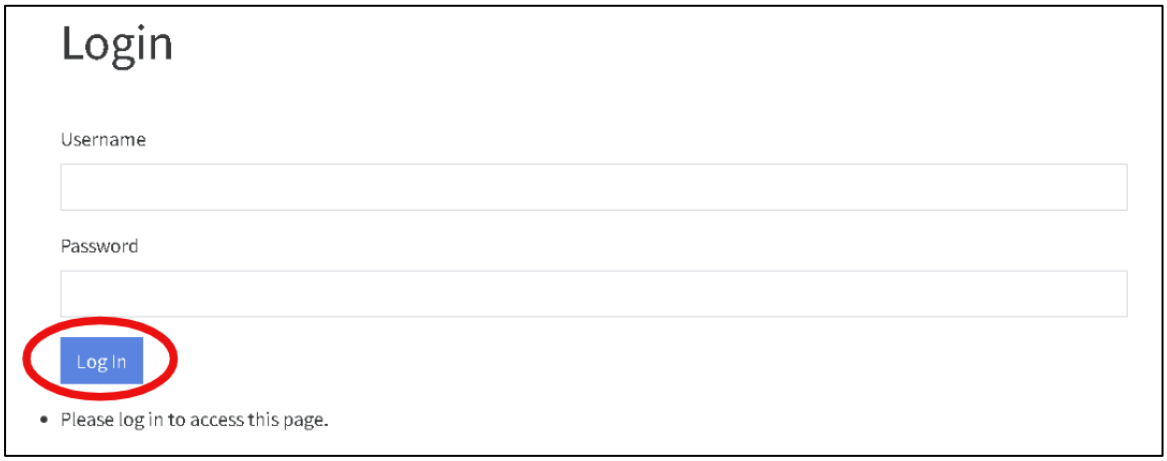


Figure: Login mask of the sensor unit

The logout is done by selecting the currently active user in the navigation and then selecting the menu item "Logout".
If there is no manual logout, a user will be logged out automatically after 20 minutes.

4.8.5 Navigation

Navigation is done using the menu items in the navigation bar in the header of the web application. The selection of available menu items differs depending on the logged in user.

The navigation bar has a mode for wide screens (above graphic) and a mode for narrow screens (following graphic), between which it switches automatically. In narrow screen mode, menu items become visible only after clicking on the menu icon .

4.8.6 Function check

To check the availability of the sensor unit, the menu item “Status” must be selected. The current availability can be ensured if no errors or warnings are displayed here.

Warning / Error	Description
WARNING (local): No data-stream available (since xs)	The browser does not receive any current data from the sensor unit. Possibly the firmware is just restarted. Wait up to one minute. If this message occurs independently of a configuration or a restart of the sensor unit, contact your service partner.
WARNING: Internal stream not available	The web server does not receive any data from the sensor unit firmware. Contact the service partner
ERROR: Connection Closed - Timeout	The browser has lost the active connection to the web application because it does not provide current data. Refresh the page in your browser and log in again if necessary. If the error message appears again, contact your service partner

4.8.7 Display of current measurement

To display current measurement results, the menu item “Status” must be selected.
The current measurement result is displayed in the column "Target" or "Reference". Distance, Magnitude, Phase / Phase Error and Temperature are displayed by default. The measurement results are updated approximately at the rate of the sensor unit / 20.
Additionally, the measurement results for Distance, Magnitude and Phase of the last ~15 s are processed in time-continuous Cartesian diagram. The scaling along the y-axis is done automatically and cannot be set manually.

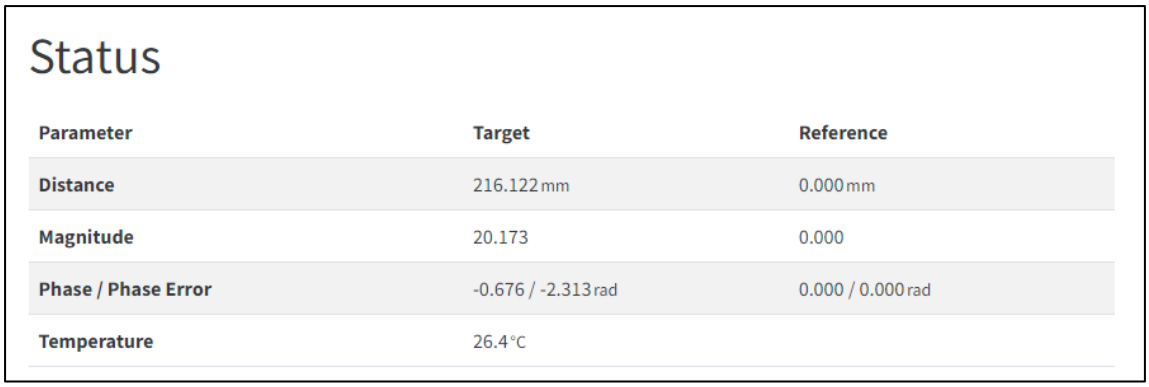


Figure: Display of the current measurement results of the sensor unit

Above each of the diagrams there is a legend. By clicking on the individual elements of the legends, the display of the corresponding data series in the diagram can be switched on or off. By default, only the data series related to the "Target" are displayed in all diagrams. In order to map the data series for the "Reference", this must be activated via the legend as described.

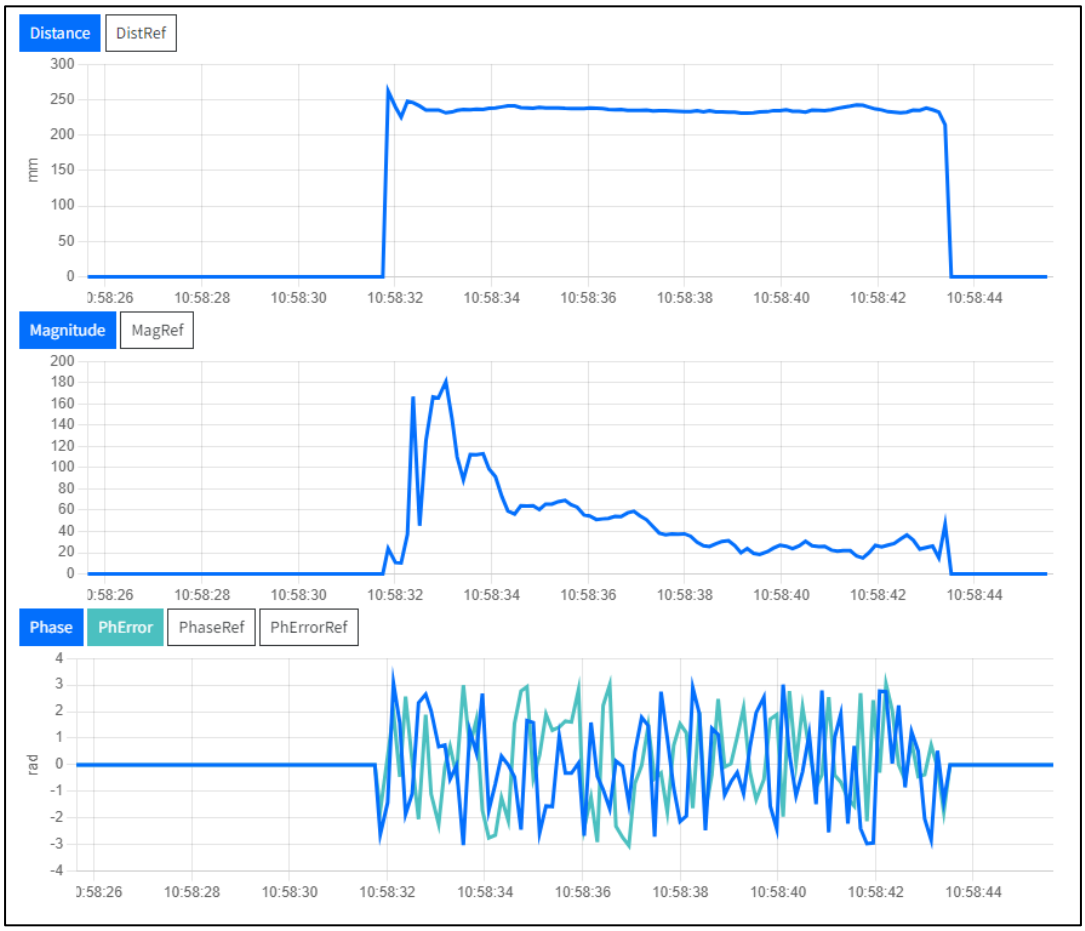


Figure: Diagrams in the web application

HINT

The scope of the displayed parameters may vary depending on the product model.

4.8.8 Parameterization of the sensor unit

The sensor unit is parameterized via the menu item "Configuration". The manipulation of all parameters available for the corresponding model is enabled. The parameters are divided into function groups that can be expanded and collapsed. For the sake of clarity, only one function group can be displayed at a time. Changes to one or more parameters can be confirmed using the "Submit" button or ENTER. Subsequently, the firmware of the sensor unit is restarted with the new parameters. This can take up to 30 s.

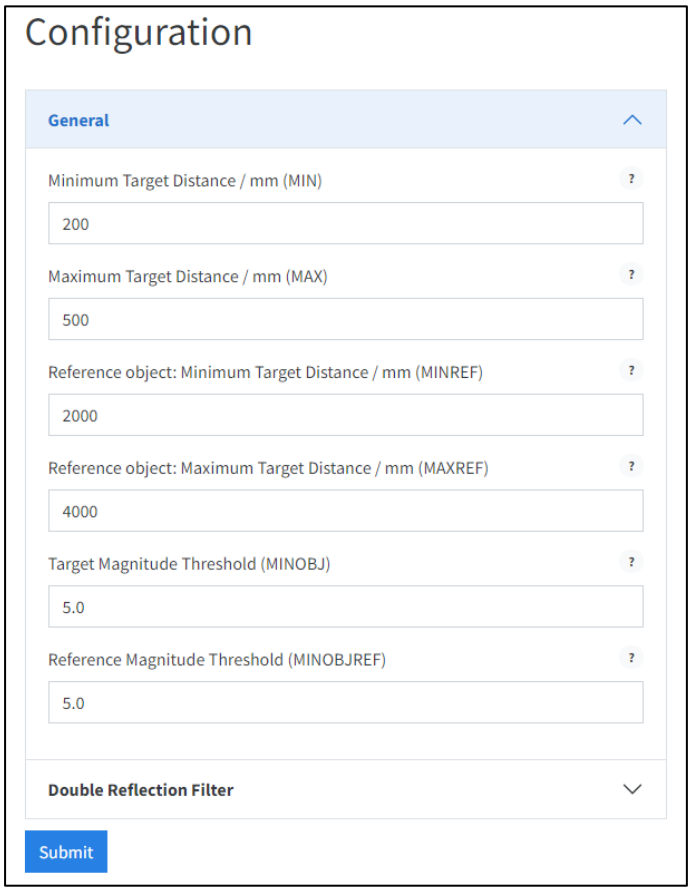


Figure: Configuration of the sensor unit

HINT

The scope of the displayed parameters differs depending on the product model.

4.8.9 Administration of the sensor unit / change of the IP address

The administration of the sensor unit is done via the control panels “Setup” and “Administration”.
Here, the IP address can be changed by entering a new IP address (IPv4) including CIDR suffix in the field “IP Address”.

WARNING

By changing the IP address, the sensor unit will only be accessible under the newly assigned IP address after a restart. If errors occur, it may be necessary to have the sensor unit reset by the manufacturer.
The change of the IP address of the sensor unit must be documented by the responsible employee.

4.9 Device limitations

4.9.1 Power supply

The sensor unit requires a PoE power supply (e.g., a PoE switch on the customer side). This PoE power supply must comply with PoE standard 802.3af-2003 or higher.

The following PoE switch is recommended by mecorad: Wago 852-1411 Industrial Ethernet Switch.

4.9.2 Network integration

The sensor unit is integrated into the existing company network, the protocol is Modbus/TCP (standard). The protocol description can be taken from the supplied document (see chapter 1.1 - Other applicable documents).

5 Installation

For the sensor unit to work properly, the customer must create the prerequisites described in chapters 5.1 and 5.2.

5.1 Structural changes

CAUTION

- Necessary structural modifications must be carried out by the customer/operator. **Safety concepts and hazard analyses** for the structural modifications must be provided by the customer.

5.2 Adaptation of the production line/measurement location

- The production line must be adapted so that the sensor unit to be installed for distance and level measurement or for object detection is not shielded by existing components. To function properly, the sensor unit must have a clear view of the surface of the workpiece or reflector to be measured (model: Scout). Furthermore, it must be ensured that the cover plate of the sensor unit is not covered or wetted with liquid water.
- A suitable holder for fixed installation of the sensor unit must be installed on the production line.
- A supply and connection cable with a maximum length of 95 meters must be provided.
- Appropriate drill holes for M6 screws are to be made in the holder for the sensor unit.
- If necessary cooling water/air must be provided

Preferably, the sensor unit should be installed using the fastening screw threads on the bottom side:

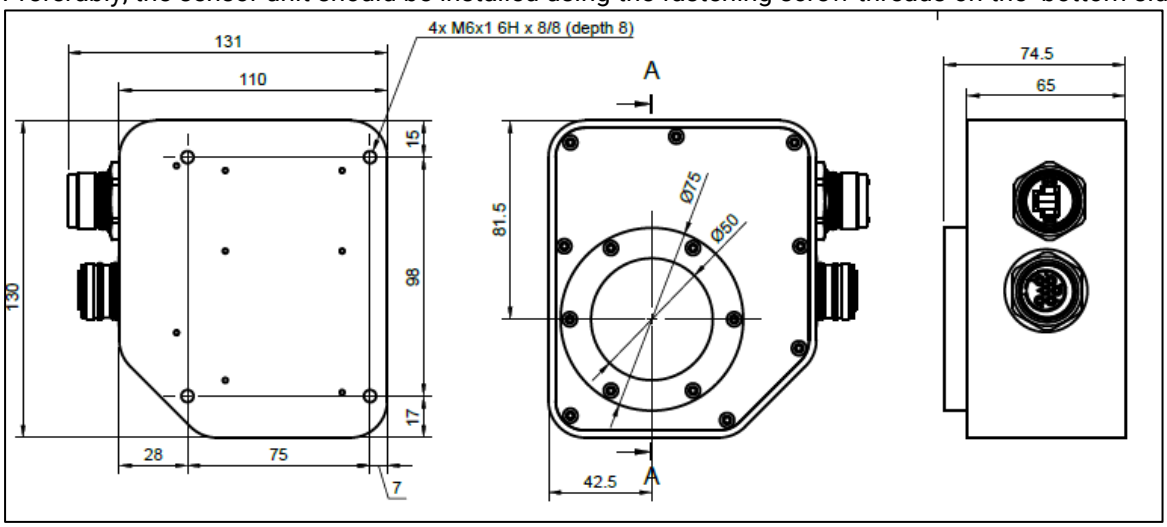


Figure: Fastening screw threads on the bottom side of the sensor unit

Alternatively, the sensor unit can be mounted via the fastening screw threads on the side of the sensor unit:

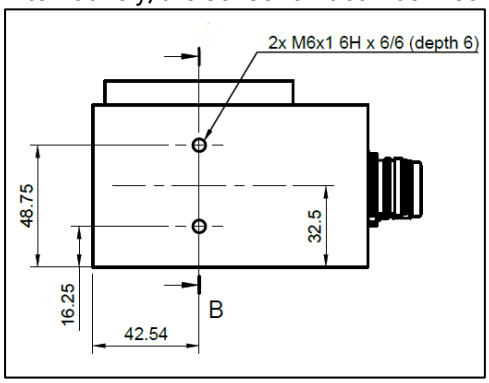


Figure: Fastening screw threads on the side surface of the sensor unit

→ In each case, 4 (fastening on the bottom side) or 2 (fastening on the side) M6 screws and serrated lock washers must be provided per sensor unit with the appropriate length (max. screw-in depth: 8 mm at the bottom or 6 mm at the side).

The sensor unit is fastened to the holder by the customer's service personnel using four (fastening on the bottom side) or two (fastening on the side) M6 screws in each case.

5.2.1 Adaptation electrical equipment

DANGER

Danger to life due to electric shock!
Electrical voltage in the sensor unit

- It is prohibited to open the sensor unit. The sensor unit must be connected by the customer's qualified personnel.
- Never carry out an installation during a thunderstorm.

The cable for the power supply and network as well as the signal cable must be laid according to industrial safety standards and protected against impermissible exposure to heat and mechanical stress.

The customer must provide the following prerequisites for installation of the device:

- Provision of a PoE power supply (e.g., PoE switch).
- Provision of a network cable (Cat6 or higher), which is connected to the PoE power supply at one end and to the sensor unit at the other end.
- The maximum length of the power supply and network cable must not exceed 95 m

5.3 Alignment of the sensor unit to the measurement object

To ensure that the sensor unit works correctly, the radar beam must be aligned to the measurement object. The alignment is carried out by means of the laser / cross line laser. It is particularly important that the radar beam hits the surface of the measurement object perpendicularly and in the center. Even small angles between the measurement object and the radar beam of the sensor unit significantly reduce the reflected signal strength.

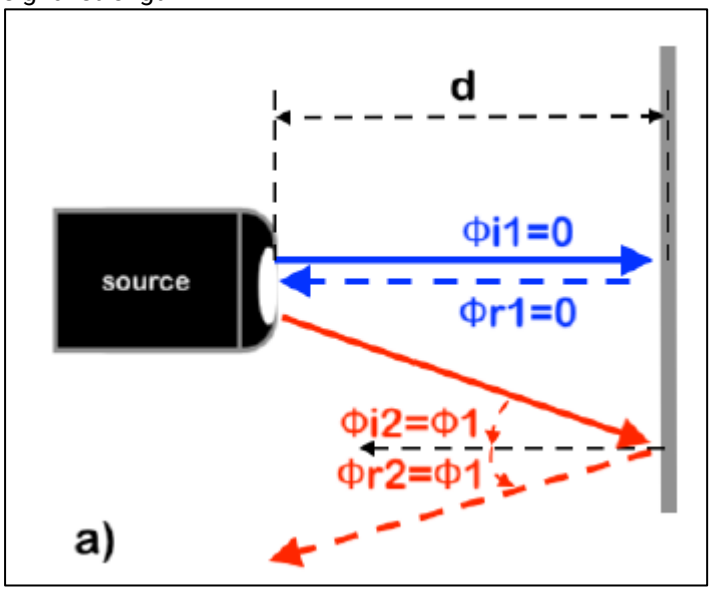


Figure: Reflection principle

In the optimum case (see above diagram), the sensor unit is aligned exactly perpendicular to the surface of the measurement object (blue lines). The red lines only serve to illustrate the reflection principle. This type of measurement is not approved for the sensor unit.

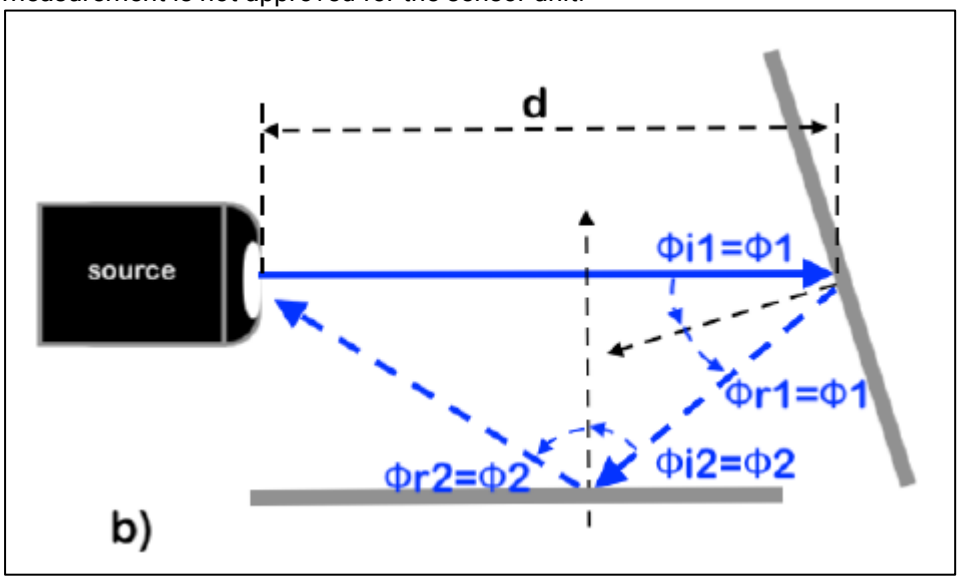


Figure: Multi-path reflections

Unwanted multi-path reflections can occur due to an unfavorable arrangement in the measurement range (often due to a non-perpendicular measurement of the measurement object surface and additional objects in the measurement range). In these cases, the radar beam is not reflected back to the sensor unit on a direct path but is redirected via an additional object and thrown back to the sensor unit. Multi-path reflections must be avoided.

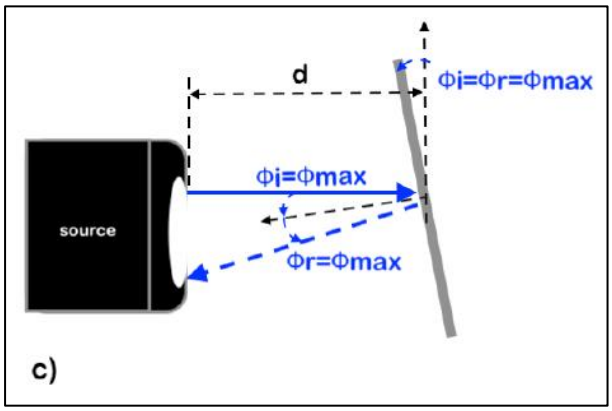


Figure: Non perpendicular measurement

The above graphic illustrates how a measurement affects a non-perpendicular surface of the measurement object. Depending on the measurement distance (d), the angle (to the surface of the measurement object) can be determined up to which a measurement is possible, typical values are less than 1° at a distance of 1 m or less than 0.5° at a distance of 1.5 m. Due to a very rough surface of the measurement object, measurements are possible at larger angles (due to diffuse radiation from rough surfaces). A perpendicular alignment to the surface should always be aimed for.

5.3.1 Alignment model Distance

In this model, the alignment is made directly to the measurement object (or a suitable reference or calibration object). The sensor unit must be loosely attached to its holder. A cross line laser is used to check whether the sensor unit is attached at the same height as the surface center of the measurement object.

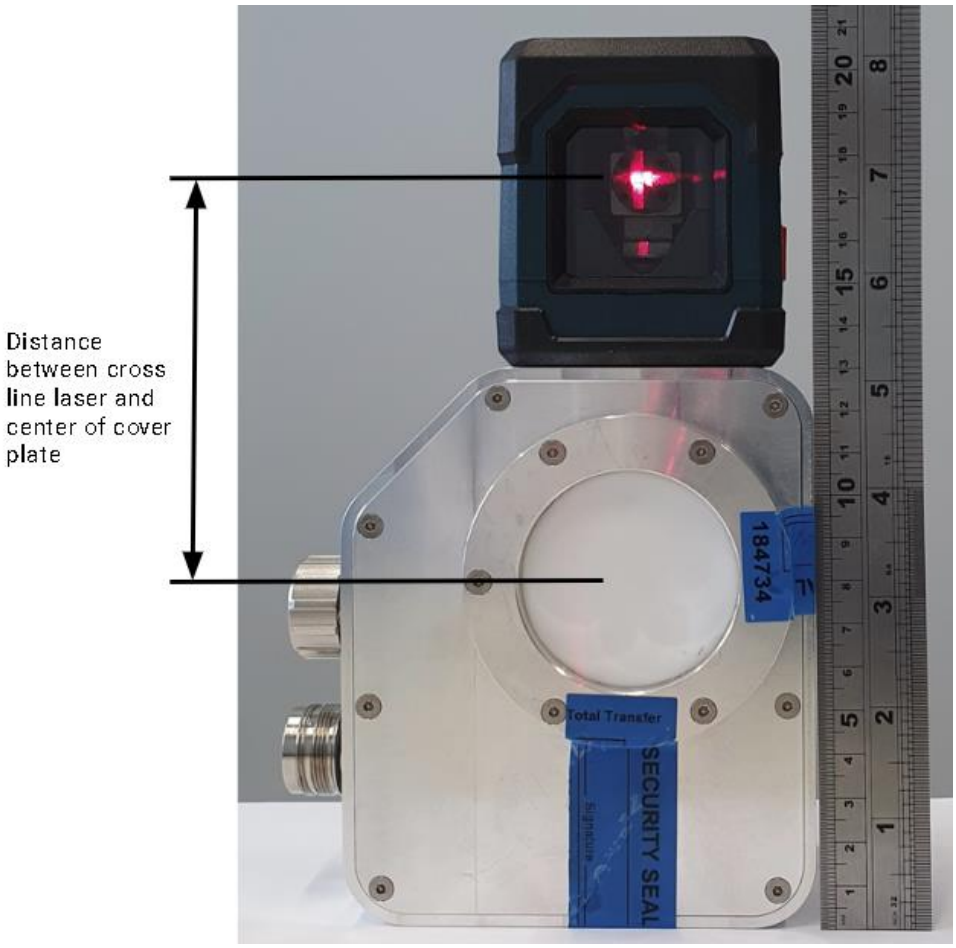


Figure: Alignment with cross line laser

The distance between the beam of the cross line laser and the center of the cover plate must be determined as shown in the figure above and taken into account during alignment. Fine alignment is then performed using an alignment laser. The alignment laser is held in the center of the cover plate as shown in the following figure and it is checked whether the laser point (and thus also the radar beam) is centered on the surface of the measurement object.

Figure: The alignment laser is positioned centrally on the cover plate of the sensor unit

If this is not the case, the sensor unit or the holder must be shifted by slight movements until the alignment laser points centrally to the surface center of the measurement object. Then the screws of the sensor unit and the holder must be fixed and the correct alignment checked again.

After successful alignment, an additional fine alignment can be performed for further improvement. This is done by displaying the signal strength of the sensor unit in the web application (diagram "Magnitude" in the subitem "Status"), see chapter 4.8.7. The fine alignment is done in two steps:

1) The maximum signal strength is determined and noted by moving the sensor unit slightly.
2) Subsequently, the sensor unit is again brought into the position with the previously determined maximum signal strength and must be fixed.

5.3.2 Alignment model Level

The model Level is aligned in the same way as the model Distance (see chapter 5.3.1). It is important that the sensor unit is aligned in such a way that the surface of the fluid can be detected perpendicularly. For the alignment, it is necessary that there is a fluid in the vessel (furnace/tank). If this is not possible, a suitable measurement object can also be used, as long as it is ensured that this is aligned in the perpendicular direction (with reference to the surface standard).

5.3.3 Alignment model Scout

The model Scout can be operated in two modes. The first is direct detection. Here, the sensor unit checks whether an object is located in the measurement range. In this operating mode, it is necessary that the sensor unit is aligned approximately perpendicular to the detected area of the object. This operating mode is preferred if the perpendicularity to the detected surface is given.

In the second mode of operation, a reference object is placed in the measurement range of the sensor unit. The detected surface of the reference object must be aligned perpendicular to the sensor unit. The advantage of this operating mode is that the sensor unit also detects objects that do not have a surface at right angles to the sensor unit. Detection in this operating mode is indirect: The sensor unit registers that an object is covering the previously attached reference.

5.3.3.1 Direct detection of the measurement object

With the direct detection of the measurement object, the alignment is carried out analogously to the model Distance. It must be ensured that the maximum and minimum distance of the measurement object are selected in such a way that only the surface of the measurement object is detected at its possible positions and not, for example, parts of the customer installation (such as the roller table or metallic parts in front of or behind the measurement object).

5.3.3.2 Indirect detection of the measurement object

If direct detection is not possible, a reflector can be installed in the measurement range. The sensor unit is first roughly aligned to the desired position of the reflector using an alignment laser. The reflector is then roughly placed. The alignment laser is now positioned centrally on the surface of the reflector, which is then aligned and fixed so that the alignment laser aims centrally on the cover plate (white opening) of the sensor unit. Subsequently, the alignment laser is again positioned centrally on the cover plate of the sensor unit and this is aligned centrally on the fixed reflector and then fixed. After the sensor unit and reflector have been fixed, check again whether both surfaces are aligned with each other (as described above). If this is not the case, please align again.

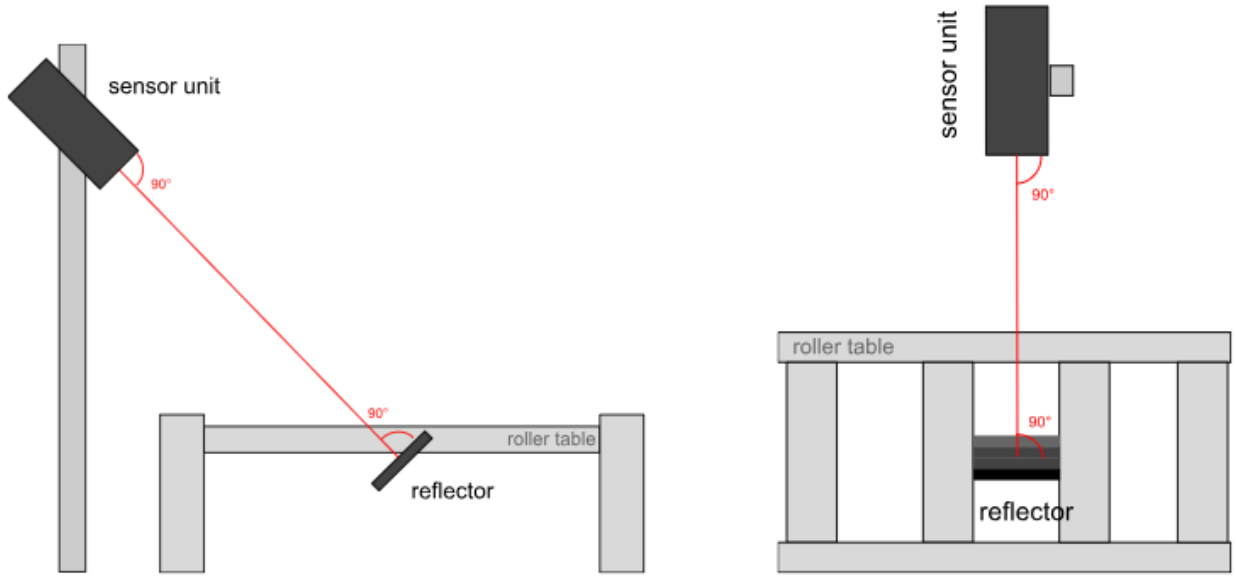


Figure: Model Scout with reflector (indirect detection)

6 Commissioning

CAUTION

Commissioning is carried out by the customer's qualified personnel. It must be ensured that the sensor unit has been aligned beforehand as described in chapter 5.3.x.

6.1 General commissioning procedure

General steps:

1. Connect the network cable to a PoE switch. When the power supply is established, the sensor unit boots for approx. 30 seconds.
2. Connect a switched-on commissioning PC with the network switch. Make sure that the commissioning PC is assigned an IP address that is within the range of the IP address of the sensor unit and that this is not used by another device (see chapter 4.8, contact the IT/system administration of your company if necessary).
3. Connect to the web interface of the sensor unit as described in chapter 4.8.

6.2 Commissioning model Distance

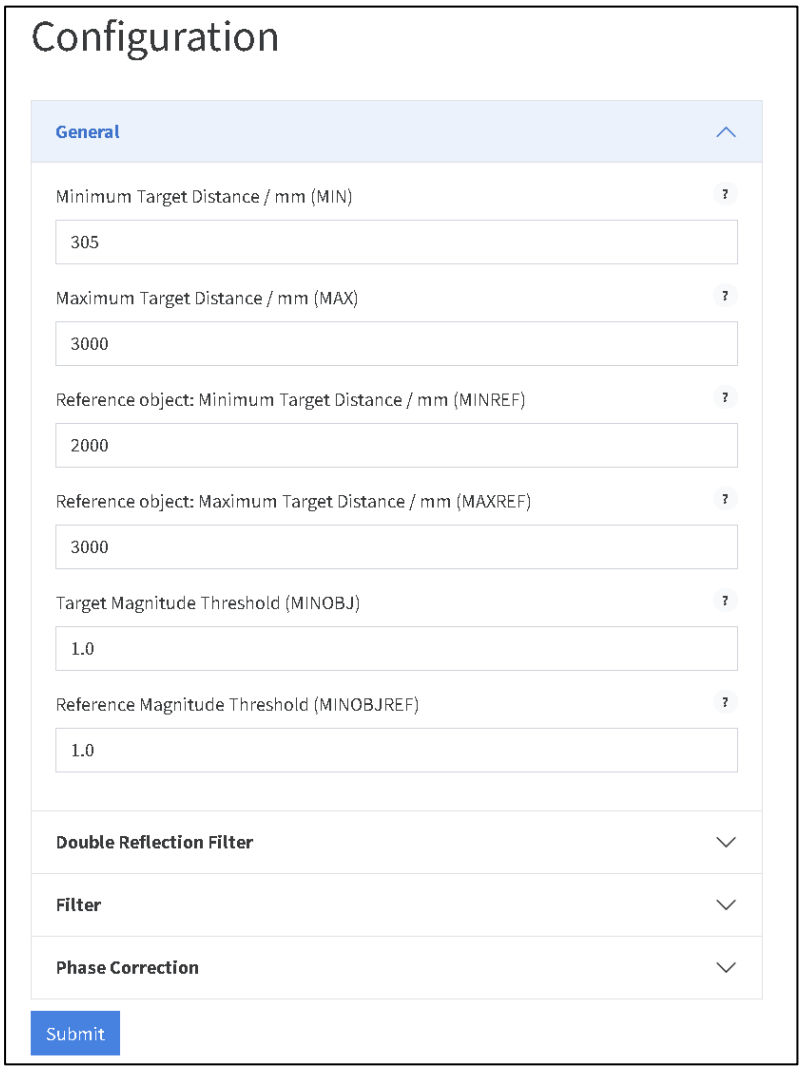


Figure: Parameters of the model Distance

1. Setting the minimum and maximum distance at which an object has to be detected. This is done via the "MIN" and "MAX" parameters. The input is made in mm.
2. Checking the signal strength without measurement object: Remove the measurement object from the measurement range. Check the signal strength of the sensor unit under "Status" → "Magnitude" and write down the value.
3. Check the signal strength with the smallest permissible measurement object and maximum distance to the sensor unit. The object that has the smallest area for radar detection is the object that provides the lowest signal strength. Make a note of this value as well.
4. Set the minimum signal strength at which a measurement is performed. This is done by the parameter "(MINOBJ)". In most cases it is sufficient to determine this parameter as follows: MINOBJ = (magnitude_no_object + magnitude_smallest object)/2.
5. If it is later determined that there are cases where a measurement object cannot be detected, this parameter can be further reduced. However, it must be ensured that it is not selected lower than the signal strength without measurement object (otherwise a measurement value would be permanently output - even if there is no measurement object in the measurement range of the sensor unit).
6. If a reference object should also be detected, the parameters "(MINREF)", "(MAXREF)", "(MINOBJREF)" must also be set.

In addition, the sensor unit offers the following setting options in the model Distance.

6.2.1 Multiple reflection filter

Under the tab "Double Reflection Filter", a special filter can be activated, which ensures that always the distance of the first detected object, which is located in the measurement range, is output. This option is useful when the surface of the workpiece is very rough, such as plasma cut parts or slabs.

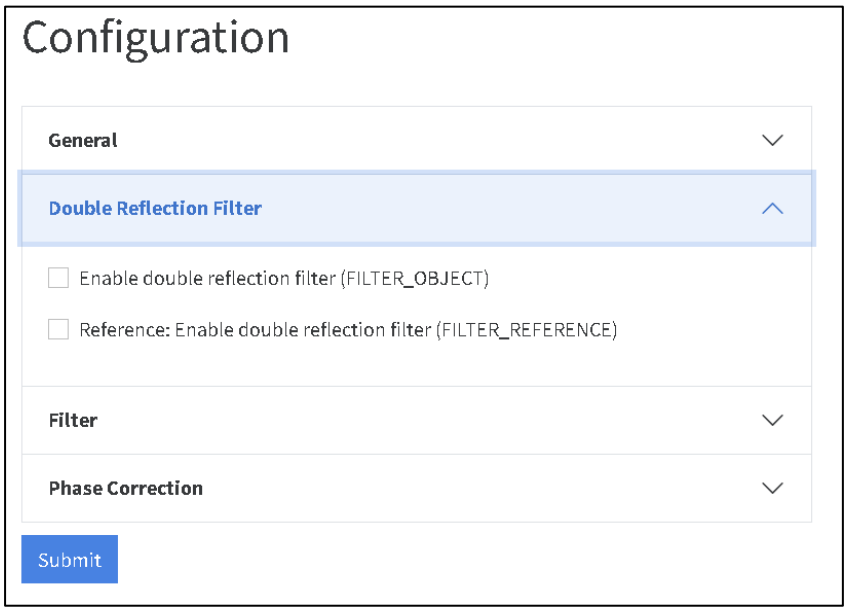


Figure: Parameters of the multiple reflection filter

6.2.2 Filtering the measurement data

Under the tab "Filter", the output of the measurement value can be filtered.

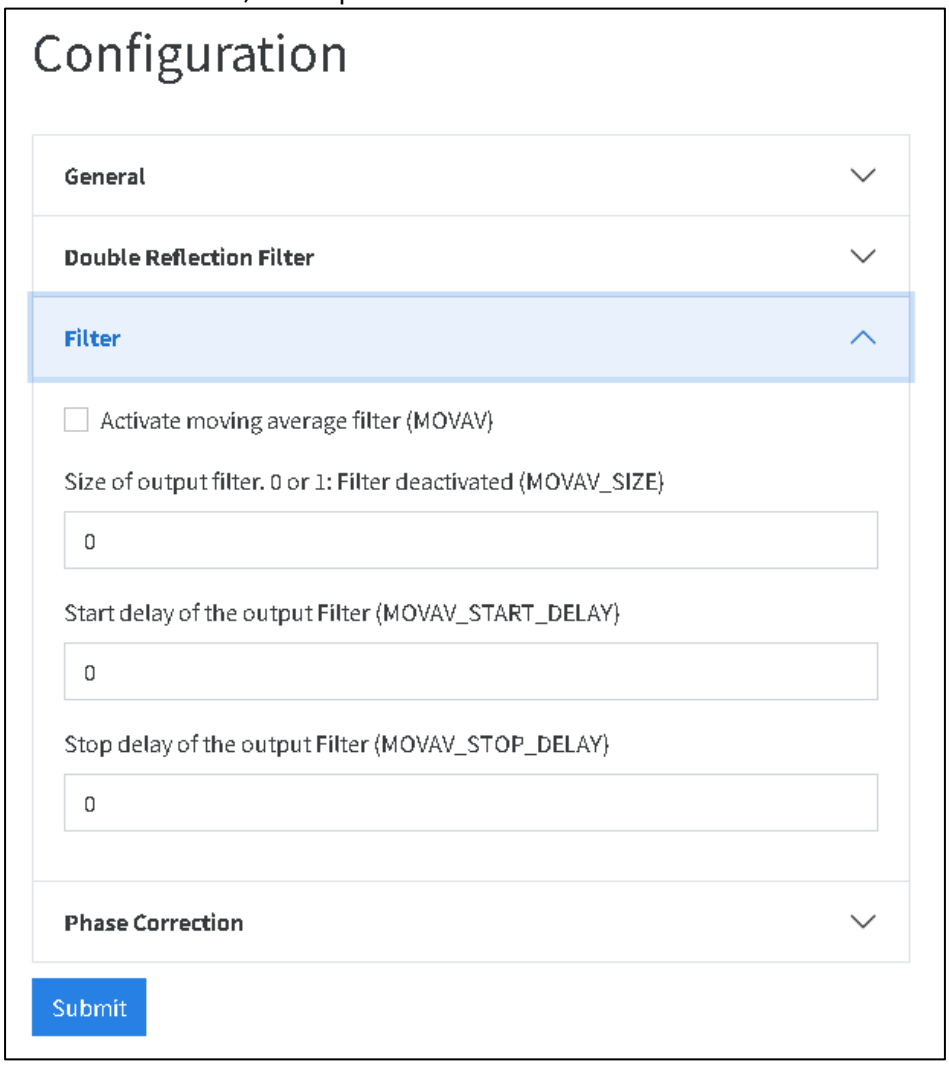


Figure: Parameters of the filter

If a filter is to be used, the checkbox "MOVAV" must be set and the filter must be defined by the number of measurement values "MOVAV_SIZE" and the parameters "MOVAV_START_DELAY" and "MOVAV_STOP_DELAY". The "MOVAV_START_DELAY" parameter specifies how many valid measured values (values >0) must be measured in a row before the filtered measurement value is output. The "MOVAV_STOP_DELAY" parameter describes how many measurements in which no object is detected (values = 0) must be measured in a row before the output of the filtered value is stopped A number of measurement values to be filtered of 0 deactivates the filter (regardless of whether the "MOVAV" checkbox is set) and the unfiltered measurement value is output.

6.2.3 Phase correction

In special situations it makes sense to activate the phase correction. This is the case, for example, if the ambient conditions are clean and the surface being detected is very uniform.

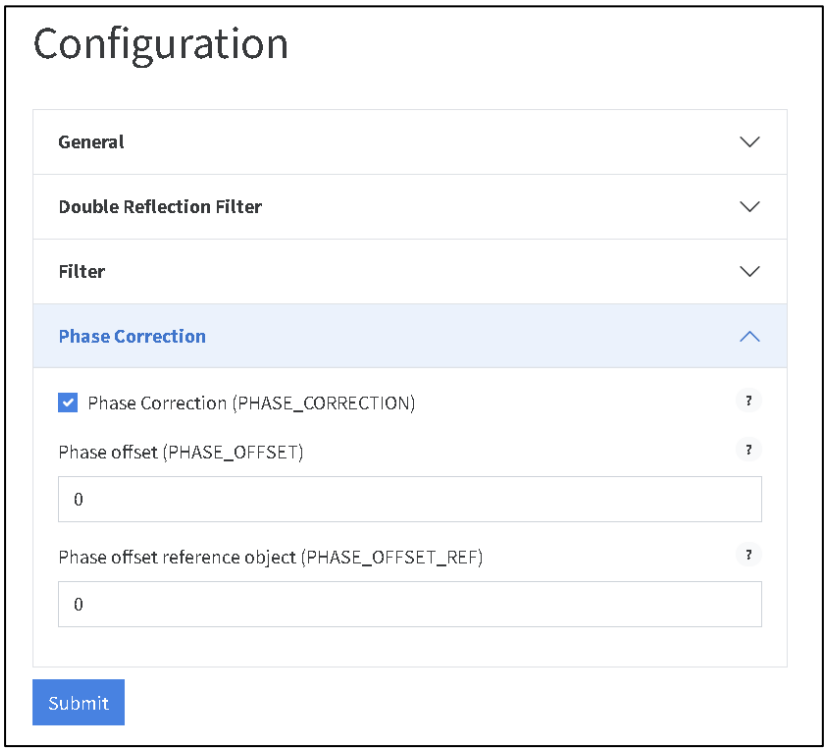


Figure: Phase correction parameters

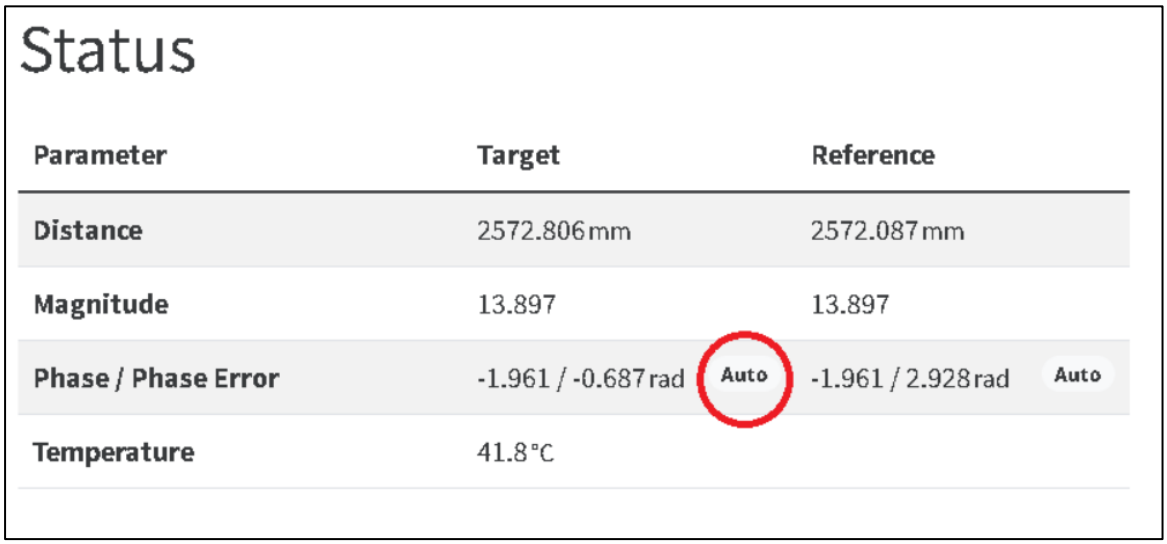
To activate phase correction, set the checkbox "Phase Correction" and click on the button "Submit" (or press “Enter” after selecting). After accepting the parameters (automatically after approx. 30 seconds), the phase correction is activated. Afterwards, (for the phase correction to work properly) the algorithm has to be adapted to the ambient conditions. Here it must be ensured that a measurement object or calibration standard is located in the measurement range of the sensor unit.
The adaptation to the ambient conditions is made by the parameters "PHASE_OFFSET" (for the ”Target”) and "PHASE_OFFSET_REF" (for the “Reference”, if this is used). There are two variants, whereby the second is to be preferred since it is simpler and more convenient.

Variant 1: Click on the tab "Status" and note the value for “Phase Error”. Then, the new "PHASE OFFSET" is calculated according to the following formula:

Phase_offset_new= Phase_offset_act - Phase Error

"Phase_offset_act" is the value which is entered at the time of the measurement at "PHASE_OFFSET". The adjustment must also be made for the “Reference” in the same way.

Variant 2 (preferred): Click on the tab "Status" and then click on the button "Auto" next to the value for the "Phase Error". The sensor unit now records 20 measurement values to determine the optimum phase offset and automatically adjusts the phase offset:



Status

Parameter	Target	Reference
Distance	2572.806 mm	2572.087 mm
Magnitude	13.897	13.897
Phase / Phase Error	-1.961 / -0.687 rad Auto	-1.961 / 2.928 rad Auto
Temperature	41.8 °C	

Figure: Automatic adjustment of the phase offset with activated phase correction

To adjust the phase offset of the reference, click on the button "Auto" to the right of the "Phase Error" value of the reference.

After clicking the button "Auto", the display in the button counts down from 20 to 0. During this period, it is extremely important that the sensor unit and the measurement object are not moving so that a correct adjustment can be made.

Notes:

- After structural changes or after re-alignment, a new adjustment of the phase correction to the ambient conditions must be carried out.
- After each adjustment of the phase correction, the customer must perform a calibration in their measurement application.

6.3 Commissioning model Level

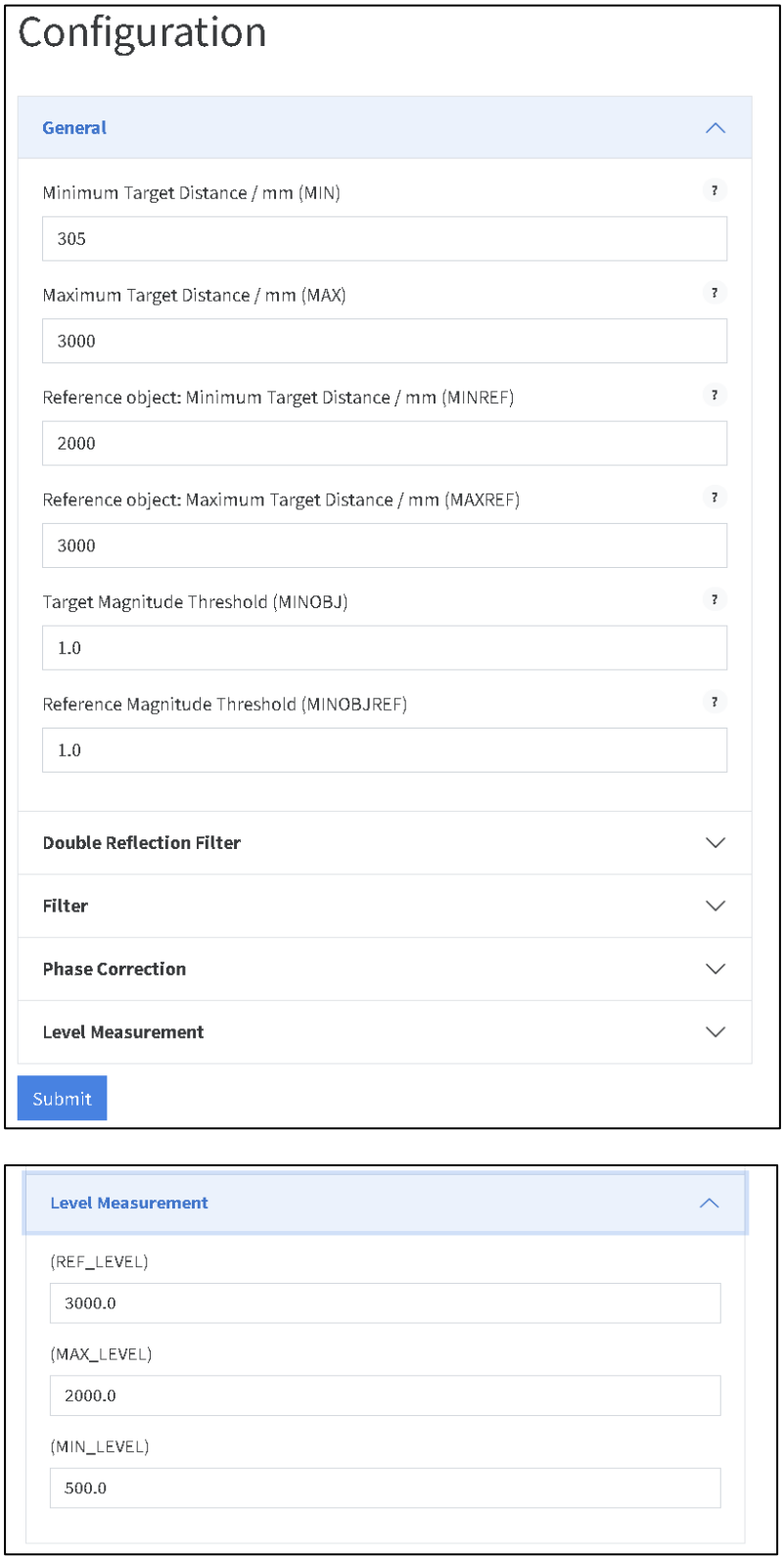


Figure: Parameters of the model Level

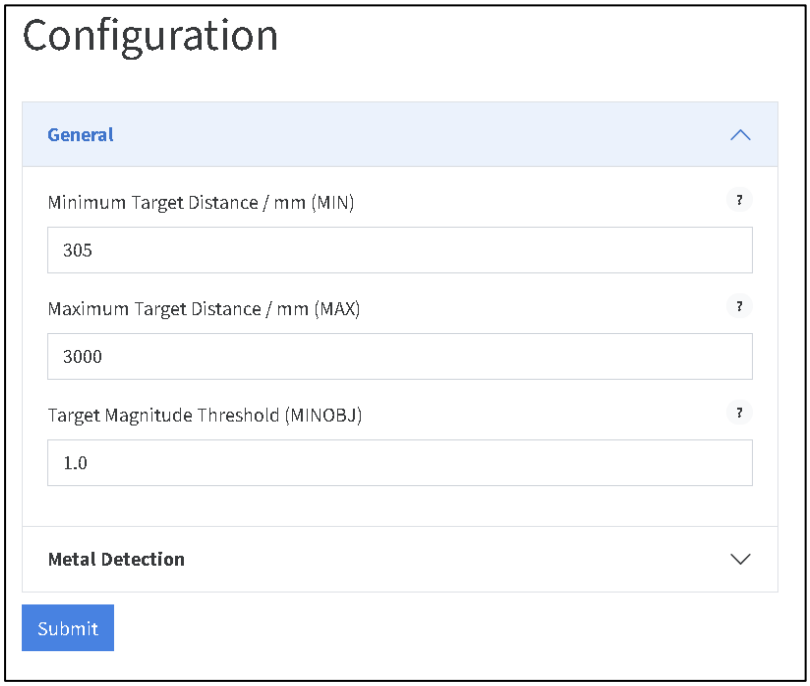
1. Set the minimum and maximum distance at which the fluid is to be detected. This is done via the parameters "MIN" and "MAX". Please note that the parameters "MIN" and "MAX" describe the direct distance to the surface of the fluid and not the minimum or maximum level of the fluid. It is advisable to define the measurement range a bit larger in order to also detect levels above the maximum level as well as below the minimum level.

2. Check the signal strength without fluid. To detect this, it is necessary that there is no fluid in the measurement range of the sensor unit. Adjust the "MAX" parameter so that no object is detected (decrease it so that no object is detected). Check the signal strength under "Status" → "Magnitude" "Target" and note the value. Then set the "MAX" parameter back to the determined value in point 1).
3. Check the signal strength at minimum level (maximum distance to sensor unit). Note down this value as well. If different fluids are used, make sure that the signal strength is recorded for the fluid with the lowest reflectance (lowest measured signal strength of the sensor unit). This is usually the fluid with the lowest conductivity as well as the roughest surface).
4. Set the minimum signal strength at which a measurement is performed. This is done by the parameter "MINOBJ". In most cases it is sufficient to determine this parameter as follows:
   MINOBJ = (magnitude_no_fluid + magnitude_lowest_fluid_level)/2.
   If it is later determined that there are cases where a fluid cannot be detected, this parameter can be further reduced. However, care must be taken that it is not chosen lower than the signal strength determined under 2), the measurement without fluid.
5. Set the distance between minimum level and sensor unit as well as the threshold value for minimum and maximum level. Under the tab "Level Measurement" in the configuration menu. The parameter "REF_LEVEL" describes the distance between the sensor unit and the bottom plate (measurement with empty vessel). This distance can be determined, with an empty vessel, via "status" → "Distance" "Target" if it is not known. The parameter "MAX_LEVEL" describes the maximum level. If the maximum level is exceeded, relay contact 2 is set. The "MIN_LEVEL" parameter describes the minimum level. If the minimum level is not reached, relay contact 1 is set.

Furthermore, it is possible to use a multiple reflection filter, to activate the filtering of the measurement data and to use the phase correction. See chapter 6.2.1-3.

6.4 Commissioning model Scout

The model Scout can be used in two different operating modes. If a perpendicular detection of the workpiece or measurement object’s surface is possible, the direct detection is to be preferred.



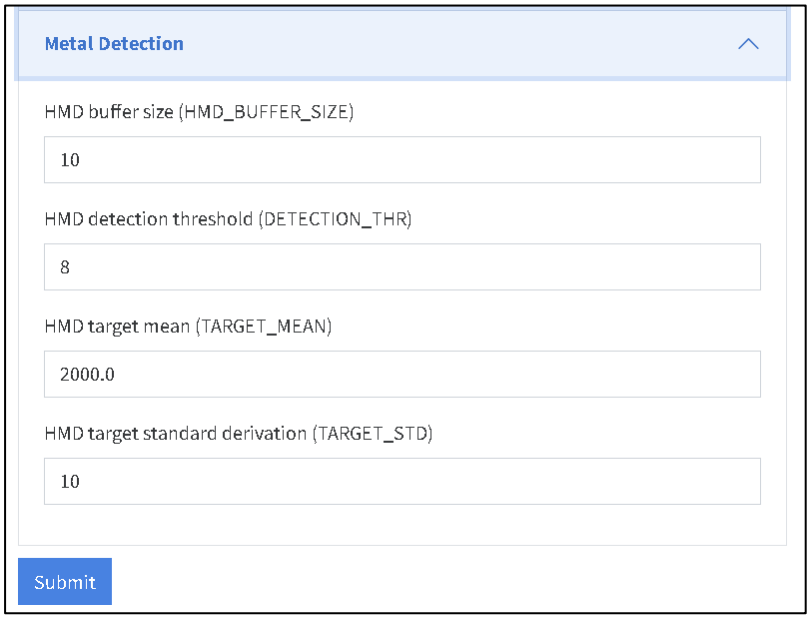


Figure: Parameters of the model Scout

6.4.1 Direct detection ("HMD_DIRECT")

1. To switch to the "HMD_DIRECT" operating mode, the checkbox "HMD_DIRECT" must be set in the configuration menu under the tab "Metal Detection" (if not already activated) and then confirmed by clicking the button "Submit" or pressing “Enter”.
2. Then, the measurement range is selected. The parameters "MIN" and "MAX" are located under the tab "General". These are initially set to a larger measurement range than the one that will be used later.
   Example: The surface of an object can be located at a distance of 1000 mm to 1200 mm. At a distance of 2000 mm there is an object which is detected if there is no object in the measurement range (e.g., a wall or a metal part on the other side of the roller table). In this case, the measurement range is set as follows: "MIN" = 500 mm and "MAX" = 3000 mm, the threshold value of the signal strength "MIN" is set to 1 to ensure that a measurement is always performed.
3. Afterwards, the measurement object is first placed at a minimum distance from the sensor unit. The currently recorded measured value is checked and noted under "Status" → "Distance" "Target". Then the measurement object is placed at the maximum distance from the sensor unit and the currently recorded measured value is also checked and noted.

4. Then, the measurement object is removed from the measurement range and the measured distance ("Distance" "Target") and the signal strength ("Magnitude" "Target") are checked and noted under "Status".
5. The measurement range is then set more precisely to prevent objects in front of or behind the area to be measured from influencing the measurement:
   The value "MIN" is set to the minimum object distance (determined in 3)) minus 100 mm, the value "MAX" is set to the distance of the object determined in 4), which is detected when there is no workpiece in the measurement range plus 200 mm.
6. Set the parameters of the metal detection. These are located under the tab "Metal Detection". The parameters can be specified by using the values determined under 3) as follows:
   "TARGET_MEAN"= (minimum_distance_object + maximum_distance_object) / 2
   "TARGET_STD"= (maximum_distance_object - minimum_distance_object) + 10 mm
7. The parameter "HMD_BUFFER_SIZE" specifies how many measured values are used for a detection. Together with the parameter "DETECTION_THR", the switching behavior of the sensor unit is determined. The parameter "DETECTION_THR" specifies how many measured values are required to cause a change of the state of the sensor unit. A small "HMD_BUFFER_SIZE" ensures a fast reaction time of the sensor unit, a large "HMD_BUFFER_SIZE" causes a slow but more reliable detection.
   Example: With an "HMD_BUFFER_SIZE" of 10 and a "DETECTION_THR" of 8, at least 8 of 10 values must have detected or not detected an object to cause a change of state of the sensor unit.

6.4.2 Object detection by using a reflector (indirect detection)

In some situations, direct detection of the measurement object is not possible (e.g., if the measurement of the measurement object's surface cannot be made at a perpendicular angle or the measurement object does not have a smooth surface that allows detection). In such a case, a reflector can be used. In this situation, the sensor unit does not detect the measurement object itself, but registers that the reflector is covered by the object. It is important that the sensor unit is installed at a perpendicular angle to the reflector's surface (or the reflector is installed at a perpendicular angle to the sensor unit), as described in chapter "Alignment model Scout". It is also important to ensure that the reflector is made of a conductive material (e.g., aluminum or steel) that detects the sensor unit with good signal strength.

1. Set the measurement range: The measurement range of the sensor unit must be set via the "MIN" and "MAX" parameters. The parameter "MIN" must be selected so that the start of the measurement range is detected by the sensor unit ("MIN"= start of measurement range -100 mm). The parameter "MAX" must be selected so that the measurement range is captured the reflector ("MAX" = distance of the reflector to the sensor unit +100 mm).
   Example: A reference object is installed at a distance of 3000 mm, objects pass the measurement range between 1000 mm and 2500 mm. In this case, set the value 900 for the parameter "MIN" (1000 mm -100 mm) and set the value 3100 for the parameter "MAX" (3000 mm + 100 mm).
2. Set the minimum signal strength "MIN_OBJ": When the object is detected indirectly, the parameter "MIN_OBJ" is always set to a value of 1. Thus, a measurement always takes place even if the signal strength of the sensor unit is low (e.g., in the case of a reflector hidden by a measurement object).
3. Set the parameters of the metal detection. These are located under the tab "Metal Detection". The parameters can be determined as follows:
   "TARGET_MEAN"= Distance to reflector.
   →This can be determined under the tab "status" → "Distance" "Target".
   In this case, "TARGET_STD" describes the measurement range for the reflector. This measurement range extends symmetrically around the mean distance of the reflector "TARGET_MEAN". To determine the measurement range of the reflector correctly, it is necessary to check a possible variation of the distance in the running process.
   "TARGET_STD"= maximum variation of the reflector distance in the process + 10 mm
4. The parameter "HMD_BUFFER_SIZE" specifies how many measured values are used for a detection. Together with the parameter "DETECTION_THR", the switching behavior of the sensor unit is determined. The parameter "DETECTION_THR" specifies how many measured values are required to cause a change of state of the sensor unit. A small "HMD_BUFFER_SIZE" ensures a fast reaction time of the sensor unit, a large "HMD_BUFFER_SIZE" causes a slow but more reliable detection.
   Example: With an "HMD_BUFFER_SIZE" of 10 and a "DETECTION_THR" of 8, at least 8 of 10 values must have detected or not detected an object to cause a change of state of the sensor unit.

HINT

The parameter "DETECTION_THR" must always be selected lower than the set "HMD_BUFFER_SIZE", otherwise no object detection can take place.

6.5 Function test

After commissioning, a function test of the sensor unit must be carried out by the customer's qualified personnel. This must be repeated at weekly intervals and in the event of a malfunction in order to guarantee the function of the sensor unit.

6.5.1 Model Distance

1. Measurement without measurement object: No measurement object is placed in the measurement range, the output must be the value "0".
2. Measurement with smallest measurement object near the minimum distance. The output should correspond to the distance between the sensor unit and the measurement object.
3. Measurement with smallest measurement object near the maximum distance. The output must correspond to the distance between the sensor unit and the measurement object.

If one of the three points cannot be carried out successfully, a visual check is first carried out for other objects and contamination in the area to be measured or on the cover plate of the sensor unit. It must also be checked whether the fastening screws of the sensor unit have loosened; if this is the case, a new alignment must be carried out. If the function test still cannot be completed successfully, the commissioning must be repeated.

6.5.2 Model Level

1. Measurement below the minimum level (if the process allows it): A level below the "MIN_LEVEL" value is set in the vessel (tank, furnace, etc.). Here, the measured value of the level must be checked, as well as the correct switching of the relay contact for falling below the minimum level (relay 1 switched, relay 2 not switched).
2. Measurement standard range of the level (value between "MIN_LEVEL" and "MAX_LEVEL"): A level which is within the normal range is set in the vessel (tank, furnace, etc.). Here, the measured value of the level must be checked. Furthermore, it must be checked whether both relay contacts are not switched (relay 1 & 2 not switched).
3. Measurement above the maximum level (if the process allows this): A level which is above the value "MAX_LEVEL" is set in the vessel (tank, furnace, etc.). Here, the measured value of the level must be checked, as well as the correct switching of the relay contact for exceeding the maximum level (relay 1 not switched, relay 2 switched).

In some cases, it is not possible to set a specific level in the vessel (tank, furnace, etc.). In this case, it is advisable to use fixtures with which a reference object with the three test distances (or test levels: low/ normal/ high) can be placed below the sensor unit.
If one of the three points cannot be carried out successfully, a visual check is first carried out for other objects and contamination in the area to be measured or on the cover plate of the sensor unit. It must also be checked whether the fastening screws of the sensor unit have loosened. If this is the case, a new alignment must be carried out and then the commissioning must be repeated.

6.5.3 Model Scout

1. Measurement without measurement object: It is ensured that there is no measurement object in the measurement range. The relay contact 1 must not be switched in this case.
2. Check with smallest measurement object at minimum distance: A measurement object is placed close to the minimum distance. Relay 1 of the sensor unit must be switched.
3. Check with smallest measurement object at maximum distance: A measurement object is placed near the maximum distance. Relay1 of the sensor unit must be switched.

If one of the three points cannot be carried out successfully, a visual check is first carried out for other objects and contamination in the area to be measured or on the cover plate of the sensor unit and any reflector used. It must also be checked whether the fastening screws of the sensor unit have loosened. If this is the case, a new alignment must be carried out and then the commissioning must be repeated.

7 Operation

WARNING

Danger because of hot surfaces!

The housing of the sensor unit can become hot.

- Do not touch the sensor unit, wear heat-resistant gloves.

7.1 Start sensor unit

Operating status: The sensor unit is always in normal operation. If the power supply is disconnected, the device is off. After the power supply is restored, the device automatically switches to normal operation after the boot process has been completed (approx. 30 seconds).

7.2 Function via digital interface Modbus/TCP

The measurement result can be requested cyclically via the digital interface Modbus/TCP (see chapter 1.1 - Other applicable documents). The measurement data is provided via the digital interface.

7.3 Function via relay contact

With the models Level and Scout, the states (object present/not present as well as level in the normal range/below the minimum or above the maximum level) can be detected or checked via the relay contacts.

7.4 Function via web application

It is also possible to monitor the function of the sensor unit via the web application. For this purpose, a connection with a computer to the web interface must be established (see chapter 4.8). Under the tab "Status", the currently measured values of the sensor unit can be monitored (see chapter 4.8.7).

7.4.1 Troubleshooting and error resolution

Permitted operator intervention applies only to easily detectable malfunctions that can be corrected without further hazards and without disassembly of components.

7.4.2 Malfunction

The sensor unit runs almost without malfunction. If a malfunction occurs, check the following:

- Is there a workpiece or object in the measurement range?
- Is the cover plate of the sensor unit dirty or damaged?
- Are all screws of the sensor unit tight?
- Check the condition of all cables and tubes used, are there any cut, damaged or loosened cables?
- Check the correct function of the PoE power supply? Is the sensor unit supplied with voltage?
- Are measured values displayed and updated in the web application (under the tab "Status")?

No status messages are currently sent via the Modbus/TCP interface.

7.5 Cleanliness

The operator must remove coarse soiling in the area to be measured. This also includes objects that have been left in the area to be measured, such as scale plates or similar. For this purpose, a visual inspection must be carried out regularly and the cover plate of the sensor unit must be cleaned if it is dirty.

8 Maintenance

8.1 Document maintenance

Maintenance work according to the maintenance schedule must be carried out by the operator of the device and documented in a maintenance log. Otherwise, improper maintenance, even during the warranty period, will void any warranty claims against the manufacturer.
The specifications made in the maintenance and care instructions are guide values which must be adapted to the operating conditions after commissioning and corrected if necessary. Under extreme conditions, such as dirty environments, the intervals must be shortened. At the end of the work shift, the operator must leave the workplace clean and tidy.

8.2 Maintenance schedule

Interval	Maintenance work	Comment
Daily	Visual inspection of the device	Immediately remove dirt and damage
Daily	Check for dropped parts, dirt or process residues	Immediately remove parts, dirt
Weekly	Function test	As described in chapter 6.5
Monthly	Check fastening screws for tight fit and check connecting cables	Tighten or replace if necessary. If the screws are loose, the alignment must be carried out again.
Annual	Check calibration (for models Distance and Level) by mecorad GmbH.	In order to achieve a constant accuracy, an annual calibration should be carried out

8.3 Regular inspections

The device must be checked daily: During this inspection, a walkaround must be made to see if any obvious defects, damage or abnormalities of any kind can be detected.

- Visual inspection to see if there is any dirt or damage on the sensor unit or in the area to be measured.

WARNING

Danger due to safety defects and hot surfaces!

If defects, damage or abnormalities of any kind are detected during the walkaround, a safety defect may be present.

- Immediately report to the supervisor, who will decide on further action.
- Do not touch the sensor unit, wear heat-resistant gloves.

This refers to defects, damage or abnormalities such as damaged cables and lines.

- In case of defective electrical lines, immediately initiate maintenance measures.

The sensor unit as well as its wiring and holder must be subjected to an annual general inspection:

- Check screw connections for tightness, retighten if necessary.
- Check all cable connections.
- The cover plate of the sensor unit must be cleaned thoroughly.

8.4 Maintenance instructions for electrical equipment

DANGER

Danger due to electric shock: Residual voltage remaining in the sensor unit in the area of the sockets must be taken into account. This can lead to injuries and damage due to the electrical voltage.

Do not use cleaning products with aggressive ingredients and do not scratch the surface with sharp objects.

At regular intervals (depending on the ambient conditions):

- Clean the cover plate of the sensor unit with a lint-free cloth and plastic cleaning product.
- Depending on the ambient conditions and dust load, the housings must also be cleaned cyclically.

8.5 Calibration

Measurement equipment and measurement systems are subject to the measurement equipment monitoring and must be checked annually.

Calibration is mandatory on an annual basis. In addition, calibration is required in case of sensor unit failure or permanent measured value deviation.

CAUTION

Calibration can only be carried out by the manufacturer's authorized qualified personnel (mecorad GmbH). In case of unauthorized violation, the warranty becomes void.

The sensor unit must be sent in for calibration. If this is not possible, please contact the manufacturer.

9 Disassembly, storage and disposal

This section contains information on disassembly, storage as well as disposal of the components.

9.1 Disassembly

A qualified electrician is responsible for disassembly. The tools for simple mechanical installations are assumed here. Consideration of the general and locally applicable safety regulations must be ensured.
The following steps must be carried out:

- Remove the power supply cable.
- Remove other cables on the sensor unit (e.g., signal cable relay contact).
- Disassemble the sensor unit.

9.2 Storage

The sensor unit and accessories must only be stored under the following conditions:

- Store in a dry and dust-free place
- Do not store outdoors
- Protect from direct sunlight
- Do not expose to aggressive media
- Avoid vibration and mechanical shocks
- The storage temperature (see chapter 4.3) must be maintained
- The relative humidity must not exceed 60%

In case of storage for a period longer than one quarter, the condition of the parts as well as the packaging must be checked.

9.3 Disposal

The disposing party is responsible for the disposal of the sensor unit and its accessories. Dispose of the low voltage equipment in accordance with the legislation of the country in which the system is disposed of. The waste generated by the system must be disposed of in a legally compliant, proper and professional manner. After disassembly, all individual parts must be sorted according to the various components made of steel, plastic and electronic scrap:

- Separate control components and recycle them as electronic scrap
- Metal components to be recycled as metal scrap
- Send plastic parts to the recycling plant
- Dispose of other components according to material properties

Local authorities and specialist disposal companies provide information on environmentally compatible disposal.

10 Declaration of conformity

10.1 Declaration of conformity USA

This device has been tested and found to comply with the requirements set forth in 47 CFR Part 15 for both fundamental emissions and unwanted emissions. These limits are designed to provide reasonable protection against any harmful interference when the device is operated in a commercial environment.

Modifying the device without mecorad's authorization may result in the device being no longer compliant with FCC requirements. In that event, your right to use the device may be limited by FCC regulations, and you may be required to correct any interference to radio or television communications at your own expense.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the device.

This device complies with the requirements set forth in 47 CFR Section 95.3385 addressing RF exposure from radio frequency devices. To maintain compliance, the minimum separation distance from the antenna to general bystander is 20 cm.

FCC Part 15.105 statement:

This equipment has been tested and found to comply with the limits for a class B digital device, pursuant to Part 15 of the FCC Rules.

These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. if this equipment does cause harmful interference or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: - Reorient or relocate the receiving antenna. - Increase the separation between the equipment and receiver. - Connect the equipment into an outlet on a circuit different from that to which the receiver is connected - Consult the dealer or an experienced radio/TV technician for help.