User Manual
OndoSense *apex*

RS485 version

ONDOSENSE *apex*

Table of Contents

1 General Information

> ⓘ Please read this instruction carefully before operating the sensor. This manual provides information on the use, care and safety of the **OndoSense *apex*** radar sensor. Further information and assistance is available via support@ondosense.com.

1.1 Legal Notices

1.2 Frequencies

Our **OndoSense *apex*** radar sensors are technically suitable of using frequencies outside the ISM bands. In many countries, the usable bandwidth for production purposes is restricted to 1 GHz between 122 GHz and 123 GHz. Please check the local regulations. It is the customer's responsibility to ensure operation of the **OndoSense *apex*** radar sensors in accordance with local regulations. This applies in particular to broadband frequency uses outside of a laboratory environment. OndoSense assumes no liability for any consequences resulting from failure to comply with these instructions.

1.3 Target Group

The device may only be planned, mounted, commissioned and serviced by persons having the following qualifications and fulfilling the following conditions:

- Technical training.
- Briefing in the relevant safety guidelines.
- Constant access to this documentation.

1.4 Preliminary Remark

The following basic safety instructions are intended to avoid personal injuries and damage to property; they relate primarily to the use of the products described herein. If you additionally use further components, also consider their warnings and safety instructions.

1.5 Feedback

We endeavor to make these instructions as informative and clear as possible. If you have any suggestions or are missing information in the instructions, please send your feedback to: support@ondosense.com.

1.6 Transport/Storage

Check the delivery immediately upon receipt for possible transport damages. If you do not mount the device immediately, store it preferably in its transport package. The device must be stored at a dry location.

1.7 Intended use

The **OndoSense *apex*** is a radar sensor for non-contact distance measurement of objects. OndoSense GmbH assumes no liability for losses or damage arising from the use of the product, either directly or indirectly. This applies in particular to uses of the product that do not conform to its intended purpose and are neither described nor mentioned in this documentation.

1.8 Improper use

The **OndoSense *apex*** radar distance sensor is not intended as a safety component in accordance with the EC Machinery Directive (2006/42/EC). It must not be used in hazardous areas without proper explosion protection. Any other use that is not described as intended use is prohibited. Never install or connect accessories if their quantity and composition are not clearly specified, or if they have not been approved by OndoSense GmbH.

1.9 Other Applicable Documents

All technical data, as well as the mechanical and electrical characteristics, are specified in the data sheets of the corresponding device variant, for special versions in the corresponding quotation / customer drawing of the product. All documents such as the original declarations of conformity or the relevant certificates can be downloaded from our support website.

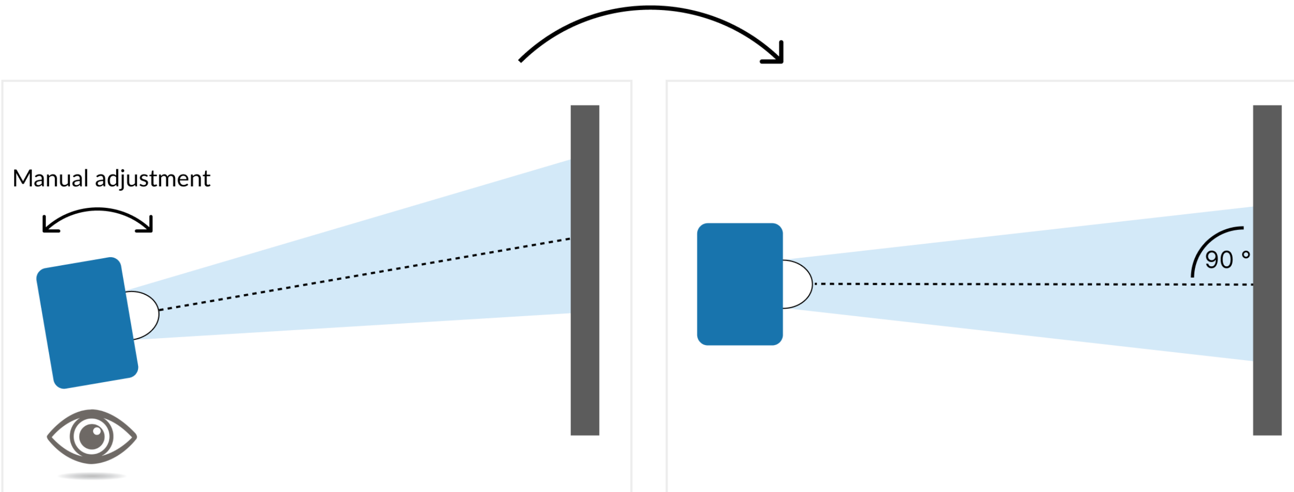
2 Quick-Start

2.1 Assembly and commissioning

Prerequisites: For the setup, you will need the sensor, a ConfigBox, a M12 cable attached to a circuit board, a power adapter and a LAN cable. Additionally, you will need a mounting bracket to position the sensor toward your target.

1 Align the sensor towards the target (rough alignment)

Visually align the sensor so that it is perpendicular to the target. Ensure the mounting allows for fine-tuning of the orientation.

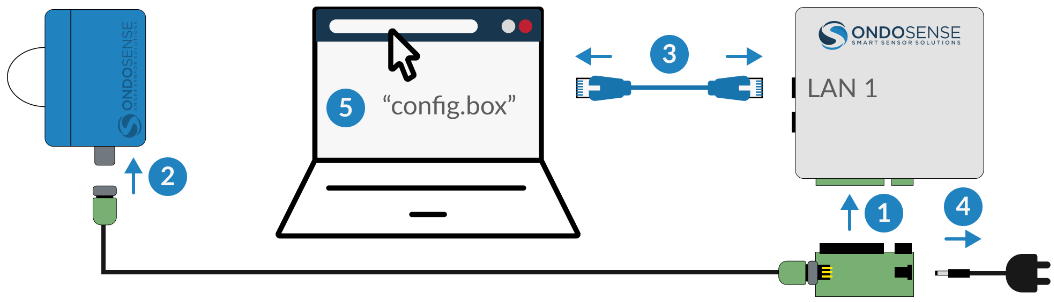


Visually align the sensor perpendicular to target

2 Setup configuration box and connect to OndoNet

Connect the sensor to the ConfigBox and your computer as illustrated below. Once connected, enter “config.box” in your browser’s address bar (no “www”). You should be able to open OndoNet within a minute, after connecting the ConfigBox to the power supply.

> The configuration box is only required for the initial setup of the sensor for the specific application.



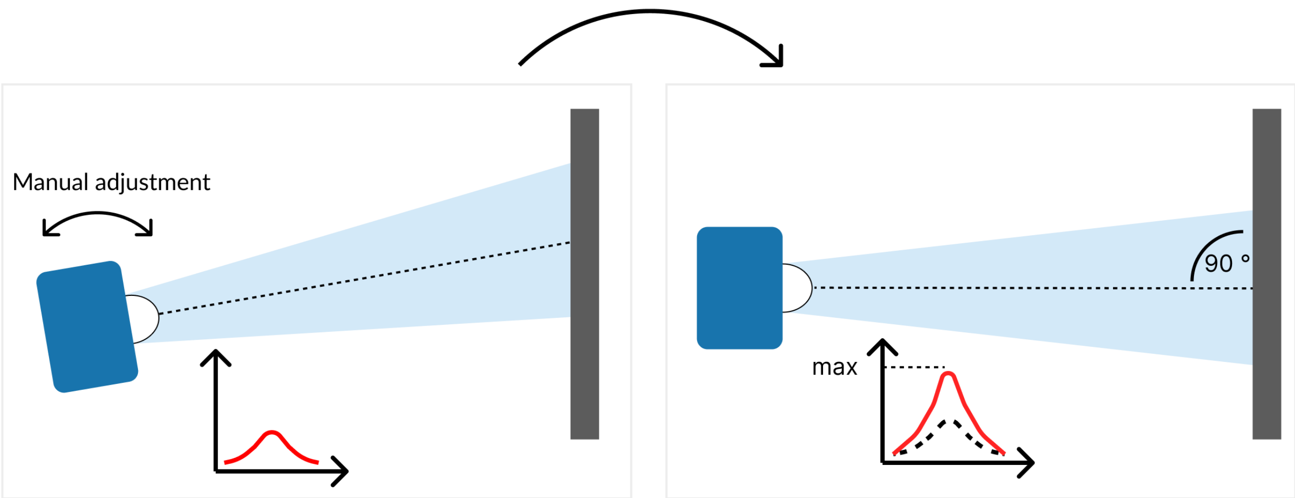
Setup your ConfigBox

2.2 Sensor configuration

Prerequisites: Ensure the sensor is roughly aligned to the target, the ConfigBox is connected to your computer and OndoNet is operational. To view measurements and adjust parameters, navigate to the 'Sensor Configuration' section.

1 Align the sensor towards the target (fine alignment)

Manually adjust the orientation of the sensor while monitoring the signal strength displayed in the configuration software. All detected objects and their signal strength are displayed in the "Spectrum" chart, which is positioned below the "Target" chart.



Align the sensor while monitoring the signal strength

To monitor the signal strength while adjusting the sensor alignment, click on FIX SCALE and ADD HOLD for the magnitude in the spectrum chart. This way you can monitor whether your adjustment leads to an increase or a decrease of the signal strength. Continue until the optimal signal strength is reached.

Once you are done, click on AUTO GAIN in the "Settings" section to further optimize the signal strength. This will automatically adjust the gain parameters of the amplifiers.

2 Adjust the measuring range

Set the measuring range according to the minimum and maximum distances at which the target should be monitored. Objects detected outside this range will be ignored, enhancing the robustness of the measurements.

3 Set a signal threshold to suppress unwanted noise

Position the object at the maximum expected distance to set the threshold. The correct threshold value is dependent on the application. However setting the threshold to 20% of the maximal signal strength at the maximum distance is a good starting point.

4 Configure the sensor outputs (Switching outputs & analog output)

The switching outputs and the current loop (4 - 20 mA) can be configured via the IO Configuration page in the navigation bar on the left.

Switching outputs:

By setting Point 1 and Point 2, you define the distances in mm where the output turns active and inactive; Set Point 2 to the maximum measurement range for Single-Point mode.

Analog output:

You can set the distances in mm at which the current should be 4 mA and 20 mA. The interface will output a current corresponding to the distance of the target. The current will be linear between the two defined distances.

2.3 Connecting to PLC

Prerequisites: The Sensor is precisely aligned and Switching outputs/Analog output and parameters are adjusted. Your Sensor is ready to be connected to your PLC. You need an additional open ended M12 8-pin a-coded female cable.

> The sensor can now be disconnected from the ConfigBox and used as stand-alone device. All parameters from the previous steps are automatically saved.

1 Disconnect the sensor from the ConfigBox

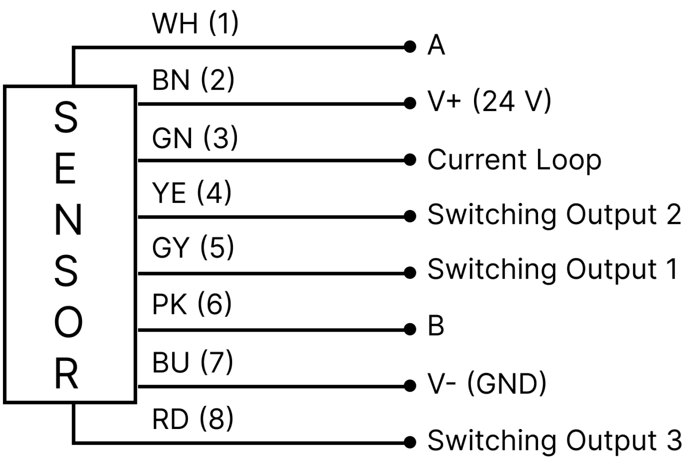
Disconnect the sensor from the ConfigBox and connect your M12 8-pin A-coded female open-ended cable to the sensor.

2 Power up Sensor

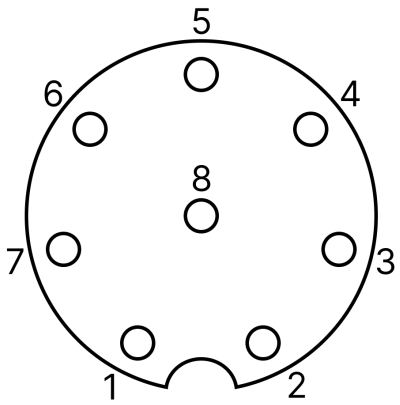
To get the sensor running, connect the **brown** (V+ (24 V)) and **blue** (V- (GND)) cables to a power source.

3 Connect Output cables

The **grey**, yellow and **red** cables transmit the previously configured switching output signals. Connect the **green** cable to obtain the analog output.



Pinout diagram sensor



M12 8-pin a-coded male layout

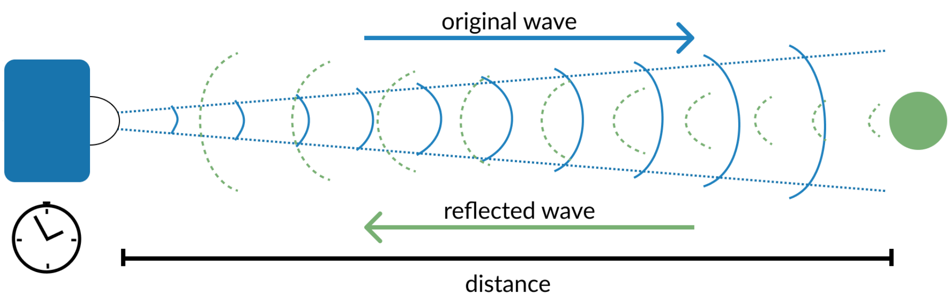
Electrical connection

3 Radar Tutorial

This chapter gives you a concise overview of radar technology, covering its key principles and practical applications. You'll gain an understanding of how radar sensors operate and the various factors that influence their performance

3.1 Distance Measurement with Radar

Radar operates by emitting electromagnetic waves, which travel through the air at nearly the speed of light. When these waves encounter an object, they are reflected back towards the radar sensor. The sensor then measures the time it takes for the waves to return. By analyzing this time delay and the frequency shift of the reflected waves, the radar sensor can accurately determine the distance and velocity of the object. This technology ensures precise and reliable measurements, making radar sensors essential for various applications.



Distance measurement with electromagnetic waves

3.2 Radar penetrates non-conductive Materials

Radar sensors can penetrate non-conductive materials such as plastic, rubber, cardboard, glass, and similar substances because radar waves are only partially reflected by these dielectric materials. Conversely, when radar waves encounter metals or closed water surfaces, they are fully reflected. This ability to penetrate certain substances or objects makes radar distance sensors highly versatile and suitable for a wide range of applications.

Material	**Penetration**	**Description**
Metal	✖	Impossible
Water/ water film	✖	Impossible in case of a closed water surface. Water drops can be penetrated.
Concrete	⚠	Difficult - depending on the thickness of the concrete
Wood	⚠	Low - the penetration decreases for an increased humidity content of the wood.

Material	Penetration	Description
Plastic / rubber	⚠ - ✔	Medium to high - depending on thickness as well as plastic or rubber type
Paper / cardboard	✔	High - in case of low humidity content
Glass	✔	High - depending on the material's thickness.
Smoke / dust / steam	✔	High

Radar sensors can detect the distance to objects behind glass, plastic or other non-conducting materials. At the interface of the dielectric material, there is a weak reflection, which allows for the determination of the distance to the object. However, most of the radar waves radiate unhindered through this material, so that the distance to an object that is positioned behind the dielectric material can be determined. To protect the radar sensor from irradiation or explosions, glass, heat-resistant plastics or a mica plate can be used. Only a limited amount of the radar signal is reflected, so that the radar sensor detects the distance to the object behind it with high accuracy.

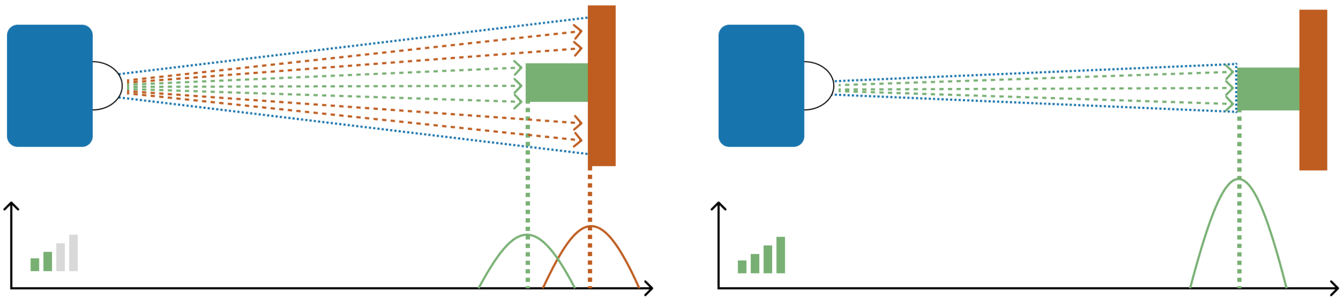
Radar allows you to measure through non-conductive materials: While water drops and high humidity, dust and smoke do not have a big impact on the radar signal, closed water surfaces are more or less impossible to penetrate.

3.3 Opening Angle: Defining the Focus of the Radar Sensor

The measuring spot size of the radar distance sensor, influenced by the opening angle (or aperture angle), significantly affects target detection and interference reflections. Imagine the radar signal as a flashlight beam: a poorly focused flashlight illuminates a wide area but does not reach large distances, while a highly focused flashlight shines further and more precisely on specific objects.

Similarly, for radar sensors, a larger aperture angle results in a larger measuring spot, increasing the field of view but reducing measurement range and accuracy due to signal dispersion and interference. Conversely, a smaller opening angle provides a smaller, more focused measuring spot, enhancing signal strength and accuracy.

The figure below illustrates how the opening angle affects measuring spot size and signal strength. A smaller opening angle offers a stronger signal and higher accuracy.



Opening angle affects measuring spot size

Use the OndoSense radar spot size calculator to determine your sensor's measuring spot size based on distance. Select your radar sensor from the list or input the opening angle and lens diameter for a calculation of the radar spot size in relation to a certain distance to the target object.

Position the sensor closer: Measure closer to the target to reduce the measuring spot size and minimize interference.

Small opening angle = Increased Focus: A small opening angle reduces interference reflections and improves measurement accuracy.

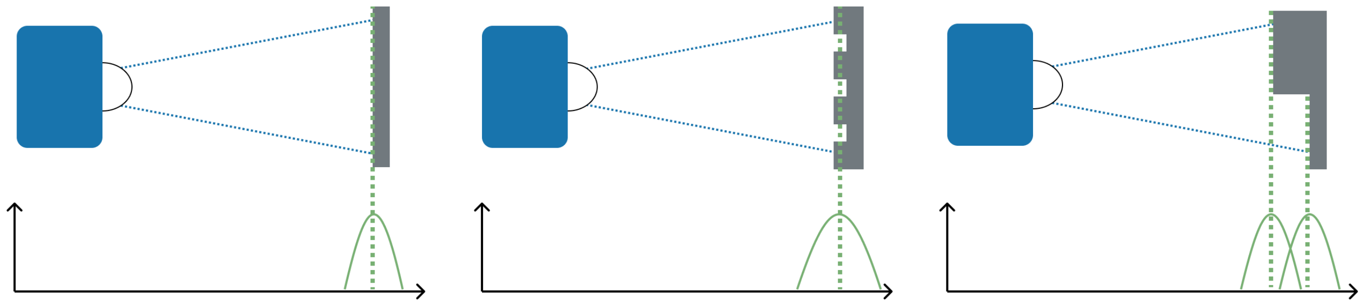
Opening angle and detection orientation: A smaller opening angle limits the maxmimum tilt the target object can have against the orientation of the sensor while still ensuring a stable signal output.

3.4 Radar Resolution and averaging across the Measuring Spot

Radar Resolution: Radar resolution is critical for determining how well a radar distance sensor can distinguish between two closely spaced objects. It defines the minimum distance at which two objects can be separately detected. If the radar signals (peaks) from these objects can be distinguished, their distances can be accurately measured, as shown in the figure below.

Averaging across the measuring spot: When objects are positioned close together or surfaces have complex structures, and the distances between reflection points are smaller than the sensor's resolution, the sensor automatically averages the distance values. This ensures stable, consistent measurements, even on uneven or irregular surfaces. Stronger reflections are given more weight in the averaging process, leading to accurate and reliable readings. By smoothing out the impact of surface irregularities, averaging enhances the sensor's overall performance. For more advanced applications, OndoSense can create customized radar algorithms to further improve measurement precision.

If the radar signals (peaks) from these objects can be distinguished, their distances can be accurately measured. If the peaks from these objects or an uneven surface cannot be distinguished, the distance is averaged across the measuring spot as shown in the figure below.



Averaging across measuring spot if the distance between reflection points is smaller than the resolution

Object Detection: Radar resolution enhances the sensor's ability to accurately detect and distinguish objects that are close to each other, ensuring reliable distance measurements for each individual object.

Measurement Averaging: When multiple reflection points are within the sensor's resolution range, the sensor effectively averages the distances, providing a consistent measurement even in complex surface scenarios.

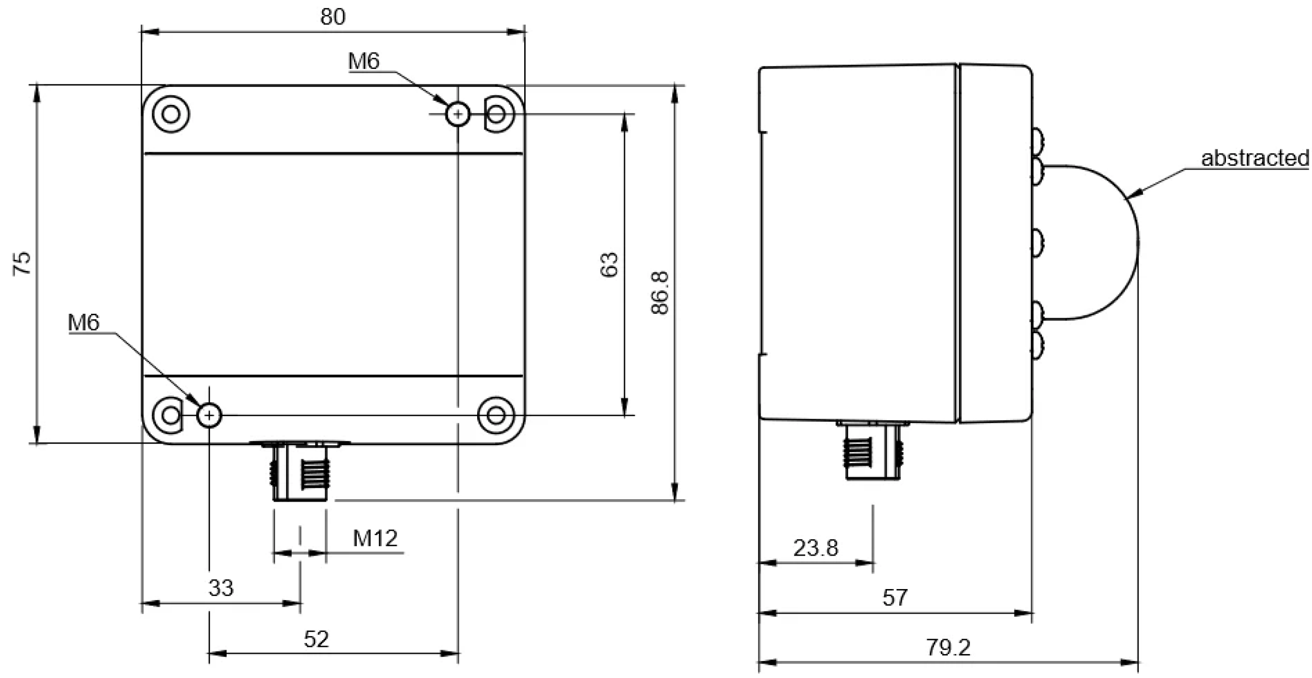
4 Product Information

This chapter provides comprehensive details about the product, including its technical specifications, setup procedures, and electrical connection guidelines. You'll gain the essential knowledge needed to understand the product's capabilities and how to correctly install and operate it.

4.1 Technical Data

ⓘ All technical data, as well as the mechanical and electrical characteristics, are specified in the data sheets of the corresponding device variant.

Mechanical data	
Dimensions (W x H x D)	80.0 mm x 79.2 mm x 75.0 mm
Housing material	Die-cast aluminum, painted
Lens material	PTFE
Connection	M12, 8-pin, a-coded connector
Weight	415 g



Technical drawing

4.2 Sensor Setup

Damage to the device due to transport or storage

- Check the packaging and the device for possible damages.
- In the event of visible damages, do not use the device and do not put it into operation.
- Do not install the device after a fall or drop of the sensor.

Do not disassemble or open the radar sensor

- In no case disassemble the radar sensor entirely or partly.
- Do not modify the radar sensor.

Do not expose the device to impact stress.

- Do not use a hammer to align the radar sensor.
- Avoid impact stress.

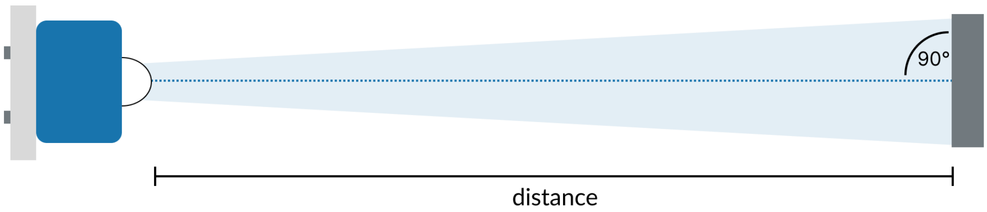
4.2.1 Physical Setup

Mount the sensor so that it is aimed directly at the target. The distance between the target and the sensor affects the size of the measuring spot and the signal strength.

Install the sensor at the recommended distance from the target as specified in the sensor’s technical documentation. This ensures optimal performance and accurate measurements. Note that the further the distance, the larger the measuring spot. More information on this can be found in the Radar Tutorial.

Use the appropriate mounting brackets and hardware to securely fix the sensor in place, ensuring it is stable and not prone to vibrations or movements. Ideally, the mounting bracket should allow for small adjustments to fine-tune the sensor's alignment.

Ensure that the sensor has a clear line of sight to the target with no obstructions. Make sure the bracket permits for a precise alignement of the sensor.

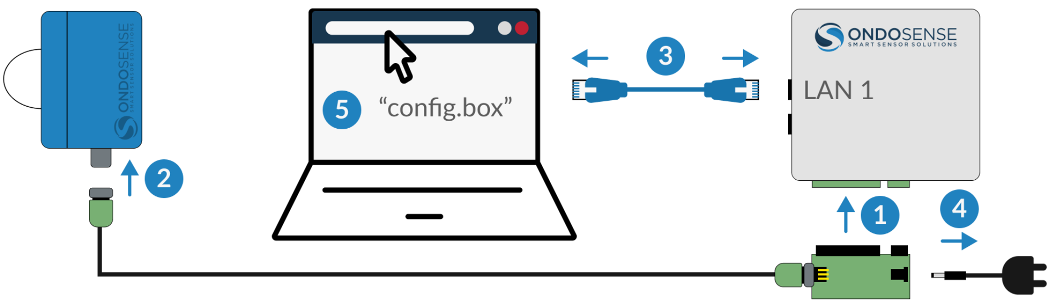


Physical setup

4.2.2 Connecting the Sensor to the ConfigBox

> The ConfigBox is only required for the initial setup of the sensor for the specific application. Once the configuration is completed, the sensor can be disconnected from the ConfigBox and used as stand-alone device.

To connect the ConfigBox to your PC and start the configuration software OndoNet do the following:



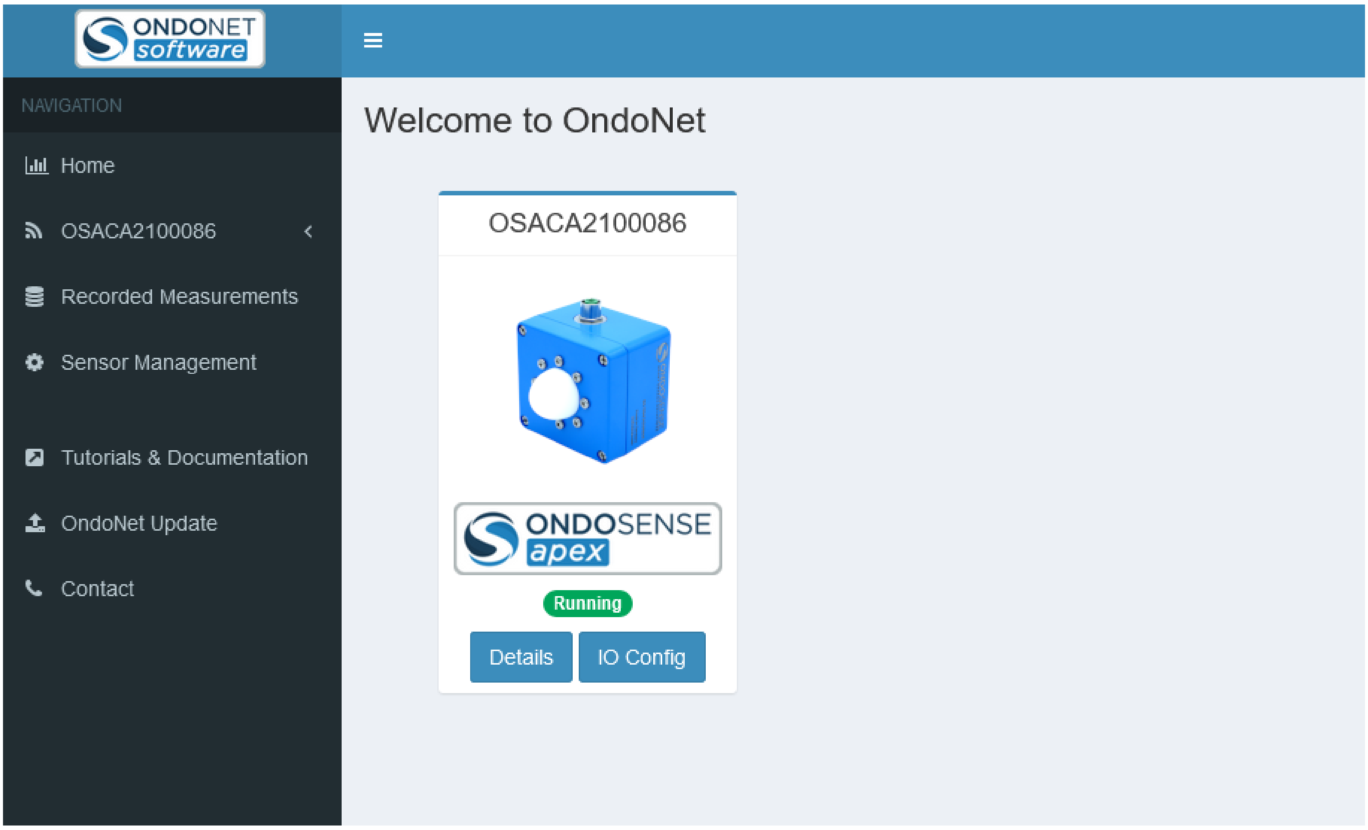
Connecting the sensor to the ConfigBox

1. Connect the circuit board to the ConfigBox
2. Connect the cable coming from the ConfigBox to the sensor using the M12 sensor plug.
3. Connect the ConfigBox on LAN-port 1 with a PC using an Ethernet cable.

4. Connect the power supply of the ConfigBox.
5. Open the browser on the PC and type in "config.box" into the address field to access OndoNet. This might take up to 1 minute.

You should now see the User Interface of OndoNet as displayed in the figure below.

You can now start with the configuration of the sensor as described in the chapter Sensor Configuration unless you want to include the CofigBox into an existing network, which is described in the following section.

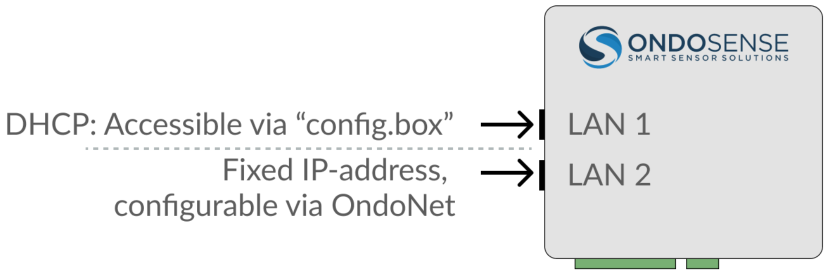


OndoNet interface

If you experience slow performance enter “10.10.42.1” into the browser instead of “config.box”. In case the page does not load, make sure the LAN port of the PC is set to "DHCP" (i.e. automatically obtaining an IP address). To check this go to the Ethernet settings of your PC.

4.2.3 IP-Address Configuration

The IP-Adress of LAN port 2 of the ConfigBox can be configured via OndoNet.
This can be helpful to add the ConfigBox to an existing network or to make the measurement data available via OPC UA.

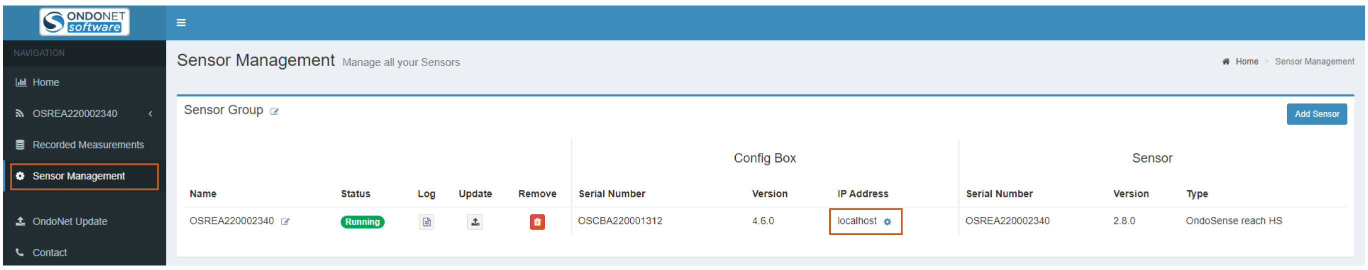


LAN ports of the ConfigBox

To setup a fixed IP address:

- Access OndoNet via LAN1 (config.box).
- Click on SENSOR MANAGEMENT in the navigation bar; click on the ⚙ symbol in the IP Address column.
- In the Pop-up, untick DHCP, enter the desired IP address, Subnet Mask & Default Gateway and Confirm.

Now the new IP address is configured for LAN2. OndoNet and the OPC UA server can now be accessed via the configured IP address.



Changing IP-Adresse to include the ConfigBox in existing network

For being able to access the ConfigBox via LAN port 2, the Ethernet port of the PC must be configured with an IP address in the network address space as the IP address that was set. For example if the IP address of the ConfigBox was set to "192.168.10.143", the IP address of the PC needs to be set to "192.168.10.xxx" with xxx being any number except for 143.

4.3 Electrical Connection

Destruction of the device

Before connecting or disconnecting the signal cable, always disconnect the power supply and secure it against switching on again.

No open cable wires

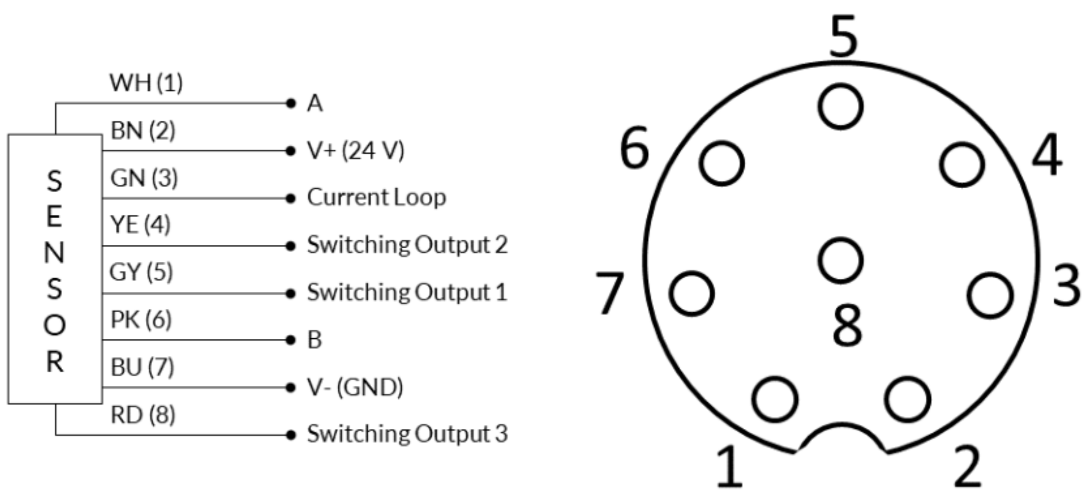
Connect all required cable wires / connectors before commissioning. Insulate individually all unused ends of the output signals to avoid short-circuits. Electrostatic discharges at the contacts of the connector or at the line ends could damage or destroy the device. Take appropriate precautionary measures.

Traction relief

Always mount all lines with traction relief.

To connect the sensor to your PLC, disconnect the ConfigBox from the sensor and connect an open ended M12 a-coded male pin cable. **Wait with this step until after you finished the sensor configuration.**

V+ (24 V) and V- (GND) are used for the power supply. The pins A and B are used for RS485 data exchange. These 4 pins are needed for operating the sensor with RS485 communication. The sensor can be connected with an 8-pin a-coded M12 cable. Additional pins are the 3 switching outputs and the current loop.



Pinout diagram sensor

M12 a-coded male pin layout

Electrical connection

5 Sensor Configuration

This chapter guides you through the process of configuring your sensor, starting with an introduction to OndoNet. It covers the mandatory settings required for proper operation, explores advanced configuration options, and explains the digital and analog interfaces available for sensor output.

5.1 Introduction to OndoNet

After connecting the ConfigBox to your sensor and entering “config.box” in your browser’s address bar you will see the User Interface of OndoNet as displayed in the figure below.

Interface of OndoNet

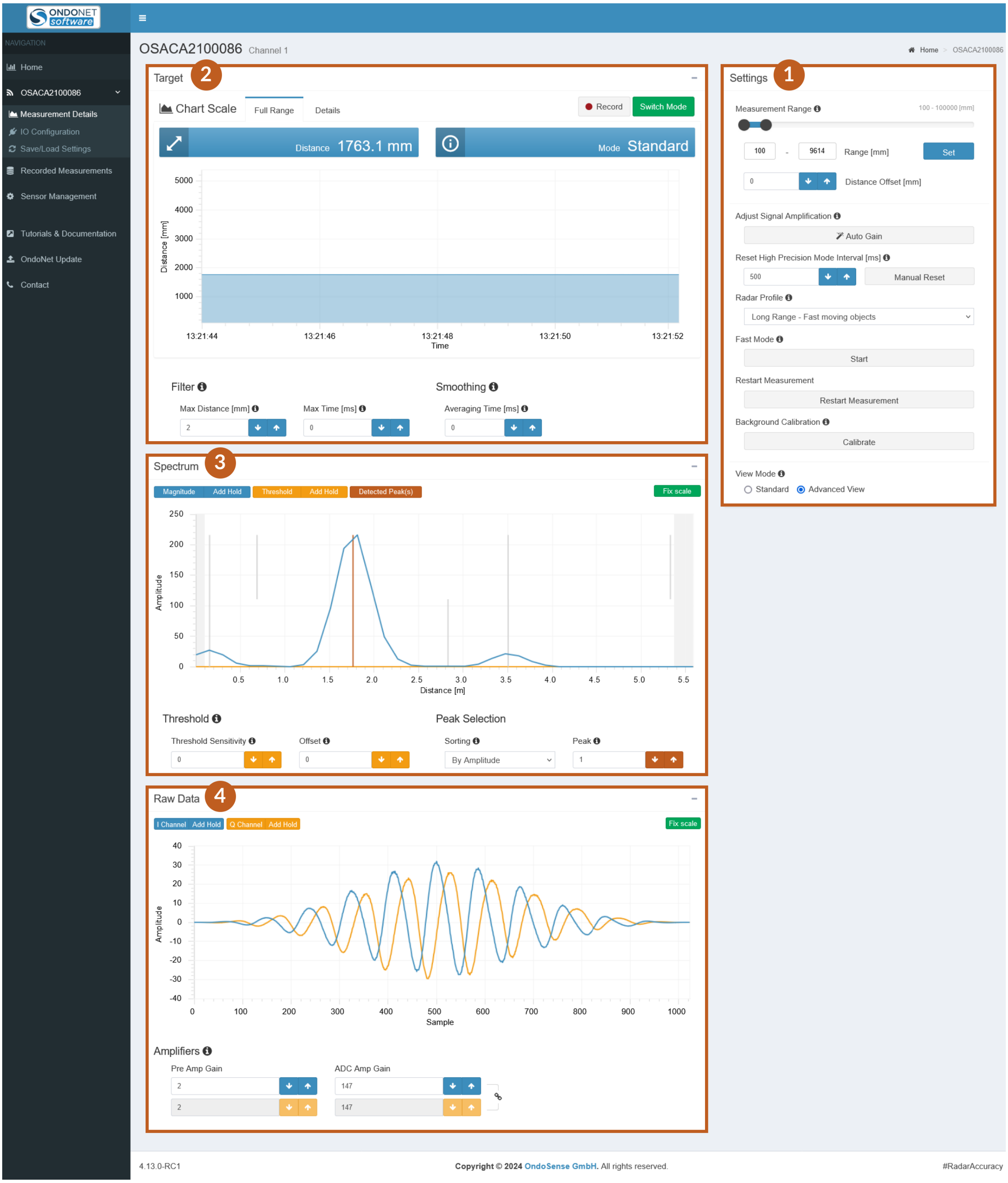
Description of the navigation tree on the left:

- **Home:** Returns you to the home page.
- **OS12345:** Expands to reveal the following menu options:
  - **Sensor Configuration:** The main page where you can view measured distances and modify parameters.
  - **IO Configuration:** Configure the switching and analog outputs here.
  - **Save/Load Configuration:** Save, load or reset your sensor configurations on this page.
- **Recorded Measurements:** Access your recorded distance measurements here, which were initially recorded on the Measurement Details page.
- **Sensor Management:** Find information about your sensor’s version and type.
- **Tutorials & Documentation:** For additional information, click here to be redirected to the support website.
- **OndoNet Update:** Update the OndoNet software on your configuration page via this page.
- **Contact:** Find OndoSense's contact information here.

The **Details** button located below the sensor image redirects you to the Sensor Configuration page, and the **IO Config** button takes you to the IO Configuration page.

The numbers in the bottom left corner display the version of your OndoNet software.

After navigating to the **Sensor Configuration** page you should see OndoNet as displayed in the figure below.



Sensor Configuration page of OndoNet

1. Settings Panel:		
Measurement Range	Standard/Mandatory	All signals received from outside the specified measuring range will be ignored.
Adjust Signal Amplification	Standard/Mandatory	Find the best amplifier parameter values.
Restart Measurement	Standard/Mandatory	Reinitializes all charts and reloads the page.
Radar Profile	Standard/Mandatory	Change the radar profile.
View Mode	Standard/Mandatory	Change from Standard to Advanced View.
Reset High Precision Mode Interval	Standard/Mandatory (only available for sensors with HP Mode)	Defines the time after which a measurement in High Precision Mode is reset, after it loses its target.
Background Calibration	Advanced	Takes a "snapshot" of the signals visible in the spectrum and subtracts these signals for all measurements done after the calibration, ensuring that only relevant signals are measured.
Distance Offset	Advanced	This value is added to the distance value.
Fast Mode	Advanced	Maximises the output rate of the distance values in the Target View by limiting the data that is being transmitted between sensor and ConfigBox.

2. Target View (displays the measured distance over time):		
Full Range	Standard/Mandatory	Displays the measured distance over time.
Details	Standard/Mandatory	The resolution of the y-axis is refined to enable you to view smaller variations of the distance in more detail.
Record	Standard/Mandatory	Enables to record distance value data and to export the data as CSV-file.
Switch Mode	Standard/Mandatory (only available for sensors with HP Mode)	Switches to High-Precision Mode.

2. Target View (displays the measured distance over time):		
Filter	Advanced	Filters sudden distance measurement jumps.
Smoothing	Advanced	Applies an exponential averaging.

3. Spectrum View (shows the signals received by the sensor over the measuring range. Note that the amplitude scale has arbitrary units):		
Magnitude/Add Hold	Standard/Mandatory	Hides or unhides the magnitude data/ Freezes or unfreezes the magnitude data.
Threshold (Offset)	Standard/Mandatory	Sets a constant signal amplitude threshold over the complete distance.
Peak Selection	Standard/Mandatory	Select the peak sorting methode.
Fix scale	Standard/Mandatory	Fixes the scaling of the y-axis.
Threshold Sensitivity	Advanced	Suppresses undesired signals near the target signal.
Peak	Advanced	Select the peak you need for your measurement task.
Threshold/Add Hold	Advanced	Hides or unhides the threshold data/ Freezes or unfreezes the threshold data.
Detected Peak(s)	Advanced	Hides/Shows all the peaks that are detected in the spectrum.

4. Raw Data View (shows how the sampled time domain raw data):		
I Channel/Add Hold	Advanced	Hides or unhides the I channel data/ Freezes or unfreezes the I channel data.
Q Channel/Add Hold	Advanced	Hides or unhides the Q channel data/ Freezes or unfreezes the Q channel data.
Fix scale	Advanced	Fixes the scaling of the y-axis.
Amplifiers	Advanced	Click AUTOGAIN in the Settings panel for an automatic optimization.

5.2 Mandatory Settings

5.2.1 Radar Signal set-up

First, align the sensor perpendicular to the target. Then use the spectrum view for final adjustments. The smoother a surface, the more crucial the precise alignment of the radar sensor becomes.

The signal strength received by the radar sensor is one of the most important factors to achieve reliable measurement results. It is visualized by the amplitude of the spectrum in OndoNet. The signal strength increases when the sensor is aligned perpendicular to the target of the measurement.

Correctly aligning the sensor to the measurement target also avoids unintended reflections by other objects. This increases the signal strength and the Signal to Noise Ratio (SNR). Measurements with a high SNR are more robust to external interference.

Another factor that affects the signal strength of the measurement is the roughness of the surface. The rougher the surface, the higher the degree of tilting that allows for a stable radar signal. For smooth surfaces, the maximum possible tilting is lower than for rough surfaces. In contrast to measurements with for example laser sensors, rough surfaces are an advantage in measurements with radar sensors because the likelihood that a part of the beem is refelcted back to the sensor is higher.

The figure below schematically shows the influence of the orientation of the sensor to the measurement target on the signal strength reflected back to the sensor. Perfectly perpendicular targets reflect a stronger signal to the sensor. With increasing tilting of the surface or object, the signal strength of the radar sensor decreases, as the radar radiation is increasingly not thrown back to the radar distance sensor.

Align sensor perpendicular to target for better signal strength

Align the sensor towards the targe: Manually adjust the orientation of the sensor while monitoring the signal strength displayed in the configuration software. All detected objects and their signal strength are displayed in the "Spectrum" chart, which is positioned below the "Target" chart.

To monitor the signal strength while adjusting the sensor alignment, click on FIX SCALE and ADD HOLD for the magnitude in the spectrum chart. This way you can monitor whether your adjustment leads to an increase or a decrease of the signal strength. Continue until the optimal signal strength is reached.

If your target is too far away or the signal strength remains low, consider using a radar reflector to enhance the signal and improve detection accuracy.

AutoGain: Once you are done, click on AUTO GAIN in the "Settings" section to further optimize the signal strength. This will automatically adjust the gain parameters of the amplifiers.

If you have a changing distance to the target, please refer to the Raw Data chapter.

5.2.2 Peak Selection

Select your peak by "Amplitude" if your target is characterized by the **strongest** signal. Choose "Distance" if your target is expected to be the **closest** peak.

With the Peak Selection feature, you can choose which peak you want to use in the measurement. The selected peak is indicated by the red line (a) in the spectrum view shown in the figure below. You can choose between the following options (g):

- Distance: Peak with the closest distance within the measurement distance (b)
- Amplitude: Peak with the highest amplitude (a)
- Normalized amplitude: Target with the highest Radar cross section.
- Distance backwards: Last peak by distance (d)
- Amplitude backwards: Last peak by amplitude (d)
- Normalized amplitude backwards: Target with the smallest Radar cross section.

5.2.3 Measurement range

Limit the measurement range to the specific area of interest for your application.

The Measurement Range should be limited to the area of interest. It is the most effective way to avoid undesired interference signals from the surroundings. It can be changed in the Settings panel on the right (e). To save the changes use the set button. The values do not get saved automatically.

The first peak shown in the spectrum below is the self-reflection of the sensor (b). As it comes from the sensor itself and not from the target it should not be taken into account during the measurement. This can be avoided by adjusting the lower end of the measuring range to a higher value.

If you know the object you want to measure the distance to will always be located at a distance between 1m and 5 m, it is recommended to limit the measuring range to approximately 0.8m and 5.2 m. Any signals originating from objects at distances below the minimal distance or above the maximum distance will be ignored, leading to more robust measurement results in production.

5.2.4 Adjust the Threshold

> Setting a threshold can increase the robustness of the measurement, but can also lead to false negatives if set too high.

Setting a threshold is an effective way to improve the measurement robustness by suppressing targets with a lower signal strength than the signal of interest. This increases the robustness of the measurement significantly. The threshold (in amplitude) is indicated by the orange area in spectrum view (c) in the figure below and can be adjusted by changing the value in the Threshold field (f). Only peaks with a signal strength above this threshold (a) are considered, all others are suppressed (d).

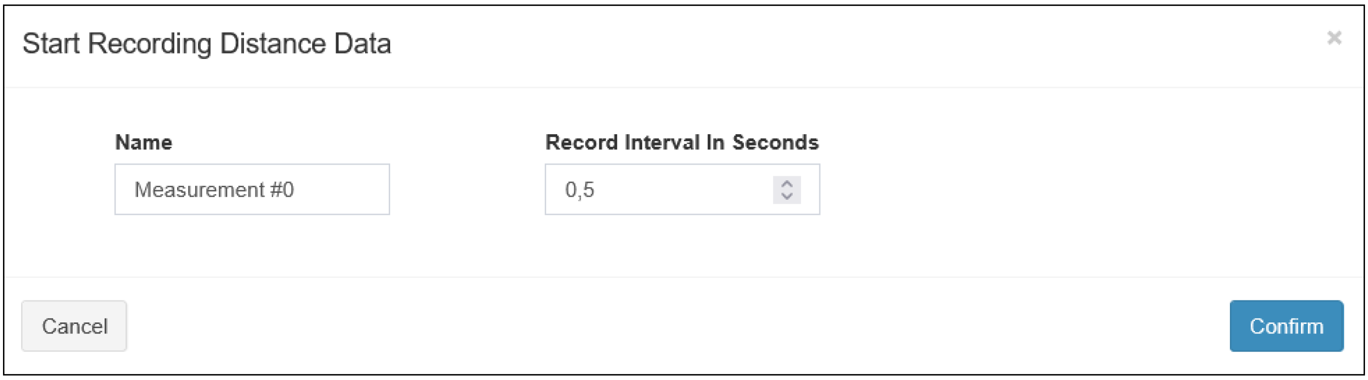
To find the right threshold for your application first position the sensor perpendicular to the target such that the signal amplitude is maximised. Choose a target that is located at the maximal measurement distance. Then set the threshold approximately to 30% of the lowest signal strength. Monitor the measurement for a while to guarantee that the signal strength is never close to the threshold. In a case of doubt, it is always better to set the threshold lower. Be careful with using this feature for collision avoidance applications as a high threshold can lead to false negatives.

Peak selection, Measurement range and Threshold

5.2.5 Data recording & management

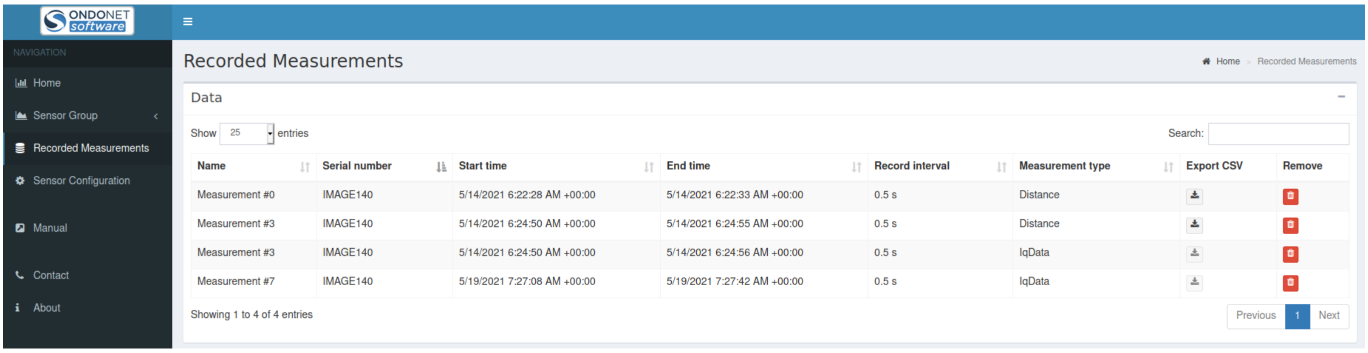
The data recording function enables to record distance value data and to export the data as CSV-file.

To record data click on **RECORD DATA** in the settings panel on the right side. There you can enter a name for the measurement, specify the recording interval in seconds and click on Confirm. If you want to stop the recording, click the button, now named **STOP RECORDING** and confirm the end of the recording. During recording, a label is displayed above the view whose data is currently being recorded.



Record distance data

To see a list of all your recorded measurements please click on **RECORDED MEASUREMENTS** at the black navigation column on the left.



Manage recorded data

In the data list you can remove measurements from the list by clicking on the ˆbin symbol in the Remove column. The measurements can be sorted differently by clicking the two arrows next to the column name. Measurements of type distance can be exported as a CSV file by clicking on the download symbol in the Export CSV column.

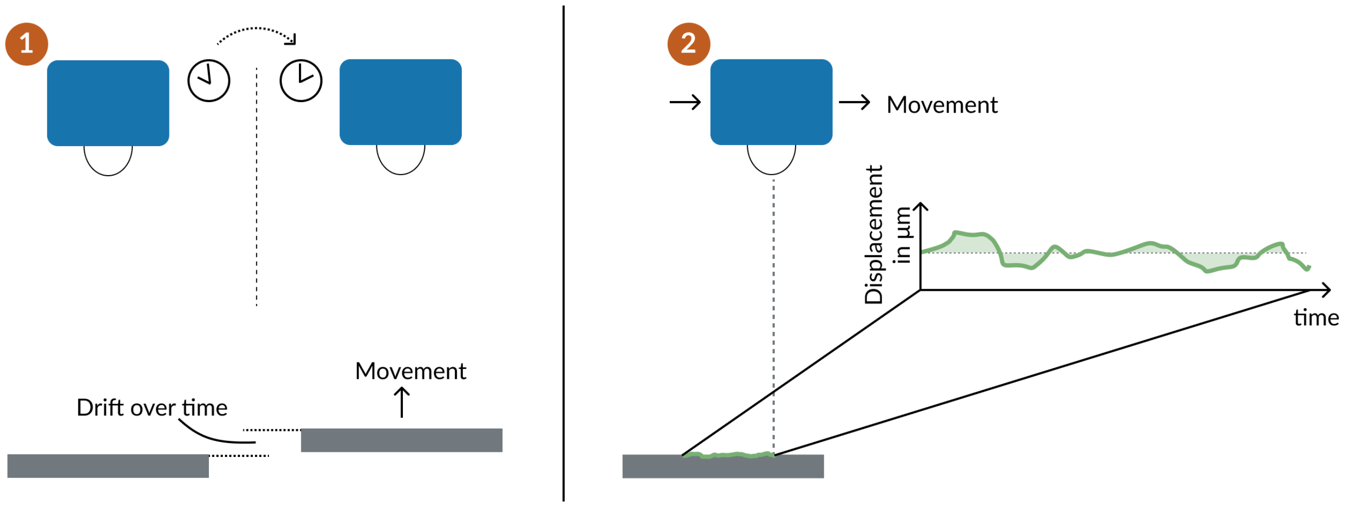
5.2.6 High Precision Mode

It is recommended to use the Maximum Accuracy Profile when operating in High Precision Mode.

The High Precision Mode allows for the measurement of distance changes with a resolution as fine as 1 µm. When this mode is activated, the current distance to the target is stored as the reference distance, serving as the baseline or zero-point. Any subsequent change in distance is measured relative to this reference. If the distance to the target increases, the output values will be positive; if the distance decreases, the output values will be negative.

Common Use Cases for High Precision Mode:

1. **Displacement & Drift Measurements Over Time:**
    - High Precision Mode can be used to monitor the position of objects over extended periods, such as tracking the temperature drift of equipment.
2. **Profile Measurement:**
    - This mode is also ideal for measuring the profile of surfaces by moving the object perpendicular to the radar beam. Unlike laser sensors, High Precision Mode can effectively measure the profile of rough surfaces due to the opening angle and the radar spot size over which the distance is averaged.



Use cases for high precision mode

Limitations

- The High Precision Mode is optimized for slow movements. When target movement exceeds **50 mm/s**, target loss events may occur.

- It is possible to combine the absolute distance measurement in the standard mode with the high-precision measurement. This can be useful to first determine the approximate distance to a target before tracking changes of the distance to that target. At the same time, this does not allow for a more accurate absolute distance measurement than via the standard absolute distance measurement. The initial absolute distance measurement will contain an error of a few hundred micrometers, that cannot be eliminated via the displacement measurement with the High Precision Mode.
- The high-precision mode will measure accurate distances for targets whose orientation towards the sensor stays relatively constant. For significant changes of the angle of the target towards the sensor, the accuracy of the high precision mode will be affected.

The **RESET HIGH PRECISION MODE INTERVAL** determines the time after which the measurement in High Precision Mode automatically resets following a target loss. This reset adjusts the baseline value to the current distance. Additionally, you can manually reset the measurement at any time by clicking the “Manual Reset” button.

The Hight Precision Mode can not be read out by the current loop or switching outputs. To access the displacement values through the PLC, you need to configure the RS485 connection via the API

Setup High Precision Mode

1. **Initial Configuration with OndoNet:**
   - Use OndoNet to set your measuring range. Adapt this to your use case to define the smallest possible range.
   - Configure the Amplifiers using AutoGain. The IQ data for a fix target should show oscillations without clipping.
   - Set the time interval for Reset High Precision Mode after a target loss.
   - Select "Maximum Accuracy" as your Profile as it is the first choice for best accuracy. Select “Long range - Slow moving objects” if you have a maximum distance beyond 6 metes.
2. **Finalize Setup:**
   - Disconnect your ConfigBox and establish the connection via API.
3. **Activate High Precision Mode:**
   - Download the Application Notes
   - Enable High Precision Mode by setting the corresponding result data selector. To stop High Precision Mode, simply set a different result data selector. For detailed instructions, refer to the Application Notes.
   - For optimum performance and measurement rate in High Precision Mode, ensure that only High Precision Mode is selected (RESULT_DATA_SELECTOR = 512).

Target lost handling

When the high-precision mode is set up (i.e. the correct result data selector is chosen), upon receiving a `MEASUREMENT` -command, the sensor returns the high precision distance together with a target lost counter. As long as the sensor is capable of "locking" a given target, the target lost counter keeps the same value. More precisely, the measurement data block corresponding to the high-precision data block consists of 6 bytes: Status (1Byte) + Target Lost Counter (1 byte, unsigned 8-bit integer) + high precision distance in µm (4 bytes, signed 32-bit integer).

Reasons for target lost events

There are two scenarios in which a target lost event is identified:

a) The non-high-precision distance between two consecutive measurements exceeds a certain threshold value defined by the parameter `HIGH_PRECISION_DISTANCE_THRESHOLD` (see section below).

b) The distance to the target changes by more than ~0.6 mm between two consecutive data points.

The former occurs typically when an obstacle interferes in the measurement path between sensor and target or when the target has a smooth surface and gets tilted away from the sensor, so that the signal path is dominated by paths including clutter reflections.

The latter occurs typically when the target moves too fast away or towards the sensor, see below under limitations.

Sensor behavior in case of target lost events

Once a target lost event occurs, the sensor increases the target lost counter by one. (Note: If the maximum value of an unsigned 8-bit integer (`255`) is reached, the counter resets to zero.) The high-precision data block is now given by a status (`TARGET_LOST = -7 (0xF9)`), a target lost counter increased by one and a distance value of zero.

For a parametrizable (see below) amount of time, the sensor will remain in this status before it automatically resumes operation of the high-precision mode. Such a resume resets the high-precision distance to 0. When the measurement resumes, the target lost counter does not increase further and does *not* reset to 0.

Manual restart of the high precision mode

When the sensor is setup for high precision mode (i.e. the result data selector includes the corresponding code (`512`)), it is possible to manually reset the high precision mode by sending a `RESTART_HIGH_PRECISION_MOCE (0x19)` command. The sensor will acknowledge the command with an `API_SUCCESS (0x01)` and set the high-precision distance to 0. Note: The command does *not* reset the target lost counter. This command also works if the sensor is in a target-lost waiting timer situation. Once the command is received and processed, the high-precision mode resumes immediately.

5.2.7 Additional Options

If you can't find what you are looking for, please contact support@ondosense.com

Restart measurement

In the Settings section, the measurement can be restarted by clicking the RESTART MEASUREMENT button. This can be helpful in case there is no measurement data visible in the target and/or spectrum view.

Choose the radar profile

The sensors can operate within the 122-123 GHz frequency range, which is part of the ISM band and freely available for industrial use. Apart from this, it is possible to use the sensor in the 119 - 125 GHz frequency range. Utilizing this wider bandwidth enhances measurement accuracy. However, in this mode, it is crucial to ensure that the sensors do not cause interference. Compliance with local regulations governing this frequency range is mandatory.

Profil	Maximum Distance to CornerCube	Apex Variant
Long range, Fast moving objects	35 m	***Ondosense*** *apex LR*, ***Ondosense*** *apex HP*
Close Range (up to 5m)	5 m	***Ondosense*** *apex ST*, ***Ondosense*** *apex ST07*, ***Ondosense*** *apex DM*, ***Ondosense*** *apex HP*
Long Range, Slow moving objects	45 m	***Ondosense*** *apex LR*, ***Ondosense*** *apex HP*
Maximum accuracy (up to 6m)	6 m	***Ondosense*** *apex ST*, ***Ondosense*** *apex ST07*, ***Ondosense*** *apex DM*, ***Ondosense*** *apex HP*

Fast Mode

The FAST MODE button disables the data display in the Spectrum and Raw Data charts. This maximises the output rate of the distance values in the Target View, allowing for quicker real-time measurements.

5.3 Advanced Settings

5.3.1 Filter and Smoothing

To ensure smooth and accurate measurements, applying filter or smoothing algorithms can be beneficial.

Filter

The filters helps reduce sudden jumps in distance measurements, which can be caused by unwanted reflections not coming from the primary target. These jumps typically occur when the sensor's alignment to the main target is momentarily disrupted.

Maximum Distance: Set the maximum distance parameter to a value that represents the largest realistic difference between two consecutive measurements for your application. This ensures that only plausible changes in distance are accepted, while any distance differences exceeding this value will trigger the filter.

Maximum Time: Set the maximum time parameter to define the duration after which a new value should be accepted, even if an unrealistic distance jump occured.

How the Filter Works:

- **Triggering the Filter:** The filter is activated when a sudden change between two consecutive measured distance values exceeds the defined maximum distance change.
- **Output During Filtering:** The sensor will continue to output the previous stable measurement until one of the following conditions is met:
  - **Restoring the Original Level:** The measured distance change returns to within the previous value ± the maximum distance change. At this point, the sensor will start displaying the new measured value.
  - **Maximum Time Reached:** If the maximum time limit is reached before the original level is restored, the sensor will start displaying the new measured value.

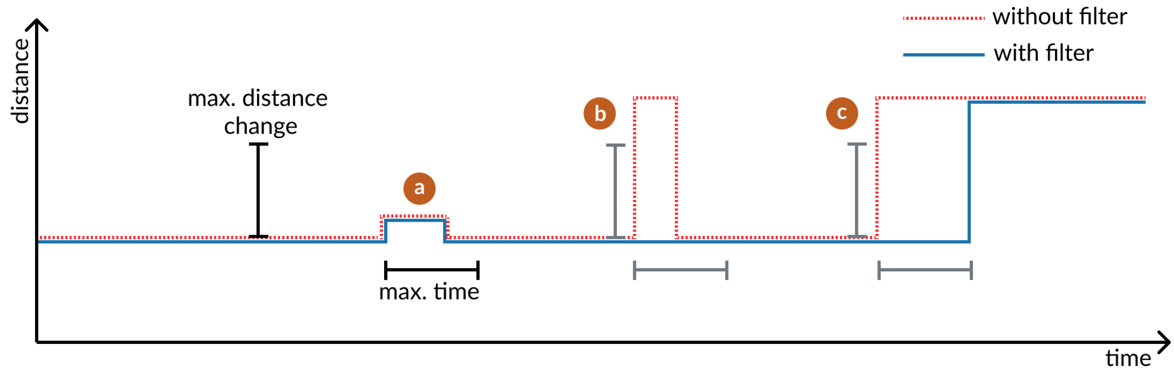
By setting the parameters for maximum distance and maximum time, you ensure the sensor ignores erratic measurements and provides more stable and accurate readings.

The following figure is a simplified representation of the Target view, where x represents time and y represents the measured distance. The events a, b, and c illustrate jumps in the measurement values and how they are managed by the filter.

a The filter is not triggered because the change in distance between two consecutive values does not exceed the max distance parameter.

b The filter is triggered because the max distance is exceeded. The filter is then deactivated as the value returns to the original level.

c The filter is triggered because the max distance is exceeded. The filter is deactivated because the max time limit is reached, and the value is adjusted to the new measured distance.



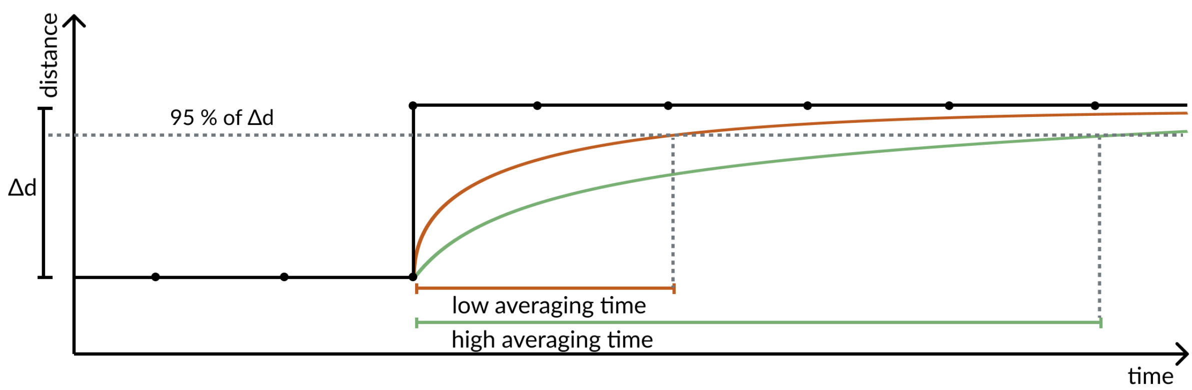
Filtered measurement events

Smoothing

Smoothing applies exponential averaging to the measurements, which is useful for stabilizing fluctuating distances to the target. This is particularly helpful in dynamic applications, such as monitoring filling levels.

The averaging time affects the time frame over which the exponential averaging is applied and specifies that 95% of the output distance come from the new distance value.

The larger the averaging time, the slower the sensor adapts to new distance values, resulting in a more smoothed output. This means that sudden changes in distance are less immediately reflected in the measurements, providing a more stable reading at the expense of responsiveness. A shorter averaging time allows the sensor to respond more quickly to changes in distance, reflecting new values more rapidly but with less smoothing, which may result in a more fluctuating measurement.



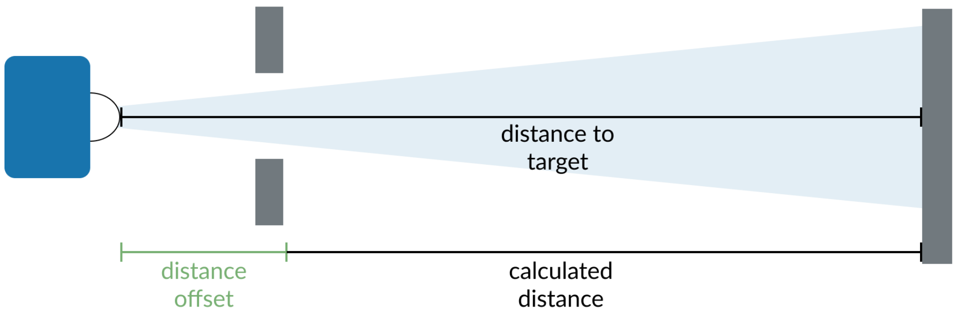
Smoothing alogorithm

5.3.2 Distance Offset

The distance offset will be automatically added to all distance measurements, ensuring that the displayed distance values are accurate and reliable for your specific application.

The distance offset is a value that is added to the measured distance value to adjust for any systematic measurement errors or specific application requirements. By setting an appropriate distance offset, you can ensure that the sensor readings accurately reflect the actual distance to the target. This adjustment is particularly useful in scenarios where the sensor cannot be placed at the optimal measurement point or where inherent measurement biases need to be corrected.

To configure the distance offset, enter the desired value in the offset field. This value will be automatically added to all distance measurements, ensuring that the displayed distance values are accurate and reliable for your specific application.

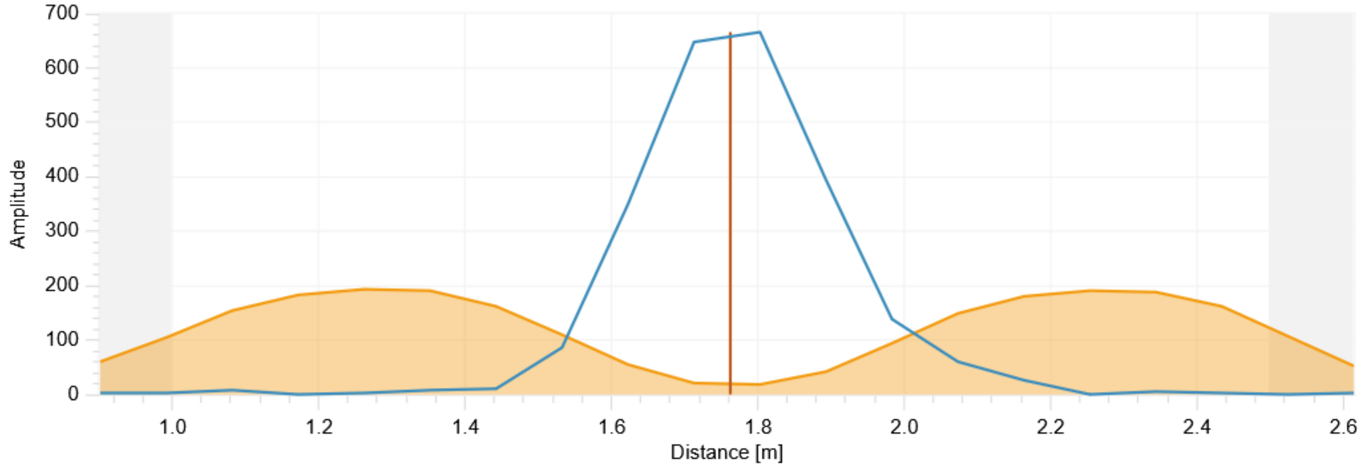


Distance offset

5.3.3 Threshold Sensitivity

The Threshold Sensitivity suppresses undesired signals close to the target signal.

The Sensitivity feature is recommended for weak signals. It can improve the measurement robustness by suppressing undesired signals close to the target signal. The sensitivity calculation is based on an algorithm which identifies the main peaks of a spectrum and suppresses side peaks. The result of this calculation can be seen in the figure below, where the threshold is low at the peak, but significantly higher next to the peak. The strength of this effect can be adjusted via the Sensitivity parameter.



Threshold sensitivity

5.3.4 Background Calibration

> The Background calibration is only useful for applications in which the surrounding is static and the sensor is not moved throughout the measurements

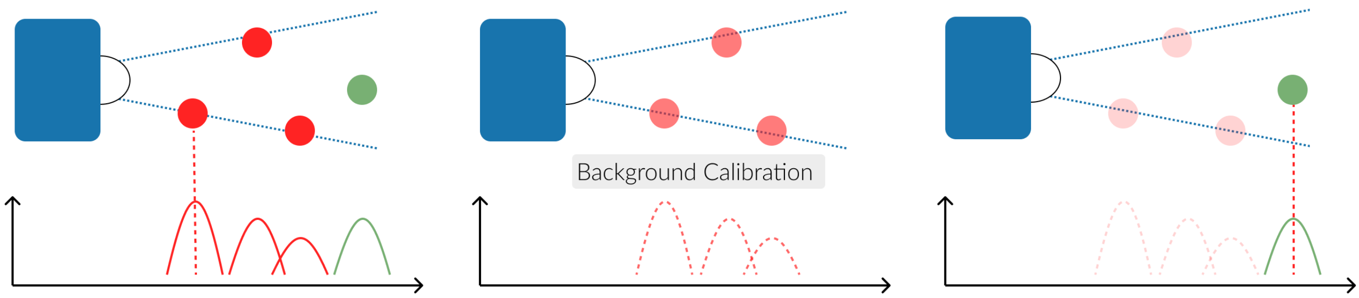
In some applications it may be useful to set a background calibration on the sensor. This is recommended, for example, if measurements are to be taken in a highly reflective environment and the reflections not required for the measurement are to be masked out.
The background calibration takes a "snapshot" of the signals visible in the spectrum and subtracts these signals for all measurements done after the calibration. Therefore, this setting is only useful for applications in which the surrounding is static and the sensor is not moved throughout the measurements.

To set the background calibration please do the following:

1. **Measurements with the measurement object:**
   Before you start setting the background calibration, position your measurement object at a medium distance within the measuring range. Please make sure that the sensor is positioned correctly, the measuring range and the parameters in the raw data view are set appropriately. These cannot be easily changed after the background calibration is set. It must also be ensured that the sensor has been placed firmly, i.e. it should not be moved by vibrations or similar.
2. **Remove the measurement object:**
   The goal of the background calibration is to subtract all signals originating from a static background in order to isolate the signals originating from the measurement object. Therefore, to take a "‘snapshot"’ of the background, please move the measurement object out of sight of the radar sensor.
3. **Setting the background calibration:**
   After removing the measurement object, start setting the background calibration by clicking on the `CALIBRATE` button in the settings panel on the right and confirm it.

4. **Measurements with the measurement object:**
   The background calibration is completed and you can now take measurements with the measurement object in sight of the sensor. The amount of signals visible in the spectrum view should be decreased compared to the amount of signals that were visible before the background calibration was set.
   After successful calibration you will see a label "calibrated" above the individual views. Also, all amplifier settings in the raw data view are disabled. If you want to change these parameters, please remove the background calibration as described below, change the parameters and set the background calibration again.
   After setting, it can take a few seconds until the sensor provides a good signal again. If your sensor is not firmly positioned and is moved, for example, by vibrations, you will be able to recognize this in the signal. The signal will then be very choppy and flicker.

Deleting the background calibration:
To delete the background calibration and thus reactivate the amplifier parameters in the raw data view, please click on the REMOVE CALIBRATION button in the settings panel on the right and confirm.



Background calibration

5.3.5 Raw Data

Use the AUTO GAIN button to optimize amplification parameters, significantly improving signal quality and measurement robustness.

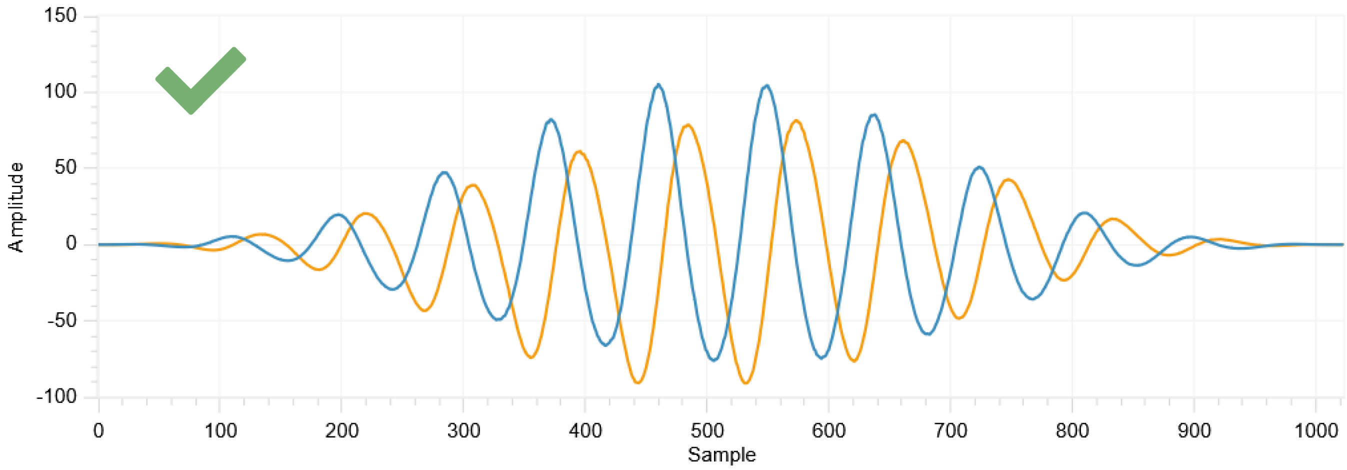
The Raw Data view shows the echo raw data for the sampled time domain. It contains information about the distance and size of the target. The AUTO GAIN button automatically optimizes the amplification parameters for your specific application, significantly enhancing signal quality and measurement robustness. The suitable values of the amplification parameters differ between measurements. Therefore, they should be adjusted during a typical measurement.

If the target is in motion, it's recommended to click AUTO GAIN when the target is positioned midway between its maximum and minimum distances. If the furthest signal isn't detected with the initial amplification, move the sensor closer to the maximum distance and click AUTO GAIN again to recalibrate. If maintaining accuracy at close range is critical, configure AUTOGAIN at a closer distance, accepting that distant targets may not be reliably detected. Conversely, if distant targets are equally important, you might prioritize their detection and set AUTOGAIN at a further distance, even if it means accepting some clipping at closer ranges. Ultimately, the choice depends on which distance is more critical for your application.

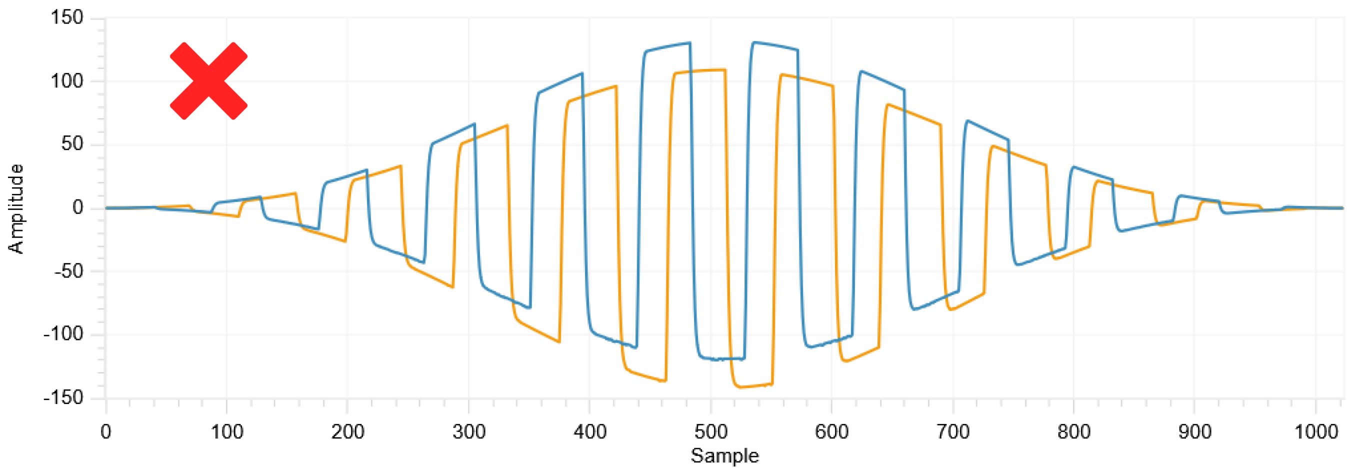
The graph should show a sinus function with high amplitudes. The images below illustrate examples of both correct and incorrect settings. Optimal results are typically achieved when the curves range between -127 and +127, ensuring that the peaks of the curves are not clipped.

Even with clipped signals, the robust OndoSense algorithms can calculate the correct distance, although the measurement accuracy will be lower. If the signal received by the sensor is too weak for a meaningful measurement, a "weak signal" label will appear above this view.

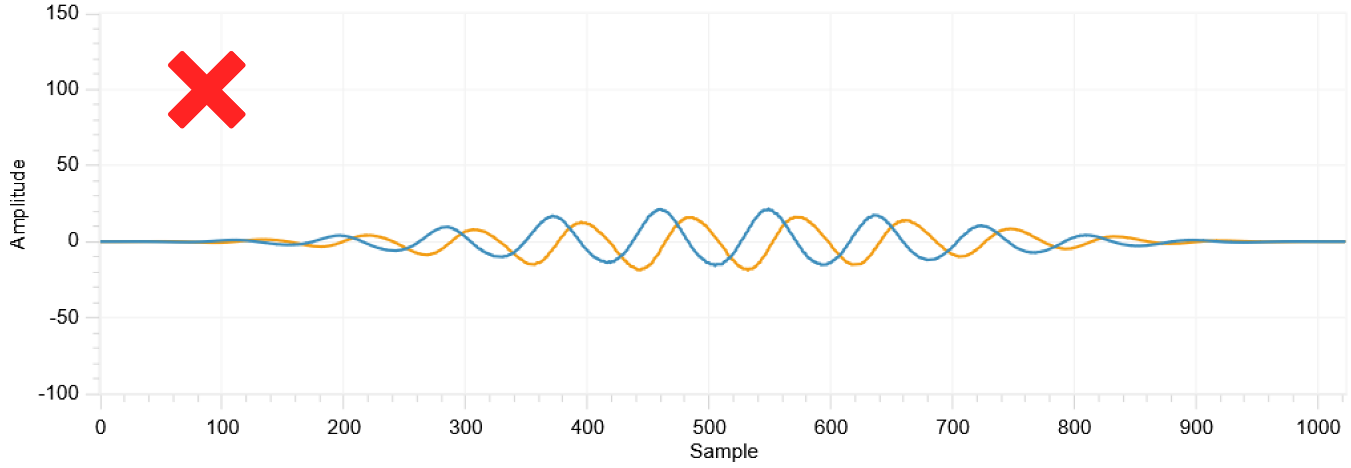
If AutoGain, in combination with all other correctly set parameters, does not yield the desired results, you can manually adjust the ADC Amp Gain and Pre Amp Gain value incrementally while monitoring the raw data display. It is good practice to use the same amplifier values for I and Q, so the amplification parameters are linked. If you want to adjust the channels individually, click on the linked button.



Ideal raw data signal



Extreme signal clipping

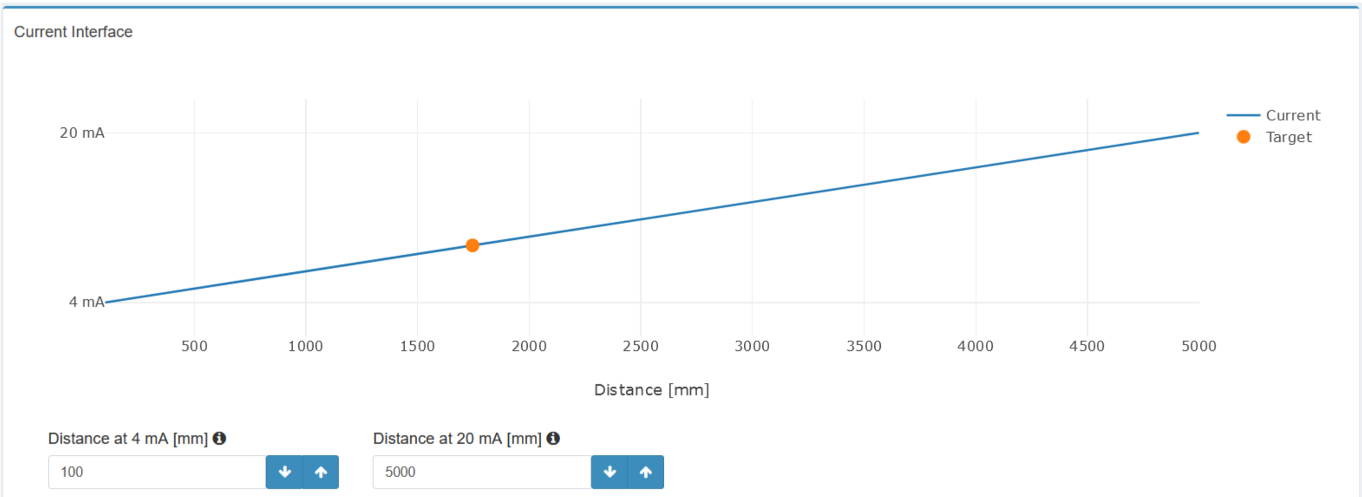


Weak amplification

5.4 Interfaces

5.4.1 Current Loop

The Current Interface can be configured on the IO Configuration page, just below the settings for the switching outputs. Here, you can specify the distances in millimeters at which the current should be 4 mA and 20 mA, as illustrated in the figure below. The interface will output a current that corresponds to the distance of the target, with the current value linearly varying between the two defined distances.



Interface for current loop

5.4.2 Switching Outputs

Each of the switching outputs can be configured individually, as demonstrated for Output 1 in the figure below. Follow these steps to set up your desired output:

- **Distance to Active (Point 1):** Set the distance in millimeters at which the output should change to active.
- **Distance to Inactive (Point 2):** Set the distance in millimeters at which the output should revert to inactive (Window-Mode). For Single-Point mode, set this value to the maximum measuring range.
- **Hysteresis:** Define a window in millimeters to adjust the switching point based on the previous state. This helps prevent multiple switches if the target distance fluctuates around the switching point.
- **Mode:** Choose between "Active High" (PNP-mode) and "Active Low" (NPN-mode) to set the output mode.
  - **Active High (PNP-mode):** In this mode, the output is considered active when it sends a positive voltage (high state). This means that when the sensor detects the specified condition, it will switch to a high voltage state.
  - **Active Low (NPN-mode):** In this mode, the output is considered active when it sends a negative voltage or zero voltage (low state). This means that when the sensor detects the specified condition, it will switch to a low voltage state.
- **Delay:** Specify the time in milliseconds that the signal needs to be registered before switching to active.
- **Release:** Specify the time in milliseconds that the signal needs to be registered before switching to inactive.

Interface for switching output configuration

6 PLC Connection

This chapter provides instructions on how to connect your sensor to a PLC (Programmable Logic Controller). It covers the necessary steps for establishing a reliable connection, configuring communication settings, and ensuring seamless integration between the sensor and your PLC system.

Before connecting the sensor to your PLC, ensure that the sensor is precisely aligned and the switching outputs, analog output, and parameters are properly adjusted. The sensor is now ready to be connected to your PLC. You will need an open-ended M12 8-pin A-coded female cable for this connection. The color code below corresponds to the OndoSense cable. If you use a different cable, the color coding may vary.

The sensor can be disconnected from the ConfigBox and used as a stand-alone device. All parameters from the previous steps are automatically saved.

Disconnect the Sensor from the ConfigBox:

- Disconnect the sensor from the ConfigBox. Ensure that the sensor remains aligned and all settings are saved. This will allow the sensor to function correctly once connected to the PLC.

Connect the M12 8-pin A-coded Female Open-ended Cable:

- Attach the open-ended M12 8-pin A-coded female cable to the sensor. Make sure the connection is secure to avoid any communication issues between the sensor and the PLC.

Power the Sensor:

- Connect the **brown** cable (V+ (24 V)) to the positive terminal of the power source.
- Connect the **blue** cable (V- (GND)) to the ground terminal of the power source.
- Ensuring proper power connections is crucial for the sensor to operate correctly.

Digital Output - Switching Output:

- The **grey**, **yellow**, and **red** cables are responsible for transmitting the previously configured switching output signals:
    - **Grey Cable**: Connect to the appropriate input on the PLC for the first switching output.
    - **Yellow Cable**: Connect to the appropriate input on the PLC for the second switching output.
    - **Red Cable**: Connect to the appropriate input on the PLC for the third switching output.

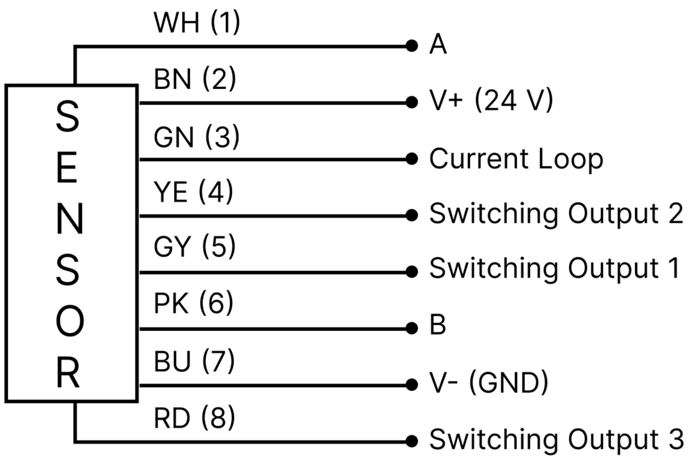
Analog Output - Current Loop:

- Connect the **green** cable to the appropriate input on the PLC to obtain the analog output. This will allow the PLC to read the analog signals sent by the sensor.

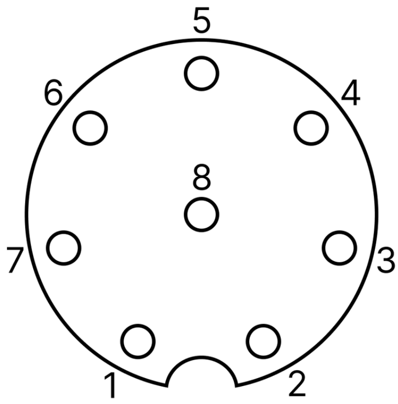
Verify Connections and Power Up:

- Power up the system and ensure the sensor is receiving power.

- Verify that the PLC is correctly receiving the signals from the sensor.



Pinout diagram sensor



M12 8-pin a-coded male layout

Electrical connection

7 System Management & Maintenance

This chapter focuses on the effective management and upkeep of your sensor system. It includes instructions on saving and loading settings and updating software and firmware.

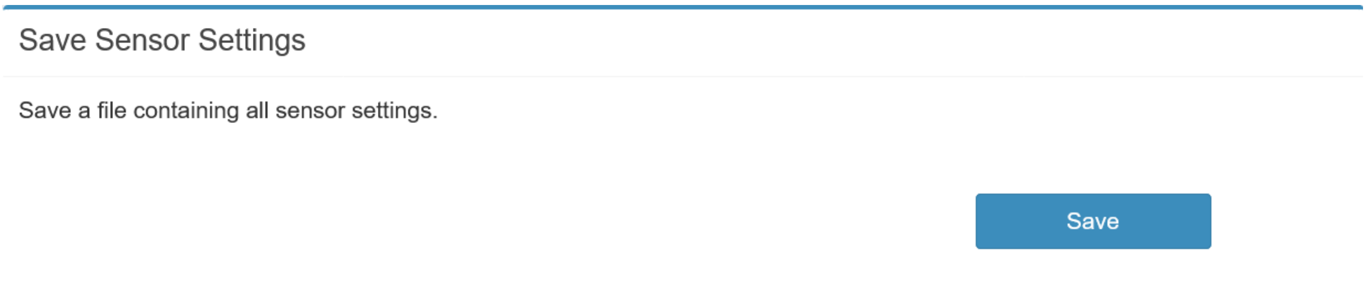
7.1 Save/Load Configuration

You do not need to save the settings after making adjustments. The sensor automatically retains the configuration changes even if you disconnect it from the ConfigBox and connect it to the PLC. The settings will remain stored on the sensor until you make further changes. Saving the settings is only necessary if you want to create a backup or transfer the configuration to another sensor.

After configuring your sensor to the desired settings, you can save these settings as a file. This saved configuration can then be easily loaded onto another sensor or reloaded onto the same sensor at a later time.

Save Settings

Once you've configured the sensor, select the Save Settings option. The browser should start downloading a file named "Date_Time_Sensor_Variant_Settings.os".

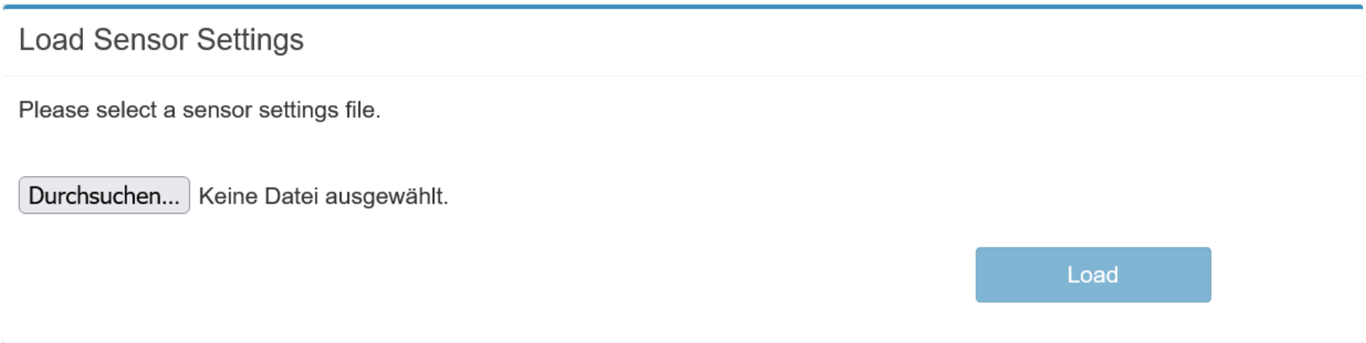


Save Sensor Settings Panel

Load Settings

To apply a previously saved configuration, use the Load Settings option. Navigate to the location of your saved file and select it. The sensor will then automatically apply the saved settings, replicating the exact configuration on either the same or a different sensor. This process ensures consistency across multiple sensors and saves time when setting up devices for similar tasks.

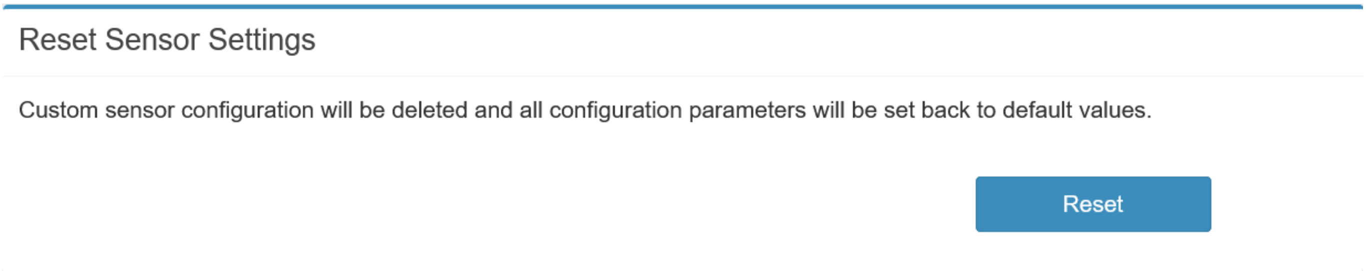
This functionality is particularly useful when working with multiple sensors in a network, ensuring that all sensors operate with the same optimized settings, or when quickly reapplying configurations after maintenance or sensor replacement.



Load Sensor Settings Panel

Reset Settings

Resetting the sensor will delete your custom configuration and restore all parameters to their default values. It is recommended to save your current configuration before performing a reset to avoid losing any important settings. This ensures you can easily restore your setup if needed after the reset.

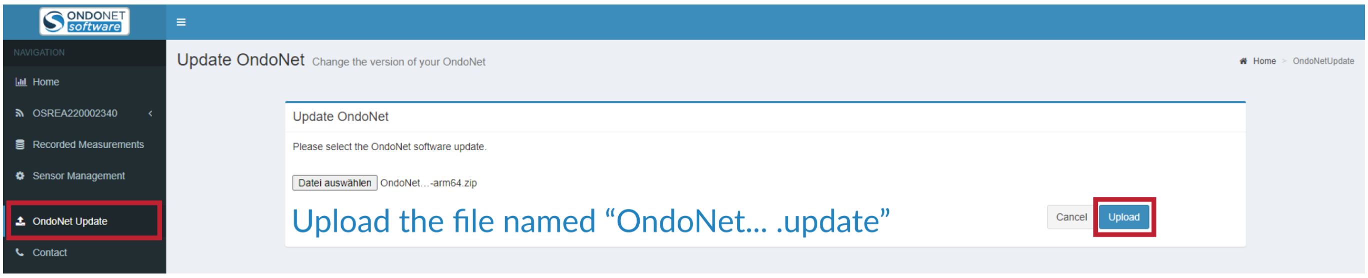


7.2 Update Software & Firmware

> ⓘ If you've been instructed or have received an update file from us download the update zip-file via the link provided by email. Unzip the zip-file and update the components in the following order:

OndoNet Software Update

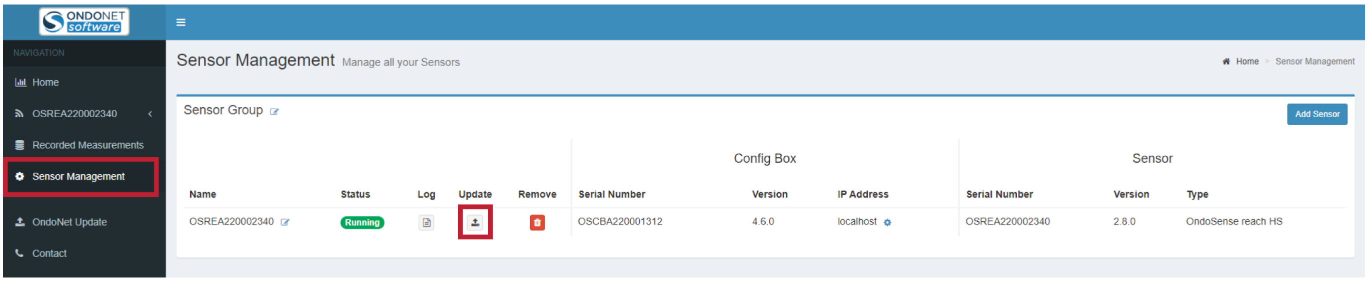
1. Navigate to OndoNet Update in the user interface
2. Upload the file named "OndoNet… .update".
3. During the update, the conection will be lost. Wait for up to 5 min. and reload the page. Do not unplug the sensor during the update process!



Update OndoNet

ConfigBox Firmware Update

1. Navigate to OndoNet Update in the user interface and click on the update icon.
2. Upload the file named “OndoSensor… .update”.
3. During the update, the conection will be lost. Wait for up to 5 min. and reload the page. Do not unplug the sensor during the update process!



Update ConfigBox und Sensor Firmware

Sensor Firmware Update

1. Navigate to OndoNet Update in the user interface and click on the update icon (again as in step 2).
2. Upload the file named “Firmware… .update”.
3. During the update, the conection will be lost. Wait for up to 5 min. and reload the page. Do not unplug the sensor during the update process!

7.3 Maintenance

ⓘ Do not disassamble the device

In harsh environments, we recommend regular inspections for firm seating and possible damages at the device. Repair or maintenance work requiring opening the device may only be performed by the manufacturer. In the event of questions or spare parts orders, please provide us the data printed on the type plate of the device.

8 Disposal

Environmental damage in case of incorrect disposal Electrical waste, electronic components, lubricants and other auxiliary materials are subject to hazardous waste treatment. Problem substances may only be disposed of by licensed specialist companies.

Always dispose of unusable or irreparable devices in an environmentally sound manner, according to the country-specific provisions and in compliance with the waste disposal regulations in force. We will be glad to help you dispose of the devices. Please contact us via support@ondosense.com

Dispose of disassembled device components as follows:

- Metal components in the scrap metal.
- Electronic components in the electrical waste.
- Plastic parts in a recycling center.
- Sort and dispose of the other components depending on the material type

9 Open Source Licenses

OndoSense is using the following open source projects and licenses:

- gRPC: https://github.com/grpc/grpc/blob/master/LICENSE
- protobuf: https://github.com/protocolbuffers/protobuf/blob/master/LICENSE
- AdminLTE: https://github.com/ColorlibHQ/AdminLTE/blob/master/LICENSE
- flot: https://github.com/flot/flot/blob/master/LICENSE.txt
- http://socket.io : https://github.com/socketio/socket.io/blob/master/LICENSE
- Winston.js: https://github.com/winstonjs/winston/blob/master/LICENSE
- Bootstrap: https://github.com/twbs/bootstrap/blob/master/LICENSE
- jQuery: https://github.com/jquery/jquery/blob/master/LICENSE.txt
- NLog: https://github.com/NLog/NLog/blob/master/LICENSE.txt
- Newtonsoft Json: https://github.com/JamesNK/Newtonsoft.Json/blob/master/LICENSE.md
- MathNet Numerics: https://github.com/mathnet/mathnet-numerics/blob/master/LICENSE.md
- nlohmann: https://github.com/nlohmann/json/blob/develop/LICENSE.MIT
- BoschSensortec: https://github.com/BoschSensortec/BMI160_driver/blob/master/LICENSE

Windows is a trademark of Microsoft Corporation.

Linux is a trademark of Linus Torvalds.

10 Contact

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