# User Manual
# OndoSense *apex*

## Profinet version

# Table of Contents

# 1 Important Safety Notes

| ⚠ CAUTION | **Read this manual carefully before operating the sensor.**<br>Failure to follow these instructions may result in improper use or reduced performance. This manual provides essential information on the **use, maintenance, and safety** of the **OndoSense *apex*** radar sensor. For further assistance, please contact support@ondosense.com. |
|---|---|

# 2  General Information

## 2.1  Legal Notices

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## 2.2  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.

## 2.3  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.

| ⚠ CAUTION | **Risk of injury due to insufficient training!**<br>Improper handling may result in considerable personal injury and material damage.<br>For this reason:<br>• All work must only ever be carried out by the stipulated persons. |
|---|---|

## 2.4  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.

## 2.5 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.

## 2.6 Used Symbols / Caution- and Security notes

| ⚠ DANGER | **Classification:**<br>This symbol, together with the signal word DANGER, warns against immediately imminent threat to life and health of persons. The non-compliance with this safety instruction will lead to death or severe adverse health effects. |
|---|---|
| ⚠ WARNING | **Classification:**<br>This symbol, together with the signal word WARNING, warns against a potential danger to life and health of persons. The non-compliance with this safety instruction may lead to death or severe adverse health effects. |
| ⚠ CAUTION | **Classification:**<br>This symbol, together with the signal word CAUTION, warns against a potential danger for the health of persons. The non-compliance with this safety instruction may lead to slight or minor adverse health effects. |
| NOTICE | **Classification:**<br>The non-compliance with the Notice note may lead to material damage. |
| 💡 NOTE | **Classification:**<br>Additional information relating to the operation of the product, and hints and recommendations for efficient and trouble-free operation. |

## 2.7 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.

| NOTICE | **Improperly transporting the distance sensor may damage it.** Substantial material damage may result in the event of improper transport. For this reason: <ul><li>The device should be transported only by trained specialist staff.</li><li>The utmost care and attention is required at all times during unloading and transportation on company premises.</li><li>Do not remove packaging until immediately before starting installation work.</li></ul> |
|---|---|

## 2.8 Intended Use

The **OndoSense *apex*** is a radar sensor for non-contact distance measurement of objects in both indoor and outdoor environments. 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.

| ⚠ CAUTION | **Sensor may become very hot during operation.** Touching the sensor without caution may result in burns. <ul><li>Allow the sensor to cool before handling.</li><li>If the sensor is too hot, use appropriate heat-resistant gloves.</li></ul> |
|---|---|

## 2.9 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.

| ⚠ CAUTION | **Danger due to improper use!** Any improper use can result in dangerous situations. For this reason: <ul><li>Distance sensors should be used only according to intended use specifications.</li><li>All information in these operating instructions must be strictly observed.</li></ul> |
|---|---|

## 2.10 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.

| | |
|---|---|
| **NOTICE** | For technical data and dimensional drawings, please refer to the data sheet of the respective product. We kindly ask you to save and retain all applicable documents at the time of commissioning. |

# 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. By analyzing the 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
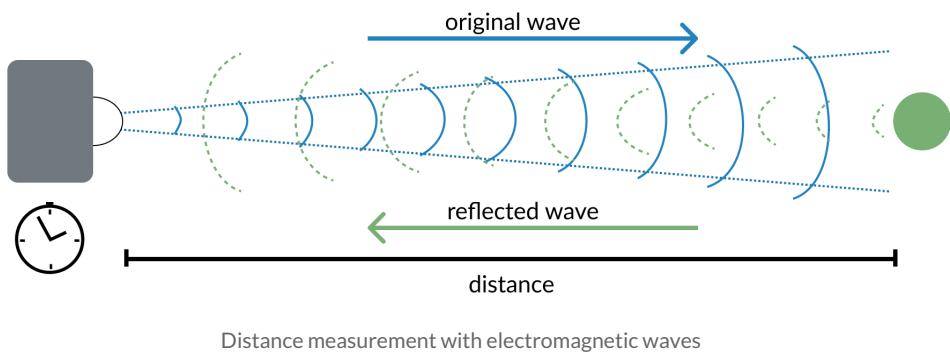
## 3.2 Radar Penetrates Non-Conductive Materials

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.

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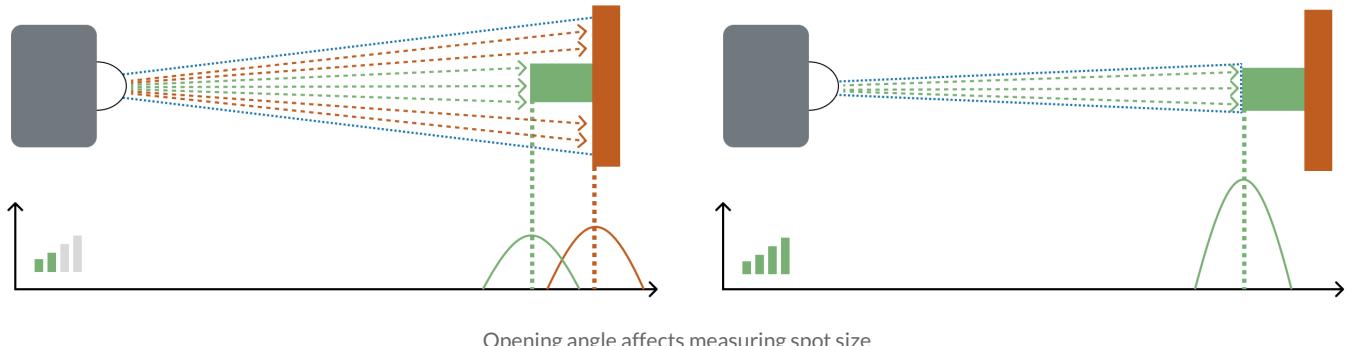
Use the OndoSense radar spot size calculator to determine your sensor's measuring spot size based on distance. Select your radar sensor from the list or input the opening angle and lens diameter for a calculation of the radar spot size in relation to a certain distance to the target object.

| | |
|---|---|
| 💡 NOTE | **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.
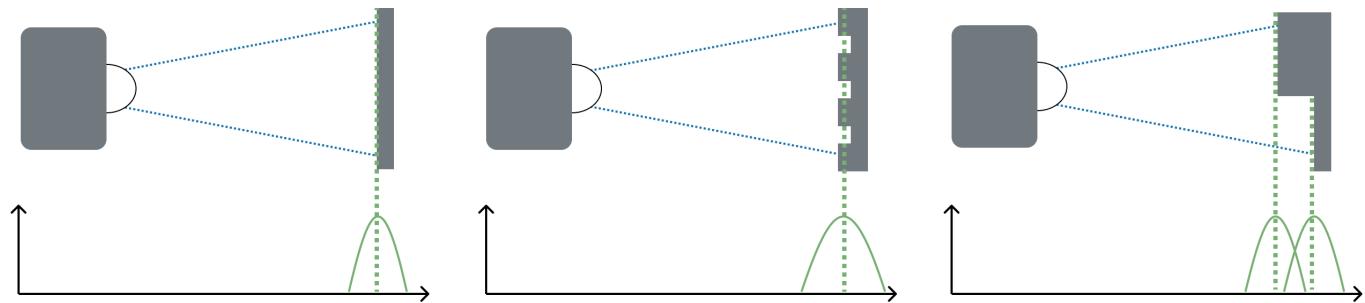
Averaging across measuring spot if the distance between reflection points is smaller than the resolution

| | |
|---|---|
| 💡 **NOTE** | **Object detection:**<br>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.<br>**Measurement averaging:**<br>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 technical data and all productvariants.

## 4.1  Technical Data

| NOTICE | 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)** | 120 mm x 100 mm x 87 mm |
| **Housing material** | Aluminum |
| **Lens material** | PTFE |
| **Connection** | M12, 4-pin d-coded female connector<br>M12, 8-pin, a-coded male connector |
| **Weight** | 740 g |
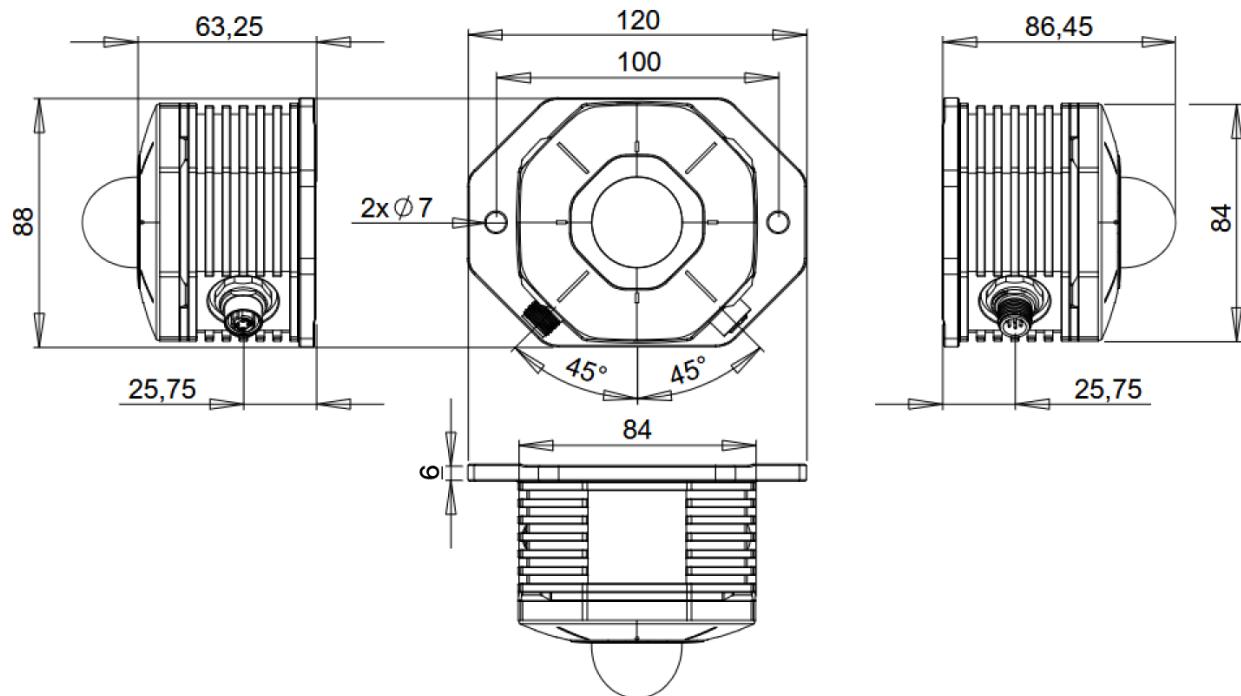
Device overview drawing with abstracted lens

## 4.2  Product Variants

|  | **Distance & Level** | **Precision** |
|---|---|---|
| **Measurement mode** | Absolute distance | Displacement |
| **Application examples** | • Dimension measurement<br>• Level control<br>• Crane detection | • Profile measurement<br>• Distance changes (± 1 µm)<br>• Building monitoring |
| **Measurement range** | 0.1 m - 6 m / 0.3 m - 40 m | 0.1 m - 40 m |
| **Linearity** | up to ± 0.3 mm | up to ± 1 µm (± 0.1%) |
| **Repeatability** | up to ± 0.1 mm | up to ± 1 µm |
| **Opening angle** | ± 1.5° (3°) | ± 1.5° (3°) |
| **Measurement rate** | 500 Hz | 500 Hz |

# 5  Installation

This chapter provides comprehensive details about the 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.

## 5.1  Sensor Setup

| NOTICE | **Damage to the device due to transport or storage**<br>Device failure, malfunction, device lifetime reduction.<br>• Check the packaging and the device for possible damages.<br>• In the event of visible damages, do not use the device and do not put it into operation.<br>• Do not install the device after a fall or drop of the sensor. |
|---|---|

| NOTICE | **Do not disassemble or open the radar sensor**<br>Sensors function may be lost partly or entirely<br>• In no case disassemble the radar sensor entirely or partly.<br>• Do not modify the radar sensor. |
|---|---|

| NOTICE | **Do not expose the device to impact stress.**<br>This would impair the sensors accuracy and reliability.<br>• Do not use a hammer to align the radar sensor.<br>• Avoid impact stress. |
|---|---|

### 5.1.1  Physical Setup

Mount the sensor so that it is aimed perpendicular to the target. Ensure that the sensor has a clear line of sight to the target with no obstructions. 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.

Install the sensor at an apropriate distance from the target. 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.

| ⚠ **CAUTION** | **Ensure secure installation of the sensor.**<br>An unsecured sensor may fall, causing injury or damage.<br>• Do not mount the sensor on unstable surfaces.<br>• Always use appropriate mounting hardware. |
| --- | --- |
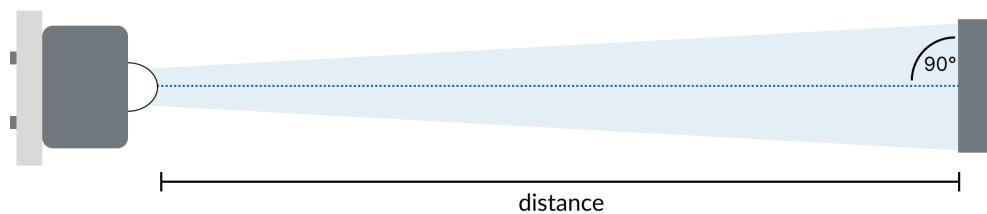


Physical setup

## 5.1.2  Cable Setup

The sensor must be connected to a 24 V power supply. For communication, connect the sensor via Profinet cable either directly to a laptop or to the PLC via a switch. Ensure proper wiring before operation.
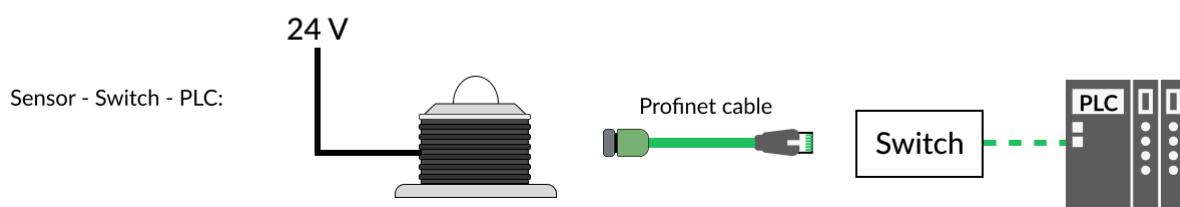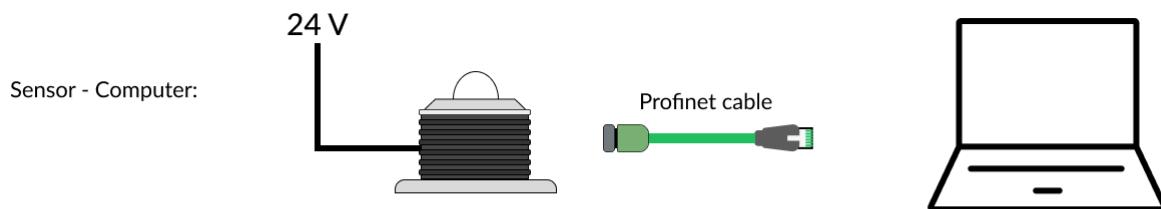


## 5.2  PLC Connection

| **NOTICE** | **Destruction of the device**<br>Before connecting or disconnecting the signal cable, always disconnect the power supply and secure it against switching on again. |
| --- | --- |

| NOTICE | **No open cable wires**<br>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. |
|---|---|

| NOTICE | **Traction relief**<br>Always mount all lines with traction relief. |
|---|---|

## 5.2.1 Electrical Connection

| NOTICE | • Outputs that are not in use must remain unconnected.<br>• Any unused conductors in cable outputs must be properly insulated.<br>• Do not bend cables below their minimum permissible radius.<br>• Always switch off the system before making electrical connections to the product.<br>• Where necessary, use shielded cables to minimize electromagnetic interference (EMI). |
|---|---|

**M12 8-pin A-coded male connector:** V+ (24 V) and V– (GND) provide the power supply. Pins A and B are used for RS485 data exchange. The sensor is connected using an 8-pin A-coded M12 cable. Additional pins are assigned to three switching outputs and the current loop, which are only available on certain sensor variants.
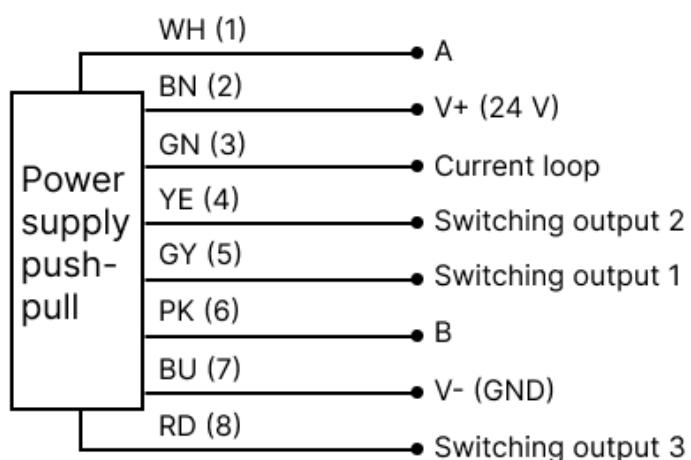


Pinout diagram sensor
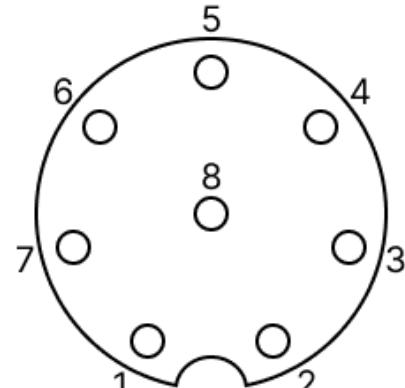
M12 8-pin a-coded male layout

**M12 4-pin d-coded female Profinet connector:** The pins Tx+ and Tx- are used for transmitting data, while Rx+ and Rx- are used for receiving data.
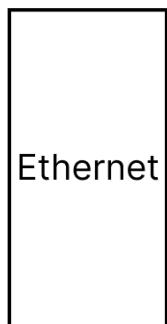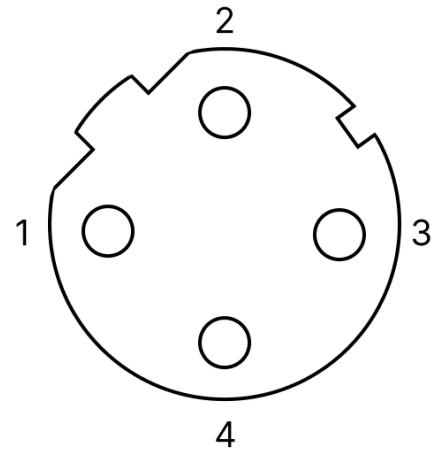


Pinout diagram sensor                    M12 4-pin d-coded female layout

## 5.2.2  Allocation of an IP Address

To integrate the radar sensor into your network, one of the following options must be used:

1. Direct connection via predefined static IP **(Option 1)**
   The radar sensor is delivered with the predefined IP address **10.10.42.2** and the subnet mask **255.255.255.0**. To establish a direct connection, configure the LAN port of the PC or laptop to the same subnet range (No DHCP!).

2. Connection via PLC **(Option 2)**
   When connected to a PLC, the PLC can assign an IP address to the radar sensor.

Ensure that the selected IP address is unique within the network to avoid conflicts.

Option 1:

24 V

10.10.42.2

Option 2:

PLC

24 V

Switch

Sensor IP address
is given by PLC
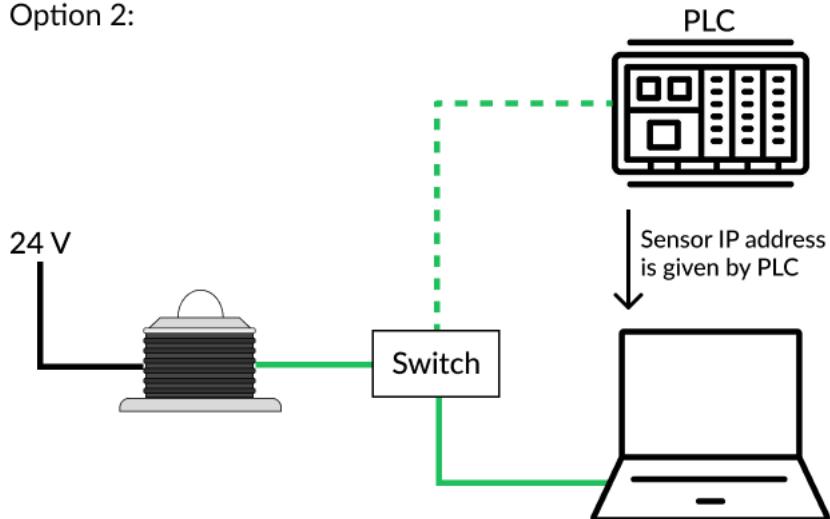
### 5.2.3  Connecting the Web Interface

Open the web interface by entering the sensor's default IP address (**10.10.42.2**) or the IP address assigned by the PLC in a web browser. After completing the configuration, disconnect the laptop and connect the sensor to the PLC, unless it is already connected.

| 💡 NOTE | • No manual saving required → all parameters are stored automatically.<br>• If you want to change sensor settings via the PLC, make sure to set the configuration source to PLC. |
| --- | --- |

# 6  Sensor Configuration

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

## 6.1  Introduction to OndoControl

After connecting the sensor to your computer and entering its IP address in your browser's address bar, the OndoControl user interface will appear as shown below.

| | |
|---|---|
| 💡 **NOTE** | If the page does not load, check your PC's ethernet settings:<br>• Direct connection: Set the LAN port to an IP address in the 10.10.42.xx subnetwork (No DHCP!) and use the default IP 10.10.42.2 in the address bar to access OndoControl.<br>• Via PLC network: Assign an IP address that matches your PLC network. |

OndoControl for OndoSense apex Dxxx



OndoControl for OndoSense apex Pxxx

## 6.1.1 Page Structure

Use the navigation tabs at the top or simply scroll to the section you're interested in.

- **Sensor Configuration** - View measured distances and adjust parameters.
- **Manage Sensor Configuration** - Save, load, or reset your sensor configurations.
- **Properties** ⚙ - View sensor properties and change general settings.

| Sensor Configuration | | | |
|---|---|---|---|
| **Name** | **View** | **Description** | **Availability** |
| Spectrum Chart | Standard | Shows the signals received by the sensor over the measuring range. Note that the amplitude scale has arbitrary units. | Pxxx, Dxxx |
| Distance Chart | Standard | Displays the measured distance over time. | Dxxx |
| Measurement Range | Standard | All signals received from outside the specified measuring range will be ignored. | Pxxx, Dxxx |
| Threshold (Offset) | Standard | Sets a constant signal amplitude threshold over the complete distance. | Pxxx, Dxxx |
| Peak Selection | Advanced | Select the peak sorting methode and select the peak you need for your measurement task. | Pxxx, Dxxx |
| Adjust Signal Amplification | Standard | Find the best amplifier parameter values. | Pxxx, Dxxx |
| Distance Offset | Advanced | This value is added to the distance value. | Dxxx |
| Filter | Advanced | Filters sudden distance measurement jumps. | Dxxx |
| Smoothing | Advanced | Applies an exponential averaging. | Dxxx |
| Add Hold | Standard | Freezes or unfreezes the magnitude data. | Pxxx, Dxxx |
| Fix Scale | Standard | Freezes or unfreezes the automatic scaling of the y-axis. | Pxxx, Dxxx |
| Set Reference | Standard | Defines the current distance as the new zero point for the displacement measurement. | Pxxx |
| Reset Time after Target Loss | Standard | Defines how long the sensor waits after a lost target before the displacement measurement automatically resets. | Pxxx |

# 6.2  Standard Settings

## 6.2.1  Signal Amplification

| | |
|---|---|
| 💡 **NOTE** | • **Sensor alignment**: Position the sensor perpendicular to the measurement target to maximize signal strength and Signal-to-Noise Ratio (SNR). A higher SNR ensures more robust and stable measurements and reduces interference from unwanted reflections.<br>• **Surface properties**: Rough surfaces are advantageous for radar measurements, as they reflect more of the radar beam back to the sensor. Smooth surfaces allow less tilting before signal strength drops significantly.<br>• **Impact of orientation**: As the target's surface tilts away from perpendicular, the reflected signal strength decreases.<br>• **Signal enhancement:** If your signal strength remains low, consider using a radar reflector to enhance the signal and improve detection accuracy. |

The signal strength received by the radar sensor is crucial for reliable measurements. In OndoControl , it is visualized by the amplitude of the spectrum.

**Optimizing Sensor Alignment**

1. **Roughly align the sensor** towards the measurement target as seen in the left part of the figure below.
2. In the **Spectrum** chart, enable **Add Hold** to monitor whether the **signal strength** increases or decreases during alignment.
3. **Manually adjust the sensor** step by step and compare the **current signal strength** with the **previous signal** shown by the **orange reference line**.
4. **Continue adjusting** until you achieve the **highest possible signal strength**. If the target is perpendicular to the sensor the signal strength is maximized.

**Optimize Signal:** Once you are done, click on  OPTIMIZE SIGNAL  to further optimize the signal strength. If the target is in motion, it's recommended to use  OPTIMIZE SIGNAL  when the target is positioned at its maximum distances.
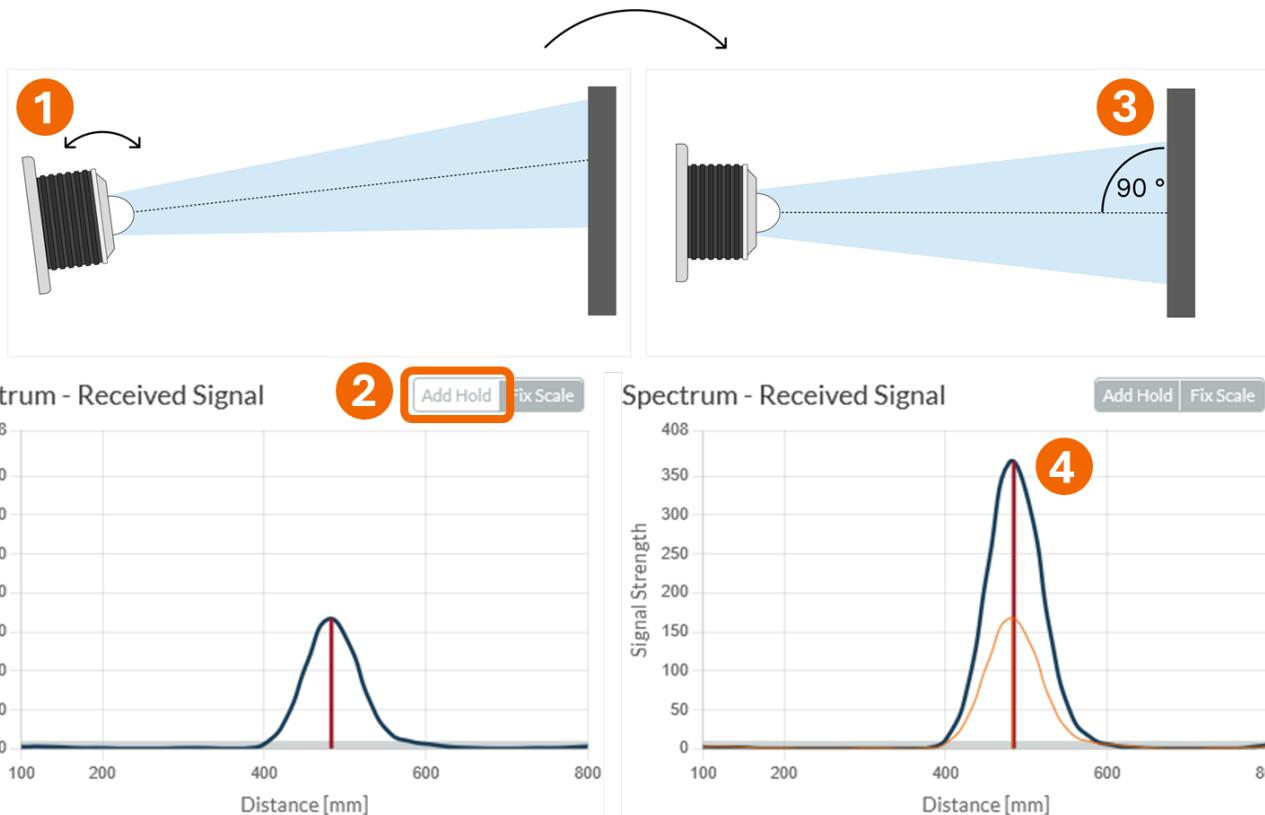
## 6.2.2 Measurement Range

> 💡 **NOTE** | Limit the measurement range to the specific area of interest for your application.

Set the measurement range to cover only the area of interest. By limiting the range, the sensor focuses on the relevant measurement zone and ignores all signals outside of it.

This is one of the most effective ways to avoid undesired interference from surrounding objects and background reflections. A well-defined measurement range improves signal quality and ensures more stable and reliable measurement results.



### Measurement Range ⓘ

| Min Distance [mm] | Max Distance [mm] |
|---|---|
| 100 | 1,000 |

## 6.2.3 Adjust the Threshold

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

Setting a threshold improves measurement robustness by ignoring all signals with a lower strength than the desired target.

The threshold (in amplitude) is indicated by the grey area in spectrum (3) in the figure below. Only peaks with a signal strength above this threshold (1) are considered, all others are suppressed (2)

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 (4).

## Spectrum - Received Signal
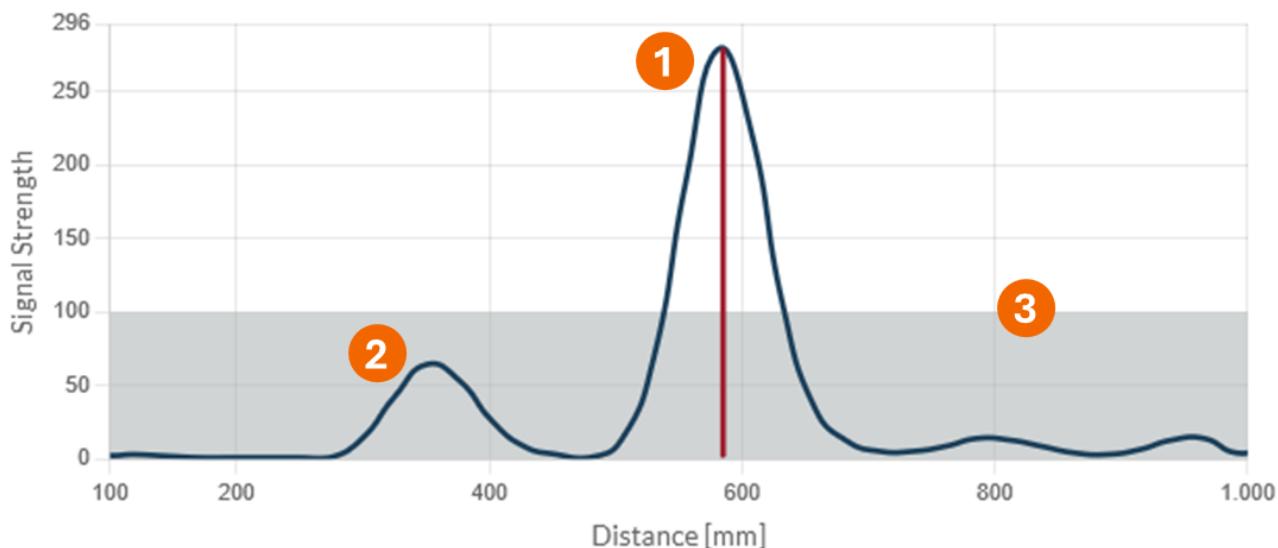


## Spectrum - Received Signal
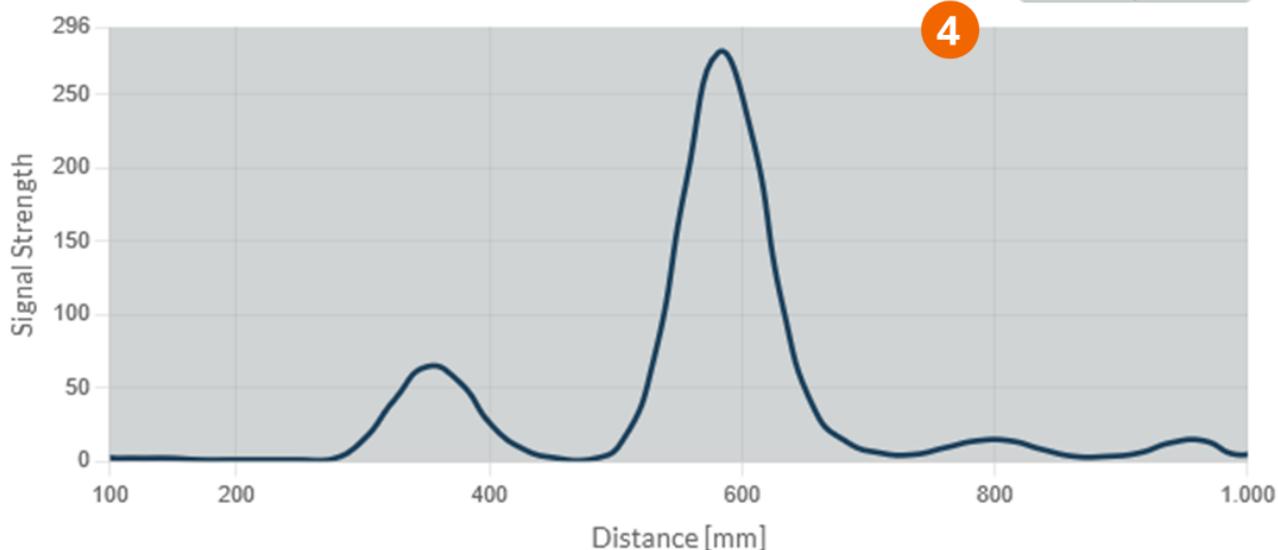


## 6.2.4 Displacement Measurement

| 💡 NOTE | This Mode is only available for the OndoSense apex Pxxx |
|---------|----------------------------------------------------------|

The High Precision displacement measurement 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:**

1. Displacement & Drift Measurements over Time:
   - Displacement measurement 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. This displacement measurement can effectively measure the profile of rough surfaces due to the opening angle and the radar spot size over which the distance is averaged.
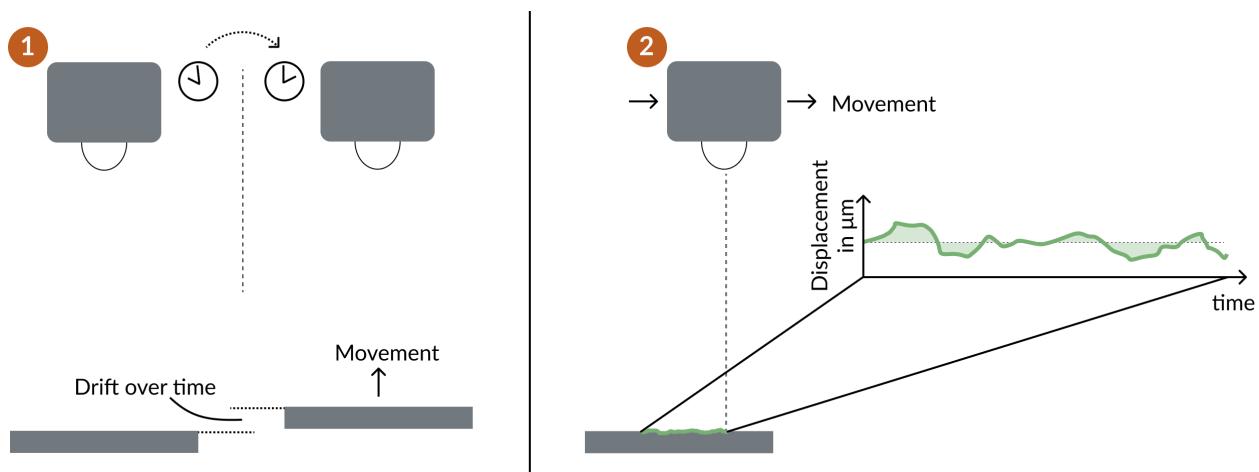


Click **Set Reference** to define the current distance as the new zero point.

**Reset Time after Target Loss** defines how long the sensor waits after a lost target before the sensor resets a new reference point automatically. When it resets, the baseline is updated to the current distance.

**Limitations**

- The displacement measurement is optimized for movements up to 50 mm/s. Target loss events may occur at higher speeds.
- The displacement measurement does not give a more accurate absolute distance than the normal absolute distance measurement. The first absolute distance measurement already has an error of a few hundred micrometers, and this error cannot be removed by the displacement measurement.
- The displacement measurement will measure accurate distances for targets whose orientation stays constant. For significant changes of the incident angle to the target, the accuracy of the displacement measurement will be affected.
- The displacement measurement can not be read out by the current loop or switching outputs.

# 6.3  Advanced Settings

## 6.3.1  Filter and Smoothing

| 💡 NOTE | To ensure smooth and accurate measurements, applying filter or smoothing algorithms can be beneficial. To disable the filters, set the values to 0. This mode is only available for OndoSense apex Dxxx. |
|---|---|

## 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 occurred.

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.

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

ⓑ 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
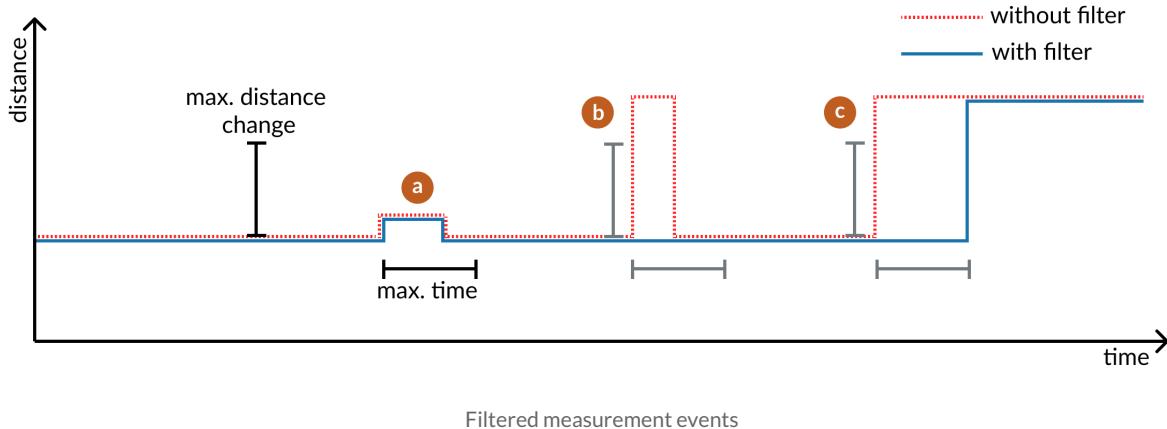
## Smoothing

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
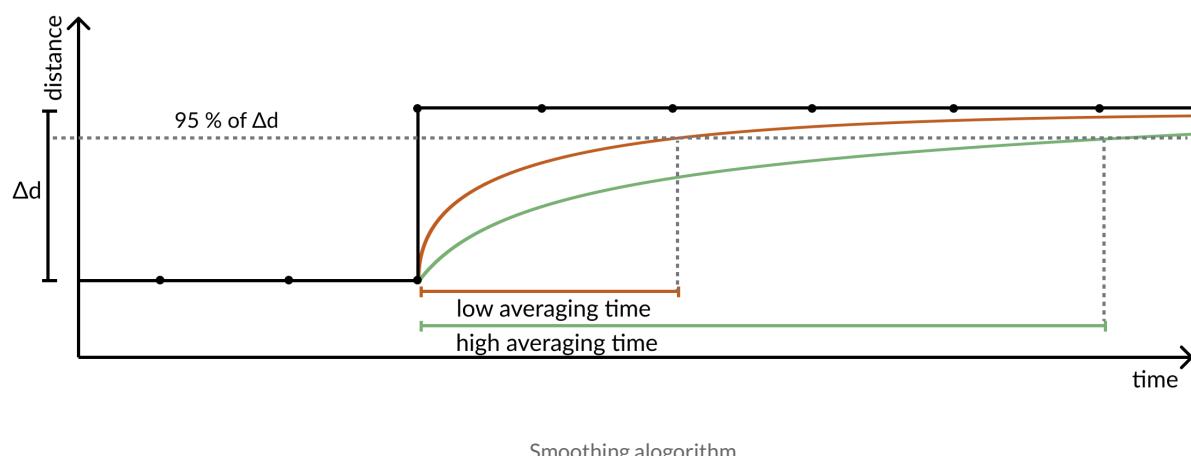
## 6.3.2  Distance Offset

| | |
|---|---|
| 💡 **NOTE** | 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. This mode is only available for OndoSense apex Dxxx. |

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.
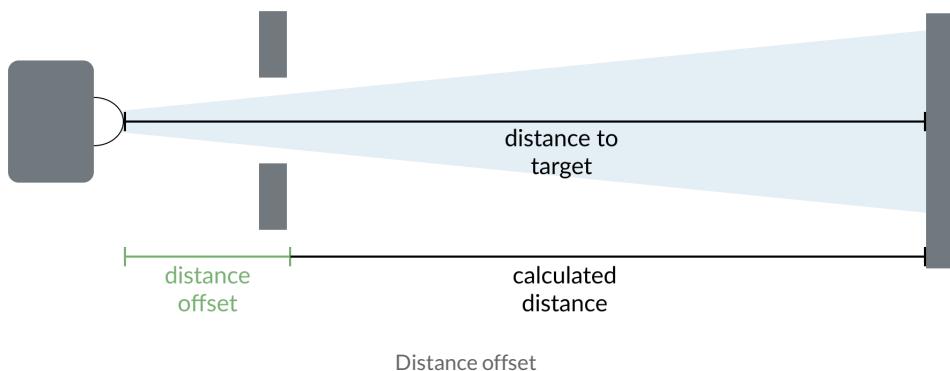


distance to target

distance offset

calculated distance

Distance offset

## 6.3.3  Peak Selection and Sorting

| | |
|---|---|
| 💡 **NOTE** | 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 in the spectrum view. You can choose between the following options:

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

# 6.4 Interfaces

## 6.4.1 Current Loop

| 🔆 NOTE | Change the Error behaviour to 3.6 mA, 21 mA or Retain previous value |
|---------|---------------------------------------------------------------------|

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.

**Error Behavior:**

- **3.6 mA**: Output current is set to 3.6 mA when the target is lost.
- **Retain Previous Value**: The last valid current value is retained when the target is lost.
- **21 mA**: Output current is set to 21 mA when the target is lost.
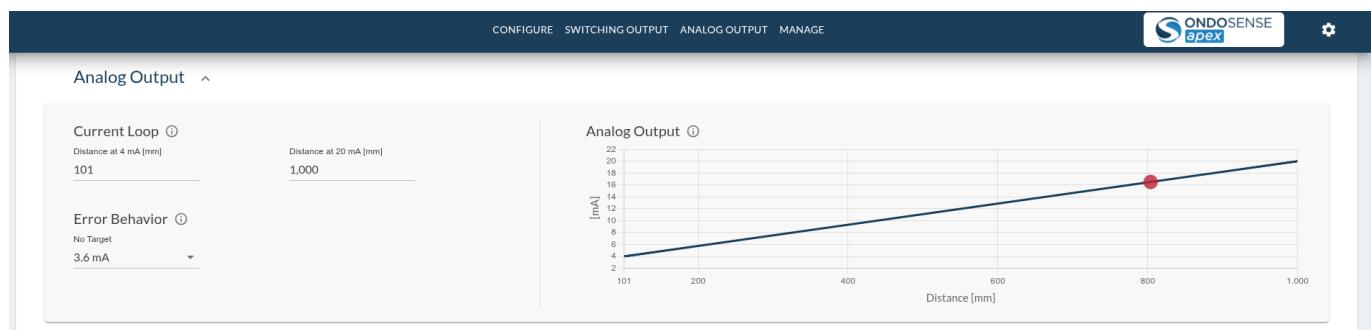


Interface for current loop

## 6.4.2 Switching Outputs

| 🔆 NOTE | Change the Error behaviour to High, Low or Retain previous state |
|---------|------------------------------------------------------------------|

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.

**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.

**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.

**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.

**Error Behavior:**

- **Low**: The switch turns off when the target is lost.
- **Retain Previous State**: The switch keeps its last state when the target is lost.
- **High**: The switch turns on when the target is lost.
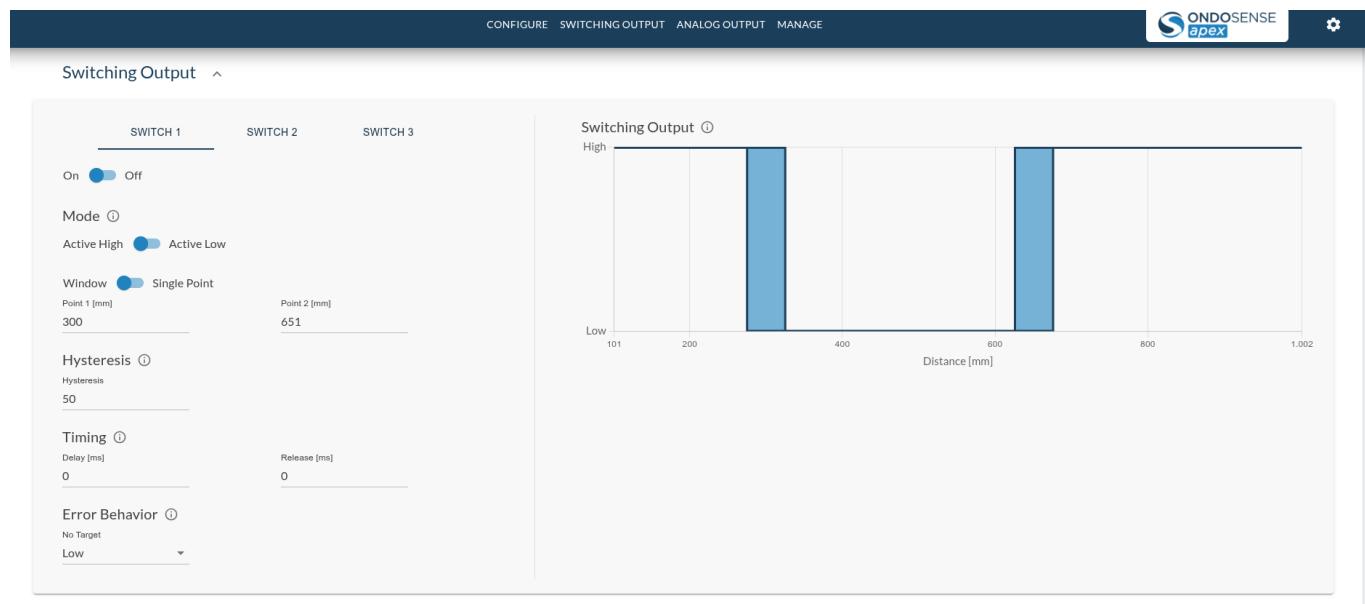


Interface for switching output configuration

# 7  Communication via Profinet IO interface

## 7.1  Profinet Device Integration

| 💡 NOTE | The GSD-file is available for download in the Download Center of the OndoSense support website. |
|---|---|

A device master file (GSD-file) is required for the configuration of a Profinet IO device. It describes the configurable functions of the device and must be integrated into the development environment (e.g. Tia Portal). The GSD-file is found on the Download Center of the OndoSense support website.

## 7.2  Module Overview

The functions (modules) described in the GSD-file allow reading out and configuration of the sensor and are defined by the following variables:

- **Module:** Name of the concerned module/description of its function
- **Size:** Size of the data to be transferred in Bytes
- **Module type:**
  - Input module: Cyclical data is transferred from the device to the control.
  - Mixed module: Cyclical data is transferred between the controller and the device, while parameters can be written non-cyclical.
  - Parameter module: Configuration data is exchanged non-cyclical.
- **Submodule:** Name of the concerned submodule/description of its function
- **Data type:** Data type of data in a submodule

### 7.2.1  Category Measurements

| Modul | Size [Byte] | Module type | Submodule | Data type |
|---|---|---|---|---|
| Distance [μm] | 5 | Input module | Distance Status | Integer8 |
| | | | Distance [μm] | Unsigned32 |
| Measurement counter | 5 | Input module | Measurement Counter Status | Integer8 |
| | | | Measurement Counter Value | Unsigned32 |

| Modul | Size [Byte] | Module type | Submodule | Data type |
|---|---|---|---|---|
| Peak | 11 | Input module | Peak Status | Integer8 |
| | | | Peak Frequency | Unsigned32 |
| | | | Peak Phase | Unsigned16 |
| | | | Peak Amplitude | Unsigned32 |
| Temperature | 5 | Input module | Temperature Status | Integer8 |
| | | | Temperature Value | Intege32 |
| High Precision Distance (only for apex P500) | 7 | Mixed module | High Precision Distance Status | Intege8 |
| | | | High Precision Distance Target Lost Counter | Unsigned8 |
| | | | High Precision Distance Value | Intege32 |
| | | | High Precision Distance Configuration | Unsigned8 |

### 7.2.2  Category Device Configuration

| Modul | Size [Byte] | Module type | Submodule | Data type |
|---|---|---|---|---|
| Device Configuration | | Parameter module | Radar Configuration | - |
| | | | Configuration Source | - |

## 7.3  Submodule overview

### 7.3.1  Module Distance [µm]

| Input value | Value range | Data type | Comment |
|---|---|---|---|
| Distance Status | -9 … 3 | Integer8 | Quality of measuring signal: See status codes below |

| Input value | Value range | Data type | Comment |
|---|---|---|---|
| Distance [µm] | | Unsigned32 | Measured distance in µm |

## 7.3.2 Module Measurement Counter

| Input value | Value range | Data type | Comment |
|---|---|---|---|
| Measurement Counter Status | -9 … 3 | Integer8 | Quality of measuring signal: See status codes below |
| Measurement Counter Value | | Unsigned32 | Value of the sensor's internal measurement counter |

## 7.3.3 Module Peak

| Input value | Value range | Data type | Comment |
|---|---|---|---|
| Peak Status | -9 … 3 | Integer8 | Quality of peak signal: See status codes below |
| Peak Frequency | | Unsigned32 | Frequency value of the detected peak |
| Peak Phase | | Unsigned16 | Phase value of the detected peak |
| Peak Amplitude | | Unsigned32 | Signal strength of the detected peak signal |

## 7.3.4 Module Temperature

| Input value | Value range | Data type | Comment |
|---|---|---|---|
| Temperature Status | -9 … 3 | Integer8 | Quality of temperature signal: See status codes below |
| Temperature Value | | Integer32 | Internal temperature of the sensor in °C |

### 7.3.5 Module High Precision Distance

| Input value | Value range | Data type | Comment |
|---|---|---|---|
| High Precision Distance Status | -9 … 3 | Intege8 | Quality of High Precision Distance signal:<br>See status codes below |
| High Precision Distance Target Lost Counter | | Unsigned8 | Counts how often the target could not be detected |
| High Precision Distance Value | | Intege32 | Measured displacement of the target relative to the reference in µm |
| High Precision Distance Configuration | | Unsigned8 | Contains the parameter "Restart HP Mode" |

### 7.3.6 Submodule High Precision Distance Configuration

This submodule contains the parameter to set a new reference for the high precision displacement.

Non-cyclical

| Parameter Name | Value range | Default value | Data type | Comment |
|---|---|---|---|---|
| Reset HP Mode | 1 | 0 | Unsigned8 | Sets a new reference for the high precision displacement<br><br>1 = Restart |

### 7.3.7 Submodule Radar Configuration

This submodule contains parameters for the configuration of the sensor.

| Parameter Name | Value range | Default value | Data type | Comment |
|---|---|---|---|---|
| Minimum Distance [mm] | 100..40000 | 100 | Unsigned32 | Measuring Range start |
| Maximum Distance [mm] | 300..40000 | 40000 | Unsigned32 | Measuring Range end |

| Parameter Name | Value range | Default value | Data type | Comment |
|---|---|---|---|---|
| Radar Profile | 3/7/26 | 26 = Max. accuracy - close range up to 6 m | Unsigned8 | 3 = High accuracy - mid range up to 20 m<br>7 = Std. accuracy - long range<br>26 = Max. accuracy - close range up to 6 m |

## 7.3.8  Submodule Configuration Source

This submodule contains parameters to set the configuration source of the sensor.

| Parameter Name | Value range | Default value | Data type | Comment |
|---|---|---|---|---|
| Configuration Source | 0/1/2 | 1 = Web GUI | Unsigned8 | 0 = PLC<br>1 = Web GUI<br>2 = ConfigBox (RS485) |

## 7.3.9  API Status Codes

| Status Code | Value | Description |
|---|---|---|
| API_SUCCESS | 1 | Command was successfully executed. |
| API_SUCCESS_WEAK_SIGNAL | 2 | The measurement was successful, but the reflected signal amplitude is too low for consistent target detection (check amplification parameters or targe |
| API_SUCCESS_OUTLIER | 3 | The measurement was successful, but the measured distance is an outlier/unexpected. |
| API_ERROR | -1 | An error has occurred. |
| API_ERROR_COMMAND | -2 | Unknown command. |
| API_ERROR_PARAMETER | -3 | Unknown parameter. |
| API_ERROR_RANGE | -4 | The value set for this parameter is not within the allowed range of values. |

| Status Code | Value | Description |
|---|---|---|
| API_ERROR_FORBIDDEN | -5 | This parameter is protected and cannot be changed. |
| API_ERROR_NO_TARGET | -6 | The sensor has not detected a target. |
| API_ERROR_TARGET_LOST | -7 | Only applicable to high precision mode: The sensor lost the target. |
| API_ERROR_CALCULATION | -8 | An error occurred in the distance calculation module. |
| API_ERROR_OTHER_CONFIG_SOURCE_SELECTED | -9 | Another config source is selected and therefore you cannot write parameters. |

# 8  System Management & Maintenance

This chapter focuses on the effective management and upkeep of your sensor system.

## 8.1  Save/Load Configuration

| NOTE | You do not need to save the settings after making adjustments. The sensor automatically retains the configuration changes even if you disconnect it from your computer 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".

**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.

**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.

## 8.2  Maintenance

| | |
|---|---|
| **NOTICE** | **Do not disassamble the device**<br>Disassembling the device may result in damage, loss of warranty, or malfunction and should only be performed by authorized personnel. |

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.

# 9  Disposal

| **NOTICE** | **Proper Disposal Required**<br>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

# 10  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

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