SYMEO LOCAL POSITIONING RADAR

ABSOLUTE POSITIONING

Product: LPR®-1DHP-291

Product Documentation

Content

The documentation for the LPR®-1DHP-291 Local Positioning Radar System is published by:

SYMEO GmbH
Prof.-Messerschmitt-Str. 3
D-85579 Neubiberg
www.symeo.com

If you have any questions or suggestions, please contact:

Email: info@symeo.com
phone: +49 89 660 7796 0

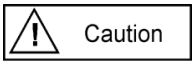
HISTORY

Version	Date	Description
0001	12.08.2022	Release for FCC/RED

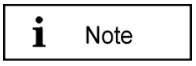
SYMBOLS USED

The following symbols are used throughout the documentation:

This symbol appears before instructions that must be followed at all times. Failure to comply with these instructions will result in personnel injury.



This symbol appears before instructions that must be followed at all times. Failure to comply with these instructions will result in damage to equipment.



This symbol appears before information of particular importance.

Delivery options and technical changes reserved.

Wherever the term LPR®-1DHP-291 is used during this documentation, all products included in the LPR®-1DHP-291 are addressed.

1 Safety Notes

General

The LPR®-1DHP-291 is a radar distance measurement sensor that may be used to measure distances between a radar unit and a reflector or between two radar units.

Warning

LPR®-1DHP-291 radars are purely tracking and assistance systems. They do not feature a functional safety level, e.g., Safety Integrity Level (SIL) or Performance Level (PL), as specified in functional safety standards (e.g., IEC 61508, EN ISO 13849, EN 62061).

Do not expose the radar to flames or heat above the specified temperature range.

Caution

Read the documentation before operation of the radar and follow the included safety notes.

Take note of the safety and operating instructions of the system in which you want to install the device.

Follow national safety norms and regulations.

Installation

Caution

Installation must be carried out by qualified and trained technicians.

When the system is mounted on tubes, measures to prevent slippage of the system must be taken.

Only screwed connections with safety against loosening may be used for mounting the radar.

Adhere to the specified tightening torques for all screws and connectors.

Warning

Screwed connections, mounting structures and the device itself must be examined at regular intervals, with respect to external damage and loosened connections especially if the radar is mounted exposed or is exposed to high stress.

Repairs and Modifications

Caution

Repairs or modifications may only be performed by the manufacturer.

Opening of the device is prohibited.

Any change or modification not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

The warranty shall be voided if defects are caused to the device by installing or exchanging system extensions.

Transport and Storage

Note

Do not drop the device and do not expose it to strong vibrations.

Power Supply

Caution

While installing or using it in open-air, transient overvoltage cannot be excluded. Overvoltage protection is to be used for low voltage in accordance with DIN EN 61643-21 and IEC 61643-21.

While connecting the plug and sockets, please observe the correspondent chapter in this document "Connectors" and adhere to the specified tightening torques.

Do not use damaged cables (damaged insulation, bare wires). A defective cable may cause a fire hazard.

Be careful that the device can be damaged by reverse polarity despite implementation of polarity reversal protection.

Setup and Operation

Caution

Protect the contacts of all the device's sockets and plugs from static electricity.

Proper operation (in accordance with IEC60950/EN60950) of the device is only assured if the housing and integral covers for mounting slots are fully installed (electric shock, cooling, fire protection, noise suppression).

In case of intense, direct solar radiation or other radiant heat, it may be necessary to provide a sun or heat shield.

Be aware, that misuse, modification, or damage of the sensor can lead to erroneous distance measurements.

After mounting and commissioning, compare the actual distance to the distance measured by the radar sensor with respect to your needed accuracy. This step must be repeated after major changes to your measurement setup.

System Extensions and Accessories

Note

For LAN cabling, the requirements in accordance with EN 50173 and EN 50174-1/2 apply. Use of either a Category 5 shielded cable for 10/100 Ethernet or Category 5e shielded cable for gigabit Ethernet is a minimum requirement. The specifications of standard ISO/IEC 11801 must be complied with.

General Requirements for Compliance of Radio Apparatus

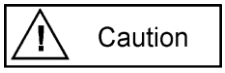
Note

The operation of this device requires compliance with regional radio regulations.
This device complies with Part 15 of the FCC Rules and with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est

autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Exposure Requirements



To satisfy FCC exposure requirements a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during operation.
To ensure compliance, operations at closer distances than this are not recommended.

To satisfy ISED exposure requirements a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during operation.
To ensure compliance, operations at closer distances than this are not recommended.

Pour satisfaire aux exigences d'exposition ISED, une distance d-e sépa ration de 20 cm ou plus doit être maintenue entre l'antenne de cet appareil et les personnes pendant le fonctionnement.
Pour assurer la conformité, les opérations à plus courte distance ne sont pas recommandées.

2 The LPR®-1DHP-291

The LPR®-1DHP-291 is a radar distance measurement sensor, which performs 1D distance measurements for short, medium and long ranges with highest accuracy.
The radar sensor can be operated in three different radar modes: primary radar mode, secondary radar mode and diversity radar mode. Table 2.1 shows the radar modes.

LPR®-1DHP-291	
Primary Radar Mode	**X**
Secondary Radar Mode	**X**
Diversity Radar Mode	**X**

Table 2.1: Supported radar modes for LPR®-1DHP-291 product types

Typical applications of the LPR®-1DHP-291 are:

- Positioning of cranes, crane trolleys, hoists and other railbound transport systems
- Process automation, monitoring and control
- Collision avoidance
- Radar barriers

Note	All LPR®-1DHP-291 product types can be configured with the help of a Web User Interface (WebUI).

3 Radar Basics

3.1 Radar Distance Measurement Principle

The LPR®-1DHP-291 radar distance sensors use electromagnetic waves to measure the distance and speed between two radars (secondary radar mode) or a single radar and a reflector (primary radar mode).

The underlying measuring principle is based on the Round-Trip Time-Of-Flight (RTOF) measurement between a transmitted radar signal and a received signal. The radar estimates the time *τ* the radar signal needs to travel the unknown distance *d* from one radar to the other (or to a reflector) and back. The distance is then calculated with the formula

$$d = 0.5\,\tau\,c$$

where *c* is the speed of light.

3.2 Radar Beam and Field of View (FoV)

The LPR®-1DHP-291 emits a high frequency electromagnetic radio signal with its integrated antenna. The EM-wave is focused by a dielectric lens and creates a radar beam with an FoV (half power beam width, HPBW) of +/-2,5°.

Distance d in m	1	3	10	30	50	70	100	200	300	400	600
Radar beam 3dB diameter in m	0.1	0.3	0.9	2.6	4.4	6.1	8.7	17.5	26.2	34.9	52.4

Table 3.1: Radar beam 3 dB diameter vs. distance

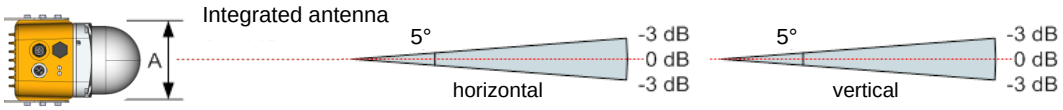


Figure 3.1: Radar beam and field of view

3.3 Fresnel Zone

The area for radio transmission between two antennas is called Fresnel zone. The main part of energy is concentrated in the first Fresnel zone.

Note	The Fresnel zone must be free of any obstacles to ensure that the signal is not attenuated or interrupted.

The maximum radius of the first Fresnel zone (in the middle between two antennas) can be calculated as follows:

$$r = 0.5 \cdot \sqrt{\lambda \cdot d}$$

λ is the wavelength and d the distance between the two radar devices or a radar device and a reflective target. For a frequency of 61 GHz the wavelength λ equals to 0.005 m. The maximum radius for different distances is given in Table 3.2.

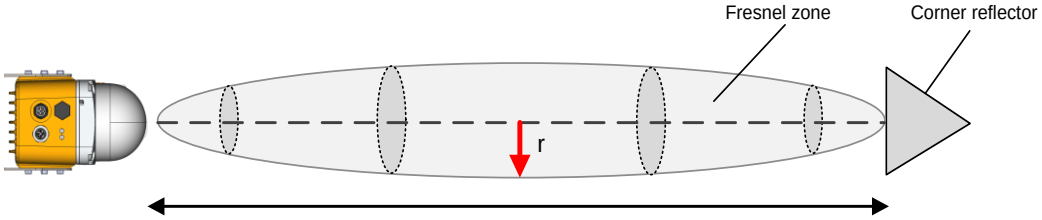


Figure 3.2: Fresnel zone

Distance d in m	10	20	30	40	50	70	100	200	300	400	600
Fresnel zone Radius r in m	0.11	0.16	0.19	0.22	0.25	0.30	0.36	0.50	0.62	0.71	0.86

Table 3.2: Fresnel zone radius vs. distance

3.4 Radar Modes

3.4.1 Primary Radar Mode

In primary radar mode, a single radar measures the distance and speed to a reflective object / target, typically a metal corner reflector.

Figure 3.3 shows the typical setup of an LPR®-1DHP-291 radar and a corner reflector for a primary radar distance measurement.

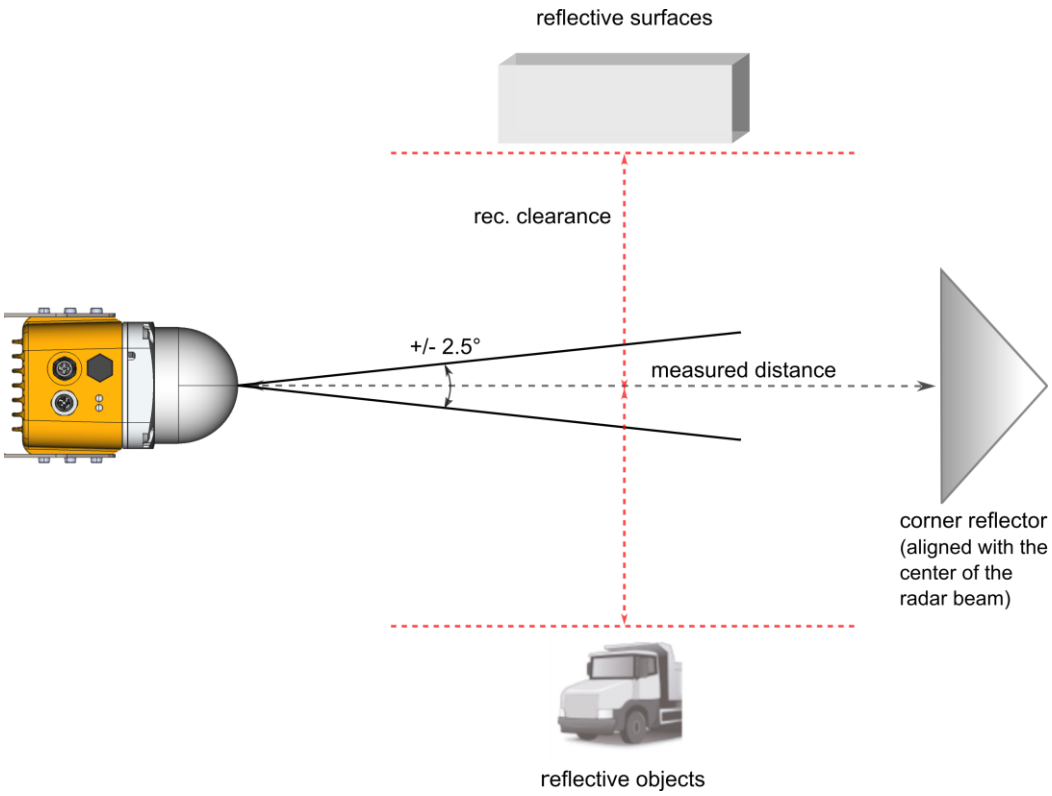


Figure 3.3: Primary radar mode measurement setup

3.4.2 Secondary Radar Mode

In secondary radar mode, two radars measure the distance and speed between each other.

Figure 3.4 shows the typical setup of two LPR®-1DHP-291 radars for a secondary radar range measurement.

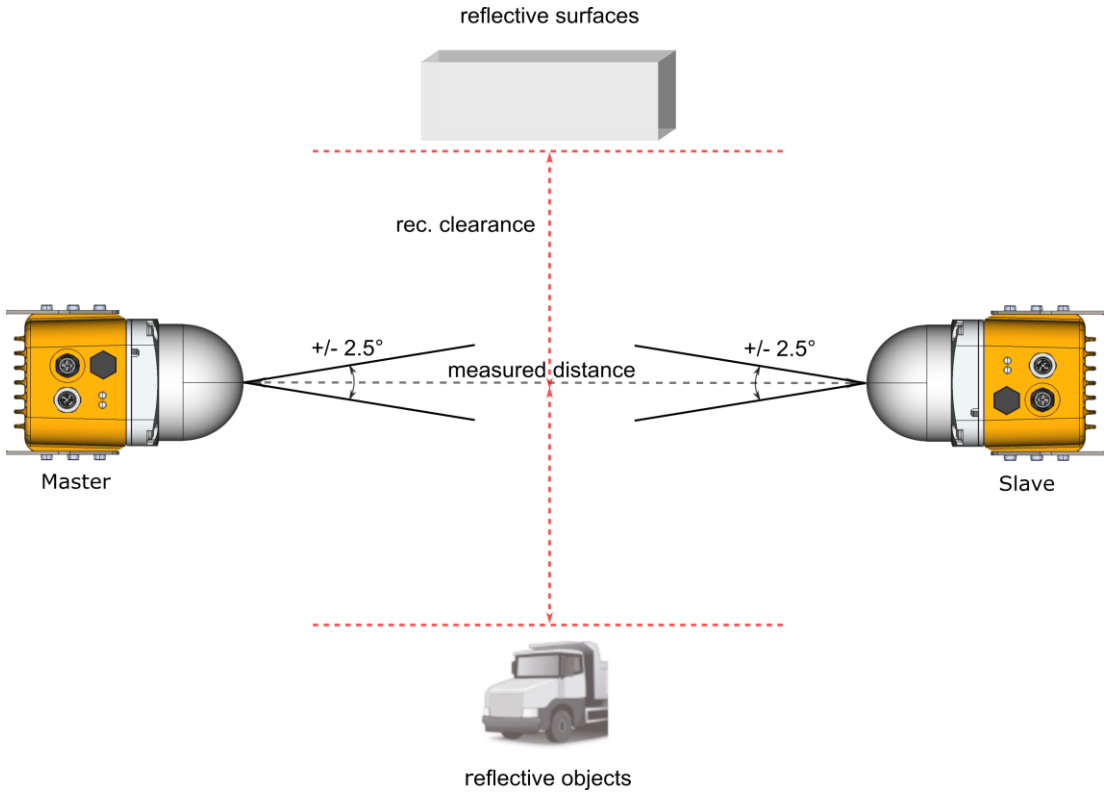


Figure 3.4: Secondary radar mode measurement setup

3.4.3 Diversity Radar Mode

In diversity radar mode, four radar units are grouped into two pairs, which are mounted in a way that two secondary radar measurements are performed side by side separated by a defined distance.

Figure 3.5 shows the typical setup of four LPR®-1DHP-291 radars for a diversity radar range measurement.

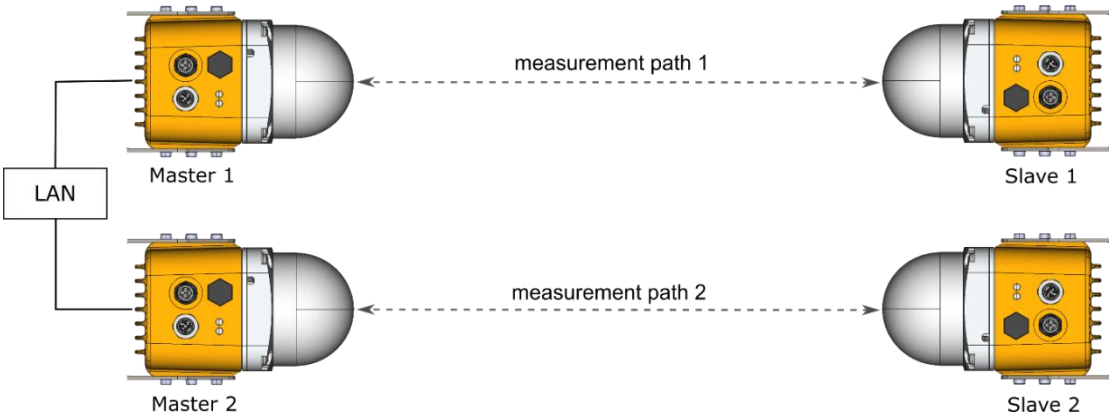


Figure 3.5: Diversity radar mode measurement setup

3.5 Bandwidth Modes

The LPR®-1DHP-291 operates in the 57 - 64 GHz band. Depending on your used region and regulatory authority setting, a limited number of bandwidth modes are available for selection in the WebUI.

The selected bandwidth modes have impact on the accuracy, resolution and range of the radar.

Within a single bandwidth mode, multiple sync channels are available. For each channel block, the effective bandwidth of a sync channel slightly reduces with increasing sync channel number.

3.6 Accuracy

To maximize the accuracy of an LPR®-1DHP-291 measurement setup, different error sources which influence the accuracy need to be taken into account:

- Mounting position
  - Adhere to the mounting instructions (see chapter 5) to minimize systematic errors (e.g., horizontal or vertical offset and alignment)
- Reflective surfaces and objects
  - Unwanted reflections of the radar signal, e.g., from crane tracks or walls, can cause distance errors which vary with the measured distance. Ensure the recommended clearance to surfaces and objects described in chapter 5.1 or use diversity radar mode to minimize errors caused by reflections
- Measurement noise
  - Measurement noise caused by the radar itself is the lower limit to the overall accuracy. The noise will decrease with increasing bandwidth. For primary radar mode the influence of noise will increase with range and decrease with target radar cross section (dependent on target size, shape and material). In secondary radar mode noise is mostly constant within the specified range and will increase for longer ranges. A reduction of the transmit power can lead to a reduction of the measurement noise at the expense of maximum range
- Temperature drift
  - Changes in device and air temperature can lead to measurement offsets. These errors vary slowly with time and can be countered by ensuring constant environmental conditions, running a warmup phase of 30 minutes before operation or by using a calibration reference
- Weather and environmental conditions
  - Under severe weather and environmental conditions such as very heavy rain or snow fall and layers of ice, snow, dust or other absorbing and reflecting material being attached to the lens the measurement may be prone to distance offsets of up to +/- 10mm.

3.7 Range

To maximize the range of an LPR®-1DHP-291 measurement setup the following aspects must be taken into account:

- Mounting position
  - Adhere to the mounting instructions (see chapter 5). Ensure minimum alignment error and vertical / horizontal offset and equal orientation (for secondary and diversity radar mode)
- Fresnel zone
  - Ensure the Fresnel zone is free of absorbing or reflecting objects
- Reflective surfaces and objects
  - Reflections of the radar signal, e.g., from walls, can lead to a reduction of the received signal strength and hence maximum range. Ensure the recommended clearance to surfaces and objects described in chapter 5.1 or use diversity radar mode to counter the effects caused by reflections
- Target RCS (only primary radar mode)
  - In primary radar mode the maximum range depends on the target RCS (radar cross section) which is a function of target size, material, and shape. If a high range is required use targets with a high RCS (e.g., the corner reflector MTE000958)
- Weather and environmental conditions
  - Under severe weather and environmental conditions as stated in chapter 3.6 the maximum operating range may be decreased.

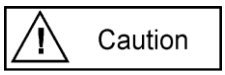
The measurement range given in the technical specification in chapter 8 and the datasheets is the typical range in which operation is possible under most conditions. The sensor may be operated at higher or lower ranges if circumstances permit.

4 Components

4.1 Device Overview

The LPR®-1DHP-291 consists of the following parts (see Figure 4.1 and Figure 4.2):

- Dielectric lens (A1)
  - focuses the radar beam
- Metal gland (A2)
  - fixes the lens to the housing with four screws
  - seals the device against water and dirt
  - holds the inner parts of the device in place
- Housing (A3)
  - provides LEDs (B1) and a pressure equalization membrane (B2)
  - provides the M12 power supply connector (C1) and the M12 Ethernet connector (C2)
  - provides 2 x 3 M6 screwing holes (B3) for mounting in the mounting bracket
  - provides an adjustment guide for usage with a laser level for exact radar beam alignment (B4)
  - ensures IP65 protection class and heat dissipation



The housing must not be opened.

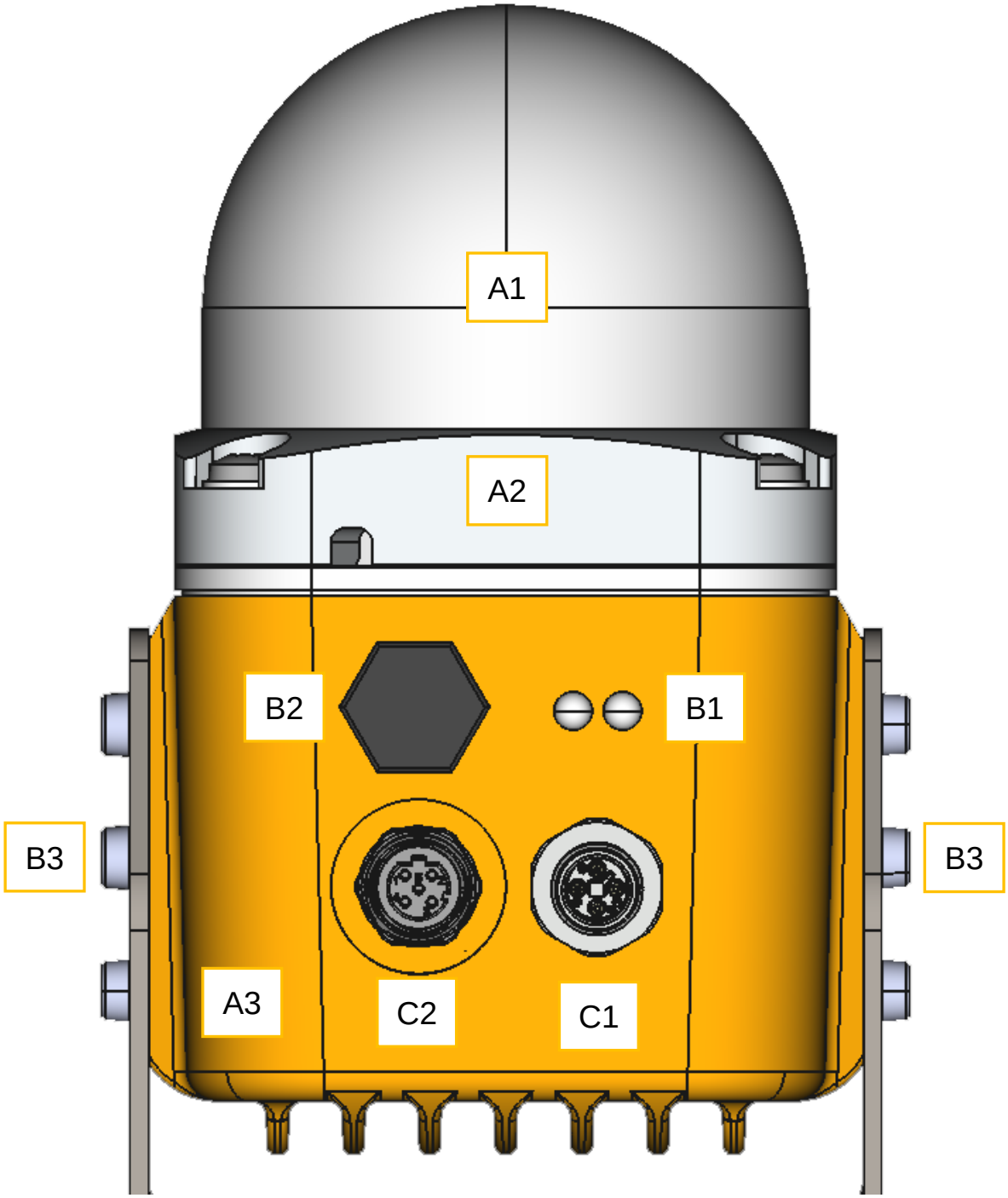


Figure 4.1: Front view of the LPR®-1DHP-291

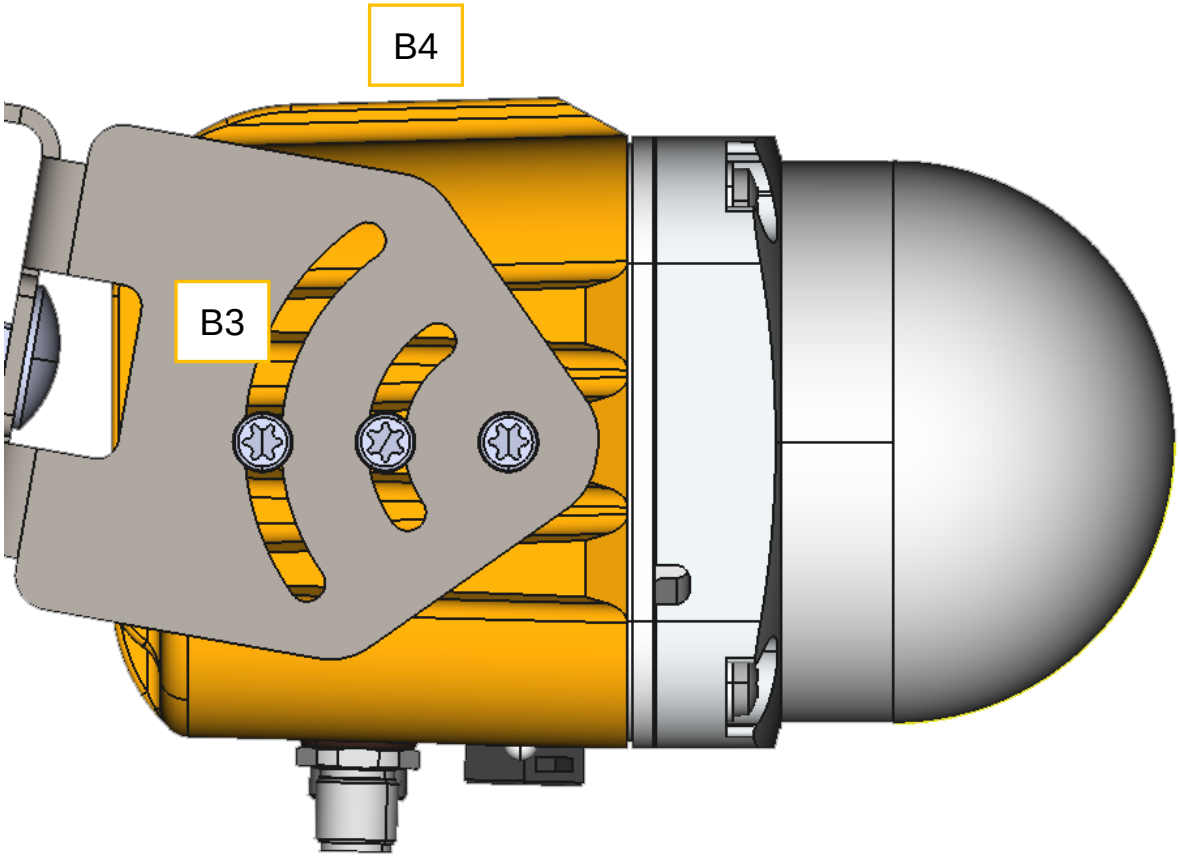


Figure 4.2: Side view of the LPR®-1DHP-291

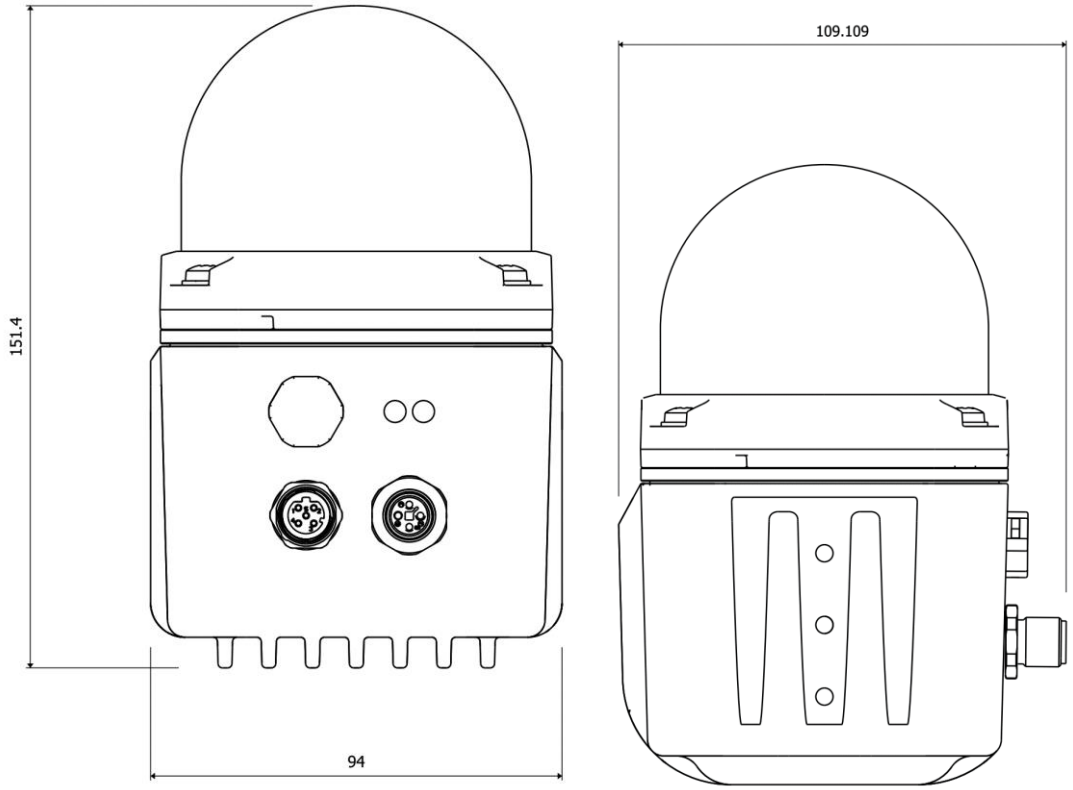


Figure 4.3: LPR®-1DHP-291 housing dimensions

4.2 LED Display

The LEDs (Status LED on the left and Ethernet LED on the right) indicate the different states of the device (see Table 4.1).

LED Indication	Status of the Device
Status LED lights up BLUE	Device is booting up
Status LED lights up RED	Invalid measurement
Status LED lights up GREEN	Valid measurement
Status LED flashes BLUE	Firmware update in progress
Ethernet LED lights up WHITE	Ethernet interface established
Ethernet LED flashes WHITE	Ethernet interface transmits data

Table 4.1: LED Display

4.3 Connectors

The housing of the LPR®-1DHP-291 provides the following M12 connectors (see Figure 4.1 and Figure 4.2*)*:

- Power supply input (C1)
- Ethernet connector (C2) for network connection

The necessary connectors for manufacturing cables that fit your installation and cable length are available from Symeo and are described in the following chapters.

We recommend the following tool set from PHOENIX CONTACT for proper M12 torque moment screwing:

- **Torque head - SAC BIT M12-D15 – 1208432**
- **Grip - TSD 04 SAC – 1208429**

4.3.1 Power Supply

The LPR®-1DHP-291 is powered via a 4-pin M12-Connector.

Plugs

Recommended connector:

- **SACC-M12FST-4CON-PG 9-M - 1418052**
  - Cable diameter: 6 - 8 mm
    Tightening torque: 0.4 Nm
  - **Symeo order number:** MTE101761

The connector is also part of the following M12 connector set:

- **M12 connector set (Ethernet + Power supply)**
  - **Symeo order number:** MTE102366

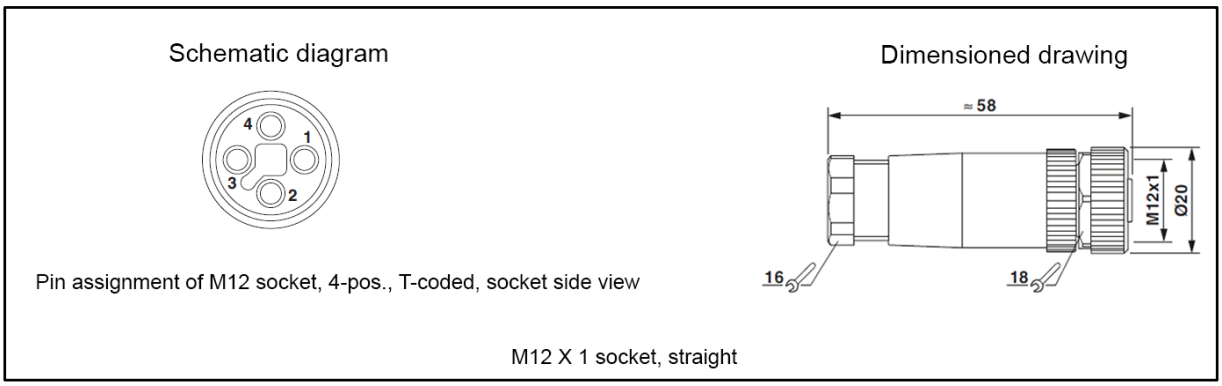


Figure 4.4: M12 power supply connector

Pin Assignment

Power Supply 11 V DC – 36 V DC	M12 Connector
V_{DC}+	Pin 1
V_{DC}+	Pin 2 (bridged to Pin 1)
V_{DC}-	Pin 3
V_{DC}-	Pin 4 (bridged to Pin 3)

Table 4.2: Pin assignment power supply

4.3.2 Ethernet M12 (TCP/IP or Profinet)

The LPR®-1DHP-291 can be connected to a TCP/IP or a Profinet bus system (Production Code "n" required) via an M12 Ethernet Connector.

Note	A Profinet interface application note is available for download in the Symeo Partner Login area.

Plugs

Recommended connector:

- **SACC-M12MSD-4CON-PG 7-SH – 1521258**
  - Cable diameter: 4 – 6 mm (PG7)
    Tightening torque: 0.4 Nm
  - **Symeo order number:** MTE101768

The connector is also part of the following M12 connector set:

- **M12 connector set (Ethernet + Power supply)**
  - **Symeo order number:** MTE102366

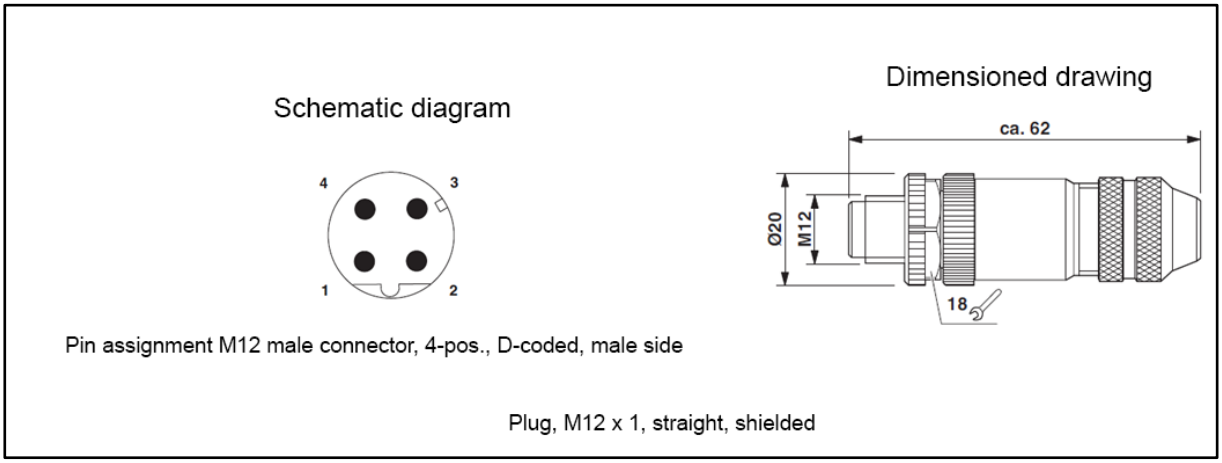


Figure 4.5: M12 Ethernet connector

Pin Assignment

Signal	Color of Wire PROFInet®	Color of Wire EIA/TIA 568B	Pin Assignment
TD+	Yellow	White/Orange	1
TD-	Orange	Orange	3
RD+	White	White/Green	2
RD-	Blue	Green	4

Table 4.3: Pin assignment for Ethernet M12

i Note

If the Ethernet connecter is left unused, install the protective cap of the connector.

Connector Cable M12 – RJ45

A connector cable M12 – RJ45 (2m) for connecting the radar to a PC for initial commissioning and configuration is available from Symeo:

- **Symeo order number**: MTE102007

4.4 Mounting Brackets

4.4.1 Mounting Bracket – MTM102513

For mounting the LPR®-1DHP-291 to a pipe, a mounting bracket is available from Symeo. The pipe diameter should measure between 40 and 75 mm.

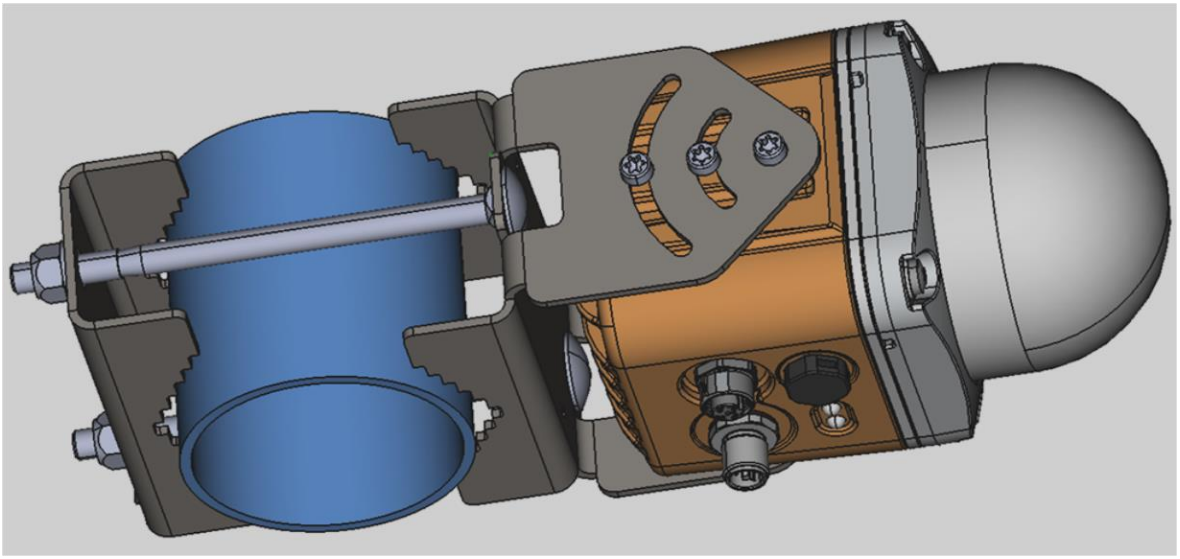


Figure 4.6: LPR®-1DHP-291 mounted to a pipe with the mounting bracket

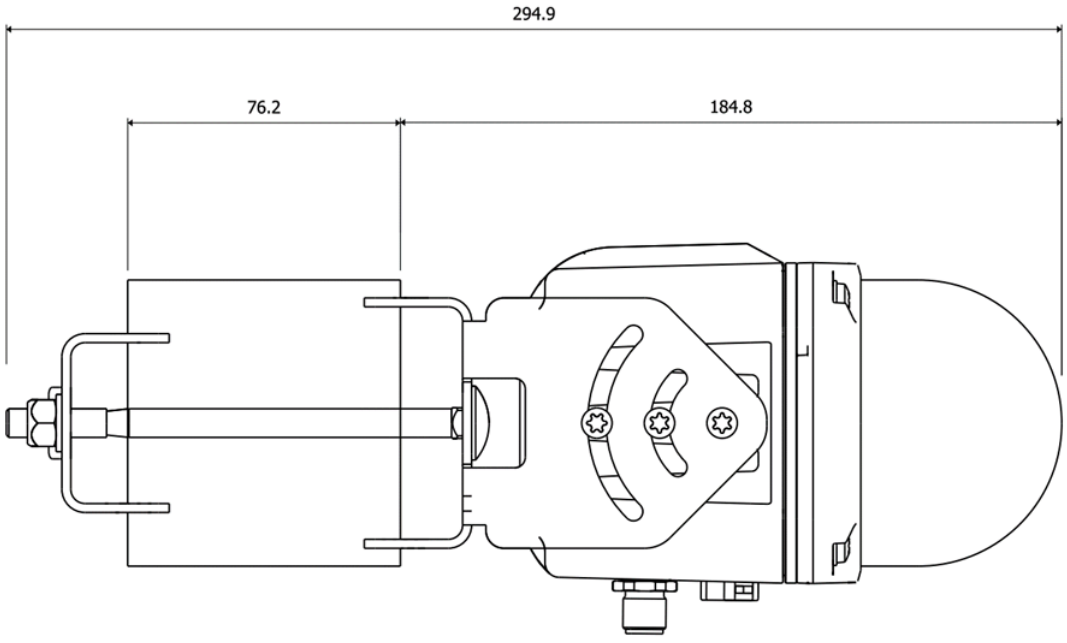


Figure 4.7: MTM102513 dimensions

Adhere to the following tightening torques for mounting:

- LPR®-1DHP-291 to mounting bracket (6x M5 screws): 3.5 Nm
- Tube clamp (2x M8 screws): 8 Nm

4.4.2 Diversity Mounting Bracket – MTM102467

For mounting two LPR®-1DHP-291 for operation in the diversity radar mode a diversity mounting bracket (Symeo part number MTM102467) is available from Symeo.

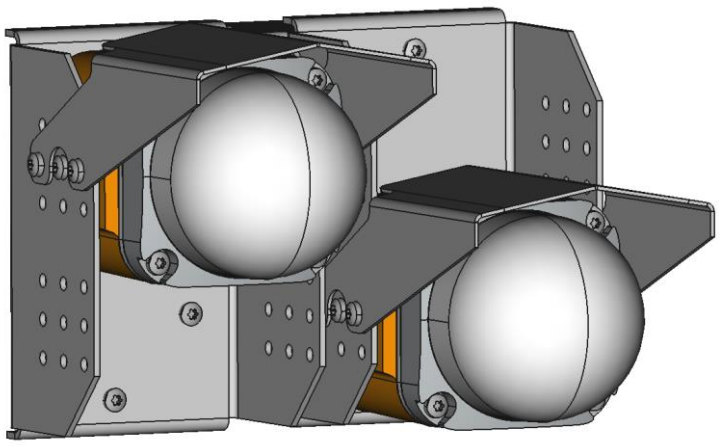


Figure 4.8: Two LPR®-1DHP-291 mounted in the diversity mounting bracket

Adhere to the following tightening torques for mounting:

- LPR®-1DHP-291 to mounting bracket (2x 6x M5 screws): 3.5 Nm
- Tube clamp (2x 2x M8 screws): 8 Nm

For more information how to assemble Diversity Mounting Bracket, please refer to our application note "DOC.EDO.000413.0001.EN_app_note_Assembly_Diversity_Mounting_Bracket_LPR-1DHP-200.pdf". This could be found in the "Partner/Customer Login" area of our website under "Symeo_Docs".

4.4.3 Protective cover – MTM102512

In addition to mounting brackets MTM102513 and Diversity mounting bracket MTM102647, protective covers (Symeo part number MTM102512) are available for use in snowy or extreme dusty environments.

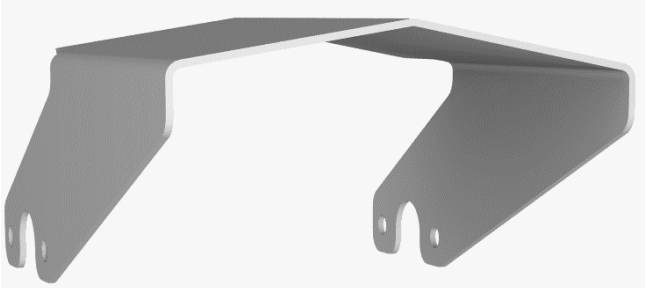


Figure 4.9: MTM102512 Cover

4.5 Corner Reflectors

For operation in the primary radar mode, different types of corner reflectors used as targets for the distance measurement are available from Symeo.

4.5.1 Corner Reflector 500 mm – MTE000958

Corner reflector with edge length 500 mm for maximum range.

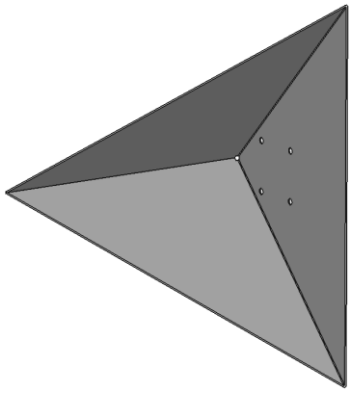


Figure 4.10: Corner reflector 500 mm

4.5.2 Corner Reflector 250 mm – MTE001011

Corner reflector with edge length 250 mm. Range is reduced to approx. 70% compared to MTE000958.

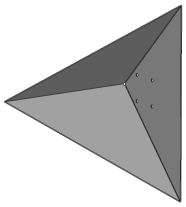


Figure 4.11: Corner reflector 250 mm

4.5.3 Adjustable mounting device tube/wall – MTM000169

For mounting the corner reflector, a pipe mounting bracket is available from Symeo. The pipe diameter should be between 40 and 75 mm.

5 Mounting

5.1 General Mounting Instructions

- Site-specific mounting instructions must be followed if available.
- The more accurately the radar units and reflectors are aligned to each other, the better the performance of the measurement setup will be in terms of accuracy and range.
- Ensure that the Fresnel Zone is free of obstacles.
- Ensure that your measured distances lie in the specified measuring range (see chapter 8).
- Ensure that reflective surfaces (e.g. walls, the roof, the floor, crane tracks) and other reflective objects (e.g. poles, tubes, bridges, vehicles) have the recommended clearance to the center of the radar beam that is in accordance with Table 5.1 (see also Figure 3.3 and Figure 3.4).

Measuring distance d in m	10	20	30	50	70	100	150	200	250	300
Recommended clearance in m	0.2	0.5	0.7	1.1	1.6	2.2	3.3	4.4	5.5	6.6

Table 5.1: Recommended clearance to reflective surfaces and objects

5.2 Mounting for Primary Radar Mode

For a primary radar distance measurement, typically a single radar unit and a recommended corner reflector are mounted facing each other (see Figure 5.1 and Figure 3.3).

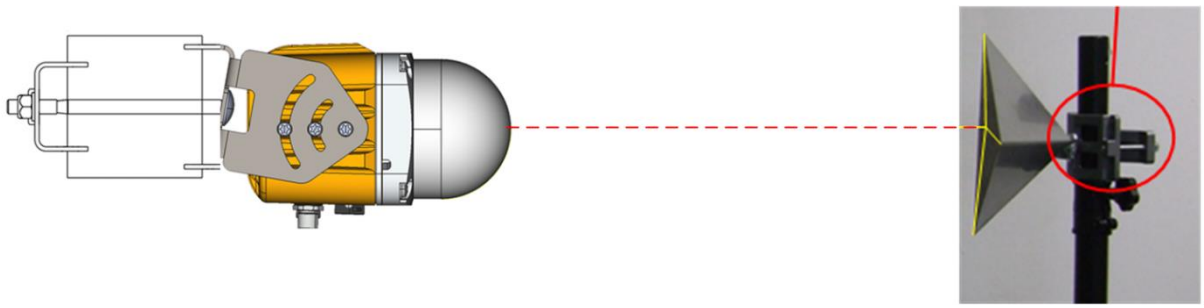


Figure 5.1: Mounting alignment of radar and reflector

For operation in the primary radar mode the following issues must be considered:

- The radar and the corner reflector must be installed in a way that the center of the corner reflector is aligned with the center of the radar beam.
- The radar units and/or corner reflectors must move parallel to the radar beam in the installation.
- The reflector must be either the nearest (first) target or the strongest target to be detected properly.

- Radar and radar reflector must be aligned to each other with maximum accuracy (at least +/- 2,5°).
- Minimum horizontal and vertical offset between radar and reflector must be ensured.

Follow the subsequent steps for proper installation of radar unit and reflector:

⇨ Mount a standard mounting bracket on one side of your measurement setup.

⇨ Mount the radar into the mounting bracket.

⇨ Mount a corner reflector to the other side of your measurement setup in a way, that the opening faces the radar. The 3 corners of the corner reflector opening should have about equal distance to the radar.

⇨ Carefully align the radar to the corner cube reflector. To do so, it is recommended to use a laser level fitted into the alignment aid, which should point at the middle of the reflector.

⇨ Fix the system by tightening the screws of the mounting bracket and the pipe clamp with the correct tightening torques.

⇨ Connect the power supply and Ethernet cable with M12 connectors as specified in chapter 4.3.1 and 4.3.2.

5.3 Mounting for Secondary Radar Mode

For a secondary radar distance measurement, two radar units, one configured as a “master” and one as a “slave” are mounted facing each other. The master unit initiates the measurement while the slave unit replies.

For operation in the secondary radar mode the following issues must be considered:

- The two radar units must be installed in a way, that the center of the emitted radar beam of each unit hits the other unit.
- The radar units must move parallel to the radar beam in the installation.
- The two radar units must be oriented exactly equally or turned by 180° along the radar beam axis (e.g., connectors of both devices facing downwards).
- Minimum horizontal and vertical offset between both radar units must be ensured.
- Both radar units must be aligned to each other with maximum accuracy (at least +/- 2,5°).

Follow the subsequent steps for proper installation of the radar units:

⇨ Mount a standard mounting bracket to one side of the measurement setup.

⇨ Mount the radar unit into the mounting bracket.

⇨ Repeat the first two steps on the other side of the measurement setup.

⇨ Carefully align both radar units to each other. To do so, it is recommended to use a laser level fitted into the alignment aids. The laser dot should point to the other sensor for both directions (Master -> Slave, Slave -> Master).

⇨ Fix the systems by tightening the screws of the mounting brackets and the pipe clamps with the correct tightening torques.

⇨ Connect the power supply and Ethernet cable with the M12 connectors as specified in chapter 4.3.1 and 4.3.2 to both stations. The Ethernet connection at the Slave unit is only required for configuration and can be removed during operation. If removed install the protective cap of the connector.

5.4 Mounting for Diversity Radar Mode

For a diversity radar distance measurement, four radar units are grouped into two pairs, which are mounted in a way that two secondary measurement paths are established side by side separated by a defined distance. As depicted in Figure 3.5 the setup contains 2 radars configured as master which must be visible to each other via LAN and 2 radars configured as slave.

For operation in the diversity radar mode the following issues must be considered:

- The radars must be installed in a way, that the center of the radar beams emitted by the master units each hit one of the slave units.
- The radar units must move parallel to the radar beam in the installation.
- The radar units must be oriented exactly equally or turned by 180° along the radar beam axis (e.g., connectors of both radars facing downwards).
- Minimum horizontal and vertical offset between the radars of one measurement path must be ensured.
- The radar units of one measurement path must be aligned to each other with maximum accuracy (at least +/- 2,5°).

Follow the subsequent steps for proper installation of the radar units:

⇨ Mount a diversity mounting bracket to one side of the measurement setup.

⇨ Mount two radars into the mounting bracket. Use the exact mounting positions shown in Figure 5.2.

⇨ Repeat the first two steps on the other side of the measurement setup. Make sure to switch the mounting positions in a way, that the sensors face each other without horizontal or vertical offset (see Figure 5.2).

⇨ Align the mounting brackets with the radars to each other. To do so, it is recommended to use a laser level fitted into the alignment aids. The laser dot should point to the other sensor for both directions (Master -> Slave, Slave -> Master).

⇨ Fix the systems by tightening the screws of the mounting brackets and the pipe clamps with the correct tightening torques.

⇨ Connect the power supply and Ethernet cable with the M12 connectors as specified in chapter 4.3.1 and 4.3.2 to all stations. The Ethernet connection at the slave units is only required for configuration and can be removed during operation. If removed install the protective cap of the connector. Make sure, that both master units are visible to each other via LAN.

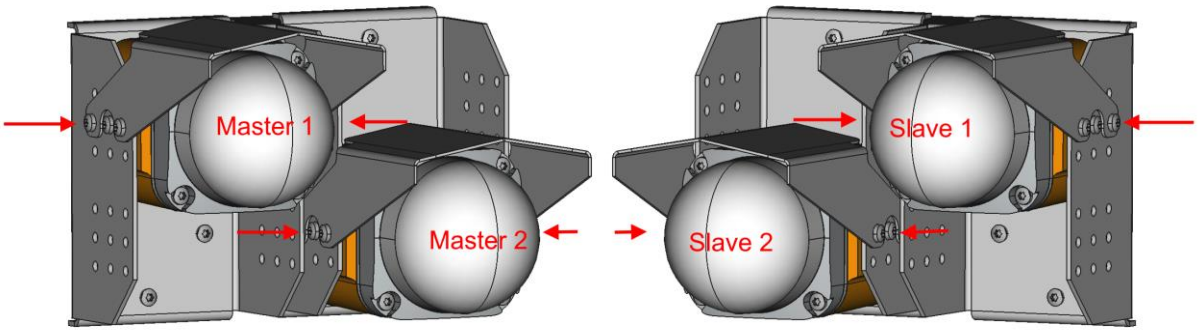


Figure 5.2: Mounting positions for mounting in the diversity mount for the master and slave side

6 Quick Setup

This chapter gives a short introduction for the setup of the radar sensors with the help of the WebUI.

6.1 Initial Setup

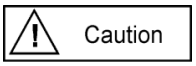
The following steps must be followed for the initial setup of all radar units:

- ⇨ Mount and align the radar units as outlined in chapter 5.
- ⇨ Connect the radar units to a power source (11 – 36V) and wait until booting is finished (blue LED switches to red or green).
- ⇨ Connect the radar units to a PC via Ethernet and open the Webinterface (WebUI) in a Webbrowser (http://192.168.1.99).
- ⇨ Sign in to the WebUI. Enter the user name "**Symeo**" and the password "**xxxxx**" and press "*Login*". Now your status is displayed as "*Logged in*".
- ⇨ Choose country and regulatory authority.
- ⇨ Change the IP addresses of all radars in your measurement setup to unique values in the same TCP/IP subnet.

6.2 Quick Setup for Primary Radar Mode

The following settings must be set in the WebUI for operation in primary radar mode:

- *Device -> Settings -> Measurement*
  - Station mode = Primary
  - Bandwidth mode = Choose a bandwidth that fits your required range and accuracy
  - Channel block = Use recommended selection
  - Sync channel = different than any other LPR®-1DHP-291 sensor in range; for neighboring measurement paths use only every fourth sync channel.
- *Device -> Settings -> Measurement details*
  - Target search mode = "First" if the reflector is the first target in range, "Strongest" if the reflector is the strongest target in range.



The setting "*Target search mode*" highly impacts the behavior of the radar, especially in multi target environments. "First target" may lead to distance measurements to unintended targets in the vicinity of the radar (e.g., a person passing the radar beam). "Strongest target" may lead to distance measurements to unintended targets present in the background of your intended target (e.g., a wall behind a corner reflector). Perform therefore always a test to verify this setting.

6.3 Quick Setup for Secondary Radar Mode

The following settings must be set in the WebUI of the master and slave sensor for operation in secondary radar mode.

Note	Only the Master unit outputs range data.

Master

- *Device -> Settings -> Measurement*
  - Station mode = Master
  - Bandwidth mode = Choose a bandwidth that fits your required range and accuracy
  - Channel block = Use recommended selection
  - Sync channel = different than any other LPR®-1DHP-291 sensor in range (except the related Slave); for neighboring measurement paths use only every fourth sync channel.

Slave

- *Device -> Settings -> Measurement*
  - Station mode = Slave
  - Bandwidth mode = same as Master
  - Channel block = same as Master
  - Sync channel = same as Master

6.4 Quick Setup for Diversity Radar Mode

The following settings must be set in the WebUI of all 4 sensors for operation in diversity radar mode.

Note	• Only the master units output range data. • Both master units must be visible to each other via LAN. • Both master units output similar distance data. • Master 1 must face slave 1 and master 2 must face slave 2 without horizontal or vertical offset.

⇨ Configure the following settings:

Master 1

- *Device -> Settings -> Measurement*
  - Station mode = Master
  - Bandwidth mode = Choose a bandwidth that fits your required range and accuracy
  - Channel block = Use recommended selection
  - Sync channel = different than any other LPR®-1DHP-291 sensor in range (except the related Slave 1); for neighboring measurement paths use only every fourth sync channel.

Slave 1

- *Device -> Settings -> Measurement*
  - Station mode = Slave
  - Bandwidth mode = same as Master 1
  - Channel block = same as Master 1
  - Sync channel = same as Master 1

Master 2

- *Device -> Settings -> Measurement*
  - Station mode = Master
  - Bandwidth mode = same as Master 1
  - Channel block = same as Master 1
  - Sync channel = different than any other LPR®-1DHP-291 sensor in range (except the related Slave 2). Also, different to Sync channel of Master 1 and Slave 1; for neighboring measurement paths use only every fourth sync channel.

Slave 2

- *Device -> Settings -> Measurement*
  - Station mode = Slave
  - Bandwidth mode = same as Master 2
  - Channel block = same as Master 2
  - Sync channel = same as Master 2

⇨ Run a warmup phase of 30 minutes. Adjust the "*Measurements details -> Customer specific offset"* parameter on both master units such, that both measurement paths show the same distance under *"Diagnostics -> Range measurement statistics -> Live range measurement".*

⇨ Continue configuring the following settings:

Master 1

- *Device -> Settings -> Measurement details*
  - Diversity mode = Enabled
  - Diversity partner IP address = IP address of Master 2
  - Diversity partner sync channel = Sync channel of Master 2

Master 2

- *Device -> Settings -> Measurement details*
  - Diversity mode = Enabled
  - Diversity partner IP address = IP address of Master 1
  - Diversity partner sync channel = Sync channel of Master 1

7 The Customer Protocol

The customer protocol (Binary Protocol XP) is the standard data protocol between LPR®-1DHP-291 and users for exchanging measurement and relay data with the help of different data types in binary data format. The transfer of a data packet of a certain data type is done in single data frames. The data can be transferred either via TCP/IP or UDP protocol.

i Note	All settings related to the customer protocol can be found in the WebUI under *Device -> Settings -> Customer protocol*
i Note	The default TCP/IP and UDP port of the customer protocol interface is 3046.
i Note	The customer protocol is not output on slave units.

7.1 General Description

7.1.1 Structure of a Data Type

Each data type has a fixed structure and length. Figure 7.1 shows the general structure of a data type.

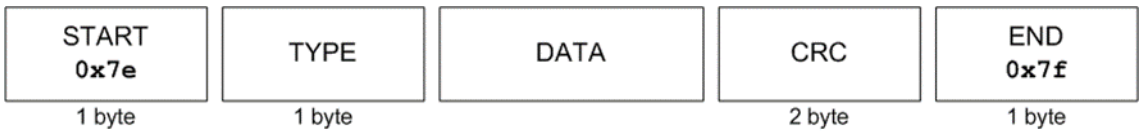


Figure 7.1: *Structure of a data type*

Each data packet begins with the START symbol (0x7e). TYPE indicates the type of the data packet. The DATA field contains the relevant data. The CRC-field contains the check sum. The data type ends with the END symbol (0x7f).

All multi byte integers (e.g., CRC field) are encoded in Network-Byte-Order (Big-Endian). All signed integers are represented in two's complement.

i Note	A custom protocol length which is bigger than the standard protocol length can be set. The data packet is then zero-padded (after the END symbol) to the selected protocol frame length before the data packet is sent.

7.1.2 CRC

The CRC-16-IBM with polynomial $x^{16}+x^{15}+x^2+1$ is used for the CRC. The CRC is calculated over the TYPE and DATA field.

7.2 Data Types

7.2.1 Type 0x16 – Distance Data

Direction: LPR®-1DHP-291 → User

The data type 0x16 is the standard output data type. It contains measurement data, system status information and settings. The default protocol frame length is 47 bytes.

Table 7.1 shows the structure of a 0x16 data packet.

Note

The standard customer protocol length of the LPR®-1DHP(-R) sensor (predecessor) was 50 bytes which must be taken into account if an LPR®-1DHP-291 is used to replace it.

The data packets are output with the internal update rate or the chosen update rate.

Note

The internal measurement rate depends on the used radar mode, FFT size and averaging setting. The output rate of the interface equals the internal measurement rate if no custom output interval is set.

Content	Length (byte)	Value	Data type
START	1	0x7E	unsigned integer
TYPE	1	0x16	unsigned integer
Sync Channel	2	0x####	unsigned integer
Distance [mm]	4	0x#### ####	signed integer
Velocity [mm/s]	4	0x#### ####	signed integer
Signal Level [dB/10]	2	0x####	signed integer
Temperature [°C/100]	2	0x####	signed integer
Counter	4	0x#### ####	unsigned integer
Age	2	0x####	unsigned integer
Error	2	0x####	unsigned integer
System Mode	2	0x####	unsigned integer (Bit mask)
Diversity Status	2	0x####	unsigned integer
Internal service information	16		
CRC	2	0x####	unsigned integer
END	1	0x7F	unsigned integer

Table 7.1: Data Type 0x16 - Distance Data Output for Group Master (47 bytes)

Diversity Status:

- The last bit refers to the current station
- The second last bit refers to the partner station
- 0: indicates errorless operation
- 1: indicates and error at the corresponding station or that the station is not visible via Ethernet

Current Station	Partner Station	Diversity Status
OK	**OK**	**0xfffc**
Error	**OK**	**0xfffd**
OK	**Error**	**0xfffe**
Error	**Error**	**0xffff**

Example of Distance Data (hex):

7E 16 10 24 00 00 0B 11 FF FF FF 35 FC C6 11 C6 00 02 54 AE 00 00 00 00 FF FF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0C 7D 48 C6 74 7F

7E hex	START byte
16 hex	TYPE (0x16: Distance Data)
10 24 hex	Sync channel
00 00 0B 11 hex = 2833 dec	Distance: 2833 mm
FF FF FF 35 hex = -203 dec	Velocity: -203 mm/s
FC C6 hex = 64710 dec	Level: 64710 – 65536 = -826 -> -82.6 dB
11 C6 hex = 4550 dec	Temperature: 45.5 C
00 02 54 AE hex = 152750 dec	Counter
00 00 hex	Age
00 00 hex	Error status: 0 means no error; unequal 0 means error (error description see section "*Distance Error Codes*" below)
FF FF hex	System mode
00 00 hex	Diversity status
00 00 00 00 00 00 00 00 00 00 00 00 00 0C 7D 48 hex	internal service information
C6 74 hex	Cyclic redundancy check
7F hex	END byte

Distance Error Codes

The following errors are indicated in the error field in the distance data type:

Value (hex)	Content	Description
0x00	No error	Measurement valid
0x01	No peak detected	No measurement signal
0x02	Peak too low	Measurement signal is imprecise
0x03	Currently not used	
0x04	Implausible speed	Velocity is outside the defined velocity limits
0x05	Measurement botched	Measurement is not feasible
0x06	Currently not used	
0x07	Currently not used	
0x08	Currently not used	
0x09	Settling	VCXO has just been tuned, needs time to settle
0x0a	PT2 filter reset	Filter reset after inconclusive distance measurements
0x0b	Planned reset	System is going to reboot
0x0c	Currently not used	
0x0d	Currently not used	
0x0e	Distance out of Range	Peak is close to the edge of the spectrum. Value is unreliable
0x0f	Currently not used	
0x10	Currently not used	
0x11	ARM sync failed	The ARM9 boards of the Group Master have not been synchronized
0x12	Target out of range	Error 18 (0x12) will be reported if no valid target is detected within system range and an internal system check will confirm error-free system operation

Table 7.2: Distance error codes

i Note

Only measurements with error code 0 are valid.

8 Technical Data

Feature	Value
Radar measuring mode	Primary, secondary, diversity radar
Frequency range	57,0 – 64,0 GHz
Supply voltage	11 - 36 V
Power consumption	7 W
Ambient temperature	-40 °C to +75°C
Protection class housing	IP65
Housing dimensions (LxWxH); weight	95 x 110 x 150 mm; 940 g
Interfaces	Ethernet (TCP/IP, Profinet)
Response Time	<11 ms
MTBF	42.2 a
External connector	Ethernet (M12), supply voltage (M12)
Antenna	Integrated, beam width = +-2,5°
Compliance	CE, FCC, IC (others on request)