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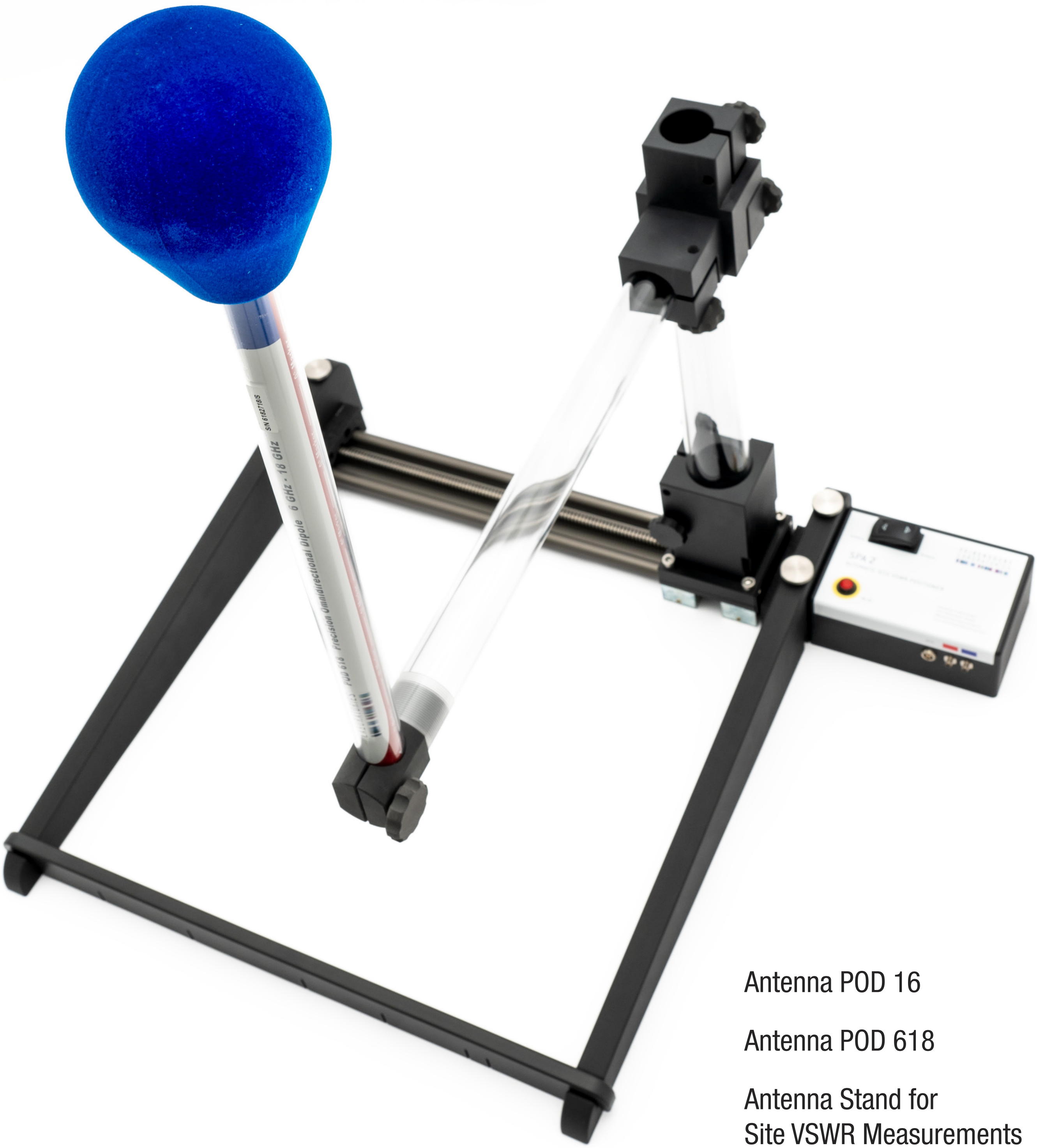

Antenna POD 16

Antenna POD 618

Antenna Stand for
Site VSWR Measurements

MANUAL

POD - PRECISION OMNIDIRECTIONAL DIPOLE

E M C & O P T I C S

MANUAL
POD – Precision Omnidirectional Dipole

Antenna POD 16
Antenna POD 618
Site VSWR Positioner SPM1 (manual)
Site VSWR Positioner SPA2 (automatic)

18.07.2024
Version 4.0

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Table of Contents

1. INTRODUCTION

The **P**recision **O**mnidirectional **D**ipole (POD) was developed by Seibersdorf Laboratories due to industry demand for an omnidirectional broadband antenna. It covers the frequency range 1-18 GHz with two antennas (1-6 GHz, 6-18 GHz).
The design goal was a superior radiation pattern performance exceeding the standard requirements for Site VSWR measurements [1] by far. Thus, has led to a construction which is patented by Seibersdorf Laboratories.

The **POD** Antenna can be used for any kind of RF test where an omnidirectional broadband characteristic is required.

This manual describes in detail the application of the POD Antenna for Site VSWR measurement using the Site VSWR Positioner SPA2 and SPM1.
Technical specification of the antennas and radiation patterns are presented.

2. DESCRIPTION OF THE POD ANTENNA & POSITIONER

2.1. POD Antenna

The POD Antennas cover the frequency range 1 GHz up to 18 GHz with two models:

POD 16 for the range 1 GHz to 6 GHz and
POD 618 for the range 6 GHz to 18 GHz.

Covering the whole frequency range with one antenna would lead to dramatic performance degradation at the band ends. So, the frequency range is split and there are two antennas with optimum performance. As split frequency 6 GHz was chosen because the standard CISPR 22 [2] requires measurements up to 6 GHz only. So, the validation is required up to 6 GHz only and can be performed with one antenna. In Figure 1 the schematic of the POD construction is shown.

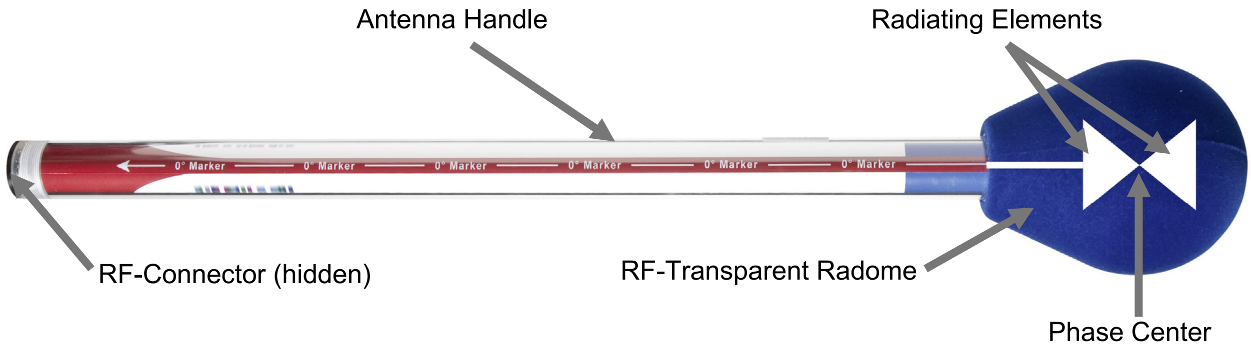

Figure 1: Schematic drawing of POD Antenna construction

In **Figure 2** a comparison of the radiation pattern of the ideal dipole and two practical realisations is given. In the **"classical" biconical design** the pattern is distorted (compared to the ideal dipole) in the region around the antenna feed cable. The biconical pattern shown in **Figure 2** does not fulfil the requirements given by CISPR [1].

[1] CISPR 16-1-4 (7.4.2.2)

E-Plane: The E-plane pattern shall not enter the forbidden area (-3 dB for ± 15°, symmetrical to the main lobe directions on both sides of the pattern).

H-Plane: "Note: Although a lower bound on the H-plane pattern is not specified outside of ±135°, it is desirable for the H-plane pattern not to show a null at ±180º, but to be omni-directional as best as possible."

The **patented POD Antenna design** avoids coupling with the feed cable and its pattern is close to the ideal dipole. In **Figure 3** an example of real measurement data is given. For the whole set of directional patterns see Chapter 4.2. The radiating elements are covered with a RF-transparent radome for protection during handling and transportation.

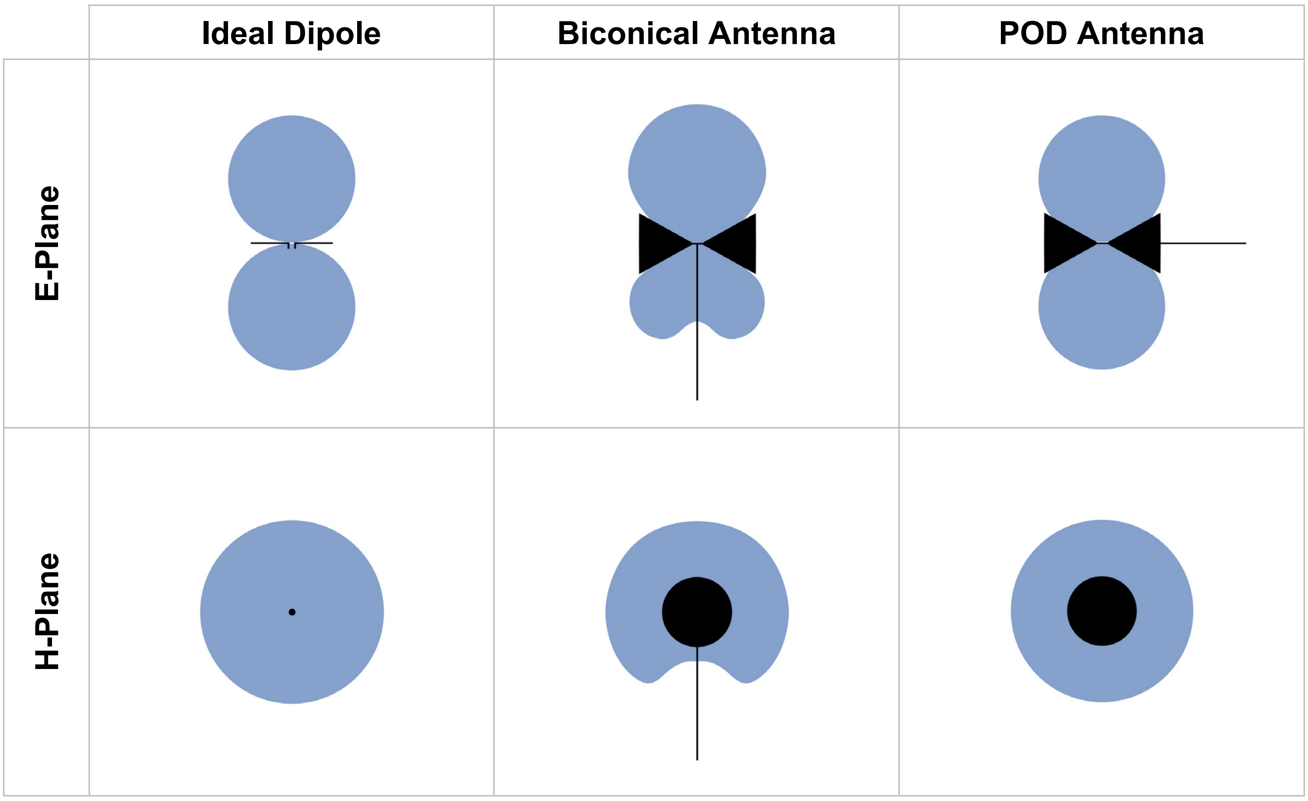

Figure 2: Radiation pattern (blue) for different dipole antenna designs (black) in E- and H-Plane. The pattern of the POD Antenna is very similar to the ideal dipole.

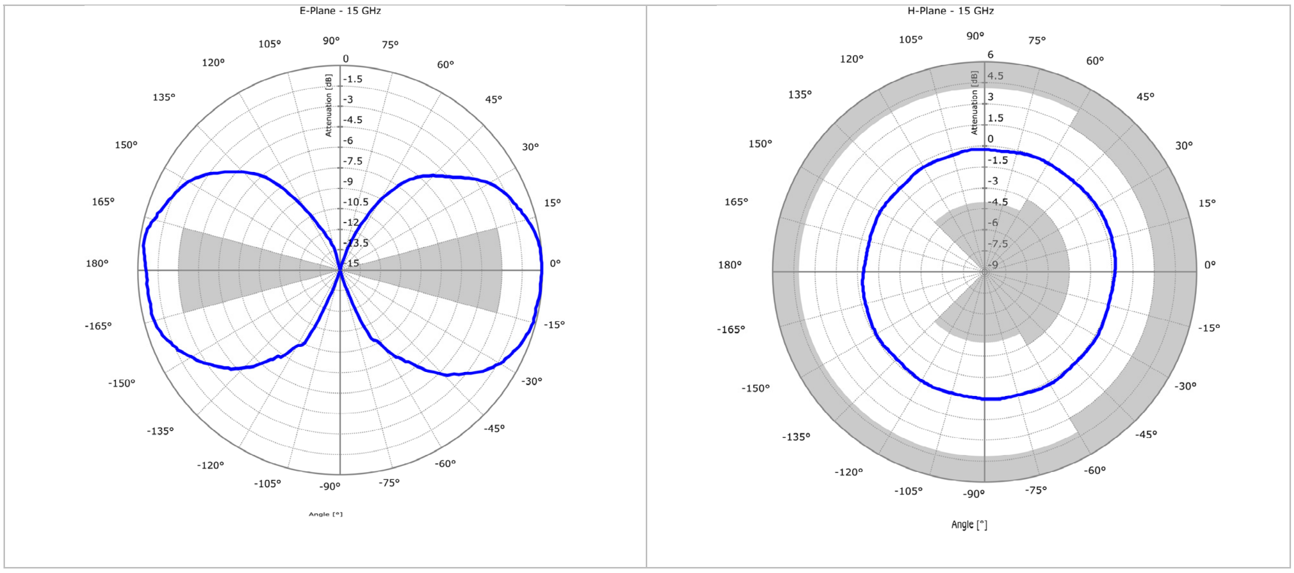

Figure 3: Normalized E- and H-plane radiation pattern
Results for a POD 618 at 15 GHz and forbidden areas (gray) defined by CISPR 16-1-4.

2.2. Site VSWR Positioner

When omnidirectional antennas are mounted special care must be taken not to influence the antenna behaviour. Biconical antennas for the frequency range 30 MHz to 200 MHz are mounted on plastic masts (and not on metal) for height scanning. This is sufficient for this frequency range but not suitable for frequencies above 1 GHz. Both metallic and plastic material must not be present within the vicinity of the radiation elements[2].

The Site VSWR Positioner SPM1, see **Figure 4, left,** is especially designed to optimize this new Site-VSWR measurement procedure in several ways:

- Minimize influence of antenna mast on result
- Well defined cable routing
- Repeatable results
- Easy positioning and polarization change

The automatic Site VSWR Positioner SPA2, see **Figure 4, right,** additionally increases the speed of validation. The 6 positions per measurement location are set up automatically via the CalStan 11 Site VSWR plug-in thus reducing the manual setup modifications by up to 84%.

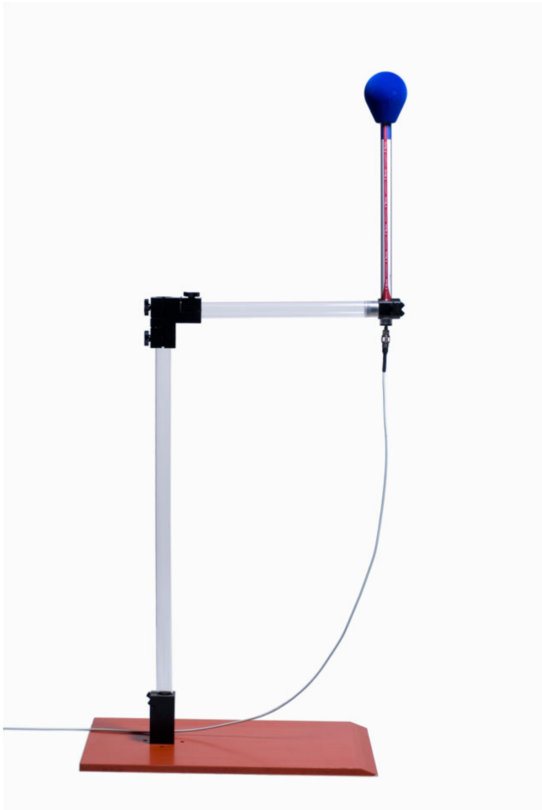

Figure 4: Site VSWR Positioner
Left: SPM1: Manual Positioner with POD Antenna mounted in vertical polarization
Right: SPA2: Automatic Positioner

[2] CISPR 16-1-4 (8.2.2.1): "Note: Guidance provided by the antenna manufacturer on the routing of the feed cabling and antenna mast should be followed, if available, to minimize the possible influence on H-plane pattern outside of ±135°"

3. CONTENT OF SETS

Seibersdorf Laboratories is offering two sets to the customers. The first one is the POD Antenna Set and the second one is the Site-VSWR Set. Optionally also single components of these sets could be ordered according to the list of options of our POD price list.

Figure 5: Available sets for Site-VSWR evaluation

3.1. POD Antenna Set

The components of this set are shown in **Figure 6**. It consists of the antennas POD 16 and POD 618, Accredited calibration for each antenna including certificates and this manual, packed in a blue transportation case.

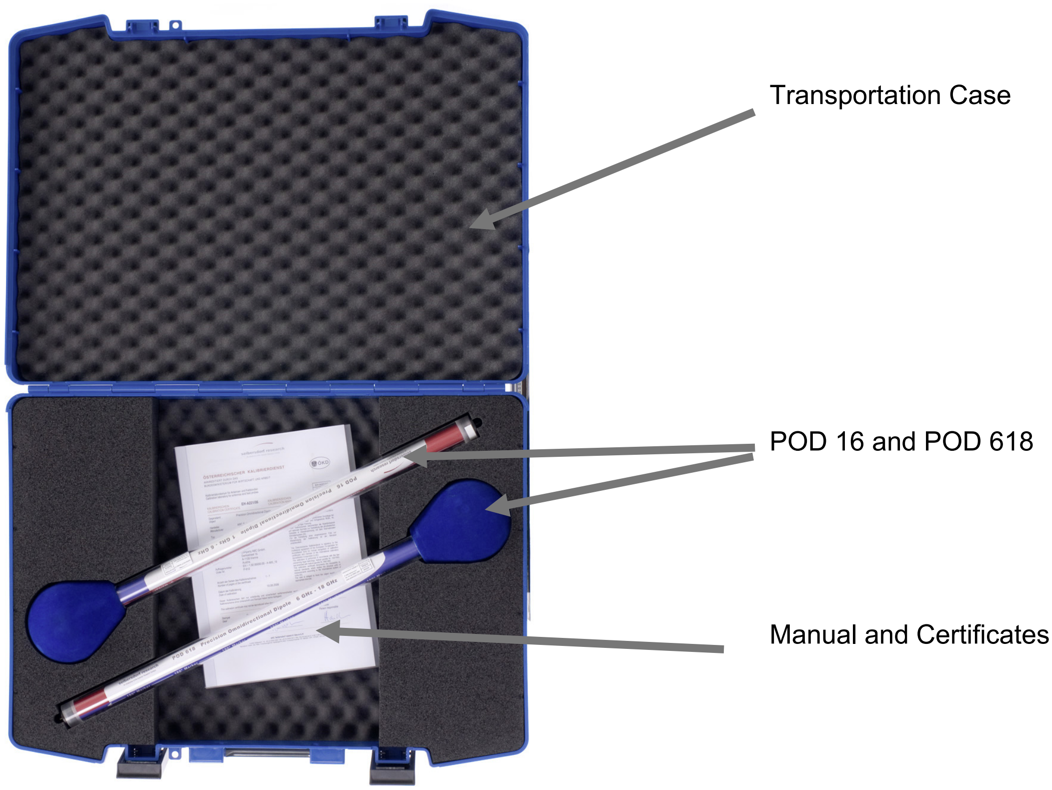

Figure 6: POD Antenna Set

3.2. Components Specific to SPA2

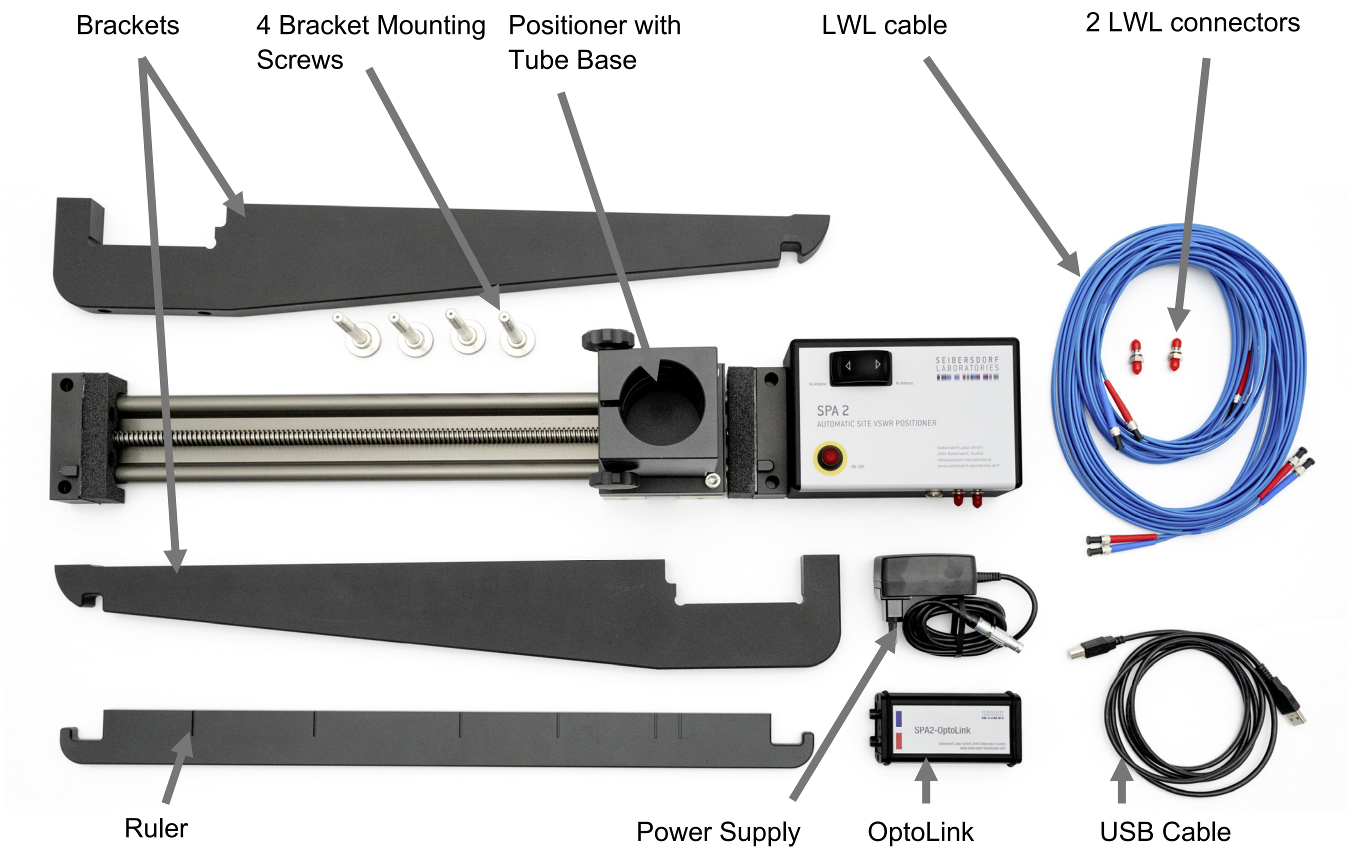

Figure 7: Components of SPA2 automatic Site VSWR Positioner

3.3. Components Specific to SPM1

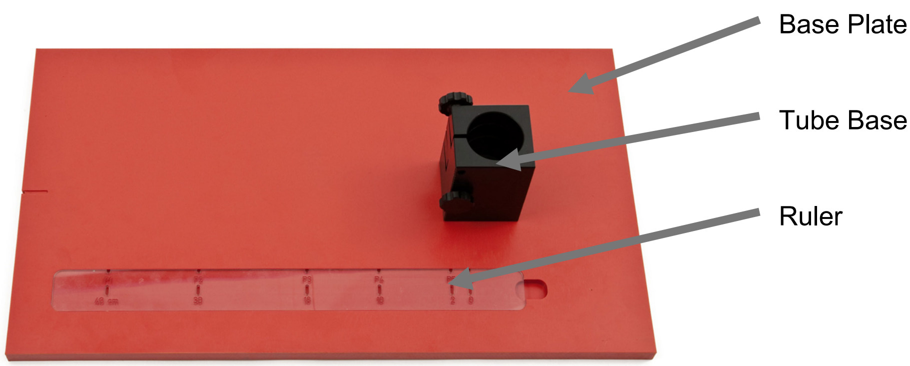

Figure 8: Components of SPM1 manual Site VSWR Positioner

3.4. Components for SPM1 and SPA2

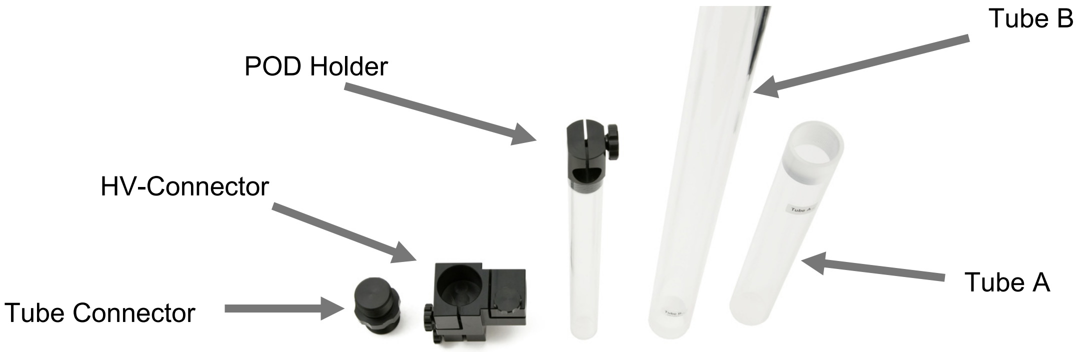

Figure 9: Components of Site VSWR Positioners

3.5. Site VSWR Set with SPM1

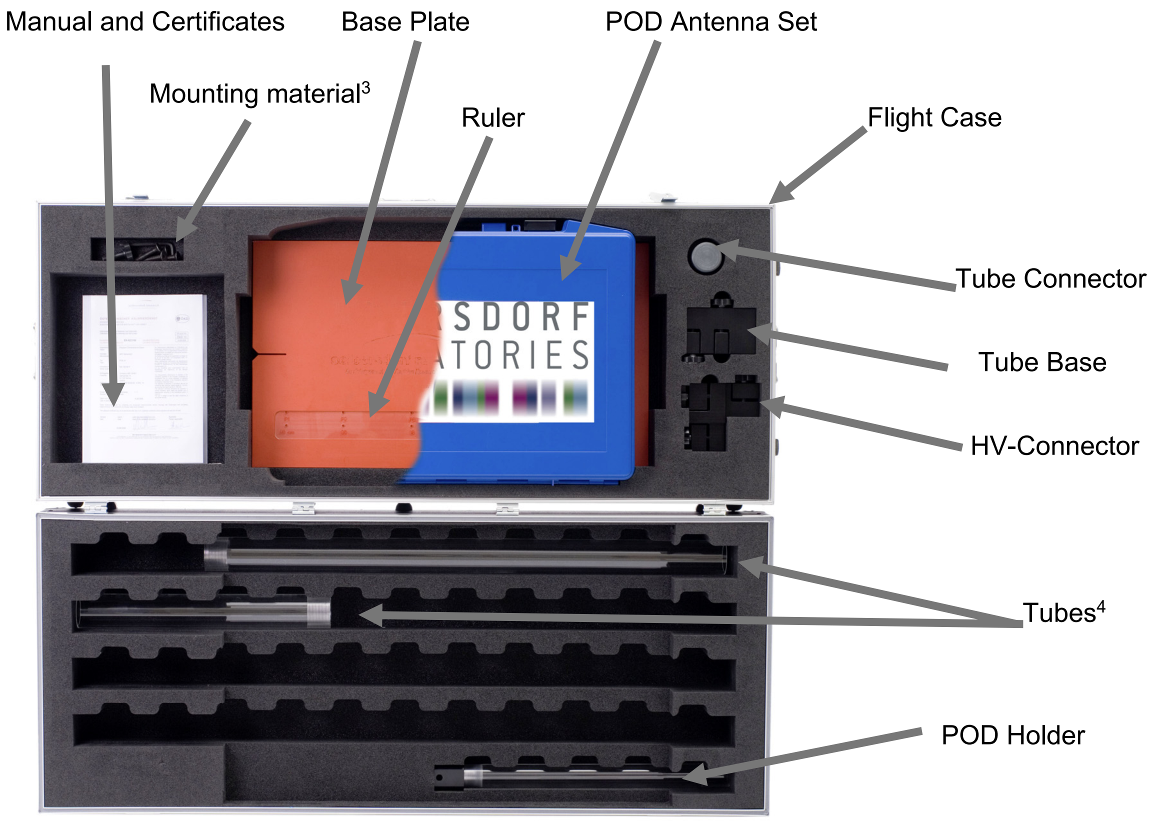

Figure 10: Site VSWR Set with SPM1 manual Site VSWR Positioner

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[3] 4 x M10 x 50 hexagon socket for mounting the Tube Base
1 x Allen key, 6 mm

[4] different length and amount, depending on the test volume height

3.6. Site VSWR Set with SPA2

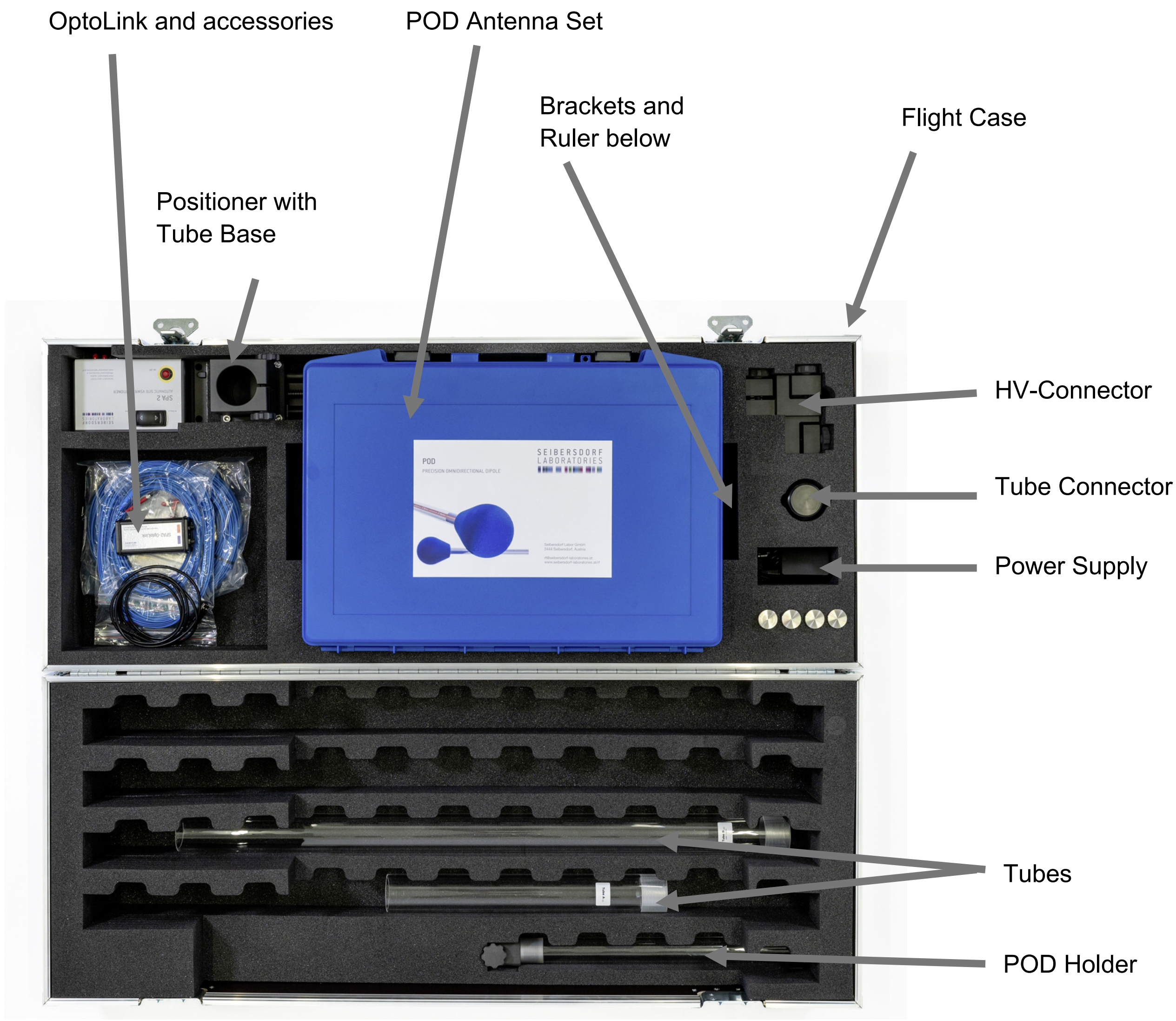


Figure 11: Site VSWR Set with SPA2 automatic Site VSWR Positioner

3.7. SPA2-OptoLink

The SPA2-OptoLink is an optical repeater for connection and communication of SPA2 automatic positioner and measuring computer via fibre optic and USB cable. The set includes 3°m and 10°m fibre optic cables and 2 adapters. A 30 m fibre optic cable can be ordered separately. Fibre optic cable lengths of up to 50°m can be realised.
Automatic detection of the SPA2 positioner in our measurement software CalStan11 is now possible and makes operation even easier.

Figure 12: SPA2-OptoLink

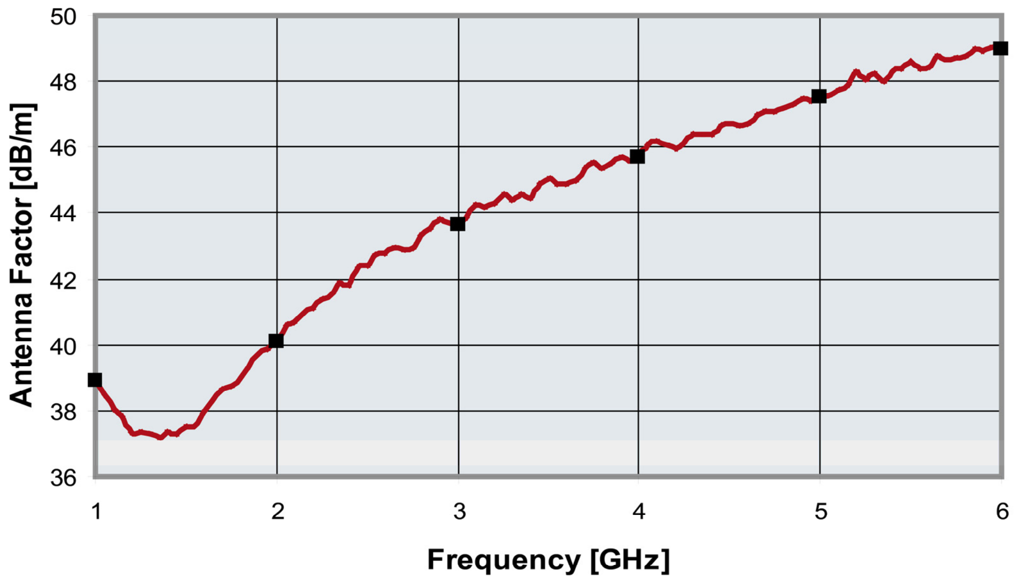
4. TECHNICAL SPECIFICATIONS

4.1. Technical Specifications of POD Antennas

Specification	POD 16	POD 618
Frequency range	1 - 6 GHz	6 - 18 GHz
H-Plane anisotropy	± 0.5 dB	± 0.8 dB
Typical antenna factor	37 - 49 dB/m	49 - 59 dB/m
Typical VSWR	< 2.0	
Phase center	center of radome	
Connector type	SMA female	
Total antenna length	610 mm	
Radome tip to phase center	50 mm	
Diameter handle	30 mm	
Antenna weight	~ 290 g	~ 255 g
Max. input RF-power	30 dBm	
Field strength damage level	200 V/m	
Temperature operating range	5°C - 45°C	
Humidity (non-condensing)	< 98%	
Dimensions of Antenna Set	64 x 47 x 15 cm	
Weight of Antenna Set	~ 5 kg	

Table 1: Technical specifications of POD Antennas

a)



b)

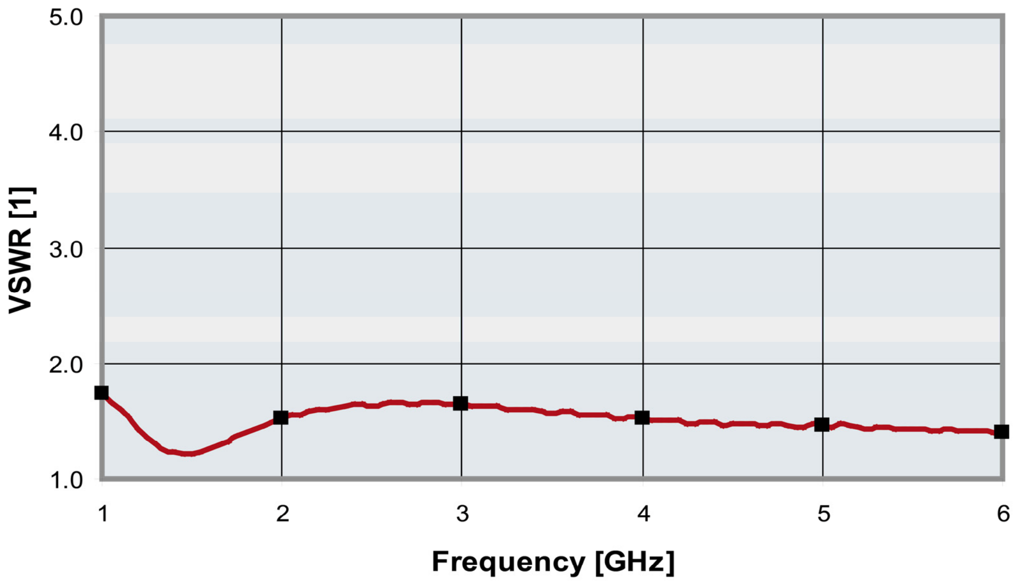
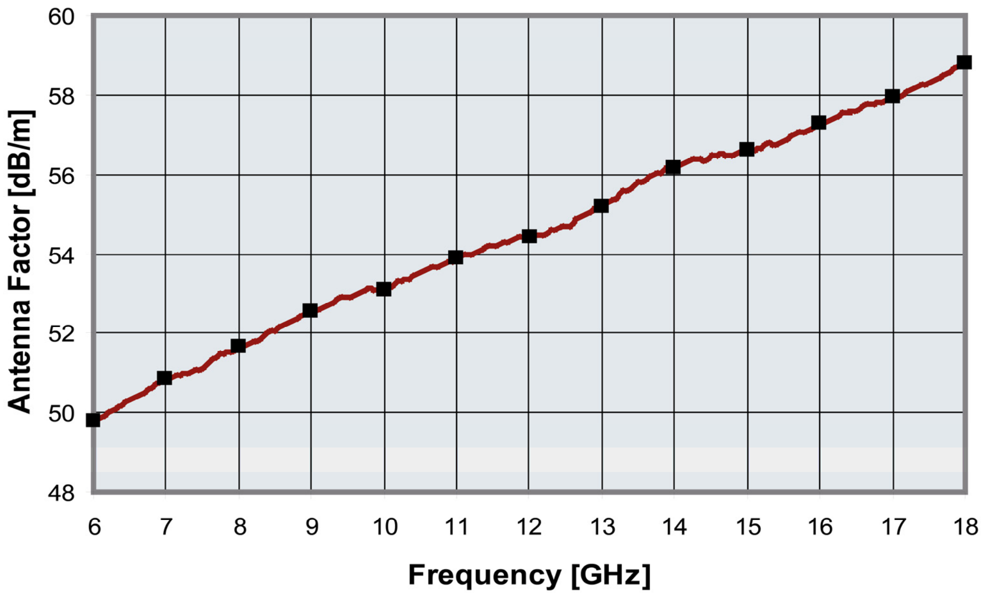


Figure 13: Typical Calibration data for POD 16
a) Antenna factor measured in 0° direction
b) VSWR

Frequency [GHz]	**1**	**2**	**3**	**4**	**5**	**6**
Antenna Factor [dB/m]	38.9	40.1	43.6	45.7	47.5	49.0
VSWR [1]	1.7	1.5	1.6	1.5	1.5	1.4

Table 2: Typical antenna factor and VSWR for POD 16

a)



b)

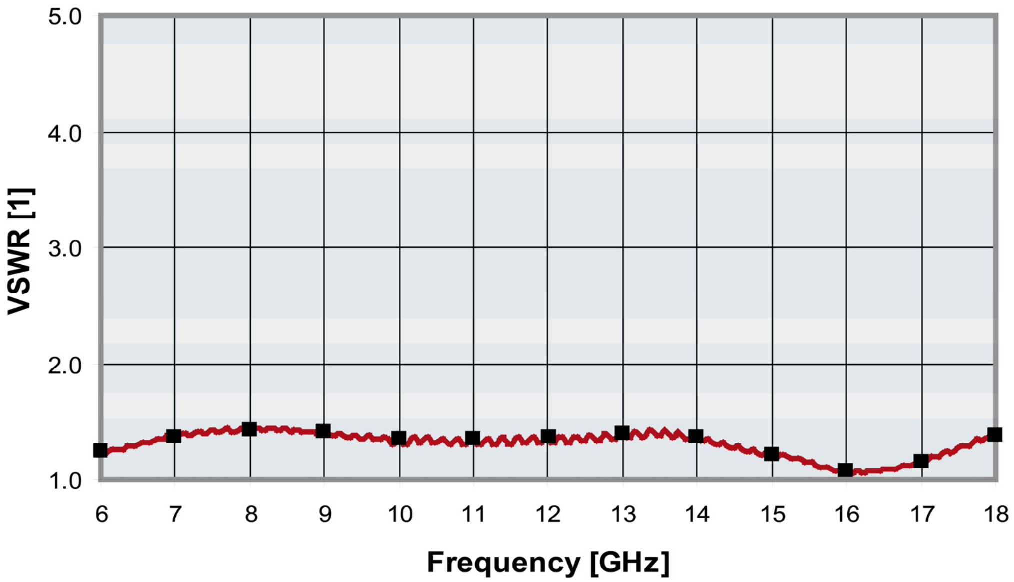


Figure 14: Typical Calibration data for POD 618
a) Antenna factor measured in 0° direction
b) VSWR

Frequency [GHz]	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Antenna Factor [dB/m]	49.8	50.8	51.7	52.6	53.1	53.9	54.4	55.2	56.2	56.6	57.3	57.9	58.8
VSWR [1]	1.2	1.4	1.4	1.4	1.3	1.4	1.4	1.4	1.4	1.2	1.1	1.2	1.4

Table 3: Typical antenna factor and VSWR for POD 618

4.2. Radiation Pattern

The following **Figure 15** shows a POD Antenna and visualizes the E- and the H-plane. The angles ϑ and φ used for the radiation pattern diagrams are also defined in this figure.

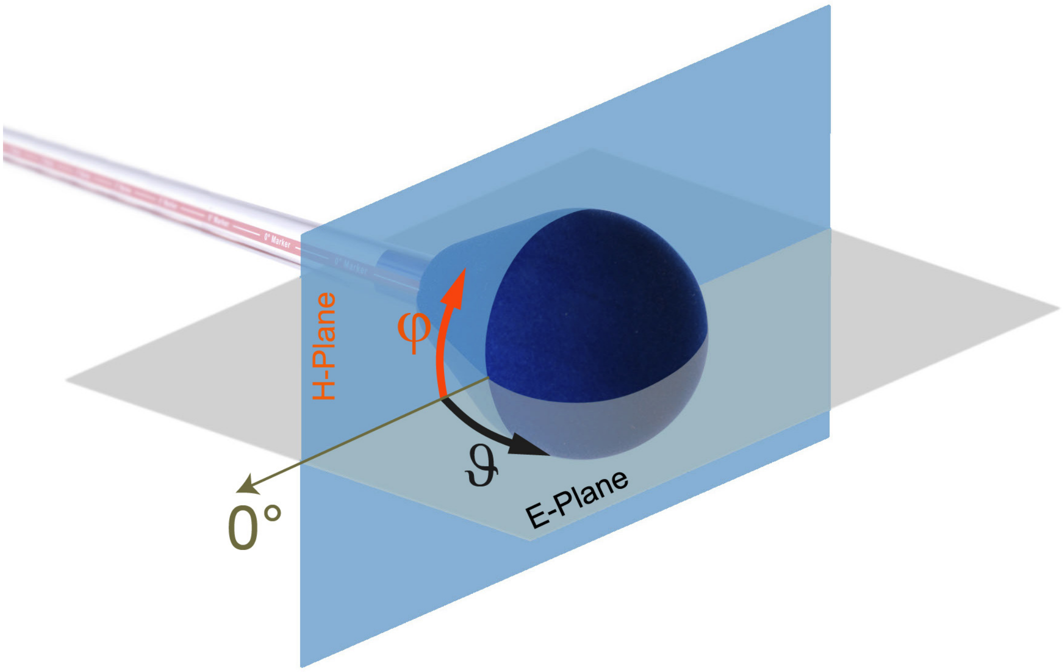


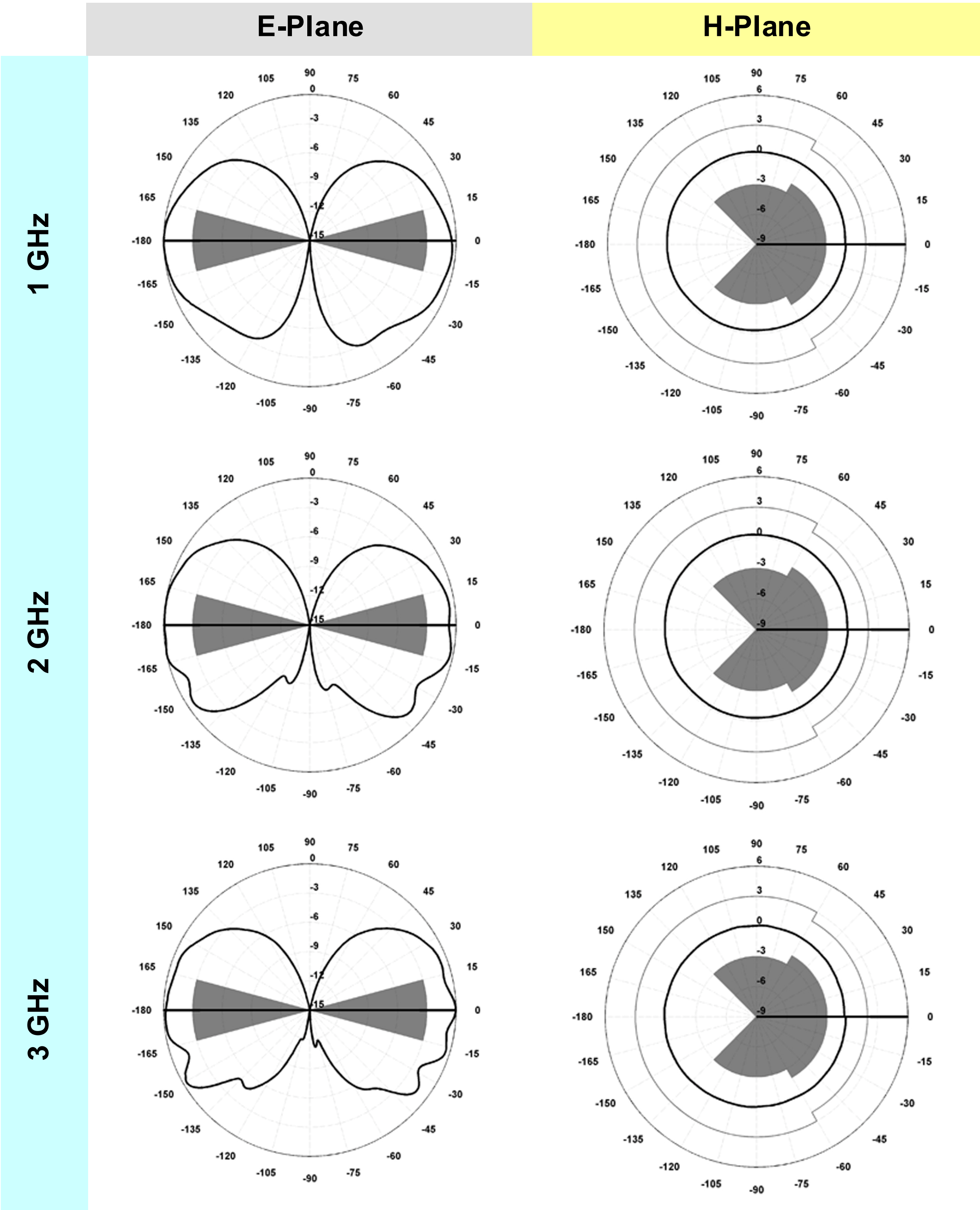
Figure 15: Definition of E- and H-planes for the radiation pattern diagrams

A normalization of the radiation pattern is required by the standard. This is necessary to apply the criteria and is performed for each pattern.

For E-plane and H-plane this is done in a different manner:

- **E-plane:**
  The pattern is normalized to the largest value (0 dB)
- **H-plane:**
  The mean value of the pattern is calculated in an angular range from -135° to +135°. The full pattern (angular range ±180 °) is normalized to this average (0 dB).

4.2.1. Radiation Pattern POD 16



Radiation Pattern POD 16 continued:

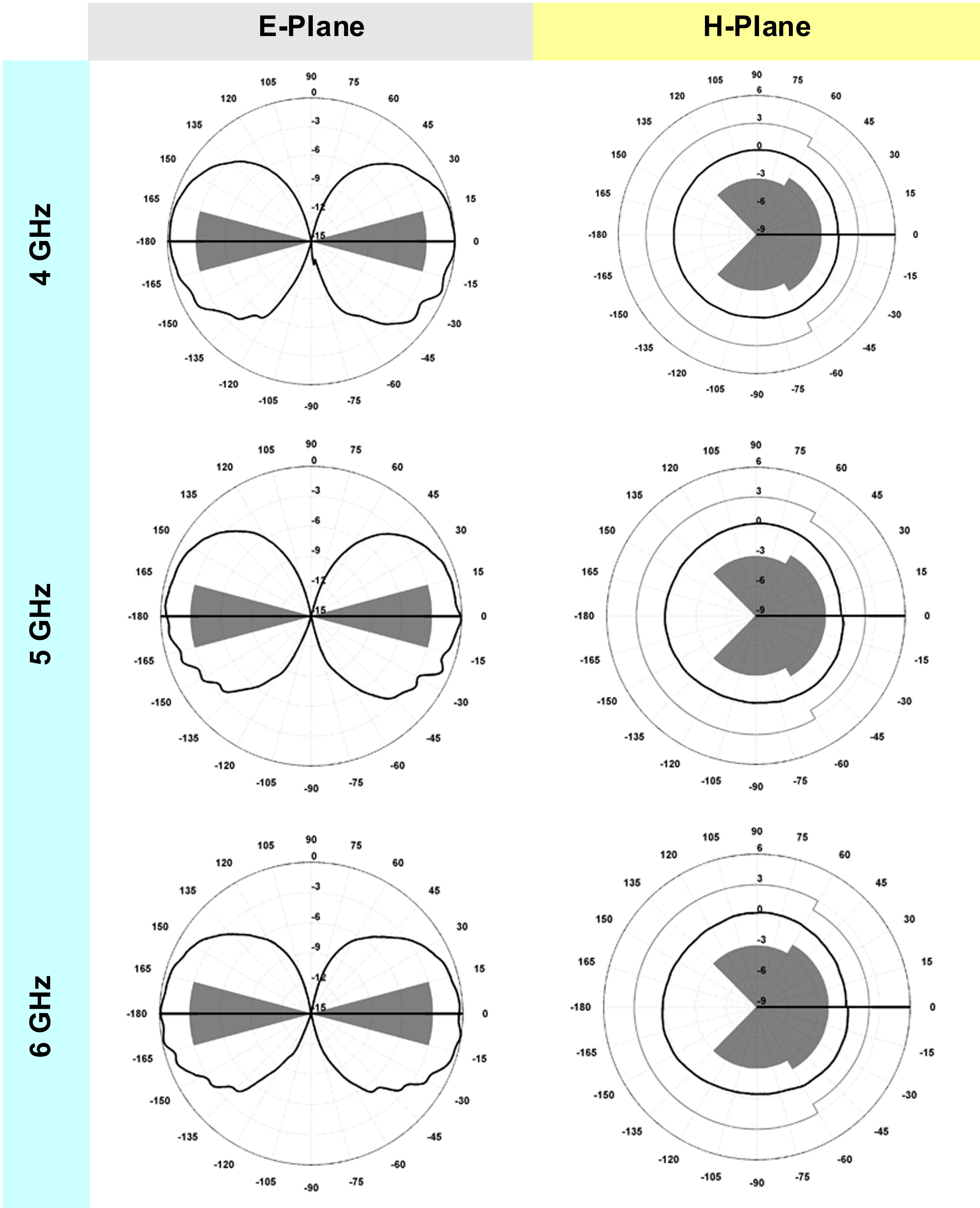
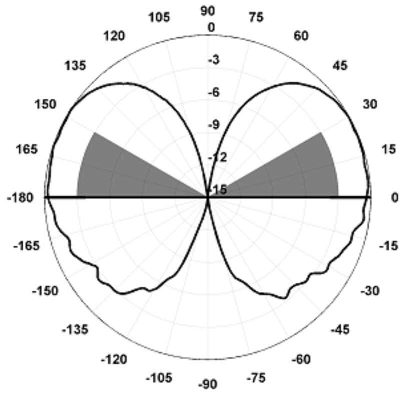
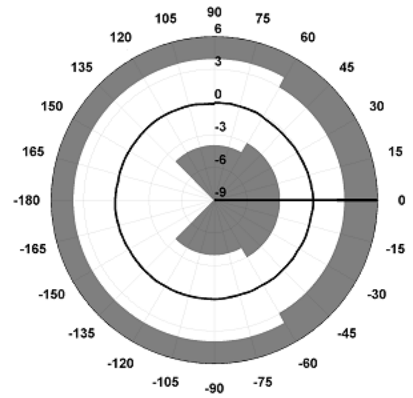
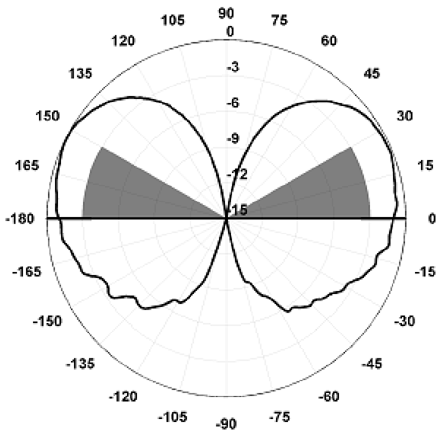
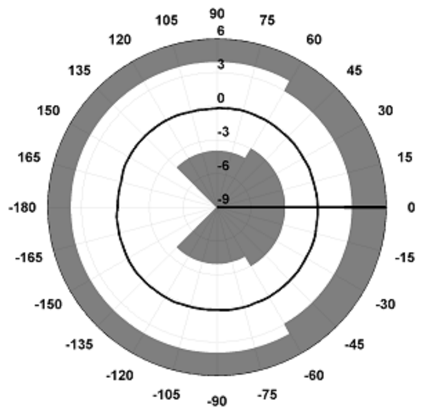
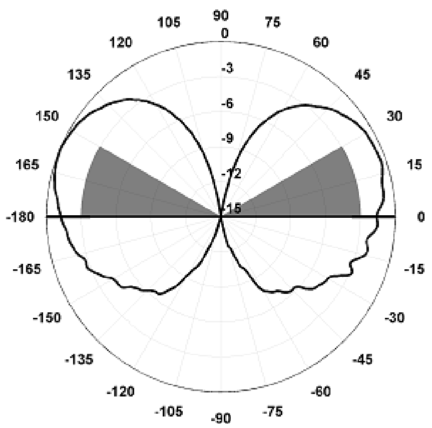
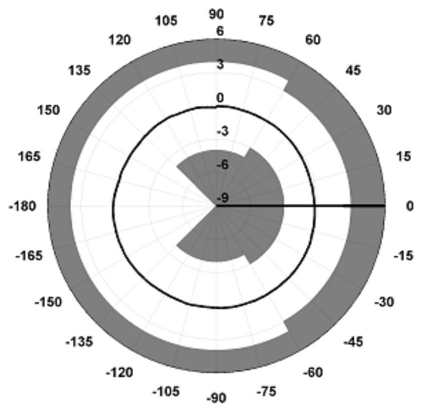
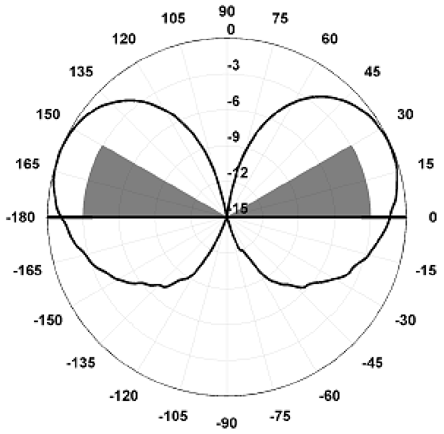
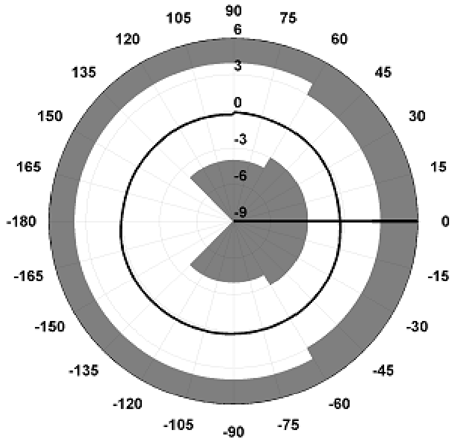
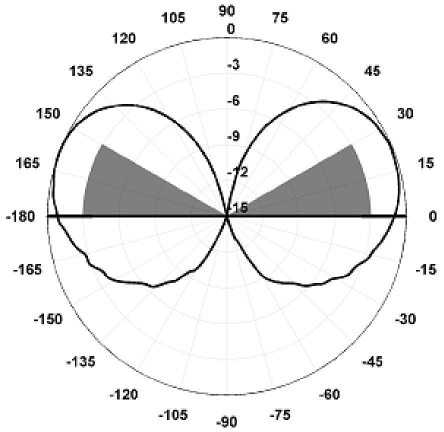
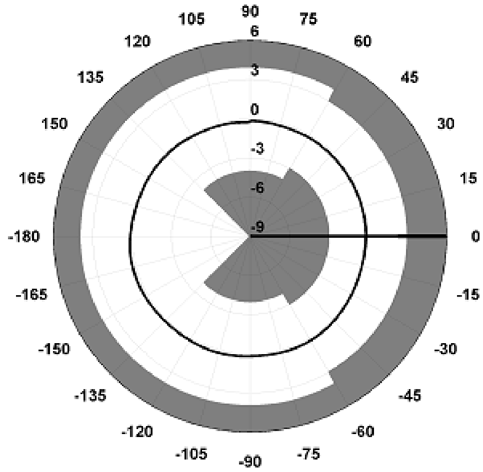
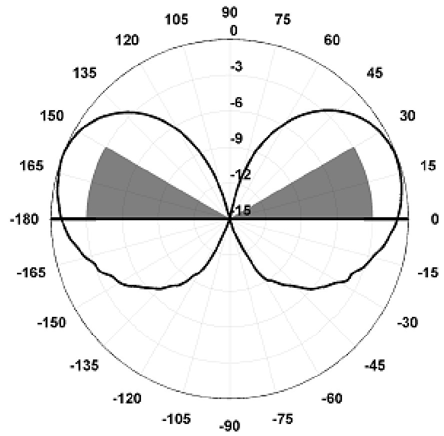
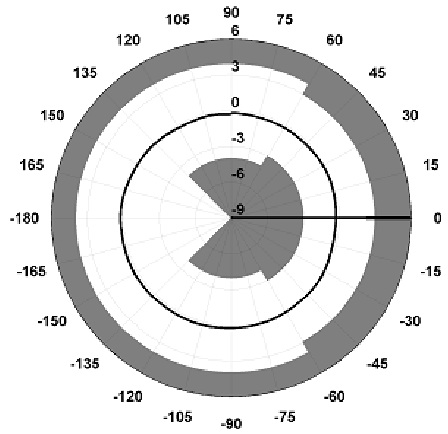


Figure 16: Radiation Pattern POD 16

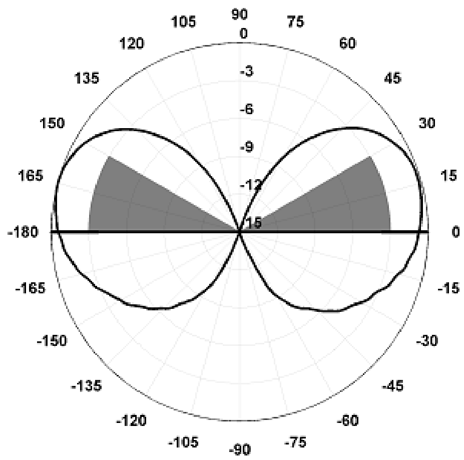
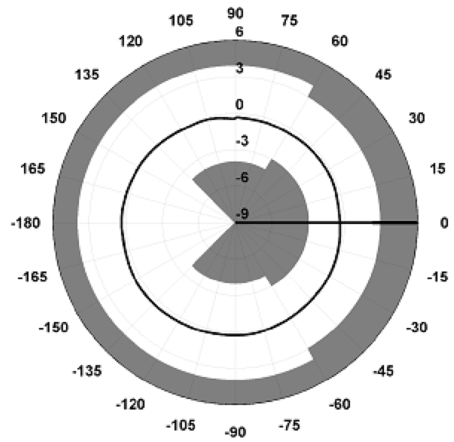
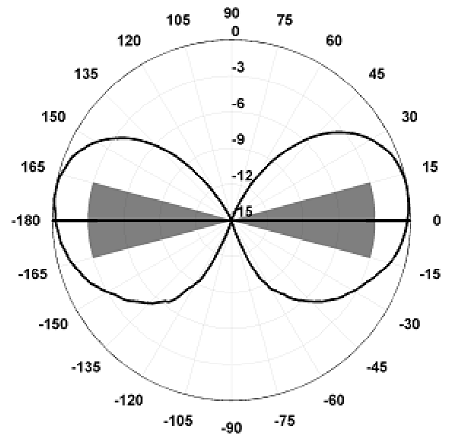
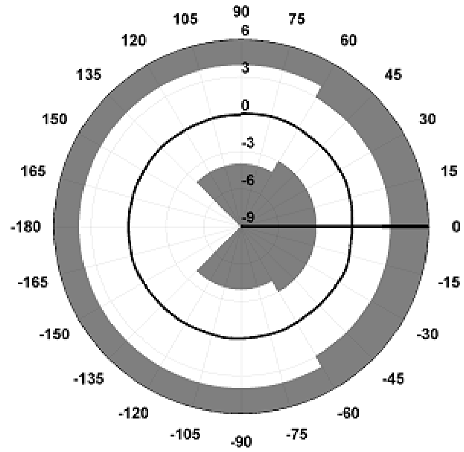
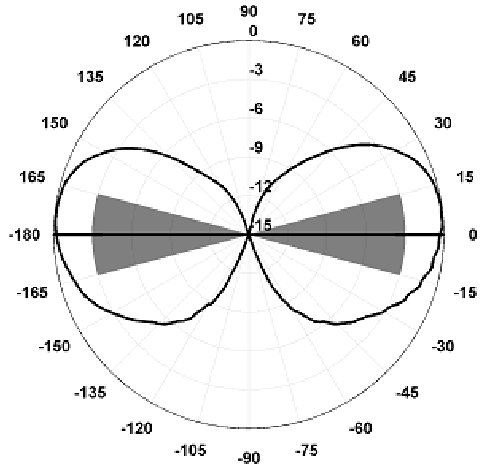
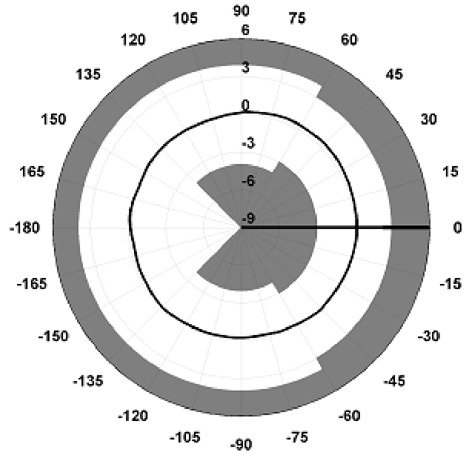
4.2.2. Radiation Pattern POD 618

	E-Plane	H-Plane
6 GHz		
7 GHz		
8 GHz		

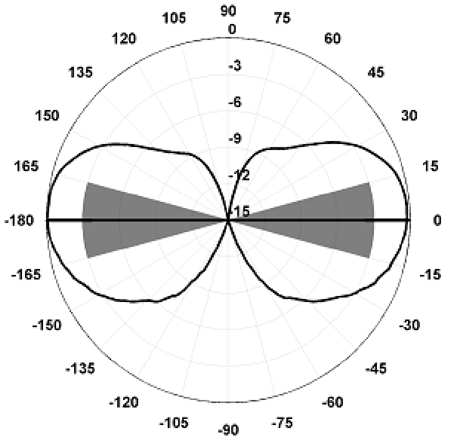
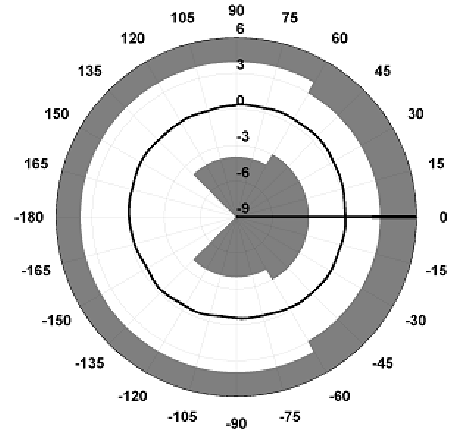
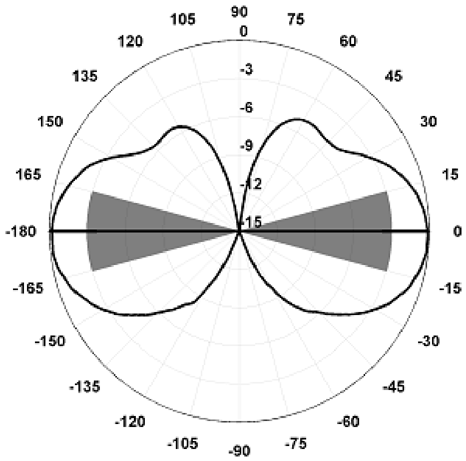
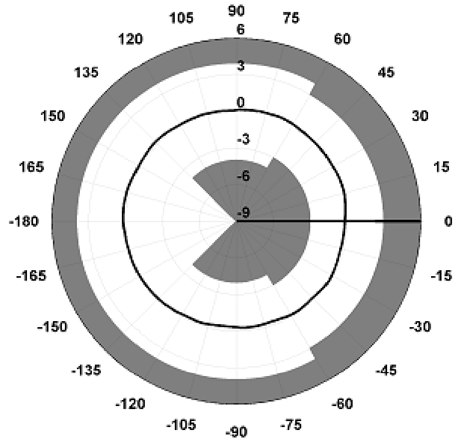
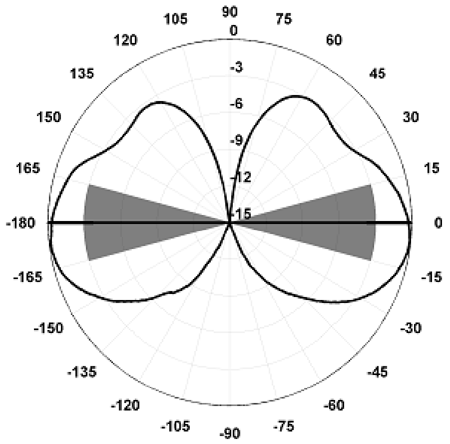
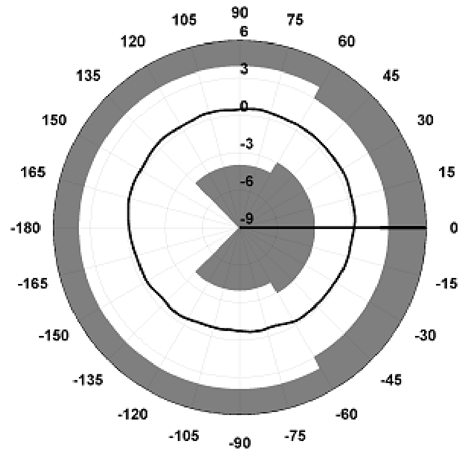
Radiation Pattern POD 618 continued:

	E-Plane	H-Plane
9 GHz		
10 GHz		
11 GHz		

Radiation Pattern POD 618 continued:

	E-Plane	H-Plane
12 GHz		
13 GHz		
14 GHz		

Radiation Pattern POD 618 continued:

	E-Plane	H-Plane
15 GHz		
16 GHz		
17 GHz		

Radiation Pattern POD 618 continued:

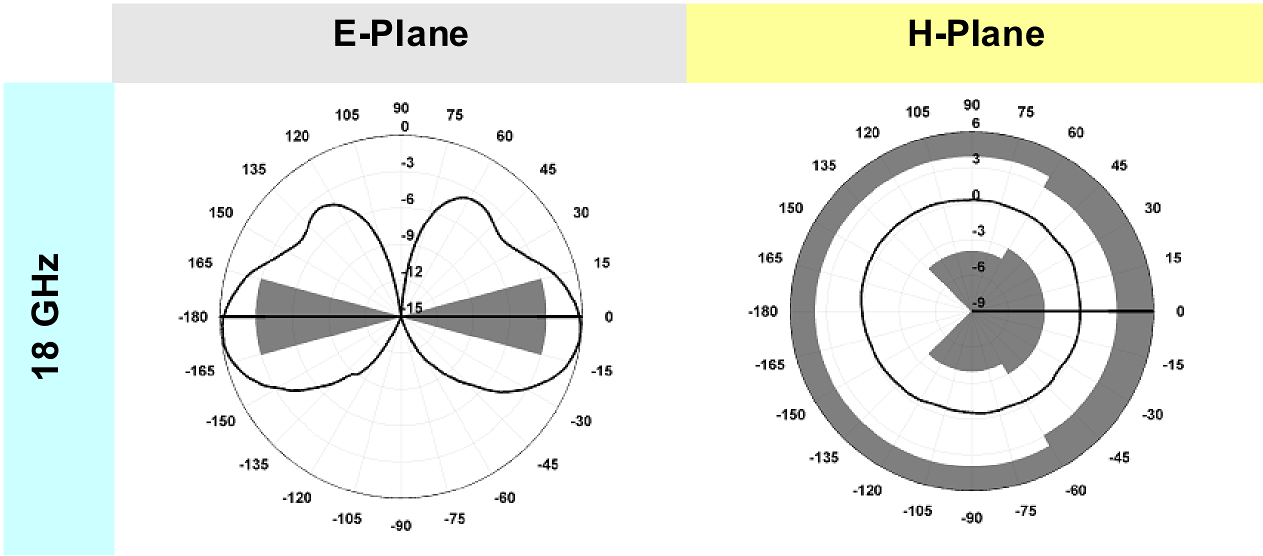


Figure 17: Radiation Pattern POD 618

4.3. Technical Specifications of Site VSWR Positioner

The Site VSWR Positioners allows easy position and polarization changes of the antenna at minimum RF influence on the measurement.

The parts are described in Chapter 3.2, 3.3 and 3.4 and the mounting instruction is given in Chapter 5.

Specification	SPM1	SPA2
Weight[5]	~ 11.5 kg	~ 11.5 kg
Base Plate dimensions (l x w)	70 x 40 cm	79 x 65 cm
Tube connector height	1,5 cm	1,5 cm
h_1 minimum	70 cm	70 cm
h_2 maximum	250 cm	250 cm
Max. length of individual Tube	115 cm	115 cm
3D-positioning tolerance	+/- 2 cm	+/- 2 cm
Movement precision	-	± 1 mm
Power supply	-	110-230V 50/60Hz
Remote control	-	USB/OptoLink
Dimensions of Site VSWR Set (flightcase)	131 x 54 x 31.5 cm	131 x 54 x 31.5 cm
Weight of Site VSWR Set (including POD Antenna Set)	37 kg	37 kg

Table 4: Specifications of Site VSWR Positioners

4.4. Technical Specifications of SPA2-OptoLink

Specification	
Weight[6]	~ 0.15 kg
Dimensions (l x w x h)	12 x 6 x 3.5 cm
Optical connector	SMA-female
Optical fibre	200/230 µm
Optical fibre length	max. 50 m, max. 3 fibers added a piece
Power supply	USB

Table 5: Specifications of SPA2-OptoLink

[5] Exact weight depending on the length and number of the Tubes.
[6] Exact weight depending on the length and number of the Tubes.

The Site VSWR measurement requires that the antenna is set up in height h_1 and h_2. With the Site VSWR Positioners these two heights can be set up by mounting the appropriate Tubes, see **Figure 18**.

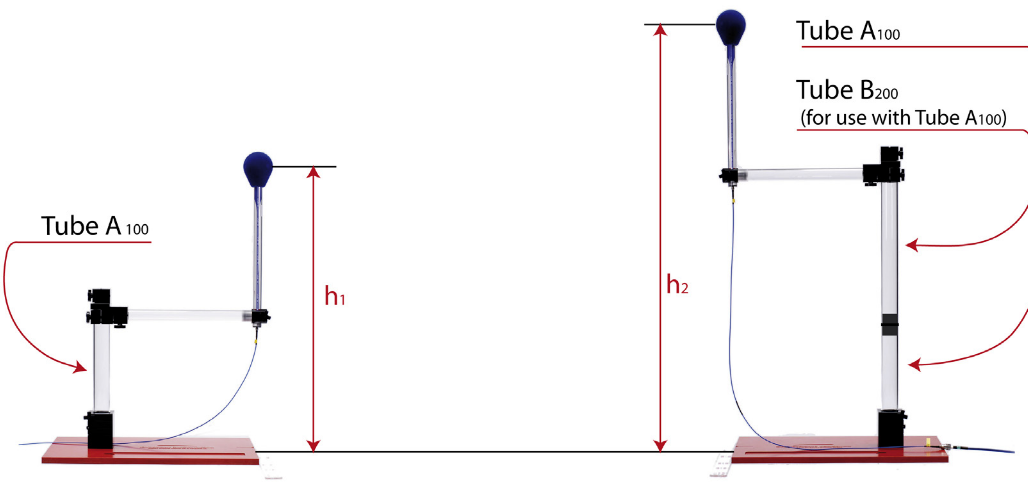


Figure 18: Site VSWR Positioner for measuring at h_1 (e.g. 100 cm) and h_2 (e.g. 200 cm)

Three configurations (see a, b, and c) of the Tubes are possible, depending on the test volume height. When you have specified your test volume at time of order, you will receive the Tubes in the right lengths:

a. Small volume height (≤ 170 cm):
For h_1 use Tube A
For h_2 use Tube B

b. Standard volume height (170 cm … 215 cm):
For h_1 use Tube A
For h_2 use Tube A + Tube Connector + Tube B

c. Large volume height (215 cm … 250 cm):
For h_1 use Tube A
For h_2 use Tube B + Tube Connector + Tube C

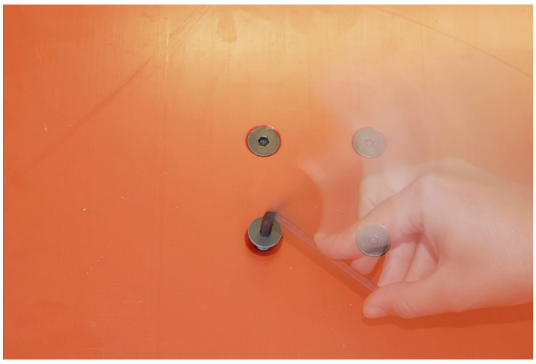
The length of the Tubes (including the Tube Connector if necessary) is calculated by subtracting 55 cm from the height the antenna must be set up, e.g., Tube A_{100} has a length of 45 cm. These calculations are valid for floor-standing equipment, where the Base Plate stands at the bottom of the test volume.

5. INSTALLATION

5.1. Assembly of SPM1 - Manual Site VSWR Positioner

The installation of the Positioner and the POD Antennas can be done within a few minutes. Here is the step-by-step description for setting up the system in horizontal polarization:

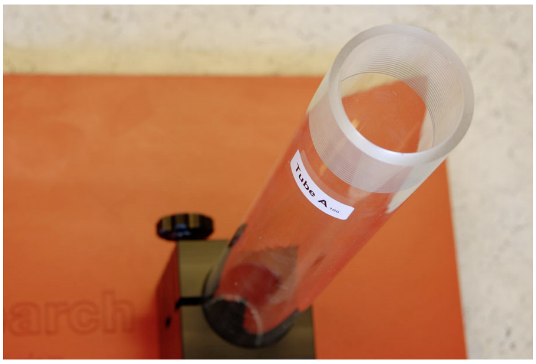
Mount the Tube Base to the red Base Stand with 4 metal screws M10 x 50 (hexagon socket) with an Allen key, 6 mm.



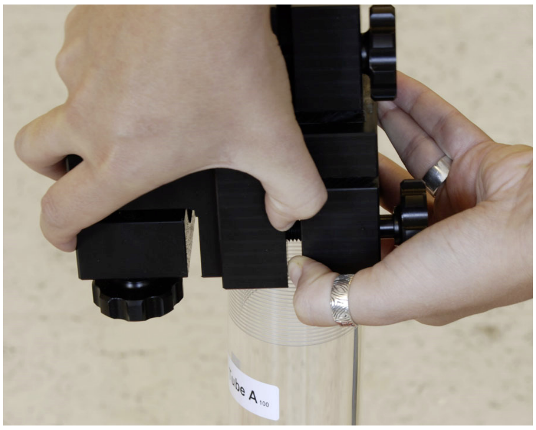
Loosen the 2 black plastic screws on the Tube Base.

Insert the required tube with the thread facing upward until it reaches the base's stop. (9 cm). You might need to stretch the bracket a bit using your thumbs.

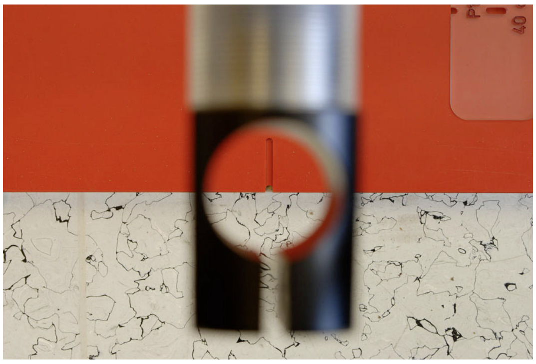
Fasten the two black screws of the Tube Base by hand.



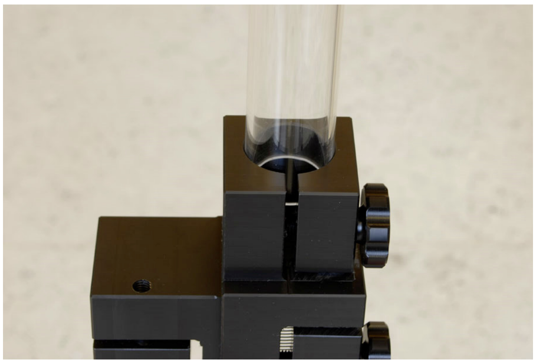
Stick the HV-Connector on the required Tube (you might need to stretch the bracket a bit using your thumbs) – but do NOT fasten the screws.



For proper alignment stick the plastic Tube of the POD Holder as far as possible into the HV-Connector front hole. Align the slit of the POD Holder with the mark on the Base Plate and fasten the screw on the HV-Connector to fix it onTube A.

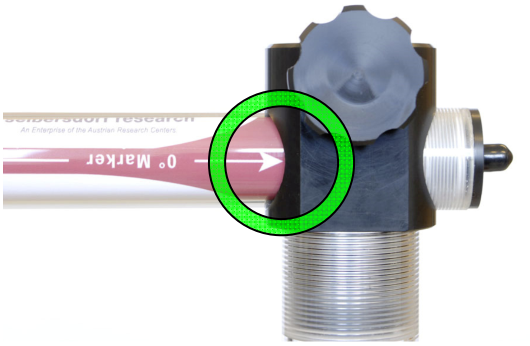


To continue the horizontal setup, remove the POD Holder from the front hole of the HV-Connector and stick it into the top hole.

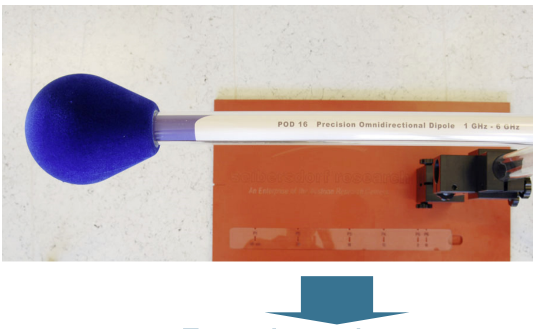


Insert the POD Antenna into the POD Holder. The red 0° marker has to look towards the receive antenna and the white arrow tip has to be aligned with the black part of the POD Holder.

Fix this position with the plastic screw of the POD Holder.



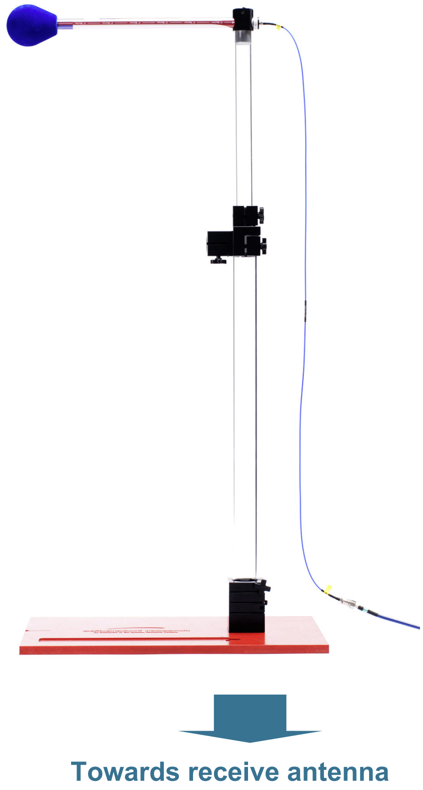
Align the handle of the POD Antenna in parallel with the long side of the Base Plate and fasten the screw on the HV-Connector.



Towards receive antenna

Connect the RF cable (SMA connector) to the antenna. Use a torque wrench to tighten the connector-nut[7].

Ready for measurement.
See Chapter 6.1 on how to use the Ruler



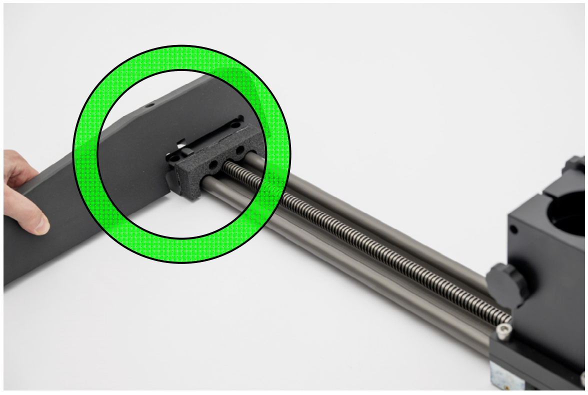
[7] Maximal 0.9 Nm (8 lb-in)

5.2. Assembly of SPA2 – Automatic Site VSWR Positioner

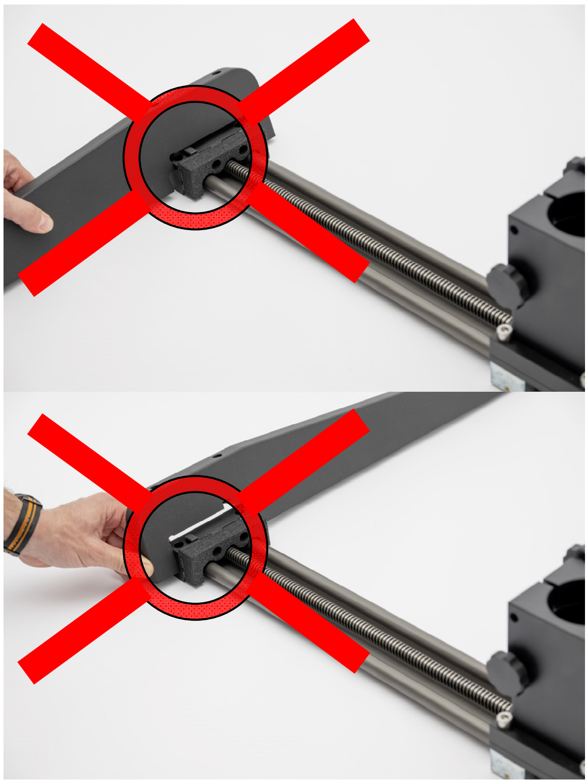
The installation of the Positioner and the POD Antennas can be done within a few minutes. Here is the step-by-step description for setting up the system in vertical polarization:

Mount the two Brackets to the Positioner with two screws each.

Correct: →



Not possible: →



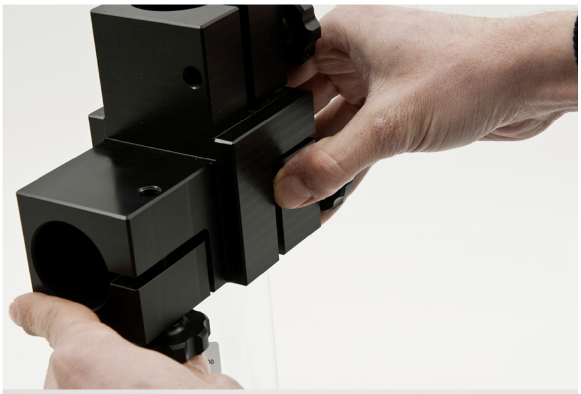
Insert the Ruler into the slots of the SPA2 Brackets.

Press the switch “To RX-Antenna >” on the SPA2 box to correspond with the actual position of the receive antenna.

Make sure that you press the switch correctly when you change the orientation of the positioner.

Loosen the screws of the Tube Base and insert the required tube with the thread facing upward until it reaches the base's stop. You might need to stretch the bracket a bit using your thumbs.
Fasten the two black screws of the tube base by hand.

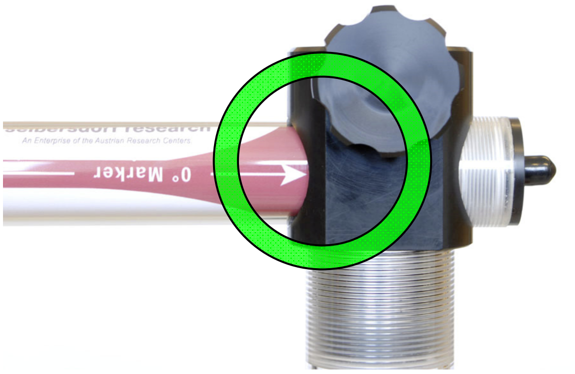
Stick the HV-Connector on the required Tube (you might need to stretch the bracket a bit using your thumbs) – but do NOT fasten the screws.



For proper alignment stick the plastic Tube of the POD Holder until it reaches HV-Connector front hole stop. Align the POD Holder to be parallel with the Bracket and fasten the screw on the HV-Connector to fix it on the Tube.

Insert the POD Antenna into the POD Holder. The red 0° marker must look towards the receive antenna and the white arrow tip has to be aligned with the black part of the POD Holder.

Fix this position with the plastic screw of the POD Holder.



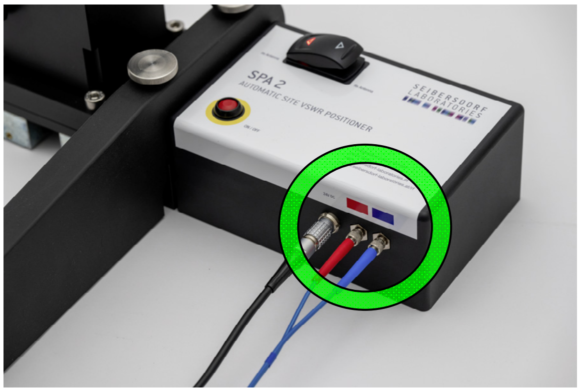
Connect the RF cable (SMA connector) to the antenna. Use a torque wrench to tighten the connector-nut[8].

[8] Maximal 0.9 Nm (8 lb-in)

Connect the power supply and the LWL cables according to the colour markings.

Make sure that all cables stay clear and that they are long enough and placed well to cover the movement range.

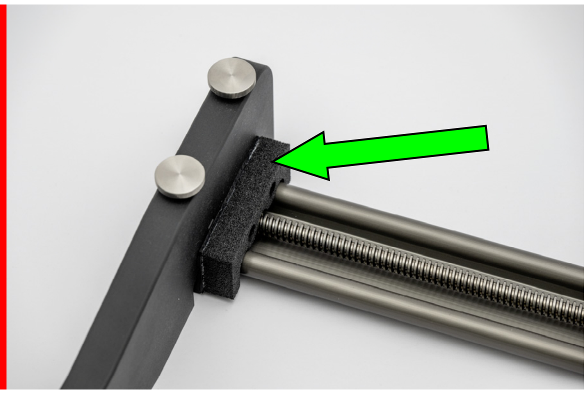
Do not touch the Positioner during operation!



Use the supplied USB cable (Type A – Type B) to connect the OptoLink to your measurement computer.
Connect the LWL cables according to the colour markings.

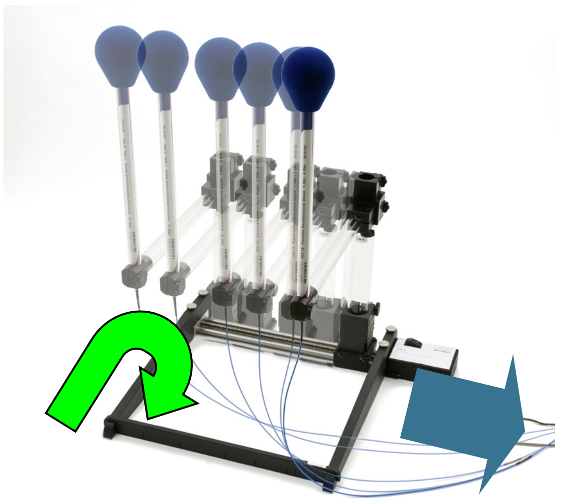
Stay away from all moving parts to avoid injury!

You must not use the positioner whenever one of the foam stoppers at the end positions is missing – it can cause injury and damage to the SPA2!



Align the inner edge of the Ruler along the line connecting the 6 test points and adjust the SPA2 so that the marks on the ruler fit to the test points.

Ready for measurement!



Towards receive antenna

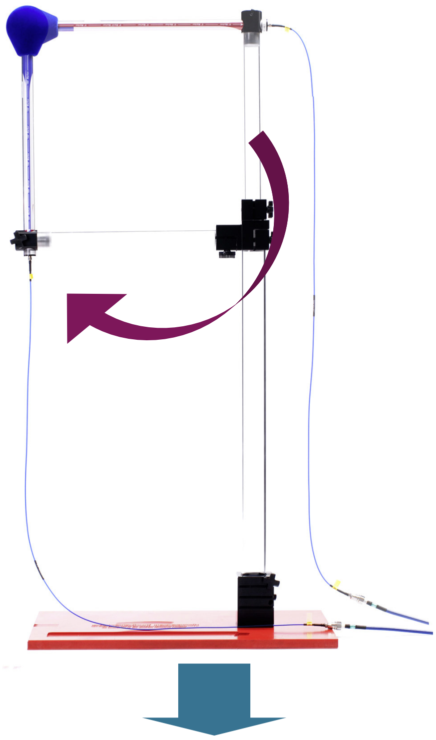
5.3. Polarization Change

Changing the polarization of the POD Antenna from horizontal to vertical is very easy and convenient:

Open the plastic screw of the HV-Connector part of the POD Holder and remove the POD Holder (with the POD Antenna still mounted) from the front hole.

Carefully turn the assembly and stick the POD Holder into the front hole of the HV-Connector.

Adjust the POD Antenna for vertical polarization and fasten the screw on the HV-Connector.



Towards receive antenna

5.4. Change of Height

To change the height of the POD Antenna from h_1 to h_2:

Loosen the screw on the HV-Connector and remove the HV-Connector (with the POD still mounted) from Tube A.

Screw the Tube Connector into Tube A

Screw Tube B onto the Tube Connector

Stick the HV-Connector on Tube B, align the antenna and fasten the screw.

5.5. SPA2 Maintenance

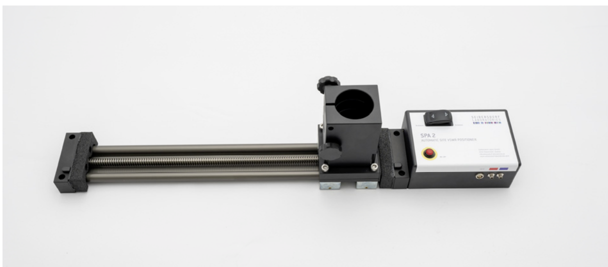
SPA2 needs only a little care to maintain a long life:

From time to time (e.g., after a measurement with a lot of dust) clean the spindle with a soft cloth, apply a drop of oil and clean again.

5.6. Storing SPA2 in Flight Case

The SPA2 must be in the “HOME POSITION” for packing in the flight case:

After the last measurement make sure to move the SPA2 to home position with your measurement software if you intend to pack it back into the flight case.



6. SOFTWARE

For operating SPA2 a positioning software is required. Seibersdorf Laboratories provides 2 possibilities:

1) CalStan11 (optional) for performing the whole measurement and evaluation
2) CalStan11 Demo (enclosed) for simple movement of SPA2

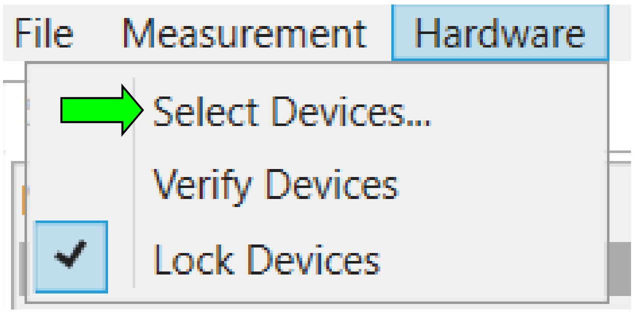
Please refer to the CalStan11 manual for information regarding the installation and start-up of CalStan11:
https://www.seibersdorf-laboratories.at/calstan

System requirements:

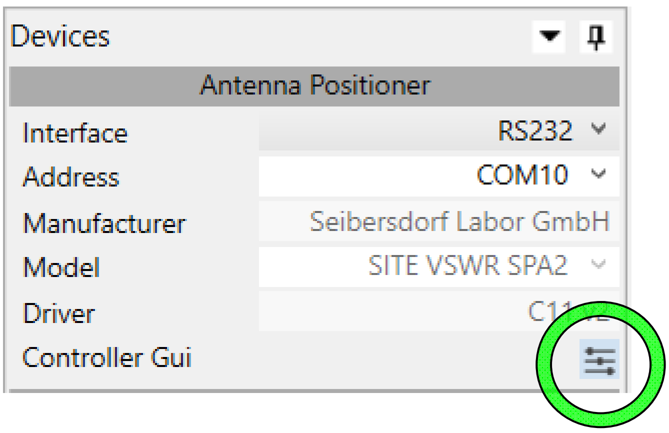
Operating systems	Windows 10 Windows 11
Additional hardware	USB port (TypeA)
Installed software	.NET framework version 4.8 (or higher)

6.1. CalStan11 Demo

1. Start CalStan11
2. Create Site VSWR Measurement
3. Detection of SPA2 (Hardware – Select devices – Detect) SPA2 is detected automatically.



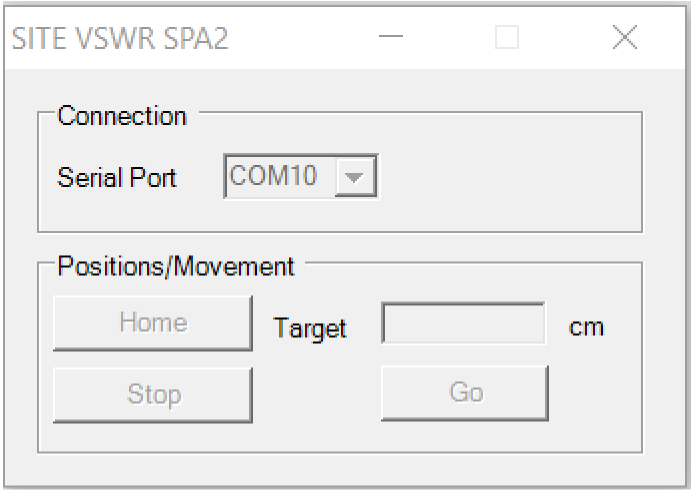
4. Open Controller Gui



5. Click Home button.

6. Type in the desired position into the target window (0 – 40 cm) and press Go button

   Stop button stops the movement immediately



7. OPERATION

7.1. Site VSWR-Measurement

In CISPR 16-1-4 [1] a technique to validate fully anechoic rooms in the frequency range 1 – 18 GHz is described. This method is called Site VSWR.
The POD Antenna and the Site VSWR Positioner (SPM1 and SPA2) are designed for this purpose. Not all information required to perform a Site VSWR test is included in this manual. It gives guidance on how to use the products.

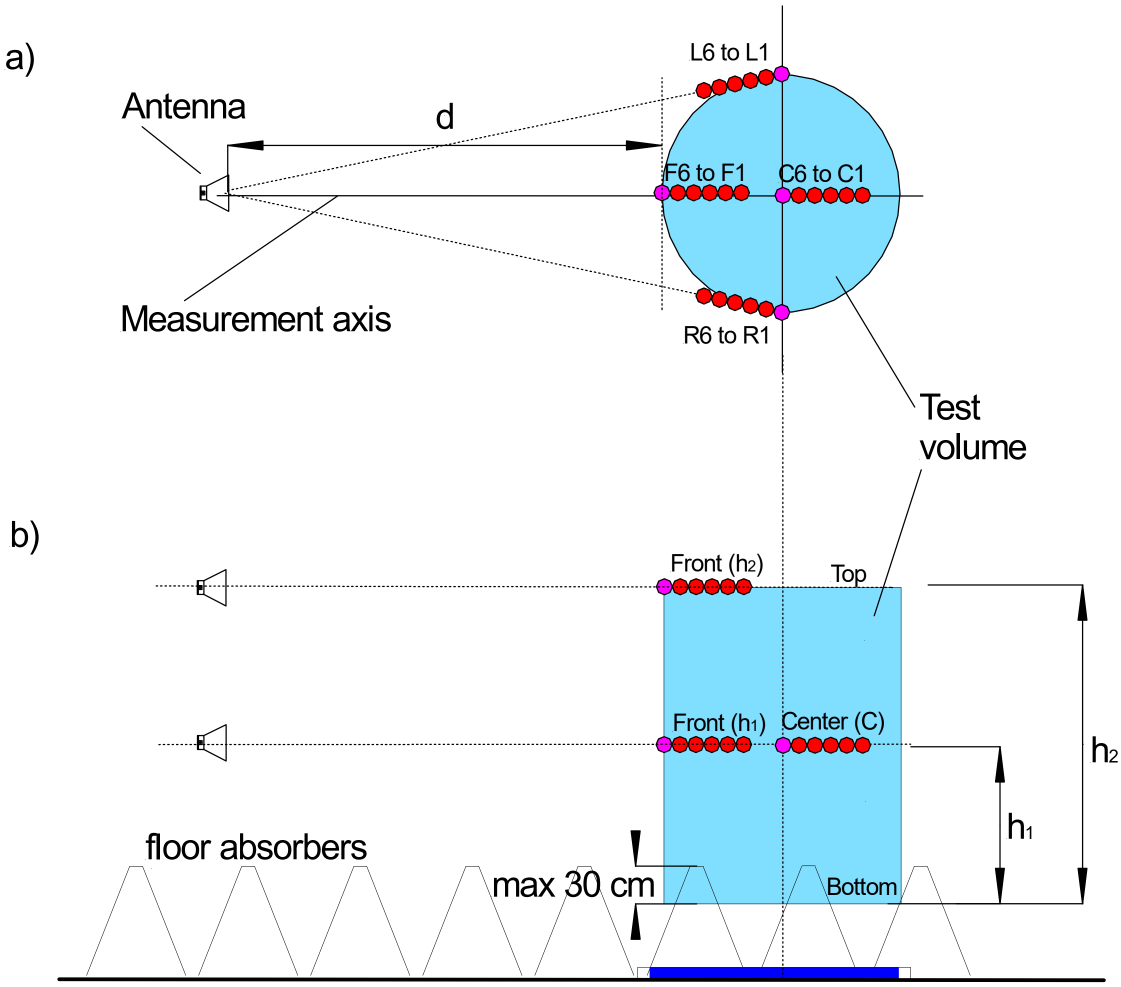


Figure 19: Location of test points for Site VSWR a) top view, b) side view

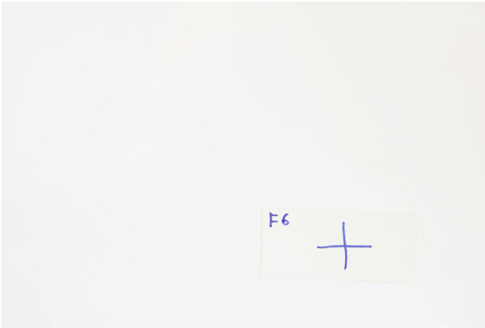
In **Figure 19** the heights h1 and h2 depend on the test volume of the chamber. The height h_1 is either half of the height of the test volume, but maximum 1 m and h2 is the height of the test volume (see also at CISPR 16-1-4).
The locations of the test points according to the standard are shown. Each location requires a sequence of six points on a line to the receive antenna reference point. These six points are distributed unequally over a 40 cm line. The ruler on the **SPA2** has engravings to visualize the six points. Make sure to set the first (or last) engraving on the measurement location, align the SPA2 to face towards the receive antenna and check

the switch “To RX-Antenna >” on the SPA2 box to correspond with the actual position of the receive antenna.

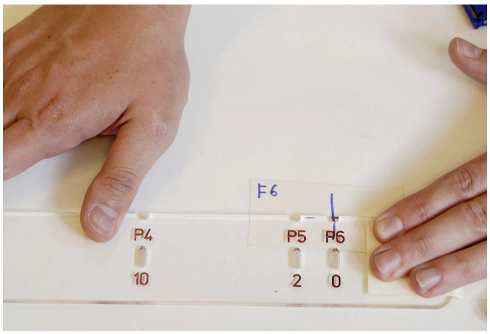
To help the user to place the Site VSWR Positioner **SPM1** correctly a Ruler is included in the Base Plate. On the Ruler the designation of the position P1 to P6 are marked as well as the distances to P6 in cm.

The Ruler should be used with the SPM1 in the following way:

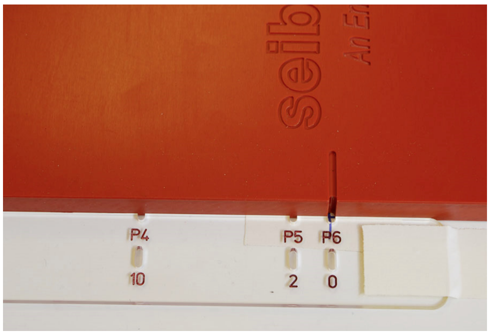
Mark the reference points for each location on the turntable. Depending on the location different positions act as reference. F6 and C6 are the reference for the front and center location, R1 and L1 are the reference for the right and left location.



Stick the Ruler on the turntable to form a line between the reference point and the receive antenna. Make sure that the furthest position to the antenna is always P1.



To place the antenna, move the Base Plate along the Ruler until the slot of the Base Plate is aligned with the desired mark on the Ruler.



The POD Antenna is mounted correctly to the Positioner when the red 0° marker points towards the receive antenna in horizontal polarization. When changing to vertical polarization the blue 180° marker will point towards the receive antenna. It is NOT necessary to turn the antenna back to the red marker. Due to the superior H-plane performance the POD Antenna is compliant to the standard in both orientations.

In semi-anechoic chambers it’s allowed to cover the bottom of the test volume with absorbing material during Site VSWR test. In this case you may place the absorbers on the top of the Base Plate of the Positioner.

For Site VSWR measurements the dynamic range of the instrumentation is an important issue. The received signal should be kept at least 20 dB over the noise floor. Especially in the frequency range 6 to 18 GHz this can cause some difficulties.

Following points should be kept in mind:

- RF cable loss can be quite large - reduce the cable length to a minimum.
- Using a high gain antenna will increase the received voltage for the location front and center. The received voltages in the side points R and L will drop dramatically if the diameter of the volume is large.
- Reducing the resolution bandwidth on the spectrum analyzer will reduce the noise floor. A coupling of the local oscillators of signal general and spectrum analyzer via a 10 MHz link may be necessary.
- The use of a low noise preamplifier can increase the received voltage. The noise floor will also be amplified dramatically if the noise figure is too high.

7.2. Field Strength Measurements

For doing accurate field strength measurements, it is very important to keep conductive and massive dielectric elements away from the POD Antenna.

$$E[\mathrm{dB}\mu\mathrm{V/m}] = U_{receiver}[\mathrm{dB}\mu\mathrm{V}] + AF_{POD}[\mathrm{dB/m}] + ATT_{cable}[\mathrm{dB}] - GAIN_{amplifier}[\mathrm{dB}]$$

To indicate the field strength the antenna factor and the cable loss should be added to the receiver reading. When a preamplifier is used, the gain has to be subtracted.

7.3. Table Influence

In CISPR 16-1-4 an evaluation procedure for set-up table influences is specified [1]. For this purpose, an omnidirectional antenna is placed 10 cm above the set-up table, see Figure 20. Two measurements are then carried out, one with and one without the set-up table, see Figure 21. The difference between the two measurements provides information about the influence of the set-up table. The POD antenna fulfils the antenna requirements for the frequency range of 1 GHz – 18 GHz.

Figure 20: Table influence measurement setup 1 GHz – 18 GHz

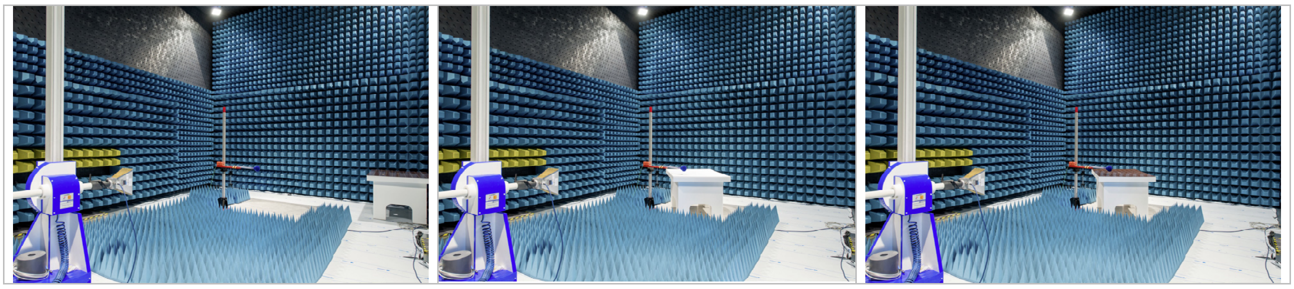


Figure 21: Table influence measurement
left: reference measurement without table
centre: measurement with table
right: measurement with table and protective cover

7.4. Validation of Absorber Lined Shielded Enclosures

In CISPR 25 Ed 5.0 emission measurements of automotive components and modules from 150 kHz – 6 GHz are specified. The “Long Wire Antenna Method” for the validation of Absorber Lined Shielded Enclosures (ALSEs) in CISPR 25 Ed 5.0 is only specified from 150 kHz – 1 GHz [6]. The POD antenna can be used for ALSE validation above 1 GHz according to two measurement methods: the Simulation Method and the Reference Measurement Method [7].

The “**Simulation Method**” is similar to the existing “Long Wire Antenna Method”, where the equivalent field strength inside an ALSE is compared to simulation data.

For the “**Reference Measurement Method**”, a reference measurement is taken on an open area test site and then compared with the measurement inside the ALSE. This approach was mentioned up to 1 GHz in CISPR 25 Ed. 4.0 but then removed in Ed. 5.0.

The validation setup for both methods is similar to the measurement setup for emission tests from 1 GHz – 6 GHz described in CISPR 25 Ed 5.0. Instead of an EUT, the POD antenna is placed on the reference ground plane on the same place. The measurement is performed in horizontal and in vertical antenna polarization. Figure 22 shows the measurement setup for both methods and a picture of a measurement is given in Figure 23.

a) b)

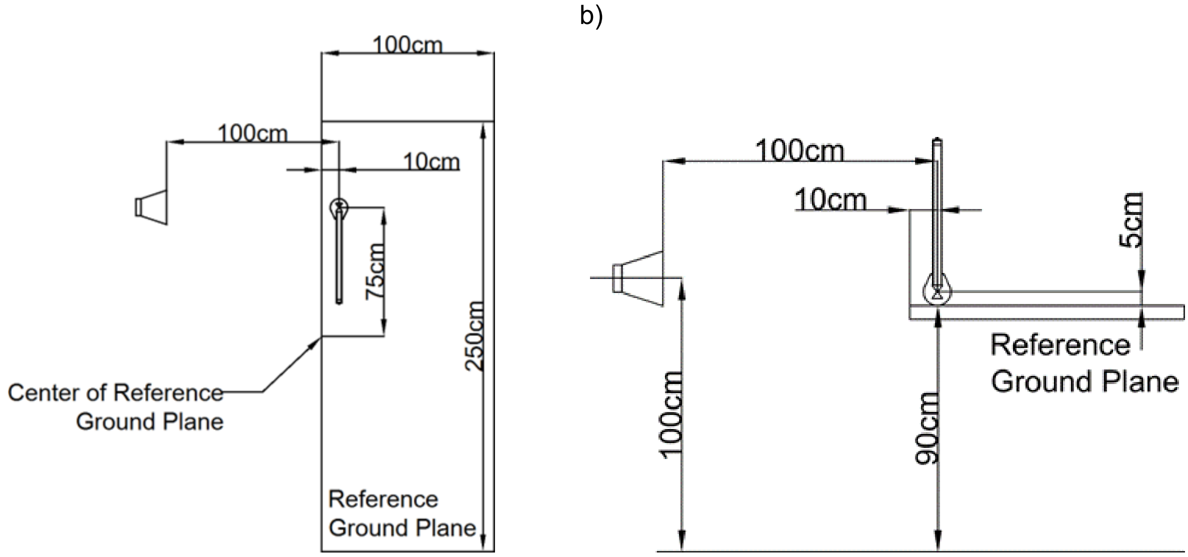


Figure 22: ALSE validation setup 1 GHz – 18 GHz
a) Horizontal polarization, top view
b) Vertical polarization, side view

Figure 23: ALSE measurement 1 GHz – 18 GHz, horizontal polarisation

Literature and information

[1] CISPR 16-1-4 Ed.4, Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-4: Radio disturbance and immunity measuring apparatus - Antennas and test sites for radiated disturbance measurements

[2] CISPR 32:2015/AMD1:2019: Electromagnetic compatibility of multimedia equipment - Emission requirements

[3] Alexander Kriz, Wolfgang Müllner: „Validierung von EMV Emissionsmessplätzen im Frequenzbereich 1 GHz bis 18 GHz nach dem Site VSWR Verfahren“, e&i, ÖVE Verbandszeitschrift, Heft 1-2.2006

[4] Alexander Kriz: „Validating Anechoic Chambers Above 1 GHz Using a Reciprocal Site VSWR Technique“, 2005 IEEE International EMC Symposium, 8. – 12. August 2005, Chicago IL USA

[5] Alexander Kriz: „Influence of H-Plane Pattern Performance of the Omnidirectional Transmit Antenna to the Site VSWR Result“, 2006 IEEE International EMC Symposium, 14. – 18. August 2006, Portland OR USA

[6] CISPR 25 Ed.5: “Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers”, IEC, Geneva, Switzerland, Dec. 2021.

[7] Michael Trischitz, Alexander Kriz: “Development of Validation Procedures for Automotive Anechoic Chambers from 1 GHz – 6 GHz”, Garbe, Heyno (Hrsg.): Proceedings EMV Kongress 2024 : Internationale Fachmesse und Kongress für Elektromagnetische Verträglichkeit. Aachen : Apprimus, 2024, S. 65-72, Doi: https://doi.org/10.15488/16969

8. FIGURES

9. TABLES

ANNEX I. WARRANTY

Seibersdorf Labor GmbH, hereinafter referred to as the Seller, warrants that standard Seibersdorf Laboratories products are free from defect in materials and workmanship for a period of two (2) years from the date of shipment.

Standard Seibersdorf Laboratories products include the following:

- Antennas
- Cables
- Reference Radiators
- Software
- Antenna stands and positioners

If the Buyer notifies the Seller of a defect within the warranty period, the Seller will, at the Seller's option, either repair and/or replace products which prove to be defective during the warranty period.
There will be no charge for warranty services performed at the location the Seller designates. The Buyer must, however, prepay inbound shipping costs and any duties or taxes. The Seller will pay outbound shipping cost for a carrier of the Seller's choice, exclusive of any duties or taxes.

This warranty does not apply to:

- Normal wear and tear of materials
- Consumable items such as fuses, batteries, etc.
- Products that have been improperly installed, maintained or used
- Products which have been operated outside the specifications
- Products which have been modified without authorization
- Calibration of products, unless necessitated by defects

THIS WARRANTY IS EXCLUSIVE. NO OTHER WARRANTY, WRITTEN OR OR
AL, IS EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE REMEDIES PROVIDED BY

THIS WARRANTY ARE THE BUYER'S SOLE AND EXCLUSIVE REMEDIES. IN NO EVENT IS THE SELLER LIABLE FOR ANY DAMAGES WHATSOEVER, INCLUDING BUT NOT LIMITED TO, DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ANNEX II. Sample Certificate of Antenna Calibration

A sample calibration certificate for the POD 16 is given on the following pages.
It contains the calibration of antenna factor, VSWR and radiation pattern.

SEIBERSDORF LABORATORIES

Kalibrierstelle für Antennen und Feldsonden
Calibration Body for Antennas and Field Probes

Akkreditiert durch / *accredited by*

AKKREDITIERUNG AUSTRIA

Kalibrierschein nach ISO/IEC 17025
Calibration Certificate according to ISO/IEC 17025

Kalibrierzeichen
Calibration mark

EH-Axxx/24
0612
21.05.2024

Gegenstand *Object*	Precision Omnidirectional Dipole
Hersteller & Typ *Manufacturer & Type*	Seibersdorf Labor GmbH POD 16
Herstellernummer *Serial number*	
Auftraggeber *Customer*	Seibersdorf Labor GmbH 2444 Seibersdorf Austria
Auftragsnummer *Order Nr.*	L.L7.00057.0.0-P-XXX
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	1 - 8
Datum und Ort der Kalibrierung *Date and place of calibration*	21.05.2024 Seibersdorf

Akkreditierung Austria ist Vollmitglied bei der International Laboratory Accreditation Cooperation ILAC und Unterzeichner der MRAs für die Bereiche „Testing, Calibration and Inspection".

Die Kalibrierung erfolgt auf der gesetzlichen Grundlage des Akkreditierungsgesetzes in gültiger Fassung entsprechend den Anforderungen der ÖVE/ÖNORM EN ISO/IEC 17025.

Dieser Kalibrierschein dokumentiert die Rückführbarkeit auf nationale Normale zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).

Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

Akkreditierung Austria is a full member of the International Laboratory Accreditation Cooperation ILAC and a signatory of the MRA for "Testing, Calibration and Inspection".

The calibration is performed in accordance with the Akkreditierungsgesetz in the amended version and the requirements of ÖVE/ÖNORM EN ISO/IEC 17025.

This calibration certificate documents the traceability to national standards, which realize the physical units or measurements according to the International System of Units (SI).

The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein gilt ausschließlich für den kalibrierten Gegenstand und darf nur vollständig und unverändert weiterverarbeitet werden. Auszüge oder Änderungen sind unzulässig. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.

This calibration certificate is valid only for the calibrated object and may not be reproduced other than in full. Calibration certificates without signature are not valid.

Datum *Date*	Zeichnungsberechtigter *Authorized person*	Bearbeiter *Person responsible*
21.05.2024	______________________	______________________

Calibration Procedure

Calibration of the **antenna factor** is carried out according to the Standard Antenna Method described in internal process guideline LE-EH-VA-A01 (2023-12).
The Antenna Factor is determined in the 0° orientation.

Calibration of the **voltage reflection coefficient** (VRC) is carried out according to the method described in internal process guideline LE-EH-VA-L02 (2022-07) using a network analyser.
Results are shown as voltage standing wave ration (VSWR) calculated from the voltage reflection coefficient as following:

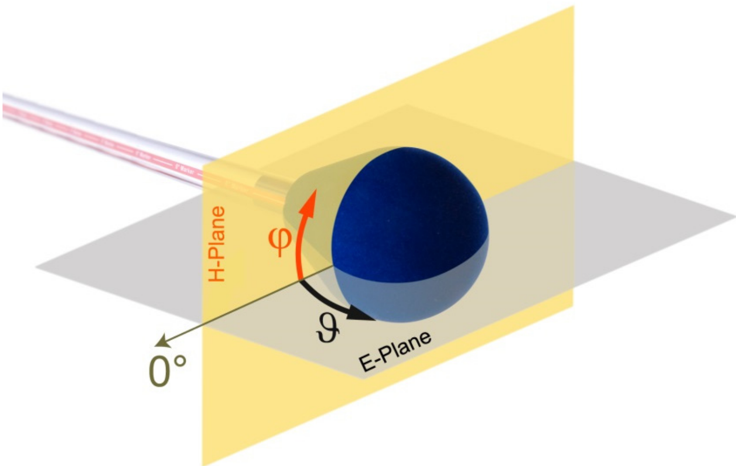
$$\mathrm{VSWR} = \frac{1+\mathrm{VRC}}{1-\mathrm{VRC}}$$

All relevant additional ports of the device under test are terminated.

Calibration of the **Radiation Pattern** is carried out according to the method described in internal process guideline LE-EH-VA-A05 (2022-06). The calibration fulfils the requirements given in CISPR 16-1-4.
The AUC is placed on a turntable which is rotated by 360° in 1° steps. Both, E- and H-Plane pattern are measured.

The following Figure shows a POD Antenna and visualizes the E- and the H-plane.

Also the angles ϑ and φ used for the radiation pattern diagrams and the 0°-orientation used for the antenna factor calibration are defined.



A normalization of the radiation pattern is required by the standard. This is necessary to apply the criteria and is performed for each pattern. For E-plane and H-plane this is done in a different manner:

- E-plane: The pattern is normalized to the largest value (0 dB)
- H-plane: The mean value of the pattern is calculated in an angular range from -135° to +135°. The full pattern (angular range ±180°) is normalized to this average (0 dB).

Test Equipment

Type	Identification
Network Analyzer Keysight N5244B	E0190
Preamplifier	E0738
Precision Omnidirectional Dipole Seibersdorf Labor GmbH POD 16	E1639
Double Ridged Horn EMCO 3115	E0599
Fully Anechoic Chamber	LE0128
NWA Calibration Kit	E0116
Turntable Maturo	LE0128a
CalStan 11	E0921

Environmental Conditions

Site Temperature	20°C - 27°C
Site Humidity	30% - 80%
Control Temperature	20°C - 27°C
Control Humidity	30% - 80%

Results

Type	Description	Fig./Table
Antenna Factor	1GHz-6GHz, d=3m, Vertical	1
VSWR	1GHz-6GHz	2
Pattern	1GHz-6GHz, d=3m, E-Plane, H-Plane	3

The uncertainty for AF and VSWR is stated in the results tables. The uncertainty for radiation pattern calibration is ± 0.54 dB.

	Criteria
Radiation Pattern	PASS for all frequencies

Accuracy of Calibration

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k = 2$, which for a normal distribution corresponds to a coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EAL Publication EA 4/02.

References

[1] EA-4/02 M: 2022 Evaluation of the Uncertainty of Measurement in calibration

Figure 1: Antenna Factor; 1GHz-6GHz, d=3m, Vertical

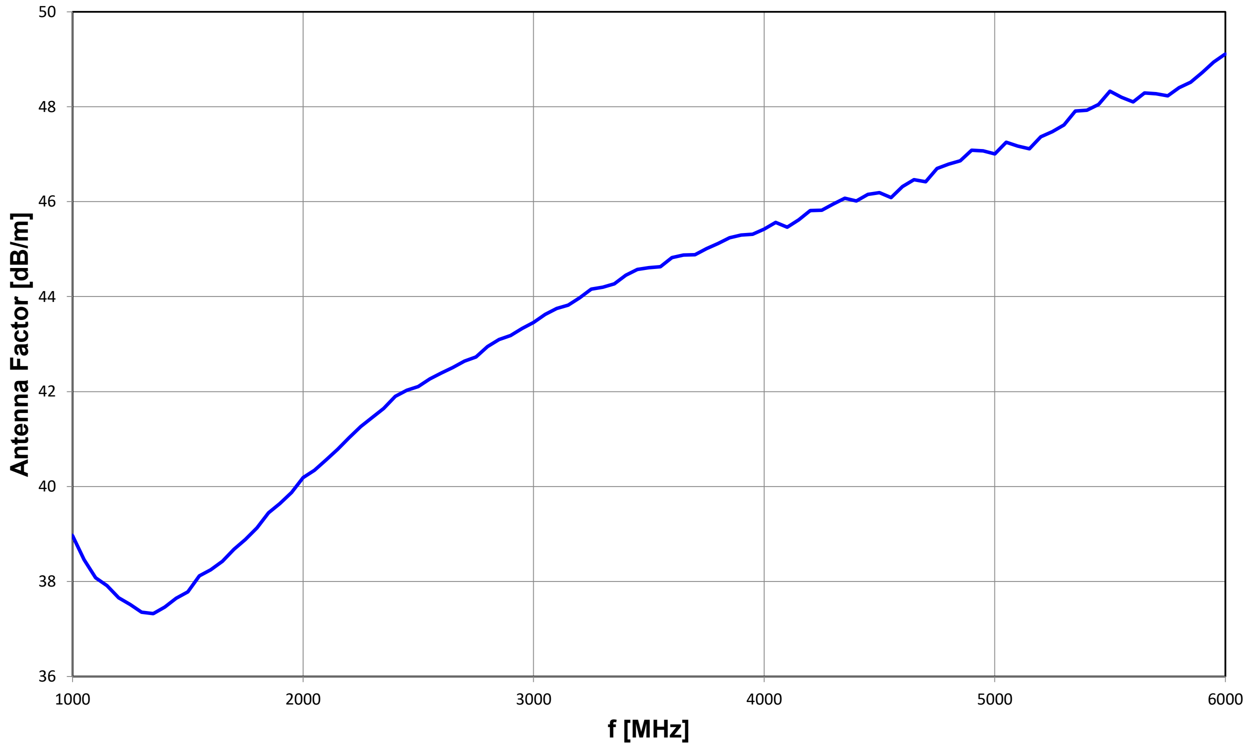


Table 1: Antenna Factor; 1GHz-6GHz, d=3m, Vertical

f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]
1 000	38.97	±1.70	2 450	42.03	±1.70	3 900	45.30	±1.70
1 050	38.46	±1.70	2 500	42.11	±1.70	3 950	45.31	±1.70
1 100	38.08	±1.70	2 550	42.27	±1.70	4 000	45.42	±1.70
1 150	37.92	±1.70	2 600	42.39	±1.70	4 050	45.56	±1.70
1 200	37.66	±1.70	2 650	42.51	±1.70	4 100	45.46	±1.70
1 250	37.51	±1.70	2 700	42.64	±1.70	4 150	45.62	±1.70
1 300	37.35	±1.70	2 750	42.73	±1.70	4 200	45.81	±1.70
1 350	37.32	±1.70	2 800	42.95	±1.70	4 250	45.82	±1.70
1 400	37.46	±1.70	2 850	43.10	±1.70	4 300	45.95	±1.70
1 450	37.65	±1.70	2 900	43.18	±1.70	4 350	46.07	±1.70
1 500	37.78	±1.70	2 950	43.33	±1.70	4 400	46.02	±1.70
1 550	38.12	±1.70	3 000	43.46	±1.70	4 450	46.15	±1.70
1 600	38.25	±1.70	3 050	43.63	±1.70	4 500	46.19	±1.70
1 650	38.43	±1.70	3 100	43.75	±1.70	4 550	46.09	±1.70
1 700	38.68	±1.70	3 150	43.82	±1.70	4 600	46.32	±1.70
1 750	38.88	±1.70	3 200	43.98	±1.70	4 650	46.46	±1.70
1 800	39.13	±1.70	3 250	44.16	±1.70	4 700	46.42	±1.70
1 850	39.45	±1.70	3 300	44.20	±1.70	4 750	46.70	±1.70
1 900	39.64	±1.70	3 350	44.27	±1.70	4 800	46.79	±1.70
1 950	39.87	±1.70	3 400	44.45	±1.70	4 850	46.86	±1.70
2 000	40.19	±1.70	3 450	44.57	±1.70	4 900	47.08	±1.70
2 050	40.35	±1.70	3 500	44.61	±1.70	4 950	47.07	±1.70
2 100	40.56	±1.70	3 550	44.63	±1.70	5 000	47.01	±1.70
2 150	40.78	±1.70	3 600	44.82	±1.70	5 050	47.25	±1.70
2 200	41.03	±1.70	3 650	44.87	±1.70	5 100	47.17	±1.70
2 250	41.26	±1.70	3 700	44.88	±1.70	5 150	47.12	±1.70
2 300	41.45	±1.70	3 750	45.01	±1.70	5 200	47.36	±1.70
2 350	41.64	±1.70	3 800	45.12	±1.70	5 250	47.47	±1.70
2 400	41.90	±1.70	3 850	45.24	±1.70	5 300	47.62	±1.70

f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]	f [MHz]	AF [dB/m]	U [dB]
5 350	47.91	±1.70	5 600	48.10	±1.70	5 850	48.52	±1.70
5 400	47.93	±1.70	5 650	48.29	±1.70	5 900	48.72	±1.70
5 450	48.04	±1.70	5 700	48.27	±1.70	5 950	48.94	±1.70
5 500	48.33	±1.70	5 750	48.23	±1.70	6 000	49.11	±1.70
5 550	48.20	±1.70	5 800	48.40	±1.70			

Figure 2: VSWR; 1GHz-6GHz

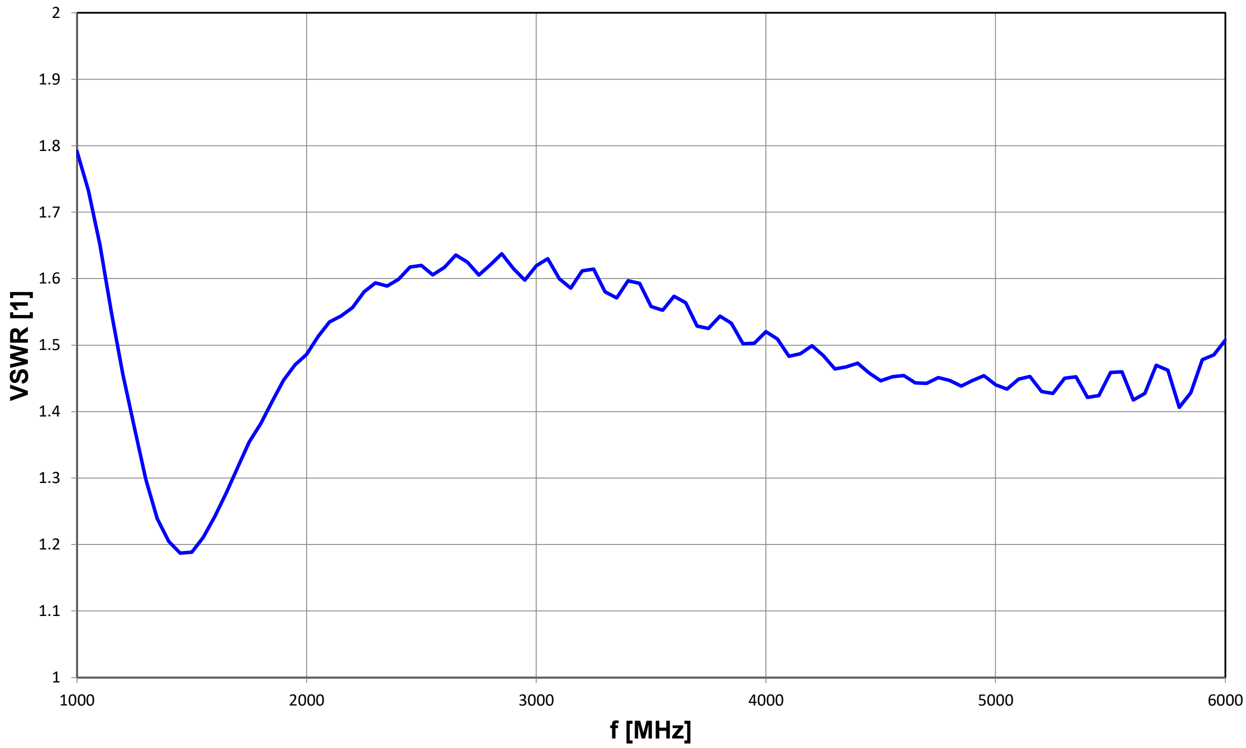
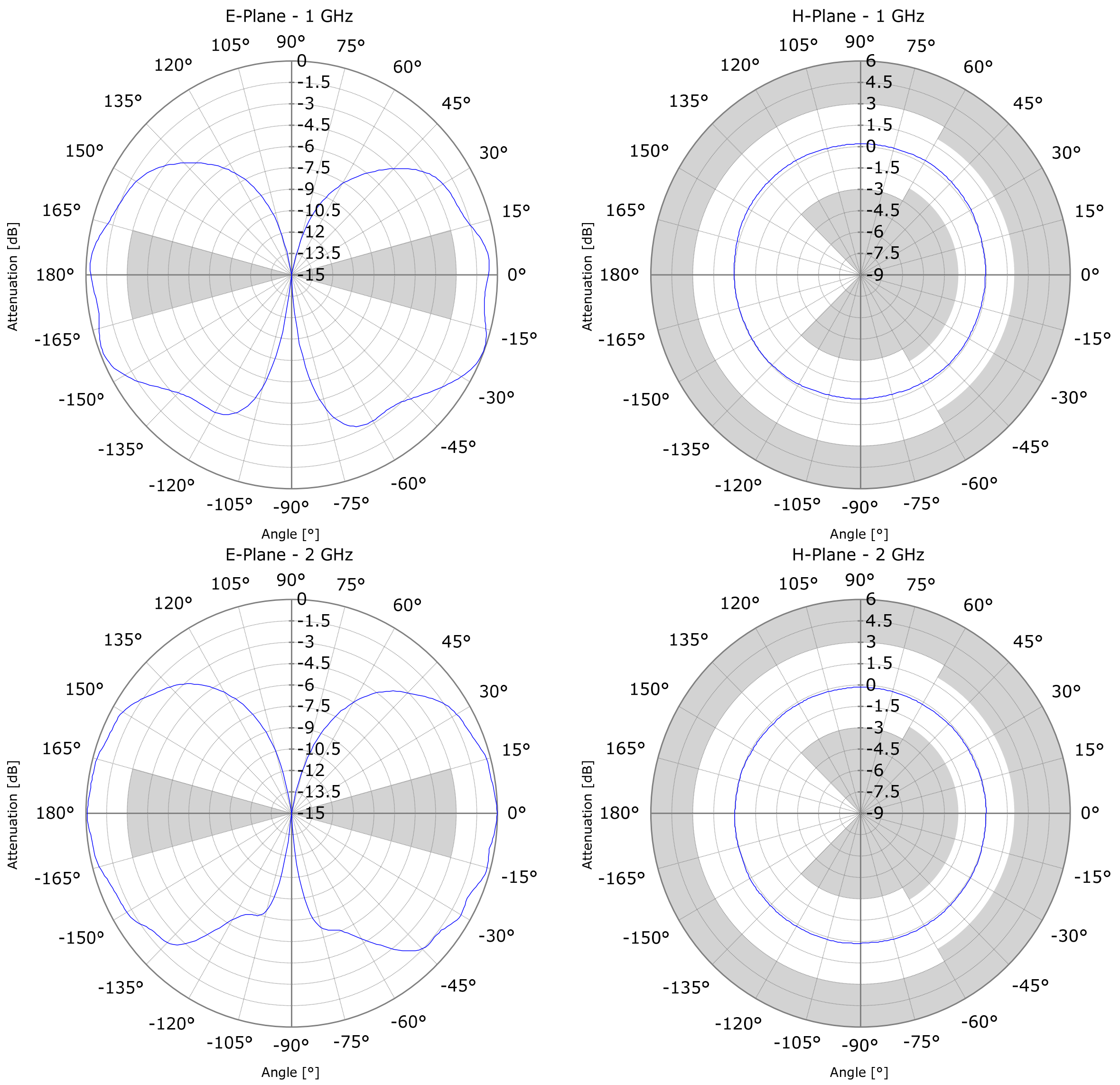


Table 2: VSWR; 1GHz-6GHz

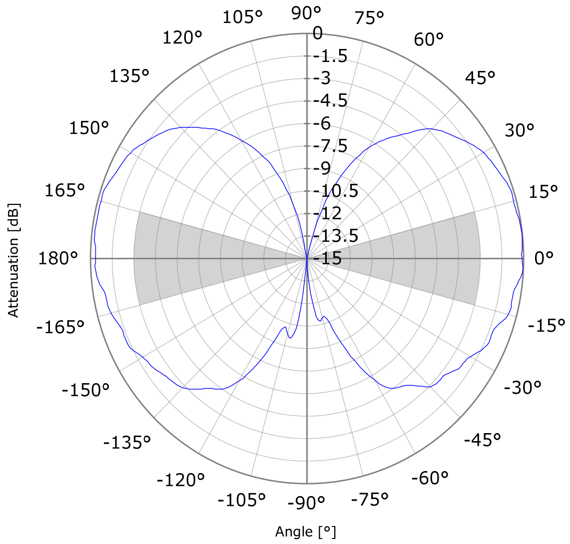
f [MHz]	VSWR [1]	U [1]	f [MHz]	VSWR [1]	U [1]	f [MHz]	VSWR [1]	U [1]
1 000	1.792	±0.10	2 050	1.513	±0.20	3 100	1.600	±0.22
1 050	1.732	±0.24	2 100	1.535	±0.21	3 150	1.586	±0.22
1 100	1.651	±0.23	2 150	1.544	±0.21	3 200	1.612	±0.22
1 150	1.549	±0.21	2 200	1.557	±0.21	3 250	1.614	±0.22
1 200	1.456	±0.20	2 250	1.580	±0.22	3 300	1.580	±0.22
1 250	1.375	±0.18	2 300	1.594	±0.22	3 350	1.571	±0.21
1 300	1.298	±0.17	2 350	1.589	±0.22	3 400	1.597	±0.22
1 350	1.239	±0.16	2 400	1.599	±0.22	3 450	1.593	±0.22
1 400	1.205	±0.16	2 450	1.617	±0.22	3 500	1.558	±0.21
1 450	1.187	±0.15	2 500	1.620	±0.22	3 550	1.552	±0.21
1 500	1.188	±0.15	2 550	1.606	±0.22	3 600	1.573	±0.22
1 550	1.211	±0.16	2 600	1.617	±0.22	3 650	1.564	±0.21
1 600	1.242	±0.16	2 650	1.635	±0.23	3 700	1.529	±0.21
1 650	1.277	±0.17	2 700	1.625	±0.22	3 750	1.525	±0.21
1 700	1.316	±0.17	2 750	1.605	±0.22	3 800	1.543	±0.21
1 750	1.354	±0.18	2 800	1.621	±0.22	3 850	1.533	±0.21
1 800	1.382	±0.18	2 850	1.637	±0.23	3 900	1.502	±0.20
1 850	1.415	±0.19	2 900	1.615	±0.22	3 950	1.503	±0.20
1 900	1.447	±0.19	2 950	1.598	±0.22	4 000	1.520	±0.21
1 950	1.470	±0.20	3 000	1.619	±0.22	4 050	1.509	±0.20
2 000	1.486	±0.20	3 050	1.630	±0.23	4 100	1.483	±0.20

f [MHz]	VSWR [1]	U [1]	f [MHz]	VSWR [1]	U [1]	f [MHz]	VSWR [1]	U [1]
4 150	1.487	±0.20	4 800	1.447	±0.19	5 450	1.424	±0.19
4 200	1.499	±0.20	4 850	1.438	±0.19	5 500	1.459	±0.20
4 250	1.484	±0.20	4 900	1.447	±0.19	5 550	1.460	±0.20
4 300	1.464	±0.20	4 950	1.454	±0.20	5 600	1.417	±0.19
4 350	1.467	±0.20	5 000	1.440	±0.19	5 650	1.427	±0.19
4 400	1.473	±0.20	5 050	1.434	±0.19	5 700	1.470	±0.20
4 450	1.458	±0.20	5 100	1.449	±0.19	5 750	1.462	±0.20
4 500	1.446	±0.19	5 150	1.453	±0.19	5 800	1.406	±0.19
4 550	1.452	±0.19	5 200	1.430	±0.19	5 850	1.428	±0.19
4 600	1.454	±0.20	5 250	1.427	±0.19	5 900	1.478	±0.20
4 650	1.443	±0.19	5 300	1.450	±0.19	5 950	1.485	±0.20
4 700	1.443	±0.19	5 350	1.452	±0.19	6 000	1.507	±0.20
4 750	1.451	±0.19	5 400	1.421	±0.19			

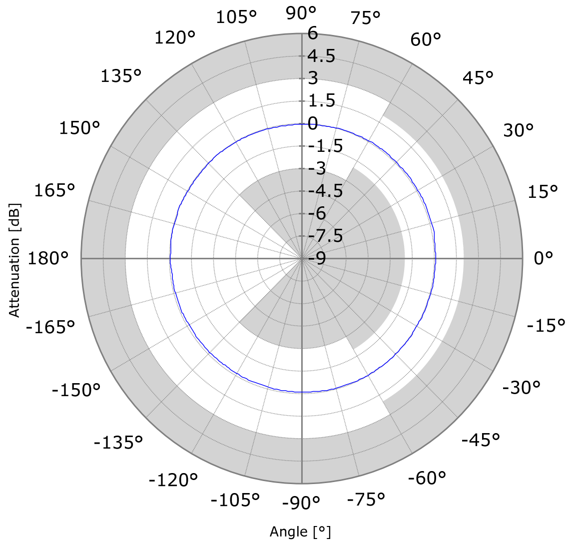
<u>Figure 3:</u> Pattern; 1GHz-6GHz, d=3m, E-Plane, H-Plane



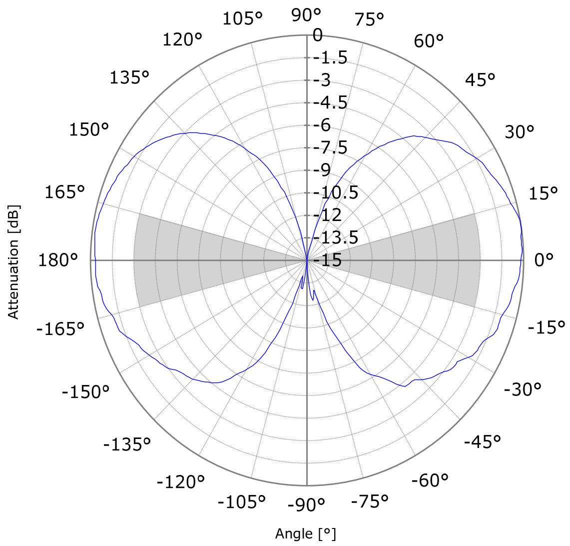
E-Plane - 3 GHz



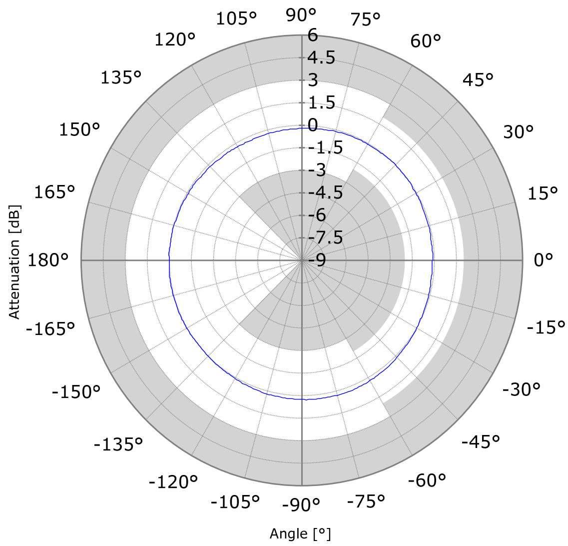
H-Plane - 3 GHz



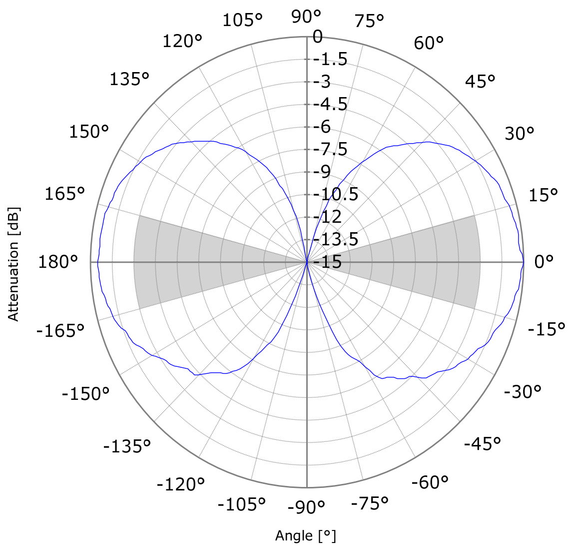
E-Plane - 4 GHz



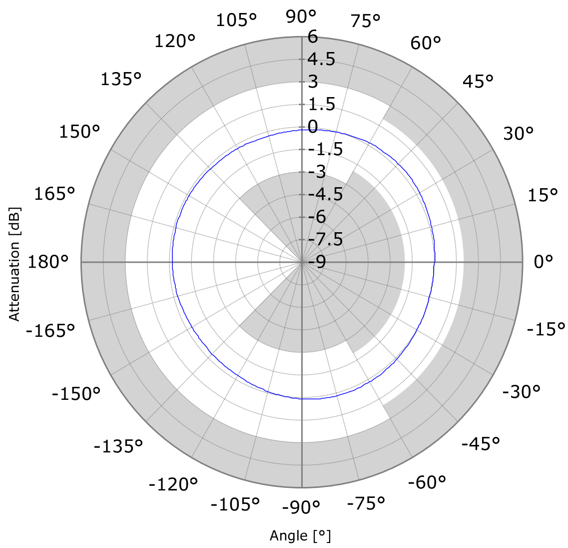
H-Plane - 4 GHz

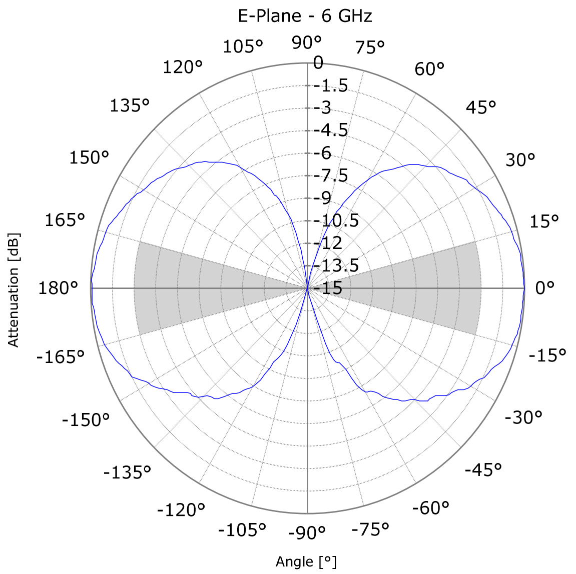


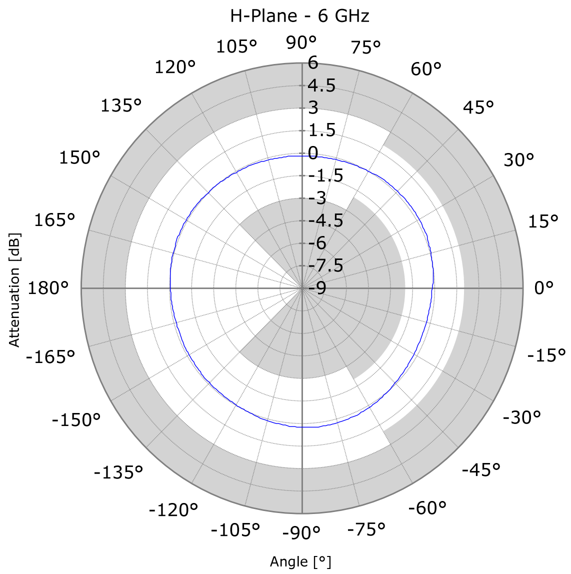
E-Plane - 5 GHz



H-Plane - 5 GHz




E-Plane - 6 GHz
90°
75°
60°
45°
30°
15°
0°
-15°
-30°
-45°
-60°
-75°
-90°
-105°
-120°
-135°
-150°
-165°
180°
165°
150°
135°
120°
105°
0
-1.5
-3
-4.5
-6
-7.5
-9
-10.5
-12
-13.5
-15
Attenuation [dB]
Angle [°]


H-Plane - 6 GHz
90°
75°
60°
45°
30°
15°
0°
-15°
-30°
-45°
-60°
-75°
-90°
-105°
-120°
-135°
-150°
-165°
180°
165°
150°
135°
120°
105°
6
4.5
3
1.5
0
-1.5
-3
-4.5
-6
-7.5
-9
Attenuation [dB]
Angle [°]

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