

SGS Germany GmbH

Test Report No.: T4LM0002

Order No.: T4LM

Pages: 42

Client: Schroff GmbH

Equipment Under Test: 24395-600: SUBR PRO EMC 6U 84HP 235D HF TEST MUC with textile gaskets

Manufacturer: Schroff GmbH

Task: Evaluation of Shielding Effectiveness

Test Specification(s): acc. to IEC 61000-5-7
[covered by accreditation]

Result: See Summary.

The results relate only to the items tested as described in this test report.

approved by:

Date

Signature

Bauer
Lab Manager EMC

Jul 27, 2023

Josef Bauer

This document was signed electronically.

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1 Summary

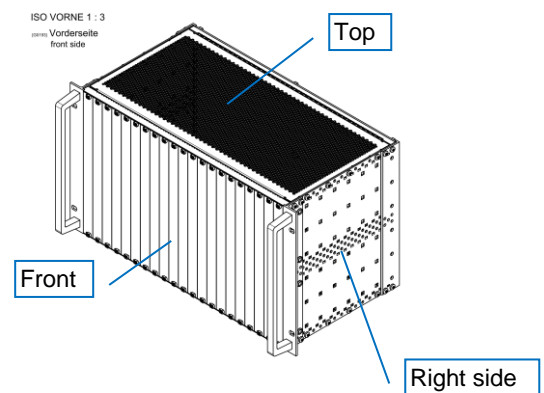
1.1 Common

The shielding effectiveness of the 24395-600: SUBR PRO EMC 6U 84HP 235D HF TEST MUC with textile gaskets should be measured acc. to IEC 61000-5-7 in the frequency range 10 kHz to 40 GHz.

1.2 Execution of the measurements

The measurements of the shielding effectiveness of the EUT were performed with three sides of EUT facing the antenna:

1. Front
2. Right side
3. Top



The measurements were performed in the following frequency ranges:

- 0.01 – 30 MHz
- 30 – 1000 MHz
- 1 – 18 GHz
- 18 – 40 GHz ¹

1.3 EM shielding code designators of IEC 61000-5-7

In Table 1 of IEC 61000-5-7, the following EM shielding code designators are defined:

Table 1 – EM shielding code designators

Frequency band	Shielding designator
10 kHz – 100 kHz	A
100 kHz – 1 MHz	B
1 MHz – 30 MHz	C
30 MHz – 1 GHz	D
1 GHz – 10 GHz	E
10 GHz – 40 GHz	F

Shielding performance dB	Shielding designator value
Untested	x
<10	0
≥10	1
≥20	2
≥30	3
≥40	4
≥50	5
≥60	6
≥70	7
≥80	8
≥100	9

¹ In this frequency range the shielding effectiveness was evaluated at the following spot frequencies: 20, 25, 30, 35, and 40 GHz.

1.4 Summary of Results

The EM code acc. to IEC 61000-5-7 derived from the results of shielding effectiveness measurements is

EM122211

Table 1-1 shows the minimum shielding effectiveness in the Frequency Bands acc. to IEC 61000-5-7 and the correlated shielding designator levels.

Frequency Band (MHz)	Shielding designator	Minimum shielding effectiveness (dB) ²	Shielding designator level
0.01 – 0.1	A	15,4	1
0.1 – 1	B	20,7	2
1 – 30	C	21.1	2
30 – 1,000	D	20.1	2
1,000 – 10,000	E	15.4	1
10,000 – 40,000	F	10.4	1

Table 1-1

2 References

2.1 Specifications

- IEC 61000-5-7: 2001-01
Electromagnetic compatibility (EMC) –
Part 5-7:
Installation and mitigation guidelines –
Degrees of protection provided by enclosures against electromagnetic disturbances (EM code)

2.2 Glossary of Terms

EMC specific Abbreviations

BW	Bandwidth
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	European Standard
EUT	Equipment Under Test
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
SE	Shielding Effectiveness
SW	Software
RX	receive
TX	transmit
VNA	Vectorial Network Analyzer
VSWR	Voltage Standing Wave Ratio

² Read from smoothed results.

3 General Information

3.1 Identification of Client

Schroff GmbH
Langenalber Str. 96-100
75334 Straubenhardt

3.2 Test Laboratory

SGS Germany GmbH
Hofmannstraße 50
81379 München

Business Address: SGS Germany GmbH, Heidenkampsweg 99, D-20097 Hamburg, Member of the SGS Group
General Manager: Wim van Loon, Chairman of the Supervisory Board: Olivier Merkt
Registered Office: Hamburg, HRB 4951 Amtsgericht Hamburg

3.3 Time Schedule

Delivery of EUT: May 18, 2023
Start of test: May 23, 2023
End of test: Jun 27, 2023

3.4 Participants

Name	Function
Richard Bandel	Setup of EUT
Waldemar Schulz	Setup of EUT
Nick Owen Wagner	Setup of EUT
Andreas Pauli	Accredited testing, Editor

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4 Equipment Under Test

All information regarding the EUT(s) was provided by the customer and has been approved by customer during report-review-process.

Test item description 19-inch Subrack EuropacPro, EMC-Version
Trade Mark nVent
Manufacturer / Importer Schroff GmbH
Model/Type 24395-600: SUBR PRO EMC 6U 84HP 235D HF TEST MUC with textile gaskets
Dimensions Rack Height: 6 U
 Rack Width: 84 HP
 Depth: 235 mm
Serial No. -
Number of tested samples.: 1

ISO VORNE 1 : 3

[G0193] Vorderseite
front side

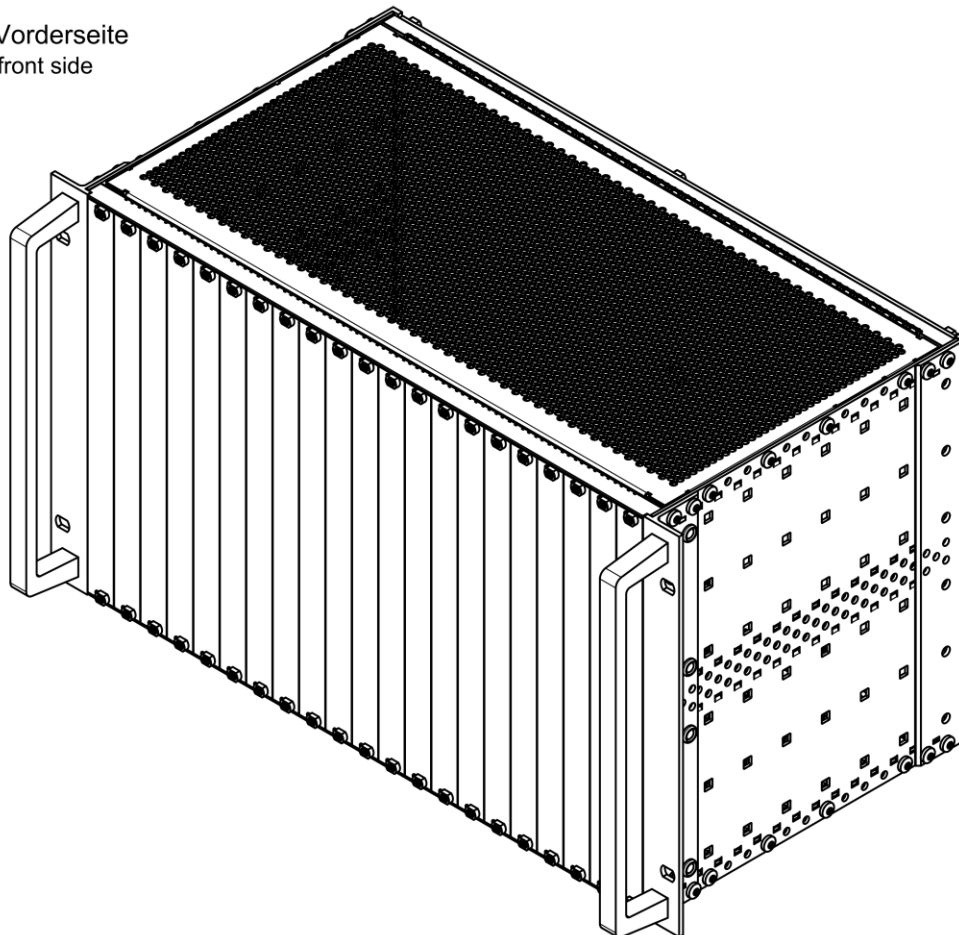


Figure 4-1: EUT

Autos ungss tufe	Positionsnr	Komponentennummer	Objektkurztext	Komponentenmenge	KompMenge nEinheit
.1	10	24566447	SEITENW.H 6HE 235T M.GRIFF 2ST	1,000	EA
.1	20	10501008	FRONTGRIFF ALU 6/9HE ELOX	2,000	EA
.1	30	64560225	SENKSCHR.M5X12 4.8-TX20 (DIN965)	4,000	EA
.1	40	.		1,000	ST
.1	50	34560284	MODULSCH.VORNE 84TE H KD	2,000	EA
.1	60	34560784	MODULSCH.HINTEN 84TE H VT	2,000	EA
.1	70	34561384	GEWINDESTREIFEN 84TE M2.5	4,000	EA
.1	80	30845253	LOCHSTREIFEN 84TE NUTZBAR	2,000	EA
.1	90	64560182	FIXIERUNGSSTIFT M2.5X9 TX8	4,000	EA
.1	100	34562284	KONTAKTSTR.MS-FPL 416,26L	4,000	EA
.1	110	61498107	LIKOSCHR.M4X14 4.8-TX20 SELBS.	8,000	EA
.1	120	61498110	LIKOSCHR.M4X10 4.8-TX20 SELBS.	8,000	EA
.1	190	.		1,000	ST
.1	200	24564499	ECKPROFIL 6HE 2STK	1,000	EA
.1	240	.		1,000	ST
.1	250	34562712	ABDECKBLECH EMC 84TE 235T	2,000	EA
.1	260	24560245	KONTAKTSTR.MS-ADBL 84TE 10STK	0,400	EA
.1	270	61498113	LIKOSCHR.M4X6 10.9-TX20 PENTAF.SELBS.	16,000	EA
.1	280	.		1,000	ST
.1	290	.		1,000	ST
.1	400	30848355	TEILFRONTPLATTE 6HE 4TE	21,000	EA
.1	410	60807133	EINPRESSNIPPEL, MS/NI	42,000	EA
.1	420	60807213	HALSSCHR.M2.5X12,3 8.8-PZ1/SCHLUTZ	42,000	EA
.1	430	21101856	PROFILDICHTUNG 6HE EMV 100ST	0,240	EA
.1	440	21102108	EMV-DICHTUNG 6HE 232LG 100ST	0,240	EA
.1	450	.		1,000	ST
.1	460	BEI EMV-TEST:		1,000	ST
.1	470	TESTAUFBAU ENTWEDER MIT		1,000	ST
.1	480	POS. 43 TEXTILDICHTUNG		1,000	ST
.1	490	ODER		1,000	ST
.1	500	POS. 44 EDELSTAHLFEDER		1,000	ST
.1	590	.		1,000	ST
.1	600	34393085	FRONTPLATTE 6HE 84TE HF TEST MUENCHEN	1,000	EA
.1	980	.		1,000	ST
.1	990	.		1,000	ST
.1	1000	BGTR KOMPLETT MONTIERT		1,000	ST
.1	1010	NACH ZG. 24395-600		1,000	ST
.1	8900	.		1,000	ST
.1	8910	.		1,000	ST
.1	8990	71000999		1,000	ST

Figure 4-2: parts list

4.1 Photographs of EUT

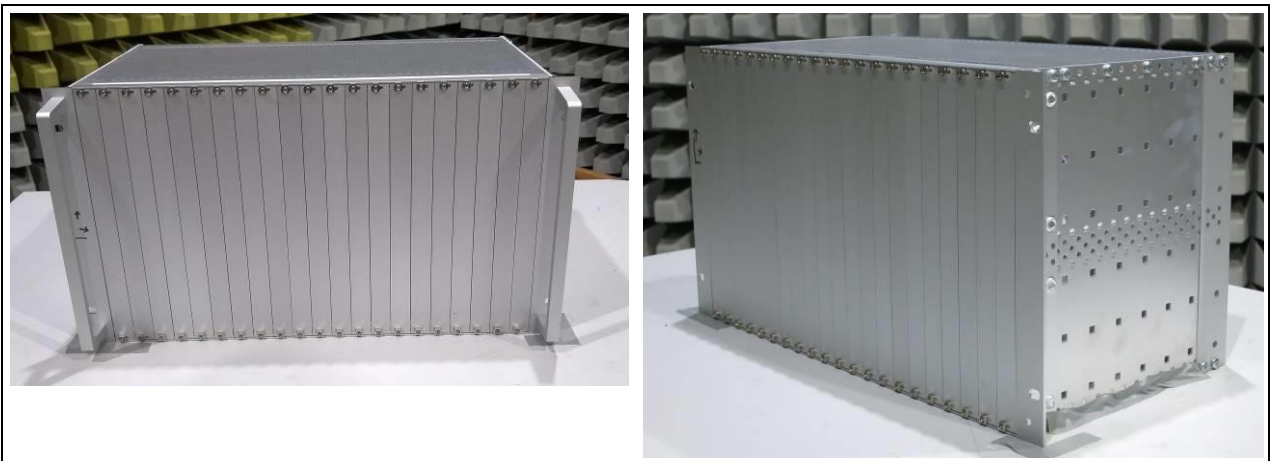


Figure 4-3: 24395-600: SUBR PRO EMC 6U 84HP 235D HF TEST MUC with textile gaskets

5 Test Equipment

5.1 Test Facility

The EMC-tests are carried out in the EMC-laboratory of SGS Germany, Consumer and Retail, Hofmannstraße 50, 81379 München, Germany.

Chamber	1	2	3	4 / 5	6	7
Dimensions (net)	17.7 * 10.8 * 6.8 m	9.6 * 8.5 * 5.3 m	7.4 * 6.6 * 5.2 m	4.1 * 3.5 * 3.5m	6.4 * 4.3 * 4.3m	4.58 * 4.28 * 3.01m
Max. Door Exit (w x h)	2.9 * 3.86 m	3.9 * 4.0 m	2.0 * 2.7 m	0.9 * 2.25 m	1.8 * 3.0 m	1.2 * 2.050 m
Shielding material	Sheet steel (Thickness:1.5mm on floor, 1.0 mm on walls and ceiling)	Sheet steel	Sheet steel	Sheet steel	Sheet steel	Sheet steel
Absorbers	Hybrid absorbers on walls and ceiling (TDK), length 1 m	Hybrid absorbers on walls and ceiling (E+C), length 0.5 m	Hybrid absorbers on walls and ceiling (E+C), length 0.3 m	Without absorbers	Without absorbers	Hybrid absorbers on walls and ceiling
Floor	Metallic ground plane floor load: 12 t/m ²	Metallic ground plane floor load: 1.5 t/m ²	Metallic ground plane floor load: 1 t/m ²	Metallic ground plane	Metallic ground plane	Metallic ground plane
Turntable	Ø 4 m / 7 t	Ø 3.2 m / 1.5 t	Ø 2.0 m / 1 t			
Listings		VCCI-listed Reg. No. R-12623, G-10266			VCCI-listed Reg. No. C-12866 T-11942	
Specials	Emission: 30 – 1000 MHz (d = 10 m) - NSA acc. to: • CISPR 16-1-4 • ANSI C63.4 1 – 18 GHz (d = 3 m) Site VSWR 1 – 18 GHz acc. to CISPR 16-1-4 Immunity: Field uniformity 27 – 6000 MHz acc. IEC/EN 61000-4-3	Emission: 30 – 1000 MHz (d = 3 m) - NSA acc. to: • CISPR 16-1-4 • ANSI C63.4 1 – 18 GHz (d = 3 m) Site VSWR 1 – 18 GHz acc. to CISPR 16-1-4 Immunity: Field uniformity 80 – 6000 MHz acc. IEC/EN 61000-4-3	Emission: 30 – 1000 MHz (d = 3 m) - NSA acc. to: • CISPR 16-1-4 • ANSI C63.4 1 – 18 GHz (d = 3 m) Site VSWR 1 – 18 GHz acc. to CISPR 16-1-4 Immunity: Field uniformity 80 – 6000 MHz acc. IEC/EN 61000-4-3			For automotive components only

FCC (Federal Communication Commission): Recognition by Bundesnetzagentur (BNetzA-CAB-14/21-09) and Designation as CAB (Conformity Assessment Body) : Designation Number DE0013; Test firm Registration #: 366296
Designation KBA (Kraftfahrt-Bundesamt) as Technical Service category A and D. Registration Number: KBA-P 00083-97
CB Testing Laboratory under the responsibility of SGS CEBEC as National Certification Body and to carry out testing within the IECEE CB Scheme .
Designation No. for RRR (Radio Research Agency) in Korea ; EU0145
VCCI Member No. 2793

5.2 Measuring Equipment

See the respective sections of Chapter 6, Results.

5.3 Test Setup

To perform the tests, a vectorial network analyzer (VNA) is used which is controlled via a software "Schirmdämpfung" based on Labview.
The software version is v2.24.

Prior to the measurement of a shielding effectiveness a reference measurement is done. For that the TX and RX antennas are positioned in the predefined distance to each other, connected to the VNA with the same cabling and preamplifiers (optional) as used during the subsequent measurements.

At each antenna, an attenuator pad is applied to improve the VSWR.

For measurement of the shielding effectiveness, the RX antenna is located inside the EUT in front of the selected measuring point with distances to metallic surfaces as large as possible. The TX antenna is positioned outside the EUT directly opposite so that the overall distance between the antennas is the same as during the reference measurement.

Now the measurement is started again, and the shielding effectiveness is calculated automatically by the software.

5.3.1 Testing above 20 GHz

In the frequency range above 20 GHz, instead of the VNA a signal generator together with a frequency doubler was used as sender. The receiving antenna was connected to a receiver R&S ESU40.

In this frequency range, no automatic measurement is possible. Therefore, the shielding effectiveness in this frequency range is performed manually at selected frequencies.

5.4 Measurement Uncertainty

As far as the underlying standards include requirements concerning the uncertainty of measuring instruments or measuring methods, they are met.

The expanded measurement uncertainty of the measuring chain was calculated for all tests according to the "ISO Guide to the expression of uncertainty in measurement (GUM)". The results are documented in an "internal controlled document".

The measuring accuracy for all measuring devices is given in their technical description. The measuring instruments, including any accessories, are calibrated respectively verified to ensure the necessary accuracy. Depending on the kind of measuring equipment it is checked within regular intervals or directly before the measurement is performed. Adjustments are made and correction factors applied to measured data in accordance with the specifications of the specific instrument.

The expanded measurement instrumentation uncertainty of our Test Laboratory meets the requirements of IEC CISPR 16-4-2 "Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modeling – Uncertainty in EMC measurements" for all listed tests.

5.5 Statement of Conformity & Decision Rule

If not otherwise stated, the Decision Rule is considered in different ways.

Emission based on CISPR 11, CISPR 14-1, CISPR 15, CISPR 32, CISPR 36, IEC 61000-6-3, IEC 61000-6-4:

The decision rule for statement of conformity is based on U_{CISPR} given in CISPR 16-4-2. The relevant MIU (Measurement Instrumentation Uncertainty) calculations U_{LAB} of the EMC-lab for the single emission tests is below U_{CISPR} . Therefore, it can be considered that the measurement result is valid without any need of adaption and e.g., a result of 0 dB to the limit can be stated as pass.

All other emission tests:

For all other emission tests, the relevant MIU have been calculated by the EMC-lab and U_{LAB} keep typical levels. In this case, the "Binary Statement for Simple Acceptance Rule" acc. 4.2.1 of ILAC G8:2019 is applied. The result can be considered to be passed if the measurement value is at least equal to the limit. Probability is only 50% in this case. If the measured value is below the limit by the amount of the measurement uncertainty, the risk of an incorrect assumption is already reduced to 2.5%.

Immunity

The calculated MIU U_{LAB} of the test levels are according to the requirements of the corresponding test standards. As the influence of the characteristics of the test disturbance is not known and the DUT shows non-linear system behaviour in most cases, no decision rule can be stated for immunity tests.

6 Results

The test results in the report refer exclusively to the test object described in section 4 and the test period in section 3.3. The results apply to the sample(s) as received.

6.1 Summary of Results

The EM code acc. to IEC 61000-5-7 derived from the results of shielding effectiveness measurements is

EM122211

Table 1-1 shows the minimum shielding effectiveness in the Frequency Bands acc. to IEC 61000-5-7 and the correlated shielding designator levels.

Frequency Band (MHz)	Shielding designator	Minimum shielding effectiveness (dB) ³	Shielding designator level
0.01 – 0.1	A	15,4	1
0.1 – 1	B	20,7	2
1 – 30	C	21.1	2
30 – 1,000	D	20.1	2
1,000 – 10,000	E	15.4	1
10,000 – 40,000	F	10.4	1

Table 6-1

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³ Read from smoothed results.

6.2 0.01 – 30 MHz

Tested by : Pauli

Test date : 2023-05-25

Test location : EMC chamber No. 3

6.2.1 Test Setup

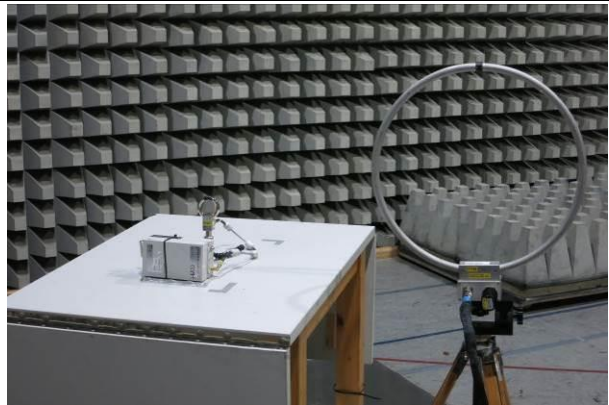
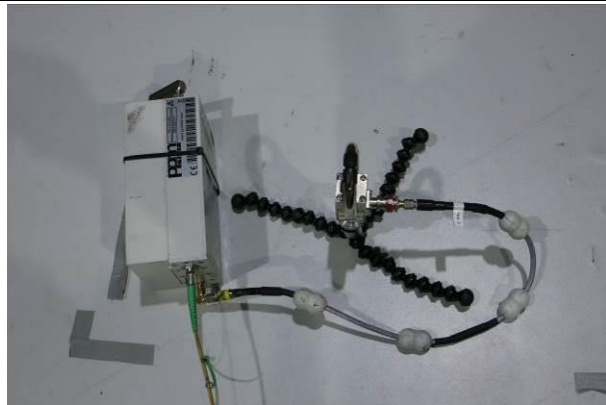
- Antenna distance = 0.42 m (between outer diameter of TX loop and center of RX loop)
- TX Antenna height = 1.07 m (center)
- RX Antenna height = 0.94 m (center)
- no preamp in RX path for Reference measurements
- preamp P1182 in RX path for EUT measurements
- amplifier P1087 (25W) @ TX antenna
- no attenuator at TX antenna
- no attenuator @ RX antenna
- measuring bandwidth = 10Hz
- Number of points = 401

6.2.2 Measuring Equipment

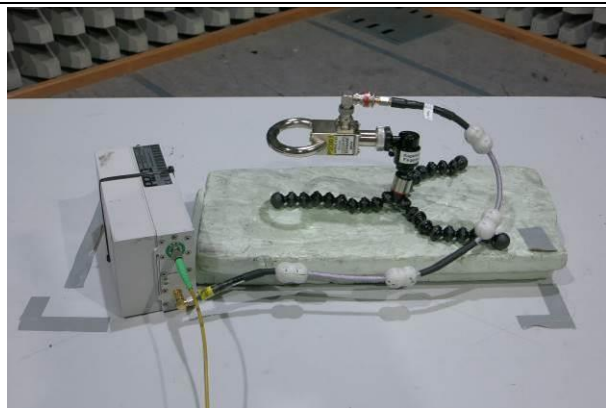
ID	Measuring Instrument	Specification	Status	Due date
P1728	antenna	9 kHz - 30 MHz	cnn	
P2361	Passive RX-Loop Antenna	9 kHz - 400 MHz, 1 turn, loop diameter 50 mm	cal	Jun 30, 2024
P1944	Point2Point - AC Coupled Fibre Optic Link	2 kHz to 1.35 GHz, 0 dBm Input/Output	chk	Jan 31, 2025
P1547	Network Analyzer	9 kHz - 4 GHz	cal	Mar 31, 2024
P1182	preamplifier	9 kHz - 1000 MHz, 32dB gain, +10dBm	cal	Mar 31, 2024
P1087	amplifier	0.01 - 100 MHz, 25 W	cnn	
P2541	Coax cable 4m (with ferrites)	50 Ohm, 3GHz	cnn	
P1808	Surface current blocking filter	1 m / 11 ferrites, with polyester mesh, L = 1.4m	chk	Jun 30, 2023
P1944	Point2Point - AC Coupled Fibre Optic Link	2 kHz to 1.35 GHz, 0 dBm Input/Output	chk	Jan 31, 2025
P2506	coax cable, L = 0.5m	DC - 2 GHz, 0.56dB @ 2GHz, SMA, with ferrites	cnn	
P2578	coax cable 0.45 m, N - SMA	DC - 18 GHz, 0.8 dB @ 18 GHz	cnn	
P2517	coax cable, L = 0,5m, N	DC - 6GHz, 0,6dB@6GHz, N	cnn	
P0338	EMC chamber 3	7.4 x 6.6 x 5.2 m (net), 0.4 m hybrid absorbers	chk	

cal = Calibration, car = Calibration restricted use, chk = Check, chr = Check restricted use, cpu = Check prior to use, calchk = Calibration and check, ind = for indication only, cnn = Calibration not necessary, service = Wartung (Service), man = Maintenance, calservice = Calibration & Service, chkservice = Check & Service, calchkservice = Calibration & Check & Service

6.2.3 Photographs of test setup for reference measurements



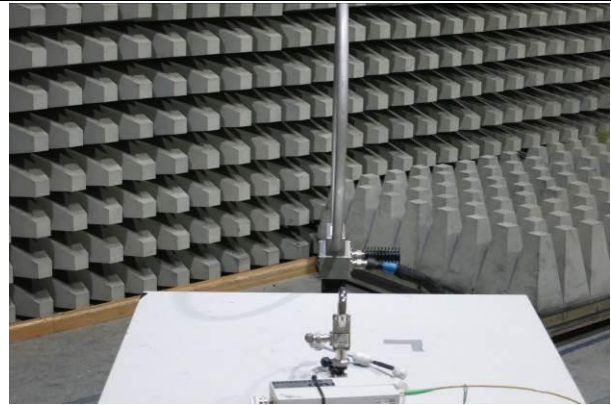
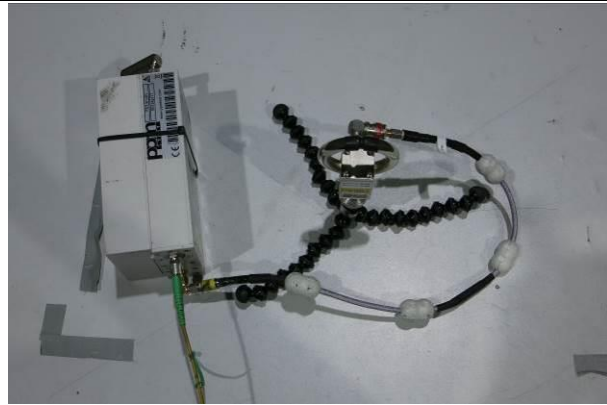
vertical



horizontal

Figure 6-1: test setup reference measurements for position front/top

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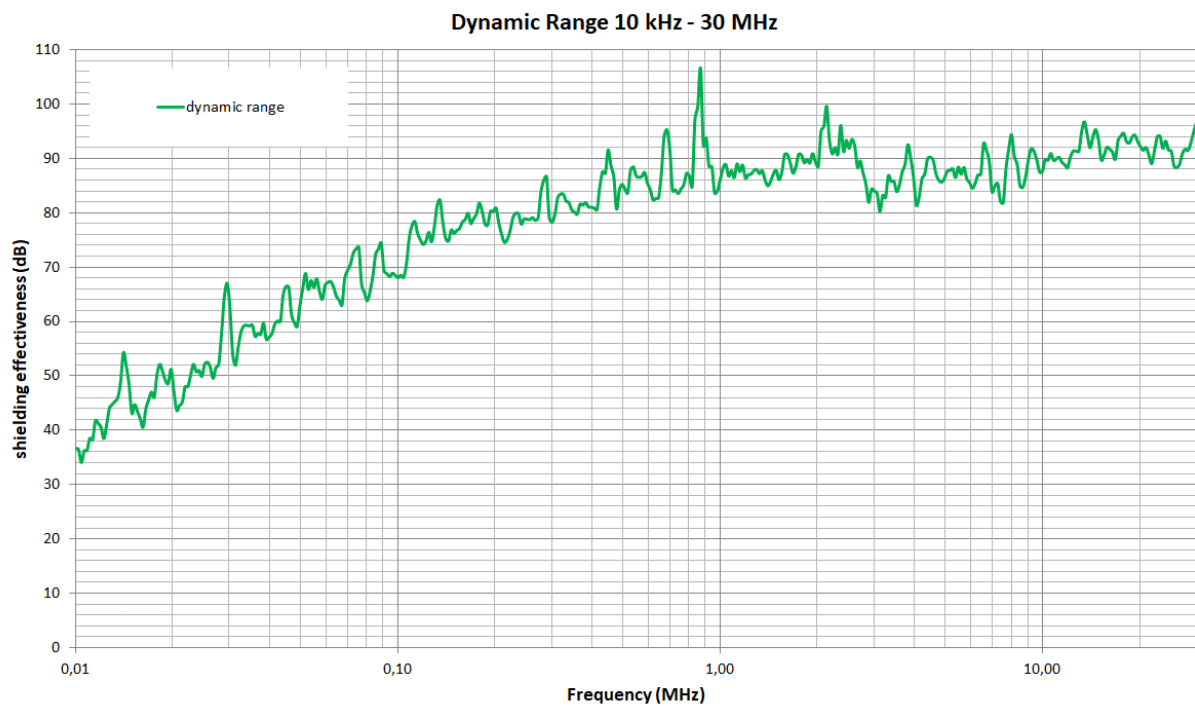
vertical



horizontal

Figure 6-2: test setup reference measurements for position side

6.2.4 Dynamic range



6.2.5 Test Results

6.2.5.1 Front

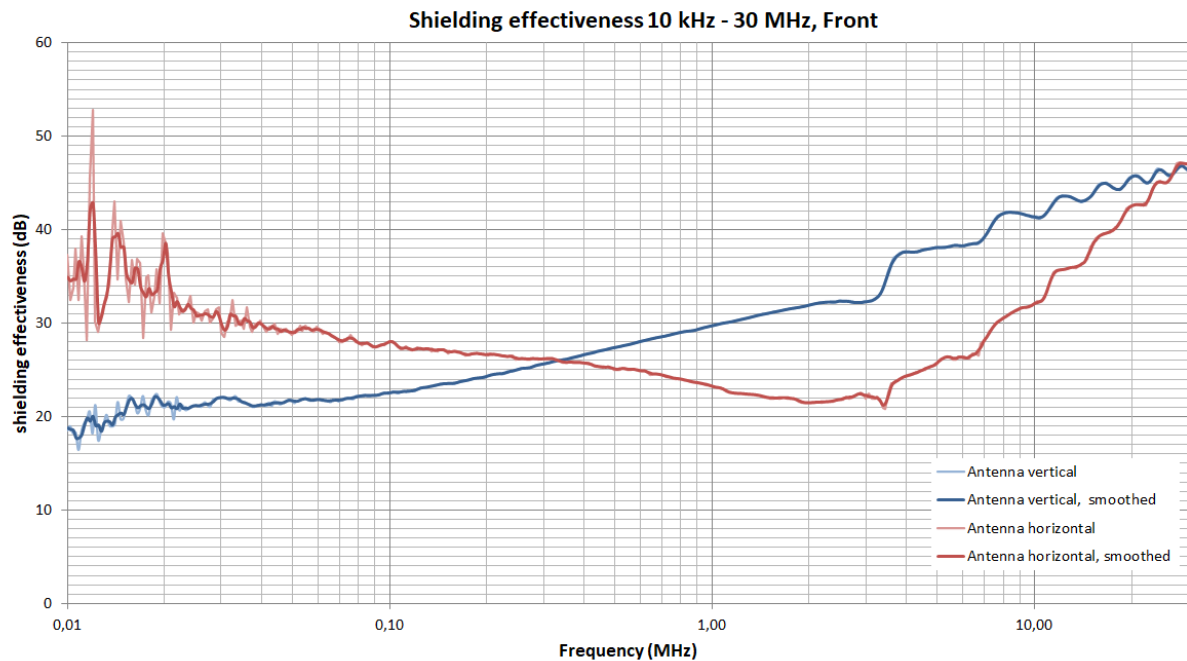


Photo documentation of the test set-up:

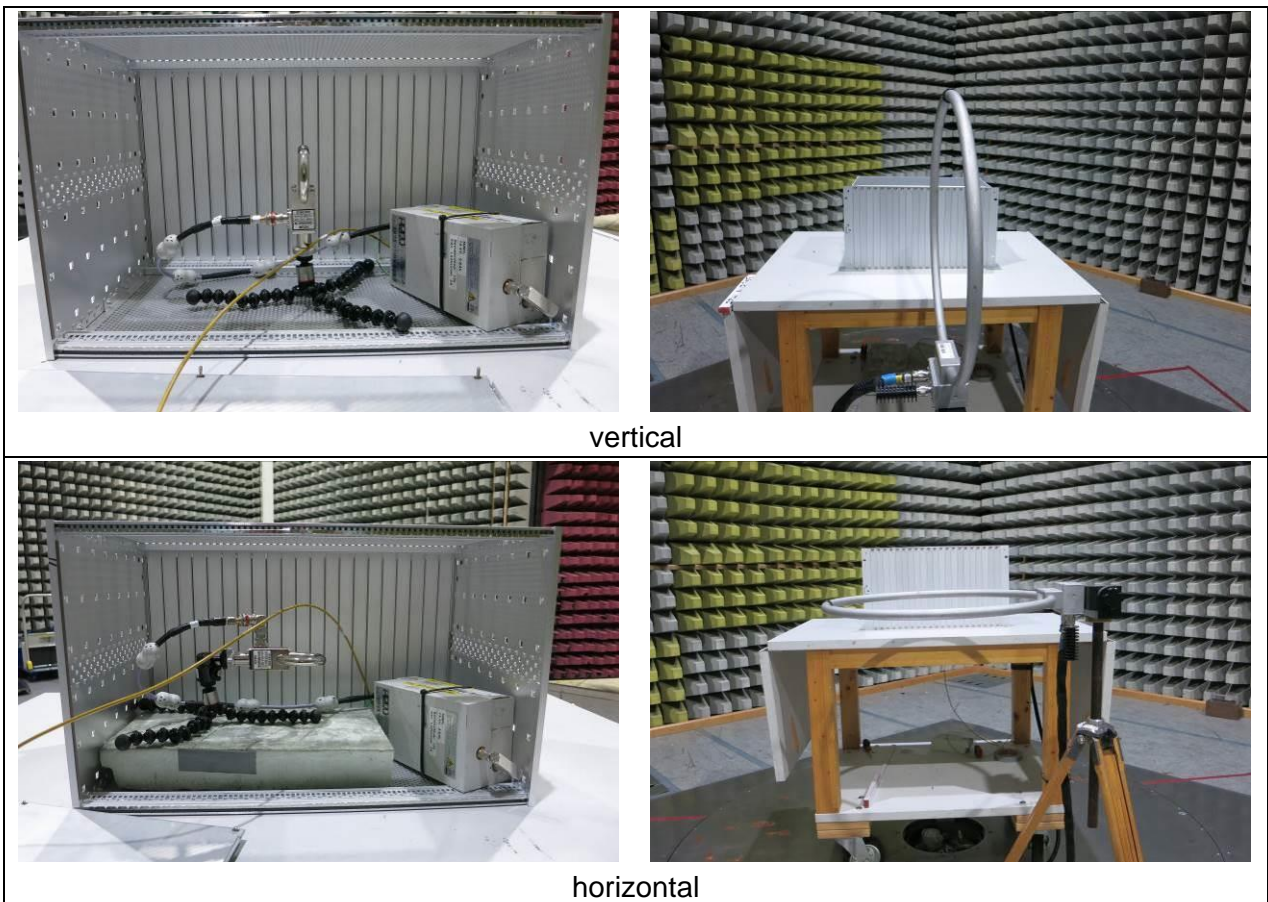


Figure 6-3: test setup 0.01 – 30 MHz

6.2.5.2 Side

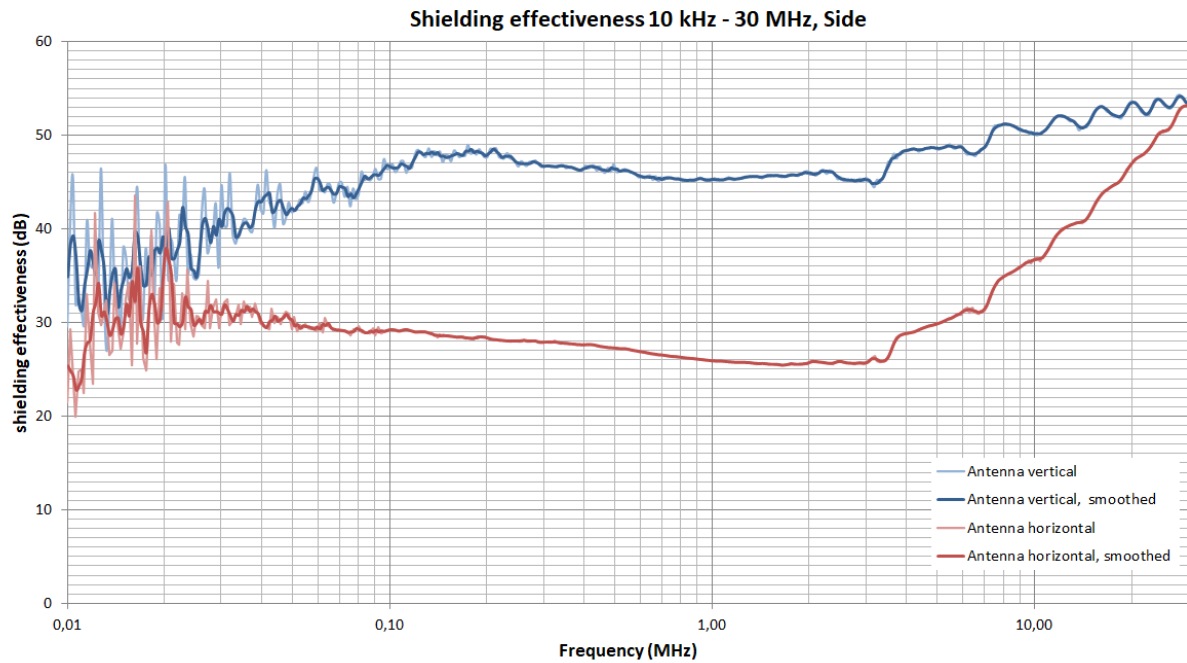


Photo documentation of the test set-up:

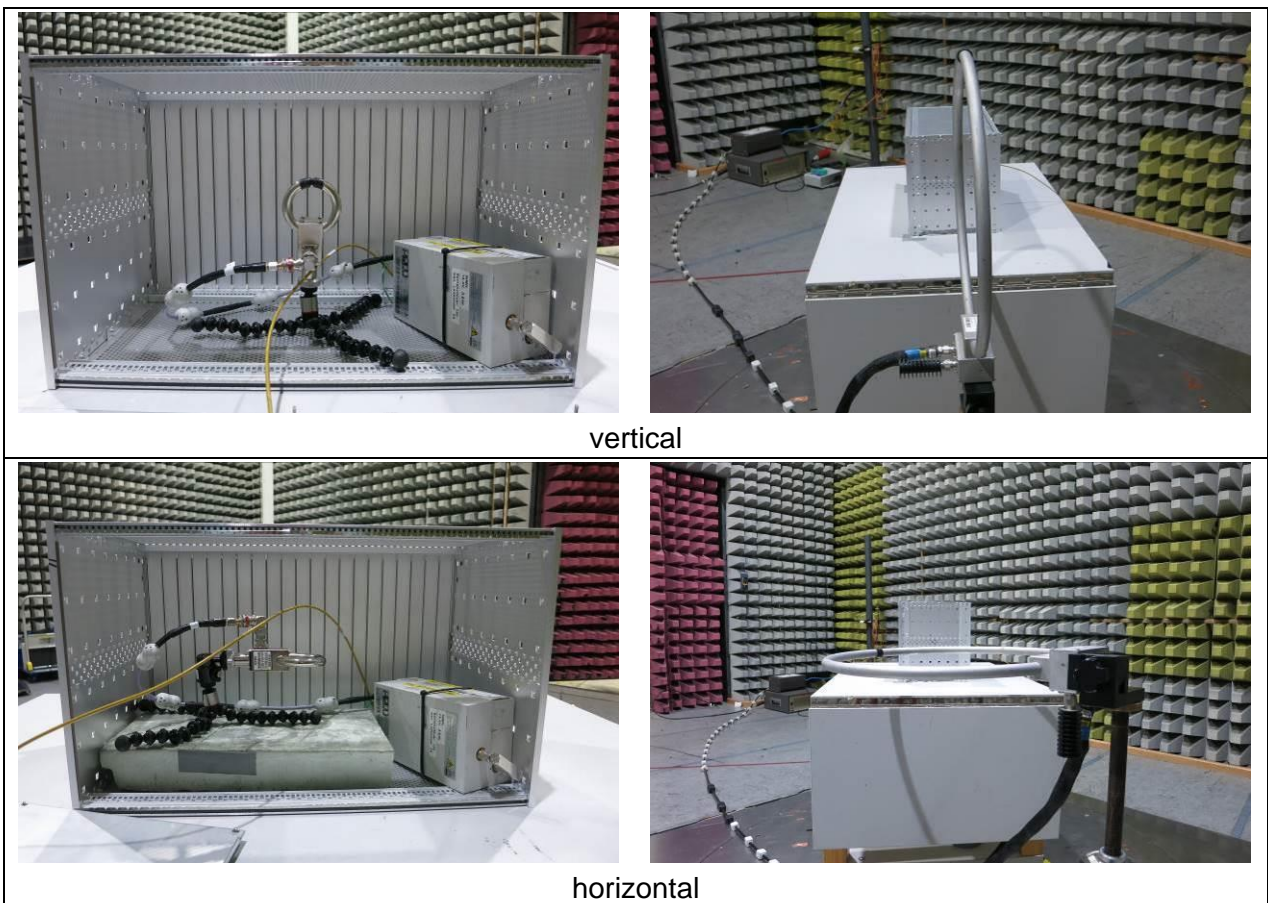


Figure 6-4: test setup 0.01 – 30 MHz

6.2.5.3 Top

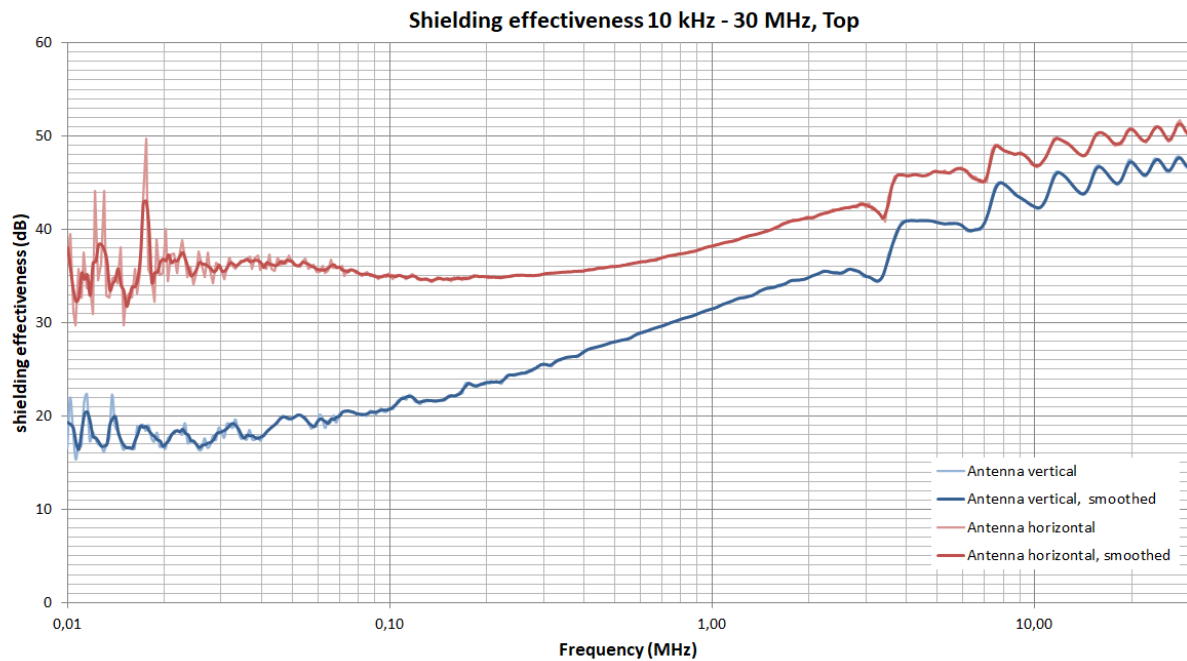
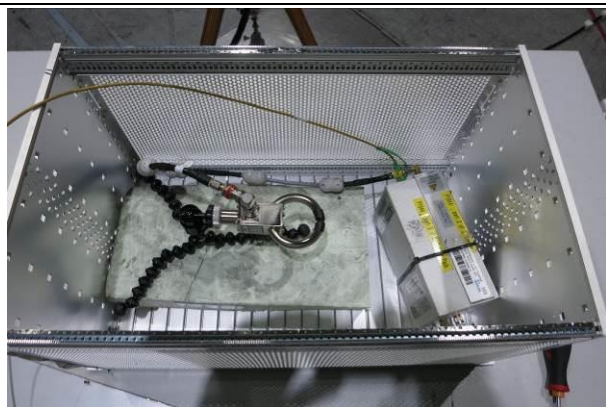
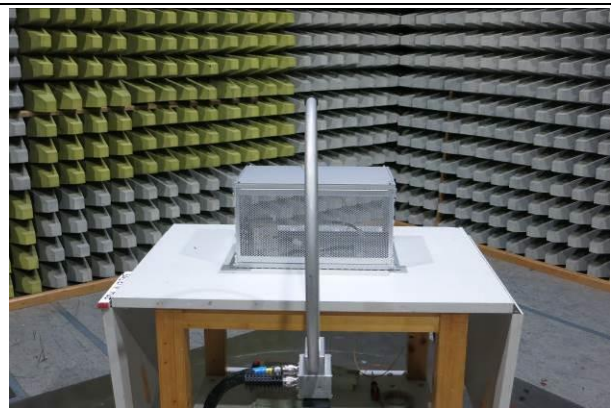


Photo documentation of the test set-up:



vertical



horizontal

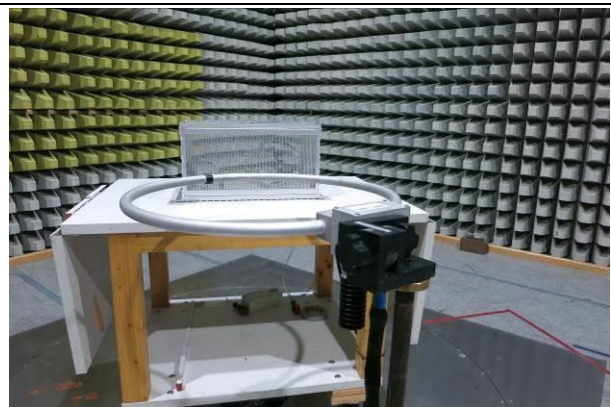
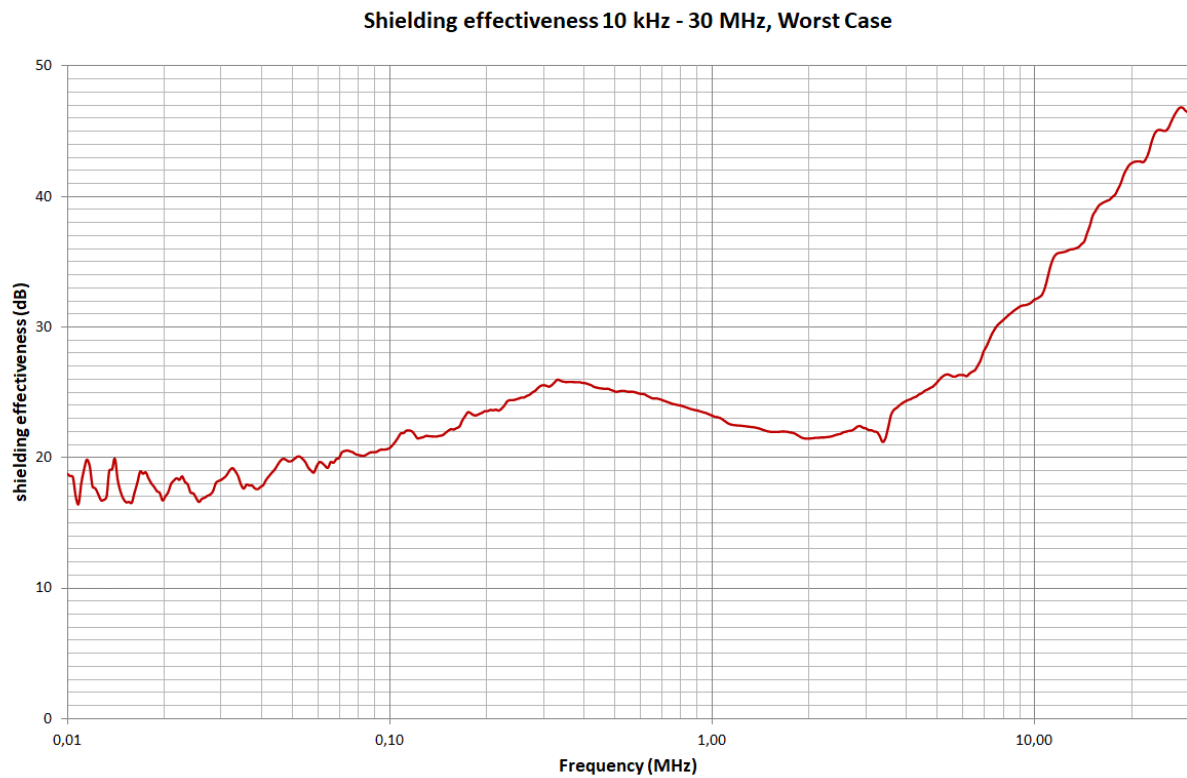


Figure 6-5: test setup 0.01 – 30 MHz

6.2.5.4 Worst case

The figure below shows the worst case of shielding effectiveness, that means the lowest value of all positions and antenna polarisations at each frequency:



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6.3 30 – 1000 MHz

Tested by : Pauli

Test date : 2023-05-24

Test location : EMC chamber No. 3

6.3.1 Test Setup

- Antenna distance = 2.50 m (between center of biconical ant. and reference point of Bilog.)
- Antenna height = 0.93 m
- no preamp in RX path for Reference measurements
- preamp P1182 (sonoma) in RX path for EUT measurements
- amplifier P0680 (10 W) @ TX antenna (with 10dB attenuator at output)
- no attenuator at TX antenna
- 6dB attenuator @ RX antenna
- measuring bandwidth = 30Hz
- Number of points = 801

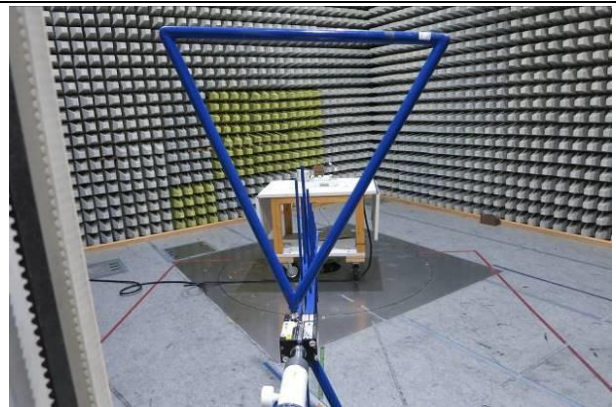
6.3.2 Measuring Equipment

ID	Measuring Instrument	Specification	Status	Due date
P2541	Coax cable 4m (with ferrites)	50 Ohm, 3GHz	cnn	
P1808	Surface current blocking filter	1 m / 11 ferrites, with polyester mesh, L = 1.4m	chk	Jun 30, 2023
P0029	antenna	1 - 12.4 GHz	chk	Oct 31, 2024
N0925	antenna cubic, 86 x 86 x 99 mm (122 mm incl. 90°-Adapter SMA)	Cubic Dipole Antenna	cnn	
P1727	attenuator 6dB	6 dB, 5.5 W, 0 - 18 GHz	chk	Jul 31, 2023
P1944	Point2Point - AC Coupled Fibre Optic Link	2 kHz to 1.35 GHz, 0 dBm Input/Output	chk	Jan 31, 2025
P2506	coax cable, L = 0.5m	DC - 2 GHz, 0.56dB @ 2GHz, SMA, with ferrites	cnn	
P1547	Network Analyzer	9 kHz - 4 GHz	cal	Mar 31, 2024
P2713	attenuator, 3 dB	Type N, 3 dB, 5 W, dc-18.GHz	chk	Feb 29, 2024
P0680	amplifier	1 - 1000 MHz	cnn	
P1714	attenuator 10dB	10 dB/ 50 W	chk	Feb 29, 2024
P2739	coax cable, L = '2m	DC - 6 GHz, 2dB @ 6GHz	cnn	
P2541	Coax cable 4m (with ferrites)	50 Ohm, 3GHz	cnn	
P2578	coax cable 0.45 m, N - SMA	DC - 18 GHz, 0.8 dB @ 18 GHz	cnn	
P2517	coax cable, L = 0,5m, N	DC - 6GHz, 0,6dB@6GHz, N	cnn	
P0338	EMC chamber 3	7.4 x 6.6 x 5.2 m (net), 0.4 m hybrid absorbers	chk	

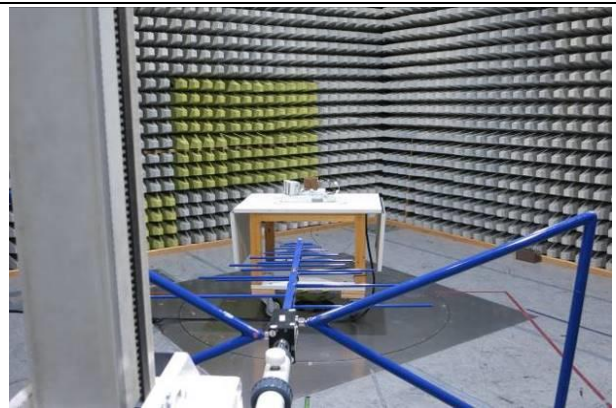
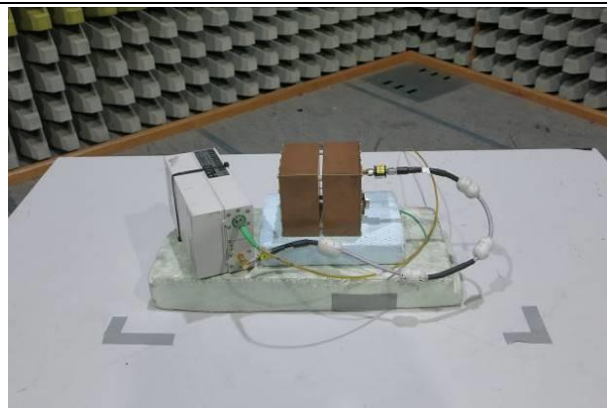
cal = Calibration, car = Calibration restricted use, chk = Check, chr = Check restricted use, cpu = Check prior to use, calchk = Calibration and check, ind = for indication only, cnn = Calibration not necessary, service = Wartung (Service), man = Maintenance, calservice = Calibration & Service, chkservice = Check & Service, calchkservice = Calibration & Check & Service

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6.3.3 Photographs of test setup for reference measurements



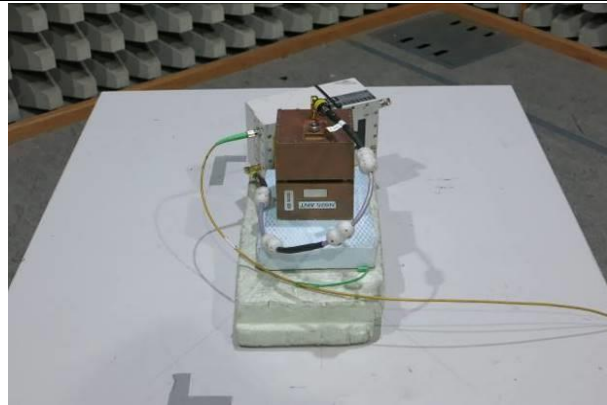
vertical



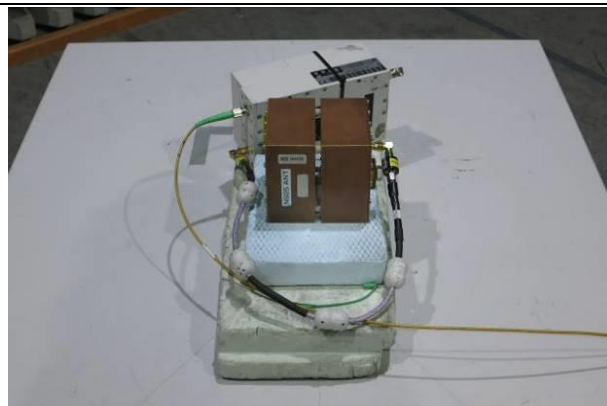
horizontal

Figure 6-6: test setup reference measurements for position front/top

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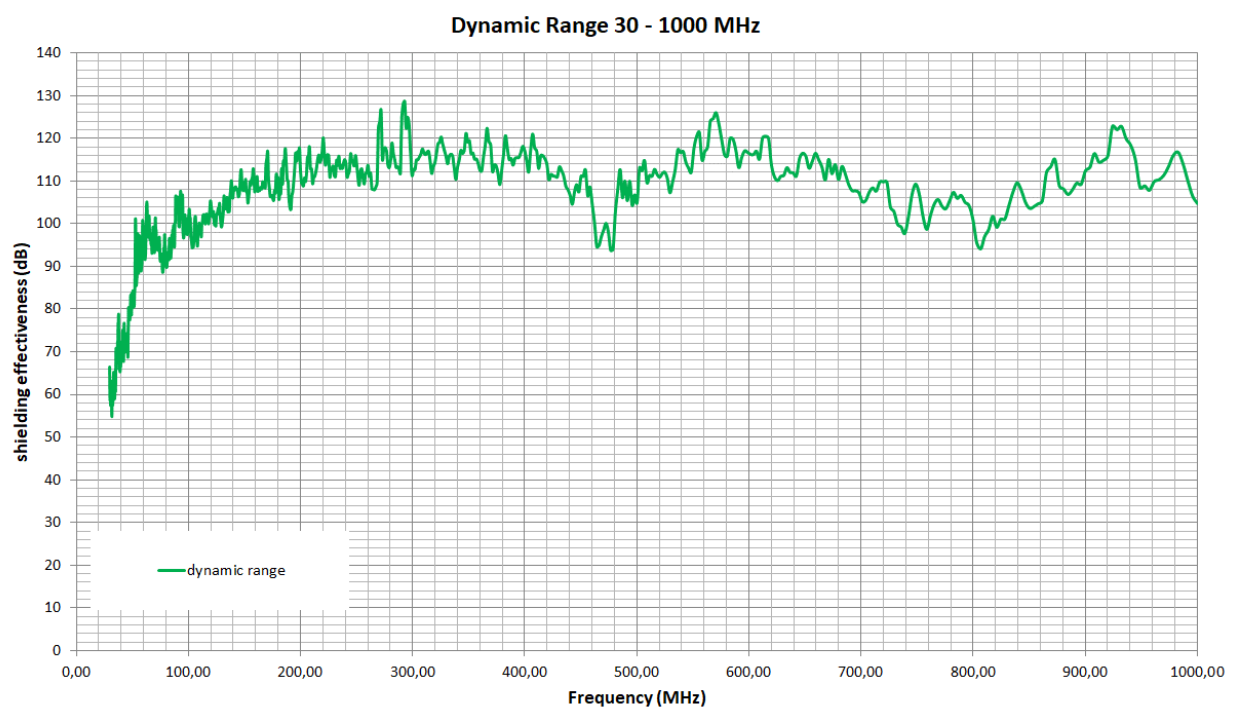
vertical



horizontal

Figure 6-7: test setup reference measurements for position side

6.3.4 Dynamic range



6.3.5 Test Results

6.3.5.1 Front

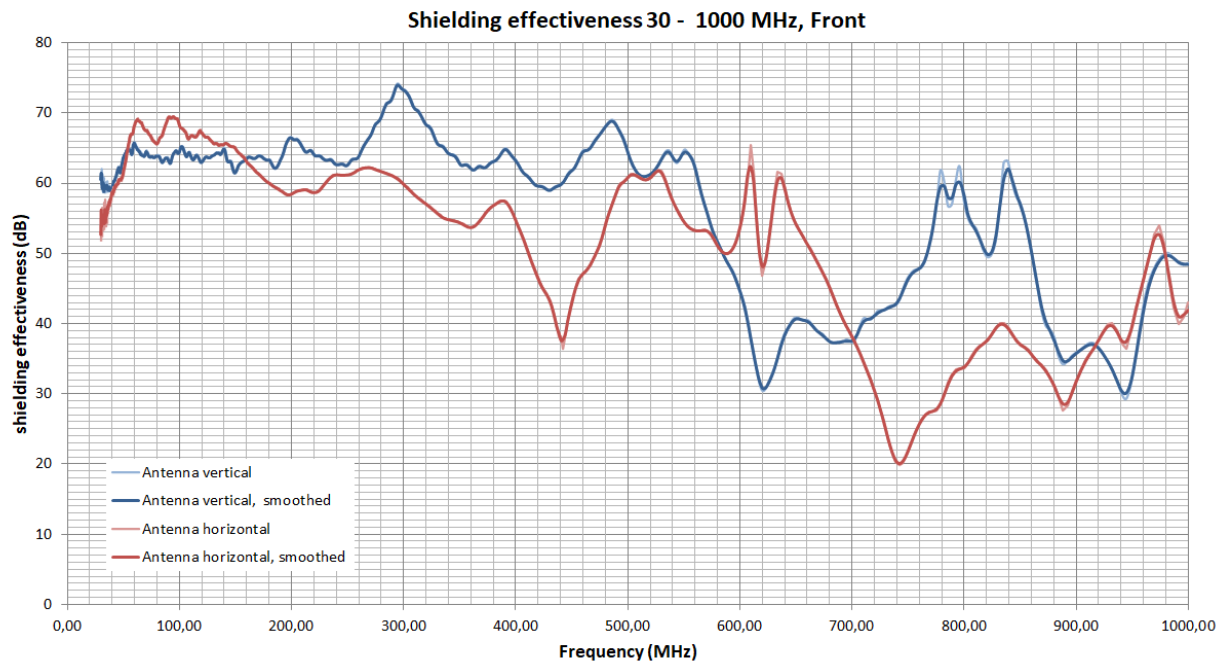


Photo documentation of the test set-up:

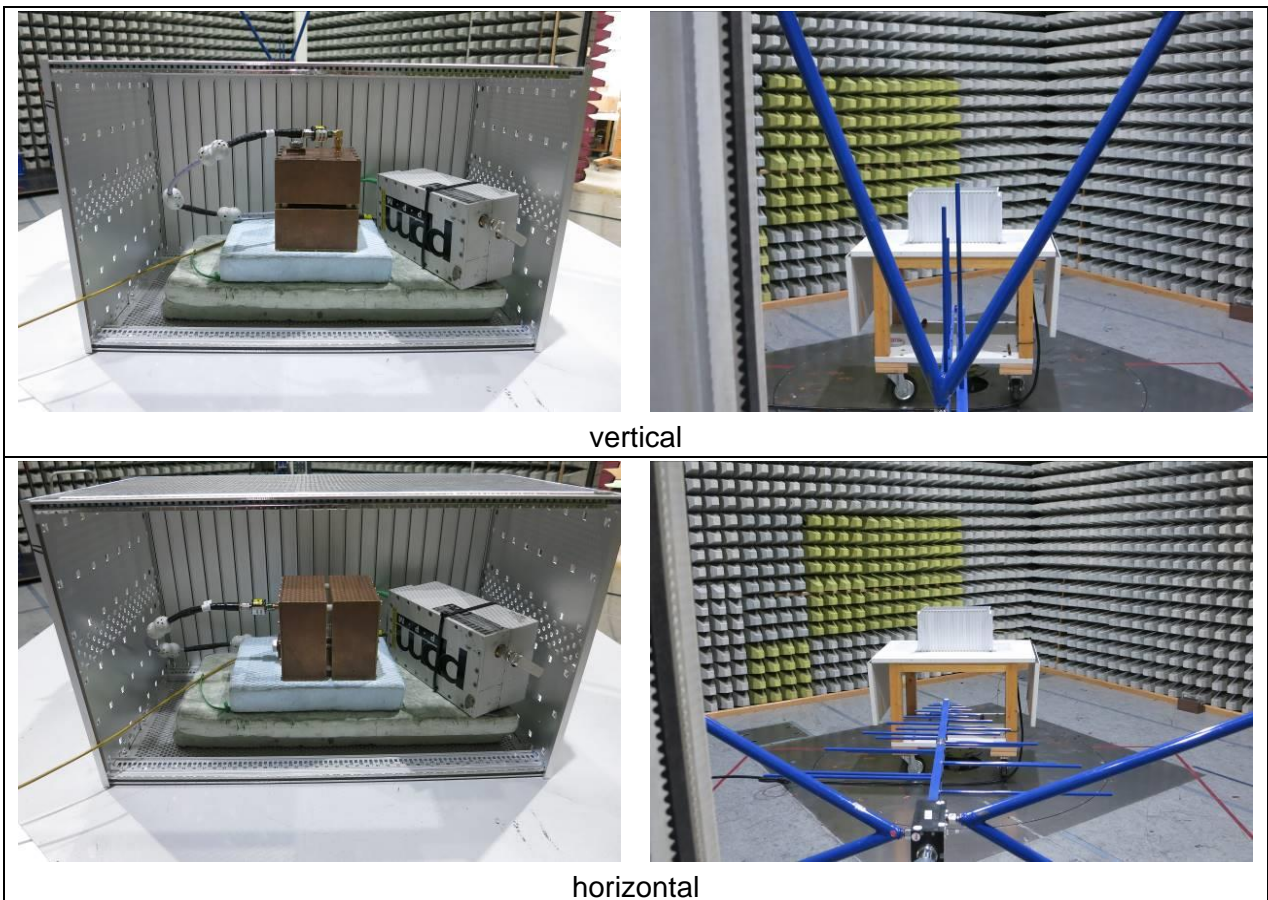


Figure 6-8: test setup 30 – 1000 MHz

6.3.5.2 Side

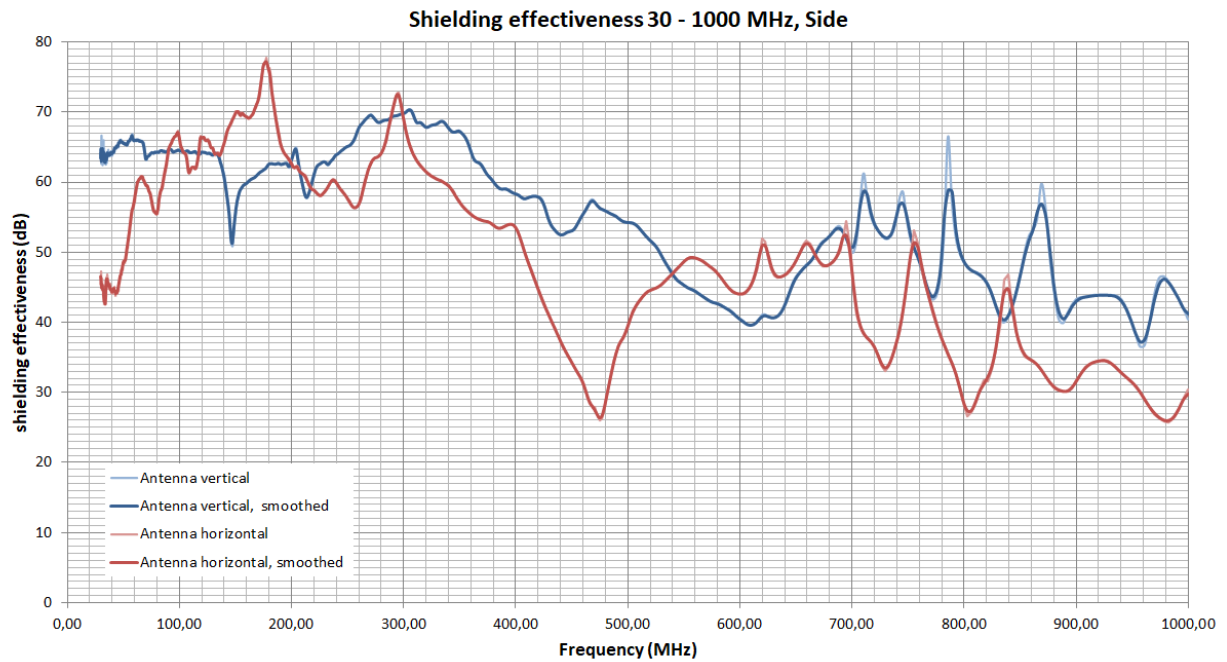
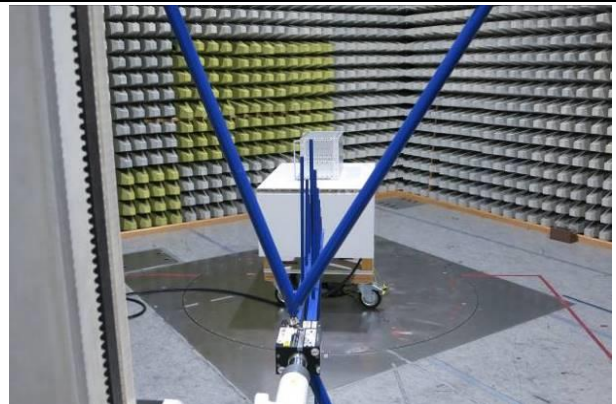
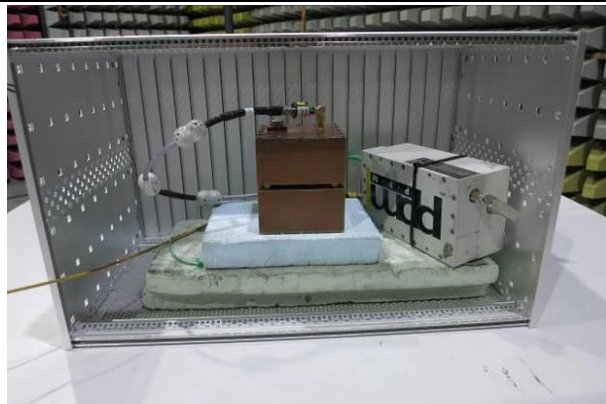
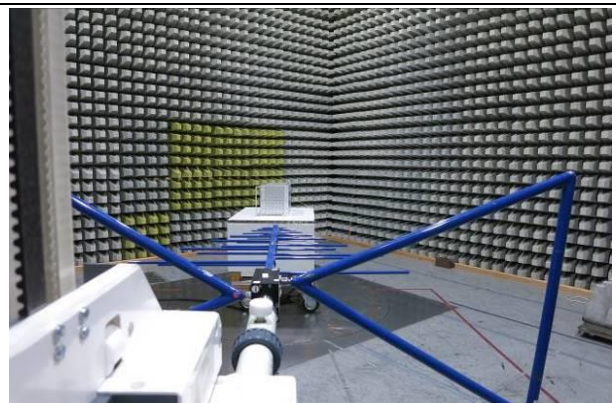


Photo documentation of the test set-up:



vertical



horizontal

Figure 6-9: test setup 30 – 1000 MHz

6.3.5.3 Top

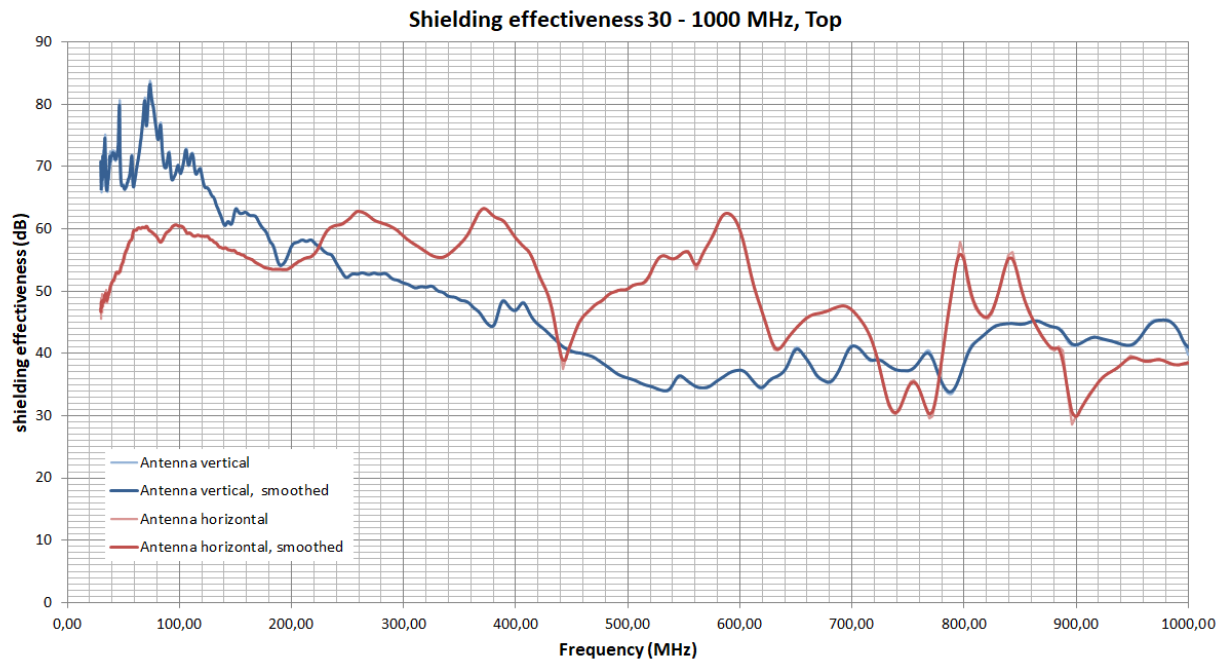
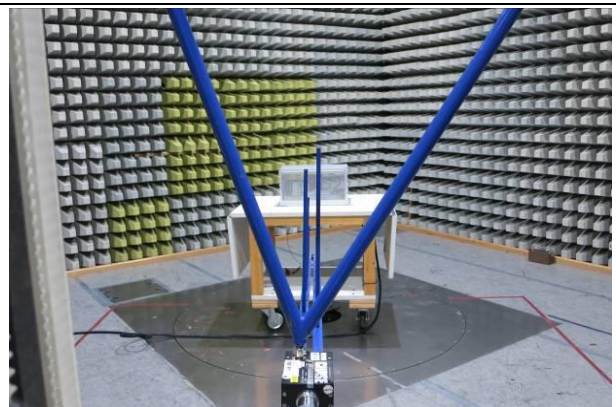
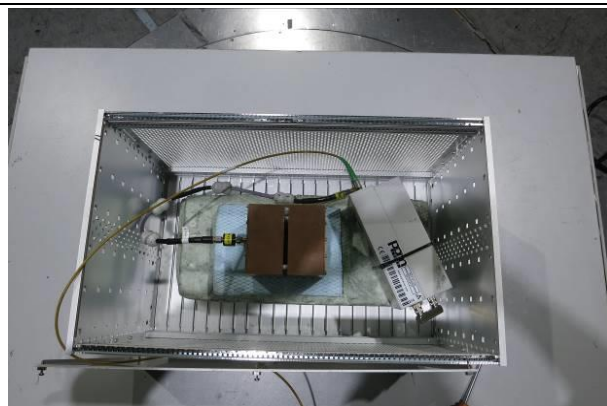


Photo documentation of the test set-up:



vertical



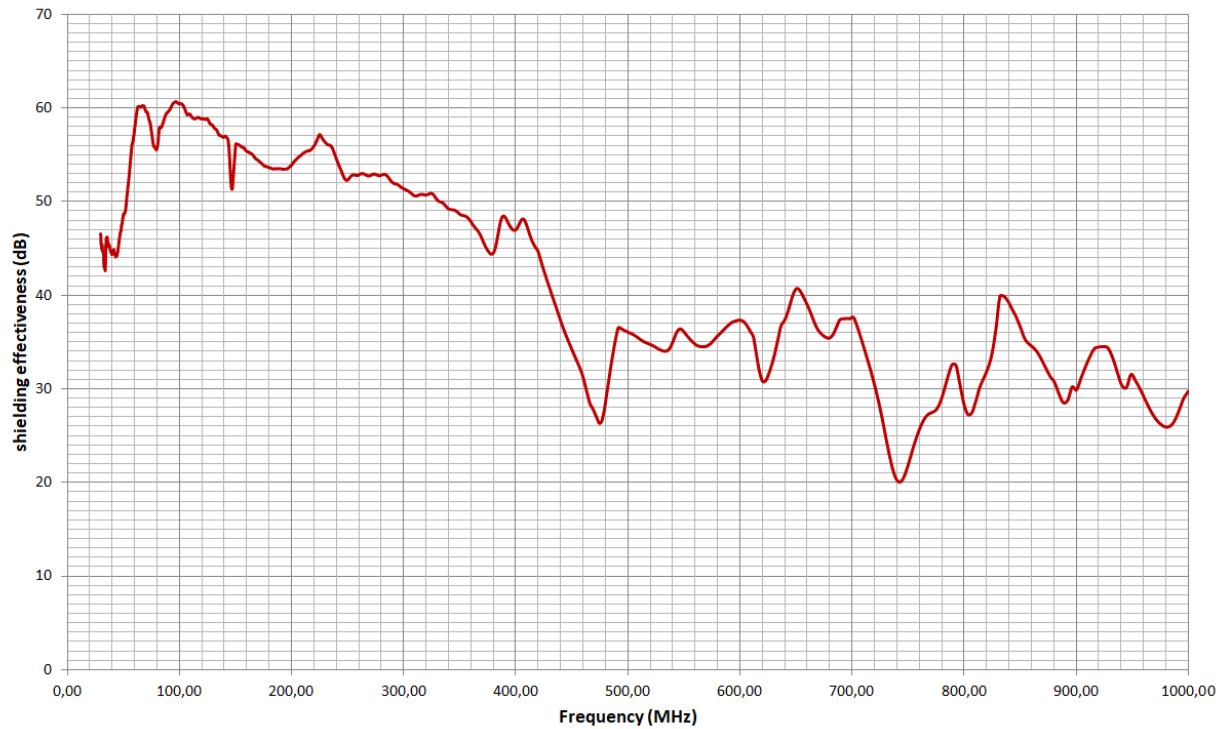
horizontal

Figure 6-10: test setup 30 – 1000 MHz

6.3.5.4 Worst case

The figure below shows the worst case of shielding effectiveness, that means the lowest value of all positions and antenna polarisations at each frequency:

Shielding effectiveness 30 - 1000 MHz, worst case



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6.4 1 – 18 GHz

Tested by : Pauli

Test date : 2023-05-25

Test location : EMC chamber No. 3

6.4.1 Test Setup

- Antenna distance = 2.00 m (front to front)
- Antenna height = 1.00 m
- no preamp in RX path for Reference measurements
- no preamp @ TX antenna
- no attenuator @ TX antenna
- no attenuator @ RX antenna
- measuring bandwidth = 100Hz
- Number of points = 801

6.4.2 Measuring Equipment

ID	Measuring Instrument	Specification	Status	Due date
P1634	Network analyzer	10 MHz - 20 GHz, 4 Channels incl. active test set	cal	Mar 31, 2024
P1575	antenna (MZ2)	0.85 GHz - 26.5 GHz	cal	Jul 31, 2024
P0940	antenna (MZ1)	1 - 18 GHz	ind	
P1070	coax cable, L = 1m, N	DC - 18 GHz, 1.8dB@18GHz	cnn	
P1953	coax cable 2m, ruggedized	DC-18GHz, 2.5dB@18GHz	chk	Jun 30, 2023
P1949	coax cable 3m	DC-18GHz, 3.3dB@18GHz	chk	Jun 30, 2023
P2512	coax cable, L = 1,5m	DC - 18GHz, 2.1dB @ 18 GHz, SMA	cnn	
P2652	coax cable 3m, ruggedized	DC-18GHz, 3.30dB@18GHz	chk	Aug 31, 2024
P2653	coax cable 5m, ruggedized	DC-18GHz, 5.45dB@18GHz	chk	Aug 31, 2024
P2518	coax cable, L = 2m, N	DC - 18 GHz, 2.8dB @ 18GHz	cnn	
P1650	preamplifier (MZ3)	0.1 - 20GHz, gain ca. 28dB	cal	Mar 31, 2025
P0338	EMC chamber 3	7.4 x 6.6 x 5.2 m (net), 0.4 m hybrid absorbers	chk	

cal = Calibration, car = Calibration restricted use, chk = Check, chr = Check restricted use, cpu = Check prior to use, calchk = Calibration and check, ind = for indication only, cnn = Calibration not necessary, service = Wartung (Service), man = Maintenance, calservice = Calibration & Service, chkservice = Check & Service, calchkservice = Calibration & Check & Service

6.4.3 Photographs of test setup for reference measurements

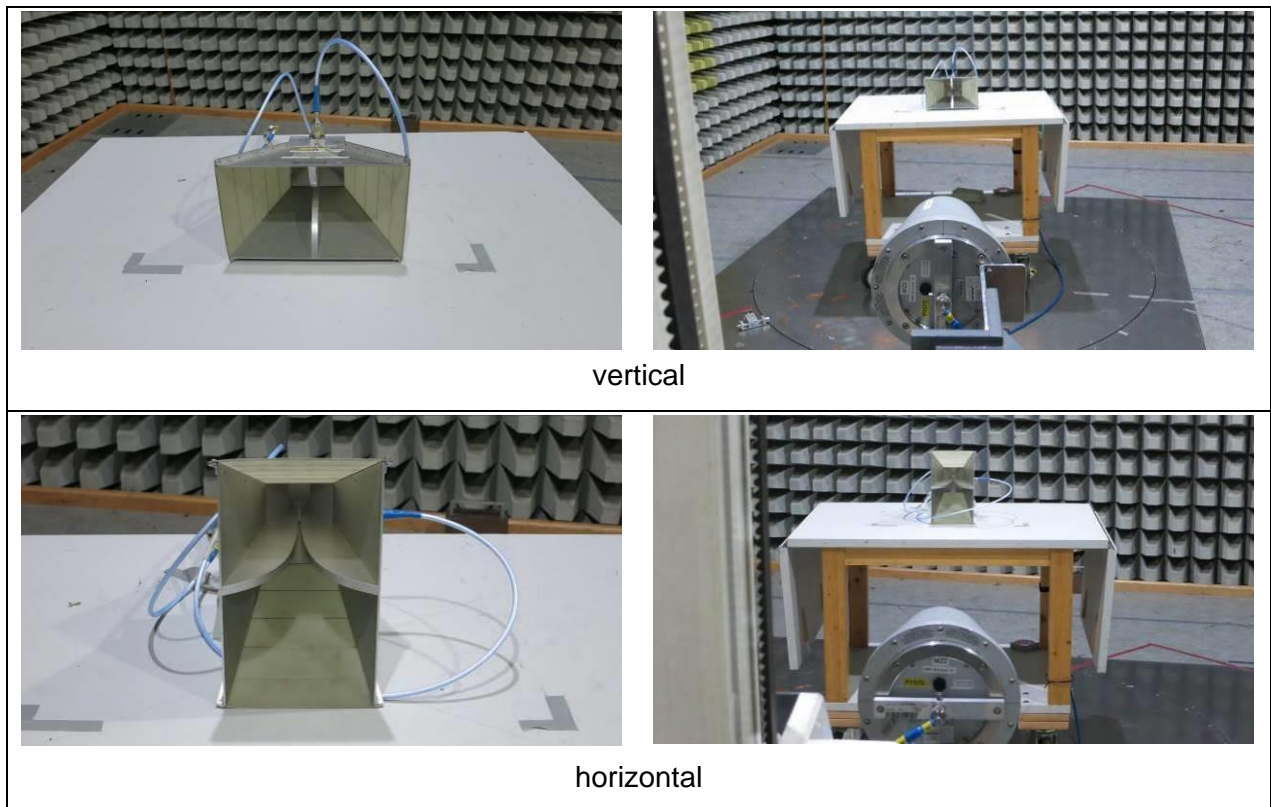
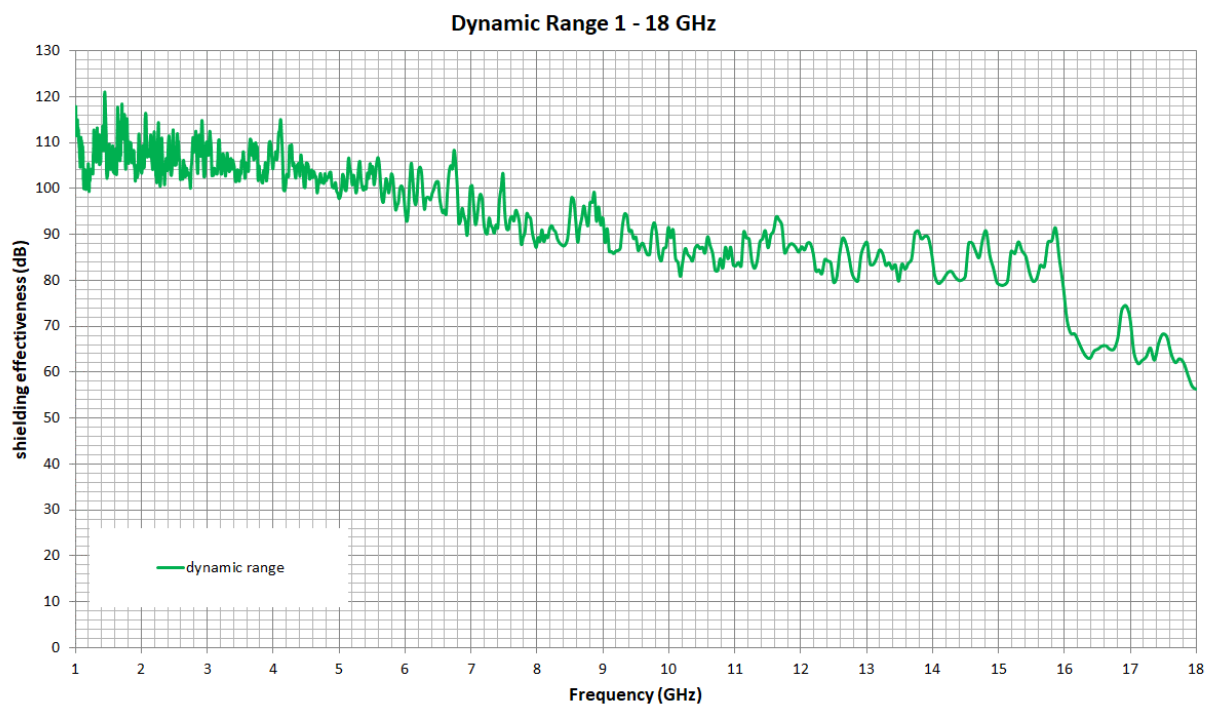


Figure 6-11: test setup reference measurements (for all positions)

6.4.4 Dynamic range



6.4.5 Test Results

6.4.5.1 Front

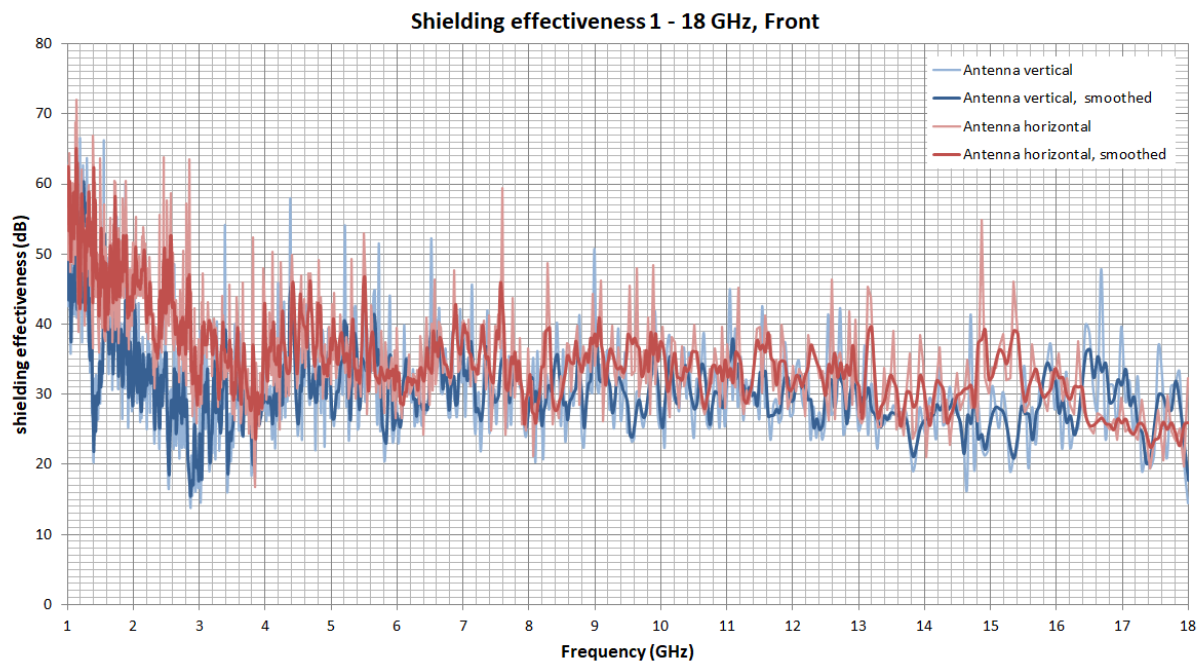


Photo documentation of the test set-up:

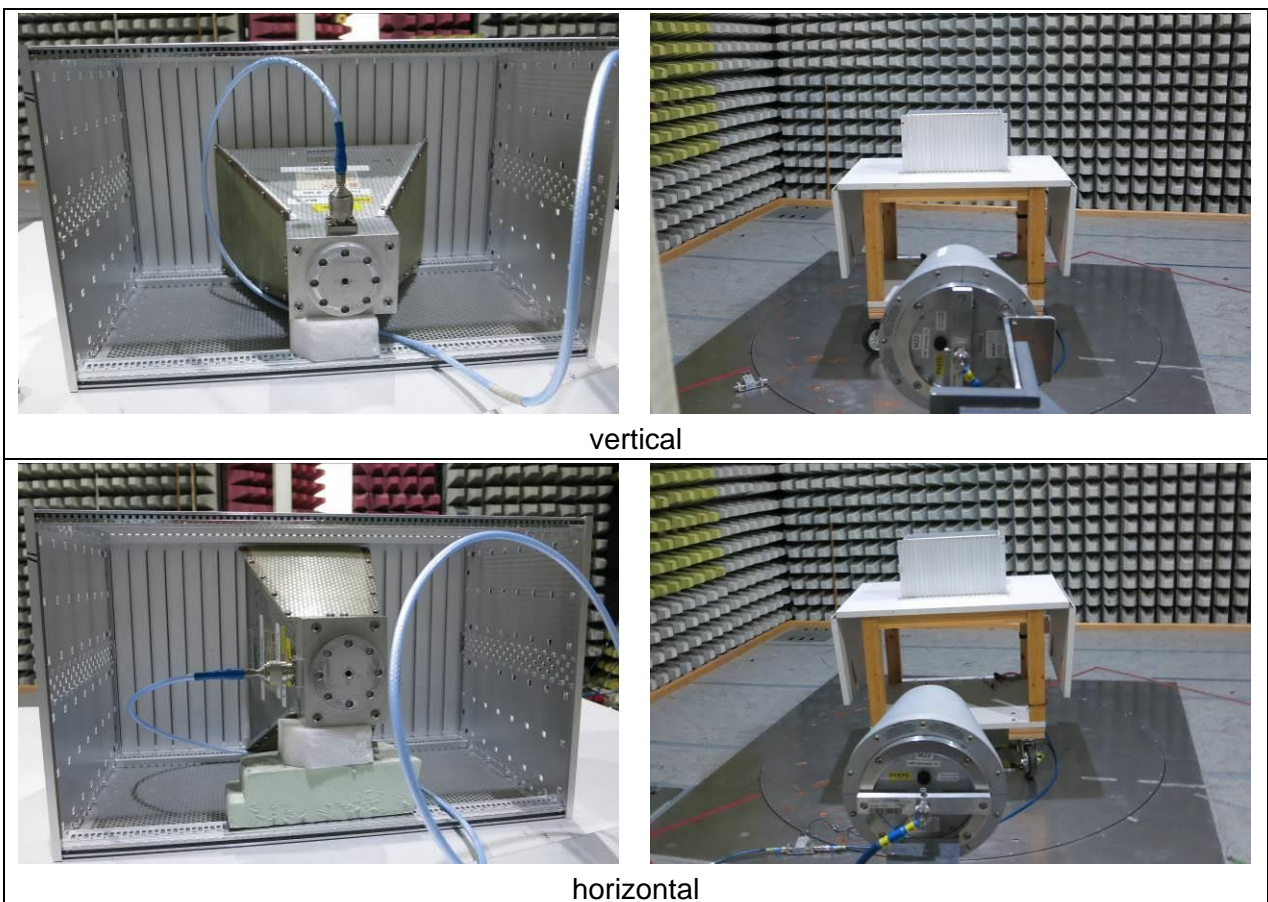


Figure 6-12: test setup 1 – 18 GHz

6.4.5.2 Side

Due to the dimensions of EUT it was not possible to place the RX antenna inside the EUT in vertical polarisation. Therefore, only a measurement in horizontal polarisation could be done.

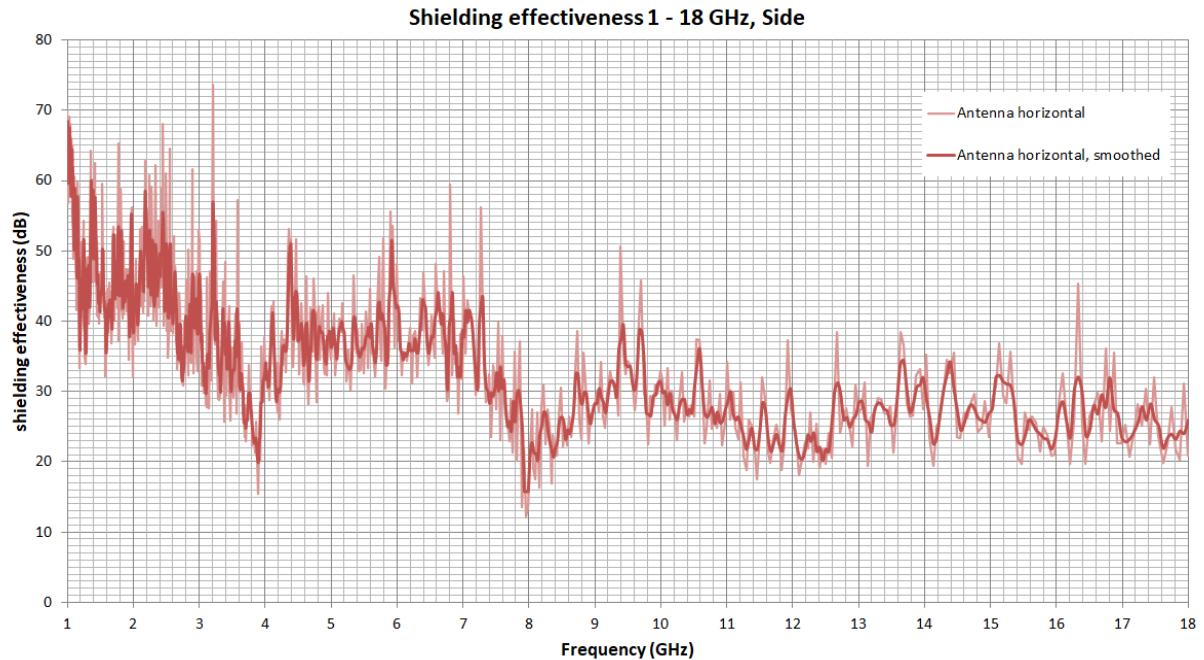


Photo documentation of the test set-up:

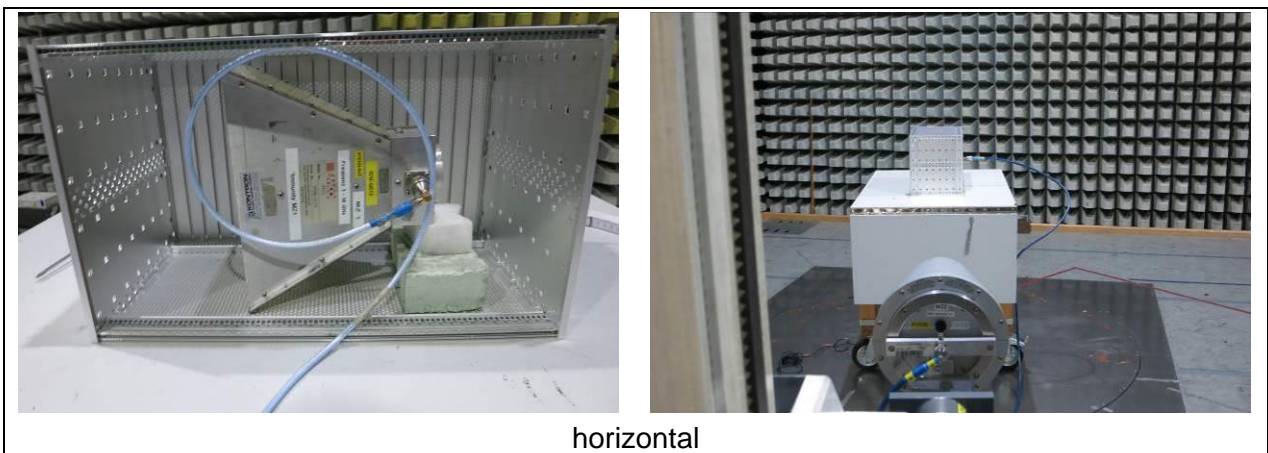


Figure 6-13: test setup 1 – 18 GHz

6.4.5.3 Top

Due to the dimensions of EUT it was not possible to place the RX antenna inside the EUT in horizontal polarisation. Therefore, only a measurement in vertical polarisation could be done.

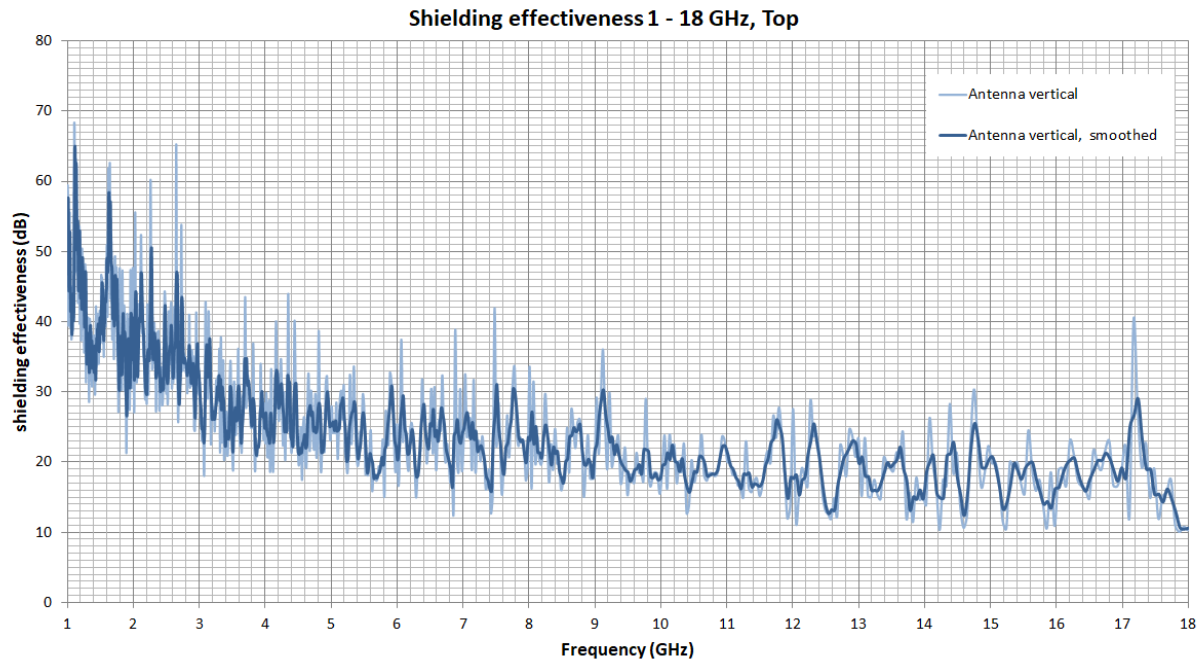
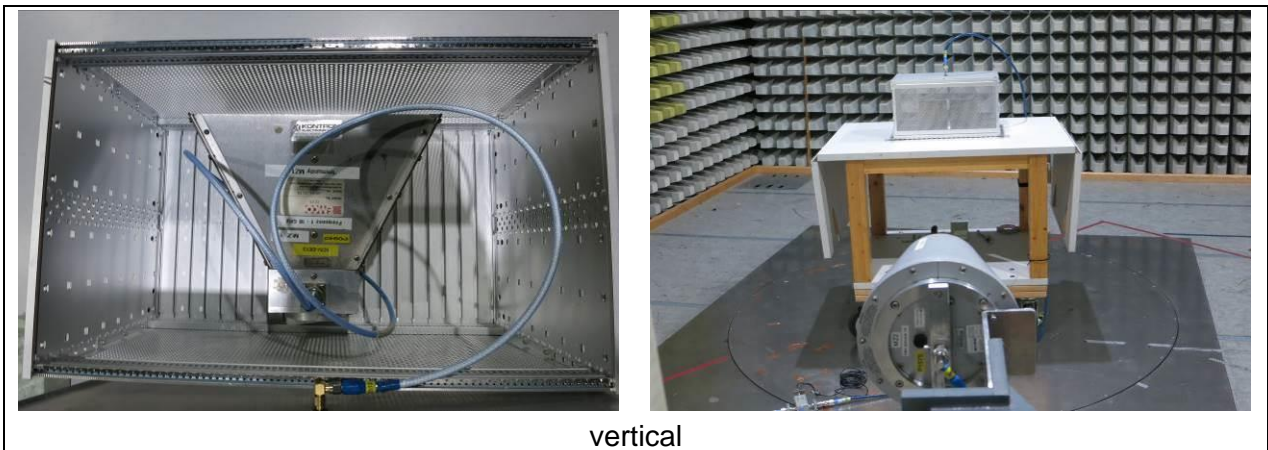


Photo documentation of the test set-up:



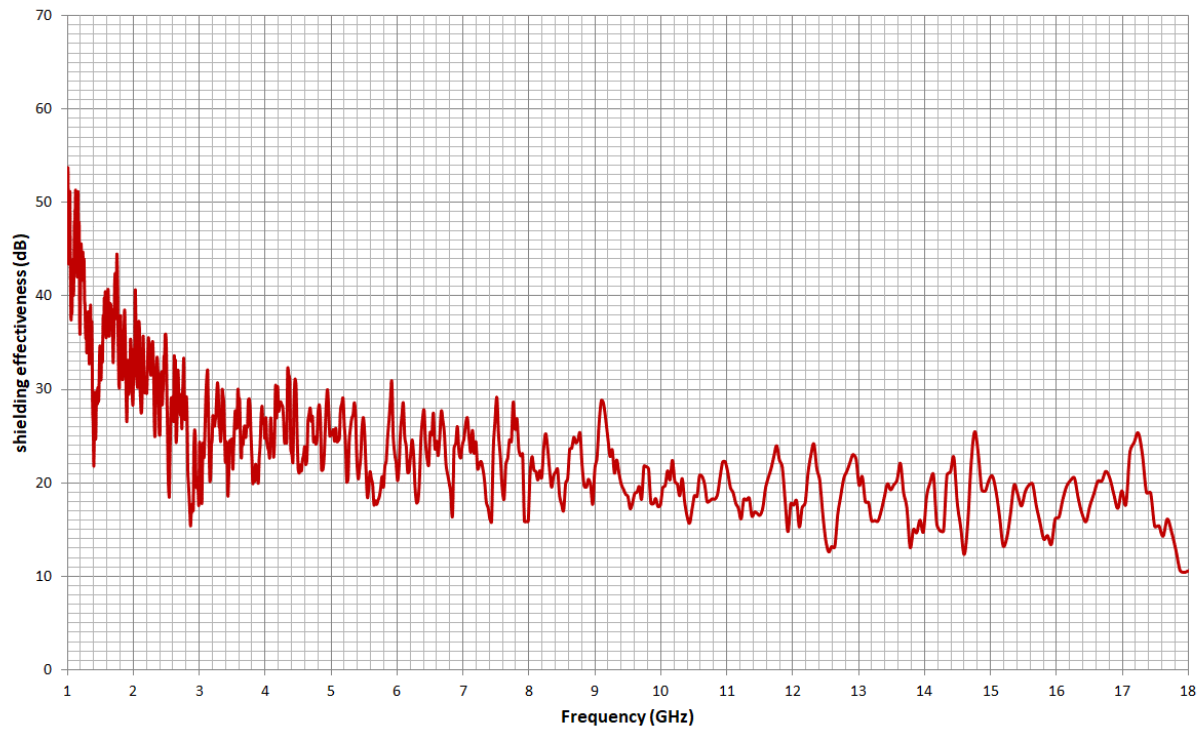
vertical

Figure 6-14: test setup 1 – 18 GHz

6.4.5.4 Worst case

The figure below shows the worst case of shielding effectiveness, that means the lowest value of all positions and antenna polarisations at each frequency:

Shielding effectiveness 1 - 18 GHz, worst case



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6.5 18 – 40 GHz (single frequencies only)

Tested by : Andreas Pauli

Test date : 2023-06-27

Test location : EMC chamber No. 3

6.5.1 Setup**6.5.2 Test Setup**

- Antenna distance = 0,80 m (front to front)
- Antenna height = 1.20 m
- no preamp in RX path
- no preamp @ TX antenna
- no attenuator at TX antenna
- no attenuator @ RX antenna
- measuring bandwidth = 120 kHz
- measuring time = 100 ms
- Detector = Average
- Internal Preamplifier = auto

6.5.3 Measuring Equipment

ID	Measuring Instrument	Specification	Status	Due date
P1148	antenna (horn 18 - 40GHz)	18 - 40 GHz	cal	May 31, 2024
P1340	antenna (18 - 40 GHz)	18- 40 GHz	cal	May 31, 2026
P1327	EMI receiver	20Hz - 40GHz, FFT-Scan, Preamplifier 100kHz - 40GHz, 30dB	cal	Apr 30, 2024
P0567	signal generator	10 MHz - 20 GHz	cal	Mar 31, 2024
P1227	frequency doubler 13-20GHz	13 - 20GHz (in), 26 - 40GHz (out)	cnn	
P2668	coax cable 3m, ruggedized	DC-18GHz, 3.28dB@18GHz	chk	Jan 31, 2024
P2669	coax cable 2m, ruggedized	DC-10GHz, 2.20dB@10GHz	chk	Jan 31, 2024
P1248	coax cable 40 GHz, 2m	DC - 40 GHz, 4.98dB @ 40GHz, L = 2m, armored	cnn	
P0338	EMC chamber 3	7.4 x 6.6 x 5.2 m (net), 0.4 m hybrid absorbers	chk	

cal = Calibration, car = Calibration restricted use, chk = Check, chr = Check restricted use, cpu = Check prior to use, calchk = Calibration and check, ind = for indication only, cnn = Calibration not necessary, service = Wartung (Service), man = Maintenance, calservice = Calibration & Service, chkservice = Check & Service, calchkservice = Calibration & Check & Service

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6.5.4 Photographs of test setup

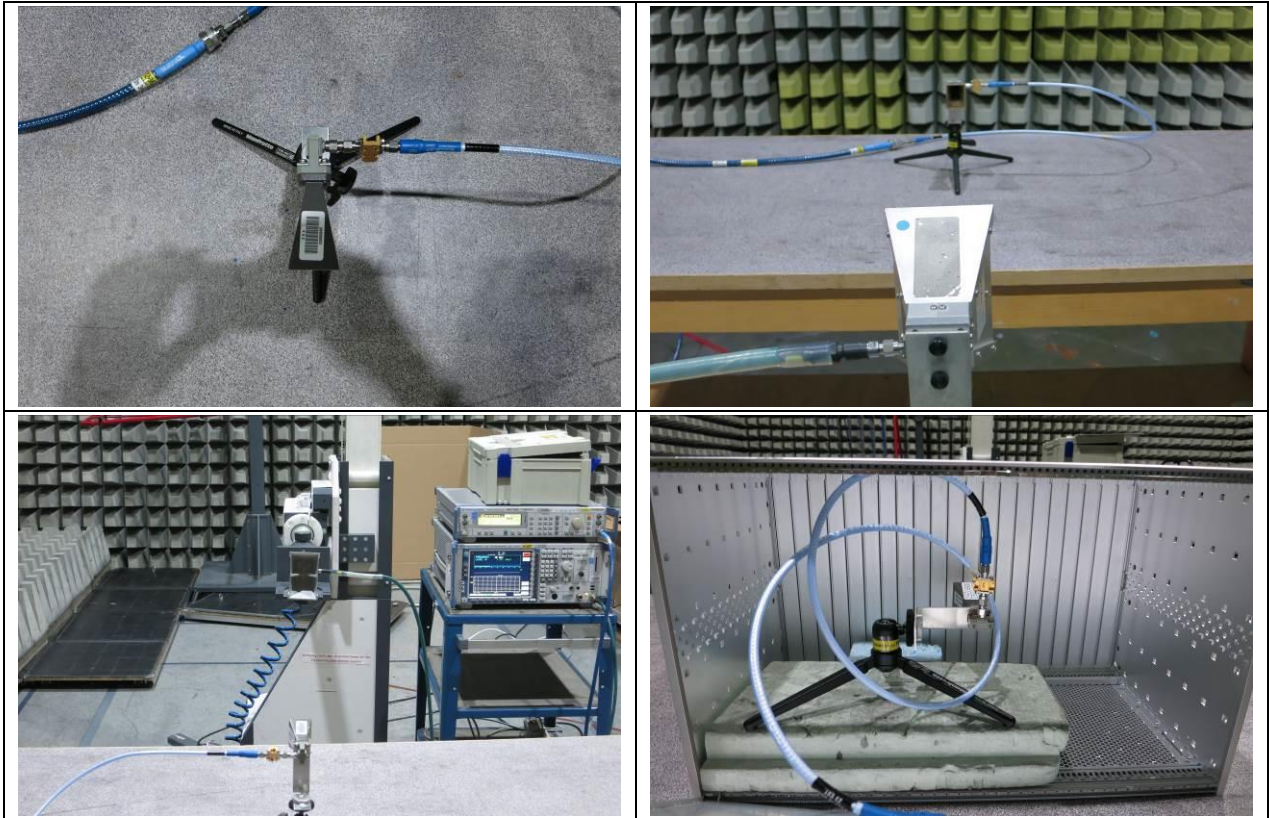


Figure 6-15: test setup, 18 – 40 GHz

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6.5.5 Test Results

6.5.5.1 Front

6.5.5.1.1 Horizontal

Frequency in GHz	measured Levels in dB μ V		Dynamic Range	Shielding effectiveness in dB
	Reference	EUT		
20,0	71,7	36,2	71,7	35,5
25,0	72,6	47,6	71,8	25,0
30,0	70,9	38,4	67,1	32,5
35,0	65,8	30,0	60,2	35,8
40,0	60,7	24,9	53,2	35,8

Photo documentation of the test set-up:

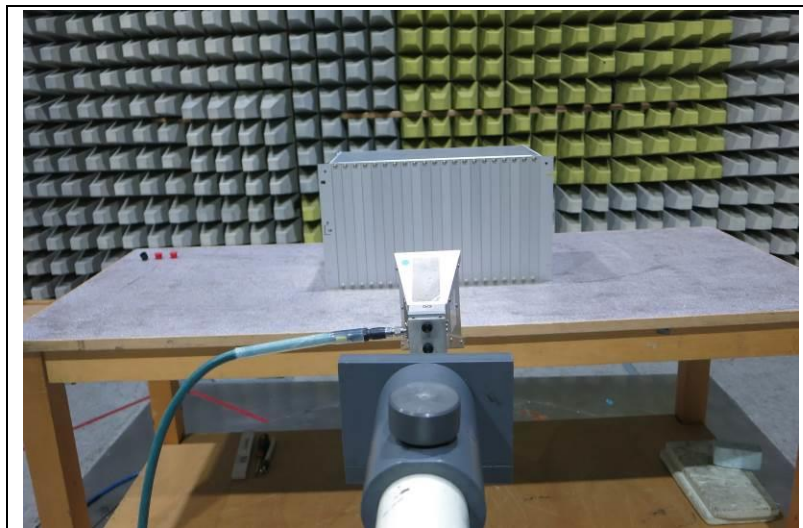


Figure 6-16: test setup horizontal, 18 – 40 GHz

6.5.5.1.2 Vertical

Frequency in GHz	measured Levels in dB μ V		Dynamic Range	Shielding effectiveness in dB
	Reference	EUT		
20,0	72,5	44,6	72,5	27,9
25,0	72,9	43,4	72,1	29,5
30,0	71,4	34,4	67,6	37,0
35,0	67,5	22,9	61,9	44,6
40,0	58,7	26,6	51,2	32,1

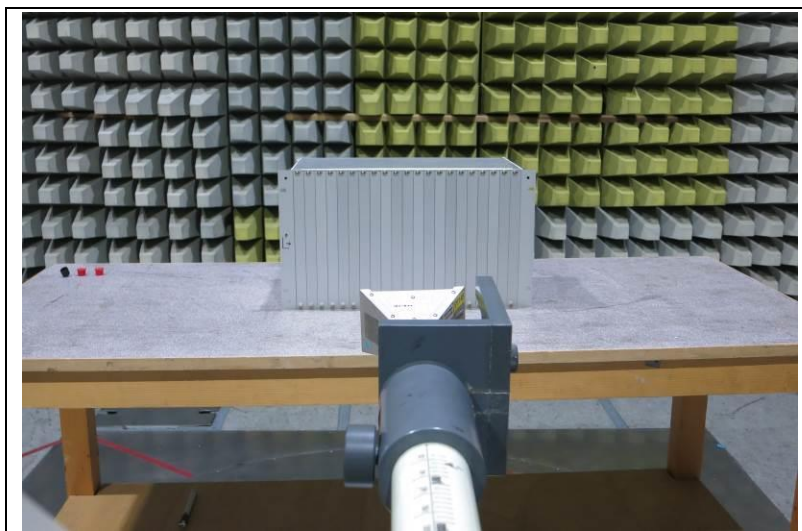


Figure 6-17: test setup vertical, 18 – 40 GHz

6.5.5.2 Side

6.5.5.2.1 Horizontal

Frequency in GHz	measured Levels in dB μ V		Dynamic Range	Shielding effectiveness in dB
	Reference	EUT		
20,0	71,7	54,3	71,7	17,4
25,0	72,6	55,9	71,8	16,7
30,0	70,9	55,2	67,1	15,7
35,0	65,8	37,7	60,2	28,1
40,0	60,7	47,1	53,2	13,6

Photo documentation of the test set-up:

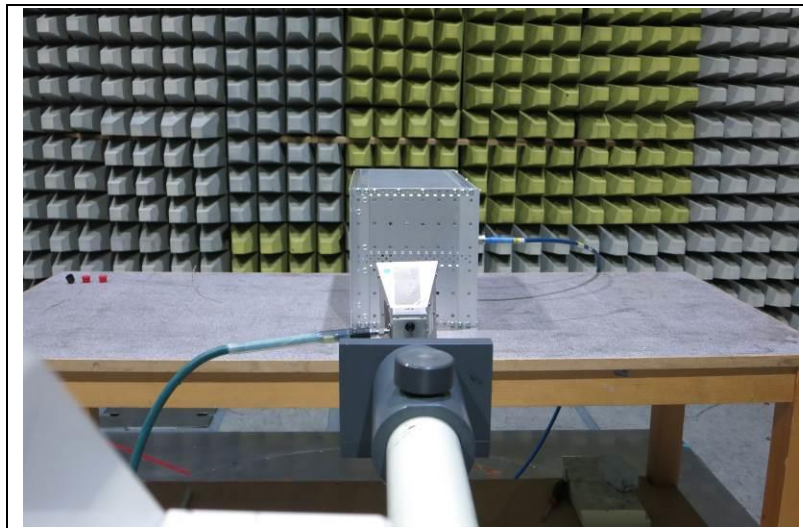


Figure 6-18: test setup horizontal, 18 – 40 GHz

6.5.5.2.2 Vertical

Frequency in GHz	measured Levels in dB μ V		Dynamic Range	Shielding effectiveness in dB
	Reference	EUT		
20,0	72,5	45,1	72,5	27,4
25,0	72,9	52,3	72,1	20,6
30,0	71,4	45,0	67,6	26,4
35,0	67,5	48,5	61,9	19,0
40,0	58,7	44,7	51,2	14,0

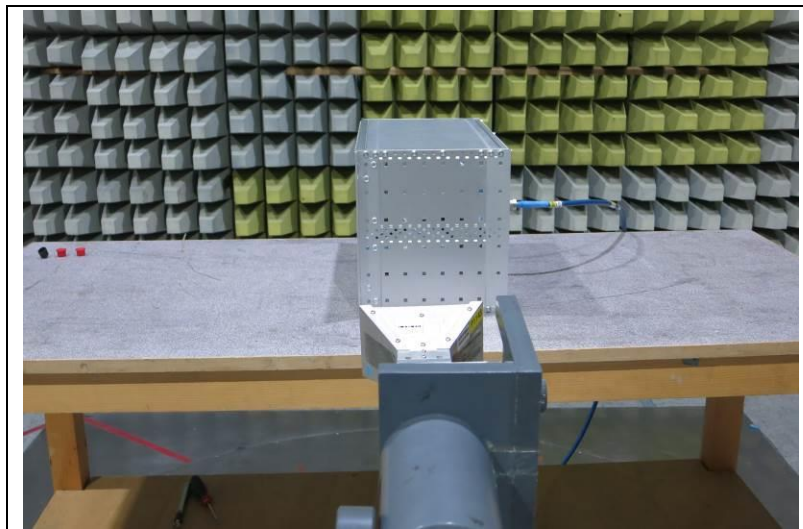


Figure 6-19: test setup vertical, 18 – 40 GHz

6.5.5.3 Top

6.5.5.3.1 Horizontal

Frequency in GHz	measured Levels in dB μ V		Dynamic Range	Shielding effectiveness in dB
	Reference	EUT		
20,0	71,7	59,6	71,7	12,1
25,0	72,6	67,2	71,8	5,4
30,0	70,9	61,5	67,1	9,4
35,0	65,8	59,9	60,2	5,9
40,0	60,7	54,4	53,2	6,3

Photo documentation of the test set-up:

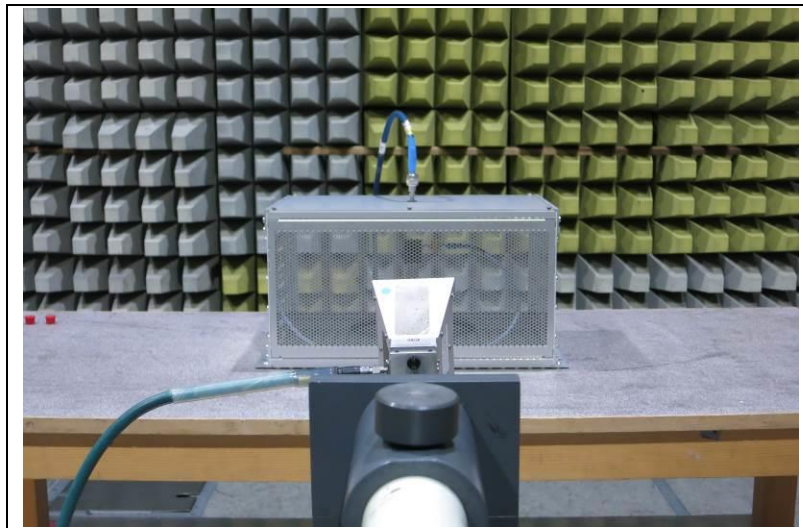


Figure 6-20: test setup horizontal, 18 – 40 GHz

6.5.5.3.2 Vertical

Frequency in GHz	measured Levels in dB μ V		Dynamic Range	Shielding effectiveness in dB
	Reference	EUT		
20,0	72,5	46,2	72,5	26,3
25,0	72,9	64,1	72,1	8,8
30,0	71,4	59,8	67,6	11,6
35,0	67,5	60,3	61,9	7,2
40,0	58,7	51,7	51,2	7,0

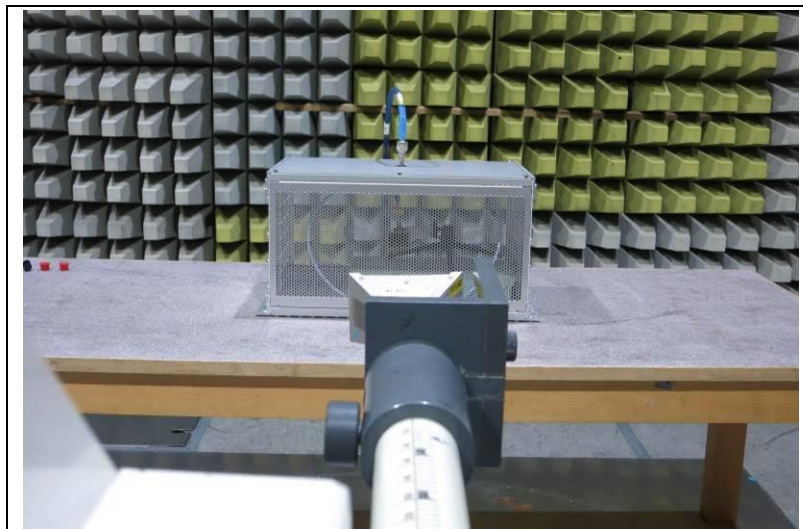


Figure 6-21: test setup vertical, 18 – 40 GHz

6.5.5.4 Worst case

The table below shows the worst case of shielding effectiveness, that means the lowest value of all positions and antenna polarisations at each frequency:

Frequency in GHz	Shielding effectiveness in dB
20,0	12,1
25,0	5,4
30,0	9,4
35,0	5,9
40,0	6,3

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