Deutsche Akkreditierungsstelle
D-PL-21375-01-02
D-PL-21375-01-03

INGENIEURBÜRO LENHARDT

Bundesnetzagentur
BNetzA-CAB-21/21-21

Partial Test Report

Test report no.: 22107886-28661-3
Date of issue: 2023-04-28

Test result: The test item **- passed - and complies** with below listed standards.

Applicant
TeraTron GmbH

Manufacturer
TeraTron GmbH

Test Item
BSS255R

RF-Spectrum Testing according to:

FCC 47 CFR Part 15
Radio Frequency Devices (Subpart C)

RSS-247, Issue 2 (2017-02)
Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

RSS-Gen, Issue 5 (2018-04)
General Requirements for Compliance of Radio Apparatus

Tested by (name, function, signature)	*Karsten Geraldy* *Lab Manager RF*	signature
Approved by (name, function, signature)	*Andreas Bender* *Deputy Managing Director*	signature

Applicant and Test item details	
Applicant	TeraTron GmbH Gewerbegebiet Sonnenberg Martin-Siebert-Str. 5 51647, Gummersbach, Germany Phone: +49 (0) 2261 8082-0 Fax: +49 (0) 2261 8082-99
Manufacturer	TeraTron GmbH Gewerbegebiet Sonnenberg Martin-Siebert-Str. 5 51647, Gummersbach, Germany
Test item description	Protective Field Reader
Model/Type reference	BSS255R
Standard specific information	
FCC ID	QLXBSS255R
IC	4430A-BSS255R
PMN	BSS255R Protective Field Reader
HMN	N/A
HVIN	0255.01.03
FVIN	N/A
Frequency	2.4 GHz ISM band (2400 – 2483.5 MHz)
Technology	Bluetooth Low Energy (BLE)
Antenna	external antenna
Power supply	10.0 to 32.0 V DC
Temperature range	-40 °C to +85 °C

Disclaimer and Notes

The content of this test report relates to the mentioned test sample(s) only.
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The last valid version is available at TAMSys®.

Within this test report, a ☒ point / ☐ comma is used as a decimal separator.
If otherwise, a detailed note is added adjected to its use.

IBL-Lab GmbH does not take test samples. The samples used for testing are provided by the applicant.

Decision rule:
Decision rule based on simple acceptance without guard bands, binary statement, based on mutually agreed uncertainty tolerances with expansion factor k=2 according to ILAC-G8:09/2019

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2 GENERAL INFORMATION

2.1 Administrative details

Testing laboratory	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany Fon: +49 6894 38938-0 Fax: +49 6894 38938-99 URL: www.ib-lenhardt.de E-Mail: info@ib-lenhardt.de
Accreditation	The testing laboratory is accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025:2018. Scope of testing and registration number: • Electronics, EMC, Radio D-PL-21375-01-01 • Electromagnetic Compatibility and Telecommunication (FCC requirements) D-PL-21375-01-02 Testing Laboratory Designation Number DE0024 • Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards D-PL-21375-01-03 ISED Company Number 27156 Testing Laboratory CAB Identifier DE0020 Website DAkkS: https://www.dakks.de/ The Deutsche Akkreditierungsstelle GmbH (DAkkS) is also a signatory to the ILAC Mutual Recognition Arrangement
Testing location	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany
Date of receipt of test samples	2022-12-13
Start – End of tests	2022-12-13 – 2023-04-11

2.2 Possible test case verdicts

Test sample meets the requirements	P (PASS)
Test sample does not meet the requirements	F (FAIL)
Test case does not apply to the test sample	N/A (Not applicable)
Test case not performed	N/P (Not performed)

2.3 Observations

No additional observations other than the reported observations within this test report have been made.

2.4 Opinions and interpretations

No appropriate opinions or interpretations according ISO/IEC 17025:2017 clause 7.8.7 are within this test report.

2.5 Revision history

-0 Initial Version
-1 Revision:
RF output power (conducted peak power) measurement for high channel repeated with different setting. Rated RF output power corrected.
-2 Revision:
Power settings used for testing corrected according to original module test report.
-3 Revision:
Rated power under 5.3 changed according to latest data sheet
This test report 22107886-28661-3 replaces the previous test report 22107886-28661-2. **Utilisation, publication and control of previous report editions is under responsibility of the applicant.**

2.6 Further documents

List of further applicable documents belonging to the present test report:
– no additional documents –

3 ENVIRONMENTAL & TEST CONDITIONS

3.1 Environmental conditions

Temperature	20°C ± 5°C
Relative humidity	25-75 % r.H.
Barometric Pressure	860-1060 mbar
Power supply	230 V / 50 Hz

3.2 Normal and extreme test conditions

	minimum	nominal	maximum
Temperature	-40 °C	20 °C	+85 °C
Relative humidity	-/-	45 % r.h.	-/-
Power supply	10.0 V DC	12 V DC	32.0 V DC

4 TEST STANDARDS AND REFERENCES

Test standard (accredited)	Description
FCC 47 CFR Part 15	Radio Frequency Devices (Subpart C)
RSS-247, Issue 2 (2017-02)	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-Gen, Issue 5 (2018-04)	General Requirements for Compliance of Radio Apparatus

Reference	Description
ANSI C63.4-2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
558074 D01 15.247 Meas Guide v05r02	Guidance for compliance measurements on digital transmission systems, frequency hopping spread spectrum systems and hybrid system devices operating under section 15.247 of the FCC rules

5 EQUIPMENT UNDER TEST (EUT)

5.1 Product description

Protective Field Reader

*: as declared by applicant

5.2 Test item description

Model name*	BSS255R
Serial number*	1122202
Hardware status*	0255.01.03
Software status*	02.02

*: as declared by applicant

5.3 Technical data of equipment

Operational frequency band*	2.4 GHz ISM band (2400 – 2483.5 MHz)
Technology*	Bluetooth Low Energy (BLE)
Modulation type*	GFSK, Pi/4-DQPSK
Data rate*	1 Mbps, 2 Mbps
Number of channels*	40 (3 advertising channels / 37 data channels)
Channel bandwidth*	2 MHz
Channel spacing*	2 MHz
Antenna*	external antenna
Antenna gain*	3.6 dBi
Rated RF Output Power*	8.4 dBm
Power supply, V_{nom}*	10.0 to 32.0 V DC
Temperature range, T_{nom}*	-40 °C to +85 °C, T_{nom}=+20°C

*: as declared by applicant

5.4 Additional information

Model differences	-/-
Ancillaries tested with	-/-
Additional equipment used for testing	Notebook with test tool – nRF Connect

5.5 Test modes	
Mode 1	GFSK, 1 Mbps
Mode 2	Pi/4-DQPSK, 2 Mbps
Low Channel	2402 MHz
Mid Channel	2440 MHz
High Channel	2480 MHz

EUT Mode	**Power settings**		
	Channel low	**Channel mid**	**Channel high**
Mode 1	5 dBm	5 dBm	5 dBm
Mode 2	5 dBm	5 dBm	5 dBm

6 SUMMARY OF TEST RESULTS

Test specification
FCC 47 CFR Part 15 **RSS-247, Issue 2 (2017-02) / RSS-Gen, Issue 5 (2018-04)**

Clause	Requirement / Test Case	Result - Remark	Verdict
§15.247(a)(2) RSS-247,5.2 (a)	DTS bandwidth (6 dB)	KDB 558074, clause: 8.2	- N/P - *)
RSS Gen, 6.7	Occupied bandwidth (99%)	-/-	- N/P - *)
§15.247(b)(3) RSS-247, 5.4 (d)	RF output power (peak power)	KDB 558074, clause: 8.3.1	- PASS -
§15.247(b)(4) RSS-247, 5.4 (d)	Antenna gain (calculated)	-/-	- N/P - *)
§15.247(e) RSS-247, 5.2 (b)	Peak power spectral density	KDB 558074, clause: 8.4	- N/P - *)
§15.247(d) RSS-247, 5.5	Band edge compliance (BEC), conducted	KDB 558074, clause: 8.5	- N/P - *)
§15.247(d) RSS-247, 5.5	Band edge compliance (BEC), radiated	KDB 558074, clause: 8.7	- PASS -
§15.247(d) RSS-247, 5.5	Conducted spurious emissions	KDB 558074 DTS clause: 8.5	- N/P - *)
§15.247(d)/§15.209 RSS-247, 5.5 / RSS-Gen, 8.9	Radiated spurious emissions	-/-	- PASS -
§15.207 RSS-Gen, 8.8	AC conducted emissions	-/-	- N/P - *)

Notes
*) partial testing based on pre-qualified BLE-module

Comments and observations
Following pages show requirements and references of FCC Part 15.247, ANSI C63.10 and KDB 558074 only. Same tests are also applicable and valid for RSS-247, with clauses given in the table above.

7 TEST RESULTS

7.1 RF output power (conducted peak power)

Applicability
This requirement applies to all types of DTS equipment.

Description
The RF Output Power is defined as the conducted peak output power.

Limit
§15.247
(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.
(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.

Test procedure
ANSI C63.10, 11.9.1.1
The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the DTS bandwidth is available to perform the measurement:
a) Set the RBW ≥ DTS bandwidth.
b) Set VBW ≥ [3 × RBW].
c) Set span ≥ [3 × RBW].
d) Sweep time = auto couple.
e) Detector = peak.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use peak marker function to determine the peak amplitude level.

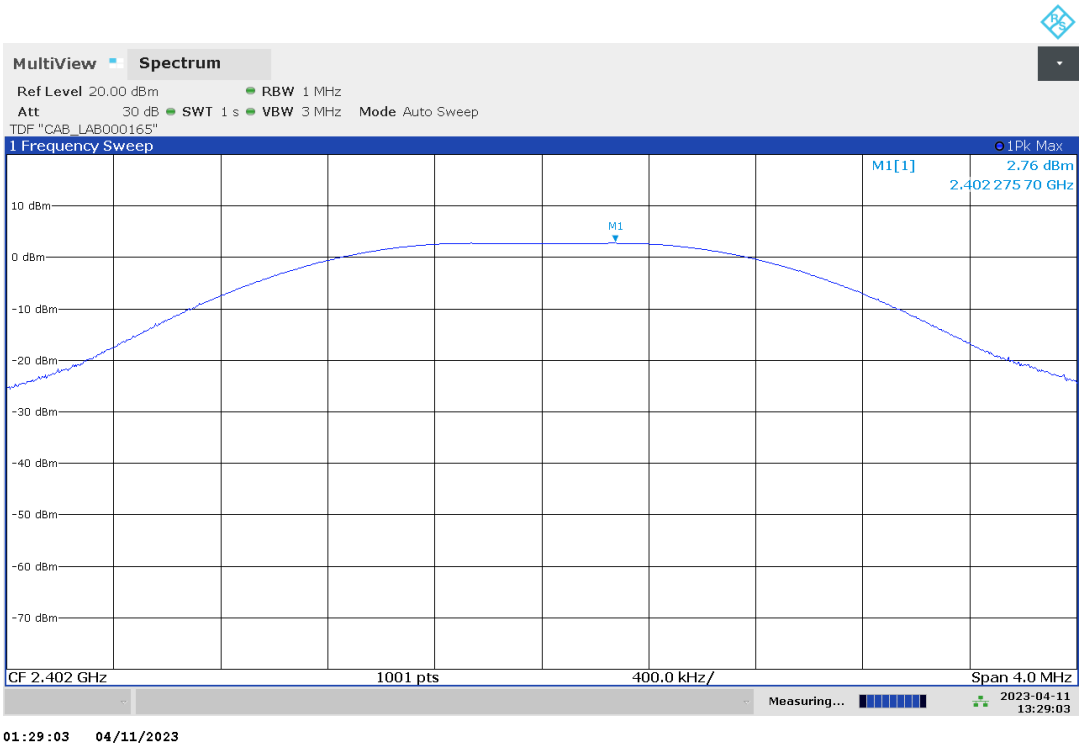
Test setup: 8.4

Test Results

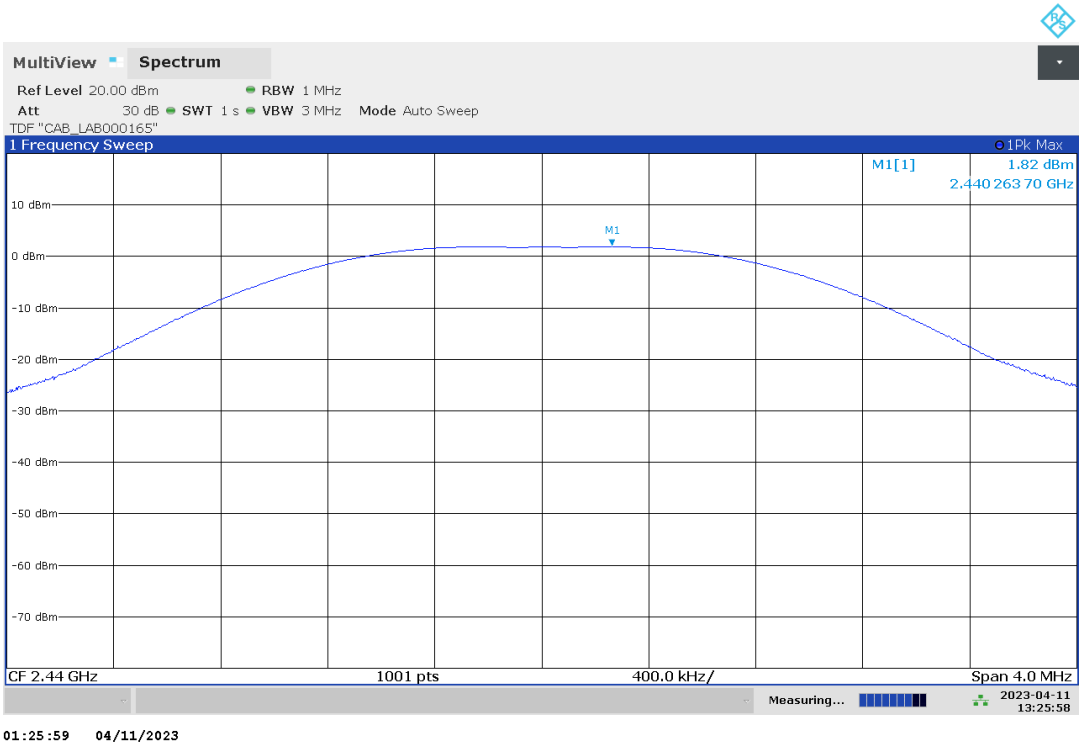
EUT Mode	RF Output Power (Conducted Peak Power)			Limit [dBm]
	low channel [dBm]	mid channel [dBm]	high channel [dBm]	
Mode 1	2.8	1.8	0.5	30

Comment:	-/-

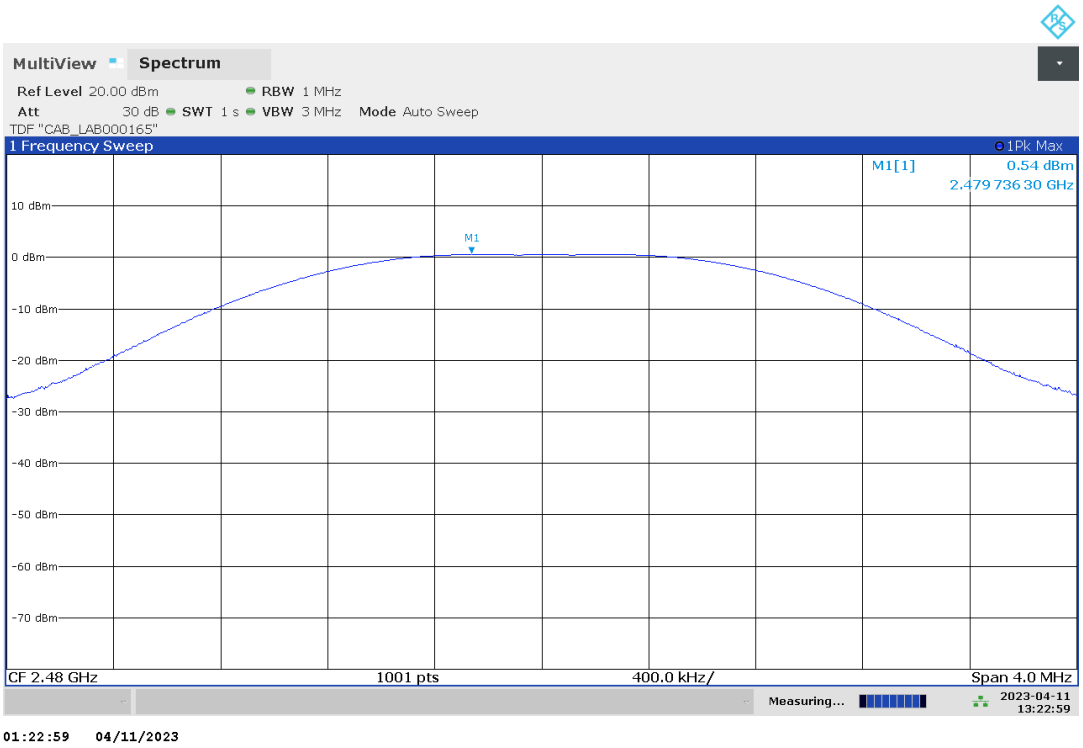
Plot 1: Mode 1, Peak Power, low channel



Plot 2: Mode 1, Peak Power, mid channel



Plot 3: Mode 1, Peak Power, high channel



7.2 Band edge compliance (BEC), radiated

Applicability
This requirement applies to all types of DTS equipment.

Description
Emissions within a restricted band and within 2 MHz of an authorized band edge may be measured using either the marker-delta method (ANSI C63.10, 6.10.6) or the integration method (ANSI C63.20, 11.13.3), provided that the DTS bandwidth (or EBW) edge falls within 2 MHz of the band edge. Otherwise, all unwanted emissions measurements shall be performed using the standard methods.

Limits
§15.247
(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Test procedure
The marker-delta method as described in ANSI C63.10, 6.10.6 or the integration methode as described in ANSI C63.10, 11.13.3 can be used to perform measurements of the unwanted emissions level at the band edges.

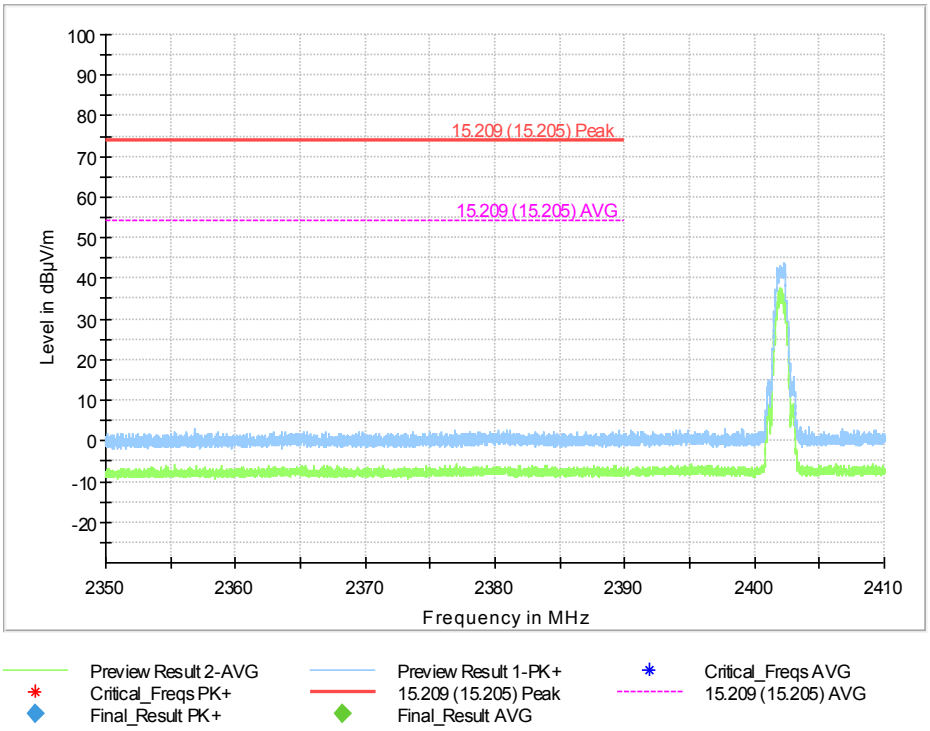
Test setup: 8.2

Test results

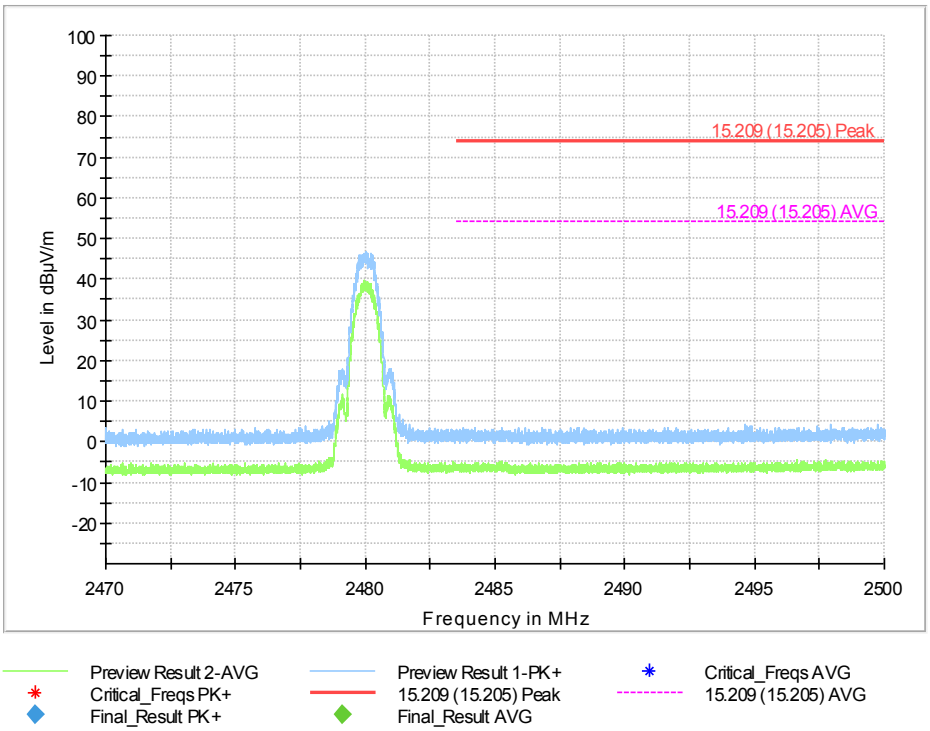
BEC	low channel [dµV/m @3m]	high channel [dµV/m @3m]	Limit [dµV/m @3m]
Mode 1	See plots	See plots	≤ 54 AVG / ≤ 74 PK

Comment:	---

Plot 4: Mode 1, BEC, low channel



Plot 5: Mode 1, BEC, high channel



7.3 Radiated spurious emissions (RSE)

Applicability
This requirement applies to all types of DTS equipment.

Description
Spurious emission / unwanted emissions are emission on a frequency or frequencies which are outside the authorized band and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products. Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation.

Limits
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Frequency [MHz]	Field Strength [µV/m] / [dBµV/m]	Measurement distance [m]
0.009 – 0.490	2400/F[kHz]	300
0.490 – 1.705	24000/F[kHz]	30
1.705 – 30.0	30.0 / 29.5	30
30 – 88	100 / 40.0	3
88 – 216	150 / 43.5	3
216 – 960	200 / 46.0	3
960 – 40 000	500 / 54.0	3

Note
Radiated Spurious Emissions (RSE) are performed for low / mid / high channel and modulation with the highest output power (worst case). In case of spurious other modulations are spot-checked.

Test setup: 8.1, 8.2, 8.3

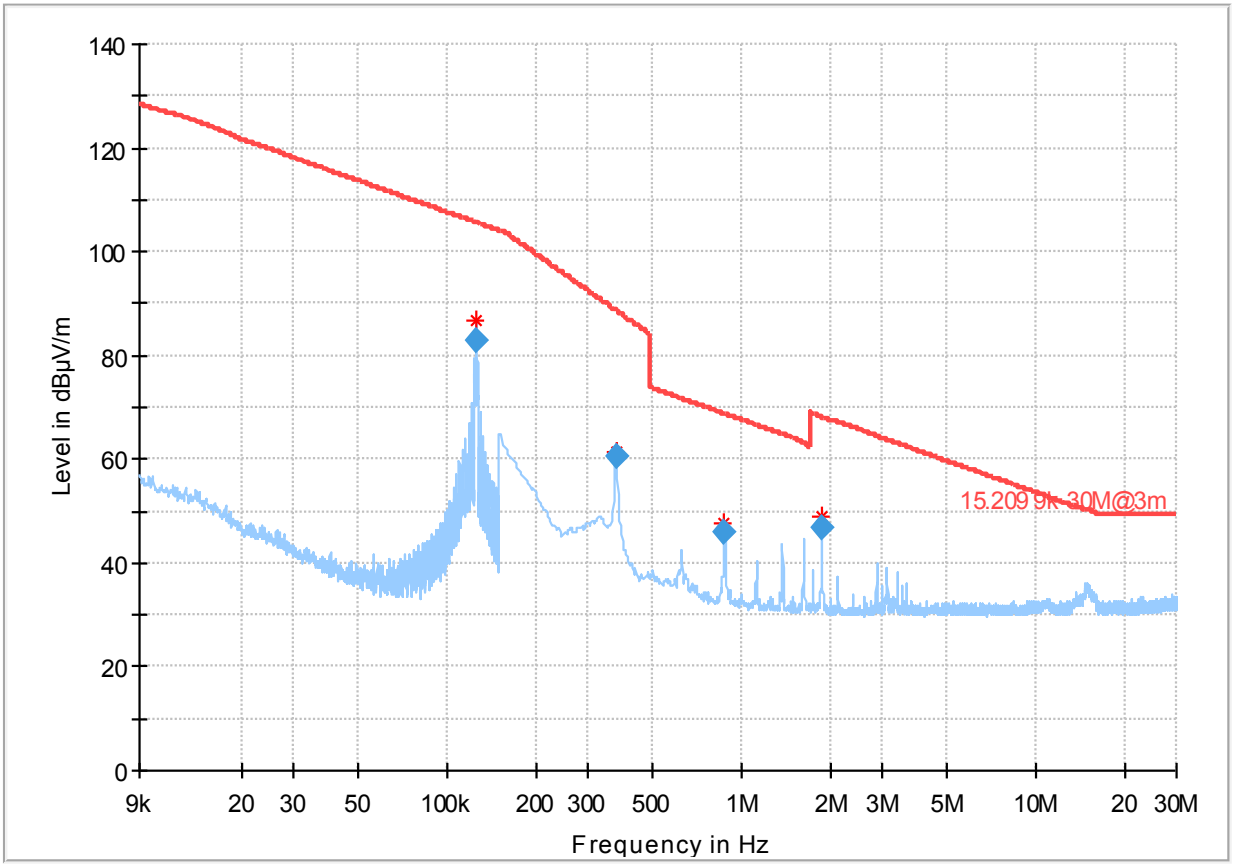
Test results

EUT Mode / Channel	Frequency [MHz]	Peak/RMS Detector	Level [dBm]	Limit [dBm]	Verdict
(see plots)	*(see plots)*	*(see plots)*	*(see plots)*	*(see plots)*	- passed -
(see plots)	*(see plots)*	*(see plots)*	*(see plots)*	*(see plots)*	- passed -
(see plots)	*(see plots)*	*(see plots)*	*(see plots)*	*(see plots)*	- passed -

* all detected peaks are more thean 6 dB below the limit

Comment:	---

Plot 6: Mode 1, RSE 9 kHz – 30 MHz, low channel, loop antenna

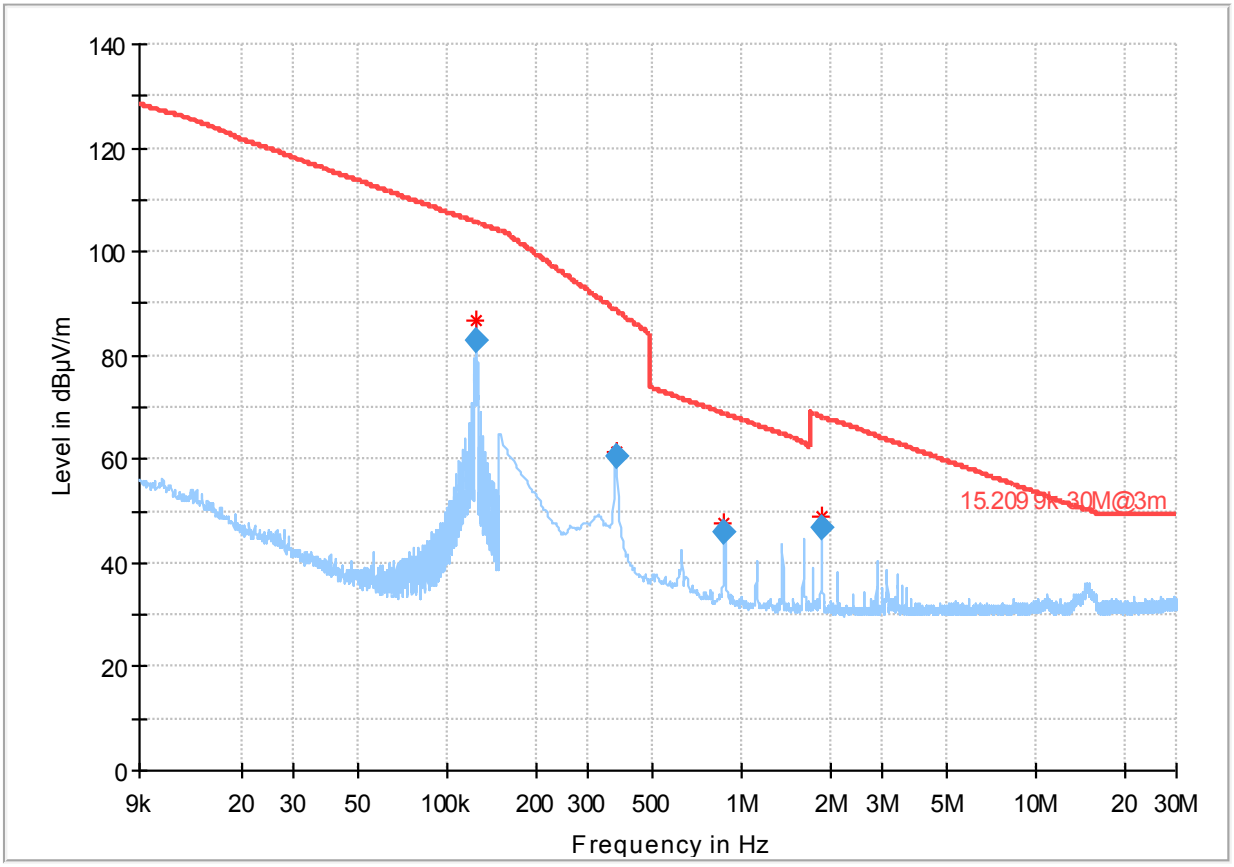


Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.125100	83.07	105.71	22.64	100.0	0.200	H	150.0	20.5
0.375000	60.51	88.68	28.17	100.0	9.000	V	150.0	20.4
0.876750	46.12	68.76	22.64	100.0	9.000	V	150.0	20.3
1.875750	46.70	68.11	21.41	100.0	9.000	H	150.0	20.4

Note:
The limits in CFR 47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-GEN Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377Ω. For example, the measurement frequency X kHz resulted in a level of Y dBµV/m, which is equivalent to Y - 51.5 = Z dBµA/m, which has the same margin, W dB, to the corresponding RSS-GEN Table 6 limit as it has to the 15.209(a) limit.

Plot 7: Mode 1, RSE 9 kHz – 30 MHz, high channel, loop antenna

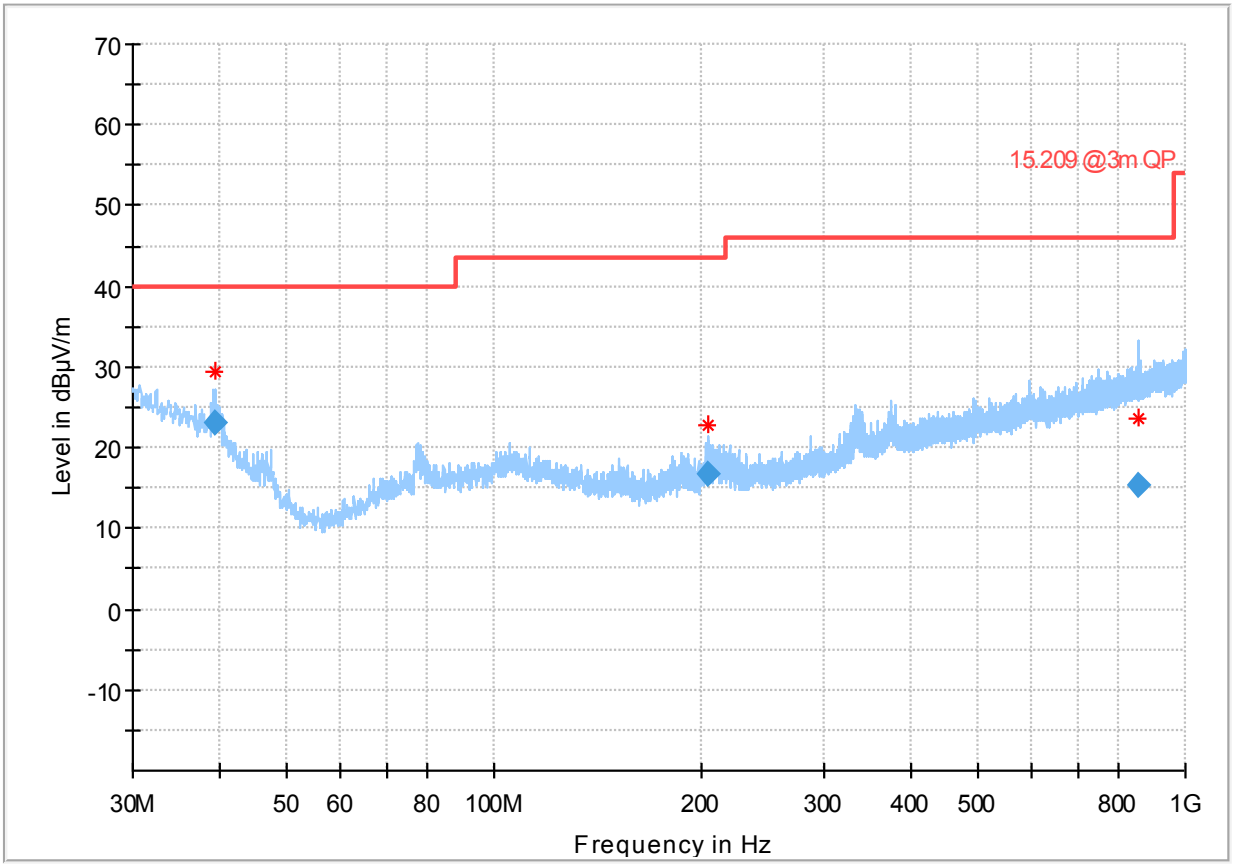


Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.125100	83.09	105.71	22.62	100.0	0.200	H	150.0	20.5
0.375000	60.46	88.68	28.22	100.0	9.000	V	150.0	20.4
0.874500	46.06	68.78	22.72	100.0	9.000	H	150.0	20.3
1.875750	46.71	68.11	21.40	100.0	9.000	H	150.0	20.4

Note:
The limits in CFR 47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-GEN Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377Ω. For example, the measurement frequency X kHz resulted in a level of Y dBµV/m, which is equivalent to Y - 51.5 = Z dBµA/m, which has the same margin, W dB, to the corresponding RSS-GEN Table 6 limit as it has to the 15.209(a) limit.

Plot 8: Mode 1, RSE 30 MHz – 1 GHz, low channel, horizontal / vertical polarisation



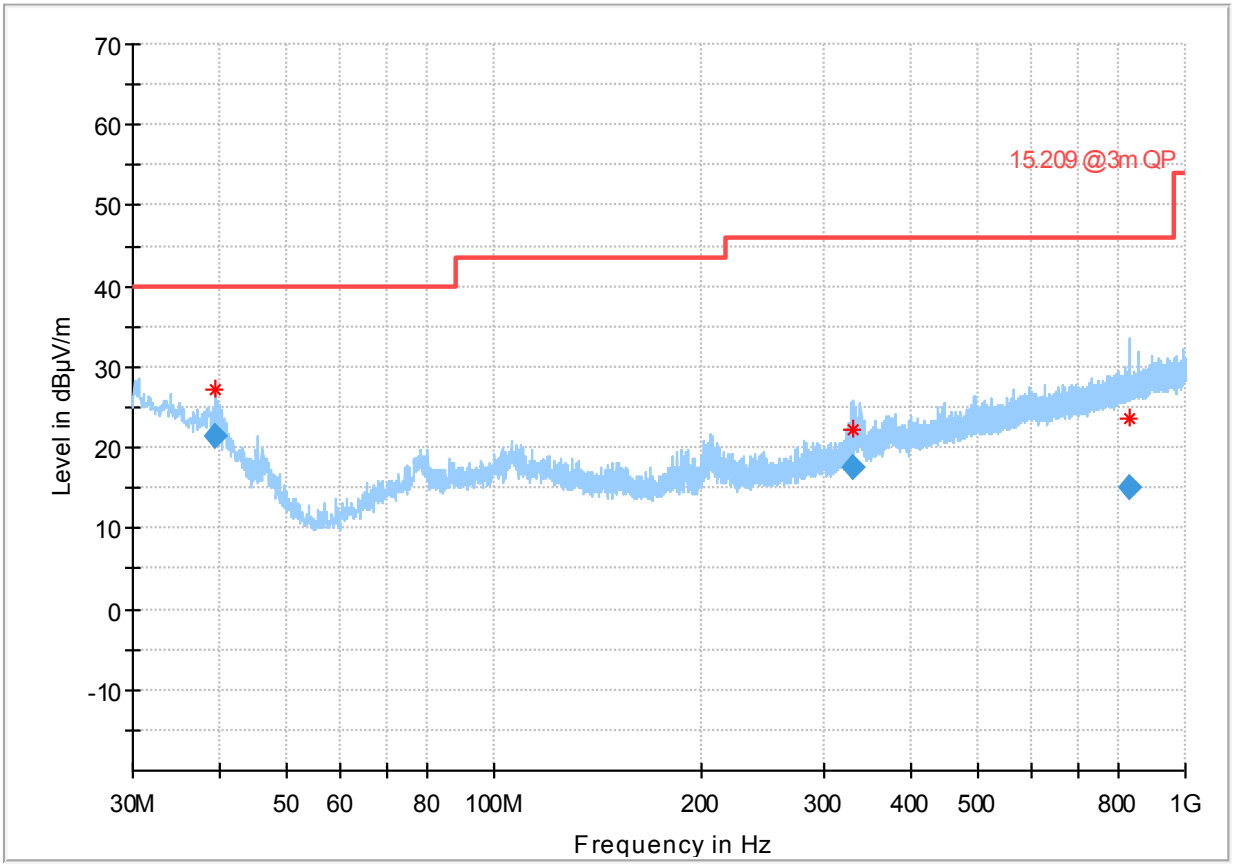
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
39.537000	23.12	40.00	16.88	100.0	120.000	100.0	V	105.0
204.679500	16.59	43.50	26.91	100.0	120.000	150.0	H	251.0
853.184500	15.21	46.00	30.79	100.0	120.000	233.0	V	2.0

(continuation of the "Final_Result" table from column 15 ...)

Frequency (MHz)	Corr. (dB/m)	Comment
39.537000	15.1	15:22:42 - 21.12.2022
204.679500	11.0	15:20:32 - 21.12.2022
853.184500	22.5	15:25:30 - 21.12.2022

Plot 9: Mode 1, RSE 30 MHz – 1 GHz, high channel, horizontal / vertical polarisation



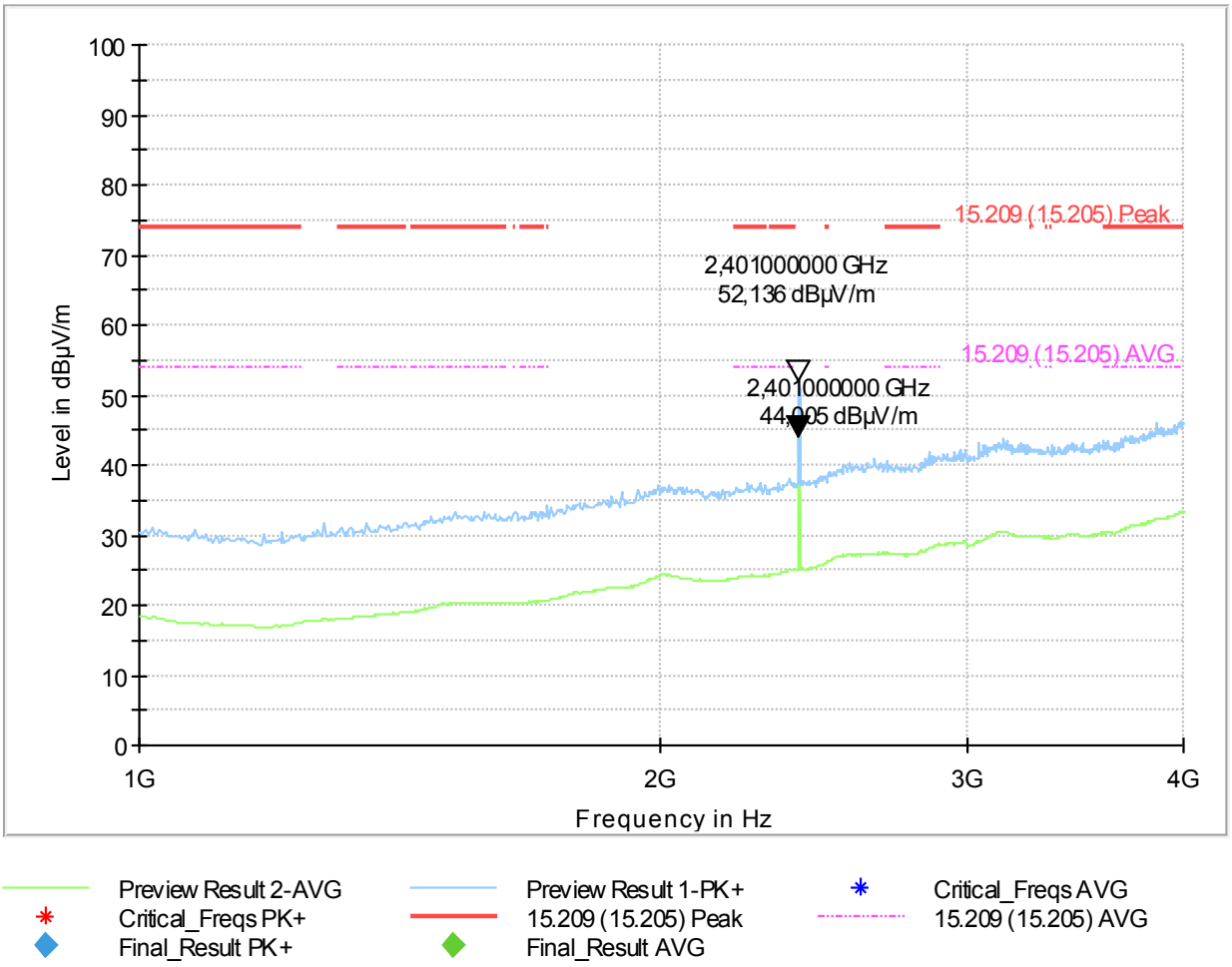
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
39.531000	21.49	40.00	18.51	100.0	120.000	103.0	V	208.0
329.815500	17.61	46.00	28.39	100.0	120.000	100.0	H	85.0
832.525000	14.97	46.00	31.03	100.0	120.000	284.0	V	132.0

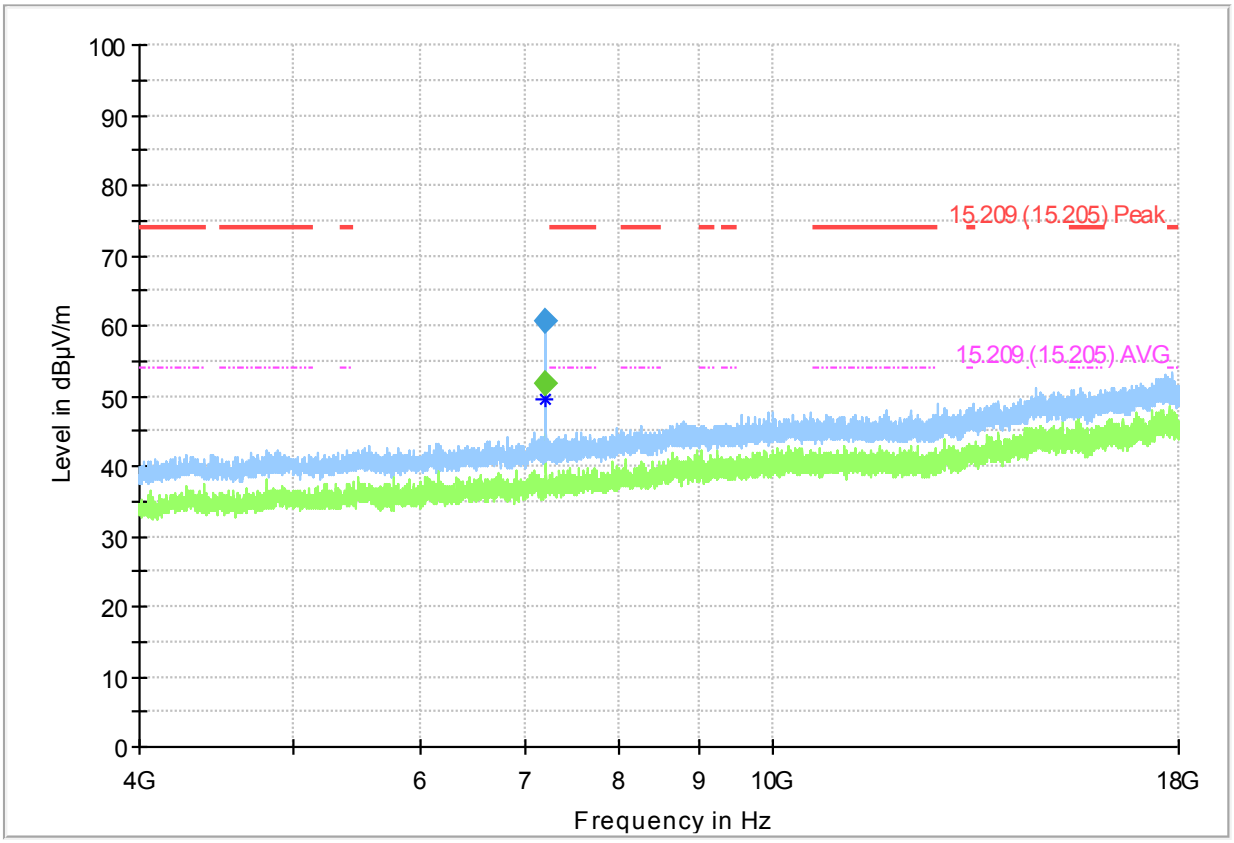
(continuation of the "Final_Result" table from column 15 ...)

Frequency (MHz)	Corr. (dB/m)	Comment
39.531000	15.1	15:42:58 - 21.12.2022
329.815500	14.1	15:40:58 - 21.12.2022
832.525000	22.5	15:45:11 - 21.12.2022

Plot 10: Mode 1, RSE 1 GHz – 4 GHz, low channel, horizontal / vertical polarisation



Plot 11: Mode 1, RSE 4 GHz – 18 GHz, low channel, horizontal / vertical polarisation



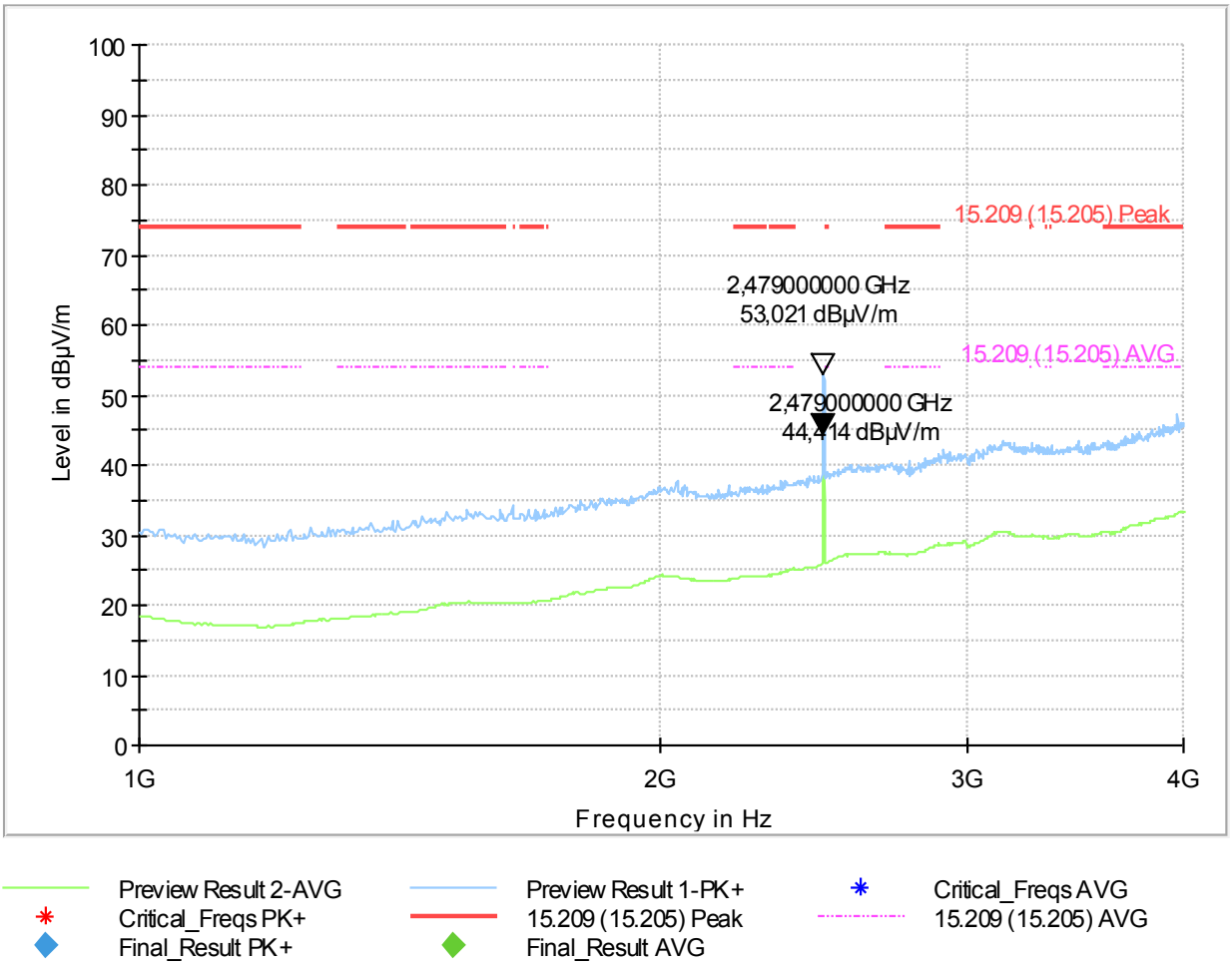
Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
7205.222222	---	51.83	---	---	100.0	1000.000	150.0	V
7205.222222	60.68	---	---	---	100.0	1000.000	150.0	V

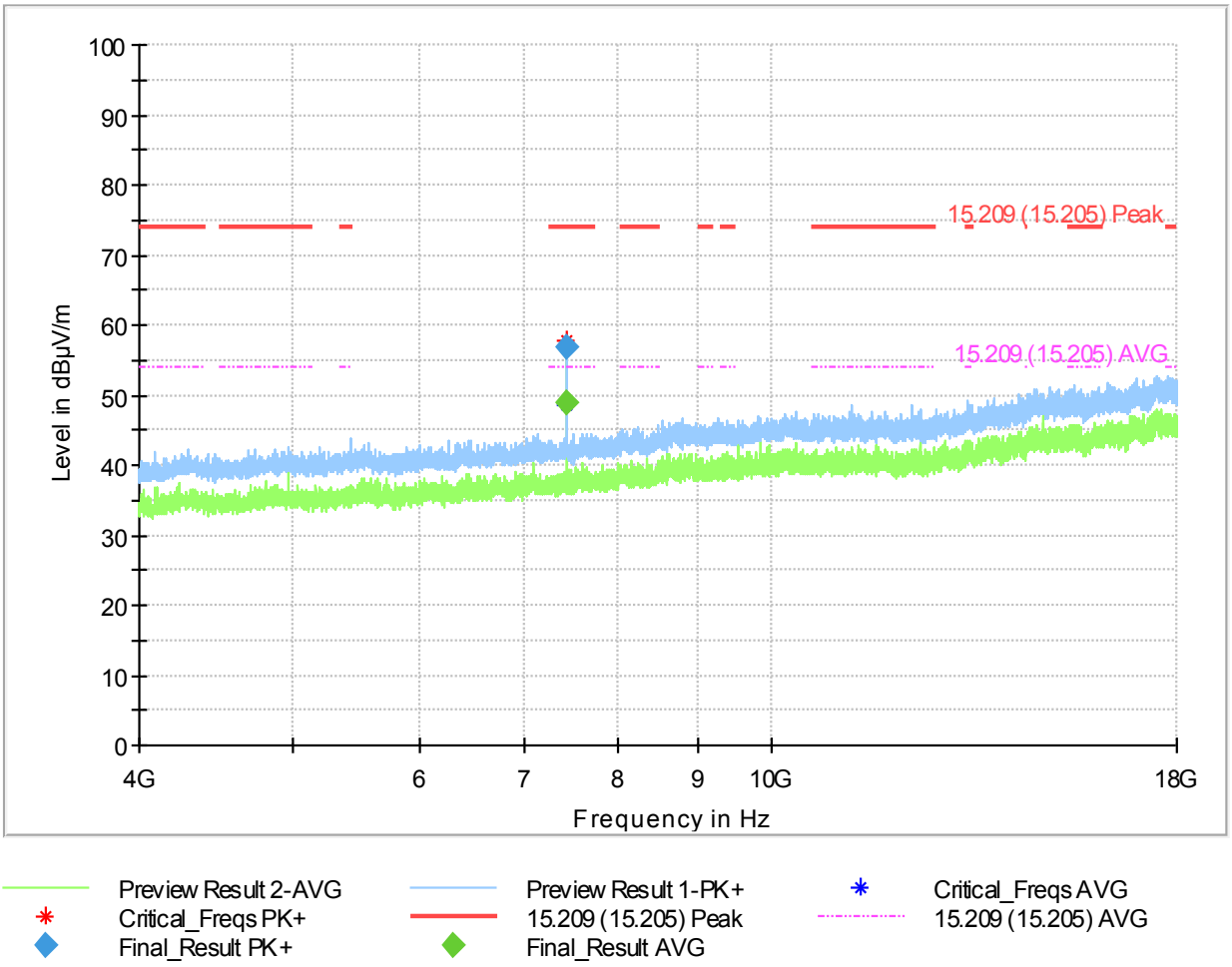
(continuation of the "Final_Result" table from column 14 ...)

Frequency (MHz)	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
7205.222222	52.0	90.0	8.8	11:06:49 - 20.12.2022
7205.222222	53.0	90.0	8.8	10:56:45 - 20.12.2022

Plot 12: Mode 1, RSE 1 GHz – 4 GHz, high channel, horizontal / vertical polarisation



Plot 13: Mode 1, RSE 4 GHz – 18 GHz, high channel, horizontal / vertical polarisation



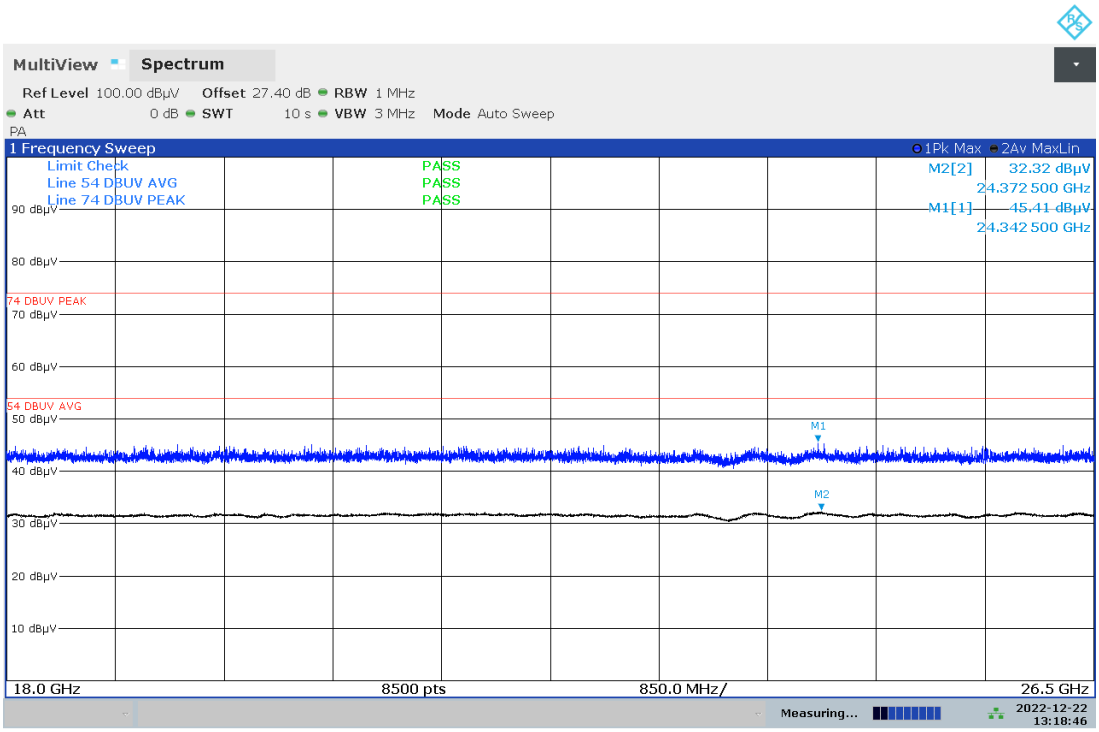
Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
7439.463889	---	48.76	54.00	5.24	100.0	1000.000	150.0	H
7440.888889	56.96	---	74.00	17.04	100.0	1000.000	150.0	H

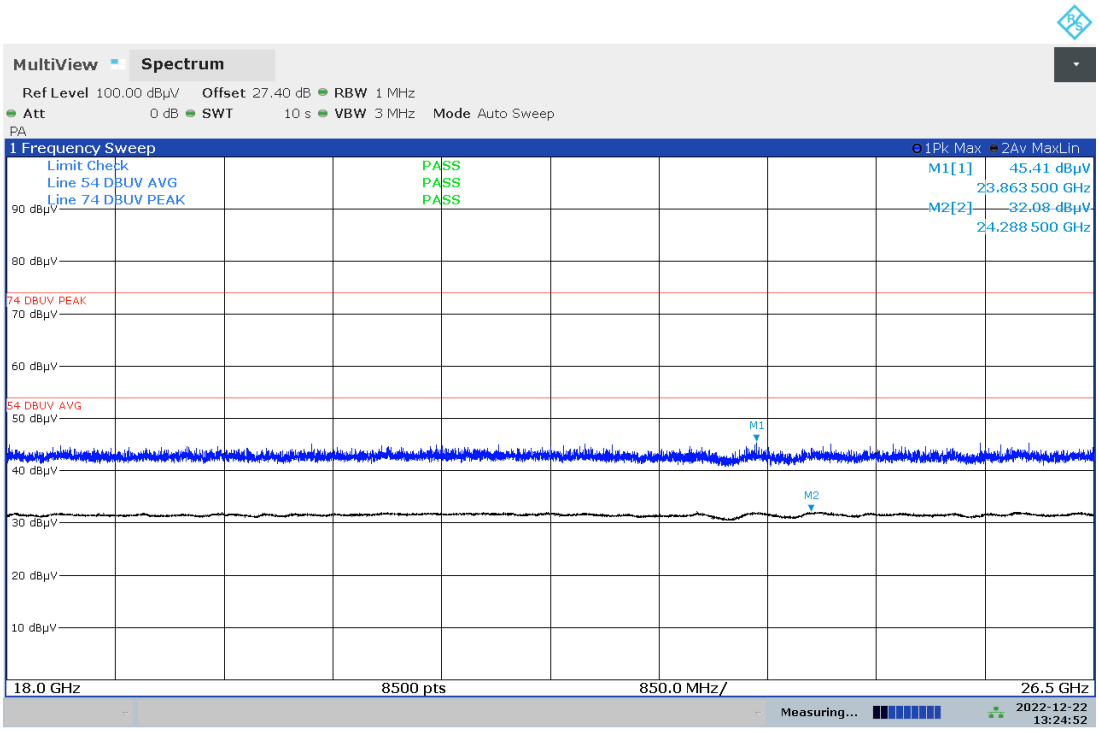
(continuation of the "Final_Result" table from column 14 ...)

Frequency (MHz)	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
7439.463889	2.0	0.0	8.9	11:24:09 - 20.12.2022
7440.888889	2.0	0.0	9.0	11:22:43 - 20.12.2022

Plot 14: Mode 1, RSE 18 GHz – 26 GHz, low channel, horizontal / vertical polarisation



Plot 15: Mode 1, RSE 18 GHz – 26 GHz, high channel, horizontal / vertical polarisation



7.4 Conducted emissions

Description / Limits

§15.207 (a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission [MHz]	Conducted limit [dBµV]	
	Quasi-Peak	Average
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5.0	56	46
5.0 – 30	60	50
*Decreases with the logarithm of the frequency.		

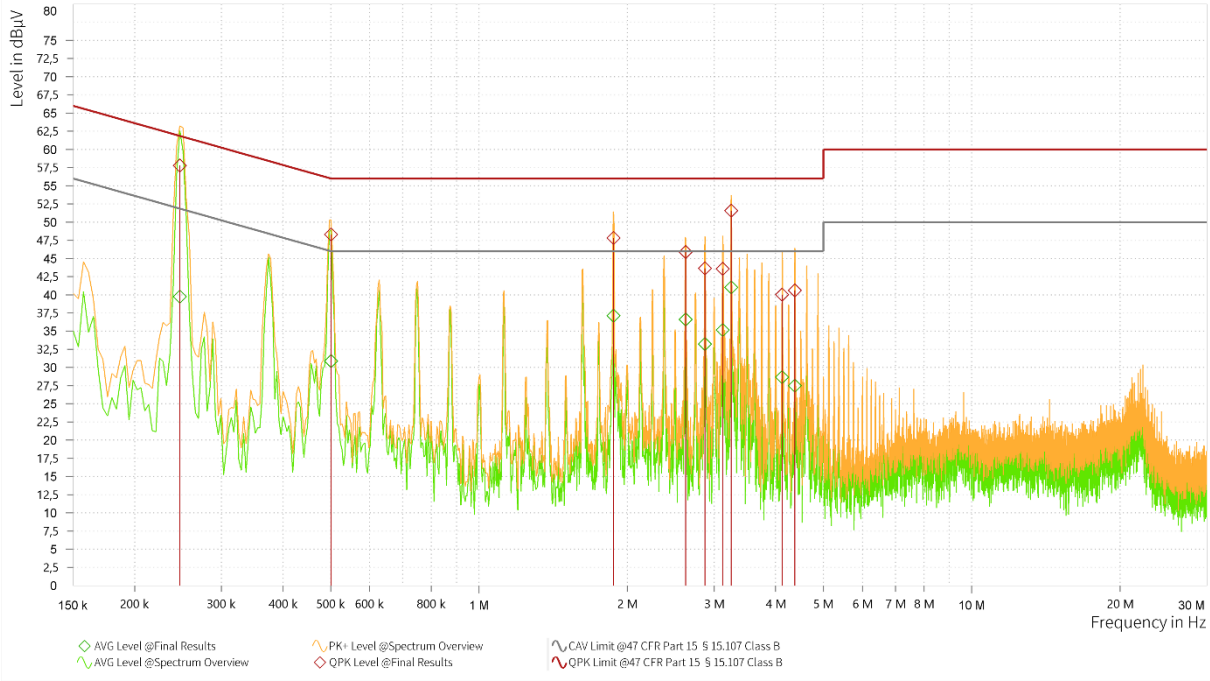
§15.207 (c) Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtainig their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

Test setup: see 8.5

Test results:

See next pages!

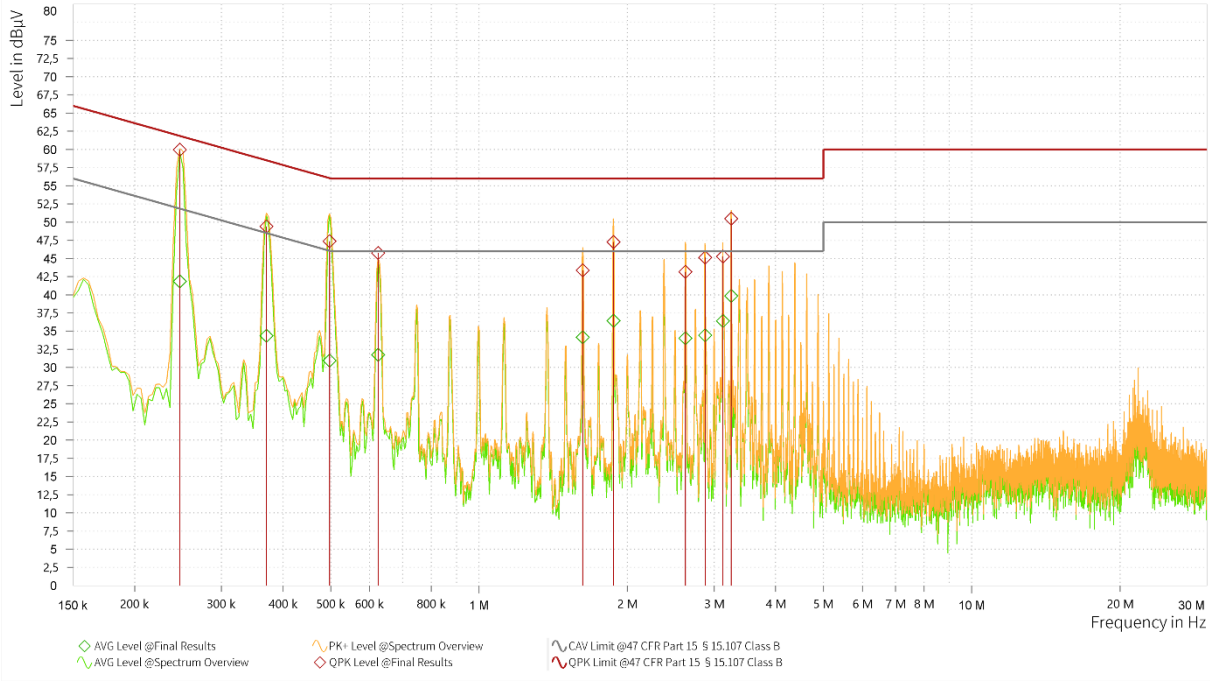
Plot no. 16: conducted emissions, line L1



EMI Final Results

Rg	Frequency [MHz]	QPK Level [dBµV]	QPK Limit [dBµV]	QPK Margin [dB]	AVG Level [dBµV]	AVG: CAV Limit [dBµV]	AVG Margin [dB]	Correction [dB]	Line	Meas. BW [kHz]	Meas. Time [ms]	Time	Source	Comment
1	0.247	57.80	61.86	4.06	39.73	51.86	12.13	9.72	L1	9.000	15 000.000	13:54:36	Critical Points	
1	0.501	48.30	56.00	7.70	30.88	46.00	15.12	10.09	L1	9.000	15 000.000	13:54:52	Critical Points	
1	1.874	47.82	56.00	8.18	37.11	46.00	8.89	9.87	L1	9.000	15 000.000	13:55:09	Critical Points	
1	2.628	45.90	56.00	10.10	36.61	46.00	9.39	9.89	L1	9.000	15 000.000	13:55:26	Critical Points	
1	2.874	43.65	56.00	12.35	33.23	46.00	12.77	9.90	L1	9.000	15 000.000	13:55:43	Critical Points	
1	3.124	43.58	56.00	12.42	35.14	46.00	10.86	9.91	L1	9.000	15 000.000	13:56:00	Critical Points	
1	3.251	51.56	56.00	4.44	41.02	46.00	4.98	9.91	L1	9.000	15 000.000	13:56:16	Critical Points	
1	4.124	40.03	56.00	15.97	28.67	46.00	17.33	9.94	L1	9.000	15 000.000	13:56:33	Critical Points	
1	4.374	40.62	56.00	15.38	27.50	46.00	18.50	9.95	L1	9.000	15 000.000	13:56:50	Critical Points	

Plot no. 17: conducted emissions, neutral N



EMI Final Results

Rg	Frequency [MHz]	QPK Level [dBµV]	QPK Limit [dBµV]	QPK Margin [dB]	AVG Level [dBµV]	AVG: CAV Limit [dBµV]	AVG Margin [dB]	Correction [dB]	Line	Meas. BW [kHz]	Meas. Time [ms]	Time	Source	Comment
1	0.247	59.95	61.86	1.91	41.83	51.86	10.03	9.72	N	9.000	15 000.000	13:58:52	Critical Points	
1	0.370	49.41	58.50	9.08	34.37	48.50	14.12	10.00	N	9.000	15 000.000	13:59:08	Critical Points	
1	0.497	47.37	56.05	8.68	30.94	46.05	15.11	10.09	N	9.000	15 000.000	13:59:25	Critical Points	
1	0.624	45.73	56.00	10.27	31.73	46.00	14.27	10.05	N	9.000	15 000.000	13:59:42	Critical Points	
1	1.624	43.35	56.00	12.65	34.16	46.00	11.84	9.88	N	9.000	15 000.000	13:59:58	Critical Points	
1	1.874	47.25	56.00	8.75	36.43	46.00	9.57	9.88	N	9.000	15 000.000	14:00:15	Critical Points	
1	2.624	43.15	56.00	12.85	34.03	46.00	11.97	9.89	N	9.000	15 000.000	14:00:32	Critical Points	
1	2.878	45.11	56.00	10.89	34.44	46.00	11.56	9.90	N	9.000	15 000.000	14:00:49	Critical Points	
1	3.128	45.24	56.00	10.76	36.40	46.00	9.60	9.91	N	9.000	15 000.000	14:01:06	Critical Points	
1	3.251	50.46	56.00	5.54	39.84	46.00	6.16	9.92	N	9.000	15 000.000	14:01:23	Critical Points	

8 TEST SETUP DESCRIPTION

Typically, the calibrations of the test apparatus are commissioned to and performed by an accredited calibration laboratory. The calibration intervals are determined in accordance with the DIN EN ISO/IEC 17025. In addition to the external calibrations, the laboratory executes comparison measurements with other calibrated test systems or effective verifications. Cyclic chamber inspections and range calibrations are performed. Where possible, RF generating and signalling equipment as well as measuring receivers and analysers are connected to an external high-precision 10 MHz reference (GPS-based or rubidium frequency standard).

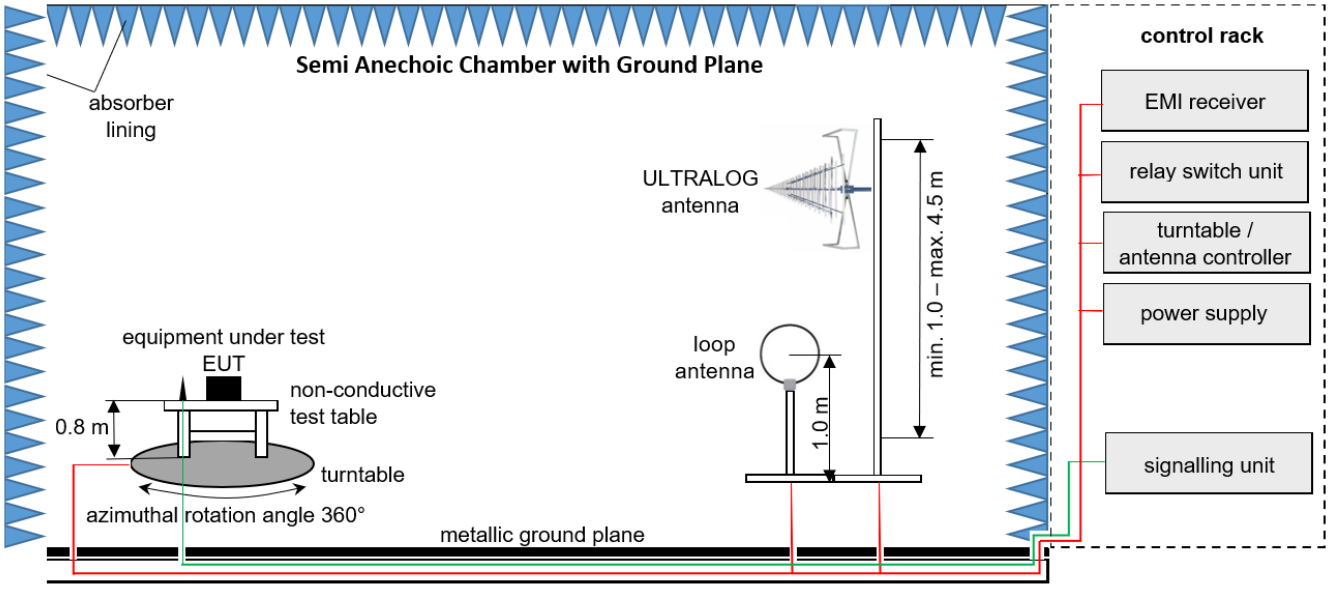
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

Kind of calibration (abbreviations):

C = calibrated
CM = cyclic maintenance
NR = not required
L = locked

8.1 Semi anechoic chamber with ground plane

Radiated measurements are performed in vertical and horizontal plane in the frequency range 30 MHz to 1 GHz in a Semi Anechoic Chamber with a metallic ground plane. The EUT is positioned on a non-conductive test table with a height of 0.80 m above the metallic ground plane that covers the whole chamber. The receiving antennas conform to specification ANSI C63.10-2013, American National Standard for Testing Unlicensed Wireless Devices. These antennas can be moved over the height range between 1.0 m and 4.5 m in order to search for maximum field strength emitted from the EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by a spectrum analyzer where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: loop antenna at 3 m, ULTRALOG antenna at 3 m
EMC32 software version: 11.20.00

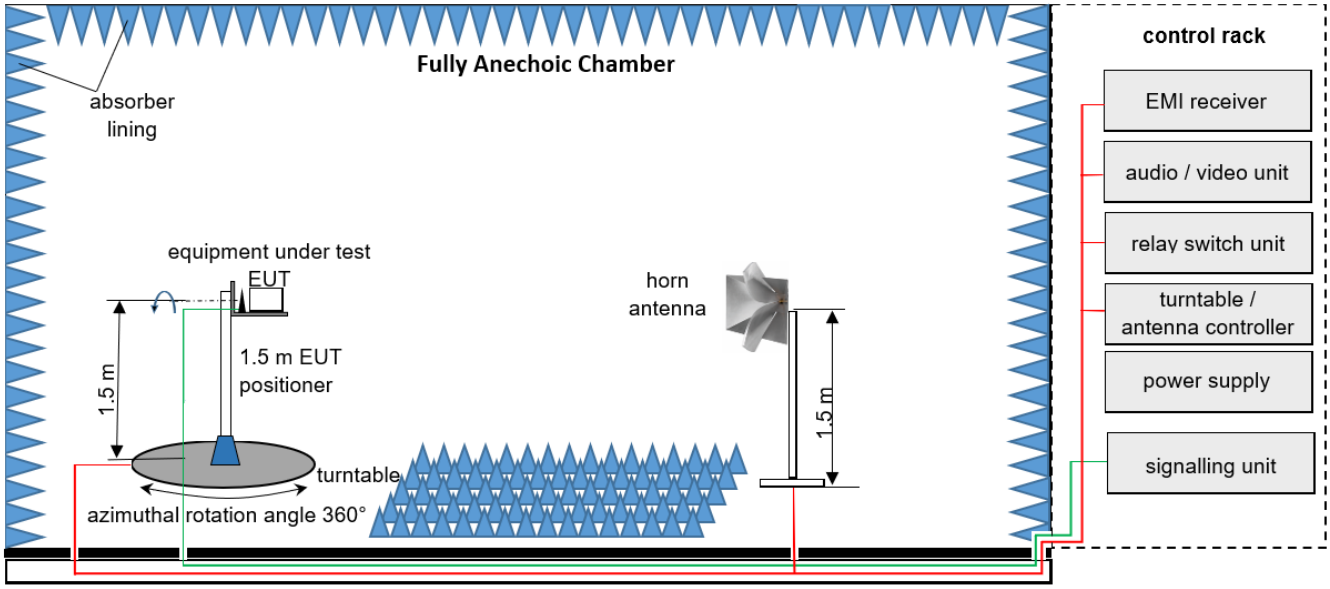
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	NR	–
2	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	NR	–
3	Power Supply	Chroma	61604	616040005416	LAB000285	NR	–
4	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	NR	–
5	Compressed Air	Implotex	1-850-30	-	LAB000256	NR	–
6	EMI Test Receiver	Rohde & Schwarz	ESW26	101481	LAB000236	C	2022-07-07 → 12M → 2023-07-07
7	Semi/Fully Anechoic Chamber (SFAC)	Albatross Projects GmbH	Babylon 5 (SAC 5)	20168.PRB	LAB000235	NR	–
8	Measurement Software	Rohde & Schwarz	EMC32 V11.20		LAB000226	NR	–
9	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	NR	–
10	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	NR	–
11	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	NR	–
12	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	NR	–
13	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350292	LAB000191	NR	–
14	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	NR	–
15	Antenna	Rohde & Schwarz	HF907	102899	LAB000151	C	2020-04-23 → 36M → 2023-04-23
16	Antenna	Rohde & Schwarz	HL562E	102005	LAB000150	C	2020-07-05 → 36M → 2023-07-05
17	Open Switch and Control Platform	Rohde & Schwarz	OSP200 Base Unit 2HU	101748	LAB000149	NR	–
18	Antenna	Rohde & Schwarz	HF907	102898	LAB000124	C	2020-04-23 → 36M → 2023-04-23
19	Antenna	Rohde & Schwarz	HL562E	102001	LAB000123	C	2020-07-05 → 36M → 2023-07-05
20	Antenna	Rohde & Schwarz	HFH2-Z2E - Active Loop Antenna	100954	LAB000108	C	2020-03-25 → 36M → 2023-03-25

8.2 Fully anechoic chamber



Measurement distance: horn antenna at 3 m
EMC32 software version: 11.20.00

FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

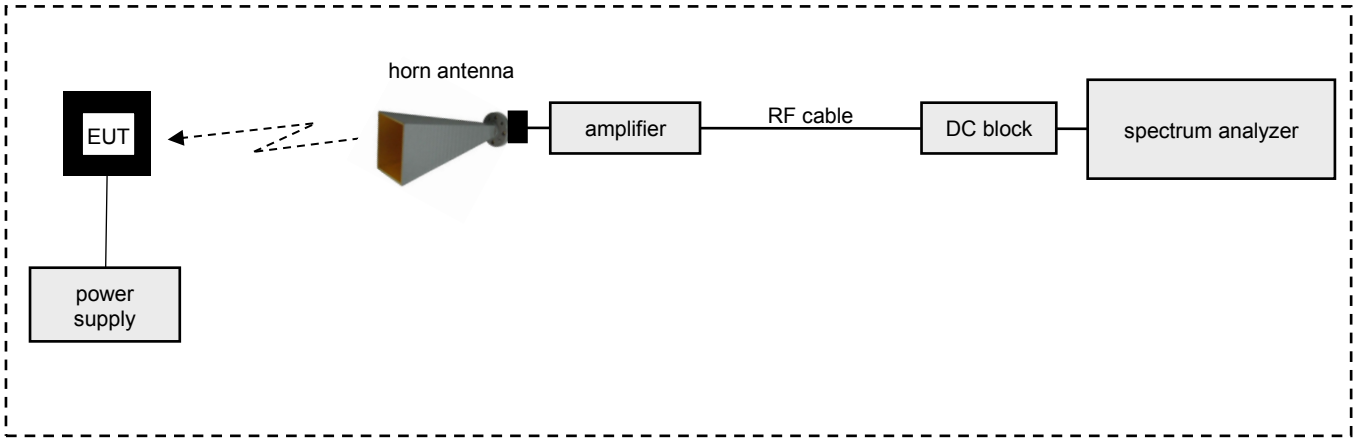
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:
OP [dBm] = -65.0 [dBm] + 50 [dB] - 20 [dBi] + 5 [dB] = -30 [dBm] (1 µW)

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	NR	–
2	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	NR	–
3	Power Supply	Chroma	61604	616040005416	LAB000285	NR	–
4	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	NR	–
5	Compressed Air	Implotex	1-850-30	-	LAB000256	NR	–
6	EMI Test Receiver	Rohde & Schwarz	ESW26	101481	LAB000236	C	2022-07-07 → 12M → 2023-07-07
7	Semi/Fully Anechoic Chamber (SFAC)	Albatross Projects GmbH	Babylon 5 (SAC 5)	20168.PRB	LAB000235	NR	–
8	Measurement Software	Rohde & Schwarz	EMC32 V11.20		LAB000226	NR	–
9	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	NR	–
10	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	NR	–
11	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	NR	–
12	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	NR	–
13	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350292	LAB000191	NR	–
14	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	NR	–
15	Antenna	Rohde & Schwarz	HF907	102899	LAB000151	C	2020-04-23 → 36M → 2023-04-23
16	Antenna	Rohde & Schwarz	HL562E	102005	LAB000150	C	2020-07-05 → 36M → 2023-07-05
17	Open Switch and Control Platform	Rohde & Schwarz	OSP200 Base Unit 2HU	101748	LAB000149	NR	–
18	Antenna	Rohde & Schwarz	HF907	102898	LAB000124	C	2020-04-23 → 36M → 2023-04-23
19	Antenna	Rohde & Schwarz	HL562E	102001	LAB000123	C	2020-07-05 → 36M → 2023-07-05
20	Antenna	Rohde & Schwarz	HFH2-Z2E - Active Loop Antenna	100954	LAB000108	C	2020-03-25 → 36M → 2023-03-25

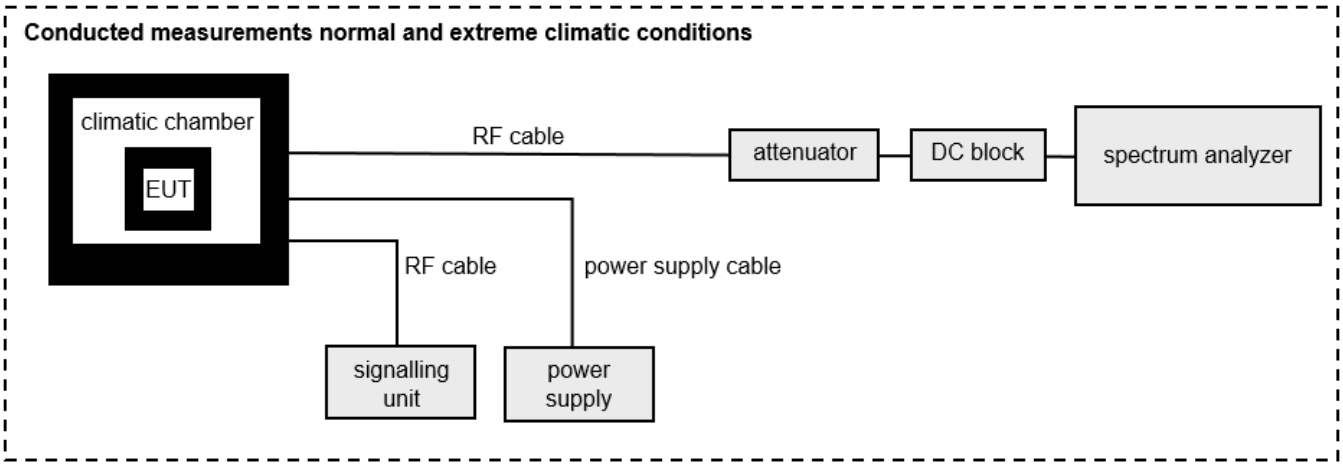
8.3 Radiated measurements > 18 GHz



List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	INV. No.	Last / Next Calibration
1	Test table	innco systems GmbH	PT0707-RH light	-	LAB000303	–
2	WG-Coax-Adapter	Flann Microwave Ltd	20093-TF30 UBR220	273374	LAB000181	2020-07-01 → 2023-07-01
3	Coaxial Cable	Huber & Suhner	SF101/1.5m	503987/1	LAB000165	
4	Antenna	Flann Microwave Ltd	20240-20	266403	LAB000128	2020-06-29 → 2023-06-29
5	Spectrum Analyser	Rohde & Schwarz	FSW43	101391	LAB000289	2022-06-10 → 2023-06-10

8.4 Measurements under normal and extreme conditions



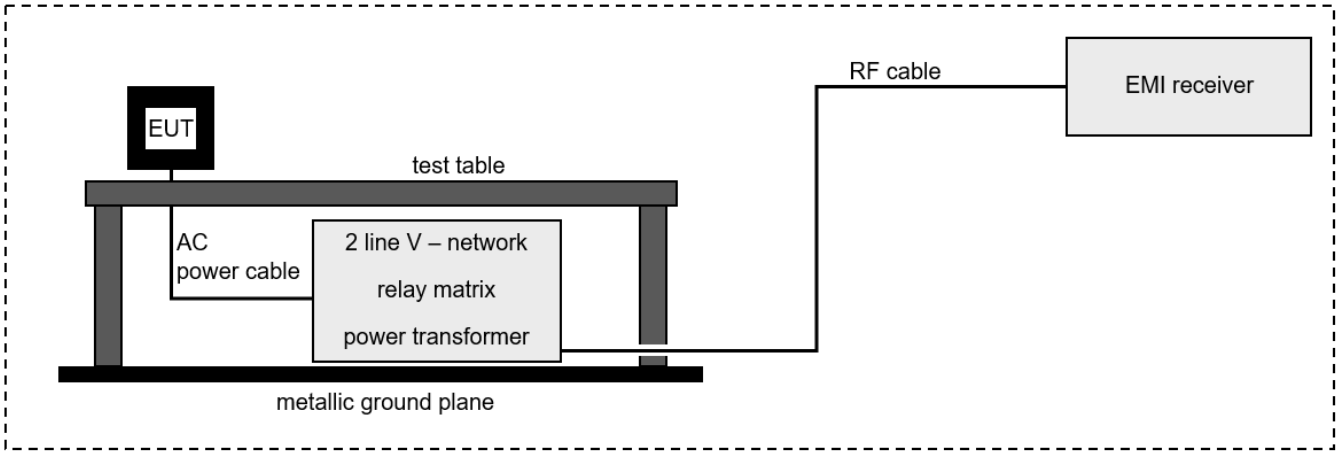
Power = UR + CL + AT
(Power; UR-voltage at the receiver; CL-loss of the cable; AT-attenuation/splitter)

Example calculation:
Power [dBm] = -65.0 [dBm] + 1.9 [dB] + 6.4 [dB] = -56.7 [dBm]

List of test equipment used:

No.	Equipment	Type	Manufacturer	Serial No.	IBL No.	Kind of Calibration	Calibration
1	Test table	innco systems GmbH	PT0707-RH light	-	LAB000303	NR	–
2	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350263	LAB000190	NR	–
3	Spectrum Analyser	Rohde & Schwarz	FSW43	101391	LAB000289	C	2022-06-10 → 12M → 2023-06-10
4	Coaxial Cable	Huber & Suhner	ST18/48"	2575556	LAB000387	CM	2022-05-31 → 12M → 2023-05-31

8.5 AC conducted



FS = UR + CF + VC
(FS-field strength; UR-voltage at the receiver; CR-loss of the cable and filter; VC-correction factor of the ISN)

Example calculation:
FS [dBµV/m] = 37.62 [dBµV/m] + 9.90 [dB] + 0.23 [dB] = 47.75 [dBµV/m] (244.06 µV/m)

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Open Switch and Control Platform	Rohde & Schwarz	OSP-B200S2	101443	LAB000239	NR	-
2	EMI Test Receiver	Rohde & Schwarz	ESW26	101481	LAB000236	C	2022-07-07 → 12M → 2023-07-07
3	Two-Line V-Network	Rohde & Schwarz	ENV216	102597	LAB000220	C	2022-09-27 → 24M → 2023-09-27

9 MEASUREMENT PROCEDURES

9.1 Radiated spurious emissions from 9 kHz to 30 MHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 315° in 45° steps.
- For each turntable step the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software by rotating the turntable from 0° to 360°.
- Loop antenna is rotated with special 3D adapter set to find maximum level of emissions.
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 40 dB/decade of distance in the region closer than λ in m divided by 2π (i.e., λ/2π), and at 20 dB/decade of distance beyond that, using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the limit line of corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.26

9.2 Radiated spurious emissions from 30 MHz to 1 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 315° in 45° steps.
- Antenna polarisation is changed (H-V / V-H) and antenna height is changed from 1 meter to 4 meters.
- For each turntable step / antenna polarisation / antenna height the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software based on evaluated data during the pre-scan by rotating the turntable and changing antenna height and polarisation.
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C6.4).
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position, antenna polarisation and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.26

9.3 Radiated spurious emissions from 1 GHz to 18 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 315° in 45° steps.
- Antenna polarisation is changed (H-V / V-H) and antenna height is changed from 1 meter to 4 meters.
- For each turntable step / antenna polarisation / antenna height the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software based on evaluated data during the pre-scan by rotating the turntable and changing antenna height and polarisation.
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C6.4).
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position, antenna polarisation and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.26

9.4 Radiated spurious emissions above 18 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- EUT is powered on and set into operation.
- Test distance depends on EUT size and test antenna size (farfield conditions shall be met).

Pre-scan

- The test antenna is handheld and moved carefully over the EUT to cover the EUT's whole sphere and for different polarizations of the antenna.

Final measurement

- Significant emissions found during the pre-scan will be maximized, i.e. position and antenna orientation causing the highest emissions with Peak and RMS detector
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C63.4 / C63.26).
- Final plot showing measurement data, levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit is recorded.

Note

- In case of measurements with external harmonic mixers (e.g. above 50 GHz) special care is taken to avoid possible overloading of the external mixer's input.
- As external harmonic mixers may generate false images, care is taken to ensure that any emission measured by the spectrum analyzer is indeed radiated from the EUT and not internally generated by the external harmonic mixer. Signal identification feature of spectrum analyzer is used to eliminate/reduce images of the external harmonic mixer.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.26

10 MEASUREMENT UNCERTAINTIES

Radio frequency	≤ ± 1 x 10^{-7}
RF power, conducted	≤ ± 0.75 dB
Power spectral density	≤ ± 3 dB
Maximum frequency deviation	≤ ± 5 %
Deviation limitation Duty Cycle, Tx-sequence, Tx-gap	≤ ± 5 %
Occupied channel bandwidth	≤ ± 5 %
Conducted spurious emission of transmitter	≤ ± 4 dB
Conducted emission of receivers	≤ ± 4 dB
Radiated emission of transmitter	≤ ± 6 dB
Radiated emission of receiver	≤ ± 6 dB
Temperature	≤ ± 2.5 °C
Humidity	≤ ± 10 %

The indicated expanded measurement uncertainty corresponds to the standard measurement uncertainty for the measurement results multiplied by the coverage factor k = 2. It was determined in accordance with EA-4/02 M:2013. The true value is located in the corresponding interval with a probability of 95 %.

Annex A EUT Photographs, external

Photo No. 1:

Photo No. 2:

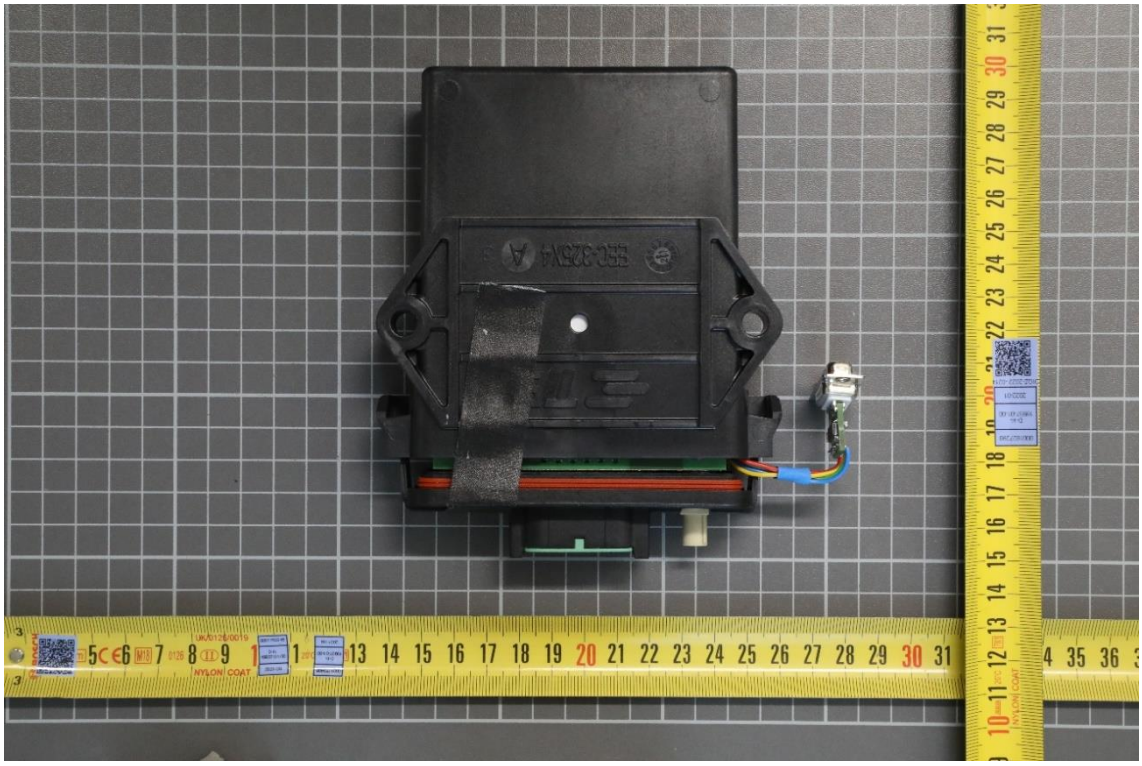


Photo No. 3:

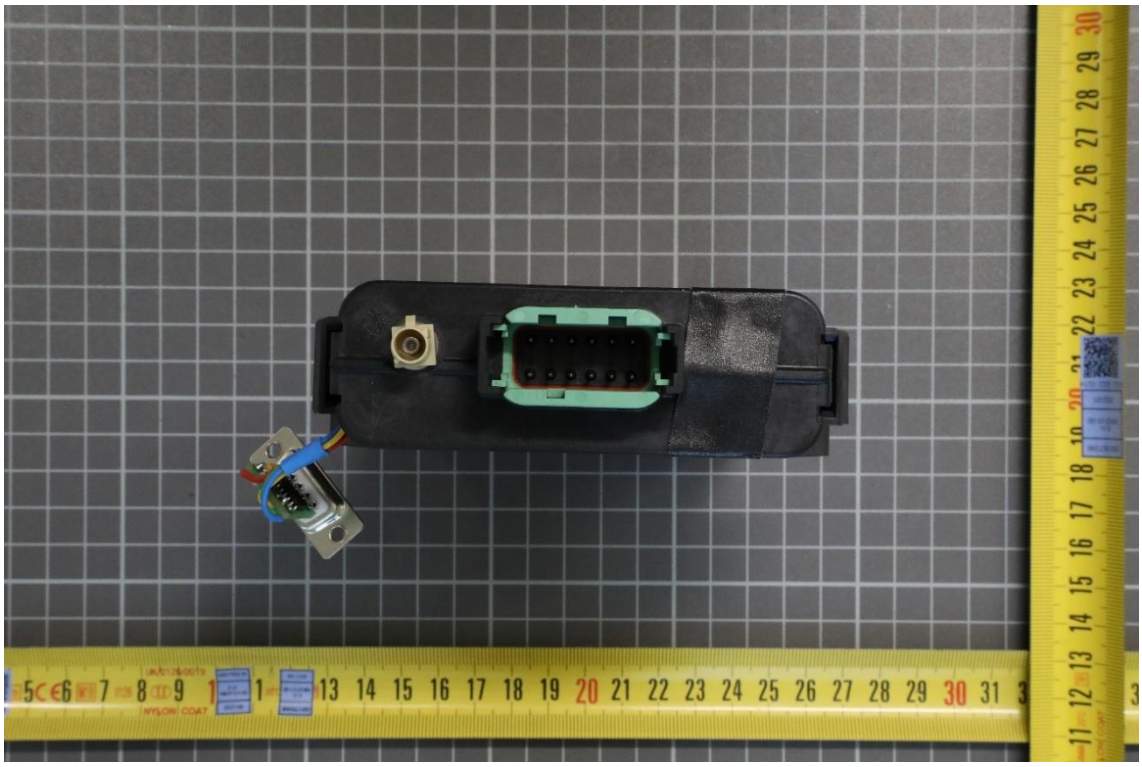


Photo No. 4:

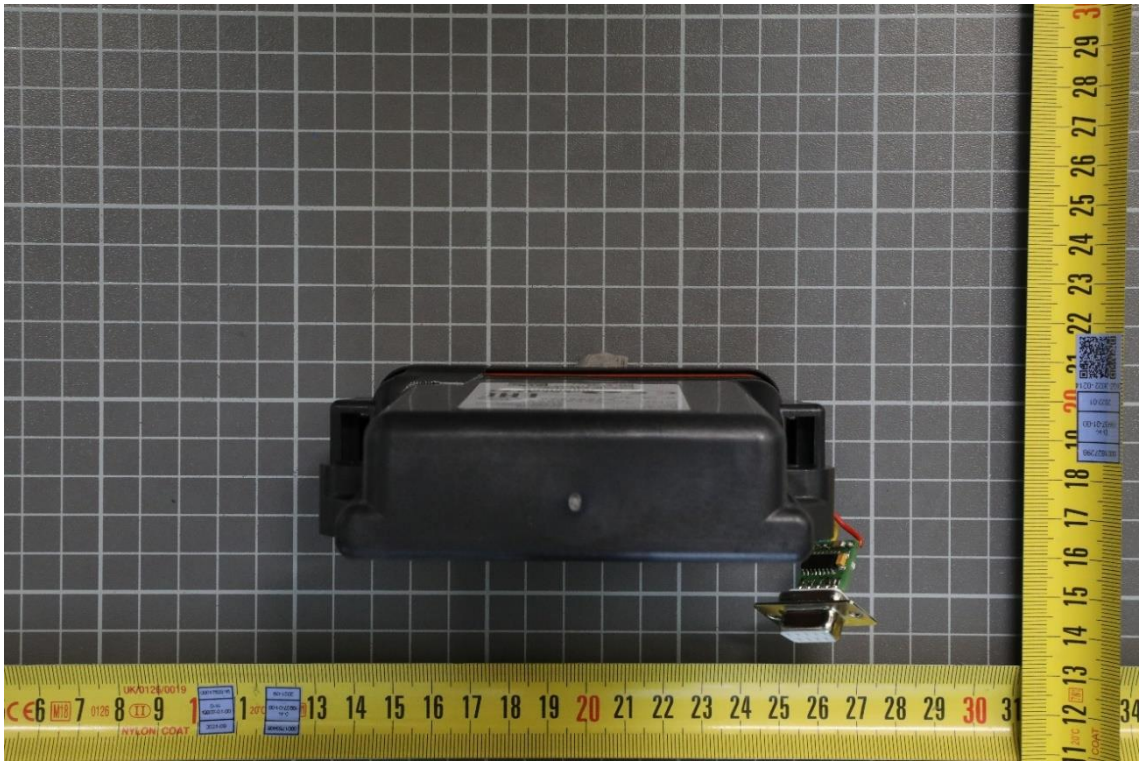


Photo No. 5:

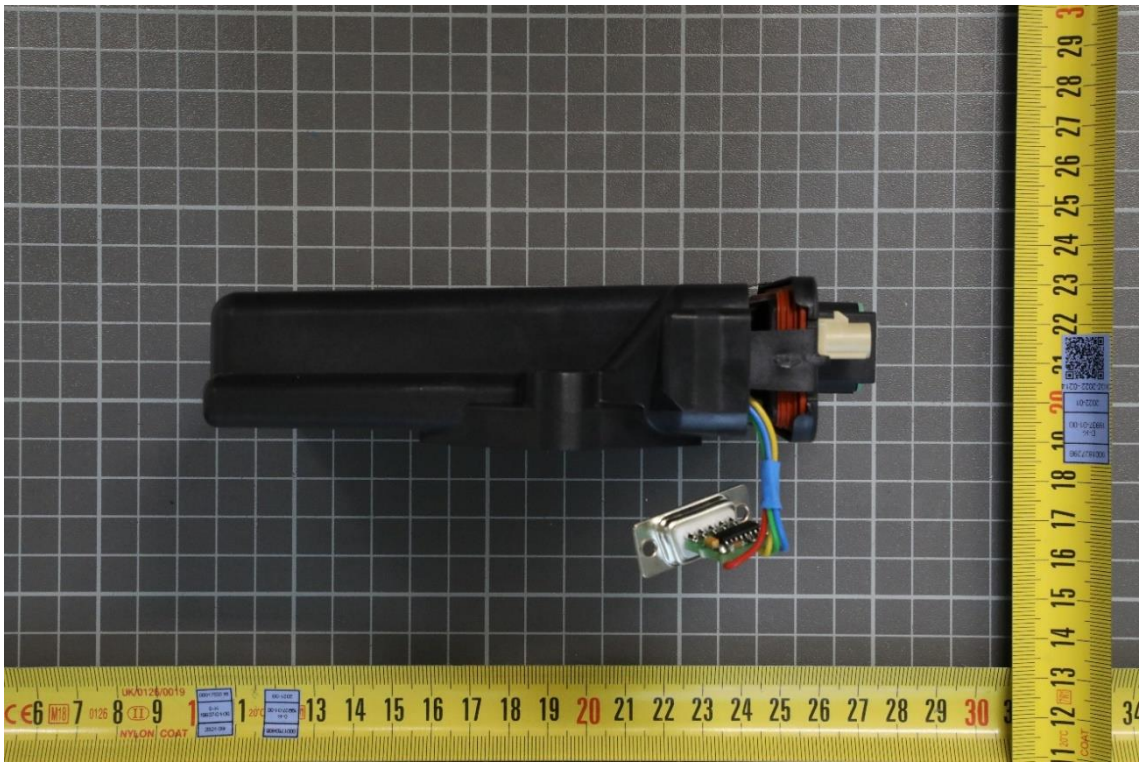


Photo No. 6:

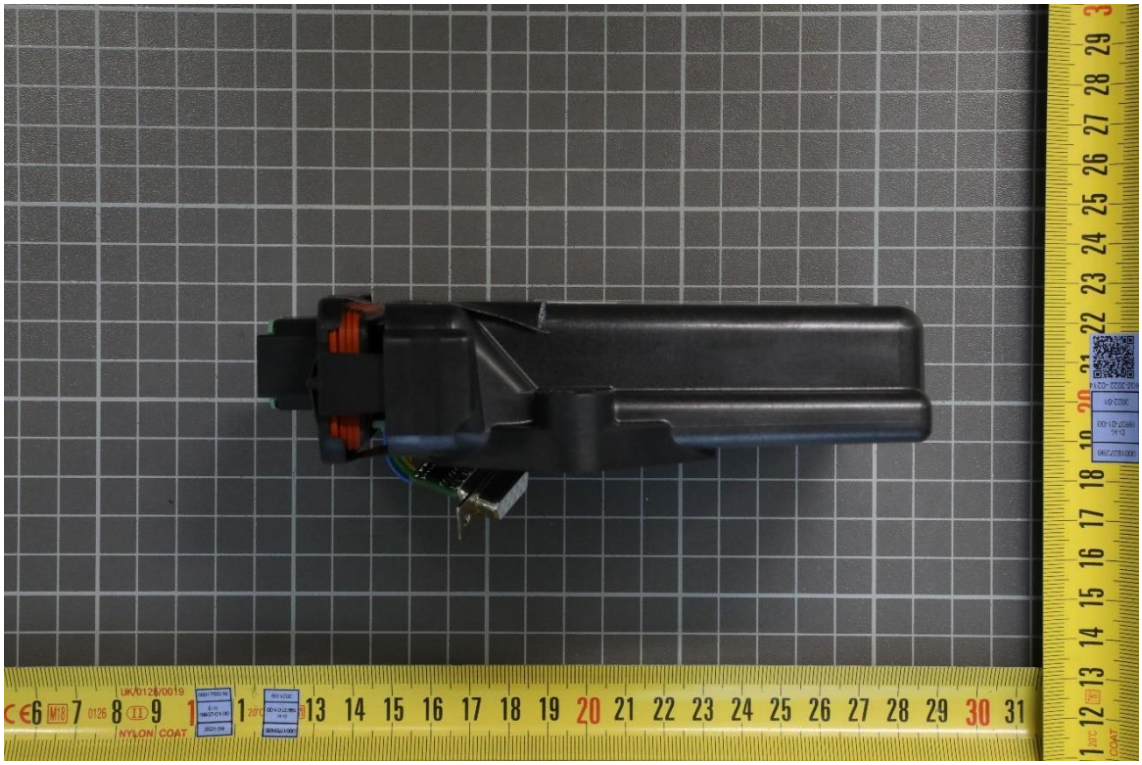
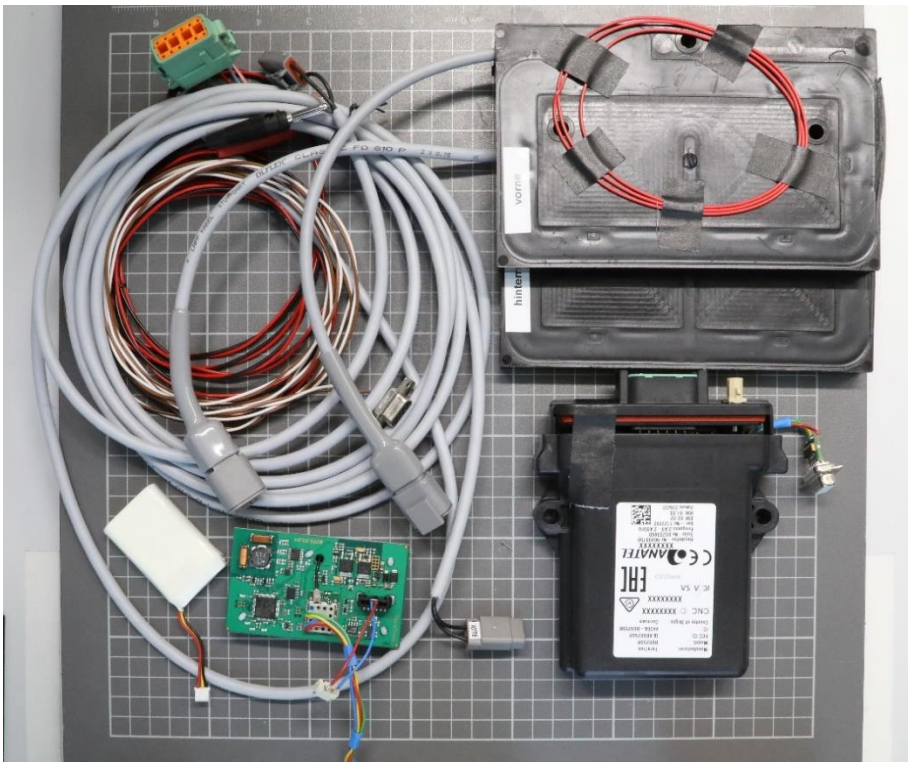


Photo No. 7:



Annex B EUT Photographs, internal

Photo No. 8:

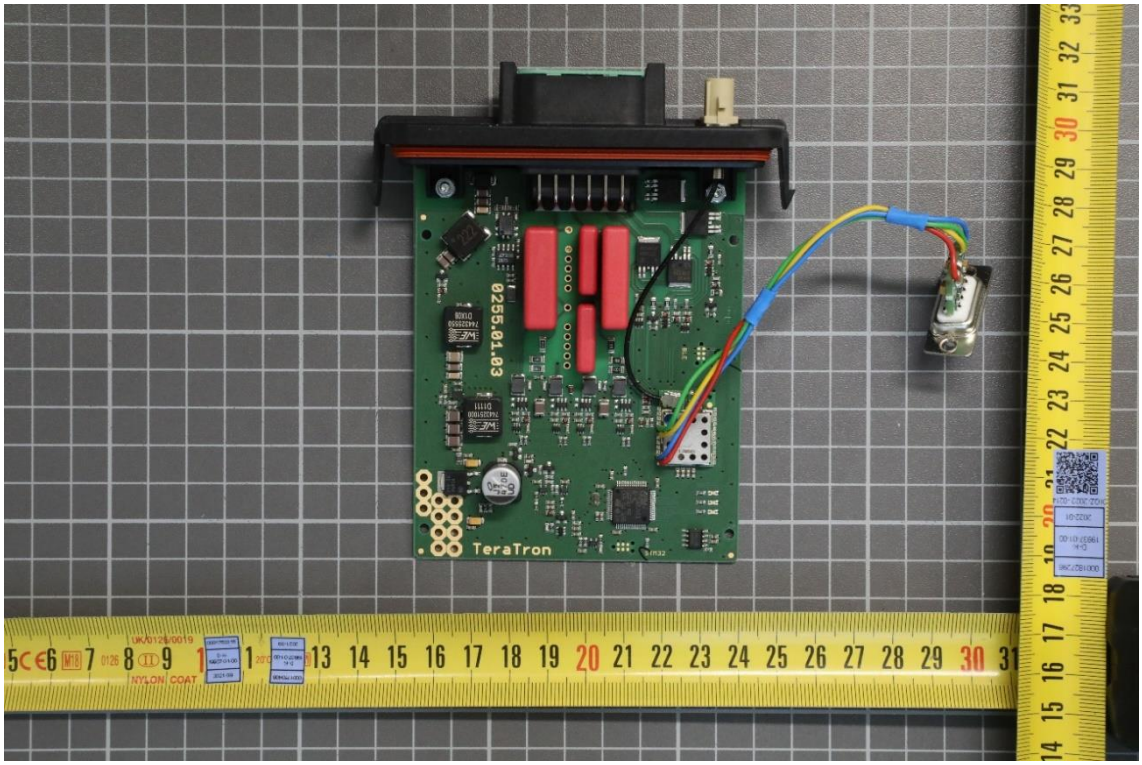


Photo No. 9:

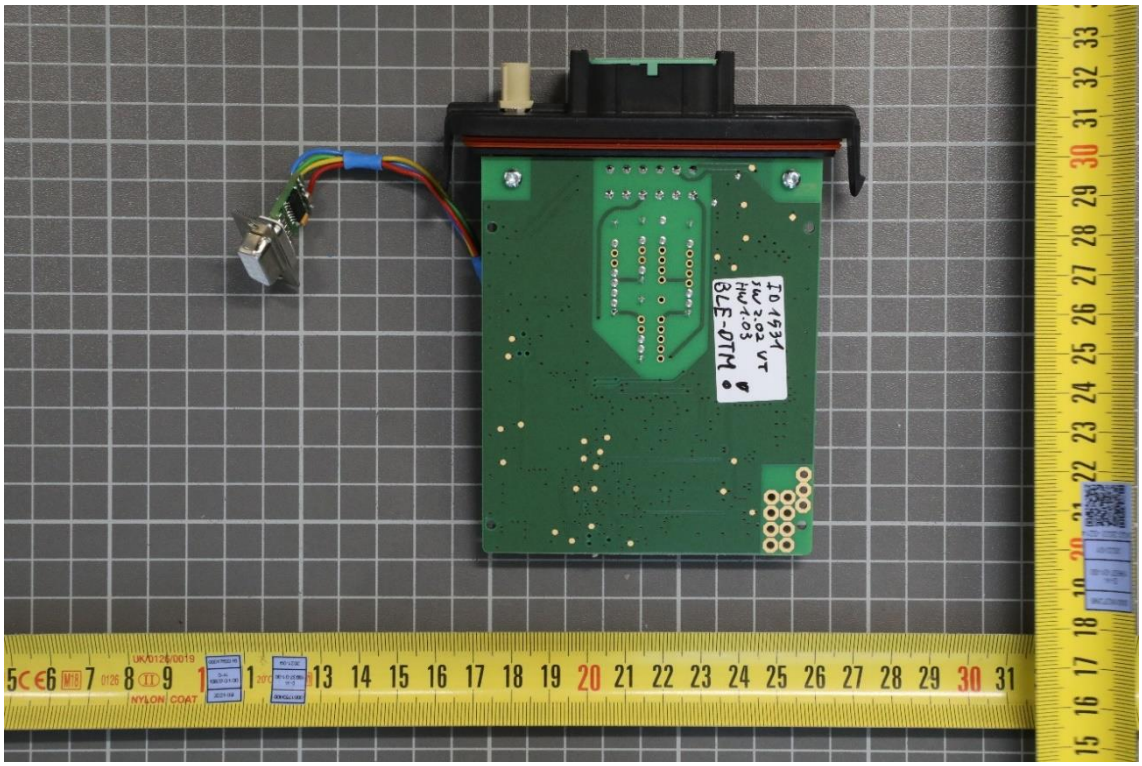


Photo No. 10:

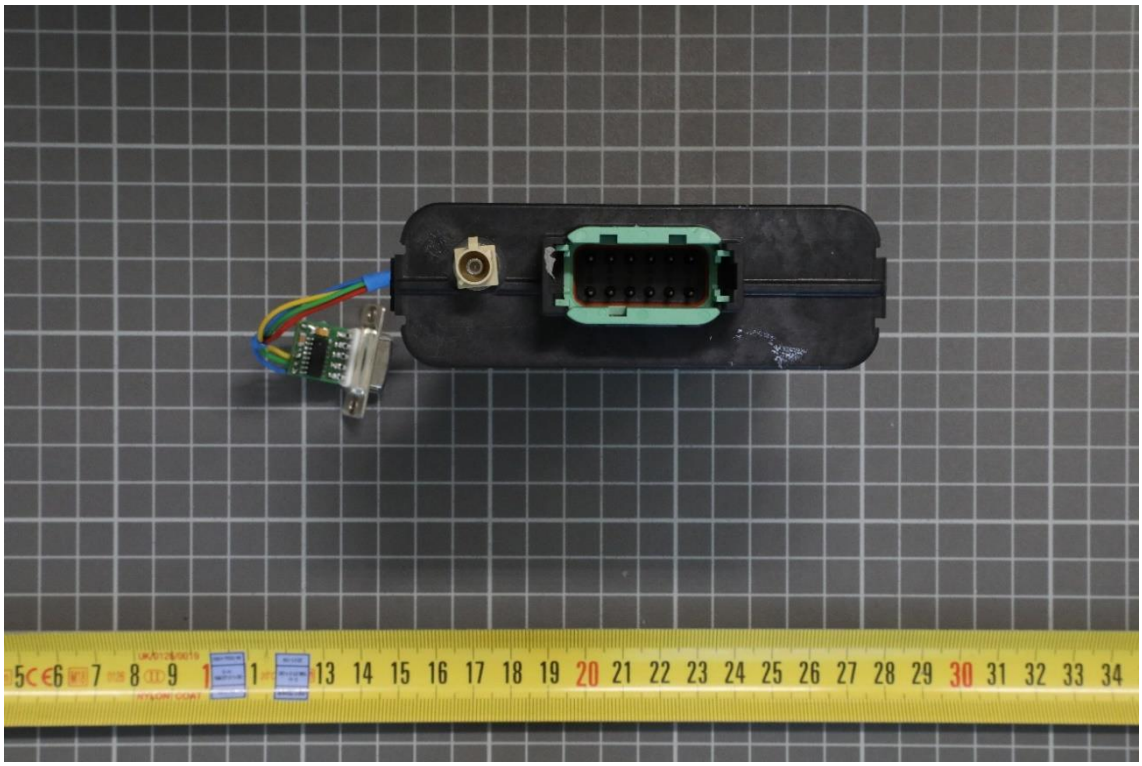


Photo No. 11:

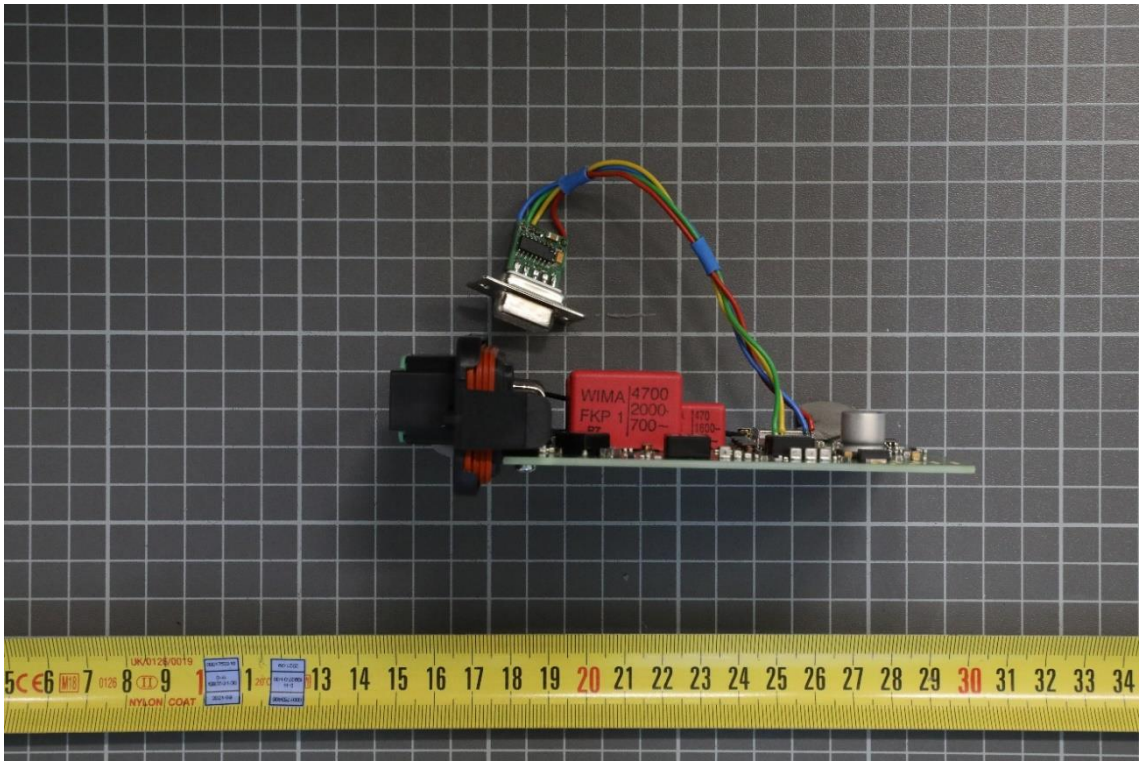
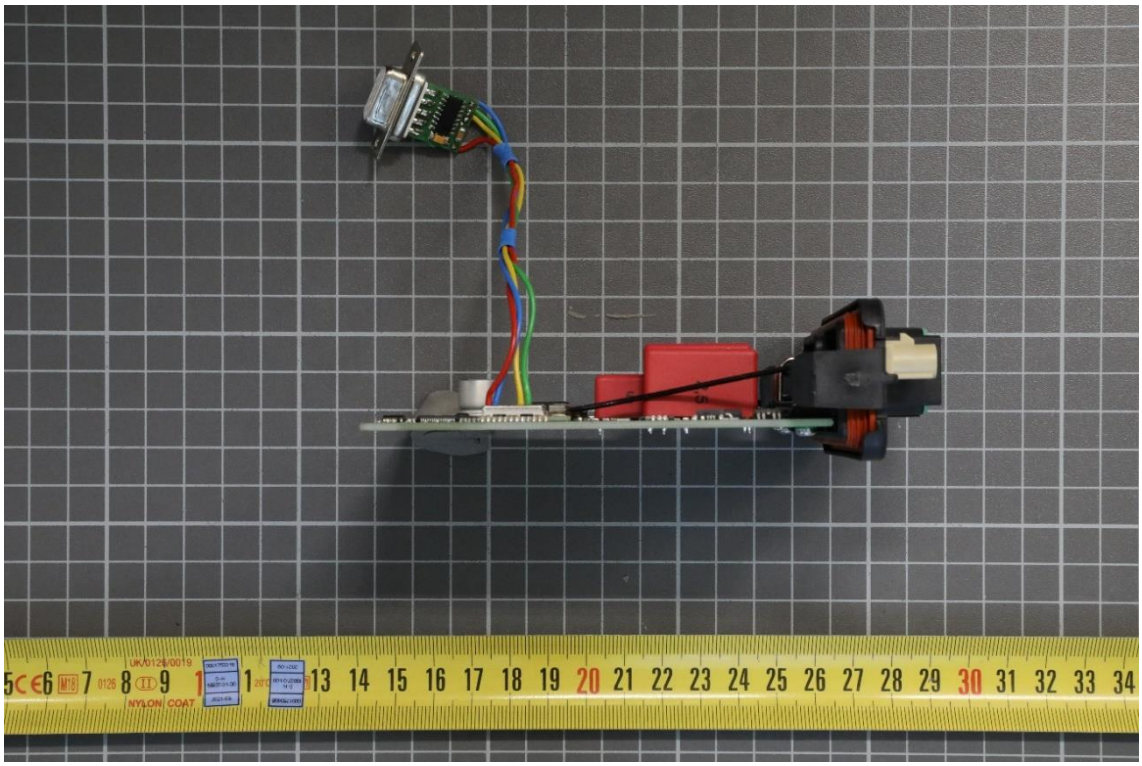


Photo No. 12:



Annex C Test Setup Photographs

Photo No. 13:

Photo No. 14:

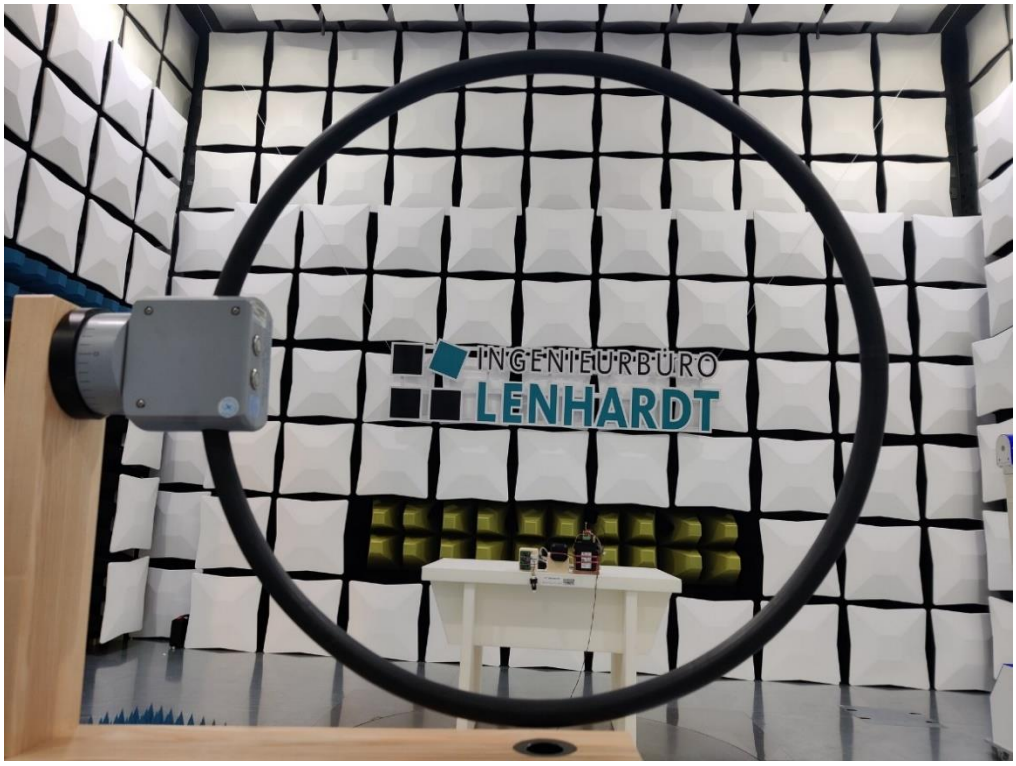


Photo No. 15:

Photo No. 16:

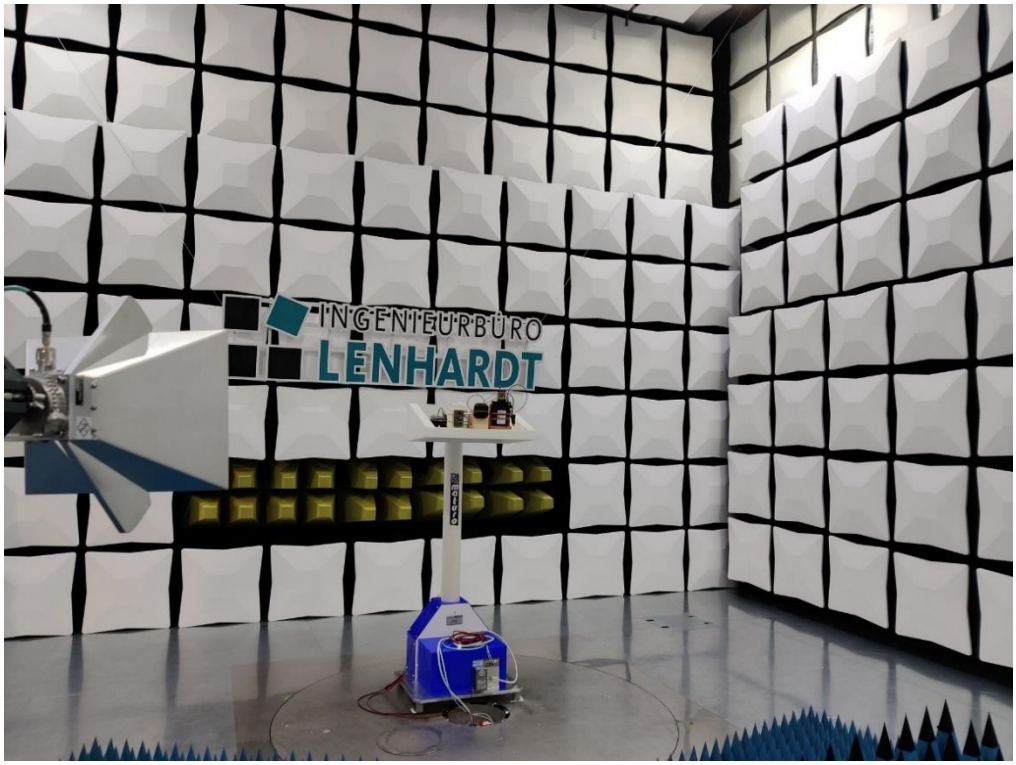


Photo No. 17:

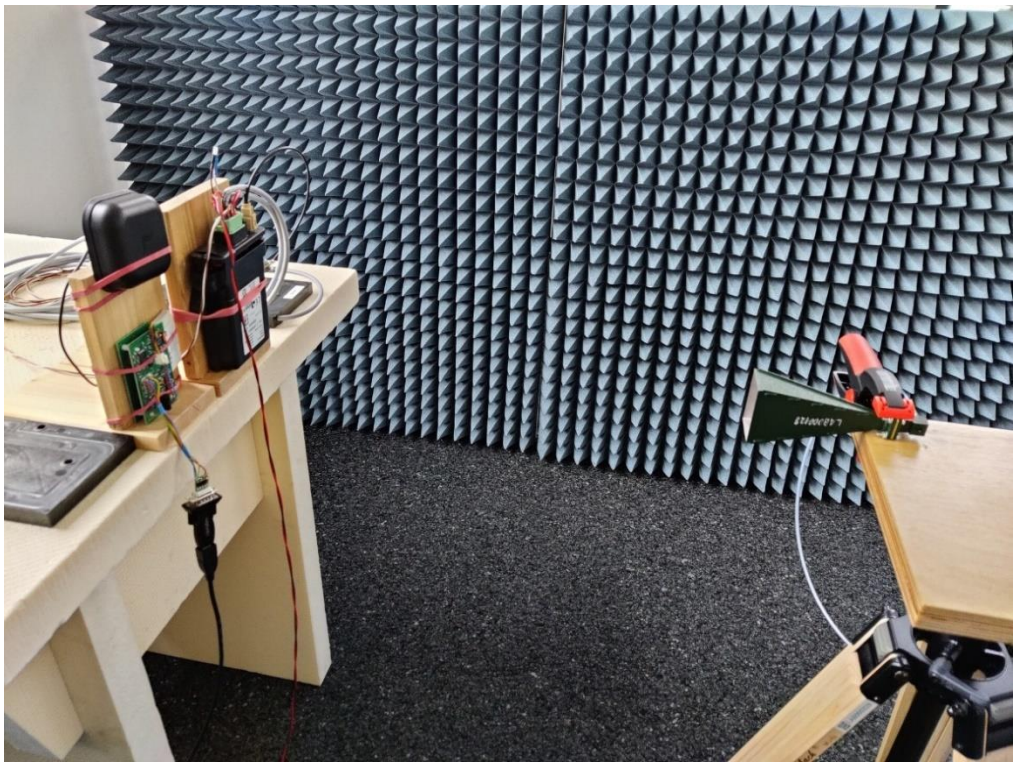
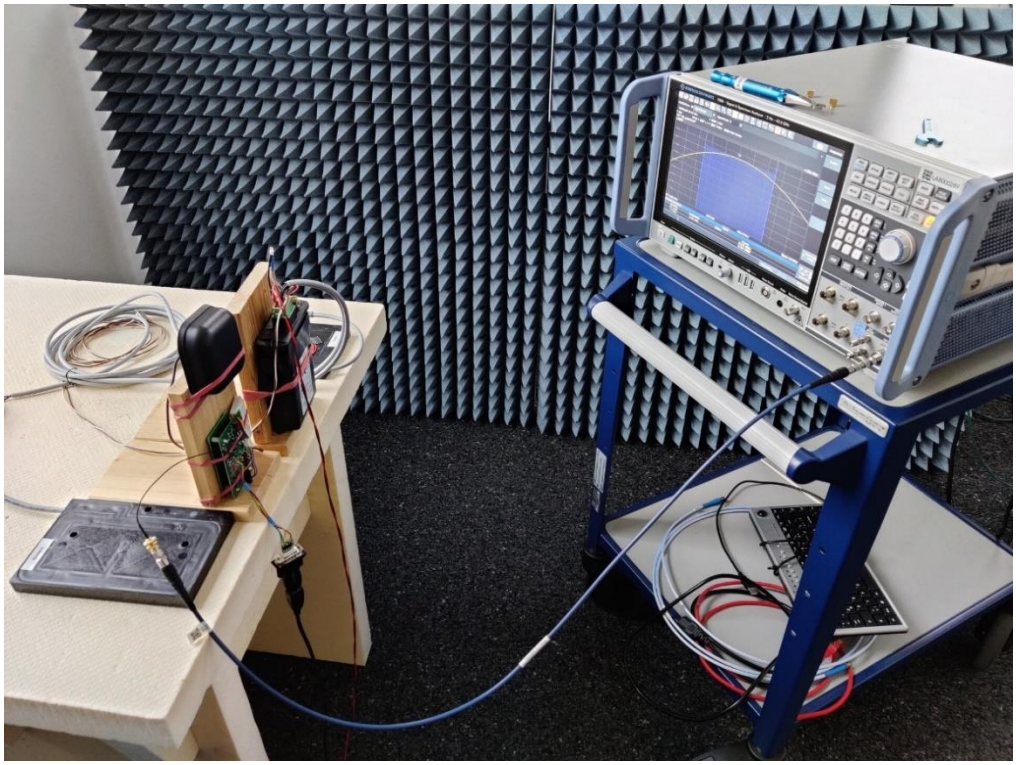


Photo No. 18:



End of Test Report