

Test Report

Report Number:

F231416E5

Equipment under Test (EUT):

Level Probing Radar

Micropilot FMR30B

Applicant:

Endress+Hauser SE+Co. KG

Manufacturer:

Endress+Hauser SE+Co. KG



Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

References

- [1] **ANSI C63.10-2020**, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15**, Radio Frequency Devices
- [3] **558074 D01 15.247 Meas Guidance v05r02 (April 2019)**, GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES
- [4] **RSS-247, Issue 3 (2023-08)** Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- [5] **RSS-Gen, Issue 5 Amendment 2 (2021-02)** General Requirements for Compliance of Radio Apparatus

Test Result

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test. The complete test results are presented in the following.

“Passed” indicates that the equipment under test conforms with the relevant limits of the testing standard without taking any measurement uncertainty into account as stated in [1]. However, the measurement uncertainty is calculated and shown in this test report.

Tested and written
by:

o. b. o.

Signature

Reviewed and
approved by:

Signature

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The test results herein refer only to the tested sample. PHOENIX TESTLAB GmbH is not responsible for any generalisations or conclusions drawn from these test results concerning further samples. Any modification of the tested samples is prohibited and leads to the invalidity of this test report. Each page necessarily contains the PHOENIX TESTLAB Logo and the TEST REPORT NUMBER.

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1 Identification

1.1 Applicant

Name:	Endress+Hauser SE+Co. KG
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Country:	Germany
Name for contact purposes:	Mr. Florian SEIDLER, Mr. Ralf REIMELT
Phone:	+49 7622 28 1450
eMail address:	florian.seidler@endress.com
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	Endress+Hauser SE+Co. KG
Address:	Hauptstr. 1, 79689 Maulburg
Country:	Germany
Name for contact purposes:	Mr. Florian SEIDLER, Mr. Ralf REIMELT
Phone:	+49 7622 28 1450
eMail address:	florian.seidler@endress.com
Manufacturer represented during the test by the following person:	-

1.3 Test Laboratory

The tests were carried out by: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) according to DIN EN ISO/IEC 17025:2018. The accreditation is only valid for the scope of accreditation listed in the annex of the certificate D-PL-17186-01-00. FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment under Test)

Test object: *1		Level Probing Radar
Model name: *1		Micropilot
Model number: *1		FMR30B
Order number: *1		FMR30B-AABAKABMXQ0VEE3
FCC ID: *1	VU231C:	LCGVU231C
	Device:	LCGFMR30BL
IC certification number: *1	VU231C:	2519A-VU231C
	Device:	2519A-30BL
PMN: *1		FMR30B
HVIN: *1		FMR30B-BM
FVIN: *1		N/A
HMN: *2		- *2

*1 Declared by the applicant

*2 No information provided by the applicant

Serial number: *	FMR30B_HA2W_0234		
PCB identifier: *	VU231C:		71599593
	Device:	Main:	71499710
		Terminal:	71581366
		Power:	71502179
		Sensor:	71574004
Hardware version: *	VU231C:		01.00.00
	Device:		01.00.00
Software version: *	VU231C:		S140 V7.2.0
	Device:		V01.00.00

* Declared by the applicant

One EUT was used for all tests.

Note: PHOENIX TESTLAB GmbH does not take samples. The samples used for tests are provided exclusively by the applicant.

1.5 Technical Data of Equipment

General EUT data			
Power supply EUT: *	DC		
Supply voltage EUT: *	$U_{nom} = 24.0 \text{ V}_{DC}$	$U_{min} = 12.0 \text{ V}_{DC}$	$U_{max} = 30.0 \text{ V}_{DC}$
Temperature range: *	-40 °C to +80 °C		
Lowest / highest internal clock frequency: *	2.25 MHz / 84 GHz		

* Declared by the applicant

Ports / Connectors				
Identification	Connector		Max. cable length	Shielding (Yes / No)
	EUT	Ancillary		
DC and data *	Fixed	-	2 m	-

* Declared by the applicant

Bluetooth® low energy frequencies			
Channel 00	2402 MHz	Channel 01	2404 MHz
Channel 02	2406 MHz	Channel 03	2408 MHz
...	...	...	...
...	...	...	...
Channel 18	2438 MHz	Channel 19	2440 MHz
...	...	...	...
...	...	...	...
Channel 36	2474 MHz	Channel 37	2476 MHz
Channel 38	2478 MHz	Channel 39	2480 MHz

Bluetooth® low energy radio mode	
Fulfills radio specification: *1	Bluetooth® low energy (BLE) 5.1
Radio chip: *1	Nordic nRF52840 (SoC)
Antenna type: *1	PCB Antenna
Antenna name: *1	-
Antenna gain: *2	Peak: 1.1 dBi
Antenna connector: *1	-
Supply voltage radio module: *1	$U_{nom} = 3.0 V_{DC}$ $U_{min} = 1.7 V_{DC}$ $U_{max} = 3.6 V_{DC}$
Type of modulation: *1	BLE (1 Mbps PHY) GFSK
	BLE (2 Mbps PHY) GFSK
	BLE (500 kbps coded PHY) GFSK
	BLE (125 kbps coded PHY) GFSK
Operating frequency range: *1	BLE (1 Mbps PHY) 2402 – 2480 MHz
	BLE (2 Mbps PHY) 2402 – 2480 MHz
	BLE (500 kbps coded PHY) 2402 – 2480 MHz
	BLE (125 kbps coded PHY) 2402 – 2480 MHz
Number of channels: *1	BLE (1 Mbps PHY) 40 (2 MHz channel spacing)
	BLE (2 Mbps PHY) 40 (2 MHz channel spacing)
	BLE (500 kbps coded PHY) 40 (2 MHz channel spacing)
	BLE (125 kbps coded PHY) 40 (2 MHz channel spacing)

*1 Declared by the applicant

*2 Based on the antenna test report F231413E5 by PHOENIX TESTLAB GmbH

1.5.1 Ancillary Equipment / Equipment used for testing

Equipment used for testing	
AC power adaptor *	PHOENIX CONTACT MINI_PS_100_240AC/24DC/1.3 (Order-No.: 28 66 44 6)

* Provided by the laboratory

Ancillary equipment	
Laptop*	Fujitsu Lifebook U759
-	-

* Provided by the laboratory

1.6 Dates

Date of receipt of test sample:	22.07.2024
Start of test:	08.08.2024
End of test:	24.10.2024

2 Operational States

2.1 Description of function of the EUT

The FMR30B is a Level Probing Radar (LPR) for liquid applications. It is intended to be used in the frequency range from 76 GHz to 84 GHz. FMR30B is working in the W-band and is a FMCW-Radar. The display of the Level Probe Radar is a modular device which uses Bluetooth Low Energy for data communication.

2.1.1 Operation modes

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate	Power setting
1	Bluetooth® LE	2402	0	GFSK	125 kbps	"pos8dBm"
2	Bluetooth® LE	2440	19	GFSK	125 kbps	"pos8dBm"
3	Bluetooth® LE	2480	39	GFSK	125 kbps	"pos8dBm"
4	Bluetooth® LE	2402	0	GFSK	500 kbps	"pos8dBm"
5	Bluetooth® LE	2440	19	GFSK	500 kbps	"pos8dBm"
6	Bluetooth® LE	2480	39	GFSK	500 kbps	"pos8dBm"
7	Bluetooth® LE	2402	0	GFSK	1 Mbps	"pos8dBm"
8	Bluetooth® LE	2440	19	GFSK	1 Mbps	"pos8dBm"
9	Bluetooth® LE	2480	39	GFSK	1 Mbps	"pos8dBm"
10	Bluetooth® LE	2402	0	GFSK	2 Mbps	"pos8dBm"
11	Bluetooth® LE	2440	19	GFSK	2 Mbps	"pos8dBm"
12	Bluetooth® LE	2480	39	GFSK	2 Mbps	"pos8dBm"

3 Additional Information

The EUT was not labeled as required by FCC / IC.

It contains the Visualization Unit VU231C which is a standalone display device with an integrated Bluetooth® LE interface. The VU231C was tested separately by PHOENIX TESTLAB GmbH what is documented in the test report F231413E3.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [4] RSS-Gen [5]	Status
Maximum peak conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [4]	Not tested* ¹
Maximum conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [4]	Not tested* ¹
DTS Bandwidth / 99% Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [4]	Not tested* ¹
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [4]	Not tested* ¹
Average Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [4]	Not tested* ¹
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [4]	Not tested* ¹
Maximum unwanted emissions	0.009 – 26.5* ¹	15.247 (d) 15.205 (a) 15.209 (a)	8.9 [5]	Passed* ²
Antenna Requirement	-	15.203 15.247 (b)	6.8 [5] 5.4 (f) (ii) [4]	Passed
Conducted emissions on supply line	0.15 – 30	15.207 (a)	8.8 [5]	Passed

*¹ Not tested, because the tests were already performed at the EUT "VU231C" and documented in the report F231413E3 by PHOENIX TESTLAB GmbH

*² As declared by the applicant the highest clock frequency of the Bluetooth part is 2.48 GHz.
Therefore, the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency of the Bluetooth part, in this case 26.5 GHz.
The tested spurious emissions of the Radar part can be found in the test report F231416E1 by PHOENIX TESTLAB GmbH.

5 Results

5.1 Test setups

5.1.1 Radiated: 9 kHz to 30 MHz

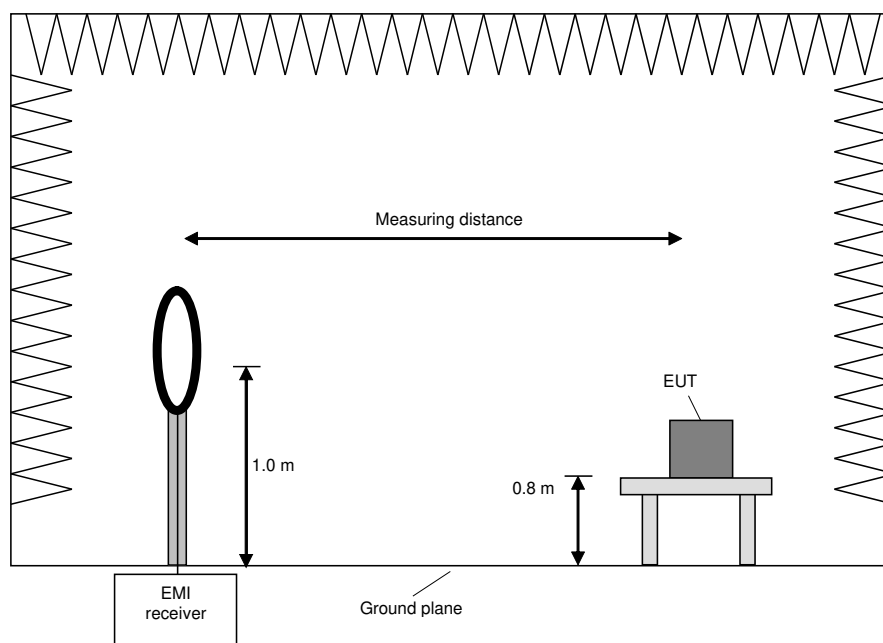
5.1.1.1 Preliminary measurement 9 kHz to 30 MHz

In the first stage a preliminary measurement is performed in a semi-anechoic chamber at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices are placed directly on the turntable / ground plane. The setup of the equipment under test is in accordance with [1].

The frequency range 9 kHz to 30 MHz is monitored with an EMI receiver while the system and its cables are manipulated to find out the configuration with the maximum emission levels if applicable. The EMI receiver is set to MAX hold mode. The EUT and the measuring antenna are rotated around their vertical axis to find the maximum emission levels.

The resolution bandwidth of the EMI receiver is set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz



Procedure preliminary measurement:

Pre-scans are performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

The following procedure is used:

- 1) Monitor the frequency range with the measuring antenna facing the EUT and an EUT / turntable azimuth of 0°.
- 2) Manipulate the system cables to produce the maximum levels of emissions.
- 3) Rotate the EUT by 360° to maximize the detected signals.

- 4) Measure the frequencies of the highest detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency values.
- 5) If the EUT is portable or ceiling mounted, repeat steps 1 to 4 with other orientations (x,y,z) of the EUT.
- 6) Rotate the measuring antenna and repeat steps 1 to 5.

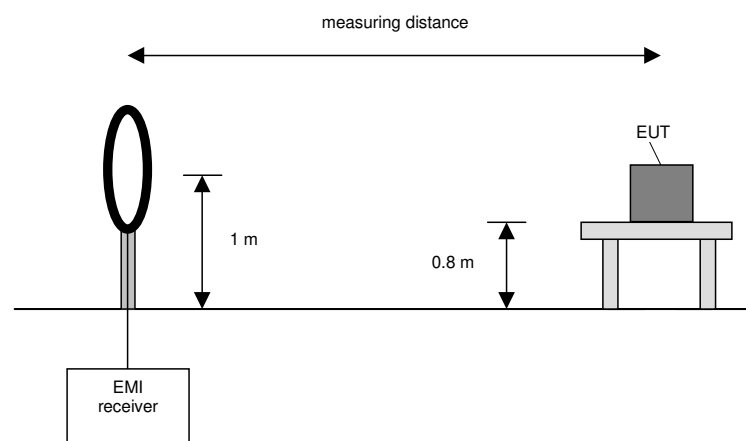
5.1.1.2 Final measurement 9 kHz to 30 MHz

In the second stage a final measurement is performed on an open area test site with no conducting ground plane at a measuring distance of 3 m, 10 m, or 30 m. If the standard requires larger measuring distances for a given frequency, the results are extrapolated according to section 15.31 (f) (2) [2]. The final measurement is performed with an EMI receiver set to Quasi-Peak detector, except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an Average detector is used according section 15.209 (d) [2].

At the frequencies, which were detected during the preliminary measurements, the final measurement is performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum level value is found.

The resolution bandwidth of the EMI receiver is set to the following values:

Frequency range	Resolution bandwidth	Measuring time
9 kHz to 150 kHz	200 Hz	1 s
150 kHz to 30 MHz	9 kHz	1 s



Procedure final measurement:

The following procedure is used:

- 1) Monitor the selected frequencies from the preliminary measurement with the measuring antenna facing the EUT and an EUT azimuth of 0 °.
- 2) Rotate the EUT by 360 ° to maximize the detected signals.
- 3) Rotate the measuring antenna and repeat steps 1 to 2 until the maximum value is found and note it.
- 4) If the EUT is portable or ceiling mounted, repeat steps 1 to 3 with other orientations (x,y,z) of the EUT.

5.1.2 Radiated: 30 MHz to 1 GHz

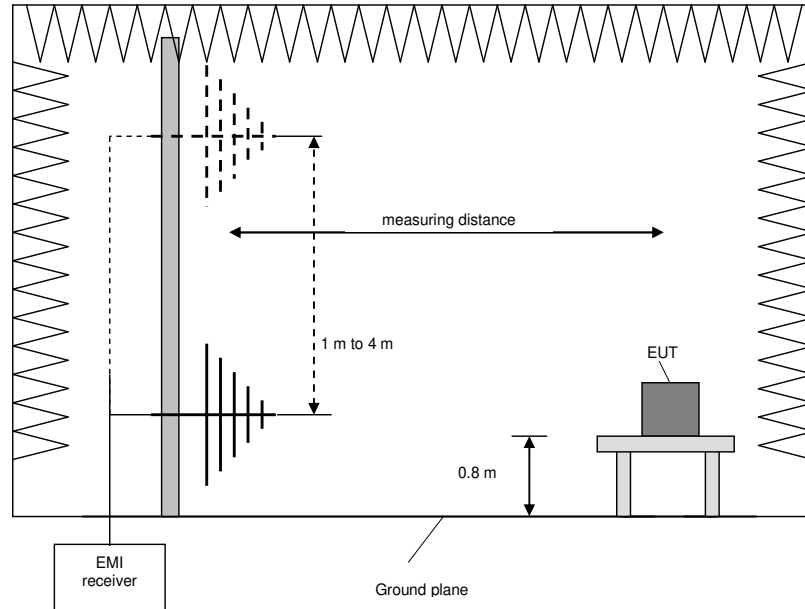
5.1.2.1 Preliminary and final measurement 30 MHz to 1 GHz

The preliminary and final measurements are performed in a semi-anechoic chamber with a metal ground plane at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices are placed directly on the turntable / ground plane. The setup of the equipment under test is in accordance with [1].

During the tests the EUT is rotated in the range of 0 ° to 360 °, the measuring antenna is set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI receiver is set to the following values:

Test	Frequency range	Step-size	Resolution bandwidth	Measuring time	Detector
Preliminary measurement	30 MHz to 1 GHz	30 kHz	120 kHz	-	Peak Average
Frequency peak search	± 120 kHz	10 kHz	120 kHz	1 s	Peak
Final measurement	30 MHz to 1 GHz	-	120 kHz	1 s	QuasiPeak



Procedure preliminary measurement:

The following procedure is used:

- 1) Set the measuring antenna to 1 m height.
- 2) Monitor the frequency range at horizontal polarization of the measuring antenna and an EUT / turntable azimuth of 0 °.
- 3) Rotate the EUT by 360° to maximize the detected signals.
- 4) Repeat steps 2 to 3 with the vertical polarization of the measuring antenna.
- 5) Increase the height of the measuring antenna for 0.5 m and repeat steps 2 to 4 until the final height of 4 m is reached.
- 6) The highest values for each frequency are saved by the software, including the measuring antenna height and polarization and the turntable azimuth for that value.

Procedure final measurement:

The following procedure is used:

- 1) Select the highest frequency peaks (lowest margin to the limit) for the final measurement.
- 2) The software determines the exact peak frequencies by doing a partial scan with reduced step size of the pre-scan of the selected peaks.
- 3) If the EUT is portable or ceiling mounted, find the worst-case EUT orientation (x,y,z) for the final test.
- 4) The worst-case measuring antenna height is found via varying the height by +/- 0.5 m from the value obtained in the preliminary measurement while monitoring the emission level.
- 5) The worst-case turntable position is found via varying the turntable azimuth by +/- 30° from the value obtained in the preliminary measurement while monitoring the emission level.
- 6) The final measurement is performed at the worst-case measuring antenna height and the worst-case turntable azimuth.
- 7) Steps 2 to 6 are repeated for each frequency peak selected in step 1.

5.1.3 Radiated: 1 GHz to 40 GHz

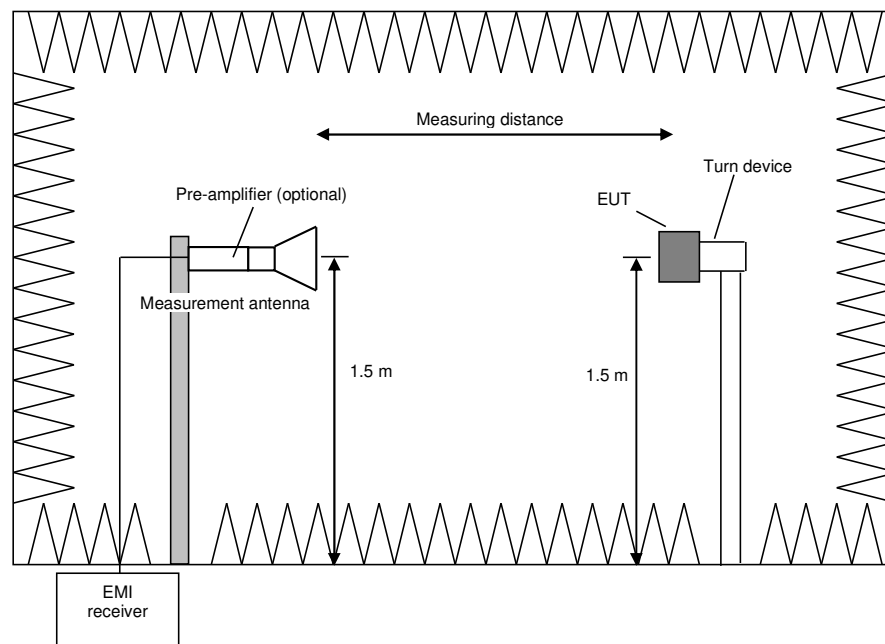
5.1.3.1 Preliminary and final measurement 1 to 40 GHz

The preliminary and final measurements are performed in a fully anechoic chamber at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting turn device at the height of 1.5 m. The setup of the equipment under test is in accordance with [1].

During the tests the EUT is rotated in the range of 0 ° to 360 ° and the measuring antenna is set to horizontal and vertical polarization to find the maximum level of emissions. After these steps, the measurement is repeated after reorientating the EUT in 30 ° steps.

The resolution bandwidth of the EMI receiver is set to the following values:

Test	Frequency range	Step-size	Resolution bandwidth	Measuring time	Detector
Preliminary measurement	1 - 40 GHz	250 kHz	1 MHz	-	Peak Average
Final measurement	1 - 40 GHz	-	1 MHz	100 ms	Peak Average



Procedure preliminary measurement:

The following procedure is used:

- 1) Monitor the frequency range at horizontal polarisation of the measuring antenna and an EUT / turntable azimuth of 0 °.
- 2) Rotate the EUT by 360° to maximize the detected signals.
- 3) Repeat steps 1 to 2 with the vertical polarisation of the measuring antenna.
- 4) Repeat steps 1 to 3 with the EUT reorientated by an angle of 30° (60°, 90°, 120° and 150°), according to 6.6.5.4 in [1].

- 5) The highest values for each frequency are saved by the software, including the measuring antenna polarization, the turntable azimuth and the turn device elevation for that value.

Procedure final measurement:

The following procedure is used:

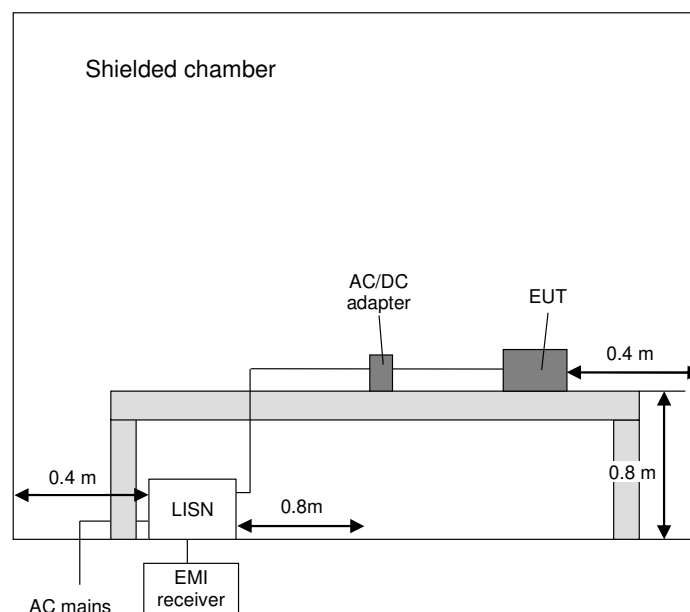
- 1) Set the turntable and the turn device to the position which leads to the highest emission for the first frequency identified in the preliminary measurements.
- 2) Set the measurement antenna to the polarisation which leads to the highest emission for the first frequency identified in the preliminary measurements.
- 3) Set the spectrum analyser to EMI mode with Peak and Average detector activated.
- 4) The worst-case turntable position is found via varying the turntable azimuth by $\pm 30^\circ$ from the value obtained in the preliminary measurement while monitoring the emission level.
- 5) The final measurement is performed at the worst-case turntable azimuth.
- 6) Repeat steps 1 to 5 for each frequency detected during the preliminary measurements.

5.1.4 Conducted: AC power line

The test is carried out in a shielded chamber. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm above the ground plane. Floor-standing devices are placed directly on the ground plane. In case of DC powered equipment, which is not exclusively powered by a battery, it is connected to the LISN via a suitable AC/DC adaptor. The setup of the equipment under test is in accordance with [1].

The frequency range 150 kHz to 30 MHz is measured with an EMI receiver set to MAX hold mode with Peak and Average detectors and a resolution bandwidth of 9 kHz. A scan is carried out on the phase and neutral line of the AC mains network. If emissions less than 10 dB below the appropriable limit are detected, these emissions are measured with an Average and Quasi-Peak detector on all lines.

Frequency range	Resolution bandwidth	Measuring time
150 kHz to 30 MHz	9 kHz	5 s



5.2 Radiated emissions

5.2.1 Test setup (Maximum unwanted emissions)

Test setup (Maximum unwanted emissions)			
Used	Setup	See sub-clause	Comment
☒	Radiated: 9 kHz to 30 MHz / 30 MHz to 1 GHz / 1 GHz to 40 GHz	5.1.1 / 5.1.2 / 5.1.3	-
☐	Conducted: AC power line	5.1.4	-

5.2.2 Test method (Maximum unwanted emissions)

☒ Test method (radiated) see sub-clause 5.1 as described herein

5.2.3 Test results (Maximum unwanted emissions)

5.2.3.1 Test results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	23 °C
Relative humidity:	65 %

Date:	16.08.2024
Tested by:	D. BRUSCHINSKI

Position of EUT: For tests for f between 9 kHz to 30 MHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: The measurement value was already corrected by 40 dB/decade as described in 47 CFR 15.31(f)(2) regarding to the measurement distance as requested in 47 CFR 15.209(a)

Remark: All 3 orthogonal planes were tested separately

Calculations:

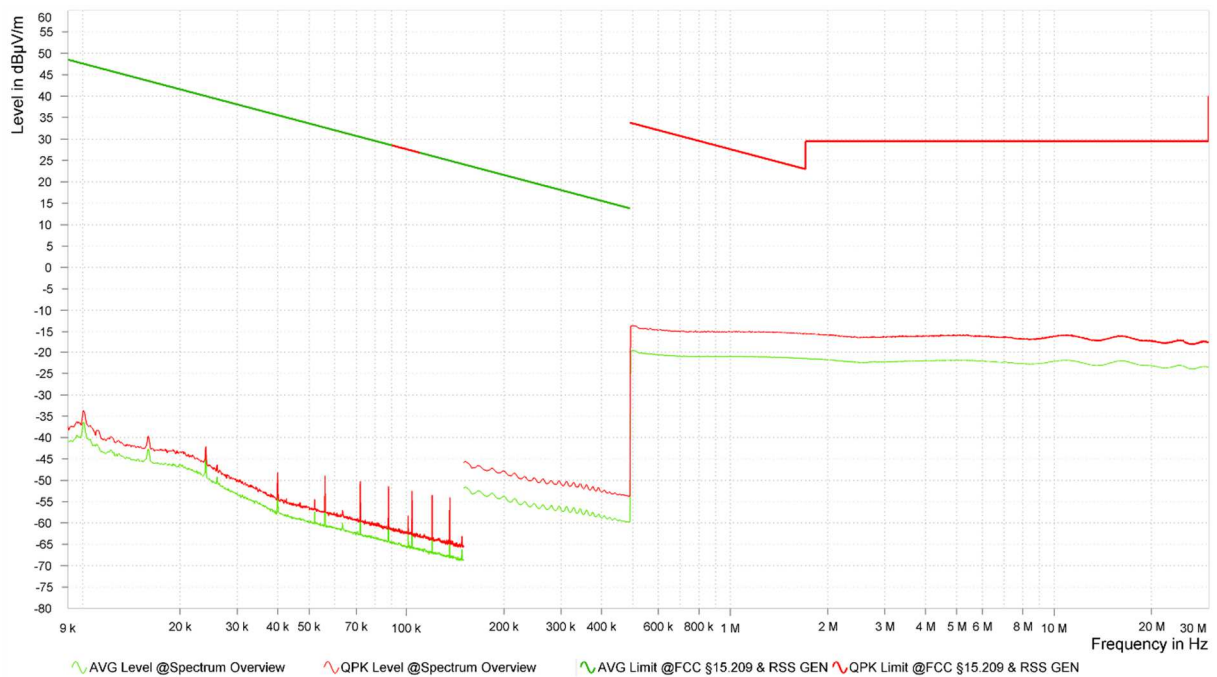
Result @ norm. dist. [dBμV/m] = Reading [dBμV] + AF [dB/m] + Distance corr. fact. [dB]

Result @ norm. dist. [dBμA/m] = Result @ norm. dist. [dBμV/m] – 20 x log₁₀ (377 Ω)

Margin [dB] = Limit [dB(μV|μA)/m] - Result [dB(μV|μA)/m]

Worst case plot:

Spurious emissions from 9 kHz to 30 MHz (operation mode 4, position 2):



Remark: No emissions close than 20 dB to the limit, so no final measurement will be carried out.

Test result: Passed

Test equipment (please refer to chapter 7 for details)

1 - 7

5.2.3.2 Test results (30 MHz – 1 GHz)

Ambient temperature:	23 °C
Relative humidity:	58 %

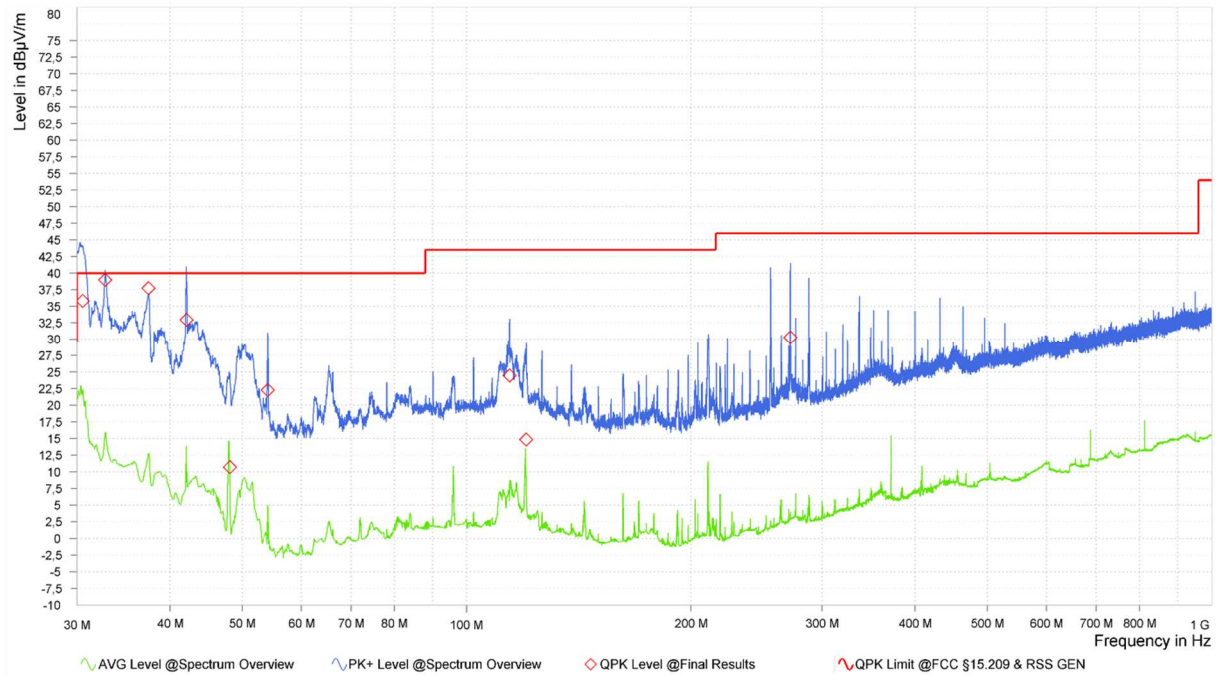
Date:	12.08.2024
Tested by:	D. BRUSCHINSKI

Position of EUT:	For tests for f between 30 MHz to 1 GHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.
Cable guide:	For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.
Test record:	Plots for each frequency range are submitted below.
Remark:	All 3 orthogonal planes were tested separately
Calculations:	
Result [dBμV/m] =	Reading [dBμV] + Correction [dB/m]
Correction [dB/m] =	AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]
Margin [dB] =	Limit [dBμV/m] - Result [dBμV/m]

The measured points and the limit line in the following diagram refer to the standard measurement of the emitted interference in compliance with the above-mentioned standard. The measured points marked with “♦” are the measured results of the standard subsequent measurement in a semi-anechoic chamber.

Worst case plot:

Spurious emissions from 30 MHz to 1 GHz (operation mode 4, position 1):



Result tables:

Operation mode 4:

Frequency [MHz]	Result (QP) [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Correction [dB/m]	Pol. (H/V)	Azimuth [deg]	Height [m]
30.540	35.79	40.00	4.21	26.33	H	103	1.54
32.730	38.98	40.00	1.02	24.97	H	162	1.77
37.440	37.74	40.00	2.26	22.00	H	283	1.97
42.090	32.93	40.00	7.07	18.89	V	156	1.01
48.120	10.69	40.00	29.31	14.83	V	343	1.47
54.120	22.27	40.00	17.73	12.19	V	21	1.12
114.270	24.48	43.50	19.02	17.71	H	255	2.94
120.210	14.84	43.50	28.66	17.48	H	248	2.62
271.980	30.27	46.00	15.73	18.02	H	128	1.07

Operation mode 5:

Frequency [MHz]	Result (QP) [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Correction [dB/m]	Pol. (H/V)	Azimuth [deg]	Height [m]
30.330	37.92	40.00	2.08	26.46	H	103	1.48
32.760	36.39	40.00	3.61	24.95	H	132	1.71
37.440	37.70	40.00	2.30	22.00	H	283	2.00
42.090	34.50	40.00	5.50	18.89	V	21	1.03
48.120	11.15	40.00	28.85	14.83	V	19	1.36
54.120	22.27	40.00	17.73	12.19	V	349	1.35
119.850	12.55	43.50	30.95	17.50	H	236	2.28
210.990	26.18	43.50	17.32	16.23	H	43	1.68
255.990	32.74	46.00	13.26	17.46	H	121	1.09

Operation mode 6:

Frequency [MHz]	Result (QP) [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Correction [dB/m]	Pol. (H/V)	Azimuth [deg]	Height [m]
30.180	35.13	40.00	4.87	26.55	H	283	1.50
30.330	33.56	40.00	6.44	26.46	H	191	1.57
32.730	38.42	40.00	1.58	24.97	H	132	1.63
37.440	37.31	40.00	2.69	22.00	H	152	2.00
42.120	33.52	40.00	6.48	18.87	V	13	1.04
54.120	23.77	40.00	16.23	12.19	V	340	1.21
78.180	13.99	40.00	26.01	15.96	V	88	1.33
126.330	16.06	43.50	27.44	17.05	H	268	1.42
138.360	18.03	43.50	25.47	16.05	H	252	1.38
224.010	26.66	46.00	19.34	16.06	H	104	1.25
255.990	40.07	46.00	5.93	17.46	H	112	1.27
271.980	37.73	46.00	8.27	18.02	H	242	1.02
336.000	28.72	46.00	17.28	19.92	H	271	1.00
432.000	21.03	46.00	24.97	22.29	V	158	1.00
742.590	20.70	46.00	25.30	27.59	V	353	1.12
917.010	23.60	46.00	22.40	29.87	H	127	1.12

Test result: Passed

Test equipment (please refer to chapter 7 for details)
2 - 10

5.2.3.3 Test results (radiated 1 GHz to 26.5 GHz)

Ambient temperature:	22 °C
Relative humidity:	60 % / 56 %

Date:	08.08.2024 / 09.08.2024
Tested by:	D. BRUSCHINSKI

Position of EUT: For tests for f between 1 GHz and the 10th harmonic, the EUT was set-up on a positioner device with a height of 150 cm. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: Plots for each frequency range are submitted below.

Remark: -

Calculation:

Max Peak [dBμV/m] = Reading [dBμV] + Correction [dB/m]

Average [dBμV/m] = Reading [dBμV] + Correction [dB/m]

Correction [dB/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB] + DCCF* [dB]
* (if applicable – only for Average values, that are fundamental related)

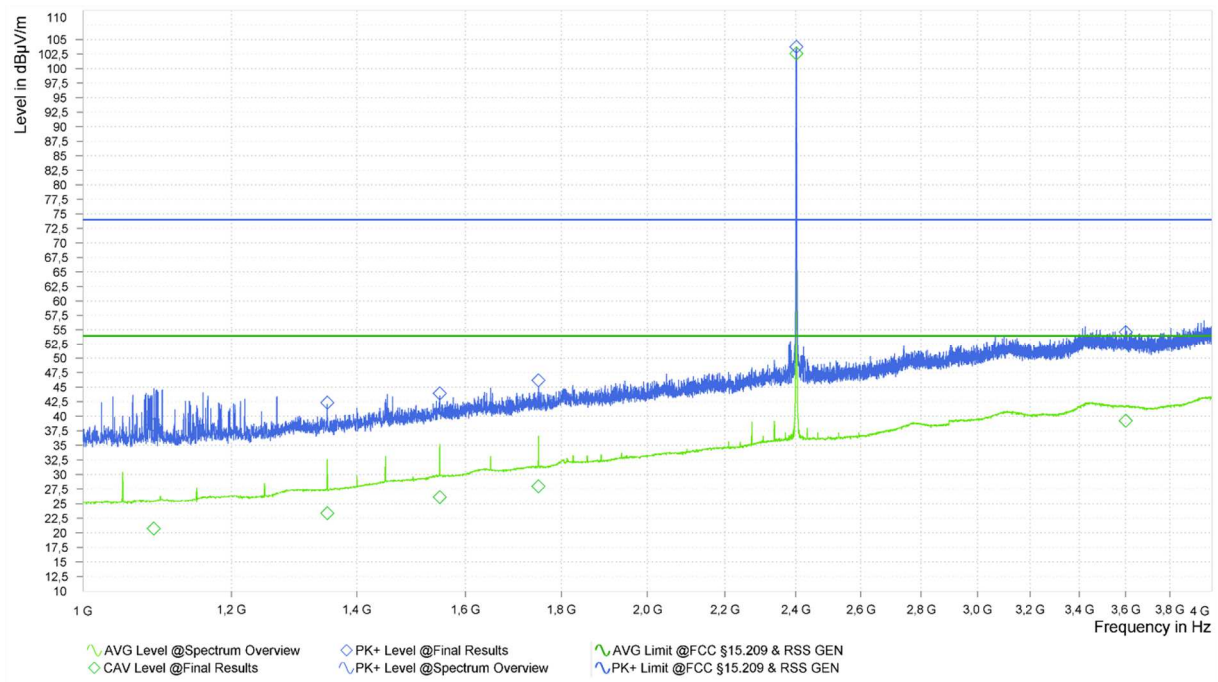
Margin [dB] = Limit [dBμV/m] – Max Peak | Average [dBμV/m]

The curves in the diagram only represent the maximum measured value for each frequency point of all preliminary measurements, which were carried out with various EUT and antenna positions.

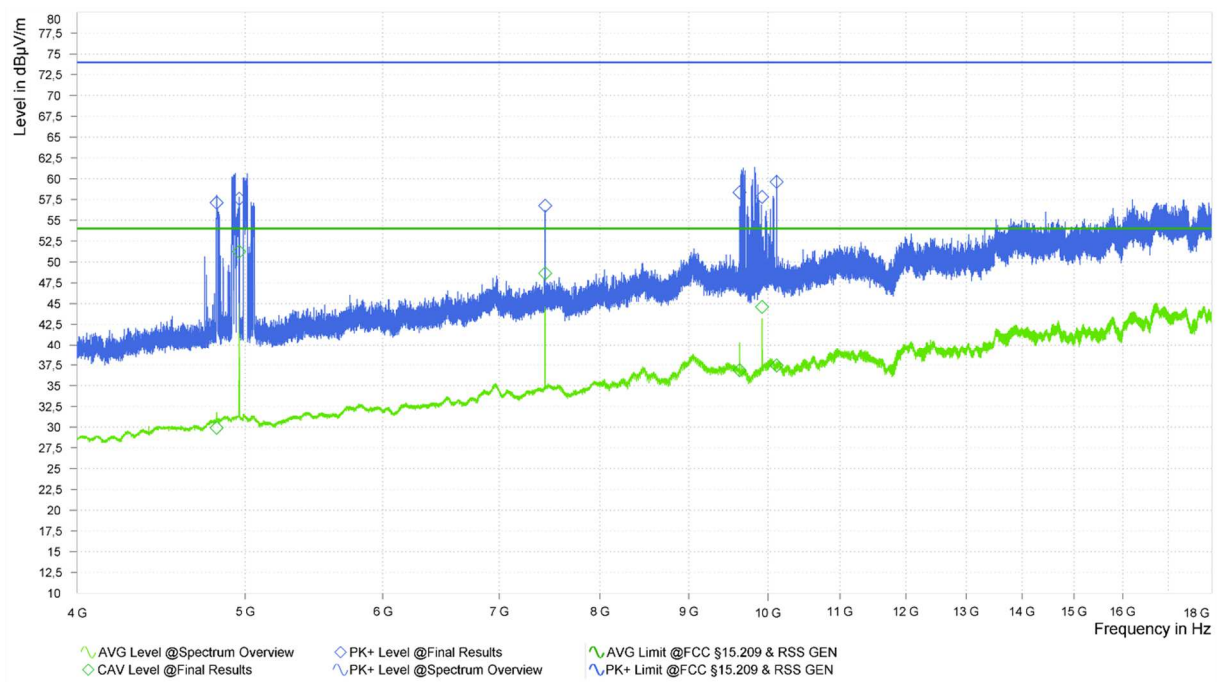
The top measured curve represents the peak measurement. The measured points marked with "◇" are frequency points for the final peak detector measurement. These values are indicated in the following table. The bottom measured curve represents the average measurement. The measured points marked with "◇" are frequency points for the final average detector measurement.

Worst case plots:

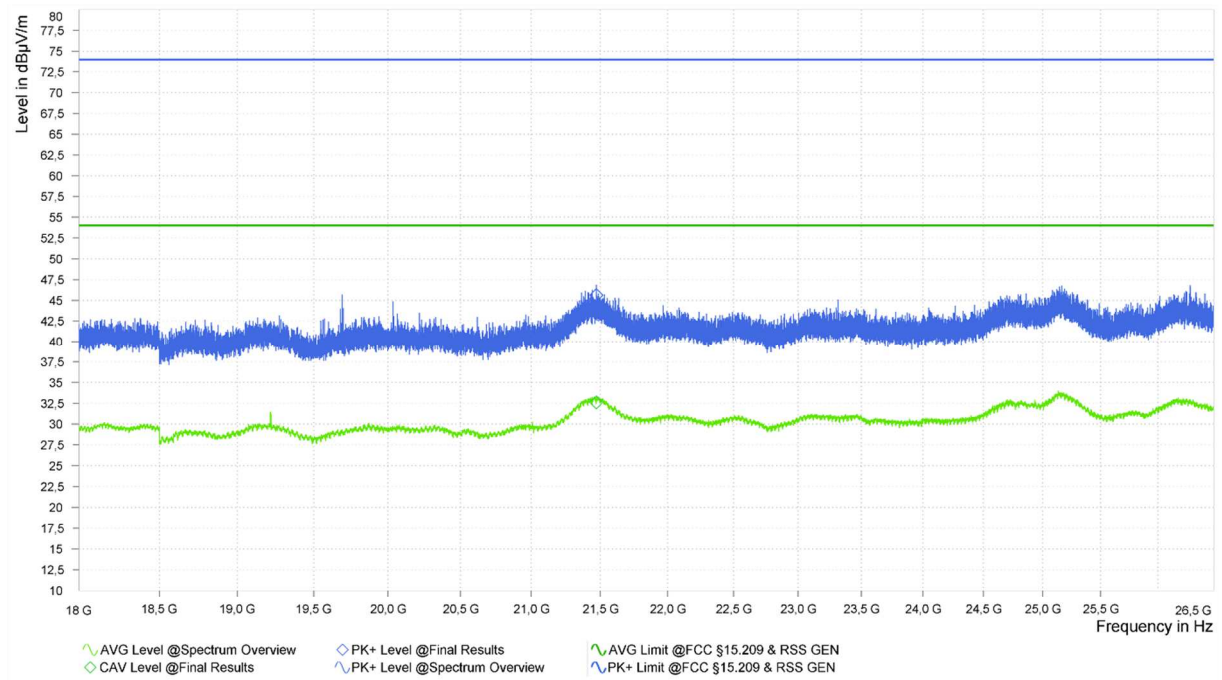
Spurious emissions from 1 GHz to 4 GHz (operation mode 4):



Spurious emissions from 4 GHz to 18 GHz (operation mode 6):



Spurious emissions from 18 GHz to 26.5 GHz (operation mode 4):



Result tables:

Operation mode 4:

Frequency [MHz]	MaxPeak [dB(μV/m)]	Average [dB(μV/m)]	Limit [dB(μV/m)]	Margin [dB]	Pol [H/V]	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
1091.000	38.56	-	74.00	35.44	H	8	150	26.14
1091.000	-	20.72	54.00	33.28	H	11	150	26.14
1350.000	42.32	-	74.00	31.68	V	197	120	28.41
1350.000	-	23.39	54.00	30.61	V	199	120	28.41
1550.000	43.95	-	74.00	30.05	H	200	120	30.42
1550.000	-	26.14	54.00	27.86	H	193	120	30.42
1750.000	46.18	-	74.00	27.82	H	185	90	31.25
1750.000	-	27.96	54.00	26.04	H	183	90	31.25
3599.250	54.62	-	74.00	19.38	H	272	150	39.81
3599.250	-	39.24	54.00	14.76	H	273	150	39.81
4804.000	55.73	-	74.00	18.27	V	273	90	9.69
4804.000	-	50.53	54.00	3.47	V	273	90	9.69
4935.500	58.85	-	74.00	15.15	H	281	120	10.09
4935.500	-	30.18	54.00	23.82	H	263	120	10.09
4993.000	56.00	-	74.00	18.00	H	101	90	10.13
4993.000	-	30.24	54.00	23.76	H	121	90	10.13
7206.500	53.73	-	74.00	20.27	V	155	30	13.56
7206.500	-	45.55	54.00	8.45	V	157	30	13.56
9609.000	54.15	-	74.00	19.85	H	71	90	18.83
9609.000	-	43.43	54.00	10.57	H	71	90	18.83
9772.250	64.60	-	74.00	9.40	H	219	90	18.42
9772.250	-	35.72	54.00	18.28	H	221	90	18.42
21471.750	45.62	-	74.00	28.38	H	91	150	11.44
21471.750	-	32.62	54.00	21.38	H	75	150	11.44

Operation mode 5:

Frequency [MHz]	MaxPeak [dB(μV/m)]	Average [dB(μV/m)]	Limit [dB(μV/m)]	Margin [dB]	Pol [H/V]	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
1000.500	38.53	-	74.00	35.47	H	5	60	25.65
1000.500	-	21.56	54.00	32.44	H	8	60	25.65
1150.000	40.48	-	74.00	33.52	H	105	120	26.86
1150.000	-	21.28	54.00	32.72	H	114	120	26.86
1450.000	44.44	-	74.00	29.56	H	178	0	29.42
1450.000	-	25.17	54.00	28.83	H	180	0	29.42
3459.500	54.23	-	74.00	19.77	H	6	120	40.36
3459.500	-	39.68	54.00	14.32	H	3	120	40.36
3971.000	55.60	-	74.00	18.40	V	360	120	40.98
3971.000	-	40.95	54.00	13.05	V	355	120	40.98
4880.250	58.53	-	74.00	15.47	V	304	90	9.92
4880.250	-	50.28	54.00	3.72	V	304	90	9.92
5058.250	61.11	-	74.00	12.89	H	47	90	9.97
5058.250	-	30.30	54.00	23.70	H	47	90	9.97
7319.250	55.49	-	74.00	18.51	H	299	150	14.47
7319.250	-	46.83	54.00	7.17	H	299	150	14.47
9628.750	62.44	-	74.00	11.56	H	272	150	18.76
9628.750	-	36.97	54.00	17.03	H	272	150	18.76
9759.000	55.73	-	74.00	18.27	H	65	90	18.46
9759.000	-	43.45	54.00	10.55	H	65	90	18.46
10102.500	50.86	-	74.00	23.14	H	195	0	20.01
10102.500	-	37.27	54.00	16.73	H	195	0	20.01
21433.500	45.15	-	74.00	28.85	V	230	120	11.35
21433.500	-	32.39	54.00	21.61	V	230	120	11.35

Operation mode 6:

Frequency [MHz]	MaxPeak [dB(μV/m)]	Average [dB(μV/m)]	Limit [dB(μV/m)]	Margin [dB]	Pol [H/V]	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
1150.000	41.08	-	74.00	32.92	H	75	150	26.86
1150.000	-	21.42	54.00	32.58	H	74	150	26.86
1350.000	43.13	-	74.00	30.87	H	181	150	28.41
1350.000	-	23.55	54.00	30.45	H	188	150	28.41
1650.000	45.15	-	74.00	28.85	V	197	150	31.37
1650.000	-	27.09	54.00	26.91	V	192	150	31.37
1935.750	47.44	-	74.00	26.56	V	145	0	32.39
1935.750	-	32.62	54.00	21.38	V	144	0	32.39
3456.500	54.41	-	74.00	19.59	H	65	150	40.38
3456.500	-	39.69	54.00	14.31	H	66	150	40.38
4814.500	57.13	-	74.00	16.87	H	29	60	9.73
4814.500	-	29.94	54.00	24.06	H	63	60	9.73
4960.000	57.59	-	74.00	16.41	V	263	90	10.06
4960.000	-	51.25	54.00	2.75	V	270	90	10.06
7440.500	56.76	-	74.00	17.24	V	249	150	15.14
7440.500	-	48.65	54.00	5.35	V	248	150	15.14
9628.750	58.35	-	74.00	15.65	V	223	150	18.76
9628.750	-	36.86	54.00	17.14	V	245	150	18.76
9919.000	57.82	-	74.00	16.18	H	267	30	19.67
9919.000	-	44.58	54.00	9.42	H	264	30	19.67
10112.750	59.62	-	74.00	14.38	H	215	60	19.98
10112.750	-	37.43	54.00	16.57	H	235	60	19.98
19257.500	50.51	-	74.00	23.49	H	263	60	10.48
19257.500	-	29.17	54.00	24.83	H	266	60	10.48

Test result: Passed

Test equipment (please refer to chapter 7 for details)
2 – 7, 10 - 16

5.3 AC power line conducted emissions

5.3.1 Test setup (Conducted emissions on power supply lines)

Test setup (Conducted emissions on power supply lines)			
Used	Setup	See sub-clause	Comment
☐	Radiated: 9 kHz to 30 MHz / 30 MHz to 1 GHz / 1 GHz to 40 GHz	5.1.1 / 5.1.2 / 5.1.3	-
☒	Conducted: AC power line	5.1.4	-

5.3.2 Test method (Conducted emissions on power supply lines)

Test setup (Conducted emissions on power supply lines)				
Used	Clause [3]	Name of method	Sub-clause	Comment
☒	6.2.3.2	Tabletop equipment testing		AC power adaptor *
☐	6.2.3.3	Floor-standing equipment testing	-	-

* The used AC power adaptor is stated in sub-clause 1.5.1. It was supplied by 120V_{AC} 60Hz.

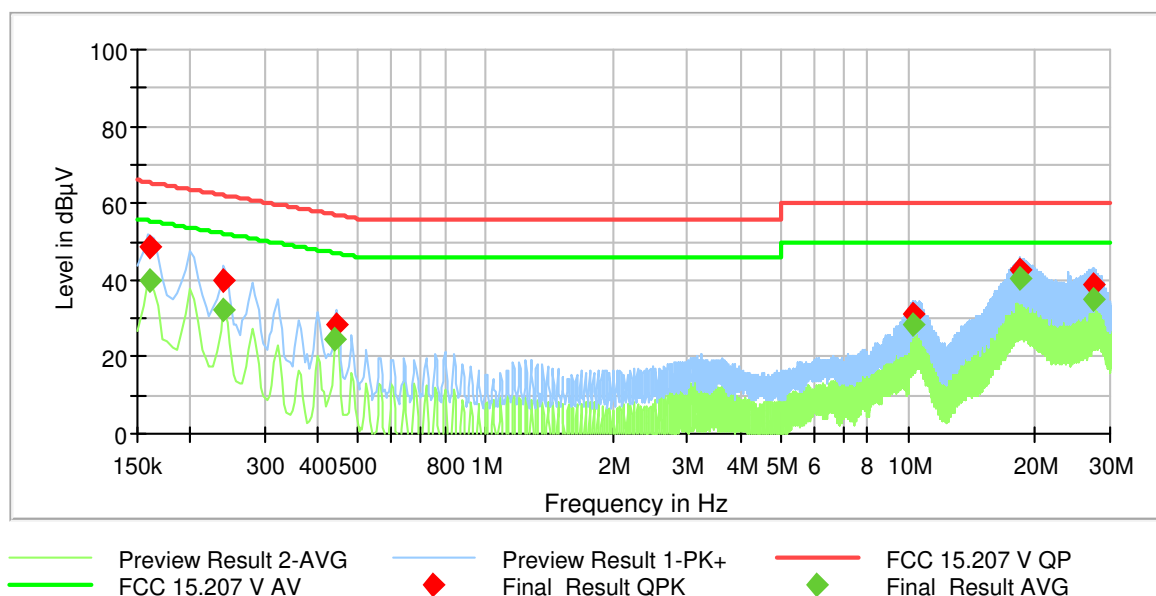
5.3.3 Test results (Conducted emissions on power supply lines)

Ambient temperature:	22 °C
Relative humidity:	31 %

Date:	24.10.2024
Tested by:	D. BRUSCHINSKI

The curves in the diagrams below only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by ◆ and the average measured points by ▼.

Operation mode 1:



Frequency [MHz]	QuasiPeak [dB(μV)]	Average [dB(μV)]	Limit [dB(μV)]	Margin [dB]	Line	PE	Corr. [dB]
0.159900	48.88	-	65.42	16.54	L1	GND	9.8
0.160800	-	39.73	55.47	15.74	L1	GND	9.8
0.240000	40.09	-	62.07	21.98	L1	GND	9.9
0.240900	-	32.24	52.10	19.86	L1	GND	9.9
0.440700	28.67	-	57.03	28.36	L1	GND	9.9
0.441600	-	24.71	47.05	22.34	L1	GND	9.9
10.247100	31.38	-	60.00	28.62	N	GND	10.6
10.249800	-	28.44	50.00	21.56	N	GND	10.6
18.335400	42.58	-	60.00	17.42	L1	GND	10.9
18.337200	-	40.21	50.00	9.79	L1	GND	10.9
27.304800	38.92	-	60.00	21.08	L1	GND	11.1
27.305700	-	34.81	50.00	15.19	L1	GND	11.1

Test result: Passed

Test equipment (please refer to chapter 7 for details)

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6 Measurement Uncertainties

Conducted measurements		
Measurement method	Standard used for calculating measurement uncertainty	Expanded measurement uncertainty (95 %) U_{lab}
Frequency error	ETSI TR 100 028	4.5×10^{-8}
Bandwidth measurements	-	9.0×10^{-8}
Conducted emissions using a spectrum analyzer		
< 3.6 GHz	ETSI TR 100 028	2.3 dB
3.6 – 8 GHz	ETSI TR 100 028	2.8 dB
8 – 22 GHz	ETSI TR 100 028	3.2 dB
22 – 40 GHz	ETSI TR 100 028	3.6 dB
Power measurements		
Power meter	ETSI TR 100 028	0.9 dB
Conducted emissions from 150 kHz to 30 MHz with LISN		
	CISPR 16-4-2	2.8 dB

Radiated measurements		
Frequency error		
(Semi-) Anechoic chamber	ETSI TR 100 028	4.5×10^{-8}
OATS	ETSI TR 100 028	4.5×10^{-8}
Test fixture	ETSI TR 100 028	4.5×10^{-8}
Bandwidth measurements		
(Semi-) Anechoic chamber	-	9.0×10^{-8}
OATS	-	9.0×10^{-8}
Test fixture	-	9.1×10^{-8}
Radiated field strength M20		
CBL6112B @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	5.3 dB
R&S HL050 @ 3 m		
1 – 6 GHz	CISPR 16-4-2	5.1 dB
6 – 18 GHz	CISPR 16-4-2	5.4 dB
Flann Standard Gain Horns 12 – 40 GHz	-	5.9 dB
Radiated field strength M276		
R&S HL562E @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	4.8 dB
R&S HL050 @ 3 m	-	
1 – 6 GHz	CISPR 16-4-2	5.1 dB
6 – 18 GHz	CISPR 16-4-2	5.4 dB
Flann Standard Gain Horns 12 – 40 GHz	-	5.9 dB
OATS		
Field strength measurements below 30 MHz on OATS without ground plane	-	4.4 dB

7 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	21.02.2024	02.2026
2	EMC test software	Elektra V5.02.1	Rohde & Schwarz		483755	Calibration not necessary	
3	RF switch matrix	OSP220	Rohde & Schwarz	101391	482976	Calibration not necessary	
4	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
5	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
6	Semi anechoic chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
7	EMI test receiver	ESW44	Rohde & Schwarz	101828	482979	21.02.2024	02.2026
8	Attenuator 6 dB	WA2-6	Weinschel		482793	Calibration not necessary	
9	Ultralog antenna	HL562E	Rohde & Schwarz	101079	482978	24.04.2024	04.2027
10	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
11	Low noise amplifier 100 MHz - 18 GHz	LNA-30-00101800-25-10P	Narda-Miteq	2110917	482967	20.02.2024	02.2026
12	Log.-per. antenna	HL050	Rohde & Schwarz	100908	482977	22.09.2022	09.2025
13	Low noise amplifier 18 GHz - 26.5 GHz	LNA-30-18002650-20-10P	Narda-Miteq	2110911	482969	19.02.2024	02.2026
14	Standard gain horn 18 GHz – 26.5 GHz	20240-20	Flann	266399	483026	Calibration not necessary	
15	Positioner	TG1.5-10kg	Maturo	110/2648.01	483042	Calibration not necessary	
16	High-pass filter	WHKX4.0/18G-8SS	Wainwright	1	480587	Calibration not necessary	
17	LISN	NSLK8128	Schwarzbeck	8128161	480138	28.02.2024	02.2026
18	AC power supply	AC6803A AC Quelle 2000VA	Keysight	JPVJ002509	482350	Calibration not necessary	
19	Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
20	Shielded chamber M4	B83117-S1-X158	Siemens	190075	480088	Calibration not necessary	
21	EMI receiver / Spectrum analyser	ESIB 26	Rohde & Schwarz	100292	481182	22.02.2024	02.2026
22	Transient filter limiter	CFL 9206A	Teseq GmbH	38268	481982	28.03.2024	03.2026

8 Test site Verification

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA	ANSI C63.4-2014 ANSI C63.4a-2017	01.03.2023	28.02.2026
Semi anechoic chamber M276	483227	1 -18 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	28.02.2023	27.02.2026
Shielded chamber M4	480088	9 kHz – 30 MHz	GND-Plane	ANSI C63.4-2014	08.11.2022	07.11.2025

9 Report History

Report Number	Date	Comment
F231416E5	23.01.2025	Initial Test Report
-	-	-

10 List of Annexes

Annex A	Test Setup Photos	18 pages
Annex B	EUT External Photos	7 pages
Annex C	EUT Internal Photos *	8 pages

* The internal photographs were provided by the applicant.

--- end of test report ---