PHOENIX TESTLAB

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Test Report

Report Number:

F231143E2

Equipment under Test (EUT):

Liquiphant FTL43

Applicant:

Endress+Hauser SE+Co. KG

Manufacturer:

Endress+Hauser SE+Co. KG

ilac-MRA

DAkkS
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

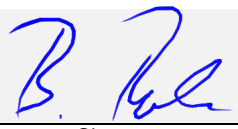
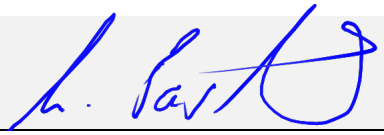
[3] **558074 D01 15.247 Meas Guidance v05r02 (April 2019),** GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES

[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 clause 1.4 of ANSI C63.10 (2020). However, the measurement uncertainty is calculated and shown in this test report.

Tested and written by:		Bernward ROHDE 22.11.2024
	Signature	
Reviewed and approved by:		Manuel BASTERT 22.11.2024
	Signature	

This test report is only valid in its original form.

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.

Contents: Page

1 Identification

1.1 Applicant

Name:	Endress+Hauser SE+Co. KG
Address:	Hauptstr. 1, 79689 Maulburg
Country:	Germany
Name for contact purposes:	Mr. Ralf REIMELT
Phone:	+49 76 22 28 – 18 90
eMail address:	ralf.reimelt@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. Ralf REIMELT
Phone:	+49 76 22 28 – 18 90
eMail address:	ralf.reimelt@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) in compliance with DIN EN ISO/IEC 17025 under Reg. No. 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: *	Point level switch
Model name: *	Liquiphant FTL43
FCC ID: *	LCGFTL4X
IC certification number: *	2519A-FTL4X
PMN: *	FTL43, FTL60
HVIN: *	FTL43-2
FVIN: *	NA

	EUT number	
	1 (radiated)	2 (conducted PCB)
Serial number: *	FTL43_RED_EUT1	Engineering sample
PCB identifier: *	Sensor board: 71603955 Mainboard: 71439136 Terminal Board: 71439136 Visualisation Board: 71599584	Visualisation Board: 71599584
Hardware version: *	01.00.00	01.00.00
Software version: *	01.00.00	S140 V7.2.0 (Soft device)

* Declared by the applicant

2 EUTs were used for the tests. In the overview (chapter 4) is shown which EUT was used for each test case.

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 V_{DC}	U_{min}= 12 V_{DC}	U_{max}= 30 V_{DC}
Temperature range: *	-40°C to +80°C		

*: Declared by the applicant.

Ports / Connectors				
Identification	Connector		Length during test	Shielding (Yes / No)
	EUT	Ancillary		
DC and data	Fixed	-	2.0 m	No
-	-	-	-	-
-	-	-	-	-

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		
Fulfils radio specification: *1	Bluetooth® low energy (BLE) 5.2	
Radio chip: *1	Nordic nRF52840 (SoC)	
Antenna type: *1	PCB IFA Antenna	
Antenna name: *1	n/a	
Antenna gain: *2	-0.3 dBi	
Antenna connector: *1	-	
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 F231143E4 by Phoenix TESTLAB GmbH

1.5.1 Ancillary Equipment / Equipment used for testing

Equipment used for testing	
AC adapter *2	PHOENIX CONTACT MINI-PS.100-240AC/24DC/1.3 Used for AC power line conducted
FTDI Adapter: *1	Used for test mode configuration
Laptop: *2	Fujitsu Lifebook U748 (PM 201607)

*1 Provided by the applicant
*2 Provided by the laboratory

1.6 Dates

Date of receipt of test sample:	25.03.2024
Start of test:	24.01.2024
End of test:	20.08.2024

2 Operational States

2.1 Description of function of the EUT

All radiated measurements were carried out with unmodified samples, supplied with 24 V_{DC}, operating in normal operation mode after powered up. Test modes were set via console commands at a connected laptop via USB-2-serial converter.

During all radiated tests, the EUT was supplied by 24 V DC
During all conducted test, the EUT (BLE PCB only) was supplied by 3.3 V DC as declared by the applicant.

2.1.1 Operation modes

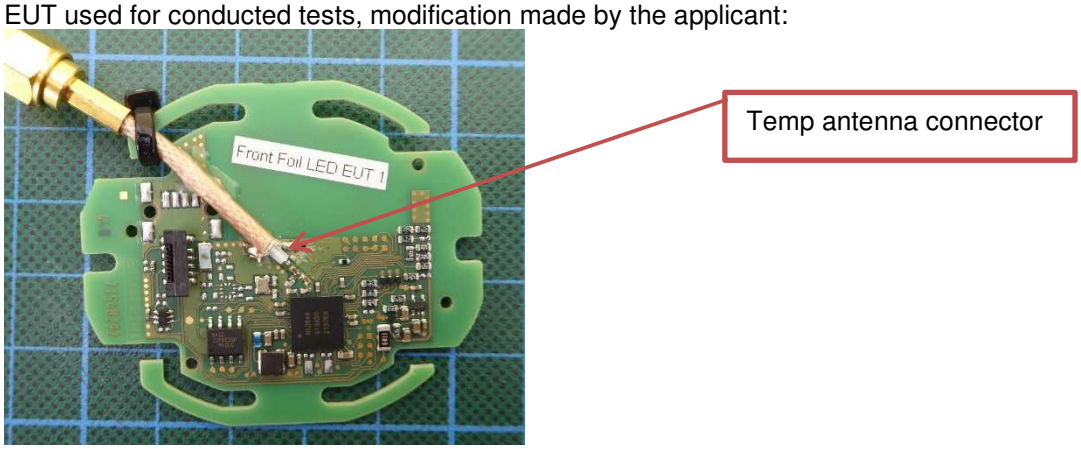
Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate	Power setting
1	Bluetooth© LE	2402	0	GFSK	2 Mbit/s	“pos8dBm”
2	Bluetooth© LE	2440	19	GFSK	2 Mbit/s	“pos8dBm”
3	Bluetooth© LE	2480	39	GFSK	2 Mbit/s	“pos8dBm”
4	Bluetooth© LE	2402	0	GFSK	1 Mbit/s	“pos8dBm”
5	Bluetooth©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

The maximum output power of the Radio chip is +8 dBm (typical)

3 Additional Information

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

EUT used for conducted tests, modification made by the applicant:



4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [4] RSS-Gen [5]	Tested EUT	Status
Maximum peak conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [4]	2	Passed
Maximum conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [4]	2	Passed
DTS Bandwidth / 99% Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [4]	2	Passed
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [4]	2	Passed
Average Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [4]	2	Passed
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [4]	1,2	Passed
Maximum unwanted emissions	0.009 – 26,500*	15.247 (d) 15.205 (a) 15.209 (a)	8.9 [5]	1,2	Passed*
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]	1	Passed

*: As declared by the applicant the highest radio clock frequency is 2.480 GHz.
Therefore, the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency in this case 26.5 GHz.

5 Results

5.1 Test setups

5.1.1 Radiated: 9 kHz to 30 MHz

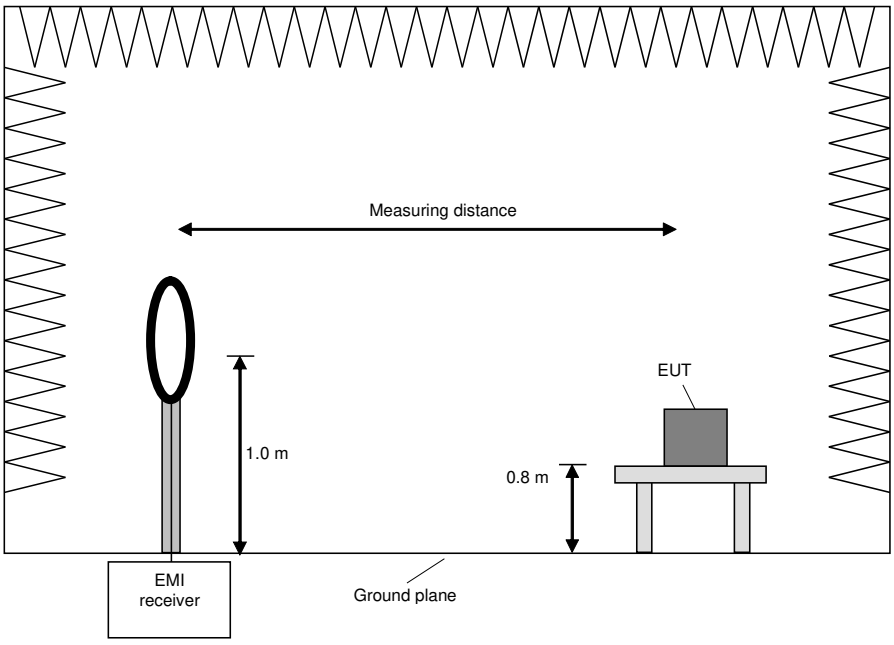
5.1.1.1 Preliminary measurement 9 kHz to 30 MHz

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.

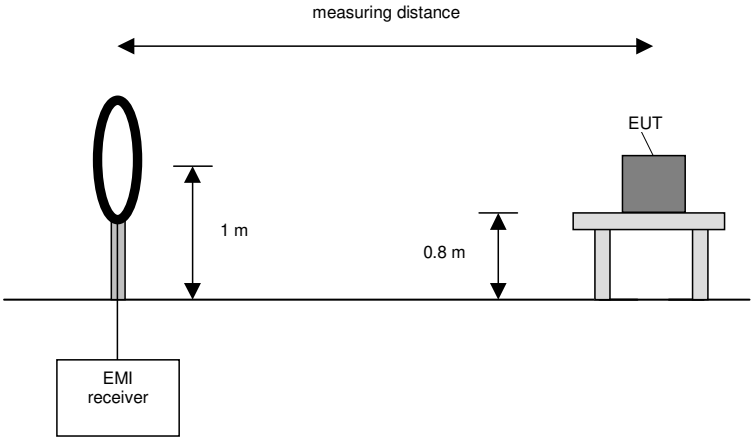
5.1.1.2 Final measurement 9 kHz to 30 MHz

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

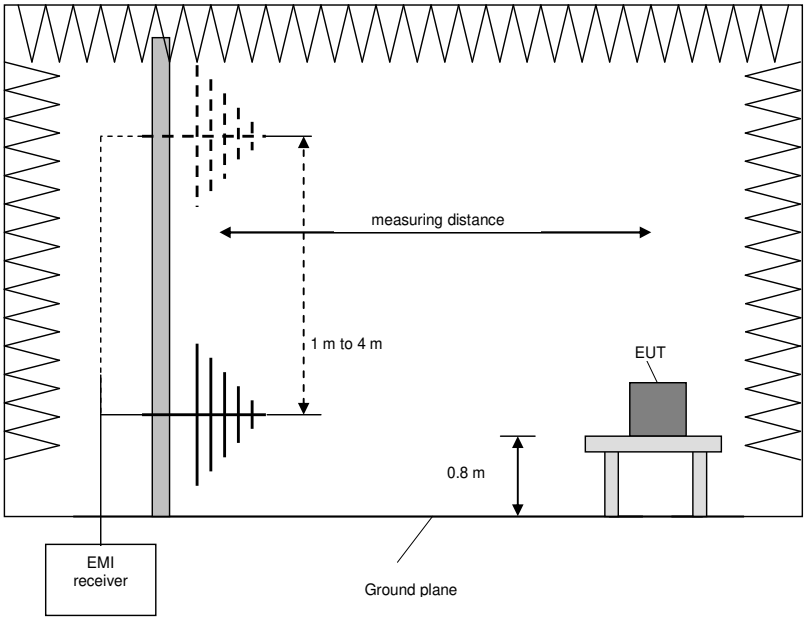
5.1.2.1 Preliminary and final measurement 30 MHz to 1 GHz

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

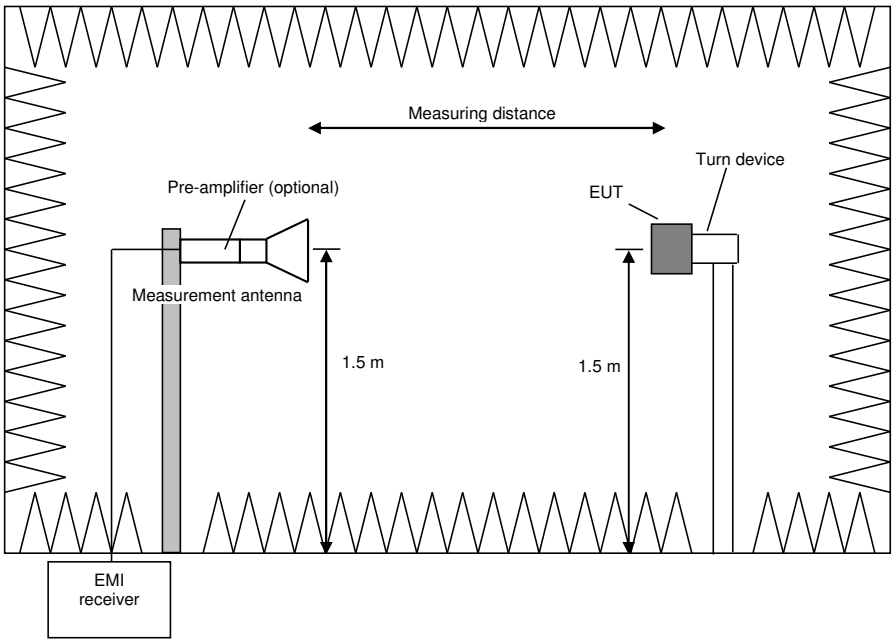
5.1.3.1 Preliminary and final measurement 1 to 40 GHz

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.

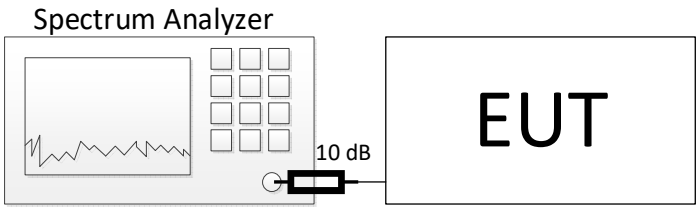
Procedure final measurement:

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 +/- 30° 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: Antenna port

Test setup (conducted)		
Used	Antenna connector	Comment
☒	Temporary antenna connector	As provided by the applicant
☐	Normal antenna connector	-



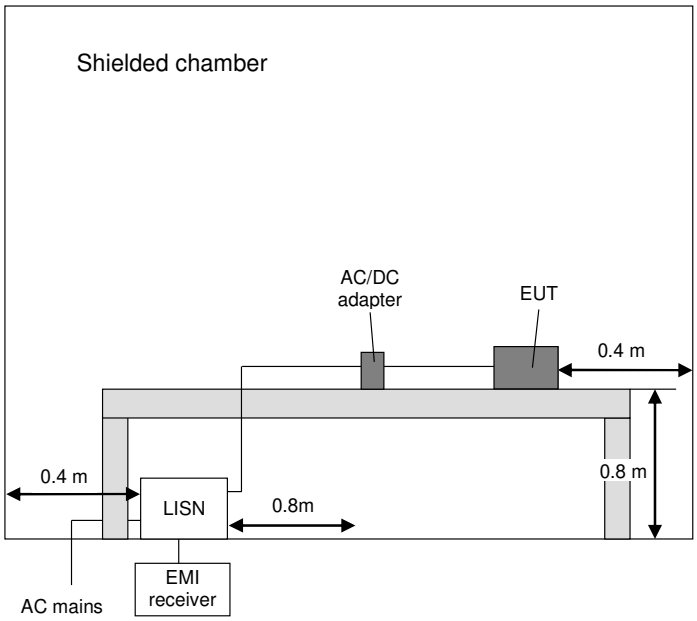
The 10 dB external attenuation are considered in all relevant plots

5.1.5 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 Duty cycle

5.2.1 Test setup (Duty cycle)

Test setup (Duty cycle)			
Used	Setup	See sub-clause	Comment
☐	Radiated: 1 GHz to 40 GHz	5.1.3	-
☒	Conducted: Antenna port	5.1.4	-

5.2.2 Test method (Duty cycle)

Test method (Duty cycle)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☐	11.6. a)	Diode detector	No limitation	-
☒	11.6. b)	Zero span	No limitation	-

5.2.3 Test results (Duty cycle)

Ambient temperature:	22 °C
Relative humidity:	40 %

Date:	24.01.2024
Tested by:	B. ROHDE

No DCCF is applied, duty cycle ≥ 98%.

Test equipment (please refer to chapter 7 for details)
1

5.3 Transmit antenna performance considerations

Test setup (Transmit antenna performance considerations)		
Integral antenna	Antenna gain ≤ 6dBi	Comment
☒	☒	No output power reduction necessary

Antenna gain calculation				
		f_{low}	f_{mid}	f_{high}
Conducted output power [dBm]		6.5	6.6	6.8
Radiated EIRP [dBm EIRP]		6.2	4.2	3.7
Antenna Gain [dBi]		**-0.3**	-2.4	-3.1
Position		Position 3	Position 3	Position 3
Position of maximum gain	**Azimuth**	17	23	23
	Polarisation	V	V	V

The above mentioned RF output power was tested in a different test mode (CW unmodulated carrier - 100% duty cycle) and is not part of this test report
For details see document: F231143E4

5.4 DTS bandwidth

5.4.1 Test setup (DTS bandwidth)

Test setup (DTS bandwidth)			
Used	Setup	See sub-clause	Comment
☐	Radiated: 1 GHz to 40 GHz	5.1.3	-
☒	Conducted: Antenna port	5.1.4	-

5.4.2 Test method (DTS bandwidth)

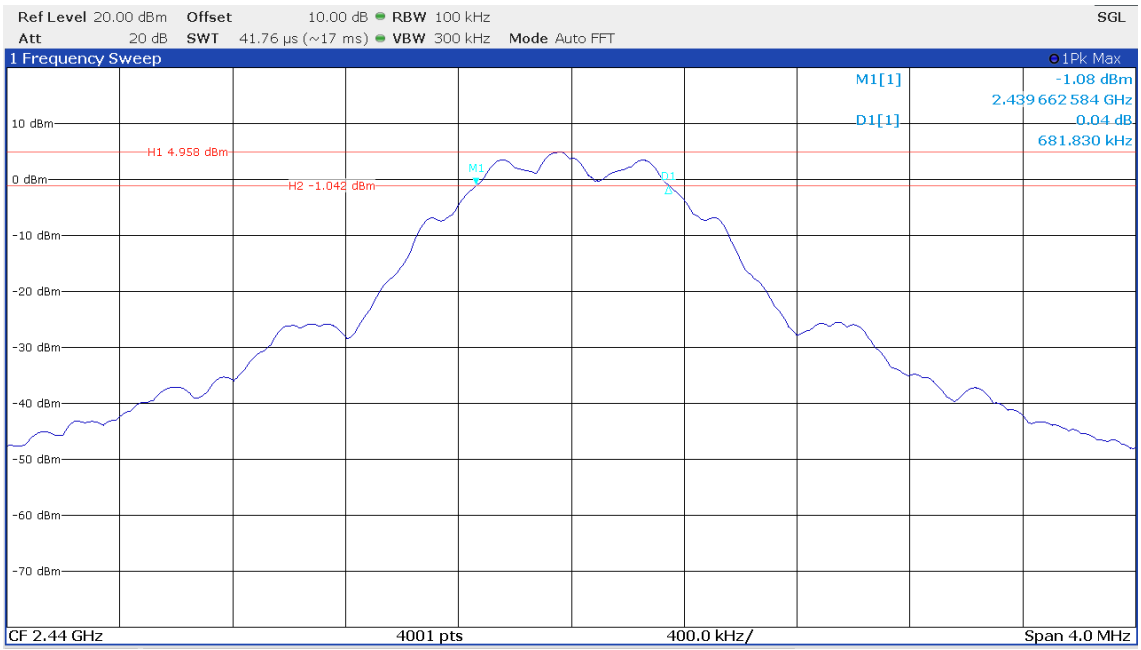
Test method (DTS bandwidth)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	11.8.1	Option 1	No limitations	-
☐	11.8.2	Option 2	No limitations	6 dB down function

5.4.3 Test results (DTS bandwidth)

Ambient temperature:	22 °C
Relative humidity:	42 %

Date:	25.01.2024
Tested by:	B. ROHDE

Worst case plot (operation mode 11):



Operation mode #	DTS bandwidth [MHz]	Minimum DTS bandwidth Limit [MHz]
1	1.365970	0.5
2	1.411647	0.5
3	1.448638	0.5
4	0.808298	0.5
5	0.780305	0.5
6	0.818795	0.5
7	0.790802	0.5
8	0.778805	0.5
9	0.76081	0.5
10	0.710822	0.5
11	**0.681830**	**0.5**
12	0.713822	0.5

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.5 Occupied bandwidth – power bandwidth (99%)

5.5.1 Test Setup (Occupied bandwidth – power bandwidth (99%))

Test setup (Occupied bandwidth – power bandwidth (99%))			
Used	Setup	See sub-clause	Comment
☐	Radiated: 1 GHz to 40 GHz	5.1.3	-
☒	Conducted: Antenna port	5.1.4	-

5.5.2 Test method (Occupied bandwidth – power bandwidth (99%))

Test method (Occupied bandwidth – power bandwidth (99%))				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☐	6.9.2	Relative measurement procedure	-	n-dB down
☒	6.9.3	Power bandwidth (99%)	*1	99% power function

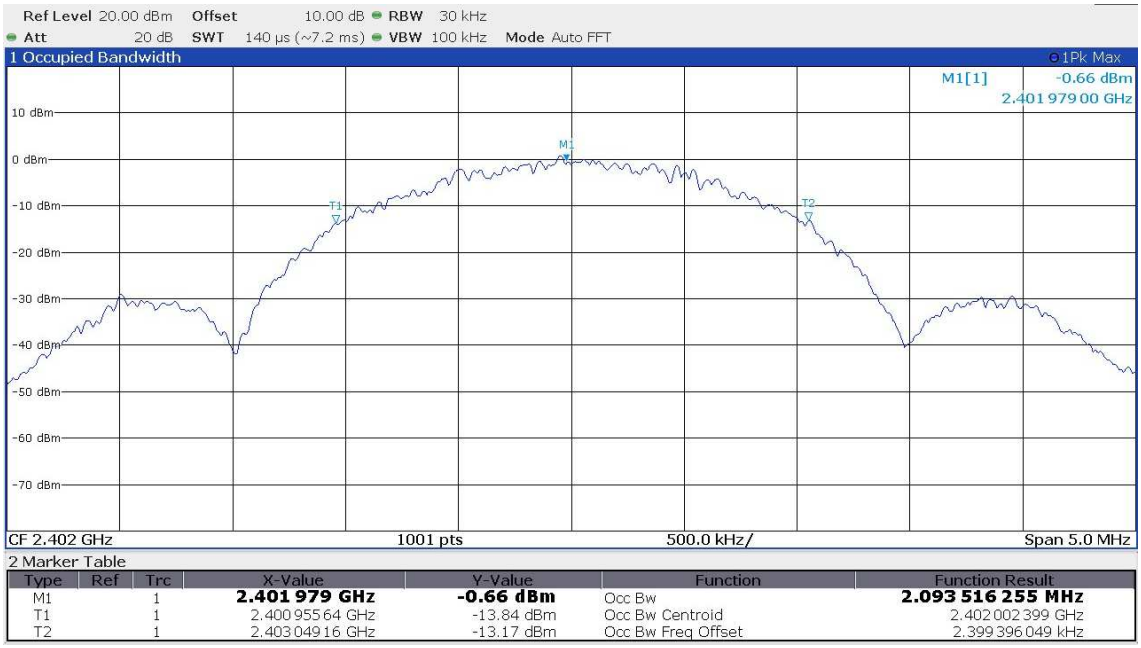
*1 See RSS-GEN Issue 5 (2018-05) sub-clause 6.7 for details.

5.5.3 Test results (Occupied bandwidth – power bandwidth (99%))

Ambient temperature:	22 °C
Relative humidity:	42 %

Date:	25.01.2024
Tested by:	B. ROHDE

Worst case plot (operation mode 1):



Operation mode #	99% bandwidth [MHz]
1	**2.09352**
2	2.09029
3	2.076989
4	1.069535
5	1.066059
6	1.085461
7	1.057399
8	1.064909
9	1.070405
10	1.089581
11	1.096792
12	1.108519

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.6 DTS fundamental emission output power

5.6.1 Test setup (DTS fundamental emission output power)

Test setup (DTS fundamental emission output power)			
Used	Setup	See sub-clause	Comment
☐	Radiated: 1 GHz to 40 GHz	5.1.3	-
☒	Conducted: Antenna port	5.1.4	-

5.6.2 Test method (DTS fundamental emission output power)

Test method (Maximum peak conducted output power)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	11.9.1.1	RBW ≥ DTS bandwidth	-	Zero span mode
☐	11.9.1.2	PKPM1 Peak power meter method*1	-	-

*1 VBW of the peak power meter has to be > OBW of the fundamental.

Test method (Maximum conducted (average) output power)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	11.9.2.2.2	Method AVGSA-1	D ≥ 98%	-
☐	11.9.2.2.3	Method AVGSA-1A (alternative)	D ≥ 98%	-
☐	11.9.2.2.4	Method AVGSA-2	Constant D (±2%)	-
☐	11.9.2.2.5	Method AVGSA-2A (alternative)	Constant D (±2%)	-
☐	11.9.2.2.6	Method AVGSA-3A	-	-
☐	11.9.2.2.7	Method AVGSA-3A (alternative)	-	-
☐	11.9.2.3.1	Method AVGPM	Constant D (±2%)	-
☐	11.9.2.3.2	Method AVGPM-G	-	-

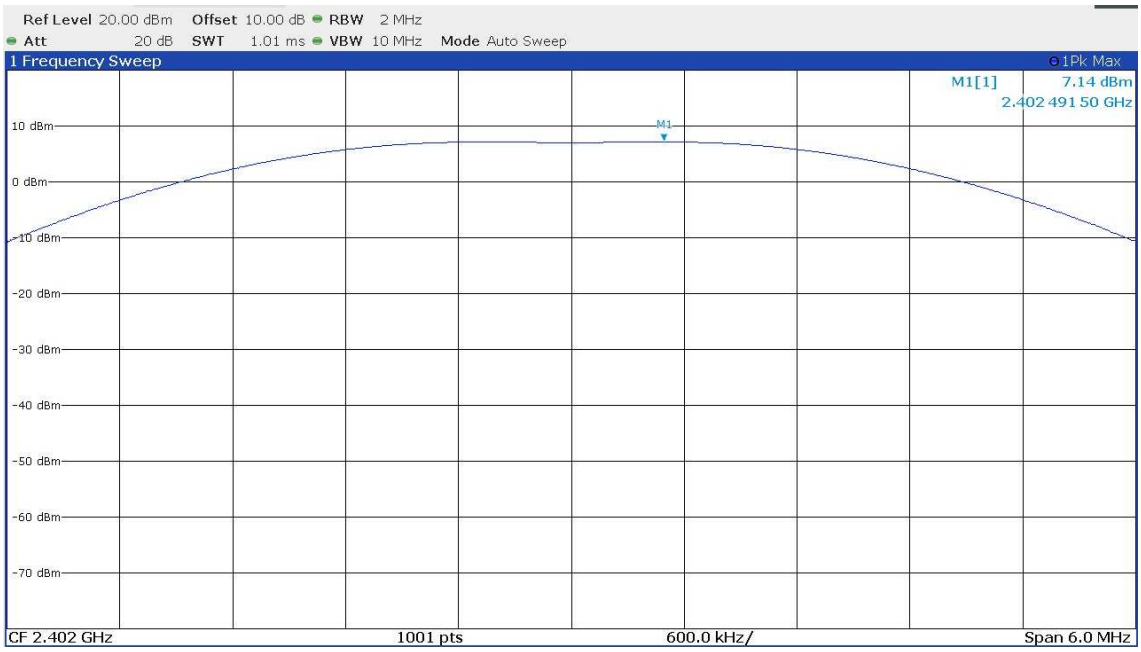
5.6.3 Test results (DTS fundamental emission output power)

Ambient temperature:	22 °C
Relative humidity:	42 %

Date:	25.01.2024
Tested by:	B. ROHDE

5.6.3.1 Maximum peak conducted output power:

Worst case plot (operation mode 1):

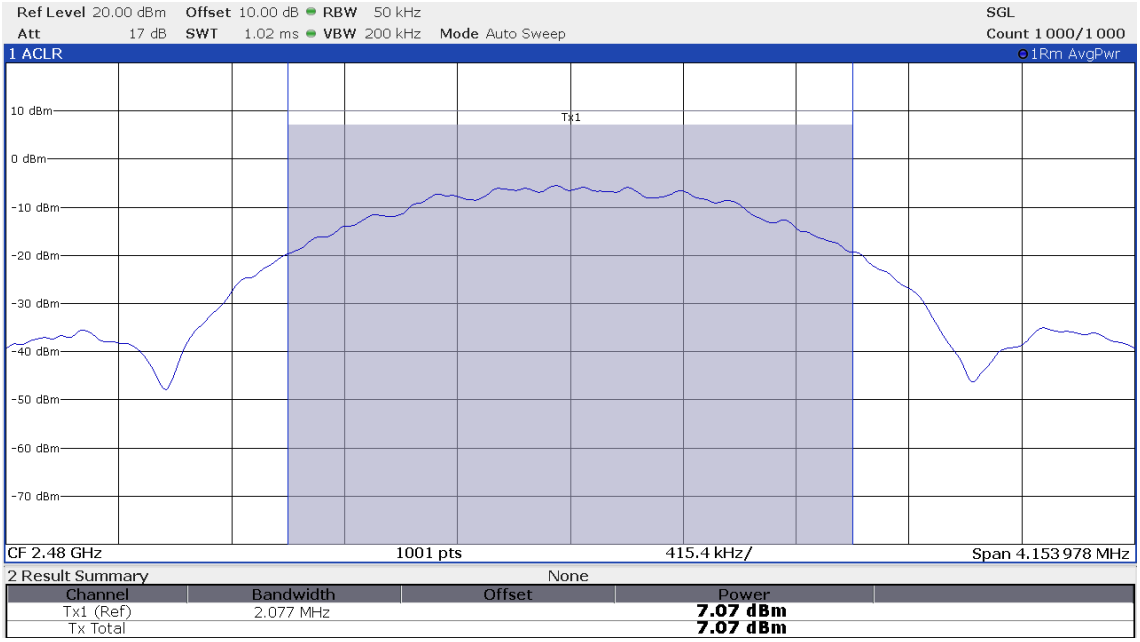


Operation mode	Reading [dBm]	Corr. Fact. [dB]	Result [dBm]	Limit [dBm]	Antenna Gain [dBi]	e.i.r.p. [dBm]	Limit e.i.r.p. [dBm]
1	**7.1**	**0.0**	**7.1**	30	-0.3	**6.8**	36
2	7.1	0.0	7.1	30	-2.4	4.7	36
3	7.1	0.0	7.1	30	-3.1	4.0	36
4	7.0	0.0	7.0	30	-0.3	6.7	36
5	7.1	0.0	7.1	30	-2.4	4.7	36
6	7.1	0.0	7.1	30	-3.1	4.0	36
7	7.1	0.0	7.1	30	-0.3	6.8	36
8	7.1	0.0	7.1	30	-2.4	4.7	36
9	7.1	0.0	7.1	30	-3.1	4.0	36
10	7.0	0.0	7.0	30	-0.3	6.7	36
11	7.0	0.0	7.0	30	-2.4	4.6	36
12	7.1	0.0	7.1	30	-3.1	4.0	36

Test result: Passed

5.6.3.2 Maximum conducted (average) output power

Worst case plot (operation mode 3):



Operation mode	Reading [dBm]	Corr. Fact. [dB]	DCCF [dB]	Result [dBm]	Limit [dBm]	Antenna Gain [dBi]	e.i.r.p. [dBm]	Limit e.i.r.p. [dBm]
1	6.9	0.0	0.0	6.9	30	-0.3	6.6	36
2	7.0	0.0	0.0	7.0	30	-2.4	4.6	36
3	7.1	0.0	0.0	**7.1**	30	-3.1	4.0	36
4	6.9	0.0	0.0	6.9	30	-0.3	6.6	36
5	7.0	0.0	0.0	7.0	30	-2.4	4.6	36
6	7.1	0.0	0.0	7.1	30	-3.1	4.0	36
7	7.0	0.0	0.0	7.0	30	-0.3	**6.7**	36
8	7.0	0.0	0.0	7.0	30	-2.4	4.6	36
9	7.1	0.0	0.0	7.1	30	-3.1	4.0	36
10	6.9	0.0	0.0	6.9	30	-0.3	6.6	36
11	7.0	0.0	0.0	7.0	30	-2.4	4.6	36
12	7.1	0.0	0.0	7.1	30	-3.1	4.0	36

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.7 DTS maximum power spectral density

5.7.1 Test setup (DTS maximum PSD level in the fundamental emission)

Test setup (DTS fundamental emission output power)			
Used	Setup	See sub-clause	Comment
☐	Radiated: 1 GHz to 40 GHz	5.1.3	-
☒	Conducted: Antenna port	5.1.4	-

5.7.2 Test method (DTS maximum PSD level in the fundamental emission)

Test method (Maximum *peak* power spectral density level in the fundamental emission)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	11.10.2	Method PKPSD (peak PSD)	No limitations	-

Test method (Maximum *average* power spectral density level in the fundamental emission)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	11.10.3	Method AVGPSD-1	D ≥ 98%	-
☐	11.10.4	Method AVGPSD-1A (alternative)	D ≥ 98%	-
☐	11.10.5	Method AVGPSD-2	Constant D (±2%)	-
☐	11.10.6	Method AVGPSD-2A (alternative)	Constant D (±2%)	-
☐	11.10.7	Method AVGPSD-3	No limitations	-
☐	11.10.8	Method AVGPSD-3A (alternative)	No limitations	-

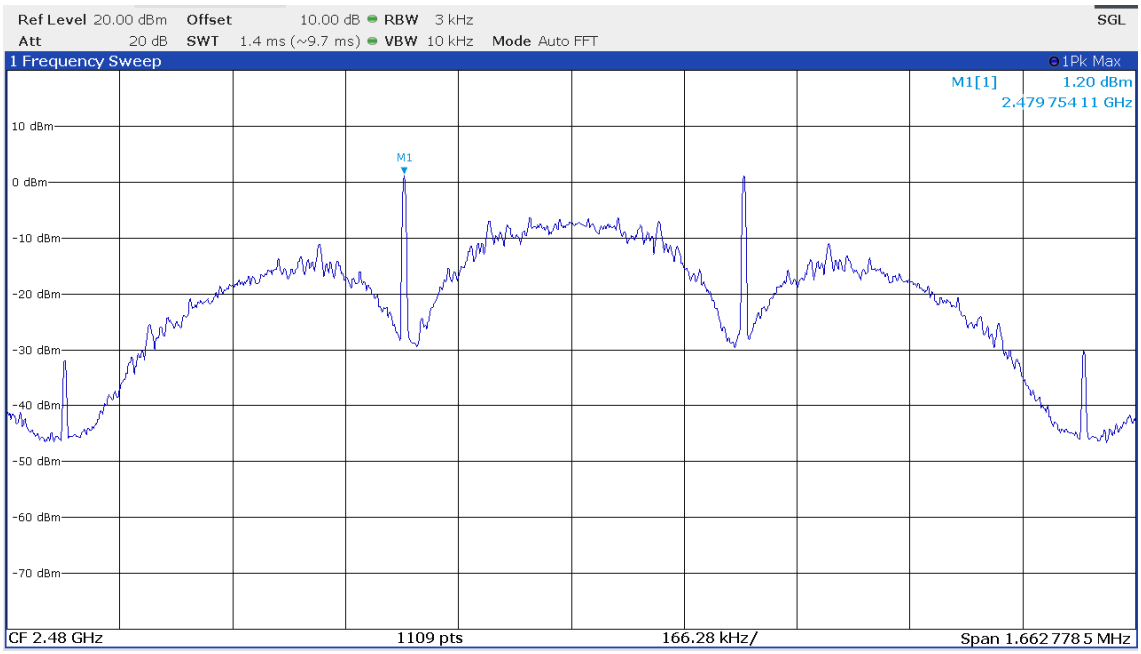
5.7.3 Test results (DTS maximum PSD level in the fundamental emission)

Ambient temperature:	22 °C
Relative humidity:	42 %

Date:	25.01.2024
Tested by:	B. ROHDE

5.7.3.1 Maximum peak PSD:

Worst case plot (operation mode 12):

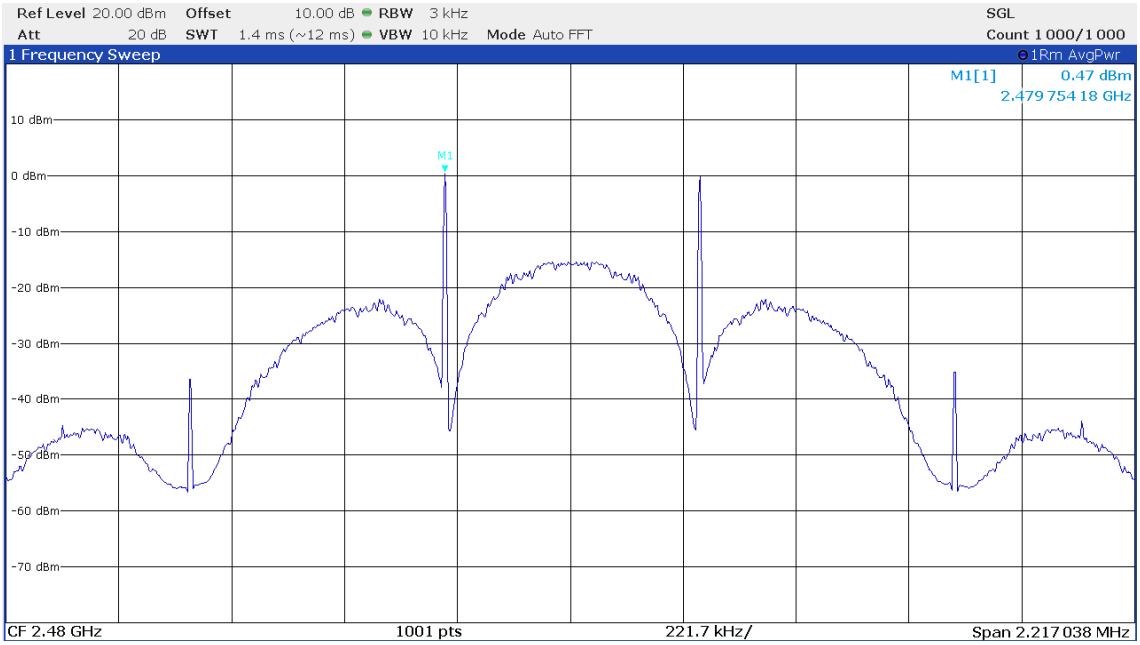


Operation mode	Reading [dBm/3 kHz]	Corr. Fact. [dB]	Result [dBm/3 kHz]	Limit [dBm/3 kHz]
1	-4.1	0.0	-4.1	8.0
2	-9.5	0.0	-9.5	8.0
3	-8.6	0.0	-8.6	8.0
4	-6.8	0.0	-6.8	8.0
5	-5.1	0.0	-5.1	8.0
6	-5.4	0.0	-5.4	8.0
7	-3.2	0.0	-3.2	8.0
8	-4.3	0.0	-4.3	8.0
9	-4.6	0.0	-4.6	8.0
10	0.9	0.0	0.9	8.0
11	1.1	0.0	1.1	8.0
12	**1.2**	0.0	1.2	8.0

Test result: Passed

5.7.3.2 Maximum average PSD

Worst case plot (operation mode 12):



Operation mode	Reading [dBm/3 kHz]	Corr. Fact. [dB]	DCCF [dB]	Result [dBm/3 kHz]	Limit [dBm/3 kHz]
1	-14.7	0.0	0.0	-14.7	8.0
2	-16.4	0.0	0.0	-16.4	8.0
3	-15.5	0.0	0.0	-15.5	8.0
4	-13.1	0.0	0.0	-13.1	8.0
5	-12.2	0.0	0.0	-12.2	8.0
6	-12.3	0.0	0.0	-12.3	8.0
7	-12.7	0.0	0.0	-20.7	8.0
8	-13.8	0.0	0.0	-13.8	8.0
9	-13.6	0.0	0.0	-13.6	8.0
10	0.4	0.0	0.0	0.4	8.0
11	0.4	0.0	0.0	0.4	8.0
12	**0.5**	0.0	0.0	0.5	8.0

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.8 DTS band-edge emission measurements

5.8.1 Test setup (Band edge – unrestricted bands)

Test setup (Band edge – unrestricted bands)			
Used	Setup	See sub-clause	Comment
☐	Radiated: 1 GHz to 40 GHz	5.1.3	-
☒	Conducted: Antenna port	5.1.4	-

5.8.2 Test method (Band edge – unrestricted bands)

Test method (Band edge – unrestricted bands)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☐	11.11.	20 dBc (Peak)	Peak power	*1
☒	11.11.	30 dBc (Average)	RMS power	*2

*1 As declared in “47 CFR 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

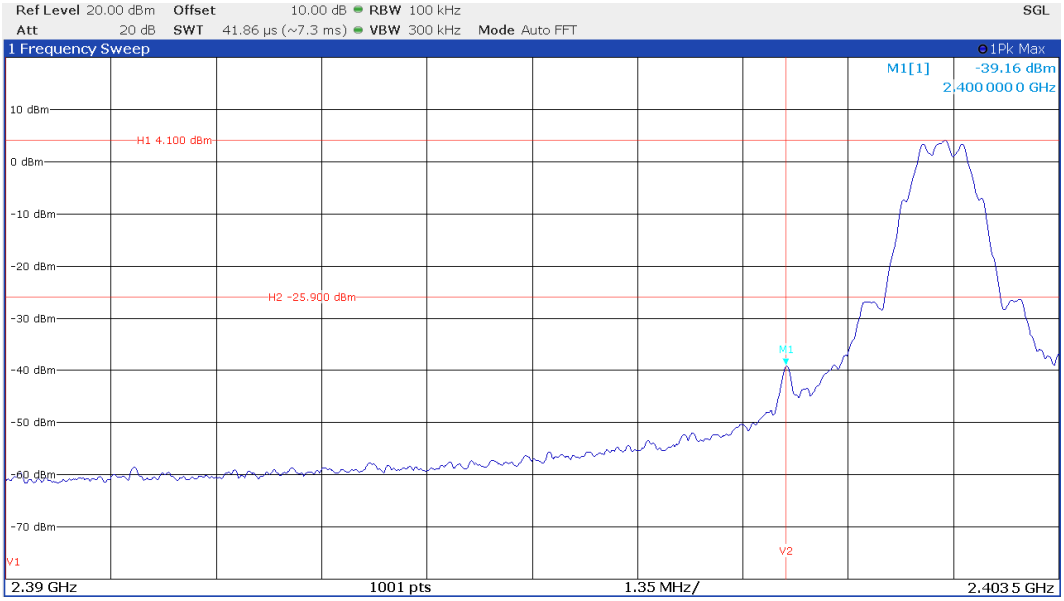
*2 If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

5.8.3 Test results (Band edge – unrestricted bands)

Ambient temperature:	22 °C
Relative humidity:	42 %

Date:	25.01.2024
Tested by:	B. ROHDE

Worst case plot Lower band edge (operation mode 10):



Lower band edge (operation mode 1):

Frequency [MHz]	Reference [dB(µV/m)]	Limit [dB(µV/m)]	Unrestricted band emission [dB(µV/m)]	Margin [dB]
2400	5.8	-24.2	-38.8	14.6

Lower band edge (operation mode 4):

Frequency [MHz]	Reference [dB(µV/m)]	Limit [dB(µV/m)]	Unrestricted band emission [dB(µV/m)]	Margin [dB]
2400.005	5.8	-24.2	-38.5	14.3

Lower band edge (operation mode 7):

Frequency [MHz]	Reference [dB(µV/m)]	Limit [dB(µV/m)]	Unrestricted band emission [dB(µV/m)]	Margin [dB]
2400	-1.6	-31.6	-49.6	18

Lower band edge (operation mode 10):

Frequency [MHz]	Reference [dB(µV/m)]	Limit [dB(µV/m)]	Unrestricted band emission [dB(µV/m)]	Margin [dB]
2400	4.1	-25.9	-39.2	13.3

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.8.4 Test setup (Band edge – restricted bands)

Test setup (Band edge – restricted bands)			
Used	Setup	See sub-clause	Comment
☒	Radiated: 1 GHz to 40 GHz	5.1.3	
☐	Conducted: Antenna port	5.1.4	

5.8.5 Test method (Band edge – restricted bands)

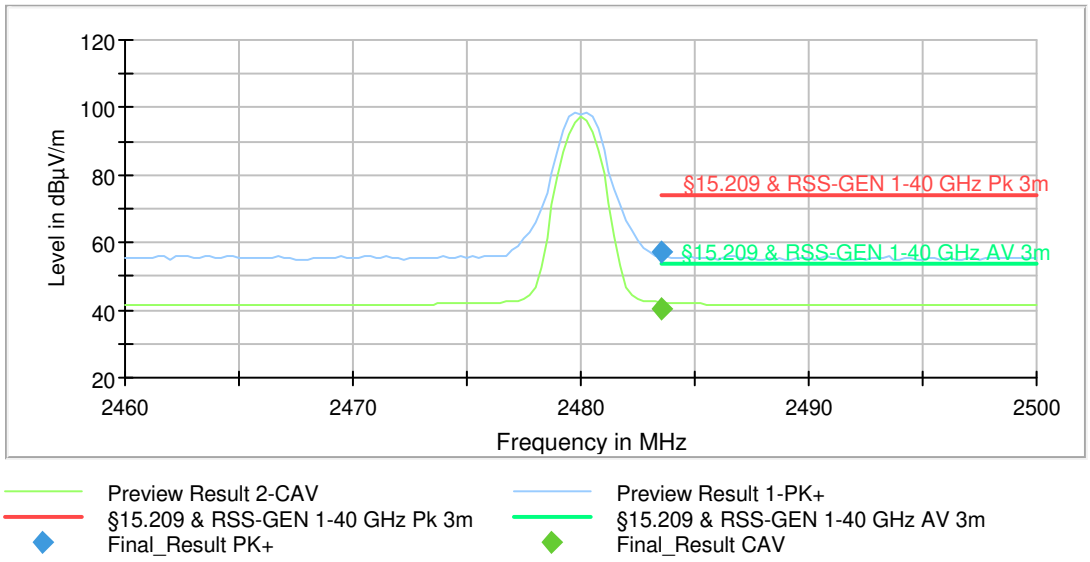
Test method (Band edge – restricted bands)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	11.12.1	Standard method	No limitations	
☐	11.12.3.1	Marker-delta method		See 6.10.6 [3] 2 MHz from band
☐	11.12.3.2	Integration method		2 MHz from band

5.8.6 Test results (Band edge – restricted bands)

Ambient temperature:	22 °C
Relative humidity:	35 %

Date:	05.06.2024
Tested by:	B. ROHDE

Worst case plot upper band edge (operation mode 6):



Upper band edge (operation mode 3):

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AV Level [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Correction [dB/m]	Polarization	Elevation [deg]	Azimuth [deg]
2483.5	54.5	74.0	19.5	39.6	54.0	14.4	33.2	V	90	289

Upper band edge (operation mode 6):

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AV Level [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]
2483.5	57.2	74.0	16.8	40.5	**54.0**	**13.5**	33.2	V	90	289

Upper band edge (operation mode 9):

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AV Level [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]
2483.5	57.2	74.0	16.8	40.5	54.0	13.5	33.2	V	90	294

Upper band edge (operation mode 12):

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AV Level [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]
2483.5	56.9	74.0	17.1	40.5	54.0	13.5	33.2	V	90	293

Test result: Passed

Test equipment (please refer to chapter 7 for details)
2 - 11

5.9 Maximum unwanted emissions

5.9.1 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: Antenna port	5.1.4	-

5.9.2 Test method (Maximum unwanted emissions - radiated)

☒ Test method (radiated) see sub-clause 5.1.1 // 5.1.2 // 5.1.3 as described herein

5.9.3 Test results (Maximum unwanted emissions - radiated)

5.9.3.1 Test results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	22 °C
Relative humidity:	65 %

Date:	27.06.2024
Tested by:	B. ROHDE

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. [dBµV/m]

Result @ norm. dist. [dBµA/m] = Result @ norm. dist. [dBµV/m] – 20 x $\log_{10}$ (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 equipment (please refer to chapter 7 for details)
12 - 19

5.9.3.2 Test results (30 MHz – 1 GHz)

Ambient temperature:	22 °C
Relative humidity:	65 %

Date:	27.06.2024
Tested by:	B. ROHDE

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
Only the worst case was reported

Calculations:

Result [dBµV/m] = Reading [dBµV] + Correction [dBµV/m]

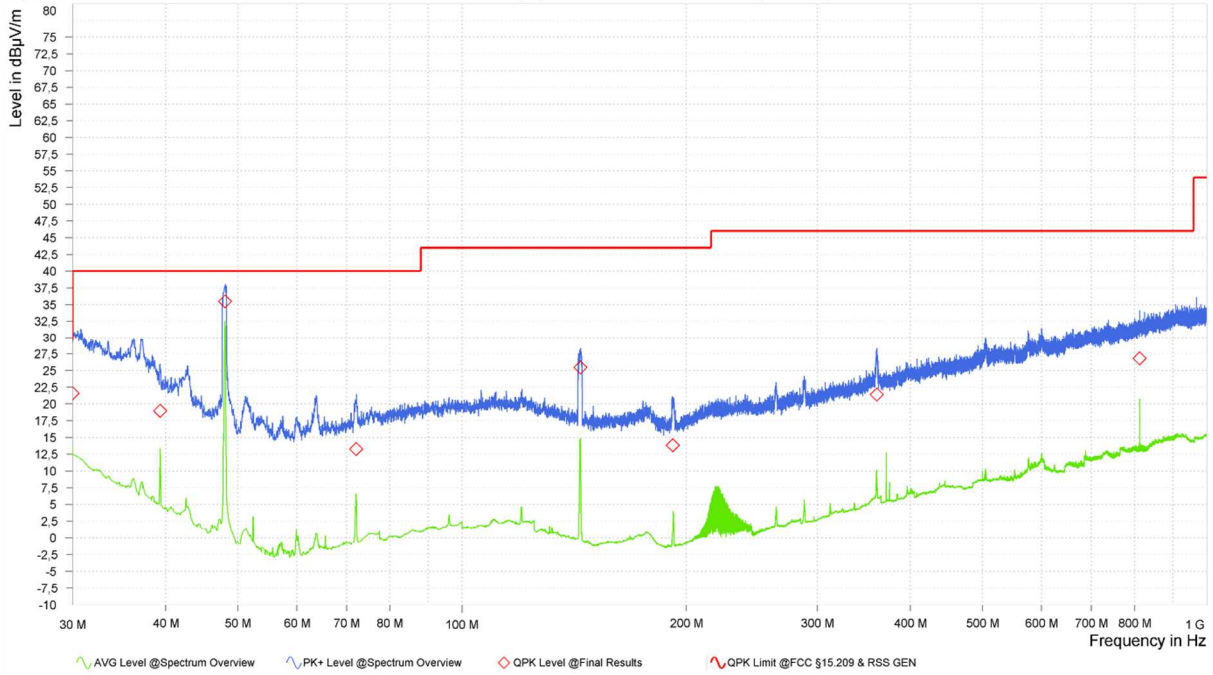
Correction [dBµV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]

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 – pos 1):



Result tables:

(Operation mode 4):

Frequency [MHz]	QPK Level [dBµV/m]	QPK Limit [dBµV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Meas. Time [s]	Position #
30.000	21.60	29.50	7.90	26.66	V	148	1.17	120.000	1.000	1
39.330	18.94	40.00	21.06	20.77	V	220	1.20	120.000	1.000	1
48.060	35.46	40.00	4.54	14.87	V	14	1.18	120.000	1.000	1
72.090	13.26	40.00	26.74	14.99	V	264	1.18	120.000	1.000	1
144.180	25.45	43.50	18.05	15.63	H	274	2.06	120.000	1.000	1
191.850	13.83	43.50	29.67	14.95	V	82	1.08	120.000	1.000	1
360.600	21.38	46.00	24.62	20.61	V	252	1.14	120.000	1.000	1
812.490	26.80	46.00	19.20	28.70	V	14	1.11	120.000	1.000	1

(Operation mode 5):

Frequency [MHz]	QPK Level [dBµV/m]	QPK Limit [dBµV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Meas. Time [s]	Position #
38.330	14.19	40.00	25.81	21.42	H	332	1.01	120.000	1.000	2
48.060	34.46	40.00	5.54	14.87	V	26	1.16	120.000	1.000	2
63.740	11.15	40.00	28.85	13.69	V	132	1.40	120.000	1.000	2
72.040	12.67	40.00	27.33	14.98	V	131	1.76	120.000	1.000	2
144.180	22.10	43.50	21.40	15.63	V	89	1.36	120.000	1.000	2
192.070	12.94	43.50	30.56	14.94	V	105	1.16	120.000	1.000	2
359.780	21.50	46.00	24.50	20.62	V	249	1.26	120.000	1.000	2
812.490	23.71	46.00	22.29	28.70	V	6	1.38	120.000	1.000	2

(Operation mode 6):

Frequency [MHz]	QPK Level [dBµV/m]	QPK Limit [dBµV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Meas. Time [s]	Position #
39.330	18.64	40.00	21.36	20.77	V	206	1.24	120.000	1.000	3
48.000	33.16	40.00	6.84	14.90	V	26	1.00	120.000	1.000	3
72.030	12.34	40.00	27.66	14.98	V	265	1.12	120.000	1.000	3
144.030	23.15	43.50	20.35	15.62	V	267	1.11	120.000	1.000	3
360.210	22.94	46.00	23.06	20.62	V	262	1.02	120.000	1.000	3
576.930	21.88	46.00	24.12	25.39	V	147	1.14	120.000	1.000	3
812.490	28.52	46.00	17.48	28.70	V	258	1.06	120.000	1.000	3

Test result: Passed

Test equipment (please refer to chapter 7 for details)
13 - 21

5.9.3.3 Test results (radiated 1 to 40 GHz)

Ambient temperature:	35-45 °C
Relative humidity:	22 %

Date:	04-05.06.2024
Tested by:	B. ROHDE

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: Only worst cases from conducted pretests were tested

Calculation:

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

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

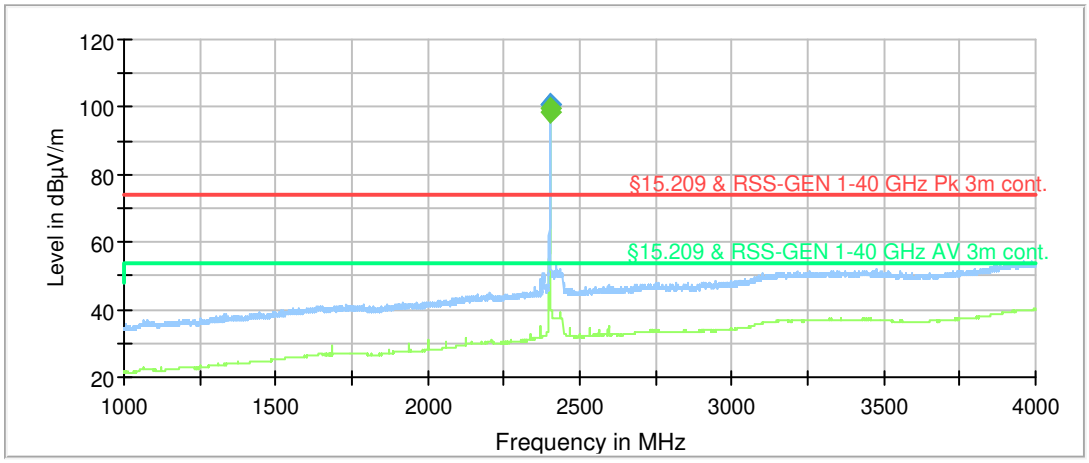
Correction [dBµV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]+DCCF* [dB]
* (if applicable – only for Average values, that are fundamental related)

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:

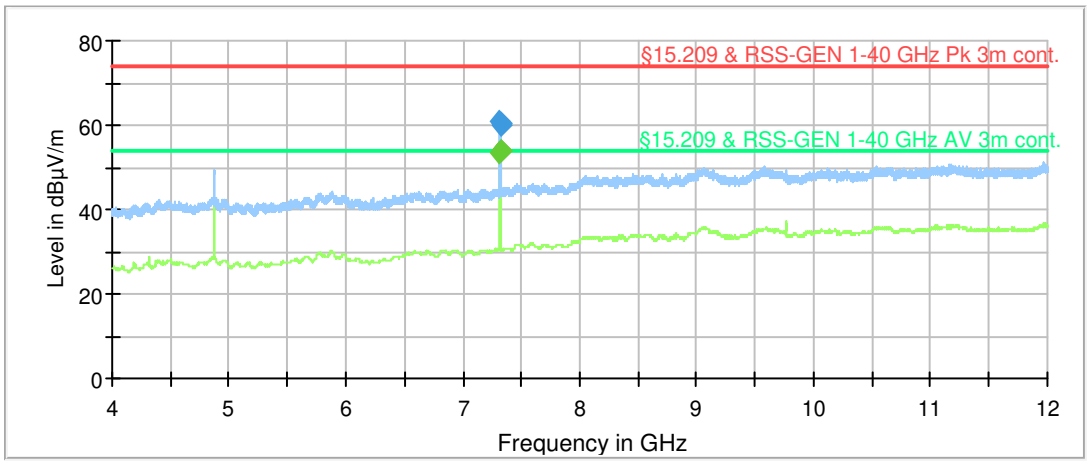
Spurious emissions from 1 GHz to 4 GHz (operation mode 3):



Preview Result 2-AVG
§15.209 & RSS-GEN 1-40 GHz Pk 3m cont.
Final_Result PK+

Preview Result 1-PK+
§15.209 & RSS-GEN 1-40 GHz AV 3m cont.
Final_Result AVG

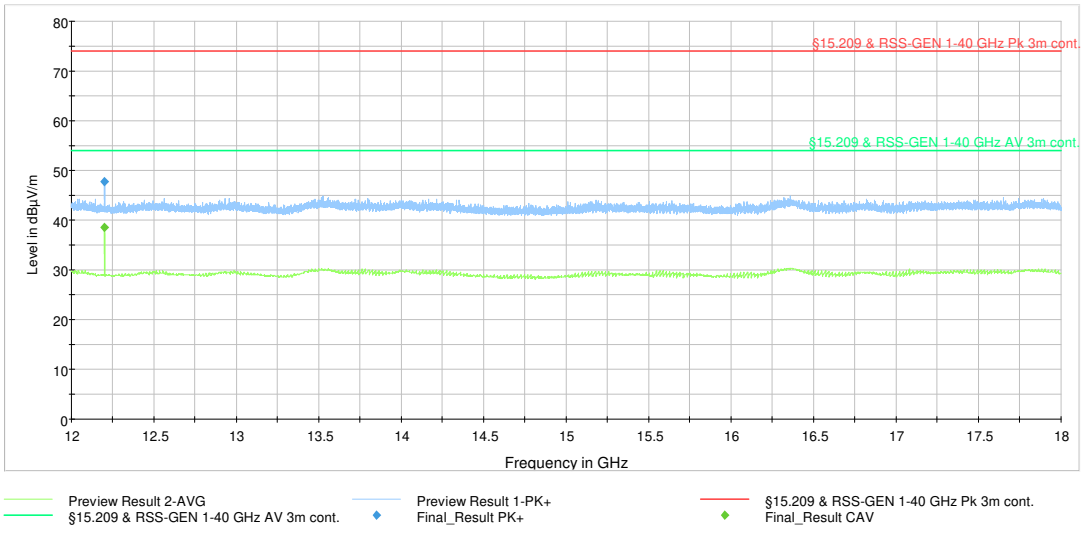
Spurious emissions from 4 GHz to 12 GHz radiated (operation mode 4):



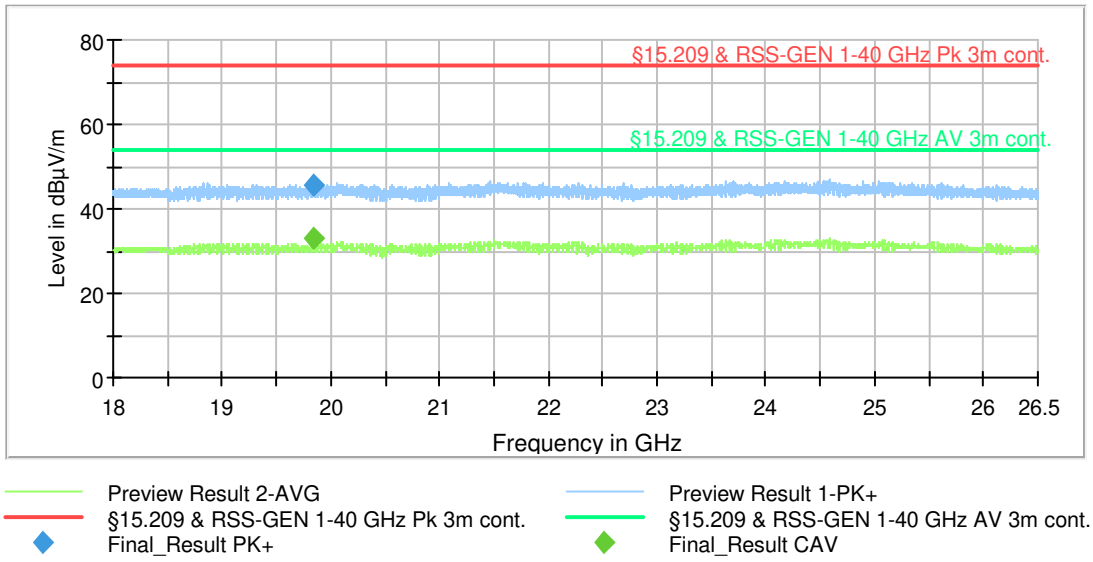
Preview Result 2-AVG
§15.209 & RSS-GEN 1-40 GHz Pk 3m cont.
Final_Result PK+

Preview Result 1-PK+
§15.209 & RSS-GEN 1-40 GHz AV 3m cont.
Final_Result AVG

Spurious emissions from 12 GHz to 18 GHz radiated (operation mode 4):



Spurious emissions from 18 GHz to 26.5 GHz radiated (operation mode 5):



Result tables:

Operation mode #4:

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AV Level [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]
2401.8	100.9	Fundamental Emission		98.5	Fundamental Emission		33.2	V	90.0	296.0
2402.0	100.7			99.9			33.2	V	90.0	297.0
12011.3	47.1	74.0	34.9	36.6	54.0	25.4	10.2	V	120.0	278.0
19218.0	44.0	74.0	30.0	32.4	54.0	21.6	3.6	V	120.0	290.0

Operation mode #5:

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AV Level [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]
2440.00	100.0	Fundamental Emission		99.0	Fundamental Emission		33.6	V	90.0	311.0
2440.25	100.0			97.7			33.6	V	90.0	310.0
7319.3	60.7	74.0	13.3	53.5	54.0	0.5	4.1	V	60.0	310.0
7319.5	60.0	74.0	14.0	53.8	54.0	0.2	4.1	V	60.0	307.0
7320.8	60.7	74.0	13.3	53.9	54.0	0.1	4.1	V	60.0	307.0
12201.3	47.8	74.0	26.2	38.6	54.0	15.4	4.1	V	60.0	307.0
19518.0	44.3	74.0	29.7	32.0	54.0	22.0	3.7	V	120	288.0

Operation mode #6:

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AV Level [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]
2479.8	98.7	Fundamental Emission		96.4	Fundamental Emission		33.2	V	90.0	287.0
2480.0	98.5			97.7			33.2	V	90.0	287.0
2483.5	48.8	74.0	25.2	34.9	54.0	19.1	33.2	V	90.0	295.0
7439.5	58.4	74.0	15.6	52.2	54.0	1.8	4.6	V	60.0	302.0
7440.8	59.2	74.0	14.8	52.0	54.0	2.0	4.6	V	60.0	307.0
12401.3	47.4	74.0	26.6	37.8	54.0	16.2	10.4	V	30.0	332.0
19842.0	45.4	74.0	28.6	33.0	54.0	21.0	3.8	V	120.0	322.0

Test result: Passed

Test equipment (please refer to chapter 7 for details)
2 - 11, 22 - 28

5.9.4 Test method (Maximum unwanted emissions - unrestricted bands - relative)

Test method (Band edge – unrestricted bands)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☐	11.11.	20 dBc (Peak)	Peak power	*1
☒	11.11.	30 dBc (Average)	RMS power	*2

*1 As declared in “47 CFR 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

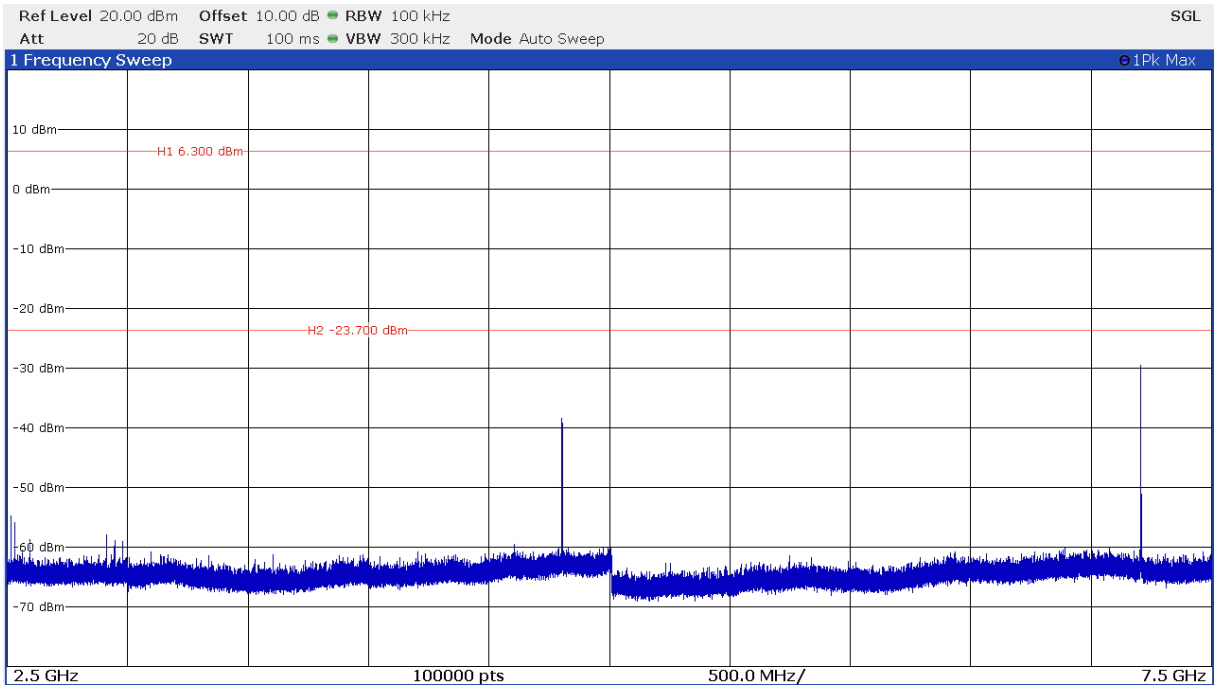
*2 If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

5.9.5 Test results (Maximum unwanted emissions - unrestricted bands - relative)

Ambient temperature:	22 °C
Relative humidity:	42 %

Date:	25.01.2024
Tested by:	B. ROHDE

Unwanted emissions (operation mode 4):



Unwanted emissions (operation mode 4):

Frequency [MHz]	Reference [dBm]	Limit [dBm]	Unrestricted band emission [dBm]	Margin [dB]
7205.225	6.3	-23.7	-29.5	5.8
9609.025	6.3	-23.7	-47.5	23.8
13800.225	6.3	-23.7	-49.5	25.8
21858.825	6.3	-23.7	-50.7	27.0
24730.475	6.3	-23.7	-52.0	28.3

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.10 AC power-line conducted emissions

5.10.1 Test setup (AC power-line conducted emissions)

Used	Setup	See sub-clause	Comment
☒	Conducted: AC power line	5.1.5	-
☐	Not applicable, because …	-	-

5.10.2 Test method (AC power-line conducted emissions)

Used	Clause	Name of method	Sub-clause	Comment
☒	6.2 [1]	Tabletop equipment testing	5.1.5	The EUT is DC supplied, therefore, an AC / DC adaptor has to be used.
☐	6.2 [1]	Floor-standing equipment testing	-	-

During the measurement the EUT was supplied with 24.0 V DC by an AC / DC adaptor MINI-PS-100-240AC/24DC/1.3. The adaptor itself was supplied by an AC mains network with $120V_{AC}$ 60Hz.

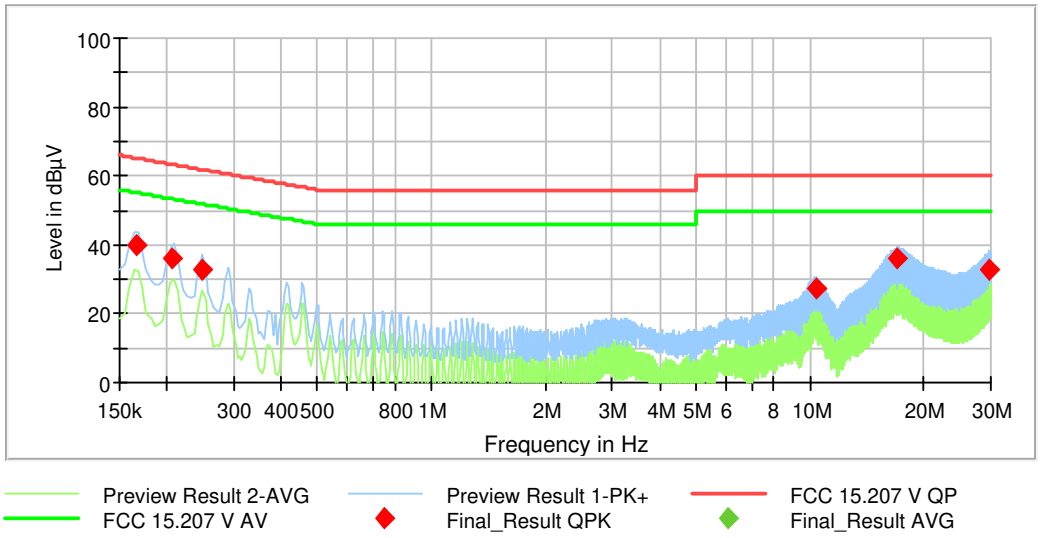
5.10.3 Test results (Conducted emissions on power supply lines)

Ambient temperature:	22°
Relative humidity:	45 %

Date:	20.08.2024
Tested by:	B. ROHDE

Operation mode: BLE transmitting @2440 MHz, operation mode #5

The curves in the diagrams in A.2 of annex A of this test report 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 curves representing the peak measurement and the bottom measured curves the average measurement.



Conducted emissions on power supply lines of EUT 4							
Frequency [MHz]	QuasiPeak level [dB(µV)]	Average level [dB(µV)]	Limit [dB(µV)]	Margin [dB]	Line	PE	Corr. [dB]
0.165300	40.01	---	65.19	25.19	L1	GND	9.8
0.206700	36.25	---	63.34	27.09	L1	GND	9.8
0.248100	32.58	---	61.82	29.24	L1	GND	9.9
10.317300	27.13	---	60.00	32.87	N	GND	10.6
17.004300	35.80	---	60.00	24.20	L1	GND	10.8
29.589000	32.59	---	60.00	27.41	N	GND	11.2

Test result: Passed

Test equipment (please refer to chapter 6 for details)
29 - 33

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	Signal & spectrum analyser	FSW43	Rohde & Schwarz	100586 & 100926	481720	07.05.2024	05.2026
2	Antenna (Log.Per.)	HL050	Rohde & Schwarz	100438	481170	Calibration not necessary	
3	RF cable	Sucoflex 106B	Suhner	0709/6B / Kabel 38	481328	Calibration not necessary	
4	RF cable	Sucoflex 104	Huber+Suhner	517402	482392	Calibration not necessary	
5	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
6	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
7	Antenna support	AS620P	Deisel	620/375	480325	Calibration not necessary	
8	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/971107	480832	Calibration not necessary	
9	Positioner	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
10	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	27.02.2024	02.2026
11	Software	EMC32 V10.60.20	Rohde & Schwarz	---	483261	Calibration not necessary	
12	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	21.02.2024	02.2026
13	EMC test software	Elektra V5.05.00	Rohde & Schwarz		483755	Calibration not necessary	
14	RF Switch Matrix	OSP220	Rohde & Schwarz	101391	482976	Calibration not necessary	
15	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
16	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
17	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
18	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
19	EMI Test receiver	ESW44	Rohde & Schwarz	101828	482979	21.02.2024	02.2026
20	Attenuator 6 dB	WA2-6	Weinschel		482793	Calibration not necessary	
21	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	24.04.2024	04.2027
22	Standard gain horn 12 GHz - 18 GHz	18240-20	Flann	483	480294	Calibration not necessary	
23	Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ Hauppauge N.Y.	571667	480343	19.02.2024	02.2026
24	Standard gain horn 18 GHz - 26 GHz	20240-20	Flann	411	480297	Calibration not necessary	
25	Preamplifier 18 GHz - 26 GHz	JS4-18002600-20-5A	MITEQ Hauppauge N.Y.	658697	480342	19.02.2024	02.2026
26	High-pass filter	WHKX4.0/18G-8SS	Wainwright	1	480587	Calibration not necessary	
27	Microwave cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800-KPS	480302	Calibration not necessary	
28	Preamplifier 100 MHz - 16 GHz	AFS6-00101600-23-10P-6-R	Narda MITEQ	2011215	482333	20.02.2024	02.2026
29	Transient Filter Limiter	CFL 9206A	Teseq GmbH	38268	481982	28.03.2024	03.2026

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
30	LISN	NSLK8128	Schwarzbeck	8128155	480058	28.02.2024	02.2026
31	Shielded chamber M4	B83117-S1-X158	Siemens	190075	480088	Calibration not necessary	
32	EMI Receiver / Spectrum Analyser	ESIB 26	Rohde & Schwarz	100292	481182	22.02.2024	02.2026
33	EMC test software	EMC32 V10.60.20	Rohde & Schwarz		483961	Calibration not necessary	

8 Test site Verification

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Shielded chamber M4	480088	9 kHz – 30 MHz	GND-Plane	ANSI C63.4-2014	08.11.2022	07.11.2025
Semi anechoic chamber M276	483227	30 MHz – 1000 MHz	NSA	ANSI C63.4-2014 ANSI C63.4a-2017	01.03.2023	28.02.2026
Semi anechoic chamber M276	483227	1 GHz -18 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	28.02.2023	27.02.2026
Fully anechoic chamber M20	480303	1 GHz -18 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	17.08.2022	16.08.2025

9 Report History

Report Number	Date	Comment
F231143E2	22.11.2024	Initial Test Report
-	-	-
-	-	-

10 List of Annexes

Annex A Test Setup Photos 8 pages

----- end of test report -----