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Test Report

Report Number:

F210365E5

Equipment under Test (EUT):

IEEE 802.11 b/g/n Module
inside dedicated Host VIS 500

Applicant:

Wöhler Technik GmbH

Manufacturer:

Wöhler Technik GmbH

ilac-MRA
DAkkS Deutsche Akkreditierungsstelle
D-PL-17186-01-01
D-PL-17186-01-02
D-PL-17186-01-03

References

[1] **ANSI C63.10-2013**, 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 2 (2017-02)** Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

[5] **RSS-Gen, Issue 5 (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.

Tested and written by:	Bernward ROHDE	o.b.o. Paul NEUFELD 30.03.2022	
	Name	Signature	
Reviewed and approved by:	Bernd STEINER	Bernd STEINER 30.03.2022	
	Name	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:	Wöhler Technik GmbH
Address:	Wöhler-Platz 1, 33181 Bad Wünnenberg
Country:	Germany
Name for contact purposes:	Mr. Nikolai DERING
Phone:	+49 2953-73-100
eMail Address:	n.dering@woehler.de
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	Wöhler Technik GmbH
Address:	Wöhler-Platz 1, 33181 Bad Wünnenberg
Country:	Germany
Name for contact purposes:	Mr. Nikolai DERING
Phone:	+49 2953-73-100
eMail Address:	n.dering@woehler.de
Applicant 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-17186-01-05 and D-PL-17186-01-06, FCC Test Firm Accreditation designation number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment under Test)

EUT	
Test object: *	IEEE 802.11 b/g/n Module
PMN / Model name: *	WMOD200
FCC ID: *	2ANWR-WMOD200
IC: * ISED Certification number: *	23256-WMOD200

* Declared by the applicant

	Tested EUT			
	1		2	3
Serial number: *	1009	(main PCB)	-	-
PCB identifier: *	VIS500-MB	(main PCB)	-	-
Hardware version: * HVIN:*	WMOD200		-	-
Software version: * FVIN:*	-		-	-
HMN:*	VIS 500			

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

1.5 Technical Data of Equipment

1.5.1 Specific host

General EUT data			
Power supply EUT: *	Lithium battery 3.7 V		
Supply voltage EUT: *	U_{Nom}= 3.3 V_{DC}	U_{Min}= 3.2 V_{DC}	U_{Max}= 3.4 V_{DC}
Temperature range: *	0 °C to 40 °C		
Lowest / highest internal clock frequency: *	32.768 kHz / 2.462 GHz (incl. radio frequency)		

Ports / Connectors				
Identification	Connector		Length during test	Shielding (Yes / No)
	EUT	Ancillary		
Power connection	USB-C	AC plug / adapter	1 m	No
USB**	USB-A	Left open	-	-
Headphone jack*	3.5 mm	Left open	-	-
Camera cable	Customized	Left open	-	-

Remark:* No ancillary devices or cables were delivered by the applicant for these connectors. Therefore, these ports were left open for the tests as declared by the applicant.

Remark:** As declared by the applicant the USB connector is only for service applications.

1.5.2 EUT

IEEE 802.11 radio module		
Fulfils radio specification: *	IEEE 802.11 b, g, n (HT20)	
Radio chip: *	Silicon Labs WFW200S	
Antenna type: *	Internal PCB Antenna	
Antenna name: *	W2.4-5P-U by Inventek Systems	
Antenna gain: *	2.6 dBi	
Antenna connector: *	U.FL	
Type of modulation: *	IEEE 802.11 b	DBPSK, DQPSK, CCK (1/2/5.5/11 Mbit/s)
	IEEE 802.11 g	BPSK, QPSK, 16-QAM, 64-QAM (6/9/12/18/24/36/48/54 Mbit/s)
	IEEE 802.11 n20	BPSK, QPSK, 16-QAM, 64-QAM (up to 72.2 Mbit/s)

IEEE 802.11 radio module		
Operating frequency range: *	IEEE 802.11 b	2412 – 2462 MHz
	IEEE 802.11 g	2412 – 2462 MHz
	IEEE 802.11 n20	2412 – 2462 MHz
Number of channels: *	IEEE 802.11 b	11 (5 MHz channel spacing)
	IEEE 802.11 g	11 (5 MHz channel spacing)
	IEEE 802.11 n20	11 (5 MHz channel spacing)

IEEE 802.11 b/g/n20 frequencies				
Channel 01	RX	2412 MHz	TX	2412 MHz
Channel 02	RX	2417 MHz	TX	2417 MHz
Channel 03	RX	2422 MHz	TX	2422 MHz
Channel 04	RX	2427 MHz	TX	2427 MHz
Channel 05	RX	2432 MHz	TX	2432 MHz
Channel 06	RX	2437 MHz	TX	2437 MHz
Channel 07	RX	2442 MHz	TX	2442 MHz
Channel 08	RX	2447 MHz	TX	2447 MHz
Channel 09	RX	2452 MHz	TX	2452 MHz
Channel 10	RX	2457 MHz	TX	2457 MHz
Channel 11	RX	2462 MHz	TX	2462 MHz

1.5.3 Ancillary Equipment / Equipment used for testing

Equipment used for testing	
USB Ethernet adaptor:*1	Logilink UA0158 USB2.0 to Gigabit Adapter
Laptop PC:*1	Fujitsu Lifebook S751 (PM-Nr. 201036)

*1 Provided by the laboratory

Ancillary equipment	
Power adaptor*1	GlobTek, Inc. P/N WR9QA3000USBCIMKTR6B Model: GTM96180-1507-2.0

*1 Provided by the applicant

1.6 Dates

Date of receipt of test sample:	17.05.2021
Start of test:	18.05.2021
End of test:	26.05.2021

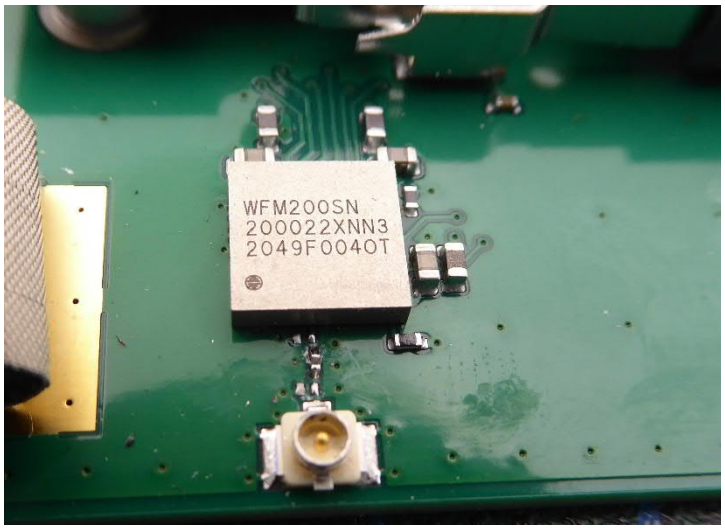
2 Operational States

2.1 Description of function of the EUT

The equipment under test (EUT) is an IEEE 802.11 b/g/n Module in a specific host, a monitor and control-unit for a chimney inspection camera.

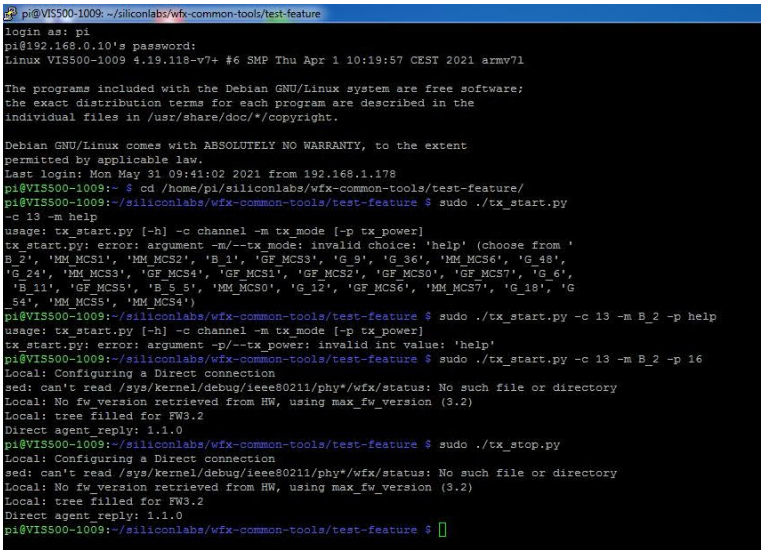
The specific host:

The EUT:



2.2 The following states were defined as the operating conditions

During all radio tests, except for the ac powerline setup, the EUTs host was supplied by its internal battery. The EUTs host was connected via a USB-2-Ethernet card to a configuration laptop. With the aid of a terminal program the test engineer was able to set the relevant radio parameter.



2.2.1 Operation modes

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate	Power setting
1	IEEE 802.11 b mode	2412	1	DQPSK	2 Mbit/s	16
2	IEEE 802.11 b-mode	2437	6	DQPSK	2 Mbit/s	16
3	IEEE 802.11 b-mode	2462	11	DQPSK	2 Mbit/s	16
4	IEEE 802.11 g-mode	2412	1	BPSK	6 Mbit/s	16
5	IEEE 802.11 g-mode	2437	6	BPSK	6 Mbit/s	16
6	IEEE 802.11 g-mode	2457	10	BPSK	6 Mbit/s	10
7	IEEE 802.11 g-mode	2462	11	BPSK	6 Mbit/s	6
8	IEEE 802.11 n-mode	2412	1	QPSK	MCS1	16
9	IEEE 802.11 n-mode	2437	6	QPSK	MCS1	16
10	IEEE 802.11 n-mode	2457	10	QPSK	MCS1	10
11	IEEE 802.11 n-mode	2462	11	QPSK	MCS1	6

3 Additional Information

All tests were done with the EUT inside the portable host with HMN: VIS 500. The host was not labeled with the final label.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [4] RSS-Gen [5]	Status	EUT
Maximum peak conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [4]	-*2	-
Maximum conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [4]	-	-
DTS Bandwidth / 99% Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [4]	-	-
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [4]	-	-
Average Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [4]	-	-
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [4]	Passed	1
Maximum unwanted emissions	0.009 – 26,500	15.247 (d) 15.205 (a) 15.209 (a)	8.9 [5]	Passed	1
Antenna Requirement	-	15.203 15.247 (b)	5.4 (f) (ii) [4]	Passed*1	-
Conducted emissions on supply line	0.15 – 30	15.207 (a)	8.8 [4]	Passed	1

*1 Fixed Antenna, gain below 6 dBi, no power reduction necessary.

*2 Power verification done in worst case mode, result identical to the original report within the measurement certainty.

5 Results

5.1 Test setup

5.1.1 Test Setup (radiated)

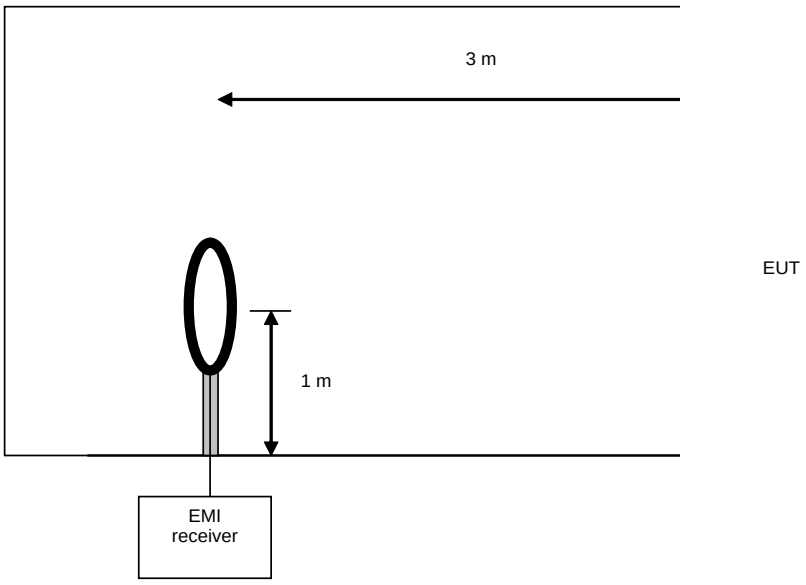
5.1.1.1 Preliminary measurement 9 kHz to 30 MHz

In the first stage a preliminary measurement is performed in an anechoic chamber with a measuring distance of 3 meters. Table-top and portable 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 to [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.

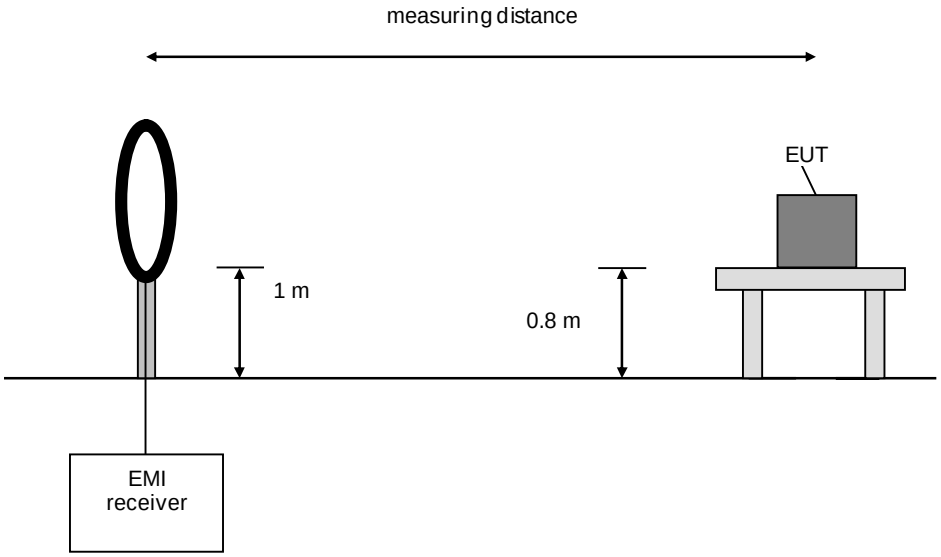
5.1.1.2 Final measurement 9 kHz to 30 MHz

In the second stage a final measurement is performed on an open area test site with no conducting ground plane in measuring distances of 3 m, 10 m or 30 m. In the case where larger measuring distances are required the results are extrapolated based on the values measured on the closer distances 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
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz



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.

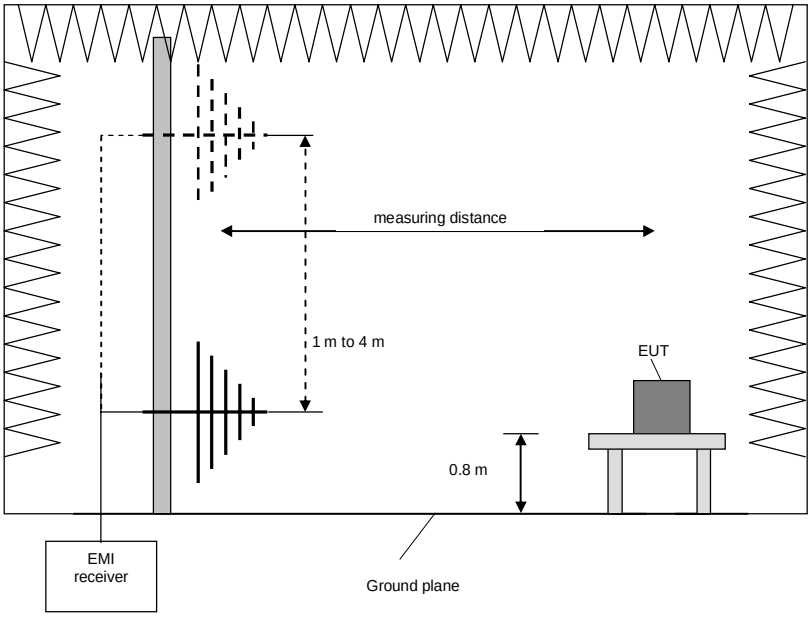
5.1.1.3 Preliminary and final measurement 30 MHz to 1 GHz

The preliminary and final measurements are performed in a semi-anechoic chamber with a metal ground plane in a 3 m distance. Table-top and portable 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.

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	Detector
Preliminary measurement	30 MHz to 1 GHz	30 kHz	120 kHz	Peak Average
Frequency peak search	± 120 kHz	10 kHz	120 kHz	Peak
Final measurement	30 MHz to 1 GHz	-	120 kHz	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.

5.1.1.4 Preliminary and final measurement > 1 GHz

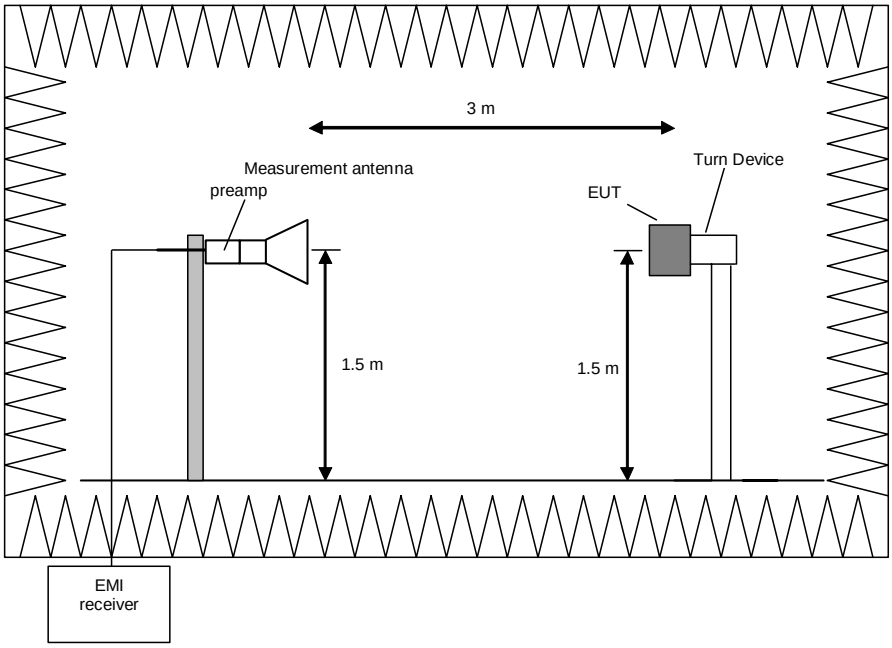
This measurement will be performed in a fully anechoic chamber. Tabletop and portable devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

Preliminary measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending on the frequency range of the used antenna. The spectrum analyser set to MAX Hold mode and a resolution bandwidth of 1 MHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °. This measurement is repeated after raising the EUT in 30° steps according to 6.6.5.4 in [1].

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 25 / 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz



Procedure preliminary measurement:

Pre-scans were performed in the frequency range 1 to 40 GHz.
The following procedure will be used:

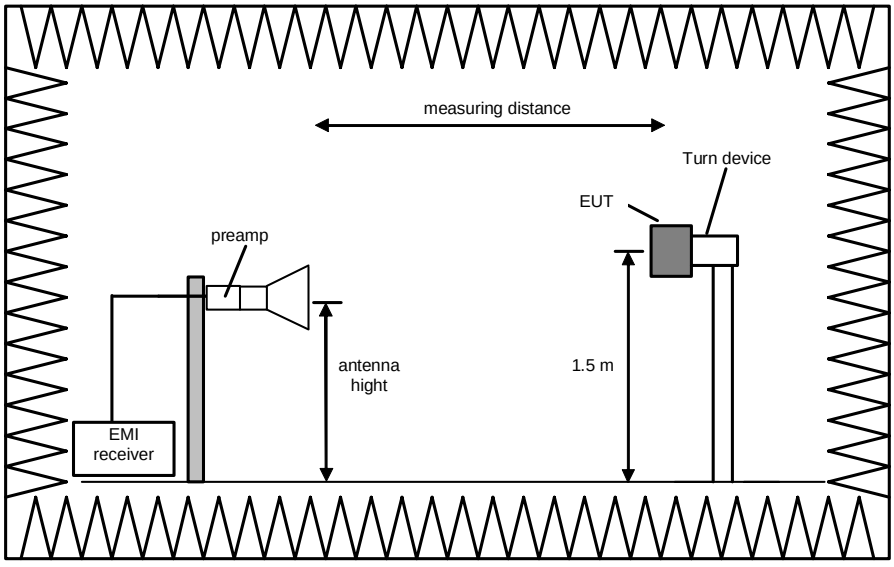
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
6. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
7. The measurement antenna polarisation, with the according EUT position (Turntable and Turn device) which produces the highest emission for each frequency will be used for the final measurement. The six closest values to the applicable limit will be used for the final measurement.

Final measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending on the frequency range of the used antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed by rotating the turntable through 0 to 360° in the worst-case EUT orientation which was obtained during the preliminary measurements.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 25 / 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz



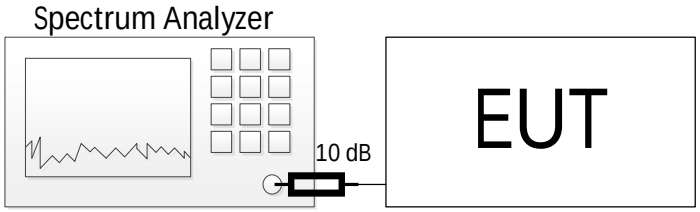
Procedure of measurement:

The measurements were performed in the frequency ranges 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 25 /26.5 GHz and 26.5 GHz to 40 GHz.
The following procedure will be used:

1) Set the turntable and the turn device to obtain the worst-case emission for the first frequency identified in the preliminary measurements.
2) 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.
3) Set the measurement antenna polarisation to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
4) Set the spectrum analyser to EMI mode with peak and average detector activated.
5) Rotate the turntable from 0° to 360° to find the TT Pos. that produces the highest emissions.
6) Note the highest displayed peak and average values
7) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.

5.1.2 Test setup (conducted)

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

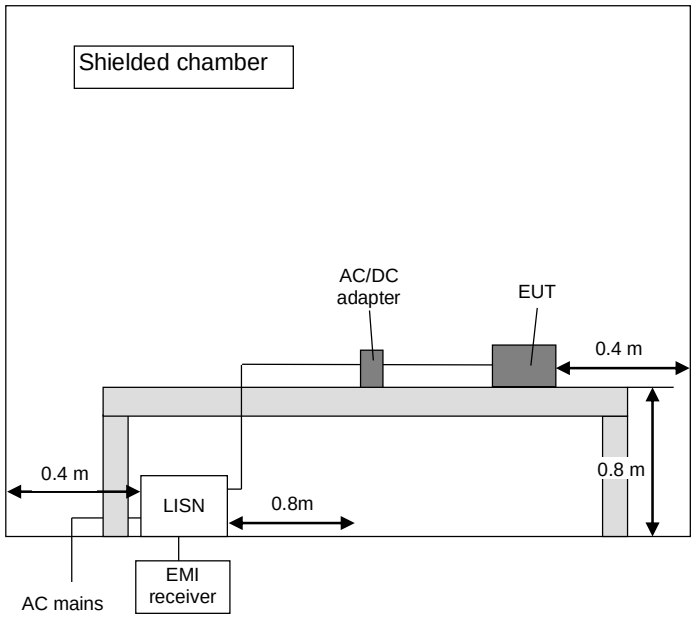
5.1.3 Test setup (AC powerline)

The test is carried out in a shielded chamber. Table-top and portable 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 to [1].

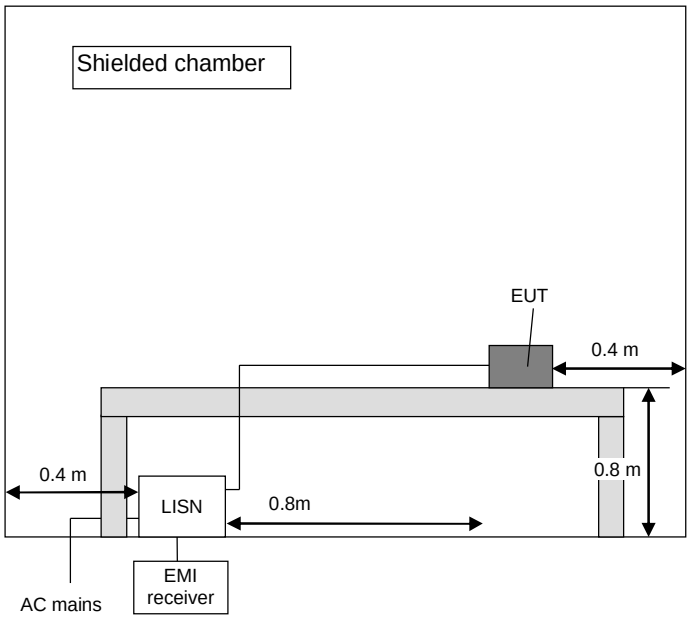
The frequency range 150 kHz to 30 MHz is measured with an EMI receiver set to MAX hold mode with Peak and Average detectors and a resolution bandwidth of 9 kHz. A scan is carried out on the phase and neutral line of the AC mains network. If emissions less than 10 dB below the appropriable limit are detected,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

Frequency range	Resolution bandwidth
150 kHz to 30 MHz	9 kHz

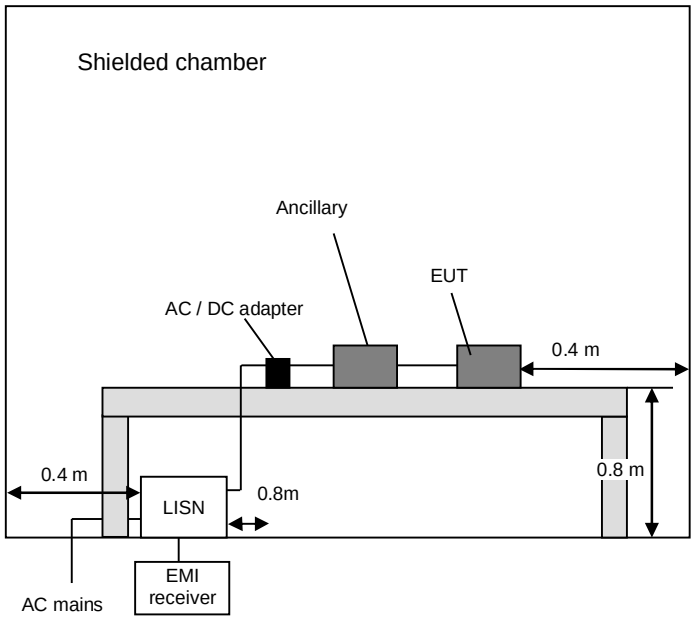
5.1.3.1 Test setup (AC powerline) with AC/DC adapter



5.1.3.2 Test setup (AC powerline) without AC adapter



5.1.3.3 Test setup (AC powerline) with AC adapter and ancillary



5.2 Duty cycle

5.2.1 Test setup (Duty cycle)

Test setup (Duty cycle)			
Used	Setup	See sub-clause	Comment
☐	Test setup (radiated)	5.1.1	
☒	Test setup (antenna port conducted)	5.1.2	

5.2.2 Test method (Duty cycle)

Test method (Duty cycle)				
Used	Sub-Clause [3]	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:	26.05.2021
Tested by:	B. ROHDE

Operation Mode #	TX_{on} [µs]	TX_{ges} [µs]	RBW [MHz]	50/T [kHz]	50/T < RBW?
1 - 3	24224	24234	20	2	☒
4 - 7	4032	4048	20	12	☒
8 – 11	1876	1892	20	27	☒

Operation Mode #	Sweep points	Sweep time [µs]	Meas points	Meas points >100?	Duty cycle %	DCCF [dB]
1 - 3	40001	30000	32299	☒	100	0.00
4 - 7	20001	6000	13494	☒	100	0.02
8 – 11	20001	5000	7568	☒	99	0.04

The DCCF (duty cycle correction factor) is calculated by:

$$DCCF = 10 * log_{10}\left(\frac{1}{Duty\ cycle}\right)$$

No DCCF is applied, duty cycle ≥ 98%.

Test equipment (please refer to chapter 6 for details)
1 - 2

5.3 Transmit Antenna Performance considerations

Test result (Transmit antenna requirements)			
Integral antenna	Antenna gain ≤ 6dBi	Result	Comment
☒	☒	Passed	No output power reduction necessary

5.4 Band edge

5.4.1 Test setup (Band edge – unrestricted bands)

Test setup (Band edge – unrestricted bands)			
Used	Setup	See sub-clause	Comment
☒	Test setup (radiated)	5.1.1	
☐	Test setup (antenna port conducted)	5.1.2	

5.4.2 Test method (Band edge – unrestricted bands)

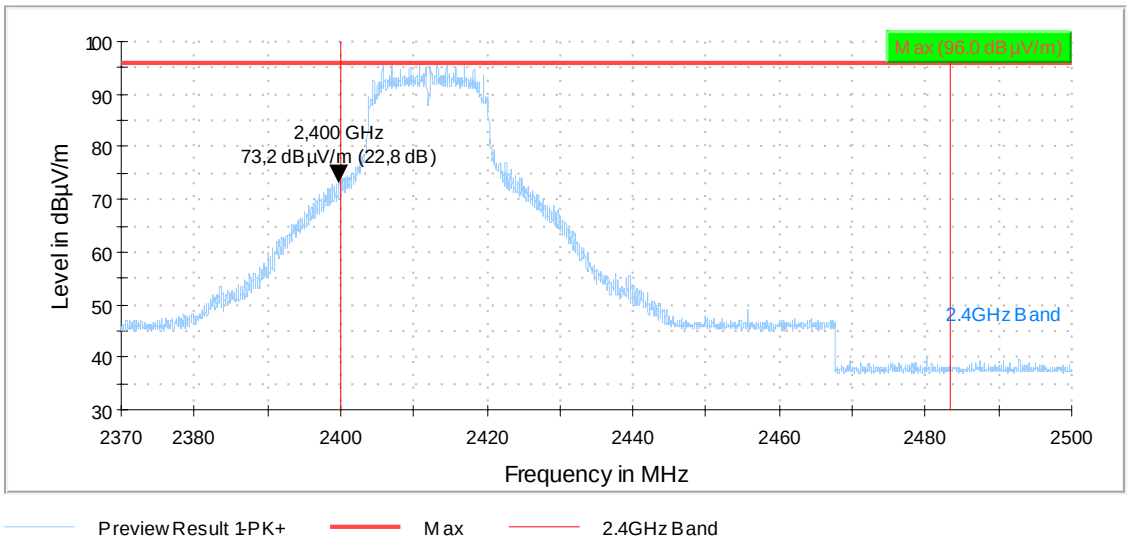
Test method (Band edge – unrestricted bands)				
Used	Sub-Clause [3]	Name of method	Applicability	Comment
☒	11.11.	20 dBc (Peak)	Peak power	*1
☐	11.11.	30 dBc (Average)	RMS power	*2

*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.

5.4.3 Test results (Band edge – unrestricted bands)

Worst case plot Lower band edge (operation mode 4):



Lower band edge (operation mode 1):

Frequency [MHz]	Reference [dBµV/m]	Limit [dBµV/m]	Unrestricted band emission [dBµV/m]	Margin [dB]	Result
2400.000	104.1	84.1	60.5	23.6	Passed
Measurement uncertainty +/- 5.1 dB					

Lower band edge (operation mode 4):

Frequency [MHz]	Reference [dBµV/m]	Limit [dBµV/m]	Unrestricted band emission [dBµV/m]	Margin [dB]	Result
2400.000	96.0	76.0	73.2	2.8	Passed
Measurement uncertainty +/- 5.1 dB					

Lower band edge (operation mode 8):

Frequency [MHz]	Reference [dBµV/m]	Limit [dBµV/m]	Unrestricted band emission [dBµV/m]	Margin [dB]	Result
2400.000	97.9	77.9	73.4	4.5	Passed
Measurement uncertainty +/- 5.1 dB					

Test equipment (please refer to chapter 6 for details)
3 - 10

5.4.4 Test setup (Band edge – restricted bands)

Test setup (Band edge – restricted bands)			
Used	Setup	See sub-clause	Comment
☒	Test setup (radiated)	5.1.1	
☐	Test setup (antenna port conducted)	5.1.2	

5.4.5 Test method (Band edge – restricted bands)

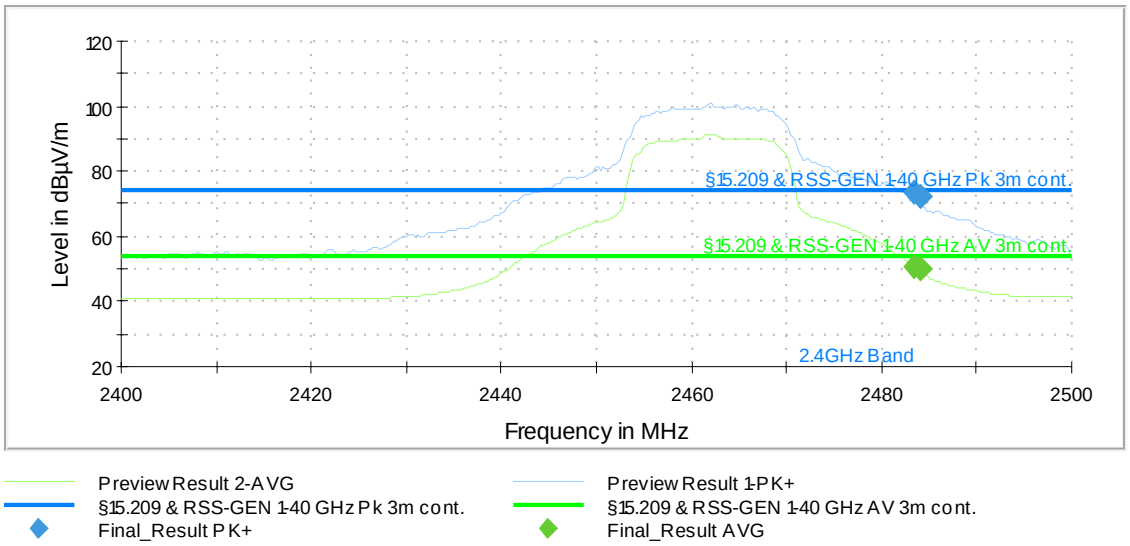
Test method (Band edge – restricted bands)				
Used	Sub-Clause [3]	Name of method	Applicability	Comment
☒	11.13.1	Standard method	No limitations	
☐	11.13.2	Marker-delta method		See 6.10.6 [3]
☐	11.13.3.2	Peak detection	Not for DTS testing	2 MHz from band
☐	11.13.3.3	Trace averaging with cont. EUT	D ≥ 98%	2 MHz from band
☐	11.13.3.4	Trace averaging with cont. EUT & D	Constant D (±2%)	2 MHz from band
☐	11.13.3.5	Reduced VBW		2 MHz from band

5.4.6 Test results (Band edge – restricted bands)

Ambient temperature:	24 °C
Relative humidity:	32 %

Date	19.05.2021
Tested by	B. ROHDE

Worst case plot upper band edge (operation mode 7):



Upper band edge (operation mode 3):

Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
2483.500	58.14	---	74.00	15.86	Passed
2483.500	---	48.49	54.00	5.51	Passed
2484.000	56.97	---	74.00	17.03	Passed
2484.000	---	45.87	54.00	8.13	Passed
Measurement uncertainty +/- 5.1 dB					

Upper band edge (operation mode 6):

Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
2483.500	---	47.55	54.00	6.45	Passed
2483.500	71.93	---	74.00	2.07	Passed
Measurement uncertainty +/- 5.1 dB					

Upper band edge (operation mode 7):

Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
2483.500000	73.47	---	74.00	0.53	Passed
2483.500000	---	50.96	54.00	3.04	Passed
2484.000000	---	49.87	54.00	4.13	Passed
2484.000000	72.05	---	74.00	1.95	Passed
Measurement uncertainty +/- 5.1 dB					

Upper band edge (operation mode 10):

Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
2483.500000	---	47.08	54.00	6.92	Passed
2483.500000	69.44	---	74.00	4.56	Passed
Measurement uncertainty +/- 5.1 dB					

Upper band edge (operation mode 11):

Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
2483.500000	69.87	---	74.00	4.13	Passed
2483.500000	---	51.75	54.00	2.25	Passed
2484.000000	69.79	---	74.00	4.21	Passed
2484.000000	---	50.96	54.00	3.04	Passed
Measurement uncertainty +/- 5.1 dB					

Test equipment (please refer to chapter 6 for details)
3 - 10

5.5 Maximum unwanted emissions

5.5.1 Test setup (Maximum unwanted emissions)

Test setup (Maximum unwanted emissions)			
Used	Setup	See sub-clause	Comment
☒	Test setup (radiated)	5.1.1	
☐	Test setup (antenna port conducted)	5.1.2	

5.5.2 Test method (Maximum unwanted emissions)

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

5.5.3 Test results (Maximum unwanted emissions)

5.5.3.1 Test results (9 kHz – 30 MHz)

Ambient temperature:	23 °C
Relative humidity:	34 %

Date	18.05.2021
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.

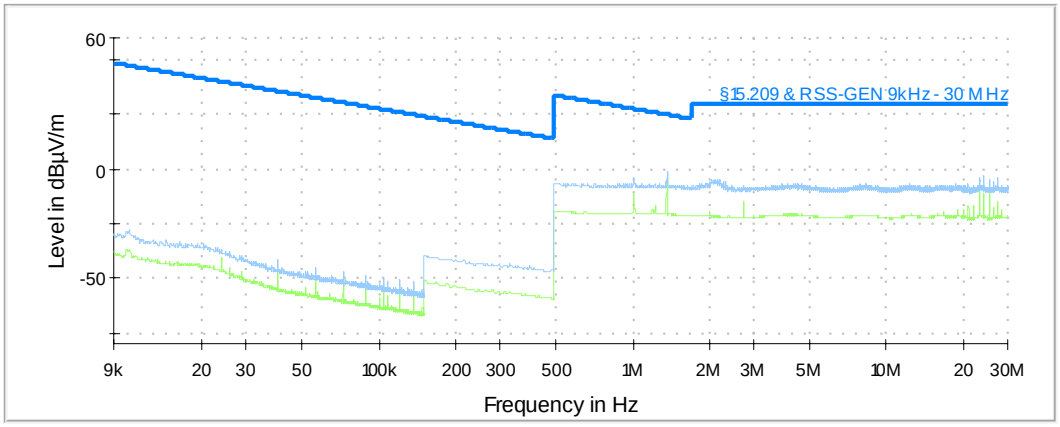
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

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

Remark: Result [dBµV/m] = Reading [dBµV] + Correction [dBµV/m]
Correction [dBµV/m] = AF [dB/m] + Cable attenuation [dB] + distance correction factor [dB]
Margin [dB] = Limit [dBµV/m] - Result [dBµV/m]
All 3 orthogonal planes were tested separately

5.5.3.1.1 Worst case plot:

Spurious emissions from 9 kHz to 30 MHz (operation mode 2 - standing):



5.5.3.1.2 Result tables

5.5.3.1.2.1 (All operation modes):

No final measurement done; no emission close than 20 dB to the limit.

Test equipment (please refer to chapter 6 for details)
3 - 9, 18

5.5.3.2 Test results (30 MHz – 1 GHz)

Ambient temperature:	23 °C
Relative humidity:	34 %

Date	18.05.2021
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.

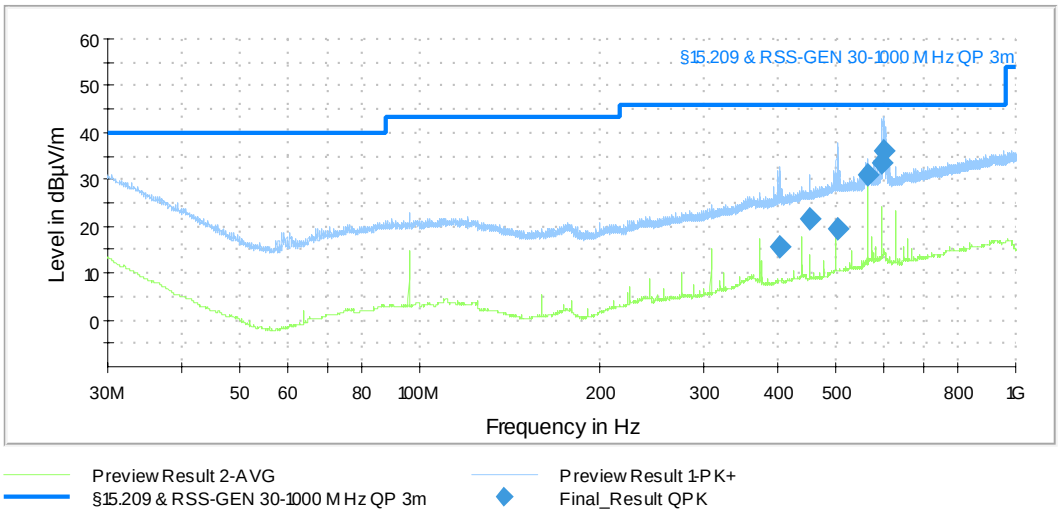
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

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

Remark: 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]
All 3 orthogonal planes were tested separately

5.5.3.2.1 Worst case plot:

Spurious emissions from 30 MHz to 1 GHz (operation mode 1 - lying):



5.5.3.2.2 Result tables

5.5.3.2.2.1 (operation mode 1):

Frequency [MHz]	Result QP [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
400.900000	15.6	46.02	30.4	-6.4	22.0	147	183	V	Passed
451.200000	21.5	46.02	24.5	-1.6	23.1	230	-4	H	Passed
501.390000	19.2	46.02	26.8	-5.3	24.6	180	13	H	Passed
564.000000	31.2	46.02	14.8	5.7	25.4	157	11	H	Passed
596.180000	33.6	46.02	12.4	7.7	26.0	132	-8	H	Passed
601.720000	36.2	46.02	9.8	10.1	26.1	140	16	H	Passed
Measurement uncertainty				±4.8 dB					

5.5.3.2.2.2 (operation mode 2):

Frequency [MHz]	Result QP [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
96.000000	20.2	43.52	23.3	3.1	17.1	240	309	H	Passed
160.000000	22.9	43.52	20.6	7.6	15.3	171	321	H	Passed
359.960000	15.5	46.02	30.5	-5.3	20.9	112	13	H	Passed
400.770000	15.6	46.02	30.4	-6.5	22.0	150	17	H	Passed
502.310000	19.1	46.02	26.9	-5.5	24.6	152	6	H	Passed
564.010000	27.5	46.02	18.5	2.1	25.4	137	188	H	Passed
Measurement uncertainty				±4.8 dB					

5.5.3.2.2.3 (operation mode 3):

Frequency [MHz]	Result QP [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
36.330000	16.0	40	24.0	-6.2	22.3	100	247	H	Passed
96.000000	20.3	43.52	23.2	3.1	17.1	185	104	H	Passed
160.000000	24.5	43.52	19.0	9.2	15.3	194	74	H	Passed
180.000000	22.0	43.52	21.5	5.5	16.5	128	292	H	Passed
400.950000	16.0	46.02	30.0	-6.0	22.0	125	253	V	Passed
502.130000	19.3	46.02	26.7	-5.3	24.6	115	259	V	Passed
564.010000	28.9	46.02	17.1	3.5	25.4	107	317	V	Passed
596.180000	25.2	46.02	20.8	-0.8	26.0	112	296	V	Passed
601.610000	28.7	46.02	17.3	2.6	26.1	100	245	V	Passed
628.000000	24.0	46.02	22.0	-2.4	26.4	142	331	V	Passed
Measurement uncertainty				±4.8 dB					

Test equipment (please refer to chapter 6 for details)
3 - 9, 16 - 17

5.5.3.3 Test results (above 1 GHz)

Ambient temperature:	24 °C
Relative humidity:	32 %

Date	19.05.2021
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.

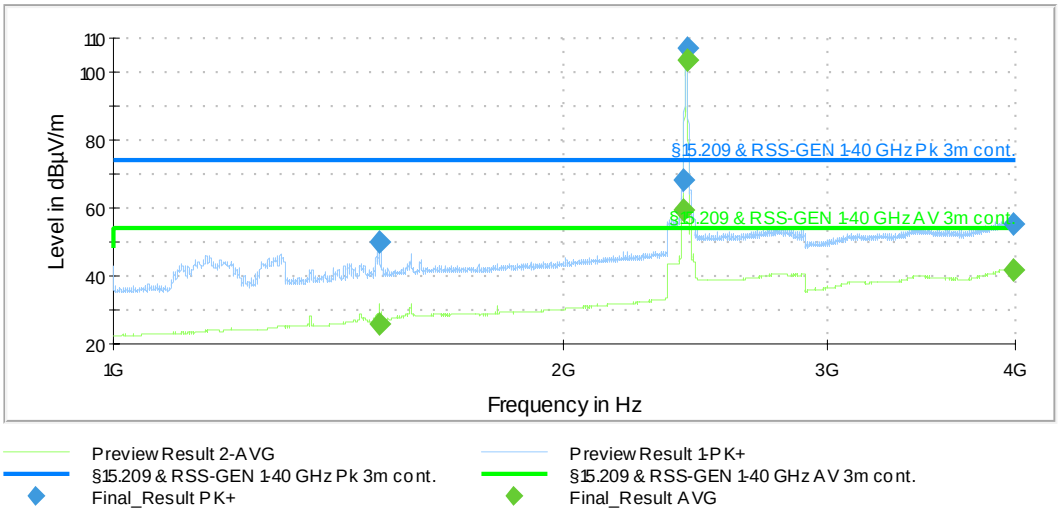
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

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

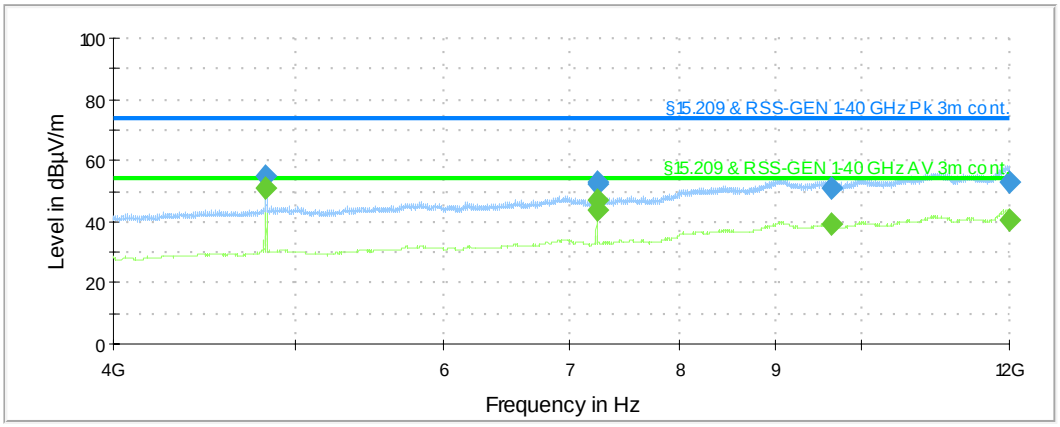
Remark: Max Peak [dBµV/m] = Reading [dBµV] + Correction [dBµV/m]
Average [dBµV/m] = Reading [dBµV] + Correction [dBµV/m]
Correction [dBµV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]+DCCF [dB] (if applicable)
Margin [dB] = Limit [dBµV/m] – Max Peak // Average [dBµV/m]

5.5.3.3.1 Worst case plot:

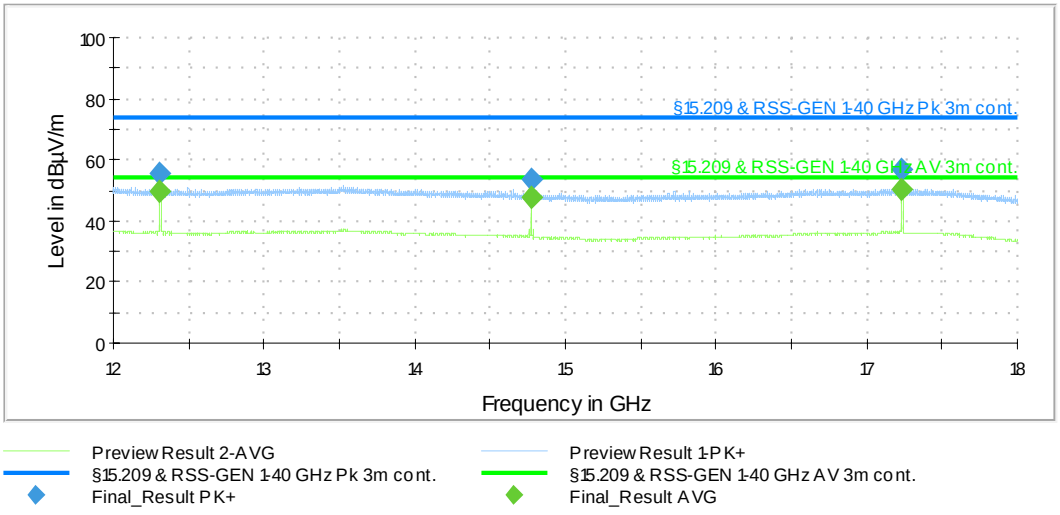
Spurious emissions from 1 GHz to 4 GHz (operation mode 1):



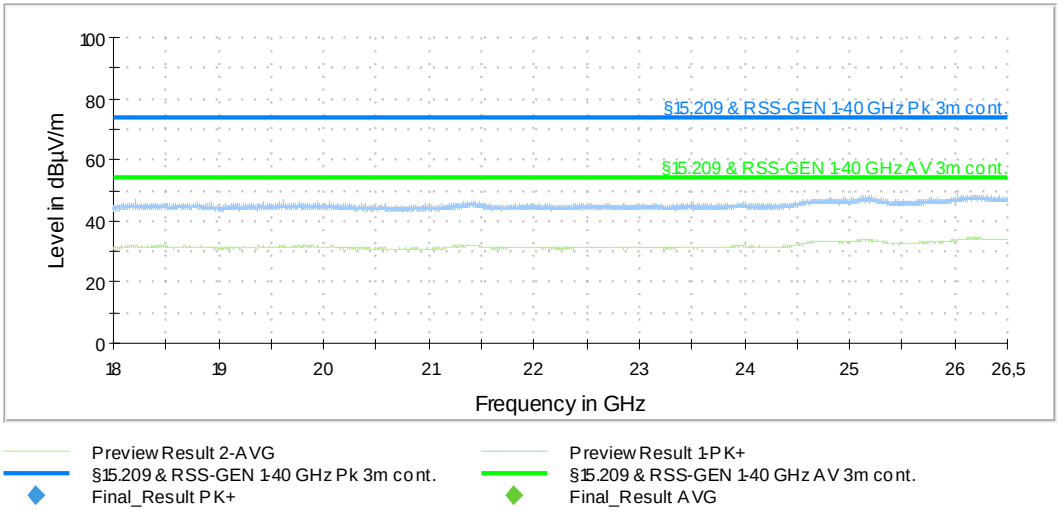
Spurious emissions from 4 GHz to 12 GHz (operation mode 1):



Spurious emissions from 12 GHz to 18 GHz (operation mode 3):



Spurious emissions from 18 GHz to 26.5 GHz (all operation modes):



5.5.3.3.2 Result tables

5.5.3.3.2.1 (operation mode 1):

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Reading [dBµV]	Corr. [dB/m]	Elevation [deg]	Azimuth [deg]	Pol	Comment
1504.000	---	25.7	54	28.3	-4	29.6	60	174	H	Passed
1504.000	49.8	---	74	24.2	20.2	29.6	60	174	H	Passed
2400.000	68.2	---	87.2*	19.0	32.9	35.3	0	54	V	Passed
2400.000	---	59.6	83.8*	24.2	24.4	35.3	0	54	V	Passed
2413.000	---	103.8	---	---	68.5	35.3	0	65	V	Fund.
2413.000	107.2	---	---	---	71.9	35.3	0	65	V	Fund.
3991.250	55.5	---	74	18.5	14.4	41	60	16	H	Passed
3991.250	---	41.5	54	12.5	0.5	41.0	60	16	H	Passed
4824.050	54.6	---	74	19.4	44.8	9.8	0	39	V	Passed
4824.050	---	51.3	54	2.7	41.5	9.8	0	39	V	Passed
7235.250	52.7	---	74	21.3	38.8	13.9	0	46	V	Passed
7235.250	---	47.0	54	7.0	33.1	13.9	0	46	V	Passed
7236.300	52.1	---	74	21.9	38.1	13.9	0	50	V	Passed
7236.300	---	43.8	54	10.2	29.9	13.9	0	50	V	Passed
9647.700	---	39.1	54	14.9	20.5	18.60	60	48	V	Passed
9647.700	51.1	---	74	22.9	32.4	18.6	60	48	V	Passed
11990.900	---	40.4	54	13.6	17.1	23.30	0	147	V	Passed
11990.900	53.2	---	74	20.8	29.8	23.3	0	147	V	Passed
12059.250	48.0	---	74	26.0	37.3	10.6	0	139	H	Passed
12059.250	---	35.8	54	18.2	25.2	10.6	0	139	H	Passed
14471.600	46.4	---	74	27.6	35.8	10.6	0	190	H	Passed
14471.600	---	34.8	54	19.2	24.2	10.6	0	190	H	Passed
16885.650	---	35.3	54	18.7	25.5	9.70	0	27	H	Passed
16885.650	48.2	---	74	25.8	38.5	9.7	0	27	H	Passed
Measurement uncertainty				+/- 5.9 dB						

* Emission in unrestricted band

5.5.3.3.2.2 (operation mode 2):

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Reading [dBµV]	Corr. [dB/m]	Elevation [deg]	Azimuth [deg]	Pol	Comment
1504.000	---	25.8	54	28.2	-3.9	29.6	30	98	H	Passed
1504.000	50.0	---	74	24.0	20.4	29.6	30	98	H	Passed
2437.750	107.2	---	---	---	71.9	35.4	0	53	V	Fund.
2437.750	---	104.5	---	---	69.1	35.4	0	53	V	Fund.
2483.500	52.1	---	74	21.9	16.7	35.4	0	88	V	Passed
2483.500	---	37.6	54	16.4	2.2	35.4	0	88	V	Passed
3989.000	---	41.5	54	12.5	0.4	41.0	120	171	V	Passed
3989.000	55.8	---	74	18.2	14.7	41	120	171	V	Passed
4874.000	50.9	---	74	23.1	41	9.9	30	47	V	Passed
4874.000	---	47.0	54	7.0	37.2	9.9	30	47	V	Passed
7310.300	---	44.6	54	9.4	30.2	14.5	0	56	V	Passed
7310.300	51.5	---	74	22.5	37	14.5	0	56	V	Passed
9748.100	50.7	---	74	23.3	32.3	18.5	120	316	H	Passed
9748.100	---	39.1	54	14.9	20.6	18.5	120	316	H	Passed
11962.150	---	40.5	54	13.5	17.3	23.3	150	260	V	Passed
11962.150	52.7	---	74	21.3	29.5	23.3	150	260	V	Passed
12184.450	54.8	---	74	19.2	44.3	10.5	30	22	H	Passed
12184.450	---	47.6	54	6.4	37.1	10.5	30	22	H	Passed
14622.350	47.6	---	74	26.4	37.1	10.5	0	63	V	Passed
14622.350	---	36.3	54	17.7	25.8	10.5	0	63	V	Passed
17060.450	---	39.0	54	15.0	29.4	9.7	30	64	H	Passed
17060.450	49.2	---	74	24.8	39.6	9.7	30	64	H	Passed
Measurement uncertainty				+/- 5.9 dB						

5.5.3.3.2.3 (operation mode 3):

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Reading [dBµV]	Corr. [dB/m]	Elevation [deg]	Azimuth [deg]	Pol	Comment
1504.100	49.6	---	74	24.4	20	29.6	30	114	H	Passed
1504.100	---	26.2	54	27.8	-3.5	29.6	30	114	H	Passed
2399.400	---	31.9	54	22.1	-3.3	35.2	0	64	V	Passed
2399.400	47.4	---	74	26.6	12.2	35.2	0	64	V	Passed
3994.250	55.5	---	74	18.5	14.5	41	120	296	H	Passed
3994.250	---	41.5	54	12.5	0.4	41.0	120	296	H	Passed
4924.150	52.4	---	74	21.6	42.2	10.1	0	45	V	Passed
4924.150	---	40.0	54	14.0	29.9	10.1	0	45	V	Passed
7385.500	50.3	---	74	23.7	35.6	14.7	0	47	V	Passed
7385.500	---	41.7	54	12.3	27	14.7	0	47	V	Passed
9847.900	50.1	---	74	23.9	30.9	19.1	30	67	H	Passed
9847.900	---	38.9	54	15.1	19.7	19.1	30	67	H	Passed
11960.750	53.5	---	74	20.5	30.2	23.3	60	121	H	Passed
11960.750	---	40.5	54	13.5	17.2	23.3	60	121	H	Passed
12309.350	55.7	---	74	18.3	45.1	10.5	30	21	H	Passed
12309.350	---	49.6	54	4.4	39.1	10.5	30	21	H	Passed
14772.100	53.3	---	74	20.7	42.8	10.5	0	100	V	Passed
14772.100	---	47.9	54	6.1	37.4	10.5	0	100	V	Passed
17235.350	---	50.3	54	3.7	40.6	9.7	30	38	H	Passed
17235.350	56.9	---	74	17.1	47.2	9.7	30	38	H	Passed
Measurement uncertainty				+/- 5.9 dB						

Test equipment (please refer to chapter 6 for details)
3 - 10, 14 - 18

5.6 Conducted emissions on power supply lines

5.6.1 Test setup (Conducted emissions on power supply lines)

Test setup (Conducted emissions on power supply lines)			
Used	Setup	See sub-clause	Comment
☒	Test setup (AC power line conducted)	5.1.3	
☐	Not applicable, because …	-	

5.6.2 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	5.1.3.1	Provided AC switching power adaptor
☐	6.2.3.3	Floor-standing equipment testing		

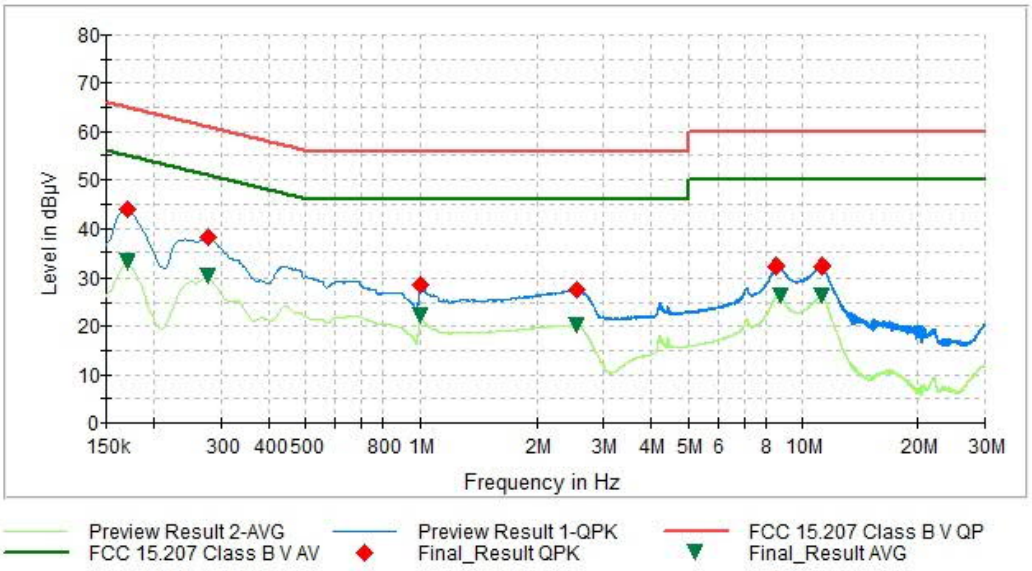
The AC power adaptor provided by the applicant was used for the tests:
GlobTek, Inc. P/N WR9QA3000USBCIMKTR6B, Model: GTM96180-1507-2.0
The power adaptor itself was supplied by 120V_{AC} 60Hz.

5.6.3 Test results (Conducted emissions on power supply lines)

Ambient temperature:	22 °C
Relative humidity:	33 %

Date:	26.05.2021
Tested by:	M. Dinter

Plot (operation mode 1):



Frequency in MHz	QuasiPeak in dB(µV)	Average in dB(µV)	Limit in dB(µV)	Margin in dB	Meas. Time in ms	Bandwidth in kHz	Line	PE	Corr. in dB
0.170250	---	32.89	54.95	22.06	15000.0	9.000	L1	FLO	9.8
0.170250	43.92	---	64.95	21.03	15000.0	9.000	L1	FLO	9.8
0.278250	---	30.21	50.87	20.66	15000.0	9.000	L1	FLO	9.8
0.278250	38.04	---	60.87	22.83	15000.0	9.000	L1	FLO	9.8
1.000500	---	21.96	46.00	24.04	15000.0	9.000	N	FLO	9.8
1.000500	28.48	---	56.00	27.52	15000.0	9.000	N	FLO	9.8
2.548500	27.42	---	56.00	28.58	15000.0	9.000	N	FLO	10.2
2.559750	---	19.99	46.00	26.01	15000.0	9.000	N	FLO	10.2
8.495250	32.40	---	60.00	27.60	15000.0	9.000	N	FLO	10.5
8.720250	---	26.12	50.00	23.88	15000.0	9.000	N	FLO	10.5
11.170500	32.48	---	60.00	27.52	15000.0	9.000	N	FLO	10.6
11.195250	---	26.20	50.00	23.80	15000.0	9.000	N	FLO	10.6
Measurement uncertainty					+/- 2.8 dB				

Test result: Passed

Test equipment (please refer to chapter 6 for details)
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6 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	30.03.2021	03.2023
2	Attenuator	WA54-10-12	Weinschel	-	481618	Calibration not necessary	
3	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
4	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
5	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
6	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
7	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
8	Measuring software EMC32 M276	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
9	EMI Test receiver	ESW44	Rohde & Schwarz	101828	482979	14.11.2019	11.2021
10	Low Noise Amplifier 100 MHz - 18 GHz	LNA-30-00101800-25-10P	Narda-Miteq	2110917	482967	18.02.2020	02.2022
11	Log.-Per. antenna	HL050	Rohde & Schwarz	100908	482977	13.08.2019	08.2022
12	Low Noise Amplifier 12 GHz - 18 GHz	LNA-30-12001800-13-10P	Narda-Miteq	2089798	482968	Calibration not necessary	
13	Standard Gain Horn 20 dB, 12 GHz-18 GHz	18240-20	Flann	267220	483025	Calibration not necessary	
14	Low Noise Amplifier 18 GHz - 26.5 GHz	LNA-30-18002650-20-10P	Narda-Miteq	2110911	482969	17.02.2020	02.2022
15	Standard Gain Horn 20 dB, 18 GHz -26 GHz	20240-20	Flann	266399	483026	Calibration not necessary	
16	Attenuator 6 dB	WA2-6	Weinschel		482793	Calibration not necessary	
17	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	18.03.2021	03.2024
18	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	25.02.2021	02.2022
19	LISN NSLK8128RC	NSLK8128RC	Rohde & Schwarz	0412	483186	Calibration not necessary	
20	Shielded chamber M155	SK3	Albatross Projects	-	482786	Calibration not necessary	
21	Measuring software EMC32	EMC32	Rohde & Schwarz	100619	483182	Calibration not necessary	
22	EMI Test receiver	ESR7	Rohde & Schwarz	101939	482558	18.02.2020	02.2022

7 Test site Validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA/RSM	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	03.03.2021	02.03.2023
Semi anechoic chamber M276	483227	1 -18 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	25.02.2021	24.02.2023
Shielded chamber M155	482784	9 kHz – 30 MHz	GND-Plane	ANSI C63.4-2014	25.09.2020	24.09.2022

8 Report History

Report Number	Date	Comment
F210365E5	30.03.2022	Initial Test Report
-	-	-
-	-	-

9 List of Annexes

Annex A	Test Setup Photos	10 pages
Annex B	External Photos	5 pages
Annex C	Internal Photos	5 pages