PHOENIX TESTLAB

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Test Report

Report Number:

F221817E1

Equipment under Test (EUT):

CTP3NA

Applicant:

Robert Bosch GmbH

Manufacturer:

Robert Bosch 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 Amendment 2 (2021-02)** General Requirements for Compliance of Radio Apparatus

[6] **662911 D01 Multiple Transmitter Output v02r01 (October 2013),** Emissions Testing of Transmitters with Multiple Outputs in the Same Band

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 1.3 of ANSI C63.10 (2013). However, the measurement uncertainty is calculated and shown in this test report.

Tested by:		Martin Eppinger 04.03.2024
	Signature	
Tested and written by:		Paul NEUFELD 04.03.2024
	Signature	
Reviewed and approved by:		Bernd STEINER 05.03.2024
	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:	Robert Bosch GmbH
Address:	Robert-Bosch-Str. 200, 31139 Hildesheim
Country:	Germany
Name for contact purposes:	Karin Silberhorn
Phone:	+49 5121-49-7662
eMail address:	karin.silberhorn@de.bosch.com
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	Robert Bosch GmbH
Address:	Robert-Bosch-Str. 200, 31139 Hildesheim
Country:	Germany
Name for contact purposes:	Karin Silberhorn
Phone:	+49 5121-49-7662
eMail address:	karin.silberhorn@de.bosch.com
Manufacturer represented during the test by the following person:	-

1.3 Factory

Name:	Bosch Car Multimedia Portugal, S.A.
Address:	Rua Max Grundig, 35-Lomar, 4705-820 Braga
Country:	Portugal
Name for contact purposes:	-
Phone:	-
eMail address:	-
Manufacturer represented during the test by the following person:	-

1.4 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-17186-01-06 and D-PL-17186-01-05, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.5 EUT (Equipment under Test)

EUT	
Test object: *	Telematic Control Unit
Model name: *	CTP3NA
Model number: *	CTP3NA Ext
Order number: *	-
FCC ID: *	2AUXS-CTP3NA
IC certification number: *	25847-CTP3NA
PMN: *	CTP3NA
HVIN: *	CTP3NA
FVIN: *	NA
HMN: *	Common Telematic Platform

	EUT number		
	1	2	3
Serial number: *	1150003409	-	-
PCB identifier: *	8157-01	-	-
Hardware version: *	C2	-	-
Software version: *	DAIMLER_CTP3_HIGHPOINT_RC2_S.006	-	-

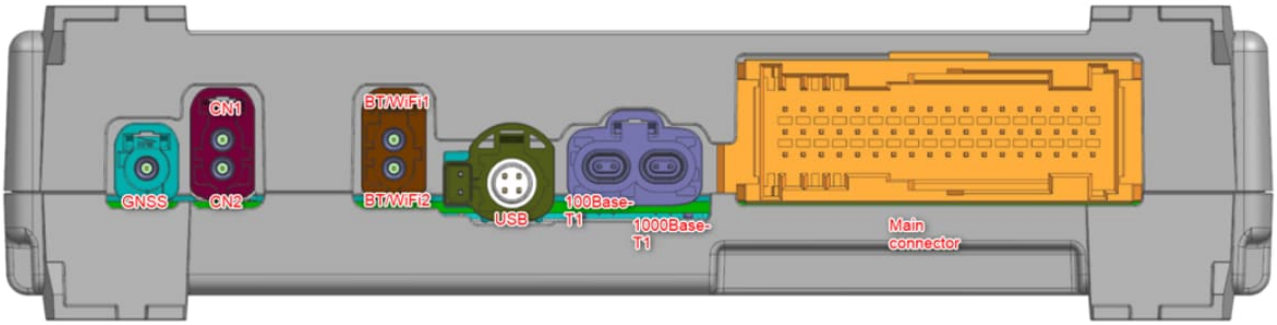
* Declared by the applicant

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.

1.6 Technical Data of Equipment

General EUT data			
Power supply EUT: *	DC		
Supply voltage EUT: *	U_{Nom}= 12 V_{DC} + 24 V_{DC}	U_{Min}= 8.0 V_{DC}	U_{Max}= 32.0 V_{DC}
Temperature range: *	-40°C to +85°C		
Lowest / highest internal radio frequency: *	LTE Band 12: **738MHz** / WiFi 5GHz: **5825 MHz**		
Lowest / highest internal clock frequency: *	**32.768 kHz** (Real time clock oscillator) / **125MHz**		



Ports / Connectors				
Identification	Connector		Length during test	Shielding (Yes / No)
	EUT	Ancillary		
Main Connector	54 Pin Connector	Customized	Appr. 3 m	No
GNSS	Fakra HFM single coding C	Fakra (Antenna)	Not connected	Yes
CN1 / CN2	Fakra HFM double coding D	2 x Fakra (Antenna)	Not connected	Yes
BT/WiFi1 / BT/WiFi2	Fakra HFM double coding F	2 x Fakra (Antenna)	Appr. 2 m	Yes
USB	HSD+2 coding C	USB	Appr. 2 m	Yes
100 base T1 / 1000 Base T1	H-MTD	Customized	Not connected	Yes

IEEE 802.11 frequencies (2.4 GHz)			
20 MHz		40 MHz	
Channel 1	2412 MHz	-	-
Channel 2	2417 MHz	-	-
Channel 3	2422 MHz	Channel 3	2422 MHz
Channel 4	2427 MHz	Channel 4	2427 MHz
Channel 5	2432 MHz	Channel 5	2432 MHz
Channel 6	2437 MHz	Channel 6	2437 MHz
Channel 7	2442 MHz	Channel 7	2442 MHz
Channel 8	2447 MHz	Channel 8	2447 MHz
Channel 9	2452 MHz	Channel 9	2452 MHz
Channel 10	2457 MHz	-	-
Channel 11	2462 MHz	-	-

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

IEEE 802.11 radio mode (2.4 GHz)		
Fulfils radio specification: *	IEEE 802.11 b IEEE 802.11 g IEEE 802.11 n (20 MHz) IEEE 802.11 n (40 MHz) IEEE 802.11 ax (20 MHz) IEEE 802.11 ax (40 MHz)	
Radio module: *	LGIT ATC6NPL002	
FCC ID (radio module):	YZP-ATC6NPL002	
IC ID (radio module):	7414C-ATC6NPL002	
Type of modulation: *	IEEE 802.11 b	BPSK, 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 1 spatial stream) (up to 144.4 Mbit/s 2 spatial stream) (up to 72.2 Mbit/s 1 spatial stream) (up to 144.4 Mbit/s 2 spatial stream)
	IEEE 802.11 n40	BPSK, QPSK, 16-QAM, 64-QAM (up to 150 Mbit/s 1 spatial stream) (up to 300 Mbit/s 2 spatial stream)
	IEEE 802.11 ax20	BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024-QAM (up to 143.4 Mbit/s 1 spatial stream) (up to 286.8 Mbit/s 2 spatial stream)
	IEEE 802.11 ax40	BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024-QAM (up to 286.8 Mbit/s 1 spatial stream) (up to 573.5 Mbit/s 2 spatial stream)
Operating frequency range: *	IEEE 802.11b	2412 – 2462 MHz
	IEEE 802.11g	2412 – 2462 MHz
	IEEE 802.11n 20 MHz	2412 – 2462 MHz
	IEEE 802.11n 40 MHz	2422 – 2452 MHz
	IEEE 802.11ax 20 MHz	2412 – 2462 MHz
	IEEE 802.11ax 40 MHz	2422 – 2452 MHz

* Declared by the applicant

Bluetooth® low energy radio mode		
Fulfils radio specification: *	Bluetooth® Low Energy (BLE) 5.2	
Radio module: *	LGIT ATC6NPL002	
FCC ID (radio module):	YZP-ATC6NPL002	
IC ID (radio module):	7414C-ATC6NPL002	
Type of modulation: *	BLE (1 Mbps PHY)	GFSK
	BLE (2 Mbps PHY)	GFSK
	BLE (0.5 Mbps PHY)	GFSK
	BLE (0.125 Mbps PHY)	GFSK
Operating frequency range: *	BLE (1 Mbps PHY)	2402 – 2480 MHz
	BLE (2 Mbps PHY)	2402 – 2480 MHz
	BLE (0.5 Mbps PHY)	2402 – 2480 MHz
	BLE (0.125 Mbps PHY)	2402 – 2480 MHz
Number of channels: *	BLE (1 Mbps PHY)	40 (2 MHz channel spacing)
	BLE (2 Mbps PHY)	40 (2 MHz channel spacing)
	BLE (0.5 Mbps PHY)	40 (2 MHz channel spacing)
	BLE (0.125 Mbps PHY)	40 (2 MHz channel spacing)

* Declared by the applicant

Antenna list			
Antenna type	Antenna name	Antenna gain	Antenna connector
Antenna Box	A 006 820 30 75	2.6 dBi (-0.8 dB/m min. cable length of 1 m)*2 = 1.8 dBi	Fakra male, Code I (Beige)
Roof Top Antenna	A 006 820 39 75	6.2 dBi (-0.8 dB/m min. cable length of 1 m)*2 = 5.4 dBi	Fakra male, Code I (Beige)
BT WLAN Antenna	A 006 820 32 75*	1.0 dBi (-0.8 dB/m min. cable length of 0.4 m)*2 = 0.68 dBi	Fakra male, Code K (Curry)
BT WLAN Antenna	A 006 820 82 75	1.0 dBi (-0.8 dB/m min. cable length of 0.4 m)*2 = 0.68 dBi	Fakra male, Code K (Curry)
Worst case combined antenna gain (gain antennas A 006 820 39 75 + A 006 820 32 75) = **6.4 dBi***3			

* The radiated tests were performed using the A 006 820 32 75 antenna on both antenna ports, because it represented the worst case according to the documentation available at the time of testing. Bluetooth Low Energy only uses antenna port BT/Wifi 2.
*2 The minimum cable length and the associated cable attenuation were declared by the applicant.
*3 The theoretical worst case combined antenna gain will be used for all antenna port conducted measurements.

Ancillary Equipment / Equipment used for testing

Equipment used for testing	
Laboratory power supply *[1]	Toellner TOE 8752 (PM. NO. 480009)
Test Laptop*[1]	Fujitsu Lifebook S760 (PM. No: 200759)

*[1] Provided by the laboratory

Ancillary Equipment	
Golden Sample*	CTP3NA S/N:1240003339

* Golden Sample is used to activate the 802.11axRU modes

1.7 Dates

Date of receipt of test sample:	30.03.2023
Start of test:	30.03.2023
End of test:	12.07.2023

2 Operational States

2.1 Description of function of the EUT

The Daimler Common Telematics Platform 3rd Generation (CTP3) is a telematic Unit to provide fleet management services & remote diagnostics, allows for remote measurement and also serves as AP-Server for Internet via WLAN.

During all test the EUT was supplied with 24.0 V DC via a laboratory power supply. During the tests, a USB connection was established to the EUT via USB-2-optic converter. All relevant HF parameters could be set with a Laptop.

For the radio tests the following settings were used:

A connection to the EUT was established via a USB connection to a Laptop computer. Test Software called “DUT Labtool” version 2.0.0.8.5 was used to set the test-modes on the EUT. Test software and Laptop computer were provided by the applicant.

For the tests of 802.11 ax Resource Unit modes a golden sample was used as companion device. The desired Resource Mode was set on the golden sample and the generated signal was transmitted to the EUT via housing emission by an antenna connected to the golden sample while the antenna ports of the EUT were connected to the measuring unit or external antenna respectively.

2.2 Operation modes (802.11 - full retest MiMo)*

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate*[2]	Power setting
1	802.11b	2412	1	QPSK	2 Mbps	12
2	802.11b	2437	6	QPSK	2 Mbps	16
3	802.11b	2462	11	QPSK	2 Mbps	15
4	802.11g	2412	1	64-QAM	54 Mbps	8
5	802.11g	2437	6	64-QAM	54 Mbps	12
6	802.11g	2462	11	64-QAM	54 Mbps	8

* The original test report does not contain MiMo results for 802.11b and 802.11g transmitting simultaneously on both antenna ports. Therefore, these tests were tested completely in this test report.
*[2] Pre-tests have shown that these data rates produced in the worst-case results.

2.3 Operation modes (802.11 – worst cases from original report)

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate*	Power setting
7	802.11n20	2412	1	BPSK	MSC0	8
8	802.11n20	2437	6	BPSK	MSC0	12
9	802.11n20	2462	11	BPSK	MSC0	7
10	802.11ax20 (RU26 High)	2412	1	BPSK	MSC0	8
11	802.11ax20 (RU26 High)	2437	6	BPSK	MSC0	12
12	802.11ax20 (RU26 High)	2462	11	BPSK	MSC0	7
13	802.11b	2412	1	BPSK	1 Mbps	12
14	802.11n40	2422	3	BPSK	MSC0	8
15	802.11ax40 (RU484_65)	2452	9	BPSK	MSC0	5

* These were identified as the worst-case data rates in the original test report OT-223-RWD-043 by LG Innotek Co., Ltd.

2.4 Operation modes (BLE – worst cases from original report)

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate*	Power setting
16	Bluetooth LE	2402	0	GFSK	0.5 Mbps	5
17	Bluetooth LE	2440	19	GFSK	0.5 Mbps	5
18	Bluetooth LE	2480	39	GFSK	0.5 Mbps	5
19	Bluetooth LE	2402	0	GFSK	2 Mbps	5
20	Bluetooth LE	2480	399	GFSK	2 Mbps	5

* These were identified as the worst-case data rates in the original test report OT-223-RWD-043 by LG Innotek Co., Ltd.

3 Additional Information

The EUT was not labeled as required by FCC / IC.
All radiated tests were performed using an unmodified EUT.

This test report contains the results of the WLAN 2.4 mode and Bluetooth low energy mode only

4 Overview

Application	Frequency range in 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]	1	Passed*3
Maximum average conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [4]	1	Passed*3
DTS Bandwidth / 99% Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [4]	1	Passed*4
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [4]	1	Passed*4
Average Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [4]	1	Passed*4
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [4]	1, 2	Passed*3
Maximum unwanted emissions	0.009 – 26,500*	15.247 (d) 15.205 (a) 15.209 (a)	8.9 [5]	1, 2	Passed**3
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]	-	n/a*2

*: As declared by the applicant the highest radio clock frequency is 2.462 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. As declared by the applicant the highest emission of the non-radio part is 5.825 GHz, therefore the emissions for the 15B part are carried out up to 40 GHz.

*2 As declared by the applicant, the EUT is to be used in vehicular environment and will not be connected to the AC mains network, therefore the EUT is exempted from this test.

*3 Only 802.11b+g modes were tested fully. For all other WLAN modes and for Bluetooth Low Energy only the worst cases from reports OT-223-RWD-043 and OT-223-RWD-043 by LG Innotek Co., Ltd. were tested.

*4 Only 802.11b+g modes were tested.

5 Results

5.1 Test setups

5.1.1 Test setup (radiated)

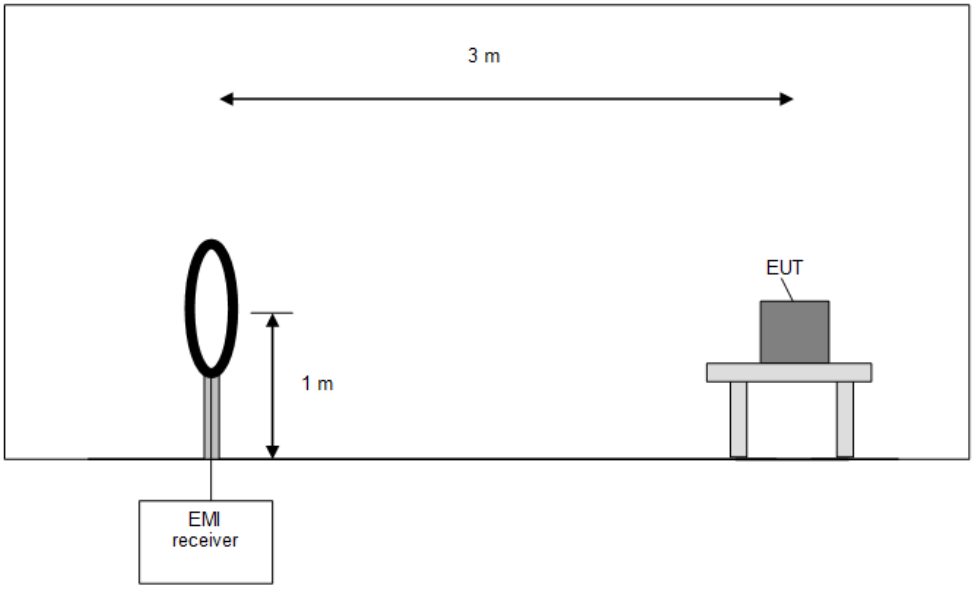
5.1.1.1 Preliminary measurement 9 kHz to 30 MHz

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.

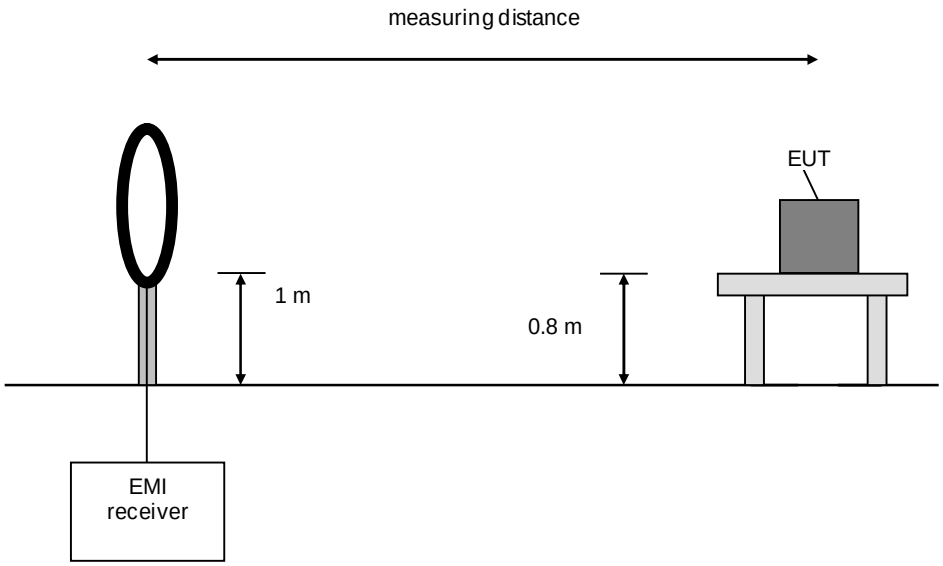
5.1.1.2 Final measurement 9 kHz to 30 MHz

In the second stage a final measurement is performed on an open area test site with no conducting ground plane in a 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.

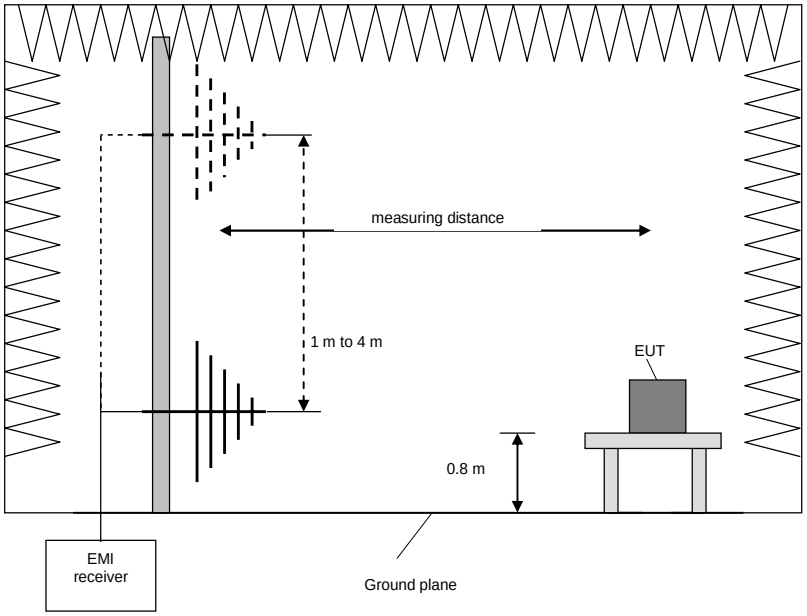
5.1.1.3 Preliminary and final measurement 30 MHz to 1 GHz

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 (Normal procedure 6.6.4 in [1])

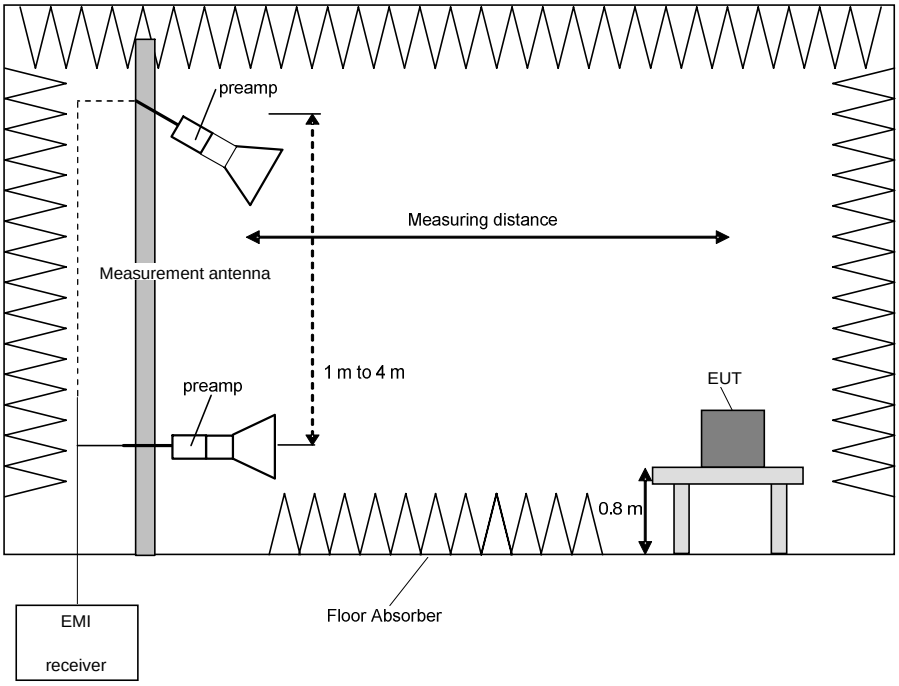
This measurement will be performed in a fully anechoic chamber or in a semi-anechoic chamber with ground absorbers between antenna and EUT. Tabletop and portable devices will set up on a non-conducting turn device on the height of 1.5m. Floor standing devices will be placed directly on the turntable. 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 with antenna-height-steps of 50 cm starting from 1 m up to 4m . When the EUT is manipulated through three different orientations, the scan height upper range for the measurement antenna is limited to 2.5 m or 0.5 m above the top of the EUT, whichever is higher. At the different height positions, the EUT is always directed at the EUT.

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:

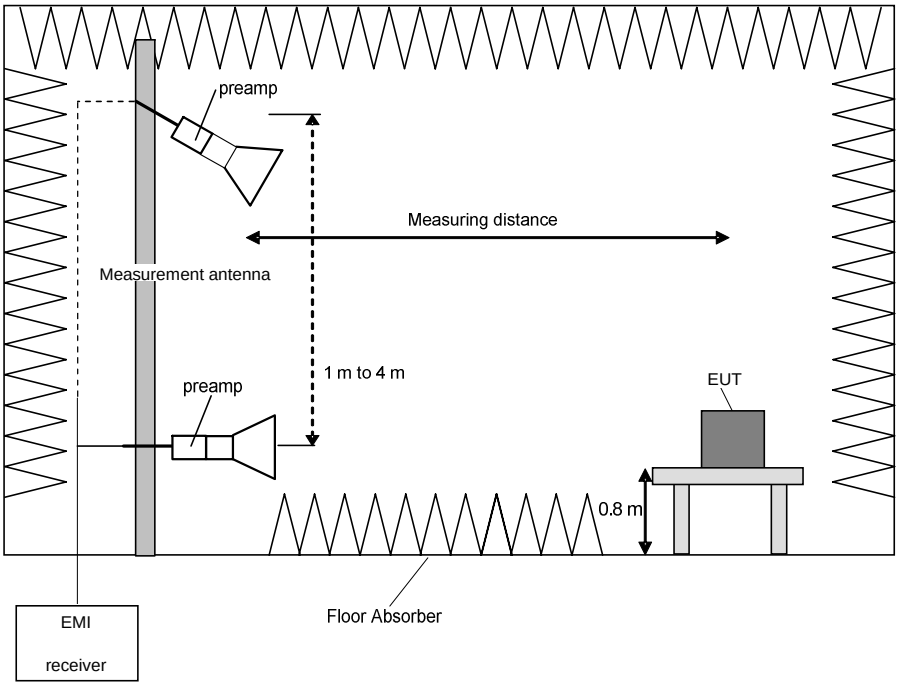
1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarisation and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat steps 1. and 2. with the horizontal polarisation of the measuring antenna.
5. Increase the height of the antenna for 0.5 m and repeat steps 2 – 4 until the final height of 4 m is reached. (If the EUT is tested in 3 orientations, the maximum height is 2.5 m or or 0.5 m above the top of the EUT, whichever is higher.)
6. The highest values for each frequency will be saved by the software, including the antenna height, measurement antenna polarization and turntable azimuth for the for each frequency step.

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 is used:

1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced RBW with +/- 10 times the RBW 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 measurement antenna height is found by the measurement software by varying the measurement antenna height by +/- 0.5 m from the worst-case value obtained in the preliminary measurement, and to monitor the emission level.
5. The worst azimuth turntable position is found by varying the turntable azimuth by +/- 30° from the worst-case value obtained in the preliminary measurement, and to monitor the emission level.
6. The final measurement is performed at the worst-case antenna height and the worst case turntable azimuth.
7. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.

5.1.1.5 Preliminary and final measurement > 1 GHz (Alternative procedure 6.6.5 in [1])

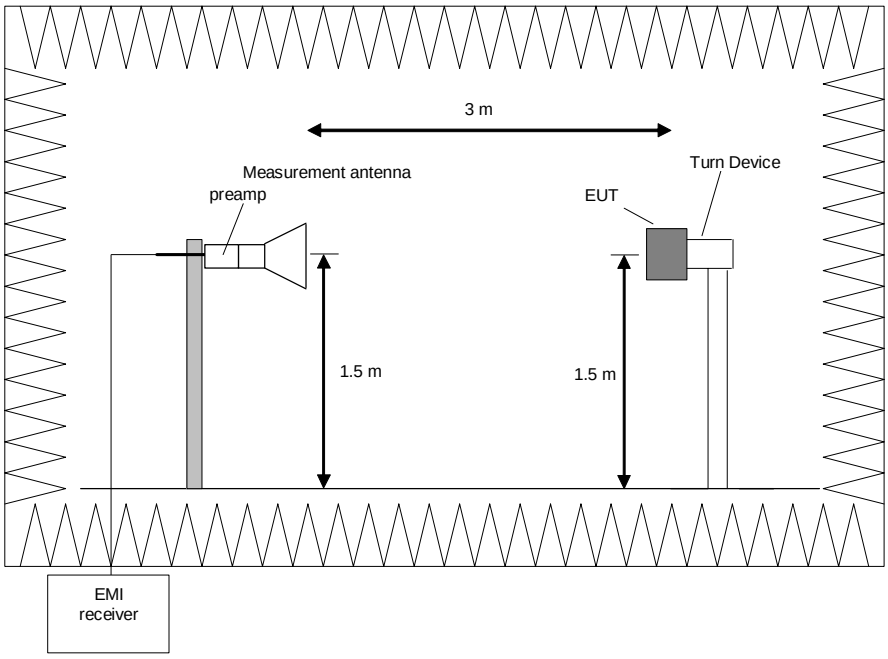
This measurement will be performed in a fully anechoic chamber or in a semi-anechoic chamber with ground absorbers between antenna and EUT. Tabletop and portable devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1]. Devices with any dimension larger than the beamwidth of the measurement antenna are not suitable for testing with this method; such devices shall be evaluated as tabletop equipment (see procedure 5.1.1.4 above).

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:

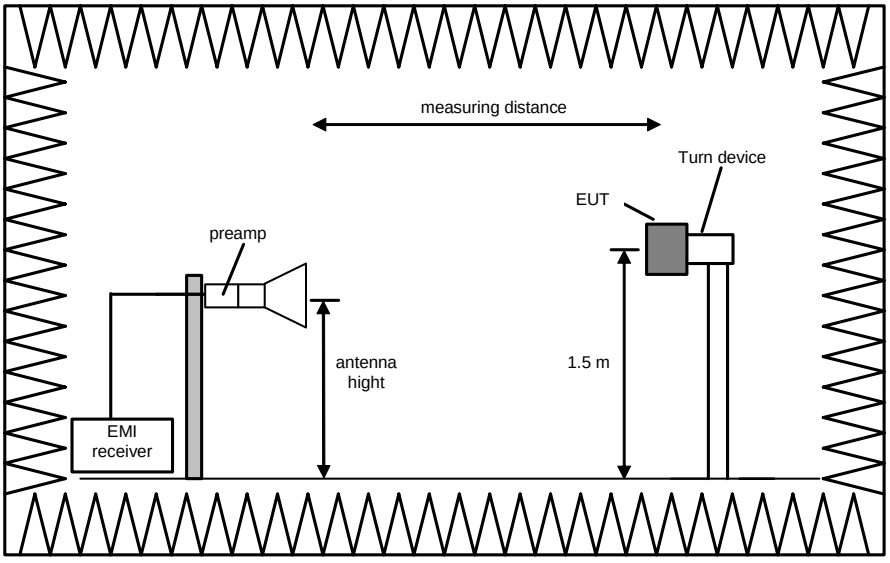
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an 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:

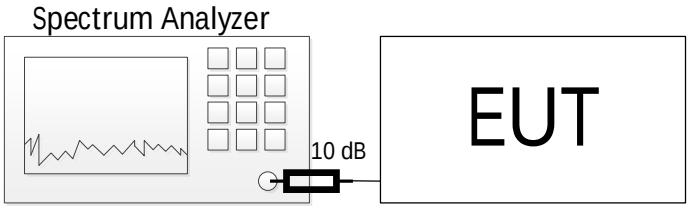
The measurements were performed in the frequency ranges 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 25 /26.5 GHz and 26.5 GHz to 40 GHz.
The following procedure will be used:

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*1	As provided by the applicant
☒	Normal antenna connector*2	

*1 for the internal antenna, a temporary antenna connector was used for the conducted tests
*2 for the external antenna, the normal antenna connector was used for the conducted tests



The 10 dB external attenuation is considered in all relevant plots

5.2 Duty Cycle

5.2.1 Test setup (Duty cycle)

Test setup			
Used	Setup	See sub-clause	Comment
☐	Test setup (radiated – normal procedure)	5.1.1.4	-
☐	Test setup (radiated – alternative procedure)	5.1.1.5	-
☒	Test setup (antenna port conducted)	5.1.2	-

5.2.2 Test method (Duty cycle)

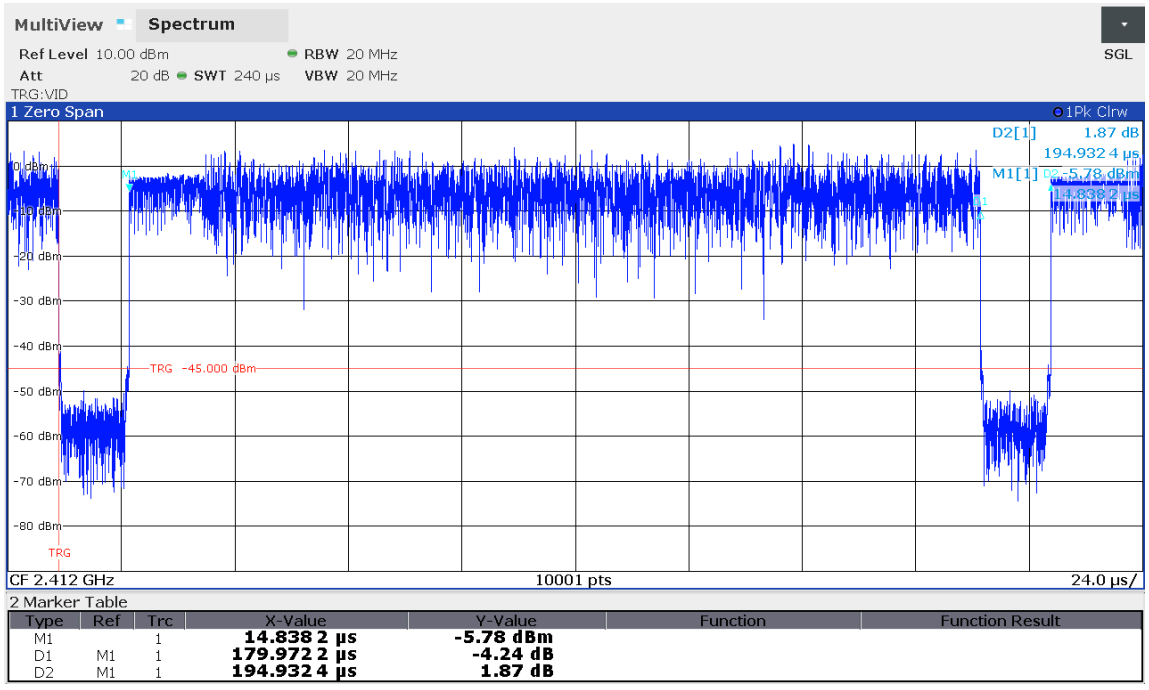
Test method (Duty cycle)				
Used	Sub-Clause [6]	Name of method	Applicability	Comment
☐	II B. 2. a)	Diode detector	No limitation	-
☒	II B. 2. b)	Zero span (analyzer or EMI receiver)	No limitation	-

5.2.3 Test results (Duty cycle)

Ambient temperature:	22 °C
Relative humidity:	63 %

Date	28.09.2023
Tested by	P. NEUFELD

Measurement plot (802.11 g – 54Mbps):



Only the duty cycle for 802.11b,g were tested, because these tests were repeated completely with MiMo activated. For all other tests, the duty cycle correction factors from the original reports OT-223-RWD-043 by LG Innotek Co., Ltd. were used.

Radio technology	TX_{On} [µs]	TX_{Cycle} [µs]	RBW [MHz]	50/T [kHz]	50/T < RBW?
IEEE 802.11b 2 Mbps	4409	4419	20	11.340	☒
IEEE 802.11g 6 Mbps	1432	1447	20	34.916	☒
IEEE 802.11g 54 Mbps	180	195	20	277.778	☒

Operation Mode #	Sweep points	Sweep time [µs]	Meas points For TX_{On}	Meas points >100?	Duty cycle %	DCCF Power [dB]	DCCF Voltage [dB]
IEEE 802.11b 2 Mbps	10001	4500	9799	☒	99.77	-*	-*
IEEE 802.11g 6 Mbps	10001	1500	9548	☒	98.96	-*	-*
IEEE 802.11g 54 Mbps	10001	240	7501	☒	92.31	0.35	0.70

* No duty cycle correction necessary because the duty cycle is above 98%. See 11.9.2.1 in [1] for details.

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

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

$$DCCF_{Fieldstrength} = 20 * log_{10}\left(\frac{1}{Duty\ cycle}\right)$$

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

5.3 DTS bandwidth

5.3.1 Test setup (DTS bandwidth)

Test setup			
Used	Setup	See sub-clause	Comment
☐	Test setup (radiated – normal procedure)	5.1.1.4	-
☐	Test setup (radiated – alternative procedure)	5.1.1.5	-
☒	Test setup (antenna port conducted)	5.1.2	-

5.3.2 Test method (DTS bandwidth)

Test method (Maximum peak conducted output power)				
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

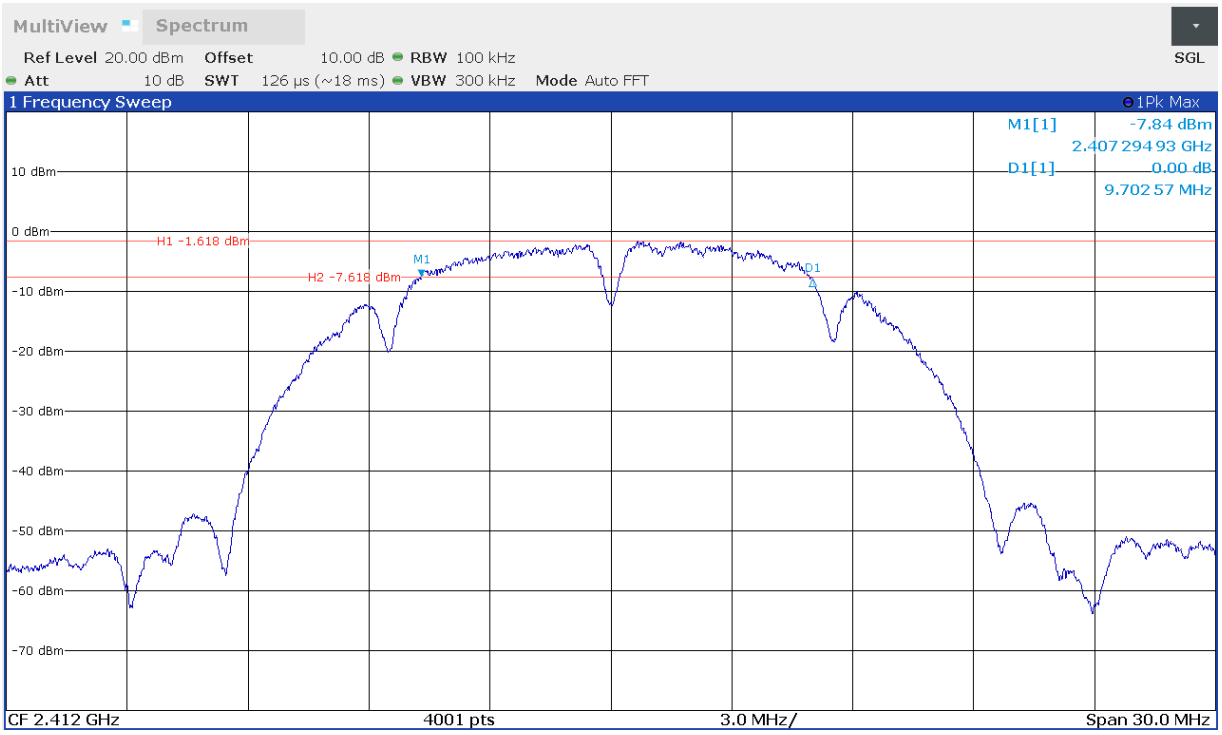
5.3.3 Test results (DTS bandwidth)

Ambient temperature:	22 °C
Relative humidity:	45 %

Date	15.05.2023
Tested by	P. Neufeld

5.3.3.1 DTS bandwidth (802.11 - full retest MiMo):

Worst case plot (operation mode 1 – Antenna port BT/WiFi2):



Operation mode #	DTS bandwidth BT/WiFi1 [MHz]	DTS bandwidth BT/WiFi2 [MHz]	Minimum DTS bandwidth Limit [MHz]	Result
1	9.852537	**9.702574**	0.5	Passed
2	9.875031	9.882529	0.5	Passed
3	9.800050	9.822544	0.5	Passed
4	16.505874	16.415896	0.5	Passed
5	16.495876	16.455886	0.5	Passed
6	16.475881	16.425894	0.5	Passed

Test: Passed

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

5.4 Transmit Antenna Performance considerations (WLAN)

Test setup (Transmit antenna performance considerations)			
Integral and/or dedicated antenna	Antenna gain ≥ 6dBi	Result	Comment
☒	☒	Passed	Output power has to reduced by 0.6 dB for conducted tests for WLAN

As declared by the applicant for all WLAN modes (mode 1 – 15) “Maximum Ratio Transmission (MRT)” is used.

Antenna gain calculation for WLAN modes (mode 1 – 15) as described in **[6]**, sub-clause F) 2) d) (i)

$$Directional\ gain = 10\ log_{10}\left[\frac{\left(10^{G_1/20} + 10^{G_2/20}\right)^2}{N_{Ant}}\right] dBi$$

Herein:

G_1 = $gain_{external\ antenna}$ = 5.4 dBi
G_1 = $gain_{internal\ antenna}$ = 0.68 dBi
N_{Ant} = number of antennas = 2
Directional gain for correlated signals = **6.4 dBi** > 6 dBi

5.5 Transmit Antenna Performance considerations (Bluetooth LE)

Test setup (Transmit antenna performance considerations)			
Integral and/or dedicated antenna	Antenna gain ≥ 6dBi	Result	Comment
☒	☐	Passed	No output power reduction necessary

5.6 Occupied bandwidth – power bandwidth (99%)

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

Test setup			
Used	Setup	See sub-clause	Comment
☐	Test setup (radiated – normal procedure)	5.1.1.4	-
☐	Test setup (radiated – alternative procedure)	5.1.1.5	-
☒	Test setup (antenna port conducted)	5.1.2	-

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

Test method (Maximum peak conducted output power)				
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.

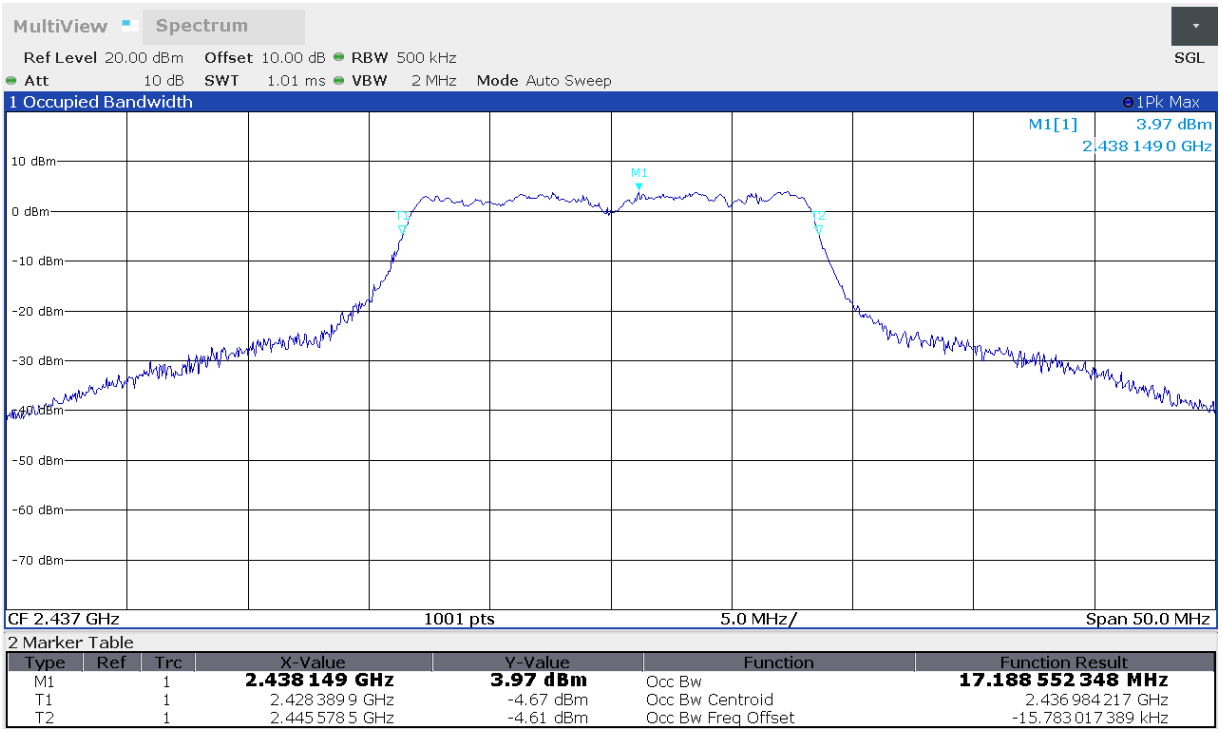
5.6.3 Test results (Occupied bandwidth – power bandwidth (99%))

Ambient temperature:	22 °C
Relative humidity:	45 %

Date	15.05.2023
Tested by	P. Neufeld

5.6.3.1 Occupied bandwidth conducted output power (802.11 - full retest MiMo):

Worst case plot (operation mode 10 Internal Antenna):



Operation mode #	99% bandwidth – BT/WiFi1 [MHz]	99% bandwidth – BT/WiFi2 [MHz]
1	13.358661	13.292235
2	13.424650	13.435973
3	13.367320	13.264607
4	17.058775	17.012864
5	17.068822	**17.188552**
6	17.059683	16.955435

Test: Passed

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

5.7 DTS transmitter output power

5.7.1 Test setup (DTS transmitter output power)

Test setup			
Used	Setup	See sub-clause	Comment
☐	Test setup (radiated – normal procedure)	5.1.1.4	-
☐	Test setup (radiated – alternative procedure)	5.1.1.5	-
☒	Test setup (antenna port conducted)	5.1.2	-

5.7.2 Test method (DTS transmitter 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	For BLE tests	
☐	11.9.1.2	Integrated band power method	Not for DTS	-
☐	11.9.1.3	PKPM1 Peak power meter method*1	For 802.11 tests	-

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

Test method (Maximum (average) conducted output power)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	11.9.2.2.2	Method AVGSA-1	D ≥ 98%	For 802.11 - full retest MiMo
☐	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		-

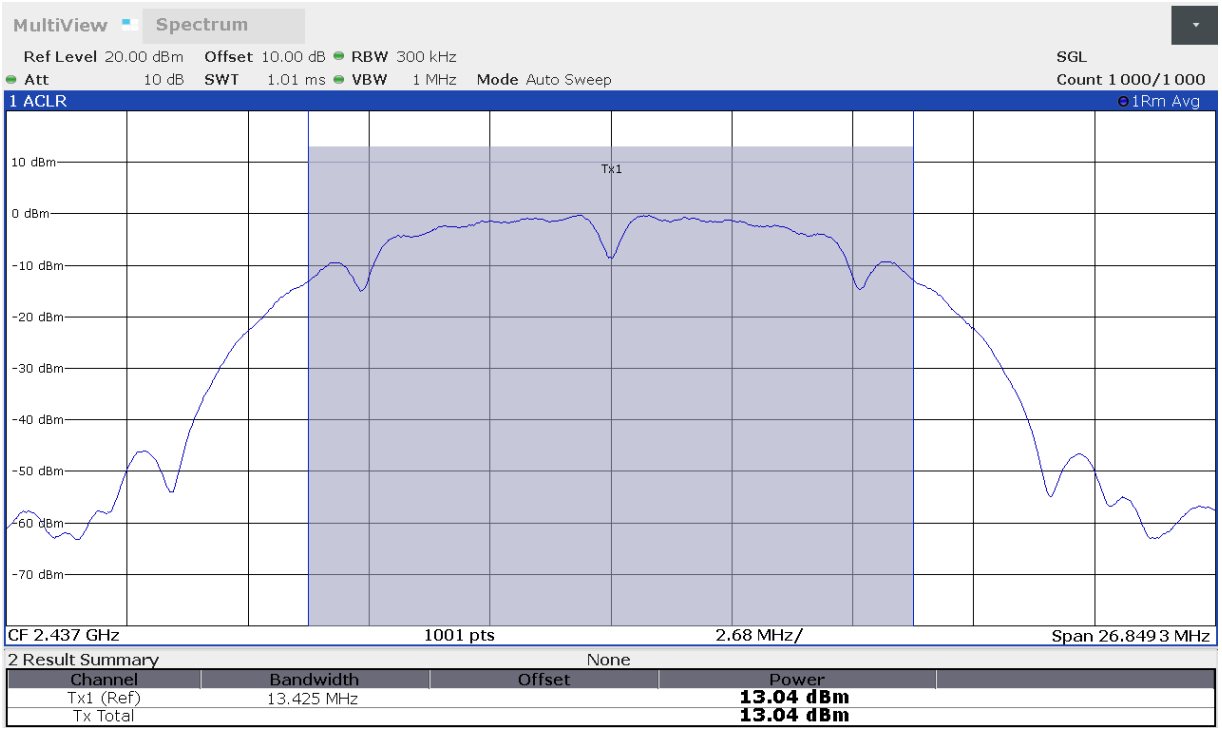
5.7.3 Test results (DTS transmitter output power)

Ambient temperature	22 - 23°C
Relative humidity:	43 - 45%

Date	15.05.2023 09.05.2023 30.03.2023
Tested by	P. Neufeld

5.7.3.1 Average conducted output power (802.11 - full retest MiMo):

Worst case plot (operation mode 2):



Calculations:
Result Corr. Ant. [dBm]= 10x $\log_{10}$(Reading Internal Ant [mW] + Reading External Ant [mW]) + $DCCF_{FS}$ [dB] + Ext. Att. [dB]

See **[6]** E 1) for details

Operation mode	Reading BT/WiFi1 [dBm]	Reading BT/WiFi2 [dBm]	DCCF [dB]	Ext. Att.* [dB]	Cond. Both Ant. [dBm]	Limit [dBm]
1	8.7	8.7	0.0	1.0	12.7	29.6
2	**13.0**	**12.4**	**0.0**	**1.0**	**16.7**	29.6
3	11.4	12.5	0.0	1.0	16.0	29.6
4	4.8	4.6	0.0	1.0	8.7	29.6
5	9.4	8.4	0.0	1.0	12.9	29.6
6	4.6	5.5	0.0	1.0	9.1	29.6

* The external attenuation of the external attenuator and the measurement cable is already taken into account with the reference level offset of 10 dB in the spectrum analyzer plot, which represents the attenuation of the 10 dB external attenuator. The cable attenuation of the external cable is submitted ad external attenuation in the table above.

Test: Passed

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

5.7.3.2 Average conducted output power (802.11 – worst cases from original report):

No plot shown, because all tests were conducted using thermal power meter.

Calculations:
Result Cond. Both Ant. [dBm]= $10x \log_{10}$(Reading Internal Ant [mW] + Reading External Ant [mW]) + $DCCF_{FS}$ [dB] + Ext. Att. [dB]
See **[6]** E 1) for details

The following test results were lower than the ones documented in the in the original report.

Operation mode	Reading BT/WiFi1 [dBm]	Reading BT/WiFi2 [dBm]	DCCF [dB]	Ext. Att.* [dB]	Cond. Both Ant. [dBm]	Limit [dBm]
7	4.9	5.3	0.1	1.0	9.2	29.6
8	9.4	9.0	0.1	1.0	13.3	29.6
9	3.8	5.2	0.1	1.0	8.7	29.6
10	4.8	5.5	0.6	1.0	9.8	29.6
11	9.4	9.1	0.6	1.0	13.9	29.6
12	3.8	2.6	0.6	1.0	7.9	29.6

* The external attenuation is comprised of the Fakra to SMA cables provided by the applicant. The attenuation of the plug inserted directly into the EUT is not taken into account for.

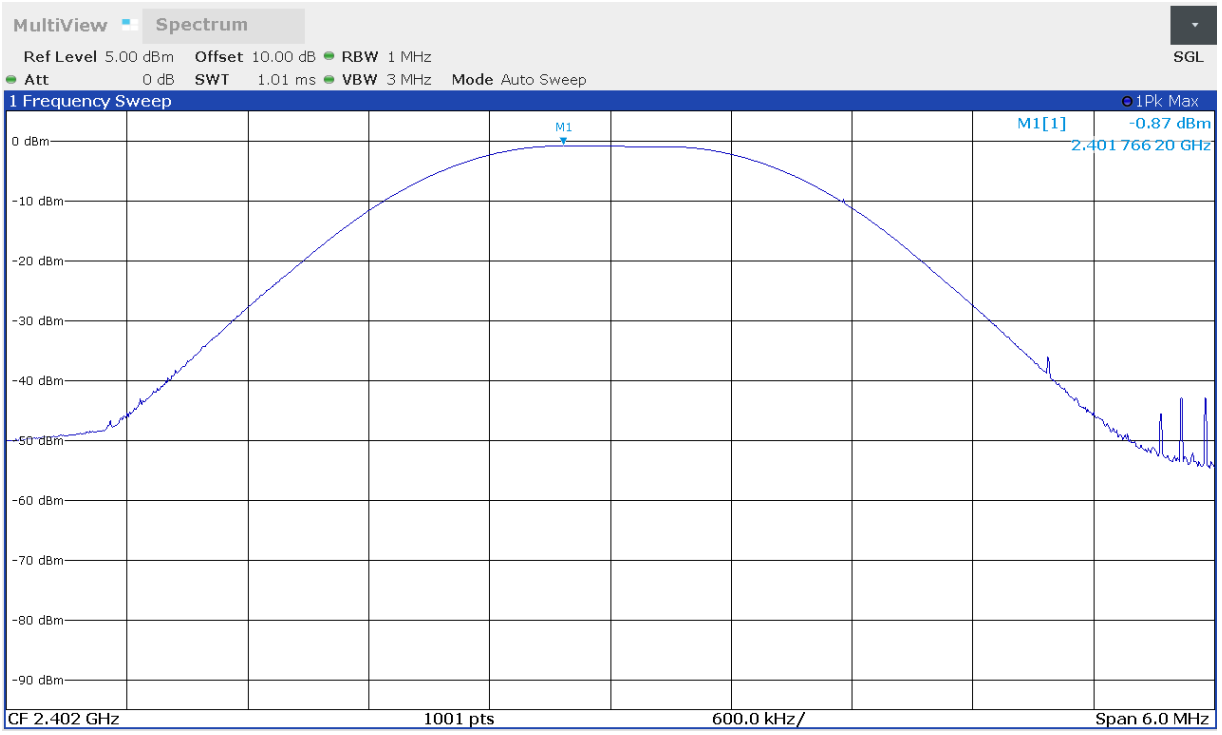
Test: Passed

Test equipment (please refer to chapter 7 for details)
19 - 21

5.7.3.3 Maximum (peak) conducted output power (Bluetooth Low Energy):

The following test results were lower or equal to the ones documented in the in the original report.

Worst case plot (operation mode 16 – antenna port BT/WiFi2):



Calculations:
Result Corr. Ant. [dBm]= Reading Internal Ant [dBm]
See **[6]** E 1) for details

Operation mode	Reading BT/WiFi1 [dBm]	Reading BT/WiFi2 [dBm]	DCCF [dB]	Ext. Att.* [dB]	Cond. Both Ant. [dBm]	Limit [dBm]
16	-	-0.9	-	1.0	0.1	30.0
17	-	-1.6	-	1.0	-0.6	30.0
18	-	-1.8	-	1.0	-0.8	30.0

* The external attenuation is comprised of the Fakra to SMA cables provided by the applicant. The attenuation of the plug inserted directly into the EUT is not taken into account for.

Test: Passed

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

5.8 DTS maximum power spectral density

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

Test setup			
Used	Setup	See sub-clause	Comment
☐	Test setup (radiated – normal procedure)	5.1.1.4	-
☐	Test setup (radiated – alternative procedure)	5.1.1.5	-
☒	Test setup (antenna port conducted)	5.1.2	-

5.8.2 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	-

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

Ambient temperature:	22 °C
Relative humidity:	45 %

Date	15.05.2023
Tested by	P. Neufeld

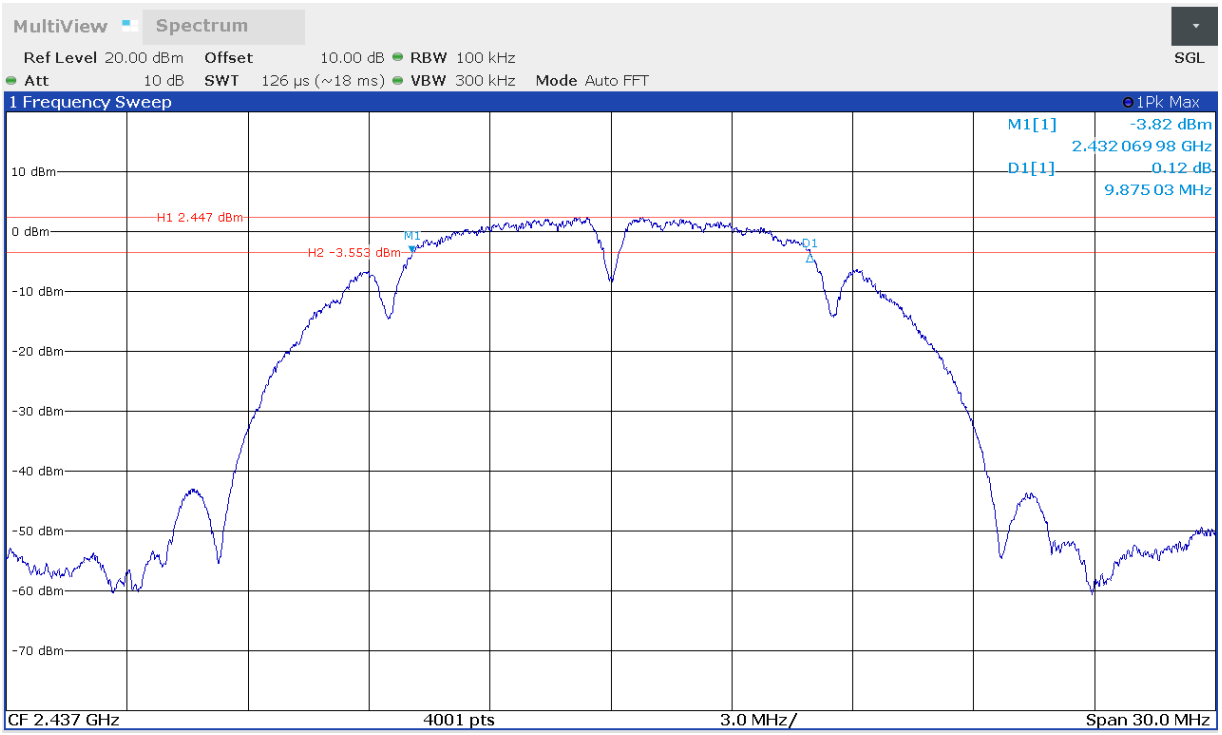
Calculations:
Result Corr. Ant. 1 [dBm/3kHz]= Reading Internal Ant [dBm/3kHz] + Ext. Att [dB]

5.8.3.1 Maximum average PSD (802.11 - full retest MiMo):

Calculations:
Result Corr. Ant. [dBm/3kHz]= Reading Ant [dBm/3kHz] + Correction 2 Antennas [dB]
+ Ext. Att [dB] + DCCF [dB]

See **[6]** E 2) c) for details

Worst case plot (operation mode 2 – antenna port BT/WiFi1):



Operation mode	Reading BT/WiFi1 [dBm/3 kHz]	Reading BT/WiFi1 [dBm/3 kHz]	Ext. Att.* [dB]	DCCF [dB]	Result Corr. Ant. [dBm/3 kHz]	Limit [dBm/3 kHz]
1	-23.7	-23.8	1.0	0.0	-19.7	7.6
2	**-19.6**	**-20.4**	**1.0**	**0.0**	**-16.0**	7.6
3	-21.0	-20.1	1.0	0.0	-16.5	7.6
4	-28.1	-27.6	1.0	0.3	-23.8	7.6
5	-23.5	-24.7	1.0	0.3	-20.0	7.6
6	-28.3	-27.2	1.0	0.3	-23.7	7.6

* The external attenuation of the external attenuator and the measurement cable is already taken into account with the reference 10.2 dB level offset in the spectrum analyzer plot, which represents the attenuation of the 10 dB external attenuator and the 0.2 dB of the measurement cable.

Test: Passed

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

5.9 DTS band-edge emission measurements

5.9.1 Test setup (Band edge – unrestricted bands)

Test setup			
Used	Setup	See sub-clause	Comment
☐	Test setup (radiated – normal procedure)	5.1.1.4	-
☐	Test setup (radiated – alternative procedure)	5.1.1.5	-
☒	Test setup (antenna port conducted)	5.1.2	-

5.9.2 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

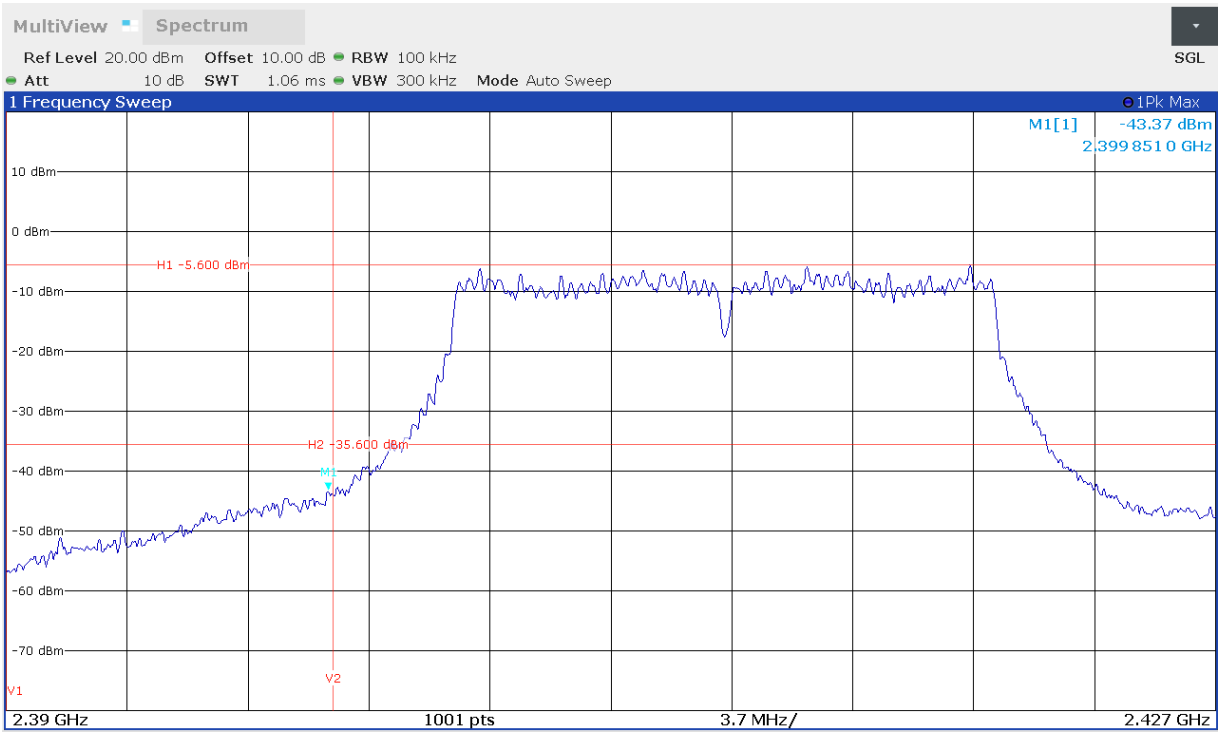
*2 If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

5.9.3 Test results (Band edge – unrestricted bands) – 30 dBc (802.11 - full retest MiMo)

Ambient temperature:	22 °C
Relative humidity:	45 %

Date	15.05.2023
Tested by	P. Neufeld

Worst case plot Lower band edge (operation mode 4 – BT/WiFi1):



	BT/WiFi1					BT/WiFi2				
Operation Mode #	Emission Frequency [MHz]	Reference [dBm]	Limit [dBm]	Emission level [dBm]	Margin [dB]	Emission Frequency [MHz]	Reference [dBm]	Limit [dBm]	Emission level [dBm]	Margin [dB]
1	2396.427	-1.1	-31.1	-53.6	22.5	2399.450	-0.8	-30.8	-52.1	21.3
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	2399.851	-5.6	-35.6	-43.4	7.8	2399.703	-5.3	-35.3	-44.4	9.1
5	-	-	-	-	-	-	-	-	-	-
6										

Test: Passed

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

5.9.4 Test setup (Band edge – restricted bands)

Test setup			
Used	Setup	See sub-clause	Comment
☐	Test setup (radiated – normal procedure)	5.1.1.4	-
☒	Test setup (radiated – alternative procedure)*1	5.1.1.5	-
☐	Test setup (antenna port conducted)	5.1.2	-

*1 Only worst-case modes from the antenna port conducted pretests were tested as radiated tests.

5.9.5 Test method (Band edge – restricted bands)

Test method (Band edge – restricted bands)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	11.13.1	Standard method	No limitations	-
☐	11.13.2	Marker-delta method		See 6.10.6 [1]
☐	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

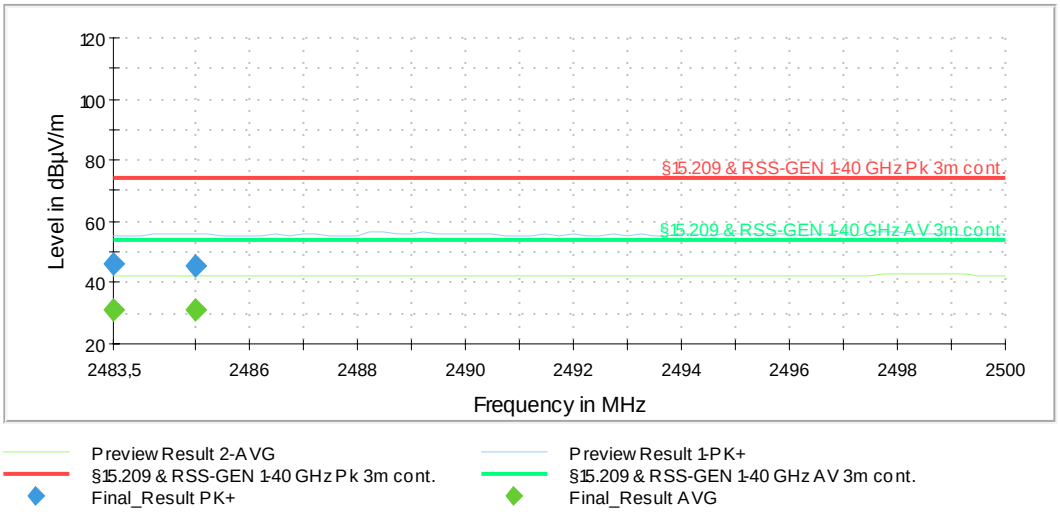
5.9.6 Test results (Band edge – restricted bands) – radiated

5.9.6.1 802.11 - full retest MiMo

Ambient temperature:	21 °C
Relative humidity:	52 %

Date	16.06.2023
Tested by	B. Rohde

Worst case plot WLAN (operation mode 3):



(operation mode 1):

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2383.250	---	27.7	54.0	26.3	V	93	90	33.3
2383.250	43.5	---	74.0	30.5	V	93	90	33.3
2389.250	---	30.1	54.0	23.9	H	219	150	33.4
2389.250	45.2	---	74.0	28.8	H	219	150	33.4

(operation mode 3):

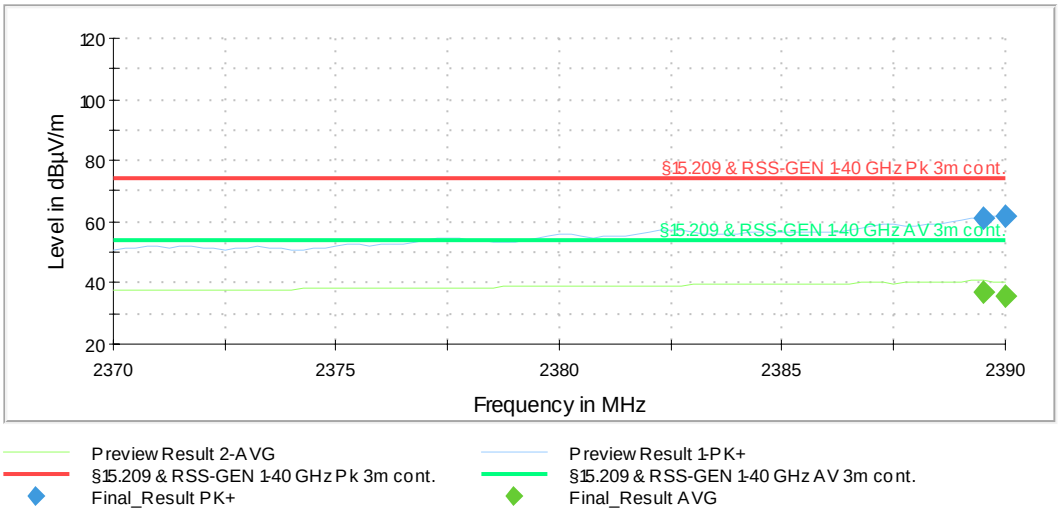
Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2483.500	46.3	---	74.0	27.7	H	172	150	33.6
2483.500	---	31.4	54.0	22.6	H	172	150	33.6
2485.000	45.6	---	74.0	28.4	H	161	150	33.6
2485.000	---	30.8	54.0	23.2	H	161	150	33.6

5.9.6.2 802.11 – worst cases from original report

Ambient temperature:	21 °C
Relative humidity:	46 - 52 %

Date	13+16.06.2023
Tested by	B. Rohde

Worst case plot WLAN (operation mode 14):



(operation mode 14):

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2389.500	---	37.3	54.0	16.7	H	141	90	33.4
2389.500	61.3	---	74.0	12.7	H	141	90	33.4
2390.000	---	36.0	54.0	18.0	H	127	90	33.4
2390.000	62.0	---	74.0	12.0	H	127	90	33.4

(operation mode 15):

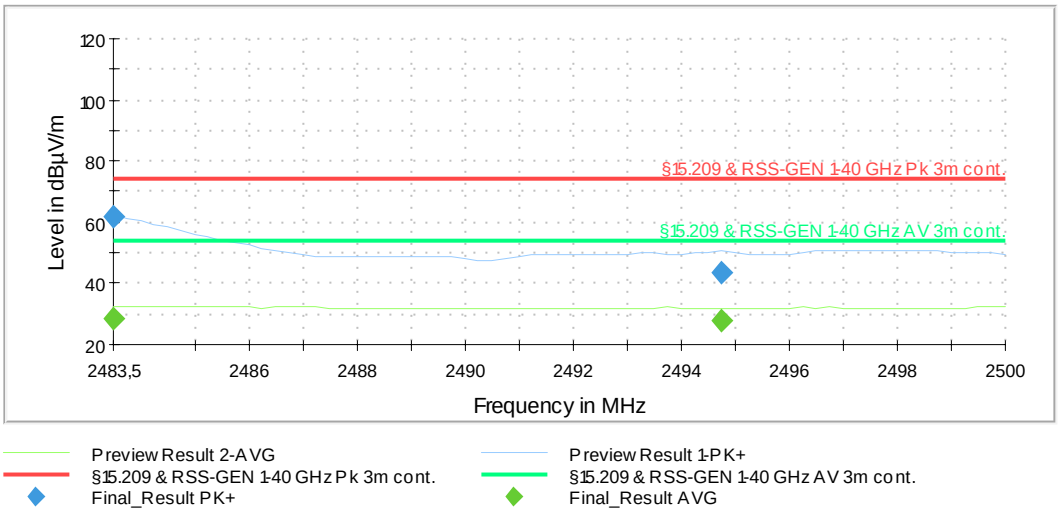
Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2484.225	---	29.9	54.0	24.1	V	122	0	33.6
2484.225	56.7	---	74.0	17.3	V	122	0	33.6
2488.975	---	29.2	54.0	24.8	V	152	90	33.6
2488.975	56.5	---	74.0	17.5	V	152	90	33.6
2499.200	---	29.2	54.0	24.8	V	122	0	33.6
2499.200	51.7	---	74.0	22.3	V	122	0	33.6

5.9.6.3 BLE - worst cases from original report

Ambient temperature:	21 °C
Relative humidity:	57 %

Date	14.07.2023
Tested by	B. Rohde

Worst case plot BLE (operation mode 20):



(operation mode 19):

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2389.750	---	28.1	54.0	25.9	V	173	30	33.4
2389.750	58.9	---	74.0	15.1	V	173	30	33.4
2390.000	---	28.2	54.0	25.8	V	172	30	33.4
2390.000	59.6	---	74.0	14.4	V	172	30	33.4

(operation mode 20):

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2483.500	---	28.4	54.0	25.6	H	184	150	33.6
2483.500	62.1	---	74.0	11.9	H	184	150	33.6
2494.750	---	28.1	54.0	25.9	V	215	0	33.5
2494.750	43.6	---	74.0	30.4	V	215	0	33.5

Test: Passed

Test equipment (please refer to chapter 7 for details)
22 – 31, 34

5.10 Radiated emissions

Test setup (Maximum unwanted emissions)			
Used	Setup	See sub-clause	Comment
☒	Test setup (radiated – normal procedure)	5.1.1.4	f < 1 GHz
☒	Test setup (radiated – alternative procedure)	5.1.1.5	f > 1 GHz
☐	Test setup (antenna port conducted)	5.1.2	-

5.10.1 Test results (Maximum unwanted emissions)

5.10.1.1 Test results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	23 °C
Relative humidity:	55 %

Date	09.06.2023
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 (802.11 - full retest MiMo):

Spurious emissions from 9 kHz to 30 MHz (operation mode 4 - Pos 1 - 3):

Worst case plot (802.11 – worst cases from original report):

Spurious emissions from 9 kHz to 30 MHz (operation mode 13 - Pos 1 - 3):

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

Worst case plot (BLE – worst cases from original report):

Spurious emissions from 9 kHz to 30 MHz (operation mode 20 - Pos 1 - 3):

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

Test equipment (please refer to chapter 7 for details)
2 - 9

5.10.1.2 Test results WLAN (30 MHz – 1 GHz)

Ambient temperature:	22 - 23°C
Relative humidity:	31 - 42%

Date	15+19.05.2023
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

Calculations:

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

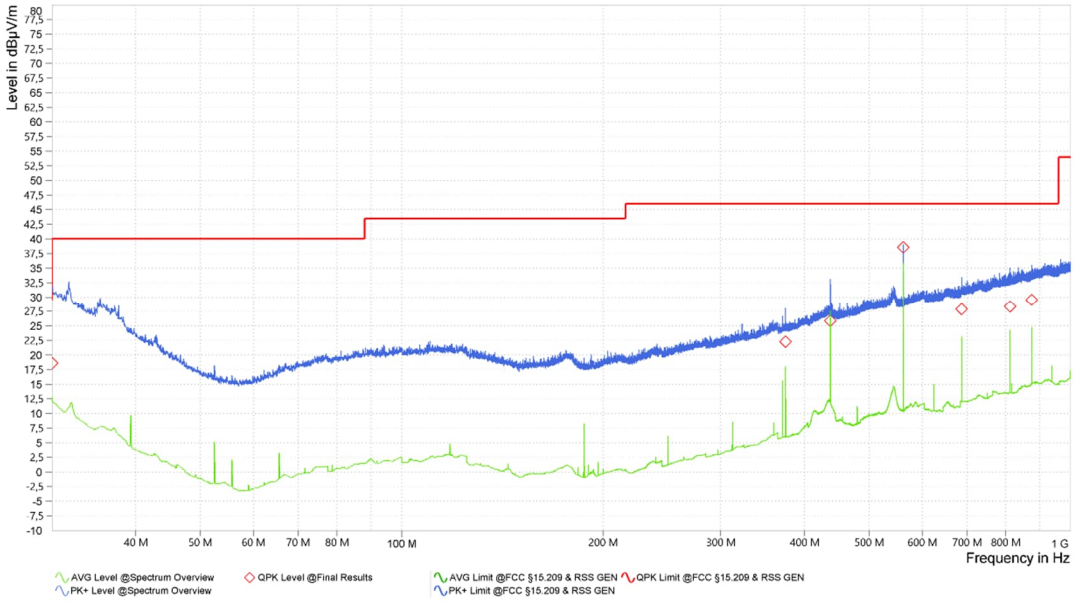
Correction [dBµV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]

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 (802.11 - full retest MiMo):

Spurious emissions from 30 MHz to 1 GHz (operation mode 6 – Pos 1-3):



Result tables (802.11 - full retest MiMo)

(operation mode 4):

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB/m]	Pol. (H/V)	Azimuth [deg]	Height [cm]	Readings [dBµV]	Position #
30.000	18.64	29.50	10.86	25.98	V	288.91	3.11	-7.34	1-3
187.510	15.60	43.50	27.90	15.19	H	232.00	1.33	0.41	1-3
437.500	24.89	46.00	21.11	22.74	H	242.00	1.77	2.15	1-3
562.480	34.23	46.00	11.77	25.37	H	272.00	1.33	8.86	1-3
687.490	31.56	46.00	14.44	27.07	H	220.76	1.00	4.49	1-3
812.500	30.32	46.00	15.68	29.12	V	201.40	1.54	1.20	1-3

(operation mode 5):

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB/m]	Pol. (H/V)	Azimuth [deg]	Height [cm]	Readings [dBµV]	Position #
30.000	18.55	29.50	10.95	25.98	H	109.11	2.83	-7.43	1-3
187.510	16.41	43.50	27.09	15.19	H	284.54	1.40	1.22	1-3
437.500	26.33	46.00	19.67	22.74	H	224.54	1.61	3.59	1-3
562.480	38.40	46.00	7.60	25.37	H	272.00	1.25	13.03	1-3
687.490	33.92	46.00	12.08	27.07	H	232.00	1.00	6.85	1-3
812.500	35.20	46.00	10.80	29.12	H	52.00	1.02	6.08	1-3

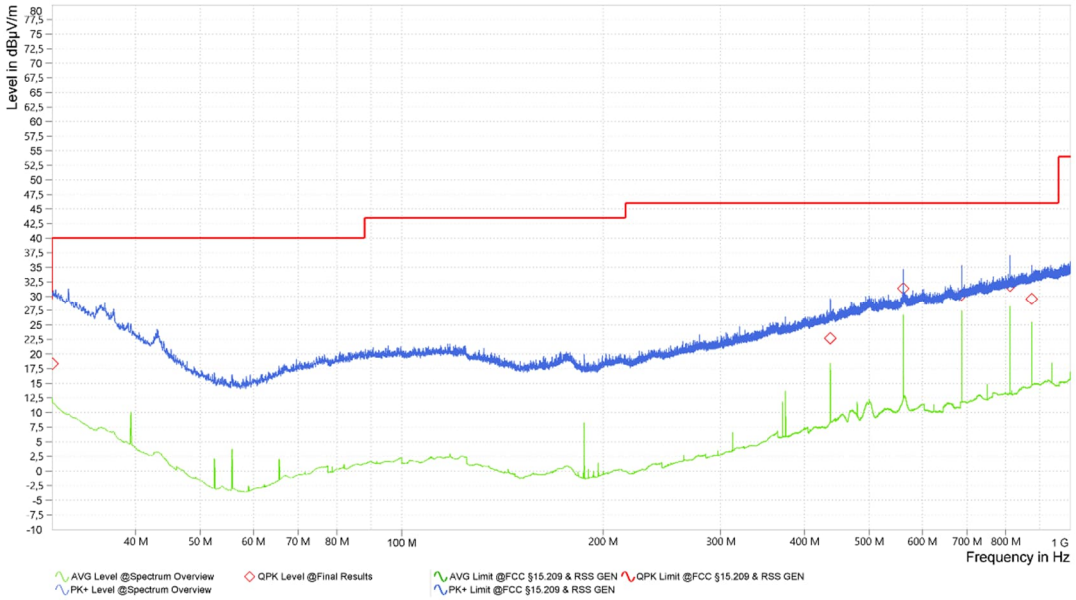
(operation mode 6):

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB/m]	Pol. (H/V)	Azimuth [deg]	Height [cm]	Readings [dBµV]	Position #
30.000	18.60	29.50	10.90	25.98	V	348.91	3.83	-7.38	1-3
375.010	22.28	46.00	23.72	21.26	H	142.00	1.00	1.02	1-3
437.500	25.85	46.00	20.15	22.74	V	2.00	1.15	3.11	1-3
562.480	38.58	46.00	7.42	25.37	H	249.46	1.25	13.21	1-3
687.490	27.87	46.00	18.13	27.07	H	242.00	1.02	0.80	1-3
812.500	28.35	46.00	17.65	29.12	H	82.00	1.00	-0.77	1-3
874.990	29.53	46.00	16.47	29.56	H	340.56	1.00	-0.03	1-3

Test result: Passed

Worst case plot (802.11 – worst cases from original report):

Spurious emissions from 30 MHz to 1 GHz (operation mode 13 – Pos 1-3):



Result tables (802.11 – worst cases from original report)

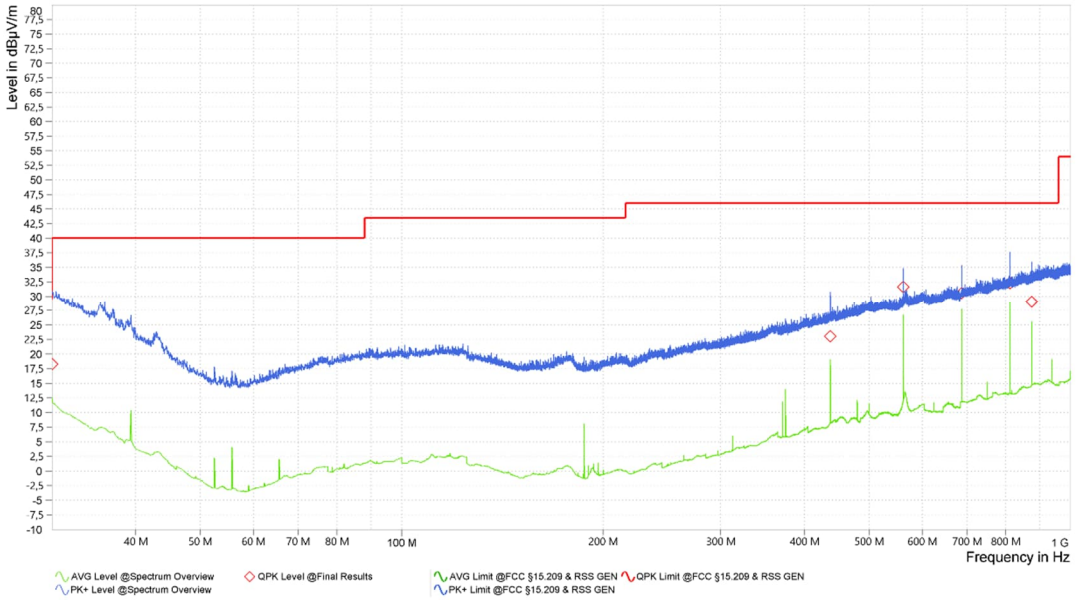
(operation mode 13):

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB/m]	Pol. (H/V)	Azimuth [deg]	Height [cm]	Readings [dBµV]	Position #
30.050	18.3	40.0	21.7	26.0	V	95.1	1.3	-7.6	1-3
437.500	22.7	46.0	23.3	22.7	V	262.0	1.3	0.0	1-3
562.480	31.4	46.0	14.6	25.4	H	122.0	1.6	6.0	1-3
687.490	30.3	46.0	15.8	27.1	H	223.2	1.0	3.2	1-3
812.500	31.8	46.0	14.2	29.1	H	246.4	1.5	2.7	1-3
874.990	29.5	46.0	16.5	29.6	V	227.8	1.0	0.0	1-3

Test result: Passed

Worst case plot (BLE – worst cases from original report):

Spurious emissions from 30 MHz to 1 GHz (operation mode 20 – Pos 1-3):



Result tables (BLE – worst cases from original report)

(operation mode):

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB/m]	Pol. (H/V)	Azimuth [deg]	Height [cm]	Readings [dBµV]	Position #
30.000	18.3	29.5	11.2	26.0	H	49.1	1.8	-7.7	1-3
437.500	23.1	46.0	23.0	22.7	V	262.0	1.3	0.3	1-3
562.480	31.6	46.0	14.4	25.4	H	122.0	1.6	6.2	1-3
687.490	30.6	46.0	15.4	27.1	H	223.2	1.0	3.5	1-3
812.500	32.3	46.0	13.7	29.1	H	246.4	1.6	3.2	1-3
874.990	29.0	46.0	17.0	29.6	H	242.6	1.3	-0.5	1-3

Test result: Passed

Test equipment (please refer to chapter 7 for details)
3 - 11

5.10.1.3 Test results WLAN (radiated 1 GHz to 26.5 GHz)

Ambient temperature:	22 - 24°C
Relative humidity:	39 - 66%

Date	13.06 – 12.07.2023
Tested by	Bernward Rohde, Martin Eppinger

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: No spurious emissions were found during the antenna port conducted pre-tests. Therefore, the emission with the highest power spectral density was used for the radiated emissions tests, namely 802.11ax b with MCS7.

When the peak emissions are below the average limit line, no final measurement is performed. Also, when only peak noise is above the average limit, only the highest noise value is measured in the final measurement.

Calculation:

Max Peak [dBµV/m] = Reading (Pk+) [dBµV] + Correction [dBµV/m]

Average [dBµV/m] = Reading (Av) [dBµV] + Correction [dBµV/m]

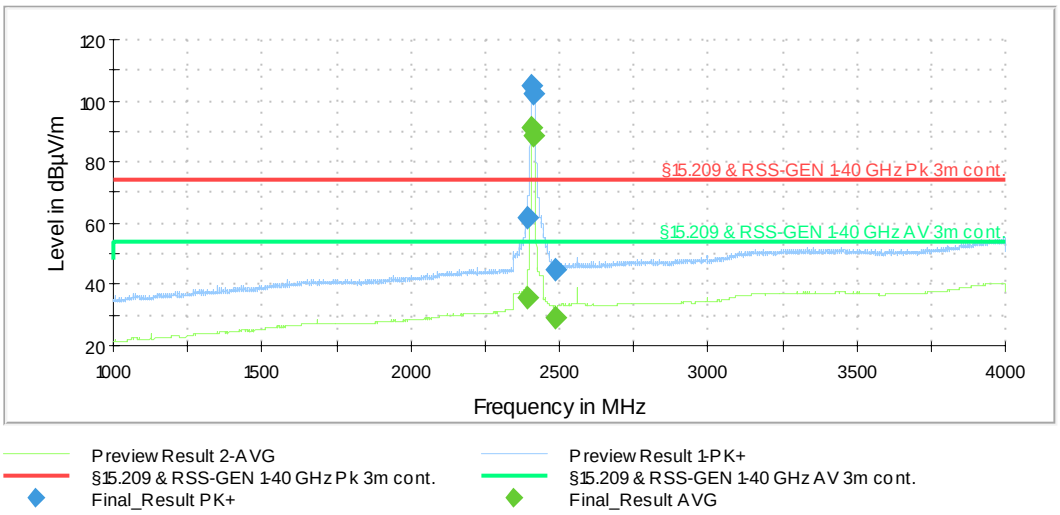
Correction [dBµV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]+DCCF* [dB]
* (if applicable – only for Average values, that are fundamental related)

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

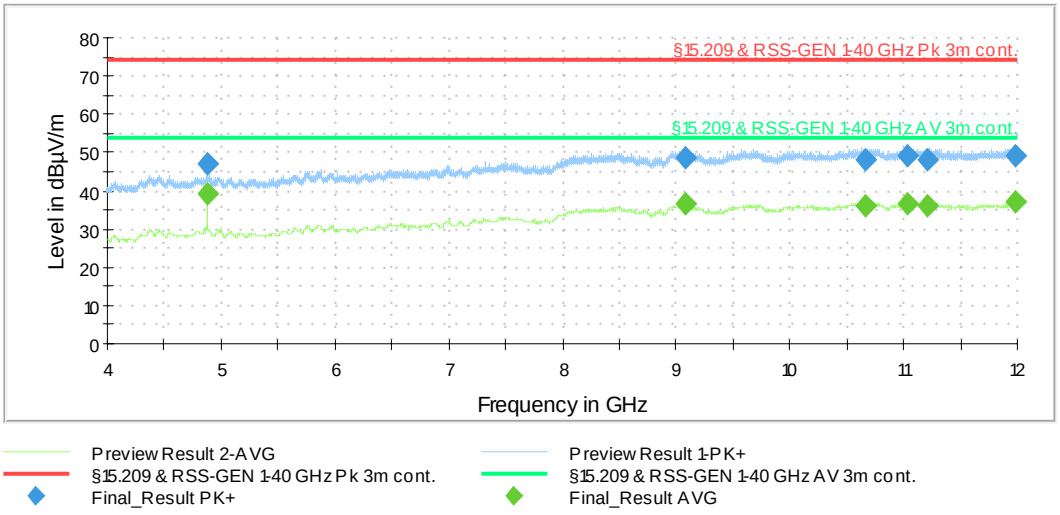
The curves in the diagram only represent the maximum measured value for each frequency point of all preliminary measurements, which were carried out with various EUT and antenna positions.
The top measured curve represents the peak measurement. The measured points marked with "◇" are frequency points 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 WLAN (802.11 - full retest MiMo):

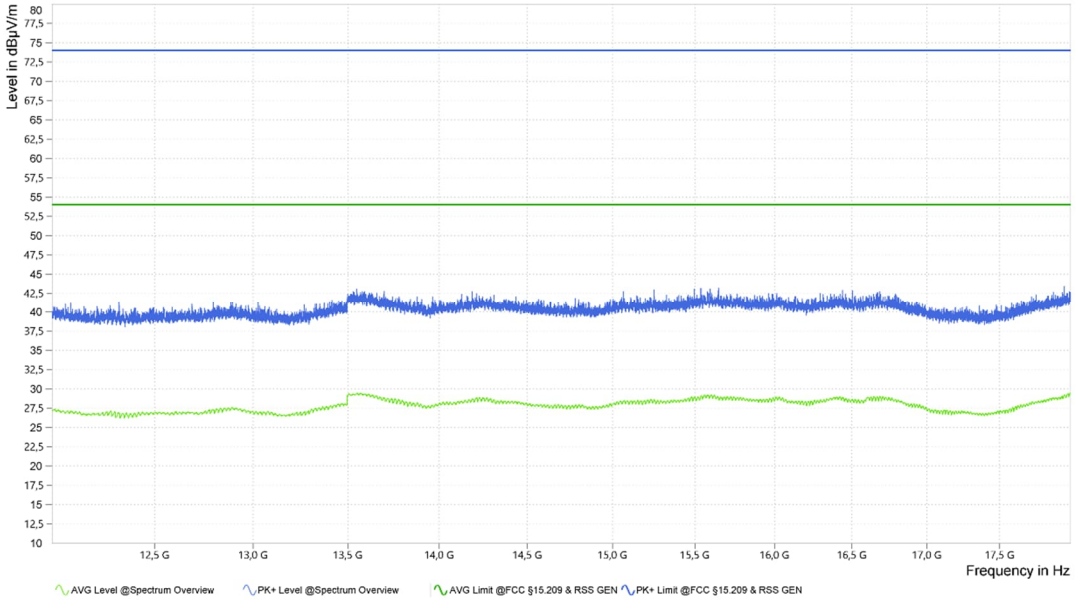
Spurious emissions from 1 GHz to 4 GHz (operation mode 4):



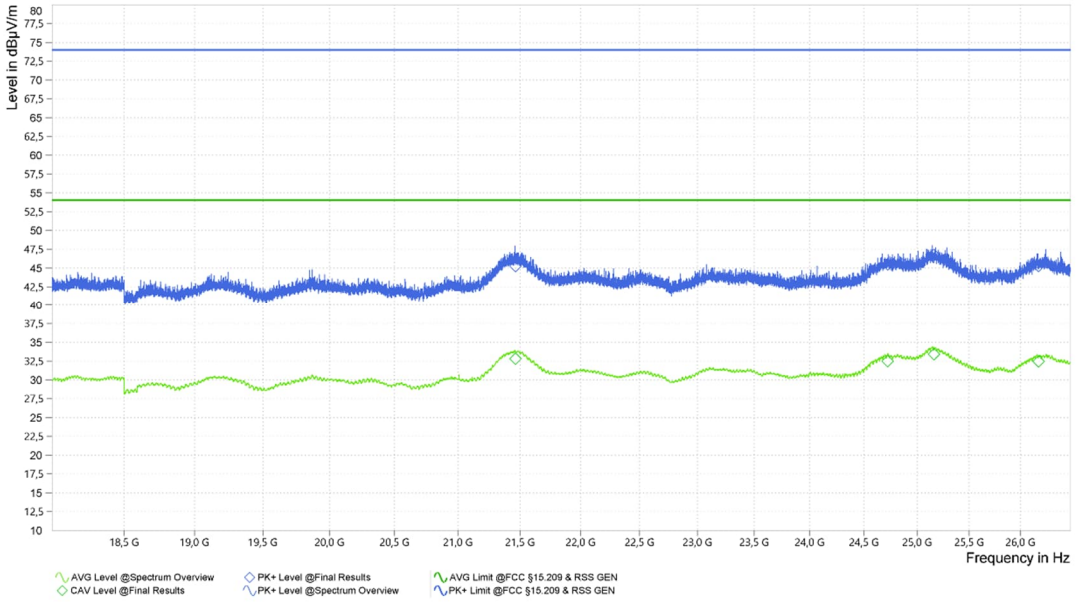
Spurious emissions from 4 GHz to 12 GHz (operation mode 2):



Spurious emissions from 12 GHz to 18 GHz (operation mode 5):



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



5.10.1.3.1 Result tables (802.11 - full retest MiMo)

Operation mode 1:

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
9080.750	48.1	---	74.0	25.9	V	-32	120	8.6
9080.750	---	36.4	54.0	17.6	V	-32	120	8.6
9720.250	47.8	---	74.0	26.2	V	114	90	7.4
9720.250	---	35.8	54.0	18.2	V	114	90	7.4
10653.750	---	36.3	54.0	17.7	V	153	150	7.1
10653.750	48.8	---	74.0	25.2	V	153	150	7.1
11040.250	---	36.5	54.0	17.5	V	227	150	7.4
11040.250	49.5	---	74.0	24.5	V	227	150	7.4
11214.500	---	36.3	54.0	17.7	H	345	0	7.0
11214.500	48.8	---	74.0	25.2	H	345	0	7.0
11980.500	---	36.9	54.0	17.1	H	-19	30	6.6
11980.500	49.4	---	74.0	24.6	H	-19	30	6.6

Operation mode 2:

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
4874.000	47.3	---	74.0	26.7	H	169	120	-1.4
4874.000	---	39.2	54.0	14.8	H	169	120	-1.4
9080.250	48.8	---	74.0	25.2	V	180	150	8.6
9080.250	---	36.4	54.0	17.6	V	180	150	8.6
10660.250	48.1	---	74.0	25.9	H	113	90	7.1
10660.250	---	36.2	54.0	17.8	H	113	90	7.1
11040.250	---	36.4	54.0	17.6	V	80	60	7.4
11040.250	49.3	---	74.0	24.7	V	80	60	7.4
11213.250	---	36.3	54.0	17.7	H	26	0	7.0
11213.250	48.1	---	74.0	25.9	H	26	0	7.0
11980.750	49.3	---	74.0	24.7	V	47	0	6.6
11980.750	---	37.0	54.0	17.0	V	47	0	6.6

Operation mode 3:

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
4923.750	---	35.1	54.0	18.9	V	170	150	-1.6
4923.750	43.9	---	74.0	30.1	V	170	150	-1.6
9080.250	48.4	---	74.0	25.6	H	17	120	8.6
9080.250	---	36.3	54.0	17.7	H	17	120	8.6
9613.750	---	35.5	54.0	18.5	V	-22	60	7.6
9613.750	48.3	---	74.0	25.7	V	-22	60	7.6
10640.250	---	36.0	54.0	18.0	V	5	90	7.0
10640.250	47.7	---	74.0	26.3	V	5	90	7.0
11041.750	---	36.2	54.0	17.8	H	112	120	7.4
11041.750	49.3	---	74.0	24.7	H	112	120	7.4
11980.250	48.6	---	74.0	25.4	V	240	90	6.6
11980.250	---	36.6	54.0	17.4	V	240	90	6.6

Operation mode 4:

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2390.000	---	35.6	54.0	18.4	H	149	120	33.4
2390.000	61.9	---	74.0	12.1	H	149	120	33.4
2408.250	---	91.2	Fund.	-	H	148	120	33.5
2408.250	105.0	---	Fund.	-	H	148	120	33.5
2412.000	---	88.8	Fund.	-	H	146	120	33.6
2412.000	102.2	---	Fund.	-	H	146	120	33.6
2483.500	---	29.1	54.0	24.9	H	170	150	33.6
2483.500	44.6	---	74.0	29.4	H	170	150	33.6

Frequency [MHz]	PK+ [dBµV/m]	Pk+ Limit [dBµV/m]	PK+ Margin [dB]	AV [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Corr. [dB/m]	Pol	Elevation [deg]	Azimuth [deg]
21471.750	46.1	74.0	28.0	32.6	54.0	21.4	11.4	H	150.0	319.2
24724.750	45.4	74.0	28.6	32.3	54.0	21.7	11.3	H	120.0	47.1
25159.500	45.9	74.0	28.2	33.2	54.0	20.8	11.5	V	90.0	106.7
26194.000	44.4	74.0	29.6	32.2	54.0	21.8	11.8	V	60.0	120.6

Operation mode 5:

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2390.000	---	32.0	54.0	22.0	V	190	0	33.4
2390.000	52.8	---	74.0	21.2	V	190	0	33.4
2434.000	108.8	---	Fund.	-	H	149	120	33.8
2434.000	---	94.9	Fund.	-	H	149	120	33.8
2437.000	---	92.1	Fund.	-	H	149	120	33.8
2437.000	105.1	---	Fund.	-	H	149	120	33.8
2483.500	50.1	---	74.0	23.9	H	190	120	33.6
2483.500	---	29.6	54.0	24.4	H	190	120	33.6

Frequency [MHz]	PK+ [dBµV/m]	Pk+ Limit [dBµV/m]	PK+ Margin [dB]	AV [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Corr. [dB/m]	Pol	Elevation [deg]	Azimuth [deg]
21464.750	45.2	74.0	28.8	32.8	54.0	21.2	11.4	H	0.0	167.8
24722.750	45.5	74.0	28.5	32.5	54.0	21.5	11.3	H	60.0	331.5
25161.000	46.7	74.0	27.3	33.4	54.0	20.6	11.5	H	150.0	381.0
26180.750	45.3	74.0	28.7	32.5	54.0	21.5	11.8	V	90.0	233.9

Operation mode 6:

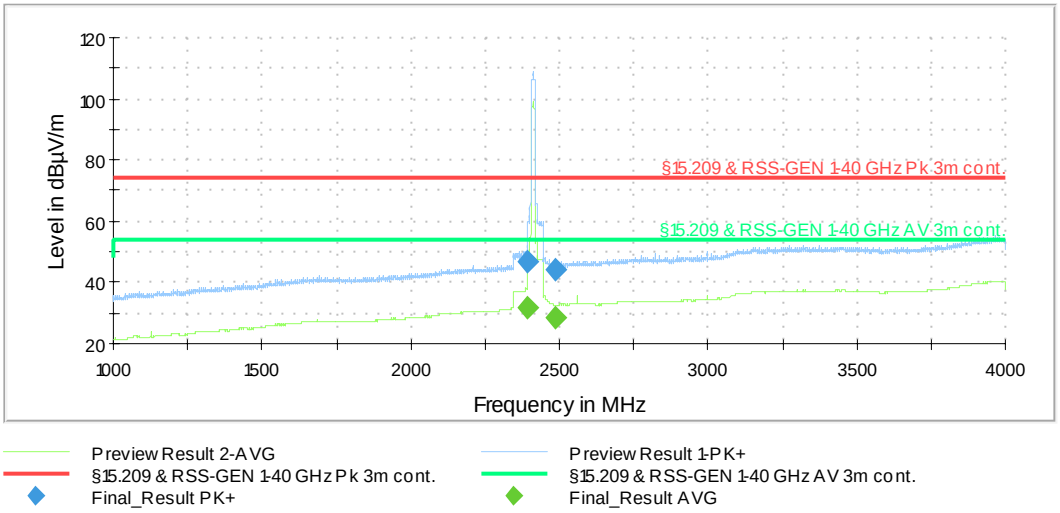
Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2390.000	---	28.1	54.0	25.9	H	180	120	33.4
2390.000	44.0	---	74.0	30.0	H	180	120	33.4
2455.250	103.4	---	Fund.	-	H	149	120	33.9
2455.250	---	89.1	Fund.	-	H	149	120	33.9
2462.000	---	85.3	Fund.	-	H	195	150	33.8
2462.000	99.2	---	Fund.	-	H	195	150	33.8
2483.500	57.5	---	74.0	16.5	H	151	120	33.6
2483.500	---	31.6	54.0	22.4	H	151	120	33.6

Frequency [MHz]	PK+ [dBµV/m]	Pk+ Limit [dBµV/m]	PK+ Margin [dB]	AV [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Corr. [dB/m]	Pol	Elevation [deg]	Azimuth [deg]
21487.250	44.9	74.0	29.1	32.5	54.0	21.5	11.5	H	150.0	179.4
24729.750	45.4	74.0	28.6	32.2	54.0	21.8	11.2	V	120.0	83.8
25159.750	45.9	74.0	28.1	33.2	54.0	20.8	11.5	V	90.0	203.5
26229.250	44.7	74.0	29.3	32.2	54.0	21.8	11.9	V	90.0	304.9

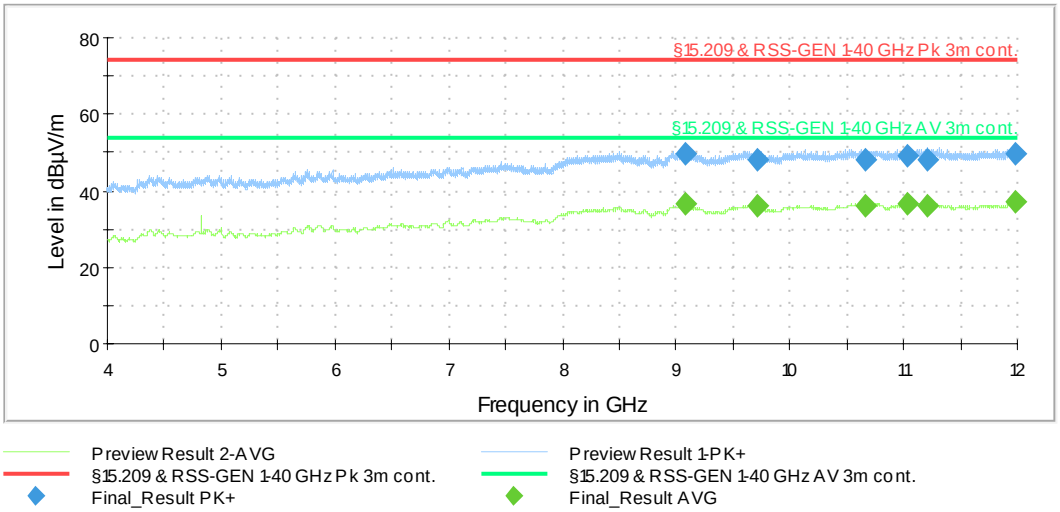
Test result: Passed

Worst case plots WLAN (802.11 – worst cases from original report):

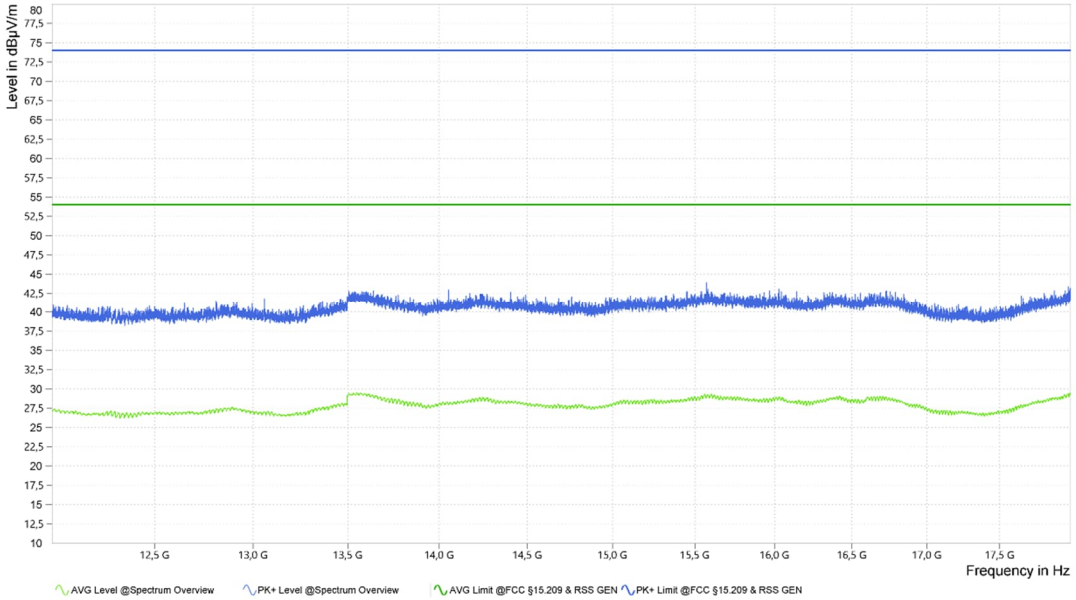
Spurious emissions from 1 GHz to 4 GHz (operation mode 13):



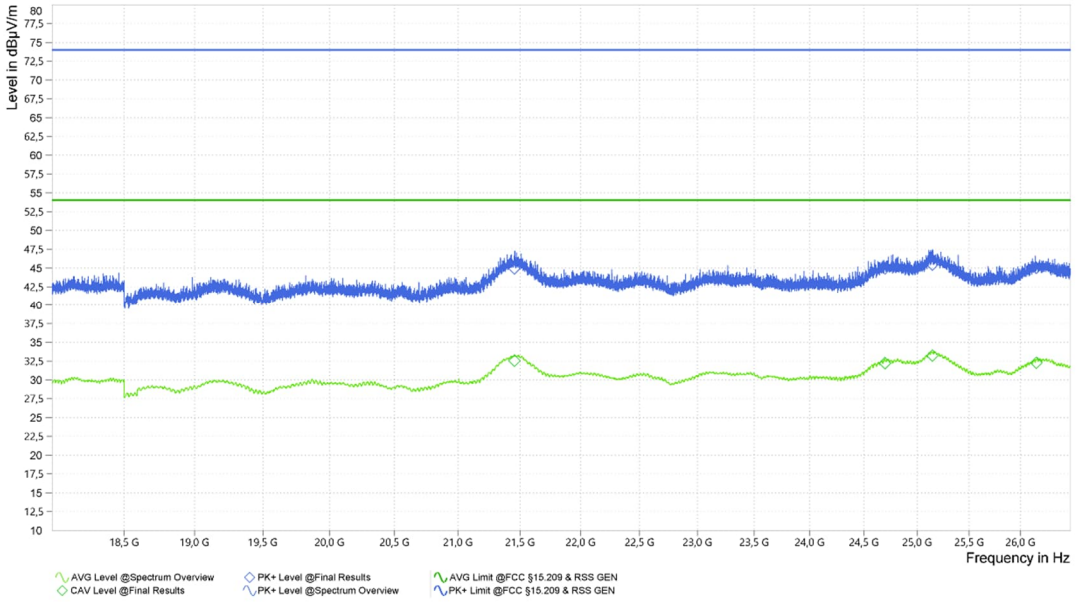
Spurious emissions from 4 GHz to 12 GHz (operation mode 13):



Spurious emissions from 12 GHz to 18 GHz (operation mode 13):



Spurious emissions from 18 GHz to 26.5 GHz (operation mode 13):



5.10.1.3.2 Result tables (802.11 – worst cases from original report)

Operation mode 13:

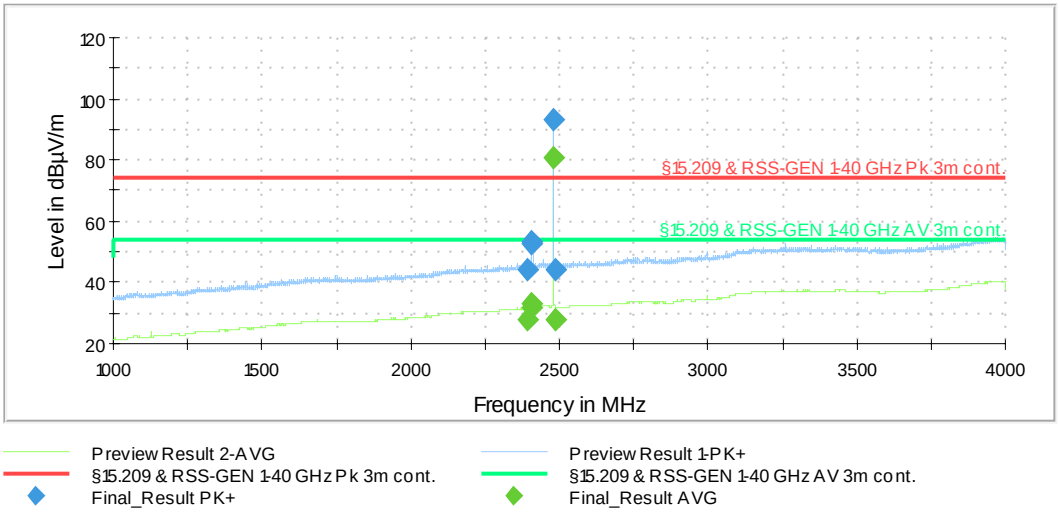
Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2390.000	46.9	---	74.0	27.1	H	147	120	33.4
2390.000	---	31.7	54.0	22.3	H	147	120	33.4
2483.500	43.9	---	74.0	30.1	H	195	0	33.6
2483.500	---	28.6	54.0	25.4	H	195	0	33.6
9080.250	49.9	---	74.0	24.1	V	76	150	8.6
9080.250	---	36.4	54.0	17.6	V	76	150	8.6
9717.750	48.2	---	74.0	25.8	V	132	120	7.4
9717.750	---	35.9	54.0	18.1	V	132	120	7.4
10660.250	47.9	---	74.0	26.1	V	352	120	7.1
10660.250	---	36.1	54.0	17.9	V	352	120	7.1
11040.250	---	36.5	54.0	17.5	V	155	150	7.4
11040.250	49.3	---	74.0	24.7	V	155	150	7.4
11214.500	48.0	---	74.0	26.0	H	201	120	7.0
11214.500	---	36.3	54.0	17.7	H	201	120	7.0
11980.500	---	36.9	54.0	17.1	H	94	30	6.6
11980.500	49.9	---	74.0	24.1	H	94	30	6.6

Frequency [MHz]	PK+ [dBµV/m]	Pk+ Limit [dBµV/m]	PK+ Margin [dB]	AV [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Corr. [dB/m]	Pol	Elevation [deg]	Azimuth [deg]
21454.500	44.9	74.0	29.1	32.6	54.0	21.4	11.4	V	120.0	28.7
24698.500	44.9	74.0	29.1	32.2	54.0	21.8	11.2	H	150.0	182.4
25147.500	45.5	74.0	28.6	33.2	54.0	20.8	11.5	V	150.0	187.9
26160.000	45.1	74.0	29.0	32.3	54.0	21.7	11.9	H	60.0	298.6

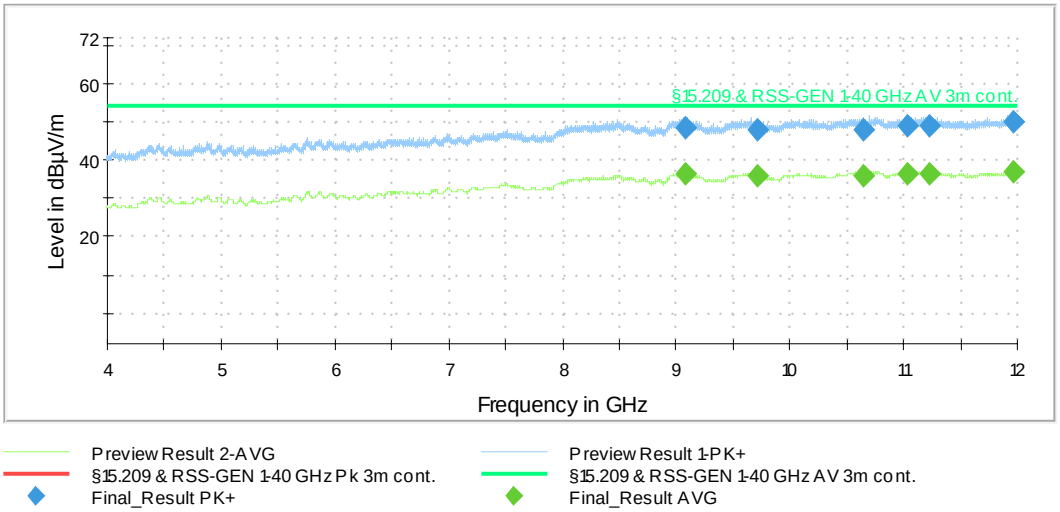
Test result: Passed

Worst case plots WLAN (BLE – worst cases from original report):

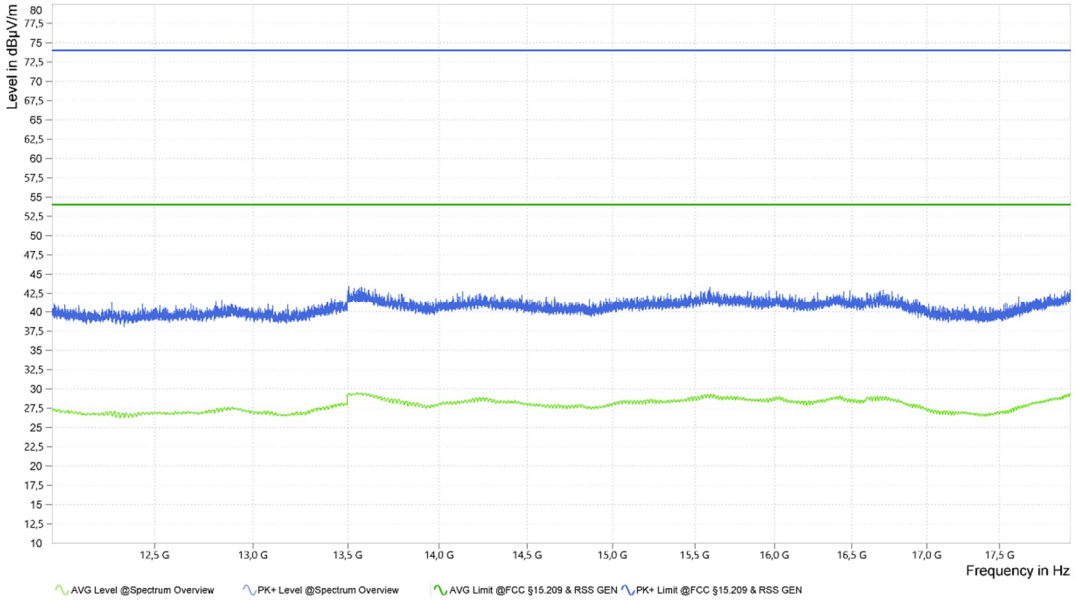
Spurious emissions from 1 GHz to 4 GHz (operation mode 20):



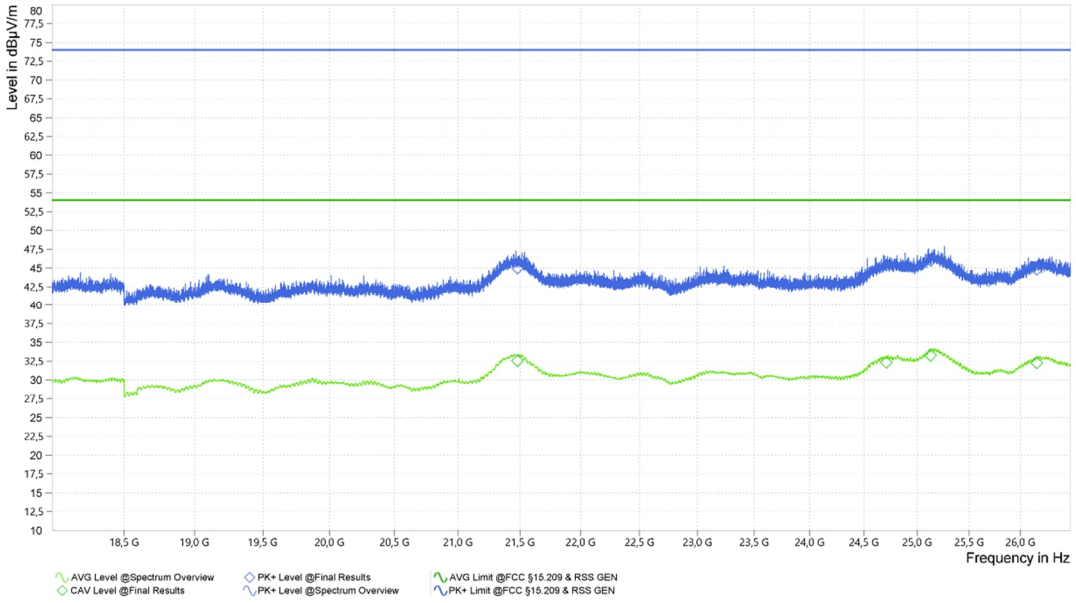
Spurious emissions from 4 GHz to 12 GHz (operation mode 20):



Spurious emissions from 12 GHz to 18 GHz (operation mode 20):



Spurious emissions from 18 GHz to 26.5 GHz (operation mode 20):



5.10.1.3.3 Result tables (BLE – worst cases from original report)

Operation mode 20:

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2390.000	43.9	---	74.0	30.1	H	32	60	33.4
2390.000	---	27.6	54.0	26.4	H	32	60	33.4
2408.250	---	32.0	54.0	22.0	V	165	0	33.5
2408.250	52.8	---	74.0	21.2	V	165	0	33.5
2409.000	53.2	---	74.0	20.8	V	160	30	33.5
2409.000	---	33.1	54.0	20.9	V	160	30	33.5
2480.000	---	80.7	Fund.	-	H	164	0	33.6
2480.000	93.0	---	Fund.	-	H	164	0	33.6
2483.500	---	28.1	54.0	25.9	V	208	150	33.6
2483.500	44.2	---	74.0	29.8	V	208	150	33.6
9075.500	---	36.4	54.0	17.6	V	35	0	8.6
9075.500	48.5	---	74.0	25.5	V	35	0	8.6
9720.250	---	35.8	54.0	18.2	V	353	0	7.4
9720.250	47.9	---	74.0	26.1	V	353	0	7.4
10640.250	---	36.1	54.0	17.9	V	134	0	7.0
10640.250	48.2	---	74.0	25.8	V	134	0	7.0
11030.750	---	36.4	54.0	17.6	V	252	0	7.4
11030.750	48.9	---	74.0	25.1	V	252	0	7.4
11232.750	49.1	---	74.0	24.9	V	296	0	7.0
11232.750	---	36.4	54.0	17.6	V	296	0	7.0
11961.000	50.0	---	74.0	24.0	V	116	0	6.5
11961.000	---	37.0	54.0	17.0	V	116	0	6.5

Frequency [MHz]	PK+ [dBµV/m]	Pk+ Limit [dBµV/m]	PK+ Margin [dB]	AV [dBµV/m]	AV Limit [dBµV/m]	AV Margin [dB]	Corr. [dB/m]	Pol	Elevation [deg]	Azimuth [deg]
21480.000	45.0	74.0	29.0	32.6	54.0	21.4	11.5	H	0.0	282.2
24710.250	45.4	74.0	28.6	32.3	54.0	21.7	11.3	H	30.0	39.1
25129.000	46.0	74.0	28.0	33.2	54.0	20.8	11.6	H	30.0	19.0
26164.750	44.8	74.0	29.2	32.3	54.0	21.7	11.9	H	90.0	25.1

Test result: Passed

Test equipment (please refer to chapter 7 for details)
3 – 9, 12 – 15, 22 - 34

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 18 – 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 18 – 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 Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	19.11.2021	11.2023
2	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	22.02.2022	02.2024
3	Testsoftware M276	Elektra V5.01	Rohde & Schwarz	101381	483755	Calibration not necessary	
4	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
5	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
6	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
7	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
8	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
9	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	08.12.2021	12.2023
10	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	18.03.2021	03.2024
11	Attenuator 6dB	WA-2	Weinschel Corp	BG0931	483499	Calibration not necessary	
12	Standard Gain Horn 20 dB, 12 GHz-18 GHz	18240-20	Flann	267220	483025	Calibration not necessary	
13	Standard Gain Horn 20 dB, 18 GHz -26 GHz	20240-20	Flann	266399	483026	Calibration not necessary	
14	Low Noise Amplifier 12 GHz – 12 GHz	LNA-30-12001800-13-10P	Narda Miteq	2173737	483430	18.02.2022	02.2024
15	Low Noise Amplifier 18 GHz - 26.5 GHz	LNA-30-18002650-20-10P	Narda Miteq	2110911	482969	18.02.2022	02.2024
16	Low Noise Amplifier 100 MHz - 18 GHz	LNA-30-00101800-25-10P	Narda Miteq	2110917	482967	18.02.2022	02.2024
18	Highpass Filter	WHK2.8/18G-10SS	Wainwright Instuments GmbH	1	480867	Calibration not necessary	
19	Power Meter	NRVD	Rohde & Schwarz	833697/030	480589	19.06.2023 30.04.2022	06.2024 04.2023
20	Power probe thermal	NRV-Z51	Rohde & Schwarz	825948/004	480247	21.06.2023 18.02.2022	06.2024 02.2022
21	Power probe thermal	NRV-Z51	Rohde & Schwarz	825948/003	480248	21.06.2023 15.02.2022	06.2024 02.2022
22	RF cable	SF 102	Huber+Suhner	510211/2	483032	Calibration not necessary	
23	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
24	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
25	Antenna support	AS620P	Deisel	620/375	480325	Calibration not necessary	
26	Multiple Control Unit	MCU	Maturo	MCU/043/971107	480832	Calibration not necessary	
27	Positioners	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
28	EMI Receiver /	ESW44	Rohde & Schwarz	101635	482467	22.02.2022	02.2024

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
	Spectrum Analyser						
29	RF cable	SF106B/11N/11N/4500.0	Huber & Suhner	500218/6B	482415	Calibration not necessary	
31	Testsoftware M20	EMC32 V10.6.2	Rohde & Schwarz	-	483261	Calibration not necessary	
32	Highpass Filter	WHK2.8/18G-10SS	Wainwright Instuments	1	480867	Calibration not necessary	
33	Preamplifier 100 MHz - 16 GHz	AFS6-00101600-23-10P-6-R	Narda MITEQ	2011215	482333	17.02.2022	02.2024
34	Log.Per Antenna 850 MHz - 26 GHz	HL050	Rohde&Schwarz	100977	483511	05.03.2021	03.2024

8 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 01.03.2023	02.03.2023 28.02.2025
Semi anechoic chamber M276	483227	1 -18 GHz	SVSWR	CISPR 16-1-4 Amd. 1	25.02.2021* 28.02.2023*	24.02.2023 27.03.2023
Fully anechoic chamber M20	480303	1 -18 GHz	SVSWR	CISPR 16-1-4 Amd. 1	17.08.2022	16.08.2024

* All tests were performed during a time period when the SVSWR for the anechoic chamber was valid.

9 Report History

Report Number	Date	Comment
F221817E1	04.03.2024	Initial Test Report
-	-	-

10 List of Annexes

Annex A Test Setup Photos 15 pages