PHOENIX TESTLAB

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Test Report

Report Number:

F220453E1

Equipment under Test (EUT):

TCC NGA Mid MY19

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

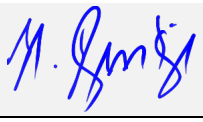
[3] **558074 D01 15.247 Meas Guidance v05r02 (April 2019),** GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES

[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

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 and written by:		Paul NEUFELD 04.07.2022
	Signature	
Reviewed and approved by:		Holger BENTJE 04.07.2022
	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:	Mr. Thomas DARGEL
Phone:	+49 5121 49-5599
eMail address:	Thomas.Dargel@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:	Mr. Thomas DARGEL
Phone:	+49 5121 49-5599
eMail address:	Thomas.Dargel@de.bosch.com
Manufacturer represented during the test by the following person:	

1.3 Test Laboratory

The tests were carried out by:

PHOENIX TESTLAB GmbH
Königswinkel 10
32825 Blomberg
Germany

Accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-06 and D-PL-17186-01-05, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment under Test)

Test object: *	Radios with Bluetooth for vehicular use (Trucks)
Model name: *	TCC NGA Mid MY19
Model number: *	7 620 002 029
Order number: *	-
FCC ID: *	2AUXS-TCCNGAMID
IC certification number: *	25847-TCCNGAMID
PMN: *	TCC NGA Mid MY19
HVIN: *	TCC NGA Mid MY19
FVIN: *	V0405

	EUT number		
	1 (temporary antenna connector)	2 (internal antenna)	3
Serial number: *	815CM2039K0000112	815CM2039K0000102	-
PCB identifier: *	Main PCB: 8 638 910 805 Switch PCB: 8 638 911 786 Supply Box PCB: 8 638 518 679	Main PCB: 8 638 910 805 Switch PCB: 8 638 911 786 Supply Box PCB: 8 638 518 679	-
Power settings set for the test:*2	43	44	
Hardware version: *	19/46	19/46	-
Software version: *	0103	0103	-

* Declared by the applicant
*2 The power settings were read from the EUTs power table as described in the test instruction provided by the applicant.

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

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

1.5 Technical Data of Equipment

General EUT data			
Power supply EUT: *	DC		
Supply voltage EUT: *	U_{nom}= 24.0 V_{DC}	U_{min}= 12.0 V_{DC}	U_{max}= 32.0 V_{DC}
Temperature range: *	-20°C to +70°C		
Lowest / highest internal clock frequency: *	32.768 kHz / 2480 MHz		

Ports / Connectors				
Identification	Connector		Length during test	Shielding (Yes / No)
	EUT	Ancillary		
USB (Front)	Type-A Plug	Not connected during test	n/a	n/a
Aux (Front)	headphone jack	Not connected during test	n/a	n/a
Aux (Rear)	headphone plug	Not connected during test	n/a	n/a
12 V switched out	-	Not connected during test	n/a	n/a
High Speed CAN	D-Sub plug	Not connected during test	n/a	n/a
Radio antenna	-	Not connected during test	n/a	n/a
Power supply (24 V)	Banana connector	Laboratory power supply	~ 3m	no
Speaker RF	Banana connector	Not connected during test	n/a	n/a
Speaker LF	Banana connector	Not connected during test	n/a	n/a
Ext mute	none	Not connected during test	n/a	n/a

Bluetooth® frequencies			
Channel 00	2402 MHz	Channel 01	2403 MHz
Channel 02	2404 MHz	Channel 03	2405 MHz
…	…	…	…
…	…	…	…
Channel 37	2439 MHz	Channel 38	2440 MHz
…	…	…	…
…	…	…	…
Channel 75	2477 MHz	Channel 76	2478 MHz
Channel 77	2479 MHz	Channel 78	2480 MHz

Bluetooth® radio mode		
Fulfils radio specification: *	Bluetooth 2.0 (Bluetooth classic + EDR)	
Radio module: *	ALPS UGZZ8	
Antenna type: *	SMD Chip Antenna	
Antenna name: *	TDK	
Antenna gain: *	1.6 dBi	
Antenna connector: *	None (temporary for the tests of this report)	
Supply voltage WLAN module: *	U_{nom} = -- VDC	U_{min} = 3.0 VDC U_{max} = 3.6 VDC
Type of modulation: *	BT (1 Mbps PHY)	GFSK
	BT (2 Mbps PHY)	π/4-DQPSK
	BT (3 Mbps PHY)	8DPSK
Operating frequency range: *	BT (1 Mbps PHY)	2402 – 2480 MHz
	BT (2 Mbps PHY)	2402 – 2480 MHz
	BT (3 Mbps PHY)	2402 – 2480 MHz
Number of channels: *	BT (1 Mbps PHY)	79 (1 MHz channel spacing)
	BT (2 Mbps PHY)	79 (1 MHz channel spacing)
	BT (3 Mbps PHY)	79 (1 MHz channel spacing)

* As declared by the applicant.

1.5.1 Ancillary Equipment / Equipment used for testing

Equipment used for testing	
DC power supply: *2	Power Supply TOE8752-32 (DC) (PM. No. 480009)
USB fibre optic converter: *2	Opto USB2.0, MK Messtechnik (PM. No. 482617)
Laptop PC: *2	Fujitsu S26391-K326-V110 (PM. No. 200784)
USB to serial converter cable: *1	TTL-232R-3V3
Car radio: *1	AGCO HIGH (For the purpose of unblocking Daimler radios)

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

Ancillary Equipment	
Connector: *1	Mains connector

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

1.6 Dates

Date of receipt of test sample:	29.03.2022
Start of test:	20.04.2022
End of test:	16.05.2022

2 Operational States

2.1 Description of function of the EUT

The EUT is a car radio with Bluetooth classic + EDR (Bluetooth 2.0) for integration in trucks.

For the test a USB to RS-232 converter-cable, which was provided by the applicant, was connected to a laptop computer. As described by the applicant the CSR Bluesuite software was installed on the test laptop, to activate the test-mode on the EUT. The value set for the internal PA was read from the EUT using the test software in the radio power table. The power read from the power table in the EUT was set for the following radio tests. During the tests, the EUT was supplied with +24.0 V DC

2.1.1 Operation modes

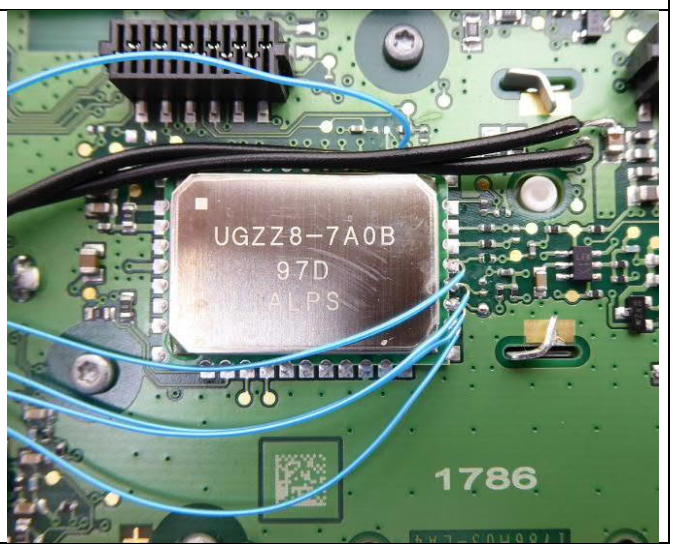
Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate	Power setting
1	Bluetooth©	2402	0	GFSK	1 Mbit/s	+4 dBm
2	Bluetooth©	2440	38	GFSK	1 Mbit/s	+4 dBm
3	Bluetooth©	2480	78	GFSK	1 Mbit/s	+4 dBm
4	Bluetooth©	2402	0	π/4-DQPSK	2 Mbit/s	+4 dBm
5	Bluetooth©	2440	38	π/4-DQPSK	2 Mbit/s	+4 dBm
6	Bluetooth©	2480	78	π/4-DQPSK	2 Mbit/s	+4 dBm
7	Bluetooth©	2402	0	8DPSK	3 Mbit/s	+4 dBm
8	Bluetooth©	2440	38	8DPSK	3 Mbit/s	+4 dBm
9	Bluetooth©	2480	78	8DPSK	3 Mbit/s	+4 dBm
10	Bluetooth©	2402 - 2480	0 - 78	GFSK	1 Mbit/s	+4 dBm
11	Bluetooth©	2402 - 2480	0 - 78	π/4-DQPSK	2 Mbit/s	+4 dBm
12	Bluetooth©	2402 - 2480	0 - 78	8DPSK	3 Mbit/s	+4 dBm

The maximum output power of the Radio chip is +4 dBm (typical)

3 Additional Information

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

For the tests, the EUTs were modified as shown below:

Antenna port conducted tests with temporary antenna connector	Radiated tests
	

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [4] RSS-Gen [5]	Tested EUT	Status
Maximum peak conducted output power	2400.0 - 2483.5	15.247 (b) (1)	5.4 (b) [4]	1	Passed
20 dB bandwidth	2400.0 - 2483.5	15.247 (a) (1)	5.1 (a) [4]	1	Passed
Carrier frequency separation	2400.0 - 2483.5	15.247 (a) (1)	5.1 (b) [4]	1	Passed
Number of hopping channels	2400.0 - 2483.5	15.247 (a) (1) (iii)	5.1 (d) [4]	1	Passed
Dwell time	2400.0 - 2483.5	15.247 (a) (1) (iii)	5.1 (d) [4]	1	Passed
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [4]	1, 2	Passed
Maximum unwanted emissions	0.009 – 26,500*	15.247 (d) 15.205 (a) 15.209 (a)	8.9 [5]	1, 2	Passed*
Antenna requirement	-	15.203 15.247 (b)	6.8 [5] 5.4 (f) (ii) [4]	1	Passed
Conducted emissions on supply line	0.15 – 30	15.207 (a)	8.8 [5]	Not tested*2	-

*: As declared by the applicant the highest radio clock frequency is 2.480 GHz.
Therefore, the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency in this case 26.500 GHz.

*2 Not tested, because the EUT will only be implemented in automotive environments and not be connected to the public power grid.

5 Results

5.1 Test setups

5.1.1 Radiated: 9 kHz to 30 MHz

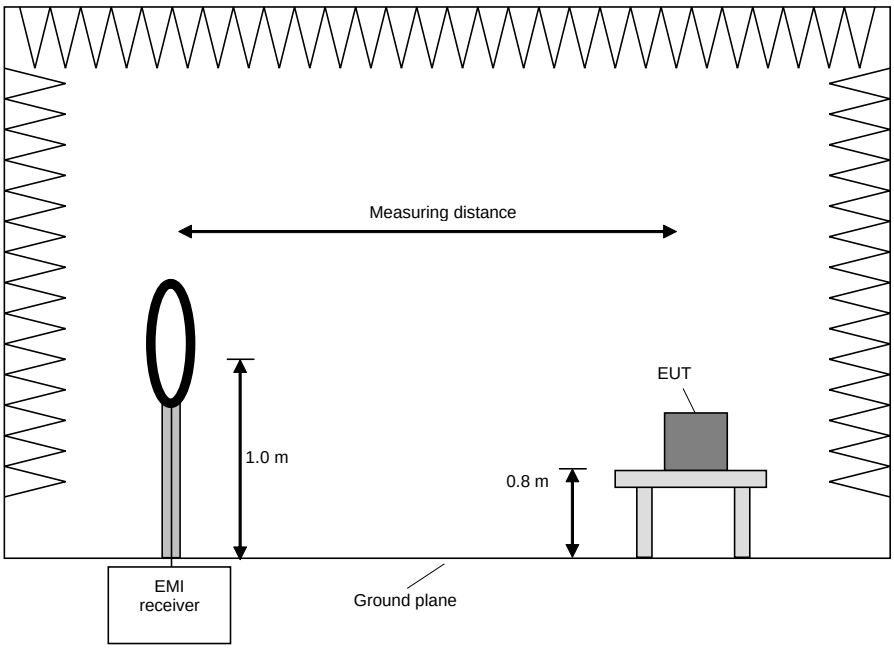
5.1.1.1 Preliminary measurement 9 kHz to 30 MHz

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

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

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

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



Procedure preliminary measurement:

Pre-scans are performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.
The following procedure is used:

1) Monitor the frequency range with the measuring antenna facing the EUT and an EUT / turntable azimuth of 0 °.
2) Manipulate the system cables to produce the maximum levels of emissions.
3) Rotate the EUT by 360 ° to maximize the detected signals.
4) Measure the frequencies of the highest detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency values.
5) If the EUT is portable or ceiling mounted, repeat steps 1 to 4 with other orientations (x,y,z) of the EUT.
6) Rotate the measuring antenna and repeat steps 1 to 5.

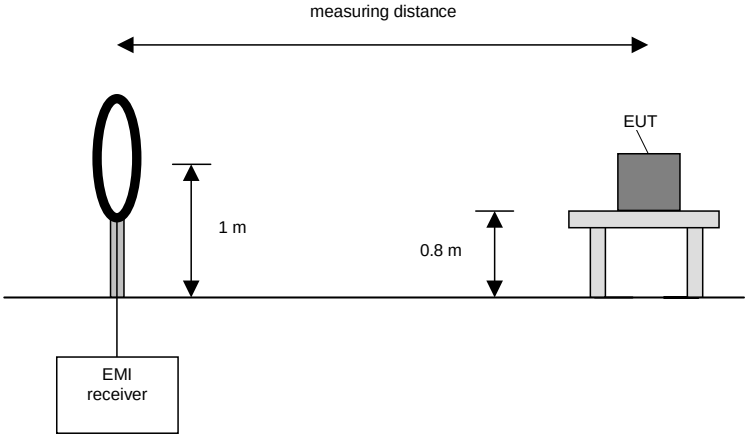
5.1.1.2 Final measurement 9 kHz to 30 MHz

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

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

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

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



Procedure final measurement:

The following procedure is used:

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

5.1.2 Radiated: 30 MHz to 1 GHz

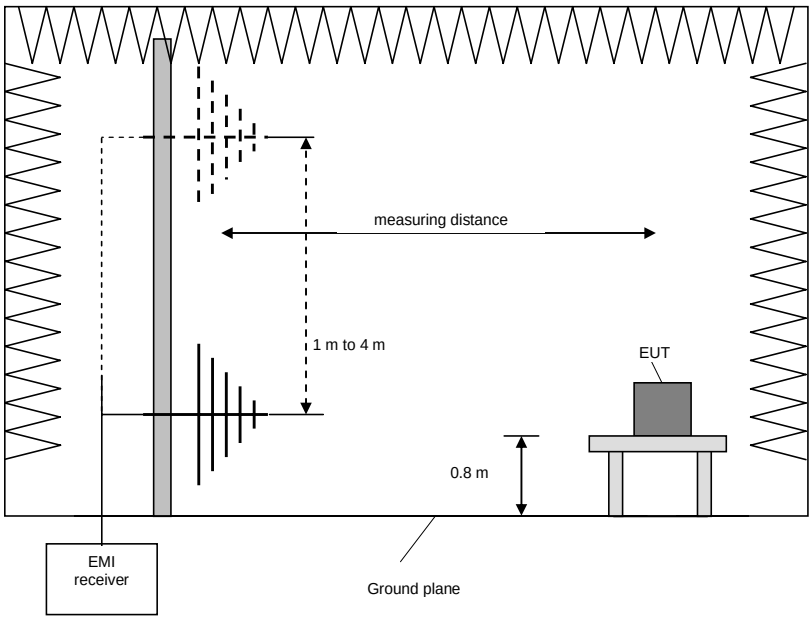
5.1.2.1 Preliminary and final measurement 30 MHz to 1 GHz

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

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

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

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



Procedure preliminary measurement:

The following procedure is used:

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

Procedure final measurement:

The following procedure is used:

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

5.1.3 Radiated: 1 GHz to 40 GHz

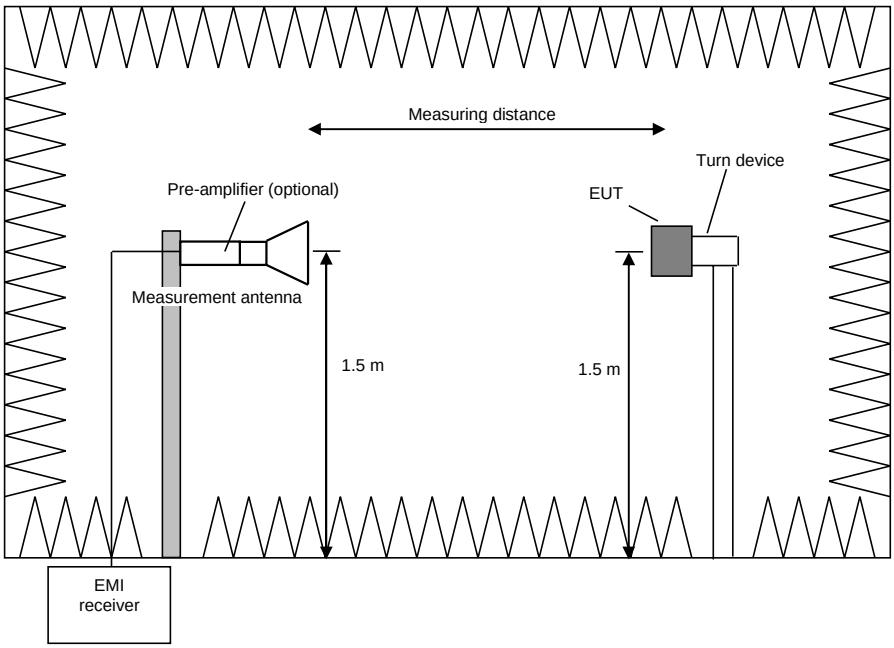
5.1.3.1 Preliminary and final measurement 1 GHz to 40 GHz

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

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

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

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



Procedure preliminary measurement:

The following procedure is used:

1) Monitor the frequency range at horizontal polarisation of the measuring antenna and an EUT / turntable azimuth of 0 °.
2) Rotate the EUT by 360° to maximize the detected signals.
3) Repeat steps 1 to 2 with the vertical polarisation of the measuring antenna.
4) Repeat steps 1 to 3 with the EUT reorientated by an angle of 30° (60°, 90°, 120° and 150°), according to 6.6.5.4 in [1].
5) The highest values for each frequency are saved by the software, including the measuring antenna polarization, the turntable azimuth and the turn device elevation for that value.

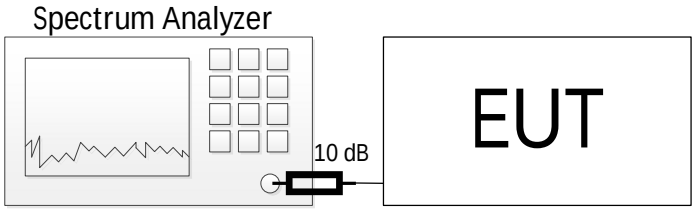
Procedure final measurement:

The following procedure is used:

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

5.1.4 Conducted: Antenna port

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



The 10 dB external attenuation are considered in all relevant plots

5.2 Duty cycle

5.2.1 Test setup (Duty cycle)

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

5.2.2 Test method (Duty cycle)

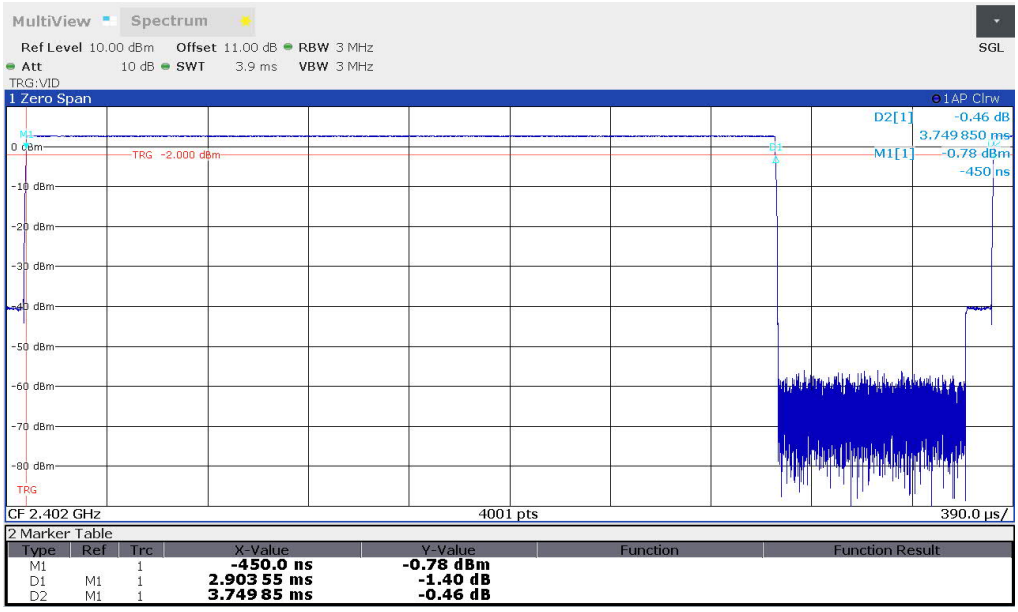
Test method (Duty cycle)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☐	11.6. a)	Diode detector	No limitation	-
☒	11.6. b)	Zero span	No limitation	-

5.2.3 Test results (Duty cycle)

Ambient temperature:	22 °C
Relative humidity:	28 %

Date:	20.04.2022
Tested by:	P. NEUFELD

Worst case plot (operation mode 1):



Operation Mode #	TX_{on} [µs]	TX_{Cycle} [µs]	RBW [MHz]	50/T [kHz]	50/T < RBW?
1 - 3	2.904	3.750	3	17.220	☒
4 - 7	2.917	3.751	3	17.140	☒
8 – 11	2.916	3.751	3	17.145	☒

Operation Mode #	Sweep points	Sweep time [µs]	Meas points	Meas points >100?	Duty cycle %	DCCF [dB]
1 - 3	4001	3.9	2978	☒	0.774	1.1
4 - 7	4001	3.9	2992	☒	0.778	1.1
8 – 11	4001	3.9	2991	☒	0.777	1.1

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

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

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

For average measurements a correction factor of 1.1 dB is used for all tests.

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

5.3 Transmit antenna performance considerations

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

5.4 20 dB bandwidth

5.4.1 Test setup (20 dB bandwidth)

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

5.4.2 Test method (20 dB bandwidth)

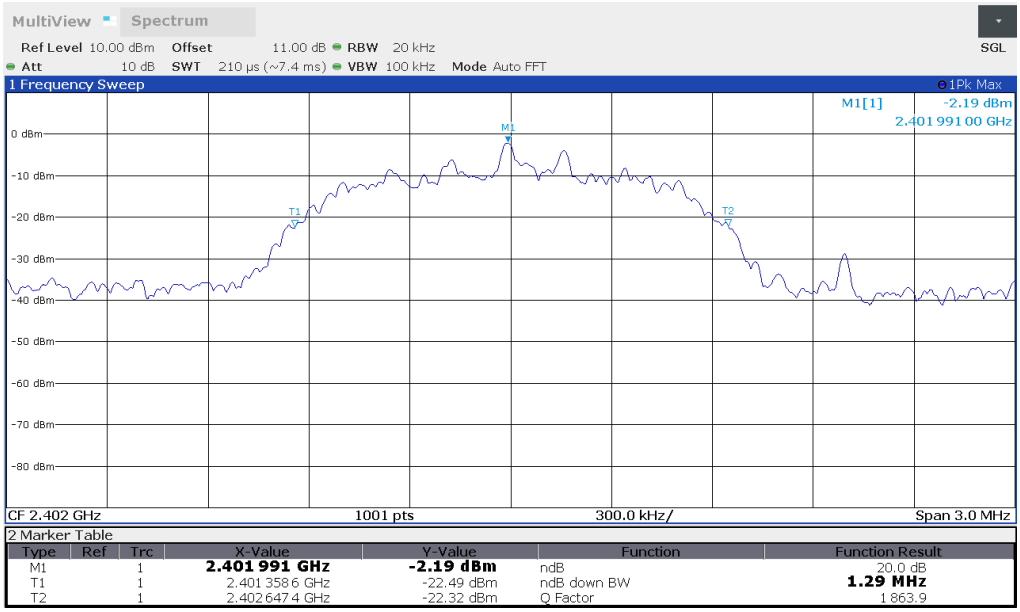
Test method (20 dB bandwidth)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	6.9.2	Occupied bandwidth - relative measurement procedure	No limitations	-

5.4.3 Test results (20 dB bandwidth)

Ambient temperature:	22 °C
Relative humidity:	28 %

Date:	20.04.2022
Tested by:	P. NEUFELD

Worst case plot (operation mode 4):



Operation mode #	20 dB bandwidth [MHz]
1	0.8117
2	0.8092
3	0.8092
4	**1.2887**
5	1.2647
6	1.2527
7	1.2378
8	1.2348
9	1.2138

Test result: Passed

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

5.5 Occupied bandwidth – power bandwidth (99%)

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

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

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

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

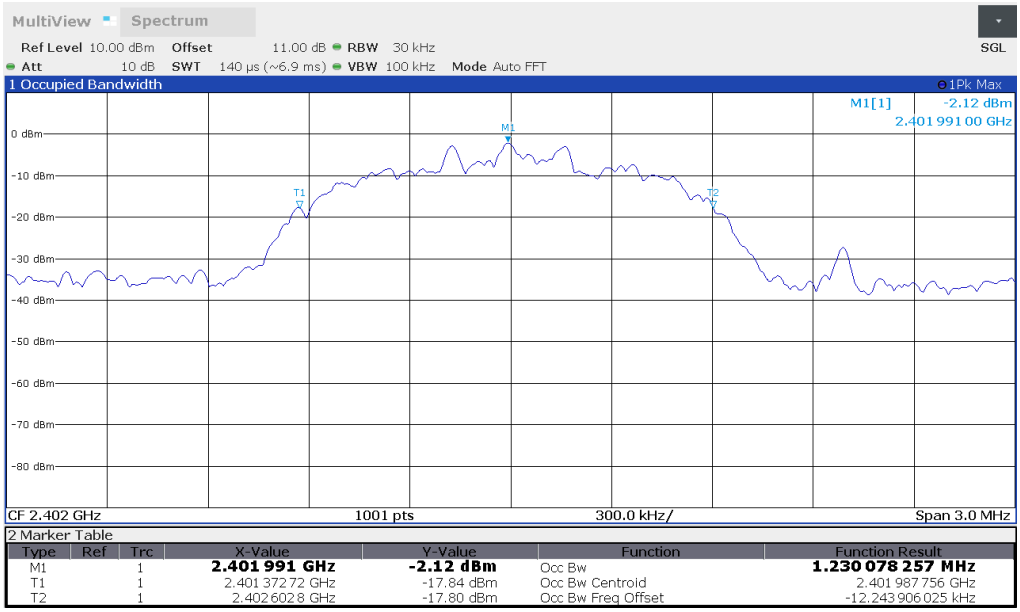
*1 See RSS-GEN Issue 5 (2018-05) sub-clause 6.7 for details.

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

Ambient temperature:	22 °C
Relative humidity:	28 %

Date:	20.04.2022
Tested by:	P. NEUFELD

Worst case plot (operation mode 7):



Operation mode #	99% bandwidth [MHz]
1	0.8819
2	0.8822
3	0.8805
4	1.2298
5	1.2083
6	1.1932
7	**1.2301**
8	1.2112
9	1.1920

Test result: Passed

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

5.6 Carrier frequency separation

5.6.1 Test setup (Carrier frequency separation)

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

5.6.2 Test method (Carrier frequency separation)

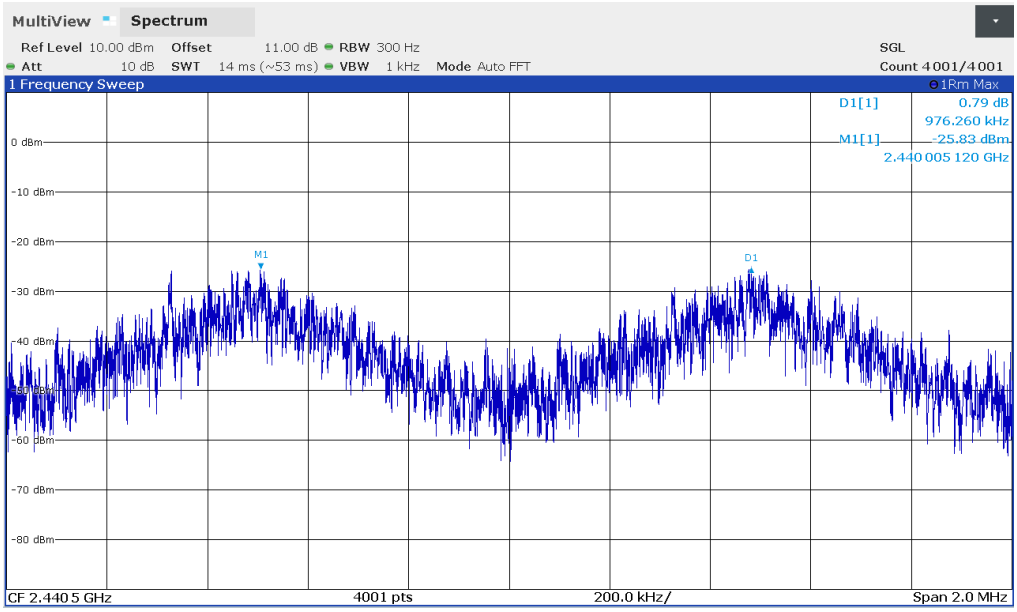
Test method (Carrier frequency separation)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	7.8.2	Carrier frequency separation	EUT hopping	-

5.6.3 Test results (Carrier frequency separation)

Ambient temperature:	22 °C
Relative humidity:	28 %

Date:	20.04.2022
Tested by:	P. NEUFELD

Worst case plot (operation mode 10):



Operation mode	Channel frequency [MHz]	Channel Separation* [kHz]	Minimum limit*2 [kHz]
10	2402	1043.240	859.134
10	2441	**976.260**	859.134
10	2480	993.750	859.134

* The test will be performed with the EUT transmitting with GFSK or 1 Mbps. When transmitting with the higher modulations, the channel separation cannot be determined on the plot of the spectrum analyser.
*2 The worst-case limit occurs for the modulation with the highest 20 dB bandwidth, which is π/4 DPSK modulation or 2 Mbps. Limit is 2/3 * 20 dB BW.

Test result: Passed

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

5.7 Number of hopping frequencies

5.7.1 Test setup (Number of hopping frequencies)

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

5.7.2 Test method (Number of hopping frequencies)

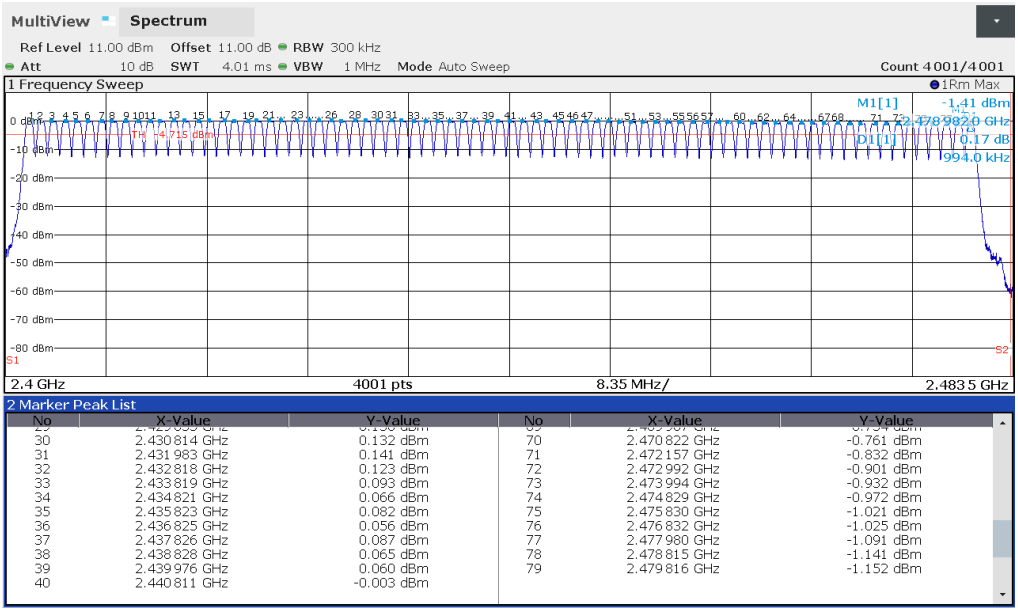
Test method (Number of hopping frequencies)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	7.8.3	Number of hopping frequencies	EUT hopping	-

5.7.3 Test results (Number of hopping frequencies)

Ambient temperature:	22 °C
Relative humidity:	28 %

Date:	20.04.2022
Tested by:	P. NEUFELD

Worst case plot (operation mode 10):



No	X-Value	Y-Value	No	X-Value	Y-Value
30	2.430 814 GHz	0.132 dBm	70	2.470 822 GHz	-0.761 dBm
31	2.431 983 GHz	0.141 dBm	71	2.472 157 GHz	-0.832 dBm
32	2.432 818 GHz	0.123 dBm	72	2.472 992 GHz	-0.901 dBm
33	2.433 819 GHz	0.093 dBm	73	2.473 994 GHz	-0.932 dBm
34	2.434 821 GHz	0.066 dBm	74	2.474 829 GHz	-0.972 dBm
35	2.435 823 GHz	0.082 dBm	75	2.475 830 GHz	-1.021 dBm
36	2.436 825 GHz	0.056 dBm	76	2.476 832 GHz	-1.025 dBm
37	2.437 826 GHz	0.087 dBm	77	2.477 980 GHz	-1.091 dBm
38	2.438 828 GHz	0.065 dBm	78	2.478 815 GHz	-1.141 dBm
39	2.439 976 GHz	0.060 dBm	79	2.479 816 GHz	-1.152 dBm
40	2.440 811 GHz	-0.003 dBm			

Number of hopping frequencies*	Limit (minimum)
79	15

* Since the number of hopping frequencies does not depend on the modulation, only one modulation is tested. The number of channels can only be seen, when the EUT transmits with 1 Mbps, because the Bluetooth channels overlap with 2 and 3 Mbps data rates.

Test result: Passed

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

5.8 Time of occupancy (dwell time)

5.8.1 Test setup (Time of occupancy (dwell time))

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

5.8.2 Test method (Time of occupancy (dwell time))

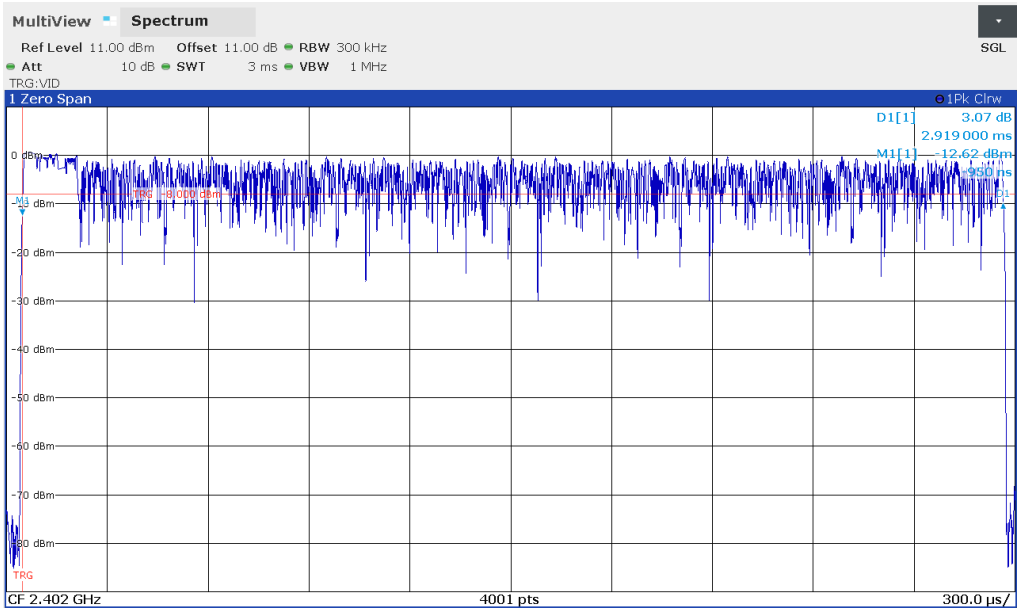
Test method (Time of occupancy (dwell time))				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	7.8.4	Time of occupancy (dwell time)	EUT hopping	-

5.8.3 Test results (Time of occupancy (dwell time))

Ambient temperature:	22 °C
Relative humidity:	28 %

Date:	20.04.2022
Tested by:	P. NEUFELD

Worst case plot (operation mode 12):



Operation mode	Paket type	Worst case Hopping channels	Hops / second	Transmit time / hop [ms]	Tx On / 1s* [ms]	Limit Tx On / s [ms]
10	DH5	15	106.67	2.908	310.196	400
11	2DH5	15	106.67	2.918	311.263	400
12	3DH5	15	106.67	2.919	**311.370**	400

Max Tx time for a single Bluetooth slot (1 hop): 625 µs.
Maximum Bluetooth TX rate on 1 channel: DH5 packet (5 TX slots) followed by one RX slot of 625.
Worst case number of hops per second (625 µs per hop -> 1 s / 625 µs): 1600
Hops per second on one single channel when hopping equally distributed on 79 channels (1600/79): 20.25
Hops per second on one single channel when hopping equally distributed on 15 channels (1600/15): 106.67
Tx On / 1s* = Hops / second * Transmit time / hop [ms]

*Transmit time on a single channel in 1 second in milliseconds

Test result: Passed

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

5.9 FHS fundamental emission output power

5.9.1 Test setup (FHS fundamental emission output power)

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

5.9.2 Test method (FHS fundamental emission output power)

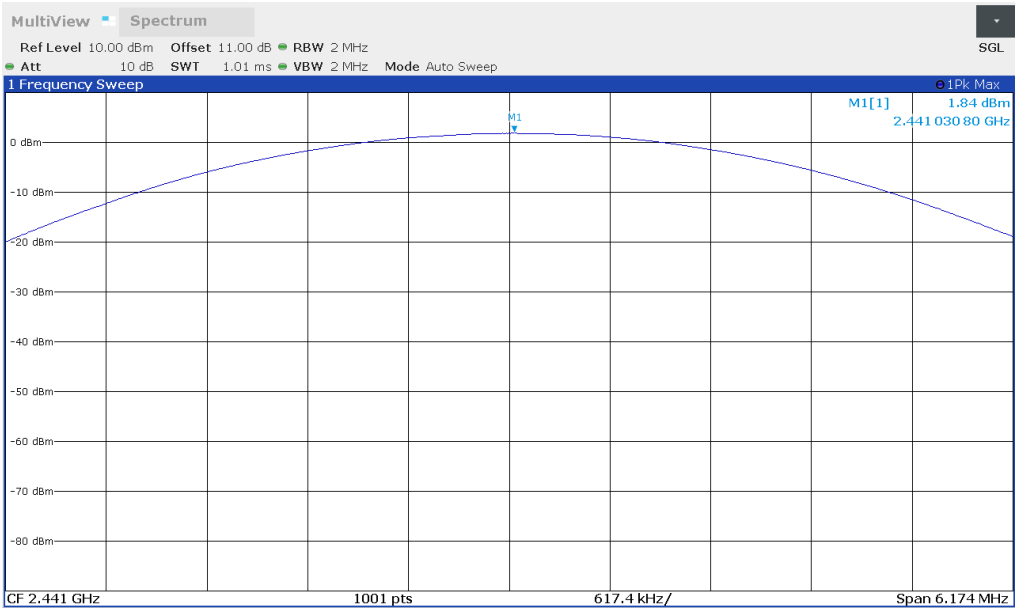
Test method (FHS fundamental emissions output power)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	7.8.5	Output power test procedure for frequency-hopping spread-spectrum (FHSS) devices	No limitations	-

5.9.3 Test results (FHS fundamental emission output power)

Ambient temperature:	22 °C
Relative humidity:	28 %

Date:	20.04.2022
Tested by:	P. NEUFELD

Worst case plot (operation mode 8):



Operation mode	Reading [dBm]	Corr. Fact.* [dB]	Result [dBm]	Limit [dBm]	Result
1	0.2	0.0	0.2	30	Passed
2	0.2	0.0	0.2	30	Passed
3	-0.9	0.0	-0.9	30	Passed
4	1.4	0.0	1.4	30	Passed
5	1.6	0.0	1.6	30	Passed
6	0.7	0.0	0.7	30	Passed
7	1.6	0.0	1.6	30	Passed
8	**1.8**	0.0	**1.8**	30	Passed
9	1.0	0.0	1.0	30	Passed

* The attenuation of the external attenuator and the antenna cable were considered as offset for the displayed emission level.

Test result: Passed

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

5.10 FHS band-edge emission measurements

5.10.1 Test setup (Band edge – unrestricted bands)

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

5.10.2 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

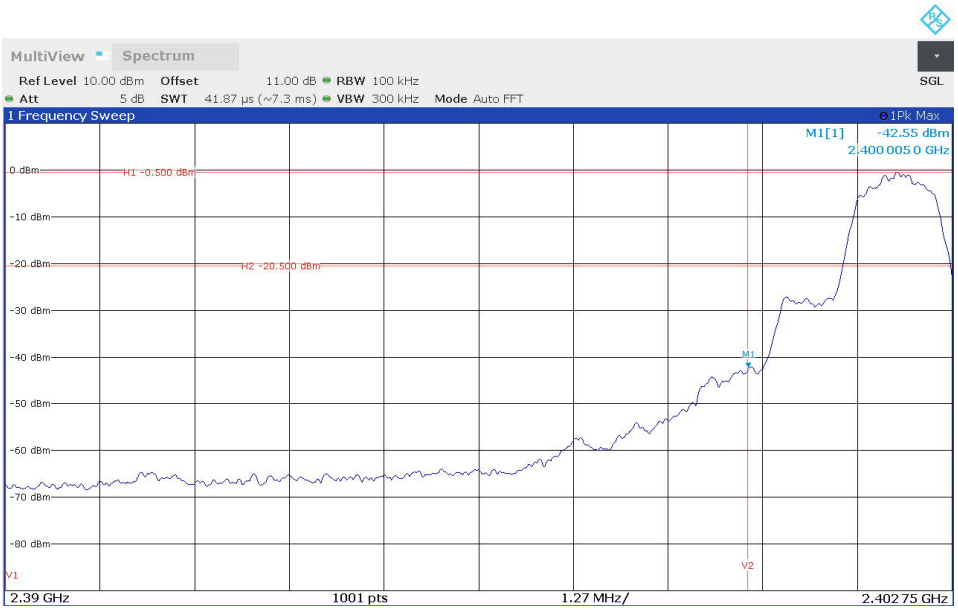
*2 If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

5.10.3 Test results (Band edge – unrestricted bands)

Ambient temperature:	22 °C
Relative humidity:	28 %

Date:	20.04.2022
Tested by:	P. NEUFELD

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



Lower band edges:

Operation mode	Frequency [MHz]	Reference [dBm]	Limit [dBm]	Unrestricted band emission [dBm]	Margin [dB]
1	2399.98	-0.5	-20.5	-46.1	25.6
10	2400.000	-0.8	-20.8	-50.6	29.8
4	2400.000	-0.5	-20.5	**-42.5**	**22.0**
11	2399.865	-2.1	-22.1	-45.9	23.8
7	2399.75	-0.7	-20.7	-45.2	24.5
12	2399.776	-0.7	-20.7	-45.2	24.5

Test result: Passed

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

5.10.4 Test setup (Band edge – restricted bands)

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

5.10.5 Test method (Band edge – restricted bands)

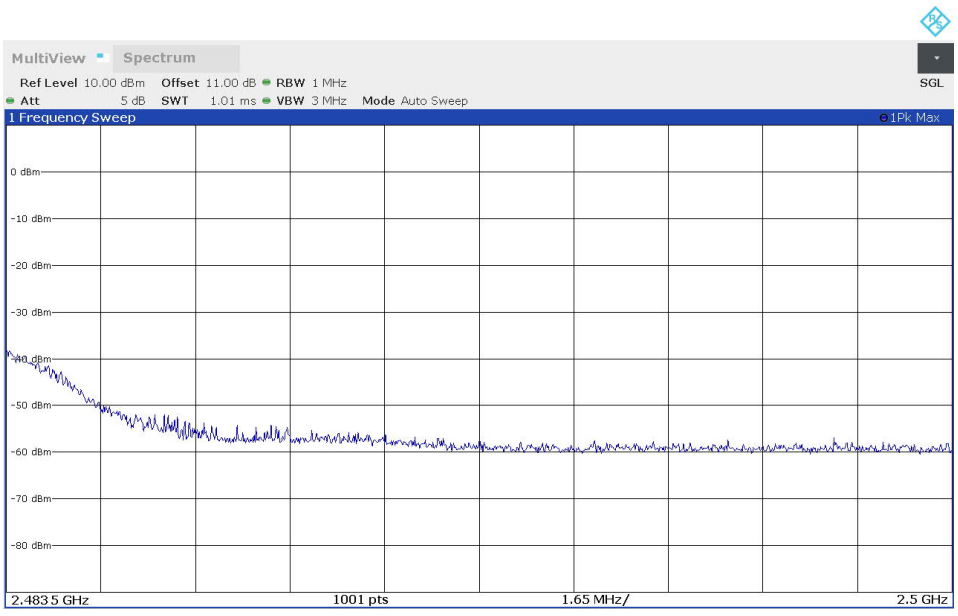
Test method (Band edge – restricted bands)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	11.13.1	Standard method	No limitations	
☐	11.13.2	Marker-delta method		See 6.10.6 [3]
☐	11.13.3.2	Peak detection	Not for DTS testing	2 MHz from band
☐	11.13.3.3	Trace averaging with cont. EUT	D ≥ 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

5.10.6 Test results (Band edge – restricted bands – antenna port conducted)

Ambient temperature:	22 °C
Relative humidity:	28 %

Date:	20.04.2022
Tested by:	P. NEUFELD

Worst case plot upper band edge (operation mode 9):



Operation Mode	PK Frequency [MHz]	PK Level [dBm]	PK Level [dBµV/m]	Corr. Number Antenna Ports [dB]	Antenna gain [dBi]	Peak level corrected [dBµV/m]	Limit [dB(µV/m)]	Margin [dB]
1	2375.7995	-56.6	38.6	0.0	0.0	38.6	74	35.4
3	2483.5000	-52.3	43.0	0.0	0.0	43.0	74	31.0
4	2375.9542	-56.7	38.5	0.0	0.0	38.5	74	35.5
6	2483.5000	-38.1	57.1	0.0	0.0	57.1	74	16.9
7	2375.9642	-56.5	38.8	0.0	0.0	38.8	74	35.2
9	2483.5000	-39.1	56.1	0.0	0.0	56.1	74	17.9
10_LBe	2388.0918	-58.0	37.2	0.0	0.0	37.2	74	36.8
10_HBe	2483.5000	-49.5	45.7	0.0	0.0	45.7	74	28.3
11_LBe	2389.1910	-58.0	37.3	0.0	0.0	37.3	74	36.7
11_HBe	2483.5011	-44.0	51.3	0.0	0.0	51.3	74	22.7
12_LBe	2389.8702	-57.4	37.9	0.0	0.0	37.9	74	36.1
12_HBe	2483.5000	-42.3	53	0.0	0.0	53.0	74	21.0

Operation Mode	AV Frequency [MHz]	AV Level [dBm]	AV Level [dBµV/m]	Corr. Number Antenna Ports [dB]	Antenna gain [dBi]	DC Corr. [dB]	AV level corrected [dBµV/m]	Limit [dB(µV/m)]	Margin [dB]
1	2375.9943	-62.9	32.3	0.0	0.0	1.1	33.4	54	20.6
3	2483.5000	-62.3	33.0	0.0	0.0	1.1	34.1	54	19.9
4	2376.0091	-63.6	31.7	0.0	0.0	1.1	32.8	54	21.2
6	2483.5080	-49.3	46.0	0.0	0.0	1.1	47.1	54	6.9
7	2375.9941	-63.7	31.6	0.0	0.0	1.1	32.7	54	21.3
9	2483.5000	-48.4	46.9	0.0	0.0	1.1	**48.0**	54	**6.0**
10_LBe	2386.5433	-72.4	22.8	0.0	0.0	1.1	23.9	54	30.1
10_HBe	2483.5001	-71.2	24.1	0.0	0.0	1.1	25.2	54	28.8
11_LBe	2390.0002	-73.2	22.1	0.0	0.0	1.1	23.2	54	30.8
11_HBe	2483.5011	-66.8	28.5	0.0	0.0	1.1	29.6	54	24.4
12_LBe	2388.2618	-73.5	21.8	0.0	0.0	1.1	22.9	54	31.1
12_HBe	2483.9526	-67.7	27.6	0.0	0.0	1.1	28.7	54	25.3

Test result: Passed

LBe: Lower band-edge
HBe: Higher band-edge

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

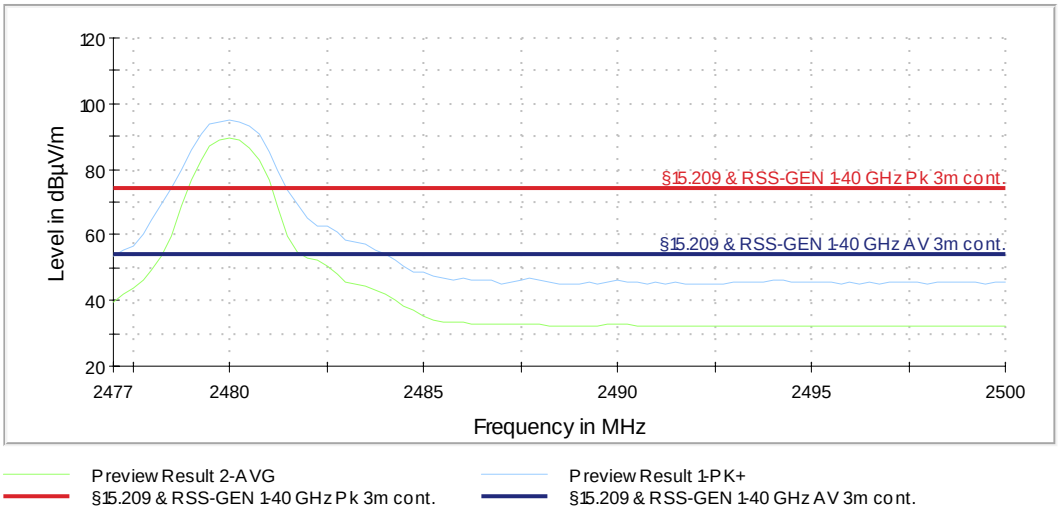
5.10.7 Test results (Band edge – restricted bands - radiated)

Ambient temperature:	22 °C
Relative humidity:	28 %

Date:	21.04.2022
Tested by:	P. NEUFELD

Only the worst-case band-edge emission from the antenna port conducted tests in 5.10.6 was repeated as radiated test.

Worst case plot upper band edge (operation mode 9):



Operation Mode	Frequency [MHz]	MaxPeak [dB(µV/m)]	Average [dB(µV/m)]	Limit [dB(µV/m)]	Margin [dB(µV/m)]	Pol [H/V]	Azimuth [deg]	Elevation [deg]	Corr. [dB]
9	2483.500	---	43.47	54.00	10.53	V	13.0	30.0	33.6
9	2483.500	57.22	---	74.00	16.78	V	13.0	30.0	33.6

Test result: Passed

Test equipment (please refer to chapter 7 for details)
5 – 7, 11 -15

5.11 Radiated emissions

5.11.1 Test setup (Maximum unwanted emissions)

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

5.11.2 Test method (Maximum unwanted emissions)

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

5.11.3 Test results (Maximum unwanted emissions)

5.11.3.1 Test results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	22 °C
Relative humidity:	35 %

Date:	25.04.2022
Tested by:	P. NEUFELD

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: The EUT was tested in normal position (lying). Since no difference was found when changing modulation/channel, only an exemplary plot is shown below.

Calculations:

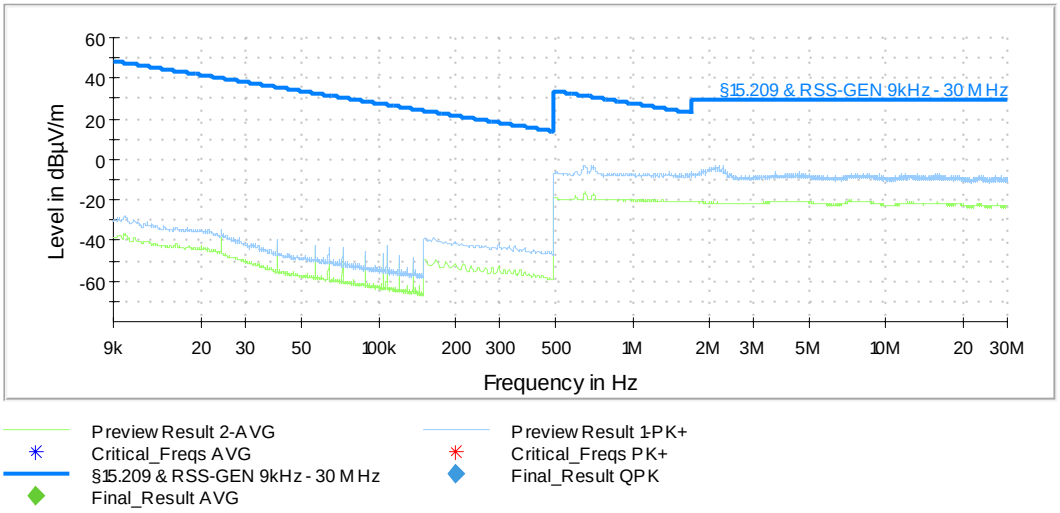
Result @ norm. dist. [dBµV/m] = Reading [dBµV] + AF [dB/m] + Distance corr. fact. [dBµV/m]

Result @ norm. dist. [dBµA/m] = Result @ norm. dist. [dBµV/m] – 20 x $\log_{10}$ (377 Ω)

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

Worst case plot:

Spurious emissions from 9 kHz to 30 MHz (operation mode 2 – lying):



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

Test equipment (please refer to chapter 7 for details)
19 – 25, 28

5.11.3.2 Test results (30 MHz – 1 GHz)

Ambient temperature:	22 °C
Relative humidity:	34 %

Date:	22.04.2022
Tested by:	P. NEUFELD

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: EUT was only tested in the normal position (lying)

Calculations:

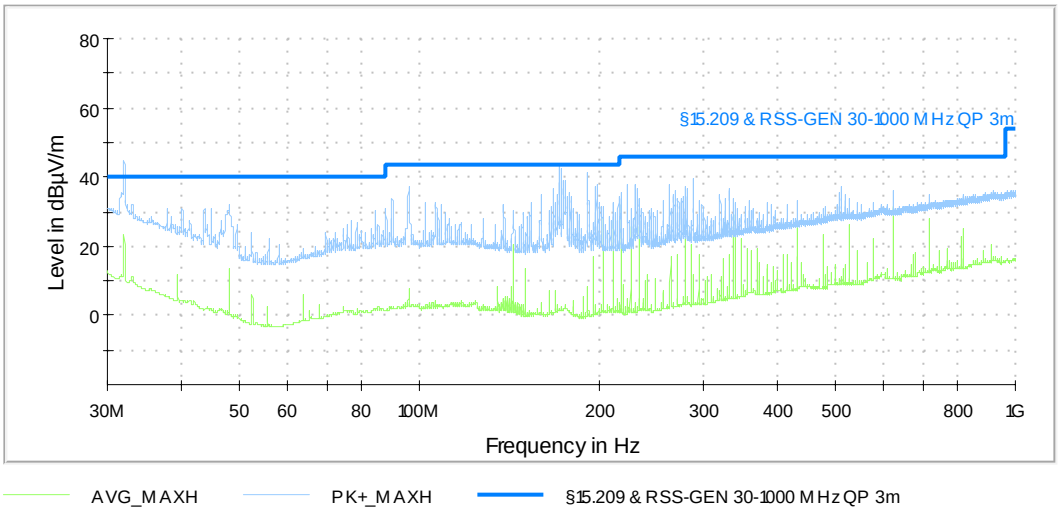
Result [dBµV/m] = Reading [dBµV] + Correction [dBµV/m]

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

Margin [dB] = Limit [dBµV/m] - Result [dBµV/m]

Worst case plot:

Spurious emissions from 30 MHz to 1 GHz (operation mode 2 – Pos 1):



Result tables:

Operation mode 1:

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol. (H/V)	Position #
32.000	38.8	40.0	1.2	14.1	24.8	102.0	107	V	1
160.000	32.3	43.5	11.2	16.9	15.3	176.0	100	H	1
192.000	31.3	43.5	12.3	16.1	15.2	129.0	105	H	1
224.000	38.6	46.0	7.5	22.4	16.2	153.0	179	V	1
230.410	16.7	46.0	29.3	-0.1	16.8	112.0	173	V	1
256.000	31.1	46.0	14.9	13.5	17.6	109.0	127	H	1

Operation mode 2:

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol. (H/V)	Position #
32.000	39.4	40.0	0.6	14.7	24.8	118.0	292	V	1
96.000	22.1	43.5	21.5	4.9	17.1	101.0	252	V	1
171.630	12.1	43.5	31.4	-3.9	16.0	101.0	160	V	1
172.860	12.4	43.5	31.2	-3.8	16.2	103.0	185	V	1
174.530	14.7	43.5	28.8	-1.7	16.4	207.0	112	H	1
192.000	35.9	43.5	7.7	20.7	15.2	109.0	202	V	1

Operation mode 3:

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol. (H/V)	Position #
32.000	37.3	40.0	2.7	12.5	24.8	120.0	-11	V	1
192.000	35.2	43.5	8.3	20.1	15.2	158.0	121	H	1
197.760	21.0	43.5	22.6	5.7	15.3	163.0	123	H	1
198.420	21.1	43.5	22.4	5.7	15.4	136.0	290	H	1
199.950	18.7	43.5	24.8	3.0	15.7	123.0	113	H	1
215.880	18.1	43.5	25.4	1.9	16.2	103.0	247	H	1

Test result: Passed

Test equipment (please refer to chapter 7 for details)
20 – 28

5.11.3.3 Test results (radiated 1 GHz to 40 GHz)

Ambient temperature:	22 °C
Relative humidity:	28 – 39 %

Date:	20-22.04.2022
Tested by:	P. NEUFELD

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: Antenna port conducted pre-tests showed, that the worst case emissions occurred when the EUT transmits in GFSK mode with 1 Mbps.

No emissions > 12 GHz were found during the radiated tests. The worst-case emissions in the frequency 4 – 12 GHz were found for operation mode 2. Therefore, the plots of operation mode 2 were used for the frequency range > 12 GHz.

Calculation:

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

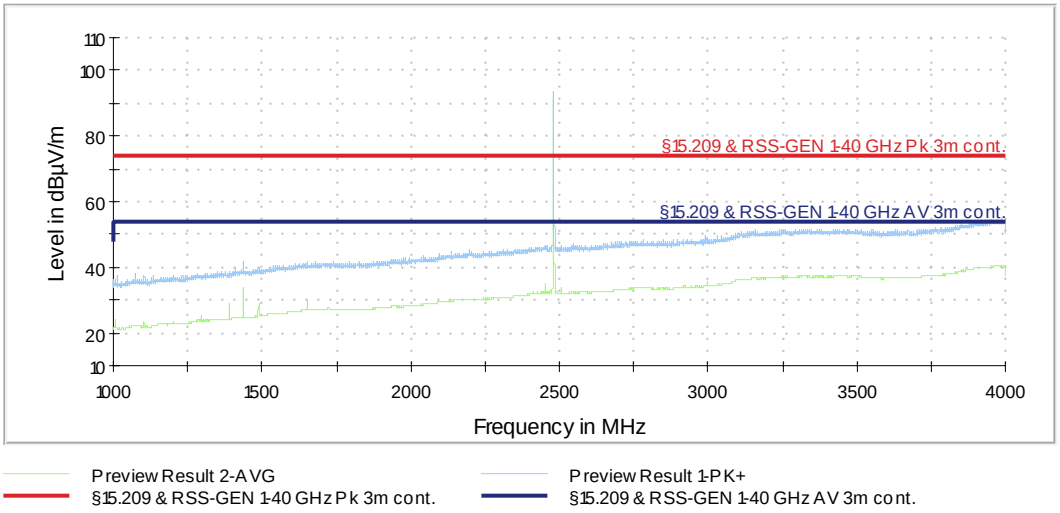
Average [dBµV/m] = Reading [dBµV] + Correction [dBµV/m]

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

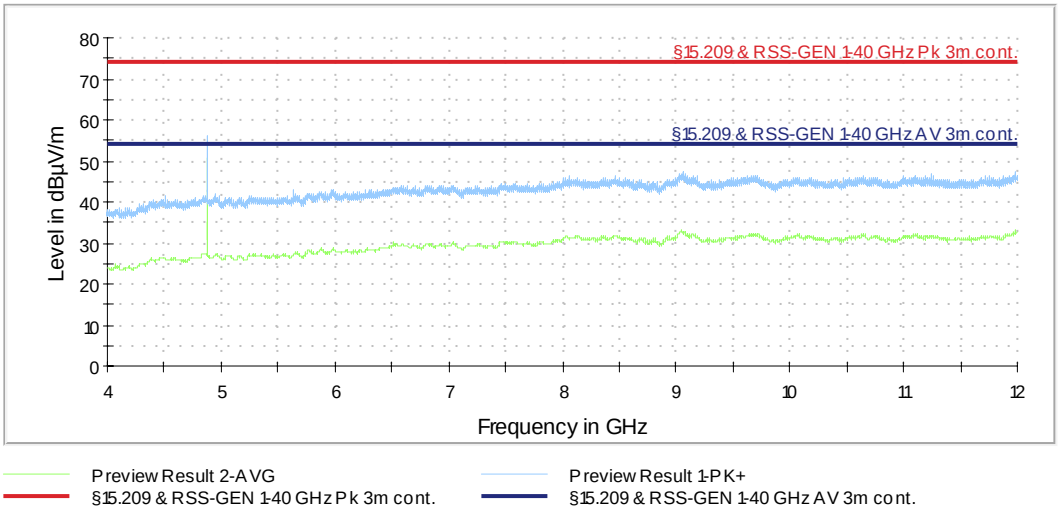
Margin [dB] = Limit [dBµV/m] – Max Peak | Average [dBµV/m]

Worst case plots:

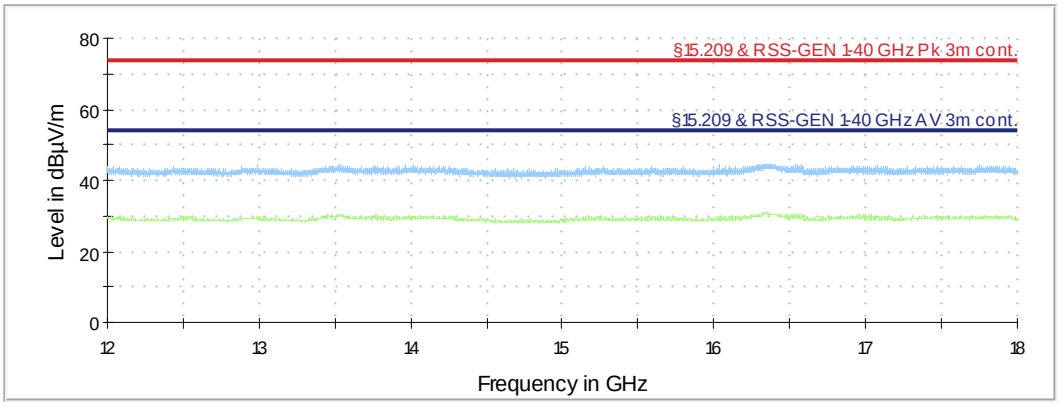
Spurious emissions from 1 GHz to 4 GHz (operation mode 3):



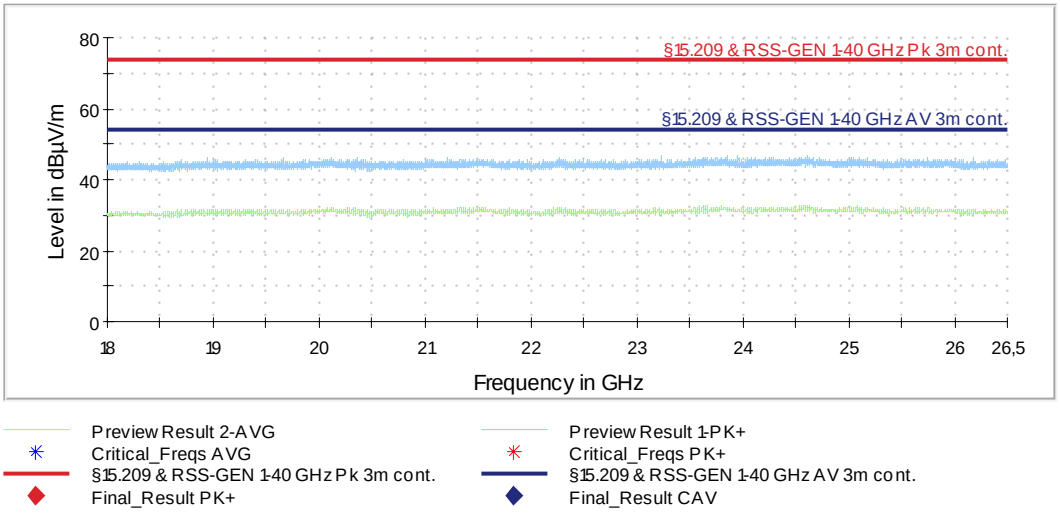
Spurious emissions from 4 GHz to 12 GHz (operation mode 2):



Spurious emissions from 12 GHz to 18 GHz (operation mode 2):



Spurious emissions from 18 GHz to 26.5 GHz (operation mode 2):



Result tables:

Operation mode 1:

Frequency [MHz]	MaxPeak [dB(µV/m)]	Average [dB(µV/m)]	Limit [dB(µV/m)]	Margin [dB(µV/m)]	Pol [H/V]	Azimuth [deg]	Elevation [deg]	Corr. [dB]
1436.000	41.47	---	74.0	32.5	H	339	90	28.0
1436.000	---	35.03	54.0	19.0	H	339	90	28.0
1602.000	41.82	---	74.0	32.2	H	119	0	29.3
1602.000	---	34.43	54.0	19.6	H	119	0	29.3
2376.000	43.90	---	74.0	30.1	H	30	150	33.2
2376.000	---	28.62	54.0	25.4	H	30	150	33.2
2386.000	---	28.61	54.0	25.4	H	240	150	33.3
2386.000	43.31	---	74.0	30.7	H	240	150	33.3
2402.000	95.32	---	Fund.	-	H	342	120	33.5
2402.000	---	93.67	Fund.	-	H	342	120	33.5
4804.000	---	45.81	54.0	8.2	V	-3	90	-1.8
4804.000	50.40	---	74.0	23.6	V	-3	90	-1.8
6408.000	---	30.72	54.0	23.3	H	244	30	2.0
6408.000	41.42	---	74.0	32.6	H	244	30	2.0

Operation mode 2:

Frequency [MHz]	MaxPeak [dB(µV/m)]	Average [dB(µV/m)]	Limit [dB(µV/m)]	Margin [dB(µV/m)]	Pol [H/V]	Azimuth [deg]	Elevation [deg]	Corr. [dB]
1436.000	---	33.81	54.0	20.2	H	28	90	28.0
1436.000	40.84	---	74.0	33.2	H	28	90	28.0
2441.000	94.84	---	Fund.	-	V	97	30	33.8
2441.000	---	93.25	Fund.	-	V	97	30	33.8
2997.250	45.93	---	74.0	28.1	V	352	0	35.4
2997.250	---	31.86	54.0	22.1	V	352	0	35.4
4882.000	---	52.42	54.0	1.6	H	144	150	-1.4
4882.000	56.52	---	74.0	17.5	H	144	150	-1.4

Operation mode 3:

Frequency [MHz]	MaxPeak [dB(µV/m)]	Average [dB(µV/m)]	Limit [dB(µV/m)]	Margin [dB(µV/m)]	Pol [H/V]	Azimuth [deg]	Elevation [deg]	Corr. [dB]
1436.000	---	32.83	54.0	21.2	V	17	0	28.0
1436.000	40.71	---	74.0	33.3	V	17	0	28.0
2480.000	---	92.09	Fund.	-	V	28	60	33.6
2480.000	93.72	---	Fund.	-	V	28	60	33.6
2483.500	---	38.31	54.0	15.7	V	18	60	33.6
2483.500	52.15	---	74.0	21.9	V	18	60	33.6
2484.000	---	34.72	54.0	19.3	V	2	60	33.6
2484.000	49.09	---	74.0	24.9	V	2	60	33.6
2997.750	---	31.86	54.0	22.1	V	158	90	35.4
2997.750	46.82	---	74.0	27.2	V	158	90	35.4
4960.000	---	50.31	54.0	3.7	H	146	150	-1.5
4960.000	55.51	---	74.0	18.5	H	146	150	-1.5
6616.000	---	31.79	54.0	22.2	H	352	90	2.8
6616.000	42.70	---	74.0	31.3	H	352	90	2.8

Test result: Passed

Test equipment (please refer to chapter 7 for details)
2 - 18

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	11.2022
2	standard gain horn antenna	18240-20	Flann Microwave	483	480294	Calibration not necessary	
3	standard gain horn antenna	20240-20	Flann Microwave	411	480297	Calibration not necessary	
4	Microwave cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800-KPS	480302	Calibration not necessary	
5	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
6	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
7	Antenna support	AS620P	Deisel	620/375	480325	Calibration not necessary	
8	Preamplifier 100 MHz - 13 GHz	JS3-00101200-23-5A	MITEQ Hauppauge N.Y.	681851	480337	17.02.2022	02.2024
9	Preamplifier 18 GHz - 26 GHz	JS4-18002600-20-5A	MITEQ Hauppauge N.Y.	658697	480342	17.02.2022	02.2024
10	Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ Hauppauge N.Y.	571667	480343	17.02.2022	02.2024
11	RF-cable No.3	Sucoflex 106B	Suhner	0563/6B / Kabel 3	480670	Calibration not necessary	
12	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/971107	480832	Calibration not necessary	
13	Antenna (Log.Per.)	HL050	Rohde & Schwarz	100438	481170	Calibration not necessary	
14	RF-Cable No. 40	Sucoflex 106B	Suhner	0708/6B / Kabel 40	481330	Calibration not necessary	
15	Testsoftware	EMC32	Rohde & Schwarz		483261	Calibration not necessary	
16	Highpass Filter	WHK2.8/18G-10SS	Wainwright Instuments GmbH	1	480867	Calibration not necessary	
17	Positioners	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
18	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	22.02.2022	02.2024
19	loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	22.02.2022	02.2024
20	Software	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
21	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
22	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
23	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
24	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
25	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	08.12.2021	12.2023
26	Attenuator 6 dB	WA2-6	Weinschel	8254	410119	Calibration not necessary	
27	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	18.03.2021	03.2024
28	Antennasupport	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	

8 Test site Verification

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA/RSM	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	03.03.2021	02.03.2023
Fully anechoic chamber M20	480303	1 -18 GHz	SVSWR	CISPR 16-1-4 Amd. 1	18.08.2020	17.08.2022

9 Report History

Report Number	Date	Comment
F220453E1	04.07.2022	Initial Test Report
-	-	-
-	-	-

10 List of Annexes

Annex A	Test Setup Photos	9 pages
Annex B	EUT External Photos*1*2	6 pages
Annex C	EUT Internal Photos*3	7 pages

*1 Most photographs were provided by the applicant
*2 The photograph of side view 2 was shot with an EUT which was modified for the radio tests.
*3 All internal photographs were provided by the applicant.