

Test Report

Report Number:

F221817E2

Equipment under Test (EUT):

CTP3NA

Applicant:

Robert Bosch GmbH

Manufacturer:

Robert Bosch GmbH



Deutsche
Akkreditierungsstelle
D-PL-17186-01-01
D-PL-17186-01-02
D-PL-17186-01-03

References

- [1] **ANSI C63.10-2013**, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15**, Radio Frequency Devices
- [3] **558074 D01 15.247 Meas Guidance v05r02 (April 2019)**, GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES
- [4] **RSS-247, Issue 2 (2017-02)** Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- [5] **RSS-Gen, Issue 5 (2021-02)** General Requirements for Compliance of Radio Apparatus

Test Result

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

Signature

Tested and written
by:

Signature

Reviewed and
approved by:

Signature

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

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1 Identification

1.1 Applicant

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

1.5 EUT (Equipment under Test)

EUT	
Test object: *	Telematic Control Unit
Model name: *	CTP3NA
Model number: *	CTP3NA Ext
Order number: *	NA
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: *	3047-05	-	-
Hardware version: *	C2	-	-
Software version: *	DAIMLER_CTP3_HIGHPOINT_RC2_S.006	-	-

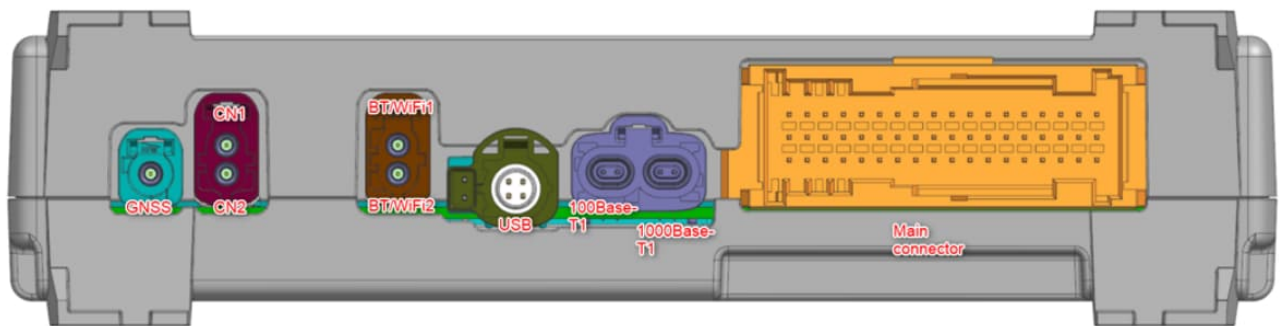
* Declared by the applicant

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

Bluetooth® classic + EDR frequencies			
Channel 00	2402 MHz	Channel 01	2403 MHz
Channel 02	2404 MHz	Channel 03	2405 MHz
...
...
Channel 38	2440 MHz	Channel 39	2441 MHz
...
...
Channel 75	2476 MHz	Channel 76	2478 MHz
Channel 77	2479 MHz	Channel 78	2480 MHz

Bluetooth® classic + EDR radio mode		
Fulfil radio specification: *	Bluetooth® classic + EDR 5.2	
Radio module: *	LGIT ATC6NPL002	
FCC ID (radio module):	YZP-ATC6NPL002	
IC ID (radio module):	7414C-ATC6NPL002	
Type of modulation: *	BT classic (1 Mbps PHY)	GFSK
	BT EDR (2 Mbps PHY)	$\pi/4$ DPSK
	BT EDR (3 Mbps PHY)	8DPSK
Operating frequency range: *	BT classic (1 Mbps PHY)	2402 – 2480 MHz
	BT EDR (2 Mbps PHY)	2402 – 2480 MHz
	BT EDR (3 Mbps PHY)	2402 – 2480 MHz
Number of channels: *	BT classic (1 Mbps PHY)	79 (1 MHz channel spacing)
	BT EDR (2 Mbps PHY)	79 (1 MHz channel spacing)
	BT EDR (3 Mbps PHY)	79 (1 MHz channel spacing)

* Declared by the applicant

*² Bluetooth® Classic only uses one antenna

*³ The minimum cable length and the associated cable attenuation were 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 ^{*3}	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)
No combined antenna gain, because Bluetooth only uses one antenna port simultaneously.			

* The radiated tests were performed using the A 006 820 32 75 antenna on antenna port BT/Wifi 2, because Bluetooth only operates only on this antenna port.

^{*2} The minimum cable length and the associated cable attenuation were declared by the applicant.

^{*3} The theoretical worst case antenna gain will be used for all antenna port conducted measurements (antenna A 006 820 39 75).

1.6.1 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	
-	-

1.7 Dates

Date of receipt of test sample:	30.03.2023
Start of test:	30.03.2023
End of test:	04.07.2023

2 Operational States

2.1 Description of function of the EUT

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 WiFi.

This test report contains the test results for the Bluetooth classic part of the EUT.

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.

2.2 Operation modes

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Hopping on/off	Modulation / Mode	Data rate	Power setting
1	Bluetooth® classic	2402	00	off	GFSK	1 Mbit/s	5
2	Bluetooth® classic	2441	39	off	GFSK	1 Mbit/s	5
3	Bluetooth® classic	2480	78	off	GFSK	1 Mbit/s	5
4	Bluetooth® EDR	2402	00	off	8DPSK	3 Mbit/s	5
5	Bluetooth® EDR	2480	78	off	8DPSK	3 Mbit/s	5

* Output power was fix and could not be set in the test software

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 in BT classic 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
20 dB bandwidth	2400.0 - 2483.5	15.247 (a) (1)	5.1 (a) [4]	Not tested*	-
99% bandwidth	2400.0 - 2483.5	-	6.7 [5]	Not tested*	-
Carrier frequency separation	2400.0 - 2483.5	15.247 (a) (1)	5.1 (b) [4]	Not tested*	-
Number of hopping channels	2400.0 - 2483.5	15.247 (a) (1) (iii)	5.1 (d) [4]	Not tested*	-
Dwell time	2400.0 - 2483.5	15.247 (a) (1) (iii)	5.1 (d) [4]	Not tested*	-
Maximum peak output power	2400.0 - 2483.5	15.247 (b) (1)	5.4 (b) [4]	1	Passed* ³
Band edge compliance	2400.0 - 2483.5	15.247 (d)	5.5 [4]	1	Passed* ³
Maximum unwanted emissions	0.009 - 26,500*	15.205 (a)	5.5 [4]	1	Passed* ^{1*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	15.209 (a)	8.8 [5]	-	n/a* ²⁻

* Not tested, because not ordered by the applicant.

*1 As declared by the applicant the highest radio clock frequency is 2.48 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 the worst case tests from the original report OT-223-RWD-041 by LG Innotek Co.,Ltd. were tested.

5 Results

5.1 Test setup

5.1.1 Test Setup (radiated)

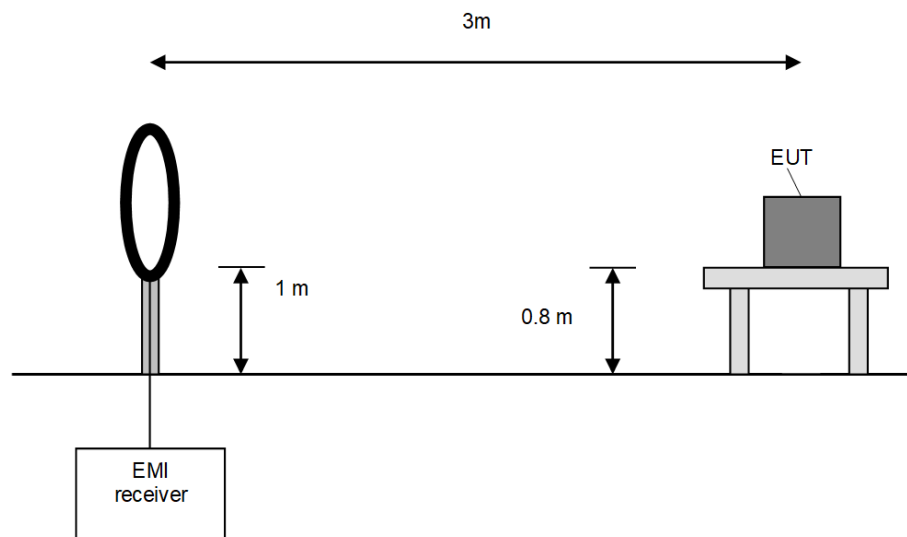
5.1.1.1 Preliminary and final measurement 9 kHz to 30 MHz

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.

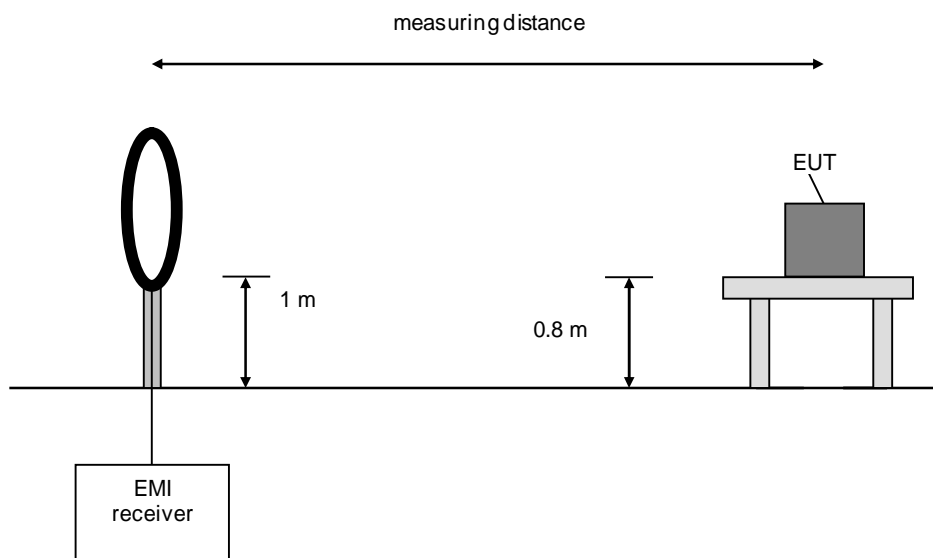
Final measurement 9 kHz to 30 MHz

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

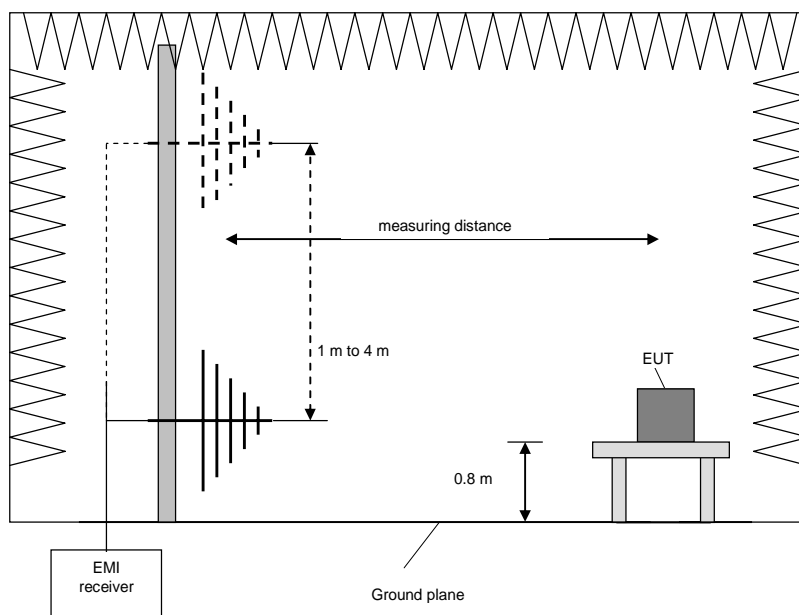
5.1.1.2 Preliminary and final measurement 30 MHz to 1 GHz

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.

5.1.1.3 Preliminary and final measurement > 1 GHz (Normal procedure 6.6.4 in [1])

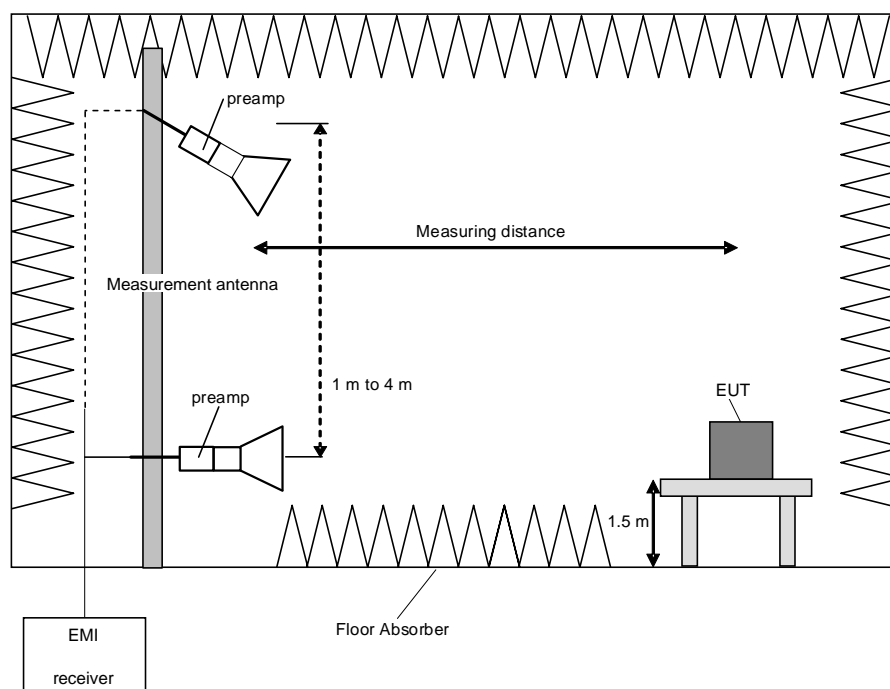
This measurement will be performed in a fully anechoic chamber or in a semi-anechoic chamber with ground absorbers between antenna and EUT. Tabletop and portable devices will set up on a non-conducting turn device on the height of 1.5m. Floor standing devices will be placed directly on the turntable. 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:

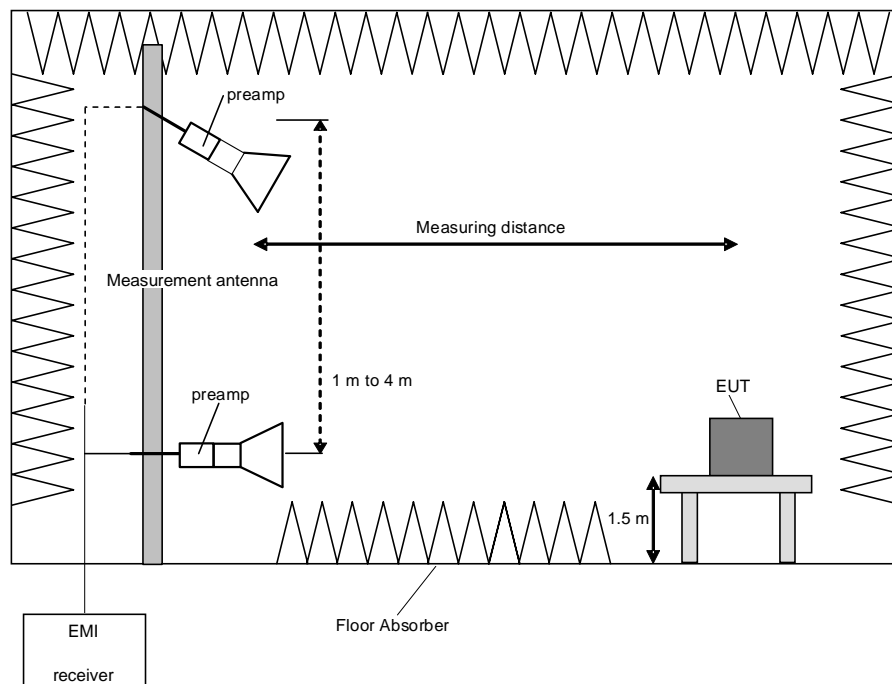
1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarisation and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat steps 1. and 2. with the horizontal polarisation of the measuring antenna.
5. Increase the height of the 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 (Normal procedure1 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.

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

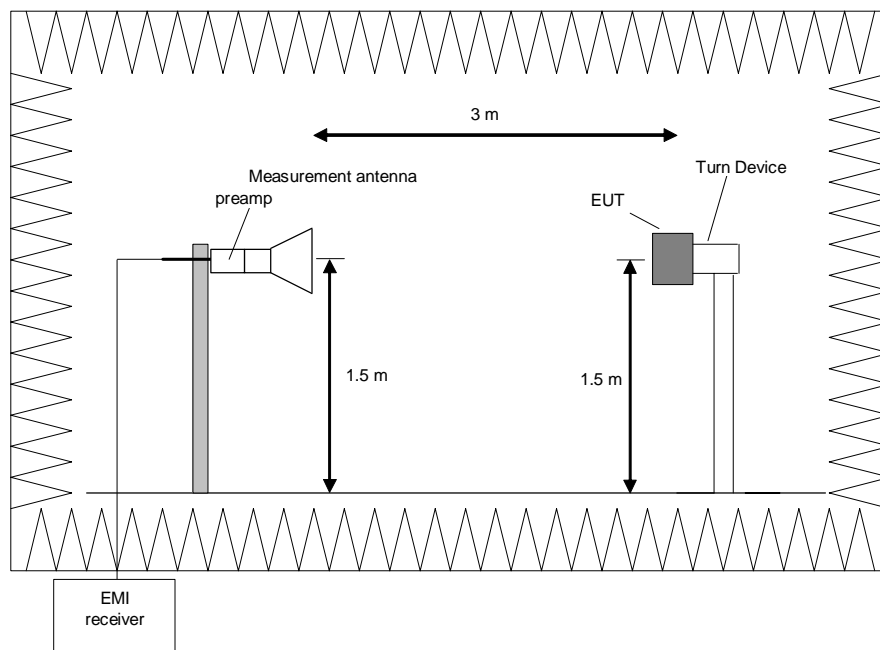
This measurement will be performed in a fully anechoic chamber or in a semi-anechoic chamber with ground absorbers between antenna and EUT. Tabletop and portable devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [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 5.1.1.3 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:

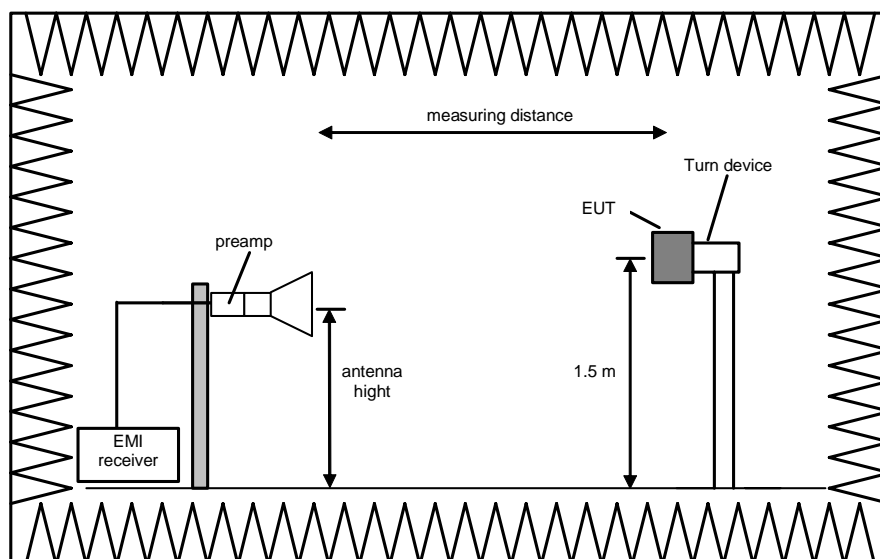
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an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

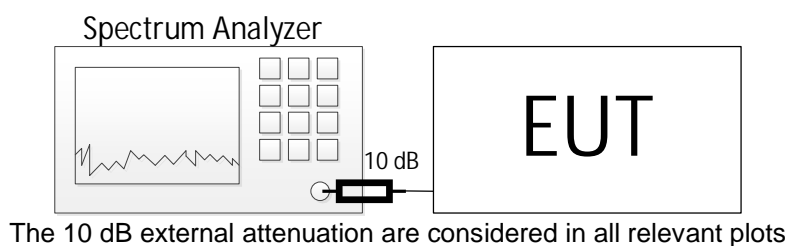
The measurements were performed in the frequency ranges 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 25 /26.5 GHz and 26.5 GHz to 40 GHz.

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
<input checked="" type="checkbox"/>	Temporary antenna connector	As provided by the applicant
<input type="checkbox"/>	Normal antenna connector	-



5.2 Duty cycle

Not tested. Where applicable the duty cycle measured in the original report OT-223-RWD-041 by LG Innotek Co.,Ltd. was used.

5.3 Transmit Antenna Performance considerations

Test setup (Transmit antenna performance considerations)			
Integral and/or dedicated antenna	Antenna gain \geq 6dBi	Result	Comment
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Passed	No output power reduction necessary

G_1 = gain_{internal antenna} = 0.68 dBi

5.4 FHS transmitter output power

5.4.1 Test setup (FHS transmitter output power)

Test setup			
Used	Setup	See sub-clause	Comment
<input type="checkbox"/>	Test setup (radiated – normal procedure)	5.1.1.3	-
<input type="checkbox"/>	Test setup (radiated – alternative procedure)	5.1.1.4	-
<input checked="" type="checkbox"/>	Test setup (antenna port conducted)	5.1.2	-

5.4.2 Test method (FHS transmitter output power)

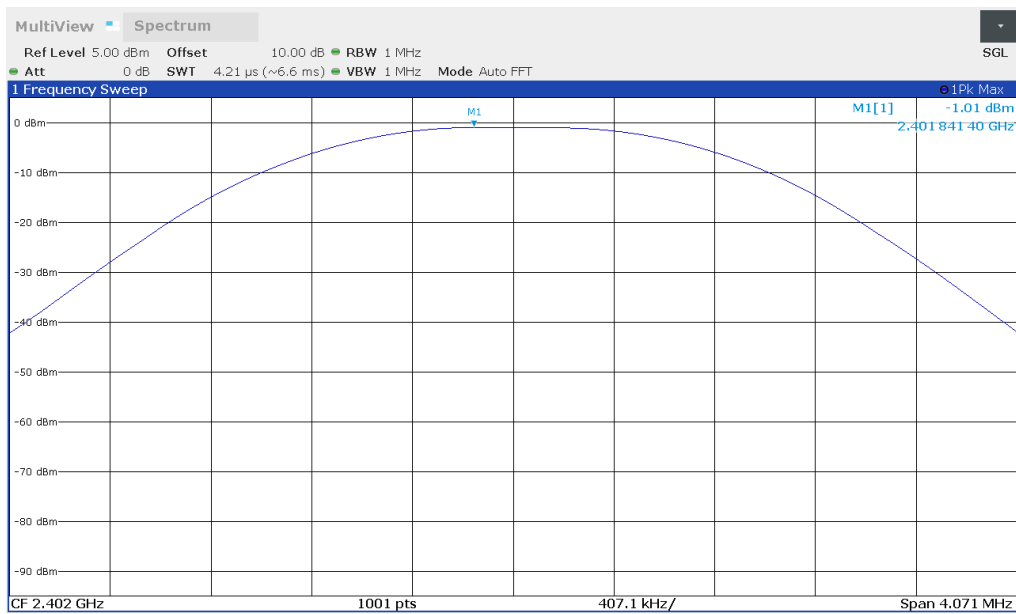
Test method				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	7.8.5	Output power test procedure for frequency-hopping spread-spectrum (FHSS) devices	No limitations	-

5.4.3 Test results (Maximum peak conducted output power)

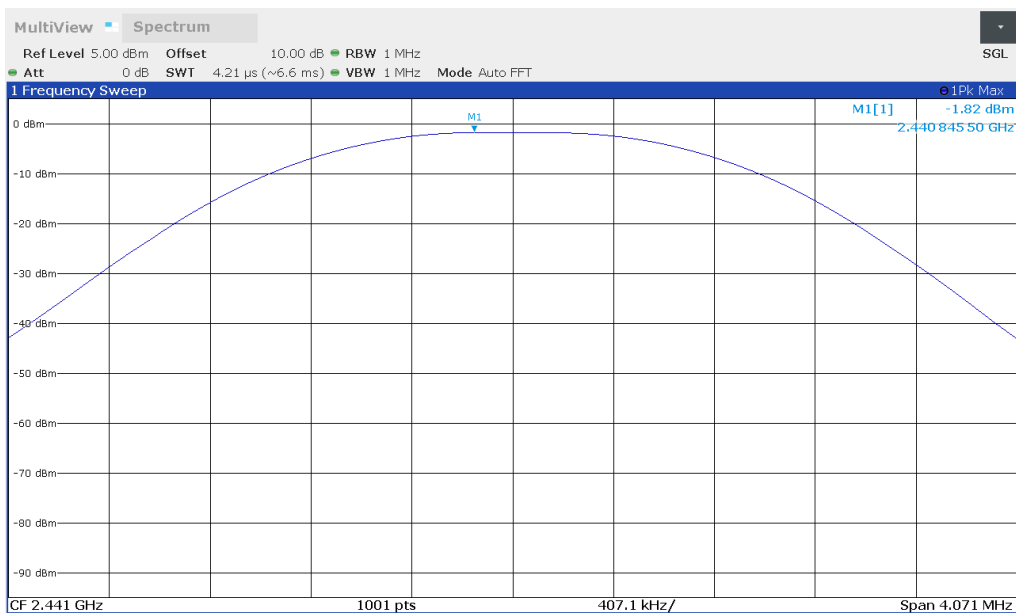
Ambient temperature:	22°C
Relative humidity:	43%

Date	30.03.2023
Tested by	P. NEUFELD

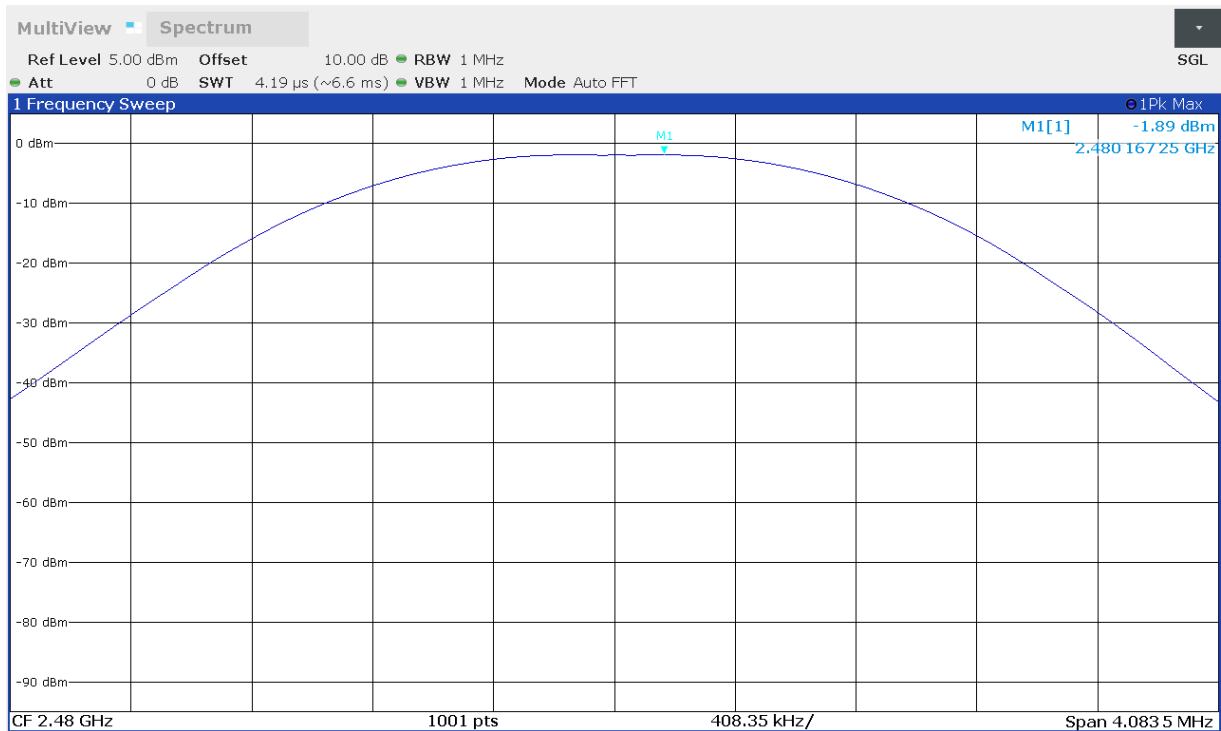
Measurement plot (operation mode 1):



Measurement plot (operation mode 2):



Measurement plot (operation mode 3):



Operation mode	Reading [dBm]	Corr. Fact.* [dB]	Result [dBm]	Limit [dBm]
1	-1.0	1.2	0.2	30
2	-1.8	1.2	-0.6	30
3	-1.9	1.2	-0.7	30

* The external attenuation is already considered with the reference 10 dB level offset in the spectrum analyzer plot, which represents the attenuation of the 10 dB external attenuator and the measurement cable. The documented correction factor resulted from the used measurement cables

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

5.4.4 Test setup (Band edge – restricted bands)

Test setup			
Used	Setup	See sub-clause	Comment
<input type="checkbox"/>	Test setup (radiated – normal procedure)	5.1.1.3	-
<input checked="" type="checkbox"/>	Test setup (radiated – alternative procedure)*1	5.1.1.4	-
<input type="checkbox"/>	Test setup (antenna port conducted)	5.1.2	-

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

5.4.5 Test method (Band edge – restricted bands)

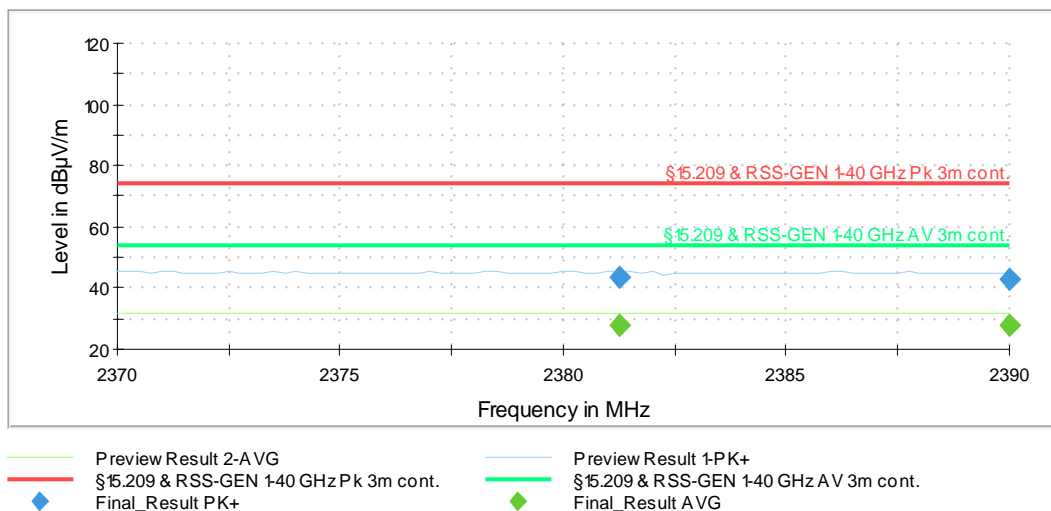
Test method (Band edge – restricted bands)				
Used	Sub-Clause [3]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	6.10.5.2	Standard method	No limitations	-
<input type="checkbox"/>	6.10.6.1	Marker-delta method	< 2 MHz from BE*	See 6.10.6 [3]
<input type="checkbox"/>	11.13.3.2	Peak detection	Not for DTS testing	2 MHz from band
<input type="checkbox"/>	11.13.3.3	Trace averaging with cont. EUT	D ≥ 98%	2 MHz from band
<input type="checkbox"/>	11.13.3.4	Trace averaging with cont. EUT & D	Constant D (±2%)	2 MHz from band
<input type="checkbox"/>	11.13.3.5	Reduced VBW	No limitations	2 MHz from band

5.4.6 Test results (Band edge – restricted bands)

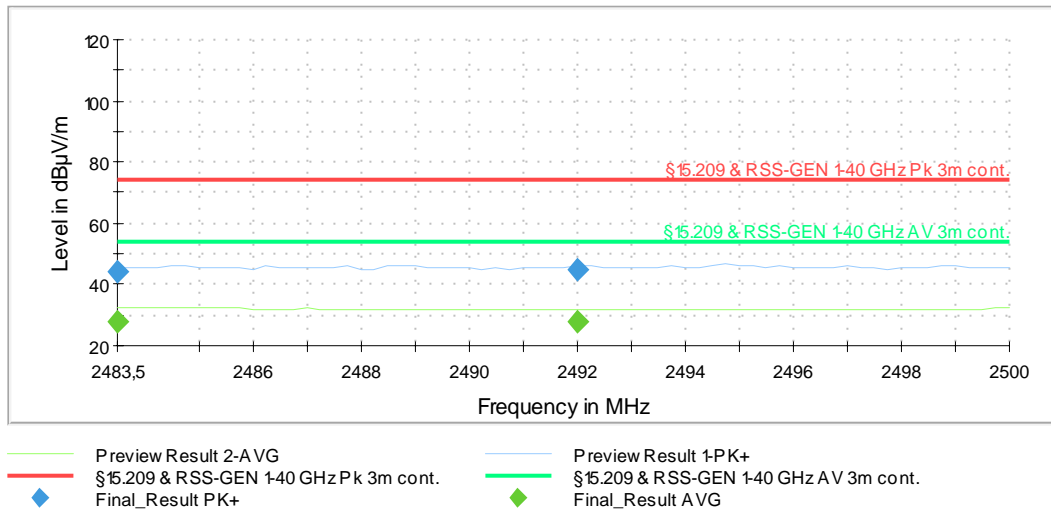
Ambient temperature:	21°C
Relative humidity:	52%

Date	04.07.2023
Tested by	B. Rohde

operation mode 4 (Lower band-edge):



operation mode 5 (Upper band-edge):



(operation mode 4):

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2381.250	---	27.6	54.0	26.4	H	20	0	33.3
2381.250	43.7	---	74.0	30.3	H	20	0	33.3
2390.000	---	27.6	54.0	26.4	H	20	30	33.4
2390.000	43.2	---	74.0	30.8	H	20	30	33.4

(operation mode 5):

Frequency [MHz]	PK+ [dBµV/m]	AV [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2483.500	---	28.1	54.0	25.9	V	166	60	33.6
2483.500	44.5	---	74.0	29.5	V	166	60	33.6
2492.000	---	28.0	54.0	26.0	V	0	90	33.5
2492.000	44.9	---	74.0	29.1	V	0	90	33.5

Test: Passed

Test equipment (please refer to chapter 6 for details)

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5.5 Maximum unwanted emissions

5.5.1 Test setup (Maximum unwanted emissions)

Test setup			
Used	Setup	See sub-clause	Comment
<input checked="" type="checkbox"/>	Test setup (radiated – normal procedure)	5.1.1.1 + 5.1.1.2	f < 1 GHz
<input checked="" type="checkbox"/>	Test setup (radiated – alternative procedure)	5.1.1.4	f > 1 GHz
<input type="checkbox"/>	Test setup (antenna port conducted)	5.1.2	-

5.5.2 Test method (Maximum unwanted emissions)

Test method				
Used	Sub-Clause [3]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	11.12	Emissions in restricted frequency bands	No limitations	-

5.5.3 Test results (Maximum unwanted emissions)

5.5.3.1 Test results (9 kHz – 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. [dB μ V/m] = Reading [dB μ V] + AF [dB/m] + Distance corr. fact. [dB μ V/m]

Result @ norm. dist. [dB μ A/m] = Result @ norm. dist. [dB μ V/m] – 20 x log₁₀(377 Ω)

Margin [dB] = Limit [dB(μ V| μ A)/m] - Result [dB(μ V| μ A)/m]

Worst case plot:

Spurious emissions from 9 kHz to 30 MHz (operation mode 2 - Pos 1 - 3):



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)
2 - 9

5.5.3.2 Test results (30 MHz – 1 GHz)

Ambient temperature:	22°C
Relative humidity:	31%

Date	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]

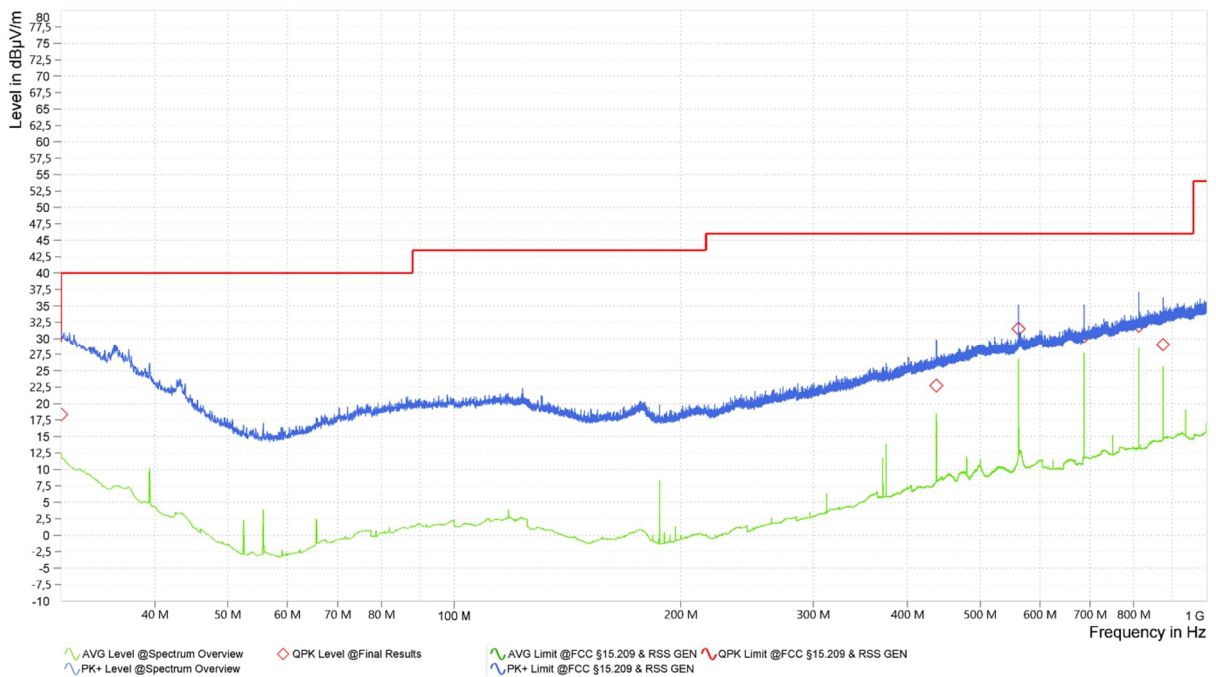
Correction [dBμV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]

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.

Measurement plot:

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



Result tables

(operation mode 3):

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB/m]	Pol. (H/V)	Azimuth [deg]	Height [cm]	Readings [dBµV]	Position #
48.660	30.030	18.4	40.0	21.7	26.0	V	13.4	1.4	1-3
312.510	437.500	22.7	46.0	23.3	22.7	V	262.0	1.3	1-3
375.000	562.480	31.5	46.0	14.5	25.4	H	122.0	1.6	1-3
437.490	687.490	30.4	46.0	15.6	27.1	H	223.6	1.0	1-3
562.500	812.500	32.0	46.0	14.0	29.1	H	246.4	1.5	1-3
687.480	874.990	29.0	46.0	17.0	29.6	V	227.8	1.0	1-3

Test result: Passed

Test equipment (please refer to chapter 6 for details)
3 - 11

5.5.3.3 Test results (above 1 GHz)

Ambient temperature:	21-23°C
Relative humidity:	31-66%

Date	19.05.2023 - 04.07.2023
Tested by	B. Rohde, M. 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: -

Calculation:

Max Peak [dB μ V/m] = Reading (Pk+) [dB μ V] + Correction [dB μ V/m]

Average [dB μ V/m] = Reading (Av) [dB μ V] + Correction [dB μ V/m]

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

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

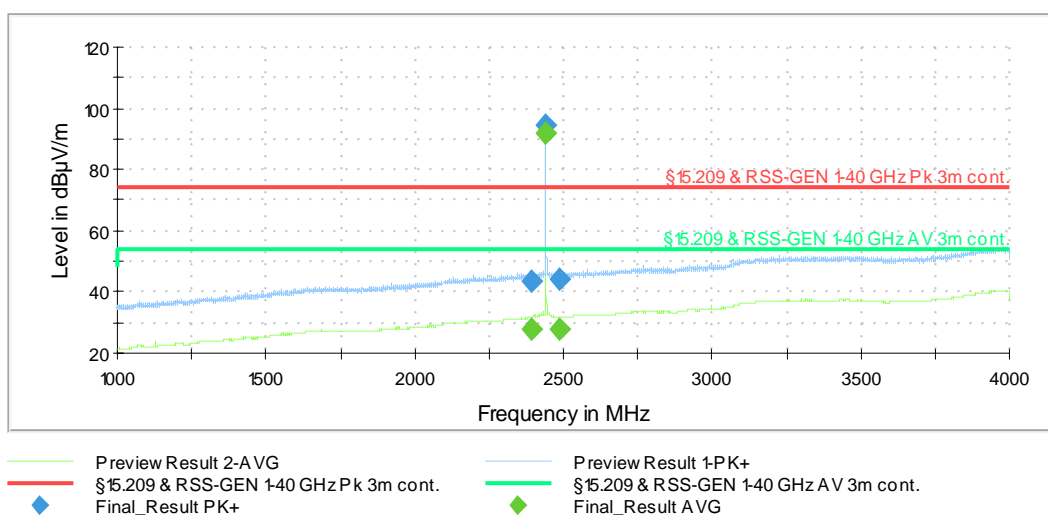
The curves in the diagram only represent the maximum measured value for each frequency point of all preliminary measurements, which were carried out with various EUT and antenna positions.

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.

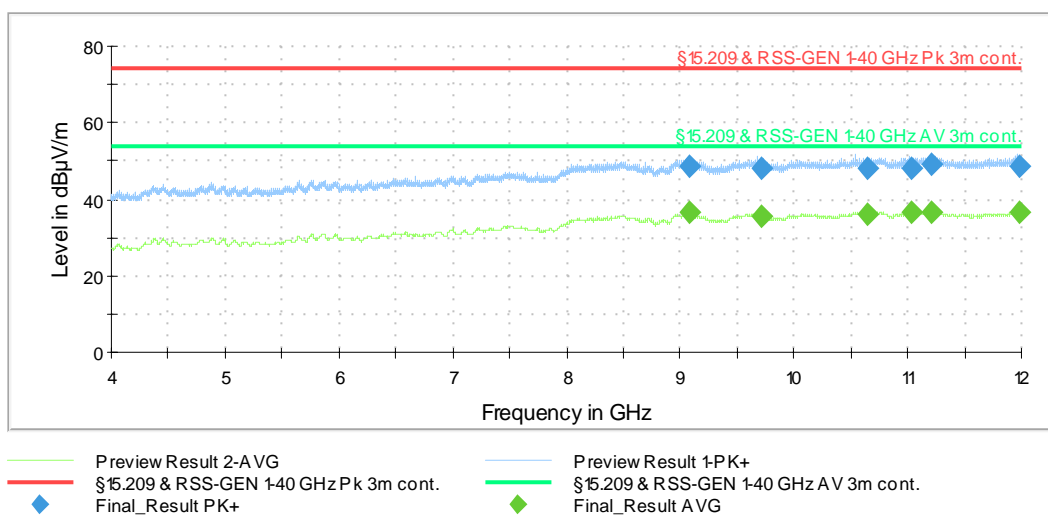
Worst case plots:

Only the plots from the worst-case emissions are submitted below.

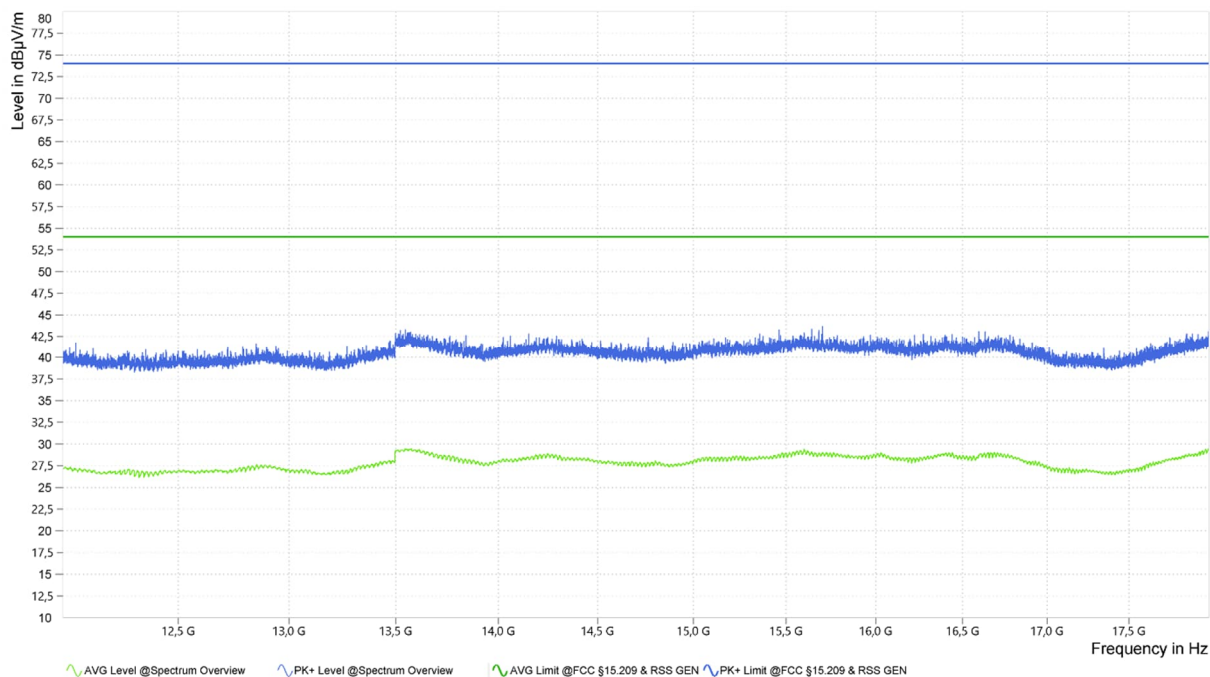
Spurious emissions from 1 GHz to 4 GHz (operation mode 2):



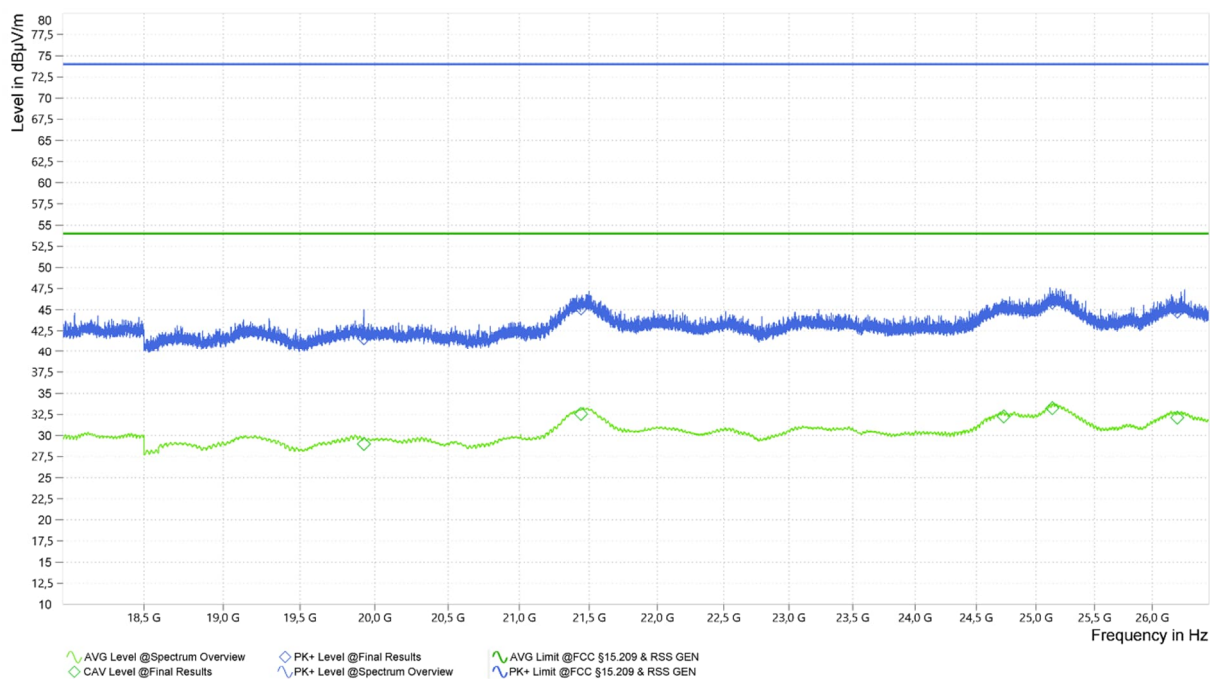
Spurious emissions from 4 GHz to 12 GHz (operation mode 2):



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 2:

Frequency [MHz]	PK+ [dB μ V/m]	AV [dB μ V/m]	Limit [dB μ V/m]	Margin [dB]	Pol	Azimuth [deg]	Elevation [deg]	Corr. [dB/m]
2390.000	43.8	---	74.0	30.2	V	188	30	33.4
2390.000	---	27.6	54.0	26.4	V	188	30	33.4
2441.000	94.8	---	Fund.	-	V	159	30	33.8
2441.000	---	92.2	Fund.	-	V	159	30	33.8
2483.500	---	28.1	54.0	25.9	H	320	120	33.6
2483.500	43.9	---	74.0	30.1	H	320	120	33.6
9081.500	48.5	---	74.0	25.5	V	305	0	8.6
9081.500	---	36.4	54.0	17.6	V	305	0	8.6
9720.250	---	35.8	54.0	18.2	V	276	0	7.4
9720.250	48.3	---	74.0	25.7	V	276	0	7.4
10640.250	---	36.0	54.0	18.0	V	124	150	7.0
10640.250	47.9	---	74.0	26.1	V	124	150	7.0
11040.250	48.3	---	74.0	25.7	V	132	0	7.4
11040.250	---	36.4	54.0	17.6	V	132	0	7.4
11211.250	48.9	---	74.0	25.1	V	187	0	7.1
11211.250	---	36.4	54.0	17.6	V	187	0	7.1
11980.250	48.8	---	74.0	25.2	V	170	0	6.6
11980.250	---	36.8	54.0	17.2	V	170	0	6.6

Frequency [MHz]	PK+ [dB μ V/m]	Pk+ Limit [dB μ V/m]	PK+ Margin [dB]	AV [dB μ V/m]	AV Limit [dB μ V/m]	AV Margin [dB]	Corr. [dB/m]	Pol	Elevation [deg]	Azimuth [deg]
19924.750	41.6	74.0	32.4	29.0	54.0	25.0	10.6	H	90.0	349.4
21441.250	45.2	74.0	28.8	32.5	54.0	21.5	11.4	V	0.0	33.2
24728.500	45.3	74.0	28.7	32.3	54.0	21.7	11.2	V	60.0	311.0
25139.250	45.8	74.0	28.2	33.2	54.0	20.8	11.5	H	120.0	2.9
26220.750	44.8	74.0	29.2	32.1	54.0	21.9	11.8	V	120.0	298.6

Test equipment (please refer to chapter 7 for details)

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6 Measurement Uncertainties

Conducted measurements:		
Measurement method	Standard used for calculating measurement uncertainty	Expanded measurement uncertainty (95 %) U_{lab}
Frequency error	ETSI TR 100 028	4.5×10^{-8}
Bandwidth measurements	-	9.0×10^{-8}
Conducted emissions using a spectrum analyzer		
< 3.6 GHz	ETSI TR 100 028	2.3 dB
3.6 – 8 GHz	ETSI TR 100 028	2.8 dB
8 – 22 GHz	ETSI TR 100 028	3.2 dB
22 – 40 GHz	ETSI TR 100 028	3.6 dB
Power measurements		
Power meter	ETSI TR 100 028	0.9 dB
Conducted emissions from 150 kHz to 30 MHz with LISN		
	CISPR 16-4-2	2.8 dB
Radiated measurements:		
Frequency error		
(Semi-) Anechoic chamber	ETSI TR 100 028	4.5×10^{-8}
OATS	ETSI TR 100 028	4.5×10^{-8}
Test fixture	ETSI TR 100 028	4.5×10^{-8}
Bandwidth measurements		
(Semi-) Anechoic chamber	-	9.0×10^{-8}
OATS	-	9.0×10^{-8}
Test fixture	-	9.1×10^{-8}
Radiated field strength M20		
CBL6112B @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	5.3 dB
R&S HL050 @ 3 m		
1 – 6 GHz	CISPR 16-4-2	5.1 dB
6 – 18 GHz	CISPR 16-4-2	5.4 dB
Flann Standard Gain Horns 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 Instruments 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/450 0.0	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 27.03.2025
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
F221817E2	04.03.2024	Initial Test Report
-	-	-

10 List of Annexes

Annex A Test Setup Photos

12 pages