PHOENIX TESTLAB

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Test Report

Report Number:

F191168E4

Equipment under Test (EUT):

Track&Trace - Marker

Applicant:

TRUMPF Werkzeugmaschinen GmbH + Co. KG

Manufacturer:

TRUMPF Werkzeugmaschinen GmbH + Co. KG

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

Test Result

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

Tested and written by:	Bernward ROHDE Name	0.5.0 P. Li Signature	07.09.2020 Date
Reviewed and approved by:	Bernd STEINER Name	B. Stu Signature	07.09.2020 Date

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1 Identification

1.1 Applicant

Name:	TRUMPF Werkzeugmaschinen GmbH + Co. KG
Address:	Johann-Maus-Str. 2, 71254 Ditzingen
Country:	Germany
Name for contact purposes:	Mr. Guido Schönhardt
Phone:	07156-303-36117
Fax:	
eMail Address:	Guido.schoenhardt@trumpf.com
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	TRUMPF Werkzeugmaschinen GmbH + Co. KG
Address:	Johann-Maus-Str. 2, 71254 Ditzingen
Country:	Germany
Name for contact purposes:	Mr. Guido Schönhardt
Phone:	07156-303-36117
Fax:	
eMail Address:	Guido.schoenhardt@trumpf.com
Applicant represented during the test by the following person:	-

1.3 Test Laboratory

The tests were carried out by:

PHOENIX TESTLAB GmbH
Königswinkel 10
32825 Blomberg
Germany

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

1.4 EUT (Equipment under Test)

EUT	
Test object: *	Marker for indoor localization
PMN / Model name: *	Track&Trace - Marker
FCC ID: *	2AVYV-2564360-01
Serial number: *	CH00: 204264690 CH19: 204268298 CH39: 204268271
PCB identifier: *	1901154A001032B8
Hardware version: *	Rev D
Software version: *	2.17.9

* Declared by the applicant

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

1.5 Technical Data of Equipment

General technical data of EUT						
Power supply EUT: *	DC (by internal battery)					
Supply voltage EUT: *	U_{nom}=	3.7 V_{DC}	U_{min}=	3.0 V_{DC}	U_{max}=	4.2 V_{DC}
Temperature range: *	-10 °C to +39 °C					
Lowest / highest internal clock frequency: *	32.768 kHz / 2480 MHz (in BLE mode)					

Identification	Connector		Length
	EUT	Ancillary	
No lines connectable to the EUT			

1.5.1 BLE Radio mode

Bluetooth® Low Energy radio mode		
Fulfils radio specification: *	BLE 4.2 (1 Mbit/s only)	
Radio chip: *	Nordic nRF52840	
Antenna type: *	Internal PCB antenna	
Antenna name: *	ANT2	
Antenna gain: *	2 dBi	
Antenna connector: *	none	
Conducted output power: *	BLE 1 Mbit/s	-1.4 dBm (Peak)
		-1.5 dBm (Average)
Type of modulation: *	BLE 1 Mbit/s	GFSK (1 Mbit/s)
Operating frequency range: *	BLE 1 Mbit/s	2402 – 2480 MHz
Number of channels: *	BLE 1 Mbit/s	40 (2 MHz channel spacing)

Bluetooth® Low Energy frequencies				
Channel 0	RX	2402 MHz	TX	2402 MHz
Channel 1	RX	2404 MHz	TX	2404 MHz
…	…	…	…	…
Channel 19	RX	2440 MHz	TX	2440 MHz
…	…	…	…	…
Channel 38	RX	2478 MHz	TX	2478 MHz
Channel 39	RX	2480 MHz	TX	2480 MHz

1.5.2 Ancillary Equipment / Equipment used for testing

Equipment used for testing
None

1.6 Dates

Date of receipt of test sample:	07.05.2020
Start of test:	10.08.2020
End of test:	06.10.2020

2 Operational States

2.1 Description of function of the EUT

The EUT is intended to be used as transceiver for locating of machine tools inside a factory building. It will be mounted onto machines. Therefore, it is defined as mobile indoor equipment.
All radiated tests were carried out with an unmodified test sample powered by an internal battery.

2.2 The following states were defined as the operating conditions

The applicant delivered 3 different samples. Each sample was set to transmit in test mode on a certain channel (channel 00, channel 19 and channel 39). All settings, like power, data rate, etc. were set by the applicant.
In the following, the EUT transmitting on channel 1 will be referred to as EUT 1. The EUT transmitting on channel 19 as “EUT 2” and the EUT transmitting on channel 39 as “EUT 3”.

2.2.1 Operation modes

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate	TX / RX	EUT #	Power setting
1	Bluetooth® LE	2402	0	GFSK	1 Mbit/s	TX	1	Not settable
2	Bluetooth® LE	2440	19	GFSK	1 Mbit/s	TX	2	Not settable
3	Bluetooth® LE	2480	39	GFSK	1 Mbit/s	TX	3	Not settable

Power settings were set by the applicant and could not be changed

3 Additional Information

The EUT also contains an IEEE802.15.4 and a UWB transceiver. The results of these technologies are documented in the test reports F191168E2 and F191161E3. The emissions of the digital part of the EUT are documented in the test report F191168E1. Object of this test report is the BLE part of the EUT only.

The tested sample was not labeled as required by the FCC.

The tests were done with an unmodified sample.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	Status	Refer page
Maximum peak conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	Passed	13
Maximum conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	Passed	13
DTS Bandwidth / 99% Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	Passed	16
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	Passed	19
Average Power Spectral Density	2400.0 - 2483.5	15.247 (e)	Passed	19
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	Passed	22
Maximum unwanted emissions	0.009 – 26,500	15.247 (d) 15.205 (a) 15.209 (a)	Passed	25
Conducted emissions on supply line	0.15 - 30	15.207 (a)	Not tested*2	-
Antenna Requirement	-	15.203 15.247 (b)	Passed*1	-

*1 internal Antenna, gain below 6 dBi, no power reduction necessary.
*2 EUT is battery powered, no connection to the AC mains network.

5 Results

5.1 Duty cycle

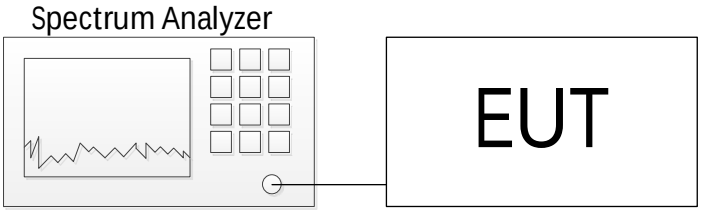
5.1.1 Method of measurement (conducted)

The EUT was measured conducted on a sample with an antenna connector, which was provided by the applicant.

Acceptable measurement configurations

According to [3] chapter 6 method b), which is equal to method described in chapter 11.6 b) of document [1] was used to perform the following test.

Test Setup:

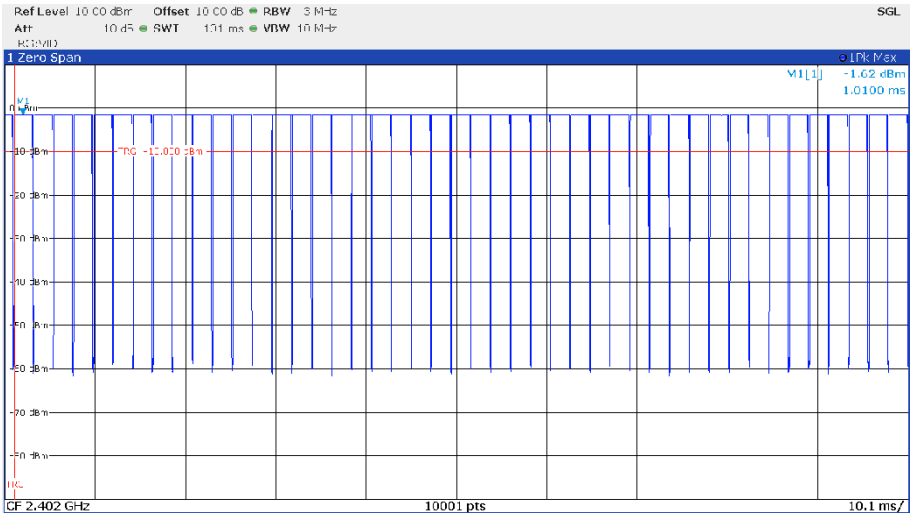


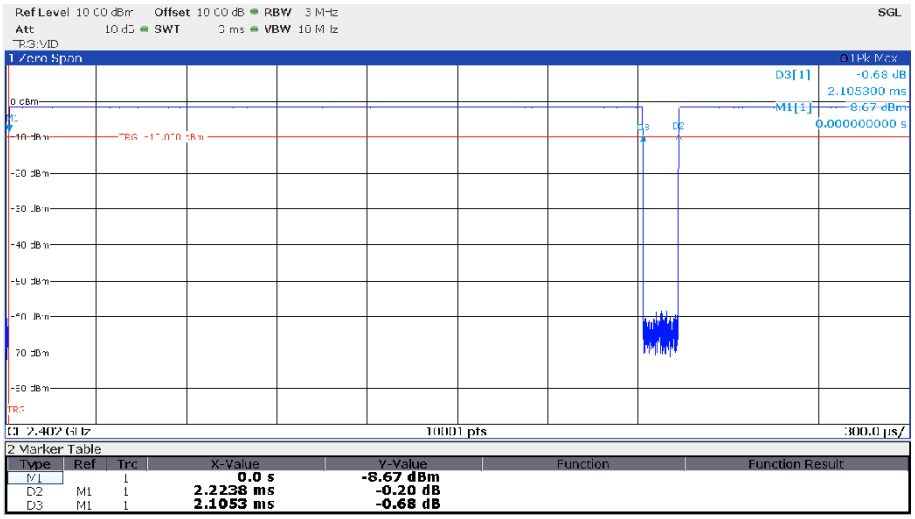
Only one representative plot is provided.

5.1.2 Test results

Ambient temperature	23 °C
Relative humidity	50 %

Date	06.10.2020
Tested by	B. ROHDE





Operation mode	TX_on [µs]	TX_ges [µs]	RBW [MHz]	50/T [kHz]	50/T < RBW?
BLE 1 Mbit/s	2105	2224	3	24	Yes

Operation mode	Sweep points	Sweep time [µs]	Meas points	Meas points >100?	Duty cycle %	DCCF [dB]
BLE 1 Mbit/s	10001	3000	7414	Yes	95	0.24

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

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

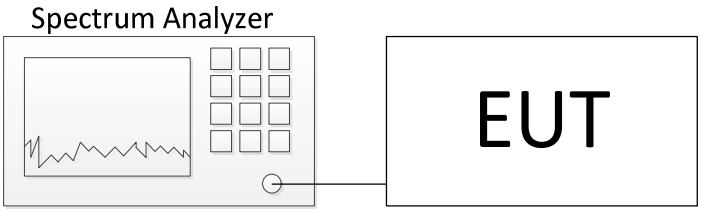
Therefore, for average measurements a correction factor of 0.3 dB is used for all tests in test mode 1 -3.

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

5.1 Maximum conducted output power

5.1.1 Method of measurement (conducted)

Test Setup:



Acceptable measurement configurations

See 8.3 of document [3] for details.

For the **Maximum *peak* conducted output power** the Procedure **11.9.1.1** in [1] was used.

For the **Maximum conducted *average* output power** the Procedure **11.9.2.2.4** in [1] was used.

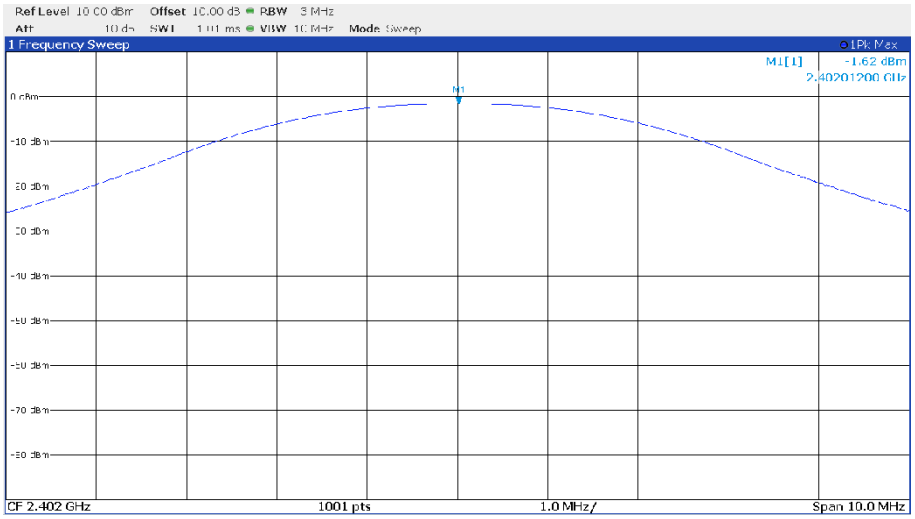
Only one representative plot for each measurement configuration is provided.

5.1.2 Test results

Ambient temperature	23 °C
Relative humidity	50 %

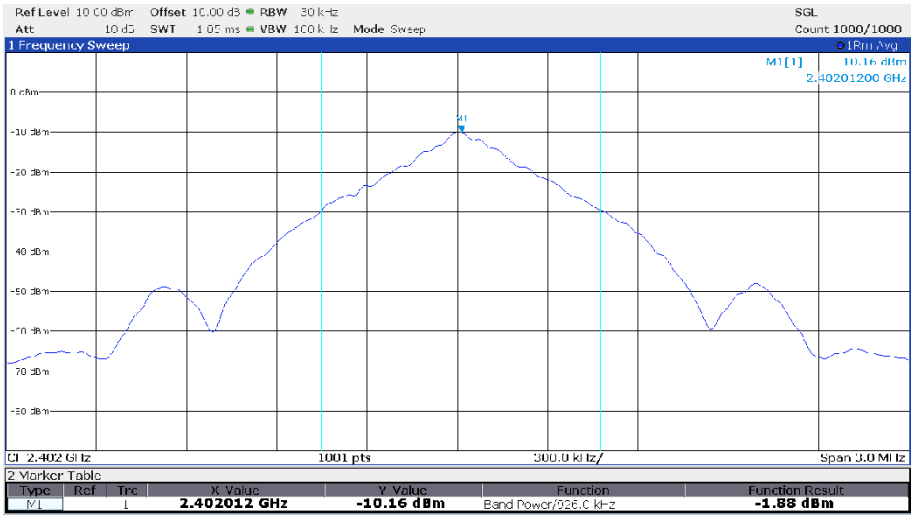
Date	06.10.2020
Tested by	B. ROHDE

Maximum *peak* conducted output power:



Operation mode	Reading [dBm]	Correction (Cable att.) [dB]	Result [dBm]	Limit [dBm]	Result
1	-1.6	0.2	-1.4	30	Passed
2	-2.0	0.2	-1.8	30	Passed
3	-1.8	0.2	-1.6	30	Passed

Maximum *average* conducted output power:



Operation mode	Reading [dBm]	Correction (Cable att.) [dB]	DCCF [dB]	Result Incl. DCCF [dBm]	Limit [dBm]	Result
1	-1.9	0.2	0.2	-1.5	30	Passed
2	-2.3	0.2	0.2	-1.9	30	Passed
3	-2.4	0.2	0.2	-2.0	30	Passed

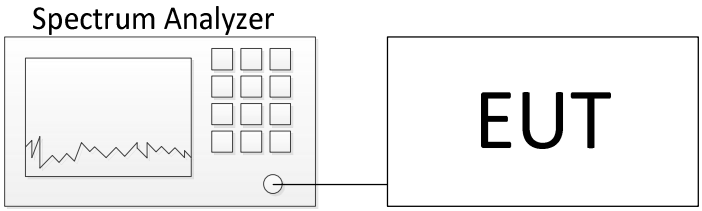
Test equipment (please refer to chapter 6 for details)
1

5.1 DTS Bandwidth / 99% Bandwidth

5.1.1 Method of measurement (conducted)

The measurements were done conducted at the antenna connectors of both antennas.

Test Setup:



Acceptable measurement configurations

See chapter 8.2 of document [3]

For the **DTS bandwidth** the Procedure **11.8.2** in [1] was used.

For the **Occupied bandwidth – 99% Bandwidth** the Procedure **6.9.3** in [1] was used.

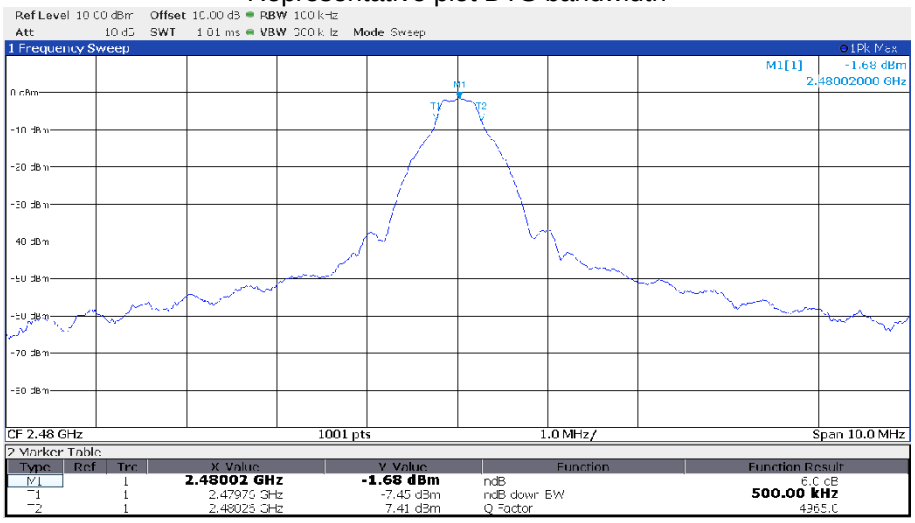
Only one representative plot for each measurement configuration is provided.

5.1.2 Test results

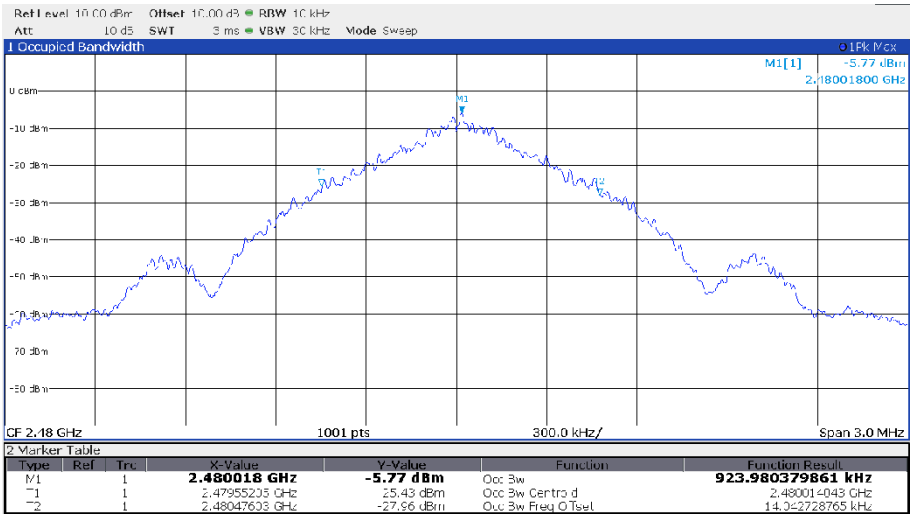
Ambient temperature	23 °C
Relative humidity	50 %

Date	06.10.2020
Tested by	B. ROHDE

Representative plot DTS bandwidth



Representative plot 99 % bandwidth



OP mode	Data rate	Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
1	1 Mbit/s	2402	0.5	0.509	0.926	Passed
2	1 Mbit/s	2440	0.5	0.509	0.937	Passed
3	1 Mbit/s	2480	0.5	0.500	0.924	Passed

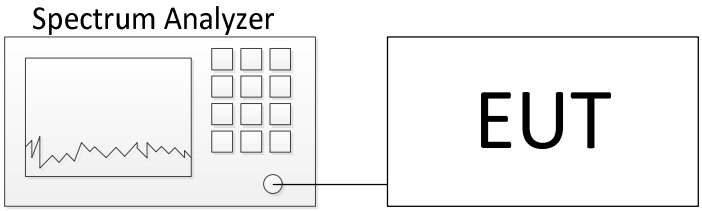
Test equipment (please refer to chapter 6 for details)
1

5.2 Power spectral density

5.2.1 Method of measurement (conducted)

The measurements were done conducted at the antenna connectors of both antennas.

Test Setup:



Acceptable measurement configurations

See chapter 8.4 of document [3]

For the **Maximum *peak* power spectral density level in the fundamental emission** the Procedure **11.10.2** in [1] was used.

For the **Maximum *average* power spectral density level in the fundamental emission** the Procedure **11.10.5** in [1] was used.

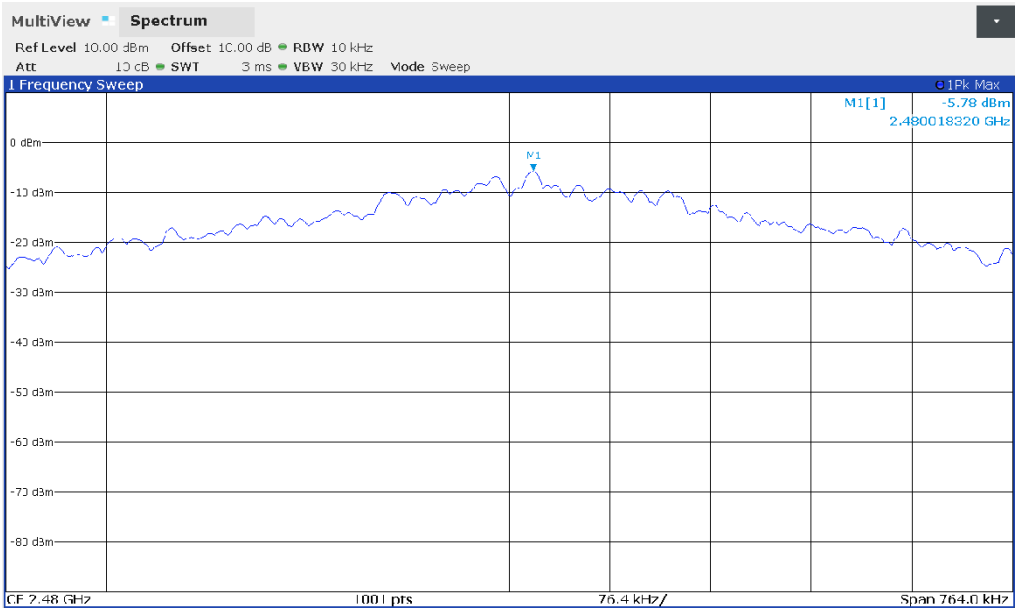
Only one representative plot for each measurement configuration is provided.

5.2.2 Test results

Ambient temperature	23 °C
Relative humidity	50 %

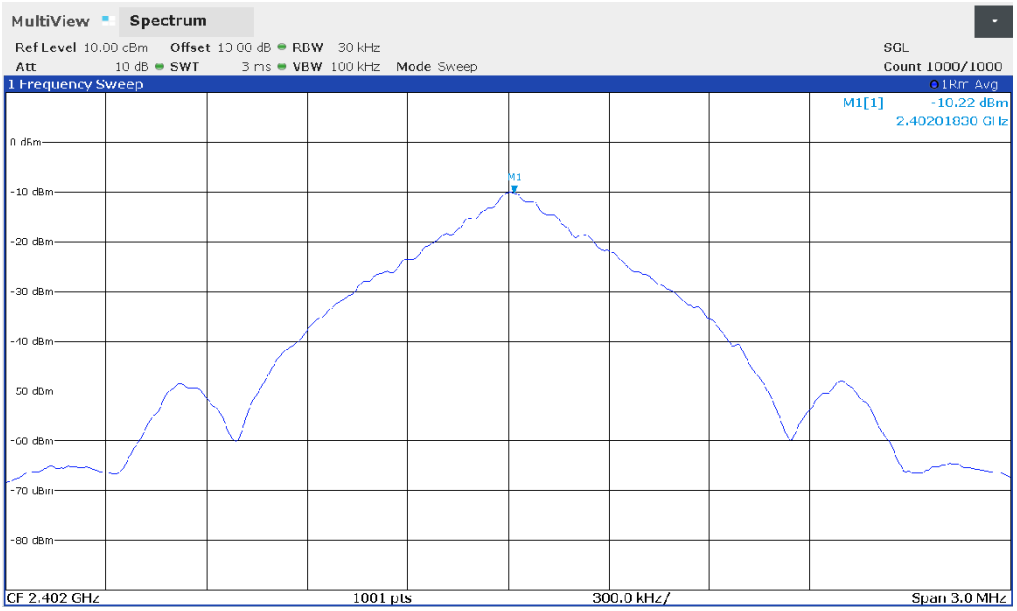
Date	06.10.2020
Tested by	B. ROHDE

Maximum *peak* power spectral density level in the fundamental emission:



OP mode	Peak Frequency [MHz]	Reading [dBm]	Correction (Cable att.) [dB]	PSD [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	2402.018	-7.2	0.2	-7.0	8	Passed
2	2440.041	-8.0	0.2	-7.8	8	Passed
3	2480.018	-5.8	0.2	-5.6	8	Passed

Maximum *average* power spectral density level in the fundamental emission:



OP mode	Peak Frequency [MHz]	PSD Reading [dBm / 30 kHz]	Correction (Cable att.) [dB]	DCCF [dB]	PSD incl. DCCF [dBm / 30 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	2402.018	-10.2	0.2	0.2	-9.8	8	Passed
2	2440.033	-10.7	0.2	0.2	-10.3	8	Passed
3	2480.030	-10.9	0.2	0.2	-10.5	8	Passed

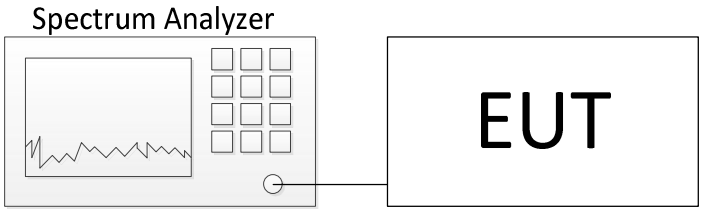
Test equipment (please refer to chapter 6 for details)
1

5.3 Band edge

5.3.1 Method of measurement (conducted)

The measurements were done conducted at the antenna connectors of both antennas.

Test Setup:



Acceptable measurement configurations

See chapter 8.7 of document [3].

For the **Band-edge testing (unrestricted bands)** the Procedure **6.10.4** in [1] was used, see remarks of #59, table A2 of document [1].

For the **Band-edge testing (restricted bands)** the tests were done radiated.

Only one representative plot is provided.

5.3.2 Method of measurement (radiated)

The EUT was measured radiated in an anechoic chamber. For test setup and measurement configuration see 5.4.1

For the **Band-edge testing (restricted bands)** the 15.209 limits apply.

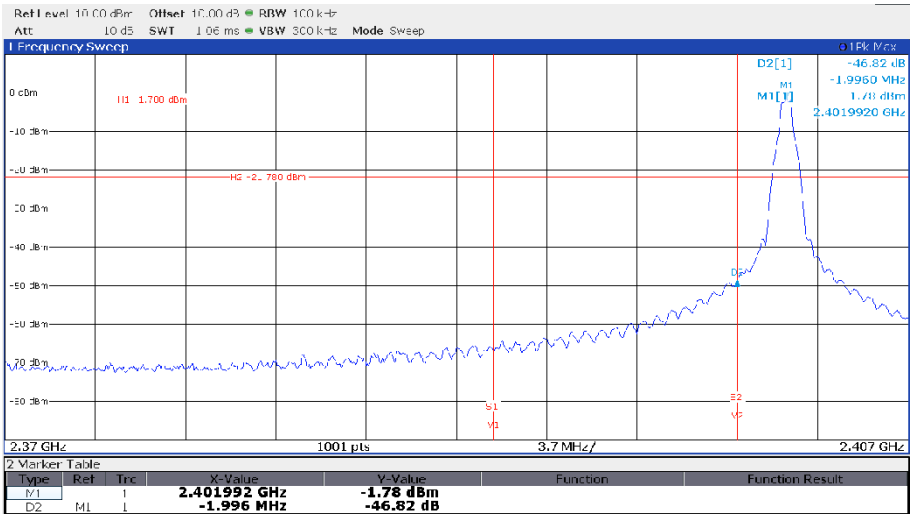
Only one representative plot is provided.

5.3.3 Test results

Ambient temperature	23 °C
Relative humidity	50 %

Date	06.10.2020
Tested by	B. ROHDE

Band-edge testing (unrestricted bands; conducted):



Operation mode	Data rate	Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Margin [dB]	Result
1	1 Mbps	2402	-1.78	-21.78	46.82	Passed

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

Ambient temperature	22 °C
Relative humidity	58 %

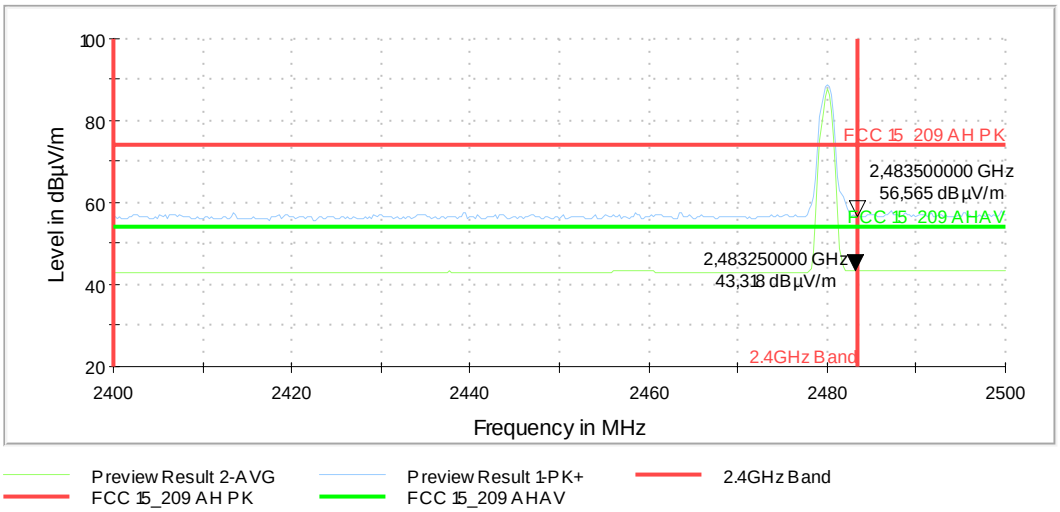
Date	10.08.2020
Tested by	B. ROHDE

Band-edge testing (restricted bands; radiated):

Operation mode 1:

No significant emission in the restricted band from 2.37 – 2.39 GHz, no final band edge measurement done.

Operation mode 3:



Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB]	Height [cm]	Azimuth [deg]	Pol.	Result
2483.500000	56.6	---	74	17.4	34.6	186	123	V	Passed
2483.500000	---	43.5	54	10.5	34.8	186	123	V	Passed
Measurement uncertainty					±5.5 dB				

The average measurement result was corrected by the DCCF according to 5.1.2.

Test equipment (please refer to chapter 6 for details)
11 - 27

5.4 Maximum unwanted emissions

5.4.1 Method of measurement (radiated)

The radiated emission measurement is subdivided into six stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A final measurement carried out on an outdoor test side without reflecting ground plane and a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A preliminary and final measurement carried out in a semi anechoic chamber with a varying antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary and final measurement carried out in a semi anechoic chamber with ground absorbers with a varying antenna height in the frequency range above 1 GHz.

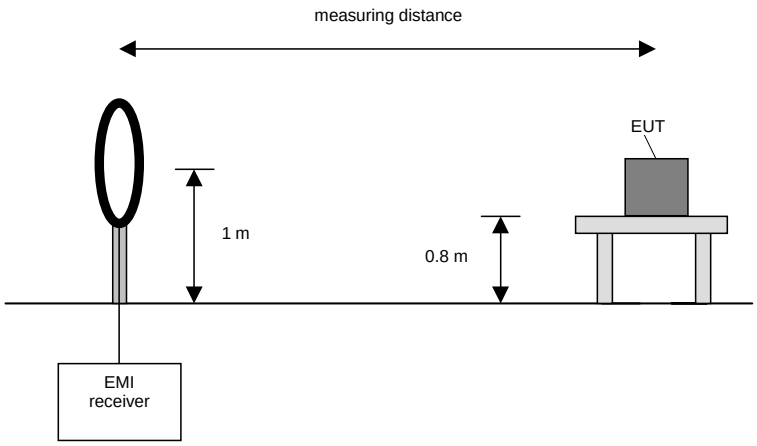
Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of 3 meters. Tabletop devices will set up on a non-conducting turn device on the height of 0.8 m. Floor-standing devices will be placed directly on the turntable/ground plane. The set-up of the Equipment under test will be in accordance to [1].

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyzer while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The EMI Receiver will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to find the maximum emissions.

The resolution bandwidth of the spectrum analyzer will be set to the following values:

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



Preliminary measurement procedure:

Pre-scans were performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

Pre-scans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz.
The following procedure will be used:

1. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Repeat 1) to 3) with the vertical polarization of the measuring antenna.
5. Make a hardcopy of the spectrum.
6. Repeat 1) to 5) with the EUT raised by an angle of 0° (45°, 90°) according to 6.6.5.4 in [1].
7. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.

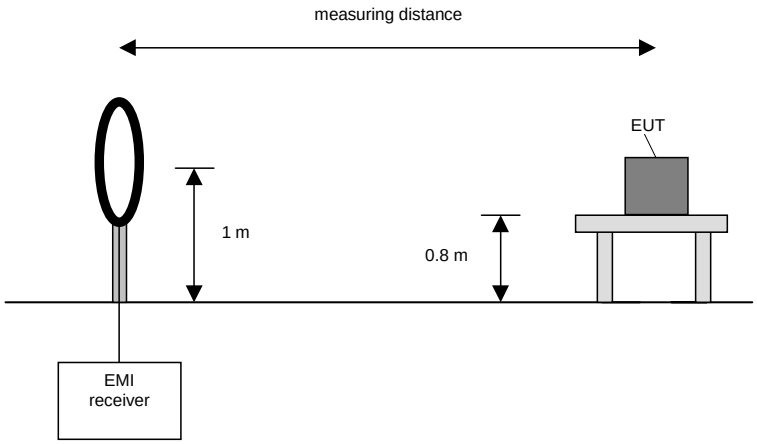
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances are required the results will be extrapolated based on the values measured on the closer distances according to Section 15.31 (f) (2) [2]. The final measurement will be performed with a 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 will be used according Section 15.209 (d) [2].

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

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

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

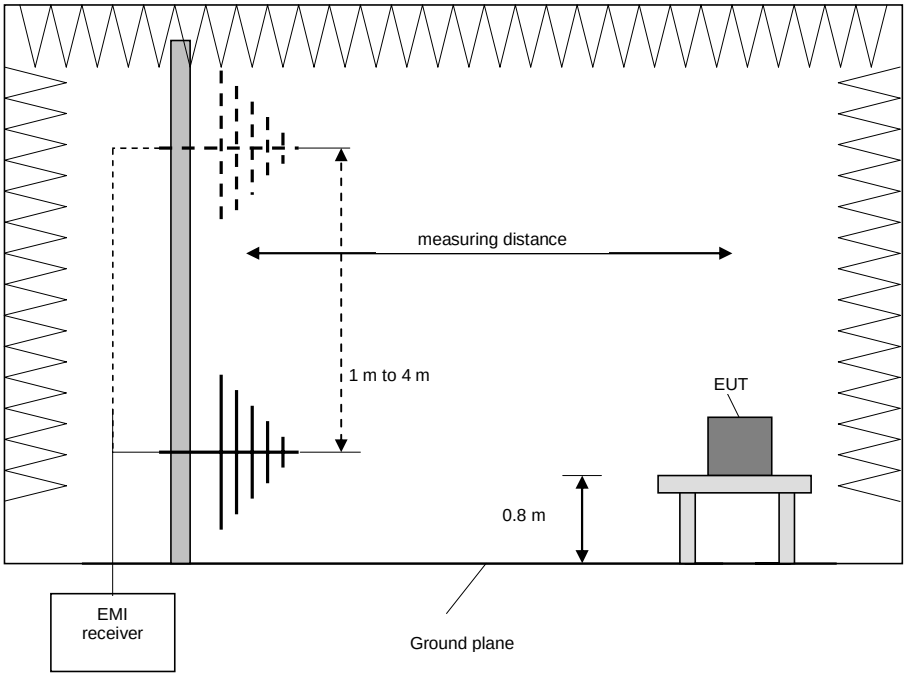


Preliminary and final measurement (30 MHz to 1 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with a metal ground plane. During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be 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 will be set to the following values:

Test	Frequency range	Resolution bandwidth	Step size	Measurement time
Preliminary measurement	30 MHz to 1 GHz	120 kHz	40 kHz	100 ms
Frequency peak search	3 x RBW	120 kHz	10 kHz	1000 ms
Final measurement	30 MHz to 1 GHz	120 kHz	-	5 x 1000 ms



Procedure preliminary measurement:

The following procedure is used:

1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarization and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat 1) to 2) with the vertical polarization 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.
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 highest value.

Procedure final measurement:

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 step size with +/- 3 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.

Preliminary and final measurement (1 GHz to 40 GHz)

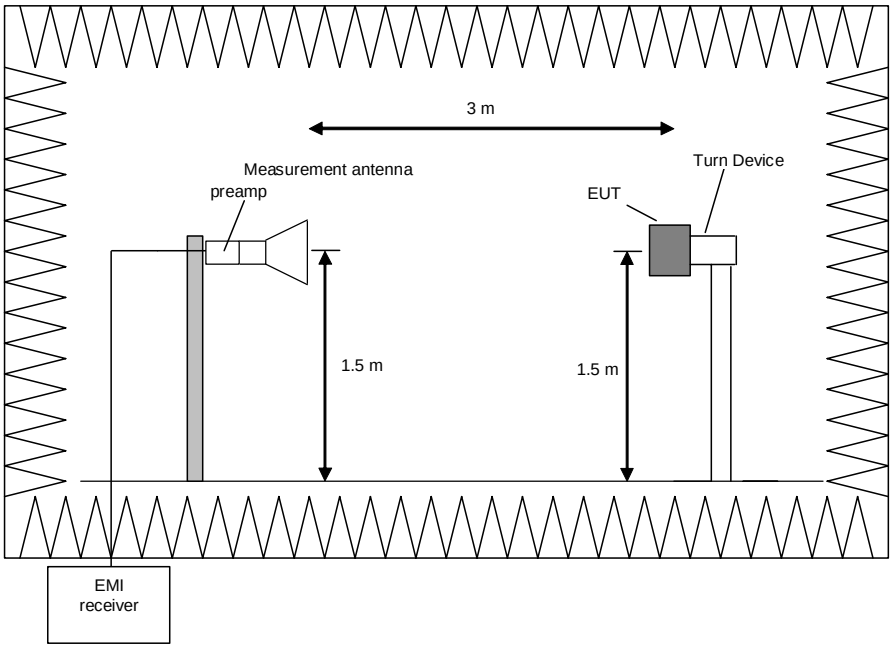
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

Preliminary measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn 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 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:

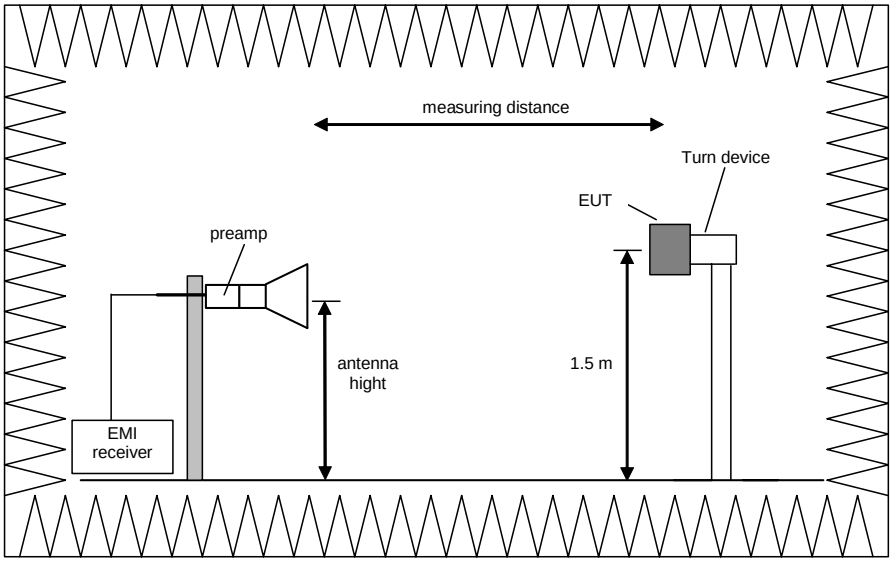
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an 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 of the frequency range of the used horn 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) Set the measurement antenna polarisation to the orientation with 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) Rotate the turntable from 0° to 360° to find the TT Pos. that produces the highest emissions.
5) Note the highest displayed peak and average values
6) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.

5.4.2 Test results (radiated)

5.4.2.1 Test results (9 kHz – 30 MHz)

Ambient temperature	23 °C
Relative humidity	62 %

Date	22.09.2020
Tested by	B. ROHDE

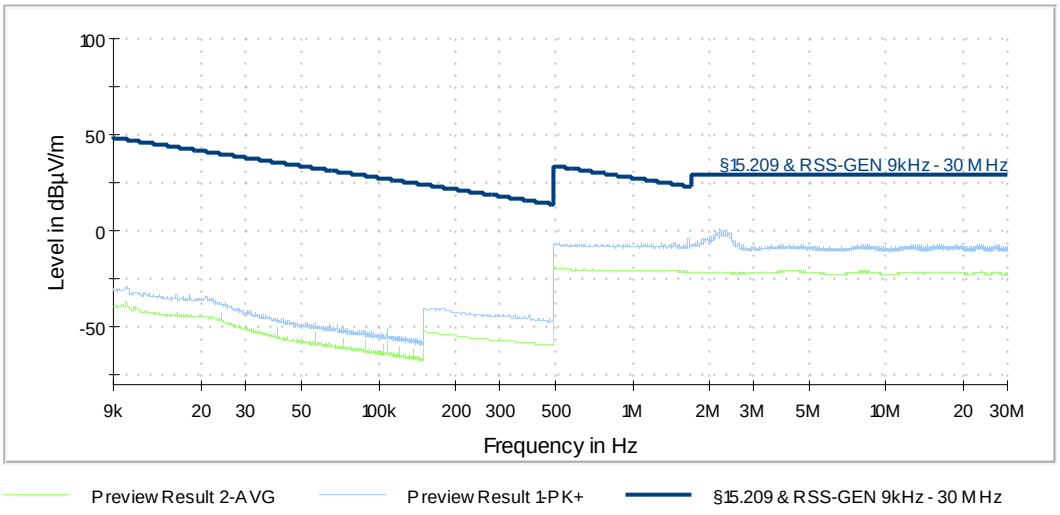
Position of EUT: For tests for f between 9 kHz and 30 MHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

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

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

5.4.2.1.1.1 Plots

9k-30M: Spurious emissions from 9 kHz to 30 MHz



Remark: In the shown plot a distance correction factor was added to the measurement results to account for the different measuring distances according to standard (9 kHz to 490 kHz @ 300 m; 490 kHz to 30 MHz @ 30 m).

5.4.2.1.1.2 Result table

All emissions are more the 20 dB from the limit, so no final measurement was conducted.

Test equipment (please refer to chapter 6 for details)
2 - 9

5.4.2.2 Test results (30 MHz – 1 GHz)

Ambient temperature	21 °C	Date	12.08.2020
Relative humidity	70 %	Tested by	B. ROHDE

Position of EUT: The EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

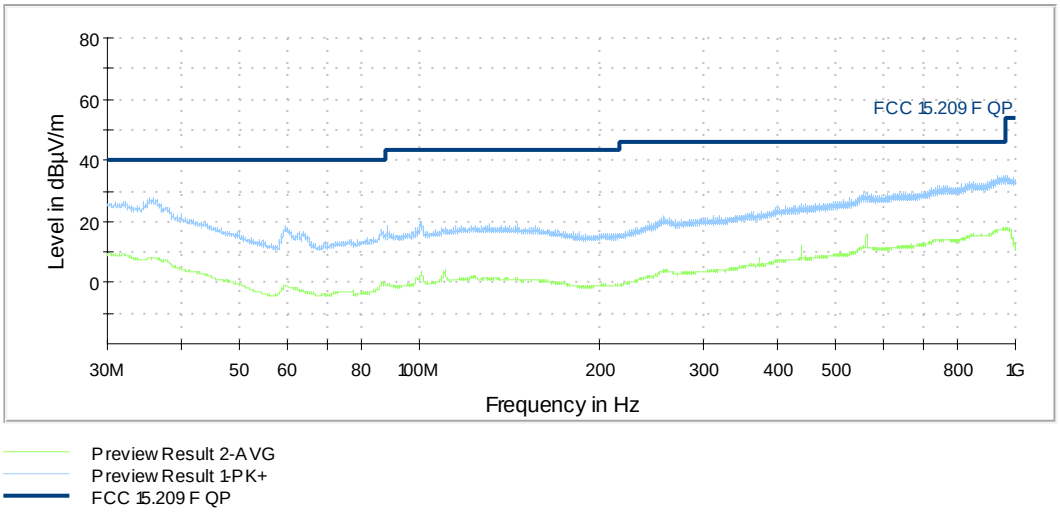
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: Only the worst-case plot is submitted below.

Remark: All other emissions were more than 20 dB below the limit

5.4.2.2.1.1 Plots

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



5.4.2.2.1.2 Result table

Result table (operation mode 1):

Frequency [MHz]	Result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
35.610000	20.6	40	19.4	-4.2	24.8	102	15	V	Passed
65.310000	5.9	40	34.1	-6.7	12.6	103	337	V	Passed
110.400000	8.4	43.5	35.1	-9.3	17.7	200	134	V	Passed
562.510000	23.3	46	22.7	-5.1	28.5	102	179	V	Passed
Measurement uncertainty				±5.5 dB					

Result table (operation mode 2):

Frequency [MHz]	Result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
35.730000	21.4	40	18.6	-3.4	24.7	100	217	V	Passed
59.810000	10.0	40	30.0	-2.6	12.6	330	69	V	Passed
100.530000	6.9	43.5	36.6	-10.0	16.9	146	346	V	Passed
562.510000	22.3	46	23.7	-6.2	28.5	410	44	H	Passed
Measurement uncertainty				±5.5 dB					

Result table (operation mode 3):

Frequency [MHz]	Result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
35.840000	21.2	40	18.8	-3.5	24.7	102	284	V	Passed
59.890000	10.4	40	29.6	-2.1	12.6	317	1	V	Passed
110.210000	7.8	43.5	35.7	-9.9	17.7	100	134	V	Passed
257.870000	11.3	46	34.7	-9.9	21.2	306	126	H	Passed
562.510000	21.9	46	24.1	-6.6	28.5	406	163	H	Passed
Measurement uncertainty				±5.5 dB					

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

5.4.2.3 Test results (above 1 GHz)

Ambient temperature	22 °C
Relative humidity	58 %

Date	31.08.2020
Tested by	R. BRAUN

Position of EUT: For tests for f between 1 GHz and the 10th harmonic, the EUT was set-up on a table with a height of 150 cm. The distance between EUT and antenna was 3 m.

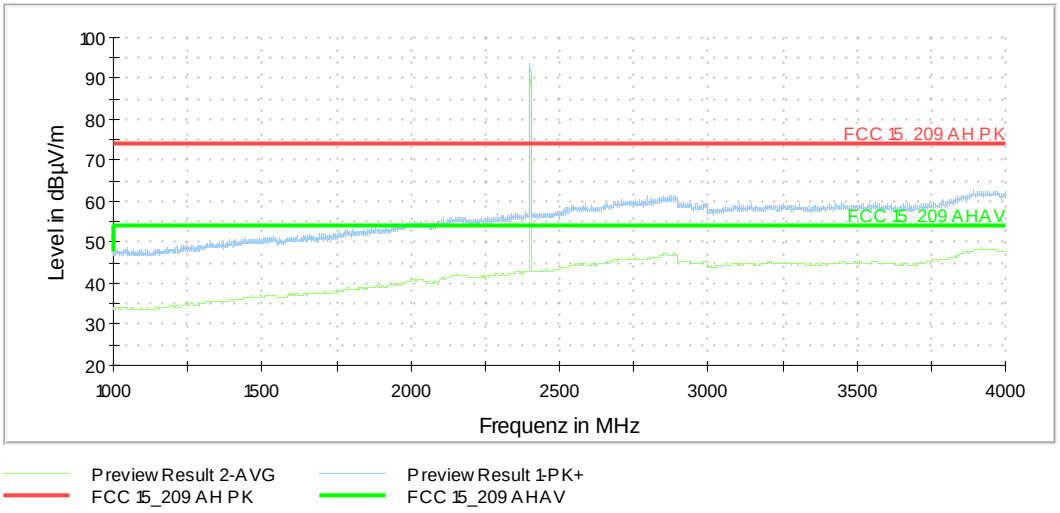
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: As shown below

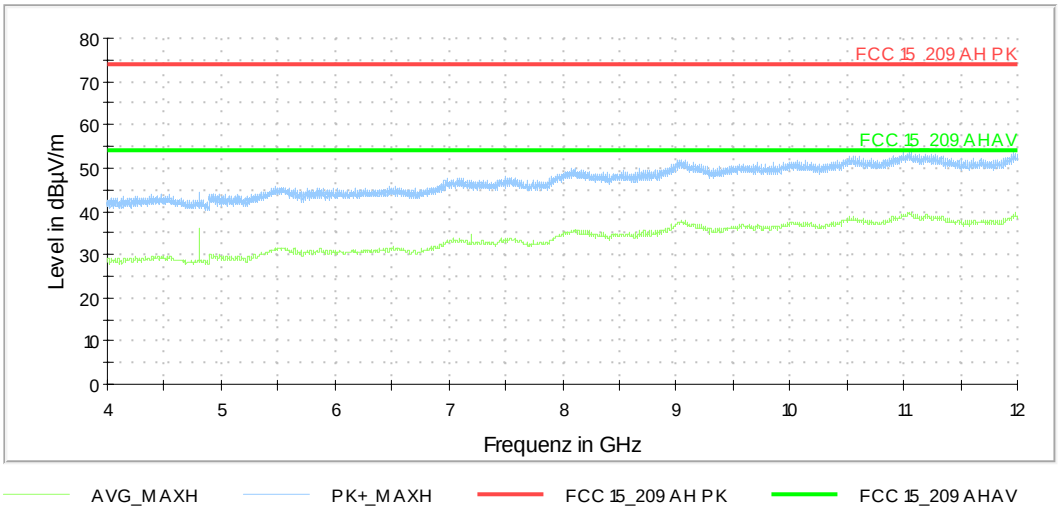
5.4.2.3.1 Operation mode 1

5.4.2.3.1.1 Plots

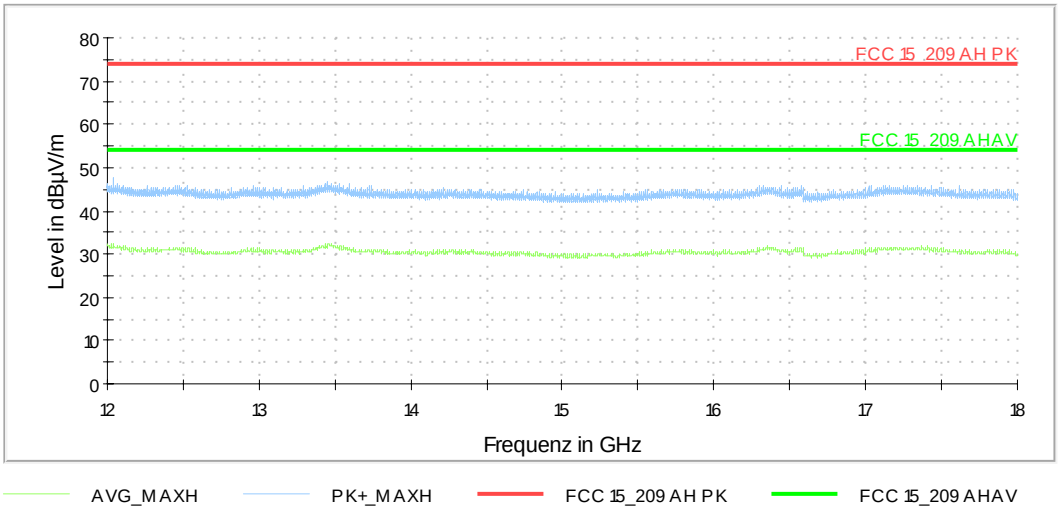
Spurious emissions from 1 GHz to 4 GHz (operation mode 1):



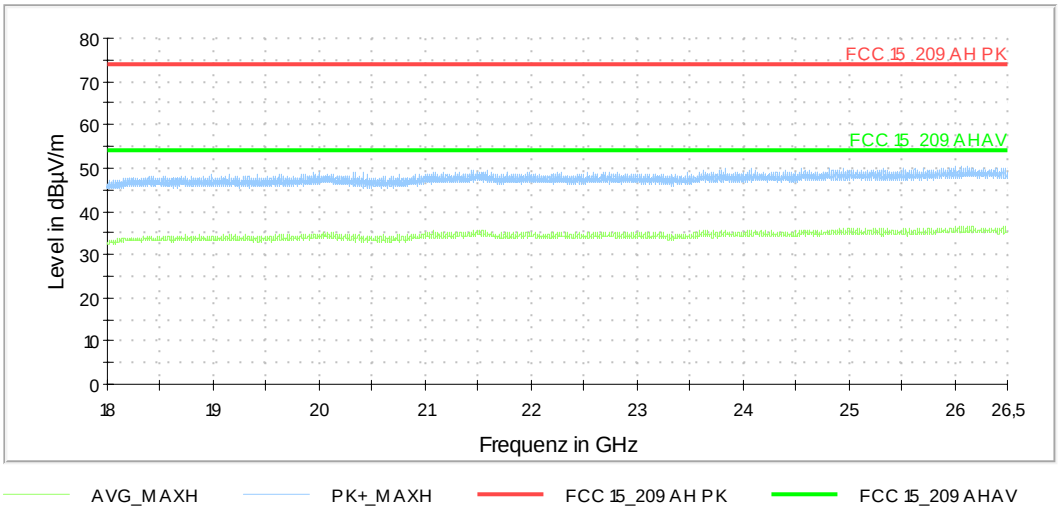
Spurious emissions from 4 GHz to 12 GHz (operation mode 1):



Spurious emissions from 12 GHz to 18 GHz (operation mode 1):



Spurious emissions from 18 GHz to 26.5 GHz (operation mode 1):



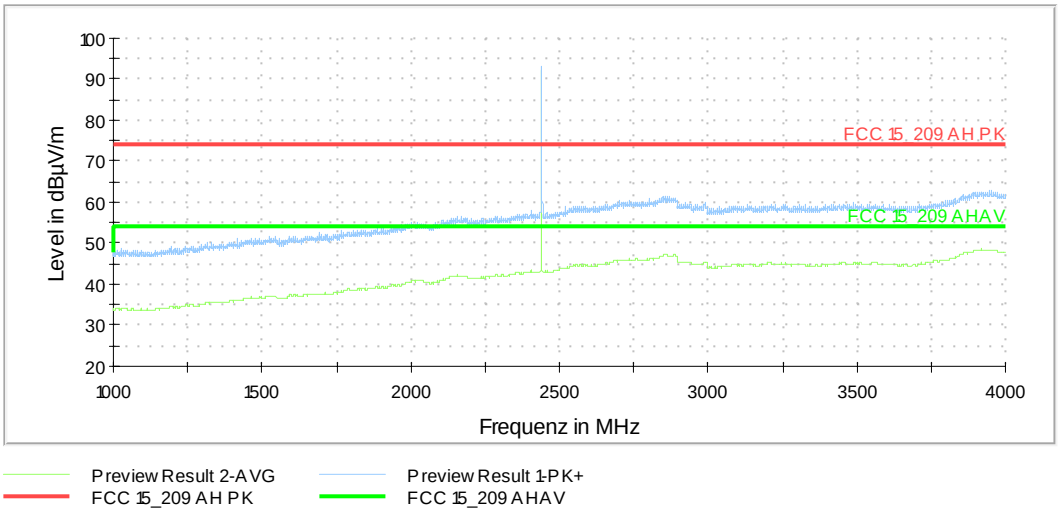
5.4.2.3.1.2 Result table

Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
2400.000000	---	36.8	54	17.2	33.5	90	152	V	Passed
2400.000000	63.0	---	74	11.0	33.3	90	152	V	Passed
2402.000000	---	92.9	--	--	33.5	90	150	V	Fund.
2402.000000	93.6	---	--	--	33.3	90	150	V	Fund.
2483.500000	---	32.1	54	21.9	33.6	0	288	V	Passed
2483.500000	43.8	---	74	30.2	33.4	0	288	V	Passed
2889.250000	---	34.0	54	20.0	35.6	0	296	H	Passed
2889.250000	46.0	---	74	28.0	35.4	0	296	H	Passed
3895.250000	---	40.8	54	13.2	39.7	120	235	V	Passed
3895.250000	53.7	---	74	20.3	39.5	120	235	V	Passed
4804.000000	---	36.0	54	18.0	-1.9	0	30	H	Passed
4804.000000	44.1	---	74	29.9	-2.1	0	30	H	Passed
11045.000000	---	39.1	54	14.9	9.2	0	141	V	Passed
11045.000000	51.1	---	74	22.9	9.0	0	141	V	Passed
12041.500000	---	29.7	54	24.3	12.3	0	258	V	Passed
12041.500000	41.5	---	74	32.5	12.1	0	258	V	Passed
19954.250000	---	33.2	54	20.8	7.1	120	294	V	Passed
19954.250000	46.0	---	74	28.0	6.9	120	294	V	Passed
Measurement uncertainty					±5.5 dB				

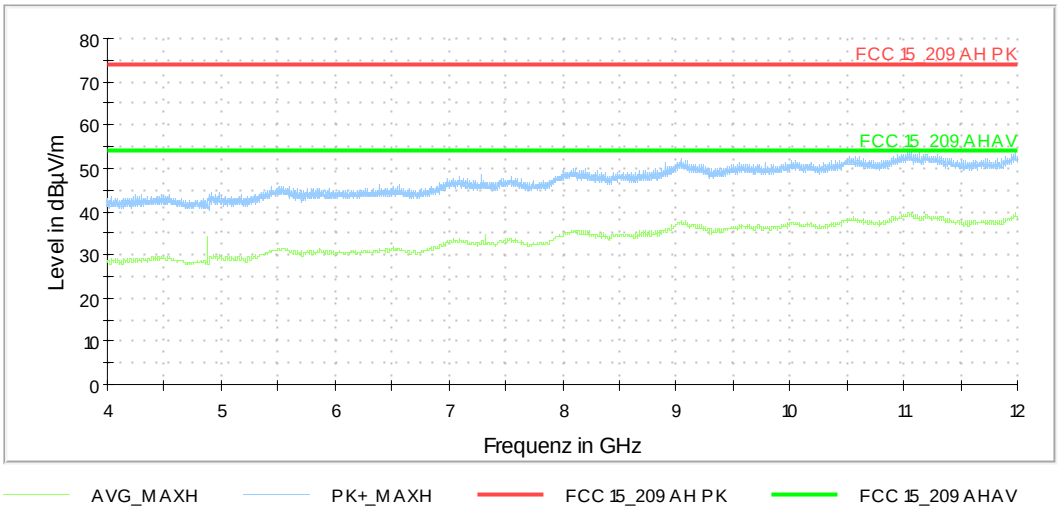
5.4.2.3.2 Operation mode 2

5.4.2.3.2.1 Plots

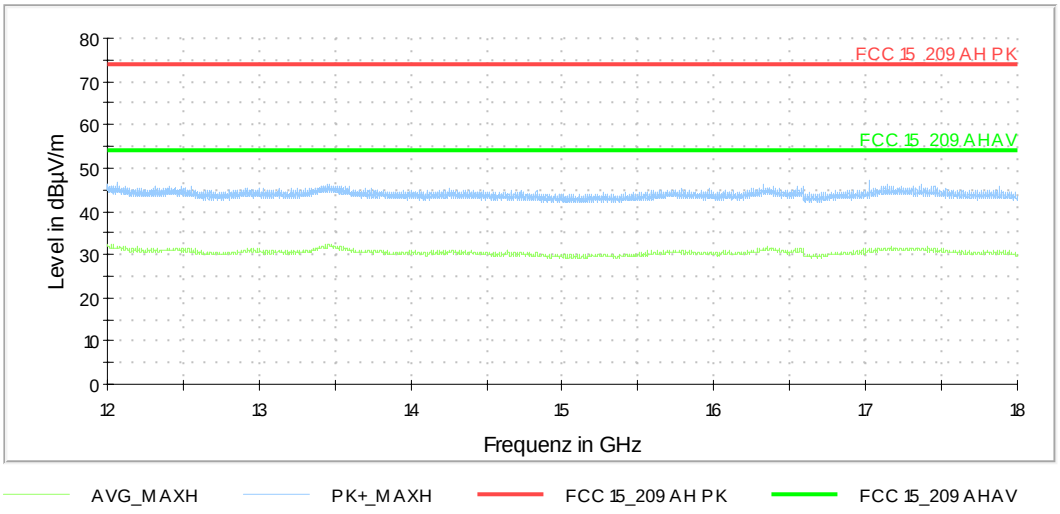
Spurious emissions from 1 GHz to 4 GHz (operation mode 2):



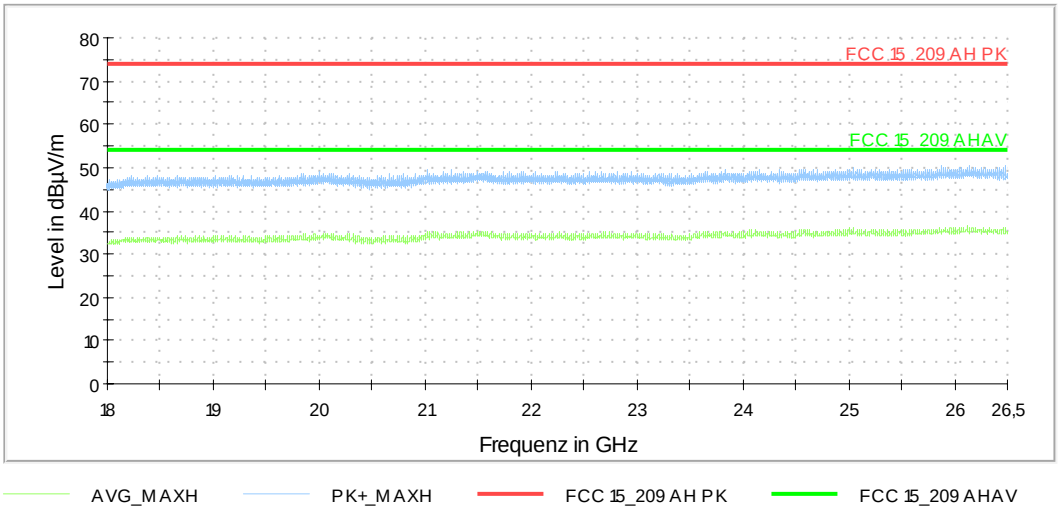
Spurious emissions from 4 GHz to 12 GHz (operation mode 2):



Spurious emissions from 12 GHz to 18 GHz (operation mode 1):



Spurious emissions from 18 GHz to 26.5 GHz (operation mode 1):



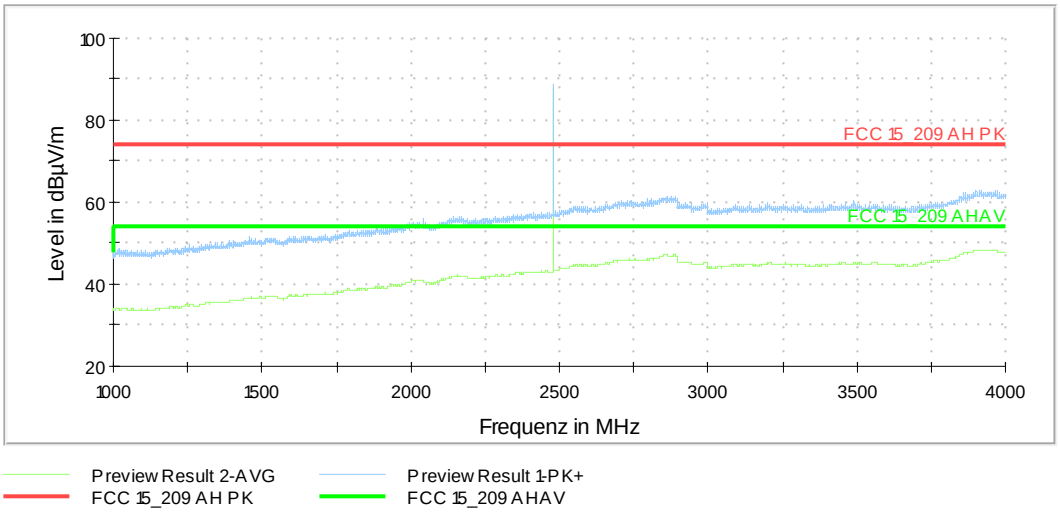
5.4.2.3.2.2 Result table

Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
2440.000000	---	92.9	--	--	33.7	90	150	V	Fund.
2440.000000	93.6	---	--	--	33.5	90	150	V	Fund.
2891.500000	---	34.0	54	20.0	35.5	30	334	H	Passed
2891.500000	46.0	---	74	28.0	35.3	30	334	H	Passed
3948.000000	---	41.1	54	12.9	39.7	150	34	V	Passed
3948.000000	52.8	---	74	21.2	39.5	150	34	V	Passed
4880.000000	43.9	---	74	30.1	-1.8	30	42	H	Passed
4880.000000	---	34.5	54	19.5	-1.6	30	42	H	Passed
7320.250000	---	34.8	54	19.2	4.8	120	22	V	Passed
7320.250000	46.0	---	74	28.0	4.6	120	22	V	Passed
11060.250000	---	39.2	54	14.8	9.2	30	122	H	Passed
11060.250000	51.9	---	74	22.1	9.0	30	122	H	Passed
12200.000000	41.3	---	74	32.7	11.9	90	72	V	Passed
12200.000000	---	29.7	54	24.3	12.1	90	72	V	Passed
17020.500000	---	29.1	54	24.9	10.9	150	182	V	Passed
17020.500000	41.7	---	74	32.3	10.7	150	182	V	Passed
21021.250000	---	33.6	54	20.4	7.6	150	176	V	Passed
21021.250000	45.7	---	74	28.3	7.4	150	176	V	Passed
Measurement uncertainty					±5.5 dB				

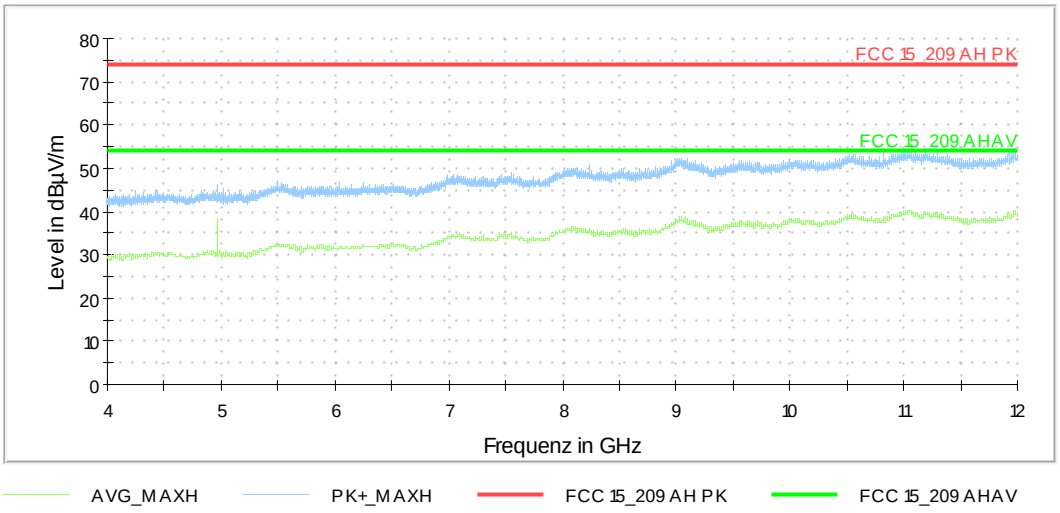
5.4.2.3.3 Operation mode 3

5.4.2.3.3.1 Plots

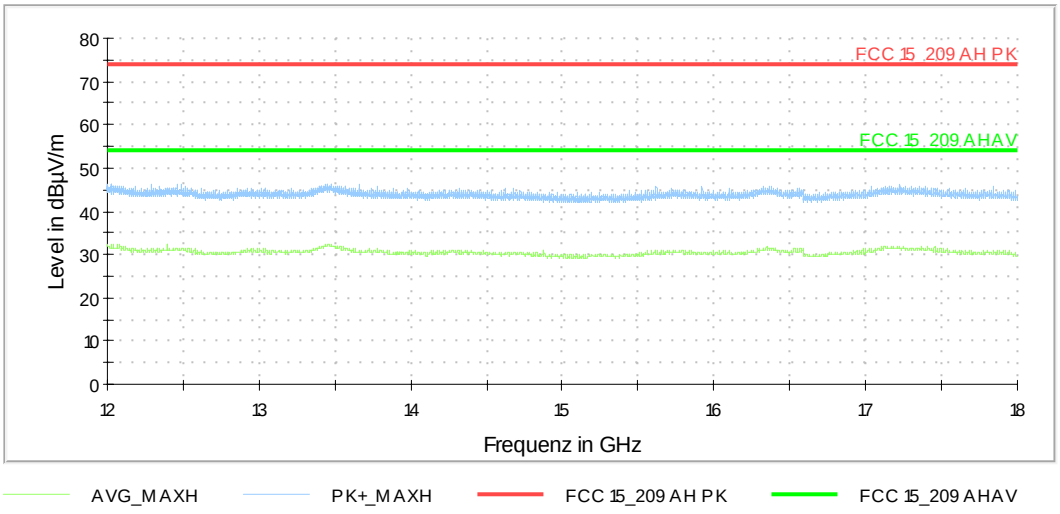
Spurious emissions from 1 GHz to 4 GHz (operation mode 3):



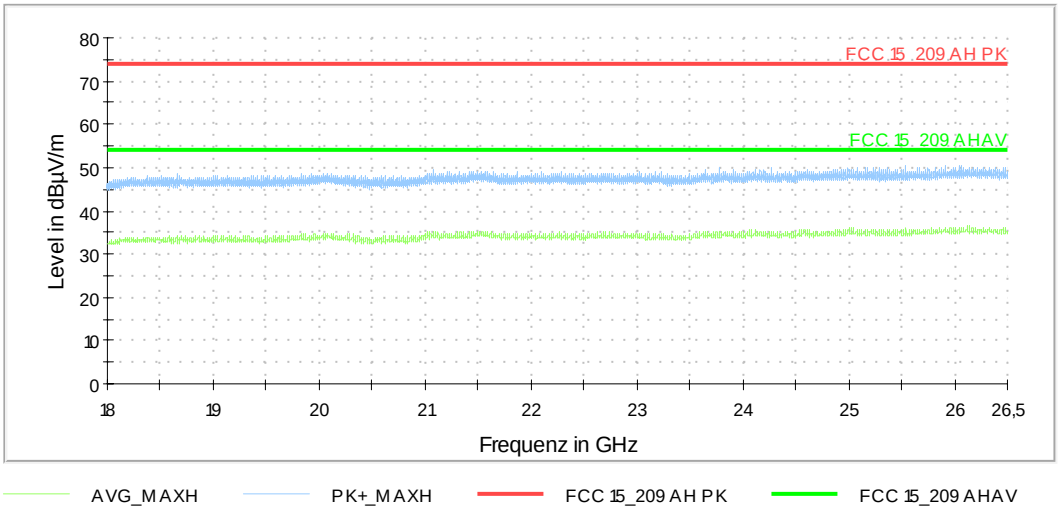
Spurious emissions from 4 GHz to 12 GHz (operation mode 3):



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



Spurious emissions from 18 GHz to 26.5 GHz (operation mode 3):



5.4.2.3.3.2 Result table

Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
2480.000000	88.3	---	--	--	33.4	30	112	H	Fund.
2480.000000	---	87.6	--	--	33.6	30	112	H	Fund.
2482.500000	---	32.9	54	21.1	33.6	30	96	H	Passed
2482.500000	54.1	---	74	19.9	33.4	30	96	H	Passed
2894.750000	---	34.0	54	20.0	35.5	60	112	V	Passed
2894.750000	46.1	---	74	27.9	35.3	60	112	V	Passed
3967.750000	---	41.1	54	12.9	39.5	150	198	V	Passed
3967.750000	54.3	---	74	19.7	39.3	150	198	V	Passed
4960.000000	---	38.8	54	15.2	-1.8	0	58	H	Passed
4960.000000	46.0	---	74	28.0	-2.0	0	58	H	Passed
11980.250000	---	39.1	54	14.9	7.3	0	306	V	Passed
11980.250000	51.5	---	74	22.5	7.1	0	306	V	Passed
12399.500000	43.2	---	74	30.8	12.1	150	131	V	Passed
12399.500000	---	31.2	54	22.8	12.3	150	131	V	Passed
21541.250000	---	34.0	54	20.0	7.8	0	251	V	Passed
21541.250000	46.1	---	74	27.9	7.6	0	251	V	Passed
Measurement uncertainty					±5.5 dB				

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

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	04.03.2020	03.2022
2	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	05.02.2020	02.2021
3	RF Switch Matrix	OSP220	Rohde & Schwarz	-	482976	Calibration not necessary	
4	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
5	Antennasupport	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
6	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
7	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
8	Measuring software EMC32 M276	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
9	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	14.11.2019	11.2021
10	Antenna (Bilog)	CBL6111D	Schaffner Elektrotest GmbH / Teseq GmbH	22921	480674	27.03.2018	03.2021
11	Antenna (Log.Per.)	HL050	Rohde & Schwarz	100438	481170	09.10.2017	10.2020
12	RF-Cable No. 40	Sucoflex 106B	Suhner	0708/6B / Kabel 40	481330	Calibration not necessary	
13	standard gain horn antenna	18240-20	Flann Microwave	483	480294	Calibration not necessary	
14	Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ Hauppauge N.Y.	571667	480343	13.02.2020	02.2022
15	standard gain horn antenna	20240-20	Flann Microwave	411	480297	Calibration not necessary	
16	Preamplifier 18 GHz - 26 GHz	JS4-18002600-20-5A	MITEQ Hauppauge N.Y.	658697	480342	13.02.2020	02.2022
17	High pass Filter	WHKX4.0/18G-8SS	Wainwright Instruments GmbH	1	480587	Calibration not necessary	
18	Microwave cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800-KPS	480302	Calibration not necessary	
19	Antenna mast	AS615P	Deisel	615/310	480187	Calibration not necessary	
20	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
21	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
22	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/971107	480832	Calibration not necessary	
23	Positioners	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
24	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	18.02.2020	02.2022
25	Software	EMC32	Rohde & Schwarz	-	481800	Calibration not necessary	
26	Preamplifier 100 MHz - 16 GHz	AFS6-00101600-23-10P-6-R	Narda MITEQ	2011215	482333	13.02.2020	02.2022
27	RF-cable No.38	Sucoflex 106B	Suhner	0709/6B / Kabel 38	481328	Calibration not necessary	

7 Test site Validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA	ANSI C63.4-2017	19.09.2019	18.09.2021
Fully anechoic chamber M20	480303	1 -18 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	24.08.2020	23.08.2022

8 Report History

Report Number	Date	Comment
F191168E4	07.09.2020	Initial Test Report
-	-	-
-	-	-

9 List of Annexes

Annex A Test Setup Photos 7 pages