PHOENIX TESTLAB

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Test Report

Report Number:

F191168E3

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	9.6.0 J. Li Signature	07.09.2020 Date
Reviewed and approved by:	Bernd STEINER Name	B. Sh Signature	07.09.2020 Date

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:	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: *	Antenna A: 204579407 Antenna B: 204579409
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 IEEE802.15.4 mode)					

Identification	Connector		Length
	EUT	Ancillary	
No lines connectable to the EUT			

IEEE 802.15.4 radio mode		
Fulfils radio specification: *	IEEE 802.15.4	
Radio chip: *	Atmega256RFR2	
Antenna type: *	Chip-Ceramic	
Antenna name: *	RFANT3216120A5T	
Antenna gain: *	2 dBi (Typical)	
Antenna connector: *	MM8030-2610RJ3	
Conducted output power: *	IEEE 802.15.4	2.9 dBm (Peak)
		2.8 dBm (Average)
Type of modulation: *	IEEE 802.15.4	O-QPSK (250 kbit/s)
Operating frequency range: *	IEEE 802.15.4	2405 – 2480 MHz
Number of channels: *	IEEE 802.15.4	16 (5 MHz channel spacing)

IEEE 802.15.4 frequencies				
Channel 11	RX	2405 MHz	TX	2405 MHz
Channel 12	RX	2410 MHz	TX	2410 MHz
Channel 13	RX	2415 MHz	TX	2415 MHz
Channel 14	RX	2420 MHz	TX	2420 MHz
Channel 15	RX	2425 MHz	TX	2425 MHz
Channel 16	RX	2430 MHz	TX	2430 MHz
Channel 17	RX	2435 MHz	TX	2435 MHz
Channel 18	RX	2440 MHz	TX	2440 MHz
Channel 19	RX	2445 MHz	TX	2445 MHz
Channel 20	RX	2450 MHz	TX	2450 MHz
Channel 21	RX	2455 MHz	TX	2455 MHz
Channel 22	RX	2460 MHz	TX	2460 MHz
Channel 23	RX	2465 MHz	TX	2465 MHz
Channel 24	RX	2470 MHz	TX	2470 MHz
Channel 25	RX	2475 MHz	TX	2475 MHz
Channel 26	RX	2480 MHz	TX	2480 MHz

1.5.1 Ancillary Equipment / Equipment used for testing

Equipment used for testing
-

1.6 Dates

Date of receipt of test sample:	07.05.2020
Start of test:	14.07.2020
End of test:	09.10.2020

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 one sample. The test modes were set with the aid of a magnet, for channel 26 different power settings could be set.

2.2.1 Radio test

The EUT is equipped with two antennas (further referred as “antenna A” and “antenna B”) for IEEE 802.15.4 communication. The EUT can switch between both antennas (only one antenna used at a time). Therefore, the measurements were done twice, for each antenna configuration separately, except for the duty cycle measurement.

2.2.2 Operation modes

Antenna A:

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate	TX / RX	Power setting
1	IEEE 802.15.4	2405	11	O-QPSK	250 kbit/s	TX	3.5 dBm
2	IEEE 802.15.4	2440	18	O-QPSK	250 kbit/s	TX	3.5 dBm
3	IEEE 802.15.4	2480	26	O-QPSK	250 kbit/s	TX	-3.5 dBm

Antenna B:

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate	TX / RX	Power setting
4	IEEE 802.15.4	2405	11	O-QPSK	250 kbit/s	TX	3.5 dBm
5	IEEE 802.15.4	2440	18	O-QPSK	250 kbit/s	TX	3.5 dBm
6	IEEE 802.15.4	2480	26	O-QPSK	250 kbit/s	TX	-3.5 dBm

3 Additional Information

The EUT also contains a BLE and a UWB transceiver. The results of these technologies are documented in the test reports F191168E3 and F191161E4. 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	12
Maximum conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	Passed	12
DTS Bandwidth / 99% Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	Passed	15
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	Passed	18
Average Power Spectral Density	2400.0 - 2483.5	15.247 (e)	Passed	18
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	Passed	21
Maximum unwanted emissions	0.009 – 26,500*	15.247 (d) 15.205 (a) 15.209 (a)	Passed*	26
Conducted emissions on supply line	0.15 - 30	15.207 (a)	Not tested*2	-
Antenna Requirement	-	15.203 15.247 (b)	Passed*1	-

*1 Fixed PCB 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

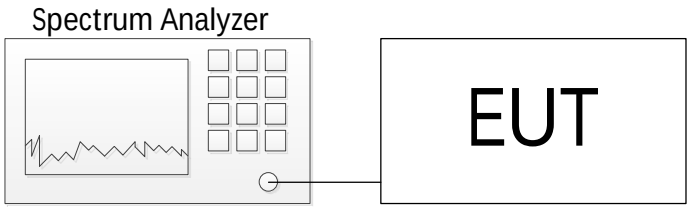
The duty cycle of the IEEE 802.15.4 part of the EUT was set to 100 %, therefore no duty cycle correction factor (DCCF) needs to be calculated.

5.1 Maximum conducted output power

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 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.

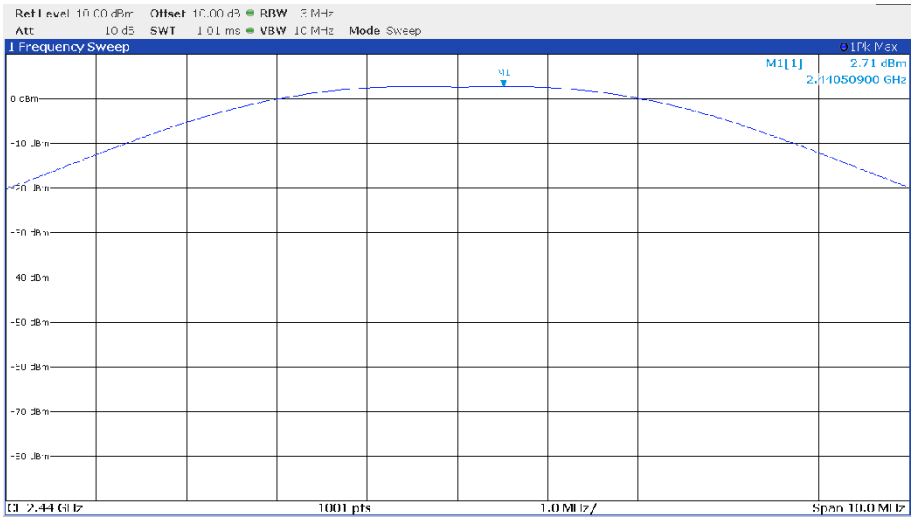
5.1.2 Test results

Ambient temperature	22 °C
Relative humidity	53 %

Date	08.10.2020
Tested by	B. ROHDE

Maximum *peak* conducted output power:

Antenna B Ch 18:



Antenna A / J1:

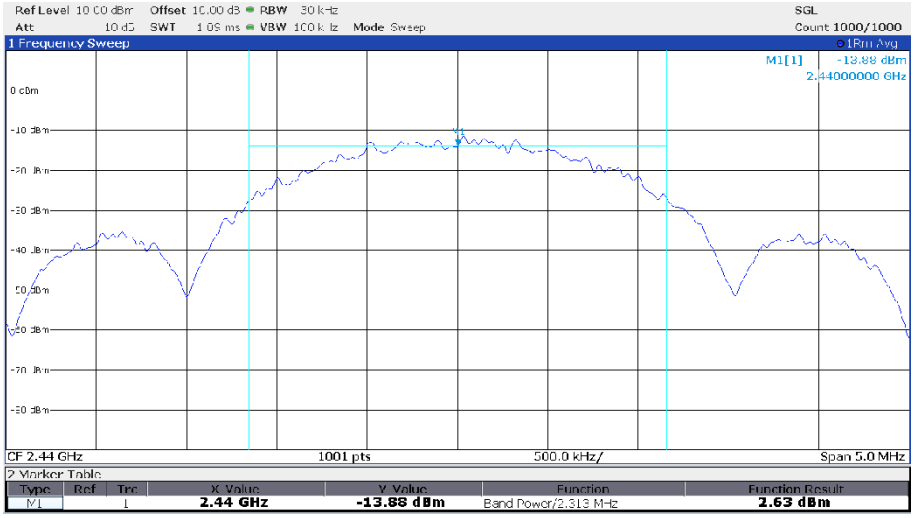
Operation mode	Reading [dBm]	Corr. Fact. [Cable] [dB]	Result [dBm]	Limit [dBm]
1	1.75	0.2	1.95	30
2	1.74	0.2	1.94	30
3	-5.45	0.2	-5.25	30

Antenna B / J2:

Operation mode	Reading [dBm]	Corr. Fact. [Cable] [dB]	Result [dBm]	Limit [dBm]
4	2.66	0.2	2.86	30
5	2.71	0.2	2.91	30
6	-4.58	0.2	-4.38	30

Maximum *average* conducted output power:

Antenna B Ch 18:



Antenna A / J1:

Operation mode	Reading [dBm]	Corr. Fact. [Cable] [dB]	DCCF [dB]	Result [dBm]	Limit [dBm]
1	1.66	0.2	0.0	1.86	30
2	1.63	0.2	0.0	1.83	30
3	-5.55	0.2	0.0	-5.35	30

Antenna B / J2:

Operation mode	Reading [dBm]	Corr. Fact. [dB]	DCCF [dB]	Result [dBm]	Limit [dBm]
4	2.59	0.2	0.0	2.79	30
5	2.63	0.2	0.0	2.83	30
6	-4.65	0.2	0.0	-4.45	30

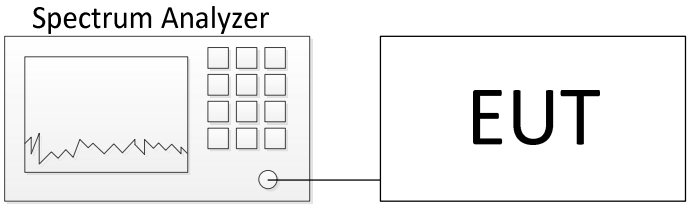
Test equipment (please refer to chapter 6 for details)
1

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 **11.8.1** 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.

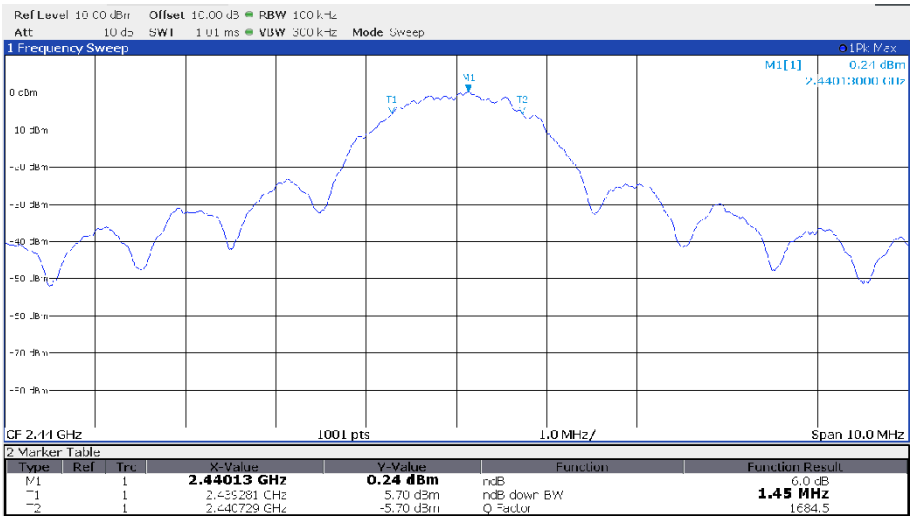
5.1.2 Test results

Ambient temperature	22 °C
Relative humidity	53 %

Date	08.10.2020
Tested by	B. ROHDE

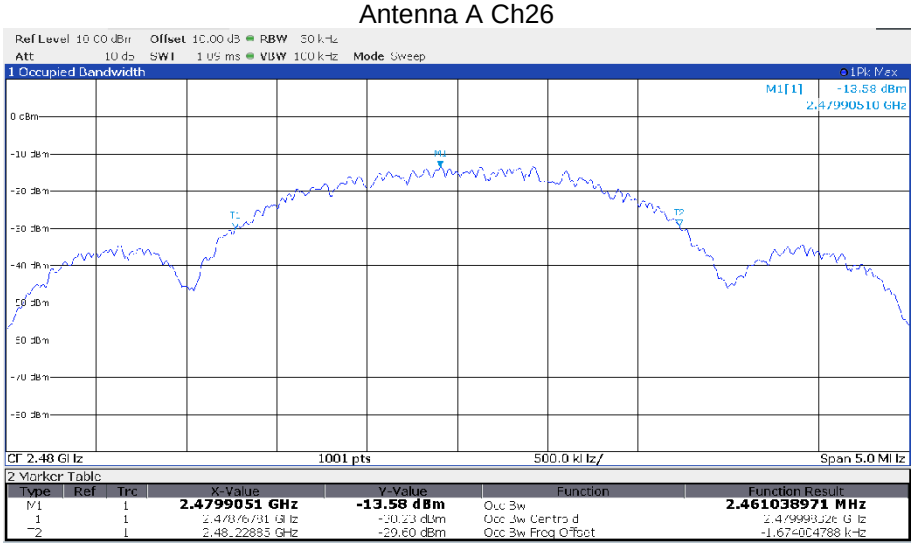
Representative plot DTS bandwidth:

Antenna B Ch18



Representative plot 99 % bandwidth

Antenna A Ch26



Antenna A:

OP mode	Data rate	Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
1	250 kbit/s	2405	0.5	1.45	2.394	Passed
2	250 kbit/s	2440	0.5	1.58	2.406	Passed
3	250 kbit/s	2475	0.5	1.81	2.461	Passed

Antenna B:

OP mode	Data rate	Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
4	250 kbit/s	2405	0.5	1.52	2.287	Passed
5	250 kbit/s	2440	0.5	1.45	2.313	Passed
6	250 kbit/s	2475	0.5	1.54	2.376	Passed

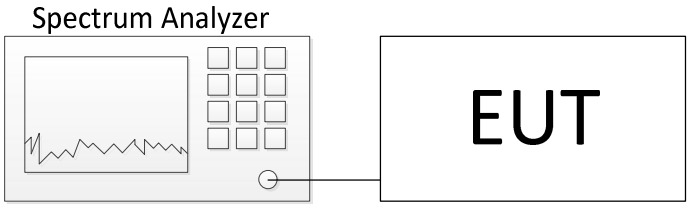
Test equipment (please refer to chapter 6 for details)
1

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.

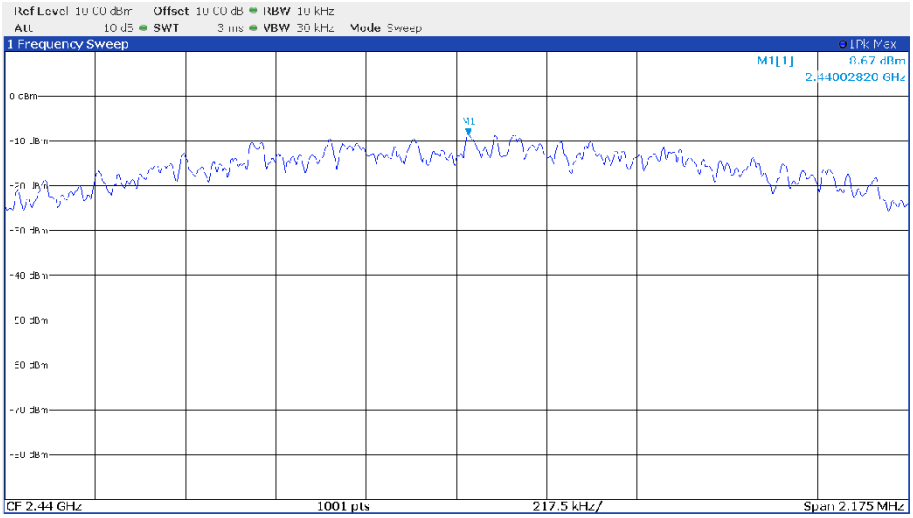
Only one representative plot for each measurement configuration is provided.

5.2.2 Test results

Ambient temperature	22 °C
Relative humidity	53 %

Date	08.10.2020
Tested by	B. ROHDE

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



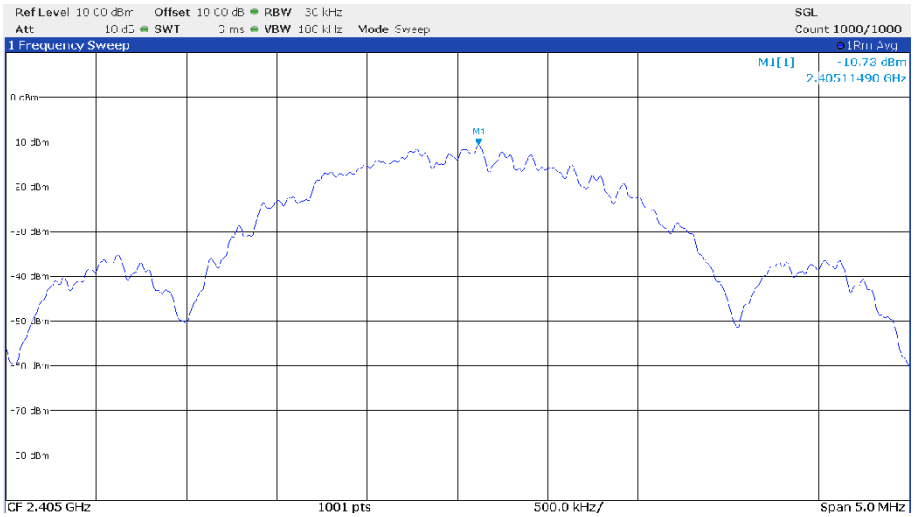
Antenna A:

OP mode		Peak Frequency [MHz]	Peak PSD Reading [dBm / 10 kHz]	Corr. Fact. [Cable] [dB]	Peak PSD Result [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
1		2404.764	-9.76	0.2	-9.56	8	Passed
2		2440.204	-10.06	0.2	-9.86	8	Passed
3		2479.908	-18.29	0.2	-18.09	8	Passed

Antenna B:

OP mode	Peak Frequency [MHz]	Peak PSD Reading [dBm / 10 kHz]	Corr. Fact. [Cable] [dB]	Peak PSD Result [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	2405.109	-8.81	0.2	-8.61	8	Passed
2	2440.028	-8.67	0.2	-8.47	8	Passed
3	2480.152	-15.62	0.2	-15.42	8	Passed

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



Antenna A:

OP mode	Peak Frequency [MHz]	PSD Reading [dBm / 30 kHz]	Corr. Fact. [Cable] [dB]	DCCF [dB]	Result incl. DCCF [dBm / 30 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	2405.110	-11.91	0.2	0.0	-11.71	8	Passed
2	2440.105	-13.62	0.2	0.0	-13.42	8	Passed
3	2480.135	-20.16	0.2	0.0	-19.96	8	Passed

Antenna B:

OP mode	Peak Frequency [MHz]	PSD Reading [dBm / 30 kHz]	Corr. Fact. [Cable] [dB]	DCCF [dB]	Result incl. DCCF [dBm /30 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	2405.115	-10.73	0.2	0.0	-10.53	8	Passed
2	2440.010	-11.45	0.2	0.0	-11.25	8	Passed
3	2480.155	-17.91	0.2	0.0	-17.71	8	Passed

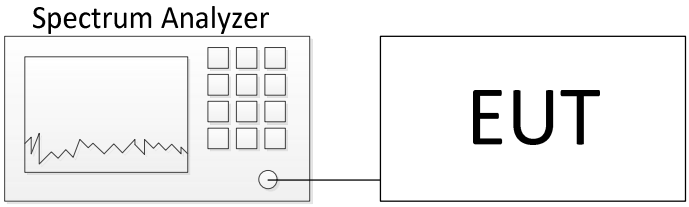
Test equipment (please refer to chapter 6 for details)
1

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.

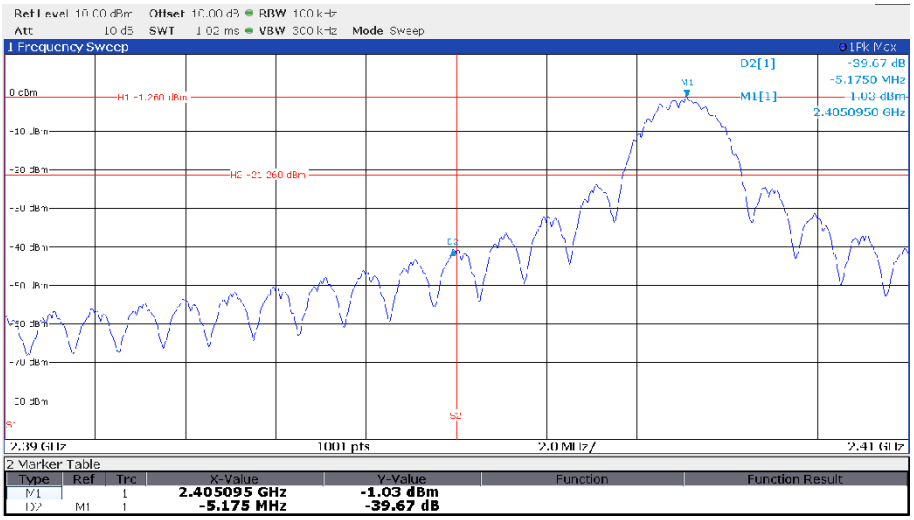
5.3.3 Test results

5.3.3.1 Band-edge testing (unrestricted bands; conducted):

Ambient temperature	22 °C
Relative humidity	53 %

Date	08.10.2020
Tested by	B. ROHDE

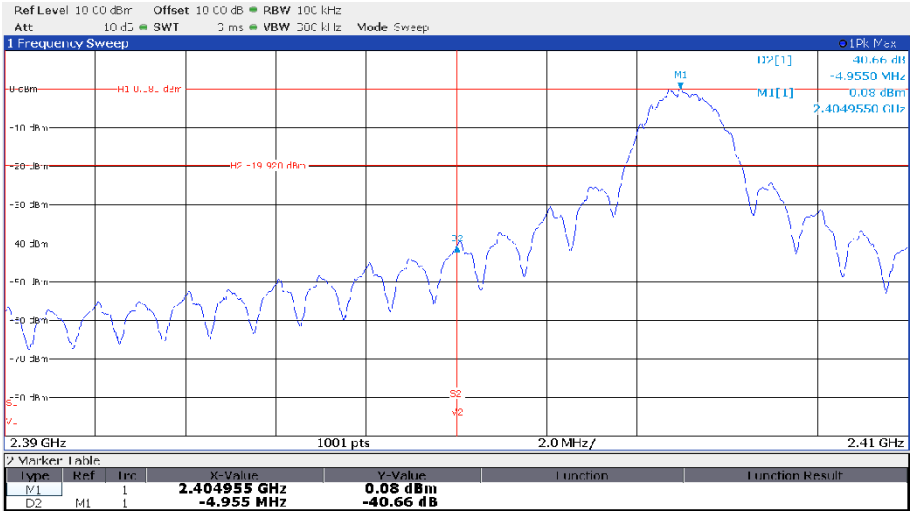
Antenna A



Antenna A:

Operation mode	Data rate	Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Margin [dB]	Result
1	250 kbit/s	2405	-1.03	-21.3	19.7	Passed

Antenna B:



Antenna B:

Operation mode	Data rate	Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Margin [dB]	Result
4	250 kbit/s	2405	0.1	-19.9	20.7	Passed

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

5.3.3.2 Band-edge testing (restricted bands; radiated):

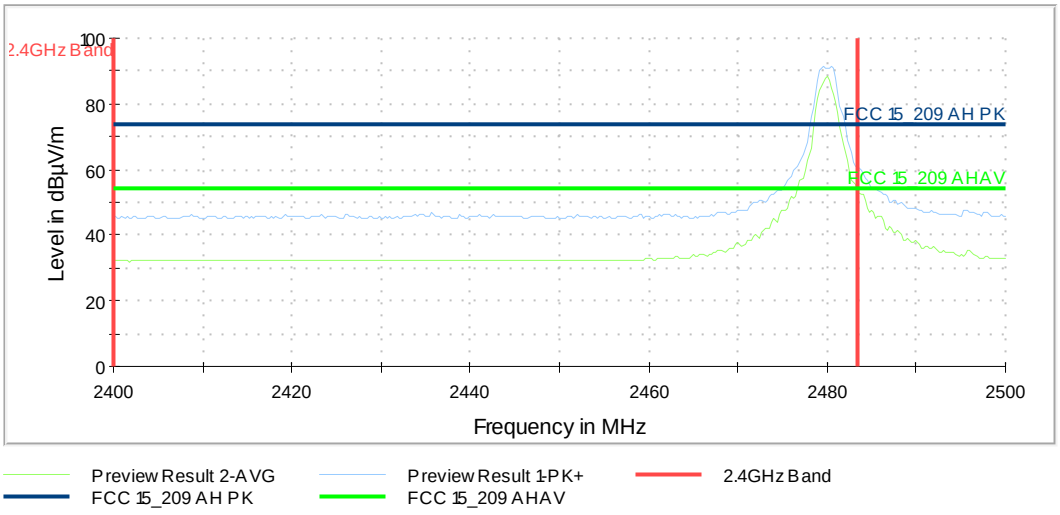
Ambient temperature	22 °C
Relative humidity	43 %

Date	09.10.2020
Tested by	B. ROHDE

Operation mode 1:
No significant emission found; no final measurement conducted

Operation mode 3:

Antenna A:

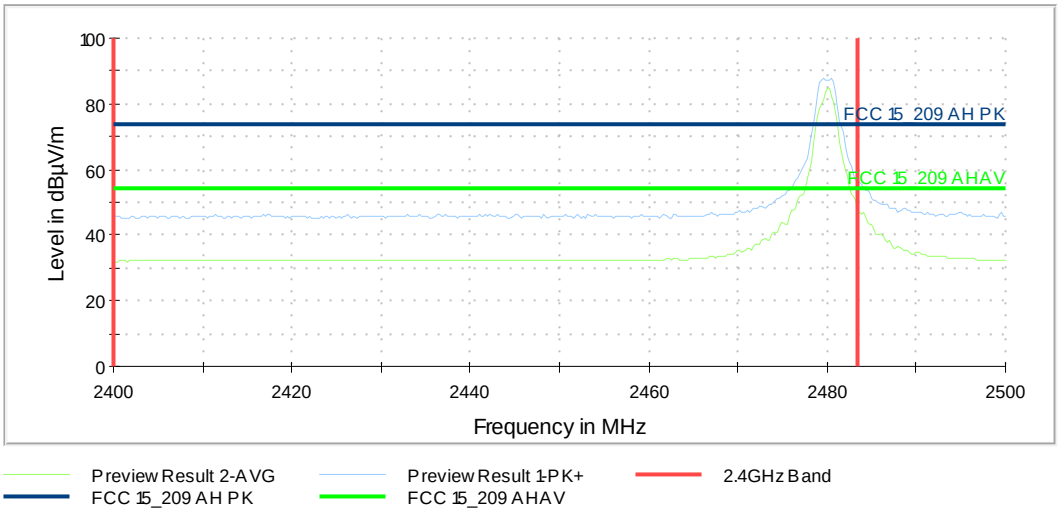


Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB]	Elevation [deg]	Azimuth [deg]	Pol.	Result
2383.500000	61.30	---	74	12.70	26.70	34.6	0	148	H	Passed
2384.000000	---	53.5	54	0.50	17.90	34.6	0	148	H	Passed
Measurement uncertainty					±5.5 dB					

Operation mode 4:
No significant emission found; no final measurement conducted

Operation mode 6:

Antenna B:



Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB]	Elevation [deg]	Azimuth [deg]	Pol.	Result
2383.500000	58.83	---	74	15.17	24.23	34.6	0	40	H	Passed
2383.500000	---	50.16	54	3.84	15.56	34.6	0	40	H	Passed
Measurement uncertainty					±5.5 dB					

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

5.4 Maximum unwanted emissions 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.

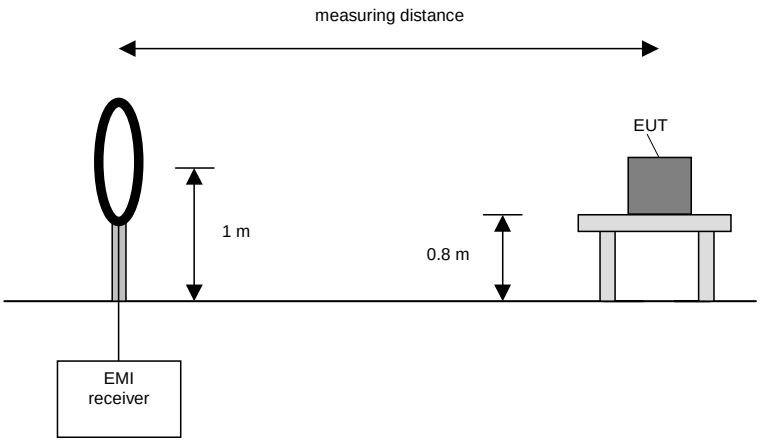
Preliminary measurement (9 kHz to 30 MHz):

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.

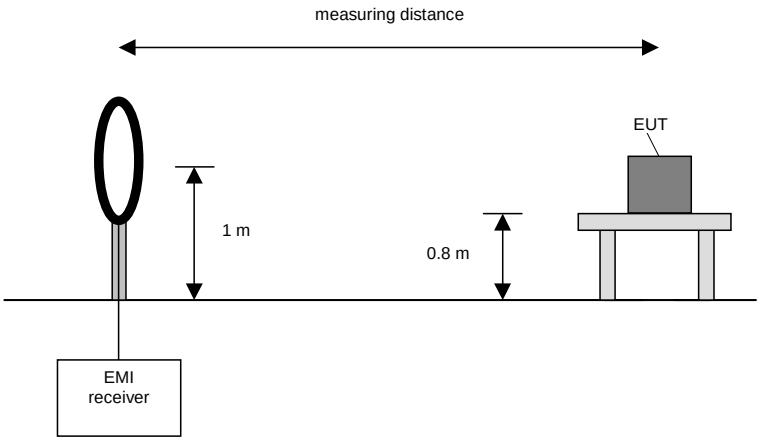
Final measurement (9 kHz to 30 MHz):

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

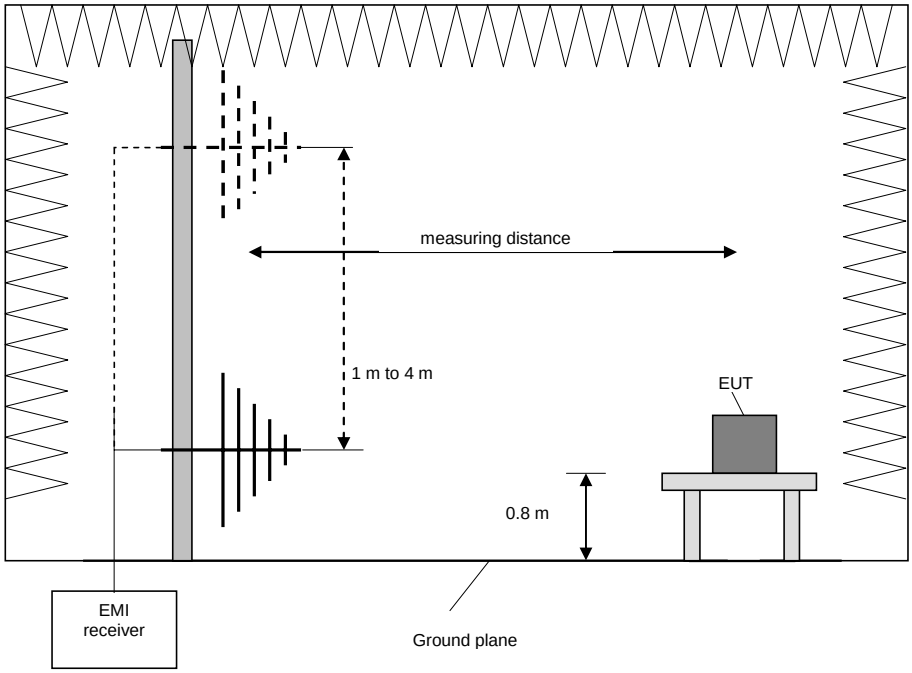


Preliminary and final measurement (30 MHz to 1 GHz)

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)

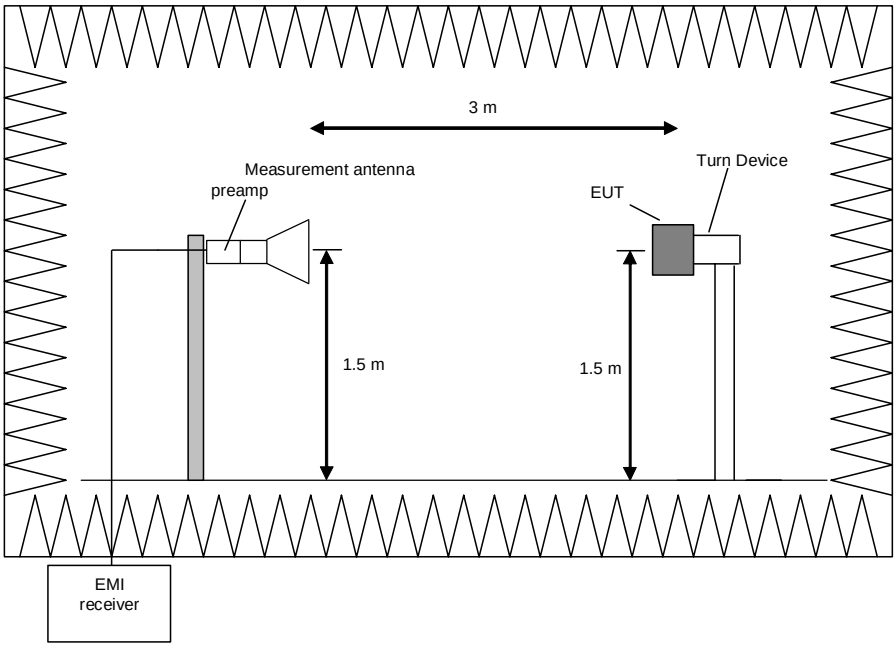
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

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:

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

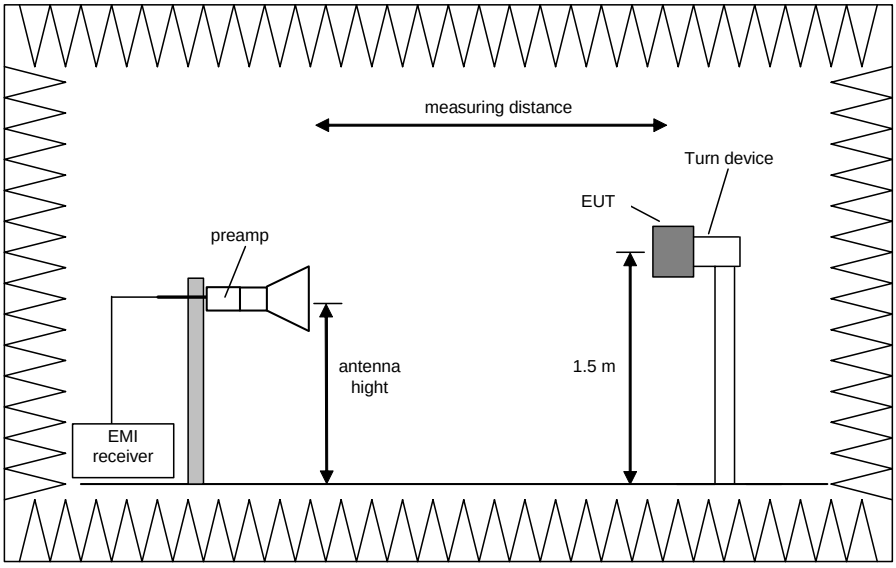
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an 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	29.09.2020
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.

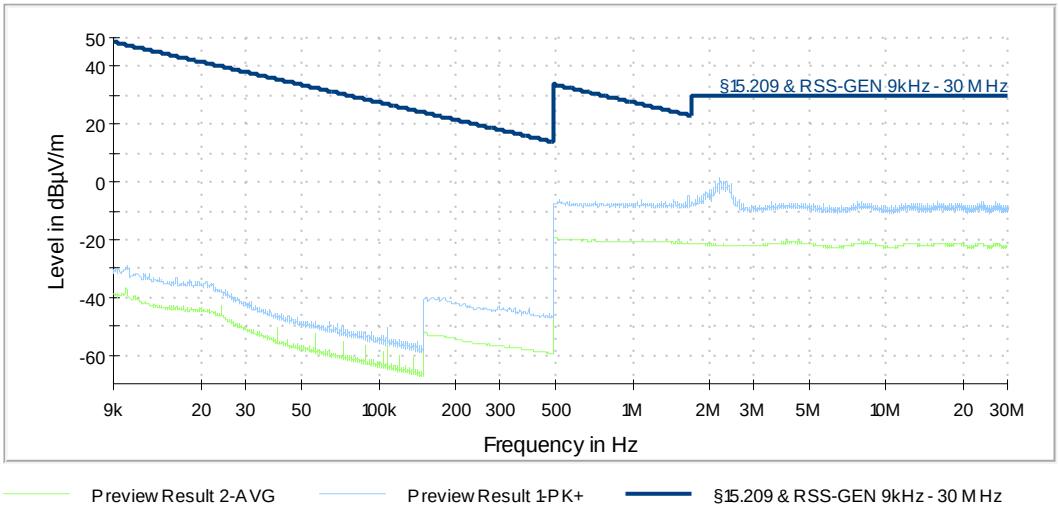
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

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

Remark: As pretests have shown, no significant difference between modes 1 – 6 could be monitored in the spectrum from 30 MHz to 1 GHz, therefore only one representative final emissions measurement in this frequency rage was conducted

5.4.2.1.1 Plots

9k-30M: Spurious emissions from 9 kHz to 30 MHz (Operation mode 5)



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).

5.4.2.1.2 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 - 8, 10

5.4.2.2 Test results (30 MHz – 1 GHz)

Ambient temperature	23 °C
Relative humidity	45 %

Date	14.07.2020
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.

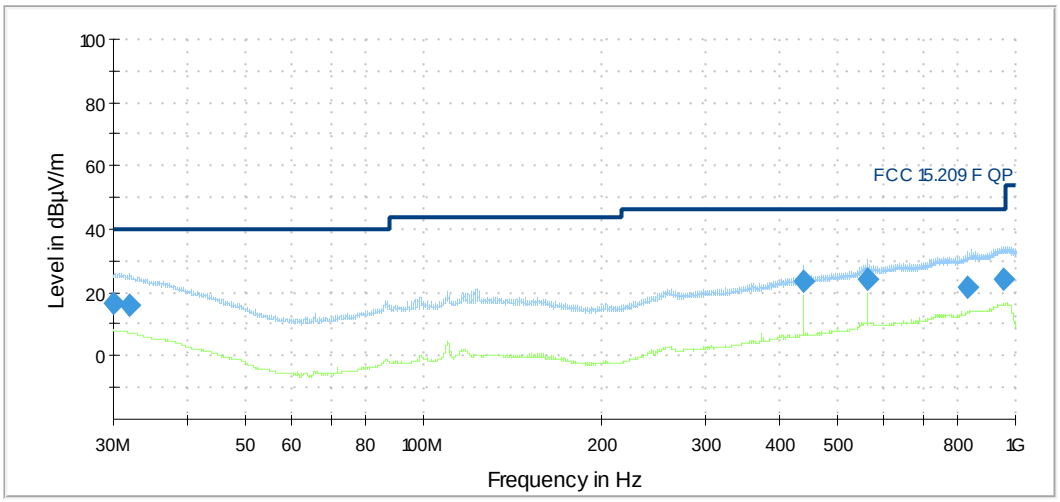
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: Only the worst-case plot is submitted below.
As pretests have shown, antenna A is the worst-case, final tests were only conducted on antenna A

Remark: As pretests have shown, no significant difference between modes 1 – 6 could be monitored in the spectrum from 30 MHz to 1 GHz, therefore only one representative final emissions measurement in this frequency rage was conducted

5.4.2.2.1 Plots

Antenna B
Spurious emissions from 30 MHz to 1 GHz (operation mode 5):



5.4.2.2.2 Result table

Result table (operation mode 5): ANT B CH18

Frequency [MHz]	Result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
30.015000	16.66	40.00	23.34	-10.7	27.4	100	335	V	Passed
31.885000	16.11	40.00	23.89	-10.4	26.6	278	267	H	Passed
437.505000	23.66	46.00	22.34	-1.1	24.8	299	307	V	Passed
562.510000	24.24	46.00	21.76	-4.2	28.5	245	81	H	Passed
832.605000	21.99	46.00	24.01	-9.8	31.8	400	86	H	Passed
953.795000	24.51	46.00	21.49	-9.6	34.1	234	141	V	Passed
Measurement uncertainty ±5.5 dB				±5.5 dB					

Test equipment (please refer to chapter 6 for details)
2 - 8, 11

5.4.2.3 Test results (above 1 GHz)

Ambient temperature	22-23 °C
Relative humidity	43 - 56 %

Date	14.07.2020 to 09.10.2020
Tested by	B. ROHDE; Y KHALEK

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.

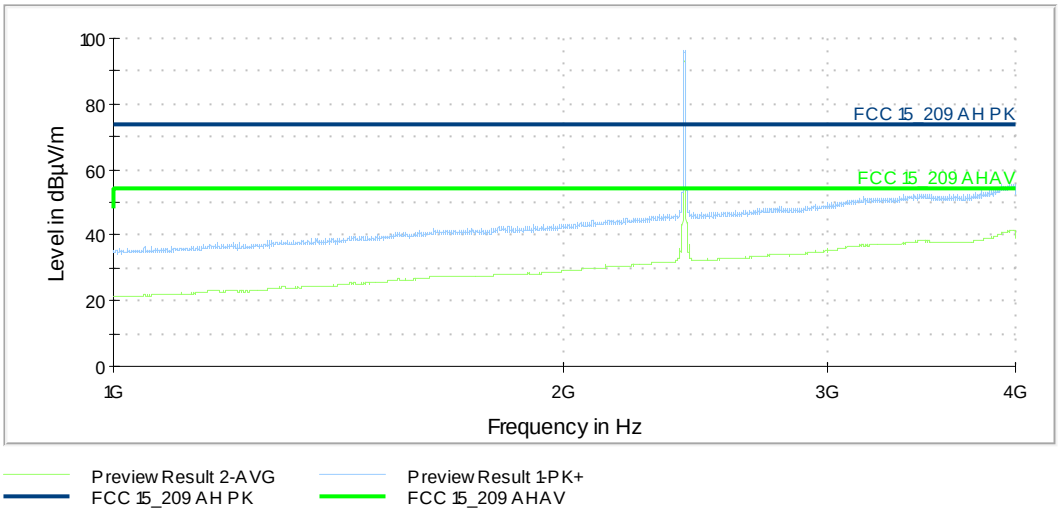
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: As pretests have shown, Antenna A is the worst case (radiated), final measurements were conducted only for antenna A

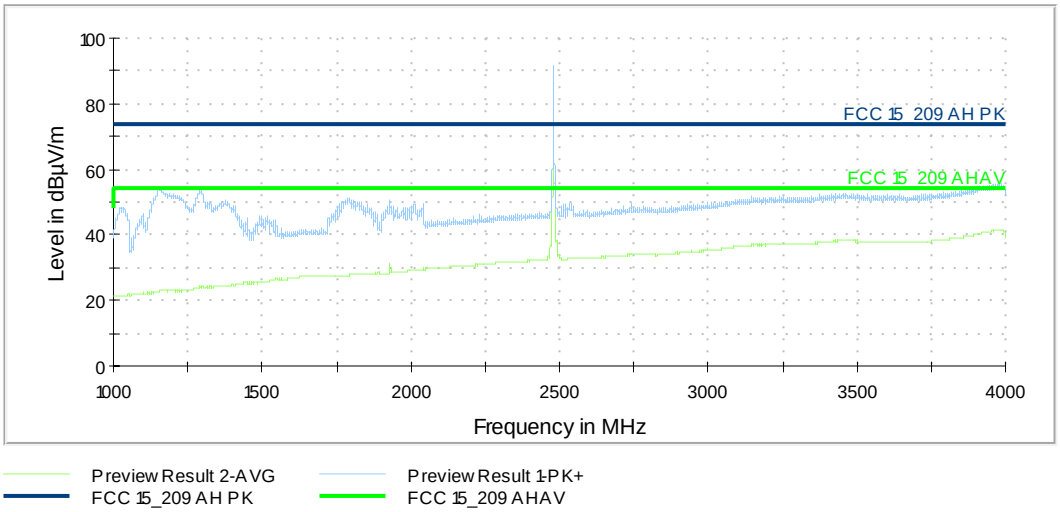
Remark: only the worst-case plots ware reported below

5.4.2.3.1 Plots

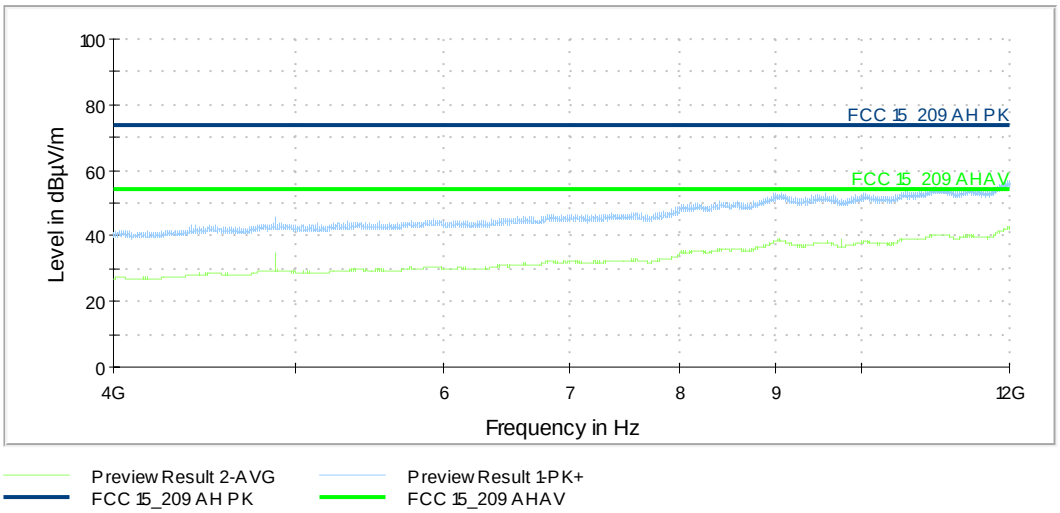
Antenna A:
Spurious emissions from 1 GHz to 4 GHz (operation mode 1):
(highest emissions level in band)



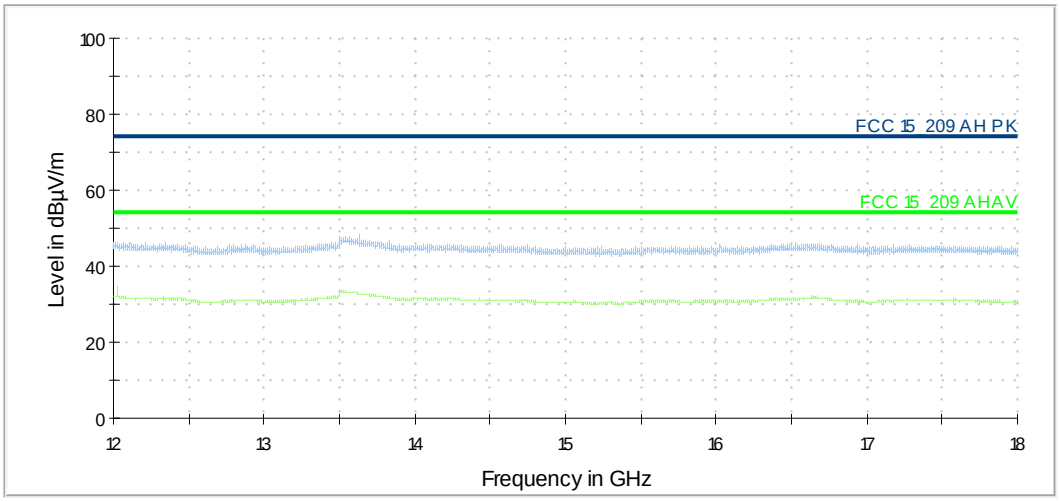
Spurious emissions from 1 GHz to 4 GHz (operation mode 1):
(highest emissions @ the band edges and out of band)



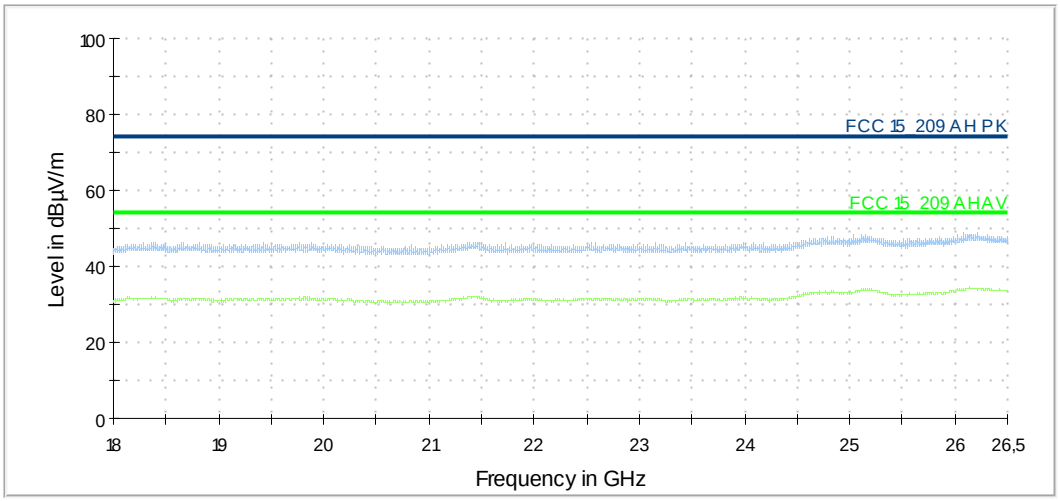
Spurious emissions from 4 GHz to 12 GHz (operation mode 1):



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



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



5.4.2.3.2 Result table

Result table antenna A operation mode 1:

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Height (deg)	Pol	Azimuth (deg)	Corr. (dB)
All emissions, except the fundamental are more than 20 dB below the limit, no final measurement conducted								
Measurement uncertainty			+/- 4.79 dB					

Result table antenna A operation mode 2:

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Height (deg)	Pol	Azimuth (deg)	Corr. (dB)
All emissions, except the fundamental are more than 20 dB below the limit, no final measurement conducted								
Measurement uncertainty			+/- 4.79 dB					

Result table antenna A operation mode 3:

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Height (deg)	Pol	Azimuth (deg)	Corr. (dB)
All emissions, except the fundamental are more than 20 dB below the limit, no final measurement conducted								
Measurement uncertainty			+/- 4.79 dB					

Test equipment (please refer to chapter 6 for details)
2 - 9, 12 - 16

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	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
3	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
4	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
5	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
6	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
7	Measuring software EMC32 M276	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
8	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	14.11.2019	11.2021
9	Log Per Antenna	HL050	Rohde & Schwarz	4062.4063.02-100908	482977	13.08.2019	08.2022
10	loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	05.02.2020	02.2021
11	Antenna (Bilog)	CBL6111D	Schaffner Elektrotest GmbH / Teseq GmbH	25761	480894	19.10.2017	10.2020
12	Low Noise Amplifier 100 MHz - 18 GHz	LNA-30-00101800-25-10P	Narda-Miteq	2110917	482967	18.02.2020	02.2022
13	Low Noise Amplifier 12 GHz - 18 GHz	LNA-30-12001800-13-10P	Narda-Miteq	2089798	482968	17.02.2020	02.2022
14	Standard Gain Horn 20 dB, 12 GHz-18 GHz	18240-20	Flann	267220	483025	Calibration not necessary	
15	Low Noise Amplifier 18 GHz - 26.5 GHz	LNA-30-18002650-20-10P	Narda-Miteq	2110911	482969	17.02.2020	02.2022
16	Standard Gain Horn 20 dB, 18 GHz -26 GHz	20240-20	Flann	266399	483026	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
Semi anechoic chamber M276	483227	1 -18 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	19.09.2019	18.09.2021

8 Report History

Report Number	Date	Comment
F191168E3	07.09.2020	Initial Test Report
-	-	-
-	-	-

9 List of Annexes

Annex A	Test Setup Photos	8 pages