PHOENIX TESTLAB

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Test Report

Report Number:

F191161E4

Equipment under Test (EUT):

omlox Satellite

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 i. Li Signature	07.09.2020 Date
Reviewed and approved by:	Bernd STEINER Name	11.02.2021 19:17 B. Steiner 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: *	Satellite for indoor localization
PMN / Model name: *	omlox Satellite
FCC ID: *	2AVYV-2554432-01
Serial number: *	204744040
PCB identifier: *	1901154A00102B90
Hardware version: *	Rev D
Software version: *	3.0.6

* 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

EUT data						
Power supply EUT: *	DC (by POE or USB)					
Supply voltage EUT POE: *	U_{nom}=	48.0 V_{DC}	U_{min}=	42.5 V_{DC}	U_{max}=	57.0 V_{DC}
Supply voltage EUT (USB): *	U_{nom}=	5.0 V_{DC}	U_{min}=	4.45 V_{DC}	U_{max}=	5.25 V_{DC}
Temperature range: *	-10 °C to +39 °C					
Lowest / highest internal clock frequency: *	32 kHz / 2480 MHz (in IEEE802.15.4 mode)					

Ports / Connectors				
Identification	EUT	Ancillary	Length during test	Shielding (Yes / No)
USB	USB-C	USB-A	2 m	Yes
Ethernet (with POE)	RJ45	RJ45	3 m	Yes

Remark:
USB was used during AC-Powerline emissions testing only
Ethernet was used for in all other testcases.

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	-14.1 dBm (Peak)
		-14.3 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	
POE switch / injector *1	PowerSine 3001
Laptop for remote access: *1	Fujitsu NS751-018; SN: DSBW019318
USB power adaptor: *1	Samsung travel adapter EP-TA20EBE

*1 Provided by the laboratory

1.6 Dates

Date of receipt of test sample:	13.09.2019
Start of test:	02.06.2020
End of test:	27.07.2020

2 Operational States

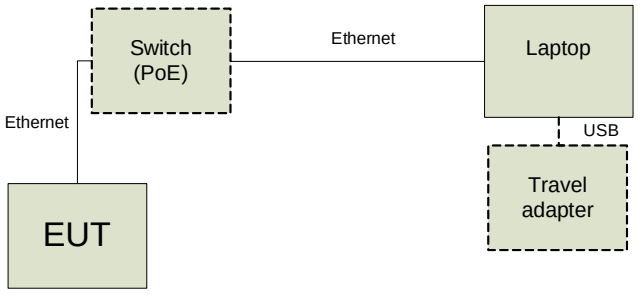
2.1 Description of function of the EUT

The EUT is intended to be used as transceiver for locating of machine tools inside a factory building. It will be fixed mounted inside the factory building. Therefore, it is defined as fixed indoor equipment.
All radiated tests were carried out with an unmodified test sample powered with 48 V_{DC} via PoE from a PoE switch. Because the EUT also could be supplied with 5.0 VDC via USB, the conducted emission measurement on the power supply line was additionally carried out with this kind of power supply.

2.2 The following states were defined as the operating conditions

2.2.1 Radio test

The system setup as follows:



The EUT is equipped with two antennas (further referred as “antenna 0” and “antenna 1”) 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 two times, for each antenna configuration separately, except for the duty cycle measurement.

2.2.2 Operation modes

Antenna 0:

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate	Power setting
1	IEEE 802.15.4	2405	11	O-QPSK	250 kbit/s	Not settable
2	IEEE 802.15.4	2440	18	O-QPSK	250 kbit/s	Not settable
3	IEEE 802.15.4	2480	26	O-QPSK	250 kbit/s	Not settable

Antenna 1:

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate	Power setting
4	IEEE 802.15.4	2405	11	O-QPSK	250 kbit/s	Not settable
5	IEEE 802.15.4	2440	18	O-QPSK	250 kbit/s	Not settable
6	IEEE 802.15.4	2480	26	O-QPSK	250 kbit/s	Not settable

Power settings were done by the customer

3 Additional Information

The EUT also contains a Wi-Fi, a Bluetooth® LE and a UWB transceiver. The results of these technologies are documented in the test reports F191161E2 and F191161E3 and F191161E5. The emissions of the digital part of the EUT are documented in the test report F191161E1. Object of this test report is the IEEE802.15.4 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*	23
Conducted emissions on supply line	0.15 - 30	15.207 (a)	Passed	41
Antenna Requirement	-	15.203 15.247 (b)	Passed*[1]	-

*[1] Fixed PCB Antenna, gain below 6 dBi, no power reduction necessary.

5 Results

5.1 Duty cycle

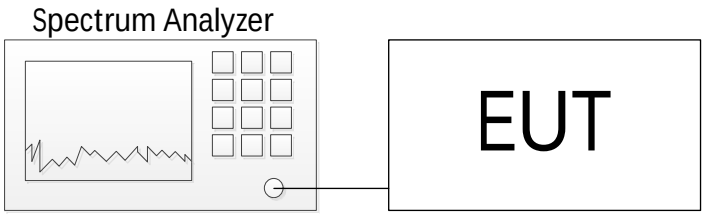
The duty cycle of the IEEE 802.15.4 part of the EUT was set to 100 %, therefore no duty cycle correction factor (DCCF) needs to be calculated.

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.

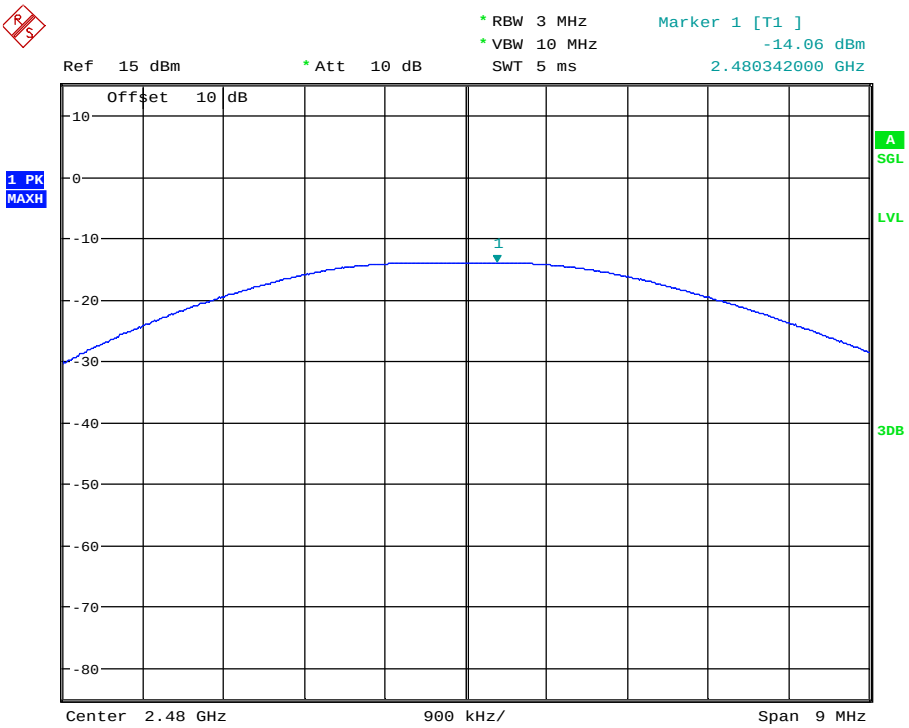
Only one representative plot for each measurement configuration is provided.

5.1.2 Test results

Ambient temperature	22 °C
Relative humidity	53 %

Date	24.07.2020
Tested by	B. ROHDE

Maximum *peak* conducted output power:



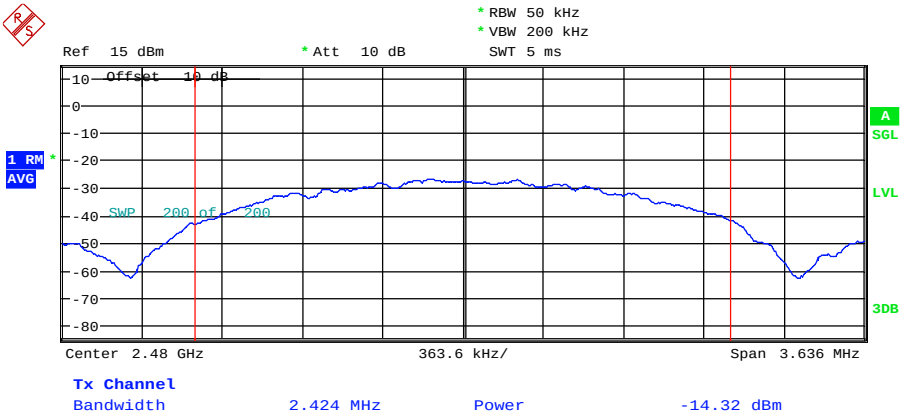
Antenna 0:

Operation mode	Reading [dBm]	Corr. Fact. [dB]	Result [dBm]	Limit [dBm]
1	-14.87	0.0	-14.87	30
2	-14.38	0.0	-14.38	30
3	-14.06	0.0	-14.06	30

Antenna 1:

Operation mode	Reading [dBm]	Corr. Fact. [dB]	Result [dBm]	Limit [dBm]
4	-15.31	0.0	-15.31	30
5	-14.95	0.0	-14.95	30
6	-14.48	0.0	-14.48	30

Maximum *average* conducted output power:



Antenna 0:

Operation mode	Reading [dBm]	Corr. Fact. [dB]	Power [dBm]	DCCF [dB]	Result [dBm]	Limit [dBm]
1	-15.18	0.0	-15.18	0.0	-15.18	30
2	-14.90	0.0	-14.90	0.0	-14.90	30
3	-14.32	0.0	-14.32	0.0	-14.32	30

Antenna 1:

Operation mode	Reading [dBm]	Corr. Fact. [dB]	Power [dBm]	DCCF [dB]	Result [dBm]	Limit [dBm]
4	-15.62	0.0	-15.62	0.0	-15.62	30
5	-15.26	0.0	-15.26	0.0	-15.26	30
6	-14.77	0.0	-14.77	0.0	-14.77	30

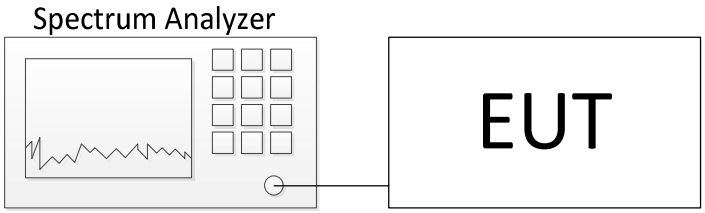
Test equipment (please refer to chapter 6 for details)
28

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.

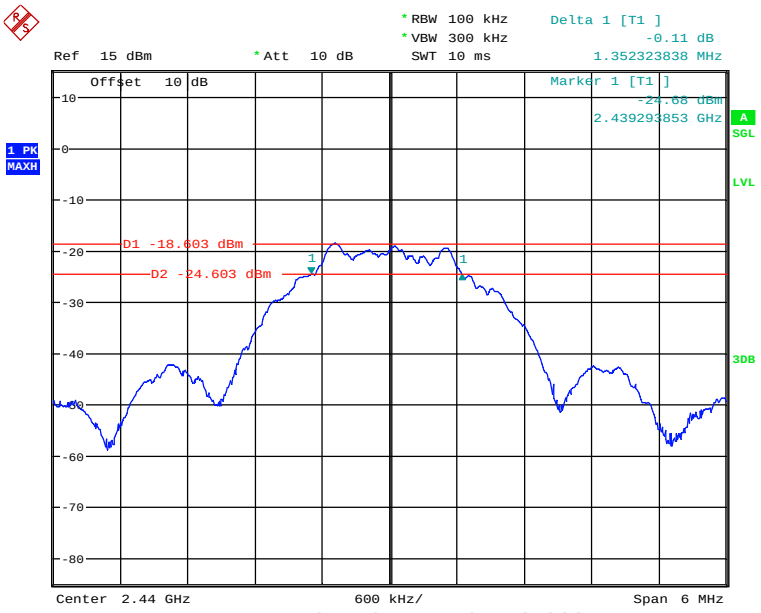
For the **Occupied bandwidth – 99% Bandwidth** the Procedure **6.9.3** in [1] was used.

Only one representative plot for each measurement configuration is provided.

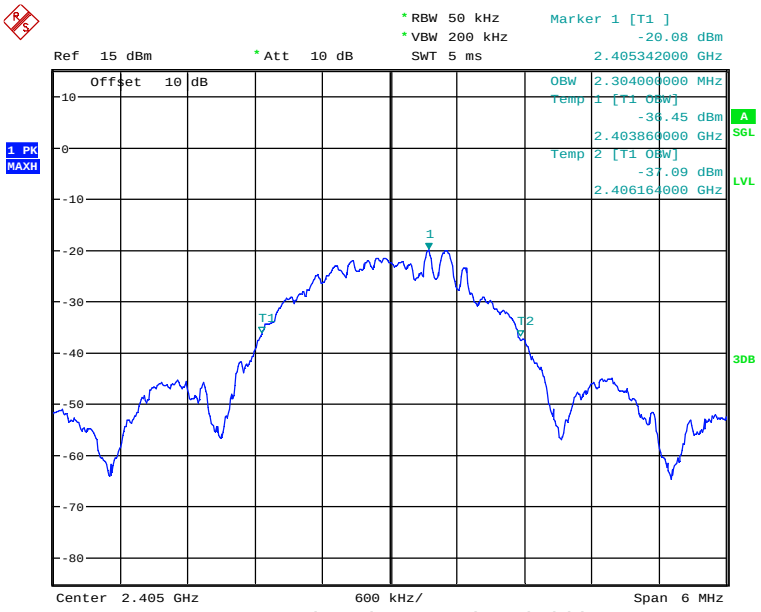
5.1.2 Test results

Ambient temperature	22 °C
Relative humidity	53 %

Date	24.07.2020
Tested by	B. ROHDE



Representative plot DTS bandwidth



Representative plot 99 % bandwidth

Antenna 0:

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	1.502	2.334	Passed
2	250 kbit/s	2440	0.5	1.595	2.394	Passed
3	250 kbit/s	2475	0.5	1.670	2.424	Passed

Antenna 1:

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	1.361	2.304	Passed
5	250 kbit/s	2440	0.5	1.352	2.358	Passed
6	250 kbit/s	2475	0.5	1.418	2.424	Passed

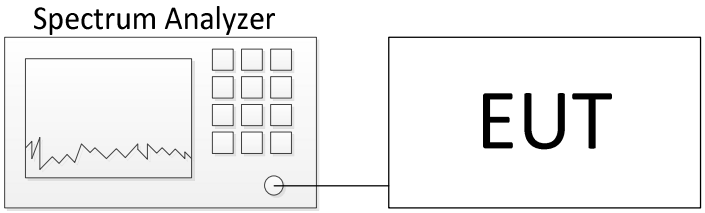
Test equipment (please refer to chapter 6 for details)
28

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.

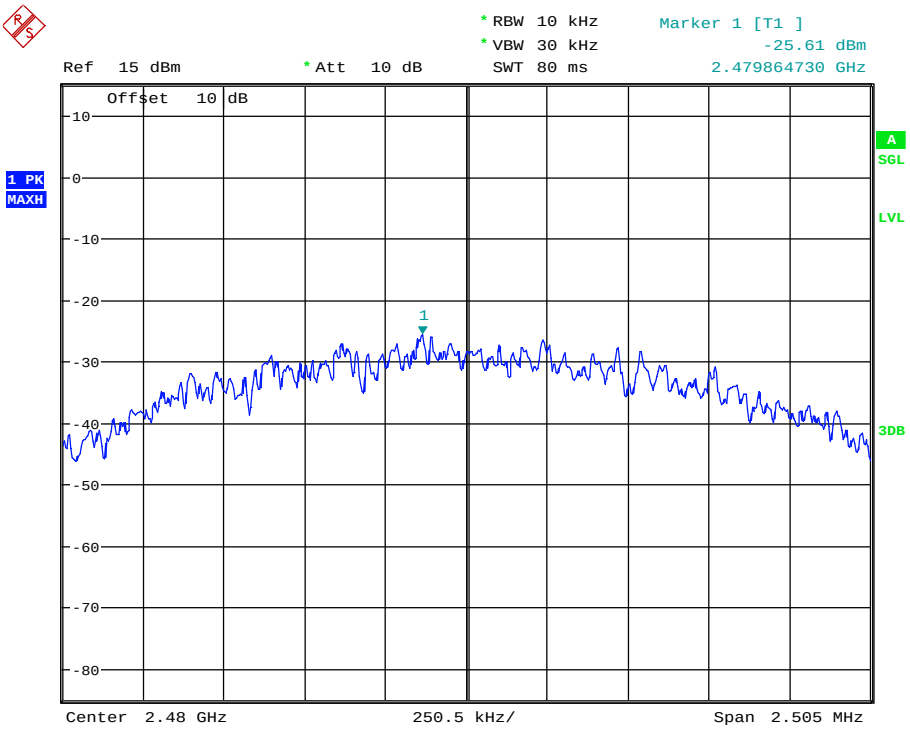
Only one representative plot for each measurement configuration is provided.

5.2.2 Test results

Ambient temperature	22 °C
Relative humidity	53 %

Date	24.07.2020
Tested by	B. ROHDE

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



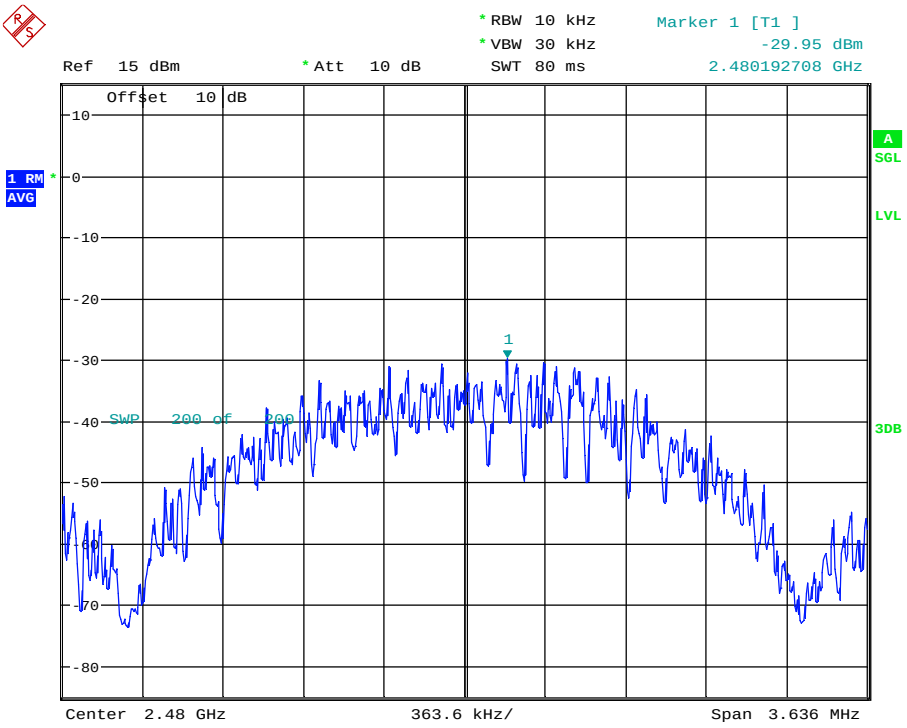
Antenna 0:

OP mode	Peak Frequency [MHz]	PPSD [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	2404.732	-25.8	8	Passed
2	2439.933	-26.1	8	Passed
3	2479.865	-25.6	8	Passed

Antenna 1:

OP mode	Peak Frequency [MHz]	PPSD [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
4	2405.090	-27.2	8	Passed
5	2439.846	-28.8	8	Passed
6	2480.234	-28.0	8	Passed

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



Antenna 0:

OP mode	Peak Frequency [MHz]	AvPSD [dBm / 10 kHz]	Result incl. DCCF [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	2404.734	-31.4	-31.4	8	Passed
2	2439.932	-30.9	-30.9	8	Passed
3	2480.240	-31.4	-31.4	8	Passed

Antenna 1:

OP mode	Peak Frequency [MHz]	AvPSD [dBm / 10 kHz]	Result incl. DCCF [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
4	2405.090	-31.6	-31.6	8	Passed
5	2439.851	-31.3	-31.3	8	Passed
6	2480.193	-30.0	-30.0	8	Passed

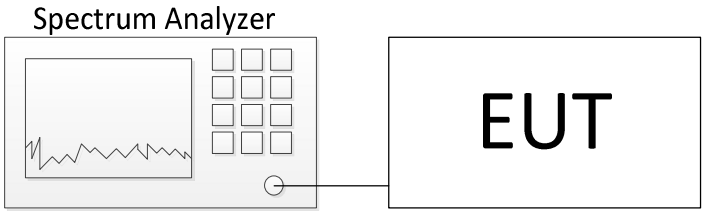
Test equipment (please refer to chapter 6 for details)
28

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.

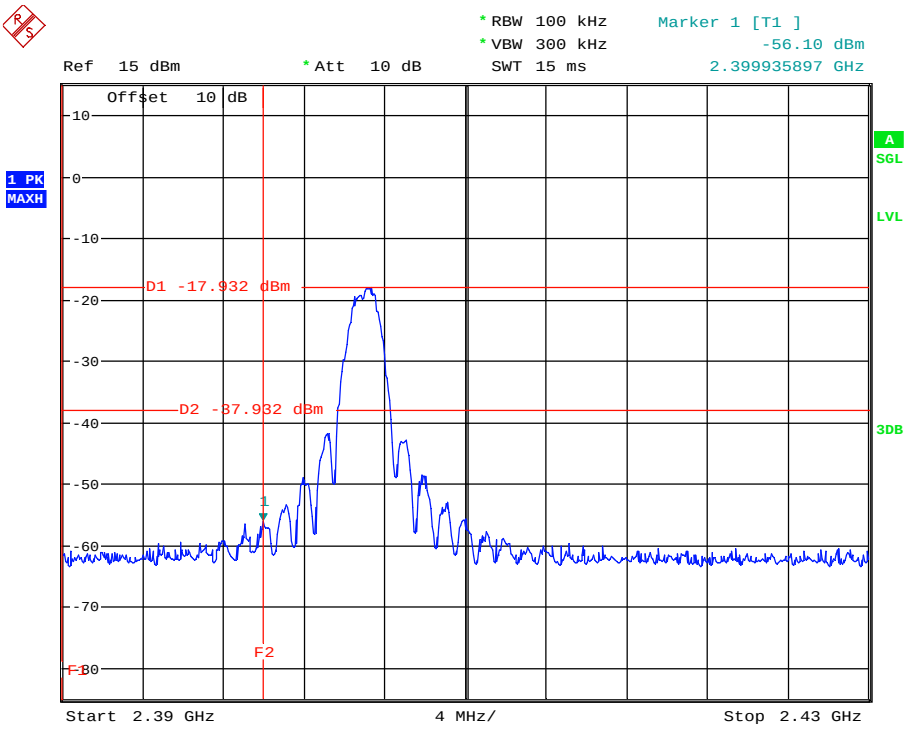
Only one representative plot is provided.

5.3.3 Test results

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

Ambient temperature	22 °C
Relative humidity	53 %

Date	24.07.2020
Tested by	B. ROHDE



Antenna 0:

Operation mode	Data rate	Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Emission Level [dBm]	Margin [dB]	Result
1	250 kbit/s	2405	-17.9	-37.9	-55.9	18.0	Passed

Antenna 1:

Operation mode	Data rate	Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Emission Level [dBm]	Margin [dB]	Result
4	250 kbit/s	2405	-16.3	-36.3	-55.6	19.3	Passed

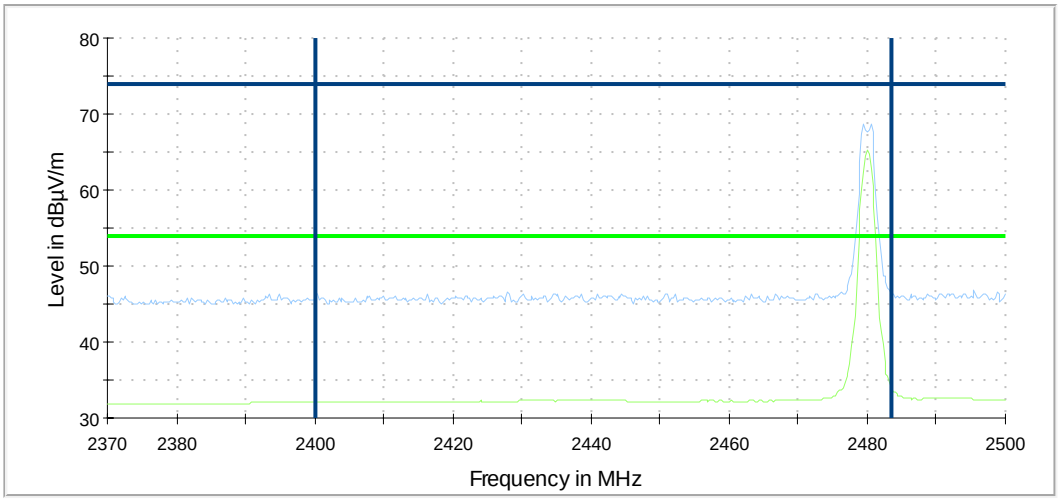
Test equipment (please refer to chapter 6 for details)
28

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

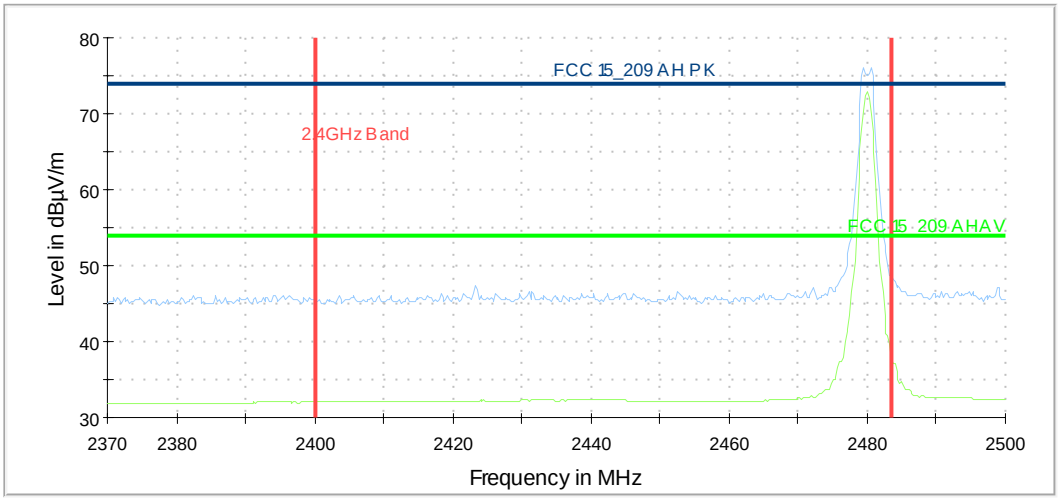
Ambient temperature	22 °C
Relative humidity	42 %

Date	02.06.2020
Tested by	B. ROHDE

Antenna 0:



Antenna 1:



Antenna 0:

Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB]	Height [cm]	Azimuth [deg]	Pol.	Result
2383.500000	46.3	---	74	27.3	11.7	34.6	150	37	H	Passed
2383.500000	---	33.8	54	20.2	-0.8	34.6	150	37	H	Passed
Measurement uncertainty					±5.5 dB					

Antenna 1:

Frequency [MHz]	Result (Pk) [dBµV/m]	Result (Av) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB]	Height [cm]	Azimuth [deg]	Pol.	Result
2383.500000	48.6	---	74	36.4	14.0	34.6	100	220	V	Passed
2383.500000	---	37.7	54	16.3	3.1	34.6	100	220	V	Passed
Measurement uncertainty					±5.5 dB					

Test equipment (please refer to chapter 6 for details)
2, 9 - 15

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.

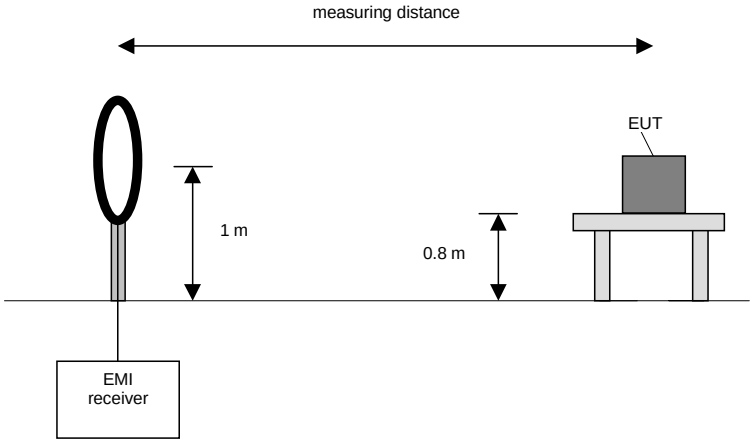
Preliminary measurement (9 kHz to 30 MHz):

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.

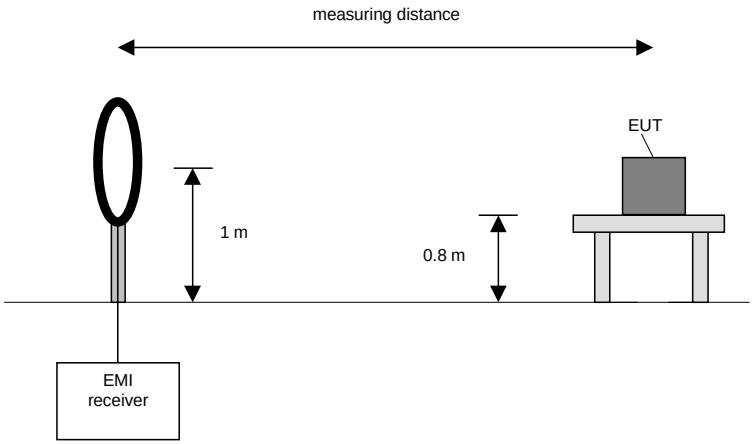
Final measurement (9 kHz to 30 MHz):

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

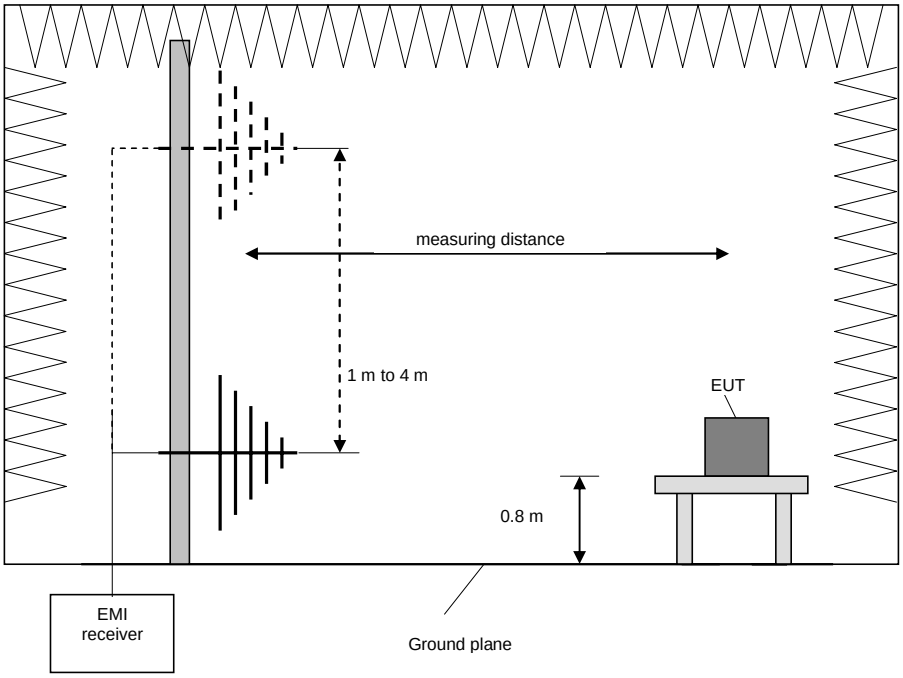


Preliminary and final measurement (30 MHz to 1 GHz)

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:

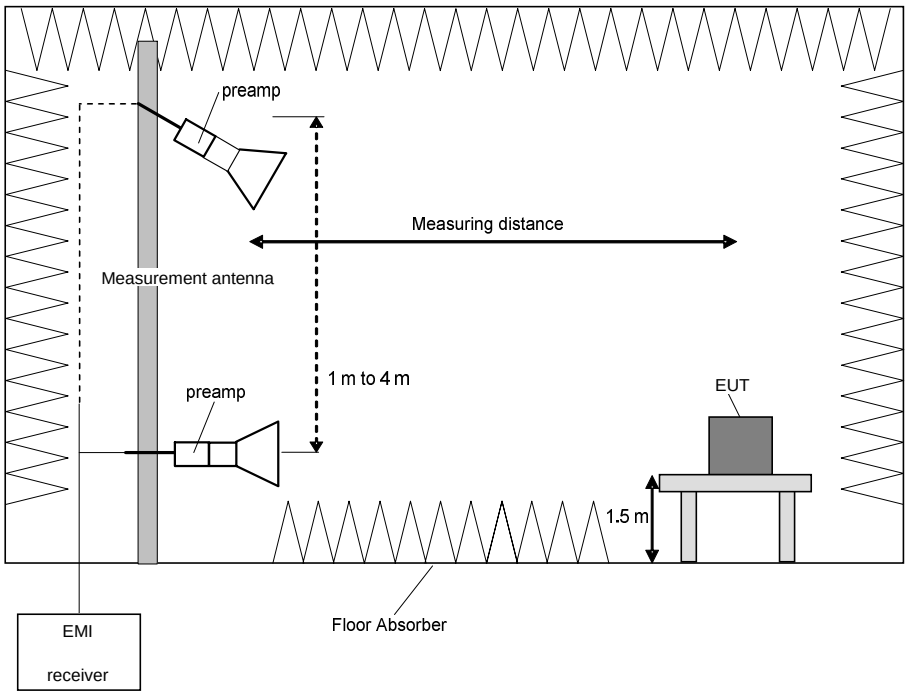
1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced step size with +/- 3 times the RBW of the pre-scan of the selected peaks.
3. If the EUT is portable or ceiling mounted, find the 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 (above 1 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with floor absorbers between EUT and measurement antenna.
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. For each height the angle of the antenna will be tilted so that the measurement antenna is always aiming at the EUT.

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	1 - 40 GHz	1 MHz	500 kHz	10 ms
Frequency peak search	+ / - 1 MHz	1 MHz	50 kHz	100 ms
Final measurement	1 - 40 GHz	1 MHz	-	10 x 100 ms



Procedure preliminary measurement:

The following procedure is used:

7. Set the measurement antenna to 1 m height.
8. Monitor the frequency range at vertical polarization and a EUT azimuth of 0 °.
9. Rotate the EUT by 360° to maximize the detected signals.
10. Repeat 1) to 2) with the vertical polarization of the measuring antenna.
11. Increase the height of the antenna for 0.5 m and repeat steps 2 – 4 until the final height of 4 m is reached.
12. 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:

8. Select the highest frequency peaks to the limit for the final measurement.
9. 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.
10. If the EUT is portable or ceiling mounted, find the worst case EUT orientation (x,y,z) for the final test.
11. 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.
12. 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.
13. The final measurement is performed at the worst-case antenna height and the worst-case turntable azimuth.
14. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.

5.4.2 Test results (radiated)

5.4.2.1 Test results (9 kHz – 30 MHz)

Ambient temperature	23 °C
Relative humidity	62 %

Date	29.07.2020
Tested by	B. ROHDE

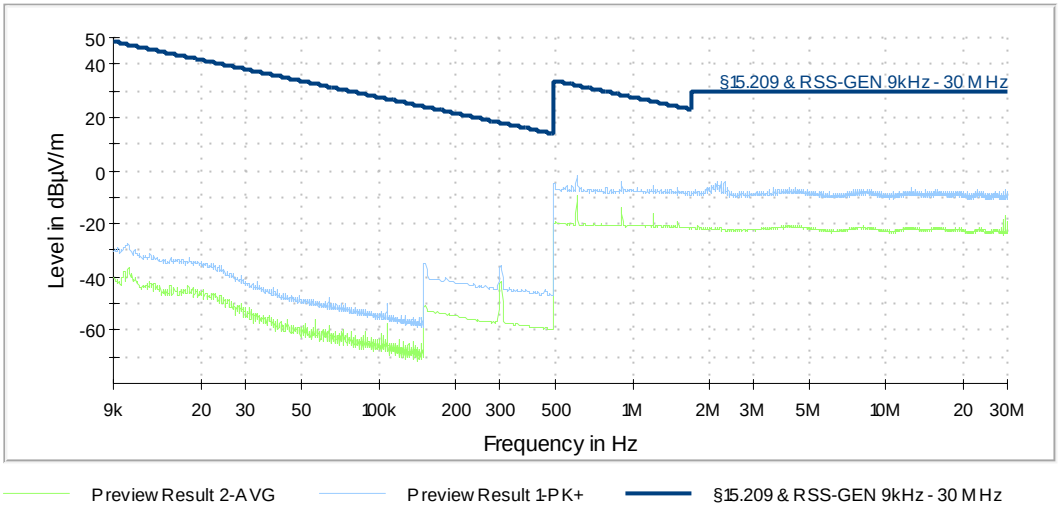
Position of EUT: For tests for f between 9 kHz and 30 MHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

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)
1 – 20, 27

5.5 Test results (radiated)

5.5.1.1 Test results (30 MHz – 1 GHz)

Ambient temperature	21 °C
Relative humidity	70 %

Date	01.07.2020
Tested by	B. ROHDE

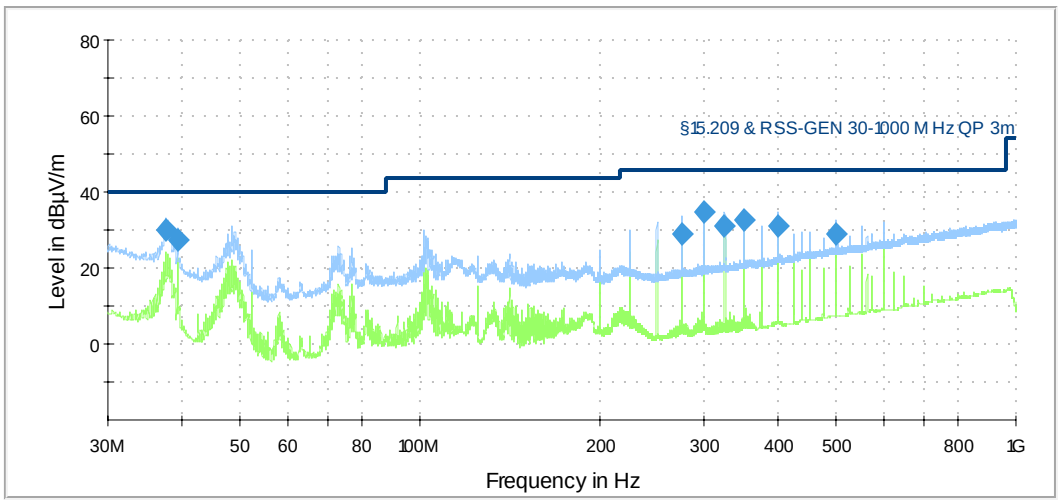
Position of EUT: The EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

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 1 is the worst-case, final tests were only conducted on antenna 1

Remark: -

Antenna 1:
Spurious emissions from 30 MHz to 1 GHz (operation mode 4):



Result table (operation mode 4):

Frequency [MHz]	Result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
37.510000	30.0	40	10.0	8.7	21.3	109	325	V	Passed
39.280000	27.2	40	12.8	7.0	20.3	102	162	V	Passed
275.020000	28.8	46.02	17.2	10.3	18.5	100	216	H	Passed
300.010000	34.9	46.02	11.1	15.6	19.3	102	202	H	Passed
325.020000	31.0	46.02	15.0	10.9	20.1	110	85	H	Passed
350.010000	32.7	46.02	13.3	11.8	20.9	100	95	H	Passed
400.010000	31.3	46.02	14.7	9.1	22.1	100	125	H	Passed
500.000000	28.8	46.02	17.2	4.2	24.6	113	77	V	Passed
Measurement uncertainty				±5.5 dB					

Result table (operation mode 5):

Frequency [MHz]	Result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
37.810000	29.6	40	10.4	8.4	21.1	106	188	V	Passed
39.290000	27.3	40	12.7	7.1	20.3	102	191	V	Passed
275.020000	28.1	46.02	17.9	9.6	18.5	110	88	H	Passed
300.000000	34.9	46.02	11.1	15.5	19.3	102	197	H	Passed
325.020000	30.7	46.02	15.3	10.6	20.1	106	93	H	Passed
349.990000	32.2	46.02	13.8	11.3	20.9	102	100	H	Passed
400.010000	30.8	46.02	15.2	8.7	22.1	102	128	H	Passed
500.000000	29.2	46.02	16.8	4.7	24.6	107	-7	V	Passed
Measurement uncertainty				±5.5 dB					

Result table (operation mode 6):

Frequency [MHz]	Result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol.	Result
37.810000	29.5	40	10.5	8.4	21.1	100	-10	V	Passed
39.280000	26.5	40	13.5	6.3	20.3	111	265	V	Passed
275.000000	28.3	46.02	17.7	9.8	18.5	125	204	H	Passed
300.000000	34.7	46.02	11.3	15.3	19.3	108	192	H	Passed
325.010000	30.8	46.02	15.2	10.7	20.1	102	105	H	Passed
350.010000	32.1	46.02	13.9	11.2	20.9	104	104	H	Passed
400.000000	30.9	46.02	15.1	8.8	22.1	100	130	H	Passed
500.010000	28.8	46.02	17.2	4.3	24.6	100	138	V	Passed
Measurement uncertainty				±5.5 dB					

5.5.1.2 Test results (above 1 GHz)

Ambient temperature	22 °C
Relative humidity	42 %

Date	02.06.2020
Tested by	B. ROHDE

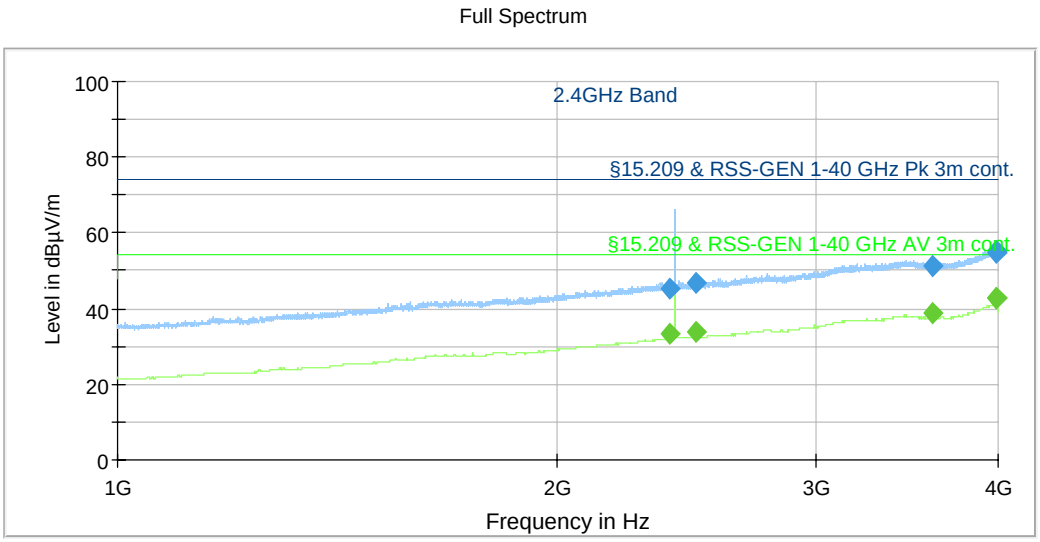
Position of EUT: For tests for f between 1 GHz and the 10th harmonic, the EUT was set-up on a table with a height of 150 cm. The distance between EUT and antenna was 3 m.

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.

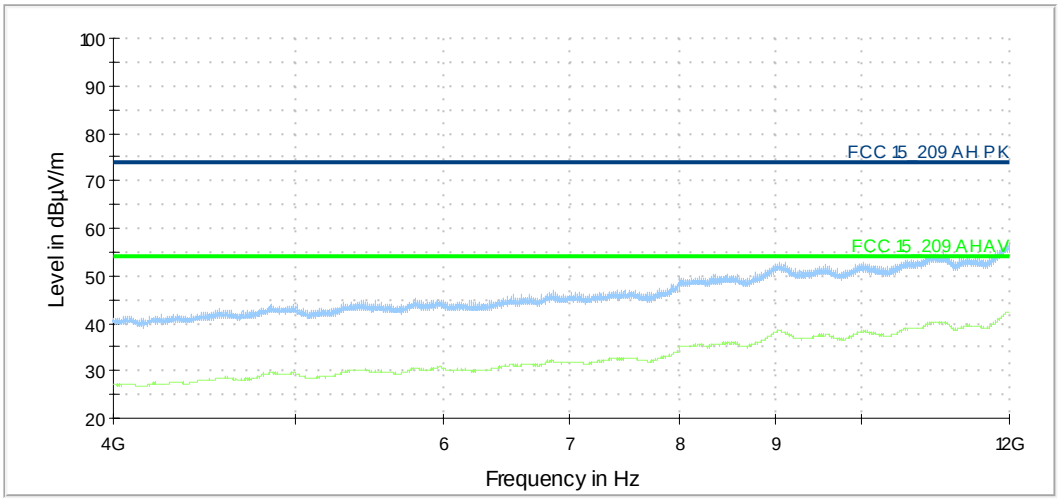
Test record: Only the worst-case plot for each frequency range for each antenna is submitted below.

Remark: -

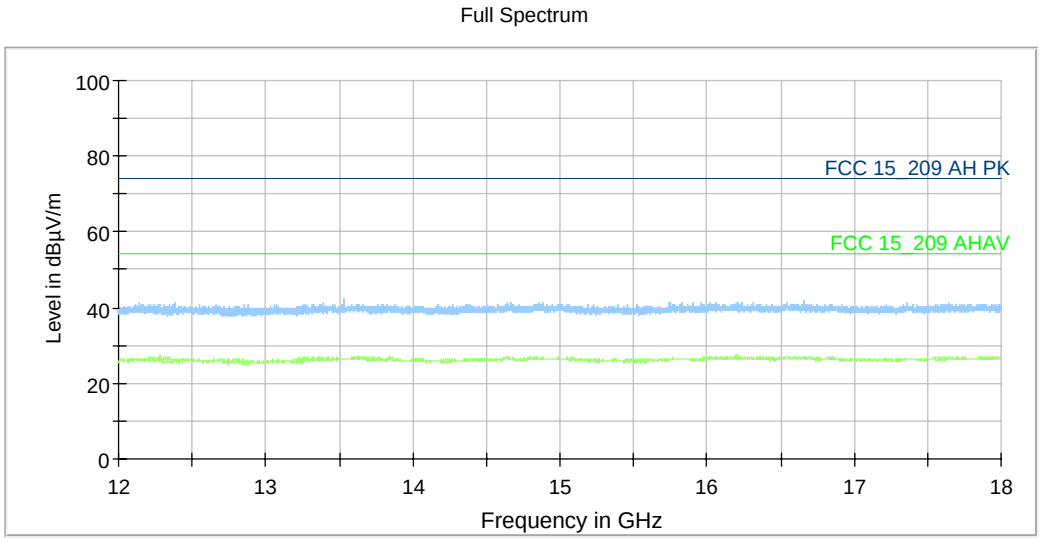
Antenna 0:
Spurious emissions from 1 GHz to 4 GHz (operation mode 1):



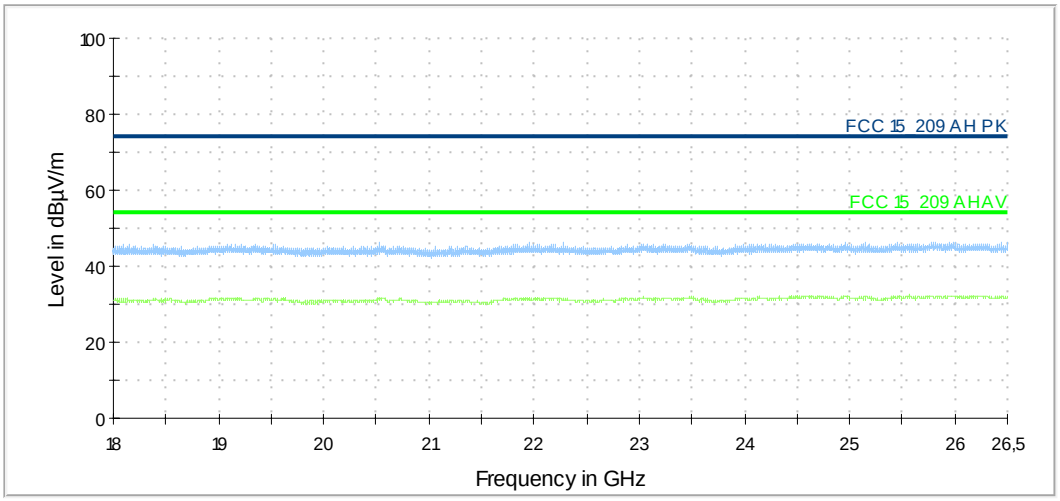
Spurious emissions from 4 GHz to 12 GHz (operation mode 1):



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



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



Result table antenna 0 operation mode 1:

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Height (deg)	Pol	Azimuth (deg)	Corr. (dB)
2388.100000	---	33.23	54.00	20.77	162.0	H	272.0	34.3
2388.100000	45.34	---	74.00	28.66	162.0	H	272.0	34.3
2483.300000	46.54	---	74.00	27.46	159.0	V	320.0	34.6
2483.300000	---	33.71	54.00	20.29	159.0	V	320.0	34.6
3604.050000	---	38.89	54.00	15.11	350.0	H	271.0	38.7
3604.050000	51.42	---	74.00	22.58	350.0	H	271.0	38.7
3988.250000	---	42.61	54.00	11.39	350.0	H	65.0	40.3
3988.250000	54.56	---	74.00	19.44	350.0	H	65.0	40.3
3993.450000	---	42.67	54.00	11.33	200.0	H	210.0	40.3
3993.450000	55.28	---	74.00	18.72	200.0	H	210.0	40.3
11982.400000	---	39.25	54.00	14.75	209.0	H	224.0	21.8
11982.400000	51.83	---	74.00	22.17	209.0	H	224.0	21.8
Measurement uncertainty			+/- 4.79 dB					

Result table antenna 0 operation mode 2:

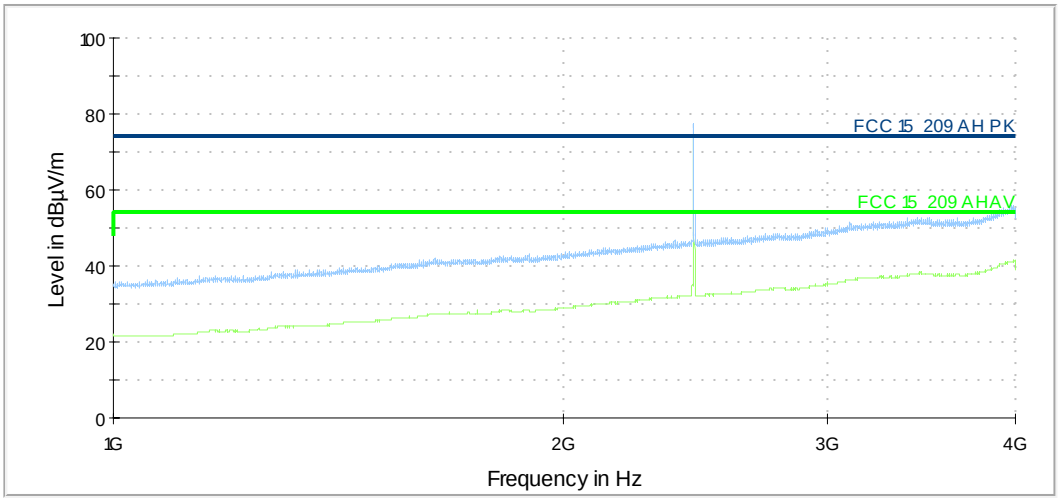
Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Height (deg)	Pol	Azimuth (deg)	Corr. (dB)
3965.900000	---	42.39	54.00	11.61	190.0	V	297.0	40.3
3965.900000	54.49	---	74.00	19.51	190.0	V	297.0	40.3
11985.650000	53.41	---	74.00	20.59	110.0	V	84.0	21.8
11985.650000	---	39.24	54.00	14.76	110.0	V	84.0	21.8
Measurement uncertainty			+/- 4.79 dB					

Result table antenna 0 operation mode 3:

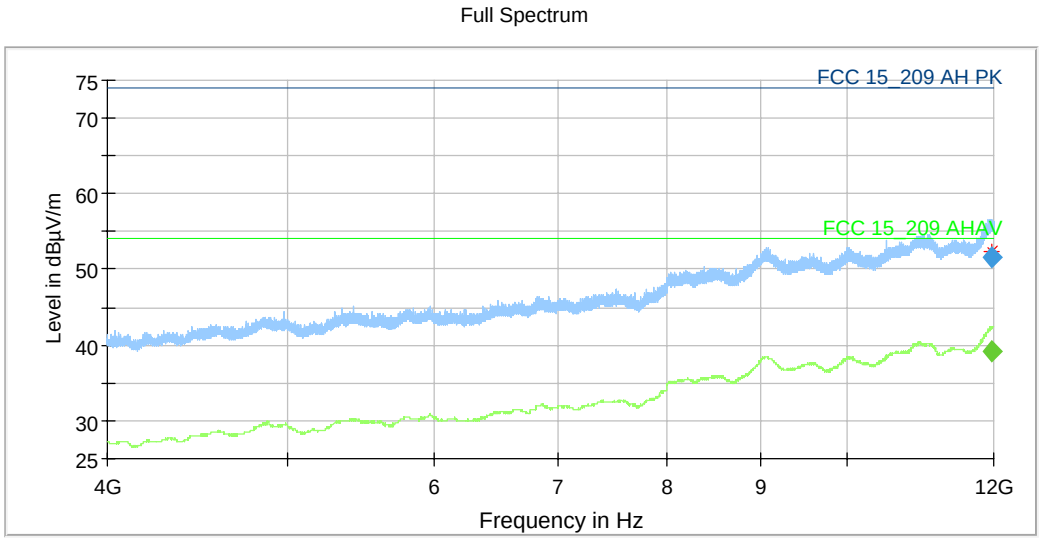
Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Height (deg)	Pol	Azimuth (deg)	Corr. (dB)
11987.650000	---	39.25	54.00	14.75	152.0	V	42.0	21.9
11987.650000	51.92	---	74.00	22.08	152.0	V	42.0	21.9
Measurement uncertainty			+/- 4.79 dB					

Antenna 1:

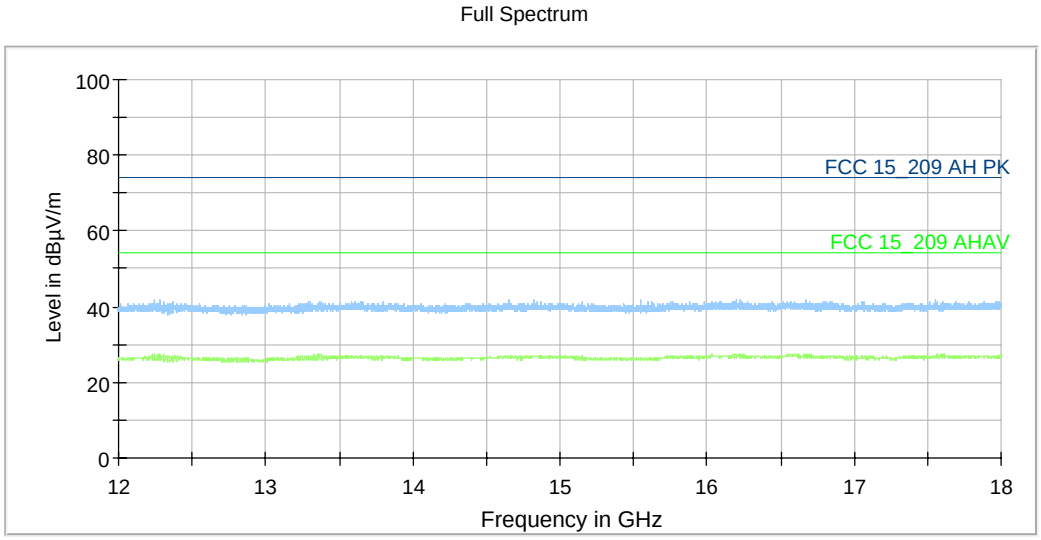
Spurious emissions from 1 GHz to 4 GHz (operation mode 5):



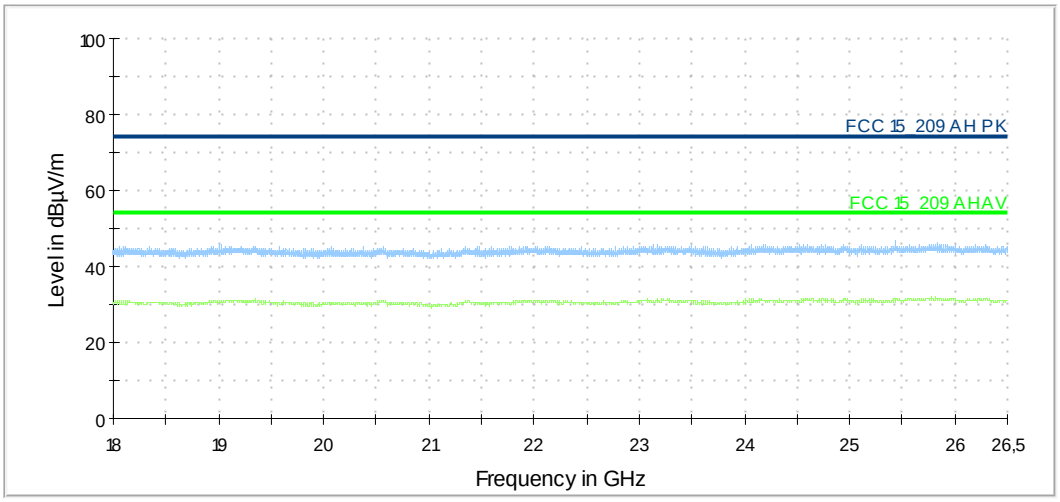
Spurious emissions from 4 GHz to 12 GHz (operation mode 5):



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



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



Result table antenna 1 operation mode 4:

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Height (deg)	Pol	Azimuth (deg)	Corr. (dB)
3988.550000	---	42.59	54.00	11.41	300.0	V	165.0	40.3
3988.550000	54.49	---	74.00	19.51	300.0	V	165.0	40.3
11967.400000	---	39.15	54.00	14.85	239.0	V	272.0	21.7
11967.400000	51.38	---	74.00	22.62	239.0	V	272.0	21.7
Measurement uncertainty			+/- 4.79 dB					

Result table antenna 1 operation mode 5:

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Height (deg)	Pol	Azimuth (deg)	Corr. (dB)
3993.650000	55.14	---	74.00	18.86	105.0	H	221.0	40.3
3993.650000	---	42.69	54.00	11.31	105.0	H	221.0	40.3
11982.900000	51.71	---	74.00	22.29	127.0	V	29.0	21.8
11982.900000	---	39.28	54.00	14.72	127.0	V	29.0	21.8
Measurement uncertainty			+/- 4.79 dB					

Result table antenna 1 operation mode 6:

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Height (deg)	Pol	Azimuth (deg)	Corr. (dB)
3969.250000	55.28	---	74.00	18.72	140.0	H	-11.0	40.3
3969.250000	---	42.46	54.00	11.54	140.0	H	-11.0	40.3
11950.300000	---	39.03	54.00	14.97	344.0	V	254.0	21.6
11950.300000	51.11	---	74.00	22.89	344.0	V	254.0	21.6
Measurement uncertainty			+/- 4.79 dB					

Test equipment (please refer to chapter 6 for details)
1 – 20, 27

5.6 Conducted emissions on power supply lines (150 kHz to 30 MHz)

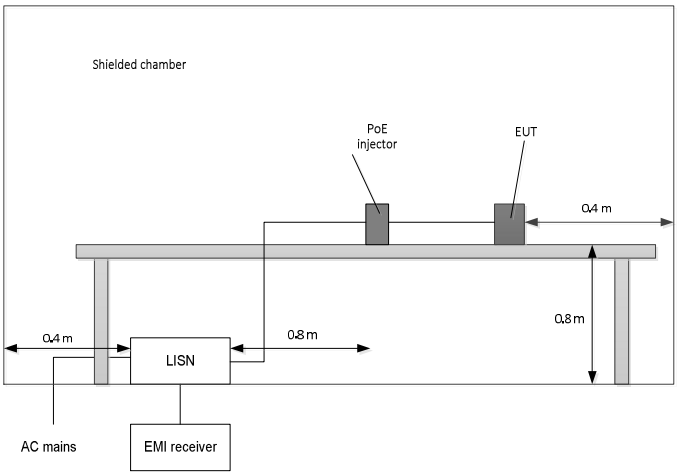
5.6.1 Method of measurement

This test will be carried out in a shielded chamber. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm above the ground plane. Floor-standing devices will be placed directly on the ground plane. The setup of the Equipment under test will be in accordance to [1].

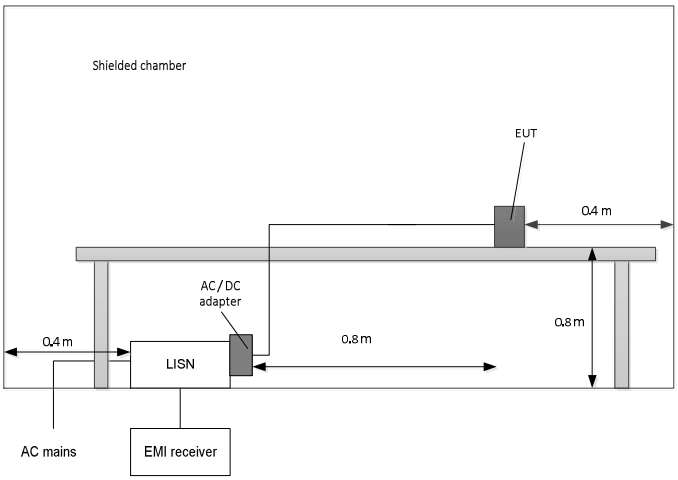
The frequency range 150 kHz to 30 MHz will be measured with an EMI Receiver set to MAX Hold mode with peak and average detector and a resolution bandwidth of 9 kHz. A scan will be carried out on the phase (or plus pole in case of DC powered devices) of the AC mains network. If levels detected 10 dB below the appropriable limit, this emission will be measured with the average and quasi-peak detector on all lines.

Frequency range	Resolution bandwidth
150 kHz to 30 MHz	9 kHz

Test setup for measurement with the EUT supplied via PoE:



Test setup for measurement with the EUT supplied via USB:



5.6.2 Test results (conducted emissions on power supply lines)

5.6.2.1 Test results with EUT supplied via PoE

Ambient temperature	21 °C
Relative humidity	71 %

Date	09.07.2020
Tested by	Y. KHALEK

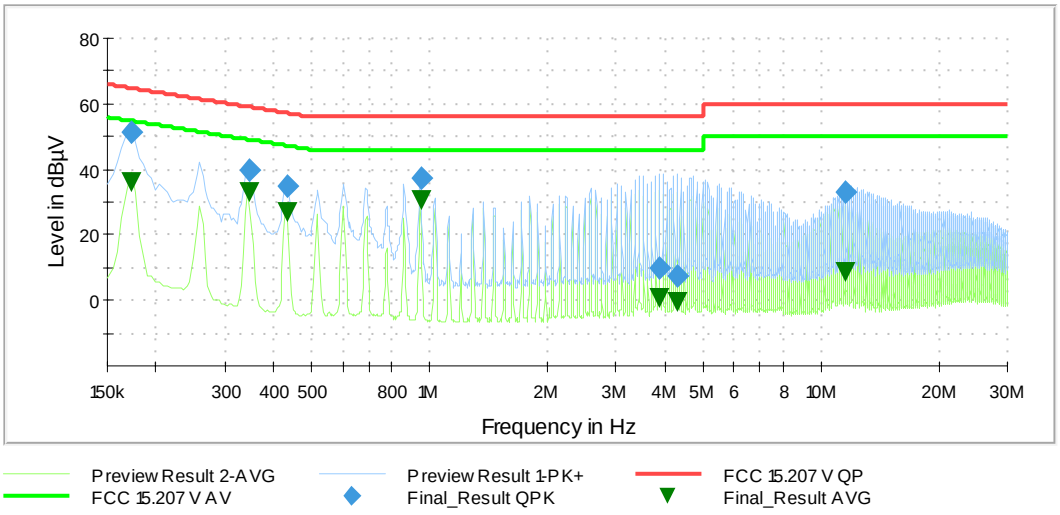
Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m.

Cable guide: The cables of the EUT were fixed on the non-conducting table. For further information of the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During this test the EUT was powered with 48 V_{DC} by the power injector PowerSine 3001, which was itself supplied with 120 V_{AC} / 60 Hz.

The curves in the diagram only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by ◆, the average measured points with ▼.



Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.173400	---	36.22	54.80	18.57	5000.0	9.000	L1	GND	9.8
0.173400	51.15	---	64.80	13.65	5000.0	9.000	N	GND	9.8
0.347100	39.96	---	59.03	19.07	5000.0	9.000	L1	FLO	9.9
0.347100	---	33.03	49.03	16.00	5000.0	9.000	N	FLO	9.9
0.433500	35.03	---	57.19	22.15	5000.0	9.000	L1	GND	9.9
0.433500	---	26.83	47.19	20.35	5000.0	9.000	N	FLO	9.9
0.954600	37.29	---	56.00	18.71	5000.0	9.000	N	GND	9.9
0.955500	---	30.42	46.00	15.58	5000.0	9.000	N	GND	9.9
3.889500	9.68	---	56.00	46.32	5000.0	9.000	N	FLO	10.3
3.889500	---	0.81	46.00	45.19	5000.0	9.000	N	FLO	10.3
4.321500	7.61	---	56.00	48.39	5000.0	9.000	N	FLO	10.3
4.321500	---	-0.75	46.00	46.75	5000.0	9.000	N	FLO	10.3
11.625000	---	8.78	50.00	41.22	5000.0	9.000	L1	GND	10.7
11.625000	32.96	---	60.00	27.04	5000.0	9.000	L1	GND	10.7
Measurement uncertainty				+2.76 dB / -2.76 dB					

5.6.2.2 Test results with EUT supplied via USB

Ambient temperature	21 °C	Date	09.07.2020
Relative humidity	71 %	Tested by	Y. KHALEK

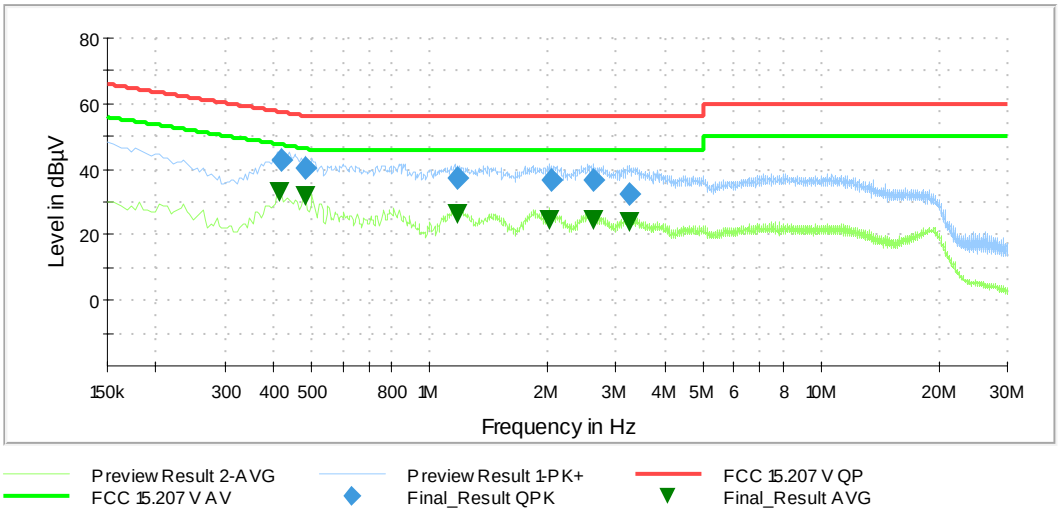
Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m.

Cable guide: The cables of the EUT were fixed on the non-conducting table. For further information of the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During this test the EUT was powered with 5.0 V_{DC} by the Samsung travel adapter EP-TA20EBE, which was itself supplied with 120 V_{AC} / 60 Hz.

The curves in the diagram only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by ◆, the average measured points with▼.



Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.411000	---	33.00	47.63	14.63	5000.0	9.000	L1	GND	9.9
0.418200	42.92	---	57.48	14.57	5000.0	9.000	L1	FLO	9.9
0.479400	---	31.64	46.35	14.71	5000.0	9.000	L1	GND	9.9
0.480300	40.66	---	56.33	15.67	5000.0	9.000	L1	FLO	9.9
1.172400	37.07	---	56.00	18.93	5000.0	9.000	L1	GND	9.9
1.174200	---	26.26	46.00	19.74	5000.0	9.000	L1	GND	9.9
2.026500	---	24.68	46.00	21.32	5000.0	9.000	L1	GND	10.1
2.049000	36.97	---	56.00	19.03	5000.0	9.000	L1	GND	10.1
2.624100	36.51	---	56.00	19.49	5000.0	9.000	L1	FLO	10.2
2.627700	---	24.74	46.00	21.26	5000.0	9.000	L1	GND	10.2
3.235200	32.35	---	56.00	23.65	5000.0	9.000	N	GND	10.2
3.249600	---	24.07	46.00	21.93	5000.0	9.000	L1	GND	10.2
Measurement uncertainty				+2.76 dB / -2.76 dB					

Test equipment (please refer to chapter 6 for details)
21 - 26

6 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Low Noise Amplifier 100 MHz - 18 GHz	LNA-30-00101800-25-10P	Narda-Miteq	2110917	482967	18.02.2020	02.2022
2	Log Per Antenna	HL050	Rohde & Schwarz	4062.4063.02-100908	482977	13.08.2019	08.2022
3	Standard Gain Horn 20 dB, 12 GHz-18 GHz	18240-20	Flann	267220	483025	Calibration not necessary	
4	Low Noise Amplifier 18 GHz - 26.5 GHz	LNA-30-18002650-20-10P	Narda-Miteq	2110911	482969	17.02.2020	02.2022
5	Standard Gain Horn 20 dB, 18 GHz -26 GHz	20240-20	Flann	266399	483026	Calibration not necessary	
6	Low Noise Amplifier 26 MHz - 40 GHz	LNA-30-26004000-27-10P	Narda-Miteq	2110293	482970	17.02.2020	02.2022
7	Standard Gain Horn 20 dB, 26 GHz - 40 GHz	22240-20	Flann	266405	483027	Calibration not necessary	
8	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	14.02.2020	02.2022
9	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
10	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
11	Antennasupport	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
12	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
13	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
14	Measurment software	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
15	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	14.11.2019	11.2021
16	Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ Hauppauge N.Y.	571667	480343	13.02.2020	02.2022
17	Antenna (Bilog)	CBL6111D	Schaffner Elektrotest GmbH / Teseq GmbH	25761	480894	19.10.2017	10.2020
18	Low Noise Amplifier 12 GHz - 18 GHz	LNA-30-12001800-13-10P	Narda-Miteq	2089798	482968	17.02.2020	02.2022
20	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	05.02.2020	02.2021
21	Shielded chamber M4	-	Siemens	B83117-S1-X158	480088	Calibration not necessary	
22	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	12.02.2020	02.2022
23	LISN	NSLK8128	Schwarzbeck	8128161	480138	11.02.2020	02.2022
24	Transient Limiter	CFL 9206A	Teseq	38268	481982	Calibration not necessary	
25	Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
26	AC source	AC6803A	Keysight	JPVJ002509	482350	Calibration not necessary	
27	Attenuator 6 dB	WA2-6	Weinschel	-	482794	Calibration not necessary	
28	Spektrum analyser	FSU46	Rohde & Schwarz	200125	480956	13.02.2020	02.2021

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
Shielded chamber M4	480088	9 kHz – 30 MHz	GND-Plane	ANSI C63.4-2014	06.11.2018	05.11.2020

8 Report History

Report Number	Date	Comment
F191161E4	07.09.2020	Initial Test Report
-	-	-
-	-	-

9 List of Annexes

Annex A Test Setup Photos 7 pages