

Test Report

Report Number:

F190546E4 2nd Version

Equipment under Test (EUT):

Controlunit PILOT

Applicant:

Fronius International GmbH

Manufacturer:

Fronius International GmbH



Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

References

- [1] **ANSI C63.10-2020**, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15**, Radio Frequency Devices
- [3] **RSS-247 Issue 3 (August 2023)**, Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- [4] **RSS-Gen Issue 5 (April 2018) +Am 1 (March 2019) + Am 2(February 2021)**, General Requirements for Compliance of Radio Apparatus
- [5] **558074 D01 15.247 Meas Guidance v05v02 (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
- [6] **996369 D04 Module Integration Guide v02 (October 2020)**, MODULAR TRANSMITTER INTEGRATION GUIDE— GUIDANCE FOR HOST PRODUCT MANUFACTURERS

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
15.08.2024

Signature

Reviewed and
approved by:



Paul NEUFELD
15.08.2024

Signature

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1 Identification

1.1 Applicant

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Applicant represented during the test by the following person:	Mr. Jan HERNDLER

1.2 Manufacturer

Name:	Fronius International GmbH
Address:	Günter-Fronius-Straße 1, 4600 Wels-Thalheim
Country:	Austria
Name for contact purposes:	Mr. Jan HERNDLER
Phone:	+43-7242-241-0
eMail address:	Handler.jan@fronius.com
Manufacturer represented during the test by the following person:	Mr. Jan HERNDLER

1.3 Test Laboratory

The tests were carried out by: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) according to DIN EN ISO/IEC 17025:2018. The accreditation is only valid for the scope of accreditation listed in the annex of the certificate D-PL-17186-01-00.

1.4 EUT (Equipment under Test)

Test object: *	Control and steering unit for solar inverters
Model name: *	Controlunit PILOT
Model number: *	43,0001,3553
Order number: *	-
FCC ID: *	QKWPILOT1
IC certification number: *	12279A-PILOT1
PMN: *	Controlunit Pilot
HVIN: *	V0.5D
FVIN: *	V0.0.64.12

	EUT number		
	1	2	3
Serial number: *	091010 0015	-	-
PCB identifier: *	0.5D	-	-

* Declared by the applicant

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

IEEE 802.11 b/g/n20 frequencies				
Channel 01	RX	2412 MHz	TX	2412 MHz
Channel 06	RX	2437 MHz	TX	2437 MHz
Channel 11	RX	2462 MHz	TX	2462 MHz

IEEE 802.11 n40 frequencies				
Channel 03	RX	2422 MHz	TX	2422 MHz
Channel 06	RX	2437 MHz	TX	2437 MHz
Channel 09	RX	2452 MHz	TX	2452 MHz

Equipment used for testing	
Cables (connected to the EUT):* ¹	Ethernet, RJ45 (5m) Laboratory cables for power supply (3m) Only during measurements $f \leq 30$ MHz: 2x Ethernet, RJ45 (5m) Modbus (3m) WSD master (3m) GPIO (3m)
Ethernet switch with fibre optic port* ²	FL SWITCH SFN 7GT/SX, Phoenix Contact (order no. 2891518)
Laptop PC:* ²	Fujitsu Lifebook S751 (PM No. 201036)
Power supply* ²	KOSH POWER, Model No. CE200A0120V1500

*¹ Provided by the applicant

*² Provided by the laboratory

1.5 Technical Data of Equipment

WiFi radio mode						
Fulfils IEEE specification: *	IEEE 802.11 b/g/n (HT20/HT40)					
Radio chip	SPB 209A; H&D Wireless AB					
Antenna type: *	Dipole antenna					
Antenna name: *	Taoglas 40.2153					
Antenna gain: *	3.74 dBi (peak); -1.07 dBi (average)					
Antenna connector: *	RP SMA					
Power supply EUT: *	DC					
Supply voltage EUT: *	U _{nom} =	12 V	U _{min} =	10.8 V	U _{max} =	13.2 V
Supply voltage radio module: *	U _{nom} =	3.3	U _{min} =	2.5 V	U _{max} =	3.6 V
Type of modulation: *	IEEE 802.11 b: DSSS (DBPSK, DQPSK, CCK) IEEE 802.11 g: OFDM (BPSK, QPSK, 16-QAM, 64-QAM) IEEE 802.11n (HT20): OFDM (BPSK, QPSK, 16-QAM, 64-QAM) IEEE 802.11n (HT40): OFDM (BPSK, QPSK, 16-QAM, 64-QAM)					
Operating frequency range: *	2412 – 2462 MHz (IEEE 802.11 b/g/HT20) 2422 – 2452 MHz (IEEE 802.11 HT40)					

WiFi radio mode	
Number of channels: *	11 [1 - 11] (5 MHz channel spacing) 7 [3 - 9] (5 MHz channel spacing)
Temperature range: *	-40 °C to +85 °C
Lowest / highest internal clock frequency: *	32.768kHz (quartz) / 2462 MHz (radio frequency)

* Declared by the applicant

1.6 Dates

Date of receipt of test sample:	03.06.2019
Start of test:	04.06.2019
End of test:	14.06.2019

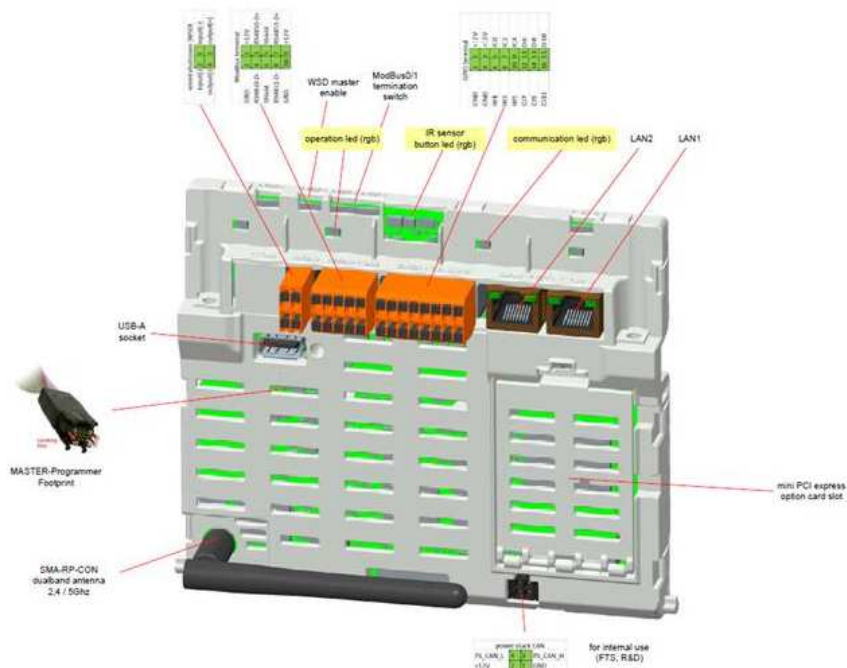
2 Operational States

2.1 Description of function of the EUT

The EUT a control unit for solar inverters, equipped with IEEE 802.11 WiFi for communication purposes. As declared by the applicant, only IEEE 802.11 radio is active, BT/BLE and NFC are disabled by software.

This test report incorporated the limited test cases for verification only. The modes were chosen from original filing, (worst cases according to Test report 0Y1604070736.XO2 by PCTEST)

The EUT:



2.2 The following states were defined as the operating conditions

2.2.1 Radio tests

For the radio tests the following settings were used:

A connection to the EUT was established via Ethernet. Special software, called "labtool" as provided by the applicant was used to set the relevant radio parameter.

2.2.2 Operation modes/Power settings

Operation mode #	Radio technology	Frequency [MHz]	Channel	Modulation / Mode	Data rate	RX / TX	Power setting
1	IEEE 802.11	2412	1	b-mode	1 Mbps	Packetized TX	18
2	IEEE 802.11	2437	6	b-mode	1 Mbps	Packetized TX	18
3	IEEE 802.11	2462	11	b-mode	1 Mbps	Packetized TX	18
4	IEEE 802.11	2412	1	g-mode	6 Mbps	Packetized TX	18
5	IEEE 802.11	2462	11	g-mode	6 Mbps	Packetized TX	18

3 Additional Information

The tests were done with a sample with the possibility to switch the firmware.
As declared by the applicant this is not possible with the "official" samples.

The EUT was not labeled with the final label.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [3] or RSS-Gen, Issue 5 [4]	Status	Refer page
Maximum Peak Output Power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [3]	Not tested ^{*1}	-
DTS Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [3]	Not tested	-
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [3]	Not tested	-
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	13 et seq.
Radiated emissions (transmitter)	0.009 – 26,500	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	20 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Passed	20 et seq.

^{*1} Maximum Peak Output Power was not tested, according to [6] 3.4 c)

5 Results

5.1 Band-edge compliance

5.1.1 Method of measurement (band edges next to unrestricted bands (radiated))

The measurement procedure refers to part 11.11.2 and 11.11.3 of document [1].

Measurement Procedure Reference – Reference Level:

- a) Set instrument center frequency to DTS channel center frequency.
- b) Set the span to ≥ 1.5 times the DTS bandwidth.
- c) Set the RBW = 100 kHz.
- d) Set the VBW $\geq [3 \times \text{RBW}]$.
- e) Detector = peak.
- f) Sweep time = auto couple.
- g) Trace mode = max hold.
- h) Allow trace to fully stabilize.
- i) Use the peak marker function to determine the maximum PSD level.

Measurement Procedure – Unwanted Emissions

- a) Set the center frequency and span to encompass frequency range to be measured.
- b) Set the RBW = 100 kHz.
- c) Set the VBW $\geq [3 \times \text{RBW}]$.
- d) Detector = peak.
- e) Sweep time = auto couple.
- f) Trace mode = max hold.
- g) Allow trace to fully stabilize.
- h) Use the peak marker function to determine the maximum amplitude level.

For the measurement, the EUT was measured radiated in the anechoic chamber using the procedures described in 5.2.1.

The upper limit line was set to the value of the highest emission in 100 kHz RBW in the frequency band (reference level). The lower limit line shows the limit located 20 dB below the reference limit.

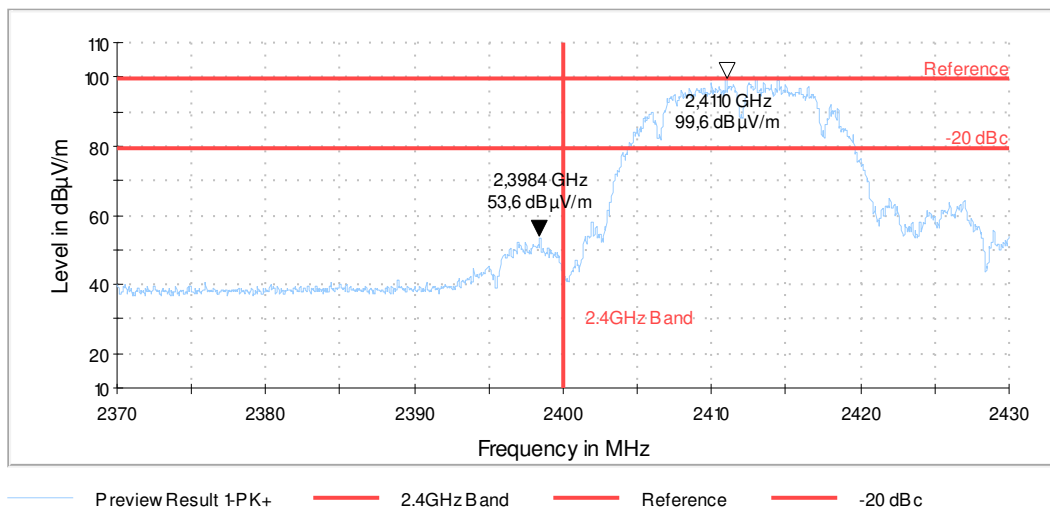
The maximum Emission in the unrestricted band was found with the aid of a marker.

5.1.1.1 Test results (radiated)

Ambient temperature	22 °C
Relative humidity	52 %

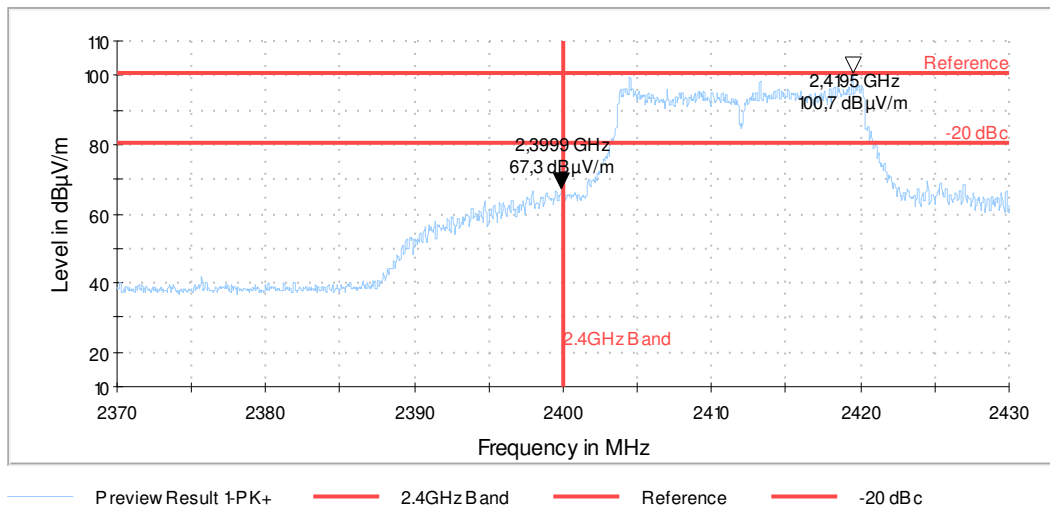
Date	24.05.2018
Tested by	B. ROHDE

Operation mode 1



Operation Mode	Tx Frequency [MHz]	Emission Frequency [MHz]	Reference Level [dBμV/m]	Limit [dBm]	Emission Level [dBμV/m]	Margin [dB]	Result
1	2412	2398.4	99.6	79.6	53.6	26.0	Passed

Operation mode 4



Operation Mode	Tx Frequency [MHz]	Emission Frequency [MHz]	Reference Level [dB μ V/m]	Limit [dB μ V/m]	Emission Level [dB μ V/m]	Margin [dB]	Result
1	2412	2399.9	100.7	80.7	67.3	13.4	Passed

Test equipment (please refer to chapter 6 for details)

1 - 9

5.1.2 Method of measurement (band edges next to restricted bands (radiated))

For the measurement, the EUT was measured radiated in the anechoic chamber using the procedures described in 5.2.1.

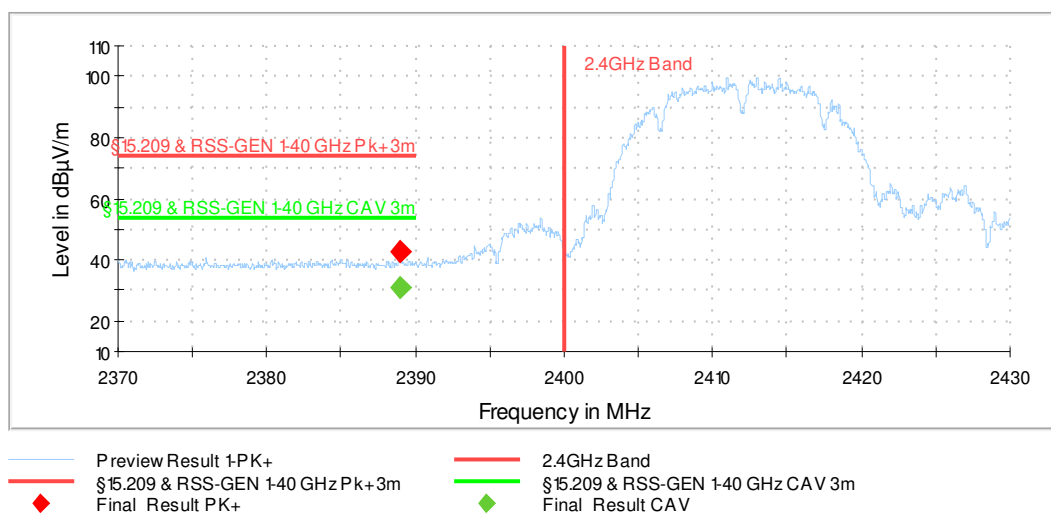
The relating measurements were carried radiated. The measurement procedure refers to part 6.10.5.2 of document [1].

5.1.2.1 Test results (radiated)

Ambient temperature	22 °C
Relative humidity	52 %

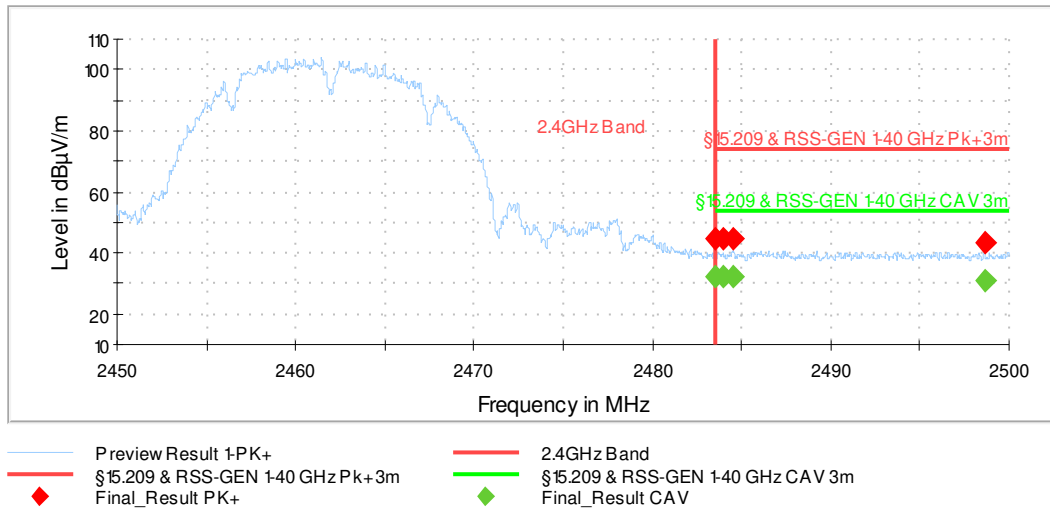
Date	24.05.2018
Tested by	B. ROHDE

5.1.2.1.1 Operation mode 1



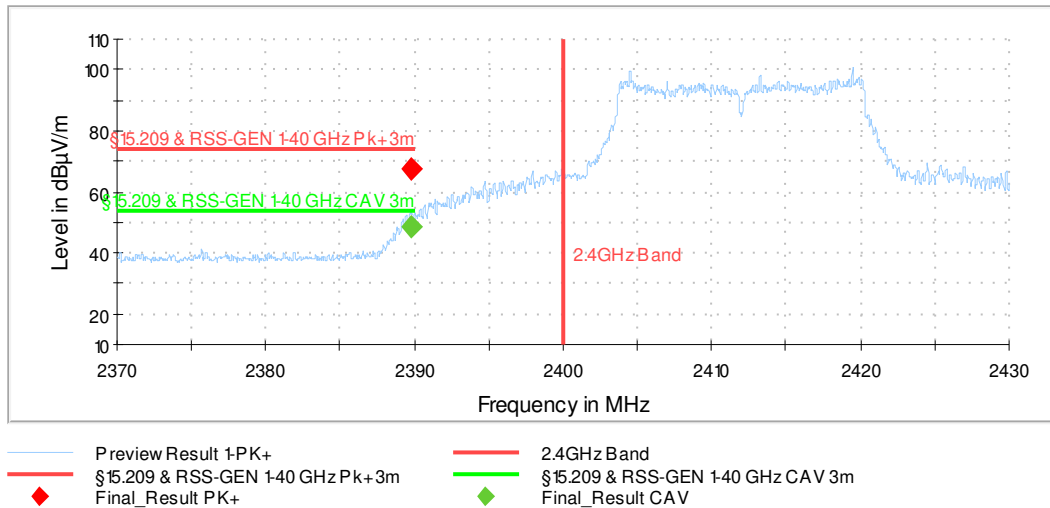
Restricted band edge						
Operation mode 1						
Frequency	Max Peak	Average	Limit	Margin	Correction	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	dB	[dB]	
2388.930000	42.6	---	74	31.4	33.0	Passed
2388.930000	---	30.6	54	23.4	33.0	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB		

5.1.2.1.2 Operation mode 3



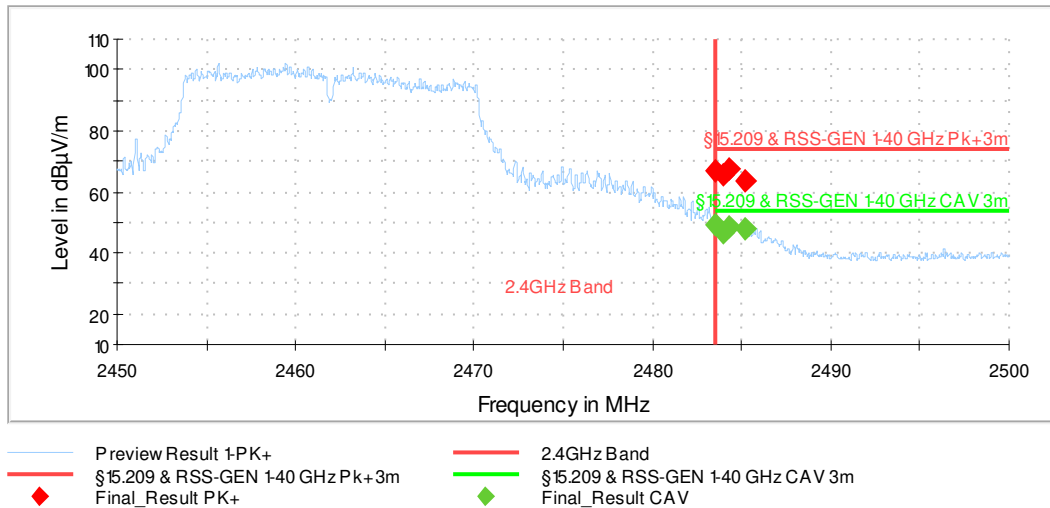
Restricted band edge						
Operation mode 3						
Frequency	Max Peak	Average	Limit	Margin	Correction	Result
[MHz]	[dBμV/m]	[dBμV/m]	[dBμV/m]	dB	[dB]	
2483.500000	44.5	---	74	29.5	34.0	Passed
2483.500000	---	32.0	54	22.0	34.0	Passed
2484.000000	44.9	---	74	29.1	34.0	Passed
2484.000000	---	32.5	54	21.5	34.0	Passed
2484.475000	44.4	---	74	29.6	34.0	Passed
2484.475000	---	32.4	54	21.6	34.0	Passed
2498.625000	43.1	---	74	30.9	33.0	Passed
2498.625000	---	31.0	54	23.0	33.0	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB		

5.1.2.1.3 Operation mode 4



Restricted band edge						
Operation mode 4						
Frequency	Max Peak	Average	Limit	Margin	Correction	Result
[MHz]	[dBμV/m]	[dBμV/m]	[dBμV/m]	dB	[dB]	
2389.740000	67.8	---	74	6.2	33.0	Passed
2389.740000	---	48.6	54	5.4	33.0	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB		

5.1.2.1.4 Operation mode 5



Restricted band edge						
Operation mode 5						
Frequency	Max Peak	Average	Limit	Margin	Correction	Result
[MHz]	[dBμV/m]	[dBμV/m]	[dBμV/m]	dB	[dB]	
2483.500000	66.8	---	74	7.2	34.0	Passed
2483.500000	---	49.5	54	4.5	34.0	Passed
2484.000000	65.6	---	74	8.4	34.0	Passed
2484.000000	---	46.9	54	7.1	34.0	Passed
2484.350000	67.5	---	74	6.5	34.0	Passed
2484.350000	---	48.9	54	5.1	34.0	Passed
2485.150000	63.8	---	74	10.2	34.0	Passed
2485.150000	---	47.7	54	6.3	34.0	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB		

Test equipment (please refer to chapter 6 for details)

1 - 9

5.2 Maximum unwanted emissions

5.2.1 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into different 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 preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 30 MHz - 1 GHz
- A final measurement carried out on an open area test site with reflecting ground plane and various antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a variable antenna distance and height in the frequency range above 1 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range above 1 GHz.

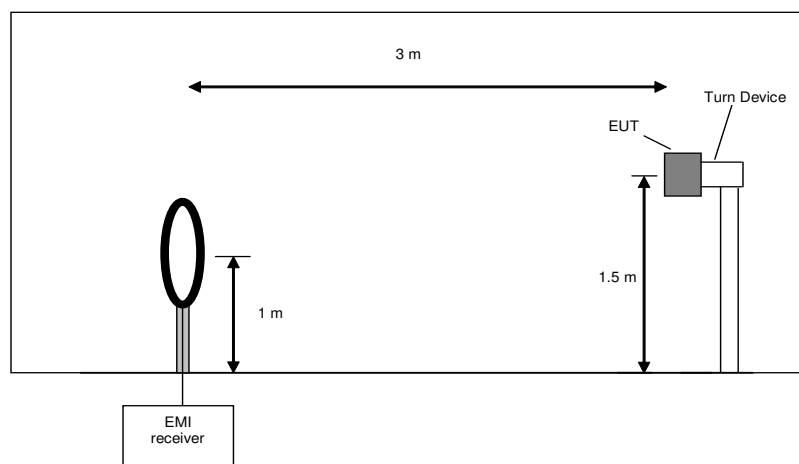
5.2.1.1 Preliminary measurement (9 kHz to 30 MHz)

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of 3 meters. Table top devices will set up on a non-conducting turn device on the height of 1.5m. Floor-standing devices will be placed directly on the turntable/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 EMI receiver 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 found 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 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.

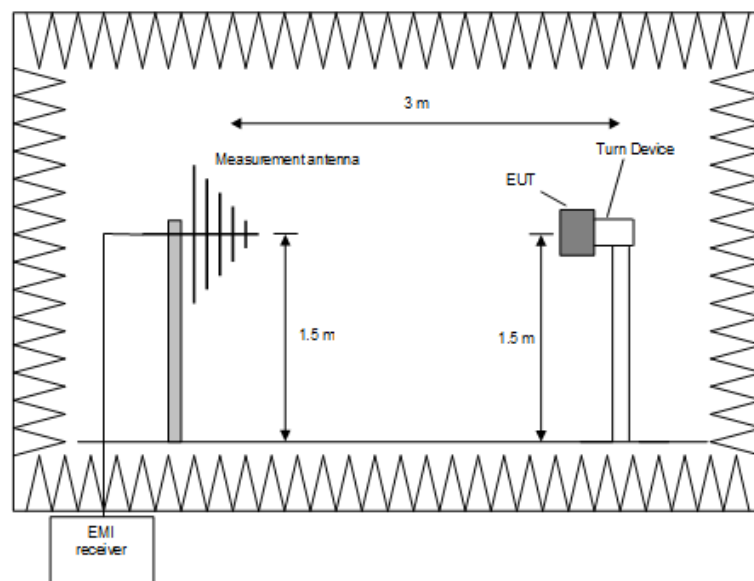
5.2.1.2 Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. Table top devices will set up on a non-conducting turn device on the height of 1.5m. Floor-standing devices will be placed directly on the turntable/ground plane. The setup of the Equipment under test will be in accordance to [1].

The frequency range 30 MHz to 1 GHz will be measured with an EMI Receiver set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarization 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
30 MHz to 1 GHz	100 kHz



Procedure preliminary measurement:

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:

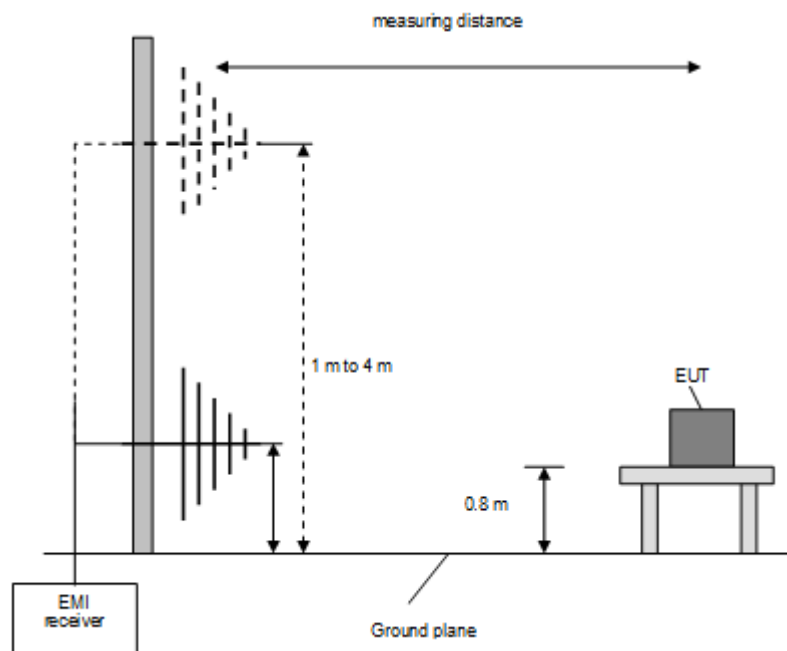
1. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0°.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat 1) to 3) with the vertical polarization of the measuring 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.

5.2.1.3 Final measurement (30 MHz to 1 GHz)

A final measurement on an open area test site will be performed on selected frequencies found in the preliminary measurement. During this 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:

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	120 kHz



Procedure final measurement:

The following procedure will be used:

- 1) Measure on the selected frequencies at an antenna height of 1 m and a EUT azimuth of 23 °.
- 2) Move the antenna from 1 m to 4 m and note the maximum value at each frequency.
- 3) Rotate the EUT by 45 ° and repeat 2) until an azimuth of 337 ° is reached.
- 4) Repeat 1) to 3) for the other orthogonal antenna polarization.
- 5) Move the antenna and the turntable to the position where the maximum value is detected.
- 6) Measure while moving the antenna slowly +/- 1 m.
- 7) Set the antenna to the position where the maximum value is found.
- 8) Measure while moving the turntable +/- 45 °.
- 9) Set the turntable to the azimuth where the maximum value is found.
- 10) Measure with Final detector (QP and AV) and note the value.
- 11) Repeat 5) to 10) for each frequency.
- 12) Repeat 1) to 11) for each orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).

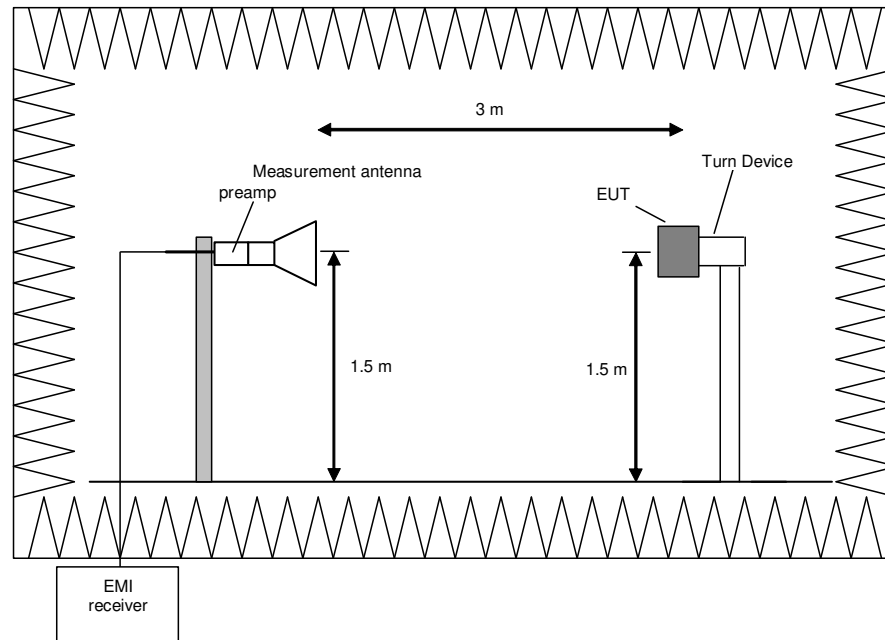
5.2.1.4 Preliminary measurement (1 GHz to 40 GHz)

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].

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The spectrum analyzer set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarization 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	1000 kHz
4 GHz to 12 GHz	1000 kHz
12 GHz to 18 GHz	1000 kHz
18 GHz to 25 / 26.5 GHz	1000 kHz
26.5 GHz to 40 GHz	1000 kHz



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 polarization 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 polarization 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 polarization, 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.

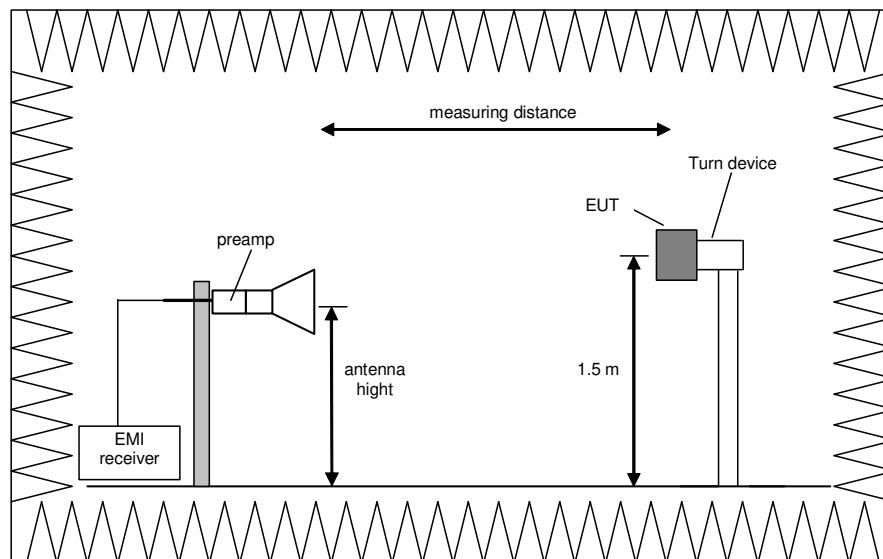
5.2.1.5 Final measurement (1 GHz to 40 GHz)

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].

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 polarization to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
- 3) Set the spectrum analyzer 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.

5.2.2 Test results (radiated emissions)

5.2.2.1 Preliminary radiated emissions measurement (below 1 GHz)

Ambient temperature	21.5 °C
Relative humidity	26 %

Date	04.06.2019 06.06.2019
Tested by	B. Rohde

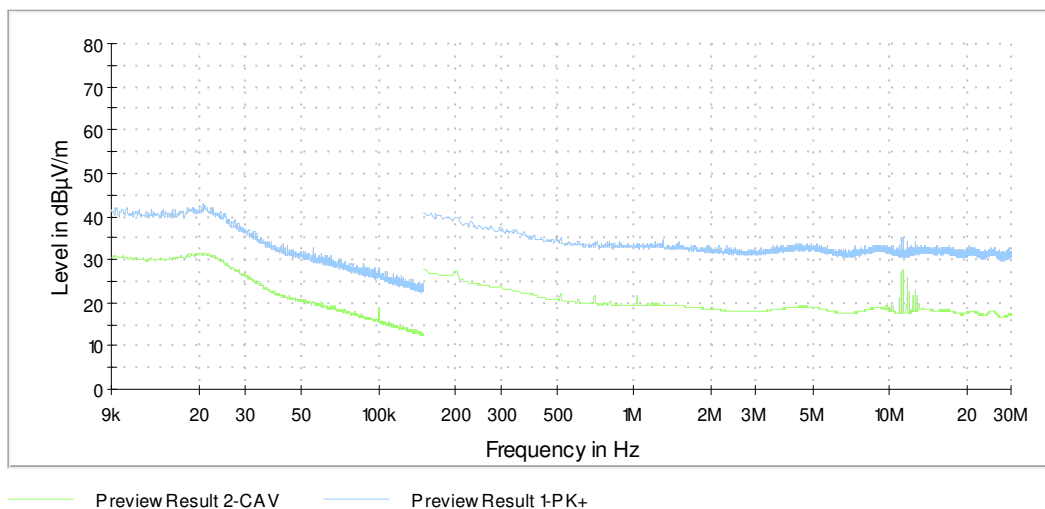
Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

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

Test record: All results are shown in the following.

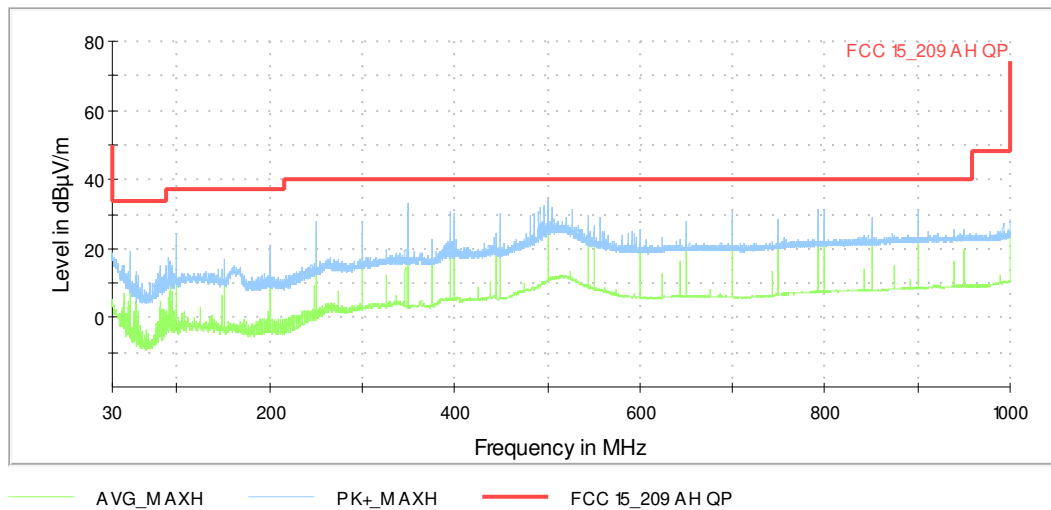
Supply voltage: During all measurements the host of the EUT was powered with 12 V DC via a laboratory power supply.

Spurious emissions from 9 kHz – 30 MHz (Operation mode 2; Preliminary plot, no final measurement conducted):



No significant emission found, all emissions were more than 20 dB from Limit, so no final measurement was conducted.

Spurious emissions from 30 MHz -1 GHz (Operation mode 2; Preliminary plot):



The following frequencies were selected for a final measurement:

Frequency (MHz)
64.770000
99.990000
104.730000
150.000000
249.990000
350.010000
399.990000
450.000000
500.010000
600.000000
699.990000
750.000000
792.000000
838.260000
900.480000
1000.000000

Test equipment (please refer to chapter 6 for details)
1 – 2, 4, 7 - 14

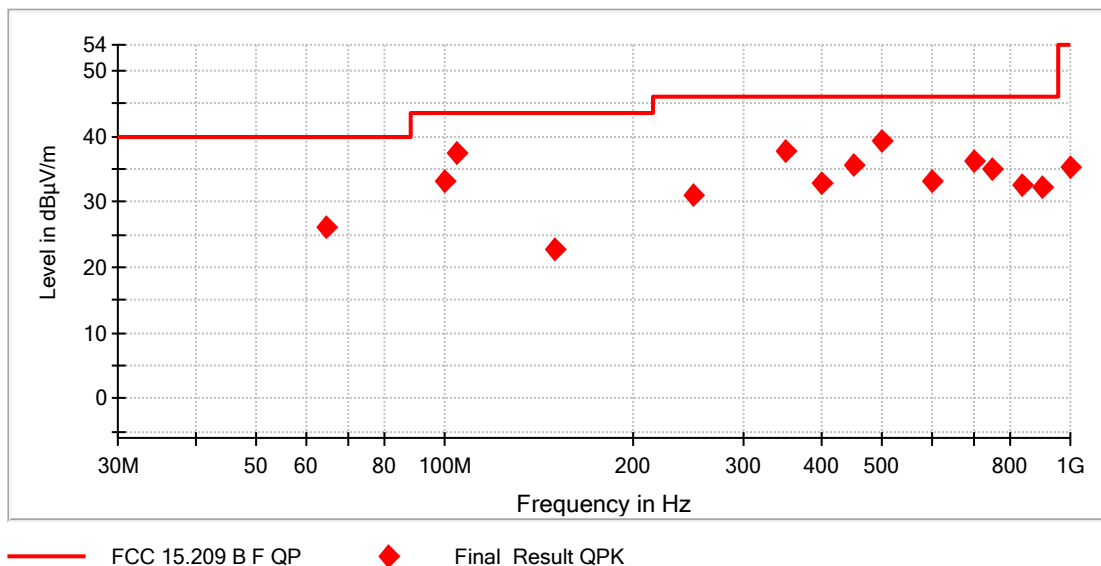
5.2.2.2 Final radiated emission measurement (below 1 GHz)

Ambient temperature	21.5 °C
Relative humidity	26 %

Date	14.06.2019
Tested by	B. Rohde

- Position of EUT: The EUT was set-up on an table at a high 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 test setup photos.
- Test record: All results are shown in the following.
- Supply voltage: During all measurements the host of the EUT was powered with 12 V DC via a laboratory power supply.
- Additional information: For simplification all values were compared to the restricted band limits.

Spurious emissions from 30 MHz - 1 GHz (Operation mode 3; final plot):



Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
64.770000	26.09	40.00	13.91	1000.0	120.000	204.0	H	219.0	12.8
99.990000	33.18	43.50	10.32	1000.0	120.000	386.0	V	8.0	17.3
104.730000	37.58	43.50	5.92	1000.0	120.000	400.0	V	320.0	17.5
150.000000	22.77	43.50	20.73	1000.0	120.000	250.0	V	264.0	19.1
249.990000	31.16	46.00	14.84	1000.0	120.000	178.0	H	39.0	20.8
350.010000	37.65	46.00	8.35	1000.0	120.000	167.0	V	112.0	23.5
399.990000	32.87	46.00	13.13	1000.0	120.000	178.0	V	151.0	25.2
450.000000	35.59	46.00	10.41	1000.0	120.000	100.0	H	169.0	26.4
500.010000	39.29	46.00	6.71	1000.0	120.000	100.0	V	160.0	27.5
600.000000	33.07	46.00	12.93	1000.0	120.000	103.0	H	232.0	29.8
699.990000	36.16	46.00	9.84	1000.0	120.000	114.0	V	146.0	31.1
750.000000	34.92	46.00	11.08	1000.0	120.000	197.0	V	114.0	32.7
792.000000	86.79	46.00	-40.79	1000.0	120.000	400.0	V	80.0	32.6
838.260000	32.61	46.00	13.39	1000.0	120.000	363.0	V	55.0	34.0
900.480000	32.20	46.00	13.80	1000.0	120.000	119.0	V	48.0	34.1
1000.000000	35.28	54.00	18.72	1000.0	120.000	202.0	V	217.0	35.8
Measurement uncertainty					+ / - 5.38				

Test equipment (please refer to chapter 6 for details)

17 - 23

5.2.2.3 Preliminary radiated emissions measurement (above 1 GHz)

Ambient temperature	22 °C
Relative humidity	45 %

Date	04.06.2019 06.06.2019
Tested by	B. ROHDE

Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. 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 Test setup Photo annex.

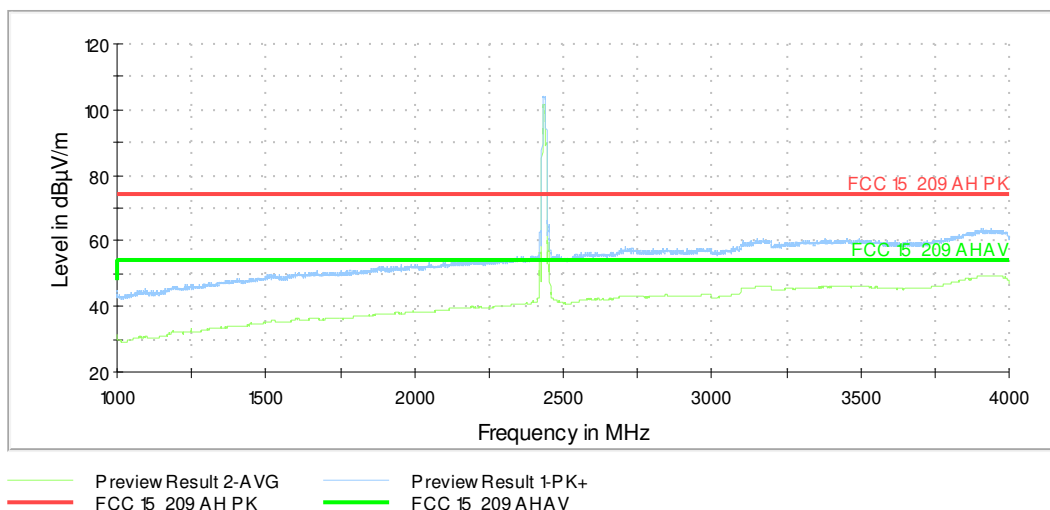
Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 12 V dc by a laboratory power supply.

The correction factor is calculated as :
 Antenna Factor [dB] + Cable Attenuation [dB] - Amplifier Gain [dB] + DCCF (if applicable) [dB]

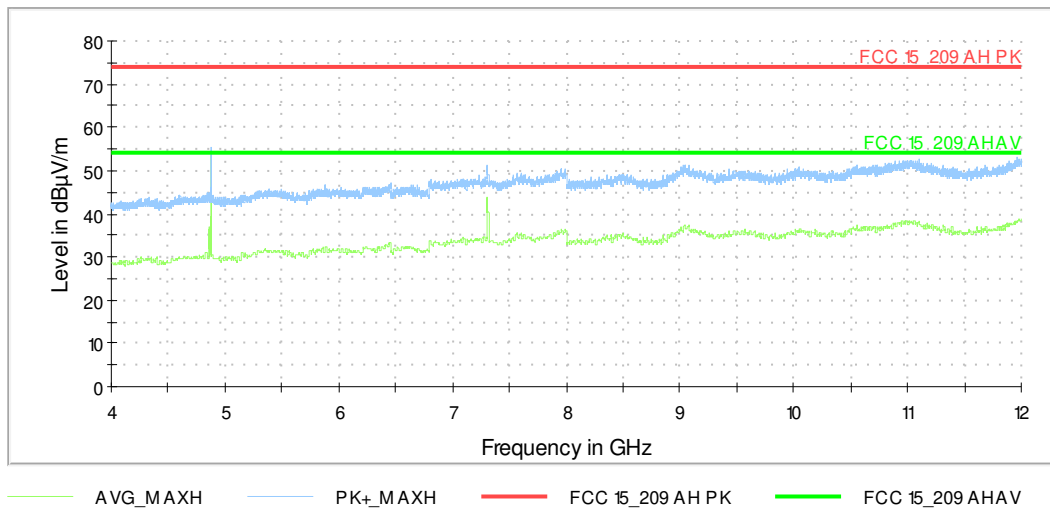
The result Peak/Average is the result of Reading [dBμV/m] – Correction factor [dB]

Spurious emissions from 1 – 4 GHz (Operation mode 1; Preliminary plot):

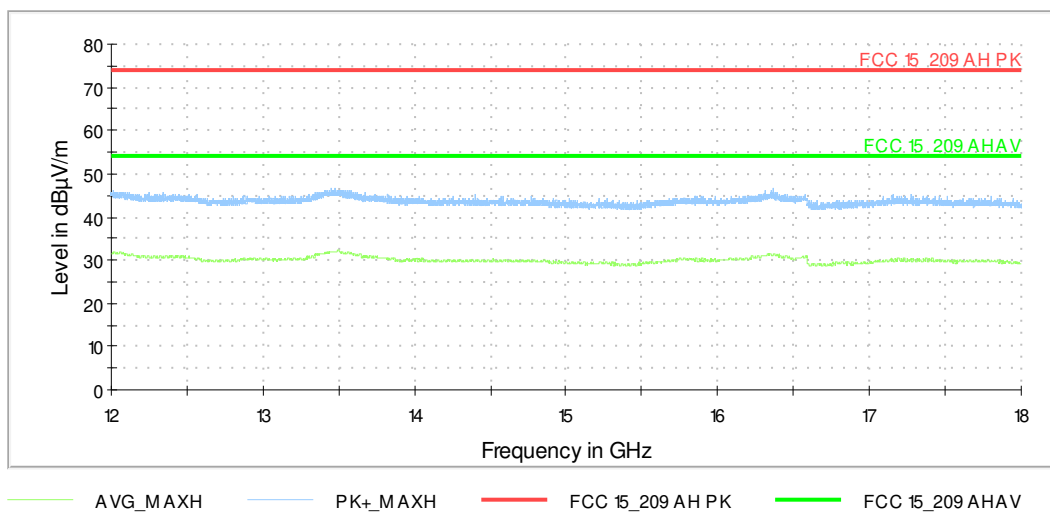


The emission @2.4 GHz is the wanted signal and therefore not rated.

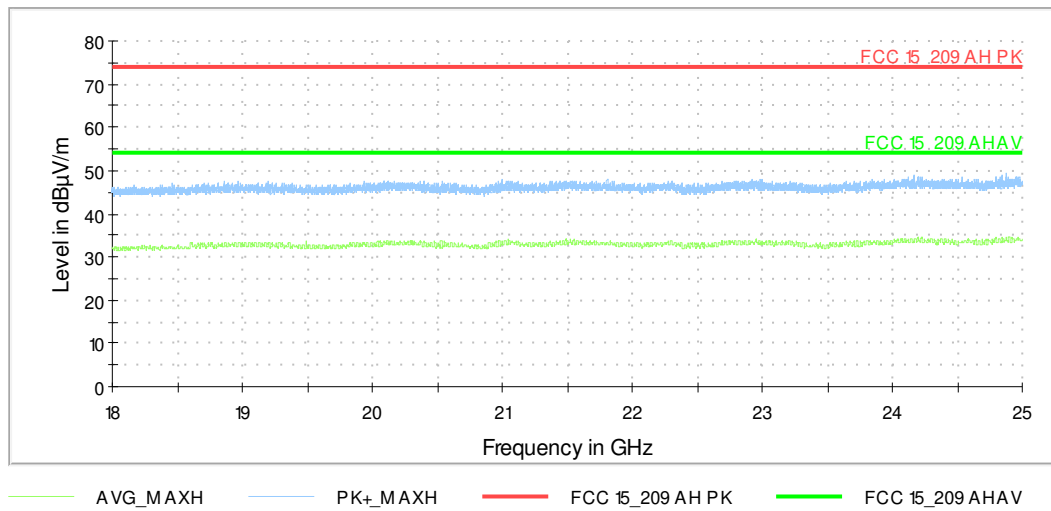
Spurious emissions from 4 - 12 GHz (Operation mode 2; Preliminary plot):



Spurious emissions from 12 - 18 GHz (Operation mode 2; Preliminary plot, no final measurement conducted):



Spurious emissions from 18 – 25 GHz (Operation mode 2; Preliminary plot, no final measurement conducted):



Test equipment (please refer to chapter 6 for details)

1 – 10, 13, 16, 24 - 30

5.2.2.4 Final radiated emission measurement (above 1 GHz)

Ambient temperature	22 °C
Relative humidity	45 %

Date	04.06.2019 06.06.2019
Tested by	B. ROHDE

Position of EUT: The EUT was set-up on a EUT turn device of a height of 1.5 m. 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 test setup photos.

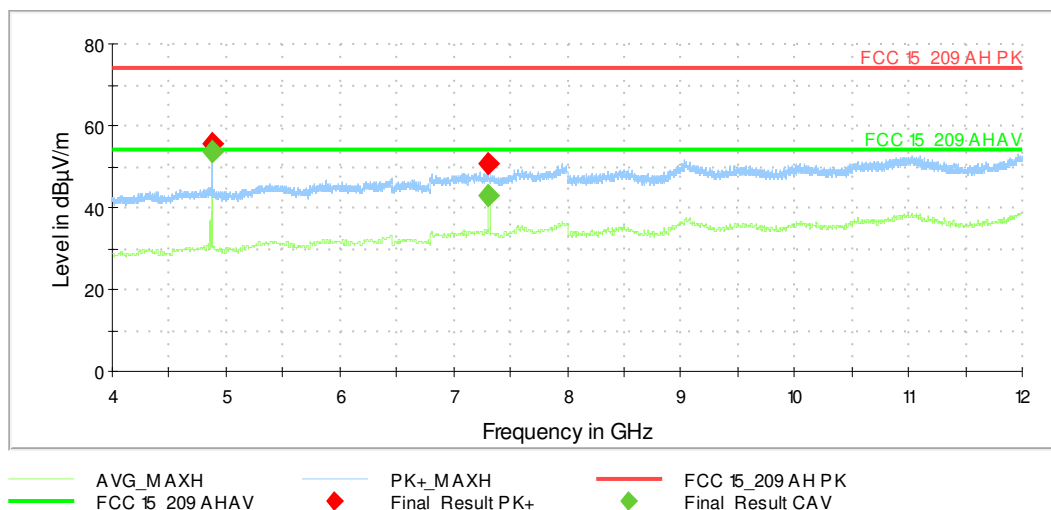
Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was powered with 12 V dc by a laboratory power supply.

Resolution bandwidth: For all measurements a resolution bandwidth of 1 MHz was used.

Additional information: For simplification all values were compared to the restricted band limits

Spurious emissions from 4 - 12 GHz (Operation mode 1; final plot):



Spurious Emissions 1 – 25 GHz (Operation mode 1)									
Frequency	Max Peak	Average	Limit	Margin	Pol	Azimuth	Elevation	Correction	Result
[MHz]	[dBμV/m]	[dBμV/m]	[dBμV/m]	dB		[°]	[°]	[dB]	
4874.000000	55.5	---	74	18.5	H	272	30	-1.7	Passed
4874.000000	---	53.6	54	0.4	H	272	30	-1.7	Passed
7310.000000	50.7	---	74	23.3	H	268	60	4.7	Passed
7310.000000	---	43.2	54	10.8	H	268	60	4.7	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

All other emissions were more than 20 dB below the limit.

Test equipment (please refer to chapter 6 for details)
1 – 10, 13, 16, 24 - 30

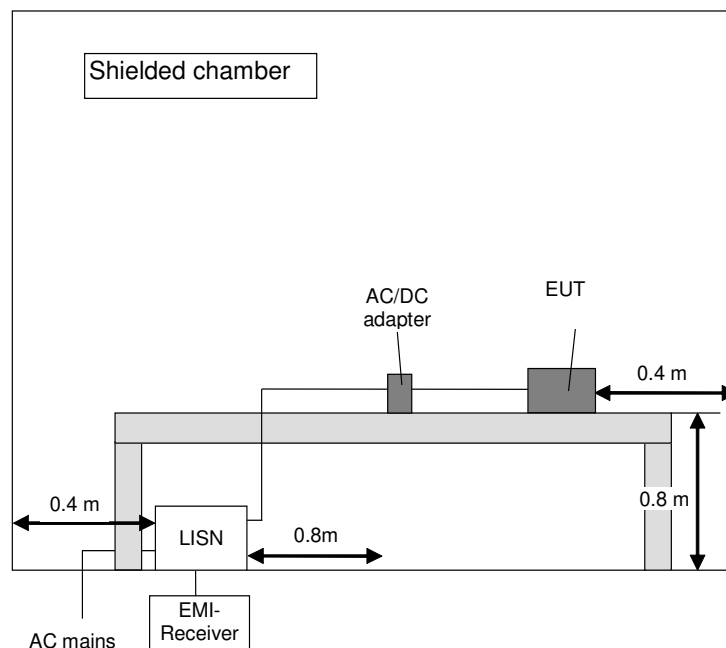
5.3 Conducted emissions on power supply lines (150 kHz to 30 MHz)

5.3.1 Test method(Conducted emissions on power supply lines)

This test will be carried out in a shielded chamber. Table top 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 appropriate 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



5.3.3 Test results (Conducted emissions on power supply lines)

Ambient temperature	22 °C	Date	14.06.2019
Relative humidity	36 %	Tested by	M. DINTER

Position of EUT: Tabletop equipment, see photos in annex A of this test report

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

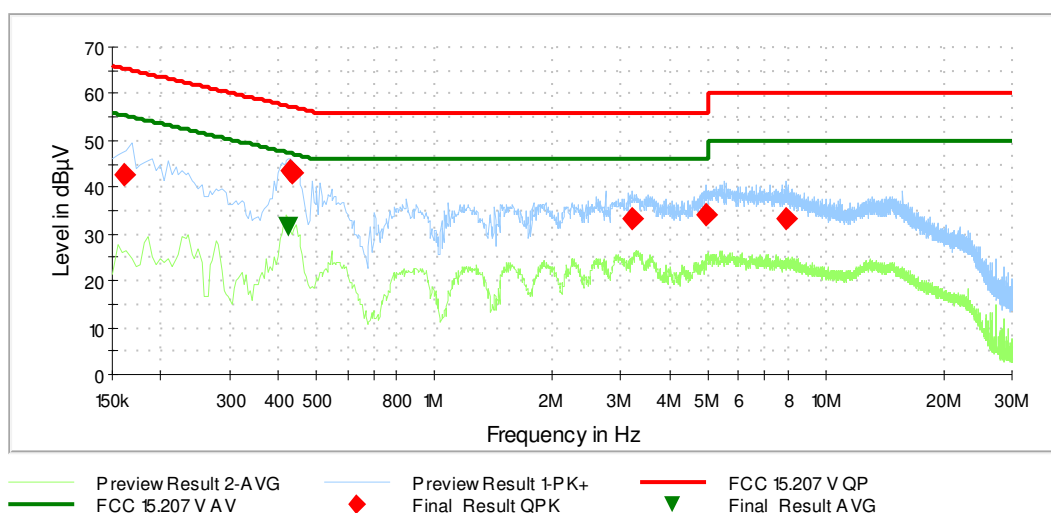
Test record: All results are shown in the following.

Supply voltage: The power supply was plugged in the LISN and was powered with 120V/60Hz. The power supply, as delivered by the applicant delivered 12 V dc to the EUT. Power supply KOSH POWER, Model No. CE200A0120V1500 was used.

Remark: In normal operation mode the EUT opened an access point, a client was connected to the AP and the EUT was pinged. An Ethernet connection was established and a ping was used to generate traffic on the Ethernet line, too.

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 "◆" and the average measured points by "▼".

Conducted emissions on power supply (Normal operation mode channel 01):



Results 150 kHz – 30 MHz									
Frequency [MHz]	QuasiPeak [dBμV]	Average [dBμV]	Limit [dBμV]	Margin [dB]	Meas. Time [ms]	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.161700	42.81	---	65.38	22.57	5000.0	9.000	N	FLO	9.8
0.422700	---	31.38	47.39	16.02	5000.0	9.000	L1	FLO	9.9
0.428100	43.34	---	57.29	13.95	5000.0	9.000	L1	FLO	9.9
0.433500	42.96	---	57.19	14.22	5000.0	9.000	L1	GND	9.9
3.212700	33.36	---	56.00	22.64	5000.0	9.000	L1	FLO	10.2
4.925400	34.04	---	56.00	21.96	5000.0	9.000	L1	GND	10.3
7.962000	33.46	---	60.00	26.54	5000.0	9.000	L1	GND	10.5
Measurement uncertainty					+ / - 2.76 dB				

Test: Passed

Test equipment (please refer to chapter 6 for details)
21; 31 – 34

6 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
2	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
3	RF-cable No.3	Sucoflex 106B	Suhner	0563/6B / Kabel 3	480670	Calibration not necessary	
4	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/971107	480832	Calibration not necessary	
5	Antenna (Log.Per.)	HL050	Rohde & Schwarz	100438	481170	09.10.2017	10.2020
6	RF-Cable No. 40	Sucoflex 106B	Suhner	0708/6B / Kabel 40	481330	Calibration not necessary	
7	HF-Cable	Sucoflex 104	Huber+Suhner	517406	482391	Calibration not necessary	
8	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	22.06.2017	06.2019*
9	Antenna mast	AS615P	Deisel	615/310	480187	Calibration not necessary	
10	Antenna support	AS620P	Deisel	620/375	480325	Calibration not necessary	
11	loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	10.01.2019	01.2020
12	Antenna (Bilog)	CBL6112B	Schaffner EMV GmbH (-Chase)	2688	480328	19.06.2017	06.2020
13	Software	EMC32	Rohde & Schwarz	-	481800	Calibration not necessary	
14	RF-cable No.36	Sucoflex 106B	Suhner	0587/6B / Kabel 36	480865	Calibration not necessary	
15	HF-Cable	Sucoflex 104	Huber+Suhner	517402	482392	Calibration not necessary	
16	Positioners	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
17	Open area test site M6	OATS M6	Phoenix Contact	-	480085	Calibration not necessary	
18	Antenna mast	MA240-0	Inn-Co GmbH	MA240-0/030/6600603	480086	Calibration not necessary	
19	Turntable	DS412	Deisel	412/316	480087	Calibration not necessary	
20	Controller	HD100	Deisel	100/349	480139	Calibration not necessary	
21	Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
22	Antenna (Bilog)	CBL6111D	Schaffner Elektrotest GmbH / Teseq GmbH	25761	480894	19.10.2017	10.2020
23	Measuring receiver	ESR7	Rohde & Schwarz	101939	482558	19.09.2017	09.2019
24	standard gain horn antenna	18240-20	Flann Microwave	483	480294	Calibration not necessary	
25	standard gain horn antenna	20240-20	Flann Microwave	411	480297	Calibration not necessary	
26	Microwave cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800-KPS	480302	Calibration not necessary	
27	Preamplifier 100 MHz - 13 GHz	JS3-00101200-23-5A	MITEQ Hauppauge N.Y.	681851	480337	10.07.2018	07.2020
28	Preamplifier 18 GHz - 26 GHz	JS4-18002600-20-5A	MITEQ Hauppauge N.Y.	658697	480342	10.07.2018	07.2020

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
29	Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ Hauppauge N.Y.	571667	480343	10.07.2018	07.2020
30	High pass Filter	WHKX4.0/18G-8SS	Wainwright Instruments GmbH	1	480587	Calibration not necessary	
31	LISN	NSLK8128	Schwarzbeck	8128161	480138	13.03.2018	02.2020
32	Shielded chamber M4	B83117-S1-X158	Siemens	190075	480088	Calibration not necessary	
33	EMI Receiver / Spectrum Analyzer	ESIB 26	Rohde & Schwarz	100292	481182	28.02.2018	02.2020
34	Transient Filter Limiter	CFL 9206A	Teseq GmbH	38268	481982	14.03.2018	03.2020

* all measurements were conducted where the calibration of the measurement equipment were still valid

7 Test site Validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
OATS M6	480085	30 – 1000 MHz	NSA	ANSI C63.4-2014	25.10.2018	24.10.2020
Fully anechoic chamber M20	480303	1 - 18 GHz	SVSWR	CISPR 16-1-4 Amd. 1	13.07.2018	12.07.2020
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
F190546E4	24.10.2019	Initial Test Report
F190546E4 2 nd Version	14.08.2024	-Changed Accreditation symbol on page 1 -Changed signature layout to digital signature on page 3 -Updated references on page 2 -Changed EUT information from contains FCC/IC ID to dedicated FCC/IC ID on page 6

9 List of Annexes

Annex A Test Setup Photos

9 pages