

Test Report

Report Number:

F181631E3

Equipment under Test (EUT):

multistreamer pro

Applicant:

audifon GmbH & Co. KG

Manufacturer:

audifon GmbH & Co. KG



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] **RSS-247 Issue 2 (March 2017)**, Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- [4] **RSS-Gen Issue 5 (April 2015)**, General Requirements for Compliance of Radio Apparatus

Test Result

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

The complete test results are presented in the following.

Test engineer:	<u>Paul NEUFELD</u> Name	<u></u> Signature	<u>28.02.2019</u> Date
Authorized reviewer:	<u>Bernd STEINER</u> Name	<u></u> Signature	<u>28.02.2019</u> Date

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1 Identification

1.1 Applicant

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eMail Address:	stephan.teders@audifon.com
Applicant represented during the test by the following person:	None

1.2 Manufacturer

Name:	audifon GmbH & Co. KG
Address:	Werner-von-Siemens-Strasse 2, 99625 Köllda
Country:	Germany
Name for contact purposes:	Mr. Stephan Teders
Phone:	+49 (0) 221-669668-14
Fax:	+49 (0) 221-669668-20
eMail Address:	stephan.teders@audifon.com
Applicant represented during the test by the following person:	None

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, FCC Test Firm Accreditation designation number DE0004, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment Under Test)

Test object: *	Smartphone to hearing aid streamer
Type / PMN: *	multistreamer pro
FCC ID: *	YU2-MS2
Serial number: *	2018-D0001E
EUT marking: *	#76
PCB identifier: *	AFAS v1.02
Hardware version: *	AFAS v1.02
Software version: *	V0.8.1

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

Bluetooth Low Energy radio channels:

Channel 0	RX:	2402 MHz	TX:	2402 MHz
Channel 19	RX:	2440 MHz	TX:	2440 MHz
Channel 39	RX:	2480 MHz	TX:	2480 MHz

1.5 Technical Data of Equipment

Fulfills specifications: *	BTLE unit: Bluetooth 5.0 low energy only (only supports 1 Mbps mode) BT classic + EDR unit: Bluetooth classic + EDR					
Antenna type: *	BTLE unit: PCB antenna BT classic + EDR unit: Ceramic antenna					
Antenna name: *	BTLE unit: none BT classic + EDR unit: none					
Antenna gain: *	BTLE unit: 4.5 dBi BT classic + EDR unit: 0 dBi					
Antenna connector: *	Both units: None					
Supply voltage EUT: *	U _{nom} =	1.25 V DC	U _{min} =	1.18 V DC	U _{max} =	3.3 V DC
Type of modulation: *	BTLE unit: GFSK (1 Mbps only) BT classic + EDR unit: GFSK, $\pi/4$ DQPSK, 8DPSK					
Operating frequency range:*	Both units: 2402 – 2480 MHz					
Number of channels: *	BTLE unit:40 BT classic + EDR unit: 79					
Temperature range: *	0 °C to +50 °C					
Lowest / highest Internal clock frequency: *	48 MHz / 2480 MHz					

* Declared by the applicant

Ancillary devices:

Ancillary Equipment:	
Cables (connected to the EUT):*	Micro-USB cable
Power supply: *	"PSM03E-050Q-3" by "Phihong Technology Co.,Ltd."
Laptop PC:**	Fujitsu Lifebook E751

* delivered by the applicant

** delivered by the laboratory

1.6 Dates

Date of receipt of test sample:	05.12.2018
Start of test:	05.12.2018
End of test:	19.12.2018

2 Operational States

The equipment under test (EUT) is a BT classic and BTLE transmitter. It connects to a hearing aid device via Bluetooth Low Energy and to an ancillary device (e.g. a smartphone) via either Bluetooth Classic radio connection or a 3.5 mm audio connector.

This test report contains the results of the Bluetooth Low Energy tests.

For the BTLE radio tests, the EUT was connected to a laptop computer using a USB cable, connecting to a micro USB interface at the EUT.

For the tests in the anechoic chamber, the USB signal was transmitted via an USB to fiber-optics converter.

During the tests the EUT was supplied with 5 V DC via the USB cable.

For the test a test software named DirectTestModeApp.exe. was used which was provided by the applicant.

Maximum power Settings for all measurements:

Modulation	Power setting ch. 0 - 39
GFSK, 1 Mbps	+3 dBm

Operation mode	Description of the operation mode	mode	channel	Modulation	Data rate / Mbps
1	Continuous transmitting on 2402 MHz	BLE	0	GFSK	1 Mbps
2	Continuous transmitting on 2440 MHz	BLE	19	GFSK	1 Mbps
3	Continuous transmitting on 2480 MHz	BLE	39	GFSK	1 Mbps

3 Additional Information

The test was performed using an unmodified sample.

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]	Passed	11 et seq
Maximum Output Power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [3]	Passed	13 et seq
DTS Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [3]	Passed	13 et seq
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [3]	Passed	18 et seq
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3]	Passed	20 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	24 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Passed	34 et seq.

5 Results

5.1 Duty cycle

The EUT was measured radiated in the anechoic chamber using the procedures described in 5.7.1.

The method described in chapter 11.6 b) of document [1] was used to perform the following test.

The following measurement technique was used:

The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between two bins on the sweep are sufficient to permit accurate measurements of the on and off times of the transmitted signal.

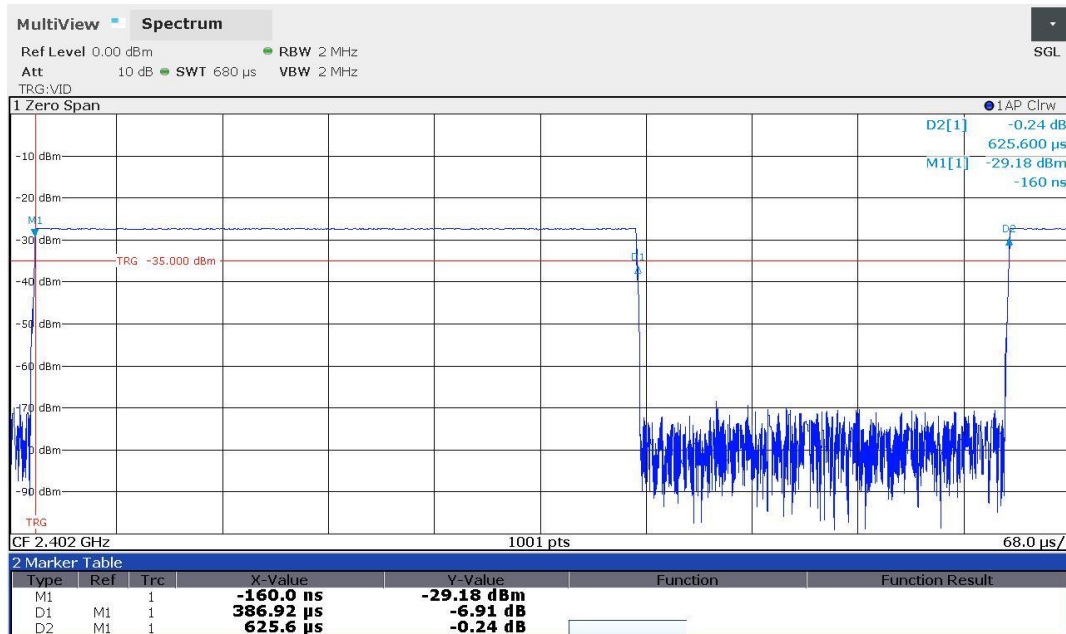
- Set the center frequency of the instrument to the center frequency of the transmission.
- Set $RBW \geq OBW$ if possible; otherwise, set RBW to the largest available value.
- Set $VBW \geq RBW$.
- Set detector = peak or average.
- The zero-span measurement method shall not be used unless both RBW and VBW are $> 50/T$ and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if $T \leq 16.7$ microseconds.)

5.1.1 Test results

Ambient temperature	22 °C	Relative humidity	40 %
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Only the worst case duty cycle plot is submitted below.

DutyCycle_BTLE_15.247.JPEG: Duty cycle measurement on channel 0 (operation mode 1):



Since only one modulation is tested, the calculation is only performed for the worst case, namely the DH5 mode with GFSK modulation.

$$T_{TX_on} = 386.92 \mu s \quad T_{TX_cycle} = 625.60 \mu s \quad (1)$$

$$\frac{50}{T_{TX_on}} = \frac{50}{386.92 \mu s} = 129.226 kHz \leq RBW \leq VBW \quad (2)$$

Measurement Points 1001 for 680 μs à 386.92 μs = 569 measurement points à Signal has 569 measurement points (and fulfils the requirement of at least 100 Points resolution for the signal)

If power averaging (RMS) mode was used in step f), then the applicable correction factor is $10 \log(1/x)$, where x is the duty cycle.

$$x = \frac{T_{TX_on}}{T_{TX_cycle}} = \frac{386.92 \mu s}{625.60 \mu s} = 0.6185 = 61.85\% \quad (3)$$

$$correction\ factor = 10 \cdot \log\left(\frac{1}{x}\right) = 10 \cdot \log\left(\frac{1}{0.6185}\right) = 2.09 dB \quad (4)$$

Therefore, for average measurements a correction factor of 2.09 dB is used.

TEST EQUIPMENT USED FOR THE TEST:

28, 29

5.2 Maximum peak conducted output power

5.2.1 Method of measurement

The EUT was measured radiated in the anechoic chamber using the procedures described in 5.7.1.

Acceptable measurement configurations

Procedure 11.9.1.1 in [1] was used for the following test.

The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the DTS bandwidth is available to perform the measurement:

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

The measurement was performed at the upper and lower end and the middle of the assigned frequency band.

The measured Electric field strength was corrected with the following correction factor:

Antenna Factor [dB] + Cable Attenuation [dB] - Amplifier Gain[dB] = correction factor [dB]

The formula in 11.12.2.2 e) in [1] was used to calculate the EIRP power:

$$E = EIRP - 20\log(d) + 104.8$$

$$EIRP = E - 95.3$$

$$MPOP = EIRP - G$$

E is the electric field strength in dB μ V/m

EIRP is the equivalent isotropically radiated power in dBm

d is the specified measurement distance in m

G is the antenna gain in dBi

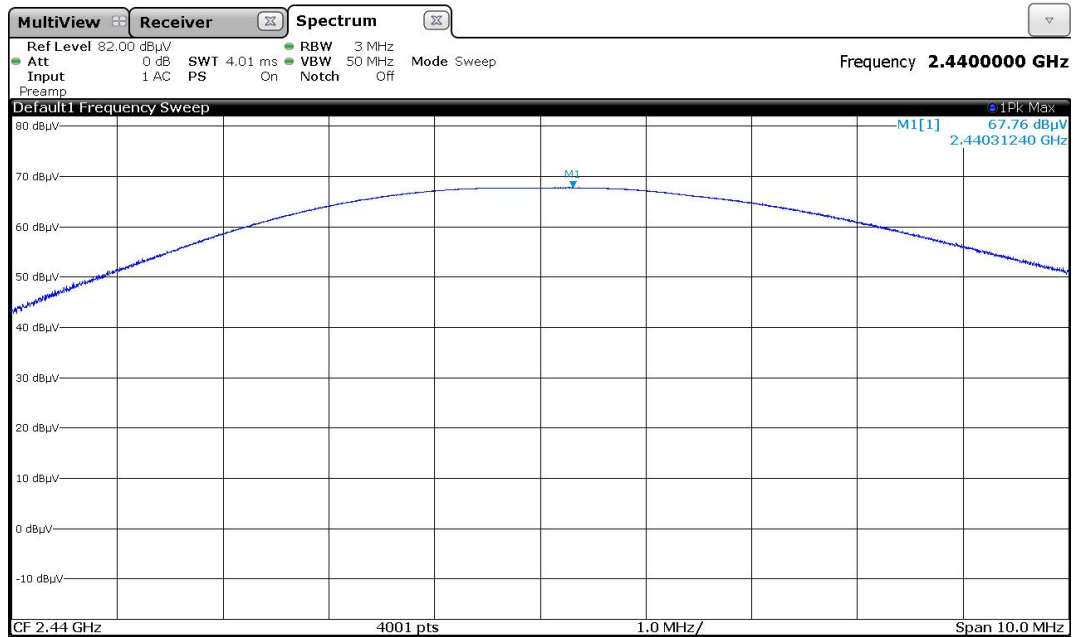
MPOP is the maximum peak output power – measured antenna port conducted – in dBm

5.2.2 Test results

Ambient temperature	22 °C	Relative humidity	62 %
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The plot below shows the worst case result. All other results are submitted in the table below

MPOP_ch19.PNG: Maximum peak output power measured on channel 19 (operation mode 2):



The antenna gain is below 6 dBi, therefore no conducted output limit reduction is necessary.

Operation mode		Frequency [MHz]	Reading [dBmV]	Corr. Fact. [dB]	Corr. Reading [dBmV]	EIRP [dBm]	MPOP [dBm]	Limit [dBm]
1	GFSK	2402	65.44	33.6	99.04	3.84	-0.66	30
2	GFSK	2440	67.76	33.7	101.46	6.26	1.76	30
3	GFSK	2480	67.42	33.8	101.22	6.02	1.52	30

Antenna gain of 4.5 dBi respected

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

8 – 14, 17, 18

5.3 Maximum conducted output power

5.3.1 Method of measurement

The EUT was measured radiated in the anechoic chamber using the procedures described in 5.7.1.

Acceptable measurement configurations

Procedure 11.9.2.2.4 in [1] was used for the following test.

Method AVGSA-2 uses trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction. The procedure for this method is as follows:

- a) Measure the duty cycle D of the transmitter output signal as described in 11.6.
- b) Set span to at least 1.5 times the OBW.
- c) Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.
- d) Set VBW $\geq [3 \times \text{RBW}]$.
- e) Number of points in sweep $\geq [2 \times \text{span} / \text{RBW}]$. (This gives bin-to-bin spacing $\leq \text{RBW} / 2$, so that narrowband signals are not lost between frequency bins.)
- f) Sweep time = auto.
- g) Detector = RMS (i.e., power averaging), if available. Otherwise, use the sample detector mode.
- h) Do not use sweep triggering. Allow the sweep to "free run."
- i) Trace average at least 100 traces in power averaging (rms) mode; however, the number of traces to be averaged shall be increased above 100 as needed such that the average accurately represents the true average over the ON and OFF periods of the transmitter.
- j) Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.
- k) Add $[10 \log (1 / D)]$, where D is the duty cycle, to the measured power to compute the average power during the actual transmission times (because the measurement represents an average over both the ON and OFF times of the transmission). For example, add $[10 \log (1/0.25)] = 6 \text{ dB}$ if the duty cycle is 25%.

The measurement was performed at the upper and lower end and the middle of the assigned frequency band.

The reading in the table below is already corrected with the duty cycle correction factor documented in 5.1.1.

The measured Electric field strength was corrected with the following correction factor:

$$\text{Antenna Factor [dB]} + \text{Cable Attenuation [dB]} - \text{Amplifier Gain [dB]} = \text{correction factor [dB]}$$

The formula in 11.12.2.2 e) in [1] was used to calculate the EIRP power:

$$E = \text{EIRP} - 20 \log(d) + 104.8$$

$$\text{EIRP} = E - 95.3$$

$$\text{MOP} = \text{EIRP} - G$$

E is the electric field strength in $\text{dB}\mu\text{V/m}$

EIRP is the equivalent isotropically radiated power in dBm

d is the specified measurement distance in m

G is the antenna gain in dBi

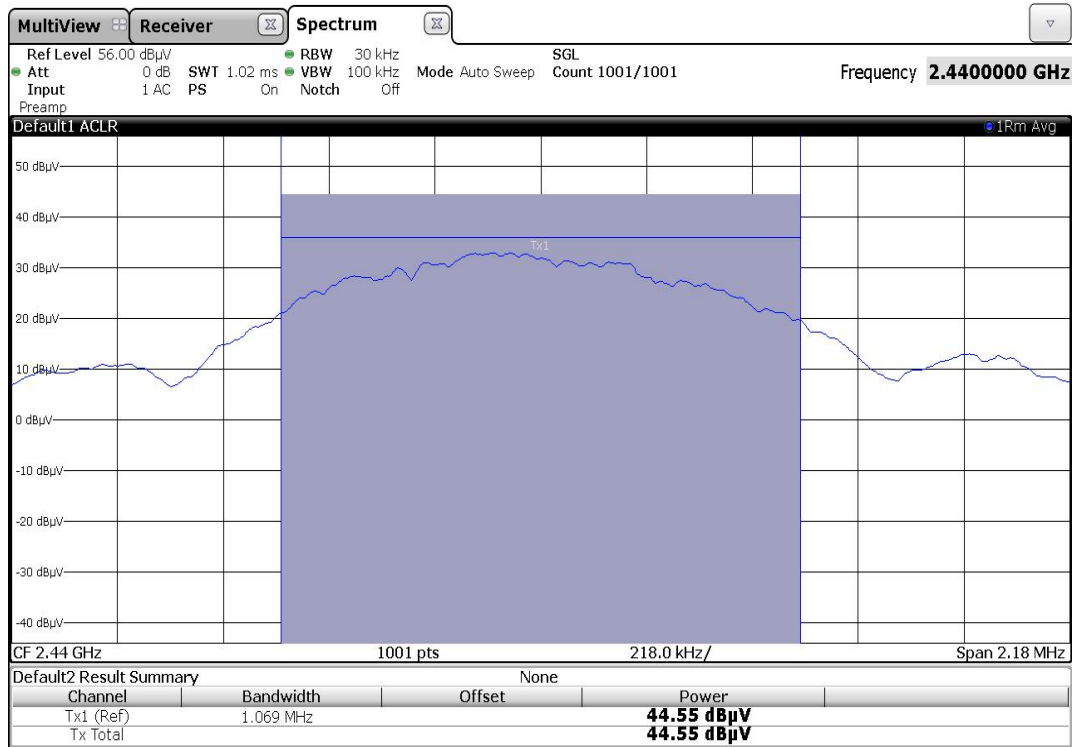
MOP is the maximum output power – measured antenna port conducted – in dBm

5.3.2 Test results

Ambient temperature	22 °C	Relative humidity	62 %
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The plot below shows the worst case result. All other results are submitted in the table below

AVSA_ch19.PNG: Maximum output power measured on channel 19 (operation mode 2):



The antenna gain is below 6 dBi, therefore no conducted output limit reduction is necessary.

Operation mode		Frequency [MHz]	Reading [dBmV]	Corr. Fact. [dB/m]	DC Corr. [dB]	Corr. Reading [dBmV/m]	EIRP [dBm]	MOP [dBm]	Limit [dBm]
1	GFSK	2402	43.2	33.6	2.1	78.9	-16.3	-20.8	30.0
2	GFSK	2440	44.6	33.7	2.1	80.3	-14.9	-19.4	30.0
3	GFSK	2480	44.1	33.8	2.1	80.0	-15.2	-19.7	30.0

Antenna gain of 4.5 dBi respected

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

8 – 14, 17, 18

5.4 DTS Bandwidth / 99% Bandwidth

5.4.1 Method of measurement

For the following bandwidth measurements, the EUT was measured radiated in the anechoic chamber using the procedures described in 5.7.1.

Acceptable measurement configurations

The measurement for the DTS bandwidth procedure refers to part 11.8.1 of document [1].

- Set RBW = 100 kHz.
- Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
- Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize.
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

The following procedure was used for measuring the 99 % bandwidth:

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission. The following procedure shall be used for measuring 99% power bandwidth:

- The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.
- Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $10 \log(\text{OBW}/\text{RBW})$ below the reference level. Specific guidance is given in 4.1.5.2.
- Step a) through step c) might require iteration to adjust within the specified range.
- e) Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.
- f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.
- g) If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.
- The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labelled. Tabular data maybe reported in addition to the plot(s).

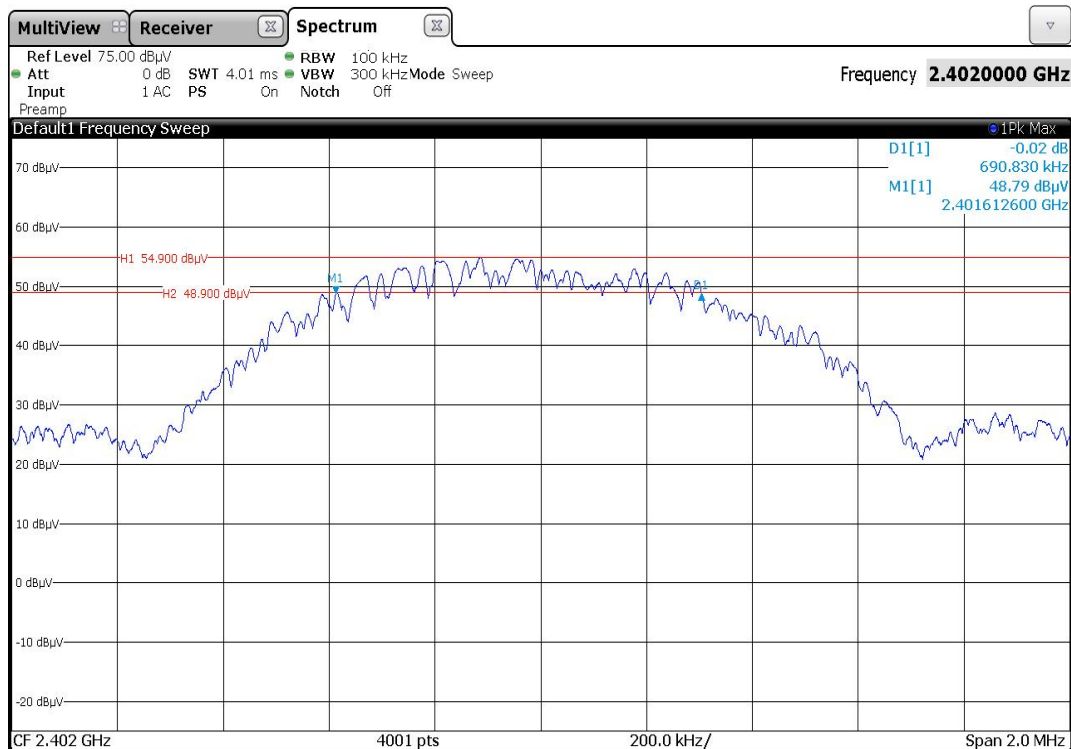
Since this is only a relative measurement, no measurement level correction was performed.

5.4.2 Test result

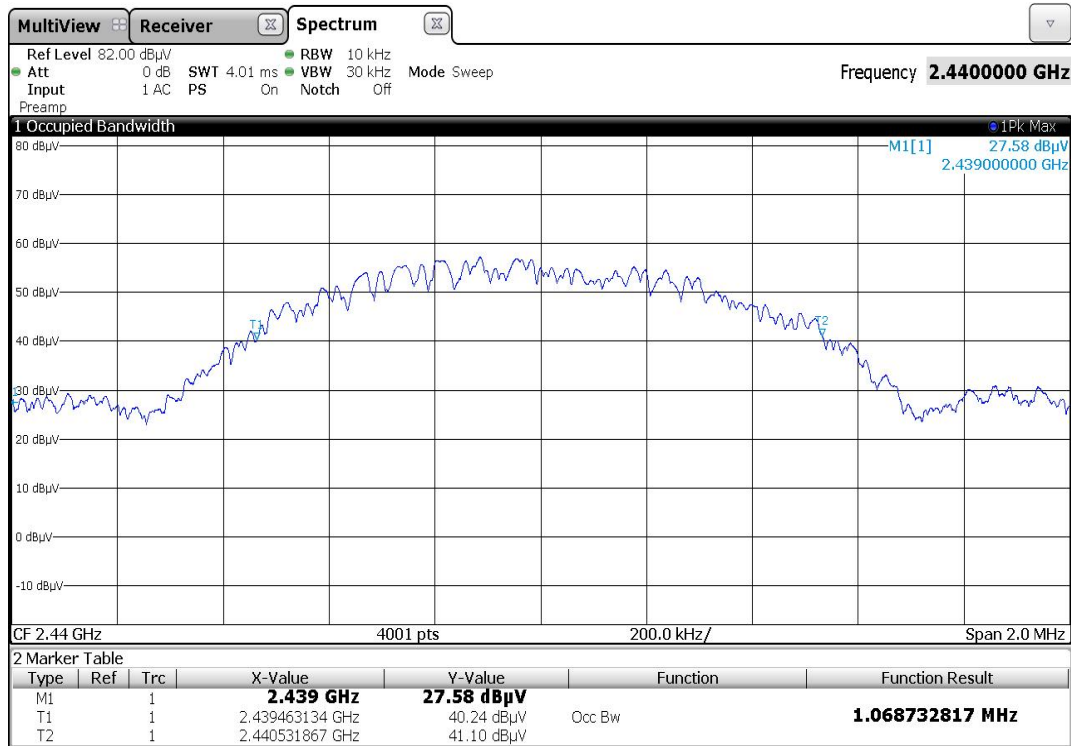
Ambient temperature	22 °C	Relative humidity	59 %
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The plots show an exemplary measurement result for the worst documented case. The other results are listed in the following tables.

6dB BW ch0.wmf: 6-dB Bandwidth (operation mode 1):



99% BW ch19.png: 99% Bandwidth (operation mode 2):



Operation Mode	Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
1 GFSK	2402	0.5	0.69083	1.066233	Passed
2 GFSK	2440	0.5	0.69183	1.068733	Passed
3 GFSK	2480	0.5	0.69083	1.062734	Passed

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

8 – 14, 17, 18

5.5 Peak Power Spectral Density

5.5.1 Method of measurement

The EUT was measured radiated in the anechoic chamber using the procedures described in 5.7.1.

Acceptable measurement configurations

The measurement procedure refers to part 11.10.2 of document [1].

- Set analyser center frequency to DTS channel center frequency
- Set the span to 1.5 times the DTS bandwidth.
- Set the RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
- Set the VBW $\geq 3 \times \text{RBW}$.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level within the RBW.
- If measured value exceeds limit, reduce RBW (not less than 3 kHz) and repeat.

The measurement was performed at the upper and lower end and the middle of the assigned frequency band.

The measured Electric field strength was corrected with the following correction factor:

Antenna Factor [dB] + Cable Attenuation [dB] – Amplifier Gain[dB] = correction factor [dB]

The formula in 11.12.2.2 e) in [1] was used to calculate the EIRP power:

$$E = EIRP - 20\log(d) + 104.8$$

$$EIRP = E - 95.3$$

$$MPOP = EIRP - G$$

E is the electric field strength in dB μ V/m

EIRP is the equivalent isotropically radiated power in dBm

d is the specified measurement distance in m

G is the antenna gain in dBi

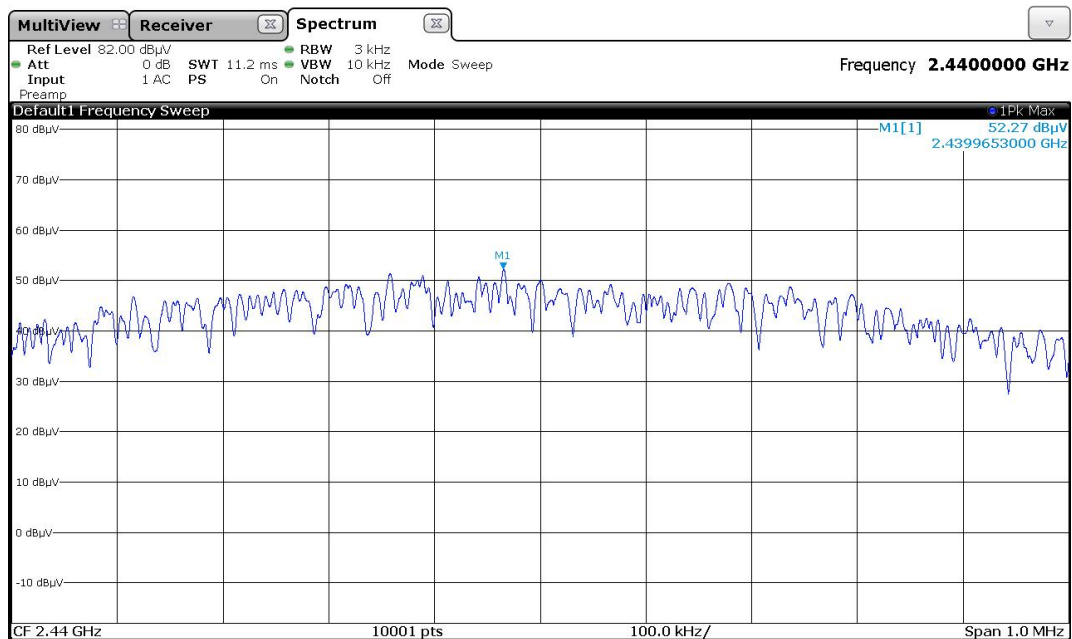
MPOP is the maximum peak output power – measured antenna port conducted – in dBm

5.5.2 Test result

Ambient temperature	22 °C	Relative humidity	59 %
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The plots show an exemplary measurement result for the worst documented case. The other results are listed in the following tables.

PPSD_ch19.png: Peak Power Spectral Density (operation mode 2):



Operation Mode		Peak Frequency [MHz]	PPSD Reading [dBmV/3 kHz]	Corr. Fact. [dB]	Corr. Reading [dBmV/3 kHz]	EIR PPSP [dBm/3 kHz]	PPSD [dBm/3 kHz]	PPSD Limit [dBm/3kHz]
1	GFSK	2401.9657	49.98	33.6	83.58	-11.62	-16.12	8
2	GFSK	2439.9653	52.27	33.7	85.97	-9.23	-13.73	8
3	GFSK	2479.9653	51.97	33.8	85.77	-9.43	-13.93	8

Antenna gain of 4.5 dBi respected

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

8 – 14, 17, 18

5.6 Band-edge compliance

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

The EUT was measured radiated in the anechoic chamber using the procedures described in 5.7.1.

Acceptable measurement configurations

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

Measurement Procedure Reference – Reference Level:

- RBW = 100 kHz.
- VBW $\geq$ 300 kHz.
- Set the span to $\geq$ 1.5 times the DTS Bandwidth.
- Detector = Peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilise.
- Use the peak marker function to determine the the maximum PSD level.

Measurement Procedure – Unwanted Emissions

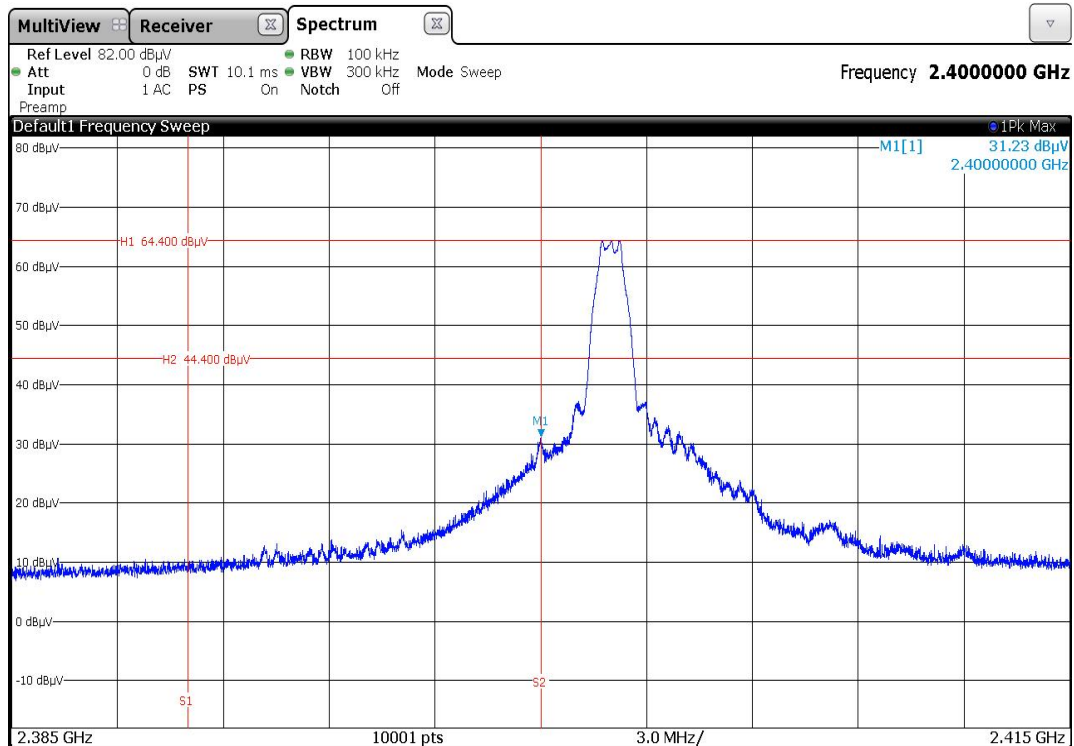
- Set the center frequency and span to encompass the frequency range to be measured.
- RBW = 100 kHz.
- VBW $\geq$ 300 kHz.
- Detector = Peak.
- Ensure that the number of measurement points $\geq$ span/RBW.
- Sweep time = auto couple.
- Trace Mode = max hold.
- Allow the trace to stabilise.
- Use the peak marker function to determine the maximum amplitude level.

The measurement procedure at the band edges was simplified by performing the measurement in just one plot. Both, the in-band-emission and the unwanted emission were be encompassed by the span. After trace stabilization, the maximum peak was be determined by a peak detector and the value was marked by an appropriate limit line. The second limit line, which is 20 dB below the first, marks the limit for the emissions in the unrestricted band. A maximum-peak-detector marks the highest emission in the unrestricted band next to the band edge.

The measurements were performed at the lower end of the 2.4 GHz band.

5.6.2 Test result (band edges next to unrestricted bands (radiated))

LowBE_ch0.PNG: Radiated band-edge compliance at an unrestricted band-edge (operation mode 1):



Operation Mode	Tx Frequency [MHz]	Emission Frequency [MHz]	Reference Level [dBmV/m]	Limit [dBmV/m]	Emission Level [dBmV/m]	Margin [dB]	Result
1 GFSK	2402	2400.000000	64.4	44.4	31.2	13.2	Passed

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

8 – 14, 17, 18

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

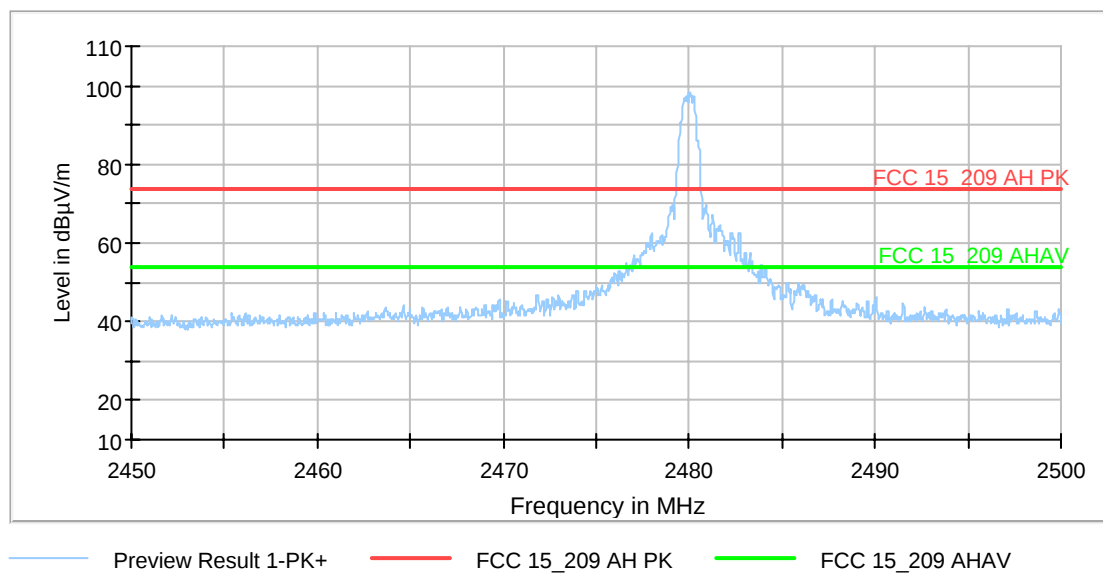
The EUT was measured radiated in the anechoic chamber using the procedures described in 5.7.1.

Acceptable measurement configurations

The same measurement configurations as described in 5.7.1. were used for the preview and final measurement.

5.6.4 Test result (band edges next to restricted bands (radiated))

181631 UpBE_ch39: radiated band-edge compliance at an restricted band-edge (operation mode 3):



Transmitter operates at the lower end of the assigned frequency band (operation mode 1 GFSK)

Frequency [MHz]	MaxPeak [dBμV/m]	Average [dBμV/m]	Limit [dBμV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2387.850000	---	38.84	54	15.16	H	157	0	33
2387.850000	50.79	---	74	23.21	H	157	0	33
Measurement uncertainty				+2.2 dB / -3.6 dB				

Transmitter operates at the upper end of the assigned frequency band (operation mode 3 GFSK)

Frequency [MHz]	MaxPeak [dBμV/m]	Average [dBμV/m]	Limit [dBμV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2483.900000	---	48.02	54	5.98	H	168	30	34
2483.900000	70.67	---	74	3.33	H	168	30	34
Measurement uncertainty				+2.2 dB / -3.6 dB				

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

8 – 14, 17, 18

5.7 Maximum unwanted emissions

5.7.1 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into five stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 30 MHz to 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.

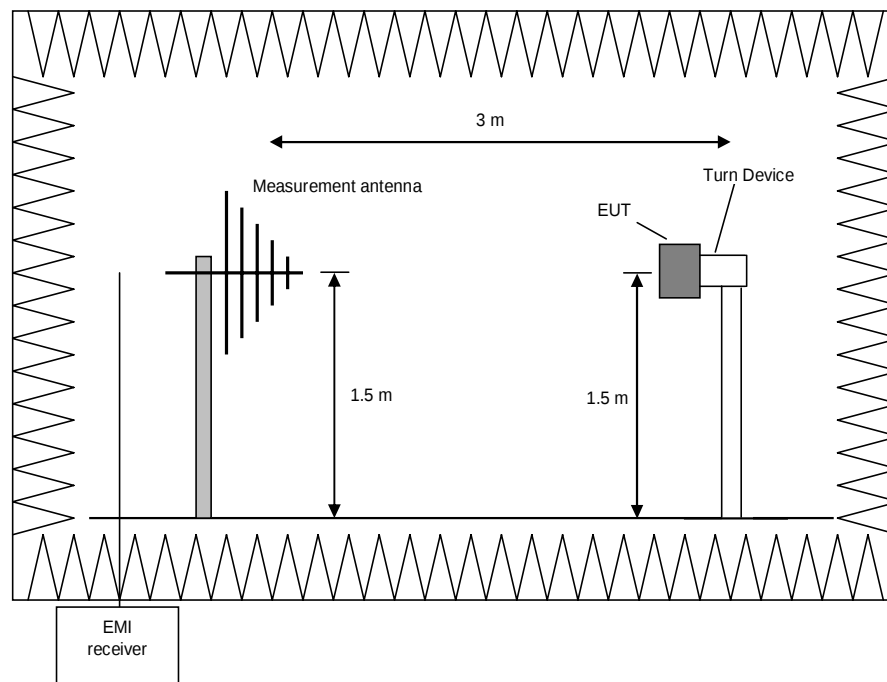
Preliminary measurement (30 MHz to 1 GHz)

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 set-up 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 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
30 MHz to 230 MHz	100 kHz
230 MHz to 1 GHz	100 kHz



Procedure preliminary measurement:

Prescans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz.

The following procedure will be used:

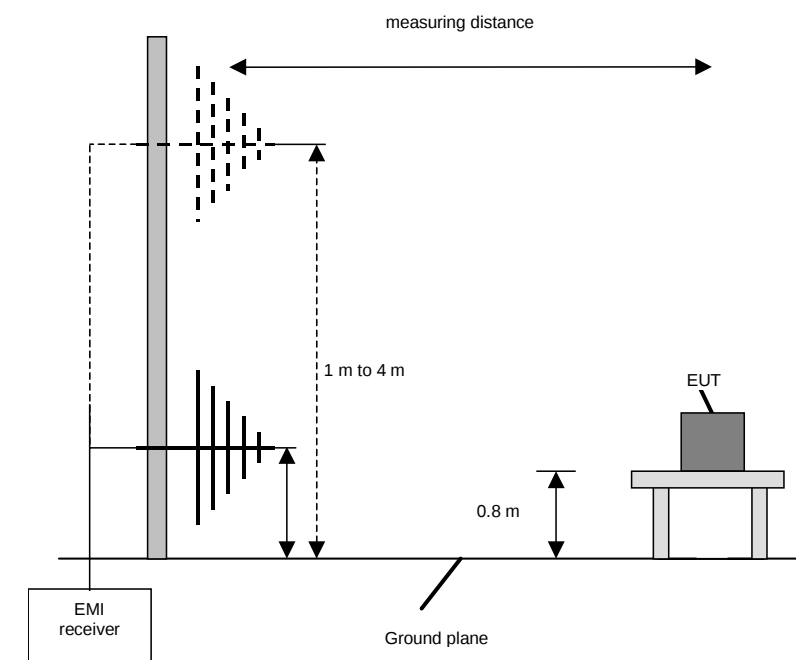
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0°.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat 1) to 3) with the vertical polarisation of the measuring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

Preliminary and final measurement (1 GHz to 40 GHz)

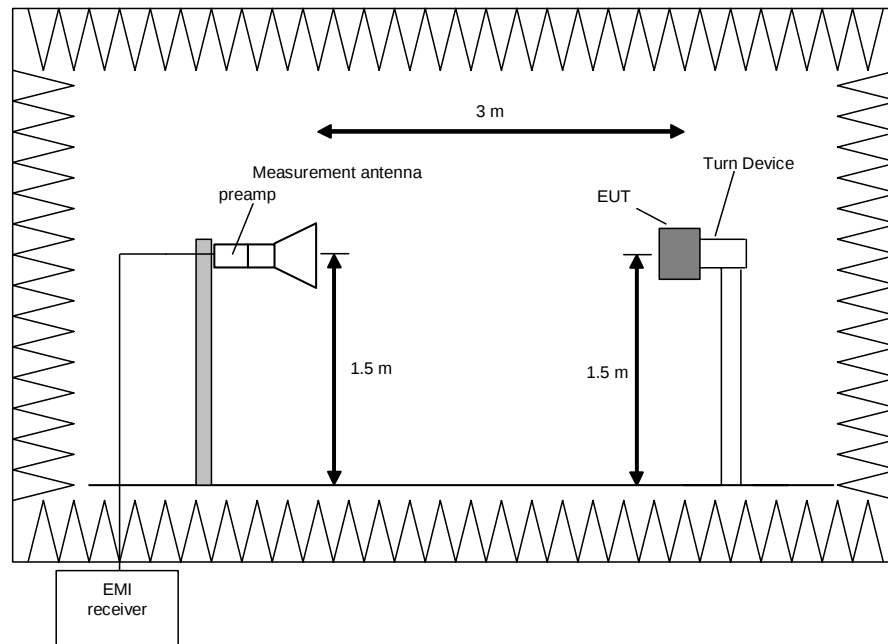
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

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 100 kHz. 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	100 kHz
4 GHz to 12 GHz	100 kHz
12 GHz to 18 GHz	100 kHz
18 GHz to 25 / 26.5 GHz	100 kHz
26.5 GHz to 40 GHz	100 kHz



Procedure preliminary measurement:

Prescans were performed in the frequency range 1 to 40 GHz.

The following procedure will be used:

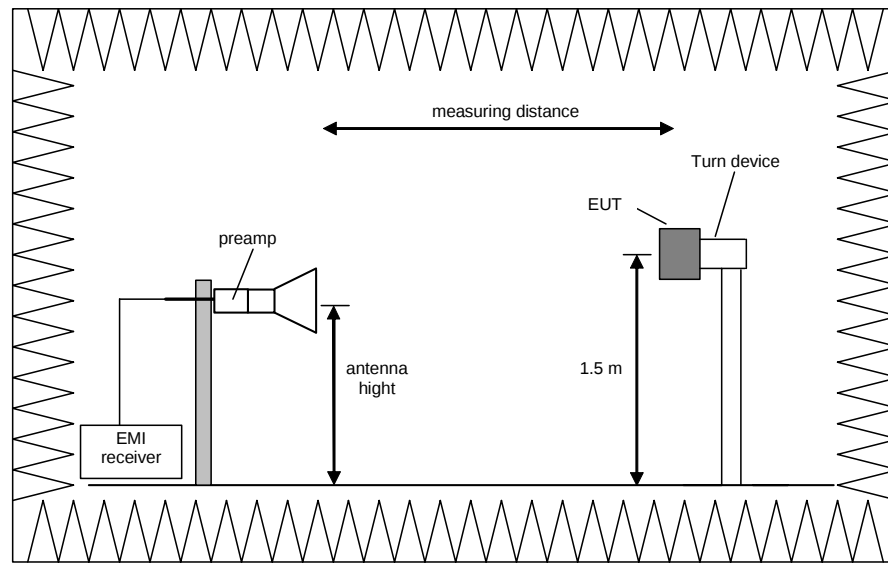
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0°.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an angle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

5.7.2 Test results (radiated emissions) – Emissions from 30 MHz – 25 GHz

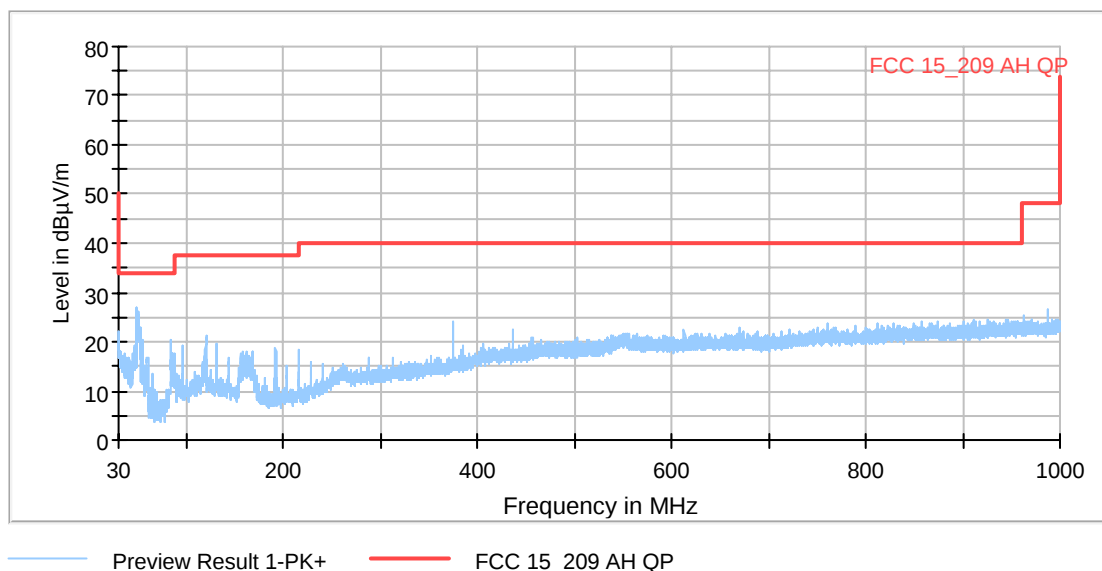
5.7.2.1 Preliminary radiated emission measurement 30 MHz – 25 GHz

Ambient temperature	22 °C	Relative humidity	59 %
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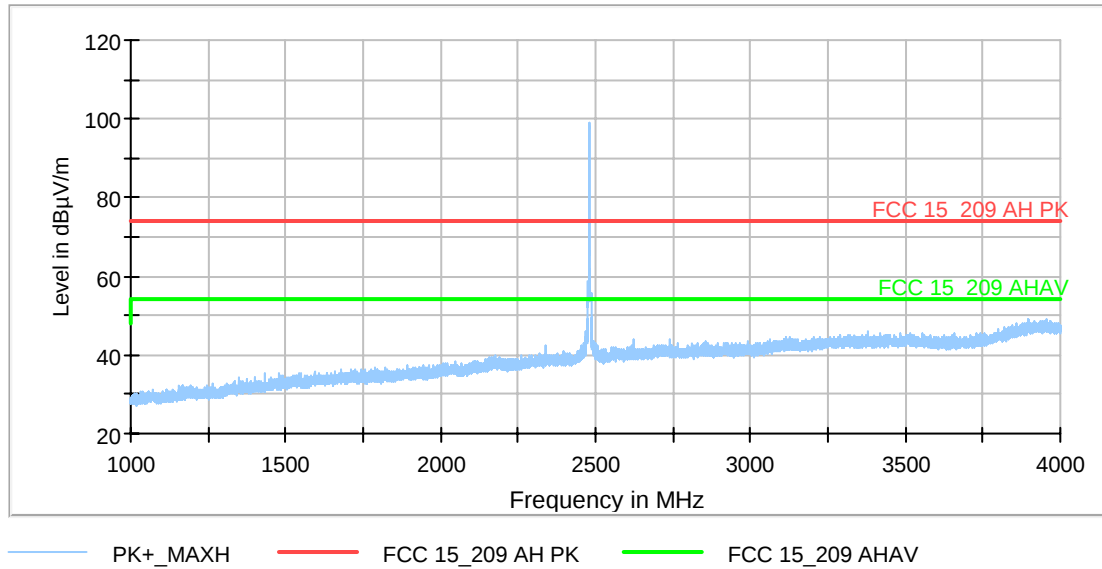
- Position of EUT:** The EUT was set-up on an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.
- For the final test on the open area test site the EUT was placed on a table with the height of 0.8 m. The distance between EUT and antenna was 3 m.
- Cable guide:** For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.
- Test record:** Only the plot of the worst case emission is submitted below.
- Supply voltage:** During all measurements the host of the EUT was powered with 5 V via the USB port of a USB to fibre-optics converter.
- Remark:** Since there were no differences in the spectrum for $f < 1$ GHz, only one representative plot is submitted below.
- Since the lowest internal frequency is 48 MHz, no tests below 30 MHz were performed.

Plots of the worst case transmitter spurious emissions

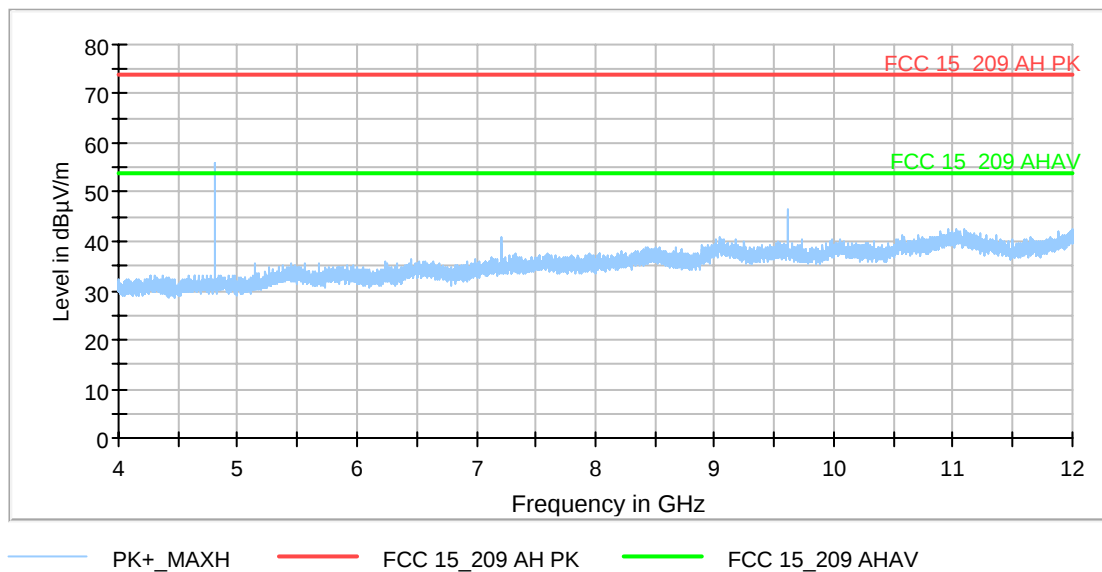
181631_ch19_30M-1G: Spurious emissions from 30 MHz to 1 GHz (operation mode 2):



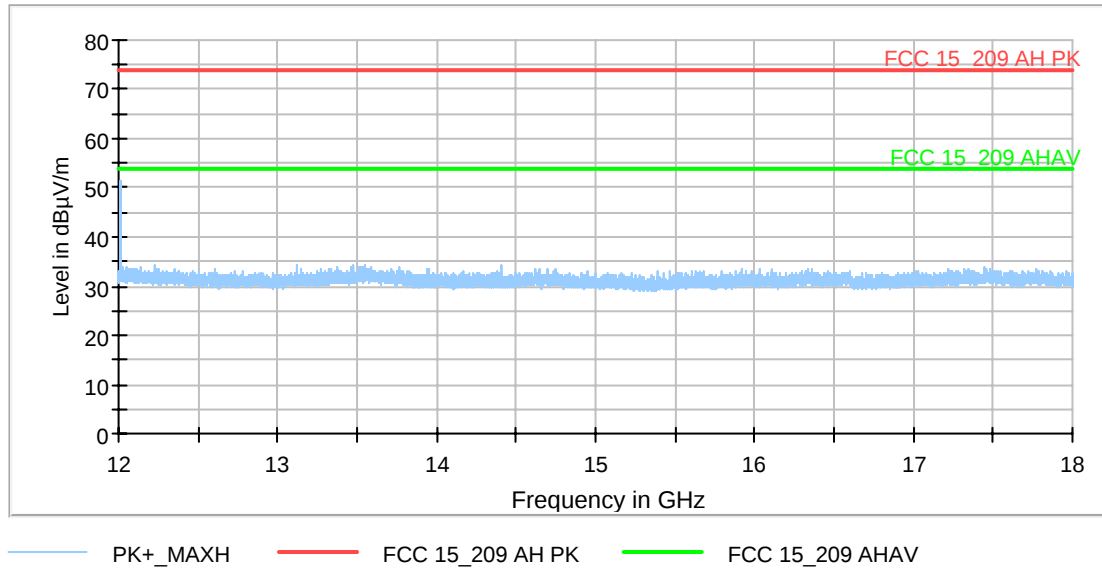
181631_ch39_1-4G: Spurious emissions from 1 GHz to 4 GHz (operation mode 3)



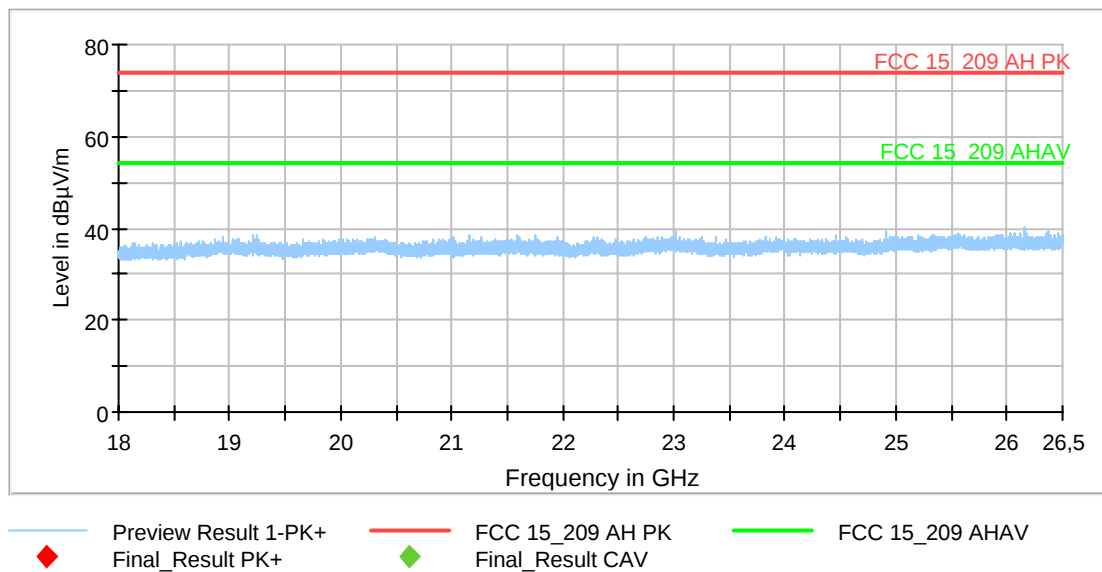
181631_ch0_4-12G: Spurious emissions from 4 GHz to 12 GHz (operation mode 1):



181631_ch0_12-18G: Spurious emissions from 12 GHz to 18 GHz (operation mode 1):



181631_ch0_18-26,5G: Spurious emissions from 18 GHz to 26.5 GHz (operation mode 1):



5.7.2.2 Final radiated measurements

All TX modes (no difference detected when comparing channel)

Frequency [MHz]	QuasiPeak [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
30.679000	32.42	40.00	7.58	1000.0	120.000	113.0	V	231.0	26.9
47.993500	38.25	40.00	1.75	1000.0	120.000	103.0	V	7.0	18.0
50.030500	32.14	40.00	7.86	1000.0	120.000	107.0	V	4.0	16.7
50.612500	32.91	40.00	7.09	1000.0	120.000	107.0	V	32.0	16.4
51.000500	32.00	40.00	8.00	1000.0	120.000	101.0	V	16.0	16.1
84.029000	27.47	40.00	12.53	1000.0	120.000	365.0	H	279.0	15.8
119.967500	26.05	43.50	17.45	1000.0	120.000	105.0	V	201.0	18.9
374.980500	20.40	46.00	25.60	1000.0	120.000	102.0	H	89.0	23.6
Measurement uncertainty					+2.2 dB / -3.6 dB				

Transmitter operates at the lower end of the assigned frequency band (operation mode 1, GFSK)

Frequency [MHz]	MaxPeak [dBμV/m]	Average [dBμV/m]	Limit [dBμV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2402.200000	---	95.65	Fund.	-	H	204	60	33
2402.200000	99.81	---	Fund.	-	H	204	60	33
4804.444444	---	53.35	54	0.65	H	291	150	-2
4804.444444	59.81	---	74	14.19	H	291	150	-2
7205.866667	---	40.97	54	13.03	V	280	90	4
7205.866667	49.35	---	74	24.65	V	280	90	4
9606.933333	---	44.05	54	9.95	V	255	150	8
9606.933333	52.21	---	74	21.79	V	255	150	8
12008.580000	---	47.31	54	6.69	V	158	90	12
12008.580000	57.05	---	74	16.95	V	158	90	12
Measurement uncertainty				+2.2 dB / -3.6 dB				

Transmitter operates at the middle of the assigned frequency band (operation mode 2, GFSK)

Frequency [MHz]	MaxPeak [dBμV/m]	Average [dBμV/m]	Limit [dBμV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2439.950000	---	96.59	Fund.	-	H	203	150	34
2439.950000	99.7	---	Fund.	-	H	203	150	34
4880.444444	---	46.55	54	7.45	H	276	150	-2
4880.444444	55.13	---	74	18.87	H	276	150	-2
7320.666667	---	38.51	54	15.49	V	272	90	5
7320.666667	48.99	---	74	25.01	V	272	90	5
9760.933333	---	43.08	54	10.92	H	8	150	7
9760.933333	53.93	---	74	20.07	H	8	150	7
12198.600000	---	42.71	54	11.29	V	242	60	12
12198.600000	52.52	---	74	21.48	V	242	60	12
Measurement uncertainty				+2.2 dB / -3.6 dB				

Transmitter operates at the upper end of the assigned frequency band (operation mode 3, GFSK)

Frequency [MHz]	MaxPeak [dBμV/m]	Average [dBμV/m]	Limit [dBμV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2479.750000	---	96.86	Fund.	-	H	205	120	34
2479.750000	100.92	---	Fund.	-	H	205	120	34
4960.444444	---	41.66	54	12.34	H	280	150	-2
4960.444444	50.62	---	74	23.38	H	280	150	-2
7439.111111	---	37.87	54	16.13	V	269	90	5
7439.111111	48.63	---	74	25.37	V	269	90	5
9918.933333	---	44.03	54	9.97	H	264	120	7
9918.933333	53.64	---	74	20.36	H	264	120	7
12401.160000	---	42.03	54	11.97	V	255	60	12
12401.160000	52.35	---	74	21.65	V	255	60	12
Measurement uncertainty				+2.2 dB / -3.6 dB				

TEST EQUIPMENT USED FOR THE TEST:

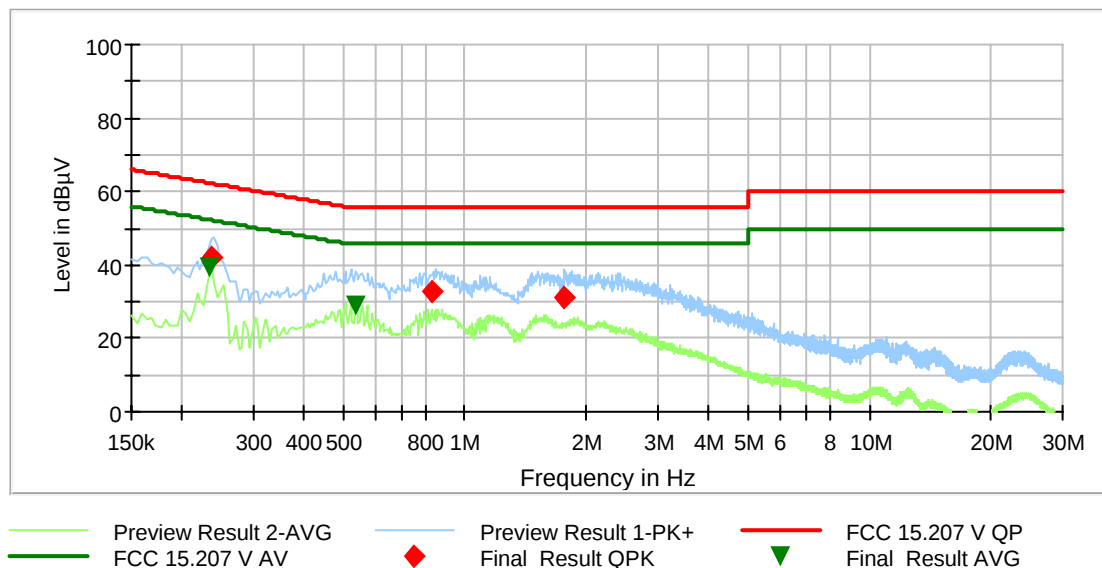
7 – 18, 20 - 26

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

Ambient temperature	20 °C	Relative humidity	52 %
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Position of EUT:	For this test, the EUT was operated in normal mode. The EUT was active and charging. One connection was from the EUT to a hearing aid, type Butterfly and marked with #33. The Bluetooth classic connection was established to an android mobile phone. BLE was activated. For the test, music was transmitted to the hearing aid via the EUT.
Cable guide:	For detail information of test set-up and 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:	Measurement performed with US 120V/60Hz. For the test a power supply type "PSM03E-050Q-3" by "Phihong Technology Co.,Ltd." was used. The power supply was provided by the applicant. The power supply was provided by the applicant and supplied the EUT with 5 V DC.

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 "▼".



Data record name: 181631vAC_FCC-Plug_2.Rtf

Frequency [MHz]	QuasiPeak [dBμV]	Average [dBμV]	Limit [dBμV]	Margin [dB]	Meas. Time [ms]	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.234600	---	39.56	52.29	12.73	5000.0	9.000	L1	FLO	9.9
0.237300	42.10	---	62.19	20.09	5000.0	9.000	N	GND	9.9
0.538800	---	29.19	46.00	16.81	5000.0	9.000	L1	FLO	9.9
0.827700	32.73	---	56.00	23.27	5000.0	9.000	N	FLO	9.9
1.758300	31.00	---	56.00	25.00	5000.0	9.000	N	GND	10.0

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1 – 6

6 Test equipment and ancillaries used for tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. Due
1	Shielded chamber M47	-	Albatross Projects	B83117-C6439-T262	480662	Calibration not necessary	
2	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	28.02.2018	02.2020
3	LISN	NSLK8128	Schwarzbeck	8128155	480058	19.04.2018	02.2020
4	High pass filter	HR 0.13-5ENN	FSY Microwave	DC 0109 SN 002	480340	Calibration not necessary	
5	EMI Software	ES-K1	Rohde & Schwarz	-	480111	Calibration not necessary	
6	Netzteil AC	AC6803A AC Quelle 2000VA	Keysight	JPVJ002509	482350	Calibration not necessary	
7	EMI Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
8	HF-Cable	Sucoflex 104	Huber+Suhner	517406	482391	Calibration not necessary	
9	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Calibration not necessary	
10	Signal & Spectrum Analyzer	ESW44	Rohde & Schwarz	101635	482467	29.03.2018	03.2020
11	Controller	MCU	Maturo	MCU/043/971107	480832	Calibration not necessary	
12	Turntable	DS420HE	Deisel	420/620/80	480315	Calibration not necessary	
13	Antenna support	AS615P	Deisel	615/310	480187	Calibration not necessary	
14	Antenna (Log.Per.)*	HL050	Rohde & Schwarz	100438	481170	09.10.2017	10.2020
15	Standard Gain Horn 11.9 GHz – 18 GHz	18240-20	Flann Microwave	483	480294	Calibration not necessary	
16	Standard Gain Horn 17.9 GHz – 26.7 GHz	20240-20	Flann Microwave	411	480297	Calibration not necessary	
17	RF-cable No. 3	Sucoflex 106B	Huber&Suhner	500234/6B	482644	Calibration not necessary	
18	RF-cable No. 40	Sucoflex 106B	Huber&Suhner	SF106B/11N/11N/1500MM	482125	Calibration not necessary	
20	Antenna (Bilog)	CBL6112B	Schaffner EMV GmbH (-Chase)	2688	480328	19.06.2017	06.2020
21	RF-cable 2 m	KPS-1533-800-KPS	Insulated Wire	-	480302	Calibration not necessary	
22	Kabel 36	Sucoflex 106B	Suhner	500003/6B / Kabel 36	481680	Calibration not necessary	
23	Preamplifier 100 MHz - 16 GHz	AFS6-00101600-23-10P-6-R	Narda MITEQ	2011215	482333	10.07.2018	07.2020
24	Preamplifier	JS3-12001800-16-5A	Miteq	571667	480343	10.07.2018	07.2020
25	Preamplifier	JS3-18002600-20-5A	Miteq	658697	480342	10.07.2018	07.2020
26	4 GHz High Pass Filter	WHKX4.0/18G-8SS	Wainwright Instruments	1	480587	Calibration not necessary	
27	Loop antenna	-	Phoenix Testlab	-	410085	Calibration not necessary	
28	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	15.03.2018	03.2020
29	Test fixture	-	Phoenix Testlab	-	410160	Calibration not necessary	

7 Report History

Report Number	Date	Comment
F181631E3	28.02.2019	Initial Test Report

8 List of Annexes

ANNEX A TEST SETUP PHOTOS

7 pages