FCC Measurement/Technical Report on

Low Power Bluetooth(R) transmitter Battery-free Wiliot Tag Generation 1

FCC ID: 2AXVQ-WILIOT1
IC: 26623-WILIOT1

Report Reference: MDE_WILIOT_1901_FCC_01_REV1

Test Laboratory:
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Borsigstrasse 11
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Deutsche Akkreditierungsstelle
D-PL-12140-01-01
D-PL-12140-01-02
D-PL-12140-01-03

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1. APPLIED STANDARDS AND TEST SUMMARY

1.1. APPLIED STANDARDS

Type of Authorization
Certification for an Intentional Radiator.

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15 (10-1-19 Edition). The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 15, Subpart C – Intentional Radiators

§ 15.201 Equipment authorization requirement

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

§ 15.249 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz, and 24.0-24.25 GHz.

Note: ANSI C63.10–2013 is applied.

Summary Test Results:

The EUT complied with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.

1.2. FCC-IC CORRELATION TABLE

Correlation of measurement requirements for general radio equipment and operation within the bands 902 – 928 MHz, 2400 – 2483.5 MHz, 5725 – 5825 MHz and 24.0 – 34.25 GHz from FCC and IC

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 5: 8.8
Transmitter spurious radiated emissions	§ 15.209	RSS-Gen Issue 5: 6.13/8.9/8.10; RSS-210 Issue 10: 7.2
Field strength of Fundamental	§ 15.249	RSS-210 Issue 10: Annex B.10 RSS-Gen Issue 5: 6.12, 8.9
Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz, and 24.0-24.25 GHz.	§15.249	RSS-210, Issue 10: Annex B.10

1.3. MEASUREMENT SUMMARY /SIGNATURES

FCC Part 15, Subpart C		**§ 15.207**	
Conducted emissions (AC power line)			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
-	-	AC Port (power line)	N/A

FCC Part 15, Subpart C		**§ 15.249 (a)**	
Field strength of Fundamental / Radiated power output			
The measurement was performed according to ANSI C63.10			2013
OP-Mode, Frequency	**Setup**	**Port**	**Final Result**
CW, low	S01_AB01	Enclosure	passed
CW, mid	S01_AB01	Enclosure	passed
CW, high	S01_AB01	Enclosure	passed

FCC Part 15, Subpart C		**§ 15.249 (a), § 15.35 (b), § 15.209**	
Field Strength of Harmonics / Spurious radiated emissions			
The measurement was performed according to ANSI C63.10			2013
OP-Mode, Frequency	**Setup**	**Port**	**Final Result**
CW, low	S01_AB01	Enclosure	passed
CW, mid	S01_AB01	Enclosure	passed
CW, high	S01_AB01	Enclosure	passed

FCC Part 2, Subpart J		**§ 2.1049**	
Occupied Bandwidth			
The measurement was performed according to ANSI C63.10			2013
OP-Mode, Frequency	**Setup**	**Port**	**Final Result**
PM, low	S01_AB01	Enclosure	passed
PM, mid	S01_AB01	Enclosure	passed
PM, high	S01_AB01	Enclosure	passed

N/A not applicable (the EUT cannot be connected to the AC mains network)

2. REVISION HISTORY / SIGNATURES

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
initial	2020-10-26	--	valid
REV1	2020-11-03	• Page 1, 7: Product name changed • IC ID added	

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(responsible for accreditation scope)
Dipl.-Ing. Daniel Gall

(responsible for testing and report)
Dipl.-Ing. Marco Kullik

2. ADMINISTRATIVE DATA

2.1. TESTING LABORATORY

Company Name:	7layers GmbH
Address:	Borsigstr. 11 40880 Ratingen Germany

The test facility is also accredited by the following accreditation organisation:

Laboratory accreditation no:	DAkkS D-PL-12140-01-01 D-PL-12140-01-02 D-PL-12140-01-03
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
ISED CAB Identifier	DE0007; ISED#: 3699A
Responsible for accreditation scope:	Dipl.-Ing. Daniel Gall

2.2. PROJECT DATA

Responsible for testing and report:	Dipl.-Ing. Marco Kullik
Date of Report:	2020-11-03
Testing Period:	2020-10-13 to 2020-10-15

2.3. APPLICANT DATA

Company Name:	Wiliot Inc.
Address:	13500 Evening Creek Dr N, Suite 120 CA 92128 San Diego United States
Contact Person:	Mr. Roberto Sandre

2.4. MANUFACTURER DATA

Company Name:	Please see Applicant Data
Address:	
Contact Person:	

3. TEST OBJECT DA

3.1. GENERAL EUT DESCRIPTION

Kind of Device product description	BTLE Transmitter operating in 2400 – 2483.5 MHz ISM frequency band.
Product name	Battery-free Wiliot Tag Generation 1
Type	Low Power Bluetooth(R) transmitter
Declared EUT data by the supplier	
Voltage Type	DC
Normal Voltage	5.0 V (only for testing purposes)
Low Voltage	-
High Voltage	-
Normal Temperature	25 °C
Low Temperature	-40 °C
High Temperature	+85 °C
Specific product description for the EUT	The EUT is tag with a Bluetooth® Low Energy Wireless Micro Controller Unit (MCU) that offers the ability to sense, compute and communicate using Bluetooth wireless communication technology. They do this without the need for a battery, and with a physical design and packaging that allows the integration onto stickers. The EUT is a transmit-only uni-directional device.
The EUT provides the following ports:	Enclosure
Special software used for testing	Wiliot Test Mode Host software, provided by the manufacturer
Antenna type / gain	Internal PCB loop antenna / -2.41 dBi
Transmitter operating frequencies	2402 MHz / 2426 MHz / 2480 MHz

The main components of the EUT are listed and described in Chapter 3.2.

3.2. EUT MAIN COMPONENTS

Sample Name	Sample Code	Description
EUT A	DE1405001ab01	radiated sample
Sample Parameter	**Value**	
Serial No.	N/A	
HW Version	Wiliot_Tag_1.0	
SW Version	Wiliot_fw_1.0	
Comment	Used for all measurements	

3.3. AUXILIARY EQUIPMENT

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it.
But nevertheless Auxiliary Equipment can influence the test results.

Device	Details (Manufacturer, Type Model, OUT Code)	Reason for using
AUX1	Laptop, Dell, Latitude E5450, DE1405001AUX1	Running the test SW
AUX2	AC/DC Adapter, Dell, DA90PM111, DE1405001AUX2	Power supply for laptop
AUX3	Wiliot Debug Board, with USB host and JTAG interface connection to Wiliot Tag, --, --, --	Connection to laptop, power supply

3.4. ANCILLARY EQUIPMENT

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

Device	Details (Manufacturer, HW, SW, S/N)	Description
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3.5. EUT SETUPS

This chapter describes the combination of EUTs and ancillary equipment used for testing.

Setup No.	Combination of EUTs	Description
S01_AB01	EUT A, AUX1, AUX2, AUX3	Used for all tests

3.6. OPERATING MODES / TEST CHANNELS

This chapter describes the operating modes of the EUTs used for testing.

Op. Mode	Description of Operating Modes	Remarks
CW	Continuous Wave signal	EUT transmits continuously an unmodulated signal
PM	Pulsed Modulated signal	EUT transmits a modulated signal with maximum possible duty cycle

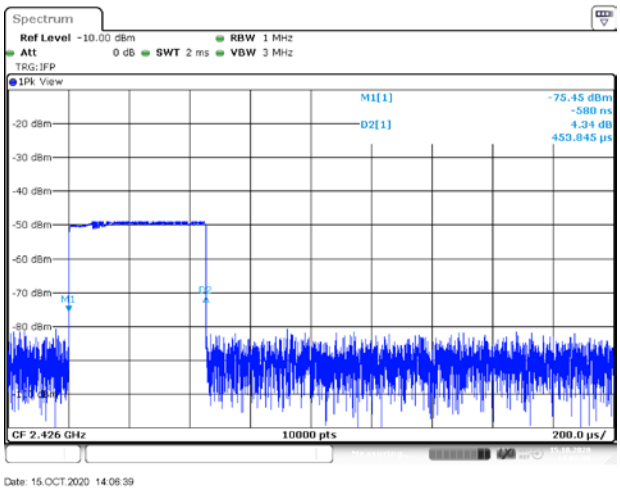
BT LE Test Channels:	**low**	**mid**	**high**
Channel:	37	38	39
Frequency [MHz]	2402	2426	2480

Modulation: GFSK, BT = 0.5, 1 Msym/s

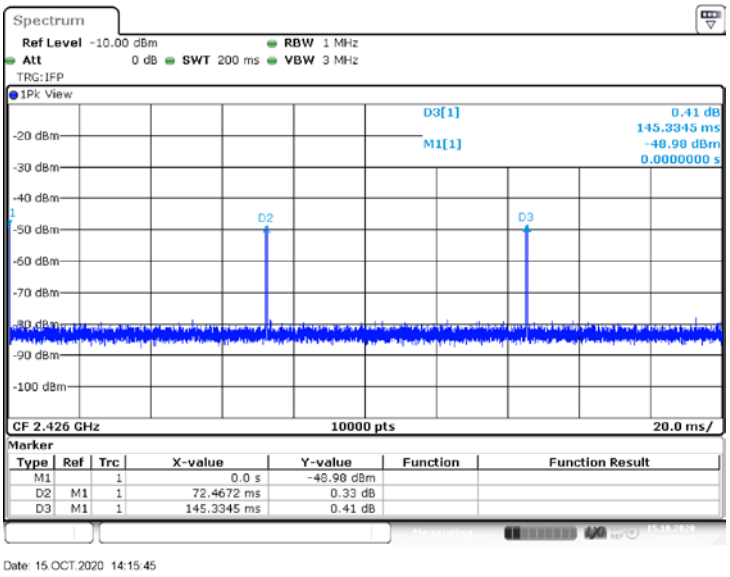
3.7. DUTY CYCLE CALCULATION

The calculation of the duty cycle and duty cycle correction value was done according ANSI C63.10: 2013, chapter 7.5, equation (11)

DC = 2 * 0.45385 ms / 100 ms = 0.009077
Duty cycle correction factor: **δ = 20 LOG(0.009077) = 20 * (-2.04206) = -40.8 dB**



Length of single burst



Number of bursts in 100 ms: 2

3.8. PRODUCT LABELLING

3.8.1. FCC ID LABEL

Please refer to the documentation of the applicant.

3.8.2. IC LABEL

Please refer to the documentation of the applicant.

3.8.3. LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

4. TEST RESULTS

4.1. FIELD STRENGTH OF FUNDAMENTAL / RADIATED POWER OUTPUT

Standard FCC Part 15, Subpart C

The test was performed according to ANSI C63.10–2013

4.1.1. TEST DESCRIPTION

Please refer to the description at sub-clause 4.2.1 esp. item no. 3. (Above 1 GHz)

4.1.2. TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.249

(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency	Field strength of fundamental (millivolts/meter)	Field strength of harmonics (microvolts/meter)
902-928 MHz	50 (94.0 dBµV/m)	500 (54.0 dBµV/m)
2400-2483.5 MHz	50 (94.0 dBµV/m)	500 (54.0 dBµV/m)
5725-5875 MHz	50 (94.0 dBµV/m)	500 (54.0 dBµV/m)
24.0-24.25 GHz	250 (108.0 dBµV/m)	2500 (68.0 dBµV/m)

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

(c) Field strength limits are specified at 3 meters.

(e) As shown in §15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.

4.1.3. TEST PROTOCOL

Temperature: 22 °C
Air Pressure: 1007 hPa
Humidity: 42 %

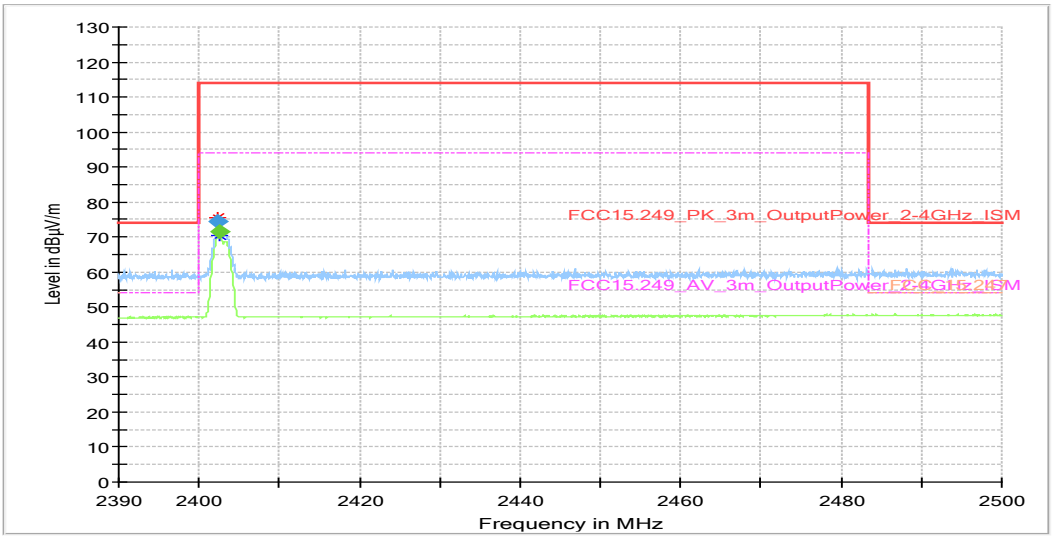
Op. Mode	Setup	Port
CW	S01_AB01	Enclosure

Frequency [MHz]	CAverage (dBµV/m)	Limit [dBµV/m]	Margin to Limit [dB]	Remarks
2402	71.7	94	22.3	No duty cycle correction applied
2426	73.0	94	21.0	No duty cycle correction applied
2480	71.5	94	22.5	No duty cycle correction applied

Notes: -

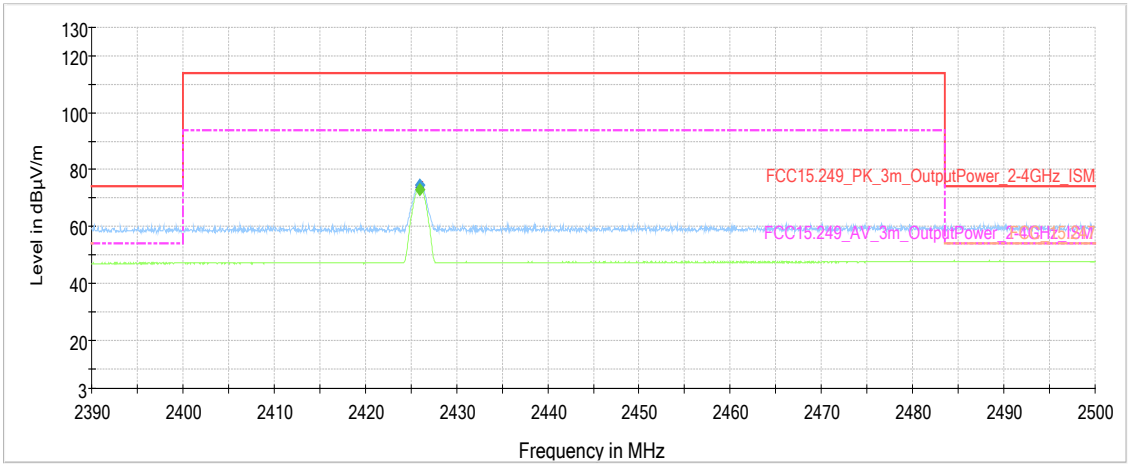
4.1.4. MEASUREMENT PLOTS

Radio Technology = BTLE, Operating Frequency = Low
(S01_AB01)



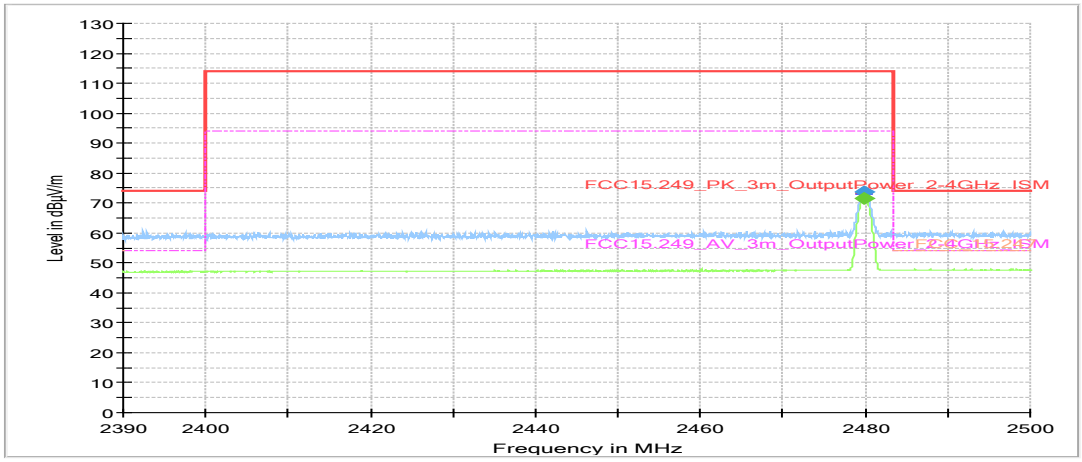
Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)
2402.430	74.3	---	113.9	39.66	1000.0	1000.000	150.0	H	-66.0	-11.0	34.9
2402.485	---	71.7	93.98	22.29	1000.0	1000.000	150.0	H	-66.0	-11.0	34.9

Radio Technology = BTLE, Operating Frequency = Mid
(S01_AB01)



Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)
2425.970	---	73.0	93.98	20.97	1000.0	1000.000	150.0	H	-28.0	0.0	34.9
2425.970	74.7	---	113.9	39.24	1000.0	1000.000	150.0	H	-28.0	0.0	34.9

Radio Technology = BTLE, Operating Frequency = High
(S01_AB01)



Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)
2479.870	---	71.5	93.98	22.44	1000.0	1000.000	150.0	H	-16.0	36.0	35.2
2479.870	73.8	---	113.9	40.23	1000.0	1000.000	150.0	H	-16.0	36.0	35.2

4.1.5. TEST EQUIPMENT USED

- Radiated Emissions

4.2. FIELD STRENGTH OF HARMONICS / SPURIOUS RADIATED EMISSIONS

Standard **FCC Part 15 Subpart C**

The test was performed according to ANSI C63.10–2013

4.2.1. TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The measurements were performed according the following sub-chapters of ANSI C63.10:

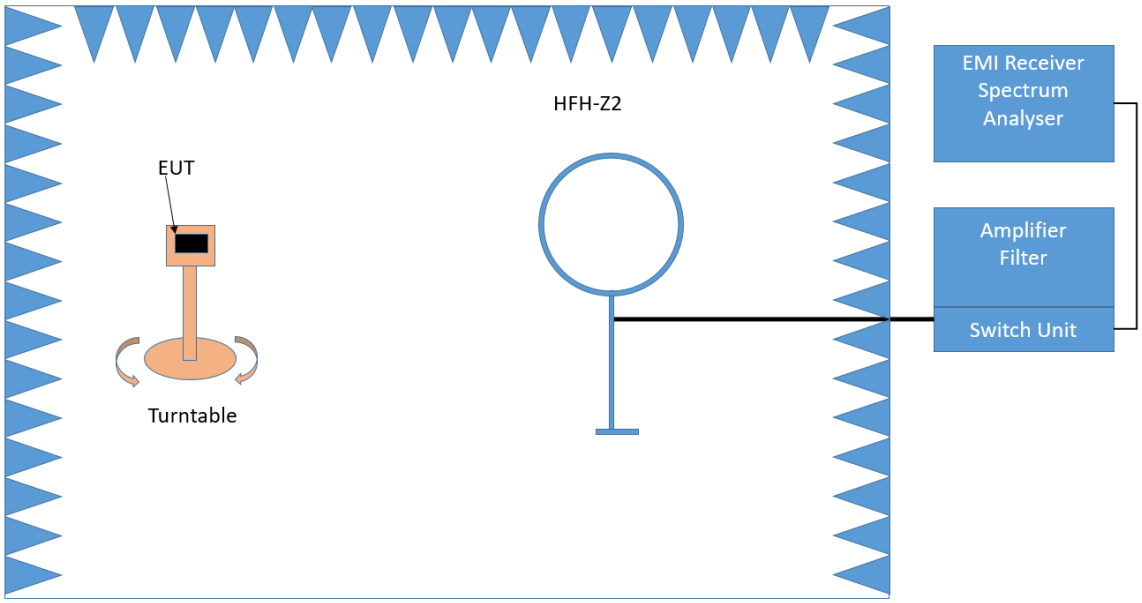
- < 30 MHz: Chapter 6.4
- 30 MHz – 1 GHz: Chapter 6.5
- > 1 GHZ: Chapter 6.6 (procedure according 6.6.5 used)

The measurement procedure is implemented into the EMI test software EMC32 from R&S. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes. A pre-check is performed while the EUT is powered.

Below 1 GHz:

The Equipment Under Test (EUT) was set up on a non-conductive table in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.

1. Measurement up to 30 MHz



Test Setup; Spurious Emission Radiated (SAC), 9 kHz – 30 MHz

The Loop antenna HFH2-Z2 is used.

Step 1: pre measurement

- Anechoic chamber
- Antenna distance: 3 m
- Antenna height: 1 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

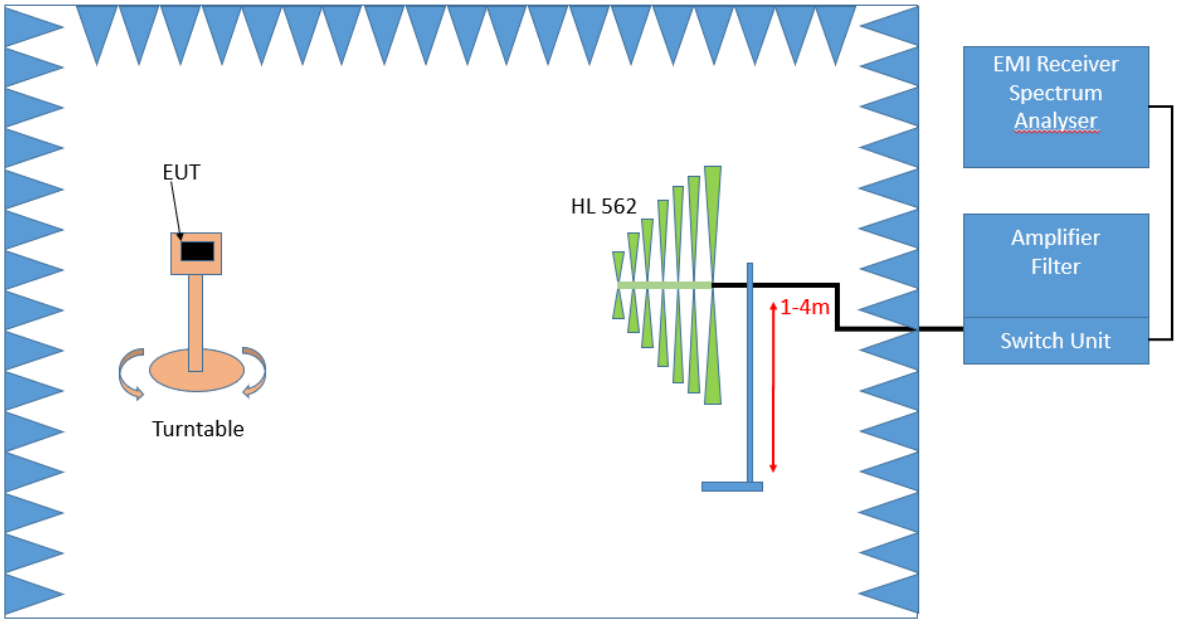
Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: final measurement

For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is to find the maximum emission level.

- Detector: Quasi-Peak (9 kHz – 150 kHz, Peak / Average 150 kHz- 30 MHz)
- Frequency range: 0.009 – 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF–Bandwidth: 0.2 - 10 kHz
- Measuring time / Frequency step: 1 s

2. Measurement above 30 MHz and up to 1 GHz



Test Setup; Spurious Emission Radiated (SAC), 30 MHz- 1GHz

Step 1: Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:
- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF–Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 4 m
- Height variation step size: 1.5 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: Adjustment measurement
In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.
For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by 360°. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary between 1 – 4 m. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.
- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range: 360 °
- Height variation range:1 – 4 m
- Antenna Polarisation: max. value determined in step 1

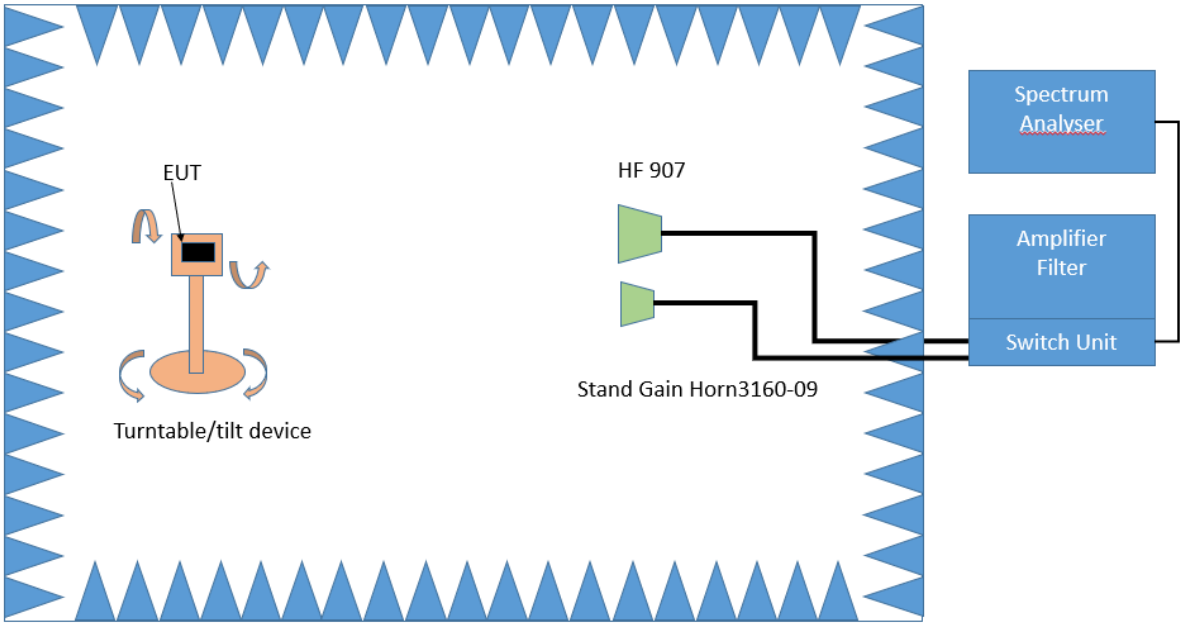
Step 3: Final measurement with QP detector
With the settings determined in step 2, the final measurement will be performed:
EMI receiver settings for step 3:
- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

Above 1 GHz:

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.
All steps were performed with one height (1.5 m) of the receiving antenna only.

3. Measurement above 1 GHz



Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

Step 1:
The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90 °.
The turn table step size (azimuth angle) for the preliminary measurement is 45 °.
Spectrum analyser settings:
- Detector: Peak, Average
- RBW = 1 MHz
- VBW = 3 MHz

Step 2:
The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°
Spectrum analyser settings:
- Detector: Peak

Step 3:
Spectrum analyser settings for step 3:
- Detector: Peak / CISPR Average
- Measured frequencies: in step 1 determined frequencies
- RBW = 1 MHz
- VBW = 3 MHz
- Measuring time: 1 s

4.2.2. TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.249

(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency	Field strength of fundamental (millivolts/meter)	Field strength of harmonics (microvolts/meter)
902-928 MHz	50 (94.0 dBµV/m)	500 (54.0 dBµV/m)
2400-2483.5 MHz	50 (94.0 dBµV/m)	500 (54.0 dBµV/m)
5725-5875 MHz	50 (94.0 dBµV/m)	500 (54.0 dBµV/m)
24.0-24.25 GHz	250 (108.0 dBµV/m)	2500 (68.0 dBµV/m)

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

(c) Field strength limits are specified at a distance of 3 meters.

(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

(e) As shown in §15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.

FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency (MHz)	Limit (µV/m)	Measurement distance (m)	Calculate Limit (dBµV/m @10m)	Limit (dBµV/m) @10m
0.009 – 0.49	2400/F (kHz)	300	(48.5 – 13.8) + 59.1 dB	107.6 – 72.9
0.49 – 1.705	24000/F (kHz)	30	(33.8 – 23.0) + 19.1 dB	52.9 – 42.1
1.705 – 30	30	30	29.5 + 19.1 dB	39.5

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limit (dBµV/m)
30 – 88	100	3	40.0
88 – 216	150	3	43.5
216 – 960	200	3	46.0
above 960	500	3	54.0

§15.35(b)
..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

§15.35(b) ..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit ...

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

§15.35(c):
[...] when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds.
As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted [...].

4.2.3. TEST PROTOCOL

MEASUREMENT 9 kHz to 30 MHz

Temperature: 23°C
Air Pressure: 1011 hPa
Humidity: 40 %

Op. Mode	Setup	Port
CW	S01_AB01	Enclosure

Measuring Antenna Polarisation	Spurious Emission Frequency [MHz]	Corrected value [dBµV/m]			Limit [dBµV/m]	Limit [dBµV/m]	Limit [dBµV/m]	Margin to limit [dB]	Margin to limit [dB]
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
X-axis*	---	---	---	---	---	---	---	---	---
Y-axis*	---	---	---	---	---	---	---	---	---
Z-axis*	---	---	---	---	---	---	---	---	---

Remark: In step 1 no spurious emissions in the range 20 dB below the limit found.

* See CISPR16-1-4 for the definition of the axis

MEASUREMENT 30 MHz to 1 GHz

Temperature: 23°C
Air Pressure: 1011 hPa
Humidity: 40 %

Op. Mode	Setup	Port
CW	S01_AB01	Enclosure

Low channel:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
33.000000	25.52	40.00	14.48	1000.0	120.000	104.0	V	-150.0	17.6
41.010000	24.15	40.00	15.85	1000.0	120.000	104.0	V	-171.0	13.0

Mid channel:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
33.000000	27.18	40.00	12.82	1000.0	120.000	105.0	V	-174.0	17.6
41.010000	22.71	40.00	17.29	1000.0	120.000	105.0	V	261.0	13.0

High channel:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
33.000000	27.39	40.00	12.61	1000.0	120.000	106.0	V	-165.0	17.6
41.010000	24.70	40.00	15.30	1000.0	120.000	110.0	V	42.0	13.0
72.000000	9.86	40.00	30.14	1000.0	120.000	183.0	V	-39.0	9.0
84.000000	11.26	40.00	28.74	1000.0	120.000	145.0	V	-197.0	10.3
120.000000	16.97	43.50	26.53	1000.0	120.000	102.0	V	90.0	11.5
132.000000	13.98	43.50	29.52	1000.0	120.000	203.0	H	-87.0	10.3
180.030000	14.95	43.50	28.55	1000.0	120.000	102.0	V	-196.0	10.1
240.000000	15.94	46.00	30.06	1000.0	120.000	124.0	H	90.0	10.9
324.000000	16.93	46.00	29.07	1000.0	120.000	112.0	H	-68.0	14.0

MEASUREMENT 1 GHz – 26.5 GHz

Temperature: 22°C
Air Pressure: 1007 hPa
Humidity: 42 %

Op. Mode	Setup	Port
CW	S01_AB01	Enclosure

Low channel:

Freq. (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m) (*)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	RBW (MHz)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)
4804.52	55.4	---	73.98	18.55	1000	1.0	H	0.0	90.0	4.6
4804.52	---	14.6	53.98	> 20	1000	1.0	H	0.0	90.0	4.6
7206.50	57.3	---	73.98	16.72	1000	1.0	V	0.0	90.0	-14.1
7206.50	---	16.5	53.98	> 20	1000	1.0	V	0.0	90.0	-14.1
9608.21	52.1	---	73.98	21.9	1000	1.0	V	-135.0	90.0	-11.6

Mid channel:

Freq. (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m) (*)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	RBW (MHz)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)
4852.46	56.0	---	73.98	17.98	1000	1.0	H	-136.0	10.0	4.5
4852.46	---	15.2	53.98	> 20	1000	1.0	H	-136.0	10.0	4.5
7279.00	58.5	---	73.98	15.48	1000	1.0	V	-92.0	72.0	-13.0
7279.00	---	17.8	53.98	> 20	1000	1.0	V	-92.0	72.0	-13.0

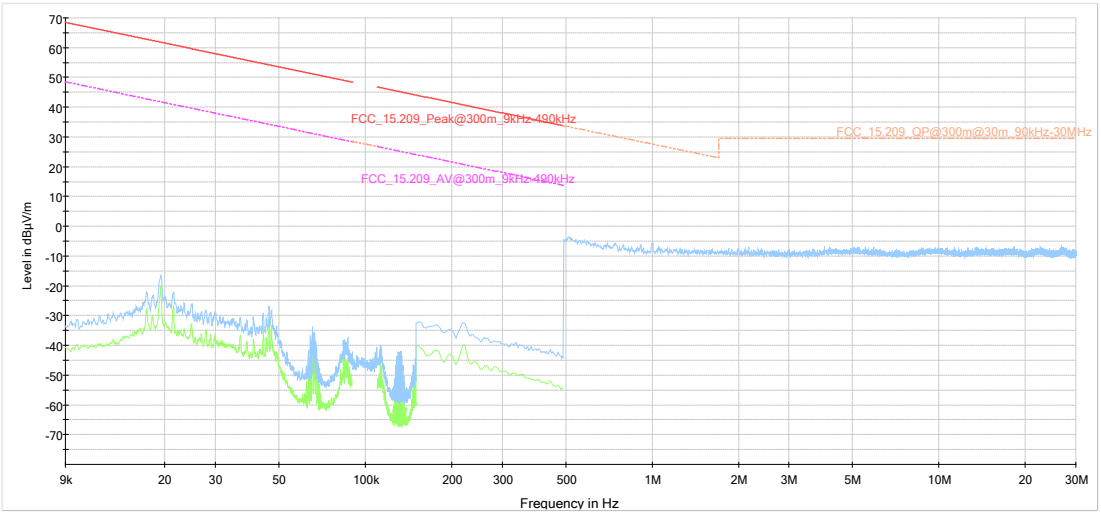
High channel:

Freq. (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m) (*)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	RBW (MHz)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)
4960.85	55.2	---	73.98	18.82	1000	1.0	H	-39.0	76.0	4.0
4960.85	---	14.4	53.98	> 20	1000	1.0	H	-39.0	76.0	4.0
7441.50	60.9	---	73.98	13.12	1000	1.0	V	-92.0	72.0	-13.6
7441.50	---	20.1	53.98	> 20	1000	1.0	V	-92.0	72.0	-13.6
9921.57	53.2	---	73.98	20.78	1000	1.0	H	43.0	72.0	-11.4

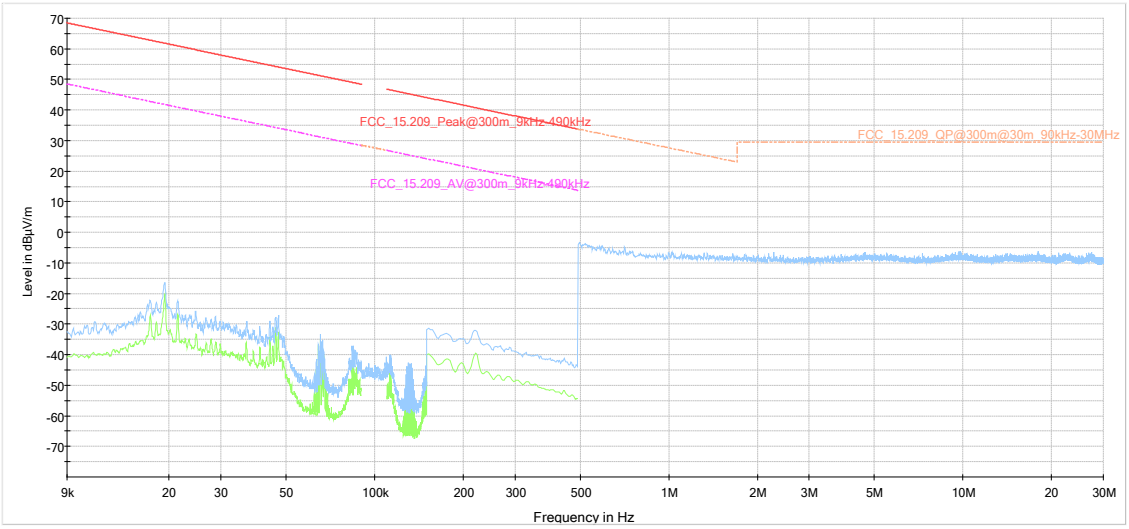
The average value has only been calculated for values, where the measured Max Peak value is above the average limit
(*) calculated according ANSI C63.10: 2013, chapter 7.5, equation (11), with a duty cycle correction factor: **δ= -40.8** (calculation see chapter 3.7)

4.2.4. MEASUREMENT PLOTS

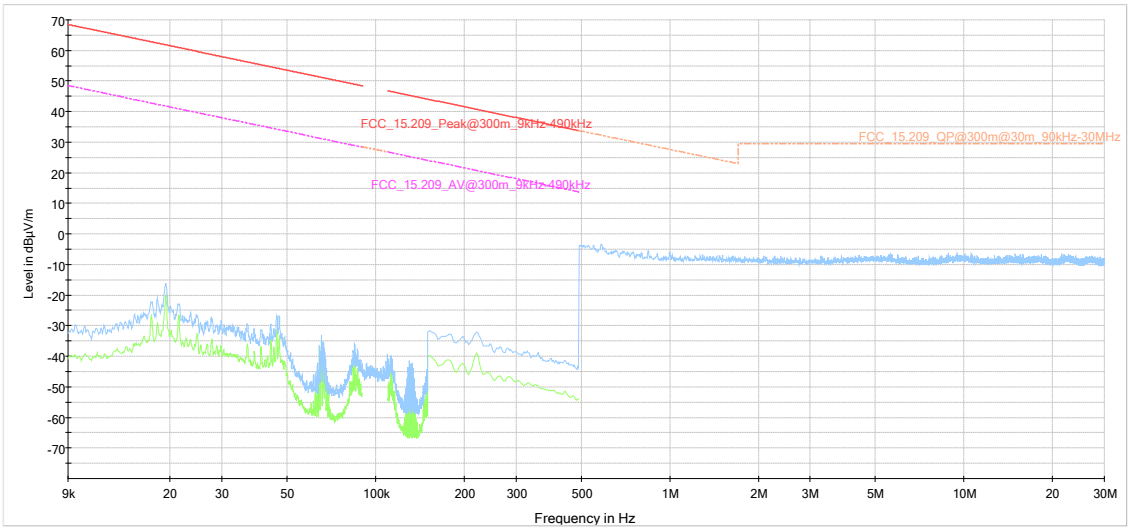
Radio Technology = BTLE, Operating Frequency = Low, Frequency Range 9 kHz – 30 MHz (S01_AB01)



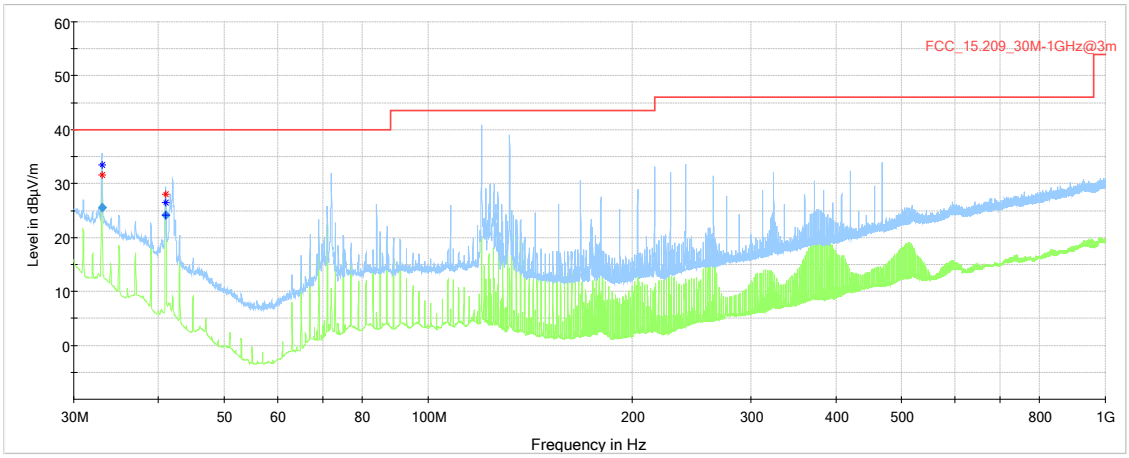
Radio Technology = BTLE, Operating Frequency = Mid, Frequency Range 9 kHz – 30 MHz (S01_AB01)



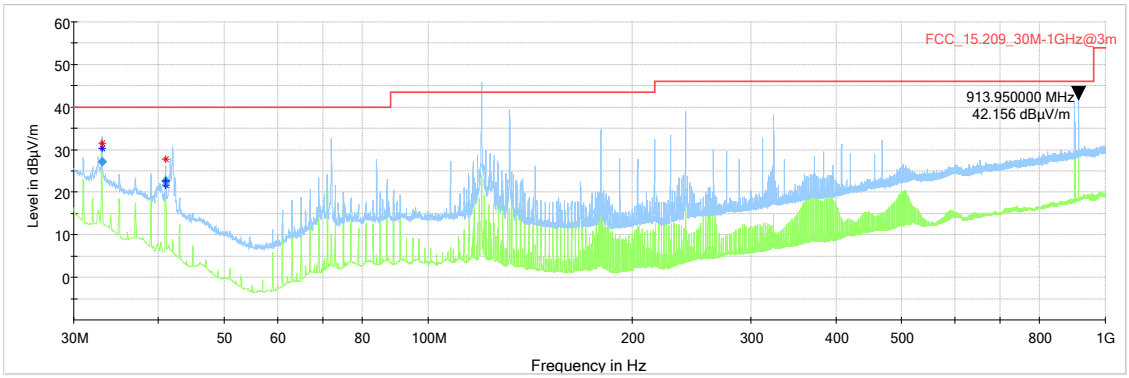
Radio Technology = BTLE, Operating Frequency = High, Frequency Range 9 kHz – 30 MHz (S01_AB01)



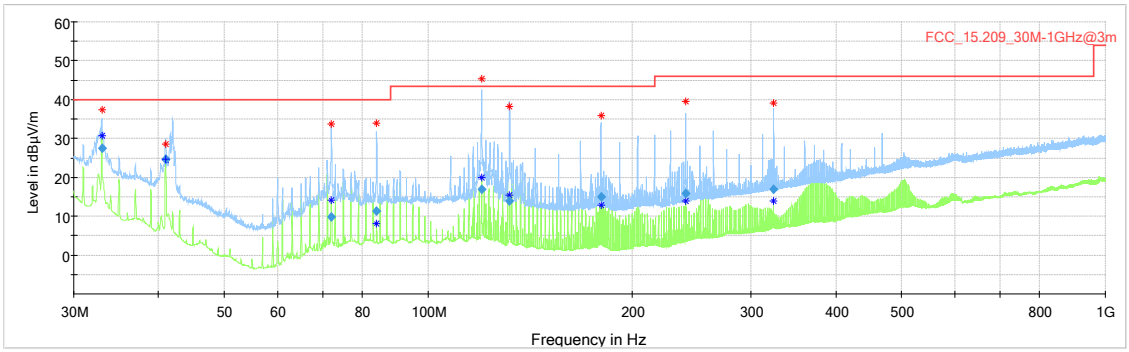
Radio Technology = BTLE, Operating Frequency = Low, Frequency Range 30 MHz – 1 GHz (S01_AB01)



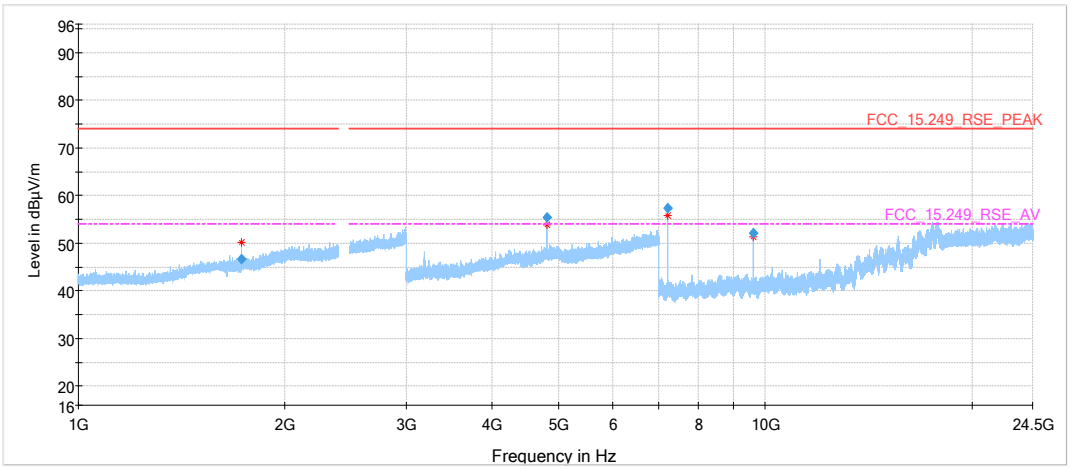
Radio Technology = BTLE, Operating Frequency = Mid, Frequency Range 30 MHz – 1 GHz (S01_AB01)



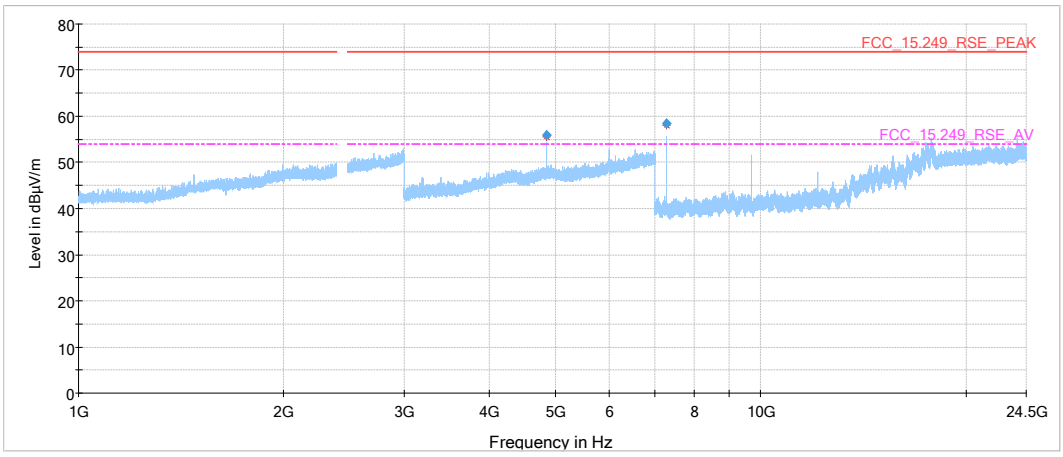
Radio Technology = BTLE, Operating Frequency = High, Frequency Range 30 MHz – 1 GHz (S01_AB01)



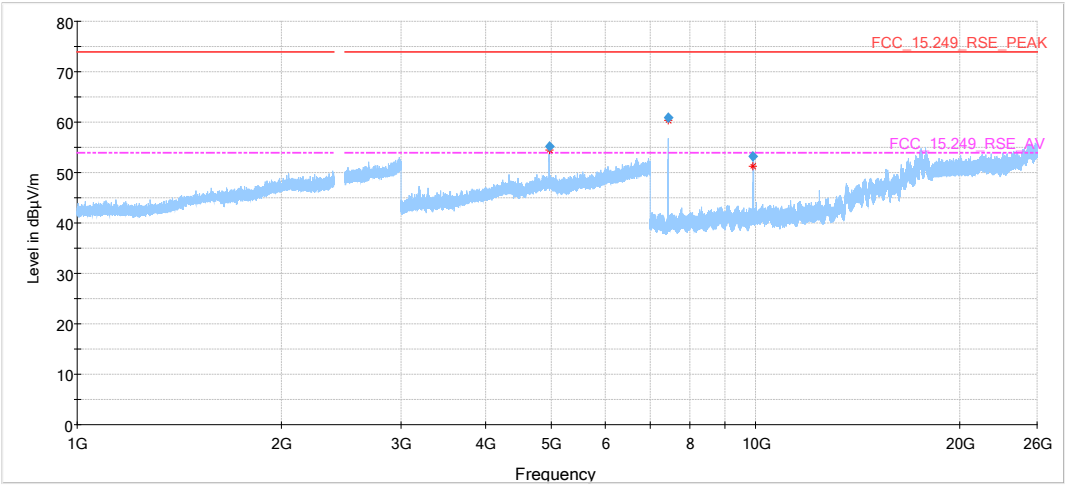
Radio Technology = BTLE, Operating Frequency = Low, Frequency Range 1 – 24.5 GHz (S01_AB01)



Radio Technology = BTLE, Operating Frequency = Mid, Frequency Range 1 – 24.5 GHz (S01_AB01)



Radio Technology = BTLE, Operating Frequency = High, Frequency Range 1 – 26.0 GHz (S01_AB01)



4.2.5. TEST EQUIPMENT USED

- Radiated Emissions

4.3. OCCUPIED BANDWIDTH (99 %)

Standard **FCC Part 15 Subpart C**

The test was performed according to ANSI C63.10–2013

4.3.1. TEST DESCRIPTION

The Equipment Under Test (EUT) was set up to perform the occupied bandwidth measurements.
The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.

The EUT was connected to the spectrum analyser via a broadband antenna. The complete setup and the broadband antenna were located in a shielded box

Analyser settings:

- Resolution Bandwidth (RBW): 1 to 5 % of the OBW
- Video Bandwidth (VBW): ≥ 3 times the RBW
- Span: 1.5 to 5 times the OBW
- Trace: Maxhold
- Sweeps: Till stable
- Sweeptime: 5 ms
- Detector: Peak

4.3.2. TEST REQUIREMENTS / LIMITS

No applicable limit.

4.3.3. TEST PROTOCOL

Temperature: 23°C
Air Pressure: 1011 hPa
Humidity: 40 %

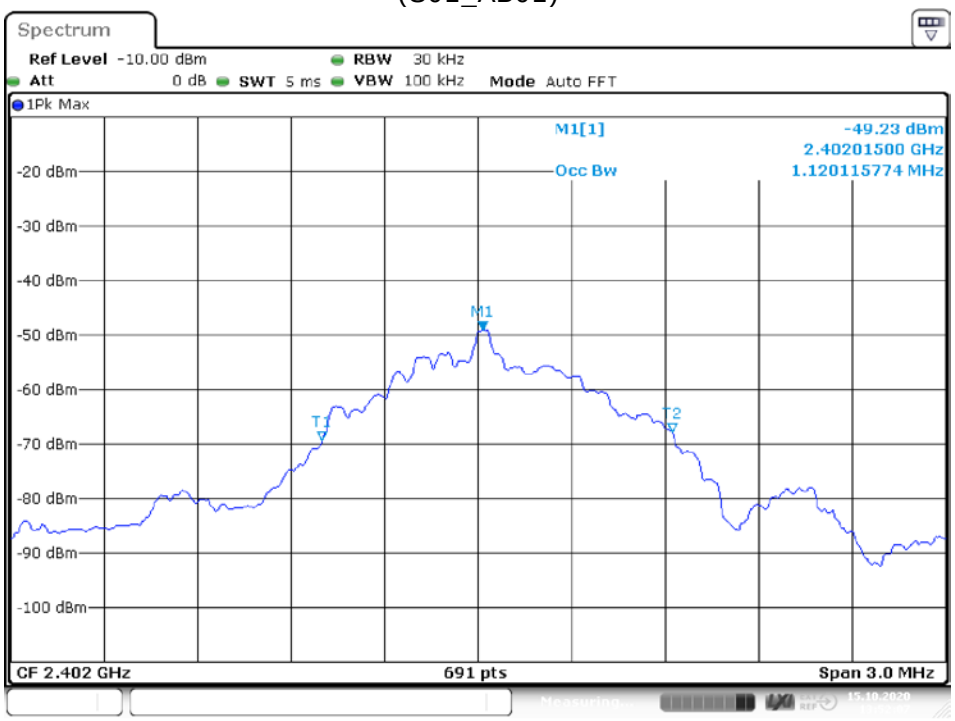
Op. Mode	Setup	Port
PM	S01_AB01	Enclosure

Frequency [MHz]	99 % OBW [MHz]	Limit [MHz]	Margin to Limit [MHz]	Remarks
2402	1.120	-	-	
2426	1.216	-	-	
2480	1.120	-	-	

Remark: Please see the measurement plots.

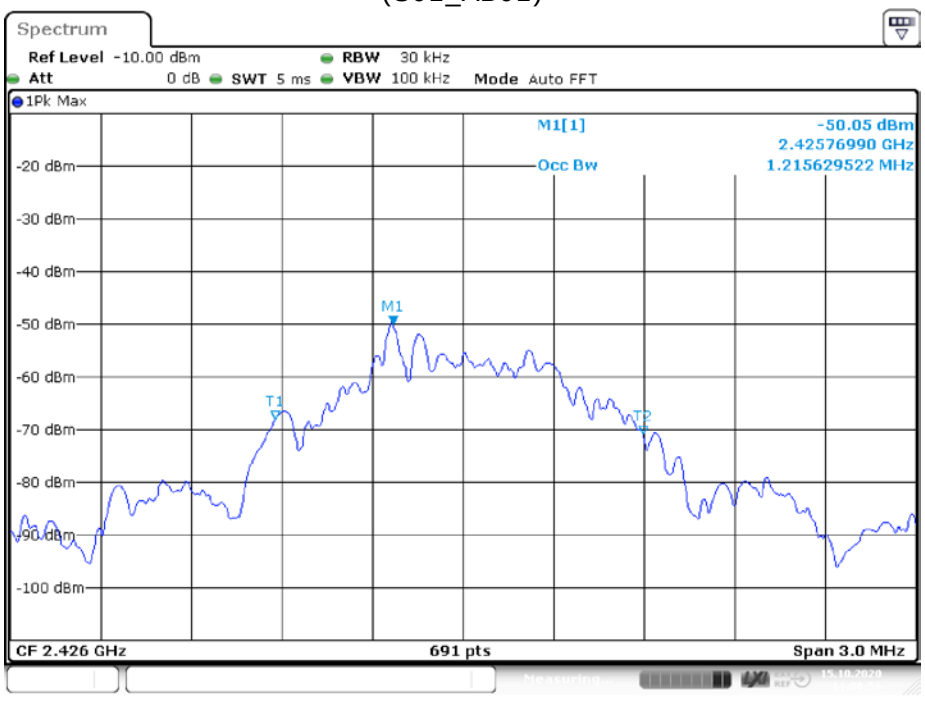
4.3.4. MEASUREMENT PLOTS

Radio Technology = BTLE, Operating Frequency = Low
(S01_AB01)



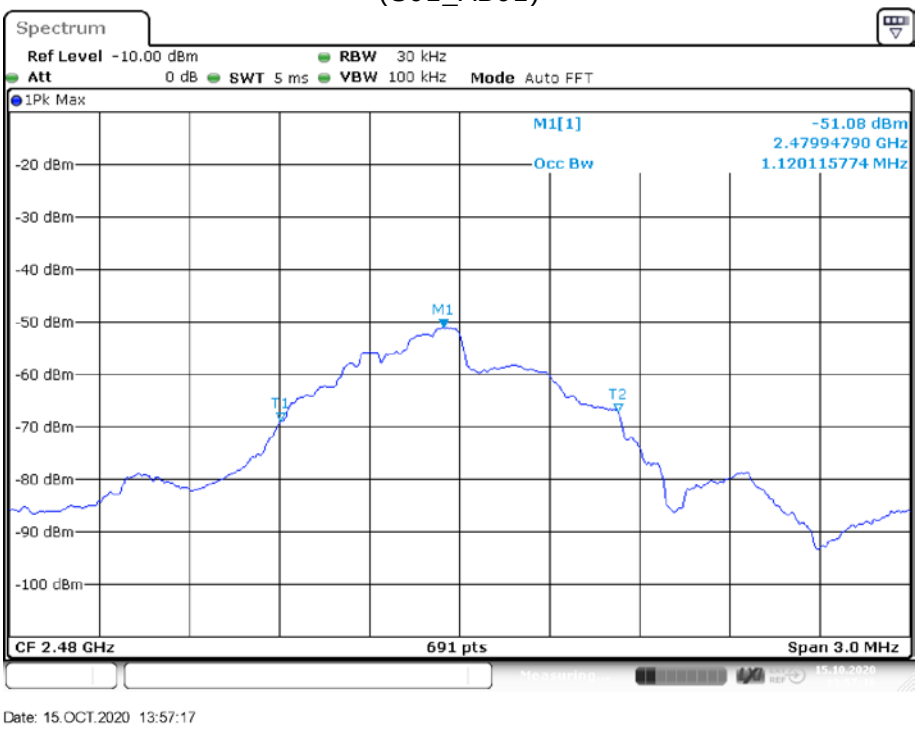
Date: 15.OCT.2020 13:52:07

Radio Technology = BTLE, Operating Frequency = Mid
(S01_AB01)



Date: 15.OCT.2020 14:00:56

Radio Technology = BTLE, Operating Frequency = High (S01_AB01)



4.3.5. TEST EQUIPMENT USED

- R&S TS8997 (only FSV 30)

5. TEST EQUIPMENT

1 Radiated Emissions

Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2019-10	2020-10
1.2	N5000/NP	Filter for EUT, 2 Lines, 250 V, 16 A	ETS-LINDGREN	241515		
1.3	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH	13936	2019-05	2021-05
1.4	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603	2019-12	2021-12
1.5	Anechoic Chamber 01	SAC/FAR, 10.58 m x 6.38 m x 6.00 m	Frankonia	none		
1.6	HL 562 ULTRALOG	Biconical-log-per antenna (30 MHz - 3 GHz) with HL 562E biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2018-07	2021-07
1.7	AMF-7D00101800-30-10P-R	Broadband Amplifier 100 MHz - 18 GHz	Miteq			
1.8	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
1.9	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
1.10	Anechoic Chamber 03	FAR, 8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB		
1.11	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2020-04	2022-04
1.12	Opus10 THI (8152.00)	T/H Logger 10	Lufft Mess- und Regeltechnik GmbH	12488	2019-06	2021-06
1.13	PONTIS Con4101	PONTIS Camera Controller		6061510370		
1.14	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
1.15	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2019-02	2021-02
1.16	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069		
1.17	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright Instruments GmbH	09		
1.18	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.19	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
1.20	foUSB-M Converter 2	Fibre optic link USB 2.0	PONTIS Messtechnik GmbH	4471520061		
1.21	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
1.22	TT 1.5 WI	Turn Table	Maturo GmbH	-		
1.23	MA4985-XP-ET	Bore Sight Antenna Mast	innco systems GmbH	none		
1.24	SGH-12	Standard Gain / Pyramidal HornAntenna (60 - 90 GHz)	RPG-Radiometer Physics GmbH	326		
1.25	JUN-AIR Mod. 6-15	Air Compressor	JUN-AIR Deutschland GmbH	612582		
1.26	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
1.27	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2018-01	2021-01
1.28	SB4-100.OLD20-3T/10 Airwin 2 x 1.5 kW	Air compressor (oil-free)	airWin Kompressoren UG	901/00503		
1.29	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
1.30	Innco Systems CO3000	Controller for bore sight mast SAC	innco systems GmbH	CO3000/967/39371016/L		
1.31	HF 907-2	Double-ridged horn	Rohde & Schwarz	102817	2019-04	2022-04
1.32	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
1.33	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324		
1.34	AM 4.0	Antenna Mast 4 m	Maturo GmbH	AM4.0/180/11920513		
1.35	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2018-07	2021-07

2 R&S TS8997

2.4 and 5 GHz Bands Conducted Test Lab

Ref. No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	107695	2020-08	2023-08
2.2	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2020-05	2022-05
2.3	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2020-04	2022-04
2.4	NGSM 32/10	Power Supply	Rohde & Schwarz GmbH & Co. KG	3456	2020-01	2022-01
2.5	SMBV100A	Enhanced GNSS	Rohde & Schwarz GmbH & Co. KG	262682-eP	2018-01	2021-01
2.6	SMB100A	Signal Generator 100 kHz - 40 GHz	Rohde & Schwarz Vertriebs-GmbH	181486	2019-11	2021-11
2.7	Temperature Chamber VT 4002	Temperature Chamber Vötsch 03	Vötsch	58566002150010	2020-05	2022-05
2.8	Opus10 THI (8152.00)	T/H Logger 03	Lufft Mess- und Regeltechnik GmbH	7482	2019-06	2021-06
2.9	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2019-11	2022-11
2.10	OSP120	Contains Power Meter and Switching Unit OSP-B157W8	Rohde & Schwarz	101158	2018-05	2021-05
2.11	Temperature Chamber VT 4002	Temperature Chamber Vötsch 05	Vötsch	58566080550010	2020-05	2022-05

The calibration interval is the time interval between “Last Calibration” and “Calibration Due”

6. ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas as well as the insertion loss of the LISN.

6.1. LISN R&S ESH3-Z5 (150 KHZ – 30 MHZ)

Frequency		Corr.	LISN insertion loss ESH3-Z5	cable loss (incl. 10 dB atten-uator)
MHz		dB	dB	dB
0.15		10.1	0.1	10.0
5		10.3	0.1	10.2
7		10.5	0.2	10.3
10		10.5	0.2	10.3
12		10.7	0.3	10.4
14		10.7	0.3	10.4
16		10.8	0.4	10.4
18		10.9	0.4	10.5
20		10.9	0.4	10.5
22		11.1	0.5	10.6
24		11.1	0.5	10.6
26		11.2	0.5	10.7
28		11.2	0.5	10.7
30		11.3	0.5	10.8

Sample calculation

U_{LISN} (dB µV) = U (dB µV) + Corr. (dB)
U = Receiver reading
LISN Insertion loss = Voltage Division Factor of LISN
Corr. = sum of single correction factors of used LISN, cables, switch units (if used)
Linear interpolation will be used for frequencies in between the values in the table.

6.2. ANTENNA R&S HFH2-Z2 (9 KHZ – 30 MHZ)

Frequency	AF HFH-Z2)	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-40 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
0.009	20.50	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.01	20.45	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.015	20.37	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.02	20.36	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.025	20.38	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.03	20.32	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.05	20.35	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.08	20.30	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.1	20.20	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.2	20.17	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.3	20.14	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.49	20.12	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.490001	20.12	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.5	20.11	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.8	20.10	-39.6	0.1	0.1	0.1	0.1	-40	30	3
1	20.09	-39.6	0.1	0.1	0.1	0.1	-40	30	3
2	20.08	-39.6	0.1	0.1	0.1	0.1	-40	30	3
3	20.06	-39.6	0.1	0.1	0.1	0.1	-40	30	3
4	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
5	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
6	20.02	-39.5	0.2	0.1	0.1	0.1	-40	30	3
8	19.95	-39.5	0.2	0.1	0.1	0.1	-40	30	3
10	19.83	-39.4	0.2	0.1	0.2	0.1	-40	30	3
12	19.71	-39.4	0.2	0.1	0.2	0.1	-40	30	3
14	19.54	-39.4	0.2	0.1	0.2	0.1	-40	30	3
16	19.53	-39.3	0.3	0.1	0.2	0.1	-40	30	3
18	19.50	-39.3	0.3	0.1	0.2	0.1	-40	30	3
20	19.57	-39.3	0.3	0.1	0.2	0.1	-40	30	3
22	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
24	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
26	19.54	-39.3	0.3	0.1	0.2	0.1	-40	30	3
28	19.46	-39.2	0.3	0.1	0.3	0.1	-40	30	3
30	19.73	-39.1	0.4	0.1	0.3	0.1	-40	30	3

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -40 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values

6.3. ANTENNA R&S HL562 (30 MHZ – 1 GHZ)

(d_{Limit} = 3 m)

Frequency	AF R&S HL562	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
30	18.6	0.6	0.29	0.04	0.23	0.02	0.0	3	3
50	6.0	0.9	0.39	0.09	0.32	0.08	0.0	3	3
100	9.7	1.2	0.56	0.14	0.47	0.08	0.0	3	3
150	7.9	1.6	0.73	0.20	0.59	0.12	0.0	3	3
200	7.6	1.9	0.84	0.21	0.70	0.11	0.0	3	3
250	9.5	2.1	0.98	0.24	0.80	0.13	0.0	3	3
300	11.0	2.3	1.04	0.26	0.89	0.15	0.0	3	3
350	12.4	2.6	1.18	0.31	0.96	0.13	0.0	3	3
400	13.6	2.9	1.28	0.35	1.03	0.19	0.0	3	3
450	14.7	3.1	1.39	0.38	1.11	0.22	0.0	3	3
500	15.6	3.2	1.44	0.39	1.20	0.19	0.0	3	3
550	16.3	3.5	1.55	0.46	1.24	0.23	0.0	3	3
600	17.2	3.5	1.59	0.43	1.29	0.23	0.0	3	3
650	18.1	3.6	1.67	0.34	1.35	0.22	0.0	3	3
700	18.5	3.6	1.67	0.42	1.41	0.15	0.0	3	3
750	19.1	4.1	1.87	0.54	1.46	0.25	0.0	3	3
800	19.6	4.1	1.90	0.46	1.51	0.25	0.0	3	3
850	20.1	4.4	1.99	0.60	1.56	0.27	0.0	3	3
900	20.8	4.7	2.14	0.60	1.63	0.29	0.0	3	3
950	21.1	4.8	2.22	0.60	1.66	0.33	0.0	3	3
1000	21.6	4.9	2.23	0.61	1.71	0.30	0.0	3	3

(d_{Limit} = 10 m)

30	18.6	-9.9	0.29	0.04	0.23	0.02	-10.5	10	3
50	6.0	-9.6	0.39	0.09	0.32	0.08	-10.5	10	3
100	9.7	-9.2	0.56	0.14	0.47	0.08	-10.5	10	3
150	7.9	-8.8	0.73	0.20	0.59	0.12	-10.5	10	3
200	7.6	-8.6	0.84	0.21	0.70	0.11	-10.5	10	3
250	9.5	-8.3	0.98	0.24	0.80	0.13	-10.5	10	3
300	11.0	-8.1	1.04	0.26	0.89	0.15	-10.5	10	3
350	12.4	-7.9	1.18	0.31	0.96	0.13	-10.5	10	3
400	13.6	-7.6	1.28	0.35	1.03	0.19	-10.5	10	3
450	14.7	-7.4	1.39	0.38	1.11	0.22	-10.5	10	3
500	15.6	-7.2	1.44	0.39	1.20	0.19	-10.5	10	3
550	16.3	-7.0	1.55	0.46	1.24	0.23	-10.5	10	3
600	17.2	-6.9	1.59	0.43	1.29	0.23	-10.5	10	3
650	18.1	-6.9	1.67	0.34	1.35	0.22	-10.5	10	3
700	18.5	-6.8	1.67	0.42	1.41	0.15	-10.5	10	3
750	19.1	-6.3	1.87	0.54	1.46	0.25	-10.5	10	3
800	19.6	-6.3	1.90	0.46	1.51	0.25	-10.5	10	3
850	20.1	-6.0	1.99	0.60	1.56	0.27	-10.5	10	3
900	20.8	-5.8	2.14	0.60	1.63	0.29	-10.5	10	3
950	21.1	-5.6	2.22	0.60	1.66	0.33	-10.5	10	3
1000	21.6	-5.6	2.23	0.61	1.71	0.30	-10.5	10	3

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -20 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

6.4. ANTENNA R&S HF907 (1 GHZ – 18 GHZ)

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay + cable inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit, atten-uator & pre-amp)	cable loss 4 (to receiver)		
MHz	dB (1/m)	dB	dB	dB	dB	dB		
1000	24.4	-19.4	0.99	0.31	-21.51	0.79		
2000	28.5	-17.4	1.44	0.44	-20.63	1.38		
3000	31.0	-16.1	1.87	0.53	-19.85	1.33		
4000	33.1	-14.7	2.41	0.67	-19.13	1.31		
5000	34.4	-13.7	2.78	0.86	-18.71	1.40		
6000	34.7	-12.7	2.74	0.90	-17.83	1.47		
7000	35.6	-11.0	2.82	0.86	-16.19	1.46		

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (inside chamber)	cable loss 3 (outside chamber)	cable loss 4 (switch unit, atten-uator & pre-amp)	cable loss 5 (to receiver)	used for FCC 15.247
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	
3000	31.0	-23.4	0.47	1.87	0.53	-27.58	1.33	
4000	33.1	-23.3	0.56	2.41	0.67	-28.23	1.31	
5000	34.4	-21.7	0.61	2.78	0.86	-27.35	1.40	
6000	34.7	-21.2	0.58	2.74	0.90	-26.89	1.47	
7000	35.6	-19.8	0.66	2.82	0.86	-25.58	1.46	

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (High Pass)	cable loss 3 (pre-amp)	cable loss 4 (inside chamber)	cable loss 5 (outside chamber)	cable loss 6 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	dB
7000	35.6	-57.3	0.56	1.28	-62.72	2.66	0.94	1.46
8000	36.3	-56.3	0.69	0.71	-61.49	2.84	1.00	1.53
9000	37.1	-55.3	0.68	0.65	-60.80	3.06	1.09	1.60
10000	37.5	-56.2	0.70	0.54	-61.91	3.28	1.20	1.67
11000	37.5	-55.3	0.80	0.61	-61.40	3.43	1.27	1.70
12000	37.6	-53.7	0.84	0.42	-59.70	3.53	1.26	1.73
13000	38.2	-53.5	0.83	0.44	-59.81	3.75	1.32	1.83
14000	39.9	-56.3	0.91	0.53	-63.03	3.91	1.40	1.77
15000	40.9	-54.1	0.98	0.54	-61.05	4.02	1.44	1.83
16000	41.3	-54.1	1.23	0.49	-61.51	4.17	1.51	1.85
17000	42.8	-54.4	1.36	0.76	-62.36	4.34	1.53	2.00
18000	44.2	-54.7	1.70	0.53	-62.88	4.41	1.55	1.91

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

6.5. ANTENNA EMCO 3160-09 (18 GHZ – 26.5 GHZ)

Frequency	AF EMCO 3160-09	Corr.	cable loss 1 (inside chamber)	cable loss 2 (pre-amp)	cable loss 3 (inside chamber)	cable loss 4 (switch unit)	cable loss 5 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB
18000	40.2	-23.5	0.72	-35.85	6.20	2.81	2.65
18500	40.2	-23.2	0.69	-35.71	6.46	2.76	2.59
19000	40.2	-22.0	0.76	-35.44	6.69	3.15	2.79
19500	40.3	-21.3	0.74	-35.07	7.04	3.11	2.91
20000	40.3	-20.3	0.72	-34.49	7.30	3.07	3.05
20500	40.3	-19.9	0.78	-34.46	7.48	3.12	3.15
21000	40.3	-19.1	0.87	-34.07	7.61	3.20	3.33
21500	40.3	-19.1	0.90	-33.96	7.47	3.28	3.19
22000	40.3	-18.7	0.89	-33.57	7.34	3.35	3.28
22500	40.4	-19.0	0.87	-33.66	7.06	3.75	2.94
23000	40.4	-19.5	0.88	-33.75	6.92	3.77	2.70
23500	40.4	-19.3	0.90	-33.35	6.99	3.52	2.66
24000	40.4	-19.8	0.88	-33.99	6.88	3.88	2.58
24500	40.4	-19.5	0.91	-33.89	7.01	3.93	2.51
25000	40.4	-19.3	0.88	-33.00	6.72	3.96	2.14
25500	40.5	-20.4	0.89	-34.07	6.90	3.66	2.22
26000	40.5	-21.3	0.86	-35.11	7.02	3.69	2.28
26500	40.5	-21.1	0.90	-35.20	7.15	3.91	2.36

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

6.6. ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

Frequency	AF EMCO 3160-10	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
GHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
26.5	43.4	-11.2	4.4				-9.5	3	1.0
27.0	43.4	-11.2	4.4				-9.5	3	1.0
28.0	43.4	-11.1	4.5				-9.5	3	1.0
29.0	43.5	-11.0	4.6				-9.5	3	1.0
30.0	43.5	-10.9	4.7				-9.5	3	1.0
31.0	43.5	-10.8	4.7				-9.5	3	1.0
32.0	43.5	-10.7	4.8				-9.5	3	1.0
33.0	43.6	-10.7	4.9				-9.5	3	1.0
34.0	43.6	-10.6	5.0				-9.5	3	1.0
35.0	43.6	-10.5	5.1				-9.5	3	1.0
36.0	43.6	-10.4	5.1				-9.5	3	1.0
37.0	43.7	-10.3	5.2				-9.5	3	1.0
38.0	43.7	-10.2	5.3				-9.5	3	1.0
39.0	43.7	-10.2	5.4				-9.5	3	1.0
40.0	43.8	-10.1	5.5				-9.5	3	1.0

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
distance correction = -20 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

7. PHOTO REPORT

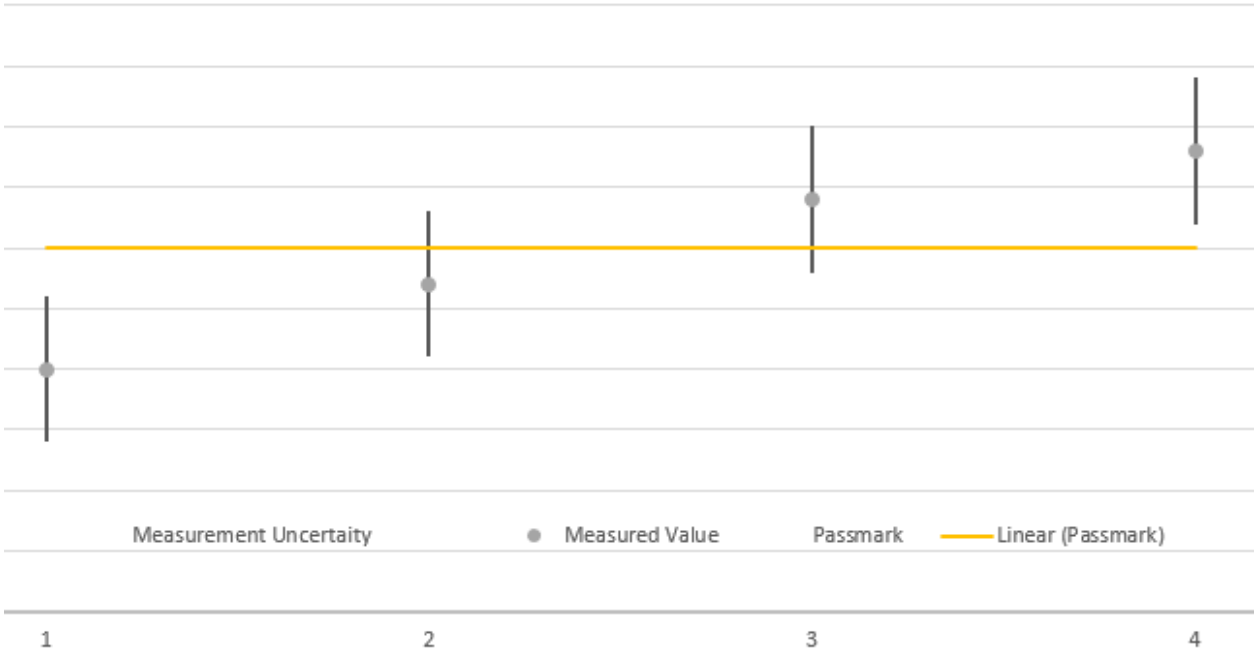
Please see separate photo report.

8. MEASUREMENT UNCERTAINTIES

Measurement Uncertainties

Parameter	Uncertainty
Antenna Power, Antenna Power Tolerance	± 1.2 dB
Frequency Tolerance	± 5.0 Hz
Transmitter Spurious Emissions, Limit on secondary radiated emissions	± 2.5 dB
Occupied bandwidth, Spread Bandwidth	± 825 kHz
Dwell time	± 30.0 µs
Temperature	± 0.3 °C
Humidity	± 3%
DC and low frequency voltages	± 1.5% + 2 digits
Time	± 5%
Antenna Gain and Pattern	± 1.8 dB

The measurement uncertainties for all parameters are calculated with an expansion factor (coverage factor) k = 1.96. This means, that the true value is in the corresponding interval with a probability of 95 %.



The verdicts in this test report are given according the above diagram:

Case	Measured Value	Uncertainty Range	Verdict
1	below pass mark	below pass mark	Passed
2	below pass mark	within pass mark	Passed
3	above pass mark	within pass mark	Failed
4	above pass mark	above pass mark	Failed

That means, the laboratory applies, as decision rule (see ISO/IEC 17025:2017), the so called shared risk principle.