InterLab®

FCC Measurement/Technical Report on

WLAN/Bluetooth/NFC module
EMMY-W161 and EMMY-W163
NFC part

Report Reference: MDE_UBLOX_1551_FCCe_Rev.1

FCC ID:
EMMY-W161: XPYEMMYW161
EMMY-W163: XPYEMMYW163

IC ID:
EMMY-W161: 8595A-EMMYW161
EMMY-W163: 8595A-EMMYW163

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

DAkkS Deutsche Akkreditierungsstelle D-PL-12140-01-01

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0 Summary

0.1 Technical Report Summary

Type of Authorization
Certification for an intentional radiator operating at 13.56 MHz

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 (10-1-15 Edition) and 15 (10-1-15 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

§ 15.205 Restricted bands of operation

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

§ 15.215 Additional provisions to the general radiated emission limitations

§ 15.225 Operation within the band 13.110-14.010 MHz

ANSI C63.10-2013 is applied

Summary Test Results:

The EUT complied with all performed tests as listed in chapter 0.2 Measurement Summary.

0.2 Measurement Summary

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**
op-mode 1	Setup_01	DC power supply	passed

FCC Part 15, Subpart C	§15.209		
Radiated Emissions			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_01	NFC antenna	passed

FCC Part 15, Subpart C	§ 15.215		
Occupied Bandwidth			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_02	NFC antenna	passed

FCC Part 15, Subpart C	§ 15.225		
Spectrum Mask			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_01	NFC antenna	passed

FCC Part 15, Subpart C	§ 15.225		
Frequency Tolerance			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 2	Setup_01	NFC antenna	passed

Revision History

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
initial	2016-03-30	--	invalid
Rev.1	2016-04-01	Page 1: Change of FCC ID and IC ID. Page 7: Change of Type Designation from W161 to EMMY-W161 and W163 to EMMY-W163.	valid

Responsible for Accreditation Scope: WOLFGANG PETER RICHTER 2016.04.01 18:19:41 +02'00'

Responsible for Test Report: DOBRIN TODOROV DOBRINOV 2016.04.01 18:15:47 +02'00'

1 Administrative Data

1.1 Testing Laboratory

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

This facility has been fully described in a report submitted to the FCC and accepted under the registration number 96716.

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

Laboratory accreditation no.:	DAkkS D-PL-12140-01-01
Responsible for Accreditation Scope:	Dipl.-Ing. Bernhard Retka Dipl.-Ing. Robert Machulec Dipl.-Ing. Andreas Petz Dipl.-Ing. Marco Kullik Dipl.-Ing. Wolfgang Richter
Report Template Version:	2015-08-24

1.2 Project Data

Responsible for testing and report:	Dipl.-Ing. Dobrin Dobrinov
Date of Test(s):	2016-01-04 to 2016-01-12
Date of Report:	2016-04-01

1.3 Applicant Data

Company Name:	u-blox AG
Address:	Zürcherstrasse 68 8800 Thalwil Switzerland
Contact Person:	Mr. Giulio Comar

1.4 Manufacturer Data

Company Name:	please see applicant data
Address:	
Contact Person:	

2 Test object Data

2.1 General EUT Description

Equipment under Test	WLAN/Bluetooth/NFC module
Type Designation:	EMMY-W161 and EMMY-W163
Kind of Device:	NFC transceiver at 13.56 MHz
(optional)	
Voltage Type:	DC
Voltage level:	3.3 V

General product description:

EMMY-W161 and EMMY-W163 are ultra-compact multi-radio modules providing Wi-Fi, Classic Bluetooth, Bluetooth low energy and NFC mode of operation.
It is designed for both simultaneous and independent operations of:
• Wi-Fi IEEE 802.11ac and a/b/g/n
• Dual-mode Bluetooth 4.2
• NFC

Specific product description for the EUT:

EMMY-W161: Shielded module, single antenna pin for WLAN 802.11 ac/a/b/g/n and Bluetooth communication
EMMY-W163: Shielded module, separate antenna pins for WLAN 802.11 ac/a/b/g/n and Bluetooth communication

According to the applicant, there is no difference between the two modules, regarding NFC parameters and functionality.

The EUT provides the following ports:

Ports

- DC power supply
- NFC antenna

The main components of the EUT are listed and described in Chapter 2.2.

2.2 EUT Main components

Type, S/ N, Short Descriptions etc. used in this Test Report

Short Description	Equipment under Test	Type Designation	Serial No.	HW Status	SW Status	Date of Receipt
EUT A (Code: DE1015031aa01)	RFID transceiver	EMMY-W161	–	03	n/a	2015-12-08
Remark: EUT A is connected to evaluation board equipped with PCB loop antenna.						
EUT B (Code: DE1015032ca01)	RFID transceiver	EMMY-W163	–	03	n/a	2015-12-08
Remark: EUT B is connected to evaluation board equipped with PCB loop antenna.						

NOTE: The short description is used to simplify the identification of the EUT in this test report.

2.3 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.

Short Description	Equipment under Test	Type Designation	Serial No.	HW Status	SW Status	FCC ID
–	–	–	–	–	–	–

2.4 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.

Short Description	Equipment under Test	Type Designation	Serial no.	HW Status	SW Status	FCC ID
AUX 1	Laptop	Acer Mod: LD1	8210205723	-	Linux	-
AUX 2	AC/DC adapter	Liteon Technology Corporation	8312774105	Rev:A05	-	-
AUX 3	Evaluation board	EVB-EMMY-161		02	n/a	-
AUX 4	AC/DC power supply	PeakTech 6005D	081062045	-	-	-

2.5 EUT Setups

This chapter describes the combination of EUTs and equipment used for testing. The rationale for selecting the EUTs, ancillary and auxiliary equipment and interconnecting cables, is to test a representative configuration meeting the requirements of the referenced standards.

Setup No.	Combination of EUTs	Description and Rationale
Setup_01	EUT A + AUX 4	Setup for Frequency Tolerance, Spectrum Mask, AC Power Line and Occupied BW tests
Setup_02	EUT B + AUX 4	Setup for Spurious Emissions tests

2.6 Operating Modes

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

Op. Mode	Description of Operating Modes	Remarks
op-mode 1	modulated carrier signal	EUT is transmitting a periodic modulated signal and is continuously reading TAG information.
op-mode 2	CW carrier signal	EUT is transmitting a non-modulated signal

2.7 Special software used for testing

Using AUX 1 to AUX 3 and a Marvell software provided by the applicant, it is possible to set the EUT operating modes.

2.8 Product labelling

2.8.1 FCC ID label

Please refer to the customer documentation.

2.8.2 IC ID label

Please refer to the customer documentation.

2.8.3 Location of the label on the EUT

Please refer to the customer documentation.

3 Test Results

3.1 Conducted Emissions AC Power line

Standard FCC Part 15, 10-1-15 Edition Subpart C

The test was performed according to: ANSI C63.10–2013 + KDB 174176 D01

3.1.1 Test Description

The test set-up was made in accordance to the general provisions of ANSI C 63.10
The Equipment Under Test (EUT) was setup in a shielded room to perform the conducted emissions measurements in a typical installation configuration. The EUT was powered from 50µH || 50 Ohm Line Impedance Stabilization Network (LISN). The LISN's unused connections were terminated with 50 Ohm loads.

The measurement procedure consists of two steps. It is implemented into the EMI test software EMC-32 from R&S.

Step 1: Preliminary scan
Intention of this step is, to determine the conducted EMI-profile of the EUT.
EMI receiver settings:
- Detector: Peak – Maxhold & Average
- Frequency range: 150 kHz – 30 MHz
- Frequency steps: 2.5 kHz
- IF–Bandwidth: 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)
- Measurement on phase + neutral lines of the power cords

On basis of this preliminary scan the highest amplitudes and the corresponding frequencies relative to the limit are identified. Emissions above the limit and emissions which are in the 10 dB range below the limit are considered.

Step 2: Final measurement
Intention of this step is, to determine the highest emissions with the settings defined in the test specification for the frequencies identified in step 1.
EMI receiver settings:
- Detector: Quasi-Peak
- IF Bandwidth: 9 kHz
- Measuring time: 1 s / frequency

At each frequency determined in step 1, four measurements are performed in the following combinations:
1) Neutral lead - reference ground (PE grounded)
2) Phase lead - reference ground (PE grounded)
3) Neutral lead - reference ground (PE floating)
4) Phase lead - reference ground (PE floating)

The highest value is reported.

KDB 174176 D01, Q5. Devices Operating Below 30 MHz

For a device with a permanent or detachable antenna operating at or below 30 MHz, the FCC will accept measurements performed with a suitable dummy load in lieu of the antenna under the following conditions:
(1) perform the AC power-line conducted tests with the antenna connected to determine compliance with Section 15.207 limits outside the transmitter's fundamental emission band;
(2) retest with a dummy load in lieu of the antenna to determine compliance with Section 15.207 limits within the transmitter's fundamental emission band.
For a detachable antenna, remove the antenna and connect a suitable dummy load to the antenna connector. For a permanent antenna, remove the antenna and terminate the RF output with a dummy load or network which simulates the antenna in the fundamental frequency band.

3.1.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.207

Frequency Range (MHz)	QP Limit (dBµV)	AV Limit (dBµV)
0.15 – 0.5	66 to 56	56 to 46
0.5 – 5	56	46
5 – 30	60	50

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

3.1.3 Test Protocol

Temperature: 23 °C
Air Pressure: 1010 hPa
Humidity: 35 %

Op. Mode	Setup	Port
op-mode 1	Setup_01	DC Port (power line)

Measurements are performed according to KDB 174176 D01

Step (1). Measurements performed with the EUT dedicated antenna

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE
13.454250	48.64	---	60.00	11.36	L1	GND
13.560000	---	62.59	50.00	-12.59	N	GND
13.560000	62.89	---	60.00	-2.89	N	GND
13.665750	49.04	---	60.00	10.96	N	GND

Step (2). Measurements provided with a dummy antenna

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE
0.217500	---	23.31	52.91	29.61	L1	GND
0.339000	23.36	---	59.23	35.87	N	GND
13.348500	---	24.65	50.00	25.35	L1	GND
13.454250	---	22.30	50.00	27.70	L1	GND
13.454250	27.39	---	60.00	32.61	N	GND
13.560000	---	41.43	50.00	8.57	L1	GND
13.560000	41.57	---	60.00	18.43	N	GND
13.665750	27.40	---	60.00	32.60	N	GND
13.665750	---	22.26	50.00	27.74	L1	GND
13.771500	---	24.43	50.00	25.57	L1	GND
23.583750	---	27.86	50.00	22.14	N	GND
26.907000	---	29.66	50.00	20.34	L1	FLO
27.120750	46.86	---	60.00	13.14	L1	FLO
27.120750	---	46.55	50.00	3.45	L1	FLO
27.332250	---	29.58	50.00	20.42	N	FLO

Remark: Please see annex for the measurement plots.

The conducted emission found in the tables above corresponds clearly to the fixed transmitter frequency of the EUT. It was determined that this emission on the AC mains is based on radiated coupling into the test setup. Therefore, for the assessment of the test result, the fixed transmitter frequency of the EUT is not considered.

The chosen operating mode is selected as representative mode to generate "worst-case" conditions, i.e. high power consumption.

3.2 Spurious radiated emissions

Standard FCC Part 15, 10-1-11 Edition Subpart C

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

3.2.1 Test Description

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m² in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.
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 from a DC power source.

1. Measurement up to 30 MHz
The Loop antenna HFH2-Z2 is used.

Step 1: pre measurement
- Anechoic chamber
- Antenna distance: 3 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.
- Open area test side
- Antenna distance: according to the Standard
- Detector: Quasi-Peak
- 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

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 – 3 m
- Height variation step size: 2 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 ± 45° around this value. 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 by ± 100 cm around the antenna height determined. 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: ± 45 ° around the determined value
- Height variation range: ± 100 cm around the determined value
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector
With the settings determined in step 3, the final measurement will be performed:
EMI receiver settings for step 4:
- 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 this 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.

3. Measurement above 1 GHz
The following modifications apply to the measurement procedure for the frequency range above 1 GHz:
Step 1:
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 of the receiving antenna only.
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 °.
Step 2:
Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna instep 2 is omitted. Instead of this, a maximum search with a step size ± 45° for the elevation axis is performed.
The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°

EMI receiver settings (for all steps):
- Detector: Peak, Average
- IF Bandwidth = 1 MHz

Step 3:
Spectrum analyser settings for step 3:
- Detector: Peak / Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 1 s

3.2.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (d)
... In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

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

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
0.009 – 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 – 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 – 30	30@30m	3	29.5@30m

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 – 88	100@3m	3	40.0@3m
88 – 216	150@3m	3	43.5@3m
216 – 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m

The measured values above 26 GHz are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

§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)

3.2.3 Test Protocol

Temperature: 23 °C
Air Pressure: 1009 hPa
Humidity: 38 %

3.2.3.1 Measurement up to 30 MHz

Op. Mode	Setup	Port
op-mode 1	Setup_01	Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/ Peak	AV
0°	–	–	–	–	–	–	–	–	–
90°	–	–	–	–	–	–	–	–	–

Remark: No spurious emissions in the range 20 dB below the limit found therefore step 2 was not performed. Please refer to the plot in the annex.

3.2.3.2 Measurement above 30 MHz

Op. Mode	Setup	Port
op-mode 1	Setup_01	Enclosure

Polarisation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Delta to limit dB	Delta to limit dB
		QP	Peak	AV	QP	Peak	AV	QP/ Peak	AV
Horizontal	352.56	38.4	–	–	46.0	–	–	7.62	–
Horizontal	352.56	35.8	–	–	46.0	–	–	10.2	–

Remark: No further spurious emissions in the range 20 dB below the limit found.

3.2.4 Test result: Spurious radiated emissions

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed

3.3 Occupied bandwidth

Standard FCC Part 15, 10-1-15 Edition Subpart C

The test was performed according to: FCC §15.31

3.3.1 Test Description

The Equipment Under Test (EUT) was setup in a shielded room 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 results recorded were measured with the modulation which produces the worst-case (widest) occupied bandwidth.

3.3.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.215 (c)
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. …

3.3.3 Test Protocol

Temperature: 22 °C
Air Pressure: 1013 hPa
Humidity: 45 %

Op. Mode	Setup	Port
op-mode 1	Setup_02	Enclosure

20 dB bandwidth kHz	99% bandwidth kHz	Remarks
432.960	492.051	The 20 dB bandwidth from 13.34322 MHz to 13.77618 MHz is contained within the designated frequency band 13.110 MHz to 14.010 MHz.

Remark: Please see annex for the measurement plot.

3.3.4 Test result: Occupied bandwidth

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed

3.4 Spectrum mask

Standard FCC Part 15, 10-1-15 Edition Subpart C

The test was performed according to: FCC §15.225

3.4.1 Test Description

The test set-up was made in accordance to the general provisions of ANSI C 63.10–2013. The Equipment Under Test (EUT) was set up on a non-conductive table in the anechoic chamber.
The radiated emissions measurements were made in a typical installation configuration.
The measurement procedure is implemented into the EMI test software ES-K1 from R&S.
The Loop antenna HFH2-Z2 is used.

- Anechoic chamber
- Antenna distance: 3 m
- Detector: Peak-Maxhold
- Frequency range: 13.06 – 14.06 MHz
- Frequency steps: 5 kHz
- IF–Bandwidth:10 kHz
- Measuring time / Frequency step: 100 ms

3.4.2 Test Limits

FCC Part 15, Subpart C, §15.225 (a-d), and §15.209, corrected by the means of the extrapolation of §15.31 due to the reduced measuring distance from 30 m to 3 m with an inverse linear distance extrapolation factor (40 dB/decade).

3.4.3 Test Protocol

Temperature: 22 °C
Air Pressure: 1013 hPa
Humidity: 40 %

Op. Mode	Setup	Port
op-mode 1	Setup_01	Enclosure

Maximum value dBµV/ m @ 30m	Limit dBµV/ m @ 30m	Remarks
15.56	84.0	measuring distance 3 m

Remark: Please see annex for the measurement plot.

3.4.4 Test result: Spectrum mask

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed

3.5 Frequency tolerance

Standard FCC Part 15, 10-1-15 Edition Subpart C

The test was performed according to: FCC §15.225

3.5.1 Test Description

The Equipment Under Test (EUT) is placed in a temperature chamber.
The frequency drift during temperature and voltage variation is measured by the means of a spectrum analyzer with frequency counter function.
The temperature was varied from –40 °C to +85 °C. At +20 °C the extreme power supply voltages of 3.0 V and 3.6 V are applied. After reaching each target temperature and waiting sufficient time allowing the temperature to stabilize, one measurement is performed immediately after powering on the EUT, and three further measurements are performed after 2, 5 and 10 minutes continuous operation of EUT.

3.5.2 Test Limits

FCC Part 15, Subpart C, §15.225 (e): The frequency tolerance of the carrier signal shall be maintained within ±0.01% of the operating frequency over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C.

3.5.3 Test Protocol

Temperature: -40°C to +85°C
Air Pressure: 1009 hPa
Humidity: 38 %

Op. Mode	Setup	Port
op-mode 2	Setup_01	Enclosure

Temperature / °C	Voltage / V	Time / min.	Frequency / MHz	Delta / Hz	Verdict
50	3.30	0	13.559882	-118	Passed
50	3.30	2	13.559880	-120	Passed
50	3.30	5	13.559879	-121	Passed
50	3.30	10	13.559878	-122	Passed
40	3.30	0	13.559924	-76	Passed
40	3.30	2	13.559920	-80	Passed
40	3.30	5	13.559919	-81	Passed
40	3.30	10	13.559918	-82	Passed
30	3.30	0	13.559997	-3	Passed
30	3.30	2	13.559976	-24	Passed
30	3.30	5	13.559974	-26	Passed
30	3.30	10	13.559972	-28	Passed
20	3.60	0	13.560031	31	Passed
20	3.60	2	13.560030	30	Passed
20	3.60	5	13.560029	29	Passed
20	3.60	10	13.560029	29	Passed
20	3.30	0	13.560032	32	Passed
20	3.30	2	13.560031	31	Passed
20	3.30	5	13.560029	29	Passed
20	3.30	10	13.560030	30	Passed
20	3.00	0	13.560031	31	Passed
20	3.00	2	13.560030	30	Passed
20	3.00	5	13.560029	29	Passed
20	3.00	10	13.560030	30	Passed
10	3.30	0	13.560086	86	Passed
10	3.30	2	13.560085	85	Passed
10	3.30	5	13.560084	84	Passed
10	3.30	10	13.560084	84	Passed
0	3.30	0	13.560130	130	Passed
0	3.30	2	13.560127	127	Passed
0	3.30	5	13.560127	127	Passed
0	3.30	10	13.560127	127	Passed
-10	3.30	0	13.560153	153	Passed
-10	3.30	2	13.560152	152	Passed
-10	3.30	5	13.560152	152	Passed
-10	3.30	10	13.560152	152	Passed
-20	3.30	0	13.560141	141	Passed
-20	3.30	2	13.560143	143	Passed
-20	3.30	5	13.560144	144	Passed
-20	3.30	10	13.560144	144	Passed

Continue on the next page

Additional measurements to prove the EUT working ability from -40° C to +85° C

Temperature / °C	Voltage / V	Time / min.	Frequency / MHz	Delta / Hz	Verdict
85	3.3	0	13.559920	-80	Passed
85	3.3	2	13.559937	-63	Passed
85	3.3	5	13.559945	-55	Passed
85	3.3	10	13.559945	-55	Passed
80	3.3	0	13.559899	-101	Passed
80	3.3	2	13.559904	-96	Passed
80	3.3	5	13.559906	-94	Passed
80	3.3	10	13.559908	-92	Passed
70	3.3	0	13.559862	-138	Passed
70	3.3	2	13.559863	-137	Passed
70	3.3	5	13.559864	-136	Passed
70	3.3	10	13.559866	-134	Passed
60	3.3	0	13.559859	-141	Passed
60	3.3	2	13.559858	-142	Passed
60	3.3	5	13.559858	-142	Passed
60	3.3	10	13.559858	-142	Passed
-30	3.3	0	13.560103	103	Passed
-30	3.3	2	13.560106	106	Passed
-30	3.3	5	13.560106	106	Passed
-30	3.3	10	13.560106	106	Passed
-40	3.3	0	13.560029	29	Passed
-40	3.3	2	13.560033	33	Passed
-40	3.3	5	13.560030	30	Passed
-40	3.3	10	13.560031	31	Passed

Remark: The limit is a delta of max. ±1356 Hz (0.01 %).

3.5.4 Test result: Frequency tolerance

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 2	passed

4 Test Equipment

1 Radiated Emissions

Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Calibration Due
1.1	Fully Anechoic Room	8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	
1.2	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513	
1.3	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2016-11-13
1.4	Anechoic Chamber	10.58 x 6.38 x 6.00 m³	Frankonia	none	2017-01-09
1.5	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2017-12-08
1.6	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709	
1.7	AS 620 P	Antenna mast	HD GmbH	620/37	
1.8	NRV-Z1	Sensor Head A	Rohde & Schwarz	827753/005	2016-05-11
1.9	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785	
1.10	HL 562	Ultralog new biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2018-06-30
1.11	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2017-03-10
1.12	HFH2-Z2	Loop Antenna	Rohde & Schwarz GmbH & Co. KG	829324/006	2017-11-27
1.13	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2016-11-17
1.14	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-02-27
1.15	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304	
1.16	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronik GmbH	00086675	
1.17	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz GmbH & Co. KG	100609	2016-03-18
1.18	HF 907	Double-ridged horn	Rohde & Schwarz GmbH & Co. KG	102444	2018-05-11
1.19	DE 325	Dreheinheit	HD GmbH		

2 Radio Lab

Conducted Radio Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Calibration Due
2.1	A8455-4	4 Way Power Divider (SMA)		-	
2.2	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz GmbH & Co. KG	107695	2017-06-06
2.3	VT 4002	Climatic Chamber	Vötsch	58566002150010	2016-03-11
2.4	SMP03	Signal Generator 2 GHz - 27 GHz 1035.5005.03	Rohde & Schwarz GmbH & Co. KG	833680/003	2016-10-29
2.5	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2018-02-10
2.6	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz GmbH & Co. KG	259291	2016-08-23
2.7	Voltcraft M-3860M	Digital Multimeter 01 (Multimeter)	Voltcraft	IJ096055	
2.8	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304	
2.9	Datum, Model: MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2016-06-25
2.10	WA1515	Broadband Power Divider SMA	Weinschel Associates	A855	
2.11	FSIQ26	Spectrum Analyzer 7layers, Ratingen OIL_RE	Rohde & Schwarz GmbH & Co. KG	840061/005	2017-04-02

3 R&S TS8997

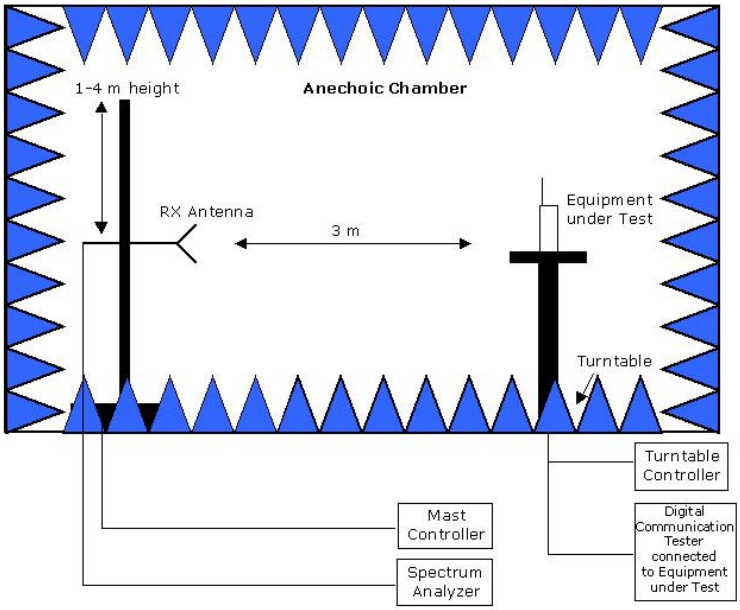
EN300328/301893 Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Calibration Due
3.1	OSP120	Switching Unit with integrated power meter	Rohde & Schwarz GmbH & Co. KG	101158	2016-08-21
3.2	A8455-4	4 Way Power Divider (SMA)		-	
3.3	Opus10 THI (8152.00)	ThermoHygro Datalogger 03 (Environ)	Lufft Mess- und Regeltechnik GmbH	7482	2017-02-27
3.4	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz GmbH & Co. KG	107695	2017-06-06
3.5	VT 4002	Climatic Chamber	Vötsch	58566002150010	2016-03-11
3.6	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2018-02-10
3.7	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz GmbH & Co. KG	259291	2016-08-23
3.8	Voltcraft M-3860M	Digital Multimeter 01 (Multimeter)	Voltcraft	IJ096055	
3.9	1515 / 93459	Broadband Power Divider SMA (Aux)	Weinschel Associates	LN673	
3.10	Datum, Model: MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2016-06-25

5 Photo Report

Photos are included in an external report.

6 Setup Drawings



Drawing 1: Setup in the Anechoic chamber:
Measurements below 1 GHz: Semi-anechoic, conducting ground plane.
Measurements above 1 GHz: Fully-anechoic, absorbers on all surfaces.

7 FCC and IC Correlation of measurement requirements

The following tables show the correlation of measurement requirements Radio equipment operating in the Band 13.110-14.010 MHz from FCC and IC.

Radio equipment

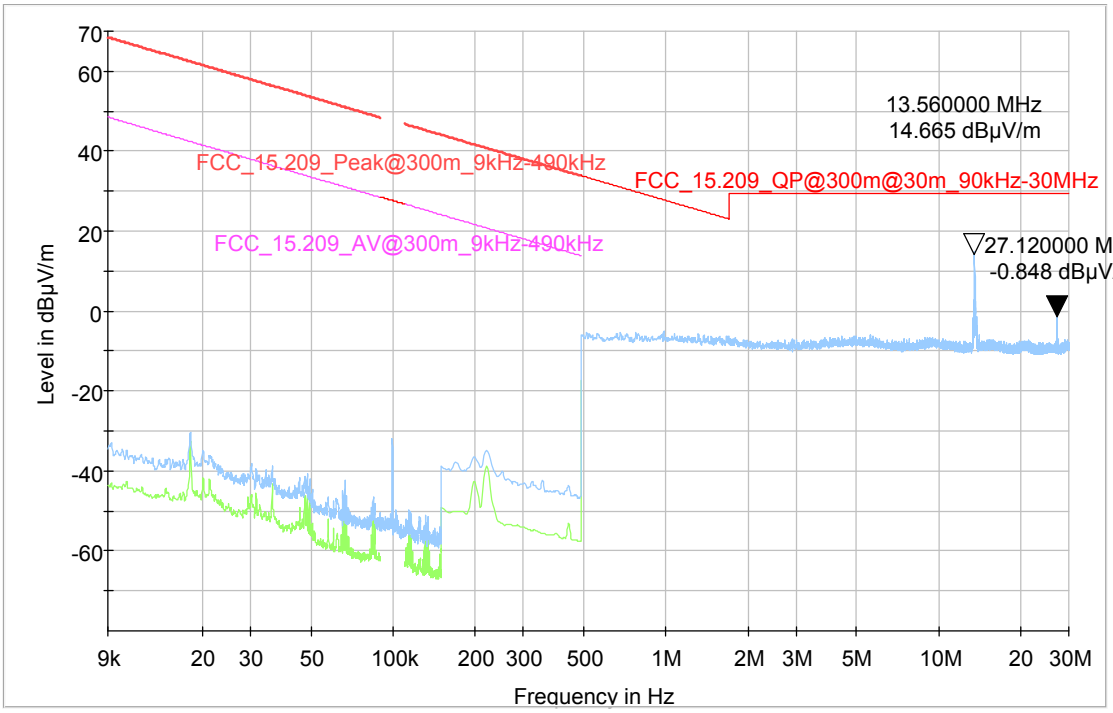
Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 4: 8.8
Additional provisions to the general radiated emission limitations	§ 15.215	RSS-Gen Issue 4: 6.6
Out-of-band emissions	§ 15.225 (d)	RSS Gen Issue 4: 6.13/8.9/8.10; RSS-210 Issue 8: A2.6
In-band emissions	§ 15.225 (a) / (b) / (c)	RSS-210 Issue 8: A2.6
Frequency Stability	§ 15.225 (e)	RSS-210 Issue 8: A2.6
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 4: 8.3
Receiver spurious emissions	–	RSS-210 Issue 8: 2.3; RSS Gen Issue 4: 5/7 *)
Handling of active and passive tag devices of RFID application	§ 15.225 (f)	RSS Gen Issue 4: 8.7

*) Receivers are exempted from certification besides if operating in stand-alone mode in the frequency range 30–960 MHz or if these are scanner receivers.

8 Annex measurement plots

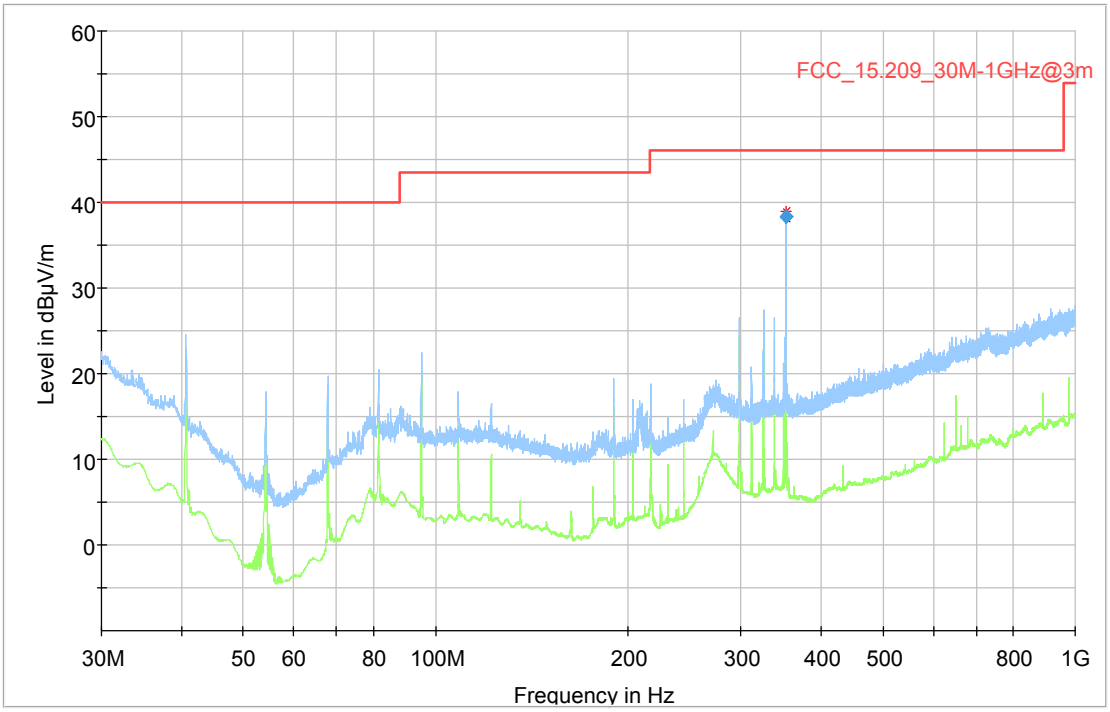
8.1 Radiated emissions

8.1.1 Radiated emissions (f < 30 MHz)

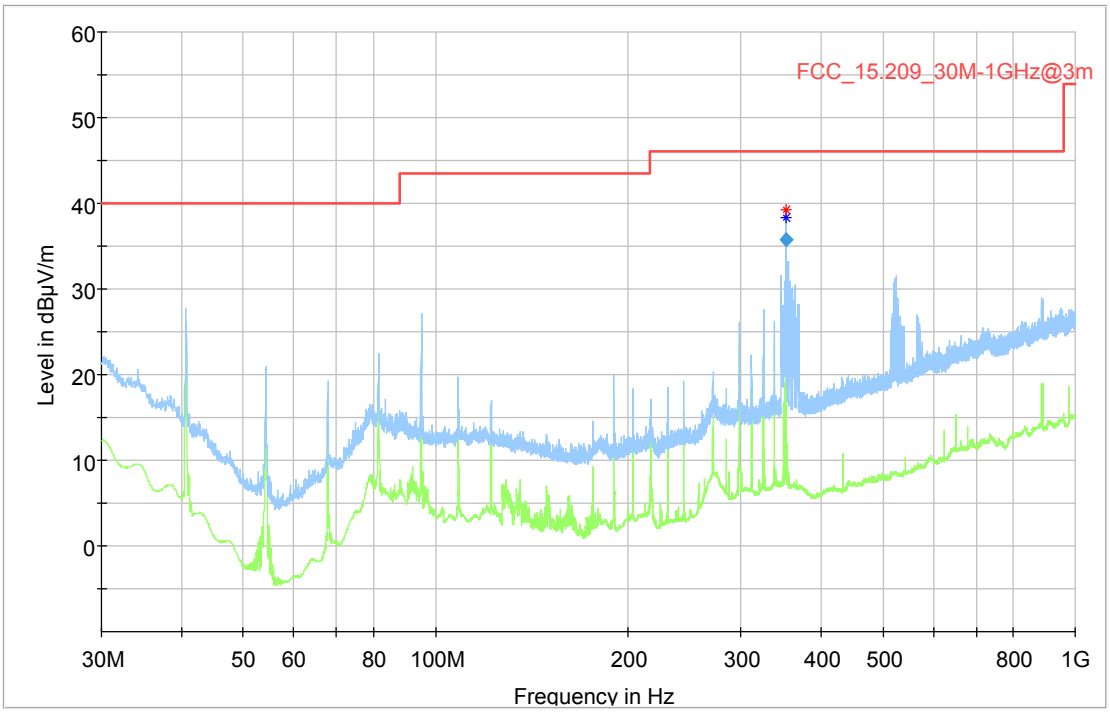


8.1.2 Radiated emissions (f > 30 MHz)

EUT in a vertical position

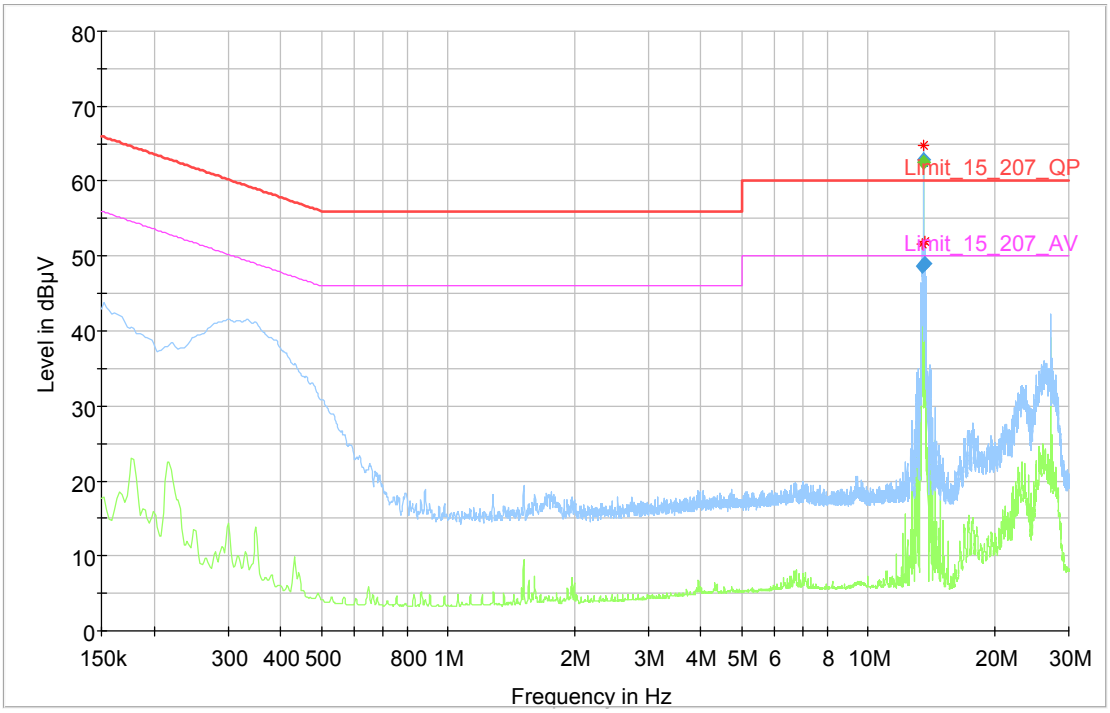


EUT in a horizontal position

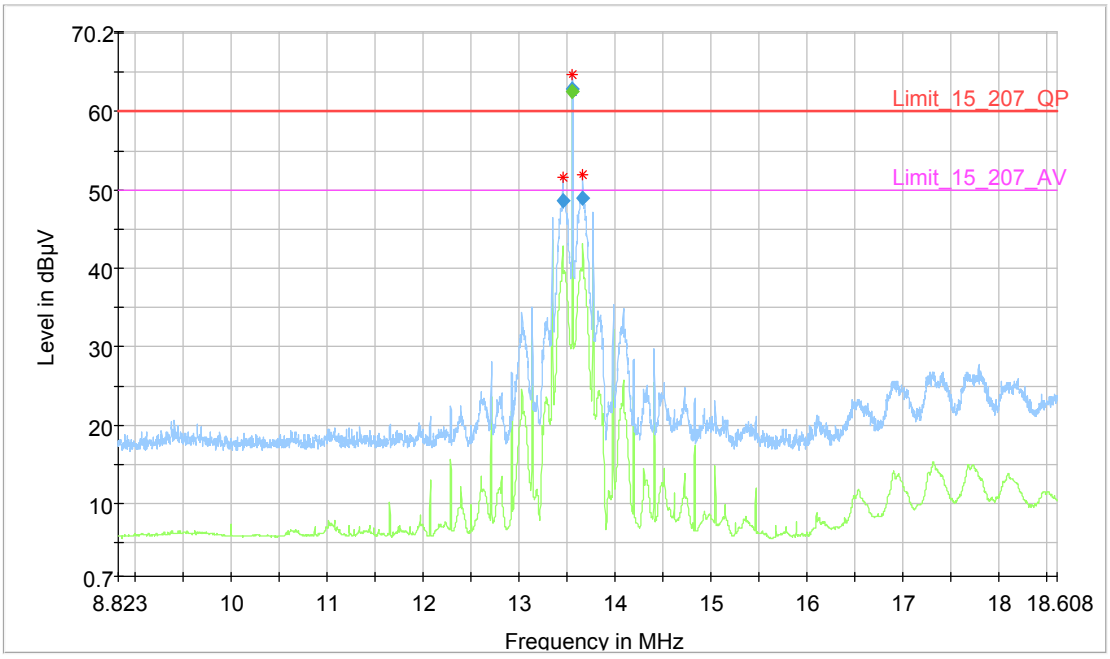


8.2 AC Mains conducted

Measurement performed with a real antenna.

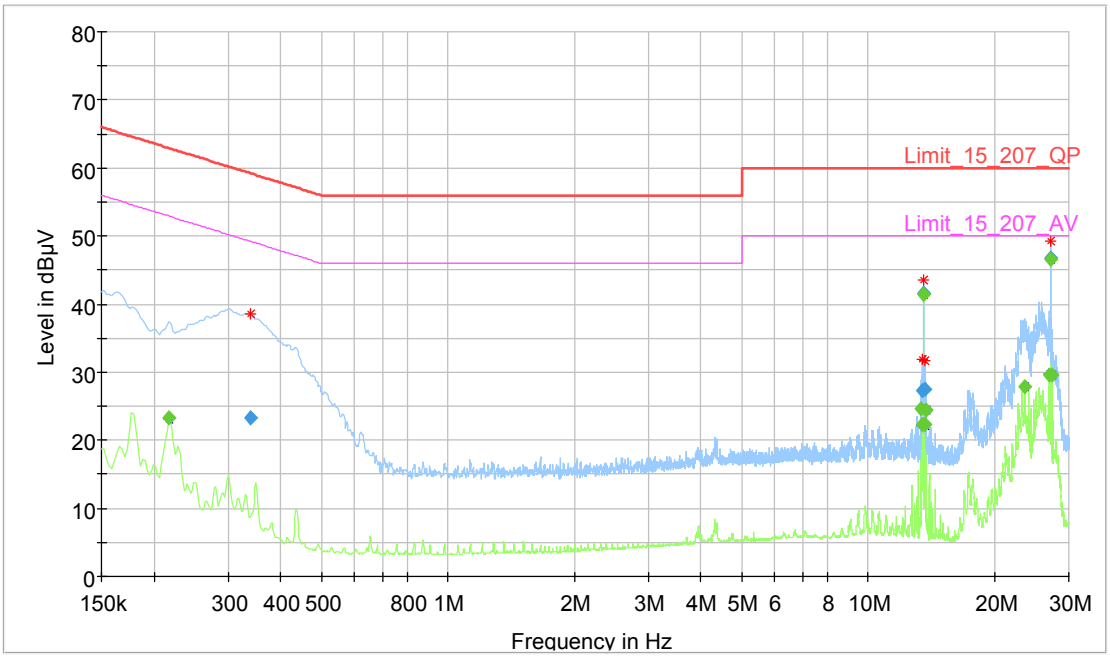


Measurement performed with a real antenna (zoomed).



Note: Measured levels above the limit are from modulated carrier signal.

Measurement performed with a 50 Ω dummy antenna



Final Result

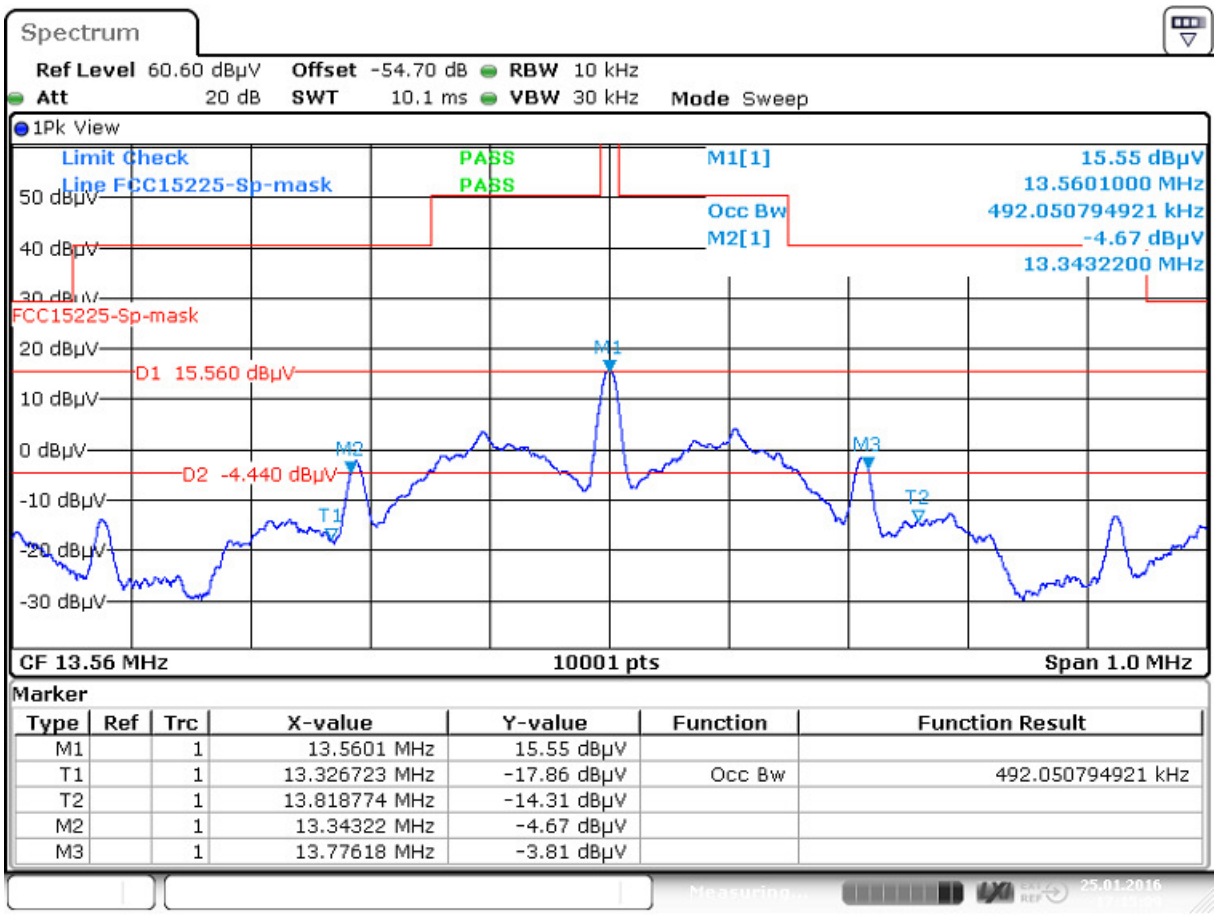
Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)	Comment
0.217500	---	23.31	52.91	29.61	1000.0	9.000	L1	GND	10.1	16:54:48 - 06/01/2016
0.339000	23.36	---	59.23	35.87	1000.0	9.000	N	GND	10.1	16:54:13 - 06/01/2016
13.348500	---	24.65	50.00	25.35	1000.0	9.000	L1	GND	10.7	16:54:53 - 06/01/2016
13.454250	---	22.30	50.00	27.70	1000.0	9.000	L1	GND	10.7	16:54:58 - 06/01/2016
13.454250	27.39	---	60.00	32.61	1000.0	9.000	N	GND	10.7	16:54:19 - 06/01/2016
13.560000	---	41.43	50.00	8.57	1000.0	9.000	L1	GND	10.7	16:55:02 - 06/01/2016
13.560000	41.57	---	60.00	18.43	1000.0	9.000	N	GND	10.7	16:54:24 - 06/01/2016
13.665750	27.40	---	60.00	32.60	1000.0	9.000	N	GND	10.7	16:54:30 - 06/01/2016
13.665750	---	22.26	50.00	27.74	1000.0	9.000	L1	GND	10.7	16:55:07 - 06/01/2016
13.771500	---	24.43	50.00	25.57	1000.0	9.000	L1	GND	10.7	16:55:11 - 06/01/2016
23.583750	---	27.86	50.00	22.14	1000.0	9.000	N	GND	11.1	16:55:16 - 06/01/2016
26.907000	---	29.66	50.00	20.34	1000.0	9.000	L1	FLO	11.2	16:54:35 - 06/01/2016
27.120750	46.86	---	60.00	13.14	1000.0	9.000	L1	FLO	11.2	16:54:07 - 06/01/2016
27.120750	---	46.55	50.00	3.45	1000.0	9.000	L1	FLO	11.2	16:54:39 - 06/01/2016
27.332250	---	29.58	50.00	20.42	1000.0	9.000	N	FLO	11.2	16:54:44 - 06/01/2016

Hardware Setup: EMI_Conducted_EN_FCC_ESH3-Z5
Measurement Type: 2 Line LISN
Frequency Range: 150 kHz - 30 MHz
Graphics Level Range: 0 dBµV - 80 dBµV

Preview Measurements:
Scan Test Template: FCC_Part207_Pre_ESH3-Z5

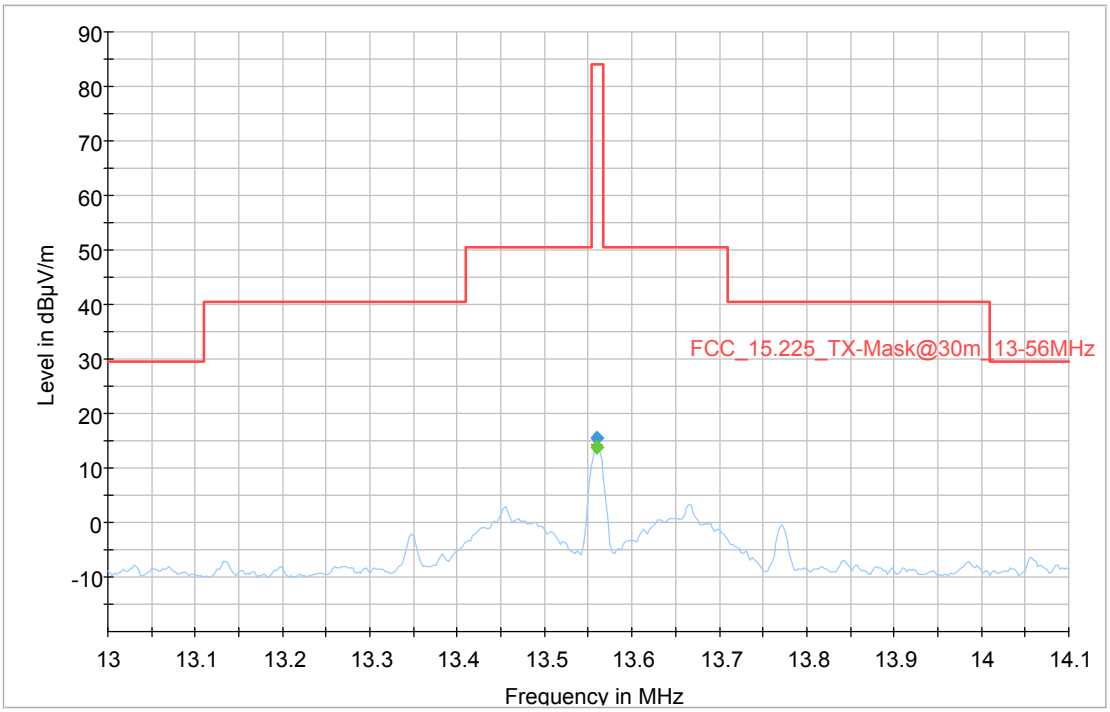
Final Measurements:
Template for Single Meas.: FCC_Part207_Final_ESH3-Z5

8.3 Occupied bandwidth



Date:25.JAN.2016 17:15:09

8.4 Spectrum mask



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	QuasiPeak (dBµV/m)	Limit (dBµV /m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
13.560000	---	13.76	84.00	70.24	1000.0	10.000	100.0	H	53.0	-19.9	10:39:14 - 05/01/2016
13.560000	15.56	---	84.00	68.44	1000.0	10.000	100.0	H	53.0	-19.9	10:39:14 - 05/01/2016