EMI – TEST REPORT

- FCC Part 15.249, RSS210 -

Type / Model Name	:	2503-537
Product Description	:	BLE2IR dongle
Applicant	:	ruwido austria gmbh
Address	:	Köstendorfer Strasse 8
		5202 NEUMARKT, AUSTRIA
Manufacturer	:	ruwido austria gmbh
Address	:	Köstendorfer Strasse 8
		5202 NEUMARKT, AUSTRIA
Licence holder	:	ruwido austria gmbh
Address	:	Köstendorfer Strasse 8
		5202 NEUMARKT, AUSTRIA

Test Result according to the standards listed in clause 1 test standards:	**POSITIVE**

Test Report No. : T40951-00-02GK	29. June 2016 Date of issue

Deutsche Akkreditierungsstelle
D-PL-12030-01-01
D-PL-12030-01-02

Contents

1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (September, 2015)

Part 15, Subpart A, Section 15.31	Measurement standards
Part 15, Subpart A, Section 15.33	Frequency range of radiated measurements
Part 15, Subpart A, Section 15.35	Measurement detector functions and bandwidths

FCC Rules and Regulations Part 15, Subpart C - Intentional Radiators (September, 2015)

Part 15, Subpart C, Section 15.203	Antenna requirement
Part 15, Subpart C, Section 15.204	External radio frequency power amplifiers and antenna modifications
Part 15, Subpart C, Section 15.205	Restricted bands of operation
Part 15, Subpart C, Section 15.207	Conducted limits
Part 15, Subpart C, Section 15.209	Radiated emission limits, general requirements
Part 15, Subpart C, Section 15.249	Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz, 5725 - 5875 MHz, and 24.0 - 24.25 GHz
ANSI C63.4: 2014	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
ANSI C63.10: 2013	Testing Unlicensed Wireless Devices
ANSI C95.1:2005	IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
CISPR 16-4-2: 2013	Uncertainty in EMC measurement
CISPR 22: 2008 EN 55022: 2010	Information technology equipment

2 EQUIPMENT UNDER TEST

2.1 Photo documentation of the EUT

Detailed photos see Attachment B

2.2 Equipment category

Bluetooth Low Energy device, fixed equipment.

2.3 Short description of the equipment under test (EUT)

The EUT is a BLE USB dongle which converts wireless commands in IR commands.

Number of tested samples	:	1 (emission test)	1 (CPC measurement)
Serial number	:	Pre-production sample	Pre-production sample
Firmware version	:	V 0.1.1	V 0.1.1

Items	Description
BT type	4.0 Low Energy
BT chipset type	Texas Instruments CC2541
Modulation	GFSK
Frequency range	2400 MHz to 2483.5 MHz
Channel numbers	40
Data rate (kbps)	1000
Antenna type	PCB

EUT configuration:
(The CDF filled by the applicant can be viewed at the test laboratory.)

2.4 Variants of the EUT

None

2.5 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan:

Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
37	2402	9	2422	18	2442	28	2462
0	2404	10	2424	19	2444	29	2464
1	2406	38	2426	20	2446	30	2466
2	2408	11	2428	21	2448	31	2468
3	2410	12	2430	22	2450	32	2470
4	2412	13	2432	23	2452	33	2472
5	2414	14	2434	24	2454	34	2474
6	2416	15	2436	25	2456	35	2476
7	2418	16	2438	26	2458	36	2478
8	2420	17	2440	27	2460	39	2480

Note: the marked frequencies are determined for final testing.

2.6 Transmit operating modes

The EUT uses GFSK and provide following data rate:

1000 kbps (kbps = *kilobits per second)*

2.7 Antenna

The following antenna shall be used with the EUT:

Number	Characteristic	Certification name	Plug	Frequency range (GHz)	Gain (dBi)
1	Omni	PCB antenna	none	2.4 - 2.4835	n/a

2.8 Power supply system utilised

Power supply voltage, V_{nom} : 5 VDC (USB powered)

2.9 Peripheral devices and interface cables

The following peripheral devices and interface cables are connected during the measurements:

- Laptop Model : Siemens Fujitsu Lifebook E780
- AC/DC adapter (test A4) Model : HYCell AN2612 (from the shelf)
- Remote control (test A4) Model : 2779 (supplied by the manufacturer)

2.10 Determination of worst case conditions for final measurement

Measurements have been made in all three orthogonal axes and the settings of the EUT were changed to locate at which position and at what setting of the EUT produce the maximum of the emissions. For the further measurement the EUT is set in X position with the following settings:

BT 4.0 LE	Available channels	Tested channels	Power setting	Modulation	Data rate
802.15.1	00 to 39	37, 18, 39	0 dBm	GFSK	1000 kbps

1000 kbps, GFSK with TX continuous modulated.

2.10.1 Test jig

No Test jig was used for test.

2.10.2 Test software

The device for emission test uses a special firmware that allows enabling a continuous modulated output signal.

3 TEST RESULT SUMMERY

Operating in the 2400 MHz – 2483.5 MHz band:

FCC Rule Part	RSS Rule Part	Description	Result
15.35(c)	RSS-Gen, 6.10	Pulsed operation	passed
15.203	RSS Gen, 8.3	Antenna requirement	passed
15.204	RSS Gen, 8.2	External radio frequency power amplifiers	passed
15.205(a)	RSS Gen, 8.1	Emissions in restricted bands	passed
15.207(a)	RSS Gen, 8.8	AC power line conducted emissions	passed
15.215(c)	-	EBW	passed
-	RSS-Gen, 6.6	OBW	passed
15.249(a)	RSS-210, A2.9(a)	Field strength of fundamental	passed
15.249(d)	RSS-210, A2.9(b)	Out-of-band emission, radiated	passed
-	RSS-Gen, 6.11	Transmitter frequency stability	not applicable

The mentioned RSS Rule Parts in the above table are related to:
RSS Gen, Issue 4, November 2014
RSS 210, Issue 8, December 2010

3.1 Final assessment

The equipment under test fulfills the EMI requirements cited in clause 1 test standards.

Date of receipt of test sample : acc. to storage records

Testing commenced on : 02 May 2016

Testing concluded on : 24 June 2016

Checked by:

Klaus Gegenfurtner
I confirm the correctness and Integrity of this document
2016.06.29 15:41:34 +02'00'

Klaus Gegenfurtner
Teamleader Radio

Tested by:

Konrad Graßl
I am the author of this document
2016.06.29 15:23:36 +02'00'

Konrad Graßl
Radio Team

4 TEST ENVIRONMENT

4.1 Address of the test laboratory

CSA Group Bayern GmbH
Ohmstrasse 1-4
94342 STRASSKIRCHEN
GERMANY

4.2 Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Temperature:	15-35 ° C
Humidity:	30-60 %
Atmospheric pressure:	86-106 kPa

4.3 Statement of the measurement uncertainty

The data and results referenced in this document are true and accurate. It is noted that the expanded measurement uncertainty corresponds to the measurement results from the standard measurement uncertainty multiplied by the coverage factor k = 2. The true value is located in the corresponding interval with a probability of 95 % The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16-4-2 / 11.2003 „Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements“ and is documented in the quality system acc. to DIN EN ISO/IEC 17025. For all measurements shown in this report, the measurement uncertainty of the test laboratory, CSA Group Bayern GmbH, is below the measurement uncertainty as defined by CISPR. Therefore, no special measures must be taken into consideration with regard to the limits according to CISPR. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Measurement uncertainty	
Test	**Uncertainty**
Conducted emissions mains	± 3.1 dB
Power spectral density	± 2.7 dB
bandwidth measurement	± 100 kHz (depends on the used RBW)
Maximum output power	± 1.0 dB
Spurious emissions radiated below 30 MHz	± 3 dB
Spurious emissions radiated 30 MHz to 1 GHz	± 4.4 dB
Spurious emissions radiated 1 GHz to 12.75 GHz	± 3.7 dB
Spurious emissions radiated above 12.75 GHz	± 5.0 dB

4.4 Measurement protocol for FCC and IC

4.4.1 General information

4.4.1.1 Test methodology

Conducted and radiated disturbance testing is performed according to the procedures set out by the International Special Committee on Radio Interference (CISPR) Publication 22, European Standard EN 55022 as shown under section 1 of this report.

The Open Area test site is a listed Open Site under the Canadian Test-Sites File-No:

IC 3009A-01

The anechoic chamber site is a listed chamber under the Canadian Test-Sites File-No:

IC 3009A-02

In compliance with RSS 210 testing for RSS compliance may be achieved by following the procedures set out in ANSI C63.4 and applying the CISPR 22 limits.

4.4.1.2 Justification

The equipment under test (EUT) is configured in a typical user arrangement in accordance with the manufacturer's instructions. A cable is connected to each available port and either terminated with a peripheral using the appropriate impedance characteristic or left unterminated. Where appropriate, cables are manually manipulated with respect to each other thus obtaining maximum disturbances from the unit.

4.4.1.3 Details of test procedures

The test methods used comply with CISPR Publication 22, EN 55022 - " Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement" and with ANSI C63.4 - "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". In compliance with 47 CFR Part 15 Subpart A, Section 15.38 testing for FCC compliance may be achieved by following the procedures set out in ANSI C63.4 and applying the CISPR 22 limits.

5 TEST CONDITIONS AND RESULTS

5.1 AC power line conducted emissions

For test instruments and accessories used see section 6 Part **A 4**.

5.1.1 Description of the test location

Test location: AREA4

5.1.2 Photo documentation of the test set-up

5.1.3 Applicable standard

According to FCC Part 15, Section 15.207(a):
Except as shown in paragraphs (b) and (c) of this Section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the given limits.

5.1.4 Description of Measurement

The measurements are performed following the procedures set out in ANSI C63.4 described under item 4.4.3. If the minimum limit margin appears to be less than 20 dB with a peak mode measurement, the emissions are remeasured using a tuned receiver with quasi-peak and average detection and recorded on the data sheets.

5.1.5 Test result

Frequency range:	0.15 MHz - 30 MHz
Min. limit margin	21.69 dB at 0.6675 MHz

Limit according to FCC Part 15, Section 15.207(a):

Frequency of Emission (MHz)	Conducted Limit (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56 *	56 to 46 *
0.5-5	56	46
5-30	60	50

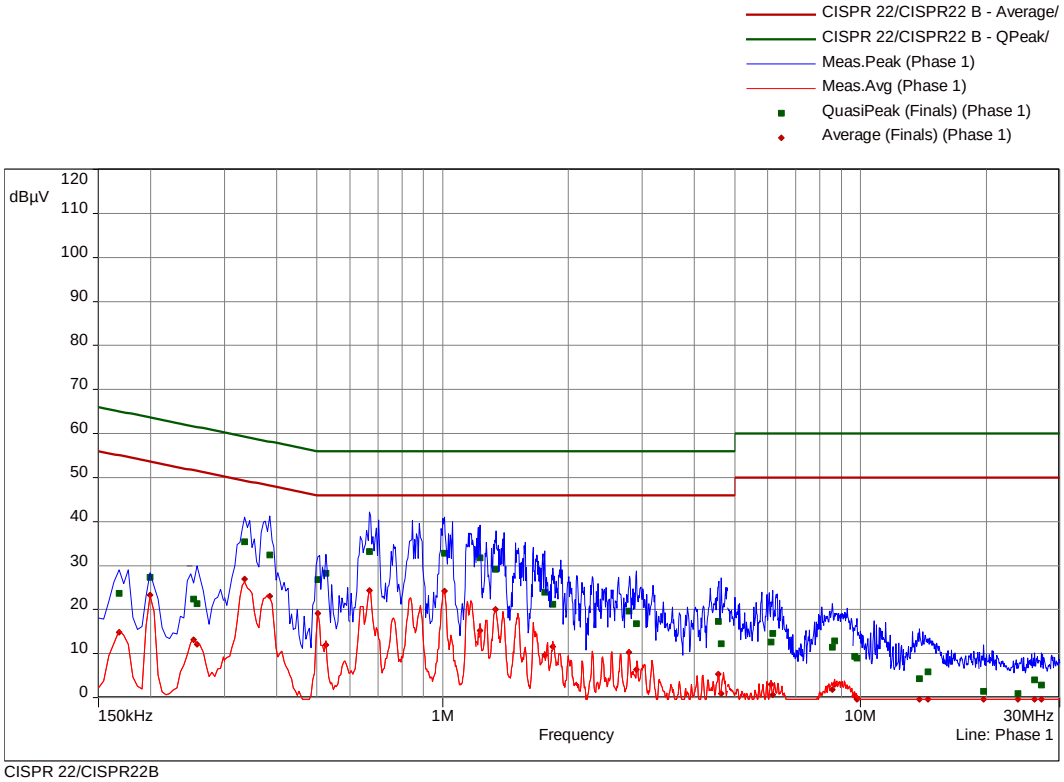
* Decreases with the logarithm of the frequency

The requirements are **FULFILLED.**

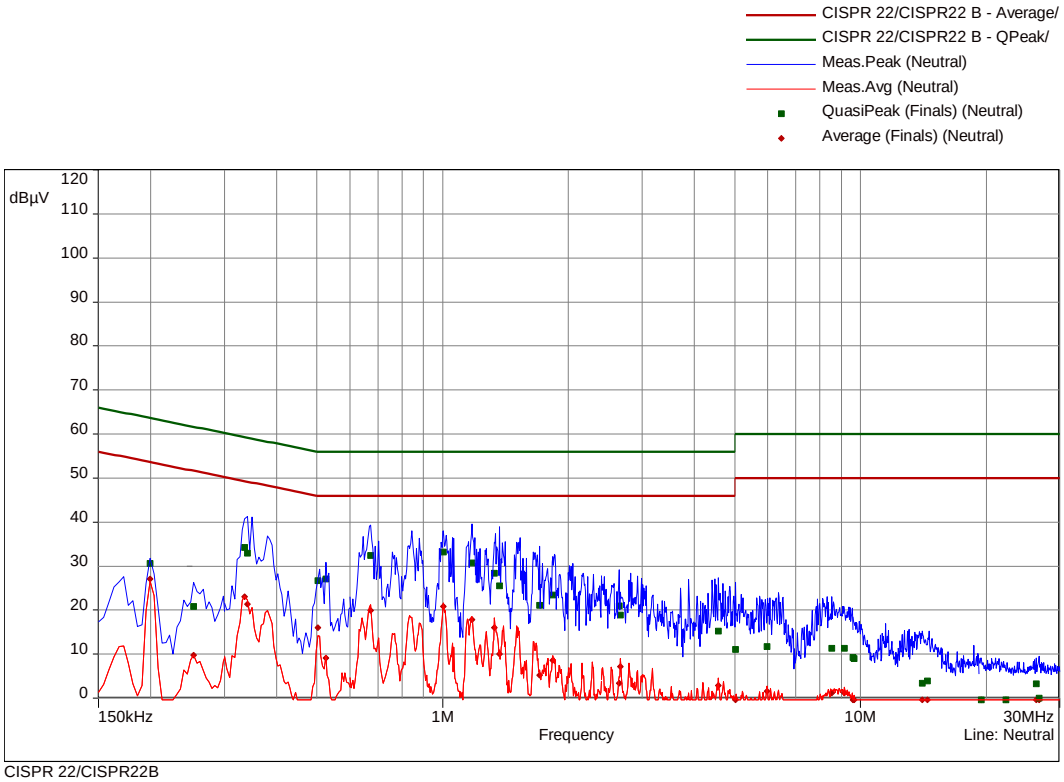
Remarks: For detailed test result please refer to following test protocols

5.1.6 Test protocol

Operation mode: EUT paired with remote control 2779



CISPR 22/CISPR22B



CISPR 22/CISPR22B

freq	SR	QP	margin	limit	AV	margin	limit	line
MHz		dB(µV)	dB	dB	dB(µV)	dB	dB	
0.168	1	23.75	41.31	65.06	14.83	40.22	55.06	Phase 1
0.1995	1	27.29	36.34	63.63	23.37	30.26	53.63	Phase 1
0.2535	1	22.45	39.20	61.64	13.11	38.53	51.64	Phase 1
0.258	1	21.34	40.15	61.50	12.07	39.42	51.50	Phase 1
0.336	2	35.42	23.88	59.30	26.96	22.34	49.30	Phase 1
0.3855	2	32.40	25.76	58.16	23.00	25.16	48.16	Phase 1
0.5025	2	26.80	29.20	56.00	19.19	26.81	46.00	Phase 1
0.525	2	28.27	27.73	56.00	11.98	34.02	46.00	Phase 1
0.6675	3	33.22	22.78	56.00	24.31	21.69	46.00	Phase 1
1.0095	3	32.77	23.23	56.00	24.22	21.78	46.00	Phase 1
1.227	4	31.80	24.20	56.00	15.27	30.73	46.00	Phase 1
1.3395	4	29.21	26.79	56.00	20.06	25.94	46.00	Phase 1
1.7535	4	23.91	32.09	56.00	9.69	36.31	46.00	Phase 1
1.8345	4	21.24	34.76	56.00	11.63	34.37	46.00	Phase 1
2.796	5	19.67	36.33	56.00	10.25	35.75	46.00	Phase 1
2.913	5	16.82	39.18	56.00	6.36	39.64	46.00	Phase 1
4.569	5	17.38	38.62	56.00	5.29	40.71	46.00	Phase 1
4.641	5	12.25	43.75	56.00	0.86	45.14	46.00	Phase 1
6.105	6	12.66	47.34	60.00	3.02	46.98	50.00	Phase 1
6.1635	6	14.65	45.35	60.00	0.63	49.37	50.00	Phase 1
8.5665	6	11.48	48.52	60.00	1.85	48.15	50.00	Phase 1
8.661	6	12.89	47.11	60.00	3.01	46.99	50.00	Phase 1
9.6855	7	9.40	50.60	60.00	0.42	49.58	50.00	Phase 1
9.807	7	9.05	50.95	60.00	-0.15	50.15	50.00	Phase 1
13.83	7	4.25	55.75	60.00	-2.15	52.15	50.00	Phase 1
14.532	7	5.85	54.15	60.00	-1.39	51.39	50.00	Phase 1
19.6995	8	1.39	58.61	60.00	-4.06	54.06	50.00	Phase 1
23.79	8	0.98	59.02	60.00	-3.91	53.91	50.00	Phase 1
26.1345	8	4.05	55.95	60.00	-1.47	51.47	50.00	Phase 1
27.111	8	2.90	57.10	60.00	-2.64	52.64	50.00	Phase 1
0.1995	9	30.62	33.01	63.63	27.05	26.58	53.63	Neutral
0.2535	9	20.89	40.75	61.64	9.82	41.82	51.64	Neutral
0.336	10	34.25	25.05	59.30	22.99	26.31	49.30	Neutral
0.3405	10	32.95	26.24	59.19	21.41	27.78	49.19	Neutral
0.5025	10	26.68	29.32	56.00	16.03	29.97	46.00	Neutral
0.525	10	27.03	28.97	56.00	9.14	36.86	46.00	Neutral
0.672	11	32.45	23.55	56.00	19.91	26.09	46.00	Neutral
1.005	11	33.19	22.81	56.00	20.78	25.22	46.00	Neutral
1.176	11	30.72	25.28	56.00	17.82	28.18	46.00	Neutral
1.3305	12	28.41	27.59	56.00	15.97	30.03	46.00	Neutral
1.3665	12	25.58	30.42	56.00	10.07	35.93	46.00	Neutral
1.7085	12	21.12	34.88	56.00	5.25	40.75	46.00	Neutral
1.8345	12	23.45	32.55	56.00	8.59	37.41	46.00	Neutral
2.6475	13	21.03	34.97	56.00	3.36	42.64	46.00	Neutral

2.6655	13	18.92	37.08	56.00	7.14	38.86	46.00	Neutral
4.5735	13	15.21	40.79	56.00	2.90	43.10	46.00	Neutral
5.016	14	11.10	48.90	60.00	-0.88	50.88	50.00	Neutral
5.9745	14	11.66	48.34	60.00	1.61	48.39	50.00	Neutral
8.526	14	11.40	48.60	60.00	1.19	48.81	50.00	Neutral
9.1605	14	11.34	48.66	60.00	1.12	48.88	50.00	Neutral
9.6045	15	9.27	50.73	60.00	-1.36	51.36	50.00	Neutral
9.672	15	8.98	51.02	60.00	-0.77	50.77	50.00	Neutral
14.0415	15	3.33	56.67	60.00	-4.21	54.21	50.00	Neutral
14.487	15	3.90	56.10	60.00	-4.16	54.16	50.00	Neutral
19.4385	16	0.00	60.00	60.00	-5.00	55.00	50.00	Neutral
22.296	16	-0.02	60.02	60.00	-4.92	54.92	50.00	Neutral
26.3235	16	3.21	56.79	60.00	-1.62	51.62	50.00	Neutral
26.805	16	0.07	59.93	60.00	-4.70	54.70	50.00	Neutral

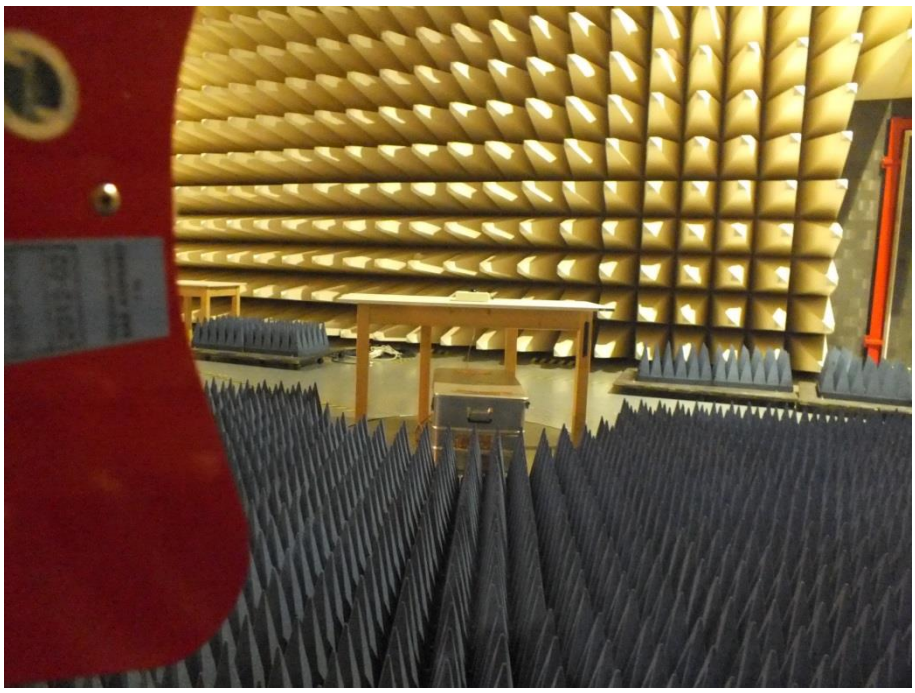
5.2 Field strength of fundamental

For test instruments and accessories used see section 6 Part **CPR 3**.

5.2.1 Description of the test location

Test location: Anechoic chamber 1
Test distance: 3 m

5.2.2 Photo documentation of the test set-up



5.2.1 Applicable standard

According to FCC Part 15C, Section 15.249(a):
The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the effective limits.

5.2.2 Description of Measurement

The radiated emission of the fundamental wave from the EUT is measured using a spectrum analyser and appropriate linear polarized antennas. The set up of the EUT and the measurement procedure is in accordance to ANSI C63.10, Item 6.5. The EUT is measured in TX continuous mode modulated under normal conditions.

Analyser settings:
Peak measurement: RBW: 3 MHz VBW: 10 MHz Detector: Max peak

5.2.3 Test result

Frequency	Level PK	Limit PK	Margin PK	Level AV	Limit AV	Margin AV
(MHz)	dB(µV/m)	dB(µV/m)	(dB)	dB(µV/m)	dB(µV/m)	(dB)
2402	92.2	114.0	-21.8	42.7	94.0	-51.3
2442	90.4	114.0	-23.6	44.9	94.0	-49.1
2480	90.0	114.0	-24.0	40.5	94.0	-53.5

Note: The correction factor includes cable loss and antenna factor.
Additional the peak values are corrected with the duty cycle of -49.5 dB to get the average value.

Average-Limit according to FCC Part 15C, Section 15.249(a):

Frequency	Field strength of fundamental	
(MHz)	(mV/m)	dB(µV/m)
902 - 928	50	94
2400 - 2483.5	**50**	**94**
5725-5875	50	94
24000 - 24250	250	108

Peak-Limit according to FCC Part 15C, Section 15.249(e):
However the peak fieldstrength shall not exceed the maximum permitted average limit by more than 20 dB.

The requirements are **FULFILLED.**

Remarks: _____

_____

5.3 Out-of-band emission, radiated

For test instruments and accessories used see section 6 Part **SER1, SER 2, SER 3**.

5.3.1 Description of the test location

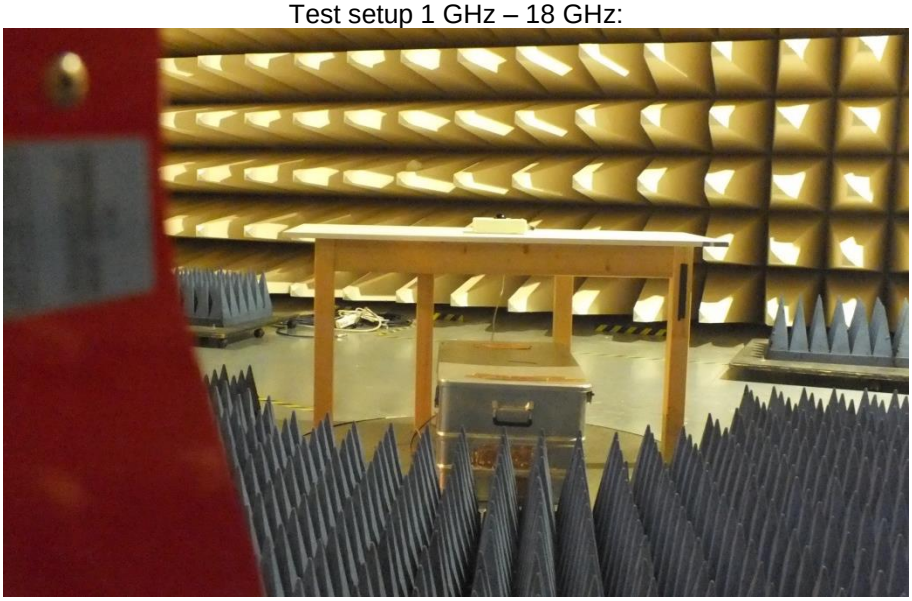
Test location: OATS 1
Test location: Anechoic chamber 1

Test distance: 3 m

5.3.2 Photo documentation of the test set-up

Test setup 30 MHz – 1000 MHz:

Test setup 1 GHz – 18 GHz:



5.3.3 Applicable standard

According to FCC Part 15C, Section 15.249 (d):
Emission radiated outside of the specified frequency bands, except harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated limit in FCC Part 15C, Section 15.209, whichever is the lesser attenuation.

5.3.4 Description of Measurement

The radiated emissions from the EUT are measured in the frequency range of 9 kHz to 1000 MHz using a tuned receiver and appropriate broadband linearly polarized antennas. The setup of the EUT and the measurement procedure is in accordance to ANSI C63.10, Item 6.3. In the frequency range above 1 GHz a spectrum analyser is used with appropriate linear polarized antennas. If the emission level in peak mode complies with the average limit testing is stopped and peak values will be reported, otherwise, the emission is measured in average mode again and reported. The EUT is measured in TX continuous mode modulated under normal conditions.

Instrument settings:

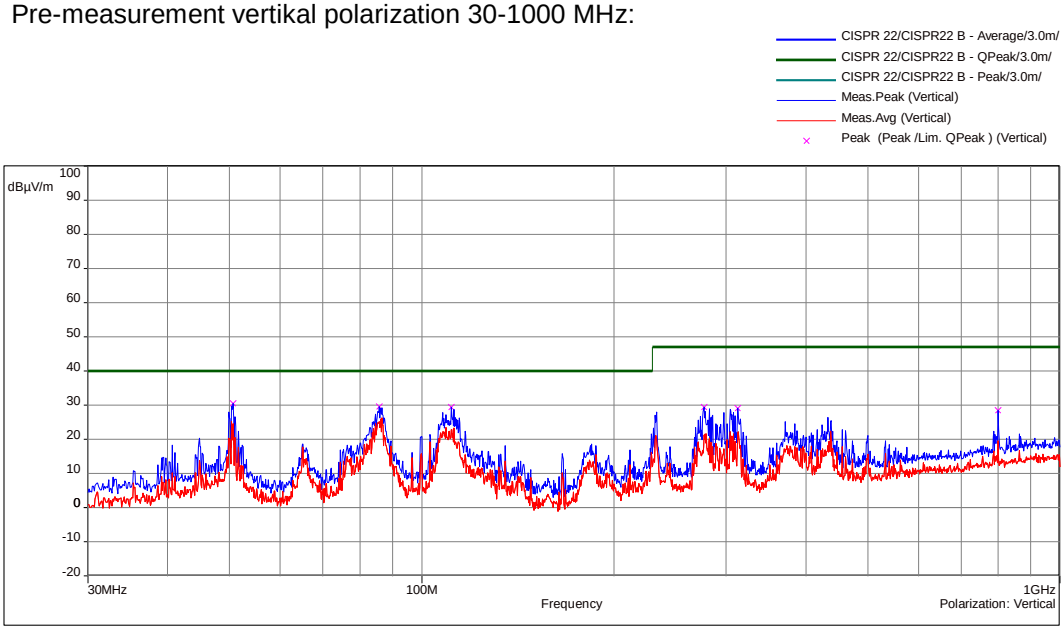
9 kHz – 150 kHz	RBW:	200 Hz
150 kHz - 30 MHz	RBW:	9 kHz
30 MHz – 1000 MHz:	RBW:	120 kHz
1000 MHz – 25 GHz	RBW:	1 MHz

5.3.1 Test result

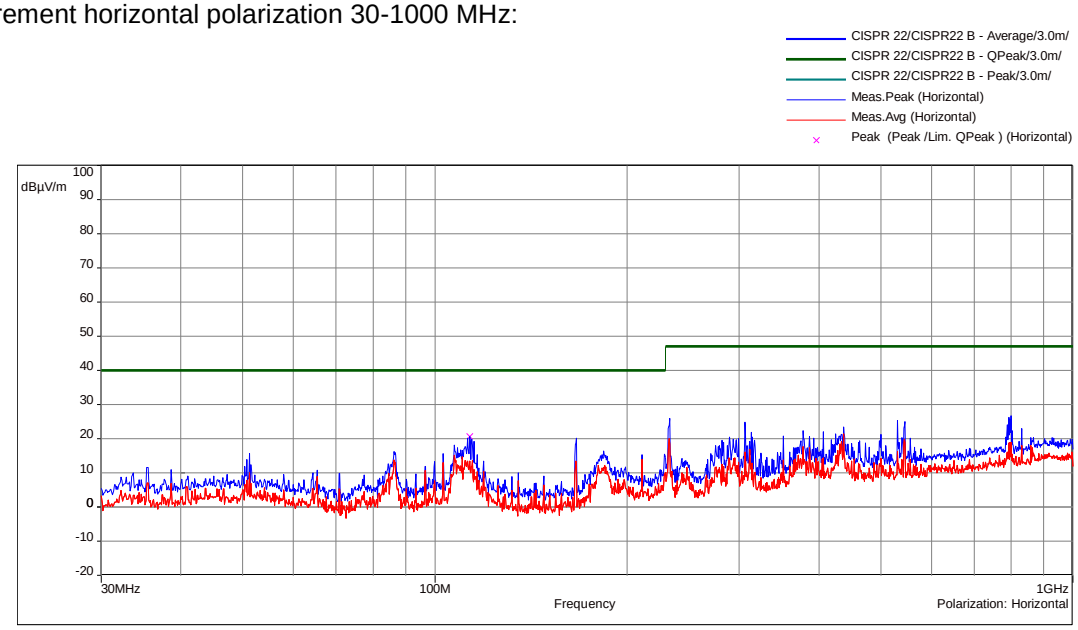
Note:
Pre-measurements were performed in the frequency range 9 kHz to 30 MHz, 30 MHz to 1000 MHz and 18 GHz to 25 GHz. The EUT showed no detectable suspects.

Only for reference the plots of the pre-measurement in TX mode at 2402 MHz

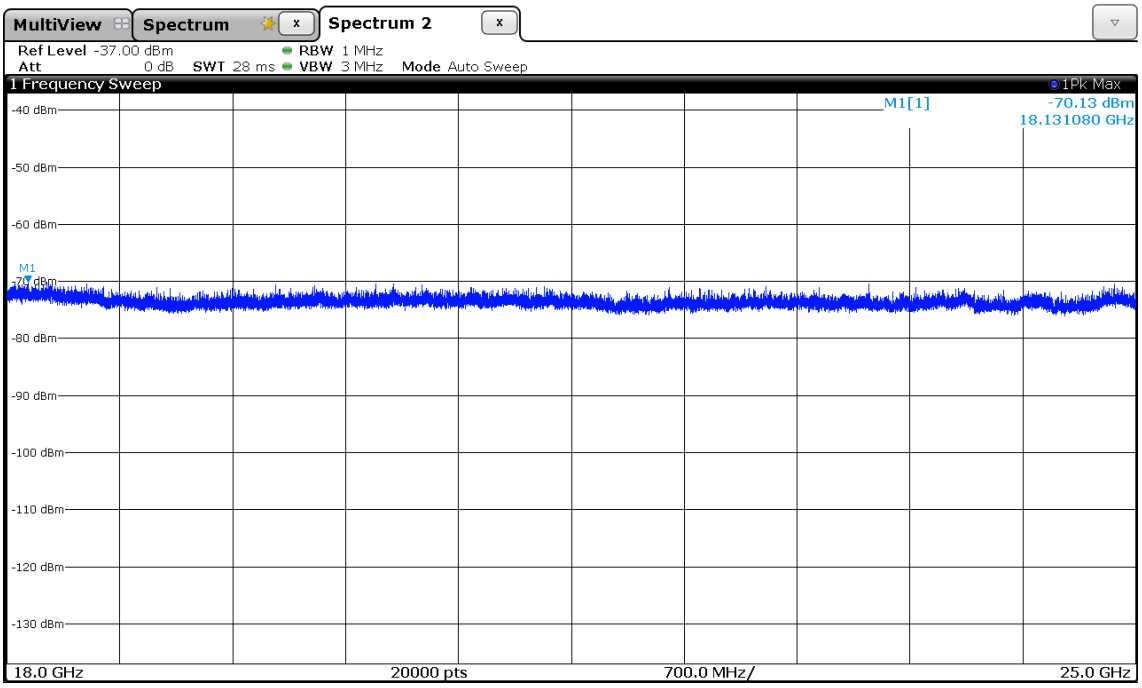
Pre-measurement vertikal polarization 30-1000 MHz:



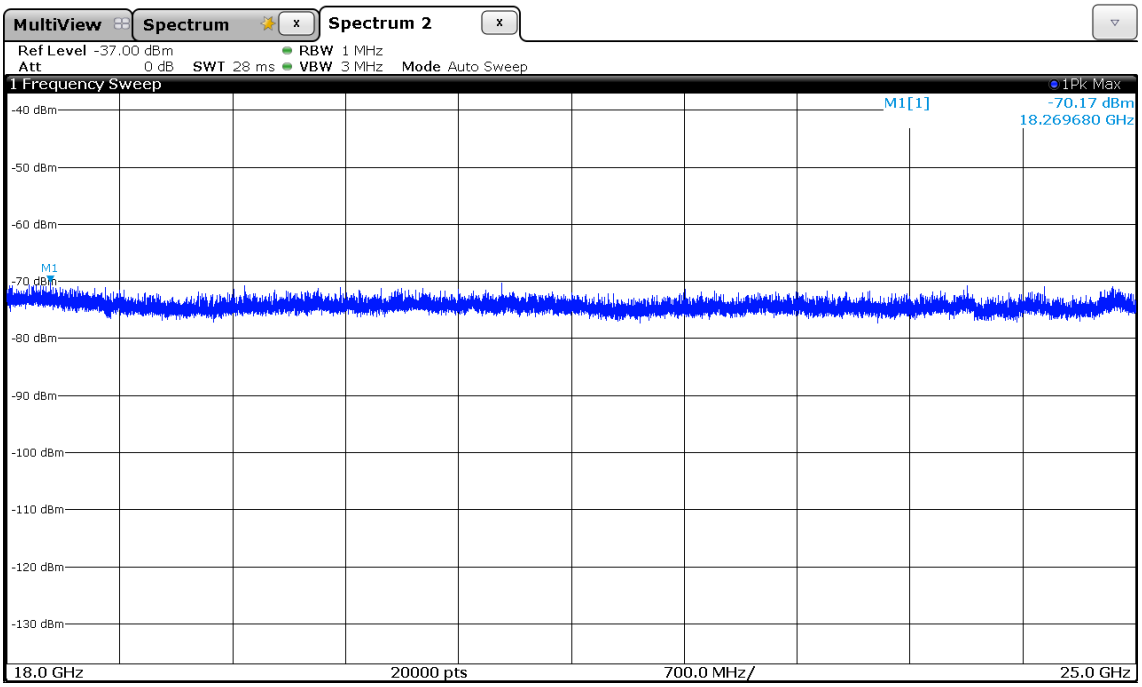
Pre-measurement horizontal polarization 30-1000 MHz:



Pre-measurement vertikal polarization 18 GHz to 25 GHz:



Pre-measurement horizontal polarization 18 GHz to 25 GHz:



5.3.2 Test result f 30 MHz - 1000 MHz

Frequency (MHz)	Reading Vert. (dBµV)	Reading Hor. (dBµV)	Correct. Vert. (dB)	Correct. Hor. (dB)	Level Vert. (dBµV/m)	Level Hor. (dBµV/m)	Limit (dBµV/m)	Dlimit (dB)
50.60	5.2		15.1		20.3		40.0	-19.7
64.40	5.3		14.1		19.4		40.0	-20.6
83.40	6.1		10.0		16.1		40.0	-23.9
114.90		12.3		11.6		23.9	43.5	-19.6
165.90	10.9		13.4		24.3		43.5	-19.2
232.30		16.2		12.7		28.9	46.0	-17.1
272.40		8.0		14.6		22.6	46.0	-23.4
306.30		10.3		16.0		26.3	46.0	-19.7
318.40	6.1		16.8		22.9		46.0	-23.1
372.10		7.2		17.8		25.0	46.0	-21.0
427.80		7.1		19.4		26.5	46.0	-19.5
474.30	6.3		21.0		27.3		46.0	-18.7
480.00		10.1		21.0		31.1	46.0	-14.9
533.30		18.7		22.4		41.1	46.0	-4.9
864.00		7.8		28.4		36.2	46.0	-9.8

Note:
The correction factor includes cable loss and antenna factor. No emission difference could be detected for the intentional radiated frequencies 2402 MHz, 2450 MHz and 2480 MHz within the frequency range from 30 MHz to 1000 MHz. The values show only the noise floor of the OATS 1, but there were no values measureable belonging to the EUT.

5.3.3 Test result f > 1 GHz

2402 MHz

Peak limit:

Detector	Frequency (MHz)	Reading Vert. (dBµV)	Reading Hor. (dBµV)	Correct. Vert. (dB)	Correct. Hor. (dB)	Level Vert. (dBµV/m)	Level Hor. (dBµV/m)	Limit (dBµV/m)	Dlimit (dB)
Peak	2400.00	68.2	76.6	-14.6	-14.6	53.6	62.0	74.0	-12.0
Peak	4108.00	42.0		-0.7		41.4		74.0	-32.6
Peak	4804.00	43.1	44.1	2.3	2.3	45.4	46.4	74.0	-27.6
Peak	12480.00	47.9		1.5		49.5		74.0	-24.5
Peak	12505.00		47.9		1.5		49.3	74.0	-24.7
Peak	12861.00		48.2		2.0		50.1	74.0	-23.9
Peak	14345.00	47.8		1.6		49.5		74.0	-24.5
Peak	14886.00	48.4		2.1		50.4		74.0	-23.6
Peak	16581.00	47.8		5.4		53.2		74.0	-20.8

Average limit:

Detector	Frequency (MHz)	Reading Vert. (dBµV)	Reading Hor. (dBµV)	Correct. Vert. (dB)	Correct. Hor. (dB)	Level Vert. (dBµV/m)	Level Hor. (dBµV/m)	Limit (dBµV/m)	Dlimit (dB)
Peak	4108.00	42.0		-0.7		41.4		54.0	-12.6
Peak	4804.00	43.1	44.1	2.3	2.3	45.4	46.4	54.0	-7.6
Peak	12480.00	47.9		1.5		49.5		54.0	-4.5
Peak	12505.00		47.9		1.5		49.3	54.0	-4.7
Peak	12861.00		48.2		2.0		50.1	54.0	-3.9
Peak	14345.00	47.8		1.6		49.5		54.0	-4.5
Peak	14886.00	48.4		2.1		50.4		54.0	-3.6
Peak	16581.00	47.8		5.4		53.2		54.0	-0.8

Apart of the value at 2400 MHz all peak values fulfil the average limit, therefore an average measurement is not required.
Calculation of the average value at 2400 MHz: peak value – DC = average value
62 dBµV/m – 49.5 dB = 12.5 dBµV/m

Frequency	Reading PK	D factor	Level AV	Limit AV	Delta
(MHz)	dB(µV)	dB(µV/m)	dB(µV/m)	dB(µV/m)	(dB)
2400	62.0	-49.5	12.5	54.0	-41.5

2442 MHz

Detector	Frequency (MHz)	Reading Vert. (dBµV)	Reading Hor. (dBµV)	Correct. Vert. (dB)	Correct. Hor. (dB)	Level Vert. (dBµV/m)	Level Hor. (dBµV/m)	Limit (dBµV/m)	Dlimit (dB)
Peak	1328.65	59.5		-19.6		39.9		54.0	-14.1
Peak	2400.00	53.9	53.7	-14.6	-14.6	39.2	39.1	54.0	-14.8
Peak	2483.50	53.2	53.8	-14.0	-14.0	39.3	39.8	54.0	-14.2
Peak	4883.40		44.2		2.3		46.5	54.0	-7.5
Peak	4884.20	41.9		2.3		44.2		54.0	-9.8
Peak	12920.20	48.0		2.1		50.1		54.0	-3.9
Peak	15769.80		48.4		3.9		52.3	54.0	-1.7
Peak	16581.40	44.6		5.4		50.0		54.0	-4.0

Note: All peak values fulfil the average limit, therefore an average measurement is not required.

2480 MHz

Detector	Frequency (MHz)	Reading Vert. (dBµV)	Reading Hor. (dBµV)	Correct. Vert. (dB)	Correct. Hor. (dB)	Level Vert. (dBµV/m)	Level Hor. (dBµV/m)	Limit (dBµV/m)	Dlimit (dB)
Peak	2400.00	54.0	53.9	-14.6	-14.6	39.4	39.3	54.0	-14.6
Peak	2483.50	60.0	64.7	-14.0	-14.0	46.0	50.7	54.0	-3.3
Peak	4114.00	36.4	35.5	-0.5	-0.5	35.9	35.0	54.0	-18.1
Peak	4884.20	37.2		2.3		39.5		54.0	-14.5
Peak	4957.80		41.4		2.7		44.1	54.0	-9.9
Peak	4959.40	43.7		2.7		46.4		54.0	-7.6
Peak	13260.60		44.9		1.3		46.2	54.0	-7.8
Peak	13491.00		47.9		1.3		49.2	54.0	-4.8
Peak	15714.20	48.0		3.6		51.6		54.0	-2.4
Peak	15741.80	44.3		3.7		48.0		54.0	-6.0

Note: All peak values fulfil the average limit, therefore an average measurement is not required.

Note: Average values were calculated from the subtraction of peak values minus correction duty cycle factor.

Limit according to FCC Part 15C, Section 15.209:

Frequency (MHz)	15.209 Limits (µV/m)	Measurement distance (m)
0.009 - -0.49	2400/f(kHz)	300
0.49 – 1.705	24000/f(kHz)	30
1.705 – 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

Average limit according to FCC Part 15C, Section 15.249(a):

Fundamental frequency	Field strength of harmonics	
(MHz)	(µV/m)	dB(µV/m)
902 - 928	500	54
2400 - 2483.5	500	54
5725 - 5875	500	54
24000 - 24250	2500	68

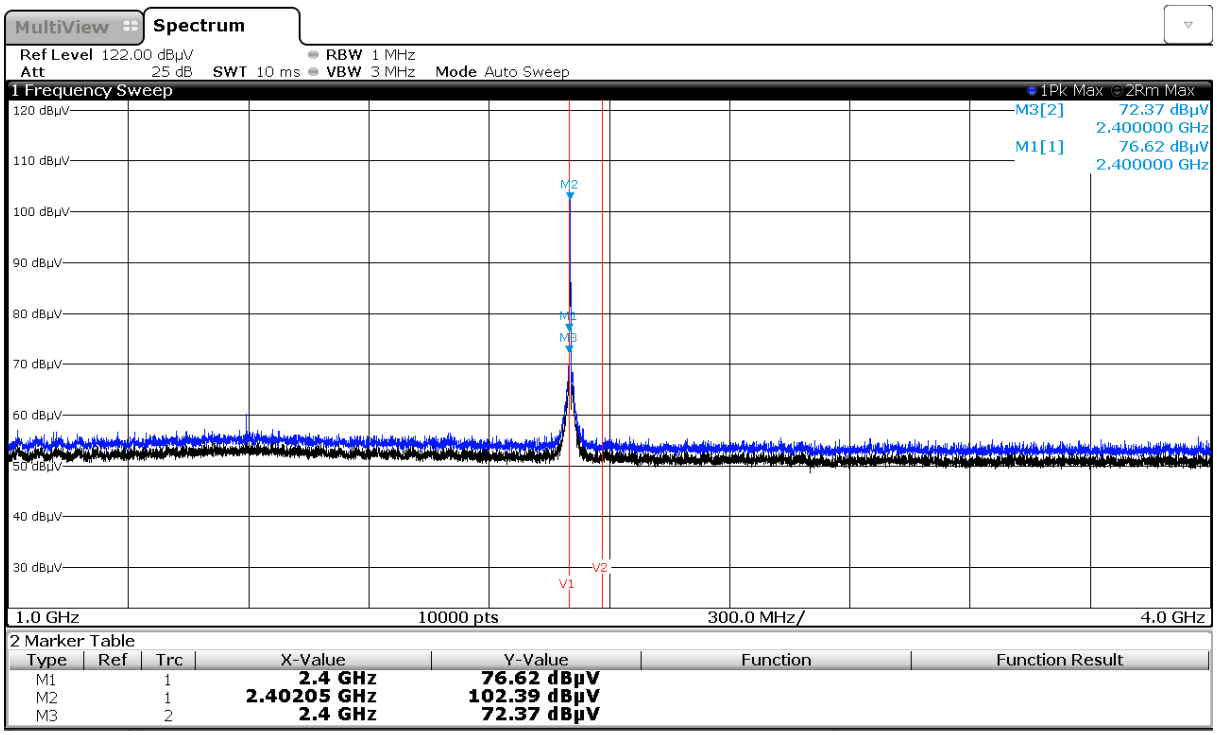
The requirements are **FULFILLED.**

Remarks: The measurement was performed up to the 10th harmonic (25000 MHz). For detailed test result please refer to following test protocols.

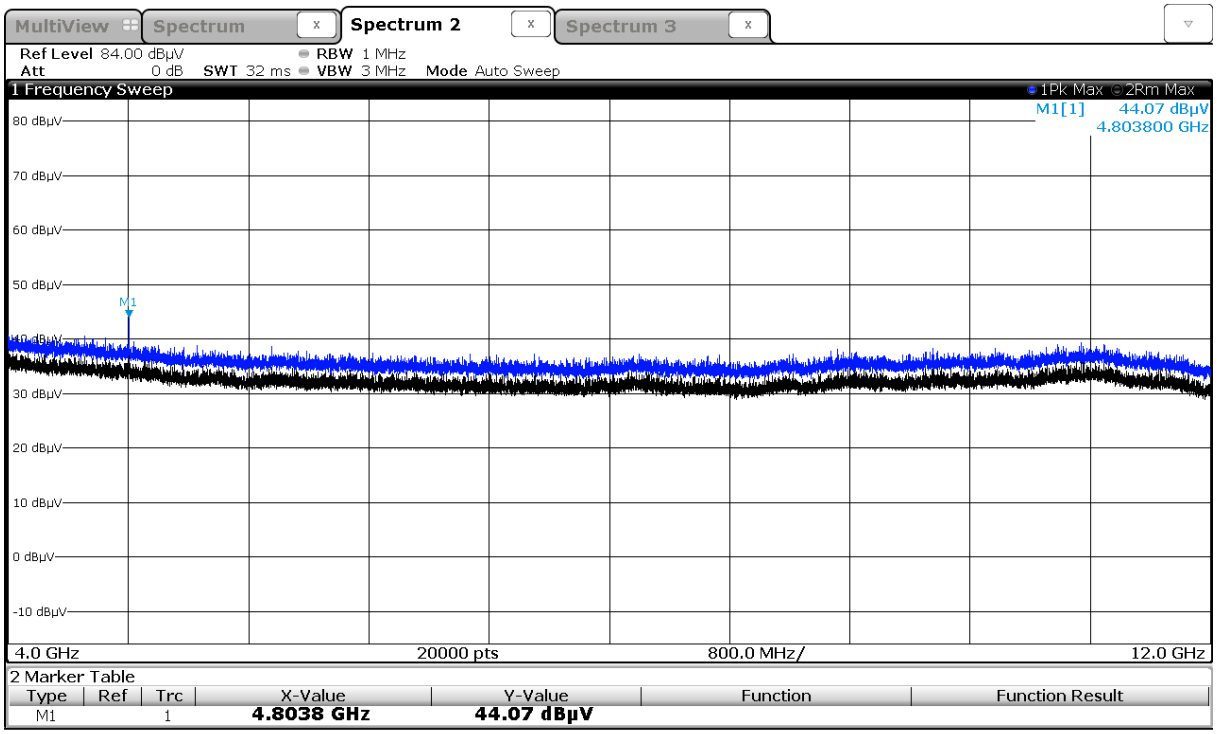
5.3.4 Test protocols

For reference the plots from 1 GHz up to 18 GHz (only raw data) at TX 2402 MHz

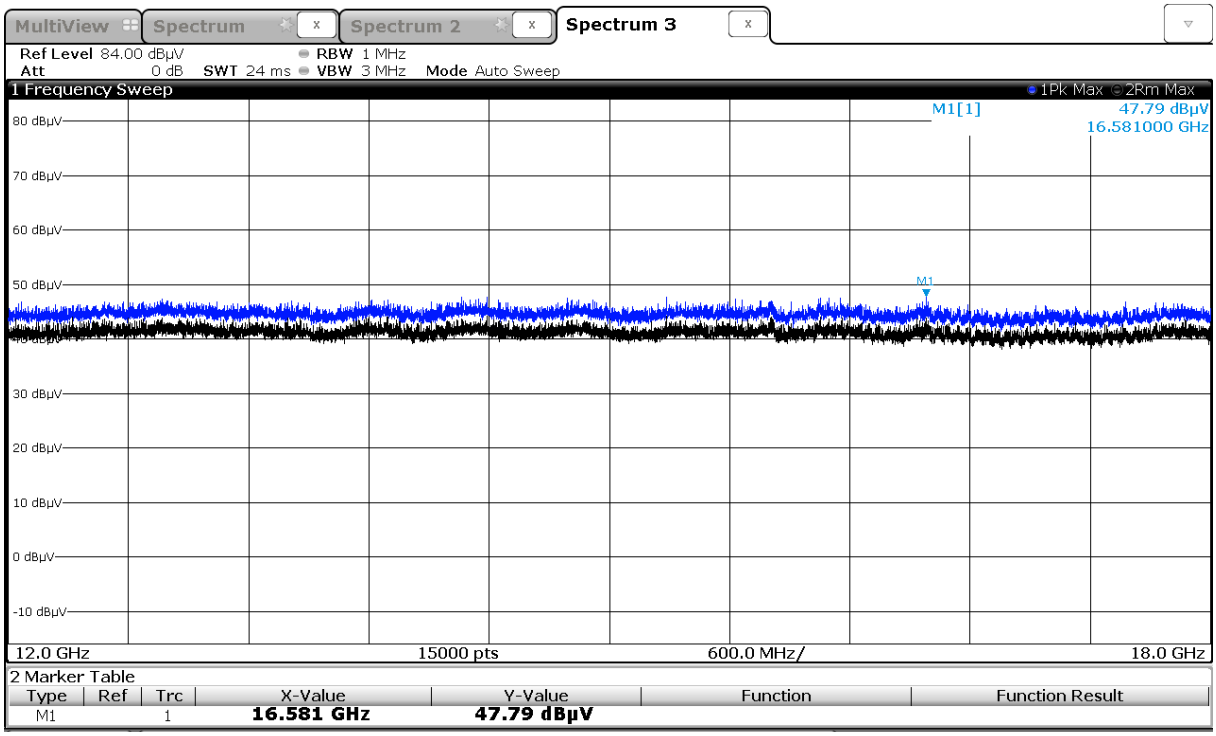
1-4 GHz



4-12 GHz



12-18 GHz


MultiView
Spectrum
Spectrum 2
Spectrum 3
Ref Level 84.00 dBµV
RBW 1 MHz
Att 0 dB
SWT 24 ms
VBW 3 MHz
Mode Auto Sweep
1 Frequency Sweep
1Pk Max
2Rm Max
M1[1]
47.79 dBµV
16.581000 GHz
80 dBµV
70 dBµV
60 dBµV
50 dBµV
30 dBµV
20 dBµV
10 dBµV
0 dBµV
-10 dBµV
12.0 GHz
15000 pts
600.0 MHz/
18.0 GHz
2 Marker Table
Type Ref Trc X-Value Y-Value Function Function Result
M1 1 16.581 GHz 47.79 dBµV

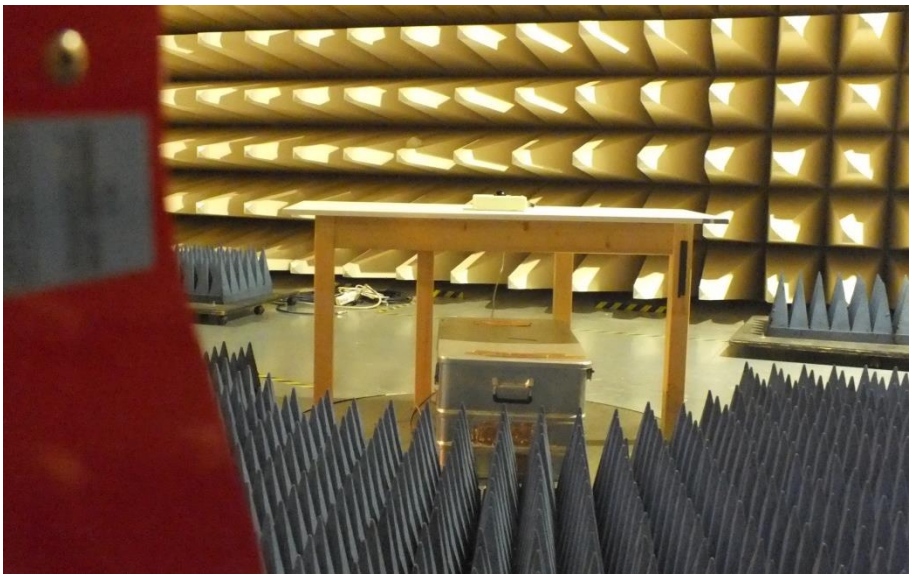
5.4 EBW and OBW

For test instruments and accessories used see section 6 Part **MB**.

5.4.1 Description of the test location

Test location: AREA4

5.4.2 Photo documentation of the test set-up



5.4.3 Applicable standard

According to FCC Part 15, Section 15.215(c):
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in Section 15.217 through Section 15.257, must be designed to ensure that the 20 dB bandwidth of the emission is contained within the frequency band designated in the rule section under which the equipment is operated.

5.4.4 Description of Measurement

The bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio of -20 dB (99%). The x-dB-down (OBW) function of the analyser is used. The measurement is performed with normal modulation in TX continuous mode.

Spectrum analyser settings:
RBW: 30 kHz, VBW: 100 kHz, Span: 3 MHz, Trace mode: max. hold, Detector: max. peak;

5.4.5 Test result

Centre *f*	20dB bandwidth	20dB bandwidth	Measured EBW
(MHz)	f_1	f_2	(MHz)
2402.17980	2401.38730	2402.97230	1.58500
2442.17305	2441.37230	2442.97380	1.60150
2480.18705	2479.38380	2480.99030	1.60650

Operating frequency band	20 dB Bandwidth
(MHz)	(MHz)
f_{low} > 2400	f_{low} = 2401.38730
f_{high}< 2483.5	f_{high} = 2480.99030
Operating Band occupancy	79.60

Operating Band occupancy percentage	95.33 %
Operating channel occupancy percentage	80.32 %

Centre *f*	99% bandwidth	99% bandwidth	Measured OBW
(MHz)	f_1	f_2	(MHz)
2401.979750	2401.45025	2402.509250	1.059000
2441.973750	2441.44425	2442.503250	1.059000
2479.985000	2479.44575	2480.524250	1.078500

Limit according to FCC Part 15C, Section 15.215(c):
If frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.Due to the channelising of the operating band into 39 channels with 20 dB channel bandwidth of 1.60 MHz within a channel pattern of 2 MHz the limit central 80% of the permitted band can not be applied. Therefore the stability of the EUT will be shown staying within the central 80% of the operating channel.

The requirements are **FULFILLED.**

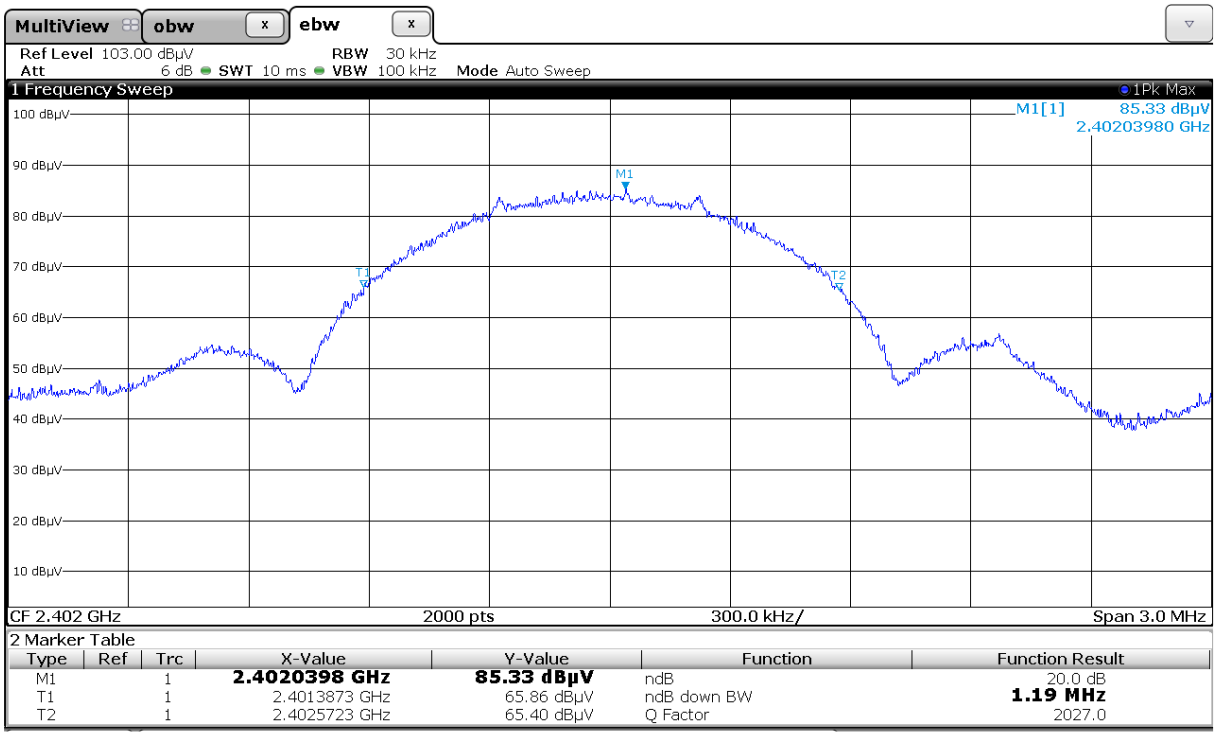
Remarks: For detailed test result please refer to following test protocols.

The OBW99 is measured for RSS only.

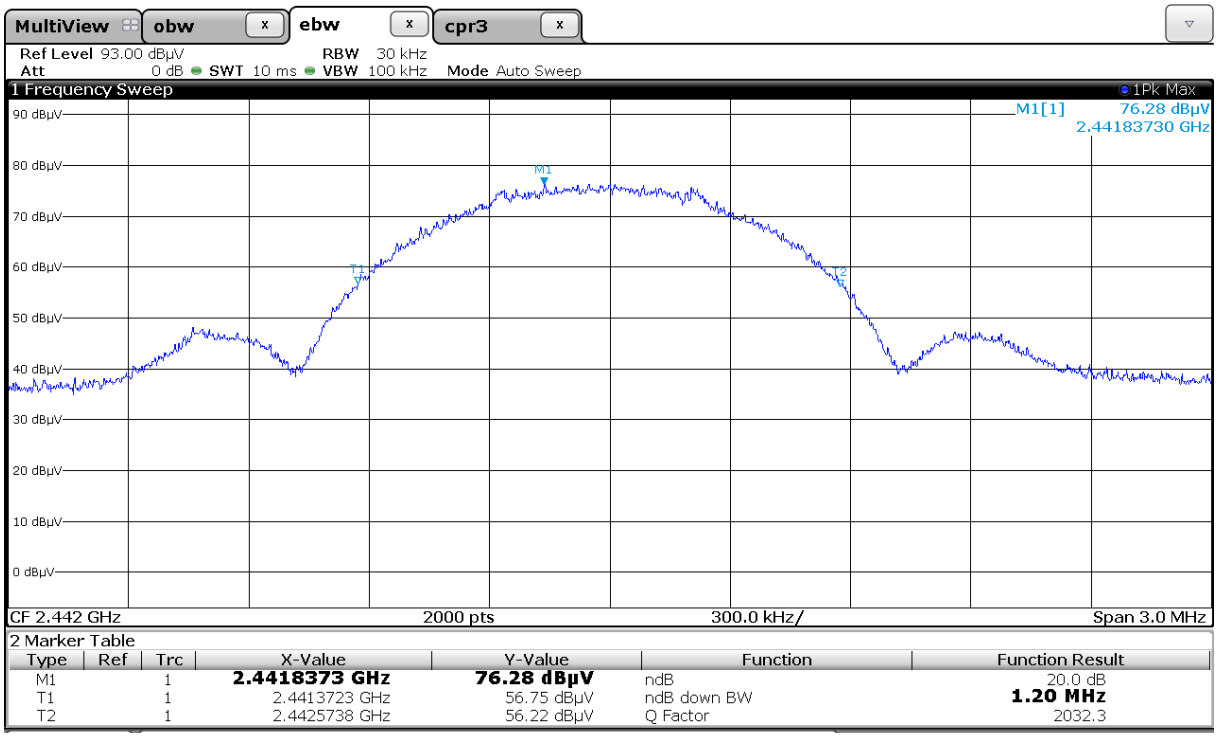
5.4.6 Test protocols

EBW

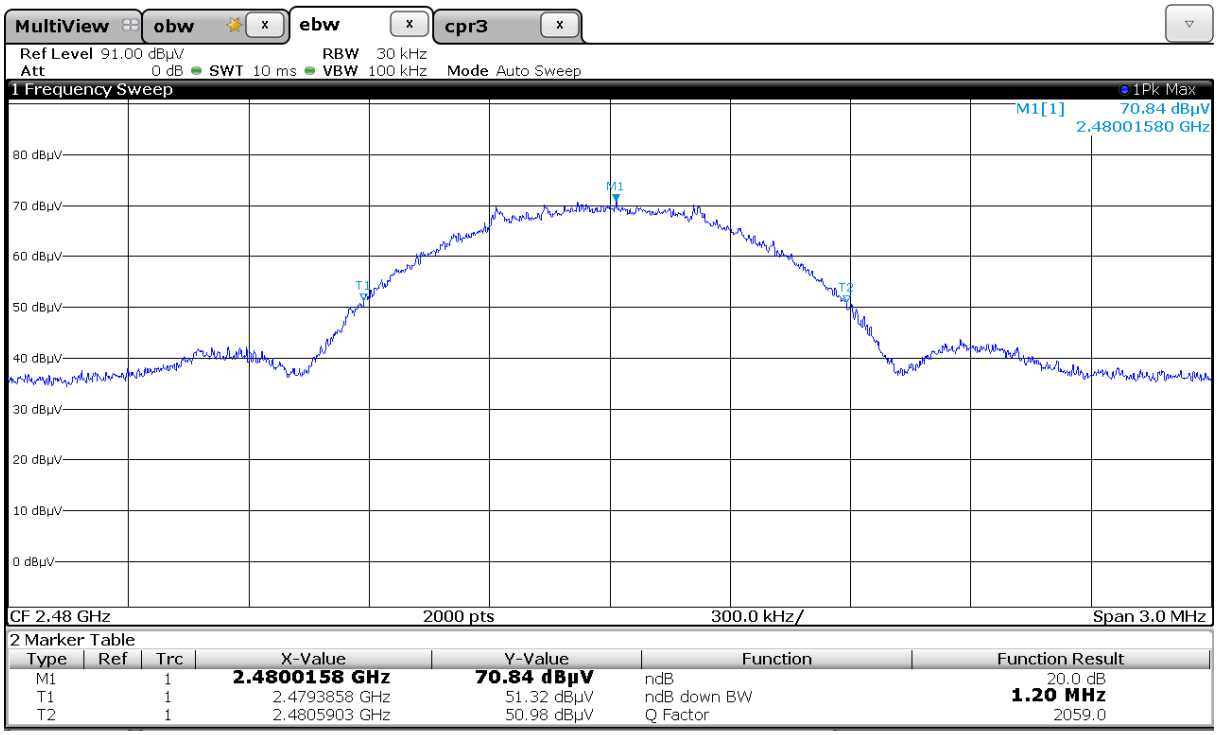
2402 MHz



2442 MHz

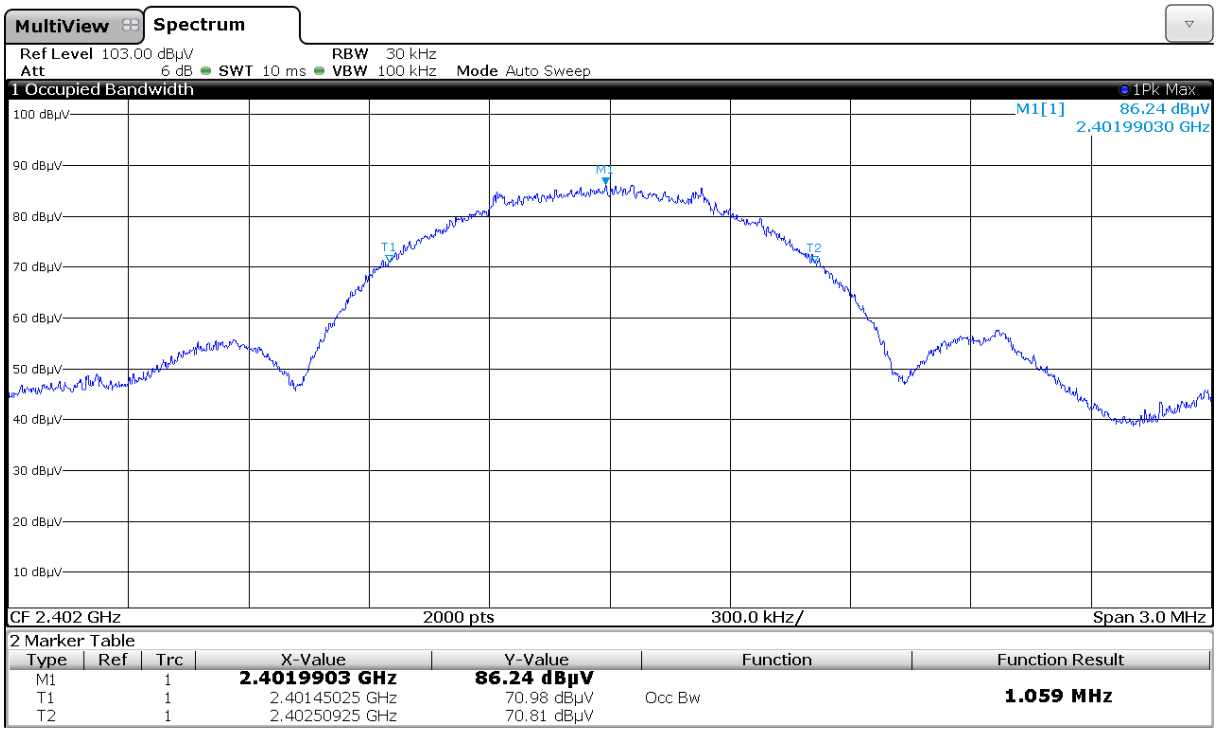


2480 MHz

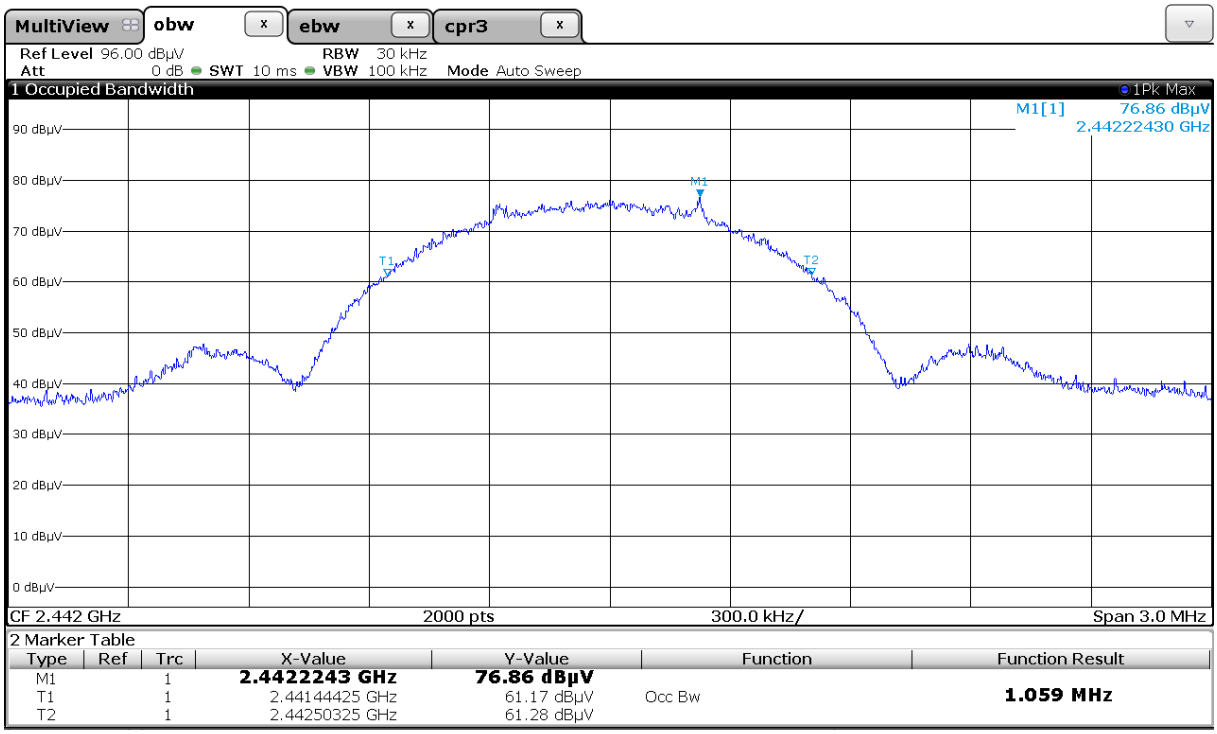

MultiView
obw
ebw
cpr3
Ref Level 91.00 dBµV
RBW 30 kHz
Att 0 dB SWT 10 ms VBW 100 kHz Mode Auto Sweep
1 Frequency Sweep
1Pk Max
M1[1] 70.84 dBµV
2.48001580 GHz
80 dBµV
70 dBµV
60 dBµV
50 dBµV
40 dBµV
30 dBµV
20 dBµV
10 dBµV
0 dBµV
M1
T1
T2
CF 2.48 GHz
2000 pts
300.0 kHz/
Span 3.0 MHz
2 Marker Table
Type Ref Trc X-Value Y-Value Function Function Result
M1 1 2.4800158 GHz 70.84 dBµV ndB 20.0 dB
T1 1 2.4793858 GHz 51.32 dBµV ndB down BW 1.20 MHz
T2 1 2.4805903 GHz 50.98 dBµV Q Factor 2059.0

OBW

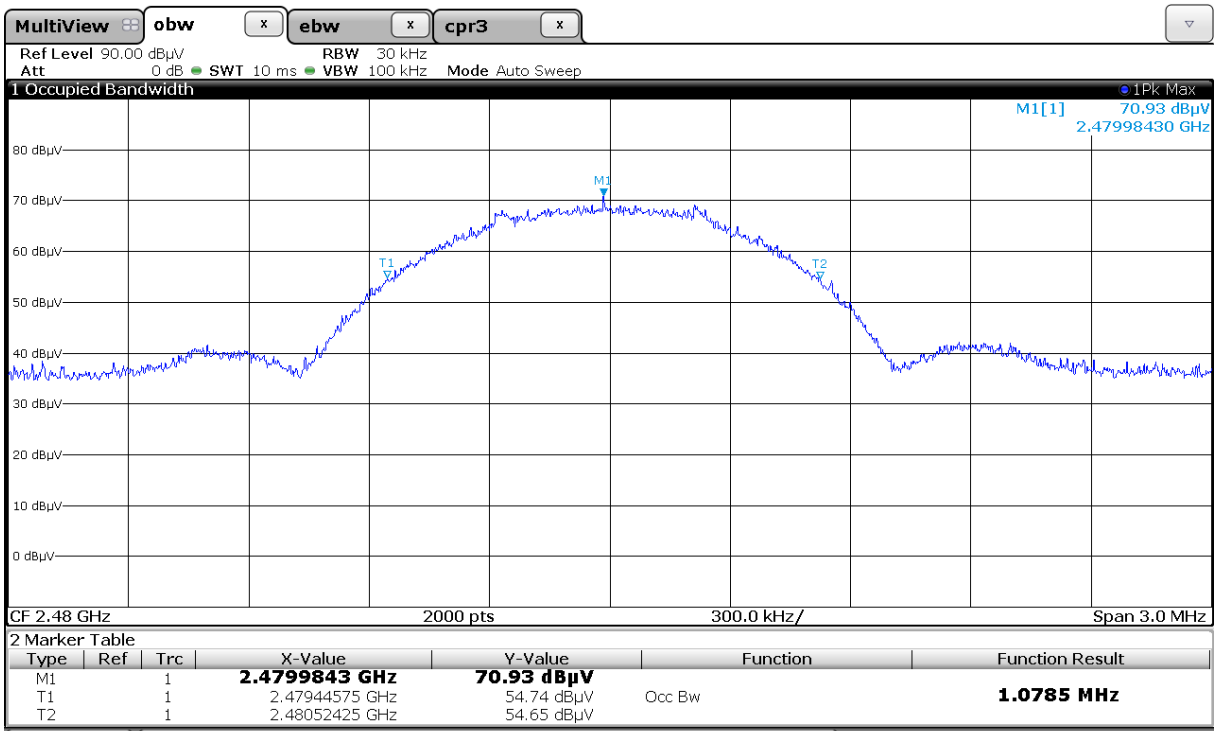
2402 MHz



2442 MHz



2480 MHz


MultiView
obw
ebw
cpr3
Ref Level 90.00 dBµV
RBW 30 kHz
Att 0 dB SWT 10 ms VBW 100 kHz Mode Auto Sweep
1 Occupied Bandwidth
1Pk Max
M1[1] 70.93 dBµV
2.47998430 GHz
80 dBµV
70 dBµV
60 dBµV
50 dBµV
40 dBµV
30 dBµV
20 dBµV
10 dBµV
0 dBµV
M1
T1
T2
CF 2.48 GHz
2000 pts
300.0 kHz/
Span 3.0 MHz
2 Marker Table
Type Ref Trc X-Value Y-Value Function Function Result
M1 1 2.4799843 GHz 70.93 dBµV
T1 1 2.47944575 GHz 54.74 dBµV Occ Bw 1.0785 MHz
T2 1 2.48052425 GHz 54.65 dBµV

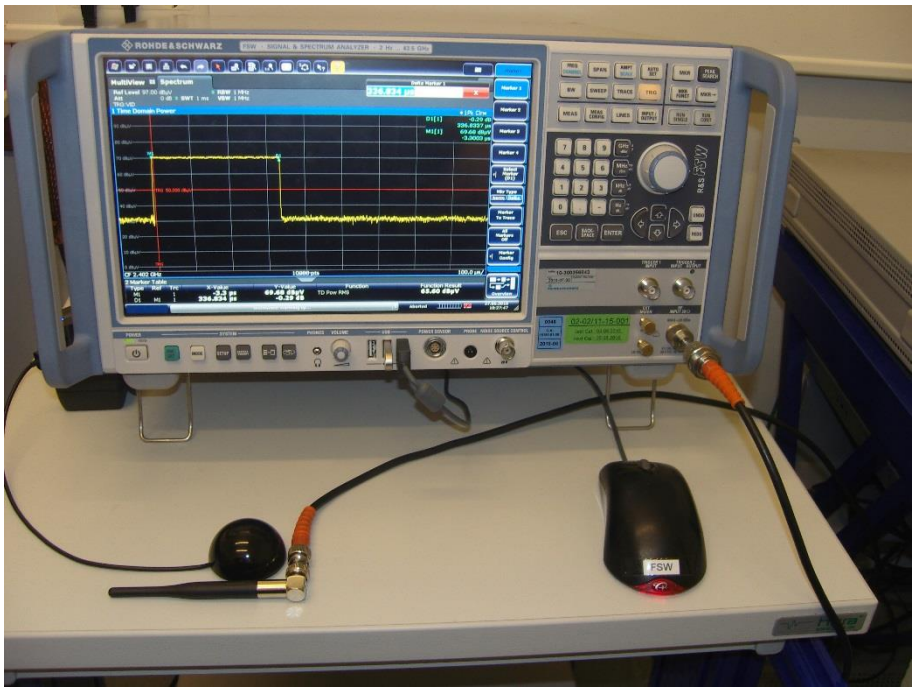
5.5 Correction for pulse operation (duty cycle)

For test instruments and accessories used see section 6 Part **DC**.

5.5.1 Description of the test location

Test location: Shielded Room S6

5.5.2 Photo documentation of the test set-up



5.5.3 Applicable standard

According to FCC Part 15A, Section 15.35(c):
When the radiated emission limits are expressed in terms of average value and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete puls train, including blanking intervals, as long as the pulse train does not exceed 0.1s. In cases where the puls train exceeds 0.1s, the measured field strength shall be determined from the average absolute voltage during a 0.1s interval during which the field strength is at its maximum. The exact method of calculating the average field strength shall be submitted.

5.5.4 Description of Measurement

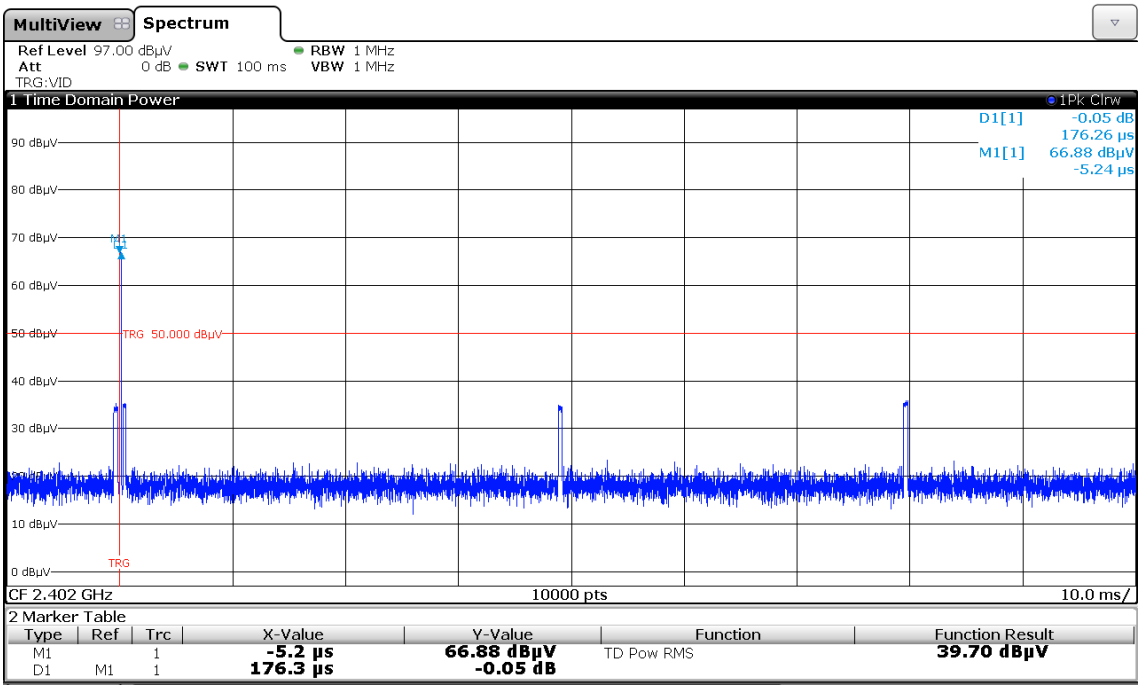
The duty cycle factor (dB) is calculated applying the following formula:

$$K_E = 20 \log (t_{iw}/0.1\ s)$$

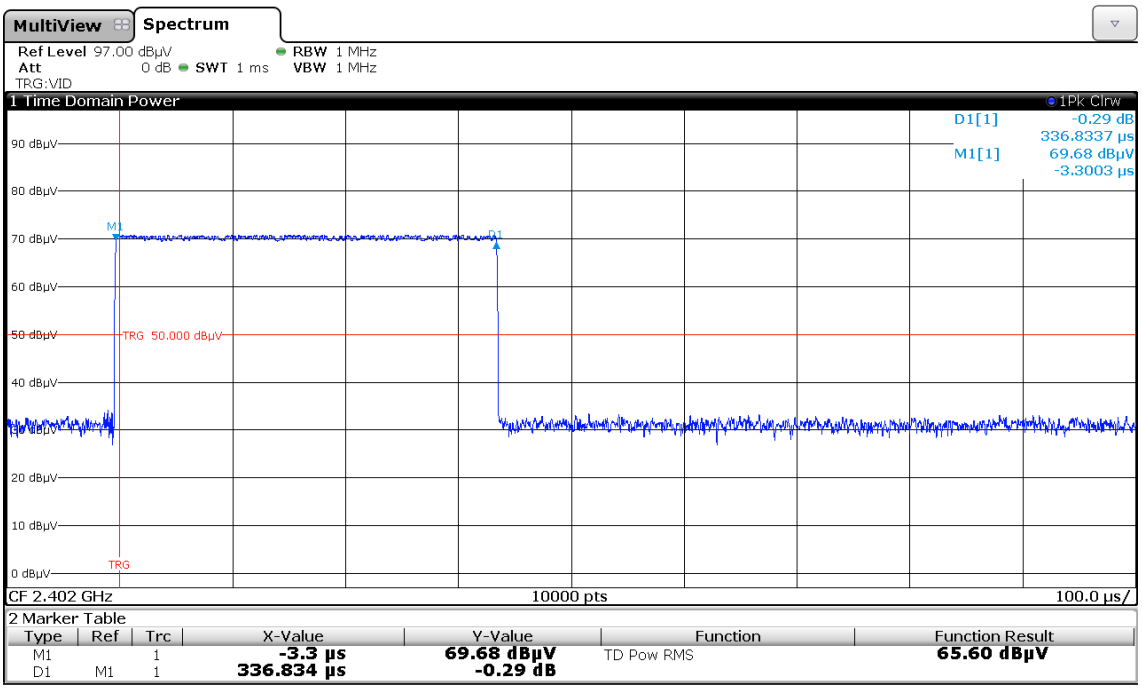
K_E: pulse operation correction factor
t_{iw} pulse duration for the complete pulse track

5.5.5 Test result

Sweeptime: 100 ms: 1 burst



Sweeptime: 1 ms: 1 burst Duration 336.8 µs (for more exactly measurement)



Note: The worst case regarding duty cycle of a BLE device is in advertising mode. Channel 37 was choosen for measurement.

Complete burst duration (1 bursts): 336.8 µs

KE = 20 log (336.8 µs */0.1 s*) = -49.5 dB

Remarks: _____

_____

_____

5.6 Antenna application

5.6.1 Applicable standard

According to FCC Part 15C, Section 15.203(a):
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section.

5.6.2 Result

The EUT uses an integrated PCB antenna. No other antenna than the furnished by the responsible party or external power amplifier can be applied by a customer.

The antenna of the EUT meets the requirement of FCC Part 15C, Section 15.203 and 15.204.

The requirements are **FULFILLED.**

Remarks: _____

_____

6 USED TEST EQUIPMENT AND ACCESSORIES

All test instruments used are calibrated and verified regularly. The calibration history is available on request.

Test ID	Model Type	Equipment No.	Next Calib.	Last Calib.	Next Verif.	Last Verif.
A 4	ESCI	02-02/03-15-001	23/05/2017	23/05/2016		
	ESH 2 - Z 5	02-02/20-05-004	26/10/2017	26/10/2015	09/12/2016	09/06/2016
	N-4000-BNC	02-02/50-05-138				
	N-1500-N	02-02/50-05-140				
	ESH 3 - Z 2	02-02/50-05-155	06/11/2016	06/11/2015	21/09/2016	21/03/2016
	6430	02-02/50-13-014				
CPR 3	FSW43	02-02/11-15-001	05/08/2016	05/08/2015		
	AFS5-12001800-18-10P-6	02-02/17-06-002				
	AFS4-01000400-10-10P-4	02-02/17-13-002				
	AMF-4F-04001200-15-10P	02-02/17-13-003				
	3117	02-02/24-05-009	24/05/2017	24/05/2016		
	Sucoflex N-2000-SMA	02-02/50-05-075				
	SF104/11N/11N/1500MM	02-02/50-13-015				
DC	FSW43	02-02/11-15-001	05/08/2016	05/08/2015		
	RF Antenna	02-02/24-05-032				
MB	FSW43	02-02/11-15-001	05/08/2016	05/08/2015		
	AFS5-12001800-18-10P-6	02-02/17-06-002				
	AFS4-01000400-10-10P-4	02-02/17-13-002				
	AMF-4F-04001200-15-10P	02-02/17-13-003				
	3117	02-02/24-05-009	24/05/2017	24/05/2016		
	Sucoflex N-2000-SMA	02-02/50-05-075				
	SF104/11N/11N/1500MM	02-02/50-13-015				
SER 2	ESVS 30	02-02/03-05-003	09/07/2016	09/07/2015		
	VULB 9168	02-02/24-05-005	20/04/2017	20/04/2016	20/10/2016	20/04/2016
	NW-2000-NB	02-02/50-05-113				
	KK-EF393/U-16N-21N20 m	02-02/50-12-018				
	KK-SD_7/8-2X21N-33,0M	02-02/50-15-028				
SER 3	FSW43	02-02/11-15-001	05/08/2016	05/08/2015		
	AFS5-12001800-18-10P-6	02-02/17-06-002				
	AFS4-01000400-10-10P-4	02-02/17-13-002				
	AMF-4F-04001200-15-10P	02-02/17-13-003				
	3117	02-02/24-05-009	24/05/2017	24/05/2016		
	Sucoflex N-2000-SMA	02-02/50-05-075				
	SF104/11N/11N/1500MM	02-02/50-13-015				