

EMI – TEST REPORT

- FCC Part 15.247, RSS210 -

Test Report No. : T38423-00-01TK

01. September 2014

Date of issue

Type / Model Name : D-RM01

Product Description : Wireless module, 2.4 GHz

Applicant : Hilti Corporation

Address : Feldkircherstrasse 100, 9494 Schaan

LIECHTENSTEIN

Manufacturer : Escatec Switzerland AG

Address : Heinrich-Wild-Strasse, 9435 Heerbrugg

SWITZERLAND

Licence holder : Hilti Corporation

Address : Feldkircherstrasse 100, 9494 Schaan

LIECHTENSTEIN

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

POSITIVE



The test report merely corresponds to the test sample.
It is not permitted to copy extracts of these test results
without the written permission of the test laboratory.

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1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (September, 2013)

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, 2013)

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 15.247	Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz and 5725 - 5850 MHz

FCC Rules and Regulations Part 1, Subpart I - Procedures Implementing the National Environmental Policy Act of 1969

Part 1, Subpart I, Section 1.1310	Radiofrequency radiation exposure limits
Part 1, Subpart 2, Section 2.1093	Radiofrequency radiation exposure evaluation: portable device

OET Bulletin 65, 65A, 65B, 65C Edition 97-01, August 1997 – Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.

ANSI C63.4: 2009	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: 2009	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: 2003	Uncertainty in EMC measurement
KDB 558074 D01 v03r01	Guidance for performing compliance measurements on DTS operating under Section 15.247, April 9, 2013.
KDB 447498 D01 v05r02	Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies

2 SUMMARY

2.1 Test result summary

ZigBee device using digital modulation:

Operating in the 2400 MHz – 2483.5 MHz:

FCC Rule Part	RSS Rule Part	Description	Result
15.207(a)	RSS Gen, 7.2.4.	AC power line conducted emissions	passed
15.247(a)(2)	RSS210, A8.2(a)	-6 dB EBW	passed
15.247(b)(3)	RSS-210, A8.4(4)	Peak power	passed
15.247(d)	RSS-210, A8.5	Out-of-band emission, radiated	passed
15.247(d)	RSS-Gen, 7.2.2	Emissions in restricted bands	passed
15.247(e)	RSS-210, A8.2(b)	PSD	passed
15.35(c)	RSS-Gen, 4.5	Pulsed operation	passed
15.247(i)	RSS 102, 2.5.2	MPE	passed
KDB 447498	RSS 102, 4	RF exposure consideration for SAR	passed
15.247(b)(4)	RSS-Gen, 7.1.2	Antenna requirement	passed
	RSS-Gen, 7.2.6	Transmitter frequency stability	not applicable
	RSS-Gen, 4.6.1	99 % Bandwidth	passed
OET Bulletin 65	RSS102, 3.2	Co-location, Co-transmission	not applicable

The mentioned RSS Rule Parts in the above table are related to:

RSS Gen, Issue 3, December 2010

RSS 210, Issue 8, December 2010

RSS 102, Issue 4, March 2010

2.2 General remarks

The EUT is a wireless module for data transmission purposes. It supports the 2.4 GHz frequency band and supports no beam forming. The EUT is based on ZigBee technology but uses a proprietary data format with a cyclic channel change technology. The channel changing cycle follows a firmware defined scheme. The module uses a stabilized voltage delivered by the application and for test performance by the EUT carrier board within the test jig. External voltage variations don't influence the output power of the RF section.

- The equipment using other types of wide band modulation (e.g. DSSS, OFDM, etc.).

Items	Description
ZigBee Module type	D-RM01
Power type	24 V DC
Modulation	DSSS
Modulation type	O-QPSK
Frequency range	2400 MHz to 2483.5 MHz
Channel numbers	15
Data rate (kbps)	250

Test jig

The used test jig provides the necessary power supply and control signals to operate the wireless module for testing. The test jig is DC power supplied with a view to the planned industrial application. The test port is connected via UFL-RSMA-Pigtail which is used also in the end application.

Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz

Channel plan Standard 802.15.4:

Channel	Frequency	Channel	Frequency
11	2405	19	2445
12	2410	20	2450
13	2415	21	2455
14	2420	22	2460
15	2425	23	2465
16	2430	24	2470
17	2435	25	2475
18	2440	26	2480

Variants of the EUT

There are two versions of the EUT:

- Version A with integrated chip antenna (Antenna type no. 1)
- Version B with U.FL antenna connector (Antenna types no. 2 and 3)

Antennas

The following antennas shall be used with the EUT:

Number	Type	Certification name	Plug	Frequency range (GHz)	Gain
1	Omni	WE-MCA, P/N: 7488910245	none	2.4	3.0
2	Omni	ANT-2.4-WRT-SMA	SMA	2.4	3.5
3	Omni	Generic antenna	SMA	2.4	3.0

Note:

The antenna number 1 and 2 were used to demonstrate compliance. An U.FL to SMA adaptor is used in the application as it is documented in the paragraph 3.1.

Transmit operating modes

The EUT use DSSS modulation with O-QPSK modulation type with 15 channels from 2405 MHz up to 2475 MHz and a fixed data rate of 250 kbps. Channel 26 is not used and excluded by firmware.

The test software for the EUT provides free power setting, the special test mode RX and the TX continuous mode, modulated. The EUT is set with test modulation to transmit data during the tests with a duty cycle (X) of $X = 0.315$. The live system shows a worst case duty cycle of $X = 0.031$ being taken into consideration for the calculation of the duty cycle correction factor. The value of the duty cycle correction factor has been computed but was not taken into account to show the EUT's compliance. Preliminary tests were performed to find the worst case mode from all possible combinations between available modulations and data rates.

As worst case the following channels and test modes are selected for the final test:

IEEE Standard	Available channel	Tested channels	Power setting	Modulation	Modulation type	Data rate
802.15.4	11 to 25	11, 18, 25	P10	DSSS	O-QPSK	250 kbps

2.3 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 : 01 July 2014

Testing concluded on : 12 August 2014

Checked by:

Tested by:

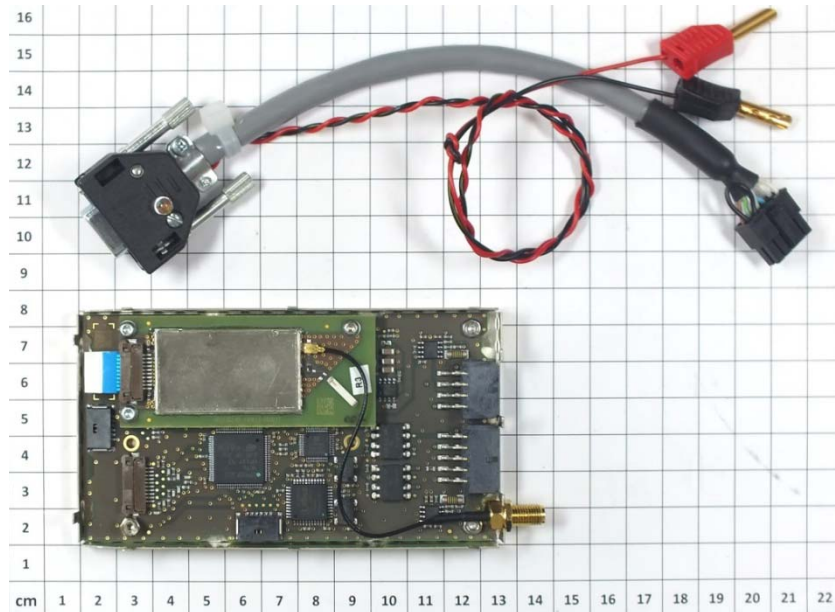
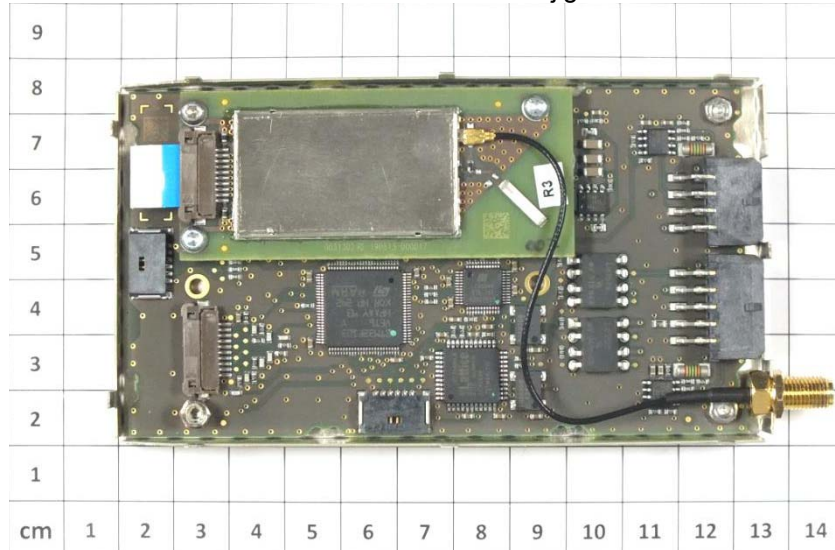
Klaus Gegenfurtner
Teamleader Radio

Tobias Kammerer
Radio Team

3 EQUIPMENT UNDER TEST

3.1 Photo documentation of the EUT

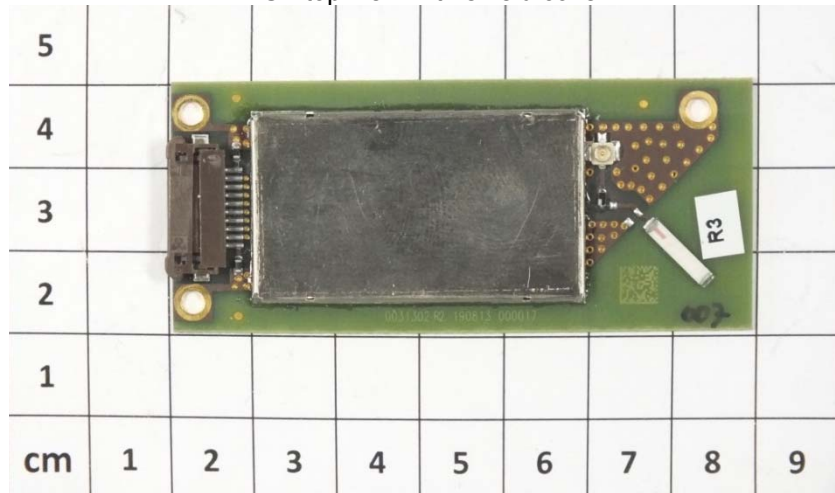
EUT mounted on test jig



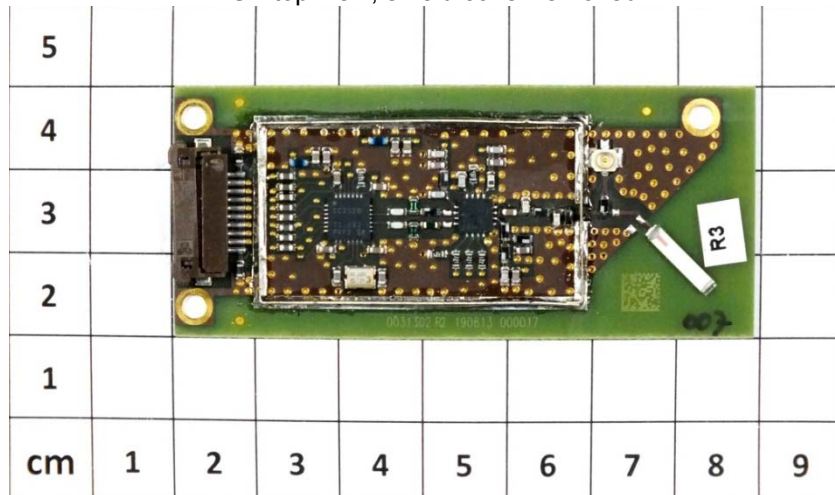
FCC ID: SDL-D-RM01

IC: 5228A-DRM01

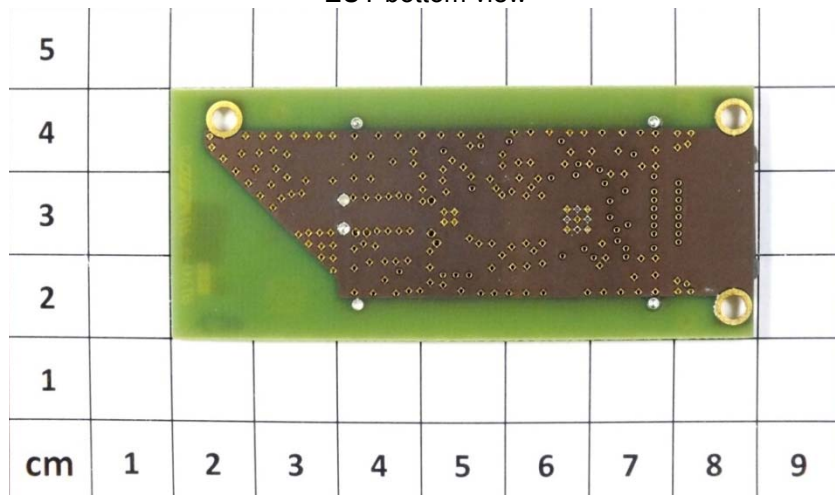
EUT top view with shield cover



EUT top view, shield cover removed



EUT bottom view



3.2 Power supply system utilised

Power supply voltage, V_{nom} : 24 V DC

3.3 Short description of the equipment under test (EUT)

The EUT is a wireless module working in the 2.4 GHz ISM band using 15 channels for data transmission and steering purposes in electric power tools. The EUT uses cyclic channel change for interference prevention.

Number of tested samples: 1
Serial number: pre-production sample

EUT operation mode:

The equipment under test was operated during the measurement under the following conditions:

- TX continuous mode, modulated

EUT configuration:

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

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

- Toshiba Laptop	Model : TECRA A11-127
- Adapter cable for EUT control	Model : USB to RS422
- Trust power supply	Model : 16426-03
-	Model :
-	Model :
-	Model :

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.

4.4 Measurement protocol for FCC and IC

4.4.1 General information

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

IC 3009A

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.

4.4.1.1 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.

4.4.1.2 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.

4.5 Determination of worst case measurement conditions

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.

The tests are carried out in the following frequency band:

2400 MHz – 2483.5 MHz

Preliminary tests were performed to find the worst case mode from all possible combinations between available modulations and data rates. The maximum output power depends on used data rate. The output power can be set by application software from 1 dBm to 20 dBm (P1 to P20) in 1 dB steps. The tests were performed with a power setting of 10 dBm at the U.FL connector.

The test software for the EUT provides free power setting, the special test mode RX and the TX continuous mode, modulated. The EUT was set with test modulation to transmit data during the tests with a duty cycle (x) of nearly $x = 0.315$ initiated by the test software.

Following channels and test modes has been selected for the final test as listed below:

IEEE Standard	Available channel	Tested channels	Power setting	Modulation	Modulation type	Data rate
802.15.4	11 to 25	11, 18, 25	P10	DSSS	O-QPSK	250 kbps

Conducted measurements are performed on the single port of the module. A test jig is used to provide the EUT with the appropriate control and data signals for testing. Between the module port and the end product port a UFL to R-SMA pigtail (10 cm) is used. All measurements are related to the R-SMA-Port.

5 TEST CONDITIONS AND RESULTS

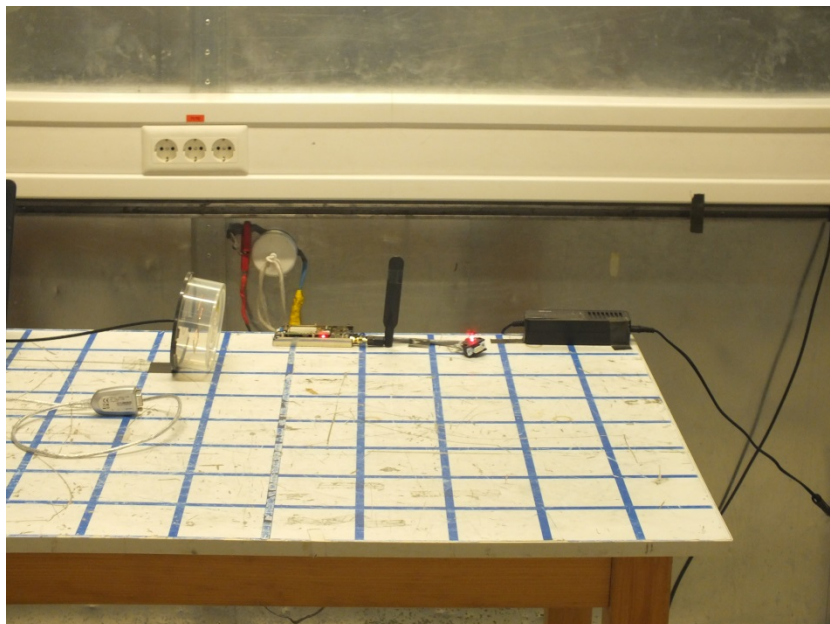
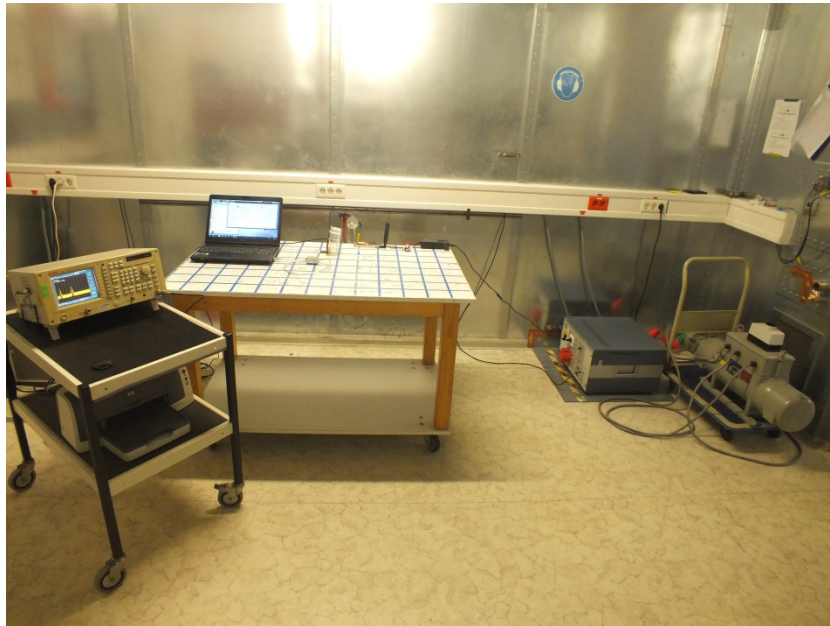
5.1 AC power line conducted emissions

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

5.1.1 Description of the test location

Test location: Shielded Room S2

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 32.6 dB at 0.314 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

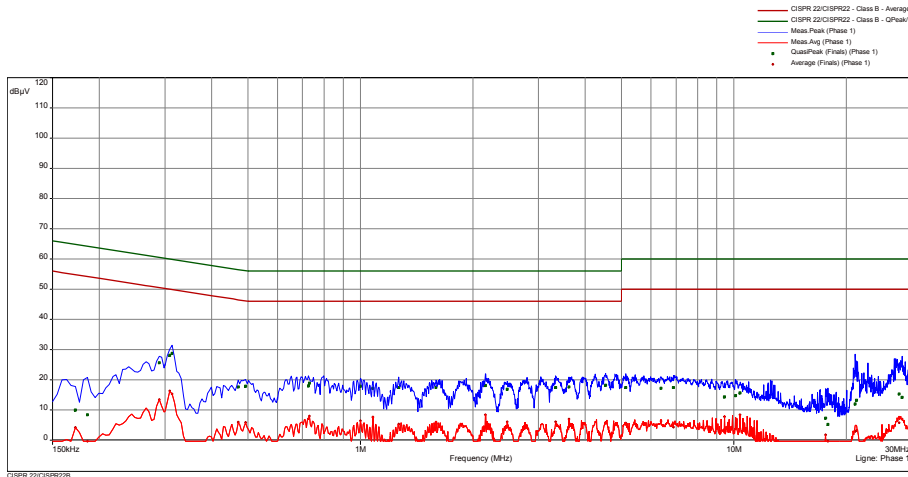
The requirements are fulfilled.

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

5.1.6 Test protocols

Test point L1
 Operation mode: TX continuous mode, modulated
 Remarks: none

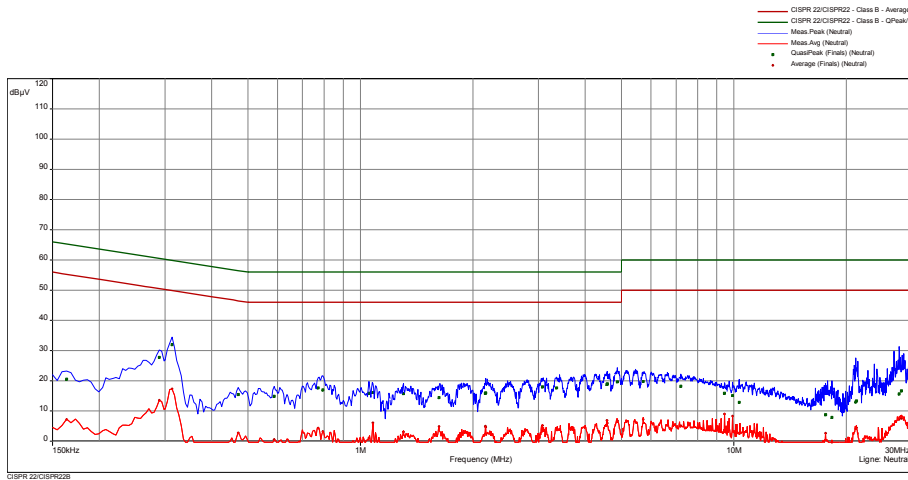
Result: passed



freq	SR	QP	margin	limit	AV	margin	limit	line
MHz		dB(μV)	dB	dB	dB(μV)	dB	dB	
0.173	1	10.0	54.8	64.8	4.2	50.6	54.8	Phase 1
0.186	1	8.5	55.7	64.2	-1.9	56.1	54.2	Phase 1
0.290	1	25.7	34.9	60.5	13.5	37.0	50.5	Phase 1
0.309	2	28.1	31.9	60.0	16.3	33.7	50.0	Phase 1
0.314	2	28.8	31.1	59.9	15.4	34.5	49.9	Phase 1
0.471	2	17.7	38.8	56.5	6.0	40.5	46.5	Phase 1
0.494	2	17.9	38.2	56.1	5.8	40.3	46.1	Phase 1
0.726	3	18.0	38.0	56.0	7.1	38.9	46.0	Phase 1
0.731	3	18.9	37.2	56.0	8.0	38.0	46.0	Phase 1
1.001	3	17.9	38.1	56.0	6.5	39.5	46.0	Phase 1
1.082	3	17.3	38.7	56.0	7.7	38.3	46.0	Phase 1
1.268	4	17.4	38.6	56.0	5.4	40.6	46.0	Phase 1
1.596	4	17.6	38.4	56.0	6.0	40.0	46.0	Phase 1
2.163	4	18.1	37.9	56.0	8.5	37.5	46.0	Phase 1
2.472	5	16.9	39.1	56.0	6.2	39.9	46.0	Phase 1
3.332	5	17.5	38.5	56.0	6.2	39.9	46.0	Phase 1
3.620	5	17.7	38.3	56.0	7.0	39.0	46.0	Phase 1
4.538	5	18.2	37.8	56.0	5.9	40.1	46.0	Phase 1
5.138	6	17.4	42.6	60.0	5.7	44.4	50.0	Phase 1
6.384	6	17.2	42.8	60.0	6.3	43.7	50.0	Phase 1
6.884	6	17.4	42.6	60.0	4.4	45.6	50.0	Phase 1
9.431	6	14.4	45.7	60.0	7.8	42.2	50.0	Phase 1
10.104	7	14.8	45.2	60.0	3.8	46.2	50.0	Phase 1
10.383	7	15.6	44.4	60.0	8.5	41.5	50.0	Phase 1
17.574	7	7.4	52.6	60.0	1.8	48.2	50.0	Phase 1
17.858	7	5.3	54.8	60.0	-1.9	51.9	50.0	Phase 1
21.126	8	12.0	48.0	60.0	2.9	47.2	50.0	Phase 1
21.266	8	13.3	46.8	60.0	3.3	46.7	50.0	Phase 1
27.660	8	15.3	44.7	60.0	5.7	44.3	50.0	Phase 1
28.196	8	14.2	45.8	60.0	7.0	43.0	50.0	Phase 1

Test point N
Operation mode: TX continuous mode, modulated
Remarks: none

Result: passed



freq	SR	QP	margin	limit	AV	margin	limit	line
MHz		dB(μV)	dB	dB	dB(μV)	dB	dB	
0.164	9	20.6	44.7	65.3	7.3	48.0	55.3	Neutral
0.290	9	27.8	32.7	60.5	13.5	37.0	50.5	Neutral
0.314	10	32.0	27.8	59.9	17.3	32.6	49.9	Neutral
0.471	10	15.4	41.1	56.5	2.8	43.7	46.5	Neutral
0.588	10	14.9	41.1	56.0	0.6	45.4	46.0	Neutral
0.771	11	17.7	38.4	56.0	4.4	41.6	46.0	Neutral
0.794	11	17.1	39.0	56.0	3.3	42.7	46.0	Neutral
1.055	11	15.9	40.1	56.0	1.0	45.0	46.0	Neutral
1.082	11	16.2	39.8	56.0	6.2	39.9	46.0	Neutral
1.304	12	15.8	40.2	56.0	3.1	42.9	46.0	Neutral
1.623	12	14.5	41.5	56.0	4.9	41.1	46.0	Neutral
2.163	12	15.9	40.1	56.0	5.0	41.0	46.0	Neutral
2.168	12	16.0	40.0	56.0	4.7	41.3	46.0	Neutral
3.071	13	18.0	38.0	56.0	5.2	40.8	46.0	Neutral
3.354	13	17.7	38.3	56.0	4.1	41.9	46.0	Neutral
4.574	13	18.8	37.2	56.0	6.9	39.1	46.0	Neutral
4.578	13	19.0	37.0	56.0	6.0	40.0	46.0	Neutral
4.872	14	19.7	36.3	56.0	6.8	39.2	46.0	Neutral
5.714	14	19.8	40.2	60.0	7.3	42.7	50.0	Neutral
7.212	14	18.3	41.8	60.0	5.1	44.9	50.0	Neutral
9.431	14	15.9	44.1	60.0	9.0	41.0	50.0	Neutral
9.906	15	15.2	44.8	60.0	8.3	41.7	50.0	Neutral
10.334	15	12.9	47.2	60.0	2.6	47.4	50.0	Neutral
17.574	15	8.8	51.2	60.0	2.7	47.3	50.0	Neutral
18.299	15	7.9	52.1	60.0	-0.2	50.2	50.0	Neutral
21.203	16	13.0	47.0	60.0	4.2	45.9	50.0	Neutral
21.257	16	13.4	46.6	60.0	4.4	45.6	50.0	Neutral
27.687	16	15.6	44.4	60.0	7.3	42.7	50.0	Neutral
28.101	16	16.7	43.3	60.0	7.6	42.4	50.0	Neutral

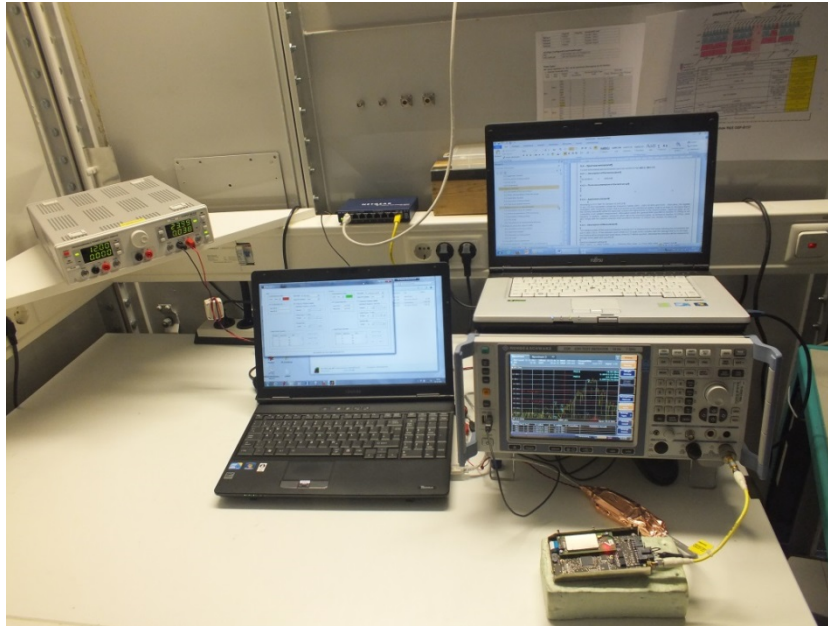
5.2 Emission bandwidth

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

5.2.1 Description of the test location

Test location: AREA4

5.2.2 Photo documentation of the test set-up



5.2.3 Applicable standard

According to FCC Part 15, Section 15.247(a)(2):

Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 – 2483.5 MHz and 5725 – 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

5.2.4 Description of Measurement

The bandwidth was measured at an amplitude level reduced from the reference level of a modulated channel by a ratio of -6 dB. The reference level is the level of the highest signal amplitude observed at the transmitter at either the fundamental frequency or the first order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical. An alternative is to use the bandwidth measurement of the analyser.

Spectrum analyser settings:

RBW: 100 kHz, VBW: 300 kHz, Detector: Peak, Sweep time: 5 ms

The table below shows the settings according to ANSI C63.4:

Fundamental frequency	Minimum resolution bandwidth
9 kHz to 30 MHz	1 kHz
30 to 1000 MHz	10 kHz
1000 MHz to 40 GHz	100 kHz

5.2.5 Test result

Standard 802.15.4

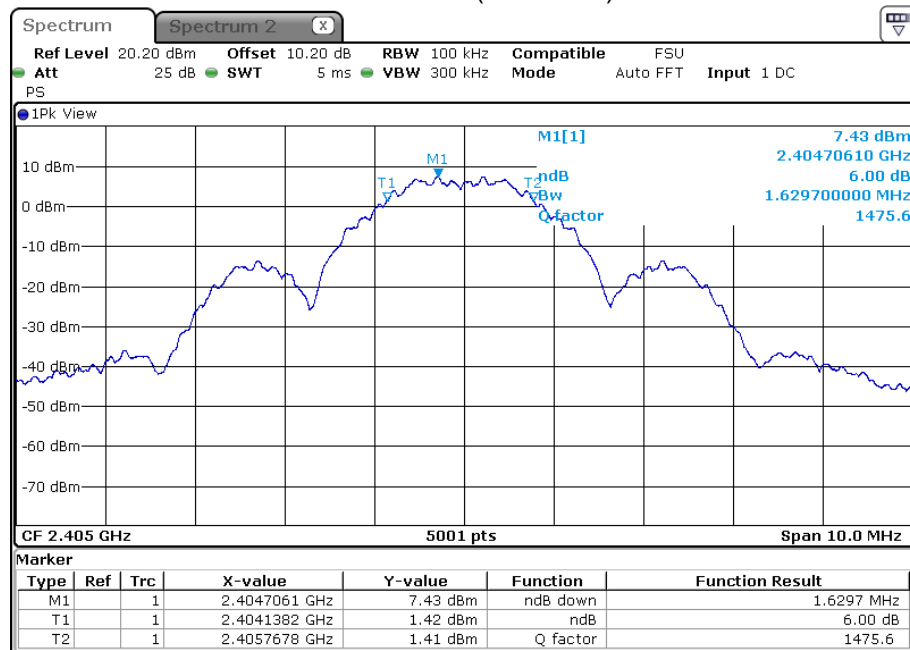
Channel No.	Centre frequency (MHz)	6 dB Bandwidth f1 (MHz)	6 dB Bandwidth f2 (MHz)	6 dB Bandwidth (MHz)	Limit (MHz)
11	2405	2404.138	2405.768	1.630	>0.5
18	2440	2439.144	2440.768	1.624	>0.5
25	2475	2474.136	2475.762	1.626	>0.5

The requirements are **FULFILLED**.

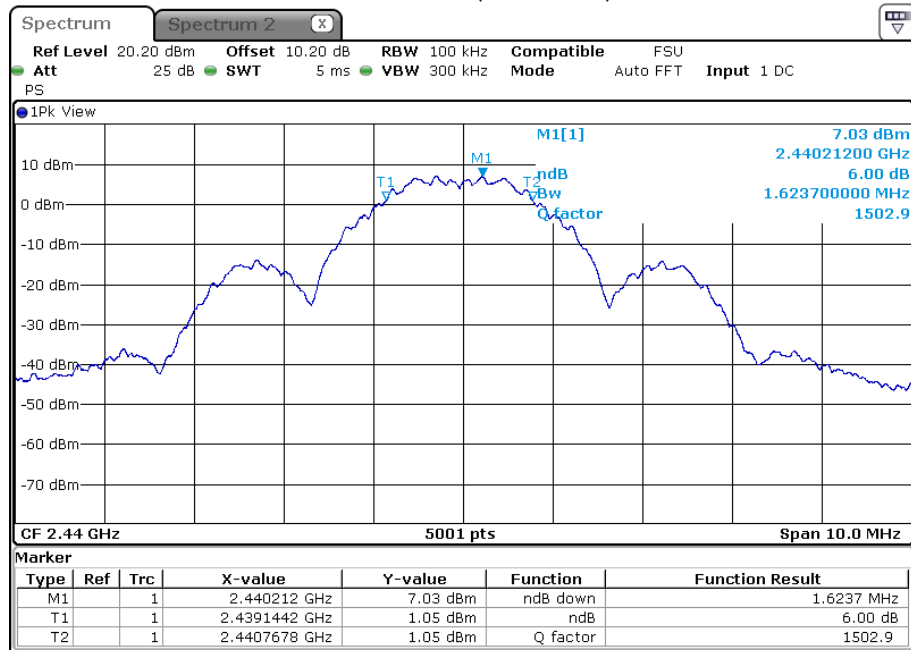
Remarks: For detailed test results please refer to following test protocols.

5.2.6 Test protocols

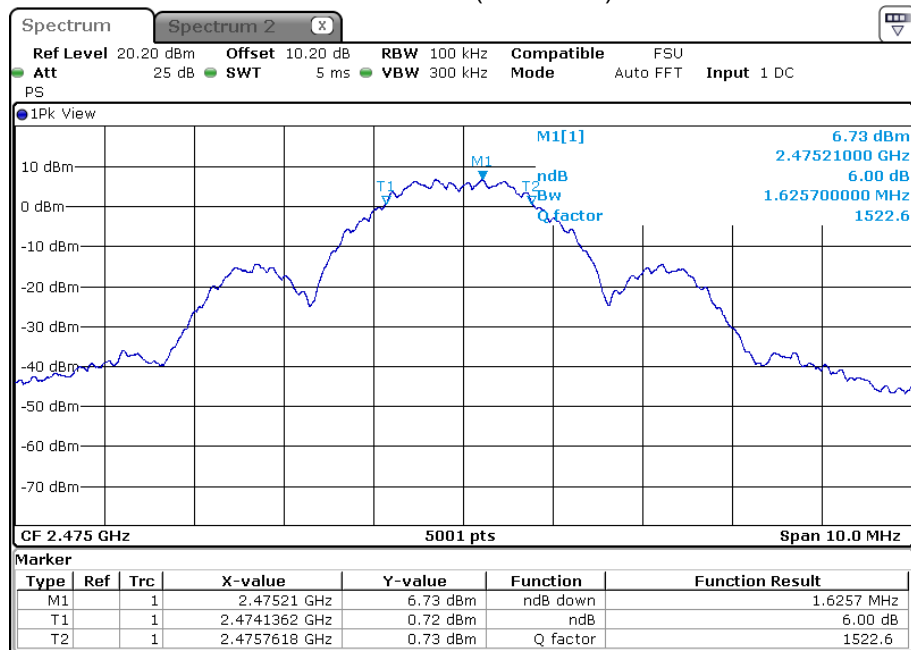
802.15.4 Channel 11 (2405 MHz)



802.15.4 Channel 18 (2440 MHz)



802.15.4 Channel 25 (2475 MHz)



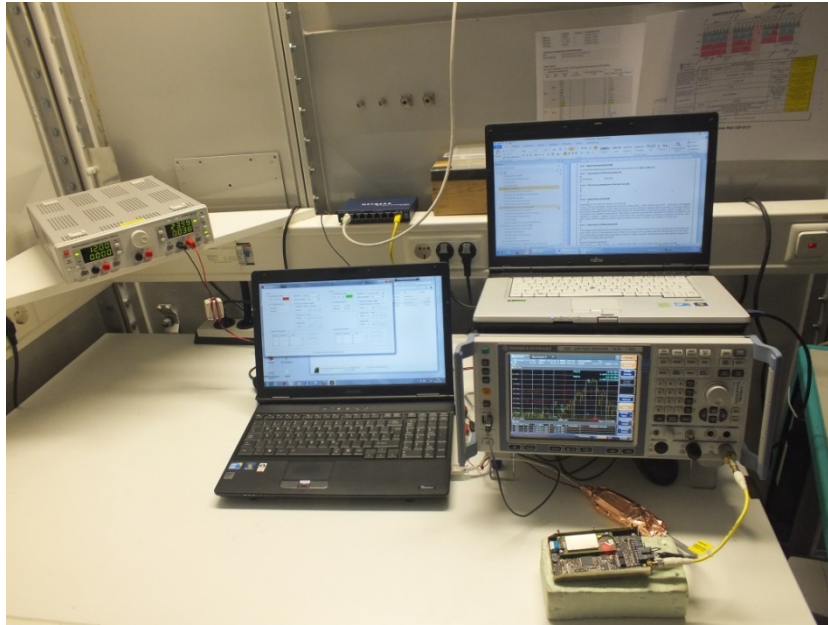
5.3 Occupied bandwidth

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

5.3.1 Description of the test location

Test location: AREA4

5.3.2 Photo documentation of the test set-up



5.3.3 Applicable standard

According to RSS-Gen, 4.6.1:

When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99 % emission bandwidth, as calculated or measured.

5.3.4 Description of Measurement

The bandwidth was measured with the function “bandwidth measurement” of the spectrum analyser. The EUT is connected via suitable attenuator at the spectrum analyser. The measurement is repeated for every different modulation standard of the EUT and recorded.

Spectrum analyser settings:

RBW: 100 kHz,

VBW: 300 kHz,

Detector: Sample detector, Sweep time: Auto

5.3.5 Test result

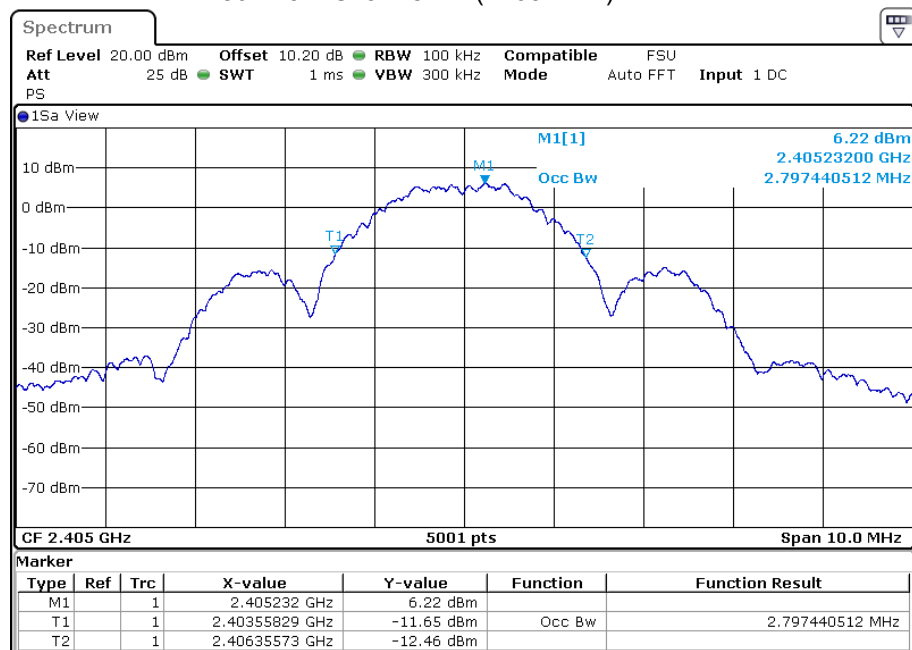
Standard 802.15.4

Channel No.	Centre frequency (MHz)	99% OBW f1 (MHz)	99% OBW f2 (MHz)	99% OBW (MHz)
11	2405	2403.558	2406.356	2.797
18	2440	2438.548	2441.352	2.803
25	2475	2473.552	2476.346	2.793

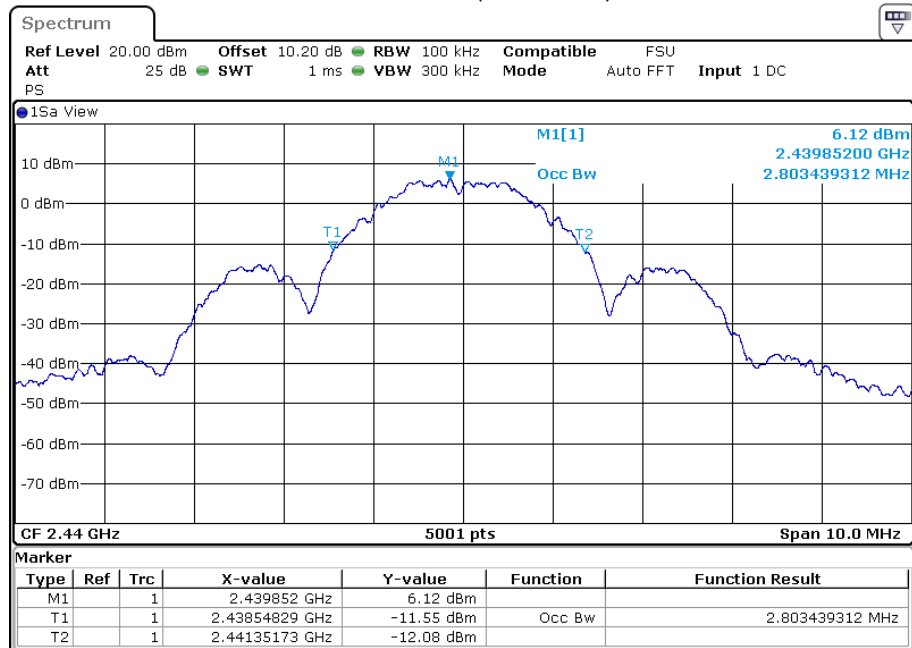
Remarks: For detailed test result please refer to following test protocols. The RSS Gen defines no limit for the occupied bandwidth!

5.3.6 Test protocols

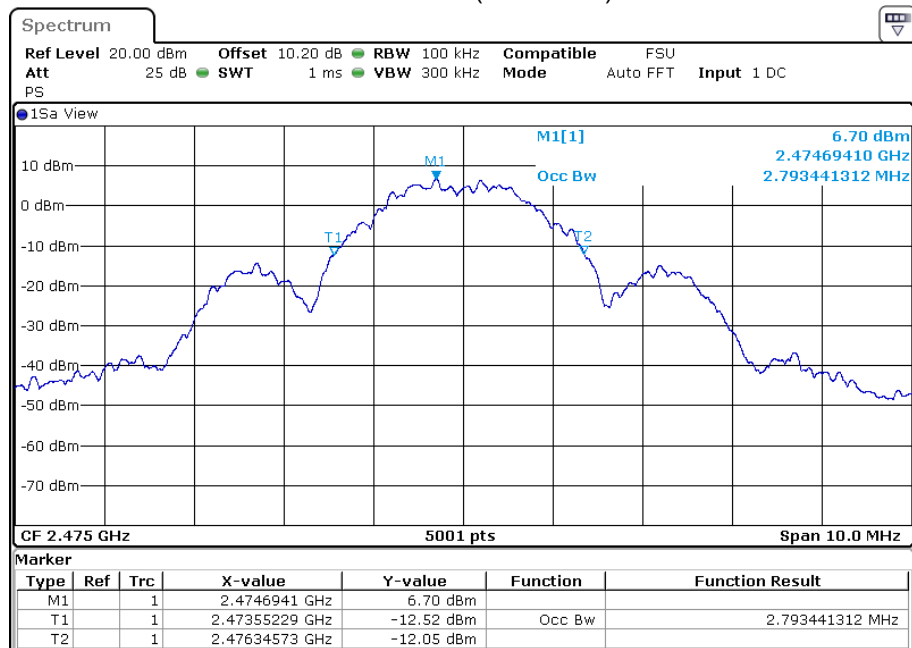
802.15.4 Channel 11 (2405 MHz)



802.15.4 Channel 18 (2440 MHz)



802.15.4 Channel 25 (2475 MHz)



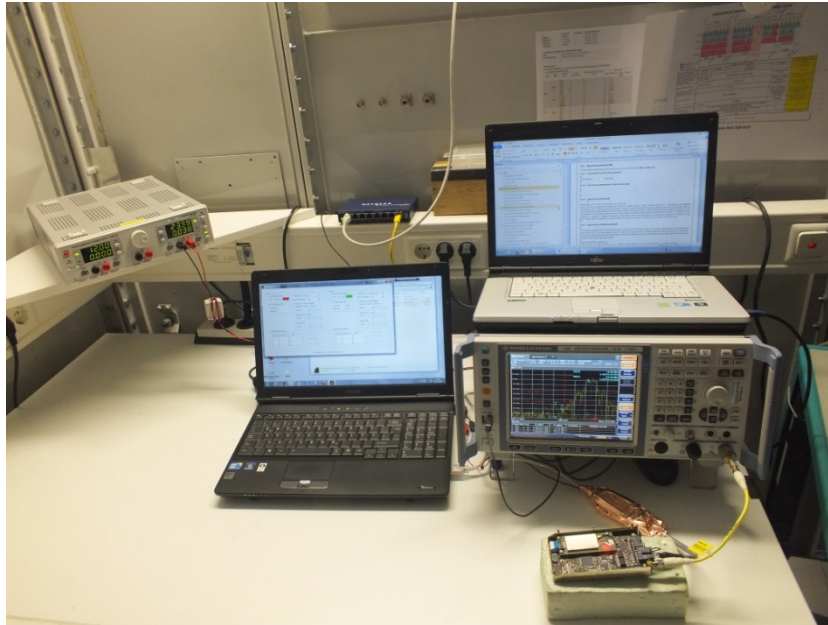
5.4 Maximum peak conducted output power

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

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 15.247(b)(3):

For systems using digital modulation in the 2400-2483.5 MHz and 5725 – 5850 MHz bands, the maximum peak output power of the transmitter shall not exceed 1 Watt. The limit is based on transmitting antennas of directional gain that do not exceed 6 dBi.

5.4.4 Description of Measurement

The maximum peak conducted output power is measured using a spectrum analyser with the function "RBW $\geq$ DTS bandwidth" following the procedure set out in KDB 558074, item 9.1.1. The EUT is set in TX continuous mode while measuring.

5.4.5 Test result

Standard 802.15.4

802.15.4, 250 kbps, 1 TX		Test results conducted		
Duty cycle: 31.5%				
		A [Pmax] (dBm)	Limit (dBm)	Margin (dB)
Lowest frequency: CH11				
T_{nom}	V_{nom}	11.1	30.0	-18.9
Middle frequency: CH18				
T_{nom}	V_{nom}	10.7	30.0	-19.3
Highest frequency: CH25				
T_{nom}	V_{nom}	10.3	30.0	-19.7

Peak Power Limit according to FCC Part 15, Section 15.247(b)(3):

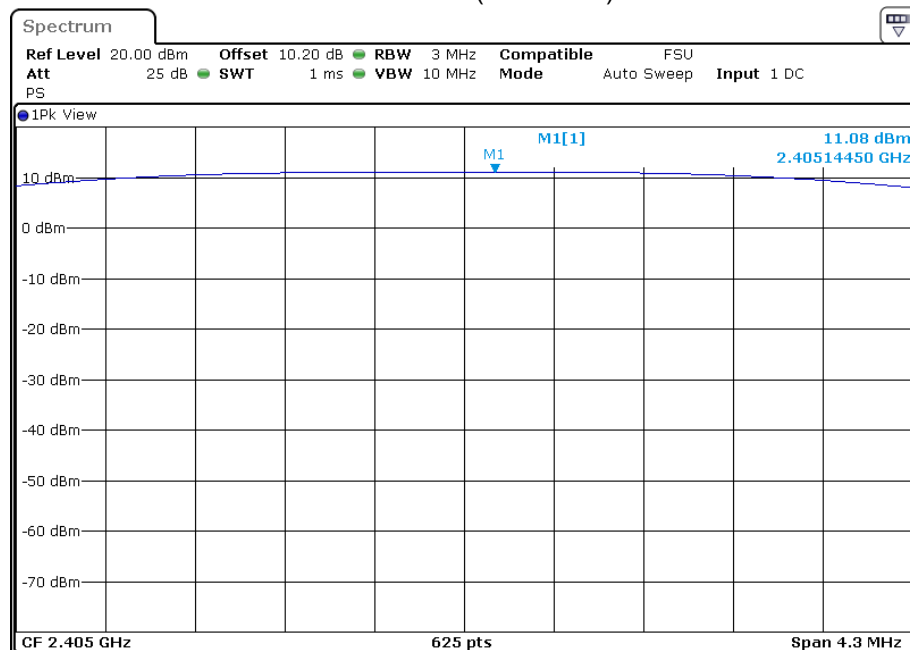
Frequency (MHz)	Peak Power Limit	
	(dBm)	(Watt)
902-928	30	1.0
2400-2483.5	30	1.0
5725-5850	30	1.0

The requirements are **FULFILLED**.

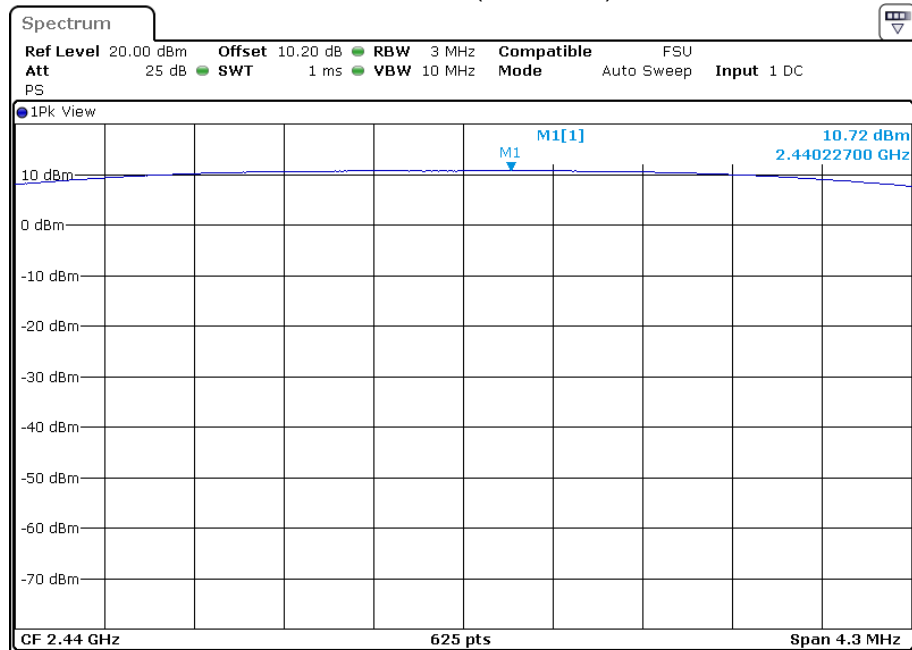
Remarks:

5.4.6 Test protocols

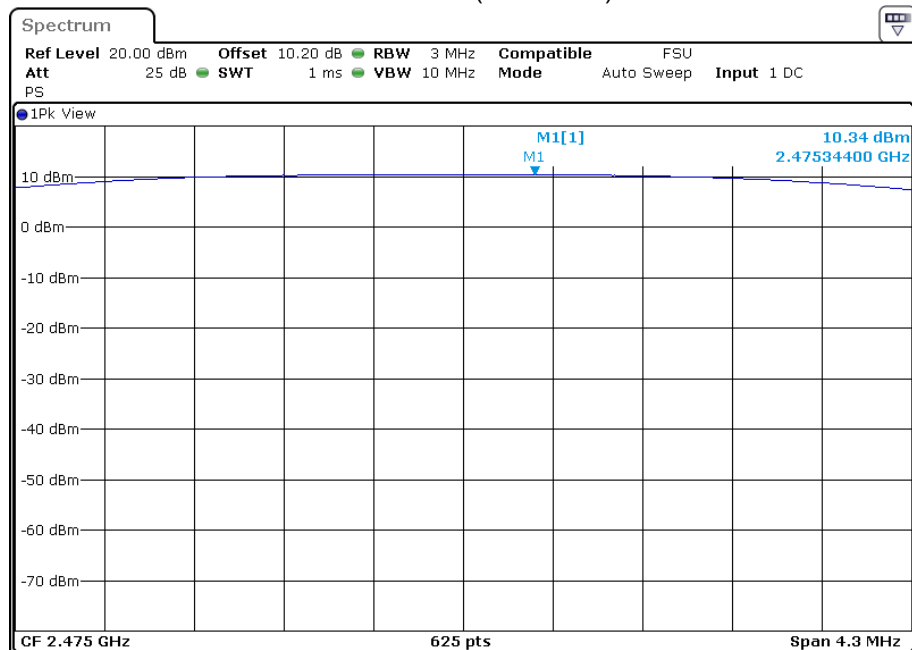
802.15.4 Channel 11 (2405 MHz)



802.15.4 Channel 18 (2440 MHz)



802.15.4 Channel 25 (2475 MHz)



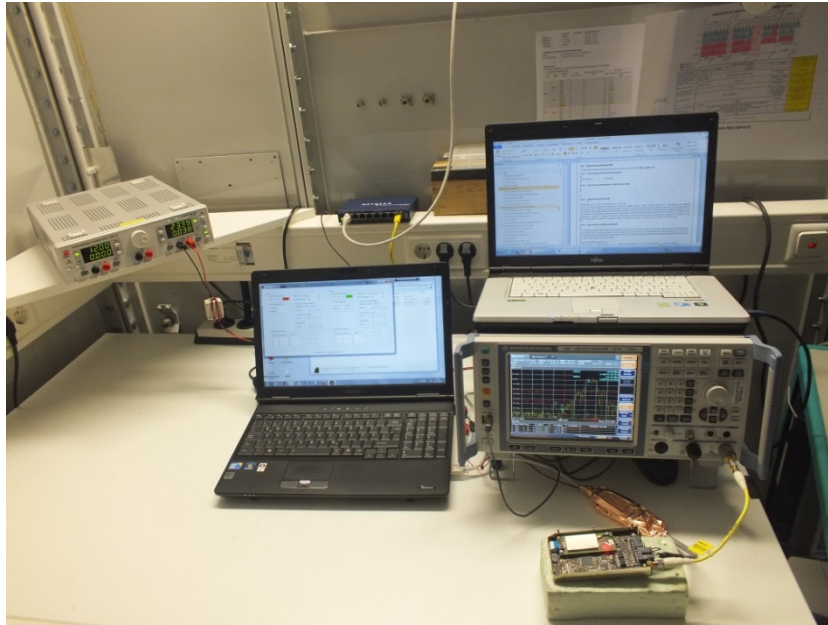
5.5 Power spectral density

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

5.5.1 Description of the test location

Test location: AREA4

5.5.2 Photo documentation of the test set-up



5.5.3 Applicable standard

According to FCC Part 15, Section 15.247(e):

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

5.5.4 Description of Measurement

The measurement is performed using the procedure 10.2 set out in KDB-558074. The power measurement was done using the integrated band power method. Therefore the PKPSD is measured. The maximum peak was located with the spectrum analyser and a marker set to peak. The attenuator or cable losses are taken into account with an amplitude offset.

Spectrum analyser settings:

RBW: 3 kHz, VBW: 10 kHz, Detector: Peak, Sweep time: auto,

5.5.5 Test result

Standard 802.15.4

802.15.4, 250 kbps, 1 TX		Test results conducted		
		PD conducted	Limit	Margin (dB)
Lowest frequency: CH11				
T_{nom}	V_{nom}	-3.7	8.0	-11.7
Middle frequency: CH18				
T_{nom}	V_{nom}	-3.9	8.0	-11.9
Highest frequency: CH25				
T_{nom}	V_{nom}	-3.8	8.0	-11.8

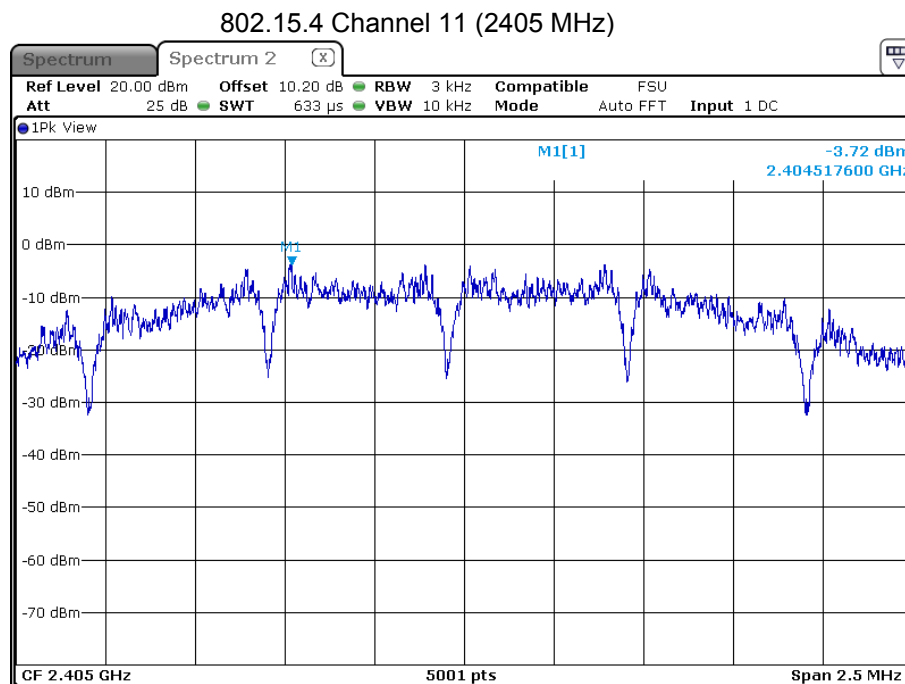
Power spectral density limit according to FCC Part 15, Section 15.247(e):

Frequency (MHz)	Power spectral density limit
	(dBm/3 kHz)
2400 - 2483.5	8

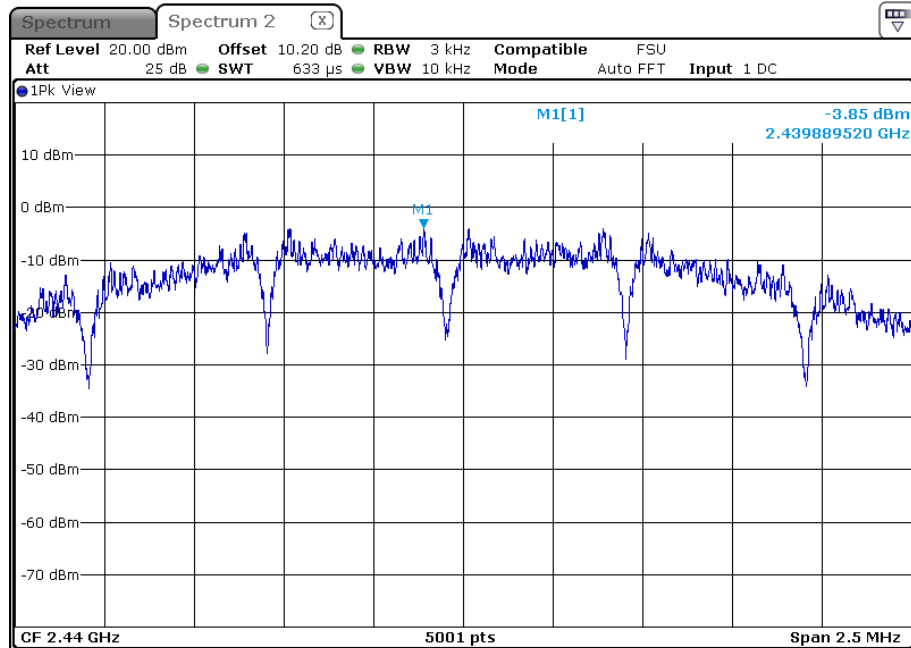
The requirements are **FULFILLED**.

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

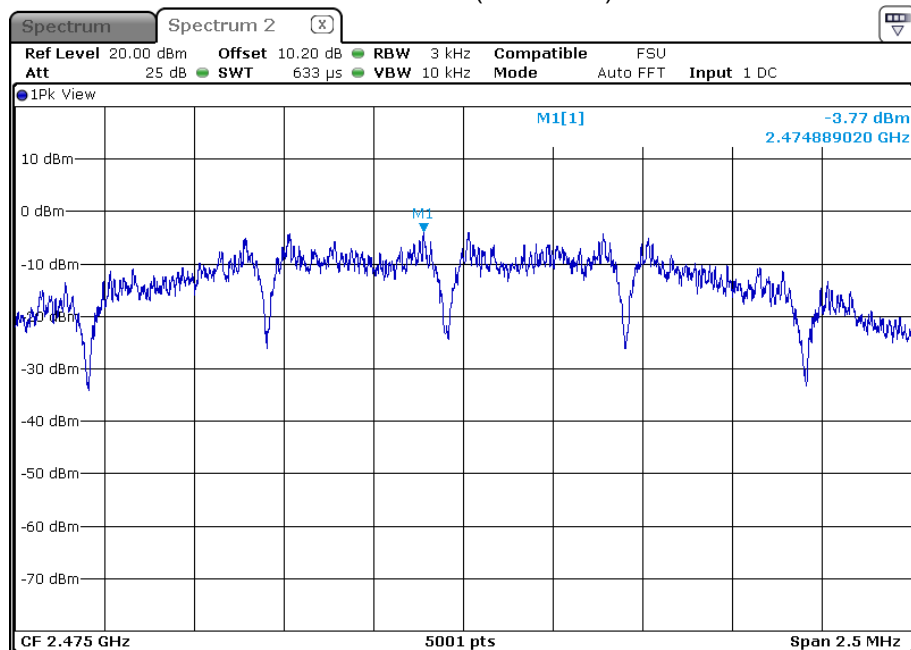
5.5.6 Test protocols



802.15.4 Channel 11 (2405 MHz)



802.15.4 Channel 11 (2405 MHz)



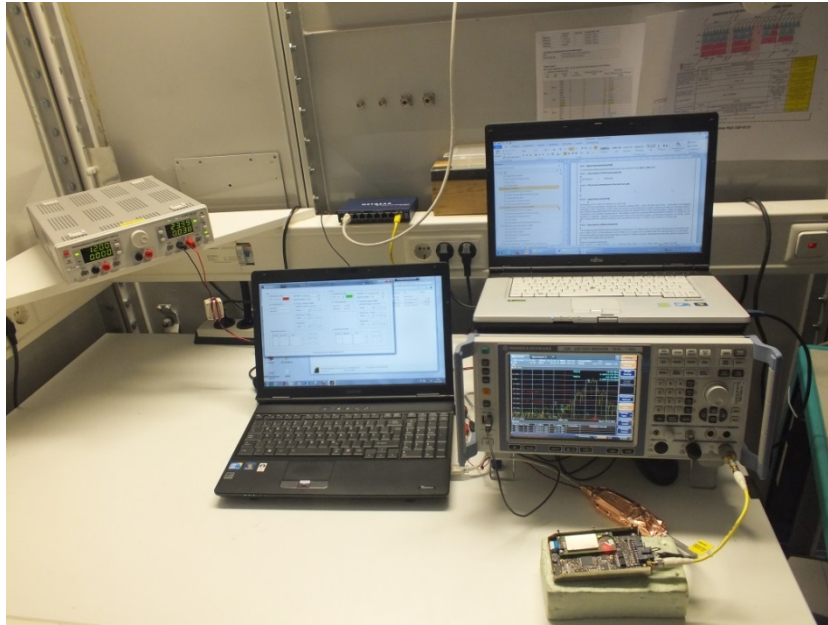
5.6 Spurious emissions conducted

For test instruments and accessories used see section 6 Part **SEC 2** and **SEC 3**.

5.6.1 Description of the test location

Test location: AREA4

5.6.2 Photo documentation of the test set-up



5.6.3 Applicable standard

According to FCC Part 15, Section 15.247(d):

In any 100 kHz bandwidth outside the frequency bands 2400 – 2483.50 MHz and 5725 – 5850 MHz, the digitally modulated radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or an radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limit specified in Section 15.209(a) (see Section 15.205(c)).

5.6.4 Description of measurement

The spurious emissions are measured conducted using a spectrum analyser in a test setup following the procedures set out in KDB 558074 for DTS. The transmitter is set to the lowest operating frequency (CH11), the middle (CH18) and to the highest operating frequency (CH25). The frequency spectrum outside from the operating frequency range (2400 - 2483.5 MHz) is scanned for emissions that exceed the defined limit. The measurement is performed at normal test conditions in modulated TX continuous mode.

Spectrum analyser search setting:

RBW: 100 kHz, VBW: 300 kHz, Detector: Max peak, Trace Mode: Max hold, Sweep time: 1 s

5.6.5 Test result

Highest level of the desired power:

Peak power conducted reference level (dBm)	Spurious emissions limit (dBm)
6.73	-13.27

Limit according to FCC Part 15, Section 15.247(d):

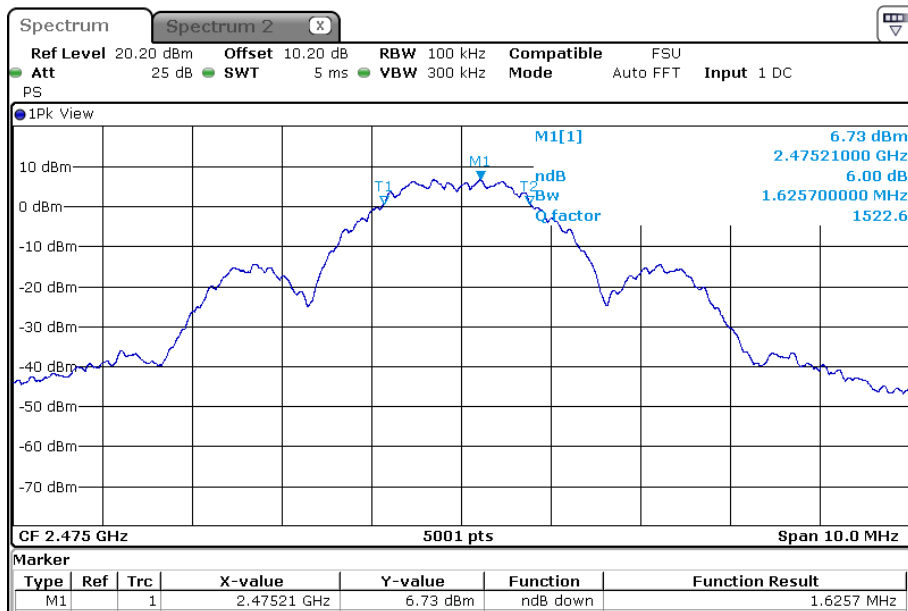
In any 100 kHz bandwidth outside the frequency bands 2400 – 2483.50 MHz and 5725 – 5850 MHz, the digitally modulated radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or an radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required.

Frequency (MHz)	Spurious emission limit
Below 960	20 dB below the highest level of the desired power
Above 960	20 dB below the highest level of the desired power

The requirements are **FULFILLED**.

Remarks:

5.6.6 Determination of the reference level and limit



Note:

Channel 25 shows the worst case and was used to determine the reference level for spurious emissions conducted measurements. Also the absolute limit for radiated limits according to FCC §15.209(a) was calculated following the KDB 558074 D01 DTS Meas Guidance v03r01 paragraph 12.2.2 using the following formula:

$$E = \text{EIRP} - 20\log D + K$$

$$E + C_D - K - G = A$$

Where:

E = electric field strength in dBμV/m (Limit value)

A = Peak power conducted in dBm (computed limit conducted)

G = Antenna gain of the used antenna in dBi

C_D = correction factor of the specified measurement distance in meters = $20\log D$ (D = 3 m),

K = 104.8

$\text{EIRP} = A + G$

Result:

E (dBμV/m)	C_D	K	G (dBi)	A Conducted limit (dBm)
74	9.54	104.8	3.5	-24.76
54	9.54	104.8	3.5	-44.76

5.6.7 Test protocols

Note:

No separate measurements for spurious emissions out of the restricted bands have been performed because the EUT fulfils the absolute Limits according to §15.205(a). Please refer to paragraph 5.9, Plots of spurious emissions conducted in restricted bands.

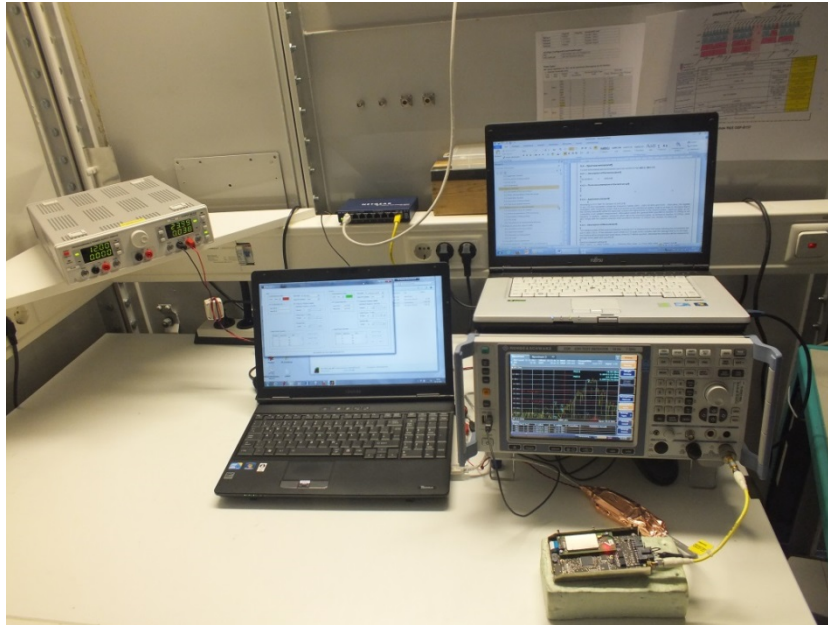
5.7 Band edge compliance

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

5.7.1 Description of the test location

Test location: AREA4

5.7.2 Photo documentation of the test set-up



5.7.3 Applicable standard

According to FCC Part 15C, Section 15.247(d):

In any 100 kHz bandwidth outside the frequency bands 2400 – 2483.5 MHz and 5725 – 5850 MHz, the digitally modulated radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or an radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required.

5.7.4 Description of Measurement

A spectrum analyser is connected to the output of the transmitter via a suitable attenuator while EUT was operating in transmit mode at the assigned frequency according Publication Number 913591, 03/26/2007.

Spectrum analyser settings:

RBW: 100 kHz, VBW: 300 kHz, Detector: Max peak, Trace: Max hold, Sweep: auto

5.7.5 Test result

Standard 802.15.4

Band edge	f (MHz)	Band edge peak level (dBm)	Limit (dBc)	Margin (dB)
lower	2399.7	-44.9	-13.3	-31.6
upper	2483.5	-53.2	-13.3	-40.0

Peak-Limit according to FCC Subpart 15.247(d):

In any 100 kHz bandwidth outside the frequency band 2400 – 2483.5 MHz, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required.

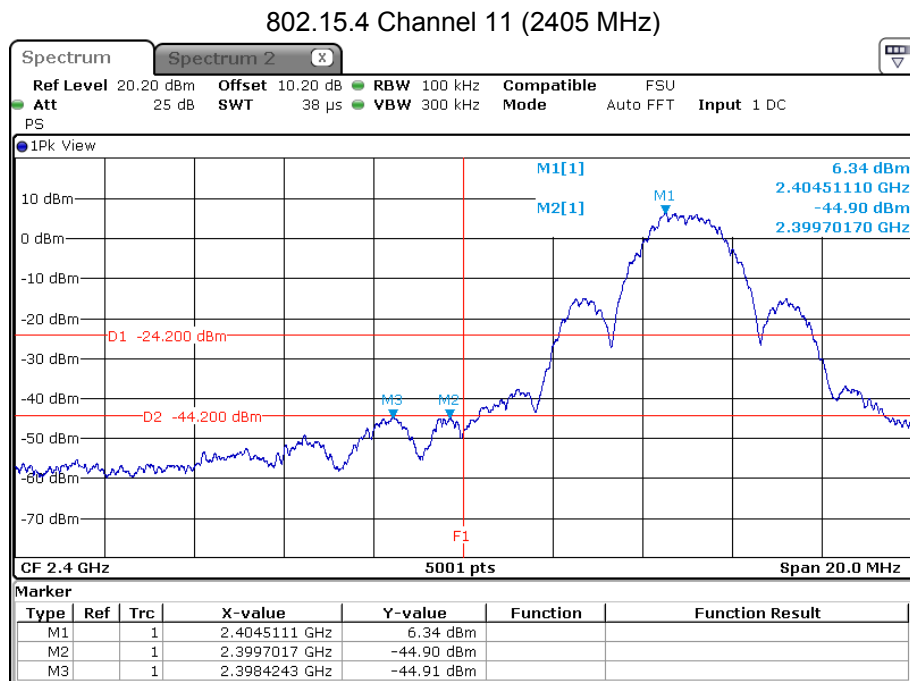
In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limit specified in Section 15.209(a) (see Section 15.205(c)).

The requirements are **FULFILLED**.

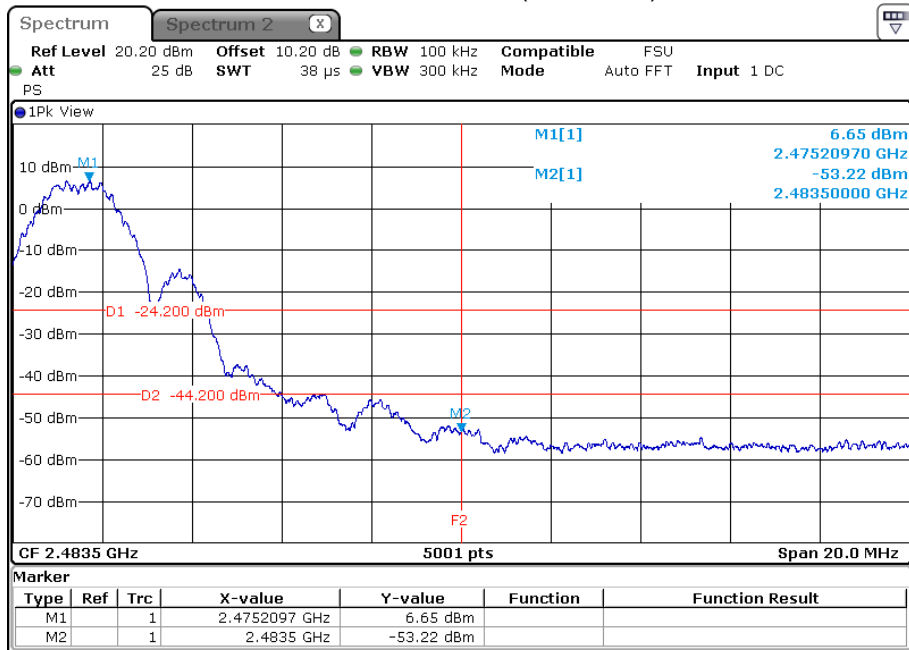
Remarks: For detailed test results please refer to following test protocols.

5.7.6 Test protocol

Standard 802.15.4



802.15.4 Channel 25 (2475 MHz)



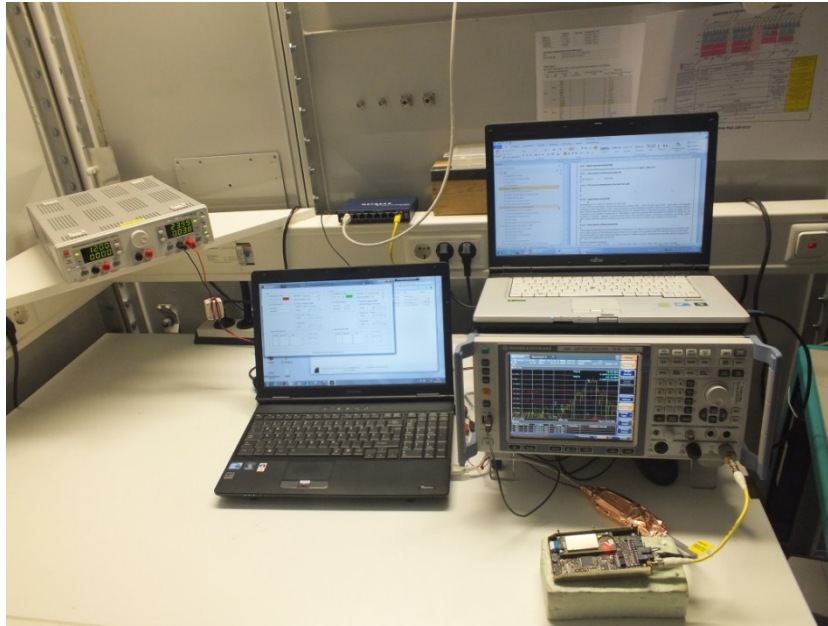
5.8 Spurious emissions in restricted bands (conducted)

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

5.8.1 Description of the test location

Test location: AREA4

5.8.2 Photo documentation of the test set-up



According to FCC Part 15, Section 15.205(a):

In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limit specified in Section 15.209(a).

5.8.3 Description of Measurement

The restricted bands are measured conducted. The span of the spectrum analyser is set wide enough to capture the restricted band and measure the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation. The restricted bands are measured falling emissions into it and the nearest restricted band are checked for emissions also the restricted band for the harmonics of the carrier.

Spectrum analyser settings:

RBW: 1 MHz, VBW: 3 MHz, Sweep: Auto, Detector function: Peak

5.8.4 Test result

Note:

For the conducted test the computed limits of paragraph 5.6.6 were used as limit lines to show compliance to the radiated absolute limits given in FCC Part 15 Section 15.209(a). The antenna provides a gain (G_{out}) of 3 dBi and is taken into account for limit lines calculation. Cable loss was compensated by using the analyser offset function. RMS detector function of the analyser was used where necessary for average re-measurements. For calculation the ground reflection factor (GRF) is taken into consideration. A duty cycle correction was calculated but not taken into consideration because it is not necessary to show the EUT's compliance. The duty cycle correction factor for pulsed operation is -30.2 dB and can be viewed in section 5.11.5.

Channel 11

PK-measurement										
Lowest frequency: CH11										
Test conditions: 1 TX, P10			Test results						Limit	
Start f (MHz)	Stop f (MHz)	RBW (kHz)	Maximum emission		G_{out} (dBi)	GRF (dB)	P_{EIRP} (dBm)	Fieldstrength (dB μ V/m)	PK (dB μ V/m)	AV (dB μ V/m)
			(MHz)	(dBm)						
30	1000	100	401.03	-65.4	3.5	4.7	-57.2	38.0	74	54
1000	2400	1000	2351.00	-39.9	3.5	0	-36.4	58.8	74	54
2483.5	4000	1000	2503.21	-46.1	3.5	0	-42.6	52.6	74	54
4000	12000	1000	7216.00	-62.6	3.5	0	-59.1	36.1	74	54
12000	18000	1000	16899.75	-65.4	3.5	0	-61.9	33.3	74	54
18000	25000	1000	24880.12	-62.4	3.5	0	-58.9	36.3	74	54
Measurement uncertainty				± 3 dB						

AV re-measurement										
Lowest frequency: CH11										
Test conditions: 1 TX, P10			Test results							
Start f (MHz)	Stop f (MHz)	RBW (kHz)	Maximum emission		G_{out} (dBi)	GRF (dB)	P_{EIRP} (dBm)	Fieldstrength (dB μ V/m)	AV Limit (dB μ V/m)	
			(MHz)	(dBm)						
1000.0	2390	1000	2351.70	-44.77	3.5	0	-41.3	53.9	54	
Measurement uncertainty				± 3 dB						

Channel 18

PK-measurement										
Middle frequency: CH18										
Test conditions: 1 TX, P10			Test results						Limit	
Start f (MHz)	Stop f (MHz)	RBW (kHz)	Maximum emission		G_{out} (dBi)	GRF (dB)	P_{EIRP} (dBm)	Fieldstrength (dB μ V/m)	PK (dB μ V/m)	AV (dB μ V/m)
			(MHz)	(dBm)						
30	1000	100	401.03	-65.3	3.5	4.7	-57.1	38.1	74	54
1000	2400	1000	2318.80	-49.7	3.5	0	-46.2	49.0	74	54
2483.5	4000	1000	2503.21	-47.7	3.5	0	-44.2	51.0	74	54
4000	12000	1000	7321.00	-64.9	3.5	0	-61.4	33.8	74	54
12000	18000	1000	15586.50	-66.1	3.5	0	-62.6	32.6	74	54
18000	25000	1000	24975.50	-61.5	3.5	0	-58.0	37.2	74	54
Measurement uncertainty				± 3 dB						

Channel 25

PK-measurement										
Highest frequency: CH25										
Test conditions: 1 TX, P10			Test results						Limit	
Start f (MHz)	Stop f (MHz)	RBW (kHz)	Maximum emission		G _{out} (dBi)	GRF (dB)	P _{EIRP} (dBm)	Fieldstrength (dBµV/m)	PK (dBµV/m)	AV (dBµV/m)
			(MHz)	(dBm)						
30	1000	100	736.04	-67.1	3.5	4.7	-58.9	36.3	74	54
1000	2400	1000	2389.50	-44.8	3.5	0	-41.3	53.9	74	54
2483.5	4000	1000	2539.99	-40.7	3.5	0	-37.2	58.0	74	54
4000	12000	1000	7423.00	-58.5	3.5	0	-55.0	40.2	74	54
12000	18000	1000	17544.75	-65.8	3.5	0	-62.3	32.9	74	54
18000	25000	1000	24840.75	-62.4	3.5	0	-58.9	36.3	74	54
Measurement uncertainty			±3 dB							

AV re-measurement									
Highest frequency: CH25									
Test conditions: 1 TX, P10			Test results						
Start f (MHz)	Stop f (MHz)	RBW (kHz)	Maximum emission		G _{out} (dBi)	GRF (dB)	P _{EIRP} (dBm)	Fieldstrength (dBµV/m)	AV Limit (dBµV/m)
			(MHz)	(dBm)					
2483.5	4000	1000	2538.85	-46.25	3.5	0	-42.8	52.5	54
Measurement uncertainty				±3 dB					

Radiated limits according to FCC Part 15 Section 15.209(a) for spurious emissions which fall in restricted bands:

Frequency (MHz)	Field strength of spurious emissions		Measurement distance
	(µV/m)	dB(µV/m)	(metres)
0.009-0.490	2400/F (kHz)		300
0.490-1.705	24000/F (kHz)		30
1.705-30	30	29.5	30
30-88	100	40	3
88-216	150	43.5	3
216-960	200	46	3
Above 960	500	54	3

Restricted bands of operation:

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in § 15.209(a).

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	399.9 – 410	4.5 – 5.15
0.495 – 0.505	16.69475 – 16.69525	608 – 614	5.35 – 5.46
2.1735 – 2.1905	16.80425 – 16.80475	960 – 1240	7.25 – 7.75
4.125 – 4.128	25.5 – 25.67	1300 – 1427	8.025 – 8.5
4.17725 – 4.17775	37.5 – 38.25	1435 – 1626.5	9.0 – 9.2
4.20725 – 4.20775	73 – 74.6	1645.5 – 1646.5	9.3 – 9.5
6.215 – 6.218	74.8 – 75.2	1660 – 1710	10.6 – 12.7
6.26775 – 6.26825	108 – 121.94	1718.8 – 1722.2	13.25 – 13.4
6.31175 – 6.31225	123 – 138	2200 – 2300	14.47 – 14.5
8.291 – 8.294	149.9 – 150.05	2310 – 2390	15.35 – 16.2
8.362 – 8.366	156.52475 – 156.52525	2483.5 – 2500	17.7 – 21.4
8.37625 – 8.38675	156.7 – 156.9	2690 – 2900	22.01 – 23.12
8.41425 – 8.41475	162.0125 – 167.17	3260 – 3267	23.6 – 24.0
12.29 – 12.293	167.72 – 173.2	3332 – 3339	31.2 – 31.8
12.51975 – 12.52025	240 – 285	3345.8 – 3358	36.43 – 36.5
12.57675 – 12.57725	322 – 335.4	3600 – 4400	Above 38.6

The requirements are **FULFILLED**.

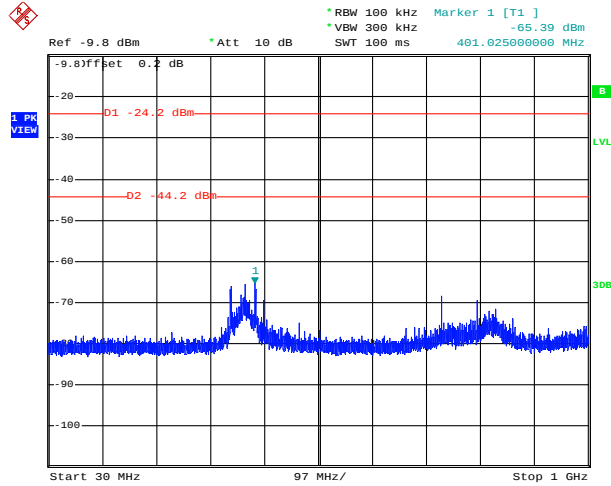
Remarks: The measurement was performed up to the 10th harmonic.

For detailed test results please see to following test protocols.

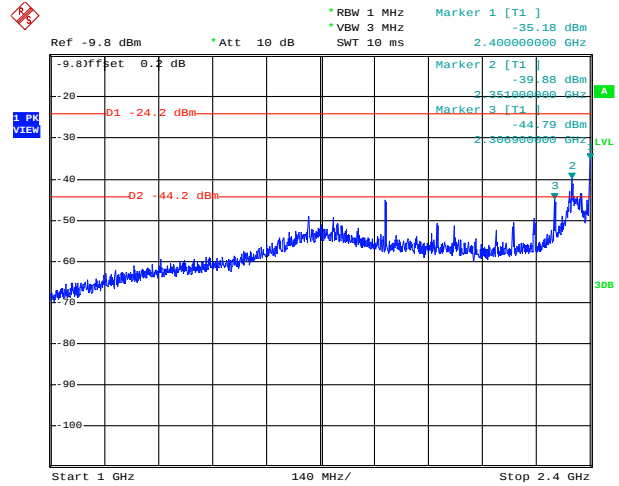
5.8.5 Test protocols of restricted band emissions

Channel 11

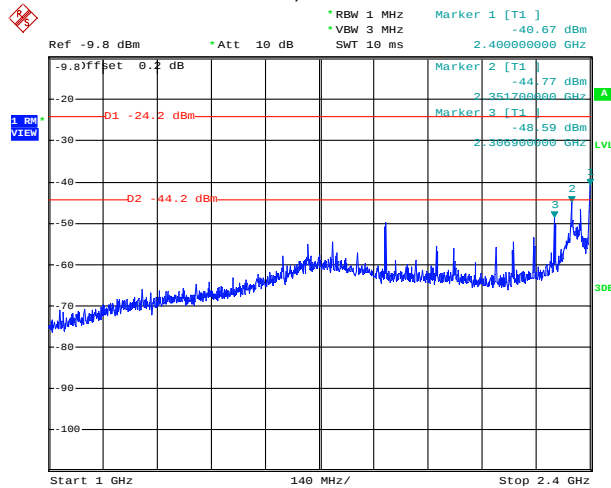
30 - 1000 MHz



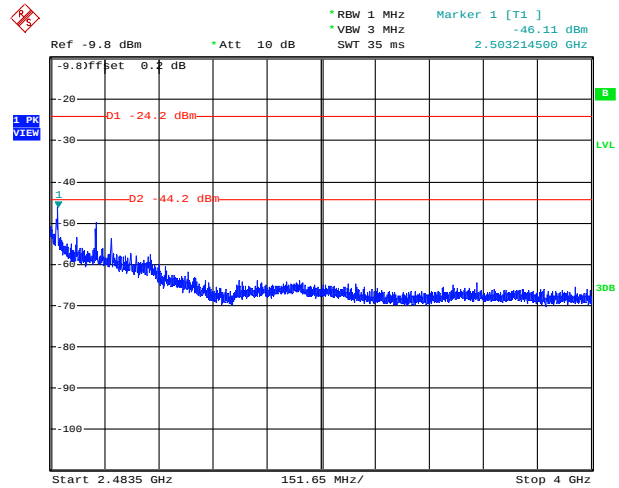
1 - 2.4 GHz



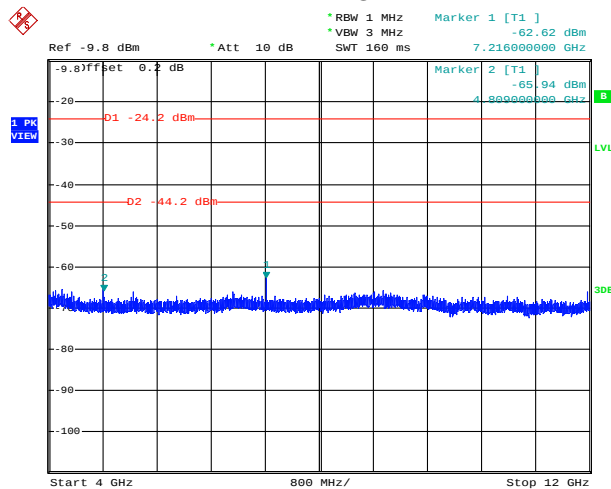
1 - 2.4 GHz, AV re-measurment



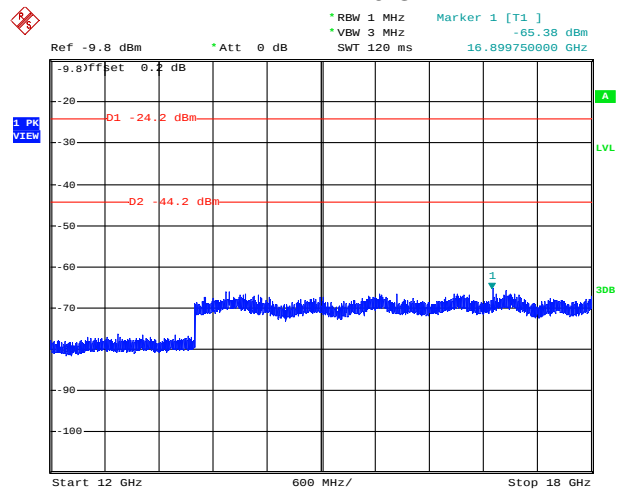
2.4835 - 4GHz



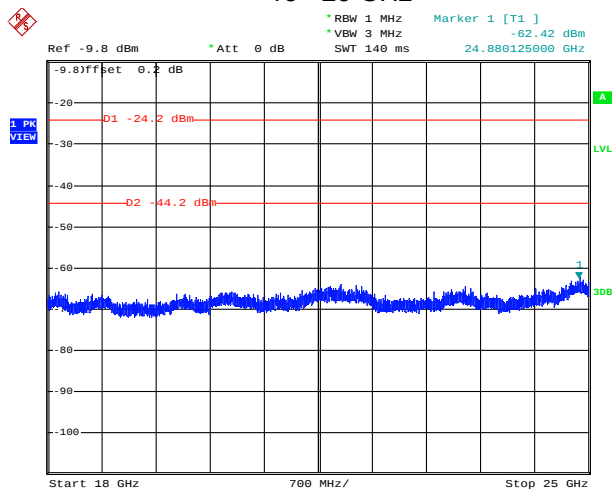
4 - 12 GHz



12 - 18 GHz

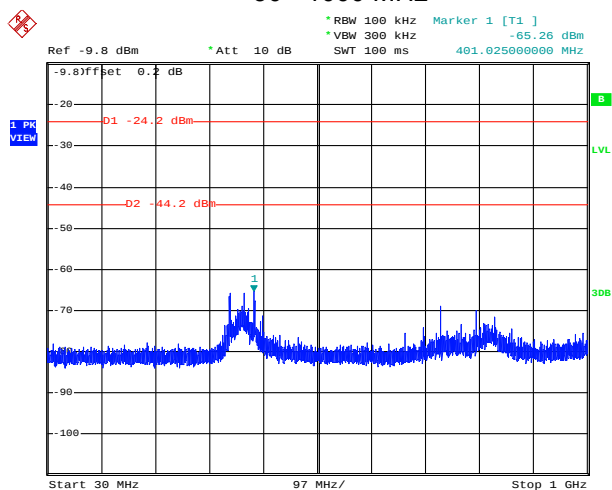


18 - 25 GHz

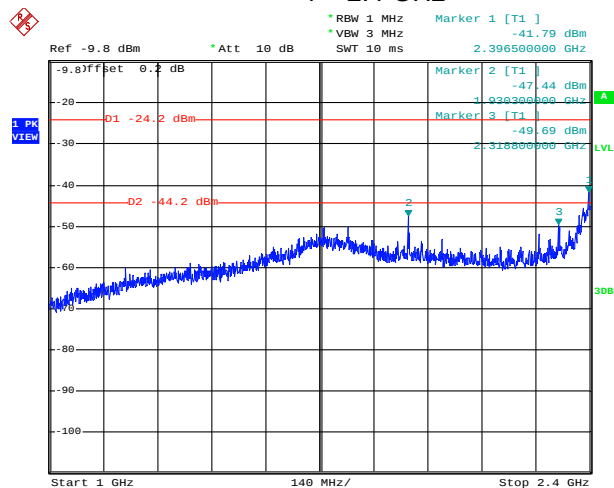


Channel 18

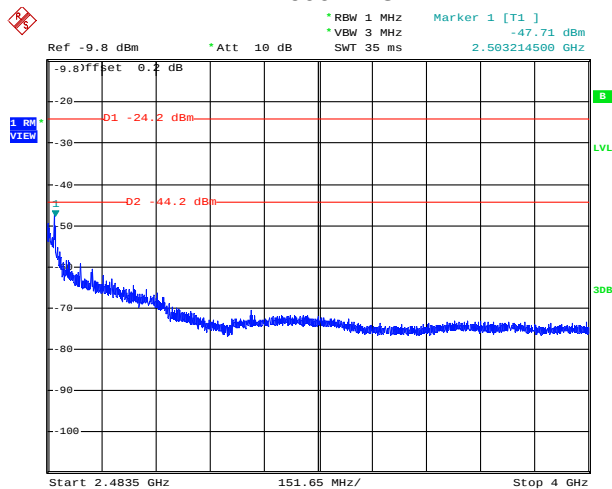
30 - 1000 MHz



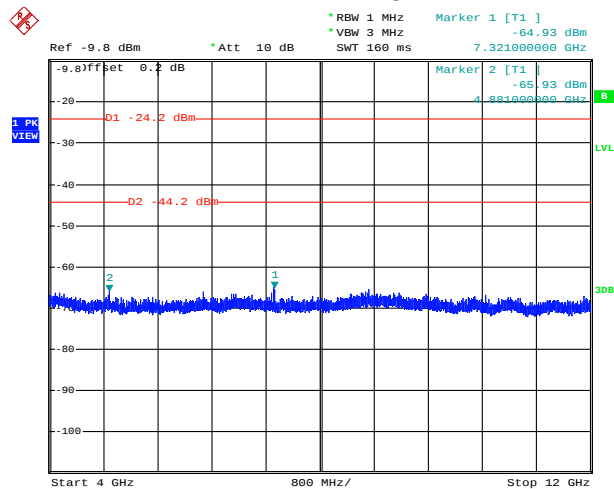
1 - 2.4 GHz



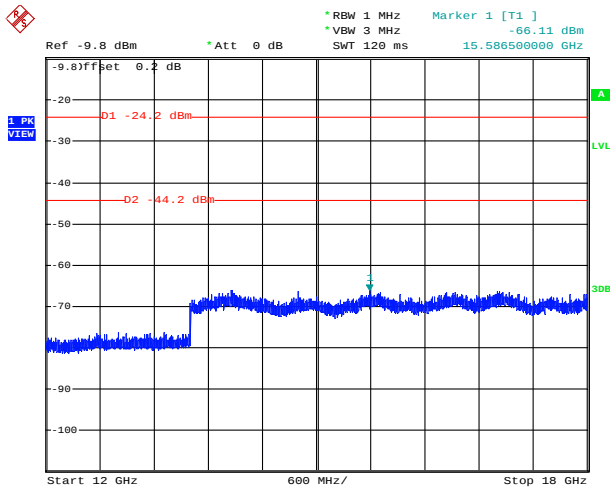
2.4835 - 4GHz



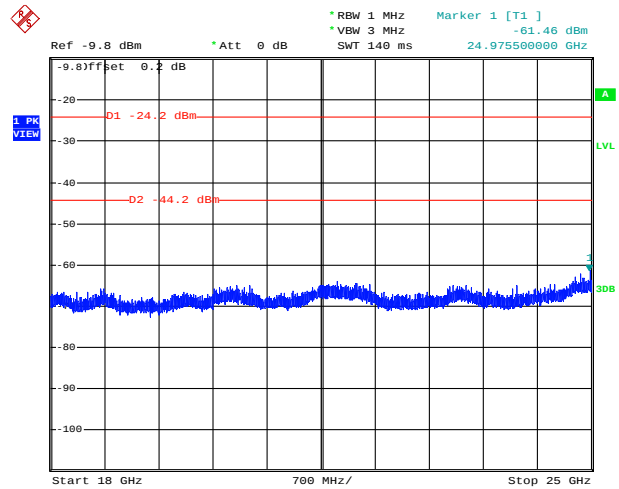
4 - 12 GHz



12 - 18 GHz

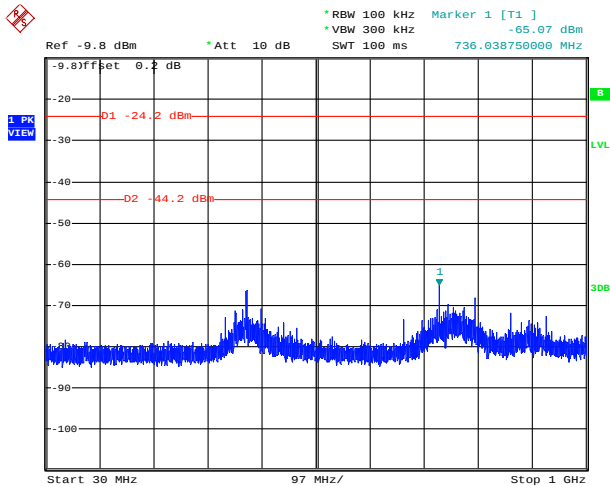


18 - 25 GHz

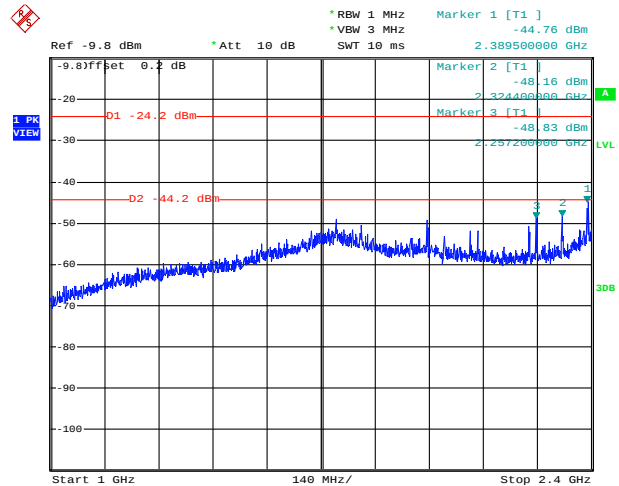


Channel 25

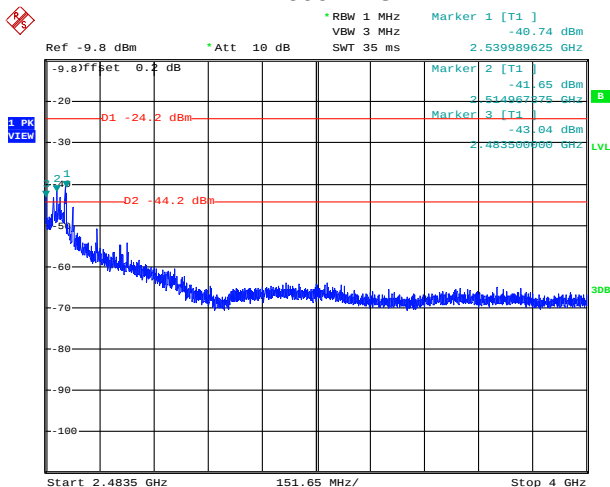
30 - 1000 MHz



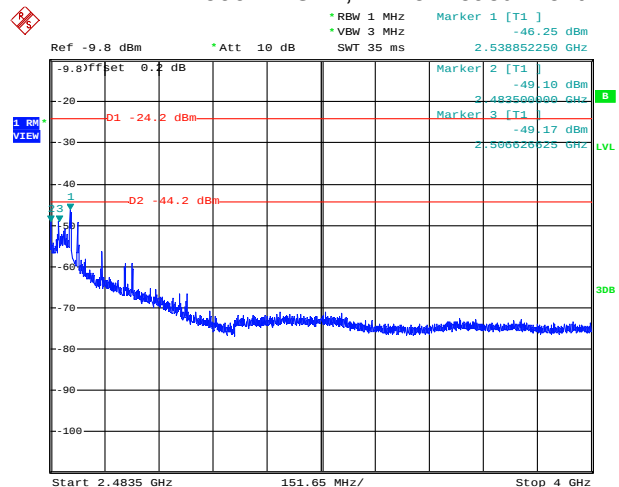
1 - 2.4 GHz



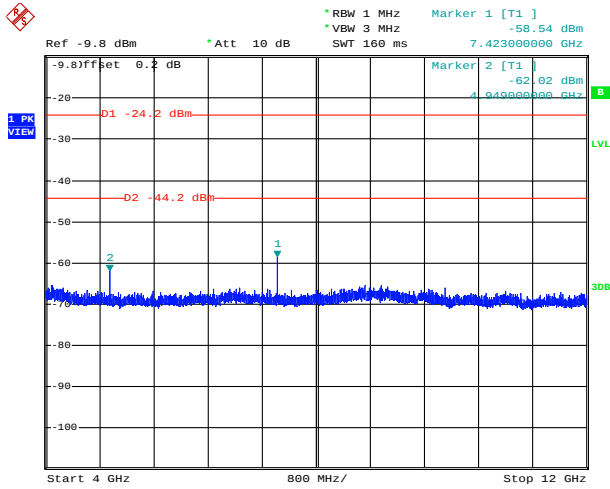
2.4835 - 4GHz



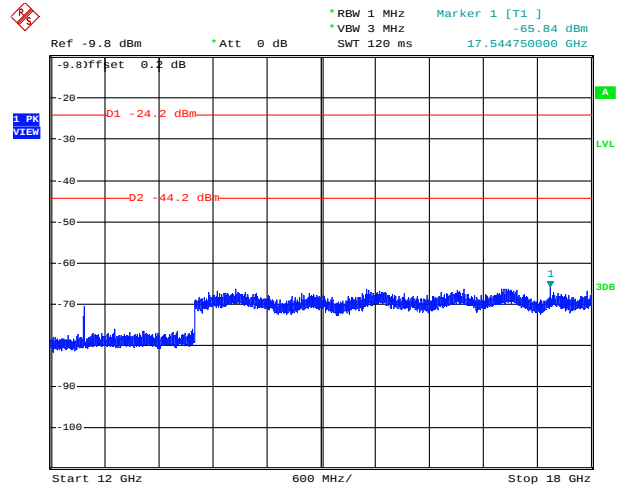
2.4835 - 4GHz, AV re-measurement



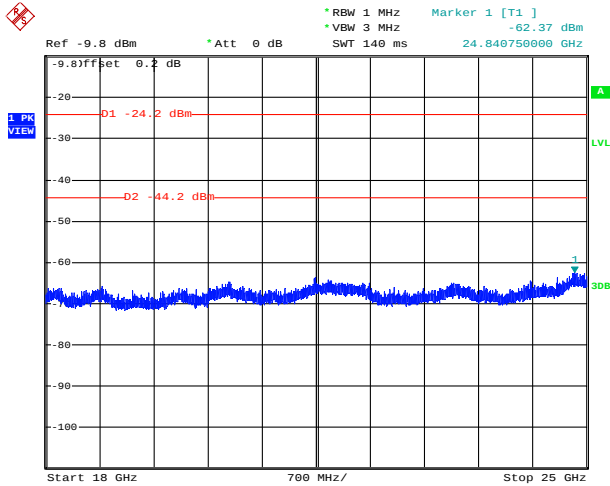
4 - 12 GHz



12 - 18 GHz



18 - 25 GHz



5.9 Radiated emissions (Cabinet radiation)

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

5.9.1 Description of the test location

Test location: OATS 1
Test location: Anechoic chamber 1
Test distance: 3 m

5.9.2 Photo documentation of the test set-up

Open area test site 1



Anechoic chamber 1



According to FCC Part 15, Section 15.205(a):

In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limit specified in Section 15.209(a).

5.9.3 Description of Measurement

The restricted bands are measured radiated. The span of the spectrum analyser is set wide enough to capture the restricted band and measure the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation. The restricted bands are measured falling emissions into it and the nearest restricted band are checked for emissions also the restricted band for the harmonics of the carrier.

Test receiver settings:

RBW: 120 kHz, Detector function: Quasi peak Meas. Time: 1 sec.

Spectrum analyser settings:

RBW: 1 MHz, VBW: 3 MHz, Sweep: Auto, Detector function: Peak

5.9.1 Test result

For the radiated test the SMA port was terminated with 50 Ω .

Note:

For measurements from 30 MHz to 1000 MHz the intentional channel change transmission mode was selected. Cabinet radiation measurements above 18 GHz were not performed.

Standard 802.15.4

Emission frequency 2405 MHz, channel 11							
Power setting: P10			Test results				
Start frequ. (MHz)	Stop frequ. (MHz)	RBW (kHz)	Maximum emission		Limit (dB μ V/m)	Margin (dB)	Detector
			(MHz)	(dB μ V/m)			
30	1000	120	126.80	27.3	43.5	-16.2	QP
30	1000	120	235.90	28.9	46	-17.1	QP
30	1000	120	249.42	24.6	46	-21.4	QP
30	1000	120	727.50	29.6	46	-16.4	QP
30	1000	120	730.60	35.3	46	-10.7	QP
30	1000	120	747.10	27.2	46	-18.8	QP
1000	4000	1000	2656.00	44.0	54	-10.0	PK
4000	12000	1000	11684.00	49.6	54	-4.4	PK
4000	12000	1000	11848.00	40.5	54	-13.5	RMS
12000	18000	1000	17598.00	55.4	54	1.4	PK
12000	18000	1000	17607.75	48.2	54	-5.8	RMS
Measurement uncertainty				± 6 dB			

Emission frequency 2440 MHz, channel 18							
Power setting: P10			Test results				
Start frequ. (MHz)	Stop frequ. (MHz)	RBW (kHz)	Maximum emission		Limit (dBµV/m)	Margin (dB)	Detector
			(MHz)	(dBµV/m)			
30	1000	120	126.80	27.3	43.5	-16.2	QP
30	1000	120	235.90	28.9	46	-17.1	QP
30	1000	120	249.42	24.6	46	-21.4	QP
30	1000	120	727.50	29.6	46	-16.4	QP
30	1000	120	730.60	35.3	46	-10.7	QP
30	1000	120	747.10	27.2	46	-18.8	QP
1000	4000	1000	2662.75	47.7	54	-6.4	PK
4000	12000	1000	11927.00	48.9	54	-5.1	PK
4000	12000	1000	9785.00	41.0	54	-13.0	RMS
12000	18000	1000	17625.75	56.8	54	2.8	PK
12000	18000	1000	17547.00	47.6	54	-6.4	RMS
Measurement uncertainty				±6 dB			

Emission frequency 2405 MHz, channel 25							
Power setting: P10			Test results				
Start frequ. (MHz)	Stop frequ. (MHz)	RBW (kHz)	Maximum emission		Limit (dBµV/m)	Margin (dB)	Detector
			(MHz)	(dBµV/m)			
30	1000	120	126.80	27.3	43.5	-16.2	QP
30	1000	120	235.90	28.9	46	-17.1	QP
30	1000	120	249.42	24.6	46	-21.4	QP
30	1000	120	727.50	29.6	46	-16.4	QP
30	1000	120	730.60	35.3	46	-10.7	QP
30	1000	120	747.10	27.2	46	-18.8	QP
1000	4000	1000	1598.50	46.2	54	-7.8	PK
4000	12000	1000	11966.00	48.5	54	-5.5	PK
4000	12000	1000	11996.00	40.5	54	-13.5	RMS
12000	18000	1000	17817.75	57.2	54	3.2	PK
12000	18000	1000	17616.00	48.1	54	-5.9	RMS
Measurement uncertainty				±6 dB			

Radiated limits according to FCC Part 15 Section 15.209(a) for spurious emissions which fall in restricted bands:

Frequency (MHz)	Field strength of spurious emissions		Measurement distance
	(µV/m)	dB(µV/m)	(metres)
0.009-0.490	2400/F (kHz)		300
0.490-1.705	24000/F (kHz)		30
1.705-30	30	29.5	30
30-88	100	40	3
88-216	150	43.5	3
216-960	200	46	3
Above 960	500	54	3

Restricted bands of operation:

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	399.9 – 410	4.5 – 5.15
0.495 – 0.505	16.69475 – 16.69525	608 – 614	5.35 – 5.46
2.1735 – 2.1905	16.80425 – 16.80475	960 – 1240	7.25 – 7.75
4.125 – 4.128	25.5 – 25.67	1300 – 1427	8.025 – 8.5
4.17725 – 4.17775	37.5 – 38.25	1435 – 1626.5	9.0 – 9.2
4.20725 – 4.20775	73 – 74.6	1645.5 – 1646.5	9.3 – 9.5
6.215 – 6.218	74.8 – 75.2	1660 – 1710	10.6 – 12.7
6.26775 – 6.26825	108 – 121.94	1718.8 – 1722.2	13.25 – 13.4
6.31175 – 6.31225	123 – 138	2200 – 2300	14.47 – 14.5
8.291 – 8.294	149.9 – 150.05	2310 – 2390	15.35 – 16.2
8.362 – 8.366	156.52475 – 156.52525	2483.5 – 2500	17.7 – 21.4
8.37625 – 8.38675	156.7 – 156.9	2690 – 2900	22.01 – 23.12
8.41425 – 8.41475	162.0125 – 167.17	3260 – 3267	23.6 – 24.0
12.29 – 12.293	167.72 – 173.2	3332 – 3339	31.2 – 31.8
12.51975 – 12.52025	240 – 285	3345.8 – 3358	36.43 – 36.5
12.57675 – 12.57725	322 – 335.4	3600 – 4400	Above 38.6

The requirements are **FULFILLED**.

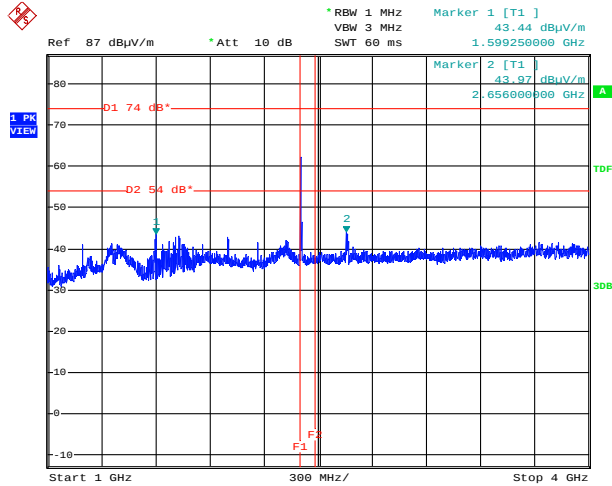
Remarks: The measurement was performed up to the 10th harmonic.

For detailed test results please see to following test protocols.

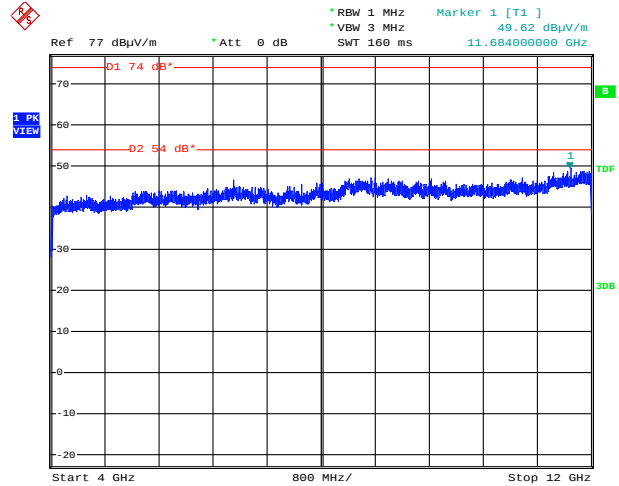
5.9.2 Test protocols of restricted band emissions

Channel 11

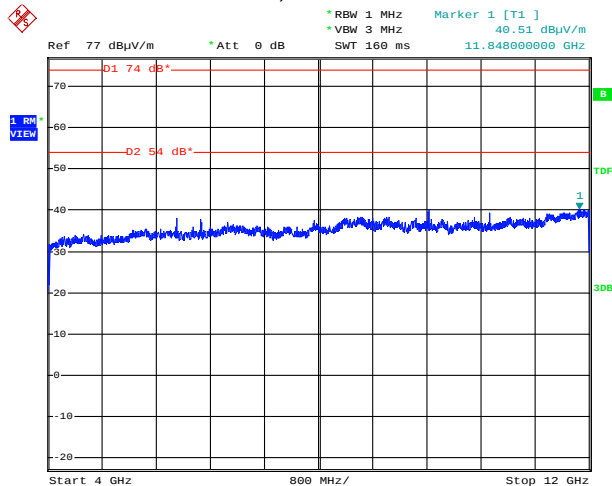
1 – 4 GHz



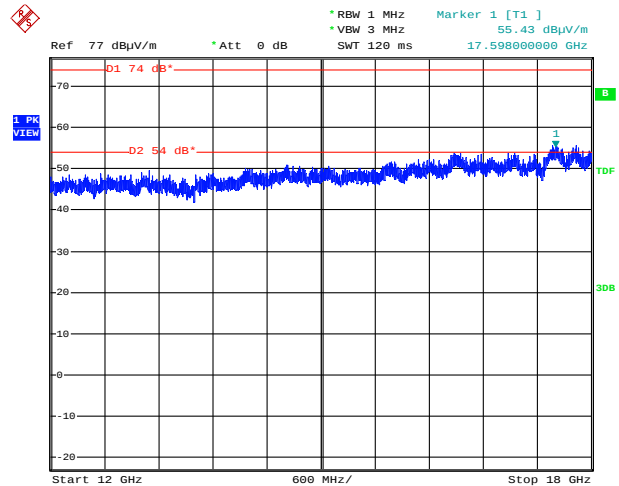
4 – 12 GHz



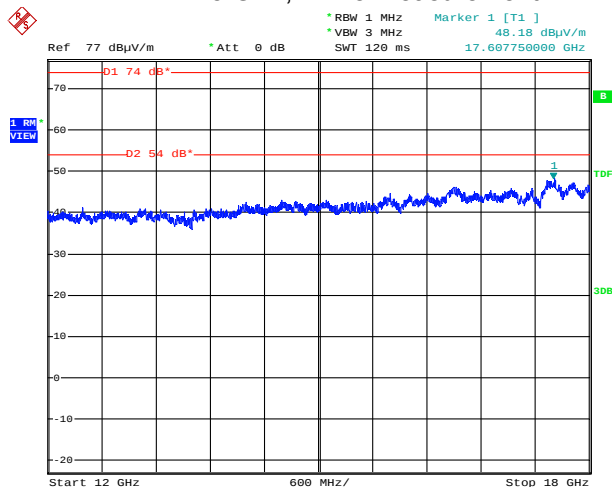
4 - 12 GHz, AV re-measurement



12 - 18 GHz

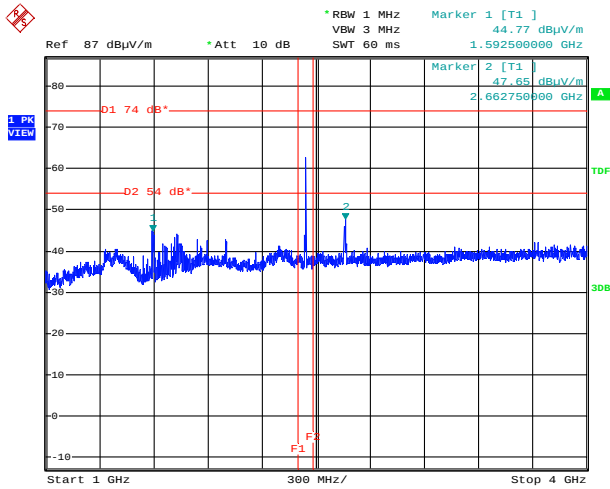


12 - 18 GHz, AV re-measurement

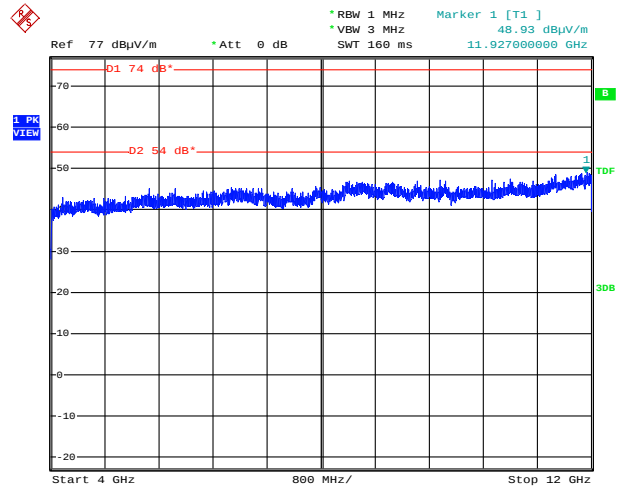


Channel 18

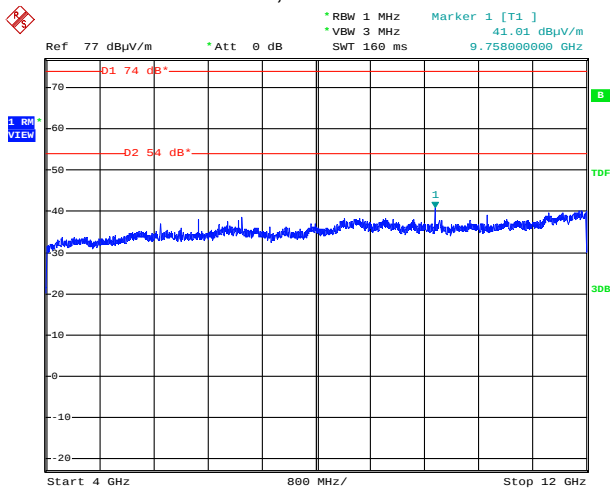
1 – 4 GHz



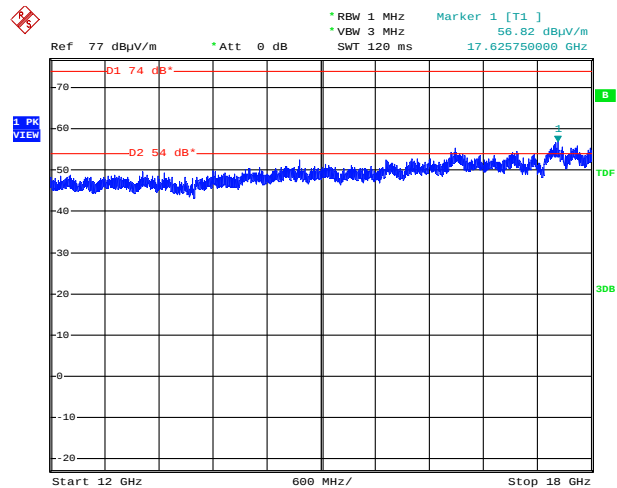
4 – 12 GHz



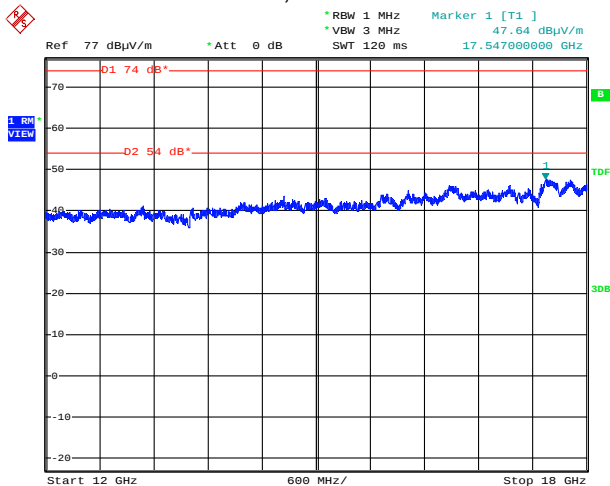
4 - 12 GHz, AV re-measurement



12 - 18 GHz

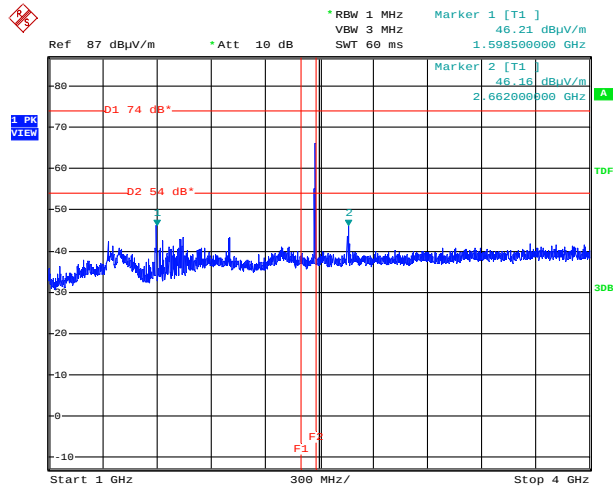


12 - 18 GHz, AV re-measurement

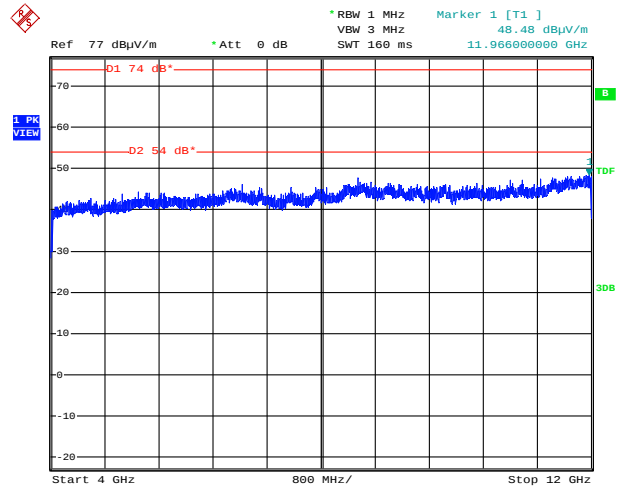


Channel 25

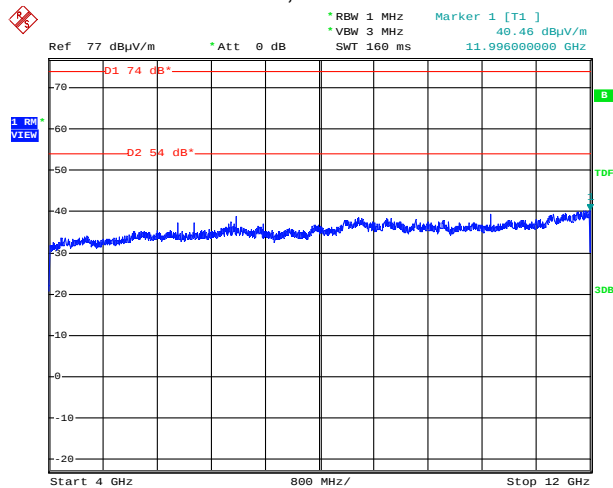
1 – 4 GHz



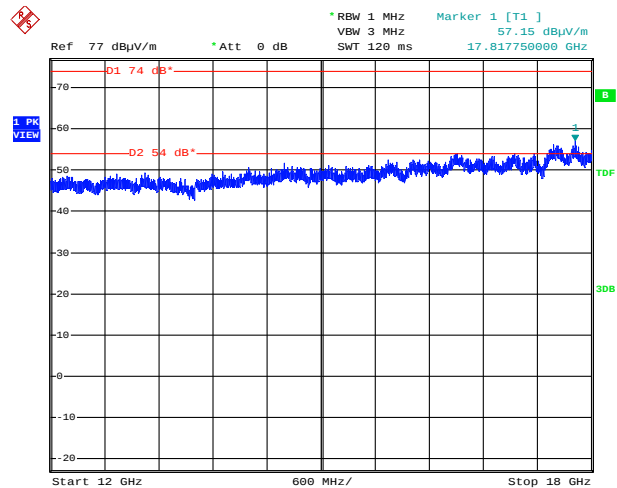
4 – 12 GHz



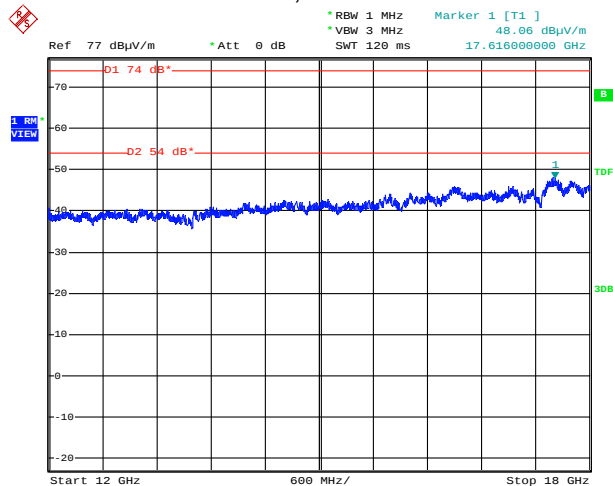
4 - 12 GHz, AV re-measurment



12 - 18 GHz



12 - 18 GHz, AV re-measurment



5.10 RF exposure consideration for SAR test exclusion

According to KDB 447498 D01 General RF Exposure Guidance v05r02 chapter 4.3.1 the 1-g SAR number is calculated for a distance of 1 mm using the following formula.

$$\left(\frac{\text{max. Pchannel (mW)}}{\text{Distance (mm)}} \right) * \sqrt{f(\text{GHz})} \leq 3$$

Where:

Max. Pchannel = EIRP (mW)

EIRP = P + G + K_E

Distance = 1 mm

f (GHz) = Channel frequency (MHz) divided by thousand

K_E = Duty cycle correction factor (see paragraph 5.11.5)

5.10.1 Test result

Standard 802.15.4

Channel frequency (MHz)	P (dBm)	G (dBi)	K _E (dB)	EIRP (dBm)	EIRP (mW)	1-g SAR (1)	Limit 1-g SAR (1)
2405	11.1	3.5	-15.1	-0.5	0.89	1.39	3.0
2440	10.7	3.5	-15.1	-0.9	0.82	1.27	3.0
2475	10.3	3.5	-15.1	-1.3	0.74	1.17	3.0

The limits for SAR test exclusion threshold are given in KDB 447498 D01 General RF Exposure Guidance Appendix A.

Channel frequency (MHz)	P (dBm)	G (dBi)	K _E (dB)	EIRP (dBm)	EIRP (mW)	SAR exclusion limit (mW)
2405	11.1	3.5	-15.1	-0.5	0.89	20.0
2440	10.7	3.5	-15.1	-0.9	0.82	20.0
2475	10.3	3.5	-15.1	-1.3	0.74	20.0

The limits for SAR test exclusion threshold for devices radiating in the frequency range from 2.2 GHz up to 3.0 GHz are given in RSS-102 section 2.5.1 .

The requirements are **FULFILLED**.

Remarks:

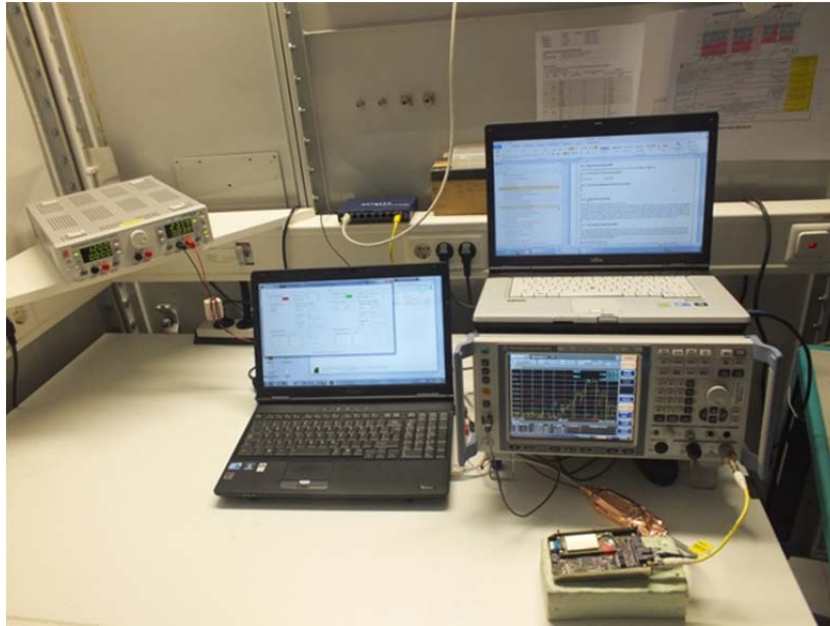
5.11 Correction for pulse operation (duty cycle)

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

5.11.1 Description of the test location

Test location: AREA4

5.11.2 Photo documentation of the test set-up



5.11.3 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 pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1s. In cases where the pulse 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.

5.11.4 Description of Measurement

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

$$K_E = 10 \log \frac{(t_{iW}/T_B) * t_{iB}}{T_W}$$

Where:

- K_E = pulse operation correction factor
- t_{iW} = pulse duration for one complete pulse track
- t_{iB} = pulse duration for one pulse
- T_W = a period of the pulse track
- T_B = a period of one pulse

5.11.5 Test result

CH	t_{iw} (ms)	T_w (ms)	t_{iB} (ms)	T_B (ms)	K_E (dB)
11	100	100	3.1	100	-15.1

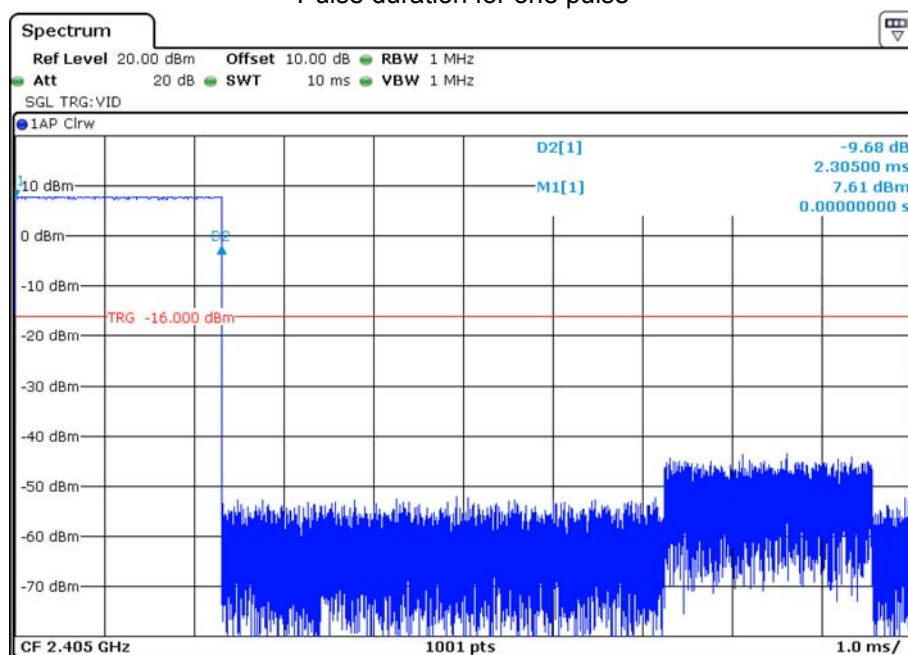
Remarks: The pulse train (T_w) exceeds 100 ms, therefore the duty cycle has been calculated by averaging the sum of the pulse widths over the 100 ms width with the highest average value.

For detailed results, please see the test protocol below.

5.11.6 Test protocol

Correction for Pulse Operation (Duty Cycle) FCC Part 15A, Section 15.35(c)

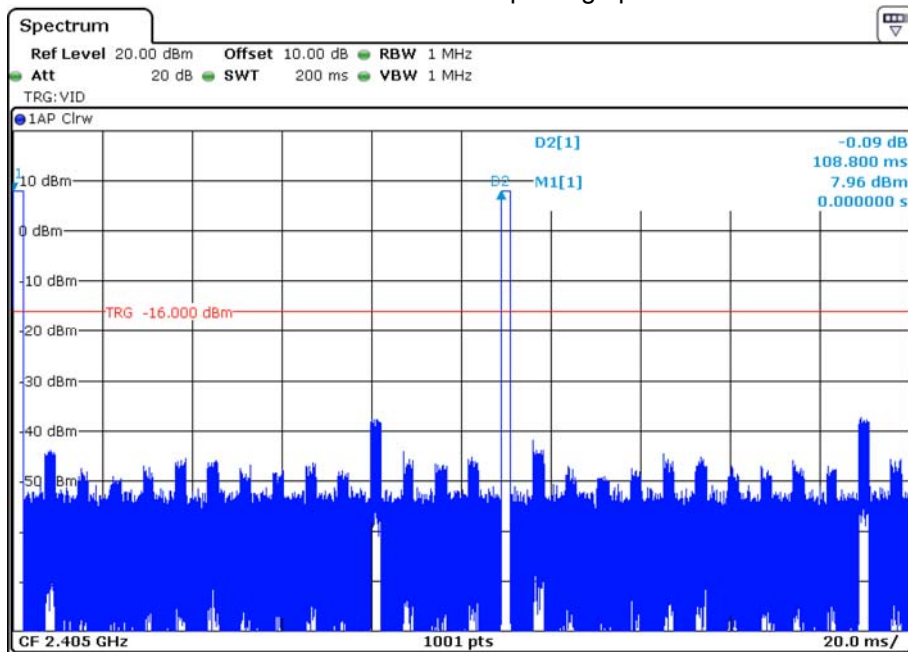
Pulse duration for one pulse



Note:

In test mode the pulse width is 2.3 ms at worst case timing. In live mode an acknowledge pulse is generated when communication with companion device is possible. The acknowledge pulse can not be measured in test mode but is taken into calculation of the worst case timing for duty cycle correction. The acknowledge pulse width is declared by the manufacturer with 0.8 ms being added to the normal data package pulse width. Therefore the total pulse duration within 100 ms is 3.1 ms instead of the measured 2.3 ms in the plot above and shows the worst case.

Time between two data package pulses



5.12 Antenna application

5.12.1 Applicable standard

According to FCC Part 15C, Section 15.203:

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. The manufacturer may design the unit that broken antennas can be replaced by the user, but the use of a standard antenna jack is prohibited.

The EUT in version A has an integrated antenna. No other antenna can be used with the device.

The EUT in version B has a U.FL antenna connector. In the application a U.FL to SMA adaptor is used to provide the connector for antenna no. 2 . The connector is mounted within the housing of the end application and is inaccessible for the end user.

All supplied antennas meet the requirements of part 15.203 and 15.204.

5.12.2 Antenna requirements

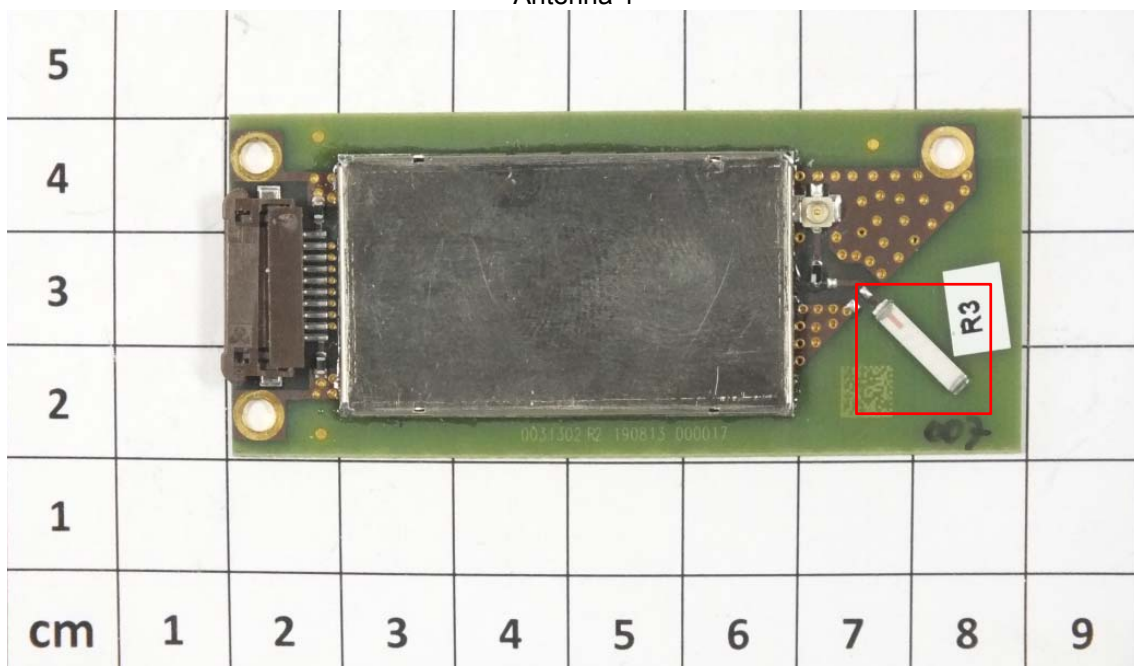
According to FCC Part 15C, Section 15.247(b)(4):

The conducted output power limit specified in paragraph (b) of 15.247 is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from intentional radiator shall be reduced below the stated values in paragraph (b)(1), (b)(2) and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

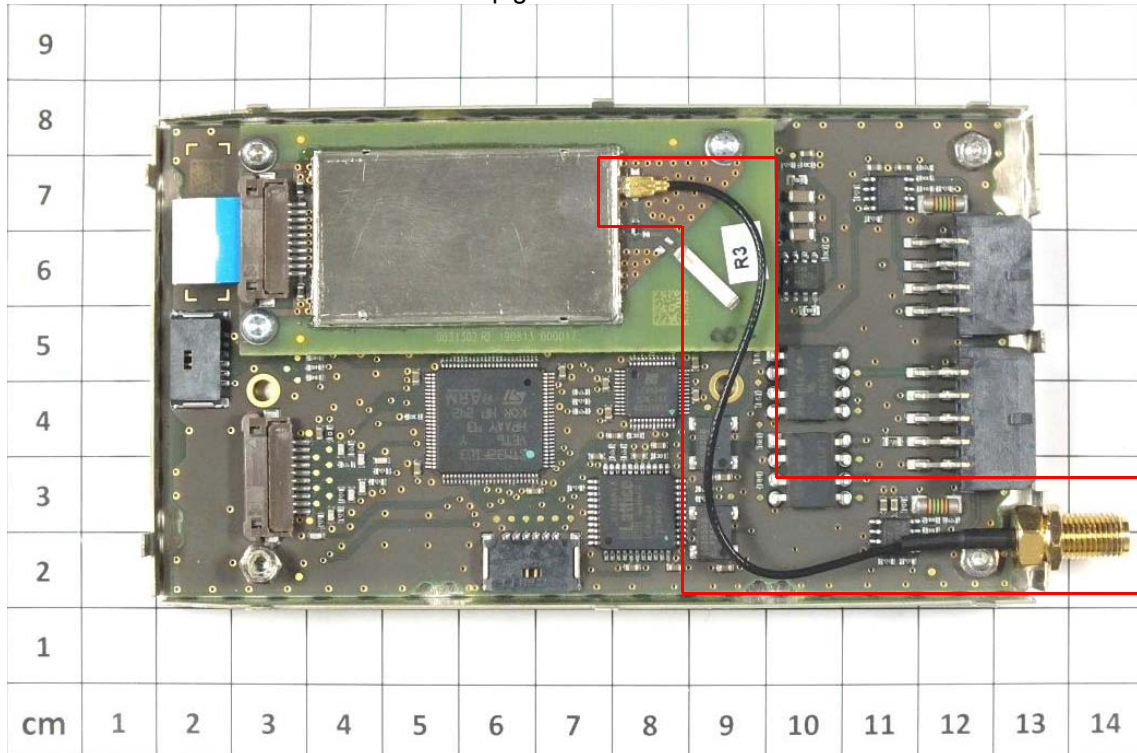
The output power has not to be reduced using of the following antennnas.

Number	Type	Certification name	Plug	Frequency range (GHz)	Gain
1	Omni	WE-MCA, P/N: 7488910245	none	2.4	3.0
2	Omni	ANT-2.4-WRT-SMA	SMA	2.4	3.5
3	Omni	Generic antenna	SMA	2.4	3.0

Antenna 1



USB to SMA pigtail for antennas 2 and 3



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.
CPC 3	ESR 7	02-02/03-13-001	03/06/2015	03/06/2014		
MB	ESR 7	02-02/03-13-001	03/06/2015	03/06/2014		
SEC 1-3	FSP 40 WLJS 1200-3EF WHK 3.0/18G-10EF	02-02/11-11-001 02-02/50-05-041 02-02/50-05-180	30/09/2014	30/09/2013		
SER 2	ESVS 30 VULB 9168 S10162-B NW-2000-NB KK-EF393/U-16N-21N20 m	02-02/03-05-006 02-02/24-05-005 02-02/50-05-031 02-02/50-05-113 02-02/50-12-018	03/07/2015 08/04/2015	03/07/2014 08/04/2014	08/10/2014	08/04/2014
SER 3	FSP 40 AFS5-12001800-18-10P-6 AFS4-01000400-10-10P-4 AMF-4F-04001200-15-10P 3117 Sucoflex N-1600-SMA Sucoflex N-2000-SMA SF104/11N/11N/1500MM	02-02/11-11-001 02-02/17-06-002 02-02/17-13-002 02-02/17-13-003 02-02/24-05-009 02-02/50-05-073 02-02/50-05-075 02-02/50-13-015	30/09/2014 07/05/2015	30/09/2013 07/05/2014		