

EMI – TEST REPORT

- FCC Part 15.247, RSS247 -

Type / Model Name : Wallpoint W012

Product Description : Chirp spread spectrum transceiver used for wireless
localization

Applicant : Smartbow GmbH

Address : Jutogasse 3
4675 WEIBERN, AUSTRIA

Manufacturer : Smartbow GmbH

Address : Jutogasse 3
4675 WEIBERN, AUSTRIA

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

POSITIVE

Test Report No. : **T43343-00-03KS**

05. December 2017

Date of issue



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

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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ATTACHMENT A as separate supplement

1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (September 2017)

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 2017)

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

ANSI C63.10: 2013	Testing Unlicensed Wireless Devices
ETSI TR 100 028 V1.3.1: 2001-03	Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Uncertainties in the Measurement of Mobile Radio Equipment Characteristics—Part 1 and Part 2
KDB 558074 D01 v04	Guidance for performing compliance measurements on DTS operating under §15.247, April 5, 2017.

2 EQUIPMENT UNDER TEST

2.1 Photo documentation of the EUT – Detailed photos see ATTACHMENT A

2.2 Equipment type

Chirp Spread Spectrum

2.3 Short description of the equipment under test (EUT)

The EUT is a chirp spread spectrum (CSS) transceiver used for wireless localization. It uses the IEEE standard 802.15.4a in the 2.4 GHz ISM band and achieves a maximum data rate of 1 Mbps. The EUT has two identical transceivers which cannot transmit at the same time. It also has two external antennas which transmit alternating.

Number of tested samples: 2 (534C & 5345)
Serial number: 180B5200534C, 180B52005345
Firmware version: 2.0.11

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. The tested middle frequency is 2441.75 MHz.

2.6 Transmit operating modes

The EUT uses CSS without modulation and has a maximum data rate of 1 Mbps.

2.7 Antennas

The following antennas shall be used with the EUT:

Number	Type	Characteristic	Plug	Frequency range (GHz)	Gain (dBi)
1	RP-SMA	Omni	male	2.4 - 2.4835	4
2	RP-SMA	Omni	male	2.4 - 2.4835	4

2.8 Power supply system utilised

Power supply voltage, V_{nom} : 115 VAC (Power over Ethernet)
 Power supply voltage range : 110 VAC – 120 VAC

2.9 Extreme test conditions

The extreme temperature range for the EUT is defined by the manufacturer:

-30 °C to +65 °C,
 $T_{nom} = 20$ °C;

2.10 Peripheral devices and interface cables

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

- Ethernet cable Model : Supplied by manufacturer
- PoE Switch Model : Netgear GS110TP (supplied by manufacturer)
- Model :

2.11 Determination of worst case conditions for final measurement

For the final test the following channels and test modes are selected:

Spreading	Tested Frequency range (GHz)	Tested Middle Frequency (MHz)	Number of transmit chains	Number of receive chains	Power setting	Modulation	Data rate
CSS	2.4 – 2.4835	2441.75	2	2	56	None	1 Mbps

- TX continuous mode
- RX continuous mode

2.11.1 Test jig

No special test jig was used.

2.11.2 Test software

The test software for the EUT provides free power setting, the special test mode RX and the TX continuous mode for both chains. The power was set to a register value of 56 during testing.

3 TEST RESULT SUMMARY

WLAN 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, 8.8	AC power line conducted emissions	passed
15.247(a)(2)	RSS247, 5.2(1)	-6 dB EBW	passed
15.247(b)(3)	RSS247, 5.4(4)	Maximum peak conducted output power	passed
15.247(b)(4)	RSS247, 5.4(4)	Defacto limit	passed
15.247(d)	RSS247, 5.5	Unwanted emission, radiated	passed
15.247(d)	RSS-Gen, 8.10	Emissions in restricted bands	passed
15.247(e)	RSS247, 5.2(2)	PSD	passed
15.35(c)	RSS-Gen, 6.10	Pulsed operation	passed
15.247(b)(4)	-	Antenna requirement	passed
	RSS-Gen, 6.11	Transmitter frequency stability	passed
	RSS-Gen, 6.6	99 % Bandwidth	passed

The mentioned RSS Rule Parts in the above table are related to:
 RSS Gen, Issue 4, November 2014
 RSS 247, Issue 2, February 2017

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 : 26 October 2017

Testing concluded on : 07 November 2017

Checked by:

Tested by:

 Klaus Gegenfurtner
 Teamleader Radio

 Kathrin Schiebl
 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 Type	Range	Confidence Level	Calculated Uncertainty
AC power line conducted emissions	0.15 MHz to 30 MHz	95%	± 3.29 dB
EBW and OBW	2400 MHz to 3000 MHz	95%	$\pm 2.5 \times 10^{-7}$
Maximum peak conducted output power	2400 MHz to 3000 MHz	95%	± 0.62 dB
Power spectral density	2400 MHz to 3000 MHz	95%	± 0.62 dB
Conducted Spurious Emissions	9 kHz to 10000 MHz	95%	± 2.15 dB
Conducted Spurious Emissions	10000 MHz to 40000 MHz	95%	± 3.47 dB
Radiated Spurious Emissions	9 kHz to 30 MHz	95%	± 3.53 dB
Radiated Spurious Emissions	30 MHz to 1000 MHz	95%	± 3.71 dB
Radiated Spurious Emissions	1000 MHz to 10000 MHz	95%	± 2.34 dB
Field strength of the fundamental	100 kHz to 100 MHz	95%	± 3.53 dB

4.4 Measurement protocol for FCC and ISCED

4.4.1 General information

4.4.1.1 Test methodology

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

IC 3009A-1

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

IC 3009A-2

In compliance with RSS 247 testing for RSS compliance may be achieved by following the procedures set out in ANSI C63.10 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 General Standard information

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 C63.10 and applying the CISPR 22 limits.

4.4.1.3.1 Radiated emission (electrical field 30 MHz - 1 GHz)

Description of measurement

Spurious emissions from the EUT are measured in the frequency range of 30 MHz to 1000 MHz using a tuned receiver and appropriate broadband linearly polarised antennas. Measurements between 30 MHz and 1000 MHz are made with 120 kHz/6 dB bandwidth and quasi-peak detection. Table top equipment is placed on a 1.0 X 1.5 m non-conducting table 80 centimetres above the ground plane. Floor standing equipment is placed directly on the turntable/ground plane. The setup of the equipment under test is established in accordance with ANSI C63.10. The interface cables that are closer than 40 centimetres to the ground plane are bundled in the center in a serpentine fashion so that they are at least 40 centimetres from the ground plane. Cables to simulators/testers (if used in this test) are routed through the center of the table and to a screened room located outside the test area. The antenna is positioned 3, 10 or 30 metres horizontally from the EUT and is repeated vertically. To locate maximum emissions from the test sample the antenna is varied in height from 1 to 4 metres and the EUT is rotated 360 degrees.

The final level in dBµV/m is calculated by taking the reading from the EMI receiver (Level dBµV) and adding the correction factors and cable loss factor (dB). The FCC or CISPR limit is subtracted from this result in order to provide the limit margin listed in the measurement protocol.

The resolution bandwidth setting:

30 MHz – 1000 MHz: RBW: 120 kHz

Example:

Frequency	Level	+	Factor	=	Level	-	CISPR Limit	=
Delta								
(MHz)	(dBµV)		(dB)		(dBµV/m)		(dBµV/m)	(dB)
719.0	75.0	+	32.6	=	107.6	-	110.0	= -2.4

4.4.1.3.2 Radiated emission (electrical field 1 GHz - 40 GHz)Description of measurement

Radiated emissions from the EUT are measured in the frequency range 1 GHz up to the maximum frequency as specified in 47 CFR Part 15, Subpart A, Section 15.33, using a spectrum analyser and appropriate linearly polarized antennas. Table top equipment is placed on a 1.0 X 1.5 metre non-conducting table, 1.5 metre above the ground plane. Floor standing equipment is placed directly on the turntable/ground plane. The setup of the equipment under test is following set out in ANSI C63.10. The interface cables that are closer than 40 centimetres to the ground plane are bundled in the center in a serpentine fashion so they are at least 40 centimetres from the ground plane. Cables to simulators/testers (if used in this test) are routed through the center of the table and to a screened room located outside the test area. Measurements are made in both the horizontal and vertical polarization planes in a fully anechoic room using a spectrum analyzer set to max peak detector function and a resolution 1 MHz and video bandwidth 3 MHz for peak measurement. The conditions determined as worst case will then be used for the final measurements. When the EUT is larger than the beam width of the measuring antenna it will be moved over the surface for the four sides of the equipment. Where appropriate, the test distance may be reduced in order to detect emissions under better uncertainty and are calculated at the specified test distance.

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 C63.10 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 re-measured 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 12.30 dB at 1.416 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

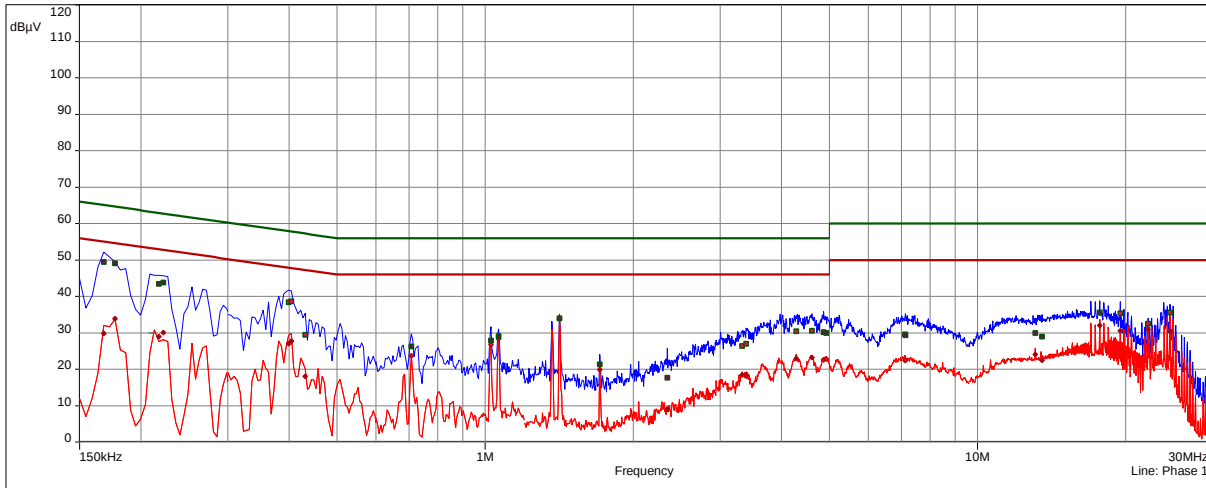
* Decreases with the logarithm of the frequency

The requirements are **FULFILLED**.**Remarks:** For detailed test result please refer to following test protocolsThe EUT has no standby mode. It starts to chirp as soon as it is powered. Therefore, only
active chirp mode was tested.

5.1.6 Test protocol

Test point L1
 Operation mode: Active Chirp
 Remarks: None

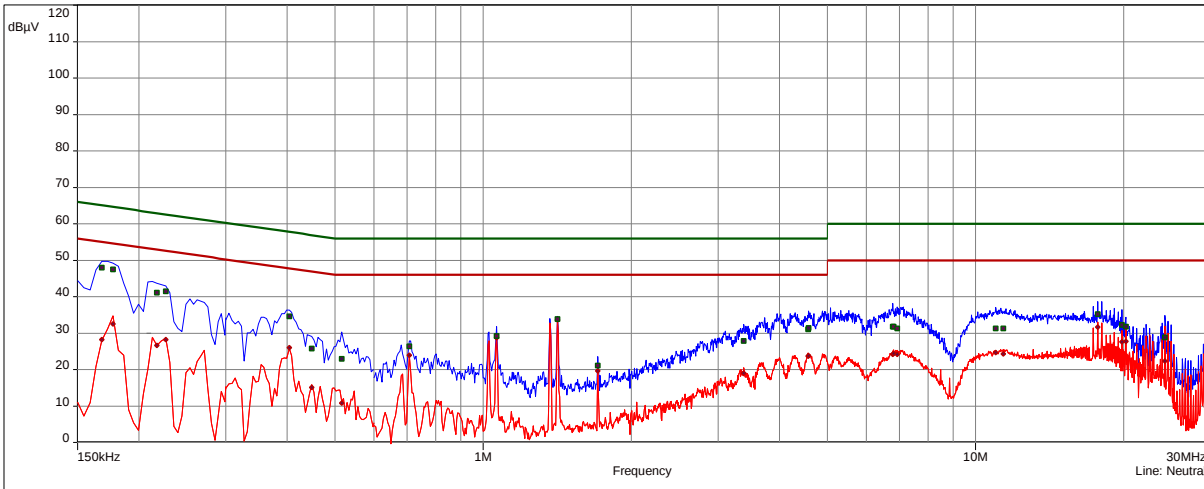
Result: passed



freq MHz	QP dB(μV)	margin dB	limit dB	AV dB(μV)	margin dB	limit dB	line	corr dB
0.168	49.51	15.55	65.06	29.87	25.19	55.06	Phase 1	10.08
0.177	49.11	15.51	64.63	33.84	20.78	54.63	Phase 1	10.08
0.2175	43.39	19.53	62.91	28.95	23.97	52.91	Phase 1	10.09
0.222	43.84	18.90	62.74	30.01	22.73	52.74	Phase 1	10.09
0.399	38.45	19.43	57.87	27.02	20.85	47.87	Phase 1	10.14
0.4035	38.60	19.18	57.78	27.69	20.09	47.78	Phase 1	10.14
0.4305	29.52	27.73	57.24	18.10	29.15	47.24	Phase 1	10.14
0.708	26.29	29.71	56.00	23.64	22.36	46.00	Phase 1	10.17
1.0275	27.92	28.08	56.00	26.70	19.30	46.00	Phase 1	10.19
1.0635	29.11	26.89	56.00	28.35	17.65	46.00	Phase 1	10.20
1.416	33.98	22.02	56.00	33.70	12.30	46.00	Phase 1	10.25
1.7085	21.37	34.63	56.00	19.88	26.12	46.00	Phase 1	10.26
2.343	17.65	38.35	56.00	9.07	36.93	46.00	Phase 1	10.30
3.327	26.37	29.63	56.00	18.41	27.59	46.00	Phase 1	10.35
3.39	26.99	29.01	56.00	18.38	27.62	46.00	Phase 1	10.35
4.2855	30.39	25.61	56.00	22.98	23.02	46.00	Phase 1	10.42
4.605	30.55	25.45	56.00	23.24	22.76	46.00	Phase 1	10.43
4.863	30.19	25.81	56.00	22.61	23.39	46.00	Phase 1	10.45
4.926	29.92	26.08	56.00	22.82	23.18	46.00	Phase 1	10.45
7.122	29.58	30.42	60.00	22.51	27.49	50.00	Phase 1	10.61
7.1445	29.36	30.64	60.00	22.49	27.51	50.00	Phase 1	10.61
13.101	29.90	30.10	60.00	24.04	25.96	50.00	Phase 1	11.02
13.5105	28.97	31.03	60.00	22.44	27.56	50.00	Phase 1	11.06
17.7045	35.63	24.37	60.00	32.03	17.97	50.00	Phase 1	11.34
19.479	35.33	24.67	60.00	30.61	19.39	50.00	Phase 1	11.44
22.215	32.49	27.51	60.00	30.89	19.11	50.00	Phase 1	11.56
24.609	35.60	24.40	60.00	30.56	19.44	50.00	Phase 1	11.67

Test point: N
Operation mode: Active Chirp
Remarks: None

Result: passed



freq MHz	QP dB(μV)	margin dB	limit dB	AV dB(μV)	margin dB	limit dB	line	corr dB
0.168	47.94	17.12	65.06	28.25	26.81	55.06	Neutral	10.09
0.177	47.53	17.09	64.63	32.51	22.11	54.63	Neutral	10.09
0.2175	41.06	21.85	62.91	26.67	26.24	52.91	Neutral	10.11
0.2265	41.43	21.15	62.58	28.22	24.36	52.58	Neutral	10.11
0.4035	34.61	23.17	57.78	26.06	21.72	47.78	Neutral	10.14
0.4485	25.77	31.14	56.90	15.06	31.84	46.90	Neutral	10.14
0.516	22.94	33.06	56.00	10.78	35.22	46.00	Neutral	10.14
0.708	26.41	29.59	56.00	23.97	22.03	46.00	Neutral	10.17
1.0635	29.19	26.81	56.00	28.75	17.25	46.00	Neutral	10.20
1.416	33.86	22.14	56.00	33.68	12.32	46.00	Neutral	10.25
1.7085	21.13	34.87	56.00	19.68	26.32	46.00	Neutral	10.26
3.3765	27.83	28.17	56.00	19.02	26.98	46.00	Neutral	10.35
4.5735	31.05	24.95	56.00	23.64	22.36	46.00	Neutral	10.42
4.5825	31.41	24.59	56.00	23.75	22.25	46.00	Neutral	10.43
6.78	31.74	28.26	60.00	24.24	25.76	50.00	Neutral	10.57
6.8115	31.80	28.20	60.00	24.44	25.56	50.00	Neutral	10.57
6.933	31.25	28.75	60.00	24.15	25.85	50.00	Neutral	10.58
10.9725	31.24	28.76	60.00	24.67	25.33	50.00	Neutral	10.74
11.373	31.28	28.72	60.00	24.34	25.66	50.00	Neutral	10.77
17.7045	35.24	24.76	60.00	31.64	18.36	50.00	Neutral	11.15
19.8255	32.26	27.74	60.00	27.61	22.39	50.00	Neutral	11.24
20.181	31.81	28.19	60.00	27.73	22.27	50.00	Neutral	11.25
24.258	28.85	31.15	60.00	22.33	27.67	50.00	Neutral	11.26

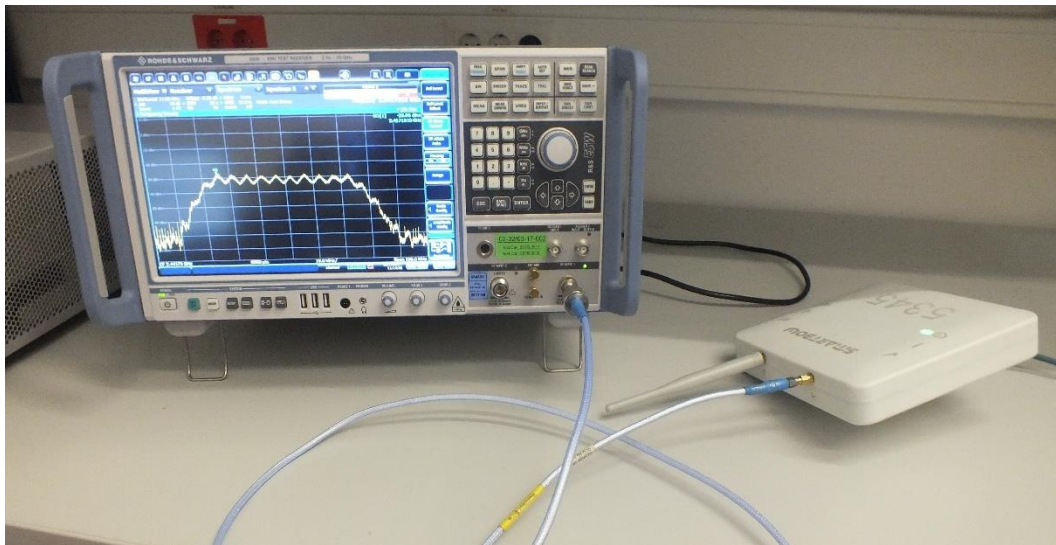
5.2 EBW and OBW

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 for EBW:

RBW: 100 kHz, VBW: 300 kHz, Detector: Max peak, Sweep time: 5 s, Span: 2 EBW;

Spectrum analyser settings for OBW:

RBW: 1-5% OBW, VBW: 3 RBW, Detector: Max peak, Sweep time: 5 s, Span: 2 OBW;

5.2.5 Test result

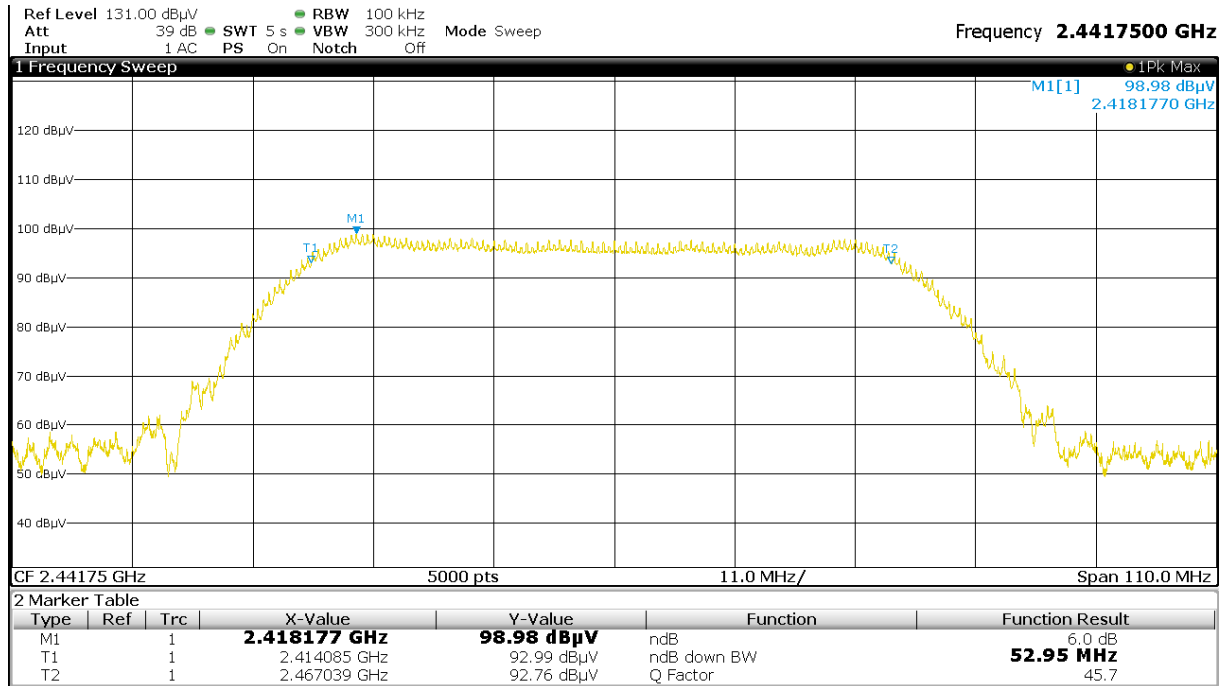
Chain	Centre frequency	6 dB bandwidth	99% OBW	Minimum limit
	(MHz)	(MHz)	(MHz)	(MHz)
1	2441.75	52.95	59.59	0.5
2	2441.75	52.49	58.58	0.5

The requirements are **FULFILLED**.

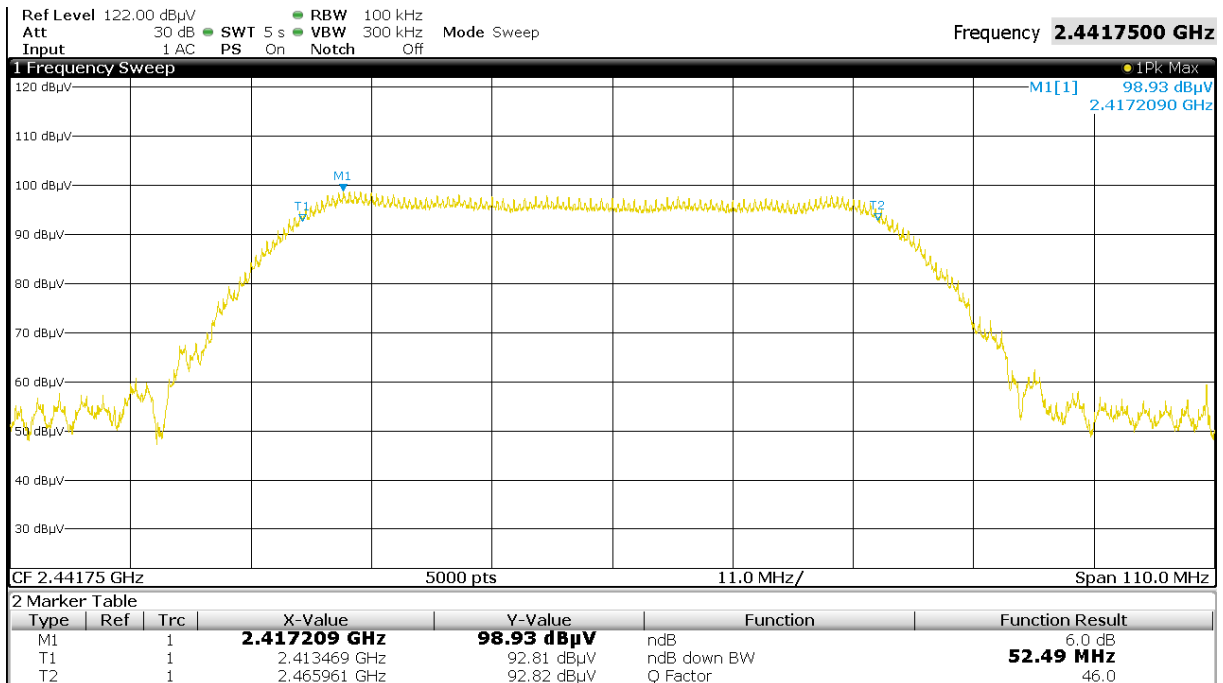
Remarks: For detailed test results please refer to following test protocols. The RSS Gen defines no limit for the occupied bandwidth.

5.2.6 Test protocols EBW

Chain 1 (2441.75 MHz)



Chain 2 (2441.75 MHz)

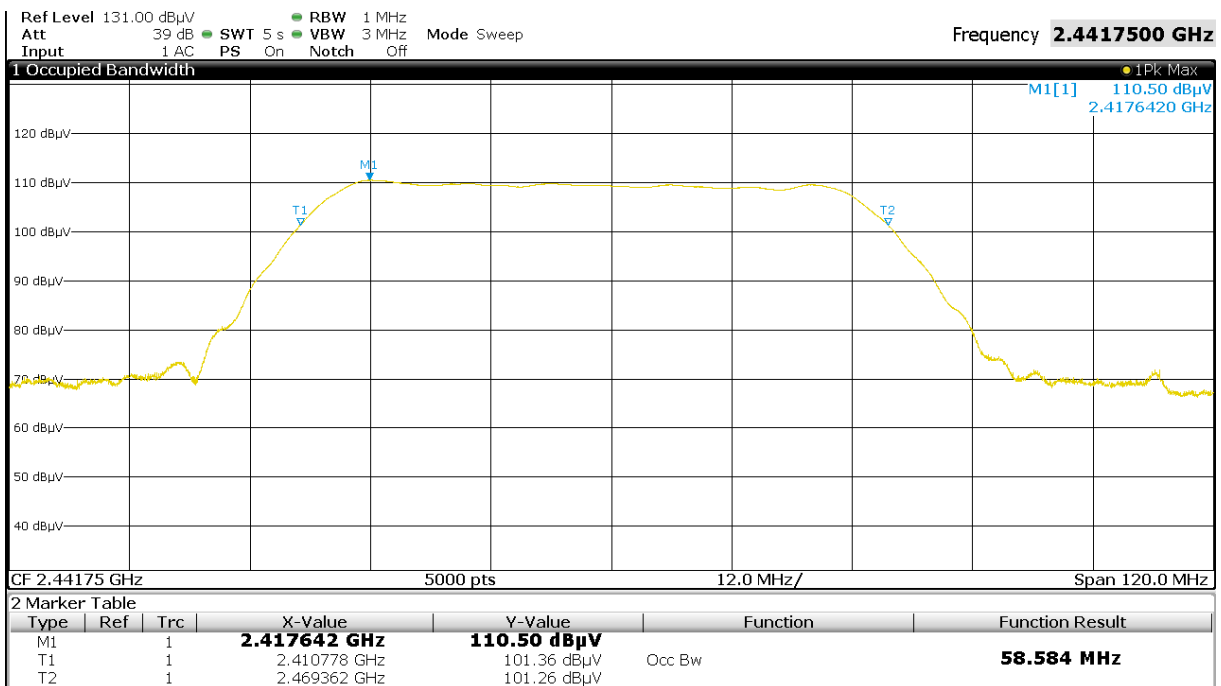


5.2.7 Test protocols OBW

Chain 1 (2441.75 MHz)



Chain 2 (2441.75 MHz)



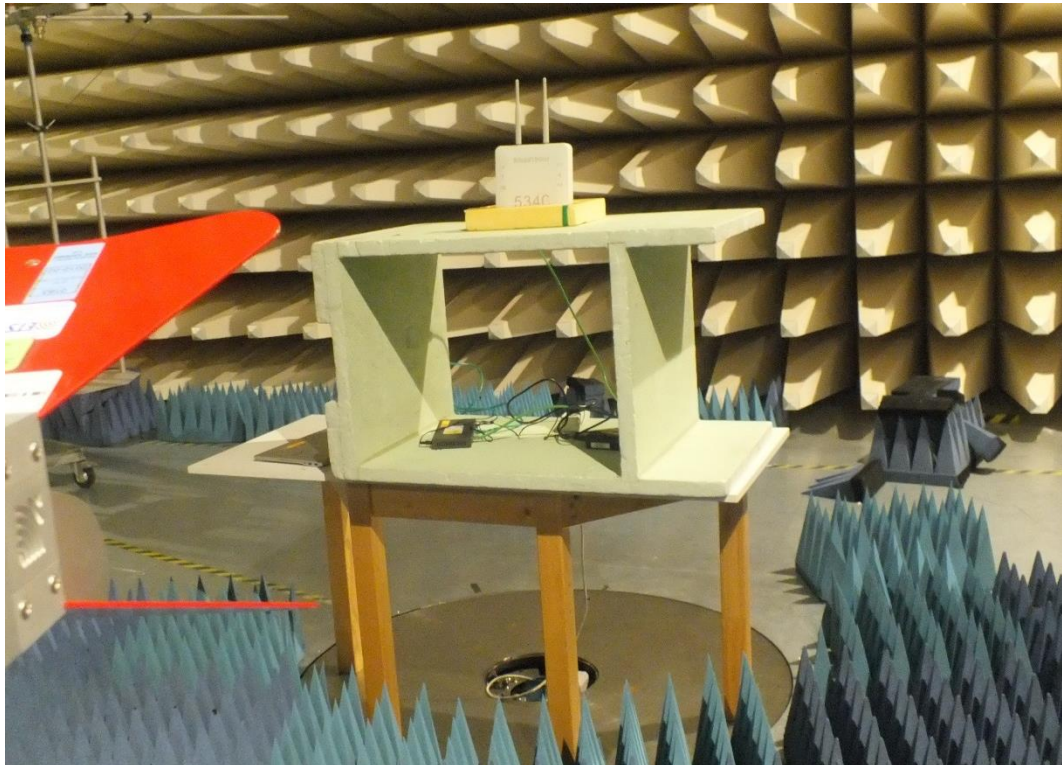
5.3 Maximum peak conducted output power

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

5.3.1 Description of the test location

Test location: Anechoic chamber 1

5.3.2 Photo documentation of the test set-up



5.3.3 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.

5.3.4 Description of Measurement

The maximum peak radiated output power is measured using a spectrum analyser following the procedure set out in KDB 558074, item 9.1.1. The EUT is set in TX continuous mode while measuring. The radiated measurement was performed as a field strength measurement and converted afterwards into power according to the following term:

$$E = \text{EIRP} - (20 \cdot \log_{10} 3) + 104.8$$

The conducted output power can be obtained by subtracting the antenna gain of 4.0 dBi.

5.3.5 Test result
Chain 1

1 Mbps, TX		Test results radiated			
Duty cycle: 100%					
Chain 1		Fieldstrength E (dBμV/m)	EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)
2441.75 MHz					
T_{nom}	V_{nom}	118.4	23.1	36.0	-12.9

1 Mbps, TX			Test results conducted			
Duty cycle: 100%						
Chain 1		EIRP (dBm)	P (dBm)	Antenna Gain (dBi)	EIRP Limit (dBm)	Margin (dB)
2441.75 MHz						
T_{nom}	V_{nom}	23.1	19.1	4.0	30.0	-10.9

Chain 2

1 Mbps, TX		Test results radiated			
Duty cycle: 100%					
Chain 2		Fieldstrength E (dBμV/m)	EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)
2441.75 MHz					
T_{nom}	V_{nom}	117.8	22.5	36.0	-13.5

1 Mbps, TX			Test results conducted			
Duty cycle: 100%						
Chain 2		EIRP (dBm)	P (dBm)	Antenna Gain (dBi)	EIRP Limit (dBm)	Margin (dB)
2441.75 MHz						
T_{nom}	V_{nom}	22.5	18.5	4.0	30.0	-11.5

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:

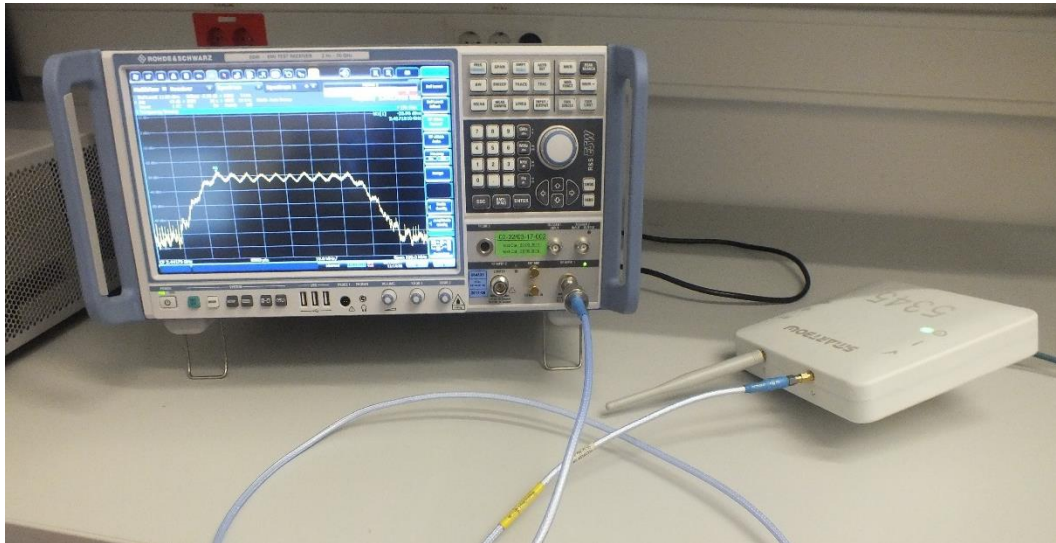
5.4 Power spectral density

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(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.

5.4.4 Description of Measurement

The measurement is performed using the procedure 10.2 set out in KDB-558074. The power measurement was done as peak power measurement. Therefore, the PKPSD is measured. The max peak was located and with the spectrum analyser and a marker set to peak.

Spectrum analyser settings:

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

5.4.5 Test result
Chain 1

Duty cycle: 100%		Test results conducted		
Chain 1		PD [Pmax] (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
2441.75 MHz				
T_{nom}	V_{nom}	-16.99	8.0	-25.0

Chain 2

Duty cycle: 100%		Test results conducted		
Chain 2		PD [Pmax] (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
2441.75 MHz				
T_{nom}	V_{nom}	-17.97	8.0	-26.0

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

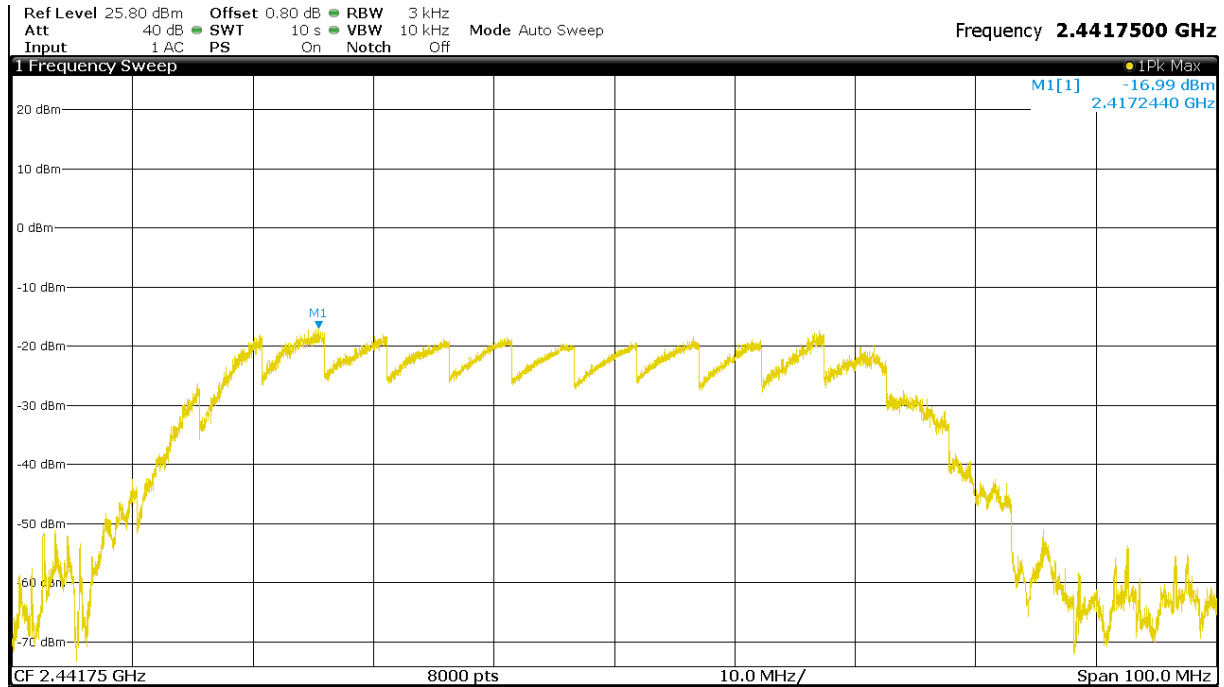
Frequency (MHz)	Power spectral density limit
	(dBm/3 kHz)
2400 - 2483.5	8

The requirements are **FULFILLED**.

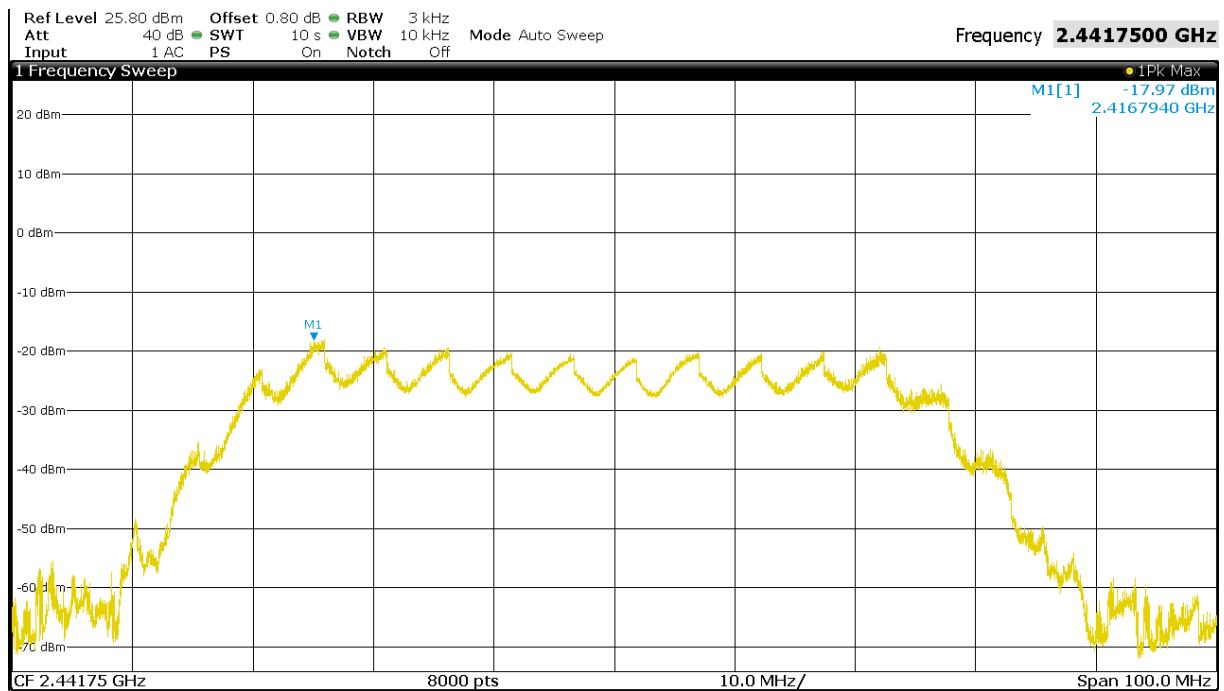
Remarks: For detailed test results please refer to following test protocols.

5.4.6 Power spectral density plots

Chain 1 (2441.75 MHz)



Chain 2 (2441.75 MHz)



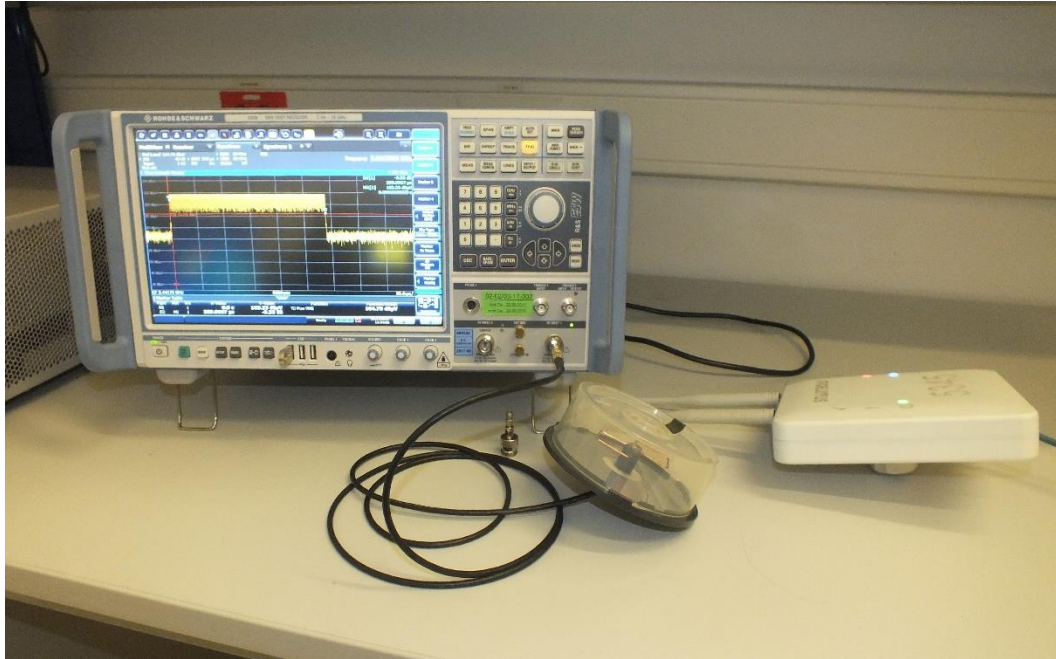
5.5 Correction for pulse operation (duty cycle)

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

5.5.1 Description of the test location

Test location: AREA4

5.5.2 Photo documentation of the test set-up



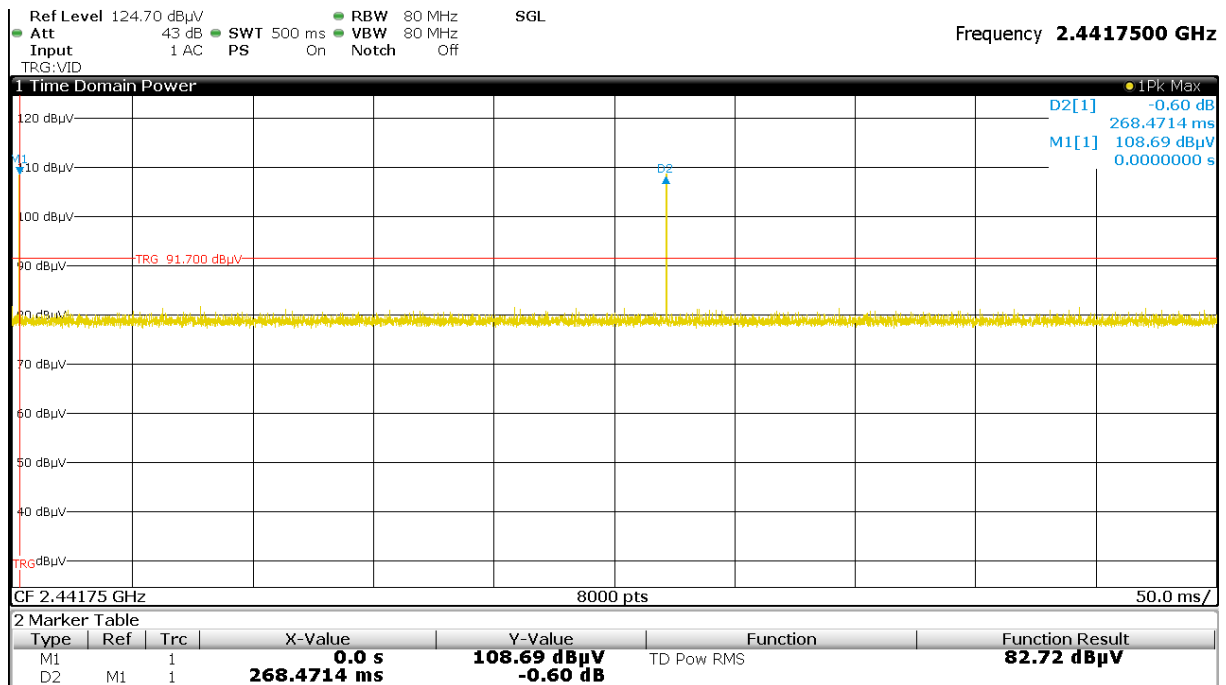
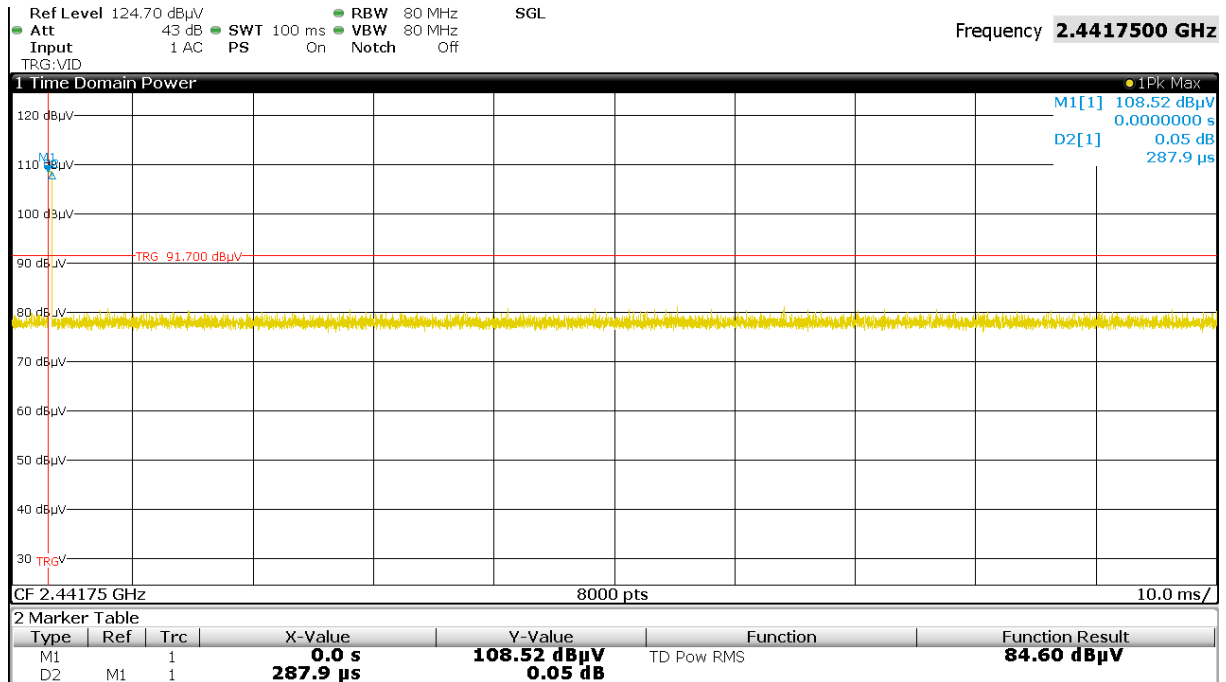
5.5.1 Applicable standard

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.

5.5.2 Description of Measurement

The pulse train exceeds 0.1 s. Therefore, the field strength is determined during a 100 ms interval.



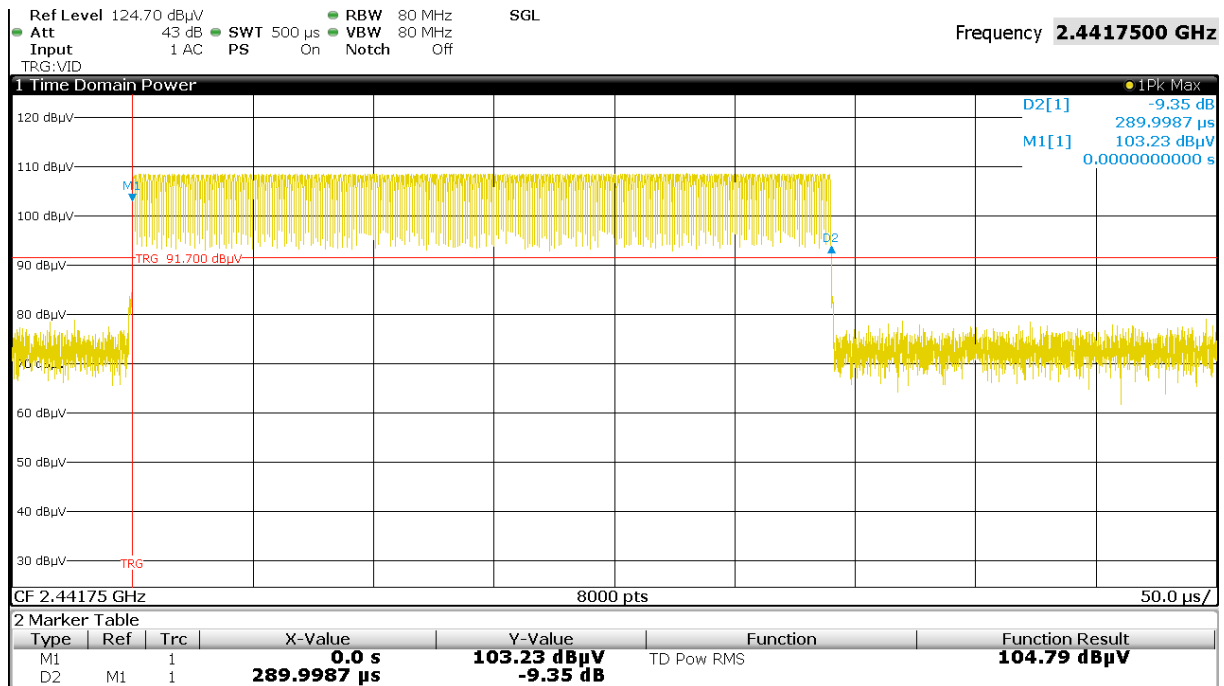
The duty cycle factor (dB) is calculated applying the following formula:

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

KE : pulse operation correction factor

t_{iw} pulse duration for one complete pulse track

5.5.3 Test result



Complete burst duration (1 burst): 0.29 ms

$$KE = 20 \log (0.29 \text{ ms} / 100 \text{ ms}) = -50.75 \text{ dB}$$

Remarks:

5.6 Unwanted emissions in restricted bands, radiated

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

5.6.1 Description of the test location

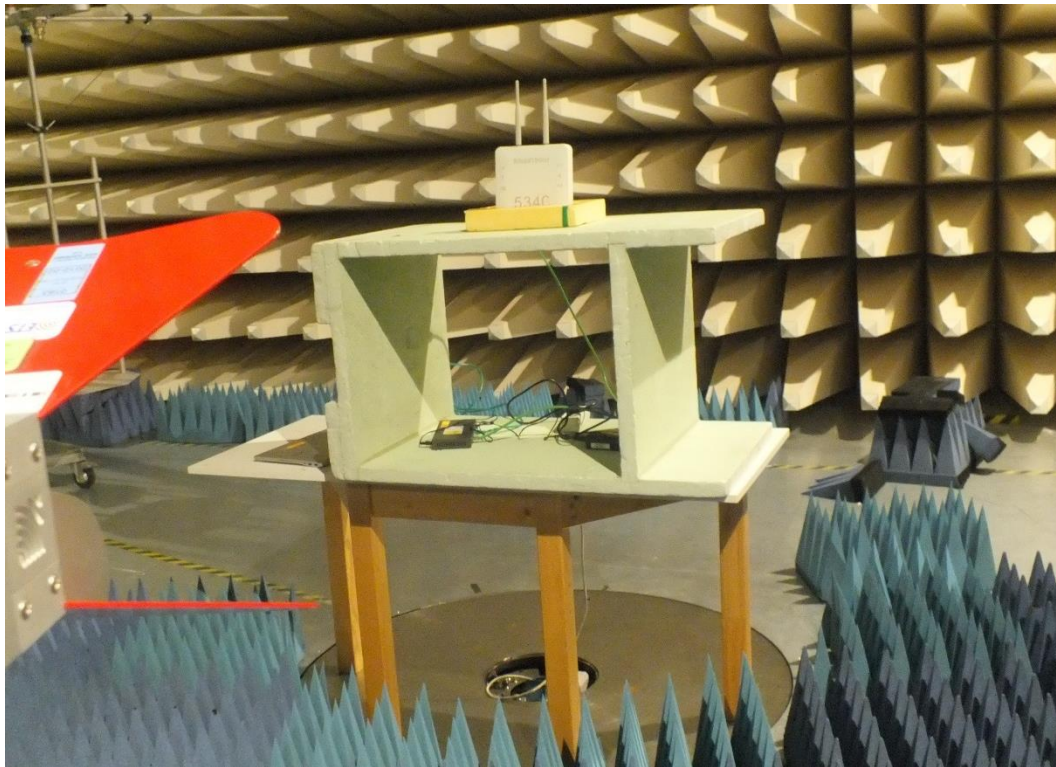
Test location: OATS 1
Test location: Anechoic chamber 1
Test distance: 3 m

5.6.2 Photo documentation of the test set-up

Open area test site



Anechoic chamber



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).

5.6.3 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. If the emission level of the EUT in peak mode complies with the average limit, then testing will be stopped and peak values of the EUT will be reported, otherwise the emission will be measured in average mode again and reported.

Spectrum analyser settings:

30 MHz – 1000 MHz:

RBW: 120 kHz

1000 MHz – 25 GHz:

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

5.6.1 Test result
30 MHz to 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)
125.00	6.6	2.7	12.7	13.2	19.3	15.9	43.5	-24.2
176.00	5.1	4.8	13.6	14.3	18.7	19.1	43.5	-24.4
208.00	7.0	5.7	11.7	12.3	18.7	18.0	43.5	-24.8
240.00	22.4	20.4	13.3	13.6	35.7	34.0	46.0	-10.3
250.00	26.3	24.5	13.8	14.0	40.1	38.5	46.0	-5.9
272.00	13.2	15.2	15.2	15.1	28.4	30.3	46.0	-15.7
304.00	10.3	9.8	17.0	16.6	27.3	26.4	46.0	-18.7
320.00	4.2	6.6	17.5	17.1	21.7	23.7	46.0	-22.3
336.00	5.3	4.4	18.0	17.6	23.3	22.0	46.0	-22.7
350.00	19.5	12.7	18.4	18.0	37.9	30.7	46.0	-8.1
450.00	14.5	11.5	21.2	20.9	35.7	32.4	46.0	-10.3
600.00	12.5	11.5	25.5	25.3	38.0	36.8	46.0	-8.0
700.00	10.5	7.8	27.0	26.5	37.5	34.3	46.0	-8.5

Note: No differences could be detected between the operating chains 1 & 2.

1 GHz to 25 GHz
Chain 1

Chain 1										
Test conditions:										
TX active			Test results							
Start frequency	Stop frequency	RBW (kHz)	Frequency (MHz)	Peak Level (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	Duty cycle correction	AV Level (dBμV/m)	AV Limit (dBμV/m)	AV Margin (dB)
1000	4000	1000	2175.85	55.9	78.5	-22.6				
1000	4000	1000	2192.35	56.5	78.5	-22.0				
1000	4000	1000	2239.75	57.2	74.0	-16.8	-50.8	6.5	54.0	-47.6
1000	4000	1000	2303.65	61.5	78.5	-17.0				
1000	4000	1000	2368.15	64.0	74.0	-10.0	-50.8	13.2	54.0	-40.8
1000	4000	1000	2559.85	56.7	78.5	-21.8				
4000	25000	1000	4830.20	45.1	74.0	-28.9			54.0	
Measurement uncertainty							± 2.34 dB			

Chain 2

Chain 2										
Test conditions:										
TX active			Test results							
Start frequency	Stop frequency	RBW (kHz)	Frequency (MHz)	Peak Level (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	Duty cycle correction	AV Level (dBμV/m)	AV Limit (dBμV/m)	AV Margin (dB)
1000	4000	1000	2196.55	54.0	78.5	-24.5				
1000	4000	1000	2240.05	55.5	74.0	-18.5	-50.8	4.8	54.0	-49.3
1000	4000	1000	2303.95	59.8	78.5	-18.7				
1000	4000	1000	2560.15	56.6	78.5	-21.9				
4000	25000	1000	4835.70	46.9	74.0	-27.1			54.0	
Measurement uncertainty							± 2.34 dB			

Note: The emissions in non-restricted bands comply with the 20 dB down limit (see chapter 5.7).

Only when the peak value exceeds the average limit an average measurement is required.

Average values are calculated by subtracting the absolute value of the correction duty cycle factor from the peak values. For example, chain 1 at 2239.75 MHz: peak value – DC = average value

57.2 dBμV/m – 50.75 = 6.45 dBμV/m

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 (metres)
	(μV/m)	dB(μV/m)	
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

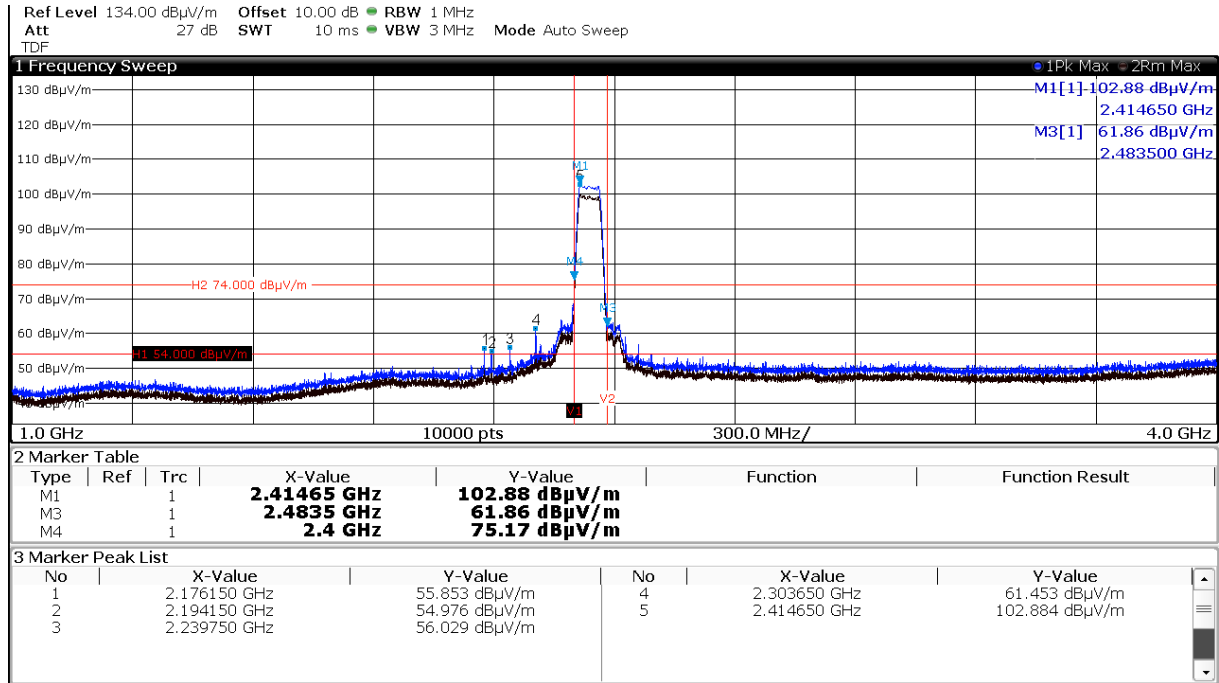
The requirements are **FULFILLED**.

Remarks: The measurement was performed up to the 10th harmonic. For detailed test results please see to
following test protocols.

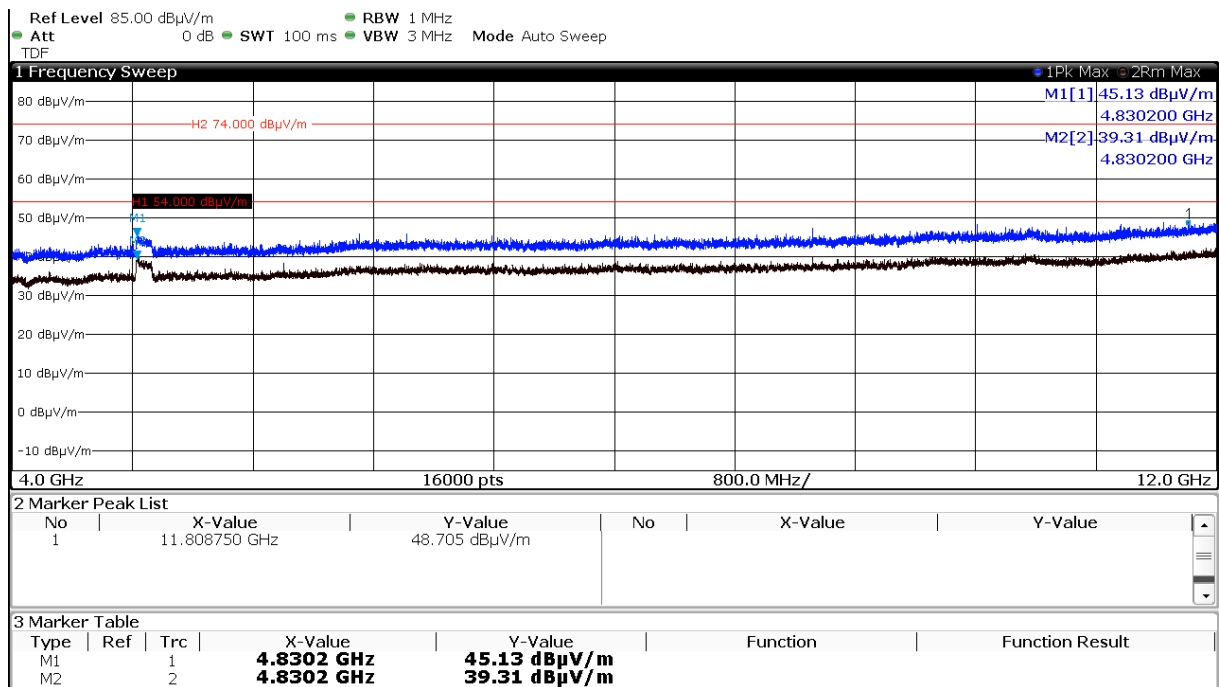
5.6.2 Test protocols

For reference the plots from 1 GHz to 25 GHz for Chain 1:

1 – 4 GHz



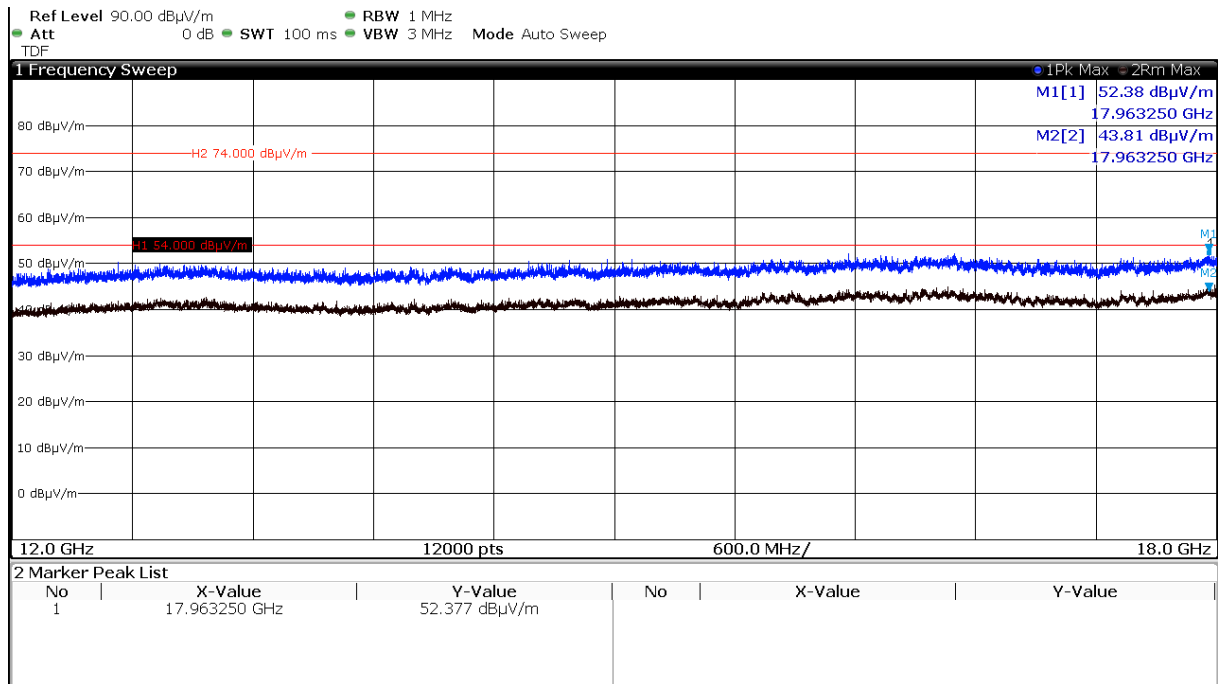
4 – 12 GHz



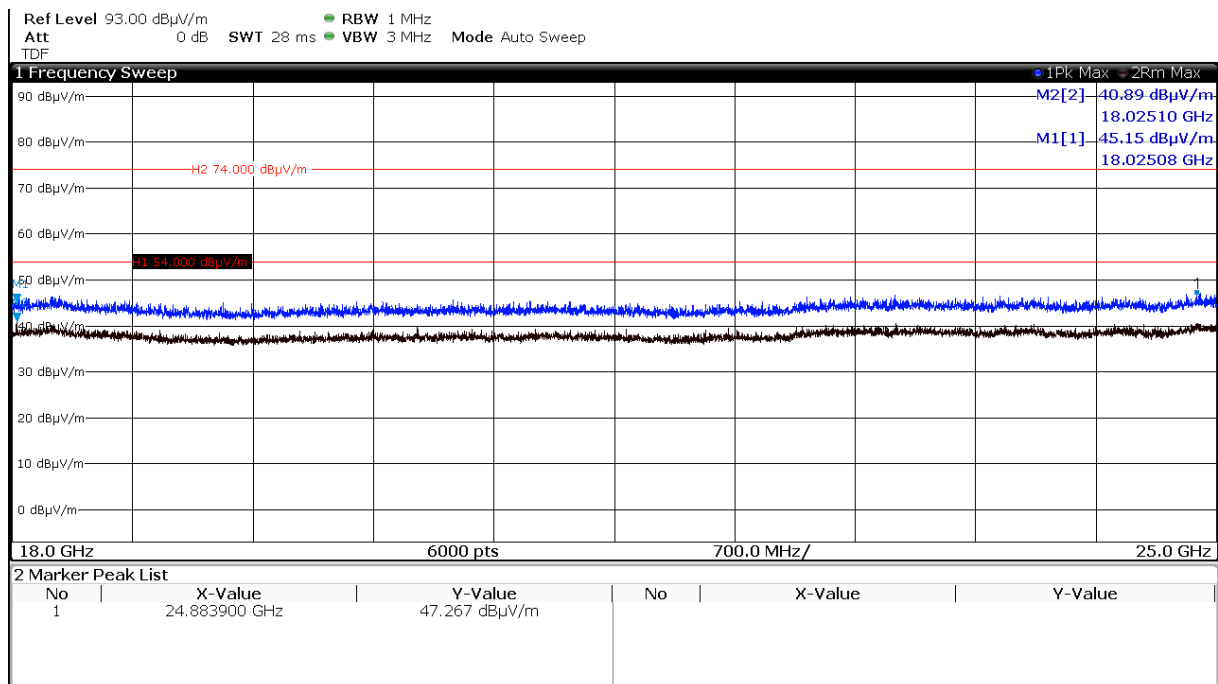
FCC ID: 2ADP3W012

IC: 12561A-W012

12 – 18 GHz

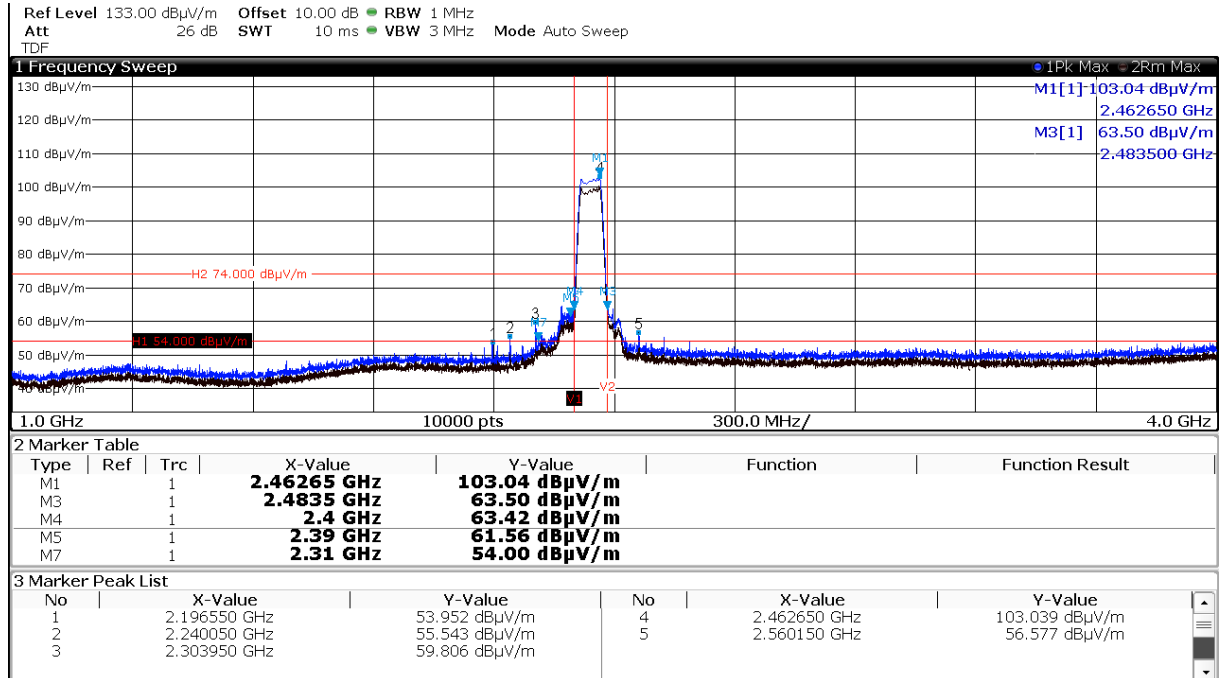


18 – 25 GHz

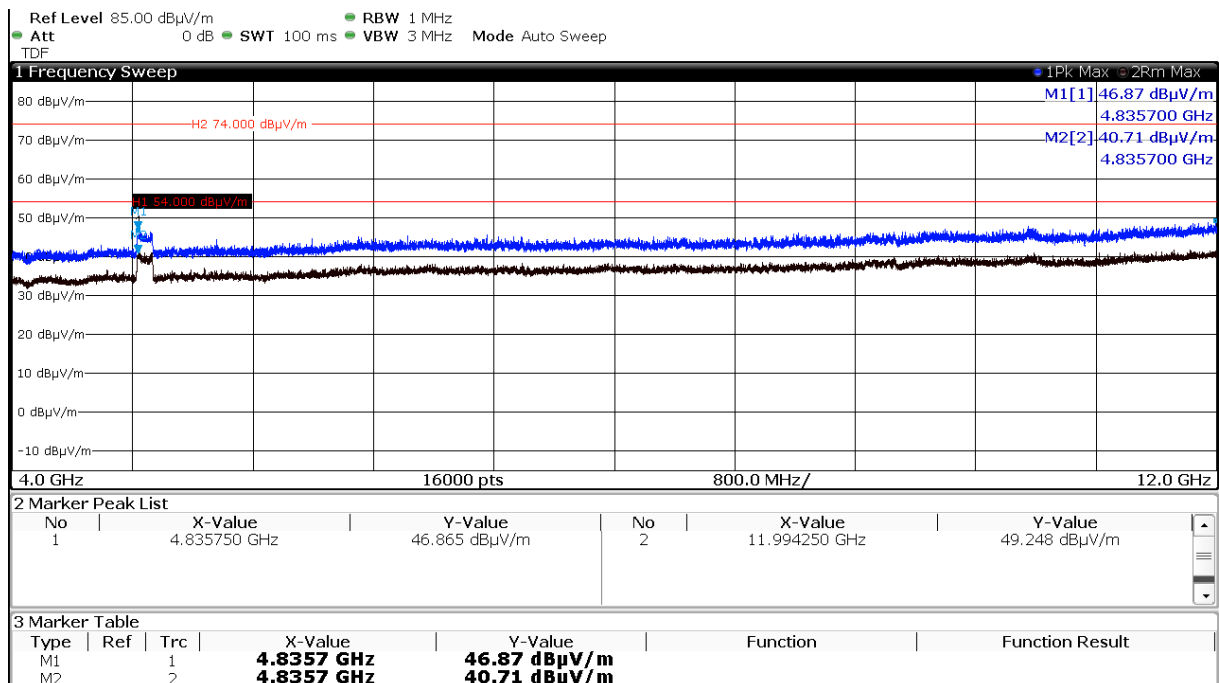


For reference the plots from 1 GHz to 25 GHz for Chain 2:

1 – 4 GHz



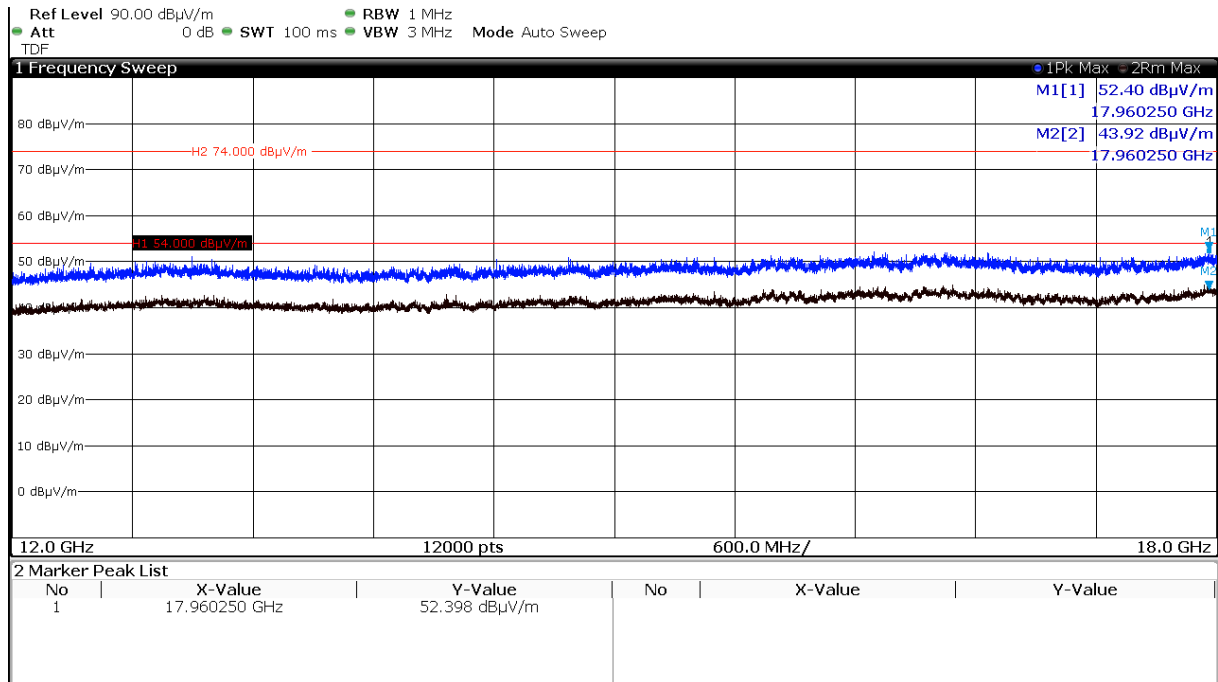
4 – 12 GHz



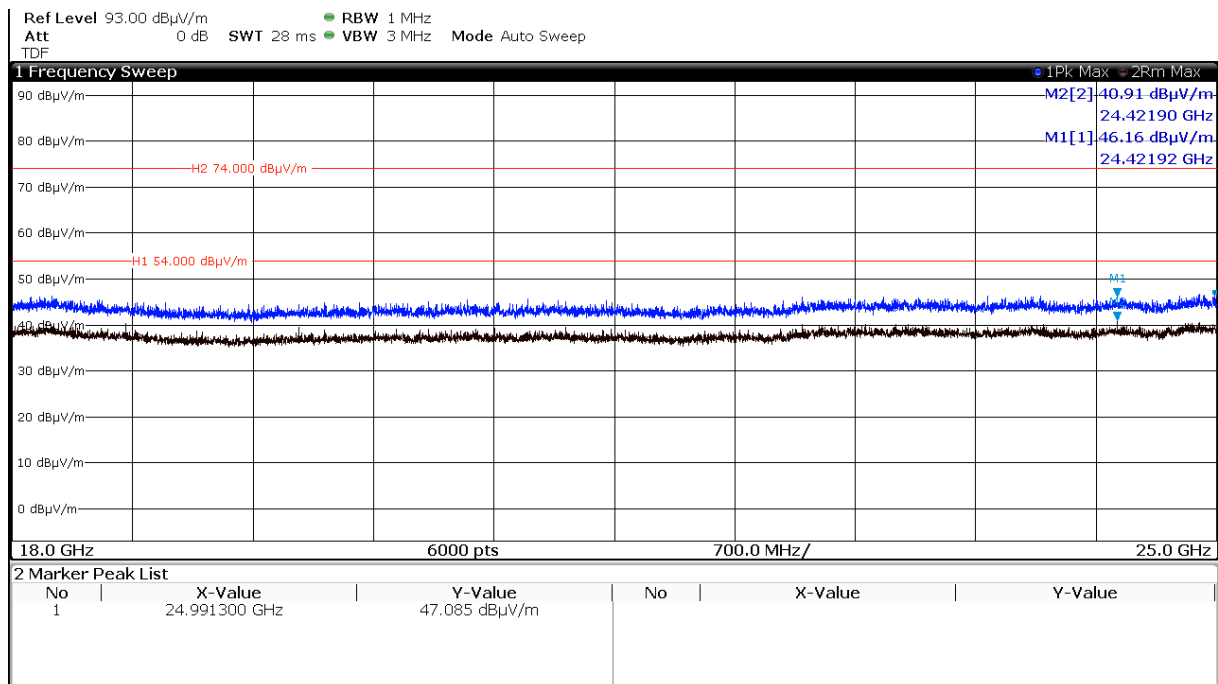
FCC ID: 2ADP3W012

IC: 12561A-W012

12 – 18 GHz



18 – 25 GHz



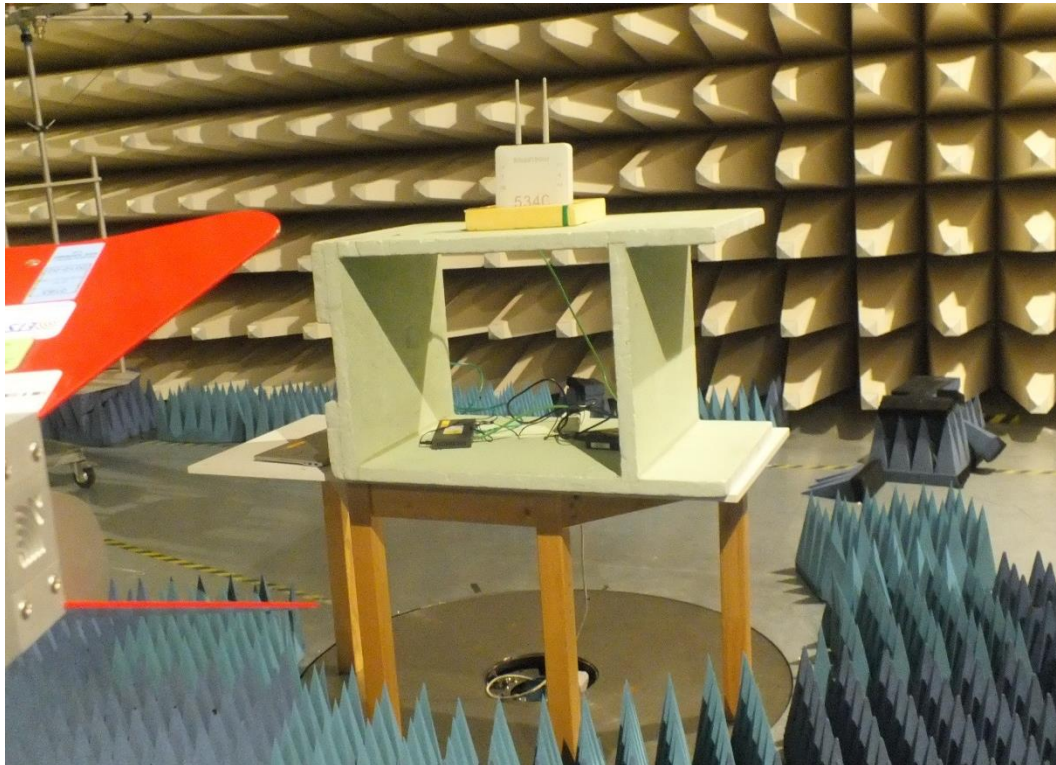
5.7 Unwanted emissions, radiated

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

5.7.1 Description of the test location

Test location: Anechoic chamber 1

5.7.2 Photo documentation of the test set-up



5.7.3 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 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)).

5.7.4 Description of measurement

The spurious emissions are measured radiated using a spectrum analyser in a test setup following the procedures set out in KDB 558074 for DTS. The frequency spectrum outside from the operating frequency range (2400 - 2483.5 MHz) is scanned for emissions that exceed the limit. The measurement is performed at normal test conditions in TX continuous mode.

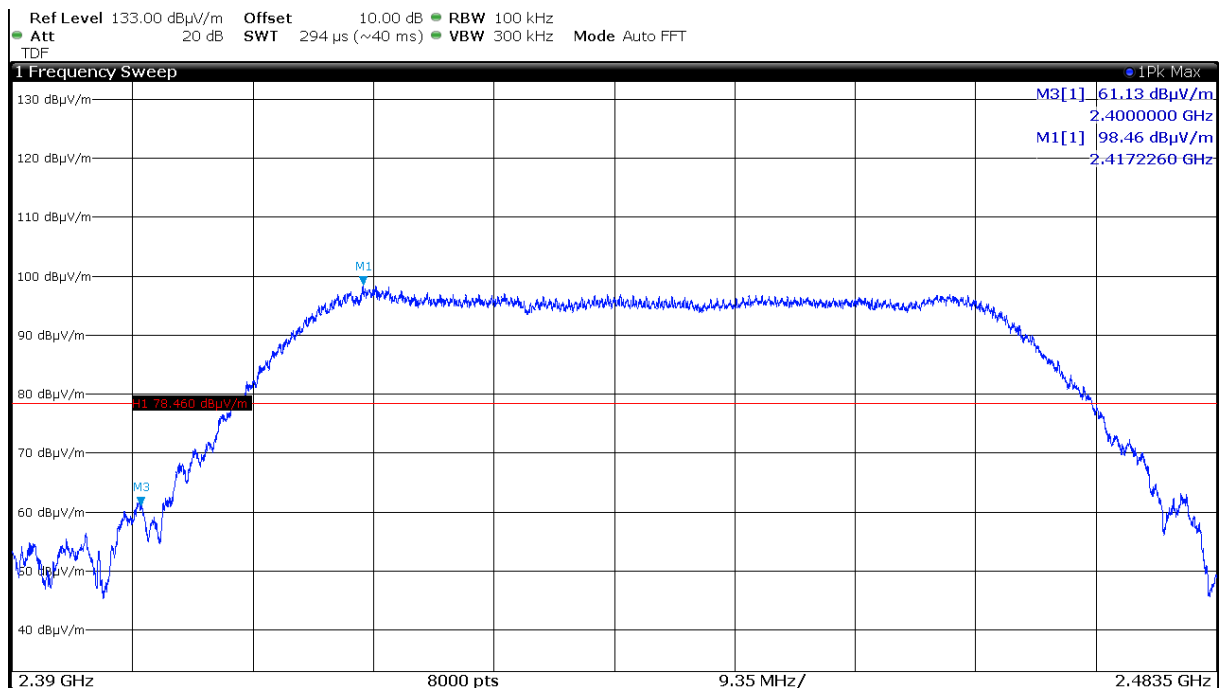
Spectrum analyser search setting:

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

5.7.5 Test result

Determination of the reference level and limit, including the lower band edge:

Chain 2



The 20 dB down limit: 78.5 dBμV/m

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 a 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: The unwanted emissions radiated are measured with a 1 MHz resolution bandwidth and are
compared with the general limits according to Section 15.209(a) for restricted band emissions
and with the 20 dB down Limit for non-restricted band emissions.
For further information, please refer to chapter 5.6.

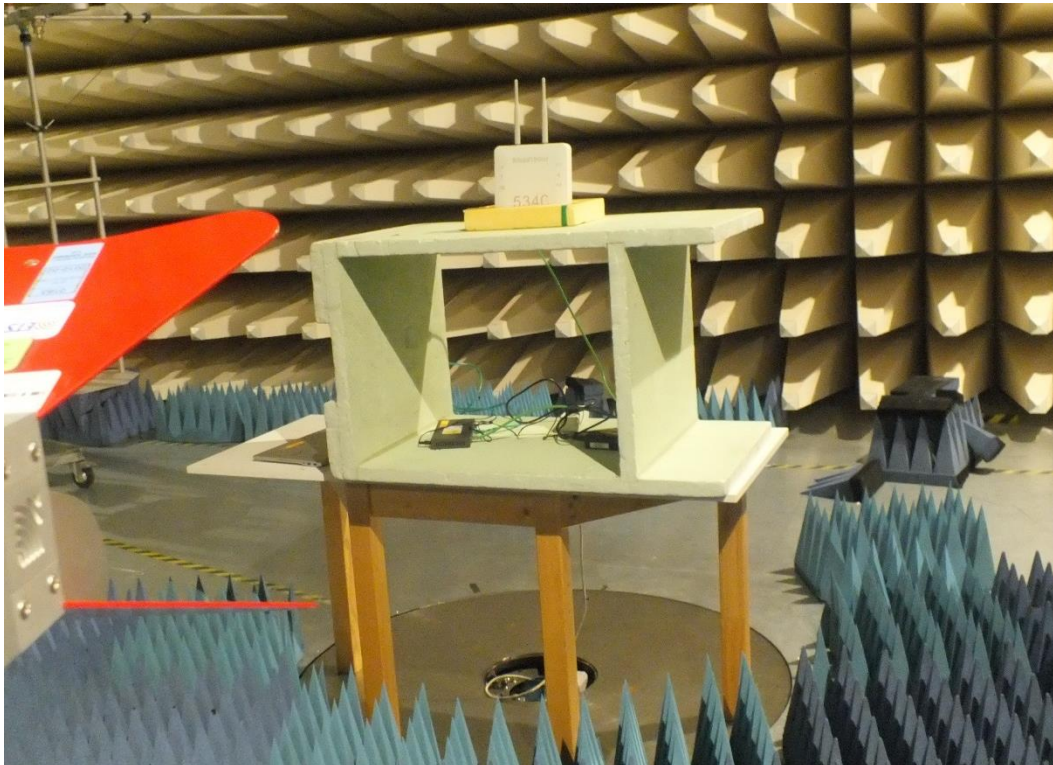
5.8 Band edge compliance

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

5.8.1 Description of the test location

Test location: Anechoic chamber 1

5.8.2 Photo documentation of the test set-up



5.8.3 Applicable standard

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

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

5.8.4 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 to OET 558074, 4/5/2017.

Spectrum analyser settings:

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

5.8.5 Test result

Frequency (MHz)	Fieldstrength (dBµV/m)	Margin (dB)
2484.00	38.69	-15.31

Limit according to FCC Subpart 15.247(d):

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

The requirements are **FULFILLED**.

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

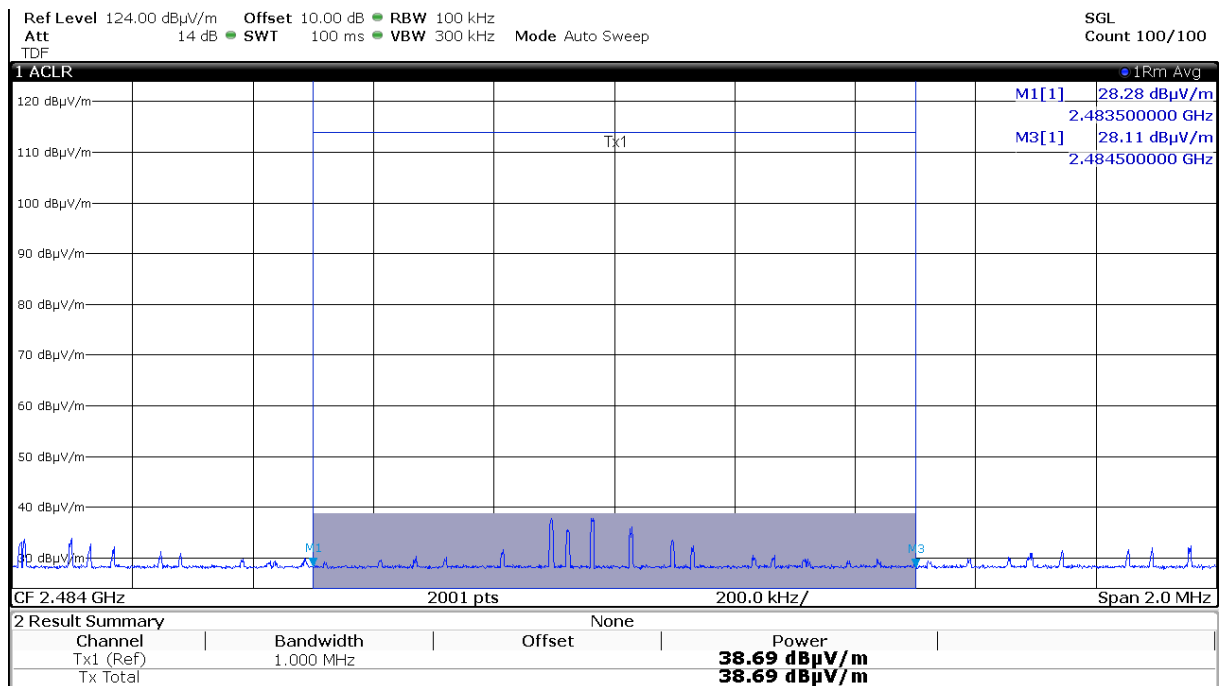
As the duty cycle of the EUT is very small (see chapter 5.5) and constant, the band edge

measurement was performed according to OET 558074 chapter 13.3.2 with active chirp mode

(both chains transmit alternatingly). A duty cycle correction is not required as the emission is

demonstrated to be continuous.

5.8.6 Test protocol



5.9 Antenna application

5.9.1 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 has two external antennas. The antennas can be replaced by the user.

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

5.9.2 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 EUT has two external antennas. The maximum peak antenna gain is 4.0 dBi, therefore the output power must not be reduced.

The requirements are **FULFILLED**.

Remarks: No power reduction results from the defacto limit.

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	BAT-EMC 3.16.0.73	01-02/68-13-001				
	ESCI	02-02/03-15-001	31/05/2018	31/05/2017		
	ESH 2 - Z 5	02-02/20-05-004	25/10/2019	25/10/2017	25/04/2018	25/10/2017
	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	18/11/2019	18/11/2016	06/05/2018	06/11/2017
	SP 103 /3.5-60	02-02/50-05-182				
CPC 3	ESW26	02-02/03-17-002	20/09/2018	20/09/2017		
	KK-SF104-11SMA-11N-2M	02-02/50-14-005				
CPR 3	FSW43	02-02/11-15-001	07/04/2018	07/04/2017		
	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	10/05/2018	10/05/2017		
	Sucoflex N-2000-SMA	02-02/50-05-075				
	SF104/11N/11N/1500MM	02-02/50-13-015				
DC	ESW26	02-02/03-17-002	20/09/2018	20/09/2017		
	RF Antenna	02-02/24-05-032				
MB	ESW26	02-02/03-17-002	20/09/2018	20/09/2017		
	FSW43	02-02/11-15-001	07/04/2018	07/04/2017		
	KK-SF104-11SMA-11N-2M	02-02/50-14-005				
	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	10/05/2018	10/05/2017		
	Sucoflex N-2000-SMA	02-02/50-05-075				
	SF104/11N/11N/1500MM	02-02/50-13-015				
SER 2	ESCI 7	01-02/03-11-001	27/03/2018	27/03/2017		
	ESVS 30	02-02/03-05-006	03/07/2018	03/07/2017		
	VULB 9168	02-02/24-05-005	12/04/2018	12/04/2017	28/03/2018	28/09/2017
	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	07/04/2018	07/04/2017		
	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	10/05/2018	10/05/2017		
	R1 _ 18 - 40 GHz	02-02/30-09-002			27/06/2018	27/06/2017
	Sucoflex N-2000-SMA	02-02/50-05-075				
	KMS102-1 m	02-02/50-11-014				
	KMS102-0.2 m	02-02/50-11-016				
	SF104/11N/11N/1500MM	02-02/50-13-015				