



EMI - TEST REPORT

- FCC Part 15.247, RSS-247 -

Type / Model Name : AudioLink (market name), Wireless Relay (internal development name)

Product Description : Audio streaming accessory for MED-EL audio processors including a
2.4 GHz proprietary transceiver

Applicant : MED-EL Elektromedizinische Geraete GmbH

Address : Fuerstenweg 77a
6020 INNSBRUCK, AUSTRIA

Manufacturer : MED-EL Elektromedizinische Geraete GmbH

Address : Fuerstenweg 77a
6020 INNSBRUCK, AUSTRIA

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

POSITIVE

Test Report No. : **T44784-00-00KS**

27. May 2019

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.

FCC ID: VNP-AL

IC: 11986A-AL

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1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (March, 2019)

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 (March, 2019)

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 15.209	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 v05

Guidance for compliance measurements on DTS; FHSS and hybrid system devices operating under Section 15.247 of the FCC rules, August 24, 2018.

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2 EQUIPMENT UNDER TEST

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

2.2 General remarks

The EUT contains a 2.4 GHz transceiver with integral antenna. The transceiver operates in the frequency band 2.400 GHz - 2.4835 GHz.

2.3 Equipment type

2.4 GHz transceiver

2.4 Short description of the equipment under test (EUT)

The AudioLink is a multifunctional battery powered body worn accessory to the MED-EL CI System that provides wireless connectivity options for MED-EL CI systems. It communicates over a proprietary low power 2.4 GHz link to supported MED-EL audio processors (e.g. SONNET & SONNET 2) and has a Bluetooth classic module integrated for connectivity to common mobile devices. From such Bluetooth devices the AudioLink can receive audio signals which are streamed to the MED-EL audio processor or control data like remote control commands e.g. from the FineTuner App. It also provides a user interface, a USB charging connector and an audio jack.

Test samples:

SN EUT	CBA	RF Transceiver FW	Main Controller FW	Tests
#1	AL-000066	rev. 1.0.0	rev. 1.0.0	Conducted measurements MB, CPC, SEC
#2	AL-000077	rev. 1.0.0	rev. 1.0.0	Conducted measurements MB, CPC, SEC
#3	AL-000080	rev. 1.0.0	rev. 1.0.0	Radiated measurements MB, SER3, SER2, DC
#4	AL-000081	rev. 1.0.0	rev. 1.0.0	Radiated measurements MB, SER3, SER2, DC

Note: The specially prepared sample #1 for conducted tests and has been used for testing. Sample #2 is a replacement to #1. Sample #3 has been used for radiated tests. Sample #4 is a replacement to #3.

2.5 Variants of the EUT

None.

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2.6 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan:

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

Note: the marked frequencies are determined for final testing.

2.7 EUT operation modes

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

- Cont. TX at CH1, CH19 and CH39 (the EUT uses GFSK and provides following data rate: 2 Mbps)

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2.8 Antenna

The following antenna shall be used with the EUT:

Number	Characteristic	Type	Plug	Frequency range (GHz)	Gain (dBi)
1	Omni	PCB	None	2.4	1.0

2.9 Power supply system utilised

Power supply voltage, V_{nom} : 3.2 VDC – 4.2 VDC Battery powered
 Power supply voltage (alternative) : 5 VDC USB powered

2.10 Peripheral devices and interface cables

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

- Power supply _____ Model : Supplied by manufacturer _____
- FTDI-USB cable _____ Model : FTDI FT2232H Mini Module _____
- _____ Model : _____

2.11 Determination of worst case conditions for final measurement

Measurements have been made in all three orthogonal axes of the EUT to locate at which position the EUT produces the maximum of the emissions.

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

Standard	Available channels	Tested channels	Power setting	Modulation	Modulation Type	Data rate
Proprietary	1 to 39	1, 19, 39	-4 dBm	DSSS	GFSK	2 Mbps

2.11.1 Test jig

No test jig is used.

2.11.2 Test software

The test software for the EUT provides the special test modes continuous TX unmodulated (CW), continuous TX modulated (bursts) and the channel settings.

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3 TEST RESULT SUMMARY

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)	RSS-247, 5.2(a)	-6 dB EBW	passed
15.247(b)(3)	RSS-247, 5.4(d)	Maximum peak conducted output power	passed
15.247(b)(4)	RSS-247, 5.4(d)	Defacto limit	passed
15.247(d)	RSS-247, 5.5	Unwanted emission, radiated	passed
15.247(d)	RSS-Gen, 8.10	Emissions in restricted bands	passed
15.247(e)	RSS-247, 5.2(b)	PSD	passed
15.35(c)	RSS-Gen, 6.10	Pulsed operation	passed
15.203	-	Antenna requirement	passed
-	RSS-Gen, 6.11	Transmitter frequency stability	not applicable
-	RSS-Gen, 6.6	99 % Bandwidth	passed

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

RSS-Gen, Issue 5, April 2018

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 : 01 February 2019

Testing concluded on : 08 March 2019

Checked by:

Tested by:

Klaus Gegenfurtner
Teamleader Radio

Hermann Smetana
Radio Team

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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

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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 30000 MHz	95%	$\pm 2.5 \times 10^{-7}$
Output power ERP, radiated	1000 MHz to 7000 MHz	95%	± 2.71 dB
Field strength of the fundamental	1000 MHz to 7000 MHz	95%	± 2.71 dB
Power spectral density	2400 MHz to 3000 MHz	95%	± 0.62 dB
Spurious Emissions, conducted	9 kHz to 10000 MHz	95%	± 2.15 dB
Spurious Emissions, conducted	10000 MHz to 40000 MHz	95%	± 3.47 dB
Spurious Emissions, radiated	9 kHz to 30 MHz	95%	± 3.53 dB
Spurious Emissions, radiated	30 MHz to 1000 MHz	95%	± 4.44 dB
Spurious Emissions, radiated	1000 MHz to 30000 MHz	95%	± 2.34 dB
Spurious Emissions, radiated	30000 MHz to 40000 MHz	95%	± 5.13 dB

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4.4 Measurement protocol for FCC and ISED

4.4.1 General information

CSA Group Bayern GmbH is recognized as wireless testing laboratory under the CAB identifier:

FCC: DE 0011
ISED: DE0009

4.4.2 General Standard information

The test methods used comply with ANSI C63.10 - "Testing Unlicensed Wireless Devices".

4.4.2.1 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.

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

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

FCC ID: VNP-AL**IC: 11986A-AL****4.4.2.3 Radiated emission (electrical field 1 GHz - 40 GHz)**

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.

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5 TEST CONDITIONS AND RESULTS

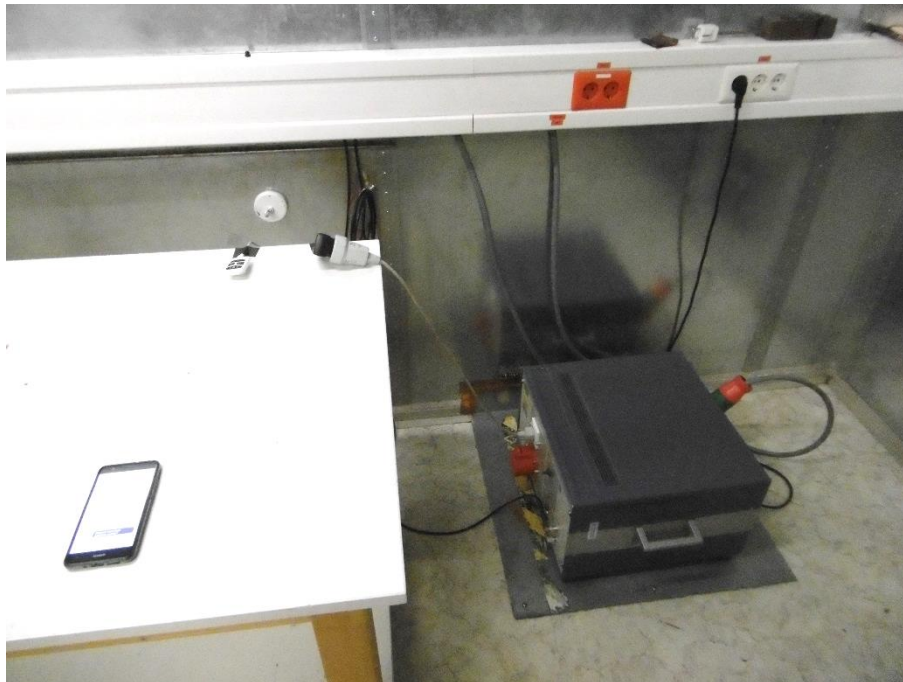
5.1 AC power line conducted emissions

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 limits under FCC 15.207(a).

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.

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Frequency range: 0.15 MHz - 30 MHz

Min. limit margin -19.5 dB at 0.290 MHz

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

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

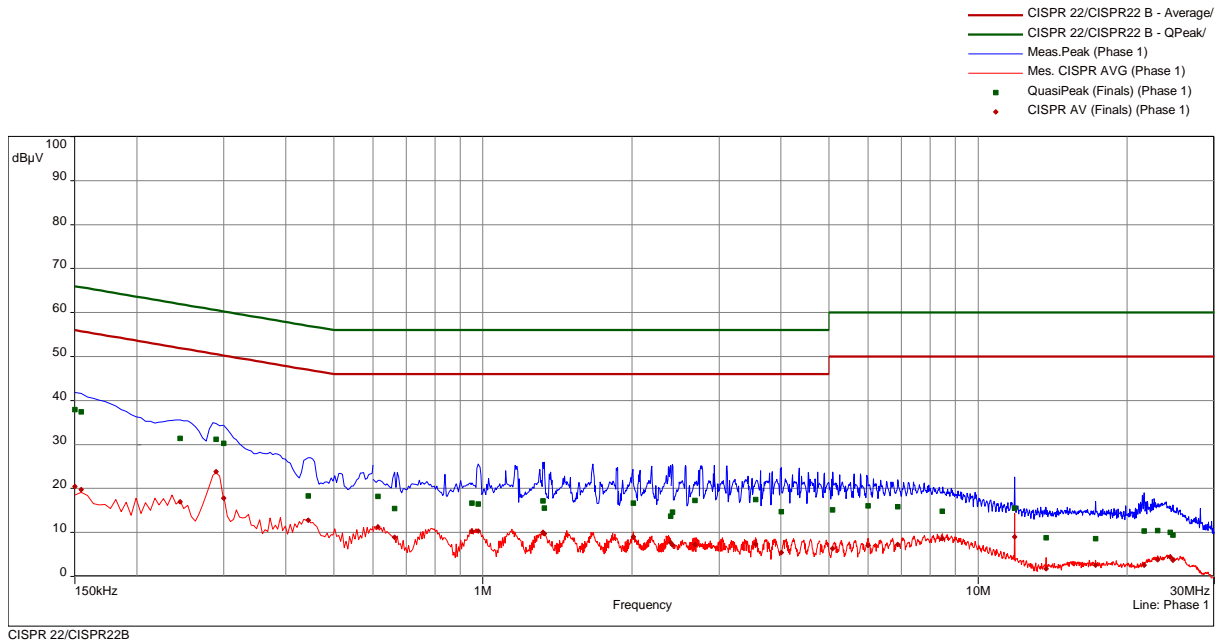
* Decreases with the logarithm of the frequency

The requirements are **FULFILLED**.**Remarks:** For detailed test result please refer to following test protocols

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5.1.6 Test protocol

Test point L1
Operation mode: Transmission 2.4 GHz
Remarks:

Result: passed



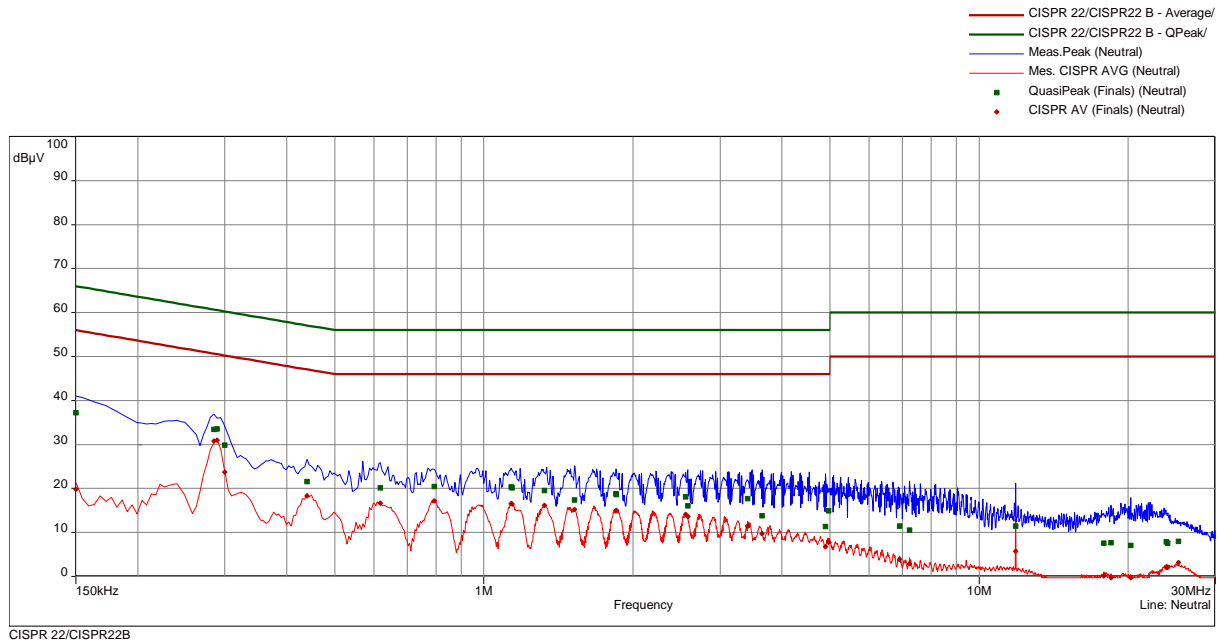
freq	SR	QP	margin	limit	AV	margin	limit	line	corr
MHz		dB(μV)	dB	dB	dB(μV)	dB	dB		dB
0.150	1	38.0	-28.0	66.0	20.5	-35.5	56.0	Phase 1	10
0.155	1	37.4	-28.3	65.8	19.7	-36.0	55.8	Phase 1	10
0.245	1	31.5	-30.5	61.9	17.0	-35.0	51.9	Phase 1	10
0.290	1	31.2	-29.4	60.5	23.9	-26.7	50.5	Phase 1	10
0.300	2	30.2	-30.0	60.2	17.8	-32.5	50.2	Phase 1	10
0.444	2	18.3	-38.7	57.0	12.8	-34.2	47.0	Phase 1	10
0.614	3	18.2	-37.8	56.0	11.3	-34.7	46.0	Phase 1	10
0.663	3	15.5	-40.5	56.0	8.9	-37.1	46.0	Phase 1	10
0.951	3	16.7	-39.3	56.0	10.2	-35.8	46.0	Phase 1	10
0.978	3	16.4	-39.6	56.0	10.4	-35.6	46.0	Phase 1	10
1.322	4	17.2	-38.8	56.0	10.0	-36.0	46.0	Phase 1	10
1.331	4	15.6	-40.5	56.0	9.7	-36.3	46.0	Phase 1	10
2.015	4	16.7	-39.4	56.0	9.0	-37.0	46.0	Phase 1	10
2.397	4	13.7	-42.3	56.0	7.7	-38.4	46.0	Phase 1	10
2.414	5	14.7	-41.3	56.0	7.1	-38.9	46.0	Phase 1	10
2.679	5	17.3	-38.7	56.0	7.2	-38.8	46.0	Phase 1	10
3.552	5	17.5	-38.5	56.0	7.4	-38.6	46.0	Phase 1	10
4.002	5	14.7	-41.3	56.0	5.4	-40.6	46.0	Phase 1	10
5.084	6	15.1	-44.9	60.0	6.3	-43.7	50.0	Phase 1	10
5.997	6	16.1	-43.9	60.0	7.0	-43.0	50.0	Phase 1	11
6.884	6	15.9	-44.1	60.0	7.3	-42.7	50.0	Phase 1	11
8.477	6	14.8	-45.2	60.0	8.6	-41.4	50.0	Phase 1	11
11.855	7	15.5	-44.5	60.0	9.0	-41.0	50.0	Phase 1	11
13.713	7	8.8	-51.2	60.0	1.8	-48.3	50.0	Phase 1	11
17.282	7	8.6	-51.4	60.0	2.5	-47.5	50.0	Phase 1	11
21.648	8	10.3	-49.7	60.0	2.6	-47.5	50.0	Phase 1	12
23.043	8	10.5	-49.5	60.0	3.8	-46.2	50.0	Phase 1	12
24.420	8	10.1	-49.9	60.0	4.4	-45.6	50.0	Phase 1	12
24.740	8	9.4	-50.6	60.0	3.7	-46.3	50.0	Phase 1	12

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Test point: N
Operation mode: Transmission 2.4 GHz
Remarks:

Result: passed



freq	SR	QP	margin	limit	AV	margin	limit	line	corr
MHz		dB(μV)	dB	dB	dB(μV)	dB	dB		dB
0.150	9	37.2	-28.8	66.0	19.8	-36.2	56.0	Neutral	10
0.285	9	33.5	-27.2	60.7	30.8	-19.9	50.7	Neutral	10
0.290	9	33.5	-27.0	60.5	31.0	-19.5	50.5	Neutral	10
0.300	10	29.8	-30.4	60.2	23.7	-26.5	50.2	Neutral	10
0.440	10	21.6	-35.5	57.1	18.3	-28.7	47.1	Neutral	10
0.618	11	20.1	-35.9	56.0	16.7	-29.3	46.0	Neutral	10
0.794	11	20.4	-35.6	56.0	17.2	-28.8	46.0	Neutral	10
1.136	11	20.3	-35.7	56.0	16.6	-29.4	46.0	Neutral	10
1.140	11	20.1	-35.9	56.0	16.5	-29.5	46.0	Neutral	10
1.326	12	19.5	-36.5	56.0	16.2	-29.8	46.0	Neutral	10
1.524	12	17.4	-38.6	56.0	15.2	-30.8	46.0	Neutral	10
1.848	12	18.9	-37.1	56.0	15.0	-31.0	46.0	Neutral	10
1.853	12	18.7	-37.3	56.0	15.0	-31.0	46.0	Neutral	10
2.553	13	18.1	-37.9	56.0	14.1	-31.9	46.0	Neutral	10
2.580	13	16.1	-39.9	56.0	13.6	-32.4	46.0	Neutral	10
3.408	13	17.7	-38.3	56.0	11.5	-34.5	46.0	Neutral	10
3.647	13	13.8	-42.2	56.0	9.7	-36.3	46.0	Neutral	10
4.895	14	11.4	-44.6	56.0	6.7	-39.3	46.0	Neutral	10
4.967	14	14.9	-41.1	56.0	7.7	-38.3	46.0	Neutral	10
6.915	14	11.5	-48.5	60.0	3.9	-46.1	50.0	Neutral	11
7.244	14	10.6	-49.5	60.0	2.9	-47.2	50.0	Neutral	11
11.855	15	11.4	-48.6	60.0	5.7	-44.3	50.0	Neutral	11
17.880	15	7.5	-52.5	60.0	0.2	-49.8	50.0	Neutral	11
18.461	15	7.7	-52.3	60.0	-0.3	-50.3	50.0	Neutral	11
20.258	16	7.1	-52.9	60.0	-0.5	-50.5	50.0	Neutral	11
23.880	16	7.9	-52.1	60.0	2.1	-47.9	50.0	Neutral	11
24.033	16	7.5	-52.5	60.0	2.0	-48.0	50.0	Neutral	11
25.293	16	8.0	-52.0	60.0	3.2	-46.8	50.0	Neutral	11

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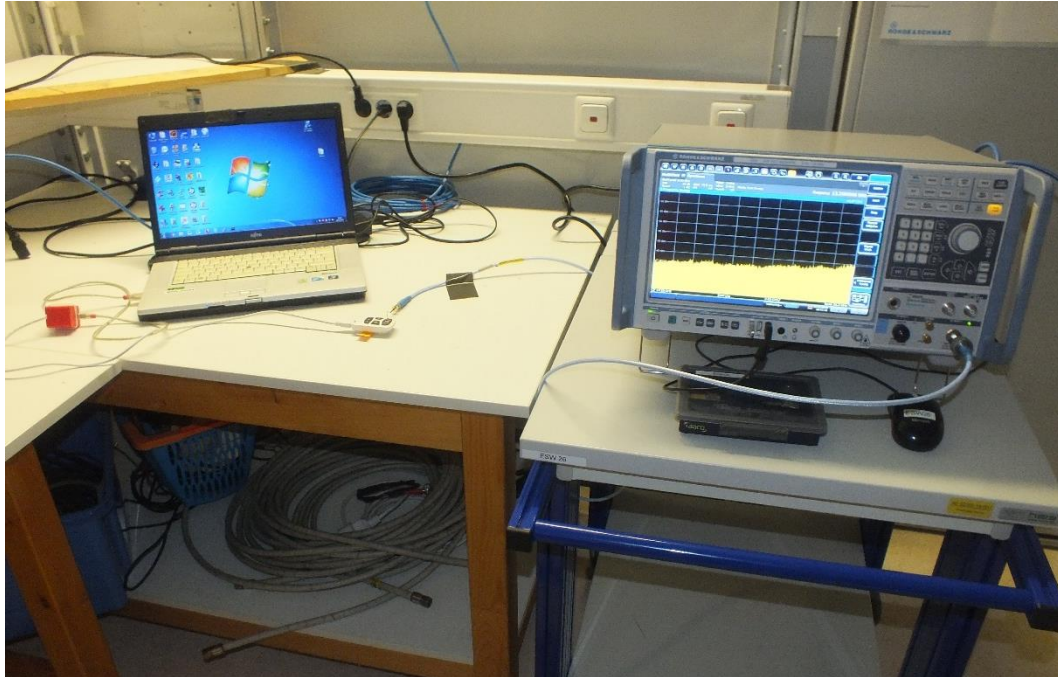
5.2 EBW and OBW

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.

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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, Span: 4 MHz;

Spectrum analyser settings for OBW:

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

5.2.5 Test result

Channel	Centre frequency	6 dB bandwidth	99% OBW	Minimum limit
	(MHz)	(MHz)	(MHz)	(MHz)
1	2404	0.810	1.657	0.5
19	2440	0.814	1.666	0.5
39	2480	0.824	1.672	0.5

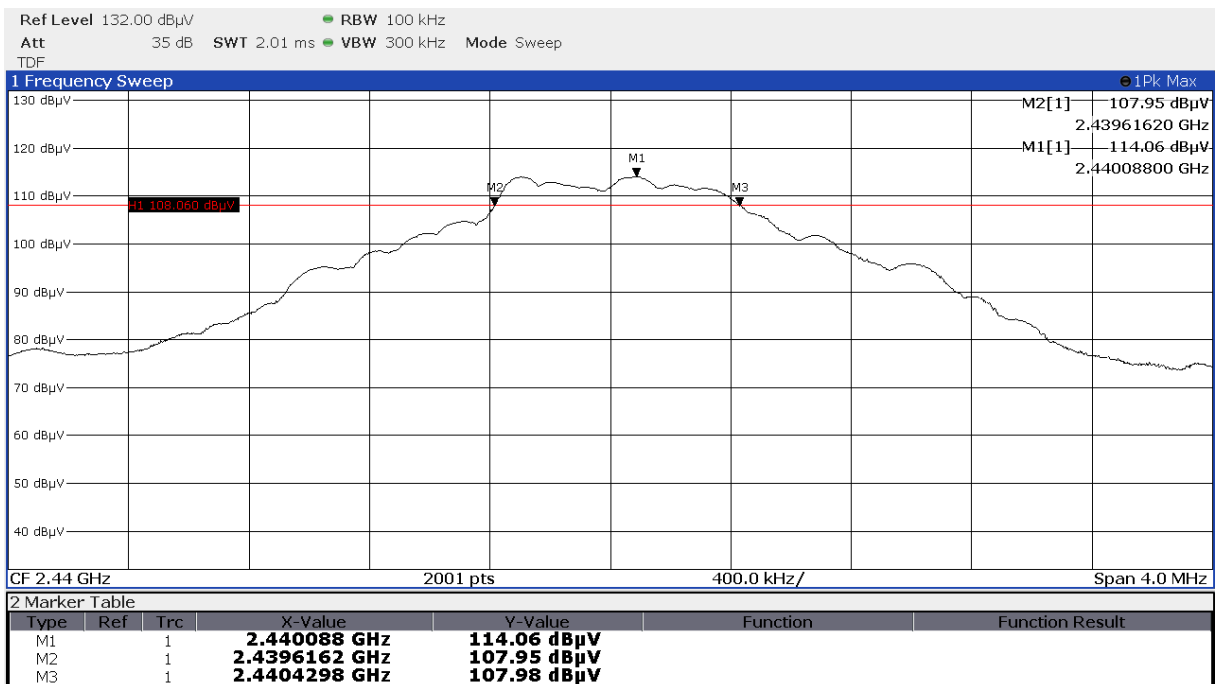
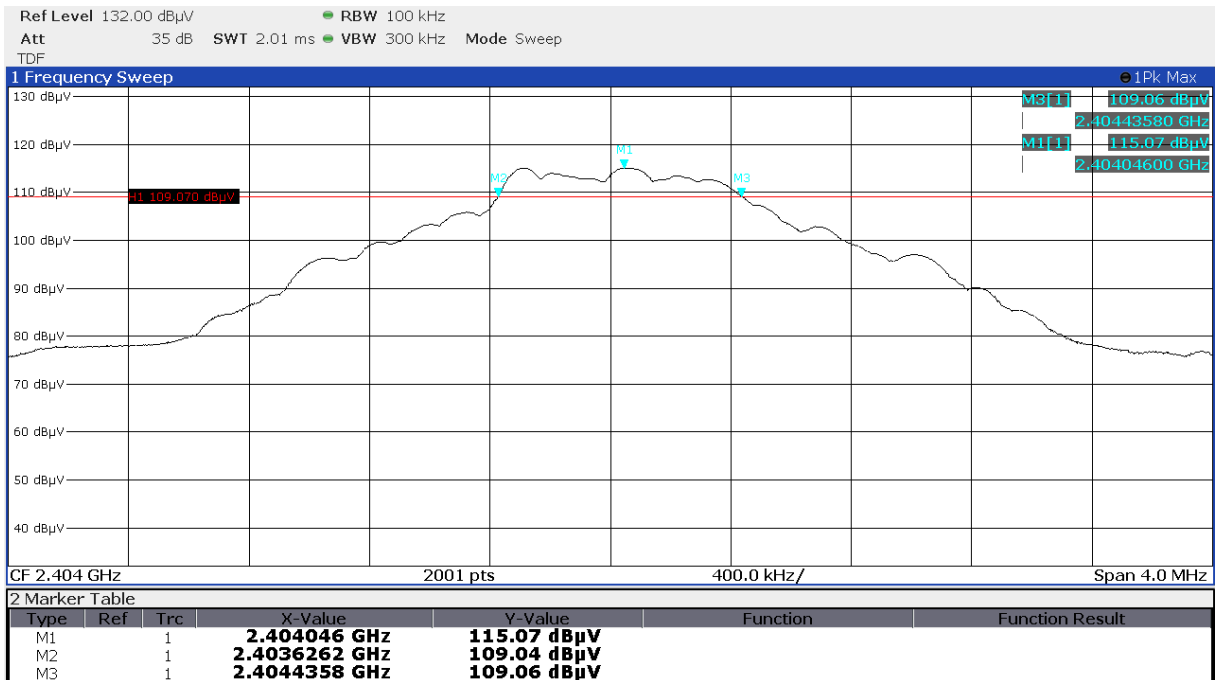
The requirements are **FULFILLED**.

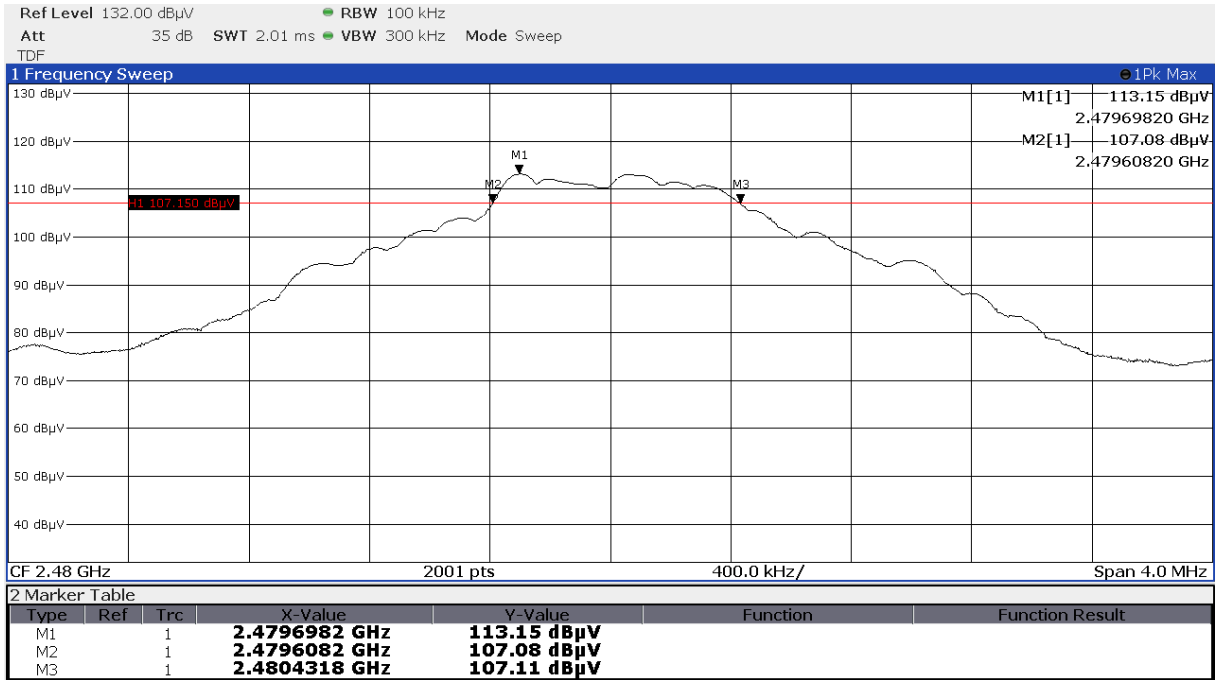
Remarks: For detailed test results please refer to following test protocols. The RSS Gen defines no limit for the occupied bandwidth!

FCC ID: VNP-AL

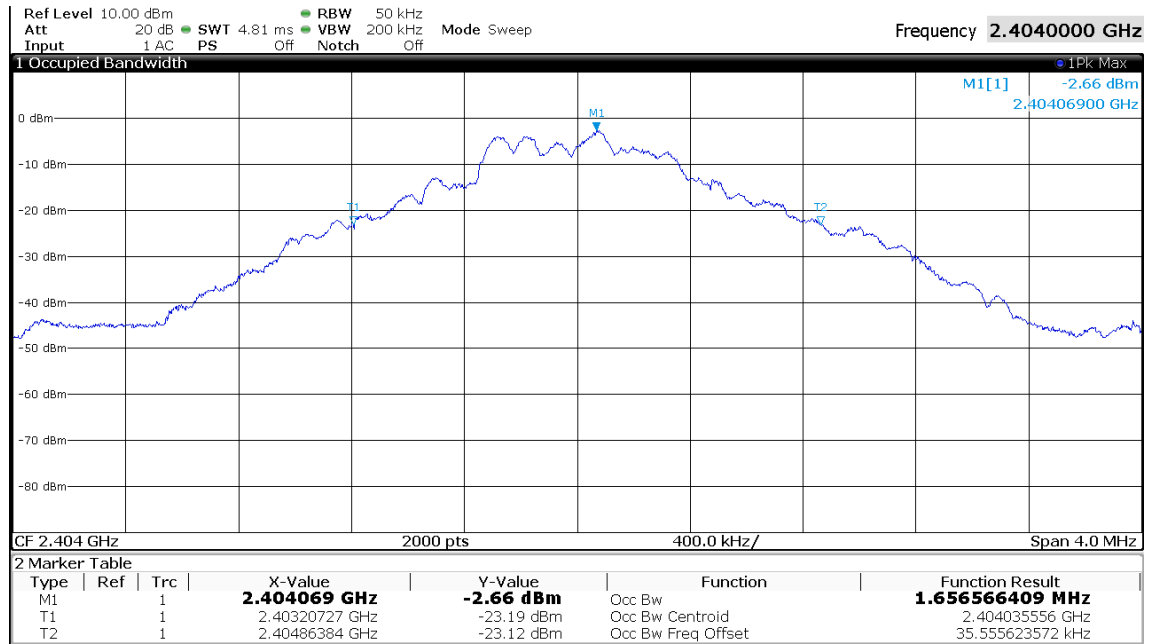
IC: 11986A-AL

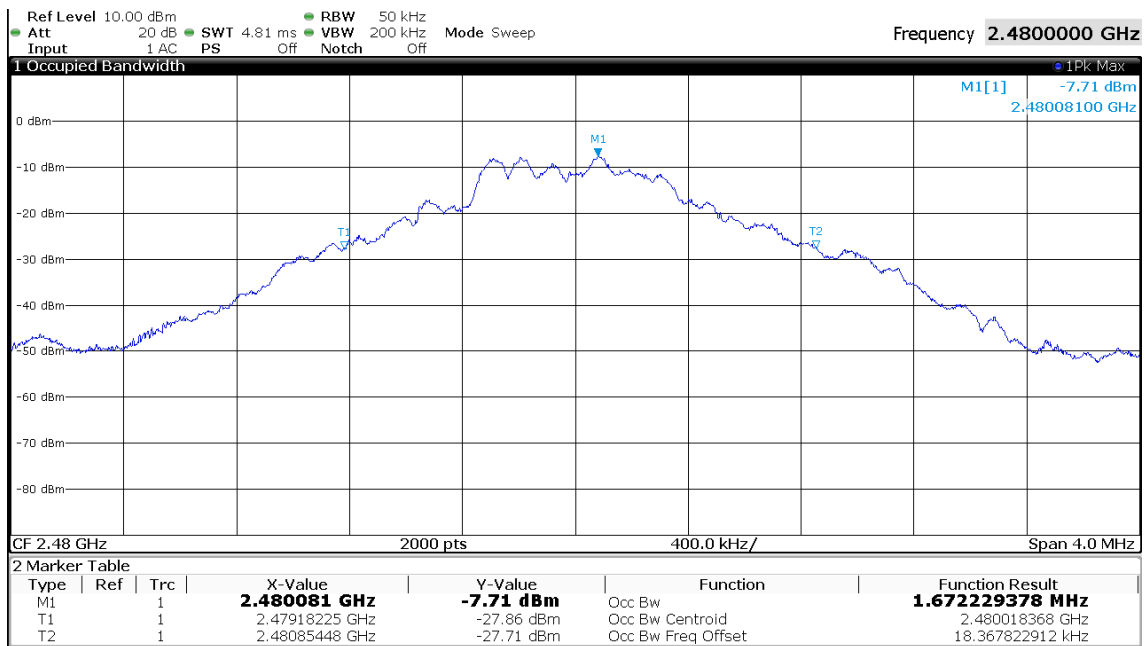
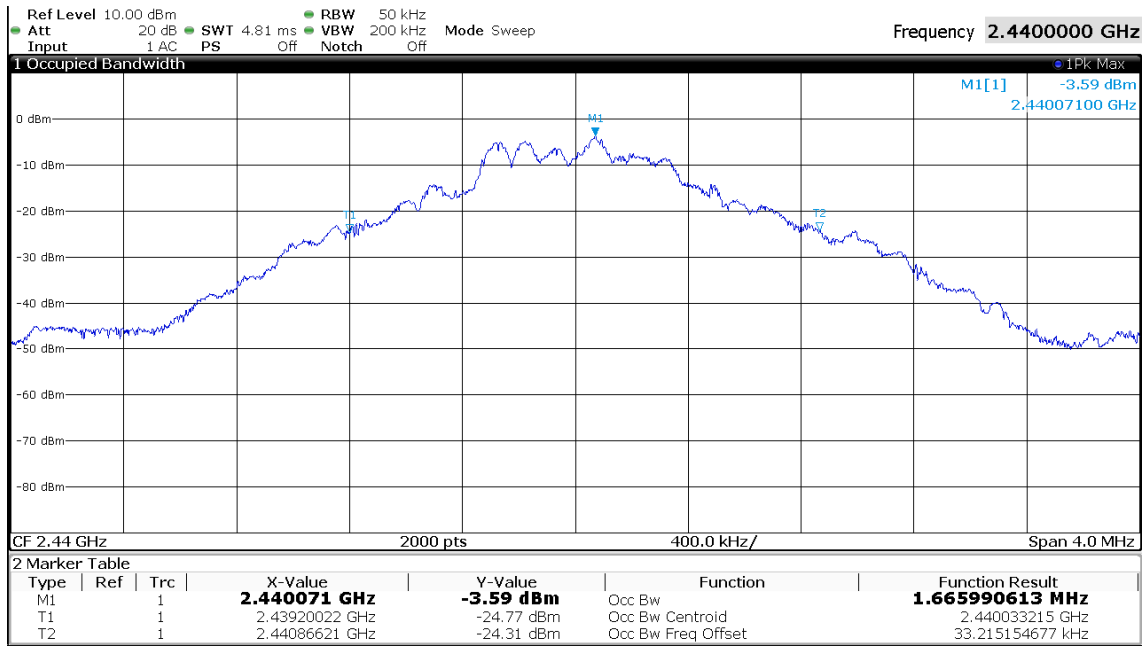
5.2.6 Test protocols EBW



FCC ID: VNP-AL
IC: 11986A-AL


5.2.7 Test protocols OBW



FCC ID: VNP-AL
IC: 11986A-AL


FCC ID: VNP-AL
IC: 11986A-AL

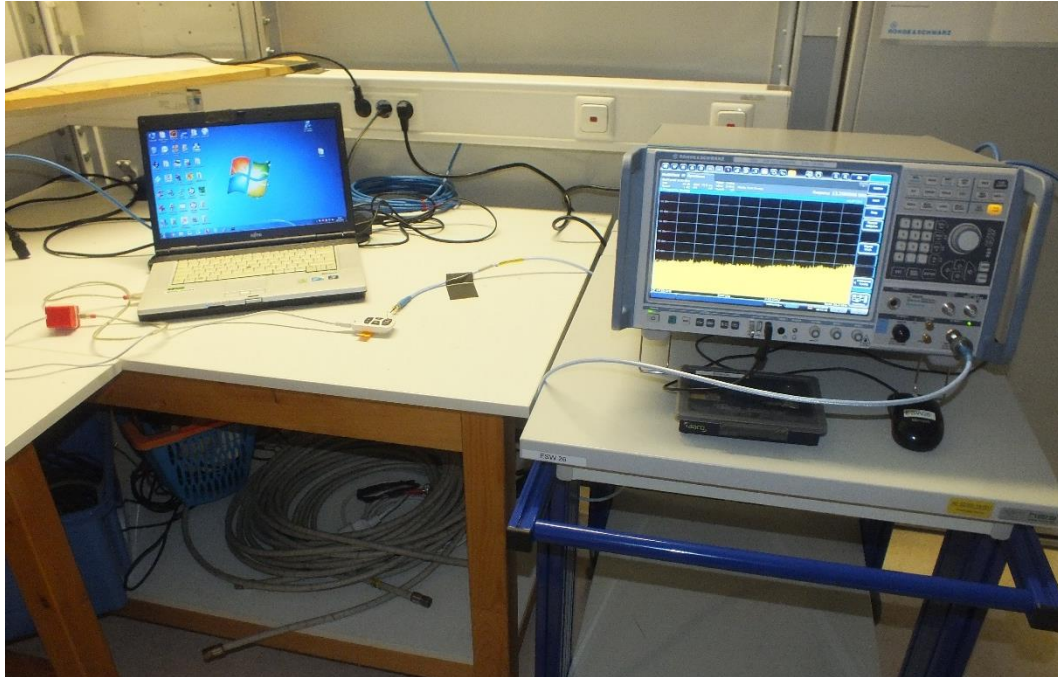
5.3 Maximum peak conducted output power

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

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 FCC Part 15, Section 15.247(b)(3):

For systems using digital modulation in the 2400 – 2483.5 MHz band, 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 conducted output power is measured using a peak power meter following the procedure set out in KDB 558074, item 8.3.1. The EUT is set in TX continuous mode while measuring.

Analyser settings:

RBW: 3 MHz, VBW \geq RBW, Detector: Max peak, Trace: Max hold, Sweep time: auto

FCC ID: VNP-AL
IC: 11986A-AL
5.3.5 Test result

Test results conducted		A [Pmax] (dBm)	Limit (dBm)	Margin (dB)
Lowest frequency: CH1				
T_{nom}	V_{nom}	7.6	30.0	-22.4
Middle frequency: CH19				
T_{nom}	V_{nom}	6.2	30.0	-23.8
Highest frequency: CH39				
T_{nom}	V_{nom}	5.6	30.0	-24.4

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: -

FCC ID: VNP-AL
IC: 11986A-AL

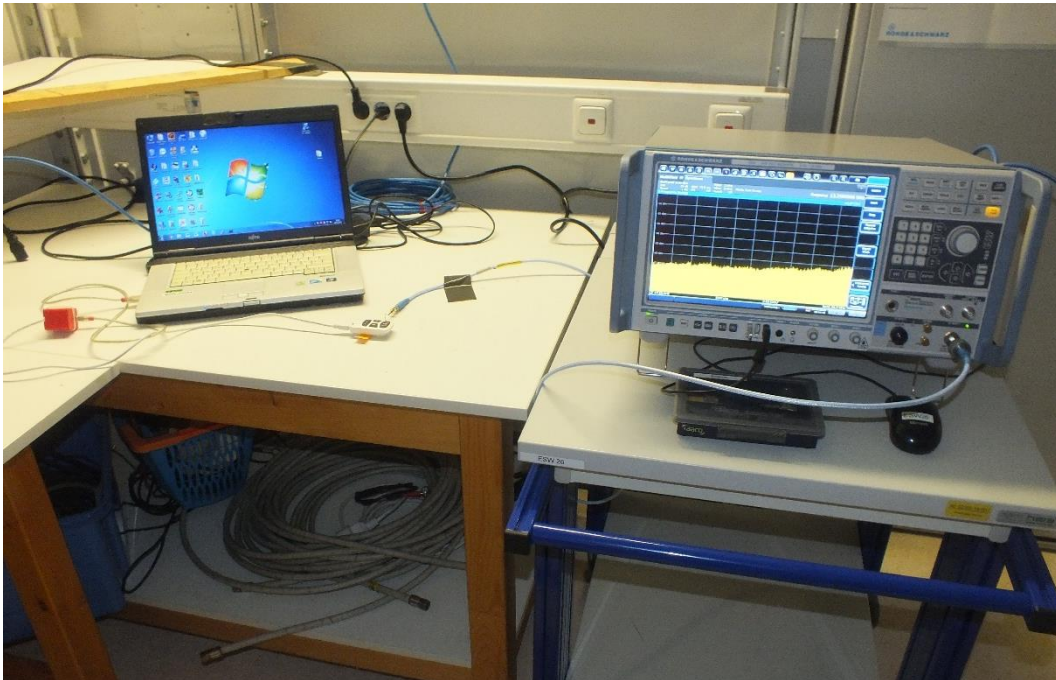
5.4 Power spectral density

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 8.4 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: auto

FCC ID: VNP-AL
IC: 11986A-AL

5.4.5 Test result

Test results conducted		PD [Pmax] (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Lowest frequency: CH1				
T_{nom}	V_{nom}	-6.7	8.0	-14.7
Middle frequency: CH19				
T_{nom}	V_{nom}	-7.6	8.0	-15.6
Highest frequency: CH39				
T_{nom}	V_{nom}	-8.4	8.0	-16.4

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

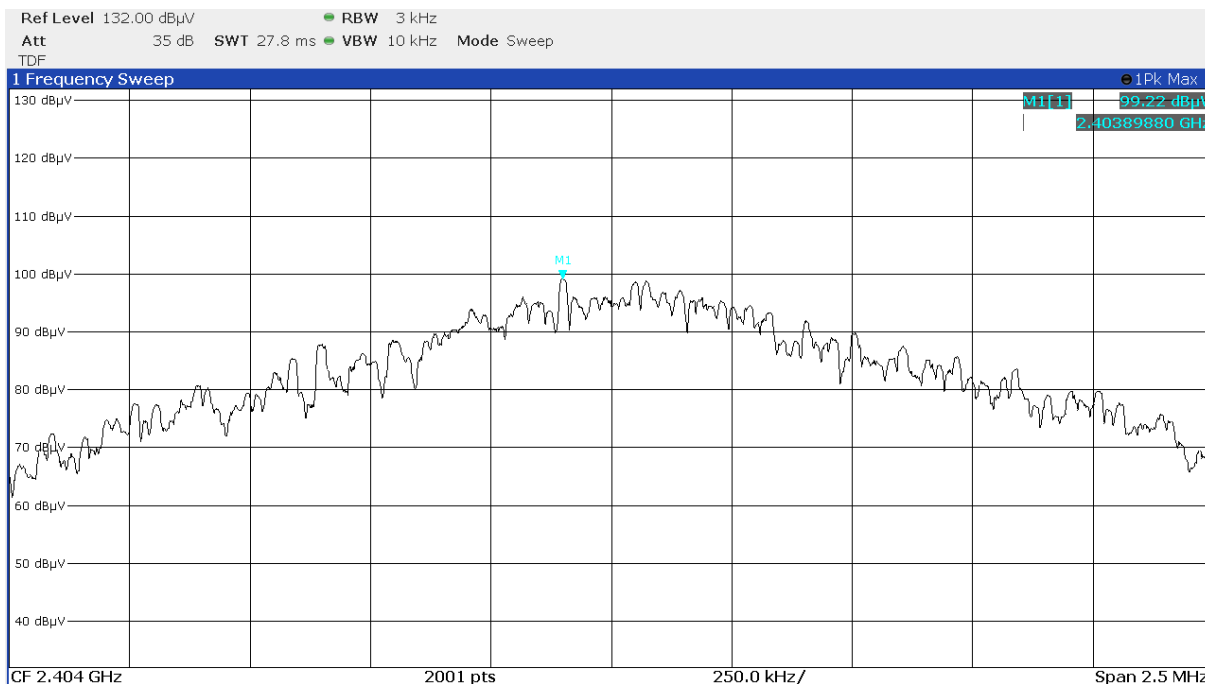
Frequency (MHz)	Power spectral density limit
	(dBm/3 kHz)
2400 - 2483.5	8

The requirements are **FULFILLED**.

Remarks: The antenna gain of 1 dBi was added to the test result.

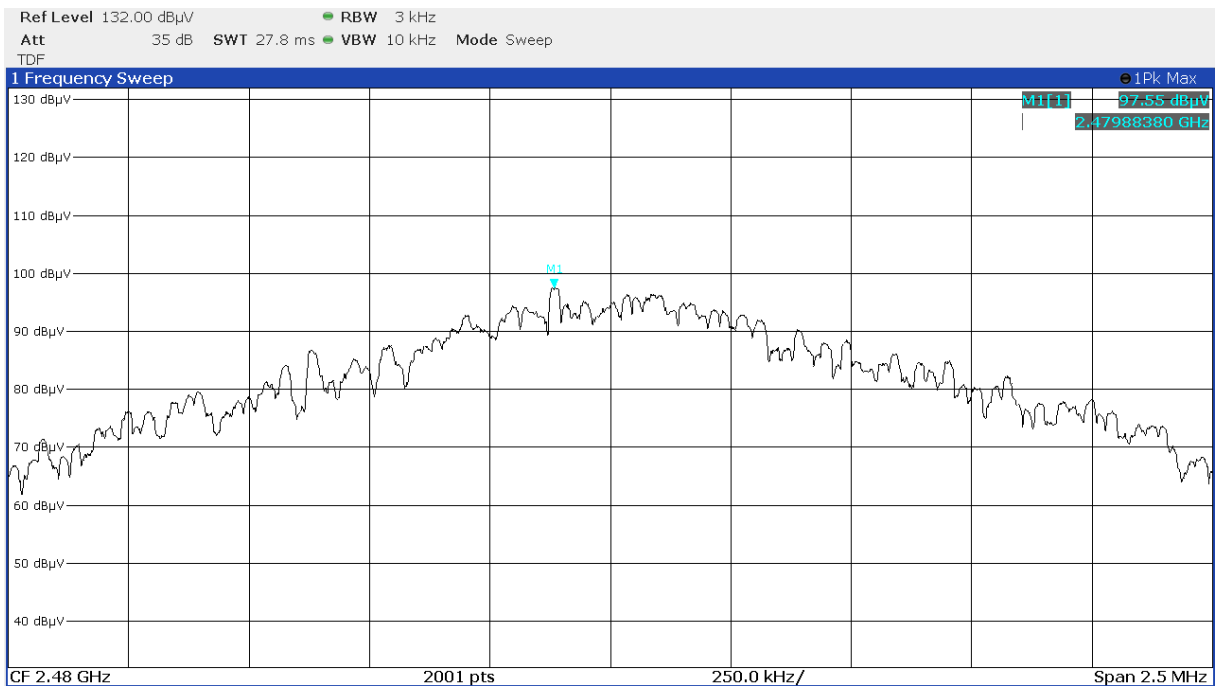
For detailed test results please refer to following test protocols.

5.4.6 Power spectral density plots



FCC ID: VNP-AL

IC: 11986A-AL



FCC ID: VNP-AL
IC: 11986A-AL

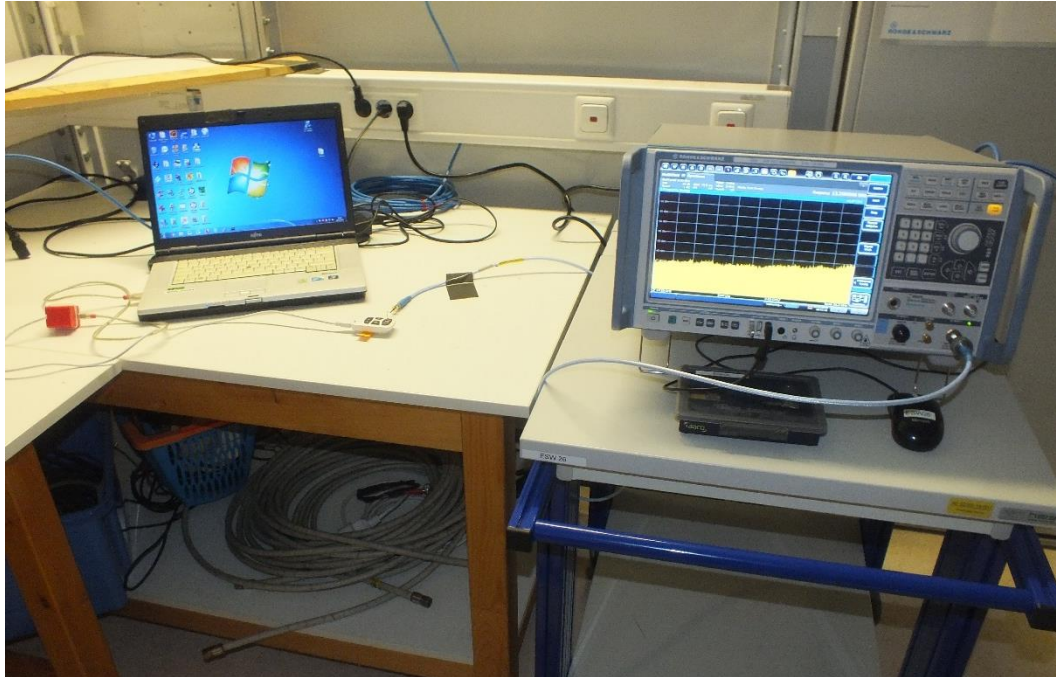
5.5 Unwanted emissions, conducted

For test instruments and accessories used see section 6 Part **SEC 1-3**.

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(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)).

5.5.4 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 equipment. The transmitter is set to the lowest operating frequency, the middle and to the highest operating frequency. 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 modulated TX continuous mode.

Spectrum analyser search setting:

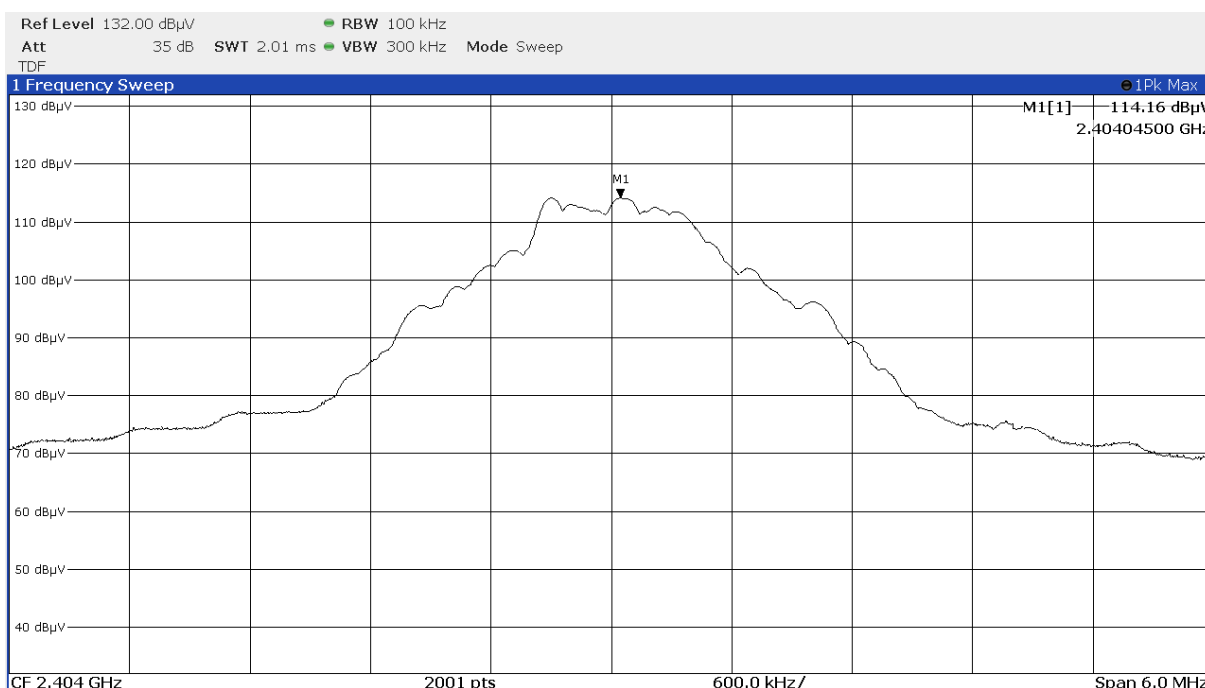
RBW: 100 kHz, VBW: 300 kHz, Detector: Max peak, Trace Mode: Max hold

FCC ID: VNP-AL

IC: 11986A-AL

5.5.5 Test result

Determination of the reference level and limit



Highest level of the desired power: 94.16 dBμV

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

In any 100 kHz bandwidth outside the frequency band 2400 – 2483.50 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: For detailed test results please refer to following test protocols.

The unwanted emissions conducted have only been performed in the non-restricted frequency range 2390 MHz to 2400 MHz. For all other emissions, please refer to chapter 5.7.

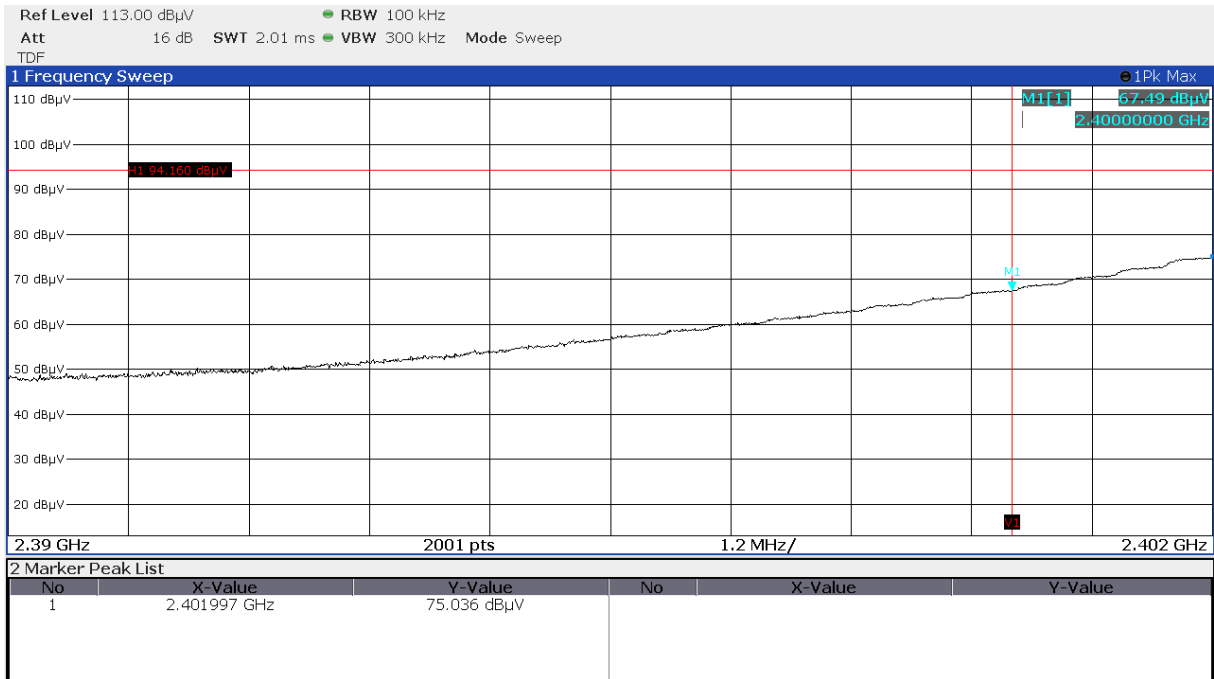
FCC ID: VNP-AL
IC: 11986A-AL

5.5.6 Test protocols

Plots of spurious emissions conducted out of operating frequency bands (-20 dBc)

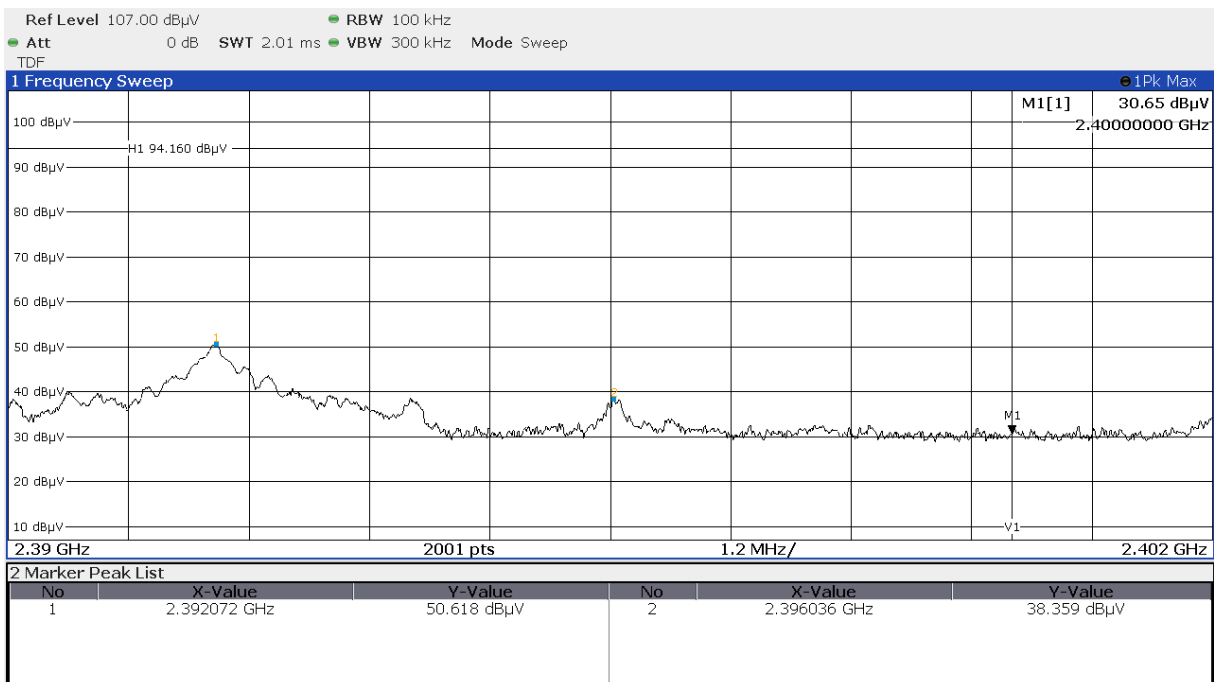
2404 MHz

Spurious emissions conducted from 2.39 GHz – 2.40 GHz including the lower bandedge



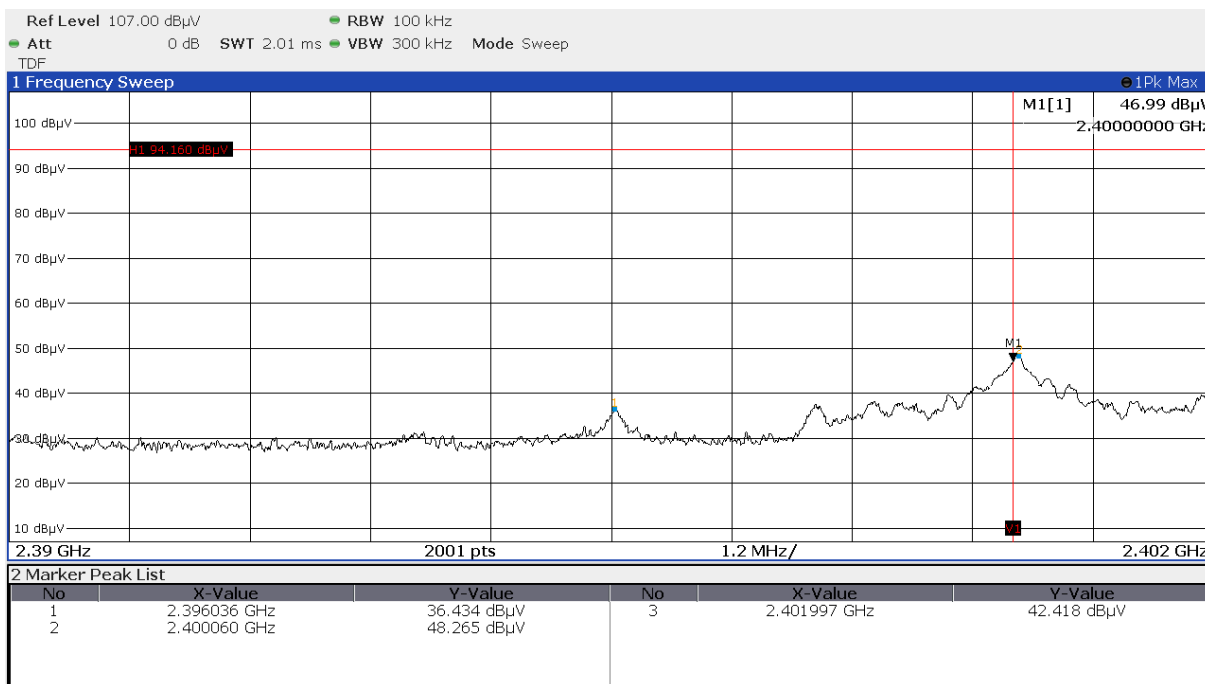
2440 MHz

Spurious emissions conducted from 2.39 GHz – 2.40 GHz including the lower bandedge



FCC ID: VNP-AL
IC: 11986A-AL
2480 MHz

Spurious emissions conducted from 2.39 GHz – 2.40 GHz including the lower bandedge



FCC ID: VNP-AL**IC: 11986A-AL**

5.6 Band edge compliance

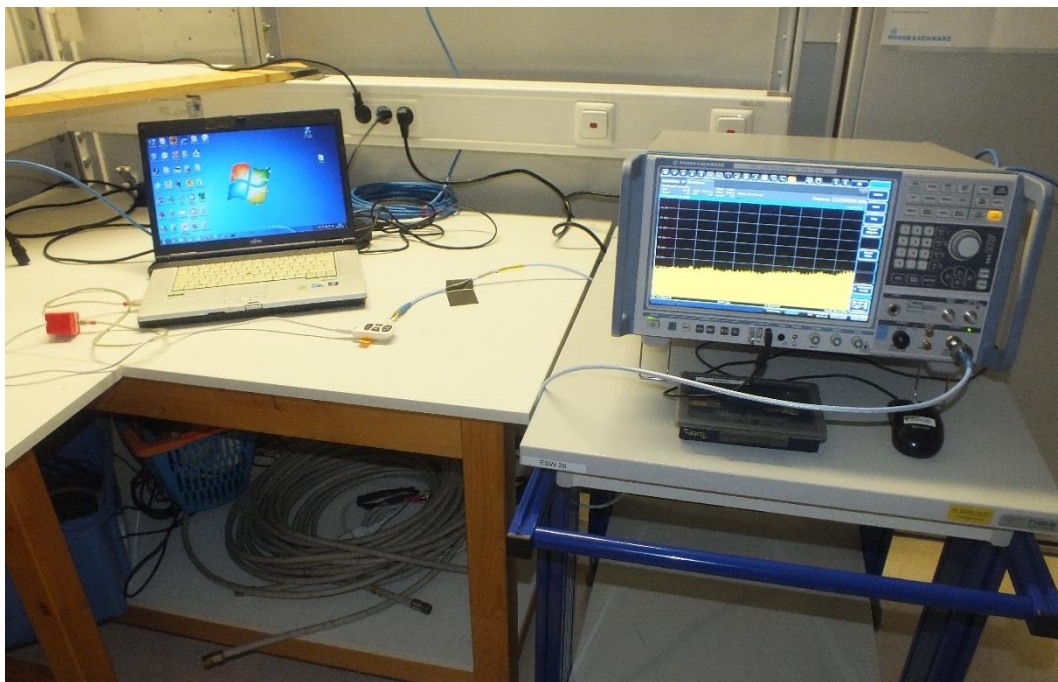
For test instruments and accessories used see section 6 Part **MB**.

5.6.1 Description of the test location

Test location: AREA4
Test location: Anechoic chamber 1
Test distance: 3 m

5.6.2 Photo documentation of the test set-up

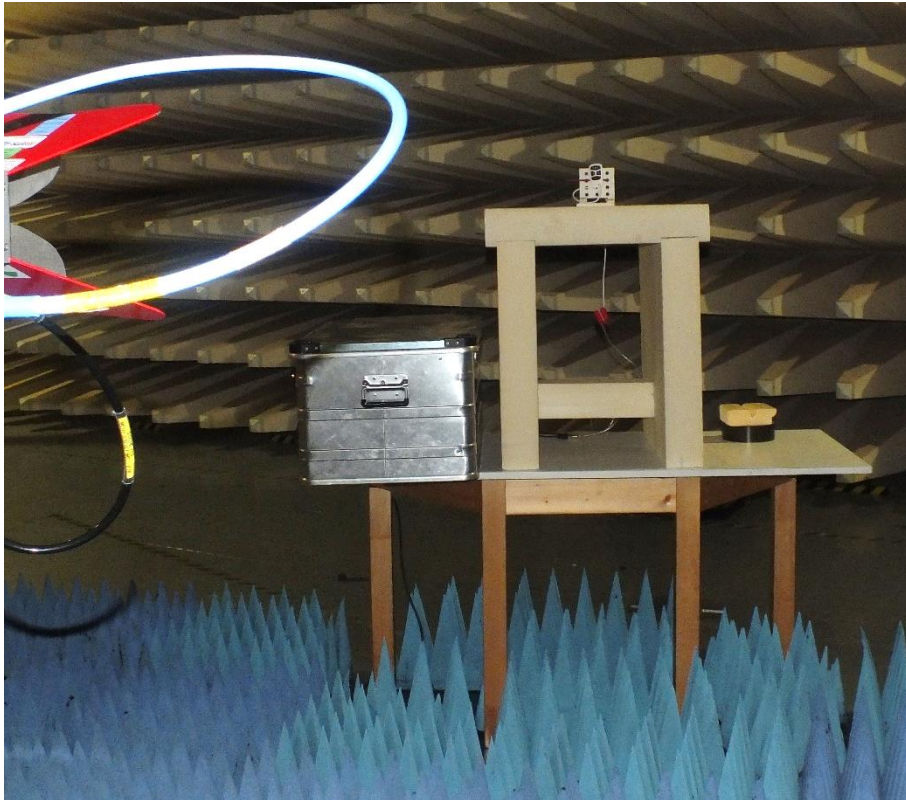
Conducted measurement lower bandedge



FCC ID: VNP-AL

IC: 11986A-AL

Radiated measurement upper bandedge



5.6.3 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)).

5.6.4 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 ANSI C63.10.

Spectrum analyser settings non-restricted band:

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

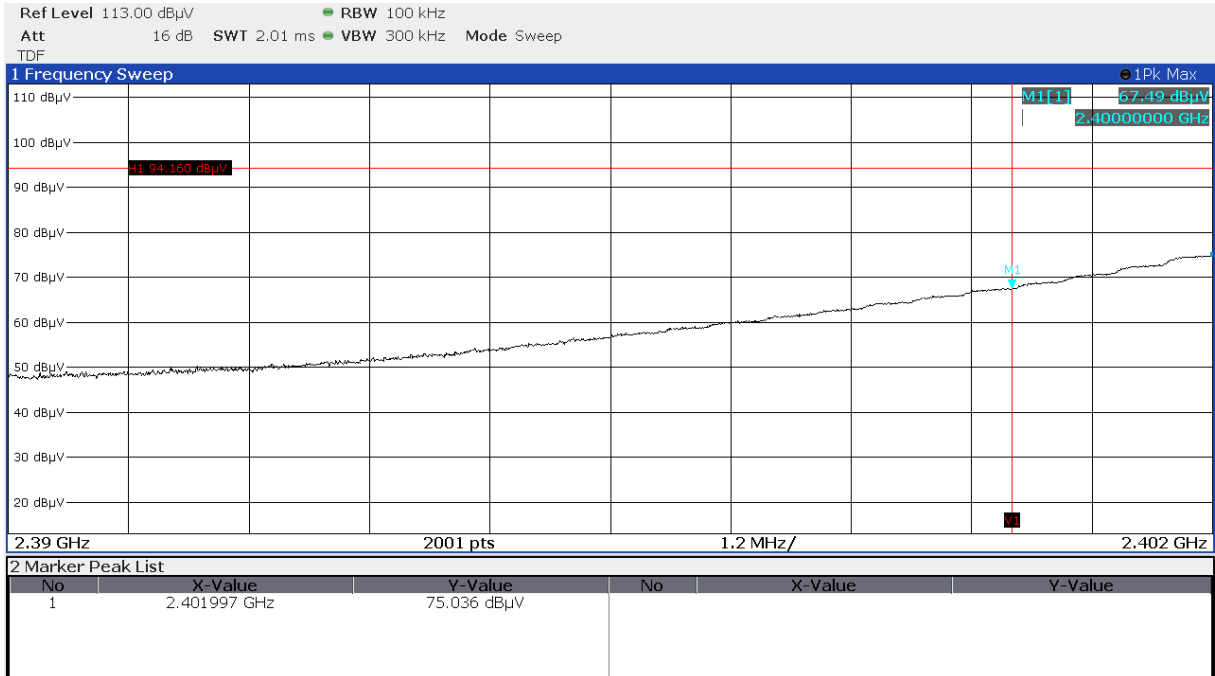
Spectrum analyser settings restricted band:

RBW: 1 MHz, VBW: 3 MHz, Detector: Max peak, Trace: Max hold, Sweep: auto

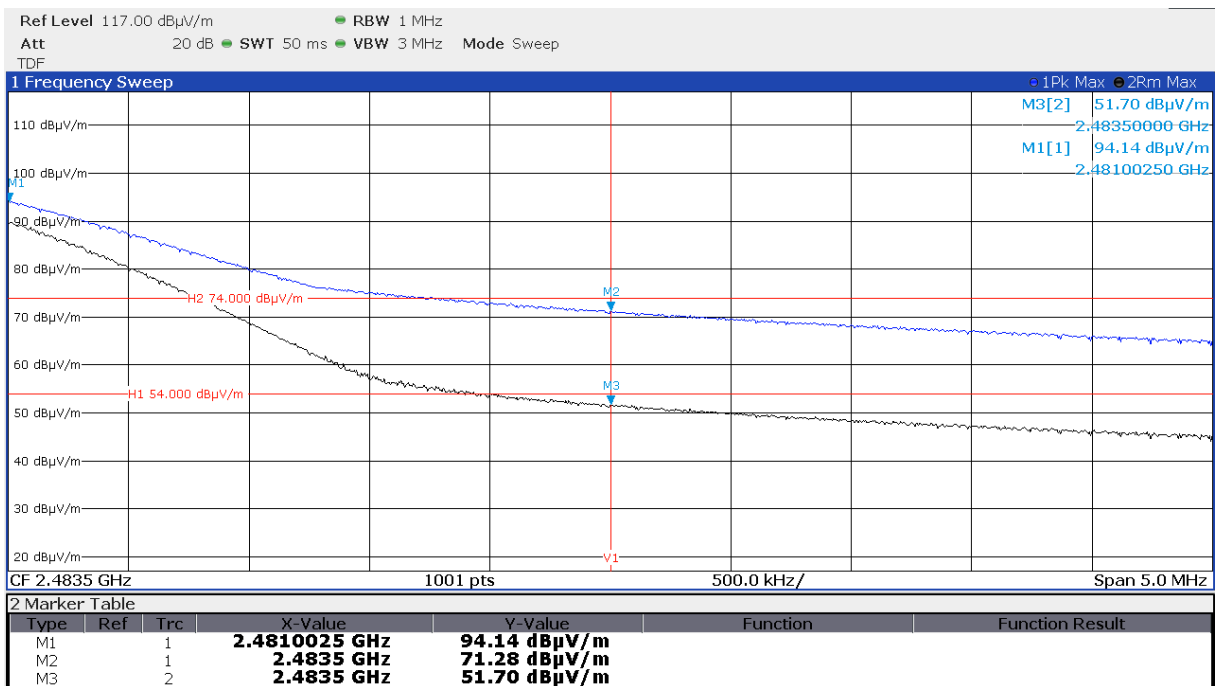
FCC ID: VNP-AL
IC: 11986A-AL

5.6.5 Test result

Lower bandedge measurement channel 1



Upper bandedge measurement channel 39



FCC ID: VNP-AL**IC: 11986A-AL**

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:

-

FCC ID: VNP-AL**IC: 11986A-AL**

5.7 Unwanted emissions, radiated

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

5.7.1 Description of the test location

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

5.7.2 Photo documentation of the test set-up

Open area test site

Test setup 9 kHz – 30 MHz



FCC ID: VNP-AL

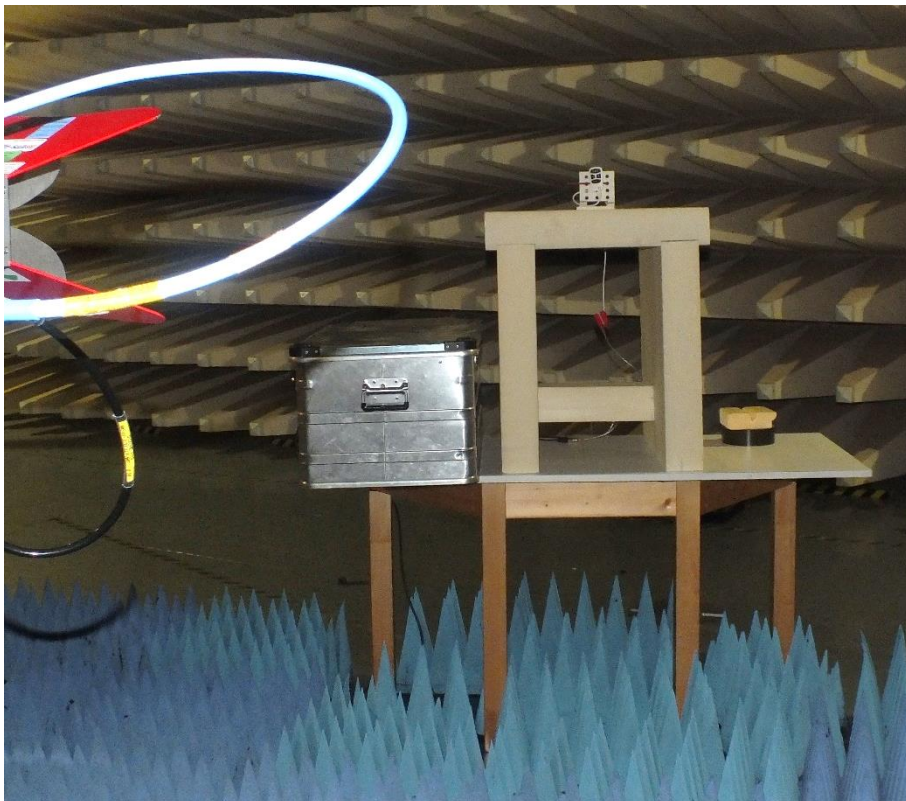
IC: 11986A-AL

Test setup 30 MHz – 1 GHz



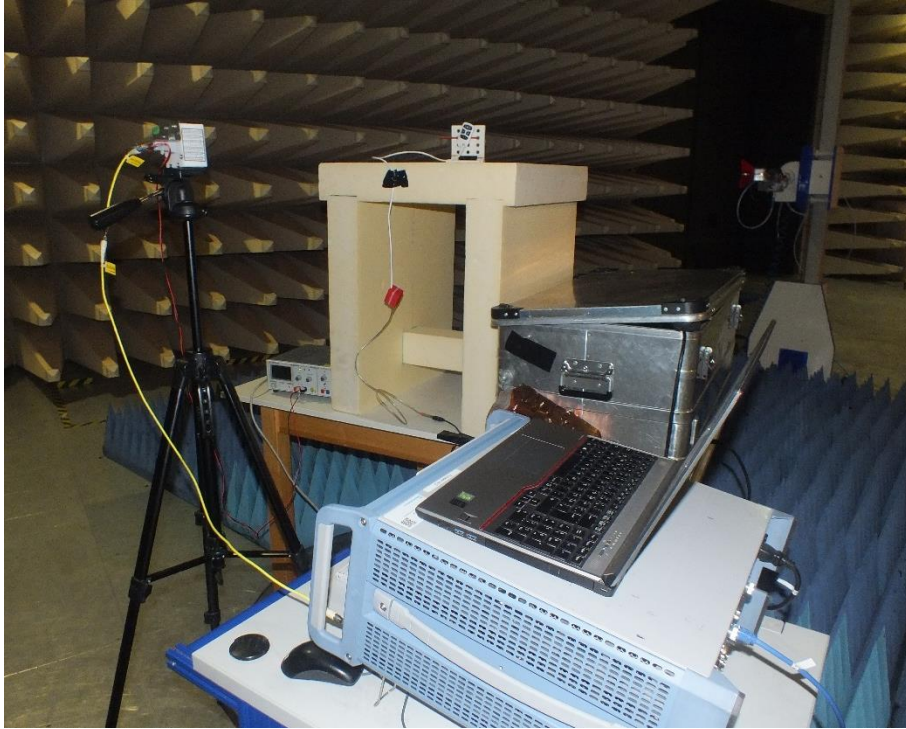
Anechoic chamber

Test setup 1 GHz – 18 GHz



FCC ID: VNP-AL
IC: 11986A-AL

Test setup 18 GHz – 26 GHz



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).

5.7.3 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.

Spectrum analyser settings:

9 kHz – 150 kHz	RBW: 200 Hz
150 kHz - 30 MHz	RBW: 9 kHz
30 MHz – 1000 MHz:	RBW: 120 kHz
1000 MHz – 25 GHz:	RBW: 1 MHz, VBW: 3 MHz, Sweep: Auto, Detector function: Peak

FCC ID: VNP-AL
IC: 11986A-AL
5.7.4 Test result $f < 1000$ MHz

Frequency (MHz)	Reading Vert. (dB μ V)	Reading Hor. (dB μ V)	Correct. Vert. (dB)	Correct. Hor. (dB)	Level Vert. (dB μ V/m)	Level Hor. (dB μ V/m)	Limit (dB μ V/m)	Dlimit (dB)
43.40	6.7	5.5	14.0	12.8	20.7	18.3	40.0	-19.3
55.94	6.8	6.3	14.0	13.0	20.8	19.3	40.0	-19.2
80.00	8.2	6.4	10.4	10.1	18.6	16.5	40.0	-21.4

Note: In the frequency range 9 kHz to 1000 MHz no emission could be detected. The frequencies mention the noise level. No difference could be detected between the operating frequencies.

5.7.5 Test result $f > 1$ GHz
2404 MHz

Frequency (MHz)	Level PK (dB(μ V/m))	Level AV (dB(μ V/m))	Limit PK (dB(μ V/m))	Margin PK (dB)	Limit AV (dB(μ V/m))	Margin AV (dB)
1440.18	41.0	-	74.0	-33.0	54.0	-
4808.72	47.7	-	74.0	-26.3	54.0	-
7211.64	46.4	-	74.0	-27.6	54.0	-
9615.05	56.9	46.0	74.0	-17.1	54.0	-7.9
12018.96	50.0	-	74.0	-24.0	54.0	-
14422.38	54.4	43.6	74.0	-19.6	54.0	-10.4
16826.29	51.3	40.5	74.0	-22.7	54.0	-13.5
19235.16	58.9	-	84.0	-25.1	64.0	-
21633.49	57.0	-	84.0	-27.0	64.0	-

Note: only when the peak value exceeds the average value, an average measurement is necessary. The AV value is calculated with the duty cycle correction factor -10.8 dB.

2440 MHz

Frequency	Level PK	Level AV (dB(μ V/m))	Limit PK (dB(μ V/m))	Margin PK (dB)	Limit AV (dB(μ V/m))	Margin AV (dB)
1440.18	40.8	-	74.0	-33.2	54.0	-
4879.72	42.5	-	74.0	-31.5	54.0	-
7319.13	47.6	-	74.0	-26.3	54.0	-
9759.04	51.1	-	74.0	-22.9	54.0	-
12198.46	50.5	-	74.0	-23.5	54.0	-
14639.37	48.8	-	74.0	-25.2	54.0	-
19521.64	56.6	-	84.0	-27.4	64.0	-
21957.47	56.7	-	84.0	-27.3	64.0	-

Note: only when the peak value exceeds the average value, an average measurement is necessary. The AV value is calculated with the duty cycle correction factor -10.8 dB.

FCC ID: VNP-AL
IC: 11986A-AL
2480 MHz

Frequency (MHz)	Level PK dB(μV/m)	Level AV dB(μV/m)	Limit PK dB(μV/m)	Margin PK (dB)	Limit AV dB(μV/m)	Margin AV (dB)
1439.68	46.2	-	74.0	-27.8	54.0	-
4960.72	42.6	-	74.0	-31.3	54.0	-
7440.63	48.0	-	74.0	-25.9	54.0	-
9918.54	50.3	-	74.0	-23.7	54.0	-
12400.45	51.8	-	74.0	-22.2	54.0	-
19838.62	54.1	-	84.0	-29.9	64.0	-
22320.44	55.3	-	84.0	-28.7	64.0	-

Note: only when the peak value exceeds the average value, an average measurement is necessary. The AV value is calculated with the duty cycle correction factor -10.8 dB.

FCC ID: VNP-AL
IC: 11986A-AL

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)
	($\mu\text{V/m}$)	dB($\mu\text{V/m}$)	
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

RSS-Gen, Table 6 – Restricted Frequency Bands

MHz	MHz	MHz	GHz
0.090 - 0.110	12.57675 - 12.57725	399.9 - 410	7.250 - 7.750
0.495 - 0.505	13.36 - 13.41	608 - 614	8.025 – 8.500
2.1735 - 2.1905	16.42 - 16.423	960 - 1427	9.0 - 9.2
3.020 - 3.026	16.69475 - 16.69525	1435 - 1626.5	9.3 - 9.5
4.125 - 4.128	16.80425 - 16.80475	1645.5 - 1646.5	10.6 - 12.7
4.17725 - 4.17775	25.5 - 25.67	1660 - 1710	13.25 - 13.4
4.20725 - 4.20775	37.5 - 38.25	1718.8 - 1722.2	14.47 - 14.5
5.677 - 5.683	73 - 74.6	2200 - 2300	15.35 - 16.2
6.215 - 6.218	74.8 - 75.2	2310 - 2390	17.7 - 21.4
6.26775 - 6.26825	108 – 138	2483.5 - 2500	22.01 - 23.12
6.31175 - 6.31225	149.9 - 150.05	2655 - 2900	23.6 - 24.0
8.291 - 8.294	156.52475 - 156.52525	3260 – 3267	31.2 - 31.8
8.362 - 8.366	156.7 - 156.9	3332 - 3339	36.43 - 36.5
8.37625 - 8.38675	162.0125 - 167.17	3345.8 - 3358	Above 38.6
8.41425 - 8.41475	167.72 - 173.2	3500 - 4400	
12.29 - 12.293	240 – 285	4500 - 5150	
12.51975 - 12.52025	322 - 335.4	5350 - 5460	

FCC ID: VNP-AL

IC: 11986A-AL

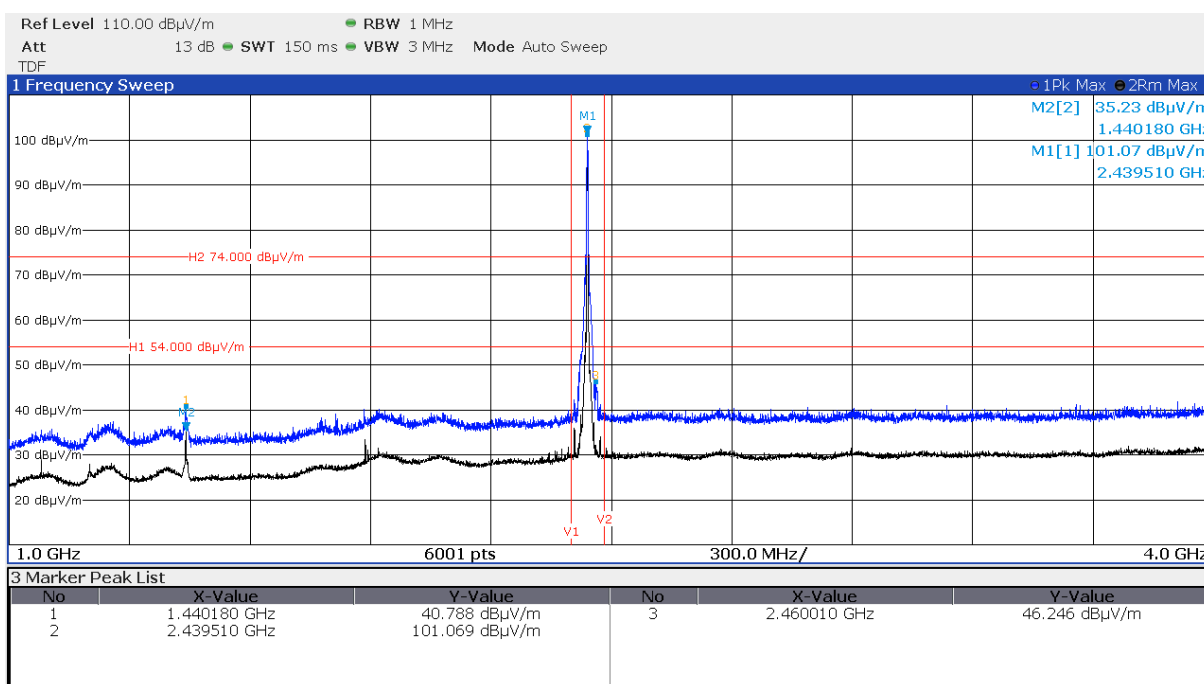
The requirements are **FULFILLED**.

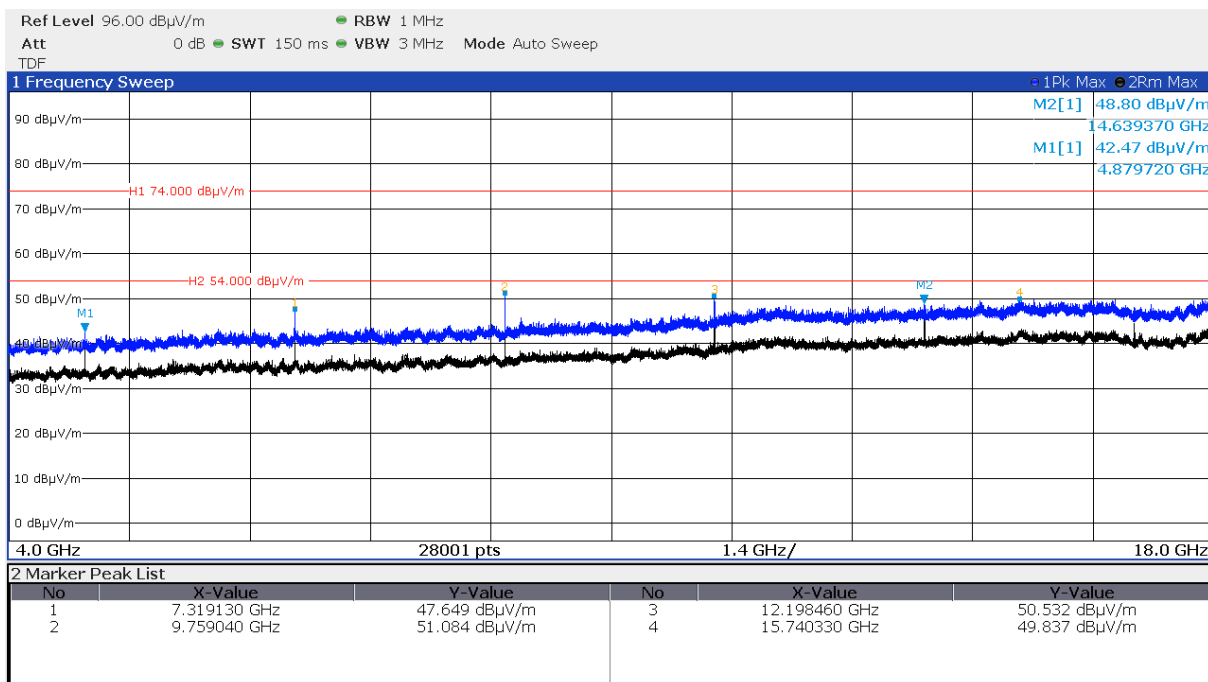
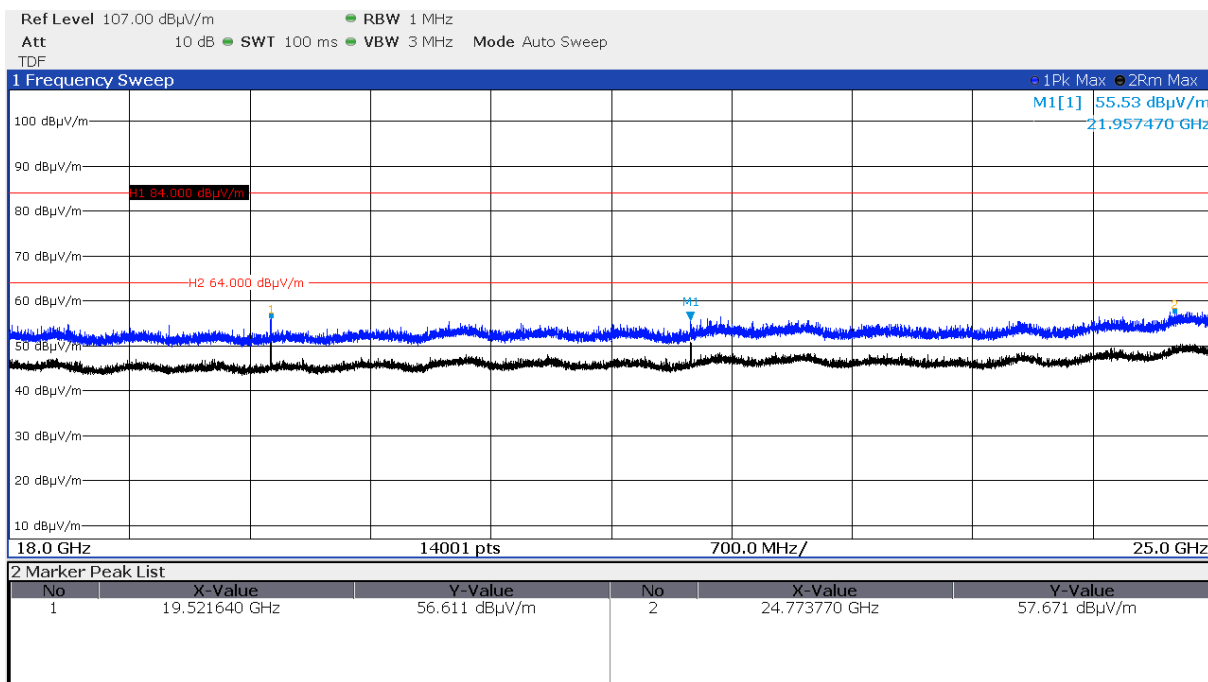
Remarks: The measurement was performed up to the 10th harmonic. For detailed test results please see to following test protocol.

5.7.6 Test protocol

2440 MHz only for reference

1 GHz to 4 GHz



FCC ID: VNP-AL
IC: 11986A-AL
4 GHz to 18 GHz

18 GHz to 25 GHz


Remark: All peak emissions were below the limits of part 15.209. The measurement distance was changed to 1 m for this frequency range, therefore the limit line has to be adjusted and was increased by 10 dB.

FCC ID: VNP-AL**IC: 11986A-AL**

5.8 Antenna application

5.8.1 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 EUT has an integrated antenna. No other antenna can be used with the device.

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

5.8.2 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.

Remarks: No power reduction results from the defacto limit.

FCC ID: VNP-AL

IC: 11986A-AL

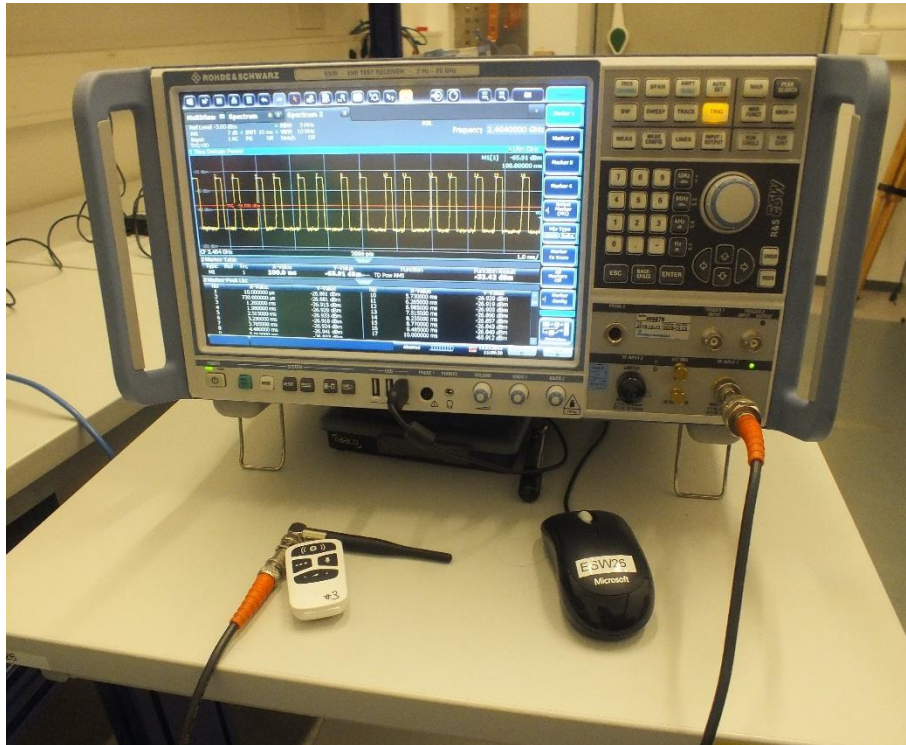
5.9 Correction for pulse operation (duty cycle)

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

5.9.1 Description of the test location

Test location: AREA4

5.9.2 Photo documentation of the test set-up



5.9.3 Applicable standard

According to FCC Part 15A, Section 15.35(c):

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

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5.9.4 Description of Measurement

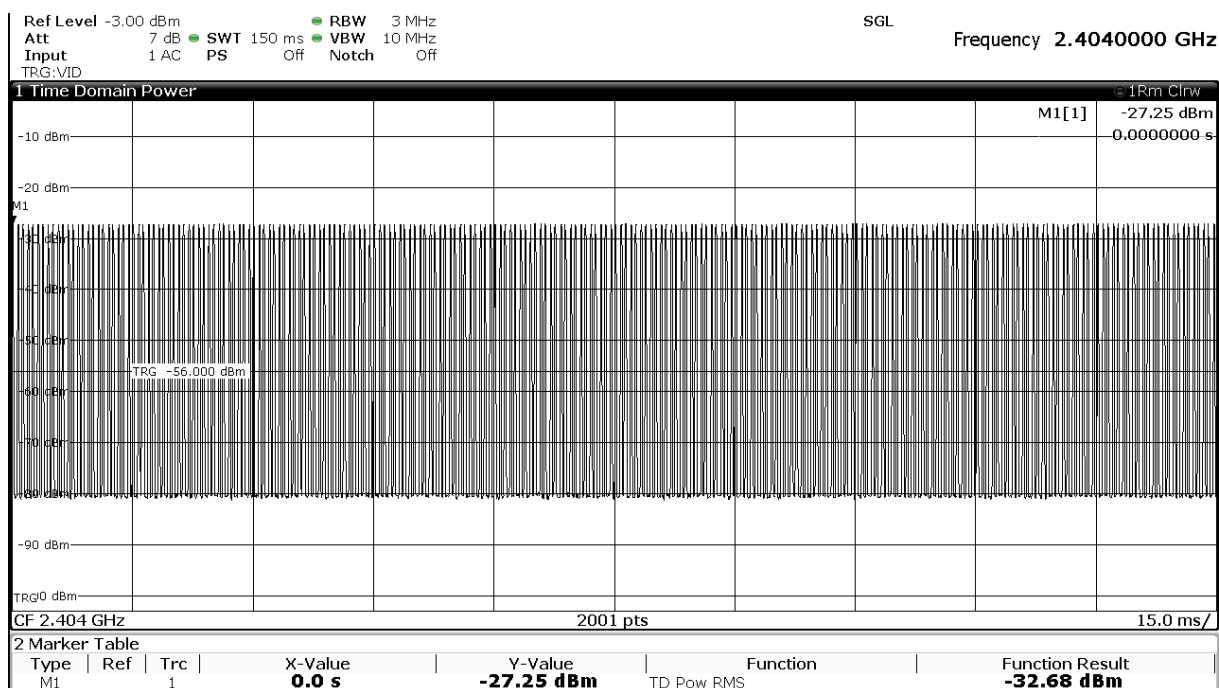
The duty cycle factor (dB) is calculated applying the following formula:

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

KE : pulse operation correction factor

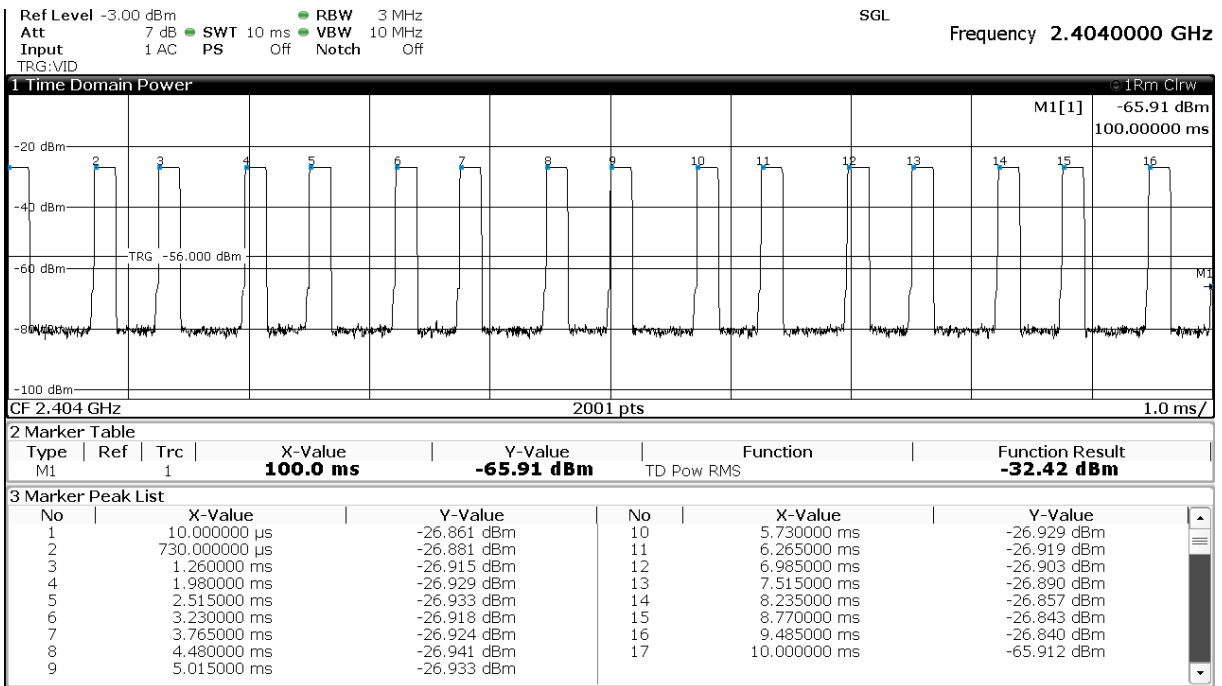
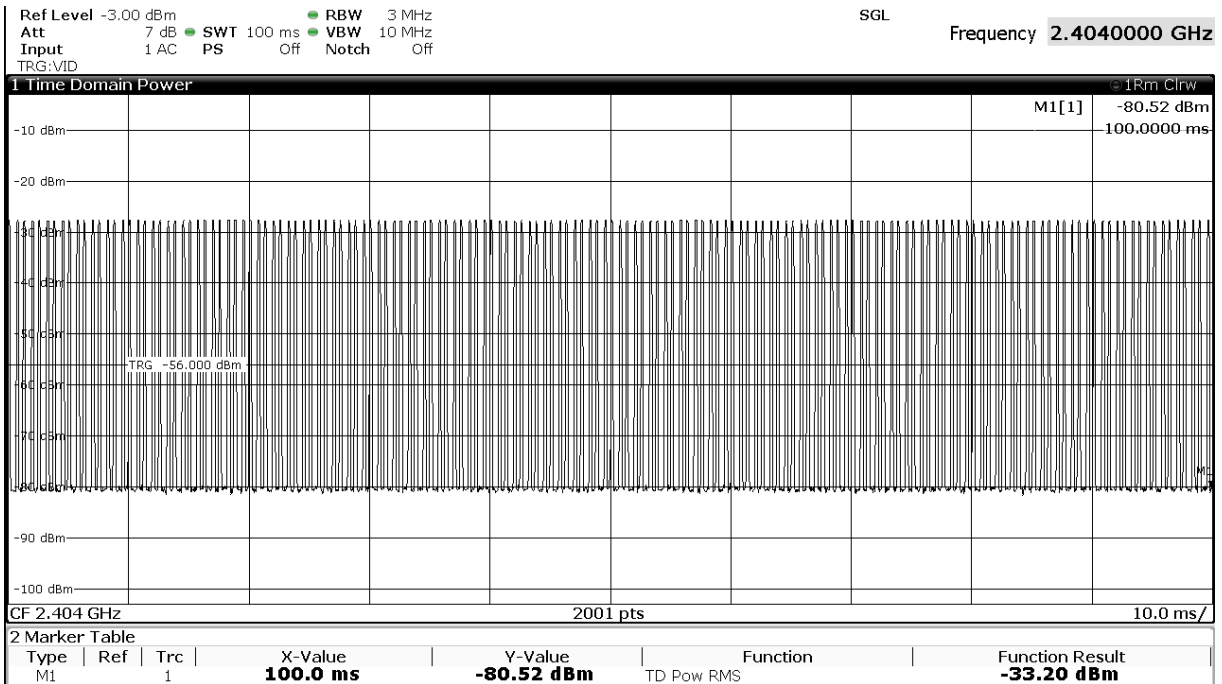
t_{iw} : pulse duration for one complete pulse track

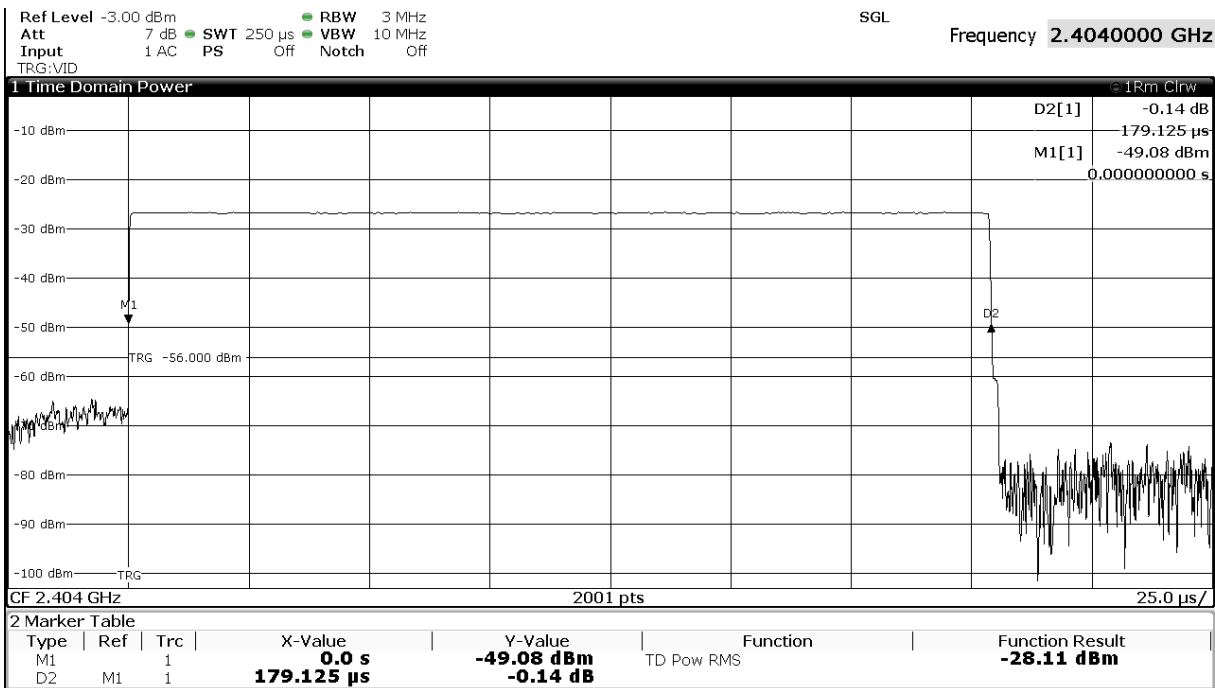
The pulse train exceeds 0.1s. Thus, the field strength is determined during a 100 ms interval.



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5.9.5 Test result



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$$K_E = 20 \log (28.8 \text{ ms} / 100 \text{ ms}) = -10.8 \text{ dB}$$

Total length of period	100 ms
Max. On time	28.800 ms
DC	0.2880
Correction factor	-10.8 dB

Remarks:

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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	ESW26	02-02/03-17-002	13/12/2019	13/12/2018		
	KK-SF104-11SMA-11N-2M	02-02/50-14-002				
DC	ESW26	02-02/03-17-002	13/12/2019	13/12/2018		
	RF Antenna	02-02/24-05-032				
MB	ESW26	02-02/03-17-002	13/12/2019	13/12/2018		
	KK-SF104-11SMA-11N-2M	02-02/50-14-002				
SEC 1-3	ESW26	02-02/03-17-002	13/12/2019	13/12/2018		
	KK-SF104-11SMA-11N-2M	02-02/50-14-002				
SER 1	ESCI	02-02/03-15-001	11/06/2019	11/06/2018	15/01/2020	15/01/2019
	HFH 2 - Z 2	02-02/24-05-020	09/08/2020	09/08/2017		
	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				
	ANT1010A	02-02/50-16-034				
SER 2	ESVS 30	02-02/03-05-006	06/06/2019	06/06/2018		
	VULB 9168	02-02/24-05-005	18/04/2019	18/04/2018		
	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	19/03/2019	19/03/2018	12/12/2019	12/12/2018
	JS4-18004000-30-5A	02-02/17-05-017				
	AMF-6D-01002000-22-10P	02-02/17-15-004				
	3117	02-02/24-05-009	08/05/2019	08/05/2018		
	BBHA 9170	02-02/24-05-014	12/06/2021	12/06/2018		
	KMS102-0.2 m	02-02/50-11-020				
	18N-20	02-02/50-17-003				
	NMS111-GL200SC01-NMS11	02-02/50-17-012				
	BAM 4.5-P	02-02/50-17-024				
	NCD	02-02/50-17-025				
	KK-SF106-2X11N-6,5M	02-02/50-18-016				
MB	FSW43	02-02/11-15-001	19/03/2019	19/03/2018	12/12/2019	12/12/2018
	JS4-18004000-30-5A	02-02/17-05-017				
	AMF-6D-01002000-22-10P	02-02/17-15-004				
	3117	02-02/24-05-009	08/05/2019	08/05/2018		
	BBHA 9170	02-02/24-05-014	12/06/2021	12/06/2018		
	KMS102-0.2 m	02-02/50-11-020				
	18N-20	02-02/50-17-003				
	NMS111-GL200SC01-NMS11	02-02/50-17-012				
	BAM 4.5-P	02-02/50-17-024				
	NCD	02-02/50-17-025				
	KK-SF106-2X11N-6,5M	02-02/50-18-016				