



EMI - T E S T R E P O R T

- FCC Part 15.249, RSS210 -

Type / Model Name : Track Box

Product Description : Tracking system with 2.4 GHz standard IEEE 802.15.4

Applicant : Race Result AG

Address : Joseph-von-Fraunhofer-Str. 11
76327 Pfinztal, GERMANY

Manufacturer : Race Result AG

Address : Joseph-von-Fraunhofer-Str. 11
76327 Pfinztal, GERMANY

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

POSITIVE

Test Report No. :

T43520-00-03KS

27. March 2018

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
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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, 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 15.249	Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz, 5725 - 5875 MHz, and 24.0 - 24.25 GHz
ANSI C63.4: 2014	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
ANSI C63.10: 2013	Testing Unlicensed Wireless Devices
ANSI C95.1:2005	IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
CISPR 16-4-2: 2013	Uncertainty in EMC measurement
CISPR 22: 2008 EN 55022: 2010	Information technology equipment

2 EQUIPMENT UNDER TEST

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

2.2 Equipment category

IEEE 802.15.4, fixed equipment

2.3 Short description of the equipment under test (EUT)

The EUT is part of a tracking system. The Track Box receives pings from tracking-enabled transponders and is also equipped with a GNSS receiver to locate itself and a cellular modem to report its position to a server. The EUT supports the 2.4 GHz frequency band and supports no beam forming. The EUT is not compatible with other IEEE 802.15.4 technologies and can only communicate with the transponders and other Track Boxes.

Number of tested samples: 1
Serial number: 20241
Firmware version: 1.0

EUT configuration:

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

2.4 Variants of the EUT

None.

2.5 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan IEEE 802.15.4:

Channel	Frequency
11	2405
13	2415
15	2425
17	2435
20	2450
22	2460
25	2475
26	2480

Note: the marked frequencies are determined for final testing.

2.6 Transmit operating modes

The EUT allows the user to select the following modes:

- TX continuous modulated

2.7 Antenna

The following antennas shall be used with the EUT:

Number	Type	Certification name	Plug	Frequency range (GHz)	Gain (dBi)
1	Omni	Laird Technologies RD2458-5	SMA	2.4 - 2.4835	3.0

2.8 Power supply system utilised

Power supply voltage, V_{nom} : 3.7 VDC Battery
 Power supply voltage (alternative) : Input: 110-240 VAC,
 Output: 10-15 VDC.

2.9 Peripheral devices and interface cables

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

- In total 10 track boxes for stack charging Model : Supplied by manufacturer
- Charging cable Model : Supplied by manufacturer
- _____ Model : _____

2.10 Determination of worst case conditions for final measurement

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

IEEE Standard	Available channel	Tested channels	Modulation	Modulation type	Data rate
802.15.4	11 to 26	11, 17, 26	DSSS	O-QPSK	250 kbps

2.10.1 Test jig

No special test jig was used.

2.10.2 Test software

The EUT has a special firmware that allows enabling a continuous transmission modulated. The output power is set to 3.5 dBm by firmware and cannot be changed.

3 TEST RESULT SUMMARY

Operating in the 2400 MHz – 2483.5 MHz band:

FCC Rule Part	RSS Rule Part	Description	Result
15.35(c)	RSS-Gen, 6.10	Pulsed operation	passed
15.203	RSS Gen, 8.3	Antenna requirement	passed
15.204	RSS Gen, 8.2	External radio frequency power amplifiers	not tested
15.205(a)	RSS Gen, 8.1	Emissions in restricted bands	passed
15.207(a)	RSS Gen, 8.8	AC power line conducted emissions	passed
15.215(c)	-	EBW	passed
-	RSS-Gen, 6.6	OBW	passed
15.249(a)	RSS-210, B10(a)	Field strength of fundamental	passed
15.249(d)	RSS-210, B10(b)	Out-of-band emission, radiated	passed
-	RSS-Gen, 6.11	Transmitter frequency stability	not applicable

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

RSS Gen, Issue 4, November 2014

RSS 210, Issue 9, August 2016

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 : 13 February 2018

Testing concluded on : 26 February 2018

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 ISED

4.4.1 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 210 testing for RSS compliance may be achieved by following the procedures set out in ANSI C63.10 and applying the CISPR 22 limits.

4.4.2 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.

4.4.2.1 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.

4.4.2.1.1 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 dB μ V/m is calculated by taking the reading from the EMI receiver (Level dB μ V) 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 Delta (MHz)	Level (dB μ V)	+	Factor (dB)	=	Level (dB μ V/m)	-	CISPR Limit (dB μ V/m)	=	(dB)
719.0	75.0	+	32.6	=	107.6	-	110.0	=	-2.4

4.4.2.1.2 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

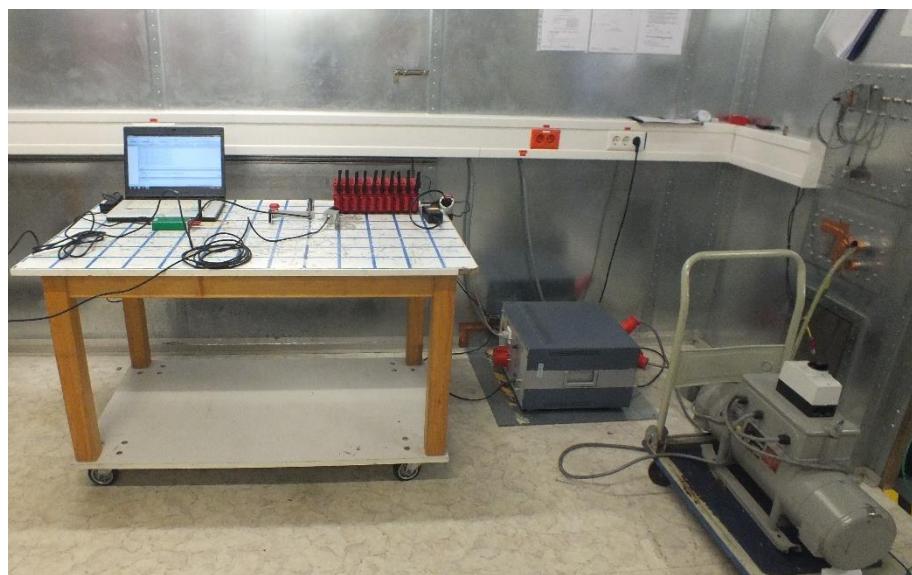
5.1 AC power line conducted emissions

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 C63.4 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 35.0 dB at 17.7405 MHz

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

Frequency of Emission (MHz)	Conducted Limit (dB μ V)	
	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**.

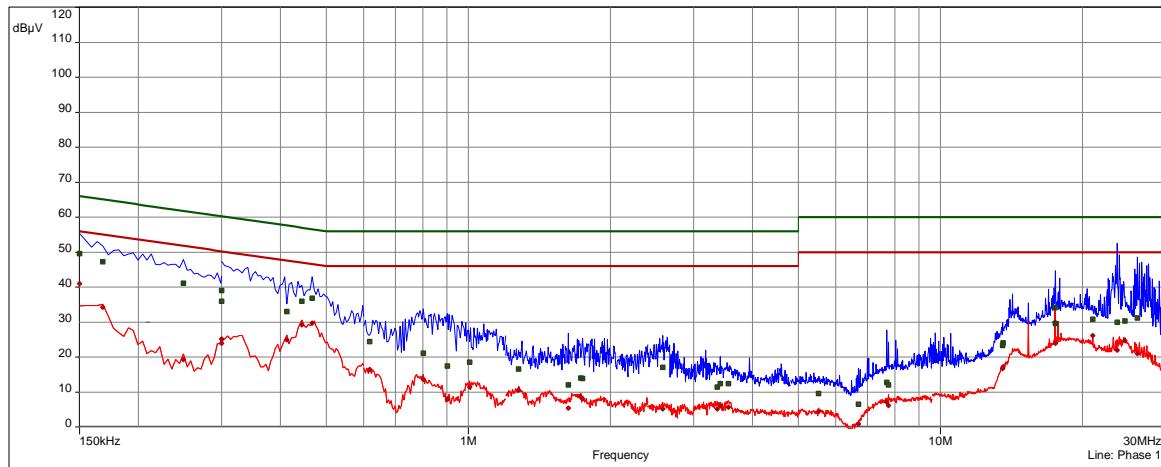
Remarks: For detailed test result please refer to following test protocols

According to the manufacturer, the EUT has no standby mode. Therefore, the test has been

performed with active transmission only.

5.1.6 Test protocol

Test point L1 Result: passed
 Operation mode: Active transmission of 2.4 GHz, GPS and GSM



freq MHz	QP dB(µV)	margin dB	limit dB	AV dB(µV)	margin dB	limit dB	line	corr dB
0.15	49.54	42.46	66.00	40.94	35.06	56.00	Phase 1	10.07
0.168	47.28	45.66	65.06	34.23	42.71	55.06	Phase 1	10.08
0.249	41.13	55.08	61.79	19.22	60.99	51.79	Phase 1	10.10
0.3	39.06	58.70	60.24	23.88	57.88	50.24	Phase 1	10.12
0.3	35.93	61.83	60.24	25.17	56.58	50.24	Phase 1	10.12
0.4125	32.97	67.43	57.60	24.93	59.47	47.60	Phase 1	10.14
0.444	35.96	65.05	56.99	29.20	55.81	46.99	Phase 1	10.14
0.4665	36.76	64.66	56.58	29.70	55.73	46.58	Phase 1	10.14
0.618	24.41	65.59	56.00	16.42	57.58	46.00	Phase 1	10.16
0.8025	21.15	68.85	56.00	13.68	60.32	46.00	Phase 1	10.18
0.9015	17.49	72.51	56.00	7.96	66.04	46.00	Phase 1	10.18
1.005	18.53	71.47	56.00	11.46	62.54	46.00	Phase 1	10.19
1.2765	16.59	73.41	56.00	10.50	63.50	46.00	Phase 1	10.23
1.6275	12.08	77.92	56.00	5.47	68.53	46.00	Phase 1	10.26
1.731	13.96	76.04	56.00	8.61	65.39	46.00	Phase 1	10.27
1.7445	13.86	76.14	56.00	8.13	65.87	46.00	Phase 1	10.27
2.58	17.05	72.95	56.00	5.11	68.89	46.00	Phase 1	10.32
3.3675	11.46	78.54	56.00	5.21	68.79	46.00	Phase 1	10.35
3.417	12.37	77.63	56.00	5.99	68.01	46.00	Phase 1	10.35
3.552	12.39	77.61	56.00	5.66	68.34	46.00	Phase 1	10.35
5.511	9.54	76.46	60.00	4.45	65.55	50.00	Phase 1	10.50
6.699	6.47	79.53	60.00	0.84	69.16	50.00	Phase 1	10.59
7.698	12.77	73.23	60.00	7.08	62.92	50.00	Phase 1	10.65
7.761	12.08	73.92	60.00	6.18	63.82	50.00	Phase 1	10.65
13.5375	23.30	62.70	60.00	16.75	53.25	50.00	Phase 1	11.06
13.56	24.00	62.00	60.00	17.23	52.77	50.00	Phase 1	11.06
17.4885	34.07	51.93	60.00	30.00	40.00	50.00	Phase 1	11.33
17.529	29.58	56.42	60.00	23.90	46.10	50.00	Phase 1	11.33
21.027	30.86	55.14	60.00	26.15	43.85	50.00	Phase 1	11.51
23.6595	29.90	56.10	60.00	22.03	47.97	50.00	Phase 1	11.63
24.609	30.30	55.70	60.00	24.69	45.31	50.00	Phase 1	11.67
26.1525	31.20	54.80	60.00	21.00	49.00	50.00	Phase 1	11.70

FCC ID: SZO-RR05
IC: 20465-RR05

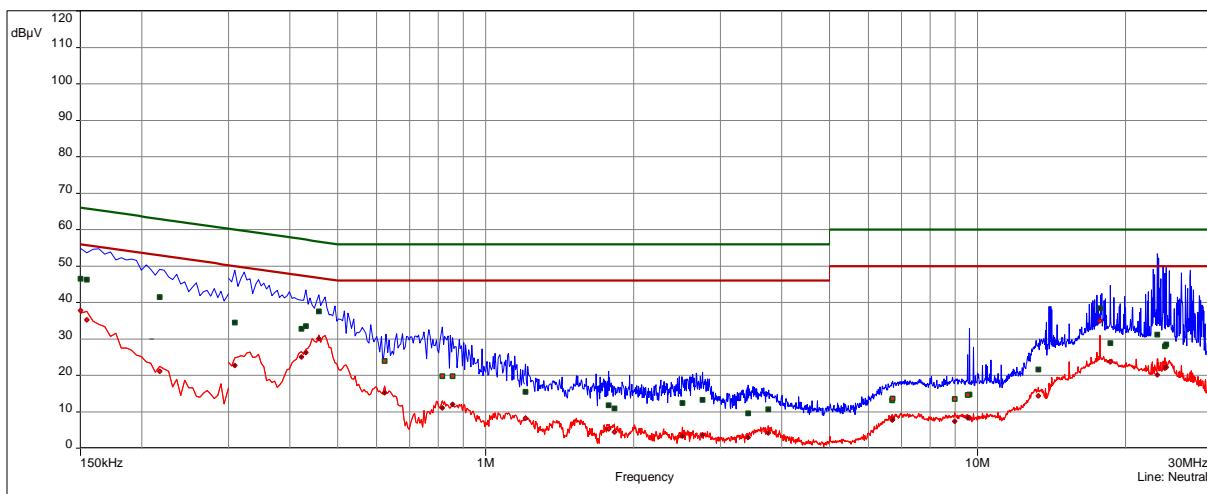
Test point:

N

Operation mode:

Active transmission of 2.4 GHz, GPS and GSM

Result: passed



freq MHz	QP dB(µV)	margin dB	limit dB	AV dB(µV)	margin dB	limit dB	line	corr dB
0.15	46.45	45.55	66.00	37.74	38.26	56.00	Neutral	10.07
0.1545	46.24	46.01	65.75	35.27	40.98	55.75	Neutral	10.08
0.2175	41.47	53.62	62.91	21.18	57.91	52.91	Neutral	10.11
0.309	34.46	63.54	60.00	22.76	59.25	50.00	Neutral	10.12
0.4215	32.82	67.76	57.42	25.03	59.56	47.42	Neutral	10.14
0.4305	33.48	67.28	57.24	26.31	58.45	47.24	Neutral	10.14
0.4575	37.55	63.71	56.74	30.13	55.13	46.74	Neutral	10.14
0.6225	23.88	66.12	56.00	15.18	58.82	46.00	Neutral	10.16
0.816	19.74	70.26	56.00	11.07	62.93	46.00	Neutral	10.18
0.8565	19.81	70.19	56.00	11.99	62.01	46.00	Neutral	10.18
1.2045	15.44	74.56	56.00	8.24	65.76	46.00	Neutral	10.22
1.776	11.80	78.20	56.00	5.28	68.72	46.00	Neutral	10.27
1.8255	10.90	79.10	56.00	4.42	69.58	46.00	Neutral	10.26
2.5125	12.39	77.61	56.00	3.31	70.69	46.00	Neutral	10.31
2.76	13.31	76.69	56.00	3.75	70.25	46.00	Neutral	10.33
3.417	9.61	80.39	56.00	2.92	71.08	46.00	Neutral	10.35
3.7545	10.64	79.36	56.00	4.20	69.80	46.00	Neutral	10.37
6.699	13.17	72.83	60.00	7.80	62.20	50.00	Neutral	10.56
6.7125	13.64	72.36	60.00	7.87	62.13	50.00	Neutral	10.56
8.976	13.56	72.44	60.00	7.37	62.63	50.00	Neutral	10.64
9.5475	14.60	71.40	60.00	8.34	61.66	50.00	Neutral	10.66
9.6315	14.78	71.22	60.00	8.38	61.62	50.00	Neutral	10.66
13.2945	21.66	64.34	60.00	14.39	55.61	50.00	Neutral	10.90
17.7405	38.41	47.59	60.00	35.00	35.00	50.00	Neutral	11.15
18.6045	28.86	57.14	60.00	23.72	46.28	50.00	Neutral	11.19
23.1735	31.14	54.86	60.00	20.10	49.90	50.00	Neutral	11.27
24.0105	27.96	58.04	60.00	21.93	48.07	50.00	Neutral	11.27
24.186	28.53	57.47	60.00	22.21	47.79	50.00	Neutral	11.26

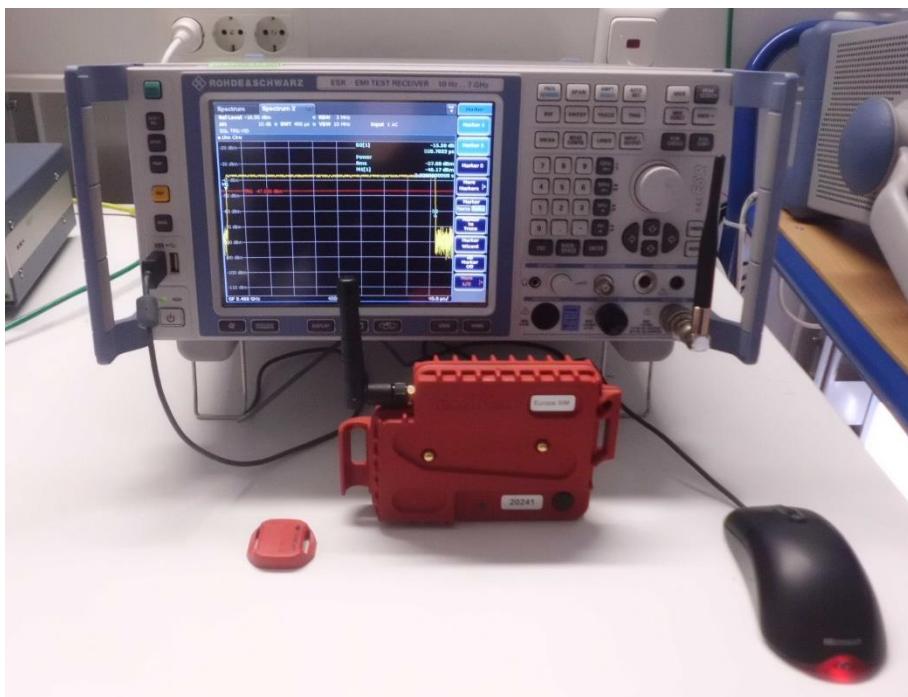
5.2 Correction for pulse operation (duty cycle)

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

5.2.1 Description of the test location

Test location: AREA4

5.2.2 Photo documentation of the test set-up



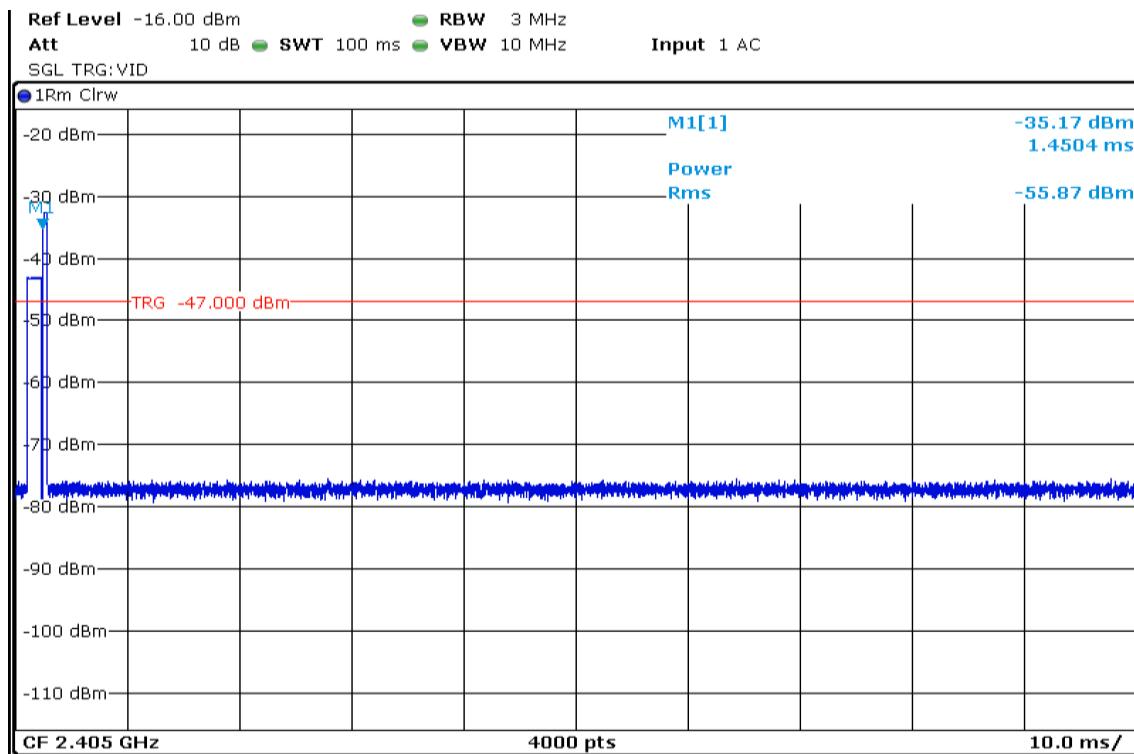
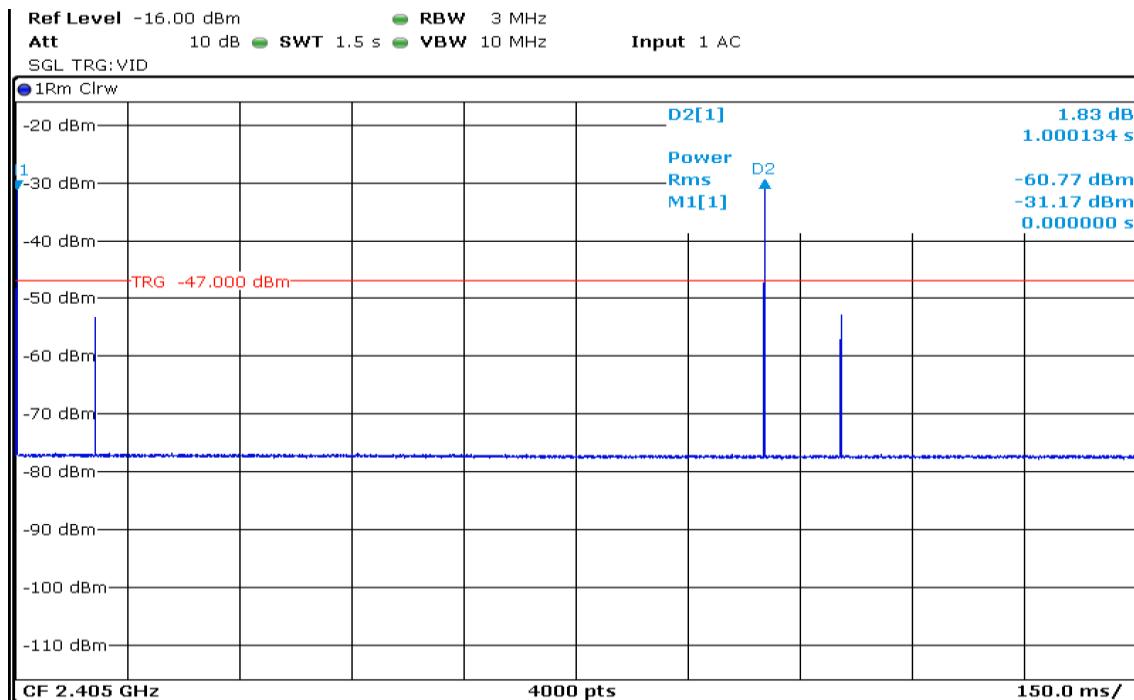
5.2.1 Applicable standard

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 power 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 power shall be determined from the average absolute voltage during a 0.1s interval during which the power is at its maximum. The exact method of calculating the average power shall be submitted.

5.2.2 Description of Measurement

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



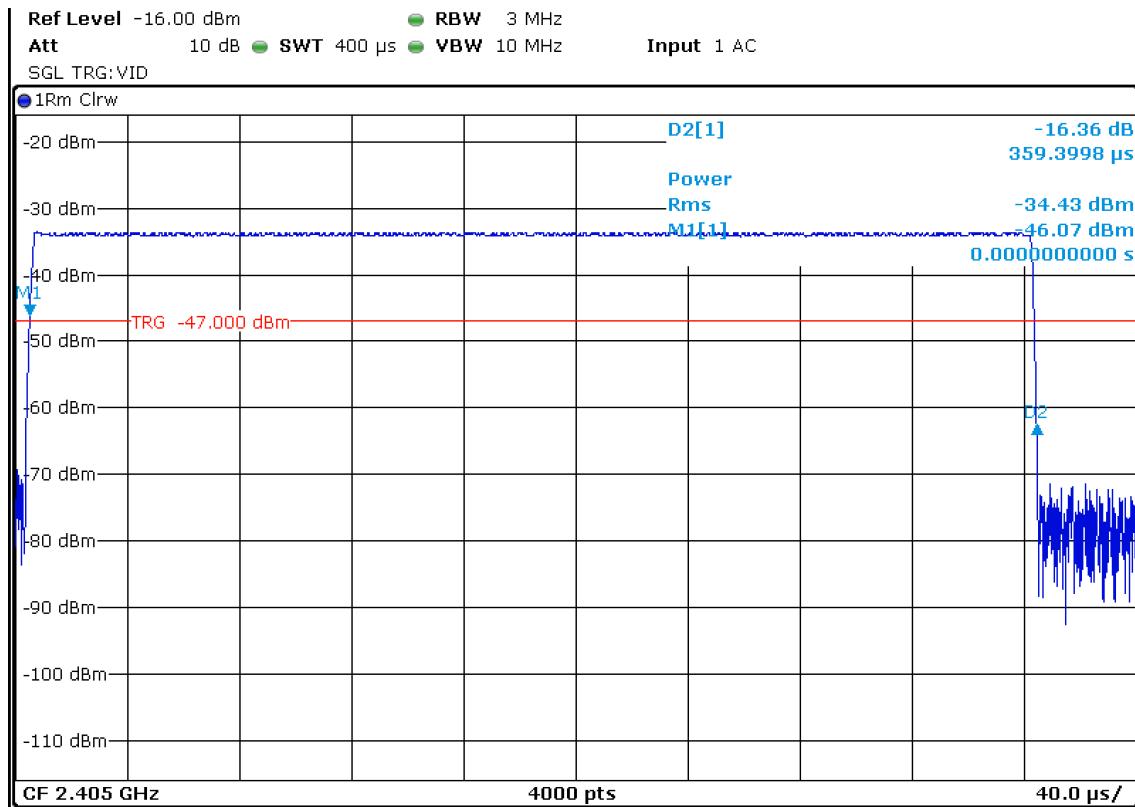
The duty cycle factor (dB) is calculated applying the following formula:

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

KE : pulse operation correction factor

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

5.2.3 Test result



Complete burst duration (1 burst): 0.3594 ms

$$KE = 20 \log (0.3594 \text{ ms} / 100 \text{ ms}) = -48.9 \text{ dB}$$

Remarks:

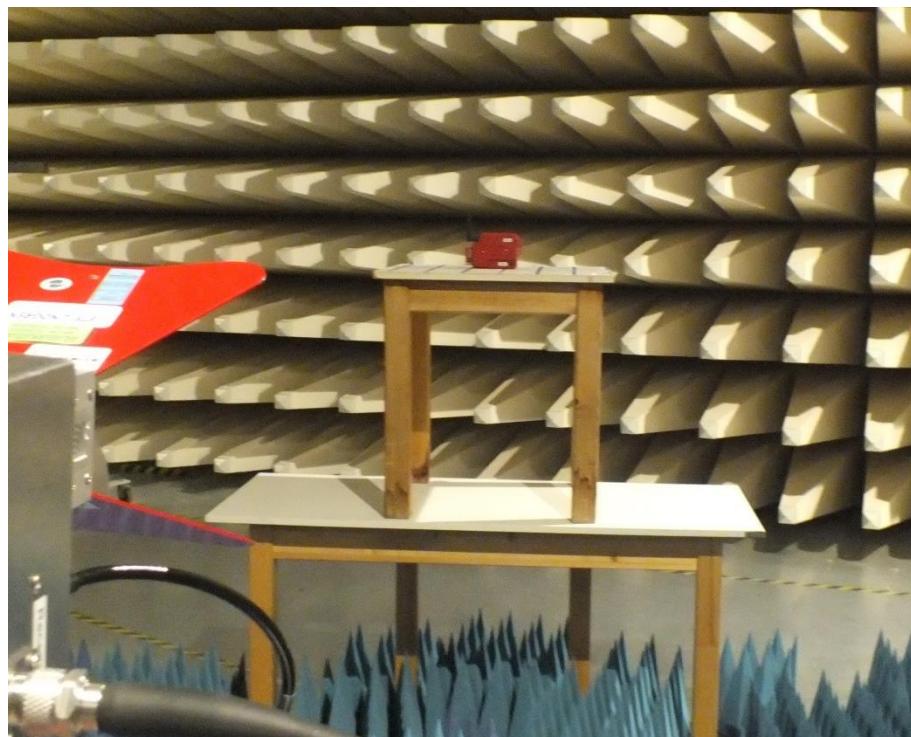
5.3 Field strength of fundamental

For test instruments and accessories used see section 6 Part **FS 1-18 GHz**.

5.3.1 Description of the test location

Test location: Anechoic chamber 1
Test distance: 3 m

5.3.2 Photo documentation of the test set-up



5.3.3 Applicable standard

According to FCC Part 15C, Section 15.249(a):

The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the effective limits.

5.3.4 Description of Measurement

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

Analyser settings:

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

5.3.5 Test result

Frequency (MHz)	Level PK dB(µV/m)	Limit PK dB(µV/m)	Margin PK (dB)	Level AV dB(µV/m)	Limit AV dB(µV/m)	Margin AV (dB)
2405	100.6	114.0	-13.4	51.7	94.0	-42.3
2435	102.1	114.0	-11.9	53.2	94.0	-40.8
2480	101.5	114.0	-12.5	52.6	94.0	-41.4

Note: The peak values are corrected with the duty cycle of -48.9 dB to get the average value.

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

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

Peak-Limit according to FCC Part 15C, Section 15.249(e):

However the peak fieldstrength shall not exceed the maximum permitted average limit by more than 20 dB.

The requirements are **FULFILLED**.

Remarks:

5.4 Out-of-band emission, radiated

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

5.4.1 Description of the test location

Test location: OATS 1
Test location: Anechoic chamber 1

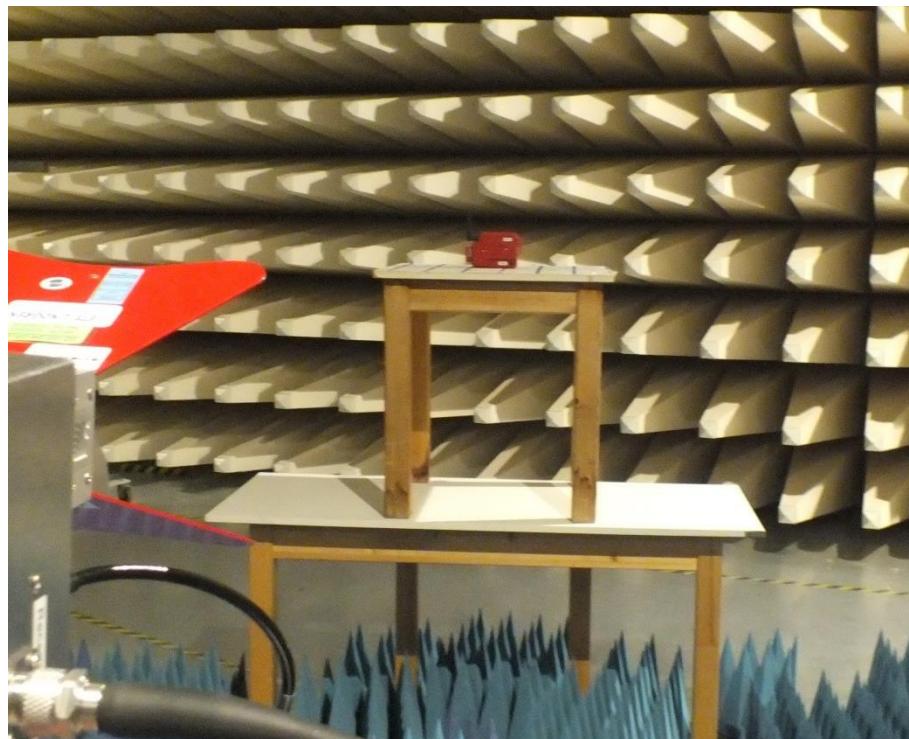
Test distance: 3 m

5.4.2 Photo documentation of the test set-up

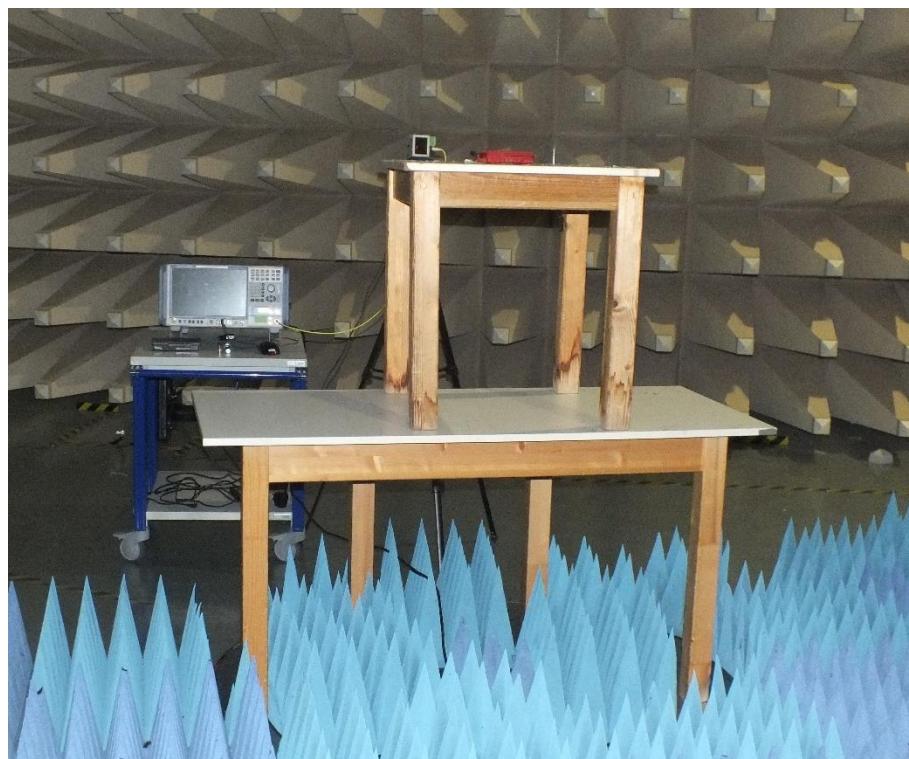
Test setup 30 MHz – 1000 MHz:



Test setup 1 GHz – 18 GHz:



Test setup 18 GHz – 25 GHz:



5.4.3 Applicable standard

According to FCC Part 15C, Section 15.249 (d):

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

5.4.4 Description of Measurement

The radiated emissions from the EUT are measured in the frequency range of 30 MHz to 1000 MHz using a tuned receiver and appropriate broadband linearly polarized antennas. The setup of the EUT and the measurement procedure is in accordance to ANSI C63.10, Item 6.3. In the frequency range above 1 GHz a spectrum analyser is used with appropriate linear polarized antennas. If the emission level in peak mode complies with the average limit testing is stopped and peak values will be reported, otherwise, the emission is measured in average mode again and reported. The EUT is measured in TX continuous mode modulated under normal conditions.

Instrument settings:

30 MHz – 1000 MHz:	RBW: 120 kHz
1000 MHz – 25 GHz	RBW: 1 MHz

5.4.5 Test result 30 MHz to 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)
280.20	12.4	11.9	16.1	16.1	28.5	28.0	46.0	-17.5
270.30	9.0	-	15.9	-	24.9	-	46.0	-21.1
259.20	9.9	-	15.6	-	25.5	-	46.0	-20.5

Note: The correction factor includes cable loss and antenna factor. No emissions could be detected in this frequency range. The noted values are noise values of the OATS.

5.4.6 Test result f > 1 GHz

Channel 11

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
2400.00	62.7	13.8	74.0	-11.3	54.0	-40.2
4811.30	53.4	-	74.0	-20.6	54.0	-
9622.17	57.0	8.1	74.0	-17.0	54.0	-45.9

Channel 17

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
4817.03	54.4	5.5	74.0	-19.6	54.0	-48.5
9741.00	59.8	10.9	74.0	-14.2	54.0	-43.1

Channel 26

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
2483.50	71.2	22.3	74.0	-2.8	54.0	-31.7
4958.77	52.7	-	74.0	-21.3	54.0	-
9918.50	56.6	7.7	74.0	-17.4	54.0	-46.3

Note: 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, channel 11 at 9622.17 MHz: peak value – DC = average value
 57.0 dBµV/m – 48.9 dB = 8.1 dBµV/m

Limit according to FCC Part 15C, Section 15.209:

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

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

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

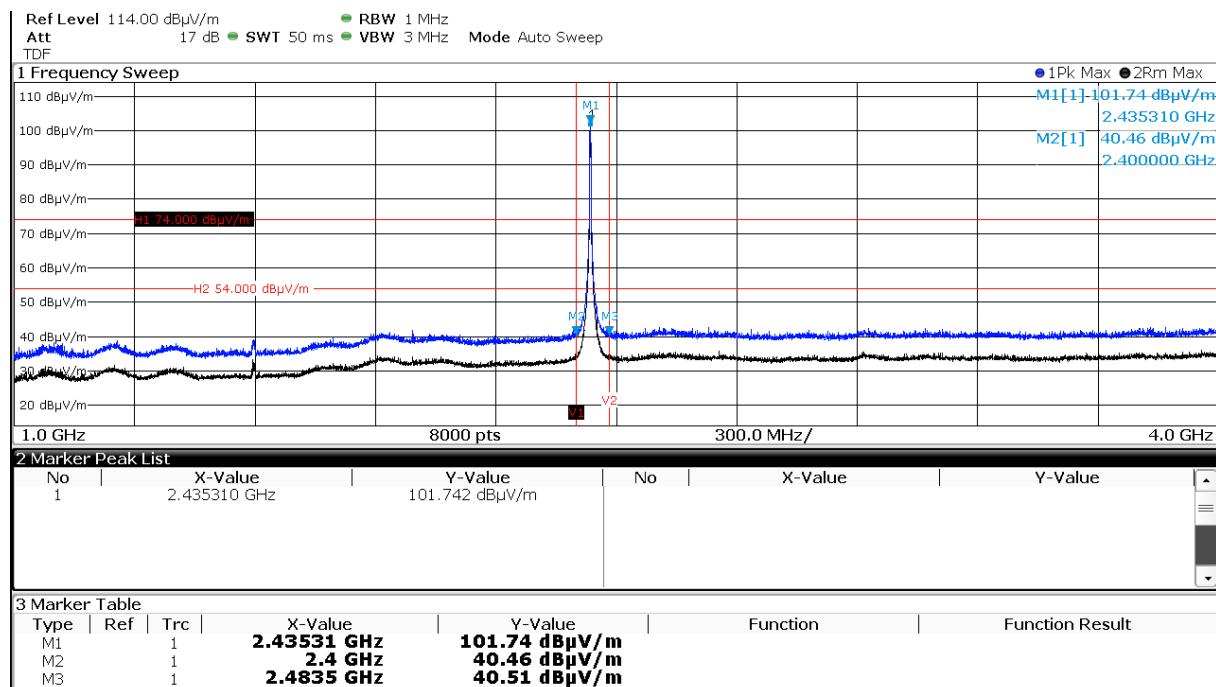
The requirements are **FULFILLED**.

Remarks: The emissions are compared to the general radiated limits according to FCC Part 15C,
Section 15.209.
The measurement was performed up to the 10th harmonic (25000 MHz). For detailed test result
please refer to following test protocols.

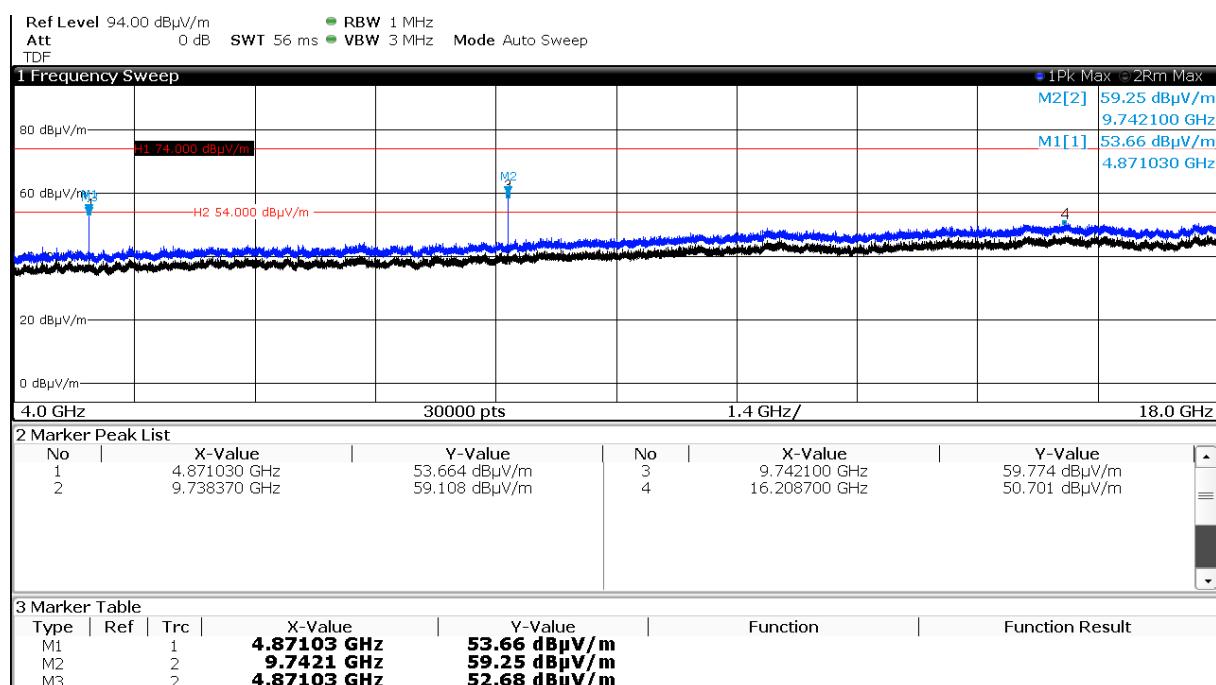
5.4.7 Test protocols

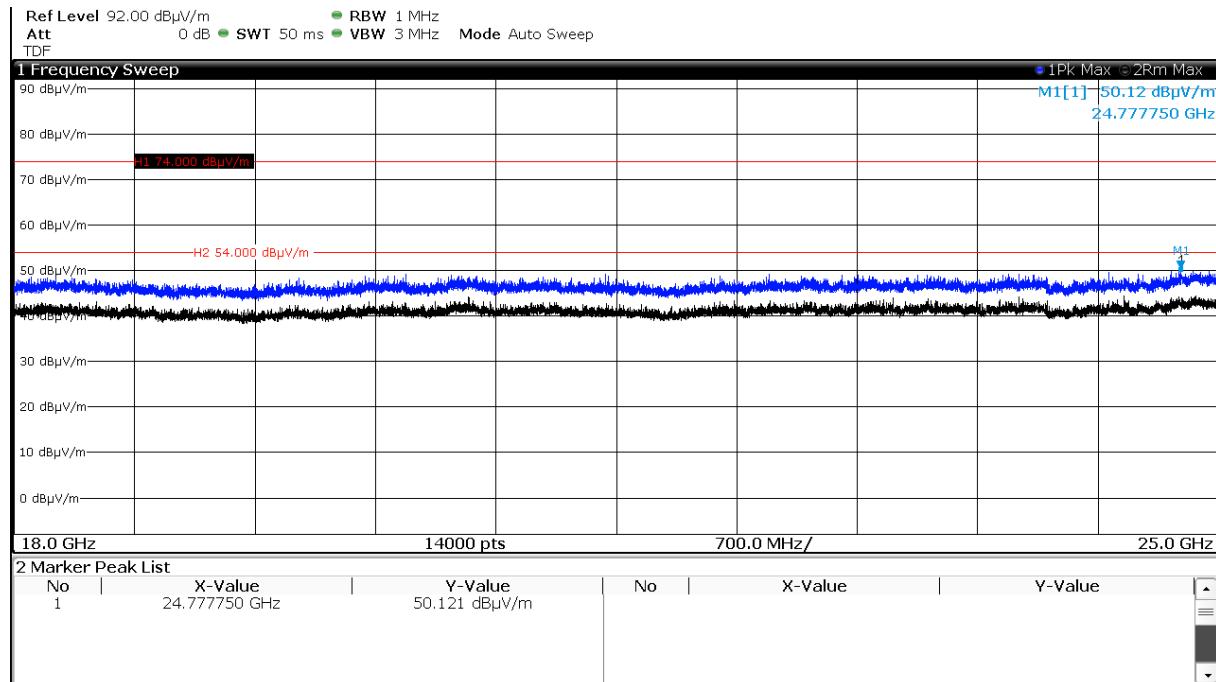
For reference the plots from 1 GHz to 25 GHz at 2435 MHz:

Spurious emissions from 1 to 4 GHz
(incl. Fundamental carrier)



Spurious emissions from 4 to 18 GHz



Spurious emissions from 18 to 25 GHz


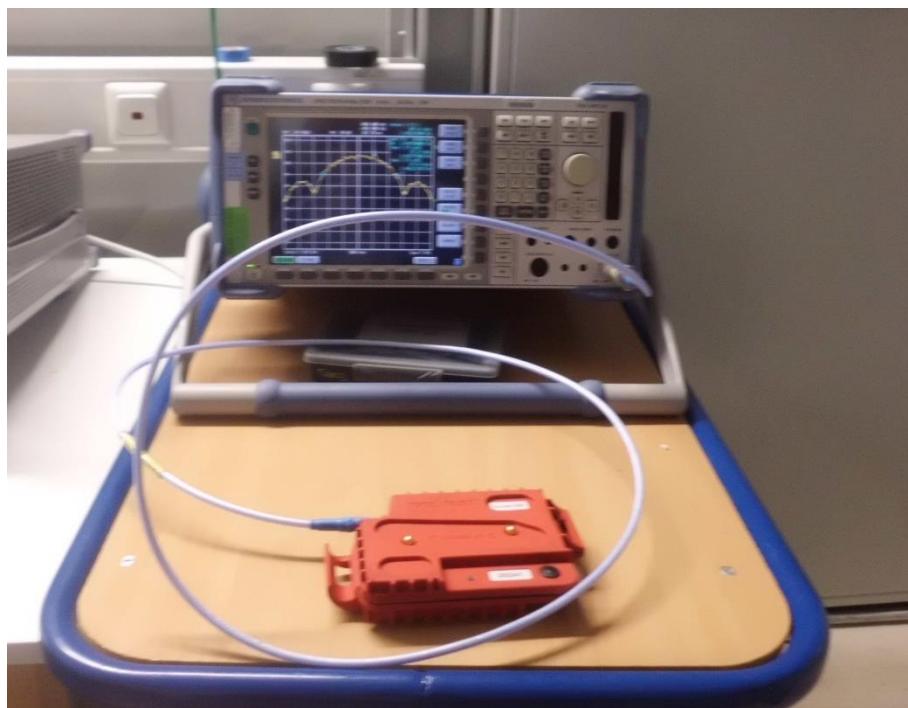
5.5 EBW and OBW

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

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 15.215(c):

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

5.5.4 Description of Measurement

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

Spectrum analyser settings:

RBW: 100 kHz, VBW: 300 kHz, Span: 5 MHz, Trace mode: max. hold, Detector: max. peak;

5.5.5 Test result

Centre f (MHz)	20dB bandwidth f_1	20dB bandwidth f_2	Measured EBW (MHz)
2405.041250	2403.75125	2406.331250	2.580000
2435.046875	2433.77250	2436.321250	2.548750
2480.056250	2478.77000	2481.342500	2.572500

Centre f (MHz)	99% bandwidth f_1	99% bandwidth f_2	Measured OBW (MHz)
2405.048750	2403.88125	2406.216250	2.335000
2435.038125	2433.87375	2436.202500	2.328750
2480.053750	2478.86000	2481.247500	2.387500

Operating frequency band (MHz)	20 dB Bandwidth (MHz)
$f_{low} > 2400$	$f_{low} = 2403.75125$
$f_{high} < 2483.5$	$f_{high} = 2481.34250$
Operating channel occupancy percentage	51.60 %

Limit according to FCC Part 15C, Section 15.215(c):

If frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within the central 80% of the permitted band in order to minimize the possibility of out-of-band operation. Due to the channelising of the operating band into 8 channels with 5 MHz channel bandwidth the limit "central 80% of the permitted band" can not be applied. Therefore, the stability of the EUT will be shown staying within the central 80% of the operating channel.

The requirements are **FULFILLED**.

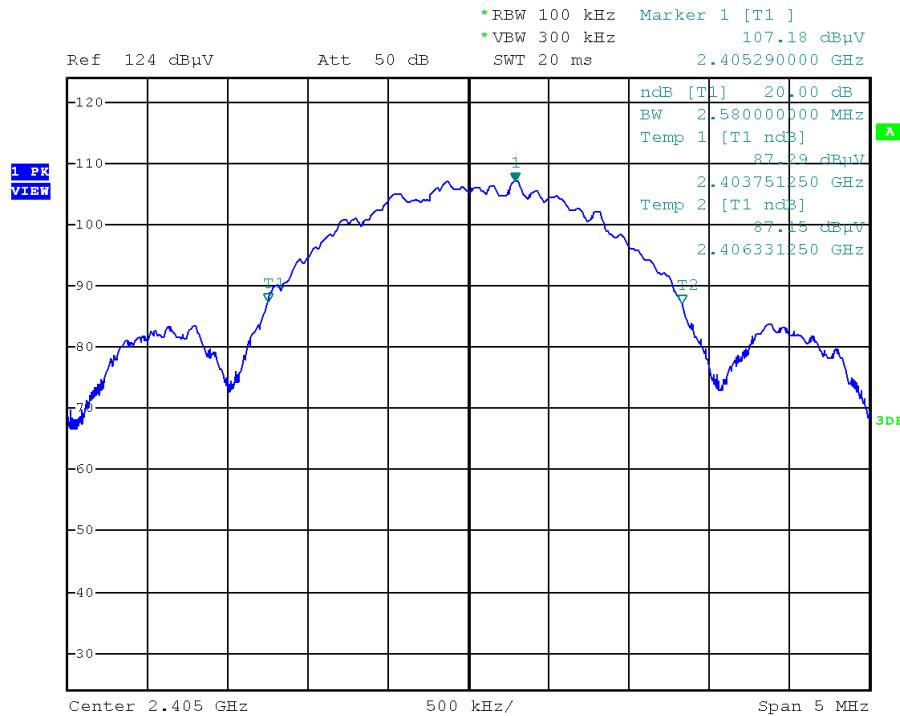
Remarks: For detailed test result please refer to following test protocols.

The OBW99 is measured for RSS only.

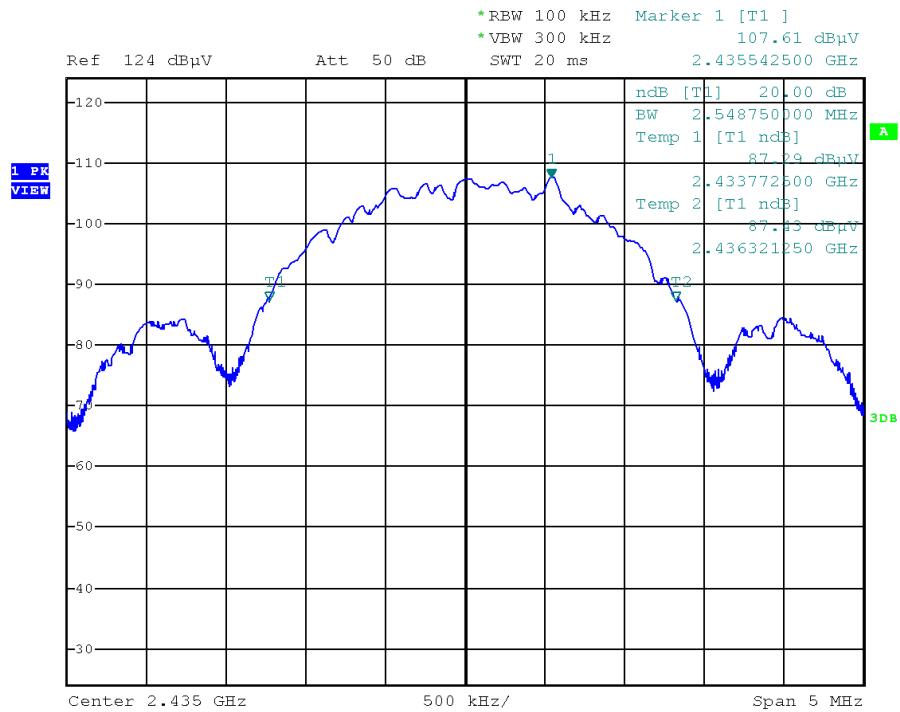
5.5.6 Test protocols

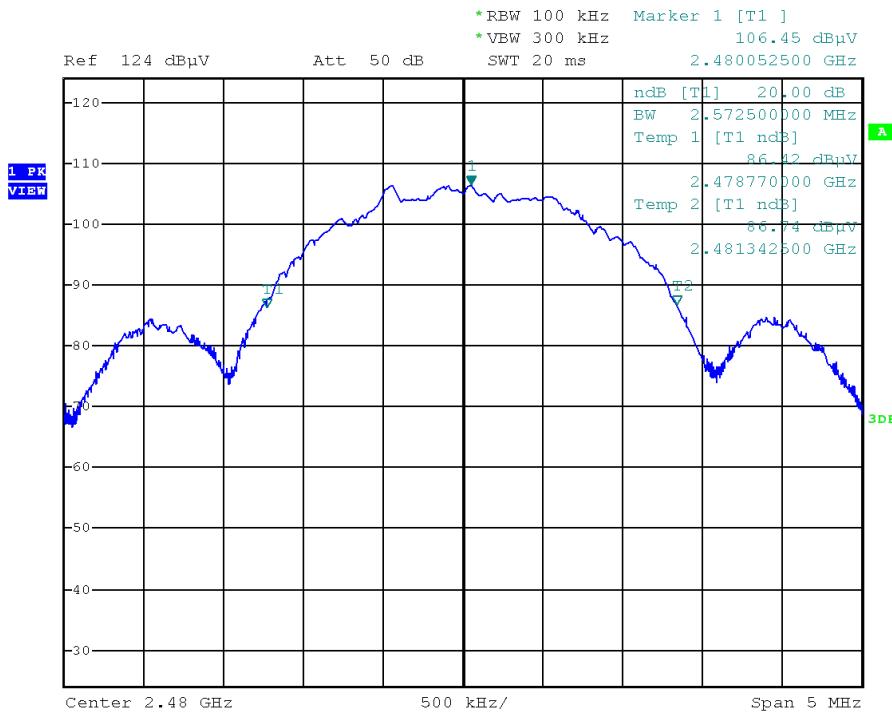
20 dB bandwidth

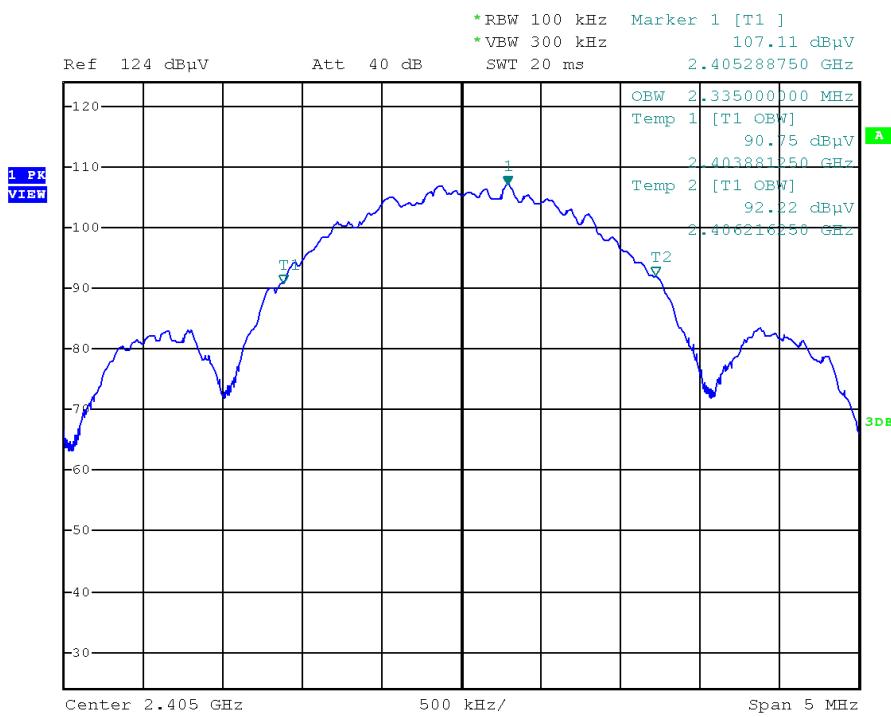
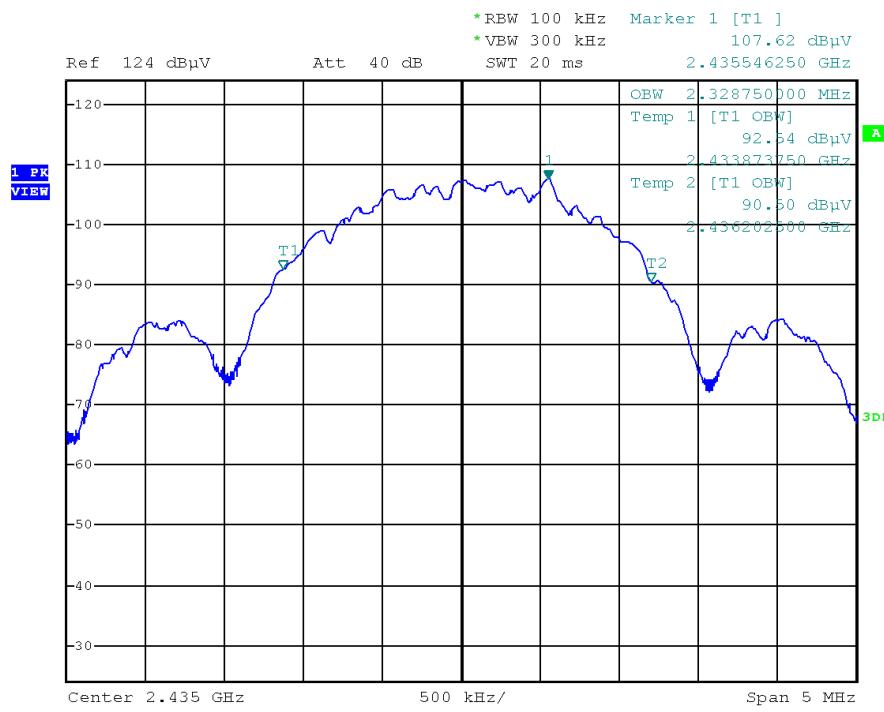
2405 MHz



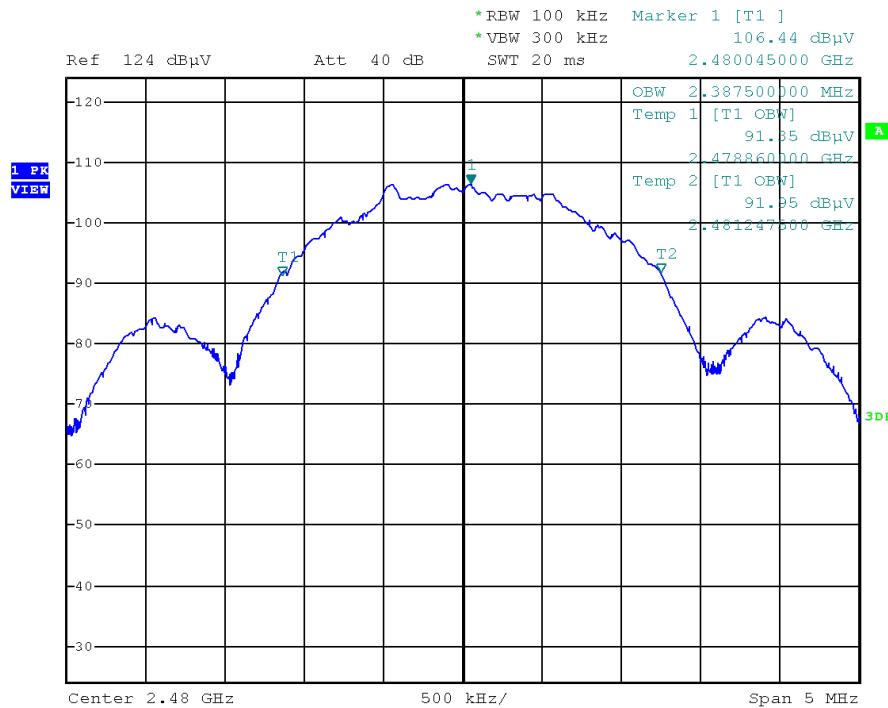
2435 MHz



2480 MHz


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IC: 20465-RR05
OBW 99%
2405 MHz

2435 MHz


2480 MHz



5.6 Antenna application

5.6.1 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 one external antenna.

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

The requirements are **FULFILLED**.

Remarks:

6 USED TEST EQUIPMENT AND ACCESSORIES

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

Test ID	Model Type	Equipment No.	Next Calib.	Last Calib.	Next Verif.	Last Verif.
A 4	BAT-EMC 3.16.0.73	01-02/68-13-001				
	ESCI	02-02/03-15-001	31/05/2018	31/05/2017		
	CMW500	02-02/05-13-002	27/12/2019	27/12/2016	27/12/2017	27/12/2016
	SMBV 100A	02-02/05-18-001	15/01/2021	15/01/2018	15/01/2019	15/01/2018
	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				
DC	ESR 7	02-02/03-17-001	25/07/2018	25/07/2017		
	RF Antenna	02-02/24-05-032				
FS 1-18 GH	FSW43	02-02/11-15-001	07/04/2018	07/04/2017		
	AMF-6D-01002000-22-10P	02-02/17-15-004				
	3117	02-02/24-05-009	10/05/2018	10/05/2017		
	SF104/11N/11N/300MM	02-02/50-13-008				
	18N-20	02-02/50-17-003				
	NMS111-GL200SC01-NMS1102-02/50-17-012					
MB	Bandpass Filter	02-02/50-17-019				
	FSP 30	02-02/11-05-001	04/10/2018	04/10/2017		
SER 2	KK-SF104-11SMA-11N-2M	02-02/50-14-004				
	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		
	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	10/05/2018	10/05/2017		
	BBHA 9170	02-02/24-05-014	02/06/2018	02/06/2015	26/10/2018	26/10/2017
	KMS102-1 m	02-02/50-11-014				
	KMS102-0.2 m	02-02/50-11-016				
	KMS102-0.2 m	02-02/50-11-020				
	SF104/11N/11N/300MM	02-02/50-13-008				
	18N-20	02-02/50-17-003				
	NMS111-GL200SC01-NMS1102-02/50-17-012					
	Bandpass Filter	02-02/50-17-019				