

EMI – TEST REPORT

- FCC Part 15.249, RSS210 -

Type / Model Name : TechUnit

Product Description : Data processing unit

Applicant : Ambiotex GmbH

Address : Fürststr. 49
72072 Tübingen

Manufacturer : Ambiotex GmbH

Address : Fürststr. 49
72072 Tübingen

Licence holder : Ambiotex GmbH

Address : Fürststr. 49
72072 Tübingen

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

POSITIVE

Test Report No. : T41870-01-00GK

24. January 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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1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (December, 2016)

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 (December, 2016)

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 C63.10: 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

The Photo documentation can be viewed in the document T41870-01-xxGK.

2.2 Equipment category

Bluetooth Low Energy device for portable use

2.3 Short description of the equipment under test (EUT)

The EUT is a Bluetooth Low Energy wireless data processing unit. The EUT is compatible with the standard 802.15.1. It supports the 2.4 GHz frequency band. A single PCB antenna is used within the system. The modulation used by the EUT is GFSK with a data rate of 1 Mbits which means worst case for testing. The EUT has only one integrated antenna, no temporary connector and no external antenna can be connected.

Number of tested samples : 2 radiated sample
Serial number : 2016-070049, 2016-070050
Firmware : 3.0.4

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

EUT configuration:

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

2.4 Variants of the EUT

None

2.5 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan:

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

Note: The marked frequencies are used for testing.

2.6 Transmit operating modes

The EUT uses GFSK and provides following data rate:

1000 kbps (kbps = kilobits per second)

2.7 Antenna

The following antenna shall be used with the EUT:

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

2.8 Power supply system utilised

Power supply voltage, V_{nom} : 3.7 VDC (Battery powered)

2.9 Peripheral devices and interface cables

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

- USB cable < 3 m Model : Supplied by manufacturer
- Smartphone Iphone 5 Model : Supplied by manufacturer
- Laptop computer Model : Fujitsu Lifebook C1410

2.10 Determination of worst case conditions for final measurement

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

BT 4.0 LE	Available channels	Tested channels	Power setting	Modulation	Data rate
802.15.1	00 to 39	37, 17, 39	4 dBm	GFSK	1000 kbps

1000 kbps, GFSK with TX continuous modulated.

2.10.1 Test jig

No special test jig was used for testing.

2.10.2 Test software

The EUT has a special firmware that allows enabling a continuous transmission modulated and receiving mode. The output power is set to 4 dBm by firmware and cannot be changed during tests.

3 TEST RESULT SUMMERY

Operating in the 2400 MHz – 2483.5 MHz band:

FCC Rule Part	RSS Rule Part	Description	Result
15.35(c)	RSS-Gen, 6.10	Pulsed operation	passed
15.203	RSS Gen, 8.3	Antenna requirement	passed
15.204	RSS Gen, 8.2	External radio frequency power amplifiers	not applicable
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 : 30 November 2016

Testing concluded on : 09 December 2016

Checked by:

Tested by:


 Klaus Gegenfurtner
 I confirm the correctness
 and integrity of this
 document
 2017.01.24 10:56:08 +01'00'


 Konrad Graßl
 I am the author of this
 document
 2017.01.24 09:19:50
 +01'00'

Klaus Gegenfurtner
 Teamleader Radio

Konrad Graßl
 Radio Team

4 TEST ENVIRONMENT

4.1 Address of the test laboratory

**CSA Group Bayern GmbH
Ohmstrasse 1-4
94342 STRASSKIRCHEN
GERMANY**

4.2 Environmental conditions

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

Temperature: 15-35 ° C

Humidity: 30-60 %

Atmospheric pressure: 86-106 kPa

4.3 Statement of the measurement uncertainty

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

4.4 Measurement protocol for FCC and ISED

4.4.1 General information

4.4.1.1 Test methodology

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

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

IC 3009A-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.

4.4.1.2 Justification

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

4.4.1.3 Details of test procedures

The test methods used comply with CISPR Publication 22, EN 55022 - "Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement" and with ANSI C63.10 - "Testing Unlicensed Wireless Devices". 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.

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 14.44 dB at 0.15 MHz

FCC ID: 2AKEB-TECHUNIT01

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

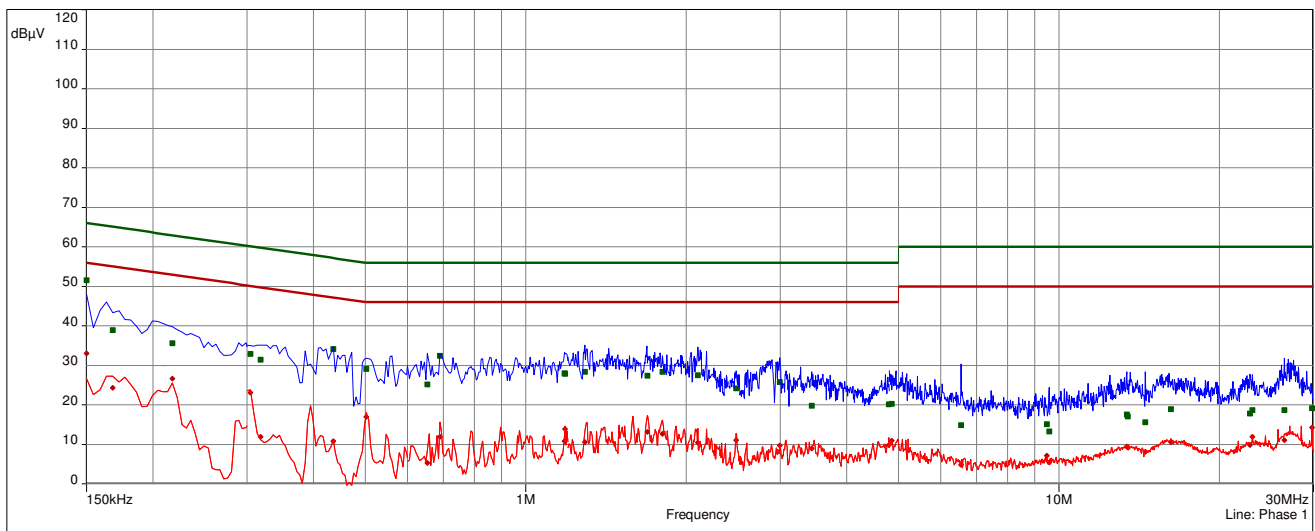
The requirements are **FULFILLED**.

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

5.1.6 Test protocol

Test point L1
Operation mode: TX
Remarks: Active BLE connection to the smartphone

Result: positive



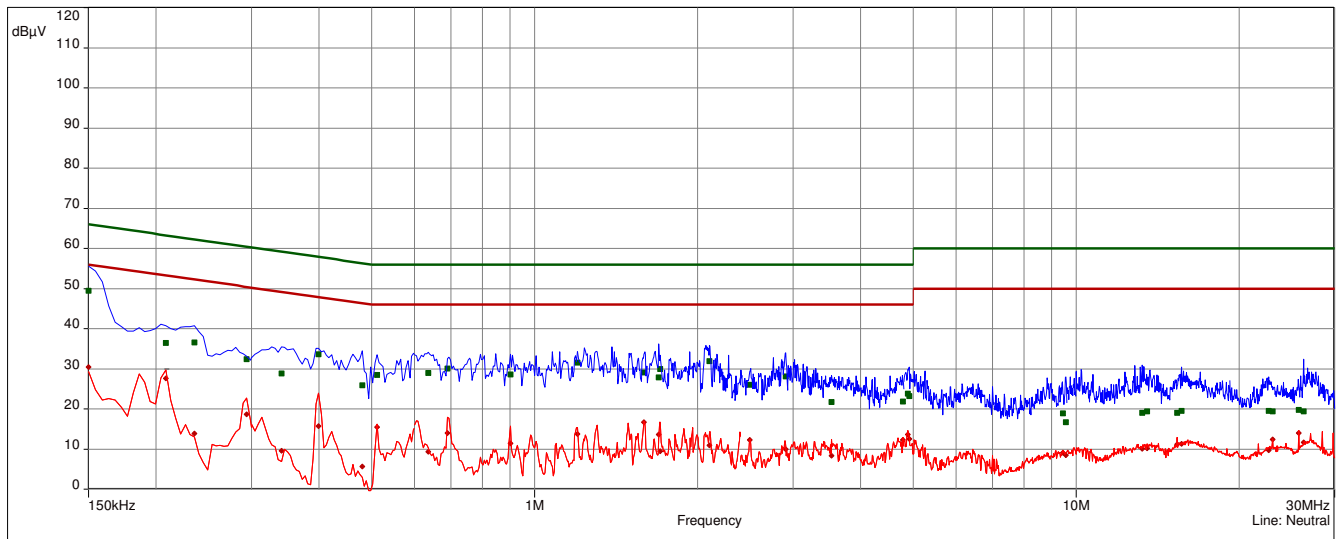
FCC ID: 2AKEB-TECHUNIT01

Frequ. (MHz)	SR	QP (dBµV)	QP Margin	QP Limit	AV (dBµV)	AV Margin	AV Limit	Line	Corr. (dB)
0.15	1	51.56	14.44	66.00	33.06	22.94	56.00	Phase 1	9.83
0.168	1	38.91	26.15	65.06	24.35	30.71	55.06	Phase 1	9.82
0.2175	1	35.61	27.30	62.91	26.57	26.34	52.91	Phase 1	9.81
0.3045	2	32.88	27.24	60.12	23.07	27.05	50.12	Phase 1	9.80
0.318	2	31.41	28.35	59.76	11.93	37.83	49.76	Phase 1	9.80
0.435	2	34.10	23.06	57.16	10.81	36.35	47.16	Phase 1	9.80
0.5025	2	29.09	26.91	56.00	16.88	29.12	46.00	Phase 1	9.80
0.654	3	25.17	30.83	56.00	5.34	40.66	46.00	Phase 1	9.80
0.69	3	32.39	23.61	56.00	11.86	34.14	46.00	Phase 1	9.80
1.1805	3	28.02	27.98	56.00	10.83	35.17	46.00	Phase 1	9.79
1.185	3	27.82	28.18	56.00	13.82	32.18	46.00	Phase 1	9.79
1.29	4	28.38	27.62	56.00	10.55	35.45	46.00	Phase 1	9.78
1.6905	4	27.43	28.57	56.00	13.20	32.80	46.00	Phase 1	9.78
1.803	4	28.31	27.69	56.00	12.64	33.36	46.00	Phase 1	9.79
2.1	4	27.52	28.48	56.00	10.41	35.59	46.00	Phase 1	9.80
2.481	5	24.13	31.87	56.00	11.11	34.89	46.00	Phase 1	9.78
2.994	5	25.77	30.23	56.00	9.73	36.27	46.00	Phase 1	9.79
3.435	5	19.82	36.18	56.00	8.91	37.09	46.00	Phase 1	9.81
4.794	5	20.18	35.82	56.00	9.83	36.17	46.00	Phase 1	9.82
4.854	6	20.25	35.75	56.00	10.90	35.10	46.00	Phase 1	9.82
6.555	6	14.91	45.09	60.00	4.76	45.24	50.00	Phase 1	9.84
9.48	6	15.09	44.91	60.00	7.18	42.82	50.00	Phase 1	9.89
9.588	6	13.24	46.76	60.00	5.40	44.60	50.00	Phase 1	9.89
13.4115	7	17.58	42.42	60.00	9.41	40.59	50.00	Phase 1	10.04
13.452	7	17.08	42.92	60.00	9.16	40.84	50.00	Phase 1	10.04
14.514	7	15.54	44.46	60.00	8.14	41.86	50.00	Phase 1	10.10
16.197	7	18.92	41.08	60.00	10.51	39.49	50.00	Phase 1	10.16
22.8045	8	17.80	42.20	60.00	9.87	40.13	50.00	Phase 1	10.34
23.0295	8	18.67	41.33	60.00	11.91	38.09	50.00	Phase 1	10.34
26.472	8	18.63	41.37	60.00	11.06	38.94	50.00	Phase 1	10.35
29.7975	8	19.14	40.86	60.00	14.25	35.75	50.00	Phase 1	10.34

FCC ID: 2AKEB-TECHUNIT01

Test point N
Operation mode: TX
Remarks: Active BLE connection to the smartphone

Result: positive



FCC ID: 2AKEB-TECHUNIT01

Frequ. (MHz)	SR	QP (dBμV)	QP Margin	QP Limit	AV (dBμV)	AV Margin	AV Limit	Line	Corr. (dB)
0.15	9	49.42	16.58	66.00	30.43	25.57	56.00	Neutral	9.83
0.2085	9	36.41	26.85	63.26	27.63	25.63	53.26	Neutral	9.83
0.2355	9	36.54	25.71	62.25	13.93	38.32	52.25	Neutral	9.82
0.294	9	32.45	27.97	60.41	18.68	31.74	50.41	Neutral	9.81
0.3405	10	28.80	30.39	59.19	9.63	39.56	49.19	Neutral	9.80
0.399	10	33.58	24.30	57.87	15.71	32.17	47.87	Neutral	9.80
0.48	10	25.93	30.41	56.34	5.62	40.72	46.34	Neutral	9.80
0.5115	10	28.47	27.53	56.00	15.52	30.48	46.00	Neutral	9.80
0.636	11	28.98	27.02	56.00	9.28	36.72	46.00	Neutral	9.80
0.69	11	30.05	25.95	56.00	13.97	32.03	46.00	Neutral	9.80
0.9015	11	28.62	27.38	56.00	11.44	34.56	46.00	Neutral	9.80
1.2	11	31.51	24.49	56.00	13.81	32.19	46.00	Neutral	9.79
1.5915	12	29.07	26.93	56.00	16.69	29.31	46.00	Neutral	9.78
1.695	12	27.83	28.17	56.00	13.66	32.34	46.00	Neutral	9.78
1.704	12	29.92	26.08	56.00	9.40	36.60	46.00	Neutral	9.78
2.1	12	31.93	24.07	56.00	10.91	35.09	46.00	Neutral	9.80
2.4945	13	26.05	29.95	56.00	12.26	33.74	46.00	Neutral	9.78
2.9085	13	28.10	27.90	56.00	9.90	36.10	46.00	Neutral	9.78
3.534	13	21.75	34.25	56.00	8.39	37.61	46.00	Neutral	9.81
4.7895	13	21.81	34.19	56.00	12.31	33.69	46.00	Neutral	9.81
4.89	14	23.83	32.17	56.00	13.61	32.39	46.00	Neutral	9.81
4.9125	14	23.16	32.84	56.00	12.54	33.46	46.00	Neutral	9.81
9.4485	14	18.88	41.12	60.00	9.12	40.88	50.00	Neutral	9.82
9.5655	14	16.71	43.29	60.00	8.53	41.47	50.00	Neutral	9.83
13.236	15	19.07	40.93	60.00	10.01	39.99	50.00	Neutral	9.89
13.5195	15	19.34	40.66	60.00	10.15	39.85	50.00	Neutral	9.90
15.351	15	18.97	41.03	60.00	11.22	38.78	50.00	Neutral	9.95
15.63	15	19.55	40.45	60.00	11.35	38.65	50.00	Neutral	9.96
22.656	16	19.50	40.50	60.00	9.69	40.31	50.00	Neutral	10.02
23.025	16	19.36	40.64	60.00	12.38	37.62	50.00	Neutral	10.01
25.734	16	19.71	40.29	60.00	13.97	36.03	50.00	Neutral	9.91
26.319	16	19.44	40.56	60.00	11.63	38.37	50.00	Neutral	9.87

5.2 Field strength of fundamental

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

5.2.1 Description of the test location

Test location: Anechoic chamber 1
Test distance: 3 m

5.2.2 Photo documentation of the test set-up



5.2.1 Applicable standard

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

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

5.2.2 Description of Measurement

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

Analyser settings:

Peak measurement: RBW: 3 MHz

VBW: 10 MHz

Detector: Max peak

5.2.3 Test result

Frequency (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)
2402	84.2	114.0	-29.8	45.5	94.0	-48.5
2440	85.5	114.0	-28.5	46.8	94.0	-47.2
2480	88.0	114.0	-26.0	49.3	94.0	-44.7

Note: The correction factor includes cable loss and antenna factor.
Additional the peak values are corrected with the duty cycle of -38.7 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:

5.3 Out-of-band emission, radiated

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

5.3.1 Description of the test location

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

5.3.2 Photo documentation of the test set-up

Test setup 30 MHz – 1000 MHz:



Test setup 1 GHz – 18 GHz:



5.3.3 Applicable standard

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

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

5.3.4 Description of Measurement

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

Instrument settings:

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

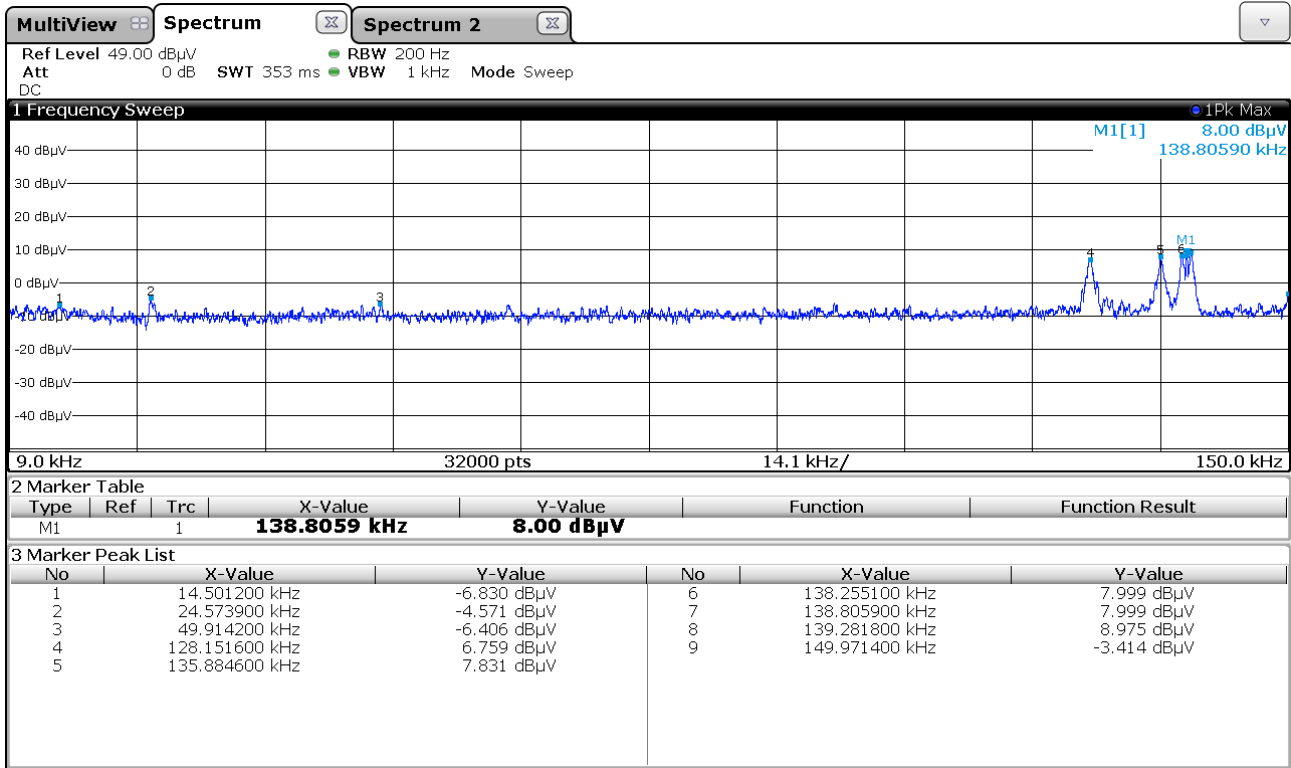
5.3.1 Test result

Note: Pre-measurements were performed in the frequency range 9 kHz to 30 MHz, 30 MHz to 1000 MHz and 18 GHz to 25 GHz (10th harmonic). No emissions could be detected in the ranges 9 kHz to 30 MHz and 18 GHz to 25 GHz.

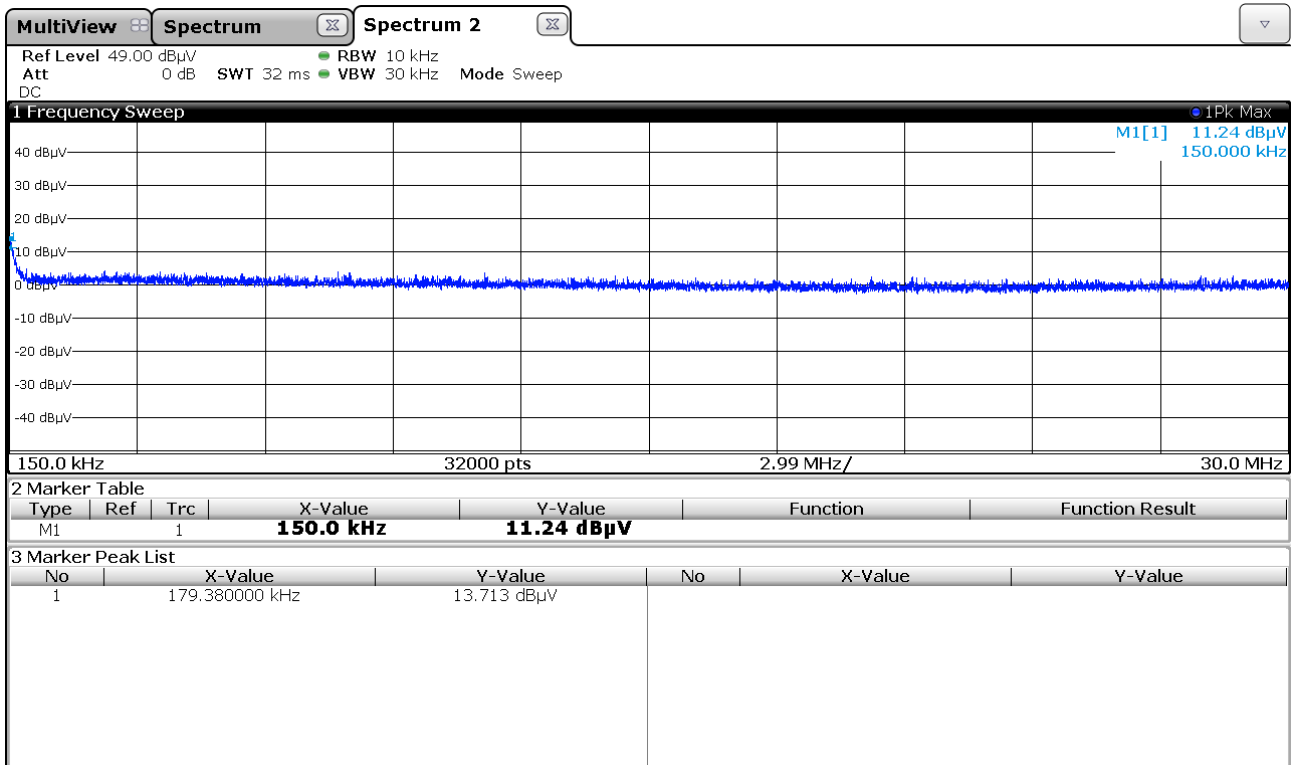
In the frequency range 30 MHz to 1000 MHz final measurements were performed in the OATS to measure the detected emissions.

The plots of the pre-measurements (9 kHz to 30 MHz and 18 GHz to 25 GHz) in TX mode at 2402 MHz is shown only for reference.

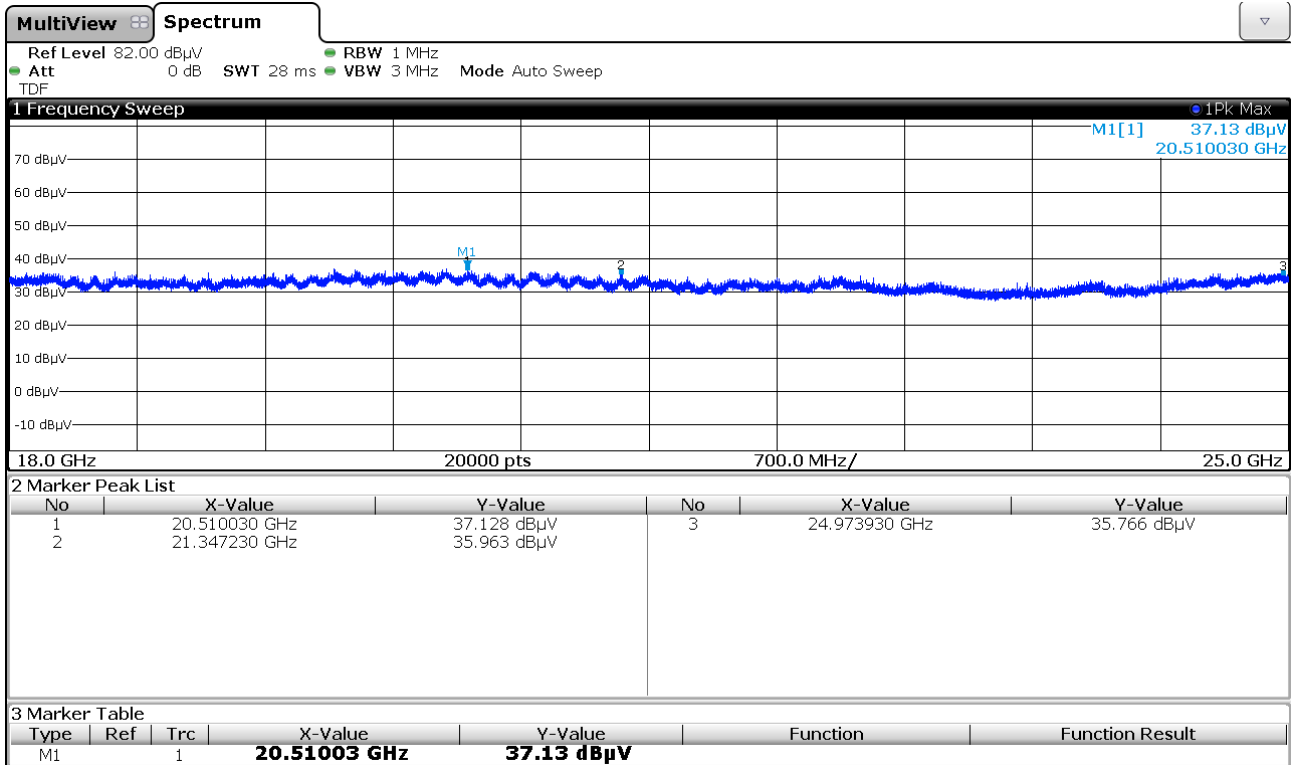
Pre-measurement 9 kHz to 150 kHz:



Pre-measurement 150 kHz to 30 MHz:



Pre-measurement 18 GHz to 25 GHz:



5.3.2 Test result of the final measurements 30 MHz – 1000 MHz

Frequency (MHz)	Reading Vert. (dBμV)	Reading Hor. (dBμV)	Correct. Vert. (dB)	Correct. Hor. (dB)	Level Vert. (dBμV/m)	Level Hor. (dBμV/m)	Limit (dBμV/m)	Dlimit (dB)
39.99	1.4	-3.8	14.7	13.4	16.1	9.6	40.0	-23.9
63.99	-1.0	-0.5	14.5	13.6	13.5	13.1	40.0	-26.5
283.40	-2.4	-1.1	15.9	15.7	13.5	14.6	46.0	-31.4

Note: The correction factor includes cable loss and antenna factor. No difference could be detected for the intentional radiated frequencies 2402 MHz, 2440 MHz and 2480 MHz within the frequency range from 30 MHz to 1000 MHz.

No emissions could be detected. The recorded values represent only the noise values of the OATS.

5.3.3 Test result of the final measurements f > 1 GHz
Channel 37

Test results							
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)
2400.00	55.9	74.0	-18.1	-38.7	17.2	54.0	-36.8
2483.50	37.8	74.0	-36.2			54.0	
4804.60	62.0	74.0	-12.0	-38.7	23.3	54.0	-30.7
7207.00	55.2	74.0	-18.8	-38.7	16.5	54.0	-37.5
9609.00	49.8	74.0	-24.2			54.0	
14351.00	47.5	74.0	-26.5			54.0	
Measurement uncertainty				±6 dB			

Channel 17

Test results							
Frequency (MHz)	Peak Level (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	Duty cycle correction	AV Level (dBμV/m)	AV Limit (dBμV/m)	Margin (dB)
2400.00	38.5	74.0	-35.5			54.0	
2483.50	38.5	74.0	-35.5			54.0	
4880.60	63.2	74.0	-10.8	-38.7	24.5	54.0	-29.5
7321.00	53.4	74.0	-20.6			54.0	
16591.80	53.6	74.0	-20.4			54.0	
12770.60	47.5	74.0	-26.6			54.0	
Measurement uncertainty				±6 dB			

Channel 39

Test results							
Frequency (MHz)	Peak Level (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	Duty cycle correction	AV Level (dBμV/m)	AV Limit (dBμV/m)	Margin (dB)
2400.00	52.9	74.0	-21.1			54.0	
2483.50	59.6	74.0	-14.4	-38.7	20.9	54.0	-33.1
4959.80	54.3	74.0	-19.7	-38.7	15.6	54.0	-38.4
7439.80	46.2	74.0	-27.8			54.0	
11310.60	39.5	74.0	-34.5			54.0	
12788.20	47.7	74.0	-26.3			54.0	
Measurement uncertainty				±6 dB			

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 37 at 4804.6 MHz: peak value – DC = average value
 $62.0 \text{ dB}\mu\text{V/m} - 38.7 = 23.3 \text{ dB}\mu\text{V/m}$

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Limit according to FCC Part 15C, Section 15.209:

Frequency (MHz)	15.209 Limits ($\mu\text{V/m}$)	Measurement distance (m)
0.009 - -0.49	$2400/f(\text{kHz})$	300
0.49 – 1.705	$24000/f(\text{kHz})$	30
1.705 – 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

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

Fundamental frequency (MHz)	Field strength of harmonics	
	($\mu\text{V/m}$)	$\text{dB}(\mu\text{V/m})$
902 - 928	500	54
2400 - 2483.5	500	54
5725 - 5875	500	54
24000 - 24250	2500	68

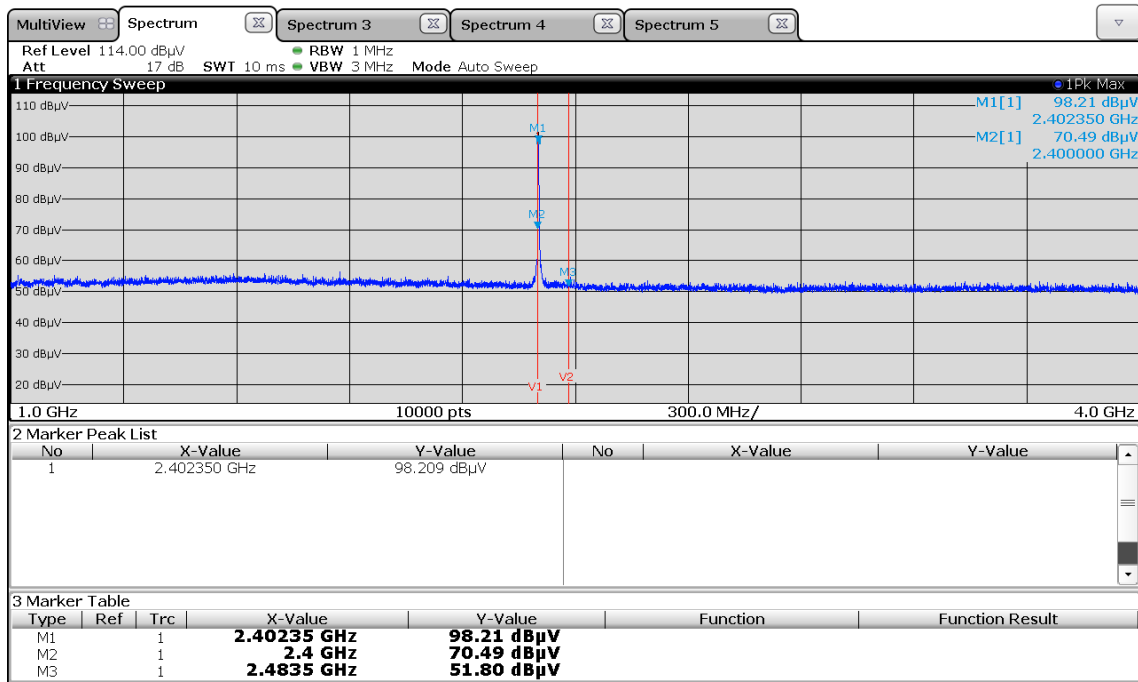
The requirements are **FULFILLED**.

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

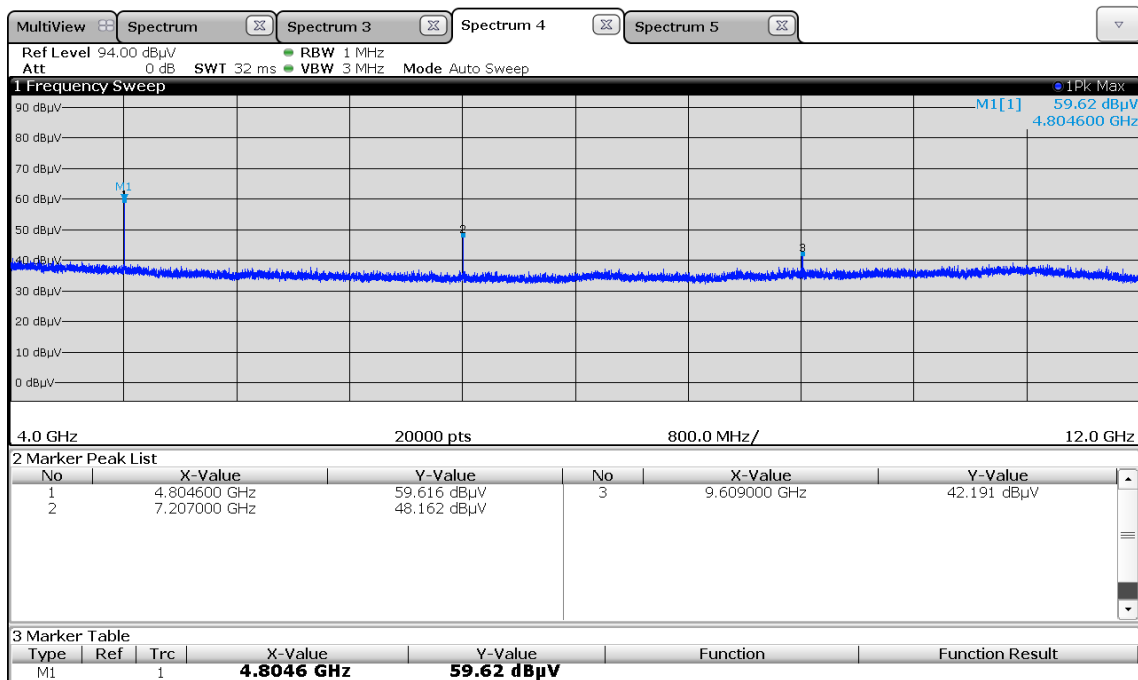
5.3.4 Test protocols

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

1 to 4 GHz

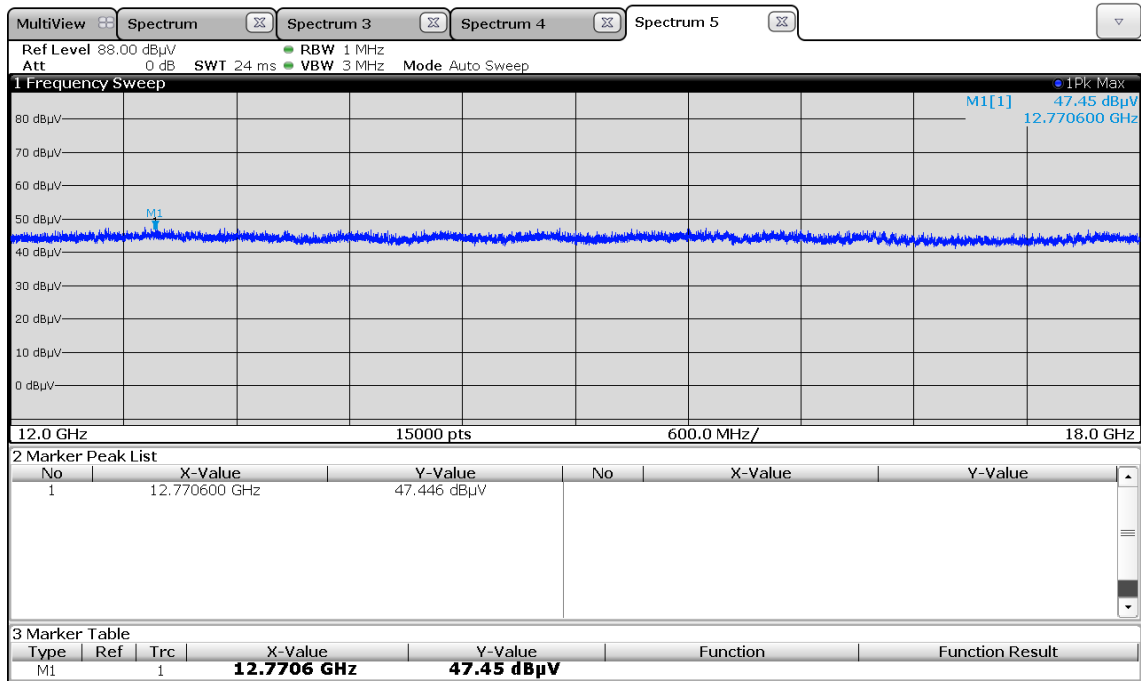


4 to 12 GHz



FCC ID: 2AKEB-TECHUNIT01

12 to 18 GHz



5.4 EBW and OBW

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

5.4.1 Description of the test location

Test location: Anechoic chamber 1

5.4.2 Photo documentation of the test set-up



5.4.3 Applicable standard

According to FCC Part 15, Section 15.215(c):

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

5.4.4 Description of Measurement

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

Spectrum analyser settings:

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

5.4.5 Test result

Centre f (MHz)	20dB bandwidth f_1	20dB bandwidth f_2	Measured EBW (MHz)
2402.09000	2401.4915	2402.6885	1.197
2440.08700	2439.4885	2440.6855	1.197
2480.08550	2479.4930	2480.6780	1.185

Centre f (MHz)	99% bandwidth f_1	99% bandwidth f_2	Measured OBW (MHz)
2402.093750	2401.562	2402.6255	1.0635
2440.090750	2439.559	2440.6225	1.0635
2480.081000	2479.547	2480.6150	1.0680

Operating frequency band (MHz)	20 dB Bandwidth (MHz)
$f_{\text{low}} > 2400$	$f_{\text{low}} = 2401.49150$
$f_{\text{high}} < 2483.5$	$f_{\text{high}} = 2480.67800$
Operating Band occupancy	79.19

Operating Band occupancy percentage	94.83 %
Operating channel occupancy percentage	59.85 %

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

If frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within the central 80% of the permitted band in order to minimize the possibility of out-of-band operation. Due to the channelising of the operating band into 39 channels with 20 dB channel bandwidth of 1.19 MHz within a channel pattern of 2 MHz the limit central 80% of the permitted band can not be applied. Therefore the stability of the EUT will be shown staying within the central 80% of the operating channel.

The requirements are **FULFILLED**.

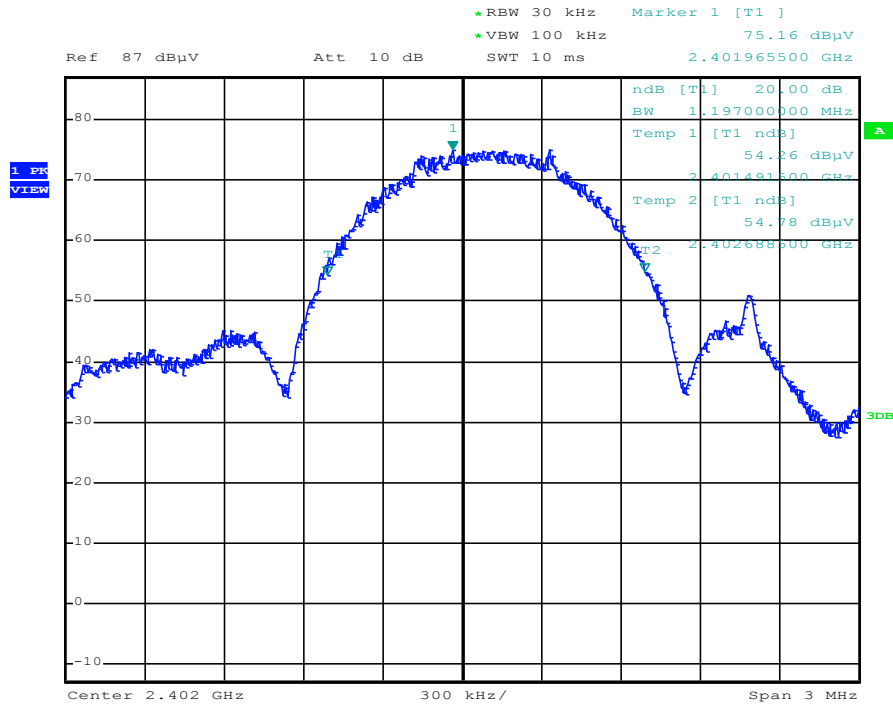
Remarks: For detailed test result please refer to following test protocols.

The OBW99 is measured for RSS only.

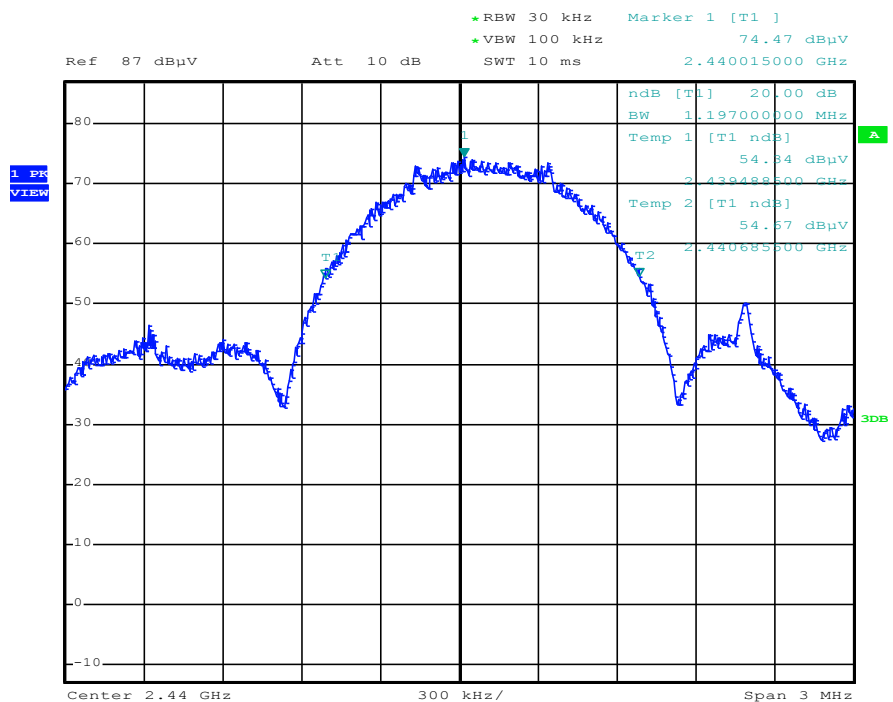
5.4.6 Test protocols

20 dB bandwidth

2402 MHz

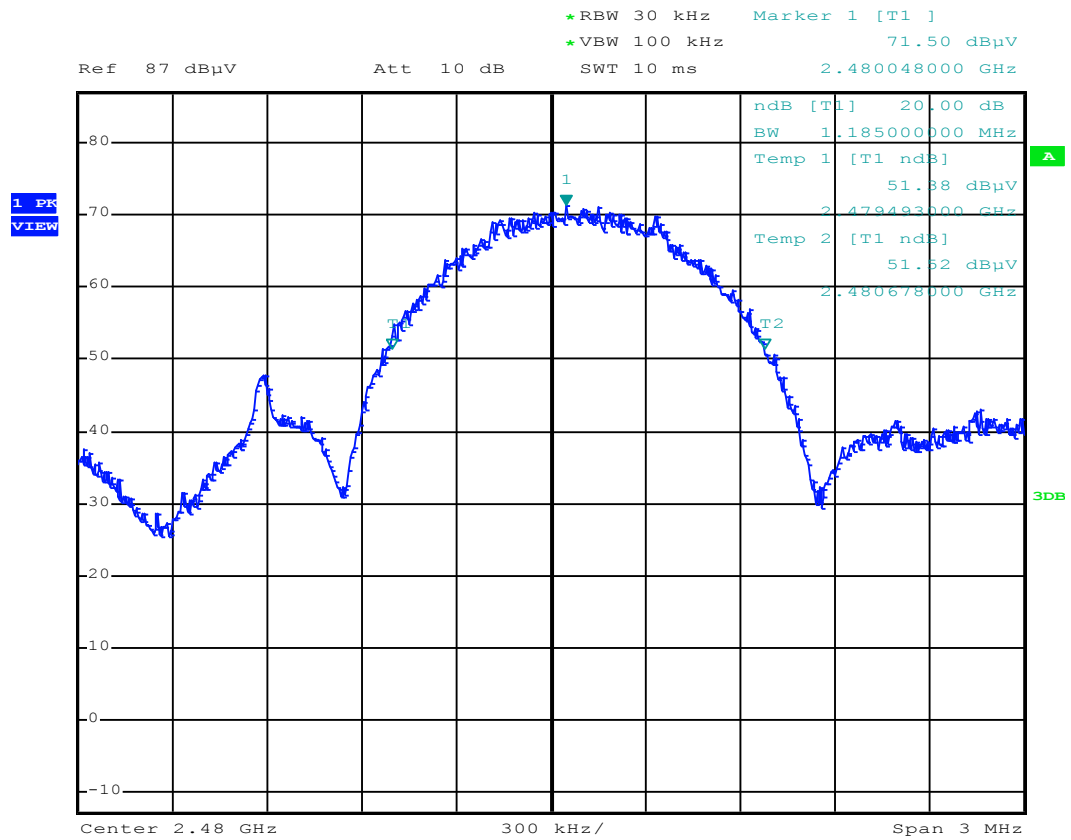


2440 MHz



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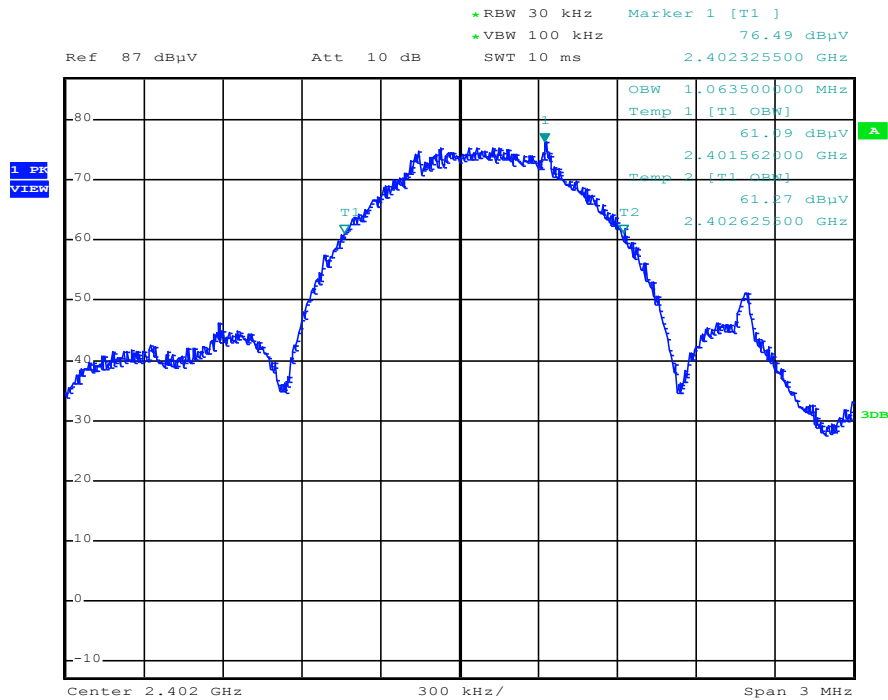
2480 MHz



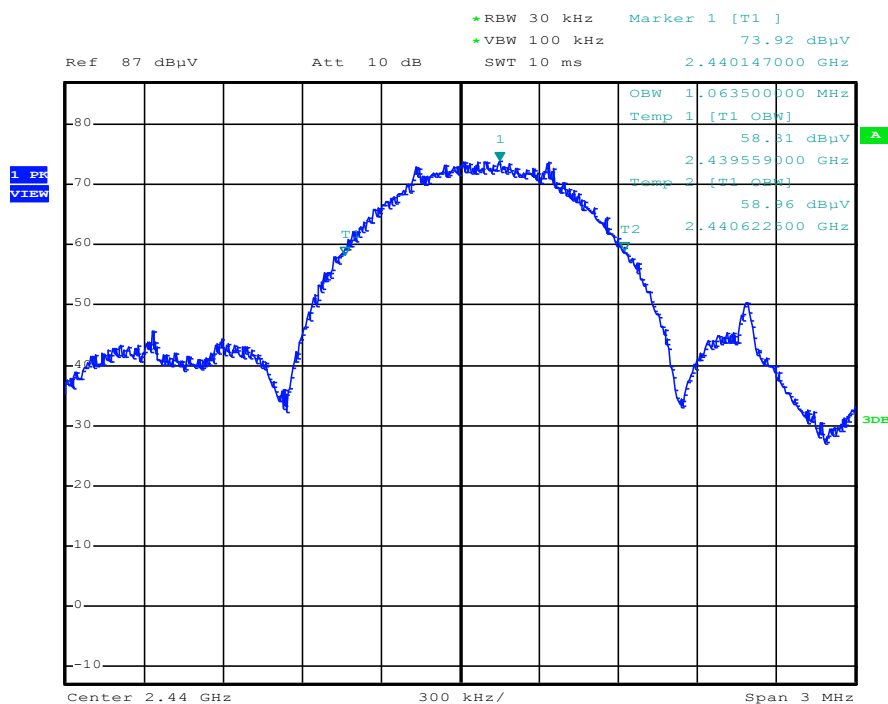
FCC ID: 2AKEB-TECHUNIT01

OBW 99%

2402 MHz

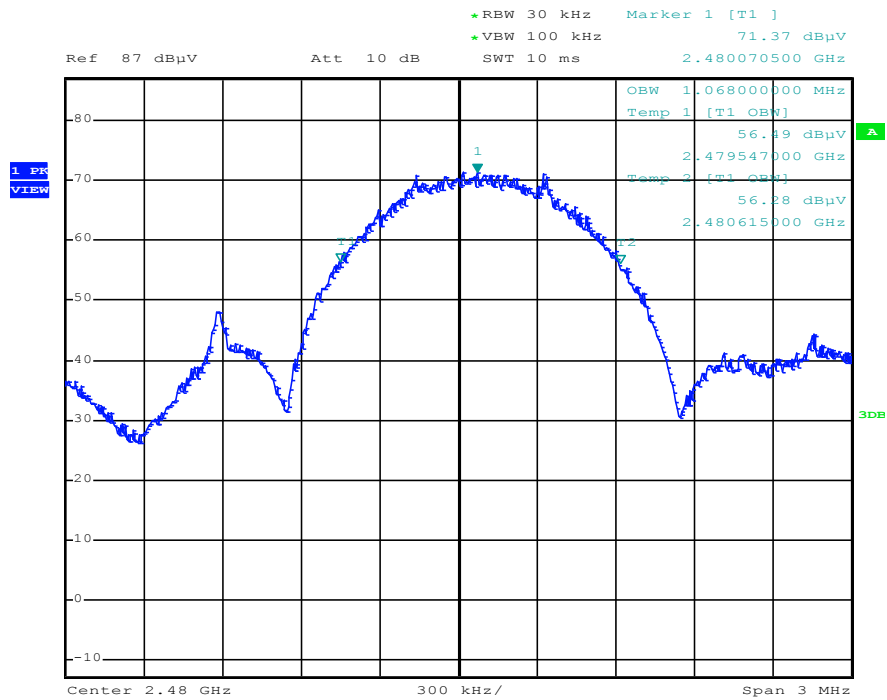


2440 MHz



FCC ID: 2AKEB-TECHUNIT01

2480 MHz



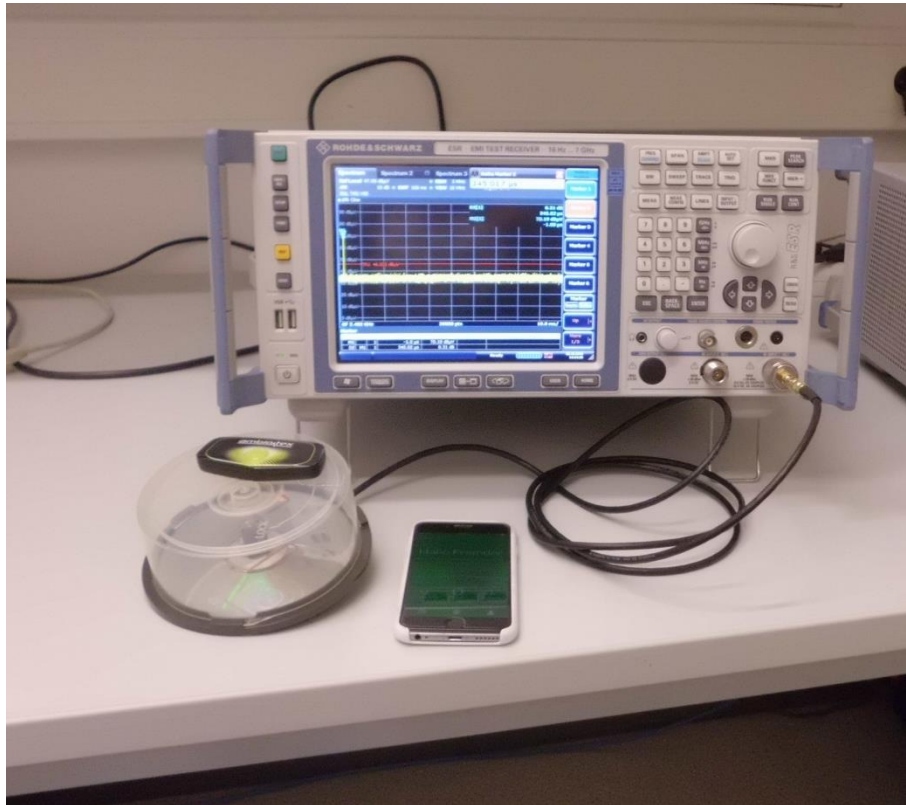
5.5 Correction for pulse operation (duty cycle)

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



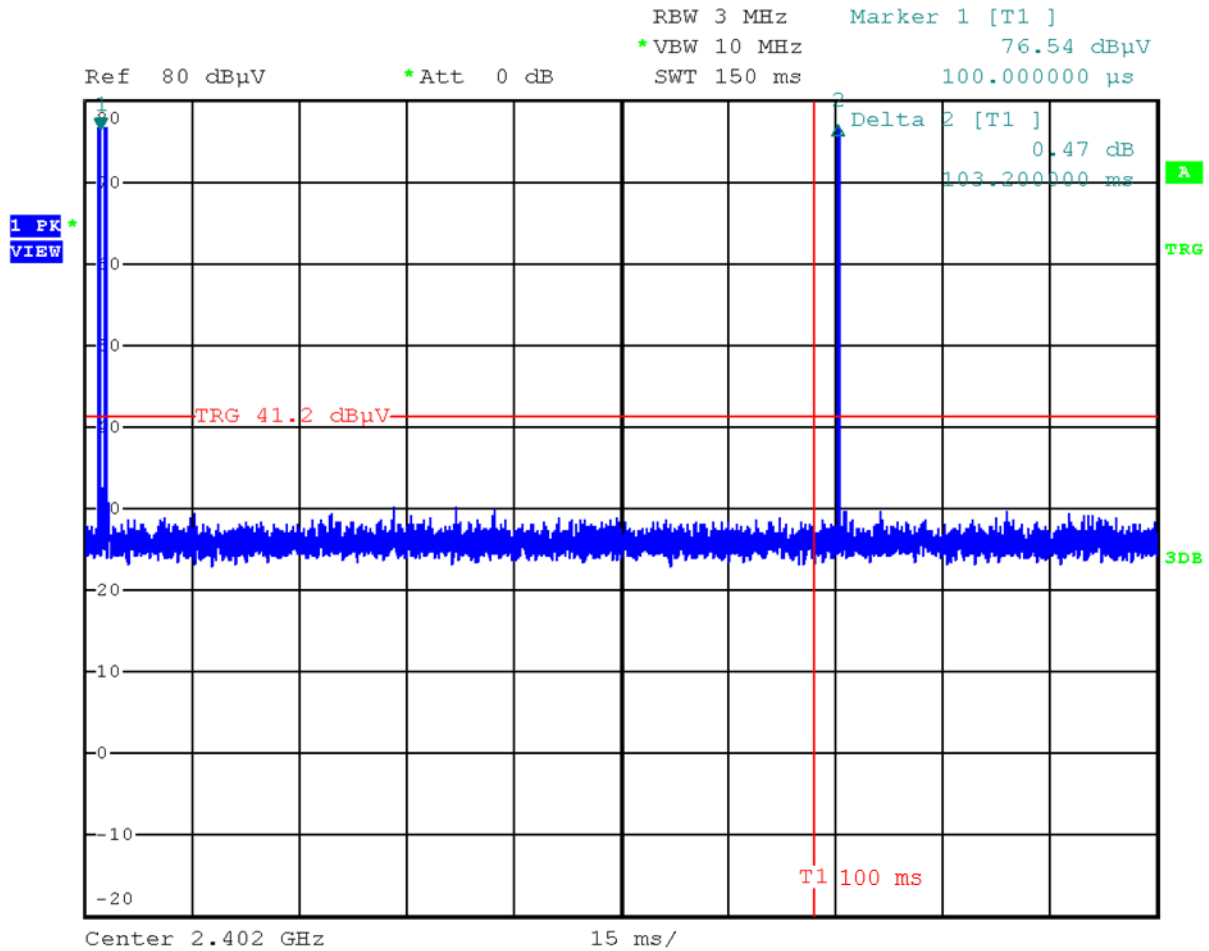
5.5.3 Applicable standard

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

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

5.5.4 Description of Measurement

The pulse train is 103.2 ms and therefore exceeds 0.1 s. Thus, the field strength is determined during a 100 ms interval.



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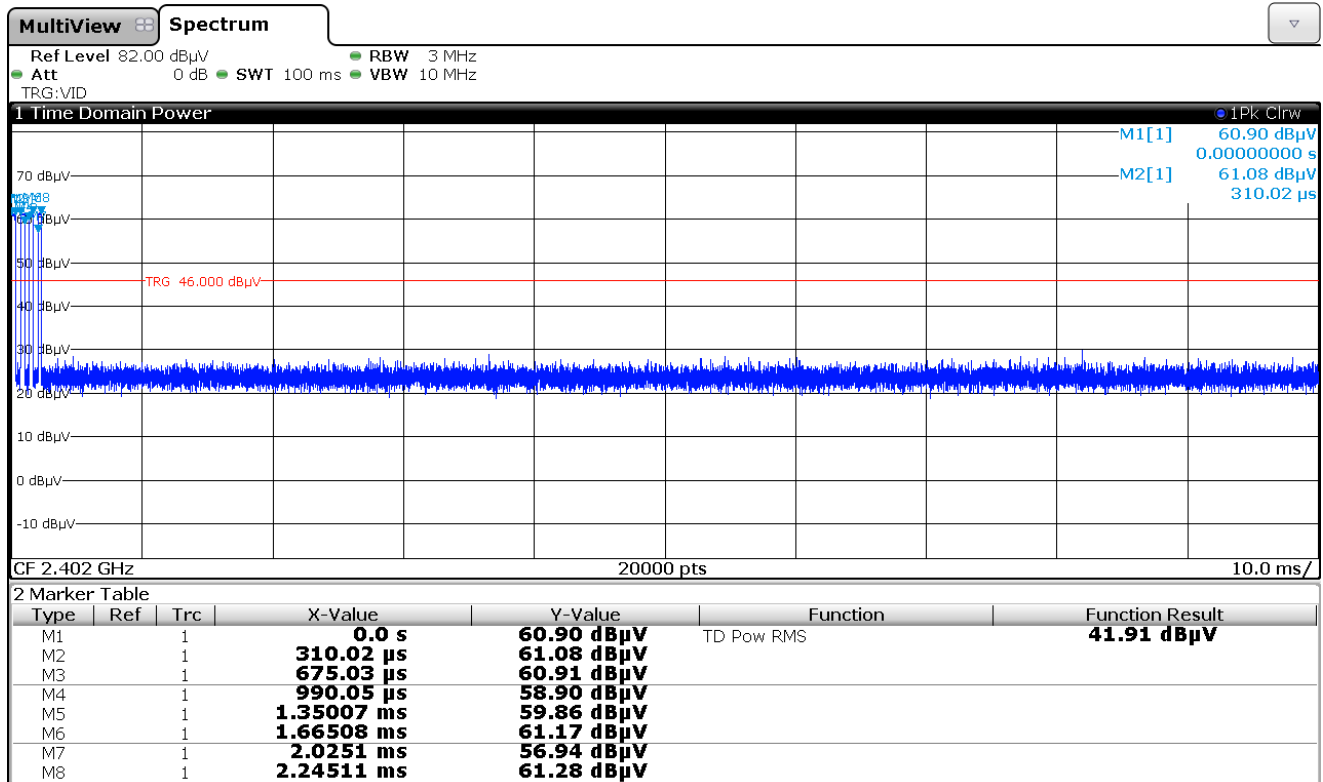
The duty cycle factor (dB) is calculated by applying the following formula:

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

KE : pulse operation correction factor

t_{iw} pulse duration for the complete pulse track

5.5.5 Test result



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

Complete burst duration (4 bursts): 310.02 μs + 310.02 μs + 315.02 μs + 220.01 μs = 1155.07 μs

$$KE = 20 * \log(1.15507 \text{ ms} / 100 \text{ ms}) = -38.74$$

Remarks:

5.6 Antenna application

5.6.1 Applicable standard

According to FCC Part 15C, Section 15.203(a):

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

5.6.2 Result

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

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

The requirements are **FULFILLED**.

Remarks:

6 USED TEST EQUIPMENT AND ACCESSORIES

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

Test ID	Model Type	Equipment No.	Next Calib.	Last Calib.	Next Verif.	Last Verif.
A 4	ESCI	02-02/03-15-001	23/05/2017	23/05/2016		
	ESH 2 - Z 5	02-02/20-05-004	26/10/2017	26/10/2015	24/05/2017	24/11/2016
	N-4000-BNC	02-02/50-05-138				
	N-1500-N	02-02/50-05-140				
	ESH 3 - Z 2	02-02/50-05-155	18/11/2019	18/11/2016	18/05/2017	18/11/2016
	SP 103 /3.5-60	02-02/50-05-182				
CPR 3	FSW43	02-02/11-15-001	25/07/2017	25/07/2016		
	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 3117	02-02/17-13-003				
	Sucoflex N-2000-SMA	02-02/24-05-009	24/05/2017	24/05/2016		
	SF104/11N/11N/1500MM	02-02/50-05-075				
DC	ESR 7	02-02/03-13-001	15/06/2017	15/06/2016		
	FSP 40	02-02/11-11-001	13/10/2017	13/10/2016		
MB	FSP 30	02-02/11-05-001	06/10/2017	06/10/2016		
SER 2	ESVS 30	02-02/03-05-003	08/07/2017	08/07/2016		
	VULB 9168	02-02/24-05-005	20/04/2017	20/04/2016	01/03/2017	01/09/2016
	NW-2000-NB	02-02/50-05-113				
	KK-EF393/U-16N-21N20 m	02-02/50-12-018				
	KK-SD_7/8-2X21N-33,0M	02-02/50-15-028				
SER 3	FSW43	02-02/11-15-001	25/07/2017	25/07/2016		
	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 3117	02-02/17-13-003				
	Sucoflex N-2000-SMA	02-02/24-05-009	24/05/2017	24/05/2016		
	SF104/11N/11N/1500MM	02-02/50-05-075				