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Bundesnetzagentur

BNetzA-CAB-02/21-102

## TEST REPORT

Test report no.: 1-8822/19-01-05

### Testing laboratory

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#### Accredited Testing Laboratory:

The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2018-03) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)

The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate starting with the registration number: D-PL-12076-01.

### Applicant

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### Manufacturer

#### steute Technologies GmbH & Co. KG

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32584 Löhne / GERMANY

FCC - Title 47 CFR Part 15 FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices

RSS - 247 Issue 2 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices

For further applied test standards please refer to section 3 of this test report.

### Test Item

Kind of test item:	2.4 GHz proprietary RF system
Model name:	TX NGF ULR2.4-safe; RX NGF ULR2.4-safe
FCC ID:	XK5-NGF24
IC:	5158A-NGF24
Frequency:	DTS band 2400 MHz to 2483.5 MHz
Technology tested:	Proprietary
Antenna:	Two integrated antennas
Power supply:	24.0 V DC by external power supply
Temperature range:	-40°C to +70°C

This test report is electronically signed and valid without handwritten signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

### Test report authorized:

Marco Bertolino  
Lab Manager  
Radio Communications

### Test performed:

Mihail Dorongovskij  
Lab Manager  
Radio Communications

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## 2 General information

### 2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CTC advanced GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.

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This test report is electronically signed and valid without handwritten signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

### 2.2 Application details

Date of receipt of order:	2019-10-16
Date of receipt of test item:	2019-12-02
Start of test:	2019-12-09
End of test:	2020-08-11
Person(s) present during the test:	-/-

### 2.3 Test laboratories sub-contracted

None

### 3 Test standard/s, references and accreditations

Test standard	Date	Description
FCC - Title 47 CFR Part 15		FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 247 Issue 2	February 2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices
RSS - Gen Issue 5 incl. Amendment 1	March 2019	Spectrum Management and Telecommunications Radio Standards Specification - General Requirements for Compliance of Radio Apparatus

Guidance	Version	Description
KDB 558074 D01	v05r02	GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES
ANSI C63.4-2014	-/-	American National Standard for 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	-/-	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

Accreditation	Description
D-PL-12076-01-04	Telecommunication and EMC Canada <a href="https://www.dakks.de/as/ast/d/D-PL-12076-01-04e.pdf">https://www.dakks.de/as/ast/d/D-PL-12076-01-04e.pdf</a>
D-PL-12076-01-05	Telecommunication FCC requirements <a href="https://www.dakks.de/as/ast/d/D-PL-12076-01-05e.pdf">https://www.dakks.de/as/ast/d/D-PL-12076-01-05e.pdf</a>

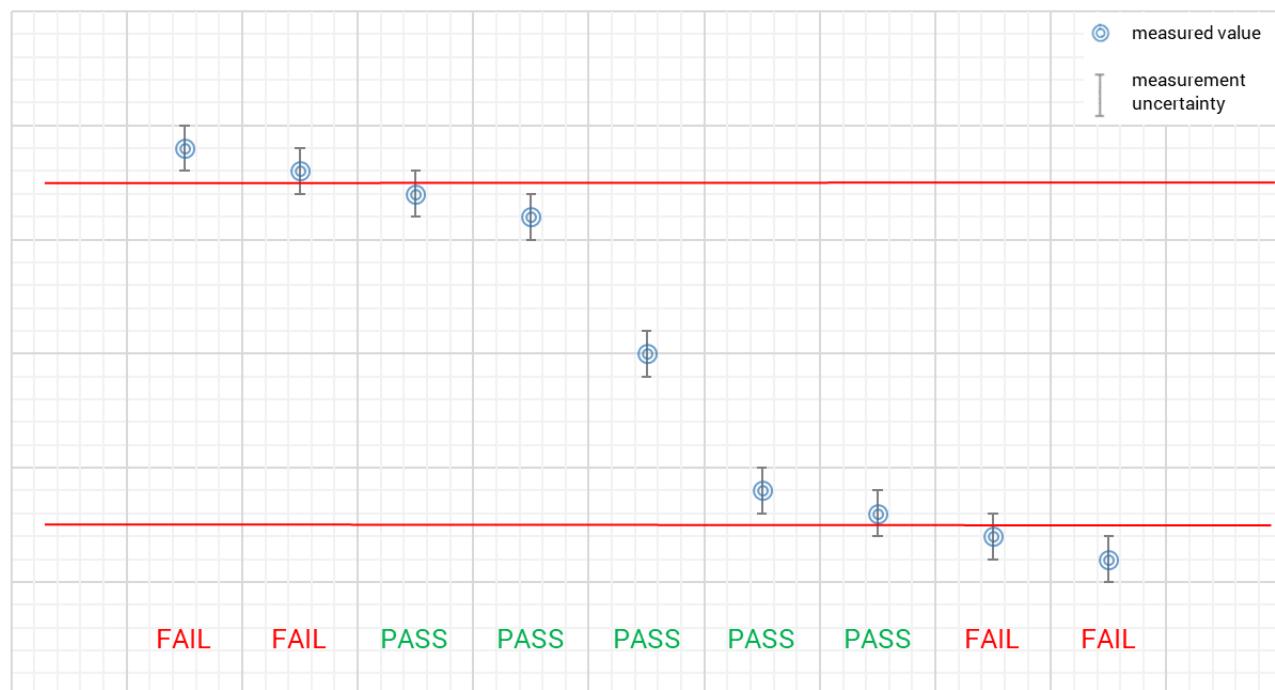


## 4 Reporting statements of conformity – decision rule

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3.

The measurement uncertainty is mentioned in this test report, see chapter 9, but is not taken into account - neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong."

measured value, measurement uncertainty, verdict



## 5 Test environment

Temperature	: T <sub>nom</sub> T <sub>max</sub> T <sub>min</sub>	+22 °C during room temperature tests No tests under extreme environmental conditions required. No tests under extreme environmental conditions required.
Relative humidity content	:	55 %
Barometric pressure	:	1021 hpa
Power supply	: V <sub>nom</sub> V <sub>max</sub> V <sub>min</sub>	24.0 V DC by external power supply No tests under extreme environmental conditions required. No tests under extreme environmental conditions required.

## 6 Test item

### 6.1 General description

Kind of test item	: 2.4 GHz proprietary RF system
Model name	: TX NGF ULR2.4-safe; RX NGF ULR2.4-safe
HMN	: n/a
PMN	: Funkneigungsgeber (NGF)
HVIN	: 1473157 1471759
FVIN	: n/a
S/N serial number	: Rad. 00000122 Cond. 1473157 / SerNo: 00034 (0x22)
Hardware status	: V3.0
Software status	: V01.07
Firmware status	: V01.07
Frequency band	: DTS band 2400 MHz to 2483.5 MHz
Type of radio transmission	: FHSS
Use of frequency spectrum	: MSK
Type of modulation	: MSK
Number of channels	: 80
Antenna	: Two integrated antennas
Power supply	: 24.0 V DC by external power supply
Temperature range	: -40°C to +70°C

### 6.2 Additional information

The content of the following annexes is defined in the QA. It may be that not all of the listed annexes are necessary for this report, thus some values in between may be missing.

Test setup and EUT photos are included in test report:

1-8822/19-01-01\_AnnexA

1-8822/19-01-01\_AnnexB

1-8822/19-01-01\_AnnexD

## 7 Sequence of testing

### 7.1 Sequence of testing radiated spurious 9 kHz to 30 MHz

#### Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, it is placed on a table with 0.8 m height.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

#### Premereasurement\*

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna height is 1 m.
- At each turntable position the analyzer sweeps with positive-peak detector to find the maximum of all emissions.

#### Final measurement

- Identified emissions during the pre-measurement are maximized by the software by rotating the turntable from 0° to 360°.
- Loop antenna is rotated about its vertical axis for maximum response at each azimuth about the EUT. (For certain applications, the loop antenna plane may also need to be positioned horizontally at the specified distance from the EUT)
- The final measurement is done in the position (turntable and elevation) causing the highest emissions with quasi-peak (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. A plot with the graph of the premeasurement and the limit is stored.

\*Note: The sequence will be repeated three times with different EUT orientations.

## 7.2 Sequence of testing radiated spurious 30 MHz to 1 GHz

### Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 10 m or 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

### Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1 m to 3 m.
- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

### Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable position  $\pm 45^\circ$  and antenna height between 1 and 4 m.
- The final measurement is done with quasi-peak detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

## 7.3 Sequence of testing radiated spurious 1 GHz to 18 GHz

### Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a 2-axis positioner with 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

### Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height is 1.5 m.
- At each turntable position and antenna polarization the analyzer sweeps with positive peak detector to find the maximum of all emissions.

### Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximizes the peaks by rotating the turntable from 0° to 360°. This measurement is repeated for different EUT-table positions (0° to 150° in 30°-steps) and for both antenna polarizations.
- The final measurement is done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

## 7.4 Sequence of testing radiated spurious above 18 GHz

### Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet.
- The measurement distance is as appropriate (e.g. 0.5 m).
- The EUT is set into operation.

### Premeasurement

- The test antenna is handheld and moved carefully over the EUT to cover the EUT's whole sphere and different polarizations of the antenna.

### Final measurement

- The final measurement is performed at the position and antenna orientation causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement and the limit is stored.

## 8 Description of the test setup

Typically, the calibrations of the test apparatus are commissioned to and performed by an accredited calibration laboratory. The calibration intervals are determined in accordance with the DIN EN ISO/IEC 17025. In addition to the external calibrations, the laboratory executes comparison measurements with other calibrated test systems or effective verifications. Weekly chamber inspections and range calibrations are performed. Where possible, RF generating and signaling equipment as well as measuring receivers and analyzers are connected to an external high-precision 10 MHz reference (GPS-based or rubidium frequency standard).

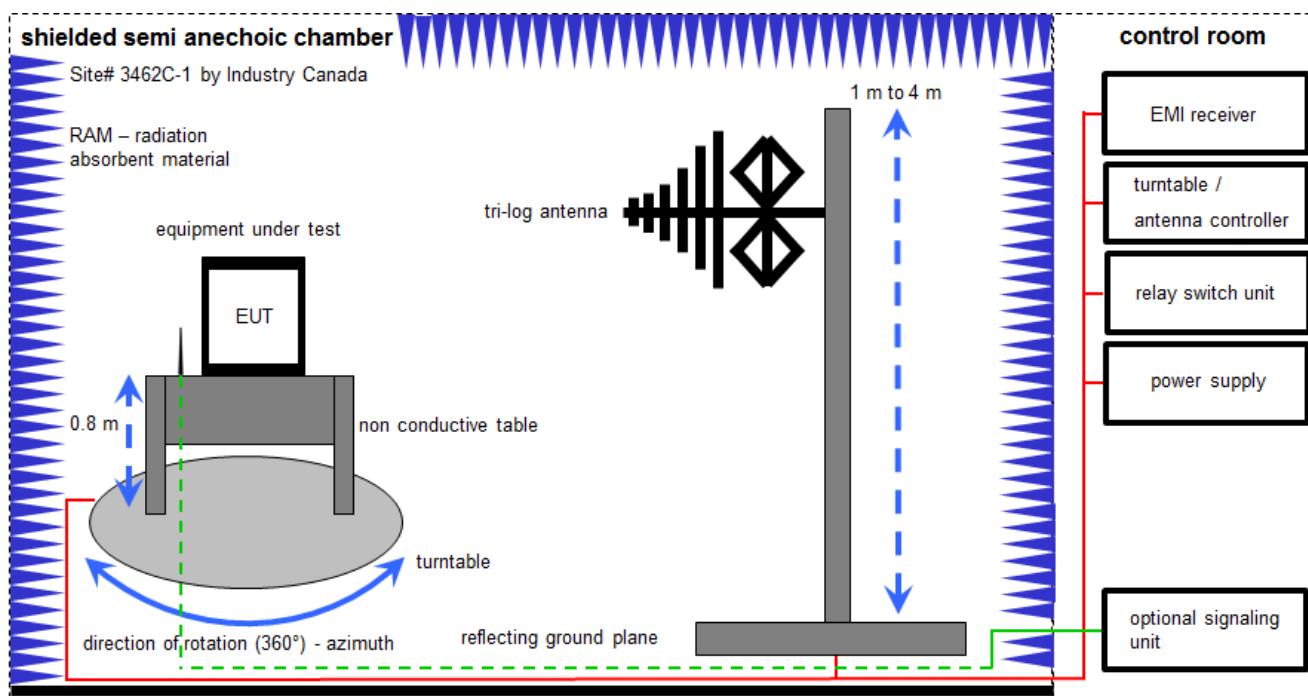
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

### Agenda: Kind of Calibration

k	calibration / calibrated	EK	limited calibration
ne	not required (k, ev, izw, zw not required)	zw	cyclical maintenance (external cyclical maintenance)
ev	periodic self verification	izw	internal cyclical maintenance
Ve	long-term stability recognized	g	blocked for accredited testing
vlkl!	Attention: extended calibration interval	*)	next calibration ordered / currently in progress
NK!	Attention: not calibrated		

## 8.1 Shielded semi anechoic chamber

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 30 MHz to 1 GHz in semi-anechoic chambers. The EUT is positioned on a non-conductive support with a height of 0.80 m above a conductive ground plane that covers the whole chamber. The receiving antennas are conform to specifications ANSI C63. These antennas can be moved over the height range between 1.0 m and 4.0 m in order to search for maximum field strength emitted from EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by spectrum analyzers where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: tri-log antenna 10 meter

EMC32 software version: 10.30.0

FS = UR + CL + AF

(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

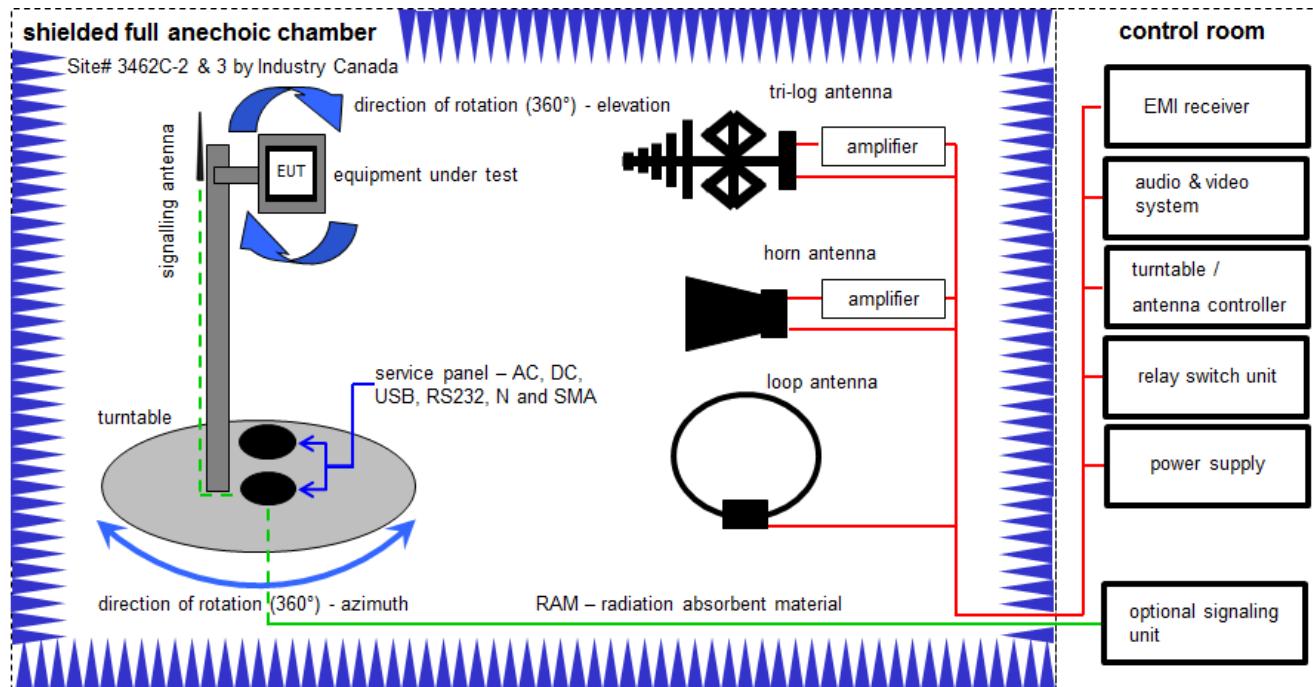
Example calculation:

$$FS [dB\mu V/m] = 12.35 [dB\mu V/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dB\mu V/m] (35.69 \mu V/m)$$

**Equipment table:**

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
2	A	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
3	A	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
4	A	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
5	A	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	295	300003787	vlKI!	19.02.2019	18.02.2021
6	A	Spectrum-Analyzer	FSU26	R&S	200809	300003874	k	16.12.2019	15.12.2020
7	A	Meßkabine 1	HF-Absorberhalle	MWB AG 300023	-/-	300000551	ne	-/-	-/-

## 8.2 Shielded fully anechoic chamber



Measurement distance: tri-log antenna and horn antenna 3 meter; loop antenna 3 meter

FS = UR + CA + AF

(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

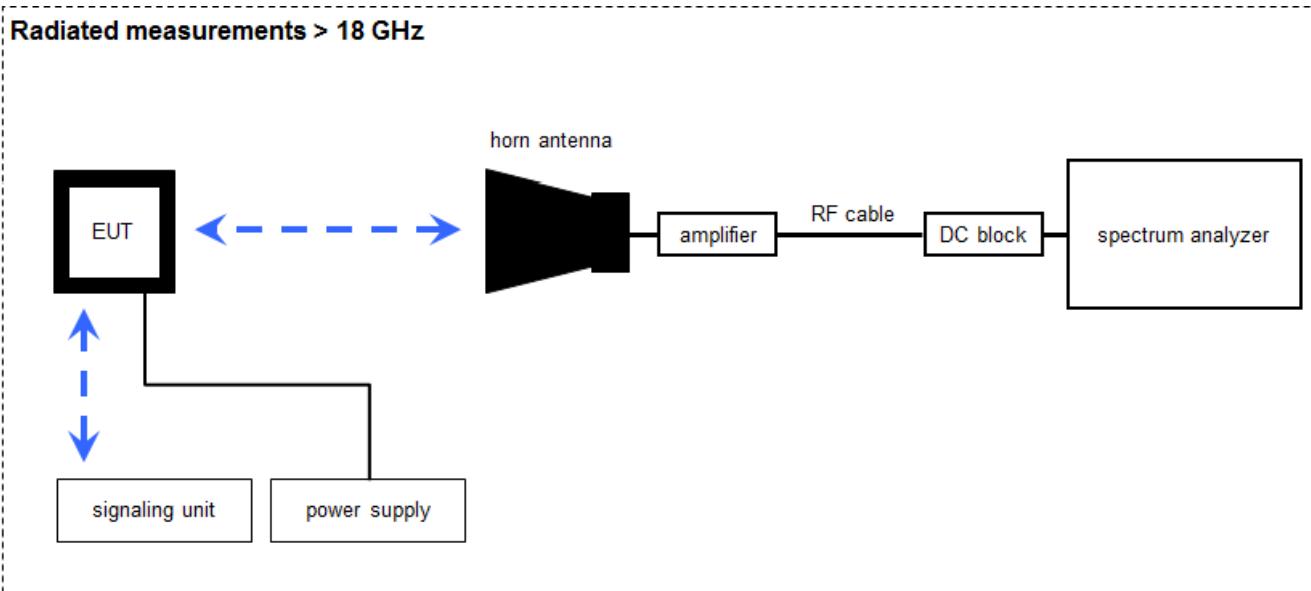
Example calculation:

$$FS [dB\mu V/m] = 40.0 [dB\mu V/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dB\mu V/m] (71.61 \mu V/m)$$

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	C	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	vlKI!	13.06.2019	12.06.2021
2	A, B, C	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	A, B	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vlKI!	27.02.2019	26.02.2021
4	A, B, C	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
5	A	Band Reject filter	WRCG2400/2483-2375/2505-50/10SS	Wainwright	11	300003351	ev	-/-	-/-
6	A, B, C	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	11.12.2019	10.12.2020
7	A	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
8	A	High Pass Filter	VHF-3500+	Mini Circuits	-/-	400000193	ne	-/-	-/-
9	A, B	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
10	A, B, C	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
11	A, B, C	NEXIO EMV-Software	BAT EMC V3.20.02	EMCO	-/-	300004682	ne	-/-	-/-
12	A, B, C	PC	ExOne	F+W	-/-	300004703	ne	-/-	-/-
13	A, B	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-

### 8.3 Radiated measurements > 18 GHz



Measurement distance: horn antenna 50 cm

FS = UR + CA + AF

(FS-field strength; UR-voltage at the receiver; CA-loss signal path & distance correction; AF-antenna factor)

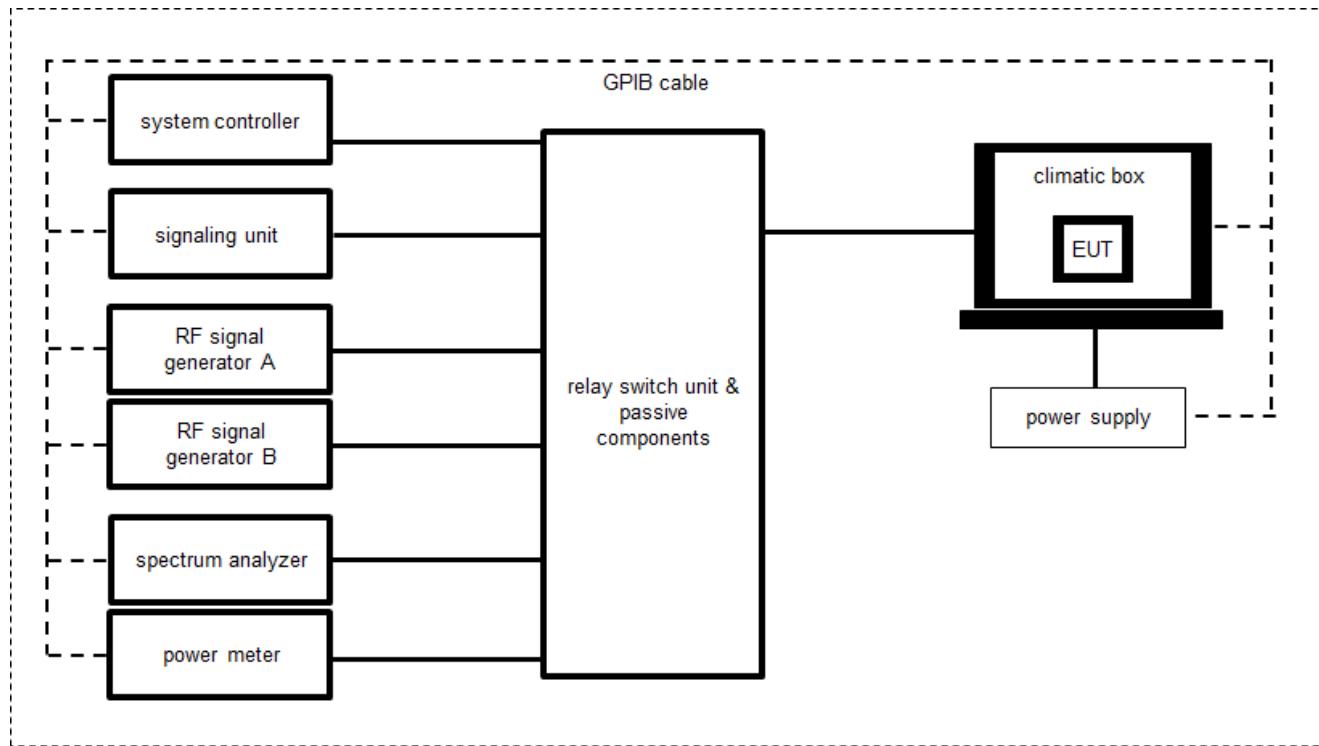
Example calculation:

$$FS [\text{dB}\mu\text{V}/\text{m}] = 40.0 [\text{dB}\mu\text{V}/\text{m}] + (-60.1) [\text{dB}] + 36.74 [\text{dB}/\text{m}] = 16.64 [\text{dB}\mu\text{V}/\text{m}] (6.79 \mu\text{V}/\text{m})$$

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Microwave System Amplifier, 0.5-26.5 GHz	83017A	HP	00419	300002268	ev	-/-	-/-
2	A	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda	01096	300000486	vlKI!	21.01.2020	20.01.2022
3	A	Signal Analyzer 40 GHz	FSV40	R&S	101042	300004517	k	17.12.2019	16.12.2020
4	A	RF-Cable	ST18/SMAm/SMAm /48	Huber & Suhner	Batch no. 600918	400001182	ev	-/-	-/-
5	A	RF-Cable	ST18/SMAm/SMAm /48	Huber & Suhner	Batch no. 127377	400001183	ev	-/-	-/-
6	A	DC-Blocker 0.1-40 GHz	8141A	Inmet	-/-	400001185	ev	-/-	-/-

## 8.4 Conducted measurements Bluetooth system



OP = AV + CA  
 (OP-output power; AV-analyzer value; CA-loss signal path)

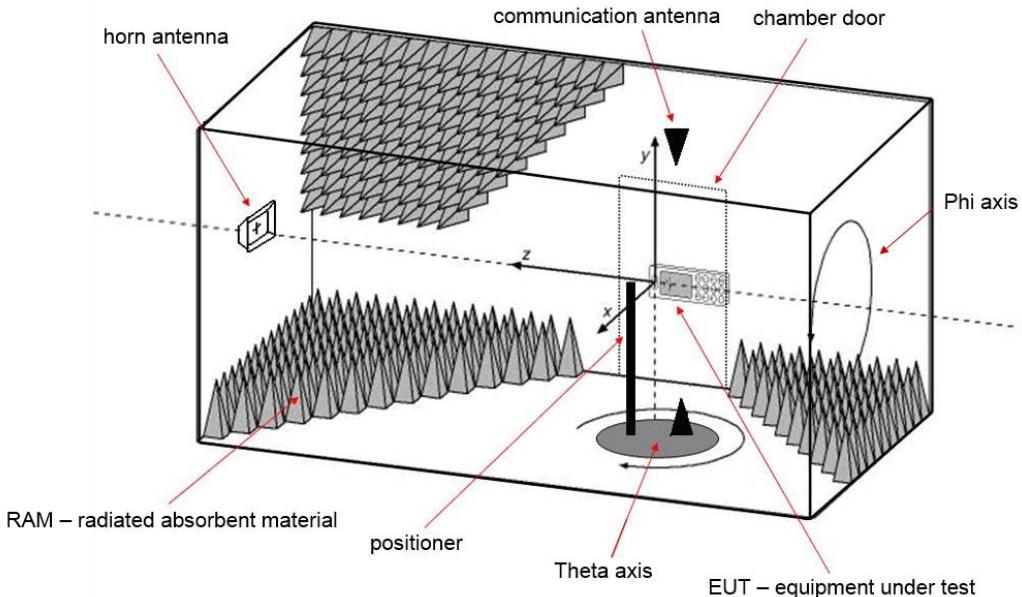
Example calculation:  
 OP [dBm] = 6.0 [dBm] + 11.7 [dB] = 17.7 [dBm] (58.88 mW)

### Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Switch / Control Unit (including DC-Block, Splitter)	3488A	HP	-/-	300000929	ne	-/-	-/-
2	A	PC Laboratory 19"	Exone i3	Fröhlich + Walter	35230157A0370	300004646	ne	-/-	-/-
3	A	Spectrum Analyzer	FSV30	Rohde & Schwarz	103170	300004855	vIKI!	11.12.2018	10.12.2020
4	A	USB-GPIB-Interface	82357B	Agilent Technologies	MY54323070	300004852	ne	-/-	-/-
5	A	Tester Software RadioStar (C.BER2 for BT Conformance)	Version 1.0.0.X	CTC advanced GmbH	0001	400001380	ne	-/-	-/-

## 8.5 Shielded fully anechoic chamber

### OTA – over the air performance



EM Quest software version: 1.0.7.0

OP = AV + D - G + CA

(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

#### Example calculation:

$$OP [dBm] = -40.0 [dBm] + 49.9 [dB] - 12.4 [dBi] + 9 [dB] = 6.5 [dBm] (4.47 \text{ mW})$$

#### Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Switch Unit	TS-RSP	R&S	100155	300003281	ev	-/-	-/-
2	A	CTIA-Chamber	CTIA-Chamber AMS 8500	ETS-Lindgren Finnland	-/-	300003327	ne	-/-	-/-
3	A	CTIA-Chamber - Positioning Equipment	CTIA-Chamber - Positioning Equipment	EMCO/2	-/-	300003328	ne	-/-	-/-
4	A	CTIA-Chamber - Software	CTIA-Chamber - Software	EMCO/2	-/-	300003328	ne	-/-	-/-
5	A	CTIA-Chamber - Antenna	3164-04	EMCO/2	00041915	300003328	ne	-/-	-/-
6	A	Spectrum Analyzer 9kHz - 30 GHz	FSP30	R&S	100623	300003464	viKI!	13.12.2018	12.12.2020

## 9 Measurement uncertainty

Measurement uncertainty	
Test case	Uncertainty
Antenna gain	± 3 dB
Carrier frequency separation	± 21.5 kHz
Number of hopping channels	-/-
Time of occupancy	According BT Core specification
Spectrum bandwidth	± 21.5 kHz absolute; ± 15.0 kHz relative
Maximum output power	± 1 dB
Detailed conducted spurious emissions @ the band edge	± 1 dB
Band edge compliance radiated	± 3 dB
Spurious emissions conducted	± 3 dB
Spurious emissions radiated below 30 MHz	± 3 dB
Spurious emissions radiated 30 MHz to 1 GHz	± 3 dB
Spurious emissions radiated 1 GHz to 12.75 GHz	± 3.7 dB
Spurious emissions radiated above 12.75 GHz	± 4.5 dB
Spurious emissions conducted below 30 MHz (AC conducted)	± 2.6 dB

## 10 Summary of measurement results

<input checked="" type="checkbox"/>	No deviations from the technical specifications were ascertained
<input type="checkbox"/>	There were deviations from the technical specifications ascertained
<input type="checkbox"/>	This test report is only a partial test report. The content and verdict of the performed test cases are listed below.

TC Identifier	Description			Verdict	Date		Remark
RF-Testing	CFR Part 15 RSS - 247, Issue 2			See table!	2020-10-29		-/-

Test specification clause	Test case	Temperature conditions	Power source voltages	Mode	C	NC	NA	NP	Remark
§15.247(b)(4) RSS - 247 / 5.4.(f)(ii)	Antenna gain	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) RSS - 247 / 5.1.(b)	Carrier frequency separation	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) RSS - 247 / 5.1 (d)	Number of hopping channels	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) (iii) RSS - 247 / 5.1 (c)	Time of occupancy (dwell time)	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) RSS - 247 / 5.1 (a)	Spectrum bandwidth of a FHSS system bandwidth	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(b)(1) RSS - 247 / 5.4 (b)	Maximum output power	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance radiated	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5	Spurious emissions conducted	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.209(a) RSS - Gen	Spurious emissions radiated below 30 MHz	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen	Spurious emissions radiated 30 MHz to 1 GHz	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen	Spurious emissions radiated above 1 GHz	Nominal	Nominal	MSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.107(a) §15.207	Conducted emissions below 30 MHz (AC conducted)	Nominal	Nominal	MSK	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	-/-

### Notes:

C	Compliant	NC	Not compliant	NA	Not applicable	NP	Not performed
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## 11 Additional comments

Reference documents: 1-8822\_19-01-05\_log1\_conducted.pdf (Chain A results)  
 1-8822\_19-01-05\_log2\_conducted.pdf (Chain B results)  
 Radio\_Certification\_Testing\_Manual\_-\_RF\_RX\_TX\_NGF\_Rev02\_en.pdf  
 english\_21.docx

Special test descriptions: Used power settings for all tests:

Channel list Chain A	Power setting Chain A	Channel list Chain B	Power setting Chain B
1	-12	1	-12
2	-10	2-3	-10
3	-8	4-6	-8
4-6	-6	7-10	-6
7-9	-4	11-15	-4
10-11	-2	16-18	-2
12-51	Maximum	19-58	Maximum
52-54	-2	59-60	-2
55-59	-4	61-63	-4
60-63	-6	64-66	-6
64-66	-8	67-69	-8
67-69	-10	70-72	-10
70-71	-12	73	-12
72-73	-14	74-75	-14
74-76	-16	76-77	-16
77	-18	78	-18
78	-20	79	-20
79	-22	80	-22
80	-24		

Configuration descriptions: There are two different versions of the EUT covered in this test report:  
 RF TX NGF ULR2.4-safe  
 RF RX NGF ULR2.4-safe  
 Both versions have the same RF design and only differ in the electronics part.  
 For tests, only the RF RX NGF ULR2.4-safe was used.  
 The device contains two identical RF transmitters (Chain A and Chain B) with identical antennas. Both chains never transmit simultaneously, so at any moment only one antenna is used.  
 All tests were performed on both chains.

Test mode:  Special software is used.  
EUT is transmitting pseudo random data by itself

Antennas and transmit operating modes:  Operating mode 1 (single antenna)  
- Equipment with 1 antenna,  
- Equipment with 2 diversity antennas operating in switched diversity mode by which at any moment in time only 1 antenna is used,  
- Smart antenna system with 2 or more transmit/receive chains, but operating in a mode where only 1 transmit/receive chain is used)

## 12 Measurement results

### 12.1 Antenna gain

#### Measurement:

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module.

Measurement parameters (radiated)	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	3 MHz
Video bandwidth	3 MHz
Span	5 MHz
Trace mode	Max hold
Test setup	See sub clause 8.5 A
Measurement uncertainty	See sub clause 9

Measurement parameters (conducted)	
External result file	1-8822_19-01-05_log1_conducted.pdf 1-8822_19-01-05_log2_conducted.pdf Common2G4 Peak Output Power conducted 3MHz_3MHz
Test setup	See sub clause 8.4 A
Measurement uncertainty	See sub clause 9

#### Limits:

FCC	IC
6 dBi / > 6 dBi output power and power density reduction required	

**Results:** Chain A

T <sub>nom</sub>	V <sub>nom</sub>	Channel 1	Channel 40	Channel 80
Conducted power [dBm] Measured with MSK modulation	17.4	17.1	16.6	
Radiated power [dBm] Measured with MSK modulation	23.4	23.4	20.4	
Gain [dBi] Calculated	6.0	6.3	3.8	

**NOTE: These tests were performed in single channel mode with maximum power settings.**

**Results:** Chain B

T <sub>nom</sub>	V <sub>nom</sub>	Channel 1	Channel 40	Channel 80
Conducted power [dBm] Measured with MSK modulation	16.1	15.5	14.6	
Radiated power [dBm] Measured with MSK modulation	22.7	23.1	21.9	
Gain [dBi] Calculated	6.6	7.6	7.3	

**NOTE: These tests were performed in single channel mode with maximum power settings.**

## 12.2 Carrier frequency separation

### Description:

Measurement of the carrier frequency separation of a hopping system. The carrier frequency separation is constant for all modulation-modes. We use MSK modulation to show compliance. EUT in hopping mode.

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Span	10 MHz
Trace mode	Max hold
Test setup	See sub clause 8.4 A
Measurement uncertainty	See sub clause 9

### Limits:

FCC	IC
Carrier frequency separation	
Minimum 25 kHz or two-thirds of the 20 dB bandwidth of the hopping system whichever is greater.	

### Result: Chain A

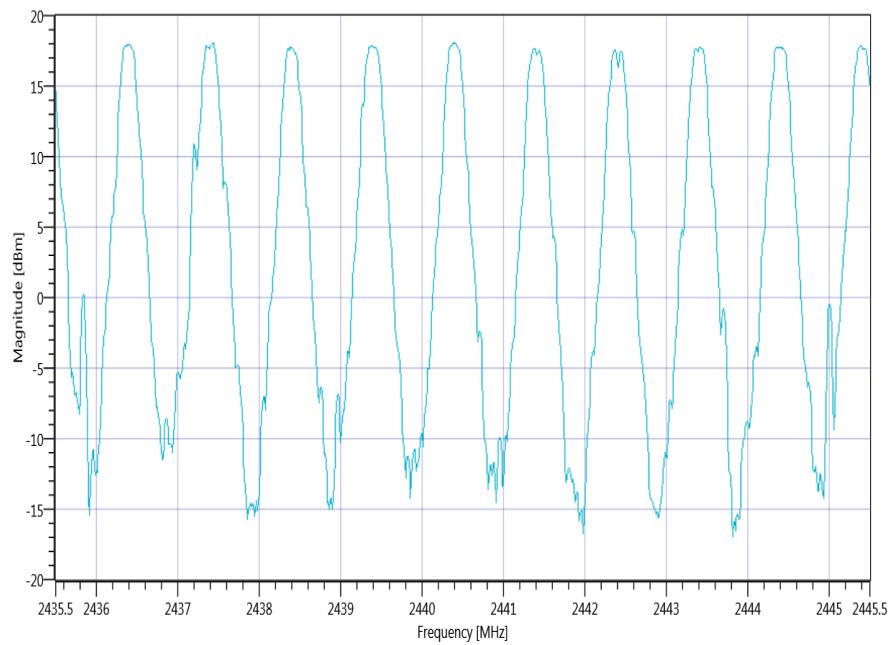
Carrier frequency separation	~ 1 MHz
------------------------------	---------

### Result: Chain B

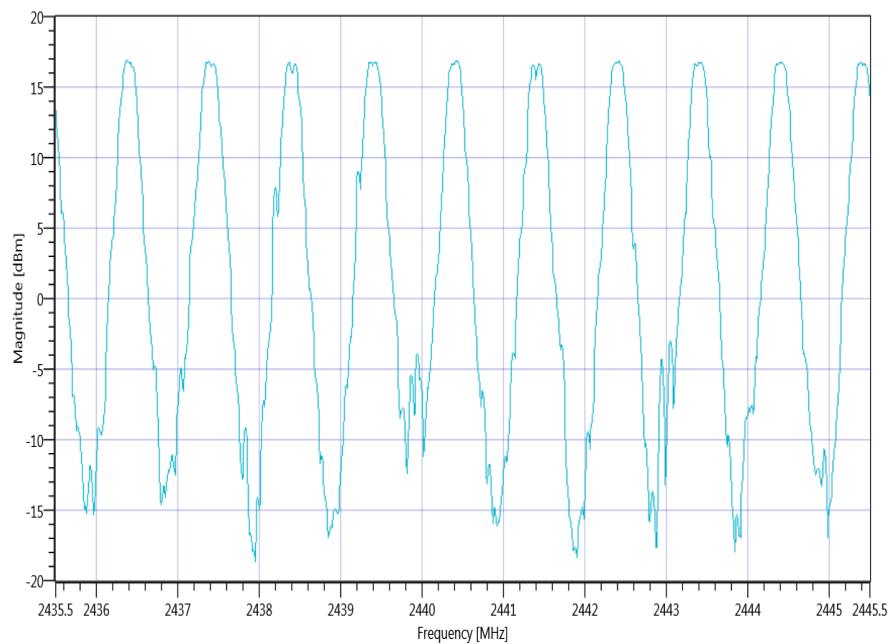
Carrier frequency separation	~ 1 MHz
------------------------------	---------

**Plots:**

**Plot 1: Chain A**



**Plot 2: Chain B**



## 12.3 Number of hopping channels

### Description:

Measurement of the total number of used hopping channels. The number of hopping channels is constant for all modulation-modes. We use MSK-modulation to show compliance. EUT in hopping mode.

Measurement parameters	
External result file	1-8822_19-01-05_log1_conducted.pdf 1-8822_19-01-05_log2_conducted.pdf Hardcopy Spectrum Analyzer
Test setup	See sub clause 8.4 A
Measurement uncertainty	See sub clause 9

### Limits:

FCC	IC
Number of hopping channels	
At least 15 non overlapping hopping channels	

### Result: Chain A

Number of hopping channels	80
----------------------------	----

### Result: Chain B

Number of hopping channels	80
----------------------------	----

## 12.4 Time of occupancy (dwell time)

Measurement parameters	
External result file	1-8822_19-01-05_log1_conducted.pdf 1-8822_19-01-05_log2_conducted.pdf Hardcopy Spectrum Analyzer
Test setup	See sub clause 8.4 A
Measurement uncertainty	See sub clause 9

### Results: Chain A

Channel	Pulse Width [ms]	Number of transmissions in 32 sec	Time of occupancy (dwell time) [Pulse width * Number of transmissions] [s]
1	2.6	17	44.2
20	2.6	9	23.4
40	2.6	19	45.6
60	2.6	14	36.4
80	2.6	8	20.8

### Results: Chain B

Channel	Pulse Width [ms]	Number of transmissions in 32 sec	Time of occupancy (dwell time) [Pulse width * Number of transmissions] [s]
1	2.6	14	36.4
20	2.6	16	41.6
40	2.6	16	41.6
60	2.6	10	26.0
80	2.6	10	26.0

### Limits:

FCC	IC
Time of occupancy (dwell time)	
The frequency hopping operation shall have an average time of occupancy on any frequency not exceeding 0.4 seconds within a duration in seconds equal to the number of hopping frequencies multiplied by 0.4.	

## 12.5 Spectrum bandwidth of a FHSS system

### Description:

Measurement of the 20dB bandwidth and 99% bandwidth of the modulated signal.

<b>Measurement parameters</b>	
External result file	1-8822_19-01-05_log1_conducted.pdf 1-8822_19-01-05_log2_conducted.pdf FCC Part 15.247 Bandwidth 99PCT
Test setup	See sub clause 8.4 A
Measurement uncertainty	See sub clause 9

### Limits:

FCC	IC
Spectrum bandwidth of a FHSS system	
The carrier has to be inside the frequency band.	

**Results:** Chain A

	20 dB bandwidth [kHz]	99 % bandwidth [kHz]
Channel 1	429	422
Channel 2	445	425
Channel 3	426	410
Channel 4	431	410
Channel 12	425	424
Channel 40	442	442
Channel 74	435	430
Channel 77	435	412
Channel 78	426	413
Channel 79	441	418
Channel 80	430	421

**Results:** Chain B

	20 dB bandwidth [kHz]	99 % bandwidth [kHz]
Channel 1	439	418
Channel 2	431	417
Channel 4	432	415
Channel 19	466	432
Channel 40	485	453
Channel 74	434	411
Channel 77	430	410
Channel 78	436	422
Channel 79	438	442
Channel 80	436	437

## 12.6 Maximum output power

### Description:

Measurement of the maximum output power conducted and radiated. EUT in single channel mode. The measurement is performed according to the ANSI C63.10.

Measurement parameters	
External result file	1-8822_19-01-05_log1_conducted.pdf 1-8822_19-01-05_log2_conducted.pdf FCC Part 15.247 Maximum Peak Conducted Output Power FHSS
Test setup	See sub clause 8.4 A
Measurement uncertainty	See sub clause 9

### Limits:

FCC	IC
Maximum output power	
Systems using more than 75 hopping channels: Conducted: 1.0 W – antenna gain max. 6 dBi Maximum antenna gain is 7.6 dBi Reduced conducted output power limit: 28.4 dBm	

**Results:** Chain A

	<b>Maximum output power conducted [dBm]</b>
Channel 1	9.2
Channel 2	11.1
Channel 3	12.2
Channel 4	14.2
Channel 12	15.8
Channel 40	17.6
Channel 74	4.3
Channel 77	2.1
Channel 78	-0.1
Channel 79	-1.3
Channel 80	-4.1

**Results:** Chain B

	<b>Maximum output power conducted [dBm]</b>
Channel 1	7.1
Channel 2	8.5
Channel 4	10.1
Channel 19	16.6
Channel 40	16.3
Channel 74	6.5
Channel 77	0.9
Channel 78	-1.3
Channel 79	-3.2
Channel 80	-4.8

## 12.7 Band edge compliance radiated

### Description:

Measurement of the radiated band edge compliance. The EUT is turned in the position that results in the maximum level at the band edge. Then a sweep over the corresponding restricted band is performed. Measurement distance is 3m.

Measurement parameters	
Detector	Peak / RMS
Sweep time	Auto
Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Span	Lower Band: 2370 – 2400 MHz Upper Band: 2480.4 – 2500 MHz
Trace mode	Max hold
Test setup	See sub clause 8.2 B
Measurement uncertainty	See sub clause 9

### Limits:

FCC	IC
Band edge compliance radiated	
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 5.205(c)).	
54 dB $\mu$ V/m AVG 74 dB $\mu$ V/m Peak	

**Results: Chain A, Channels 1 and 80**

Scenario	Band edge compliance radiated [dB $\mu$ V/m]
Modulation	MSK
Lower restricted band	46.3* dB $\mu$ V/m AVG 72.0 dB $\mu$ V/m Peak
Upper restricted band	44.8* dB $\mu$ V/m AVG 70.5 dB $\mu$ V/m Peak

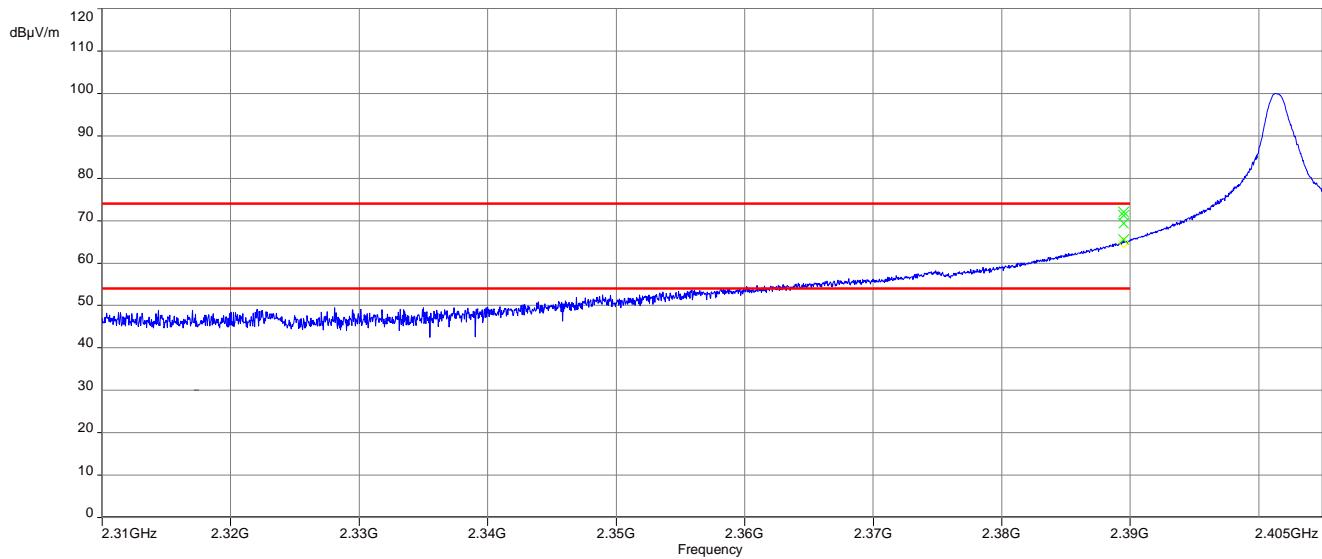
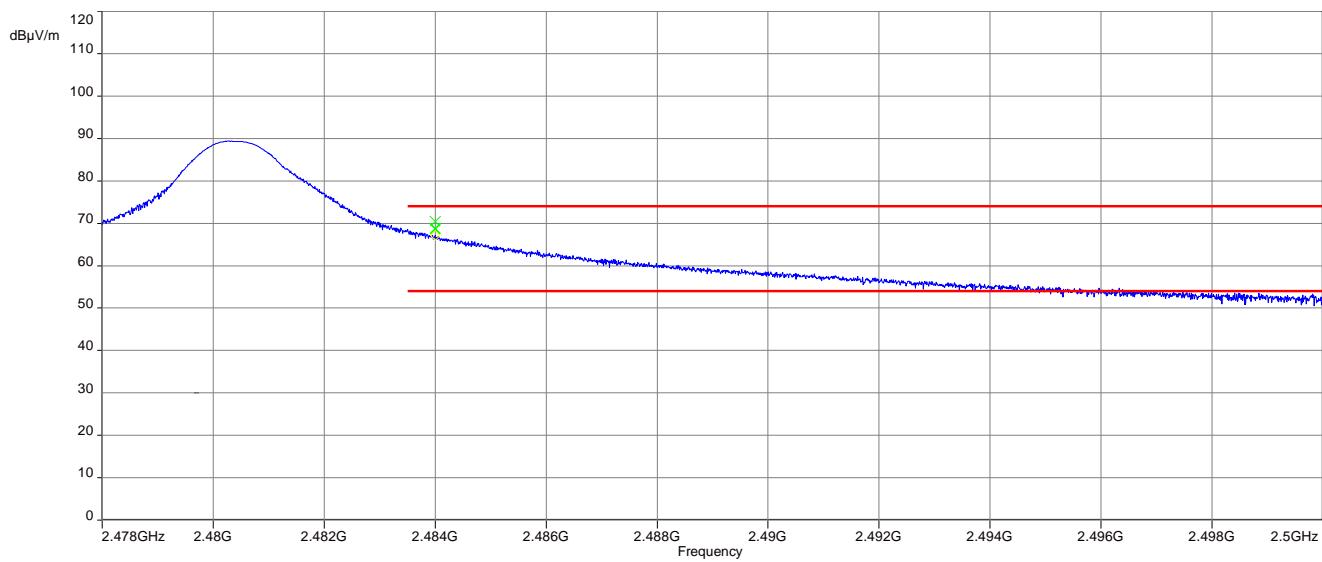
\* Average emission adjusting factor of -25.7 dB was used. For detailed calculation see chapter 12.11.

**Results: Chain B, Channels 1 and 80**

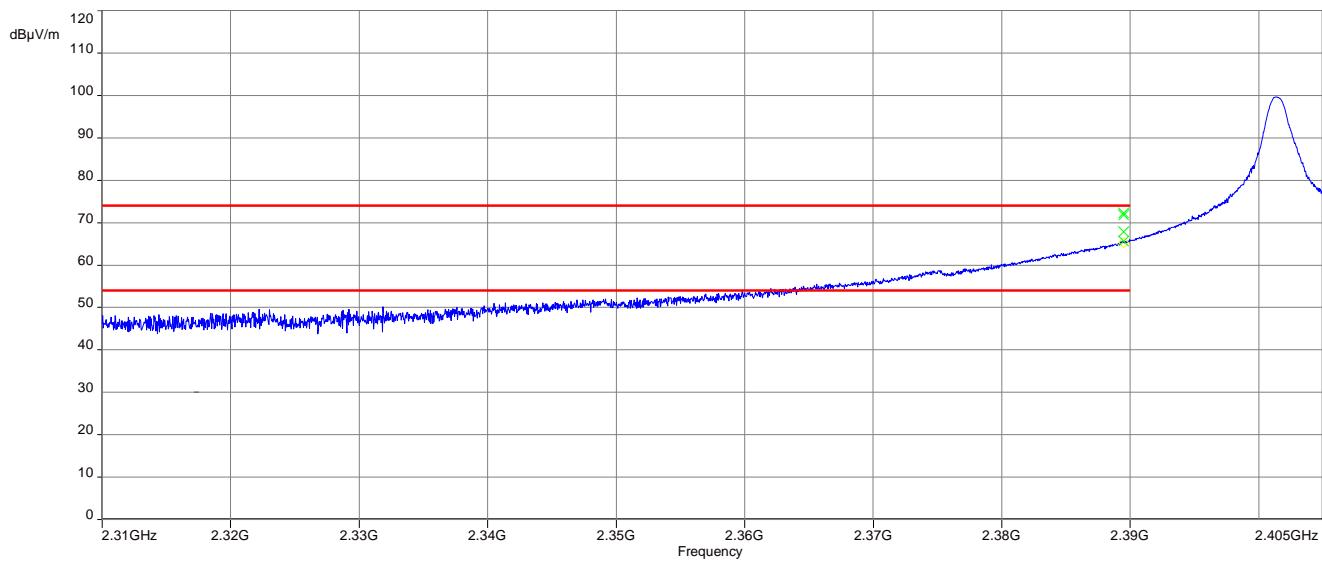
Scenario	Band edge compliance radiated [dB $\mu$ V/m]
Modulation	MSK
Lower restricted band	46.6* dB $\mu$ V/m AVG 72.3 dB $\mu$ V/m Peak
Upper restricted band	45.7* dB $\mu$ V/m AVG 71.4 dB $\mu$ V/m Peak

\* Average emission adjusting factor of -25.7 dB was used. For detailed calculation see chapter 12.11.

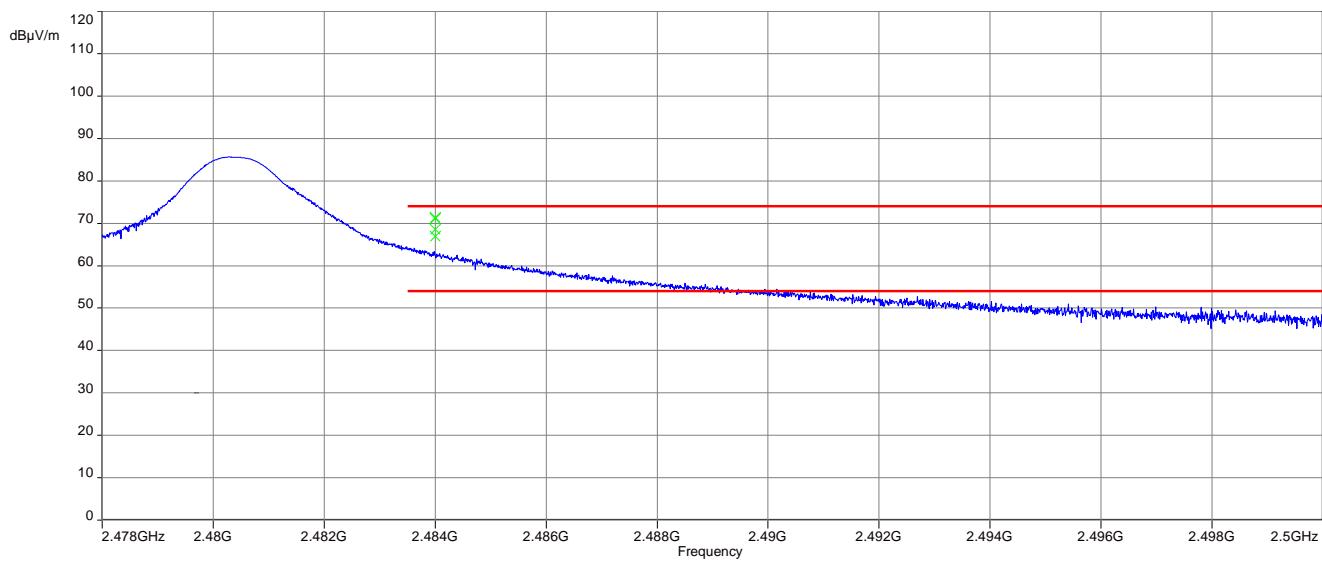
**NOTE: Only the worst case plots and results are noted in this chapter. Additionally to channels 1 and 80 the band edge compliance test was performed on the channels 2-12 and 51 to 79 for Chain A and 2-19 and 58-79 for Chain B. With the power setting table from chapter 11 all channels are compliant with the band edge compliance requirement. The measured values were the same or lower as the values from channels 1 and 80.**

**Plots:****Plot 1: Lower band edge, MSK modulation, vertical & horizontal polarization, Chain A****Plot 2: Upper band edge, MSK modulation, vertical & horizontal polarization, Chain A**

**Plot 3: Lower band edge, MSK modulation, vertical & horizontal polarization, Chain B**



**Plot 4: Upper band edge, MSK modulation, vertical & horizontal polarization, Chain B**



## 12.8 Spurious emissions conducted

### Description:

Measurement of the conducted spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit channel is channel 1, channel 40 and channel 80. The measurement is repeated for all modulations.

Measurement parameters	
External result file	1-8822_19-01-05_log1_conducted.pdf 1-8822_19-01-05_log2_conducted.pdf FCC Part 15.247 TX Spurious Conducted
Test setup	See sub clause 8.4 A
Measurement uncertainty	See sub clause 9

### Limits:

FCC	IC
TX spurious emissions conducted	
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required	

**Results: Chain A**

TX spurious emissions conducted					
MSK - mode					
f [MHz]		amplitude of emission [dBm]	limit max. allowed emission power	actual attenuation below frequency of operation [dB]	results
2401.4		8.9	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2402.4		10.8	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2403.4		11.9	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2404.4		13.8	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2412.4		15.3	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2440.4		17.1	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2474.4		3.8	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2477.4		1.6	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2478.4		-4.2	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2479.4		-3.2	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2480.4		-4.6	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant

**Results: Chain B**

TX spurious emissions conducted					
MSK - mode					
f [MHz]		amplitude of emission [dBm]	limit max. allowed emission power	actual attenuation below frequency of operation [dB]	results
2401.4		6.5	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2402.4		8.0	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2404.4		9.6	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2419.4		7.8	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2440.4		16.0	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2474.4		6.0	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2477.4		0.5	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2478.4		-1.7	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2479.4		-3.6	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant
2480.4		-5.2	30 dBm		Operating frequency
All detected emissions are below the -20 dBc criteria. Please take a look at the plot!			-20 dBc		compliant

## 12.9 Spurious emissions radiated below 30 MHz

### Description:

Measurement of the radiated spurious emissions in transmit mode below 30 MHz. The EUT is set to single channel mode and the transmit channels are 00; 39 and 78. The measurement is performed in the mode with the highest output power. The limits are recalculated to a measurement distance of 3 m according the ANSI C63.10.

Measurement parameters	
Detector	Peak / Quasi peak
Sweep time	Auto
Resolution bandwidth	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Video bandwidth	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span	9 kHz to 30 MHz
Trace mode	Max hold
Test setup	See sub clause 8.2 C
Measurement uncertainty	See sub clause 9

### Limits:

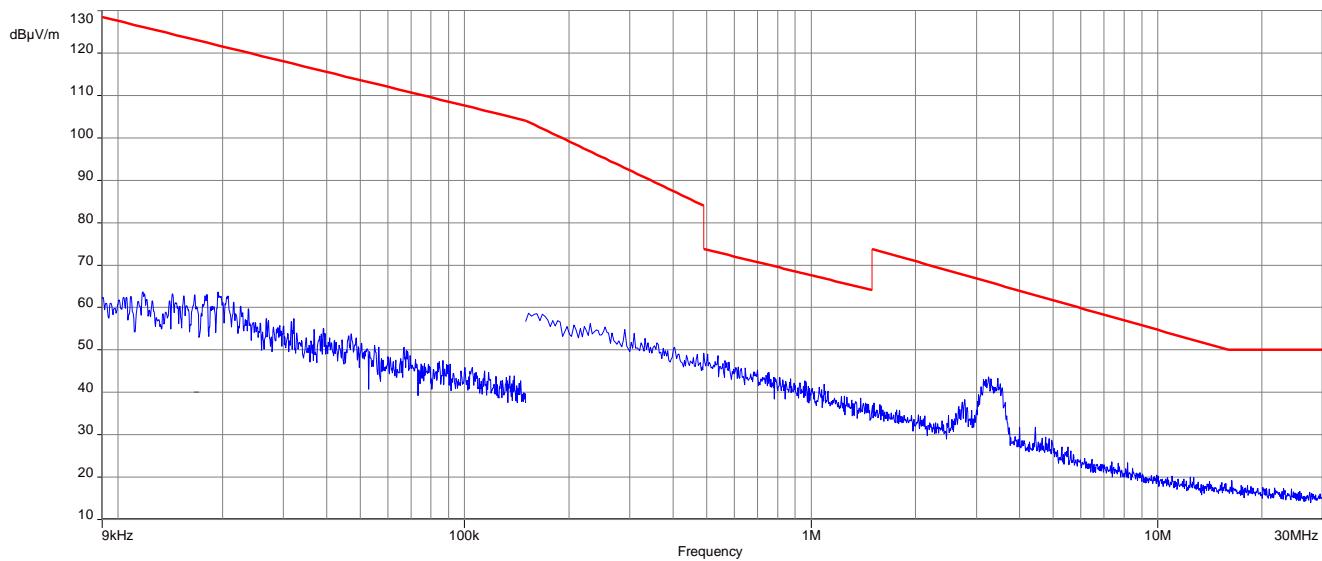
FCC	IC	
TX spurious emissions radiated below 30 MHz		
Frequency (MHz)	Field strength (dB $\mu$ V/m)	Measurement distance
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30

### Results:

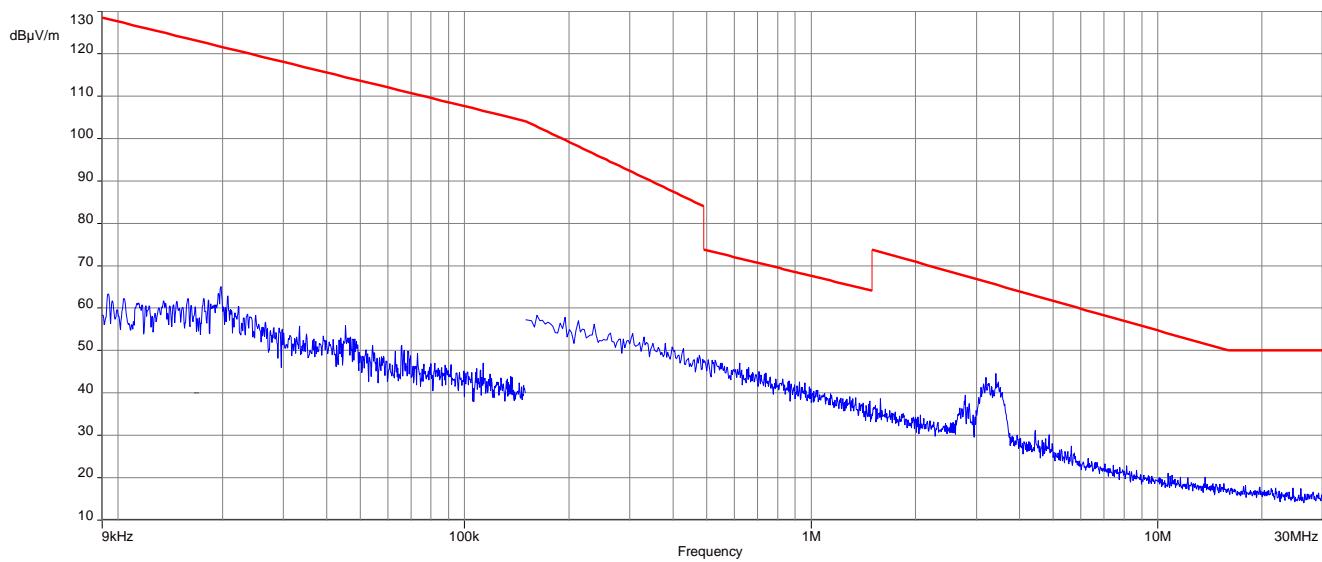
TX spurious emissions radiated below 30 MHz [dB $\mu$ V/m]		
F [MHz]	Detector	Level [dB $\mu$ V/m]
All detected emissions are more than 20 dB below the limit.		

**Plots:**

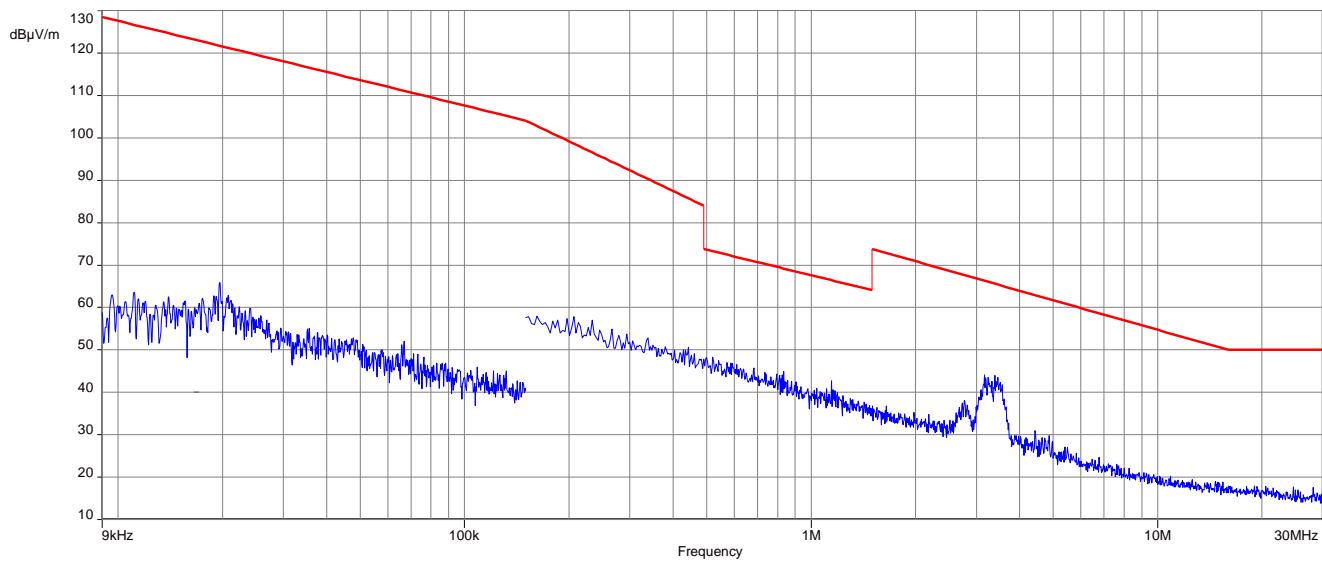
**Plot 1: 9 kHz to 30 MHz, channel 1, Chain A**



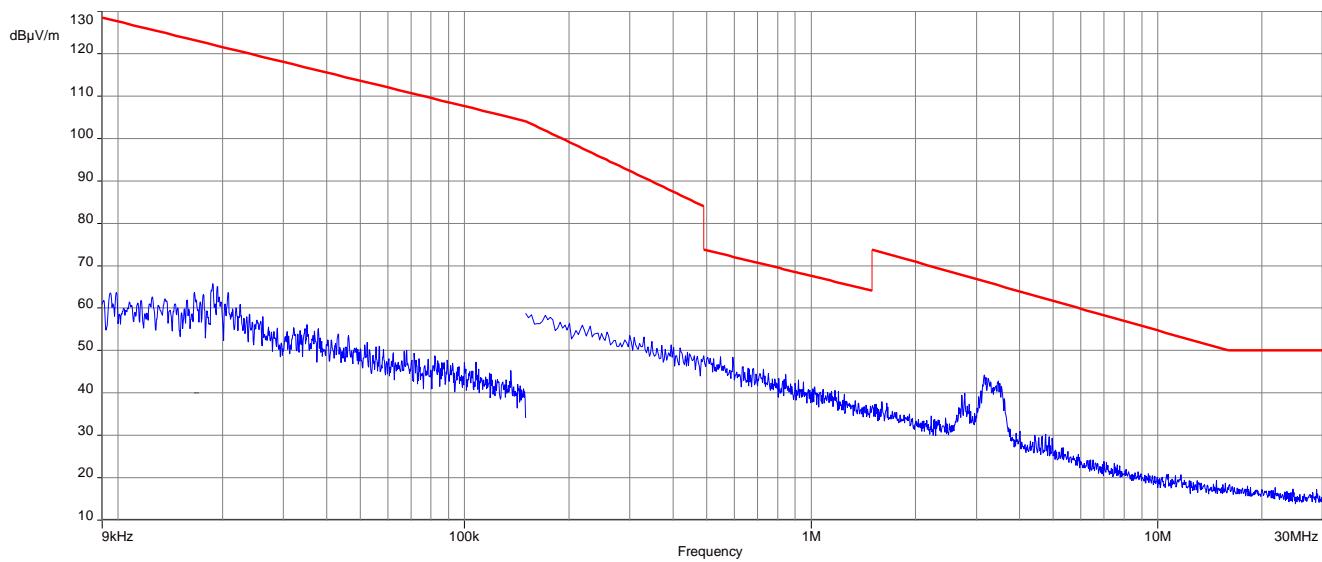
**Plot 2: 9 kHz to 30 MHz, channel 40, Chain A**



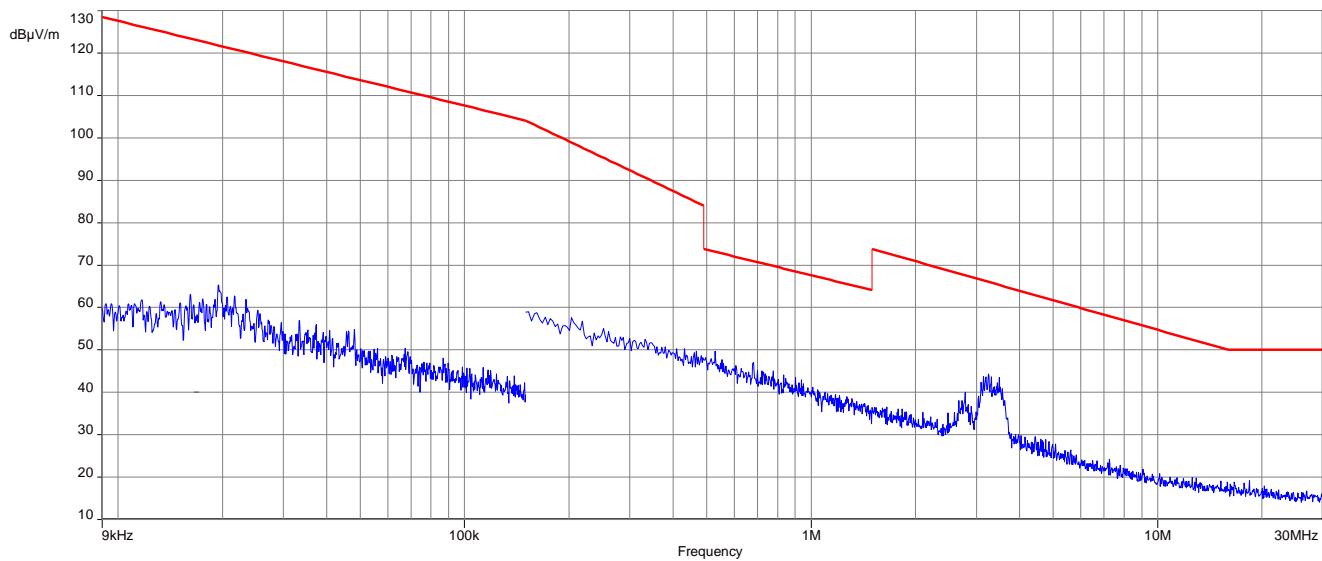
**Plot 3: 9 kHz to 30 MHz, channel 80, Chain A**



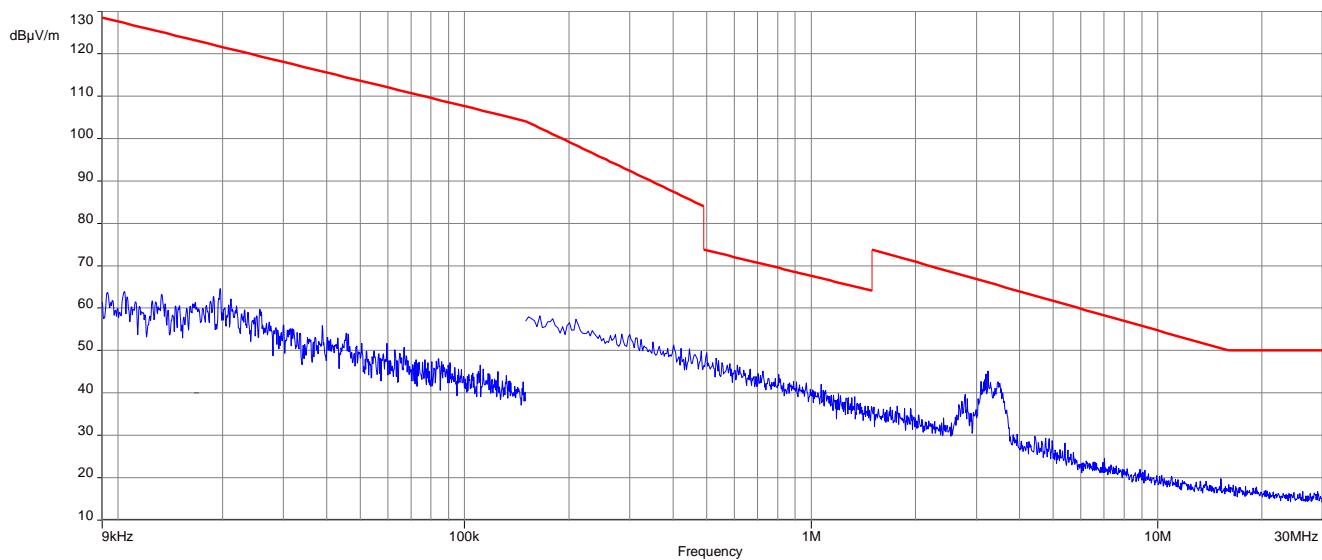
**Plot 4: 9 kHz to 30 MHz, channel 1, Chain B**



**Plot 5: 9 kHz to 30 MHz, channel 40, Chain B**



**Plot 6: 9 kHz to 30 MHz, channel 80, Chain B**



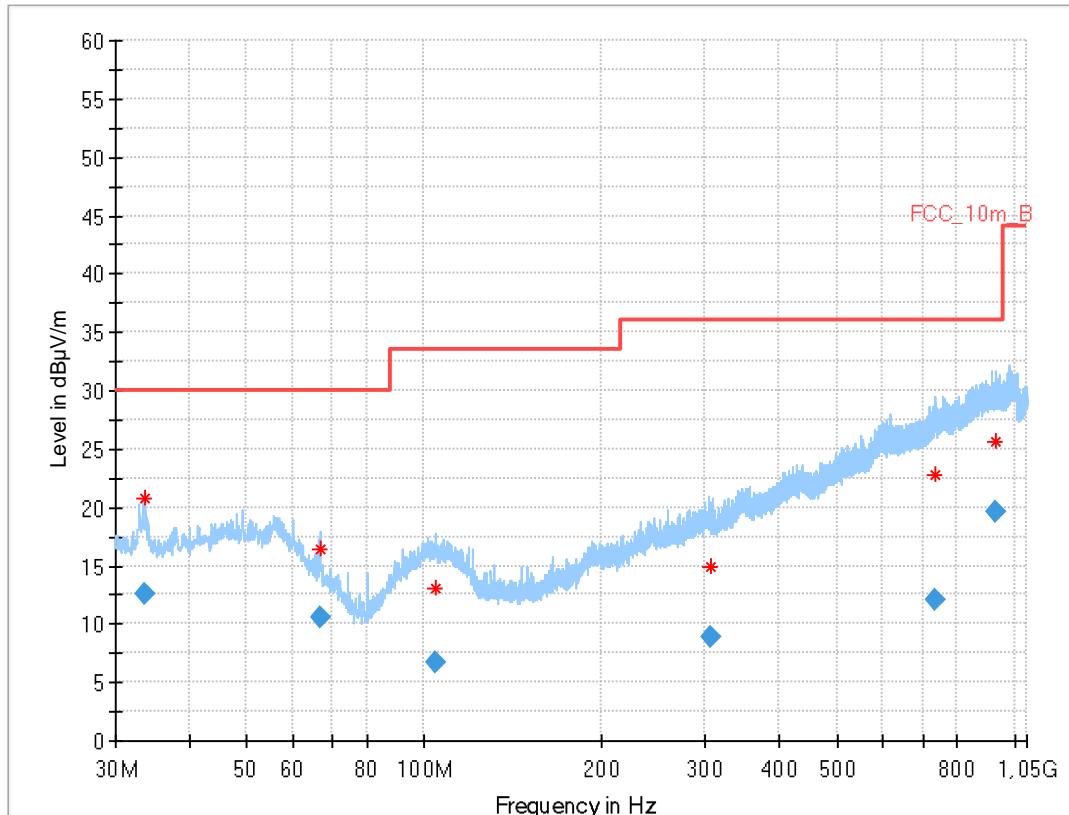
## 12.10 Spurious emissions radiated 30 MHz to 1 GHz

Measurement parameters	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	120 kHz
Video bandwidth	3 x RBW
Span	30 MHz to 1 GHz
Trace mode	Max hold
Test setup	See sub clause 8.1 A
Measurement uncertainty	See sub clause 9

### Limits:

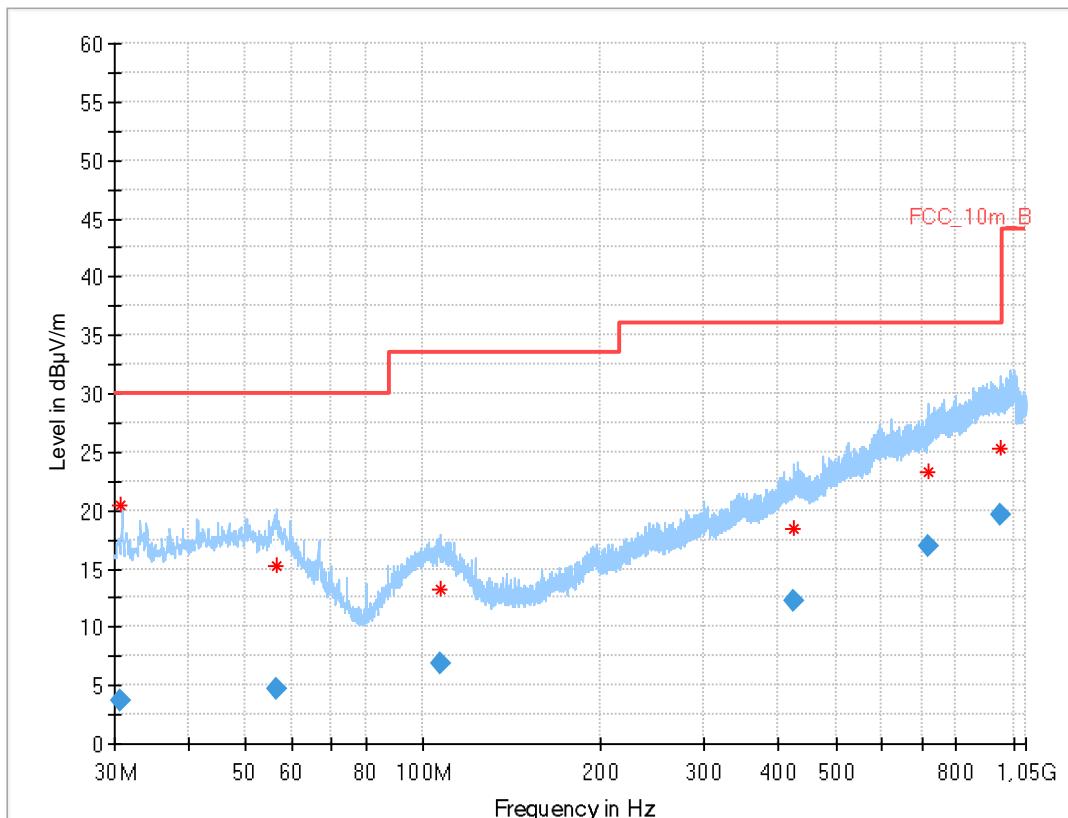
FCC	IC	
TX spurious emissions radiated		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).		
§15.209		
Frequency (MHz)	Field strength (dB $\mu$ V/m)	Measurement distance
30 - 88	30.0	10
88 - 216	33.5	10
216 - 960	36.0	10
Above 960	54.0	3

**Plots:** Transmit mode

**Plot 1:** 30 MHz to 1 GHz, TX mode, channel 1, vertical & horizontal polarization, both Chains active

**Final results:**

Frequency (MHz)	QuasiPeak (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
33.586	12.65	30.0	17.4	1000	120.0	149.0	V	129	12
66.572	10.59	30.0	19.4	1000	120.0	276.0	V	134	11
104.175	6.68	33.5	26.8	1000	120.0	200.0	V	238	13
305.475	8.91	36.0	27.1	1000	120.0	116.0	H	0	14
735.280	12.15	36.0	23.9	1000	120.0	204.0	V	29	22
931.247	19.61	36.0	16.4	1000	120.0	400.0	H	290	24

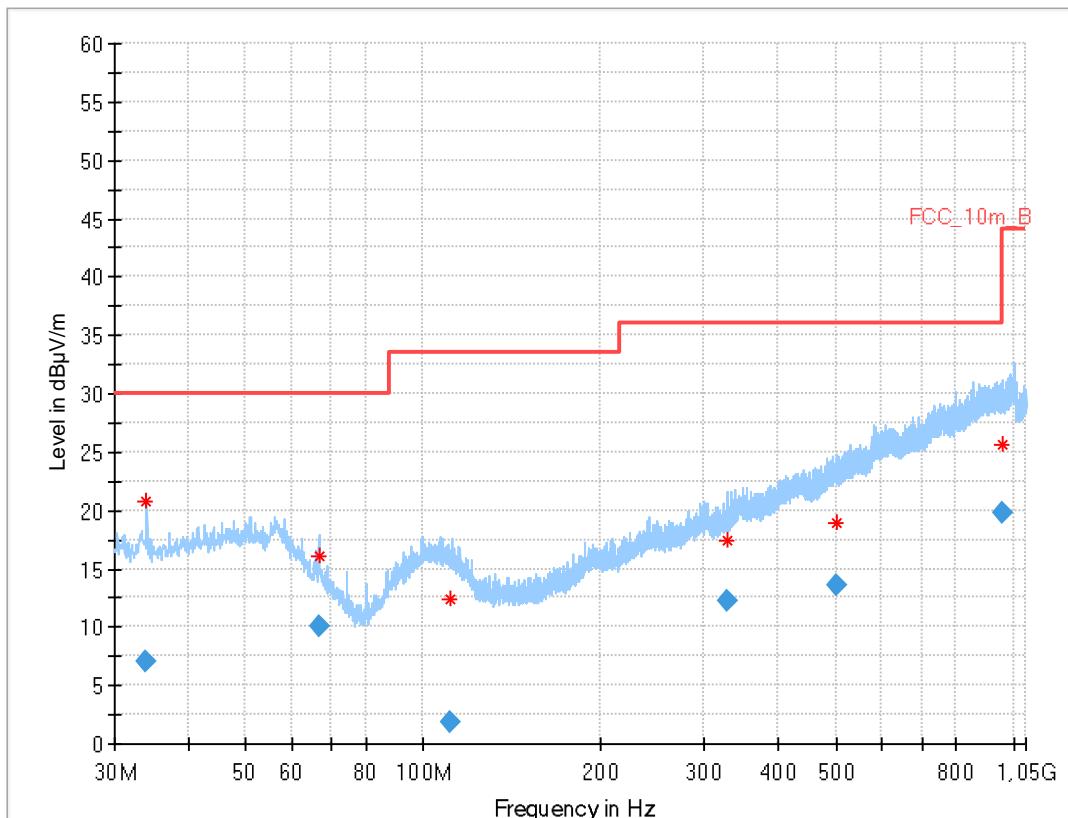
**Plot 2: 30 MHz to 1 GHz, TX mode, channel 40, vertical & horizontal polarization, both Chains active**



#### Final results:

Frequency (MHz)	QuasiPeak (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
30.608	3.74	30.0	26.3	1000	120.0	120.0	V	195	12
56.614	4.67	30.0	25.3	1000	120.0	200.0	V	155	15
107.063	6.84	33.5	26.7	1000	120.0	400.0	V	-45	13
424.450	12.31	36.0	23.7	1000	120.0	200.0	V	0	17
717.043	16.85	36.0	19.2	1000	120.0	200.0	V	135	21
950.102	19.61	36.0	16.4	1000	120.0	250.0	V	90	24

**Plot 3: 30 MHz to 1 GHz, TX mode, channel 80, vertical & horizontal polarization, both Chains active**



#### Final results:

Frequency (MHz)	QuasiPeak (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
33.948	6.97	30.0	23.0	1000	120.0	200.0	V	54	12
66.547	10.07	30.0	19.9	1000	120.0	275.0	V	45	11
111.098	1.85	33.5	31.7	1000	120.0	200.0	V	270	12
327.992	12.29	36.0	23.7	1000	120.0	161.0	V	45	15
501.501	13.55	36.0	22.5	1000	120.0	200.0	V	45	18
959.343	19.78	36.0	16.2	1000	120.0	200.0	H	45	24

## 12.11 Spurious emissions radiated above 1 GHz

### Description:

Measurement of the radiated spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit channel is channel 1, channel 40 and channel 80.

Measurement parameters	
Detector	Peak / RMS
Sweep time	Auto
Resolution bandwidth	1 MHz
Video bandwidth	3 x RBW
Span	1 GHz to 26 GHz
Trace mode	Max hold
Test setup	See sub clause 8.2 A (1 GHz - 18 GHz) See sub clause 8.3 A (18 GHz - 26 GHz)
Measurement uncertainty	See sub clause 9

### Limits:

FCC	IC	
TX spurious emissions radiated		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).		
§15.209		
Frequency (MHz)	Field strength (dB $\mu$ V/m)	Measurement distance
Above 960	54.0	3

**Results:** Transmitter mode, Chain A

TX spurious emissions radiated [dB $\mu$ V/m]								
2401.4 MHz			2440.4 MHz			2480.4 MHz		
F [MHz]	Detector	Level [dB $\mu$ V/m]	F [MHz]	Detector	Level [dB $\mu$ V/m]	F [MHz]	Detector	Level [dB $\mu$ V/m]
-/-	Peak	-/-	2842	Peak	44.4	-/-	Peak	-/-
	AVG	-/-		AVG	32.6		AVG	-/-
-/-	Peak	-/-	7321	Peak	60.3	-/-	Peak	-/-
	AVG	-/-		AVG	34.6*		AVG	-/-
-/-	Peak	-/-	-/-	Peak	-/-	-/-	Peak	-/-
	AVG	-/-		AVG	-/-		AVG	-/-

\*) Average emission adjusting factor:

$$F = 20 * \log (\text{dwell time} / 100 \text{ ms})$$

The pulse width of one transmission is 2.6 ms. In a period of 100 ms a maximum of 2 transmissions is possible and that implies a correction factor for spurious measurement emissions:

$$F = 20 * \log (2 * 2.6 / 100) = -25.7 \text{ dB}$$

**Results:** Transmitter mode, Chain B

TX spurious emissions radiated [dB $\mu$ V/m]								
2401.4 MHz			2440.4 MHz			2480.4 MHz		
F [MHz]	Detector	Level [dB $\mu$ V/m]	F [MHz]	Detector	Level [dB $\mu$ V/m]	F [MHz]	Detector	Level [dB $\mu$ V/m]
-/-	Peak	-/-	4880	Peak	60.6	-/-	Peak	-/-
	AVG	-/-		AVG	34.9*		AVG	-/-
-/-	Peak	-/-	7321	Peak	59.4	-/-	Peak	-/-
	AVG	-/-		AVG	33.7*		AVG	-/-
-/-	Peak	-/-	12201	Peak	59.2	-/-	Peak	-/-
	AVG	-/-		AVG	33.5*		AVG	-/-

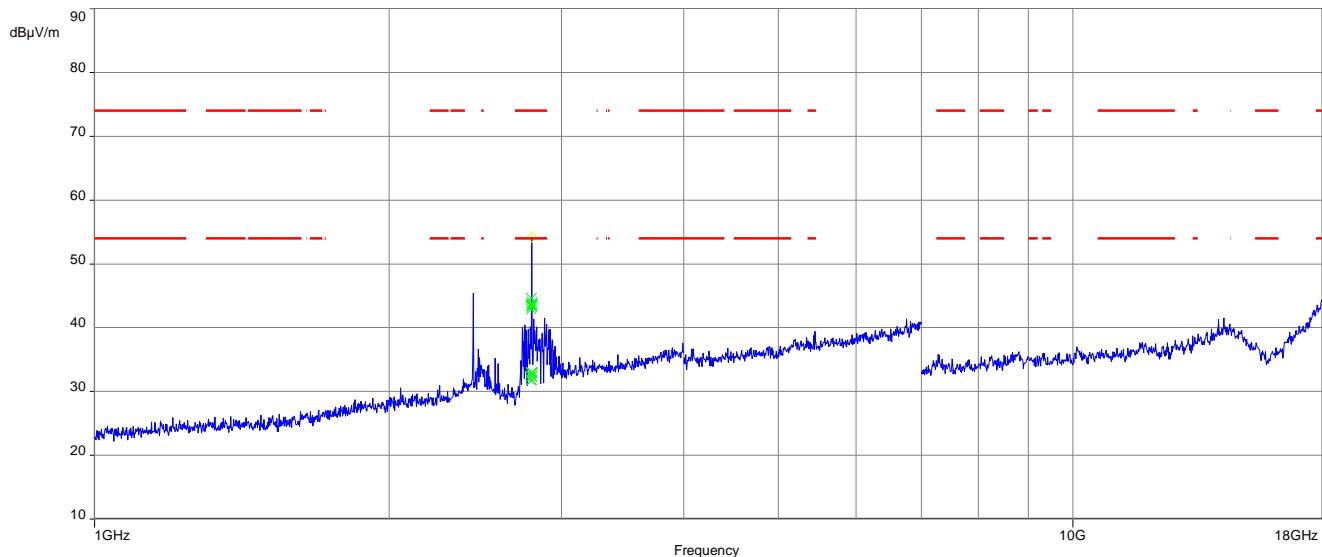
\*) Average emission adjusting factor:

$$F = 20 * \log (\text{dwell time} / 100 \text{ ms})$$

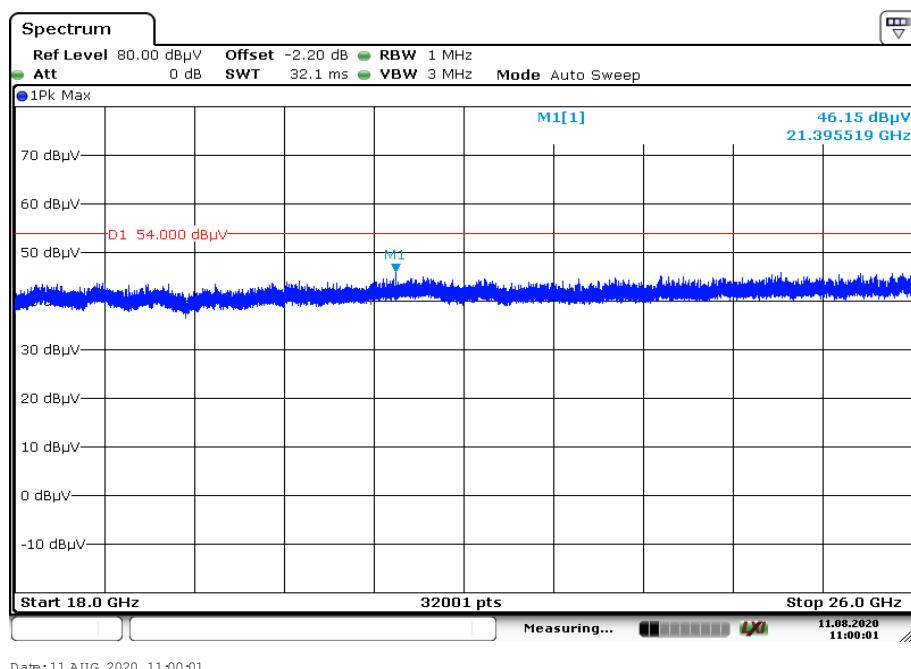
In a period of 100 ms, we have a maximum of transmission and that implies a correction factor for spurious measurement emissions:

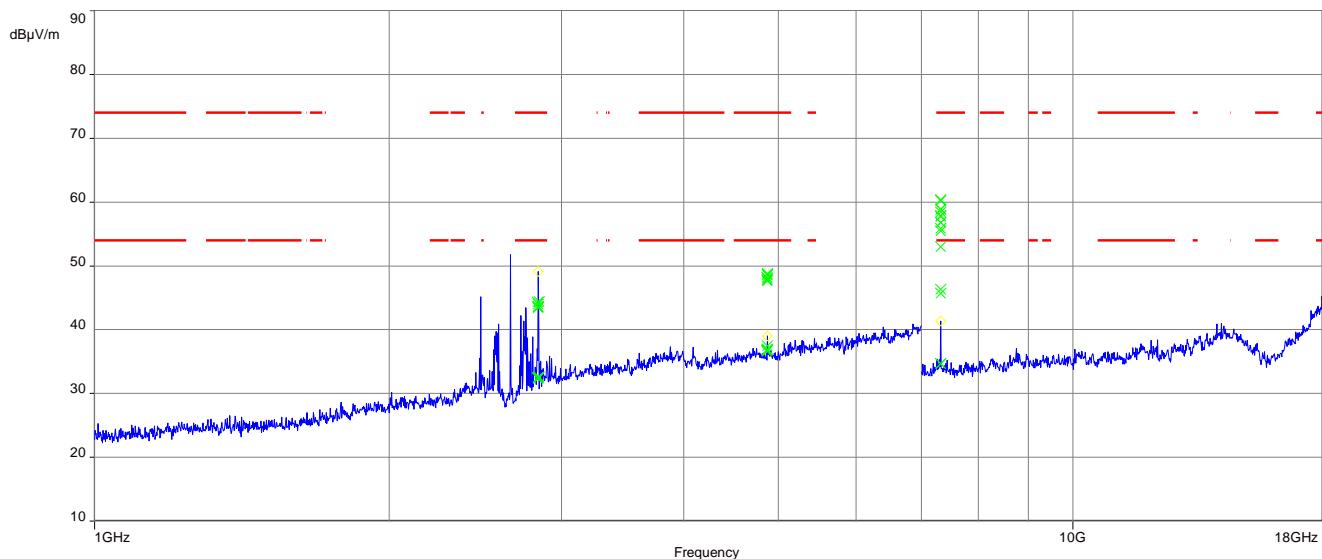
$$F = 20 * \log (1 * / 100) = - \text{dB}$$

**Plots:** Transmitter mode

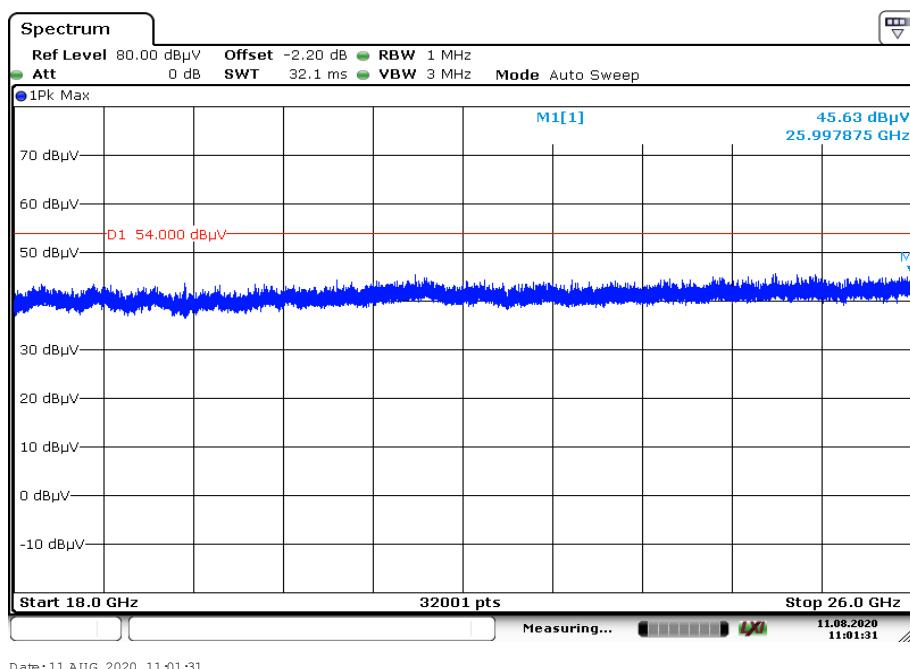
**Plot 1:** 1 GHz to 18 GHz, TX mode, channel 1, vertical & horizontal polarization, Chain A


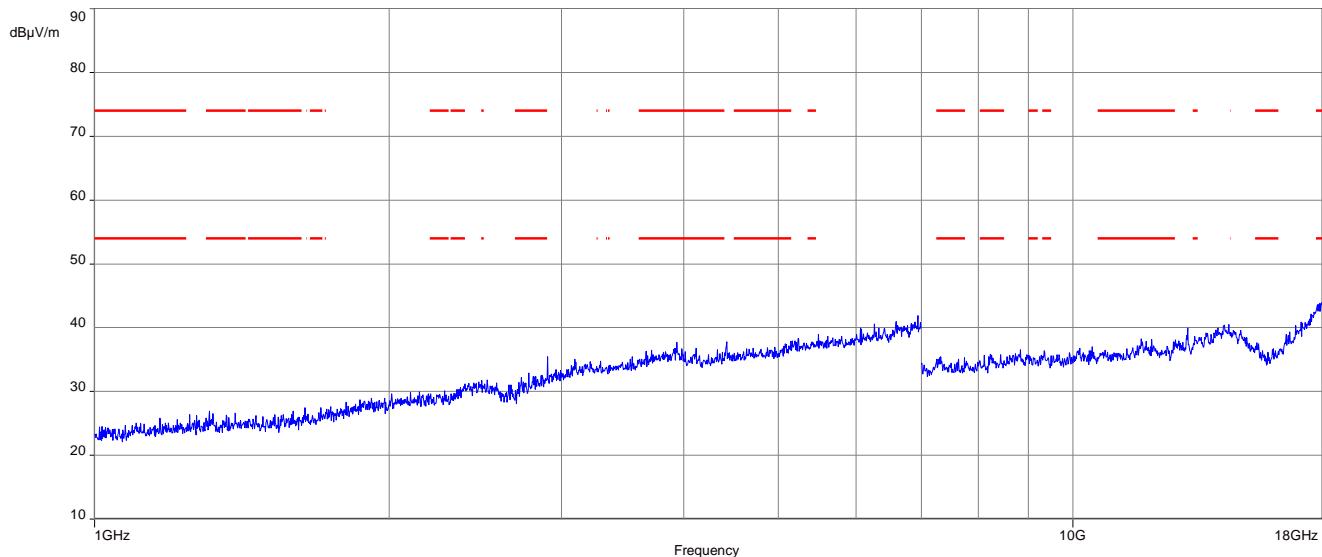
The carrier signal is notched with a 2.4 GHz band rejection filter.

**Plot 2:** 18 GHz to 26 GHz, TX mode, channel 1, vertical & horizontal polarization, Chain A


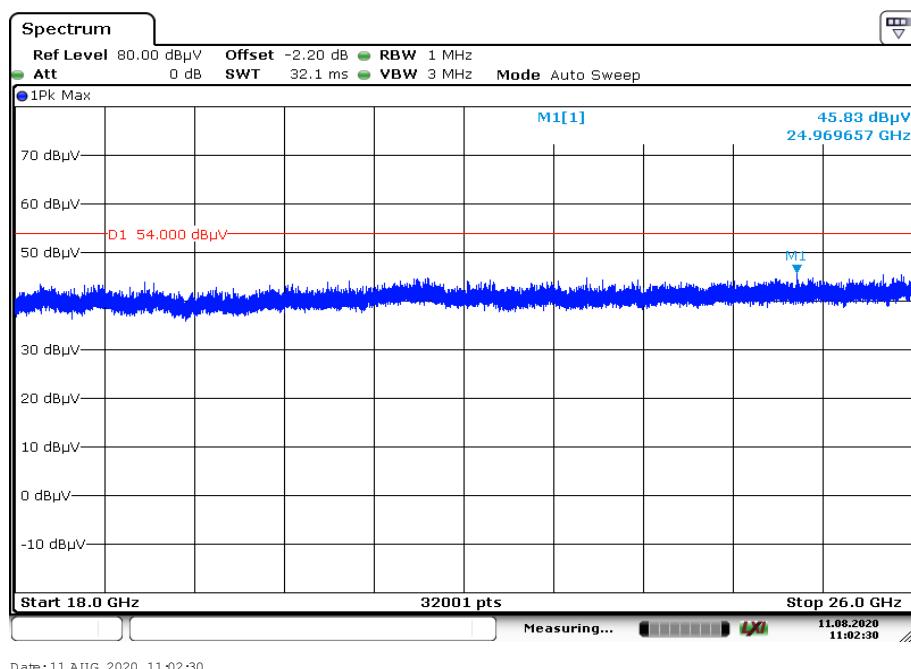
**Plot 3:** 1 GHz to 18 GHz, TX mode, channel 40, vertical & horizontal polarization, Chain A


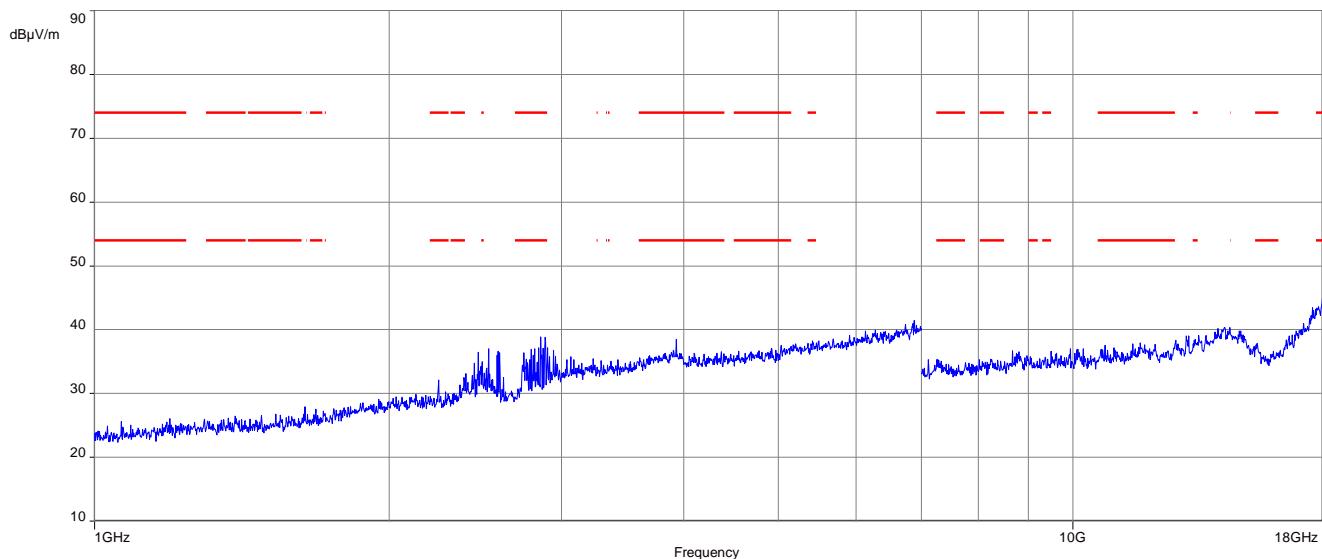
The carrier signal is notched with a 2.4 GHz band rejection filter.

**Plot 4:** 18 GHz to 26 GHz, TX mode, channel 40, vertical & horizontal polarization, Chain A


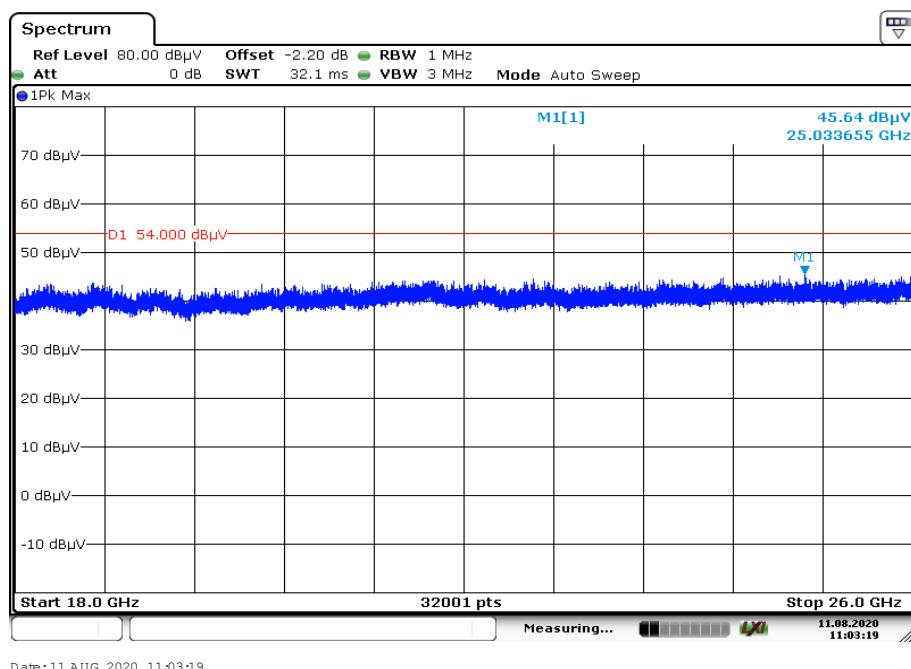
**Plot 5:** 1 GHz to 18 GHz, TX mode, channel 80, vertical & horizontal polarization, Chain A


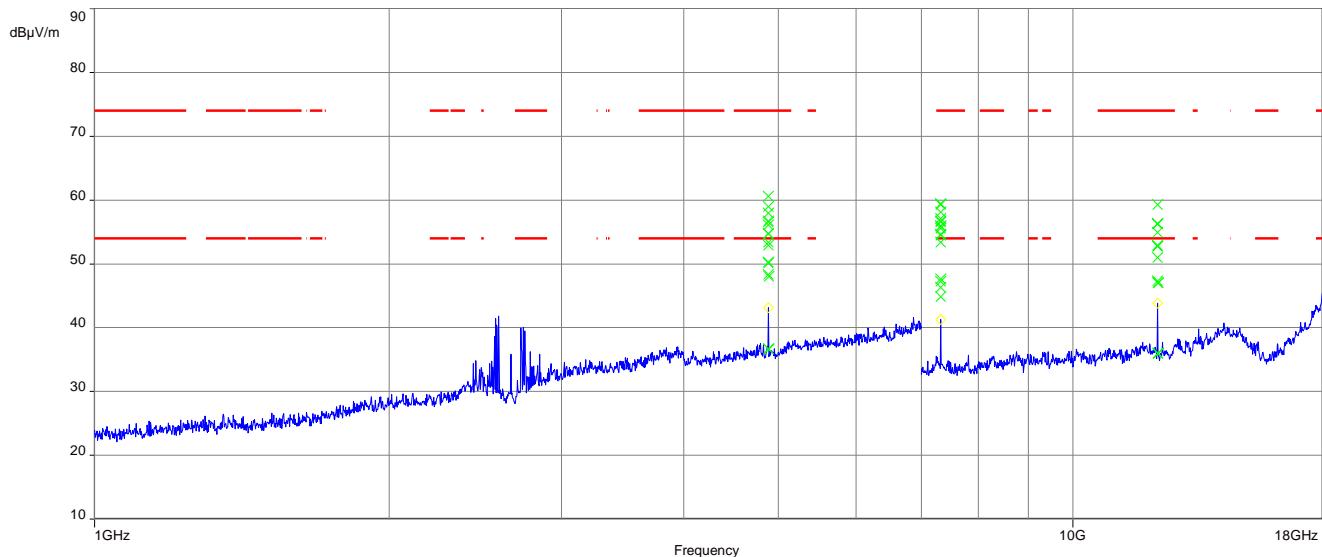
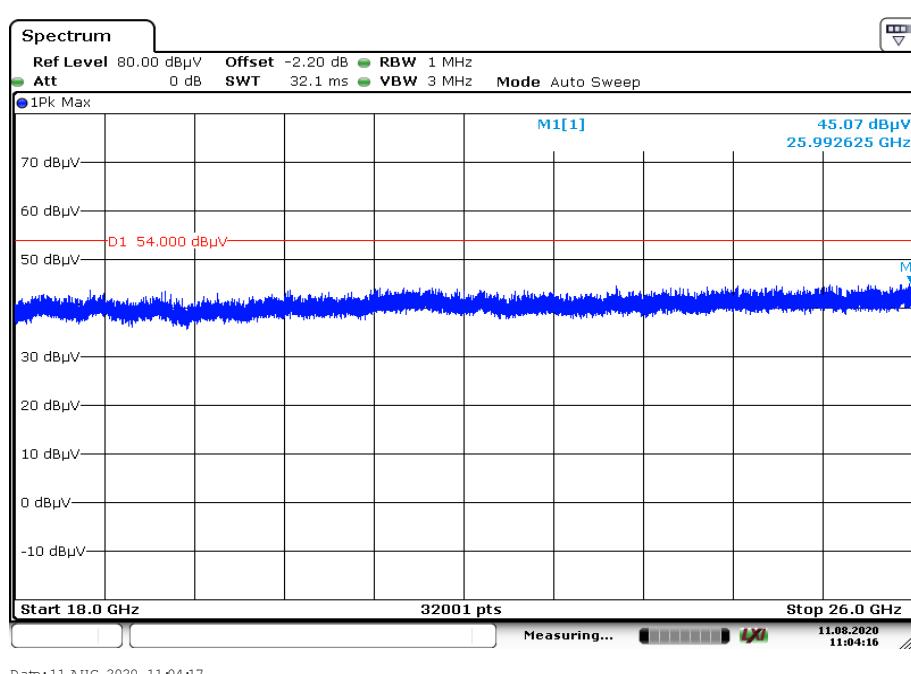
The carrier signal is notched with a 2.4 GHz band rejection filter.

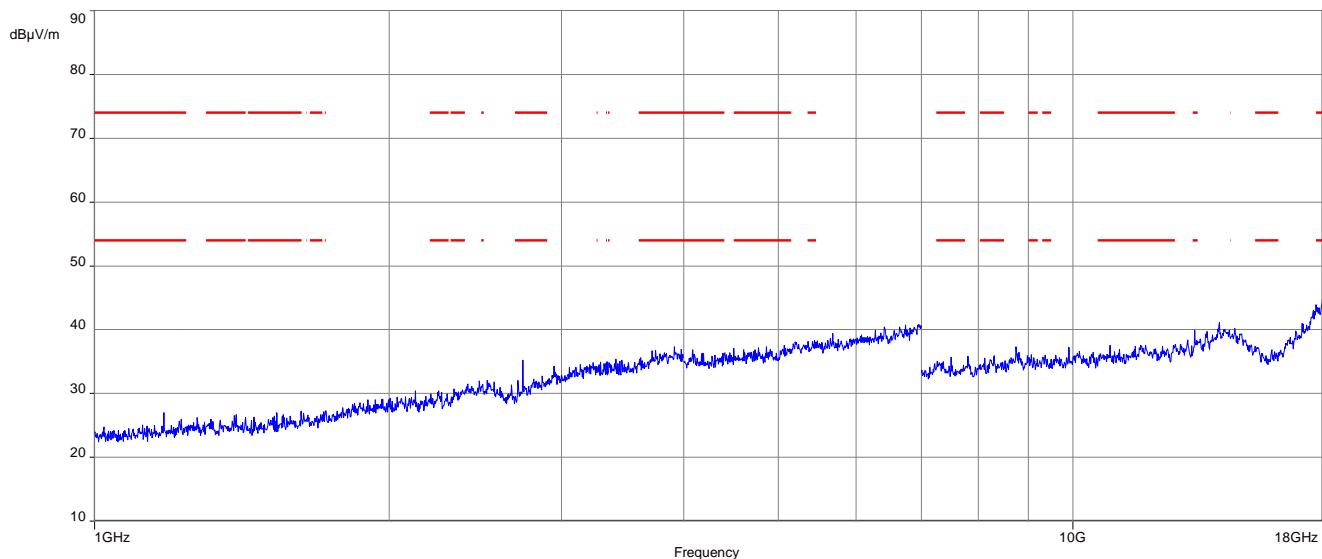
**Plot 6:** 18 GHz to 26 GHz, TX mode, channel 80, vertical & horizontal polarization, Chain A


**Plot 7:** 1 GHz to 18 GHz, TX mode, channel 1, vertical & horizontal polarization, Chain B

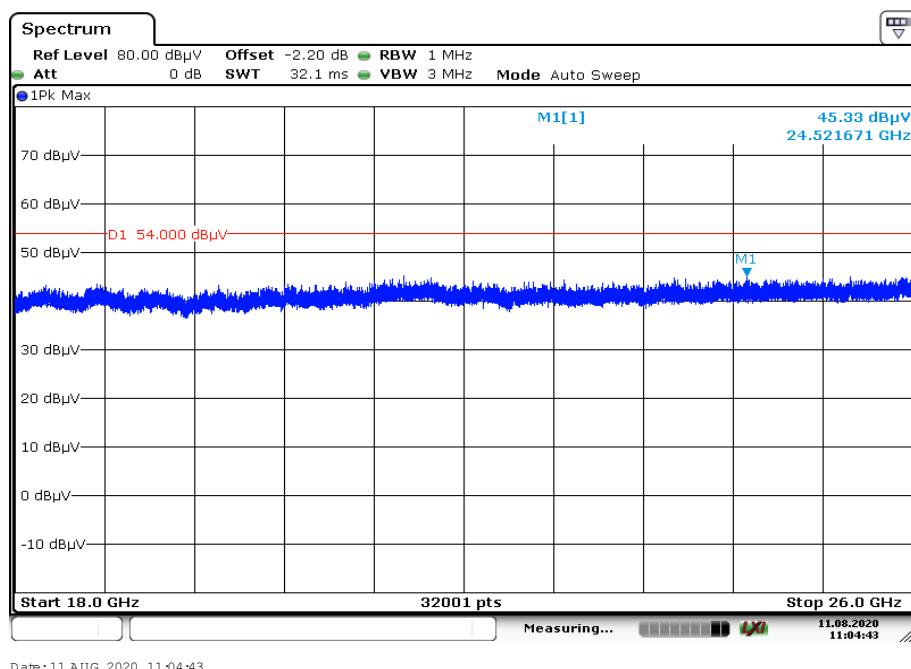
The carrier signal is notched with a 2.4 GHz band rejection filter.

**Plot 8:** 18 GHz to 26 GHz, TX mode, channel 1, vertical & horizontal polarization, Chain B

**Plot 9:** 1 GHz to 18 GHz, TX mode, channel 40, vertical & horizontal polarization, Chain B**Plot 10:** 18 GHz to 26 GHz, TX mode, channel 40, vertical & horizontal polarization, Chain B

**Plot 11:** 1 GHz to 18 GHz, TX mode, channel 80, vertical & horizontal polarization, Chain B


The carrier signal is notched with a 2.4 GHz band rejection filter.

**Plot 12:** 18 GHz to 26 GHz, TX mode, channel 80, vertical & horizontal polarization, Chain B


## 13 Glossary

<b>EUT</b>	Equipment under test
<b>DUT</b>	Device under test
<b>UUT</b>	Unit under test
<b>GUE</b>	GNSS User Equipment
<b>ETSI</b>	European Telecommunications Standards Institute
<b>EN</b>	European Standard
<b>FCC</b>	Federal Communications Commission
<b>FCC ID</b>	Company Identifier at FCC
<b>IC</b>	Industry Canada
<b>PMN</b>	Product marketing name
<b>HMN</b>	Host marketing name
<b>HVIN</b>	Hardware version identification number
<b>FVIN</b>	Firmware version identification number
<b>EMC</b>	Electromagnetic Compatibility
<b>HW</b>	Hardware
<b>SW</b>	Software
<b>Inv. No.</b>	Inventory number
<b>S/N or SN</b>	Serial number
<b>C</b>	Compliant
<b>NC</b>	Not compliant
<b>NA</b>	Not applicable
<b>NP</b>	Not performed
<b>PP</b>	Positive peak
<b>QP</b>	Quasi peak
<b>AVG</b>	Average
<b>OC</b>	Operating channel
<b>OCW</b>	Operating channel bandwidth
<b>OBW</b>	Occupied bandwidth
<b>OOB</b>	Out of band
<b>DFS</b>	Dynamic frequency selection
<b>CAC</b>	Channel availability check
<b>OP</b>	Occupancy period
<b>NOP</b>	Non occupancy period
<b>DC</b>	Duty cycle
<b>PER</b>	Packet error rate
<b>CW</b>	Clean wave
<b>MC</b>	Modulated carrier
<b>WLAN</b>	Wireless local area network
<b>RLAN</b>	Radio local area network
<b>DSSS</b>	Dynamic sequence spread spectrum
<b>OFDM</b>	Orthogonal frequency division multiplexing
<b>FHSS</b>	Frequency hopping spread spectrum
<b>GNSS</b>	Global Navigation Satellite System
<b>C/N<sub>0</sub></b>	Carrier to noise-density ratio, expressed in dB-Hz

## 14 Document history

Version	Applied changes	Date of release
-/-	Initial release	2020-10-29

## 15 Accreditation Certificate – D-PL-12076-01-04

first page	last page
 <p>Deutsche Akkreditierungsstelle GmbH</p> <p>Entrusted according to Section 8 subsection 1 AkkStelleG in connection with Section 1 subsection 1 AkkStelleGBV Signatory to the Multilateral Agreements of EA, ILAC and IAF for Mutual Recognition</p> <p><b>Accreditation</b> </p> <p>The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory</p> <p><b>CTC advanced GmbH</b> Untertürkheimer Straße 6-10, 66117 Saarbrücken</p> <p>is competent under the terms of DIN EN ISO/IEC 17025:2018 to carry out tests in the following fields:</p> <p>Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards</p> <p>The accreditation certificate shall only apply in connection with the notice of accreditation of 09.06.2020 with the accreditation number D-PL-12076-01. It comprises the cover sheet, the reverse side of the cover sheet and the following annex with a total of 07 pages.</p> <p>Registration number of the certificate: D-PL-12076-01-04</p> <p>Frankfurt am Main, 09.06.2020</p> <p>by order of Dipl.-Ing. (FH) Ralf Egner Head of Division</p> <p><small>The certificate together with its annex reflects the status at the time of the date of issue. The current status of the scope of accreditation can be found in the database of accredited bodies of Deutsche Akkreditierungsstelle GmbH. <a href="https://www.dakks.de/en/content/accredited-bodies-dakks">https://www.dakks.de/en/content/accredited-bodies-dakks</a> See notes section.</small></p>	<p>Deutsche Akkreditierungsstelle GmbH</p> <p>Office Berlin Spittelmarkt 10 10117 Berlin</p> <p>Office Frankfurt am Main Europa-Allee 52 60327 Frankfurt am Main</p> <p>Office Braunschweig Bundesallee 100 38116 Braunschweig</p> <p>The publication of extracts of the accreditation certificate is subject to the prior written approval by Deutsche Akkreditierungsstelle GmbH (DAkkS). Exempted is the unchanged form of separate disseminations of the cover sheet by the conformity assessment body mentioned overleaf.</p> <p>No impression shall be made that the accreditation also extends to fields beyond the scope of accreditation attested by DAkkS.</p> <p>The accreditation was granted pursuant to the Act on the Accreditation Body (AkkStelleG) of 31 July 2009 (Federal Law Gazette I p. 2625) and the Regulation (EU) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products (Official Journal of the European Union L 218 of 9 July 2008, p. 30). DAkkS is a signatory to the Multilateral Agreements for Mutual Recognition of the European co-operation for Accreditation (EA), International Accreditation Forum (IAF) and International Laboratory Accreditation Cooperation (ILAC). The signatories to these agreements recognise each other's accreditations.</p> <p>The up-to-date state of membership can be retrieved from the following websites: EA: <a href="http://www.european-accreditation.org">www.european-accreditation.org</a> ILAC: <a href="http://www.ilac.org">www.ilac.org</a> IAF: <a href="http://www.iaf.nu">www.iaf.nu</a></p>

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<https://www.dakks.de/as/ast/d/D-PL-12076-01-04e.pdf>

## 16 Accreditation Certificate – D-PL-12076-01-05

first page	last page
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##### END OF TEST REPORT #####