

TEST REPORT

BNetzA-CAB-02/21-102

Test report no.: 1-9746/19-01-05-A

Testing laboratory

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Accredited Testing Laboratory:

The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2005) 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

Mahr GmbH

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Test standard/s

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

RSS - 210 Issue 10 Radio Standards Specification - Licence-Exempt Radio Apparatus: Category II Equipment

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

Test Item

Kind of test item: Digital Caliper / Universal Caliper

Model name: MarCal 18EWRI; Multimar 25EWRI

FCC ID: N33MC1825EWRI

IC: 10315A-MC1825EWRI

Frequency: DTS band 2400 MHz to 2483.5 MHz

Technology tested: ANT+

Antenna: Integrated antenna

Power supply: 3.0 V DC by battery CR2032

Temperature range: +10°C to +45°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:

Michael Dorongovski
Lab Manager
Radio Communications

Test performed:

Marco Bertolino
Lab Manager
Radio Communications

1 Table of contents

1	Table of contents	2
2	General information	3
2.1	Notes and disclaimer	3
2.2	Application details	3
2.3	Test laboratories sub-contracted	3
3	Test standard/s, references and accreditations	4
4	Test environment	5
5	Test item	5
5.1	General description	5
5.2	Additional information	5
6	Sequence of testing	6
6.1	Sequence of testing radiated spurious 9 kHz to 30 MHz	6
6.2	Sequence of testing radiated spurious 30 MHz to 1 GHz	7
6.3	Sequence of testing radiated spurious 1 GHz to 18 GHz	8
6.4	Sequence of testing radiated spurious above 18 GHz	9
7	Description of the test setup.....	10
7.1	Shielded semi anechoic chamber	11
7.2	Shielded fully anechoic chamber.....	12
7.3	Radiated measurements > 18 GHz.....	13
7.4	Conducted measurements Bluetooth system	14
8	Summary of measurement results	15
9	Additional comments	16
10	EUT classification.....	17
11	Measurement results.....	18
11.1	Timing of the transmitter.....	18
11.2	Occupied bandwidth – 99% bandwidth.....	19
11.3	Maximum field strength	20
11.4	Band edge compliance radiated	21
11.5	Spurious emissions radiated < 30 MHz	23
11.6	Spurious emissions radiated 30 MHz to 1 GHz	26
11.7	Spurious emissions radiated above 1 GHz	31
12	Measurement uncertainty	37
13	Observations.....	37
Annex A	Glossary.....	38
Annex B	Document history	39
Annex C	Accreditation Certificate – D-PL-12076-01-04.....	39
Annex D	Accreditation Certificate – D-PL-12076-01-05.....	40

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 replaces the test report with the number 1-9746/19-01-05 and dated 2020-05-14.

2.2 Application details

Date of receipt of order:	2020-01-14
Date of receipt of test item:	2020-03-03
Start of test:	2020-03-05
End of test:	2020-03-13
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 - 210 Issue 10	12-2019	Radio Standards Specification - Licence-Exempt Radio Apparatus: Category II Equipment
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
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 https://www.dakks.de/as/ast/d/D-PL-12076-01-04.pdf   DAkkS Deutsche Akkreditierungsstelle D-PL-12076-01-04
D-PL-12076-01-05	Telecommunication FCC requirements https://www.dakks.de/as/ast/d/D-PL-12076-01-05.pdf   DAkkS Deutsche Akkreditierungsstelle D-PL-12076-01-05

4 Test environment

Temperature :	T_{nom} T_{max} T_{min}	+24 °C during room temperature tests No tests under extreme environmental conditions required. No tests under extreme environmental conditions required.
Relative humidity content :		38 %
Barometric pressure :		1021 hpa
Power supply :	V_{nom} V_{max} V_{min}	3.0 V DC by battery CR2032 No tests under extreme environmental conditions required. No tests under extreme environmental conditions required.

5 Test item

5.1 General description

Kind of test item :	Digital Caliper / Universal Caliper	
Model name :	MarCal 18EWRI; Multimar 25EWRI	
HMN :	n/a	
PMN :	MarCal 18EWRI Multimar 25EWRI	
HVIN :	401.460.41.0101.0_00	
FVIN :	n/a	
S/N serial number :	Radiated unit:	02010260
	Conducted unit:	02010247
Hardware status :	401.460.41.0101.0_00	
Software status :	2	
Firmware status :	-/-	
Frequency band :	DTS band 2400 MHz to 2483.5 MHz	
Type of radio transmission :	DSSS	
Use of frequency spectrum :		
Type of modulation :	GFSK	
Number of channels :	3	
Antenna :	Integrated antenna	
Power supply :	3.0 V DC by battery CR2032	
Temperature range :	+10°C to +45°C	

5.2 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:

1-9746/19-01-01_AnnexA
 1-9746/19-01-01_AnnexB
 1-9746/19-01-01_AnnexD

6 Sequence of testing

6.1 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.

Premeasurement*

- 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.

6.2 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.

6.3 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.

6.4 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.

7 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).

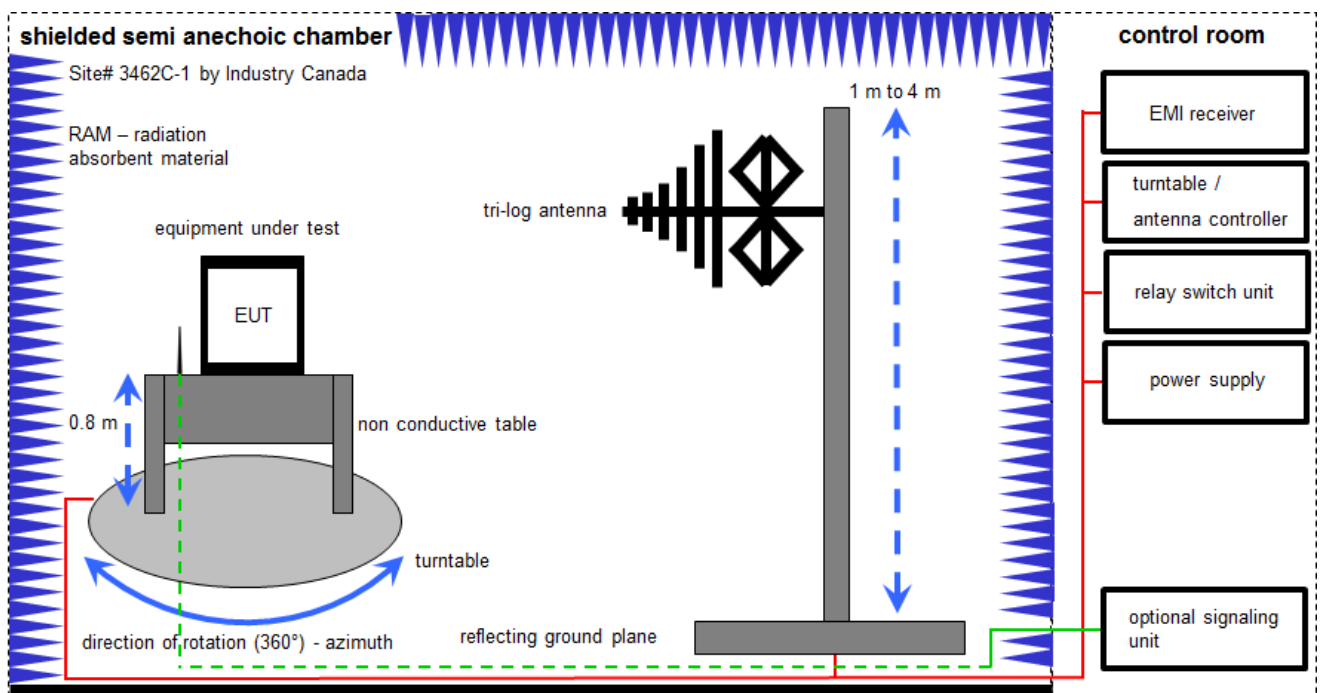
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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
vlk!	Attention: extended calibration interval		
NK!	Attention: not calibrated	*)	next calibration ordered / currently in progress

7.1 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)

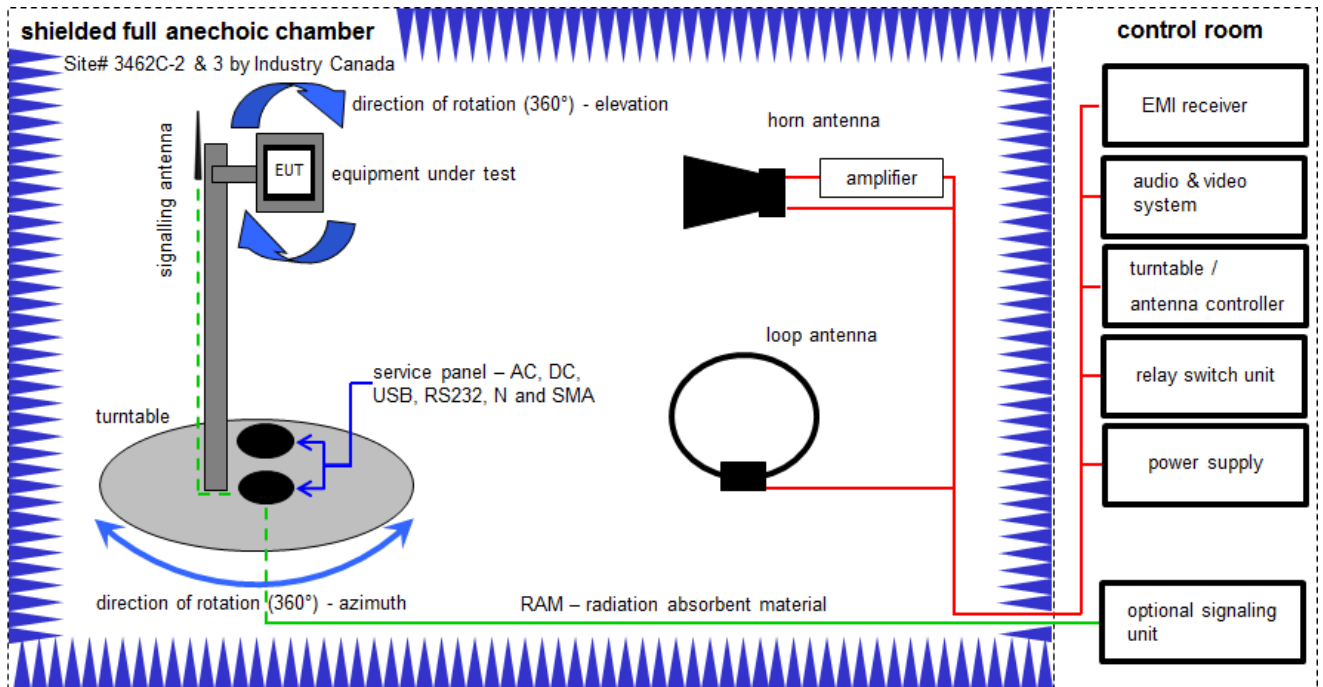
Example calculation:

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

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	Meßkabine 1	HF-Absorberhalle	MWB AG 300023	-/-	300000551	ne	-/-	-/-
3	A	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
4	A	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
5	A	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
6	A	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess-Elektronik	295	300003787	vKI!	19.02.2019	18.02.2021
7	A	Spectrum-Analyzer	FSU26	R&S	200809	300003874	k	16.12.2019	15.12.2020

7.2 Shielded fully anechoic chamber



Measurement distance: 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)

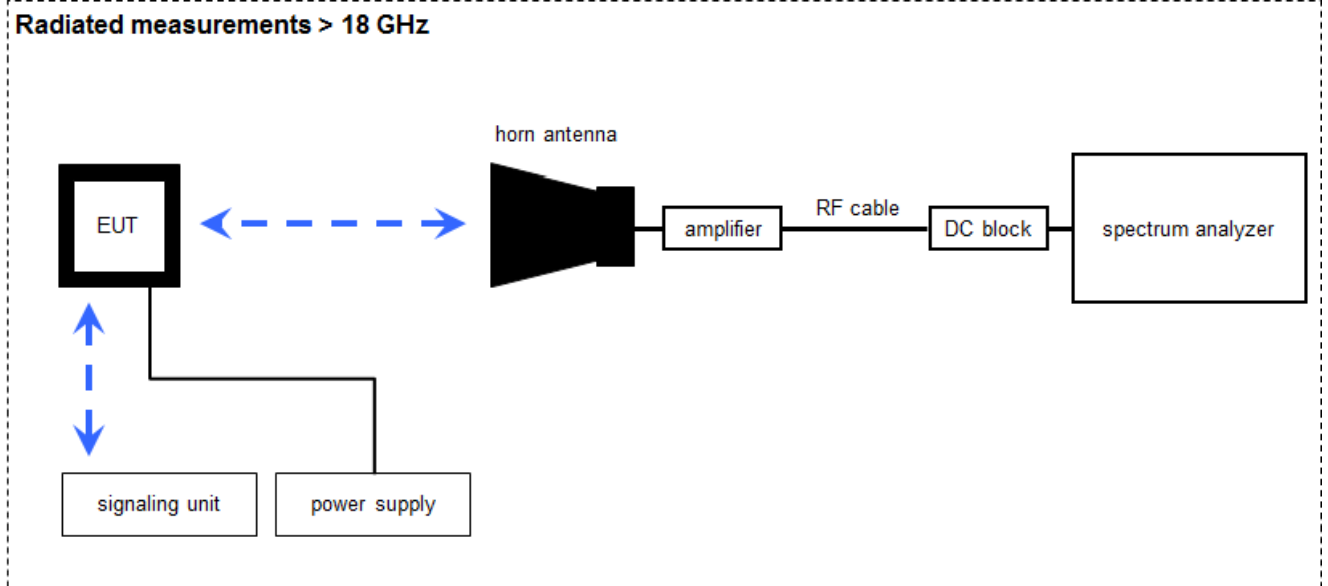
Example calculation:

FS [dBμV/m] = 40.0 [dBμV/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dBμV/m] (71.61 μV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A, B, C	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
2	A, B	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vKI!	27.02.2019	26.02.2021
3	A, B, C	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
4	C	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO/2	8905-2342	300000256	vKI!	11.04.2019	10.04.2021
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	WHK1.1/15G-10SS	Wainwright	3	300003255	ev	-/-	-/-
8	A	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	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 V3.19.1.19	EMCO	-/-	300004682	ne	-/-	-/-
12	A, B, C	PC	ExOne	F+W	-/-	300004703	ne	-/-	-/-
13	A	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-

7.3 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)

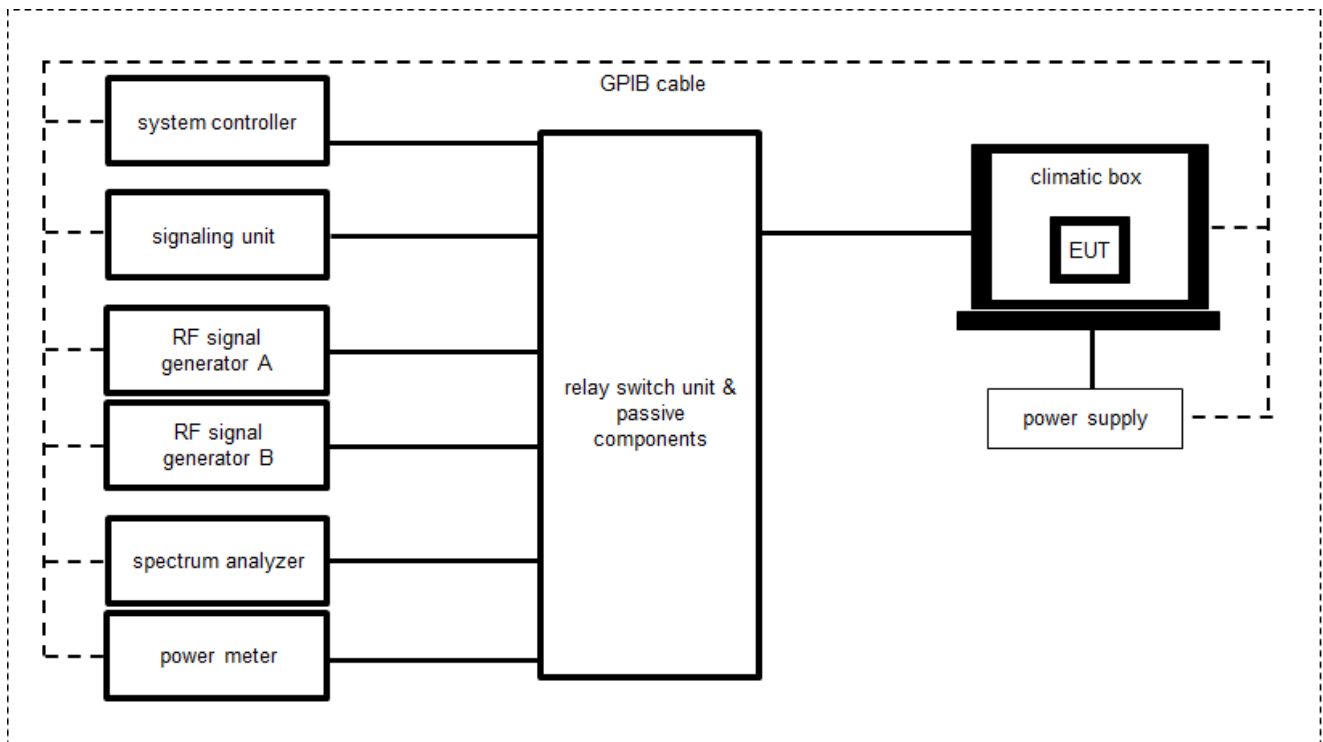
Example calculation:

FS [dB μ V/m] = 40.0 [dB μ V/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dB μ V/m] (6.79 μ V/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	vIKI!	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	Amplifier 2-40 GHz	JS32-02004000-57-5P	MITEQ	1777200	300004541	ev	-/-	-/-
5	A	RF-Cable	ST18/SMAm/SMAm /48	Huber & Suhner	Batch no. 600918	400001182	ev	-/-	-/-
6	A	RF-Cable	ST18/SMAm/SMAm /48	Huber & Suhner	Batch no. 127377	400001183	ev	-/-	-/-
7	A	DC-Blocker 0.1-40 GHz	8141A	Inmet	-/-	400001185	ev	-/-	-/-

7.4 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	Tester Software RadioStar (C.BER2 for BT Conformance)	Version 1.0.0.X	CTC advanced GmbH	0001	400001380	ne	-/-	-/-
2	A	Hygro-Thermometer	-/-, 5-45C, 20-100rF	Thies Clima	-/-	400000080	ev	11.05.2018	10.05.2020
3	A	PC Laboratory 19"	Exone i3	Fröhlich + Walter	35230157A0370	300004646	ne	-/-	-/-
4	A	Spectrum Analyzer	FSV30	Rohde & Schwarz	103170	300004855	vKI!	11.12.2018	10.12.2020
5	A	USB-GPIB-Interface	82357B	Agilent Technologies	MY54323070	300004852	ne	-/-	-/-

8 Summary of measurement results

☒	No deviations from the technical specifications were ascertained
☐	There were deviations from the technical specifications ascertained
☐	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 – 210 Issue 10	See table	2021-01-27	-/-

Test specification clause	Test case	Temperature & voltage conditions	Mode	C	NC	NA	NP	Remark
CFR 15.35 RSS Gen	Timing of the transmitter	Nominal	TX	☒	☐	☐	☐	-/-
RSS Gen	99% - Occupied Bandwidth	Nominal	TX	☒	☐	☐	☐	-/-
§15.249 RSS-210	Maximum field strength	Nominal	TX	☒	☐	☐	☐	-/-
§15.249 RSS-210	Band edge compliance radiated	Nominal	TX	☒	☐	☐	☐	-/-
§15.249 RSS-210	TX spurious emissions radiated	Nominal	TX	☒	☐	☐	☐	-/-
§15.109 RSS-Gen	RX spurious emissions radiated	Nominal	Idle	☒	☐	☐	☐	-/-
§15.209 RSS-Gen	Spurious emissions radiated < 30 MHz	Nominal	TX/Idle	☒	☐	☐	☐	-/-
§15.107 §15.207 RSS-Gen	Spurious emissions conducted < 30 MHz	Nominal	TX/Idle	☐	☐	☒	☐	-/-

C	Compliant	NC	Not compliant
NA	Not applicable	NP	Not performed

9 Additional comments

Reference documents: 1-9746_19-01-05_Annex_MR_A_1.pdf
Testmenu_manual_18EWRi_v1.docx

Special test descriptions: None

Configuration descriptions: None

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

EUT selection: ☒ Only one device available
☐ Devices selected by the customer
☐ Devices selected by the laboratory (Randomly)

10 EUT classification

- Type of equipment:
- ☒ stand alone equipment
 - ☐ plug in radio equipment
 - ☐ combined equipment
- Modulation types:
- ☒ Wide band modulation (none hopping – e.g. DSSS, OFDM)
 - ☐ Frequency hopping spread spectrum (FHSS)
- Adaptive equipment:
- ☐ Yes, LBT-based
 - ☒ Yes, non-LBT-based
 - ☐ Yes (but can be disabled)
 - ☐ No
- Antennas and transmission 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)
 - ☐ Operating mode 2 (multiple antennas, no beamforming)
 - Equipment operating in this mode contains a smart antenna system using two or more transmit/receive chains simultaneously but without beamforming.
 - ☐ Operating mode 3 (multiple antennas, with beamforming)
 - Equipment operating in this mode contains a smart antenna system using two or more transmit/receive chains simultaneously with beamforming.
In addition to the antenna assembly gain (G), the beamforming gain (Y) may have to be taken into account when performing the measurements.

11 Measurement results

11.1 Timing of the transmitter

Measurement:

Measurement parameters	
External result file	1-9746_19-01-05_Annex_MR_A_1.pdf Hardcopy Spectrum Analyzer
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 12

Limits:

FCC	IC
Timing of the transmitter	
(c) Unless otherwise specified, e.g. Section 15.255(b), when the radiated emission limits are expressed in terms of the average value of the emission, 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 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to notification or verification.	

Result:

	Frequency		
	2403 MHz	2439 MHz	2475 MHz
Burst length [ms]	0.165	0.165	0.165
Total transmission time (TTT) in 100 ms [ms]	0.825	0.825	0.825
Duty cycle correction factor ($F = 20 * \log (TTT / 100 \text{ ms})$) [dB]	-41.7	-41.7	-41.7

11.2 Occupied bandwidth – 99% bandwidth

Description:

Measurement of the 99% bandwidth of the modulated signal.

Measurement:

Measurement parameters	
External result file	1-9746_19-01-05_Annex_MR_A_1.pdf FCC Part 15.247 Bandwidth 99PCT
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 12

Limits:

FCC	IC
Spectrum Bandwidth – 99% Bandwidth	
Required for emission designator	

Results:

	Frequency		
	2403 MHz	2439 MHz	2475 MHz
99% bandwidth [kHz]	916	941	929

11.3 Maximum field strength

Description:

Measurement of the maximum field strength radiated.

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	3 MHz
Video bandwidth:	3 MHz
Span:	5 MHz
Trace mode:	Max Hold
Measurement distance:	3 m
Test setup	See sub clause 7.2 B
Measurement uncertainty	See sub clause 12

Limits:

FCC	IC
Maximum field strength	
The field strength of emissions of intentional radiators shall comply with the following: Field strength of fundamental: 50 mV/m / (94 dB μ V/m) @ 3 m (AVG) 500 mV/m / (114 dB μ V/m) @ 3 m (Peak)	

Result:

Modulation Frequency	Maximum field strength [dB μ V/m]		
	Lowest channel	Middle channel	Highest channel
Peak	88.5	85.1	79.1
AVG*)	46.8	43.4	37.4

*) Average value calculated with duty cycle correction factor. (see chapter 11.1)

11.4 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. The EUT is set to lowest channel for the lower restricted band and to highest channel for the upper restricted band. Measurement distance is 3m.

Measurement:

Measurement parameters	
Detector	Peak / RMS
Sweep time	Auto
Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Span	Lower Band: 2300 – 2400 MHz higher Band: 2480 – 2500 MHz
Trace mode	Max hold
Test setup	See sub clause 7.2 B
Measurement uncertainty	See sub clause 12

Limits:

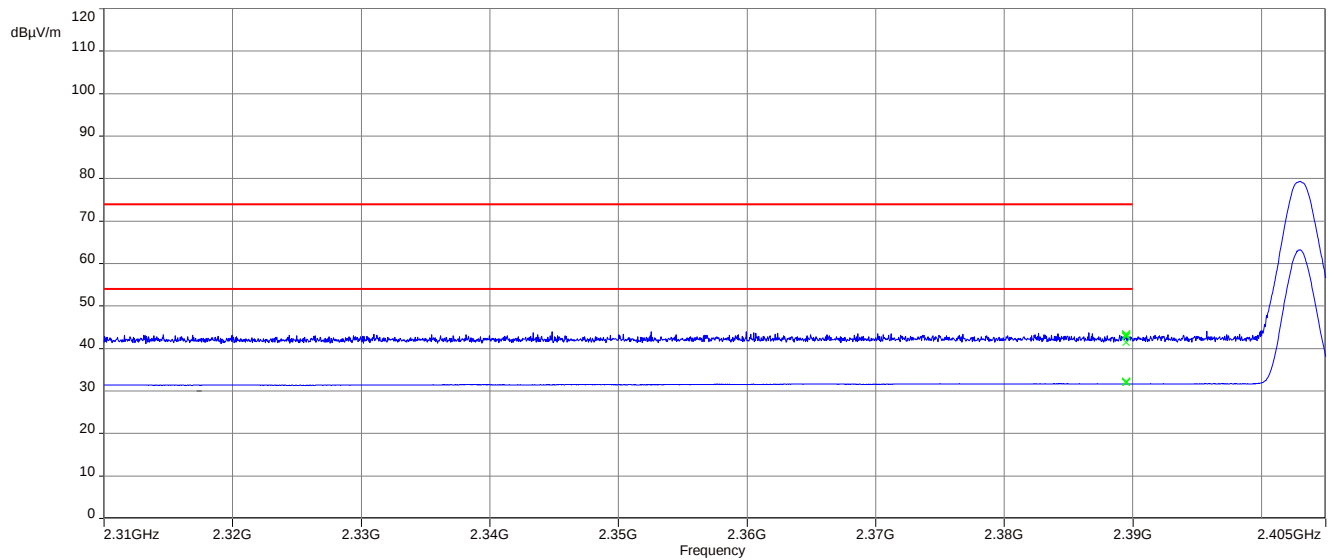
FCC	IC
Band edge compliance radiated	
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth 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 dBµV/m AVG 74 dBµV/m Peak	

Result:

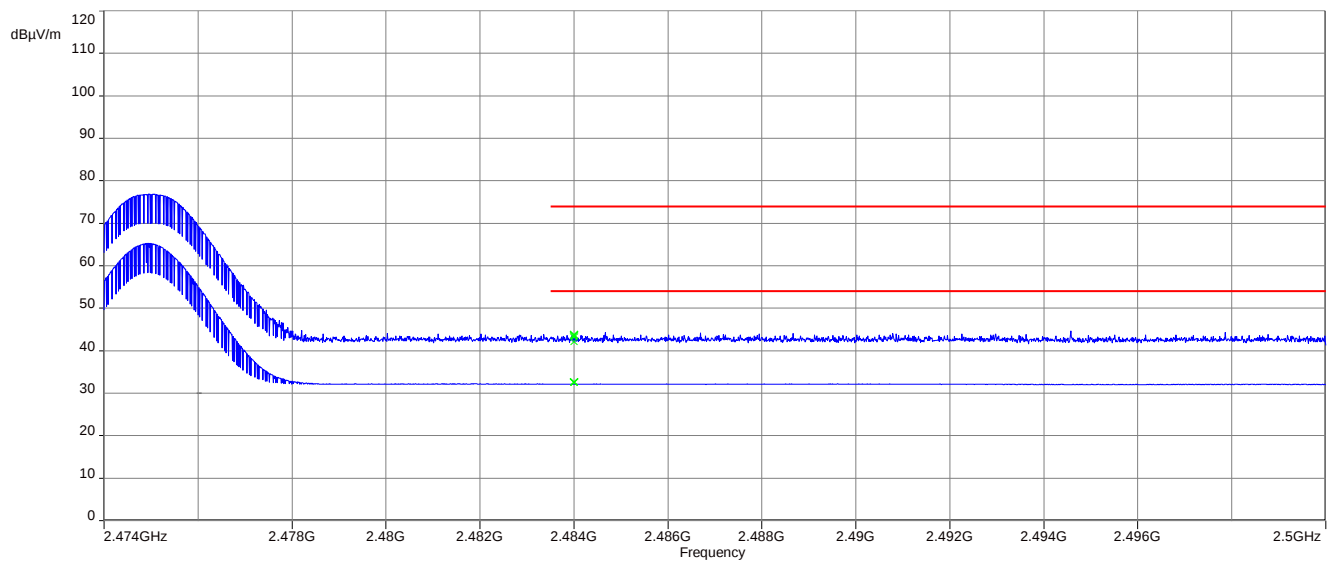
Modulation	Band Edge Compliance Radiated [dBµV/m]
	GFSK
Lower Band Edge – Lowest Channel	< 54 dBµV/m (AVG) < 74 dBµV/m (Peak)
Upper Band Edge – Highest Channel	< 54 dBµV/m (AVG) < 74 dBµV/m (Peak)

Plots:

Plot 1: lower band edge, vertical & horizontal polarization, peak & AVG



Plot 2: upper band edge, vertical & horizontal polarization, peak & AVG



11.5 Spurious emissions radiated < 30 MHz

Description:

Measurement of the radiated spurious emissions in transmit mode below 30 MHz. The EUT is set to lowest, middle and highest channel. The limits are recalculated to a measurement distance of 3 m with 40 dB/decade according CFR Part 2.

Measurement:

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: 30 kHz
Span	9 kHz to 30 MHz
Trace mode	Max hold
Test setup	See sub clause 7.2 C
Measurement uncertainty	See sub clause 12

Limits:

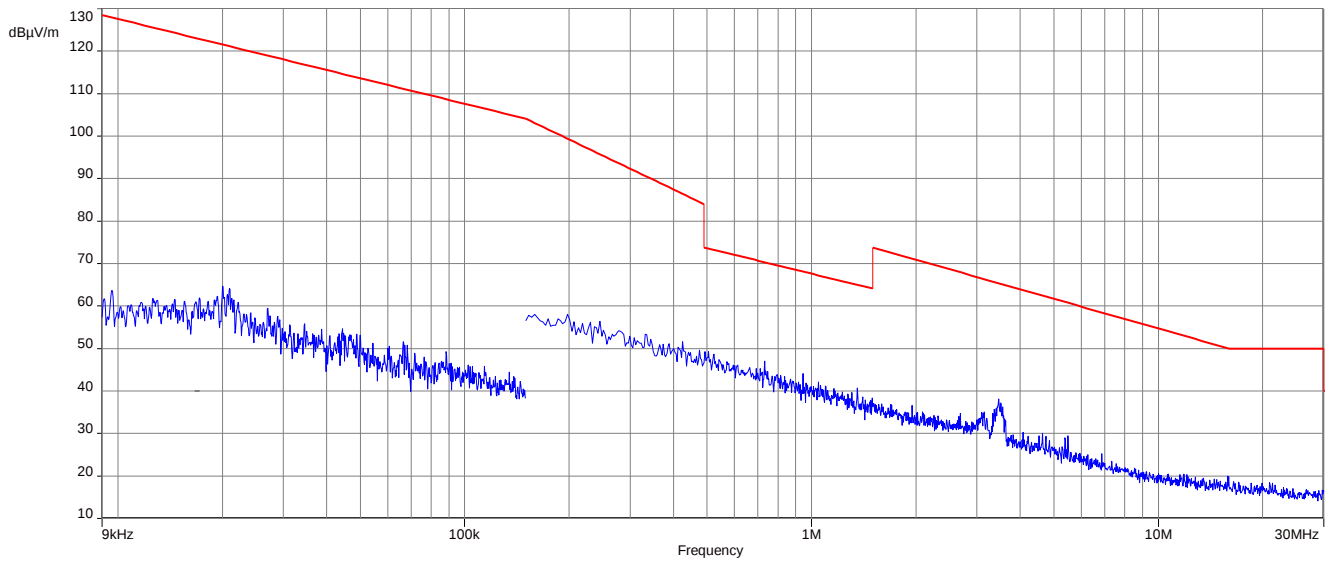
FCC		IC
Spurious Emissions Radiated < 30 MHz		
Frequency (MHz)	Field Strength (dBµV/m)	Measurement distance
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30

Results:

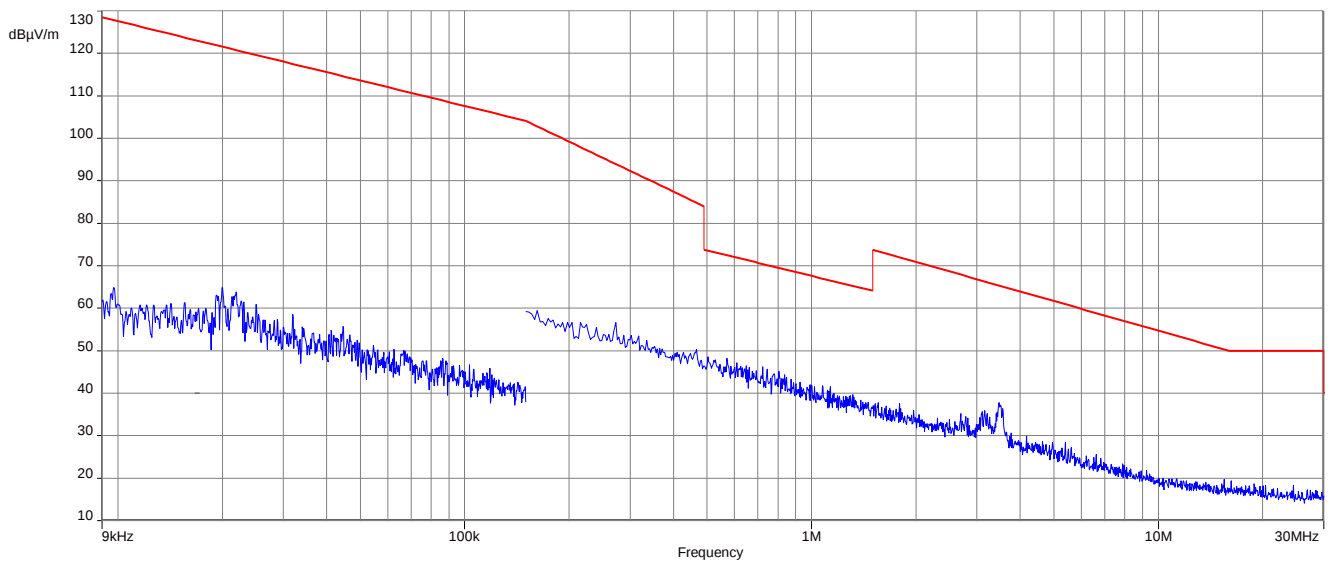
TX spurious emissions radiated below 30 MHz [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
All detected emissions are more than 20 dB below the limit.		

Plots:

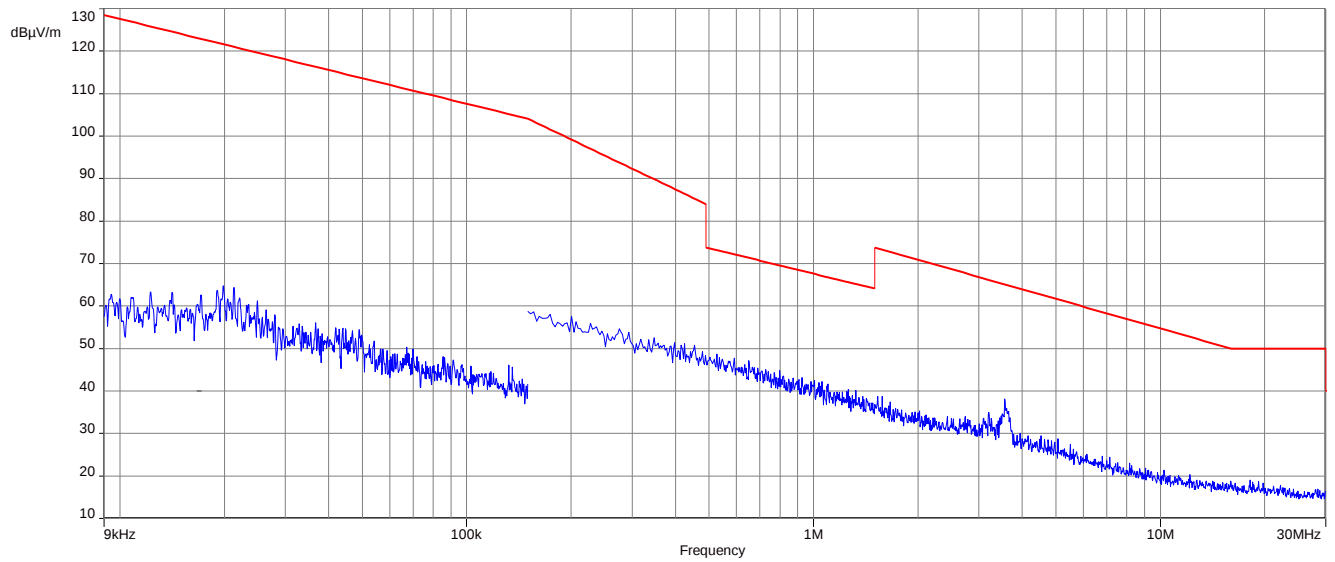
Plot 1: 9 kHz to 30 MHz, 2403 MHz, transmit mode



Plot 2: 9 kHz to 30 MHz, 2439 MHz, transmit mode



Plot 3: 9 kHz to 30 MHz, 2475 MHz, transmit mode



11.6 Spurious emissions radiated 30 MHz to 1 GHz

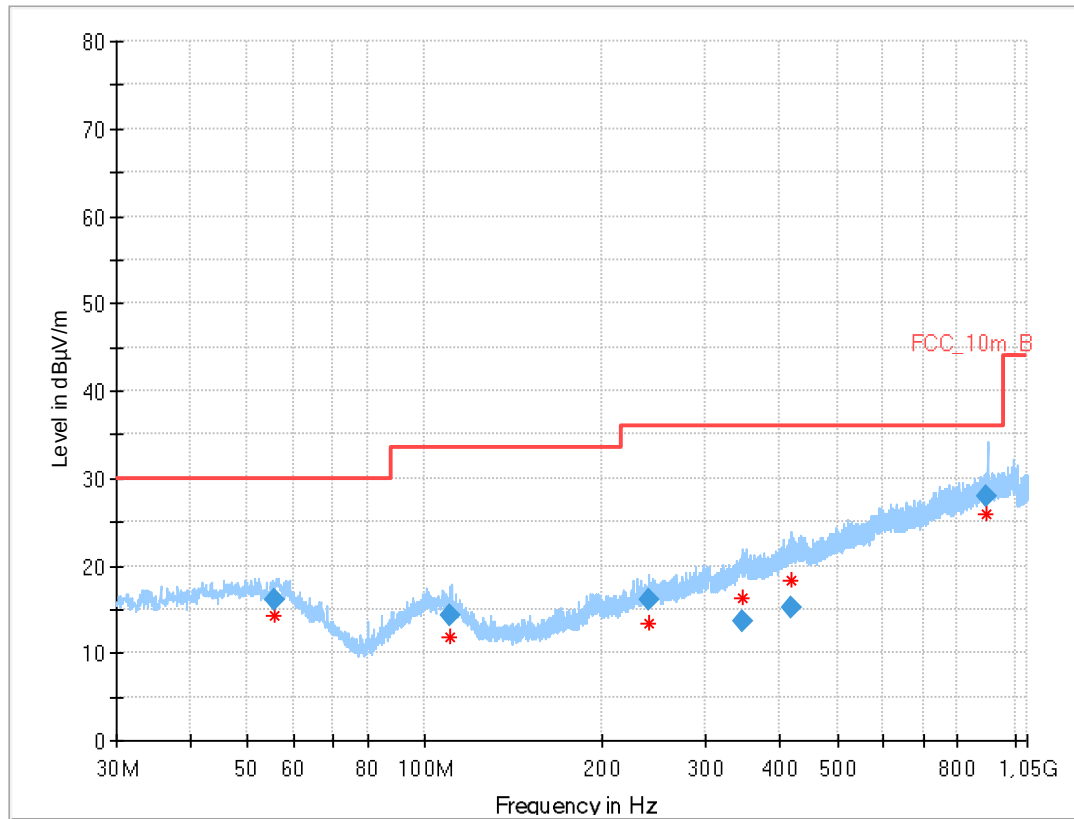
Description:

Measurement of the radiated spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit frequencies are 2403 MHz, 2439 MHz and 2475 MHz.

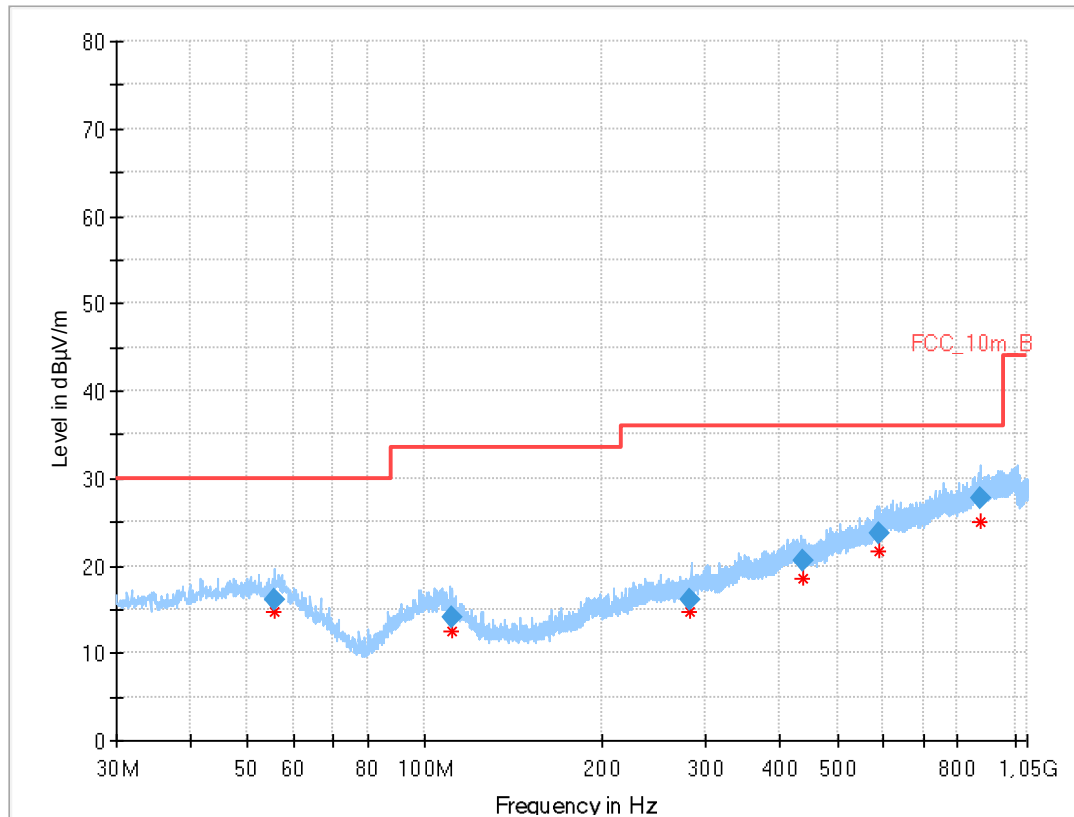
Measurement parameters	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	120 kHz
Video bandwidth	3 x RBW
Span	30 MHz to 1 GHz
Trace mode	Max hold
Measured modulation	GFSK
Test setup	See sub clause 7.1 A
Measurement uncertainty	See sub clause 12

Limits:

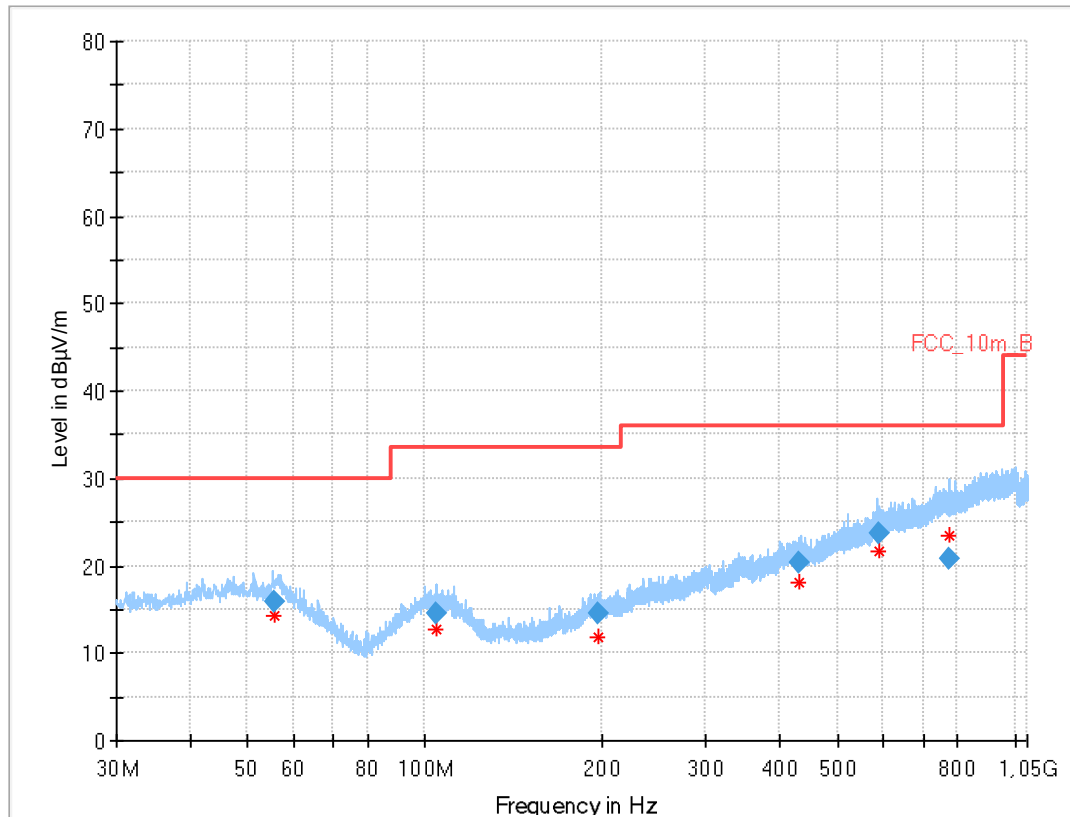
FCC		IC
TX spurious emissions radiated		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz 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 (dBµV/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, 2403 MHz, vertical & horizontal polarization**Final results:**

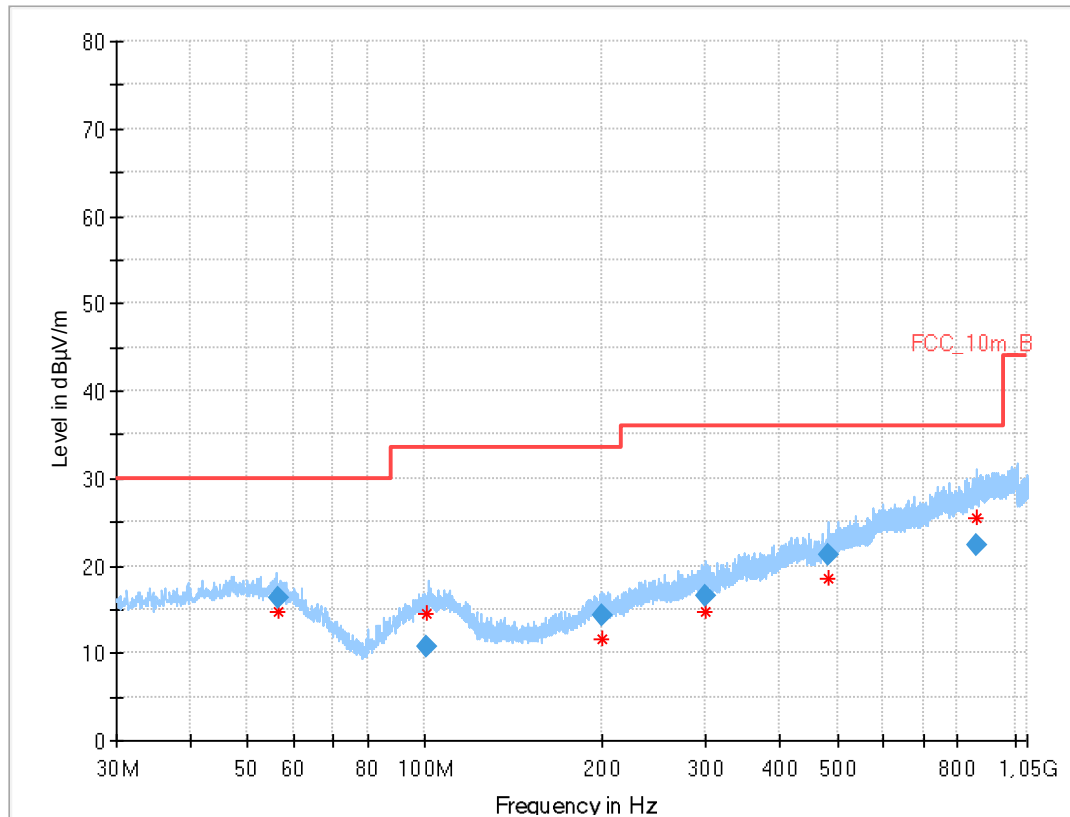
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
55.725	16.15	30.0	13.9	1000	120	118.0	V	67	15
110.452	14.22	33.5	19.3	1000	120	102.0	H	-22	12
239.933	16.00	36.0	20.0	1000	120	150.0	V	247	13
345.500	13.68	36.0	22.3	1000	120	170.0	V	257	16
416.369	15.11	36.0	20.9	1000	120	170.0	H	247	17
898.256	27.83	36.0	8.2	1000	120	170.0	V	-22	24

Plot 2: 30 MHz to 1 GHz, TX mode, 2439 MHz, vertical & horizontal polarization**Final results:**

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
55.669	16.15	30.0	13.9	1000	120	127.0	V	67	15
110.823	14.14	33.5	19.4	1000	120	142.0	V	157	12
281.995	16.19	36.0	19.8	1000	120	142.0	V	269	14
436.310	20.47	36.0	15.5	1000	120	149.0	H	157	17
587.628	23.67	36.0	12.3	1000	120	98.0	V	157	20
875.866	27.80	36.0	8.2	1000	120	170.0	H	67	23

Plot 3: 30 MHz to 1 GHz, TX mode, 2475 MHz, vertical & horizontal polarization**Final results:**

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
55.532	15.91	30.0	14.1	1000	120	170.0	H	-22	15
104.856	14.53	33.5	19.0	1000	120	170.0	V	292	13
196.968	14.63	33.5	18.9	1000	120	170.0	V	-21	12
430.640	20.43	36.0	15.6	1000	120	170.0	H	157	17
587.046	23.58	36.0	12.4	1000	120	159.0	V	-22	20
774.191	20.76	36.0	15.2	1000	120	104.0	H	247	22

Plots: Receiver mode**Plot 1:** 30 MHz to 1 GHz, RX / idle – mode, vertical & horizontal polarization**Final results:**

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
56.557	16.24	30.0	13.8	1000	120	170.0	V	202	15
100.997	10.69	33.5	22.8	1000	120	170.0	V	159	13
199.273	14.40	33.5	19.1	1000	120	170.0	H	193	11
299.715	16.60	36.0	19.4	1000	120	170.0	H	-22	14
482.592	21.30	36.0	14.7	1000	120	170.0	V	-22	18
860.913	22.28	36.0	13.7	1000	120	166.0	H	67	23

11.7 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 frequencies are 2403 MHz, 2439 MHz and 2475 MHz.

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
Measured modulation	GFSK
Test setup	See sub clause 7.2 A (1 GHz - 18 GHz) See sub clause 7.3 A (18 GHz - 26 GHz)
Measurement uncertainty	See sub clause 12

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 (dBµV/m)	Measurement distance
Above 960	54.0 (Average)	3
Above 960	74.0 (Peak)	3

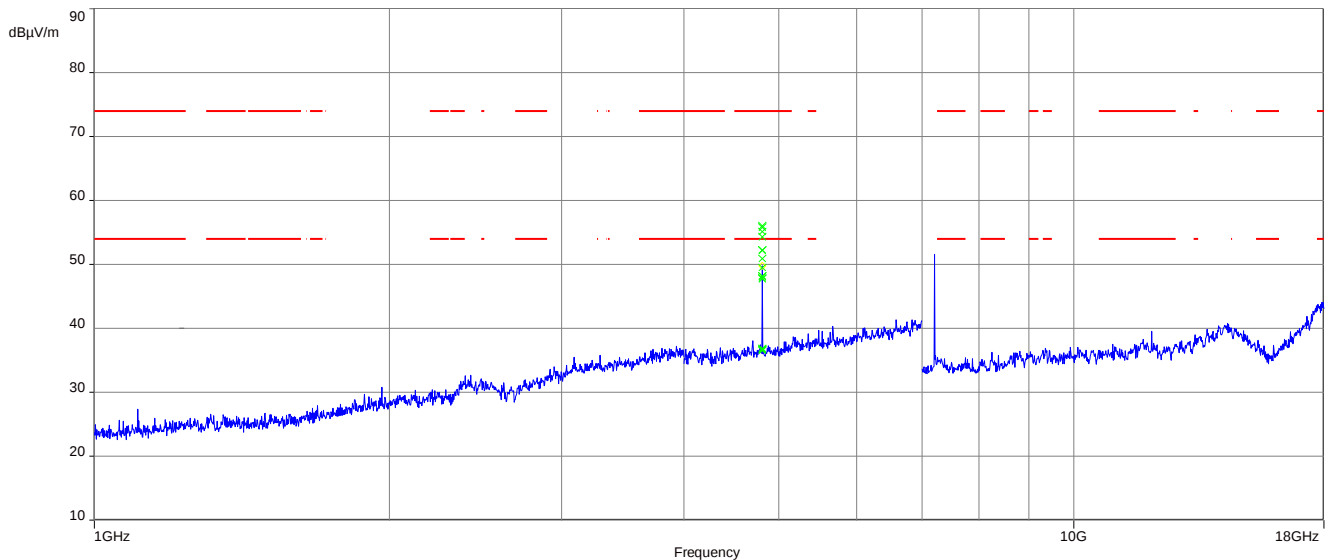
Results: Transmitter mode

TX spurious emissions radiated [dBµV/m]								
2403 MHz			2439 MHz			2475 MHz		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
4806	Peak	56.0	4878	Peak	56.2	4950	Peak	54.9
	AVG	14.3*		AVG	14.5*		AVG	13.2*
	Peak		7317	Peak	53.1	7425	Peak	58.7
	AVG			AVG	11.4*		AVG	17.0*
	Peak			Peak			Peak	
	AVG			AVG			AVG	

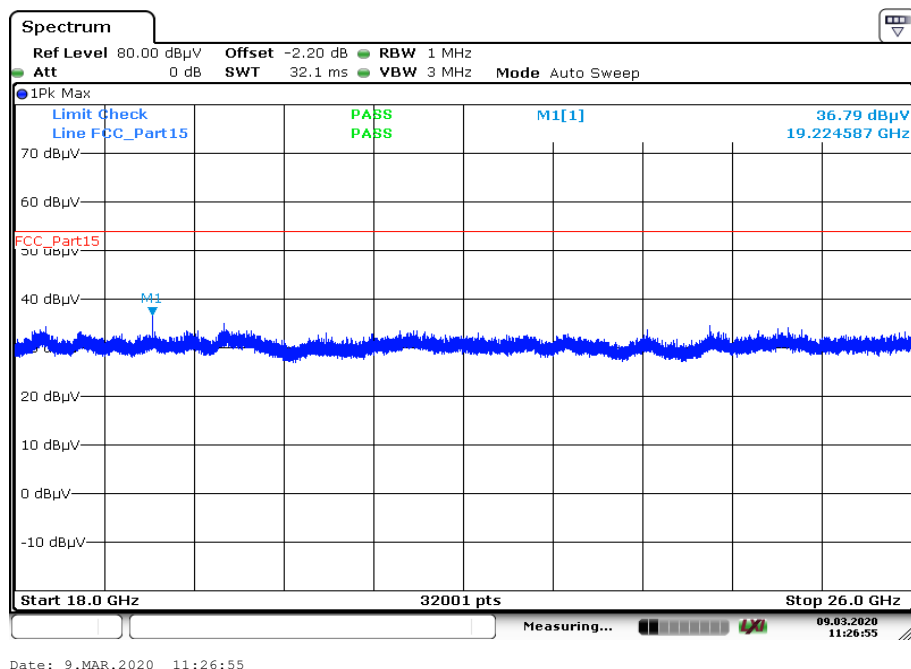
*) Average value calculated with duty cycle correction factor. (see chapter 11.1)

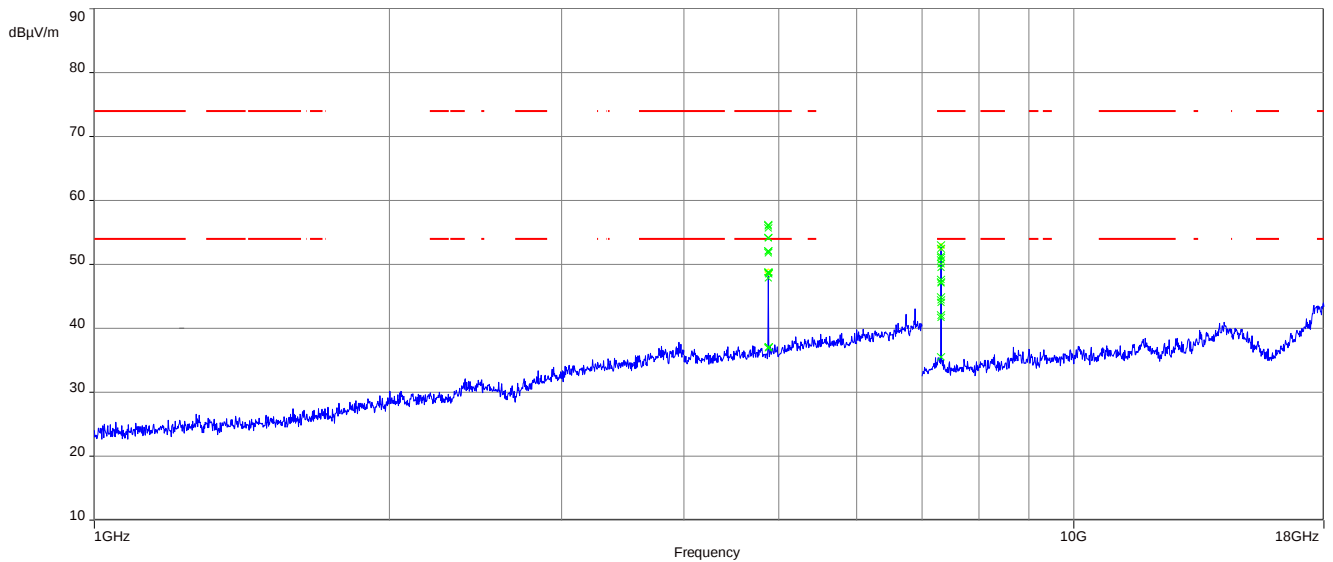
Results: Receiver mode

RX spurious emissions radiated [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
All detected emissions are more than 20 dB below the limit.		
	Peak	
	AVG	

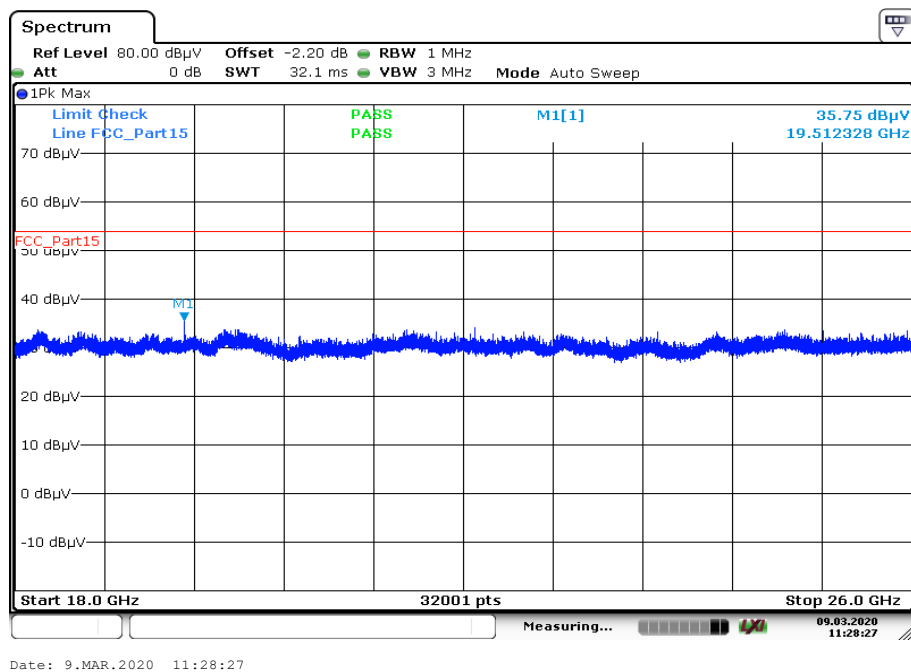
Plots: Transmitter mode**Plot 1:** 1 GHz to 18 GHz, TX mode, 2403 MHz, vertical & horizontal polarization

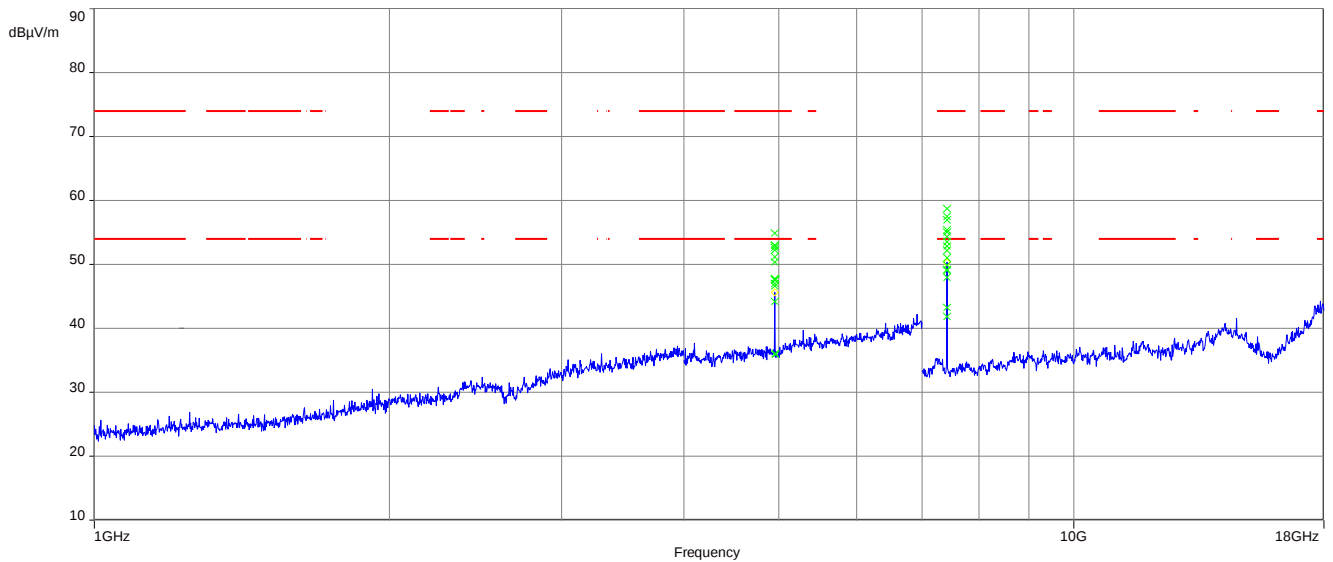
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 2: 18 GHz to 26 GHz, TX mode, 2403 MHz, vertical & horizontal polarization

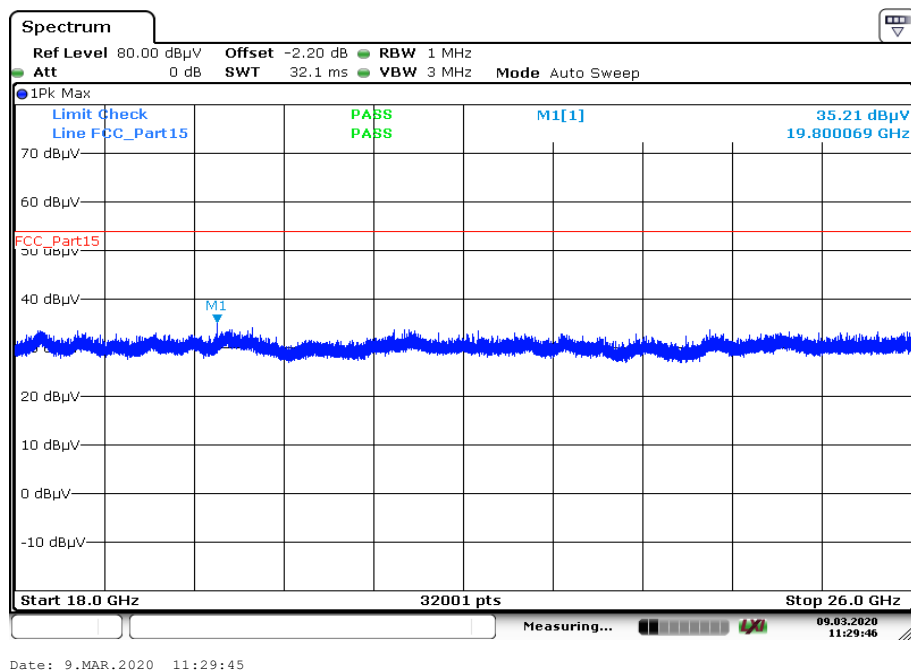
Plot 3: 1 GHz to 18 GHz, TX mode, 2439 MHz, vertical & horizontal polarization

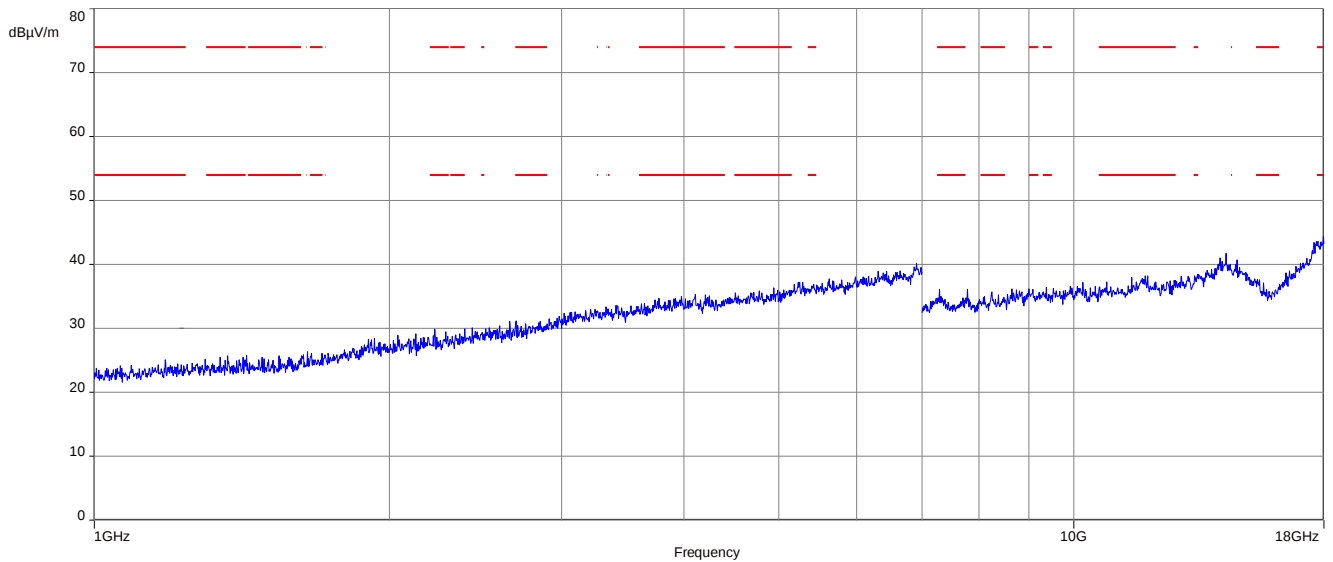
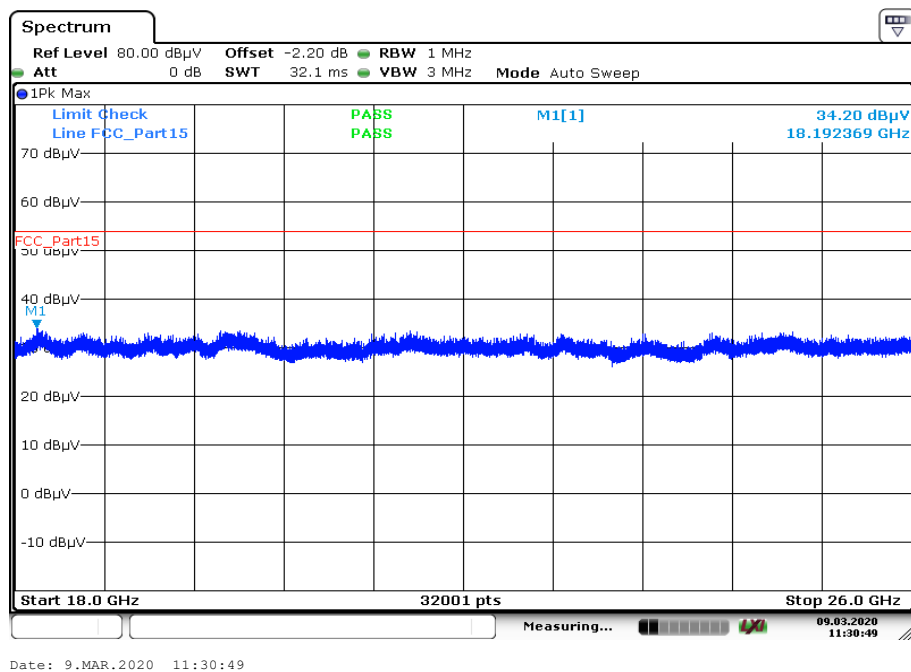
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 4: 18 GHz to 26 GHz, TX mode, 2439 MHz, vertical & horizontal polarization

Plot 5: 1 GHz to 18 GHz, TX mode, 2475 MHz, vertical & horizontal polarization

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

Plot 6: 18 GHz to 26 GHz, TX mode, 2475 MHz, vertical & horizontal polarization

Plots: Receiver mode**Plot 1:** 1 GHz to 18 GHz, RX / idle – mode, vertical & horizontal polarization**Plot 2:** 18 GHz to 26 GHz, RX / idle – mode, vertical & horizontal polarization

12 Measurement uncertainty

Measurement uncertainty	
Occupied channel bandwidth	±5 %
RF output power, conducted	±1.5 dB
Power spectral density, conducted	±3 dB
Unwanted emissions, conducted	±3 dB
All emissions, radiated	±3 dB
Temperature	±1 °C
Humidity	±5 %
DC and low frequency voltages	±3 %
Time	±5 %
Duty cycle	±5 %

13 Observations

No observations except those reported with the single test cases have been made.

Annex A Glossary

EUT	Equipment under test
DUT	Device under test
UUT	Unit under test
GUE	GNSS User Equipment
ETSI	European Telecommunications Standards Institute
EN	European Standard
FCC	Federal Communications Commission
FCC ID	Company Identifier at FCC
IC	Industry Canada
PMN	Product marketing name
HMN	Host marketing name
HVIN	Hardware version identification number
FVIN	Firmware version identification number
EMC	Electromagnetic Compatibility
HW	Hardware
SW	Software
Inv. No.	Inventory number
S/N or SN	Serial number
C	Compliant
NC	Not compliant
NA	Not applicable
NP	Not performed
PP	Positive peak
QP	Quasi peak
AVG	Average
OC	Operating channel
OCW	Operating channel bandwidth
OBW	Occupied bandwidth
OOB	Out of band
DFS	Dynamic frequency selection
CAC	Channel availability check
OP	Occupancy period
NOP	Non occupancy period
DC	Duty cycle
PER	Packet error rate
CW	Clean wave
MC	Modulated carrier
WLAN	Wireless local area network
RLAN	Radio local area network
DSSS	Dynamic sequence spread spectrum
OFDM	Orthogonal frequency division multiplexing
FHSS	Frequency hopping spread spectrum
GNSS	Global Navigation Satellite System
C/N₀	Carrier to noise-density ratio, expressed in dB-Hz

Annex B Document history

Version	Applied changes	Date of release
-/-	Initial release	2020-05-14
A	ISED data changed, editorial changes	2021-01-27

Annex C Accreditation Certificate – D-PL-12076-01-04

first page	last page
 Deutsche Akkreditierungsstelle GmbH 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 Accreditation  The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory CTC advanced GmbH Untertürkheimer Straße 6-10, 66117 Saarbrücken is competent under the terms of DIN EN ISO/IEC 17025:2005 to carry out tests in the following fields: Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards The accreditation certificate shall only apply in connection with the notice of accreditation of 11.01.2019 with the accreditation number D-PL-12076-01 and is valid until 21.04.2021. It comprises the cover sheet, the reverse side of the cover sheet and the following annex with a total of 7 pages. Registration number of the certificate: D-PL-12076-01-04 Frankfurt am Main, 11.01.2019  Dipl.-Ing. Uwe Zimmermann Head of Division	Deutsche Akkreditierungsstelle GmbH Office Berlin Spittelmarkt 10 10117 Berlin Office Frankfurt am Main Europa-Allee 52 60327 Frankfurt am Main Office Braunschweig Bundesallee 100 38116 Braunschweig 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. No impression shall be made that the accreditation also extends to fields beyond the scope of accreditation attested by DAkKS. 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 (EC) 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. The up-to-date state of membership can be retrieved from the following websites: EA: www.european-accreditation.org ILAC: www.ilac.org IAF: www.laf.nu

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

Annex D Accreditation Certificate – D-PL-12076-01-05

first page	last page
 Deutsche Akkreditierungsstelle GmbH 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 Accreditation  The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory CTC advanced GmbH Untertürkheimer Straße 6-10, 66117 Saarbrücken is competent under the terms of DIN EN ISO/IEC 17025:2005 to carry out tests in the following fields: Telecommunication (FCC Requirements) The accreditation certificate shall only apply in connection with the notice of accreditation of 11.01.2019 with the accreditation number D-PL-12076-01 and is valid until 21.04.2021. It comprises the cover sheet, the reverse side of the cover sheet and the following annex with a total of 5 pages. Registration number of the certificate: D-PL-12076-01-05 Frankfurt am Main, 11.01.2019  Head of Division	Deutsche Akkreditierungsstelle GmbH Office Berlin Spittelmarkt 10 10117 Berlin Office Frankfurt am Main Europa-Allee 52 60527 Frankfurt am Main Office Braunschweig Bundesallee 100 38116 Braunschweig 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. No impression shall be made that the accreditation also extends to fields beyond the scope of accreditation attested by DAkKS. 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 (EC) 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. The up-to-date state of membership can be retrieved from the following websites: EA: www.european-accreditation.org ILAC: www.ilac.org IAF: www.iaf.nu

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<https://www.dakks.de/as/ast/d/D-PL-12076-01-05.pdf>

END OF TEST REPORT