
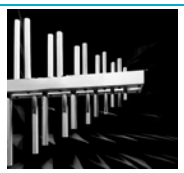
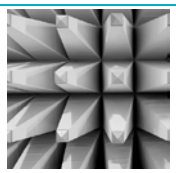

Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-4939_22-01-03

Testing laboratory

CTC advanced GmbH
Untertuerkheimer Strasse 6 – 10
66117 Saarbruecken / Germany
Phone: + 49 681 5 98 - 0
Fax: + 49 681 5 98 - 9075
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e-mail: mail@ctcadvanced.com

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

Brose Fahrzeugteile SE & Co. KG, Bamberg
Berliner Ring 1
96052 Bamberg / GERMANY
Phone: +49 9517474-0
Contact: Bertram Bopp
e-mail: Bertram.Bopp@brose.com
Phone: +49 951 7474 2375

Manufacturer

Brose Fahrzeugteile SE & Co. KG, Bamberg
Berliner Ring 1
96052 Bamberg / GERMANY

Test standard/s

FCC - Title 47 CFR Part 95	FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 95 - Personal Radio Services
RSS - 251 Issue 2	Spectrum Management and Telecommunications Radio Standards Specification - Vehicular Radar and Airport Fixed or Mobile Radar in the 76-81 GHz Frequency Band

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

Test Item

Kind of test item:	Automotive FMCW Radarsensor 77-81GHz
Model name:	PMRGEN1
FCC ID:	2AHV8- PMRG33375
IC:	29958- PMRG33375
Frequency:	77GHz – 81GHz
Antenna:	Integrated antenna
Power supply:	9 V to 16 V DC by Battery
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:

Thomas Vogler

cn=Thomas Vogler, o=CTC advanced GmbH, ou=VOG-211118, email=thomas.vogler@ctcadvanced.com, c=DE
2023.03.27 15:06:34 +02'00'

Thomas Vogler
Lab Manager
Radio Labs

Test performed:

cn=Stephan Thiel, o=CTC advanced GmbH, ou=THL-220401, email=Stephan.Thiel@ctcadvanced.com, c=DE
2023.03.27 14:52:00 +02'00'

Stephan Thiel
Testing Manager
Radio Labs

1 Table of contents

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:	2022-10-26
Date of receipt of test item:	2022-11-07
Start of test:*	2023-01-24
End of test:*	2020-02-23
Person(s) present during the test:	-/-

*Date of each measurement, if not shown in the plot, can be requested. Dates are stored in the measurement software.

2.3 Test laboratories sub-contracted

None

3 Test standard/s, references and accreditations

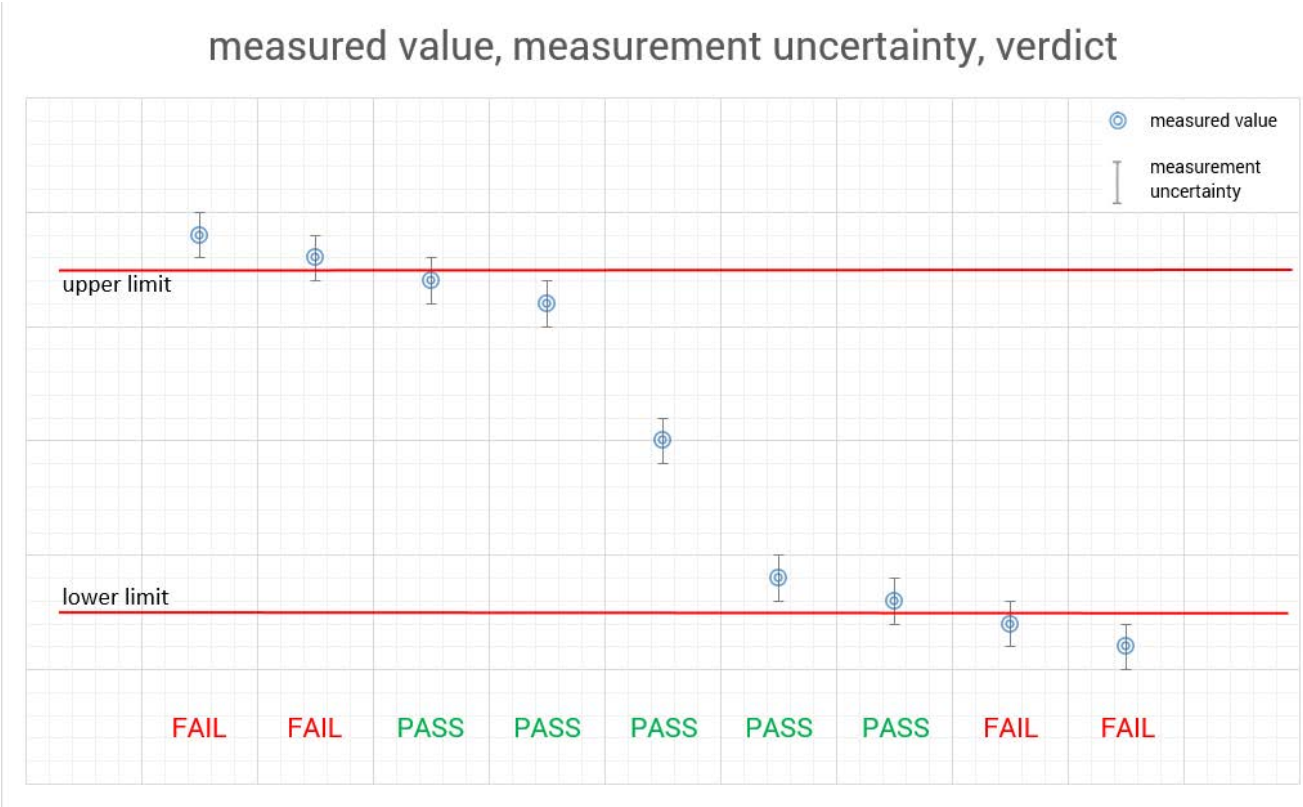
Test standard	Date	Description
FCC - Title 47 CFR Part 95	-/-	FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 95 - Personal Radio Services
RSS - 251 Issue 2	July 2018	Spectrum Management and Telecommunications Radio Standards Specification - Vehicular Radar and Airport Fixed or Mobile Radar in the 76-81 GHz Frequency Band
RSS - Gen Issue 5 incl. Amendment 1 & 2	February 2021	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
76-81 GHz Radars KDB	v01r02	653005 D01 76-81 GHz Radars v01r02: EQUIPMENT AUTHORIZATION GUIDANCE FOR 76-81 GHz RADAR DEVICES

Accreditation	Description
D-PL-12076-01-04	Telecommunication and EMC Canada https://www.dakks.de/files/data/as/pdf/D-PL-12076-01-04e.pdf
D-PL-12076-01-05	Telecommunication FCC requirements https://www.dakks.de/files/data/as/pdf/D-PL-12076-01-05e.pdf

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.



5 Test environment

Temperature	:	T_{nom} T_{max} T_{min}	+20 °C during room temperature tests +70°C during high temperature tests -40°C during low temperature tests
Relative humidity content	:		40-60 %
Barometric pressure	:		not relevant for this kind of testing
Power supply	:	V_{nom} V_{max} V_{min}	13.5 V DC by Battery 16 V 9 V

6 Test item

6.1 General description

Kind of test item	:	Automotive FMCW Radarsensor 77-81GHz
Model name	:	PMRGEN1
PMN	:	PMRGEN1
HVIN	:	G33375
S/N serial number	:	EUT1: G28900-100
Hardware status	:	G33375-100
Software status	:	G47455-100
Firmware status	:	B320
Frequency band	:	77GHz – 81GHz
Type of modulation	:	FMCW
Number of channels	:	1
Antenna	:	Integrated antenna
Power supply	:	9 V to 16 V DC by Battery
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: 1-4939/22-01-01_AnnexA
1-4939/22-01-01_AnnexB
1-4939/22-01-01_AnnexD

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).

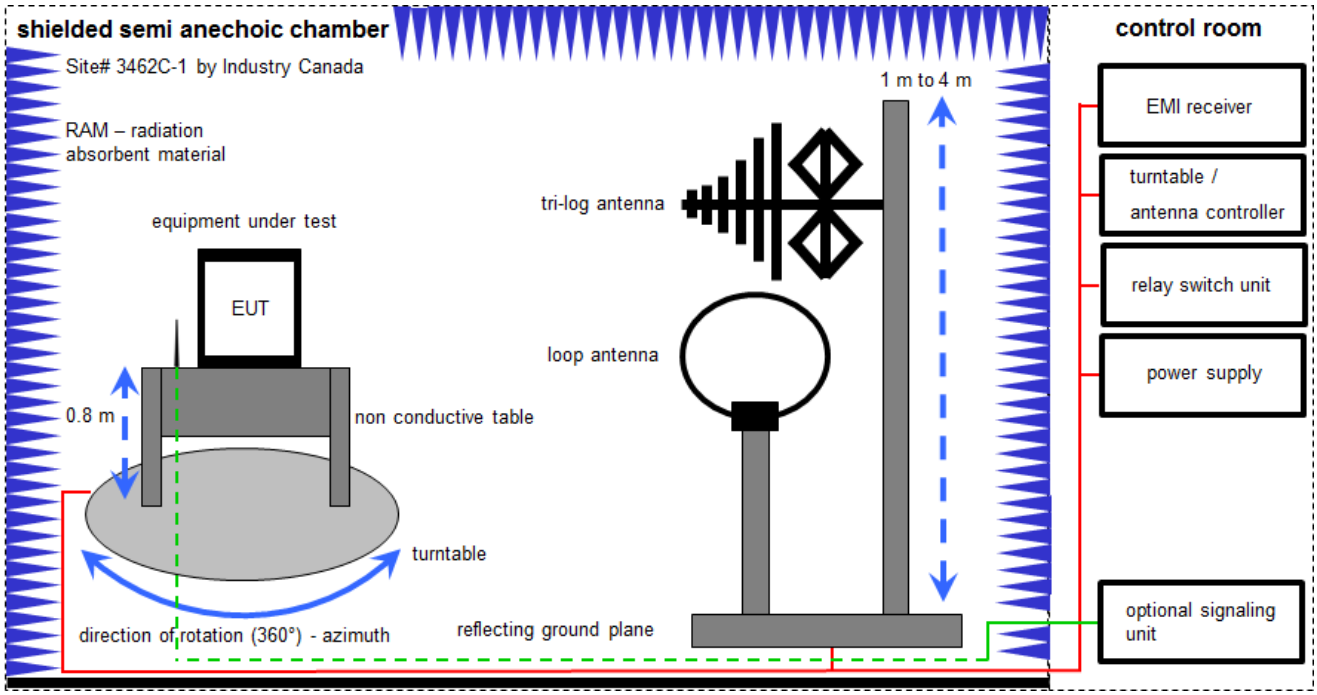
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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
vlkl!	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 specification ANSI C63.10-2013, American National Standard for Testing Unlicensed Wireless Devices. 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: 10.59.00

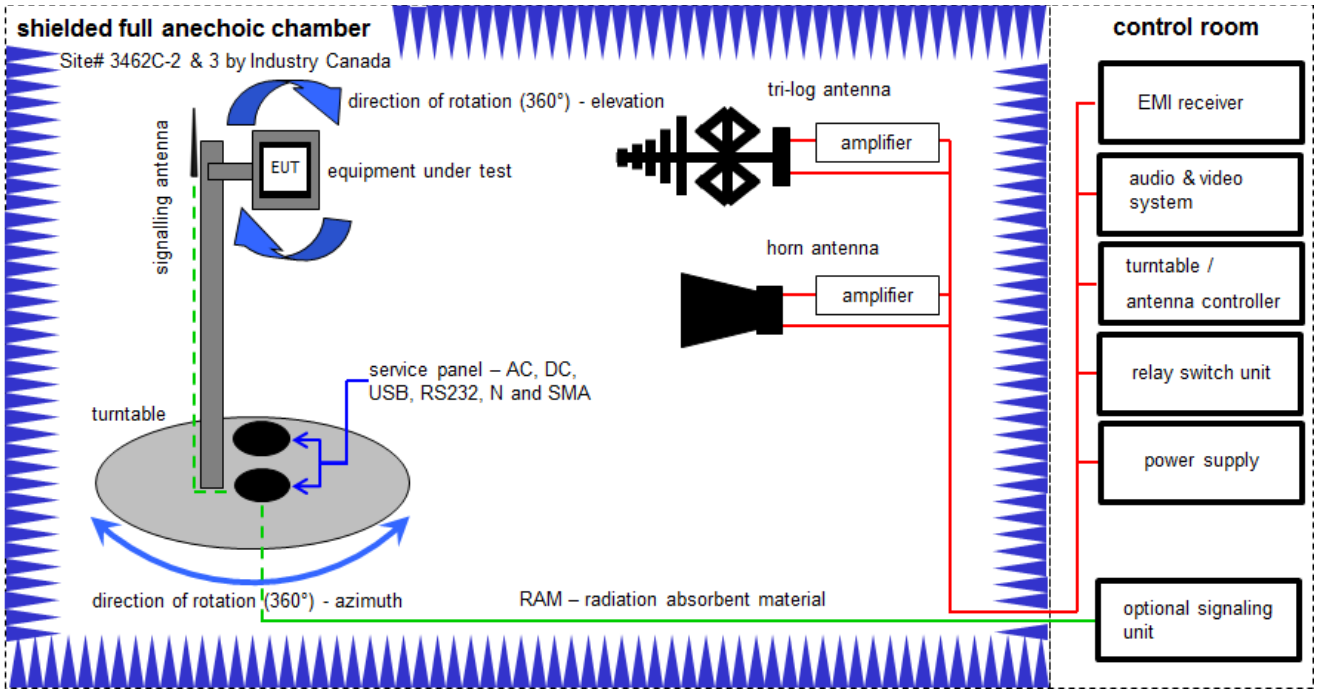
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	19	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vIKI!	12.03.2021	11.03.2023
2	45	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
3	50	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04466	300000580	ne	-/-	-/-
4	n. a.	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
5	n. a.	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
6	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	01029	300005379	vIKI!	18.08.2021	30.08.2023
7	n. a.	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	09.12.2022	31.12.2023

7.2 Shielded fully anechoic chamber



Measurement distance: tri-log antenna 3 meter and horn 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)

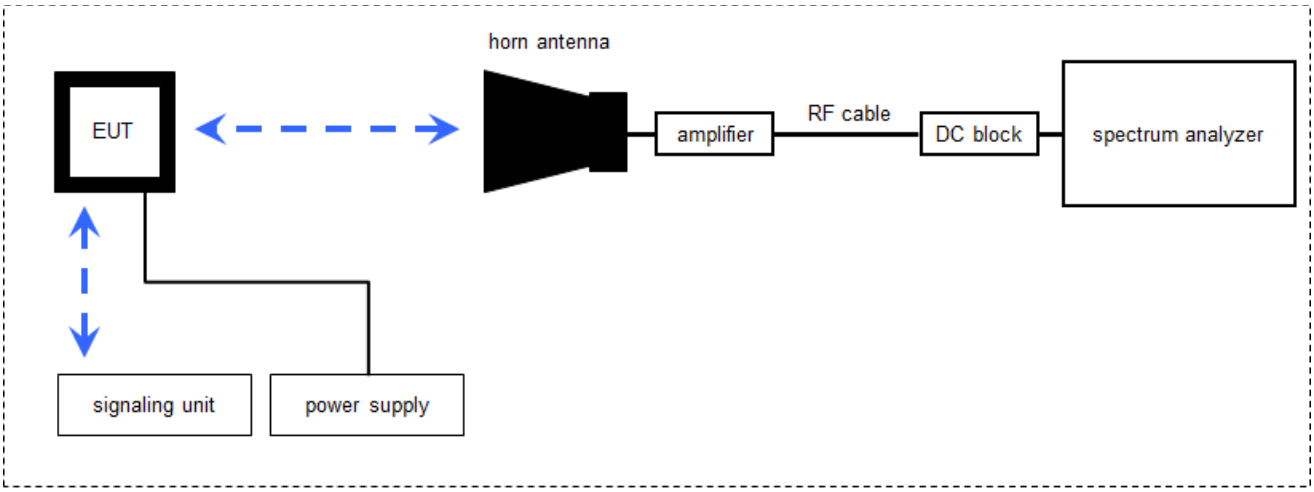
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:
OP [dBm] = -65.0 [dBm] + 50 [dB] - 20 [dBi] + 5 [dB] = -30 [dBm] (1 µW)

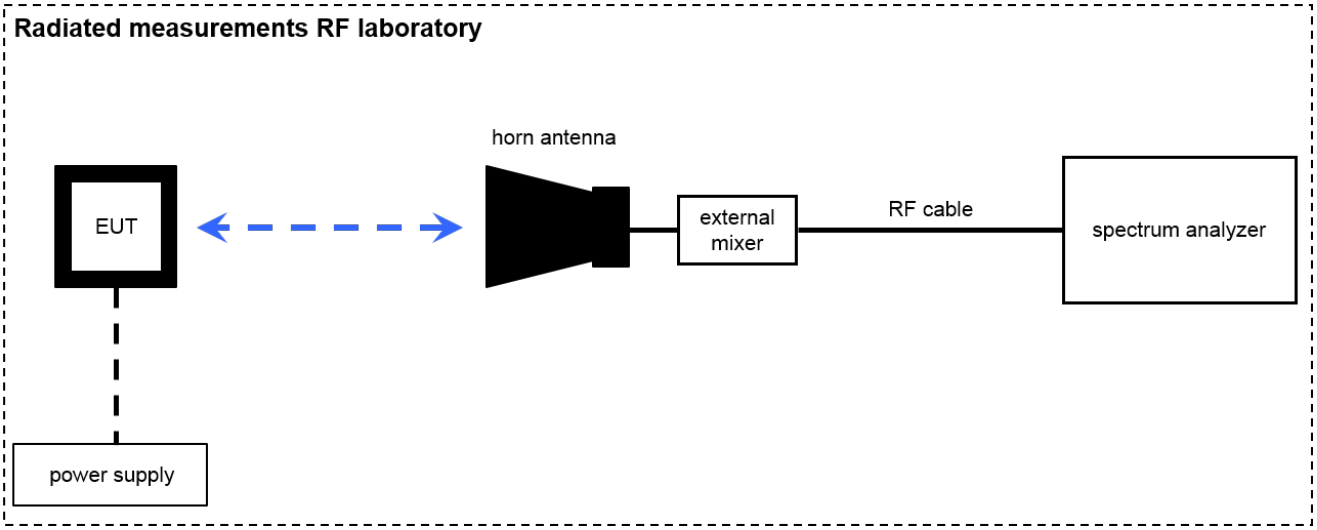
Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2818A03450	300001040	vIKI!	09.12.2020	08.12.2023
2	n. a.	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	n. a.	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
4	A037	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	8812-3089	300000307	vIKI!	11.02.2022	29.02.2024
5	9	Variable isolating transformer	MPL IEC625 Bus Variable isolating transformer	Erfi	91350	300001155	ne	-/-	-/-
6	90	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO/2	8905-2342	300000256	vIKI!	17.06.2021	30.06.2023
7	n. a.	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	07.12.2022	31.12.2023
8	n. a.	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
9	n. a.	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
10	n. a.	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
11	n. a.	NEXIO EMV-Software	BAT EMC V2022.0.22.0	Nexio		300004682	ne	-/-	-/-
12	n. a.	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-
13	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	318	300003696	vIKI!	30.09.2021	29.09.2023

7.3 Radiated measurements > 18 GHz



7.4 Radiated measurements > 50/85 GHz



Measurement distance: horn antenna e.g. 75 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 [dBµV/m] = 40.0 [dBµV/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dBµV/m] (6.79 µV/m)

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] = -59.0 [dBm] + 44.0 [dB] - 20.0 [dBi] + 5.0 [dB] = -30 [dBm] (1 µW)

Note: conversion loss of mixer is already included in analyzer value.

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	CR 79	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	7911	300001751	ne	-/-	-/-
2	A029	Std. Gain Horn Antenna 92.3-140 GHz	2824-20	Flann	*	300001993	ne	-/-	-/-
3	A027	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda	01096	300000486	vlKl!	17.01.2022	31.01.2024
4	A036	Std. Gain Horn Antenna 60-90 GHz	COR 60_90	Thomson CSF		300000814	ev	-/-	-/-
5	n. a.	Harmonic Mixer 3-Port, 110-170 GHz	FS-Z170	Radiometer Physics GmbH	100014	300004156	k	01.07.2022	31.07.2023
6	n. a.	Harmonic Mixer 3-Port, 140-220 GHz	SAM-220	Radiometer Physics GmbH	200001	300004157	k	21.07.2022	31.07.2023
7	n. a.	Harmonic Mixer 3-Port, 220-325 GHz	SAM-325	Radiometer Physics GmbH	100002	300004158	k	25.07.2022	31.07.2023
8	n. a.	Std. Gain Horn Antenna 33.0-50.1 GHz	2324-20	Flann	57	400000683	ne	-/-	-/-
9	n. a.	Harmonic Mixer 3-Port, 60-90 GHz	FS-Z90	R&S	101555	300004691	k	21.07.2022	31.07.2023
10	n. a.	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev	09.03.2022	08.03.2024
11	n. a.	Std. Gain Horn Antenna 217-330 GHz	32240-20	Flann	233278	300004960	ne	-/-	-/-
12	n. a.	Signal- and Spectrum Analyzer 2 Hz - 85 GHz	FSW85	Rohde&Schwarz	101333	300005568	k	11.07.2022	31.07.2023
13	n. a.	Harmonic Mixer 3-port, 90-140 GHz	FS-Z140	Rohde & Schwarz	101119	300005581	k	20.07.2022	31.07.2023
14	n. a.	Signal- and Spectrum Analyzer 2 Hz - 50 GHz	FSW50	Rohde&Schwarz	101332	300005935	k	03.01.2023	31.01.2024
15	n. a.	Power Supply	E3632A	Agilent Technologies	MY40001320	400000396	vlKl!	14.12.2021	31.12.2024
16	n. a.	Temperature Test Chamber	T-40/50	CTS GmbH	064023	300003540	ev	09.05.2022	31.05.2024
17	A034	Std. Gain Horn Antenna 145-220 GHz	3024-20	Flann	*	300002001	ne	-/-	-/-

8 Sequence of testing

8.1 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.

8.2 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 ± 45° 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.

8.3 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.

8.4 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.

8.5 Sequence of testing radiated spurious above 50 GHz with external mixers

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 for far field (e.g. 0.25 m).
- The EUT is set into operation.

Premeasurement

- The test antenna with external mixer is handheld and moved carefully over the EUT to cover the EUT's whole sphere and different polarizations of the antenna.
- Caution is taken to reduce the possible overloading of the external mixer.

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).
- As external mixers may generate false images care is taken to ensure that any emission measured by the spectrum analyzer does indeed originate in the EUT. Signal identification feature of spectrum analyzer is used to eliminate false mixer images (i.e., it is not the fundamental emission or a harmonic falling precisely at the measured frequency).
- 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.

9 Measurement uncertainty

Test case	Uncertainty
Equivalent isotropically radiated power (e.i.r.p.)	Conducted value ± 1 dB Radiated value ± 3 dB
Permitted range of operating frequencies	± 100 kHz
Conducted unwanted emissions in the spurious domain (up to 18 GHz)	± 1 dB
Radiated unwanted emissions in the spurious domain (up to 18 GHz)	± 3 dB
Conducted unwanted emissions in the spurious domain (18 to 40 GHz)	± 4 dB
Radiated unwanted emissions in the spurious domain (18 to 40 GHz)	± 4 dB
Conducted unwanted emissions in the spurious domain (40 to 50 GHz)	± 4.5 dB
Radiated unwanted emissions in the spurious domain (40 to 50 GHz)	± 4.5 dB
Conducted unwanted emissions in the spurious domain (above 50 GHz)	± 5 dB
Radiated unwanted emissions in the spurious domain (above 50 GHz)	± 5 dB
DC and low frequency voltages	± 3 %
Temperature	± 1 °C
Humidity	± 3 %

10 Summary of measurement results

10.1 Summary

☒	**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	47 CFR Part 95 Subpart M	see below	2023-03-27	-/-
RF-Testing	RSS – 251 Issue 2	see below	2023-03-27	-/-

Test specification clause	Test case	Temperature conditions	Power source voltages	Pass	Fail	NA	NP	Remark
§2.1046 §95.3367 (a) / (b) RSS-251 chapter 8 RSS-251 chapter 9	Radiated power	Nominal	Nominal	☒	☐	☐	☐	complies
§2.1047 RSS-251 chapter 6	Modulation characteristics	-/-	-/-	☒	☐	☐	☐	complies
§2.1049 RSS-251 chapter 7	Occupied bandwidth (99% bandwidth)	Nominal	Nominal	☒	☐	☐	☐	complies
§2.1051	Spurious emissions at antenna terminals	Nominal	Nominal	☒	☐	☐	☐	complies
§2.1053 §95.3379 (a)(1) §95.3379 (a)(2) §95.3379 (a)(3) RSS-251 chapter 10 RSS-Gen chapter 6.13 / 8.9	Unwanted emissions (radiated spurious)	Nominal	Nominal	☒	☐	☐	☐	complies
§2.1055 §95.3379 (b) RSS-251 chapter 11 RSS-Gen chapter 6.11 / 8.11	Frequency stability	Nominal and Extreme	Nominal and Extreme	☒	☐	☐	☐	complies

Note: C = Compliant; NC = Not compliant; NA = Not applicable; NP = Not performed

See FCC's Millimeter Wave Test Procedures:
I. A radiated method of measurements in order to demonstrate compliance with the various regulatory requirements has been chosen in consideration of test equipment availability and the limitations of many external harmonic mixers. A conducted method of measurement could be employed if EUT and mixer waveguides both are accessible and of the same type (WG number) and if waveguide sections and transitions can be found. Another potential problem is that the peak power output of devices operating under Sections 15.253 and 15.255 may exceed the +20 dBm input power limit of many commercially available mixers. For these reasons a radiated method is preferred.

10.2 Additional comments

Reference documents: None

Special test descriptions: None

Configuration descriptions: None

10.3 Operation mode for testing

Test mode: ☒ No test mode available.

☒ Special test software is used.

Description of test modes as declared by customer:

- The operation of the radar sensor can be start and stop by a special software.
- In the operation mode, the radar sensor works in normal mode

11 Measurement results

11.1 Radiated power

Description:

§95.3367:
The fundamental radiated emission limits within the 76-81 GHz band are expressed in terms of Equivalent Isotropically Radiated Power (EIRP) and are as shown below.

RSS-251 chapter 8.1:
The average e.i.r.p. measurement shall be performed using a power averaging detector with a 1 MHz resolution bandwidth (RBW). The power shall be integrated over the occupied bandwidth.

RSS-251 chapter 9.1:
The peak e.i.r.p. measurement shall be performed by sweeping the transmitted occupied bandwidth with a positive peak power detector, using a peak hold display mode, and a 1 MHz resolution bandwidth. The power integration is not to be used in performing this measurement.

Limits: **FCC §95.3367 (a) (b)/ RSS-251 (5.2.2)**

Frequency	Limit (eirp)
76.0 - 81.0 GHz	50 dBm (Average)
76.0 - 81.0 GHz	55 dBm/MHz (PEAK)

Measurement: Average Power

Measurement parameter	
Detector:	RMS
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Trace-Mode:	Max Hold

Measurement: Peak Power

Measurement parameter	
Detector:	Pos-Peak
Resolution bandwidth:	50 MHz
Video bandwidth:	80 MHz
Trace-Mode:	Max Hold

Note: **KDB 653005 4.(c)(1)**
Peak power measurements of swept frequency radar implementations (e.g., high sweep rate FMCW) may require a desensitization correction factor to be applied to the measurement results.

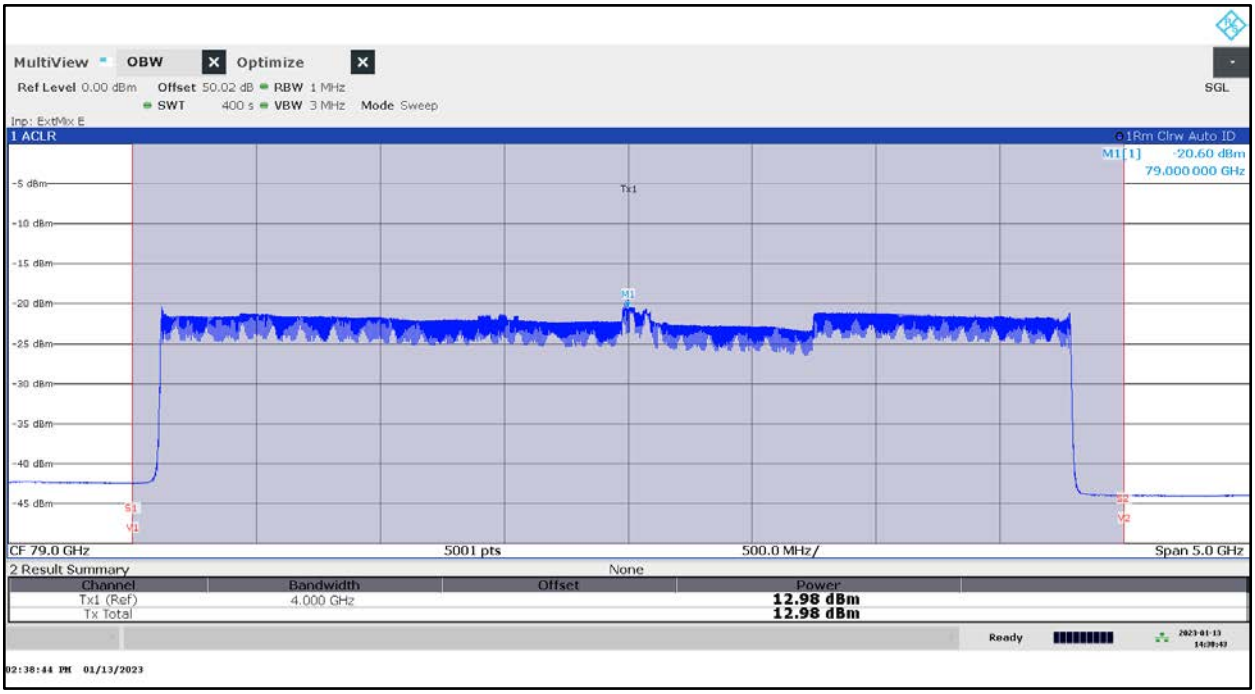
Consequence:
Worst case measurement, the peak power measurement is performed with a greater resolution bandwidth to solve the problem with the desensitization.

Measurement results:

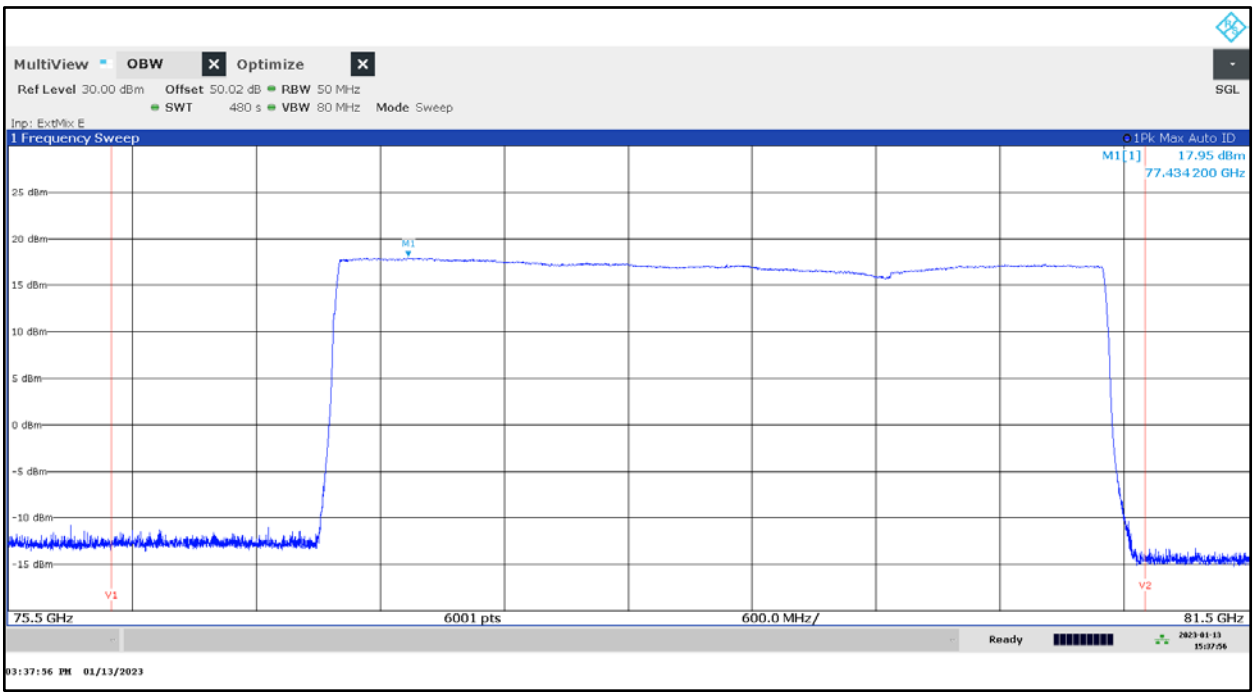
EUT	Mode	Test condition	Radiated peak power (eirp) [dBm/MHz]	Radiated Mean Power (eirp) [dBm]
1	Normal	T_{nom} / V_{nom}	17.95	12.98

Verdict: **Complies**

Plot 1: Channel power



Plot 2: Peak power



11.2 Modulation characteristics

Description:

§2.1047 (d) *Other types of equipment.* A curve or equivalent data which shows that the equipment will meet the modulation requirements of the rules under which the equipment is to be licensed.

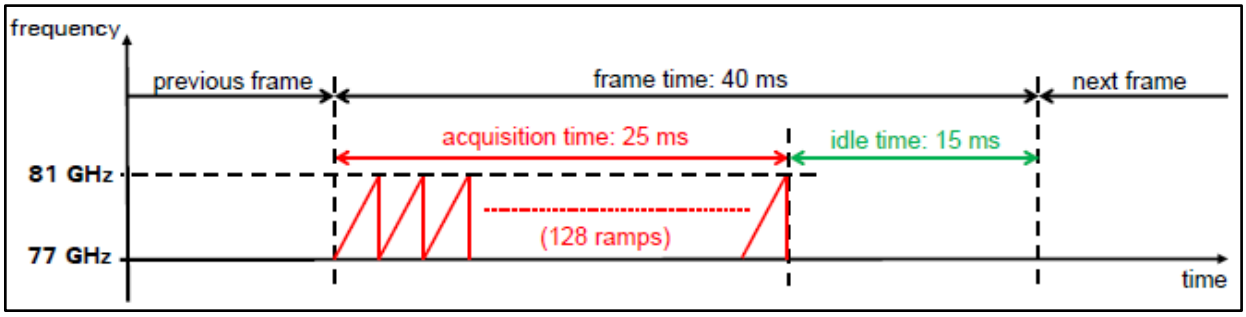
RSS-251 chapter 6:
In addition to the reporting requirements of RSS-Gen, the following information shall be provided, as per the applicable modulation type:

- Pulsed radar: pulse width and pulse repetition frequency (PRF). If the PRF is variable, the maximum and minimum values shall be reported.
- Non-pulsed radar (e.g. frequency modulated continuous wave (FMCW)): modulation type (i.e. sawtooth, sinusoid, triangle, or square wave) and sweep characteristics (sweep bandwidth, sweep rate, sweep time).

Comments from manufacturer on modulation characteristics according to KDB 653005 3.(g):

Modulation Type	sawtooth
Modulation characteristics:	
Sweep Bandwidth	See Plot 3
Sweep rate	See Plot 3
Sweep time	See Plot 3

Plot 3: provided by customer



11.3 Occupied bandwidth

Description:

§2.1049 The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission.

RSS-251 chapter 7.2:
The radar device's occupied bandwidth (i.e. 99% emission bandwidth) shall be contained in the 76-81GHz frequency band.

Limits:

FCC	IC
FCC §95.3379 (b)	RSS-251 chapter 7.2:
The occupied bandwidth from intentional radiators operated within the specified frequency band shall comply with the following:	
Frequency range	
76 GHz – 81 GHz	

Measurement:

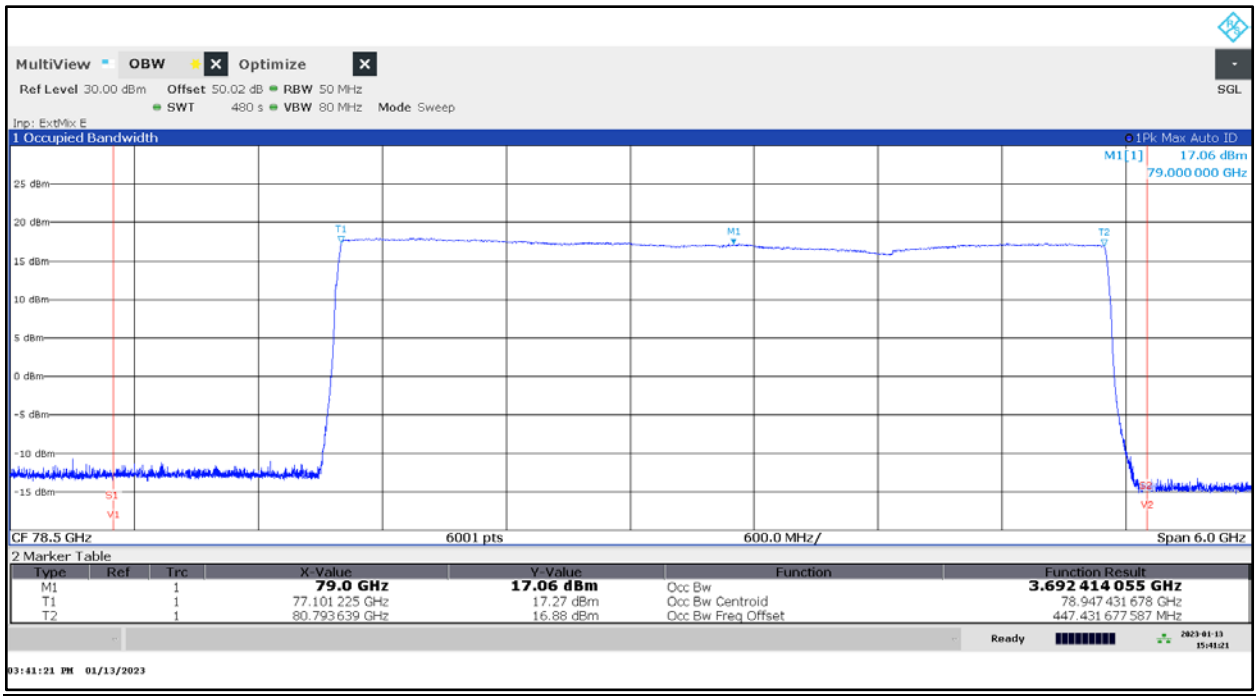
Parameters	
Detector:	Pos-Peak
Resolution bandwidth:	50 MHz
Video bandwidth:	80 MHz
Trace-Mode:	Max Hold

Results:

EUT	TEST CONDITIONS	f_L in GHz	f_H in GHz	Occupied Bandwidth (99%) in MHz	Plot
EUT 1	T_{nom} / V_{nom}	77.101	80.794	3.692	Plot 4

Verdict: **Complies**

Plot 4: 99% Bandwidth



11.4 Band edge compliance

Description:

Investigation of the emission limits at the band edge.

Limits: **FCC §95.3379 (a) (2) (i) + (ii) / ANSI C63.10-2013 / 6.10**

Frequency Range [GHz]	Measurement distance	Power Density
40 – 76 and 81 – 200	3.0 m	600 pW/cm² → -1.7 dBm

Limits: **RSS-251 (10.2)**

Frequency Range [GHz]	Power Density
40 – 76 and 81 – 162	-30 dBm/MHz (e.i.r.p)

Limits: **FCC §95.3367 (a) (b)/ RSS-251 (5.2.2)**

Frequency Range [GHz]	Power Density
76 - 81	50 dBm/MHz (e.i.r.p)

Measurement:

Parameters	
Detector:	RMS
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Trace-Mode:	Max Hold

Measurement results:

- Results are part of chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**

Verdict: **Complies**

11.5 Unwanted emissions

Description:

Measurement of the radiated unwanted emissions.

Limits:

FCC §95.3379

(a) The power density of any emissions outside the 76-81 GHz band shall consist solely of spurious emissions and shall not exceed the following:

(1) Radiated emissions below 40 GHz shall not exceed the field strength as shown in the following emissions table.

FCC		
CFR Part 95.3379 (a) (1) / CFR Part 95.3379 (a) (3)		
Radiated unwanted emissions		
Frequency (MHz)	Field Strength (µV/m)	Measurement distance (m)
0.009 – 0.490	2400/F[kHz]	300
0.490 – 1.705	24000/F[kHz]	30
1.705 – 30.0	30	30
30 88	100	3
88 – 216	150	3
216 – 960	200	3
960 – 40 000	500	3

(i) In the emissions table in paragraph (a)(1) of this section, the tighter limit applies at the band edges.

(ii) The limits in the table in paragraph (a)(1) of this section are based on the frequency of the unwanted emissions and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

(iii) The emissions limits shown in the table in paragraph (a)(1) of this section are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9.0-90.0 kHz, 110.0-490.0 kHz, and above 1000 MHz. Radiated emissions limits in these three bands are based on measurements employing an average detector with a 1 MHz RBW

(2) The power density of radiated emissions outside the 76-81 GHz band above 40.0 GHz shall not exceed the following, based on measurements employing an average detector with a 1 MHz RBW:

(i) For radiated emissions outside the 76-81 GHz band between 40 GHz and 200 GHz from field disturbance sensors and radar systems operating in the 76-81 GHz band: 600 pW/cm2 at a distance of 3 meters from the exterior surface of the radiating structure.

(ii) For radiated emissions above 200 GHz from field disturbance sensors and radar systems operating in the 76-81 GHz band: 1000 pW/cm2 at a distance of 3 meters from the exterior surface of the radiating structure.

Frequency Range (GHz)	Power Density	EIRP
40 – 200	600 pW/cm^2 @ 3m	-1.7 dBm
200 – 231	1000 pW/cm^2 @ 3m	+0.5 dBm

(3) For field disturbance sensors and radar systems operating in the 76-81 GHz band, the spectrum shall be investigated up to 231.0 GHz.

Limit conversion (ANSI C63.10-2013 9.6):

EIRP[dBm] = 10 × log(4 × π × d² × PD[W/m²])

- Power density at the distance specified by the limit: PD [W/m²]
- Equivalent isotropically radiated power: EIRP [dBm]
- Distance at which the power density limit is specified: d [m]

According to this formula, an emission limit of PD = 600 pW/cm² at a distance of d = 3 m corresponds to an equivalent isotropically radiated power of EIRP = -1.7 dBm.

RSS-251 10

10.1 In addition to the requirements specified in RSS-Gen and the method of measurement of ANSI C63.10, the spectrum shall be investigated up to 162 GHz.

10.2

The radar device's unwanted emissions outside the 76-81 GHz frequency band shall comply with the limits in table below.

RSS		
RSS-251 chapter 10.2 Table 1		
Radiated unwanted emissions		
Emission frequency range	Limit	Applicable detector
Below 40 GHz	RSS-Gen general field strength limits for licence-exempt radio apparatus	RSS-Gen requirements
40-162 GHz *	-30 dBm/MHz (e.i.r.p.)	RMS detector
Note: * For radar devices that operate solely in the 76-77 GHz band (i.e. the occupied bandwidth is entirely contained in the 76-77 GHz band), an unwanted emissions limit of 0 dBm/MHz shall apply for the unwanted emission that fall in the 73.5-76 GHz band. Outside of the 73.5-76 GHz band, the unwanted emission limits prescribed in table above shall apply.		

RSS-Gen 8.9

Except where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in the tables below. Additionally, the level of any transmitter unwanted emission shall not exceed the level of the transmitter's fundamental emission.

RSS		
RSS-Gen chapter 8.9 Table 5/6		
Radiated emissions		
General field strength limits at frequencies above 30 MHz		
Frequency (MHz)	Field strength (µV/m)	
30 88	100 µV/m	
88 – 216	150 µV/m	
216 – 960	200 µV/m	
960 – 40 000	500 µV/m	
General field strength limits at frequencies below 30 MHz		
Frequency	Magnetic field strength (H-Field) (µA/m)	Measurement distance (m)
9 - 490 kHz Note 1	6.37/F (F in kHz)	300
490 - 1705 kHz	63.7/F (F in kHz)	30
1.705 - 30 MHz	0.08	30
Note 1: The emission limits for the ranges 9-90 kHz and 110-490 kHz are based on measurements employing a linear average detector.		

Measurement:

Measurement parameter	
Detector:	Quasi Peak / Pos-Peak / LinAV / RMS
Resolution bandwidth:	F < 1 GHz: 100 kHz F > 1 GHz: 1 MHz
Video bandwidth:	F < 1 GHz: 300 kHz F > 1 GHz: 3 MHz
Trace-Mode:	Max Hold

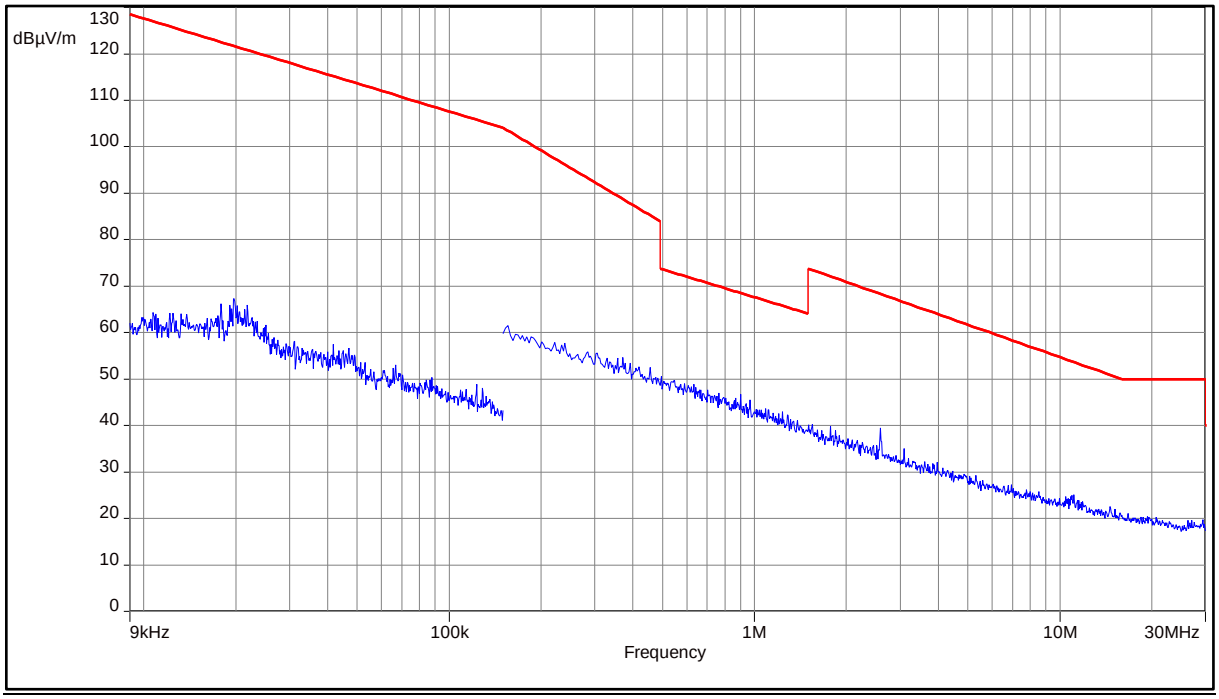
Measurement results:

Frequency [GHz]	Detector	Bandwidth [MHz]	Level	Limit	Margin [dB]
28.798	LinAV	1	52.6 [dBuV]	54.0 [dBuV]	1.4

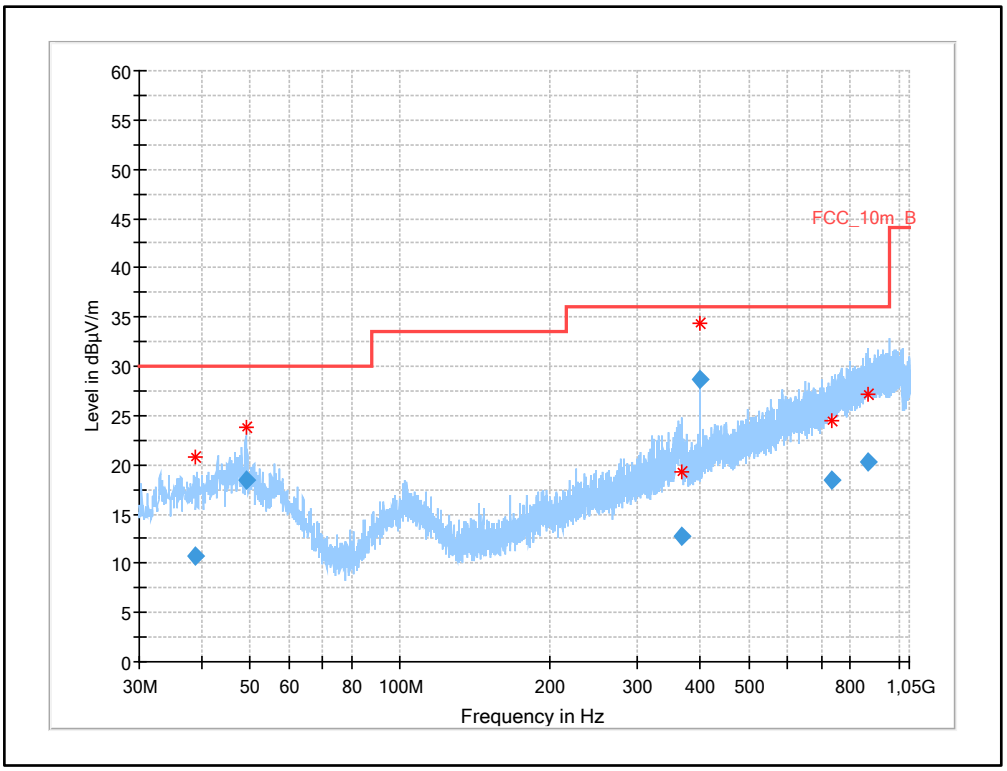
For emissions below 1 GHz, please refer to plot Plot 5 to Plot 6.

Verdict: Complies

Plot 5: Spurious Emission 9kHz – 30 MHz

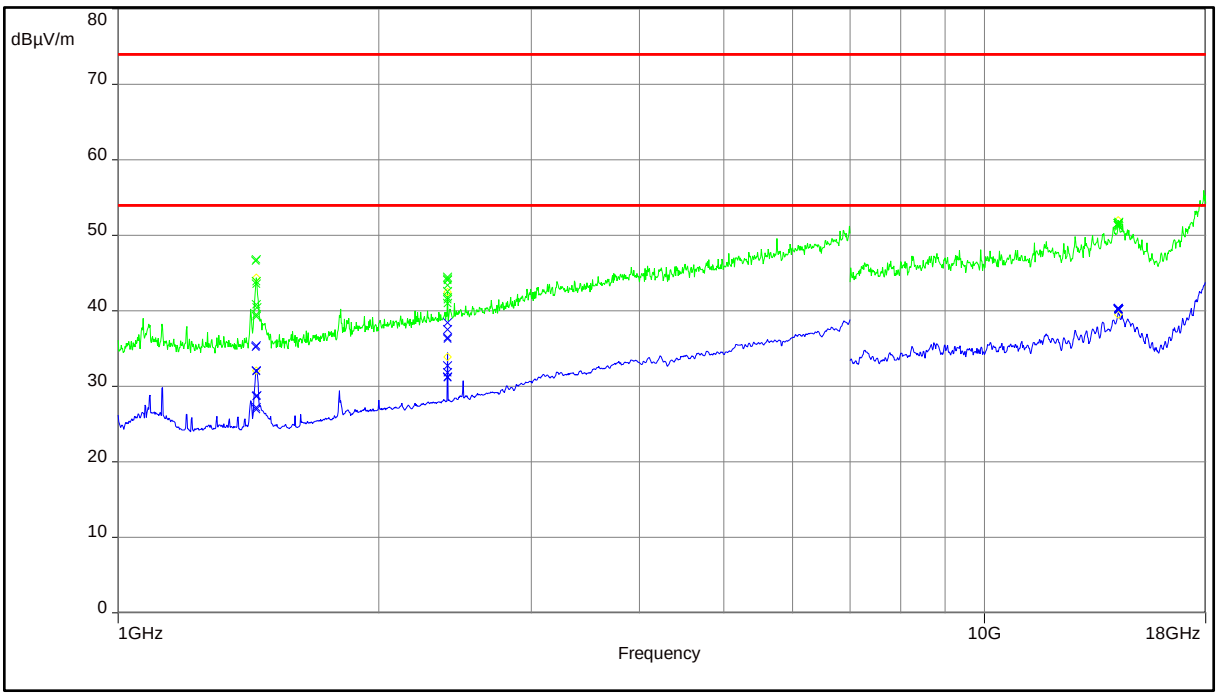


Plot 6: Spurious Emission 30 MHz – 1 GHz

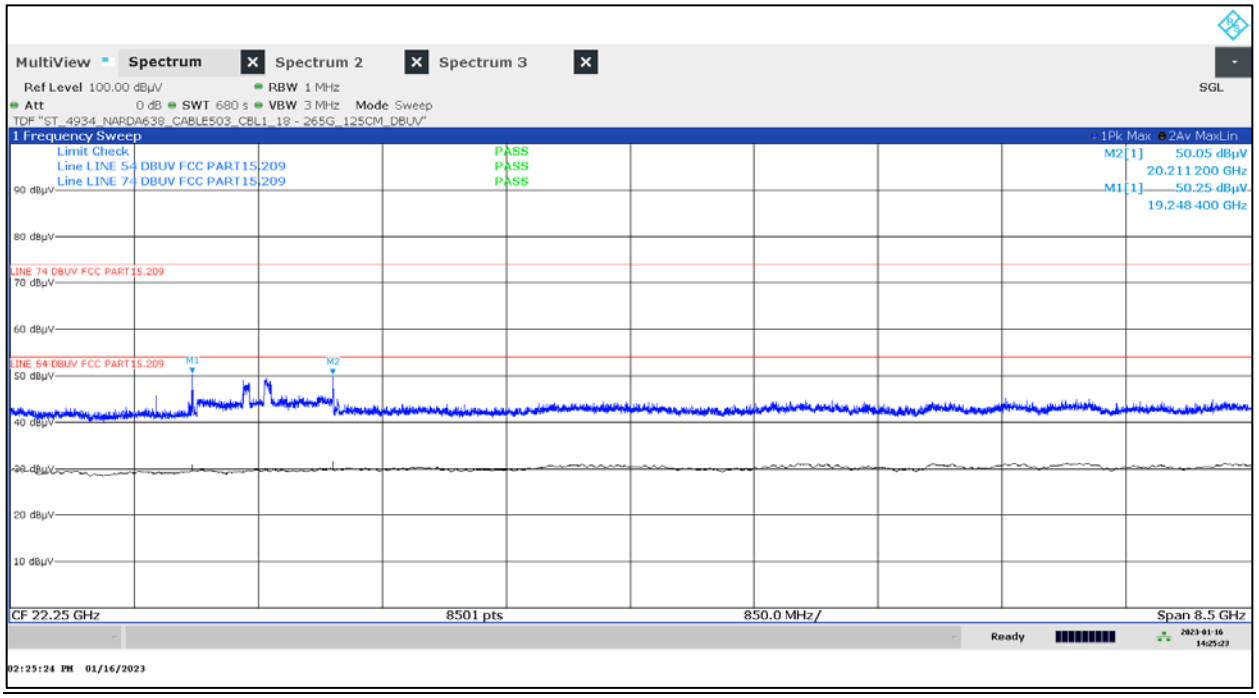


Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
38.719	10.65	30.0	19.4	1000	120.0	119.0	V	135	15
49.055	18.47	30.0	11.5	1000	120.0	123.0	V	97	16
366.056	12.71	36.0	23.3	1000	120.0	104.0	V	90	17
400.023	28.66	36.0	7.3	1000	120.0	266.0	V	104	18
734.463	18.39	36.0	17.6	1000	120.0	112.0	V	225	23
870.319	20.36	36.0	15.6	1000	120.0	400.0	H	270	25

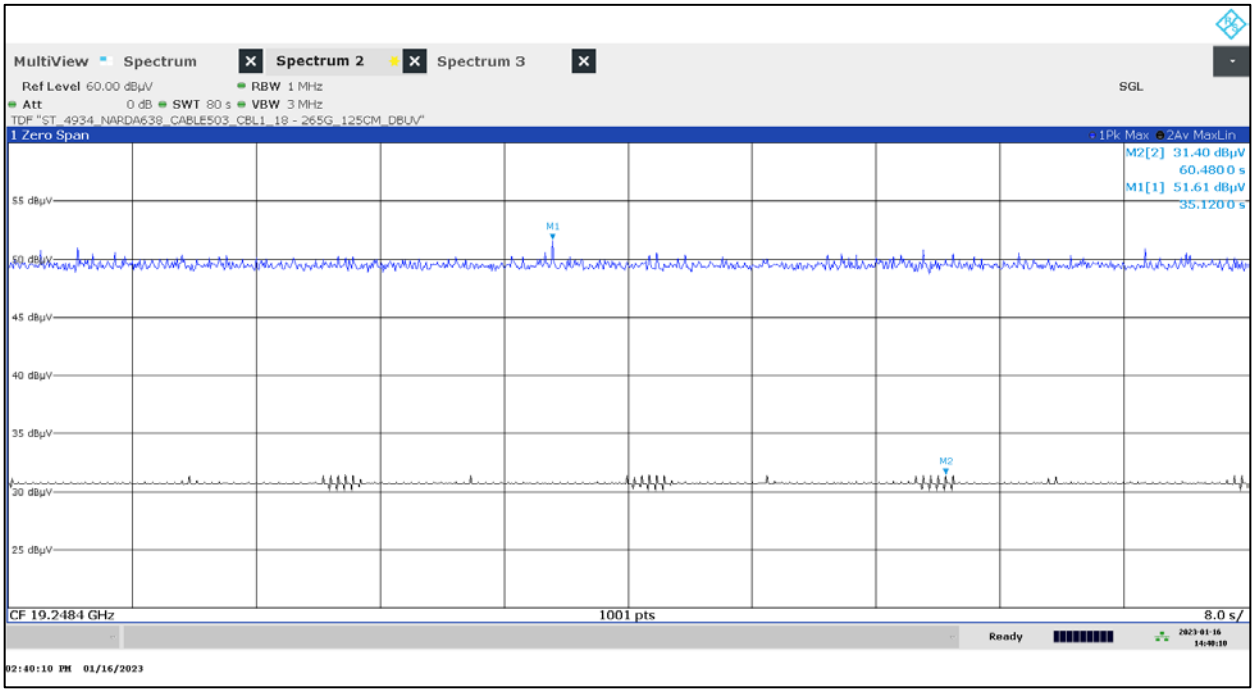
Plot 7: Spurious Emission 1 GHz – 18 GHz



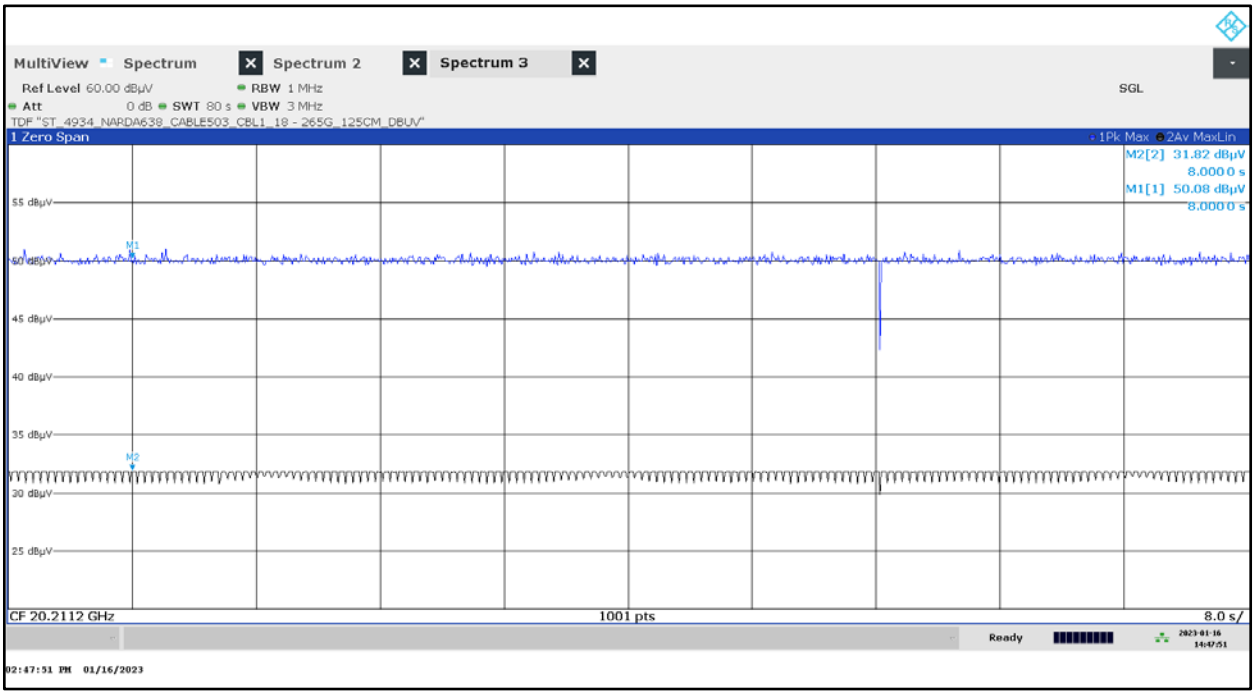
Plot 8: Spurious Emission 18 GHz – 26.5 GHz



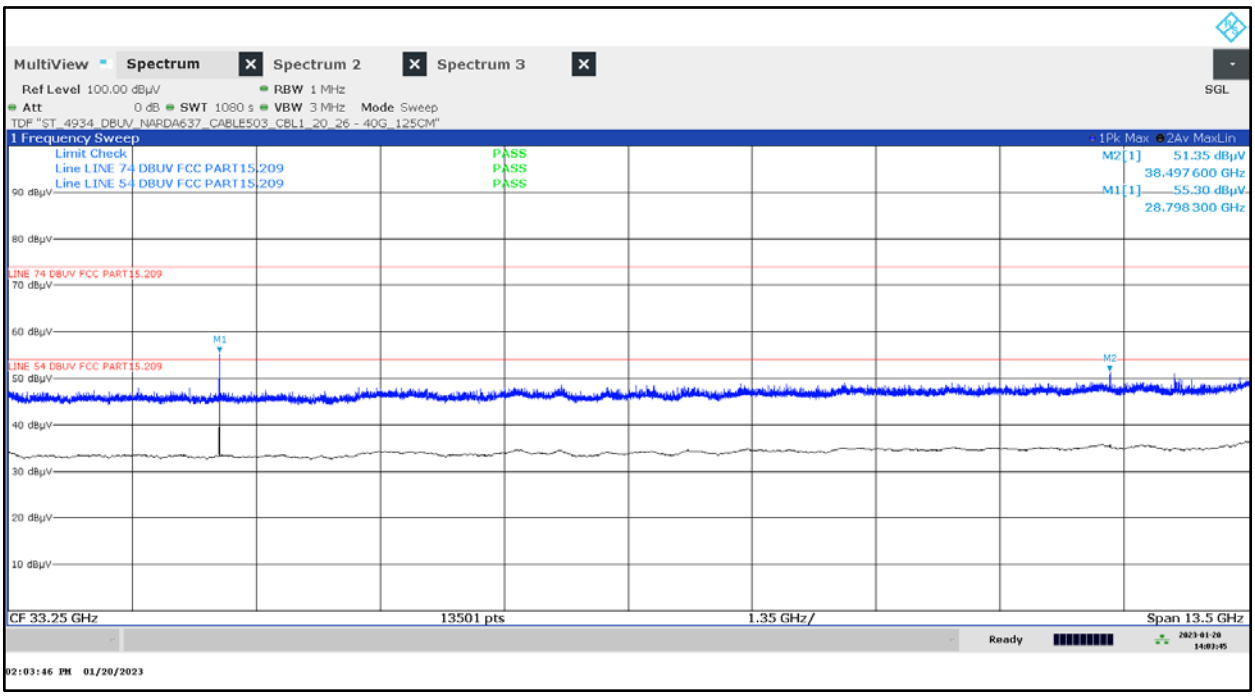
Plot 9: Spurious Emission 19.248 GHz



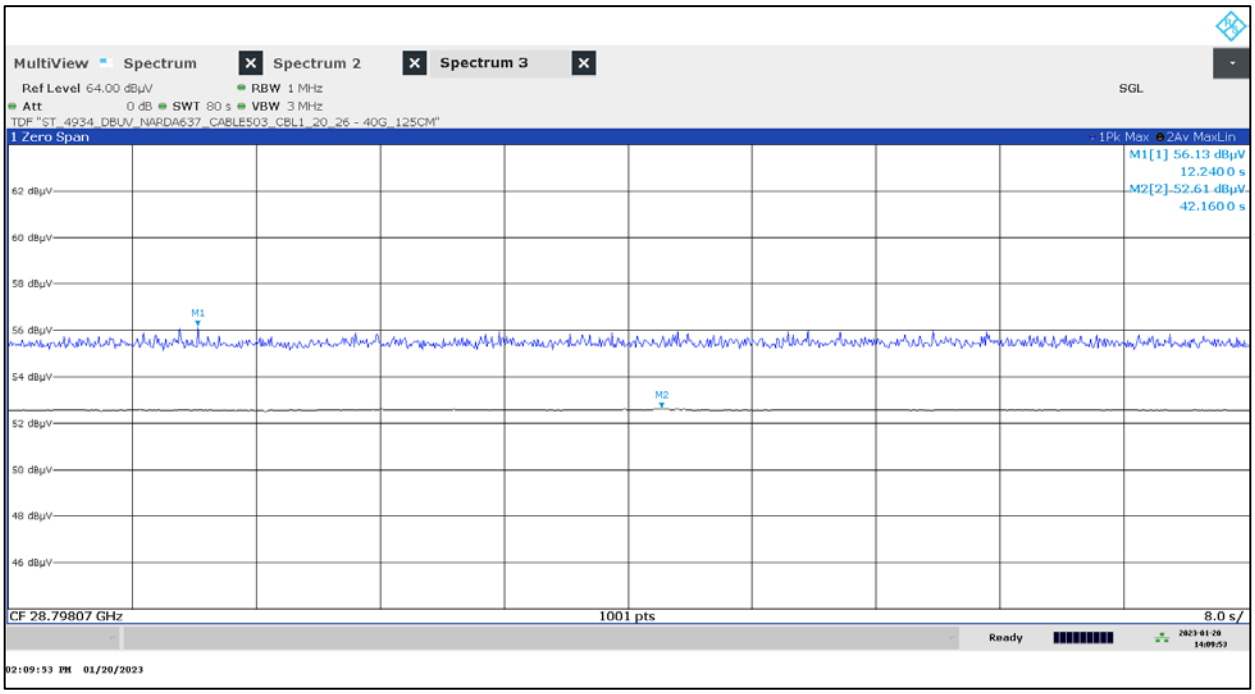
Plot 10: Spurious Emission 20.2112 GHz



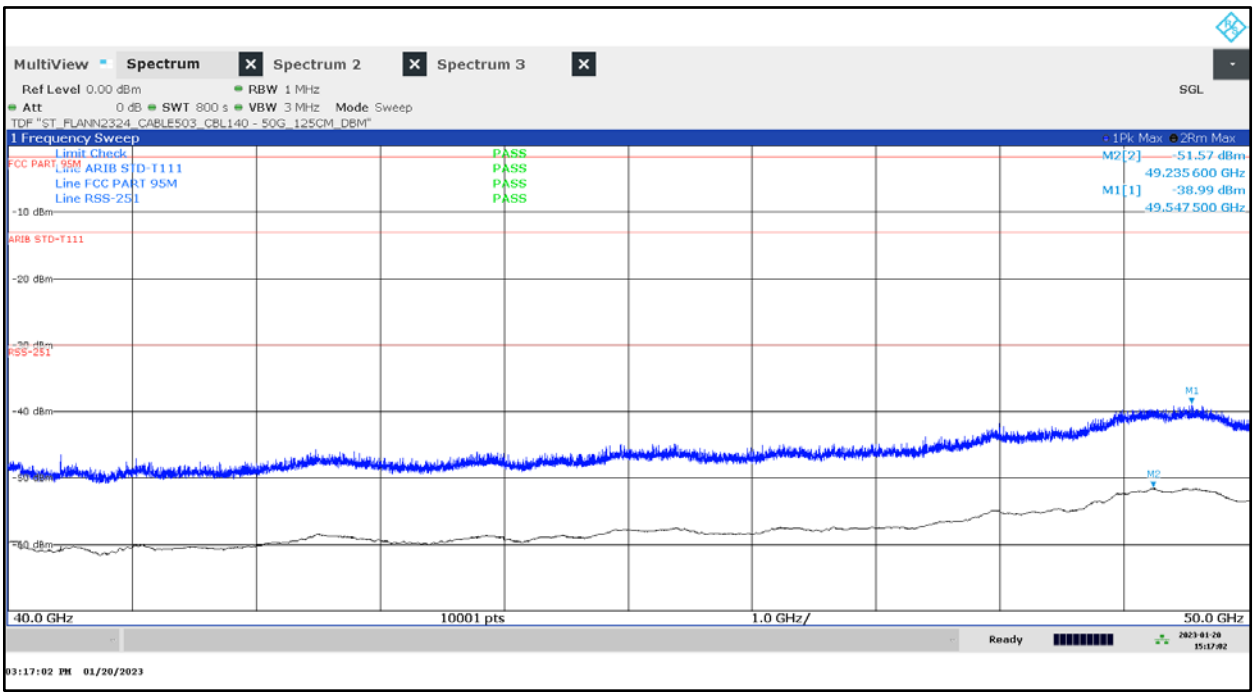
Plot 11: Spurious Emission 26.5 GHz – 40 GHz



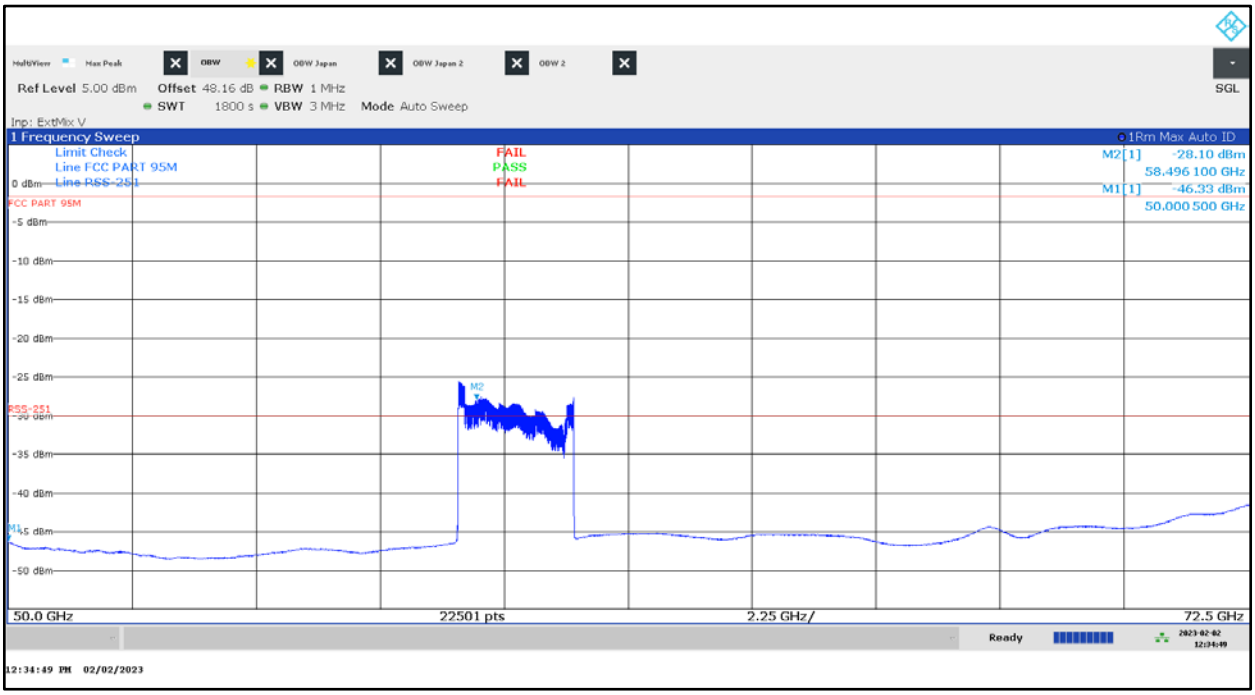
Plot 12: Spurious Emission 28.798 GHz



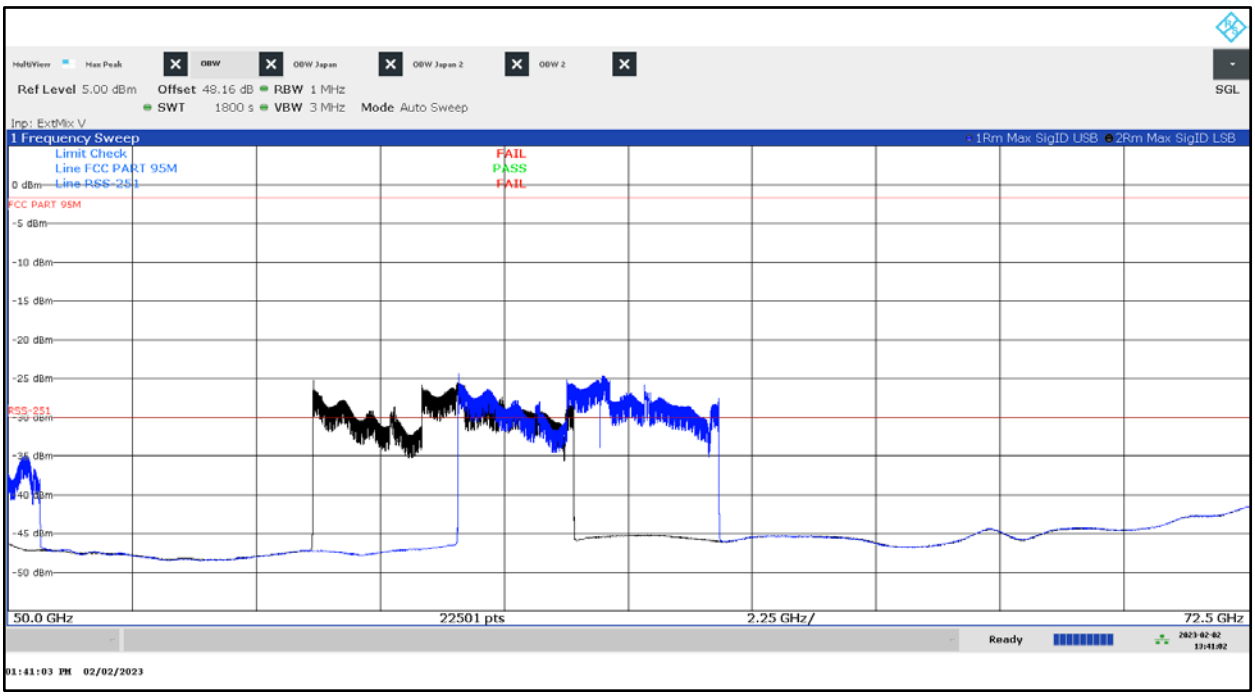
Plot 13: Spurious Emission 40 GHz – 50 GHz



Plot 14: Spurious Emission 50 GHz – 72.5 GHz measured with Auto ID



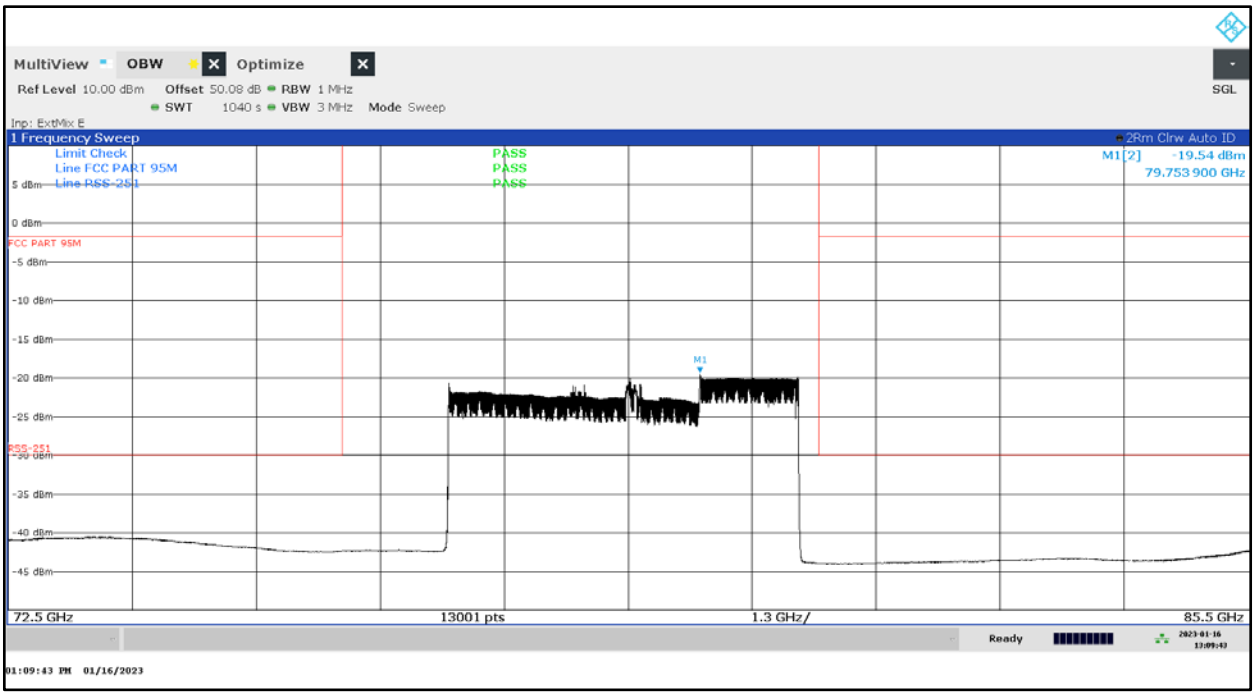
Plot 15: Spurious Emission 50 GHz – 72.5 GHz measured with Signal ID



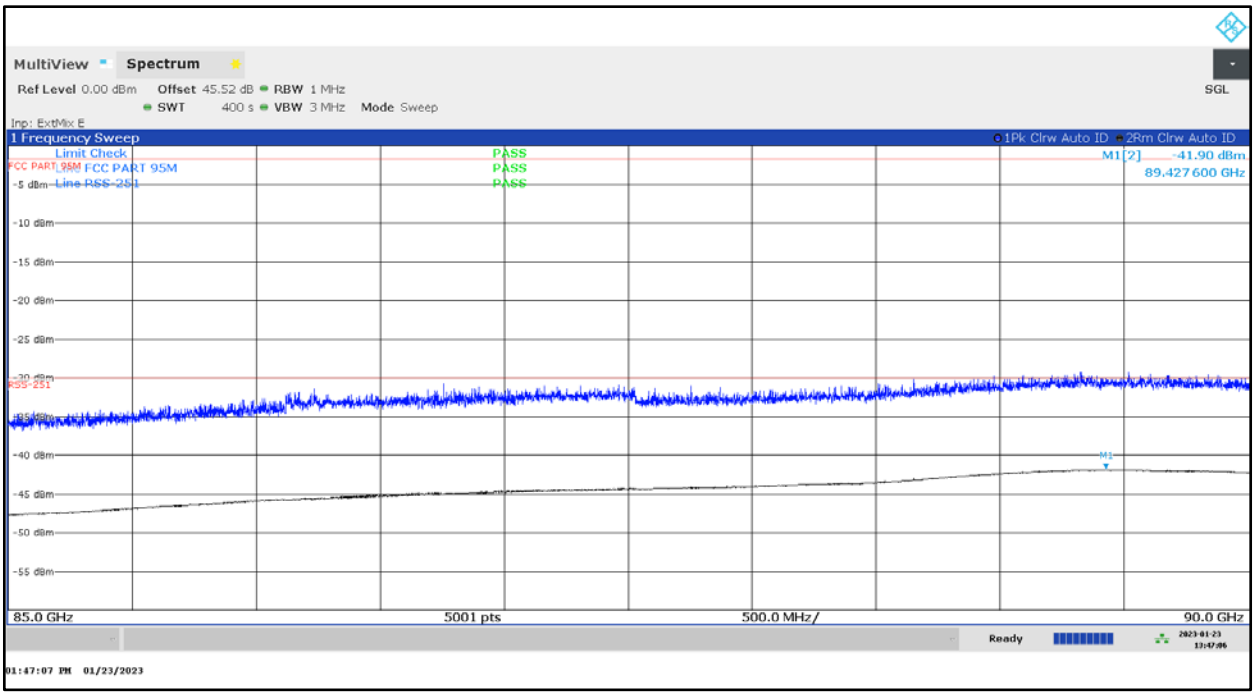
Note:

- In the Signal ID mode, the spectrum analyser displays the upper and the lower sideband
- Plot 15 shows the shift of the upper and the lower sideband and therefore the signal in Plot 14 is not a real signal. The signal is produced by the external mixer.

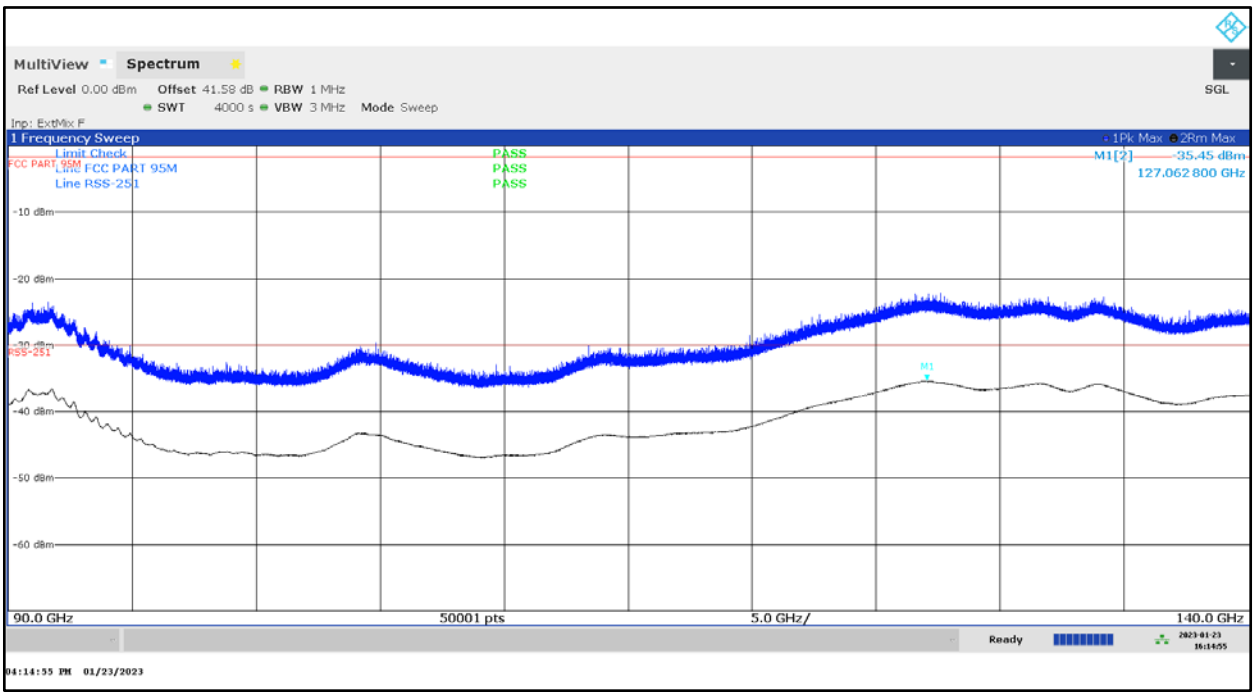
Plot 16: Out of Band Emission between 72.5 GHz and 85.5 GHz



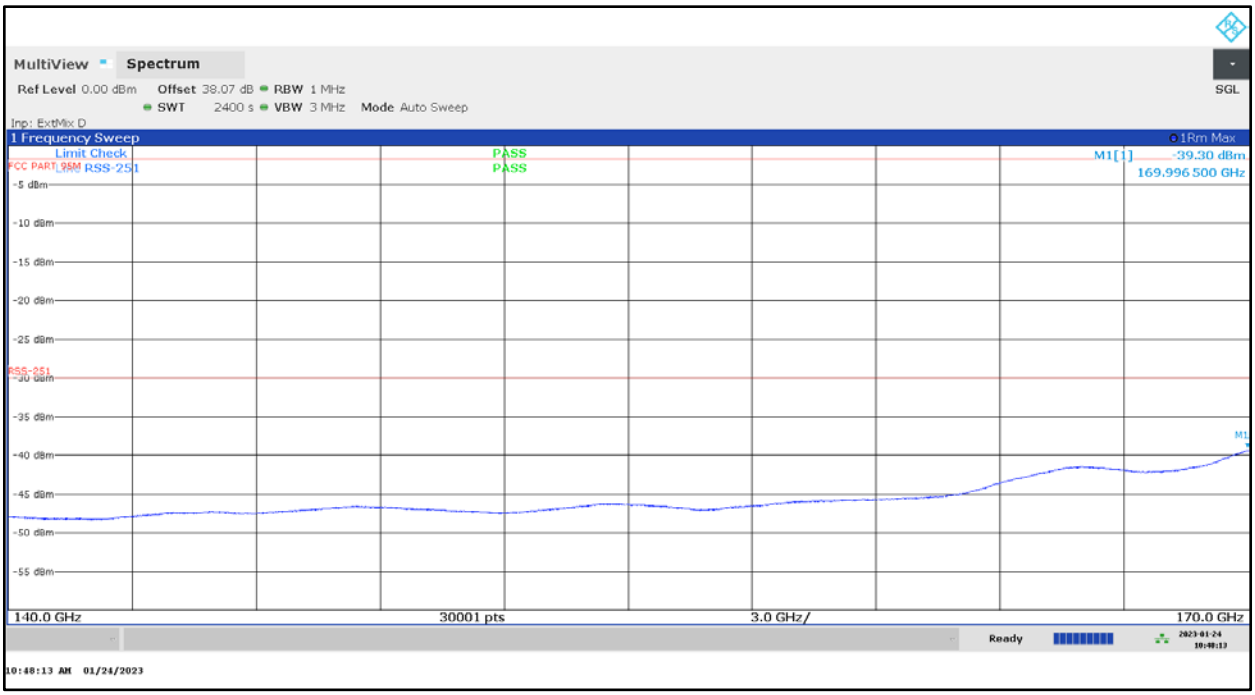
Plot 17: Spurious Emission 85 GHz – 90 GHz



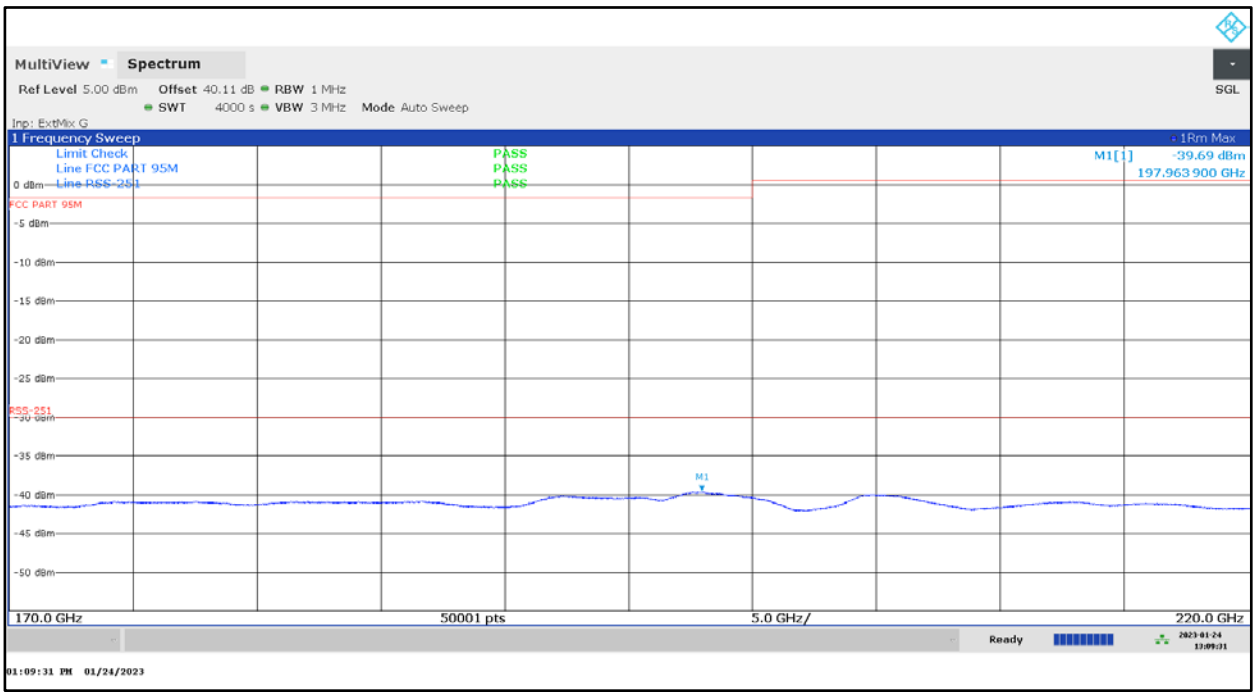
Plot 18: Spurious Emission 90 GHz – 140 GHz



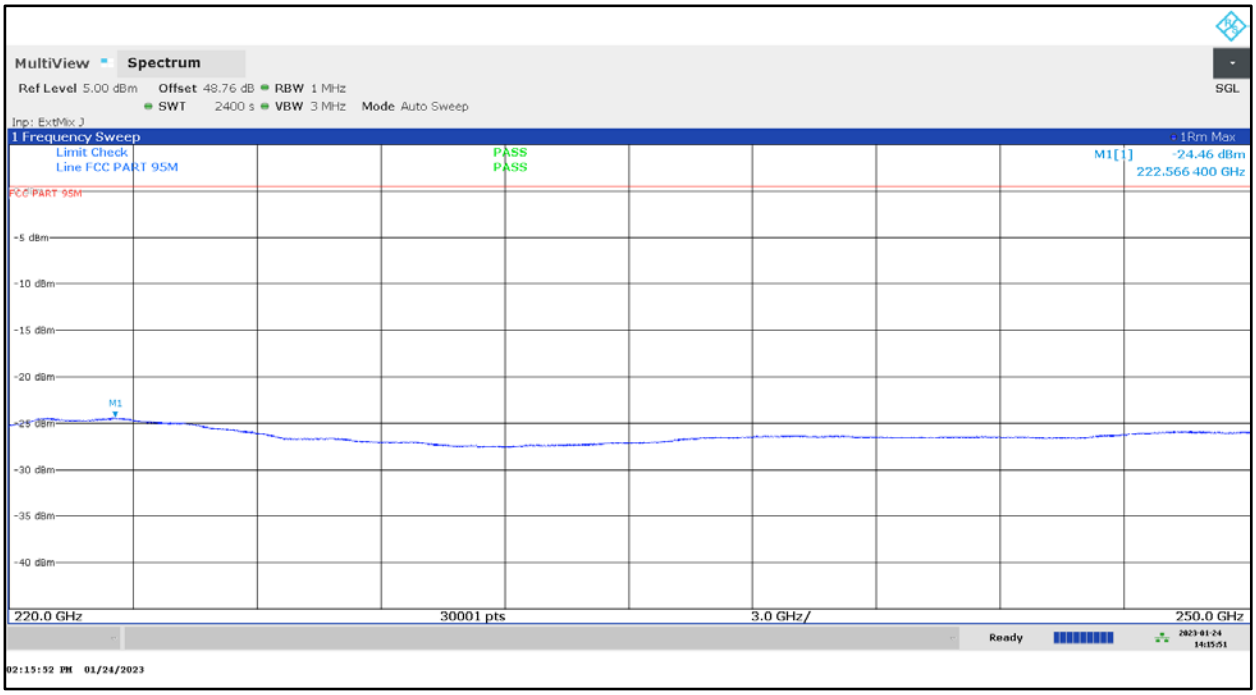
Plot 19: Spurious Emission 140 GHz – 170 GHz



Plot 20: Spurious Emission 170 GHz – 220 GHz



Plot 21: Spurious Emission 220 GHz – 250 GHz



11.6 Frequency stability

Description:

§95.3379 (b) Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range −20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

RSS-251 chapter 11.1:
The radar device's occupied bandwidth (i.e. 99% emission bandwidth) shall be maintained within the 76-81 GHz frequency band while subjected to all conditions of operation specified in RSS-Gen.

Limits:

FCC	IC
FCC §95.3379 (b)	RSS-251 chapter 7.2:
The occupied bandwidth from intentional radiators operated within the specified frequency band shall comply with the following:	
Frequency range	
76 GHz – 81 GHz	

Measurement:

Parameters	
Detector:	Pos-Peak
Resolution bandwidth:	50 MHz
Video bandwidth:	80 MHz
Trace-Mode:	Max Hold

Measurement results:

Test condition	Frequency f_L [GHz]	Frequency f_H [GHz]	Bandwidth [GHz]
-40 °C / V_{nom}	77.105	80.818	3.713
-20 °C / V_{nom}	77.102	80.819	3.717
-10 °C / V_{nom}	77.100	80.819	3.718
0 °C / V_{nom}	77.100	80.815	3.715
10 °C / V_{nom}	77.099	80.816	3.717
20 °C / V_{nom}	77.097	80.817	3.720
20 °C / V_{min}	77.096	80.814	3.717
20 °C / V_{max}	77.098	80.817	3.720
30 °C / V_{nom}	77.099	80.816	3.717
40 °C / V_{nom}	77.099	80.816	3.717
50 °C / V_{nom}	77.099	80.816	3.716
70 °C / V_{nom}	77.099	80.813	3.713

Note:

- Vertical Line V1 = 76 GHz
- Vertical Line V2 = 77 GHz
- Vertical Line V3 = 81 GHz

Verdict: **Complies**

Plot 22: -40 °C / V_{nom}

Plot 23: -20 °C / V_{nom}

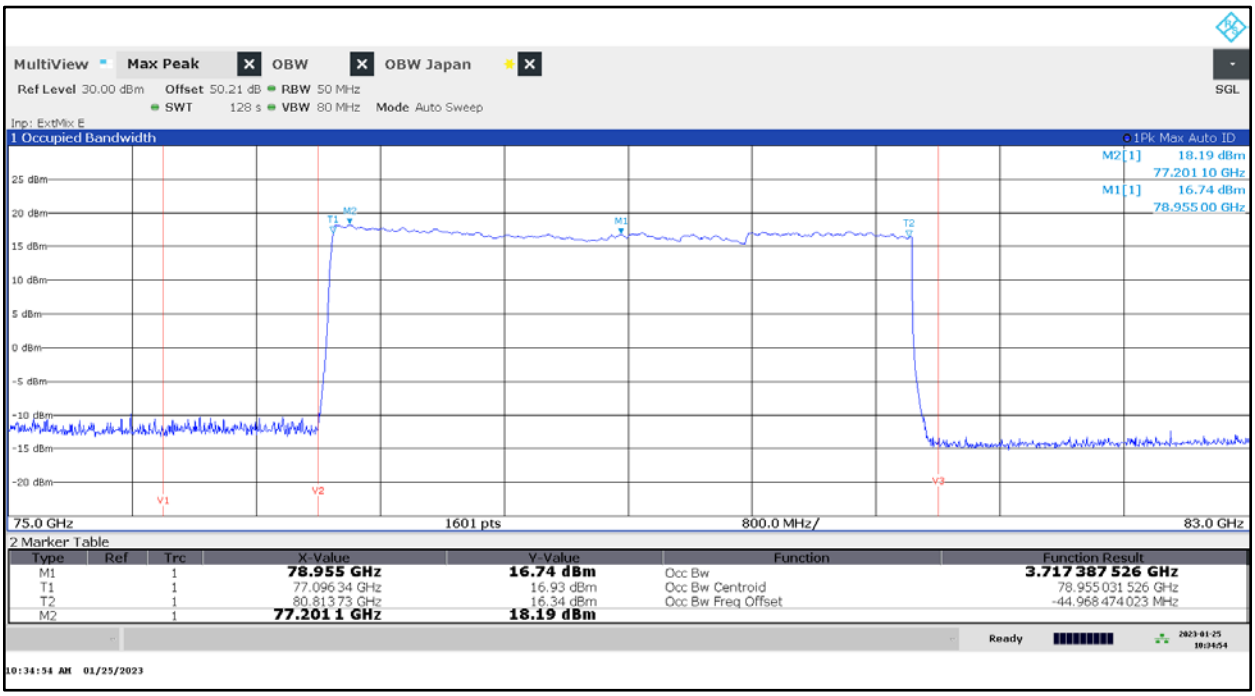
Plot 24: -10 °C / V_{nom}

Plot 25: 0 °C / V_{nom}

Plot 26: 10 °C / V_{nom}

Plot 27: 20 °C / V_{nom}

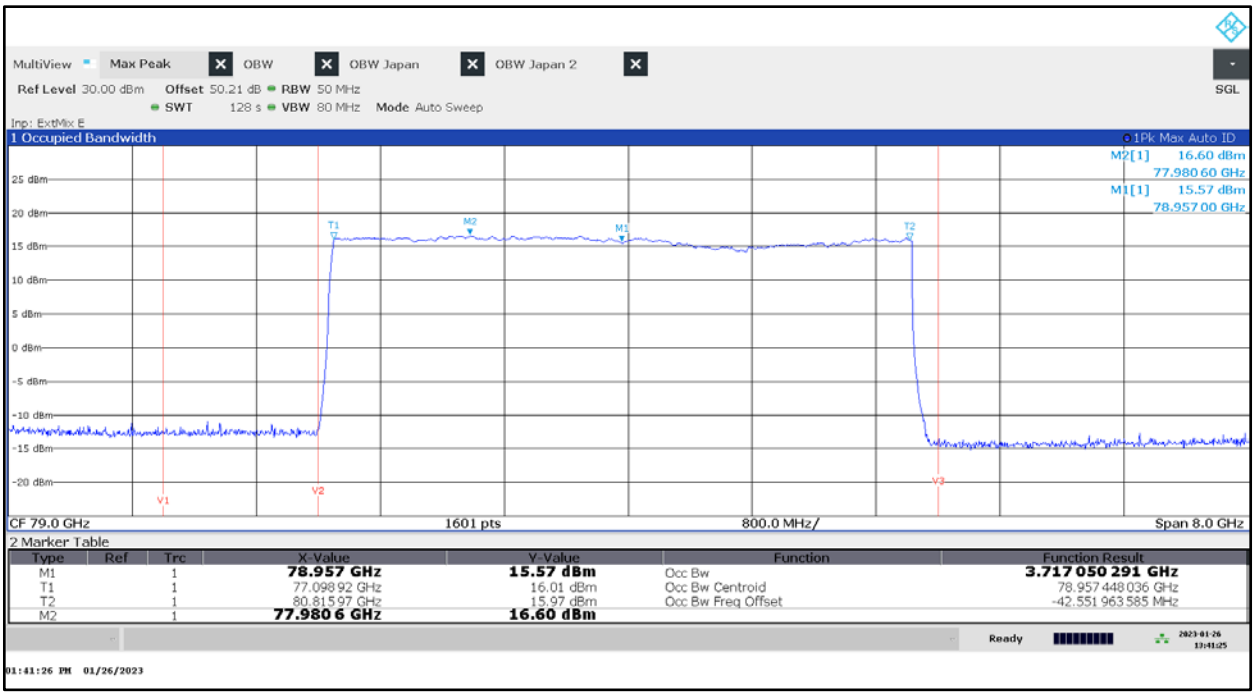
Plot 28: 20 °C / V_{min}



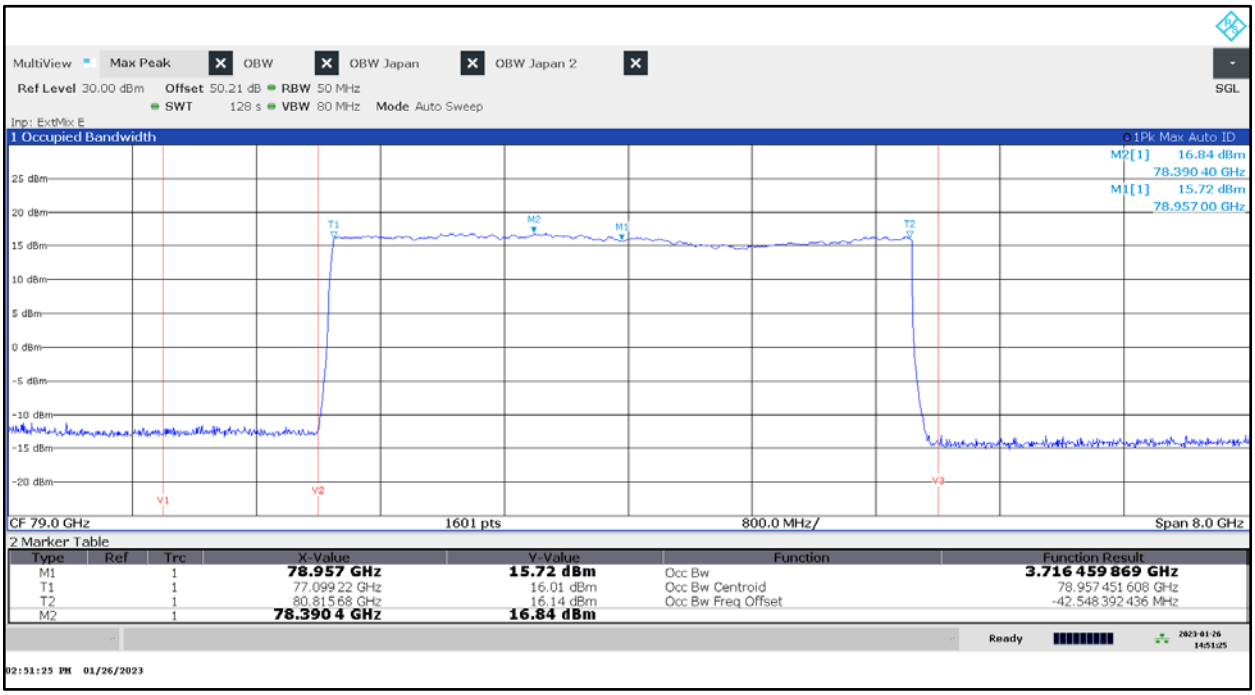
Plot 29: 20 °C / V_{max}

Plot 30: 30 °C / V_{nom}

Plot 31: 40 °C / V_{nom}



Plot 32: 50 °C / V_{nom}



Plot 33: -70 °C / V_{nom}

12 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/N_0	Carrier to noise-density ratio, expressed in dB-Hz

13 Document history

Version	Applied changes	Date of release
-/-	Initial release	2023-03-27

14 Accreditation Certificate – D-PL-12076-01-04

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	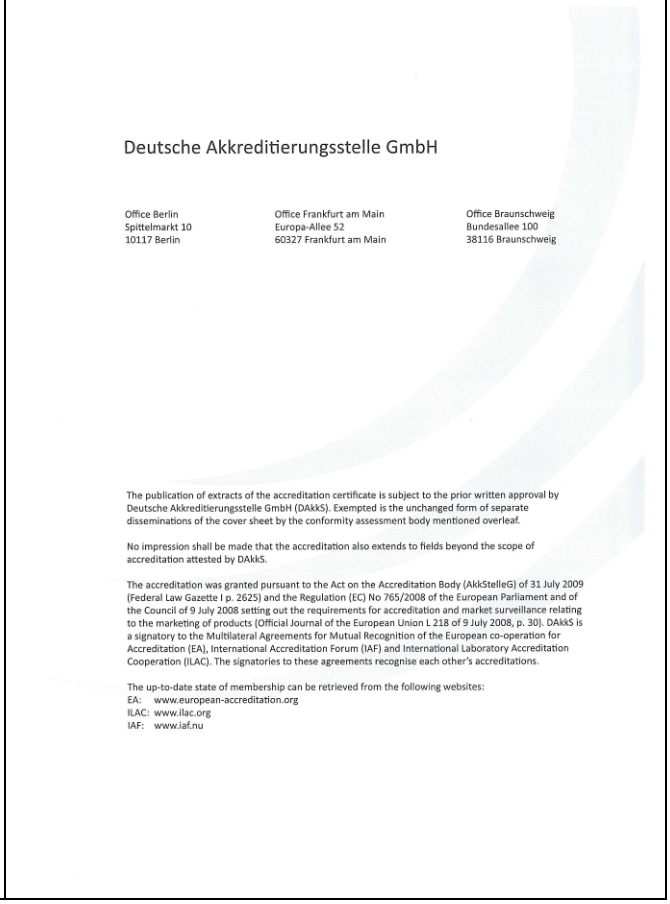

Note: The current certificate annex is published on the websites (link see below).

https://www.dakks.de/files/data/as/pdf/D-PL-12076-01-04e.pdf
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https://ctcadvanced.com/app/uploads/2020/06/D-PL-12076-01-04_Canada_TCEMC.pdf

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

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	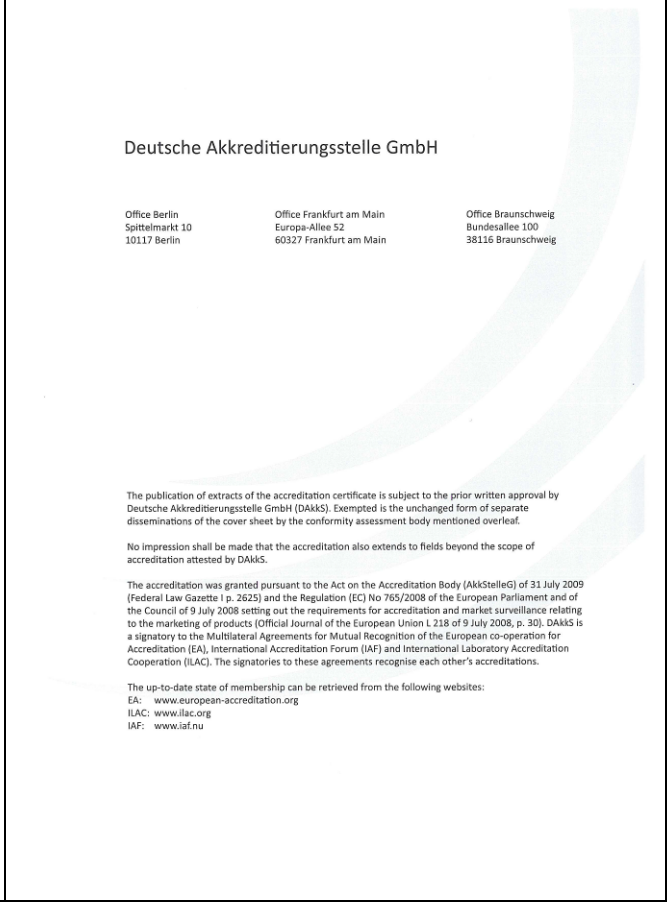

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########## END OF TEST REPORT ##########