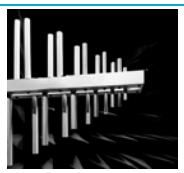
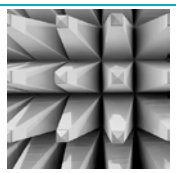




Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-3179_21-01-08

Testing laboratory

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

ifm electronic gmbh
Friedrichsstraße 1
45128 Essen / GERMANY
Phone: +49 201 2422-0
Contact: Holger Wenzel
e-mail: Holger.Wenzel@ifm.com
Phone: +49 7542 518-9108

Manufacturer

ifm electronic gmbh
Friedrichsstraße 1
45128 Essen / GERMANY

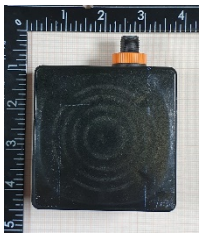
Test standard/s

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	Spectrum Management and Telecommunications Radio Standards Specification - Licence-Exempt Radio Apparatus: Category I Equipment
RSS - Gen	RSS-Gen — General Requirements for Compliance of Radio Apparatus

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

Test Item

Kind of test item:	Distance Radar, 60 GHz
Model name:	R1D102 (TR22)
FCC ID:	UN6-R1D1
IC:	6799A-R1D1
Frequency:	57 GHz – 71 GHz
Antenna:	Integrated antenna
Power supply:	10 V to 30 V DC
Temperature range:	-40°C to +85°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
2023.03.13 16:08:39 +01'00'

Thomas Vogler
Lab Manager
Radio Communications

Test performed:

cn=Stephan Thiel, o=CTC advanced GmbH, ou=THL-220401, email=Stephan.Thiel@ctcadvanced.com, c=DE
2023.03.13 16:07:15 +01'00'

Stephan Thiel
Testing Manager
Radio Communications

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:	2021-12-20
Date of receipt of test item:	2022-10-05
Start of test:*	2022-11-01
End of test:*	2022-12-01
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

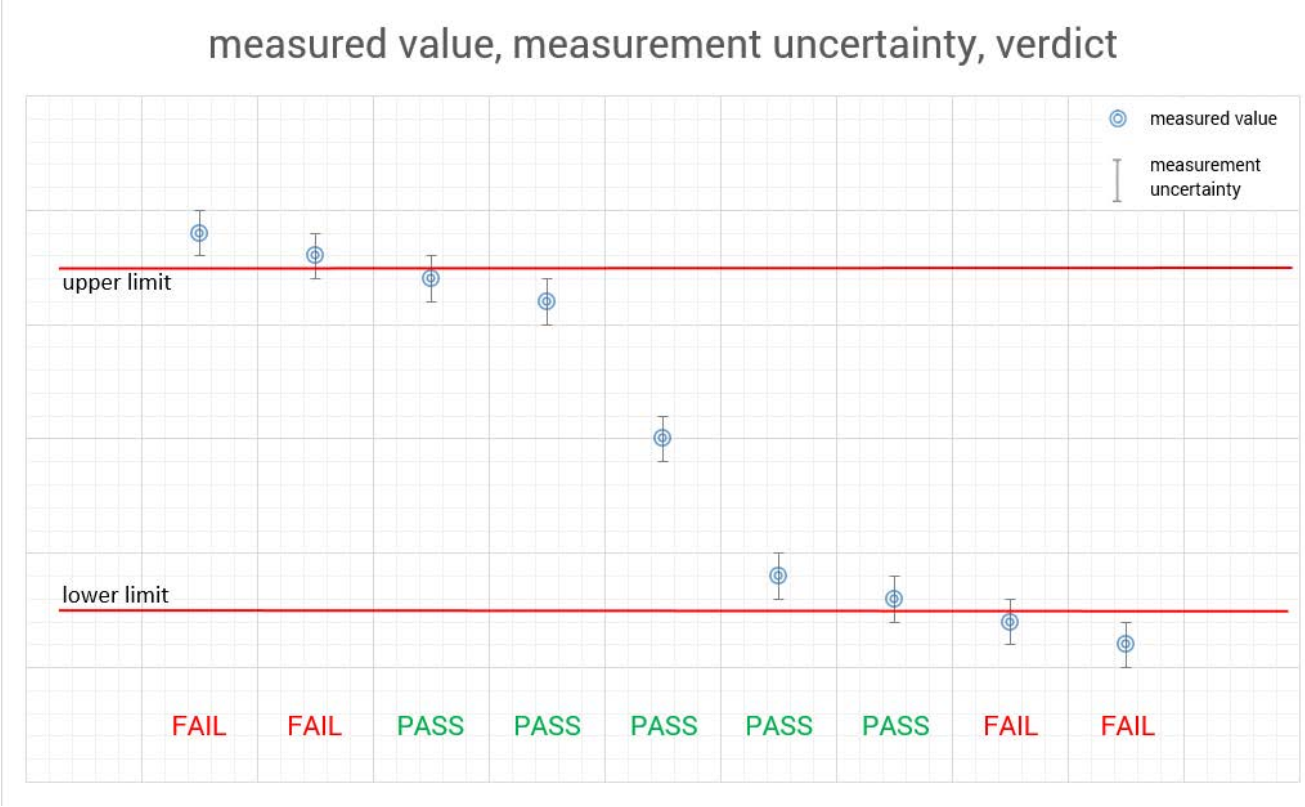
Test standard	Date	Description
FCC - Title 47 CFR Part 15		FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 210 Issue 10	04-2020	Spectrum Management and Telecommunications Radio Standards Specification - Licence-Exempt Radio Apparatus: Category I Equipment
RSS - Gen	02-2021	RSS-Gen — General Requirements for Compliance of Radio Apparatus

Guidance	Version	Description
ANSI C63.4-2017	-/-	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/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}	+22 °C during room temperature tests +85 °C during high temperature tests -40 °C during low temperature tests
Relative humidity content	:		49 %
Barometric pressure	:		990 hPa to 1010 hPa
Power supply	:	V_{nom} V_{max} V_{min}	24 V DC 30 V 10 V

6 Test item

6.1 General description

Kind of test item	:	Distance Radar, 60 GHz
Model name	:	R1D102 (TR22)
S/N serial number	:	EUT1 normal Mode: 000000000090 EUT2 stop Mode : 000000000092
Marking of Sample	:	M04285
Hardware status	:	AA2209
SW status radio frontend	:	1.007
SW normal mode IO-Link Backend	:	1.2.0
SW stop mode IO-Link Backend	:	1.0.8
Frequency band	:	57 GHz – 71 GHz
Type of modulation	:	FMCW
Number of channels	:	1
Antenna	:	Integrated antenna
Power supply	:	10 V to 30 V DC
Temperature range	:	-40°C to +85°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: 1-3179/21-01-01_AnnexA
1-3179/21-01-01_AnnexB
1-3179/21-01-01_AnnexD

3D pattern measurement report based on TRP measurement method :

- 1-3179_21-01-13.pdf

3D antenna pattern based on simulation:

- IDR-2060_Antenna_Simulation_Results.pdf

In addition to the normal operation mode, a test mode is used in accordance with CFR 47 Part §15.31 (c) & (m), in which the frequency sweep is stopped at the following positions in the range of operation:

- Stop mode, low frequency: 60.1 GHz
- Stop mode, middle frequency: 62.0 GHz
- Stop mode, high frequency: 63.9 GHz

A detailed description of the mode nomenclature in these test report can find in chapter 11.

7 Sequence of testing

7.1 Sequence of testing radiated spurious 9 kHz to 30 MHz

Setup

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

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.

7.2 Sequence of testing radiated spurious 30 MHz to 1 GHz

Setup

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

Premeasurement

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

Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable position ± 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.

7.3 Sequence of testing radiated spurious 1 GHz to 18 GHz

Setup

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

Premeasurement

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

Final measurement

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

7.4 Sequence of testing radiated spurious above 18 GHz

Setup

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

Premeasurement

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

Final measurement

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

7.5 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.

8 Description of the test setup

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

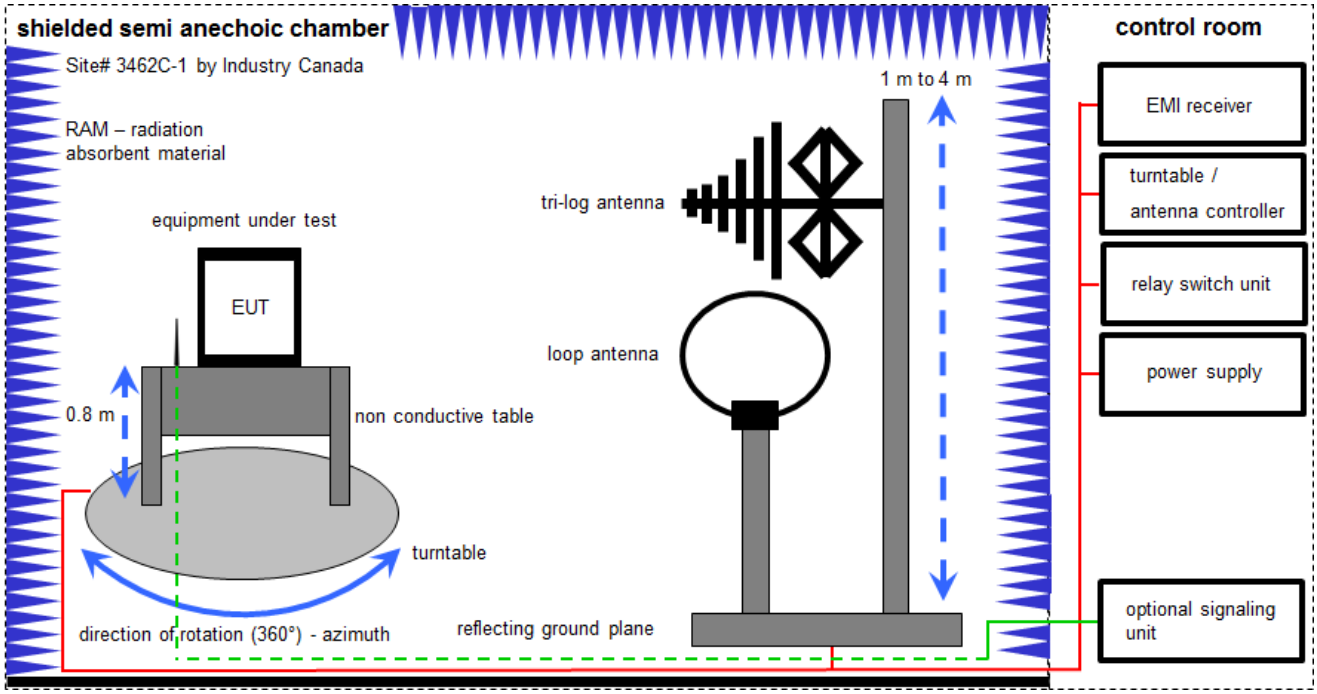
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

Agenda: Kind of Calibration

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

8.1 Shielded semi anechoic chamber

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 30 MHz to 1 GHz in semi-anechoic chambers. The EUT is positioned on a non-conductive support with a height of 0.80 m above a conductive ground plane that covers the whole chamber. The receiving antennas are conform to 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

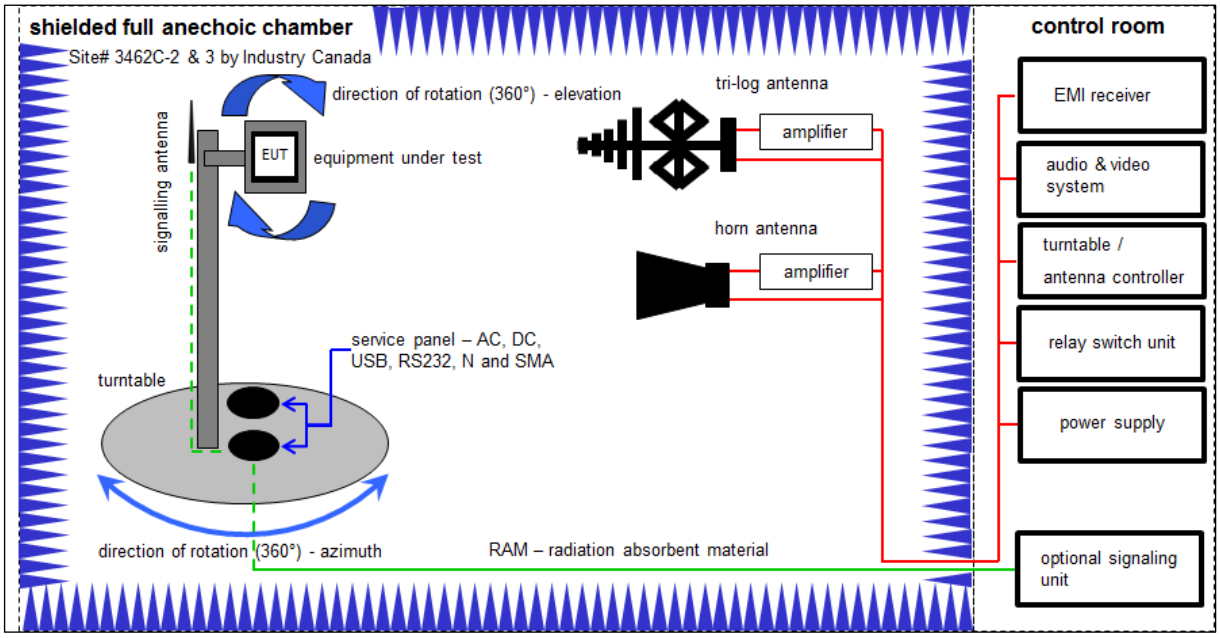
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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	vlKl!	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	vlKl!	18.08.2021	30.08.2023
7	n. a.	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	08.12.2021	07.12.2022

8.2 Shielded fully anechoic chamber



Measurement distance: tri-log antenna 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)

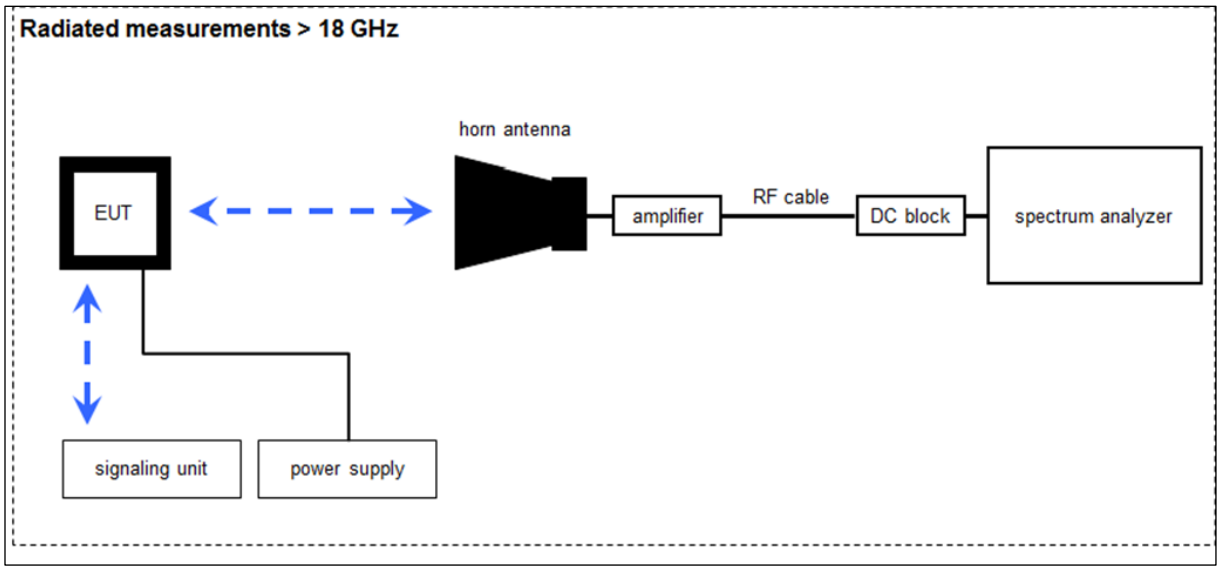
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

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

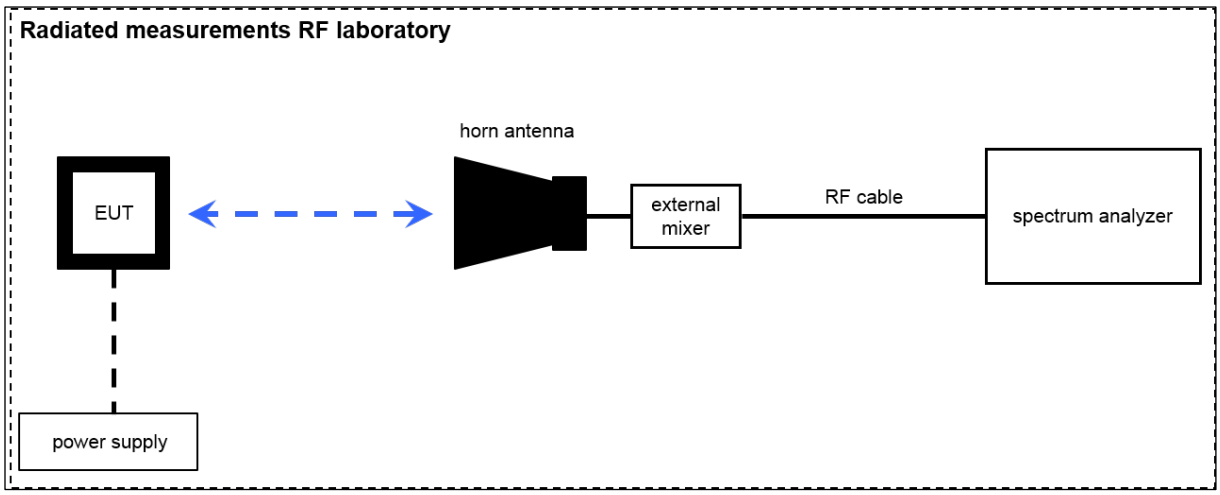
Equipment table:

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.	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	vIKI!	01.07.2021	31.07.2023
3	n. a.	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
4	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	318	300003696	vIKI!	30.09.2021	29.09.2023
5	n. a.	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	8812-3089	300000307	vIKI!	11.02.2022	29.02.2024
6	n. a.	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
7	n. a.	Variable isolating transformer	MPL IEC625 Bus Variable isolating transformer	Erfi	91350	300001155	ne	-/-	-/-
8	n. a.	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	09.12.2020	31.12.2022
9	n. a.	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
10	n. a.	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
11	n. a.	Broadband Amplifier 5-13 GHz	CBLU5135235	CERNEX	22010	300004491	ev	-/-	-/-
12	n. a.	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
13	n. a.	NEXIO EMV-Software	BAT EMC V3.16.0.49	EMCO		300004682	ne	-/-	-/-
14	n. a.	PC	ExOne	F+W		300004703	ne	-/-	-/-
15	n. a.	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-

8.3 Radiated measurements > 18 GHz



8.1 Radiated measurements > 50 GHz



OP = AV + D - G
(OP-rad. output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain)

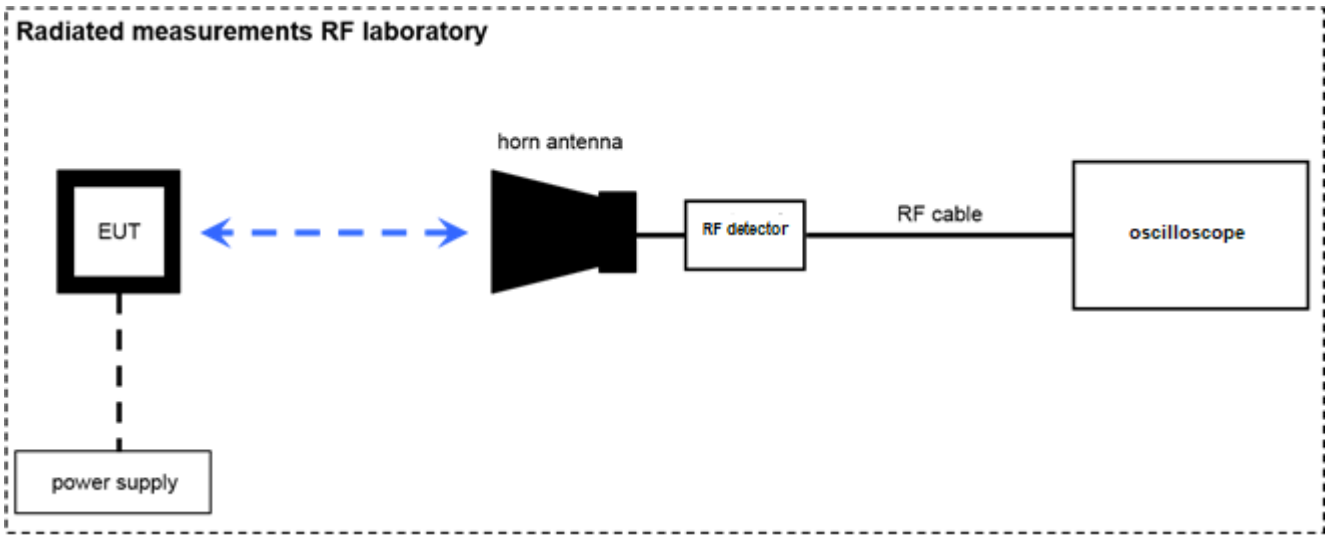
Example calculation:
OP [dBm] = -54.0 [dBm] + 64.0 [dB] - 20.0 [dBi] = -10 [dBm] (100 µW)

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	n.a.	Horn Antenna 18,0-40,0 GHz	LHAF180	Microw.Devel	39180-103-021	300001747	vIKI!	17.01.2022	31.01.2024
2	n. a.	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda		300000486	vIKI!	17.01.2022	31.01.2024
3	n. a.	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	82-16	300000510	vIKI!	17.01.2022	31.01.2024
4	n.a.	Std. Gain Horn Antenna 40-60 GHz	2424-20	Flann	76	400001981	ne	-/-	-/-
5	n. a.	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne	-/-	-/-
6	n. a.	Std. Gain Horn Antenna 60-90 GHz	COR 60_90	Thomson CSF		300000814	ev	-/-	-/-
7	n. a.	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300001988	ne	-/-	-/-
8	n.a.	Std. Gain Horn Antenna 92.3-140 GHz	2824-20	Flann		300001993	ne	-/-	-/-
9	n. a.	Std. Gain Horn Antenna 114-173 GHz	2924-20	Flann	*	300001999	ne	-/-	-/-
10	n. a.	Std. Gain Horn Antenna 145-220 GHz	3024-20	Flann	*	300002000	ne	-/-	-/-
11	n. a.	Std. Gain Horn Antenna 217-330 GHz	32240-20	Flann	233278	300004960	ne	-/-	-/-
13	n. a.	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev	09.03.2022	08.03.2024
12	n. a.	Harmonic Mixer 3-Port, 50-75 GHz	FS-Z75	R&S	101578	300005788	k	07.07.2022	31.07.2023
13	n. a.	Harmonic Mixer 3-Port, 60-90 GHz	FS-Z90	R&S	101555	300004691	k	21.07.2022	31.07.2023
14	n.a.	Harmonic Mixer 3-port, 75-110 GHz	FS-Z110	Rohde & Schwarz	101411	300004959	k	07.07.2022	31.07.2023
15	n.a.	Harmonic Mixer 3-port, 90-140 GHz	FS-Z140	Rohde & Schwarz	101119	300005581	k	20.07.2022	31.07.2023
16	n.a.	Harmonic Mixer 3-port, 110-170 GHz	FS-Z170	Rohde & Schwarz	100014	300004156	k	01.07.2022	31.07.2023
17	n. a.	Harmonic Mixer 3-Port, 140-220 GHz	SAM-220	Radiometer Physics GmbH	200001	300004157	k	21.07.2022	31.07.2023
18	n. a.	Spectrum Analyzer	FSW50	Rohde & Schwarz	101332	300005935	k	20.01.2022	31.01.2023
19	n. a.	Spectrum Analyzer	FSW50	Rohde & Schwarz	101560	300006179	k	07.03.2022	31.03.2023
20	n. a.	Temperature Test Chamber	T-40/50	CTS GmbH	064023	300003540	ev	09.05.2022	31.05.2024

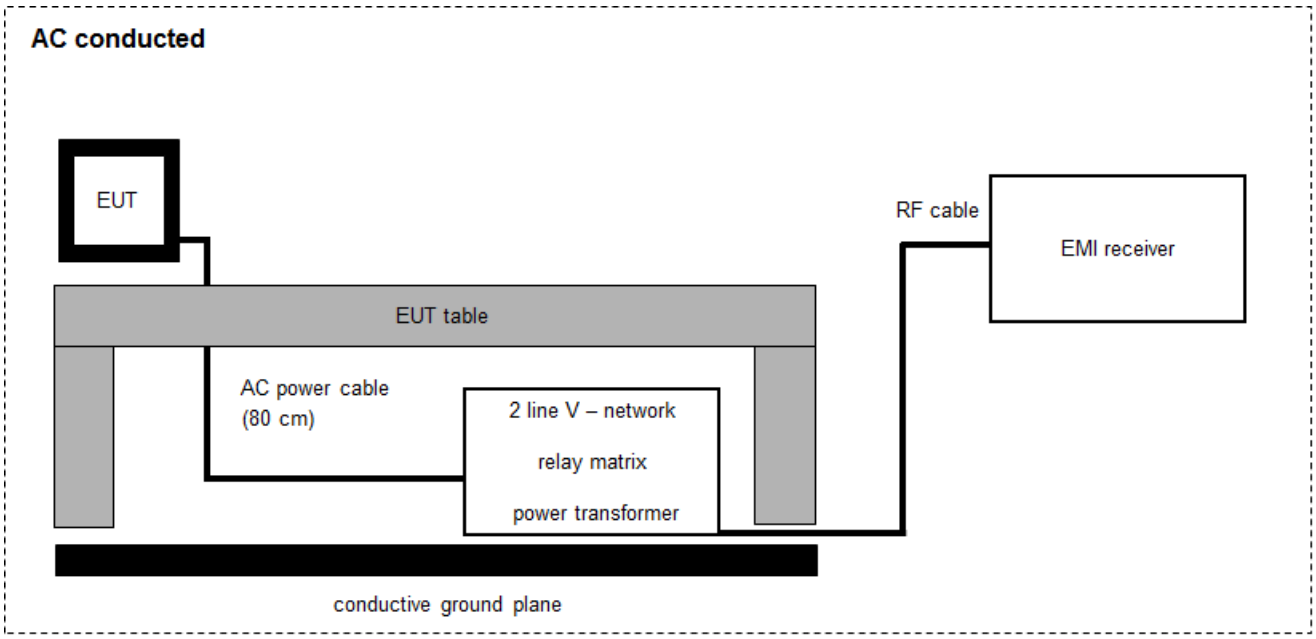
8.2 Radiated power measurements using RF detector according to ANSI C63.10-2013



Note: EUT is replaced by reference source for substitution measurement

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	n.a.	Std. Gain Horn Antenna 50 - 75 GHz	COR 50_75	Thomson CSF		300000813	ev	-/-	-/-
2	n.a.	Low Noise Amplifier, Waveguide, 50-75 GHz	AFB-V30LN-02	TACTRON	1026151-01	300005899	ev	-/-	-/-
3	n.a.	V-Band Positive Amplitude Detector	SFD-503753-15SF-P1	Sage Millimeter Inc.	07353-1	300006118	ev	-/-	-/-
4	n.a.	SG Extension Module 50 - 75 GHz	E8257DV15	VDI	US54250124	300005541	ev	-/-	-/-
5	n.a.	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne	-/-	-/-
6	n.a.	Synthesized Sweeper 10 MHz - 40 GHz	83640A	HP	3119A00458	300002266	vlKl!	10.12.2021	31.12.2023
7	n.a.	Oscilloscope	DPO5054	Tektronix	C010174	300004169	vlKl!	07.12.2021	31.12.2023
8	n.a.	2.5 GHz Digital Phosphor Oscilloscope	DPO7254	Tektronix	B022702	300003573	vlKl!	07.12.2020	06.12.2022
9	n.a.	Thermal Power Sensor, DC-110GHz, 300nW-100mW	NRP-Z58	R&S	100913	300004808	vlKl!	04.01.2022	31.01.2024
10	n.a.	WG Rotary Attenuator	25110 UG-385/U-AC	Flann Microwave	266740	300005798	ev	-/-	-/-

8.3 AC conducted



FS = UR + CF + VC
(FS-field strength; UR-voltage at the receiver; CR-loss of the cable and filter; VC-correction factor of the ISN)

Example calculation:
FS [dBµV/m] = 37.62 [dBµV/m] + 9.90 [dB] + 0.23 [dB] = 47.75 [dBµV/m] (244.06 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	Two-line V-Network (LISN) 9 kHz to 30 MHz	ESH3-Z5	R&S	892475/017	300002209	vIKI!	14.12.2021	13.12.2023
2	n. a.	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	vIKI!	29.12.2021	28.12.2023
3	n. a.	Hochpass 150 kHz	EZ-25	R&S	100010	300003798	ev	-/-	-/-
4	n. a.	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	09.12.2021	08.12.2022
5	n. a.	PC	TecLine	F+W	-/-	300003532	ne	-/-	-/-

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 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	FCC 47 CFR Part 15 IC RSS-210 Issue 10 IC RSS-Gen Issue 5	see below	2023-03-13	-/-

Test specification clause	Test case	Temperature conditions	Power supply	Pass	Fail	NA	NP	Remark
§15.215 RSS-Gen 6.7	Occupied bandwidth	Nominal	Nominal	☒	☐	☐	☐	complies
§15.255(e) RSS-210 J.4	Maximum conducted output power	Nominal	Nominal	☒	☐	☐	☐	complies
§15.255 (a) (c) RSS-210 J.2	Maximum E.I.R.P.	Nominal	Nominal	☒	☐	☐	☐	complies
§15.255(d) RSS-210 J.3	Spurious Emissions	Nominal	Nominal	☒	☐	☐	☐	complies
§15.207 RSS-Gen 8.8	Conducted emissions < 30 MHz (AC power line)	Nominal	Nominal	☒	☐	☐	☐	complies
§15.255(f) RSS-210 J.6	Frequency stability	Extreme Nominal	Extreme Nominal	☒	☐	☐	☐	complies
§15.255(h) RSS-210 J.7	Beamforming	Nominal	Nominal	☐	☐	☒	☐	-/-

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

11 Additional comments

Reference documents: IDR-2060_Antenna_Simulation_Results.pdf
1-3179_21-01-13.pdf

Special test descriptions: None

Configuration descriptions: The EUT comes up with 3 different operation modes. The test report use the following nomenclature:

- Mode A: Fast
- Mode B: Normal
- Mode C: High

The nomenclature for the “Stop Mode” describe in chapter 6.2 is:

- Stop mode, low frequency: CW F_{low}
- Stop mode, middle frequency: CW F_{mid}
- Stop mode, high frequency: CW F_{high}

12 Measurement results

12.1 Occupied bandwidth (20 dB bandwidth / 99% Bandwidth)

Description:

Measurement of the bandwidth of the wanted signal.

Limits:

FCC	IC
CFR Part 15.255 / Part 15.215(c)	RSS-Gen 6.7
The occupied bandwidth from intentional radiators operated within the specified frequency band shall comply with the following:	
Frequency range	
57 GHz – 71 GHz	

Measurement:

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

Measurement results for RSS-Gen 6.7: 99% Bandwidth

EUT	Mode	Test condition	f_L [GHz]	f_H [GHz]	Occupied bandwidth [GHz]
1	A	T_{nom} / V_{nom}	60.139 GHz	63.895 GHz	3.756 GHz
1	B	T_{nom} / V_{nom}	60.144 GHz	63.901 GHz	3.757 GHz
1	C	T_{nom} / V_{nom}	61.310 GHz	62.629 GHz	1.318 GHz

Measurement results for Part 15.215(c): 20dB Bandwidth

EUT	Mode	Test condition	f_L [GHz]	f_H [GHz]	Occupied bandwidth [GHz]
1	A	T_{nom} / V_{nom}	60.069 GHz	63.961 GHz	3.89 GHz
1	B	T_{nom} / V_{nom}	60.090 GHz	63.994 GHz	3.90 GHz
1	C	T_{nom} / V_{nom}	61.270 GHz	62.754 GHz	1.48 GHz

Note:

- Mode definition see chapter 11
- Vertical Line V1 in plots: 57 GHz
- Vertical Line V2 in plots: 71 GHz
- Vertical Lines S1 & S2 marks the interval for 99% Bandwidth calculation

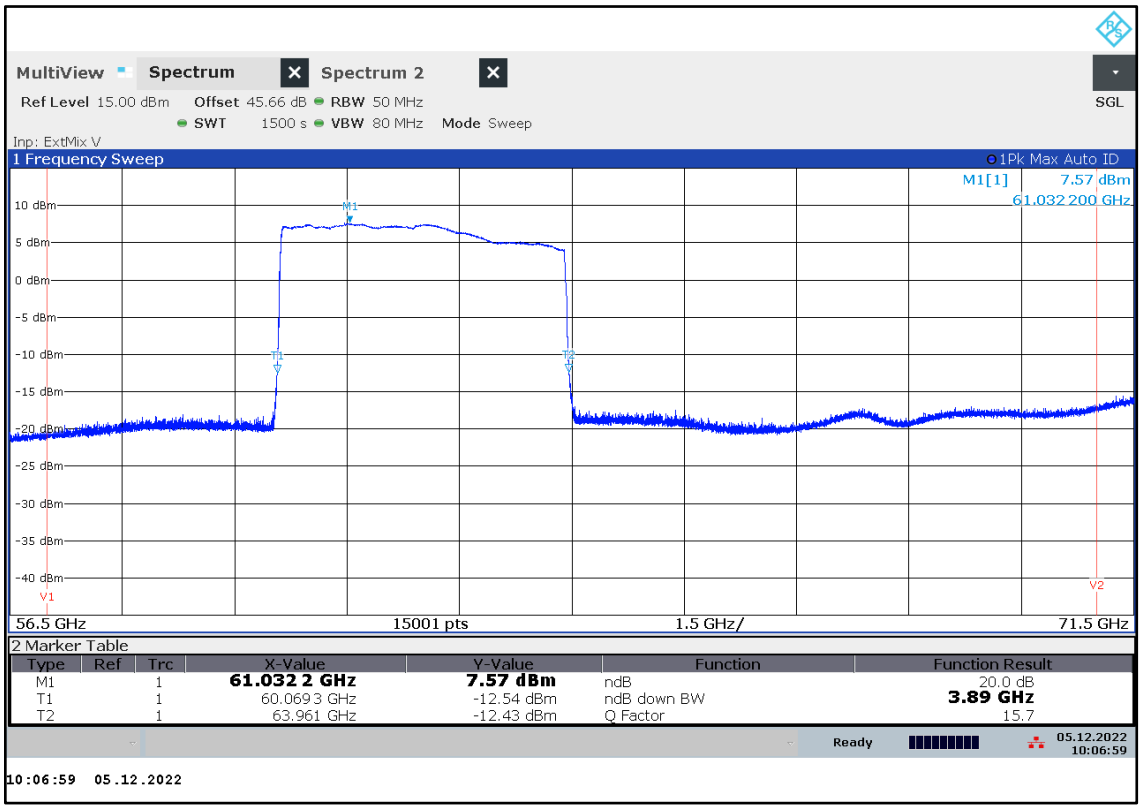
Verdict: Complies

Plot 1: Mode A, 99% OBW

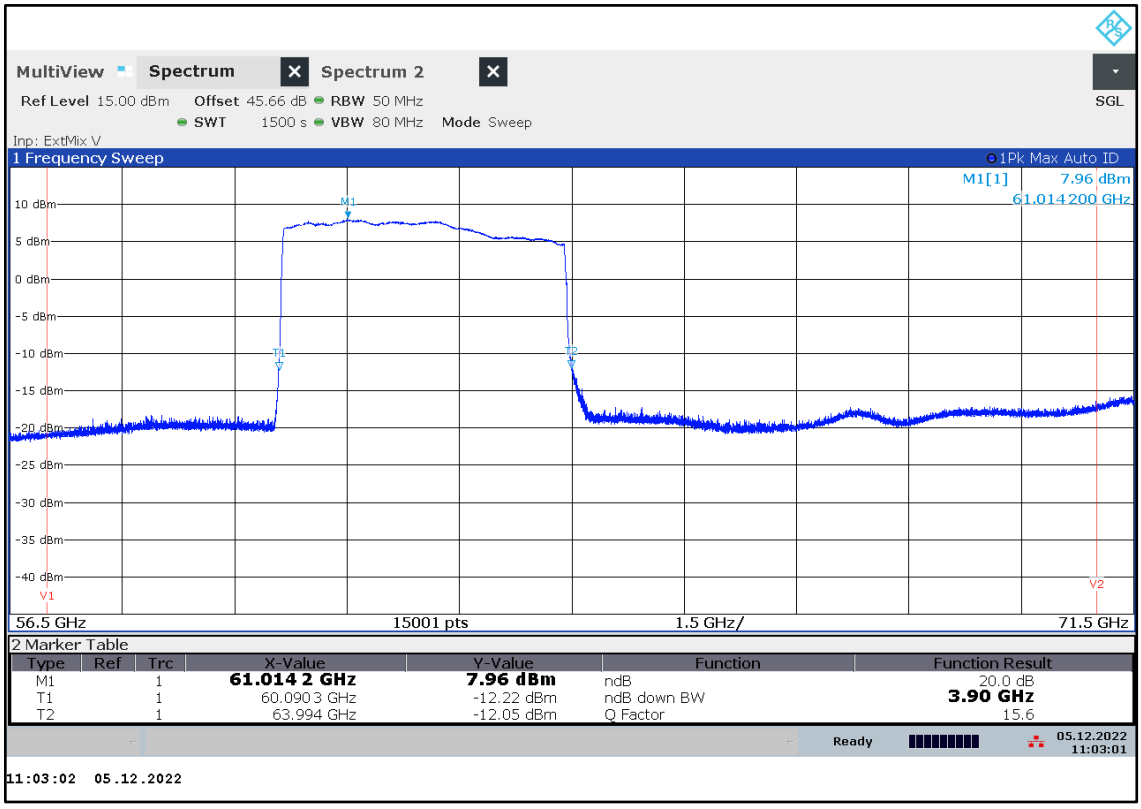
Plot 2: Mode B, 99% OBW

Plot 3: Mode C, 99% OBW

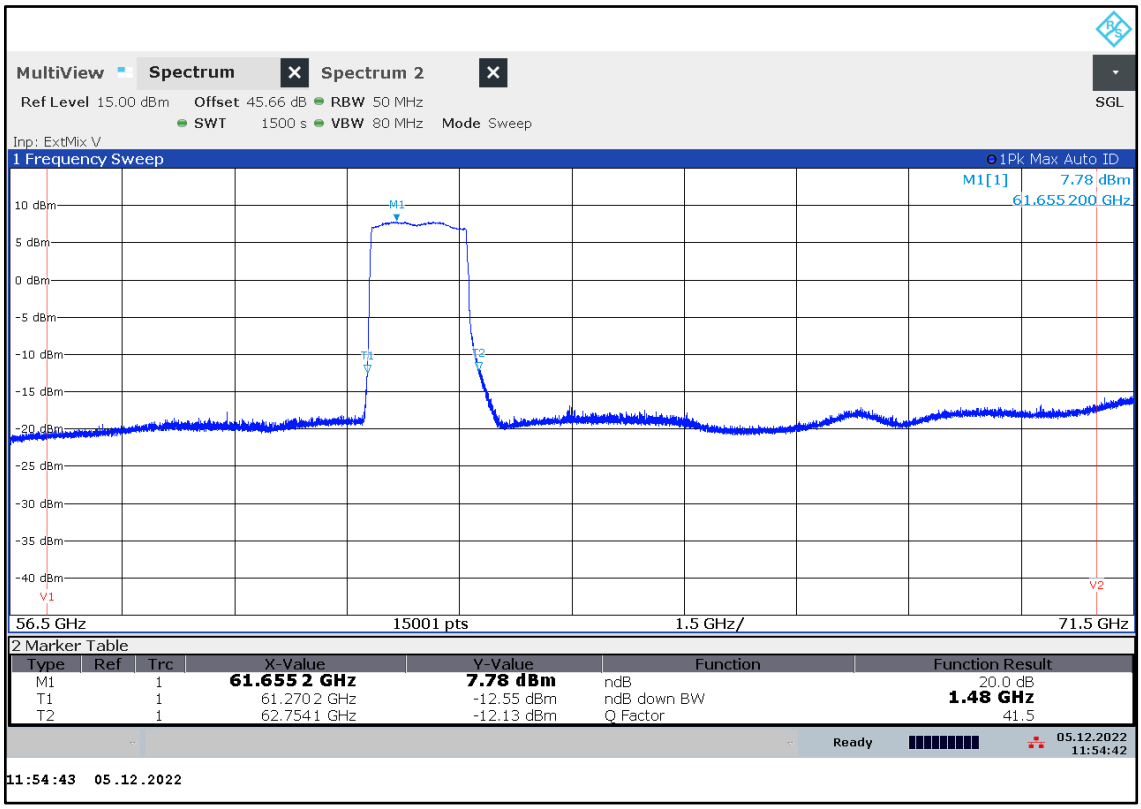
Plot 4: Mode A, OBW 20 dB Bandwidth



Plot 5: Mode B, OBW 20 dB Bandwidth



Plot 6: Mode C, OBW 20 dB Bandwidth



12.2 Maximum E.I.R.P. / Peak transmitter conducted output power

Description:

Measurement of the maximum radiated e.i.r.p. of the wanted signal.

Limits:

FCC Part 15.255

(c) Within the 57-71 GHz band, emission levels shall not exceed the following equivalent isotropically radiated power (EIRP):

(1) Products other than fixed field disturbance sensors and short-range devices for interactive motion sensing shall comply with one of the following emission limits, as measured during the transmit interval:

(i) The average power of any emission shall not exceed 40 dBm and the peak power of any emission shall not exceed 43 dBm; or

(ii) For fixed point-to-point transmitters located outdoors, the average power of any emission shall not exceed 82 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi. The peak power of any emission shall not exceed 85 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi.

(A) The provisions in this paragraph for reducing transmit power based on antenna gain shall not require that the power levels be reduced below the limits specified in paragraph (b)(1)(i) of this section.

(B) The provisions of §15.204(c)(2) and (4) that permit the use of different antennas of the same type and of equal or less directional gain do not apply to intentional radiator systems operating under this provision. In lieu thereof, intentional radiator systems shall be certified using the specific antenna(s) with which the system will be marketed and operated. Compliance testing shall be performed using the highest gain and the lowest gain antennas for which certification is sought and with the intentional radiator operated at its maximum available output power level. The responsible party, as defined in §2.909 of this chapter, shall supply a list of acceptable antennas with the application for certification.

(2) For fixed field disturbance sensors that occupy 500 MHz or less of bandwidth and that are contained wholly within the frequency band 61.0-61.5 GHz, the average power of any emission, measured during the transmit interval, shall not exceed 40 dBm, and the peak power of any emission shall not exceed 43 dBm. In addition, the average power of any emission outside of the 61.0-61.5 GHz band, measured during the transmit interval, but still within the 57-71 GHz band, shall not exceed 10 dBm, and the peak power of any emission shall not exceed 13 dBm.

(3) For fixed field disturbance sensors other than those operating under the provisions of paragraph (b)(2) of this section, and short-range devices for interactive motion sensing, the peak transmitter conducted output power shall not exceed −10 dBm and the peak EIRP level shall not exceed 10 dBm.

(4) The peak power shall be measured with an RF detector that has a detection bandwidth that encompasses the 57-71 GHz band and has a video bandwidth of at least 10 MHz. The average emission levels shall be measured over the actual time period during which transmission occurs.

(e) Except as specified paragraph (e)(1) of this section, the peak transmitter conducted output power shall not exceed 500 mW. Depending on the gain of the antenna, it may be necessary to operate the intentional radiator using a lower peak transmitter output power in order to comply with the EIRP limits specified in paragraph (b) of this section.

(1) Transmitters with an emission bandwidth of less than 100 MHz must limit their peak transmitter conducted output power to the product of 500 mW times their emission bandwidth divided by 100 MHz. For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g., for frequency hopping devices).
(2) Peak transmitter conducted output power shall be measured with an RF detector that has a detection bandwidth that encompasses the 57-71 GHz band and that has a video bandwidth of at least 10 MHz.
(3) For purposes of demonstrating compliance with this paragraph, corrections to the transmitter conducted output power may be made due to the antenna and circuit loss.

Limits:

RSS-210 J.2.2 b.

Within the band 57-64 GHz, the power of any emissions, measured during in the transmit interval, shall comply with the e.i.r.p. limits in this section.

For the purpose of this standard, the terms" average e.i.r.p." and "peak e.i.r.p." refer to e.i.r.p. with transmitter output power measured in terms of average value or peak value respectively.

Measurement:

Measurement parameter	
Detector:	Pos-Peak (RF-Detector)
Video bandwidth:	≥ 10 MHz
Trace-Mode:	Max Hold

Measurement results:

Mode	Test condition	Peak E.I.R.P.	Peak E.I.R.P Limit	Antenna gain (EUT)	Peak transmitter conducted output power	Peak transmitter conducted output power Limit
A	T_{nom} / V_{nom}	8.3 dBm	10 dBm	19.1 dBi	-10.8 dBm	-10 dBm
B	T_{nom} / V_{nom}	8.3 dBm	10 dBm	19.1 dBi	-10.8 dBm	-10 dBm
C	T_{nom} / V_{nom}	8.0 dBm	10 dBm	19.1 dBi	-11.1 dBm	-10 dBm

Note:

- Peak transmitter conducted output power = Peak E.I.R.P – Antenna gain (EUT)
- Mode definition see chapter 11

Additional Information:

For the EUT Antenna gain, 2 different sources are available. One is the antenna simulation provided by the customer and the second source is a pattern measurement based on the TRP method. The corresponding documents can be found in chapter 6.2.

Results:

Method	Antenna Gain
Simulation	19.1 dBi
Measurement	20.6 dBi

Based on the documents, the simulation represent the worst case estimation.

- The value of 19.1 dBi for the antenna gain is used for the calculation in these test report

Verdict: Complies

Description of the E.I.R.P. measurement by substitution method:

1) EUT emission measured with RF-detector:
   - Measurement distance: d_{EUT}
   - Maximum readout value on oscilloscope: $V_{max,EUT}$

2) Substitution of EUT by a cw reference source with a frequency of f_{REF} and a fixed output power of P_{REF}
   - Positioning of the cw reference source at distance: d_{EUT}
   - Adjustment of the readout value on oscilloscope to V_{max} via the variable attenuator of the source: $V_{max,CW} = V_{max,EUT}$

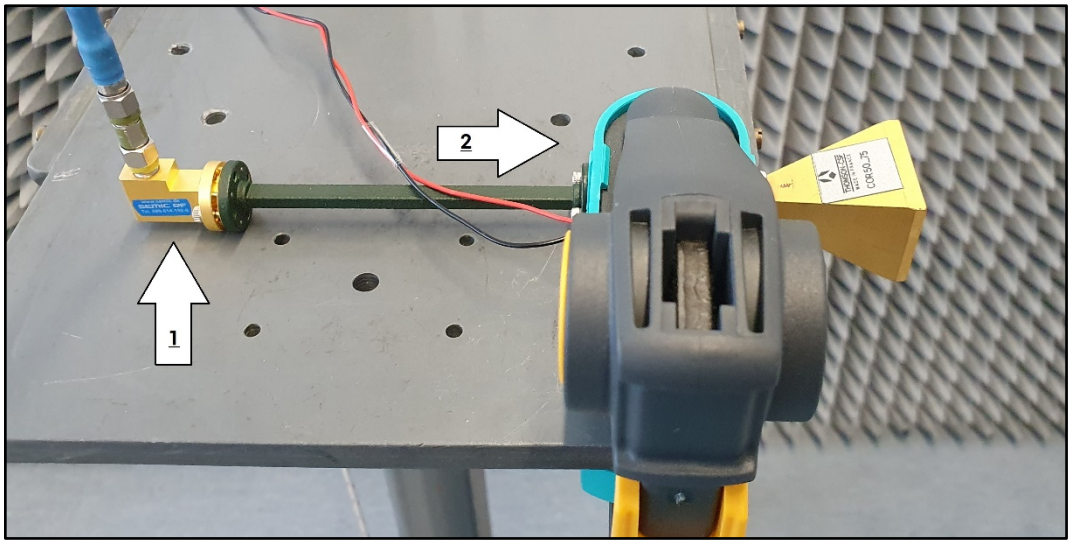
3) Measurement of the conducted output power $P_{cond,CW}$ of the cw reference source (without horn antenna) using the power meter

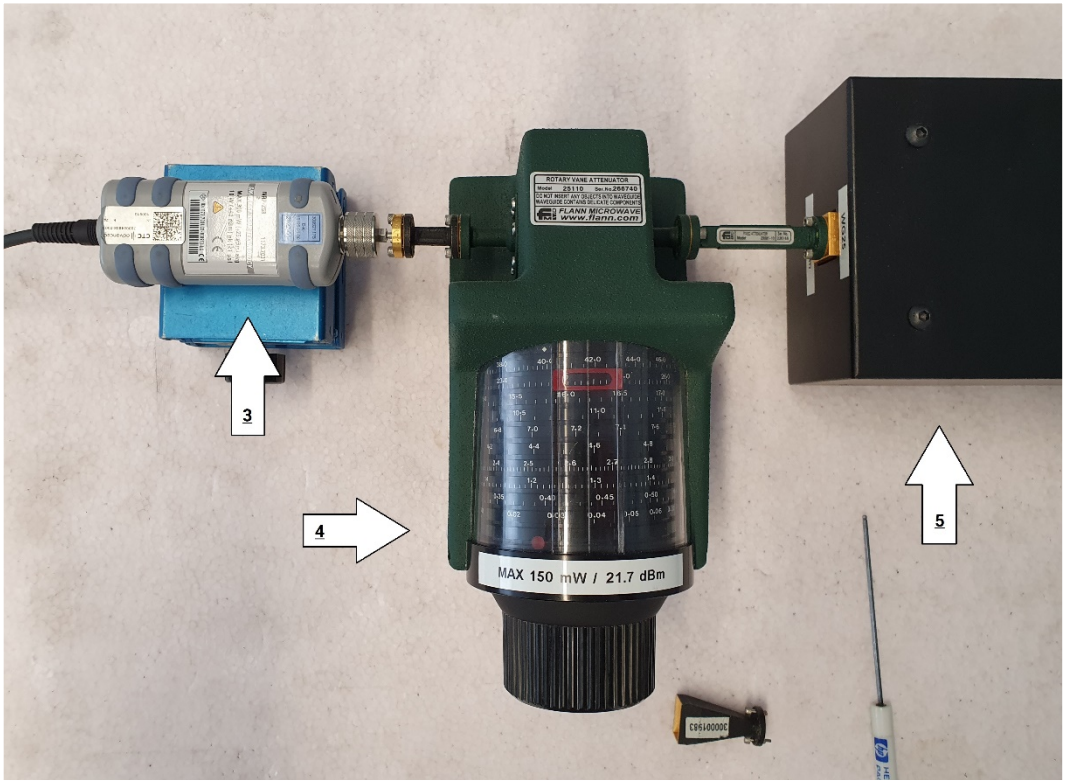
4) Calculation of the Peak E.I.R.P. of the EUT taking into account the gain of the substitution antenna G_{CW}:
   - $P_{Peak\ E.I.R.P.} = P_{cond,CW} + G_{CW}$

5) Calculation of the Peak transmitter conducted output power $P_{con,EUT}$ of the EUT:
   - $P_{con,EUT} = P_{Peak\ E.I.R.P} - G_{EUT}$

Measurement step	Measurement parameter	EUT Mode		
		A	B	C
1	$V_{max\text{-}EUT}$ [mV]	8.48 mV	8.48 mV	7.36 mV
2	f_{REF} [GHz]	62 GHz	62 GHz	62 GHz
3	$P_{cond\text{-}CW}$ [dBm]	-11.8 dBm	-11.8 dBm	-12.1 dBm
4	$P_{Peak\ E.I.R.P.}$ [dBm]	8.3 dBm	8.3 dBm	8.0 dBm
	G_{CW} [dBi]	20.1 dBi	20.1 dBi	20.1 dBi
5	$P_{con\text{-}EUT}$ [dBm]	-10.8 dBm	-10.8 dBm	-11.1 dBm
	G_{EUT} [dBi]	19.1 dBi	19.1 dBi	19.1 dBi

Setup of the substitution:





1) RF Detector

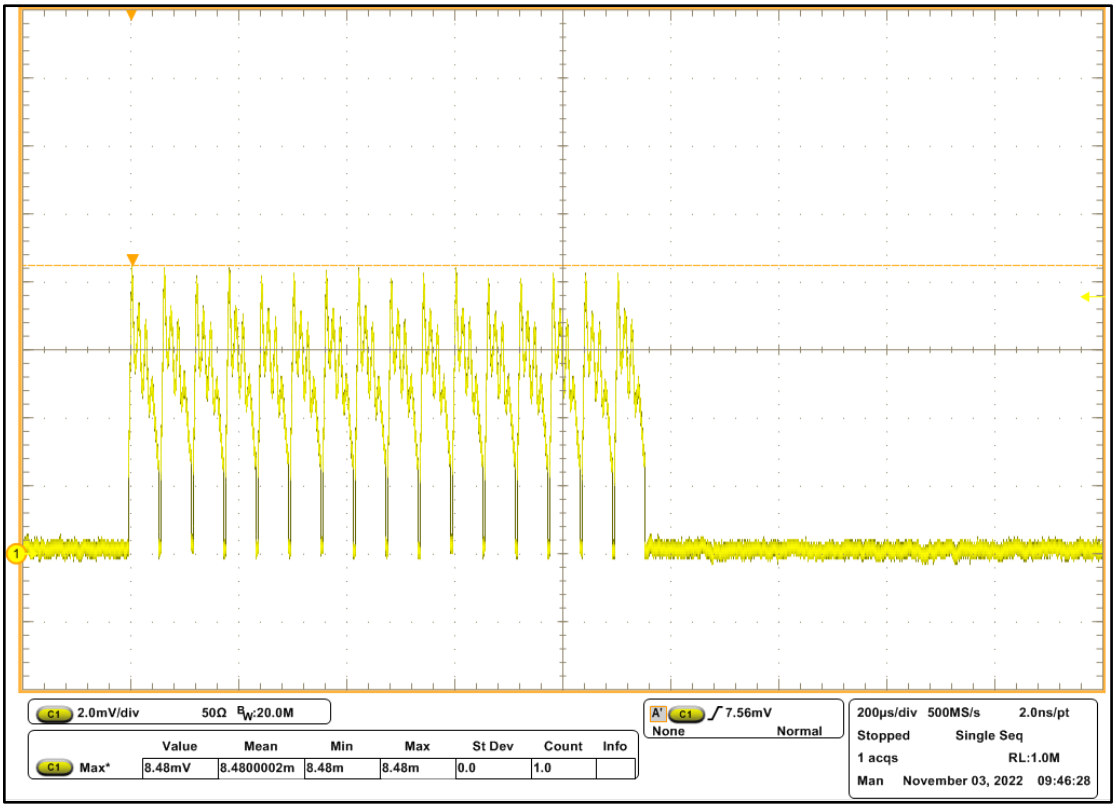
2) Low Noise Amplifier Waveguide & Std. Gain Horn Antenna 50-75 GHz

3) Power Meter Sensor

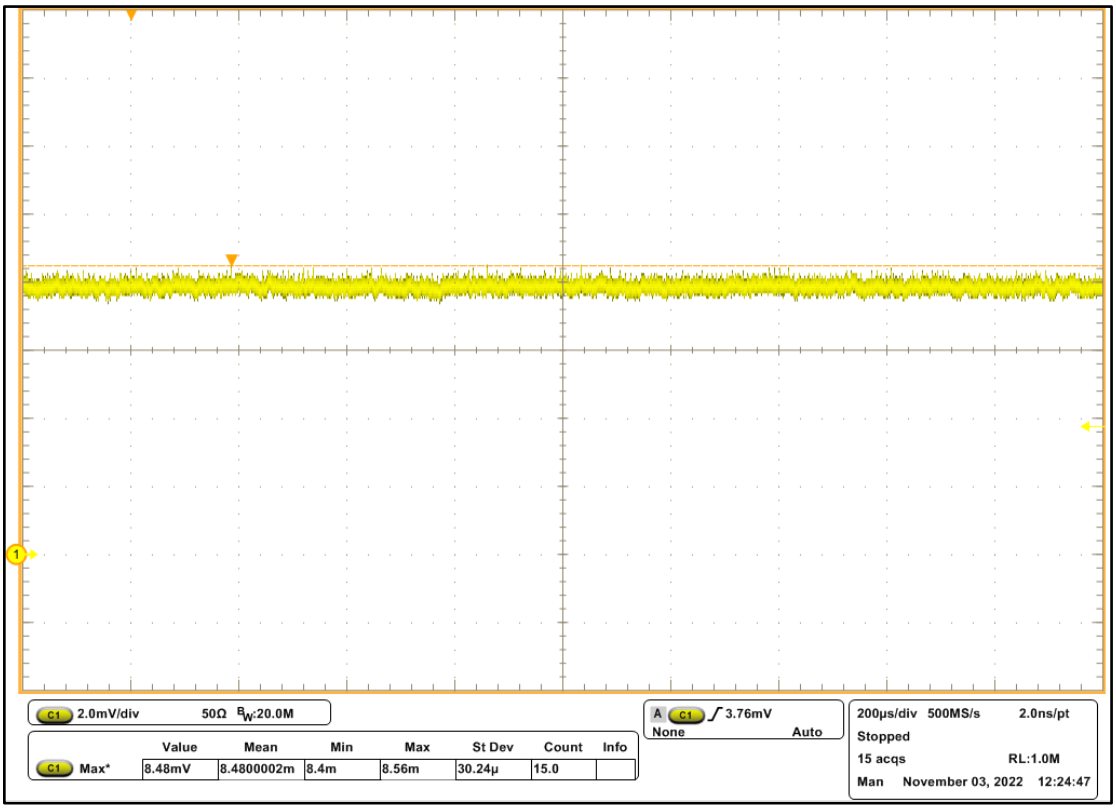
4) Rotary Attenuator

5) SG Extension Module 50 - 75 GHz (connected to Synthesized Sweeper 10 MHz - 40 GHz)

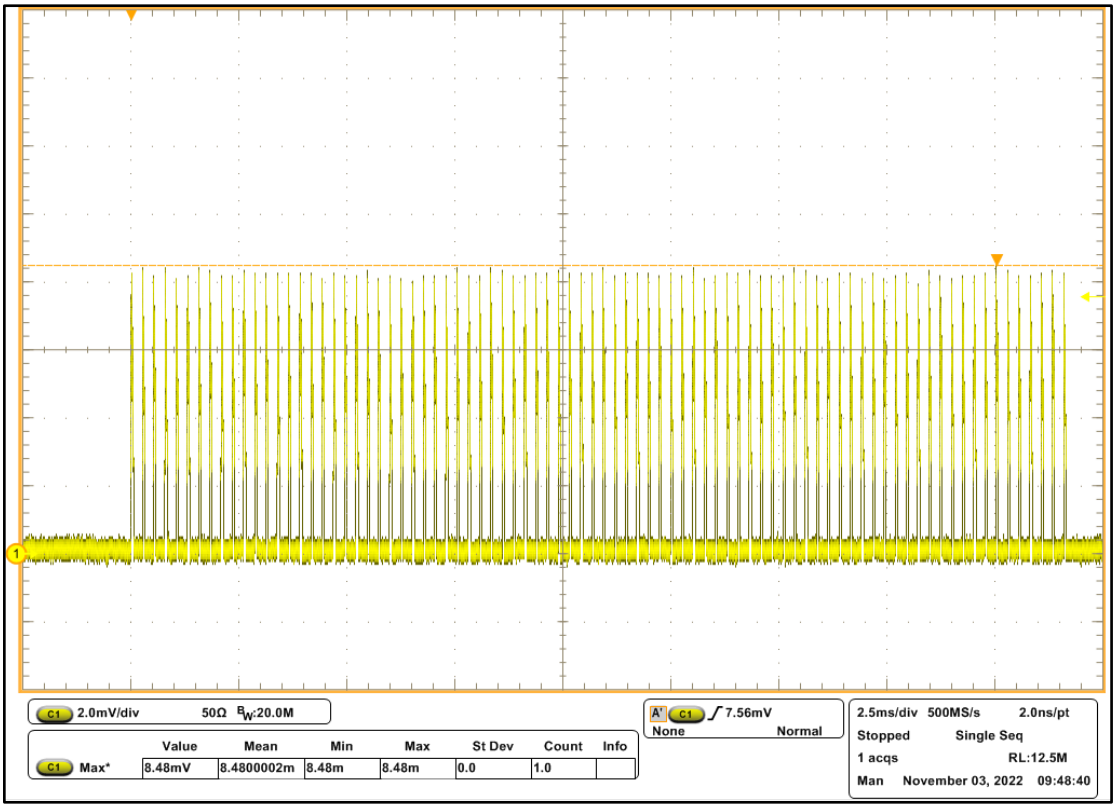
Plot 7: EUT emission Mode A



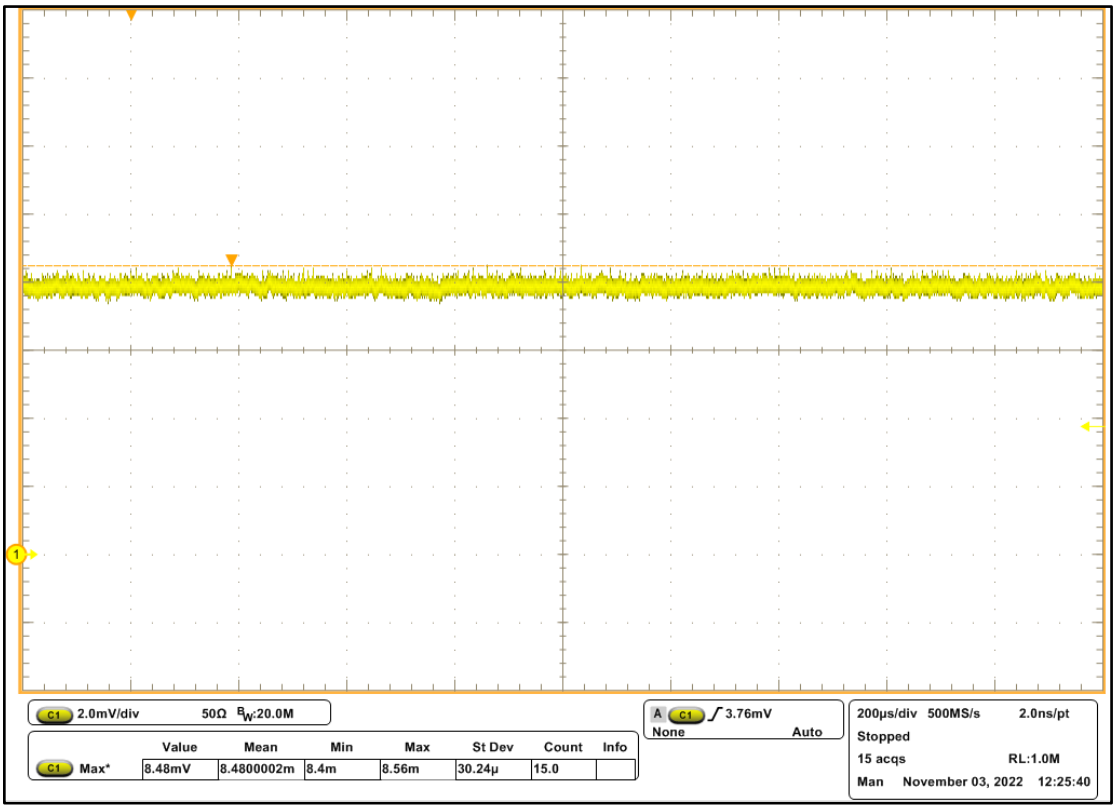
Plot 8: CW emission for Mode A



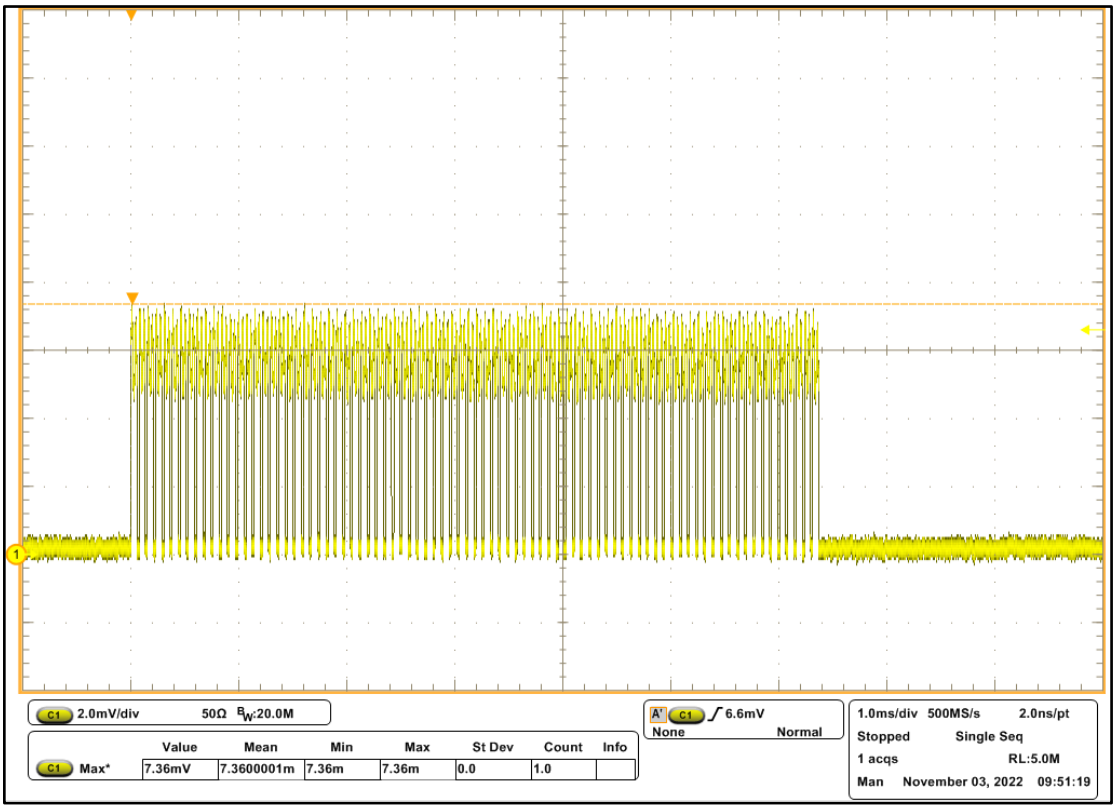
Plot 9: EUT emission Mode B



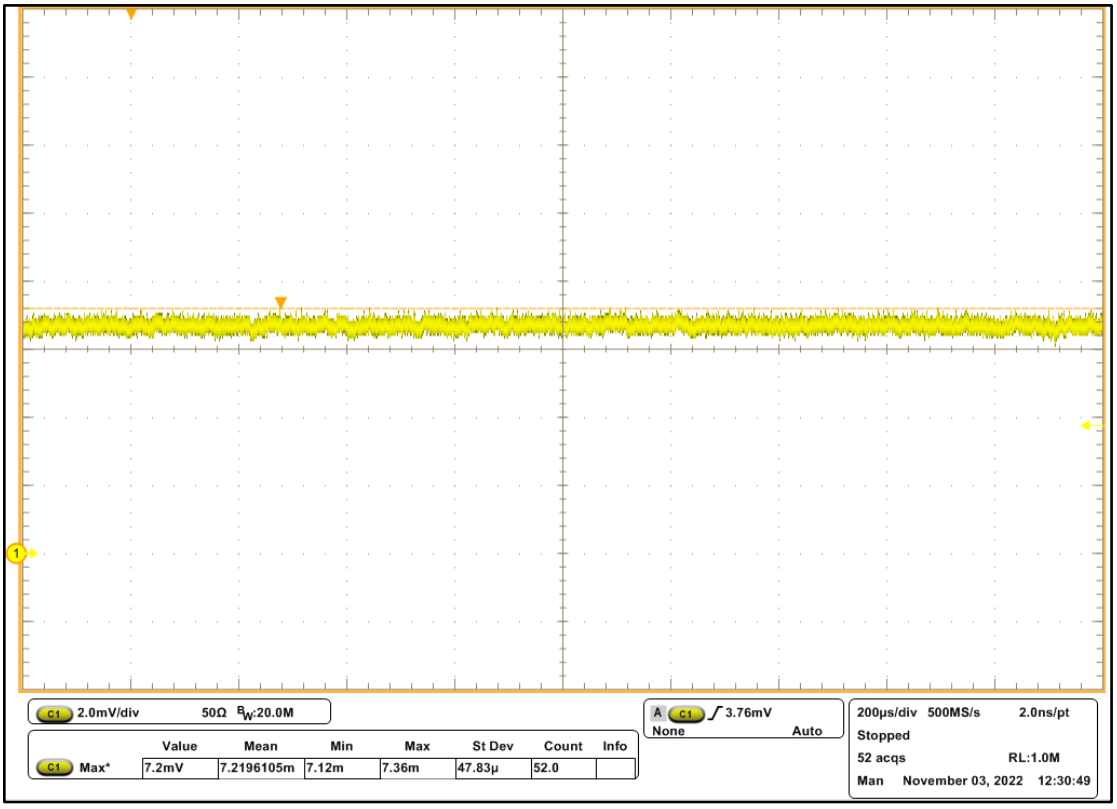
Plot 10: CW emission for Mode B



Plot 11: EUT emission Mode C



Plot 12: CW emission for Mode B



12.3 Spurious emissions radiated

Description:

Measurement of the radiated spurious emissions.

Limits:

FCC §15.255 (c)
Limits on spurious emissions:

(1) The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.

(2) Radiated emissions below 40 GHz shall not exceed the general limits in §15.209.

(3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm^2 at a distance of 3 meters.

(4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.

RSS-210 J.3
The power of any emissions outside the band 57-71 GHz shall consist solely of spurious emissions and shall not exceed:

a. the fundamental emission levels

b. the general field strength limits specified in RSS-Gen for emissions below 40 GHz

90 pW/cm2 at a distance of 3 m for emissions between 40 GHz and 200 GHz

FCC / IC		
CFR Part 15.209(a) / RSS-Gen 8.9		
Radiated emission limits		
Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
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
Above 960	500	3

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

$EIRP[dBm] = 10 \times \log(4 \times \pi \times d^2 \times PD[W/m^2])$

- 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 = 90 pW/cm² at a distance of d = 3 m corresponds to an equivalent isotropically radiated power of EIRP = -10 dBm.

Measurement:

Measurement parameter	
Detector:	Quasi Peak / Pos-Peak / 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:

Stop mode, low frequency: CW F_{low}

Frequency [GHz]	Detector	Bandwidth [MHz]	Level	Limit	Margin [dB]
-/-	-/-	1	-/-	-/-	-/-
Please refer to the following plots for more information on the level of spurious emissions					

Stop mode, middle frequency: CW F_{mid}

Frequency [GHz]	Detector	Bandwidth [MHz]	Level	Limit	Margin [dB]
-/-	-/-	1	-/-	-/-	-/-
Please refer to the following plots for more information on the level of spurious emissions					

Stop mode, high frequency: CW F_{high}

Frequency [GHz]	Detector	Bandwidth [MHz]	Level	Limit	Margin [dB]
-/-	-/-	1	-/-	-/-	-/-
Please refer to the following plots for more information on the level of spurious emissions					

Operation mode with maximum power output: Mode A

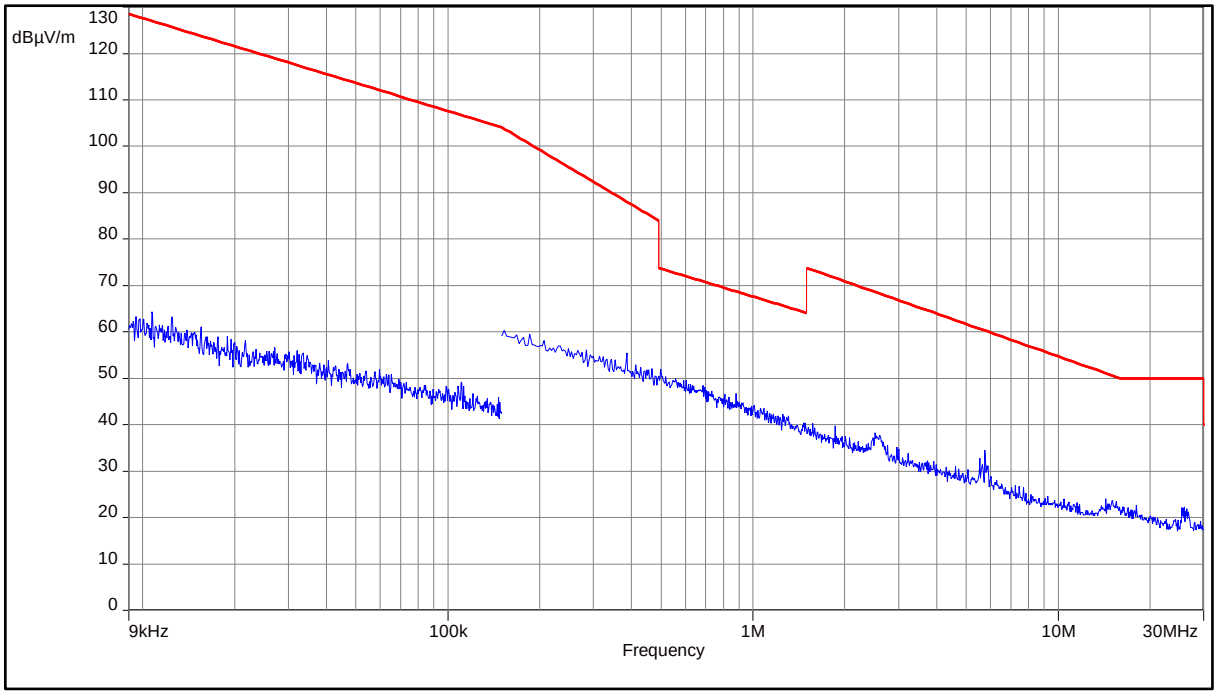
Frequency [GHz]	Detector	Bandwidth [MHz]	Level	Limit	Margin [dB]
-/-	-/-	1	-/-	-/-	-/-
Please refer to the following plots for more information on the level of spurious emissions					

Note:

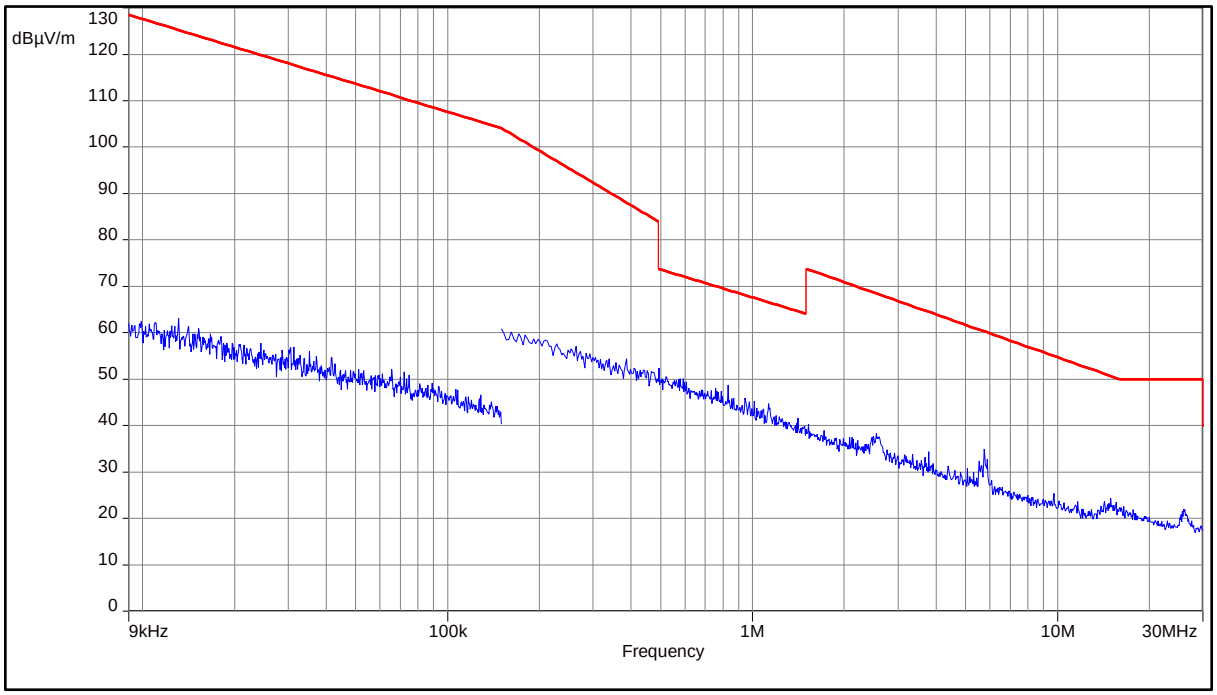
- The 3 stop modes are required for FCC
- The mode with the maximum output power is required for RSS
- Mode definition see chapter 11
- Please see plots below.

Verdict: Complies

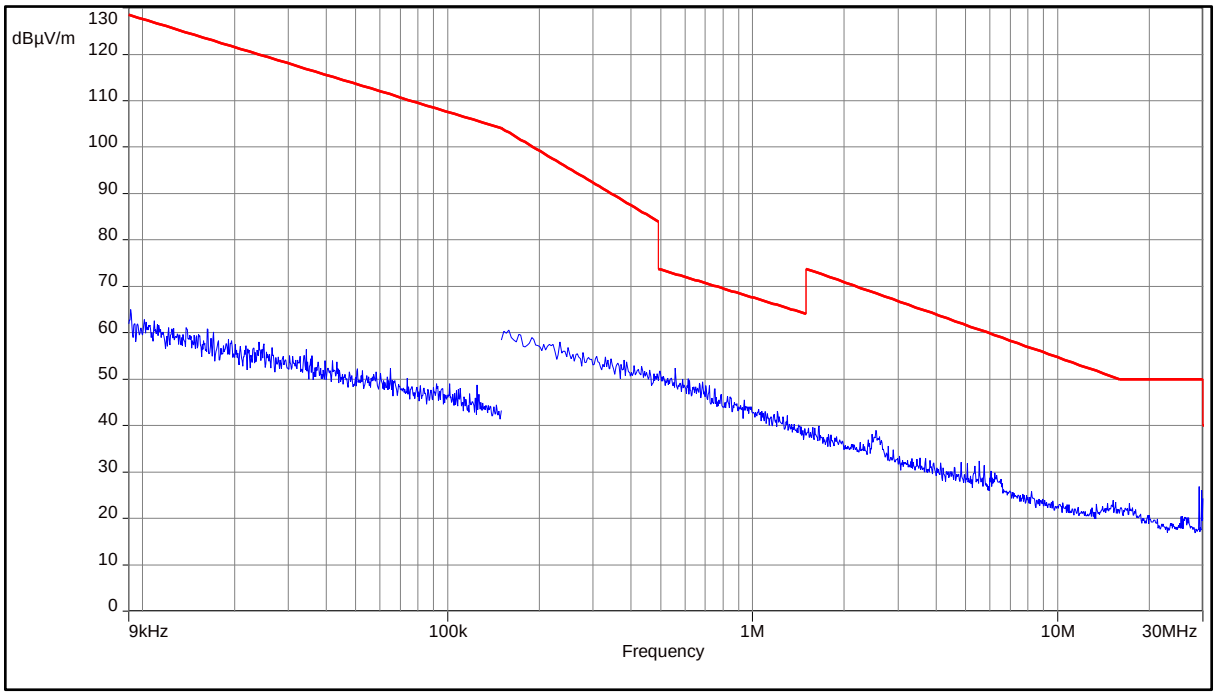
Plot 13: 9 kHz – 30 MHz, CW F_{low}



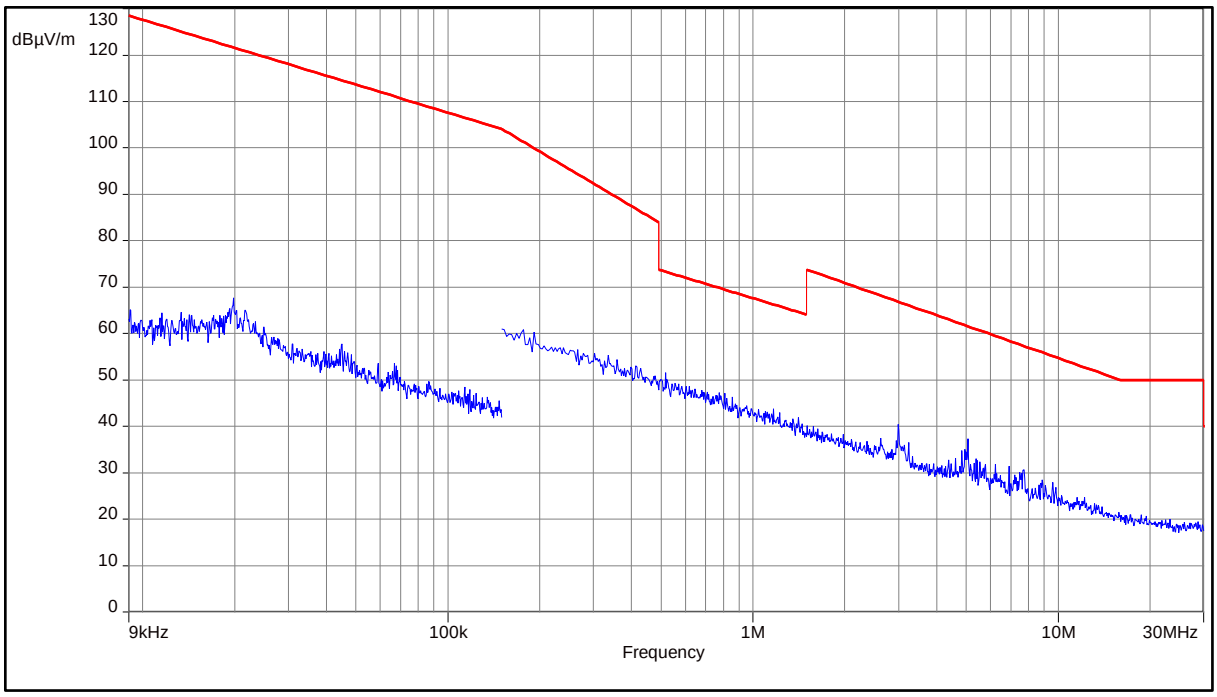
Plot 14: 9 kHz – 30 MHz, CW F_{mid}



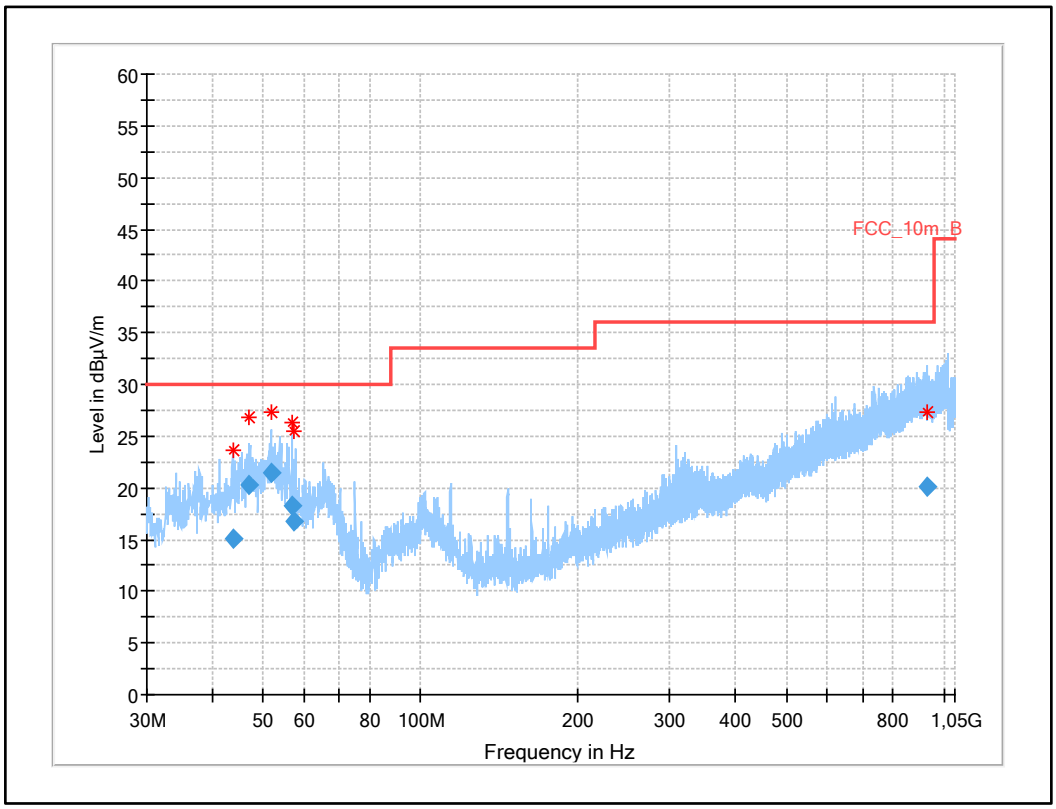
Plot 15: 9 kHz – 30 MHz, CW F_{high}



Plot 16: 9 kHz – 30 MHz, Mode A

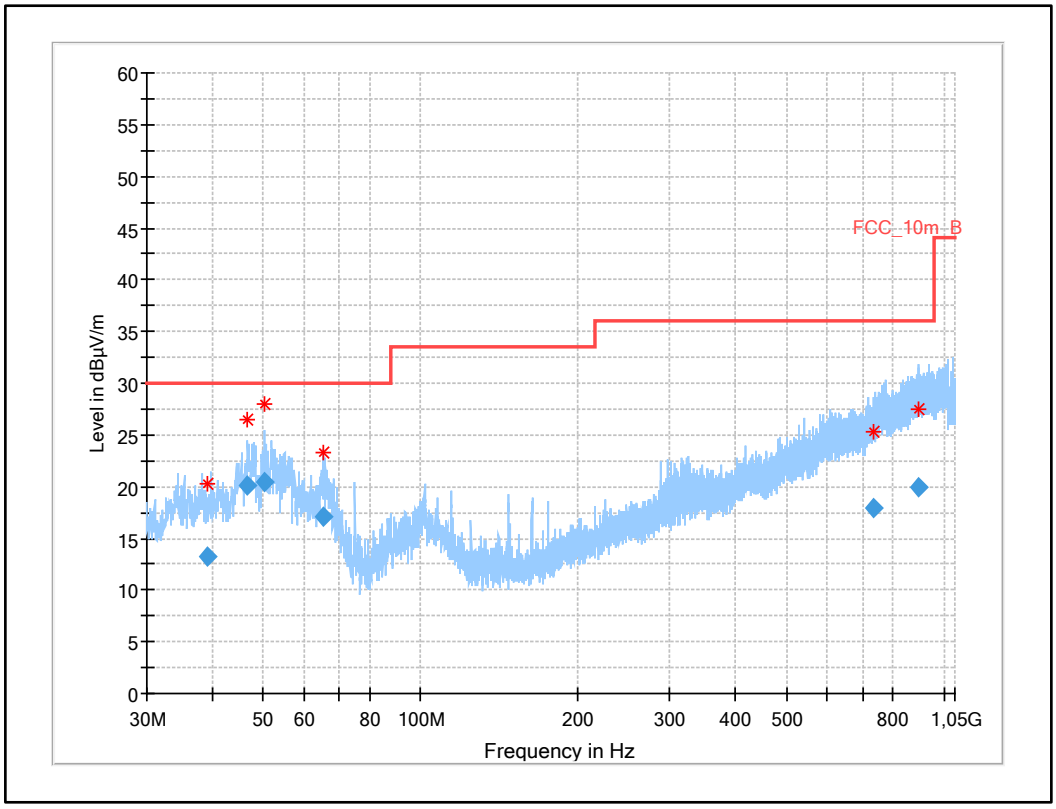


Plot 17: 30 MHz – 1GHz, CW F_{low}



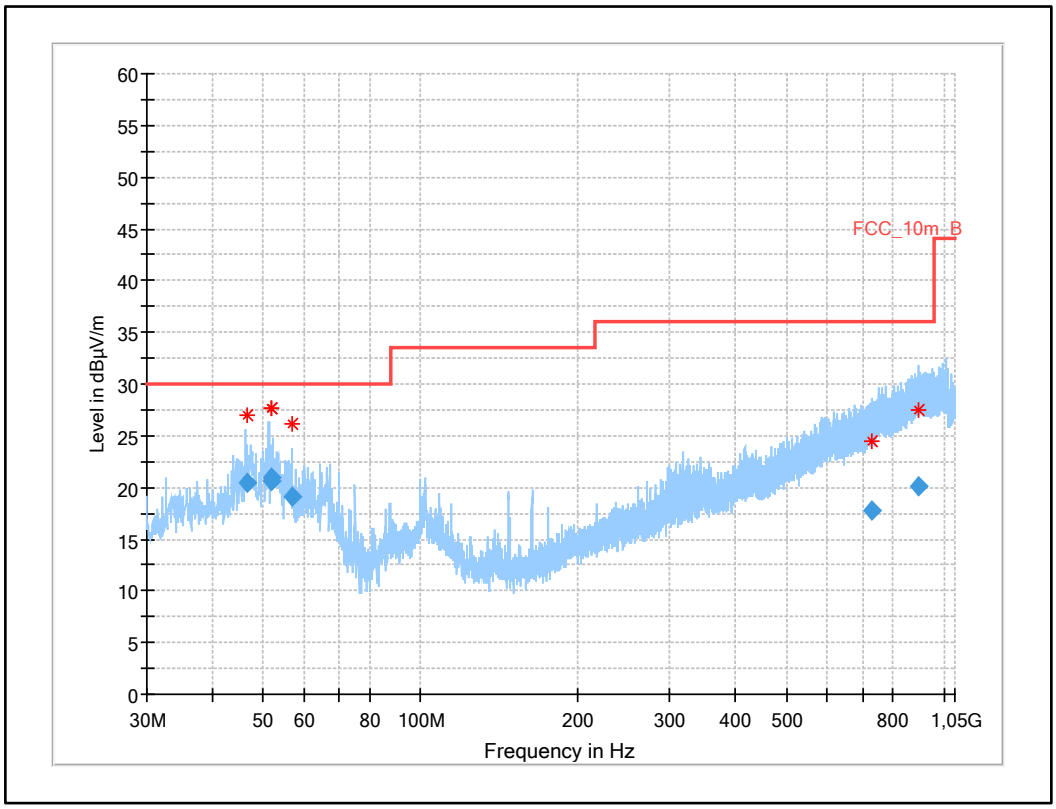
Frequency (MHz)	QuasiPeak (dBµV/m	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
43.780	15.13	30.0	14.9	1000	120.0	177.0	V	186	16
47.010	20.26	30.0	9.7	1000	120.0	200.0	V	302	16
51.756	21.41	30.0	8.6	1000	120.0	109.0	V	143	15
56.708	18.21	30.0	11.8	1000	120.0	220.0	V	254	16
57.203	16.78	30.0	13.2	1000	120.0	192.0	V	45	16
931.749	20.15	36.0	15.9	1000	120.0	140.0	H	225	26

Plot 18: 30 MHz – 1GHz, CW F_{mid}



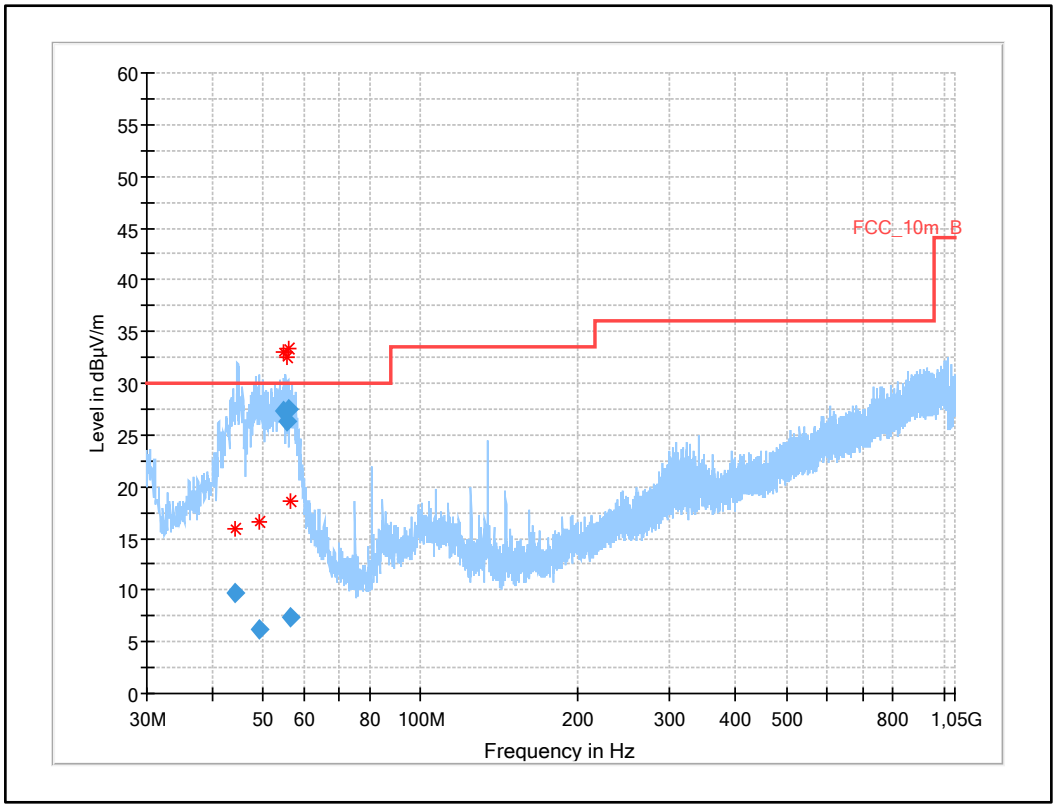
Frequency (MHz)	QuasiPeak (dBµV/m	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
39.260	13.22	30.0	16.8	1000	120.0	104.0	V	185	15
46.755	20.15	30.0	9.9	1000	120.0	123.0	V	109	16
50.235	20.38	30.0	9.6	1000	120.0	125.0	V	301	16
65.419	17.07	30.0	12.9	1000	120.0	363.0	V	18	12
734.773	17.89	36.0	18.1	1000	120.0	269.0	H	45	23
892.157	19.98	36.0	16.0	1000	120.0	400.0	V	135	25

Plot 19: 30 MHz – 1GHz, CW F_{high}



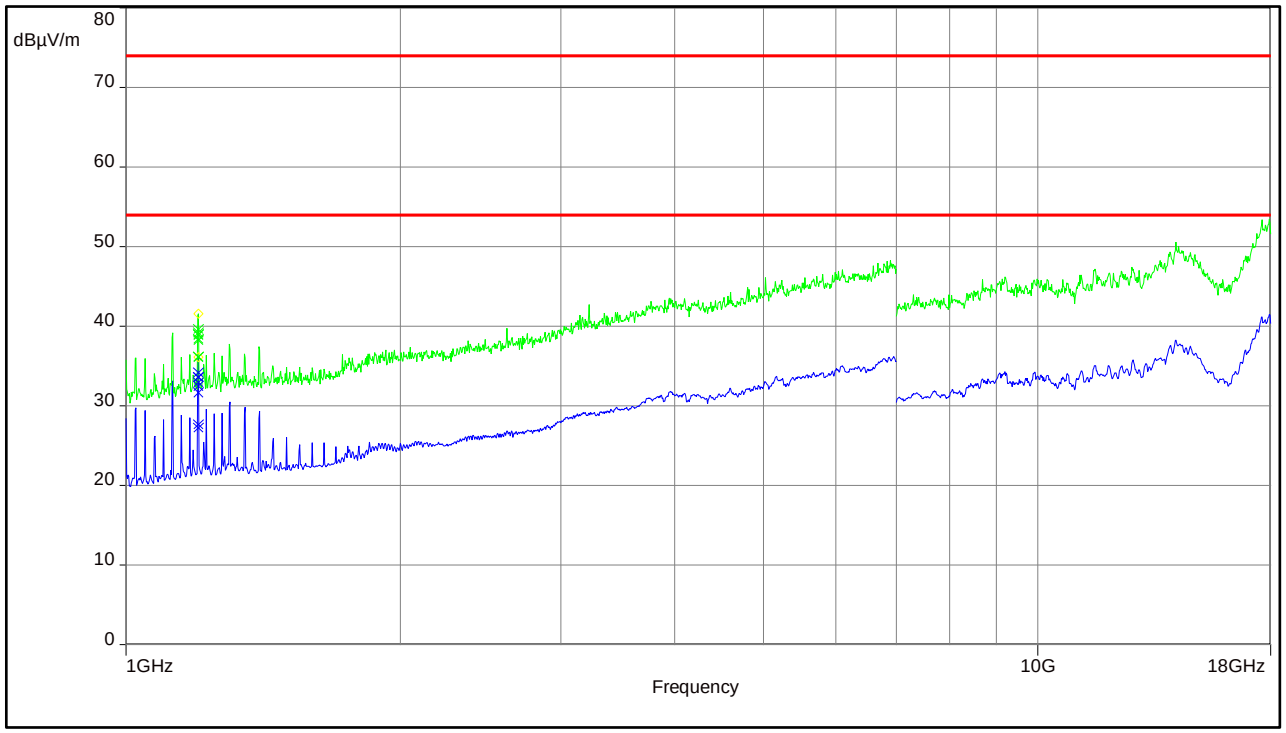
Frequency (MHz)	QuasiPeak (dBµV/m	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
46.773	20.41	30.0	9.6	1000	120.0	200.0	V	192	16
51.833	20.64	30.0	9.4	1000	120.0	121.0	V	280	15
51.838	20.89	30.0	9.1	1000	120.0	106.0	V	289	15
56.779	19.16	30.0	10.8	1000	120.0	200.0	V	188	16
729.638	17.79	36.0	18.2	1000	120.0	343.0	H	90	23
897.088	20.09	36.0	15.9	1000	120.0	292.0	H	225	25

Plot 20: 30 MHz – 1GHz, Mode A

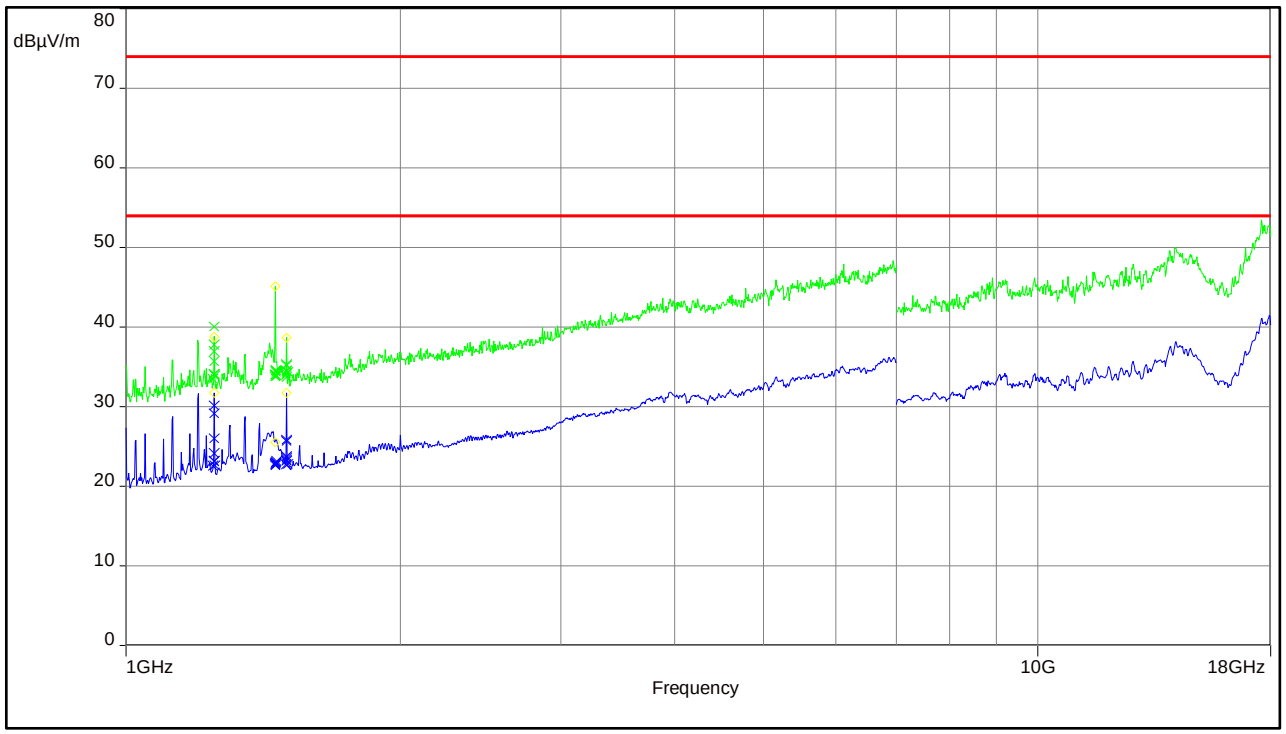


Frequency (MHz)	QuasiPeak (dBµV/m	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
44.370	9.66	30.0	20.3	1000	120.0	121.0	H	0	16
49.143	6.24	30.0	23.8	1000	120.0	158.0	H	0	16
54.934	27.38	30.0	2.6	1000	120.0	249.0	V	240	15
55.421	26.37	30.0	3.6	1000	120.0	194.0	V	106	16
55.873	27.46	30.0	2.5	1000	120.0	116.0	V	0	16
56.309	7.44	30.0	22.6	1000	120.0	200.0	H	30	16

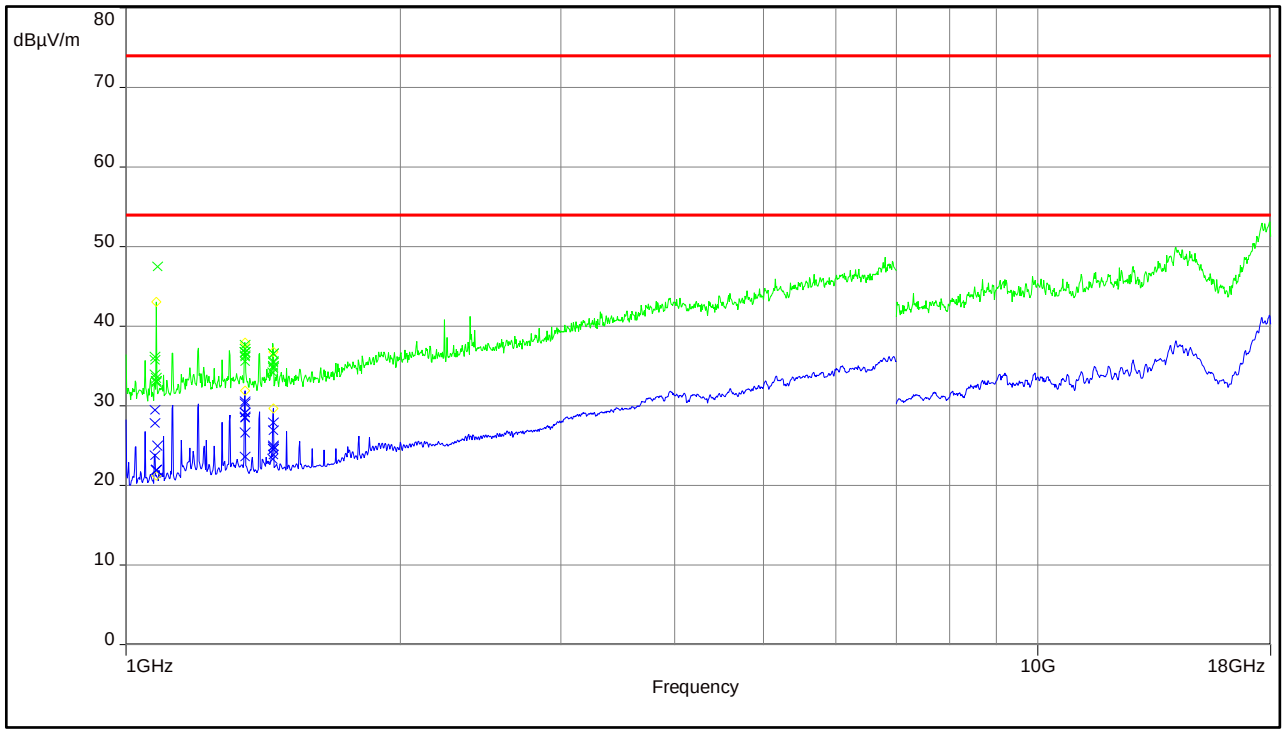
Plot 21: 1GHz – 18 GHz, CW F_{low}



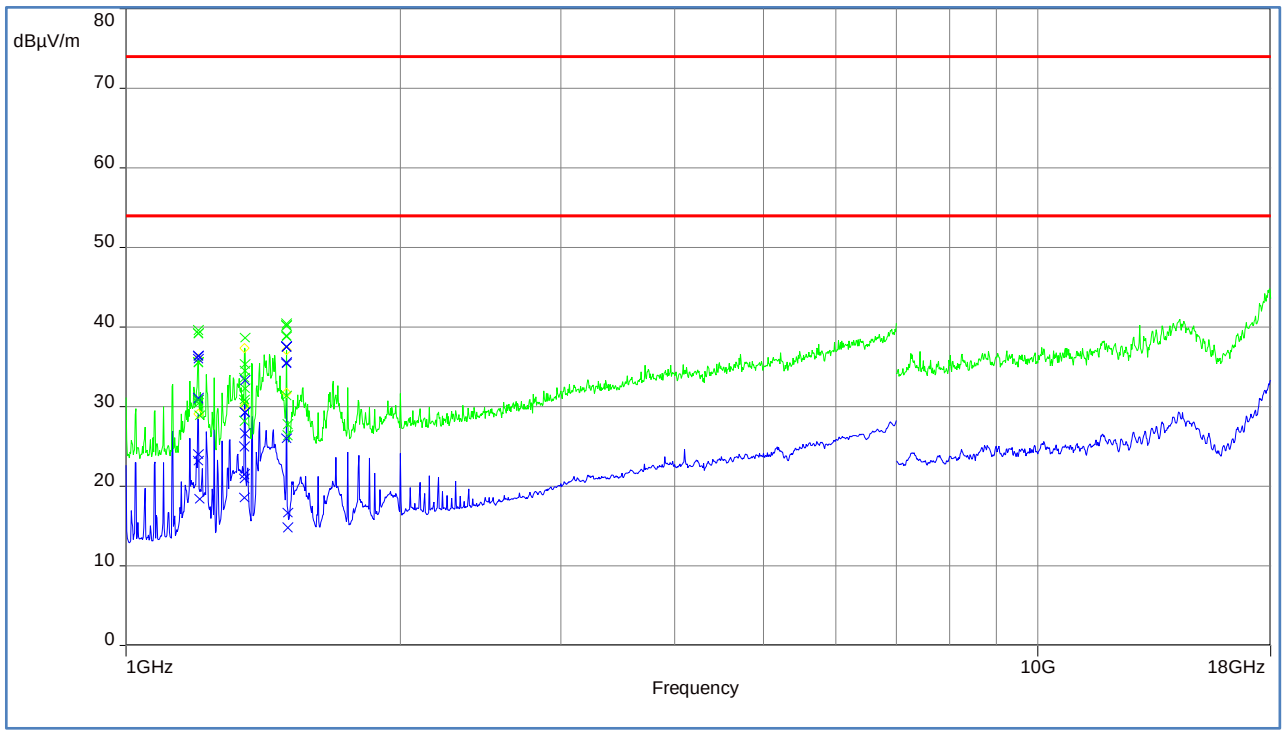
Plot 22: 1GHz – 18 GHz, CW F_{mid}



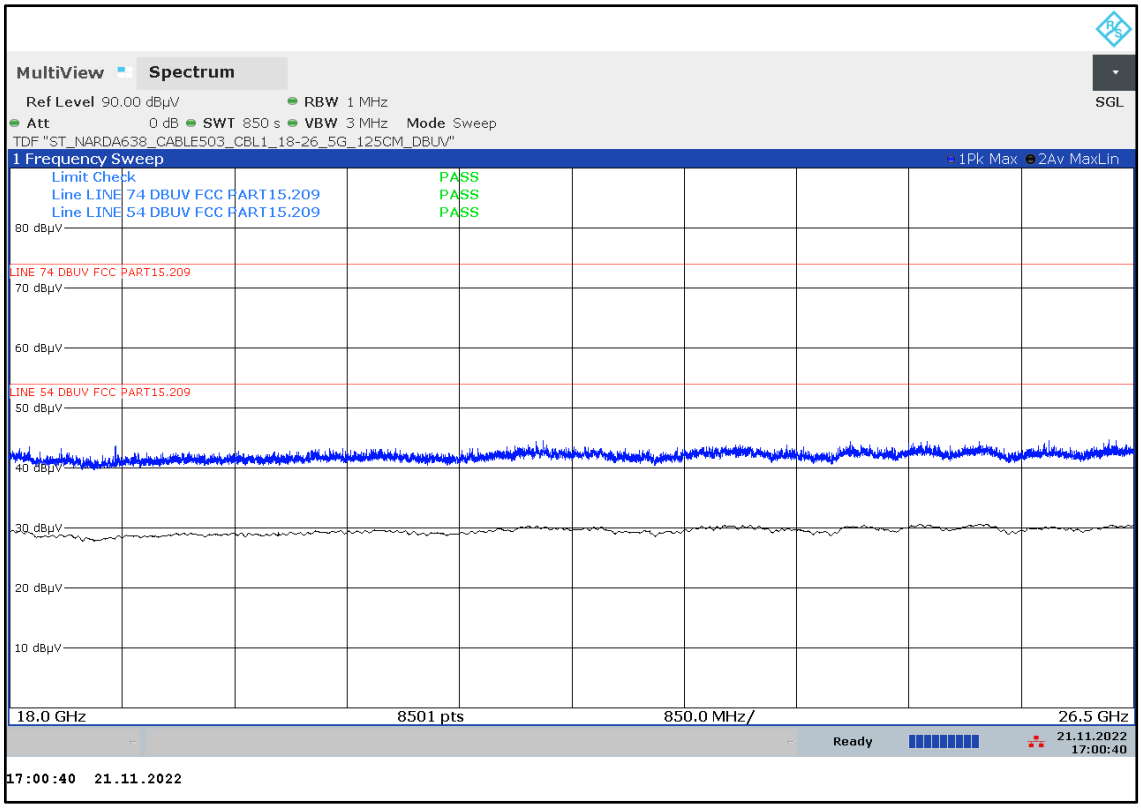
Plot 23: 1GHz – 18 GHz, CW F_{high}



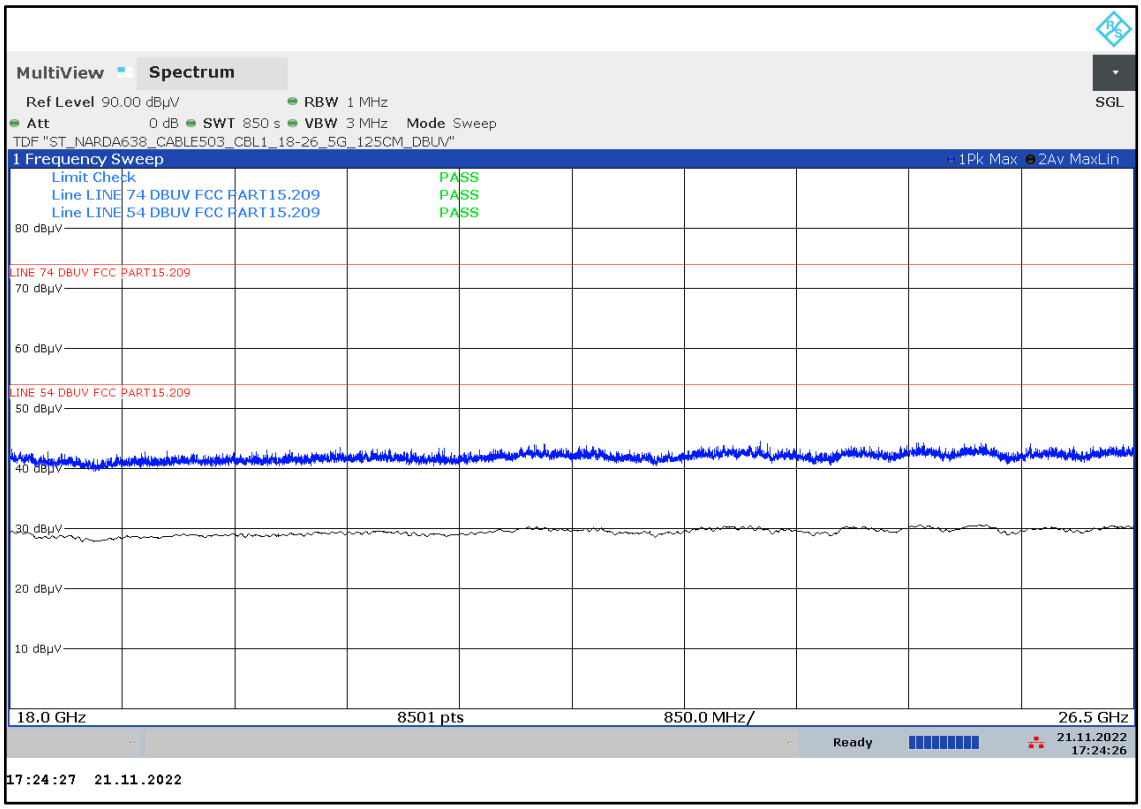
Plot 24: 1GHz – 18 GHz, Mode A



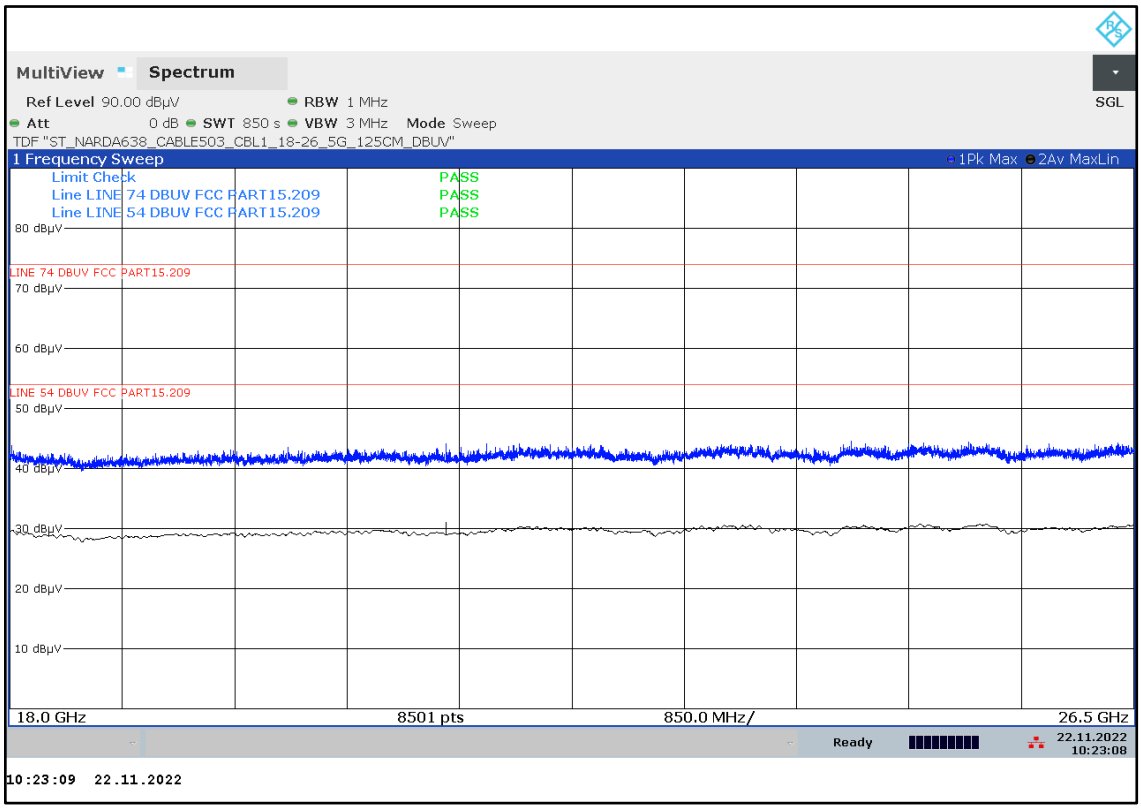
Plot 25: 18 GHz – 26.5 GHz, CW F_{low}



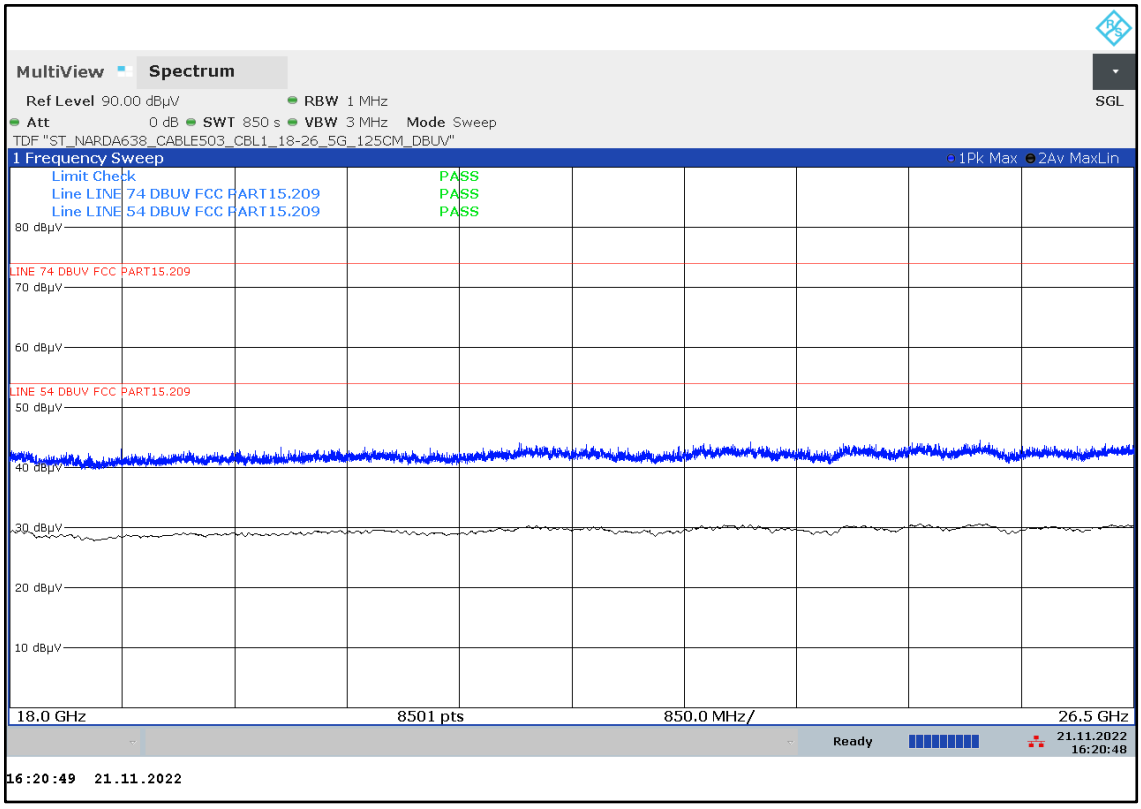
Plot 26: 18 GHz – 26.5 GHz, CW F_{mid}



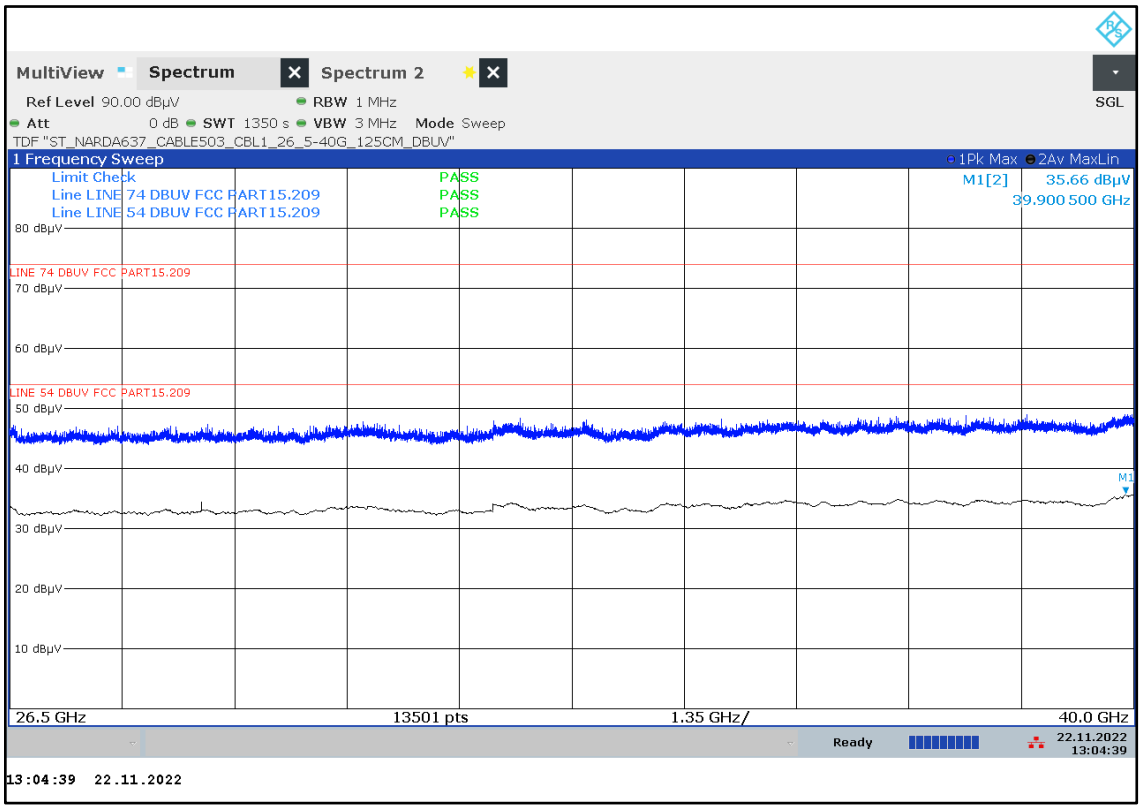
Plot 27: 18 GHz – 26.5 GHz, CW F_{high}



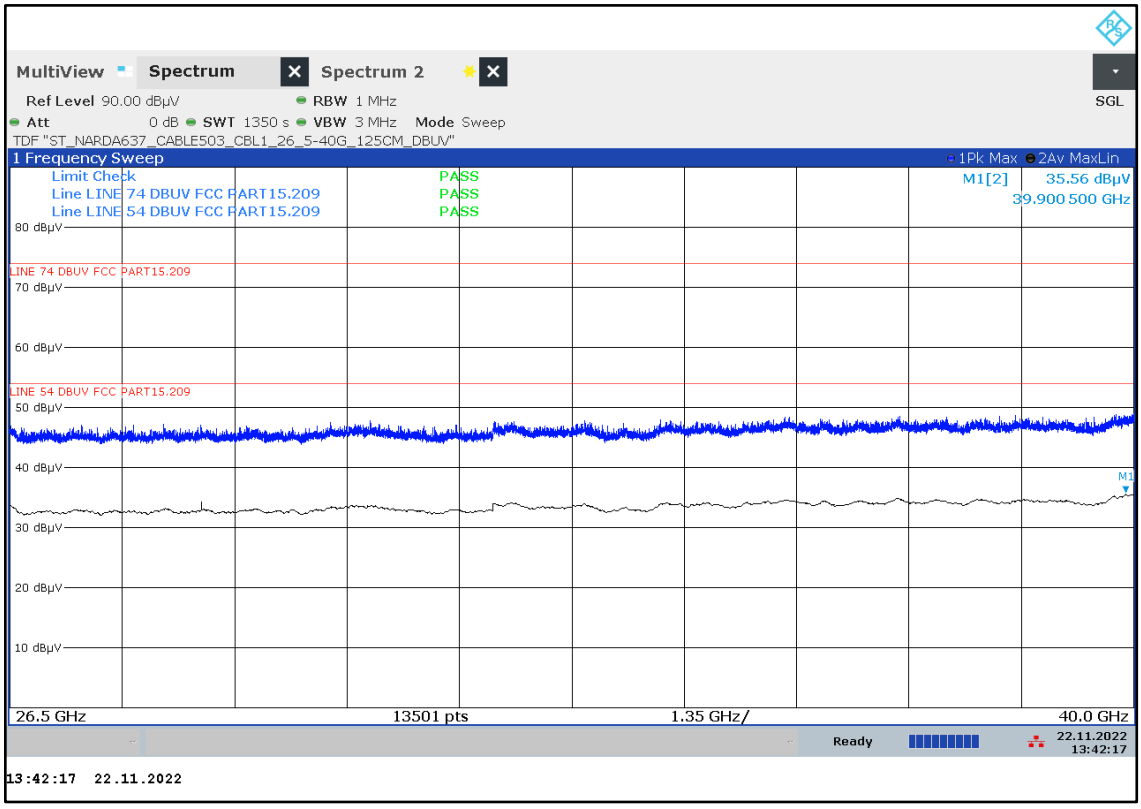
Plot 28: 18 GHz – 26.5 GHz, Mode A



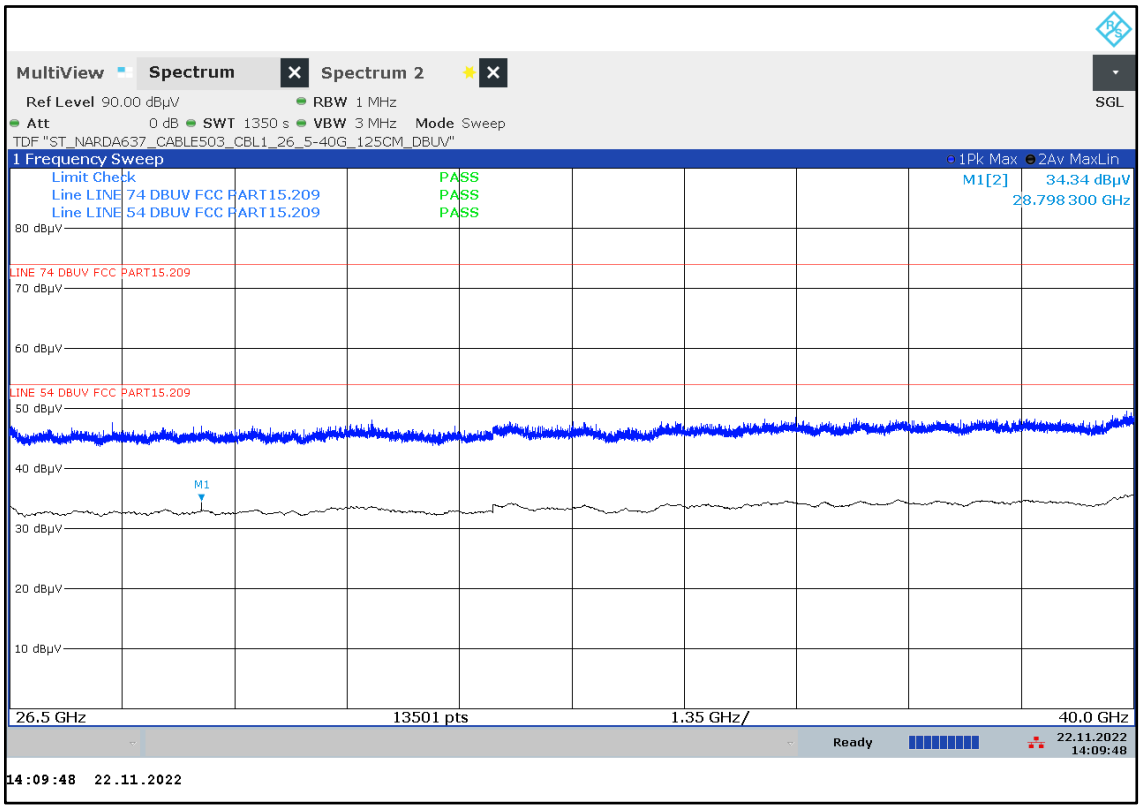
Plot 29: 26.5 GHz – 40 GHz, CW F_{low}



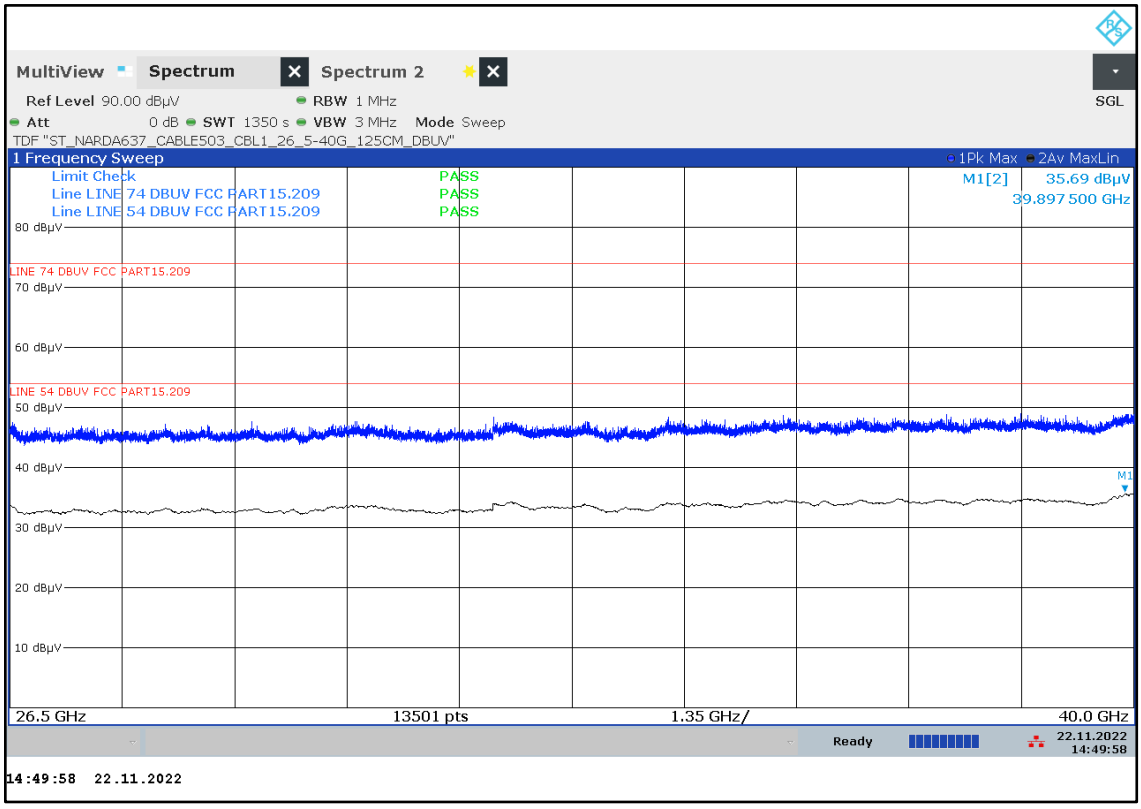
Plot 30: 26.5 GHz – 40 GHz, CW F_{mid}



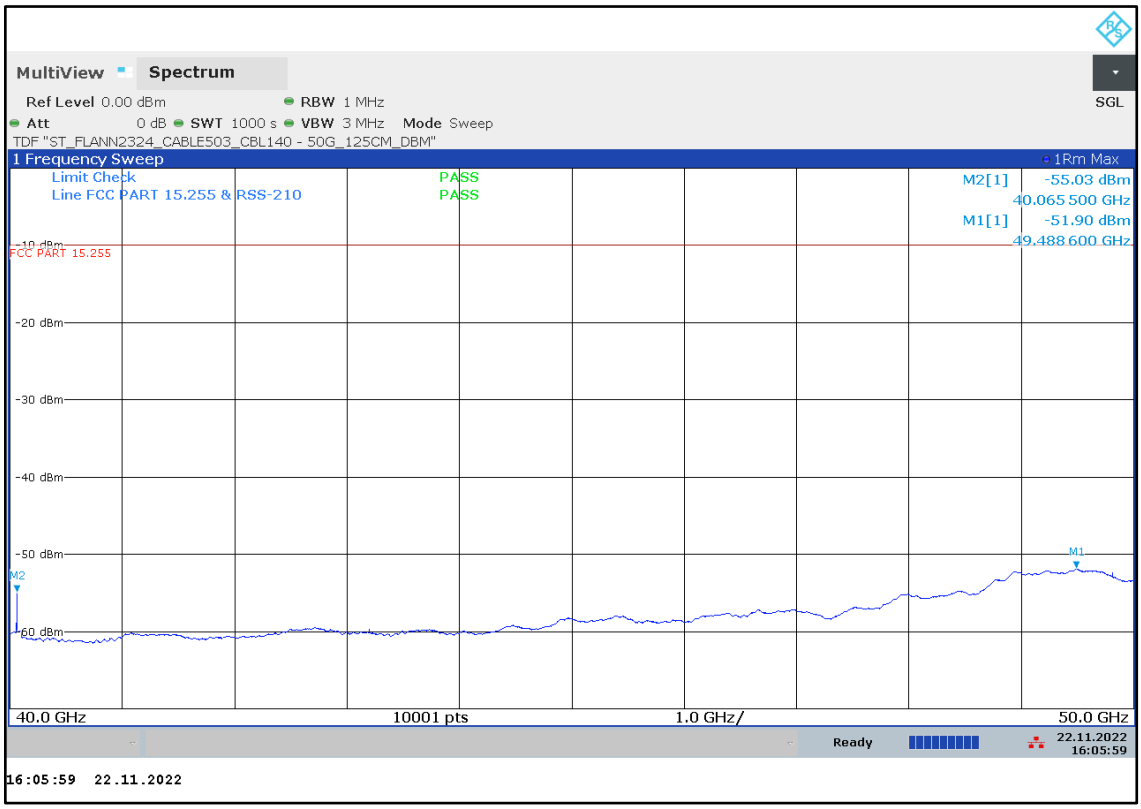
Plot 31: 26.5 GHz – 40 GHz, CW F_{high}



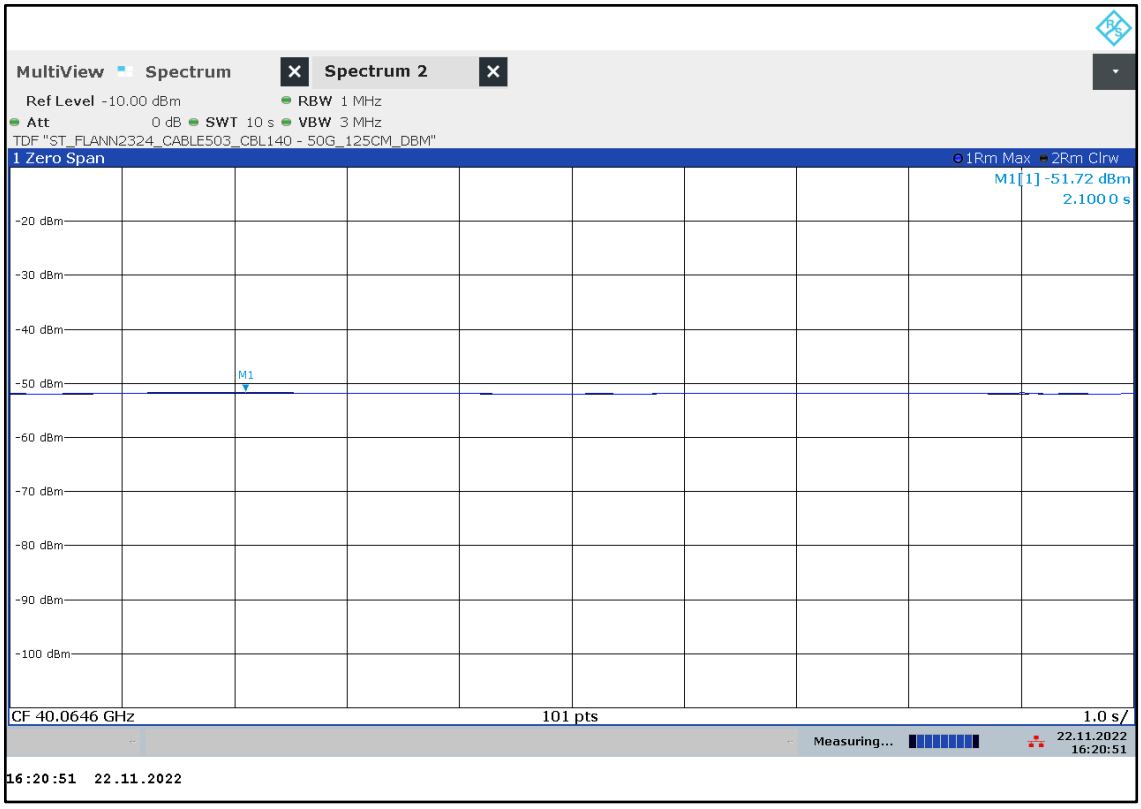
Plot 32: 26.5 GHz – 40 GHz, Mode A



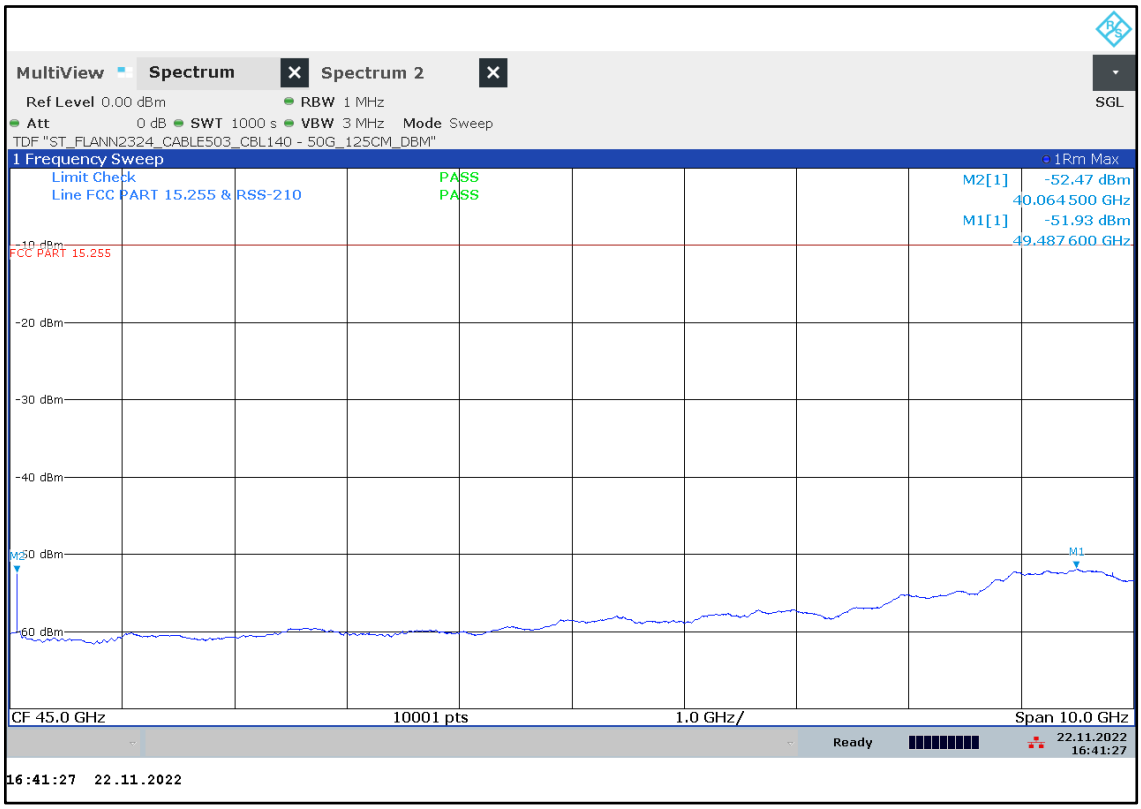
Plot 33: 40 GHz – 50 GHz, CW F_{low}



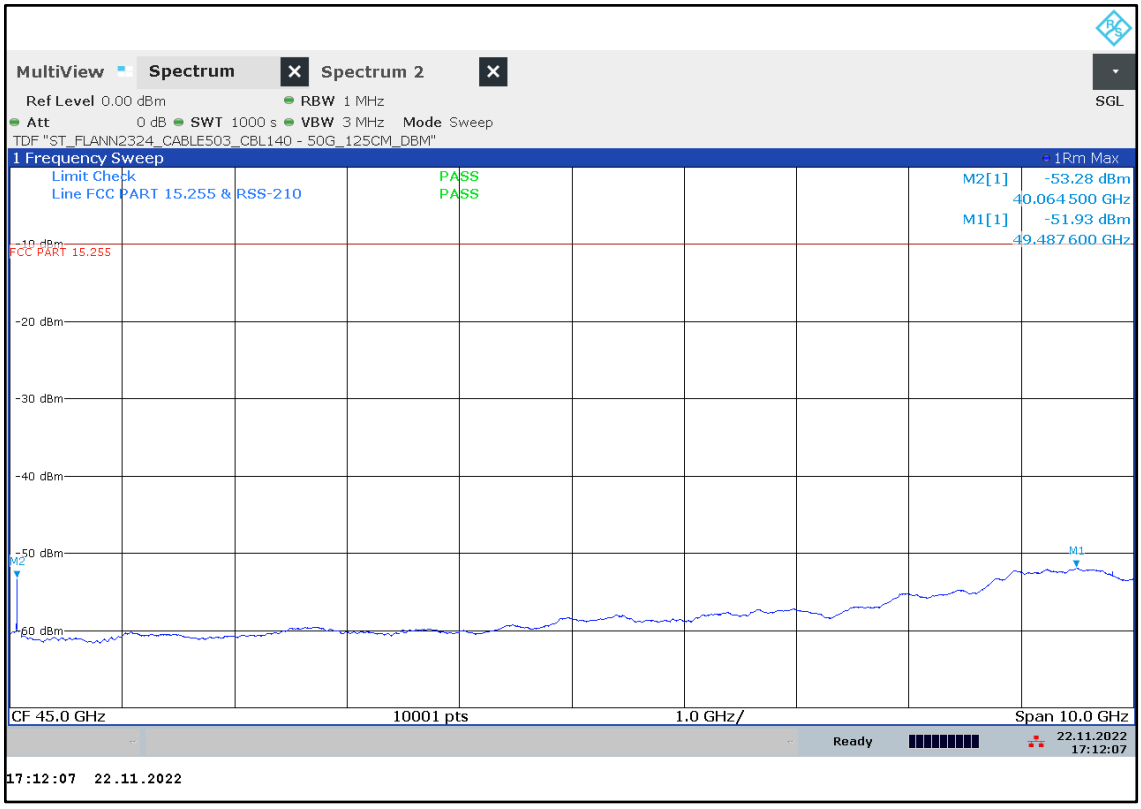
Plot 34: 40.06 GHz, Detail CW F_{low}



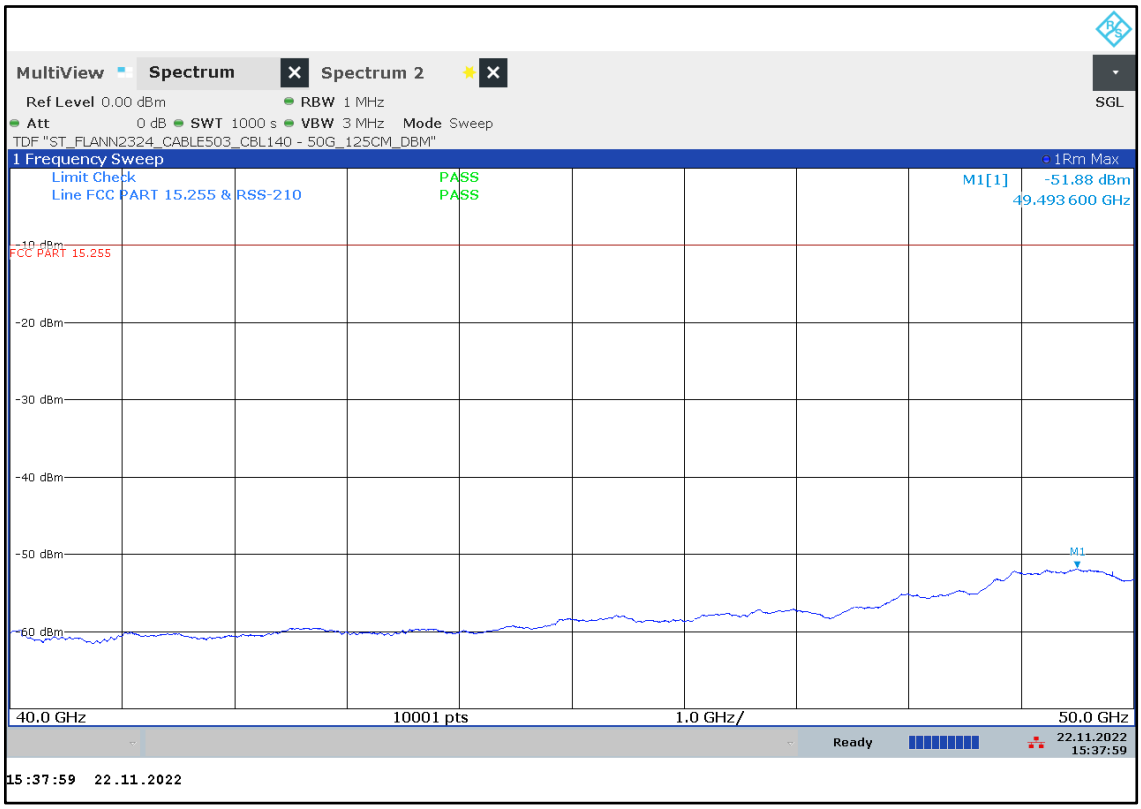
Plot 35: 40 GHz – 50 GHz, CW F_{mid}



Plot 36: 40 GHz – 50 GHz, CW F_{high}



Plot 37: 40 GHz – 50 GHz, Mode A



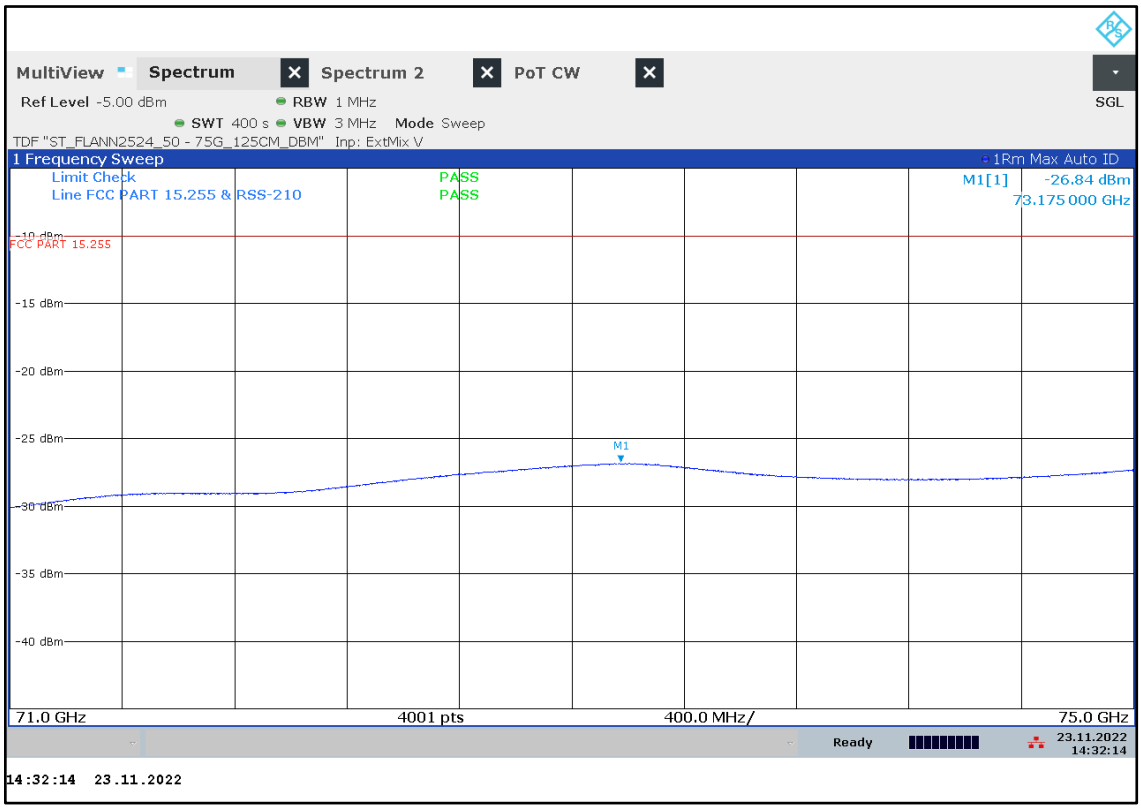
Plot 38: 50 GHz – 57 GHz, CW F_{low}

Plot 39: 50 GHz – 57 GHz, CW F_{mid}

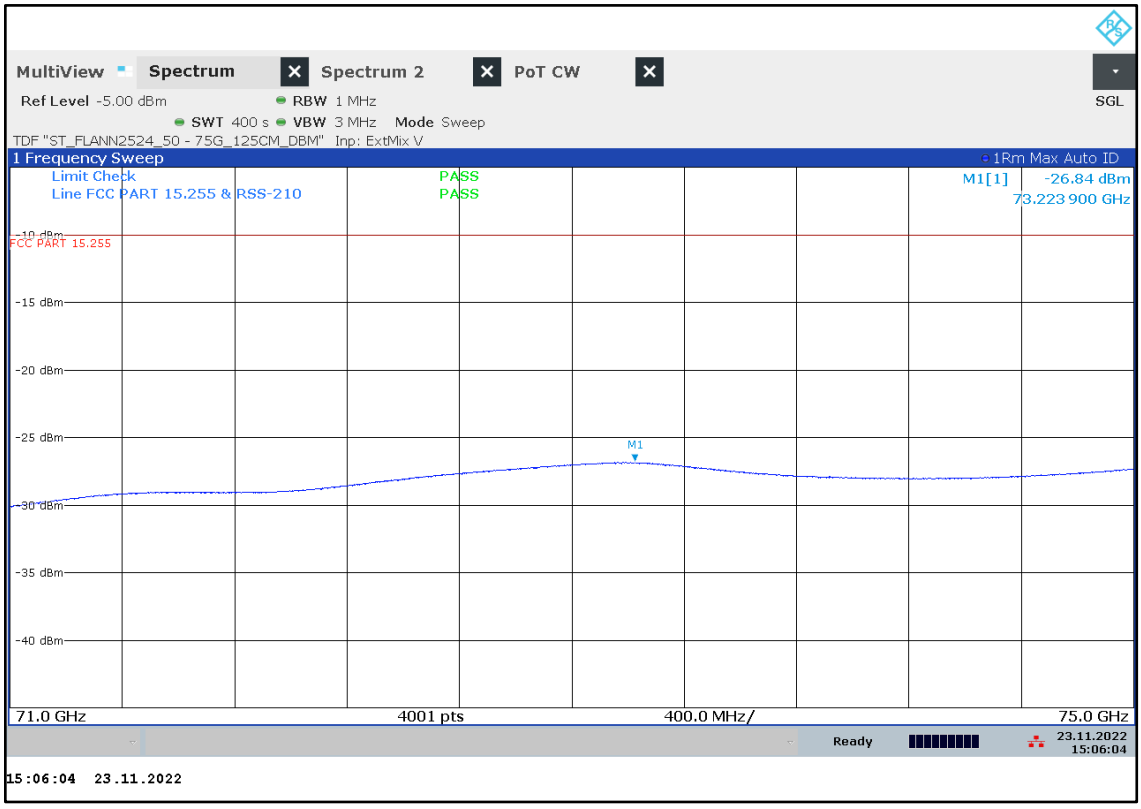
Plot 40: 50 GHz – 57 GHz, CW F_{high}

Plot 41: 50 GHz – 57 GHz, Mode A

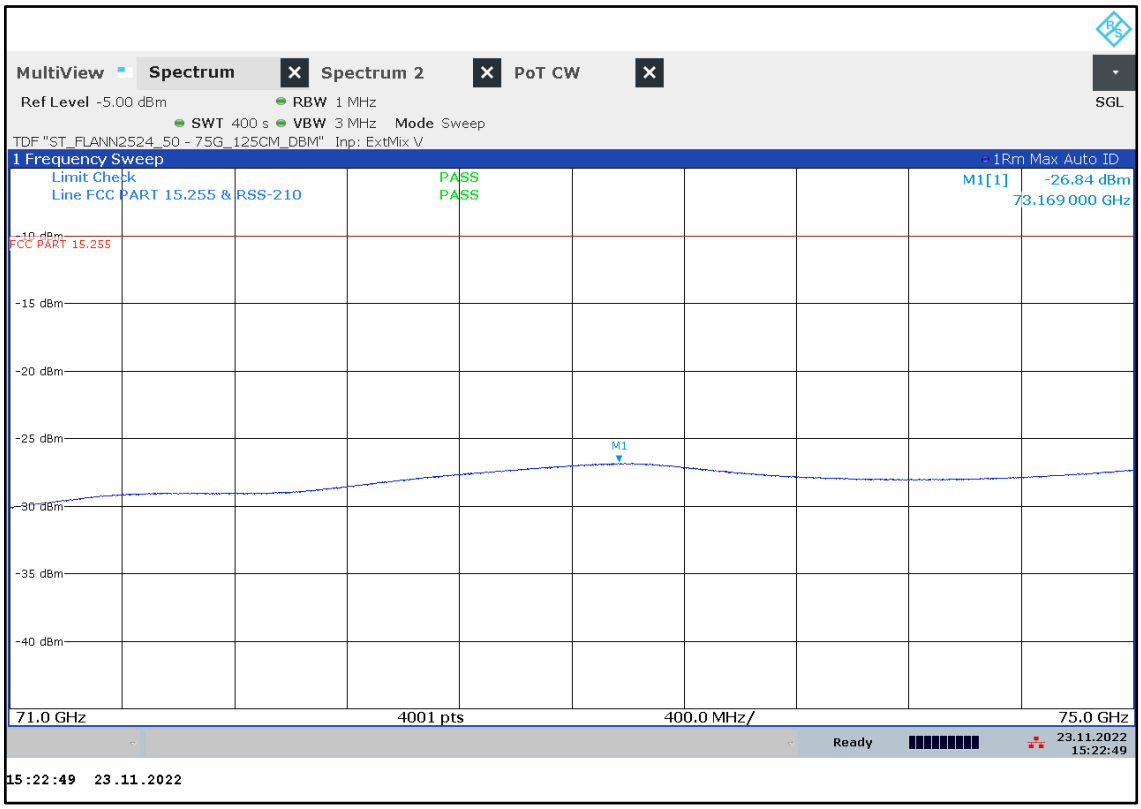
Plot 42: 71 GHz – 75 GHz, CW F_{low}



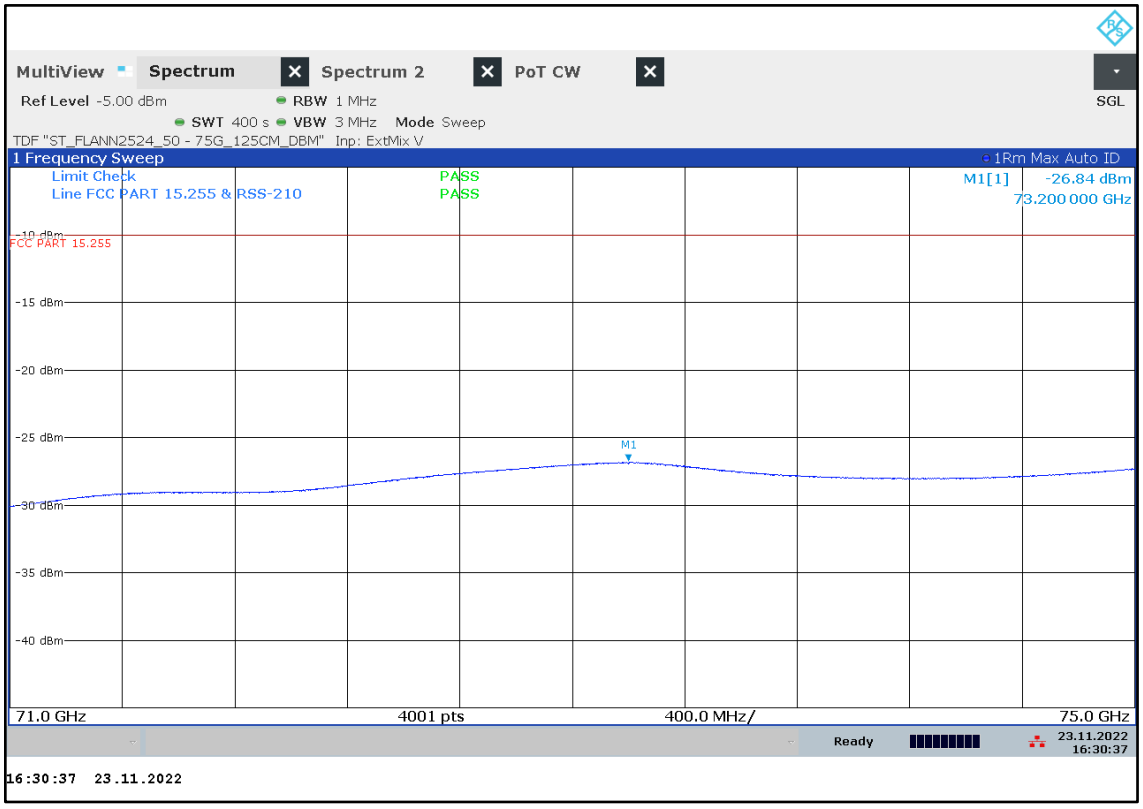
Plot 43: 71 GHz – 75 GHz, CW F_{mid}



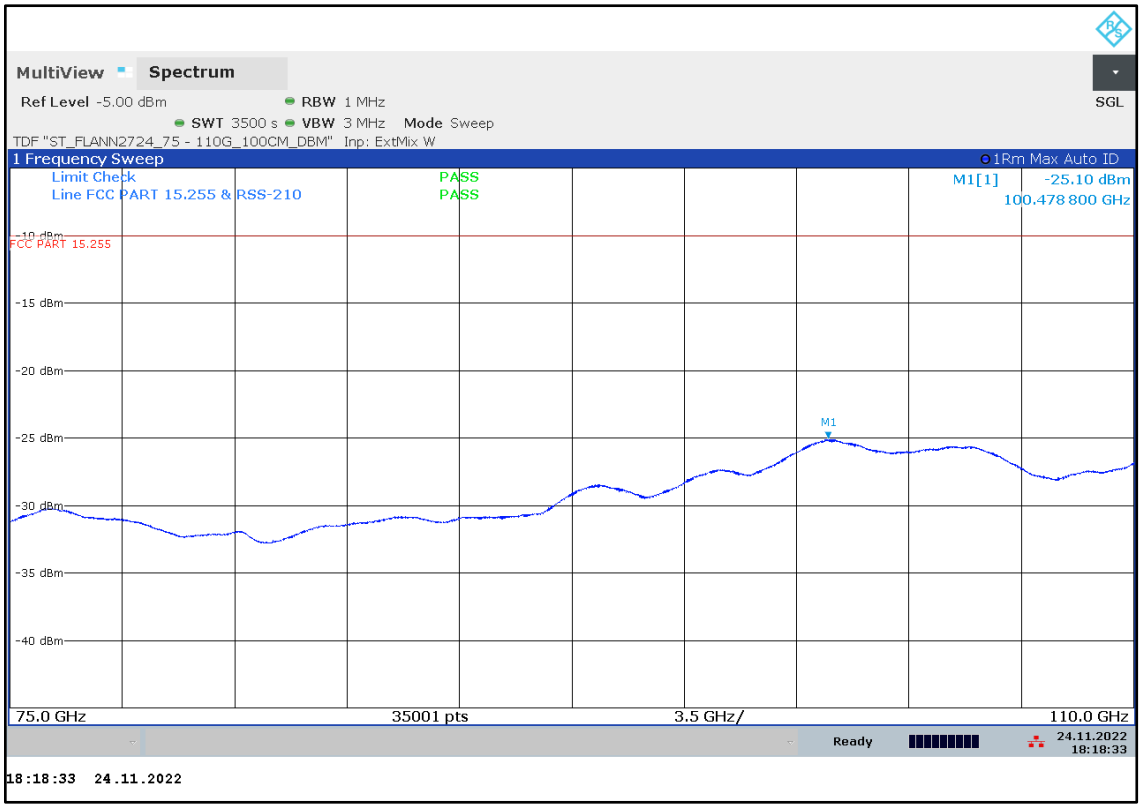
Plot 44: 71 GHz – 75 GHz, CW F_{high}



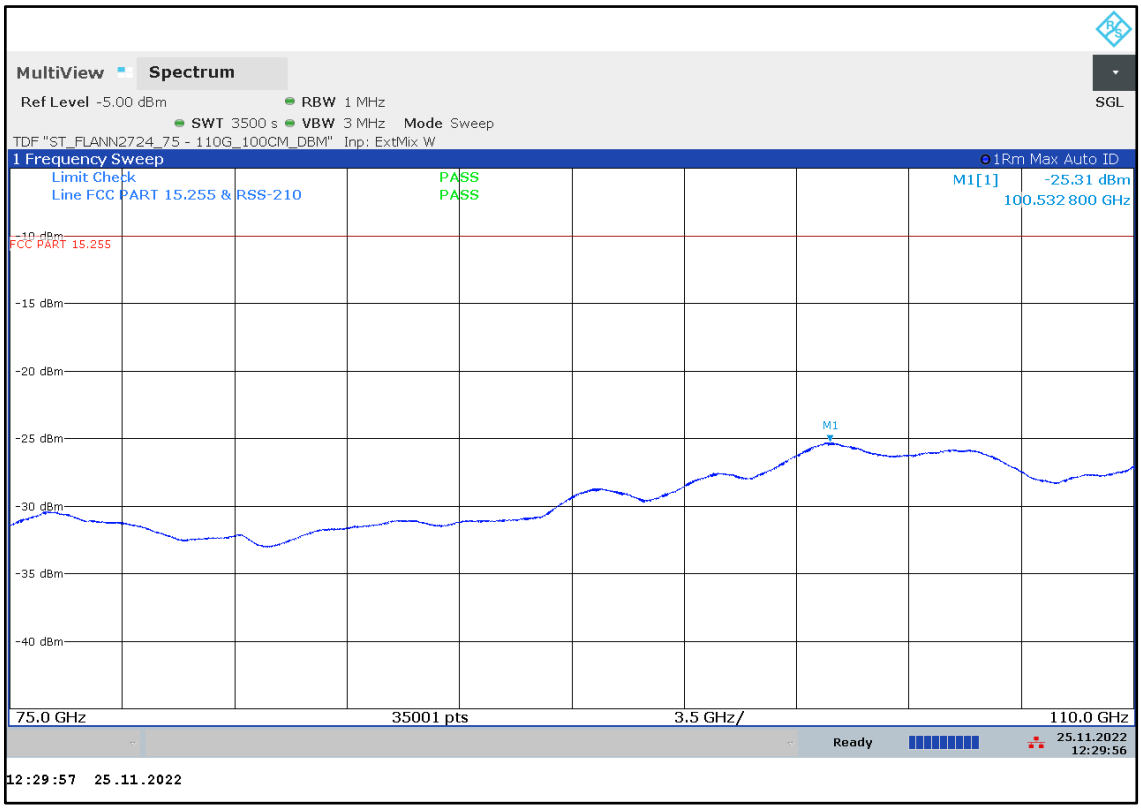
Plot 45: 71 GHz – 75 GHz, Mode A



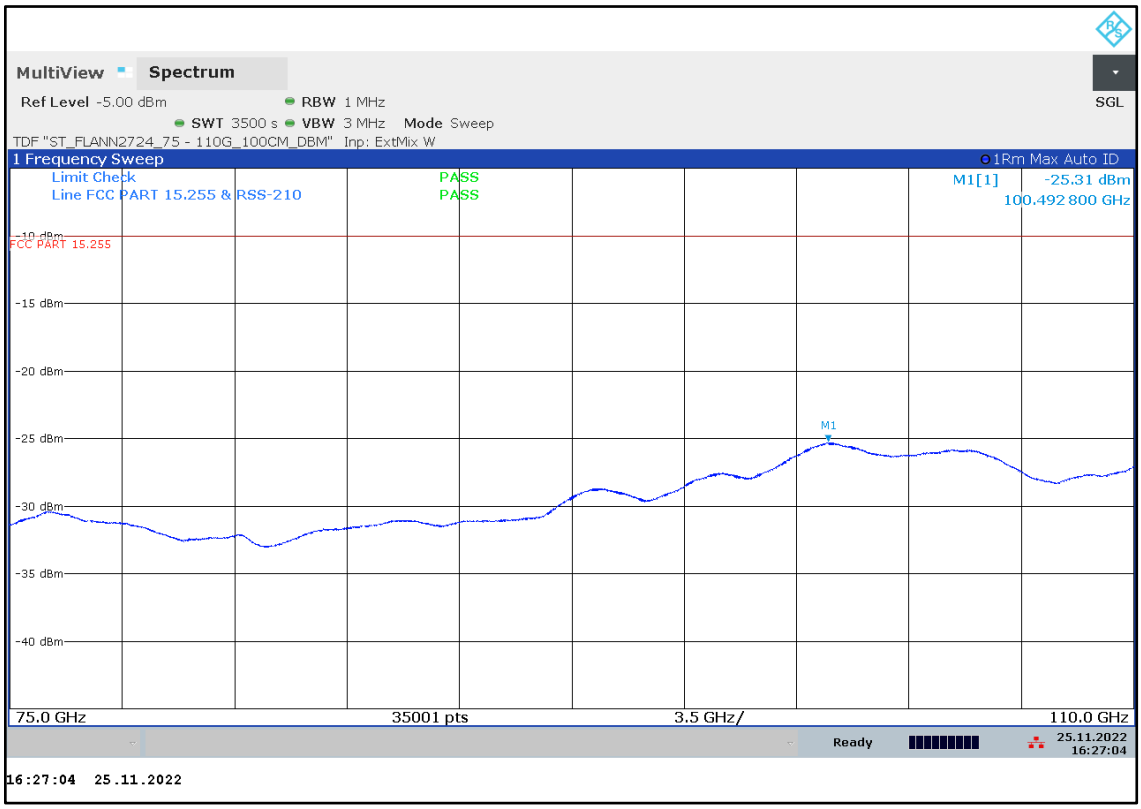
Plot 46: 75 GHz – 110 GHz, CW F_{low}



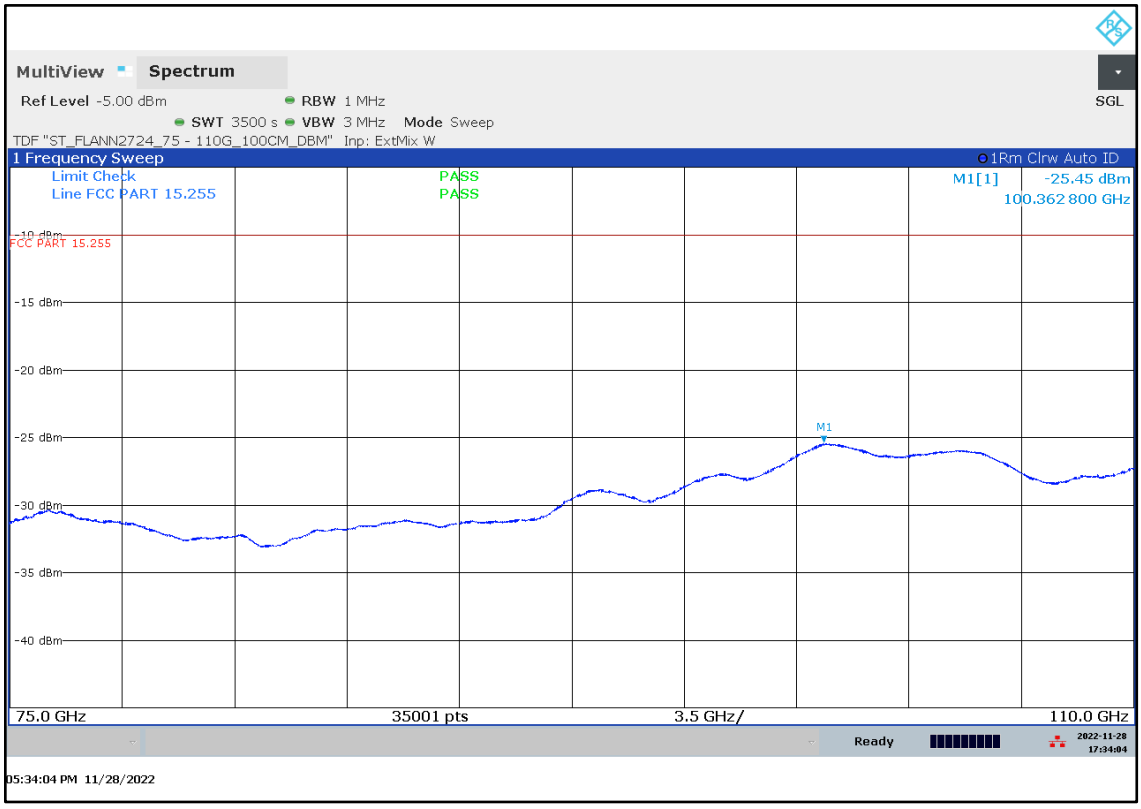
Plot 47: 75 GHz – 110 GHz, CW F_{mid}



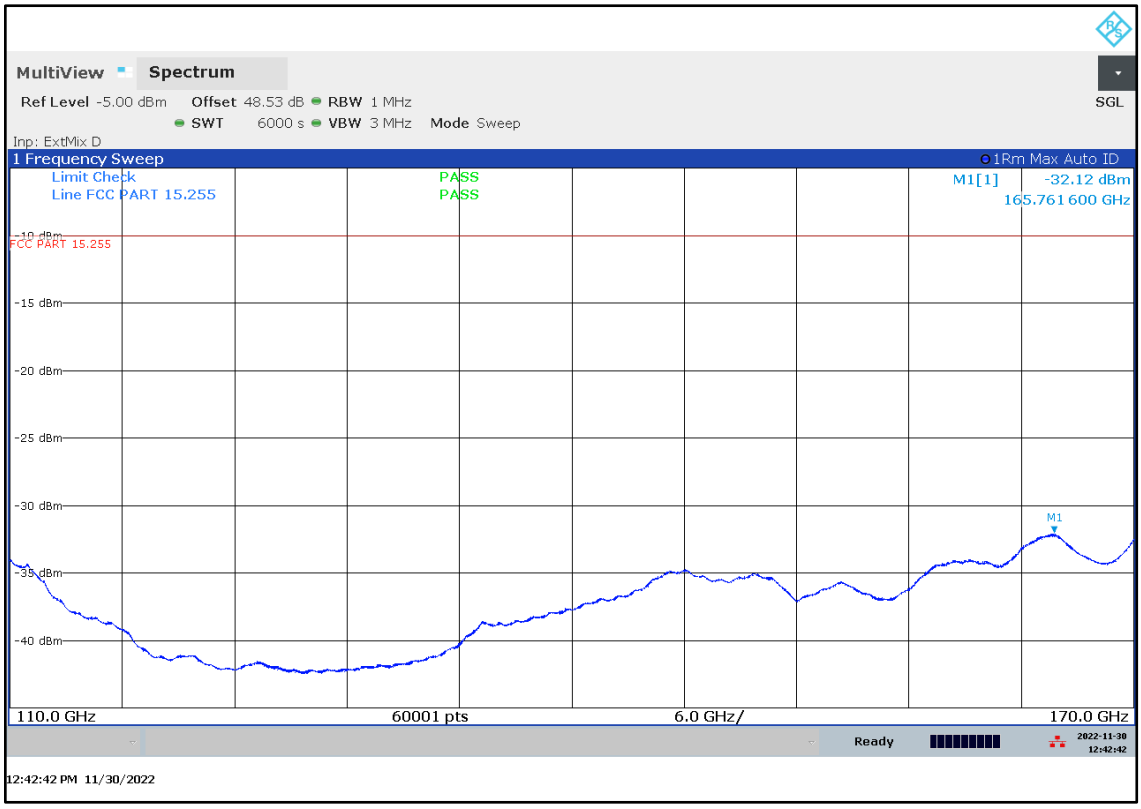
Plot 48: 75 GHz – 110 GHz, CW F_{high}



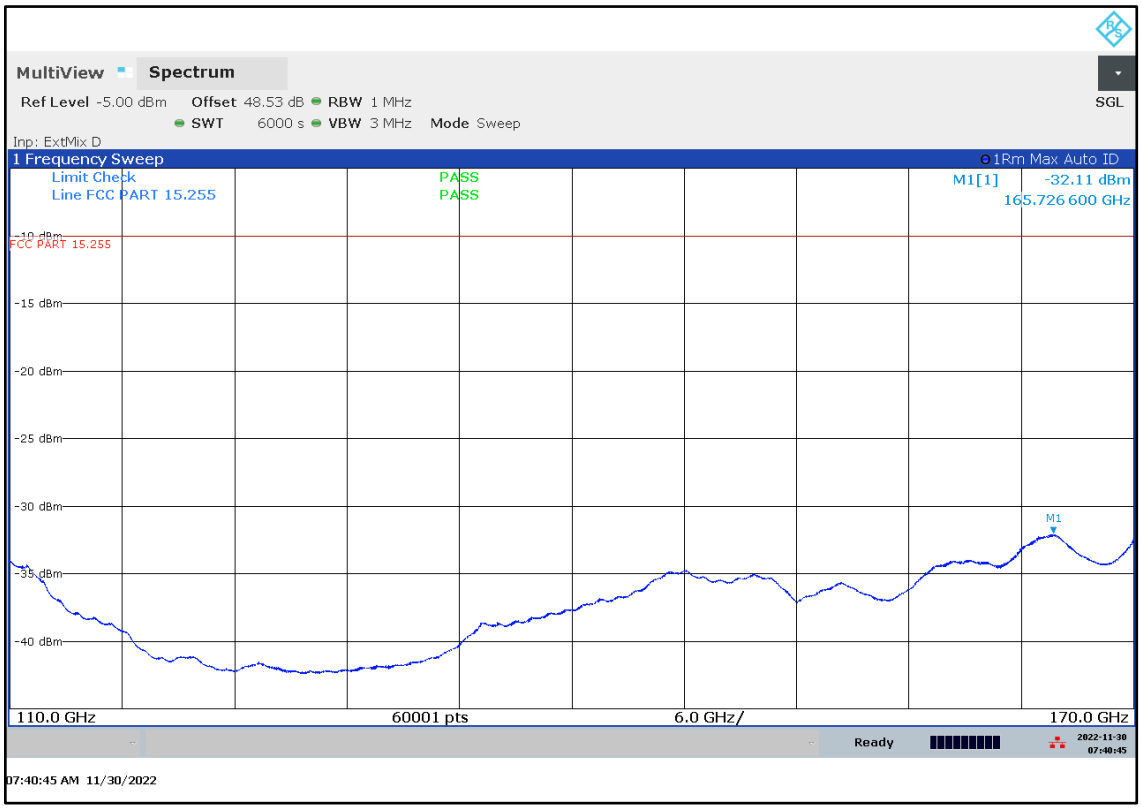
Plot 49: 75 GHz – 110 GHz, Mode A



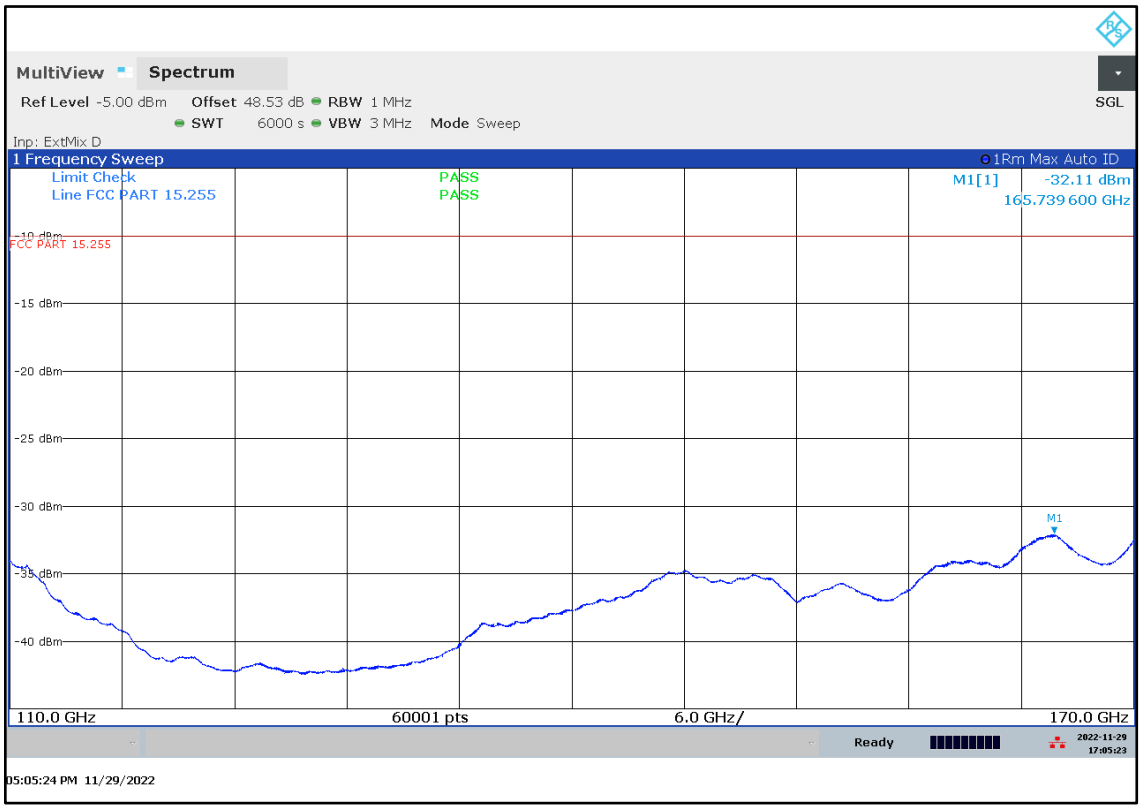
Plot 50: 110 GHz – 170 GHz, CW F_{low}



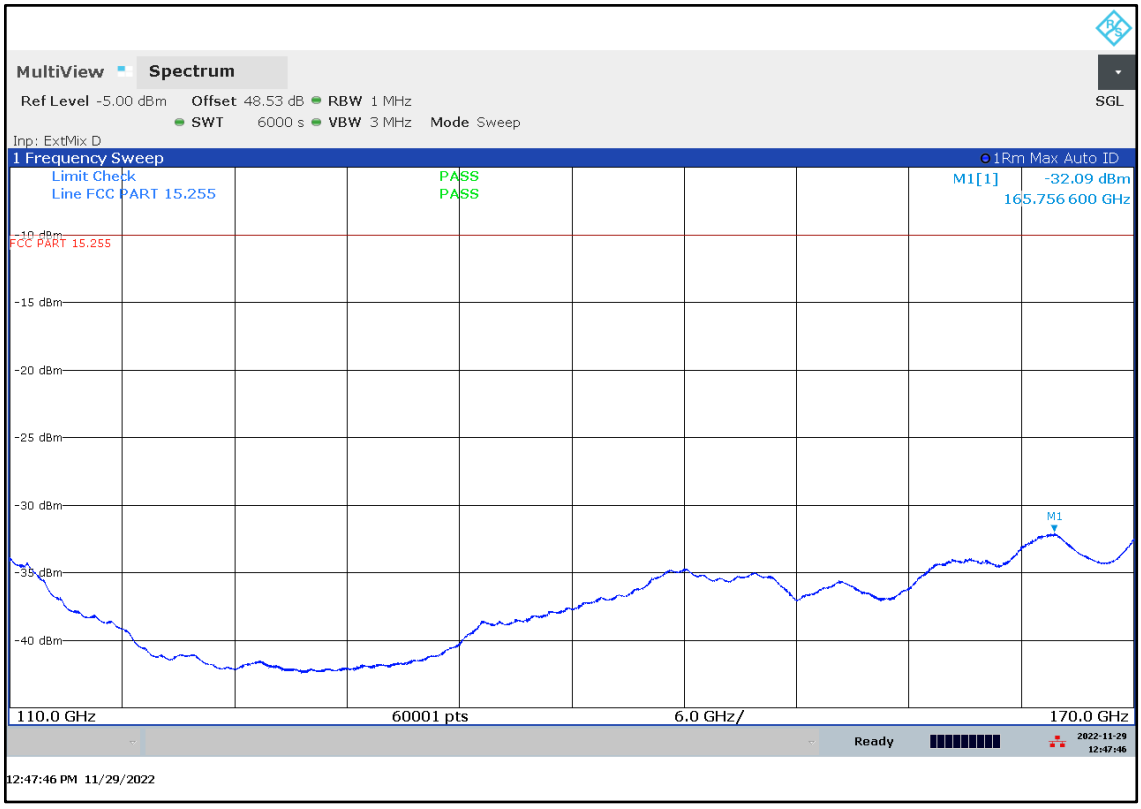
Plot 51: 110 GHz – 170 GHz, CW F_{mid}



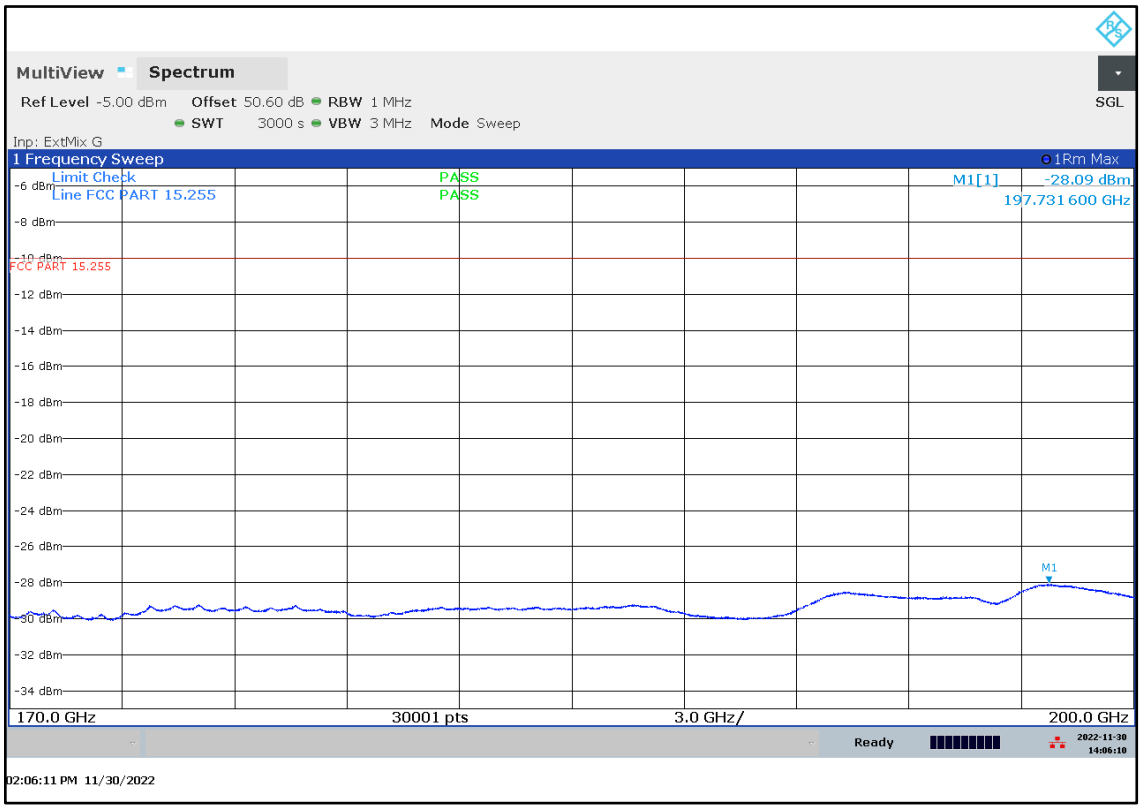
Plot 52: 110 GHz – 170 GHz, CW F_{high}



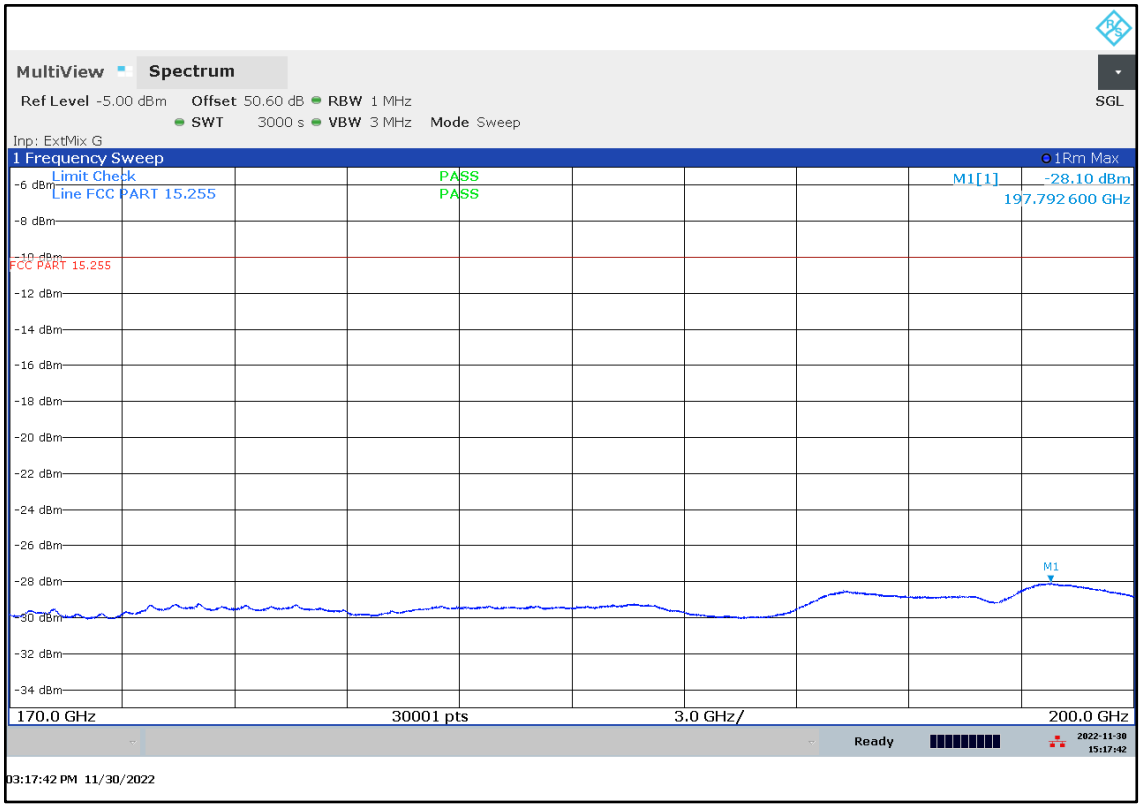
Plot 53: 110 GHz – 170 GHz, Mode A



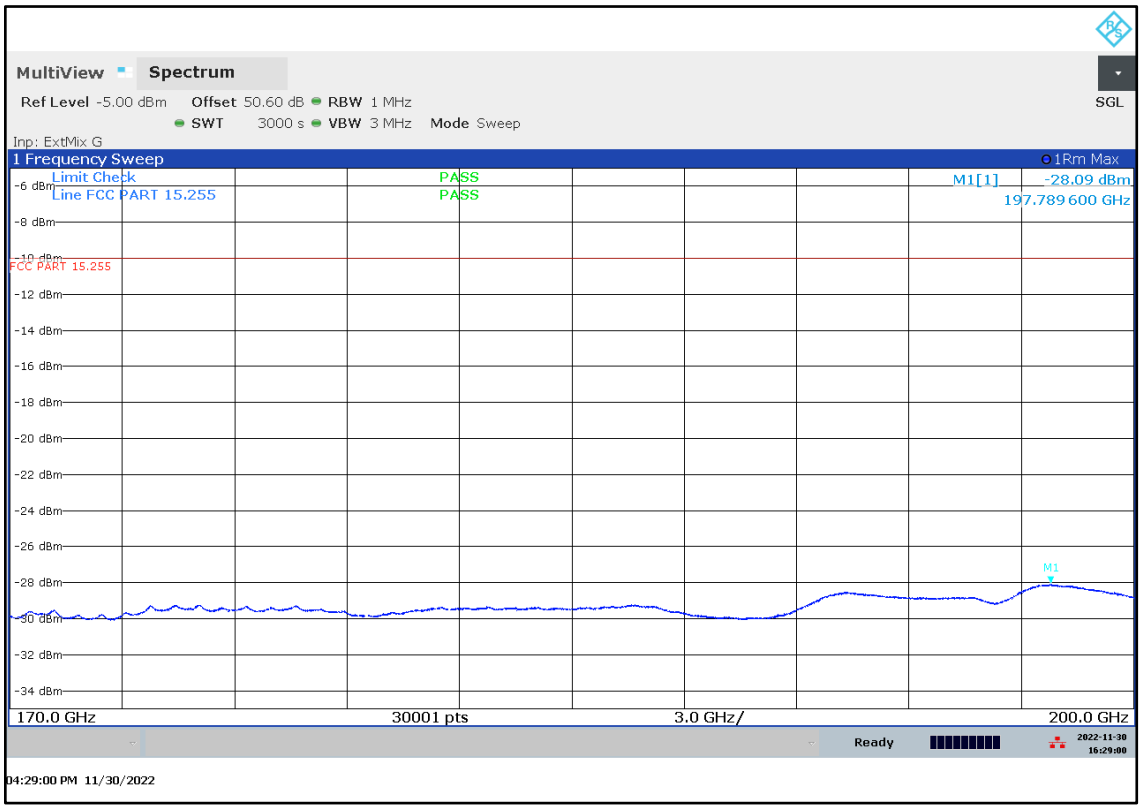
Plot 54: 170 GHz – 200 GHz, CW F_{low}



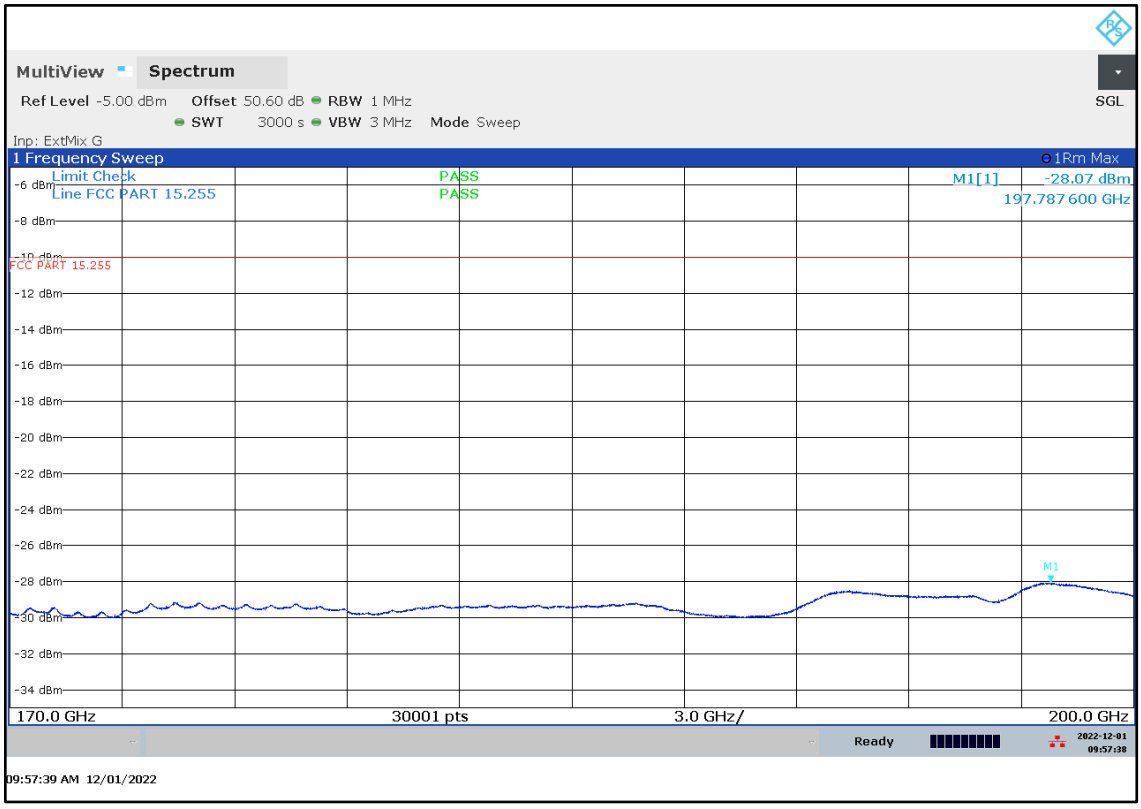
Plot 55: 170 GHz – 200 GHz, CW F_{mid}



Plot 56: 170 GHz – 200 GHz, CW F_{high}



Plot 57: 170 GHz – 200 GHz, Mode A



12.4 Spurious emissions conducted < 30 MHz (AC power line)

Description:

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. Both power lines, phase and neutral line, are measured. Found peaks are re-measured with average and quasi peak detection to show compliance to the limits.

Limits:

FCC		IC
CFR Part 15.207(a)		RSS-Gen 8.8
Conducted Spurious Emissions < 30 MHz		
Frequency (MHz)	Quasi-Peak (dBµV)	Average (dBµV)
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30.0	60	50

*Decreases with the logarithm of the frequency

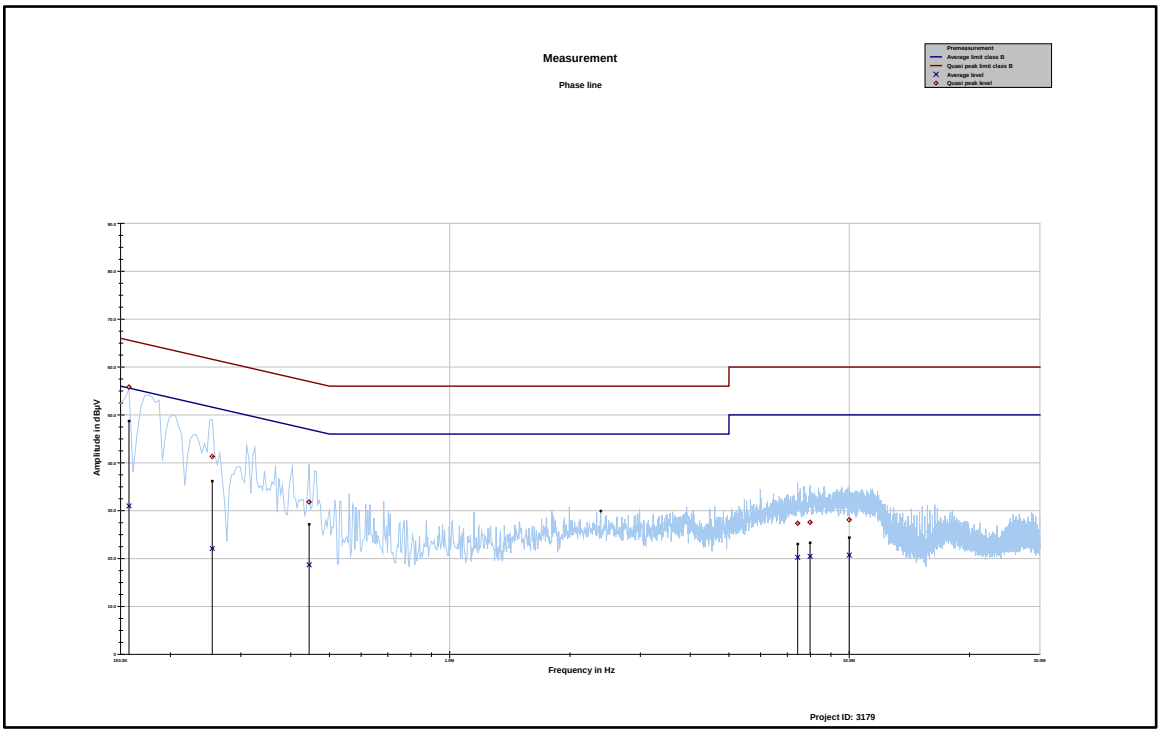
§15.207 (c)
Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtainig their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

Measurement:

Measurement parameter	
Detector:	Peak - Quasi Peak / Average
Sweep time:	Auto
Resolution bandwidth:	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Video bandwidth:	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Span:	9 kHz to 30 MHz
Trace-Mode:	Max Hold

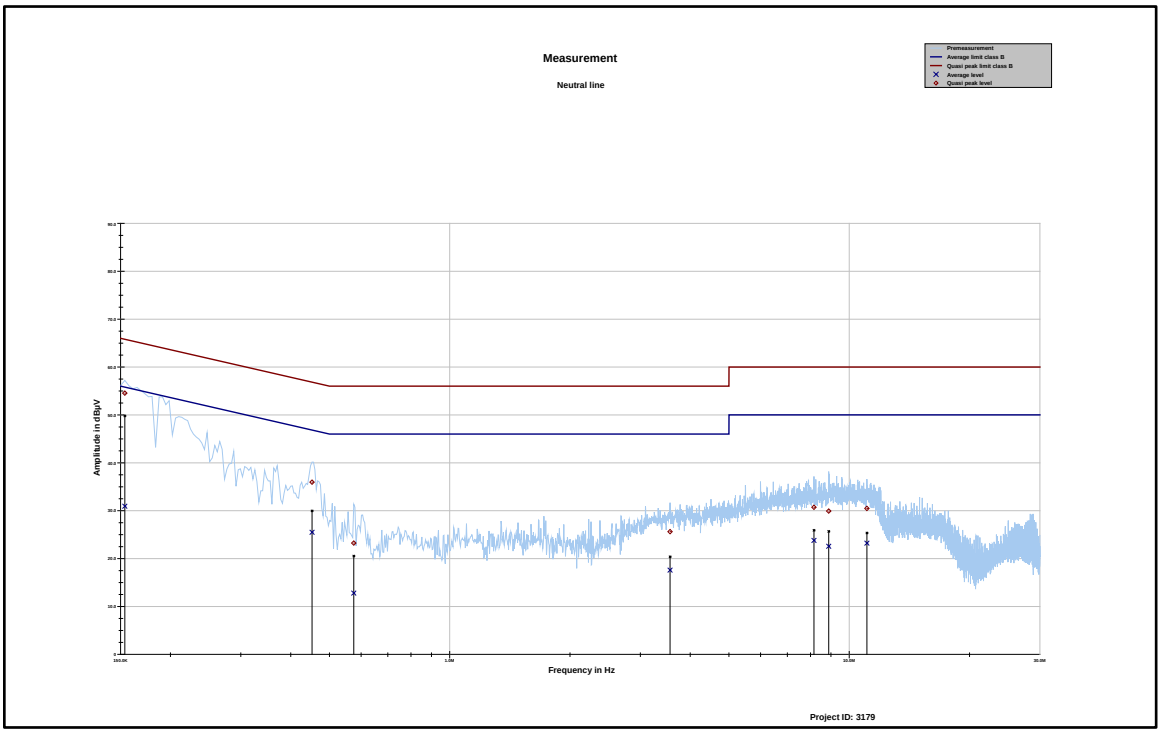
Verdict: **Complies**

Plot 58: Phase line



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.157463	55.82	9.78	65.597	30.99	24.80	55.787
0.254475	41.30	20.31	61.610	22.09	30.93	53.015
0.444769	31.81	25.16	56.972	18.69	28.89	47.578
7.429669	27.36	32.64	60.000	20.27	29.73	50.000
7.978162	27.57	32.43	60.000	20.46	29.54	50.000
10.000500	28.09	31.91	60.000	20.73	29.27	50.000

Plot 59: Neutral line



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin Average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.153731	54.54	11.26	65.796	30.94	24.95	55.893
0.452231	35.95	20.89	56.834	25.49	21.87	47.365
0.575362	23.23	32.77	56.000	12.79	33.21	46.000
3.560363	25.61	30.39	56.000	17.58	28.42	46.000
8.160994	30.71	29.29	60.000	23.78	26.22	50.000
8.884856	29.92	30.08	60.000	22.57	27.43	50.000
11.075100	30.47	29.53	60.000	23.22	26.78	50.000

12.5 Frequency Stability

Description:

§15.215(c)
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

§15.255 (f)
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.

Limits:

FCC	IC
CFR Part 15.255 (f)	RSS-Gen 6.11 / RSS-210 J.6
The occupied bandwidth from intentional radiators operated within the specified frequency band shall comply with the following:	
Frequency range	
57 GHz – 71 GHz	

Measurement:

Measurement parameter	
Detector:	Pos-Peak
Resolution bandwidth:	50 MHz
Video bandwidth:	80 MHz
Trace-Mode:	Max Hold
Temperature:	-20°C / +50°C

Note:

- The temperature range can be extended by customer declaration
  - T_L = -40 °C
  - T_h = 85 °C

Measurement results: Mode A

Test condition	Frequency f_L [GHz]	Frequency f_H [GHz]	Bandwidth [GHz]
-40 °C / V_{nom}	60.103 GHz	63.900 GHz	3.797 GHz
-20 °C / V_{nom}	60.139 GHz	63.898 GHz	3.759 GHz
-10 °C / V_{nom}	60.081 GHz	63.898 GHz	3.817 GHz
0 °C / V_{nom}	60.090 GHz	63.900 GHz	3.811 GHz
10 °C / V_{nom}	60.101 GHz	63.902 GHz	3.801 GHz
20 °C / V_{nom}	60.122 GHz	63.905 GHz	3.783 GHz
20 °C / V_{min}	60.105 GHz	63.901 GHz	3.796 GHz
20 °C / V_{max}	60.105 GHz	63.902 GHz	3.796 GHz
30 °C / V_{nom}	60.086 GHz	63.902 GHz	3.816 GHz
40 °C / V_{nom}	60.118 GHz	63.904 GHz	3.786 GHz
50 °C / V_{nom}	60.119 GHz	63.906 GHz	3.787 GHz
85 °C / V_{nom}	60.092 GHz	63.912 GHz	3.819 GHz

Note:

- Mode definition see chapter 11
- Vertical Line V1 in plots: 57 GHz
- Vertical Line V2 in plots: 71 GHz
- Vertical Lines S1 & S2 marks the interval for 99% Bandwidth calculation

Verdict: Complies

Plot 60: Occupied bandwidth, -40 °C / V_{nom}

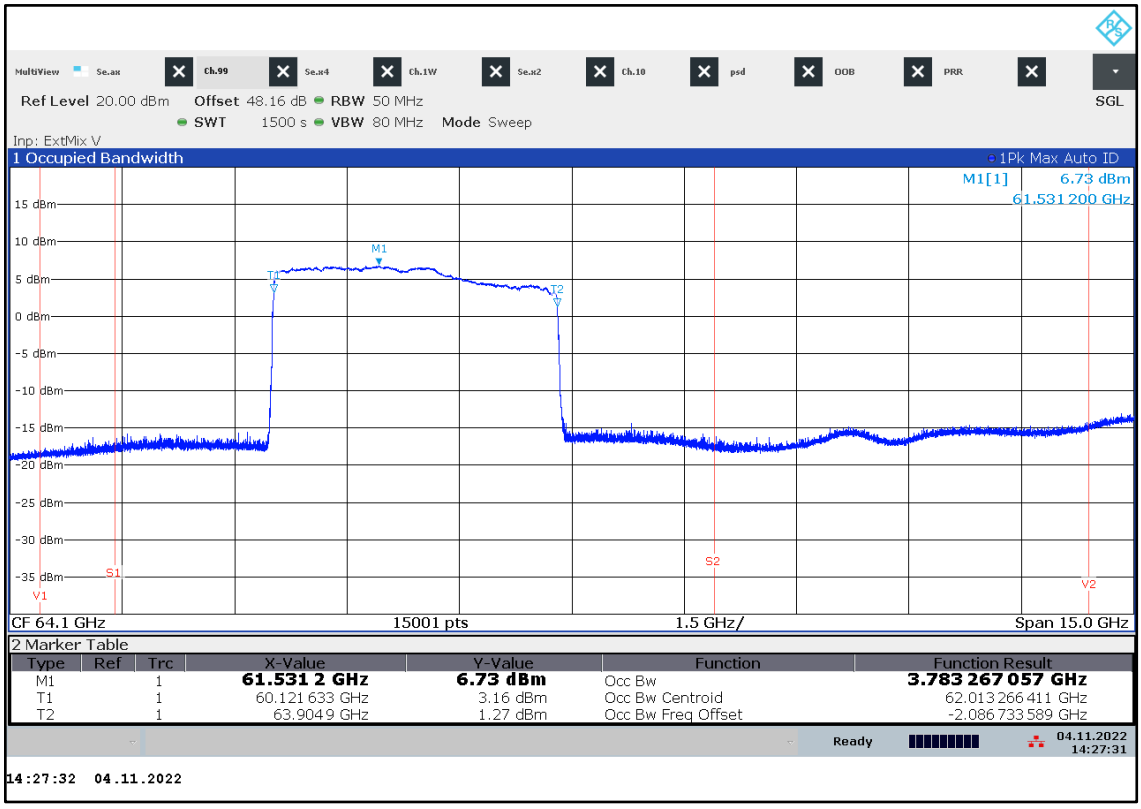
Plot 61: Occupied bandwidth, -20 °C / V_{nom}

Plot 62: Occupied bandwidth, -10 °C / V_{nom}

Plot 63: Occupied bandwidth, 0 °C / V_{nom}

Plot 64: Occupied bandwidth, +10 °C / V_{nom}

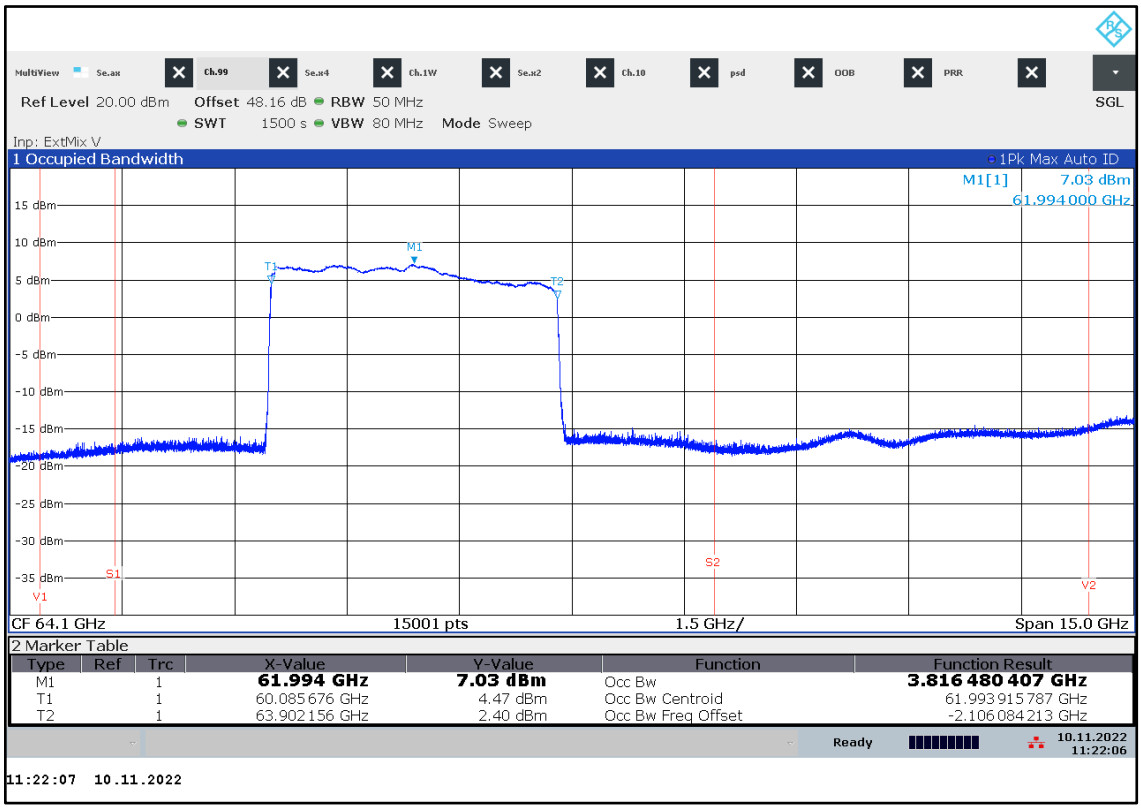
Plot 65: Occupied bandwidth, +20 °C / V_{nom}



Plot 66: Occupied bandwidth, +20 °C / V_{min}

Plot 67: Occupied bandwidth, +20 °C / V_{max}

Plot 68: Occupied bandwidth, +30 °C / V_{nom}



Plot 69: Occupied bandwidth, +40 °C / V_{nom}

Plot 70: Occupied bandwidth, +50 °C / V_{nom}

Plot 71: Occupied bandwidth, +85 °C / V_{nom}

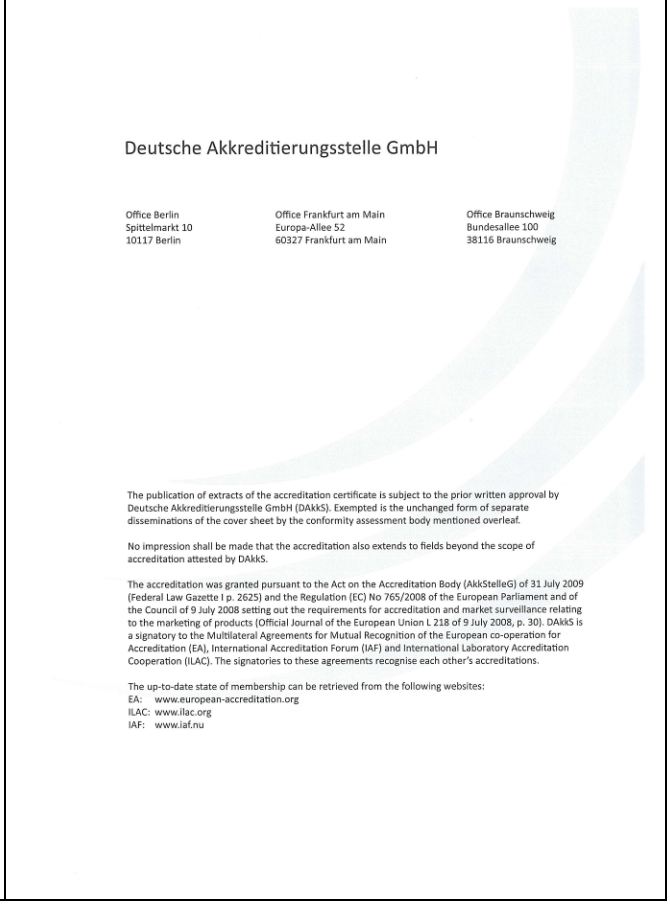
13 Glossary

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

14 Document history

Version	Applied changes	Date of release
-/-	Initial release	2023-03-13

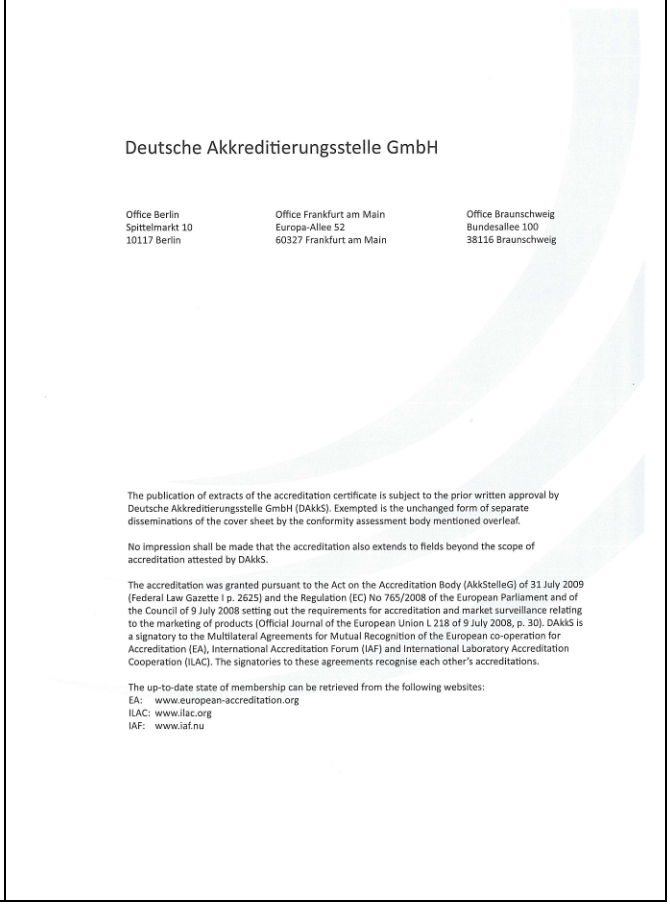
15 Accreditation Certificate – D-PL-12076-01-04

first page	last page
	

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
or
https://ctcadvanced.com/app/uploads/2020/06/D-PL-12076-01-04_Canada_TCEMC.pdf

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

first page	last page
	

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

https://www.dakks.de/files/data/as/pdf/D-PL-12076-01-05e.pdf
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########## END OF TEST REPORT ##########