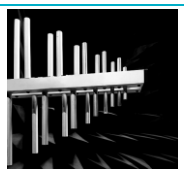
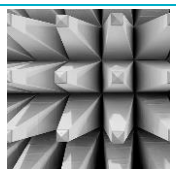



CTC advanced
member of RWTÜV group

Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-2991/21-01-02

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

Topgolf Sweden AB
Svardvagen 3A
18233 Danderyd / SWEDEN
Phone: +46 707 778758
Contact: Jonas Norlander
e-mail: jonas.norlander@topgolf.com

Manufacturer

Topgolf Sweden AB
Svardvagen 3A
18233 Danderyd / SWEDEN

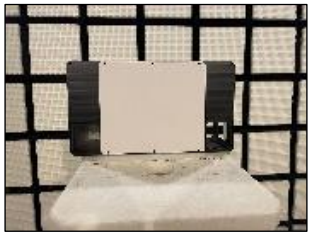
Test standard/s

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 Annex F	Licence-Exempt Radio Apparatus: Category I Equipment
RSS - Gen Issue 5	Spectrum Management and Telecommunications Radio Standards Specification - 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:	**Ball Tracking Radar**
Model name:	**Toptracer**
FCC ID:	**2A3E9-PTRSHV1**
ISED certification number:	**27817-PTRSHV1**
Frequency:	10.50 GHz – 10.55 GHz
Antenna:	Integrated patch antenna
Power supply:	12 V to 28 V DC or 100 to 240 V AC, 50/60 Hz – 1.5A max
Temperature range:	-20°C to +50°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

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Thomas Vogler
Lab Manager
Radio Communications

Test performed:

M. Walla

cn=Meheza Walla, o=CTC advanced GmbH, ou=WAL-200806, email=meheza.walla@ctcadvanced.com, c=DE
2021.11.17 15:49:12 +01'00'

Meheza Walla
Lab Manager
Radio Communications

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2 General information

2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CTC advanced GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.
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In no case this test report can be considered as a Letter of Approval.

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:	2021-09-07
Date of receipt of test item:	2021-09-17
Start of test:*	2021-09-20
End of test:*	2021-09-30
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 Annex F	12-2019	Licence-Exempt Radio Apparatus: Category I Equipment
RSS - Gen Issue 5	04-2018	Spectrum Management and Telecommunications Radio Standards Specification - General Requirements for Compliance of Radio Apparatus

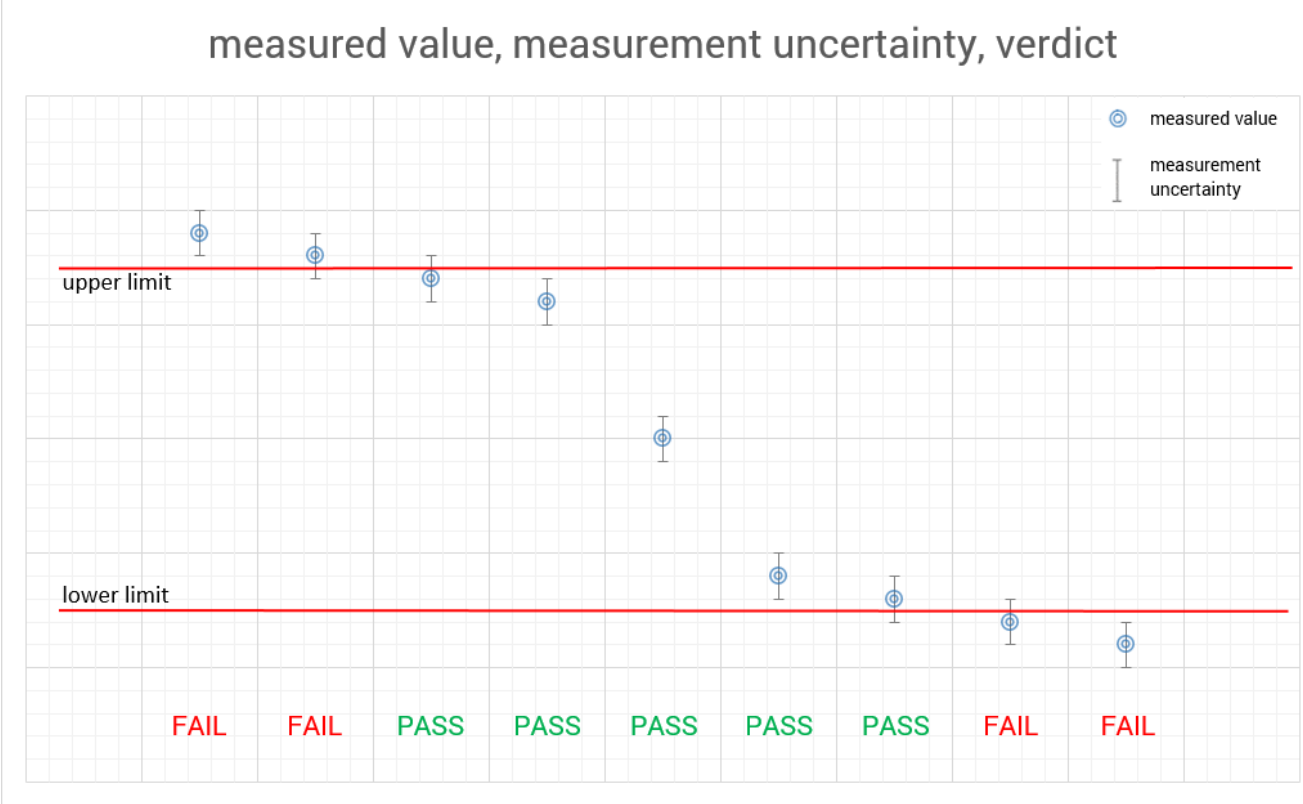
Guidance	Version	Description
ANSI C63.4-2014	-/-	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	-/-	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

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

ISED Testing Laboratory Recognized Listing Number: DE0001
FCC designation number: DE0002

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 9.
The measurement uncertainty is mentioned in this test report, see chapter 7, 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 +50 °C during high temperature tests -20 °C during low temperature tests
Relative humidity content	:		55 %
Barometric pressure	:		1021 hpa
Power supply	:	V_{nom} V_{max} V_{min}	24.0 V DC from power supply or 100-240 V AC, 50/60 Hz, 1.5A max 28.0 V 12.0 V

6 Test item

6.1 General description

Kind of test item	:	Ball Tracking Radar
Model name	:	Toptracer
HMN	:	-/-
PMN	:	PTRS-HV1
HVIN	:	PTRS-VV1
FVIN	:	-/-
S/N serial number	:	-/-
Hardware status	:	Frontend: R2A; Backend: R3A; Antenna: 9xE
Software status	:	-/-
Frequency band	:	10.50 GHz – 10.55 GHz
Type of modulation	:	FMCW
Number of channels	:	1
Antenna	:	Integrated patch antenna
Power supply	:	12 V to 28 V DC or 100 to 240 V AC, 50/60 Hz – 1.5A max
Temperature range	:	-20°C to +50°C

6.2 Additional information

Special test software was used to change from normal operation mode to test mode (low / middle / high) as required by CFR 47 Part 15.31(m).

Low Channel F=10.505 GHz, Middle Channel F = 10.525 GHz and High Channel F=10.545 GHz

The power settings: VVA Code 1023

Test setup and EUT photos are included in test report: 1-2991/21-01-01_AnnexA
1-2991/21-01-01_AnnexB
1-2991/21-01-01_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).

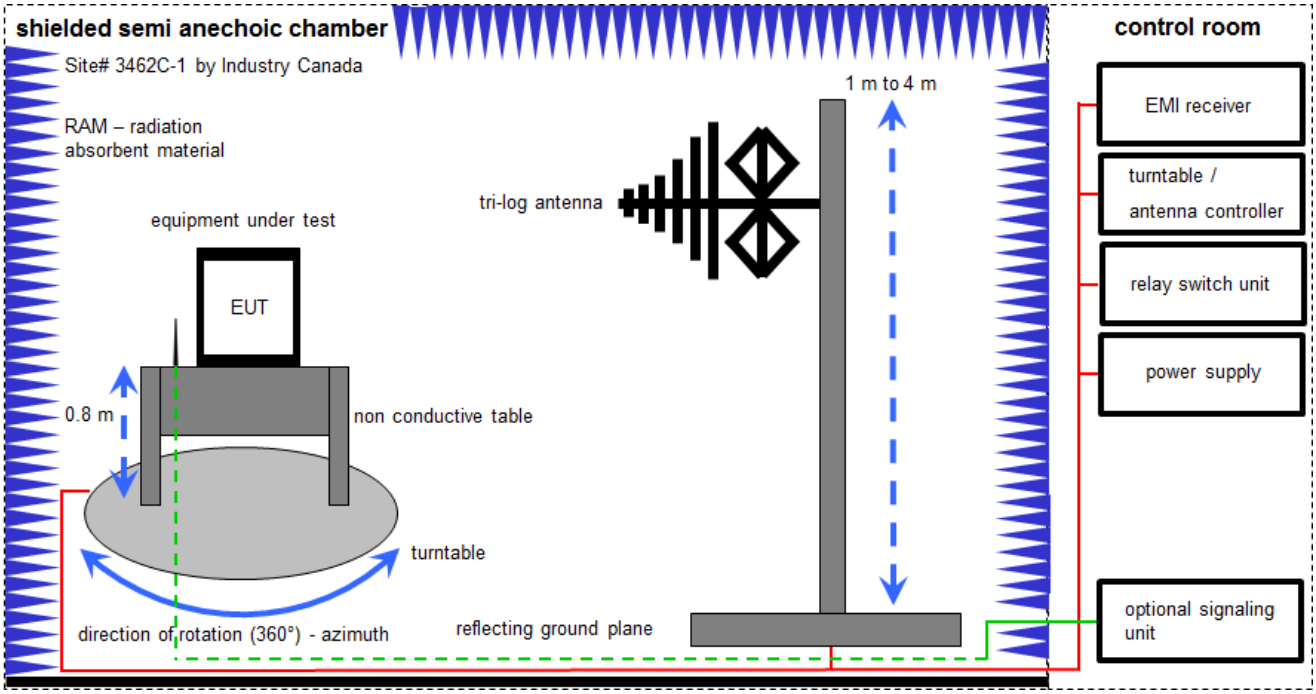
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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 specifications ANSI C63. These antennas can be moved over the height range between 1.0 m and 4.0 m in order to search for maximum field strength emitted from EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by spectrum analyzers where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: tri-log antenna 10 meter

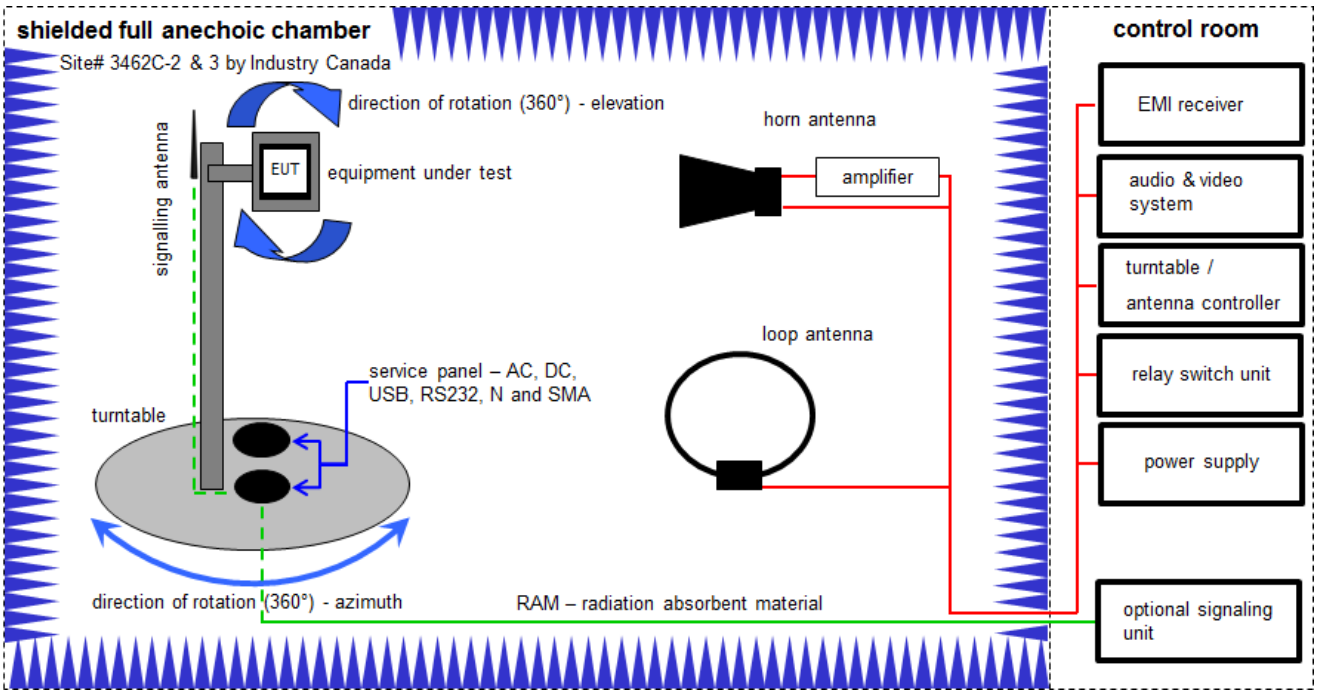
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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	n. a.	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
2	n. a.	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04466	300000580	ne	-/-	-/-
3	n. a.	Semi anechoic chamber	300023	MWB AG	-/-	300000551	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.	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
7	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	295	300003787	vlKl!	21.04.2021	20.04.2023
8	n. a.	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	10.12.2020	09.12.2021
9	n. a.	PC	TecLine	F+W	-/-	300004388	ne	-/-	-/-

7.2 Shielded fully anechoic chamber



Measurement distance: horn antenna 3 meter; loop antenna 3 meter / 1 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)

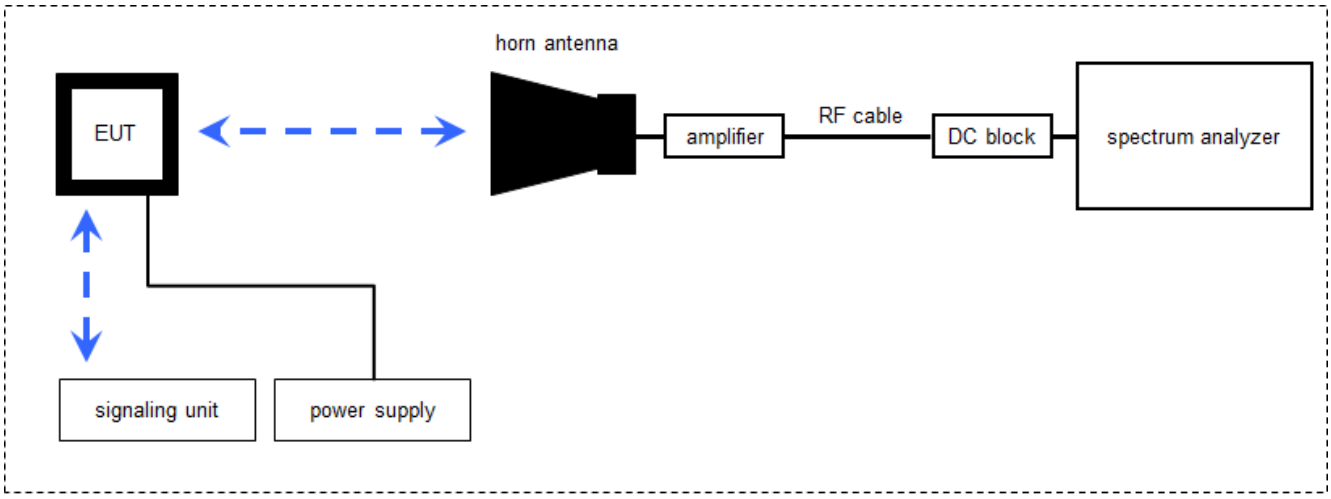
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:
OP [dBm] = -39.0 [dBm] + 57.0 [dB] - 12.0 [dBi] + (-36.0) [dB] = -30 [dBm] (1 µW)

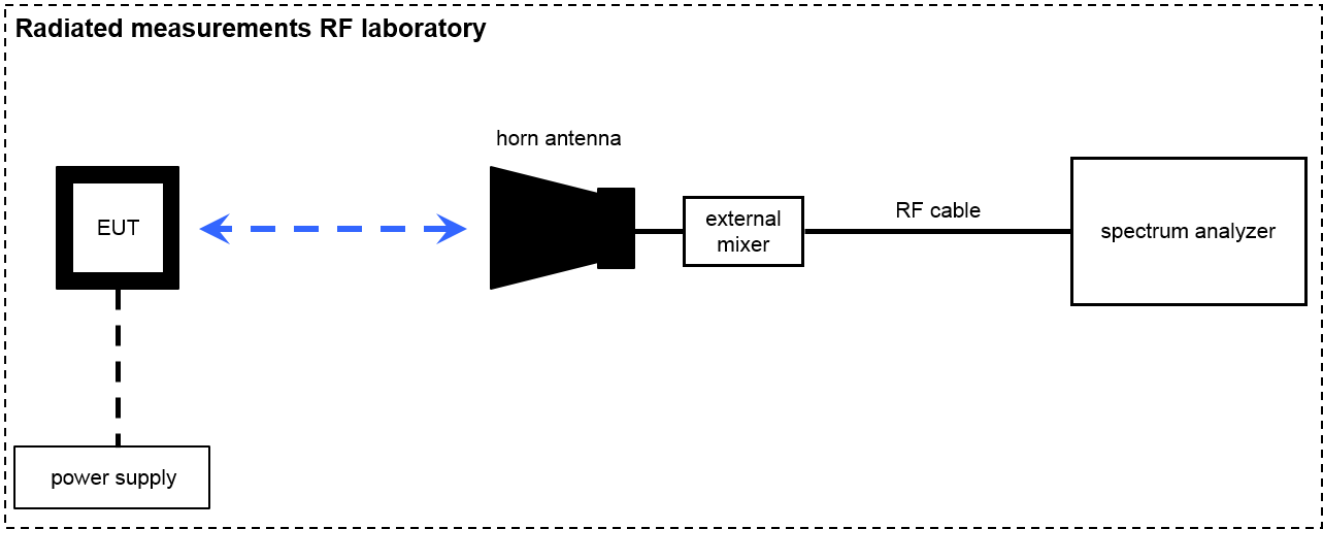
Equipment table:

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.	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vIKI!	12.03.2021	11.03.2023
4	n. a.	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
5	n. a.	Variable isolating transformer	MPL IEC625 Bus Variable isolating transformer	Erfi	91350	300001155	ne	-/-	-/-
6	n. a.	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	11.12.2020	10.12.2021
7	n. a.	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
8	n. a.	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
9	n. a.	Broadband Amplifier 5-13 GHz	CBLU5135235	CERNEX	22010	300004491	ev	-/-	-/-
10	n. a.	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
11	n. a.	NEXIO EMV-Software	BAT EMC V3.16.0.49	EMCO		300004682	ne	-/-	-/-
12	n. a.	PC	ExOne	F+W		300004703	ne	-/-	-/-
13	n. a.	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-
14	n. a.	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	vIKI!	13.06.2019	12.06.2022

7.3 Radiated measurements > 18 GHz



7.4 Radiated measurements > 50/85 GHz



Measurement distance: horn antenna e.g. 25 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)

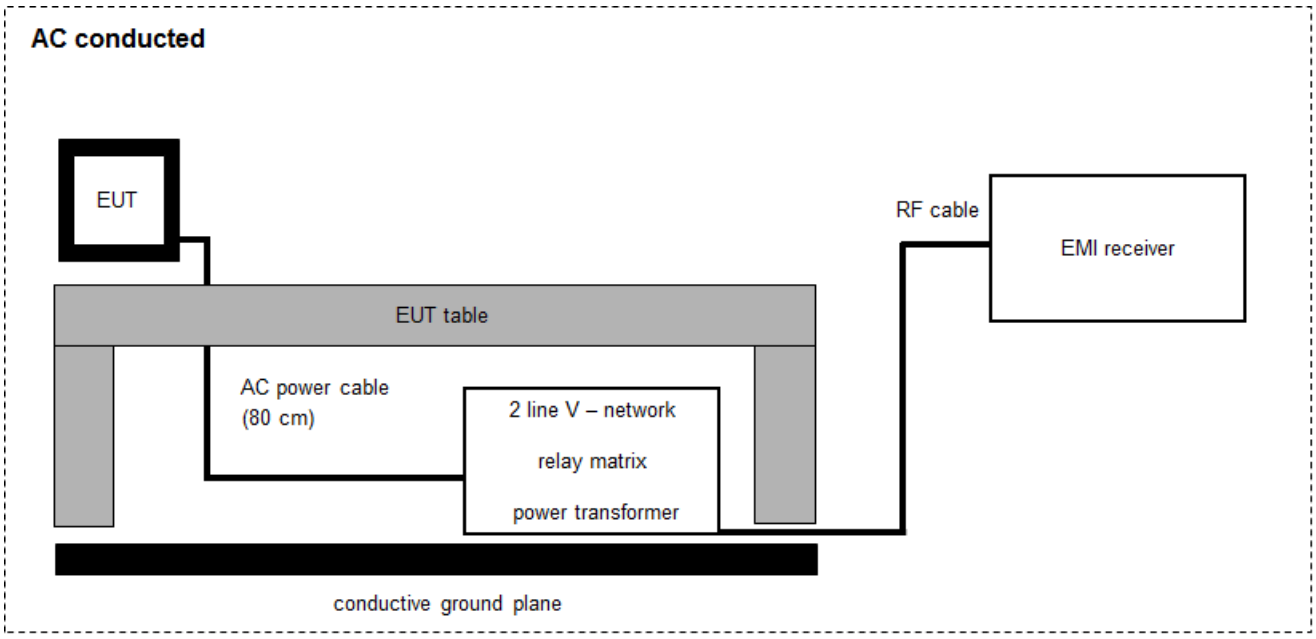
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance;
G-antenna gain+amplifier gain; CA-loss signal path)

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

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	n. a	Spectrum Analyzer	FSW50	Rohde & Schwarz	101560	300006179	k	05.03.2021	04.03.2022
2	n. a	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev	09.03.2020	08.03.2022
3	n. a	Horn Antenna 18,0-40,0 GHz	LHAF180	Microw.Devel	39180-103-021	300001747	vIKI!	18.02.2019	17.02.2022
4	n. a	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda	01096	300000486	vIKI!	21.01.2020	20.01.2022
5	n. a	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	82-16	300000510	vIKI!	23.01.2020	22.01.2022
6	n. a	Std. Gain Horn Antenna 33.0-50.1 GHz	2324-20	Flann	57	400000683	ne	-/-	-/-
7	n. a	Harmonic Mixer 3-Port, 50-75 GHz	FS-Z75	Rohde & Schwarz	101578	300005788	k	15.06.2021	14.06.2022
8	n. a	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001986	ne	-/-	-/-
9	n. a	Harmonic Mixer 3-Port, 75-110 GHz	FS-Z110	R&S	101411	300004959	k	15.06.2021	14.06.2022
10	n. a	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300001988	ne	-/-	-/-

7.5 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	-/-	Two-line V-Network (LISN) 9 kHz to 30 MHz	ESH3-Z5	R&S	892475/017	300002209	vIKI!	11.12.2019	10.12.2021
2	-/-	RF-Filter-section	85420E	HP	3427A00162	300002214	NK!	-/-	-/-
3	-/-	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	09.12.2020	08.12.2021
4	-/-	Hochpass 150 kHz	EZ-25	R&S	100010	300003798	ev	-/-	-/-

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 %

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10 Summary of measurement results

☒	**No deviations from the technical specifications were ascertained**
☐	There were deviations from the technical specifications ascertained
☐	This test report is only a partial test report. The content and verdict of the performed test cases are listed below.

TC Identifier	Description	Verdict	Date	Remark
RF-Testing	47 CFR Part 15 RSS 210, Issue 10, Annex F	see table	2021-11-17	-/-

Test specification clause	Test case	Temperature conditions	Power source voltages	C	NC	NA	NP	Results (max.)
§15.245 (b) RSS-210 F1 RSS-Gen	Field strength of emissions (wanted signal)	Nominal	Nominal	☒	☐	☐	☐	128 dBµV
§2.1049	Occupied bandwidth (99% bandwidth)	Nominal	Nominal	☒	☐	☐	☐	39.3 MHz
§15.209 (a) §15.245 (a) §15.245 (b)(3) RSS-210 F1 (a) RSS-210 F1 (b) RSS-210 F1 (c) RSS-210 F1 (e) RSS-Gen	Field strength of emissions (band edge / spurious / harmonics)	Nominal	Nominal	☒	☐	☐	☐	complies
§15.207 (a) ICES-003	Conducted emissions < 30 MHz	Nominal	Nominal	☒	☐	☐	☐	Complies

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

11 Measurement results

11.1 Field strength of emissions (wanted signal)

Description:

Measurement of the maximum radiated field strength of the wanted signal.

Measurement:

Measurement parameter	
Detector:	Pos-Peak / AVERAGE
Sweep time:	1s
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Span:	60 MHz
Trace-Mode:	Max Hold

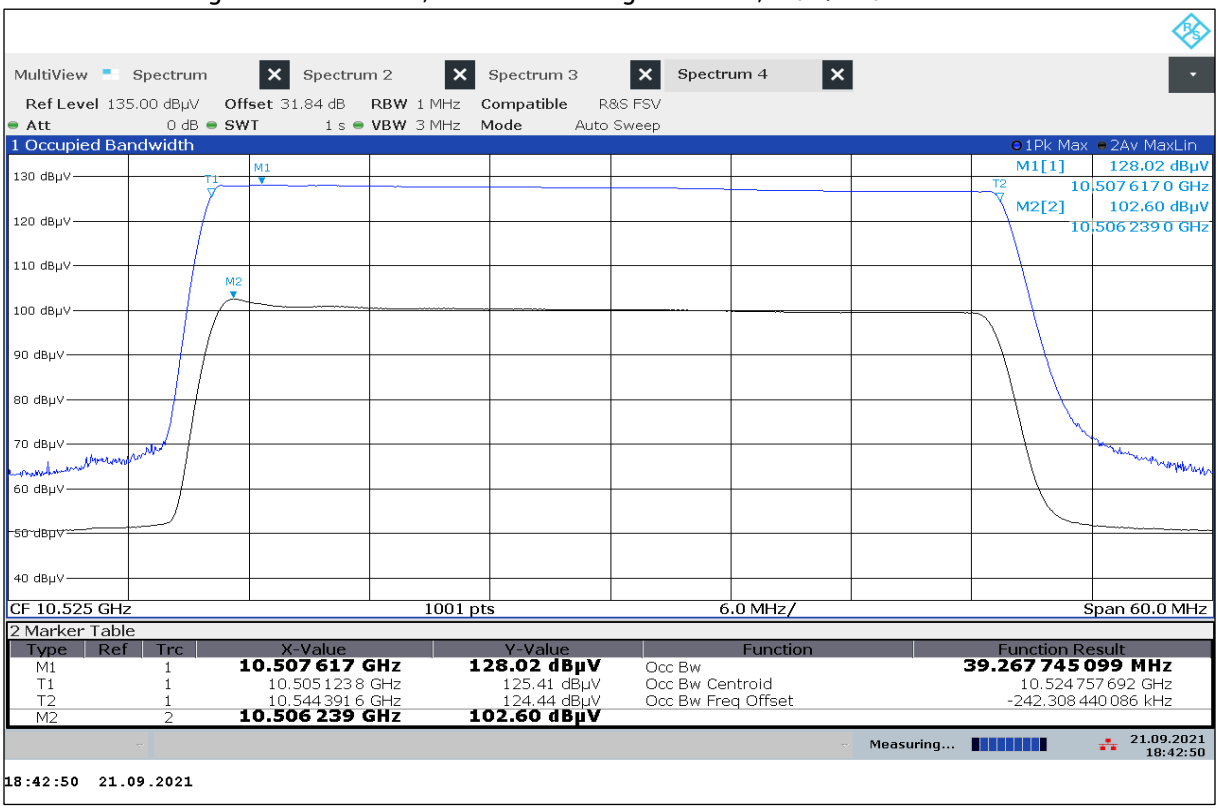
Limits:

FCC		IC
CFR Part 15.245 (b)		RSS - 210, F.1 (a)
Field strength of emissions		
The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:		
Frequency [GHz]	Field Strength [dBµV/m]	Measurement distance [m]
10.500 – 10.550	128 (Average) / 148 (Peak)	3

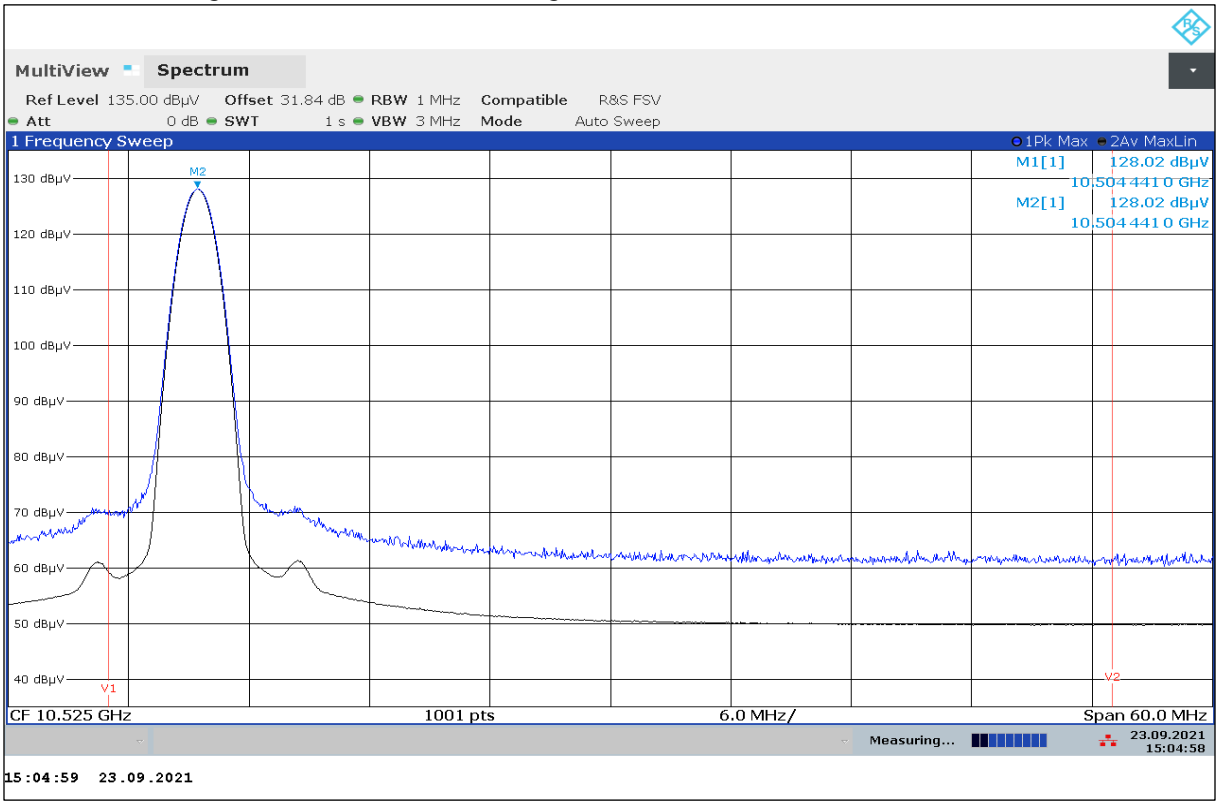
Result:

Test condition T_{nom} / V_{nom}	Maximum field strength [dBµV/m @ 3 m]
Normal Mode	128.0 (Peak) / 102.6 (Average)
Stopped Mode, Low Channel	128.0 (Peak and Average)
Stopped Mode, Middle Channel	127.8 (Peak and Average)
Stopped Mode, High Channel	127.6 (Peak and Average)
Measurement uncertainty	± 3 dB

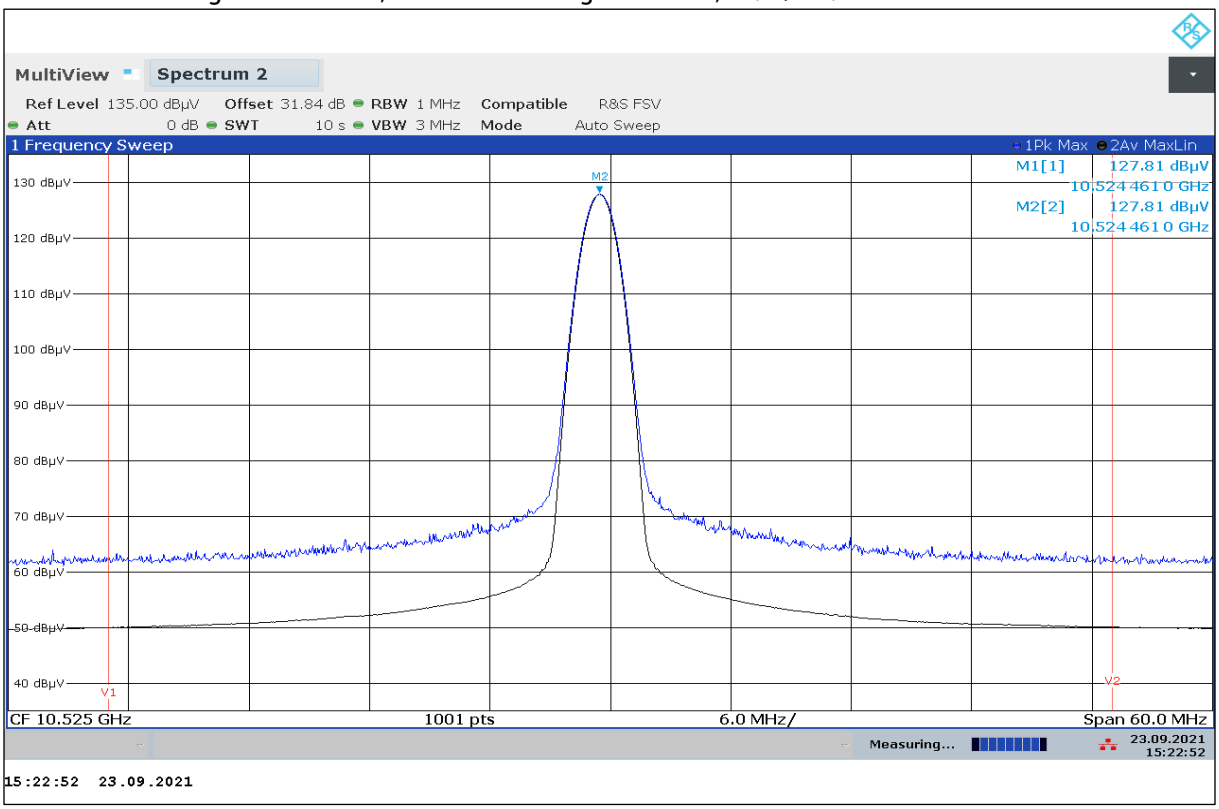
Plot No. 1: Field Strength Normal Mode., Peak and Average detector, T_{nom} / V_{nom}



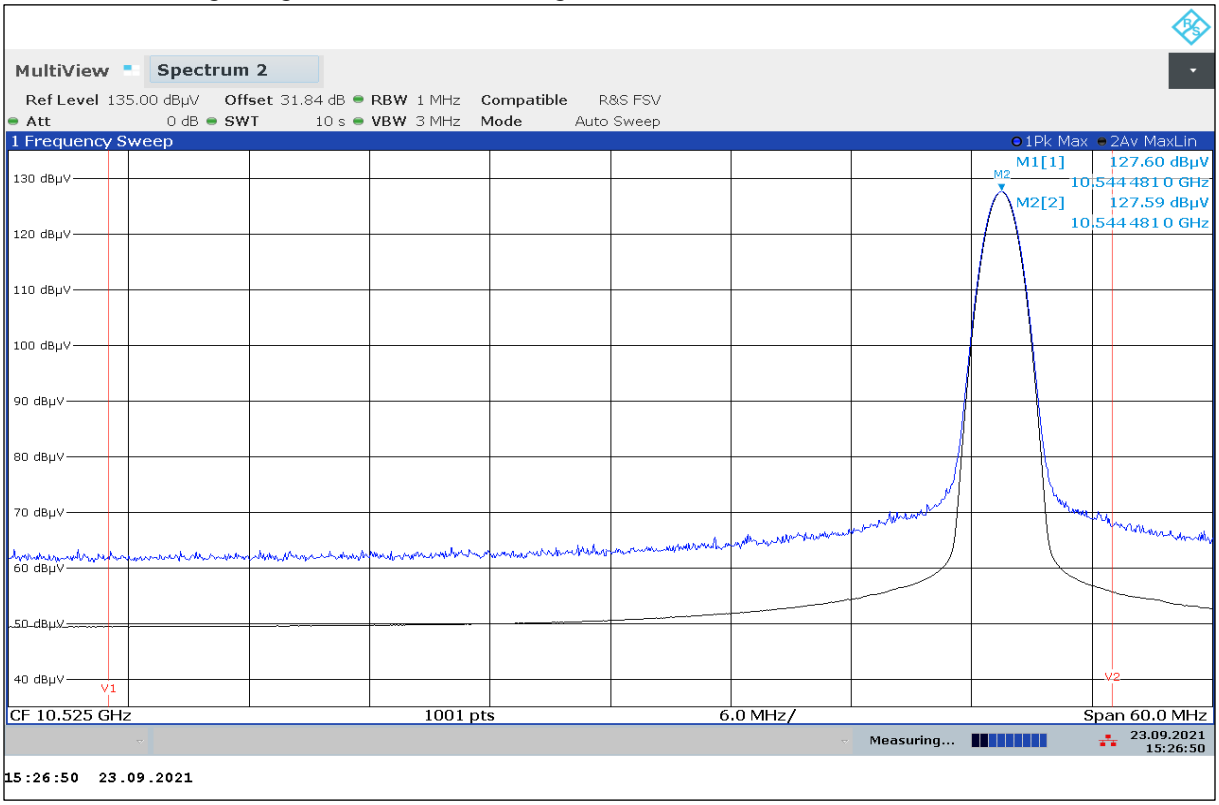
Plot No. 2: Field Strength Low Ch., Peak and Average detector, T_{nom} / V_{nom}



Plot No. 3: Field Strength Middle Ch., Peak and Average detector, T_{nom} / V_{nom}



Plot No. 4: Field Strength High Ch., Peak and Average detector, T_{nom} / V_{nom}



11.2 Occupied bandwidth (99% bandwidth)

Definition:

The occupied bandwidth is defined as the 99% bandwidth.

Measurement:

The EUT is powered on and set up to transmit its normal signal modulation sequence(s).
A spectrum analyzer with the following settings is used:

The test was performed under normal and extreme test conditions.

Measurement parameter	
Detector:	Pos-Peak / AVERAGE
Sweep time:	10s
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Span:	60 MHz
Trace-Mode:	Max Hold

Limits:

FCC	IC
CFR Part 15.245 (b)	RSS - 210, F.1 (a)
Fundamental frequency	
10.500 GHz – 10.550 GHz (50 MHz):	

Results:

Test condition	99% Occupied bandwidth [MHz]
T_{nom} / V_{nom}	39.3
Measurement uncertainty	± span/1000

11.3 Field strength of emissions and band edge (radiated spurious)

Description:

Measurement of the radiated spurious emissions in transmit mode.

Measurement:

Measurement parameter	
Detector:	F < 1 GHz: Quasi-Peak F > 1 GHz: Pos-Peak / AVERAGE
Sweep time:	Auto
Video bandwidth:	Auto
Resolution bandwidth:	F < 1 GHz: 100 kHz F > 1 GHz: 1 MHz
Trace-Mode:	Max-Hold

Limits:

FCC	IC
CFR Part 15.209 (a) / CFR Part 15.245 (b)(1)(ii)	RSS-210 F.1 (a)(b)(c) / RSS - GEN
Field strength of harmonics	
The field strength of harmonics from intentional radiators shall comply with the following:	
Harmonics: **PEAK→ 108 dBµV/m / Average → 88 dBµV/m** (at a distance of 3 m) Harmonic emissions falling into restricted bands listed in RSS-Gen and which are at and above 17.7 GHz shall not exceed the following field strength limits measured at a distance of 3 m: **PEAK→ 97.5 dBµV/m / Average → 77.5 dBµV/m**	
CFR Part 15.209 (a) / CFR Part 15.245 (b)(3)	RSS-210 F.1 (e) / RSS - GEN
Radiated Spurious Emissions	
Emissions radiated outside of the specified frequency bands, except for harmonic emissions shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits specified in §15.209, whichever is less stringent **PEAK→ 98 dBµV/m / Average → 78 dBµV/m** (at a distance of 3 m)	Emissions radiated outside of the specified frequency bands, except for harmonic emissions shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits specified in RSS-Gen, whichever is less stringent **PEAK→ 74.0 dBµV/m / Average → 54.0 dBµV/m** (at a distance of 3 m)

Frequency (MHz)	Field Strength (dBµV/m)	Measurement distance
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 88	30.0	10
88 – 216	33.5	10
216 – 960	36.0	10
Above 960	54.0	3

Results:

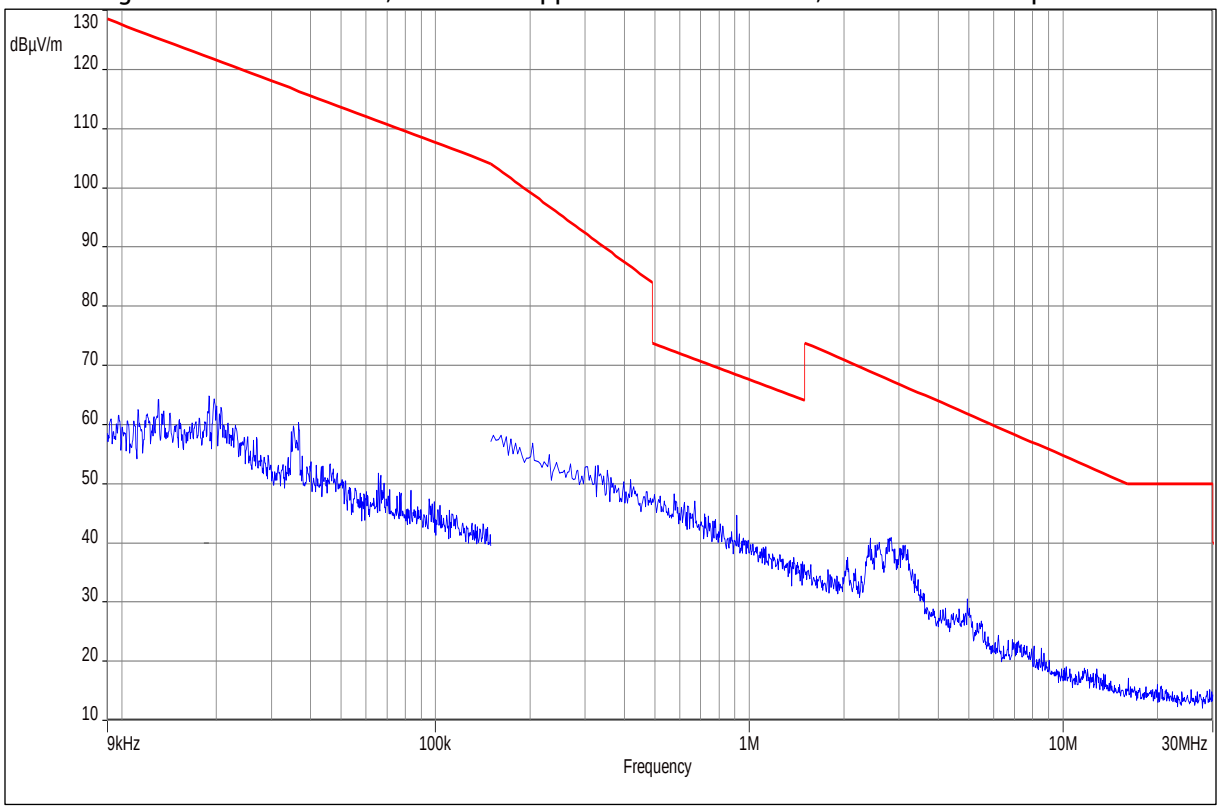
FCC requirement (stopped mode)

TX Spurious Emissions Radiated [dBµV/m]								
Low Channel			Middle Channel			High Channel		
Frequency [GHz]	Detector	Level [dBµV/m]	Frequency [GHz]	Detector	Level [dBµV/m]	Frequency [GHz]	Detector	Level [dBµV/m]
21.0	PK	68.2	21.0	PK	65.9	21.1	PK	64.8
21.0	AVG	67.9	21.0	AVG	65.5	21.1	AVG	64.4
31.5	PK	76.3	31.6	PK	76.0	31.6	PK	71.8
31.5	AVG	76.2	31.6	AVG	75.8	31.6	AVG	71.5
42.0	PK	73.5	42.1	PK	74.1	42.2	PK	72.7
42.0	AVG	73.4	42.1	AVG	73.9	42.2	AVG	72.6
52.5	PK	66.4	52.6	PK	67.2	52.7	PK	66.6
52.5	AVG	63.8	52.6	AVG	65.0	52.7	AVG	64.5
63.0	PK	64.2	63.1	PK	62.8	63.3	PK	63.8
63.0	AVG	60.2	63.1	AVG	57.4	63.3	AVG	58.7
Measurement uncertainty			± 3 dB					

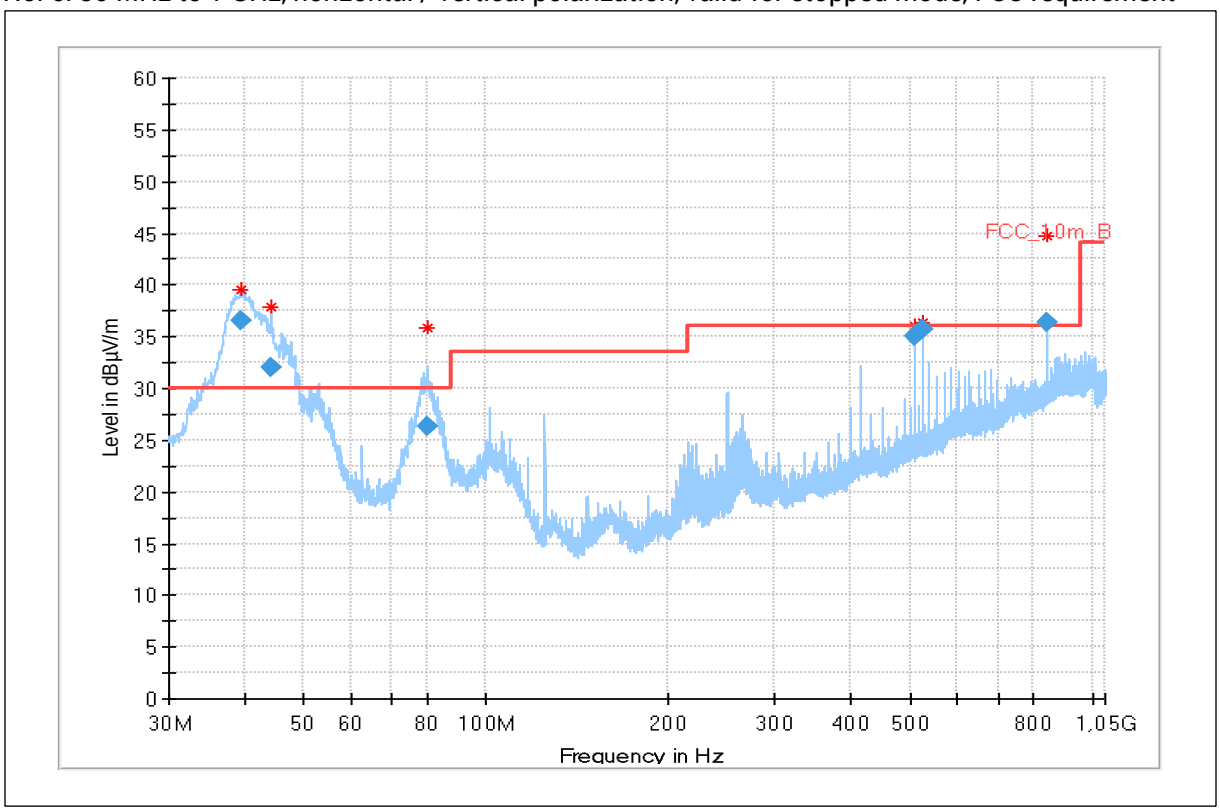
ISED requirement (normal mode)

TX Spurious Emissions Radiated [dBµV/m]								
Normal mode			-/-			-/-		
Frequency [GHz]	Detector	Level [dBµV/m]	Frequency [GHz]	Detector	Level [dBµV/m]	Frequency [GHz]	Detector	Level [dBµV/m]
0.430	QPK	33.4						
0.507	QPK	35.9						
0.523	QPK	34.3						
21.0	PK	65.7						
21.0	AVG	37.5						
31.5	PK	73.1						
31.5	AVG	44.5						
42.0	PK	73.7						
42.0	AVG	44.5						
52.5	PK	62.6						
52.5	AVG	42.5						
Measurement uncertainty			± 3 dB					

Plot No. 5: Magnetic: 9 kHz - 30 MHz, valid for stopped and normal mode, FCC and ISED requirements are met

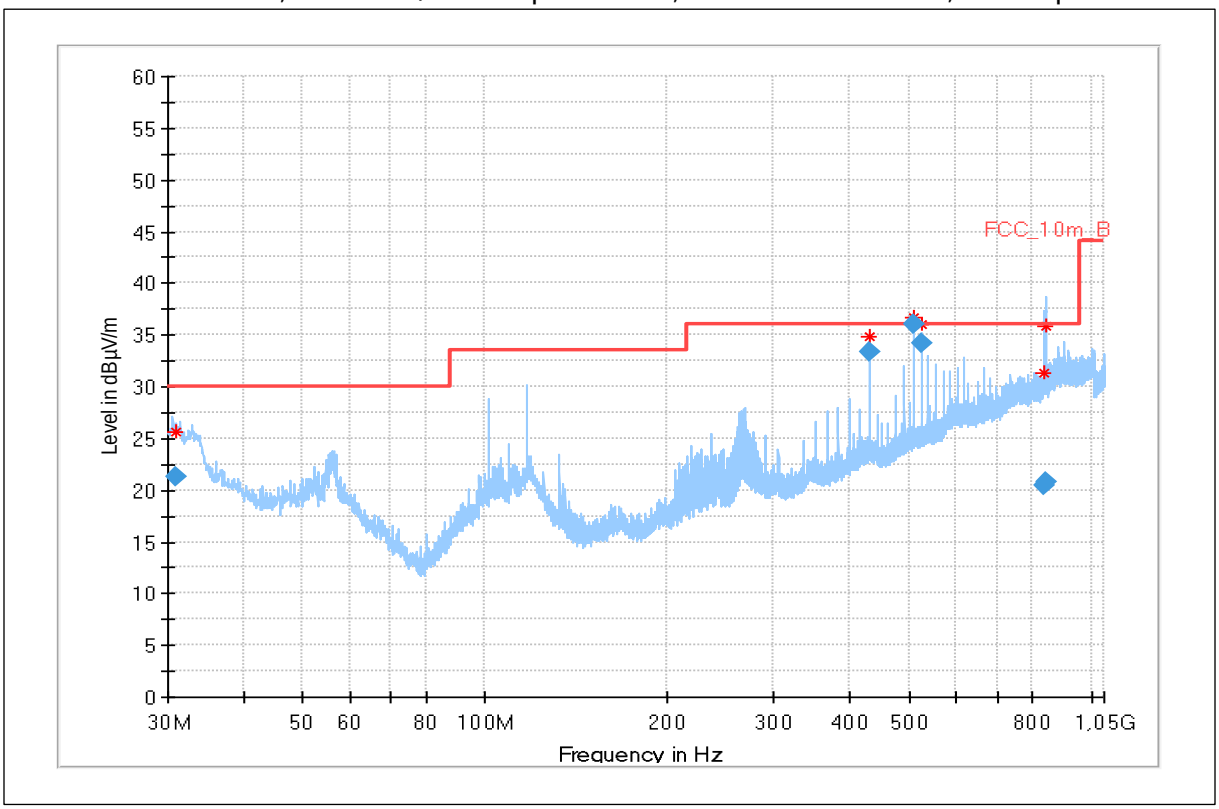


Plot No. 6: 30 MHz to 1 GHz, horizontal / vertical polarization, valid for stopped mode, FCC requirement

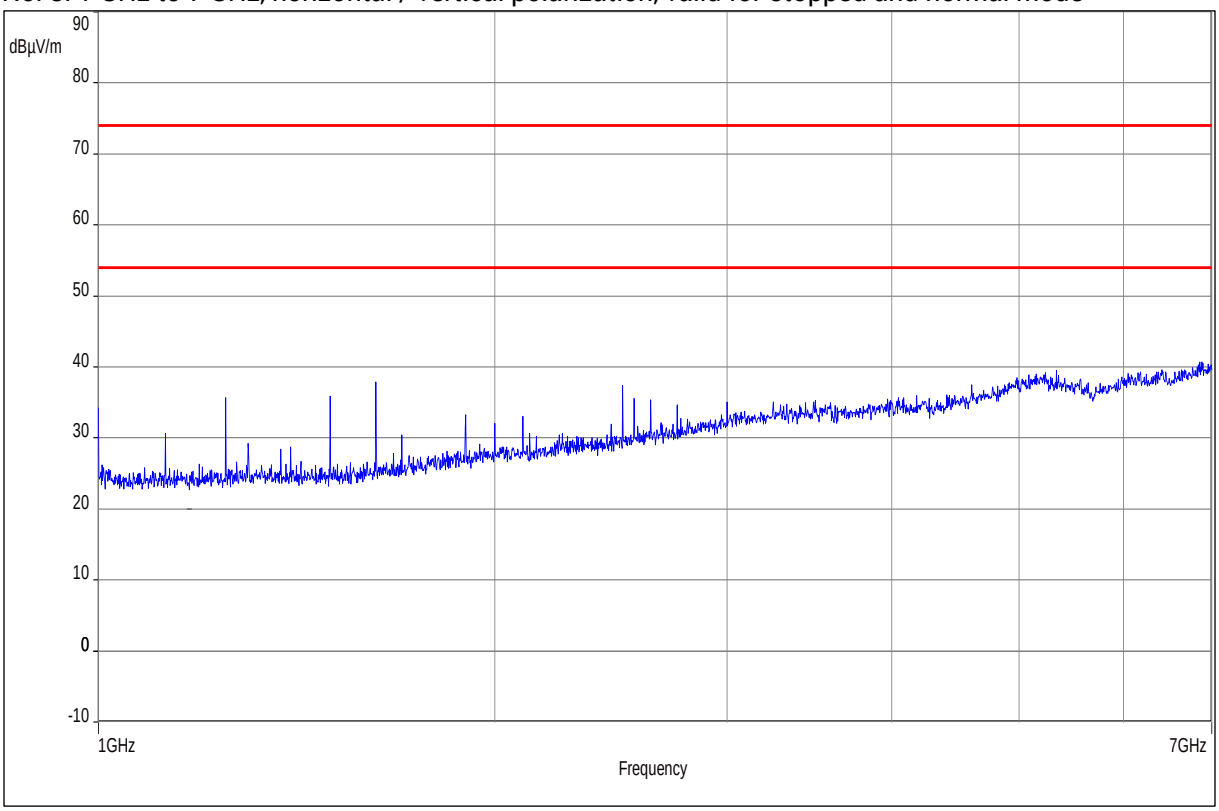


Peak Limit: 87.5 dBuV/m @ 10m and Average Limit: 67.5 dBuV/m @ 10m. Therefore, FCC limits are met

Plot No. 7: 30 MHz to 1 GHz, horizontal / vertical polarization, valid for normal mode, ISED requirement

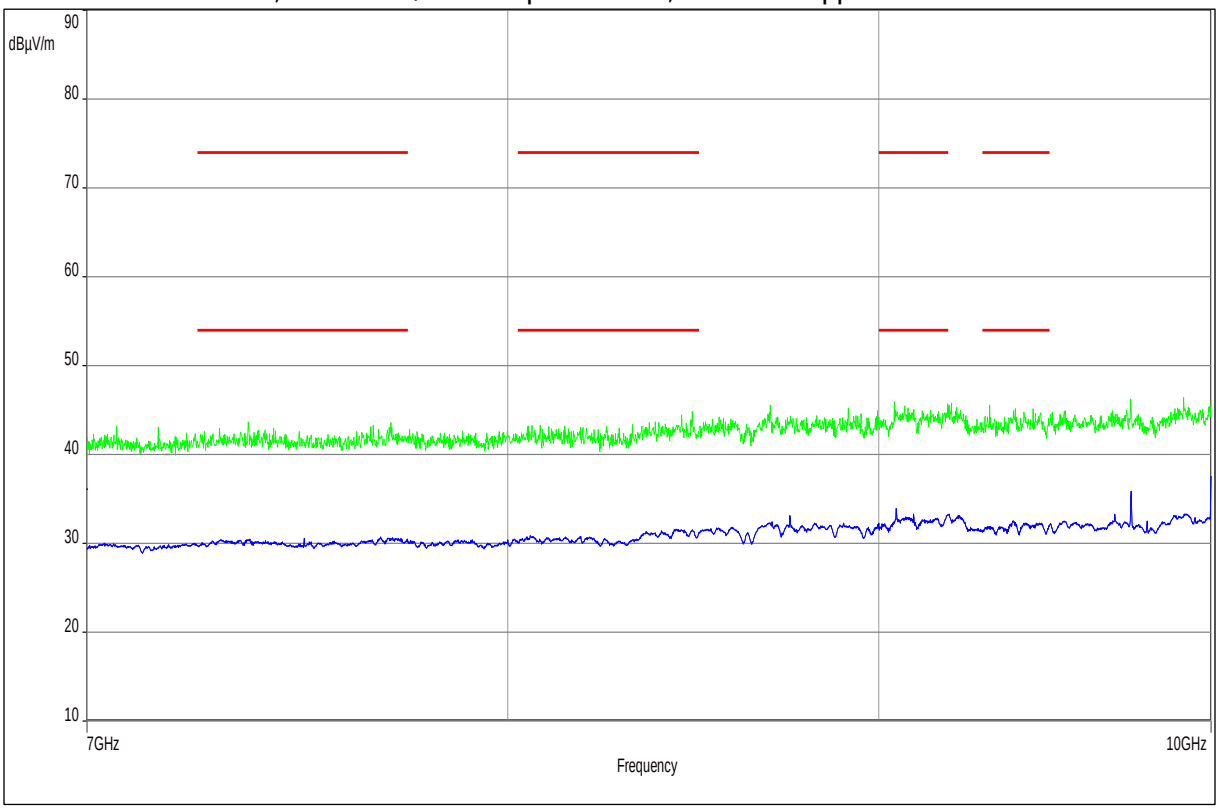


Plot No. 8: 1 GHz to 7 GHz, horizontal / vertical polarization, valid for stopped and normal mode



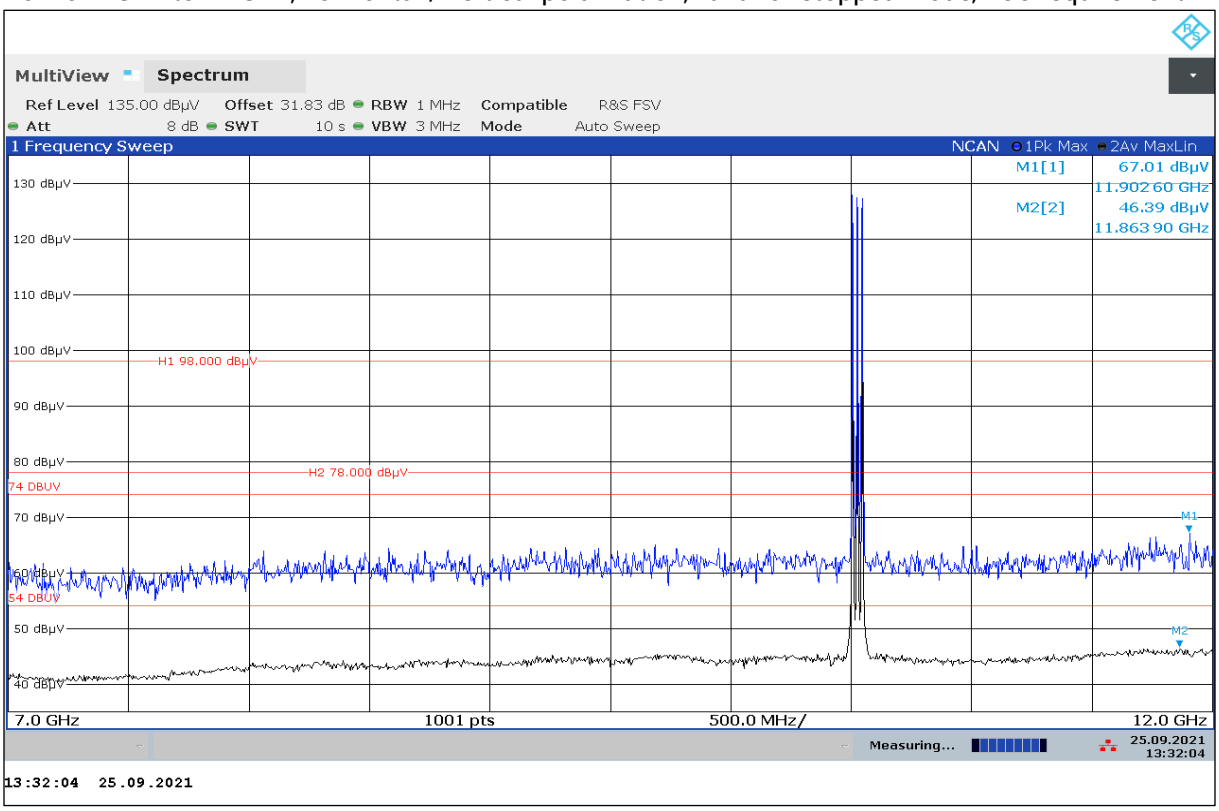
FCC part 15 class B is more stringent than FCC part 15.245. Therefore, both FCC and ISED requirements are met

Plot No. 9: 7 GHz to 10 GHz, horizontal / vertical polarization, valid for stopped and normal mode

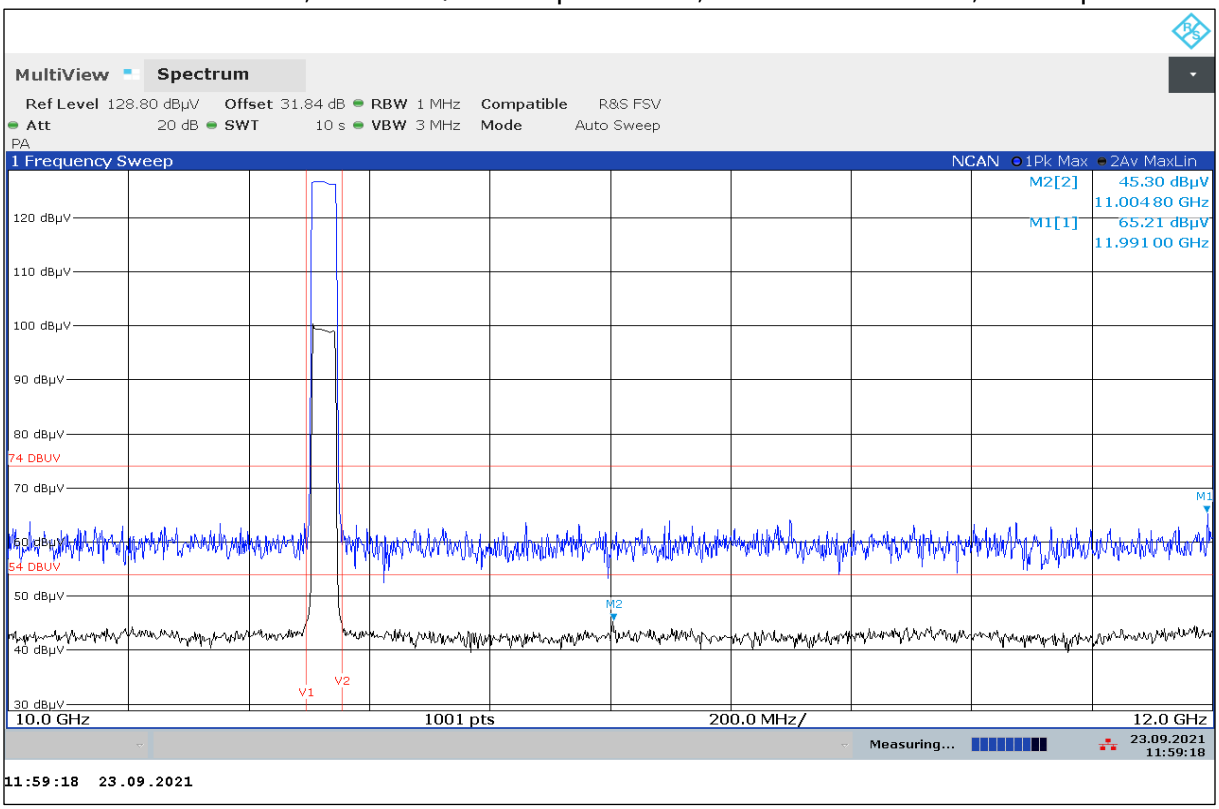


FCC part 15 class B is more stringent than FCC part 15.245. Therefore, both FCC and ISED requirements are met

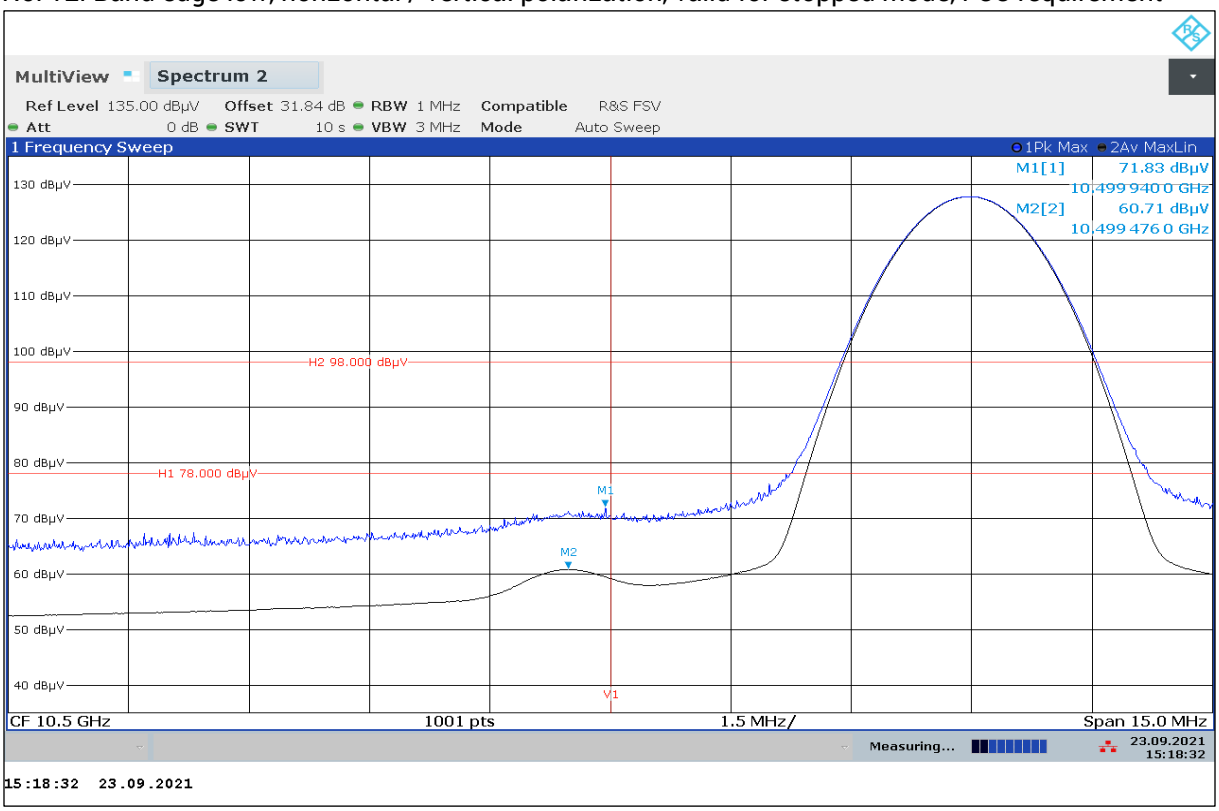
Plot No. 10: 7 GHz to 12 GHz, horizontal / vertical polarization, valid for stopped mode, FCC requirement



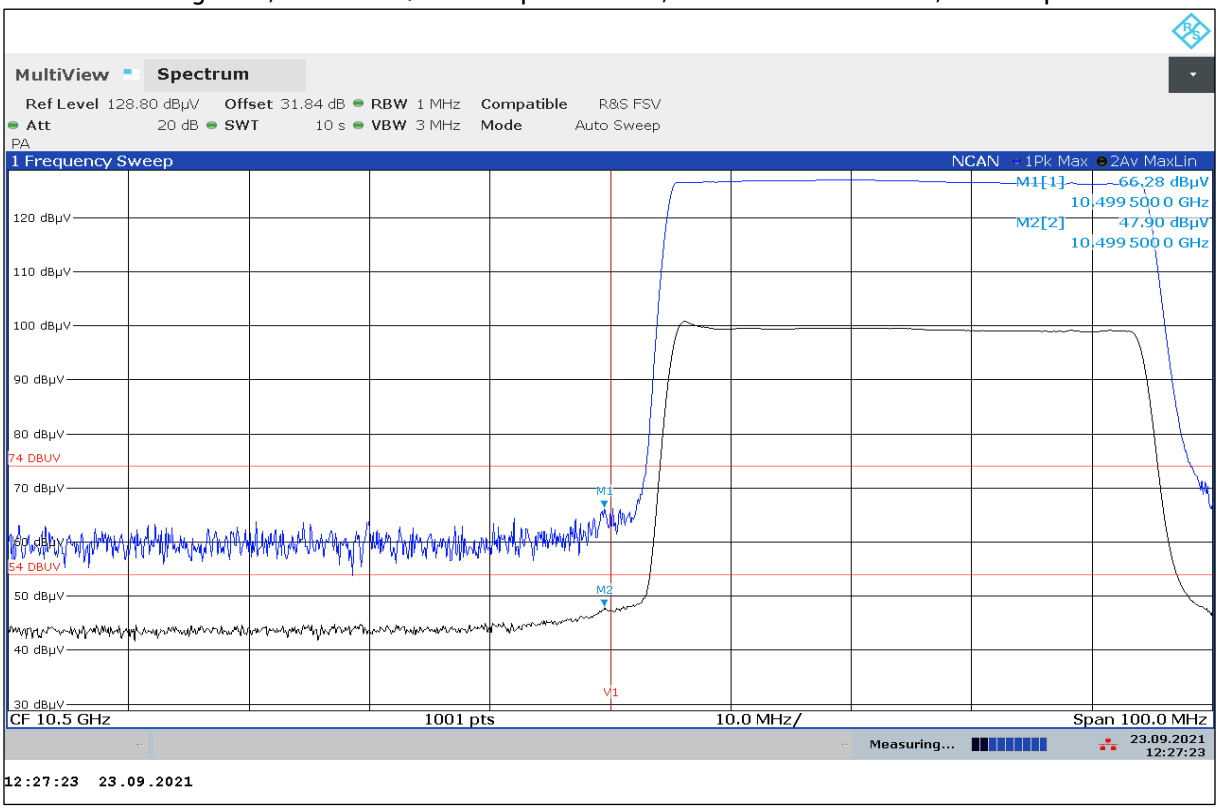
Plot No. 11: 10 GHz to 12 GHz, horizontal / vertical polarization, valid for normal mode, ISED requirement



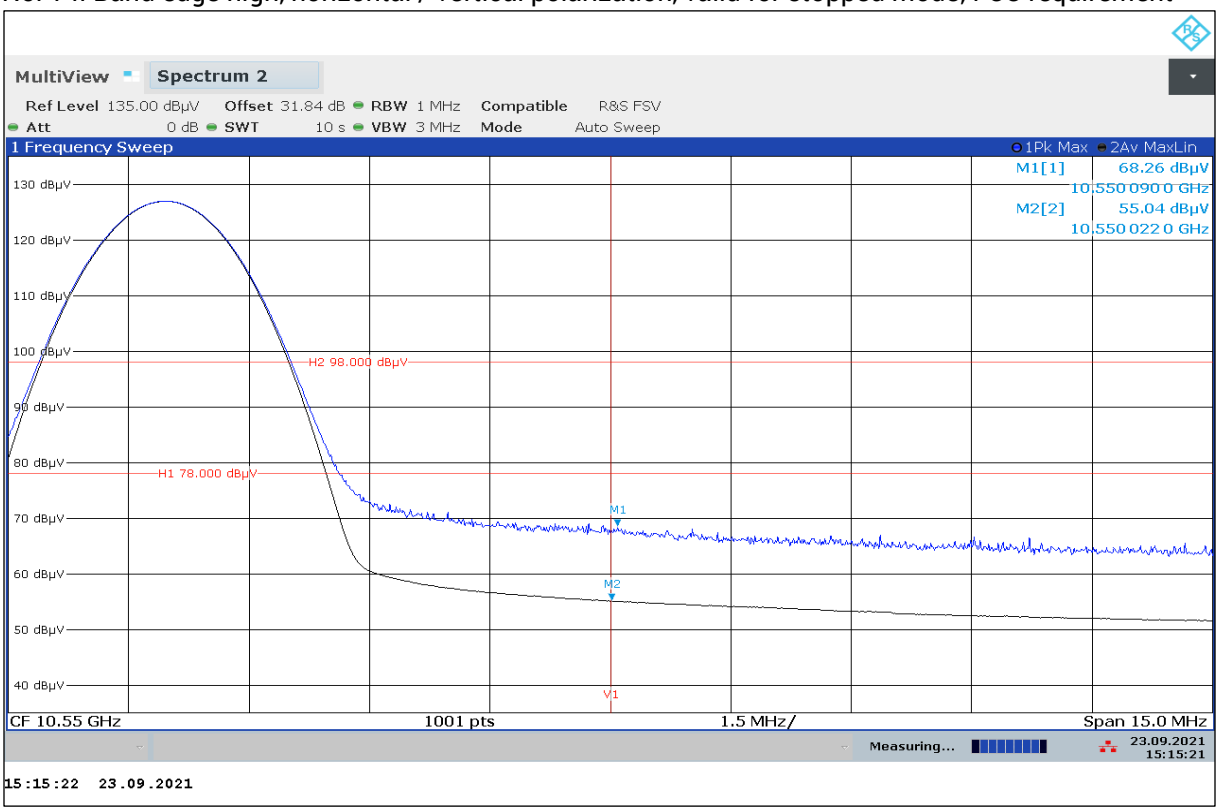
Plot No. 12: Band edge low, horizontal / vertical polarization, valid for stopped mode, FCC requirement



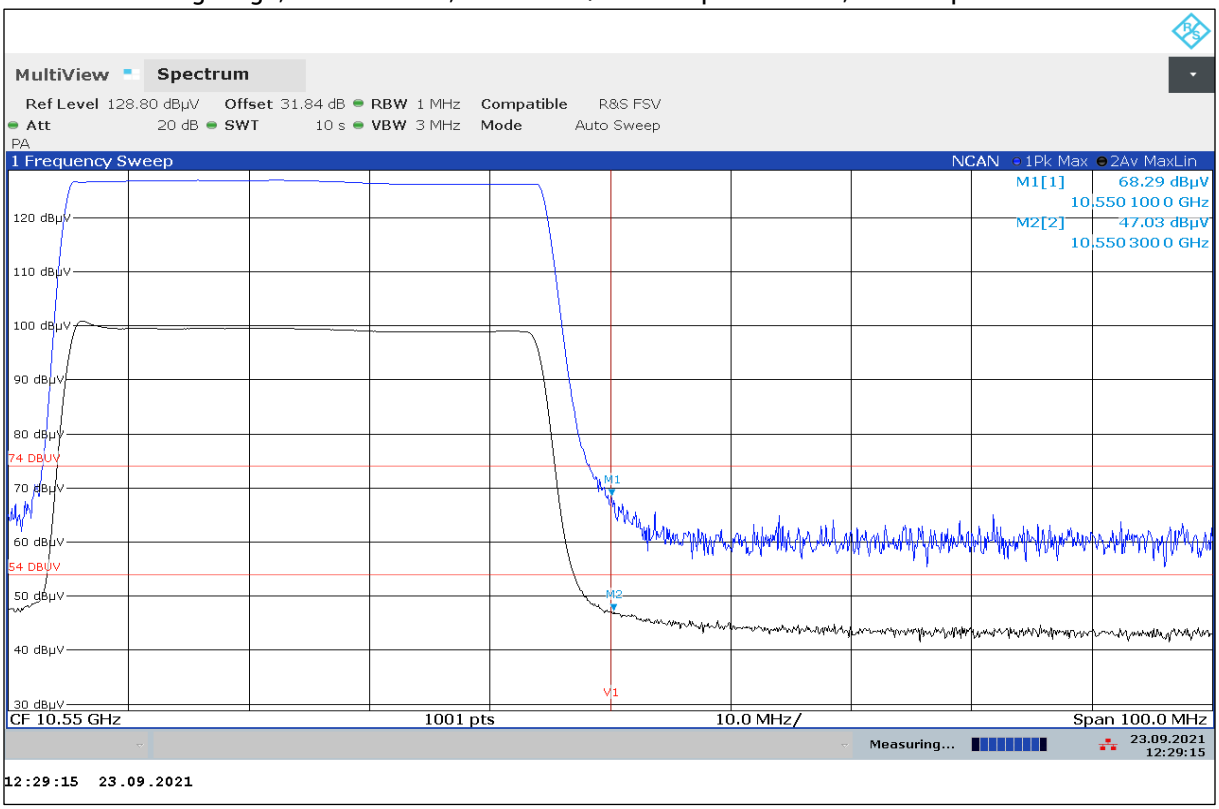
Plot No. 13: Band edge low, horizontal / vertical polarization, valid for normal mode, ISED requirement



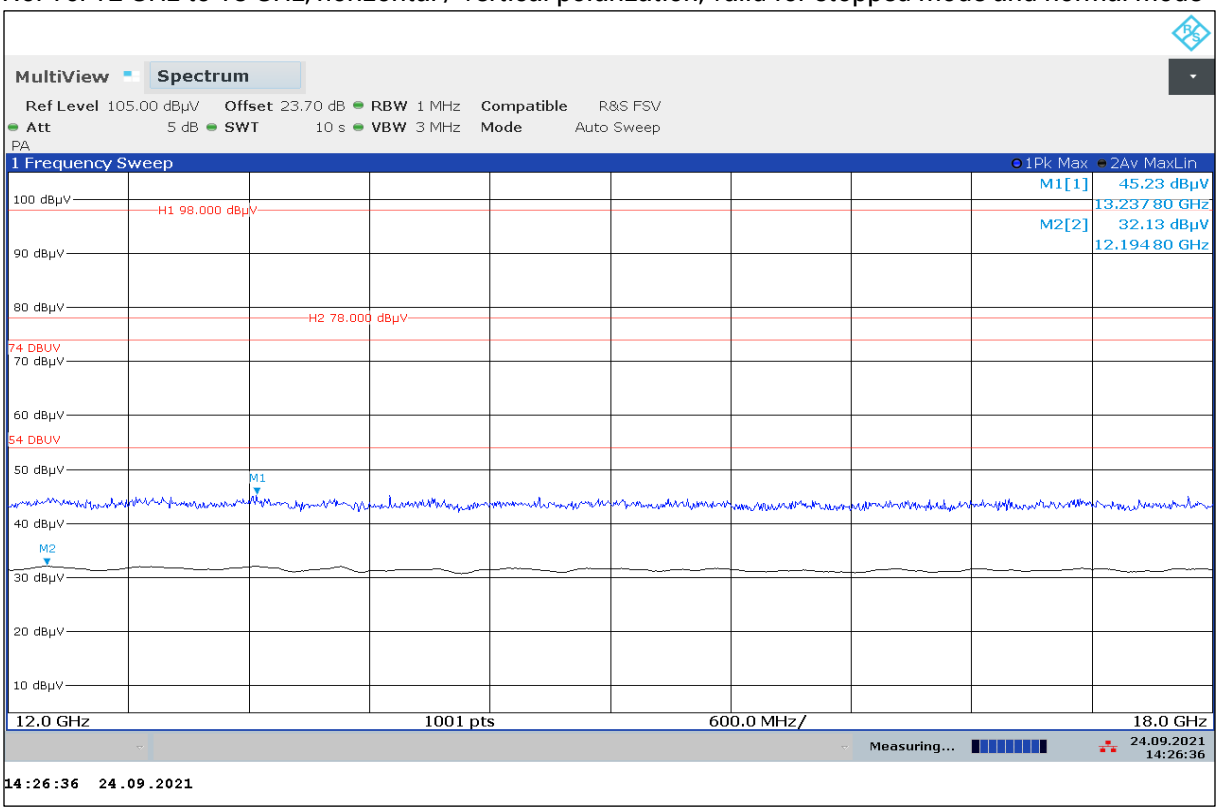
Plot No. 14: Band edge high, horizontal / vertical polarization, valid for stopped mode, FCC requirement



Plot No. 15: Band edge high, normal mode, horizontal / vertical polarization, ISED requirement

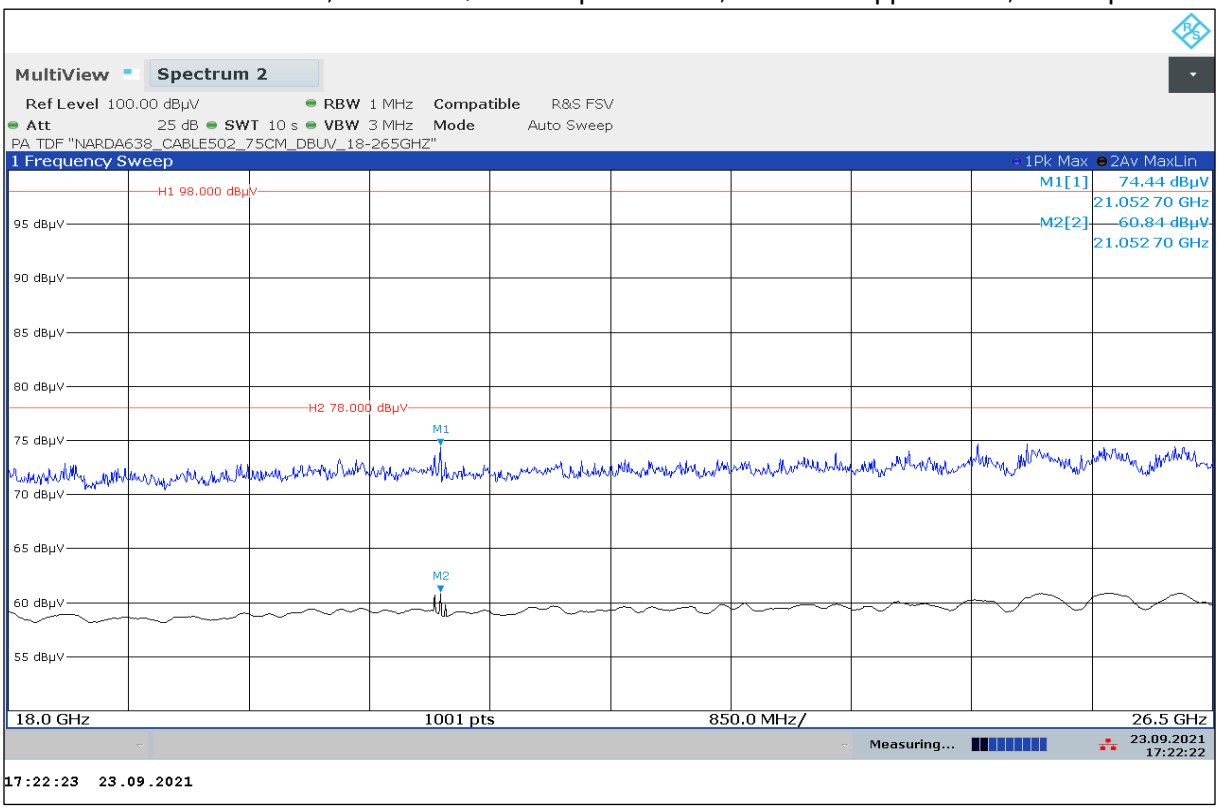


Plot No. 16: 12 GHz to 18 GHz, horizontal / vertical polarization, valid for stopped mode and normal mode

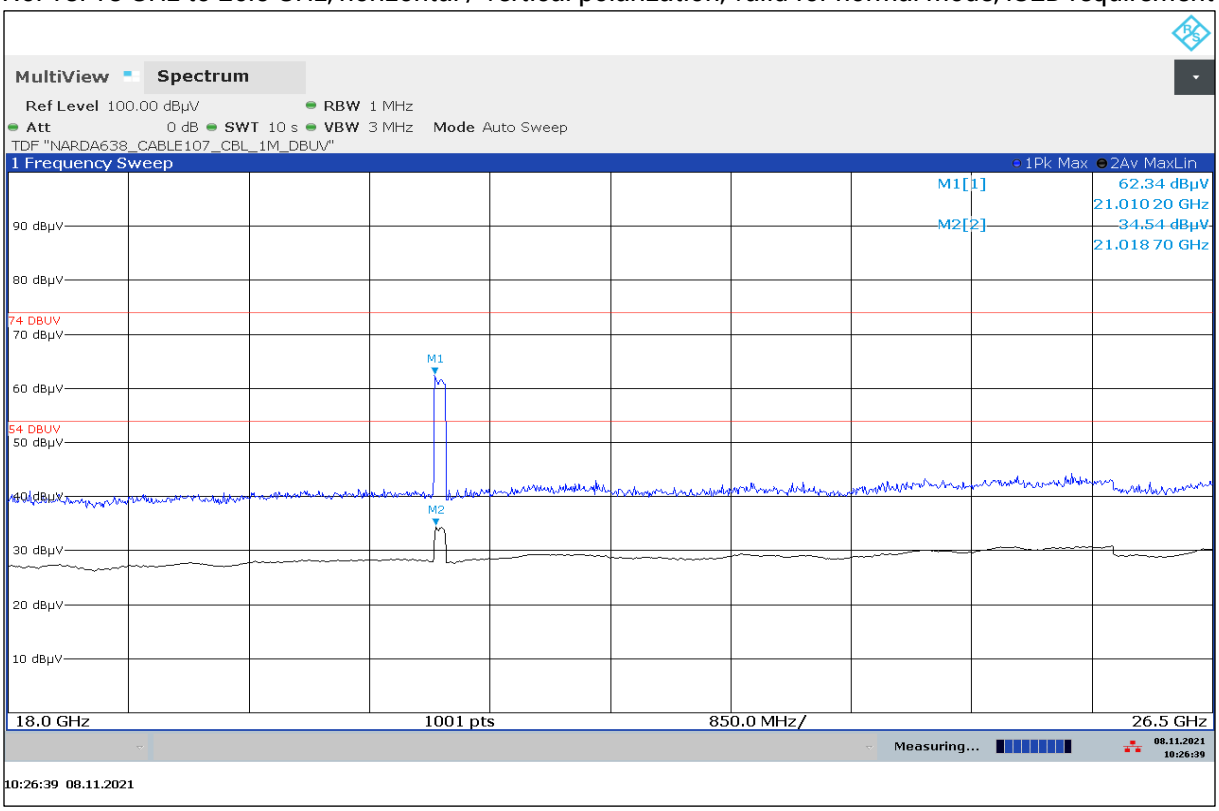


Both FCC and ISED requirements are met

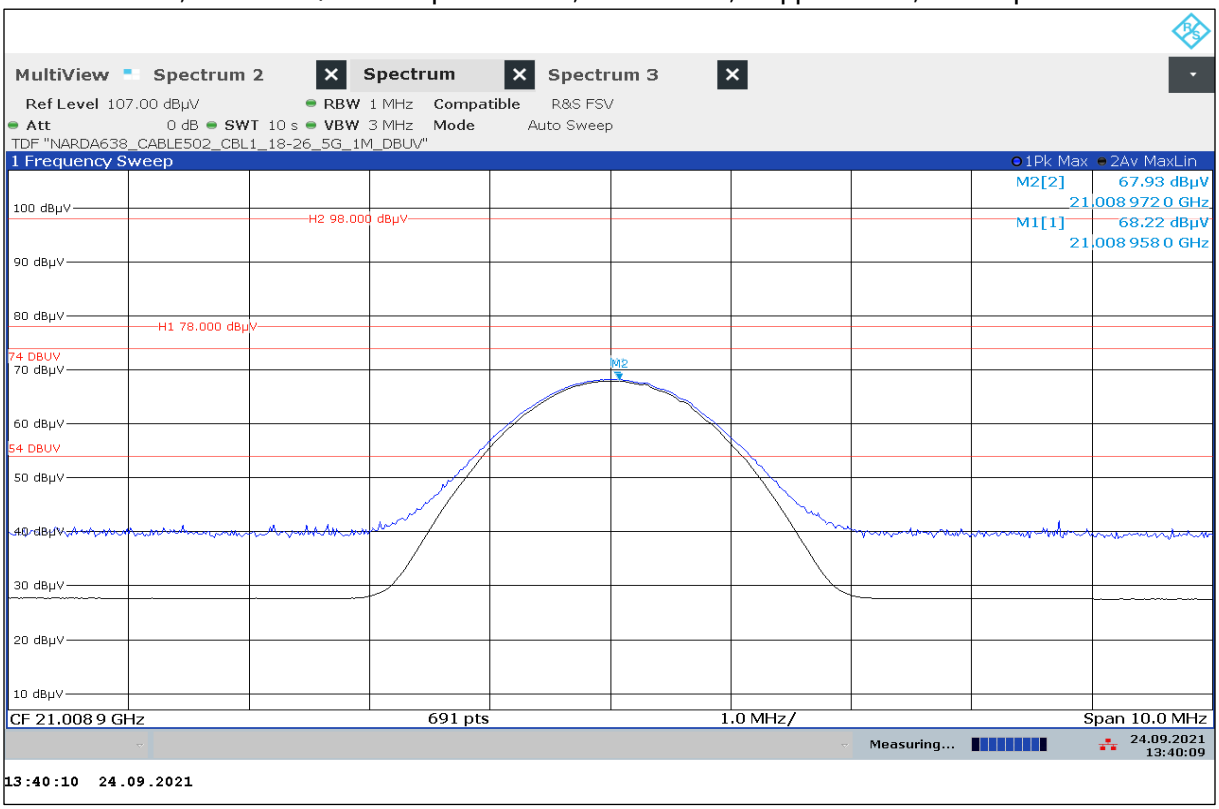
Plot No. 17: 18 GHz to 26.5 GHz, horizontal / vertical polarization, valid for stopped mode, FCC requirement



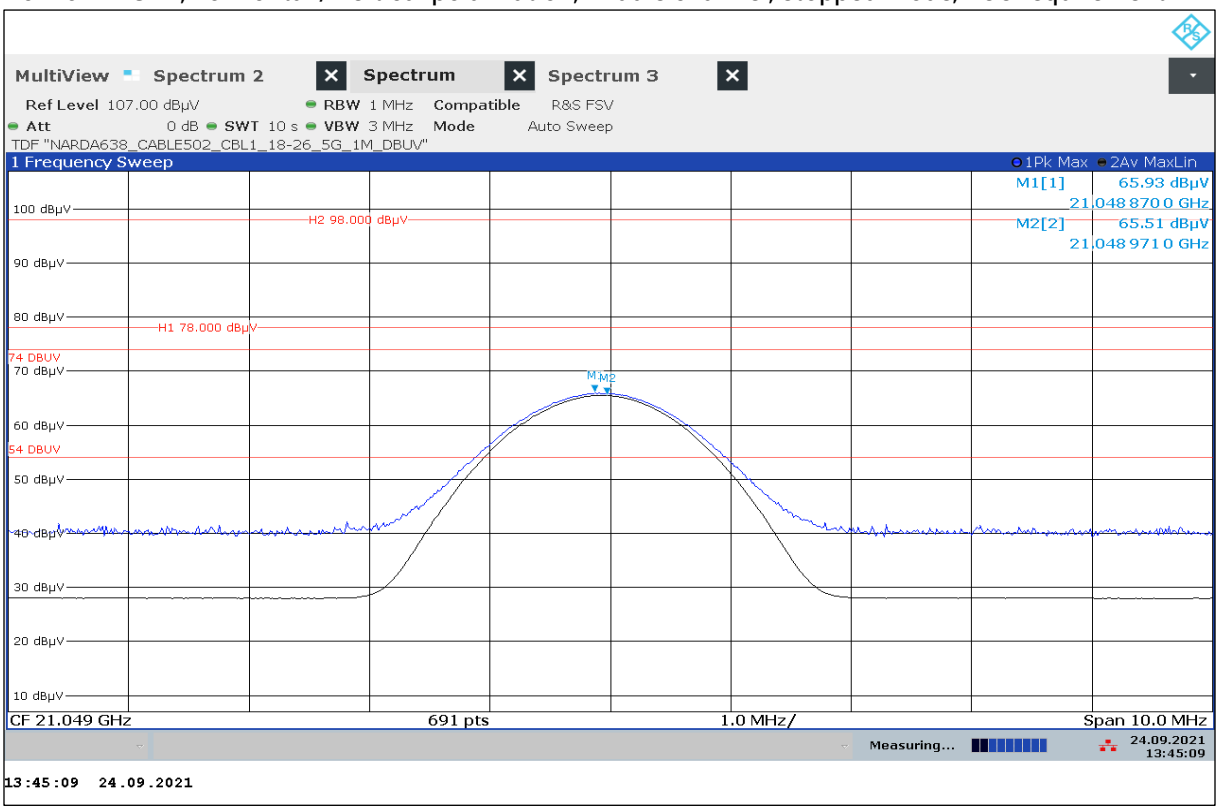
Plot No. 18: 18 GHz to 26.5 GHz, horizontal / vertical polarization, valid for normal mode, ISED requirement



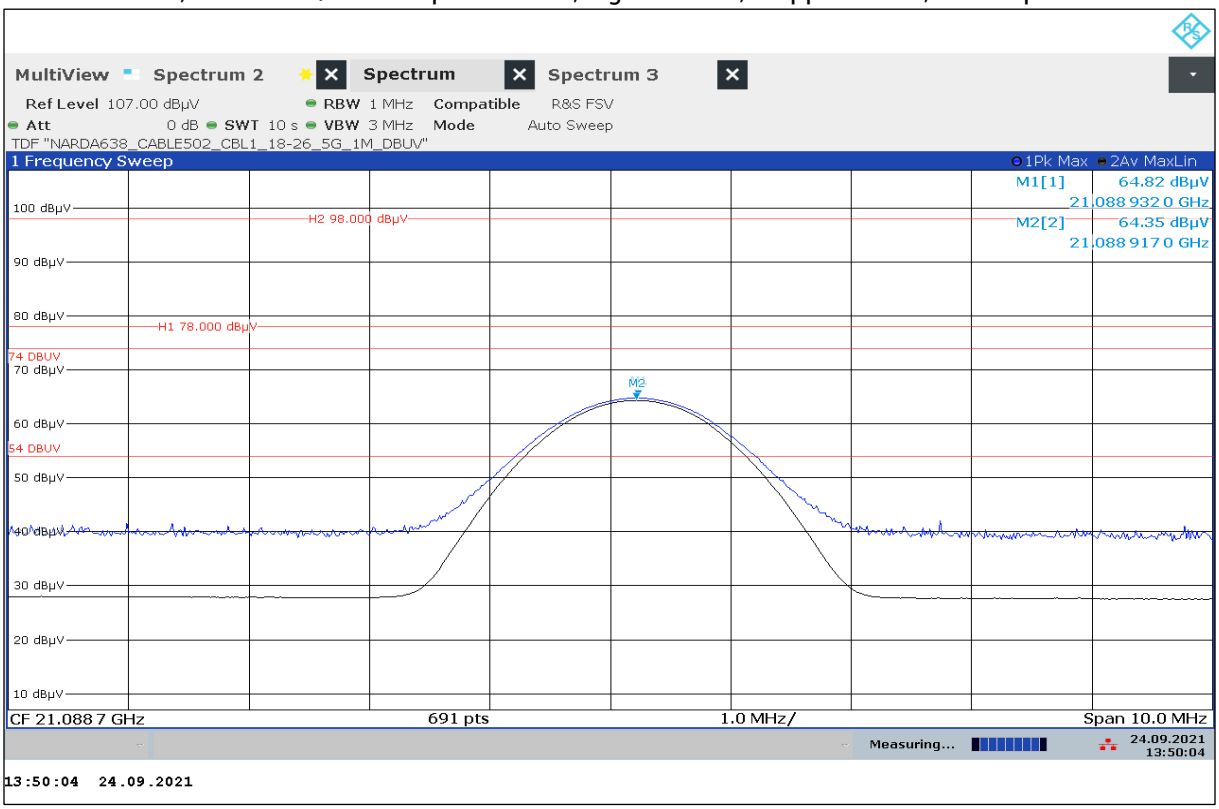
Plot No. 19: 21 GHz, horizontal / vertical polarization, low channel, stopped mode, FCC requirement



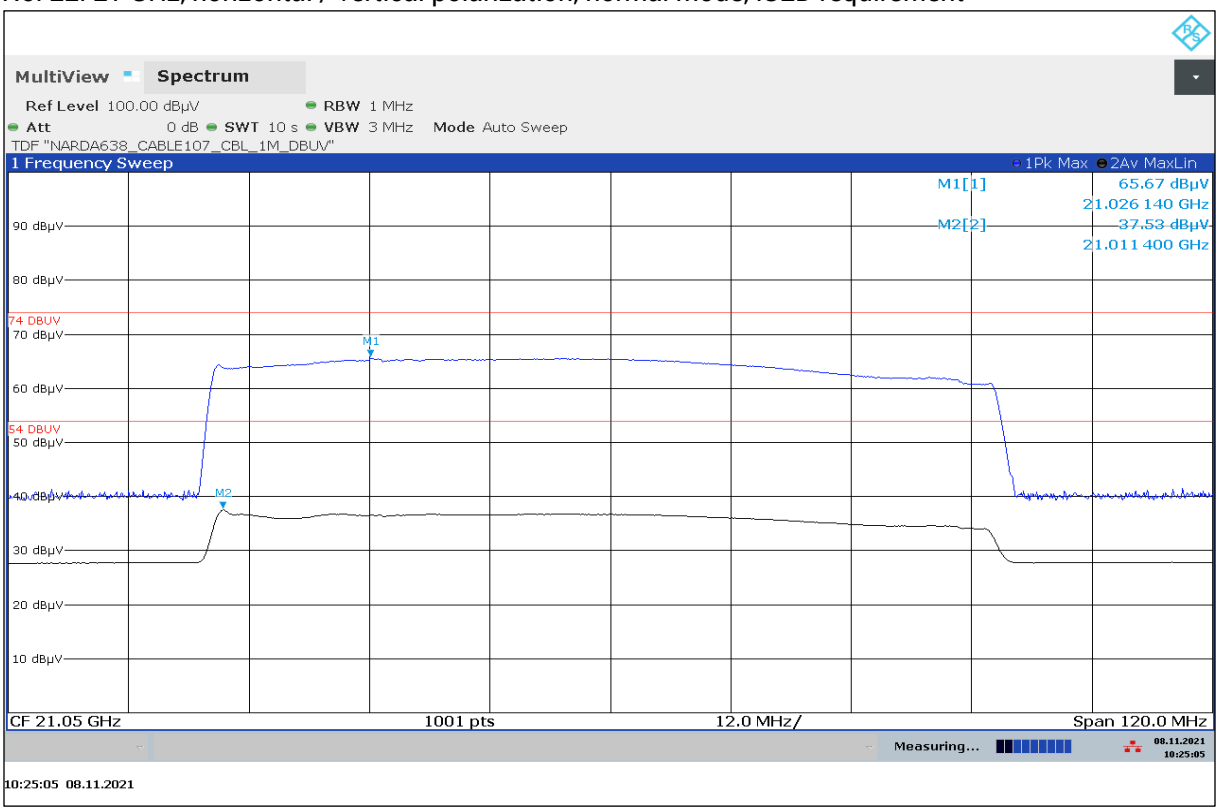
Plot No. 20: 21 GHz, horizontal / vertical polarization, middle channel, stopped mode, FCC requirement



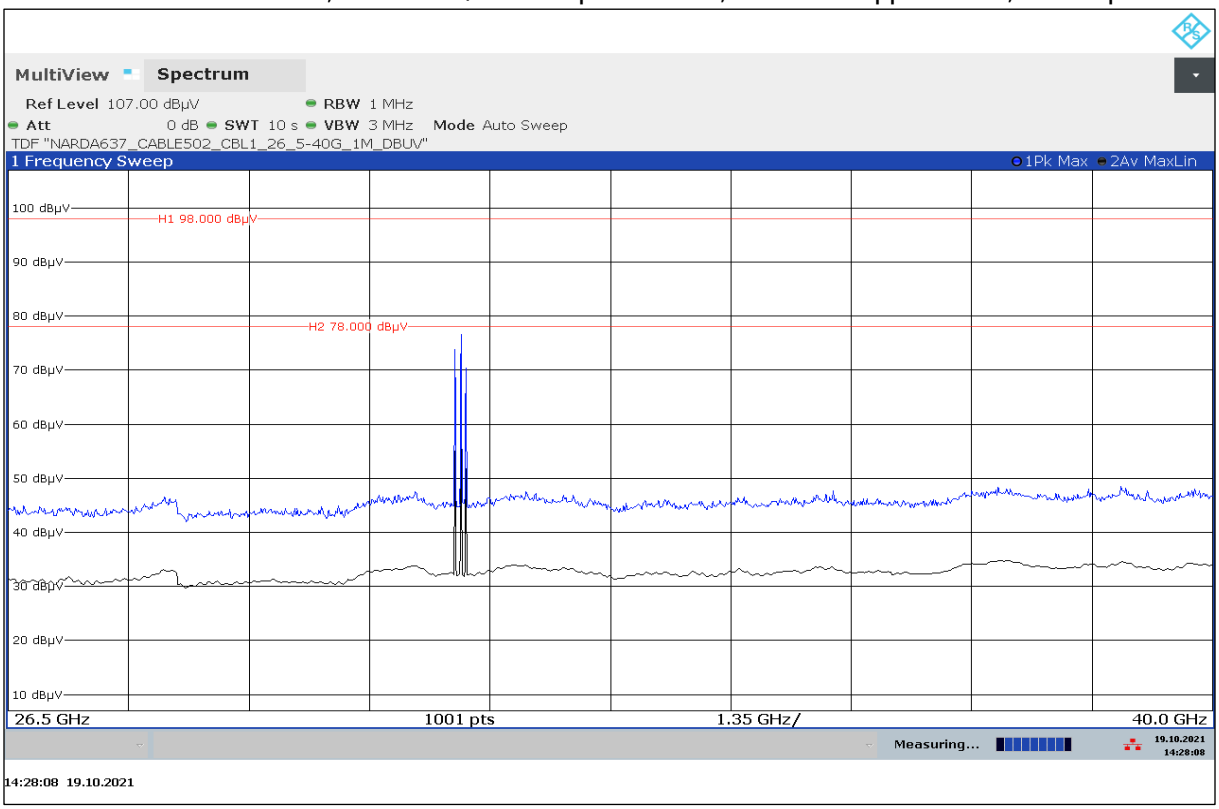
Plot No. 21: 21 GHz, horizontal / vertical polarization, high channel, stopped mode, FCC requirement



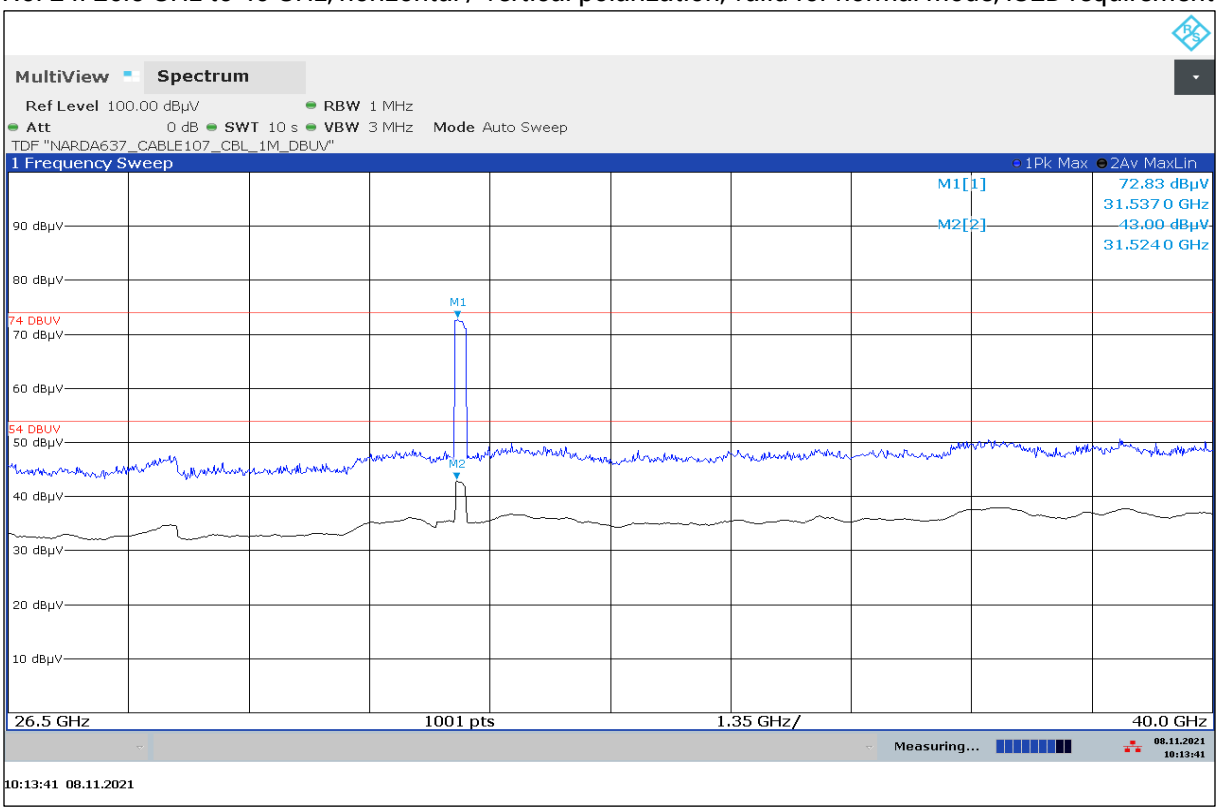
Plot No. 22: 21 GHz, horizontal / vertical polarization, normal mode, ISED requirement



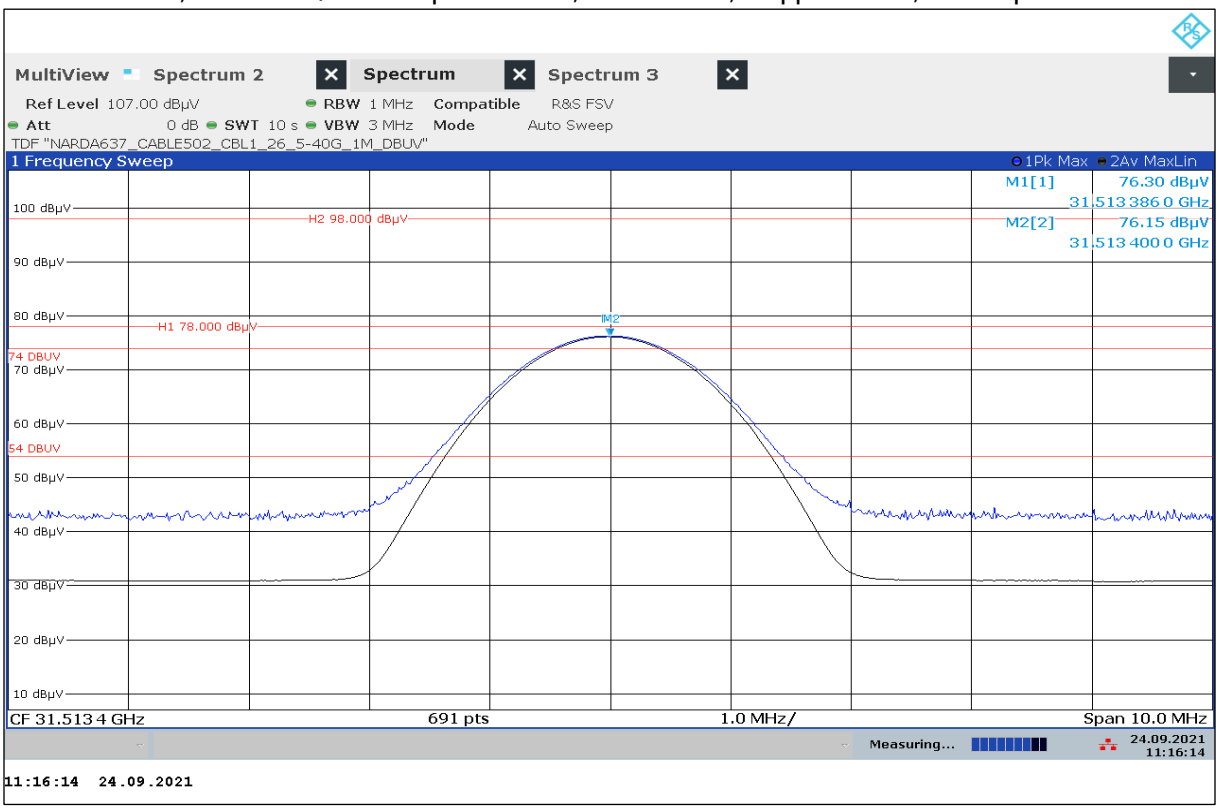
Plot No. 23: 26.5 GHz to 40 GHz, horizontal / vertical polarization, valid for stopped mode, FCC requirement



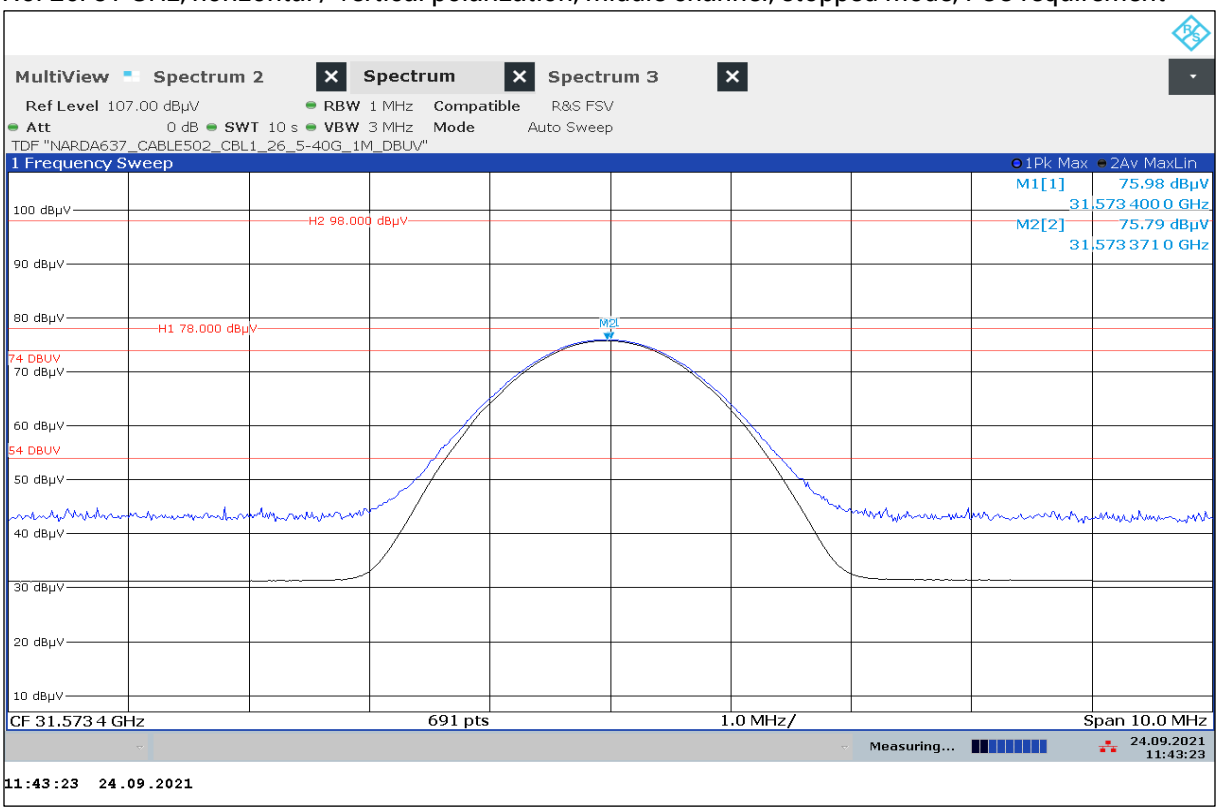
Plot No. 24: 26.5 GHz to 40 GHz, horizontal / vertical polarization, valid for normal mode, ISED requirement



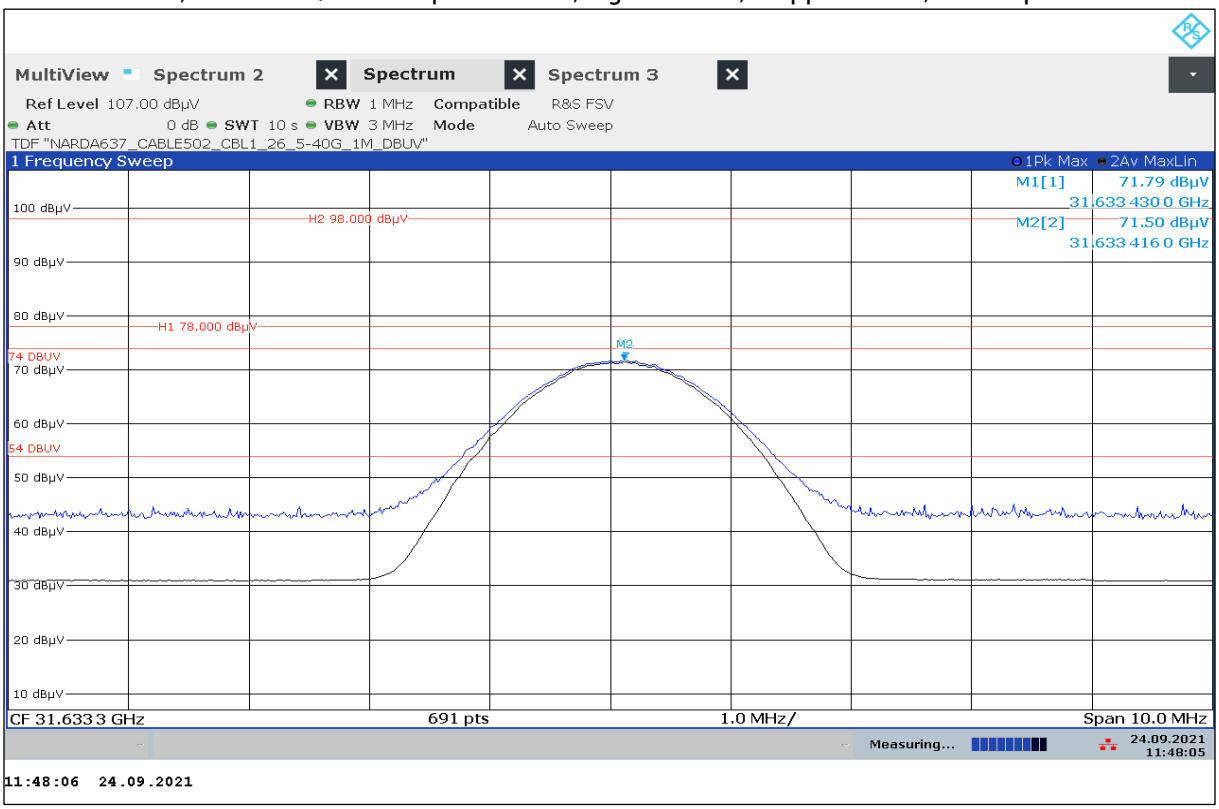
Plot No. 25: 31 GHz, horizontal / vertical polarization, low channel, stopped mode, FCC requirement



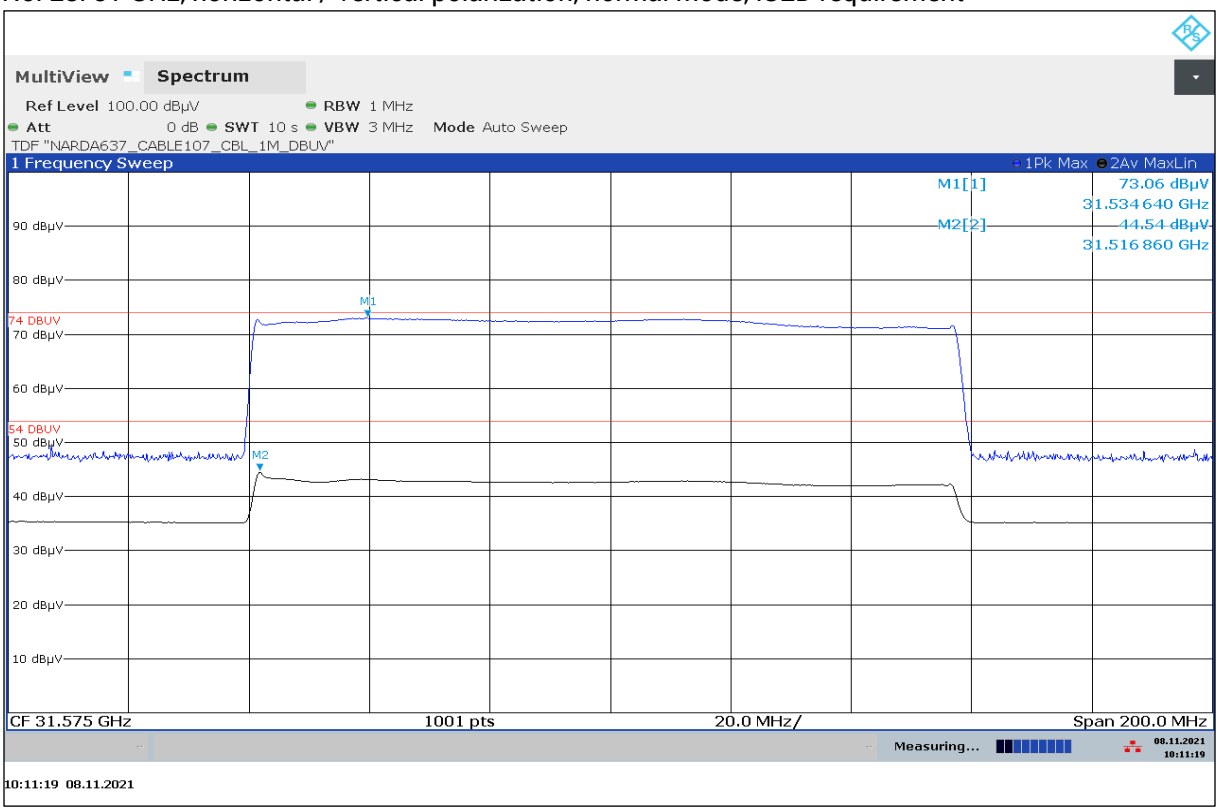
Plot No. 26: 31 GHz, horizontal / vertical polarization, middle channel, stopped mode, FCC requirement



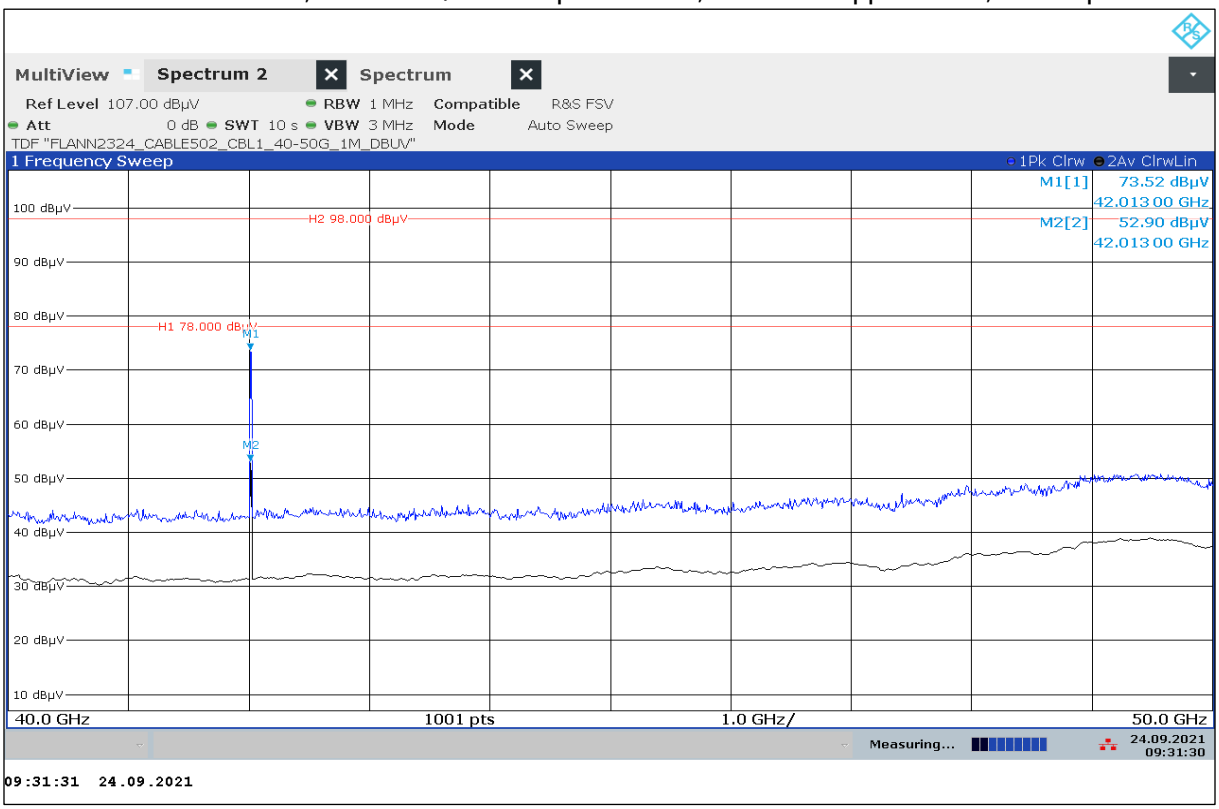
Plot No. 27: 31 GHz, horizontal / vertical polarization, high channel, stopped mode, FCC requirement



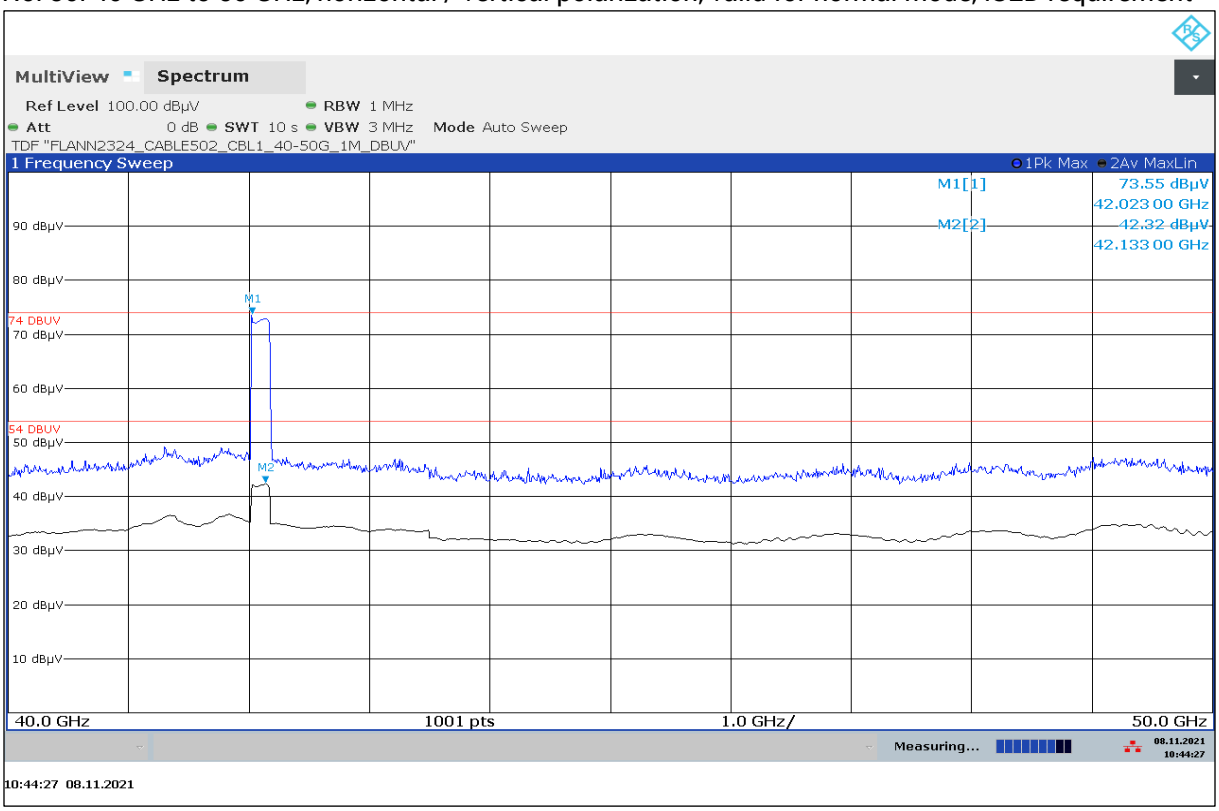
Plot No. 28: 31 GHz, horizontal / vertical polarization, normal mode, ISED requirement



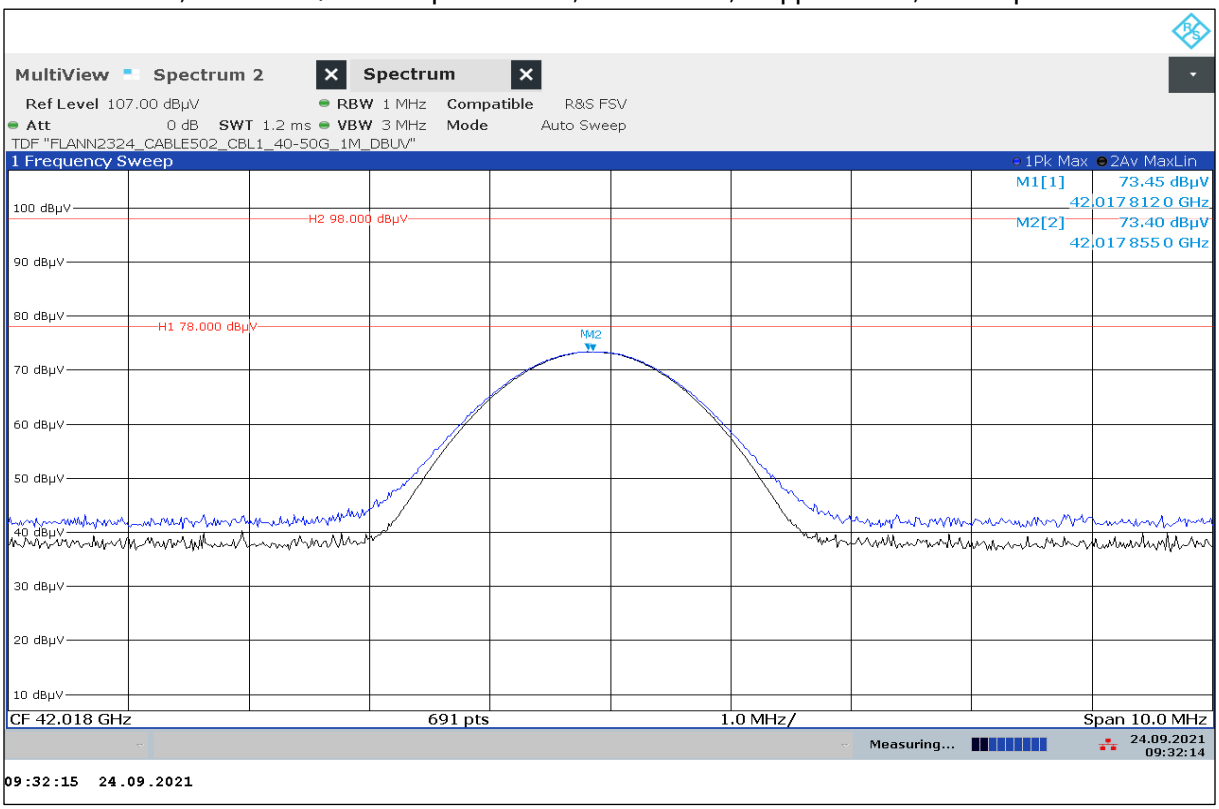
Plot No. 29: 40 GHz to 50 GHz, horizontal / vertical polarization, valid for stopped mode, FCC requirement



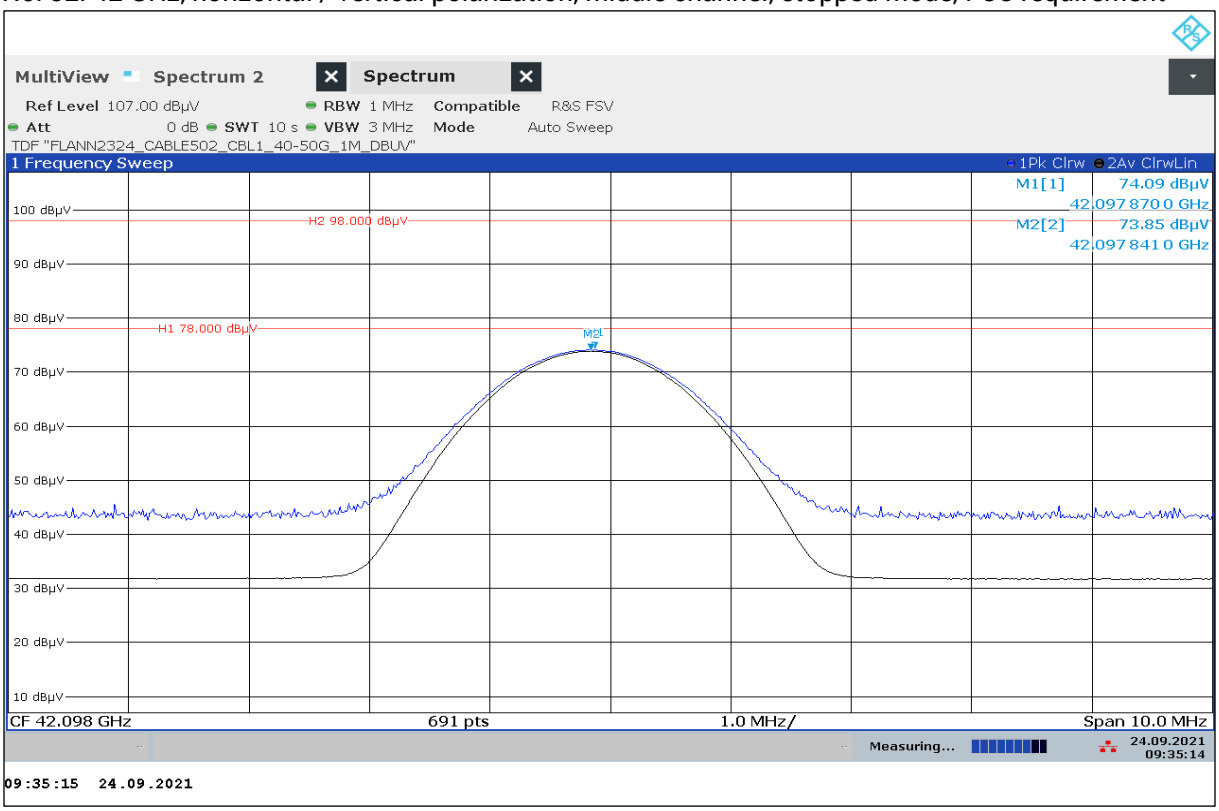
Plot No. 30: 40 GHz to 50 GHz, horizontal / vertical polarization, valid for normal mode, ISED requirement



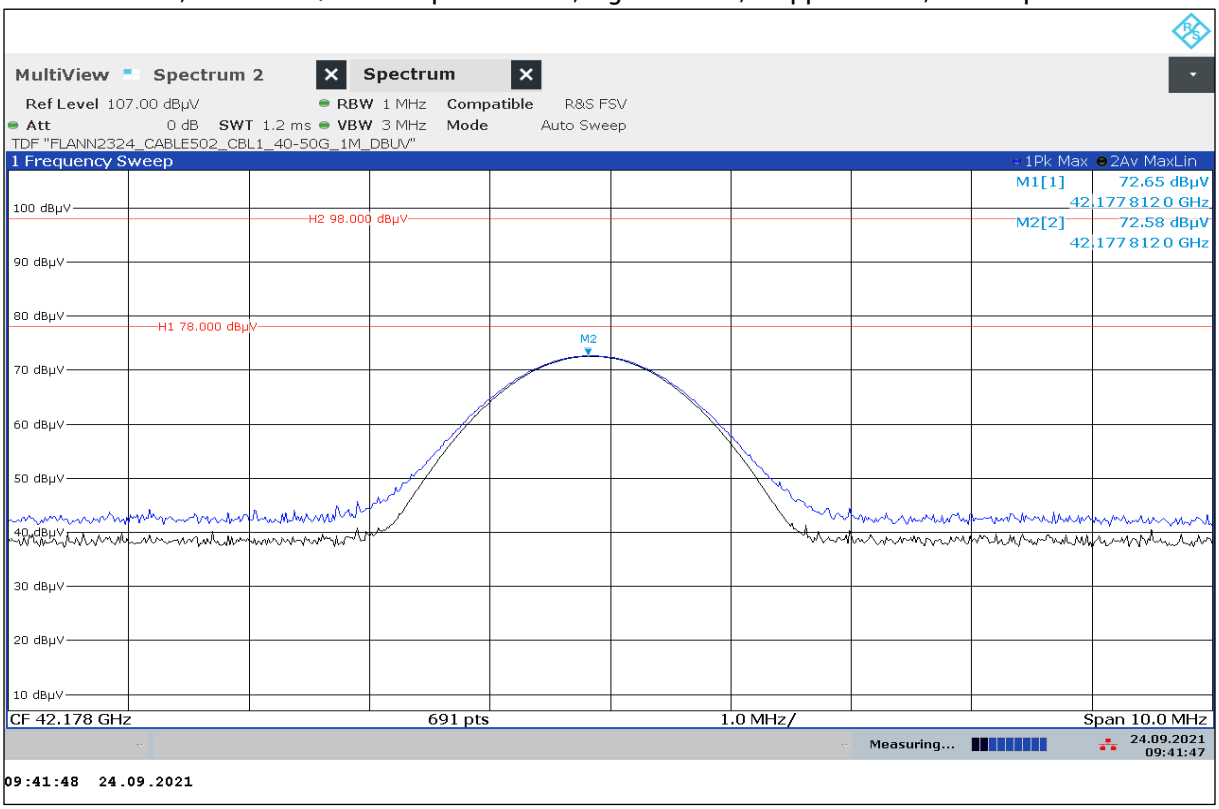
Plot No. 31: 42 GHz, horizontal / vertical polarization, low channel, stopped mode, FCC requirement



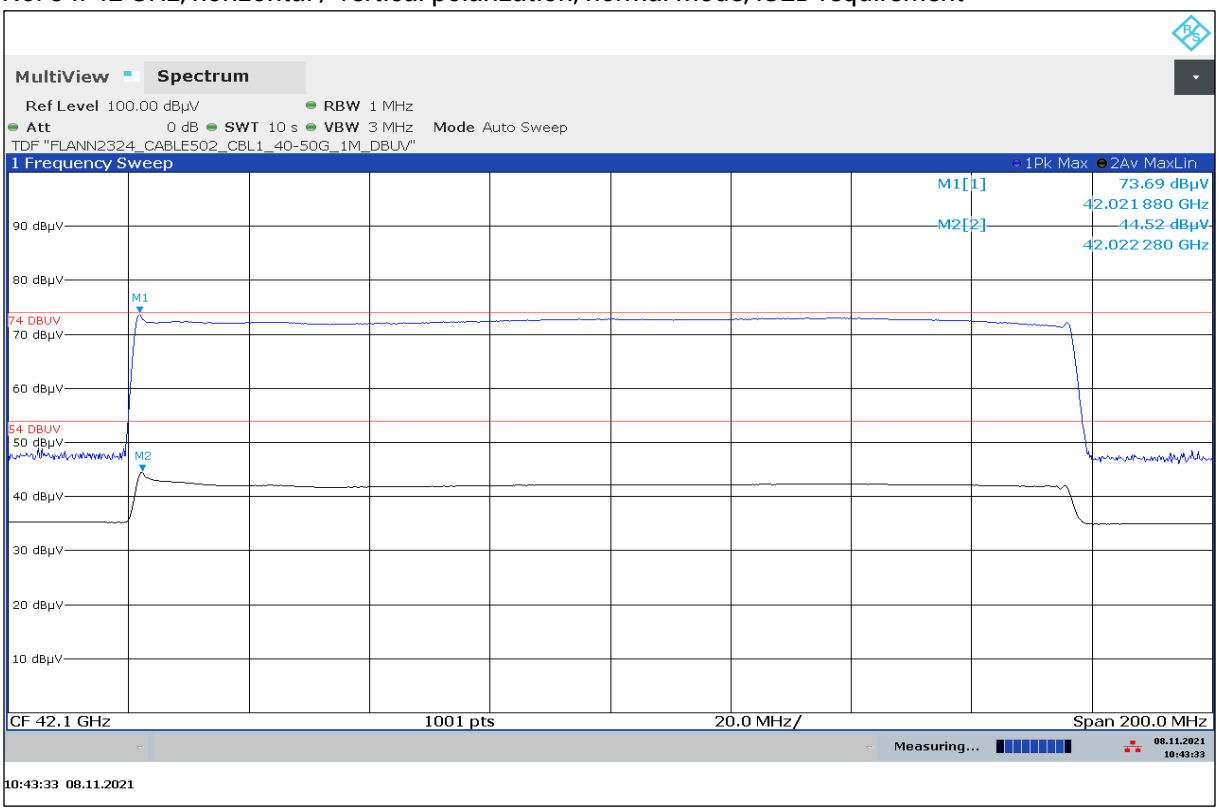
Plot No. 32: 42 GHz, horizontal / vertical polarization, middle channel, stopped mode, FCC requirement



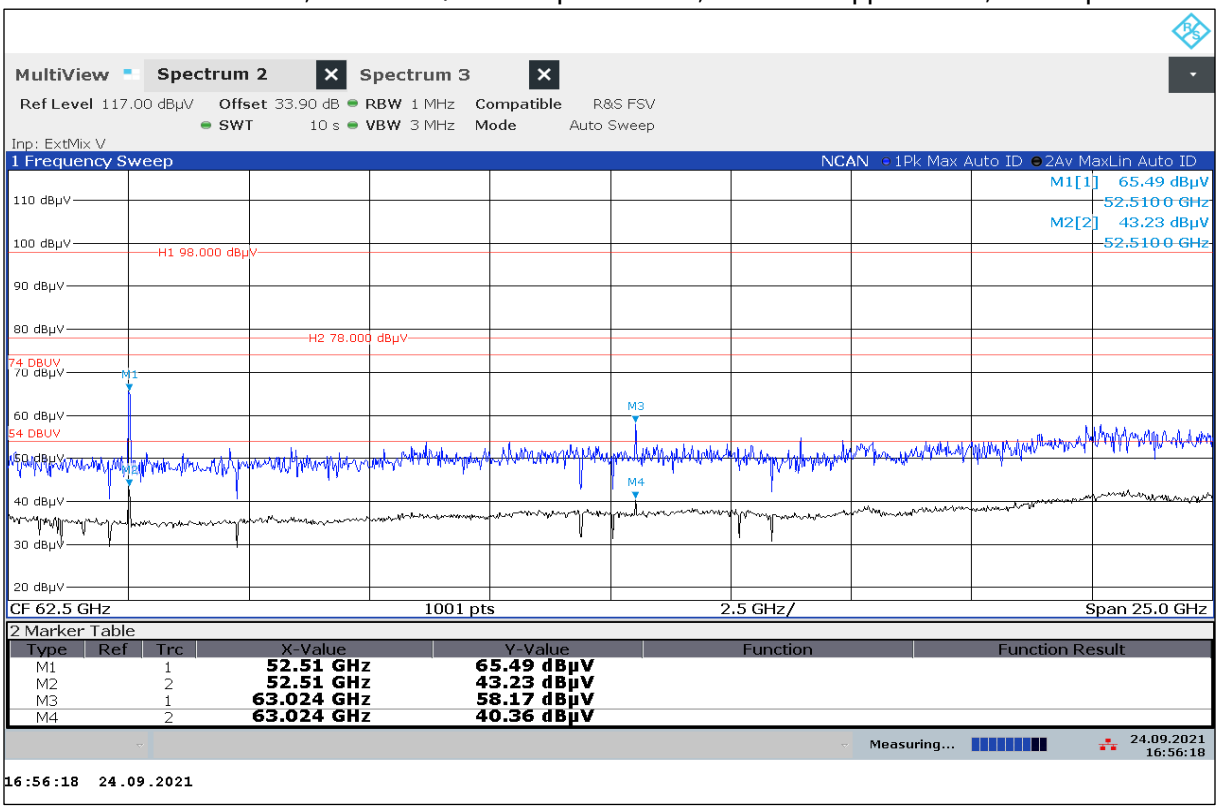
Plot No. 33: 42 GHz, horizontal / vertical polarization, high channel, stopped mode, FCC requirement



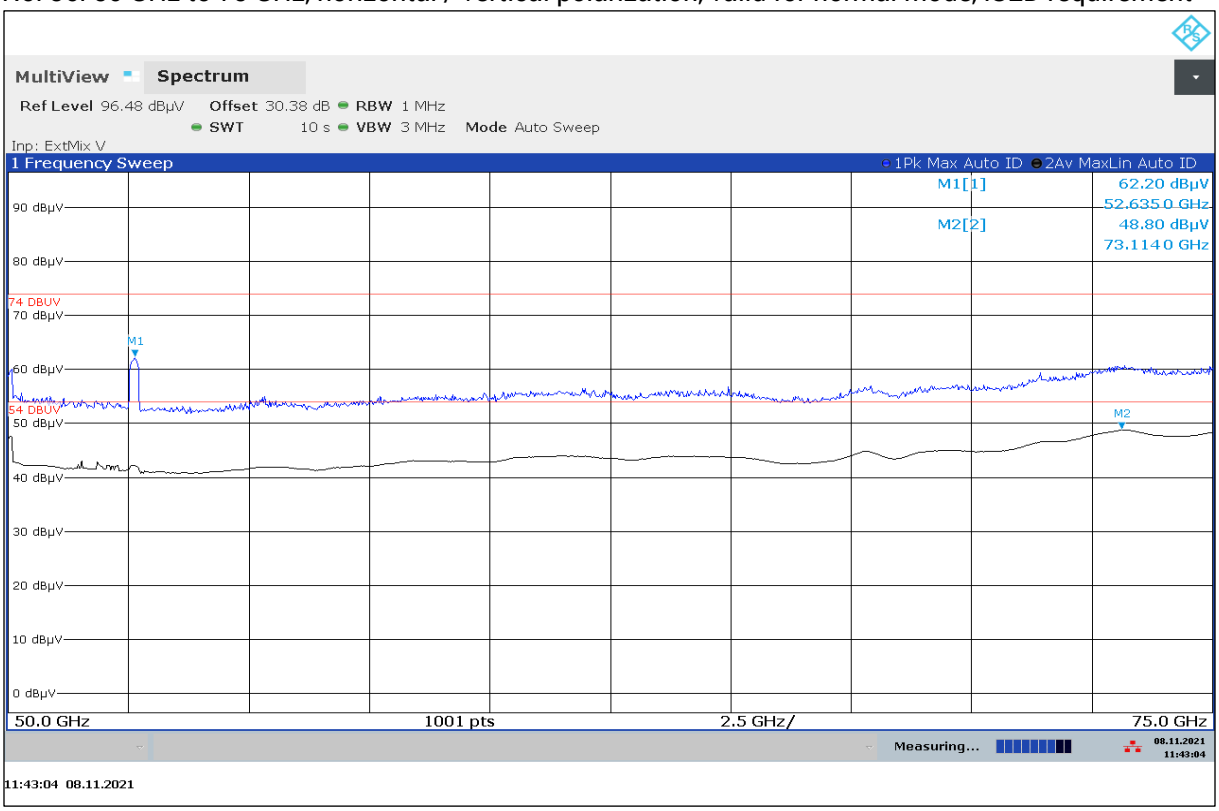
Plot No. 34: 42 GHz, horizontal / vertical polarization, normal mode, ISED requirement



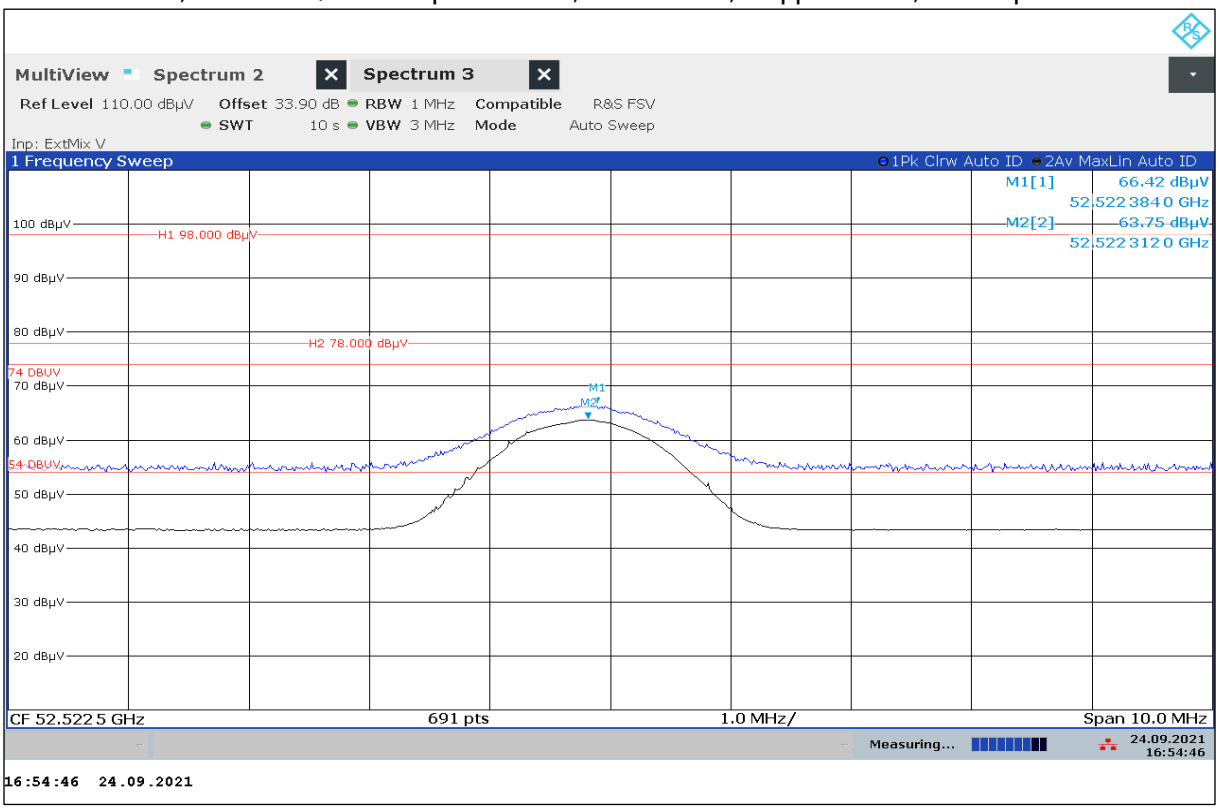
Plot No. 35: 50 GHz to 75 GHz, horizontal / vertical polarization, valid for stopped mode, FCC requirement



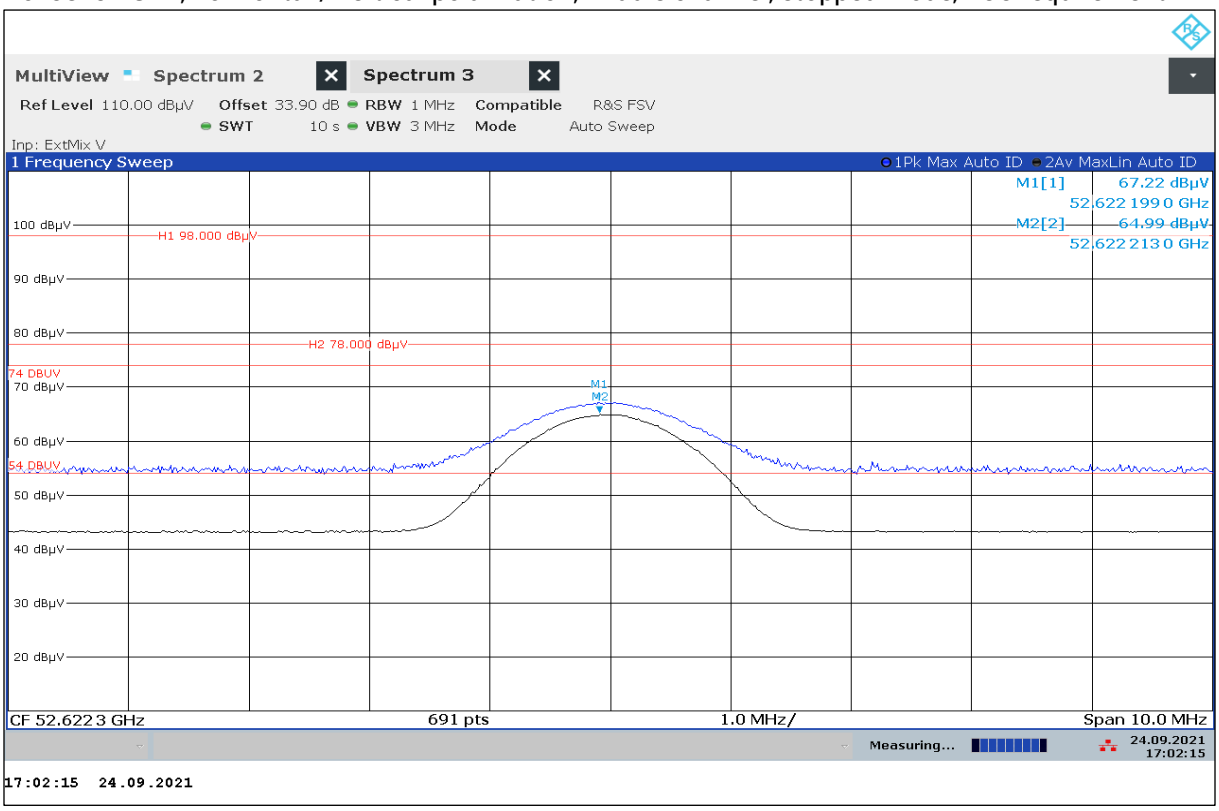
Plot No. 36: 50 GHz to 75 GHz, horizontal / vertical polarization, valid for normal mode, ISED requirement



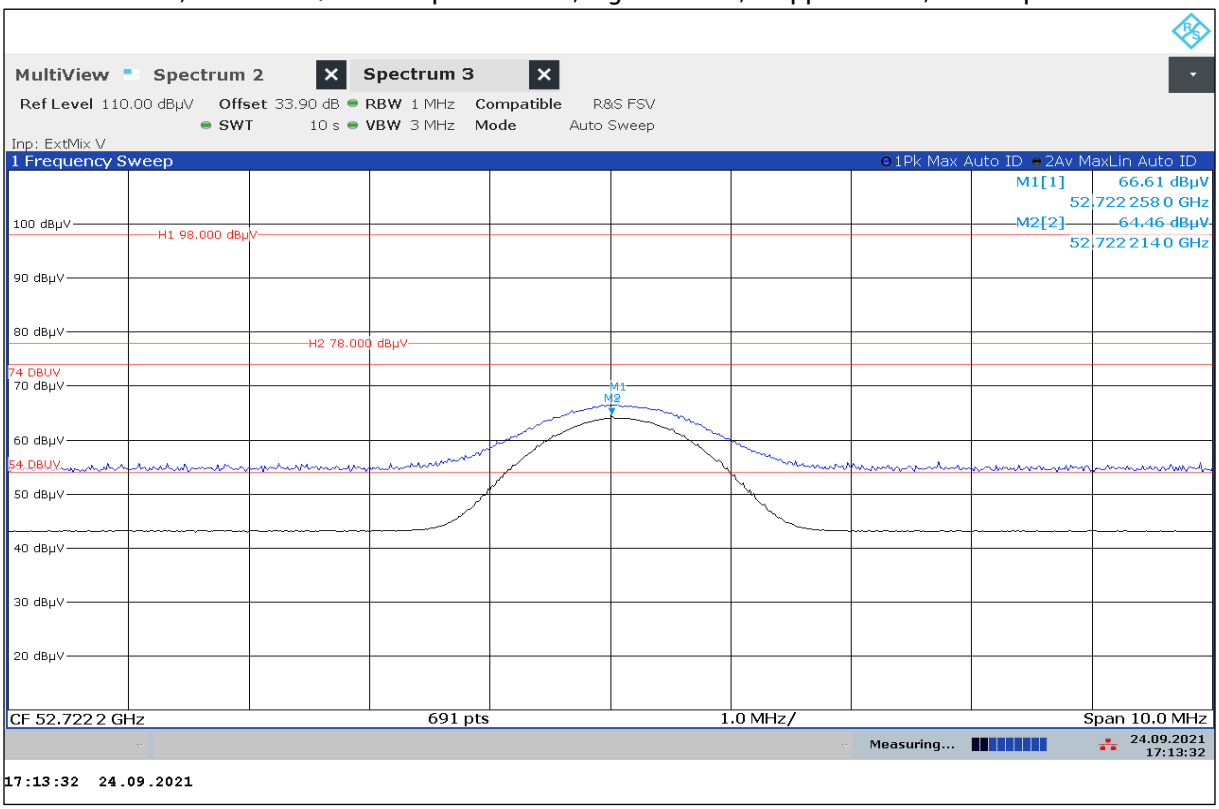
Plot No. 37: 52 GHz, horizontal / vertical polarization, low channel, stopped mode, FCC requirement



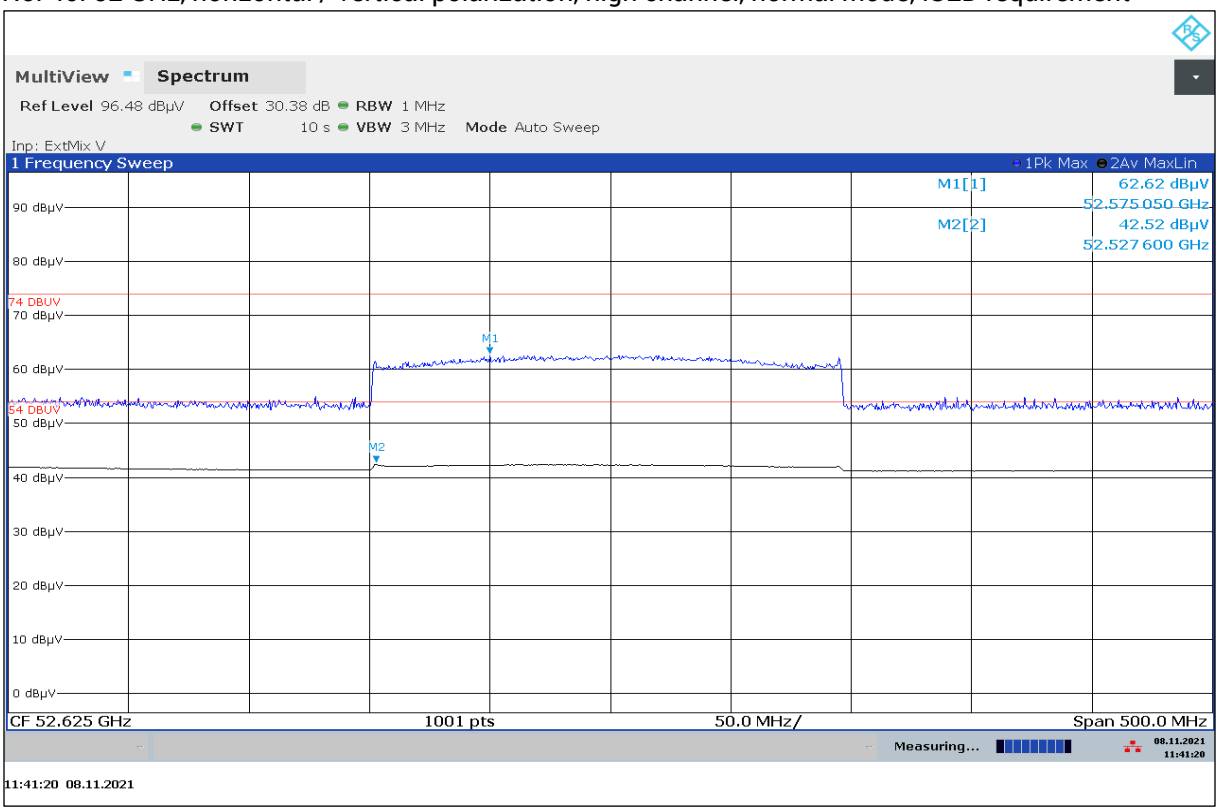
Plot No. 38: 52 GHz, horizontal / vertical polarization, middle channel, stopped mode, FCC requirement



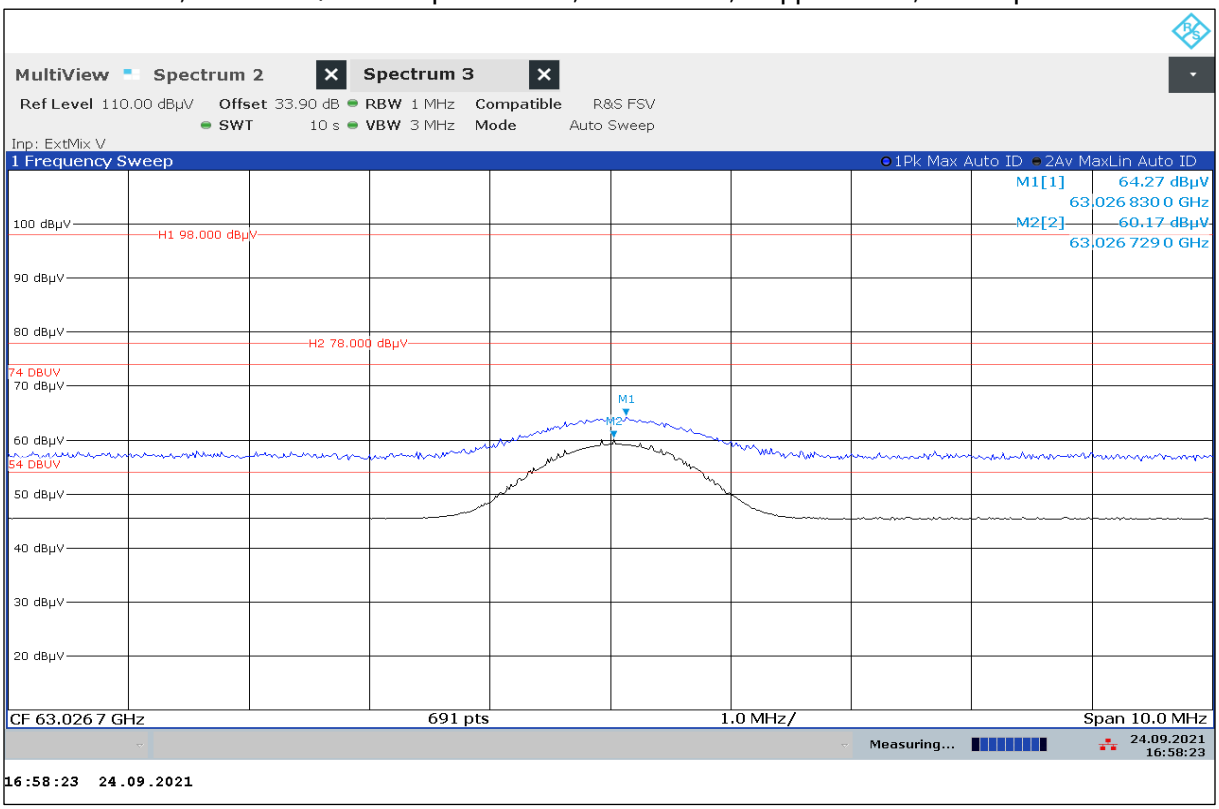
Plot No. 39: 52 GHz, horizontal / vertical polarization, high channel, stopped mode, FCC requirement



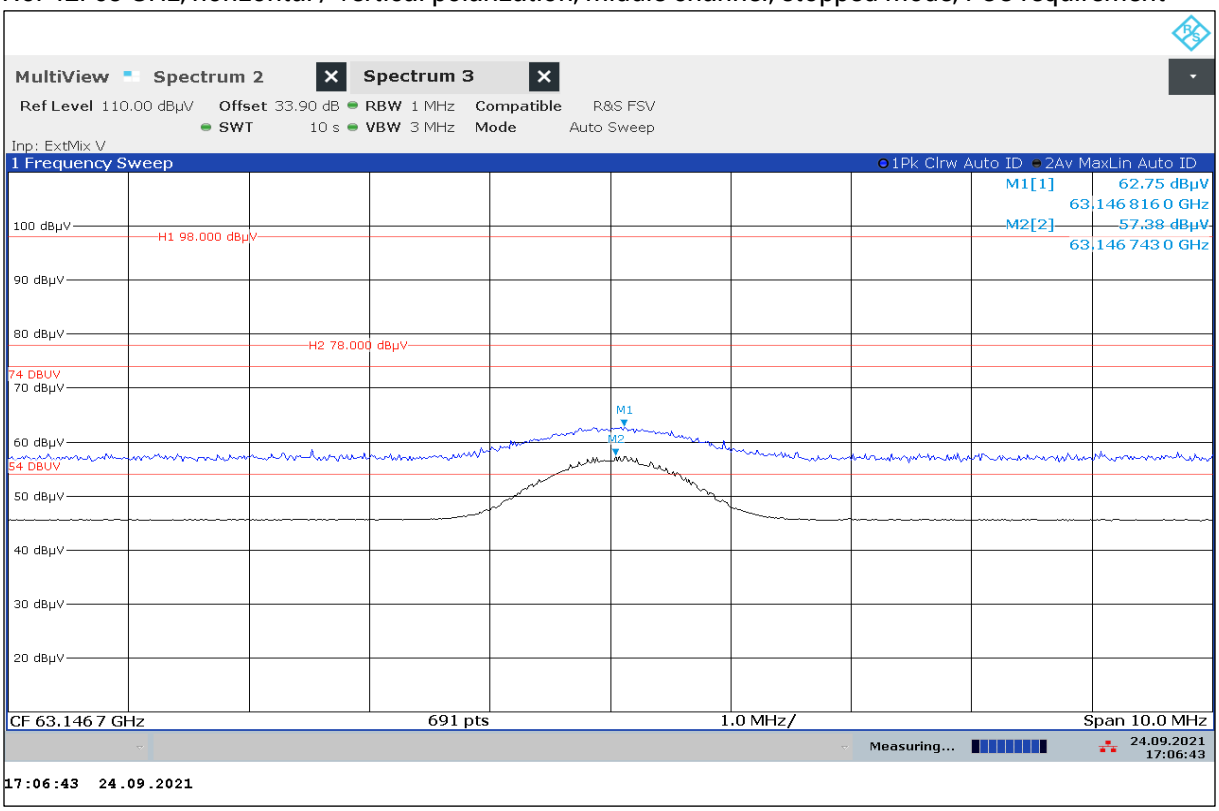
Plot No. 40: 52 GHz, horizontal / vertical polarization, high channel, normal mode, ISED requirement



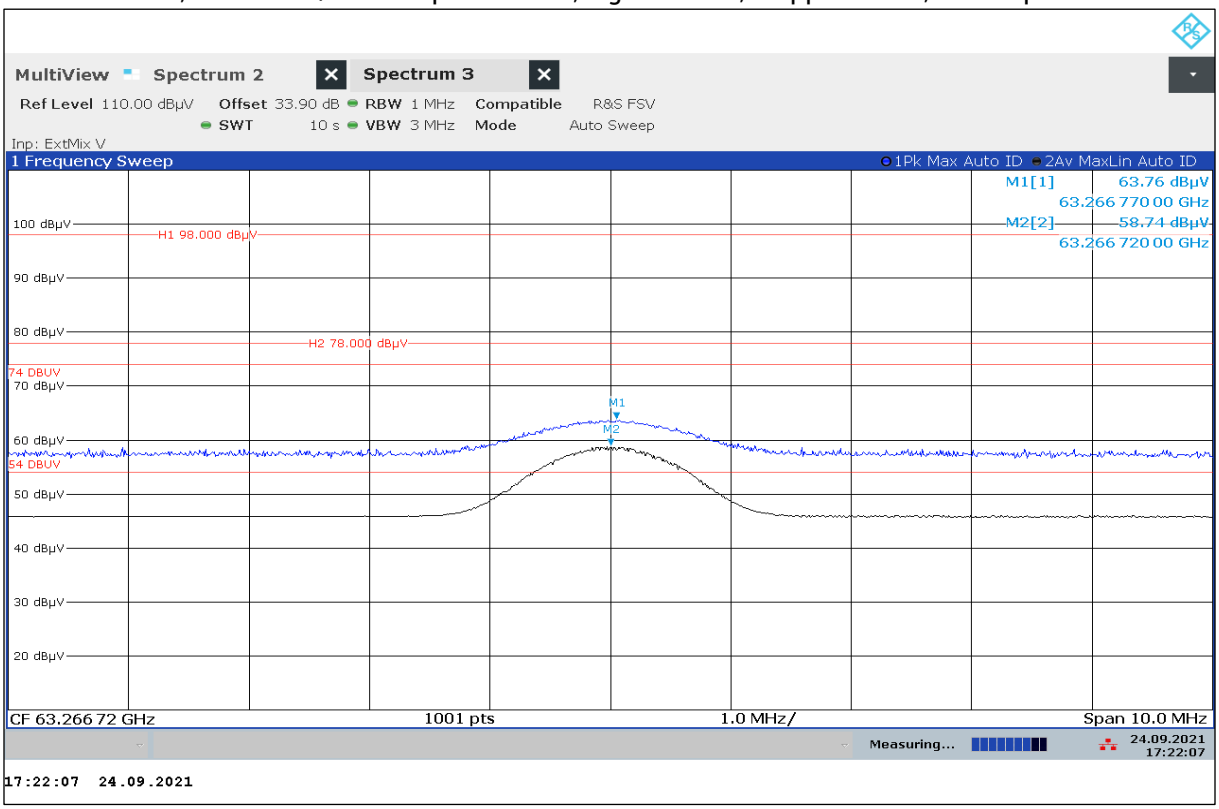
Plot No. 41: 63 GHz, horizontal / vertical polarization, low channel, stopped mode, FCC requirement



Plot No. 42: 63 GHz, horizontal / vertical polarization, middle channel, stopped mode, FCC requirement



Plot No. 43: 63 GHz, horizontal / vertical polarization, high channel, stopped mode, FCC requirement



11.4 Conducted spurious emissions < 30 MHz

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.

Measurement:

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

Limits:

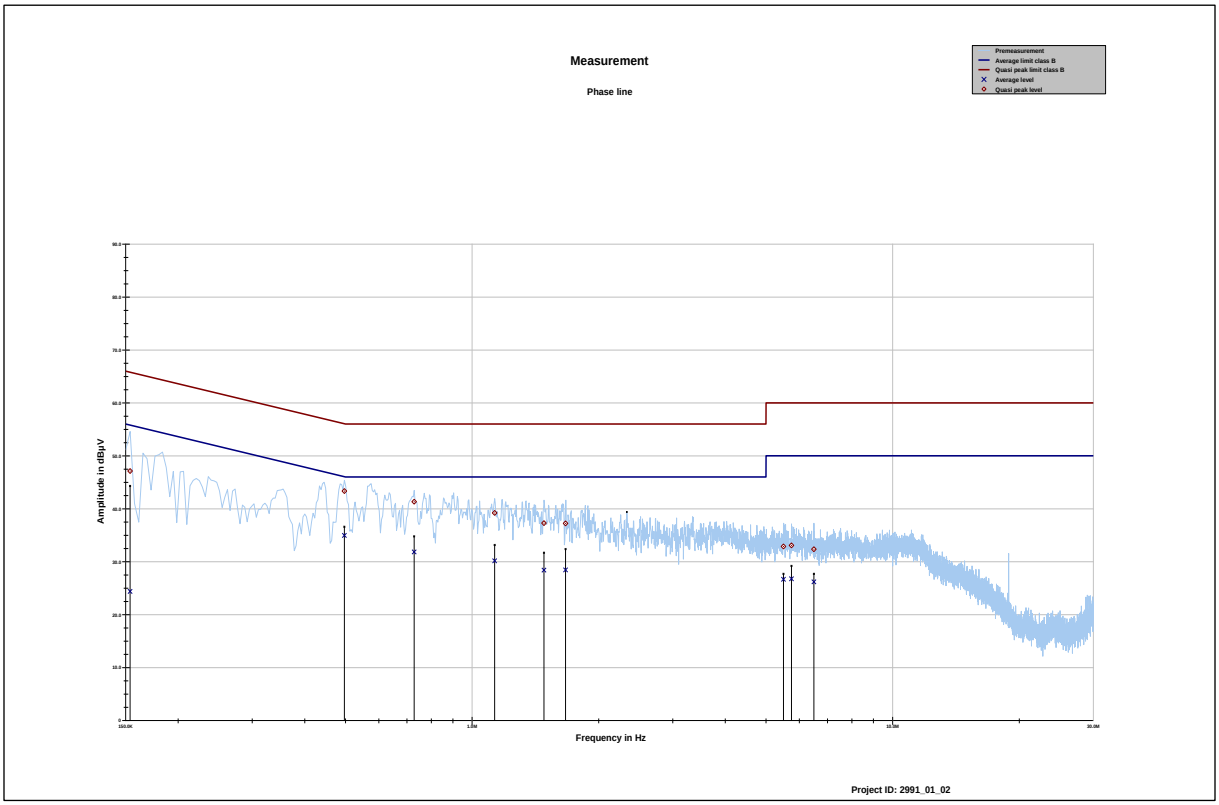
FCC		IC
CFR Part 15.207(a)		RSS-Gen 8.8
Conducted Spurious Emissions < 30 MHz		
Frequency (MHz)	Quasi-Peak (dBµV/m)	Average (dBµV/m)
0.15 – 0.5	79 to 69* (Class A) 66 to 56* (Class B)	79 to 69* (Class A) 56 to 46* (Class B)
0.5 – 5	73 (Class A) 56 (Class B)	63 (Class A) 46 (Class B)
5 – 30.0	73 (Class A) 60 (Class B)	63 (Class A) 50 (Class B)

*Decreases with the logarithm of the frequency

Measurement results:

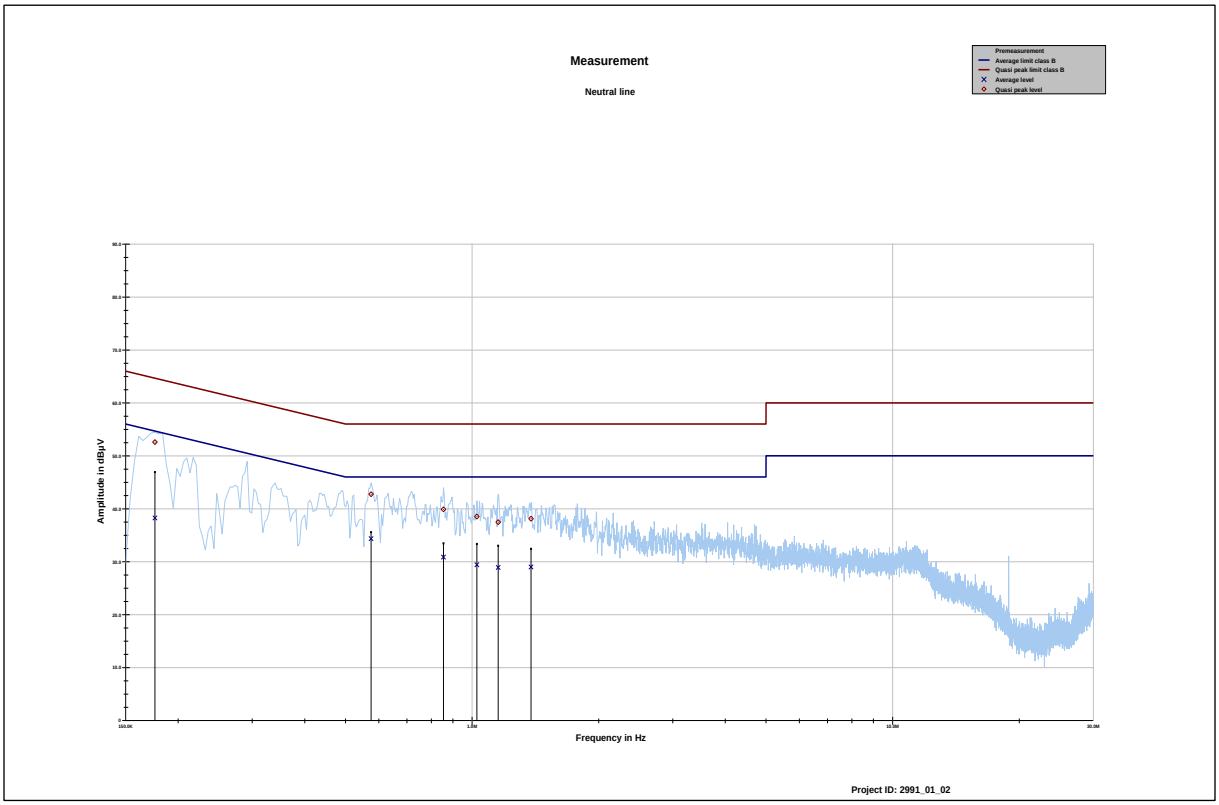
See plots below.

Plot No. 44: Phase line



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.202237	40.35	23.17	63.518	28.07	26.44	54.508
0.377606	34.42	23.92	58.332	22.03	27.47	49.497
0.687300	25.81	30.19	56.000	16.41	29.59	46.000
3.224550	28.91	27.09	56.000	20.95	25.05	46.000
3.403650	27.22	28.78	56.000	21.42	24.58	46.000
3.765581	27.14	28.86	56.000	21.82	24.18	46.000
18.873413	39.99	20.01	60.000	40.13	9.87	50.000

Plot No. 45: Neutral line



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin Average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.150000	45.60	20.40	66.000	31.82	24.18	56.000
0.314175	38.77	21.08	59.859	25.14	26.17	51.309
0.545512	32.51	23.49	56.000	20.51	25.49	46.000
3.373800	22.38	33.62	56.000	11.87	34.13	46.000
3.735731	20.33	35.67	56.000	12.17	33.83	46.000
3.847669	13.08	42.92	56.000	7.40	38.60	46.000
18.873413	40.14	19.86	60.000	40.29	9.71	50.000

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 - DRAFT	2021-10-26
-/-	Minor changes	2021-11-17

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

first page	last page

DAkkS Deutsche Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Entrusted according to Section 8 subsection 1 AkkStelleG in connection with Section 1 subsection 1 AkkStelleGBV
Signatory to the Multilateral Agreements of EA, ILAC and IAF for Mutual Recognition

Accreditation

The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory

CTC advanced GmbH
Untertürkheimer Straße 6-10, 66117 Saarbrücken

is competent under the terms of DIN EN ISO/IEC 17025:2018 to carry out tests in the following fields:

Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards

The accreditation certificate shall only apply in connection with the notice of accreditation of 09.06.2020 with the accreditation number D-PL-12076-01. It comprises the cover sheet, the reverse side of the cover sheet and the following annex with a total of 07 pages.

Registration number of the certificate: **D-PL-12076-01-04**

Frankfurt am Main, 09.06.2020

by order: Dipl.-Ing. (FH) Ralf Egner
Head of Division

The certificate together with its annex reflects the status at the time of the date of issue. The current status of the scope of accreditation can be found in the database of accredited bodies of Deutsche Akkreditierungsstelle GmbH.
https://www.dakks.de/en/content/accredited-bodies-dakks
See notes overleaf.

Deutsche Akkreditierungsstelle GmbH

Office Berlin	Office Frankfurt am Main	Office Braunschweig
Spittelmarkt 10	Europa-Allee 52	Bundesallee 100
10117 Berlin	60327 Frankfurt am Main	38116 Braunschweig

The publication of extracts of the accreditation certificate is subject to the prior written approval by Deutsche Akkreditierungsstelle GmbH (DAkkS). Exempted is the unchanged form of separate disseminations of the cover sheet by the conformity assessment body mentioned overleaf.

No impression shall be made that the accreditation also extends to fields beyond the scope of accreditation attested by DAkkS.

The accreditation was granted pursuant to the Act on the Accreditation Body (AkkStelleG) of 31 July 2009 (Federal Law Gazette I p. 2625) and the Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products (Official Journal of the European Union L 218 of 9 July 2008, p. 30). DAkkS is a signatory to the Multilateral Agreements for Mutual Recognition of the European co-operation for Accreditation (EA), International Accreditation Forum (IAF) and International Laboratory Accreditation Cooperation (ILAC). The signatories to these agreements recognise each other's accreditations.

The up-to-date state of membership can be retrieved from the following websites:
EA: www.european-accreditation.org
ILAC: www.ilac.org
IAF: www.iaf.nu

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

https://www.dakks.de/files/data/as/pdf/D-PL-12076-01-04.pdf

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

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

first page	last page

DAkkS Deutsche Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Entrusted according to Section 8 subsection 1 AkkStelleG in connection with Section 1 subsection 1 AkkStelleGBV
Signatory to the Multilateral Agreements of EA, ILAC and IAF for Mutual Recognition

Accreditation

The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory

CTC advanced GmbH
Untertürkheimer Straße 6-10, 66117 Saarbrücken

is competent under the terms of DIN EN ISO/IEC 17025:2018 to carry out tests in the following fields:

Telecommunication (FCC Requirements)

The accreditation certificate shall only apply in connection with the notice of accreditation of 09.06.2020 with the accreditation number D-PL-12076-01. It comprises the cover sheet, the reverse side of the cover sheet and the following annex with a total of 05 pages.

Registration number of the certificate: **D-PL-12076-01-05**

Frankfurt am Main, 09.06.2020

by order Dipl.-Ing. (FH) Ralf Egner
Head of Division

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https://www.dakks.de/en/content/accredited-bodies-dakks

See notes overleaf.

Deutsche Akkreditierungsstelle GmbH

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Spittelmarkt 10	Europa-Allee 52	Bundesallee 100
10117 Berlin	60327 Frankfurt am Main	38116 Braunschweig

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or
https://ctcadvanced.com/app/uploads/2020/06/D-PL-12076-01-05_TCB_USA.pdf

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